HYDROLOGICAL ASSESSMENT OF PROPOSED EXPLORATION DECLINE BLACK BUTTE COPPER PROJECT

Prepared for:

Tintina Alaska Exploration
Suite 1723 - 595 Burrard Street
Vancouver, BC, Canada V7X1G4

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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1.0 INTRODUCTION

Hydrometrics conducted a hydrological assessment of the proposed exploration decline for the Black Butte Copper Project. The purpose of the assessment was to estimate potential inflows to the proposed exploration adit and to establish baseline water quality for groundwater in the geologic formations the adit will penetrate. The results will be used in development of the decline and future permitting.

The scope of the assessment consisted of installation of two test wells along the path of the proposed exploration decline, aquifer testing of the wells, sampling and analysis of groundwater quality at the adit completion depths, and evaluation of hydrologic characteristics of the bedrock and potential adit inflows based on test results.

1.1 SITE BACKGROUND

The Black Butte Copper Project is located approximately 16 miles north of White Sulphur Springs, Montana in Meagher County (Figure 1). The project is in the exploration phase of a potential underground copper-cobalt-silver mine and is collecting initial baseline data to be used in project development and future permitting. The ore body consists of a massive sulfide deposit within the Newland Formation of the Belt Supergroup. The Newland Formation can be divided into a lower member that consists of primarily dolomitic shale and an upper member of interstratified shales and carbonates (Nelson, 1963).

The length of the proposed exploration adit is approximately 5200 feet (a horizontal distance of 5000 feet) and is divided into two segments. The first segment trends north-northwest and declines approximately 460 feet in elevation over a distance of approximately 3200 feet. This segment of the adit passes beneath Coon Creek at a depth of approximately 90 feet and ultimately reaches a depth of approximately 250 feet below ground surface (BGS) at its lower end. The adit then turns to the northwest and the second segment continues at a fixed elevation for an additional 1800 feet. The location of the exploration adit is shown in Figure 2. The adit is shown in a geologic cross-section in Figure 3.

2.0 HYDROGEOLOGIC INVESTIGATION

Hydrometrics conducted the hydrologic field investigation from March through May, 2012. The field investigation and methods used for well installation, aquifer testing and water quality analyses are described Sections 2.1, 2.2 and 2.3, respectively.

2.1 WELL INSTALLATION

Two new wells (PW-3 and PW-4) were installed and tested for this investigation. The locations of the test wells and monitoring wells are shown on Figure 2. H & L Drilling was contracted to drill the wells using air-rotary drilling techniques. All drilling was supervised by a qualified scientist or engineer, with detailed lithologic and construction logs recorded on field forms and a project field book. Well locations and measuring point elevations were surveyed by Tintina using a survey grade GPS. Well completion details are described in Section 3.1 of this report.

2.2 AQUIFER TESTING

Forty-eight hour pumping tests were conducted at test wells PW-3 and PW-4 to establish aquifer characteristics for the bedrock units that would be encountered along the path of the proposed exploration adit. Datalogger transducers were installed in the two wells (PW-3 and PW-4), and also in nearby observation wells (MW-1B and MW-2B), as well as in an exploration borehole along the trace of the exploration adit (SC12-115). Background water level data was collected at 30-minute intervals from November 11 to November 15. A separate Barologger was used to collect barometric pressure changes throughout the background monitoring period, pumping tests, and recovery tests. Water level data collected from transducers were corrected for barometric changes. Manual water levels were also collected from the wells with dataloggers and in other surrounding wells. Observation points used in the pumping tests are listed in Table 1 and shown in Figure 2.

TABLE 1. PUMPING TEST OBSERVATION POINTS

Obs. Point	Northing	Easting	Measuring Point Elevation (feet)	Distance from PW-3 (feet)	Distance from PW-4 (feet)	Instrumentation
	UTM Zone 12 North					
MW-1A	506935	5180842	5637.73	1083	475	None
MW-1B	506934	5180845	5637.9	1093	486	Datalogger
MW-2A	506598	5180332	5745.31	871	1411	None
MW-2B	506597	5180329	5745.53	880	1420	Datalogger
MW-3	506484	5180740	5762.17	1289	1268	None
PW-1	506301	5180698	5913.74	1721	1810	None
PW-2	506443	5180865	5791.28	1622	1481	None
PW-3	506846	5180479	5657.42	0	610	Datalogger
PW-4	506897	5180691	5680.02	610	0	Datalogger
SC12-115	506951	5180297	5860.99	697	1189	Datalogger
SC12-116	507030	5180380	5793.89	686	475	None

The 48-hour pumping test at PW-3 was initiated on May 8, 2012 at 2:05 p.m. Water level measurements at PW-3 were collected at log intervals using the datalogger/transducer system and manual water levels were collected regularly to confirm transducer readings. A short step test was initially conducted to identify a suitable pumping rate for testing and then pumping was continued at a constant rate of 27 gpm for the duration of the test. Discharge rates during the pumping test were monitored using both a digital flow meter (Omega paddle wheel) and through manual measurement. Water from the test well was piped through a 2-inch line to an infiltration trench located approximately 3000 feet to the southwest (Figure 2). A water quality sample was collected prior to completion of the pumping test and the test was terminated on May 10, 2012 at 4:15 p.m.

The pumping test at PW-4 was initiated on May 15, 2012 at 2:53 p.m. Pumping rates were adjusted between 1 gpm and 6 gpm in order achieve an optimum pumping rate for the test.

Very small adjustments in the discharge flow rate produced substantial changes in drawdown in the well. As a result it was necessary to make several adjustments over the course of the test to achieve a pumping rate that adequately stressed the well without completely dewatering it by the end of test period.

Water from the test well was piped through a 2-inch line to an infiltration trench located approximately 3500 feet to the southwest (Figure 2). A water quality sample was collected prior to completion of the pumping test and the test was terminated on May 17, 2012 at 3:25 p.m.

2.3 WATER QUALITY ANALYSES

Water samples were submitted to Energy Laboratories in Helena, Montana for analysis of physical parameters, common constituents, nutrients, and a comprehensive suite of trace constituents as listed in Table 2.

TABLE 2. ANALYTICAL METHODS AND DETECTION LIMITS FOR GROUNDWATER SAMPLES

Parameter	Analytical Method[1]	Project-Required Detection Limit (mg/L)
Physical Parameters		
TDS	SM 2540C	10
Common Ions		
Alkalinity	SM 2320B	4
Sulfate	300.0	1
Chloride	300.0/SM 4500CL-B	1
Fluoride	A4500-F C	0.1
Calcium	215.1/200.7	1
Magnesium	242.1/200.7	1
Sodium	273.1/200.7	1
Potassium	258.1/200.7	1
Nutrients		
Nitrate+Nitrite as N	353.2	0.01
Trace Constituents (Dissolved[2])		
Aluminum (Al)	200.7/200.8	0.03
Antimony (Sb)	200.7/200.8	0.003
Arsenic (As)	200.8/SM 3114B	0.003
Barium (Ba)	200.7/200.8	0.005
Beryllium (Be)	200.7/200.8	0.001
Cadmium (Cd)	200.7/200.8	0.00008
Chromium (Cr)	200.7/200.8	0.001
Cobalt (Co)	200.7/200.8	0.01
Copper (Cu)	200.7/200.8	0.001
Iron (Fe)	200.7/200.8	0.03
Lead (Pb)	200.7/200.8	0.0005
Manganese (Mn)	200.7/200.8	0.005
Mercury (Hg)	245.2/245.1/200.8/SM 3112B	0.00001
Molybdenum (Mo)	200.7/200.8	0.005
Nickel (Ni)	200.7/200.8	0.01
Selenium (Se)	200.7/200.8/SM 3114B	0.001
Silver (Ag)	200.7/200.8	0.0005
Strontium (Sr)	200.7/200.8	0.1
Thallium (Tl)	200.7/200.8	0.0002
Uranium	200.7/200.8	0.0003
Zinc (Zn)	200.7/200.8	0.01
Field Parameters		
Stream Flow	HF-SOP-37/-44/-46	NA
Water Temperature	HF-SOP-20	0.1 °C
Dissolved Oxygen (DO)	HF-SOP-22	0.1 mg/L
pH	HF-SOP-20	0.1 s.u.
Specific Conductance (SC)	HF-SOP-79	1 µmhos/cm

(1) Analytical methods are from *Standard Methods for the Examination of Water and Wastewa*ter (SM) or EPA's *Methods for Chemical Analysis of Water and Waste* (1983).

(2) Samples to be analyzed for dissolved constituents will be field-filtered through a 0.45 µm filter.

3.0 FIELD INVESTIGATION RESULTS

3.1 WELL INSTALLATION

The well completion details for test wells PW-3 and PW-4 are summarized in Table 3 and well logs are included in Appendix A.

TABLE 3. WELL COMPLETION DETAILS

Well Name	Easting (meters)	Northing (meters)	G.S. Elev. (feet amsl)	M.P. Elev. (feet amsl)	Total Depth (feet, bgs)	Perforated/ Screen Interval (feet, bgs)	Filter Pack Interval (feet, bgs)
	UTM Zone 12 North						
PW-3	506846	5180479	5655.2	5657.42	131	90-127	80-130
PW-4	506897	5180691	5678.1	5680.02	242	200-239	191-242

PW-3 was completed with a well screen at the depth of the proposed exploration adit. The well is screened from 90 to 127 feet below the ground surface (bgs) within a sequence of non-dolomitic and dolomitic black shales of the lower Newland Formation. The upper portion of the borehole was advanced through approximately 20 feet of unconsolidated alluvial deposits overlying lower Newland Formation black shale. The upper 50 feet of the borehole produced very little water at the time of drilling (less than 1 gpm). The lower portion of the borehole produced 15 to 18 gpm at the time of drilling but yielded up to 27 gpm during the subsequent pumping test (described in more detail in Section 3.2).

Test well PW-4 was completed to the north of PW-3 on the hillside behind the existing ranch house. The borehole was advanced through brownish orange sandy-gravely clay from 0 to 50 feet bgs and through coarser grained sand and gravel to a depth of 118 feet bgs. Neither of these shallow unconsolidated deposits produced significant groundwater inflow during drilling. Bedrock was encountered at a depth of 118 feet bgs composed of gray to black shale with some intermixed tan to light gray siltstone and very fine quartzite sandstone. The bedrock from 118 to 130 feet bgs produced approximately 30 gpm of groundwater inflow during drilling. Below this depth the borehole encountered lower Newland Formation black shales to the completion depth of 242 feet. Reported flow rates varied slightly as the borehole was advanced below 130 feet but there was no significant increase in groundwater inflow. Once the upper borehole was cased-off and the annular space was sealed, there was minimal inflow to the well from the deeper strata.

Both test wells were completed with 6-inch steel casing within a 10-inch oversized borehole. The borehole annulus was backfilled with gravel from the well bottom to at least 10 feet above the top of the well screen. The remaining borehole annulus was backfilled with bentonite gel to seal the borehole annulus and prevent vertical migration of fluids between the well casing and the borehole walls. All well construction and grouting details were consistent with State of Montana water well construction regulations (ARM 36.21.600). The test wells were developed with air for 1 hour after well completion. PW-3 made approximately 18 gpm during well development, and PW-4 made approximately 1 gpm.

3.2 AQUIFER TESTING

Water level data collected prior to the aquifer tests were measured to evaluate background water level trends. Water level data for the wells/boreholes showed variable background fluctuations in water levels from 0.3 feet up to 1.2 feet with gradually increasing trends prior to the start of the pumping test in most of the wells.

The PW-3 pumping test produced 70 feet of drawdown in the pumping well at a pumping rate of 27 gpm and approximately 20 feet of drawdown at exploration borehole SC12-16, which is located along the alignment of the exploration decline approximately 700 feet to the southeast of the test well. PW-4, which is located a similar distance to the northeast along the path of the decline showed only 3.5 feet of drawdown. No drawdown was noted at the remaining monitoring wells. MW-1B and MW-2B had increasing water levels during the test. MW-2B showed some sporatic water level fluctuations during and after the conclusion of the test, but these appear to correlate with nearby exploration drilling activity. There was no measurable change in stage or flow in Coon Creek during the pumping test based on periodic flow and stage measurements at the mouth of Coon Creek. Drawdown graphs from the PW-3 pumping test are shown in Figure 4.

The PW-4 pumping test produced 120 feet of drawdown in the pumping well at a pumping rate of 2.7 gpm with no observable drawdown in surrounding monitoring wells. Drawdown graphs from the PW-4 pumping test are shown in Figure 5.

3.2.1 Aquifer Test Analyses

Step tests results provide a means to identify the extent to which well and formational losses may be influencing drawdown trends from pumping tests, and therefore help in the interpretation of pumping test results. In theory drawdown is directly proportional to the pumping rate (i.e., doubling the pumping rate should double the drawdown). In practice, there may be additional well loss or formational losses if turbulent flow conditions develop. This is often a factor in bedrock fracture flow systems if high flow velocities develop within the fractures. Drawdown results from the pumping tests at PW-3 and PW-4 both showed disproportional increases in drawdown as pumping rates were increased. Analysis of the step drawdown data based on methodology developed by Jacob (1947) indicates significant non-linear drawdown effects and “efficiencies” around 20% (see calculations in Appendix B). The low efficiency is likely due to formational losses related to fracture flow, since the gravel pack construction of the wells should not produce turbulent flow. When there are significant non-linear drawdown effects indicated, recovery test data and observation well hydraulic conductivity solutions typically provide the most reliable results.

Aquifer test results were analyzed using AQTESOLV (v.4.01) to calculate aquifer transmissivities, hydraulic conductivities and storage coefficients. Analyses were performed using several analytical solutions including the Theis (1935) solution for confined aquifers, the Theis recovery solution, the Hantush-Jacob (1955) solution for leaky confined aquifers and the Moench (1984) dual porosity solution for fractured rock systems. Curve-matching graphs for PW-3, PW-4 and SC12-16 are included in Appendix B.

Both PW-3 and SC12-116 yield similar hydraulic conductivity estimates for the PW-3 pumping test, with estimated hydraulic conductivity values ranging from 1.1 to 2.2 feet/day. Results are summarized in Table 4 and drawdown graphs showing calculated transmissivities and storage coefficients are included in Appendix B. As previously discussed, recovery solutions and observation well results tend to be more reliable when step test data show non-linear well loss effects. In this case however, observation well results and recovery solutions yielded similar results.

TABLE 4. CALCULATED HYDRAULIC CONDUCTIVITY FROM AQUIFER TEST RESULTS

Pumping Test Well	Obs. Well	Hydraulic Conductivity (ft/day)			
		Confined Solution		Leaky-Confined Solution	Bedrock Solution
		Theis	Theis recovery	Hantush-Jacob	Moench
PW-3	PW-3	2.1	1.1	2.2	1.6
	SC12-116	1.2	1.7	1.1	1.3
PW-4	PW-4	0.016	0.017	0.010	0.010

The calculated hydraulic conductivities assume a 50 foot aquifer thickness, which is the approximate thickness of the producing zone in the shallow aquifer at PW-3. A similar thickness is assumed at SC12-16, since no flow data was recorded in this exploration borehole. The average hydraulic conductivity of approximately 1.5 feet per day is representative of a moderately fractured bedrock aquifer (Freeze and Cherry, 1979).

During the PW-3 pumping test, PW-4 exhibited much less drawdown than SC12-16 despite the fact that they are similar distances from the pumping well. The decreased drawdown at PW-4 could be attributed to recharge from Coon Creek, which lies between PW-3 and PW-4. The PW-4 drilling results and aquifer test results, however, suggest the lower drawdown response at PW-4 is the result of a decrease in hydraulic conductivity of the bedrock at the PW-4 completion depth. During drilling, PW-4 exhibited higher groundwater inflow rates when the borehole was advanced through the equivalent depth interval of PW-3 (130 feet), but produced much lower inflow rates at the final completion depth (242 feet). PW-4 also produced much lower yields during testing than PW-3 indicating a significant decrease in hydraulic conductivity. Since these solutions assume relatively homogeneous conditions between the pumping and observation wells, hydrologic characteristics of the aquifer at PW-4 were determined from pumping test results at that location rather than test results from PW-3.

The drawdown and recovery responses for the PW-4 pumping test were analyzed in a similar fashion as PW-3. The analysis of PW-4 drawdown yielded hydraulic conductivity estimates of approximately 0.01 to 0.02 ft/day. The drawdown trend was variable during this test as it was necessary to adjust the pumping rate during the test to achieve optimal drawdown. Very small variations in pumping rates translated to large changes in drawdown response. As a result, a constant flow rate was not established until the second half of the pumping test. Despite fluctuating pumping rates, the Theis confined aquifer solution matches the general drawdown trend; however, water levels in the well stabilized and recovered somewhat faster than predicted by the Theis solution, which is likely due to well loss effects.

All of the solutions produce similar hydraulic conductivity estimates for PW-4. Results of the PW-4 aquifer test analyses are summarized in Table 4 and drawdown graphs are included in Appendix B. The resultant hydraulic conductivity estimate of 0.01 to 0.02 feet per day falls within in a typical range for competent bedrock (Freeze and Cherry, 1979).

3.3 WATER QUALITY RESULTS

Groundwater from both wells is a calcium/magnesium bicarbonate type water, with neutral pH (6.98 to 7.14 s.u.). The groundwater analytical results are summarized in Table 5.

Results from PW-3 are typical of the water quality observed in the shallow bedrock monitoring wells on site. The water quality is characterized by moderately high alkalinity and sulfate, and low concentrations of nitrate, arsenic and metals. The only metal that is present at an elevated concentration at PW-3 is iron, which exceeds aesthetic guidelines for drinking water based on recommended thresholds for taste and staining.

TABLE 5. LABORATORY ANALYTICAL RESULTS

	PW-3	PW-4	***Human Health Standard***
DATE	**5/10/2012**	**5/17/2012**	
FIELD PARAMETERS			
pH (s.u.)	6.98	7.14	--
Specific Conductance (µmhos/cm)	676	620	--
GENERAL PARAMETERS			
Total Dissolved Solids	448	403	--
COMMON IONS (mg/L)			
Alkalinity as CaCO3	280	230	--
Sulfate	120	120	--
Chloride	2	1	--
Fluoride	0.4	0.4	*4*
Calcium	76	81	--
Magnesium	43	37	--
Sodium	4	4	--
Potassium	3	2	--
NUTRIENTS (mg/L)			
Nitrate and Nitrite as N	<0.01	<0.01	*10*
DISSOLVED TRACE CONSTITUENTS (mg/L)			
Aluminum	<0.03	<0.03	--
Antimony	<0.003	<0.003	*0.006*
Arsenic	0.005	**0.067**	*0.01*
Barium	0.015	0.033	*1*
Beryllium	<0.001	<0.001	*0.004*
Cadmium	<0.00008	<0.00008	*0.005*
Chromium	<0.001	<0.001	*0.1*
Cobalt	<0.01	<0.01	--
Copper	<0.001	<0.001	*1.3*
Iron	**1.09**	**0.95**	*0.3 #*
Lead	<0.0005	<0.0005	*0.015*
Manganese	0.038	**0.073**	*0.05 #*
Mercury	<0.00001	<0.00001	*0.002*
Molybdenum	<0.005	<0.005	--
Nickel	<0.01	<0.01	*0.1*
Selenium	<0.001	<0.001	*0.05*
Silver	<0.0005	<0.0005	*0.1*
Strontium	0.22	**9.3**	*4*
Thallium	<0.0002	0.0008	*0.002*
Uranium	0.0013	0.0013	*0.03*
Zinc	0.09	0.45	*2*

Guidance value based on secondary aesthetic drinking water standards.

The deeper bedrock water chemistry from PW-4 is similar to PW-3 however it has higher concentrations of selected metals including arsenic, manganese strontium, thallium and zinc. The arsenic concentration at PW-4 of 0.067 mg/L exceeds the Human Health Standard of 0.010 mg/L. The strontium concentration of 9.3 mg/L also exceeds the Human Health standard of 4 mg/L. The iron and manganese concentrations exceed the recommended drinking water aesthetic guidelines for taste and staining. All of the remaining parameters meet applicable regulatory limits with most metals at concentrations below detection limits including cadmium, chromium, copper, mercury, nickel, selenium, silver and thallium.

4.0 ADIT INFLOW ANALYSIS

Analytical solutions were used to estimate rates of groundwater inflow into the proposed adit. These analytical solutions yield generalized predictions representing average inflow rates over time and are based on a large scale analysis of flow through the bedrock systems. The bedrock aquifers are assumed at a large scale to respond like an equivalent porous media. The results therefore do not assess the potential for short term variability in flow rates that may occur as fractures are encountered in the bedrock and initially dewatered. The flow rates predicted by these analytical solutions should be reasonably representative of average inflow rates over time, however for water management planning purposes provisions should be made to accommodate short term flow rates several times greater than the predicted averages.

4.1 ANALYSIS METHODOLOGY

The results of the hydrologic investigation were used to develop the adit inflow analysis. The potentiometric data from the investigation indicate that the initial 1700 feet of the decline is likely to lie above the regional water table as shown in the cross section depicted in Figure 3. Hydrologic characteristics at test well PW-3, located near Coon Creek are assumed to be representative of the next 1200 feet of adit decline, which penetrates the lower Newland formation above the orebody. Test results from PW-4 are assumed to be representative of the remaining 2300 feet of the decline that extends down through the orebody.

For purposes of assessing inflows, the adit was split into the three sections described above based on depth/permeability characteristics and hydrologic head over the adit. The hydrologic properties used to calculate inflows for each section of the adit are summarized in Table 6. The methods used to estimate the groundwater inflow rates are described below.

TABLE 6. HYDROLOGICAL PARAMETERS USED IN ADIT INFLOW ANALYSES

Units Penetrated by Adit	Distance from Portal (ft)	Hydraulic Conductivity (ft/day)	Specific Storage	Specific Yield (assumed)	Average Saturated Thickness (ft)	Average Head over Adit (ft)
Upper Newland Fm (above water table)	0’-1700’	--	--	--	0	0
Lower Newland Fm above Upper Sulfide Zone	1700’-2900’	1.5	$1.6x10^{-6}$	0.1	50	65
Upper Sulfide Zone and Lower Newland	2900’-5200’	0.015	$2.4x10^{-6}$	0.2	50	225

Groundwater inflow rates to the adit were calculated assuming homogenous/isotropic conditions. The calculations are based on linear flow and assume the water table does not drawdown below the adit. Steady state groundwater inflow rates to the adit are calculated using both Darcy’s Law and the Herth and Arndts (1973) solution.

Discharge to the adit can be calculated based on Darcy’s Law as follows:

$$Q=KAi$$

Where:

Q = steady state inflow (ft^3/day)

K = hydraulic conductivity (ft/day)

A = Area (ft^2) of the adit receiving seepage

i = hydraulic gradient at the seepage face.

The hydraulic gradient is the most difficult parameter to estimate as it can change considerably when the water table reaches the adit. The gradient is steep (approaching 1) close to the adit and is significantly less than 1 for most of the radius of influence. For this analysis a hydraulic gradient of one is assumed.

The Herth and Arndts (1973) empirical solution was also used to estimate the steady state groundwater inflow to the adit. This solution uses the difference in head in the proximity of the adit to the head at a distant point from the adit. To establish the proximity of heads at proximal and distant locations the drainage area was assumed to be four times as wide as the groundwater measures vertically (h2) as suggested by El Tani (1999). The Herth and Arndts solution estimates the groundwater inflow based on the following formula:

$$Q = \left[0.73+0.27* \frac{h_2-h_1}{h_2} \right] \frac{K}{D} (h_2^2-h_1^2)$$

Where:

Q = adit inflow (ft^3/day)
K = hydraulic conductivity (ft/day)
h_1 = head proximate to adit (feet)
h_2 = head distant to adit (feet)
D = distance from adit to h_2 (feet).

4.2 ADIT INFLOW RESULTS

The calculated groundwater inflow results for each section of the adit are shown in Table 8. The first 1700 feet of the adit will be above the regional water table and therefore should not receive any direct inflow from the groundwater system. This portion of the adit may, nevertheless, receive some seasonal seepage due to direct infiltration of snowmelt during the spring, however, since the overlying topography is steep with no well-defined drainages to concentrate runoff seasonal seepage inflow should be minimal.

The next section of the adit from 1700 feet to 2900 feet (distance from portal) is projected to have the highest rate of groundwater inflow receiving approximately 175 gpm to 615 gpm (Herth and Arndts vs Darcy’s Law estimates) of inflow from the shallow bedrock groundwater system.

As the adit continues downward it will encounter more competent, lower permeability bedrock and the predicted rate of groundwater inflow decreases significantly. The remainder of the adit is estimated to contribute less than 15 gpm of inflow.

TABLE 7. RESULTS OF INFLOW ANALYSIS

Section	**Herth and Arndts**	**Darcy's Law**
	(gpm)	
0-1700’	--	--
1700-2900’	175	614
2900-5200’	10	12
Total*	**190**	**630**

**Results rounded to two significant figures*

The flow rate estimated from Darcy’s Law solution is significantly higher than estimates using the Herth and Arndts solution. The difference is due to an assumed gradient of 1 for the Darcy’s Law analysis. This is a very conservative assumption. It assumes that the inflow never lowers the water table to the elevation of the adit, which would actually occur within a fairly short time frame in the shallow bedrock aquifer based on the aquifer test results. Therefore, the Darcy’s law flow estimate would be most representative of initial inflow rates. The flow range defined by these two solutions, therefore provide an estimate of the range of groundwater inflow rates that may be encountered in the adit over time. As previously discussed, for planning purposes these values should be regarded as average inflow estimates. The adit may have higher short-term inflow rates when localized fractures are encountered and dewatered.

These scenarios assume that grouting is not used to control inflows. Grouting can be employed as a contingency measure to manage inflows, particularly if necessary to reduce inflows where localized structures result in more highly fractured rock.

5.0 SUMMARY AND CONCLUSIONS

For purposes of hydrologic characterization, the evaluation adit can be divided into three sections. Based on water level data from existing wells, the first 1700 feet of the adit will be above the regional water table. While this portion of the adit could receive some seasonal seepage due to direct infiltration of snowmelt during spring runoff, groundwater inflow should be minimal or absent during most of the year.

The adit decline drops below the water table over the next 1200 feet where test wells show moderately fractured bedrock conditions. Aquifer test results indicate a hydraulic conductivity for the bedrock at this depth interval of approximately 1.5 feet/day. The majority of the groundwater inflow to the adit is expected to occur over this interval with inflows estimated to range from approximately 175 to 614 gpm assuming no grouting. Water quality results from the test well PW-3 indicates that ambient water quality in the shallow bedrock groundwater system over this interval is good, meeting applicable water quality standards with the exception of the aesthetic based secondary drinking water quality standard for iron.

As the adit drops deeper it penetrates the ore body and encounters much lower permeability bedrock. Aquifer test results indicate a hydraulic conductivity for the bedrock at this depth interval of approximately 0.015 ft/day. Calculated inflow to this lower section of the adit is less than 15 gpm. The major ion chemistry of the water at the lower portion of the adit is similar to the shallow groundwater system, however there are several metals at higher concentrations including arsenic, manganese strontium, thallium and zinc. The arsenic concentration of 0.067 mg/L exceeds the Human Health Standard of 0.010 mg/L and the strontium concentration of 9.3 mg/L exceeds the Human Health standard of 4 mg/L. The iron and manganese concentrations exceed the recommended drinking water aesthetic guidelines for taste and staining. All of the remaining parameters meet applicable regulatory limits with most metals at concentrations below detection limits including cadmium, chromium, copper, mercury nickel, selenium, silver and thallium.

The bedrock permeability determined from this investigation appears to be consistent with results of previous testing at other locations on the site, with higher permeability conditions present in the shallow bedrock system transitioning to significantly lower permeability with depth. Water quality data collected during this investigation also appear to be representative of baseline water quality trends observed in shallow bedrock and ore body monitoring wells on site (Hydrometrics, 2012).

The development of the evaluation adit may produce some ancillary water quality effects that need to be considered in development of a final water management plan. Typically mine water contains some ammonium-nitrate residuals and may also contain oil and grease residuals. In addition, the chemistry of the water in the adit may evolve over time as a result of dewatering the wall rock. These factors will need to be assessed further to identify specific water treatment needs and assess regulatory issues related to discharge of the water.

6.0 REFERENCES

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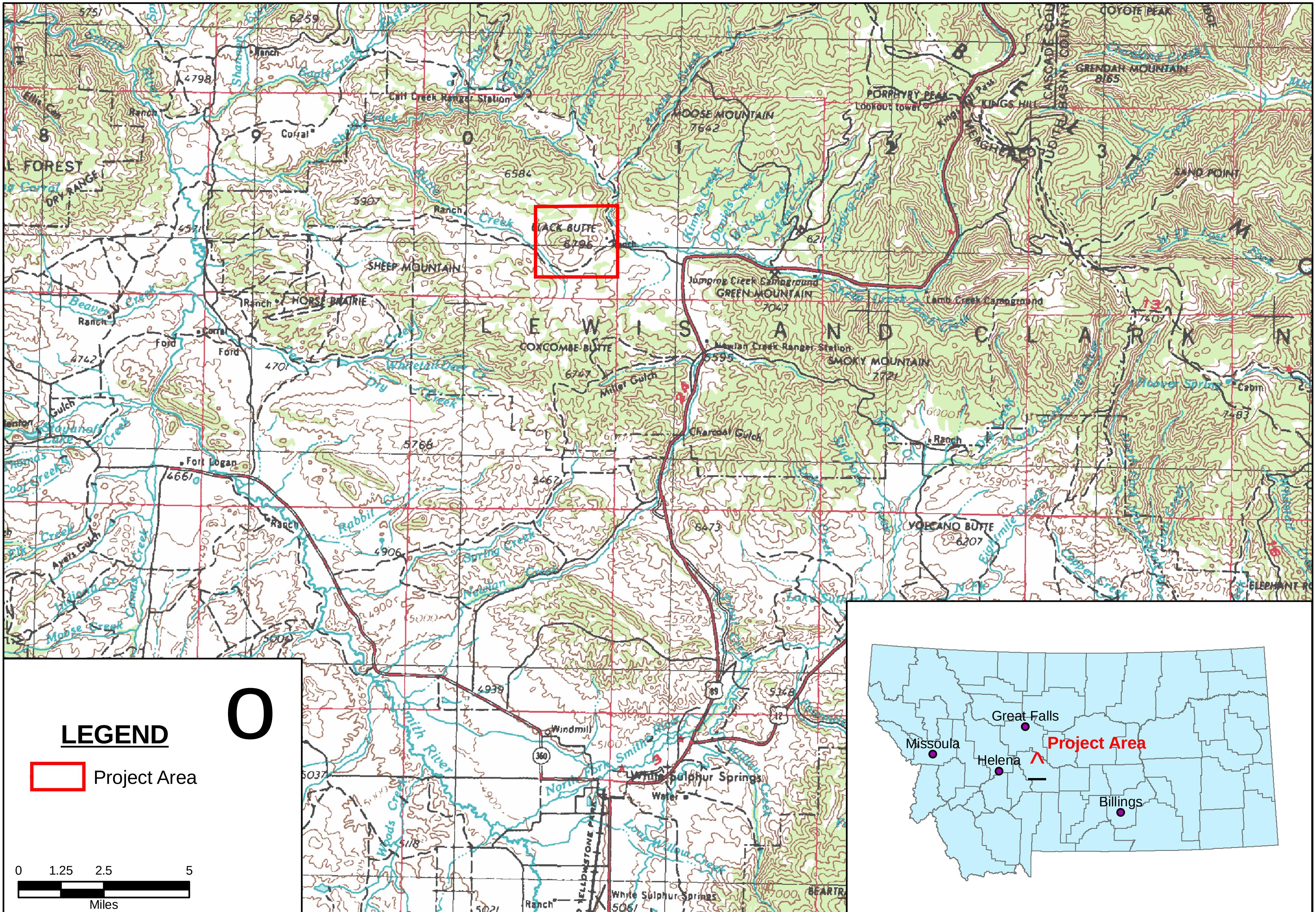
FIGURES



Hydrometrics, Inc.
Consulting Scientists and Engineers

Tintina Resources
Black Butte Copper Project
Meagher County, Montana

PROJECT LOCATION

FIGURE
1

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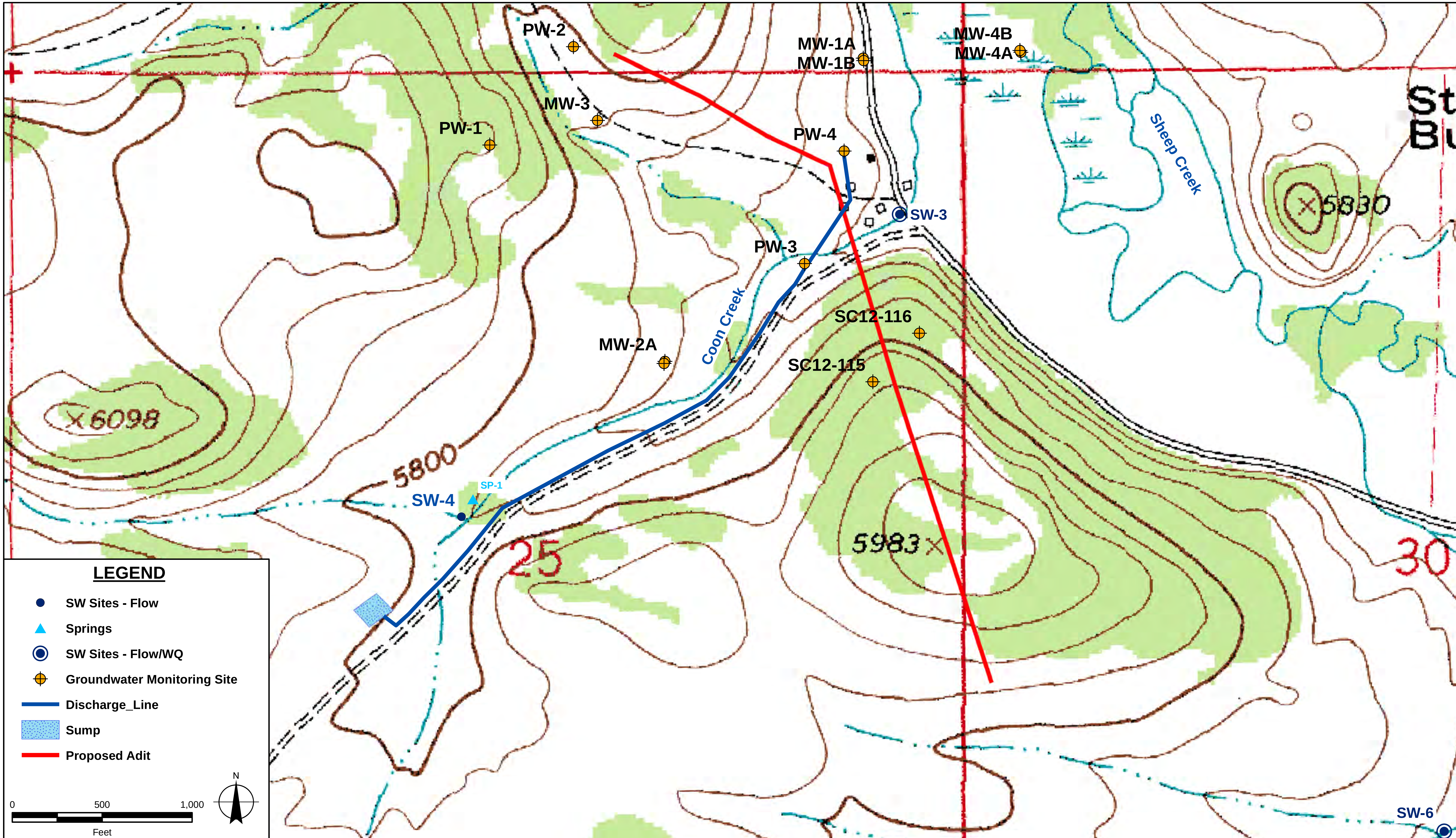

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Tintina Alaska Exploration Inc.
Black Butte Project
Meagher County, Montana

GROUNDWATER AND SURFACE WATER MONITORING SITES

FIGURE 2

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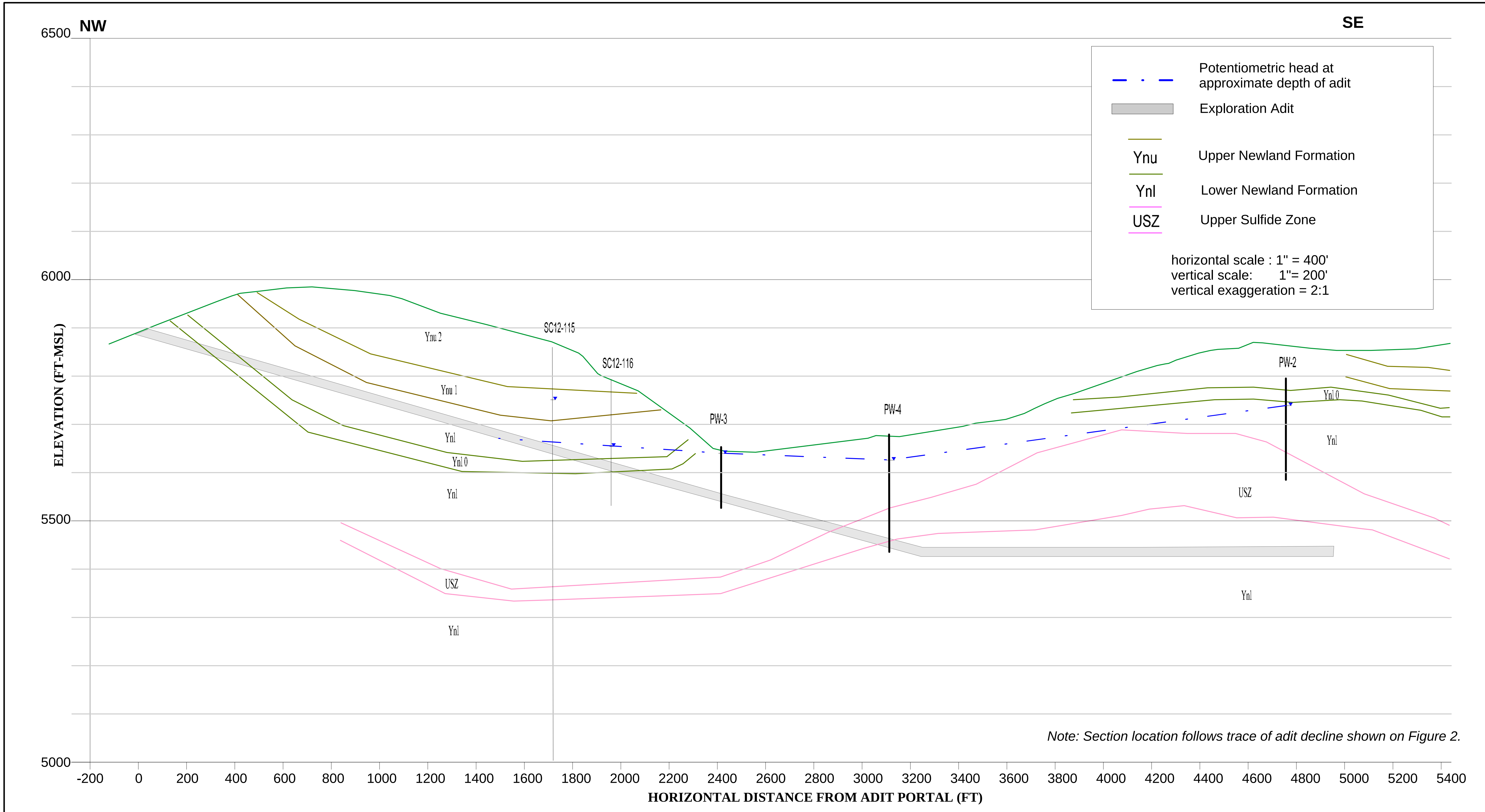

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TINTINA ALASKA EXPLORATION INC.
BLACK BUTTE PROJECT
HYDROLOGIC ASSESSMENT OF ADIT DECLINE

EXPLORATION DECLINE CROSS SECTION

FIGURE
3

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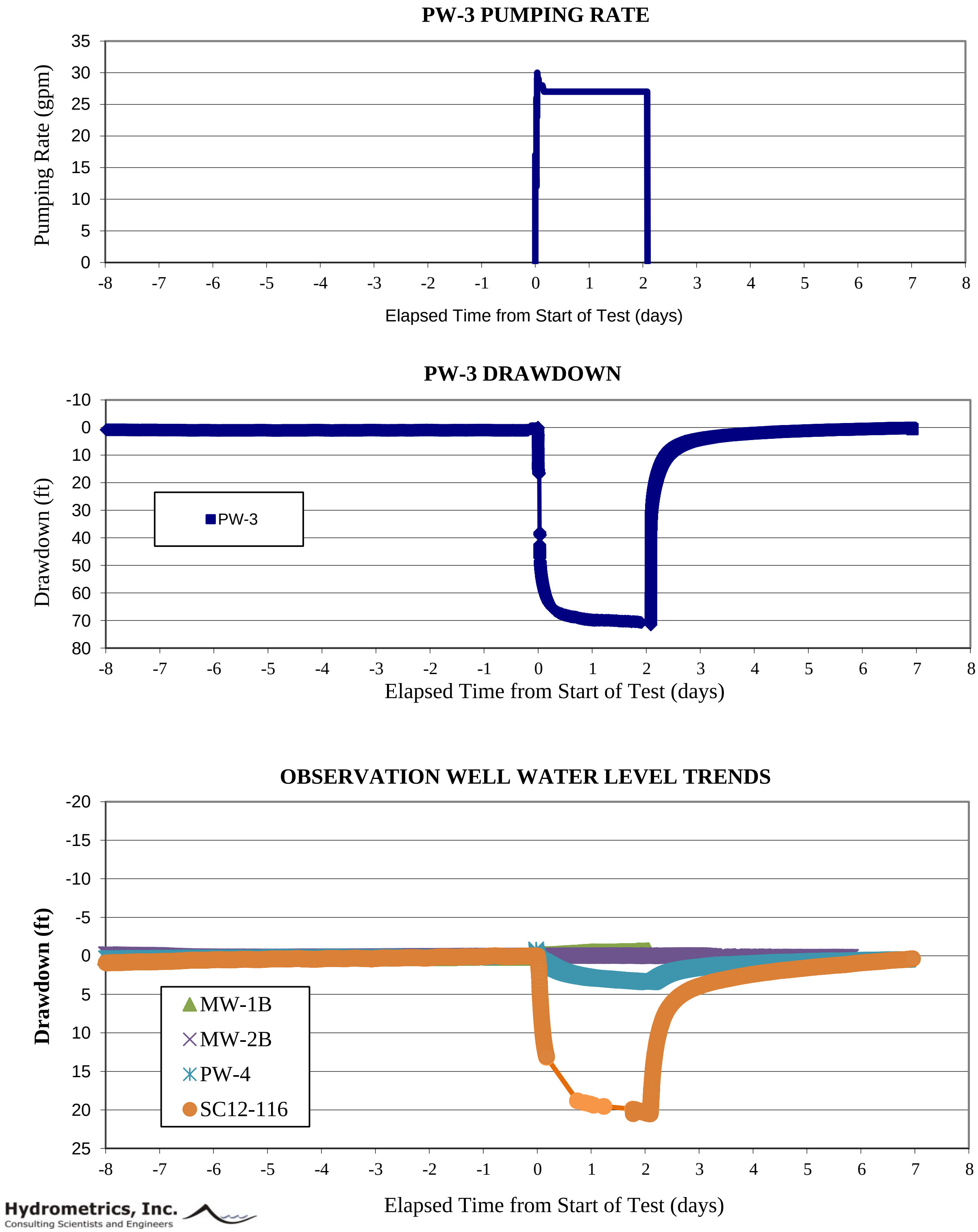
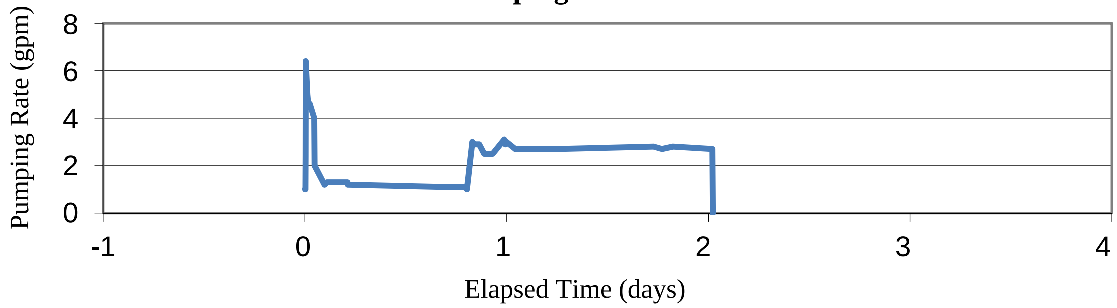
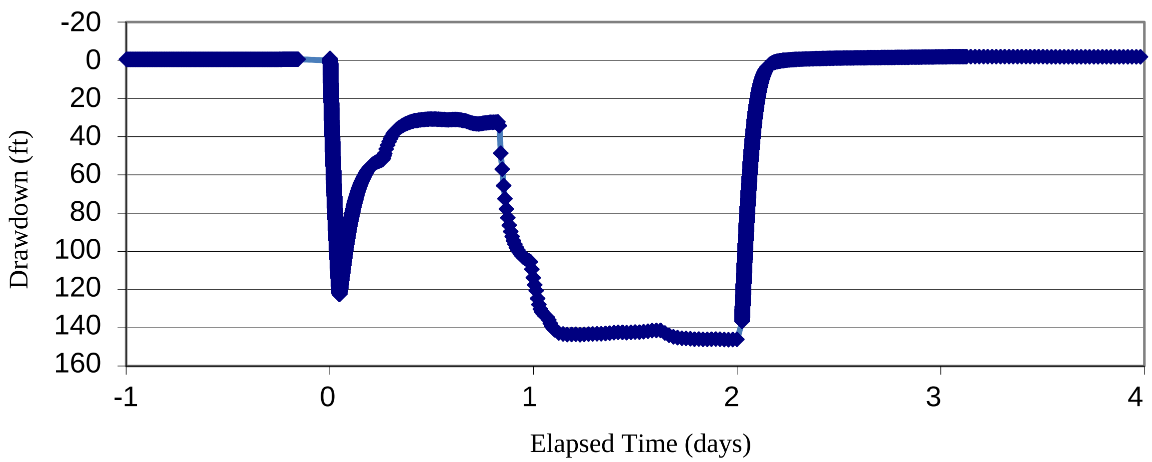


TINTINA ALASKA EXPLORATION INC. BLACK BUTTE PROJECT MEAGHER COUNTY, MONTANA	PW-3 AQUIFER TEST DRAWDOWN RESULTS	FIGURE 4

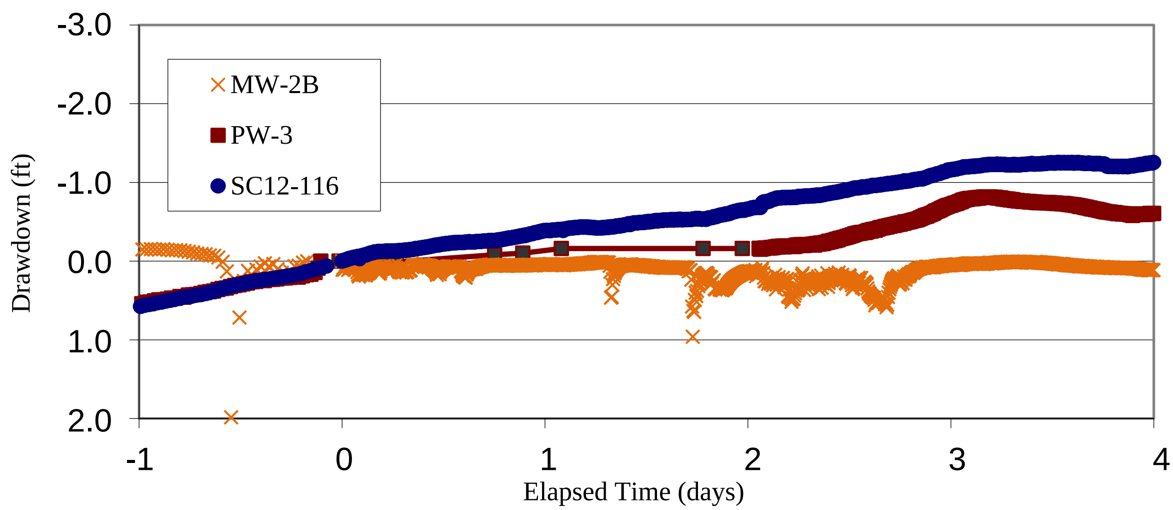
Pumping Rate



PW-4 Water Level Trend



Observation Well Water Level Trends



TINTINA ALASKA BLACK BUTTE PROJECT MEAGHER COUNTY, MT	PW-4 AQUIFER TEST RESULTS	FIGURE 5

APPENDIX A

WELL LOGS

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Hole Name: PW-3

Date Hole Started: 3/14/12 Date Hole Finished: 3/15/12

Client: Tintina Alaska Exploration Inc.
Project: Black Butte Copper Project
County: Meagher State: MT
Property Owner: Bar Z Ranch Inc
Legal Description: NW, NE, NE S25, T12N, R06E
Location Description: Middle section of proposed adit, near Coon Creek & SC11-057
Recorded By: Larry Johnson
Drilling Company: H&L Drilling
Driller: Derrick
Drilling Method: Air Rotary
Drilling Fluids Used: Water/Foam
Purpose of Hole: Aquifer Test Well
Target Aquifer: Bedrock
Hole Diameter (in): 10
Total Depth Drilled (ft): 131

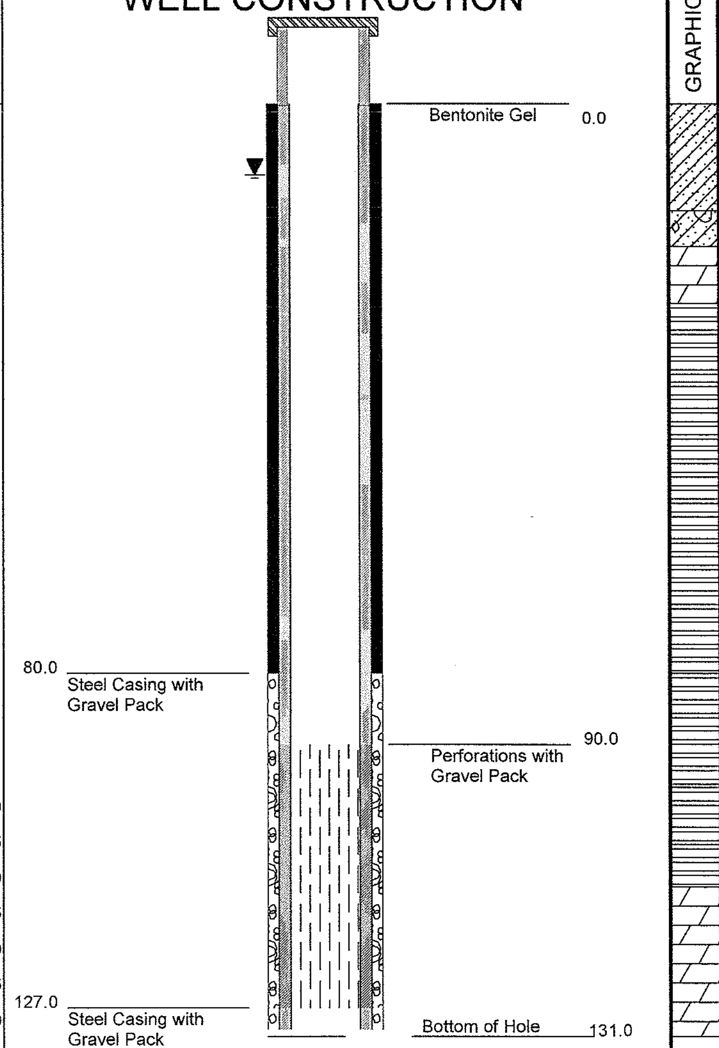
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	6-inch, steel casing	+2 to 130
Surface Casing Used?	Y	10-inch, steel casing	+2 to 27.5
Screen/Perforations?	Y	Perforated 6" Steel	90-127
Sand Pack?	Y	Gravel and 10/20 Silica Sand	Gravel:84-130 Sand:80-84
Annular Seal?	Y	Bentonite Grout	1-80
Surface Seal?	Y	Portland Cement	0-1
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Air for 1 hour	
Water Samples Taken?	Y	Commons, Nutrients, Metals	
Boring Samples Taken?	Y	Every 10 feet	

Northing: Easting:
Static Water Level Below MP: 12.0
Date: 3/15/12
MP Description: Top of Steel
MP Height Above or Below Ground (ft): 2
Surface Casing Height (ft):
Riser Height (ft): 2
Ground Surface Elevation (ft):
MP Elevation (ft):

Remarks:

WELL CONSTRUCTION

DEPTH: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135



GEOLOGICAL DESCRIPTION

0.0 - 15.0' Clayey, Sandy, Cobbles
Clayey sand with gravels to 1", trace black shale cobbles. Not making water.

15.0 - 20.0' Sandy, Gravel
Poorly sorted sandy gravel to 2" with black shale cobbles. Orange silty clay matrix. Not making water.

20.0 - 28.0' Dolomitic Black Shale
Highly fractured black shale with calcite veins. Orange silty clay matrix, effervesces. Hard drilling. At 24' made <1gmp.

28.0 - 39.0' Black Shale
Black shale with calcite veins on fractures. Some red oxidation and pyrite present.

39.0 - 48.0' Black Shale
Black shale with pyrite present. Little to no calcite present. Making <1 gpm. Water sample taken BBPW3-2 17:00

48.0 - 80.0' Black Shale
Black Shale with pyrite present as well as small veins of calcite. At 66' well made 5 gpm.

80.0 - 96.0' Black Shale
Black Shale with pyrite present as well as some fine bladed barite crystals. At 86' well made 5 gpm.

96.0 - 104.0' Black Shale
Black Shale pyrite on bedding and on fractures, some fine bladed barite crystals. At 96' bigger chips, possible fracture.

104.0 - 110.0' Black Shale
Lighter Black Shale, pyrite on bedding and fractures, some fine bladed barite crystals. At 106' well made 15 gpm (from possible fracture at 96')

110.0 - 131.0' Dolomitic Black Shale
Dolomitic Black Shale with calcite veins and pyrite on fractures and bedding. Effervesces. Makes 15-18gpm.

DOMESTIC_WELL2 K:\GINT\PROJECTS\11048.GPJ HYDHLN2.GDT 8/9/12

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Hole Name: PW-4

Date Hole Started: 3/16/12 Date Hole Finished: 3/21/12

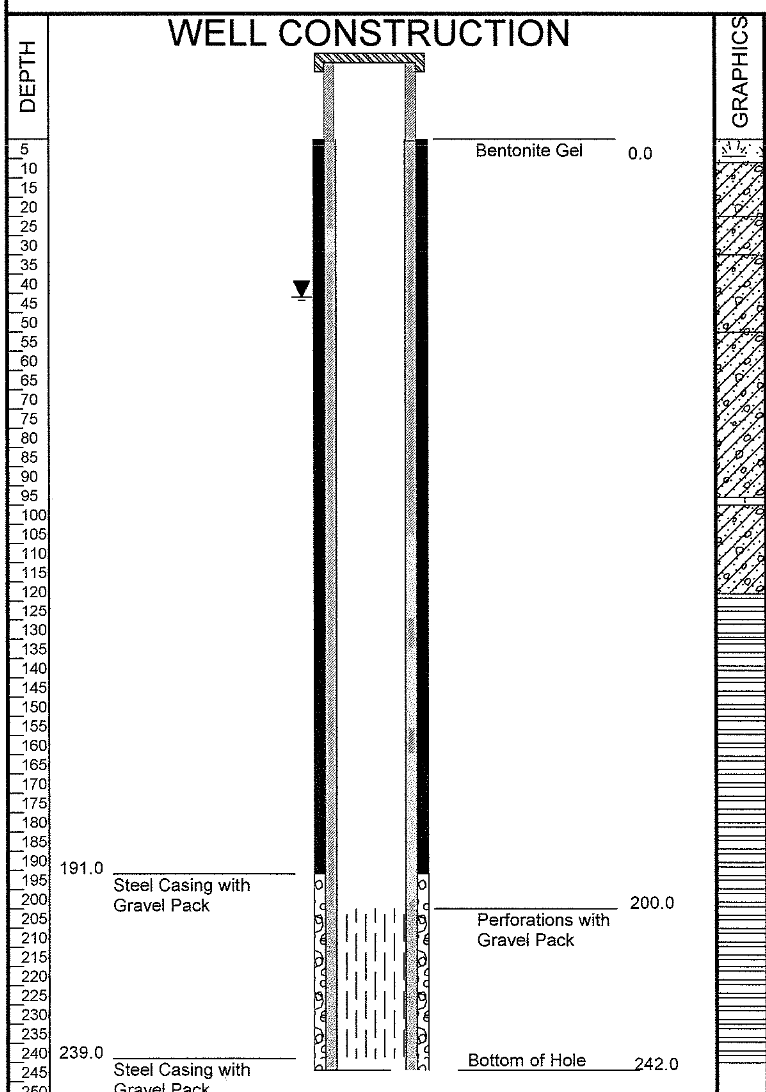
Client: Tintina Alaska Exploration Inc.
Project: Black Butte Copper Project
County: Meagher State: MT
Property Owner: Bar Z Ranch Inc
Legal Description: SW, NE, NE S25, T12N, R06E
Location Description: Western portion of proposed adit, east of SC11-016.
Recorded By: Larry Johnson
Drilling Company: H&L Drilling
Driller: Derrick
Drilling Method: Air Rotary
Drilling Fluids Used: Water/Foam
Purpose of Hole: Aquifer Test Well
Target Aquifer: Bedrock
Hole Diameter (in): 10
Total Depth Drilled (ft): 242

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	6-inch, steel casing	+2 to 242
Surface Casing Used?	Y	10-inch, steel casing	+2 to 93
Screen/Perforations?	Y	Perforated 6" Steel	200-239
Sand Pack?	Y	Gravel and 10/20 Silica Sand	Grvl:195-242 Sand: 191-195
Annular Seal?	Y	Bentonite Grout	1-191
Surface Seal?	Y	Portland Cement	0-1
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Air for 1 hour	
Water Samples Taken?	Y	Commons, Nutrients, Metals	
Boring Samples Taken?	Y	Every 10 feet	

Northing: Easting:
Static Water Level Below MP: 43.0 Surface Casing Height (ft):
Date: 3/4/12 Riser Height (ft): 2
MP Description: Top of Steel Ground Surface Elevation (ft):
MP Height Above or Below Ground (ft): 2 MP Elevation (ft):

Remarks:

WELL CONSTRUCTION



GEOLOGICAL DESCRIPTION

0.0 - 6.0' **Alluvium**
Dark grey clay w/ small sand 3%.

6.0 - 20.0' **Alluvium**
Multilithic rock fragments 10%, in predominantly red/brown clay 90% (oxdized).

20.0 - 30.0' **Alluvium**
Multilithic rock fragments including black shale and gray quartz 10%, in predominantly red/brown clay (oxdized) 90%.

30.0 - 50.0' **Alluvium**
Tan to brown clay 75%, multilithic sand and rock fragments 25%.

50.0 - 93.0' **Alluvium**
Multilithic gravel 85% and coarse sand 15%. At 84' not producing water.

93.0 - 95.0' **Boulder**
Big Boulder.

95.0 - 118.0' **Alluvium**
Multilithic gravel 80%, sand 10%, tan clay 10%.

118.0 - 130.0' **Black Shale**
Hard drilling. Predominantly black shale with gray/tan rock fragments 95% and tan sandy clay 5%. Trace of pyrite and some fine bladed barite crystals. At 125' hole is making 30gpm.

130.0 - 140.0' **Black Shale**
Predominatly black shale 95% some sand 4% and fine bladed barite crystals 1%.

140.0 - 150.0' **Black Shale**
Lighter black shale with tan/grey rock fragments 85%, and fine black sand 14% in cuttings, some fine bladed barite crystals 1%. At 145' making 15gpm.

150.0 - 215.0' **Black Shale**
Black shale with some calcite veins. Between 165' and 205' making ~20gpm.

215.0 - 230.0' **Black Shale**
Black Shale, cuttings were sand sized 80% and gravel sized 20%. At both 225' and 240' making 30gpm.

230.0 - 240.0' **Black Shale**
Lighter black shale, cuttings mostly gravel sized.

DOMESTIC_WELL2 K:\GINT\PROJECTS\11048.GPJ HYDHLN2.GDT 8/9/12

APPENDIX B

AQUIFER TEST ANALYSES

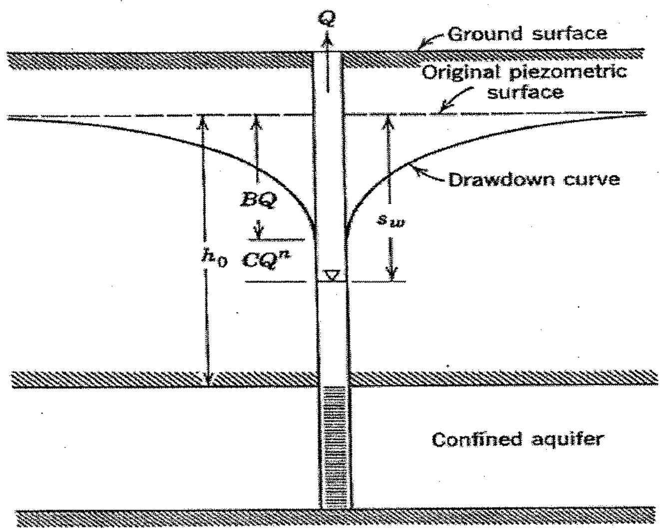
Worksheet for Evaluation of Well Loss and Well Efficiency

Total drawdown in a pumping well is a function of the drawdown in the formation (formation loss) plus any additional loss in head that occurs in the well (well loss) due to any frictional resistance as water flows from the formation to the pump intake. Jacob (1947) developed the following equation describing the drawdown components to a well at a given pumping rate:

eqn 1 $s_w = B*Q + C*Q^2$

where:

s_w = Total Drawdown
Q = Pumping Rate (gpm)
B = Formation Loss Coefficient
C = Well Loss Coefficient



(Figure from Todd, 1980)

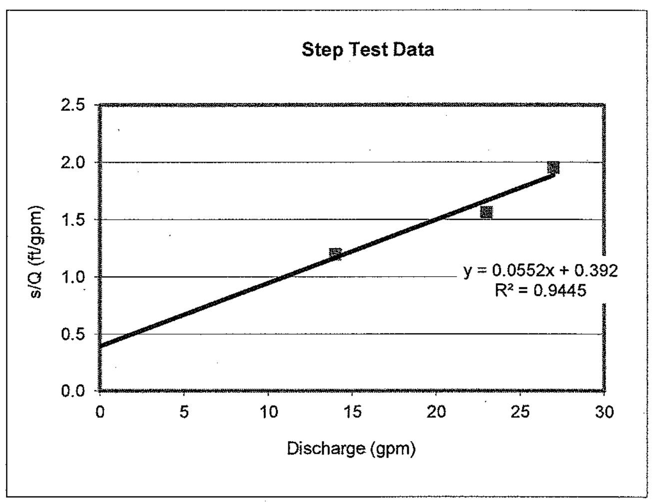
Well loss and well efficiency can be calculated from step drawdown pumping test results by plotting s/Q versus discharge and fitting a straight line through the observed data. The slope of the best fit line is equal to C (well loss) and the intercept of this line with Q = 0 is B (aquifer drawdown).

BLACK BUTTE PW-3 STEP TEST EVALUATION

Test Date: 3/7/2006

Test Results

Q (gpm)	s(ft)	s/Q
14	16.75	1.196
23	35.93	1.562
27	52.74	1.953



Loss Coefficients

drawdown	B =	0.392
well loss	C =	0.0552

Calculated Losses

discharge rate	Q =	27 gpm
aquifer drawdown	BQ =	10.6 ft
well/formation loss	CQ^2 =	40.2 ft

Well Efficiency

Well efficiency is a comparison of the total drawdown in a well versus the drawdown in the formation immediately outside the well. The efficiency of a well can be calculated at a given pumping rate using the following equation:

eqn. 2 $E_w = 100 * (B*Q)/s_w$

	B =	0.392
	Q =	27 gpm
(from eqn 1)	sw =	50.8 ft

$\boxed{E_w = 21\%}$

REFERENCES

Jacob C.E., 1947. Drawdown test to determine effective radius of artesian well, Trans. Amer. Soc. Civil Engrs. v. 112 pp.1047-1070
Todd, D.K, 1980. Groundwater Hydrology 2nd Edition. p.153.

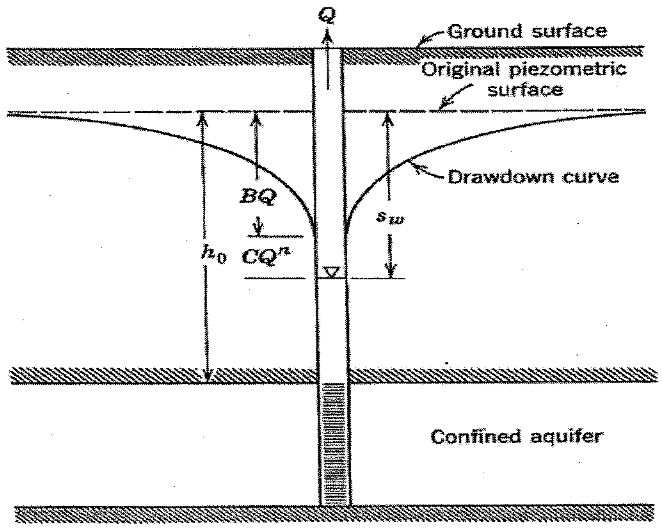
Worksheet for Evaluation of Well Loss and Well Efficiency

Total drawdown in a pumping well is a function of the drawdown in the formation (formation loss) plus any additional loss in head that occurs in the well (well loss) due to any frictional resistance as water flows from the formation to the pump intake. Jacob (1947) developed the following equation describing the drawdown components to a well at a given pumping rate:

eqn 1 $s_w = B*Q + C*Q^2$

where:

s_w = Total Drawdown
Q = Pumping Rate (gpm)
B = Formation Loss Coefficient
C = Well Loss Coefficient



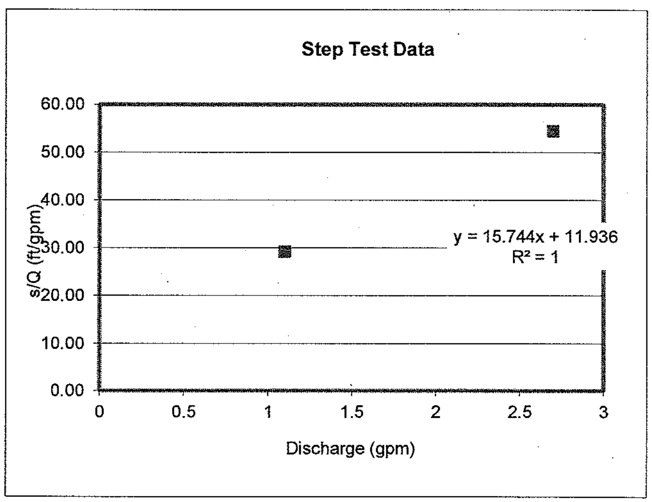
(Figure from Todd, 1980)

Well loss and well efficiency can be calculated from step drawdown pumping test results by plotting s/Q versus discharge and fitting a straight line through the observed data. The slope of the best fit line is equal to C (well loss) and the intercept of this line with Q = 0 is B (aquifer drawdown).

BLACK BUTTE PW-4 STEP TEST EVALUATION

Test Date: 3/7/2006
Test Results

Q (gpm)	s(ft)	s/Q
1.1	32.18	29.255
2.7	147	54.444



Loss Coefficients

drawdown	B =	11.936
well loss	C =	15.744

Calculated Losses

discharge rate	Q =	2.7 gpm
aquifer drawdown	BQ =	32.2 ft
well/formation loss	CQ^2 =	114.8 ft

Well Efficiency
Well efficiency is a comparison of the total drawdown in a well versus the drawdown in the formation immediately outside the well. The efficiency of a well can be calculated at a given pumping rate using the following equation:

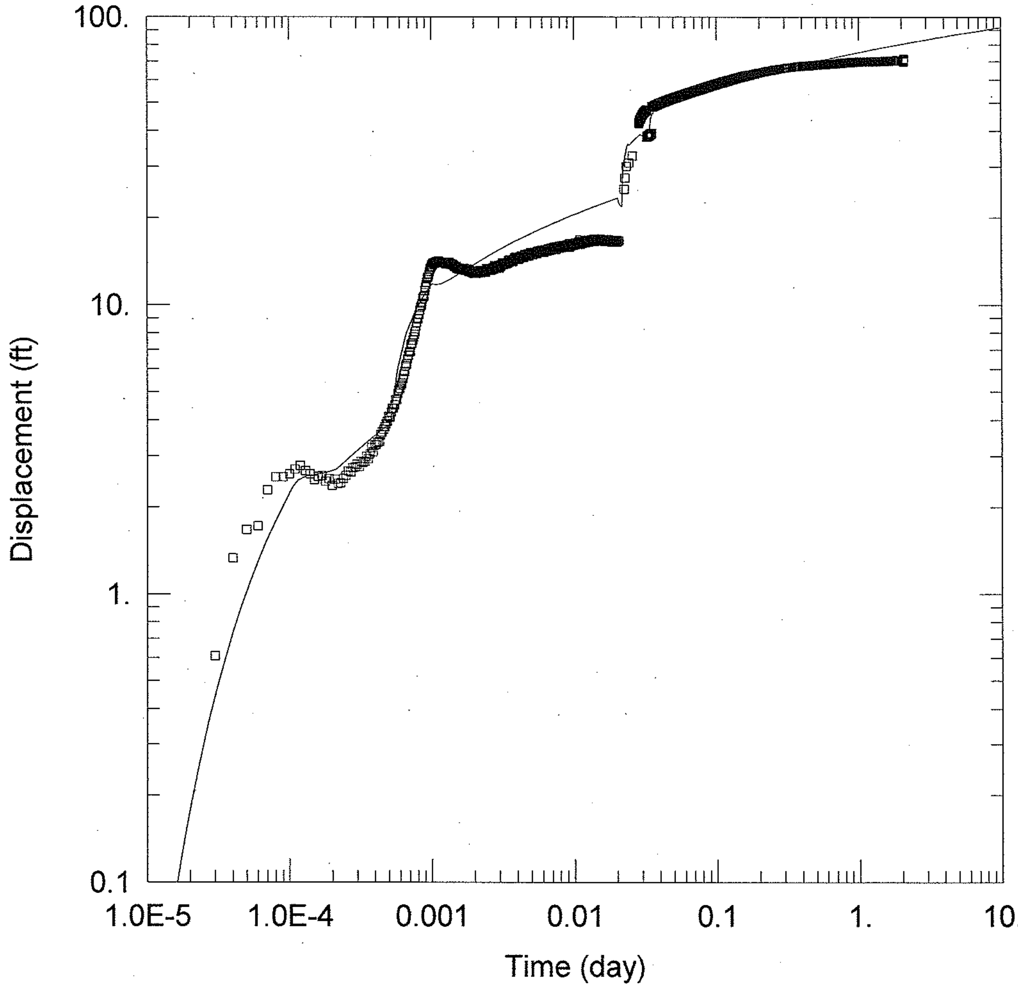
eqn. 2 $E_w = 100 * (B*Q)/s_w$

B = 11.936
Q = 2.7 gpm
(from eqn 1) sw = 147.00096 ft

$\boxed{E_w = 22\%}$

REFERENCES

Jacob C.E., 1947. Drawdown test to determine effective radius of artesian well, Trans. Amer. Soc. Civil Engrs. v. 112 pp.1047-1070
Todd, D.K, 1980. Groundwater Hydrology 2nd Edition. p.153.



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\Pw-3 Pump Test PW-3 Theis.aqt
Date: 08/13/12 Time: 06:57:14

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-3

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-3	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ PW-3	0	0

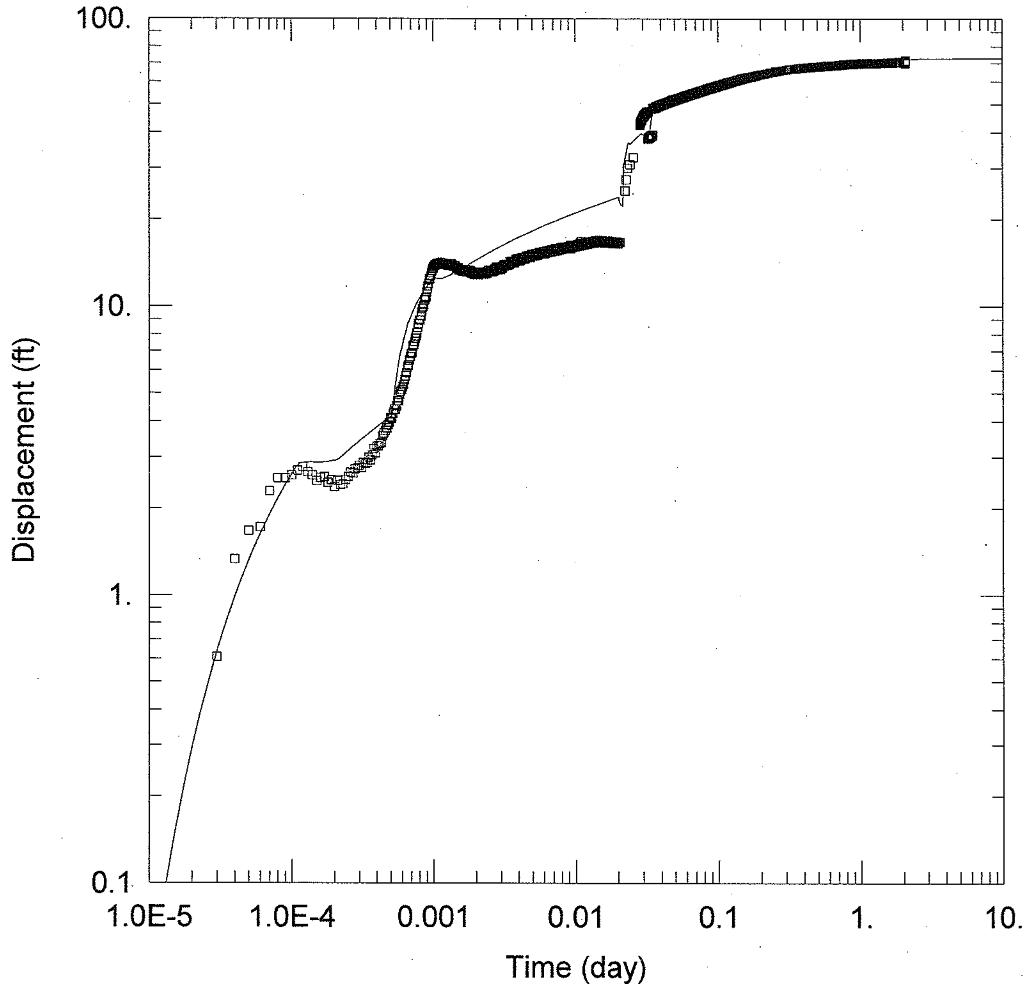
SOLUTION

Aquifer Model: Confined

Solution Method: Theis

T = 106.3 ft^2/day
Kz/Kr = 1.

S = 10.39
b = 75. ft



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\Pw-3 Pump Test PW-3 Hantush.aqt
Date: 08/13/12 Time: 06:45:30

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-3

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-3	0	0

Observation Wells

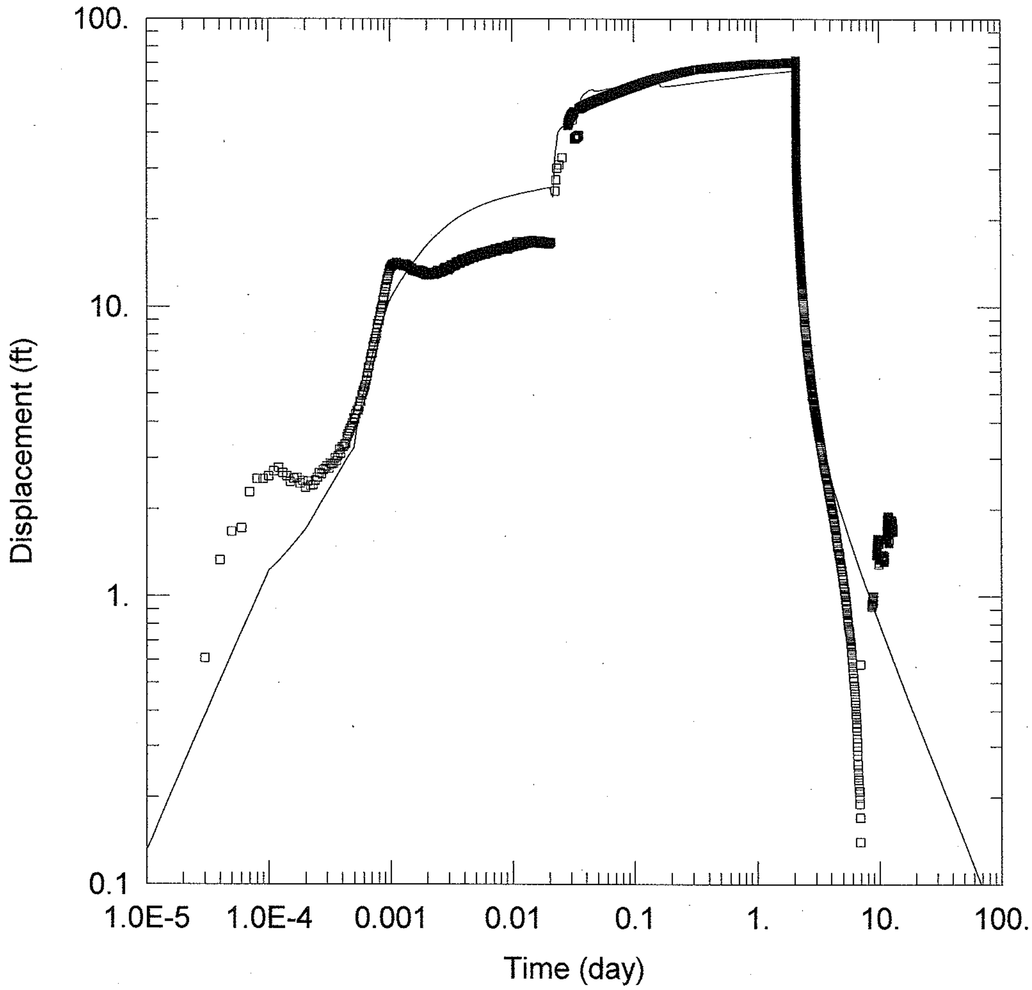
Well Name	X (ft)	Y (ft)
□ PW-3	0	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 107.7 ft^2/day
r/B = 0.01
b = 75. ft

S = 8.522
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\Pw-3 Pump Test PW-3 Moench.aqt
Date: 08/13/12 Time: 06:53:30

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-3

AQUIFER DATA

Saturated Thickness: 75. ft Slab Block Thickness: 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-3	0	0

Observation Wells

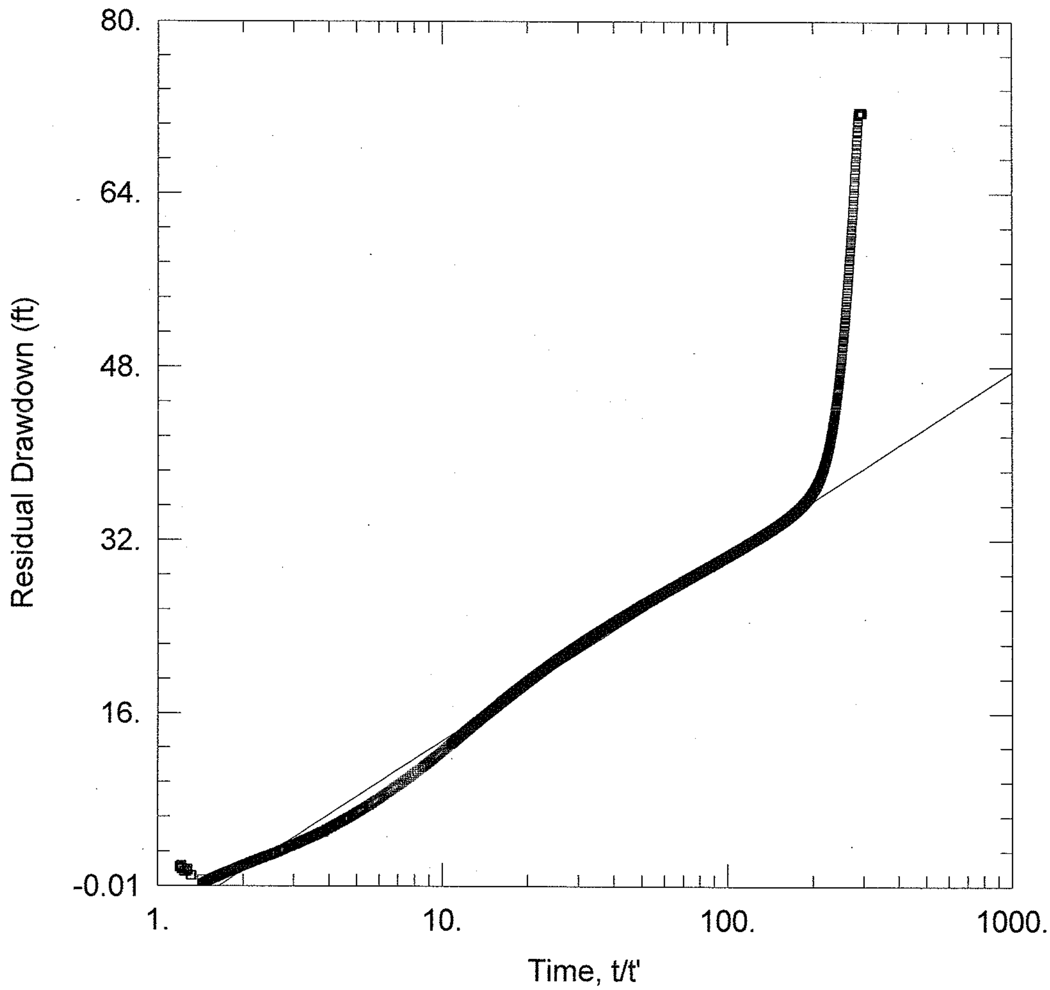
Well Name	X (ft)	Y (ft)
□ PW-3	0	0

SOLUTION

Aquifer Model: Fractured Solution Method: Moench w/slab blocks

K = 1.6 ft/day
K' = 3.481E-6 ft/day
Sw = -3.225
r(w) = 0.07726 ft

Ss = 1.2E-6 ft^{-1}
Ss' = 2.818E-6 ft^{-1}
Sf = 20.
r(c) = 0.2679 ft



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\Pw-3 Pump Test PW-3 Theis rec.aqt
Date: 08/13/12 Time: 06:58:31

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-3

AQUIFER DATA

Saturated Thickness: 75. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-3	0	0

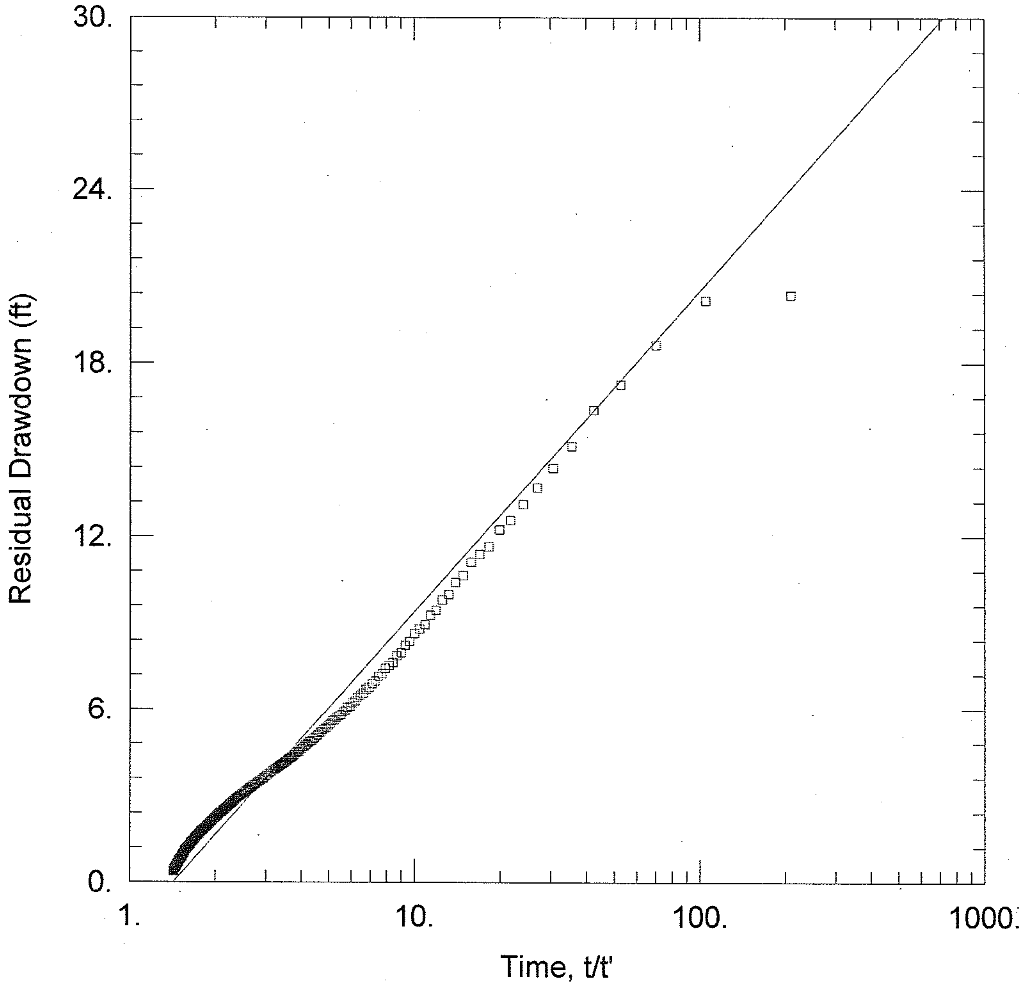
Observation Wells

Well Name	X (ft)	Y (ft)
▫ PW-3	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 55.73 ft^2/day S/S' = 1.644



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\Pw-3 Pump Test AH12-5 Theis rec.aqt
Date: 08/13/12 Time: 07:00:07

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-3

AQUIFER DATA

Saturated Thickness: 75. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-3	0	0

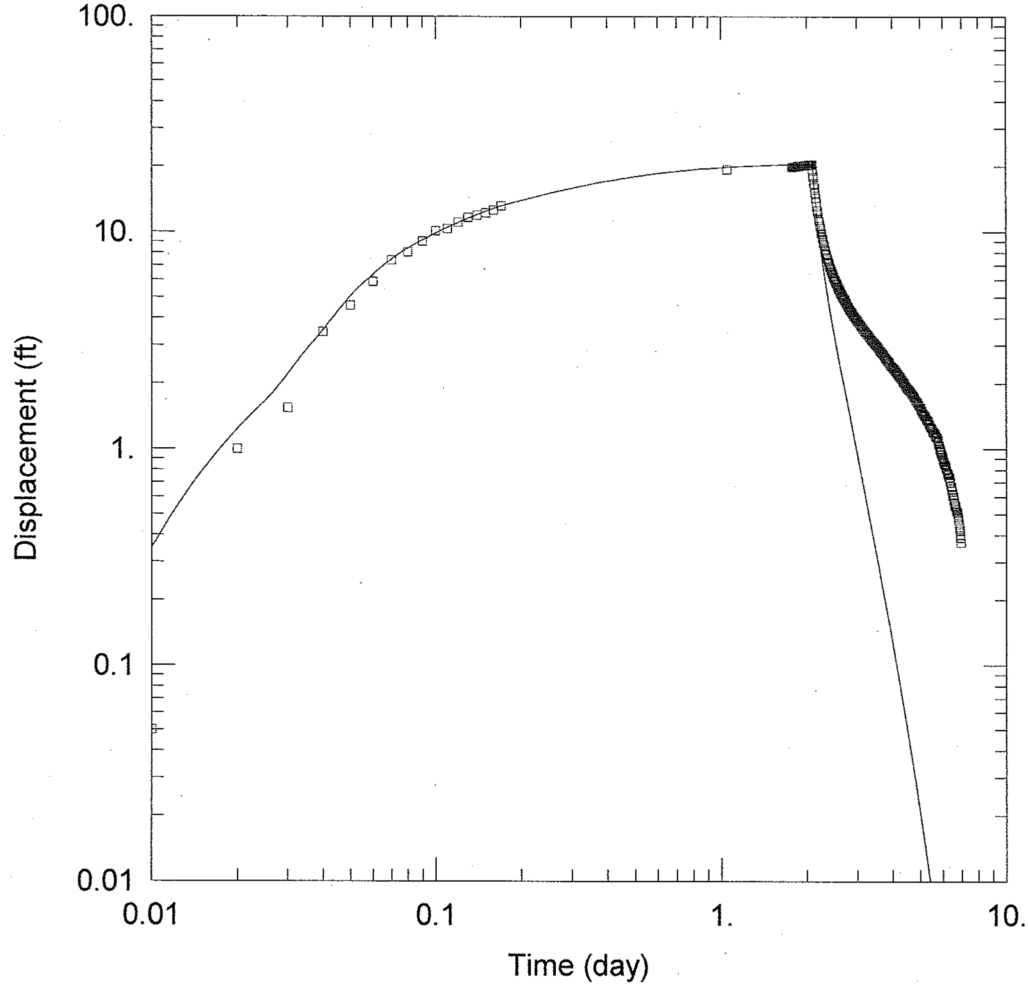
Observation Wells

Well Name	X (ft)	Y (ft)
□ SC12-16	775	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 85.85 ft^2/day S/S' = 1.424



WELL TEST ANALYSIS

Data Set: K:\...\Pw-3 Pump Test SC12-16 Hantush Leaky.aqt
Date: 08/13/12 Time: 07:02:02

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-3

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-3	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ SC12-16	697	0

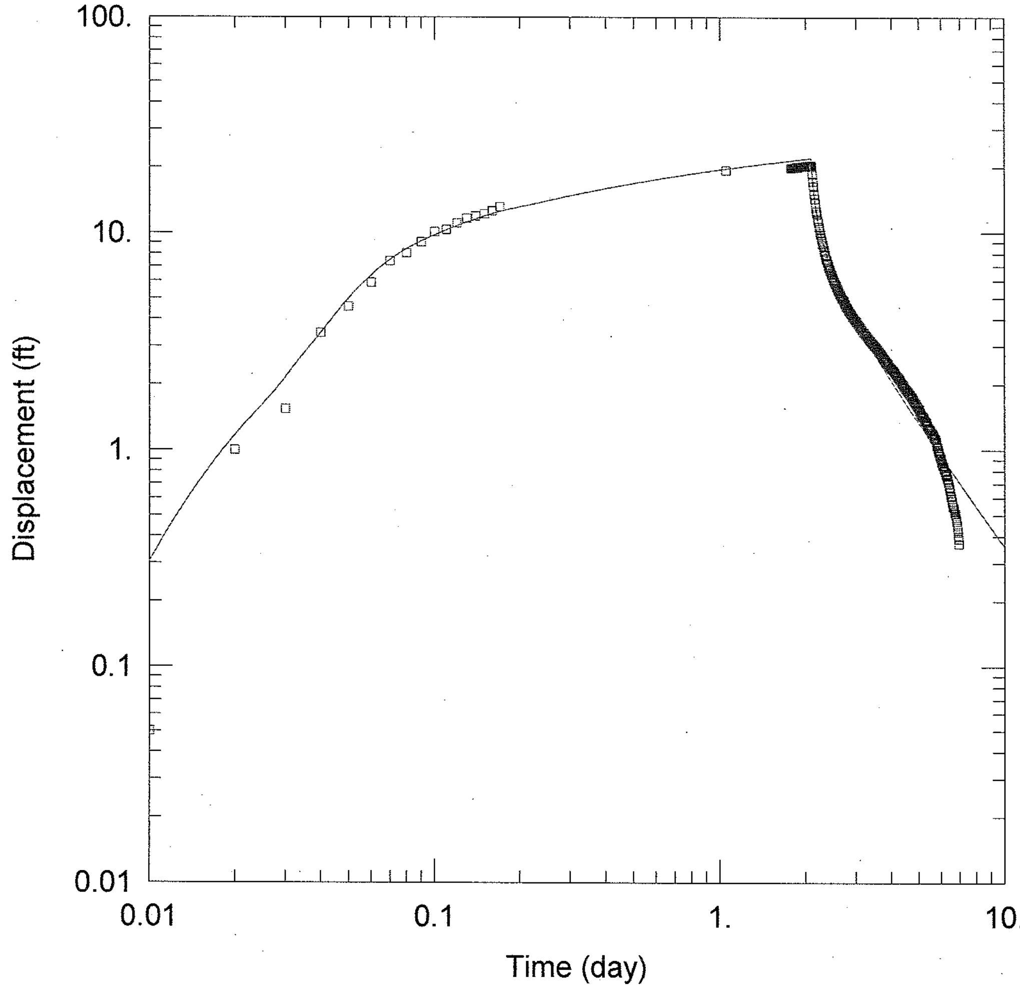
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush-Jacob

T = 55. ft^2/day
r/B = 0.3
b = 100. ft

S = 7.0E-6
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\Pw-3 Pump Test AH12-5 Moench.aqt
Date: 08/13/12 Time: 06:47:41

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-3

AQUIFER DATA

Saturated Thickness: 75. ft Slab Block Thickness: 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-3	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ SC12-16	775	0

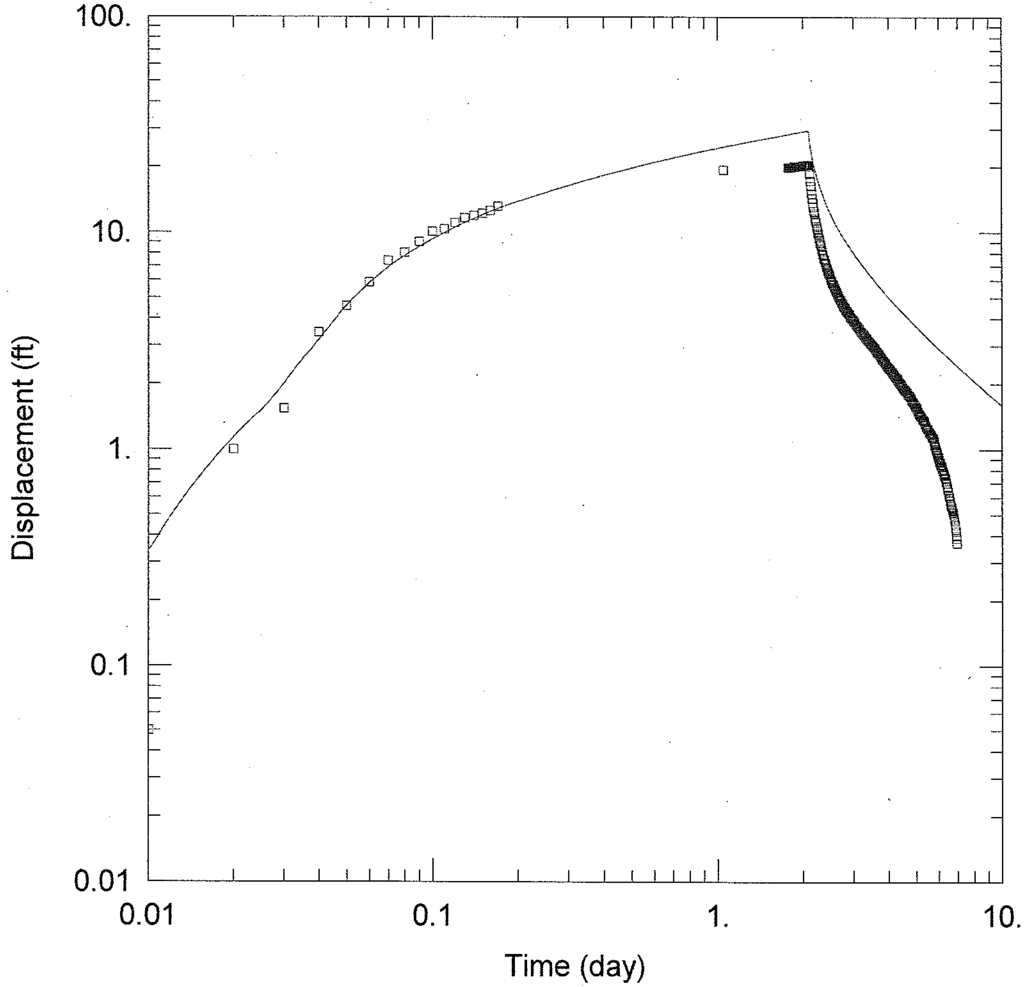
SOLUTION

Aquifer Model: Fractured

Solution Method: Moench w/slab blocks

K = 1.3 ft/day
K' = 3.981E-7 ft/day
Sw = -3.225
r(w) = 0.07726 ft

Ss = 4.092E-8 ft^{-1}
Ss' = 2.512E-6 ft^{-1}
Sf = 0.35
r(c) = 0.2679 ft



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\Pw-3 Pump Test AH12-5 Theis rec.aqt
Date: 08/13/12 Time: 06:55:40

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-3

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-3	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ SC12-16	775	0

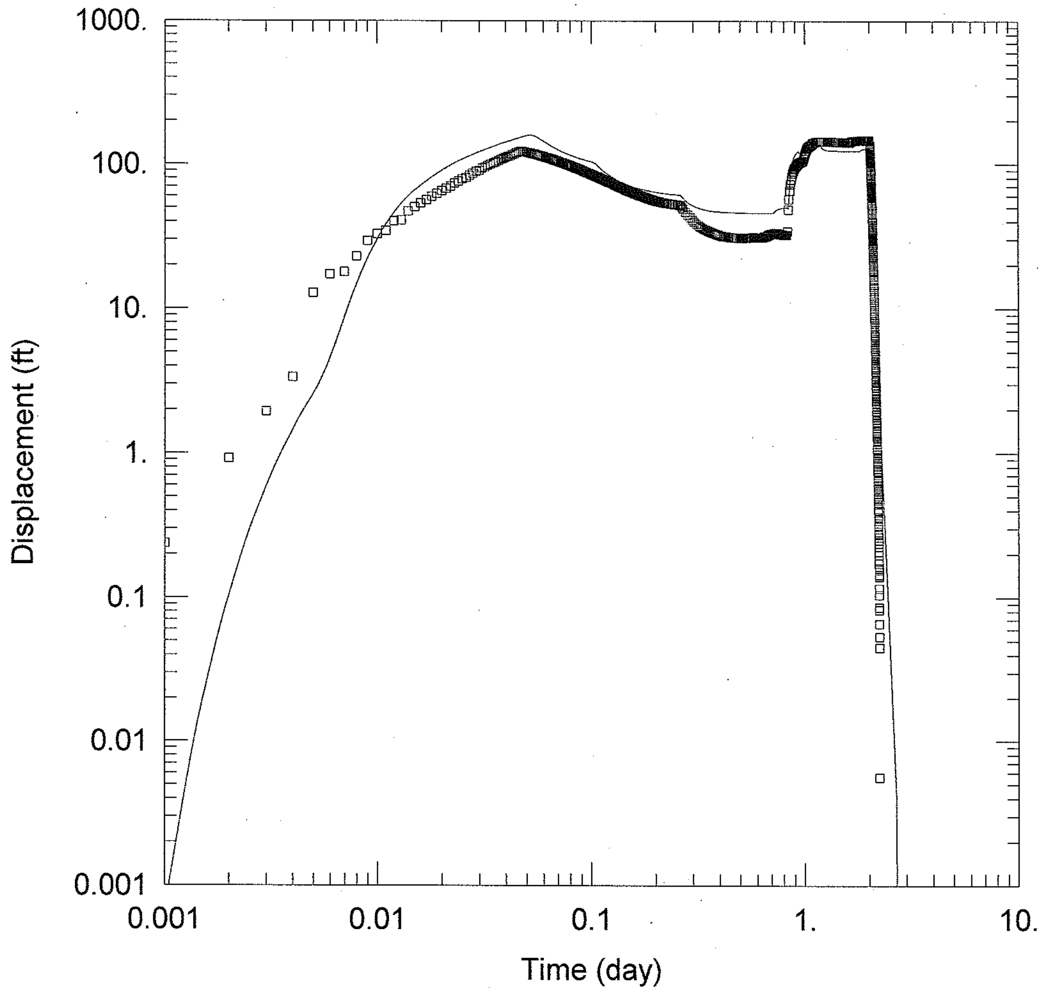
SOLUTION

Aquifer Model: Confined

Solution Method: Theis

T = 60. ft^2/day
Kz/Kr = 1.

S = 6.5E-6
b = 75. ft



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\PW-4 Pump Test Hantush.aqt
Date: 08/13/12 Time: 07:28:10

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-4

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-4	0.5	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ PW-4	0.5	0

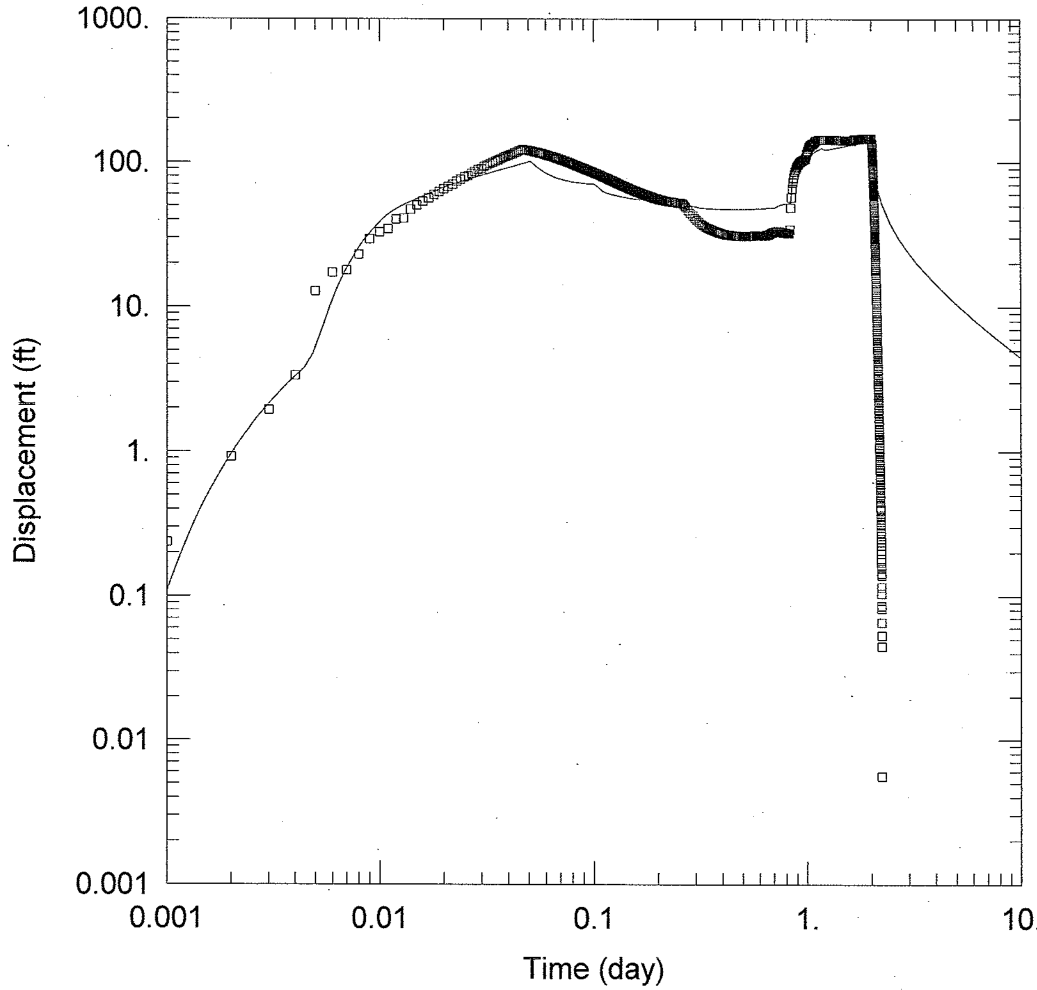
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush-Jacob

T = 0.5198 ft^2/day
r/B = 0.6
b = 50. ft

S = 0.2548
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\PW-4 Pump Test Moench.aqt
Date: 08/13/12 Time: 07:29:58

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-4

AQUIFER DATA

Saturated Thickness: 200. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-4	0.5	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ PW-4	0.5	0

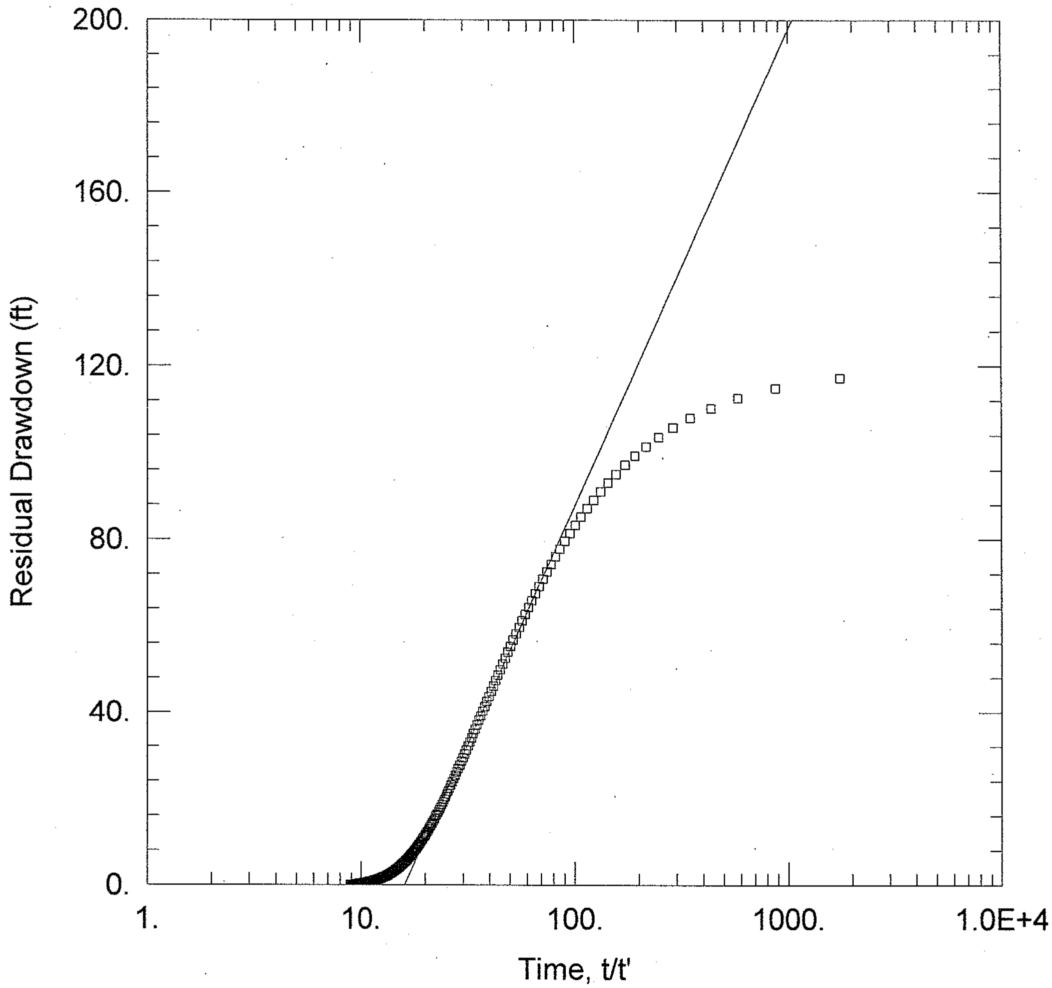
SOLUTION

Aquifer Model: Confined

Solution Method: Theis (Step Test)

$T = 1.708$ ft^2/day
$Sw = 0.$
$P = 2.$

$S = 0.3009$
$C = 0.$ day^2/ft^5



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\PW-4 Pump Test Theis rec.aqt
Date: 08/13/12 Time: 07:19:55

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-4

AQUIFER DATA

Saturated Thickness: 200. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-4	0.5	0

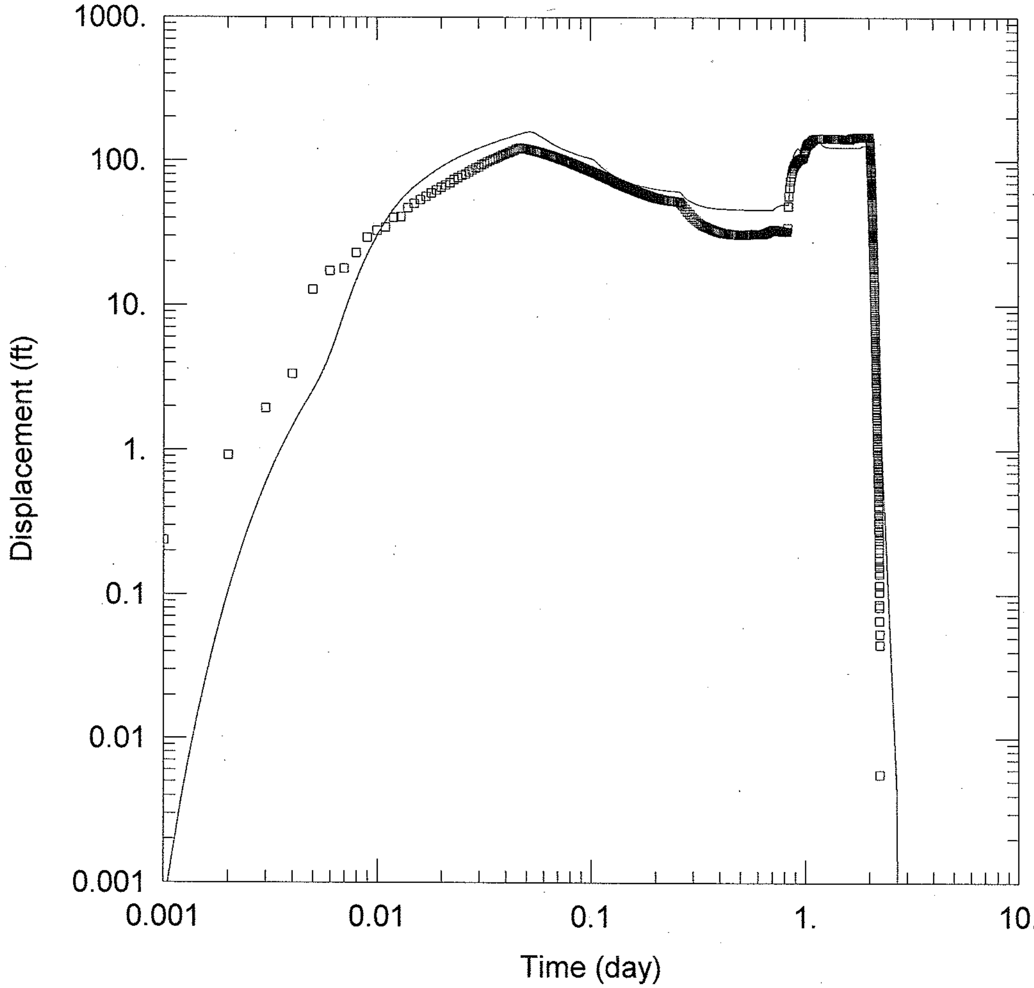
Observation Wells

Well Name	X (ft)	Y (ft)
□ PW-4	0.5	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 0.8647 ft^2/day S/S' = 16.06



WELL TEST ANALYSIS

Data Set: K:\project\11048\GW\Aqtesolve Files Aquifer Tests\PW-4 Pump Test Hantush.aqt
Date: 08/13/12 Time: 07:20:33

PROJECT INFORMATION

Company: Hydrometrics
Client: Tintina
Location: Black Butte
Test Well: PW-4

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW-4	0.5	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ PW-4	0.5	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 0.5198 ft^2/day
S = 0.2548
r/B = 0.6
Kz/Kr = 1.
b = 200. ft

APPENDIX C

ADIT INFLOW CALCULATIONS

Black Butte Copper Project
Adit Inflow Analyses
Adit Section: 1700'-2900'

Analytical Solutions for inflow to adit

Herth and Arndts Solution

$$Qh := \left(0.73 + 0.27 \cdot \frac{h2 - h1}{h2}\right) \cdot \frac{K}{D} \cdot \left(h2^2 - h1^2\right) L$$

Where:

Hydraulic Conductivity	$K := 1.5 \frac{ft}{day}$	
Length of Adit	$L := 1200\ ft$	
Assumed Head at Adit	$h1 := 1\ ft$	
Head at point of zero drawdown	$h2 := 75\ ft$	*(avg. premining head above adit)*
Distance to zero drawdown	$D := 4 \cdot h2$	$D = 300 \circ ft$

$$Qh := \left(0.73 + 0.27 \cdot \frac{h2 - h1}{h2}\right) \cdot \frac{K}{D} \cdot \left(h2^2 - h1^2\right) L \qquad Qh = 175 \circ \frac{gal}{min}$$

Darcy's Law Solution

$$Qc := (K \cdot A \cdot i)$$

Where:

Hydraulic Conductivity	$K = 1.5 \circ \frac{ft}{day}$	
Area of Infiltration Face *(perimeter x length)*	$A := 20 \cdot m \cdot L$	$A = 7.874 \bullet 10^4 \circ ft^2$
Hydraulic Gradient at infiltration face	$i := 1$	

$$Qc := (K \cdot A \cdot i) \qquad Qc = 614 \circ \frac{gal}{min}$$

Black Butte Copper Project
Adit Inflow Analyses
Adit Section: 2900'-5200'

Analytical Solutions for inflow to adit

Herth and Arndts Solution

$$Qh := \left(0.73 + 0.27\cdot\frac{h2 - h1}{h2}\right)\cdot\frac{K}{D}\cdot\left(h2^2 - h1^2\right) L$$

Where:

Hydraulic Conductivity	$K := 0.015\ \frac{ft}{day}$
Length of Adit	$L := 2300\ ft$
Assumed Head at Adit	$h1 := 1\ ft$
Head at point of zero drawdown	$h2 := 225\ ft$ *(avg. premining head above adit)*
Distance to zero drawdown	$D := 4\cdot h2 \qquad D = 900\ ft$

$$Qh := \left(0.73 + 0.27\cdot\frac{h2 - h1}{h2}\right)\cdot\frac{K}{D}\cdot\left(h2^2 - h1^2\right) L \qquad Qh = 10\ \frac{gal}{min}$$

Darcy's Law Solution

$$Qc := (K\cdot A\cdot i)$$

Where:

Hydraulic Conductivity	$K = 0.015\ \frac{ft}{day}$	
Area of Infiltration Face *(perimeter x length)*	$A := 20\cdot m\cdot L$	$A = 1.509\cdot 10^5\ ft^2$
Hydraulic Gradient at infiltration face	$i := 1$	

$$Qc := (K\cdot A\cdot i) \qquad Qc = 12\ \frac{gal}{min}$$