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Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

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July 12, 1985
Contract NRC-02-82-044
FIN # B7372-3
Communication #134

Mr. Matthew Gordon
Division of Waste Management
Mail Stop 623-SS
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Matt:

Two copies of our review of the letter report from Mr. Rowe (Golder Assoc.) to Mr. Luttrell (Rockwell Hanford Operations) are enclosed. Our review of SD-BWI-TP-039 is being completed at this time. We are still working on our review of the Lu and Yeh report on inverse modeling. Please call if you have any questions.

Sincerely,

Gerry

Gerry Winter

2215

WMGT DOCUMENT REVIEW SHEET

FILE #:

GOLDER ASSOCIATES CORRESPONDENCE: March 27, 1985

DOCUMENT: Letter from Jerry Rowe to Stuart Luttrell

REVIEWER: Williams and Associates, Inc.

DATE REVIEW COMPLETED: July 1985

BRIEF SUMMARY OF DOCUMENT: DATE APPROVED:

A. Introduction and Overview

The letter report by Golder Associates under review herein summarizes the simulations conducted using the G. der two-dimensional axisymmetric finite element code. The purpose of the subject report is to "provide technical input to RHO to assist in the design and location of dense zone piezometers in hole RRL-2C." The simulations were conducted in a manner which simulates the large scale tests planned for the Rocky Coulee, Cohassett, and the Grande Ronde #5 flow tops.

The report under review summarizes the three basic conclusions derived from the simulations. It is noted that a piezometer located in the middle of an overlying or underlying dense zone will "generally respond with a drawdown of one foot or more within 10 days of pumping." Exceptions to this conclusion are noted also. The second general conclusion is that in some cases drawdowns will extend through the dense zone into adjacent flow tops. Golder notes that generally this occurs when the adjacent flow tops are significantly less permeable than the pumping zone. The third conclusion notes that the boundary conditions assumed by the ratio method "(i.e. no drawdown in adjacent aquifers)" may be most appropriate for those cases where a relatively low permeability flow top is pumped.

B. Conceptual Model

The conceptual model consists of alternating layers of extensive horizontal basalts. Dense basalt interiors and basalt interflows are modeled in the report under review as a 773 ft vertical

profile. The finite element mesh extends to a radial distance of 46,000 ft from the pumping well; a constant head boundary exists at this radial limit. Upper and lower mesh boundaries are treated as constant head boundaries. The finite element mesh contains 1036 nodes and 972 elements. Although unstated, we assume that the Golder model was used as a porous media simulator. Local heterogeneities were not considered.

C. Parameter Estimation

Input data for the model are summarized in tabular form in the report under review. The tabulated data are appended to this review. The initial values used in the simulation were based upon measured values from the single hole test conducted in borehole RRL-2A. Sensitivity studies were conducted using the base case values. A second set of values, referred to as "base case geometric mean values" also were used in the simulations.

D. Simulations

The simulations are summarized as a series of logarithmic time/drawdown graphs for varying depths in the dense zones at a radial distance of 250 ft from the pumping well. Consolidation curves also are presented; these curves present the pressure response as a function of depth within the dense zones at a distance of 250 ft from the simulated pumping well.

The sensitivity studies were conducted as a means of estimating the pressure response that will occur in the dense zones between the flow tops due to pumping a flow top. The sensitivity studies evaluate the effects of changing the ratio of K_v to S_s. The simulations were conducted assuming a radius of 250 feet from the pumping well (borehole RRL-2B); the radius is dependent upon the location of the proposed borehole RRL-2C. Borehole RRL-2C is a proposed multi-piezometer observation well. The model used a 773-foot vertical profile with a radial distance to a constant head boundary of 46,000 feet. The upper and lower mesh boundaries were also treated as constant head boundaries.

The letter report states that selected model results were compared with several analytical solutions "(Theis, Neuman-Witherspoon)". Support for statements concerning the comparison are not presented in the report under review. The report under review states that the numerical solution matches "well with the Theis solution considering slight leakage from adjacent aquitards." The report under review states further that "Aquitard pressure response from the model solution matches the Neuman-Witherspoon analytical solution well except in areas where the mesh is course (coarse) in the vertical direction."

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

This document is important to the Waste Management Program due to its potential use as a support document for the selection of piezometer locations in the dense interiors of the basalt flows. The first large scale stress test is planned for this fall (Public Meeting, May 1985). The document under review provides the summary output from the finite element simulation of a pump test in a multi-layered system. The assumptions, data input, and validity of the model are very important to the weight which should be placed on the material included in the report reviewed herein. The locations of the piezometers in the basalt interiors are very important with respect to quantifying the vertical hydraulic conductivity of these basalt interiors. One of the primary goals of the large scale testing at the BWIP site is to quantify vertical hydraulic conductivity.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

General Technical Discussion

The report contains several deficiencies. One of the basic problems is understanding what was actually done for RHO. The text portion of the letter report is very brief and does not present details concerning the simulations. The purpose of the report under review is appropriate; however, the scope of the report is limited. The conceptual model used in the report under review is appropriate for the purpose intended (simulating pumping tests with simple boundary conditions).

The document under review (page 2) states that "selected model results have been compared with several analytical solutions ..." The comparisons were not provided in the report under review. The statement must be taken at face value since the statement is not supported. It is important that this support be provided because it is possible that early-time simulations with the Golder model may not follow the theoretically correct analytical solution. Frequently, finite difference models and other models experience a period of inaccurate predictions with respect to head and pressure responses due to stress imposed during a pumping test. These inaccuracies are greatest during early time simulation. Several time steps frequently are required to minimize or eliminate the sometimes significant variations from the analytical solution. Therefore, it is important that this information be provided to the reviewer rather than forcing the reviewer to accept the author's opinion on face value. The importance of early time data is based on the fact that a pressure pulse could move rapidly through a dense interior. Such rapid movement could be due to the very low storativity of the interior rather than to a high hydraulic conductivity. The

report under review requires that the reviewer accept the validity of this simulation without support. This is not justified.

The report under review states, as a preliminary result, that the drawdown can be expected to be at least one foot or more in a confining unit after 10 days of pumping. This statement is supported by the figures attached to the letter report under review. The statement however is somewhat misleading because a limited range of values were used for the simulations. This is particularly true with respect to the storativities assigned to the confining units. It is entirely possible that the storativity (storage coefficient) of the confining units (flow interiors) will be very low and hence the pressure pulse will move rapidly through the interiors. The simulations conducted with the finite element model may not be adequate for the purpose intended (locating piezometers in dense interiors).

The limitations noted previously apply to the second and third summary conclusions stated on pages 2 and 3 of the document under review. The conclusions are assumed to be accurate and the data input and assumptions appropriate for the BWIP site. As noted previously, the limitations of using a model(s) to simulate early time drawdown data should be demonstrated explicitly.

The figure series, 1a through 3h, show the apparent effects of a limited data output from the model. Only one figure in this sequence (3b), shows a drawdown simulation for 10^{-2} days. This simulation is equivalent to a 14-minute time interval since the beginning of pumping. The remainder of the figures in this group show simulated time drawdown data beginning no earlier than 10^{-1} days (144 minutes). It is not clear whether earlier time simulations were eliminated from the graphs due to inaccuracies or whether the data were culled judgementally. The absence of early time simulated data should be clarified in the report under review. This same group of figures shows several lines connecting drawdown points which apparently are extrapolated from a single time drawdown simulation point. This extrapolation obviously is inaccurate if only one point was used for drawing the drawdown curve; additional data used to construct these plots should be presented in the report. The use of a single point for curve drawing occurs in figures 2d, 2f, 3a, 3f, 3g, and 3h.

The series of figures presented from 4a through 6d seem to illustrate that the time effects of pumping will have to be considered very carefully when selecting the locations of monitoring points in the dense interiors. The simulations do not show the effects of encountering lateral boundaries such as the postulated Cold Creek barrier. The piezometer locations in the basalt interiors will have to be selected to minimize potential

lateral boundary effects on drawdown in the flow tops. The Neuman-Witherspoon ratio method is dependent upon the measurement of an accurate drawdown in the interior with a corresponding drawdown measurement in a pumped flow top at the same time at the same radial distance from the pumping well. The ratio of drawdowns is used to calculate the vertical hydraulic conductivity of the intervening basalt flow interior between that monitoring point and the pumped flow top. This issue is not addressed in the report under review; it is probable that Rockwell did not request Golder Associates to conduct an analysis involving lateral boundary conditions such as the postulated Cold Creek Barrier. This point should be kept in mind by reviewers of the report under review so that the reviewers are not misled into thinking that lateral boundary effects cannot occur before the necessary vertical hydraulic conductivity data values are obtained.

SUGGESTED FOLLOW-UP ACTIVITY:

We suggest that the NRC approach DOE with regard to clarifying the points questioned in the report under review.

TABLE 1

SUMMARY OF CASES MODELED

Pump Test Zone	Test Zone Kh (ft/d)	Dense Zone Monitored (Overlying/Underlying)	Cv (K'/Ss')	Comments
Rocky Coulee Flow Top (GR#3)	1.2 E-1	None/ Rocky Coulee Dense (GR#3)	9.1 E+1	Base Case Parameters - RRL 2
			9.1 E+0	Sensitivity - Low Cv
			9.1 E+2	Sensitivity - High Cv
	3.2 E-2		9.1 E+1	Base Case Geometric Mean
Cohassett Flow Top (GR#4)	2.5 E-3	Rocky Coulee Dense (GR#3)/ Cohassett Dense (GR#4)	9.1 E+1	Base Case Parameters - RRL 2
			9.1 E+0	Sensitivity - Low Cv
			9.1 E+2	Sensitivity - High Cv
	1.3 E-2		9.1 E+1	Base Case Geometric Mean
GR #5 Flow Top	1.0 E+1	Cohassett Dense (GR#4)/ GR #5 Dense	9.1 E+1	Base Case Parameters - RRL 2
			9.1 E+0	Sensitivity - Low Cv
			9.1 E+2	Sensitivity - High Cv
	2.3 E-2		9.1 E+1	Base Case Geometric Mean

TABLE 2

MODEL GEOMETRY AND BASE CASE PARAMETERS
(based on SD BWI-TI-113, Table 1)

Unit	Top of Unit Depth (ft)	Thickness (ft)	Kh (ft/d)	Kv (ft/d)	Ss (/ft)	Comments
Vantage	2683	4				Not included in mesh
GR#1 FT	2687	15	Upper boundary			Treat as constant head
GR#1 D	2702	19	1.0 E-6	1.0 E-5	1.1E-7	
GR#2 FT	2721	40	2.5 E-3	2.5 E-3	3.1E-7	
GR#2 D	2761	62	1.0 E-6	1.0 E-5	1.1E-7	
GR#3 FT (Rocky Coulee	2823	82	1.2 E-1	1.2 E-1	3.1E-7	
GR#3 D (Rocky Coulee)	2905	88	1.0 E-6	1.0 E-5	1.1E-7	
GR#4 FT (Cohassett)	2993	17	2.5 E-3	2.5 E-3	3.1E-7	
GR#4 D (Cohassett)	3010	73	1.0 E-6	1.0 E-5	1.1E-7	
GR#4 Ves (Cohassett)	3083	24	1.0 E-6	1.0 E-5	1.1E-7	
GR#4 D (Cohassett)	3107	148	1.0 E-6	1.0 E-5	1.1E-7	
GR#5 FT	3255	80	1.0 E+1	1.0 E+1	3.1E-7	
GR#5 D	3335	53	1.0 E-6	1.0 E-5	1.1E-7	
GR#6 FT	3388	9	1.2 E-1	1.2 E-1	3.1E-7	
GR#6 D	3397	21	1.0 E-6	1.0 E-5	1.1E-7	
GR#7 FT	3418	24	1.2 E-1	1.2 E-1	3.1E-7	
GR#7 D	3442	33	1.0 E-6	1.0 E-5	1.1E-7	
GR#8 FT	3475	21	Lower boundary			Treat as constant head

TABLE 3

MODEL GEOMETRY AND BASE CASE GEOMETRIC MEAN PARAMETERS

Unit	Top of Unit Depth (ft)	Thickness (ft)	Kh (ft/d)	Kv (ft/d)	Ss (/ft)	Comments
Vantage	2683	4				Not included in mesh
GR#1 FT	2687	15	Upper boundary			Treat as constant head
GR#1 D	2702	19	1.0 E-6	1.0 E-5	1.1E-7	
GR#2 FT	2721	40	1.3 E-2	2.5 E-3	3.1E-7	
GR#2 D	2761	62	1.0 E-6	1.0 E-5	1.1E-7	
GR#3 FT (Rocky Coulee	2823	82	3.2 E-2	1.2 E-1	3.1E-7	
GR#3 D (Rocky Coulee)	2905	88	1.0 E-6	1.0 E-5	1.1E-7	
GR#4 FT (Cohassett)	2993	17	1.3 E-2	2.5 E-3	3.1E-7	
GR#4 D (Cohassett)	3010	73	1.0 E-6	1.0 E-5	1.1E-7	
GR#4 Ves (Cohassett)	3083	24	1.0 E-6	1.0 E-5	1.1E-7	
GR#4 D (Cohassett)	3107	148	1.0 E-6	1.0 E-5	1.1E-7	
GR#5 FT	3255	80	2.3 E-2	1.0 E+1	3.1E-7	
GR#5 D	3335	53	1.0 E-6	1.0 E-5	1.1E-7	
GR#6 FT	3388	9	3.2 E-2	1.2 E-1	3.1E-7	
GR#6 D	3397	21	1.0 E-6	1.0 E-5	1.1E-7	
GR#7 FT	3418	24	3.2 E-2	1.2 E-1	3.1E-7	
GR#7 D	3442	33	1.0 E-6	1.0 E-5	1.1E-7	
GR#8 FT	3475	21	Lower boundary			Treat as constant head