



State of Utah

DEPARTMENT OF ENVIRONMENTAL QUALITY DIVISION OF RADIATION CONTROL

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April 10, 1997

Mr. Ken Alkema
Envirocare of Utah, Inc.
46 West Broadway, Suite 240
Salt Lake City, UT 84101

Re: Adrian Brown Consultants Slug Test Technical Memoranda of January 23, February 25, and March 14, 1997: Results of DRC Completeness Review and **Request for Additional Information**, Radioactive Materials License Renewal Application.

Dear Mr. Alkema:

As you are aware, we are engaged in review of several documents from Envirocare submitted in support of the license renewal process. The purpose of this letter is to pass on to you a request for additional information needed regarding slug test permeability results and reports recently submitted as part of site characterization by Adrian Brown Consultants (ABC), as referenced above.

During a recent weekly meeting with Envirocare, we were informed that the March 14, 1997 ABC report on slug testing permeability would be a stand-alone document, that would summarize all previous work, respond to previous DRC issues, and formulate a final technical effort for aquifer permeability in the re-licensing file. With this understanding, it was agreed that there would be no need for DRC review of the February 25, 1997 ABC Technical Memorandum, which was submitted to us in response to a February 21, 1997 DRC Request for Additional Information.

Review of the March 14, 1997 ABC slug testing report shows that it failed to include needed slug testing analysis details and output files, nor adequately summarize the previous work. We also found that the March 14 report did not adequately address issues raised in the DRC February 21, 1997 Request for Additional Information. We do acknowledge receipt of some electronic files via Internet E-mail on April 7, however, we have still found several output files still missing.

In an effort to provide clear communication regarding these technical issues, we have elected to provide a second written request for additional information. In order to avoid missing any important issues raised previously, our comments are organized in first in response to the February 25, 1997 ABC submittal, and then in general for all three ABC submittals. Based on our current review findings, we suggest that the March 14, 1997 submittal be considered draft and revised according to the remaining open issues and concerns listed below.

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February 25, 1997 ABC Technical Memorandum

Review of the February 25, 1997 ABC Technical Memorandum shows several issues remain outstanding from our February 21, 1997 Request for Additional Information. These open issues are listed below:

1. Borehole Diameters for Well I-2-30 and Other Wells (DRC Comment 1.c) - our original comment asked for resolution of apparent discrepancies regarding the actual borehole diameter for well I-20-30. The February 21, 1997 ABC response simply reverted to the 4-inch diameter quoted in a March 15, 1991 Envirocare "As-Built" Report.

DRC review of this Envirocare "As-Built" report for well I-2-30 shows additional evaluation is warranted. As originally reported by Envirocare, well I-2-30 was installed in a 4-inch diameter borehole drilled by hollow-stem auger and completed with a 2-inch I.D. well casing. After consideration of the wall thickness of the Schedule 40 PVC well casing, the auger's casing thickness, and the width needed in the borehole to accommodate the auger's flights, it appears little annular space was available to emplace sand filterpack and seals in the well. To add to this discrepancy, common hollow-stem auger diameters used in the water well industry, typically range from 6.25 to 22 inches (Driscoll, 1986, p.313).

To add to the uncertainty of borehole diameter in well I-2-30, review the four Envirocare monitoring wells completed in the same month as well I-2-30 show the three other wells were reported with larger 6.5-inch borehole diameters, see Table 1, below.

As a result of these findings, it is apparent that the reported borehole diameter for well I-2-30 may be in error. Other shallow Envirocare monitoring wells at the site completed in this same era and recently slug tested may have the same problem, namely Envirocare wells I-1-30 and I-3-30. As a consequence, use of a 2-inch well radius (4-inch diameter) in evaluation of slug test data for the wells in question may not be representative of field conditions, and can result in erroneously high permeability estimates. In preparation of the final slug test report, Envirocare should carefully evaluate borehole diameters for the wells in question to ensure diameters used are representative of actual field condition, and amend well formerly submitted "As-Built" reports as needed.

Table 1. Selected List of Envirocare Monitoring Wells: Reported Borehole Diameter

Well I.D.	Aquifer Monitored	Completion Date	Current Status	Reported Borehole Diameter (inches)
Wells Completed in June, 1990				
I-2-30	shallow	6/11/90	open	4.0
GW-11	confined	6/13/90	plugged	6.5
GW-12	confined	6/15/90	plugged	6.5
GW-13	confined	6/19/90	plugged	6.5
Wells Completed in May, 1990				
I-3-30	shallow	5/9/90	open	4.0
I-1-30	shallow	5/10/90	open	4.0
I-1-50	confined	5/14/90	?	4.0
I-4-30	shallow	5/15/90	plugged	4.0
I-4-50	confined	5/16/90	plugged	4.0
I-2-50	confined	5/23/90	?	4.0

2. Well Penetration Status (DRC Comment 2) - contrary to the February 25, 1997 ABC response, the penetration status as per the Bouwer-Rice Method, i.e. full or partial aquifer penetration, has not been disclosed in Table 2 of either the January 23 or March 14, 1997 ABC Technical Memoranda. However, we have reviewed Aqtesolv output files and deciphered the penetration status for most of the wells in question. We have also held discussions with ABC staff who indicated that full penetration status was selected for all wells in the Bouwer-Rice solution used by the Aqtesolv program. In addition, ABC staff have provided electronic copy of 35 additional Aqtesolv output files via Internet E-mail on April 7, 1997, previously not included in the January 23, February 25, or March 14, 1997 written submittals. After review of the three written submittals and the electronic copy provided, several open issues remain, as follows:

- A. Missing GW-22-A1 Output File - the written January 23 and February 25, 1997 ABC Technical Memoranda, and the April 7, 1997 electronic submittal omitted copy of the detailed Aqtesolv program output file for well GW-22-A1. Please provide copy of the Aqtesolv program output file for well and slug test GW-22-A1.

- B. Addition of All Aqtesolv Input and Output Files to Final Report - in preparation of the final stand-alone report on the slug testing effort, at a minimum please include electronic copy of all input and output files for the Aqtesolv model.
 - C. Resolution of Penetration Status for Well/Test GW-16R-A1 - review of the February 25, 1997 ABC Technical Memorandum shows partial penetration status was assumed for well/test GW-16R-A1 (ibid, Attachment 1, p. 2). However, electronic copy found in the March 14, 1997 submittal indicates full penetration status was assumed. Please explain this change in assumed penetration status for well GW-16R, and indicate which assumption will be used in the final report.
3. Disclosure of Bouwer-Rice y_o , y_v , and t Values (DRC Comment 3) - we acknowledge that the Bouwer-Rice variables y_o , y_v , and t are graphically displayed in Attachment 1 of the January 23, 1997 ABC submittal. We also acknowledge that numeric quantities of y_o are provided in Attachment 1 of the February 25, 1997 ABC submittal, and in electronic files provided in Attachment 3 of the March 14, 1997 ABC submittal, and in electronic files provided on April 7, 1997. However, we have yet to receive disclosure of the numeric quantities of the variables y_v and t for each slug test that would allow us to confirm Envirocare's permeability estimates. Please provide the necessary values in the final report.
4. Anisotropic Permeability Conditions. Need for Additional Information (DRC Comment 4) - after review of the February 25, 1997 ABC response, two follow up issues have surfaced, as follows:
- A. Identification of Wells/Tests - in order to expedite review of the final report, please identify those individual wells and slug tests where anisotropic permeability conditions were used in the Aqtesolv calculations.
 - B. Evaluation of Applicability of Anisotropic Conditions to Unit 3 Wells/Tests - review of the technical papers reference by the Aqtesolv model indicates that the anisotropy ratio, horizontal : vertical, should be evaluated independently of interpreting slug test data (V. Zlotnik, 1994, p. 764). This same paper also suggests that such independent evaluation should include "... Neuman's (1975) method for analyzing pumping tests..." (ibid.).

However, we agree that the use of the anisotropic assumption in the Aqtesolv model is conservative in that it will result in a higher permeability estimate, than if isotropic conditions were used. For this reason, use of this assumption is acceptable for wells where the slug tests were conducted across clay strata, e.g. Unit 2 Clay. However, it may also be appropriate for wells and slug tests completed in the Unit 3 Sand, where clay interbeds were found in the zone tested. In the final report, please include an evaluation of soil logs for wells completed in the Unit 3 Sand to determine if clay

interbeds were present in the zone slug tested, which may in turn dictate the need to consider anisotropic permeability conditions for these wells/tests.

5. Well Casing Radius, r_c (DRC Comment 5) - February 25, 1997 ABC arguments that comparable values for both measured bailer volume (V_b) and calculated purge volumes (V_c), as shown in the January 23, 1997 ABC submittal (Table 2, seventh and eleventh columns) are evidence that the filterpack permeability is not significantly higher than the aquifer are weak. After consideration of the physical limitations of the slug test and the transducer's time sampling interval, the calculated volume (V_c) should always be equal to or less than the measured bailer volume (V_b). Hence, the difference between the measured bailer volume and the calculated volume ($V_b - V_c$) should always be greater than zero. In contrast, review of the differences in these volumes from Table 2 of the March 14, 1997 ABC submittal shows that 88 of 111 slug tests listed show a negative volume difference, i.e., the calculated volume was greater than the measured volume.

Other inaccuracies also are apparent in the bailer volume measurements made. Leakage from the bailer during the recovery portion of each slug test could have decreased the actual volume measured in the bailer. Human error in physically measuring the height of the water column in the bailer could also compound this problem.

In addition, 24 of 35 head response curves in the 1/23/97 ABC submittal (Attachment 2) and 75 of 84 head response graphs in the 3/14/97 ABC submittal (Attachment 2) show evidence of the double-line effect, which indicates the filterpack permeability is greater than the aquifer for a the majority of the wells tested.

A contradiction in ABC analysis of the slug test data is also apparent. The Bouwer-Rice method calls for use of a well radius (r_w) that includes both the filterpack and developed zone within the aquifer, "... if they are much more permeable than the aquifer itself ..." (Bouwer and Rice, p. 424).

Similarly, the method calls for adjusting well casing (r_c) after consideration of filterpack thickness and porosity under two conditions: 1) if the water level at the beginning of the test occurs in the well's screened interval, and 2) if the permeability of the filterpack or developed zone is much higher than the aquifer (ibid.). After preliminary review of the well completion diagrams and the static water levels reported in the January 23 and March 14, 1997 ABC submittals, it appears that most if not all of the wells tested meet the first criteria above.

Filterpack considerations appears to be important for the Envirocare slug test analysis, in that inaccuracy or variability of filterpack thickness has a greater effect on permeability calculations for wells with a small casing diameter (Bouwer, 1989, p. 308). All monitoring wells at the Envirocare facility have been constructed of small diameter casings (2-inch I.D.), and hence appear more prone to filterpack effects.

Consequently, it appears that if the filterpack was deemed to be more permeable than the aquifer for purposes of determining well radius (r_w), that it should also be considered for adjustment of the well casing radius (r_c). Contrary to this approach, the January 23 and March 14, 1997 ABC submittals elected only to adjust the well radius (r_w). In order to provide consistency in the Bouwer-Rice calculations, the same approach should be taken for both the well and casing radius variables. Please resolve this discrepancy by determining appropriate values for filterpack porosity and adjusting both variables according to Bouwer-Rice recommendations, or justify why it is appropriate to consider filterpack effects for only the well radius.

6. Need for Additional Well Testing (DRC Comment 7) - after review of the slug tests reported in both the January 23 and March 14 ABC submittals, and electronic files provided on April 7, 1997 it appears that slug testing is needed in two existing wells: GW-29 and DH-59. In addition, the two new monitoring wells planned for the south side of the LARW Cell, to be installed the week of April 21, are also in need of slug testing. Results from these three wells should be added to the final slug testing report.

Three ABC Technical Memoranda of January 23, February 25, and March 14, 1997

1. Resolution of Test Identities for Three ABC Submittals - comparison of well tests reported, shows a lack of consistency between the January 23 and March 14, 1997 ABC Technical Memoranda, and the April 7, 1997 electronic submittal. In some cases, slug tests identified in the January 23 submittal are not listed in the March 14 submittal, and visa versa. In other cases, electronic slug test output files provided on April 7, 1997 are not included in the written submittals provided. Examples of these discrepancies are summarized in Table 2, below.

Please resolve all such discrepancies among the submittals and indicate which slug test results are to be considered in the final report. Please ensure that electronic copy is provided in Attachment 3 for each and every slug tests identified in Table 2 of the final report. For results removed or culled from consideration in the final report, please explain and justify why this is appropriate.

2. Clarification of Re-tested Wells - in the final report, please clearly identify both in writing and among electronic copy to be attached, those wells that were re-tested after submittal of the January 23, 1997 ABC Technical Memorandum. For sake of clarity, please provide a distinct identity for re-test data and output files, or clearly segregate the related files for the repeated testing.

Table 2. Examples of Slug Test Identity Problems Among Three APC Submittals

Well ID	ABC Slug Tests Identified			
	1/23/97 ABC Submittal, Table 2	3/14/97 ABC Submittal		4/7/97 Electronic Copy
		Table 2	Attachment 3	
DH-62	not included	DH-62-A1, A1, and A1 ⁽¹⁾	DH-62-A1, A2, A3, B, B1, and B2	DH-62A1 ⁽²⁾
GW-16R	GW-16R-A1, A2, and A3	GW-16R-A1, B1, and B2	GW-16R-A1, B1, and B2	not included
GW-43	not included	GW-43A1, B1, and B2	GW-43A1, B2, and B3	not included
GW-60	GW-60-A1, A2, and A3	GW-60-A1, A2a, A3a, and A3	not included	GW-60-A1, A2, and A3
GW-63	GW-63-A1, A2, and A3	GW-63-A2, and A3	not included	GW-63-A1, A2, and A3
GW-64	GW-64-B1, B2, and B4	GW-64-A1, B1, and B2	not included	GW-64b1, GW-64-b1, GW-64b2, GW-64-b2, and GW-64-b4
I-3-30	not included	I-3-30A1, A2, and A3	I-3-30A1, B1, and B2	not included

Footnotes:

- 1) DH-62-A1 slug tests are repeated three times in 3/14/97 ABC Submittal, Table 2.
- 2) Two output files available for slug test DH-62, DH-62-A1 (3/14/97 ABC Submittal, Attachment 3) and DH-62A1 (4/7/97 Electronic Copy).

3. March 14, 1997 ABC Submittal: Missing or Unreadable Output Files - after review of electronic output files provided in the March 14, 1997 ABC submittal, and electronic copy provided April 7, 1997, we have identified several slug tests for which copies of output files have yet to be provided. These wells and slug tests include those listed in Table 3, below. Please ensure that the final report includes all missing or unreadable Aqtesolv output files for all wells and slug test conducted.

Table 3. March 14 and April 7, 1997 ABC Submittals: Missing and Unreadable Files

Well ID	Aqtesolve Output File	Well ID	Aqtesolve Output File
Missing Slug Test Results (as listed in 3/14/97 ABC Submittal, Table 2)			
GW-43	GW-43B1	GW-58	GW-58B1
GW-44	GW-44B2	GW-64	GW-64A1
GW-57	GW-57B2	I-3-30	I-3-30A2 and A3
Unreadable Slug Test Output Files (3/14/97 ABC Submittal, Attachment 3)			
DH-62	DH-62A1.out and DH-62B1.out		

4. Justification for Partial Penetration Assumption for Well Test GW-37B1 - review of electronic copy of the Aqtesolve program output for slug test GW-37B1 (March 14, 1997 ABC Submittal, Attachment 3), shows Envirocare assumed a partial penetration for this slug test. However, a full penetration assumption was used for another slug test of the same well (GW-37A1). Please justify why the partial penetration assumption is appropriate or re-do the Aqtesolv solution for slug test GW-37B1.
5. Resolution of Apparently Defective Aqtesolv Output Files - review of electronic output files shows apparent errors in input files used by the Aqtesolv program to estimate permeability from the slug tests. Details follow in Table 4, below. Please ensure that all Aqtesolve output files used, and display in the output files the appropriate input data set file.

Table 4. Discrepancies in Aqtesolv Output Files: March 14, 1997 Submittal

Well ID	March 14, 1997 ABC Technical Memorandum		Referenced Input Data set Name
	Table 2 Reference	Attachment 3 Output File Name	
DH-62	DH-62A1 ⁽¹⁾	DH-62B.out	DH-B1.out
GW-41	GW-41A1	GW-41a1.out	DH-62A1.dat
GW-41	GW-41B1	GW-41b1.out	DH-62B2.dat

Footnote: 1) Slug test for well DH-62 was repeated three times in Table 2.

6. Resolution of Different Report Permeability Results, January 23 vs. February 25 and April 7, ABC Submittals - after comparison of permeability values listed in the January 23, 1997 ABC submittal (Table 2) with values found in the February 25 ABC submittal (Attachment 1) and electronic files created in January, 1997 (received April 7, 1997), it appears that several discrepancies exist in the summary Table 2 values which need to be corrected. These discrepancies are listed in Table 5, below.

Table 5. Discrepancies in Reported Permeability: January 23, 1997 ABC and Related Submittals

Well / Test	1/23/97 ABC Technical Memo		2/25/97 ABC Technical Memo and Electronic Files			
	Table 2 (cm/sec)	Attachment 2		Attachment 1		
		Reported K, ft/sec	Calc. K cm/sec	Aqtesolv File Name	Reported K, ft/sec	Calc. K cm/sec
GW-16R-A1	5.03e-04	7.588e-05	2.31e-03	GW-16RA1.out	1.646e-05	5.02e-04
GW-16R-A2	2.47e-03	1.801e-05	5.49e-04	GW-16RA2.out	8.101e-05	2.47e-03
GW-20-A3	9.49e-04	3.112e-05	9.49e-04	GW-20-A3.out	3.865e-05	1.18e-03 ⁽¹⁾
GW-60-A2	2.53e-03	1.55e-05	4.72e-04	GW-60-A2.out	1.485e-04	4.53e-03 ⁽¹⁾
GW-64-B1	7.23e-04	2.366e-05	7.21e-04	GW-64B1.out	1.357e-04	4.13e-03 ⁽¹⁾
GW-64-B2	6.62e-04	2.168e-05	6.61e-04	GW-64B2.out	1.243e-04	3.79e-03 ⁽¹⁾
GW-64-B4	1.05e-03	1.981e-04	6.04e-03	n/a	n/a	n/a
I-2-30A2	1.69e-04	5.551e-06	1.69e-04	I-2-30A2.out	3.069e-05	9.35e-04 ⁽¹⁾

Footnote: 1) Values from ABC electronic files created in January, 1997 and submitted to DRC on April 7, 1997 by E-mail.

In order to render a final report that is a stand-alone document, please resolve the above discrepancies and ensure that all attached documents and files support permeability values found in summary tables.

7. Missing Head Response Graphs and Other Data - review of the March 14, 1997 ABC report, Table 2 shows 116 separate slug tests were conducted recently at the Envirocare facility. However, review of the head response graphs in Attachment 2 of the same report shows only 84 have been included in the report. Please ensure that a head response graph (log y_t versus t) is provided in the final report for each slug test conducted. Please ensure that head recovery plots are provided for all wells tested in Attachment 1 (depth to water versus time). Also, please ensure that electronic input and output files for the Aqtesolv program are provided in Attachment 3 for each slug test conducted.
8. Justification for Slug Tests Without Double-Line Effect - review of the currently available head response graphs in both the January 23 and March 14, 1997 ABC submittals shows a number of wells and slug tests wherein a double-line effect was not observed, see Table 6 below. As a result, it is difficult to distinguish filterpack from aquifer response during these tests. Please carefully evaluate all wells without the double-line effect, and justify why the measured response is indicative of aquifer response, or provide plans to improve the slug testing procedure and repeat test these wells.

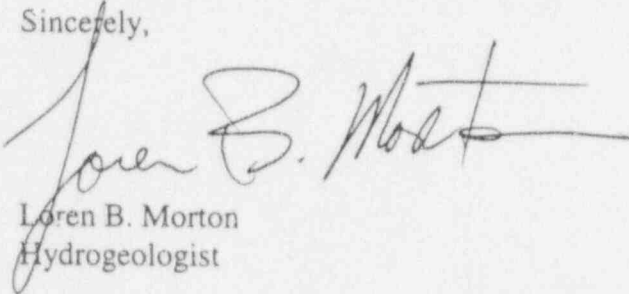
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Table 6. Envirocare Slug Tests Without Double-Line Effect

January 23, 1997 ABC Submittal, Attachment 2		March 14, 1997 ABC Submittal, Attachment 2	
Well	Test	Well	Test
GW-25	B1, B2, B3, B5	GW-36	A2, A3
GW-56R	3	GW-37	B1, B2
GW-64	E1, B2, B4	GW-38	A1, B1, B2
I-2-30	A1, A2	I-2-30	A1, A2
GW-63	A3		

If you have any questions regarding these comments, please call me at (801) 536-4262. I appreciate your cooperation on this project and look forward to our upcoming meeting to discuss these issues.

Sincerely,



Loren B. Morton
Hydrogeologist

LBM:lm

cc: Susan Wyman, Adrian Brown Consultants
Jim Dana, RAE
Otis Willoughby, DS/HW
Larry Mize, DWQ
Harold LeFever, NRC

F:\slugst2.ltr

File: Envirocare Groundwater Permit - Horizontal GW Velocity
Envirocare Re-Licensing File

References

- Adrian Brown Consultants, January 23, 1997, "Hydraulic Conductivity Measurements", unpublished technical memorandum from Susan Wyman to Ken Alkema, 5 pp. plus tables and attachments.
- Adrian Brown Consultants, February 25, 1997, "Response to DRC Comments Regarding ABC Slug Test Analyses", unpublished technical memorandum from Dan Reeder to Ken Alkema, 4 pp. plus attached output files.
- Adrian Brown Consultants, March 14, 1997, "Technical Memorandum Phase II Hydraulic Conductivity Measurements, Envirocare of Utah, Inc.", unpublished consultants report, 8 pp. plus figure, tables, graphs, and attached electronic files.
- Bouwer, H. And Rice, R.C., 1976, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells", Water Resources Research, June, 1976, Vol. 12, No. 3, pp. 423-428.
- Bouwer, Herman, 1989, "The Bouwer and Rice Slug Test - An Update", Ground Water, May-June, 1989, Vol. 27, No. 3, pp. 304 - 309.
- Driscoll, F.G., 1986, "Groundwater and Wells", Johnson Division, St. Paul Minnesota, 1089 pp.
- Envirocare of Utah, Inc., March 15, 1991, "Submittal of Monitoring Well Completion Reports and Other Data as Required by Envirocare Permit Condition VI.E.3.f", report and transmittal letter from Jay Vance to Dennis Downs, 26 pp. with well completion diagrams and well design and construction worksheets.
- Zlotnik, V., 1994, "Interpretation of Slug and Packer Tests in Anisotropic Aquifers", Ground Water, vol. 32, no. 5, pp. 761-766.