AQUIFER TEST COMPLETED IN THE NORTHERN BITTERROOT VALLEY, LOLO, MONTANA

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Cover photo: Measuring and recording water levels during an aquifer test, Lolo, MT.

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1.0 INTRODUCTION

This report presents an analysis of an aquifer test completed in the spring of 2018 in the Lolo, Montana area. The aquifer test results are summarized in table 1. The test location (fig. 1) is located within the city limits of Lolo at a residential dwelling (latitude 46.7559, longitude -114.1076; Bantam Acres Loop, off Hwy 12 approximately 1 mi west of Lolo).

Table 1. Aquifer parameter results.

193691 Test

	GWIC ID	T ft^2/day	S
LQ22	290663	4,346	0.0003
LQ23	290662	2,201	0.00005

The aquifer testing consisted of pumping a well at a constant discharge and plotting the resulting water-level drawdown. Plots showed the water levels in both the pumping and nearby observation wells as a function of time after the start of pumping. These time-drawdown plots were matched with type curves based on modifications of the Theis nonequilibrium equation (Theis, 1935).

The aquifer tested in this report was a deep alluvial-filled aquifer that was separated by a locally low-permeability confining layer of silt and clay from a shallow alluvial-filled aquifer. The shallow aquifer is described as heterogeneous sand and gravels with isolated clay intervals (Gebril and Sutherland, in prep.). The deeper aquifer consists of Tertiary sediments described as unconsolidated sands, gravels, and cobbles with finer-grained sediments.

As with many aquifer tests, the heterogeneity, anisotropy, and limited lateral extent of the valley-fill are not fully consistent with the Theis solution. We applied modifications of the Theis solution that account for partially penetrating wells and recharge boundaries for the analysis.

Recovering water levels were monitored in all wells following the cessation of pumping. These data were analyzed to determine whether rising or falling water-level trends unrelated to pumping influenced the test analysis (i.e., background trends).

Well and staff gage locations are referred to by their Ground Water Information Center (GWIC) number. The well logs, aquifer test data, and chemistry data can be accessed through the GWIC database (http://mbmggwic.mtech.edu/). Within GWIC, the aquifer test data are accessed by the pumping well GWIC number as an Excel file (Form 633 created by the Montana Department of Natural Resources).

Additional aquifer tests were completed at this site in the spring of 2018. However, analysis indicated that these tests did not reach steady-state conditions, were relatively short in duration, and appeared to be affected by transient stage levels in Lolo Creek. These tests are not discussed further in this report due to those complications.

2.0 193691 TEST

2.1 Background

2.1.1 Purpose of Test

The purpose of this test was to estimate the properties of the deeper sand and gravel alluvial aquifer near Lolo Creek and to evaluate a hydraulic connection between the shallow and deep aquifers.

2.1.2 Test Type

A constant-rate aquifer test was conducted with an average pumping rate of 54 gallons per minute (gpm). Wells included the pumping well, 193691 (LQDom), and three observation wells: 290663 (LQ22), 290662 (LQ23), and 290557 (LQ25). LQDom, LQ22, LQ23, and LQ25 are the local names for the corresponding wells (fig. 2). The 72-h aquifer test began March 27, 2018 at 8:25 am and ended on March 30, 2018 at 8:25 am. Recovery water levels were monitored manually with an e-tape and automatically with a pressure transducer with a data logger (transducer) for 72 h.

2.1.3 Hydrogeologic Setting

The pumping and observation wells were located within the floodplain of Lolo Creek. The wells were completed in alluvium consisting of sand, gravel, and cobbles with clay. The lithology logged for the deepest well (well 193691) consisted of:

- soil (0–2 ft),
- sand and gravel (2–6 ft), and
- sand, silt sand, and gravel with clay-covered gravel (6–60 ft).

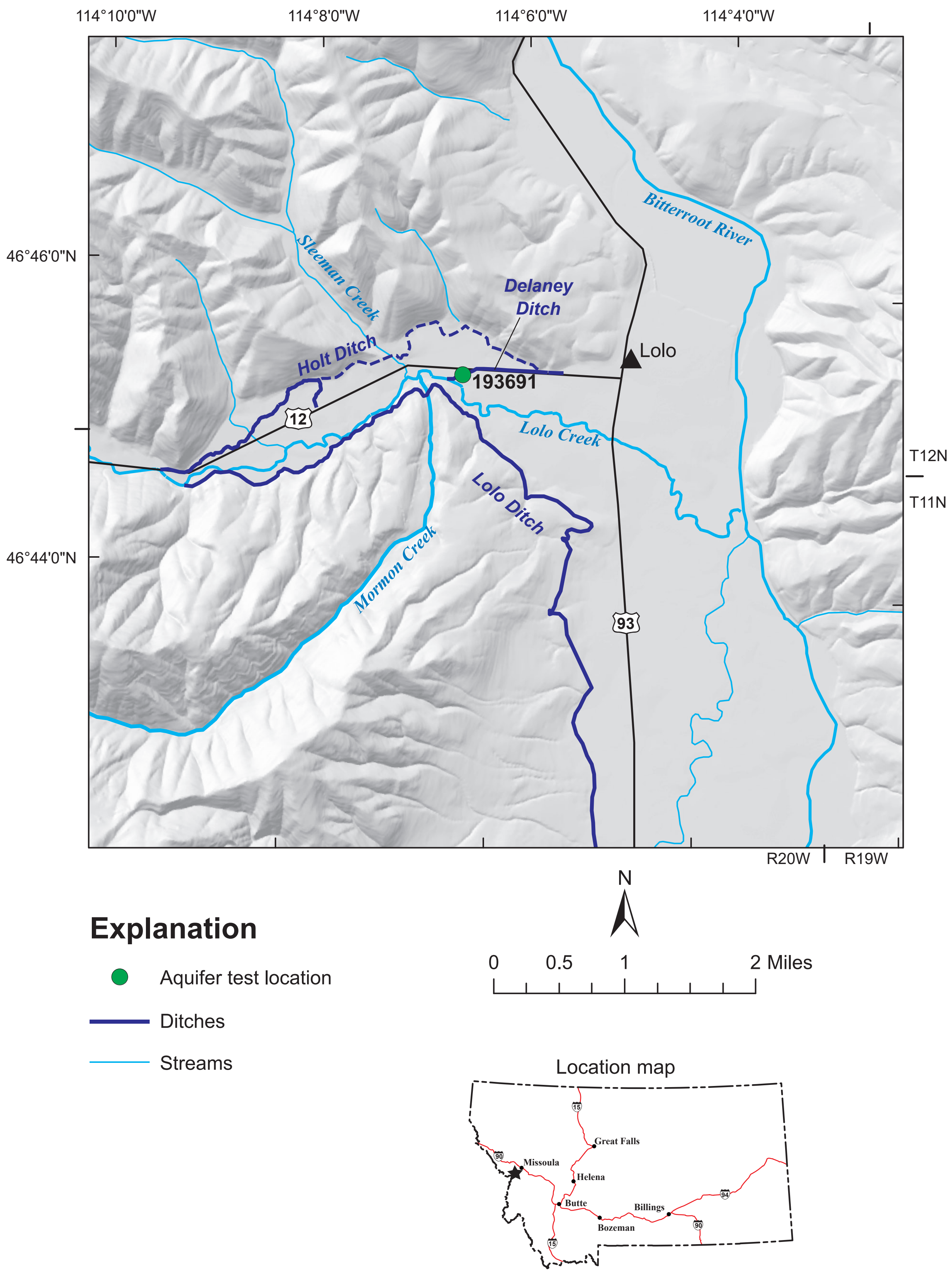


Figure 1. Location of the aquifer test near Lolo, MT.

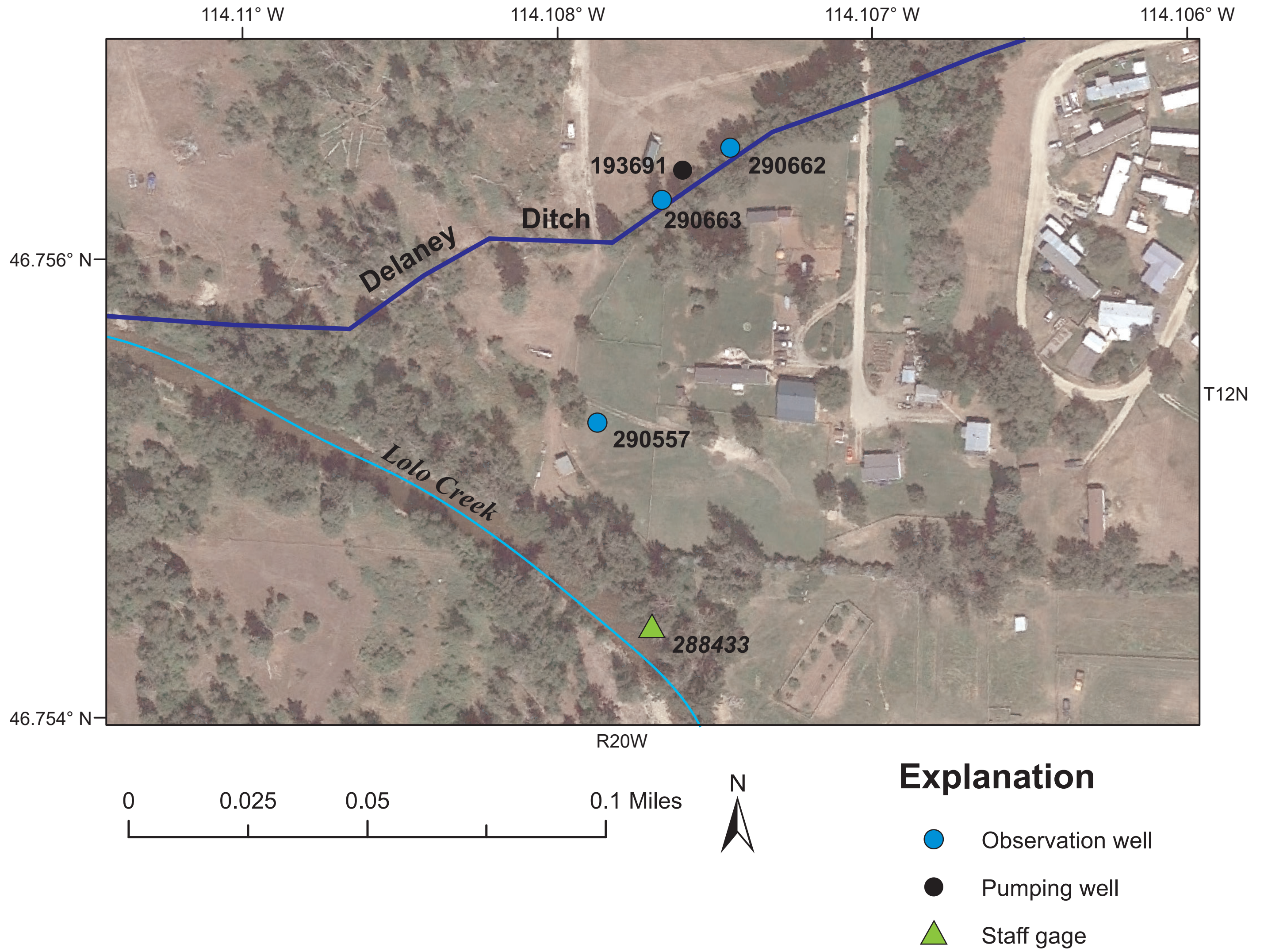


Figure 2. Aquifer test 193691 site map.

Wells 290662, 290663, and 193691 are assumed to have similar lithology as they are less than 80 ft from one another. The pumping well (193691) and two observation wells (290663 and 290662) had total depths between 43 and 60 ft below ground surface (bgs), while the third observation well (290557) was completed at a total depth of 18 ft (table 2). The driller's log for well 290557 included more gravel, cobbles, and coarse sand with clay bound to gravel from 14 to 18 ft bgs. Groundwater ranged between 7.5 and 11 ft bgs from late October 2015 through early June 2016.

2.1.4 Hydrologic Features

The primary hydrologic feature is Lolo Creek, located about 490 ft south of the pumping well (fig. 2). An irrigation ditch (Delaney Ditch) is located about 45 ft south of the pumping well. The ditch was dry during the test.

Table 2. Landquist site well information for 193691 test.

GWIC ID	Name	Diameter (in)	Well Depth (ft)	Screened Interval (ft-bgs)	Distance from PW (ft)	Max Drawdown (ft)
193691	LQDom	6	60	Open Bottom	0	12.33
290663	LQ22	2	48	43-48	40	1.72
290662	LQ23	2	55	50-55	60	1.83
290557	LQ25	2	18	13-18	285	0.00

2.2. Field Procedure

2.2.1 Monitoring Locations

Each well is partially penetrating and completed in the floodplain deposits. Well 290663 was screened from 43 to 48 ft bgs, well 290662 was screened from 50 to 55 ft bgs, and well 290557 was screened from 13 to 18 ft bgs (table 1). In addition to the wells, a staff gage (288443) was installed in Lolo Creek (fig. 2).

2.2.2 Data Collection

Each monitoring location was equipped with a transducer. These data were used to ascertain if there were any pre- or post-pumping water-level trends. Before the test, the transducers were programmed to record background water levels and temperature every hour. They were reprogrammed to record every minute during the aquifer test and recovery period. Manual depth to water measurements were taken at a frequency shown in table 3 in case of transducer failure. Transducer data are available in GWIC, though the manual measurements were not recorded there. A totalizing flow meter installed on the well discharge line tracked the total amount of water pumped and was used to calculate the flow rate. Periodic manual discharge measurements were taken and did not vary from the discharge recorded from the totalizer.

A step-drawdown test was performed on March 26, 2018, 1 d prior to the constant-rate test, to determine an appropriate pumping rate. Four steps were conducted at discharge rates of about 44, 50, 60, and 80 gpm. Each of the first three steps lasted about 1 h, and the last step lasted only a few minutes, as the pumping water levels were declining rapidly. Water levels fully recovered prior to the start of the constant-rate test. The pumped water was discharged to Lolo Creek downgradient of the test site.

The constant-rate aquifer test began March 27, 2018 at 8:25 am and continued for 72 h at a time-weighted average of 54 gpm. Recovery was monitored for 72 h, until April 2, 2018 at 9:30 am. All wells recovered to between 99 and 100% of pre-pumping levels by the end of the recovery period (fig. 3).

2.3. Results

The time-weighted average pumping rate of 54 gpm was used for the test analysis. Water levels monitored during the test indicated the capture zone intersected Lolo Creek; therefore, a constant-head boundary was used for the drawdown data analysis. There were not any measurable water-level trends after pumping ceased or after recovery in wells 193691, 290662, and 290663. There was a rising trend in well 290557 due to increasing stream stage, but the trend did not require removal for analysis as the water levels were not influenced by pumping, indicating a confining unit in this area.

2.3.1 Hydrographs

Figure 3 shows the pumping and observation well hydrographs for 1 d prior to pumping, during the 72 h pumping interval, and for 3 d of recovery. The stage values for Lolo Creek are also presented to demonstrate that there was no observable influence to stage due to pumping (fig. 3). Table 2 includes the maximum drawdown for each well.

2.3.2 Aquifer Properties

A Theis curve (1935) analysis for confined aquifers was performed on the drawdown data to estimate

Table 3. Manual water-level measurement frequency.

Time since Start of Test	Frequency of Manual Measurements
0–5 min	Pumping well as frequently as possible Others monitoring wells, when possible
5–60 min	5 min
1–2 h	10 min
2–4 h	15 min
4–8 h	30 min
8–16 h	1 h
>16 h	4 h

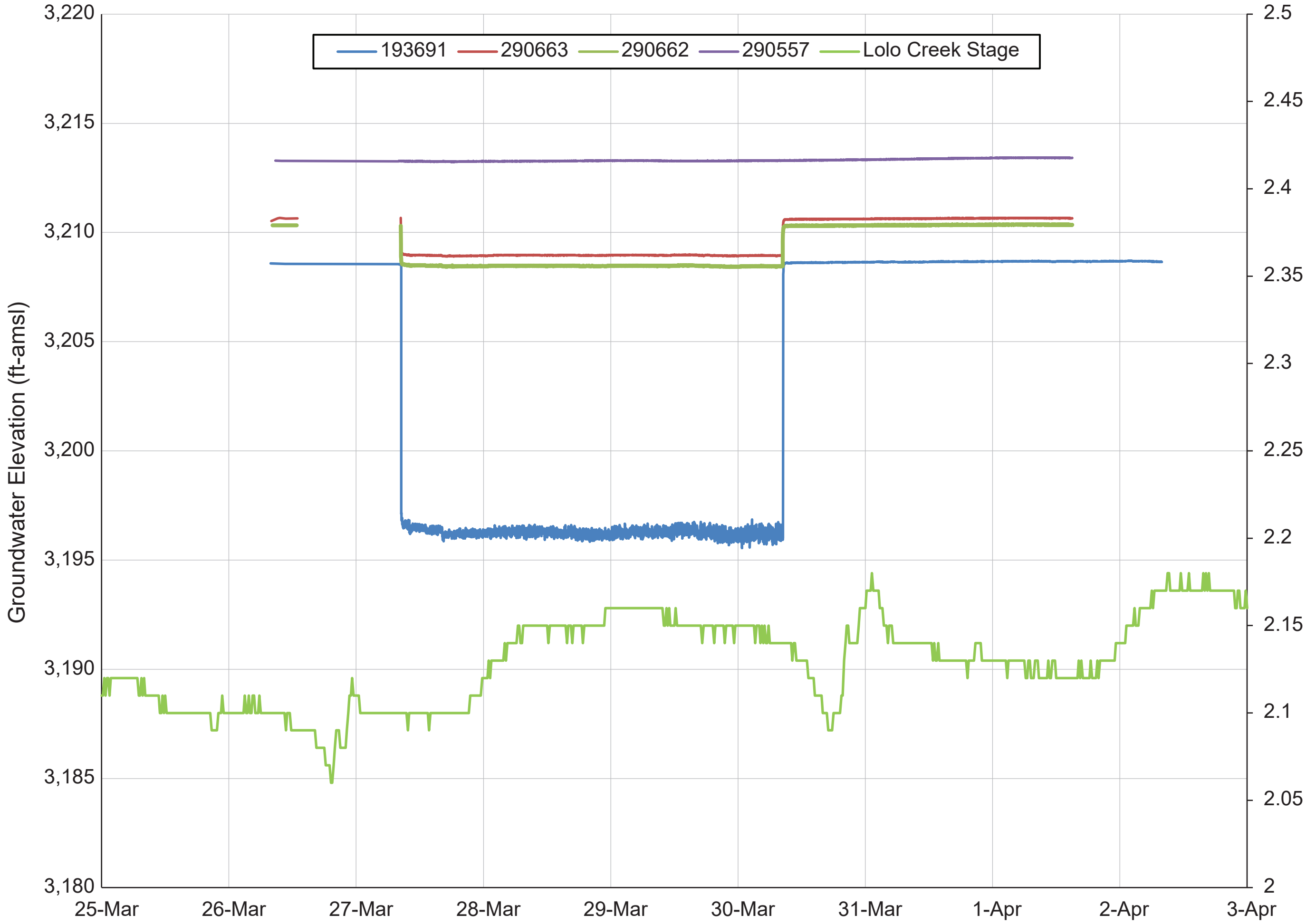


Figure 3. Hydrographs for the 193691 test.

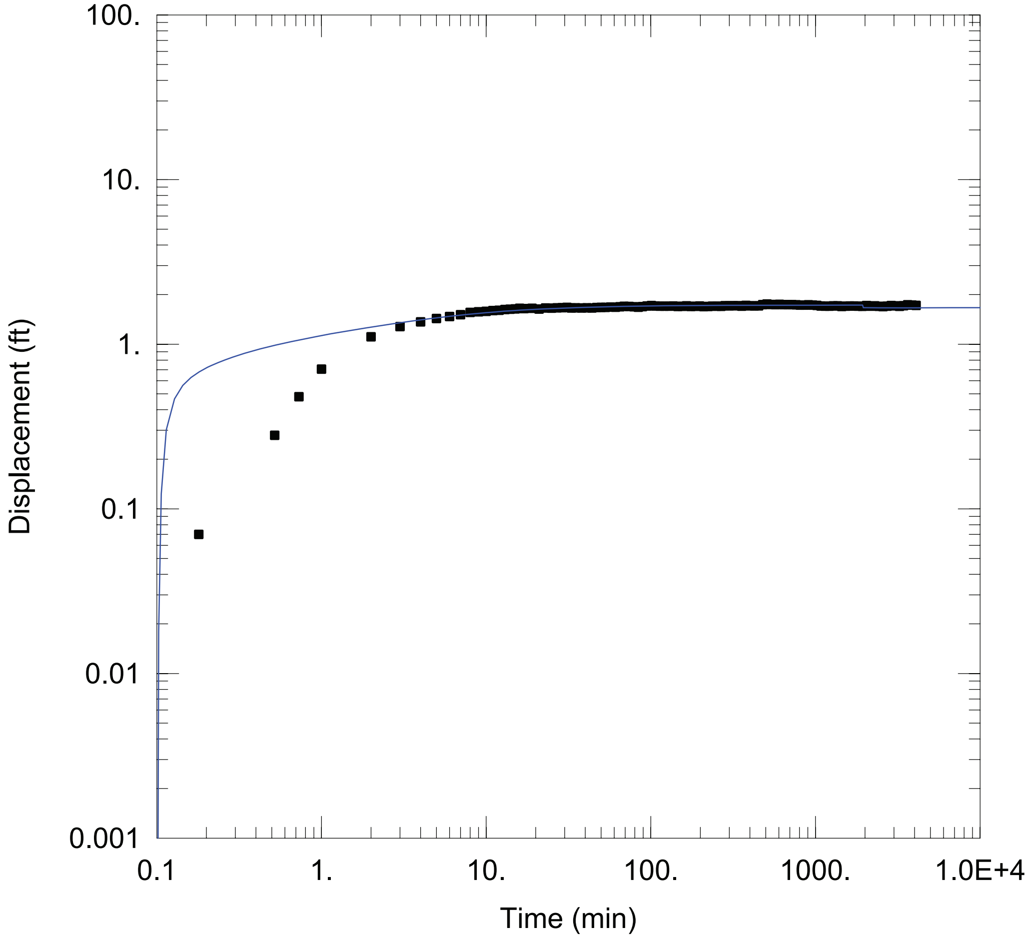
transmissivity and storativity values (table 1, figs. 4–5). As a result of the cone of depression intersecting Lolo Creek, a constant-head boundary was applied to the Theis solution to match the drawdown data.

Assuming an aquifer thickness between 50 and 60 ft (based on lithology), the hydraulic conductivity ranges from 37 to 87 ft/d (table 1). This range falls within sand and gravel mixes (Fetter, 1994), though it is considered high with the clay reported in the well logs.

Storativity estimated for the confined aquifer was 0.0003 for well 290663 and 0.00005 for well 290662. For confined systems, the range of storativity is typically 0.005 or less (Fetter, 1994).

2.4. Summary

Based on the drawdown data and Theis analysis, the cone of depression intersected Lolo Creek (about 420 ft to the SSW of the pumping well). However, the pumping influence was not great enough to be measured directly through stage or discharge measurements. The hydraulic conductivity estimates are within the range of sand and gravel aquifers, but are relatively high in light of the clay reported in the well logs. The storativity, 0.0003 and 0.00005, indicates a confined aquifer.



WELL TEST ANALYSIS

Data Set: M:\...\AqtwLQ_Dom_LQ22_Auto_filtered_constant head_tm.aqt
Date: 09/29/21 Time: 13:54:39

PROJECT INFORMATION

Company: MBMG
Client: Lolo Creek
Project: BWIPLO
Location: Lolo Creek Montana
Test Well: LQWELL
Test Date: 3/26/2018

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
LQ Dom	0	0

Observation Wells

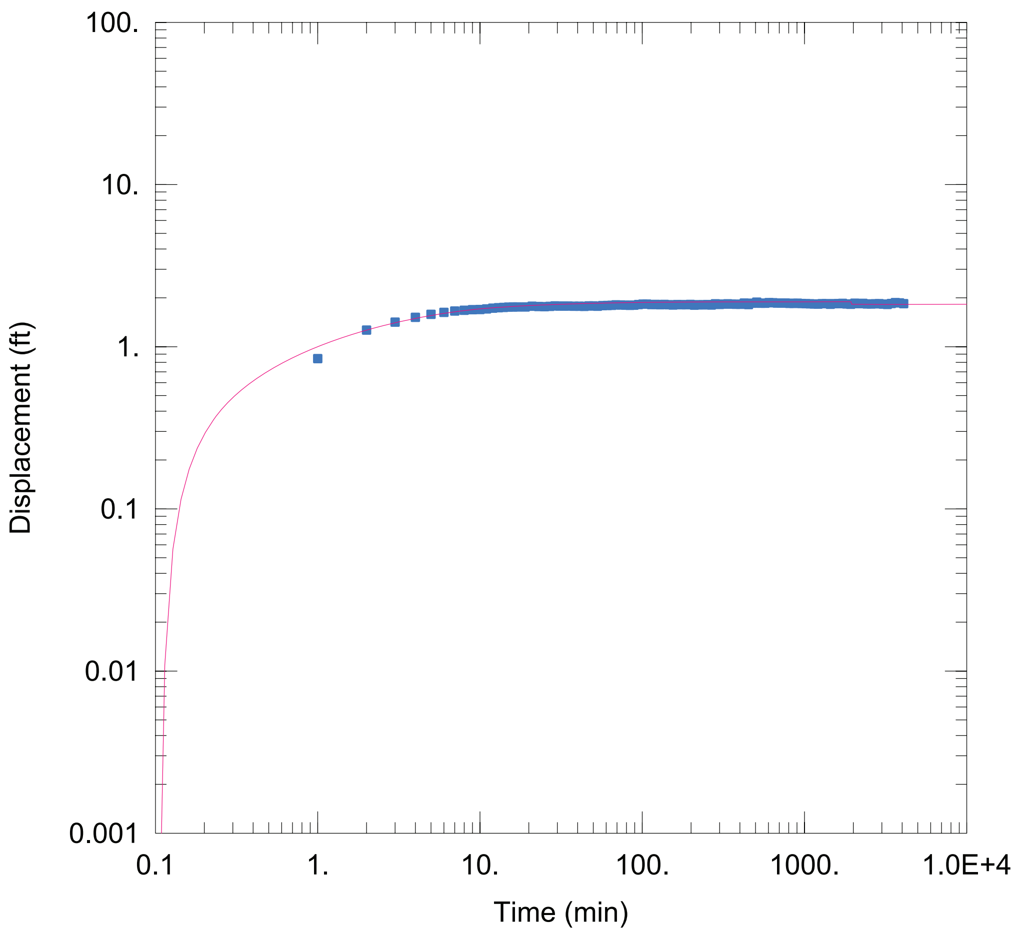
Well Name	X (ft)	Y (ft)
▪ LQ22	-6	-11

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

T = 4345.8 ft^2/day
S = 0.0002662
Kz/Kr = 1.
b = 100. ft

Figure 4. Theis analysis for observation well 290663.



WELL TEST ANALYSIS

Data Set: M:\...\AqtwLQ_Dom_LQ23_Auto_filtered_constant head.aqt
Date: 09/29/21 Time: 13:52:13

PROJECT INFORMATION

Company: MBMG
Client: Lolo Creek
Project: BWIPLO
Location: Lolo Creek Montana
Test Well: LQWELL
Test Date: 3/26/2018

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
LQ Dom	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▪ LQ23	63	21

SOLUTION

Aquifer Model: Confined

Solution Method: Theis

T = 2200.6 ft^2/day

Kz/Kr = 1.

S = 5.351E-5

b = 100. ft

Figure 5. Theis analysis for observation well 290662.

3.0 REFERENCES

Fetter, C.W., 1994, Applied hydrogeology: Upper Saddle River, N.J., Prentice-Hall, 598 p.

Gebril, A., and Sutherland, M., in preparation, Hydrologic investigation of the end reach of Lolo Creek Valley, Montana.

Theis, C.V., 1935, the relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage: American Geophysical Union Transactions, v. 16, p. 519–524.