OCT 12 1999

21

ENGINEERING DATA TRANSMITTAL

Station 15

Page 1 of 1 KN
1. EDT 627796

2. To: (Receiving Organization) Distribution		3. From: (Originating Organization) RPP Vadose Zone Project		4. Related EDT No.: N/A	
5. Proj./Prog./Dept./Div.:		6. Design Authority/Design Agent/Cog. Engr.:		7. Purchase Order No.: N/A	
8. Originator Remarks: For Approval/Release				9. Equip./Component No.: N/A	
				10. System/Bldg./Facility: 200E/BX Tank Farm	
				12. Major Assem. Dwg. No.: N/A	
11. Receiver Remarks:				13. Permit/Permit Application No.: N/A	
				14. Required Response Date: N/A	
				11A. Design Baseline Document? ☐ Yes ☒ No	

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	HNF-3531	All	0	Analysis of Historical Gross Gamma Logging Data from BX Tank Farm	N/A	2	1	

16. KEY		
Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)											
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
		Design Authority									
		Design Agent									
1	1	Cog. Eng. D. A. Myers	<i>[Signature]</i>	10/8/99	H0-22						
1	1	Cog. Mgr. A. J. Knepp	<i>[Signature]</i>	10/8/99	H0-22						
		QA									
		Safety									
		Env.									

18. Signature of EDT Originator <i>[Signature]</i>	19. Authorized Representative for Receiving Organization <i>[Signature]</i>	20. Design Authority/Cognizant Manager <i>[Signature]</i>	21. DOE APPROVAL (if required) Ctrl No. _____ ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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[illegible]

Analysis of Historical Gross Gamma Logging Data from BX Tank Farm

D. A. Myers

Waste Management Northwest/Three Rivers Scientific

Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 627796

UC: 2010

Org Code: 73100

Charge Code: ~~106501~~

B&R Code: EW3130010

Total Pages: ~~442~~

^{KN} 110167/CA40
HMLM0131
^{KN} 442

Key Words: Vadose Zone, BX Tank Farm, Dry Well Gross Gamma, Gross Gamma Logs

Abstract: Gross gamma ray logs, recorded from January 1975 through mid-year 1994 as part of the Single-Shell Tank Farm Dry Well Surveillance Program, have been reanalyzed for the BX tank farm to locate the presence of mobile radionuclides in the subsurface. This report presents the BX tank farm gross gamma ray data in such a way as to assist others in their study of vadose zone mechanisms.

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Karen L. Noland 10/12/99
Release Approval Date

Approved For Public Release

WMNW

Project: 772028
Task: 23020001

**ANALYSIS OF
HISTORICAL GROSS GAMMA
LOGGING
DATA FROM BX TANK FARM**

Data Analysis By: 3 Rivers Scientific

Borehole 21-00-01

No Gamma-Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1993 in the vadose zone from 2 to 145 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	145 ft
Survey Depth :	145 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	154

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-00-01

**Oldest Survey
1/14/1975**

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-00-01

Dry Well Survey Analysis - Notes

Borehole 21 BX-00-01Total # Surveys 156Probe Type 04Log Date: 1-14-75 1st# neutron surveys 2# GR Surveys 1546-12-93 LastPresentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): none GRIsotope from Spectral Survey: CsMax Survey Depth 145

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

<u>Cs 3mm w/ HPLC - tried 0-25 bkg but still no clear</u>
<u>or clear delay in clear using 0-50 procedure</u>
<u>(For exp. time 12-10 @ 25 bkg)</u>

Analyst Name R³S/W ver TFGRDES 2.2

01/14/75

Borehole 21-00-01

Reference ONLY: Used threshold of 25, thus low clean freq and still no clear decay nature.

Depth: 0-10 ft

06/17/93

Borehole 21-00-02

Contamination (Cs-137 & Ru-106) from 70-80 feet is Stable, late
Contamination (Co-60) from 80-90 feet is Stable

Grade thickness product from 70 to 80 feet increased starting 1975, but consistent with a least squares fit for Cs-137 (HPGe identified) and Ru-106 (hypothesis) from 1976 to 1994.

The least squares fit results in a gross gamma contribution ratio of Ru-106 to Cs-137 of 17.1 as of Dec 1975. This zone appears stable since 1976.

Grade thickness product from 80 to 90 feet appears stable from 1975 to 1993.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	141

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	70-80 Stable late, 80-90 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/14/75

Borehole 21-00-02

Depth: 70-80 ft

06/17/93

01/14/75

Borehole 21-00-02

Depth: 80-90 ft

06/17/93

Borehole 21-00-02

Dry Well Survey Analysis - Notes

Borehole BX 21-00-02Total # Surveys 145Probe Type 04Log Date: 1-14-75 1st# neutron surveys 4
6-17-93 Last# GR Surveys 141Presentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): 70-90 70-80 & 80-90Isotope from Spectral Survey: Cs @ low levels 0-15'Max Survey Depth 100Co @ " " 80-90

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

<u>Co⁶⁰ @ low levels in H₂PO₄, but history also low & fast decay. No depth shifts & source gone stable</u>

Analyst Name RJS/W ver TFGRASS 2.2

filein := "two.txt"

Well 21-00-02

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 107

i := 0..N

k := 0..300

j := 0..299

$$\tau_{eu} := \frac{368.2}{365.25}$$
 $\tau_{co} := 5.27$ $\tau_{cs} := 30.17$

aco := 00

acs := 50

Eu variables are
Ru-106 aeu := 700

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[\text{gross}_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 46.585$$

$$\alpha_{eu} = 799.464$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.058$$

$$\frac{Eu_N}{Cs_N} = 8.048 \cdot 10^{-5}$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

Borehole 21-00-05

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1993 in the vadose zone from 5 to 140 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	140 ft
Survey Depth :	140 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	100

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-00-05

**Oldest Survey
1/14/1975**

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-00-05

Dry Well Survey Analysis - Notes

Borehole 21-00-05Total # Surveys 100Probe Type 04Log Date: 1-14-75 1st# neutron surveys 3# GR Surveys 976-17-93 LastPresentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): none by areaIsotope from Spectral Survey: Cs-137 Co-60
3x61gMax Survey Depth 140

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Clear, truly 0-5 with no show. Natural bkg
changes more than contaminated zones.

Analyst Name Anna K. KinsellS/W ver TF-6RDS 2.2

Borehole 21-00-07

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1993 in the vadose zone from 5 to 145 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: shielded NaI, 02: GM; 04: Neutron
Borehole Depth :	90 ft
Survey Depth :	90 ft
First Survey Date :	1/15/1975
Last Survey Date :	10/5/1993
Number Surveys :	358

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-00-07

**Oldest Survey
1/15/1975**

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

HNF-3531 -REV0

Borehole 21-00-07

Dry Well Survey Analysis - Notes

Borehole 21-00-07Total # Surveys 363Probe Type 04Log Date: 1-15-75 1st# neutron surveys 3# GR Surveys 358112-5-93 LastPresentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): None + 2' atIsotope from Spectral Survey: Cs very lowMax Survey Depth 8'7

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Freq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>Very low H/C levels seen not shown on graph</u>

Analyst Name R³

S/W ver

TFGROSS 2.2

Borehole 21-00-09**Contamination (Ru-106) from 45-60 feet is Undetermined**

Grade thickness product from 45 to 60 feet was specially processed with no natural background subtraction, due to fitting inconsistencies. There is only a possible show of Ru-106 early provided no background subtraction. Activity levels are near threshold.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	75 ft
Survey Depth :	75 ft
First Survey Date :	1/15/1975
Last Survey Date :	10/5/1993
Number Surveys :	205

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<10	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	45-60 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/15/75

Borehole 21-00-09

Depth: 45-60 ft

10/05/93

Borehole 21-00-09

Dry Well Survey Analysis - Notes

Bx
Borehole 21-00-09Total # Surveys 208Probe Type 04Log Date: 1-15-75 1st# neutron surveys 3# GR Surveys 2057-12-93 LastPresentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): Cs + Ru?Isotope from Spectral Survey: very low CsMax Survey Depth 75

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg Bkg	Comment
	Cs from HPLC too low, but stuck #				
	low bkg above Ru early - went to no				
	bkg & Ru → Vaseline				
	a 45-60 b high bkg → o's Ru				
	a 45-60 c " " miss 75'				
well →	a 45-60 d no bkg				
	a 45-60 e moved into well bkg				

left out for info

Analysis Notes

very early Ru¹⁰⁶ possible in last part of waste front
 White labels are low & Ru history very short
 Given levels on HPLC & are superficial OR acc. decay
 especially at end (93)

Analyst Name RS/W ver TFGR052.2

filein := "two.txt"

Well 21-00-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 131

i := 0..N

k := 0..300

j := 0..299

$$\tau_{eu} := \frac{368.2}{365.25}$$

 $\tau_{co} := 5.27$ $\tau_{cs} := 30.17$ $aco := 2760$ $acs := 56$

Eu variables are

Ru-106

aeu := 1270

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i + Co_i$$

gross_i := net_i

This data edited for spurious points

a2 := aco

$$ssq(a1, a3, a2) := \sum_i \left[\text{gross}_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \right] \right]^2 \right]$$

Given

$$ssq(acs, aeu, aco) = 0$$

1=1

2=2

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aeu, aco)$$

$$\alpha_{cs} = 48.288$$

$$\alpha_{eu} = 1.281 \cdot 10^3$$

$$\alpha_{co} = 2.769 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.038$$

$$tot_i := Cs_i + Eu_i + Co_i$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Eu_N}{Cs_N} = 1.244 \cdot 10^{-4}$$

filein := "twor3.txt"

Well 21-00-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 160

i := 0..N

k := 0..300

j := 0..299

$$\tau_{eu} := \frac{368.2}{365.25}$$

 $\tau_{co} := 5.27$ $\tau_{cs} := 10^9$

aco := 00

acs := 443

Eu variables are
Ru-106 aeu := 142

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 443.157$$

$$\alpha_{eu} = 142.533$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 3.109$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Eu_0}{Cs_0} = 0.313$$

Borehole 21-00-11

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1993 in the vadose zone from 2 to 140 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	140 ft
Survey Depth :	140 ft
First Survey Date :	1/21/1975
Last Survey Date :	10/5/1993
Number Surveys :	189

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-00-11

**Oldest Survey
1/21/1975**

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

HNF-3531 -REV0

Borehole 21-00-11

Dry Well Survey Analysis - Notes

BX
Borehole 21-00-11Total # Surveys 192Probe Type 04Log Date: 1-21-75 1st# neutron surveys 3
10-5-93 Last# GR Surveys 187Presentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): none (nailed)Isotope from Spectral Survey: Ce low marginal read depth Max Survey Depth 135 13

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

near surface, but has consistency problem: light
paper read plot, but not electronic.

Analyst Name R³S/W ver TF6R0522

01/21/75

Borehole 21-00-11

For reference only

Depth: 0-10 ft

Threshold at 32 c/s

10/05/93

Borehole 21-00-21

Contamination (Co-60, Cs-137 & Ru-106) from 45-80 feet appears Stable

Grade thickness product from 45 to 80 feet is decreasing consistent with a least squares fit for Co-60 (HPGe identified), Cs-137 (HPGe identified) and Ru-106 (hypothesis) from 1975 to 1993.

The least squares fit results in gross gamma contribution ratios of Ru-106:Cs-137:Co-60 of 1281:48.3:2769 as of Jan 1975. Special note, a fit can be obtained for Ru & Co just as well since this low level of Cs is not a significant factor in the total gross gamma observed. Likewise the confidence for the stability of Cs is extremely low.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	145 ft
Survey Depth :	145 ft
First Survey Date :	1/28/1975
Last Survey Date :	6/17/1993
Number Surveys :	134

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	45-80 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/28/75

Borehole 21-00-21

Depth: 45-80 ft

06/17/93

HNF-3531 - REV 0

Borehole 21-00-21

Dry Well Survey Analysis - Notes

Borehole 21-00-21Total # Surveys 137Probe Type 04Log Date: 1-28-75 1st# neutron surveys 3# GR Surveys 1346-17-93 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): Rn + Co (Leak at surface)Isotope from Spectral Survey: Co at Co (40-50 & 85-90)650-75Max Survey Depth 145

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>cannot depth separate ∴ 1 zone leak square Rn + Co</u>

Analyst Name R³S/W ver TFGRPF22

Borehole 21-00-22

Contamination (Ru-106) from 10-26 feet appears Stable
Contamination (Co-60) from 26-40 feet is Undetermined

Grade thickness product from 10 to 26 feet is decreasing consistent with Ru-106 (hypothesis). The level of Ru-106 is near threshold. The Cs-137 and Co-60 isotopes identified by the HPGe detector are at sufficiently low levels to not register with the gross gamma log data.

Grade thickness product from 26 to 40 feet is undetermined due to low levels. The Co-60 concentrations identified with the HPGe are higher in this interval, but statistical precision is lacking for a rigorous conclusion.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	75 ft
Survey Depth :	75 ft
First Survey Date :	1/28/1975
Last Survey Date :	6/17/1993
Number Surveys :	154

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<32	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	10-26 Appears Stable, 26-40 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/28/75

Borehole 21-00-22

Depth: 10-26 ft

06/17/93

01/28/75

Borehole 21-00-22

Depth: 26-40 ft

06/17/93

Borehole 21-00-22

BX

Dry Well Survey Analysis - Notes

Borehole 21-00-22Total # Surveys 157Probe Type 04# neutron surveys 3# GR Surveys 154Log Date: 128-25 1st6-17-93 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): 10-26 25-40 RuIsotope from Spectral Survey: Co & Cs from levelsMax Survey Depth 75

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

26-40 & 10-26 from stack	data 245-55 → may be internal ∴ 0 = 75
32 c/s threshold data not valid	26-40 clearance then file not saved
30-40 is Co + Cs	

Analyst Name H³

S/W ver

TF6R04 2.2

01/28/75

Borehole 21-00-22

Depth: 45-55 ft

06/17/93

Borehole 21-01-01

Contamination (Cs-137) from 0-6 feet is Undetermined
Contamination (Cs-137) from 6-13 feet is Undetermined
Contamination (Cs-137) from 13-23 feet is Stable, late
Contamination (Eu-154, Co-60, & Ru-106) from 23-37 feet is Stable
Contamination (Eu-154, Co-60, & Ru-106) from 37-49 feet is Stable
Contamination (Sb-125) from 49-53 feet is Undetermined*
Contamination (Sb-125 & Co-60) from 53-60 feet is UNSTABLE early
Contamination (Sb-125) from 70-79 feet is Stable
Contamination (Sb-125 & Ru-106) from 79-86 feet is Stable
Contamination (Sb-125) from 86-90 feet is Stable

*Believed UNSTABLE, but conservative classification

These data for this well over the history is complex. Several items need explanation. Depth shifting is necessary in order to analyze the historical data, and one or two zones exhibit downward movement after depth shifting. The other zones display very consistent depth control after the depth shift, indicating accurate depth shifting. Two low level zones near the surface are labeled undetermined due to possible surface effects, (i.e. 0-6 and 6-13 feet). Cs is identified by the HPGe for the classification of stable late for the zone 13-23 feet.

The two zones over 23-37 and 37-49 feet were identified by the HPGe to contain various combinations of Cs-137, Co-60, Sb-125, & Eu-154; however, Ru-106 is necessary in order to achieve a reasonable least squares fit to the historical trends. The interval from 23-37 feet shows consistent decay with a least squares fit for Co-60 (identified by HPGe), Eu-154 (identified by HPGe), and Ru-106 (hypothesis), with relative gross contributions of 32,210:79,250:194,900 ft*c/s for Co:Eu:Ru as of 1/14/75. Note that Sb-125 and Cs-137 were identified by the HPGe in this interval, but does not affect the least squares fit results. The interval from 37-49 feet shows consistent decay with a least squares fit for Co-60 (identified by HPGe), Eu-154 (identified by HPGe), and Ru-106 (hypothesis), with relative gross contributions of 39,140:1,723:97,060 ft*c/s for Co:Eu:Ru as of 1/14/75. Note that very low levels of Sb-125 were identified by HPGe in this interval, but does not affect the quoted least squares fit. The interval from 53-60 feet shows consistent decay with a least squares fit for Co-60 (identified by HPGe) and Sb-125 (hypothesis) from mid 1980 to 1994, with relative gross contributions of 1,014:5,542 ft*c/s for Co:Sb as of 1/14/75. The interval from 79-86 feet shows consistent decay with a least squares fit for Sb-125 and Ru-106, (both hypothesized), with relative gross contributions of 898:70 ft*c/s for Sb:Ru as of 1/14/75.

The zone from 49-53 feet is believed unstable, but conservatively classified as undetermined due to low levels and possible nearby zone influences. The zone from 53 to 60 feet is unstable early, refer to expanded stack plot. This interval has only Co-60 identified from the HPGe data, and the historical trend definitely requires Sb-125 and Co-60 decay; furthermore, the depth shifting is judged to be precise based upon the results for the two zones centered at 76 and 83 feet (refer to expanded stack plot). The zone at 70-79 feet follows Sb-125 (hypothesis) decay to low enough levels to not be detectable with the HPGe system. The low level contaminated zone from 86-90 feet is consistent with Sb-125 (hypothesis) decay at levels below detection threshold for the HPGe system.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	4/20/1994
Number Surveys :	238

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-6 & 6-13 Undetermined 13-23 Stable late 23-37 & 37-49 Stable 49-53 Undetermined 53-60 UNSTABLE 70-79 & 79-86 & 86-90 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/14/75

Borehole 21-01-01

Depth: 0-6 ft

Depth Shifted

04/20/94

01/14/75

Borehole 21-01-01

Depth: 6-13 ft

Depth Shifted

Analysis by: Three Rivers Scientific

01/14/75

Borehole 21-01-01

Depth: 13-23 ft

Depth Shifted

Analysis by: Three Rivers Scientific

04/20/94

01/14/75

Borehole 21-01-01

Depth: 23-37 ft

Depth Shifted

04/20/94

01/14/75

Borehole 21-01-01

Depth: 37-49 ft

Depth Shifted

Analysis by: Three Rivers Scientific

04/20/94

01/14/75

Borehole 21-01-01

Depth: 49-53 ft

Depth Shifted

04/20/94

01/14/75

Borehole 21-01-01

Depth: 53-60 ft

Depth Shifted

Appears to exhibit downward movement, refer to stack plot. Depth interval covers all movement, thus appears stable later

Analysis by: Three Rivers Scientific

04/20/94

01/14/75

Borehole 21-01-01

Depth: 70-79 ft

Depth Shifted

04/20/94

01/14/75

Borehole 21-01-01

Depth: 79-86 ft

Depth Shifted

04/20/94

Analysis by: Three Rivers Scientific

01/14/75

Borehole 21-01-01

Depth: 86-90 ft

Depth Shifted

Analysis by: Three Rivers Scientific

04/20/94

HNF-3531 -REVO

Borehole 21-01-01

HNF-3531 -REV0

Borehole 21-01-01 Depth shifted

HNF-3531 -REV0

Borehole 21-01-01 Depth shifted & time expanded

HNF-3531 -REV0

Borehole 21-01-01 Depth shifted & time expanded

Reference only for depth shift evaluation

950 00

Dry Well Survey Analysis - Notes

BX
Borehole 21-01-01Total # Surveys 247Probe Type D4# neutron surveys 9# GR Surveys 238Log Date: 1-14-75 1"4-20-94 Last

Presentation Plot Dates

(If different from 1" & Last)

Contamination Zone Depth(s): Several are not at allIsotope from Spectral Survey: Cs Co EN²⁴ U SbMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Freq. Clean	Avg. Bkg	Comment

Analysis Notes

Depth problems (Rn from stack is likely)

Depth shift (SHF) (SHF) (SHF)

3 components in lateral zones (maybe 4) Sb in 49-53 run

compare may be depth control problem with rings of nearby zones

531-60 could be Co + Sb in latter stages

Downward movement verified by 2 lower peaks after depth shift = con

Analyst Name

Russ RausellS/W ver TFGRDS 2.2

filein := "two23-37.txt"

Well 21-01-01

 $\tau_{eu} := 30.17$ $\tau_4 := 8.5$

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

a4 := 80000

 $\tau_{eu} := \frac{368.2}{365.25}$

N := last(yr)

N = 132

i := 0..N

k := 0..300

j := 0..299

 $\tau_{co} := 5.27$ $\tau_{cs} := 2.77$

aco := 33000

acs := 000

Eu variables are

Ru-106

aeu := 196000

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

gross_i := net_i

This data edited for spurious points

$$tot_i := Co_i + Eu_i + Cs_i + \left[a4 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_4}} \right]$$

$$ssq(a3, a2, a4) := \sum_i \left[\frac{gross_i}{(yr_i - 74)^6} - \frac{\left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + \left[a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a4 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_4}} \right] \right]^2}{(yr_i - 74)^6} \right] \quad cs := 0 \quad \alpha_{co} := 0$$

Given

ssq(aeu, aco, a4) = 0

1=1

2=2

$$\begin{bmatrix} \alpha_{eu} \\ \alpha_{co} \\ \alpha_{eur} \end{bmatrix} := \text{Minerr}(aeu, aco, a4)$$

$\alpha_{co} = 3.221 \cdot 10^4$

$\alpha_{eu} = 1.949 \cdot 10^5$

$\alpha_{cs} = 0$

$$\alpha_{eur} = 7.925 \cdot 10^4 \quad \frac{\alpha_{co}}{\alpha_{eu}} = 0.165$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eur_i := \alpha_{eur} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_4}}$$

tot_i := Co_i + Eu_i + Cs_i + Eur_i

out<0> := yr

out<1> := tot

WRITEPRN("twop23-37.txt") := out

$$\frac{Eu_N}{Co_N} = 1.319 \cdot 10^{-4}$$

filein := "two37-49.txt"

HNF-3531 - REV0 Well 21-01-01

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 130

i := 0..N

k := 0..300

j := 0..299

$\tau_{eu} := \frac{368.2}{365.25}$

$\tau_{co} := 5.27$

$\tau_{cs} := 8.5$

aco := 30000

acs := 8000

Eu variables are

Ru-106

aeu := 100000

$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$

$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$

$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$

$tot_i := Co_i + Eu_i + C$

gross_i := net_i

This data edited for spurious points

Cs variable is Eu-154

$$ssq(a1, a3, a2) := \sum_i \left[\frac{gross_i}{gross_i} - \frac{\left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} \right] \right]}{gross_i} \right]^2$$

Given

ssq(aco, aeu, acs) = 0

l=1

2=2

$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \\ \alpha_{cs} \end{bmatrix} := \text{Minerr}(aco, aeu, acs)$

$\alpha_{co} = 3.914 \cdot 10^4$

$\alpha_{eu} = 9.706 \cdot 10^4$

$\alpha_{cs} = 1.723 \cdot 10^3$

$\frac{\alpha_{co}}{\alpha_{eu}} = 0.403$

$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$

$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$

$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$

$tot_i := Co_i + Eu_i + Cs_i$

out<0> := yr

out<1> := tot

WRITEPRN("twop37-49.txt") := out

$\frac{Eu_N}{Co_N} = 5.409 \cdot 10^{-5}$

$$\delta_i := \text{gross}_i - \text{tot}_i$$

$$\delta n_i := \text{gross}_i \cdot \frac{\text{bkg}_i}{\text{mean}(\text{bkg})} - \text{tot}_i$$

filein := "two53-60.txt"

Well 21-01-01

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 24

i := 0..N

k := 0..300

j := 0..299

 $\tau_{eu} := 2.77$ $\tau_{co} := 5.27$ $\tau_{cs} := 32.17$

aco := 1000

acs := 0

Eu variables areSb-125

aeu := 5500

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(aco, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(aco, aeu)$$

$$\alpha_{co} = 1.014 \cdot 10^3$$

$$\alpha_{eu} = 5.542 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

$$\frac{\alpha_{co}}{\alpha_{eu}} = 0.183$$

out<0> := yr

out<1> := tot

WRITEPRN("twop53-60.txt") := out

$$\frac{Eu_N}{Co_N} = 0.553$$

$$\delta_i := gross_i - tot_i \quad \delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$$

filein := "two79-86.txt"

Well 21-01-01

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 123

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 1

taucs := 32.17

aco := 200

acs := 0

Eu variables areSb-125 aeu := 900

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(aco, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(aco, aeu)$$

$$\alpha_{co} = 69.557$$

$$\alpha_{eu} = 898.178$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

$$\frac{\alpha_{co}}{\alpha_{eu}} = 0.077$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop79-86.txt") := out$$

$$\frac{Eu_N}{Co_N} = 2.066 \cdot 10^3$$

$$\delta_i := gross_i - tot_i \quad \delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$$

HNF-3531 -REV0

Borehole 21-01-01

Det ~~of~~ shift

Borehole 21-01-02

Contamination (Cs-137) from 5-12 feet is **UNSTABLE** early
 Contamination (Co-60 & Ru-106) from 54-64 feet is **UNSTABLE** early
 Contamination (Co-60 & Ru-106) from 64-72 feet is **UNSTABLE** early
 Contamination (Co-60) from 72-78 feet is **UNSTABLE** early

Grade thickness product over 5 to 12 feet sharply increased at the start of 1977 and again just before 1978. The character since this time is consistent with the natural decay of the HPGe identified Cs-137. Grade thickness product from 54 to 64 feet appears unstable from 1975 to 1977. Since 1977 the grade thickness product is decreasing consistent with a least squares fit for Co-60 (HPGe identified) and Ru-106 (hypothesis) until 1994. The least squares fit results in gross gamma contribution ratio of Ru-106 to Co-60 of 8.8 as of Jan 1975. Grade thickness product from 64 to 72 feet is unstable from 1975 to 1977. Since 1977 the grade thickness product is decreasing consistent with a least squares fit for Co-60 (HPGe identified) and Ru-106 (hypothesis) until 1994. The least squares fit results in gross gamma contribution ratio of Ru-106 to Co-60 of 4.3 as of Jan 1975. Grade thickness product from 72 to 78 feet begins an increase in 1980 and rises until 1985. Since 1985 this interval appears stable for Co-60 as identified by HPGe detector.

Special note: There may be some indication of Ru-106 moving down from the 54-64 feet zone to the 64-72 feet zone between 1975 and 1977, but more study would be required to make this conclusion, (refer to grade thickness product plot from 54 to 72 feet). Likewise, pre 1975 data would assist this study. Additionally, the Co-60 increase in the 72-78 feet interval is most likely not due to downward movement from the Co-60 in the adjacent interval above, since this interval above is stable from 1980 to 1985.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	4/20/1994
Number Surveys :	147

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold 0<val<50
Depth(s) where Contamination Identified in Gross Gamma Surveys :	5-12, 54-64, 64-72, & 72-78 UNSTABLE early
Analyst Name :	R.R. Randall
Company Name :	Three Rivers Scientific

01/14/75

Borehole 21-01-02

Depth: 5-12 ft

04/20/94

01/14/75

Borehole 21-01-02

Depth: 54-64 ft

04/20/94

01/14/75

Borehole 21-01-02

Depth: 64-72 ft

04/20/94

01/14/75

Borehole 21-01-02

Depth: 72-78 ft

04/20/94

01/14/75

Borehole 21-01-02

Depth: 54-72 ft

04/20/94

Borehole 21-01-02

Borehole 21-01-02 Depth Shifted

HNF-3531 - REV0

Dry Well Survey Analysis - Notes

Borehole 21-D1-02 Total # Surveys 157 Probe Type 04 02 14
 Log Date: 1-14-75 1st # neutron surveys 8 # GR Surveys 147
4-20-74 Last Presentation Plot Dates _____
 (If different from 1st & Last)
 Contamination Zone Depth(s): Ru Co Co
 Isotope from Spectral Survey: Co Co U²³⁵ Eu¹⁵⁴ Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Depth control critical on Co material zone at 72-74'
 Early character 4-14 not too (due to 1) bkg const. 2) other zones still
 (same time) 54-64 has Eu but as low as low no effect
 with fit (not disagreement in Ru + Co data)

Analyst Name Russ Rouben S/W ver TF6ROSS2.2

filein := "two54-64.txt"

Well 21-01-02

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 46

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

taucs := 1

aco := 2700

acs := 23000

Eu variables are

Sb-125 aeu := 0

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Cs_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

tau := 1

$$ssq(a1, a3) := \sum_i \left[\text{gross}_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} \right] \right]^2$$

Given

$$ssq(aco, acs) = 0$$

I = 1

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{cs} \end{bmatrix} := \text{Minerr}(aco, acs)$$

$$\alpha_{co} = 2.621 \cdot 10^3$$

$$\alpha_{cs} = 2.3 \cdot 10^4$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$tot_i := Co_i + Cs_i$$

$$\frac{\alpha_{co}}{\alpha_{cs}} = 0.114$$

out<0> := yr

out<1> := tot

WRITEPRN("twop54-64.txt") := out

$$\frac{Eu_N}{Co_N} = 0$$

k := 0..100

$$t_k := 75 + \frac{k}{100} \cdot 20$$

$$tr_k := \alpha_{co} \cdot e^{-\left(t_k - 75\right) \frac{\ln(2)}{\tau_{co}}} + \alpha_{cs} \cdot e^{-\left(t_k - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

Two component decay54-64.mcd

7/15/98

00 075

out<0> := t out<1> := tr WRITEPRN("twop54-64.txt") := out

$$\delta_i := \text{gross}_i - \text{tot}_i$$

$$\delta n_i := \text{gross}_i \cdot \frac{\text{bkg}_i}{\text{mean}(\text{bkg})} - \text{tot}_i$$

filein := "two64-72.txt"

HNF=3531 -REV0
Well 21-01-02

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 60

i := 0..N

k := 0..300

j := 0..299

teu := 2.77

tco := 5.27

tcs := 1

aco := 2000

acs := 8000

Eu variables are
Sb-125 aeu := 0

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{teu}} \cdot 1$$

$$tot_i := Co_i + Cs_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

teu := 1

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}} \right] \right]^2$$

Given

$$ssq(aco, acs) = 0$$

$$1 = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{cs} \end{bmatrix} := \text{Minerr}(aco, acs)$$

$$\alpha_{co} = 1.811 \cdot 10^3$$

$$\alpha_{cs} = 7.801 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}}$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}}$$

$$tot_i := Co_i + Cs_i$$

$$\frac{\alpha_{co}}{\alpha_{cs}} = 0.232$$

$$\frac{Eu_N}{Co_N} = 0$$

out<0> := yr

out<1> := tot

WRITEPRN("twop64-72.txt") := out

k := 0..100

$$t_k := 75 + \frac{k}{100} \cdot 20$$

$$tr_k := \alpha_{co} \cdot e^{-\left(t_k - 75\right) \frac{\ln(2)}{tco}} + \alpha_{cs} \cdot e^{-\left(t_k - 75\right) \frac{\ln(2)}{tcs}}$$

Two component decay64-72.mcd

7/15/98

00 077

HNF=3531 -REVO

out<0> := t

out<1> := tr

WRITEPRN("twop64-72.txt") := out

$$\delta_i := gross_i - tot_i$$

$$\delta n_i := gross_i \frac{bkg_i}{mean(bkg)} - tot_i$$

Co Eu 44 Co 72 Co 78

PEAK

Is very low

PSAK

79-8344X

MA-68

Page 104

81.4
Lower zone 1985

2020-2021

1975

1990

1995

Date (Year)

Borehole 21-02-01

Contamination (Cs-137) from 0-5 feet is Tank Farms Activity
 Contamination (Cs-137) from 5-10 feet is Stable

Grade thickness product from 0 to 5 feet has the characteristic signature of very rapid changes indicative of tank farm activities such as transfer lines close to surface and this borehole.

Grade thickness product from 5 to 10 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1994.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	159

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-5 Tank Farm Activities 5-10 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/14/75

Borehole 21-02-01

Depth: 0-5 ft

06/13/94

01/14/75

Borehole 21-02-01

Depth: 5-10 ft

06/13/94

Borehole 21-02-01

Borehole 21-02-01 Depth Shifted

Dry Well Survey Analysis - Notes

Borehole 21-02-01 Total # Surveys 163 Probe Type 04
 Log Date: 1-14-98 1st # neutron surveys 4 # GR Surveys 159
6-13-94 Last Presentation Plot Dates _____
 (If different from 1st & Last)
 Contamination Zone Depth(s): ~~2-15~~ (2-5) & 5-10
 Isotope from Spectral Survey: Cs Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<i>Depth at surface may be problem in required void 9175472</i>

Analyst Name

Randy Randall

S/W ver

TFGRS 2.2

Borehole 21-02-01

Borehole 21-02-03

Contamination (Cs-137) from 36-42 feet is Stable

Contamination (Sb-125 & U238/235) from 70-75 feet is Stable

Contamination (Sb-125 & U238/235) from 80-86 feet is Stable

Contamination (Sb-125 & Co-60 & U238/235) from 86-95 feet is Stable

Grade thickness product from 36 to 42 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1994. Grade thickness product from 70 to 75 feet is decreasing consistent with a least squares fit for Sb-125 (hypothesis) and U-238/235 (HPGe identified) from 1975 to 1994. The least squares fit results in gross gamma contribution ratio of U-238/235 to Sb-125 of 0.068 as of Jan 1975. Grade thickness product from 80 to 86 feet is decreasing consistent with a least squares fit for Sb-125 (HPGe identified) and U-238/235 (HPGe identified) from 1975 to 1994. The least squares fit results in gross gamma contribution ratio of U-238/235 to Sb-125 of 0.020 as of Jan 1975. Grade thickness product from 86 to 95 feet is decreasing consistent with a least squares fit for Sb-125 (hypothesis), Co-60 (HPGe identified) and U-238/235 (HPGe identified) from 1975 to 1994. The least squares fit results in gross gamma contribution relation of Sb:Co:U of 291:80:41 as of Jan 1975.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	169

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	36-42, 70-75, 80-86, & 86-95 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/14/75

Borehole 21-02-03

Depth: 36-42 ft

06/13/94

Analysis by: Three Rivers Scientific

01/14/75

Borehole 21-02-03

Depth: 70-75 ft

06/13/94

01/14/75

Borehole 21-02-03

Depth: 80-86 ft

06/13/94

Borehole 21-02-03

Depth: 86-95 ft

01/14/75

06/13/94

HNF-3531 -REV0

Borehole 21-02-03

HNF-3531 - REV 0

Borehole 21-02-03 Depth Shifted

HNF-3531 - REV 0

Dry Well Survey Analysis - Notes

Borehole BX 21-02-03

Total # Surveys 172

Probe Type 04

neutron surveys 3

GR Surveys 169

Log Date: 1-14-75 1st

6-13-74 Last

Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: C₂ C₃ N₂ S₂

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<p>Rapid changes in C₂ @ 40' may be real based on other zones well behaved with same inst. & logs's good.</p> <p>S₂ detected & SGLS not in 70-75 & 86-95 SGLS don't show S₂ in 75-80 24 now showing at threshold</p>					

Analyst Name Bme

S/W ver TFGR055 2.2

Borehole 21-02-03

filein := "two70-75.txt"

Well 21-02-03

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 157

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

tauco := 4.7·10⁹

aco := 00

acs := 40

Eu variables areSb-125 aeu := 550

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 36.937$$

$$\alpha_{eu} = 545.202$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.068$$

out<0> := yr

out<1> := tot

WRITEPRN("two70-75.txt") := out

$$\frac{Eu_N}{Cs_N} = 0.114$$

$$\delta_i := gross_i - tot_i$$

$$\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$$

filein := "two80-86.txt"

Well 21-02-03

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 159

i := 0..N

k := 0..300

j := 0..299

teu := 2.77

tco := 5.27

tcs := $4.7 \cdot 10^9$

aco := 00

acs := 35

Eu variables areSb-125

aeu := 1800

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{teu}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{teu}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 37.091$$

$$\alpha_{eu} = 1.825 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{teu}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.02$$

out<0> := yr

out<1> := tot

WRITEPRN("twop80-86.txt") := out

$$\frac{Eu_N}{Cs_N} = 0.379$$

$$\delta_i := gross_i - tot_i \quad \delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$$

filein := "two86-95.txt"

Well 21-02-03

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 161

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

tcsc := 4.7·10⁹

aco := 80

acs := 30

Eu variables are

Sb-125 aeu := 300

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcsc}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}}$$

$$tot_i := Cs_i + Eu_i + Co_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3, a2) := \sum_i \left[\text{gross}_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcsc}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}} + a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}} \right] \right]^2 \right]$$

Given

$$ssq(acs, aeu, aco) = 0$$

1=1

2=2

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aeu, aco)$$

$$\alpha_{cs} = 41.212$$

U-238

$$\alpha_{eu} = 291.286$$

Sb-125

$$aco = 80$$

Co-60

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcsc}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}}$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.141$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}}$$

$$tot_i := Cs_i + Eu_i + Co_i$$

$$\frac{Eu_N}{Cs_N} = 0.054$$

out<0> := yr

out<1> := tot

WRITEPRN("twop86-95.txt") := out

Two comp decay 86-95.mcd

7/16/98

Page 1

$$\delta_i := gross_i - tot_i \quad \delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$$

Borehole 21-02-04

Contamination (Cs-137) from 0-8 feet is Stable
 Contamination (Cs-137) from 8-15 feet is Stable
 Contamination (Cs-137) from 29-38 feet is Stable
 Contamination (Cs-137) from 38-62 feet is Stable
 Contamination (Cs-137) from 62-74 feet is Stable
 Contamination (Cs-137) from 74-84 feet is Stable
 Contamination (Cs-137) from 84-110 feet is Stable
 Contamination (Cs-137) from 125-134 feet is Stable
 Contamination (Cs-137) from 134-144 feet is Stable
 Contamination (Cs-137) from 144-148 feet is Stable

Grade thickness products for each of the intervals listed above exhibit the same historical character. Early stages of instrumentation development for the red GM resulted in calibration changes prior to mid 1980, but apparent consistency after this time. All zones exhibit decreases in grade thickness product consistent with Cs-137 (HPGe identified in zones below detector saturation) from mid 1980 to 1994. Note the reason for computing grade thickness products for discreet intervals within a contaminated zone is to analyze for possible downward migration.

Gross Gamma Survey Information

Probe Type :	02: Red GM
Other Probe Types :	04: NaI, 14: Shielded NaI
Borehole Depth :	150 ft
Survey Depth :	150 ft
First Survey Date :	1/15/1975
Last Survey Date :	6/13/1994
Number Surveys :	181

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8, 8-15, 29-38, 38-62, 62-74, 74-84, 84-110, 125-134, 134-144, and 144-148 Stable 1980-1994	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/15/75

Borehole 21-02-04 Red GM

Depth: 0-8 ft

06/13/94

Analysis by: Three Rivers Scientific

Borehole 21-02-04 Red GM

Depth: 8-15 ft

Analysis by: Three Rivers Scientific

01/15/75

Borehole 21-02-04 Red GM

Depth: 29-38 ft

06/13/94

Analysis by: Three Rivers Scientific

01/15/75

Borehole 21-02-04 Red GM

Depth: 38-62 ft

06/13/94

Analysis by: Three Rivers Scientific

01/15/75

Borehole 21-02-04 Red GM

Depth: 62-74 ft

06/13/94

01/15/75

Borehole 21-02-04 Red GM

Depth: 74-84 ft

Analysis by: Three Rivers Scientific

06/13/94

Borehole 21-02-04 Red GM

Depth: 84-110ft

01/15/75

06/13/94

01/15/75

Borehole 21-02-04 Red GM

Depth: 125-134 ft

Analysis by: Three Rivers Scientific

06/13/94

01/15/75

Borehole 21-02-04 Red GM

Depth: 134-144 ft

06/13/94

Analysis by: Three Rivers Scientific

Borehole 21-02-04 Red GM

Depth: 144-148 ft

01/15/75

06/13/94

Analysis by: Three Rivers Scientific

HNF-3531 -REV0

Borehole 21-02-04 Red GM

HNF-3531 -REV0

Borehole 21-02-04 Depth Shifted - Tool 02 Red GM

Dry Well Survey Analysis - Notes

BX
Borehole 21-02-04Total # Surveys 228
neutron surveys 17
6-13-94 LastProbe Type 04 14
GR Surveys 181
Presentation Plot Dates _____
(If different from 1st & Last)11 19
181
02Log Date: 1-15-75 1st

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs

Max Survey Depth _____

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

CM system field testing (all zones same character)
multiple zones on stack plot
All have same character - no background

Analyst Name BraceS/W ver TF6ROS22

HNF-3531 - REV0 (

Borehole 21-02-04

SHC-740

Borehole 21-02-06

Contamination (Co-60) from 34-46 feet is **UNSTABLE**

Grade thickness product over 34 to 46 feet is increasing starting 1975 and rapidly decreasing at different rates until 1984, from which time the grade thickness product is consistent with the Co-60 (HPGe identified) decay. A depth shifted and expanded stack plot is provided as an aid to demonstrating no vertical zone changes, indicating no vertical contaminant migration. Additionally, a Ru-106 plus Co-60 decay curve is presented for relative indications of intensity, but no least squares fitting is performed since instability is still present. However, possibilities of Ru-106 may prove significant for other investigations and should be pointed to as possible.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	171

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	34-46 UNSTABLE early	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/14/75

Borehole 21-02-06

Depth: 34-46 ft

06/13/94

Borehole 21-02-06

Borehole 21-02-06 Depth Shifted

Dry Well Survey Analysis - Notes

Borehole 21-02-06Total # Surveys 174Probe Type 04Log Date: 1-14-75 1st# neutron surveys 3# GR Surveys 1716-13-94 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): 32-48Isotope from Spectral Survey: Co 425Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Unstable, could be argued down movement (very unlikely)
 moved up :- depth control. Co
 Ash 14-46 is an depth shift for ref.

Analyst Name S/W ver TFLRIS 2.2

HNF-3531 -REV0

Borehole 21-02-06

75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
Date (Year)

Borehole 21-02-07

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	179

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-02-07

**Oldest Survey
1/14/1975**

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-02-07

Dry Well Survey Analysis - Notes

Borehole 21-02-07Total # Surveys 181Probe Type 04Log Date: 1-14-75 1st# neutron surveys 2# GR Surveys 1796-13-94 LastPresentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): noneIsotope from Spectral Survey: Cs-137 @ surfaceMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

very low @ surface have ref. plot but labeled
clean. also depth problem and surface

Analyst Name RussS/W ver TF6ROSS 2.2

06/13/94

Borehole 21-02-07

Depth: 2-10 ft

For Reference Only

Cesium-137 Decay Line

01/14/75

Borehole 21-02-11

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	156

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-02-11**Oldest Survey
1/14/1975** **No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

HNF=3531 -REVO

Borehole 21-02-11

BX
Dry Well Survey Analysis - Notes

Borehole 21-02-11Total # Surveys 158Probe Type 04Log Date: 1-14-75 1st# neutron surveys 2# GR Surveys 1566-13-74 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs low @ anyMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

Analyst Name RossS/W ver TFGR05022

Borehole 21-03-03

Contamination (Ru-106) from 60-80 feet is Stable late

Grade thickness product over 60 to 80 feet increased starting 1975 and from mid 1976 exhibits the decay rate of Ru-106 (hypothesis) down to background levels near 1980.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	324

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	60-80 Stable late	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/14/75

Borehole 21-03-03

Depth: 60-80 ft

06/17/93

Borehole 21-03-03

HNF-3531 -REVO

Borehole 21-03-03 Expanded time scale

Dry Well Survey Analysis - Notes

Borehole BX 21-03-03Total # Surveys 328Probe Type 04# neutron surveys 4# GR Surveys 324Log Date: 1-14-75 1st6-17-93 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Ce low @ any Co lowMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
	<u>Shows early signal + rapid decay</u>		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

2-10

Analysis Notes

Bu from 60-80From expanded stack looks like noise gone stable & lower noise rise & then falls (note told noise 1st then falls)

Analyst Name

BooneS/W ver TFGRS 2.2

Borehole 21-03-05

Contamination (Co-60 & Ru-106) from 60-80 feet is Stable

Grade thickness product from 60 to 80 feet is decreasing consistent with
a least squares fit for Co-60 (HPGe identified)
and Ru-106 (hypothesis) from 1975 to 1993.

The least squares fit results in gross gamma contribution ratio of
Ru-106 to Co-60 of 7.7 as of Jan 1975.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI, 01: Green GM, 02: Red GM, & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	332

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	60-80 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/14/75

Borehole 21-03-05

Depth: 60-80 ft

06/17/93

Borehole 21-03-05

Dry Well Survey Analysis - Notes

Borehole 21-03-05Total # Surveys 343Probe Type 04 01 02 14Log Date: 1-14-75 1st# neutron surveys 5
6-17-93 Last# GR Surveys 332Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs 137 Co 60Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
	<u>Rn 60-80</u>		<u>gone by '84</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>2-10</u>
<u>Rn 60-80</u>

Analyst Name RMAKS/W ver TEGROSS 2.2

filein := "two.txt"

Well 21-03-05

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 317

i := 0..N

k := 0..300

j := 0..299

$$\tau_{eu} := \frac{368.2}{365.25}$$

 $\tau_{co} := 5.27$ $\tau_{cs} := 30.17$

aco := 650

acs := 0

Eu variables are
Ru-106

aeu := 2500

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$\tau_{eu} := 1$

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(aco, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(aco, aeu)$$

$$\alpha_{co} = 386.758$$

$$\alpha_{eu} = 2.989 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

$$\frac{\alpha_{eu}}{\alpha_{co}} = 7.728$$

$$\frac{Eu_N}{Co_N} = 2.427 \cdot 10^{-4}$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\delta_i := gross_i - tot_i \quad \delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$$

Borehole 21-03-07**Contamination (Cs-137) from 2-10 feet is Tank Farms Activity**

Grade thickness product over 2 to 10 feet increased April 27, 1977, from this time, the interval is decreasing consistent with a least squares fit for Cs-137 (HPGe identified) and Ru-106 (hypothesis) from April 27, 1977 to June 17, 1993. However, the rapid change character is indicative of tank farms activity such as transfer line proximity. The least square fit results in gross gamma contribution ratio of Cs-137 to Ru-106 of 0.30 as of July 1, 1977. Even if no Ru-106 is present, it was added for relative comparison that might be useful for other studies as a possibility. Note readings between 6/29/82 & 11/16/83 are artificially low due to incomplete logging of entire interval.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: shielded NaI & 03: Neutron
Borehole Depth :	95 ft
Survey Depth :	95 ft
First Survey Date :	3/3/1976
Last Survey Date :	6/17/1993
Number Surveys :	271

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	2-10 Tank Farms Activity	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

03/03/76

Borehole 21-03-07

Depth: 2-10 ft

06/17/93

Analysis by: Three Rivers Scientific

03/03/76

Borehole 21-03-07

Depth: 2-10 ft

06/17/93

Analysis by: Three Rivers Scientific

Borehole 21-03-07

BX
Dry Well Survey Analysis - Notes

Borehole 21-03-07Total # Surveys 275Probe Type 04 14Log Date: 3-3-76 1st# neutron surveys 3
6-17-93 Last# GR Surveys 271
Presentation Plot Dates _____(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Ce Eu UMax Survey Depth 95near amplifier GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
	An event occurred between 4-27-77 & 4-20-77		
	& higher still after 7-1-77		
	From 6-29-82 thru 11-16-83 not complete logging		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

2-10

Analysis Notes

near amplifier region increases 4-27-77 & 6-29-82 no log of					
near amplifier (could bottom of interval)					
Least squares fit for Ce & Eu cannot fit data					
Least square for Pu & Ce looks good					
				$\frac{Ce GR}{Pu GR} = 1.30$	
				77	
				7-1-77	

Analyst Name Roger RandallS/W ver TFG ROSS 2.2

filein := "two.txt"

Well 21-03-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 189

i := 0..N

k := 0..300

j := 0..299

 $\tau_{eu} := 8.5$ $\tau_{co} := 5.27$ $\tau_{cs} := 30.17$

aco := 00

acs := 2000

aeu := 2000

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$\tau_{eu} := 1$

acs := 2800

aeu := 10000

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} acs \\ aeu \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$acs = 2.831 \cdot 10^3$$

$$aeu = 9.418 \cdot 10^3$$

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{acs}{aeu} = 0.301$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Eu_N}{Cs_N} = 1.408 \cdot 10^{-5}$$

$$\delta_i := gross_i - tot_i \quad \delta n_i := gross_i \cdot \frac{bkg_i}{\text{mean}(bkg)} - tot_i$$

Borehole 21-03-11

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1976 and 1993 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	3/2/1976
Last Survey Date :	10/5/1993
Number Surveys :	154

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold $0 < \text{val} < 50$	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-03-11

Oldest Survey
3/02/1976

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-03-11

PX
Dry Well Survey Analysis - Notes

Borehole 21-03-11Total # Surveys 284Probe Type 04

3

14

Log Date: 3-2-76 1st# neutron surveys 3# GR Surveys 10-5-93 LastPresentation Plot Dates (If different from 1st & Last)Contamination Zone Depth(s): NoneIsotope from Spectral Survey: Cs low @ 210' Co low @ 210'Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Freq. Clean	Avg. Bkg	Comment

2-10 start

Analysis Notes

Analyst Name R³S/W ver TFGR05532

Borehole 21-03-12

Contamination (Cs-137) from 15-35 feet appears Stable

Grade thickness product from 15 to 35 feet is decreasing consistent with Cs-137 from 1983 to 1993. However, there is some question of exceeding high count rate limits for this interval, particularly prior to 1983.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: shielded NaI & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980
Last Survey Date :	6/17/1993
Number Surveys :	80

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	15-35 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

07/24/80

Borehole 21-03-12

Depth: 15-35 ft

06/17/93

Analysis by: Three Rivers Scientific

Borehole 21-03-12

Dry Well Survey Analysis - Notes

Borehole BX 21-03-12Total # Surveys 101Probe Type 04# neutron surveys 3# GR Surveys 80Log Date: 7-24-80 1st1-17-93 Last

Presentation Plot Dates _____

(If different from 1st & Last)Contamination Zone Depth(s): 15-35Isotope from Spectral Survey: CsMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

15-35 start

Analysis Notes

at 40K c/s dead time is questioned for 04, but looks stable

Analyst Name R³S/W ver TF6R05 2.2

Borehole 21-04-01**Contamination (Cs-137) from 2-20 feet is Stable**

Grade thickness product from 2 to 20 feet is decreasing consistent with
Cs-137 (HPGe identified) decay from 1977 to 1994.
The levels are near threshold.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	2/24/1977
Last Survey Date :	3/25/1994
Number Surveys :	273

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<32	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	2-20 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

02/24/77

Borehole 21-04-01

Depth: 2-20 ft

03/25/94

Analysis by: Three Rivers Scientific

Borehole 21-04-01

Dry Well Survey Analysis - Notes

Borehole 21-04-01Total # Surveys 277Probe Type 04 02 14Log Date: 2-24-77 1st# neutron surveys 2# GR Surveys 2733-25-74 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs near surface (2 gpm)Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>Need to use lower threshold</u>
			<u>32</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Freq. Clean	Avg. Bkg	Comment
					<u>Threshold not @</u>

Analysis Notes

2-15 start
2-15' diamond 2-20' used. Recalibration for
keep $0 \leq x \leq 32$ Wt in order to
help peak start at threshold

Analyst Name R³S/W ver TFGRSS 2.2

Borehole 21-04-03

**Contamination (Cs-137 & Eu-154) from 0-12 feet is Tank Farm
Activity early, stable late**

Grade thickness product over 0 to 12 feet exhibits changing behavior from Jan 14, 1975 until Jun 1, 1982. Also from Jun 1, 1982 until Feb 8, 1984 readings are artificially low due to incomplete logging of entire depth interval. From Feb 8, 1984 until Mar 25, 1994 the interval is decreasing consistent with a least squares fit for Cs-137 (identified from HPGe detector) and Eu-154 (identified from HPGe detector). Note the Co-60 identified from HPGe data is too low to observe with gross gamma response. The least square fit results in gross gamma contribution ratio of Cs-137 to Eu-154 of 6.0 as of Mar 25, 1994.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI, 02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	3/25/1994
Number Surveys :	389

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold $0 < \text{val} < 50$	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-12 Tank Farm Activity early, Stable late	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-04-03

Depth: 0-12 ft

01/14/75

Borehole 21-04-03

Dry Well Survey Analysis - Notes

Borehole FX 21-04-03 Total # Surveys 394 Probe Type 04-14-02
 Log Date: 1-14-75 1st # neutron surveys 3 # GR Surveys 389
3-25-94 Last Presentation Plot Dates 1-20-75
 (If different from 1st & Last)
 Contamination Zone Depth(s): _____
 Isotope from Spectral Survey: Cs Eu Co same near surface Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			From 6-22-82 to 2-8-84 incomplete logging of top interval

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

2-20 start

Analysis Notes

Eu should be on a just bench in?

Analyst Name Russ RoubicekS/W ver TFGR052.2

filein := "two.txt"

Well 21-04-03

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 82

i := 0..N

k := 0..300

j := 0..299

 $\tau_{eu} := 8.5$ $\tau_{co} := 5.27$ $\tau_{cs} := 30.17$

aco := 00

acs := 3000

aeu := 1500

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 3.029 \cdot 10^3$$

$$\alpha_{eu} = 1.568 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 1.933$$

$$\frac{Eu_N}{Cs_N} = 0.168$$

$$\frac{Cs_N}{Eu_N} = 5.961$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\delta_i := \text{gross}_i - \text{tot}_i$$

$$\delta n_i := \text{gross}_i \cdot \frac{\text{bkg}_i}{\text{mean}(\text{bkg})} - \text{tot}_i$$

Borehole 21-04-04

Contamination (Cs-137) from 2-25 feet is Stable

Grade thickness product from 2 to 25 feet is decreasing consistent with Cs-137 (HPGe identified) decay from 1977 to 1994.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI, 02: Red GM, 03: Neutron
Borehole Depth :	96 ft
Survey Depth :	96 ft
First Survey Date :	5/4/1977
Last Survey Date :	3/25/1994
Number Surveys :	338

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<32	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	2-25 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

05/04/77

Borehole 21-04-04

Depth: 2-25 ft

03/25/94

Borehole 21-04-04

Dry Well Survey Analysis - Notes

Borehole EX 21-04-04 Total # Surveys 342 Probe Type D4 14 02
 Log Date: 5-4-77 1st # neutron surveys 2 # GR Surveys 335
3-25-94 Last Presentation Plot Dates _____
 (If different from 1st & Last)
 Contamination Zone Depth(s): 2-25 ft Cs
 Isotope from Spectral Survey: Cs Max Survey Depth 96

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

2-25 start

Set threshold @ 32 c/s

Analyst Name Bruce RandallS/W ver TFGRDS 2.2

Borehole 21-04-06

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity
 Contamination (Cs-137) from 8-20 feet is **UNSTABLE**, Stable late

Grade thickness product over 0 to 10 feet demonstrates radical changes indicative of tank farm activities. The higher readings from mid 1984 to last readings may be affected by high count rate limitations, but are still significantly higher than from 1975 to 1982. The grade thickness product over 8 to 20 feet also shows some changes that may be caused by the upper interval. However, since 1985 this interval shows a decrease consistent with the natural decay of Cs-137.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	3/29/1994
Number Surveys :	392

Analysis Notes

Survey Dates Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold $0 < \text{bkg} < 50$	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity, 8-20 UNSTABLE Early	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/20/75

Borehole 21-04-06

Depth: 0-10 ft

03/29/94

Analysis by: Three Rivers Scientific

01/20/75

Borehole 21-04-06

Depth: 8-20 ft

03/29/94

Analysis by: Three Rivers Scientific

Borehole 21-04-06

Dry Well Survey Analysis - Notes

BX
Borehole 21-04-06Total # Surveys 397Probe Type 04 14Log Date: 1-14-75 1st# neutron surveys 4# GR Surveys 3923-29-94 LastPresentation Plot Dates 1-20-75(If different from 1st & Last)Contamination Zone Depth(s): 0-5 & 5-15Isotope from Spectral Survey: Cs & Eu - 7 bar low in 95Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>Dead time or problem but still agreed & real increase</u>
<u>Rate in time 1st plot only 30 ft</u>

Analyst Name

Priscilla Randall

S/W ver

TFE 2.2

Borehole 21-04-08

Contamination (Cs-137) from 0-14 feet is Stable
 Contamination (Co-60) from 59-65 feet is Stable
 Contamination (Co-60) from 80-100 feet is Stable

Grade thickness product from 0 to 14 feet is decreasing consistent with Cs-137 (HPGe identified), even though the logging system was not designed to operate near the surface or bottom of the well. Also, during 1983, the top 2 feet of the well was not logged. Grade thickness product from 59 to 65 feet is decreasing consistent with Co-60 (HPGe identified), and at very low levels. Grade thickness product from 80 to 100 feet is decreasing consistent with Co-60 (HPGe identified).

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	5/4/1977
Last Survey Date :	3/25/1994
Number Surveys :	346

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-14, 59-65, & 80-100 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

03/25/94

Borehole 21-04-08

Depth: 0-14 ft

05/04/77

05/04/77

Borehole 21-04-08

Depth: 59-65 ft

03/25/94

03/25/94

Borehole 21-04-08

Depth: 80-100 ft

05/04/77

Borehole 21-04-08

Dry Well Survey Analysis - Notes

Borehole 21-04-08 Total # Surveys 351 Probe Type 04 02 14
 Log Date: 5-4-77 1st # neutron surveys 3 # GR Surveys 346
3-25-94 Last Presentation Plot Dates _____
 (If different from 1st & Last)
 Contamination Zone Depth(s): 0-14 60 85
 Isotope from Spectral Survey: Co and Co deep Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>Co early is clearly visible</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Very low levels of Co-60

Analyst Name RamakS/W ver TFGROSS 2.2

Borehole 21-04-11

Contamination (Cs-137) from 2-17 feet is Stable late
Contamination (Co-60) from 60-95 feet is Stable

Grade thickness product from 2 to 17 feet is decreasing consistent with Cs-137 (HPGe identified). Due to system limitations near the surface and very low contamination levels, the grade thickness product was computed for the larger interval.

Prior to 1984, the historical trend is undetermined, but stable from 1984 to 1994.

Grade thickness product from 60 to 95 feet is decreasing consistent with Co-60 (HPGe identified). Again, the low levels of Co-60 required the wider intervals, thus, no statement of downward movement is possible.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	5/4/1977
Last Survey Date :	3/25/1994
Number Surveys :	275

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	2-17 Stable late, 60-95 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

05/04/77

Borehole 21-04-11

Depth: 2-17 ft

03/25/94

05/04/77

Borehole 21-04-11

Depth: 60-95 ft

03/25/94

Borehole 21-04-11

Dry Well Survey Analysis - Notes

Borehole DX 11-04-11Total # Surveys 279Probe Type 04 02 14Log Date: 5-4-77 1st# neutron surveys 2
3-25-94 Last# GR Surveys 275

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs surf Co surf

Max Survey Depth

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name [Signature]S/W ver TFGRoss 2.2

Borehole 21-05-02

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	362

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-05-02

**Oldest Survey
1/14/1975**

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-05-02

Dry Well Survey Analysis - Notes

Borehole 21-05-02Total # Surveys 367Probe Type 04 02Log Date: 1-14-75 1st# neutron surveys 4# GR Surveys 3621-13-94 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs near surfaceMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Freq. Clean	Avg. Bkg	Comment

Analysis Notes

The threshold for the well & Cs is higher than others

Analyst Name [Signature]

S/W ver

IFG RMS 2.2

Borehole 21-05-03

Contamination (Cs-137) from 2-20 feet is Undetermined

Grade thickness product from 2 to 20 feet is near threshold and the stability cannot be determined.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	348

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific

Borehole 21-05-03

Depth: 2-20 ft

Borehole 21-05-03

Dry Well Survey Analysis - Notes

Borehole 21-05-03Total # Surveys 356Probe Type 04 02Log Date: 1-14-75 1st# neutron surveys 7
6-13-94 Last# GR Surveys 248Presentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): NoneIsotope from Spectral Survey: Cs low & surfaceMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>intermittent near surface</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>Check & also higher threshold for near surface</u>
<u>isn't consistent about shallow low</u>
<u>levels</u>

Analyst Name RmaxS/W ver TFGRDSE 22

Borehole 21-05-05

Contamination (Co-60) from 60-80 feet is Undetermined

Grade thickness product from 60 to 80 feet appears to decrease slower than Co-60 (HPGe identified), but the levels are at threshold and over the history drop below threshold for the gross gamma instrumentation.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	375

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	60-80 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/14/75

Borehole 21-05-05

Depth: 60-80 ft

06/13/94

Borehole 21-05-05

BX
Dry Well Survey Analysis - Notes

Borehole 21-05-05Total # Surveys 380Probe Type 04 02Log Date: 1-14-79 1st# neutron surveys 4# GR Surveys 3756-13-94 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): 70"Isotope from Spectral Survey: Cs sample @ 100 Co 70"Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>bottom & surface not shown</u>
			<u>but Co @ 70 shows</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Undetermined due to background subtraction

Analyst Name

Russell RandallS/W ver TFRCSS2.2

Borehole 21-05-06

Contamination (Cs-137) from 2-15 feet is Stable late
 Contamination (Co-60) from 60-95 feet is Undetermined

Grade thickness product from 2 to 15 feet is decreasing consistent with Cs-137 (HPGe identified), from 1984 to 1994. However, due to system limitations near the surface, no conclusion can be stated for the history before 1984. Grade thickness product from 60 to 80 feet appears to decrease slower than Co-60 (HPGe identified), but the levels are at threshold and over the history drop below threshold for the gross gamma instrumentation. Note that the larger interval was used for the two intervals (one at 70 and other at 87 feet) in order to assist the low threshold, thus no statement can be made concerning downward movement.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	370

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	2-15 Stable late 60-80 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/14/75

Borehole 21-05-06

Depth: 2-15 ft

06/13/94

01/14/75

Borehole 21-05-06

Depth: 60-95 ft

06/13/94

Borehole 21-05-06

Dry Well Survey Analysis - Notes

Borehole EX 21-05-06 Total # Surveys 377 Probe Type 04 ¹ 14 ¹ 02
 Log Date: 1-14-75 1st # neutron surveys 5 # GR Surveys 370
1-13-94 Last Presentation Plot Dates _____
 (If different from 1st & Last)
 Contamination Zone Depth(s): 70 & 83 but very low
 Isotope from Spectral Survey: [G Rm] Co 80-90 Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>60 & 83 but low add together</u>
			<u>= 60-95</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>surface is erratic</u>

Analyst Name RossS/W ver TFGRDSS 2.2

Borehole 21-05-10

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 98 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	98 ft
Survey Depth :	98 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	372

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold $0 < \text{val} < 50$	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-05-10

Oldest Survey

1/14/1975

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-05-10

BX
Dry Well Survey Analysis - Notes

Borehole 21-05-10Total # Surveys 379Probe Type 04Log Date: 1-14-75 1"# neutron surveys 7# GR Surveys 3721-13-94 Last

Presentation Plot Dates

(If different from 1" & Last)

Contamination Zone Depth(s): NoneIsotope from Spectral Survey: Ca low & amorphousMax Survey Depth 98

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

ClearAnalyst Name S/W ver TF6R0052.2

Borehole 21-05-12

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 98 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	6/13/1994
Number Surveys :	381

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-05-12**Oldest Survey****1/15/1975**

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-05-12

Dry Well Survey Analysis - Notes

BX
Borehole 21-05-12Total # Surveys 386Probe Type 04Log Date: 1-15-75 1st# neutron surveys 5# GR Surveys 3816-13-94 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): NoneIsotope from Spectral Survey: Cs from 2 surfaceMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

Analyst Name RomanS/W ver TFGRD522

Borehole 21-06-01

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1993 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	10/5/1993
Number Surveys :	331

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-06-01

Oldest Survey
1/15/1975

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-06-01

Dry Well Survey Analysis - Notes

Borehole BK 21-06-01Total # Surveys 336Probe Type D4 02# neutron surveys 4# GR Surveys 331Log Date: 1-15-75 1st10-5-93 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): NoneIsotope from Spectral Survey: CS @ ~MDLMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name BauerS/W ver TFGR0592.2

Borehole 21-06-02

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1993 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/13/1975
Last Survey Date :	10/5/1993
Number Surveys :	334

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-06-02**Oldest Survey****1/13/1975****Gamma (c/s)** **No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-06-02

Dry Well Survey Analysis - Notes

Borehole 21-06-02Total # Surveys 341Probe Type D4 14 02Log Date: 1-13-75 1st# neutron surveys 4# GR Surveys 33410-5-93 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs very low & avg.Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name

[Signature]

S/W ver

YFG00122

Borehole 21-06-05

Contamination (Cs-137) from 32-44 feet is Stable
Contamination (U-238/235 & Sb-125) from 44-60 feet is Stable

Grade thickness product from 32 to 44 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993. Note that Sb-125 is HPGe identified, but at low levels for this interval.

Grade thickness product from 44 to 60 feet is decreasing consistent with a least squares fit for U-238/235 (HPGe identified) and Sb-125 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of U-238/235 to Sb-125 of 0.07 as of Jan 1975. Special note, the HPGe did identify Sb-125 at shallower depths than 44-60, but the Sb-125 in 44-60 feet decayed to level below detection. Likewise, the levels in the 32-44 feet were completely masked by the strong Cs-137 signal.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI, 02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	10/20/1995
Number Surveys :	344

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	32-44 & 44-60 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/15/75

Borehole 21-06-05

Depth: 32-44 ft

10/20/95

Analysis by: Three Rivers Scientific

Borehole 21-06-05

Dry Well Survey Analysis - Notes

Bx
Borehole 21-06-05Total # Surveys 353
neutron surveys 7
10-20-99 LastProbe Type 04 14 02
GR Surveys 344
Presentation Plot Dates _____
(If different from 1st & Last)Log Date: 1-15-75 1st

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs Sb K'sMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

may need depth shift for Cs/A zone

Analyst Name RollerS/W ver TEGR0502-12

Borehole 21-06-05

filein := "two.txt"

Well 21-06-05

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 331

i := 0..N

k := 0..300

j := 0..299

 $\tau_{eu} := 2.77$ $\tau_{co} := 5.27$ $\tau_{cs} := 3 \cdot 10^9$

aco := 00

acs := 90

Eu variables areRu-106

aeu := 1150

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are U238

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

ssq(acs, aeu) = 0

l = 1

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

 $\alpha_{cs} = 83.878$
 U-238

 $\alpha_{eu} = 1.19 \cdot 10^3$
 Sb-125

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.07$$

$$\frac{Eu_N}{Cs_N} = 0.078$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\delta_i := gross_i - tot_i$$

$$\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$$

Borehole 21-06-10

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1993 in the vadose zone from 10 to 100 feet. There are some activities from 0 to 10 feet, but most likely surface phenomena, thus the classification of clean.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	103 ft
Survey Depth :	103 ft
First Survey Date :	1/17/1975
Last Survey Date :	10/20/1995
Number Surveys :	341

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-06-10

**Oldest Survey
1/17/1975**

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-06-10

Dry Well Survey Analysis - Notes

Borehole 21-06-10Total # Surveys 345Probe Type 04Log Date: 1-17-75 1st# neutron surveys 4# GR Surveys 34110-20-95 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs 137 & 134Max Survey Depth 103

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

Plotted peak 0-10' but left for reference only
classified as clean

Analyst Name BakerS/W ver TF6R0552.2

01/17/75

Borehole 21-06-10

Depth: 0-10 ft
Reference Only

10/20/95

Borehole 21-07-03

Contamination (Co-60) from 62-68 feet and 82-100 feet is Stable

Grade Thickness Product for two radioactive zones (62-68 and 82-100 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Cobalt-60 (identified from HPGe detector).

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/16/1994
Number Surveys :	495

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	45 to 60 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	62-68 feet is Stable 82-100 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-07-03

Depth: 62-68 ft

05/16/94

01/14/75

Borehole 21-07-03

Depth: 82-100 ft

05/16/94

Borehole 21-07-03

Dry Well Survey Analysis - Notes

Borehole BX (21-07-03)Total # Surveys 500Probe Type 07Log Date: 75-01-14 1st# neutron surveys 3# GR Surveys 595 49594-05-16 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0.70 2027) 65 pCi/g Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
75-04-22	21	50	
76-07-27	61	75	
77-06-01	83	98	
84-02-01	18	100	
90-08-30	49	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-03-20	HI-BKG	100	
76-05-12	HI-BKG	100	
88-06-02	TOOL PROB	180	
88-12-21	TOOL PROB	98	
92-02-13	HI-BKG	100	TOOL MALFUNCTION

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-03-21	AVG-BKG	99	51%	39.4	
75-04-22	%CLEAN	58	54%	29.8	
75-12-24	LENGTH	170	96%	28.0	
76-05-12	AVG-BKG	97	41%	44.3	
76-07-27	%CLEAN	79	18%	27.0	
77-06-01	AVG-BKG	97	14%	1.0	
92-02-13	AVG-BKG	99	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
TWO LOW LEVEL RADIATION ZONES IDENTIFIED

Analyst Name Randall PuroS/W ver T6ROSS 12.20

Borehole 21-07-06**Contamination (Cs-137) from 20-34, 34-53, and 53-99 feet
is Stable**

Grade Thickness Product in the two lower radioactive zones (20-34 and 53-99 feet) is decreasing at rate consistent with the decay of Cesium-137 from July 1980 through May 1994 for the intermediate sensitivity probe (01 Green GM).

For the high radioactive zone (34-53 feet) the Green GM probe (01) was unable to confirm the stability, whereas the Red GM probe (02) was run during the same time interval and confirmed that the radioactive zone is decreasing at a rate consistent with the decay of Cesium-137.

Gross Gamma Survey Information

Probe Type :	01: Green GM (Intermediate Sensitivity) 02: Red GM (Lowest Sensitivity) 14: Shielded NaI (Saturated)
Other Probe Types :	04: Sodium Iodide Scintillator (Saturated) 03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980 (Type 01) 5/05/1980 (Type 02) 1/11/1980 (Type 14)
Last Survey Date :	5/26/1994 (Type 01) 5/26/1994 (Type 02) 9/02/1980 (Type 14)
Number Surveys :	274 (Type 01) 283 (Type 02) 32 (Type 14)

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold ($0 < \text{val} < 10$)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	20-34 feet is Stable 34-53 feet is Stable 53-99 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

07/24/80

Borehole 21-07-06

Depth: 20-34 ft

Probe Type: 01 - Green GM

Cs-137 Decay Line

Analysis by: Three Rivers Scientific

07/24/80

Borehole 21-07-06

Depth: 34-53 ft

Probe Type: 01 Green GM
(Intermediate Sensitivity)

05/26/94

05/26/94

Borehole 21-07-06

Depth: 53-99 ft

Probe Type: 01 Green GM
(Intermediate Sensitivity)

Cs-137 Decay Line

07/24/80

Analysis by: Three Rivers Scientific

Borehole 21-07-06 Probe: 01-Green GM Depth Shifted

05/05/80

Borehole 21-07-06

Depth: 20-34 ft

Probe Type: 02 Red GM
(Lowest Sensitivity)

Cs-137 Decay Line

Analyte by: Three Rivers Scientific

05/26/94

06/09/80

Borehole 21-07-06

Depth: 34-53 ft

Probe Type: 02 Red GM
(Lowest Sensitivity)

Probe 02 (Red GM) shows
radiation zone as stable
[Note: Probe 01 (Green GM)
exceeded system linearity]

Cs-137 Decay Line

Analysis by: Three Rivers Scientific

05/26/94

Borehole 21-07-06 Probe Type: 02 (Red GM)

Dry Well Survey Analysis - Notes

Borehole BX(21-07-06)Total # Surveys 598Probe Type 01 64(4)# neutron surveys 4# GR Surveys 274Log Date: 80-07-24 1st94-05-26 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs-137 (Full Well LNTAD)Max Survey Depth 102

01 (274) 80-07-24 → 94-05-26
 02 (283) 80-05-05 → 94-05-26
 89-03-17 → 94-05-26
 80-01-11 → 80-05-01
 SATURATED

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
85-07-12B	21	100	
87-02-02	14	100	
89-10-23	11	100	
93-07-14	101	101	
93-11-11	22	100	
89-03-17	53	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
87-06-05A	TOOL FAIL	102	
89-02-02	TOOL FAIL	100	
89-10-23	TOOL FAIL	100	
89-11-22A	TOOL FAIL	100	
90-07-02	TOOL FAIL	100	
91-01-17A	TOOL FAIL	100	
91-02-15	BAD SURVEY	100	
93-07-14	TURING HOLE		
93-11-11	TOOL FAIL		
PROBE 02 - RPD GM			
80-07-07A	TOOL FAIL		
87-06-05A	TOOL FAIL		
93-07-21	TOOL FAIL		
93-11-04	TOOL FAIL		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
82-04-19	AUG BKG	76	17%	8.9	
85-07-12	% CLEAN	102	3%	25.3	
87-06-05	AUG BKG	102	0%	0.0	
93-07-14	AUG BKG	101	0%	0.0	
93-11-11A	AUG BKG	101	36%	25.3	
87-06-05	% CLEAN	102	98%	9.6	
91-09-24	AUG BKG	101	0%	0.0	
80-05-29	AUG BKG	101	0%	1.0	

Analysis Notes

NO SURVEYS REJECTED
3 RADIATION ZONES WERE SELECTED FOR ANALYSIS

Analyst Name

Randall Reed

S/W ver

TRACROS V2.20

Borehole 21-08-02**Contamination (Cs-137) from 0 to 14 feet is Tank Farm Activity**

Grade Thickness Product from 0 to 14 feet is erratic from 1975 through 1979, and is categorized as Tank Farm Activity. Grade Thickness Produce from 1980 through 1994 the is decreasing at a rate consistent with the decay of Cesium-137 (identified from HPGe detector).

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	130 ft
Survey Depth :	130 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	228

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-14 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-08-02

Depth: 0-14 ft

06/13/94

Analysis by: Three Rivers Scientific

Borehole 21-08-02

Dry Well Survey Analysis - Notes

Borehole BX(21-08-02)Total # Surveys 231Probe Type 04Log Date: 75-01-14 1st# neutron surveys 3# GR Surveys 22894-06-13 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: CS-137 (0-11 FT) MAX 100 PCU/4 Max Survey Depth 130

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-04-27	11	130	
77-08-12	34	100	
79-07-11	33	60	
79-09-04	36	120	

80-05-29 88 130

94-03-24 125 130

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
77-08-10	HI-BKG	130	
93-11-17	HI-BKG	130	TOOL MALFUNCTION

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-10-21	LENGTH	46	93%	27.0	
76-05-12	%CLEAN	96	45%	45.3	
77-06-01	AVG BKG	98	7%	11.4	
77-11-16	LENGTH	45	95%	26.1	
78-05-09	AVG BKG	98	94	11.5	
93-07-11	%CLEAN	124	29%	28.7	
93-11-17	%CLEAN	100	11%	16.3	
94-03-24	AVG BKG	100	95%	20.3	

Analysis Notes

RADIATION ZONE FIRST APPEARED 76-01-07 (NOT CONTINUOUS)
RADIATION ZONE CONSTANT - AFTER 79-08-23

Analyst Name

Randall Rued

S/W ver

TPGROSS V2.20

Borehole 21-08-04**Contamination (Cs-137 & Eu-154) from 0 to 12 feet
appears Stable**

Grade Thickness Product from 0 to 12 feet is decreasing within log acquisition procedures, consistent with a least squares fit for Cesium-137 and Europium-154 (both identified from HPGe detector) between January 1975 and June 1994. The radiation zone was partially logged from May 1982 through February 1984, as shown on the stack plot. The least squares fit results in a gross gamma contribution ratio of 0.28 for Eu-154 to Cs-137 on June 1994.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	341

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold ($0 < \text{val} < 50$)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-12 feet appears Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-08-04

Depth: 0-12 ft

06/13/94

Analysis by: Three Rivers Scientific

Depth Shifted

Borehole 21-08-04

1995

1990

1985

Date (Year)

1980

1975

0

10

20

30

40

50

60

70

80

90

100

Depth (feet)

254

Dry Well Survey Analysis - Notes

Borehole BX(21-08-04)Total # Surveys 346Probe Type 04Log Date: 75-01-14 1st# neutron surveys 5# GR Surveys 34194-06-13 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: CS-137 (0 TO 25 FT) < 30 PCU/g
CO-60 5 FT < 0.3 PCU/gMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
77-06-01	91	100	
78-09-13	35	90	
79-07-11	95	120	
79-09-04	22	100	
93-11-17	92	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-03-20	HI-BKG	100	
75-06-21A	BAD SURVEY	45	NO PEAK AT 10 FT
76-07-27	BAD SURVEY	120	TOP PEAK 710 FT
76-10-06A	BAD SURVEY	105	TOP PEAK 710 FT
77-04-20A	BAD SURVEY	80	NO PEAK
77-06-01	BAD SURVEY	100	NO PEAK - WRONG WELL
77-11-16	BAD		
78-09-13	BAD		
79-07-11A	BAD		
82-06-15 TO 84-02-08			[PEAK TRUNCATED]
91-09-09	BAD		
94-03-24	BAD		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-10-21	LENGTH	46	93%	27.0	
76-05-12	AUG BKG	76	45%	45.3	
76-07-27	LENGTH	125	72%	26.8	
77-06-01	AUG BKG	98	7%	11.4	
77-11-16	LENGTH	45	95%	26.1	
78-05-09	LENGTH	124	29%	28.7	
93-11-17	AUG BKG	100	11%	16.3	
94-03-24	AUG BKG	100	95%	2.3	

Analysis Notes

NO SURVEYS REJECTED
DEPTH SHIFT ON TRAILING EDGE
DECREASE IN GTP IS NOT CONSISTENT WITH HPGE EXPECTED
RESULTS $EO/GS = 0.28$ RATIO OF GROSS GAMMA

Analyst Name

Randall Price

S/W ver

TRACROSS V2.20

filein := "two.txt"

Well 21-08-04

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 330

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 30.17$ $acs := 4000$

2nd Isotope is Eu-154 (8.5 yrs)

 $\tau_2 := 8.5$ $a_2 := 3500$

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$gross_i := net_i$$

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(acs, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(acs, a2)$$

$$\alpha_{cs} = 4 \cdot 10^3$$

$$\alpha_2 = 3.5 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$\frac{\alpha_{cs}}{\alpha_2} = 1.143$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\frac{X2_N}{Cs_N} = 0.28$$

Borehole 21-08-05

Contamination (Cs-137) from 0 to 35 feet is Stable

Contamination (Co-60) from 62 to 72 feet is Stable

Surveillance logging activities were not designed to monitor low contamination levels and monitor contamination at the surface.

The upper radioactive zone (0 to 35 feet) indicates that a short lived radionuclide, such as Ru-106, may have been present from 1975 to 1976. Ru-106 was identified (hypothesis) in the adjacent borehole, 21-08-06.

Grade Thickness Product from 0 to 35 feet is decreasing within counting system limitation at a rate consistent with Cesium-137 (identified from HPGe detector) between January 1975 and June 1994.

Grade Thickness Product from 62 to 72 feet is decreasing within counting system limitation at a rate consistent with Cobalt-60 (identified from HPGe detector) between January 1975 and June 1994. After 1984 the concentration of Co-60 is at and below the sensitivity threshold.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	360

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-35 feet is Stable 62-72 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-08-05

Depth: 0-35 ft

06/13/94

01/14/75

Borehole 21-08-05

Depth: 62-72 ft

06/13/94

Borehole 21-08-05

Dry Well Survey Analysis - Notes

Borehole BX(21-08-05)Total # Surveys 363Probe Type 04# neutron surveys 3# GR Surveys 360Log Date: 75-01-14 1st94-06-13 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): Low zone (65-72 FT)Isotope from Spectral Survey: CS-137 (0-40 FT) < 5 pCi/g)Max Survey Depth 100'

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-05-26	139	170	93-11-17 B (51 GAPS) 94-03-24 (98 GAPS)
76-07-20 B	38	50	
77-04-20 A, B	93	100	
79-07-11 A, B	53	60	
79-09-04	24	95	
92-05-18	99	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-02-06	HI-BKG	100	HIGH TOOL SENSITIVITY
76-07-20	TOOL PROB	60	TOOL FAILURE
76-08-18		100	POSSIBLE TOOL MALFUNCTION
76-09-22	HI-BKG	100	HI-TOOL SENSITIVITY?
81-10-21	HI-BKG	100	
93-11-17 A	TOOL FAIL	100	TOOL FAILURE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-03-24	AVG BKG	96	100%	8.0	
76-07-20	LENGTH	52	3%	30.0	
77-04-20	%CLEAN	97	1%	45.0	
79-07-11	LENGTH	47	34%	30.9	
92-05-18	AVG BKG	99	0%	0.0	
93-11-17	%CLEAN	99	8%	29.9	
94-03-24	AVG BKG	99	1%	1.0	

Analysis Notes

NO SURVEYS REJECTED
LOW ACTIVITY ZONE 62-72 FT SEEN FROM 1975 TO 1982
LOW LEVEL CS-137 AT SURFACE TO 40 FT NOT EASILY SEEN
IN CROSS SURVEILLANCE LOGS

Analyst Name

Randall PinedaS/W ver TAGROSS V2.20

Borehole 21-08-06

Contamination (Ru-106) from 43 to 52 feet is Stable

Grade Thickness Product from 43 to 52 feet is decreasing at a rate consistent with Ruthenium-106 (hypothesis) half-life between January 1975 and June 1981.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	458

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	43-52 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-08-06

Depth: 43-52 ft

06/13/94

Analyse by: Three Rivers Scientific

Dry Well Survey Analysis - Notes

Borehole BX(21-08-06)Total # Surveys 461Probe Type 04Log Date: 75-01-14 1st# neutron surveys 3# GR Surveys 45894-06-13 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0-15 ft) < 1 p Ci/gMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
77-08-12	27	80	
79-07-11A	35	40	
79-09-04	21	100	
85-01-22	29	102	

94-03-24 8 100

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-03-24		100	RAD ZONE MISSING
77-08-12B		90	REDUCED RAD ZONE
89-03-15A		100	TOO NOISE
92-02-13	HI-CAS	100	TOOL MALFUNCTION

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-03-24	AVG BKG	96	94%	8.7	
76-09-22	"	97	78%	39.0	
78-09-24	"	97	85%	38	
79-07-11AB	% CLEAN	42	16%	25.4	
91-08-27	AVG BKG	98	95%	38.5	
92-02-13	AVG BKG	98	0%	0.0	
94-03-24	AVG BKG	98	91%	1.1	

Analysis Notes

NO SURVEYS REJECTED
SHORT LIVED RADIATION ZONE

Analyst Name Randall RuizS/W ver T46LOSS V.2.20

Borehole 21-08-07

**Contamination (Cs-137) from 0-12 feet is Tank Farm Activity,
Contamination (Cs-137 & Co-60) from 30-42, & 42-54 feet
is Stable**

Grade Thickness Product from 0 to 12 feet is erratic from 1975 through 1979, and is categorized as Tank Farm activity. Grade Thickness Product from 1980 through 1994 is decreasing at a rate consistent with Cs-137 (identified from HPGe detector).

The main radioactive interval was evaluated as two radioactive zones to identify if downward movement had occurred. Grade Thickness Products from 30 to 42 and 42 to 54 feet is decreasing at a rate consistent with a least squares fit for Cesium-137 and Cobalt-60 (identified from HPGe detector) between January 1975 and June 1994. The least squares fit results in a gross gamma contribution ratio for Co-60 to Cs-137 of 1.8 and 8.6, respectively, on June 1994.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	250

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-12 feet is Stable 30-42 feet is Stable 44-54 feet are Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-08-07

Depth: 0-12ft

1/14/75

6/13/94

Analysis by: Three Rivers Scientific

01/14/75

Borehole 21-08-07

Depth: 30-42 ft

06/13/94

Analysis by: Three Rivers Scientific

01/14/75

Borehole 21-08-07

Depth: 42-54 ft

06/13/94

Analysis by: Three Rivers Scientific

Dry Well Survey Analysis - Notes

Borehole BX(21-08-07)Total # Surveys 253Probe Type 04Log Date: 75-01-14^{1st}# neutron surveys 3# GR Surveys 25094-06-13 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: _____

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
79-07-11	78		
79-09-04	22		
94-03-24	54		

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
75-10-15	DEPTH ERROR	140	
76-03-24	BAD SURVEY	100	
76-07-22	DEPTH ERROR	120	TOOL DID NOT STOP RECORDING AT TOP
79-07-11	BAD SURVEY	120	
82-06-30 TO 83-06-22	STOP RECORDING AT SURFACE (TOP)		
94-03-24	BAD SURVEY		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-10-15	LENGTH	139	75%	27.2	
76-03-24	Avg Bkg	97	78%	13.1	
76-09-24	Avg Bkg	98	59%	42.9	
76-09-22	Avg Bkg	98	45%	44.9	
79-07-11	% CLEAN	117	27%	23.9	
93-11-17	Avg Bkg	99	38%	42.7	
94-03-24	Avg Bkg	99	41%	30.1	

Analysis Notes

NO SURVEYS REJECTED

Analyst Name

Randall Puccia

S/W ver

TR Gross V2020

filein := "two30-42.txt"

Well 21-08-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 245

i := 0..N

k := 0..300

j := 0..299

tco := 5.27

tcs := 30.17

aco := 3400

acs := 220

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}}$$

$$tot_i := Cs_i + Co_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}} \right] \right]^2$$

Given

$$ssq(acs, aco) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aco)$$

$$\alpha_{cs} = 228.235$$

$$\alpha_{co} = 3.459 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}}$$

$$Eu_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}}$$

$$tot_i := Cs_i + Co_i$$

$$\frac{\alpha_{cs}}{\alpha_{co}} = 0.066$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Co_N}{Cs_N} = 1.803$$

filein := "two42-54.txt"

Well 21-08-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 244

i := 0..N

k := 0..300

j := 0..299

 $\tau_{co} := 5.27$ $\tau_{cs} := 30.17$

aco := 1500

acs := 30

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$tot_i := Cs_i + Co_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \right] \right]^2$$

Given

$$ssq(acs, aco) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aco)$$

$$\alpha_{cs} = 21.068$$

$$\alpha_{co} = 1.567 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$tot_i := Cs_i + Co_i$$

$$\frac{\alpha_{cs}}{\alpha_{co}} = 0.013$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Co_N}{Cs_N} = 8.62$$

Borehole 21-08-10**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1995 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	229

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-08-10

Oldest Survey

1/14/1975

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-08-10

Dry Well Survey Analysis - Notes

Borehole BX(21-08-10)Total # Surveys 232Probe Type 04# neutron surveys 3# GR Surveys 229Log Date: 75-01-14 1st94-06-13 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: CS-137 (0.35 FT) < 5 µCi/gMax Survey Depth 100'

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
77-08-12	22	90	
79-07-11	77	90	
79-09-04	16	95	
80-05-29	18	100	
94-03-24	100	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
75-02-11	HI-B/KL	102	
75-06-25	HI-CPS	100	
76-06-30	HI-B/KG	95	
76-09-22	HI-B/KL	100	
77-08-10	HI-CPS	100	TOOL FAIL
77-07-11	TOOL FAIL	95	
80-03-31	HI-CPS	100	
93-11-17	HI-B/KL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-06-18	LENVTH	31	100%	27.9	
76-06-30	AVG-B/KL	95	1%	46.0	
76-09-22	%CLEAN	98	16%	41.0	
77-07-11	LENVTH	39	25%	23.6	
80-03-31	%CLEAN	98	0%	0.0	
80-08-05	LENVTH	26	88%	27.7	
93-11-17	AVG-B/KL	100	53%	44.2	
94-03-24	AVG-B/KL	100	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONE FOUND ABOVE DETECTION THRESHOLD

Analyst Name Randall PuroS/W ver TFGRASS V2.20

Borehole 21-08-12

Contamination (Cs-137) from 2 to 10 feet is Tank Farm Activity

Grade Thickness Product from 2 to 10 feet is generally zero (0) with time intervals of erratic activity, indicating the possible Tank Farm activity. The radionuclide identified from the HPGe detector survey is Cesium-137.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	226

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	2-10 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-08-12

Depth: 2-10 ft

See Stack Plot for radiation zone (2-10 ft) with limited time period.

06/13/94

Borehole 21-08-12

Dry Well Survey Analysis - Notes

Borehole BV(21-08-12)Total # Surveys 329Probe Type 04Log Date: 75-01-14 1st# neutron surveys 3
94-06-13 Last# GR Surveys 226Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (3-20FT) < 3 PC/4
CO-60 (50-70FT) < 1 PC/4
GAPS.TxtMax Survey Depth 104.27

Survey Date	num. Gaps	approx #Samp's	Comment
77-08-12	14	90	
78-09-13A	30	95	
79-07-11A	52	50	
79-09-04	35	95	

92-05-18 103 104

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-02-11	HI-BKG	100	
75-04-09	HI-BKG	100	
75-06-25	HI-BKG	100	
76-06-15B	TOOL FAIL	100	
76-06-30	HI-BKG		
86-08-20(TO)	90-01-31		HI-CPS AT SURFACE (4FT)

93-11-17 TOOL FAIL 100

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	% CLEAN	99	44%	40.1	
76-03-23	AUG BKG	97	100%	10.8	
76-06-30	% CLEAN	94	1%	39.0	
79-07-11A	% CLEAN	49	32%	23.9	
80-12-01	LEAKY	40	95%	26.8	
92-05-16	AUG BKG	103	0%	0.0	
93-11-17	AUG BKG	103	23%	46.0	

Analysis Notes

NO SURVEYS REJECTED
HIGH Gamma Zone (2-10FT) 86-90 HAS LIMITED TIME INTERVAL

Analyst Name Randall ReedS/W ver TFGROSS V2.20

Borehole 21-09-02**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	10/05/1993
Number Surveys :	378

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-09-02

Oldest Survey

1/14/1975

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-09-02

Borehole 21-09-04**Contamination (Cs-137) from 5 to 14 feet is Tank Farm Activity**

Grade Thickness Product from 5 to 14 feet is erratic from 1975 through 1984, and is categorized as Tank Farm activity. Grade Thickness Product from 1984 through 1994 is decreasing at a rate that is slightly greater than the decay of Cs-137 (identified from HPGe detector).

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	01/14/1975
Last Survey Date :	10/05/1993
Number Surveys :	381

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold ($0 < \text{val} < 50$)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	5-14 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-09-04

Depth: 5-14 ft

10/05/93

Analyse by: Three Rivers Scientific

Borehole 21-09-04

Dry Well Survey Analysis - Notes

Borehole BX(21-69-04)Total # Surveys 385Probe Type 64Log Date: 75-01-14 1st# neutron surveys 4# GR Surveys 38193-10-05 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: CS-137 (8AT $\approx$ 20 pCi/g)Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-05-26	65	90	79-07-11 A,B (24 GAPS)
77-08-12	24	90	79-09-04 A,B (44 GAPS)
78-09-13A	32	100	92-05-18 98 GAPS
78-11-02	17	98	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-04-09	HI-BKG	100	
75-06-25	HI-BKG	98	
(76-01-07) (76-03-04)	RAD		ZONE NEAR SURFACE
76-06-23	TOOL FAIL	100	
(77-03-08) (78-07-11)	RAD		ZONE NEAR SURFACE
80-10-28	HI-BKG	100	HIGH BKG CPS

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	Avg BKG	100	51%	40.5	
76-03-23	"	98	95%	15.4	
76-05-26	% CLEAN	93	29%	27.6	
76-06-23	"	100	42%	33.3	
79-07-11	% CLEAN	45	11%	27.4	
80-10-28	Avg BKG	99	3%	50.0	
92-05-18	"	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
RADIATION ZONE MAY BE FOR SHOWING ACTIVITY FROM A NEAR SURFACE TRANSFER LINE (ASSUMED)

Analyst Name

Randall Price

S/W ver

TFGROSS V.2.20

Borehole 21-09-08**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	10/05/1993
Number Surveys :	367

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-09-08

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-09-08

Dry Well Survey Analysis - Notes

Borehole BX (21-09-08)Total # Surveys 370Probe Type 04# neutron surveys 3# GR Surveys 367Log Date: 75-01-14 1st93-10-05 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0 to 15 FT) < 5 pCi/gMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
77-08-12	22	95	
79-09-04	29	98	
84-05-02	10	100	
92-05-18A	97	98	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-04-09	HI-BKG	98	POSSIBLE TOOL NOISE
75-06-25	HIGH-BKG	98	"
76-06-15A,B	TOOL FAIL	98,95	TOOL FAILURE
80-11-19	HI-CPS	100	TOOL FAILURE
89-02-27A	TOOL NOISE	98	TOOL INTERMITTENT FAILURE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	% CLEAN	98	66%	37.9	
75-06-25	"	96	62%	36.5	
76-03-24	Avg BKG	95	100%	4.5	
76-11-23	"	97	95%	34.7	
80-11-19	% CLEAN	99	0%	0.0	
82-05-18	"	97	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION gone above detection threshold present

Analyst Name Randell RuedS/W ver TAGROSS v2.20

Borehole 21-09-12**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	10/05/1993
Number Surveys :	306

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-09-12

Oldest Survey

1/14/1975

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-09-12

Dry Well Survey Analysis - Notes

Borehole BX (21-09-12)Total # Surveys 309Probe Type 04Log Date: 75-01-14 1st# neutron surveys 3
93-10-05 Last# GR Surveys 306Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0.7035 CT) < 20 G/gMax Survey Depth 100 ft

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
92-05-18	97	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-04-09	HI-BKG	98	
75-06-25	HI-BKG	98	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	Avg BKG	97	40%	35.3	
75-06-25	% CLEAN	96	69%	36.1	
75-10-29	LENGTH	31	96%	26.0	
76-03-23A	Avg BKG	95	100%	14.6	
92-05-18	Avg BKG	97	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONE IDENTIFIED above detection threshold

Analyst Name

Randall Price

S/W ver

TF6LOSS V2.70

Borehole 21-10-01

Contamination (Cs-137) from 0 to 10 feet is Tank Farm Activity
Contamination (Cs-137 & Co-60) from 38 to 52 feet is Stable

Grade Thickness Product from 0 to 10 feet is somewhat erratic from 1975 through 1985 and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing at a rate consistent with Cs-137 (identified from HPGe detector) within the logging system sensitivity.

Grade Thickness Product from 38 to 52 feet is decreasing at a rate consistent with a least squares fit for Cesium-137 and Cobalt-60 (both identified from HPGe detector) between January 1975 and February 1994. The least squares fit results in a gross gamma contribution ratio of 0.05 for Co-60 to Cs-137 on February 1994.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	2/23/1994
Number Surveys :	369

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity 38-52 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

1/16/75

Borehole 21-10-01

Depth: 0-10 ft

2/23/94

01/16/75

Borehole 21-10-01

Depth: 38-52 ft

2/23/94

Analysis by: Three Rivers Scientific

Depth Shifted

Borehole 21-10-01

Dry Well Survey Analysis - Notes

Borehole BX(21-10-01)Total # Surveys 373Probe Type 4Log Date: 75-01-16^{1st}# neutron surveys 24
94-02-23 Last# GR Surveys 369Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 & Co-60Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
76-05-26	131	170	
79-07-11	40	60	
79-09-04	31	95	
92-05-18	98	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
75-02-13		100	TOOL FAIL
75-03-05		100	TOOL FAIL
75-03-11	LONG SURVEY	170	RECORDING ERROR
75-04-08		100	TOOL FAIL
76-05-26	LONG SURVEY	170	RECORDING ERROR
76-11-23 B		102	BAD SURVEY
78-01-04 B		90	BAD DEPTHS
78-02-28		100	WRONG WELL

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-01-15	AUG BKC	99	0%	0.0	
75-02-13	"	98	0%	0.0	
75-03-05	"	78	0%	0.0	
75-04-08	"	99	0%	0.0	
76-05-12	%CLEAN	76	33%	46.5	
76-09-22	AUG BKC	97	72%	37	
79-08-22	%CLEAN	97	15%	43.5	
92-05-18	AUG BKC	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
Co/CS = 1817 of GROSS COUNTS ON 2-1994 (CONSISTENT W/SCS 1997)

Analyst Name Randall RuedS/W ver TKGROSS V2.20

filein := "two.txt"

Well 21-10-01

A := READPRN(filein)

yr := A<1> net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 356

i := 0..N

k := 0..300

j := 0..299

tco := 5.27

tcs := 30.17

aco := 400

acs := 900

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}}$$

$$tot_i := Cs_i + Co_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}} \right] \right]^2$$

Given

$$ssq(acs, aco) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aco)$$

$$\alpha_{cs} = 905.409$$

$$\alpha_{co} = 407.919$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcs}}$$

$$Eu_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tco}}$$

$$tot_i := Cs_i + Co_i$$

$$\frac{\alpha_{cs}}{\alpha_{co}} = 2.22$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Co_N}{Cs_N} = 0.055$$

Borehole 21-10-03**Contamination (Cs-137) from 0 to 96 feet is Stable**

The surveillance logs were analyzed as six radioactive zones to identify if downward movement had occurred. The NaI and Green GM probe types were not designed to monitor high contamination levels (greater than 40,000 and 20,000 c/s, respectively). The radiation zone (0-23 feet) exceeded the count rate capabilities of the Green GM. The Red GM probe (0-23 and 23-41 feet) showed that the Grade Thickness Product was decreasing at a rate consistent with Cs-137 between July 1980 and May 1994. The lower five radiation zones (23-41, 41-57, 57-72, 72-88, and 88-96 feet) have Grade Thickness Products (Green GM) that are decreasing at a rate consistent with the decay of Cesium-137 between July 1980 and May 1994.

Gross Gamma Survey Information

Probe Type :	01: Green GM (Intermediate Sensitivity) 02: Red GM (Lowest Sensitivity)
Other Probe Types :	03: Neutron (4 surveys) 04: Sodium Iodide Scintillator (saturated) 14: Shielded NaI (saturated, limited time)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980 (Type 01) 5/05/1980 (Type 02) 1/11/1980 (Type 14)
Last Survey Date :	5/26/1994 (Type 01) 5/26/1994 (Type 02) 9/02/1980 (Type 14)
Number Surveys :	133 (Type 01) 155 (Type 02) 32 (Type 14)

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 10)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-23, 23-41, 41-57, 57-72, 72-88, 88-95 feet are Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

6/09/80

Borehole 21-10-03

Depth: 4-23 ft

Probe Type 02 (Red GM)

Cs-137 Decay Line

Analyte by: Three Rivers Scientific

5/26/94

6/09/80

Borehole 21-10-03

Depth: 23-41 ft
Probe Type 02 (Red GM)

Analysis by: Three Rivers Scientific

Borehole 21-10-03 Depth Shifted Tool Type: 02

7/24/80

Borehole 21-10-03

7/24/80

Borehole 21-10-03

Depth: 10-23 ft

Probe Type: 01 Green GM
(Intermediate Sensitivity)

Analysis by: Three Rivers Scientific

5/26/94

7/24/80

Borehole 21-10-03

Depth: 23-41 ft

Probe Type: 01 Green GM
(Intermediate Sensitivity)

Probe 01 (Green GM) count rate in this zone is approaching the non linear region of counting system (approx 20,000 c/s).
[See probe 02 Red GM analysis for stability of radiation zone]

Analysis by: Three Rivers Scientific

5/26/94

Borehole 21-10-03

Depth: 41-57 ft
 Probe Type: 01 Green GM
 (Intermediate Sensitivity)

7/24/80

5/26/94

Analyte by: Three Rivers Scientific

5/26/94

Borehole 21-10-03

Depth: 57-72 ft

Probe Type: 01 Green GM
(Intermediate Sensitivity)

Analysis by: Three Rivers Scientific

7/24/80

7/24/80

Borehole 21-10-03

Depth: 72-88 ft
 Probe Type: 01 Green GM
 (Intermediate Sensitivity)

Analysis by: Three Rivers Scientific

5/26/94

Borehole 21-10-03

7/24/80

5/26/94

Analysis by: Three Rivers Scientific

Dry Well Survey Analysis - Notes

* 01 (133) 80-07-24 → 94-05-02 (155) 80-05-05 → 94-05-02
 04 (16) 91-09-09 → 94-05-16
 # GR Surveys 133/4 (32) 80-01-11 → 80-09-02
 Presentation Plot Dates
 (If different from 1st & Last)

Borehole BX (21-10-03)Total # Surveys 330Probe Type 01Log Date: 80-07-24 1st# neutron surveys 04
94-05-26 Last AMP# GR Surveys 133/4 (32)Presentation Plot Dates
 (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs-137 FULL WALL
Co-60 (< 1 pCi/g)Max Survey Depth 100

GAPS.Txt

064

Survey Date	num. Gaps	approx #Samp's	Comment
81-10-26B	40	100	
87-05-01A	11	100	
93-07-12	99	100	
93-07-14	99	100	

80-05-27 26 100 9 80-06-02 (18 GAPS)
 82-02-22 9 100

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
81-07-15A	SHORT SURVEY	40	
81-10-26C	BAD SURVEY	100	
87-05-01A	DEPTH ERROR	102	
92-08-11	TOOL NOISE	100	
93-07-12	WRONG HOLE	100	
93-07-14	WRONG HOLE	100	

80-05-22A TOOL NOISE
 80-11-18A BAD SURVEY SD
 82-01-04A WRONG TOOL 102

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
81-07-15A	LENGTH	31	45%	24.1	
81-10-26C	AUG-BKG	98	77%	4.6	
87-05-01A	AUG-BKG	100	10%	0.7	
93-07-12	AUG-BKG	99	100%	0.0	
93-07-14	AUG-BKG	99	100%	0.0	
80-08-18	LENGTH	23	75%	1.0	
80-11-18	LENGTH	60	93%	1.5	
82-01-04	AUG-BKG	99	28%	24.7	

80-03-31A AUG-BKG 97 17% 0.0

Analysis Notes

SURVEYS THAT WONT DEPTH SHORT: 86-04-22/87-05-01A/

Analyst Name

Randall Price

S/W ver

TFGLoss V2.20

Borehole 21-10-05

Contamination (Cs-137) from 31-52, 52-62 and 74-85 feet
is Stable

Grade Thickness Product in three contamination zones
(i.e. 31-52, 52-62, and 74-85 feet) is decreasing at a rate consistent
with Cesium-137 decay between July 1980 and November 1989.

Gross Gamma Survey Information

Probe Type :	01: Green GM (Intermediate Sensitivity)
Other Probe Types :	02: Red GM (Lowest Sensitivity) 04: Sodium Iodide Scintillator (Saturated) 14: Shielded NaI (limited time)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980 (Type 01) 1/14/1980 (Type 02) 1/11/1980 (Type 04) 7/24/1980 (Type 14)
Last Survey Date :	11/06/1989 (Type 01) 7/22/1981 (Type 02) 12/16/1980 (Type 04) 5/05/1981 (Type 14)
Number Surveys :	74 (Type 01) 36 (Type 02) 32 (Type 04) 39 (Type 14)

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= -1
Method Used to Compute Background :	Threshold (0 < val < 10)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	31-52 ft is Stable 74-85 ft is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

07/24/80

Borehole 21-10-05

Depth: 31-52 ft

Analysis by: Three Rivers Scientific

07/24/80

Borehole 21-10-05

Depth: 52-62 ft

Analyse by: Three Rivers Scientific

11/06/89

07/24/80

Borehole 21-10-05

Depth: 74-85 ft

11/06/89

Analysis by: Three Rivers Scientific

Borehole 21-10-05 Depth Shifted Tool Type: 01

Dry Well Survey Analysis - Notes

Borehole BX(21-10-05)Total # Surveys 181Probe Type 01Log Date: 80-07-24^{1st}# neutron surveys 0# GR Surveys 17(39)87-11-06 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: CS-137 (FULL WELL) + Co-60 <100ug Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
81-10-26	9	85	
81-12-07	9	85	
82-09-20	10	100	
80-05-27	24	96	
80-06-02A	42	96	
06-02B	44	96	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
81-05-27	SEVERE DEPTH	110	SEVERE DEPTH ERROR
81-10-12	DEPTH	40	OFF DEPTH (SHORT SURVEY)
81-10-26A	DEPTH	85	"
81-12-07	DEPTH	85	"
80-06-02A	BAD SURVEY	100	WRONG HOUSE
80-03-31A	TOOL BAD	100	TOOL MALFUNCTION
88-09-15	TOOL BAD	102	"
80-09-16	DEPTH	110	OFF DEPTH (LONG SURVEY)

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
81-10-12A	DEPTH	42	73%	9.1	
80-06-02	% CLEAN	96	54%	1.2	
80-03-31	Avg Bkg	96	0%	0.0	
89-09-14	% CLEAN	99	97%	29.0	WRONG BOREHOLE

Analysis Notes

NO SURVEYS REJECTED
VARIATIONS IN GTP MAY BE RESULT OF TOOL CHANGES
TIME LAPS OF PROBE TYPES 02, 04, 14 LIMIT USEFULNESS OF THESE SURVEYS
RED GM TOOL (02) HAD 6 MONTH WITH ONE TOOL THAT CHANGED TO LESS SENSITIVE TOOL JUN 80
NAI TOOL (04) WAS SATURATED AT 60KCS (10X MULTIPLIER TO 3/29/90)
SHIELDED NAI (14) SURVEY PROVIDES CLOSER MATCH TO 02 TOOL TYPES

Analyst Name

Randall Rued

S/W ver

TP6ROSS V2.20

Borehole 21-10-07**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	395

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-10-07

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-10-07

Dry Well Survey Analysis - Notes

Borehole BX(21-10-07)Total # Surveys 399Probe Type 04Log Date: 75-01-15 1st# neutron surveys 4# GR Surveys 39594-02-23 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (C2PC/4) AT SURFACEMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
75-12-03	13	98	
79-09-04	25	96	
81-01-06	12	45	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-03-11	HI BKG	100	
76-06-09	HI CPS	100	LOW SENSITIVITY TOOL
76-06-15	TOOL MALFUNCTION	98	PROBABLE TOOL FAILURE
78-06-13A	HI-CPS	100	POSSIBLE TOOL NOISE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-03-11	AUG BKG	98	59%	(41.9)	
75-12-10	LENGTH	(31)	100%	26.9	
76-05-19	AUG BKG	97	81%	40.4	
76-06-09	%CLEAN	96	37%	29.4	
76-06-15	%CLEAN	94	41%	22.8	
77-02-09	LENGTH	42	100%	27.0	
81-01-06	LENGTH	49	75%	24.8	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONE ABOVE DETECTION THRESHOLD

Analyst Name Randall RuedS/W ver TPGROSS V2.20

Borehole 21-10-11**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	363

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-10-11

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-10-11

Dry Well Survey Analysis - Notes

Borehole BX(21-10-11)Total # Surveys 367Probe Type 04Log Date: 75-01-15st# neutron surveys 4# GR Surveys 36394-02-23 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 SURFACE ONLY (TO 2567) Max Survey Depth 100< 1 PC/g

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
76-07-20	32	60	
79-07-11	18	50	
79-09-04	35	95	
92-05-18	96	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
76-06-15	HI-PRCA	95	PROBABLE TOOL MAL FUNCTION
76-11-23A	HI-CPS	100	HIGH TOOL CPS
78-06-15B	HI-CPS	100	HIGH TOOL CPS
78-06-15B	HZ-CPS	100	"
79-03-20	HI-CPS	98	HIGH TOOL CPS
83-03-09	HI-CPS	100	HIGH TOOL CPS

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-05-19	AUG-BKL	96	87%	(41.3)	
76-07-20	%CLEAN	(60)	46%	24.4	
76-08-24	LENGTH	(132)	100%	25.4	
76-09-08					
78-03-14	AUG-BKL	97	100%	(11.8)	
79-07-11	LENGTH	(48)	62%	27.7	
92-03-09	%CLEAN	96	5%	45.6	
92-05-18	%CLEAN	96	3%	1.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONES ABOVE DETECTION THRESHOLD IDENTIFIED

Analyst Name Randall PinedaS/W ver TFGROSS V2.20

Borehole 21-11-03

Contamination (Cs-137) from 0 to 10 feet is Undetermined
 Contamination (Cs-137) from 34 to 44 feet is Undetermined
 Contamination (Cs-137) from 44 to 62 feet is Stable
 Contamination (Cs-137) from 62 to 70 feet is Stable
 Contamination (Cs-137) from 70 to 94 feet is Stable

Surveillance logging activities were not designed to monitor high contamination levels with count rates exceeding 40,000 c/s (34-44 feet) and monitor contamination at the surface (0-10 feet).

Grade Thickness Product from 44-62, 62-70, and 70-94 feet is decreasing at a rate consistent with Cesium-137 (identified from HPGe detector) between July 1980 and December 1989.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	14: Shielded NaI (21 surveys; 1980, 81, 89)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980
Last Survey Date :	12/19/1989
Number Surveys :	176

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is Undetermined 34-44 feet is Undetermined 44-62, 62-70, 70-94 ft Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

07/24/80

Borehole 21-11-03

Depth: 0-10 ft

12/27/89

Analysis by: Three Rivers Scientific

07/24/80

Borehole 21-11-03

Depth: 34-44 ft

Probe 04 (NaI) has exceeded linear region of counting system (approx 40,000 c/s).
Stability of radioactive zone can not be established.

Analysis by: Three Rivers Scientific

12/27/89

07/24/80

Borehole 21-11-03

Depth: 44-62 ft

12/27/89

Analysis by: Three Rivers Scientific

07/24/80

Borehole 21-11-03

Depth: 62-70 ft

Analysis by: Three Rivers Scientific

07/24/80

Borehole 21-11-03

Depth: 70-94 ft

Analysis by: Three Rivers Scientific

Borehole 21-11-03

1975 1980 1985 1990 1995

Dry Well Survey Analysis - Notes

14 = 80-01-10 → 89-08-
(21)Borehole BX(21-11-03)Total # Surveys 97Probe Type 64, 14Log Date: 80-07-27st# neutron surveys 0# GR Surveys 176, 2189-12-19 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: C5-137Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
81-10-13	12	100	
85-07-30	13	98	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
89-09-22	NO PEAKS	100	WRONG BOREHOLE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
81-09-22	HI-BKG	97	15%	42.3	
89-09-22	PO CLEAN	98	97%	23.8	

Analysis Notes

ZONE 34-44 FT EXCEED LINEAR REGION OF S45

Analyst Name

Randall Rine

S/W ver

TFGROSS V2.2

Borehole 21-11-04

Contamination (Cs-137) from 35 to 46 ft is Stable

Surveillance logging activities were not designed to monitor high contamination levels with count rates exceeding 40,000 c/s. Grade Thickness Product from 35 to 46 feet is decreasing within counting system limitations at a rate consistent with Cesium-137 decay between July 1980 and December 1989.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	14: Shielded NaI (22 surveys; 1980, 85, 89)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980
Last Survey Date :	12/27/1989
Number Surveys :	218

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold ($0 < \text{val} < 50$)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	35-46 ft is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

07/24/80

Borehole 21-11-04

Depth: 35-46 ft

12/27/89

Analysis by: Three Rivers Scientific

Depth Shifted

Borehole 21-11-04

0

10

20

30

40

Depth (feet)

341

50

60

70

80

90

100

1975

1980

1985
Date (Year)

1990

1995

Dry Well Survey Analysis - Notes

Borehole BX (21-11-04)Total # Surveys 240Probe Type 04, 14Log Date: 80-07-24 1st# neutron surveys 0# GR Surveys 21889-12-27 LastPresentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): 30-46 FTIsotope from Spectral Survey: CS-137 60-60Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
<u>81-10-13</u>	<u>24</u>	<u>98</u>	
<u>84-08-15</u>	<u>10</u>	<u>100</u>	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
<u>89-01-10</u>	<u>NO RAD ZONE</u>	<u>98</u>	<u>PEAK MISSING</u>
<u>89-08-09A</u>	<u>BAD PEAK</u>	<u>98</u>	<u>POORLY DEFINED RAD ZONE</u>
<u>89-10-02</u>	<u>BAD PEAK</u>	<u>98</u>	<u>"</u>
<u>89-12-13A</u>	<u>BAD PEAK</u>	<u>98</u>	<u>"</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
<u>81-10-13</u>	<u>90% CLEAN</u>	<u>96</u>	<u>67%</u>	<u>24.9</u>	
<u>85-03-12B</u>	<u>AVG BKG</u>	<u>98</u>	<u>92%</u>	<u>4.5</u>	
<u>85-08-26</u>	<u>AVG BKG</u>	<u>98</u>	<u>86%</u>	<u>17.1</u>	

Analysis Notes

Analyst Name _____

S/W ver _____

Borehole 21-11-05**Contamination (Cs-137) from 40 to 46 ft is Undetermined**

Grade Thickness Product from 40 to 46 feet is decreasing at a rate that appears to be greater than the decay rate of Cesium-137 (identified from HPGe detector) between January 1975 and February 1994.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	2/23/1994
Number Surveys :	558

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	50 to 90 ft
Depth(s) where Contamination Identified in Gross Gamma Surveys :	40-46 feet is Undetermined
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-11-05

Depth: 40-46 ft

02/23/94

Analysis by: Three Rivers Scientific

Dry Well Survey Analysis - Notes

Borehole BX (21-11-05)Total # Surveys 362Probe Type 04# neutron surveys 4# GR Surveys 558Log Date: 75-01-14 1st94-02-23 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): 42 FTIsotope from Spectral Survey: CS-137Max Survey Depth 100 FT

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
81-10-13A	11	98	
81-10-13B	24	98	
81-10-13C	22	98	
85-09-23	8	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-02-13	HI-CPS	100	TOOL MALFUNCTION
75-04-08	HI-CPS	100	POSSIBLE TOOL MALFUNCTION
75-04-09	HI-CPS	100	TOOL MALFUNCTION
76-06-22	HI-CPS	100	TOOL FAILURE
76-06-24	HI-CPS	100	TOOL MALFUNCTION
85-02-26	TOOL FAIL	100	TOOL FAILURE
92-09-29	TOOL FAIL	100	TOOL FAILURE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-02-13	Avg Bkg	98	0%	0.0	
75-04-09	Avg Bkg	99	25%	38.8	
76-06-22	% CLEAN	96	41%	30.6	
76-06-24	Avg Bkg	96	100%	15.0	
81-10-13	% CLEAN	97	71%	22.7	
85-02-26	Avg Bkg	99	0%	0.0	
85-08-26	Avg Bkg	99	93%	13.2	
91-08-21	Avg Bkg	98	97%	48.0	
92-09-29	Avg Bkg	98	0%	0.0	

Analysis Notes

BKG (50-90 FT)

Analyst Name

Randall Pineda

S/W ver

TFGROSS V2.20

Borehole 21-11-07

Contamination (Cs-137 & Co-60) from 35 to 45 feet is Stable

Surveillance logging activities were not designed to monitor low contamination levels.

Grade Thickness Product from 35 to 45 feet is decreasing at a rate consistent with a least squares fit for Cesium-137 and Cobalt-60 (both identified from HPGe detector) between January 1975 and February 1994. The least squares fit results in a gross gamma contribution ratio for Co-60 to Cs-137 of 1.3 on February 1994.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	561

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	5 to 35 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	35-45 ft is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/15/75

Borehole 21-11-07

Depth: 34-45 ft

2/23/94

Borehole 21-11-07

Dry Well Survey Analysis - Notes

Borehole 6X(21-11-07)Total # Surveys 565Probe Type 04Log Date: 75-01-15 1st# neutron surveys 4# GR Surveys 56194-02-23 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): 40 FT (35-45 FT)Isotope from Spectral Survey: CS-137 (< 5 p.w.g @ 0.940') Max Survey Depth 100
CO-60 @ 44 FT < 0.1 p.w.g/m

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
76-09-02	8	40	BAO SURVEY
81-10-13	21	98	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-03-05	HI CPS	100	
76-06-23	MALFUNCTION	100	TOOL PROBABLY MALFUNCTION
76-09-02A	TOOL FAIL	40	TOOL MALFUNCTION
76-11-23A	MALFUNCTION	102	PROBABLY TOOL MALFUNCTION
79-12-26	HI-CPS	98	POSSIBLE TOOL MALFUNCTION
85-02-26	TOOL FAIL	100	TOOL MALFUNCTION

87-11-30 HI-CPS 100 TOOL MALFUNCTION
 91-02-19 (91-02-20B) 91-03-05) - TOOL MALFUNCTION
 91-08-21 HI-CPS TOOL MALFUNCTION

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-03-05	% CLEAN	98	12%	47.4	
76-03-24	Avg Bkg	95	98%	12.7	
76-05-19	Avg Bkg	96	77%	42.4	
85-02-26	% CLEAN	99	0%	0.0	
85-08-26	Avg Bkg	99	95%	15.1	
91-08-21	% CLEAN	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
BACKGROUND 5-35 FT

Analyst Name

Randall Pua

S/W ver

TF6GROSS V2.20

filein := "two.txt"

Well 21-11-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 550

i := 0..N

k := 0..300

j := 0..299

$\tau_{co} := 5.27$

$\tau_{cs} := 30.17$

$\alpha_{co} := 170$

$\alpha_{cs} := 20$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$tot_i := Cs_i + Co_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \right] \right]^2$$

Given

$$ssq(\alpha_{cs}, \alpha_{co}) = 0$$

$$1 = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(\alpha_{cs}, \alpha_{co})$$

$$\alpha_{cs} = 15.785$$

$$\alpha_{co} = 170.204$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$tot_i := Cs_i + Co_i$$

$$\frac{\alpha_{cs}}{\alpha_{co}} = 0.093$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Co_N}{Cs_N} = 1.347$$

Borehole 21-11-10**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	554

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-11-10

Oldest Survey

1/15/1975

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-11-10

Dry Well Survey Analysis - Notes

Borehole BX (21-11-10)Total # Surveys 558Probe Type 04Log Date: 75-01-15 1st# neutron surveys 4# GR Surveys 55494-02-23 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: CS-137 SURFACE ONLYMax Survey Depth 100'

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
78-09-13	9	98	
81-10-13	16	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
76-06-15	HIGH CPS	98	PROBABLE TOOL MALFUNCTION
76-08-18	HI-BKG	100	HIGH AVG BKG
85-02-26	TOOL FAIL	100	TOOL FAILURE
88-11-14A	TOOL FAIL	100	TOOL FAILURE PROBABLE
88-11-14C	TOOL FAIL	100	"
91-08-21	HI-BKG	100	HIGH AVG BKG
93-09-01	HIGH BKG	100	PROBABLE TOOL FAILURE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-05-19	HI-BKG	97	95%	40.1	
76-08-18	HI-BKG	98	39%	39.1	
81-03-30	SHORT SURVEY	12	91%	23.9	
85-02-26	HI-BKG	100	0%	0.0	
91-08-21	HI-BKG	99	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONES IDENTIFIED

Analyst Name

Randall Reed

S/W ver

TF6055 V2.20

Borehole 21-11-11**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	554

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-11-11

Oldest Survey
1/15/1975

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-11-11

Dry Well Survey Analysis - Notes

Borehole BX(21-11-11)Total # Surveys 558Probe Type 04Log Date: 75-01-15 1st# neutron surveys 4# GR Surveys 55494-02-23 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (SURFACE ONLY)Max Survey Depth 100 ft

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
75-12-30	6	95	
78-09-13	20	95	
81-10-13	22	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
81-10-15	HI-BKG	100	
85-02-26	TOOL-FAILURE	100	TOOL MALFUNCTION
91-03-05	SURVEY DIA	100	POSSIBLE WRONG HOLE ZN
91-08-21	HI-BKG	100	HI AVG TOOL COUNTS

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-05-19	HI-BKG	99	91%	38.6	
79-12-26	HI-BKG	99	100%	32.6	
81-10-13	TOOL CLEAN	100	78%	24.0	
81-10-15	HI-BKG	99	92%	34.1	
85-02-26	ACTIVITY	101	0%	0.0	
85-08-26	AVG BKG	101	96%	13.4	
91-08-21	AVG CNTS	100	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONE IDENTIFIED ON TR SURVEYS

Analyst Name Randall RutoS/W ver 74GROSS V2.20

Borehole 21-12-02

Contamination (Cs-137) from 0 to 6 feet is Tank Farm Activity
Contamination (Cs-137) from 6 to 20 ft is Undetermined

Grade Thickness Product from 0 to 6 feet is erratic from 1975 to 1986 and is categorized as Tank Farm activity. Surveillance logging activities were not designed to monitor low contamination levels or contamination near the surface. Grade Thickness Product from 1986 through 1995 is decreasing at a rate consistent with Cs-137 (identified from HPGe detector).

The radioactive zone from 6 to 20 feet has three time intervals that warrant discussion. (1) From 1975 to 1976 the Grade Thickness Product appears to be decreasing at a high rate which may indicate a short lived radionuclide, possibly Ru-106. (2) From 1976 to 1982 the Grade Thickness Product is decreasing within counting statistics at a rate consistent with Cesium-137, then a step increase appears to have occurred. (3) From 1982 through 1994 the Grade Thickness Product is decreasing within counting statistics at a rate consistent with Cesium-137 (identified from HPGe detector).

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	361

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	20 to 95 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-6 ft is TF Activity 6-20 feet is Undetermined
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-12-02

Depth: 0-6 ft

05/25/95

01/14/75

Borehole 21-12-02

Depth: 6-20 ft

05/25/95

Borehole 21-12-02

Dry Well Survey Analysis - Notes

Borehole BX (21-12-02)Total # Surveys 364Probe Type 04Log Date: 75-01-14 1st# neutron surveys 3# GR Surveys 36195-05-25 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): SURFACE TO 20 FTIsotope from Spectral Survey: CS-137 (Co-60 @ 42 FT < .2 pCi/g) Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
76-01-07	8	98	
76-03-24	96	98	
81-10-13	13	100	
92-05-18	97	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			1982-02-08 LOG PROCEDURE CHANGES, TO INCLUDE SURVEY TO TOP OF WELL

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-04	7% CLEAN	98	61%	34.0	HIGH BKG
76-03-24	BAD SURVEY	96	0%	0.0	
76-06-30	8% CLEAN	93	52%	33.9	
77-02-10	HI BKG	97	83%	38.7	
79-12-26	7% CLEAN	96	75%	35.2	
92-05-18	BAD SURVEY	97	0%	0.0	

Analysis Notes

LOW LEVEL CONTAMINATION FROM SURFACE (0 FT) TO 20 FT.
max CS-137 = 20 pCi/g @ 2 FT
DEPTH ZONE 0-6 FT & 6 TO 20 FT
BACK GROUND 20-95 FT

Analyst Name

Kendall Pitzer

S/W ver

TF6GROSS V2020

Borehole 21-12-05**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1995 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	344

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-12-05

Early Survey
1/21/1975

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-12-05

Dry Well Survey Analysis - Notes

Borehole BX(21-12-05)Total # Surveys 348Probe Type 04Log Date: 75-01-14 1st# neutron surveys 4# GR Surveys 34495-05-25 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): NONE (CLEAN)Isotope from Spectral Survey: CS-137 AT SURFACEMax Survey Depth 97 FT

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
78-09-13	22	97	
81-10-13	7	100	
92-05-18	98	98	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-04-09	HIGH BKG	298	
76-06-30	HIGH CPS	295	
76-09-22	HIGH BKG	295	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
75-04-09	% CLEAN	99	55%	39.1	
76-06-30	% CLEAN	94	38%	29.5	
76-09-22	% CLEAN	97	27%	43.2	
78-09-13	% CLEAN	95	76%	26.2	
92-05-18	% CLEAN	98	0%	0.0	

Analysis Notes

NO HIGH CPS ZONE IDENTIFIED / CONFIRMED ON HI-ZONES FILE
NO SURVEYS REJECTED
'CLEAN'

Analyst Name Randall P.S/W ver TKGROSS V2.20

Borehole 21-12-07**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1995 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	359

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold ($0 < \text{val} < 50$)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-12-07

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-12-07

Dry Well Survey Analysis - Notes

Borehole BX (21-12-07)Total # Surveys 363Probe Type 64# neutron surveys 4# GR Surveys 359Log Date: 75-01-14 1st95-05-25 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: CS-137 AT SURFACEMax Survey Depth 100'

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
78-09-13	15	295	
81-10-13	31	102	
84-07-25	14	100	
92-05-18	98	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-04-09	HI-CPS	100	
76-06-30A	HI-CPS	100	TOOL READING HIGH
76-06-30C	HI-CPS	140	TOOL MALFUNCTION
77-02-03A	HI-CPS 80'	100	MAYBE WRONG HOLE OR TOOL MALFUNCTION
77-02-03C	HI-CPS 20' 40'		TOOL MALFUNCTION
78-05-03A	HI-CPS 80'	100	
79-03-05A	HI-CPS 80'	100	PROBABLY TOOL MALFUNCTION
81-11-09	"	80' 100	" BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
75-04-09	BKGR	99	34%	40.8	
75-07-02A	DEPTH	46	100%	28.5	
76-03-17	DEPTH	196	99%	26.2	
76-06-30A	% CLEAN	95	0%	0.0	
77-01-19	DEPTH	143	95%	25.7	
77-02-09	DEPTH	36	63%	27.6	
81-10-13	% CLEAN	100	69%	23.8	
92-05-18	% CLEAN	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONE IDENTIFIED ABOVE DETECTION THRESHOLD
'CLEAN'

Analyst Name Randall RuedS/W ver TALROSS V.2.20

Borehole 21-12-10**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1994 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	355

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-12-10

Oldest Survey
1/14/1975

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-12-10

Dry Well Survey Analysis - Notes

Borehole BX(21-12-10)Total # Surveys 360Probe Type 04Log Date: 75-01-14 1st# neutron surveys 5# GR Surveys 35595-05-25 LastPresentation Plot Dates SAME
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: _____

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
81-00-13	26	~100	
92-05-18	98	~100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
76-06-23A	HI-CPS	~100	PROBT TOOL MALFUNCTION
76-06-30	ABOVE AVG CPS	100	HIGHER CPS THAN NORMAL

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	LOW % CLEAN	100	72%	31.0	
76-03-24	LOW BKG	98	98	10.9	
76-06-23A	BAD SURVEY	98	0%	0.0	
76-06-30	BAD SURVEY	94	0%	0.0	
81-10-13	LOW % CLEAN	98	72%	23.8	
92-05-18	LOW BKG	98	0%	0.0	

Analysis Notes

NO CONSISTANT INTERVAL (TIME RANGE) OR CPS > 50 CPS
LOW LEVEL ACTIVITY ZONE (CS-137) AT SURFACE (0-25 FT)
WAS NOT IDENTIFIED ABOVE NATURAL FORMATION CHARACTER
(40-100 FT) THUS CLASSIFIED AS 'CLEAN' FOR TR SURVEYS
NO SURVEYS REJECTED.

Analyst Name Randall P. [Signature]S/W ver TRACLOSS V2.20

Borehole 21-12-12**Contamination (Cs-137) at 4-10 ft is Stable**

Grade Thickness Product between 4-10 feet appears to be decreasing at a rate consistent with Cesium-137 (identified from HPGe detector) between January 1975 and May 1995.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	335

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	4-10 ft. is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/14/75

Borehole 21-12-12

Depth: 4-10 ft

05/25/95

Dry Well Survey Analysis - Notes

Borehole BX (21-12-12)Total # Surveys 340³³⁹Probe Type 04Log Date: 75-01-14^{1st}# neutron surveys 4# GR Surveys 33595-05-25 LastPresentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): 7 FT (2-28 FT FROM SGLS)Isotope from Spectral Survey: CS-137Max Survey Depth 100 FT

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
78-09-13	13	98	
81-10-13	13	102	
92-05-18	98	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-04-09		100	TOOL RESPONSE > AVERAGE
76-06-23	HIZONE 19-25'	100	POSSIBLE TOOL MALFUNCTION OR WRONG HOLE
76-06-30		100	TOOL RESPONSE > NORM

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
76-06-30	HIGH CPS	94	1%	49.0	
92-05-18	HIGH GAPS	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
DEPTH SHIFTED USING SHF AUTO V1.0 (TMAX 13.98)
BKG COMPUTED (<= 50 CPS)
RAO ZONE ANALYSIS 4-10 FT
ZONE AT 6 FT IS STABLE (LOW ACTIVITY 30 PL/g MAX FROM SGLS)

Analyst Name

Randall Price

S/W ver

TF GROSS V2.20 JAN 8/98

Borehole 21-27-01

Contamination (Sb-125 & U-235/238) from 68 to 78 feet is Stable

Grade Thickness Product for the radioactive zone (68-78 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Antimony-125 and Uranium-235/238 (both identified from HPGe detector) between January 1979 and March 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to U-235/238 of 0.5 on March 1993.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1979
Last Survey Date :	3/17/1993
Number Surveys :	38

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	68-78 ft is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/79

Borehole 21-27-01

Depth: 68-78 ft

03/17/93

Borehole 21-27-01

Dry Well Survey Analysis - Notes

Borehole BX(21-27-01)Total # Surveys 40Probe Type 4Log Date: 79-01-09 1st# neutron surveys 2
93-03-17 Last# GR Surveys 38Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0-2027) < 2 PC/4Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
NO SURVEYS WITH > 5 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
79-03-05	Tool Pass	100	APPEARS TO HAVE 2 RADIATION ZONES

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
NO UNUSUAL SURVEYS IDENTIFIED					

Analysis Notes

NO SURVEYS REJECTED	
SHORT LIVED RADIONUCLIDES (SB-25)	

Analyst Name

Randall Puro

S/W ver

TKGROSS V2.20

Well 21-27-01

filein := "two68-78.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 37

i := 0..N

k := 0..300

j := 0..299

1st Isotope is U (4.5 e6 yrs)

 $\tau_{co} := 4.5 \cdot 10^9$

aco := 30

2nd Isotope is Sb-125 (2.77 yrs) $\tau_2 := 2.77$

a2 := 1550

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 30.656$$

$$\alpha_2 = 1.572 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = 0.019$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

Ratio Sb/U

$$\frac{X2_N}{Co_N} = 0.505$$

Borehole 21-27-02

Contamination (Sb-125 & U-235/238) from 68 to 78 feet is Stable

Grade Thickness Product for the radioactive zone (68-78 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Antimony-125 and Uranium-235/238 (both identified from HPGe detector) between January 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to U-235/238 of 0.2 on June 1993.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1979
Last Survey Date :	6/17/1993
Number Surveys :	41

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	68-78 ft is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/79

Borehole 21-27-02

Depth: 68-78 ft

06/17/93

Dry Well Survey Analysis - Notes

Borehole BX(21-27-02)Total # Surveys 43Probe Type 04Log Date: 79-01-09 1st# neutron surveys 2# GR Surveys 4193-06-17 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
NO SURVEYS WITH		> 7	GAPS

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
79-07-09	BAD SURVEY	55 FT	SHORT SURVEY
79-01-09	BAD SURVEY	80	4

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
79-07-09	LENGTH	53	96%	27.5	

Analysis Notes

NO SURVEYS REJECTED
SHORT LIVED RADIATION ZONE 27 FT
ASSUMED TO BE Sb-125 BASED ON OTHER HALL LOGS IN ADJACENT
WELLS.

Analyst Name

Randall Pineda

S/W ver

TK GROSS V2.20

filein := "two68-78.txt"

Well 21-27-02

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 36

i := 0..N

k := 0..300

j := 0..299

1st Isotope is U (4.5 e6 yrs) $\tau_{co} := 4500000$ $aco := 30$ 2nd Isotope is Sb-125 (2.77 yrs) $\tau_2 := 2.77$ $a2 := 600$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \quad X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \quad tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 30.229$$

$$\alpha_2 = 607.599$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \quad X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \quad tot_i := Co_i + X2_i \quad \frac{\alpha_{co}}{\alpha_2} = 0.05$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\text{Ratio U/Sb} = \frac{Co_N}{X2_N} = 5.048$$

Borehole 21-27-06**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1979 and 1993 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1979
Last Survey Date :	6/17/1993
Number Surveys :	41

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-27-06

Oldest Survey
1/19/1979

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 21-27-06

Dry Well Survey Analysis - Notes

Borehole BX(21-27-06)Total # Surveys 43
neutron surveys 2Probe Type 4
GR Surveys 41Log Date: 79-01-09^{1st}93-06-17 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: C5-137Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
NO SURVEYS w/ 75 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
84-06-12A	TOOL FAIL		
AB			

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
84-06-12A	% CLEAN	97	45%	22.5	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONES ABOVE DETECTION THRESHOLD

Analyst Name Randall PuraS/W ver TFGROSS V2.20

Borehole 21-27-07

Contamination (Sb-125 & U-235/238) from 68 to 84 feet and 90 to 118 feet is Stable

Grade Thickness Product for the two radioactive zones (68-84 and 90-118 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Antimony-125 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to U-235/238 of 0.5 and 0.04, respectively, on June 1993.

The majority of U-235/238 in the lower radioactive zone (90-118 feet) is concentrated in the lowest portion from 108 to 118 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	138 ft
Survey Depth :	138 ft
First Survey Date :	1/22/1979
Last Survey Date :	6/17/1993
Number Surveys :	37

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold ($0 < \text{val} < 50$)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	68-84 feet is Stable 90-118 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/22/79

Borehole 21-27-07

Depth: 68-84 ft

06/17/93

01/22/79

Borehole 21-27-07

Depth: 90-118 ft

Analysis by: Three Rivers Scientific

Borehole 21-27-07

Dry Well Survey Analysis - Notes

Borehole BX(21)-27-07Total # Surveys 39Probe Type 04Log Date: 79-01-22 1st# neutron surveys 2# GR Surveys 3793-06-17 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS, SB-125, UMax Survey Depth 150'1240
AKP

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
<u>NO SURVEYS WITH 7 6 GAPS</u>			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
<u>NO BAD SURVEYS</u>			

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
<u>NO SURVEYS DEVIATED FROM NORM</u>					

Analysis Notes

<u>NO SURVEYS REJECTED</u>					

Analyst Name Randall PinedaS/W ver TAGROSS V2.20

filein := "two68-084.txt"

Well 21-27-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 36

i := 0..N

k := 0..300

j := 0..299

1st Isotope is U (4.5 e6 yrs) $\tau_{co} := 4500000$ $aco := 80$ 2nd Isotope is Sb-125 (2.77 yrs) $\tau_2 := 2.77$ $a2 := 3900$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$gross_i := net_i$$

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 82.557$$

$$\alpha_2 = 3.911 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\text{Ratio U/Sb} = \frac{Co_N}{X2_N} = 2.142$$

filein := "two90-118.txt"

Well 21-27-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 36

i := 0..N

k := 0..300

j := 0..299

1st Isotope is U (4.5 e6 yrs)

 $\tau_{co} := 4500000$

aco := 560

2nd Isotope is Sb-125 (2.77 yrs) $\tau_2 := 2.77$

a2 := 2400

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$gross_i := net_i$$

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 566.072$$

$$\alpha_2 = 2.426 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = 0.233$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\frac{Co_N}{X2_N} = 23.682$$

Ratio U/Sb

Borehole 21-27-08

Contamination (Sb-125) from 40 to 86 feet is Stable

Contamination (Co-60&Sb-125&U-235/238) from

92 to 116 feet is Stable

Contamination (U-235/238) from 130 to 146 feet is Stable

Grade Thickness Product for the radioactive zone (40-86 feet) is decreasing at a rate consistent with the decay of Antimony-125 (identified from HPGe detector) between April 1979 and June 1993.

Grade Thickness Product for the radioactive zone (92-116 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Antimony-125 (hypothesis), Cobalt-60 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Co-60:Sb-125:U-235/238 is 182:43:1097 on June 1993.

Grade Thickness Product of the radioactive zone (130-146 feet) appears to be stable, within the measurement counting uncertainty, with Uranium-235/238 (identified from HPGe detector). Surveillance logging activities were not designed to monitor low contamination levels.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	150 ft
Survey Depth :	150 ft
First Survey Date :	4/30/1979
Last Survey Date :	6/17/1993
Number Surveys :	35

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	40-86 feet is Stable 92-116 feet is Stable 130-146 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

04/03/79

Borehole 21-27-08

Depth: 40-86 ft

06/17/93

04/03/79

Borehole 21-27-08

Depth: 92-116 ft

06/17/93

04/03/79

Borehole 21-27-08

Depth: 130-146 ft

06/17/93

HNF-3531 - REV0
Depth (feet)

0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

Borehole 21-27-08

1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-27-08)Total # Surveys 37Probe Type 04Log Date: 79-04-03^{1st}# neutron surveys 2# GR Surveys 3593-06-17 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS, Co, EU, SB, UMax Survey Depth 150

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
NO SURVEYS WITH 76 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
84-06-12	PROBABLY WRONG WELL		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
84-06-12	70% CLEAN	97	100%	24.0	

Analysis Notes

NO SURVEYS REJECTED					

Analyst Name Randall BuedS/W ver TFGROSS V.2.20

filein := "two92-116.txt"

Well 21-27-08

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 33

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 5.27$

acs := 2000

2nd Isotope is Sb-125 (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 4030

B := 1100 B is Uranium

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i + B$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3, a5) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} + a5 \right] \right]^2$$

Given

$$ssq(acs, a2, B) = 0$$

$$l = 1$$

$$B = B$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \\ bk \end{bmatrix} := \text{Minerr}(acs, a2, B)$$

$$\frac{C_0}{\alpha_{cs}} = 2.072 \cdot 10^3$$

$$\frac{S_0}{\alpha_2} = 4.39 \cdot 10^3$$

$$\frac{U}{bk} = 1.097 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i + B$$

$$\frac{\alpha_{cs}}{\alpha_2} = 0.472$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{S_0}{C_0} = 0.237$$

$$\frac{S_0}{C_0} X2_N = 43.262$$

$$Cs_N = 182.74$$

filein := "two130-146.txt"

Well 21-27-08

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 33

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Co (5.27 yrs)

 $\tau_{co} := 5.27$

aco := 100

2nd Isotope is U (4.5 e6 yrs)

 $\tau_2 := 4500000$

a2 := 150

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 99.729$$

$$\alpha_2 = 156.799$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = 0.636$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Co_N}{X2_N} = 0.056$$

Ratio Co/U

Borehole 21-27-09**Five Zones of Radioactive Contamination Established**

70 to 91 feet (Cs-137 & Sb-125) is Stable

91 to 101 feet (Cs-137 & Sb-125) is Stable

101 to 107 feet (Cs-137 & Sb-125) is Stable

107 to 116 feet (Cs-137 & U-235/238) is Stable

116 to 124 feet (Cs-137 & Sb-125 & U-235/238) is Stable

Grade Thickness Product from 70 to 91 feet is decreasing at a rate consistent with a least squares fit for Antimony-125 and Cesium-137 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 1.8 on June 1993.

Grade Thickness Product from 91 to 101 feet is decreasing at a rate consistent with a least squares fit for Antimony-125 (hypothesis) and Cesium-137 (identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 0.6 on June 1993.

Grade Thickness Product from 101 to 107 feet is decreasing at a rate consistent with a least squares fit for Antimony-125 (hypothesis) and Cesium-137 (identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 0.09 on June 1993.

Grade Thickness Product from 107 to 116 feet is decreasing at a rate consistent with a least squares fit for Cesium-137 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for U-235/238 to Cs-137 of 4.6 on June 1993.

Grade Thickness Product from 116 to 124 feet is decreasing at a rate consistent with a least squares fit for Antimony-125 (hypothesis), Cesium-137 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for U-235/238:Cs-137:Sb-125 of 171:143:5 on June 1993.

Borehole 21-27-09**Gross Gamma Survey Information**

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	150 ft
Survey Depth :	150 ft
First Survey Date :	4/03/1979
Last Survey Date :	6/17/1993
Number Surveys :	34

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	70-91 feet is Stable 91-101 feet is Stable 101-107 feet is Stable 107-116 feet is Stable 116-124 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

04/03/79

Borehole 21-27-09

Depth: 70-91 ft

06/17/93

04/03/79

Borehole 21-27-09

Depth: 91-101 ft

06/17/93

Analysis by: Three Rivers Scientific

04/03/79

Borehole 21-27-09

Depth: 101-107 ft

06/17/93

Analysis by: Three Rivers Scientific

04/03/79

Borehole 21-27-09

Depth: 107-116 ft

06/17/93

Analysis by: Three Rivers Scientific

04/03/79

Borehole 21-27-09

Depth: 116-124 ft

06/17/93

Analysis by: Three Rivers Scientific

04/03/79

Borehole 21-27-09

Depth: 70-124 ft

06/17/93

Dry Well Survey Analysis - Notes

Borehole Bx (21-27-09)Total # Surveys 36Probe Type 04Log Date: 79-04-03 1st# neutron surveys 2# GR Surveys 3493-06-17 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): 64-122 FTIsotope from Spectral Survey: Cs, Sb, UMax Survey Depth 150

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
NO SURVEYS WITH 76 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
NO BAD SURVEYS			

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
NO SURVEYS WITH ABNORMAL AVG BKG OR % CLEAN					

Analysis Notes

NO SURVEYS REJECTED					
SURVEYS SHIFTED W/ SHF-AUTO AND DETAIL ZONE ANALYSIS					
PERFORMED THEN COMPARED TO COMPOSITE ZONE (70-124 FT)					
(DETAIL ZONES 70-91, 91-101, 101-107, 107-116, 116-124 FT)					
CONCLUSION: Sb-125 DID NOT MIGRATE AS DEEP AS Cs-137					
RATIO ^{Sb} /Cs DECREASES FROM 1.8 (UPPER ZONE) TO 0.01 (LOWER ZONE)					
INDICATING LARGER PENETRATION DEPTH FOR Cs RELATIVE TO Sb					

Analyst Name Randall ReedS/W ver TKGROSS V2.20

↓
needs to
in hand

filein := "Ab-070-091.txt"

Well 21-27-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 33

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 30.17$

acs := 300

2nd Isotope is Sb-125 (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 20000

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(acs, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(acs, a2)$$

$$\alpha_{cs} = 166.337$$

$$\alpha_2 = 2.003 \cdot 10^4$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$\frac{\alpha_{cs}}{\alpha_2} = 8.306 \cdot 10^{-3}$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{X2_N}{Cs_N} = 1.813$$

filein := "Ab-091-101.txt"

Well 21-27-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 33

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 30.17$

acs := 200

2nd Isotope is Sb-125 (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 7000

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(acs, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(acs, a2)$$

$$\alpha_{cs} = 189.428$$

$$\alpha_2 = 7.295 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$\frac{\alpha_{cs}}{\alpha_2} = 0.026$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{X2_N}{Cs_N} = 0.58$$

filein := "Ab-101-107.txt"

Well 21-27-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 33

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 30.17$

acs := 100

2nd Isotope is Sb-125 (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 500

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$gross_i := net_i$$

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(acs, a2) = 0$$

$$1 = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(acs, a2)$$

$$\alpha_{cs} = 93.113$$

Sb-125

$$\alpha_2 = 552.88$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$\frac{\alpha_{cs}}{\alpha_2} = 0.168$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\frac{X2_N}{Cs_N} = 0.089$$

filein := "Ab-107-116.txt"

Well 21-27-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 33

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 30.17$ $acs := 100$

2nd Isotope is U (4.5 E9 yrs)

 $\tau_2 := 4.55 \cdot 10^9$ $a_2 := 300$

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$gross_i := net_i$$

This data edited for spurious points

$$ssq(a_1, a_3) := \sum_i \left[gross_i - \left[a_1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a_3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(acs, a_2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(acs, a_2)$$

$$\alpha_{cs} = 100.651$$

$$\alpha_2 = 301.399$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$\frac{\alpha_{cs}}{\alpha_2} = 0.334$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\frac{X2_N}{Cs_N} = 4.576$$

filein := "Ab-116-124.txt"

Well 21-27-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 33

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 30.17$

acs := 217

2nd Isotope is Sb-125 (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 530

B := 170 B is Uranium

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i + B$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3, a5) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} + a5 \right] \right]^2$$

Given

$$ssq(acs, a2, B) = 0$$

$$l = 1$$

$$B = B$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \\ bk \end{bmatrix} := \text{Minerr}(acs, a2, B)$$

$$\alpha_{cs} = 218.629$$

$$\alpha_2 = 537.142$$

$$bk = 171.423$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i + B$$

$$\frac{\alpha_{cs}}{\alpha_2} = 0.407$$

$$\frac{X2_N}{Cs_N} = 0.037$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\begin{array}{l} Sb \\ X2_N = 5.293 \\ Cs_N = 143.053 \end{array}$$

filein := "Ab-070-124.txt"

Well 21-27-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 33

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 30.17$

acs := 1300

2nd Isotope is Sb-125 (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 22000

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(acs, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(acs, a2)$$

$$\alpha_{cs} = 1.29 \cdot 10^3$$

$$\alpha_2 = 2.196 \cdot 10^4$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$\frac{\alpha_{cs}}{\alpha_2} = 0.059$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{X2_N}{Cs_N} = 0.256$$

Borehole 21-27-10

Contamination (Cs-137&Sb-125) from 70 to 102 ft is Stable
Contamination (Cs-137&U-235/238) from 118 to 135 ft is Stable

Grade Thickness Product for the radioactive zone (70-102 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Cesium-137 and Antimony-125 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 0.55 on June 1993.

Grade Thickness Product for the radioactive zone (118-135 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Cesium-137 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for U-235/238 to Cs-137 of 0.35 on June 1993.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	150 ft
Survey Depth :	150 ft
First Survey Date :	4/03/1979
Last Survey Date :	6/18/1993
Number Surveys :	35

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	70-102 ft is Stable 118-135 ft is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

04/03/79

Borehole 21-27-10

Depth: 70-102 ft

06/18/93

04/03/79

Borehole 21-27-10

Depth: 118-135 ft

06/18/93

Dry Well Survey Analysis - Notes

Borehole BX(21-27-10)Total # Surveys 37Probe Type 6YLog Date: 79-04-03 1st# neutron surveys 2# GR Surveys 3593-06-18 LastPresentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): SHORT LWD ZONE (70-100 FT & 120-135)Isotope from Spectral Survey: CS, Sx, U, SbMax Survey Depth 150

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
<u>80-01-08</u>	<u>56</u>	<u>145</u>	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
<u>80-01-08</u>	<u>%CLEAN</u>	<u>150</u>	<u>48%</u>	<u>26.8</u>	

Analysis Notes

<u>NO SURVEYS REJECTED</u>
<u>BROAD ZONE ANALYZED (70-102 FT)</u>

Analyst Name Randall PinedS/W ver TKGROSS V2.20

filein := "two118-135.txt" **Well 21-27-10**

A := READPRN(filein) yr := A<1> net := A<7> bkg := A<6> max := A<4>

N := last(yr) N = 32 i := 0..N k := 0..300 j := 0..299

 $\tau_{cs} := 30.17$ acs := 1802nd Isotope is U-235/238 (4.5e9 yrs) $\tau_2 := 4.5 \cdot 10^9$ a2 := 40

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} \quad X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \quad tot_i := Cs_i + X2_i$$

gross_i := net_i This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(acs, a2) = 0 \quad 1 = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(acs, a2)$$

$$\alpha_{cs} = 181.528$$

$$\alpha_2 = 41.26$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} \quad X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \quad tot_i := Cs_i + X2_i$$

out<0> := yr out<1> := tot WRITEPRN("twop.txt") := out

$$\frac{\alpha_{cs}}{\alpha_2} = 4.4$$

$$\frac{X2_N}{Cs_N} = 0.347$$

filein := "two70-102.txt"

Well 21-27-10

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 33

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 30.17$

acs := 122

2nd isotope is Sb-125 (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 4470

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(acs, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(acs, a2)$$

$$\alpha_{cs} = 122$$

$$\alpha_2 = 4.47 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i$$

$$\frac{\alpha_{cs}}{\alpha_2} = 0.027$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{X2_N}{Cs_N} = 0.552$$

Borehole 21-27-11

Contamination (Co-60 & Sb-125 & U-235/238) from 66 to 110 feet is Stable

Stability of Contamination (Co-60 & U-235/238) from 110 to 138 feet is Undetermined

Grade Thickness Product for the radioactive zone (66-110 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Cobalt-60, Antimony-125, and Uranium-235/238 (all three identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Co-60:Sb-125:U-235/238 of 144:818:890 on June 1993.

Grade Thickness Product of the radioactive zone (110-138 feet) can not be established. A least squares fit for the HPGe detected radionuclides (Cobalt-60 and Uranium-235/238) is presented. The least squares fit results in a gross gamma contribution ratio for Co-60 to U-235/238 of 0.2 on June 1993.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	138 ft
Survey Depth :	138 ft
First Survey Date :	4/30/1979
Last Survey Date :	6/17/1993
Number Surveys :	36

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	40 to 60 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	66-110 feet is Stable 110-138 feet Undetermined
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

04/30/79

Borehole 21-27-11

Depth: 66-110 ft

06/17/93

04/30/79

Borehole 21-27-11

Depth: 110-138 ft

06/17/93

Borehole 21-27-11

filein := "two110-138.txt" **Well 21-27-11**

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 30

i := 0..N

k := 0..300

j := 0..299

 $\tau_{co} := 5.27$

aco := 1200

2nd Isotope is U (4.5 E6 yrs)

 $\tau_2 := 4500000$ $a_2 := 530$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 1.21 \cdot 10^3$$

$$\alpha_2 = 533.806$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = 2.267$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Co_N}{X2_N} = 0.2$$

Well 21-27-11

filein := "two66-110.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 34

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Co-60 (5.27 yrs) $\tau_{cs} := 5.27$

acs := 1660

2nd Isotope is Sb-125 (2.77 yrs) $\tau_2 := 2.77$

a2 := 83000

B := 888 B is Uranium

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i + B$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3, a5) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} + a5 \right] \right]^2$$

Given

$$ssq(acs, a2, B) = 0$$

1=1

2=2

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_2 \\ bk \end{bmatrix} := \text{Minerr}(acs, a2, B)$$

$$\alpha_{cs} = 1.631 \cdot 10^3$$

$$\alpha_2 = 8.301 \cdot 10^4$$

$$bk = 890.279$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Cs_i + X2_i + B$$

$$\frac{\alpha_{cs}}{\alpha_2} = 0.02$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{X2_N}{Cs_N} = 5.686$$

$$\begin{array}{l} Sb \\ X2_N = 817.994 \\ Cs_N = 143.856 \\ Co \end{array}$$

Dry Well Survey Analysis - Notes

Borehole BX(21-27-11)Total # Surveys 38Probe Type 07Log Date: 77-4-30 1st# neutron surveys 2# GR Surveys 3693-06-17 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs (Ca, Sb) UMax Survey Depth 13825-75 FT 70-100 FT 70-137 FT
GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
80-01-08	16	145	
84-06-12	128	140	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
84-06-12	BAD SURVEY	140	(RAPID DEPTH FROM 1980 TO 1990)

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
84-06-12	AVG BICG	137	0%	48.0	

Analysis Notes

RATIO $Cs/Sb @ 6/93 = 0.57/1$ OF GAMMA EMISSIONS
NO SURVEYS RE JECT 4/

Analyst Name Randall RuedS/W ver TKGROSS V.2.20