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State of Utah

DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF RADIATION CONTROL

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MEMORANDUM

TO: Envirocare Ground Water Permit File

FROM: Loren Morton
Hydrogeologist

DATE: October 1, 1996

SUBJECT: Shallow Aquifer Permeability at Envirocare LARW, 11e.(2) and Mixed Waste Disposal Facility, Clive, Utah.

Purpose

The purpose of this memorandum is to document staff findings regarding permeability distribution in the shallow aquifer at the Envirocare low activity radioactive waste (LARW), uranium mill tailings [11e.(2)], and Mixed Waste Disposal Embankments.

This current analysis updates and augments previous staff analysis of hydraulic conductivity found in a July 10, 1995 Division of Radiation Control (DRC) letter to Envirocare of Utah.

Introduction

Previous DRC staff analysis included review of the permeability of the Unit 3 Sand at the 11e.(2) and LARW Disposal units. This analysis now includes review of all shallow aquifer permeability data available at the LARW, 11e.(2), and Mixed Waste embankments, plus other Envirocare wells in Section 32. In addition, detailed evaluation is made of hydrostratigraphic intervals tested during each slug test event, comparisons made between slug test and laboratory results, evaluation of contrasts in horizontal and vertical permeability, and conclusions drawn regarding lateral distribution of permeability of the shallow aquifer.

Evaluation of Slug Test Intervals

Previously monitoring wells at the Envirocare facility were classified by both the hydrostratigraphic intervals exposed across a well's filter pack, and the depth where groundwater was encountered at the time of well installation. This review now revisits previously existing information, and adds well completion and slug test data collected at the Envirocare Mixed Waste Area. Previous data for the LARW and 11e.(2) embankments was found in the January 31, 1992 Bingham Environmental Hydrogeologic Peport, Addendum 1 (Appendix A). Similar well slug test information and well

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completion data for the Mixed Waste Disposal Area was recently provided to the DRC, and can be found in a November 18, 1994 Bingham Environmental Hydrogeologic Report (Appendix A). Soil log and well completion data for the GW-5 well slug test were found in the November 29, 1989 Delta Geotechnical Hydrogeologic Report .

Previous DRC review focused on local hydrostratigraphic units present in the wells of interest, i.e., Unit 3 Sand or Unit 2 Clay. This study now includes detailed review of the lithologies tested during each slug test. Several slug test details were considered for each monitoring well tested, including:

1) Initial Head (H_i) - or height of the water column measured in the well before addition of the slug head,

2) Additional Head (H_o) - instaneously added to the static water level at the start of the slug test, and

3) Total Head (Ht) - or total height of water column provided at the start of the slug test, or the sum of the initial head (H_i) and the additional head (H_o).

Total head from each slug test was determined and tabulated from the above referenced Bingham Environmental reports. Individual total head values were then compared to their respective well completion diagram to determine lithologies exposed to additional hydraulic stress during each test. Soil lithologies were simply classified as sand, silt, and clay. Thicknesses were measured and totaled for each soil class and tabulated on a well-by-well basis.

Slug Test Results

Results for wells completed across the Unit 3 Sand and Unit 2 Clay are summarized below.

1. Unit 3 Sand Slug Tests - slug test data was available from 8 Envirocare monitoring wells where total head was all or in part induced across the Unit 3 Sand, see Attachment 1, DRC spreadsheet 3SANDK.XLS-Litho, below. Although many of these wells intercepted the Unit 2 Clay in their lower filter pack reaches, results were concluded to be representative of Unit 3 Sand due to the higher permeability of this sand and the short term hydraulic stresses imposed during the tests. In addition, results from well GW-3 were culled from the Unit 3 Sand data set, due to possible hydraulic interconnection with the underlying Unit 1 Sand (see July 10, 1995 DRC letter, pp. 4 and 5).

   Because permeability data are commonly log-normally distributed (Domenico & Schwartz, pp. 66-67), average permeability for the Unit 3 Sand slug tests was determined using the geometric mean, found to be 1.09E-4 cm/sec, see Attachment 1. To estimate the first standard deviation of the slug test data, the raw data were normalized by transformation to $\log_{10}$ equivalents and the first standard deviation determined from the transformed values.

Using the transformed values, the first standard deviation value was then added ($\bar{x} + \sigma$) and subtracted ($\bar{x} - \sigma$) from the mean of the transformed values (66% confidence interval). These $\log_{10}$ values were then re-transformed, the difference between them determined and divided by 2 to approximate the first standard deviation for the raw data. Based on this approximation, it was clear that the 66% confidence interval was larger than the geometric mean at 1.27E-4 cm/sec, suggesting that additional data may be needed in order to achieve a normal data distribution. Consequently, it is apparent that additional slug test permeability data are in needed in order to adequately characterize the permeability of the Unit 3 Sand.

2. Unit 2 Clay Slug Tests - slug test data were available from 27 Envirocare monitoring wells and piezometers completed with filter packs across the Unit 2 Clay and in many cases across both the Unit 2 Clay and Unit 3 Sand, see Attachment 2, DRC spreadsheet 2CLAYK2.XLS-slug. Of these 27 wells, data from one well, GW-16, was culled because of indiscrete well completion across Units 1 Sand, 2 Clay and 3 Sand; resulting in a hydraulic connection with the deep confined aquifer (Unit 1 Sand). For this reason and others, well GW-16 was previously removed from the list of compliance monitoring wells. As a result of this evaluation, the remaining 26 wells were found to have had slug tests wherein the applied hydraulic stress was limited to only the Unit 2 Clay.

   From these results, the average permeability (geometric mean) for these Unit 2 Clay wells was found to be 9.86E-5 cm/sec, slightly less than the average permeability determined for the Unit 3 Sand slug tests. In a similar fashion as described above, the first standard deviation was determined for the Unit 2 Clay wells, and at 7.80E-5 cm/sec was found to be smaller than the geometric mean, suggesting a possible normal distribution for the permeability data set.

Unit 2 Clay vs. Unit 3 Sand: Lack of Permeability Distinction

Next, the DRC staff compared the range of slug test permeability results from the Unit 2 Clay and Unit 3 Sand, respectively, see Attachment 3, DRC graph 23SLUG.XLS-2vs3. Comparison of these data clearly show an overlap in range of field permeability, despite the fact that these tests were conducted on distinct and separate hydrostratigraphic units.

The overlap of permeability seen in these two lithologic units may be explained by heterogeneity in each of these stratum. For example, thin sand interbeds have been found in soil logs for the Unit 2 Clay, see wells GW-41, GW-42, GW-43, GW-44, GW-45, GW-46 (November 18, 1994 Bingham Report, Appendix A), and I-1-30, I-2-30, I-3-30, and I-4-30 (January 31, 1992 Bingham Report, Appendix A). These sand interbeds may explain the wide permeability distribution in the Unit 2 Clay, relative to those values seen in the Unit 3 Sand. It is also important to note that the same wells in question range widely across the Unit 2 Clay permeability results available; suggesting that when sand interbeds are present, they may not always contribute to higher permeability, but in fact may be of lower permeability clayey or silty sands.

Conversely, the Unit 3 Sand appears to be just as heterogeneous. Silty clay interbeds were also encountered in wells GW-26, GW-27, and GW-37 (January 31, 1992 Bingham Report, Appendix A). Envirocare permeability data show that these Unit 3 Sand wells with clay interbeds range across the lower 71 percentile (5 of 7 tests) of the slug tests available, see Attachment 3. Review of other well logs also shows mention of gradations of clayey sand, silty sands, and "occasional clay interbeds" in soil units reported to be the Unit 3 Sand (see GW-18 and GW-19A, January 31, 1992 Bingham Report, Appendix A). Such heterogeneity either by low permeability interbeds or by gradations of silts and clays could easily reduce the permeability of the Unit 3 Sand, and thus spread its permeability distribution making it overlapping and comparable to the Unit 2 Clay.

As a result of the apparent heterogeneity in both hydrostratigraphic units and their overlapping ranges of permeability, it appears that no distinction in hydraulic conductivity of the shallow aquifer is warranted on the basis of hydrostratigraphy or lithology alone at the Envirocare facility.

New Conceptual Model for Shallow Aquifer Permeability

Based on the permeability overlap seen between the Unit 2 Clay and Unit 3 Sand, it is apparent that previous hydrostratigraphic designations are unreliable indicators of field scale permeability. In light of the westerly dipping interface between the Unit 2 Clay and Unit 3 Sand boundaries, and the occurrence of the water table in both units across the site; lateral groundwater flow at the Envirocare facility should be considered easily possible, if not unrestricted, across presently identified hydrostratigraphic boundaries.

In lieu of using stratigraphic designations as general indicators of field permeability, careful evaluation of permeability distribution should be made for the shallow aquifer irrespective of previous hydrostratigraphic classifications.

Shallow Aquifer Permeability Distribution

In order to assess the spatial distribution of shallow aquifer permeability, slug test results from all shallow monitoring wells were consolidated and contoured by DRC staff. 35 shallow aquifer slug test results were available from Envirocare monitoring wells and piezometers, see Attachment 4, DRC spreadsheet 23SLUGK.XLS-SlugK-All. These 35 tests included duplicate from Envirocare piezometers DH-31, DH-32, and DH-33. Consequently, the greatest value from each piezometer was used for the contour map. Two other monitoring wells, GW-3 and GW-16, were found to have hydraulic connection with the deep confined aquifer, see discussion above. Consequently, these two monitoring wells were also removed from consideration in the contour map.

In order to arrive at more representative presentation of horizontal permeability, it was important to consider how aquifer permeability values are commonly log-normally distributed (Domenico & Schwartz, pp. 66-67). In addition DRC staff were cognizant that many computer contouring

software programs commonly assume linear data distribution in interpolation of known data points. Consequently, the Envirocare slug test permeability data was transformed to log base-10 (Log_{10}) equivalents before contouring began.

From the DRC permeability contour map, several key observations were made, as follows (see map in Attachment 5):

1. Higher Permeability Trough in Mixed Waste Area - from the available data it is apparent that a north-south trending trough of higher permeability exists in the shallow aquifer between well GW-43 and piezometer DH-33. Such a trend may have significant local effect on ground water flow directions.

2. Higher Permeability Trough Across Vitro Embankment - a northeast striking trough of higher permeability also is apparent between monitoring wells GW-5 and GW-21. However, this spatial trend is based on only two data points, and should therefore be confirmed with the completion of additional wells/piezometers and slug tests before any conclusions are reached for this apparent trend.

3. Low Permeability Ridge Across Facility - an east-west striking ridge of low permeability is apparent between well I-3-30 / piezometer DH-31 found in the north end of the Mixed Waste Area, and well GW-27 near the northwest corner of the 11.e.(2) disposal facility. This ridge may also be related to a localized area of low permeability near LARW piezometer DH-32 and Mixed Waste well GW-46. This ridge of low permeability may direct local groundwater flow into other directions, primarily in south, southeast or southwestern directions.

4. Southerly Increasing Trend At LARW and 11e.(2) Disposal Areas - review of the spatial distribution of shallow aquifer permeability suggests a southerly increasing trend away from wells GW-36, GW-37, GW-38 in the 11e.(2) Area, and south away from well GW-20 and piezometer DH-32 in the LARW Area. This general increase in permeability to the south may have significant effect on local groundwater flow directions, and should be investigated further with the installation of additional wells/piezometers and completion of slug tests.

Based on the available slug test results, it is apparent that permeability in the shallow aquifer increases in a southerly direction across most of the Envirocare LARW, Mixed Waste, and 11e.(2) Disposal Facilities.

Need for Additional Slug Tests

After review of the available slug test permeability data, it was apparent that a number of existing compliance monitoring wells, completed in the shallow aquifer, have not been slug tested to determine local permeability. Collection of this information would be valuable to confirm and improve current permeability trend observations. These existing wells and piezometers include:

1. LARW Area - three existing compliance monitoring wells are in need of slug testing at the LARW disposal area, including GW-16R, GW-56R, and GW-64.

2. Mixed Waste Area - one existing compliance monitoring well is in need of slug test work, GW-66. The four recently installed compliance wells for the Phase II expansion should also be slug tested to determine local permeability.

3. 11e.(2) Area - four existing compliance monitoring wells need to be slug tested, including GW-57, GW-58, GW-60, and GW-63.

After review of permeability data collected from these existing wells, it may be necessary to install additional wells/piezometers and conduct further slug testing in order to adequately characterize the spatial distribution of shallow aquifer permeability at the Envirocare facility.

Hydrodynamic Dispersivity Implications

The above finding of increased heterogeneity in the shallow aquifer reinforces previous hydrodynamic dispersion assumptions. The previous value used in contaminant transport modeling, 10% of the transport field scale, represented an average literature value for many saturated groundwater flow environments. Based on our new understanding of shallow aquifer heterogeneity, use of any lower value would be inappropriate. Further, sensitivity tests should be considered for future transport modeling which include higher hydrodynamic dispersion values. It may also be advisable to require Envirocare to conduct tracer or other studies of the shallow aquifer at their facility to provide actual field values for this important transport parameter.

Vertical vs. Horizontal Permeability (Anisotropy)

In order to assess the possibility of field scale anisotropy, brief comparison was also made of the above slug test results and available core sample permeability tests run by Envirocare contract laboratories. Such core sample results represent vertical permeability values for the shallow aquifer. On the other hand, slug test results represent an integration of both vertical and horizontal permeability across the shallow aquifer segments tested. From these comparisons, several conclusions were drawn by DRC staff, including:

1. Higher Vertical Permeability in Unit 3 Sand - review of available core data shows vertical permeability, in all cases, was greater than the slug test values produced from the Unit 3 Sand, see Attachments 1 and 6, below. Although limited laboratory data are available, this relationship may have been caused by one or more of the following factors:

   A. Core Sample Bias - wherein Envirocare biased selection of coarser Unit 3 Sand samples selected for laboratory testing, or

B. Permeability Reduction by Field Heterogeneity - in that clay interbeds and gradations of silts and clays in the Unit 3 Sand reduced effective field permeability measured by the slug tests.

Because Envirocare has not yet tested horizontal permeability exclusive of any vertical components, and in light of the higher vertical permeabilities seen in the core samples, there exists the possibility that discrete zones of higher horizontal permeability could exist in the shallow aquifer which could provide preferential zones for contaminant transport.

As a result, the spatial distribution of shallow aquifer permeability presented in the contour map in Attachment 5, below, should be considered the best case possible for Envirocare, in that: 1) higher horizontal permeabilities are possible in the field than those measured by the slug tests, and 2) small discrete zones of preferred groundwater flow may exist at the facility which have gone unmeasured by the slug test data, and hence are not represented on the DRC permeability contour map.

2. Lower Vertical Permeability in Unit 2 Clay - comparison of available laboratory data with slug test data discussed above, shows the vertical permeability to be significantly lower; on the order of about 10 times lower, on average, than the slug test results for the Unit 2 Clay, see Attachments 2 and 7, below. This relationship confirms the fact that the slug tests conducted on the Unit 2 Clay represent an integration of both vertical and horizontal permeabilities at the field scale. Similar to the discussion above, it also confirms that the field permeabilities measured likely represent the best case possible for Envirocare, in that higher horizontal permeabilities may exist in the shallow aquifer at the locales measured by the slug tests.

3. Vertical Permeability in Both Unit 3 Sand and Unit 2 Clay - comparison of Attachments 6 and 7 also shows that the vertical permeability for the Unit 3 Sand ranges between about 1E-4 to 4E-4 cm/sec; whereas vertical permeability in the Unit 2 Clay ranges for the most part between 1E-6 to 4E-6 cm/sec, or about two orders of magnitude lower. This would suggest that infiltration from the Envirocare embankments could encounter some resistance to flow in some areas of the facility after encountering the Unit 2 Clay, causing a degree of lateral spreading. However, no-flow boundaries are generally created after 3 or more orders of magnitude contrast in field permeability. Consequently, this limited permeability contrast combined with the heterogeneity apparent in the shallow aquifer, suggests that any lateral spreading of vertical infiltrating waters should be limited at the facility.

REFERENCES

Bingham Environmental, January 31, 1992, "Addendum #1 to Hydrogeologic Report, Envirocare Waste Disposal Facility, South Clive, Utah", unpublished consultant's report, 27 pp. plus tables, figures, and appendices.

Bingham Environmental, November 18, 1994, "Hydrogeologic Report, Mixed Waste Disposal Area, Envirocare Waste Disposal Facility, South Clive, Utah", unpublished consultant's report, 19 pp. plus tables, figures, and appendices.

Delta Geotechnical Consultants, November 29, 1989, "Hydrogeologic Study, Mixed Waste Landfill Cell, South Clive, Tooele County, Utah", unpublished consultants report, 32 pp. plus tables, figures, and attachments.

Domenico, P.A., and Schwartz, F.W., 1990, "Physical and Chemical Hydrogeology", John Wiley & Sons, New York, 824 pp.

Utah Division of Radiation Control, July 10, 1995, "May 16, 1995 Bingham Environmental Report Regarding Unit 3 Sand Ground Water Velocity: DRC Conclusions and Request for Additional Information", staff letter from Loren Morton to Charles Judd, Envirocare of Utah, 10 pp. plus attachments.

Attachments (7)

LBM:lm

cc: Otis Willoughby, DS/HW (w/attach.)
Bob Baird, RAE (w/attach.)
Fred Ross, NRC (w/attach.)
Latif Hamden, NRC (w/attach.)

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File: Envirocare GW Permit - Horizontal GW Velocity

ATTACHMENT 1

Summary of
Field Permeability, Slug Test Data,
and Well Completion Details
for Unit 3 Sand

Division of Radiation Control
Spreadsheet
3SANDK.XLS-Litho.

Envirocare Unit 3 Sand Permeability Data: Slug & Lab Tests																		*Sorted from Low to High*	
Tests Across Unit 3 Sand Intervals in Wells										Lithologies Slug Tested				Lithology					
			Hydraulic Conductivity				Slug Heads (ft)			Approx. Thick. (ft)				Tested, %				Soil Type Tested	
Well ID	Test Type	Hydro Strat Units	(cm/sec)	(cm/yr)	Log (K)	Water Added (gal)	Ho	Hi	Ht	sand	silt	clay	Tot.	sand	silt	clay	Data Source	USCS	Description
Slug Tests (field tests for integrated vertical & horizontal K)																			
GW-26	slug	2,(3)	3.20E-05	1,009.8	-4.5	0.22	1.50	4.26	5.76	2.56	0.00	3.20	5.76	44%	0%	56%	1	CL, SM	silty clay, silty sand
GW-27	slug	2,(3)	4.10E-05	1,293.9	-4.4	0.40	2.70	4.80	7.50	5.00	0.00	2.50	7.50	67%	0%	33%	1	SM, CL	silty sand, silty clay
GW-19A	slug	2,(3)	5.90E-05	1,861.9	-4.2	1.72	8.10	6.21	14.31	11.41	0.00	2.90	14.31	80%	0%	20%	1	SM, CL	silty sand, silty clay
GW-17A	slug	(2),3	1.10E-04	3,471.3	-4.0	1.77	12.09	3.90	15.99	7.69	0.00	8.30	15.99	48%	0%	52%	1	CL, SM	silty clay, silty sand
GW-37	slug	2,(3)	1.70E-04	5,364.8	-3.8	0.76	5.16	4.44	9.60	1.90	0.00	7.70	9.60	20%	0%	80%	1	CL, SM	silty clay, silty sand
GW-18	slug	(2),3	2.90E-04	9,151.7	-3.5	2.40	16.50	5.05	21.55	5.35	0.00	16.20	21.55	25%	0%	75%		CL, SM	silty clay, silty sand
GW-36	slug	2,(3)	4.40E-04	13,885.3	-3.4	0.63	3.87	4.12	7.99	2.29	0.00	5.70	7.99	29%	0%	71%	1	CL, SM	silty clay, silty sand
GW-3	slug	1,2,(3)	r0.0019	n/a	n/a	0.20	2.36	5.18	7.54	1.74	0.00	5.80	7.54	23%	0%	77%	1	CL, SM	silty clay, silty sand
		Max:	4.40E-04	13,885.3	-3.4	*Re-transformed*													
		Min:	3.20E-05	1,009.8	-4.5	*Values (cm/sec)*													
		Mean:	1.63E-04	5,148.4	-4.0	1.09E-04	x												
		Geomean:	1.09E-04	3,444.9	n/a														
		Std. Dev.:	1.52E-04	4,795.9	0.4	4.04E-05	x-s												
		Count:	7			2.95E-04	x+s												
						1.27E-04	s												
Laboratory Tests (Vertical Core Samples)																			
GW-19B, L-5	lab	3	1.60E-04	5,049.2	-3.8	n/a	n/a	n/a	n/a	5.00				100%			3	SM	silty sand
GW-17A, L-5	lab	3	2.00E-04	6,311.5	-3.7	n/a	n/a	n/a	n/a	5.00				100%			3	SM	silty sand
GW-18, S-4	lab	3	4.40E-03	138,853.4	-2.4	n/a	n/a	n/a	n/a	2.00				100%			2	SM	silty sand
		Max:	4.40E-03	138,853.4	-2.4	*Re-transformed*													
		Min:	1.60E-04	5,049.2	-3.8	*Values (cm/sec)*													
		Mean:	1.59E-03	50,071.4	-3.3	5.20E-04	x	**Vertical Seepage Flux Rate*:**							*Permeability Data Sources:*				
		Geomean:	5.20E-04	16,417.4	n/a			a) Non-Mobile Area = 2.47 cm/yr							1 = 1/92 Bingham H.G. Report, pp. B-69 & 70				
		Std. Dev.:	2.44E-03	76,890.1	0.8	8.16E-05	x-s	b) Mobile Area = 0.29 cm/yr							2 = 10/90 Bingham H.G. Report, p. B-31				
		Count:	3			3.32E-03	x+s	* Based on currently approved							3 = 5/91 CSU Unsat. Soil Report, Table 3, p. 8				
						1.62E-03	s	engineered cover design.											

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Tests Across l			
Well ID	Comments		
Slug Tests (fie			
GW-26	clay @ base of tested interval		
GW-27	clay @ base of tested interval		
GW-19A	clay @ base of tested interval		
GW-17A	clay @ base of tested interval		
GW-37	clay @ base of tested interval		
GW-18	clay @ base of tested interval		
GW-36	clay @ base of tested interval		
GW-3	? - discontinuous soil log		
Laboratory T			
GW-19B, L-5			
GW-17A, L-5			
GW-18, S-4			

ATTACHMENT 2

Summary of
Field Permeability, Slug Test Data,
and Well Completion Details
for Unit 2 Clay

Division of Radiation Control
Spreadsheet
2CLAYK2.XLS-Slug

Envirocare Unit 2 Clay Permeability: Slug Test Results

Tests Across Unit 2 Clay Intervals in Wells

Sorted from Low to High Values

Well ID	Test Type	Hydro Strat Unit	Hydraulic Conductivity (cm/sec)	(cm/yr)	Log (K)	Water Added (gal)	Slug Heads (ft) Ho	Hi	Ht	Lithologies Slug Tested Approx. Thick. (ft) sand	silt	clay	Tot.	Lithology Slug Tested, % sand	silt	clay	Data Source	Soil Type Slug Tested USCS	Description
GW-38	slug	2,[3]	2.80E-05	883.6	-4.6	0.13	0.76	3.01	3.77	0.00	0.00	3.77	3.77	0%	0%	100%	1	CL	silty clay
I-4-30	slug	2	2.90E-05	915.2	-4.54	1.00	0.67	2.50	3.17	2.00	0.00	1.17	3.17	63%	0%	37%	4	SM, CL	silty sand & silty clay
GW-24	slug	[2],3	3.60E-05	1,136.1	-4.44	0.55	3.00	2.92	5.92	0.00	0.00	5.92	5.92	0%	0%	100%	1	CL	silty clay
GW-46	slug	[2],3	3.90E-05	1,230.7	-4.41	1.00	1.03	1.73	2.76	1.90	0.00	0.86	2.76	69%	0%	31%	4	SM, CL	silty sand & silty clay
GW-28	slug	2,[3]	4.50E-05	1,420.1	-4.3	0.12	0.68	2.04	2.72	0.00	0.00	2.72	2.72	0%	0%	100%	1	CL	silty clay
DH-32	slug	2	5.00E-05	1,577.9	-4.30	0.77	4.76	5.22	9.98	0.00	0.00	9.98	9.98	0%	0%	100%	1	CL	silty clay
DH-32	slug	2	5.00E-05	1,577.9	-4.30	1.00	4.71	5.22	9.93	0.00	0.00	9.93	9.93	0%	0%	100%	4	CL	silty clay
GW-45	slug	[2],3	7.20E-05	2,272.1	-4.14	1.00	1.33	1.61	2.94	2.94	0.00	0.00	2.94	100%	0%	0%	4	SM	sity sand
DH 31	slug	2	7.30E-05	2,303.7	-4.14	0.27	1.68	1.55	3.23	0.00	1.23	2.00	3.23	0%	38%	62%	1	CL, ML	silt & clay
GW-16	slug	[1,2],3	r0.000076	n/a	n/a	0.90	6.56	4.47	11.03	0.00	0.00	11.03	11.03	0%	0%	100%	1	CL	silty clay
DH-33	slug	2	7.80E-05	2,461.5	-4.11	0.70	2.75	2.79	5.54	0.00	0.00	5.54	5.54	0%	0%	100%	1	CL	silty clay
I-2-30	slug	2	7.80E-05	2,461.5	-4.11	1.00	1.70	5.74	7.44	1.50	1.24	4.70	7.44	20%	17%	63%	4	CL, SC, ML	clay, clayey sand, silt
I-3-30	slug	2	9.20E-05	2,903.3	-4.04	1.00	0.85	2.76	3.61	1.00	0.00	2.61	3.61	28%	0%	72%	4	CL, SC	silty clay, clayey sand
GW-23	slug	[2],3	9.70E-05	3,061.1	-4.01	0.23	1.44	3.83	5.27	0.00	0.00	5.27	5.27	0%	0%	100%	1	CL	silty clay
GW-22	slug	[2],3	1.00E-04	3,155.8	-4.00	0.16	0.91	2.05	2.96	0.00	0.00	2.96	2.96	0%	0%	100%	1	CL	silty clay
DH-31	slug	2	1.10E-04	3,471.3	-3.96	1.00	1.92	1.25	3.17	0.00	1.17	2.00	3.17	0%	37%	63%	4	CL, ML	silty clay, silt
GW-25	slug	2,[3]	1.40E-04	4,418.1	-3.9	0.20	1.90	4.63	6.53	0.00	0.00	6.53	6.53	0%	0%	100%	1	CL	silty clay
GW-44	slug	[2],3	1.50E-04	4,733.6	-3.82	1.00	1.70	4.38	6.08	0.60	0.00	5.48	6.08	10%	0%	90%	4	CL, SM	silty clay, silty sand
GW-29	slug	[2],3	1.70E-04	5,364.8	-3.77	0.20	1.22	2.69	3.91	0.00	0.00	3.91	3.91	0%	0%	100%	1	CL	silty clay
GW-21	slug	2	1.70E-04	5,364.8	-3.77	0.60	3.50	6.52	10.02	0.00	0.00	10.02	10.02	0%	0%	100%	1	CL	silty clay
GW-5	slug	2,3?	1.80E-04	5,680.4	-3.7	0.75	4.60	5.01	9.61	0.00	0.00	9.61	9.61	0%	0%	100%	1	CL	silty clay
GW-41	slug	[2],3	1.80E-04	5,680.4	-3.74	1.00	1.36	2.01	3.37	3.37	0.00	0.00	3.37	100%	0%	0%	4	SM	silty sand
GW-42	slug	[2],3	1.80E-04	5,680.4	-3.74	1.00	1.96	1.99	3.95	2.00	0.00	2.95	4.95	51%	0%	75%	4	CL, SM	silty clay, silty sand
I-1-30	slug	[2], 3	1.90E-04	5,995.9	-3.72	1.00	0.71	5.83	6.54	4.00	0.00	2.54	6.54	61%	0%	39%	4	SC, CL	clayey sand, clay
DH-33	slug	2	2.10E-04	6,627.1	-3.68	0.70	3.80	3.00	6.80	0.00	0.00	6.80	6.80	0%	0%	100%	4	CL	silty clay
GW-20	slug	[2],3	2.60E-04	8,205.0	-3.59	0.65	4.00	5.14	9.14	0.00	0.00	9.14	9.14	0%	0%	100%	1	CL	silty clay
GW-43	slug	[2],3	4.70E-04	14,832.1	-3.33	1.00	2.33	2.03	4.36	0.40	0.00	3.96	4.36	9%	0%	91%	4	CL	silty clay
		Max:	4.70E-04	14,832.1	-3.3	*Re-transformed*													
		Min:	2.80E-05	883.6	-4.6	*Values*		Count > 0:		10									
		Mean:	1.26E-04	3,977.5	-4.0	9.86E-05	x	Total Count:		27									
		Geomean:	9.86E-05	3,111.9				% of Total:		37%									
		Std. Dev.:	9.53E-05	3,006.4	0.3	4.77E-05	x-s												
		Count:	26			2.04E-04	x+s												
						7.80E-05	s												

Vertical Seepage Flux Rate*:

a) Non-Mobile Area = 2.47 cm/yr

b) Mobile Area = 0.29 cm/yr

* Based on currently approved engineered cover design.

Data Sources:
1 = 1/92 Bingham H.G. Report, pp. B-69 & 70
2 = 10/91 Bingham H.G. Report, p. B-31
3 = 8/1/94 Bingham Report on Perched Leachate Potential
4 = 11/18/94 Bingham Final Mixed Waste H.G. Report, p. A-71

Enviroc	
Tests A	
Well ID	Comments
GW-38	clay @ base of tested interval
I-4-30	sand @ base of tested interval
GW-24	
GW-46	sand @ base of tested interval
GW-28	
DH-32	
DH-32	same as 1/92 B.E. H.G. Report value
GW-45	sand @ base of tested interval
DH-31	
GW-16	
DH-33	
I-2-30	sand near base of tested interval
I-3-30	sand @ base of tested interval
GW-23	
GW-22	
DH-31	higher than 1/92 B.E. H.G. Report value
GW-25	
GW-44	sand @ base of tested interval
GW-29	
GW-21	
GW-5	
GW-41	sand @ base of tested interval
GW-42	sand @ base of tested interval
I-1-30	sand @ base of tested interval
DH-33	higher than 1/92 B.E. H.G. Report value
GW-20	
GW-43	sand @ base of tested interval

Envirocare Unit 2 Clay Permeability Tests: Vertical Core Samples										*Sorted from Low to High Values*
Laboratory Permeameter Tests of Unit 2 Clay (Vertical K)										
	Sample Depth	Hydro Strat	Soil Type		Hydraulic Conductivity			Depth Below Top of	Data	
Well ID	(ft)	Unit	USCS	Description	(cm/sec)	(cm/yr)	Log (K)	Unit 2	Source	Comments
GW-17A, L7	32 - 34.5	2	CL	Silty Clay	6.00E-08	1.89	-7.22	7.0 - 9.5	2	Top of Unit 2 Clay @ 25.0 ft
DH-4, S-2	16 - 18	2	CL	Silty Clay	1.20E-06	37.87	-5.92	0.7 - 2.7	3	Top of Unit 2 Clay @ 15.3 ft
DH-3, S-3	15.5 - 17	2	CL	Silty Clay	1.50E-06	47.34	-5.82	0.9 - 2.9	3	Top of Unit 2 Clay @ 14.6 ft
DH-1, S-5	15 -17	2	CL	Silty Clay	1.70E-06	53.65	-5.77	1.0 - 3.0	3	
DH-1, S-4	13 - 15	2	CL	Silty Clay	1.80E-06	56.80	-5.74	0 - 1.0	3	Top o. Unit 2 Clay @ 14.0 ft
DH-2, S-4	15 - 17	2	CL	Silty Clay	2.60E-06	82.05	-5.59	0.5 - 2.5	3	Top of Unit 2 Clay @ 14.5 ft
DH-3, S-4	17.5 - 19.5	2	CL	Silty Clay	3.10E-06	97.83	-5.51	2.9 - 4.9	3	
DH-4, S-3	18 - 20	2	CL	Silty Clay	4.40E-06	138.85	-5.36	2.7 - 4.7	3	
DH-2, S-5	17 - 19	2	CL	Silty Clay	n/a	n/a			3	
				Max:	4.40E-06	138.9	-5.4	*Re-transformed*		**Vertical Seepage Flux Rate*:**
				Min:	6.00E-08	1.9	-7.2	*Values*		a) Non-Mobile Area = 2.47 cm/yr
				Mean:	2.05E-06	64.5	-5.9	1.36E-06	x	b) Mobile Area = 0.29 cm/yr
				Geomean:	1.36E-06	42.9				* Based on currently approved
				Std. Dev.:	1.31E-06	41.5	0.6	3.60E-07	x-s	engineered cover design.
				Count:	8			5.14E-06	x+s	
								2.39E-06	s	

Notes:

1) Undisturbed shelby tube samples of Unit 2 Clay. Soil described ranged from brown fine sandy clay to brown clay.

2) Core sample results = vertical permeability.

Data Sources:

1 = 1/92 Bingham H.G. Report, pp. B-69 & 70

2 = 10/91 Bingham H.G. Report, p. B-31

3 = 8/1/94 Bingham Report on Perched Leachate Potential

4 = 11/18/94 Bingham Final Mixed Waste H.G. Report, p. A-71

Envirocare Unit 2 Permeability Test: Slug vs Lab Results

Permeability Tests Across Unit 2 Clay Intervals in Wells

Sorted from Low to High Values

Well ID	Test Type	Hydro Strat Unit	Hydraulic Conductivity (cm/sec)	(cm/yr)	Log (K)	Lithology Tested, % sand	silt	clay	Data Source	Soil Type Tested USCS	Description
GW-17A, L7	lab	2	6.00E-08	1.89	-7.22			100%	2	CL	silty clay
DH-4, S-2	lab	2	1.20E-06	37.87	-5.92			100%	3	CL	silty clay
DH-3, S-3	lab	2	1.50E-06	47.34	-5.82			100%	3	CL	silty clay
DH-1, S-5	lab	2	1.70E-06	53.65	-5.77			100%	3	CL	silty clay
DH-1, S-4	lab	2	1.80E-06	56.80	-5.74			100%	3	CL	silty clay
DH-2, S-4	lab	2	2.60E-06	82.05	-5.59			100%	3	CL	silty clay
DH-3, S-4	lab	2	3.10E-06	97.83	-5.51			100%	3	CL	silty clay
DH-4, S-3	lab	2	4.40E-06	138.85	-5.36			100%	3	CL	silty clay
GW-38	slug	2,[3]	2.80E-05	883.61	-4.55	0%	0%	100%	1	CL	silty clay
I-4-30	slug	2	2.90E-05	915.17	-4.54	63%	0%	37%	4	SM, CL	silty sand & silty clay
GW-24	slug	[2],3	3.60E-05	1,136.07	-4.44	0%	0%	100%	1	CL	silty clay
GW-46	slug	[2],3	3.90E-05	1,230.75	-4.41	69%	0%	31%	4	SM, CL	silty sand & silty clay
GW-28	slug	2,[3]	4.50E-05	1,420.09	-4.35	0%	0%	100%	1	CL	silty clay
DH-32	slug	2	5.00E-05	1,577.88	-4.30	0%	0%	100%	1	CL	silty clay
DH-32	slug	2	5.00E-05	1,577.88	-4.30	0%	0%	100%	4	CL	silty clay
GW-45	slug	[2],3	7.20E-05	2,272.15	-4.14	100%	0%	0%	4	SM	sity sand
DH-31	slug	2	7.30E-05	2,303.70	-4.14	0%	38%	62%	1	CL, ML	silt & clay
DH-33	slug	2	7.80E-05	2,461.5	-4.11	0%	0%	100%	1	CL	silty clay
I-2-30	slug	2	7.80E-05	2,461.5	-4.11	20%	17%	63%	4	CL, SC, ML	clay, clayey sand, silt
I-3-30	slug	2	9.20E-05	2,903.3	-4.04	28%	0%	72%	4	CL, SC	silty clay, clayey sand
GW-23	slug	[2],3	9.70E-05	3,061.09	-4.01	0%	0%	100%	1	CL	silty clay
GW-22	slug	[2],3	1.00E-04	3,155.76	-4.00	0%	0%	100%	1	CL	silty clay
DH-31	slug	2	1.10E-04	3,471.3	-3.96	0%	37%	63%	4	CL, ML	silty clay, silt
GW-25	slug	2,[3]	1.40E-04	4,418.06	-3.85	0%	0%	100%	1	CL	silty clay
GW-44	slug	[2],3	1.50E-04	4,733.6	-3.82	10%	0%	90%	4	CL, SM	silty clay, silty sand
GW-29	slug	[2],3	1.70E-04	5,364.79	-3.77	0%	0%	100%	1	CL	silty clay
GW-21	slug	2	1.70E-04	5,364.8	-3.77	0%	0%	100%	1	CL	silty clay
GW-5	slug	2,3?	1.80E-04	5,680.37	-3.74	0%	0%	100%	1	CL	silty clay
GW-41	slug	[2],3	1.80E-04	5,680.4	-3.74	100%	0%	0%	4	SM	silty sand
GW-42	slug	[2],3	1.80E-04	5,680.4	-3.74	51%	0%	75%	4	CL, SM	silty clay, silty sand
I-1-30	slug	[2], 3	1.90E-04	5,995.9	-3.72	61%	0%	39%	4	SC, CL	clayey sand, clay
DH-33	slug	2	2.10E-04	6,627.1	-3.68	0%	0%	100%	4	CL	silty clay
GW-20	slug	[2],3	2.60E-04	8,204.98	-3.59	0%	0%	100%	1	CL	silty clay
GW-43	slug	[2],3	4.70E-04	14,832.1	-3.33	9%	0%	91%	4	CL	silty clay
DH-2, S-5	lab	2	n/a	n/a	n/a			100%	3	CL	silty clay
GW-16	slug	[1,2],3	r0.000076	n/a	n/a	0%	0%	100%	1	CL	silty clay
		Max:	4.70E-04	14,832.1	-3.3	*Re-transformed*					
		Min:	6.00E-08	1.9	-7.2	*Values*					
		Mean:	9.69E-05	3,056.8	-4.4	3.60E-05	x				
		Geomean:	3.60E-05	1,135.8	#NUM!						
		Std. Dev.:	9.86E-05	3,112.2	0.9	4.66E-06	x-s				
		Count:	34			2.78E-04	x+s				
						1.37E-04	s				

Vertical Seepage Flux Rate*:

a) Non-Mobile Area = 2.47 cm/yr

b) Mobile Area = 0.29 cm/yr

* Based on currently approved engineered cover design.

Data Sources:

1 = 1/92 Bingham H.G. Report, pp. B-69 & 70

2 = 10/91 Bingham H.G. Report, p. B-31

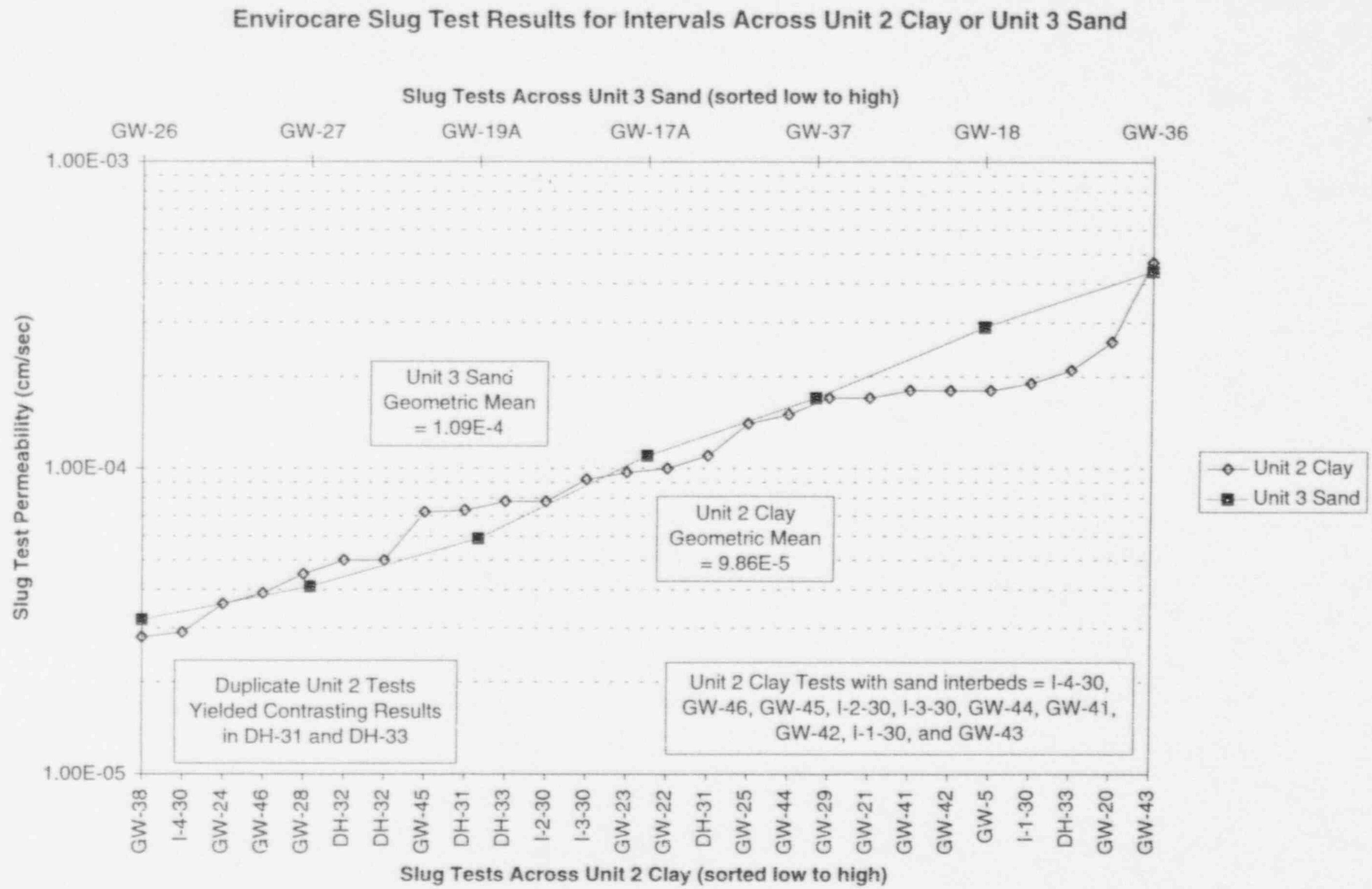
3 = 8/1/94 Bingham Report on Perched Leachate Potential

4 = 11/18/94 Bingham Final Mixed Waste H.G. Report, p. A-71

ATTACHMENT 3

Comparison of
Slug Test Field Permeability Results
Unit 2 Clay vs. Unit 3 Sand

Division of Radiation Control
Graph
23SLUGK.XLS-2vs3


Envirocare Slug Test Results for Intervals Across Unit 2 Clay or Unit 3 Sand
Slug Tests Across Unit 3 Sand (sorted low to high)
GW-26
GW-27
GW-19A
GW-17A
GW-37
GW-18
GW-36
1.00E-03
1.00E-04
1.00E-05
Slug Test Permeability (cm/sec)
Unit 3 Sand Geometric Mean = 1.09E-4
Unit 2 Clay Geometric Mean = 9.86E-5
Duplicate Unit 2 Tests Yielded Contrasting Results in DH-31 and DH-33
Unit 2 Clay Tests with sand interbeds = I-4-30, GW-46, GW-45, I-2-30, I-3-30, GW-44, GW-41, GW-42, I-1-30, and GW-43
Unit 2 Clay
Unit 3 Sand
GW-38
I-4-30
GW-24
GW-46
GW-28
DH-32
DH-32
GW-45
DH-31
DH-33
I-2-30
I-3-30
GW-23
GW-22
DH-31
GW-25
GW-44
GW-29
GW-21
GW-41
GW-42
GW-5
I-1-30
DH-33
GW-20
GW-43
Slug Tests Across Unit 2 Clay (sorted low to high)

ATTACHMENT 4

Consolidation of Shallow Aquifer
Slug Test Field Permeability Results
from both the
Unit 2 Clay and Unit 3 Sand

Division of Radiation Control
spreadsheet
23SLUGK.XLS-SlugK-All

Envirocare Shallow Aquifer Permeability: Slug Test Results

Tests Across Unit 2 Clay or Unit 3 Sand Intervals in Wells

Well ID	Test Type	Filter Hydro Strat Unit	Slug Test Interval	Hydraulic Conductivity (cm/sec)	(cm/yr)	Log (K)	Water Added (gal)	Slug Heads (ft) Ho	Hi	Ht	Lithologies Slug Tested Approx. Thick. (ft) sand	silt	clay	Tot.	Lithology Tested, sand	silt
GW-38	slug	2,[3]	2	2.80E-05	883.6	-4.6	0.13	0.76	3.01	3.77	0.00	0.00	3.77	3.77	0%	0%
I-4-30	slug	2	2	2.90E-05	915.2	-4.54	1.00	0.67	2.50	3.17	2.00	0.00	1.17	3.17	63%	0%
GW-24	slug	[2],3	2	3.60E-05	1,136.1	-4.44	0.55	3.00	2.92	5.92	0.00	0.00	5.92	5.92	0%	0%
GW-46	slug	[2],3	2	3.90E-05	1,230.7	-4.41	1.00	1.03	1.73	2.76	1.90	0.00	0.86	2.76	69%	0%
GW-28	slug	2,[3]	2	4.50E-05	1,420.1	-4.3	0.12	0.68	2.04	2.72	0.00	0.00	2.72	2.72	0%	0%
DH-32	slug	2	2	5.00E-05	1,577.9	-4.30	0.77	4.76	5.22	9.98	0.00	0.00	9.98	9.98	0%	0%
DH-32	slug	2	2	5.00E-05	1,577.9	-4.30	1.00	4.71	5.22	9.93	0.00	0.00	9.93	9.93	0%	0%
GW-45	slug	[2],3	2	7.20E-05	2,272.1	-4.14	1.00	1.33	1.61	2.94	2.94	0.00	0.00	2.94	100%	0%
DH-31	slug	2	2	7.30E-05	2,303.7	-4.14	0.27	1.68	1.55	3.23	0.00	1.23	2.00	3.23	0%	38%
DH-33	slug	2	2	7.80E-05	2,461.5	-4.11	0.70	2.75	2.79	5.54	0.00	0.00	5.54	5.54	0%	0%
I-2-30	slug	2	2	7.80E-05	2,461.5	-4.11	1.00	1.70	5.74	7.44	1.50	1.24	4.70	7.44	20%	17%
I-3-30	slug	2	2	9.20E-05	2,903.3	-4.04	1.00	0.85	2.76	3.61	1.00	0.00	2.61	3.61	28%	0%
GW-23	slug	[2],3	2	9.70E-05	3,061.1	-4.01	0.23	1.44	3.83	5.27	0.00	0.00	5.27	5.27	0%	0%
GW-22	slug	[2],3	2	1.00E-04	3,155.8	-4.00	0.16	0.91	2.05	2.96	0.00	0.00	2.96	2.96	0%	0%
DH-31	slug	2	2	1.10E-04	3,471.3	-3.96	1.00	1.92	1.25	3.17	0.00	1.17	2.00	3.17	0%	37%
GW-25	slug	2,[3]	2	1.40E-04	4,418.1	-3.9	0.20	1.90	4.63	6.53	0.00	0.00	6.53	6.53	0%	0%
GW-44	slug	[2],3	2	1.50E-04	4,733.6	-3.82	1.00	1.70	4.38	6.08	0.60	0.00	5.48	6.08	10%	0%
GW-29	slug	[2],3	2	1.70E-04	5,364.8	-3.77	0.20	1.22	2.69	3.91	0.00	0.00	3.91	3.91	0%	0%
GW-21	slug	2	2	1.70E-04	5,364.8	-3.77	0.60	3.50	6.52	10.02	0.00	0.00	10.02	10.02	0%	0%
GW-41	slug	[2],3	2	1.80E-04	5,680.4	-3.74	1.00	1.36	2.01	3.37	3.37	0.00	0.00	3.37	100%	0%
GW-42	slug	[2],3	2	1.80E-04	5,680.4	-3.74	1.00	1.96	1.99	3.95	2.00	0.00	2.95	4.95	51%	0%
GW-5	slug	2,3?	2	1.80E-04	5,680.4	-3.7	0.75	4.60	5.01	9.61	0.00	0.00	9.61	9.61	0%	0%
I-1-30	slug	[2], 3	2	1.90E-04	5,995.9	-3.72	1.00	0.71	5.83	6.54	4.00	0.00	2.54	6.54	61%	0%
DH-33	slug	2	2	2.10E-04	6,627.1	-3.68	0.70	3.80	3.00	6.80	0.00	0.00	6.80	6.80	0%	0%
GW-20	slug	[2],3	2	2.60E-04	8,205.0	-3.59	0.65	4.00	5.14	9.14	0.00	0.00	9.14	9.14	0%	0%
GW-43	slug	[2],3	2	4.70E-04	14,832.1	-3.33	1.00	2.33	2.03	4.36	0.40	0.00	3.96	4.36	9%	0%
GW-16	slug	[1,2],3	2	r0.000076	n/a	n/a	0.90	6.56	4.47	11.03	0.00	0.00	11.03	11.03	0%	0%
GW-26	slug	2,[3]	3	3.20E-05	1,009.8	-4.5	0.22	1.50	4.26	5.76	2.56	0.00	3.20	5.76	44%	0%
GW-27	slug	2,[3]	3	4.10E-05	1,293.9	-4.4	0.40	2.70	4.80	7.50	5.00	0.00	2.50	7.50	67%	0%
GW-19/	slug	2,[3]	3	5.90E-05	1,861.9	-4.2	1.72	8.10	6.21	14.31	11.41	0.00	2.90	14.31	80%	0%
GW-17/	slug	[2],3	3	1.10E-04	3,471.3	-4.0	1.77	12.09	3.90	15.99	7.69	0.00	8.30	15.99	48%	0%
GW-37	slug	2,[3]	3	1.70E-04	5,364.8	-3.8	0.76	5.16	4.44	9.60	1.90	0.00	7.70	9.60	20%	0%
GW-18	slug	[2],3	3	2.90E-04	9,151.7	-3.5	2.40	16.50	5.05	21.55	5.35	0.00	16.20	21.55	25%	0%
GW-36	slug	2,[3]	3	4.40E-04	13,885.3	-3.4	0.63	3.87	4.12	7.99	2.29	0.00	5.70	7.99	29%	0%
GW-3	slug	1,2,[3]	3	r0.0019	n/a	n/a	0.20	2.36	5.18	7.54	1.74	0.00	5.80	7.54	23%	0%

Max:	4.70E-04	14,832.1	-3.33	Re-transformed				
Min:	2.80E-05	883.6	-4.55	Values			Count > 0:	10
Mean:	1.34E-04	4,225.8	-4.00	1.01E-04	x		Total Count:	23
Geomean:	1.01E-04	3,179.7					% of Total:	43%
Std. Dev.:	1.08E-04	3,407.4	0.34	4.65E-05	x-s			
Count:	33			2.18E-04	x+s			
				8.60E-05	s			

Data Sources:

1 = 1/92 Bingham H.G. Report, pp. B-69 & 70

2 = 10/91 Bingham H.G. Report, p. B-31

3 = 8/1/94 Bingham Report on Perched Leachate Potential

4 = 11/18/94 Bingham Final Mixed Waste H.G. Report, p. A-71

Enviroc			*Sorted from Low to High Values*		
Tests Ac					
	Slug				
	%	Data	Soil Type Slug Tested		
Well ID	clay	Source	USCS	Description	Comments
GW-38	100%	1	CL	silty clay	clay @ base of tested interval
I-4-30	37%	4	SM, CL	silty sand & silty clay	sand @ base of tested interval
GW-24	100%	1	CL	silty clay	
GW-46	31%	4	SM, CL	silty sand & silty clay	sand @ base of tested interval
GW-28	100%	1	CL	silty clay	
DH-32	100%	1	CL	silty clay	
DH-32	100%	4	CL	silty clay	same as 1/92 B.E. H.G. Report value
GW-45	0%	4	SM	sity sand	sand @ base of tested interval
DH-31	62%	1	CL, ML	silt & clay	
DH-33	100%	1	CL	silty clay	
I-2-30	63%	4	CL, SC, ML	clay, clayey sand, silt	sand near base of tested interval
I-3-30	72%	4	CL, SC	silty clay, clayey sand	sand @ base of tested interval
GW-23	100%	1	CL	silty clay	
GW-22	100%	1	CL	silty clay	
DH-31	63%	4	CL, ML	silty clay, silt	higher than 1/92 B.E. H.G. Report value
GW-25	100%	1	CL	silty clay	
GW-44	90%	4	CL, SM	silty clay, silty sand	sand @ base of tested interval
GW-29	100%	1	CL	silty clay	
GW-21	100%	1	CL	silty clay	
GW-41	0%	4	SM	silty sand	sand @ base of tested interval
GW-42	75%	4	CL, SM	silty clay, silty sand	sand @ base of tested interval
GW-5	100%	1	CL	silty clay	
I-1-30	39%	4	SC, CL	clayey sand, clay	sand @ base of tested interval
DH-33	100%	4	CL	silty clay	higher than 1/92 B.E. H.G. Report value
GW-20	100%	1	CL	silty clay	
GW-43	91%	4	CL	silty clay	sand @ base of tested interval
GW-16	100%	1	CL	silty clay	
GW-26	56%	1	CL, SM	silty clay, silty sand	clay @ base of tested interval
GW-27	33%	1	SM, CL	silty sand, silty clay	clay @ base of tested interval
GW-19/	20%	1	SM, CL	silty sand, silty clay	clay @ base of tested interval
GW-17/	52%	1	CL, SM	silty clay, silty sand	clay @ base of tested interval
GW-37	80%	1	CL, SM	silty clay, silty sand	clay @ base of tested interval
GW-18	75%	1	CL, SM	silty clay, silty sand	clay @ base of tested interval
GW-36	71%	1	CL, SM	silty clay, silty sand	clay @ base of tested interval
GW-3	77%	1	CL, SM	silty clay, silty sand	? - discontinuous soil log

Vertical Seepage Flux Rate*:

a) Non-Mobile Area = 2.47 cm/yr

b) Mobile Area = 0.29 cm/yr

* Based on currently approved engineered cover design.

Data Sc

1 = 1/92

2 = 10/9

3 = 8/1/9

4 = 11/1

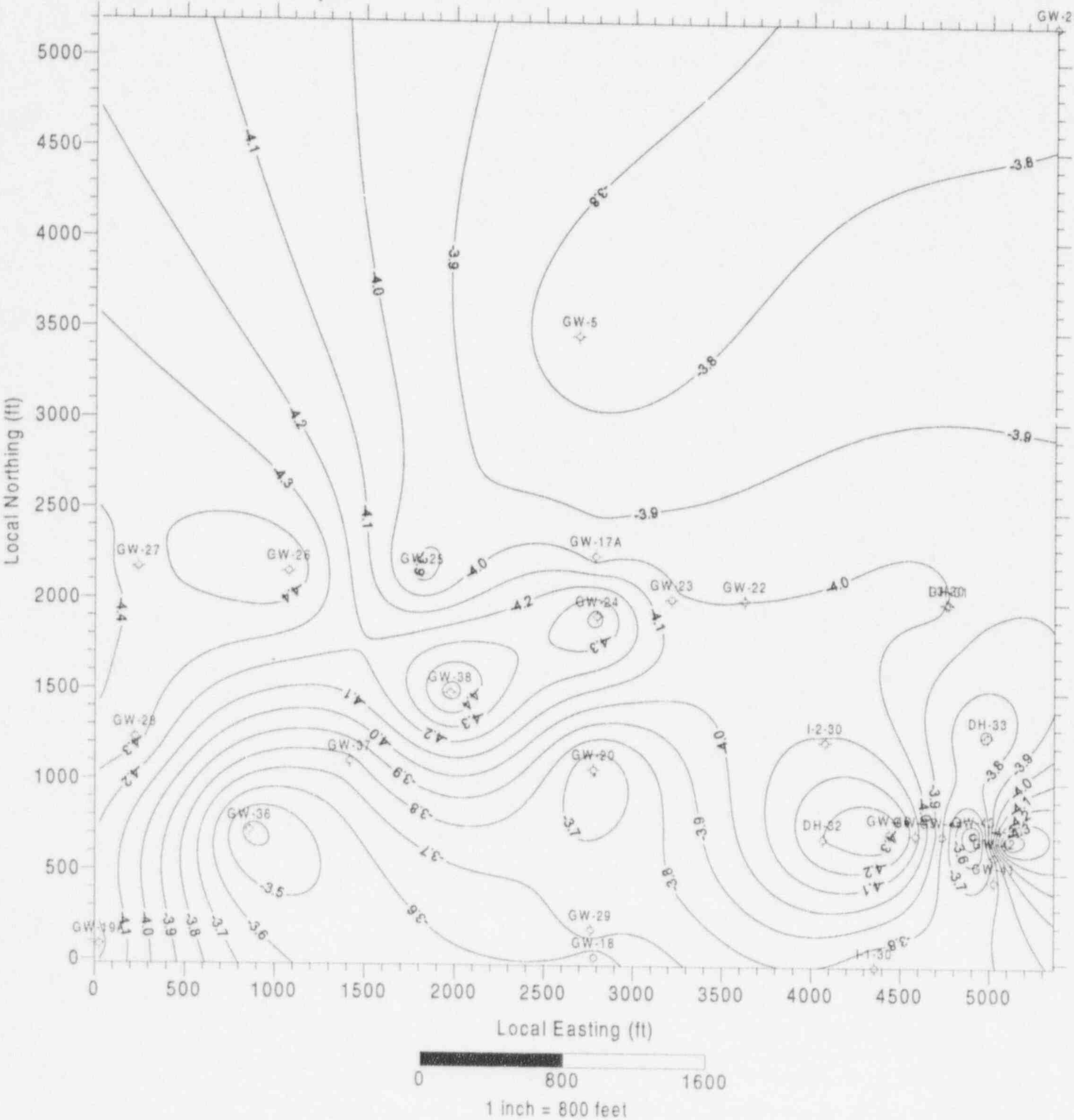
ATTACHMENT 5

Envirocare Shallow Aquifer
Slug Test Field Permeability Contour Map

Division of Radiation Control

Envirocare Shallow Aquifer Slug Test Permeability Map
LARW & Mixed Waste Disposal, Unit 2 Clay and Unit 3 Sand Data

Log10 Transforms (higher Log10 = higher K)
Labels oriented uphill



Permeability Conversions:

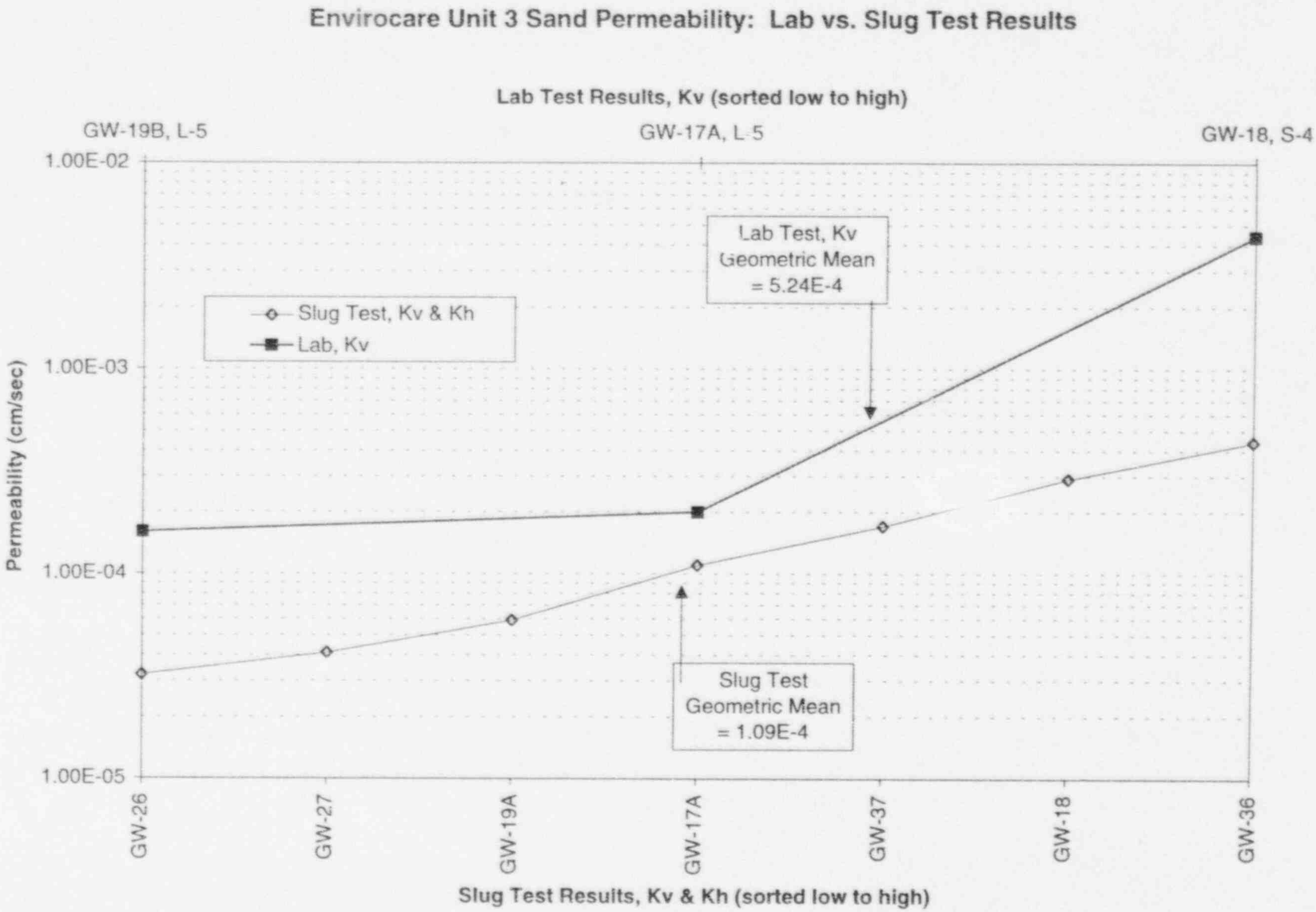
Log10 (K)	K (cm/sec)	Log10 (K)	K (cm/sec)	Log 10(K)	K (cm/sec)
-4.4	3.98E-5	-4.0	1.00E-4	-3.6	2.51E-4
-4.3	5.01E-5	-3.9	1.26E-4	-3.5	3.16E-4
-4.2	6.31E-5	-3.8	1.58E-4	-3.4	3.98E-4
-4.1	7.94E-5	-3.7	2.00E-4	-3.3	5.01E-4

Envirocare Shallow Aquifer Slug Test Permeability Results (Units 2 & 3)						
	Local Coordinates				Test	Test
Well ID	X (ft)	Y (ft)	K cm/sec	Log (K)	Type	Interval
GW-38	1975.07	1484.59	2.80E-05	-4.55284	slug	2
I-4-30	5088.97	664.79	2.90E-05	-4.5376	slug	2
GW-26	1076.77	2151.39	3.20E-05	-4.49485	slug	3
GW-24	2798.47	1913.29	3.60E-05	-4.4437	slug	2
GW-46	4438.57	717.29	3.90E-05	-4.40894	slug	2
GW-27	241.77	2169.89	4.10E-05	-4.38722	slug	3
GW-28	226.07	1227.39	4.50E-05	-4.34679	slug	2
DH-32	4066.57	688.59	5.00E-05	-4.30103	slug	2
DH-32	4066.57	688.59	5.00E-05	-4.30103	slug	2
GW-19A	27.17	82.79	5.90E-05	-4.22915	slug	3
GW-45	4584.17	709.79	7.20E-05	-4.14267	slug	2
DH-31	4765.57	1994.09	7.30E-05	-4.13668	slug	2
DH-33	4987.87	1257.69	7.80E-05	-4.10791	slug	2
I-2-30	4075.67	1223.49	7.80E-05	-4.10791	slug	2
I-3-30	4751.67	1998.19	9.20E-05	-4.03621	slug	2
GW-23	3214.87	2009.79	9.70E-05	-4.01323	slug	2
GW-22	3624.87	2005.09	1.00E-04	-4	slug	2
DH-31	4765.57	1994.09	1.10E-04	-3.95861	slug	2
GW-17A	2789.57	2246.29	1.10E-04	-3.95861	slug	3
GW-25	1815.57	2138.59	1.40E-04	-3.85387	slug	2
GW-44	4734.17	706.89	1.50E-04	-3.82391	slug	2
GW-21	5364.47	5202.39	1.70E-04	-3.76955	slug	2
GW-29	2764.37	174.79	1.70E-04	-3.76955	slug	2
GW-37	1418.57	1100.99	1.70E-04	-3.76955	slug	3
GW-41	5025.17	455.89	1.80E-04	-3.74473	slug	2
GW-42	5028.47	595.49	1.80E-04	-3.74473	slug	2
GW-5	2693.97	3463.79	1.80E-04	-3.74473	slug	2
I-1-30	4358.17	-23.91	1.90E-04	-3.72125	slug	2
DH-33	4987.87	1257.69	2.10E-04	-3.67778	slug	2
GW-20	2779.27	1063.89	2.60E-04	-3.58503	slug	2
GW-18	2781.67	22.19	2.90E-04	-3.5376	slug	3
GW-36	862.17	717.39	4.40E-04	-3.35655	slug	3
GW-43	4913.17	713.89	4.70E-04	-3.3279	slug	2
		Count:	33			

ATTACHMENT 6

Comparison of
Envirocare Shallow Aquifer Permeability
Slug Test Results vs. Vertical Permeability Data
(Unit 3 Sand)

Division of Radiation Control
graph
3SANDK.XLS - labVSslug


Envirocare Unit 3 Sand Permeability: Lab vs. Slug Test Results
Lab Test Results, Kv (sorted low to high)
GW-19B, L-5
GW-17A, L-5
GW-18, S-4
1.00E-02
1.00E-03
1.00E-04
1.00E-05
Permeability (cm/sec)
Lab Test, Kv
Geometric Mean
= 5.24E-4
Slug Test, Kv & Kh
Lab, Kv
Slug Test
Geometric Mean
= 1.09E-4
GW-26
GW-27
GW-19A
GW-17A
GW-37
GW-18
GW-36
Slug Test Results, Kv & Kh (sorted low to high)

ATTACHMENT 7

Comparison of
Envirocare Shallow Aquifer Permeability
Slug Test Results vs. Vertical Permeability Data
(Unit 2 Clay)

Division of Radiation Control
graph
2CLAYK.XLS - labVSslug

Envirocare Unit 2 Clay Permeability: Lab vs. Slug Test Results