Appendix 6

October 11, 2011 Geodesign Revised Groundwater Interference Testing Report (Application Question 8)

GEODESIGN INC

REVISED

GROUNDWATER INTERFERENCE TESTING REPORT

Swan Lake North Pumped Storage Hydroelectric Project

Klamath County, Oregon

FERC No. 13318

OWRD Permit Application HE 592

For
Symbiotics

On behalf of
Swan Lake North Hydro, LLC

October 11, 2011

GeoDesign Project: Symbiotics-3-01

GEODESIGN INC

October 11, 2011

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, OR 97301

Attention: Mr. Jerry Grondin

Revised
Groundwater Interference Testing Report
Swan Lake North Pumped Storage Hydroelectric Project
Klamath County, Oregon
GeoDesign Project: Symbiotics-3-01
FERC No. 13318
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GeoDesign Inc. is pleased to submit this *Revised Groundwater Interference Testing Report* for the proposed Swan Lake North Pumped Storage Hydroelectric Project in Klamath County, Oregon.

Please call if you have questions regarding this submittal.

Sincerely,

GeoDesign, Inc.

Stephen P. Palmer

Stephen P. Palmer, Ph.D., R.G.
Principal Engineering Geologist

cc: Mr. Erik Steimle, Symbiotics (via email only)

EAH:SMD:SPP:kt
Attachments
One copy submitted
Document ID: Symbiotics-3-01-101111-geor-interference-rev.doc

REVISED
GROUNDWATER INTERFERENCE TESTING REPORT
Swan Lake North Pumped Storage Hydroelectric Project
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Prepared for:
Symbiotics

On Behalf Of

Swan Lake North Hydro, LLC

Prepared by:
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1.0 INTRODUCTION

This Groundwater Interference Testing Report has been prepared on behalf of Symbiotics and Swan Lake North Hydro, LLC in support of the proposed Swan Lake North Pumped Storage Project in Klamath County, Oregon (project site, Figure 1). GeoDesign completed groundwater testing in general accordance with our Groundwater Interference Testing Plan (Plan) dated January 14, 2011. Development of the testing program was based on (1) requirements set forth in OWRD's "Proposed Order for Preliminary Permit for Hydroelectric Application HE 592 at Swan Lake North," (2) input from project team members, and (3) input from OWRD Groundwater Section Staff.

For your reference, acronyms used in this report are defined at the end of the document.

1.1 PURPOSE AND OBJECTIVES

GeoDesign completed groundwater testing to support evaluation of potential water level drawdown interferences at selected water wells distal to pumping wells intended for use in filling the proposed reservoirs[1]. Because the pumping wells and other irrigation wells in the study area are developed in common aquifer units[2], pumping the production wells over an extended period of time (for reservoir filling and maintenance) has the potential to cause drawdown at other wells. An estimation of the amount of drawdown at distal wells was required to evaluate possible damage to other water right holders; specifically, whether associated drawdowns could limit allowable pumping rates at other wells under their associated permitted or certificated appropriation rates.

Three primary objectives governed methods employed during this study, as follows:

- Conduct a single-well drawdown and recovery test by pumping one of the reservoir supply wells and measuring drawdown in selected observation wells within the groundwater compartment[3]. Selection of the pumping well and observation wells supported estimation of average transmissivity and storage coefficient values for the compartment.
- Conduct a multiple-well interference test by pumping each of the four reservoir supply wells at maximum allowable appropriation rates. Monitor water levels in the pumping wells and selected observation wells within and outside the compartment in order to support an evaluation of potential drawdown (interference) at the distal observation wells. Evaluate water levels with respect to pumping influence and other potential factors affecting water levels.
- Evaluate the collective data to determine the potential for groundwater interference at distal observation wells, and use the estimated values of transmissivity to project long-term drawdown values within and outside the compartment.

[1] A description of the project background and scope is presented in Section 2.
[2] A description of hydrogeologic formations is presented in Section 3.
[3] Groundwater compartments are defined in Section 3.2

1.2 SUMMARY OF CONCLUSIONS

As presented in Section 10, this study presents the following conclusions:

- Evaluation of the single-well pumping test data suggests the principal basalt aquifer in the northern Swan Lake Valley compartment is highly transmissive. Overlying basin fill sedimentary deposits are characterized by much lower transmissivity values. Well log records indicate many area wells receive flows from both hydrogeologic units, and the wide range of reported specific capacities reflects the variable degree to which a given well communicates with the sedimentary deposit and basalt unit. Estimated transmissivity values ranged from 49,400 to 8,823,500 ft^2/day. Storage coefficient values ranged from 0.0029 to 0.105.
- Water level response data to single-well pumping and multiple-well pumping indicates the presence of a subsurface in Swan Lake Valley causing resistance to groundwater flow that appears to reduce the effects of pumping stress beyond the feature. The location of this feature appears to be just north of Swan Lake.
- Drawdown and/or interference were not observed in project observation wells south of KLAM 2269.
- Theis' solution to the groundwater flow equation was used to derive conservative estimates of potential drawdowns arising from long-term (three years) pumping at prorated extraction rates from the pumping well array. The range of theoretical drawdowns in project observation wells ranged from 0.35 foot (at KLAM 2260, north end) to 0.13 foot (at KLAM 12420, south end). The projected drawdown values are conservative based on assumed inputs. In all cases, the actual realized drawdowns (if observed or measurable) are expected to be less than the values presented and are not expected to impact the ability to fully exercise a given water right in the study area.

2.0 BACKGROUND

The project is located approximately 11 miles northeast of Klamath Falls in Klamath County, Oregon. The project boundary extends from the east side of Grizzly Butte to approximately 1 mile east of Swan Lake Rim, located in Sections 13, 14, 15, 22, 23 and 24, Township 32 South, Range 10 East, Willamette Meridian. The project site vicinity and locations of proposed reservoirs are shown on Figure 1.

A detailed summary of the project setting, background, and scope is presented in the *"Swan Lake North Pumped Storage Project Pre-Application Document"* (Symbiotics, 2010).

2.1 PROPOSED RESERVOIR FILLING AND MAINTENANCE PUMPING

The project will include an upper reservoir and a lower reservoir as depicted on Figure 1. The project proposes to initially fill the lower reservoir by pumping groundwater from four wells (herein referred to as supply wells or pumping wells) under transfer of water right Certificate 29530 and transfer of water right Certificate 87006. Additional water rights held under a subset of the pumping wells (specifically, Certificates 83121 and 67564) will not be exercised by the supply wells in filling the reservoirs. Once initial filling is completed, the lower reservoir will receive maintenance flows from one of the supply wells under permanent transfer. The project is expected to require 13,935 acre-feet of water for initial filling and an additional 1,574 acre-feet annually to offset evaporative losses (maintenance pumping).

A description of proposed supply wells is presented in Section 4.1 and Table A-1.

2.2 CALCULATED PUMPING RATES

Initial reservoir filling (13,935 acre-feet) is expected to take place over a two- to three-year period of continuous pumping. This duration is governed by annual duties applicable to the associated water rights and is intended to minimize potential damage to surrounding water right holders by distributing the pumping activities over an extended period of time. Based on the anticipated initial reservoir filling volume and annual maintenance pumping projections, initial estimates of long-term pumping rates were developed. The estimated long-term pumping rates for each supply well consider the allowable instantaneous pumping rates and annual duties associated with the respective water rights. In addition, the estimated pumping rates are intended to distribute the pumping period over the entire year as opposed to the typical irrigation season. This distribution of pumping over the entire year is expected to reduce the potential for interferences with other irrigation wells during peak demand periods (i.e., late summer). A summary of estimated pumping rates and associated water right conditions is presented in Table A-2.

Despite the reduced extraction rates (relative to typical irrigation season pumping) associated with proposed year-round pumping, pumping rates employed during this testing program reflected maximum allowable instantaneous appropriation rates under the relevant water rights. The rationale for testing the supply wells at a higher rate was twofold: (1) testing at the highest allowable pumping rates supports and evaluation of worst-case drawdown scenarios and (2) testing at the highest allowable pumping rates would increase the likelihood of obtaining measurable drawdown at relatively greater distances from the pumped wells; therefore, resulting in a more robust data set supporting estimates of transmissivity, effective transmissivity, and storage coefficient over a relatively larger area than could be obtained using lower pumping rates.

3.0 STUDY AREA CHARACTERISTICS

3.1 REGIONAL GEOLOGY

The project site is located in the northwest corner of the Great Basin physiographic region. This region is characterized by north-trending, fault-controlled mountain ranges and broad valleys. The proposed project is sited on the Modoc Plateau near the convergence of the Cascade Range physiographic region and Great Basin physiographic region. The proposed upper reservoir is sited near the Swan Lake Rim, a steep escarpment bounding the eastern side of Swan Lake Valley. The lower reservoir is located along the eastern margin of Swan Lake Valley, north of Swan Lake and south of Grizzly Butte. Geomorphic characteristics throughout much of this region include large vertical escarpments with gently sloping plateaus and broad valleys. Faulting has formed the graben and half-graben valleys throughout much of the region. Vertical displacement from faulting has created the Swan Lake Rim escarpment, which is 2,000 feet tall (Sherrod and Pickthorn, 1992).

Swan Lake Valley is bound on the east and west by plateaus of Pliocene volcanic rock. The volcanic and volcaniclastic rocks found on the Modoc Plateau are part of the Winema Volcanic

Field. The valley floor is primarily composed of Plio-Pleistocene sediments and Holocene lake deposits. Tertiary and Quaternary sedimentary rocks and deposits form alluvial fans near the base of the escarpment.

The lower reservoir sits atop Quaternary sediment. The proposed lower reservoir is bound by Pliocene andesite on the west side and Pliocene basalt on the east side. The upper reservoir sits atop Pliocene basaltic andesite.

3.2 REGIONAL HYDROGEOLOGY

As summarized by Grondin (2004), early researchers, including Newcomb and Hart (1958), Illian (1970), and Leonard and Harris (1974), described the basin's primary hydrogeologic units as:

- an older, highly permeable lower basalt unit that serves as the principal aquifer in the area;
- the Yonna Formation (a medial zone of stratified lacustrine deposits consisting of tuff, agglomerate, shale, diatomite, sandstone, and volcanic ash with some volcanic intrusives or interbeds of thin lava flows) that primarily confines groundwater; and
- upper, younger units of lava flows forming cap rock in places, eruptive deposits, and alluvium, which occur above the water table or yield small quantities of perched water.

Sherrod and Pickthorn (1992) described and mapped a more complex stratigraphic sequence and abandoned the Yonna Formation as a valid stratigraphic unit. Grondin (2004) indicates that the geology and water-bearing characteristics may be more complex than previously described.

The two principle sources of groundwater recharge are underflow from the unconfined system of the adjacent volcanic rocks and, less significantly, infiltration of surface water through sedimentary deposits. In the Swan Lake Valley groundwater in the deeper portion of the basin fill has an efficient hydraulic connection to groundwater in the basalt below. The hydraulic properties of the basin fill and basalt aquifers generally differ, resulting in low yield from the basin fill and much higher yields from the basalt. Although the surface layer of fine-grained, unconsolidated aquifers yield little water, the underlying volcanic aquifers have large water yields. Maximum well yields are approximately 4,750 gpm at depths between 180 and 860 feet BGS (Grondin, 2004; Whitehead 2004).

The general pattern of groundwater movement is from north to south. In the Swan Lake Valley groundwater flow direction tends toward the Lost River to the south with a gradient less than 10 feet per mile (Grondin, 2004). Swan Lake Valley groundwater appears to discharge from basalt at springs adjacent to the Lost River in western Poe Valley (Grondin, 2004).

Grondin (2004) categorized the Swan Lake Valley to Poe Valley as one of four hydraulically connected sub-areas within the upper Lost River sub-basin. Within the Swan Lake to Poe Valley sub-area, there are hydraulically connected compartments. The pumping wells pertinent to this study are located in the northern-most compartment of the sub-area. Although the bounding conditions of the compartments are poorly defined, they appear to create some resistance to groundwater flow and help categorize compartment and sub-area response to seasonal stress. As suggested by Grondin (2004) and indicated by this study, the north Swan Lake Valley compartment roughly coincides with the approximate northern one-third of the Swan Lake Valley, with a southern boundary of the compartment consisting of an east to west-trending line at the approximate latitude of Swan Lake.

Grondin (2004) conducted a pumping test in northern Poe Valley, located in the Swan Lake Valley to Poe Valley sub-area (approximately 16 miles southeast of the north Swan Lake Valley compartment). Results of the pumping test indicated an effective transmissivity of 150,000 ft^2/day and a storage coefficient of 0.0004 for the central portion of the Swan Lake Valley to Poe Valley sub-area.

Estimates of hydraulic parameters within the greater Eastern Lost River sub-basin (including South Langell Valley, Lorella, Bonanza and Swan Lake Valley to Poe Valley sub-areas) vary considerably, with effective transmissivity estimates ranging from 2,050 to 600,000 ft^2/day and storage coefficient estimates ranging from 0.00015 to 0.00096 (Grondin, 2004).

3.3 GROUNDWATER USE

Groundwater is heavily utilized for irrigation within the study area and within the primary basalt hydrogeologic unit. Between the northern limit of Swan Lake Valley and Pine Flat (generally coinciding with this study area), 39 irrigation wells were identified during our water well review. Review of the associated well logs indicates that nearly all of the wells are developed primarily within the basalt unit, although a number of wells also pump water from the valley fill. Based on our review of available water right records, associated groundwater appropriations for these wells is on the order of 35,000 acre-feet per year. A summary of wells identified within the study area is presented in Table A-1.

Grondin (2004) indicated seasonal groundwater level fluctuations on the order of 2 to 4 feet in the north Swan Lake Valley compartment and 4 to 7 feet in the central Swan Lake to Poe Valley sub-area. These seasonal groundwater fluctuations helped distinguish the compartments.

4.0 TESTING WELLS AND METHODS

This section presents a discussion of wells utilized during this testing program. Detailed information gathered for the study wells are also summarized in Table A-1. The locations of the pumping observation wells are depicted on Figure 2. Copies of well logs and records for the proposed pumping wells, observation wells, and other wells within the study area are presented in Appendix A.

4.1 PUMPING WELLS

The pumping wells utilized during this study are briefly described in Table 1. These pumping wells are proposed for use in initial reservoir filling; pumping well KLAM 2265 is proposed for use in providing maintenance flows to compensate for evaporative reservoir losses as described in Section 2.1.

Table 1. Summary of Pumping Wells

Pumping Well	Installation Date	Total Depth (feet BGS)	Cased Depth (feet BGS)	Source Aquifer	Allowable Appropriation Rate (gpm)	Allowable Annual Duty (acre-feet)
KLAM 2263 (Well #1; "Cove")	1951	142	19	Basalt	2,800	1,503.3
KLAM 2259 (Well #2; "100-Horse")	1952	281	170	Basalt	2,033	1,944.0
KLAM 2262 (Well #4; "Aspen")	1979	187	81	Basalt	2,567	1,371.6
KLAM 2265 (Well #5; "Lake")	Unknown	123	Unknown	Basalt, Basin Fill	3,541	1,894.2

4.2 OBSERVATION WELLS

Observations wells used during this study are briefly characterized in Table 2. Observation wells were selected based on input from OWRD Groundwater Section Staff and further selected based on accessibility and/or permission for access.

Table 2. Summary of Observation Wells

Observation Well	Installation Date	Total Depth (feet BGS)	Cased Depth (feet BGS)	Source Aquifer(s)	Allowable Appropriation Rate (gpm)
KLAM 2260 ("Wilson")	1977	200	20	Basalt	3,236
KLAM 2269 ("Marengo")	1954	325	Unknown	Basalt, Basin Fill	431
KLAM 2289 ("Coleman")	1949	99	81	Basalt, Basin Fill	875
KLAM 12186 ("Liskey""	1957	850	39	Basalt, Basin Fill	1,450
KLAM 12203 ("Venable")	1949	221	40	Basalt	3,914
KLAM 12420	1950	135	16	Basalt	1,629
KLAM 50362	Unknown	224	16	Basalt, Basin Fill	2,684

4.3 WATER LEVEL MONITORING

Water level measurements were collected using calibrated, vented In Situ LevelTroll 700® pressure transducer data loggers with 5 psi pressure ratings[4]. During deployment, water level datums were established by comparing logger readings with manual depth-to-water measurements to calculate the transducer depth relative to the static water level. For this purpose, a consistent measuring point at each wellhead was established. Transducer readings were collected during all phases of the testing program at one minute intervals[5].

Manual depth-to-water measurements were collected using a Slope-Indicator® electronic tape. Manual water-level readings were collected during transducer deployment and retrieval, and periodically during pumping/recovery periods of the tests pending access.

4.4 BAROMETRIC PRESSURE MONITORING

Barometric pressures were recorded during all phases of the testing program. Barometric pressures were recorded in proximity to pumping well KLAM 2259 using a calibrated In Situ Baro-Troll® instrument rated for 15 psi. Barometric pressures were recorded at one minute intervals during the entire testing program.

4.5 FLOW MEASUREMENTS

Flow measurements were recorded for each pumping well using McCrometer analog flow meters with instantaneous and totalizer capability. Instantaneous flow readings were displayed in gpm, and totalizer readings were displayed in acre-feet x 0.001. Total pumped volumes were recorded from flow meter totalizer readings. Totalizer readings were also used to calculate averaged time-step pumping rates as an independent check against the instantaneous readings. Comparison of the instantaneous readings and calculated rates based on periodic totalizer readings indicated close agreement.

Flow measurements were collected in general accordance with the schedule described in our Plan, as follows:

- Hourly for the first 24 hours of pumping
- Every 4 hours for the subsequent 48 hours of pumping
- Every 8 hours for subsequent periods of pumping

Observed flow meter readings from each pumping well indicated steady flow rates. As such, no measures were required to maintain consistent flow rates from the pumping wells.

4.6 WATER MANAGEMENT

Pumped water from each supply well was routed via 12-inch-diameter irrigation pipe to nearby conveyance ditches discharging to Swan Lake. A total of approximately 486 acre-feet of water

[4] Initial baseline water levels were recorded using 30 psi transducers. The 30 psi transducers were replaced with 5 psi transducers on February 5, 2011. The 5 psi transducers provided a measurement accuracy of 0.01 foot of water or better.

[5] Initial baseline water level and barometric pressure readings were collected at one hour intervals. Upon transducer change-out to the 5 psi transducers, the water level and barometric pressure measurement schedule was updated to one minute readings for the remainder of the testing program.

was generated and directed to Swan Lake during this testing program. Each canal discharge point was located at least 3,940 feet from any respective pumping well and at least 5,490 feet from any given observation well.

5.0 BASELINE DATA COLLECTION

Baseline data was used to evaluate ambient water levels and any associated trends during pre-pumping periods. Baseline data collection included continuous logging of barometric pressure and water levels in all pumping and observation wells. The baseline data collection period began on January 27, 2011 and extended to the beginning of the single-well pumping test on February 8, 2011. Baseline water level data was collected in two phases representing different equipment deployment and measurement frequency, as shown in Table 3.

Table 3. Baseline Measurement Schedule

Baseline Data	Equipment	Measurement Frequency	Begin Date	End Date
Water Levels – Pumping and Observation Wells	30 psi Transducers	One Hour	1/27/11	2/5/11
	5 psi Transducers[1]	One Minute	2/5/11	Initiation of Single-Well Pumping Test
Barometric Pressure	15 psi Transducer	One Hour	1/27/11	2/5/11
		One Minute	2/5/11	2/24/11

1. Pressure transducer change-out from 30 psi to 5 psi units was completed in accordance with OWRD request.

6.0 SINGLE-WELL PUMPING TEST

A single-well pumping and recovery test was performed by pumping KLAM 2259 (Well #2; "100-Horse"). Generally speaking, a single-well test usually refers to an aquifer test where the pumping well is the sole source of data used to derive hydraulic property estimates (i.e., no observation wells are utilized). However, we use this terminology herein to clearly differentiate this initial test from the multiple-well interference test.

Pumping well KLAM 2259 was selected due its approximate central location relative to the other three pumping wells. Pumping well KLAM 2259 was pumped at a rate to approximately reflect the maximum allowable instantaneous rate allowed under Water Right Certificate 29530. A summary of pumping rate, duration, and observed drawdown in pumping well KLAM 2259 (Well #2; "100-Horse") are presented in Table 4.

Table 4. Pumping Summary
Single-Well Pumping Test

Begin Pumping	End Pumping	Pumping Duration (minutes)	Flow Rate (gpm)	Pumping Well Drawdown (feet)
2/8/11 10:39	2/10/11 10:39	2,880	3,000	4.5

Although transducers were deployed in all study area wells during the single-well pumping test, the observation wells most closely observed during the single-well test included those presented in Table 5. This pumping/observation well distribution was selected to support estimates of transmissivity in several directions within the northern Swan Lake Valley compartment.

Table 5. Observation Wells for Single-Well Pumping Test

Observation Well	Distance From KLAM 2259 (miles)	Direction From KLAM 2259	Remarks
KLAM 2262 (Well #4)	0.37	North	Future pumping well for reservoir
KLAM 2269	0.41	Southwest	Marengo Well
KLAM 2260	0.79	North/Northeast	Jesperson Edgewood ("Wilson")
KLAM 2263 (Well #1)	1.64	East	Future pumping well for reservoir
KLAM 2265 (Well #5)	3.37	East/Southeast	Future pumping well for reservoir

Cessation of the pumping phase initiated the recovery phase of the single-well pumping test. Recovery measurements were obtained in the pumping and observation wells until initiation of the multiple-well interference test (a minimum of 5,762 minutes).

Tabulated data for the pumping and observation wells is presented in Appendix B. Water level plots for the pumping and observation wells are presented in Appendix C. Evaluation of the data and corresponding hydraulic parameter estimates are discussed in Section 8.

7.0 MULTIPLE-WELL INTERFERENCE TEST

Multiple-well testing was performed to support the evaluation of potential groundwater interferences at distal wells relative to the supply well array (KLAM 2259, KLAM 2262, KLAM 2263, and KLAM 2265). Completion of the multiple-well testing program included pumping each of the four supply wells at the approximate maximum allowable instantaneous rates allowed from the wells under the respective water rights.

The multiple-well interference test was initiated on February 14, 2011. Pumping rates for each pumping well approximately reflected the maximum allowable instantaneous rates allowed from their respective water rights. A summary of the pumping duration is presented in Table 6.

Table 6. Pumping Summary
Multiple-Well Interference Test

Pumping Well	Begin Pumping	End Pumping	Pumping Duration (minutes)[1]	Pumping Rate (gpm)
KLAM 2263 (Well #1; "Cove")	2/14/11 11:16	2/23/11 07:50	12,754	2,350
KLAM 2259 (Well #2; "100-Horse")	2/14/11 10:40	2/23/11 07:45	12,785	3,000
KLAM 2262 (Well #4; "Aspen")	2/14/11 10:45	2/23/11 07:39	12,774	3,500
KLAM 2265 (Well #5; "Lake")	2/14/11 11:01	2/23/11 07:40	12,759	3,400

1. Intermittent power outages experienced during the multiple-well interference test affected the testing duration, as discussed in Section 9.
2. The initial 188 minutes of pumping of KLAM 2263 did not include booster pump; refer to Appendix B.

The distribution of observation wells utilized during the multiple-well interference test reflected locations inside and outside the north Swan Lake Valley compartment. A summary of observation wells relative to the pumping wells used for the multiple-well interference test are detailed in Table 7.

Table 7. Observation Wells for Multiple-Well Interference Test

Observation Well	Distance From KLAM 2260[1] (miles)	Well Owner	Water Right Priority Date (earliest if multiple)
KLAM 2260 ("Wilson")	0.00	Jesperson Edgewood	3/3/1977
KLAM 2269	1.19	Jesperson Edgewood	5/28/1952
KLAM 2289	3.04	Coleman	8/2/1948
KLAM 12186	5.44	Liskey	2/10/1958
KLAM 12203	7.66	Venable	7/19/1949
KLAM 50362 ("Lone Rock")	6.64	Jesperson Edgewood	7/19/1949
KLAM 12420	10.42	Hankins	7/19/1949

1. Relative distances are based on the location of KLAM 2260, which represents the northern-most well located in the north Swan Lake Valley compartment.

Tabulated data for the pumping and observation wells is presented in Appendix B. Water level plots for the pumping and observation wells are presented in Appendix C. Evaluation of potential interferences is discussed in Section 8.

8.0 DATA REDUCTION AND ANALYSES

Data collected during the initial single-well pumping and recovery test was evaluated with the following objectives:

- Estimate values of transmissivity and storage coefficient representative of the north Swan Lake Valley compartment. These estimates were derived using drawdown and recovery data from pumping and observation wells. Methods employed for this analysis included those developed by Theis (1935) and Cooper and Jacob (1946).
- Identify potential leaky conditions and/or flow boundaries that may affect piezometric surfaces during extended periods of pumping. As appropriate, approximate the locations of flow boundaries based on image-well methodology.
- Project long-term pumping water level conditions in the reservoir supply wells.
- Develop drawdown scenarios within the north Swan Lake Valley compartment that reflect different pumping periods and/or durations relative to initial reservoir filling and reservoir maintenance pumping.

Data collected during the multiple-well pumping and recovery test was evaluated with the following objectives:

- Characterize the likelihood and magnitude of drawdown at selected distal wells as a result of pumping the array of supply wells required to fill the reservoir. Project long-term drawdown conditions at distal wells based on different pumping scenarios.
- Based on field data, develop values of "effective" transmissivity and storage coefficient that represent larger areas and/or multiple compartments of the basalt aquifer. Inherently, these estimates may incorporate flow boundaries that may affect long-term pumping and drawdown conditions. As appropriate, approximate the locations of flow boundaries based on image-well methodology.
- Evaluate the projected drawdown values at distal wells with respect to allowable appropriation rates, well specific capacity, and available drawdown based on well construction and pump intake settings.

8.1 DATA CORRECTIONS

This section presents a discussion of the methods employed to correct water level data records. As demonstrated in the appended water level plots, ambient water level trends observed in the study wells varied considerably. We attribute the variability in ambient water level trends to several factors described below.

8.1.1 Factors Affecting Water Levels

Our review of the collective water level data in pumping and observation wells indicates study area water levels are affected by three phenomena, as follows.

8.1.1.1 Barometric Pressure

Changes in water levels caused by variations in barometric pressure are evident in all wells, and variations in barometric pressure observed during the testing program were significant. The degree to which water levels change with respect to the magnitude of barometric pressure change (i.e., barometric efficiency) varied considerably. Generally, wells situated in the northern Swan Lake Valley compartment exhibit a relatively higher degree of barometric efficiency than those wells observed in the southern portions of the study area. A summary of estimated barometric efficiencies calculated from the baseline record is presented in Table 8.

Table 8. Estimated Barometric Efficiencies for Study Wells

Well	Estimated Barometric Efficiency	Remarks
KLAM 2259	0.60	Pumping well, northern compartment (west side)
KLAM 2260	0.60	Observation well, northern compartment (west side)
KLAM 2262	0.70	Pumping well, northern compartment (west side)
KLAM 2263	0.55	Pumping well, northern compartment (east side)
KLAM 2265	0.45	Pumping well, northern compartment (east side)
KLAM 2269	0.88	Observation well, northern compartment (west side)
KLAM 2289	0.15	Observation well, west of Swan Lake
KLAM 12186	0.65	Observation well, southwest of Swan Lake
KLAM 50362	0.30	Observation well, east/southeast of Swan Lake
KLAM 12203	0.20	Observation well, south of Swan Lake
KLAM 12420	0.28	Observation well, southeast of Swan Lake

Observation wells situated in the middle and southern portion of the study area (e.g., outside the northern Swan Lake Valley compartment) exhibit a more dampened response to barometric pressure change. Variability in response to barometric pressure changes is evident in the baseline (and generally all) data records presented in Appendix B.

8.1.1.2 Earth Tidal Influences

Water level data corrected for barometric changes using the simple barometric efficiency method revealed an influence from earth tides. This influence was characterized by an underlying harmonic in water levels that generally coincided with a periodicity of the moon phase. Again, the magnitude of observed changes due to the earth tide harmonic varied by location within the study area with more discernable effects occurring in wells located in the northern Swan Lake Valley compartment, suggesting a more rigid structure in those locations.

8.1.1.3 Ambient Recharge

Water level records indicate natural recharge to several of the wells during the course of the study. A marked difference (increase) in recharge rate was observed in selected wells located in the southern portion of the study area relative to those wells in the northern Swan Lake Valley compartment (specifically, refer to the magnitude of recharge experienced at KLAM 12186 in Appendix B). A depiction of the variable recharge rates observed during the baseline data collection period is presented on Figure 2. We infer the rate of recharge experienced by a given well may be directly related to the extent of intake interval open to the sedimentary deposits overlying the principal basalt aquifer. Refer to Table A-1 for a summary of well intake intervals.

8.1.2 Baseline Data

The baseline data record provided the most reliable information for establishing corrected data sets because the potential effects of outside influences (i.e., pumping were removed). The initial baseline water level record was obtained through the use of 30 psi data loggers recording at one hour intervals from January 27 through February 5, 2011. In accordance with OWRD request and in preparation for pumping phases of the testing program, the baseline water level record was obtained through the use of 5 psi data loggers recording at one minute intervals from February 5 through February 8, 2011. Our comparative evaluation of the early baseline records and the later baseline records indicates the information generated from the 30 psi dataloggers (at one hour intervals) yielded data of sufficient quality to incorporate into the data analysis.

Evaluation of the baseline data record revealed notable differences in water level responses to barometric pressure changes, earth tides, and ambient recharge which support the hypothesis that the northern Swan Lake Valley compartment experiences some level of hydraulic separation from areas generally south of Swan Lake. The baseline hydrographs depicting water levels and barometric pressures for each well are presented in Appendix B. Figure 2 depicts corrected baseline water level trends in pumping an observation wells used in this study.

8.1.3 Methodology for Water Level Corrections

Water level corrections for barometric pressure and earth tide influences were generally successful. Significant weather changes occurred throughout the testing program, resulting in a maximum barometric pressure change of approximately 1.16 feet (of equivalent water head). Because the magnitude of barometric pressure change was greater than any observed observation well drawdown, correction of the data was necessary to support the evaluation.

In correction of the water level data records, we employed two methods to remove barometric pressure effects. The first method included preparation of a parallel plot of baseline water levels and barometric pressures on a consistent time scale. During more significant barometric events, we calculated slopes for water levels and barometric changes to derive a ratio of water level response versus atmospheric pressure change. This ratio is defined as barometric efficiency. The second method for barometric pressure correction included the use of BETCO software available from the University of Georgia (Rasmussen) at http://www.hydrology.uga.edu/rasmussen/BETCO/BETCO.html.

The BETCO software provided the most rigorous analytical tool for generating corrected (synthetic) hydrographs. However, our analysis suggests the BETCO software is most successful when applied to long-term data sets not affected by pumping wells. As such, the BETCO-derived water level plots were largely applied to the baseline data records because it provided the most useful tool for filtering the effects of earth tides. The BETCO analysis created edge effects in the data, which reflect the algorithm inherent to the software. A certain number of initial data points must be contemplated by the algorithm before output begins. These edge effects are apparent on the baseline hydrographs presented in Appendix B.

Drawdown and recovery phases associated with well pumping were best evaluated using a dataset corrected using the barometric efficiency method. We point out that application of the barometric efficiency method does not filter effects of earth tides but provided "smoothed" dataset of sufficient quality to evaluate potential response to pumping. Drawdown and recovery plots for pumping and observation wells are presented in Appendix B.

8.2 DATA ANALYSIS

Analysis of the pumping data proceeded in two phases. The single-well pumping test data was evaluated to determine if measurable drawdown was experienced at any given observation well. If response to pumping was discernable, we utilized the non-equilibrium method developed by Theis (1935) and the modified non-equilibrium method developed by Cooper and Jacob (1946) to derive estimates of transmissivity and storage coefficient. In addition, we employed a simple distance-drawdown plot to visualize the radius of influence created by pumping well KLAM 2259. Rapid drawdown/stabilization and/or relatively turbulent conditions in selected wells precluded the use of some analytical methods, including the Theis drawdown (match-point) method. We also noted that late-recovery data in some datasets may have been affected (although corrected) by ambient factors affecting water levels.

Analysis of the pumping data generated during the multiple-well interference test was generally more simplistic. The corrected water level data from observation wells was reviewed to determine if any measurable or discernable effect was created via pumping the four supply wells. In light of the observed recharge experienced by several observation wells, "interference" could be signaled by drawdown as well as a reduction in the rate of recharge experienced by the well. For the multiple-well testing data, we also employed the Cooper-Jacob wellfield method (Kruseman and de Ridder, 1994) to estimate values of "effective" transmissivity for the area of influence created by the pumping well array.

Pumping test analysis plots for all pumping and observation wells are presented in Appendix C.

8.2.1 Observed Drawdowns

This section presents a discussion of responses to pumping observed at study area wells and a general discussion of boundary effects drawn from the drawdown and recovery plots presented in Appendix C.

8.2.1.1 Single-Well Pumping Test

Review of corrected water levels from the single-well pumping test indicated measurable drawdown at three of the five observation wells used for this phase of testing. The estimated drawdown values are presented in Table 9.

Table 9. Estimated Drawdown at Study Observation Wells Induced from Constant-Rate Pumping Well KLAM 2259 Single-Well Pumping Test

Observation Well	Distance From KLAM 2259		Estimated Drawdown (feet)	Remarks
	miles	feet		
KLAM 2262	0.37	1,940	0.15	
KLAM 2269	0.41	2,190	0.10	
KLAM 2260	0.79	4,150	0.13	
KLAM 2263	1.64	8,660	0.00	No drawdown observed
KLAM 2265	3.37	17,800	0.00	No drawdown observed

Drawdown and/or interference was also not observed in other study area observation wells during the single-well pumping test.

8.2.1.2 Multiple-Well Interference Test

Aside from the pumping well drawdown levels summarized in Section 7.0, review of corrected water levels from the multiple-well interference test indicated measurable drawdown at two of the seven observation wells used for this phase of testing. The estimated drawdown values are presented in Table 10.

Table 10. Estimated Drawdown at Study Observation Wells Multiple-Well Interference Test

Observation Well	Distance From KLAM 2260[1] (miles)	Estimated Drawdown[2] (feet)	Remarks
KLAM 2260	0.00	0.50	
KLAM 2269	1.19	0.26	
KLAM 2289	3.04	0.00	No drawdown or interference observed
KLAM 12186	5.44	0.00	No drawdown or interference observed
KLAM 12203	7.66	0.00	No drawdown or interference observed
KLAM 50362	6.64	0.00	No drawdown or interference observed
KLAM 12420	10.42	0.00	No drawdown or interference observed

1. Relative distances are based on the location of KLAM 2260, which represents the northern-most well located in the north Swan Lake Valley compartment.
2. Estimated drawdown reflects maximum value determined from water level data corrected for barometric effects.

Estimated drawdowns at observation wells KLAM 2260 and 2269 reached their maximum values at pumping time of approximately 7,900 to 8,400 minutes. Theoretically, the maximum induced drawdown would be realized at the end of the pumping period (approximately 12,780 minutes). We attribute this deviation from theoretical conditions to several possible factors, including (1) a significant barometric event near the completion of the pumping phase that may have not been fully corrected using the calculated barometric efficiencies designed to most accurately correct the majority of the data record and/or (2) recharge effects to the aquifer.

8.2.2 Well Performance and Hydraulic Property Estimates

8.2.2.1 Specific Capacity

Specific capacity is defined as well yield per unit drawdown. Pumping rates and observed drawdown for each pumping well are presented in Table 11.

Table 11. Pumping Rates and Pumping Well Drawdowns for Multiple-Well Interference Test

Pumping Well	Pumping Rate (gpm)	Observed Drawdown[1,2] (feet)	Calculated Specific Capacity (gpm/ft)
KLAM 2263 (Well #1; "Cove")	2,350	2.6	903.8
KLAM 2259 (Well #2; "100-Horse")	3,000	3.3	909.1
KLAM 2262 (Well #4; "Aspen")	3,500	15.3	229.8
KLAM 2265 (Well #5; "Lake")	3,400	21.1	161.1

1. Observed values given to nearest 1/10th of 1 foot due to turbulence associated with pumping. Refer to appended data.
2. The pumping level drawdown observed at KLAM 2259 during the multiple-well test was 1.2 feet less than the observed pumping level drawdown during the single-well pumping from this well. This may be attributed to an overall loss in formation pressure head as a result of pumping other wells.

We point out two specific observations from the summary table above:

- Calculated specific capacity for pumping wells KLAM 2262 and 2265 are significantly less than the calculated values for pumping wells KLAM 2259 and 2263. We infer the differences to reflect well intake intervals with more extensive communication with the basin fill overlying the principal basalt unit in wells KLAM 2262 and 2265.
- The pumping level drawdown observed at KLAM 2259 during the multiple-well test was 1.2 feet less than the observed pumping level drawdown during the single-well pumping from this well. We verified this observation at the end of the pumping phase of the multiple-well test by shutting off nearby pumping well KLAM 2262 prior to shutting off KLAM 2259; the pumping water level almost immediately increased in KLAM 2259 when this was performed. We infer this to reflect partial de-pressurization of the formation as a result of pumping the other three production wells.

8.2.2.2 Transmissivity and Storage Coefficient

A summary of estimated transmissivity and storage coefficient values are presented in Table 12. As demonstrated by this summary, supporting analysis plots in Appendix C, and calculated specific capacity values, the northern Swan Lake Valley compartment is characterized as highly transmissive.

Table 12. Summary of Estimated Transmissivity and Storage Coefficient Values Northern Swan Lake Valley Compartment

Well	Testing Phase[1]	Analysis Method[2]	Transmissivity (ft^2/day)[3]	Storage Coefficient	Remark
KLAM 2259	SWT, P	CJ	176,500	--	Early Drawdown
		CJ	705,900	--	Late Drawdown
		TR	4,812,800	--	Early Recovery
		TR	1,393,200	--	Middle Recovery
		TR	2,941,200	--	Late Recovery
	MWT, P	CJ	529,400	--	Best Fit All Data
		TR	2,406,400	--	Early Recovery
		TR	980,400	--	Late Recovery
KLAM 2259 KLAM 2260 KLAM 2262 KLAM 2269	SWT, P/O	DD	146,044	0.105	Using observation wells 2262 and 2269
			176,470	0.028	Using observation well 2260
KLAM 2260	SWT, O	CJ	1,925,100	0.0044	Early Drawdown
		CJ	814,500	0.0063	Late Drawdown
		T	919,300	0.0069	Late Drawdown
		TR	8,144,800	--	Early Recovery
		TR	1,512,600	--	Middle Recovery
		TR	920,716	--	Late Recovery
	MWT, O	CJW	1,896,200	0.0074	Wellfield Method
KLAM 2262	SWT, O	CJ	5,294,100	--	Early Drawdown
		CJ	1,008,400	0.013	Middle Drawdown
		T	1,532,100	0.008	Middle-Late Drawdown
		TR	2,647,100	--	Middle-Late Recovery
	MWT, P	CJ	49,400	--	Early Drawdown, may reflect component from basin fill
		TR	1,314,100	--	Early Recovery
		TR	667,700	--	Late Recovery
KLAM 2263	MWT, P	CJ	188,100	--	Middle Drawdown
			82,100	--	Late Drawdown

Table 12. Summary of Estimated Transmissivity and Storage Coefficient Values Northern Swan Lake Valley Compartment (continued)

Well	Testing Phase[1]	Analysis Method[2]	Transmissivity (ft²/day)[3]	Storage Coefficient	Remark
KLAM 2265	MWT, P	CJ	171,400	--	Middle Drawdown, may reflect component from basin fill
			266,700	--	Late Drawdown, may reflect component from basin fill.
		TR	130,400	--	Indicates delayed yield or leaky condition
			240,000	--	Indicates delayed yield or leaky condition
KLAM 2269	SWT, O	CJ	8,823,500	--	Early Drawdown
			1,825,600	--	Middle Drawdown
		T	2,298,100	0.0029	Middle-Late Drawdown
		TR	3,529,400	--	Middle-Late Recovery
	MWT, O	CJW	4,392,000	0.0069	Wellfield Method

1. SWT = Single-Well Test; MWT = Multiple-Well Interference Test; P = Pumping Well; O = Observation Well
2. CJ = Cooper-Jacob semi-log; T = Theis Log-Log Drawdown vs. t/r^2; TR = Theis Recovery; DD = Distance Drawdown; CJW = Cooper-Jacob wellfield
3. Values rounded to nearest 100 ft²/day

The values of the test data analysis indicate that the North Swan Lake Valley basalt aquifer is highly transmissive. The range of estimated transmissivity varies considerably; the lower ranges of values likely represent those wells with substantial communication with basin fill overlying the basalt unit. The higher range reflects results from early drawdown/recovery data and "effective" transmissivities representing the effects of potential boundary conditions. We estimate transmissivity values of the primary basalt unit in North Swan Lake Valley on the order of 300,000 to 900,000 ft²/day. The Cooper-Jacob wellfield method provides a good basis for estimating an overall effective transmissivity supporting long-term drawdown estimates. Effective transmissivity inherently considers the effects of overlying basin fill and boundary conditions present between pumping and observation wells.

General evaluation of the drawdown and recovery data indicate the possible presence of both negative and positive flow boundaries near the pumping well array. While present, these boundary conditions did not appear to heavily influence the later drawdown curves, which is most important to this study. The changes in slopes present on the pumping test analysis charts (Appendix C) reveal these features. The limited number of observation wells exhibiting discernable drawdown complicates the ability to identify the specific locations of positive and/or negative flow boundaries. Recovery data from pumping well KLAM 2265 exhibits a characteristic curve indicative of delayed yield and/or leaky aquifer response from the basin fill sediments. Pumping test analysis plots are presented in Appendix C.

We note a particular observation during the drawdown phase of the single-well pumping test. Approximately 250 minutes into the pumping phase, a sharp increase in barometric pressure was experienced. Although the calculated drawdown values were based on barometrically corrected data, the middle drawdown data at observation wells KLAM 2260 and KLAM 2269 (suggesting a negative flow boundary) could be misinterpreted as the result of a sharp increase in barometric pressure, particularly in light of the barometric effects on the data during late pumping time. However, evaluation of the multiple-well testing drawdown data (when barometric pressures were much more constant) also indicated a break in slope at the 100-minute elapsed time, similar to the single-well drawdown data. Evaluation of the recovery curves also indicated the existence of the feature. This exercise verified the existence of some boundary condition affecting the middle drawdown data. To support this discussion, additional analytical charts depicting barometric pressures and uncorrected data for observation well KLAM 2260 during the single-well and multiple-well testing phases are included in Appendix C.

8.2.3 Projected Drawdowns Associated with Reservoir Filling and Maintenance

The Theis method was applied to estimate long-term drawdowns associated with reservoir filling and maintenance. Spreadsheet calculations are presented in Appendix D. These estimates were developed based on hydraulic parameters derived from the testing program, and the projected pumping rates and durations described in Section 2.2. The spreadsheet calculation was initially calibrated to match observed drawdowns at KLAM 2260 and KLAM 2269 during the testing program by adjusting entered values of transmissivity These entered values fall within the range of estimates provided above and inherently represent "effective" hydraulic parameters. Further calibration calculations were then completed using the entered values of transmissivity and storage coefficient to estimate potential drawdowns at other distal wells. Resulting estimates for distal wells did not match observed values for a seven-day pumping projection. For example, entering the calibrated values of transmissivity and storage coefficient and the pumping rates/durations reflecting actual multiple-well pumping test conditions (or the average of values determined by the Cooper-Jacob wellfield method) yielded a projected drawdown of 0.16 feet at KLAM 2289; however, no actual drawdown or interference was observed during the field study. This exercise was repeated for other observation wells in the southern portion of the study area. The results support the idea that some resistance to flow is apparently located near the northern latitude of Swan Lake. Using observation well KLAM 2289 as a further example, the entered value of transmissivity required to effect 0.01-foot of drawdown (based on actual multiple-well test pumping rates and duration) would be on the order of 91,000,000 ft^2/day; an unrealistically high value.

The Theis method is the most appropriate approach in estimating potential drawdowns at distal wells. We employed the Theis method to conservatively assess the aquifer response to the three-year reservoir filling duration at prorated pumping rates. Prorated pumping rates reflect annual duties applicable to the respective water rights distributed throughout the entire year and are calculated in Table A-2. To estimate projected drawdowns at the pumping (supply) wells, values of transmissivity and storativity were entered into the spreadsheet that resulted in a match to observed data from the multiple-well interference test. The entered values of time and prorated pumping rate were then used to estimate long-term pumping well drawdowns. To estimate projected drawdowns at distal observation wells, values of transmissivity and storativity were entered into the spreadsheet that reflected calibration values (for KLAM 2260 and KLAM 2269) or average values obtained using the Cooper-Jacob wellfield analysis method. Projected theoretical drawdowns are summarized in Table 13.

Table 13. Projected Theoretical Drawdowns Arising from Reservoir Filling and Maintenance Pro-Rated Pumping Rates for Three Years of Pumping[1]

Well	Pumping Rate (gpm)	Calculated Drawdown[2] (feet)	Remark
Reservoir Supply Wells			
KLAM 2263 (Well #1; "Cove")	932	1.8	
KLAM 2259 (Well #2; "100-Horse")	1,205	2.0	
KLAM 2262 (Well #4; "Aspen")	893	8.4	
KLAM 2265 (Well #5; "Lake")	1,190	13.7	Also to serve as maintenance well for reservoir losses
Observation Wells Used in Groundwater Study			
KLAM 2260	--	0.35	
KLAM 2269	--	0.17	
KLAM 2289	--	0.17	
KLAM 12186	--	0.15	
KLAM 50362	--	0.15	
KLAM 12203	--	0.14	
KLAM 12420	--	0.13	

1. Projected values assume three years (1,095 days) of uninterrupted pumping at prorated rates based on water right limitations for a given pumping well (see Table A-2).
2. Projected values for pumping wells given to nearest 1/10th of 1 foot given the level of assumptions in the analytical method.

The projected theoretical drawdowns are conservative for the following reasons:

- Reservoir filling will not be completed by an uninterrupted 1,095 days of pumping. Temporary idle periods related to pump/equipment maintenance and/or power interruptions are expected. The resulting periods of recovery will reduce distal drawdown caused by supply well pumping.
- The values entered into the calculation spreadsheet reflect an assumed, effective transmissivity calibrated to the northern Swan Lake Valley compartment. Because drawdowns and/or interference were not observed in wells south of Swan Lake during the field testing program, the actual effective transmissivity value representing the presence of the flow boundary between the northern compartment and southern study areas is greater than the values assumed. This actual value also is not accurately estimated given the results of the multiple-well interference test because no observed drawdown or interference was observed outside the northern Swan Lake Valley compartment.

This analysis indicates that projected drawdowns and/or interferences to wells in the Swan Lake Valley would be minimal under the most conservative conditions. The estimated, theoretical drawdown values of approximately 0.17 to 0.13 feet are not expected to affect the ability to fully exercise a given water right within the study area.

9.0 PROBLEMS ENCOUNTERED AND RESOLUTION

This section presents a discussion of problems encountered during the field investigation program and measures implemented to remedy the problems.

Problem: GeoDesign did not receive owner authorization to access proposed observation wells KLAM 12223 and KLAM 12224.
Resolution: GeoDesign notified OWRD of the access limitation. OWRD concurred with the revised array of proposed observation wells in comments dated February 2, 2011.

Problem: Water level meter and transducer deployment was not possible in proposed observation wells KLAM 12385 and KLAM 12386.
Resolution: GeoDesign was able to deploy equipment in proposed observation well KLAM 50362. Anticipating access limitations to some wells, we proposed use of one of the three wells located in this area (KLAM 50362, KLAM 12385, or KLAM 12386). As such, this did not cause a change in scope.

Problem: Water level meter and transducer deployment was not possible in proposed observation wells KLAM 10082 and KLAM 50341.
Resolution: GeoDesign notified OWRD of the access limitation and achieved deployment in another nearby replacement wells (KLAM 10082 replaced with KLAM 2269 and KLAM 50341 replaced with KLAM 12420). OWRD concurred with the revised array of proposed observation wells in comments dated February 2, 2011.

Problem: Many of the study wells had no access ports or did not have sufficient annular space to deploy transducers along with manual water level indicators. Equipment hang-up was generally a problem, and some deployment depths were limited based on space restrictions (i.e., pump column couplings).
Resolution: GeoDesign anticipated this potential problem and indicated in our Plan that manual measurements would be collected during deployment and retrieval of transducers and also as possible during pumping/recovery periods of the testing program. We collected and recorded hand-measurements in accordance with these limitations and our Plan.

Problem: Transducer deployment in pumping well KLAM 2263 during the multiple-well testing program was not possible given access limitations.
Resolution: GeoDesign deployed a transducer within the pump column at this well to record baseline observations and potential response to the initial single-well test. During the multiple-well interference testing, access to the pump column was not possible so manual measurements were obtained to the extent possible during this period to document pumping water levels and associated total drawdown.

Problem: During change-out of the 30 psi transducers to 5 psi transducers in pumping and observation wells, the 30 psi transducer encountered a hang-up during retrieval in observation well KLAM 2260.
Resolution: The original 30 psi transducer was re-lowered to the original setting depth and manual measurements were collected to verify setting depth. The use of the 30 psi transducer was required given this hang-up problem. Fortunately, the drawdown response in this well was sufficient to allow data analysis despite the lower resolution of the transducer.

Problem: The observed drawdown in pumping well KLAM 2265 was significantly greater than prior specific capcacity records indicated. Consequently, the water level fell below the transducer depth, which was deployed to the maximum extent possible given down-hole obstructions.
Resolution: Upon discovery of the problem, GeoDesign initiated hand measurements to the extent possible to document (later) drawdown pumping levels. Sufficient manual measurements were collected to evaluate total drawdown and general characteristics of the late drawdown curve. The transducer was allowed to continue recording in order to capture recovery data.

Problem: Several minutes into the single-well pumping test, electrical problems at KLAM 2259 caused the pump to shut down approximately seven minutes into the test.
Resolution: Jesperson fixed the electrical problem and the well was allowed to recover to within 0.01 foot of the baseline water level. The test was re-initiated after recovery was allowed to occur.

Problem: Three power outages were experienced during the multiple-well interference testing. Power outages were experienced between February 15, 2011 at 0117 and February 26, 2011 at 0658.
Resolution: GeoDesign notified OWRD of the problem and extended the pumping period of the multiple-well interference test to achieve seven consecutive days of uninterrupted pumping as proposed in our Plan. This circumstance was not entirely detrimental. Review of the data shows clear response to the power outages at observation well KLAM 2269 and no response signal at any other observation wells. This provided a separate check on the overall evaluation of study area well communication.

Problem: Several weather fronts were experienced during the testing program, causing significant shifts in barometric pressure. This, coupled with minor (if any) drawdowns and variable barometric efficiencies at the observation well array, made data reduction and correction more complex
Resolution: GeoDesign put forth significant effort in correcting the dataset for barometric influences to prepare a dataset suitable to evaluate potential interferences with project area wells.

10.0 CONCLUSIONS

Groundwater interference testing was completed in general accordance with our Plan dated January 14, 2011. We incorporated comments received from OWRD on February 2, 2011 into the testing program. This analysis supports the following conclusions:

- Evaluation of the single-well pumping test data suggests the principal basalt aquifer in the northern Swan Lake Valley compartment is highly transmissive. Overlying basin fill sedimentary deposits are characterized by much lower transmissivity values. Well log records indicate many area wells receive flows from both hydrogeologic units, and the wide range of reported specific capacities reflects the variable degree to which a given well communicates with the sedimentary deposit and basalt unit. Estimated transmissivity values ranged from 49,400 to 8,823,500 ft^2/day. Storage coefficient values ranged from 0.0029 to 0.105. We estimate transmissivity values of the primary basalt unit in North Swan Lake Valley on the order of 300,000 to 900,000 ft^2/day.
- Water level response data to single-well pumping and multiple-well pumping indicates the presence of a hydrologic boundary condition that appears to reduce the effects of pumping stress on wells located on the distal side of this boundary. The location of this boundary appears to be just north of Swan Lake and correlates to the division of the North Swan Lake and Central Swan Lake to Poe Valley sub-areas postulated by Grondin (2004).
- Drawdowns and/or interferences were not observed in project observation wells south of KLAM 2269.
- Theis' solution to the groundwater flow equation was used to derive conservative estimates of potential drawdowns arising from long-term (three years) pumping at prorated extraction rates from the pumping well array. The range of theoretical drawdowns in project observation wells ranged from 0.35 foot (at KLAM 2260, north end) to 0.13 foot (at KLAM 12420, south end). The projected drawdown values are conservative based on assumed inputs.

The 2 to 7 feet of seasonal groundwater fluctuation reported by Grondin (2004) reflects the cumulative effect of groundwater withdrawal from all wells within the Swan Lake Basin. This analysis suggests that use of the four proposed reservoir supply wells at year-round, prorated pumping rates under current annual duties will not create additional or excessive stress on the groundwater resource. Actual realized drawdowns (if observed or measurable) caused by the proposed reservoir filling are expected to be less than the values estimated during this analysis, particularly for wells located south of the apparent flow boundary between the North Swan Lake and Central Swan Lake to Poe Valley sub-areas.

In conclusion, this study indicates that the proposed reservoir filling is not expected to impact the ability to fully exercise a given water right in the study area.

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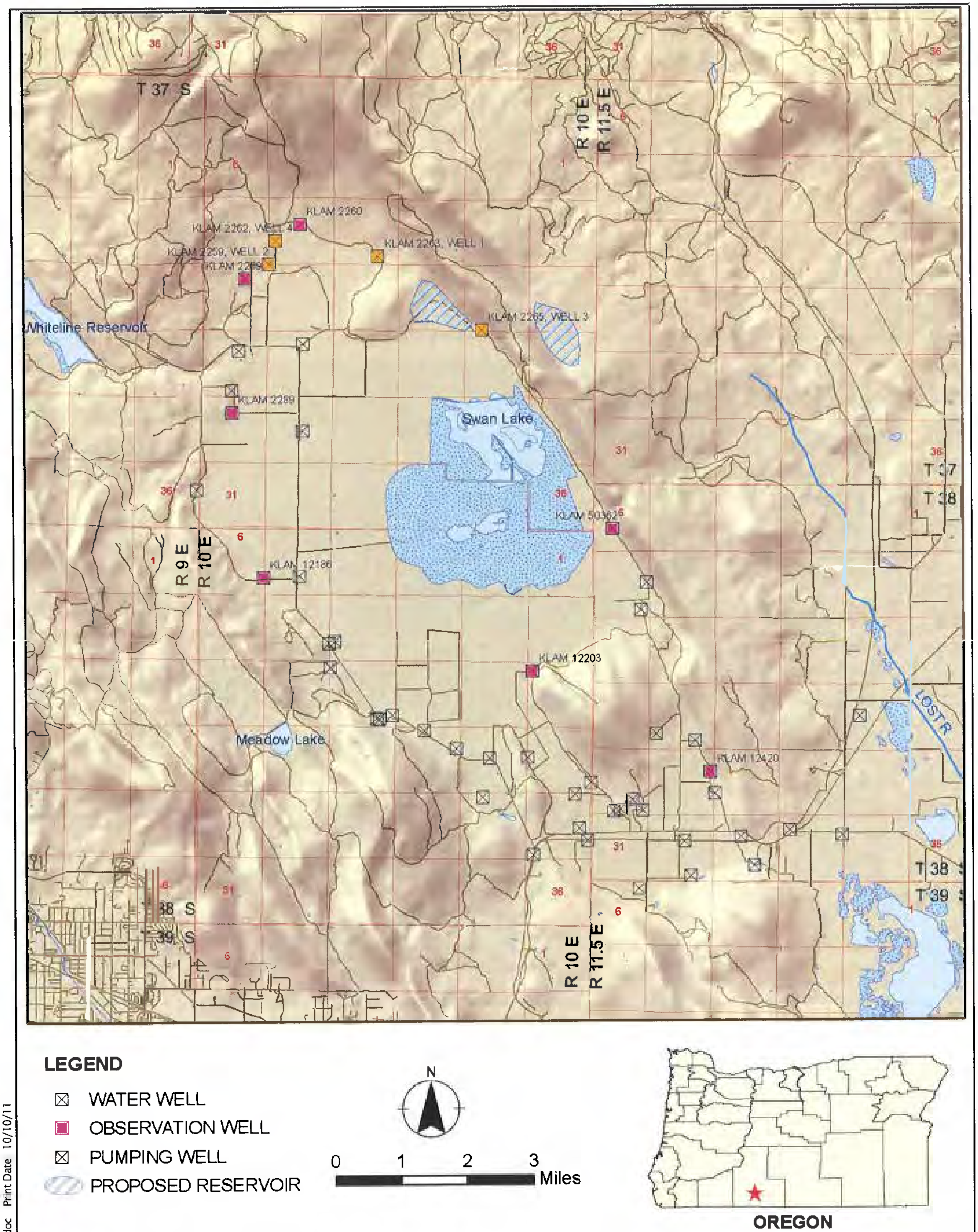
FIGURES



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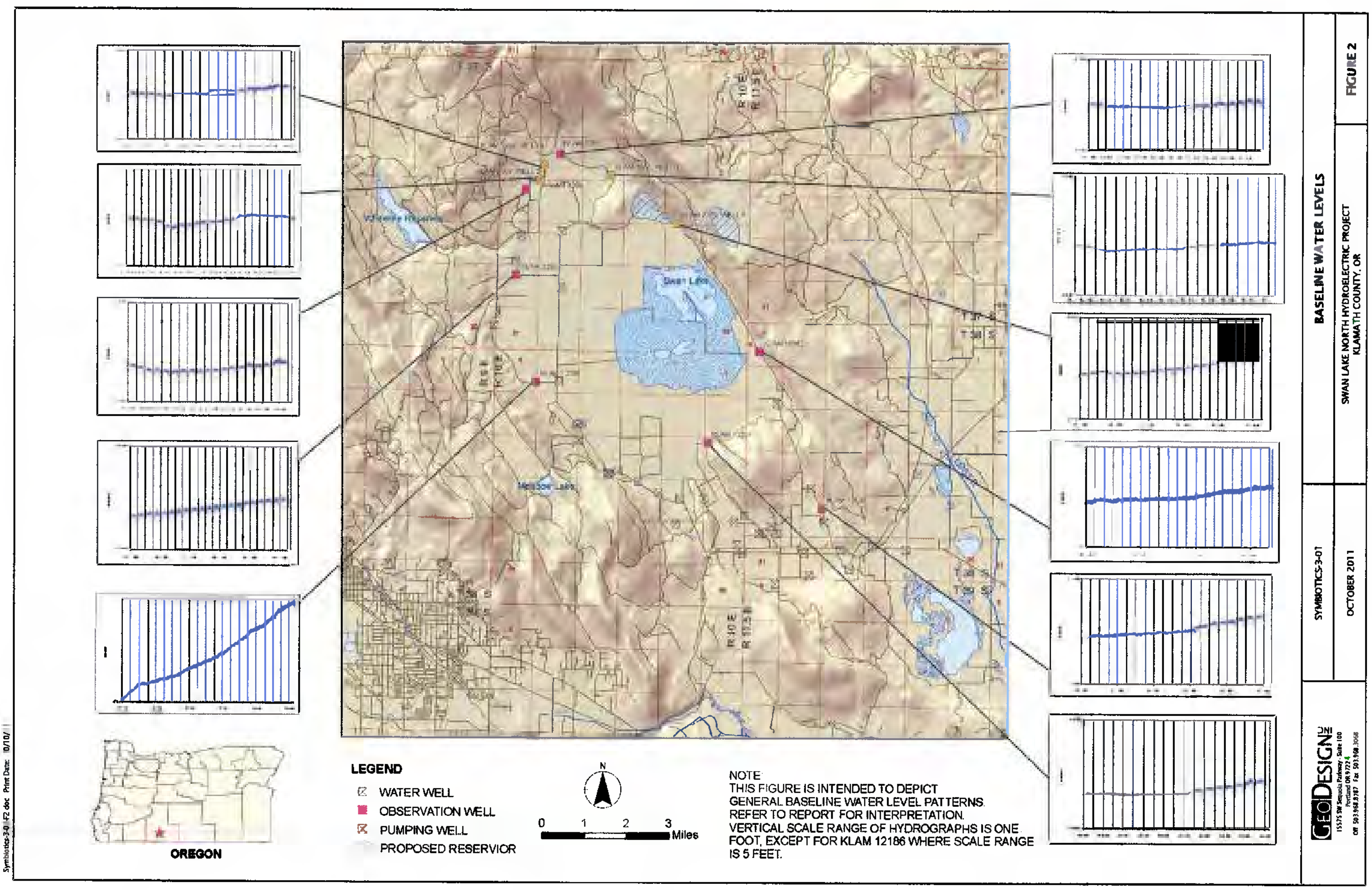
SYMBIOTICS-3-01	STUDY AREA AND PROPOSED RESERVOIR LOCATIONS		
OCTOBER 2011	SWAN LAKE NORTH HYDROELECTRIC PROJECT KLAMATH COUNTY, OR	FIGURE 1	


Swan Lake
Meadow Lake
LEGEND
WATER WELL
OBSERVATION WELL
PUMPING WELL
PROPOSED RESERVIOR
OREGON
0 1 2 3 Miles
N
NOTE
THIS FIGURE IS INTENDED TO DEPICT
GENERAL BASELINE WATER LEVEL PATTERNS.
REFER TO REPORT FOR INTERPRETATION.
VERTICAL SCALE RANGE OF HYDROGRAPHS IS ONE
FOOT, EXCEPT FOR KLAM 12186 WHERE SCALE RANGE
IS 5 FEET.
BASELINE WATER LEVELS
SWAN LAKE NORTH HYDROELECTRIC PROJECT
KLAMATH COUNTY, OR
FIGURE 2
SYMBIOTICS-3-01
OCTOBER 2011
GEODESIGN

APPENDIX A

APPENDIX A

STUDY AREA WELLS, WATER RIGHTS, AND PROJECTED PUMPING RATES

Table A-1

Summary of Water Wells and Water Rights
Proposed Swan Lake North Pumped Storage Hydroelectric Project

TABLE A-1
Summary of Wells and Water Rights
Proposed Swan Lake North Pumped Storage Hydroelectric Project
Klamath County, Oregon

County Well (KLAM)	Distance From KLAM 2260 (north end of compartment) miles	Distance From KLAM 2260 (north end of compartment) feet	Owner's I.D.	Date Drilled	Reported Ground Surface Elevation (feet)	Well Owner (log)	Township/ Range/Section/ Quarter/Quarter-Quarter	Water Rights (non-cancelled) (Current) Holder	Application	Permit	Certificate	Priority Date	Total Acres	Annual Duty	Appropriation Rate cfs	Appropriation Rate gpm	Well Depth (feet)	Casing Diameter (inches)	Casing Depth (feet)	Hydro Unit	Well Log First Water (feet)	Yield (gpm)	Drawdown (feet)	Duration (hours)	Estimated Specific Capacity (gpm/ft of drawdown)	Pump Information
Proposed Pumping Wells																										
2263	1.28	6,762	Well 1	1951	–	Devincenze	37S/10E/9DC	Devincenze	U 453	U 486	29530	12/24/1951	683	[illegible]	8.58	3,816	142	[illegible]	19	Basalt ("cinders")	–	4,758	[illegible]	[illegible]	1,188	100-HP turbine
								Jesperson Edgewood	G 7873	G 7293	83121	3/3/1977	66	[illegible]	8.83	373										
2259	0.75	3,951	Well 2	1952	–	Edgewood Ranch/Devincenze	37S/10E/8CC	Devincenze	U 453	U 486	29530	12/24/1951	1,002.2	[illegible]	7.00	3,142	281	18	178	Basalt	98	3,000	[illegible]	[illegible]	1,500	100-HP turbine
								Devincenze	G 7873	G 7293	83121	3/3/1977	476.3	[illegible]	5.50	2,469										
2262	0.45	2,355	Well 4	8/15/1979	–	Jesperson Edgewood	37S/18E/8BC	Jesperson Edgewood	G 10135	G 10952	87006	6/28/1982	457.2	[illegible]	5.72	2,567	187	16	[illegible]	Basalt ("cinders")	160	4,000	[illegible]	[illegible]	1,333	150-horsepower turbine
								Jesperson Edgewood	G 10340	G 9332	67564	5/26/1981	252.2	[illegible]	3.15	1,414										
2265	3.17	16,715	Well 5	–	4220	Devincenze	37S/10E/14CC	Jesperson Edgewood	G 10135	G 10952	87006	6/28/1982	631.4	[illegible]	7.09	3,541	123	10	–	Basalt ("cinders")	–	4,000	–	–	–	75-HP turbine
Observation Wells																										
2260	8.00	0	Well 3	2/23/1977	–	Jesperson Edgewood	37S/10E/8BA	Jesperson Edgewood	G 7873	G 7293	83121	3/3/1977	576.7	[illegible]	7.21	3,236	200	[illegible]	20	Basalt ("cinders")	[illegible]	3,200	[illegible]	4	1,600	–
2269	1.17	6,154	–	1954	–	Mario Marengo	37S/10E/18AB	Mario Marengo	U 501	U 585	38572	5/28/1952	76.8	[illegible]	0.96	431	325	[illegible]	–	Basalt ("cinders")	–	2,500	88	[illegible]	[illegible]	–
2289	3.85	16,188	–	1949	4205	C Fred Collman	37S/10E/30BA	C. Fred Collman	U 279	U 250	22847	8/2/1948	156	[illegible]	1.95	875	[illegible]	16	[illegible]	Basalt ("cinders")	–	2,000	17	–	118	–
12186	5.43	28,644	–	9/14/1957	–	Maude E. Liskey	38S/10E/5CB	Maude Liskey	G 856	G 764	34519	2/18/1958	258.4	[illegible]	3.23	1,458	850	18	[illegible]	Basalt	78	2,150	90	4	24	–
50362	6.65	35,102	"Lone Rock"	–	4188	LM Hankins (Swan Lake Ranch)	38S/11.5E/6BC	Jesperson Edgewood Nevin Cattle	U 319	U 343	58381	7/19/1949	478.4	[illegible]	5.98	2,684	224	[illegible]	–	Basalt	–	–	–	–	–	–
12203	7.67	40,497	No. 7 "Uskey"	1948	4192	LM & Loyd Hankins (Swan Lake Ranch)	38S/10E/13BB	Jesperson Edgewood Nevin Cattle	U 319	U 343	50381	7/19/1949	304	[illegible]	3.80	1,706	221	16	40	Basalt ("cinders")	–	1,600	[illegible]	[illegible]	84	75-HP turbine
								Jesperson Edgewood Nevin Cattle	G 5390	G 5191	–	1/4/1971	410	–	4.83	2,168										
								Nevin Cattle	G 10510	G 10129	–	8/31/1982	7.2	[illegible]	0.09	40										
12420	10.43	55,885	No. 13 "Thomas"	1950	4206	LM. Hankins	38S/11.5E/29AD	Lloyd Hankins	U 318	U 402	29619	7/19/1949	229.7	[illegible]	2.87	1,288	135	16	–	Basalt ("cinders")	–	2,660	07	4	3,800	–
								Nevin Cattle	G 4673	G 4401	38246	11/6/1968	60.8	[illegible]	0.76	341										
Other Wells in Swan Lake Valley (Southern Limit Assumed Hwy. 78 at Pine Flat)																										
2277	1.83	9,649	–	12/14/1987	–	[illegible]	37S/10E/20AB	Exempted Use (Domestic)									330	8	28	"Clay and Sand"	[illegible]	45	13	[illegible]	[illegible]	–
10082	2.14	11,321	–	7/12/1989	–	Jeld Wen	37S/10E/19A	Jeld Wen T and R	G 12228	G 11432	83328	9/13/1990	242.4	[illegible]	3.03	1,360	310	16	Also Perf 79-199	? Below basalt?	61	2,800	4.5	[illegible]	622	110 HP
50445	2.73	14,436	–	8/9/1996	4230	Jeld Wen	37S/10E/19CD	Jeld Wen Craig Dittman	G 14900	G 13725	–	1/7/1999	108	[illegible]	[illegible]	606	220	18 (16" liner)	Perf 80-220	Basalt ("cinders")	–	1,800	53	4	34	–
2288	3.15	16,639	No. 3	1949	4186	Edgewood Ranch/Devincenze	37S/10E/28DB	–	–	–	–	–	–	–	–	–	800	16	20	"chalk"	–	–	–	–	–	–
2256	4.35	22,946	–	1953	–	John & William Marshall	37S/9E/36AD	John & William Marshall	U 457	U 465	29529	1/30/1952	161.6	[illegible]	2.02	907	1,800	16 12	600	"chalk and rock"	–	–	–	–	–	–
10336	5.35	28,264	–	10/15/1991	–	Bar C-L	38S/10E/5AC	Bar C-L Glenn Lorenz	G 14993	G 13832	–	6/1/1999	499.2	[illegible]	6.24	2,801	1,620	16	210	Basalt & shale	–	2,800	79	[illegible]	[illegible]	–

TABLE A-1 Summary of Wells and Water Rights Proposed Swan Lake North Pumped Storage Hydroelectric Project Klamath County, Oregon																										
County Well (KLAM)	Distance From KLAM 2260 (north end of compartment)		Owner's I.D.	Date Drilled	Reported Ground Surface Elevation (feet)	Well Owner (log)	Township/ Range/Section/ Quarser/Quarter-Quarter	Water Rights (non-cancelled)							Appropriation Rate		Well Depth (feet)	Casing Diameter (inches)	Casing Depth (feet)	Hydro Unit	Well Log				Estimated Specific Capacity (gpm/ft of drawdown)	Pump Information
	miles	feet						(Current) Holder	Application	Permit	Certificate	Priority Date	Total Acres	Annual Duty (ft/acre)	cfs	gpm					First Water (feet)	Yield (gpm)	Drawdown (feet)	Duration (hours)		
12197	6.48	33,811	—	1949	4190	Rogers and Stacy	38S/18E/9CB	Felbert Rodgers	U 440	U 411	24678	18/12/1951	338.4	3	4.23	1,899	[illegible]	18	68	Basalt ("cinders")	—	2,300	43	[illegible]	[illegible]	—
								Delbert & Sam Dehlinger	G 3428	G 3214	38085	3/23/1966	40	3	8.50	224										
11643	6.43	33,963	—	5/22/1979	—	Curtis Underwood	38S/10E/9CC	Curtis Underwood	G 9339	G 8625	83040	8/2/1979	431.2	3	5.39	2,420	610	16	26	Basalt	188	1,800	—	[illegible]	—	—
12209	6.78	35,786	No. 2	1965	—	Dave Liskey	38S/18E/16BB	Maude Liskey	G 3316	G 3088	45487	12/9/1965	504	3	6.30	2,828	290	18	[illegible]	Basalt	148	2,850	8[illegible]	4	343	—
								Meadow Lake Inc.	G 11495	G 10610	81384	3/17/1986	183.2	3	1.29	579										
12385	7.58	48,841	"Schmore"	3/21/1976	—	Biaggi and Venable	38S/11.5E/7AD	Biaggi Veneble	G 7396	G 6835	66457	9/38/1976	274.3	3	3.43	1,548	[illegible]	16	Perf (14") 145-180	Basalt ("cinders")	118	2,500	4	4	625	—
12211	7.61	40,193	No. 1	1957	—	Maude E. Liskey	38S/18E/16DC	Maude Liskey	G 762	G 700	34518	9/20/1957	403.2	3	5.04	2,262	225	18	[illegible]	[illegible]	148	2,650	[illegible]	4	1,325	—
								Maude Liskey	G 3316	G 3088	45487	12/9/1965	76	3	0.95	426										
								Meadow Lake Inc.	G 11495	G 10610	81394	3/17/1986	36	3	0.45	282										
12213	7.63	48,269	—	1962	—	Daniel House	38S/18E/16DD	Daniel Hause	G 4804	G 4529	40188	3/6/1969	50.4	3	0.63	283	460	18	9	Basalt ("cinders")	—	1,808	[illegible]	[illegible]	[illegible]	—
50493	7.64	40,345	No. 2	10/1/1996	—	Richard Czarapata	38S/18E/16DD	[illegible]	G 17298	G 16883	—	1/15/2010	6.4	3	0.08	[illegible]	206	[illegible]	192	Basalt	63	75	—	[illegible]	—	—
12386	7.83	41,333	No. 6 "Hamaker"	—	4200	LM & Loyd Hankins (Swan Lake Ranch)	38S/11.5E/7DD	Jesperson Edgewood Nevin Cattle	U 319	U 343	58381	7/19/1949	175.2	3	2.19	993	~250	16	—	Basalt	—	—	—	—	—	100-HP Johnston turbine
12217	7.96	42,016	No. 9	<1957	—	Loyd Hankins (Mike Short)?	38S/10E/22BA	Mike & Bessie Short	G 5504	G 4968	48023	5/7/1871	444	3	5.55	2,491	460	18	100	Basalt	—	1,275 2,000 2,350 2,550 2,750	2.5 4.5 5.5 6.0 7.5	1 2 2.5 3 3.5	518 444 427 425 367	—
12218	8.35	44,068	No. 10 "Short"	7/28/1955	—	Loyd Hankins	38S/18E/22AD	Mike & Bessie Short	U 319	U 343	35151	7/19/1849	416.8	3	5.21	2,339	348	18	100	Basalt "rock"	—	3,800	[illegible]	4	1,000	100-HP Johnston turbine
—	8.63	44,068	"Swan Lake Junction"	Unknown <1949	—	Unknown	38S/10E/23AD	Jesperson Edgewood Nevin Cattle	U 319	U 343	58381	7/19/1949	280.8	3	3.51	1,576	—	—	—	Basalt	—	—	—	—	—	—
12221	8.66	45,739	No. 11 "Carl"	<1957	—	Gene Carl Loyd Hankins	38S/18E/23BD	Gene & Vera Carl	U 319	U 343	35150	7/19/1949	505.1	3	6.31	2,832	260	18	94	Basalt ("cinders")	—	—	—	—	—	100-HP Peerless turbine
12223	8.84	46,651	"Deer Ridge"	3/2/1982	—	Nevin Cattle Co.	38S/10E/24BC	Nevin Cattle	G 10510	G 10129	—	8/31/1982	65.6	3	0.82	368	443	[illegible]	[illegible]	Basalt	121	1,750	181	4.5	10	—
12228	9.18	48,475	—	1949	4221	Maude E. Liskey	38S/18E/26BA	Maude Liskey	U 323	U 298	22854	8/24/1848	157.6	3	1.97	884	592	16	[illegible]	Basalt	198	2,165	[illegible]	—	866	—
12406	8.47	59,002	No. 4	11/6/1967	—	David Moore Whispering Pines	38S/11.5E/20CC	Melvin McCollum	G 4812	G 4552	42502	3/11/1969	158.4	3	1.98	889	341	[illegible]	150	Basalt	—	2,000	10	4	200	—
12421	9.61	50,754	No. 12 "Pine Flat" Mitchell	<1951	4215	Loyd Hankins	38S/11.5E/38CB	Jesperson Edgewood Nevin Cattle	U 319	U 343	50381	7/19/1949	280	3	3.50	1,571	276	16	—	Basalt ("cinders")	—	—	—	—	—	—
								Nevin Cattle	G 4672	G 4400	50382	11/6/1968	32.8	3	0.41	184										
								Nevin Cattle	G 10510	G 10129	—	8/31/1982	5.6	3	0.07	[illegible]										
12224	9.64	50,906	—	1949	4190	Garrison Mitchell	38S/10E/25AA	Garrison Mitchell	U 333	U 307	26511	10/13/1949	[illegible]	3	1.90	853	524	[illegible]	329	Basalt	—	2,048	[illegible]	[illegible]	293	—
50341	9.98	52,274	No. 117	6/20/1996	—	Swan Lake Ranch	38S/11.5E/28BC ??	Jesperson Edgewood	G 14546	G 13929	—	6/11/1997	159.1	3	1.99	893	216	16	67	Basalt	—	2,500	8	1	313	—
12425	18.16	53,641	No. 9 ?	10/21/1975	—	Mel Kendall	38S/11.5E/30DC	Melvin Kendall	G 7481	G 7132	65411	8/17/1976	28.8	3	0.36	162	230	18	20	Basalt	—	650	[illegible]	4	8	—

TABLE A-1
Summary of Wells and Water Rights
Proposed Swan Lake North Pumped Storage Hydroelectric Project
Klamath County, Oregon

County Well (KLAM)	Distance From KLAM 2260 (north end of compartment)		Owner's I.D.	Date Drilled	Reported Ground Surface Elevation (feet)	Well Owner (log)	Township/ Range/Section/ Quarter/Quarter-Quarter	Water Rights (non-cancelled)							Appropriation Rate		Well Depth (feet)	Casing Diameter (inches)	Casing Depth (feet)	Hydro Unit	Well Log				Estimated Specific Capacity (gpm/ft of drawdown)	Pump Information
	miles	feet						(Current) Holder	Application	Permit	Certificate	Priority Date	Total Acres	Annual Duty (ft/acre)	cfs	gpm					First Water (feet)	Yield (gpm)	Drawdown (feet)	Duration (hours)		
12226	10.19	53,793	–	8/17/1965	–	Vern Deyarmie	38S/10E/25DA	Vern Deyarmie	G 3262	G 3060	36378	10/18/1965	23.2	[illegible]	0.28	130	834	8	138	Basalt Shale	–	1,000	9 [illegible]	[illegible]	188	–
50446	10.19	53,793	–	9/5/1996	4158	John Venable	38S/11.5E/30DC	Exempted Use (Domestic)									249	6	Perf 209-249	Basalt ("cinders")	208	30	–	[illegible]	–	–
12424	19.36	54,705	No. 1	1933	4190	W. Hall (G. McCollum?)	38S/11.5E/30DD	Melvin McCollum	G 4812	G 4552	42502	3/11/1969	[illegible]	[illegible]	0.15	67	145	[illegible]	–	Basalt ("cinders")	–	875	–	–	–	1,000 gpm capacity
								Wilbert Hall	U 299	U 272	27302	4/14/1949	170.4	[illegible]	2.13	956										
59337	10.13	53,489	No. 3	<1948	4217	W. Hall (Moore?)	38S/11.5E/39DD										175	[illegible]	[illegible]	Basalt ("cinders")	–	950	–	–	–	1,100 gpm capacity
12419	10.72	56,605	No. 1	1948	4200	Guy Barton	38S/11.5E/28CB	Guy Barton	U 300	U 275	26807	4/18/1949	168	[illegible]	2.10	343	136	16	60	Basalt	–	1,450	4	–	363	50 HP, 1,400 gpm capacity

Notes.
– not reported or not applicable
Static and pumping water levels for study area wells as measured by OWRD and USGS are included in Appendix A of this report

Table A-2

Pumping Rate Calculation for Proposed Supply Wells - Reservoir Filling and Maintenance, Proposed Swan Lake North Pumped Storage Hydroelectric Project

TABLE A-2
Pumping Rate Calculation For Proposed Supply Wells - Reservoir Filling and Maintenance
Proposed Swan Lake North Pumped Storage Hydroelectric Project
Klamath County, Oregon

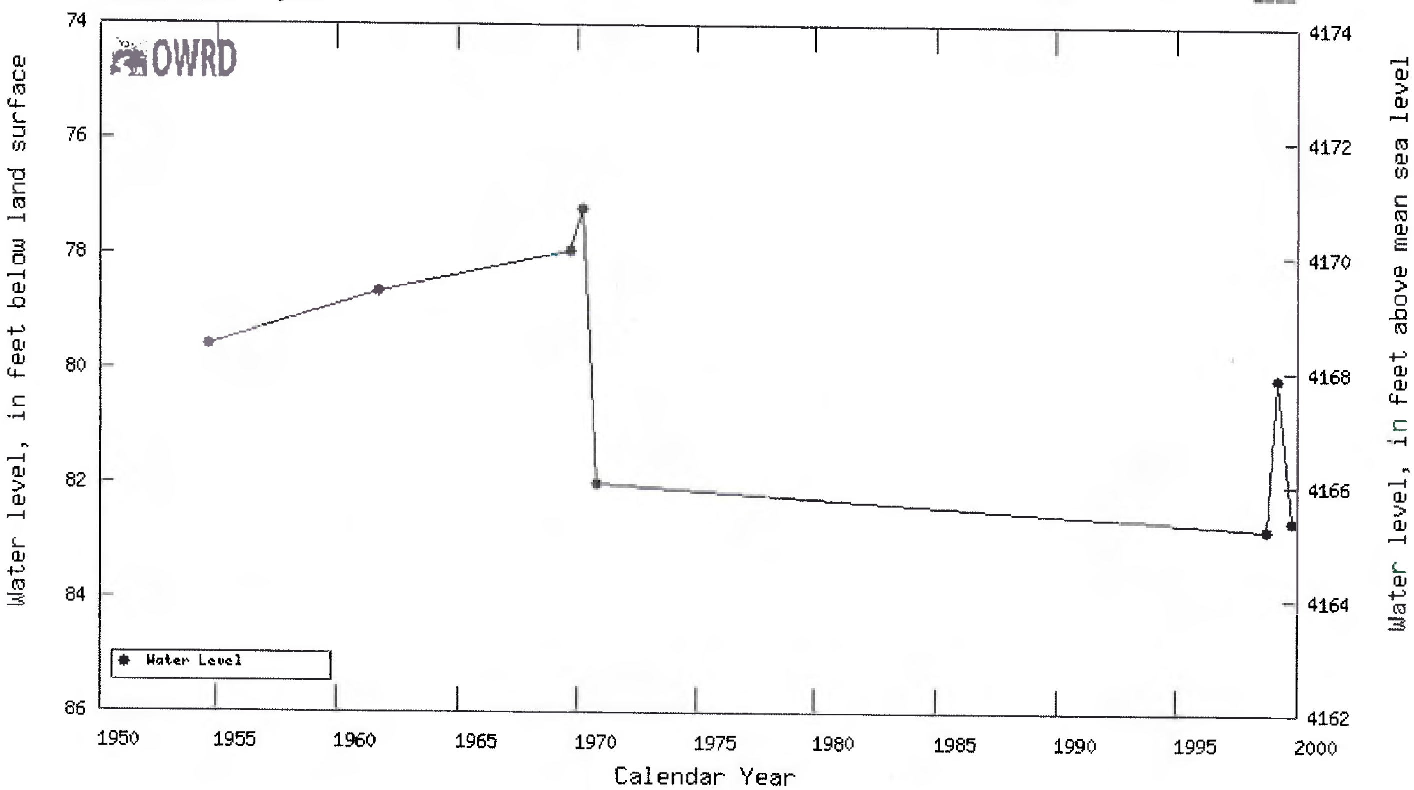
County Well (KLAM)	Owner's I.O.	Township/ Range/Section/ Quarter/Quarter-Quarter	Water Rights						Maximum Allowed Instantaneous Appropriation Rate Under Relevant Transfer or Right		Duty Allowed Under Water Right									Calculated Pumping Rates (gpm)	
											Acre-Feet Per Acre	Acres Irrigated			Total Acre-Feet Per Year			Total Cubic Feet Per Year	Total Gallons Per Year	Calculated Pumping Rate 365 Oays per Year (12 months)	Maintenance Pumping (acre-feet per year)
			(Current) Holder	App.	Permit	Cert.	Status	Priority Date	cfs	gpm		Primary	Supp.	Total	Primary	Supp.	Total				
Proposed Pumping Wells																					
2263	Well 1	37S/10E/9DC	Devincenze	U 453	U 486	29530	NC	12/24/1951	6.24	2,800	3.0	501.1	--	501.1	1,503.3	--	1,503.3	6.55E+07	4.90E+08	932	--
2259	Well 2	37S/10E/8CC	Devincenze	U 453	U 486	29530	NC	12/24/1951	4.53	2,033	3.0	648	--	648	1,944	--	1,944.0	8.47E+07	6.33E+08	1,205	--
2262	Well 4	37S/10E/88C	Jesperson Edgewood	G 10135	G 10952	87006	NC	6/28/1982	5.72	2,567	3.0	457.2	--	457.2	1,372	--	1,371.6	5.97E+07	4.47E+08	850	--
2265	Well 5	37S/10E/14CC	Jesperson Edgewood	G 10135	G 10952	87006	NC	6/28/1982	7.89	3,541	3.0	631.4	--	631.4	1,894	--	1,894.2	8.25E+07	6.17E+08	1,174	1,894.2

Notes:
--: not reported or not applicable
App: application
Cert: certificate
NC: non cancelled
Supp: supplemental
Water rights under Certificates 83121 and 67564 (Table A-1) will not be excercised by the supply wells in filling the reservoirs.
Supplemental rights under Certificate 29530 will not be transferred for use in reservoir filling.

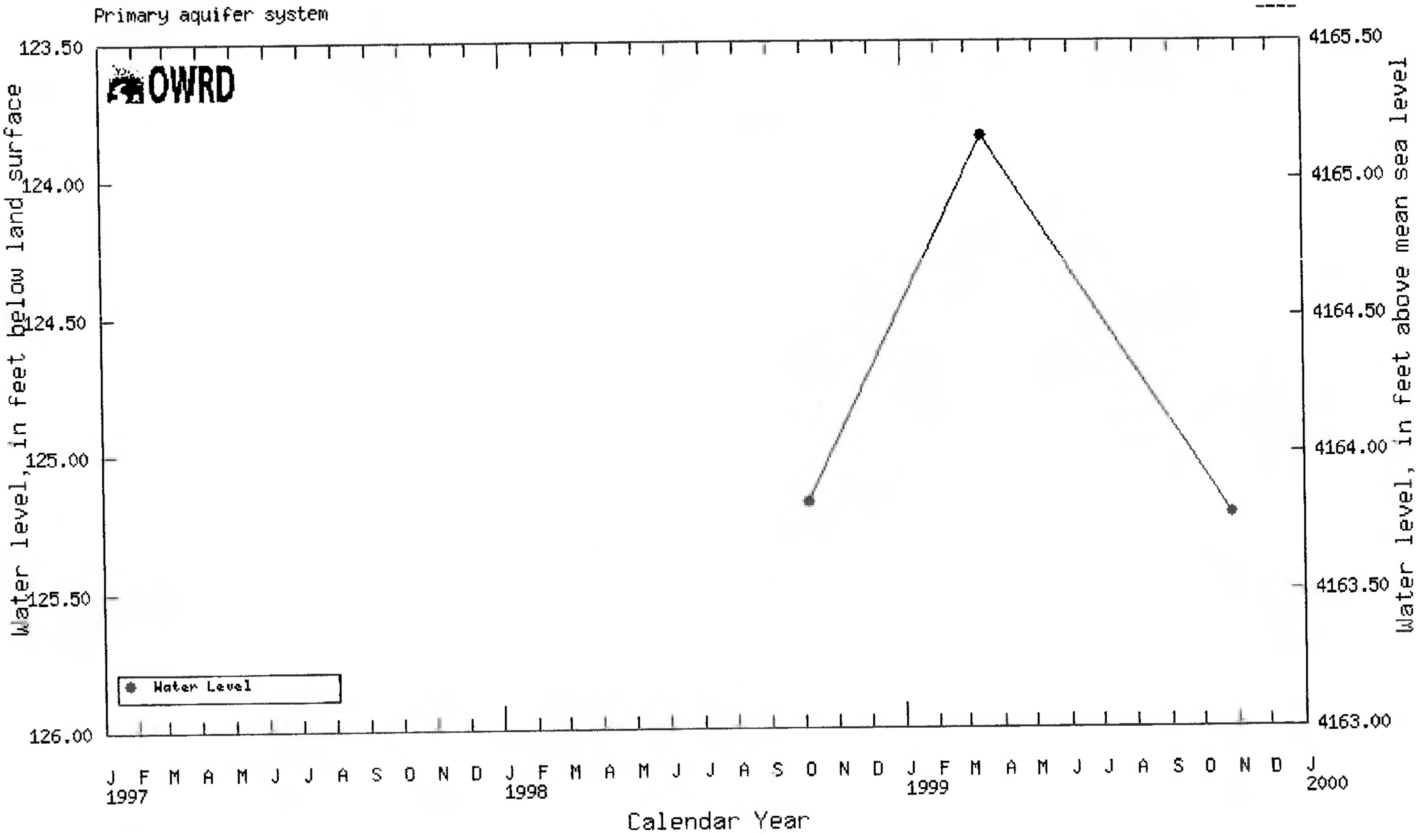
Total Rates (gpm)	4,162
Total Volumes (gallons)	2.19E+09
Total Volumes (cubic feet)	2.92E+08
Total Volumes (acre-feet per year)	6713.10
Pumping Oays to Fill Reservoir	758

Historical Water Levels

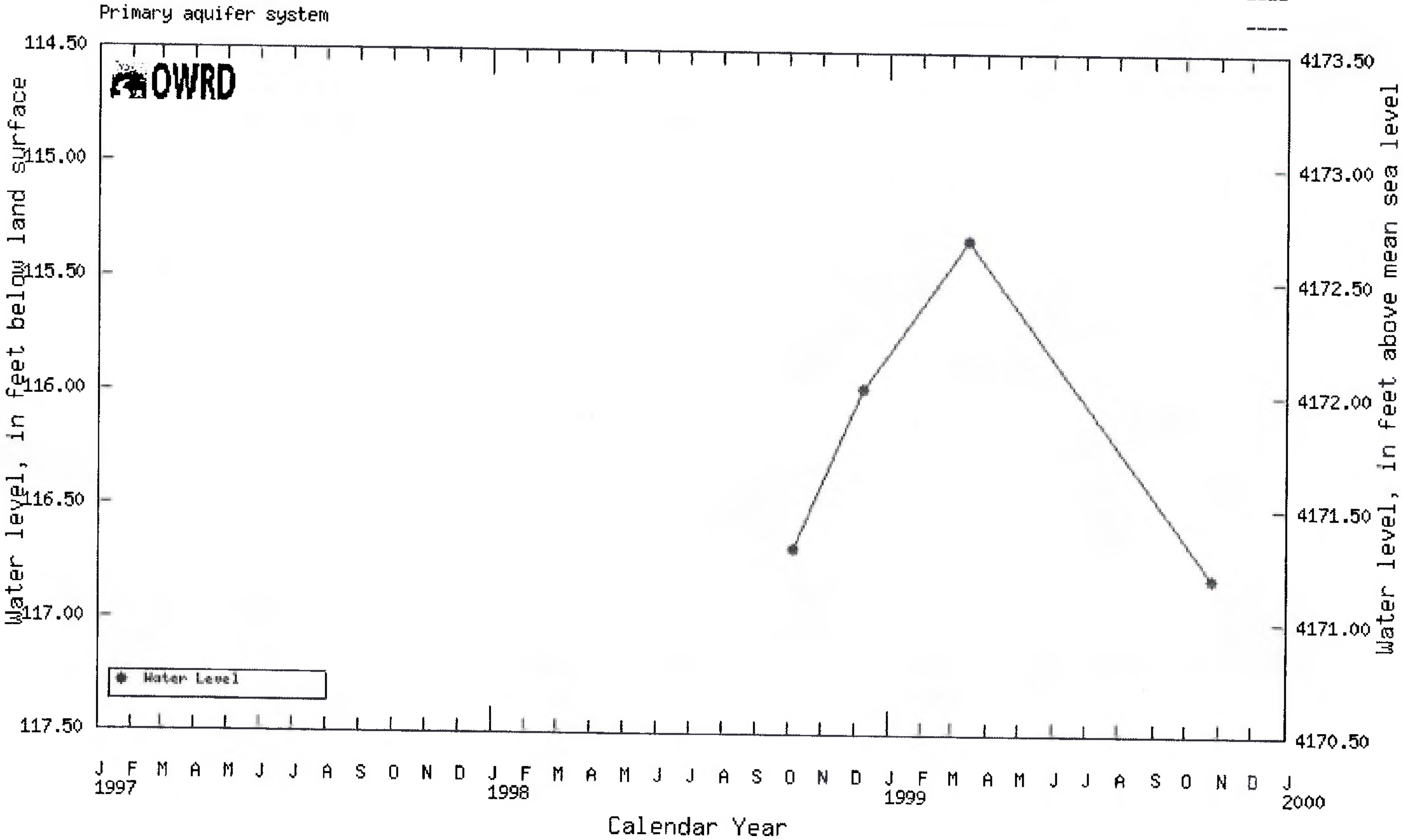
Oregon Water Resources Department Well Location	37.00S/10.00E-8ccc
Oregon Water Resources Department Logid	KLAM 2259
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	308
Total well depth (feet below land surface)	281
Land surface elevation (feet above mean sea level)	4248
Primary use of well	----
Primary aquifer system	----



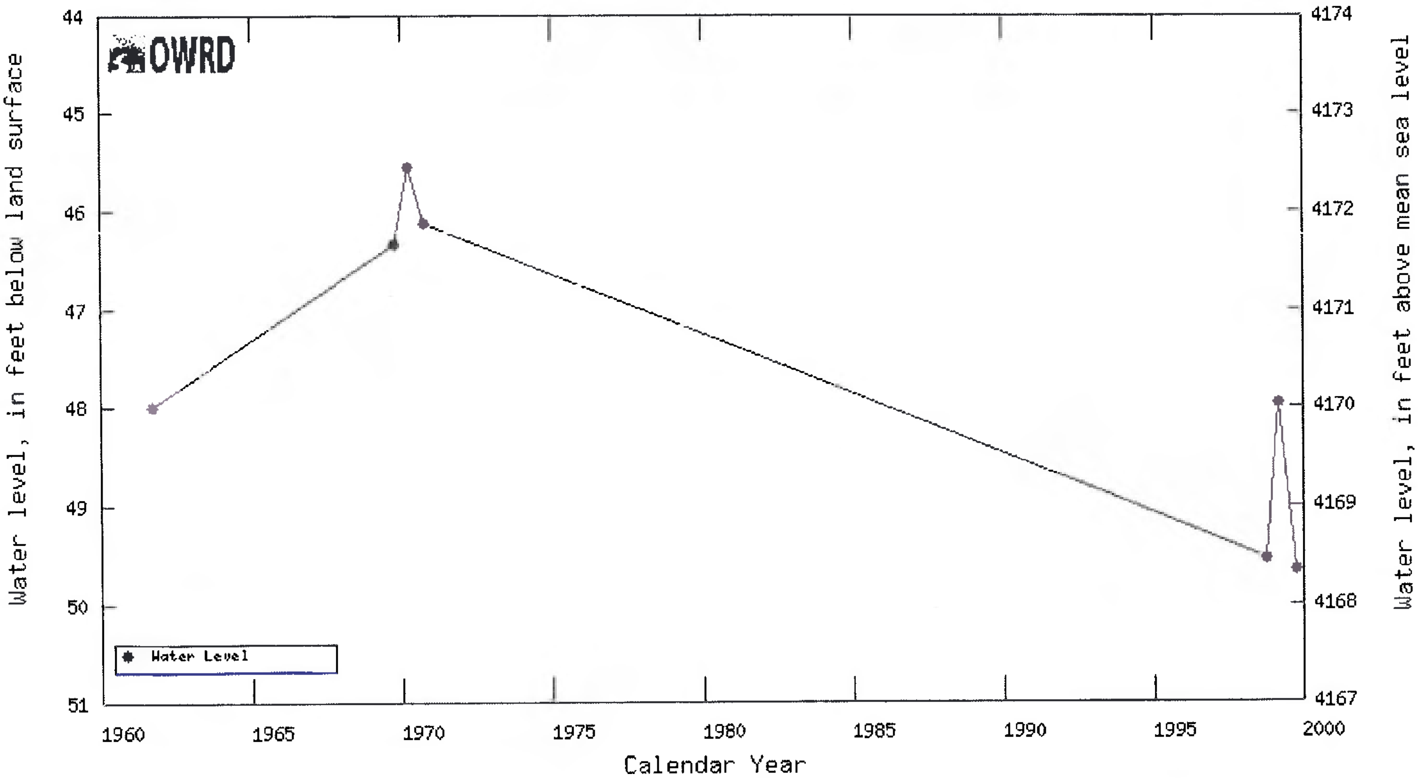
Oregon Water Resources Department Well Location	37.00S/10.00E-8bdd
Oregon Water Resources Department Logid	KLAM 2260
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	200
Land surface elevation (feet above mean sea level)	4289
Primary use of well	----
Primary aquifer system	----



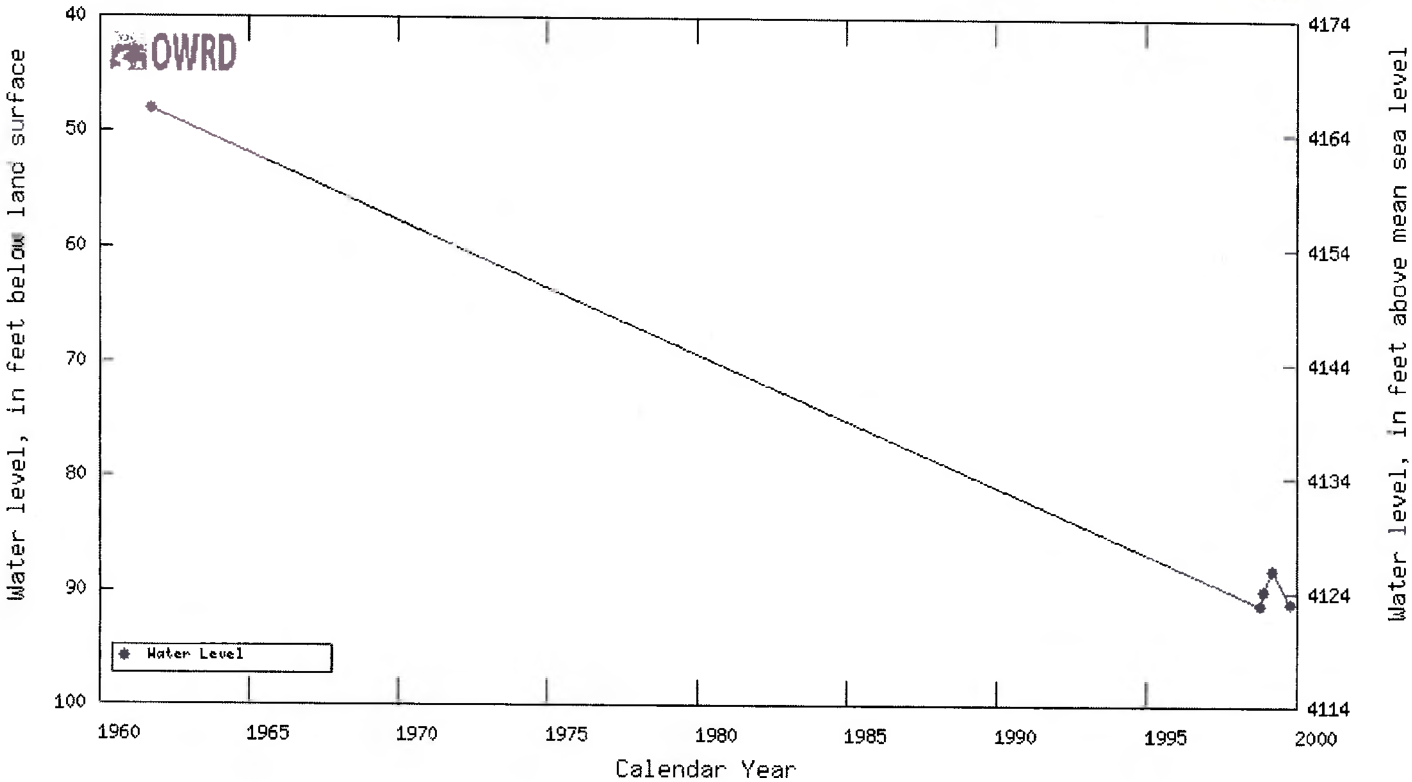
Oregon Water Resources Department Well Location	37.00S/10.00E-8cbc
Oregon Water Resources Department Logid	KLAM 2262
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	192
Land surface elevation (feet above mean sea level)	4288
Primary use of well	----
Primary aquifer system	----



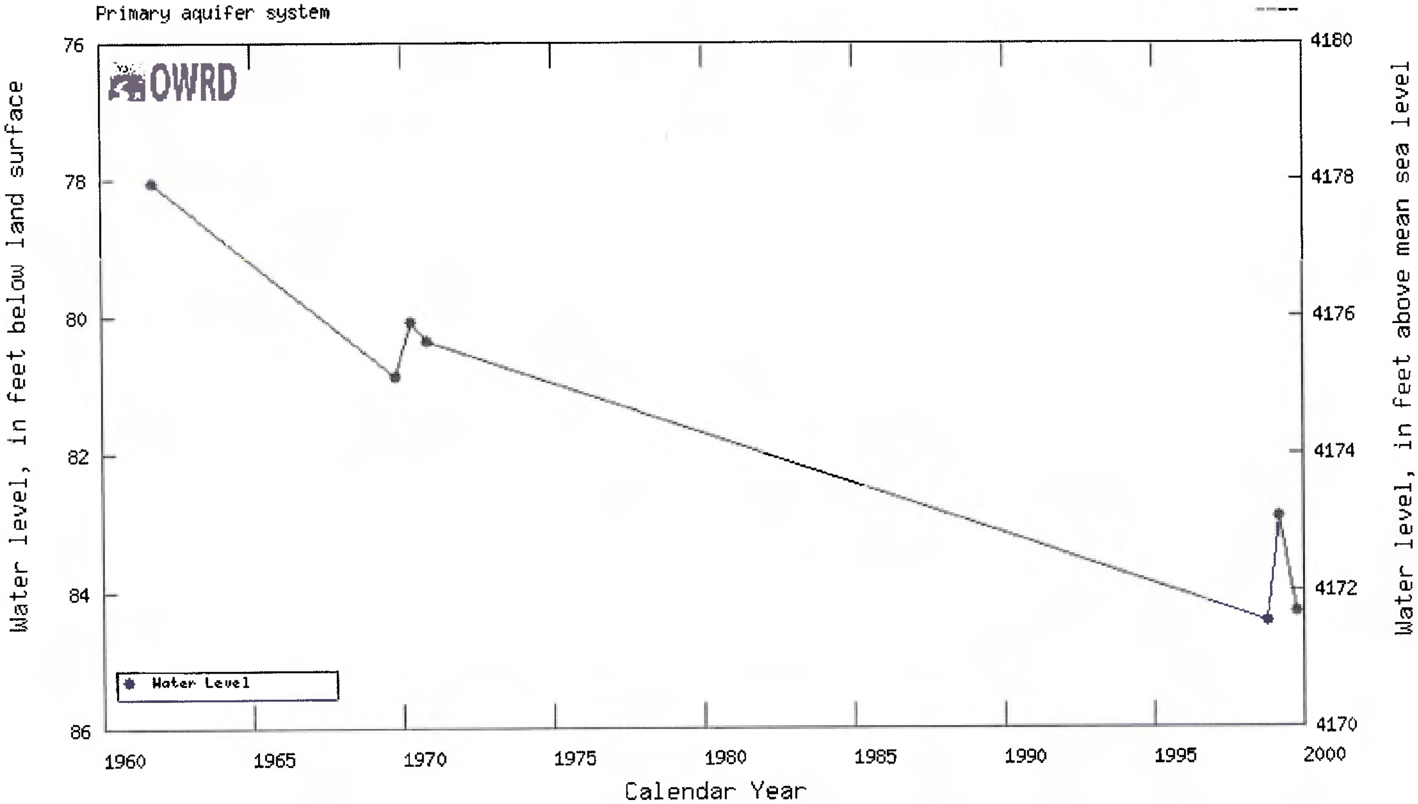
Oregon Water Resources Department Well Location	37.00S/10.00E-9dca
Oregon Water Resources Department Logid	KLAM 2263
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	2264
Land surface elevation (feet above mean sea level)	4218
Primary use of well	----
Primary aquifer system	----



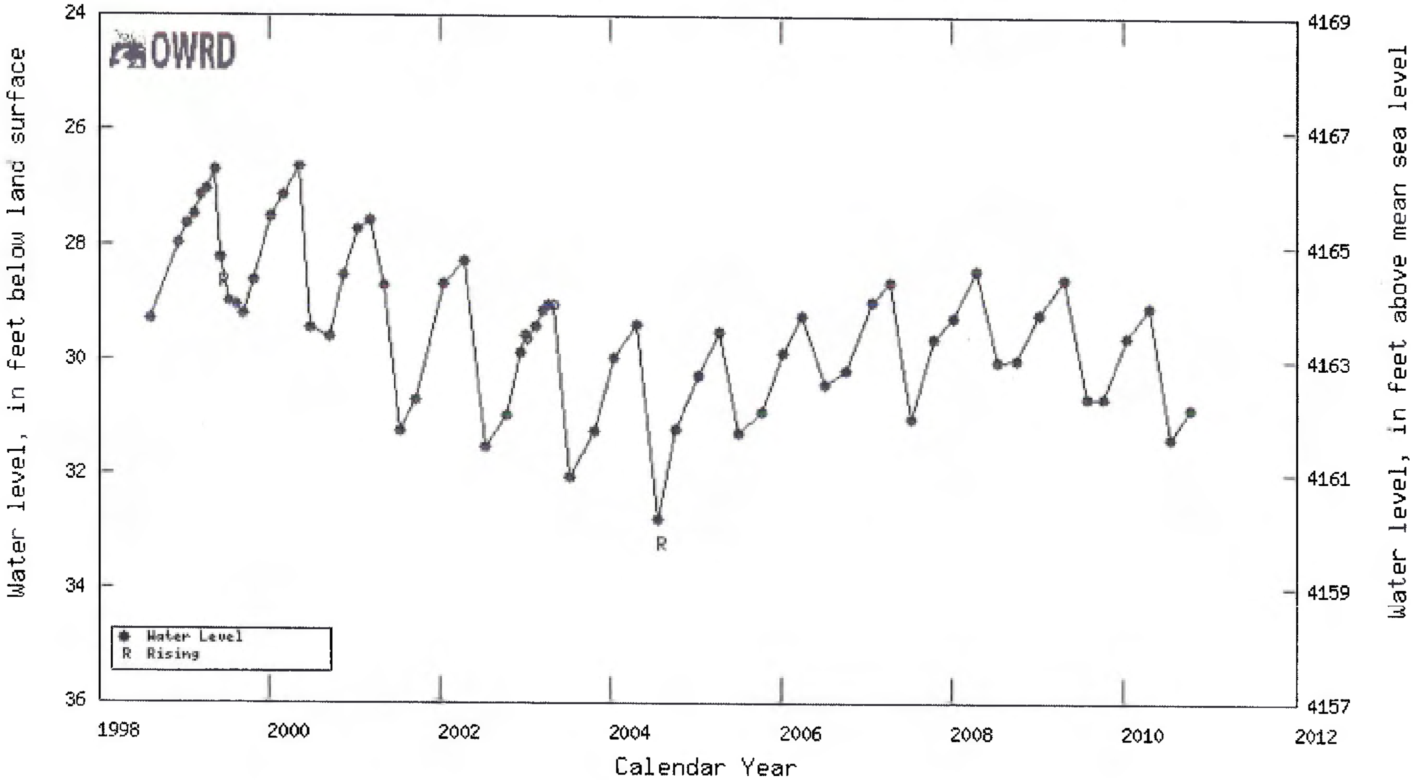
Oregon Water Resources Department Well Location	37.00S/10.00E-14cdc
Oregon Water Resources Department Logid	KLAM 2265
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	515
Land surface elevation (feet above mean sea level)	4214
Primary use of well	----
Primary aquifer system	----



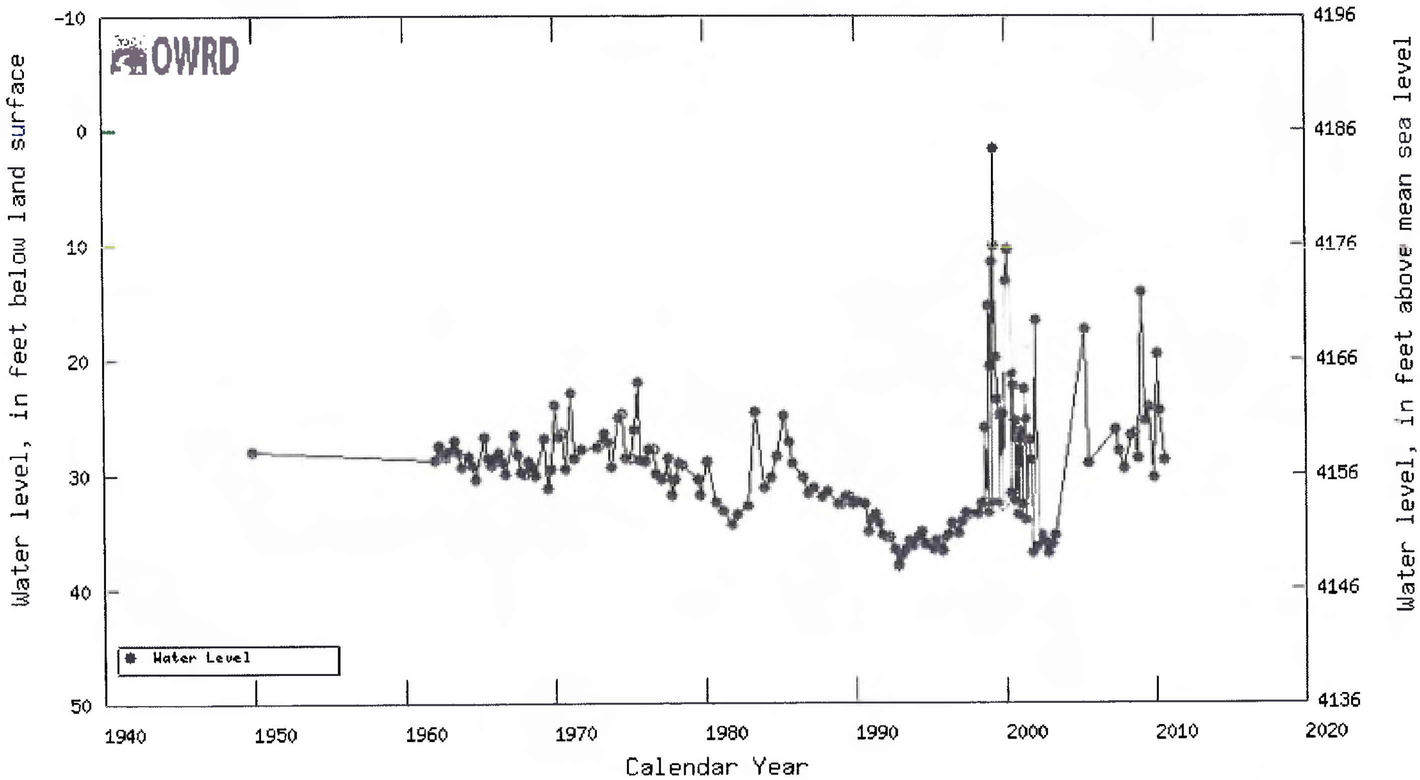
Oregon Water Resources Department Well Location	37.00S/10.00E-18abd
Oregon Water Resources Department Logid	KLAM 2269
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	309
Total well depth (feet below land surface)	325
Land surface elevation (feet above mean sea level)	4256
Primary use of well	----
Primary aquifer system	----



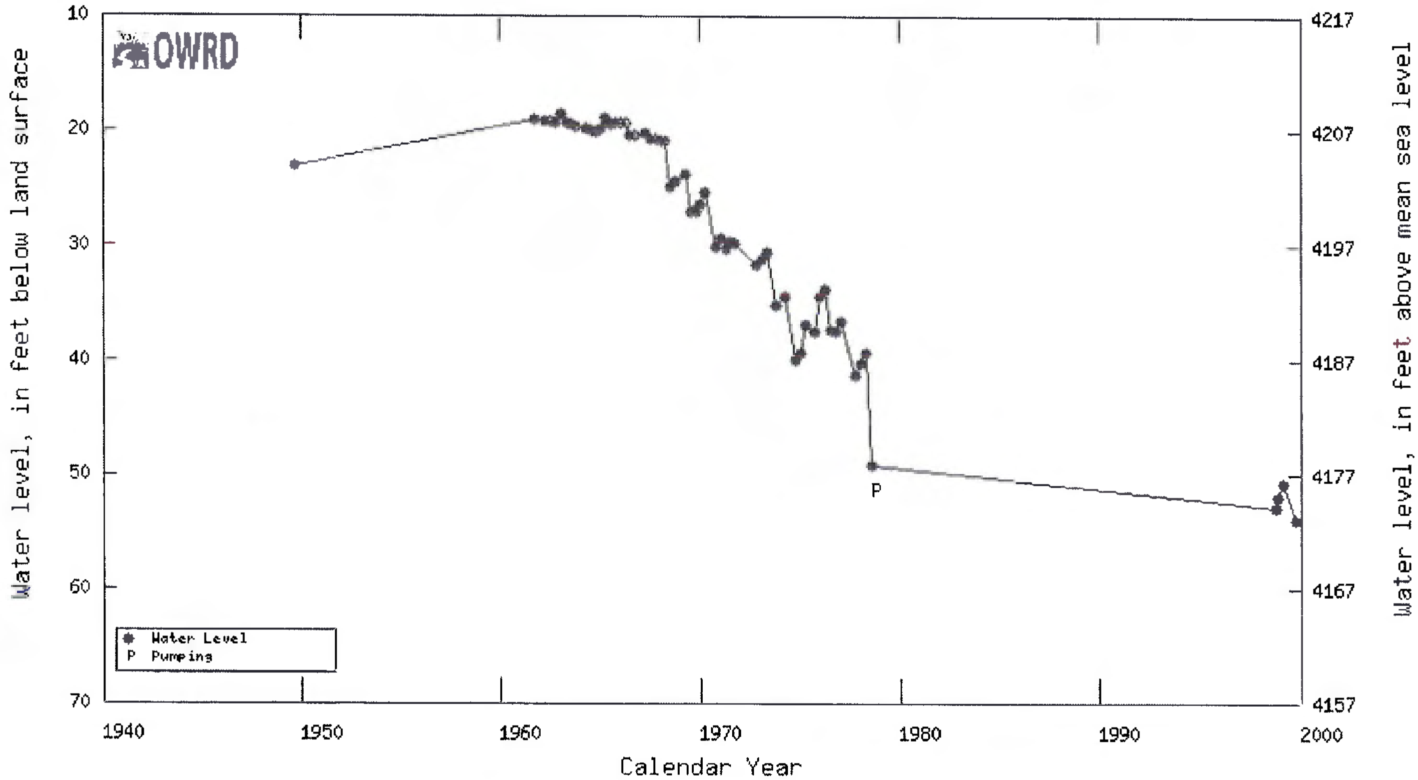
Oregon Water Resources Department Well Location	37.00S/10.00E-20abc
Oregon Water Resources Department Logid	KLAM 2277
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	345
Land surface elevation (feet above mean sea level)	4193.0
Primary use of well	DOMESTIC
Primary aquifer system	----



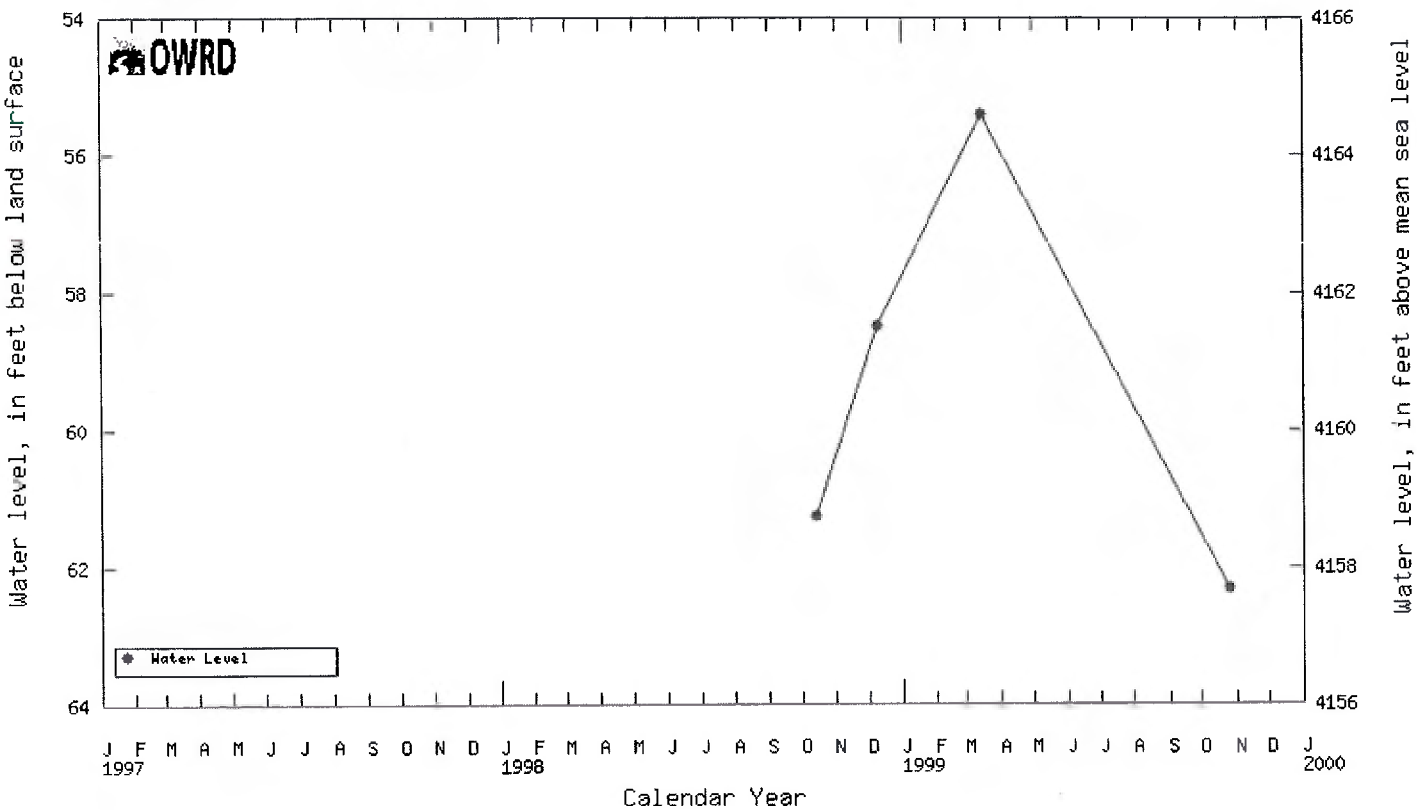
Oregon Water Resources Department Well Location	37.00S/10.00E-29dbb
Oregon Water Resources Department Logid	KLAM 2288
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	281
Total well depth (feet below land surface)	800
Land surface elevation (feet above mean sea level)	4186
Primary use of well	UNUSED
Primary aquifer system	----



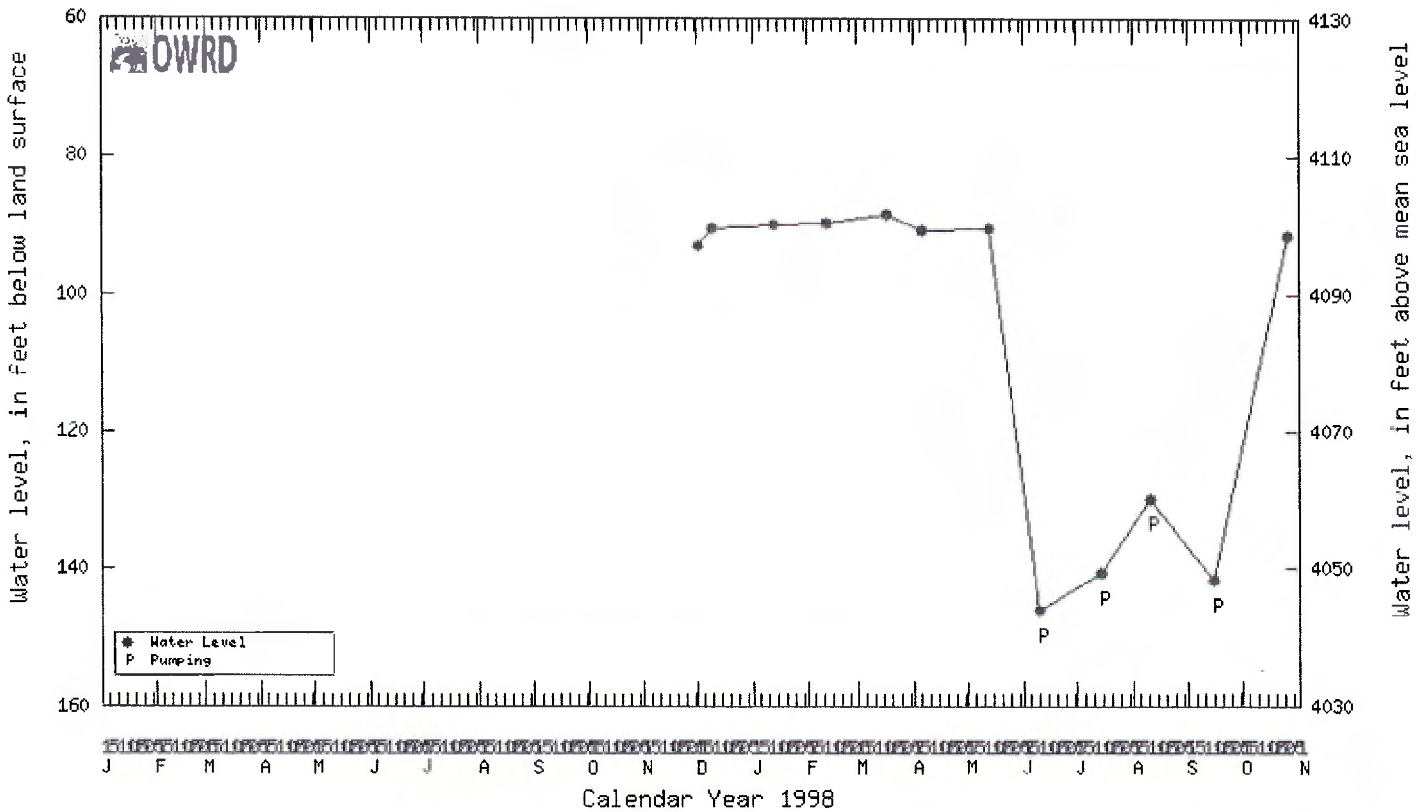
Oregon Water Resources Department Well Location	37.00S/10.00E-30bad
Oregon Water Resources Department Logid	KLAM 2289
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	311
Total well depth (feet below land surface)	100
Land surface elevation (feet above mean sea level)	4227
Primary use of well	----
Primary aquifer system	----



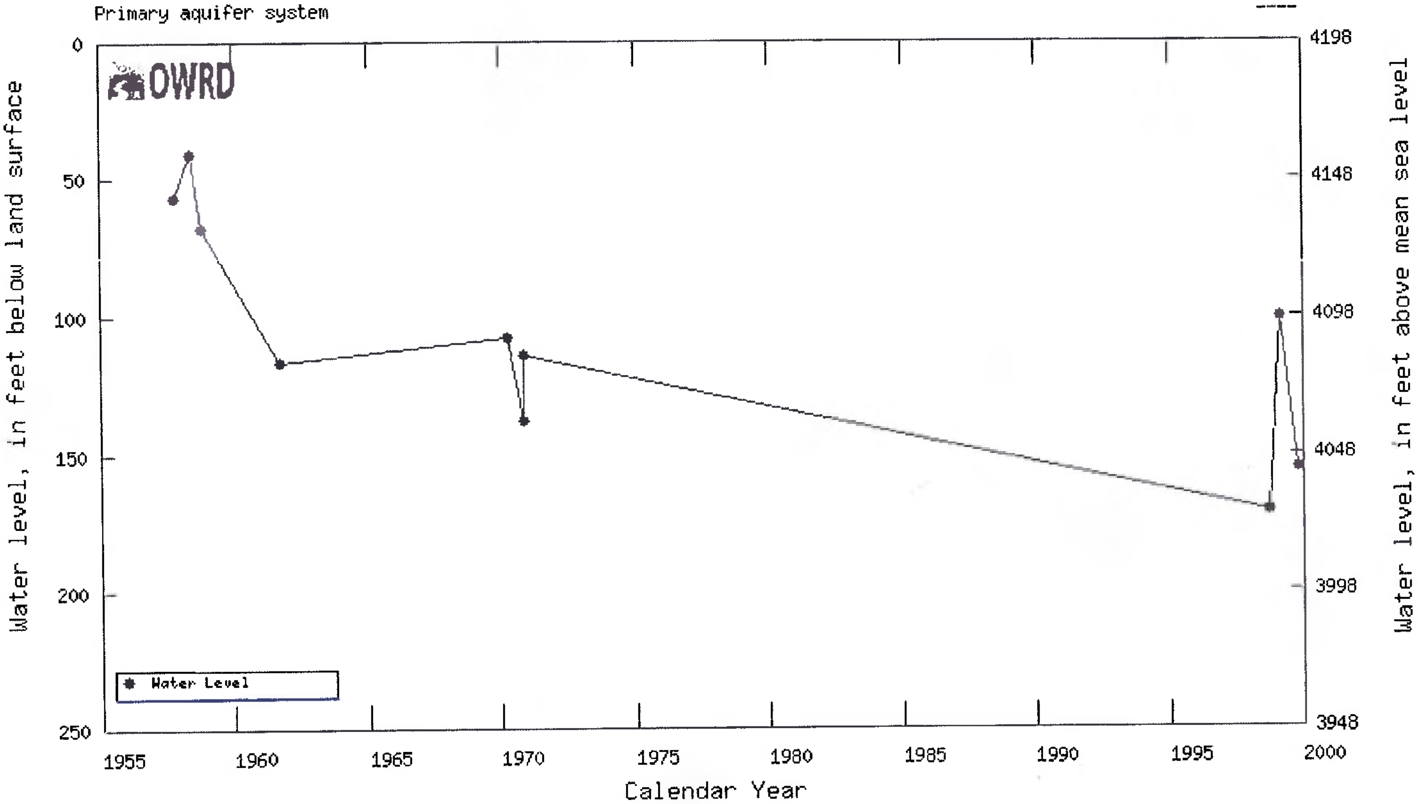
Oregon Water Resources Department Well Location	37.00S/10.00E-19acb
Oregon Water Resources Department Logid	KLAM 10082
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	320
Land surface elevation (feet above mean sea level)	4220
Primary use of well	----
Primary aquifer system	----



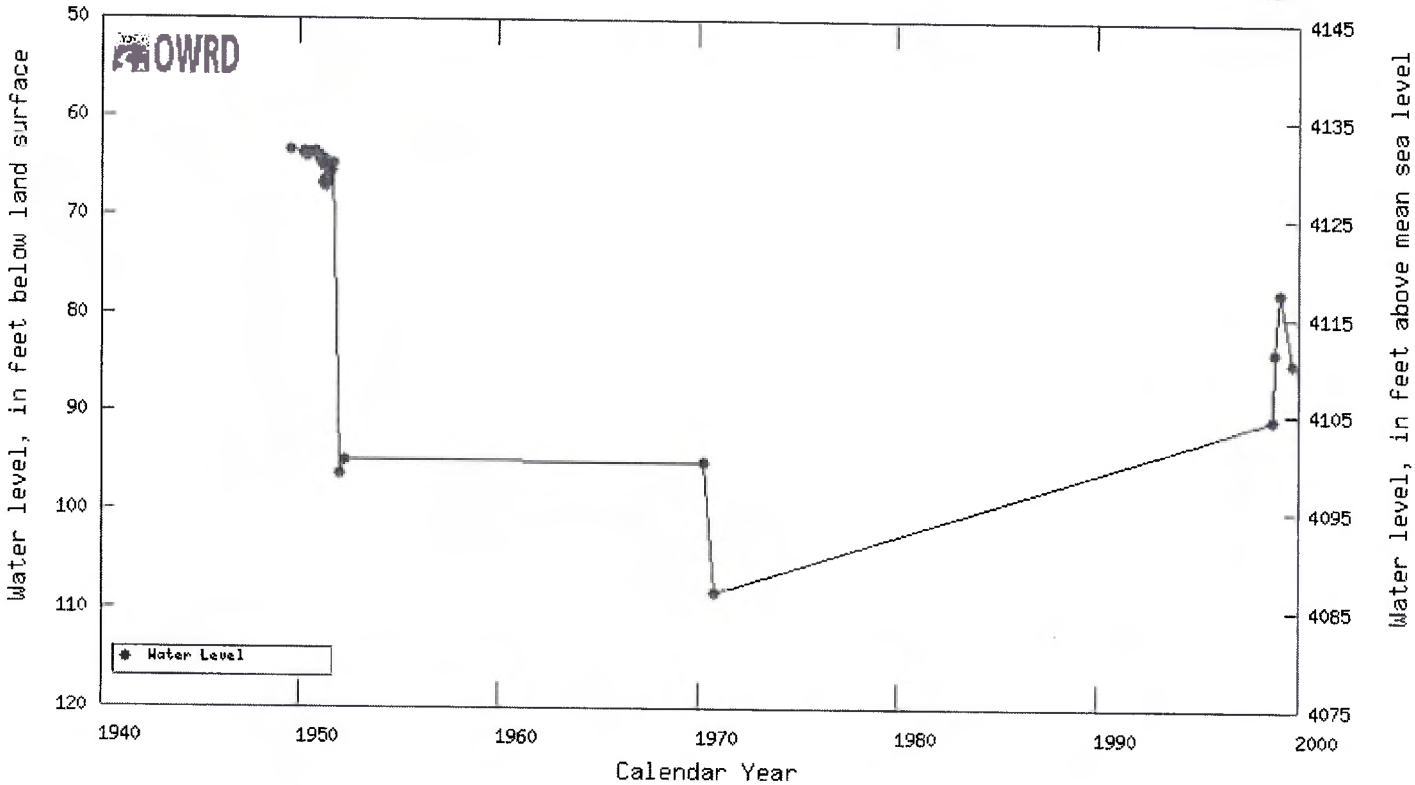
Oregon Water Resources Department Well Location	38.00S/10.00E-5dbc
Oregon Water Resources Department Logid	KLAM 10336
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	1620
Land surface elevation (feet above mean sea level)	4190
Primary use of well	----
Primary aquifer system	----



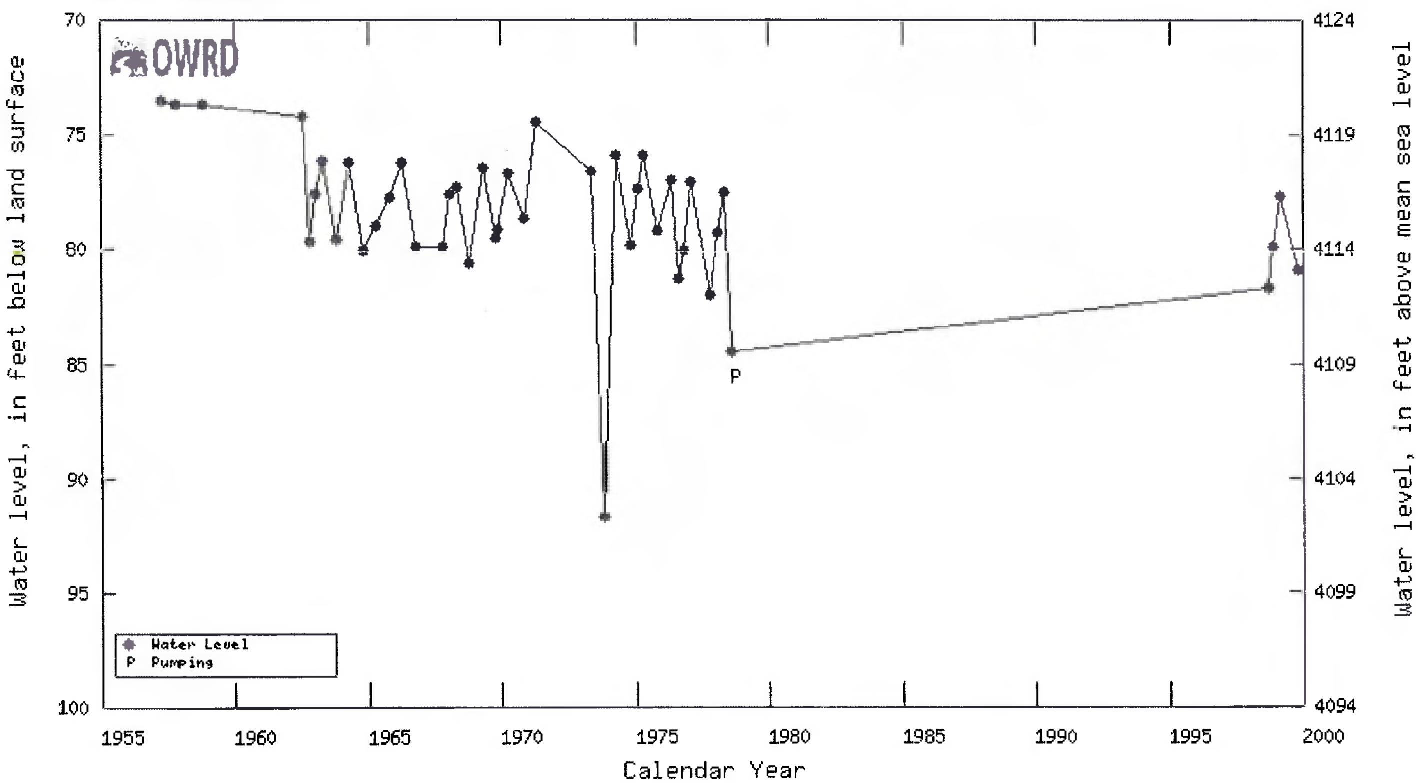
Oregon Water Resources Department Well Location	38.00S/10.00E-5cbc
Oregon Water Resources Department Logid	KLAM 12186
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	850
Land surface elevation (feet above mean sea level)	4198.0
Primary use of well	----
Primary aquifer system	----



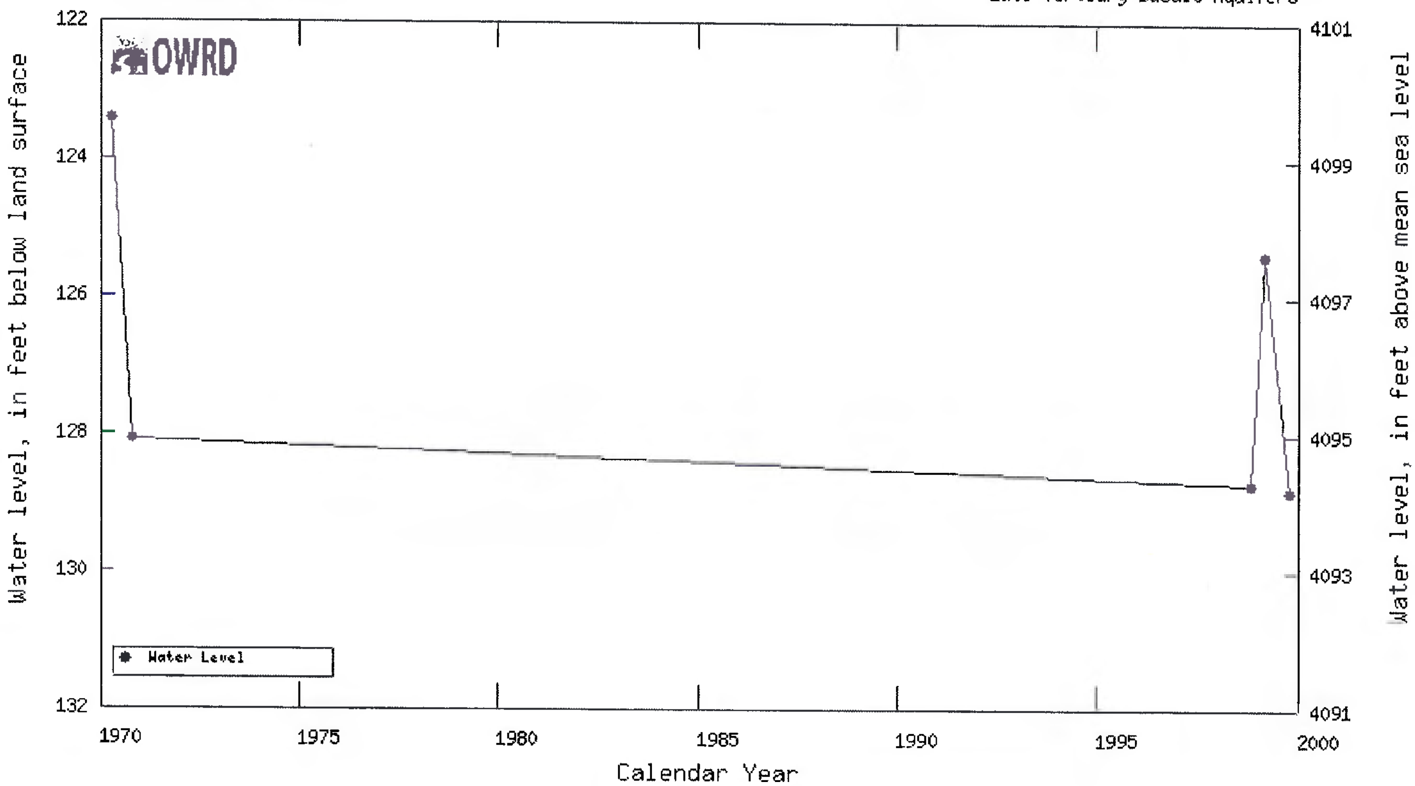
Oregon Water Resources Department Well Location	38.00S/10.00E-9cbc
Oregon Water Resources Department Logid	KLAM 12197
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	325
Land surface elevation (feet above mean sea level)	4195.1
Primary use of well	----
Primary aquifer system	----



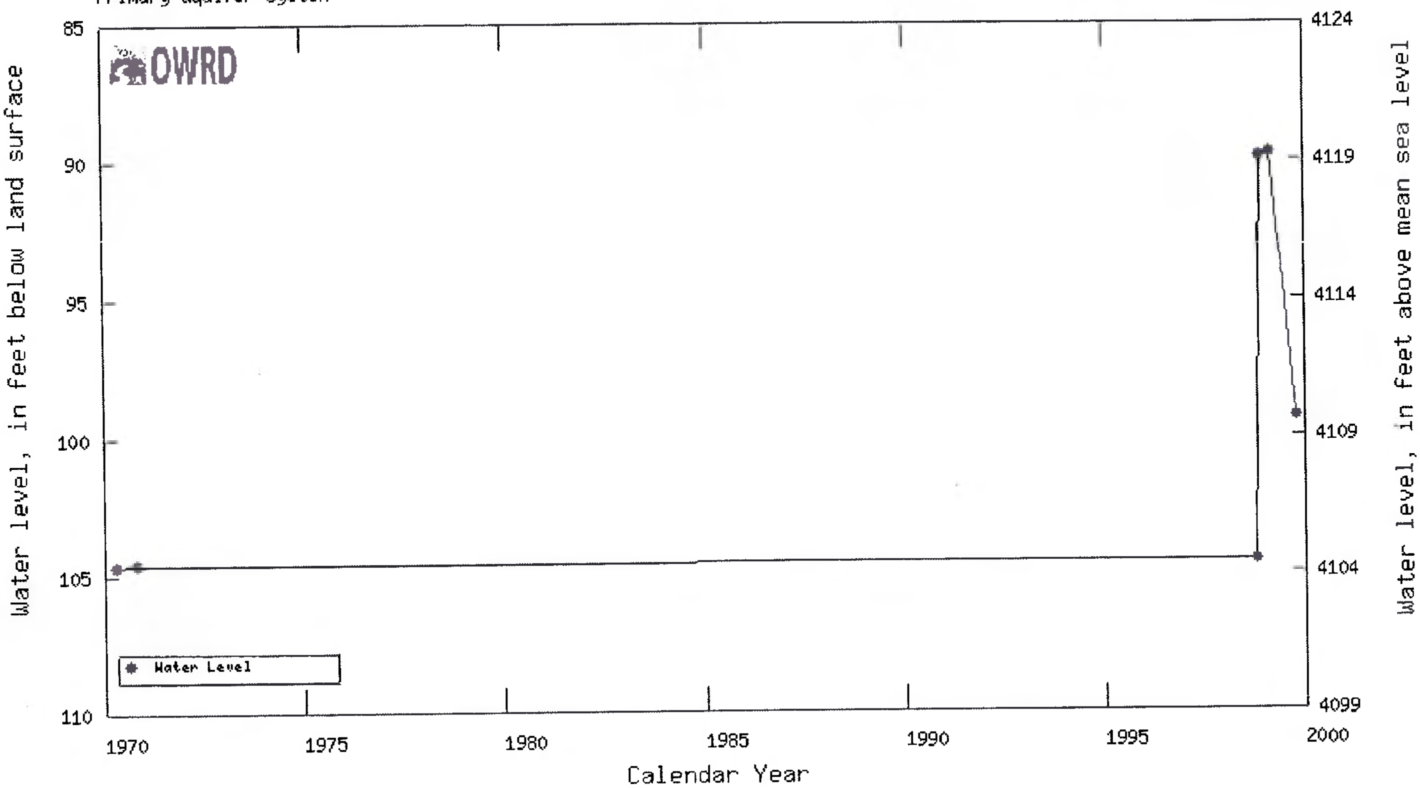
Oregon Water Resources Department Well Location	38.00S/10.00E-13bbc
Oregon Water Resources Department Logid	KLAM 12203
Oregon Water Resources Department Well Tag (Well ID)	-----
Oregon Water Resources Department State Observation Well Number	313
Total well depth (feet below land surface)	276
Land surface elevation (feet above mean sea level)	4194
Primary use of well	-----
Primary aquifer system	-----



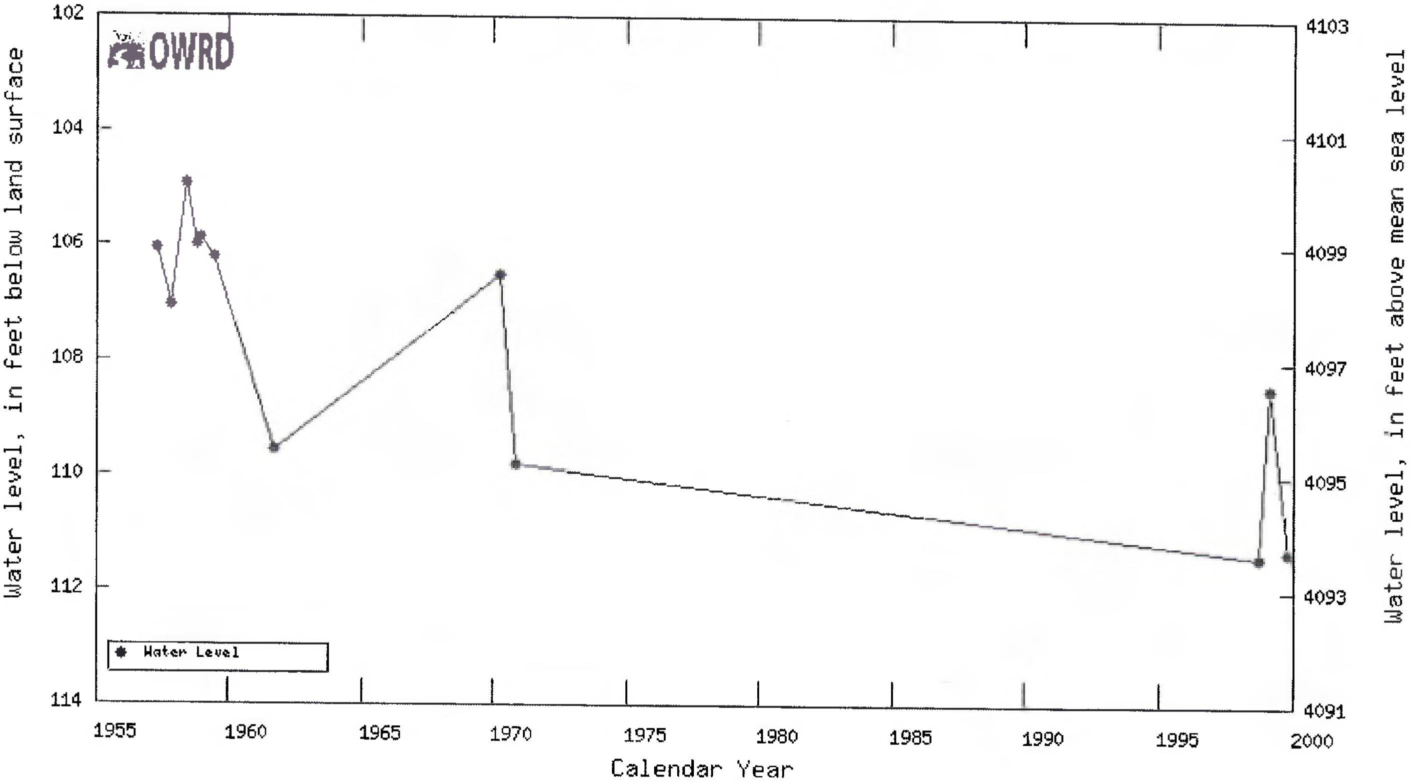
Oregon Water Resources Department Well Location	38.00S/10.00E-16bbb
Oregon Water Resources Department Logid	KLAM 12209
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	295
Land surface elevation (feet above mean sea level)	4223.2
Primary use of well	----
Primary aquifer system	Late Tertiary Basalt Aquifers



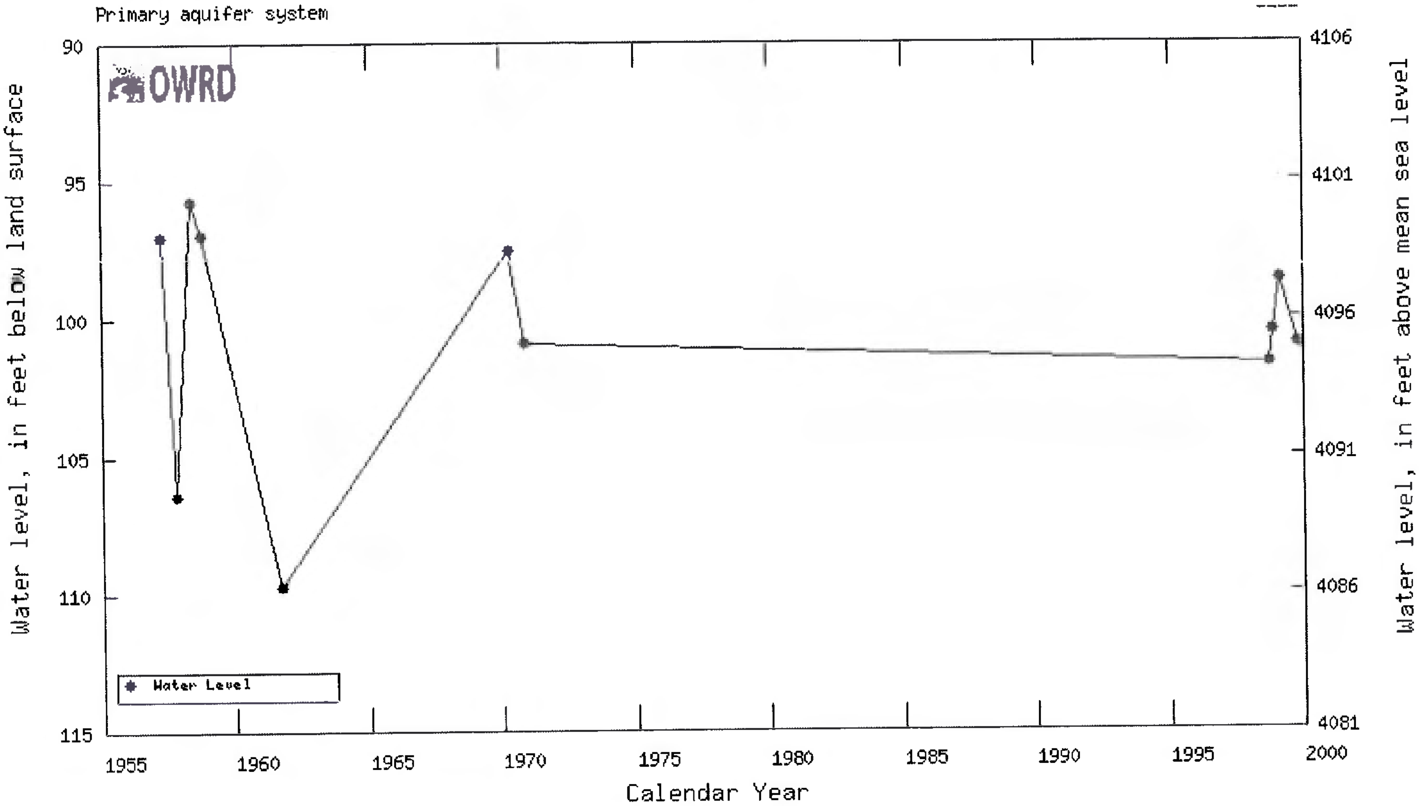
Oregon Water Resources Department Well Location	38.00S/10.00E-16dda
Oregon Water Resources Department Logid	KLAM 12213
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	460
Land surface elevation (feet above mean sea level)	4209.3
Primary use of well	----
Primary aquifer system	Late Tertiary Basalt Aquifers



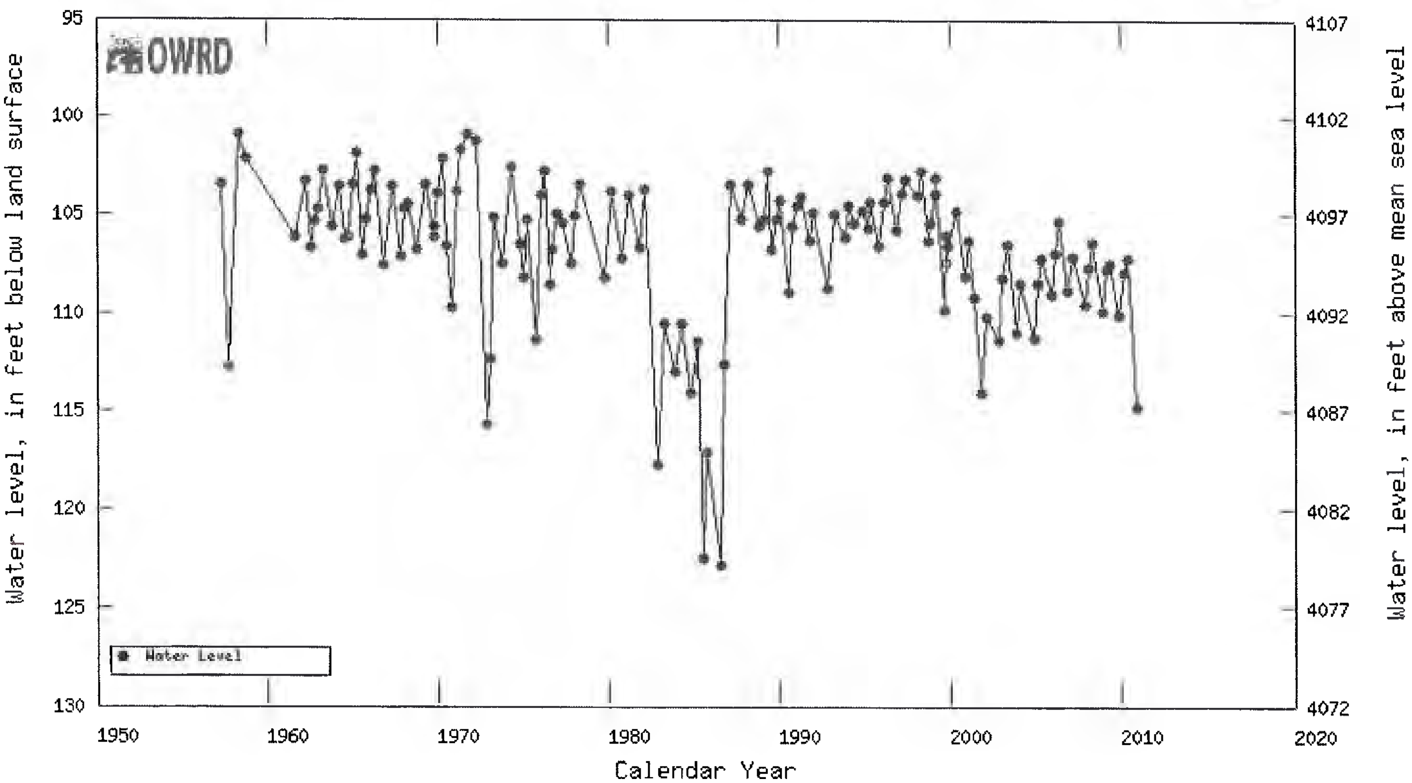
Oregon Water Resources Department Well Location	38.00S/10.00E-22baa
Oregon Water Resources Department Logid	KLAM 12217
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	315
Total well depth (feet below land surface)	460
Land surface elevation (feet above mean sea level)	4205.7
Primary use of well	----
Primary aquifer system	----



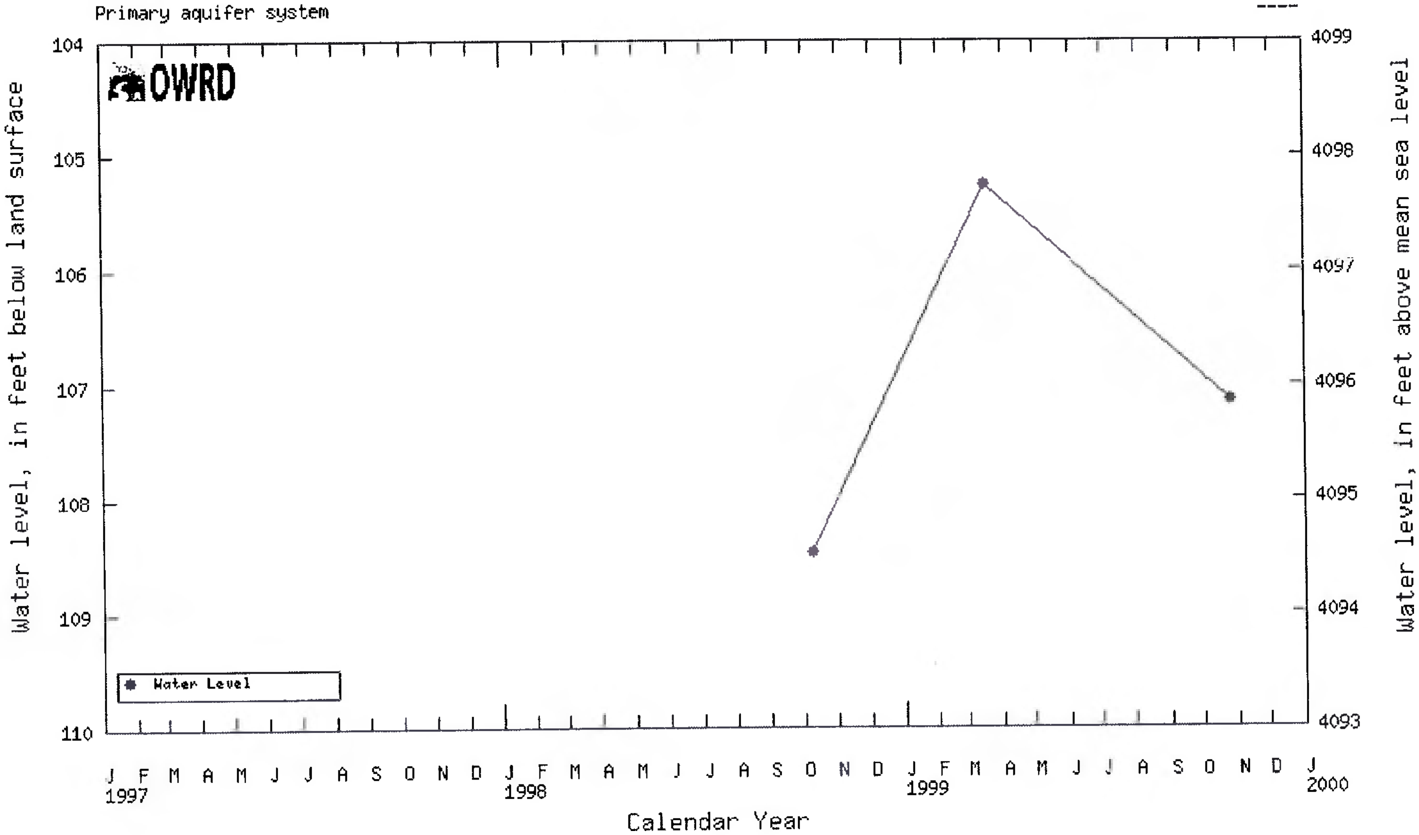
Oregon Water Resources Department Well Location	38.00S/10.00E-22ada
Oregon Water Resources Department Logid	KLAM 12218
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	348
Land surface elevation (feet above mean sea level)	4196.1
Primary use of well	----
Primary aquifer system	----



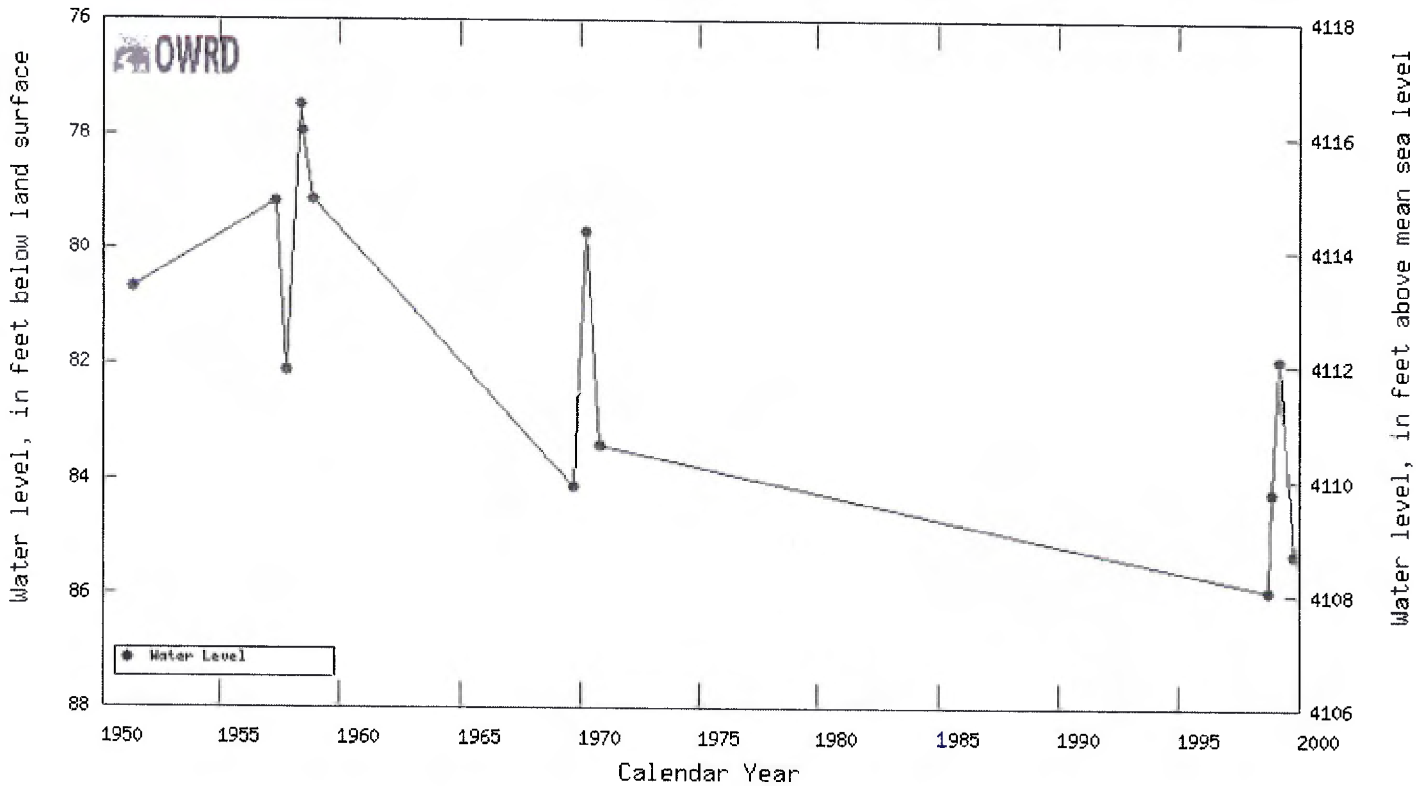
Oregon Water Resources Department Well Location	38.00S/10.00E-23bdd
Oregon Water Resources Department Logid	KLAM 12221
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	285
Total well depth (feet below land surface)	260
Land surface elevation (feet above mean sea level)	4202.4
Primary use of well	IRRIGATION
Primary aquifer system	----



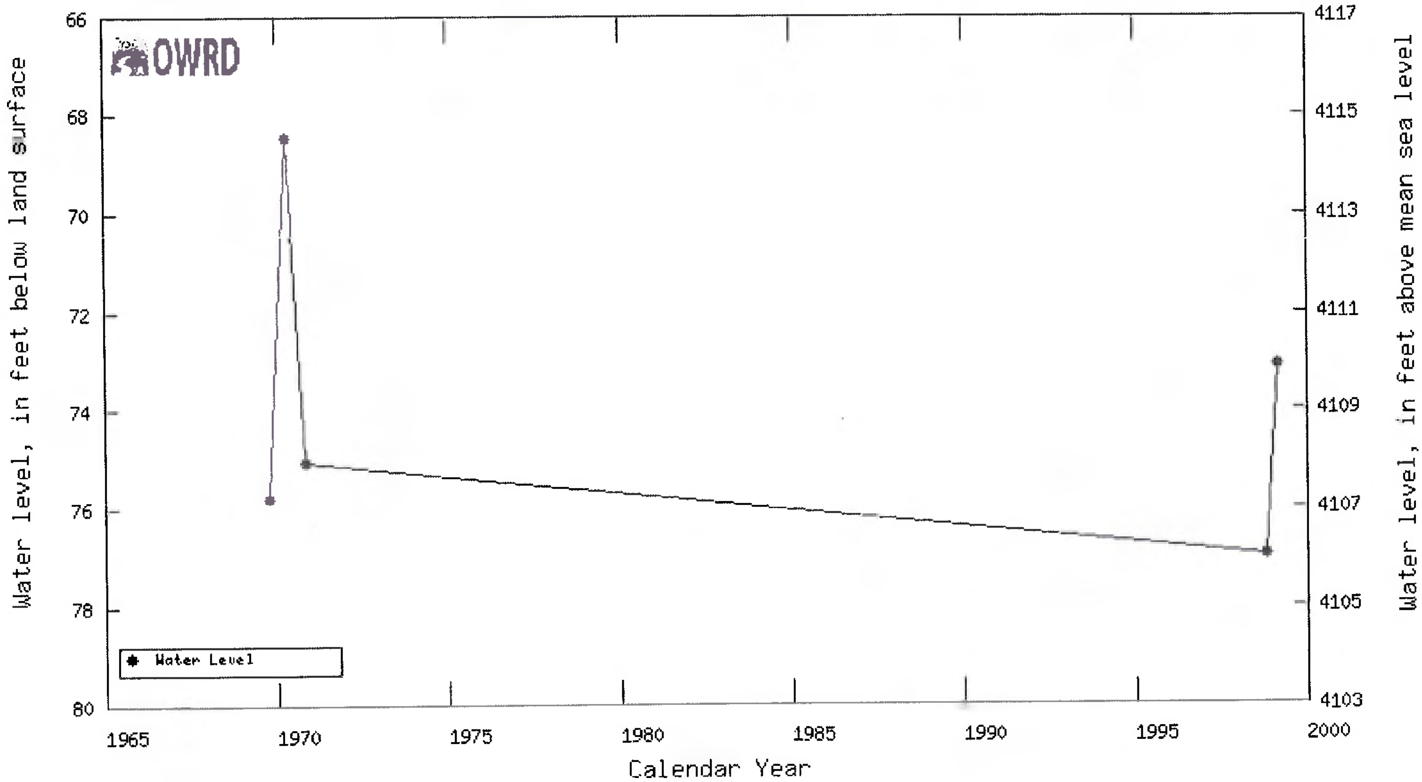
Oregon Water Resources Department Well Location	38.00S/10.00E-24bcc
Oregon Water Resources Department Logid	KLAM 12223
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	443
Land surface elevation (feet above mean sea level)	4203.1
Primary use of well	----
Primary aquifer system	----



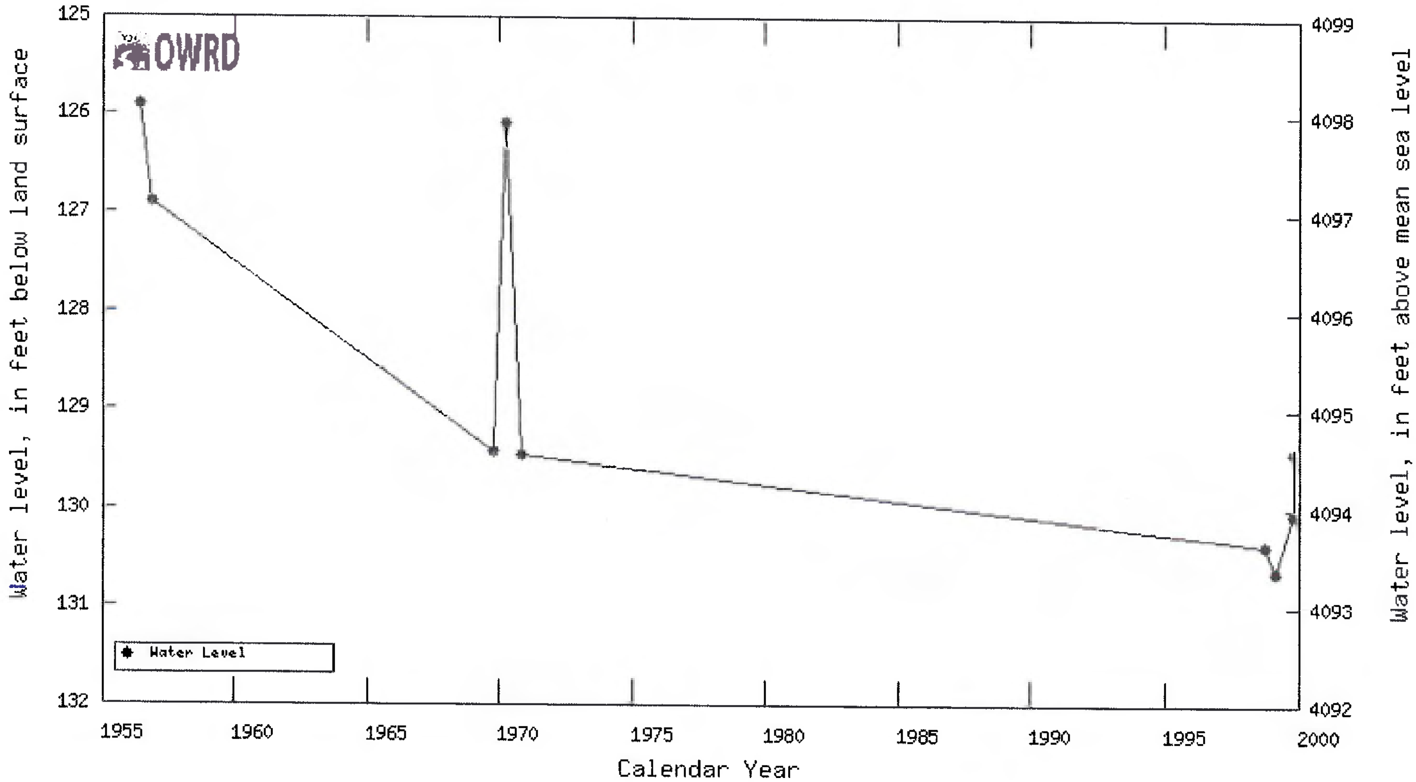
Oregon Water Resources Department Well Location	38.00S/10.00E-25aab
Oregon Water Resources Department Logid	KLAM 12224
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	316
Total well depth (feet below land surface)	524
Land surface elevation (feet above mean sea level)	4194.7
Primary use of well	----
Primary aquifer system	----



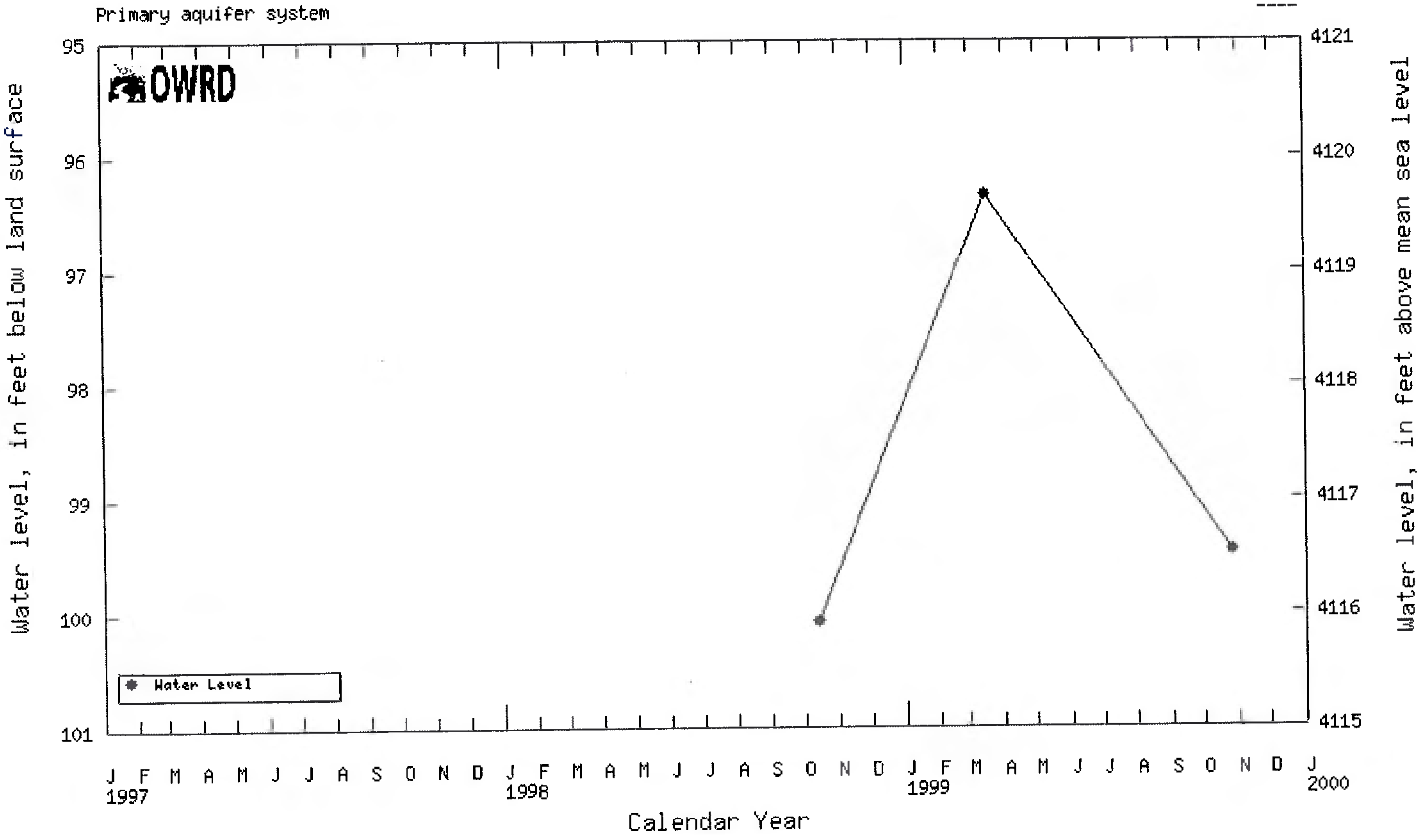
Oregon Water Resources Department Well Location	38.00S/10.00E-25dab
Oregon Water Resources Department Logid	KLAM 12226
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	834
Land surface elevation (feet above mean sea level)	4183
Primary use of well	----
Primary aquifer system	----



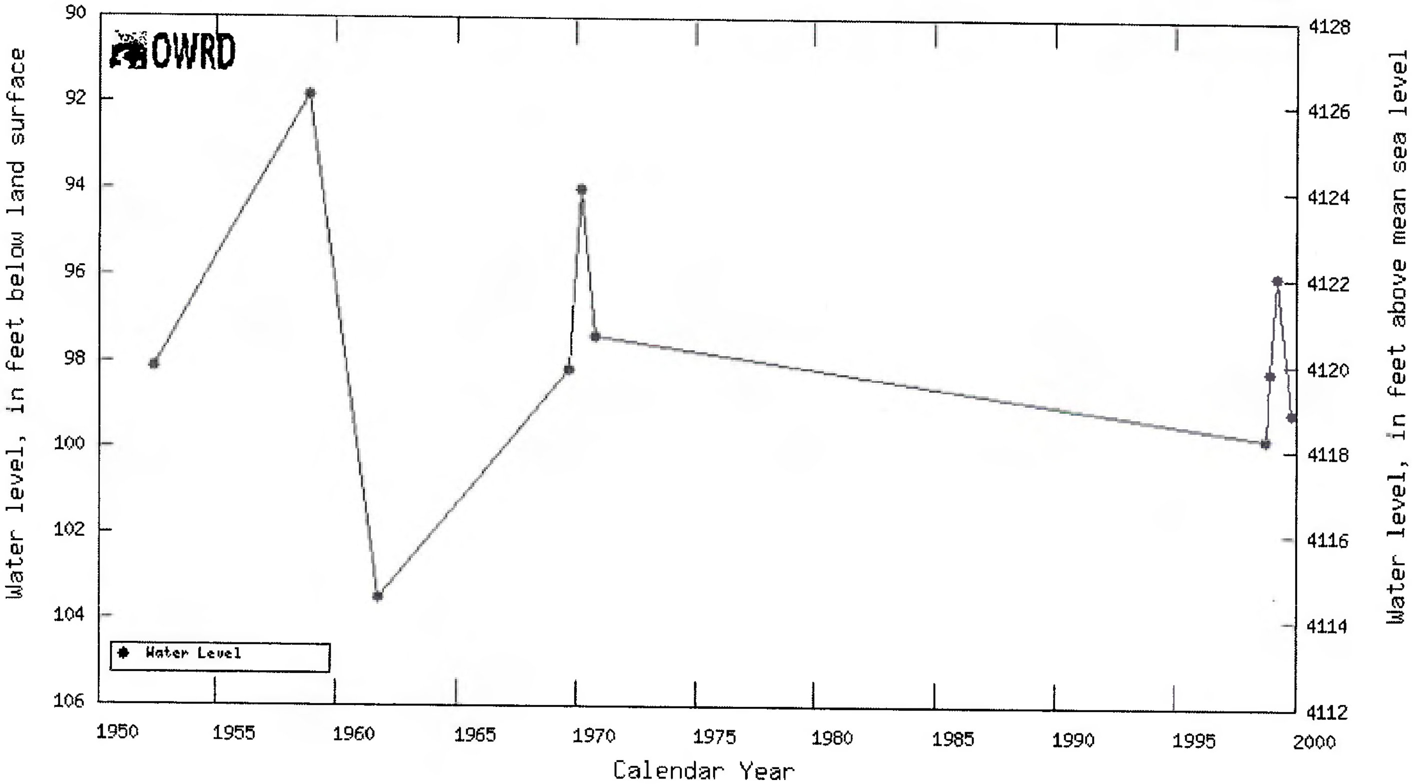
Oregon Water Resources Department Well Location	38.00S/10.00E-26baa
Oregon Water Resources Department Logid	KLAM 12228
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	582
Land surface elevation (feet above mean sea level)	4224.7
Primary use of well	----
Primary aquifer system	----



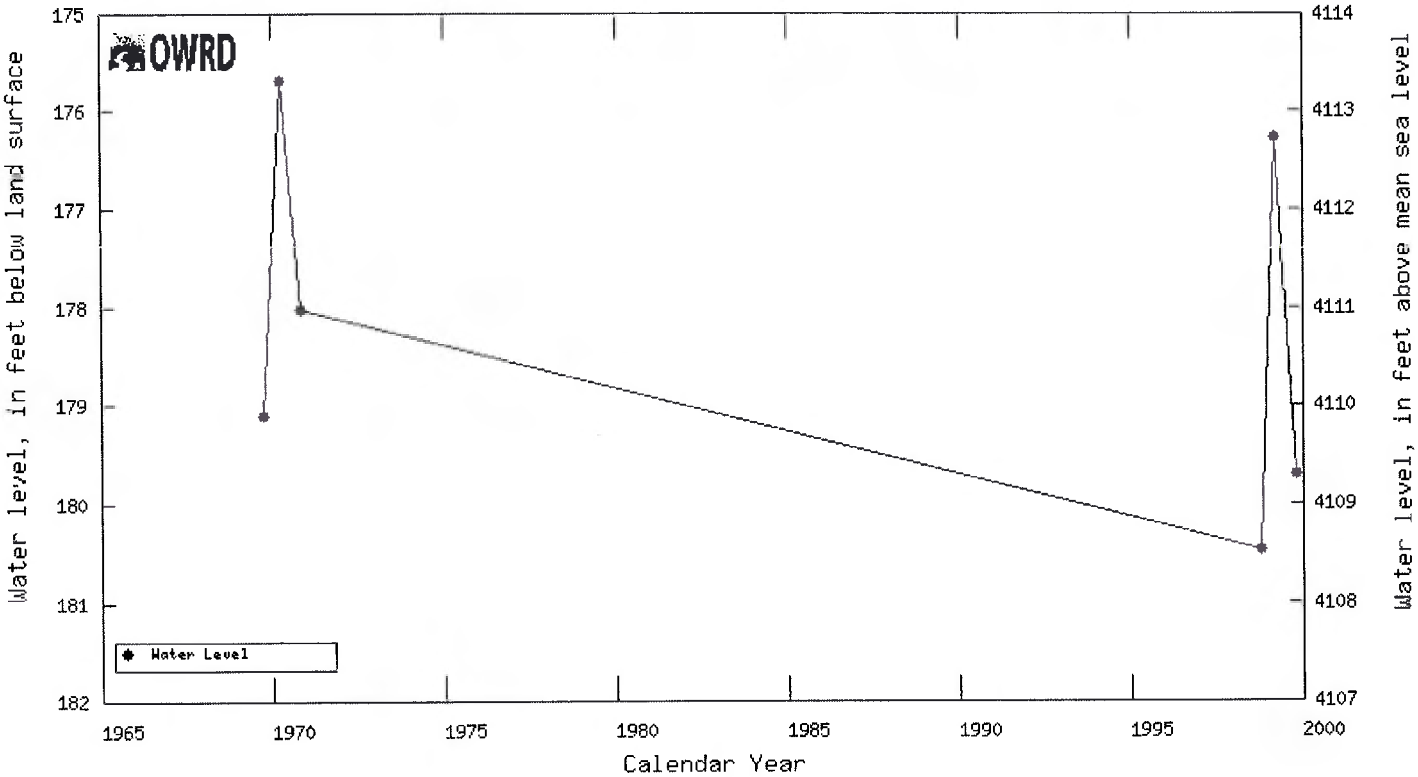
Oregon Water Resources Department Well Location	38.00S/11.50E-7add
Oregon Water Resources Department Logid	KLAM 12385
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	186
Land surface elevation (feet above mean sea level)	4216
Primary use of well	----
Primary aquifer system	----



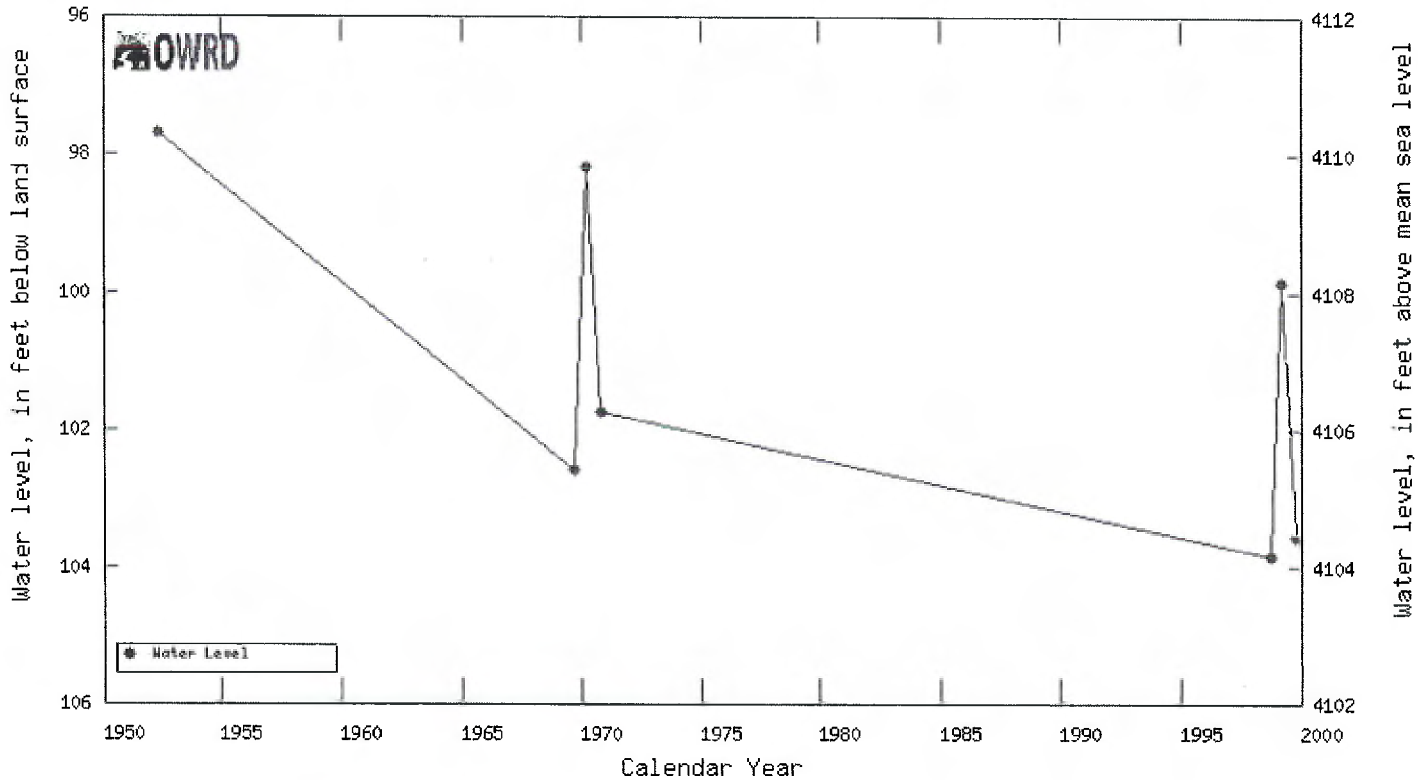
Oregon Water Resources Department Well Location	38.00S/11.50E-7ddd
Oregon Water Resources Department Logid	KLAM 12386
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	319
Total well depth (feet below land surface)	250
Land surface elevation (feet above mean sea level)	4218
Primary use of well	----
Primary aquifer system	----



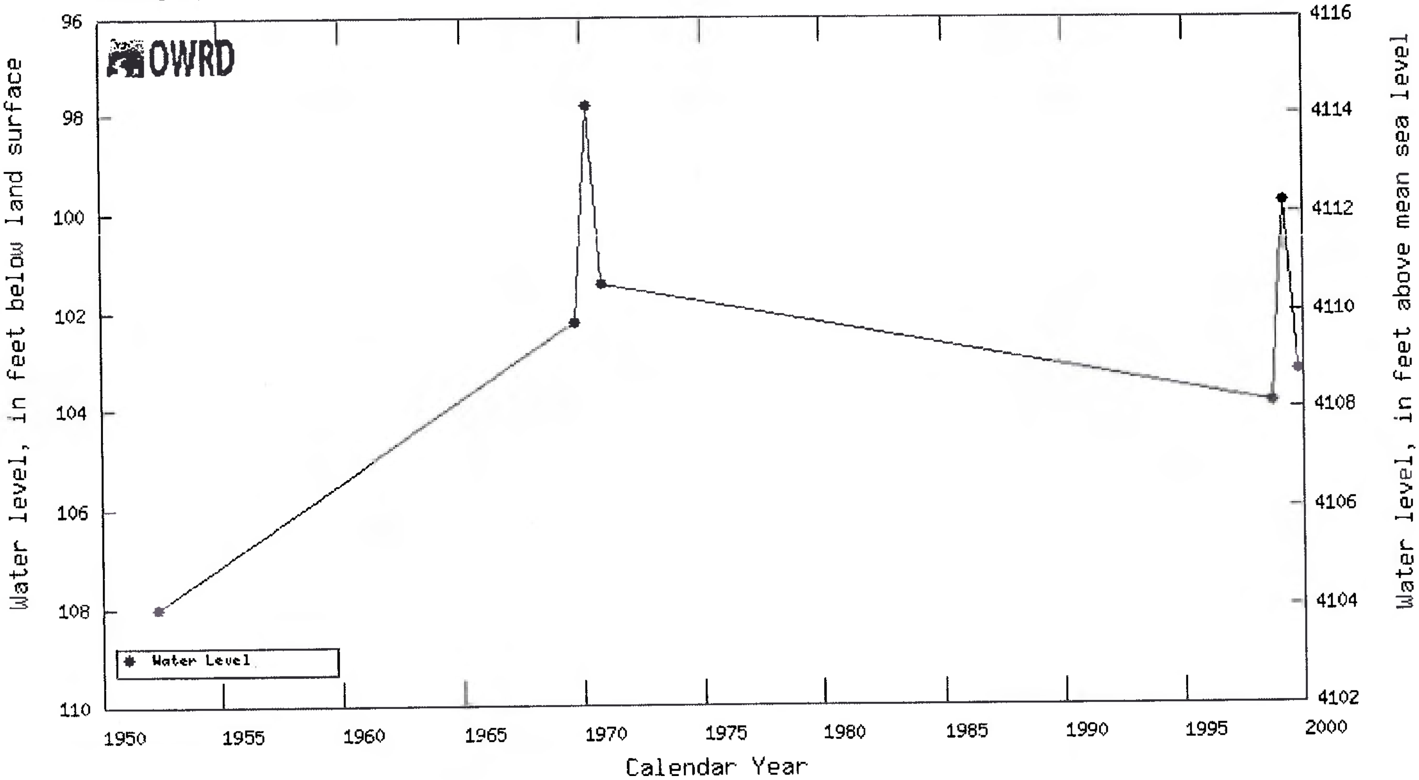
Oregon Water Resources Department Well Location	38.00S/11.50E-20ccb
Oregon Water Resources Department Logid	KLAM 12406
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	341
Land surface elevation (feet above mean sea level)	4289.2
Primary use of well	----
Primary aquifer system	----



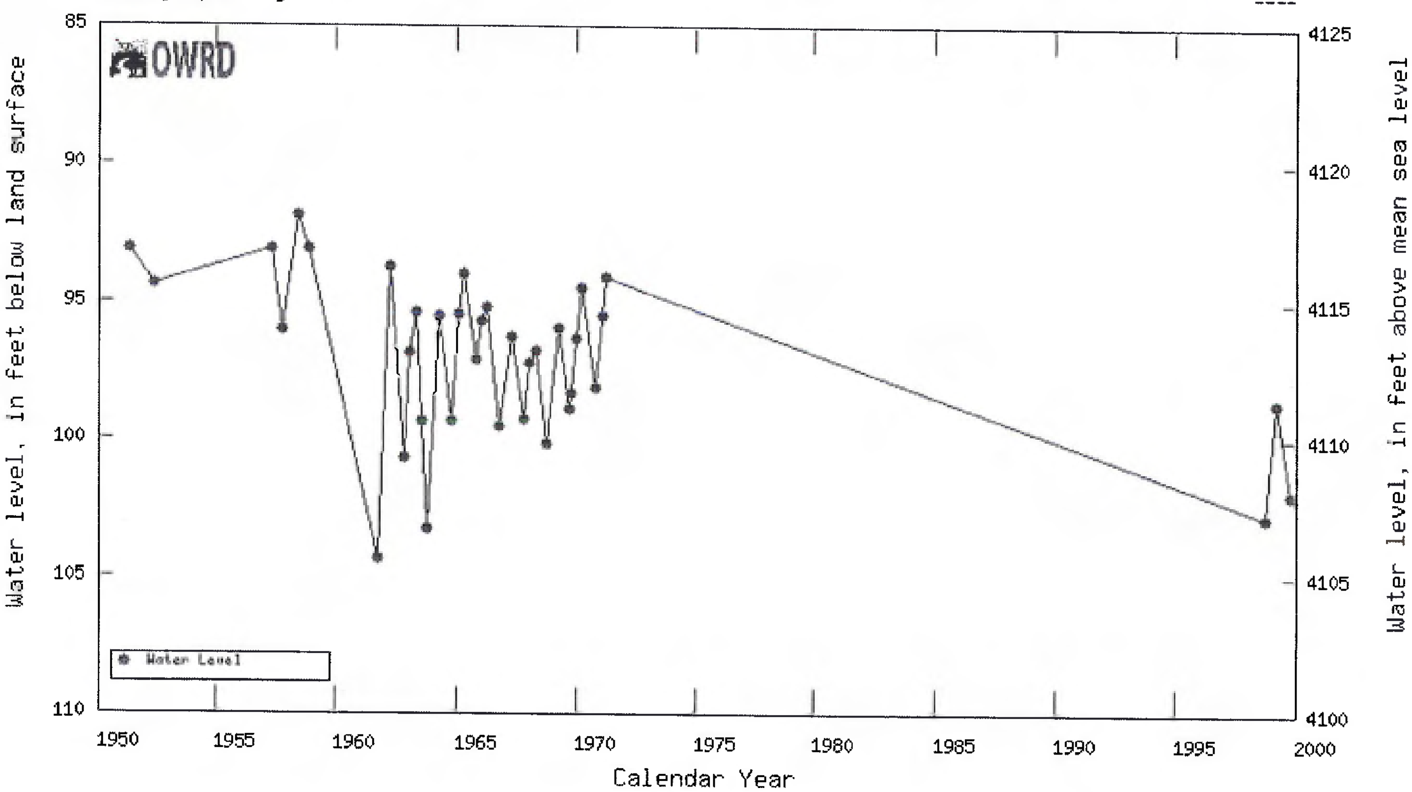
Oregon Water Resources Department Well Location	38.00S/11.50E-28cbc
Oregon Water Resources Department Logid	KLAM 12419
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	136
Land surface elevation (feet above mean sea level)	4208.0
Primary use of well	----
Primary aquifer system	----



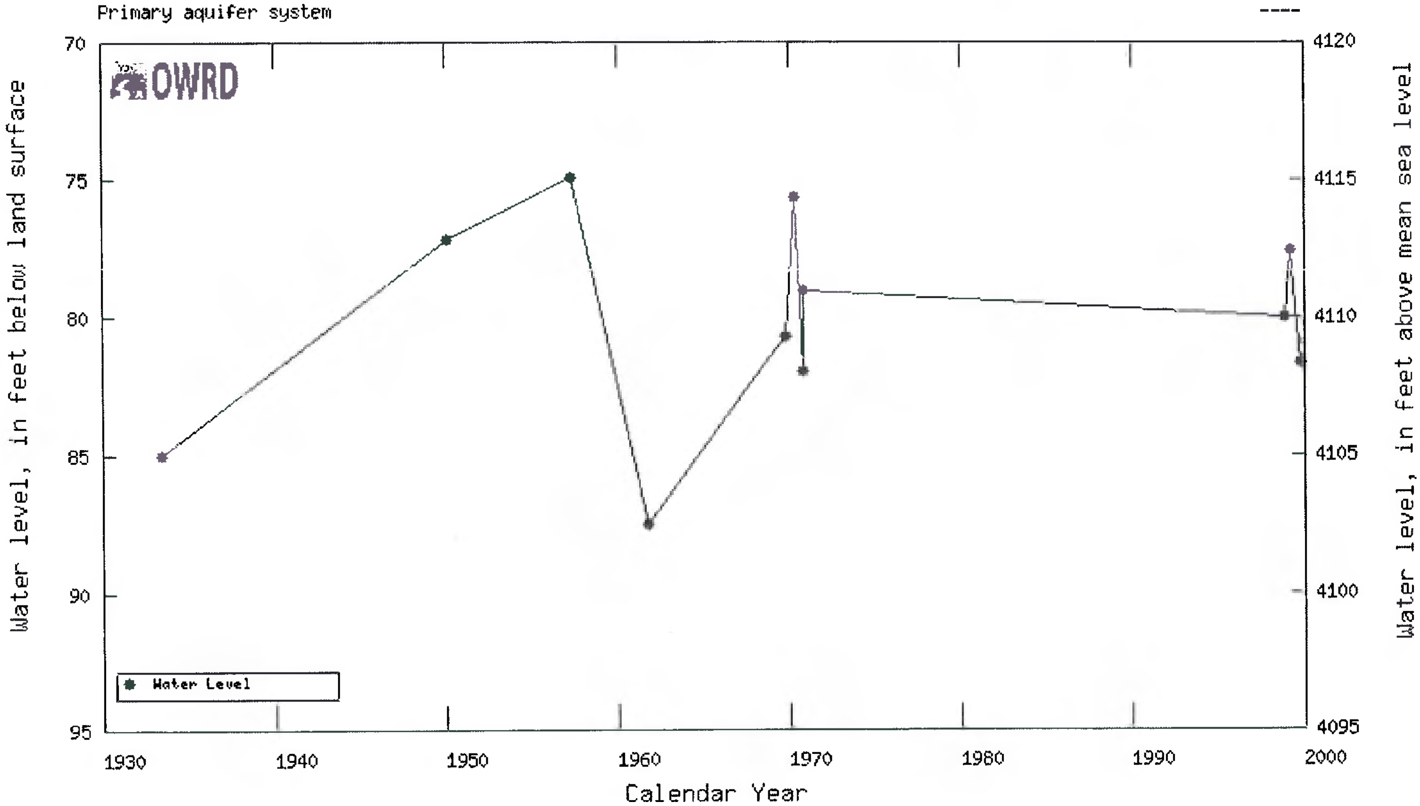
Oregon Water Resources Department Well Location	38.00S/11.50E-29ada
Oregon Water Resources Department Logid	KLAM 12420
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	135
Land surface elevation (feet above mean sea level)	4212.3
Primary use of well	----
Primary aquifer system	----



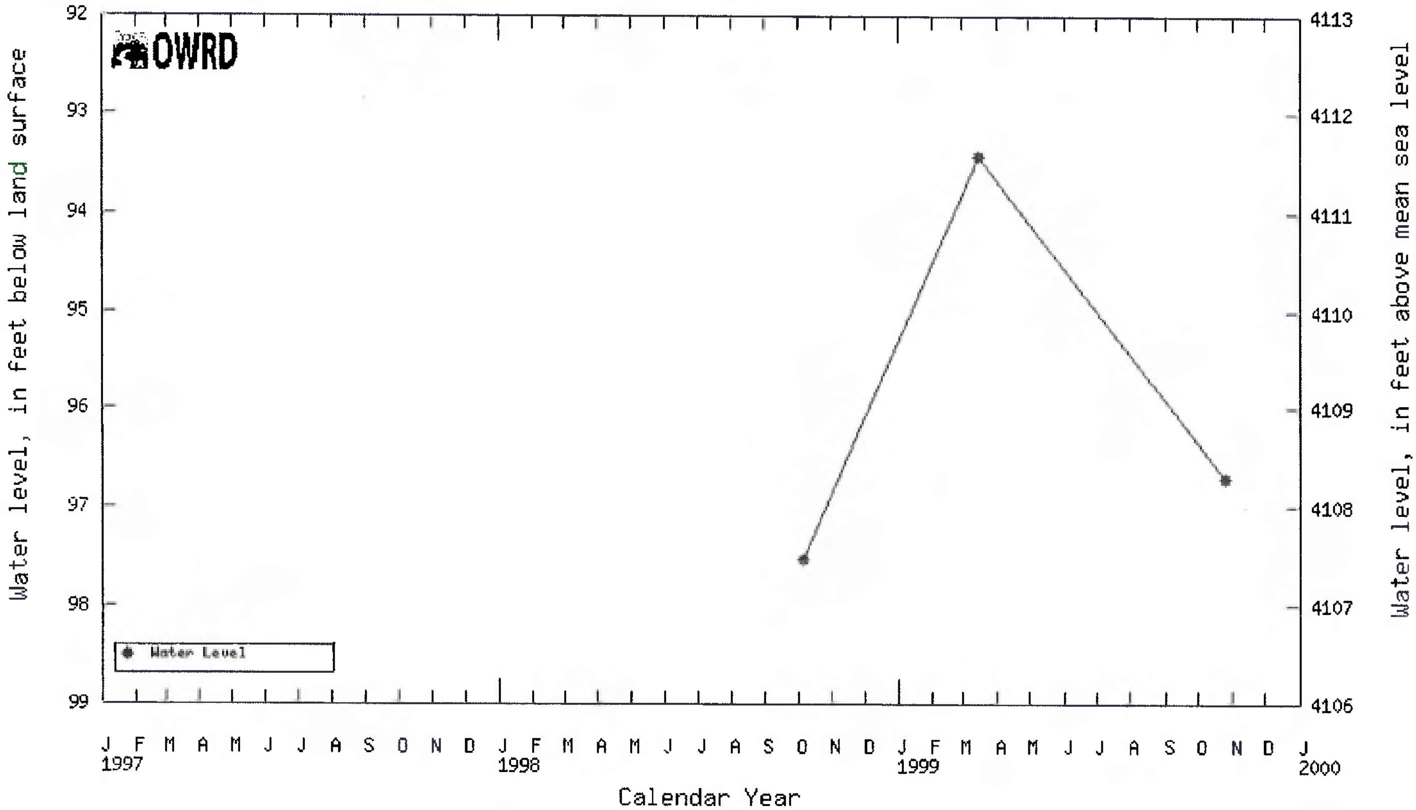
Oregon Water Resources Department Well Location	38.00S/11.50E-30cbb
Oregon Water Resources Department Logid	KLAM 12421
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	325
Total well depth (feet below land surface)	276
Land surface elevation (feet above mean sea level)	4210.5
Primary use of well	----
Primary aquifer system	----



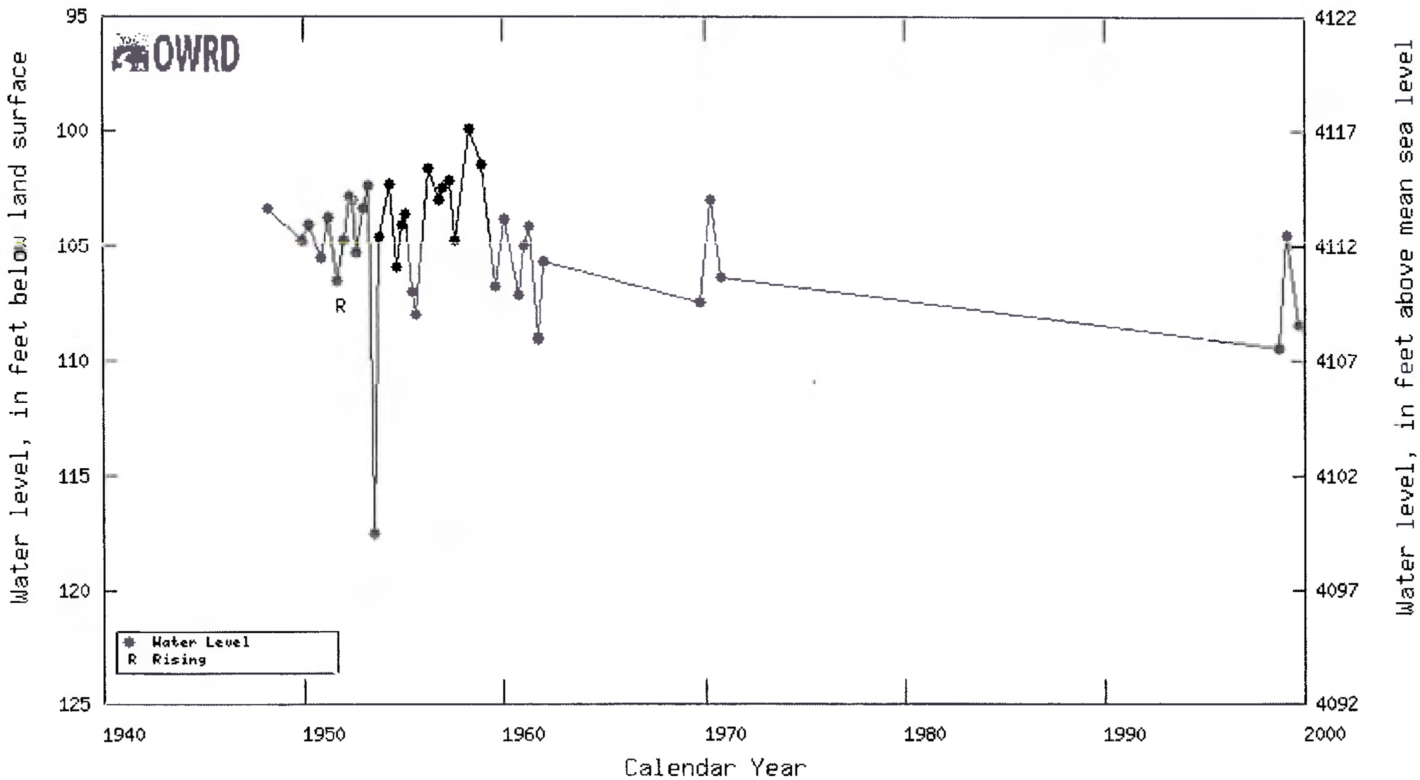
Oregon Water Resources Department Well Location	38.00S/11.50E-30ddd
Oregon Water Resources Department Logid	KLAM 12424
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	326
Total well depth (feet below land surface)	145
Land surface elevation (feet above mean sea level)	4190.5
Primary use of well	----
Primary aquifer system	----



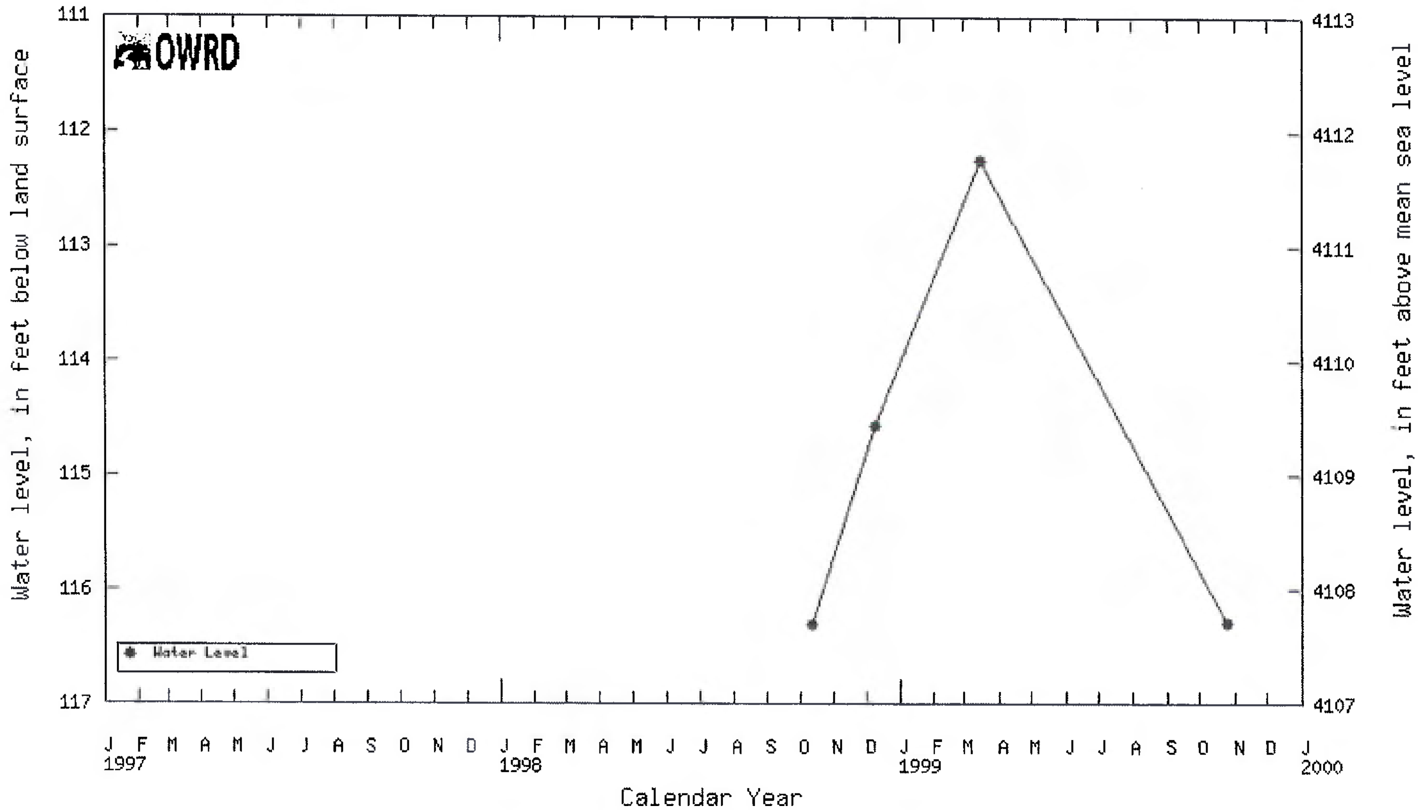
Oregon Water Resources Department Well Location	38.00S/11.50E-30dcc
Oregon Water Resources Department Logid	KLAM 12425
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	230
Land surface elevation (feet above mean sea level)	4205.9
Primary use of well	----
Primary aquifer system	----



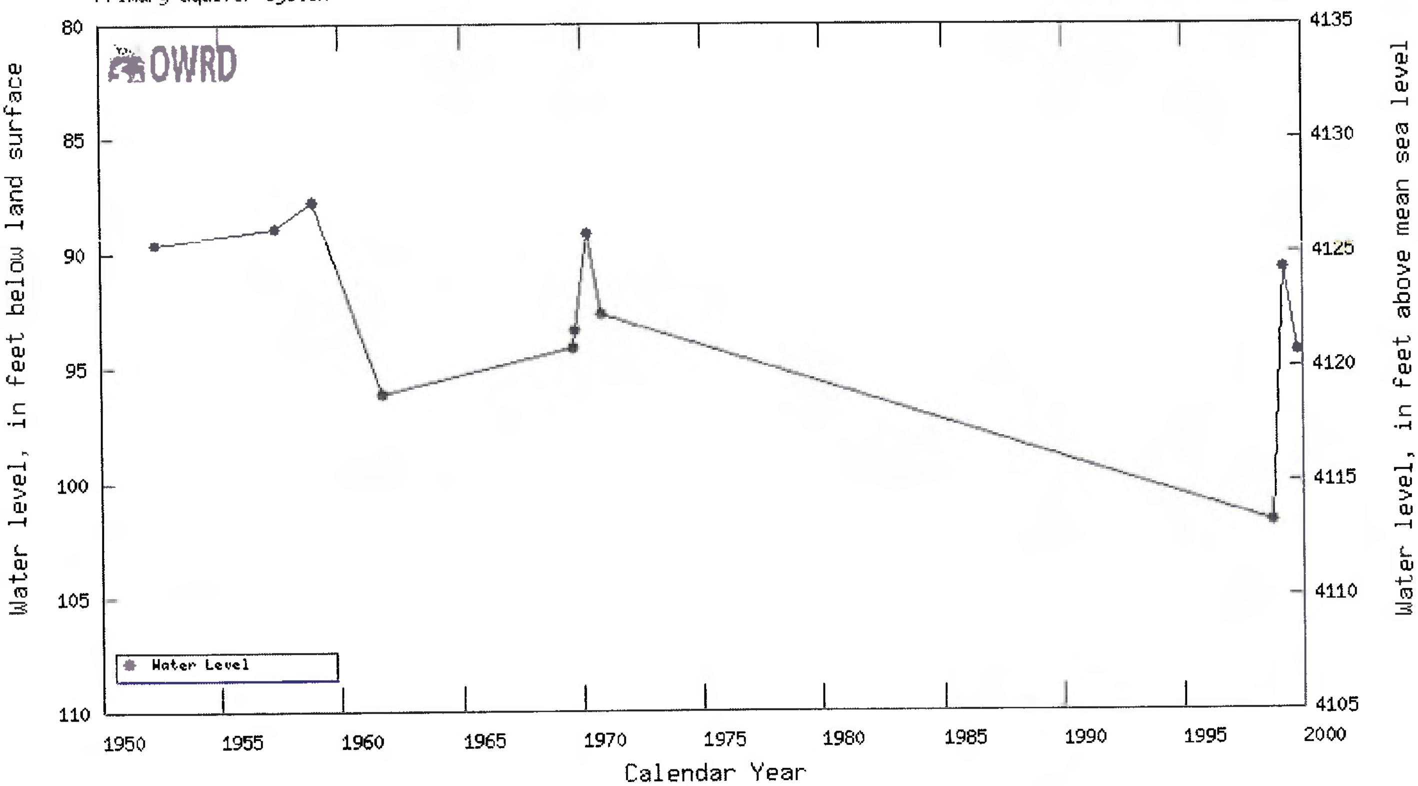
Oregon Water Resources Department Well Location	38.00S/11.50E-30dac
Oregon Water Resources Department Logid	KLAM 50337
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	327
Total well depth (feet below land surface)	175
Land surface elevation (feet above mean sea level)	4217.6
Primary use of well	----
Primary aquifer system	----



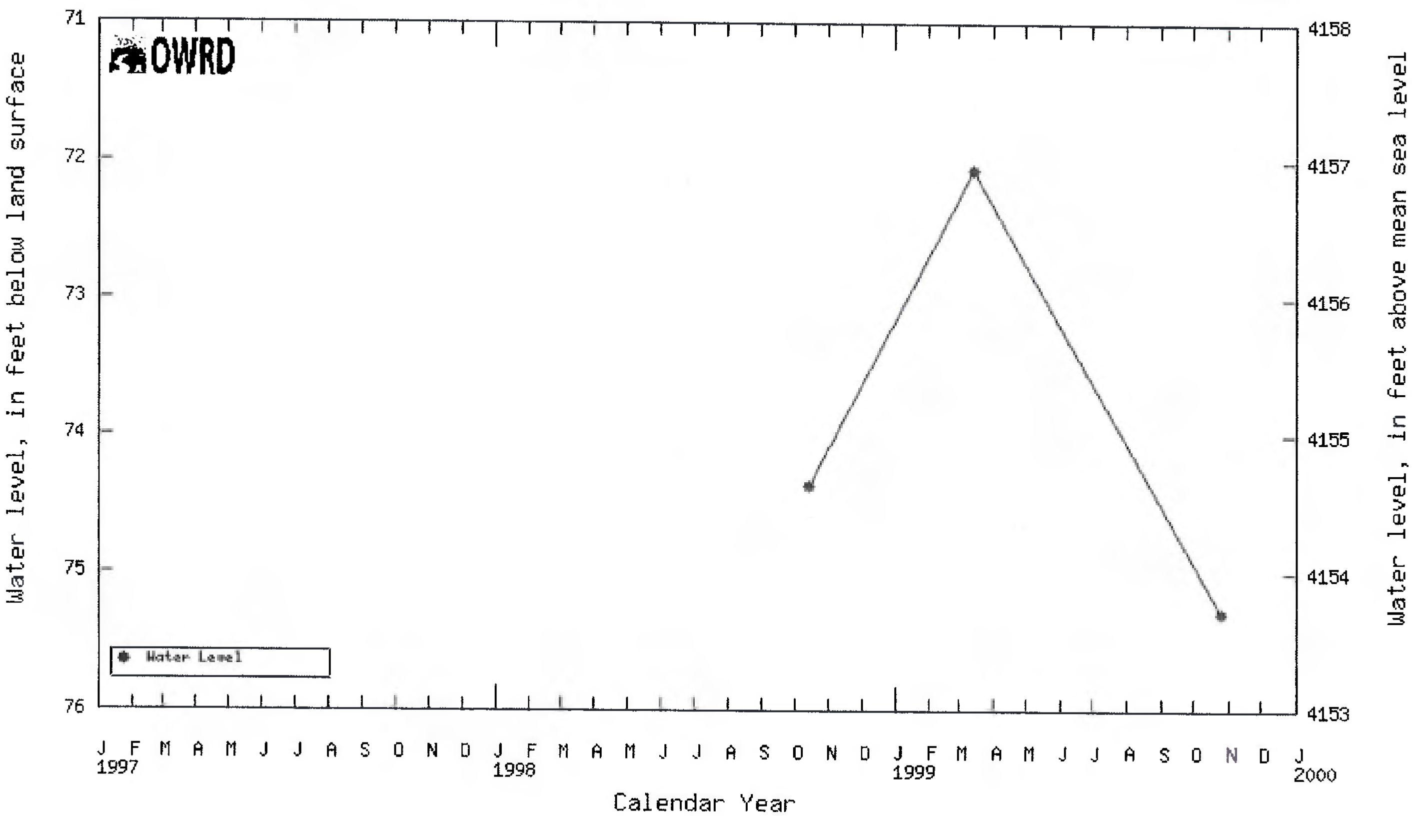
Oregon Water Resources Department Well Location	38.00S/11.50E-20dca
Oregon Water Resources Department Logid	KLAM 50341
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	216
Land surface elevation (feet above mean sea level)	4224.6
Primary use of well	----
Primary aquifer system	Late Tertiary Basalt Aquifers



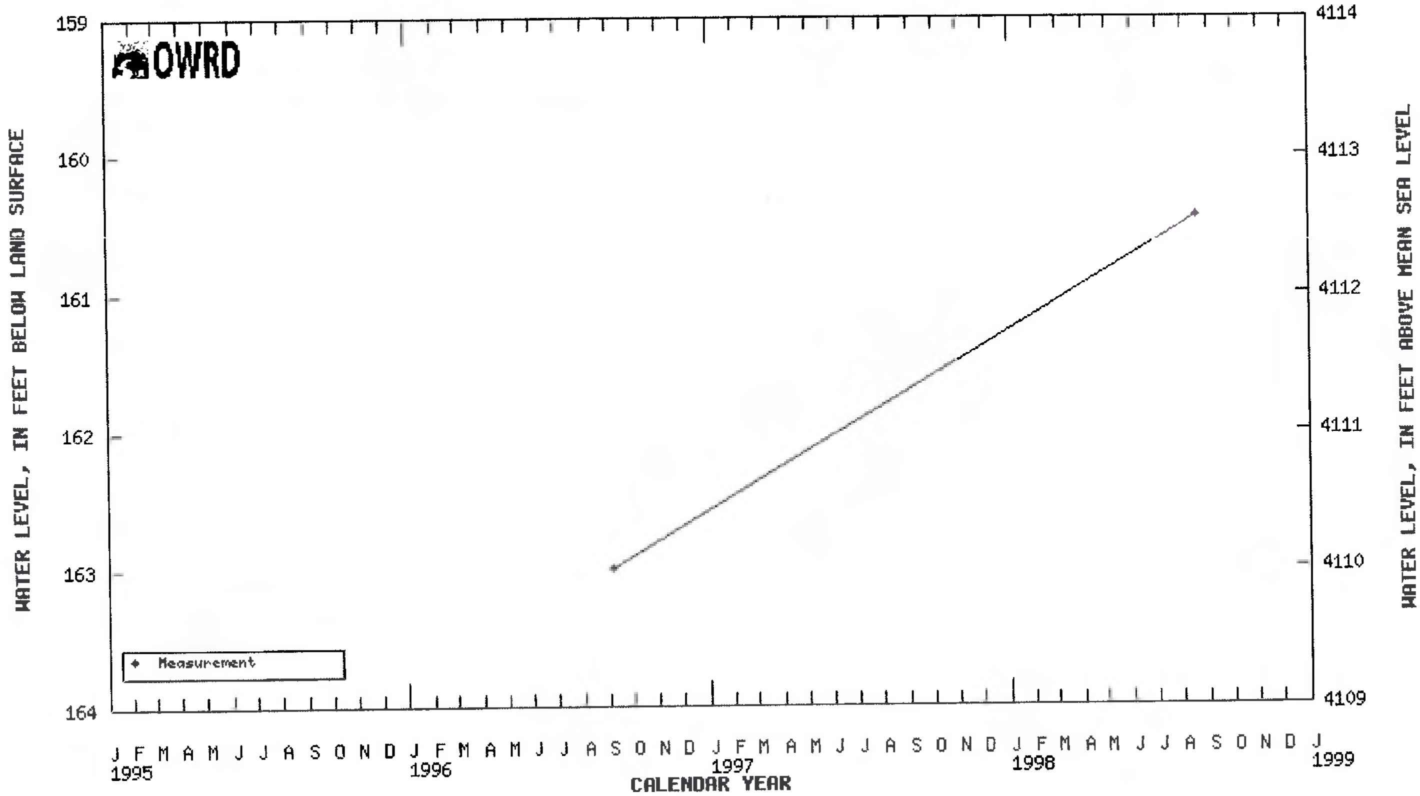
Oregon Water Resources Department Well Location	38.00S/11.50E-6cad
Oregon Water Resources Department Logid	KLAM 50362
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	318
Total well depth (feet below land surface)	224
Land surface elevation (feet above mean sea level)	4215
Primary use of well	----
Primary aquifer system	Late Tertiary Basalt Aquifers



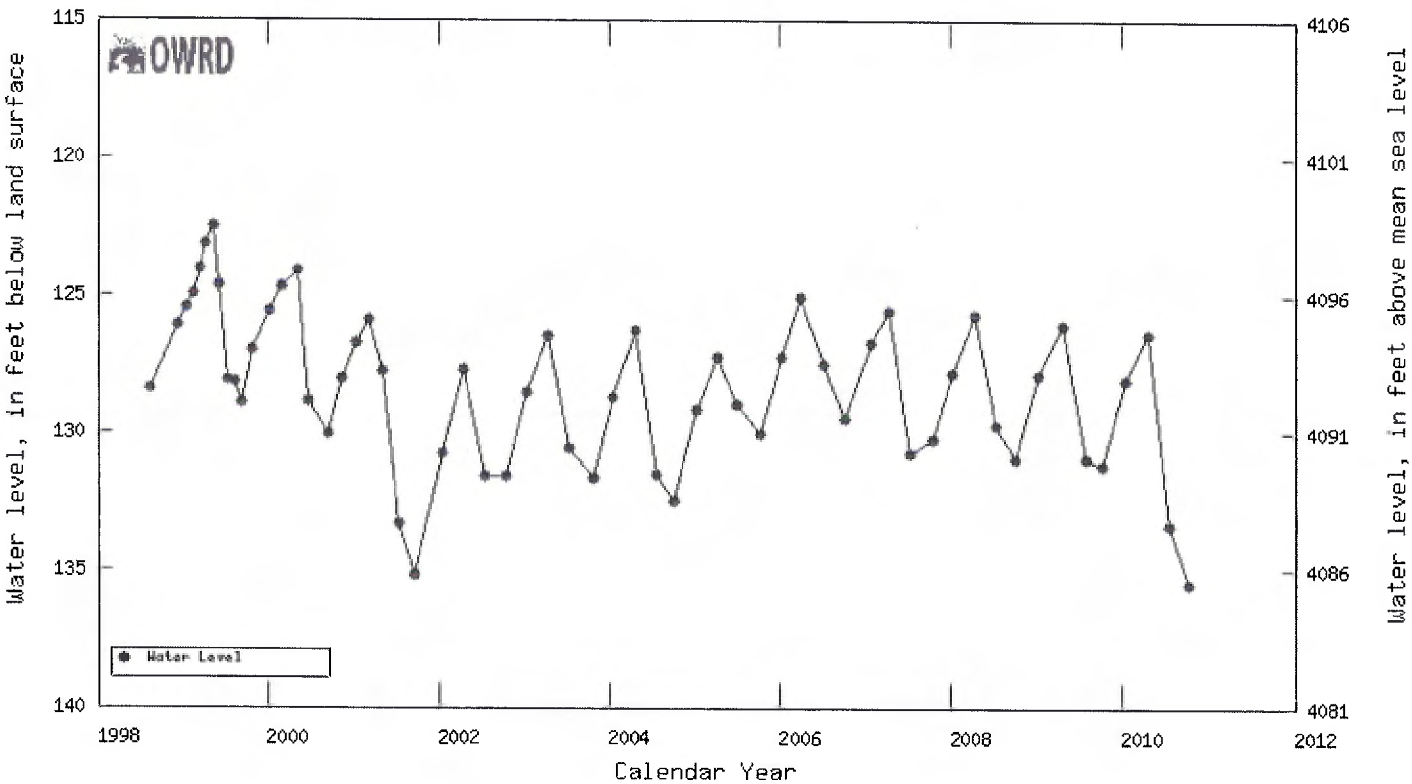
Oregon Water Resources Department Well Location	37.00S/10.00E-19cdd
Oregon Water Resources Department Logid	KLAM 50445
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	220
Land surface elevation (feet above mean sea level)	4229
Primary use of well	----
Primary aquifer system	----



Well Location	38.00S11.50E30dcc
Oregon Water Resources Department Well Log ID	KLAM 50446
Oregon Water Resources Department State Observation Well Number	----
Well depth, in feet below land surface	249
Land surface elevation, in feet above mean sea level	4273
Primary use of well	not determined



Oregon Water Resources Department Well Location	38.00S/10.00E-16ddc
Oregon Water Resources Department Logid	KLAM 50493
Oregon Water Resources Department Well Tag (Well ID)	----
Oregon Water Resources Department State Observation Well Number	----
Total well depth (feet below land surface)	206
Land surface elevation (feet above mean sea level)	4221.8
Primary use of well	DOMESTIC
Primary aquifer system	----

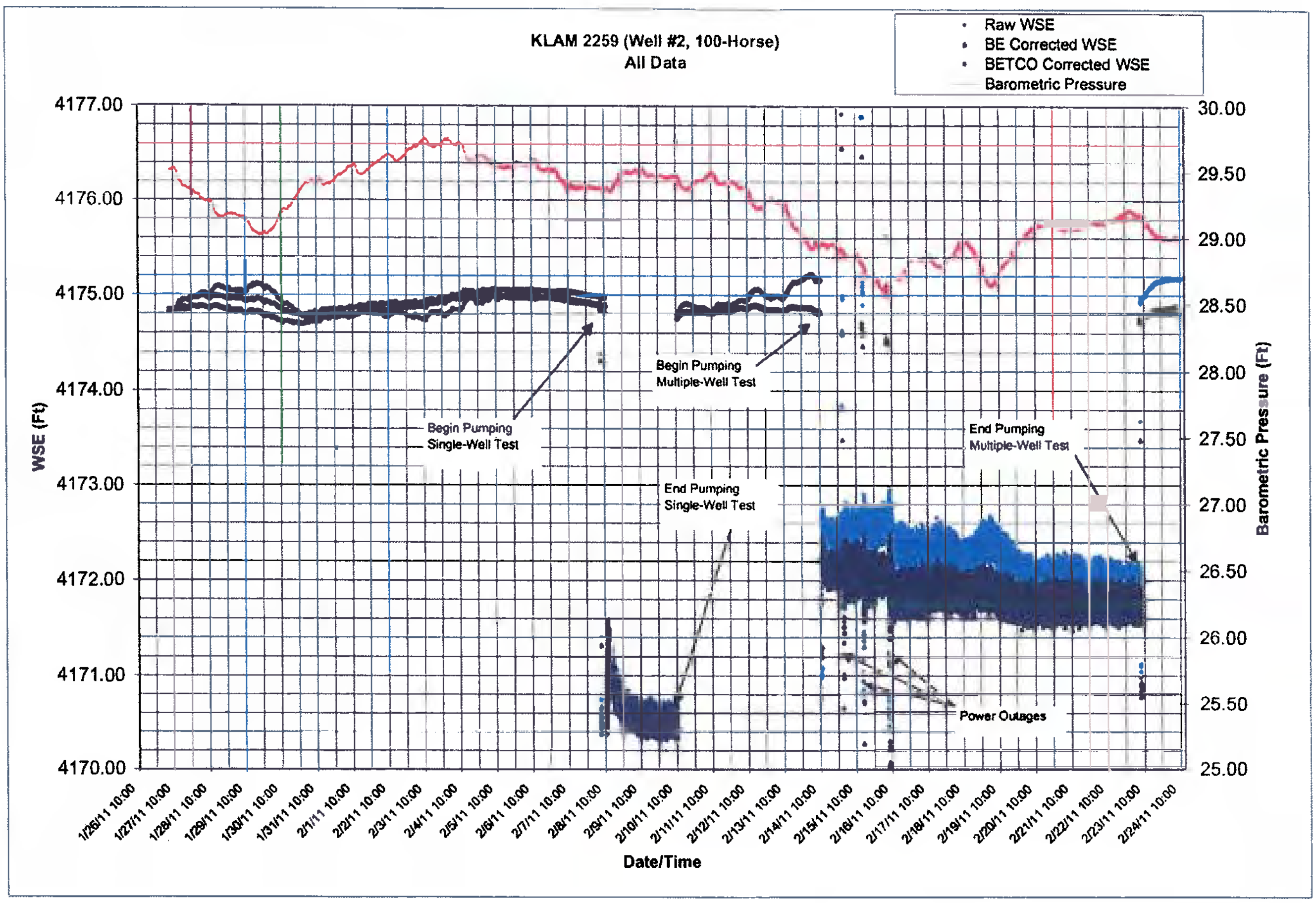


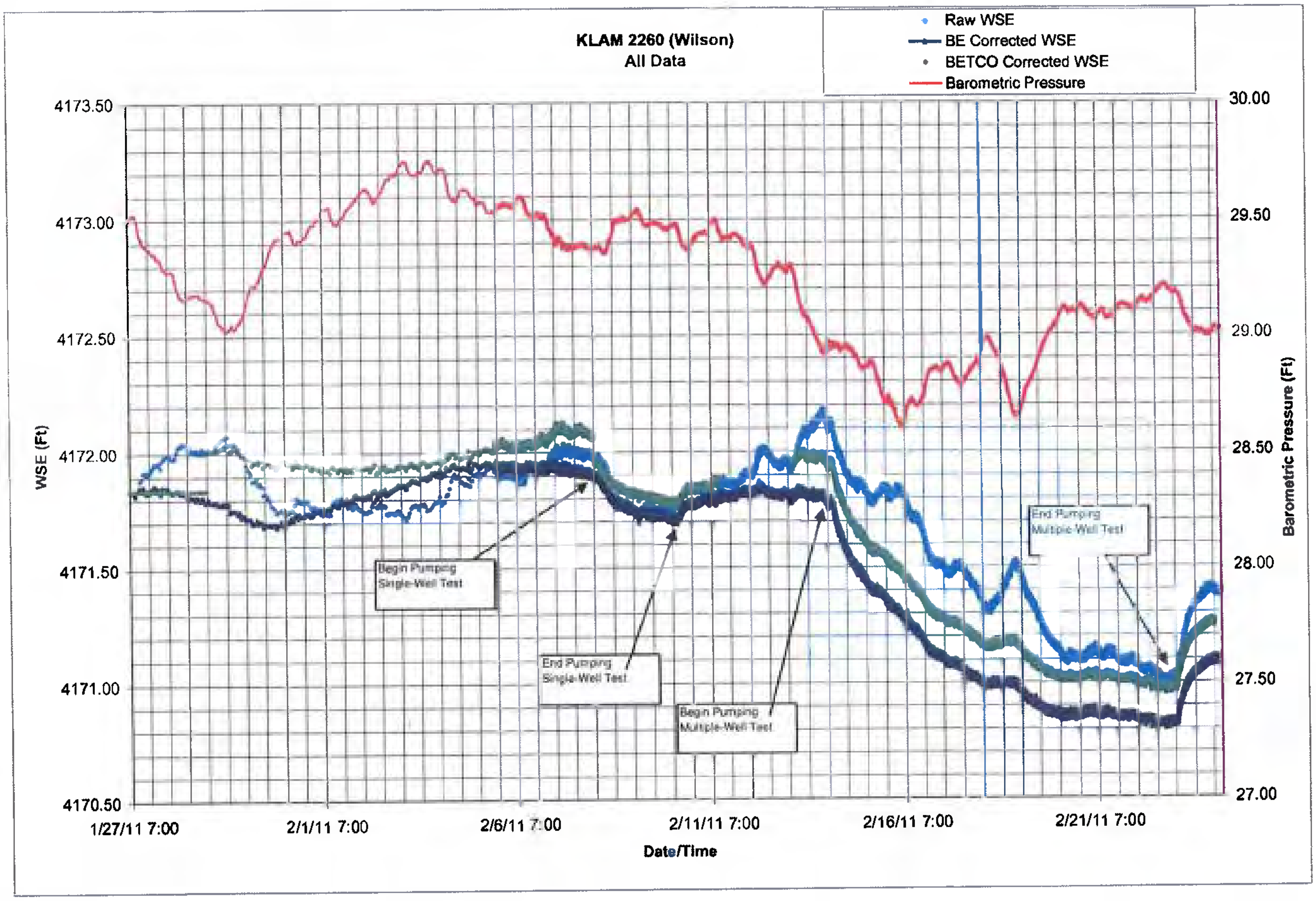
APPENDIX B

APPENDIX B

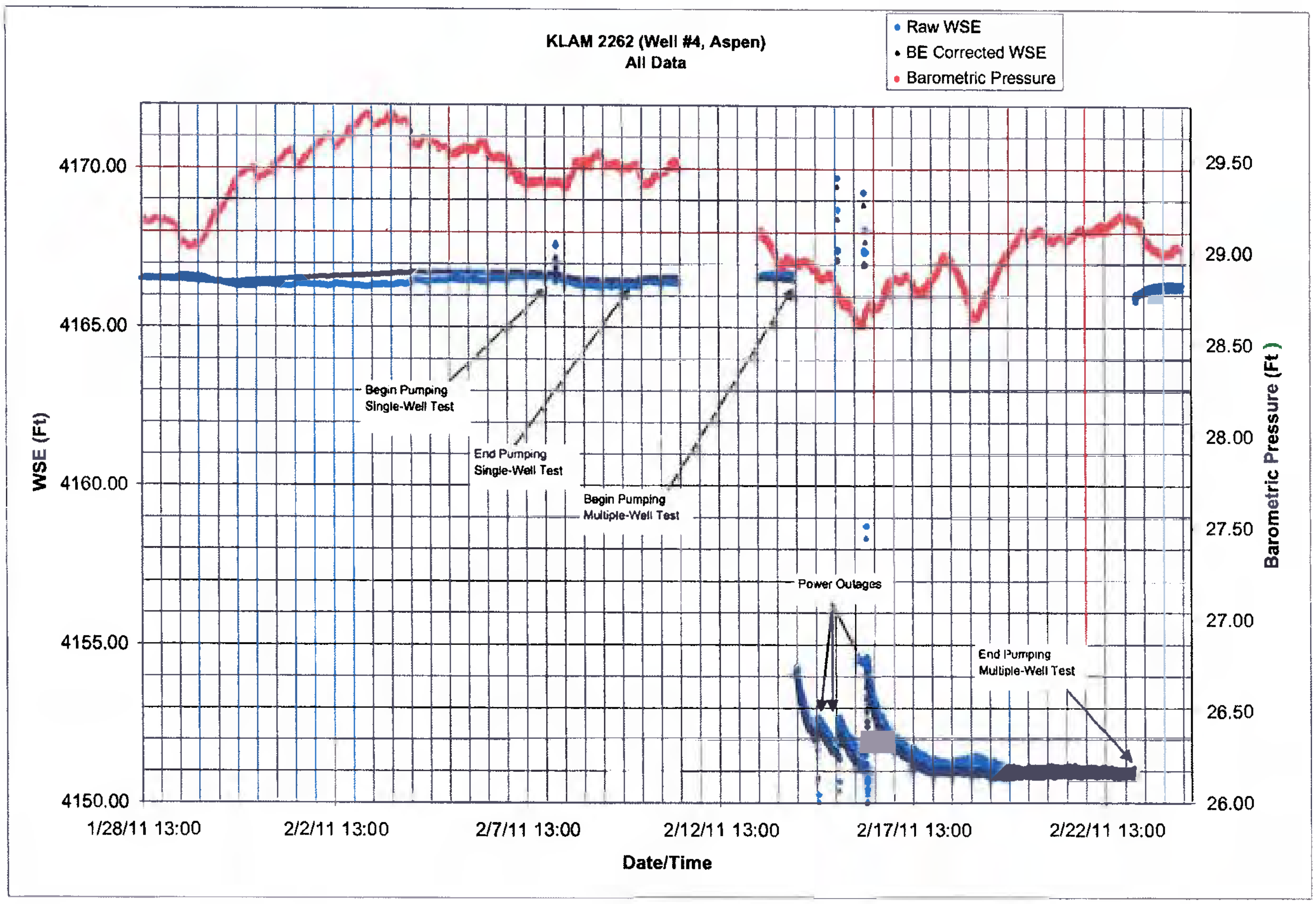
WATER LEVEL PLOTS

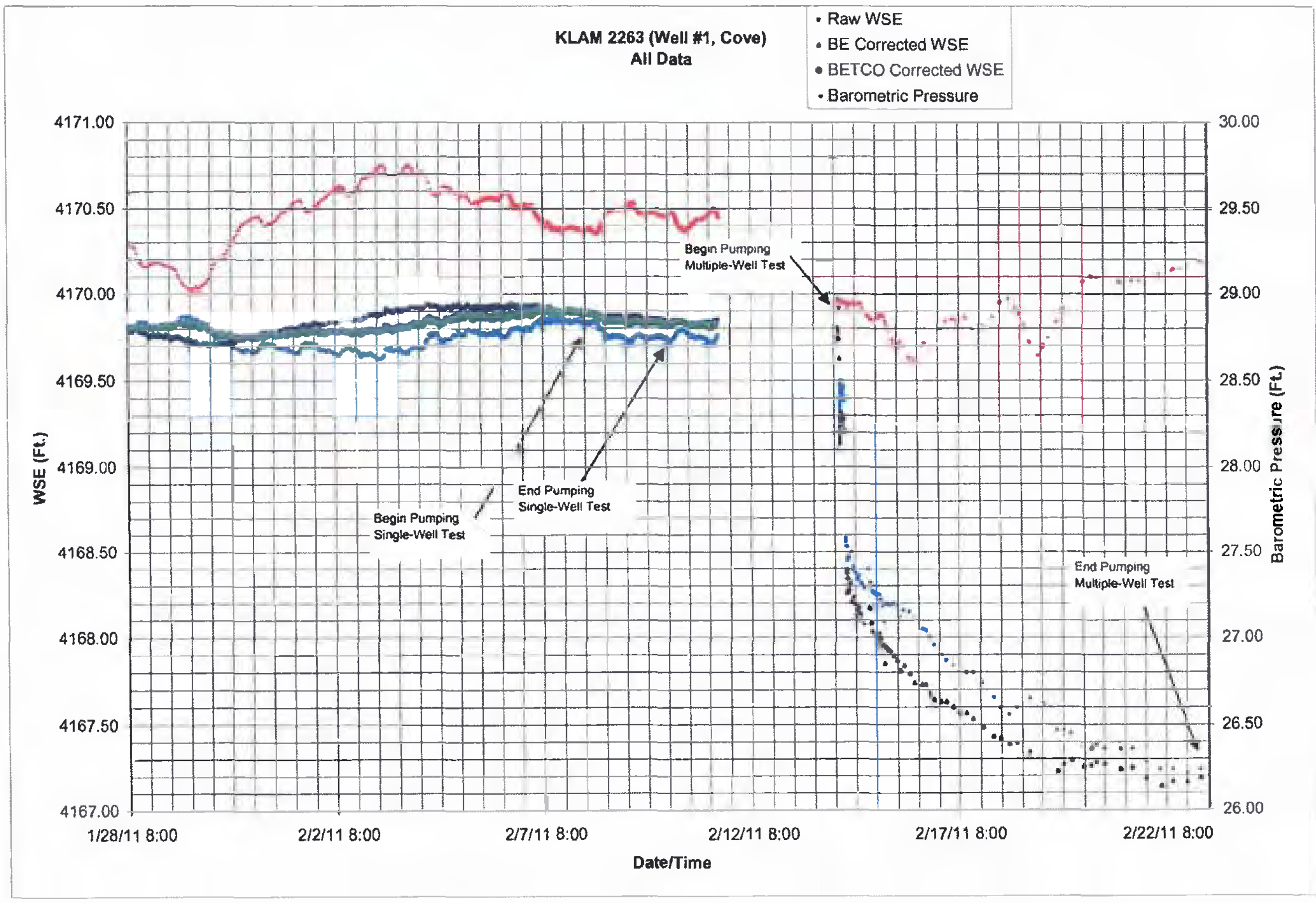
Water-Level Plots – All Testing Phases


KLAM 2259 (Well #2, 100-Horse)
All Data
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft)
Barometric Pressure (Ft)
Date/Time
Begin Pumping
Single-Well Test
Begin Pumping
Multiple-Well Test
End Pumping
Single-Well Test
End Pumping
Multiple-Well Test
Power Outages

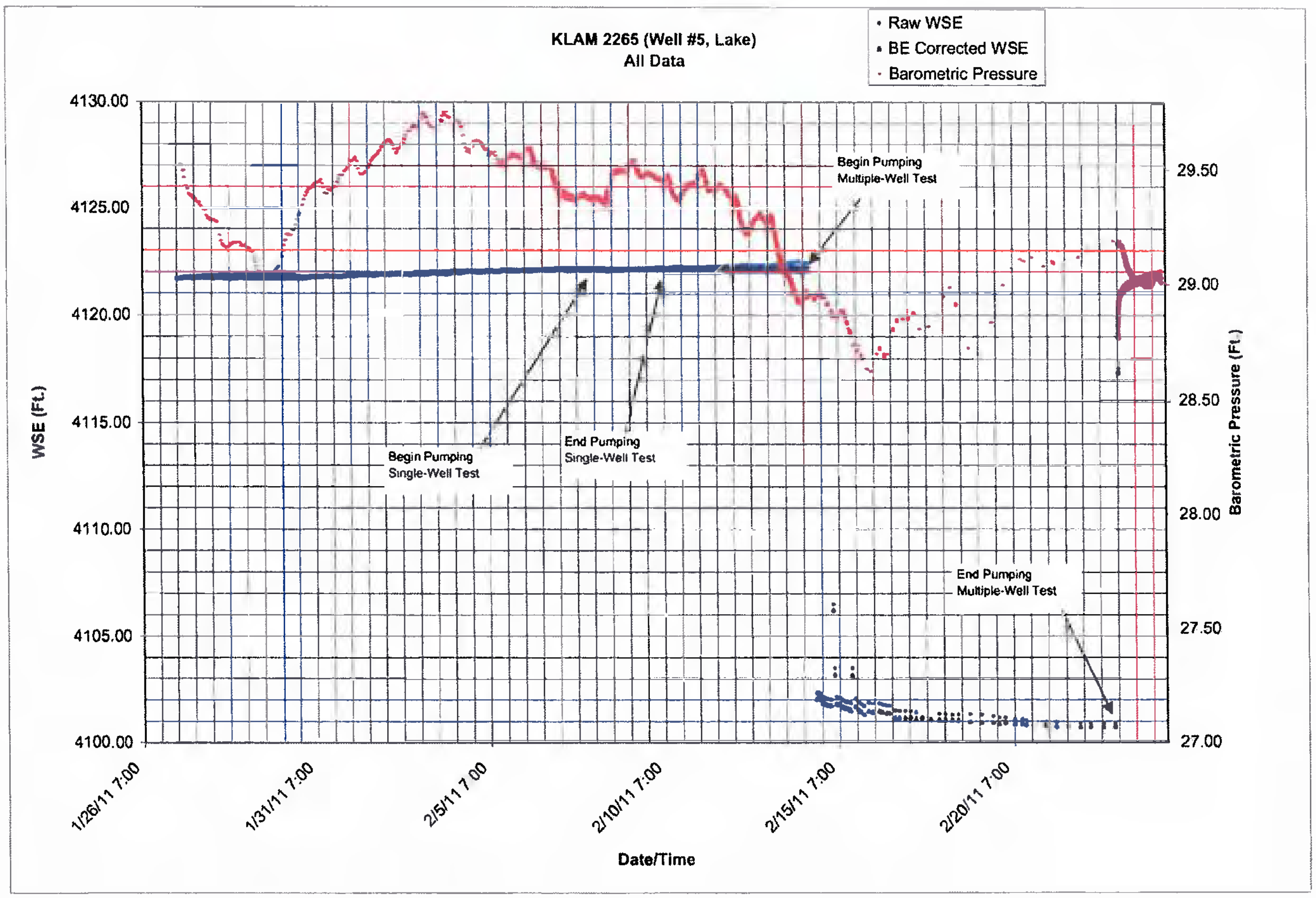


KLAM 2260 (Wilson)
All Data
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
4173.50
4173.00
4172.50
4172.00
4171.50
4171.00
4170.50
WSE (Ft)
30.00
29.50
29.00
28.50
28.00
27.50
27.00
Barometric Pressure (Ft)
Begin Pumping Single-Well Test
End Pumping Single-Well Test
Begin Pumping Multiple-Well Test
End Pumping Multiple-Well Test
1/27/11 7:00
2/1/11 7:00
2/6/11 7:00
2/11/11 7:00
2/16/11 7:00
2/21/11 7:00
Date/Time

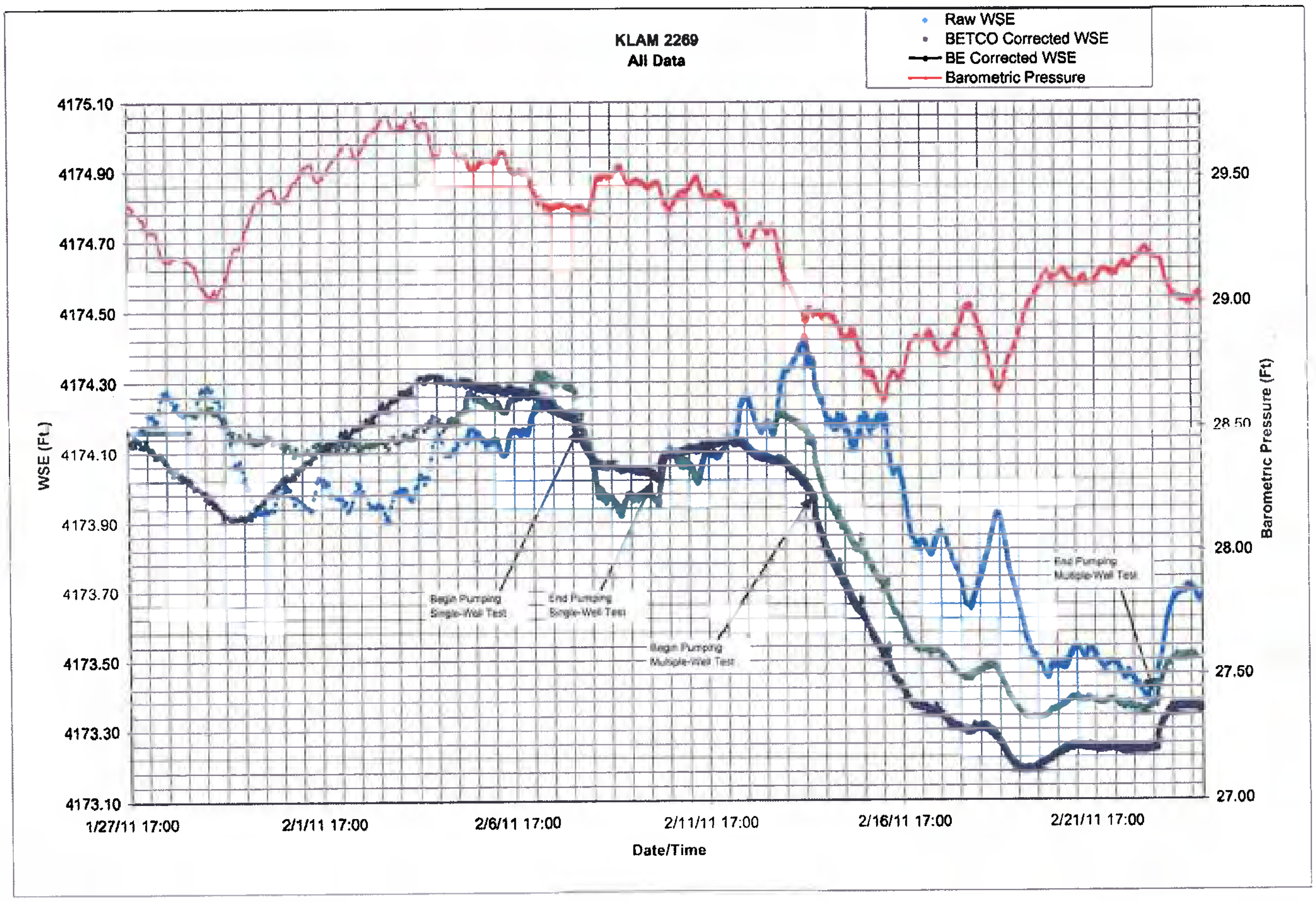

KLAM 2262 (Well #4, Aspen)
All Data
Raw WSE
BE Corrected WSE
Barometric Pressure
WSE (Ft)
4170.00
4165.00
4160.00
4155.00
4150.00
Barometric Pressure (Ft)
29.50
29.00
28.50
28.00
27.50
27.00
26.50
26.00
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
Begin Pumping
Multiple-Well Test
Power Outages
End Pumping
Multiple-Well Test
1/28/11 13:00
2/2/11 13:00
2/7/11 13:00
2/12/11 13:00
2/17/11 13:00
2/22/11 13:00
Date/Time



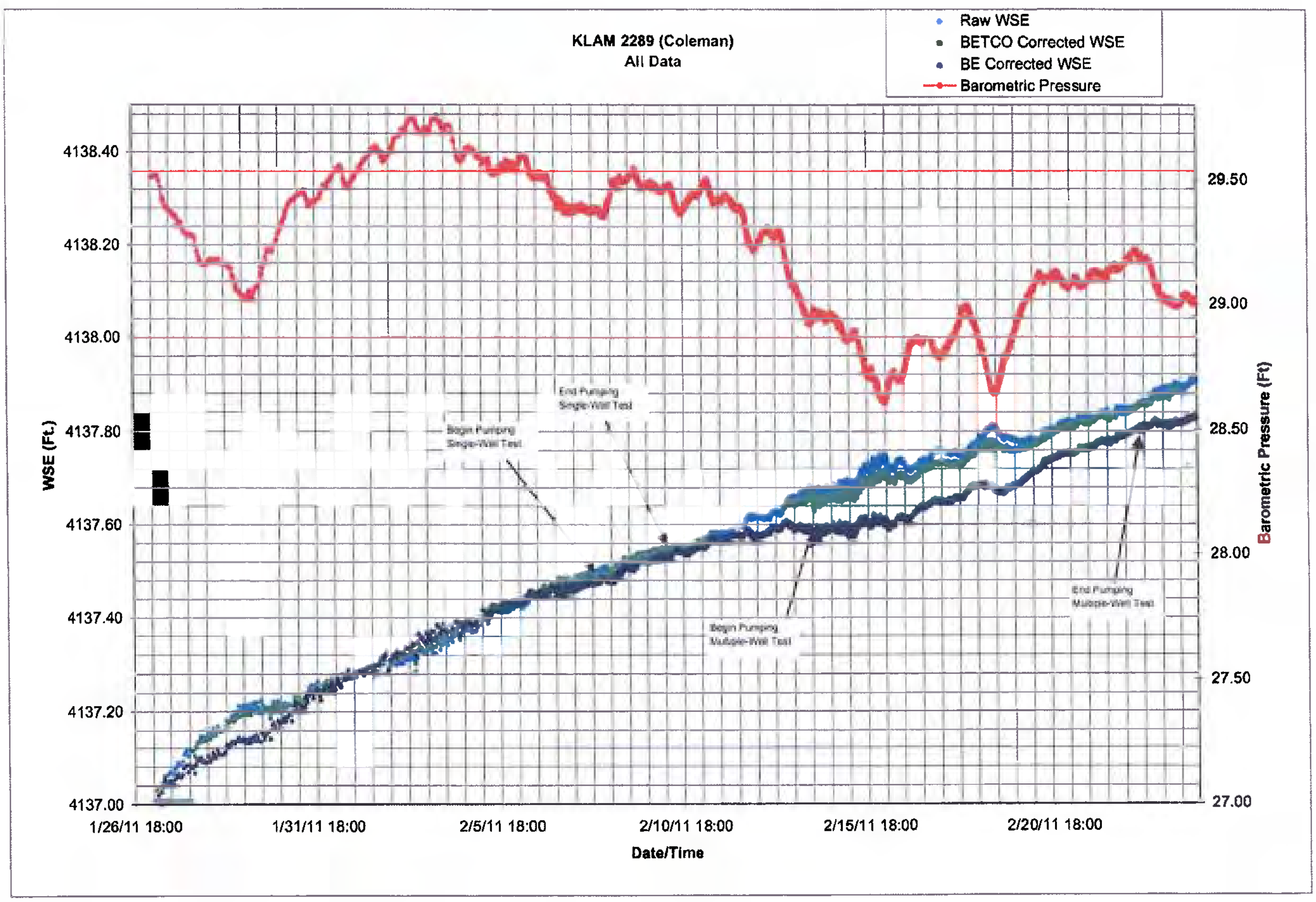
KLAM 2263 (Well #1, Cove)
All Data
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
4171.00
4170.50
4170.00
4169.50
4169.00
4168.50
4168.00
4167.50
4167.00
30.00
29.50
29.00
28.50
28.00
27.50
27.00
26.50
26.00
Begin Pumping Multiple-Well Test
Begin Pumping Single-Well Test
End Pumping Single-Well Test
End Pumping Multiple-Well Test
1/28/11 8:00
2/2/11 8:00
2/7/11 8:00
2/12/11 8:00
2/17/11 8:00
2/22/11 8:00
Date/Time



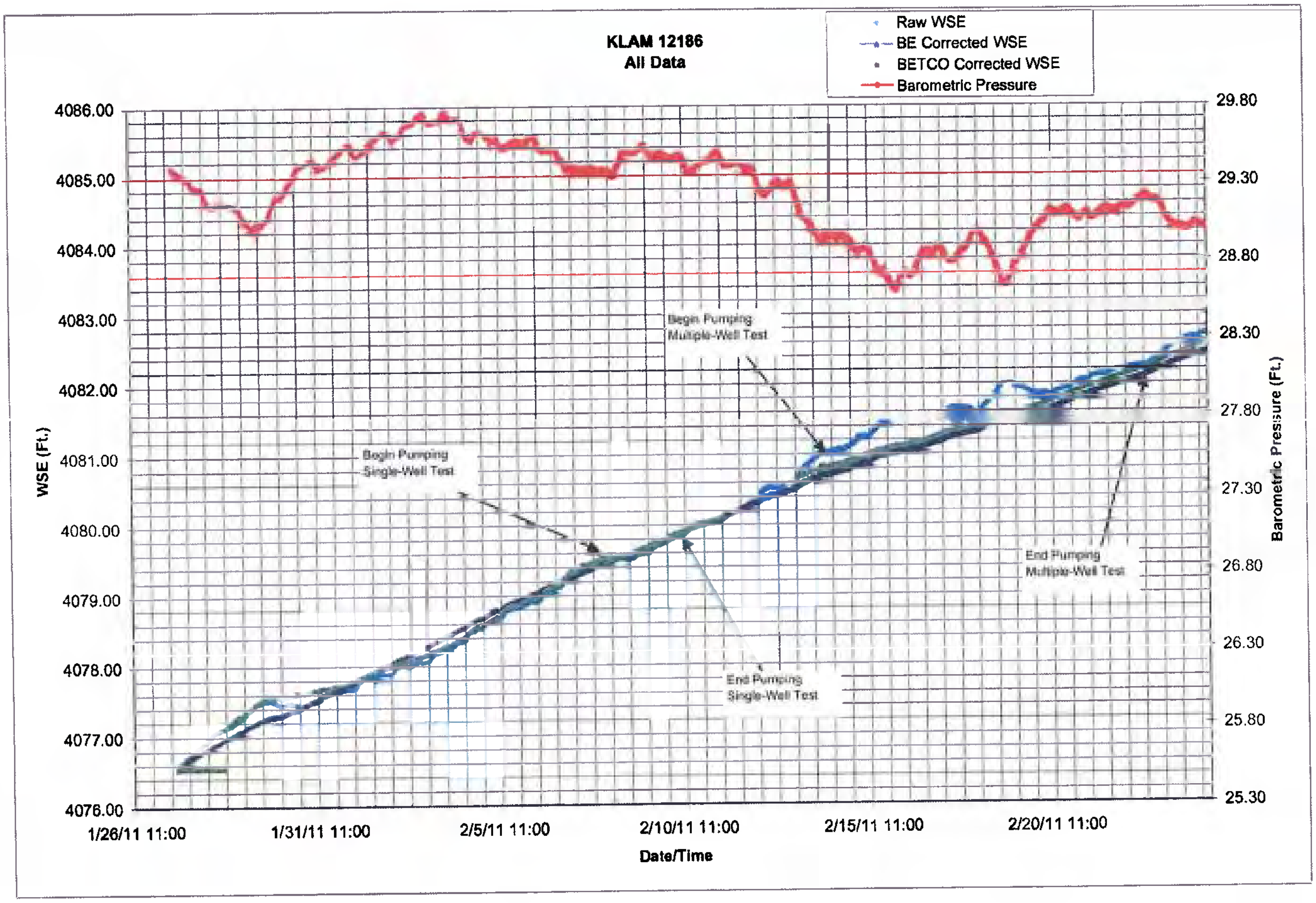
KLAM 2265 (Well #5, Lake)
All Data
Raw WSE
BE Corrected WSE
Barometric Pressure
4130.00
4125.00
4120.00
4115.00
4110.00
4105.00
4100.00
WSE (Ft.)
29.50
29.00
28.50
28.00
27.50
27.00
Barometric Pressure (Ft.)
Begin Pumping
Multiple-Well Test
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
End Pumping
Multiple-Well Test
1/26/11 7:00
1/31/11 7:00
2/5/11 7:00
2/10/11 7:00
2/15/11 7:00
2/20/11 7:00
Date/Time



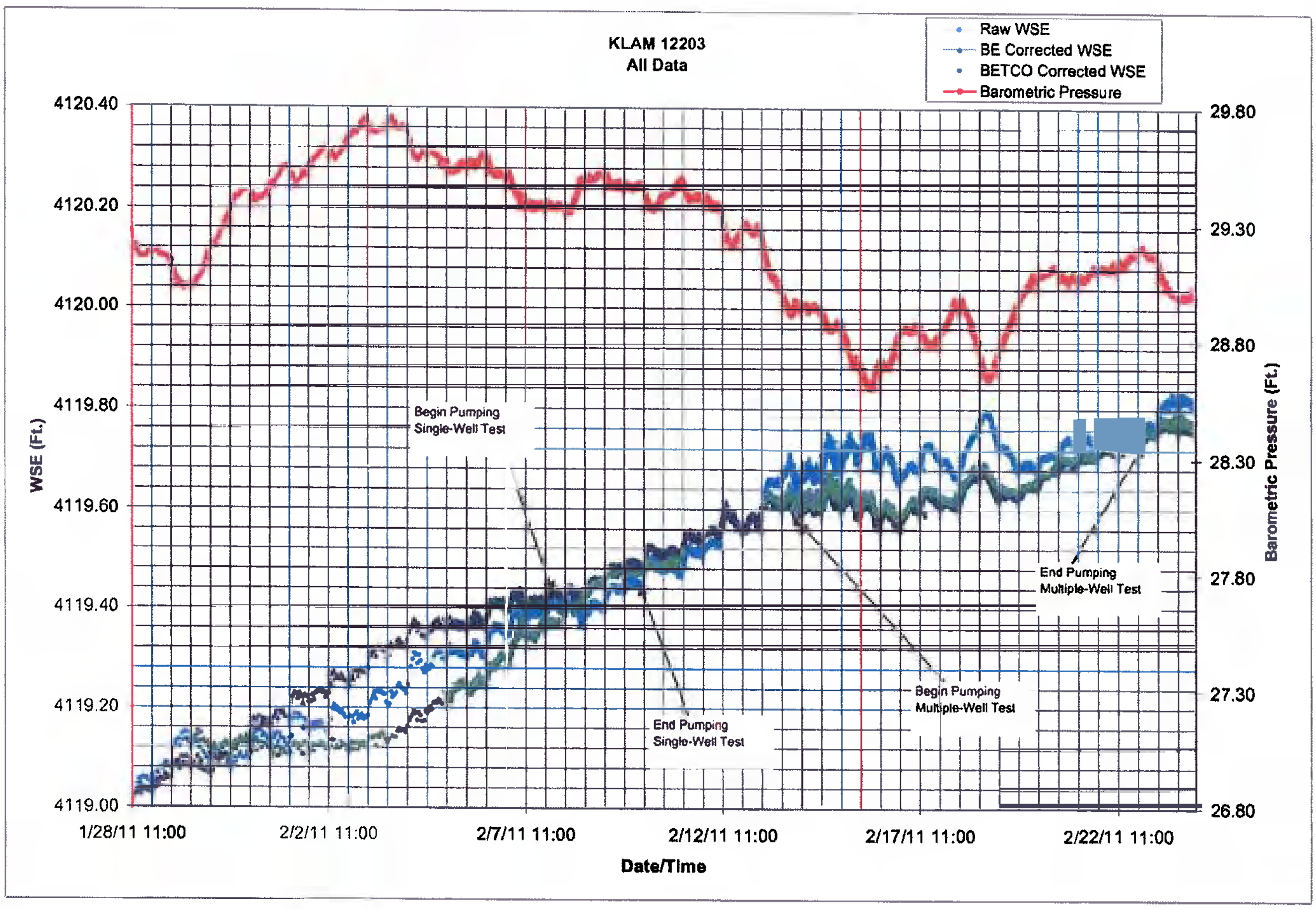
KLAM 2269
All Data
Raw WSE
BETCO Corrected WSE
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft)
4175.10
4174.90
4174.70
4174.50
4174.30
4174.10
4173.90
4173.70
4173.50
4173.30
4173.10
29.50
29.00
28.50
28.00
27.50
27.00
1/27/11 17:00
2/1/11 17:00
2/6/11 17:00
2/11/11 17:00
2/16/11 17:00
2/21/11 17:00
Date/Time
Begin Pumping Single-Well Test
End Pumping Single-Well Test
Begin Pumping Multiple-Well Test
End Pumping Multiple-Well Test

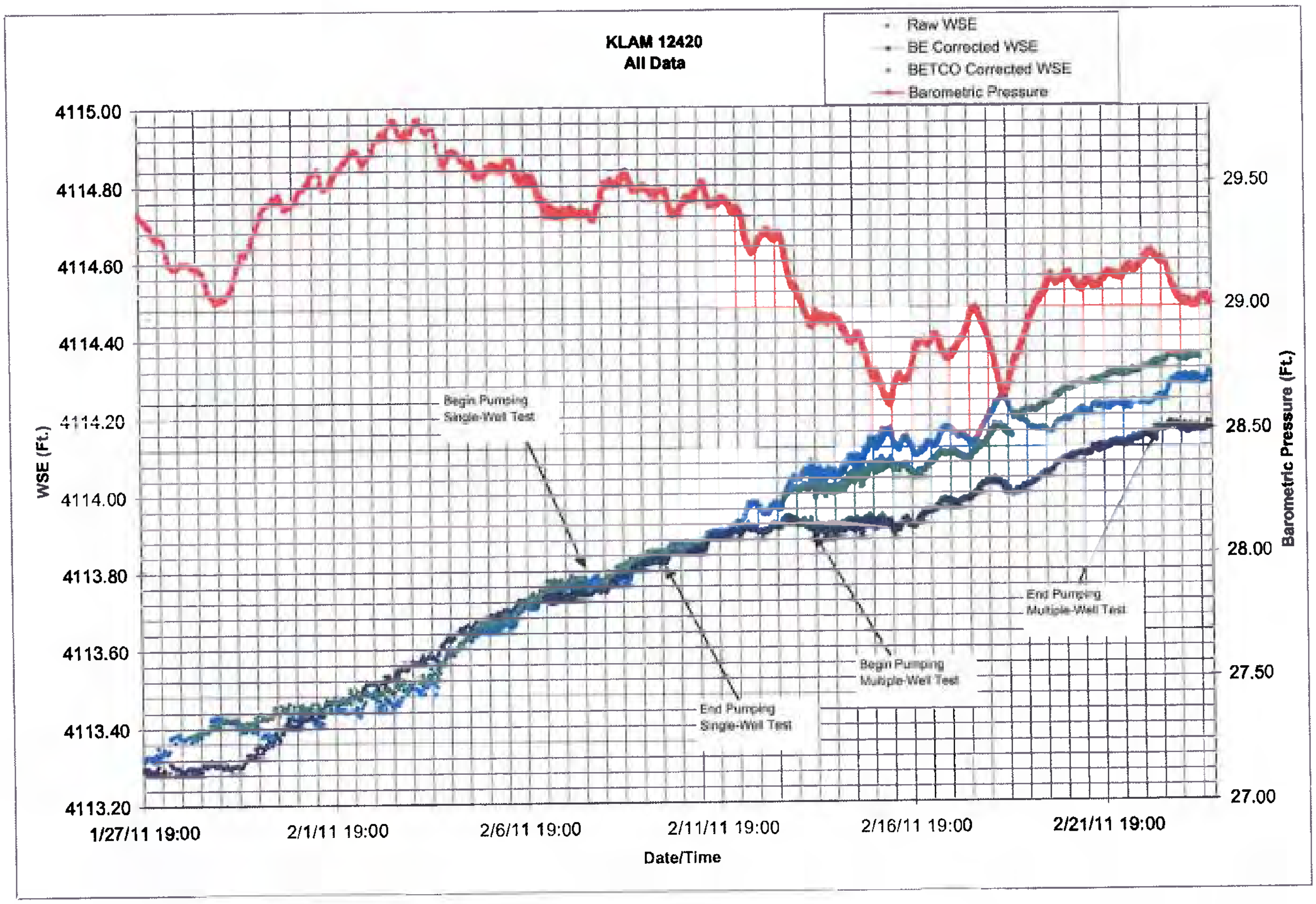


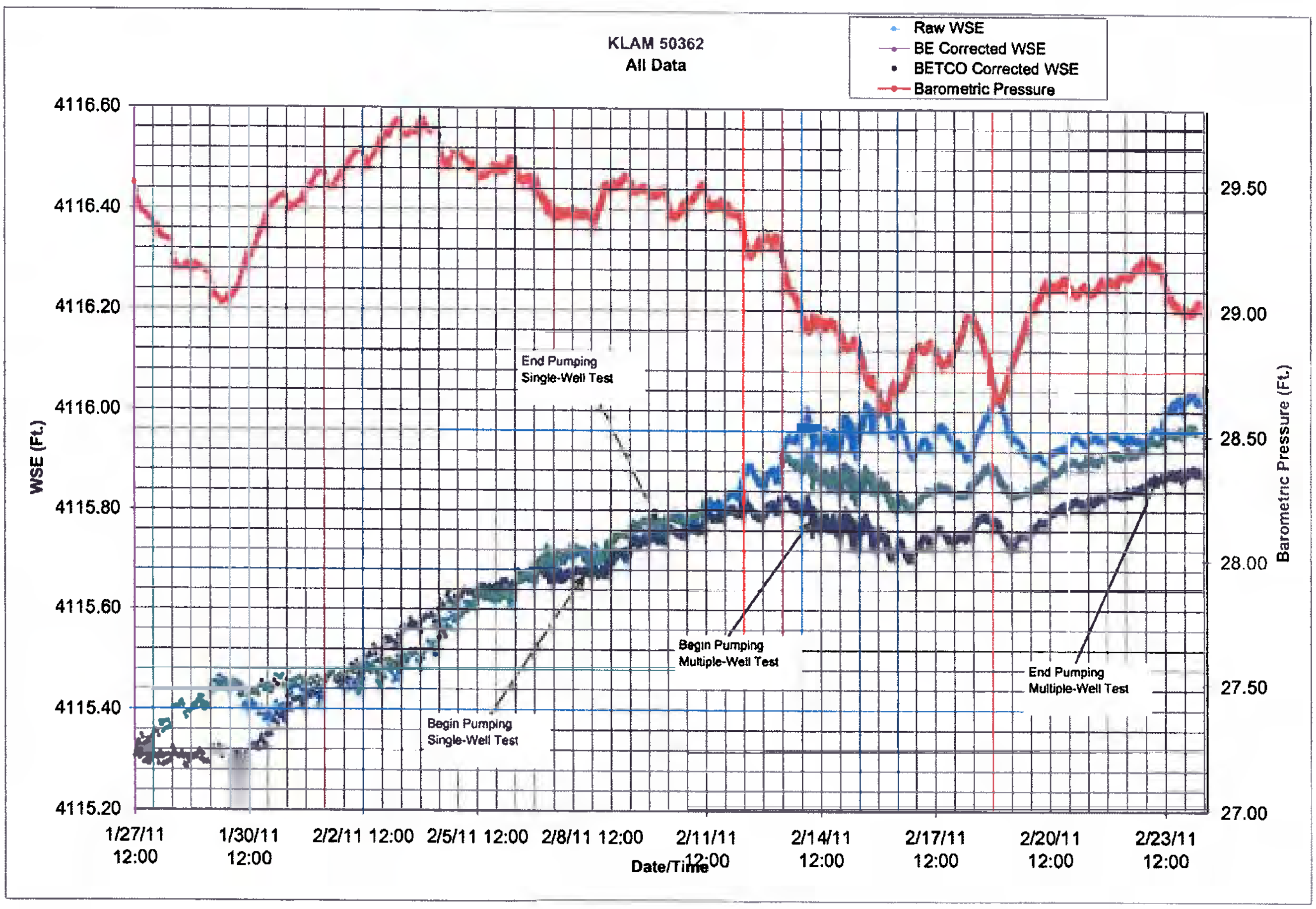
KLAM 2289 (Coleman)
All Data
Raw WSE
BETCO Corrected WSE
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
4138.40
4138.20
4138.00
4137.80
4137.60
4137.40
4137.20
4137.00
Barometric Pressure (Ft)
29.50
29.00
28.50
28.00
27.50
27.00
Begin Pumping Single-Well Test
End Pumping Single-Well Test
Begin Pumping Multiple-Well Test
End Pumping Multiple-Well Test
1/26/11 18:00
1/31/11 18:00
2/5/11 18:00
2/10/11 18:00
2/15/11 18:00
2/20/11 18:00
Date/Time



KLAM 12186
All Data
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
4086.00
4085.00
4084.00
4083.00
4082.00
4081.00
4080.00
4079.00
4078.00
4077.00
4076.00
WSE (Ft.)
29.80
29.30
28.80
28.30
27.80
27.30
26.80
26.30
25.80
25.30
Barometric Pressure (Ft.)
Begin Pumping
Multiple-Well Test
Begin Pumping
Single-Well Test
End Pumping
Multiple-Well Test
End Pumping
Single-Well Test
1/26/11 11:00
1/31/11 11:00
2/5/11 11:00
2/10/11 11:00
2/15/11 11:00
2/20/11 11:00
Date/Time

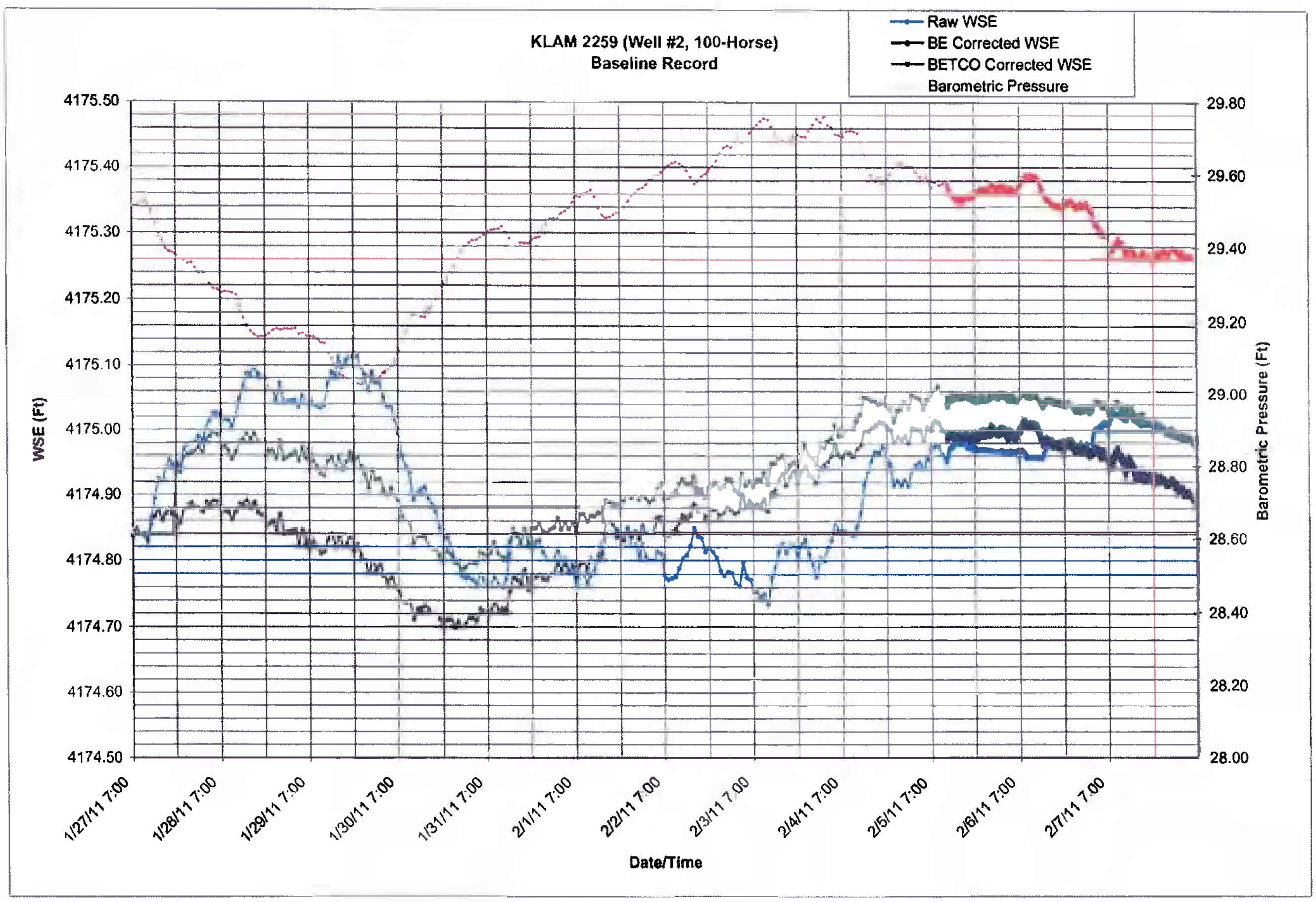

KLAM 12203
All Data
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
4120.40
4120.20
4120.00
4119.80
4119.60
4119.40
4119.20
4119.00
29.80
29.30
28.80
28.30
27.80
27.30
26.80
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
Begin Pumping
Multiple-Well Test
End Pumping
Multiple-Well Test
1/28/11 11:00
2/2/11 11:00
2/7/11 11:00
2/12/11 11:00
2/17/11 11:00
2/22/11 11:00
Date/Time


KLAM 12420
All Data
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
Date/Time
4115.00
4114.80
4114.60
4114.40
4114.20
4114.00
4113.80
4113.60
4113.40
4113.20
29.50
29.00
28.50
28.00
27.50
27.00
1/27/11 19:00
2/1/11 19:00
2/6/11 19:00
2/11/11 19:00
2/16/11 19:00
2/21/11 19:00
Begin Pumping Single-Well Test
End Pumping Single-Well Test
Begin Pumping Multiple-Well Test
End Pumping Multiple-Well Test

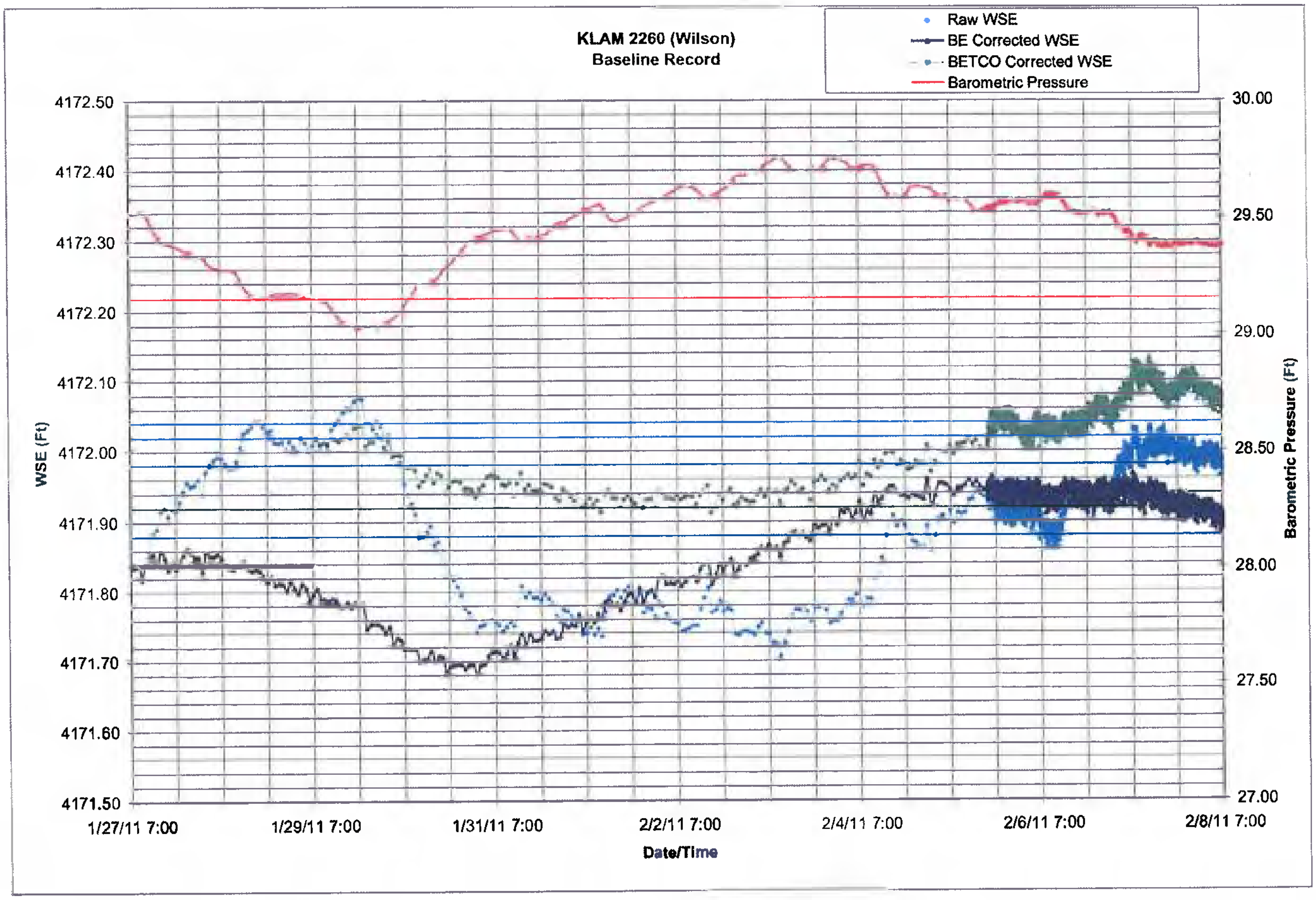


KLAM 50362
All Data
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
4116.60
4116.40
4116.20
4116.00
4115.80
4115.60
4115.40
4115.20
29.50
29.00
28.50
28.00
27.50
27.00
End Pumping
Single-Well Test
Begin Pumping
Single-Well Test
Begin Pumping
Multiple-Well Test
End Pumping
Multiple-Well Test
1/27/11 12:00
1/30/11 12:00
2/2/11 12:00
2/5/11 12:00
2/8/11 12:00
2/11/11 12:00
2/14/11 12:00
2/17/11 12:00
2/20/11 12:00
2/23/11 12:00
Date/Time

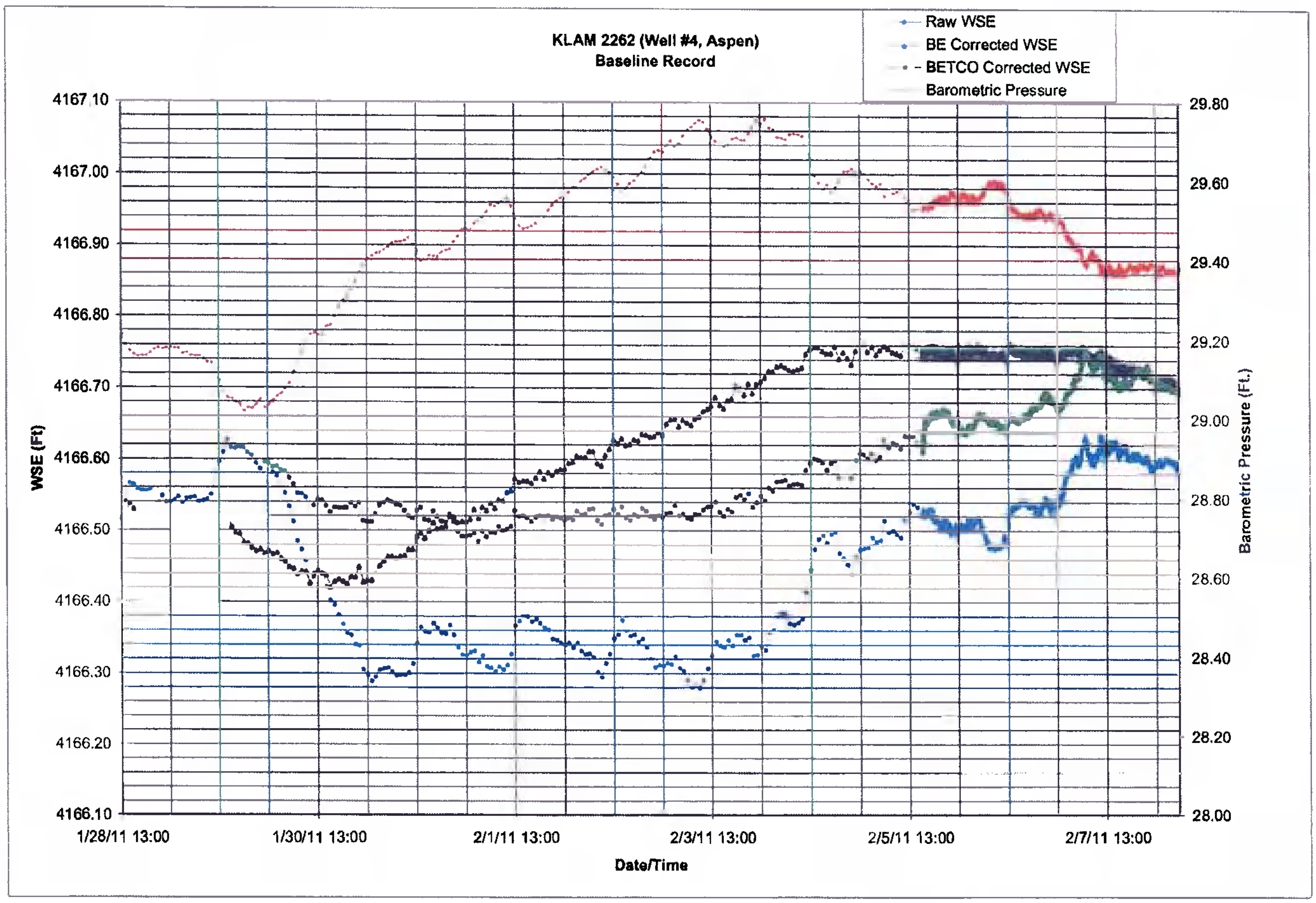
Water-Level Plots - Baseline Record

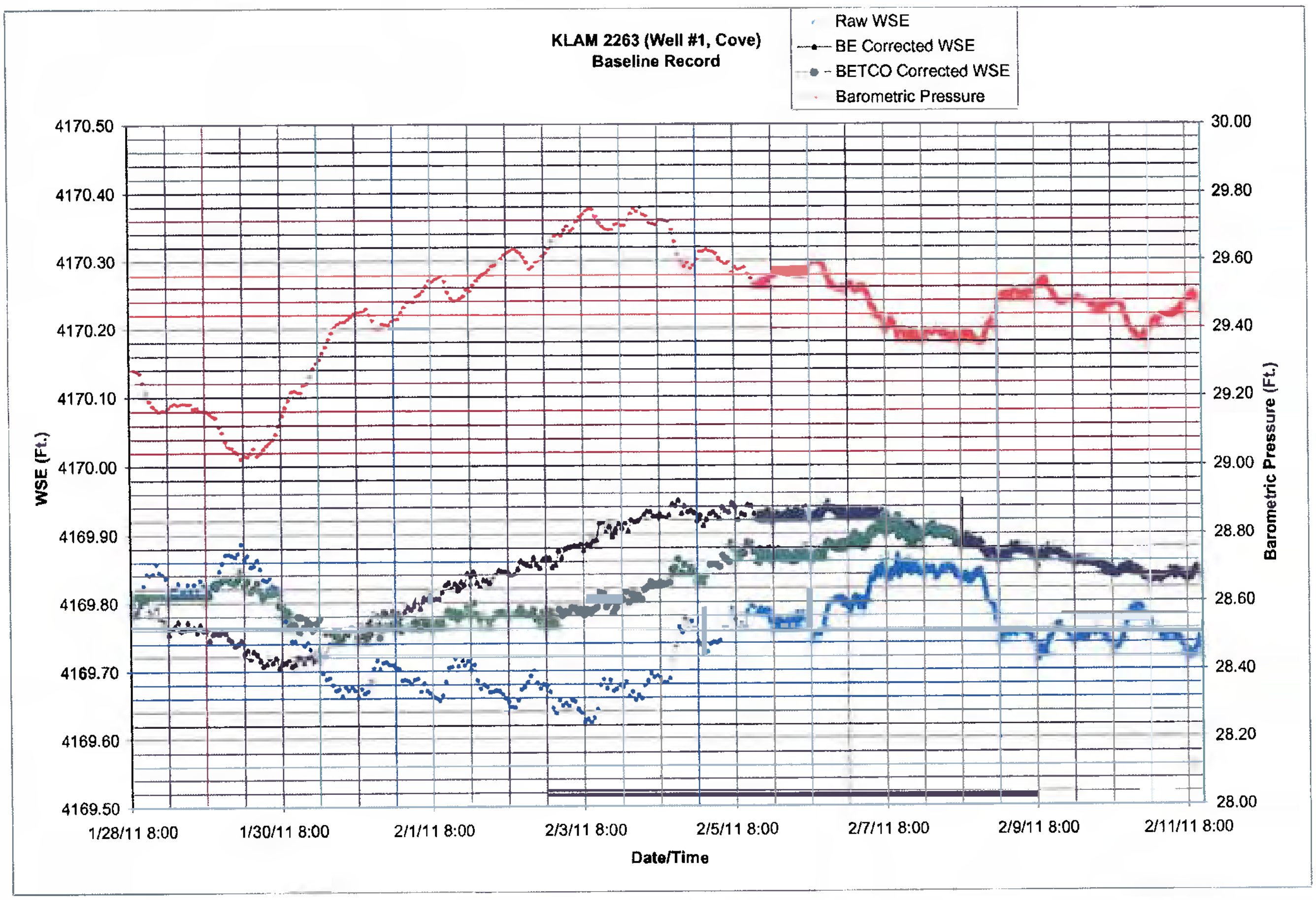


KLAM 2259 (Well #2, 100-Horse)
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft)
Barometric Pressure (Ft)
Date/Time
4175.50
4175.40
4175.30
4175.20
4175.10
4175.00
4174.90
4174.80
4174.70
4174.60
4174.50
29.80
29.60
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
1/27/11 7:00
1/28/11 7:00
1/29/11 7:00
1/30/11 7:00
1/31/11 7:00
2/1/11 7:00
2/2/11 7:00
2/3/11 7:00
2/4/11 7:00
2/5/11 7:00
2/6/11 7:00
2/7/11 7:00

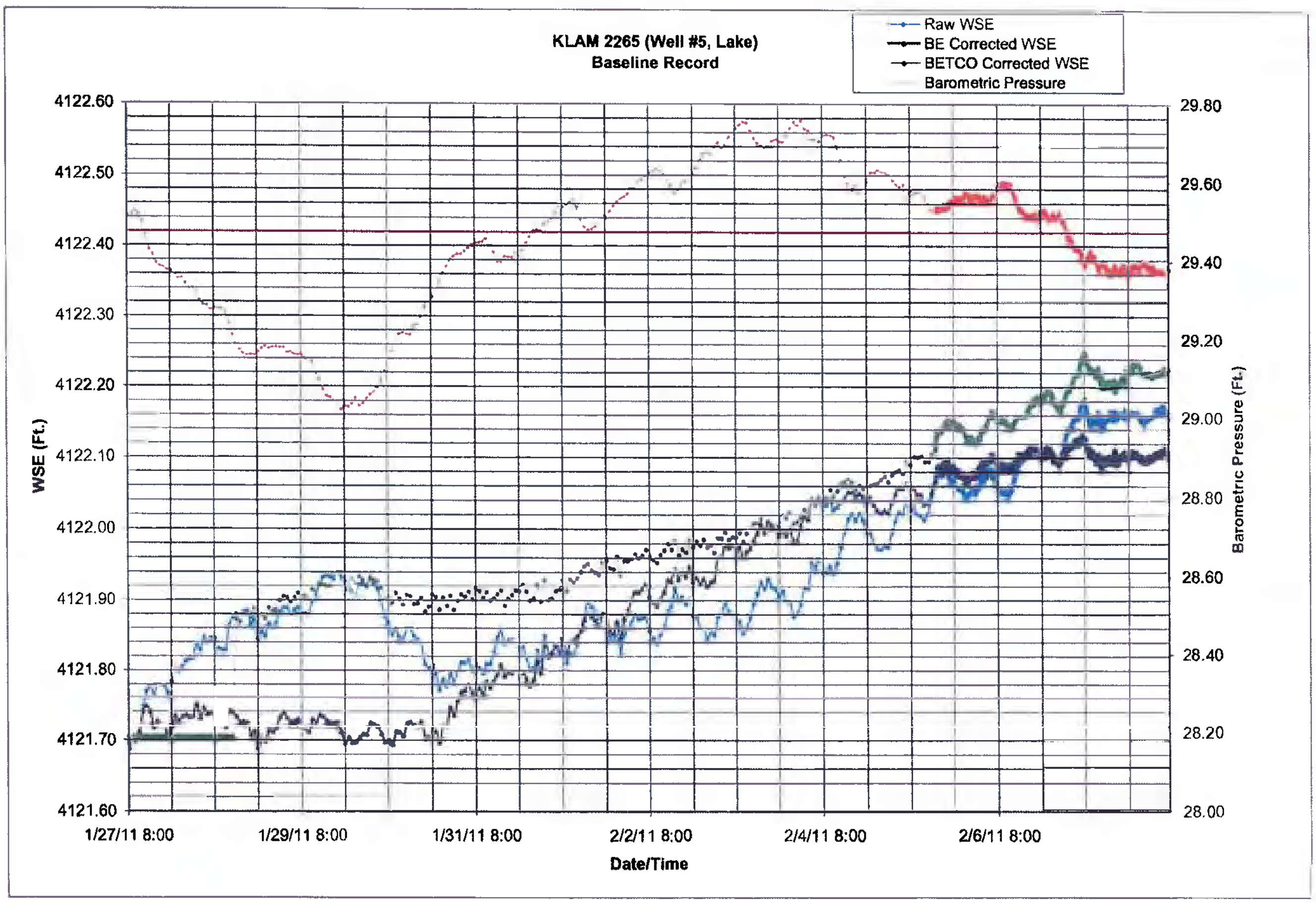


KLAM 2260 (Wilson)
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft)
4172.50
4172.40
4172.30
4172.20
4172.10
4172.00
4171.90
4171.80
4171.70
4171.60
4171.50
Barometric Pressure (Ft)
30.00
29.50
29.00
28.50
28.00
27.50
27.00
1/27/11 7:00
1/29/11 7:00
1/31/11 7:00
2/2/11 7:00
2/4/11 7:00
2/6/11 7:00
2/8/11 7:00
Date/Time

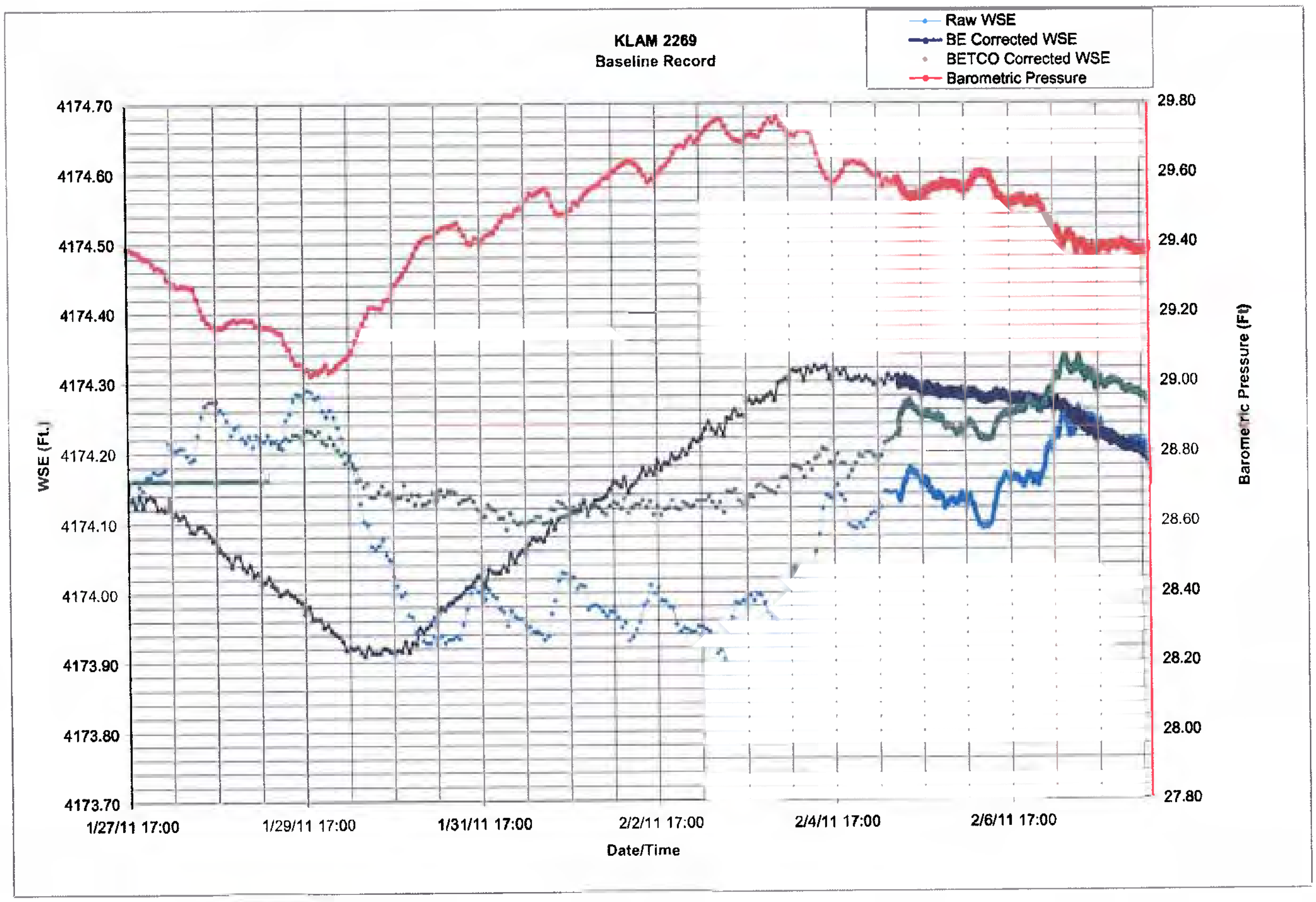

KLAM 2262 (Well #4, Aspen)
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft)
4167.10
4167.00
4166.90
4166.80
4166.70
4166.60
4166.50
4166.40
4166.30
4166.20
4166.10
Barometric Pressure (Ft.)
29.80
29.60
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
1/28/11 13:00
1/30/11 13:00
2/1/11 13:00
2/3/11 13:00
2/5/11 13:00
2/7/11 13:00
Date/Time



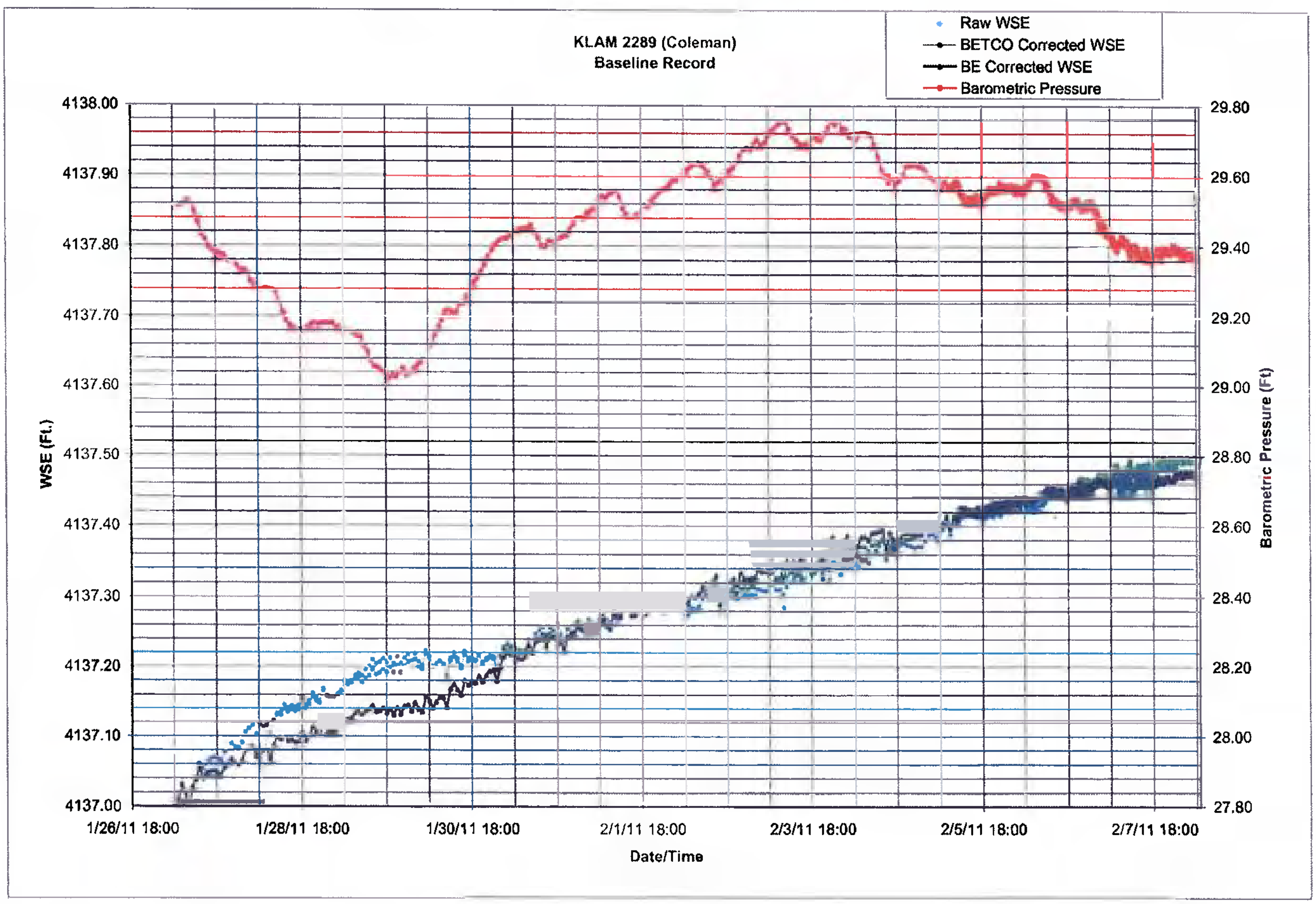
KLAM 2263 (Well #1, Cove)
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
4170.50
4170.40
4170.30
4170.20
4170.10
4170.00
4169.90
4169.80
4169.70
4169.60
4169.50
Barometric Pressure (Ft.)
30.00
29.80
29.60
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
1/28/11 8:00
1/30/11 8:00
2/1/11 8:00
2/3/11 8:00
2/5/11 8:00
2/7/11 8:00
2/9/11 8:00
2/11/11 8:00
Date/Time

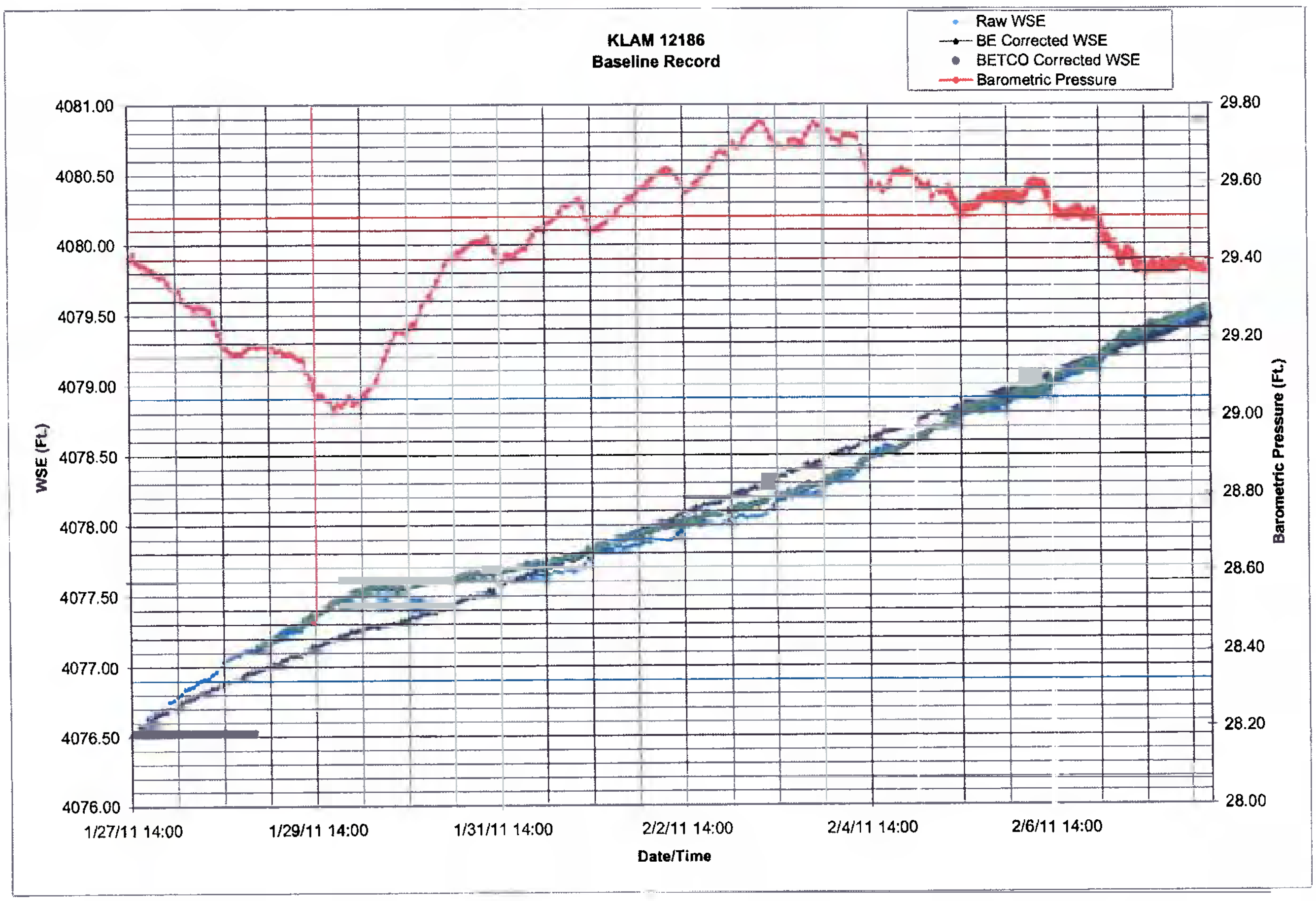


KLAM 2265 (Well #5, Lake)
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
4122.60
4122.50
4122.40
4122.30
4122.20
4122.10
4122.00
4121.90
4121.80
4121.70
4121.60
Barometric Pressure (Ft.)
29.80
29.60
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
1/27/11 8:00
1/29/11 8:00
1/31/11 8:00
2/2/11 8:00
2/4/11 8:00
2/6/11 8:00
Date/Time

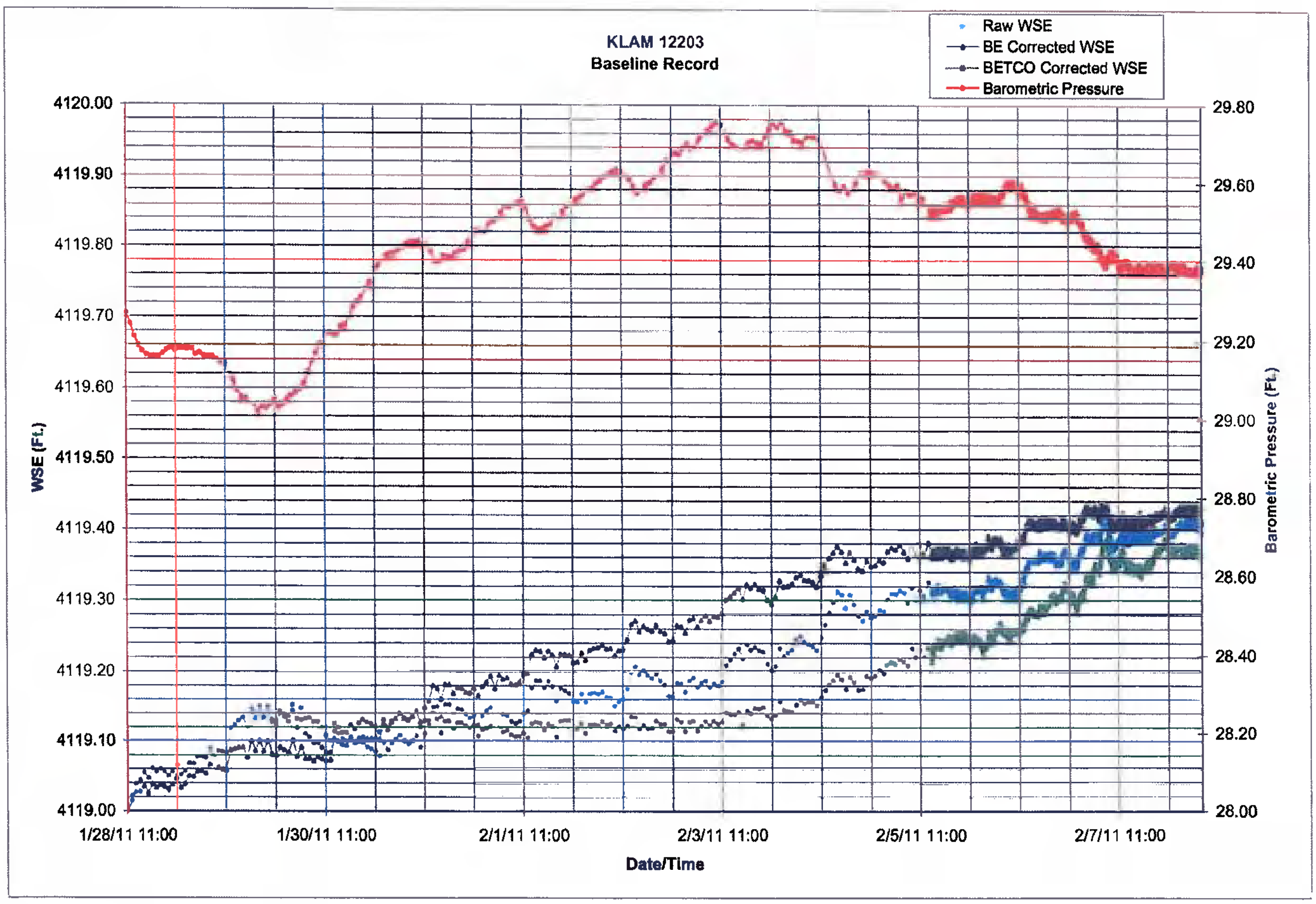


KLAM 2269
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
4174.70
4174.60
4174.50
4174.40
4174.30
4174.20
4174.10
4174.00
4173.90
4173.80
4173.70
Barometric Pressure (Ft)
29.80
29.60
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
27.80
1/27/11 17:00
1/29/11 17:00
1/31/11 17:00
2/2/11 17:00
2/4/11 17:00
2/6/11 17:00
Date/Time

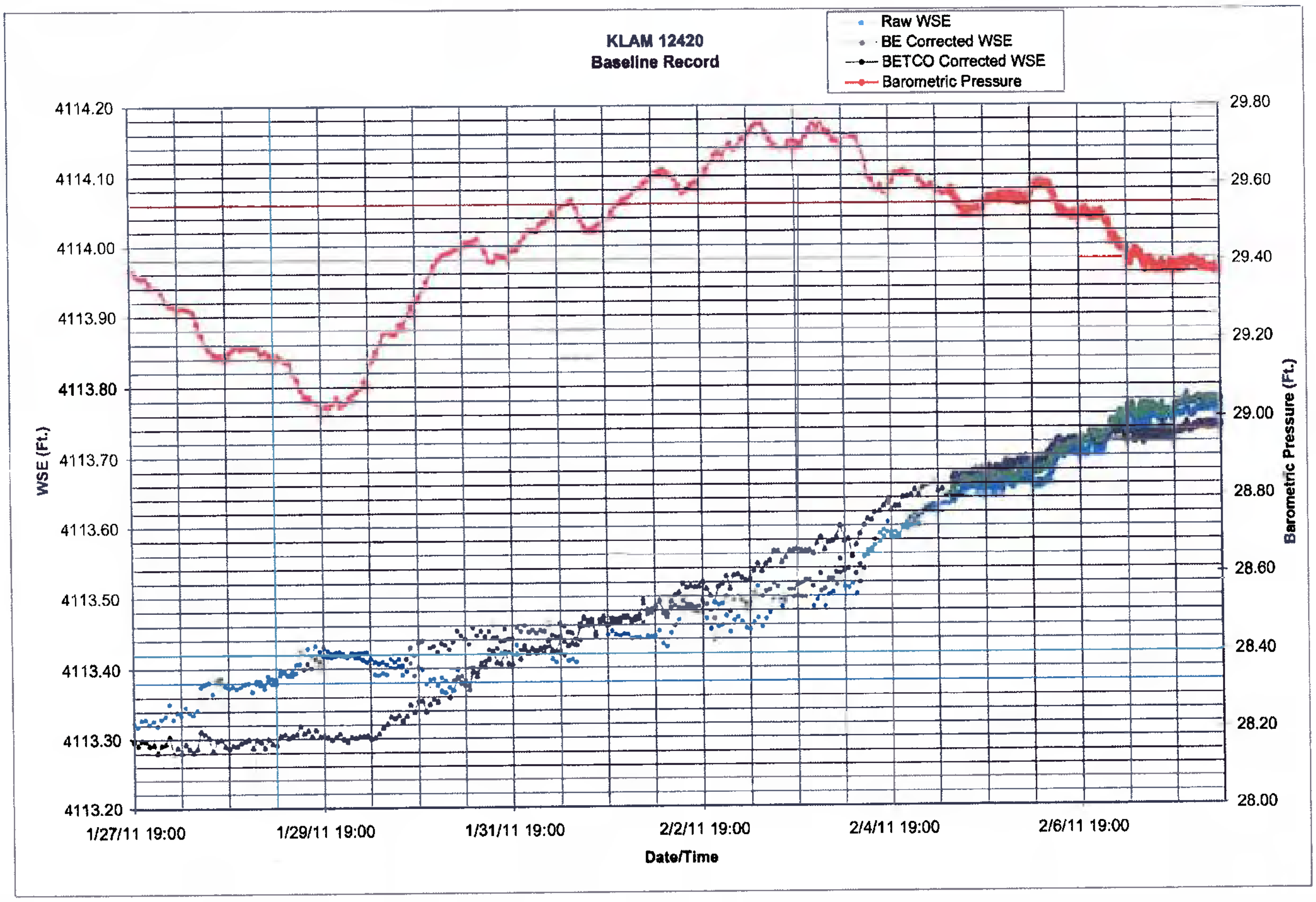

KLAM 2289 (Coleman)
Baseline Record
Raw WSE
BETCO Corrected WSE
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
4138.00
4137.90
4137.80
4137.70
4137.60
4137.50
4137.40
4137.30
4137.20
4137.10
4137.00
Barometric Pressure (Ft)
29.80
29.60
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
27.80
1/26/11 18:00
1/28/11 18:00
1/30/11 18:00
2/1/11 18:00
2/3/11 18:00
2/5/11 18:00
2/7/11 18:00
Date/Time



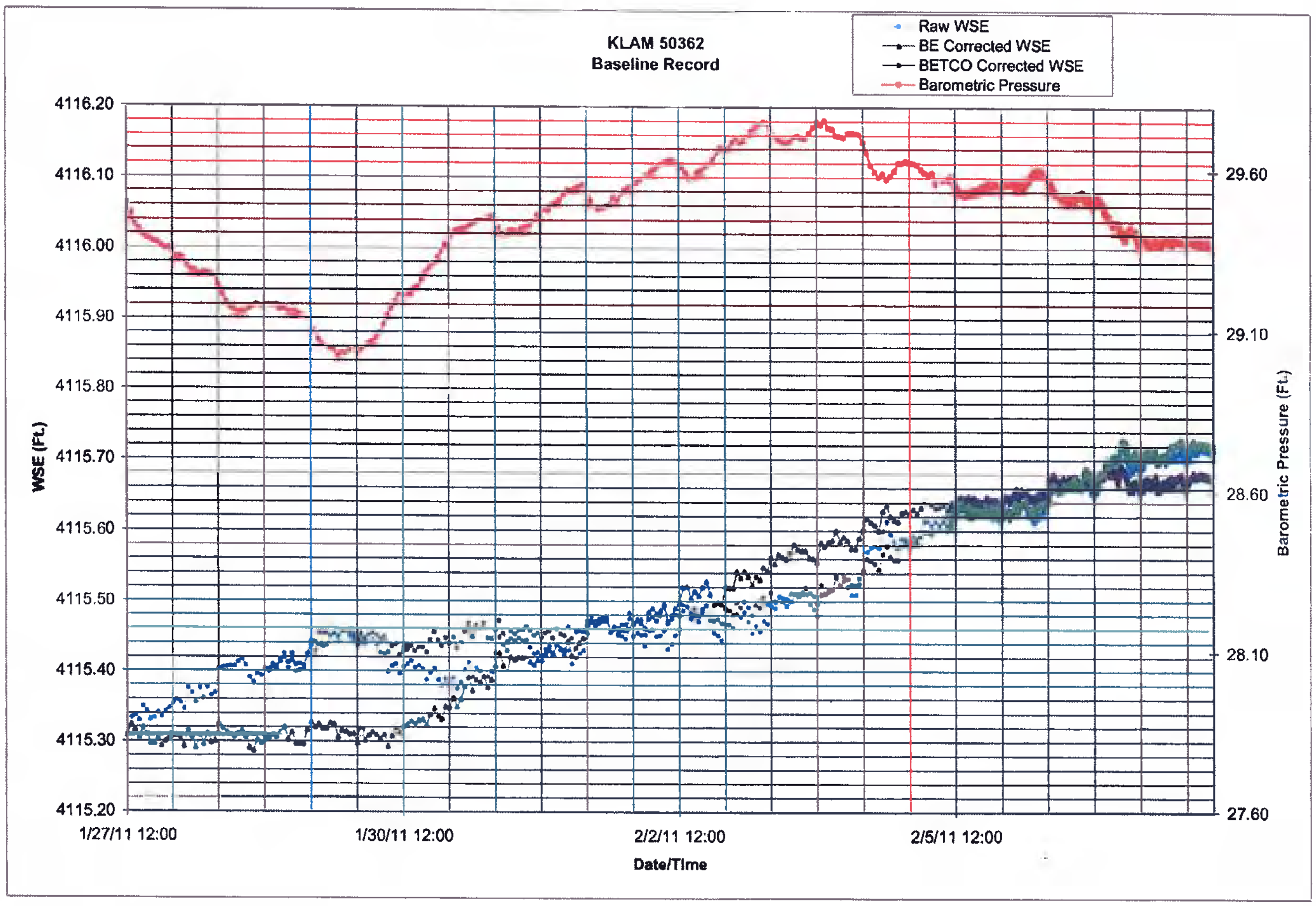
KLAM 12186
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
4081.00
4080.50
4080.00
4079.50
4079.00
4078.50
4078.00
4077.50
4077.00
4076.50
4076.00
29.80
29.60
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
1/27/11 14:00
1/29/11 14:00
1/31/11 14:00
2/2/11 14:00
2/4/11 14:00
2/6/11 14:00
Date/Time



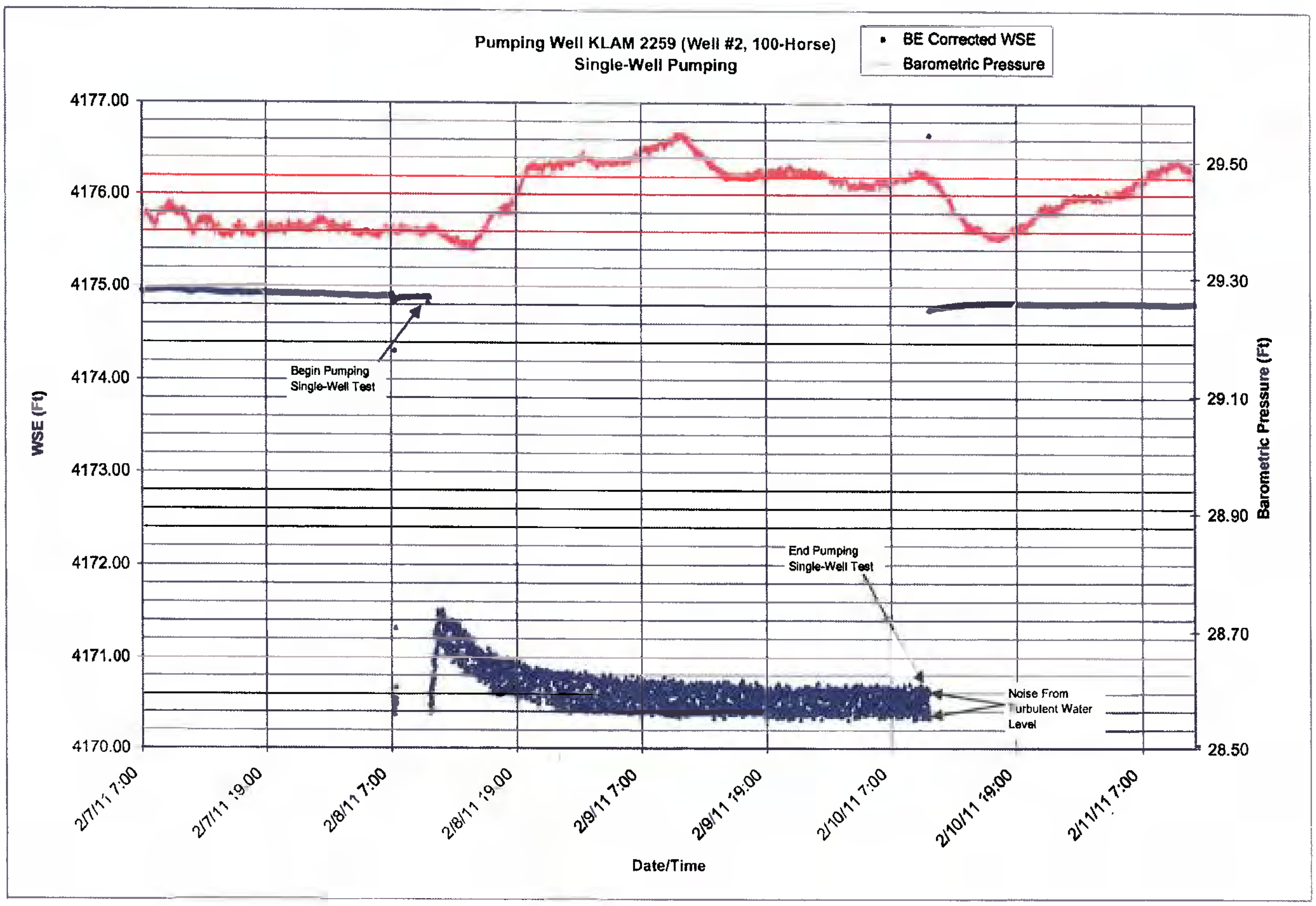
KLAM 12203
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
4120.00
4119.90
4119.80
4119.70
4119.60
4119.50
4119.40
4119.30
4119.20
4119.10
4119.00
Barometric Pressure (Ft.)
29.80
29.60
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
1/28/11 11:00
1/30/11 11:00
2/1/11 11:00
2/3/11 11:00
2/5/11 11:00
2/7/11 11:00
Date/Time



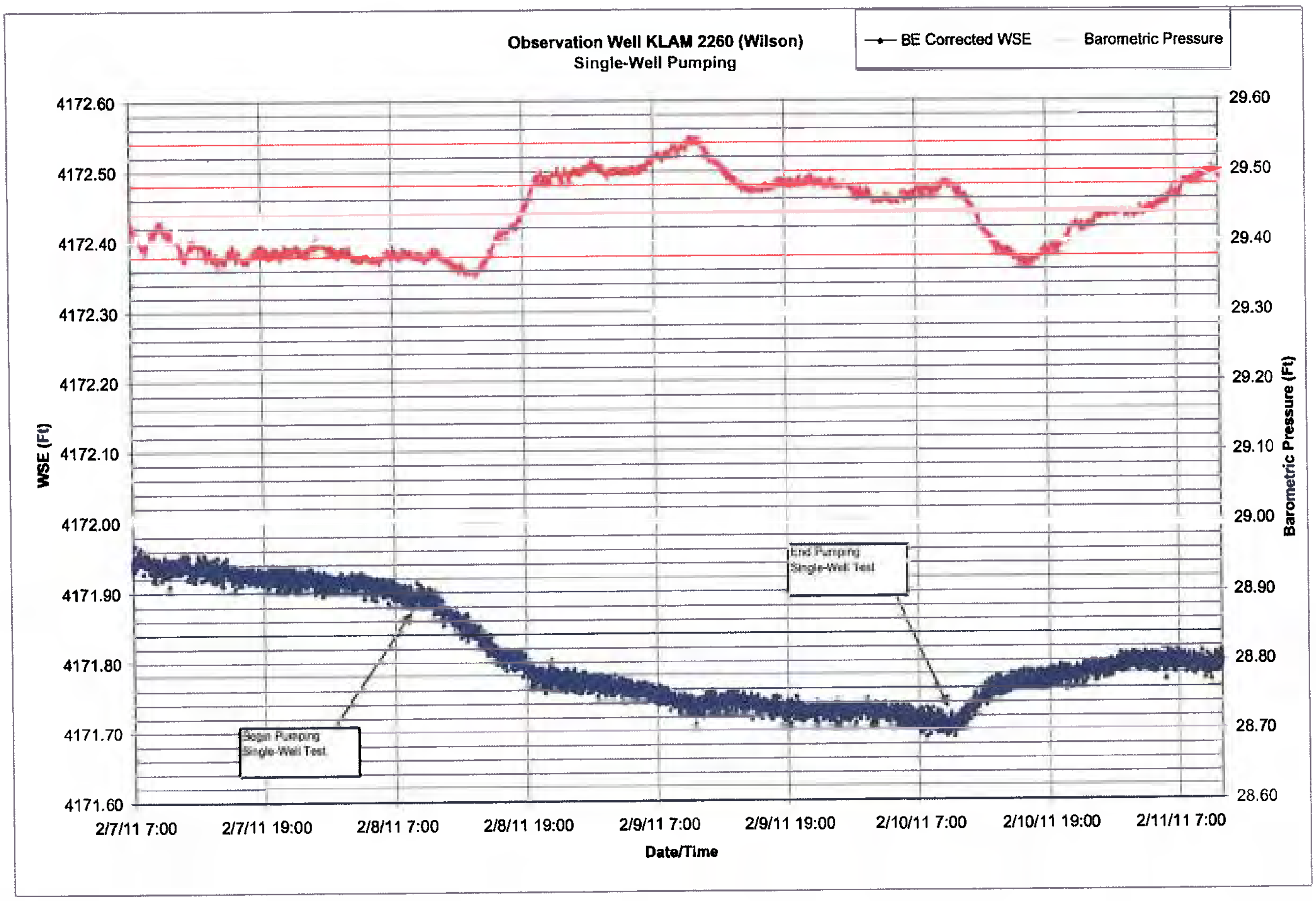
KLAM 12420
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
WSE (Ft.)
4114.20
4114.10
4114.00
4113.90
4113.80
4113.70
4113.60
4113.50
4113.40
4113.30
4113.20
Barometric Pressure (Ft.)
29.80
29.60
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
1/27/11 19:00
1/29/11 19:00
1/31/11 19:00
2/2/11 19:00
2/4/11 19:00
2/6/11 19:00
Date/Time


KLAM 50362
Baseline Record
Raw WSE
BE Corrected WSE
BETCO Corrected WSE
Barometric Pressure
4116.20
4116.10
4116.00
4115.90
4115.80
4115.70
4115.60
4115.50
4115.40
4115.30
4115.20
WSE (Ft.)
29.60
29.10
28.60
28.10
27.60
Barometric Pressure (Ft.)
1/27/11 12:00
1/30/11 12:00
2/2/11 12:00
2/5/11 12:00
Date/Time

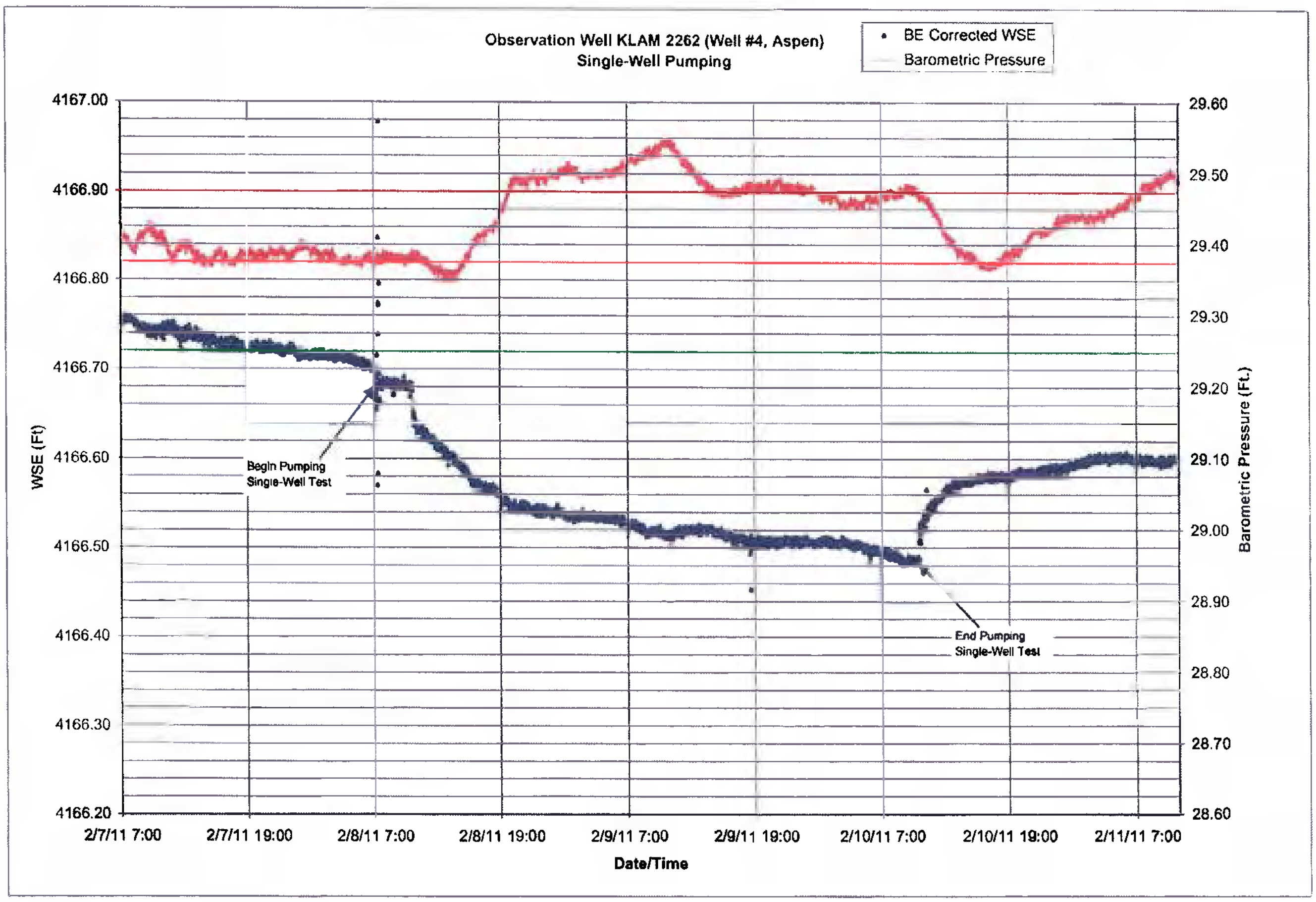
Water-Level Plots – Single-Well Pumping Test

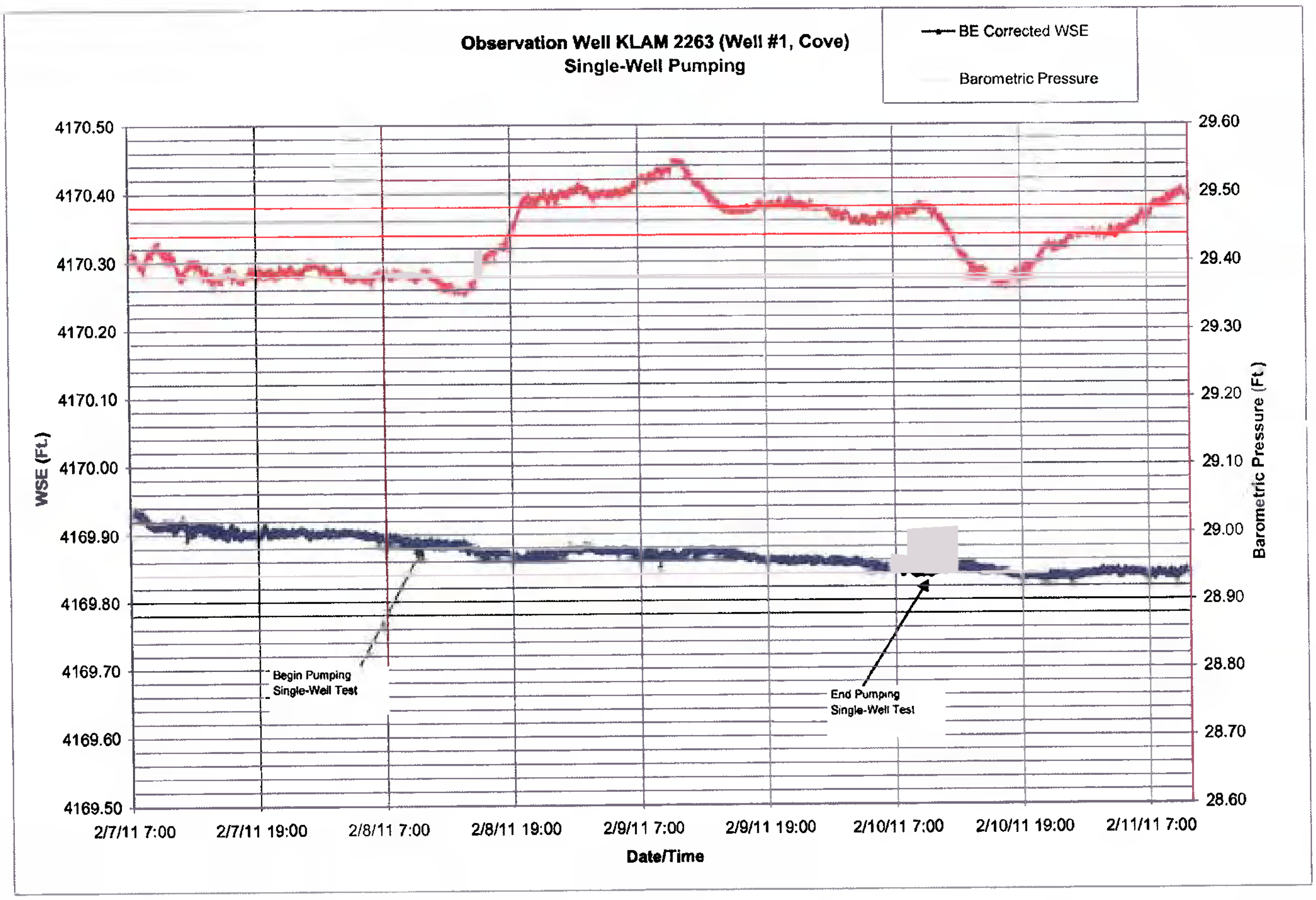


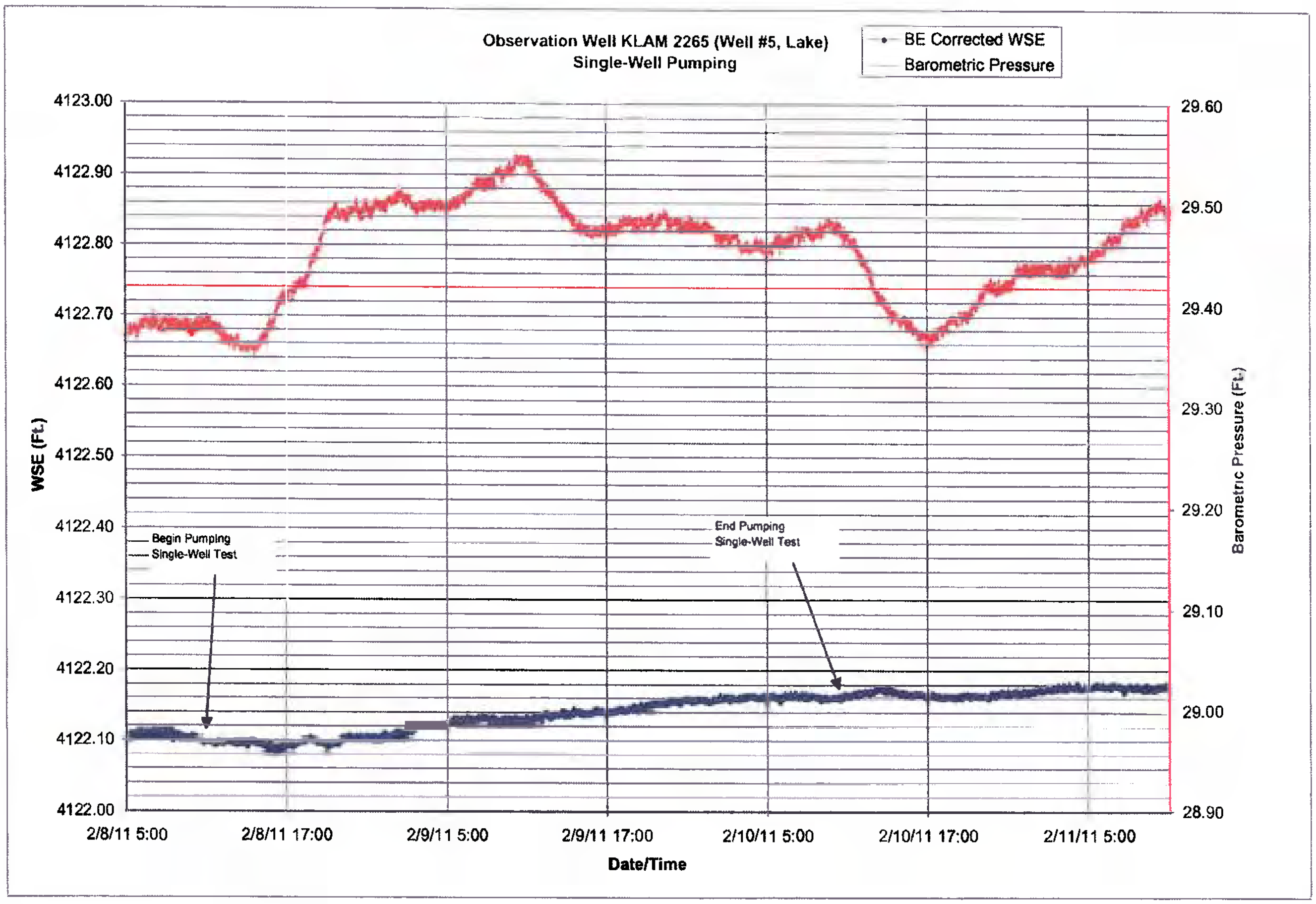
Pumping Well KLAM 2259 (Well #2, 100-Horse)
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
4177.00
4176.00
4175.00
4174.00
4173.00
4172.00
4171.00
4170.00
WSE (Ft)
29.50
29.30
29.10
28.90
28.70
28.50
Barometric Pressure (Ft)
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
Noise From
Turbulent Water
Level
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00
Date/Time

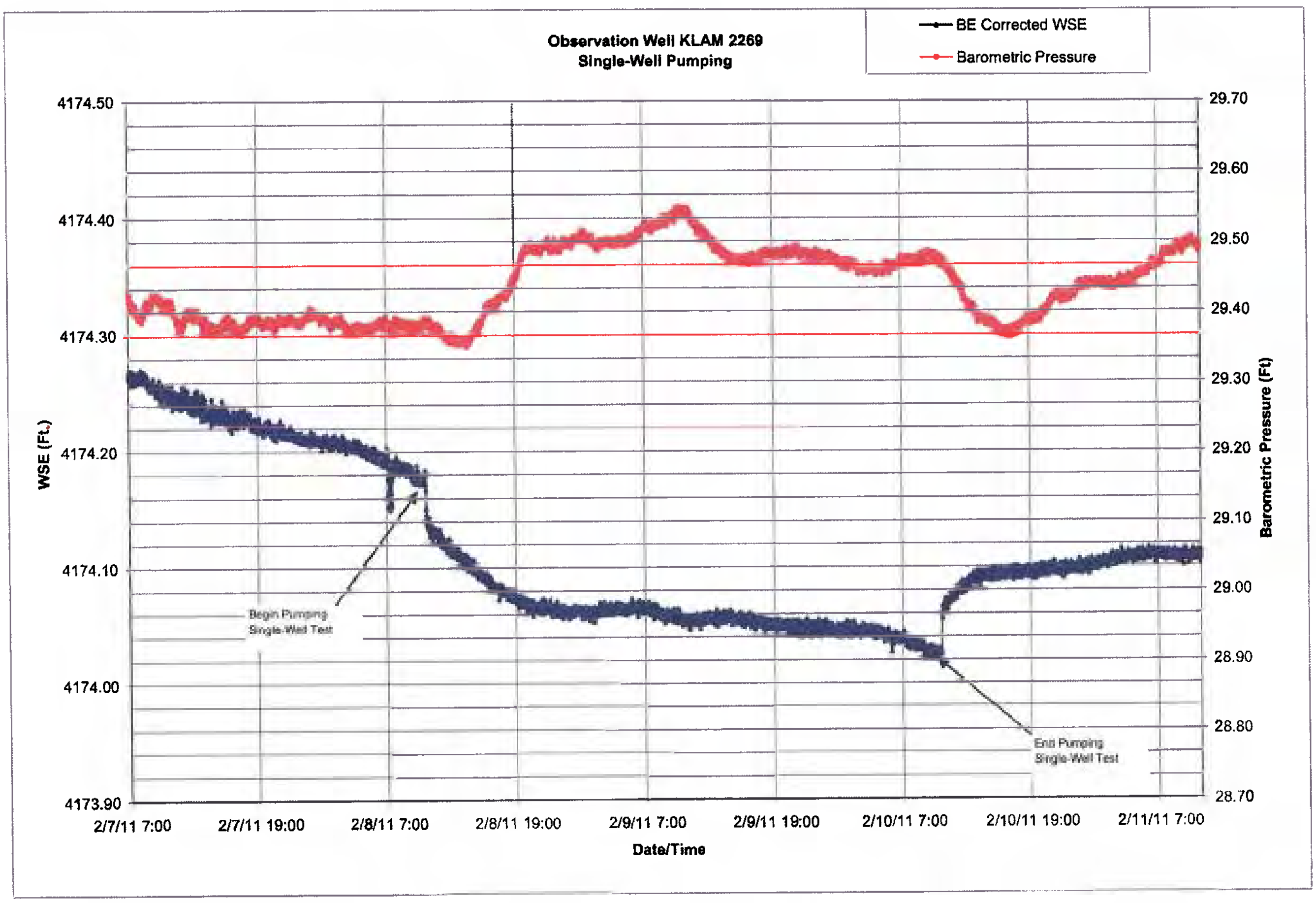


Observation Well KLAM 2260 (Wilson)
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft)
4172.60
4172.50
4172.40
4172.30
4172.20
4172.10
4172.00
4171.90
4171.80
4171.70
4171.60
Barometric Pressure (Ft)
29.60
29.50
29.40
29.30
29.20
29.10
29.00
28.90
28.80
28.70
28.60
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00
Date/Time

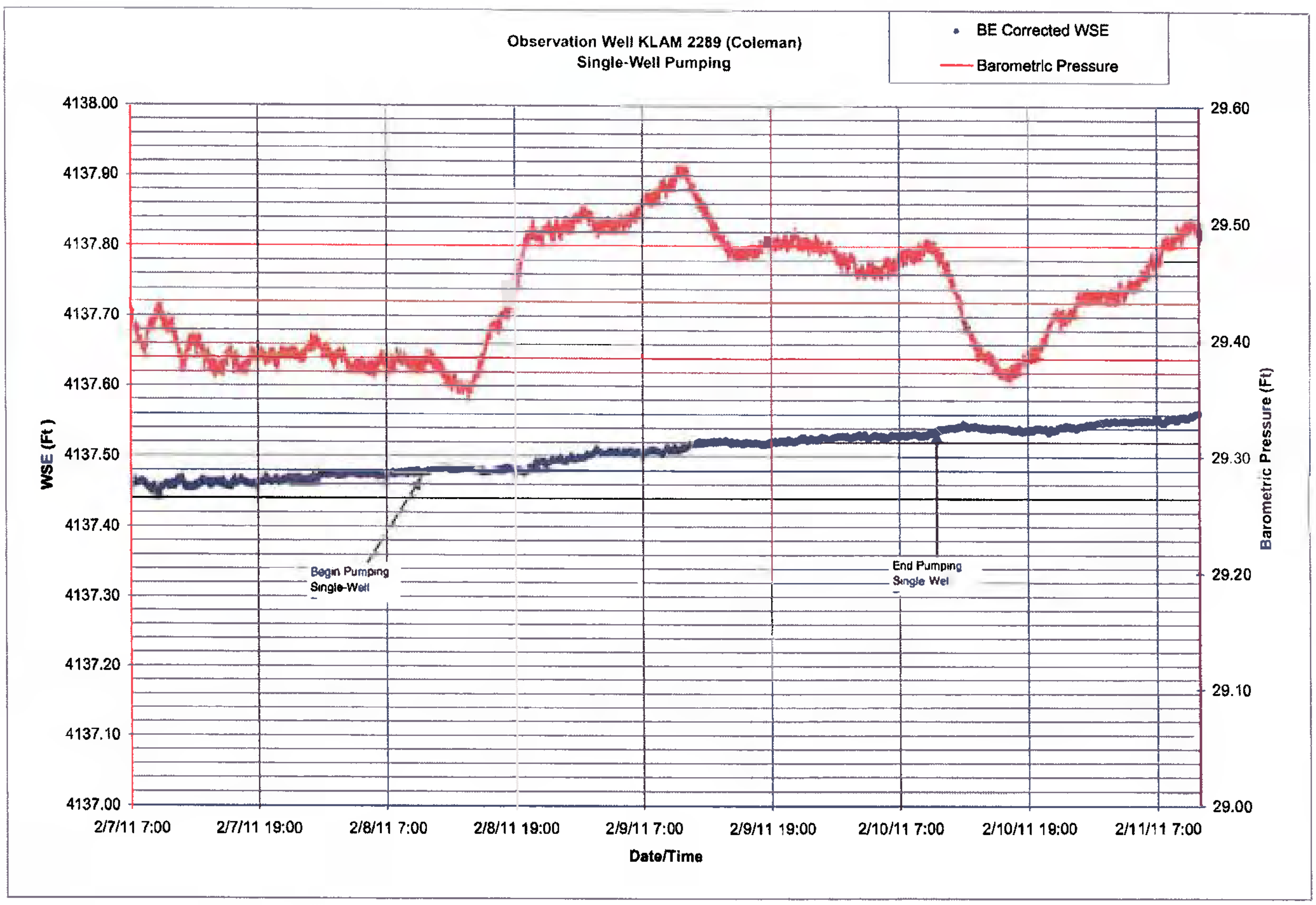

Observation Well KLAM 2262 (Well #4, Aspen)
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft)
Barometric Pressure (Ft.)
Date/Time
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
4167.00
4166.90
4166.80
4166.70
4166.60
4166.50
4166.40
4166.30
4166.20
29.60
29.50
29.40
29.30
29.20
29.10
29.00
28.90
28.80
28.70
28.60
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00


Observation Well KLAM 2263 (Well #1, Cove)
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
4170.50
4170.40
4170.30
4170.20
4170.10
4170.00
4169.90
4169.80
4169.70
4169.60
4169.50
29.60
29.50
29.40
29.30
29.20
29.10
29.00
28.90
28.80
28.70
28.60
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00
Date/Time

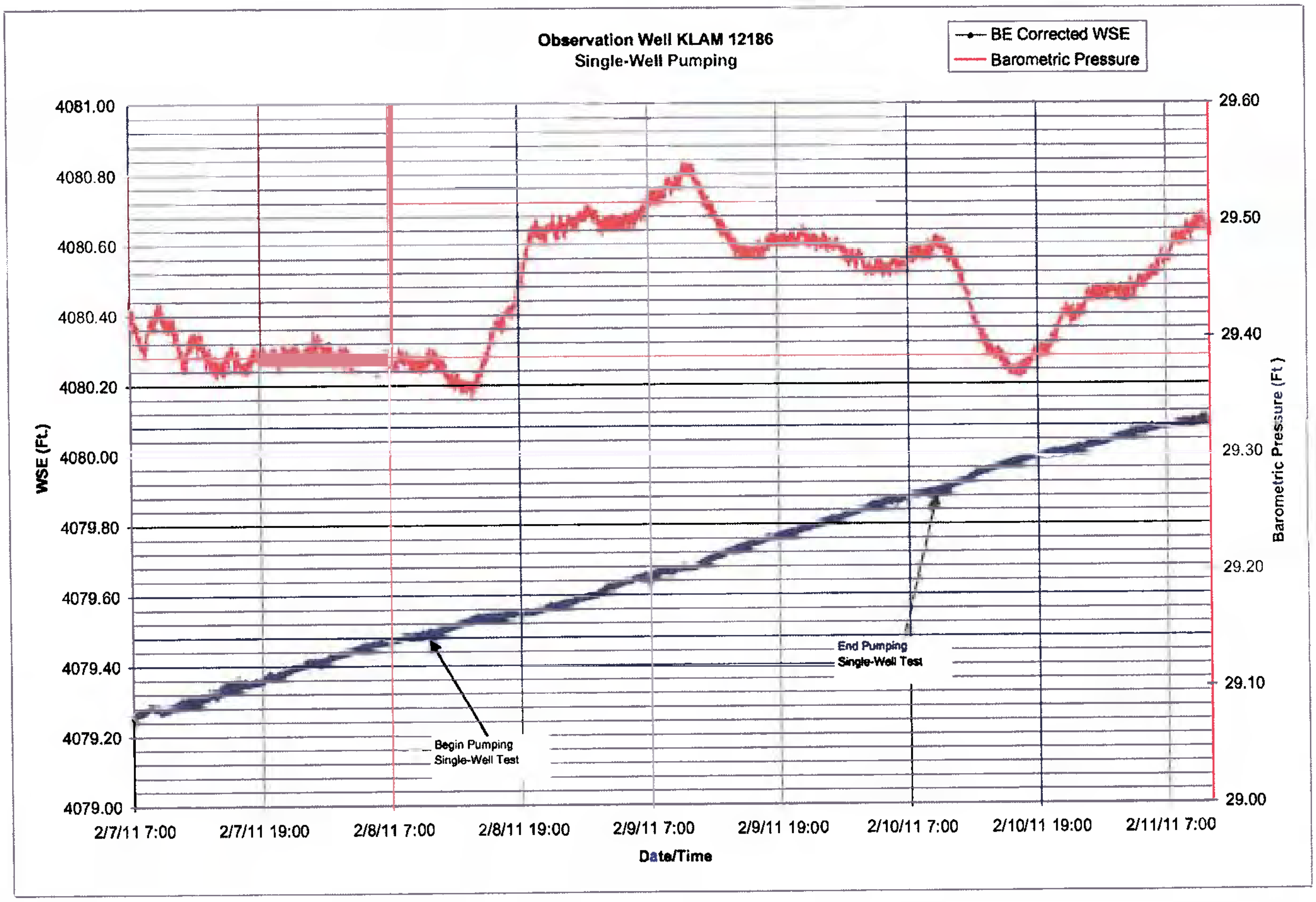

Observation Well KLAM 2265 (Well #5, Lake)
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
4123.00
4122.90
4122.80
4122.70
4122.60
4122.50
4122.40
4122.30
4122.20
4122.10
4122.00
WSE (Ft.)
29.60
29.50
29.40
29.30
29.20
29.10
29.00
28.90
Barometric Pressure (Ft.)
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
2/8/11 5:00
2/8/11 17:00
2/9/11 5:00
2/9/11 17:00
2/10/11 5:00
2/10/11 17:00
2/11/11 5:00
Date/Time



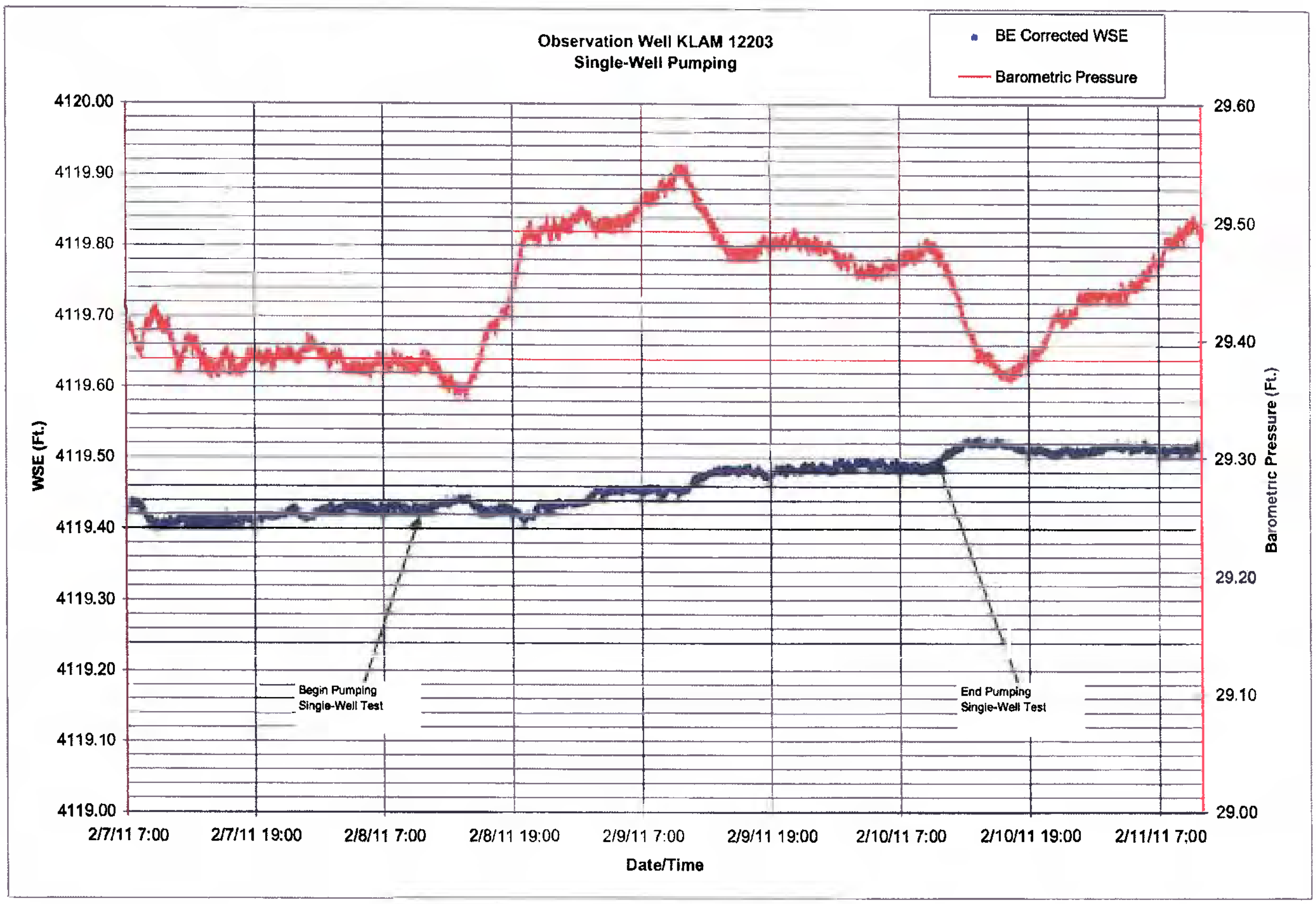
Observation Well KLAM 2269
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft)
Date/Time
4174.50
4174.40
4174.30
4174.20
4174.10
4174.00
4173.90
29.70
29.60
29.50
29.40
29.30
29.20
29.10
29.00
28.90
28.80
28.70
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test

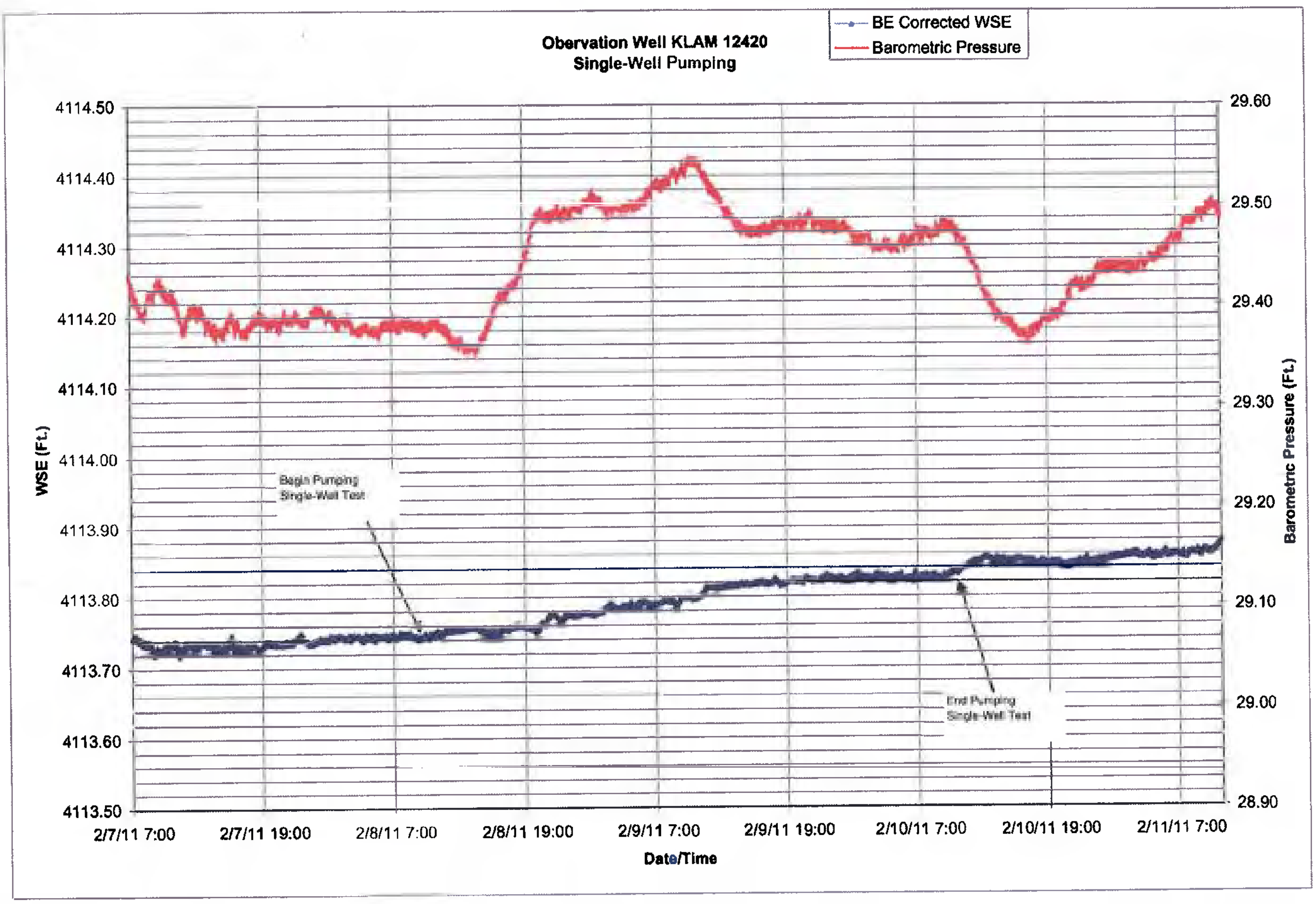


Observation Well KLAM 2289 (Coleman)
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft)
Barometric Pressure (Ft)
4138.00
4137.90
4137.80
4137.70
4137.60
4137.50
4137.40
4137.30
4137.20
4137.10
4137.00
29.60
29.50
29.40
29.30
29.20
29.10
29.00
Begin Pumping
Single-Well
End Pumping
Single Wel
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00
Date/Time

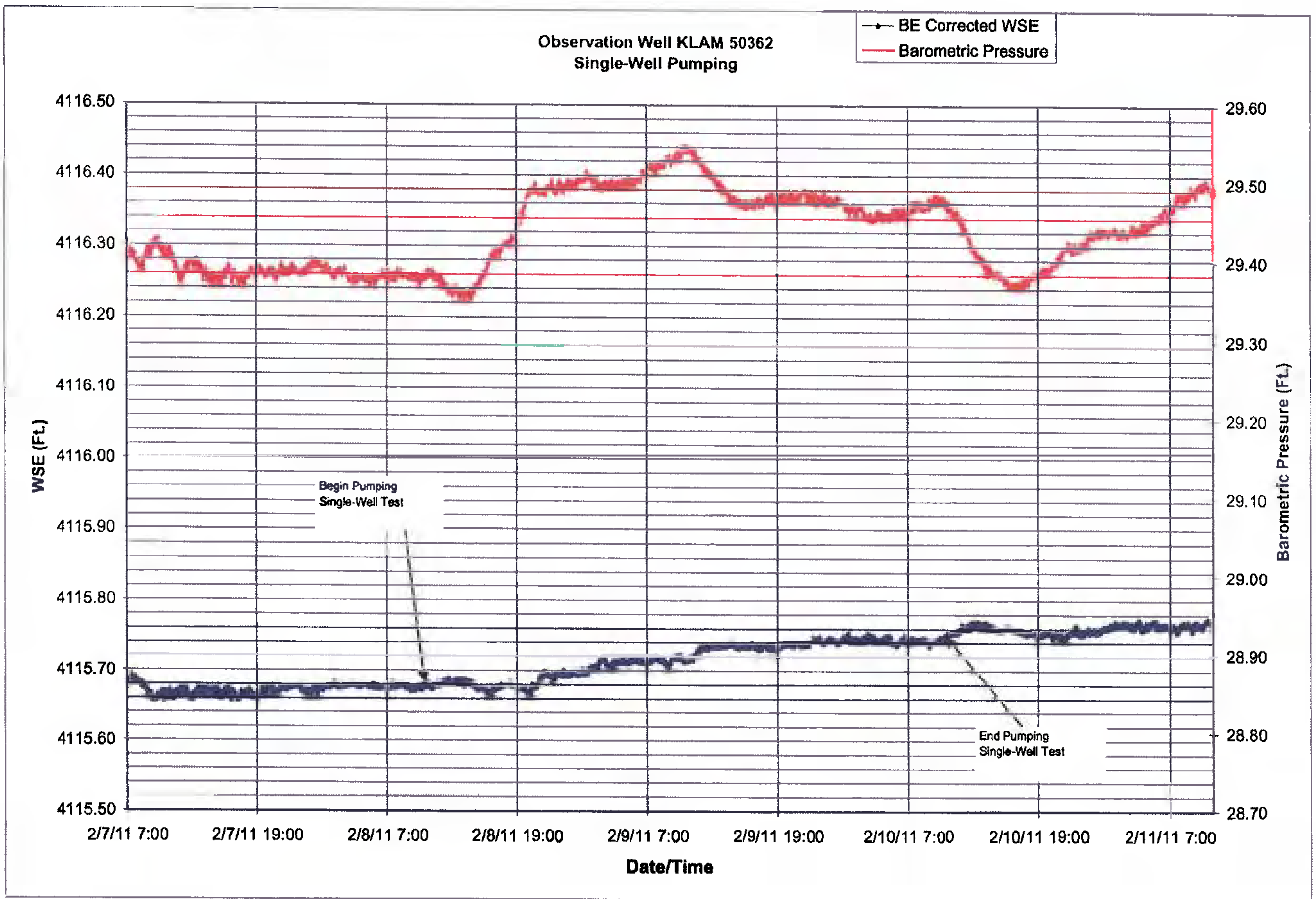


Observation Well KLAM 12186
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
4081.00
4080.80
4080.60
4080.40
4080.20
4080.00
4079.80
4079.60
4079.40
4079.20
4079.00
WSE (Ft.)
29.60
29.50
29.40
29.30
29.20
29.10
29.00
Barometric Pressure (Ft.)
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00
Date/Time

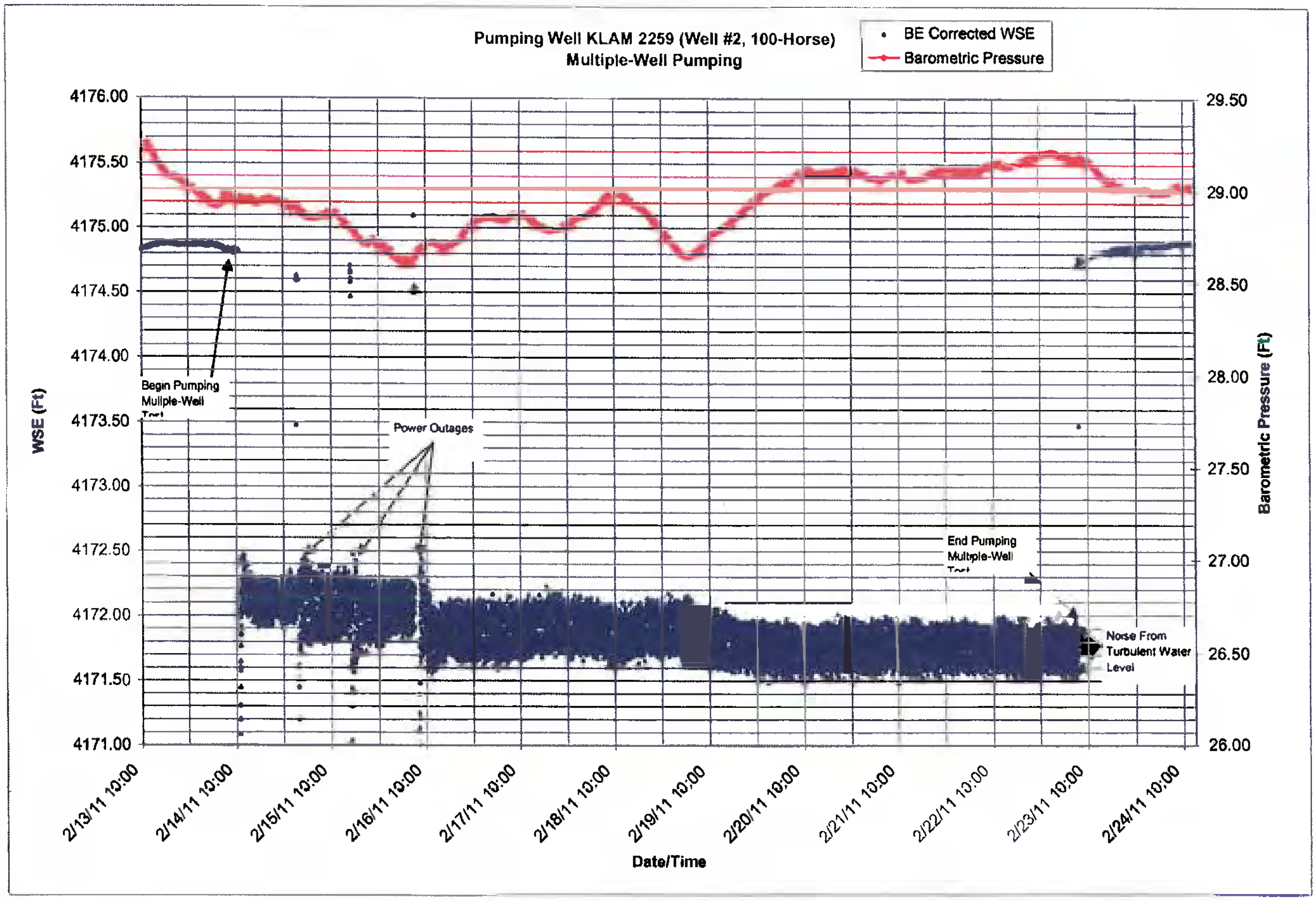

Observation Well KLAM 12203
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
Date/Time
4120.00
4119.90
4119.80
4119.70
4119.60
4119.50
4119.40
4119.30
4119.20
4119.10
4119.00
29.60
29.50
29.40
29.30
29.20
29.10
29.00
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test



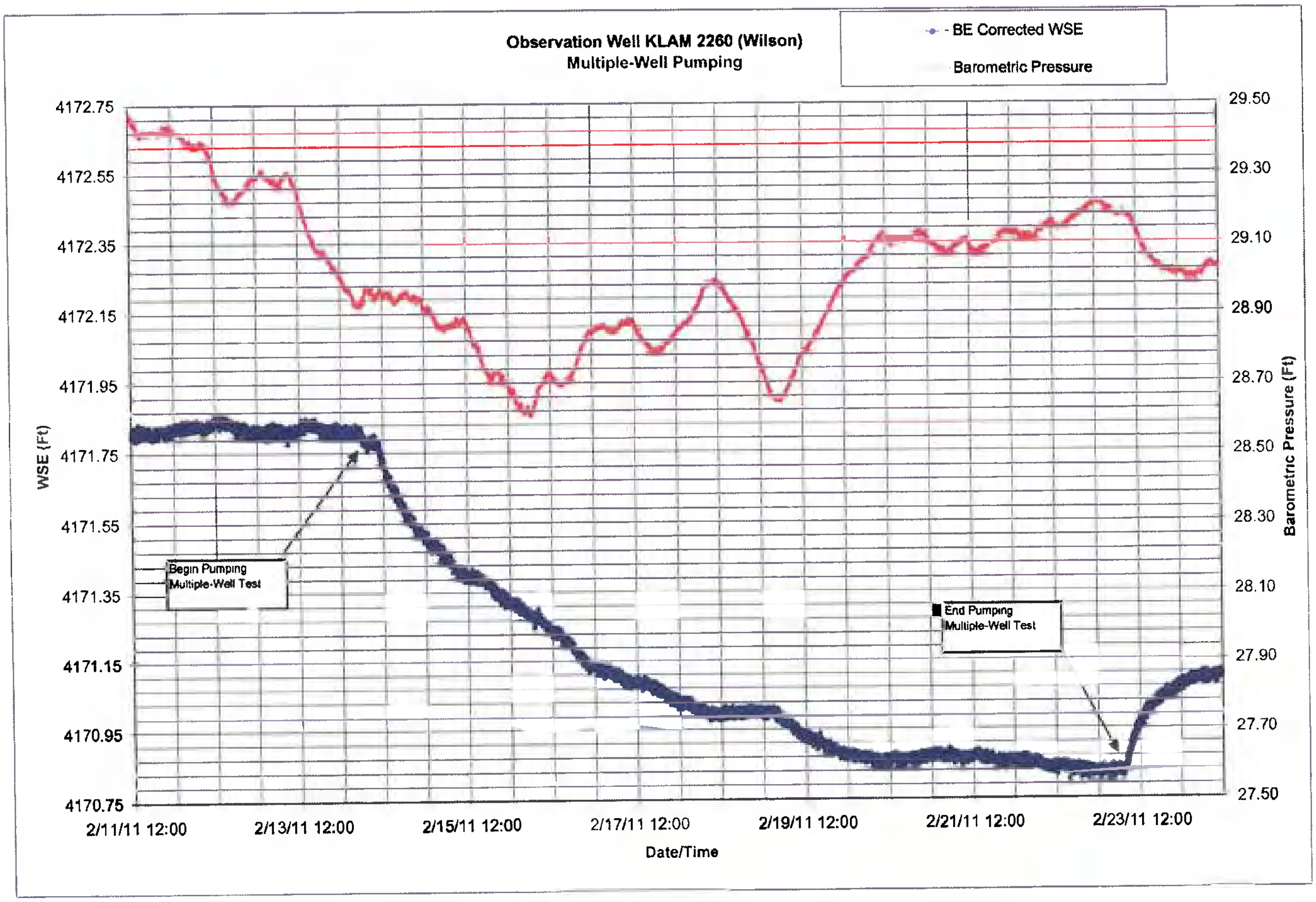
Obervation Well KLAM 12420
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
4114.50
4114.40
4114.30
4114.20
4114.10
4114.00
4113.90
4113.80
4113.70
4113.60
4113.50
WSE (Ft.)
29.60
29.50
29.40
29.30
29.20
29.10
29.00
28.90
Barometric Pressure (Ft.)
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00
Date/Time


Observation Well KLAM 50362
Single-Well Pumping
BE Corrected WSE
Barometric Pressure
4116.50
4116.40
4116.30
4116.20
4116.10
4116.00
4115.90
4115.80
4115.70
4115.60
4115.50
WSE (Ft.)
29.60
29.50
29.40
29.30
29.20
29.10
29.00
28.90
28.80
28.70
Barometric Pressure (Ft.)
Begin Pumping
Single-Well Test
End Pumping
Single-Well Test
2/7/11 7:00
2/7/11 19:00
2/8/11 7:00
2/8/11 19:00
2/9/11 7:00
2/9/11 19:00
2/10/11 7:00
2/10/11 19:00
2/11/11 7:00
Date/Time

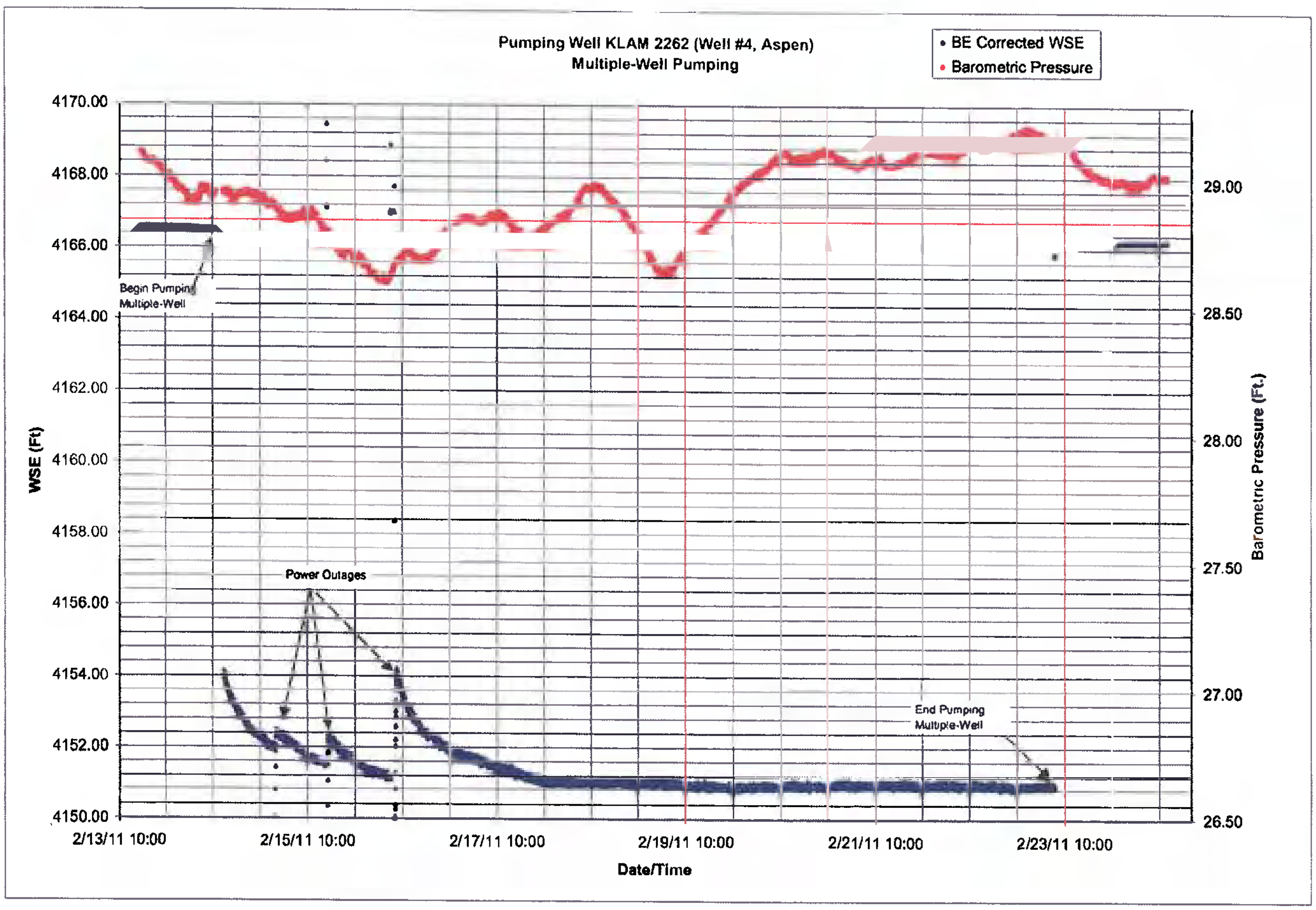
Water-Level Plots – Multiple-Well Interference Testing



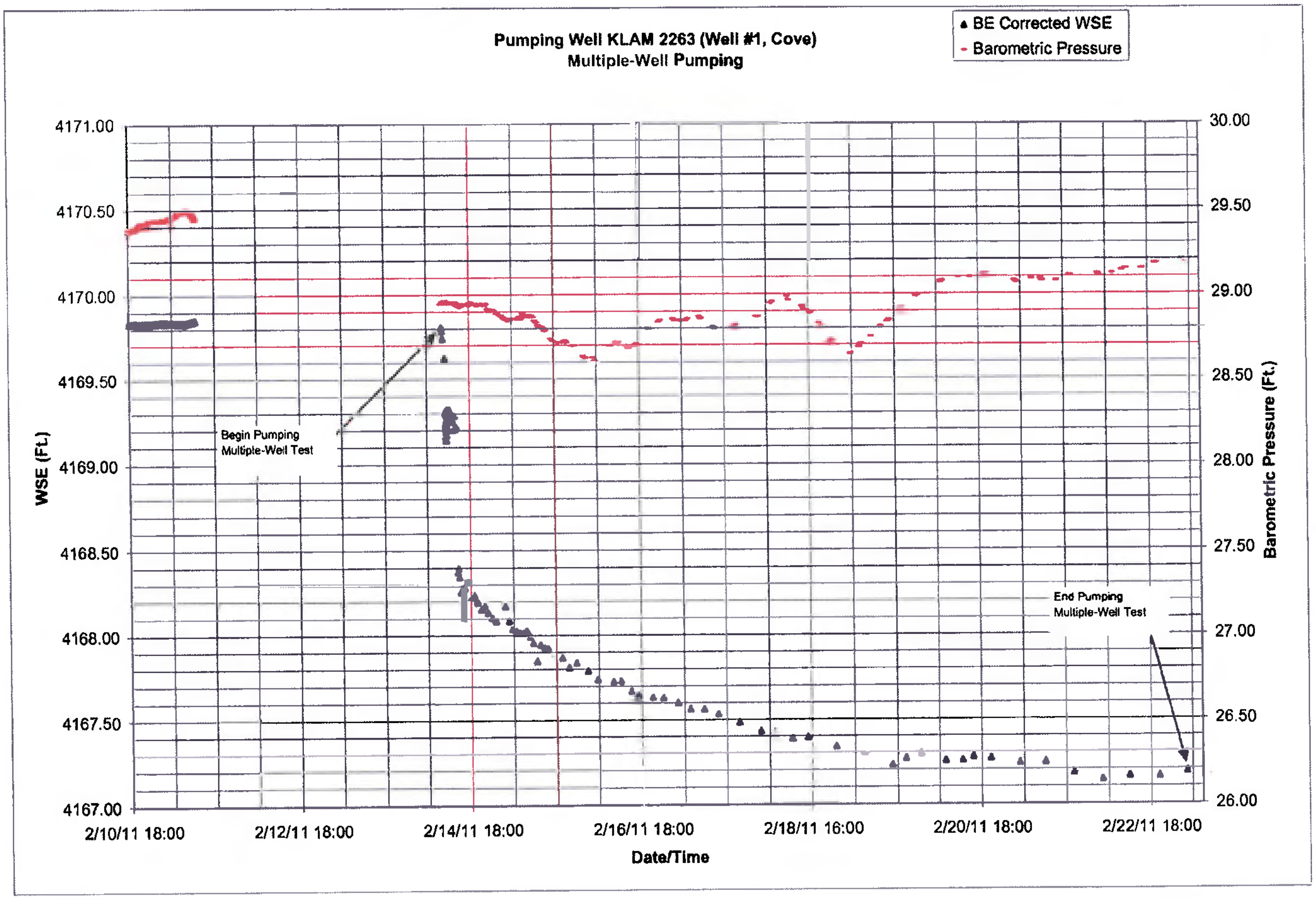
Pumping Well KLAM 2259 (Well #2, 100-Horse)
Multiple-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft)
Barometric Pressure (Ft)
Date/Time
4176.00
4175.50
4175.00
4174.50
4174.00
4173.50
4173.00
4172.50
4172.00
4171.50
4171.00
29.50
29.00
28.50
28.00
27.50
27.00
26.50
26.00
2/13/11 10:00
2/14/11 10:00
2/15/11 10:00
2/16/11 10:00
2/17/11 10:00
2/18/11 10:00
2/19/11 10:00
2/20/11 10:00
2/21/11 10:00
2/22/11 10:00
2/23/11 10:00
2/24/11 10:00
Begin Pumping Multiple-Well Test
Power Outages
End Pumping Multiple-Well Test
Noise From Turbulent Water Level

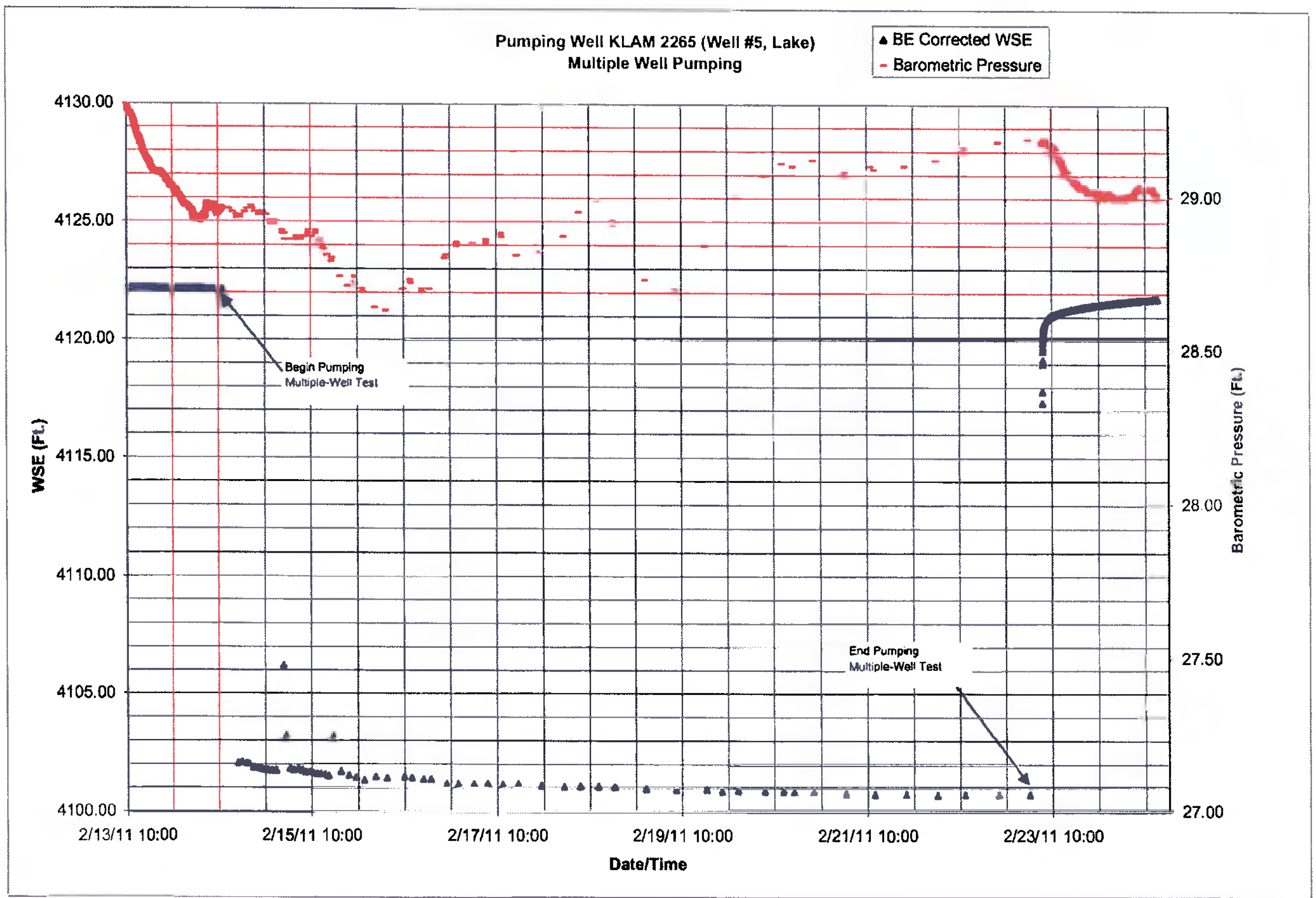


Observation Well KLAM 2260 (Wilson)
Multiple-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft)
Barometric Pressure (Ft)
Date/Time
4172.75
4172.55
4172.35
4172.15
4171.95
4171.75
4171.55
4171.35
4171.15
4170.95
4170.75
29.50
29.30
29.10
28.90
28.70
28.50
28.30
28.10
27.90
27.70
27.50
2/11/11 12:00
2/13/11 12:00
2/15/11 12:00
2/17/11 12:00
2/19/11 12:00
2/21/11 12:00
2/23/11 12:00
Begin Pumping Multiple-Well Test
End Pumping Multiple-Well Test

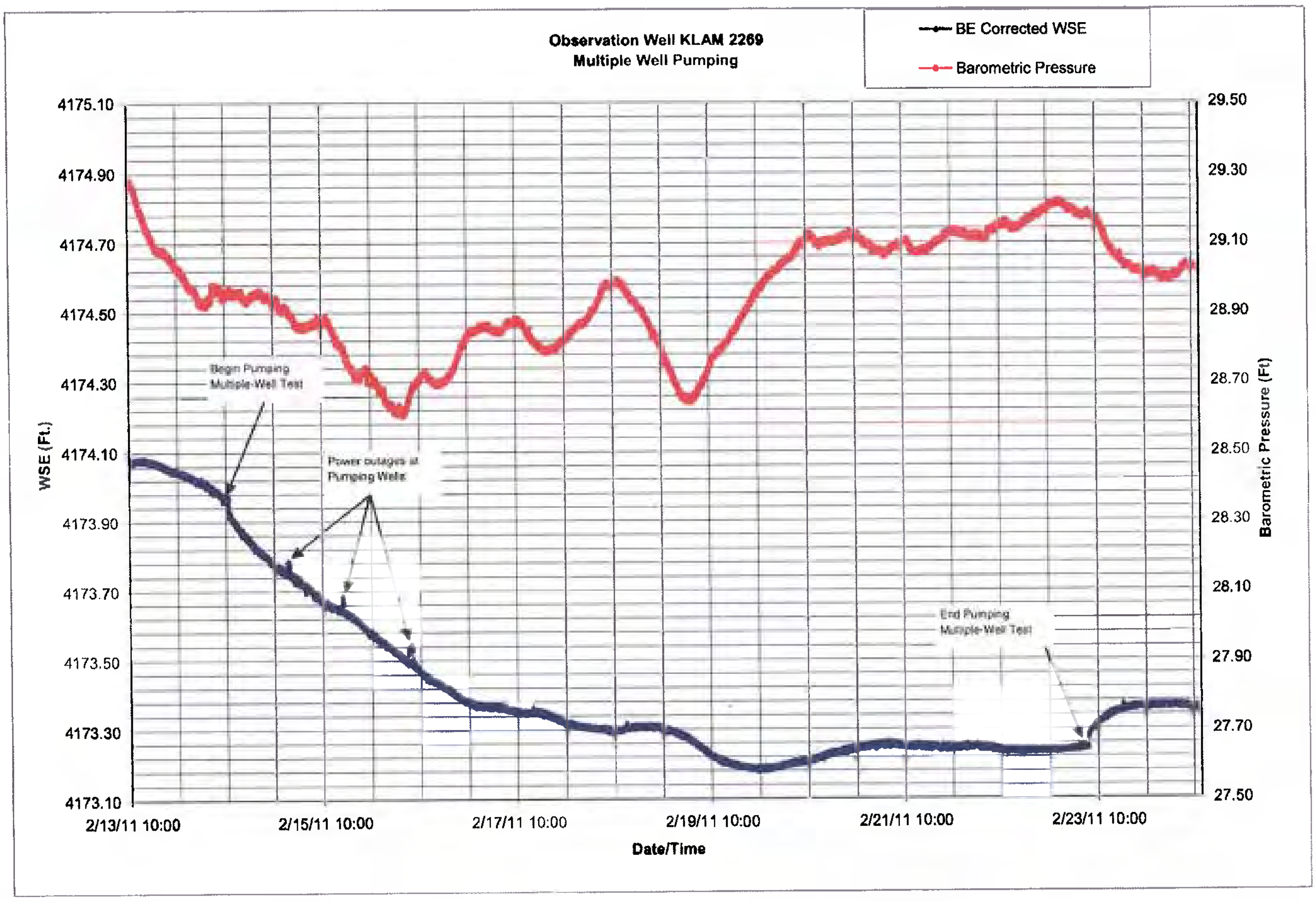


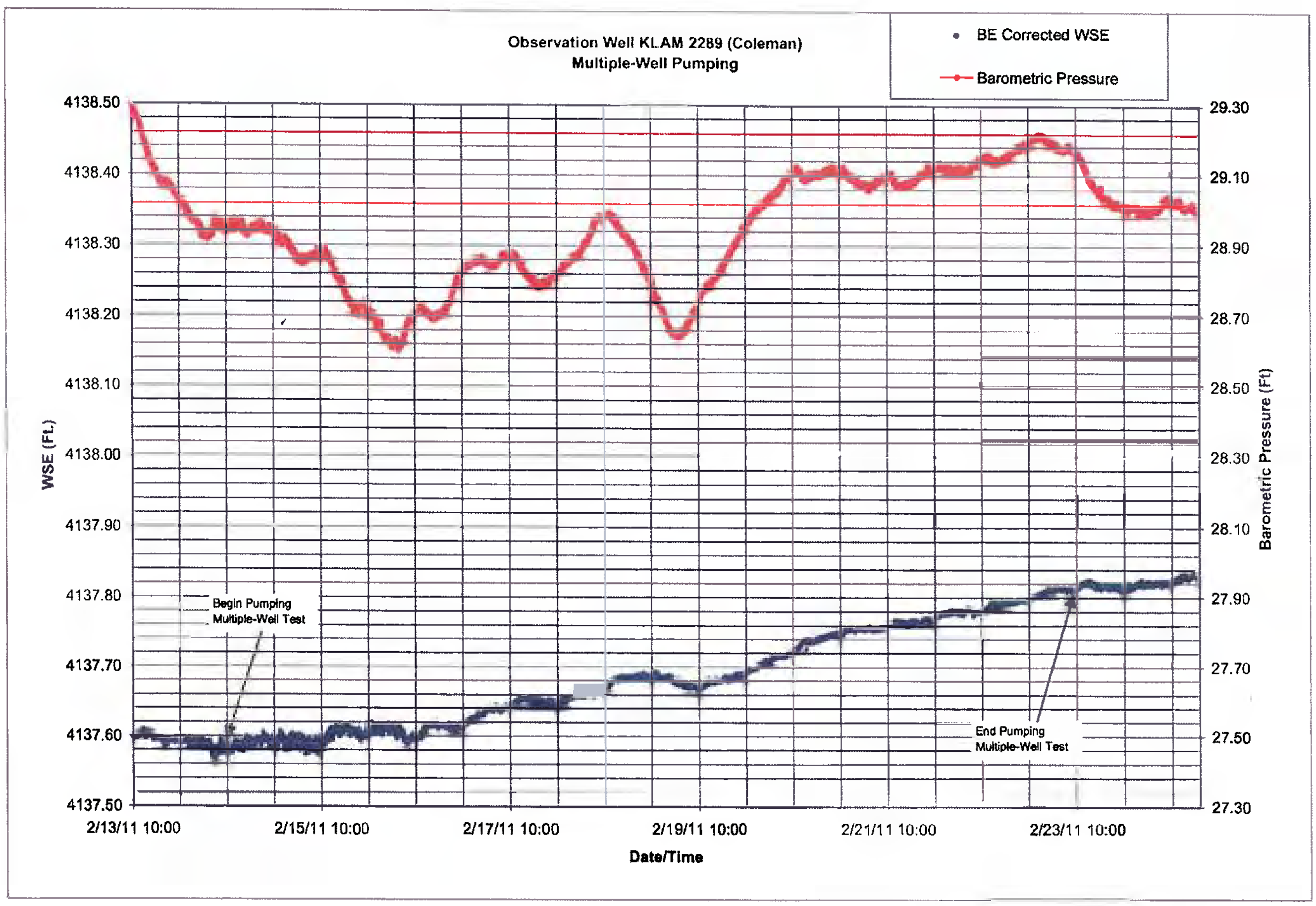
Pumping Well KLAM 2262 (Well #4, Aspen)
Multiple-Well Pumping
BE Corrected WSE
Barometric Pressure
4170.00
4168.00
4166.00
4164.00
4162.00
4160.00
4158.00
4156.00
4154.00
4152.00
4150.00
WSE (Ft)
29.00
28.50
28.00
27.50
27.00
26.50
Barometric Pressure (Ft.)
Begin Pumping
Multiple-Well
Power Outages
End Pumping
Multiple-Well
2/13/11 10:00
2/15/11 10:00
2/17/11 10:00
2/19/11 10:00
2/21/11 10:00
2/23/11 10:00
Date/Time

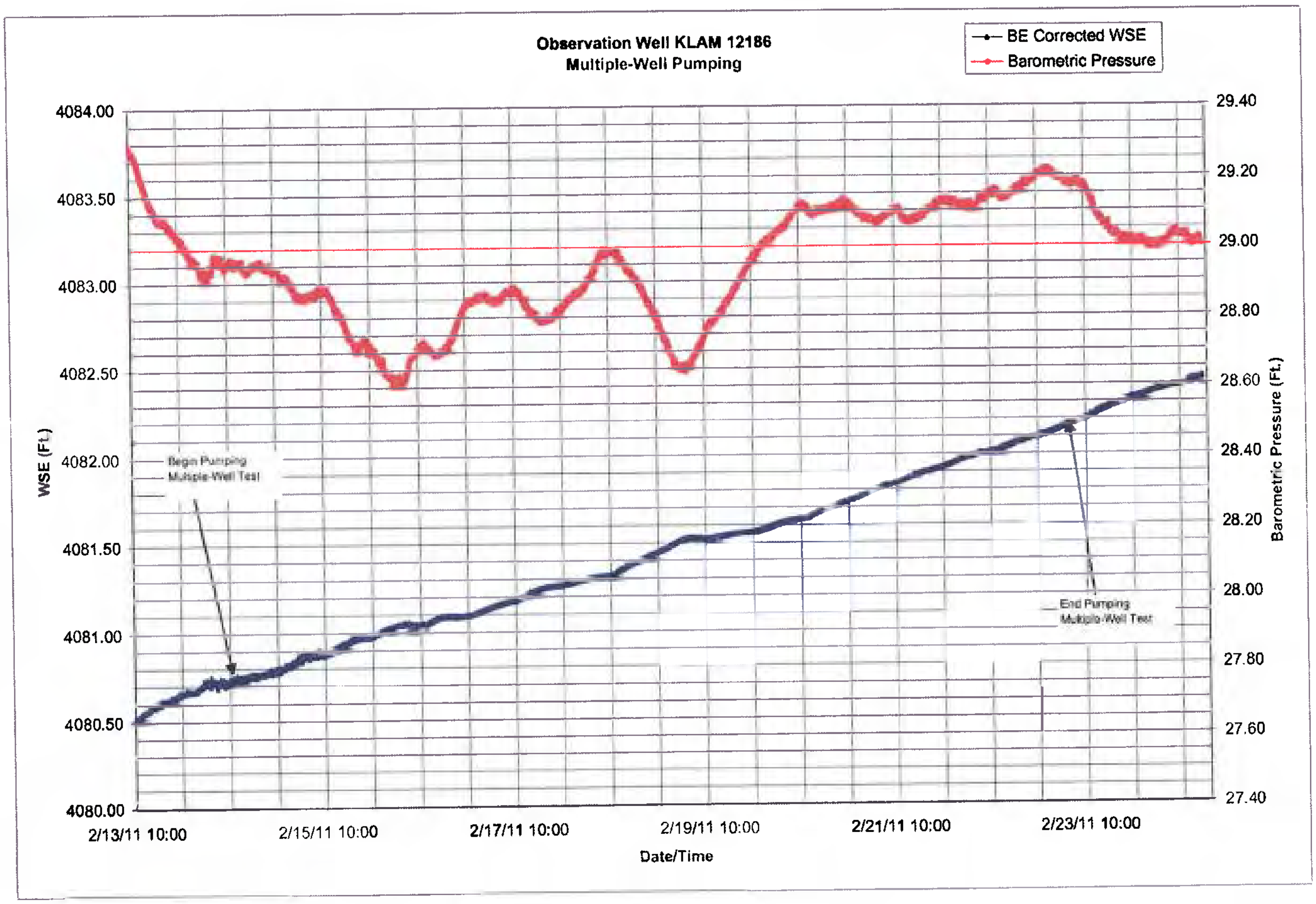

Pumping Well KLAM 2263 (Well #1, Cove)
Multiple-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
Date/Time
4171.00
4170.50
4170.00
4169.50
4169.00
4168.50
4168.00
4167.50
4167.00
30.00
29.50
29.00
28.50
28.00
27.50
27.00
26.50
26.00
2/10/11 18:00
2/12/11 18:00
2/14/11 18:00
2/16/11 18:00
2/18/11 16:00
2/20/11 18:00
2/22/11 18:00
Begin Pumping
Multiple-Well Test
End Pumping
Multiple-Well Test



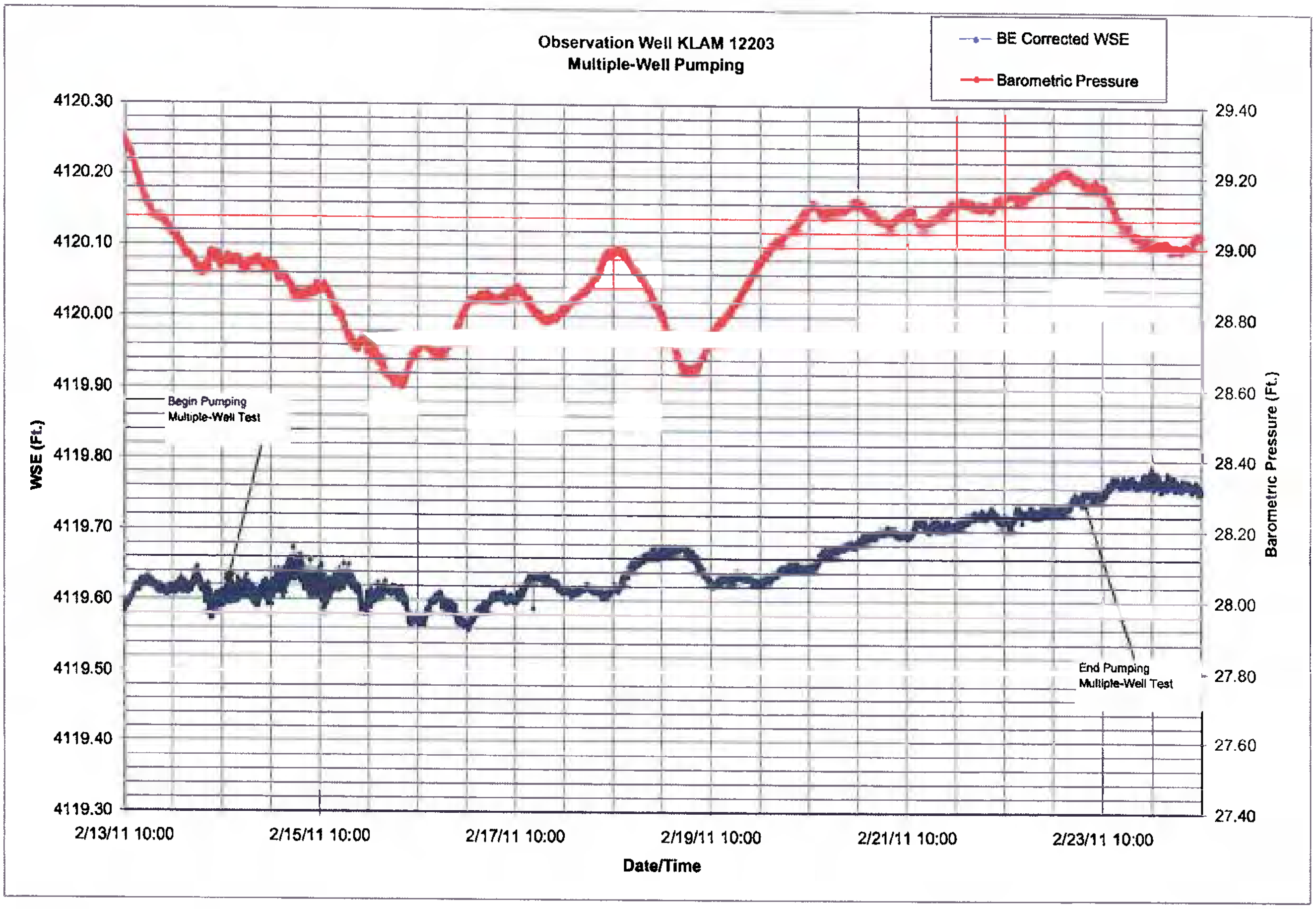
Pumping Well KLAM 2265 (Well #5, Lake)
Multiple Well Pumping
BE Corrected WSE
Barometric Pressure
4130.00
4125.00
4120.00
4115.00
4110.00
4105.00
4100.00
WSE (Ft.)
29.00
28.50
28.00
27.50
27.00
Barometric Pressure (Ft.)
Begin Pumping
Multiple-Well Test
End Pumping
Multiple-Well Test
2/13/11 10:00
2/15/11 10:00
2/17/11 10:00
2/19/11 10:00
2/21/11 10:00
2/23/11 10:00
Date/Time

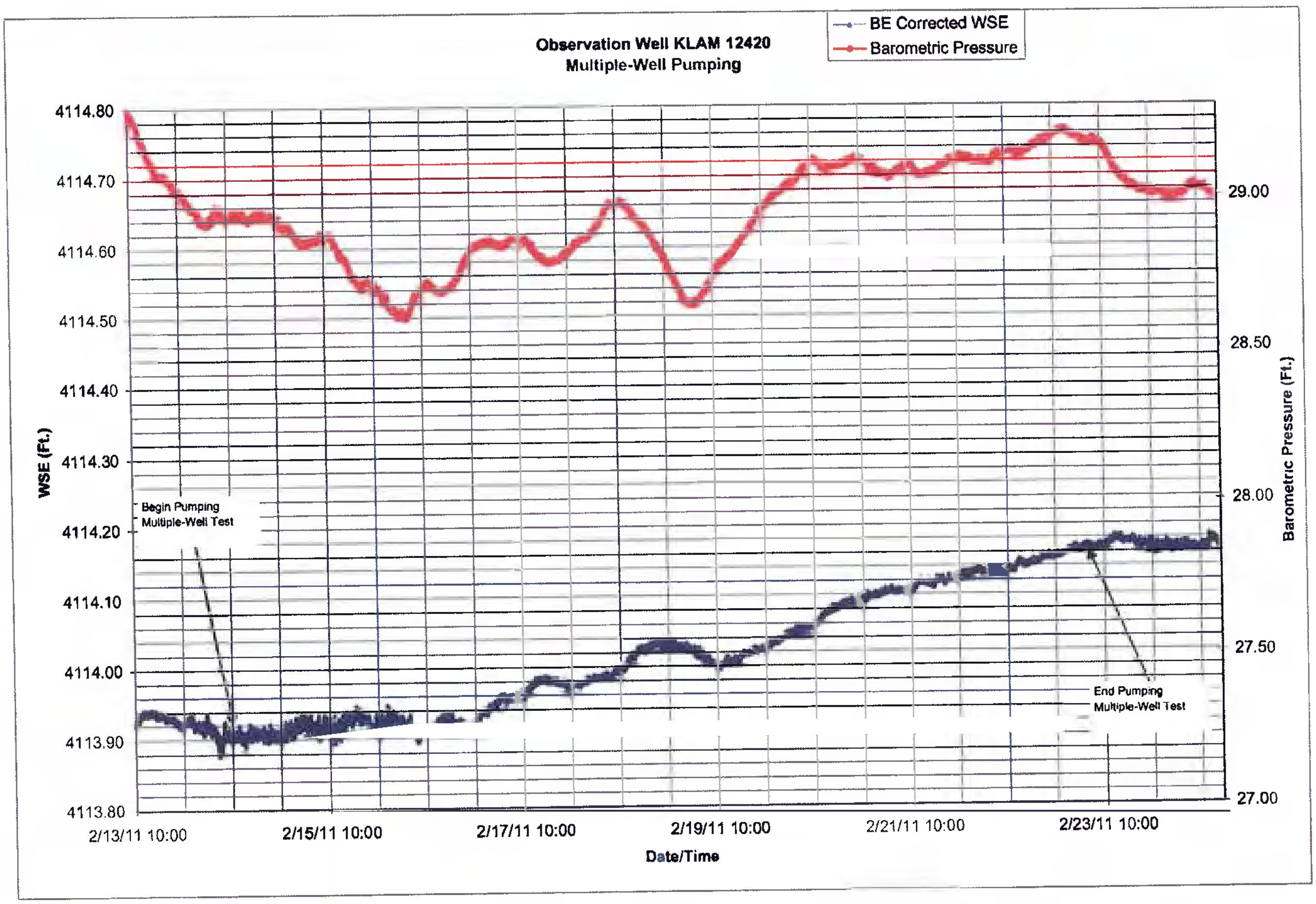

Observation Well KLAM 2269
Multiple Well Pumping
BE Corrected WSE
Barometric Pressure
4175.10
4174.90
4174.70
4174.50
4174.30
4174.10
4173.90
4173.70
4173.50
4173.30
4173.10
29.50
29.30
29.10
28.90
28.70
28.50
28.30
28.10
27.90
27.70
27.50
WSE (Ft.)
Barometric Pressure (Ft)
Begin Pumping
Multiple-Well Test
Power outages at
Pumping Wells
End Pumping
Multiple-Well Test
2/13/11 10:00
2/15/11 10:00
2/17/11 10:00
2/19/11 10:00
2/21/11 10:00
2/23/11 10:00
Date/Time


Observation Well KLAM 2289 (Coleman)
Multiple-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft)
Date/Time
4138.50
4138.40
4138.30
4138.20
4138.10
4138.00
4137.90
4137.80
4137.70
4137.60
4137.50
29.30
29.10
28.90
28.70
28.50
28.30
28.10
27.90
27.70
27.50
27.30
2/13/11 10:00
2/15/11 10:00
2/17/11 10:00
2/19/11 10:00
2/21/11 10:00
2/23/11 10:00
Begin Pumping Multiple-Well Test
End Pumping Multiple-Well Test

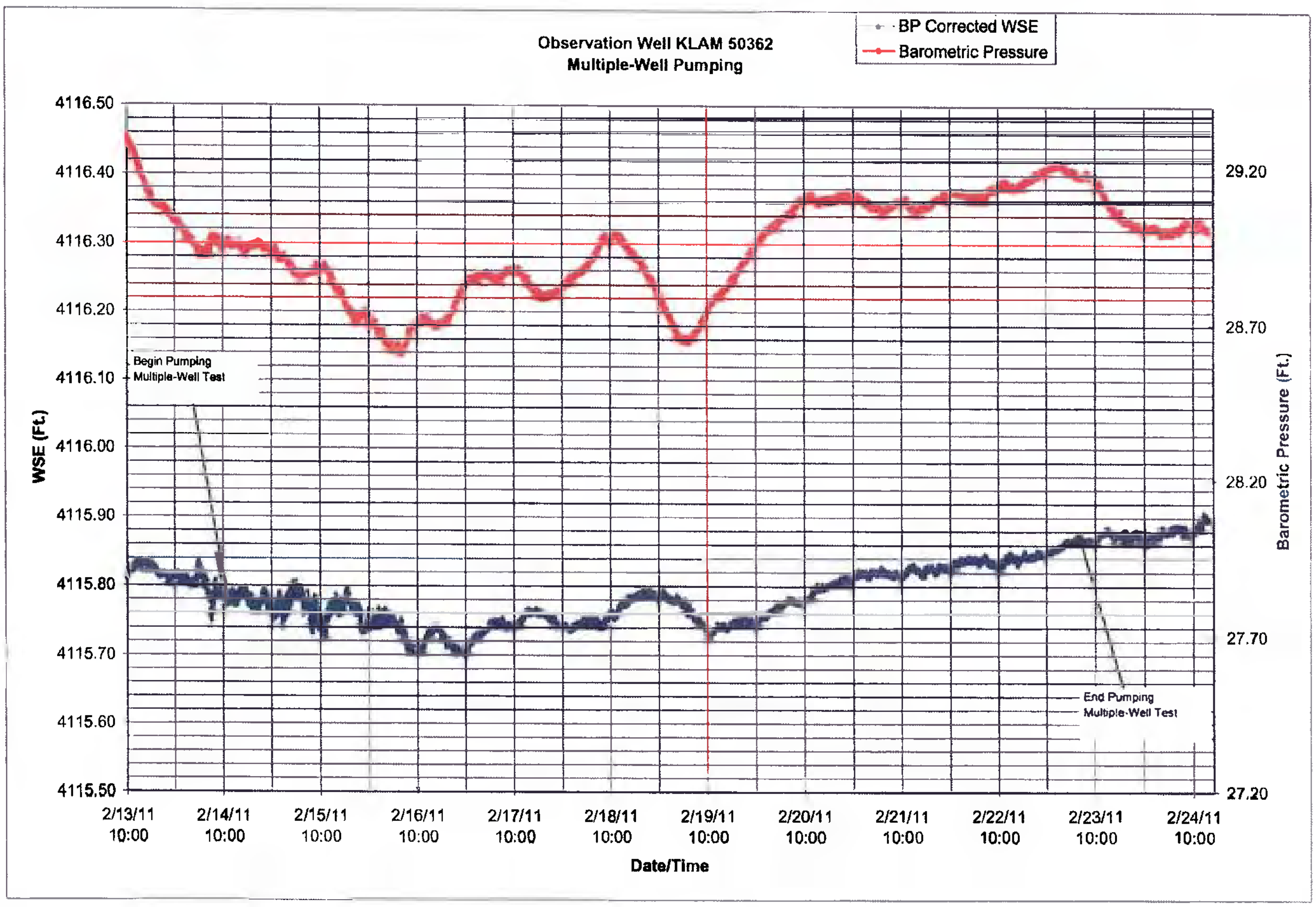


Observation Well KLAM 12186
Multiple-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
4084.00
4083.50
4083.00
4082.50
4082.00
4081.50
4081.00
4080.50
4080.00
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
27.80
27.60
27.40
Begin Pumping
Multiple-Well Test
End Pumping
Multiple-Well Test
2/13/11 10:00
2/15/11 10:00
2/17/11 10:00
2/19/11 10:00
2/21/11 10:00
2/23/11 10:00
Date/Time


Observation Well KLAM 12203
Multiple-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
Date/Time
Begin Pumping
Multiple-Well Test
End Pumping
Multiple-Well Test
4120.30
4120.20
4120.10
4120.00
4119.90
4119.80
4119.70
4119.60
4119.50
4119.40
4119.30
29.40
29.20
29.00
28.80
28.60
28.40
28.20
28.00
27.80
27.60
27.40
2/13/11 10:00
2/15/11 10:00
2/17/11 10:00
2/19/11 10:00
2/21/11 10:00
2/23/11 10:00



Observation Well KLAM 12420
Multiple-Well Pumping
BE Corrected WSE
Barometric Pressure
WSE (Ft.)
Barometric Pressure (Ft.)
Date/Time
4114.80
4114.70
4114.60
4114.50
4114.40
4114.30
4114.20
4114.10
4114.00
4113.90
4113.80
29.00
28.50
28.00
27.50
27.00
2/13/11 10:00
2/15/11 10:00
2/17/11 10:00
2/19/11 10:00
2/21/11 10:00
2/23/11 10:00
Begin Pumping
Multiple-Well Test
End Pumping
Multiple-Well Test



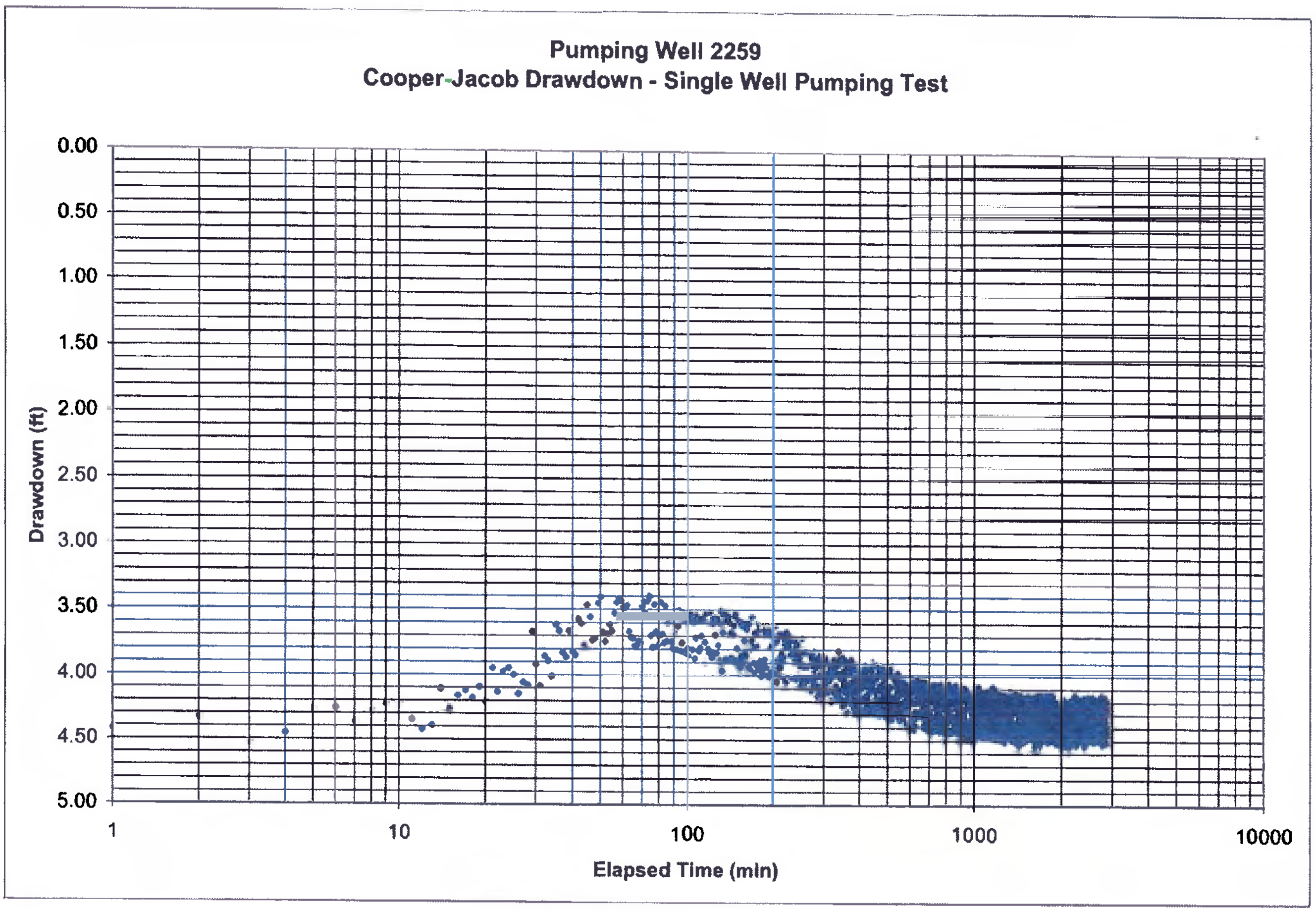
Observation Well KLAM 50362
Multiple-Well Pumping
BP Corrected WSE
Barometric Pressure
4116.50
4116.40
4116.30
4116.20
4116.10
4116.00
4115.90
4115.80
4115.70
4115.60
4115.50
WSE (Ft.)
29.20
28.70
28.20
27.70
27.20
Barometric Pressure (Ft.)
Begin Pumping
Multiple-Well Test
End Pumping
Multiple-Well Test
2/13/11 10:00
2/14/11 10:00
2/15/11 10:00
2/16/11 10:00
2/17/11 10:00
2/18/11 10:00
2/19/11 10:00
2/20/11 10:00
2/21/11 10:00
2/22/11 10:00
2/23/11 10:00
2/24/11 10:00
Date/Time

APPENDIX C

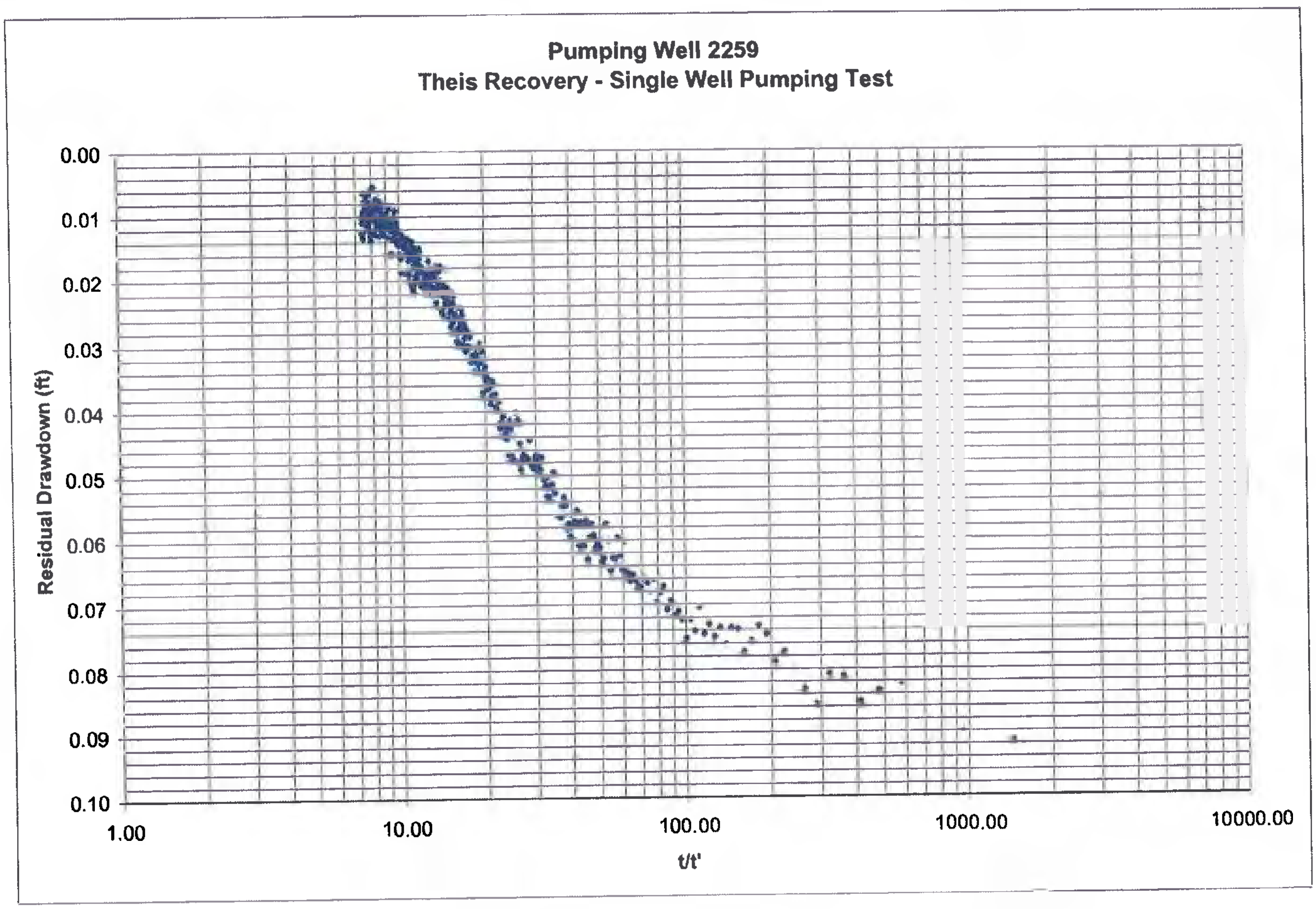
APPENDIX C

PUMPING TEST ANALYSIS PLOTS

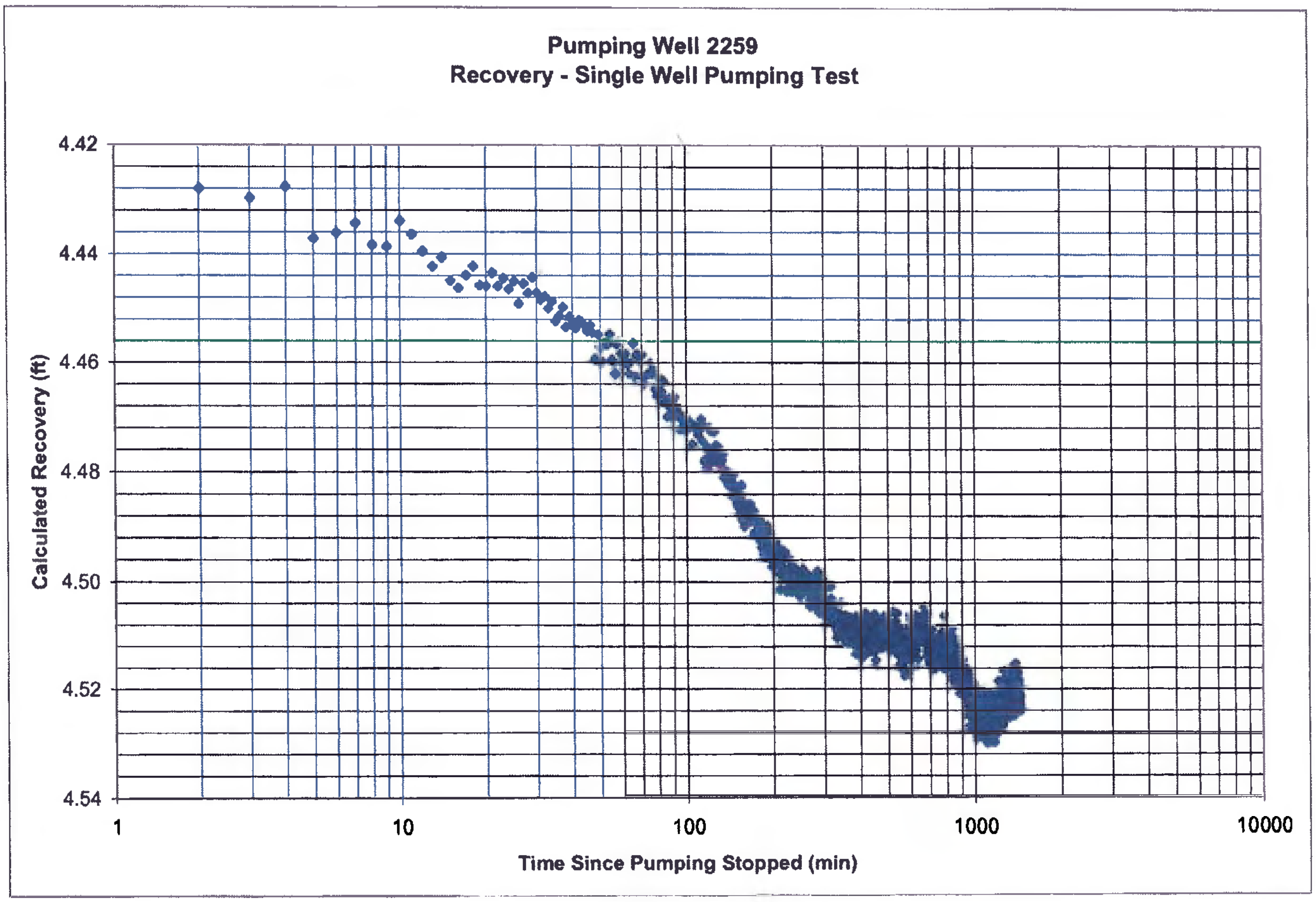
KLAM 2259



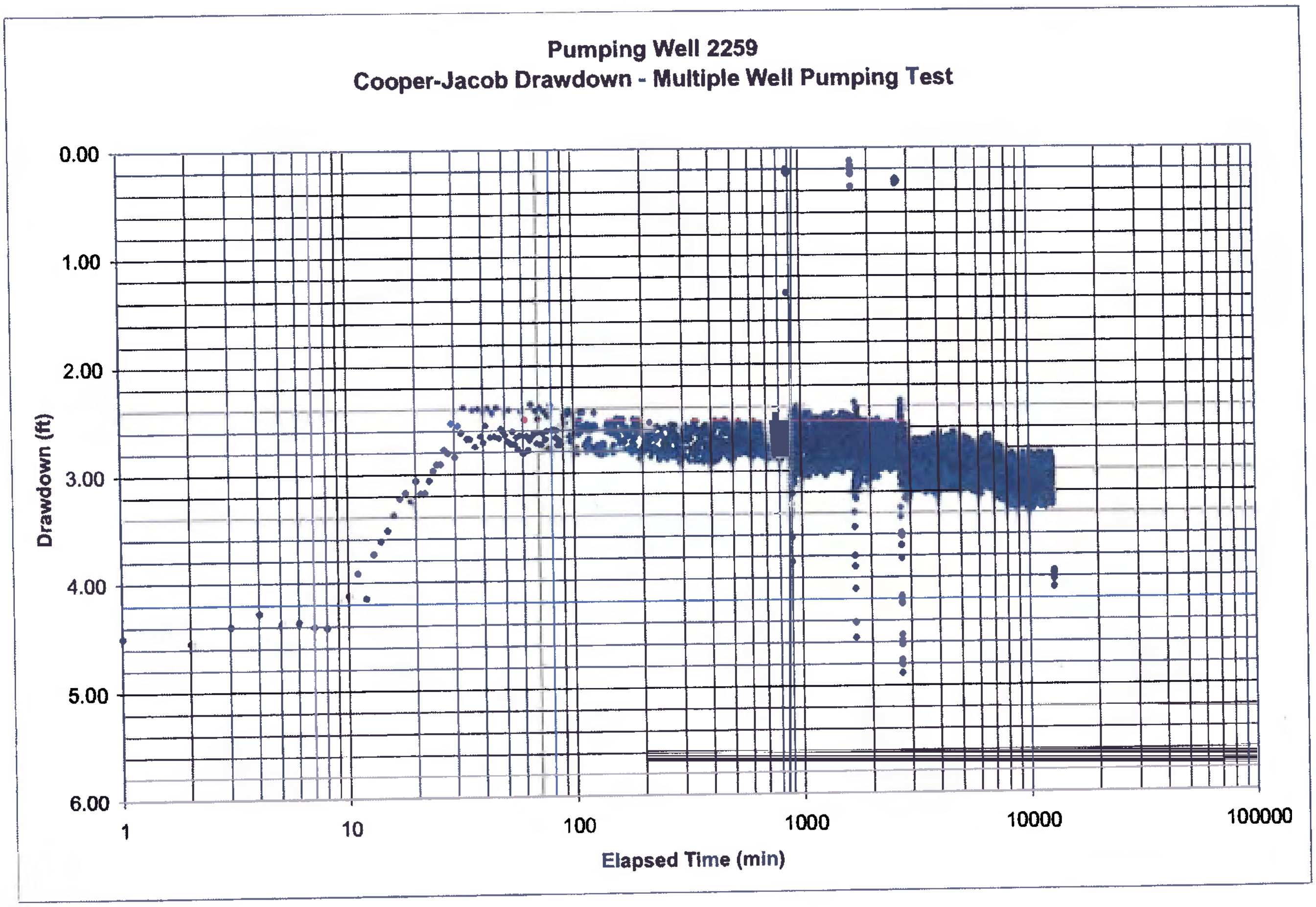
Pumping Well 2259
Cooper-Jacob Drawdown - Single Well Pumping Test
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Drawdown (ft)
1
10
100
1000
10000
Elapsed Time (min)



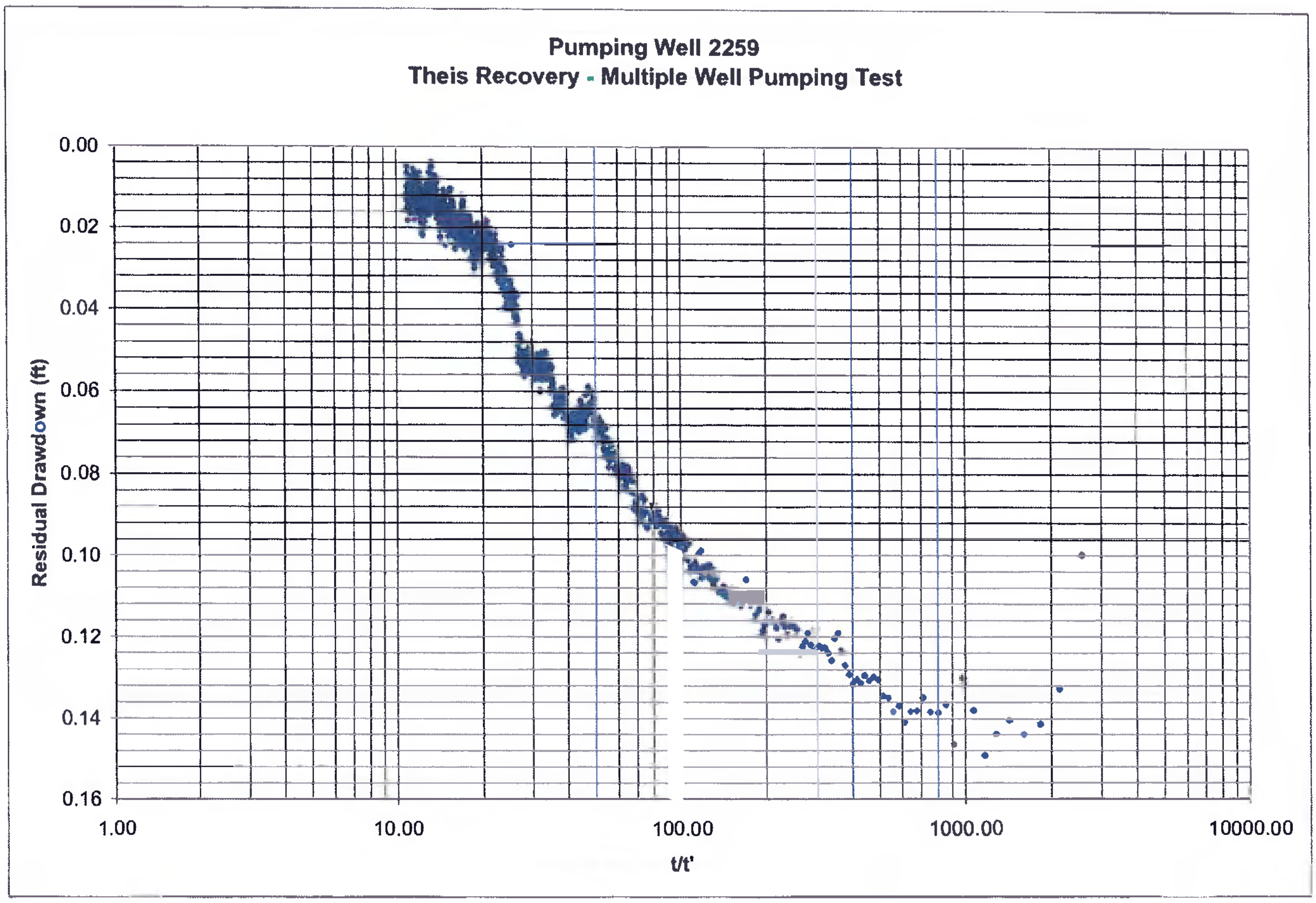
Pumping Well 2259
Theis Recovery - Single Well Pumping Test
Residual Drawdown (ft)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
1.00
10.00
100.00
1000.00
10000.00
t/t'



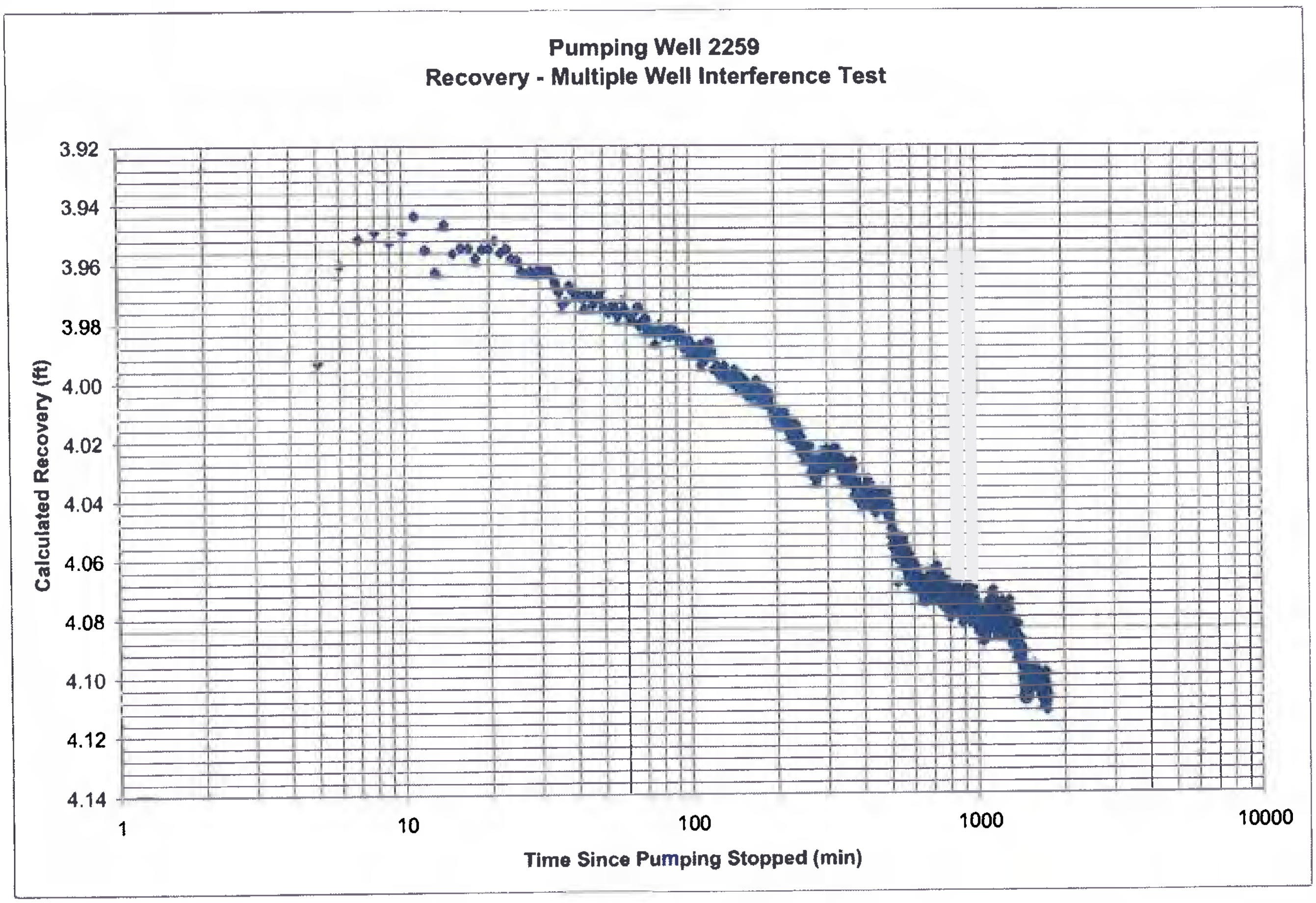
Pumping Well 2259
Recovery - Single Well Pumping Test
Calculated Recovery (ft)
4.42
4.44
4.46
4.48
4.50
4.52
4.54
1
10
100
1000
10000
Time Since Pumping Stopped (min)



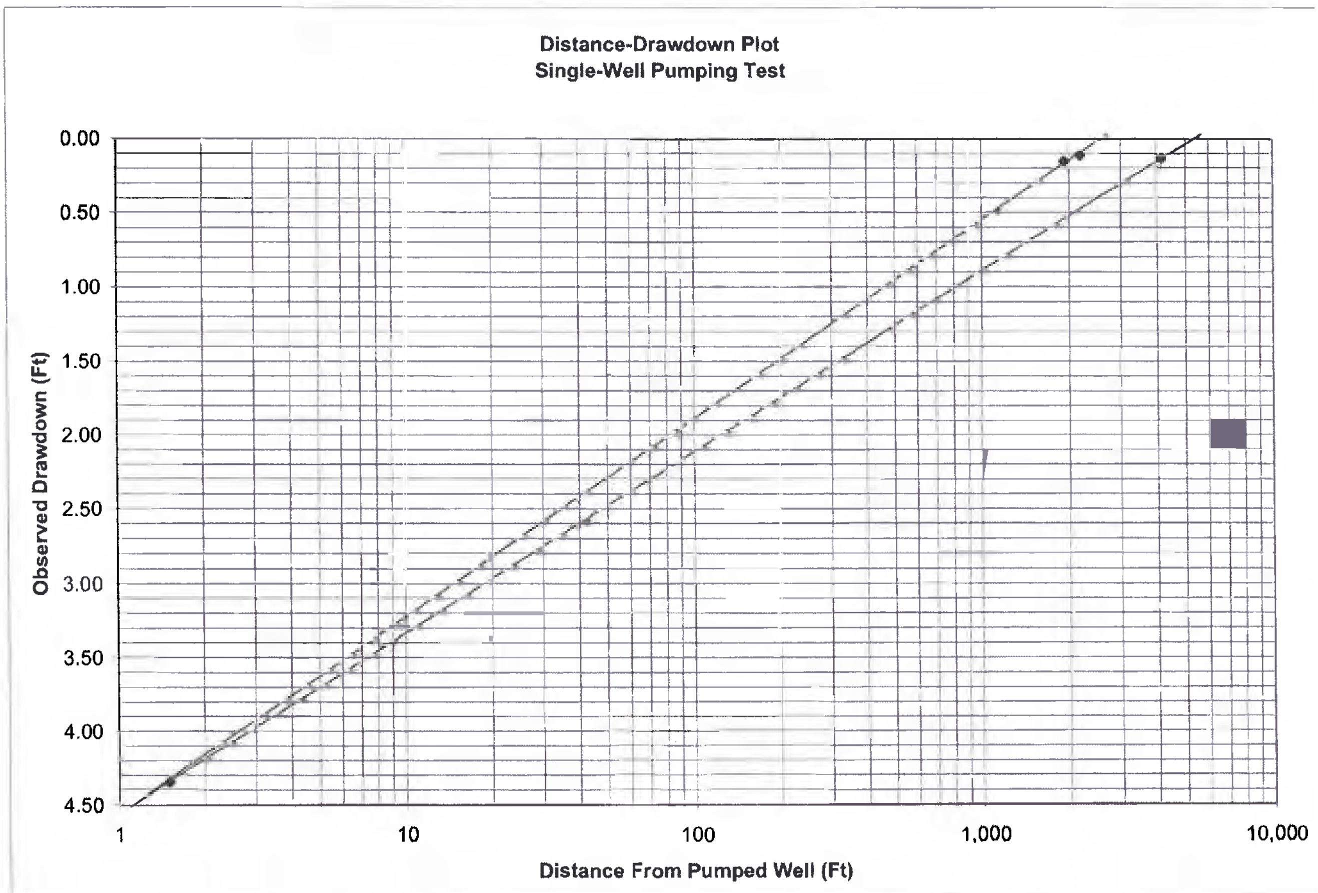
Pumping Well 2259
Cooper-Jacob Drawdown - Multiple Well Pumping Test
Drawdown (ft)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
1
10
100
1000
10000
100000
Elapsed Time (min)



Pumping Well 2259
Theis Recovery - Multiple Well Pumping Test
Residual Drawdown (ft)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
1.00
10.00
100.00
1000.00
10000.00
t/t'

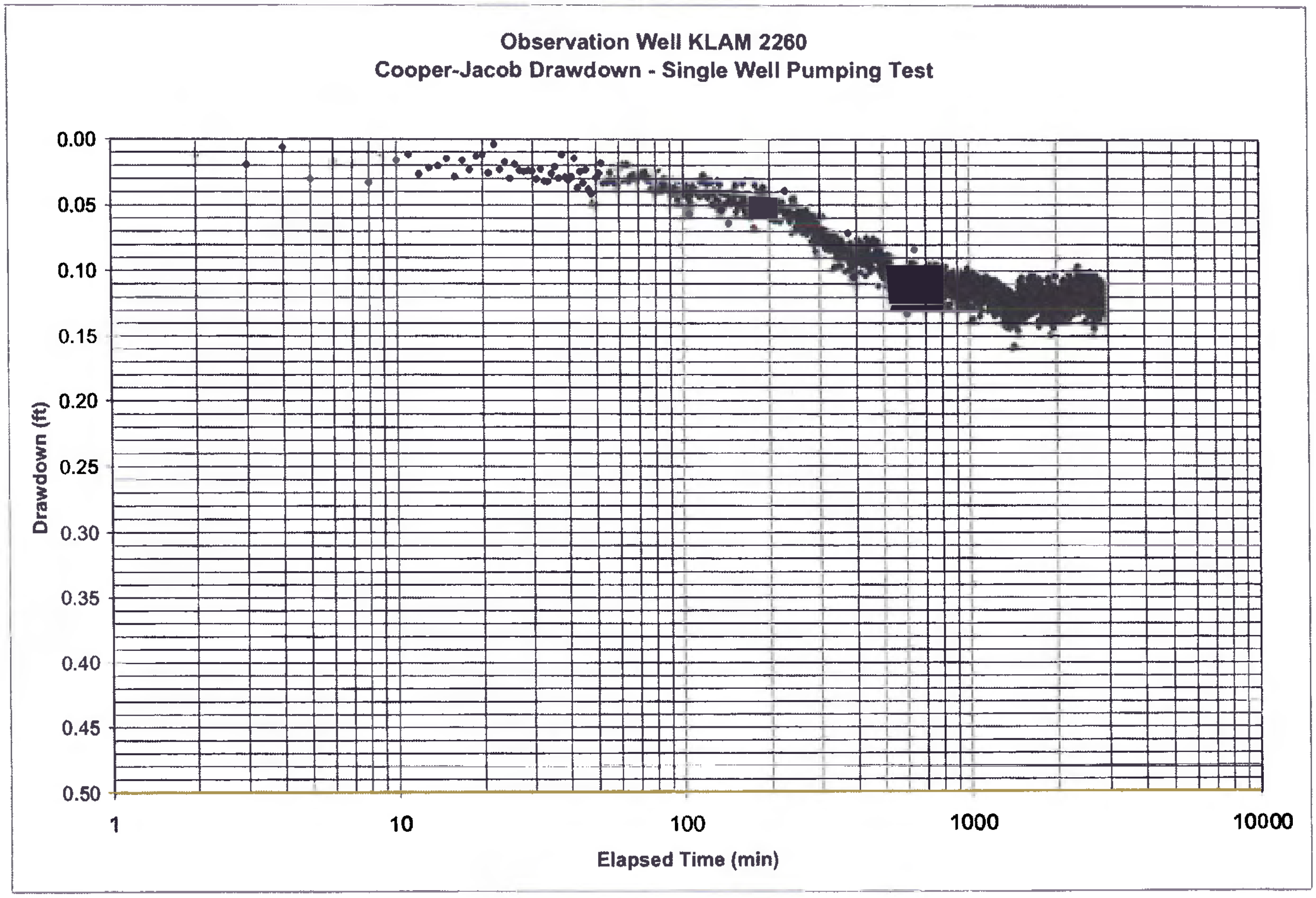


Pumping Well 2259
Recovery - Multiple Well Interference Test
Calculated Recovery (ft)
3.92
3.94
3.96
3.98
4.00
4.02
4.04
4.06
4.08
4.10
4.12
4.14
1
10
100
1000
10000
Time Since Pumping Stopped (min)

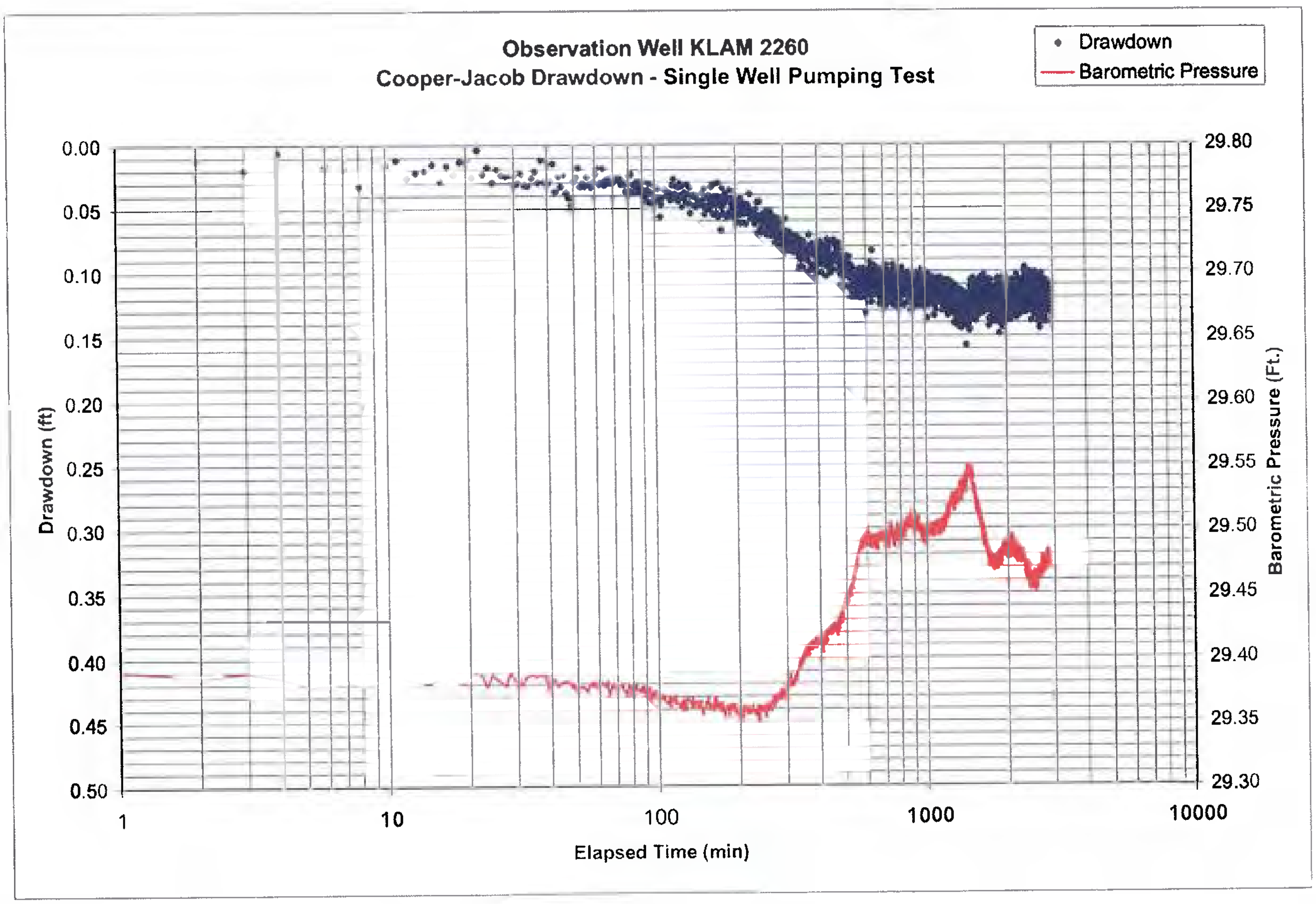


Distance-Drawdown Plot
Single-Well Pumping Test
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
Observed Drawdown (Ft)
1
10
100
1,000
10,000
Distance From Pumped Well (Ft)

KLAM 2260

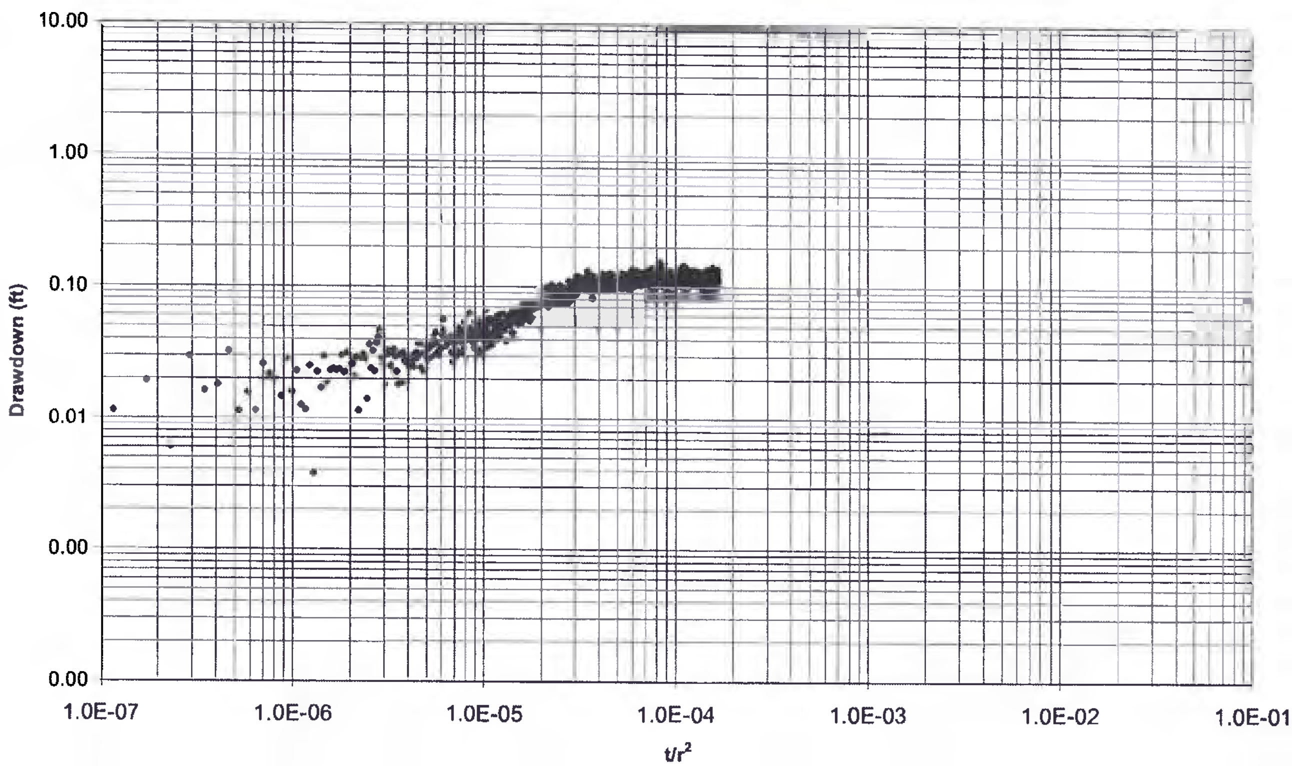


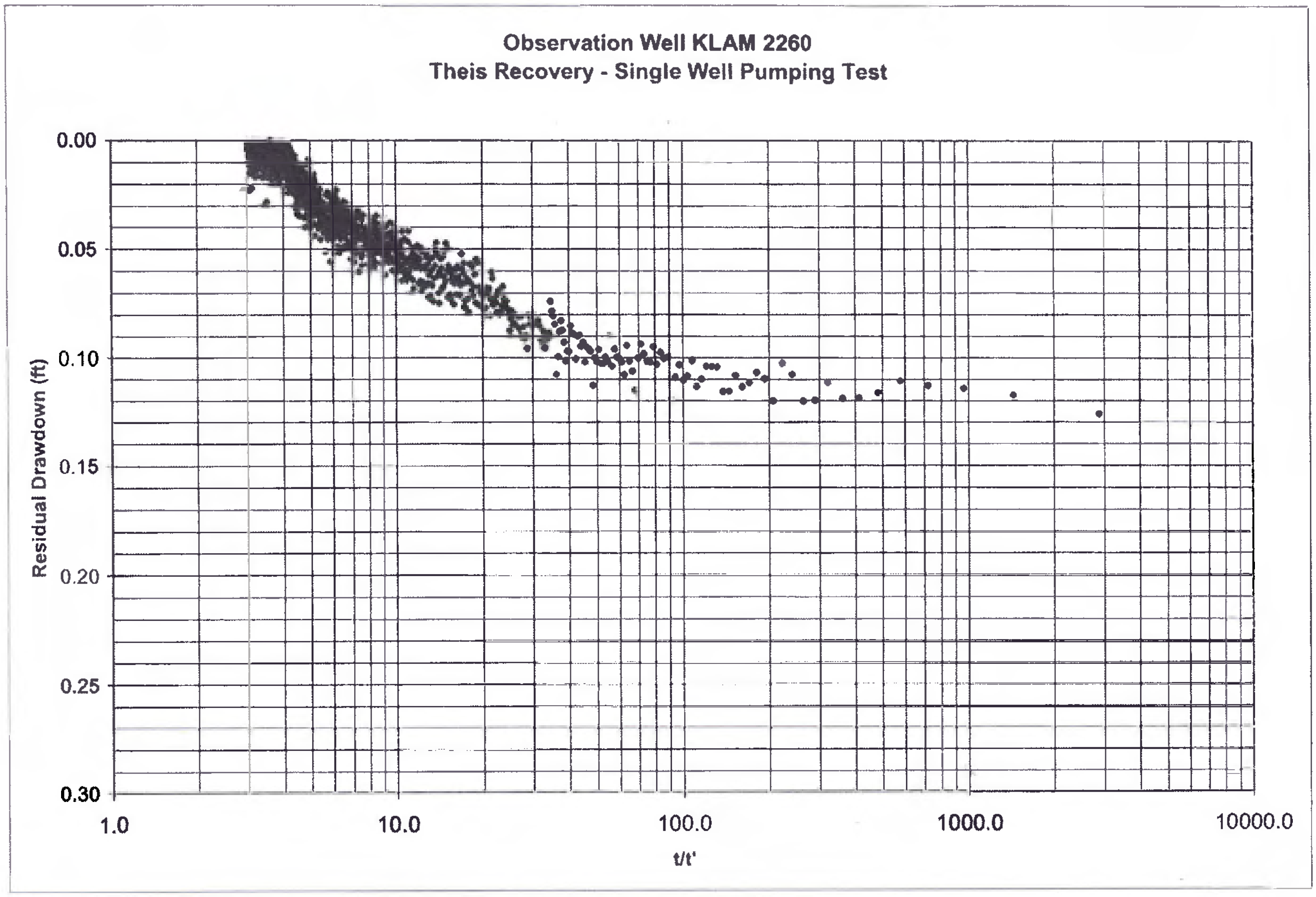
Observation Well KLAM 2260
Cooper-Jacob Drawdown - Single Well Pumping Test
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
Drawdown (ft)
1
10
100
1000
10000
Elapsed Time (min)

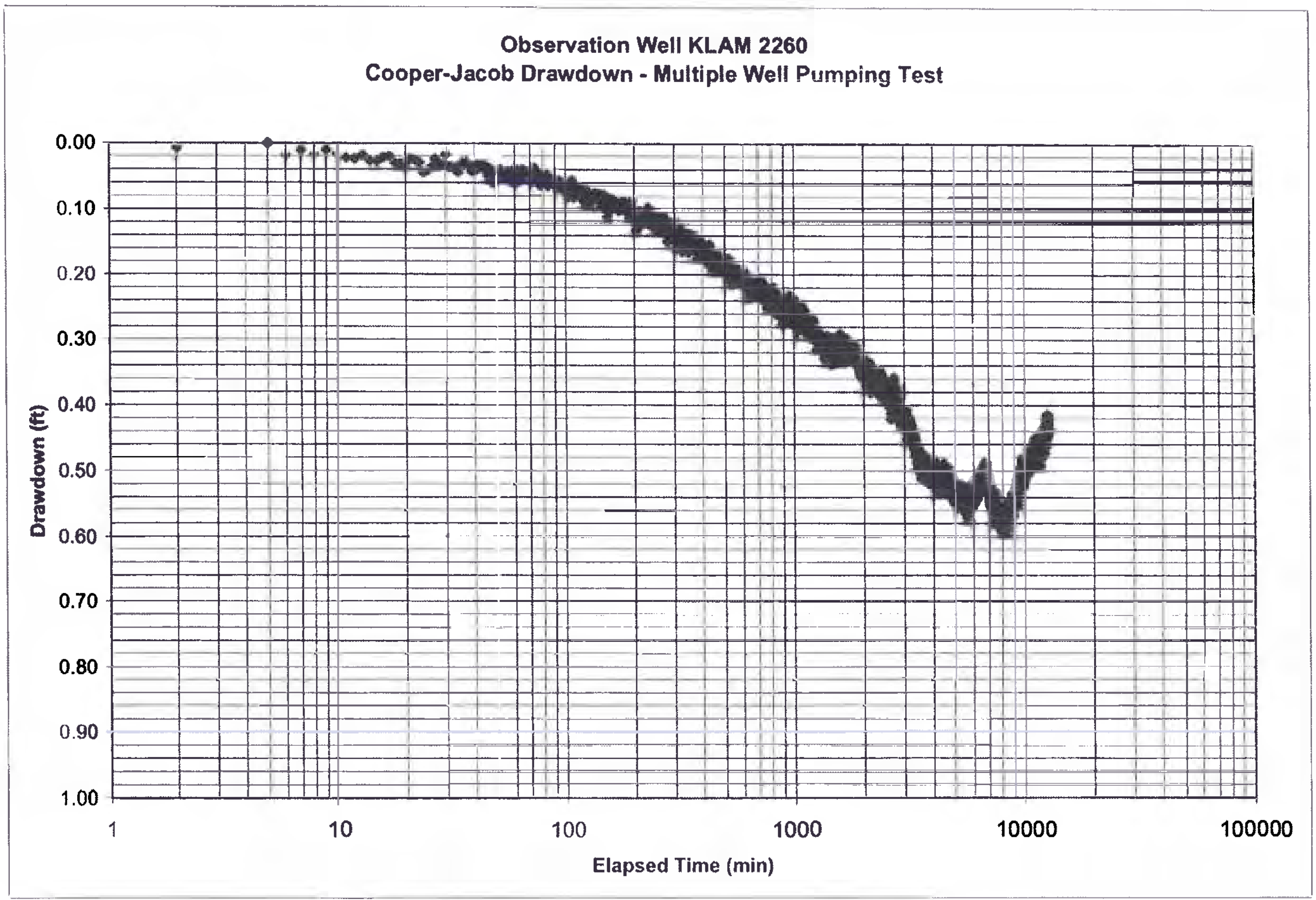


Observation Well KLAM 2260
Cooper-Jacob Drawdown - Single Well Pumping Test
Drawdown
Barometric Pressure
Drawdown (ft)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
Barometric Pressure (Ft.)
29.80
29.75
29.70
29.65
29.60
29.55
29.50
29.45
29.40
29.35
29.30
1
10
100
1000
10000
Elapsed Time (min)

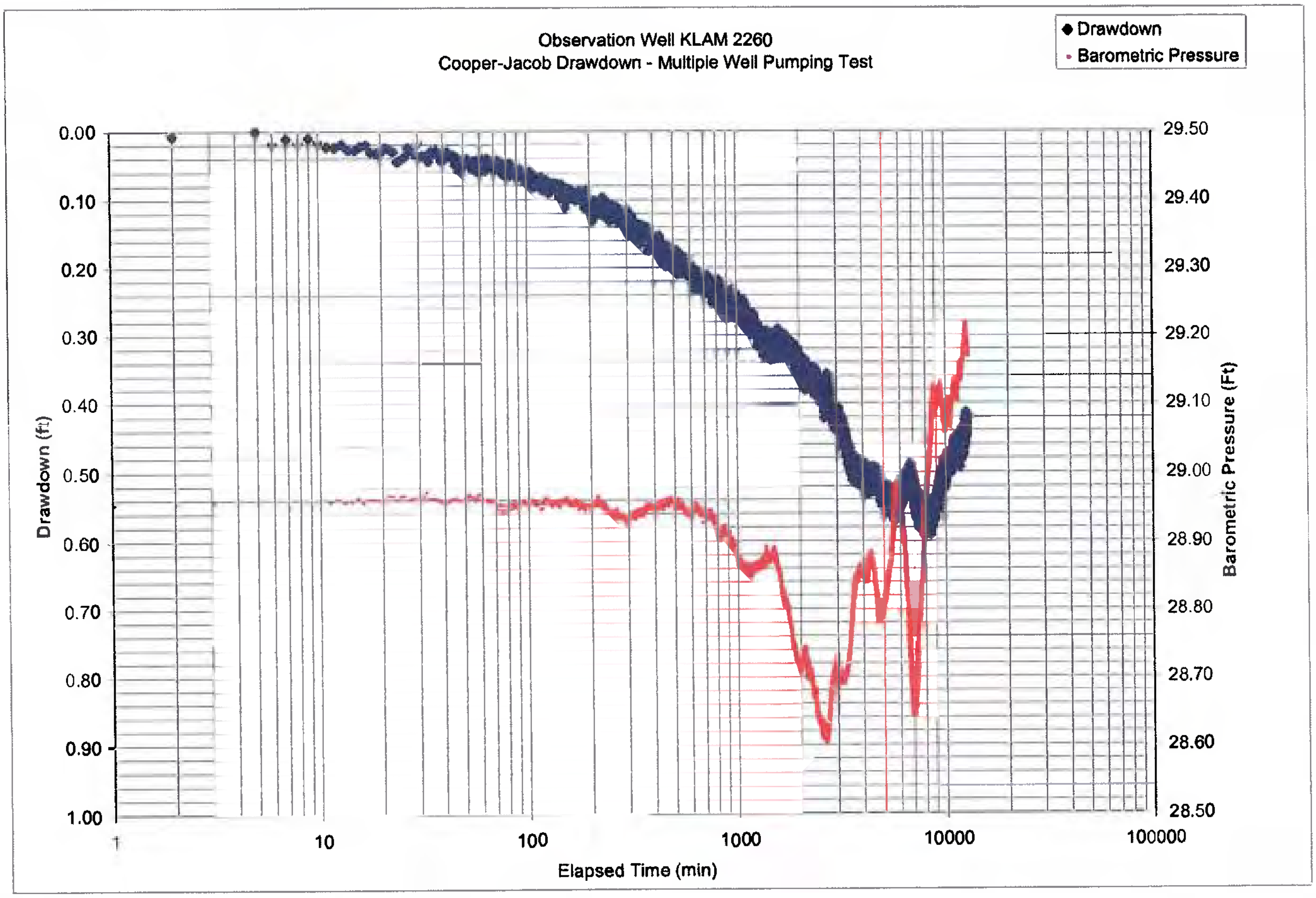
Observation Well KLAM 2260
Theis Drawdown - Single Well Pumping Test



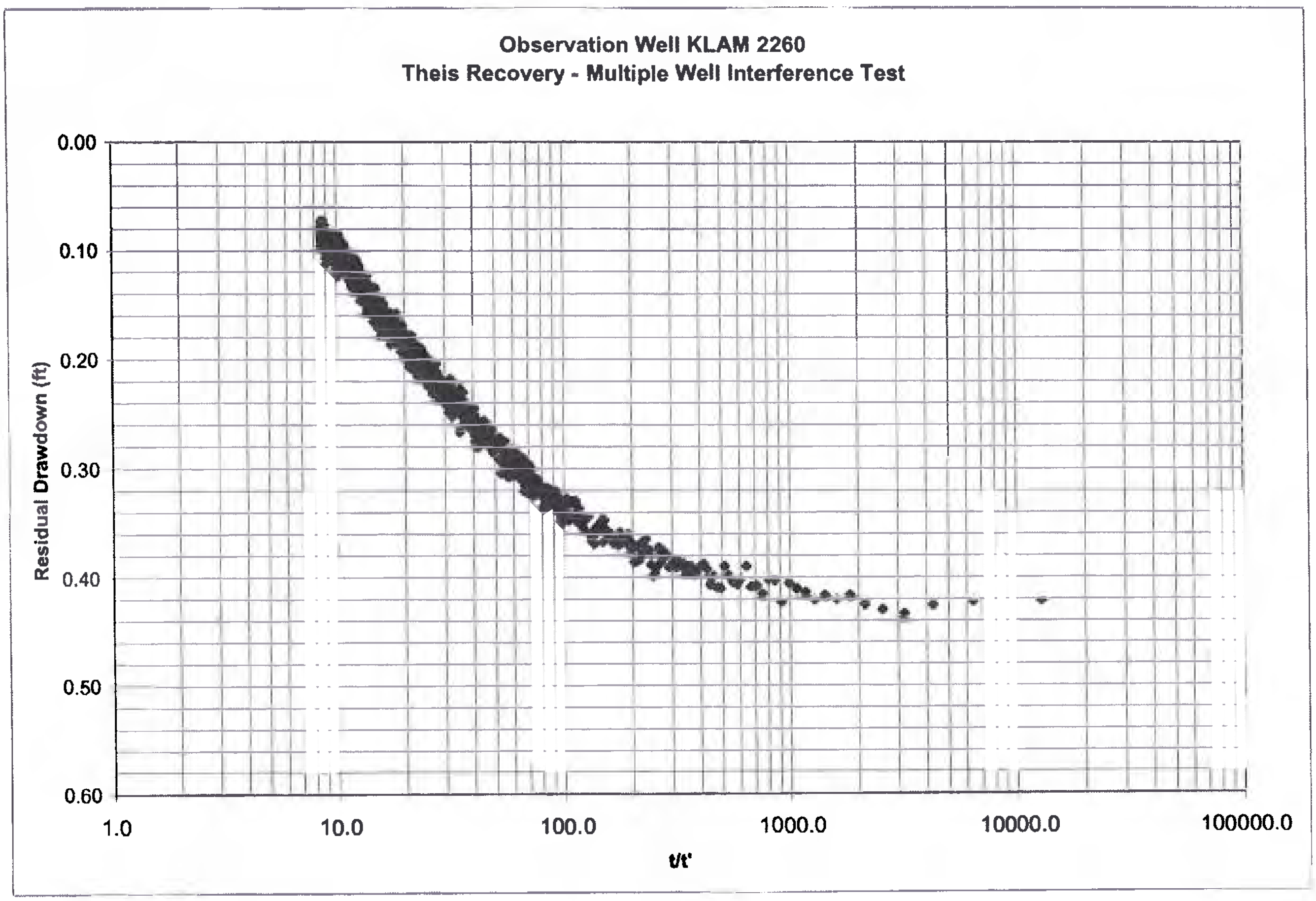

Observation Well KLAM 2260
Theis Recovery - Single Well Pumping Test
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Residual Drawdown (ft)
1.0
10.0
100.0
1000.0
10000.0
t/t'



Observation Well KLAM 2260
Cooper-Jacob Drawdown - Multiple Well Pumping Test
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Drawdown (ft)
1
10
100
1000
10000
100000
Elapsed Time (min)



Observation Well KLAM 2260
Cooper-Jacob Drawdown - Multiple Well Pumping Test
Drawdown
Barometric Pressure
Drawdown (ft)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Barometric Pressure (Ft)
29.50
29.40
29.30
29.20
29.10
29.00
28.90
28.80
28.70
28.60
28.50
1
10
100
1000
10000
100000
Elapsed Time (min)



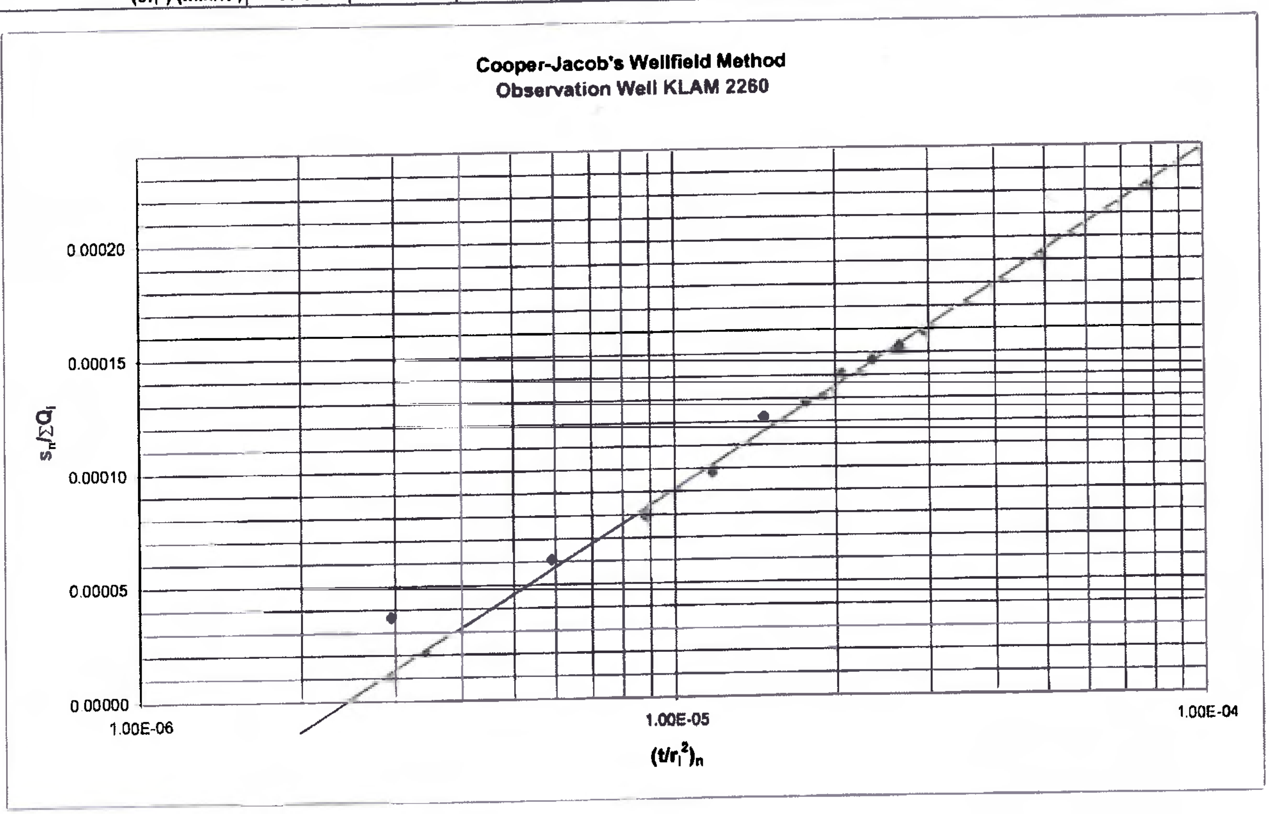
Observation Well KLAM 2260
Theis Recovery - Multiple Well Interference Test
Residual Drawdown (ft)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
1.0
10.0
100.0
1000.0
10000.0
100000.0
t/t'

Cooper-Jacob's Well Field Method - Observation Well KLAM 2260 (Wilson)
(Ref: Kruseman p. 189-191)

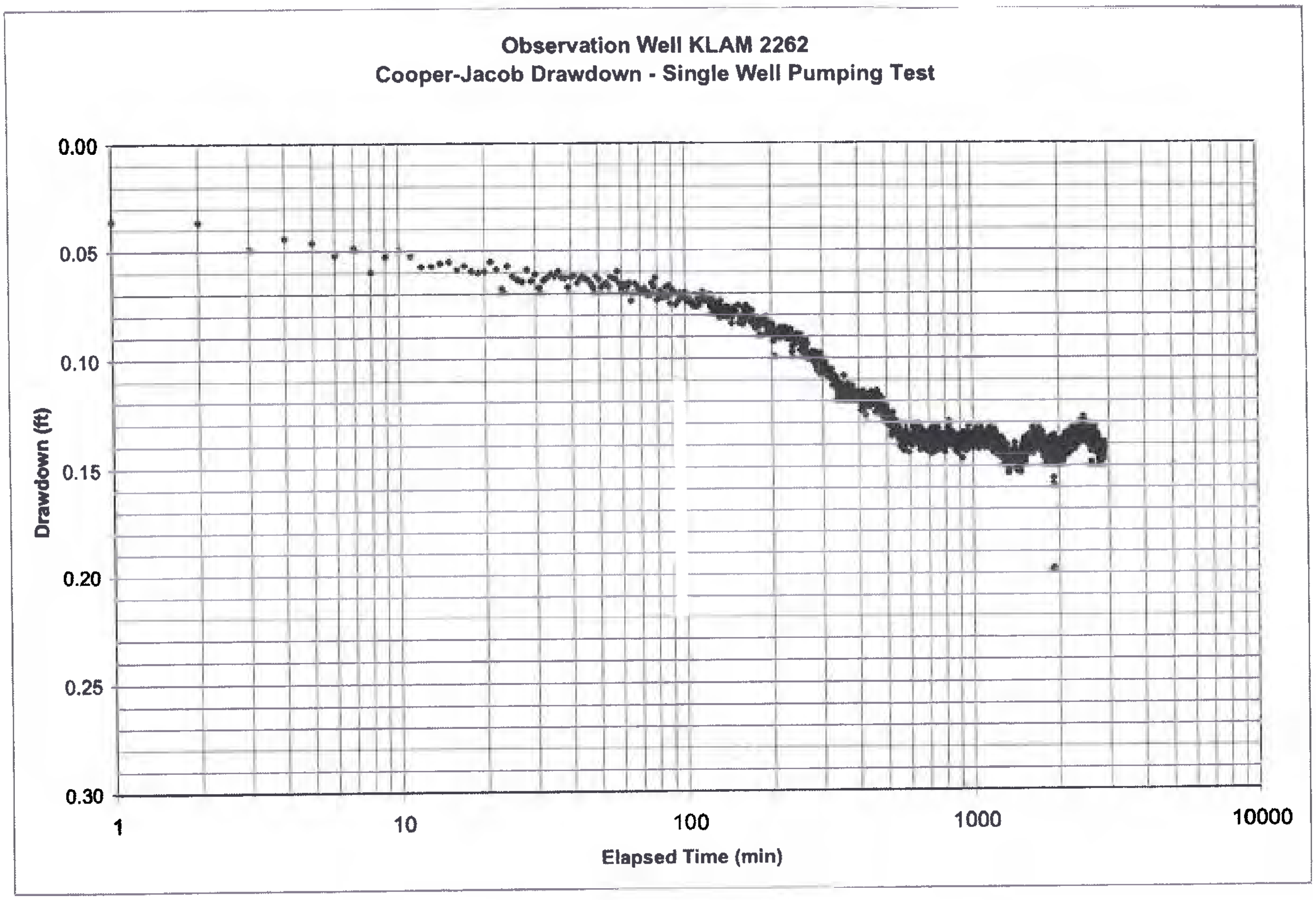
4 Pumping Wells
Well 1 = 2263 (Cove)
Well 2 = 2259 (100 Horse)
Well 3 = 2265 (Lake)
Well 4 = 2262 (Aspen)

Q_1 (cfm)	314	r_1 (ft)	6,615
Q_2 (cfm)	401	r_2 (ft)	4,147
Q_3 (cfm)	455	r_3 (ft)	17,072
Q_4 (cfm)	468	r_4 (ft)	2,516

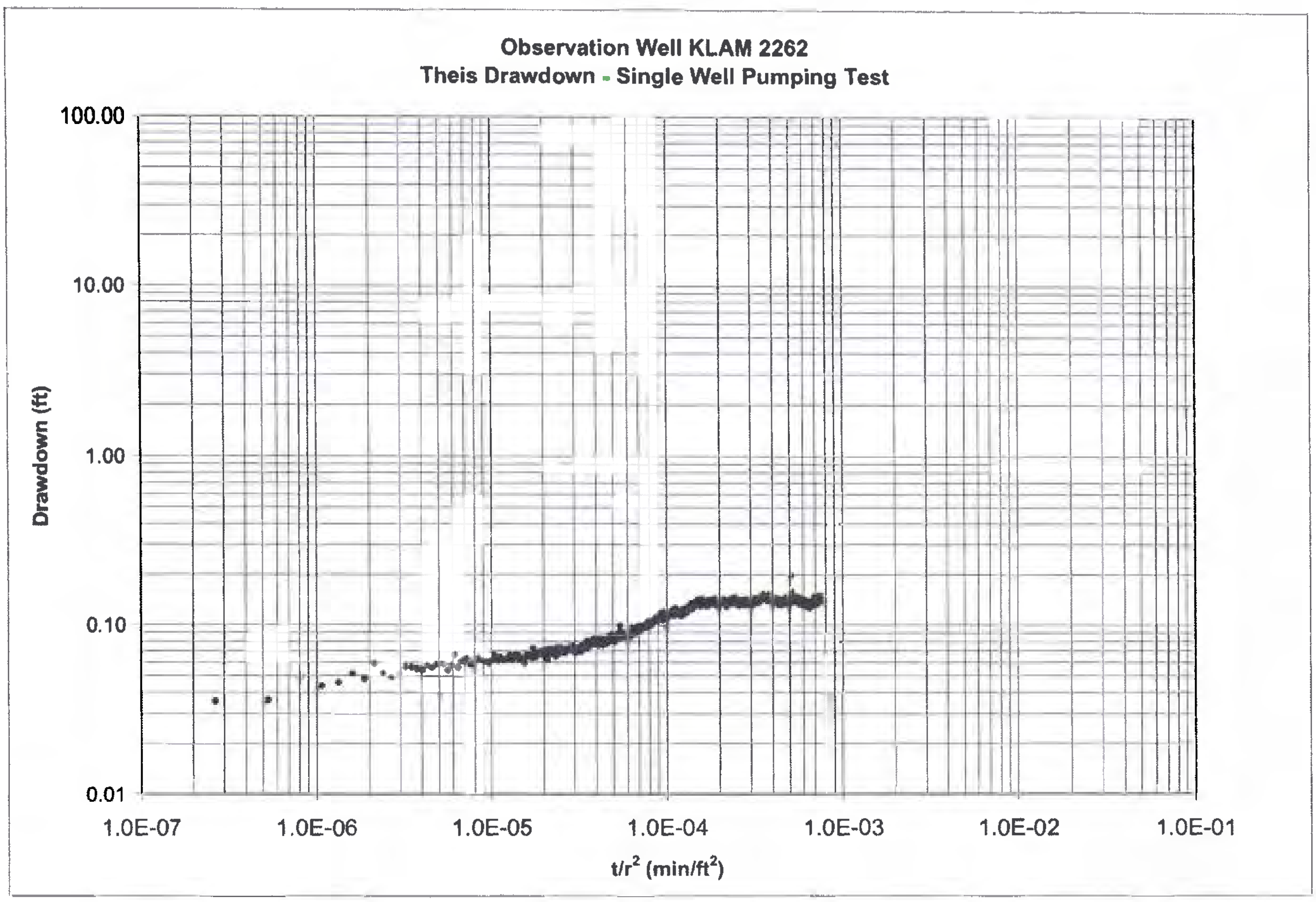
	Run									
	1	2	3	4	5	6	7	8	9	10
s_n (ft)	0.06	0.10	0.13	0.16	0.20	0.21	0.23	0.24	0.25	0.26
ΣQ_i (ft^3/min)	1638	1638	1638	1638	1638	1638	1638	1638	1638	1638
$s_n/\Sigma Qi$ (min/ft^2)	3.66E-05	6.11E-05	7.94E-05	9.77E-05	1.22E-04	1.28E-04	1.40E-04	1.47E-04	1.53E-04	1.59E-04
t_n (min)	100	200	300	400	500	600	700	800	900	1000
t_n/r_1^2	2.29E-06	4.57E-06	6.86E-06	9.14E-06	1.14E-05	1.37E-05	1.60E-05	1.83E-05	2.06E-05	2.29E-05
t_n/r_2^2	5.81E-06	1.16E-05	1.74E-05	2.33E-05	2.91E-05	3.49E-05	4.07E-05	4.65E-05	5.23E-05	5.81E-05
t_n/r_3^2	3.43E-07	6.86E-07	1.03E-06	1.37E-06	1.72E-06	2.06E-06	2.40E-06	2.74E-06	3.09E-06	3.43E-06
t_n/r_4^2	1.58E-05	3.16E-05	4.74E-05	6.32E-05	7.90E-05	9.48E-05	1.11E-04	1.26E-04	1.42E-04	1.58E-04
$Q_1 \log (t_n/r_1^2)$	-1.77E+03	-1.68E+03	-1.62E+03	-1.58E+03	-1.55E+03	-1.53E+03	-1.51E+03	-1.49E+03	-1.47E+03	-1.46E+03
$Q_2 \log (t_n/r_2^2)$	-2.10E+03	-1.98E+03	-1.91E+03	-1.86E+03	-1.82E+03	-1.79E+03	-1.76E+03	-1.74E+03	-1.72E+03	-1.70E+03
$Q_3 \log (t_n/r_3^2)$	-2.94E+03	-2.80E+03	-2.72E+03	-2.67E+03	-2.62E+03	-2.59E+03	-2.56E+03	-2.53E+03	-2.51E+03	-2.49E+03
$Q_4 \log (t_n/r_4^2)$	-2.25E+03	-2.11E+03	-2.02E+03	-1.97E+03	-1.92E+03	-1.88E+03	-1.85E+03	-1.82E+03	-1.80E+03	-1.78E+03
$\Sigma Q_i \log (t_n/r_i^2)$	-9.06E+03	-8.57E+03	-8.28E+03	-8.07E+03	-7.91E+03	-7.78E+03	-7.67E+03	-7.58E+03	-7.50E+03	-7.42E+03
$\Sigma Q_i \log (t_n/r_i^2) / \Sigma Q_i$	-5.53E+00	-5.23E+00	-5.05E+00	-4.93E+00	-4.83E+00	-4.75E+00	-4.69E+00	-4.63E+00	-4.58E+00	-4.53E+00
(t/r_i^2) (min/ft^2)	2.95E-06	5.89E-06	8.84E-06	1.18E-05	1.47E-05	1.77E-05	2.06E-05	2.36E-05	2.65E-05	2.95E-05



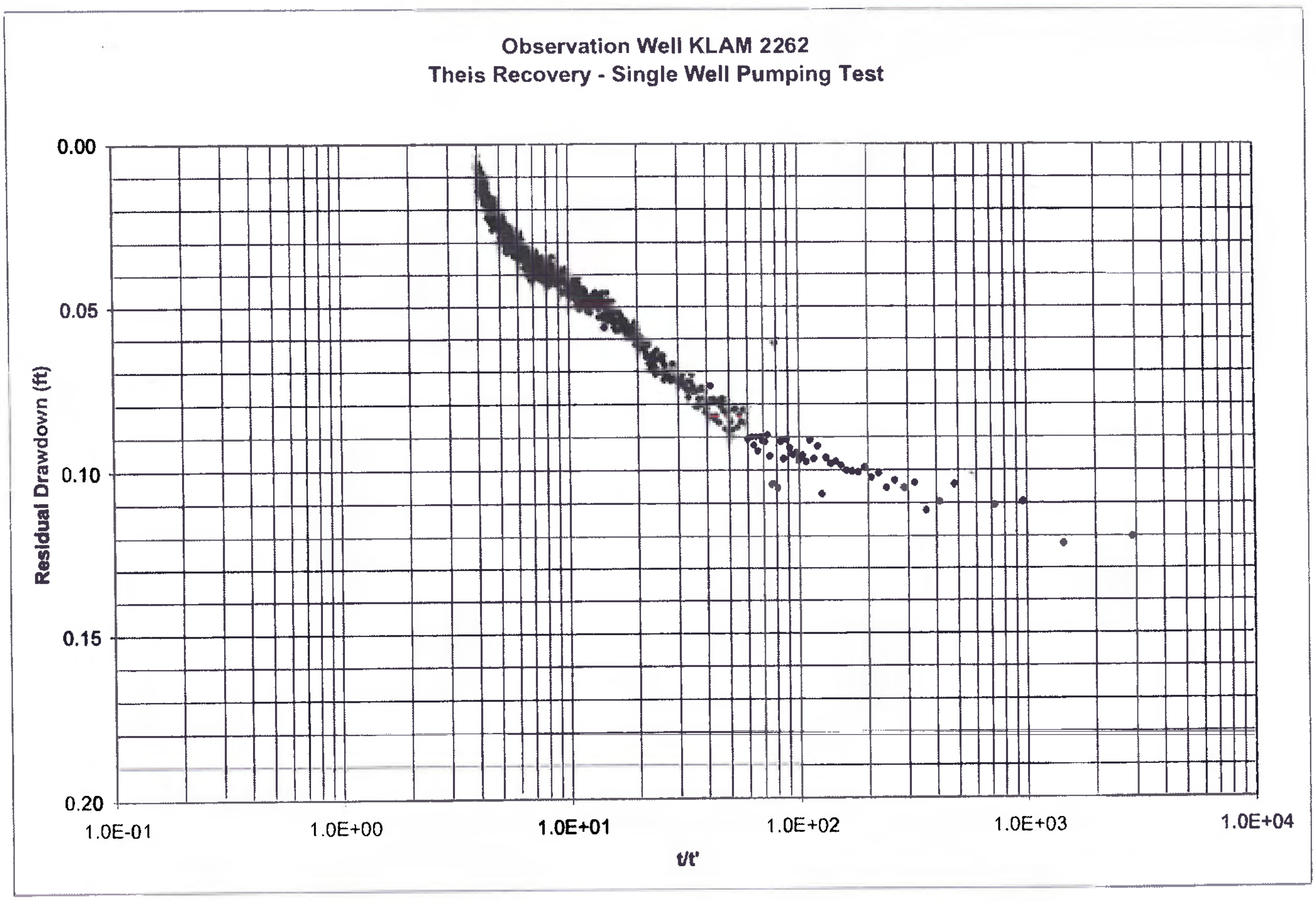
Transmissivity = 1,896,175 ft2/day
Storage Coeff = 0.0074



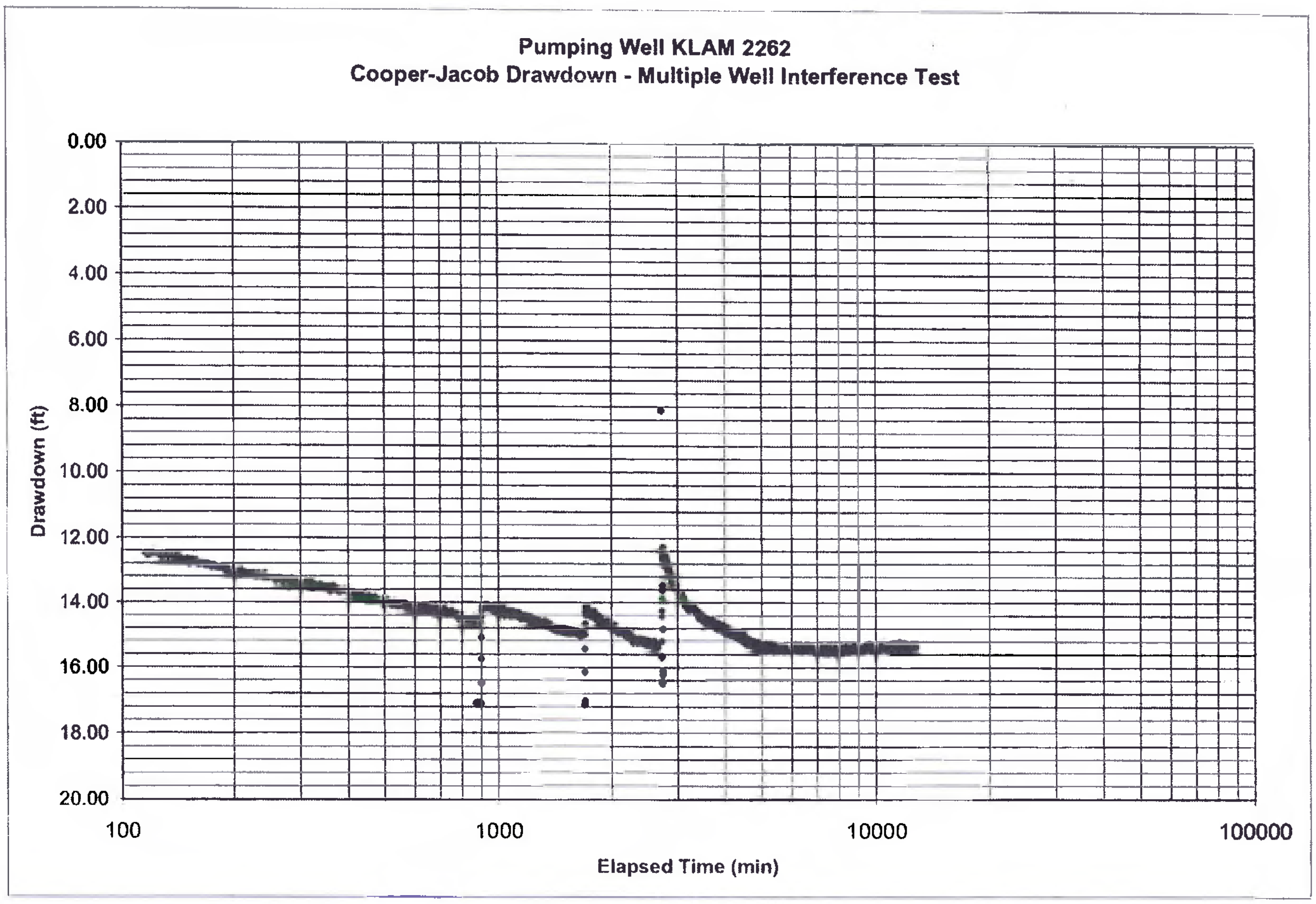
Observation Well KLAM 2262
Cooper-Jacob Drawdown - Single Well Pumping Test
Drawdown (ft)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1
10
100
1000
10000
Elapsed Time (min)



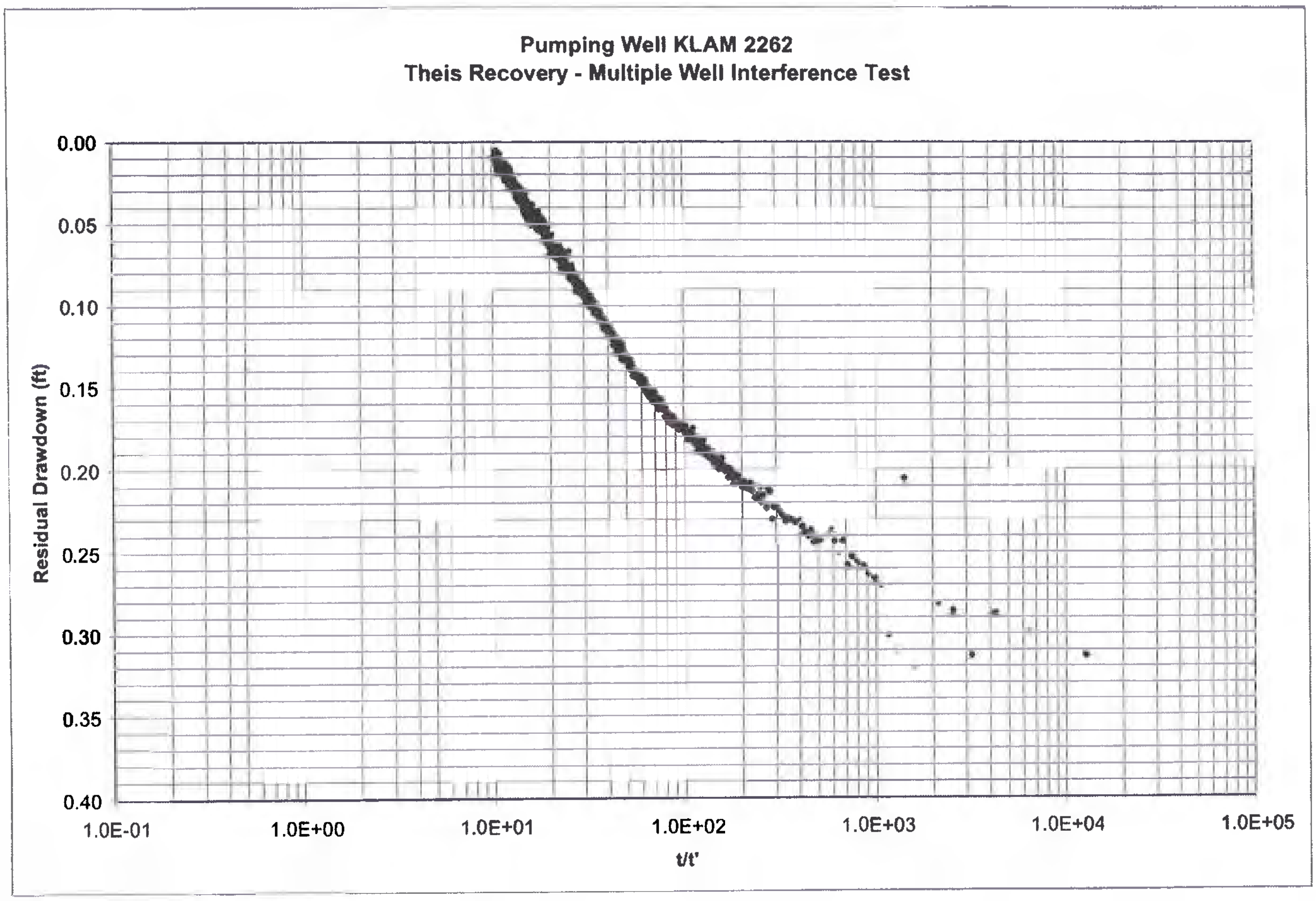
Observation Well KLAM 2262
Theis Drawdown - Single Well Pumping Test
Drawdown (ft)
100.00
10.00
1.00
0.10
0.01
1.0E-07
1.0E-06
1.0E-05
1.0E-04
1.0E-03
1.0E-02
1.0E-01
t/r2 (min/ft2)



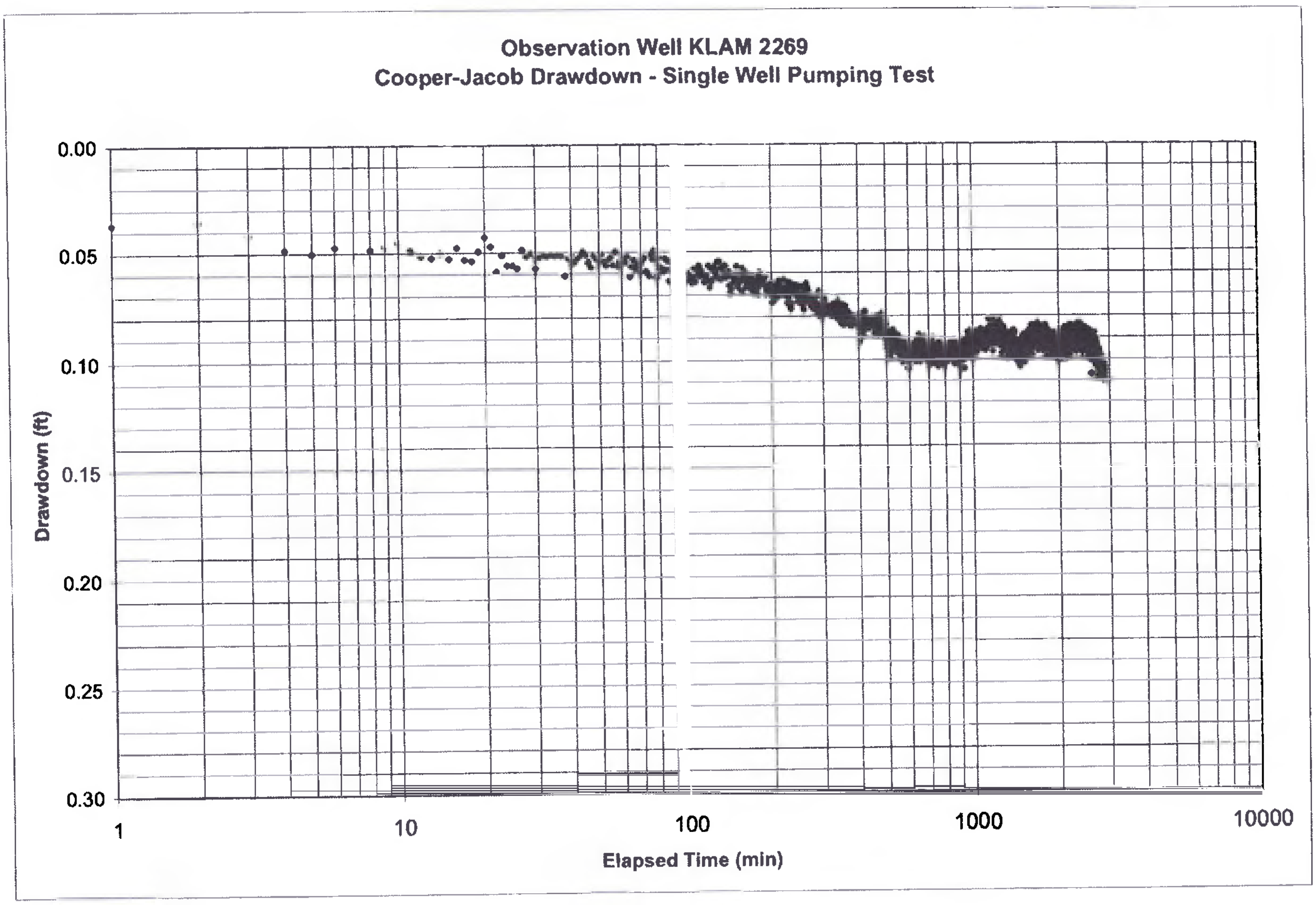
Observation Well KLAM 2262
Theis Recovery - Single Well Pumping Test
0.00
0.05
0.10
0.15
0.20
Residual Drawdown (ft)
1.0E-01
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
t/t'

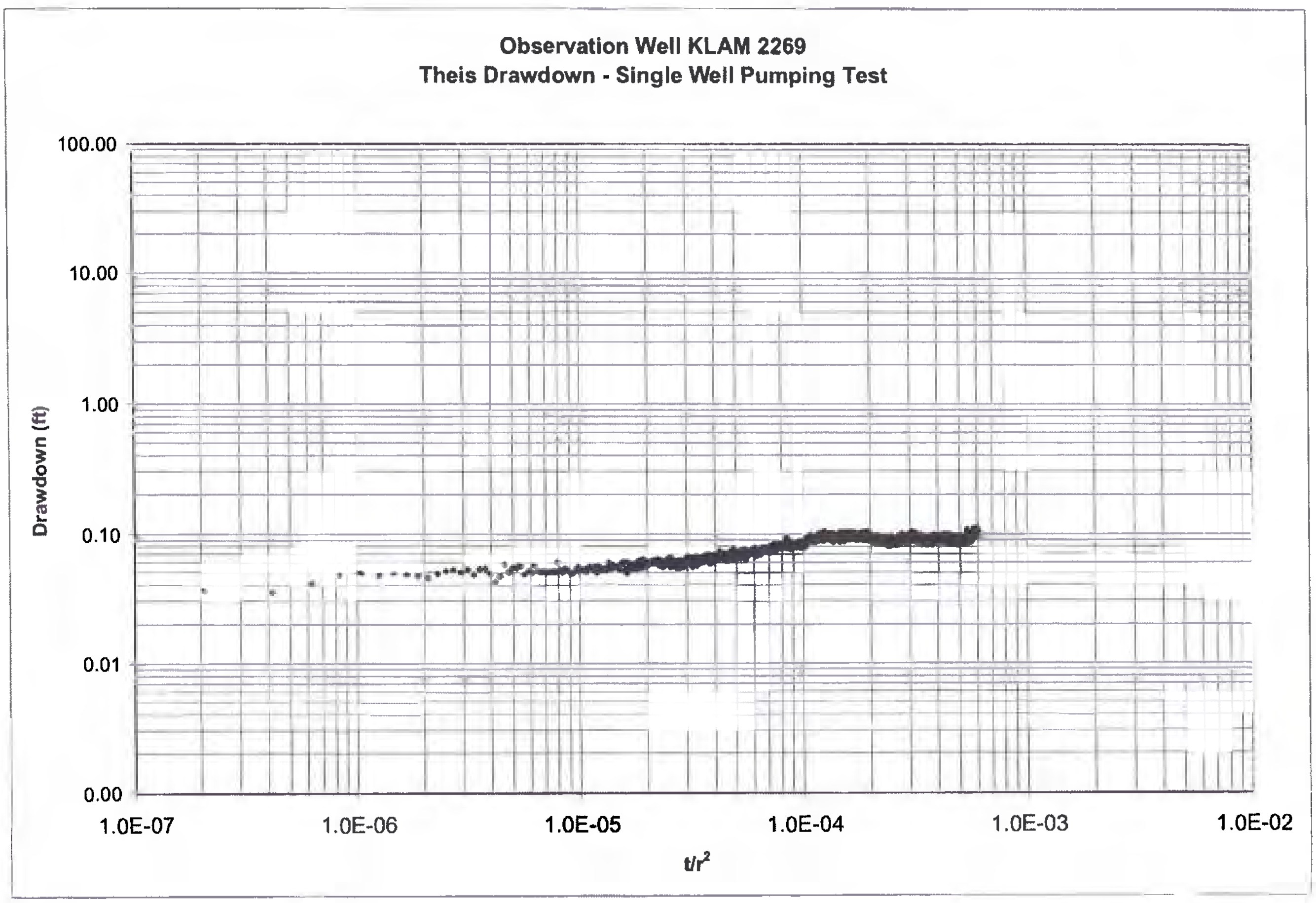


Pumping Well KLAM 2262
Cooper-Jacob Drawdown - Multiple Well Interference Test
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
Drawdown (ft)
100
1000
10000
100000
Elapsed Time (min)

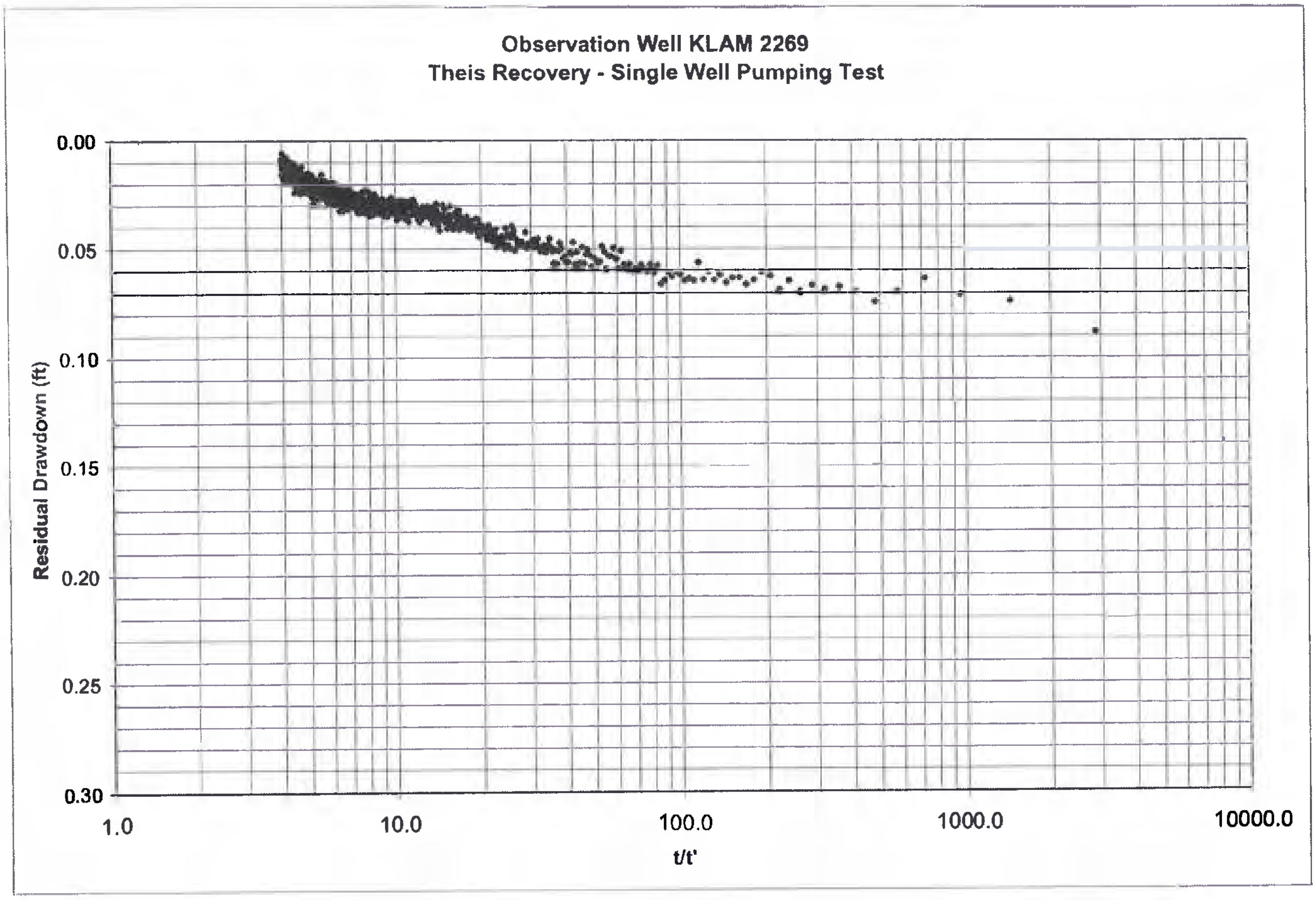

Pumping Well KLAM 2262
Theis Recovery - Multiple Well Interference Test
Residual Drawdown (ft)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
1.0E-01
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
1.0E+05
t/t'

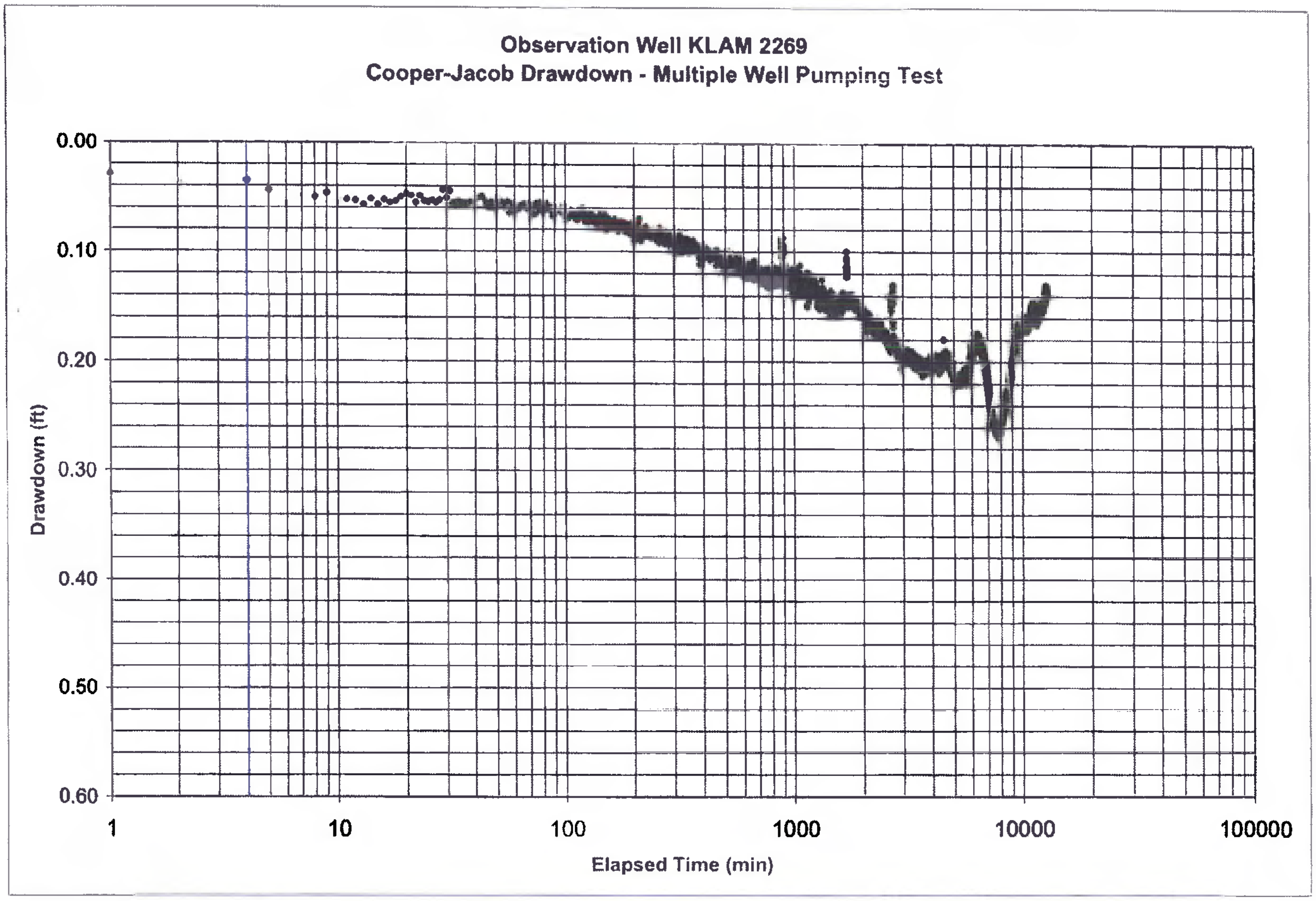
KLAM 2269


Observation Well KLAM 2269
Cooper-Jacob Drawdown - Single Well Pumping Test
Drawdown (ft)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1
10
100
1000
10000
Elapsed Time (min)

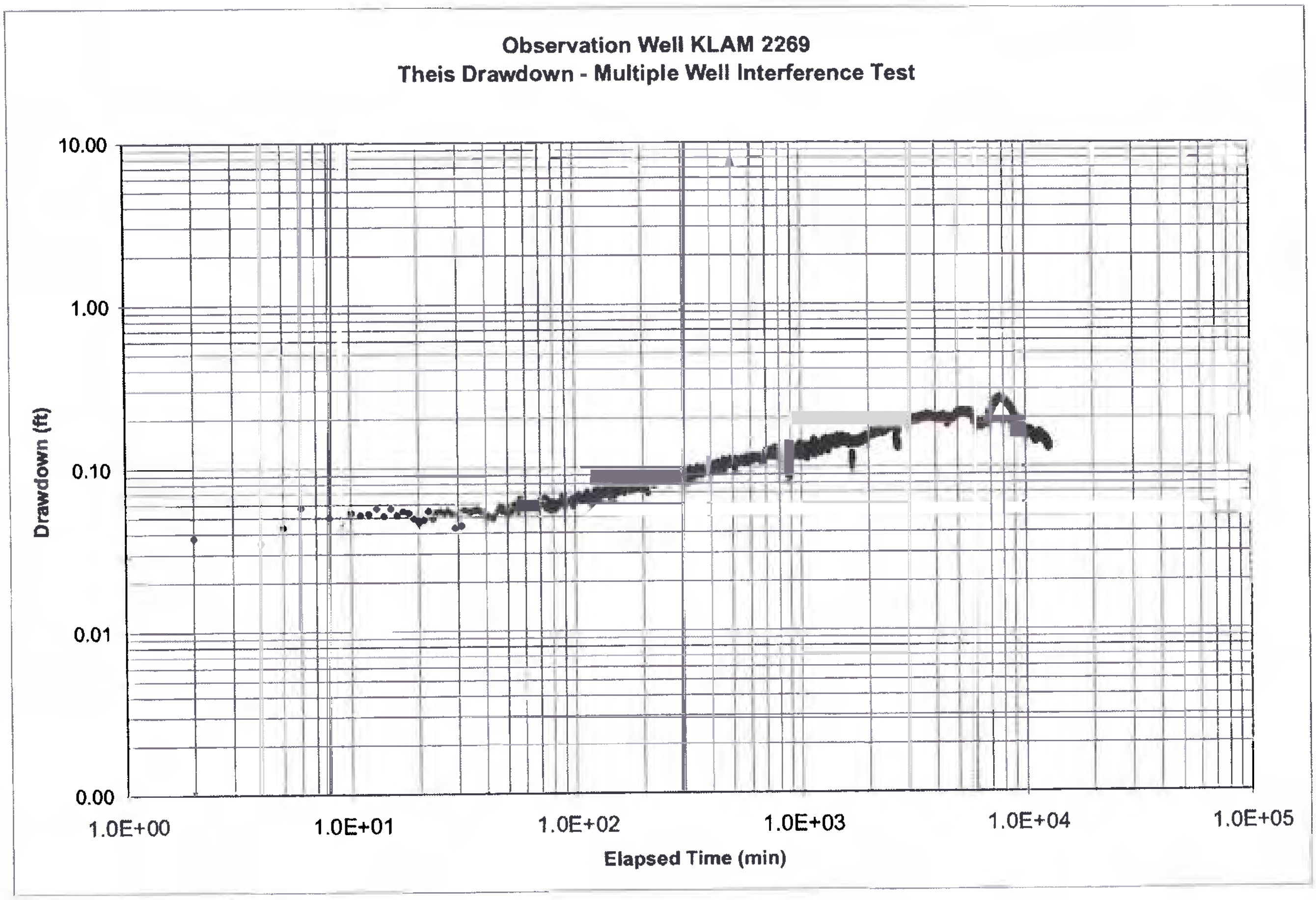


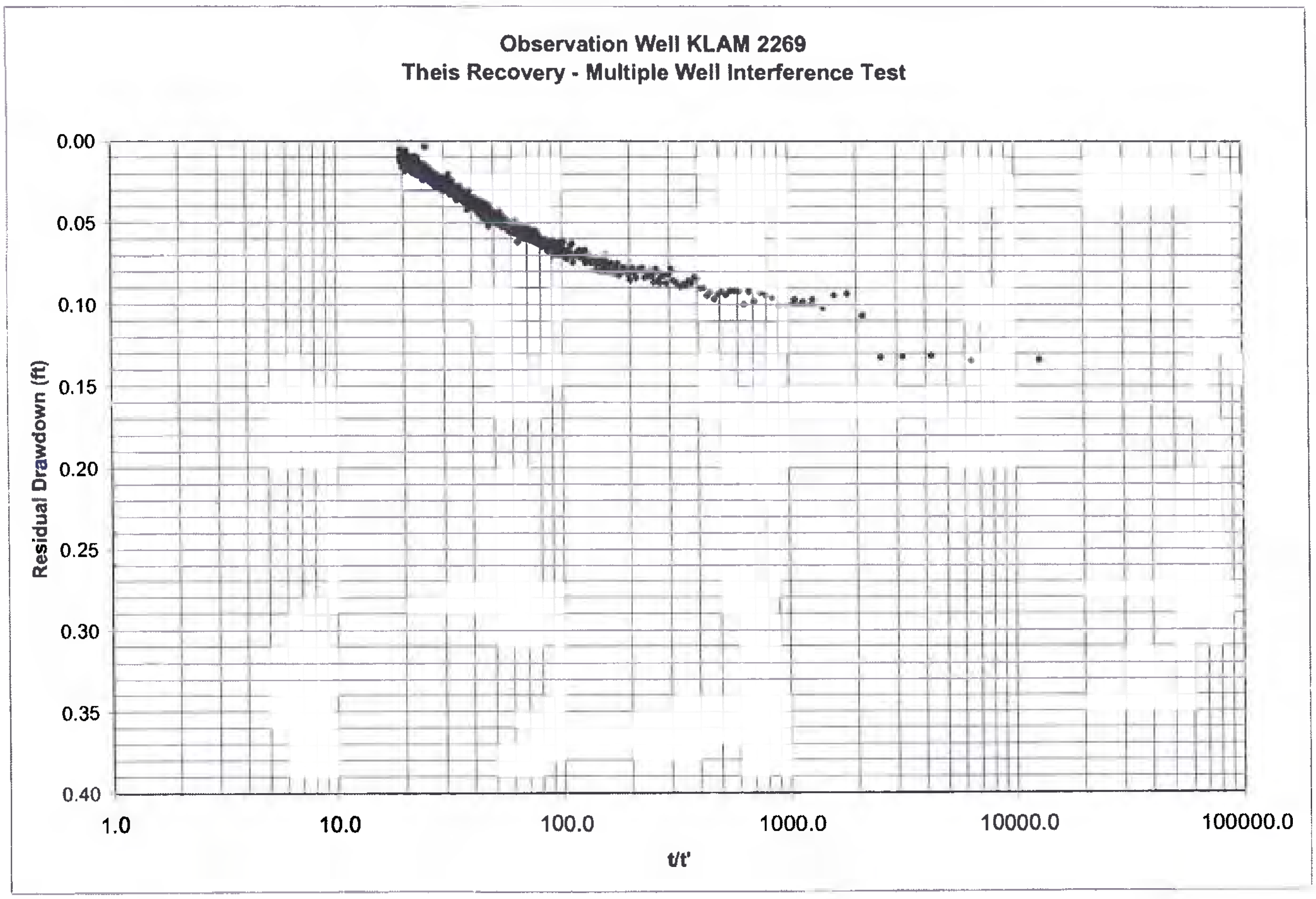
Observation Well KLAM 2269
Theis Drawdown - Single Well Pumping Test
100.00
10.00
1.00
0.10
0.01
0.00
Drawdown (ft)
1.0E-07
1.0E-06
1.0E-05
1.0E-04
1.0E-03
1.0E-02
t/r2


Observation Well KLAM 2269
Theis Recovery - Single Well Pumping Test
Residual Drawdown (ft)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1.0
10.0
100.0
1000.0
10000.0
t/t'



Observation Well KLAM 2269
Cooper-Jacob Drawdown - Multiple Well Pumping Test
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Drawdown (ft)
1
10
100
1000
10000
100000
Elapsed Time (min)


Observation Well KLAM 2269
Theis Drawdown - Multiple Well Interference Test
10.00
1.00
0.10
0.01
0.00
Drawdown (ft)
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
1.0E+05
Elapsed Time (min)



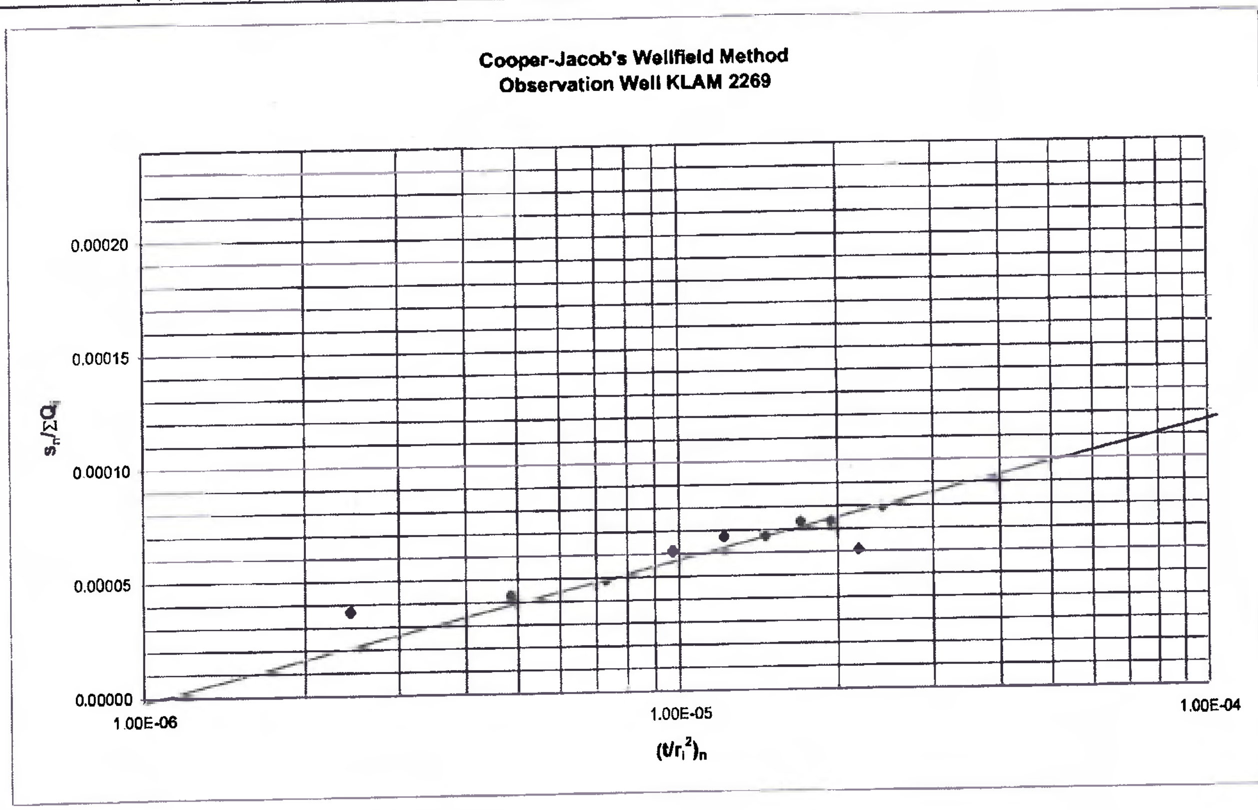
Observation Well KLAM 2269
Theis Recovery - Multiple Well Interference Test
Residual Drawdown (ft)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
1.0
10.0
100.0
1000.0
10000.0
100000.0
t/t'

Cooper-Jacob's Well Field Method - Observation Well KLAM 2269
(Ref: Kruseman p. 189-191)

4 Pumping Wells
Well 1 = 2263 (Cove)
Well 2 = 2259 (100 Horse)
Well 3 = 2265 (Lake)
Well 4 = 2262 (Aspen)

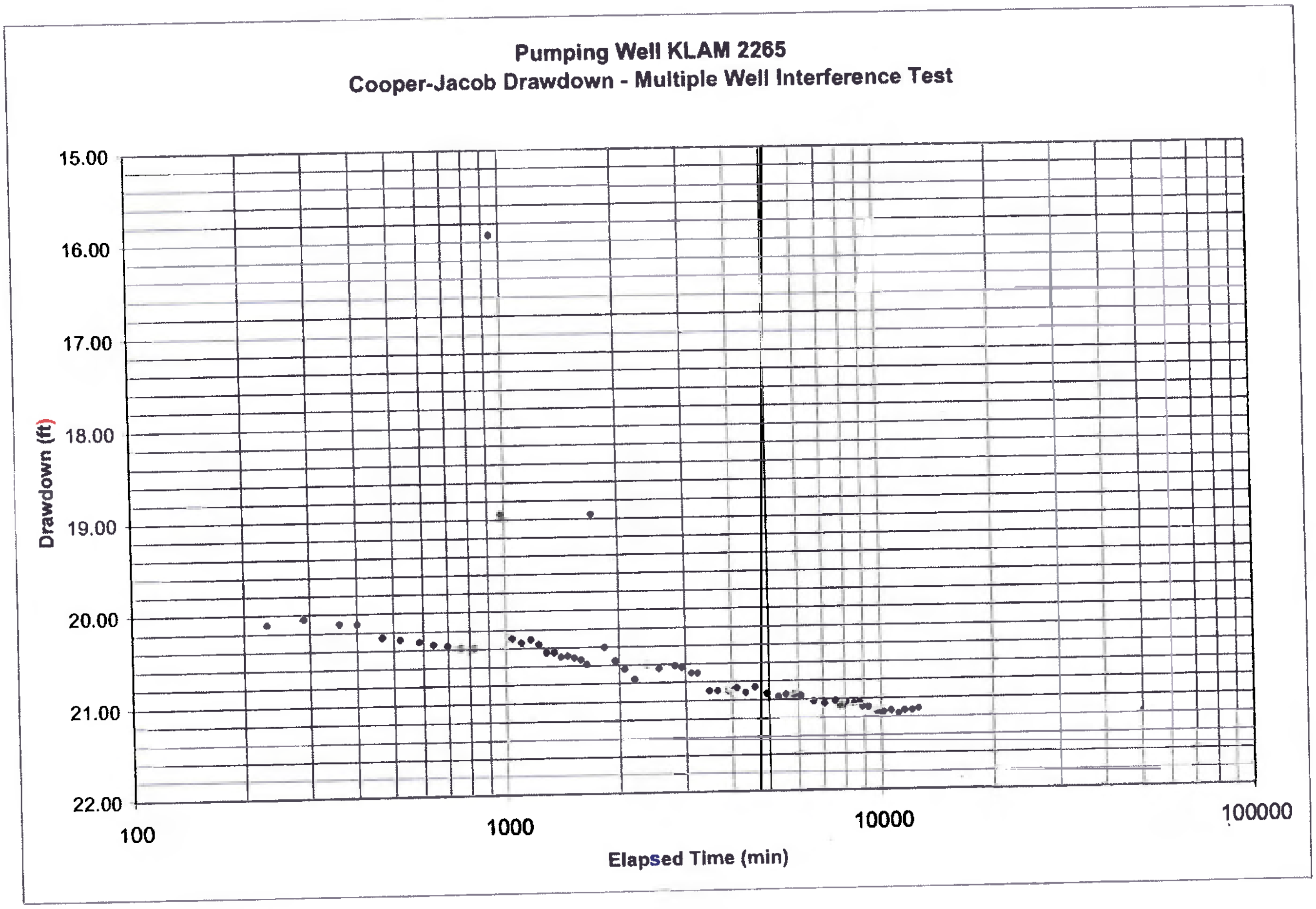
Q_1 (cfm)	314	r_1 (ft)	10,702
Q_2 (cfm)	401	r_2 (ft)	2,192
Q_3 (cfm)	455	r_3 (ft)	19,660
Q_4 (cfm)	468	r_4 (ft)	3,840

	Run									
	1	2	3	4	5	6	7	8	9	10
s_n (ft)	0.06	0.07	0.08	0.10	0.11	0.11	0.12	0.12	0.10	0.13
ΣQ_i (ft^3/min)	1638	1638	1638	1638	1638	1638	1638	1638	1638	1638
$s_n/\Sigma Qi$ (min/ft^2)	3.66E-05	4.27E-05	4.88E-05	6.11E-05	6.72E-05	6.72E-05	7.33E-05	7.33E-05	6.11E-05	7.94E-05
t_n (min)	100	200	300	400	500	600	700	800	900	1000
t_n/r_1^2	8.73E-07	1.75E-06	2.62E-06	3.49E-06	4.37E-06	5.24E-06	6.11E-06	6.98E-06	7.86E-06	8.73E-06
t_n/r_2^2	2.08E-05	4.16E-05	6.24E-05	8.32E-05	1.04E-04	1.25E-04	1.46E-04	1.66E-04	1.87E-04	2.08E-04
t_n/r_3^2	2.59E-07	5.17E-07	7.76E-07	1.03E-06	1.29E-06	1.55E-06	1.81E-06	2.07E-06	2.33E-06	2.59E-06
t_n/r_4^2	6.78E-06	1.36E-05	2.03E-05	2.71E-05	3.39E-05	4.07E-05	4.75E-05	5.43E-05	6.10E-05	6.78E-05
$Q_1 \log (t_n/r_1^2)$	-1.90E+03	-1.81E+03	-1.75E+03	-1.71E+03	-1.68E+03	-1.66E+03	-1.64E+03	-1.62E+03	-1.60E+03	-1.59E+03
$Q_2 \log (t_n/r_2^2)$	-1.88E+03	-1.76E+03	-1.69E+03	-1.64E+03	-1.60E+03	-1.57E+03	-1.54E+03	-1.52E+03	-1.49E+03	-1.48E+03
$Q_3 \log (t_n/r_3^2)$	-3.00E+03	-2.86E+03	-2.78E+03	-2.72E+03	-2.68E+03	-2.64E+03	-2.61E+03	-2.59E+03	-2.56E+03	-2.54E+03
$Q_4 \log (t_n/r_4^2)$	-2.42E+03	-2.28E+03	-2.20E+03	-2.14E+03	-2.09E+03	-2.05E+03	-2.02E+03	-2.00E+03	-1.97E+03	-1.95E+03
$\Sigma Q_i \log (t_n/r_i^2)$	-9.20E+03	-8.70E+03	-8.41E+03	-8.21E+03	-8.05E+03	-7.92E+03	-7.81E+03	-7.72E+03	-7.63E+03	-7.56E+03
$\Sigma Q_i \log (t_n/r_i^2) / \Sigma Q_i$	-5.61E+00	-5.31E+00	-5.14E+00	-5.01E+00	-4.92E+00	-4.84E+00	-4.77E+00	-4.71E+00	-4.66E+00	-4.61E+00
(t/r_i^2) (min/ft^2)	2.43E-06	4.86E-06	7.29E-06	9.73E-06	[illegible]	1.46E-05	1.70E-05	1.95E-05	2.19E-05	[illegible]

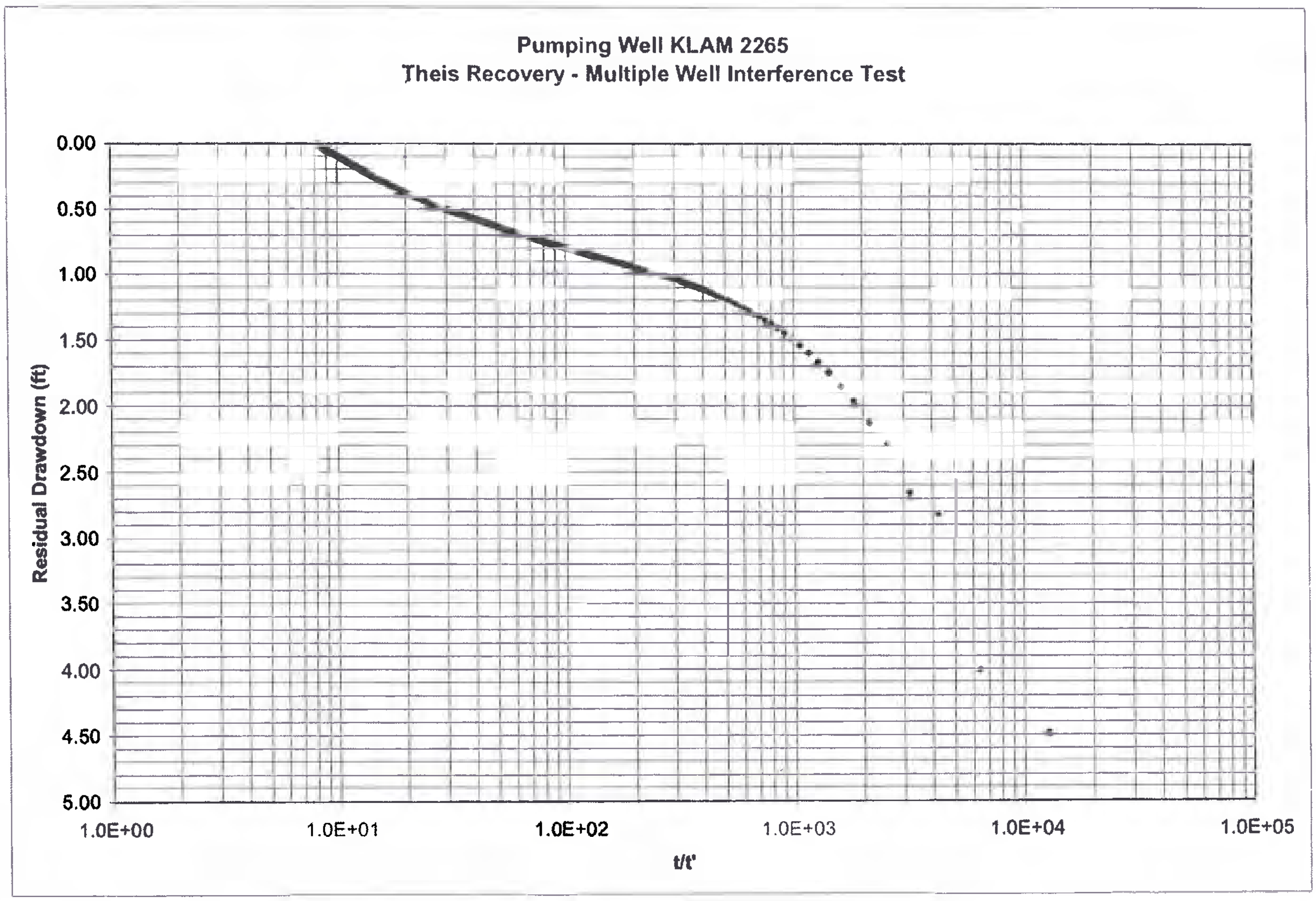


Transmissivity = 4,392,000 ft2/day
Storage Coeff = 0.0069

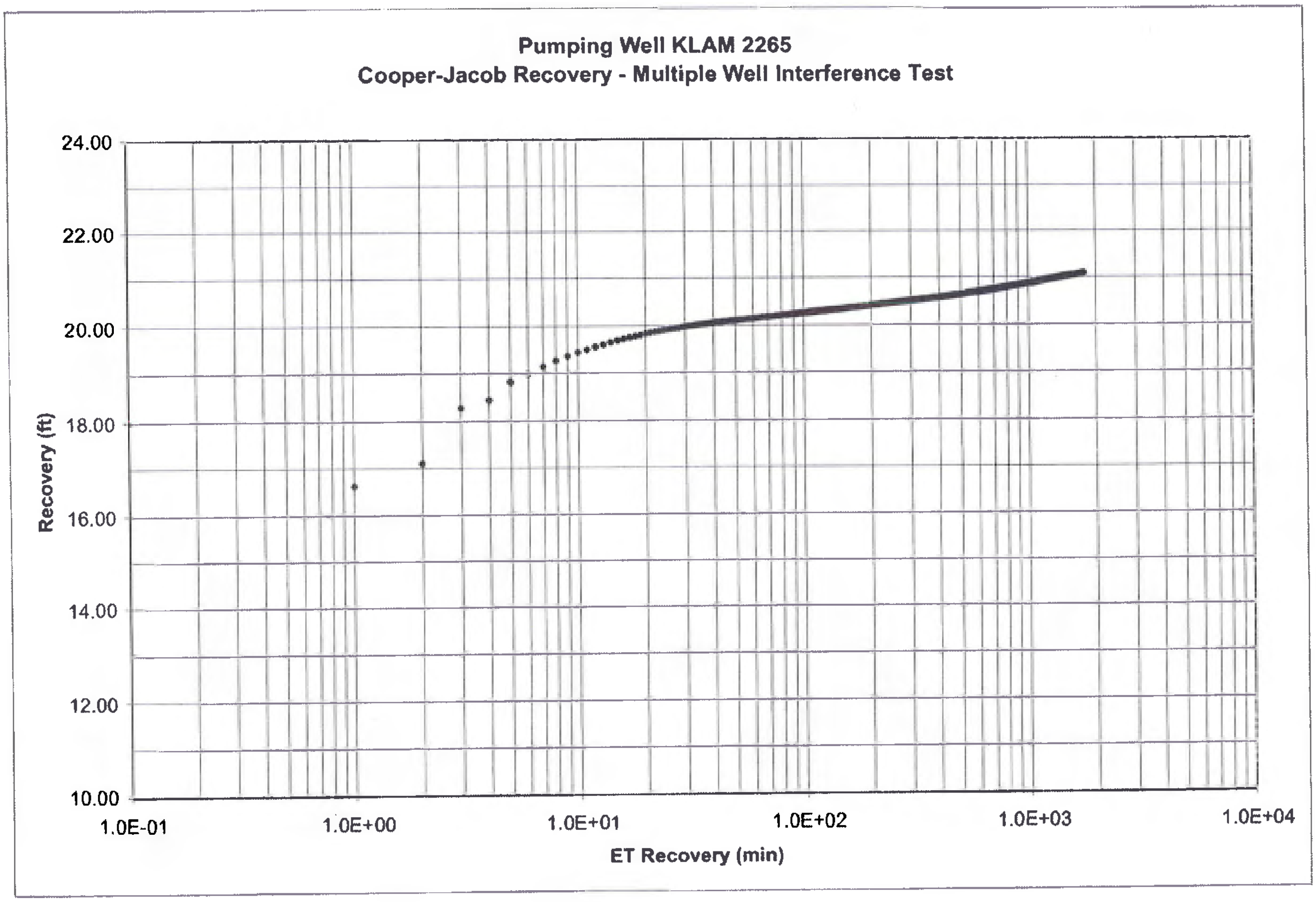
KLAM 2265



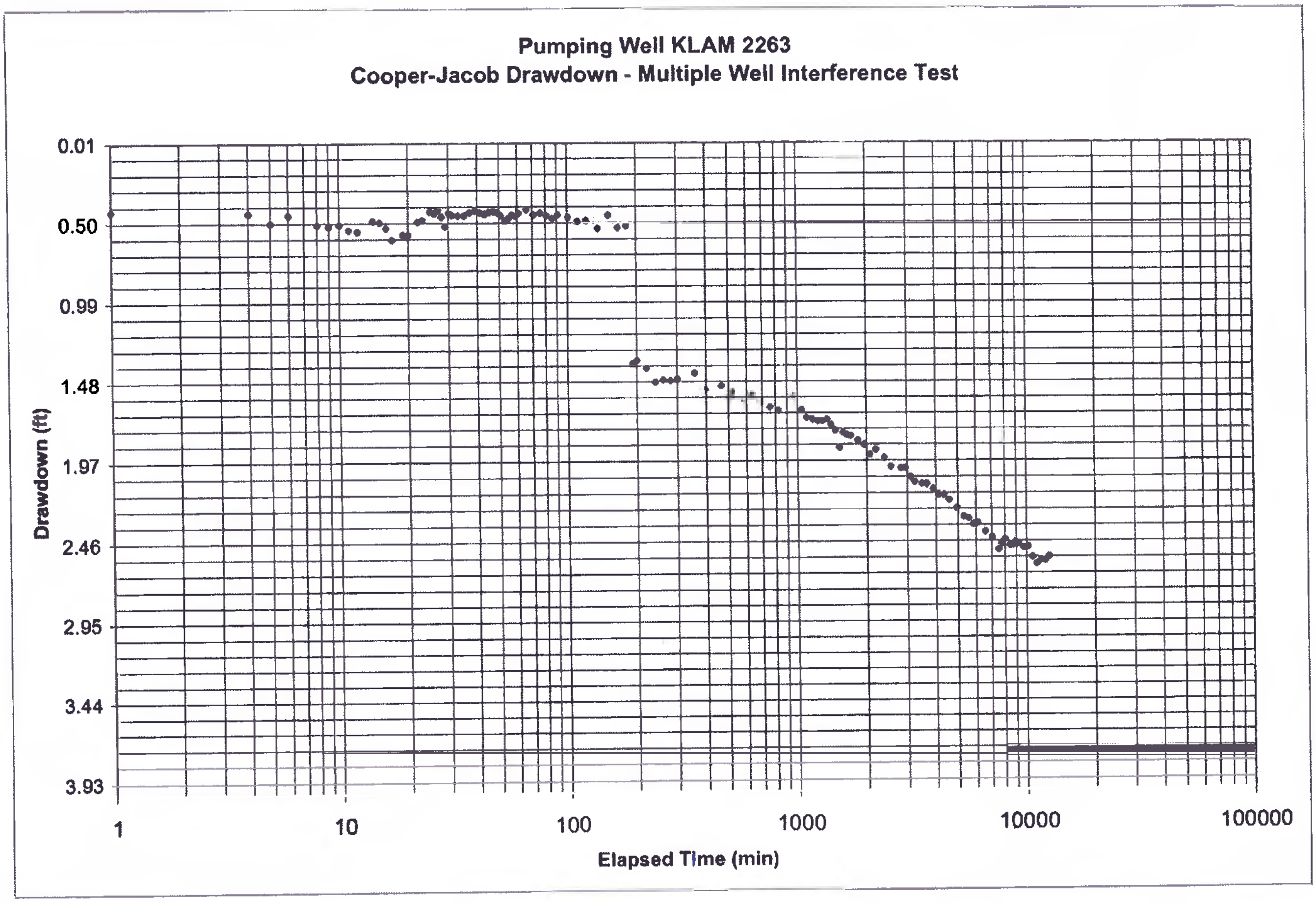
Pumping Well KLAM 2265
Cooper-Jacob Drawdown - Multiple Well Interference Test
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
Drawdown (ft)
100
1000
10000
100000
Elapsed Time (min)



Pumping Well KLAM 2265
Theis Recovery - Multiple Well Interference Test
Residual Drawdown (ft)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
1.0E+05
t/t'


Pumping Well KLAM 2265
Cooper-Jacob Recovery - Multiple Well Interference Test
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
Recovery (ft)
1.0E-01
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
ET Recovery (min)

KLAM 2263



Pumping Well KLAM 2263
Cooper-Jacob Drawdown - Multiple Well Interference Test
Drawdown (ft)
0.01
0.50
0.99
1.48
1.97
2.46
2.95
3.44
3.93
1
10
100
1000
10000
100000
Elapsed Time (min)

APPENDIX D

APPENDIX D

DRAWDOWN ESTIMATIONS

Theis Drawdown Approximation

CALIBRATION RUN

$$s = \frac{Q}{4\pi T} W(u)$$

$$u = \frac{r^2 S}{4Tt}$$

Where:

s = drawdown
Q = pumping rate
T = transmissivity
W(u) = Well function using approximation by Srivastava (1995):
r = distance from pumping well
S = Storage coefficient
t = time

For u<1
$$W(u) = \ln\left(\frac{C_1}{u}\right) + 0.9563\,u - 0.1690\,u^2$$

For u>1
$$W(u) = \frac{1}{ue^u}\,\frac{u + 0.3575}{u + 1.280}$$

DO NOT EDIT HIGHLIGHTED CELLS

Drawdown at KLAM 2260 (Used T to match observed data)

T			Q		Time	Distance			Drawdown At r	
(gpd/ft)	(Ft^3/day)	S	(gpm)	(Ft^3/day)	(days)	(feet)	u	W(u)	(feet)	Remark
13,440,056	1,796,799	0.007	3000	577540.11	7	4,147	0.002392812	5.460373	0.14	Due to KLAM 2259
13,440,056	1,796,799	0.007	3500	673796.79	7	2,516	0.000880769	6.458358	0.19	Due to KLAM 2262
13,440,056	1,796,799	0.007	2350	452406.42	7	6,615	0.006088359	4.529993	0.09	Due to KLAM 2263
13,440,056	1,796,799	0.007	3400	654545.45	7	17,072	0.040551724	2.666479	0.06	Due to KLAM 2265
									0.50	NET Drawdown at KLAM 2260, matches observed value

Drawdown at KLAM 2269 (Used T to match observed data)

T			Q		Time	Distance			Drawdown At r	
(gpd/ft)	(Ft^3/day)	S	(gpm)	(Ft^3/day)	(days)	(feet)	u	W(u)	(feet)	Remark
28,913,758	3,885,476	0.007	3000	577540.11	7	2,192	0.000310755	7.499603	0.09	Due to KLAM 2259
28,913,758	3,865,476	0.007	3500	673796.79	7	3,840	0.000953673	6.378902	0.09	Due to KLAM 2262
28,913,758	3,885,476	0.007	2350	452406.42	7	10,702	0.00740742	4.335148	0.04	Due to KLAM 2263
28,913,758	3,865,476	0.007	3400	654545.45	7	19,660	0.024997932	3.135562	0.04	Due to KLAM 2265
									0.26	NET Drawdown at KLAM 2269, matches observed value

Drawdown at KLAM 2289 (T value average of CJ Wellfield Method)

T			Q		Time	Distance			Drawdown At r	
(gpd/ft)	(Ft^3/day)	S	(gpm)	(Ft^3/day)	(days)	(feet)	u	W(u)	(feet)	Remark
23,517,868	3,144,100	0.007	3000	577540.11	7	12,240	0.011912598	3.864327	0.06	Due to KLAM 2259
23,517,868	3,144,100	0.007	3500	673796.79	7	14,175	0.0159788	3.574653	0.06	Due to KLAM 2262
23,517,866	3,144,100	0.007	2350	452406.42	7	16,959	0.02286884	3.222561	0.04	Due to KLAM 2263
23,517,868	3,144,100	0.007	3400	654545.45	7	21,076	0.035319947	2.799673	0.05	Due to KLAM 2265
									0.20	NET Drawdown at KLAM 2289; does NOT match observed value (no drawdown observed)

Drawdown at KLAM 12186 (T value average of CJ Wellfield Method)

T			Q		Time	Distance			Drawdown At r	
(gpd/ft)	(Ft^3/day)	S	(gpm)	(Ft^3/day)	(days)	(feet)	u	W(u)	(feet)	Remark
23,517,868	3,144,100	0.007	3000	577540.11	7	25,336	0.051041069	2.446295	0.04	Due to KLAM 2259
23,517,868	3,144,100	0.007	3500	673796.79	7	27,218	0.058905531	2.310365	0.04	Due to KLAM 2262
23,517,868	3,144,100	0.007	2350	452406.42	7	27,452	0.059922737	2.294197	0.03	Due to KLAM 2263
23,517,868	3,144,100	0.007	3400	654545.45	7	26,572	0.056142551	2.355816	0.04	Due to KLAM 2265
									0.14	NET Drawdown at KLAM 12186 does NOT match observed value (no drawdown observed)

Drawdown at KLAM 50362 (T value average of CJ Wellfield Method)

T			Q		Time	Distance			Drawdown At r	
(gpd/ft)	(Ft^3/day)	S	(gpm)	(Ft^3/day)	(days)	(feet)	u	W(u)	(feet)	Remark
23,517,868	3,144,100	0.007	3000	577540.11	7	34,941	0.097076547	1.846297	0.03	Due to KLAM 2259
23,517,668	3,144,100	0.007	3500	673796.79	7	35,734	0.101532931	1.805526	0.03	Due to KLAM 2262
23,517,868	3,144,100	0.007	2350	452406.42	7	28,981	0.066783687	2.192208	0.03	Due to KLAM 2263
23,517,868	3,144,100	0.007	3400	654545.45	7	18,916	0.02845131	3.009432	0.05	Due to KLAM 2265
									0.13	NET Drawdown at KLAM 50362 does NOT match observed value (no drawdown observed)

Drawdown at KLAM 12203 (T value average of CJ Wellfield Method)

T			Q		Time	Distance			Drawdown At r	
(gpd/ft)	(Ft^3/day)	S	(gpm)	(Ft^3/day)	(days)	(feet)	u	W(u)	(feet)	Remark
23,517,888	3,144,100	0.007	3000	577540.11	7	38,966	0.120730031	1.649989	0.02	Due to KLAM 2259
23,517,668	3,144,100	0.007	3500	673796.79	7	40,294	0.129099459	1.590613	0.03	Due to KLAM 2262
23,517,886	3,144,100	0.007	2350	452406.42	7	35,560	0.100546548	1.814379	0.02	Due to KLAM 2263
23,517,888	3,144,100	0.007	3400	654545.45	7	27,506	0.060158713	2.290487	0.04	Due to KLAM 2265
									0.11	NET Drawdown at KLAM 50362 does NOT match observed value (no drawdown observed)

Drawdown at KLAM 12420 (T value average of CJ Wellfield Method)

T			Q		Time	Distance			Drawdown At r	
(gpd/ft)	(Ft^3/day)	S	(gpm)	(Ft^3/day)	(days)	(feet)	u	W(u)	(feet)	Remark
23,517,868	3,144,100	0.007	3000	577540.11	7	54,149	0.233144159	1.092668	0.02	Due to KLAM 2259
23,517,868	3,144,100	0.007	3500	673796.79	7	55,257	0.242782994	1.060599	0.02	Due to KLAM 2262
23,517,868	3,144,100	0.007	2350	452406.42	7	49,363	0.193752248	1.242916	0.01	Due to KLAM 2263
23,517,868	3,144,100	0.007	3400	654545.45	7	39,772	0.125776214	1.613657	0.03	Due to KLAM 2265
									0.08	NET Drawdown at KLAM 50362 does NOT match observed value (no drawdown observed)

Reference

Srivastava, R.,1995, Implications of using approximate expressions for well function. J. Irrig. And Drain. Engineering. 121, no. 6: 459-462

Theis Drawdown Approximation

PROJECTION RUN - 3 YEARS PUMPING AT PRO-RATED RATES (PUMPING WELLS)

$$s = \frac{Q}{4\pi T} W(u)$$

$$u = \frac{r^2 S}{4Tt}$$

Where:

s = drawdown
Q = pumping rate
T = transmissivity
W(u) = Well function using approximation by Srivastava (1995):

For u<1
$$W(u) = \ln\left(\frac{C_1}{u}\right) + 0.9563u - 0.1690u^2$$

For u>1
$$W(u) = \frac{1}{ue^u}\frac{u + 0.3575}{u + 1.280}$$

r = distance from pumping well
S = Storage coefficient
t = time

DO NOT EDIT HIGHLIGHTED CELLS

Drawdown at KLAM 2259 (Used T to match observed data from MWT)

T		S	Q		Time	Distance	u	W(u)	Drawdown At r	Remark
(gpd/ft)	(Ft²/day)		(gpm)	(Ft³/day)	(days)	(feet)			(feet)	
3,087,403	412,754	0.007	1205	231978.61	1095	2	8.71194E-12	24.889127	1.11	Due to KLAM 2259
3,087,403	412,754	0.007	893	171914.44	1095	1,936	1.45125E-05	10.563313	0.35	Due to KLAM 2262
3,087,403	412,754	0.007	932	179422.46	1095	8,719	0.000294351	7.553819	0.26	Due to KLAM 2263
3,087,403	412,754	0.007	1190	229090.91	1095	18,167	0.001277905	6.086555	0.27	Due to KLAM 2265
									1.99	NET Projected Drawdown at KLAM 2259

Drawdown at KLAM 2262 (Used T to match observed data from MWT)

T		S	Q		Time	Distance	u	W(u)	Drawdown At r	Remark
(gpd/ft)	(Ft²/day)		(gpm)	(Ft³/day)	(days)	(feet)			(feet)	
571,226	76,367	0.007	1205	231978.61	1095	1,936	7.84383E-05	8.876073	2.15	Due to KLAM 2259
571,226	76,367	0.007	893	171914.44	1095	2	8.37101E-11	22.626462	4.05	Due to KLAM 2262
571,226	76,367	0.007	932	179422.46	1095	8,304	0.001443086	5.965151	1.12	Due to KLAM 2263
571,228	76,367	0.007	1190	229090.91	1095	18,362	0.007055985	4.383418	1.05	Due to KLAM 2265
									8.36	NET Projected Drawdown at KLAM 2262

Drawdown at KLAM 2263 (Used T to match observed data from MWT)

T		S	Q		Time	Distance	u	W(u)	Drawdown At r	Remark
(gpd/ft)	(Ft²/day)		(gpm)	(Ft³/day)	(days)	(feet)			(feet)	
3,132,725	418,813	0.007	1205	231978.61	1095	8,719	0.000290093	7.568388	0.33	Due to KLAM 2259
3,132,725	418,813	0.007	893	171914.44	1095	8,304	0.000263135	7.665897	0.25	Due to KLAM 2262
3,132,725	418,813	0.007	932	179422.46	1095	2	8.5859E-12	24.903700	0.85	Due to KLAM 2263
3,132,725	418,813	0.007	1190	229090.91	1095	10,543	0.000424162	7.188601	0.31	Due to KLAM 2265
									1.75	NET Projected Drawdown at KLAM 2263

Drawdown at KLAM 2265 (Used T to match observed data from MWT)

T		S	Q		Time	Distance	u	W(u)	Drawdown At r	Remark
(gpd/ft)	(Ft²/day)		(gpm)	(Ft³/day)	(days)	(feet)			(feet)	
332,592	44,464	0.007	1205	231978.61	1095	18,167	0.011862622	3.868483	1.61	Due to KLAM 2259
332,592	44,464	0.007	893	171914.44	1095	18,362	0.01211865	3.847374	1.18	Due to KLAM 2262
332,592	44,464	0.007	932	179422.46	1095	10,543	0.003995236	4.949270	1.59	Due to KLAM 2263
332,592	44,464	0.007	1190	229090.91	1095	2	8.08717E-11	22.660957	9.29	Due to KLAM 2265
									13.67	NET Projected Drawdown at KLAM 2265

Reference

Srivastava, R.,1995, Implications of using approximate expressions for well function. J. Irrig. And Drain. Engineering. 121. no. 6: 459-462

Theis Drawdown Approximation

PROJECTION RUN - 3 YEARS PUMPING AT PRO-RATED RATES

$$s = \frac{Q}{4\pi T} W(u)$$

$$u = \frac{r^2 S}{4Tt}$$

Where:
- s = drawdown
- Q = pumping rate
- T = transmissivity
- W(u) = Well function using approximation by Srivastava (1995)
- r = distance from pumping well
- S = Storage coefficient
- t = time

For u<1
$$W(u) = \ln\left(\frac{C_1}{u}\right) + 0.9563\,u - 0.1690\,u^2$$

For u>1
$$W(u) = \frac{1}{ue^u}\,\frac{u + 0.3575}{u + 1.280}$$

DO NOT EDIT HIGHLIGHTED CELLS

Drawdown at KLAM 2260 (Used T to match observed data from MWT)

T (gpd/ft)	T (Ft^2/day)	S	Q (gpm)	Q (Ft^3/day)	Time (days)	Distance (feet)	u	W(u)	Drawdown At r (feet)	Remark
13,440,056	1,796,799	0.007	1205	231978.61	1095	4,147	1.52965E-05	10.510700	0.11	Due to KLAM 2259
13,440,056	1,796,799	0.007	893	171914.44	1095	2,516	5.63048E-06	11.510121	0.09	Due to KLAM 2262
13,440,056	1,796,799	0.007	932	179422.46	1095	6,615	3.8921E-05	9.576813	0.08	Due to KLAM 2263
13,440,056	1,796,799	0.007	1190	229090.91	1095	17,072	0.000259235	7.680824	0.08	Due to KLAM 2265
									0.35	NET Projected Drawdown at KLAM 2260

Drawdown at KLAM 2269 (Used T to match observed data from MWT)

T (gpd/ft)	T (Ft^2/day)	S	Q (gpm)	Q (Ft^3/day)	Time (days)	Distance (feet)	u	W(u)	Drawdown At r (feet)	Remark
28,913,758	3,865,476	0.007	1205	231978.61	1095	2,192	1.98656E-06	12.551907	0.06	Due to KLAM 2259
28,913,758	3,865,476	0.007	893	171914.44	1095	3,840	6.09854E-06	11.430595	0.04	Due to KLAM 2262
28,913,758	3,865,476	0.007	932	179422.46	1095	10,702	4.73534E-05	9.380718	0.03	Due to KLAM 2263
28,913,758	3,865,476	0.007	1190	229090.91	1095	19,660	0.000159804	8.164514	0.04	Due to KLAM 2265
									0.17	NET Projected Drawdown at KLAM 2269

Drawdown at KLAM 2289 (T value average of CJ Wellfield Method)

T (gpd/ft)	T (Ft^2/day)	S	Q (gpm)	Q (Ft^3/day)	Time (days)	Distance (feet)	u	W(u)	Drawdown At r (feet)	Remark
23,517,868	3,144,100	0.007	1205	231978.61	1095	12,240	7.61536E-05	8.905631	0.05	Due to KLAM 2259
23,517,868	3,144,100	0.007	893	171914.44	1095	14,175	0.000102135	8.612115	0.04	Due to KLAM 2262
23,517,868	3,144,100	0.007	932	179422.46	1095	16,959	0.000146193	8.253519	0.04	Due to KLAM 2263
23,517,868	3,144,100	0.007	1190	229090.91	1095	21,076	0.00022579	7.618923	0.05	Due to KLAM 2265
									0.17	NET Projected Drawdown at KLAM 2289

Drawdown at KLAM 12186 (T value average of CJ Wellfield Method)

T (gpd/ft)	T (Ft^2/day)	S	Q (gpm)	Q (Ft^3/day)	Time (days)	Distance (feet)	u	W(u)	Drawdown At r (feet)	Remark
23,517,868	3,144,100	0.007	1205	231978.61	1095	25,336	0.00032629	7.450836	0.04	Due to KLAM 2259
23,517,868	3,144,100	0.007	893	171914.44	1095	27,218	0.000376565	7.307580	0.03	Due to KLAM 2262
23,517,866	3,144,100	0.007	932	179422.46	1095	27,452	0.000383068	7.290465	0.03	Due to KLAM 2263
23,517,868	3,144,100	0.007	1190	229090.91	1095	26,572	0.000358902	7.355604	0.04	Due to KLAM 2265
									0.15	NET Projected Drawdown at KLAM 12186

Drawdown at KLAM 50362 (T value average of CJ Wellfield Method)

T (gpd/ft)	T (Ft^2/day)	S	Q (gpm)	Q (Ft^3/day)	Time (days)	Distance (feet)	u	W(u)	Drawdown At r (feet)	Remark
23,517,868	3,144,100	0.007	1205	231978.61	1095	34,941	0.000620581	6.808248	0.04	Due to KLAM 2259
23,517,868	3,144,100	0.007	893	171914.44	1095	35,734	0.000649069	6.763392	0.03	Due to KLAM 2262
23,517,868	3,144,100	0.007	932	179422.46	1095	28,981	0.000426928	7.162104	0.03	Due to KLAM 2263
23,517,868	3,144,100	0.007	1190	229090.91	1095	18,916	0.000181681	8.035134	0.05	Due to KLAM 2265
									0.15	NET Projected Drawdown at KLAM 50362

Drawdown at KLAM 12203 (T value average of CJ Wellfield Method)

T (gpd/ft)	T (Ft^2/day)	S	Q (gpm)	Q (Ft^3/day)	Time (days)	Distance (feet)	u	W(u)	Drawdown At r (feet)	Remark
23,517,868	3,144,100	0.007	1205	231978.61	1095	38,966	0.00077179	6.590336	0.04	Due to KLAM 2259
23,517,868	3,144,100	0.007	893	171914.44	1095	40,294	0.000825293	6.523361	0.03	Due to KLAM 2262
23,517,868	3,144,100	0.007	932	179422.46	1095	35,560	0.000642763	6.773149	0.03	Due to KLAM 2263
23,517,868	3,144,100	0.007	1190	229090.91	1095	27,506	0.000384576	7.286536	0.04	Due to KLAM 2265
									0.14	NET Projected Drawdown at KLAM 12203

Drawdown at KLAM 12420 (T value average of CJ Wellfield Method)

T (gpd/ft)	T (Ft^2/day)	S	Q (gpm)	Q (Ft^3/day)	Time (days)	Distance (feet)	u	W(u)	Drawdown At r (feet)	Remark
23,517,868	3,144,100	0.007	1205	231978.61	1095	54,149	0.001490419	5.932923	0.03	Due to KLAM 2259
23,517,868	3,144,100	0.007	893	171914.44	1095	55,257	0.001552037	5.892471	0.03	Due to KLAM 2262
23,517,868	3,144,100	0.007	932	179422.46	1095	49,363	0.001238599	6.117759	0.03	Due to KLAM 2263
23,517,868	3,144,100	0.007	1190	229090.91	1095	39,772	0.000804049	6.549419	0.04	Due to KLAM 2265
									0.13	NET Projected Drawdown at KLAM 12420

Reference

Srivastava, R.,1995, Implications of using approximate expressions for well function. J. Irrig. And Drain. Engineering. 121. no. 6: 459-462

APPENDIX E

APPENDIX E

TABULATED DATA (COMPACT DISK)

APPENDIX F

APPENDIX F

OWRD PROPOSED ORDER, HYDROELECTRIC APPLICATION HE 592

PROPOSED ORDER for PRELIMINARY PERMIT for HYDROELECTRIC APPLICATION HE 592 at SWAN LAKE NORTH

Proposed Action:

Approve Preliminary Permit for Hydroelectric Project HE 592.

NOTE:

This Proposed Order and Proposed Preliminary Permit do NOT convey the right to construct any project facilities for hydroelectric purposes. A preliminary permit will allow the applicant to gather streamflow or groundwater data; pursue the necessary use permits; assess environmental impacts of the proposed action, develop mitigation measures, complete detail design plans and associated cost estimates, and file draft and/or final water right applications. Issuance of a preliminary permit does not assure approval of any subsequent license application for hydroelectric use. The applicant must yet demonstrate that the proposed project will not impair or be detrimental to the public interest.

A. APPLICATION HISTORY

On May 12, 2010, Swan Lake North Hydro, LLC (Applicant) submitted an application for a preliminary permit for a major hydroelectric project to use up to 15,922 cubic feet per second (cfs) of stored water from groundwater wells in the Swan Lake basin of Klamath County. The Project would use up to 1304 feet of hydraulic head and four reversible pump-turbine units to generate up to 1380 megawatts of power for sale to an electrical utility.

Notice of open comment period and public hearing was included in OWRD's weekly public notice published on August 3, 10, 17, 24 and 31, 2010. An e-mail notice was sent to local, state and federal agencies, the local watershed group and interested citizens. Agencies notified included:

Oregon Department of Fish and Wildlife (ODFW)
Oregon Department of Environmental Quality (ODEQ)
Oregon Division of State Lands
Klamath County Board of County Commissioners
Oregon Department of Forestry
Oregon Department of Agriculture
Oregon State Historic Preservation Office
Kyle Gorman, OWRD Regional Manager
Legislative Commission on Indian Services

The notice of open comment period and public hearing were also published in the Klamath Falls

Herald and News on August 10, 17, 24 and 31, 2010.

A public hearing was held at the Klamath County Government Center, in Klamath Falls on August 31, 2010 at 6:30 p.m. The purpose of the meeting was to receive comments on the application for preliminary permit and whether the impacts of this project are such that they might be cumulative with other proposed or existing projects in the Klamath basin. Requests for additional studies related to project impacts could also be submitted.

About 34 members of the public attended the hearing (Attachment 1). A presentation about the project was given by Erik Steimle of Symbiotics LLC. Written comments were filed by several parties and are shown in Attachment 2.

Comments were also filed by several parties in response to the Federal Energy Regulatory Commission (FERC) request for comments in February 2009, on a preliminary permit application. The FERC docket number is p-13318.

Comments were considered by OWRD in making its findings of fact and recommendations for further studies.

B. PROJECT DESCRIPTION

The upper reservoir will be constructed with an east dam approximately 150 feet high and a west dam approximately 80 feet high. It will have a surface area of 242 acres and 12,655 acre feet of storage. The lower reservoir will be constructed with a dam approximately 130 feet high. It will have a surface area of 197 acres and storage of 13,935 acres-feet. Up to 15,922 cubic feet per second (cfs) of water would be released from the upper reservoir when all four turbines are generating. The maximum operating head between the two reservoirs is 1304 feet.

The points of appropriation for initial fill of the reservoirs would be located at existing wells:
Well #1: 660 Feet North and 1690 Feet West from the SE Corner of Section 9, being within the SW¼ SE¼ Section 9, Township 37 South, Range 10 East, W.M.,

Well #2: 48 Feet North and 20 Feet East from the SW Corner of Section 8, being within the SW¼ SW¼ Section 8, Township 37 South, Range 10 East, W.M.,

Well #4: 2000 feet North and 800 Feet East from the SW Corner of Section 8, being within the NW¼ SW¼ Section 8, Township 37 South, Range 10 East, W.M.,

Well #5: 100 Feet North and 1400 Feet East from the SW Corner of Section 14, being within the SE¼ SW¼ Section 14, Township 37 South, Range 10 East, W.M.

Initial filling of the reservoir is proposed under a transfer or forbearance agreement of the rights under Water Rights Certificate No. 29530 (3446.4 acre-feet per year) and Water Rights Permit G-10952 (3360 acre-feet per year). Reservoir maintenance is proposed from Well #5 under a permanent transfer (1574 acre feet per year).

The location of the upper reservoir is proposed to be in Sections 13, 14, and 24:
The location of the lower reservoir is proposed to be in the South half of Section 15.
The location of the underground powerhouse is proposed in the SE ¼ SW ¼, Section 14,
all being in Township 37 South, Range 10 East, W.M.

The upper reservoir will be located on Swan Lake Rim, approximately 1 mile west of Welsh Spring. The reservoir will have a maximum surface elevation of 5,500 feet above mean sea level (MSL). The lower reservoir site is located north of Swan Lake, between Grizzly Butte and Stiles Spring. The reservoir will have a maximum surface elevation of 4280 feet MSL.

Each of the three proposed dams will be more than 5,000 feet long. The dams will be constructed with an impervious clay core surrounded by zones of more pervious outer layers, referred to as shells. The dams will be designed and constructed in compliance with Uniform Building Code Seismic Zone 3 minimum requirements. The shell material is available locally from outcrops in the project area. Additional study will be required to identify a source for the core material (i.e. clay).

Water will be exchanged between the reservoirs via a concrete-lined 36.5-foot-diameter, 1,200-foot vertical shaft which will connect to a concrete-lined penstock. The penstock will extend for 4,160 feet at a slope of three percent. The penstock will bifurcate into four 640-foot-long, 12.25-foot-diameter steel penstocks, each of which will connect to a reversible pump-turbine. At the top of the shaft, in the upper reservoir, there will be an intake/discharge structure with a trash rack to exclude debris.

Four 150-foot-long, 17-foot-diameter steel tailrace tunnels will extend from the reversible pump-turbines and will combine into one 2,225-foot-long, 49-foot-diameter concrete-lined draft tube. The tailrace tunnel will discharge into the lower reservoir during generation mode and intake during pumping mode. At the end of the draft tube there will be an intake/discharge structure with a trash rack to exclude debris.

The proposed powerhouse will be located underground. It will be 125 feet wide and 555 feet long and contain four reversible pump-turbine units with a total installed capacity of 1,380 megawatts (MW). A 30-foot-diameter access tunnel would extend 1,000 feet to the powerhouse. The entrance to the access tunnel would be approximately 1,000 feet southeast of the lower dam. Other factors contributing to the selection of the powerhouse location include: (1) minimizing disturbance to the area, (2) the proximity to quality bedrock, and (3) the ability to place the tunnel to the powerhouse in bedrock.

Approximately 23 miles of 345 kilovolt transmission lines will be constructed to connect the project to the existing Bonneville Power Administration's Captain Jack Substation located southeast of the project site. The transmission corridor will be approximately 221 acres. One 6.5 acre surface switchyard/substation will be constructed near the power plant site.

Existing roads would provide access to the project.

C. RESOURCE STANDARDS

All proposed hydroelectric projects in Oregon must meet the resource protection standards contained in OAR 690-051-0170 to –0290.

- **Protection of Designated Resource Areas and Special Management Areas (OAR 690-051-0170)**

The Project will be located on property owned by Jeld-Wen Inc., the U.S. Bureau of Land Management or Jespersen-Edgewood Inc. A final application must show that the project will not have effects on any designated resource areas listed in OAR 690-051-0030(1) or 690-051-0170(2).

- **Mitigation, No Net Loss (OAR 690-051-0180)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on mitigation and no net loss.

- **Water Resources (OAR 690-051-190)**

In its preliminary permit application, Swan Lake North Hydro LLC proposes to initially fill the lower reservoir and to offset annual losses due to evaporation with groundwater from the wells identified above. Irrigation uses from these wells are expected to be halted while the reservoir is being filled. Filling of the reservoir will be conducted over a two to three year period to reduce impacts to the aquifer.

The Department shall require a groundwater study to include conducting a one-week to one-month groundwater interference test. The test shall be conducted under controlled conditions and directed by a qualified hydrogeologist to determine the possible impacts of pumping the proposed well(s) on other wells in the vicinity of the project. The plan for the proposed groundwater interference test should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. Generally, such a test should be conducted during the months of January or February before groundwater pumping for irrigation begins for the season. OWRD can offer assistance in selecting other wells in the vicinity to be monitored during the drawdown and recovery periods of the test. It should be noted that a water level response to the test in the wells monitored in a given compartment and/or sub-area does imply a potential for interference, but a lack of response does not imply no interference will occur.

It was recommended in a comment from the Pine Flat District Improvement Company that surplus water that is now pumped from the Pine Flat area to the Lost River basin be considered as an alternate source of water for this project. The Applicant may pursue further investigation of this option.

The water basin program that applies to the Klamath Basin is the Klamath River Basin Compact Oregon Revised Statute (ORS) 542.610 through 542.630. ORS 542.620 Article IV Hydroelectric Power states "It shall be the objective of each state, in the formulation and the execution and the granting of authority for the formulation and the execution of plans for the distribution and use of water of the Klamath River Basin, to provide for the most efficient use of available power head and its economic integration with the distribution of water for other beneficial uses in order to secure the most economical distribution and use of water and lowest power rates which may be reasonable for irrigation and drainage pumping, including pumping from wells."

Construction and operation of the proposed project shall comply with water quality standards established in OAR Chapter 340, Division 41. The applicant must comply with all water quality standards adopted by the Environmental Quality Commission pursuant to state and federal law, ORS 468B.048 and Section 303 of the Clean Water Act.

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards for water resources.

- **Fish Resources (OAR 690-051-0200)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on fish resources.

This project will consist of two man-made reservoirs working as a closed-loop system. The project is entirely off stream; therefore no fish will be directly impacted by the project. Every reasonable precaution should be taken to ensure that fish and aquatic species are not introduced in either reservoir.

- **Wildlife (OAR 690-051-0210)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on wildlife resources.

The location, design, construction or operation of the proposed project shall not jeopardize the continued existence of animal species which have been designated, or officially proposed as threatened or endangered.

The location design, construction, or operation of the proposed project will minimize adverse impacts on wildlife habitat, nesting and wintering grounds, and wildlife migratory routes. Unavoidable adverse impacts on wildlife or wildlife habitat will be mitigated in the project vicinity.

The proposed project must be consistent with ODFW management programs.

- **Plant Life (OAR 690-051-0220)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on plant resources.

The location, design, construction or operation of the proposed project shall not jeopardize the continued existence of plant species which have been designated, or officially proposed as threatened or endangered.

- **Recreation (OAR 690-051-0230)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on recreation resources.

Project facilities will be designed, located and operated to substantially avoid visible or audible intrusion on the natural setting. The proposed project will not reduce the abundance or variety of recreational facilities or opportunities available in the vicinity.

- **Historic, Cultural, and Archaeological Resources (OAR 690-051-240)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on historic, cultural, and archaeological resources.

The project will not result in significant adverse impacts on any historic district, site, building, structure, or object included in or eligible for inclusion in the National Register of Historic Places.

The project will comply with state laws to protect Indian graves (ORS 97.740-97.760), historical materials (ORS 273.705-273.711, and archaeological objects and sites (ORS 358.905-358.955).

- **Land Resources (OAR 690-051-0250)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on land resources.

Adverse impacts on prime forest lands, high value or important farmlands or agricultural lands, or wetlands shall be avoided, minimized or offset by acceptable mitigation.

The location, design, construction or operation of the project will not disturb fragile or unstable soils, or cause soil erosion.

Project facilities shall be designed with appropriate safety standards with regards to geological hazards and naturally occurring conditions or hazards, such as flooding or ice formation.

- **Land Use (OAR 690-051-260)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards of Acknowledged Comprehensive Plans from the local county government.

- **Economics (OAR 690-051-270)**

The applicant must show in a final hydroelectric application that the applicant, along with all co-owners, possesses or has reasonable assurance of obtaining the funds necessary to cover estimated construction, maintenance, operating, mitigation and compensation costs.

- **Need for Power (OAR 690-051-280)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards of Need for Power.

- **Consolidated Review (OAR 690-051-290)**

The Klamath Irrigation District has an approved preliminary permit for a project at the C-Drop on its existing canal in the Lost River subbasin. This Project in the Swan Lake basin will not cause any additional impacts with the KID project in the Lost River subbasin. There are no other proposed projects in the Klamath basin at this time.

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards of avoiding individual and cumulative impacts to natural resources when considered with other existing, approved, or proposed hydroelectric projects in the same river basin.

D. STUDY PLAN REQUIREMENTS

The Applicant shall conduct a short-term (seasonal) one-week to one-month groundwater interference test. The test shall be conducted under controlled conditions and directed by a qualified hydrogeologist to determine the possible impacts of pumping the proposed well(s) on other wells in the vicinity of the project. The plan for the proposed groundwater interference test should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. Generally, such a test should be conducted during the months of January or February before groundwater pumping for irrigation begins for the season. OWRD can offer assistance in selecting other wells in the vicinity to be monitored during the drawdown and recovery periods of the test. Results of the pump test shall be submitted to OWRD for its review. It should be noted that a water level response to the test in the wells monitored in a given compartment and/or sub-area does imply a potential for interference, but a lack of response does not imply no interference will occur.

A condition of the water right may include a requirement to monitor the long-term groundwater levels at wells within the north Swan Lake Valley compartment and within the main body of the Swan Lake to Poe Valley sub-area. The plan for the groundwater level monitoring should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. It should be prepared by a qualified hydrogeologist and should include installing water level recorders at 2 wells minimum (one well inside and one well outside the north Swan Lake Valley compartment). The monitoring may require construction of one or two wells if existing wells are not suitable.

E. FINDINGS OF FACT

The application for preliminary permit was complete and accepted for filing.

No competing applications have been filed with the Director within 180 days of the first notice published for this preliminary permit application.

The project is to be more than 25 MW of generating capacity.

F. ULTIMATE FINDINGS

ORS 543.225 (3)(a) requires consideration whether this project would conserve the highest use of water for all purposes, including irrigation, domestic use, municipal water supply, power development, public recreation, protection of commercial and game fishing and wildlife, fire protection, mining, industrial purposes, navigation, scenic attraction or any other beneficial use to which the water may be applied for which it may have a special value to the public. *Because the water is used in a closed loop system, the annual water requirements are modest and are offset by transfer from an existing irrigation use. Water is conserved for other beneficial uses.*

(3)(b) requires consideration of the maximum economic development of the water. *This project increases the economic benefits of the waters.*

(3)(c) requires consideration of the control of the waters of this state for all beneficial purposes, including drainage, sanitation and flood control. *A pump test and groundwater monitoring will help to ensure that this project will have no effects on drainage, sanitation or flood control.*

(3)(d) requires consideration of the amount of waters available for appropriation for beneficial use. *Some existing irrigation use will be halted during the initial fill of the reservoir, so that water can be temporarily transferred to a new use. Groundwater records are available for wells in the Swan Lake Valley to provide information about past drawdown and recovery cycles. A groundwater interference test will be required to document the drawdown and recovery cycles in the vicinity of the project. Some existing irrigation uses will be permanently transferred to the project for water make-up needs.*

(3)(e) requires consideration of the prevention of wasteful, uneconomic, impracticable or unreasonable use of the water involved. *There is no evidence in the record that the proposed use represents a wasteful, uneconomic, impracticable or unreasonable use of the waters.*

(3)(f) requires consideration of all vested and inchoate rights to the waters of this state or to the use thereof, and the means necessary to protect such rights. *Because the annual water requirements are small and are being transferred from an existing use, it is not expected that any vested or inchoate water rights will be affected by the project.*

(3)(g) requires consideration of the state water resources policy for the Klamath River Basin. *The Klamath River Compact provides for the use of water for hydroelectric purposes.*

G. PROPOSED CONCLUSIONS OF LAW

The project proposed by the applicant is eligible for a preliminary permit for hydroelectric development.

Upon a review of the application and the public hearing record, OWRD finds no evidence that the proposed project would not be in the public interest because of significant adverse impacts on natural resources or other uses of the water involved.

Approval of a preliminary permit application shall not convey the right to construct any project facilities. Issuance of a preliminary permit shall not constitute approval or assurance of approval for any subsequent application for hydroelectric license for the project.

A final application must show that the resource protection standards contained in ORS 543.017(1) and OAR 690-051-0170 to –0270, and -0290 will be met by the project.

The proposed preliminary permit will allow the applicant to gather streamflow and groundwater data; pursue the necessary use permits; assess environmental impacts of the proposed action, develop mitigation measures, complete detail design plans and associated cost estimates, and file draft and/or final water right applications within a two year period.

H. PRELIMINARY PERMIT CONDITIONS

The preliminary permit is subject to the following express conditions:

The priority date for the proposed preliminary permit is May 12, 2010.

The Applicant shall prepare a study plan to conduct a groundwater interference test under the direction of a qualified hydrogeologist. The applicant will collect data of groundwater levels during pumping and recovery of the wells over a one-week to one-month test period. The test shall be conducted under controlled conditions to determine the possible impacts of pumping the proposed well(s) on other wells in the vicinity of the project. The plan for the proposed groundwater interference test should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. Generally, such a test should be conducted during the months of January or February before groundwater pumping for irrigation begins for the season. OWRD can offer assistance in selecting other wells in the vicinity to be monitored during the drawdown and recovery periods of the test. It should be noted that a water level response to the test in the wells monitored in a given compartment and/or sub-area does imply a potential for interference, but a lack of response does not imply no interference will occur. Data and analyses shall be provided to OWRD for review.

If the Applicant fails to file an application for hydroelectric water right within two years, the permit may be subject to termination by the OWRD.

Issuance of the permit does not absolve the Applicant from compliance with the requirements and enforcement of the requirements under other applicable local, state, and federal laws.

I. PROPOSED ORDER

OWRD proposes to issue a preliminary permit to Swan Lake North LLC to study and develop a pumped storage hydroelectric project near Swan Lake in Klamath County. The preliminary permit would allow the applicant to gather streamflow and groundwater data; pursue the necessary use permits; assess environmental impacts of the proposed action, develop mitigation measures, complete detail design plans and associated cost estimates, and file draft and/or final water right applications within a two year period. Issuance of a preliminary permit does not assure license approval if the applicant fails to demonstrate that the proposed project will not impair or be detrimental to the public interest.

Dated: ________________________

____

DWIGHT W. FRENCH,
Administrator of Water Rights & Adjudications

J. PROCESS FOR COMMENTS, OBJECTIONS, PROTESTS, CONTESTED CASE, AND JUDICIAL REVIEW

Comments and Objections to the Proposed Order

This Proposed Order has been distributed to the Applicant and all individuals, including all governmental agencies, who have filed timely comments with the OWRD. Comments and objections to this Proposed Order must be received by the OWRD Director by 5:00 PM on Friday, **January 21, 2011.**

Comments or objections must state facts, which support the allegation that the proposed preliminary permit should not be approved as proposed by the technical report.

Judicial Review of Preliminary Permit

After all comments on the Proposed Order are finalized, a preliminary permit may be issued to the Applicant. The preliminary permit may be a final order in other than contested case, subject to judicial review under ORS 183.484. Any petition for judicial review of the preliminary permit must be filed within 60 days of the date of service of the preliminary permit.

STATE OF OREGON
COUNTY OF KLAMATH
PRELIMINARY PERMIT
FOR A HYDROELECTRIC PROJECT

SWAN LAKE NORTH HYDRO, LLC
975 SOUTH STATE HIGHWAY
LOGAN, UTAH 84321

is issued this preliminary permit to develop a pumped storage hydroelectric project in the Swan Lake basin for a project with a total installed capacity of 1,380 Megawatts (2,359,350 Theoretical Horsepower).

This preliminary permit is issued under application HE 592. The date of priority is MAY 12, 2010. The upper reservoir will be constructed with an east dam approximately 150 feet high and a west dam approximately 80 feet high. It will have a surface area of 242 acres and 12,655 acre feet of storage. The lower reservoir will be constructed with a dam approximately 130 feet high. It will have a surface area of 197 acres and storage of 13,935 acres-feet. Up to 15,922 cubic feet per second (cfs) of water would be released from the upper reservoir when all four turbines are generating. The maximum operating head between the two reservoirs is 1304 feet.

The points of appropriation for initial fill of the reservoirs would be located at existing wells:
Well #1: 660 Feet North and 1690 Feet West from the SE Corner of Section 9, being within the SW¼ SE¼ Section 9, Township 37 South, Range 10 East, W.M.,

Well #2: 48 Feet North and 20 Feet East from the SW Corner of Section 8, being within the SW¼ SW¼ Section 8, Township 37 South, Range 10 East, W.M.,

Well #4: 2000 feet North and 800 Feet East from the SW Corner of Section 8, being within the NW¼ SW¼ Section 8, Township 37 South, Range 10 East, W.M.,

Well #5: 100 Feet North and 1400 Feet East from the SW Corner of Section 14, being within the SE¼ SW¼ Section 14, Township 37 South, Range 10 East, W.M.

Initial filling of the reservoir is proposed under a transfer or forbearance agreement of the rights under Water Rights Certificate No. 29530 (3446.4 acre-feet per year) and Water Rights Permit G-10952 (3360 acre-feet per year). Reservoir maintenance is proposed from Well #5 under a permanent transfer (1574 acre feet per year).

The location of the upper reservoir is proposed to be in Sections 13, 14, and 24:
The location of the lower reservoir is proposed to be in the South half of Section 15.
The location of the underground powerhouse is proposed in the SE ¼ SW ¼, Section 14, all being in Township 37 South, Range 10 East, W.M.

The upper reservoir will be located on Swan Lake Rim, approximately 1 mile west of Welsh Spring. The reservoir will have a maximum surface elevation of 5,500 feet above mean sea level (MSL). The lower reservoir site is located north of Swan Lake, between Grizzly Butte and Stiles Spring. The reservoir will have a maximum surface elevation of 4280 feet MSL.

Each of the three proposed dams will be more than 5,000 feet long. The dams will be constructed with an impervious clay core surrounded by zones of more pervious outer layers, referred to as shells. The dams will be designed and constructed in compliance with Uniform Building Code Seismic Zone 3 minimum requirements. The shell material is available locally from outcrops in the project area. Additional study will be required to identify a source for the core material (i.e. clay).

Water will be exchanged between the reservoirs via a concrete-lined 36.5-foot-diameter, 1,200-foot vertical shaft which will connect to a concrete-lined penstock. The penstock will extend for 4,160 feet at a slope of three percent. The penstock will bifurcate into four 640-foot-long, 12.25-foot-diameter steel penstocks, each of which will connect to a reversible pump-turbine. At the top of the shaft, in the upper reservoir, there will be an intake/discharge structure with a trash rack to exclude debris.

Four 150-foot-long, 17-foot-diameter steel tailrace tunnels will extend from the reversible pump-turbines and will combine into one 2,225-foot-long, 49-foot-diameter concrete-lined draft tube. The tailrace tunnel will discharge into the lower reservoir during generation mode and intake during pumping mode. At the end of the draft tube there will be an intake/discharge structure with a trash rack to exclude debris.

The proposed powerhouse will be located underground. It will be 125 feet wide and 555 feet long and contain four reversible pump-turbine units with a total installed capacity of 1,380 megawatts (MW). A 30-foot-diameter access tunnel would extend 1,000 feet to the powerhouse. The entrance to the access tunnel would be approximately 1,000 feet southeast of the lower dam. Other factors contributing to the selection of the powerhouse location include: (1) minimizing disturbance to the area, (2) the proximity to quality bedrock, and (3) the ability to place the tunnel to the powerhouse in bedrock.

Approximately 23 miles of 345 kilovolt transmission lines will be constructed to connect the project to the existing Bonneville Power Administration's Captain Jack Substation located southeast of the project site. The transmission corridor will be approximately 221 acres. One 6.5 acre surface switchyard/substation will be constructed near the power plant site.

RESOURCE STANDARDS

All proposed hydroelectric projects in Oregon must meet the resource protection standards contained in Oregon Administrative Rule (OAR) 690-051-0170 to –0290.

- **Protection of Designated Resource Areas and Special Management Areas (OAR 690-051-0170)**

The Project will be located on property owned by Jeld-Wen Inc., the U.S. Bureau of Land Management or Jespersen-Edgewood Inc. A final application must show that the project will not have effects on any designated resource areas listed in OAR 690-051-0030(1) or 690-051-0170(2).

- **Mitigation, No Net Loss (OAR 690-051-0180)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on mitigation and no net loss.

- **Water Resources (OAR 690-051-190)**

In its preliminary permit application, Swan Lake North Hydro LLC proposes to initially fill the lower reservoir and to offset annual losses due to evaporation with groundwater from the wells identified above. Irrigation uses from these wells are expected to be halted while the reservoir is being filled. Filling of the reservoir will be conducted over a two to three year period to reduce impacts to the aquifer.

The Applicant shall prepare a study plan to conduct a groundwater interference test under the direction of a qualified hydrogeologist. The applicant will collect data of groundwater levels during pumping and recovery of the wells over a one-week to one-month test period. The test shall be conducted under controlled conditions to determine the possible impacts of pumping the proposed well(s) on other wells in the vicinity of the project. The plan for the proposed groundwater interference test should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. Generally, such a test should be conducted during the months of January or February before groundwater pumping for irrigation begins for the season. OWRD can offer assistance in selecting other wells in the vicinity to be monitored during the drawdown and recovery periods of the test. It should be noted that a water level response to the test in the wells monitored in a given compartment and/or sub-area does imply a potential for interference, but a lack of response does not imply no interference will occur. Data and analyses shall be provided to OWRD for review.

It was recommended in a comment from the Pine Flat District Improvement Company that surplus water that is now pumped from the Pine Flat area to the Lost River basin be considered as an alternate source of water for this project. The Applicant may pursue further investigation of this option.

The water basin program that applies to the Klamath Basin is the Klamath River Basin Compact Oregon Revised Statute (ORS) 542.610 through 542.630. ORS 542.620 Article IV Hydroelectric Power states "It shall be the objective of each state, in the formulation and the execution and the granting of authority for the formulation and the execution of plans for the distribution and use of water of the Klamath River Basin, to provide for the most efficient use of available power head and its economic integration with the distribution of water for other beneficial uses in order to secure the most economical distribution and use of water and lowest power rates which may be reasonable for irrigation and drainage pumping, including pumping from wells."

Construction and operation of the proposed project shall comply with water quality standards established in OAR Chapter 340, Division 41. The applicant must comply with all water quality standards adopted by the Environmental Quality Commission pursuant to state and federal law, ORS 468B.048 and Section 303 of the Clean Water Act.

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards for water resources.

- **Fish Resources (OAR 690-051-0200)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on fish resources.

This project will consist of two man-made reservoirs working as a closed-loop system. The project is entirely off stream, therefore no fish will be directly impacted by the project. Every reasonable precaution should be taken to ensure that fish and aquatic species are not introduced in either reservoir.

- **Wildlife (OAR 690-051-0210)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on wildlife resources.

The location, design, construction or operation of the proposed project shall not jeopardize the continued existence of animal species which have been designated, or officially proposed as threatened or endangered.

The location design, construction, or operation of the proposed project will minimize adverse impacts on wildlife habitat, nesting and wintering grounds, and wildlife migratory routes. Unavoidable adverse impacts on wildlife or wildlife habitat will be mitigated in the project vicinity.

The proposed project must be consistent with ODFW management programs.

- **Plant Life (OAR 690-051-0220)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on plant resources.

The location, design, construction or operation of the proposed project shall not jeopardize the continued existence of plant species which have been designated, or officially proposed as threatened or endangered.

- **Recreation (OAR 690-051-0230)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on recreation resources.

Project facilities will be designed, located and operated to substantially avoid visible or audible intrusion on the natural setting. The proposed project will not reduce the abundance or variety of recreational facilities or opportunities available in the vicinity.

- **Historic, Cultural, and Archaeological Resources (OAR 690-051-240)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on historic, cultural, and archaeological resources.

The project will not result in significant adverse impacts on any historic district, site, building, structure, or object included in or eligible for inclusion in the National Register of Historic Places.

The project will comply with state laws to protect Indian graves (ORS 97.740-97.760), historical materials (ORS 273.705-273.711, and archaeological objects and sites (ORS 358.905-358.955).

- **Land Resources (OAR 690-051-0250)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards on land resources.

Adverse impacts on prime forest lands, high value or important farmlands or agricultural lands, or wetlands shall be avoided, minimized or offset by acceptable mitigation.

The location, design, construction or operation of the project will not disturb fragile or unstable soils, or cause soil erosion.

Project facilities shall be designed with appropriate safety standards with regards to geological hazards and naturally occurring conditions or hazards, such as flooding or ice formation.

Land Use (OAR 690-051-260)

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards of Acknowledged Comprehensive Plans from the local county government.

- **Economics (OAR 690-051-270)**

The applicant must show in a final hydroelectric application that the applicant, along with all co-owners, possesses or has reasonable assurance of obtaining the funds necessary to cover estimated construction, maintenance, operating, mitigation and compensation costs.

- **Need for Power (OAR 690-051-280)**

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards of Need for Power.

- **Consolidated Review (OAR 690-051-290)**

The Klamath Irrigation District has an approved preliminary permit for a project at the C-Drop on its existing canal in the Lost River subbasin. This Project in the Swan Lake basin will not cause any additional impacts with the KID project in the Lost River subbasin. There are no other proposed projects in the Klamath basin at this time.

The applicant must show in a final hydroelectric application that the proposed use will be consistent with the standards of avoiding individual and cumulative impacts to natural resources when considered with other existing, approved, or proposed hydroelectric projects in the same river basin.

PRELIMINARY PERMIT CONDITIONS

This Preliminary Permit does NOT convey the right to construct any project facilities for hydroelectric purposes. A preliminary permit will allow the applicant to gather streamflow and groundwater data; pursue the necessary use permits; assess environmental impacts of the proposed action, develop mitigation measures, complete detail design plans and associated cost estimates, and file draft and/or final water right applications. Issuance of a preliminary permit does not assure approval of any subsequent license application for hydroelectric use.

A final application must show that the resource protection standards contained in ORS 543.017(1) and OAR 690-051-0170 to –0270, and -0290 will be met by the project.

The Applicant shall prepare a study plan to conduct a groundwater interference test under the direction of a qualified hydrogeologist. The applicant will collect data of groundwater levels during pumping and recovery of the wells over a one-week to one-month test period. The test shall be conducted under controlled conditions to determine the possible impacts of pumping the proposed well(s) on other wells in the vicinity of the project. The plan for the proposed groundwater interference test should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. Generally, such a test should be conducted during the months of January or February before groundwater pumping for irrigation begins for the season. OWRD can offer assistance in selecting other wells in the vicinity to be monitored during the drawdown and recovery periods of the test. It should be noted that a water level response to the test in the wells monitored in a given compartment and/or sub-area does imply a potential for interference, but a lack of response does not imply no interference will occur. Data and analyses shall be provided to OWRD for review.

If the Applicant fails to file an application for hydroelectric water right within two years, the permit may be subject to termination by the OWRD.

Issuance of the permit does not absolve the Applicant from compliance with the requirements and enforcement of the requirements under other applicable local, state, and federal laws.

Dated: ______________________

____

DWIGHT W. FRENCH, Administrator of Water Rights & Adjudications
{For}
PHILLIP C. WARD, DIRECTOR
Water Resources Department

ATTENDANCE RECORD

8-31-2010

Date

Symbiotic's Swan Lake Pump Storage Project

Meeting Name

Name	Organization	Address	Phone/Fax	e-mail
Bill Hawkins	C2F Shoualle	3130 S. 6th	541-882-2151	cntry211@charter.net
PAT GRAY		21440 Hwy 140 E DAIRY OR 97625	541 591 3305	
Greg. Jackson	—	10919 Yonna Loop Bonanza.	541-281-7978	
Trey Senn	KCEDA	POB 1777 KF 97601	541 882.9600 / 541.882.7648	trey@fireserve.net
CHARLES MASSIE	CHAMBER	205 RIVERSIDE ST SUITE A KF 97601	541-884-5193	CMASSIE@KLAMATH.ORG
Erik Steimle	Symbiotics	2950 SE Stark St. Ste110 Portland OR, 97214	503-235-3424	
Glenn T Lorenz		2626 Swan Lake Rd.	541-884-5938	
John Venable		767 Mitchell Rd Dairy	545-1244	

ATTENDANCE RECORD

8/31/10

Date

____

Meeting Name

Name	Organization	Address	Phone/Fax	e-mail
Cheri Monteith 5089 Cherry Blossom K Falls OR 97601		5089 Cherry Blossom Lane	541 887-8516	dcmonteith@yahoo.com
		Klamath Falls OR 97601		
Neil and Mary Hurley		1929 Terrace	541 882-3892	
		KFalls OR 97601		
Mike Romtvedt		7691 Harpold Rd	541-545-1208	
		KFalls 97603		
Bill Haskins 3815 South 6th ST STE 110 Klamath falls, OR 97603		3815 S 6th ST #110		BHaskins@CBKfalls.com
		K-falls, OR 97603	541-884-1343	
Roger Smith ODFW Klamath Falls		1850 Miller Is. Rd		Roger.C.Smith@State.or.us
		KF - 97603	541-883-5732	
Lenny + Maureen Jespersen		12441 Swan Lake Rd		vmjespersen@msn.com
		K.Falls, OR	541-884-7878	
Kenny and Bethany Holmes		13110 Swan Lake Rd	541-850-9232	kbjholmes@gmail.com
		Klamath Falls 97603		
Tom MALLAMS		29163 Goodow ASPRINGS ROAD	541-533-2580	TMbrokenboxranch@gmail.com
		BEATTY 97621		

ATTENDANCE RECORD

8/31/10
Date

Meeting Name

Name	Organization	Address	Phone/Fax	e-mail
DAVE B. WIRTH	MEADOW LAKES INC.	3708 SWAN LAKE Rd. KLAMATH FALLS, OR	Phone 541-882-7483 Fax same	?
Woodrow McLin	3MC RANCH	21330 Hwy 140 E DAIRY OR 97603	Phone Fax	
DAVE McLin	3MC RANCH	21330 HWY 140 E DAIRY OR 97603	Phone 545-1602 Fax 545-1603	—
Sam Porter	JWTR		Phone Fax	sPorter@JW-TR.com
MATT Hurley		826 MAIN Klamath Falls	Phone Fax	MATT.Hurley@gr8basin.com
Ken Mayer?		5233 Ukrmann Rd ? K. Falls, OR 97601	Phone Fax	jmayer@?earthlink.net
STAN GILBERT	CHAMBER OF COMMERCE	2210 ELDORADO KF 97601	Phone Fax	sgilbert@klamathyouth.org
			Phone Fax	
			Phone Fax	

ATTENDANCE RECORD

8/31/10
Date

Meeting Name

Name	Organization	Address	Phone/Fax	e-mail
Jacen Jespersen		12525 Swanlake Rd Klamath Falls OR	541-891-1238	
Leonard Jespersen		Klamath Falls OR	541 891 8890	
Steve Gorden		23921 Hwy 140E Bonanza or.	(541) 892-0063	
Donald Holmstrom	BLM	2795 Anderson Ave. K-Falls, OR 97603	541-885-4100	dholmstrom@blm.gov
Don Hoffheins		1944 Euclid Ave Klamath Falls, OR 97601	541 885 4105	dhoffheins@blm.gov
Scott Senter		~~23~~340 MT. Pitt Klamath Falls OR 97601	541 882-3236	scott_senter@ ~~ees~~ blm.gov
Pete Nevin		17017 Hwy 140 E Dairy OR 97625	541 891 1744	
Tim Davis		751 Mitchell Rd	541-545-6540	

Attachment 2

Responses to Comments on Swan Lake North Hydro LLC's Preliminary Permit State Application

Commenter: Del Fox

Organization: President of the Pine Flat District Improvement Company (PFDIC) (A Taxing District)

Comment(s): "Pine Flat District Iimprovement Company was formed to drain/pump excess water from the basin just west of Dairy Oregon and south of Swan Lake ridge. We have to get the excess water out of this basin because there is no natural drainage. Water collects in the basin from rain and snow melt, which in this country comes in the winter and spring. We are proposing a win-win solution for Symbiotic's refill from evaporation and partial filling of the reservoir that would not require use of precious well water. We pump approximately 1600 to 2000 acre feet of excess water in dryer years and up to 6000 acre feet in wet years over the west ridge and it runs in a ditch for about 6 miles; then thru KID's "e" Sump into the Lost River. We propose Symbiotics be required to take this "FREE" water instead of using already over allocated well water. We would not charge Symbiotics for the water and we would save on pumping costs. A WIN-WIN. Symbiotics would be responsible for getting the water from our ditch/reservoir to their reservoir, but Pine Flat personnel must maintain control of pumping since it is our responsibility to drain the basin. We will be happy to assist and prefer to be included in any infrastructure planning."

Response: The Applicant may pursue further investigation of this option as part of the project studies during the next two years.

Commenter: David R Mc Lin

Organization: 3MC Ranch Hay Sales

Comment(s): Mr. Mc Lin stated that his ranch is located on Pine Flats approximately 3-4 miles South of the proposed project. He has three irrigation wells producing approximately 5,400 gallons per minute. He states "Our concern is the huge amount of ground water proposed to be pumped year round for this project. The irrigation wells are drawn down in the late summer and generally recharge in the winter. My question is will our wells recharge with the large amount of water being drawn so close." He proposes that his wells be monitored starting this fall thru spring and summer months of 2011 to establish his "normal capacity." Then, if any fluctuation should occur once pumping is under way on the project and his watering operation is impacted, he proposes that: 1) that the project pumps be turned off or 2) actual damages to his farming operation be assessed and immediately be paid to his ranch at market values. He "proposes, as a condition of the permit, that Swan Lake North LLC be required to pay damages if damages occur."

Response: The plans for this project assume that irrigation on several hundred acres of land would cease while groundwater is being pumped in the initial fill of the lower reservoir. Available data indicates that most to all wells proposed for the project are within the north Swan Lake Valley compartment within the Swan Lake to Poe Valley sub-area as defined by Grondin (2004). The compartment is hydraulically connected to the main body of the sub-area that extends from south of Grizzly Butte in Swan Lake Valley to northern Poe Valley. However within an irrigation season, pumping in the compartment does not appear to show in the main body and vice versa. Their hydrographs appear different.

The Department shall require a groundwater study to include conducting a one-week to one-month groundwater interference test. The test shall be conducted under controlled conditions and directed by a qualified hydrogeologist to determine the possible impacts of pumping the proposed well(s) on other wells in the vicinity of the project. The plan for the proposed groundwater interference test should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. Generally, such a test should be conducted during the months of January or February before groundwater pumping for irrigation begins for the season. OWRD can offer assistance in selecting other wells in the vicinity to be monitored during the drawdown and recovery periods of the test. It should be noted that a water level response to the test in the wells monitored in a given compartment and/or sub-area does imply a potential for interference, but a lack of response does not imply no interference will occur.

The long-term groundwater interference concern can be assessed by establishing long-term groundwater level monitoring at wells within the north Swan Lake Valley compartment and within the main body of the Swan Lake to Poe Valley sub-area. The plan for the groundwater level monitoring should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. It should be prepared by a qualified hydrogeologist and should include installing water level recorders at 2 wells minimum (one well inside and one well outside the north Swan Lake Valley compartment). The monitoring may require construction of one or two wells if existing wells are not suitable.

Commenter: L. H. "Trey" Senn

Organization: Klamath County Economic Development Association (KCEDA)

Comment(s): Mr. Senn appreciated the opportunity to express his groups support for the proposed Swan Lake Pump Storage Project. The KCEDA, he states, "has added substantial power generation and as one of its "highest goals and objectives" to bring jobs and economic security to Klamath County." He adds " … Team Klamath also identified substantial power generation through its recently completed Klamath 2020 Vision as vital to the health and stability of the county."

Response noted.

Commenter(s): Kimberly Priestly and Doug Heiken

Organization: WaterWatch of Oregon and Oregon Wild

Comment(s):

1. **"The temporary transfer of an irrigation groundwater right to a one time fill of a reservoir is not allowed by the temporary transfer statutes**: Under Oregon law, temporary transfers are limited to "place of use and, if necessary to convey water to the new temporary place of use, temporarily change the point of diversion or point of appropriation…." ORS 540.523. A temporary transfer of "type" of use is not allowed under Oregon law. Thus, Symbiotics cannot legally achieve their plan of temporarily transferring the two irrigation rights for a "one time" fill of the reservoir.

2. **"The transfer statutes don't allow change from a groundwater water right (G) to a reservoir right (R):** ORS 540.520 allows for a transfer of a change in character of use, place of use, or point of diversion. The statutes do not contemplate a change in the method of appropriation. It appears from the preliminary application materials that Symbiotics is proposing to do just that– transfer a groundwater right to a reservoir right. Changing a groundwater water right to a storage rights does not fit within the construct of changing the character of use. As noted above, a ground water right and a storage right refer to the method of appropriation, not use. The G- and R- in the permit codes are not designations of use or place of use. The character of use has to be designated separately in either case: i.e. irrigation, mining, municipal, hydro, etc."

   Reservoir rights are not the same as ground water rights and cannot be treated as interchangeable under the transfer statutes. A wholly separate section of the Water Code is dedicated to reservoir rights. See ORS 537.400 et al. To allow this transfer not only would be in violation of the transfer statutes, but by expanding the method of appropriation to also allow storage would result in an enlargement of the underlying ground water right, which is specifically prohibited by the transfer statutes. See ORS 540.510.

3. **"The transfer would result in injury to other water users:** The preliminary application materials indicate that Symbiotics believes it would be able to transfer 6800 AF per year form G-10952 and C 29530 for an initial fill the reservoir, and then use well #5 under G-10952 for refill purposes for water lost to evaporation (1,574 AF). To allow Symbiotics the full duty allowed under the underlying

rights might in fact appropriate the full duty of 6800 AF a year, irrigation practices do not consumptively use 100% of the water. In fact, based on the WRD's consumptive use factors for irrigation, it is likely that upwards of 50% of this water is not in fact consumed by the water right holder but instead is lost to evaporation and/or groundwater recharge/return flow. In the Klamath basin both surface water and groundwater are over appropriated. Given the very over appropriated state of the Klamath River Basin, any return flows/groundwater recharge is most certainly used by other water right holders. Thus, allowing full appropriation for a reservoir fill and/or evaporation replacement would injure other water rights. This is prohibited by the transfer statutes. ORS 540.510.

4. **"The proposed project will impair water resources in the Klamath Basin:** As the WRD is well aware, groundwater resources in the Klamath Basin, including the Lost River Basin, have undergone serious decline. This has been exacerbated by the 2001 and 2010 droughts. See Ground-Water Hydrology of the Upper Klamath Basin, Oregon and California, Scientific Investigations Report 2007-5050, Version 1.1., April 2010 USGS, WRD; See also, The Oregonian, Klamath Basin's water worries extend to wells, August 28, 2010. Heavy well use is also reducing stream flows. Id. The amount of water sought for Symbiotics' project is significant (29.5 cfs). Both the initial filling of the reservoir and the annual replacement of evaporation will further deplete already declining groundwater, and likely surface water, resources of this basin." "Despite the significant amount of water being sought for this project, Symbiotics' application appears to discount the effects of its proposed project on water resources of this state because it plans to use existing permits and certificates. ORS 543.017 governing the development of hydroelectric projects applies whether or not the applicant is seeking a "new" water right or seeking to transfer an "old" water right. The statutes set forth strict standards that apply to <u>all</u> new hydroelectric projects. Regardless of the underlying water right, this is a new hydroelectric project which is subject to all provisions of ORS 543. To that end, in addition to conducting a full public interest review of this application under ORS 543.225, the state cannot approve the application unless it can ensure that the project will not result in a net loss of wild game fish, or in the mortality, injury, or loss of natural habitat of anadromous salmon or steelhead. Given the over appropriated state of groundwater resources of this basin, the documented connection to already over appropriated surface flows and the presence of endangered fish species in this basin (including the Lost River and Short-nosed Sucker), the use of water needed for this project will likely impair or be detrimental to the public interest."

Conclusion: For the aforementioned reasons, WaterWatch and Oregon Wild have concerns about the legality of this proposed project, and also about the probable effects on the groundwater and surface water resources of the Klamath River Basin. We also have concerns about the applications lack of adequate specificity to allow a thorough review of the project and its impacts, and thus reserve the right to submit further comments as more information becomes available.

Response: The right to use water under this application will be reviewed under the hydroelectric statutes of ORS 543. These statutes provide for the authorization of the entire project including project reservoirs. Therefore, there is no consideration of transferring a groundwater right to a right to construct a reservoir. The reservoirs will be considered under the hydroelectric authorization. The right to store water shall be reviewed as part of the hydroelectric right albeit with a 2010 priority date.

It is proposed that irrigation water use be foregone during the period of the initial fill. Because the wells currently provide irrigation uses and declines are not evident in the groundwater levels, this would seem to indicate that water would likely be available for the project.

The Department shall require a groundwater study to include conducting a one-week to one-month groundwater interference test. The test shall be conducted under controlled conditions and directed by a qualified hydrogeologist to determine the possible impacts of pumping the proposed well(s) on other wells in the vicinity of the project. The plan for the proposed groundwater interference test should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. Generally, such a test should be conducted during the months of January or February before groundwater pumping for irrigation begins for the season. OWRD can offer assistance in selecting other wells in the vicinity to be monitored during the drawdown and recovery periods of the test. It should be noted that a water level response to the test in the wells monitored in a given compartment and/or sub-area does imply a potential for interference, but a lack of response does not imply no interference will occur.

The Department may also require the applicant to establish long-term groundwater level monitoring at wells within the north Swan Lake Valley compartment and within the main body of the Swan Lake to Poe Valley sub-area. The plan for the groundwater level monitoring should be discussed with, reviewed by, and approved by OWRD Groundwater Section staff before beginning. It should be prepared by a qualified hydrogeologist and should include installing water level recorders at 2 wells minimum (one well inside and one well outside the north Swan Lake Valley compartment). The monitoring may require construction of one or two wells if existing wells are not suitable.

The Department may require the schedule for filling of the reservoirs to be modified to provide for groundwater levels to recover, if necessary. The Applicant expects that most of the irrigation uses would resume after initial fill of the reservoir is completed. All of these issues can be considered during the application phase of the project. Therefore, the project should be eligible for further study and development of application information.

ACRONYMS

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BETCO	Barometric and Earth Tide Correction
BGS	below ground surface
cfs	cubic feet per second
FERC	Federal Energy Regulation Commission
ft/acre	feet per acre
ft^2/day	square feet per day (measure of transmissivity)
gpm	gallons per minute
gpm/ft	gallons per minute per foot of drawdown
I.D.	identification
OWRD	Oregon Water Resources Department\
psi	pounds per square inch
USGS	U.S. Geological Survey