SNOW CAMP QUARRY
HYDROGEOLOGICAL SITE EVALUATION AND ANALYTICAL GROUNDWATER FLOW MODEL

SNOW CAMP, ALAMANCE COUNTY,
NORTH CAROLINA

Latitude: N 36° 04′ 28.3″
Longitude: W 77° 56′ 06.0″

GMA Project #: 163101

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1.0 INTRODUCTION AND FIELD RECONNAISSANCE DISCUSSION

Groundwater Management Associates, Inc. (GMA) is pleased to provide this report evaluating the hydrogeology of the proposed quarry near Snow Camp, Alamance County, North Carolina (Figure 1). The purpose of this work is to address a request from the North Carolina Department of Environmental Quality (NCDEQ) for additional information regarding a mining permit application they received for the site. The NCDEQ letter was dated June 21, 2019. Particularly, Alamance Aggregates, Inc. contracted GMA to address item #3 in the NCDEQ letter, which requested the following: "***Provide results of an on-site pump test and modeling of ground water movement. Determine the possible impact of the diabase dikes may have on the area ground water wells with respect to the dewatering activities***."

2.0 PREVIOUS INVESTIGATIONS AND GEOLOGIC SETTING

Robert Christian Reinhardt (2018a) (Reinhardt) described the geology of the quarry site. Reinhardt (2018b and 2019) also prepared groundwater monitoring plans for the quarry site. Tyler Clark (2019) conducted a geophysical survey across the site to investigate diabase that may be located at or below land surface. All of those reports reference geologic reports by Carpenter (1982), the North Carolina Geologic Map (NCGS, 1985), and Schmidt and others (2006). In general, those reports describe the lithology of the area surrounding the site, and the entire subject site itself, as being underlain by Cambrian to Late Proterozoic age felsic meta-volcanic rock (FVR). FVR is described by Carpenter (1982) as medium- to light-gray, fine-grained, dense felsic tuffs and felsic crystal tuffs containing, in places, subhedral to euhedral feldspar crystals. Cleavage and foliation is commonly well developed in the FVR. Schmidt and others (2006) identified the rock formation at the quarry site and surrounding area as the Reedy Branch Tuff, with the western portion described as strongly altered and locally heavily sheared. The eastern portion of the site was described as slightly to moderately altered/sheared. The boundary between those two parts of the Reedy Branch Tuff was mapped (Schmidt, et al., 2006) roughly in the middle of the quarry property along a northeast to southwest trending contact (Figure 2).

The second rock type mapped near the site is Jurassic age diabase. Diabase is a hard, dense, black fine-grained intrusive igneous rock that cuts across existing rocks or layers of rocks. Diabase is often mapped as a long, narrow, linear feature that is nearly vertical, called a dike. Diabase dikes are located where the diabase was injected into fractures. Diabase in the region is often associated with enhanced fracturing of the surrounding rocks due to intrusion of magma, thermal alteration of the adjacent rocks, and fracturing of the diabase during cooling of the rock. Diabase has a mafic composition, and it tends to weather more quickly that felsic to intermediate rocks. Thus, the presence of diabase can be important for evaluating preferential groundwater flow pathways. Diabase was mapped west of the site by Carpenter (1982) and the NCGS (1985). Clark (2019) also identified the same diabase rock type just west of the site. Although diabase occurs in the region, no diabase has been mapped on the quarry site.

The third rock type of interest is Cambrian to Late Proterozoic age intermediate meta-volcanic rock (IVR), which was described by Carpenter (1982) as medium to dark grayish-green, dense, fine-grained tuffs of probable andesitic composition. Although this rock type has not been mapped by others on the site, it has been identified both northeast and southwest of the site (Carpenter, 1982). Clark (2019) conducted a magnetic survey of the site with the purpose of investigating the presence and orientation of diabase at the quarry site. Clark identified a magnetic anomaly on the quarry site, which trends northeast to southwest across the site (see Figure 2). However, Clark (2019) reported that the magnetic anomaly is likely IVR and not diabase. GMA observed two outcrops of IVR on the quarry site during our field investigation, and one of the outcrops was within the anomaly identified by Clark (2019), and these outcrops appear to support Clark's conclusion that the magnetic anomaly is IVR and not diabase.

3.0 GMA's Site Investigation

A team of GMA Geologists visited the site and conducted a field reconnaissance investigation of the quarry property on October 3, 4, and 30, 2019. The proposed pit area is 28.29 acres (Figure 2), with a maximum depth ranging from 270 to 332 feet below land surface (BLS). The initial quarry operation will be in the southeast corner of the proposed pit area, and the pit will expand toward the northwest. The quarry site is either wooded or is pasture land, and there is easy access across the site. There is site access off Clark Road (at 342 Clark Road at an old collapsing house with no address marker). That road extends into the site and can reach the north side of the property. A second access is on the north side of the site off of Quakenbush Road. The quarry property boundaries and the proposed pit boundary are shown in Figure 2.

During the reconnaissance, GMA observed four existing inactive water-supply wells located on the property. The GMA field team also reviewed site specific information provided in previous reports by Clark (2019) and Reinhardt (2019). GMA selected final sites for exploratory drilling to support aquifer testing. Stakes were set in the ground marking potential drilling sites, and GPS coordinates of the potential drill sites were established.

Four new observation wells were constructed. The area chosen for the wells is close to a major stream system on the northern side of the property and within the magnetic anomaly identified by Clark (2019). The drilling contractor, Derry's Well Drilling (DWD) constructed these wells and estimated well yields for the existing inactive water-supply wells and the newly installed observation wells. Videos were also made of each well borehole by DWD. These well data provide critical baseline information about the nature of the bedrock aquifer, fracture occurrences, and yield characteristics of the aquifer.
Upon completion of well drilling, a 6-hour variable rate step-drawdown test and a 24-hour

constant rate aquifer pumping test were conducted using observation well OW-2 as the pumping well. Data collected from these tests were evaluated along with the geologic information obtained from GMA's field investigations. Together, these data were used by GMA to prepare a site conceptual model and to perform analytical calculations to predict the response of the groundwater system to future withdrawals from the proposed quarry. GMA elected to perform analytical calculations using specific observation well water-level data to predict groundwater impacts associated with the proposed quarry. Analytical calculations using assumptions of aquifer homogeneity, isotropy, and equivalent porous media provide conservative assumptions for predicting the area of drawdown impact associated with the proposed quarry. The details of analytical calculations, and supporting field data, are presented in the following sections.

3.1 EXISTING WATER-SUPPLY WELLS ON THE SITE

There are four existing inactive water-supply wells on the site, and all are accessible (Figure 2). Prior to GMA's investigation, there was no well construction information available for these wells. Wells WSW-1 (a 6-inch diameter well with steel casing, 94 feet deep) and WSW-4 (a six-inch diameter well with steel casing, 405 feet deep) are accessed from Clark Road (Figure 2). Well WSW-1 was modified during the investigation by adding a piece of PVC casing to extend the top of the well casing to approximately 2 feet above ground. WSW-1 is located near the site entrance off Clark Road, about 100 feet north of Clark Road and about 20 feet east of barbed wire fencing. WSW-4 is located in tall grass about 200 feet southeast of WSW-1 inside a concrete ring cover.

On October 30, 2019, the water levels were measured in both wells. The water level in WSW-1 was 19.9 feet below the top of PVC casing. The water level in WSW-4 was 15.5 feet below the top of the steel casing, which is about 1 foot above land surface.

Water-supply wells WSW-2 and WSW-3 are accessed from Quackenbush Road (Figure 2). Water-supply well WSW-2 is 96 feet depth and is equipped with a 6-inch diameter steel casing. Well WSW-3 is a dug well about 2 to 3 feet in diameter, stone lined, and located about 10 feet northwest of WSW-2. On October 30, 2019, the water levels were measured in both wells. The water level in WSW-2 was 30.35 feet below the top of the casing, which is about 7 inches (about 0.6 feet) above land surface. The water level in WSW-3 was 29.38 feet below the top of the concrete slab/foundation which is about 2 feet above land surface.

DWD also characterized the casing depth and well yield of the four existing water-supply wells identified on site, including performing a video log of each well. Table 1 summarizes well construction information for the existing water-supply wells.

Table 1. Summary of Well Construction Information for Existing Water-Supply Wells Located On Site

Well Name	Depth BLS	Casing Diameter (inches)	Static Water Level Depth in Feet BMP (10/30/19)	Height of Measuring Point above Land Surface in Feet	Well Yield Estimated by Driller (GPM)
WSW-1	94	6	19.9	2	1
WSW-2	96	6	30.35	0.7	2.5
WSW-3	38.5	30-36	29.38	2	---
WSW-4	405	6	15.5	1	3

BLS = Below Land Surface. BMP = Below Measuring Point. GPM = Gallons per Minute.
--- = Not Measured.

3.2 OBSERVATION WELL CONSTRUCTION

DWD installed four observation wells (OW-1 through OW-4) at the site (Figure 2). For each observation well, DWD advanced a 14-inch boring (using air-rotary drilling methods) into bedrock, set an 8-inch PVC casing, and grouted the annulus of the well casing with cement grout. The following day, DWD drilled a 6-inch diameter boring into the rock below the casing. Each well was drilled to a depth of 350 feet below land surface (BLS). DWD collected and bagged samples of cuttings for every 10 foot depth drilled, and they provided those bagged samples to GMA for inspection. DWD also documented when fracture zones were encountered in each boring and approximated the well yield periodically during drilling. A GMA geologist was present to inspect the drilling of two of the well borings: OW-3 and OW-4.

Fracture zones and well yields were identified/estimated by the driller during drilling operations, and geologic logs were prepared by GMA based on boring cuttings and notes from the driller. Those logs are included in Appendix I. Estimated well yields for each of the four new observation wells ranged from 2.5 gallons per minute (gpm) to 10 gpm. Water-bearing zones are described in the geologic logs and summarized on the Table 2.

Table 2: Water-Bearing Zones and Estimated Yields for Observation Wells

Well Name	Well Depth (Feet BLS)	Depth of Water-Bearing Zones Determined During Drilling (Feet BLS)	Total Well Yield Estimated by Driller
OW-1	350	77, 145-165, 185-205, 248-255	10 gpm
OW-2	350	25-45, 50, 56, 70, 272	2.5 gpm
OW-3	350	56, 97	4 gpm
OW-4	350	39-40, 80-85, 290-300	3 gpm

BLS = Below Land Surface. GPM = Gallons per Minute.

All new wells and existing water supply wells on the property are located within the slightly sheared portion of the Reedy Branch Tuff identified by Schmidt and others (2006).

3.3 GEOLOGIC INTERPRETATION OF THE SITE

GMA traversed all of the stream valleys and pasture areas during site reconnaissance, and we identified several rock outcrops. The majority of the rock types encountered in these outcrops was a gray meta-volcanic rock with feldspar phenocrysts and minor quartz veins. These rocks correspond to the FVR identified by Carpenter (1982). Schmidt and others (2006) described these rocks as the Reedy Creek Tuff. Some rocks were described as heavily sheared and other rocks were described as slightly sheared.

One stream valley had exposed bedrock where field measurements of rock structure could be obtained. The stream is located on the north side of the property, with its headwaters near the old house at the Quackenbush Road entrance in the vicinity of existing water-supply wells WSW-2 and WSW-3. Hard FVR is located at the higher elevations in the stream valley and over the majority of the site, which is mapped as being within the slightly sheared portion of the Reedy Branch Tuff (Schmidt and others, 2006). The stream in those areas with outcrops had ponded water. The stream was dry in the upper reaches where saprolite/overburden were present. To the northwest, downstream along this creek, outcrops exhibited weaker, friable, heavily sheared rocks, and the streambed was dry. These rocks correspond the FVR identified by Carpenter (1982) and the heavily sheared Reedy Branch Tuff identified by Schmidt and others (2006). The dry streambed observed in this area suggests that the sheared rocks are more permeable than the less-altered rocks at the site, and the sheared zone may result in a losing stream condition in this reach of the intermittent stream. No major fractures or faulting were observed in outcrops along the stream bed or in other outcrops on the quarry site.

A dense, greenish- to dark-gray meta-volcanic rock was observed at the land surface on the site, and in drill cuttings from all of the new observation wells. That rock appears to have a fine-grained dark-green matrix. GMA interprets these rocks as the IVR identified by Carpenter (1982). These rocks were also included in the slightly sheared zone of the Reedy Creek Tuff identified by Schmidt and others (2006). One outcrop of IVR was observed in the northwest corner of the site in the stream valley near the property boundary and near the power line and gas line right-of-ways (Figure 2). This outcrop of IVR is about 1,000 feet east of the diabase dike that has been mapped in the area (Carpenter, 1982; Clark, 2019). The stream in this area had ponded water.

A second outcrop of IVR identified by GMA is located about 235 feet south of well OW-4, which places that outcrop in the center of the magnetic anomaly identified by Clark (2019). All of the observation wells are within the boundary of the magnetic anomaly identified by Clark (2019) as well. The magnetic anomaly has the same northeast to southwest orientation as other masses of IVR identified northeast and southwest of the site by Carpenter (1982). The diabase dike that has been mapped by others west of the site has a more north to south orientation. The orientations of those rock bodies were at least part of the reason Clark (2019) determined that the anomaly was caused by IVR and not diabase. Field evidence collected by GMA supports Clark's interpretation.

GMA did not observe diabase dikes on the subject property, either at the surface or at depth during drilling in the magnetic anomaly identified by Clark (2019). Because the existing diabase dike is located significantly to the west of the quarry property, the influence of that dike on groundwater recharge to water-supply wells could not be measured directly by GMA during this investigation.

4.0 AQUIFER TESTING

GMA installed water-level recorders (pressure transducers) in each of the new observation wells and in each of the existing water-supply wells. The transducers were programmed to record water levels at 5 minute intervals. Periodic water-level measurements were also taken in each well using an electronic water-level meter. Transducers were installed on November 18, 2019, and they were removed on November 23, 2019. This time period included non-pumping (background) and pumping events.

4.1 VARIABLE-RATE STEP-DRAWDOWN TESTING AND DATA EVALUATION

DWD was employed directly by Alamance Aggregates Inc. to operate the equipment for the variable rate step-drawdown pumping test under the direction of GMA. DWD completed the step-drawdown test on November 19, 2019. Well OW-2 was chosen as the pumping well because the original yield estimate of OW-2 was 6 gpm. Three 2-hour pumping steps were planned to be performed, one at each of the following rates: 4 gpm, 6 gpm, and 8 gpm.

Static water level in OW2 prior to the beginning of the test was 16.20 feet below the top of casing (TOC). After 2 hours of pumping at 4 gpm, the water level had declined to 22.38 feet below TOC, for a drawdown of 6.18 feet. Discharge was then increased to 6 gpm. The water level dropped to 34.71 after 105 minutes of pumping, and was declining at a rate of about 1 foot every 15 minutes. The rate of water-level decline increased to about 15 feet every 30 minutes thereafter. At the end of 4 hours of pumping, the total drawdown was 138.74 feet. The third part of the step test, at 8 gpm, was cancelled because excessive drawdown below the pump intake was expected. Step-drawdown test data are presented in Appendix II.

The water-bearing fracture at about 52 feet below land surface appears to be the main contributing fracture to this well. Pumping the water level below that depth resulted in rapid drawdown levels in the well. GMA determined that pumping the well at 2.5 gpm for 24 hours should result in a pumping water level that remains just above the fracture zone at 52 feet depth, and 2.5 gpm was selected as the pumping rate to use for the 24-hour pumping test.

4.2 CONSTANT RATE PUMPING AQUIFER TEST AND DATA EVALUATION

Rorie Well Repair Inc. (RWR) was employed directly by Alamance Aggregates Inc. to operate the equipment for the 24-hour constant rate pumping aquifer test, under the direction of GMA. Based on the results of the step-drawdown testing, GMA decided that the pumping rate for the pumping well (OW-2) would be 2.5 gpm for the 24-hour test. The 24-hour constant rate pumping aquifer test was completed on November 23, 2019.

Immediately prior the aquifer test, the static water level was measured to be 15.33 feet below the measuring point (Top of Casing or TOC) in well OW-2. The pumping water level in well OW-2 after 1200 minutes of pumping at a constant rate of 2.5 gpm was 45.84 feet below TOC. A steady rain began to fall about 20 hours (1200 minutes) into the test, which caused the water levels in some wells to noticeably rise. Therefore, the drawdown analysis was limited to the first 1200 minutes of the aquifer pumping test. The total drawdown (difference between static and pumping water level depths) recorded after 1200 minutes of testing was 30.51. The specific capacity of the well was determined to be 0.082 gpm/foot of drawdown.

Because background (pre-pumping) water levels were monitored for more than 24-hours prior to the pumping test, records of background water-level trends were available to perform corrections of drawdown values from the observation wells. Appendix II presents the uncorrected pre-pumping and pumping test water-level measurements from the pressure transducers. Four non-pumping wells (OW1, OW3, OW-4, and WSW-2) revealed evidence of drawdown influence during the pumping test. Therefore, GMA determined average linear pre-pumping water-level trends for each of these wells, and we corrected the pumping water levels to remove the natural background trends. Background trends in each of these wells indicated rising water levels that followed a linear trend. Rising head trends averaged about 0.15 feet per day, and we applied the well-specific corrections to the first 1200 minutes of observations during the pumping test. Because significant water-level increases occurred in some of the wells after 1200 minutes of pumping due to a heavy rain event, GMA did not use drawdown data beyond 1200 minutes of pumping for our aquifer test analyses.

Table 3: Summary of Static Water Levels and Corrected Drawdown

Well Name	Total Well Depth (Feet) BLS	Well Casing Diameter in inches	Depth to Static Water Level Below Measuring Point Measured November 22, 2019	Distance in Feet from the Pumping Well OW-2	Corrected Drawdown (Feet) After 1200 Minutes of Withdrawals
WSW-1	94	6	19.43	3,280	0
WSW-2	96	6	30.81	258	0.32
WSW-3	38.5	30-36	30.31	265	0
WSW-4	405	6	14.95	3,340	0
OW-1	351	6	32.47	377	0.02
OW-2	350	6	15.33	0.25	30.51
OW-3	350	6	8.81	181	4.85
OW-4	350	6	18.07	436	0.2

BLS – Below Land Surface

A distance-drawdown plot was prepared using the corrected drawdown data in the table above. The distance-drawdown method (Jacob, 1950) provides a means of estimating average aquifer hydraulic properties based upon observations of drawdown in wells at varying distances from the pumped well. The distance-drawdown plot is included in Figure 3. Based on this plot, the theoretical limit of the cone of depression would extend out to 409 feet from the pumping well after 1200 minutes of pumping. GMA utilized the distance-drawdown method to estimate the average transmissivity and storage coefficient of the bedrock aquifer across the site. Transmissivity describes an aquifer's ability to transmit water, and storage coefficient describes the volume of water released from, or taken into, storage in the aquifer per unit surface area of aquifer per unit change in head. The average transmissivity of the fractured rock aquifer estimated from the distance-drawdown graph is 18.4 ft^2/day, which is quite low. The storage coefficient for the aquifer is 0.0002 (or 2×10^{-4}), which indicates a low volume of water released from storage in the fractured rock. Storage coefficient values below 0.001 are commonly associated with confined aquifers. However, we know that the bedrock aquifer at the site is unconfined because it receives recharge from rainfall through the regolith, and there is no confining layer above the bedrock. The low storage coefficient determined from the aquifer test is a function of the very low porosity of the rock and the small volume of water released by gravity drainage from storage in fractures in the rock.

GMA also evaluated the drawdown and recovery data from the pumping well (OW-2) and observation wells OW-3, OW-1, OW-4, and WSW-2 using the Cooper-Jacob Method (Cooper and Jacob, 1946). GMA utilized these evaluations to estimate the local heterogeneity of transmissivity and storage coefficient of the bedrock aquifer across the site. These analyses also provide information on variation with depth of the hydraulic conductivity (permeability) of the rock. Plots and more detailed notes regarding the analyses are included in Appendix III.

The Cooper-Jacob method was used to determine transmissivity of the aquifer at the pumping well (OW-2). The transmissivity estimates of the aquifer at OW-2 decreased with time during the test, ranging from 11.12 ft^2/day in the early part of the test, to 2.4 ft^2/day in the middle of the test, and 1.9 ft^2/day in the late stages of the test. The significantly lower transmissivity values derived from the later portions of the drawdown data, as compared to the transmissivity derived from the early data, are indicative of dewatering of the upper fractures. The data from well OW2 indicates that the bedrock below 40 feet depth has very low permeability.

The transmissivity of the fractured rock aquifer observed in the observation well OW-3 was about 12 ft^2/day for both the early and later portions of the data. Of all the observation wells, OW-3 exhibited the greatest drawdown effects from pumping from OW-2, and GMA believes that aquifer test data from OW-3 present the most reliable individual estimates of transmissivity and storage coefficient from the aquifer testing because the magnitude of drawdown was orders of magnitude larger than background water-level fluctuations, thus any errors of data corrections for background water-level changes would be less significant than at wells where background fluctuations and drawdown observations of a similar magnitude.

The highest transmissivity estimate from all drawdown data sets was 339 ft^2/day in WSW-2 using the Cooper-Jacob method. The higher value of transmissivity at WSW-2 could represent a thicker saturated regolith than is present at most of the other wells. Furthermore, well WSW-2 does not reach to the deeper fractures encountered in the observation wells, and therefore WSW-2 is partially penetrating. Partial penetration likely affected the drawdown response in WSW-2.

The observed drawdown in wells OW-1 and OW-4 were so small that GMA considers those analyses unreliable for valid analytical solutions, especially in consideration of the diurnal water-level fluctuations the were observed in the background water-level data and our inability to reliably correct for these oscillations for wells that experienced very limited drawdown.

5.0 SITE CONCEPTUAL MODEL AND ANALYTICAL CALCULATIONS

The Snow Camp Quarry site lies within a typical Piedmont hydrogeologic setting. Heath (1984) discussed the hydrogeologic characteristics of the Piedmont region, wherein ridge tops occupy interstream areas with hard rock that has limited fractures. Stream valleys occur in areas where the underlying bedrock is intensively fractured and more deeply weathered. Ridge tops often have bedrock outcrops and thin regolith (soil and saprolite). Figure 4 illustrates this conceptual model for groundwater flow in a Piedmont setting.

The proposed Snow Camp Quarry site lies on a ridge top where regolith is nearly absent, the bedrock has few water-bearing fractures, and permeability of the bedrock is low. The ridge tops are recharge areas for the aquifer, and the volume of water in storage on the ridge tops is very small. In this setting, groundwater withdrawals required to maintain a dry quarry pit are expected to be small, and the low permeability of the bedrock will significantly inhibit the expansion of drawdown away from the quarry. Data collected from drilling and aquifer testing at the site provide site-specific data on the transmissivity and storage coefficient of the upland (ridge-top) portion of the groundwater flow regime. These data provide important information from which predictive analytical calculations can be made.

5.1 Cone of Depression from the Pumping Test and Indications of Heterogeneity

Water-level drawdown resulting from the 24-hour constant rate pumping aquifer test was measured in wells OW-2, OW-3, OW-4, OW-1, and WSW-2. The corrected drawdown values are contoured and presented in Figure 5. The drawdown cone is elliptical, owing to the orientation of fractures that generally following bedrock foliation at the site. Flow lines, representing the direction of groundwater flow, will be perpendicular to elevation contours of the groundwater surface (the potentiometric surface), which may be generally represented by the drawdown cone contours. The major axis, or direction, of groundwater flow will trend northeast-southwest, which is also parallel to the bedrock foliation. Using the observations from the 24-hour pumping test, we can project that the future drawdown area around the proposed Snow Camp Quarry will be elongated in the northeast-southwest direction.

The distance-drawdown plot (Figure 3) indicates that the radius of the cone of influence (0 feet of drawdown) created by 30.51 feet of drawdown at the pumping well after 20 hours of pumping was about 409 feet. Since drawdown in the quarry will ultimately be as much as 330 feet, GMA projected the theoretical distance-drawdown plot (see Appendix III) to steady state conditions (assumed to be 365 days). Steady state projections suggest that the theoretical zero drawdown may extend to a distance of 8,700 from the pumping well after one year of pumping. The distance-drawdown method assumes homogeneous and isotropic conditions with an aquifer that has an infinite areal extent. The calculation also assumes a constant withdrawal rate that is uniformly applied to the full thickness of the aquifer. The Snow Camp Quarry does not match the assumptions of the distance-drawdown method. The fractured bedrock is <u>not</u> homogeneous and isotropic, and the decreasing productivity with depth of the pumping well (OW2) clearly demonstrates anisotropy. Furthermore, the aquifer is an unconfined system that is bounded locally by groundwater flow divides (ridge tops in recharge areas) and discharge boundaries (streams) which are located much closer to the quarry than the theoretical 8700 feet limit of a cone of depression. Lastly, as shallow and more productive fractures become dewatered locally around the pit, groundwater flow contribution into the pit will be limited by the much lower-permeability deeper fractures, thereby reducing the pumping rate from the quarry as steady state is approached. *Nonetheless, utilizing the distance-drawdown method* *provides a starting point for considering potential drawdown associated with groundwater withdrawals from the proposed quarry.*

5.2 ANALYTICAL MODELING OF GROUNDWATER INFLUENCE FROM THE QUARRY

We utilized the distance versus drawdown method to estimate the theoretical drawdown at different distances from proposed quarry (Appendix III). This prediction assumes a transmissivity of 18.4 ft^2/day, a storage coefficient of 0.0002, and a maximum drawdown of 330 feet in the quarry. Table 4 presents these theoretical drawdown values at varying distances.

Table 4. Theoretical Maximum Drawdown at Steady State Conditions

Distance From the Quarry Wall in Feet	Theoretical Drawdown in Feet at Steady State, Without Considering Effects of Hydrologic Boundaries That Occur
1,000	72
1,500	58.5
2,000	49
3,000	35.5

However, the actual drawdown that may occur at these distances will be substantially reduced by hydrologic boundaries that will be encountered by the cone of influence as it extends outward. These boundaries were NOT encountered by the cone of influence created by the 24 hour aquifer test. Major hydrologic boundaries that may be encountered include streams, recharge areas (such as drainage basin divides along major ridge tops) and different rock characteristics (such as greater permeability of sheared rock zones and/or thicker saturated overlying saprolite) that the cone of influence may encounter as it extends outwards.

The highly sheared volcanic rock zone located just west of the projected pit area likely has a higher permeability than the slightly sheared rock zones of the pit area as demonstrated by the losing stream flow in the sheared rock zone. GMA expects the connection between these two zones will be minimal based on the eight low yielding wells present on the quarry site and the results of our aquifer testing. Also, the major flow lines in the quarry area are expected to be preferentially oriented northeast to southwest along rock foliation. That orientation is parallel to the contact between the highly-sheared and slightly-sheared zones.

5.3 Projected Pumping Rates from Initial Quarry Operations

GMA estimated the groundwater contribution to quarry withdrawals using the information we collected.

We used Darcy's Law (Q = KA dh/dl) as presented in Heath (1984):

Where:

> **dh/dl** is hydraulic gradient. GMA estimated average dh/dl from the distance drawdown plot for the initial pit using the projected head difference between 1000 feet from the pit (22 feet at steady state) and the 100 feet deep pit. So, there is a dh of 78 feet over a dl of 1000 feet, giving dh/dl of 0.078 ft/ft.
>
> **K** is hydraulic conductivity. GMA used the average transmissivity of 18.4 ft^2/day divided by the full thickness (320 feet) to get an average hydraulic conductivity (K) of 0.058 ft/day.
>
> **A** is cross-sectional area of flow. GMA estimated the cross-sectional area of the pit wall using an estimated perimeter of the final pit (about 5,000 feet) with an assumed initial 100 feet of thickness at the pit, providing a cross-sectional area for flow of 500,000 ft^2.

Solving for Q resulted in the following:

> **Q** = (0.058 ft/day)(500,000 ft^2)(0.078) = 2,262 ft^3/day = 16,920 gal/day = 11.75 gpm.

While this method may be the simplest method, GMA believes this value of Q may be underestimated because the full bedrock aquifer thickness was used as the divisor for determining K. Our aquifer testing shows that the deeper portion of the rock is very tight and likely accounts for only about 10% of the total transmissivity we calculated. We calculated an alternate estimate that apportions 90% of the calculated transmissivity to the upper 100 feet of thickness. This exercise resulted in an estimated average K value of 0.17 ft/day. Using this higher K estimate resulted in a projected groundwater contribution to the initial pit of about 6,630 ft^3/day, which equals 49,600 gallons/day or about 34.4 gpm. GMA believes that the 34.4 gpm groundwater pumping estimate is a reasonable approximation of the groundwater contribution to the proposed initial quarry. However, this pumping does not account for precipitation contribution to the pit.

Rainfall will be a significant source of water for pumping withdrawals to maintain a dry pit in the quarry. The area of the proposed pit is estimated to be 28.29 acres, or 1,232,312 square feet. The average annual rainfall for this area is 44.92 inches (https://www.usclimatedata.com/climate/burlington/north-carolina/united-states/usnc0087), or about 3.74 feet. If half of that rainfall is lost due to evapo-transpiration and reuse by the quarry for dust suppression and other uses, that leaves about 1.87 feet of annual rainfall over that entire 1,232,312 square feet that would compose most of the water to be discharged from the quarry. So annually about 2.306 million cubic feet of water may be discharged from the quarry operation as a result of precipitation. Precipitation contribution would be equivalent to 47,267 gallons per day, or about 32.8 gallons per minute.

To estimate the total rate of quarry withdrawals, GMA added the estimate of the groundwater contribution to the estimate contributed by annual rainfall. The estimated average discharge rate is 67.2 gallons per minute. Discharge from the quarry would likely not occur every day, only as needed after rainfall events. Discharge from the quarry would be directed to existing streams where some of that water would infiltrate into the groundwater, recharging the system in losing reaches of the stream, if they occur.

5.4 ESTIMATED ZONE OF INFLUENCE FROM THE INITIAL QUARRY

Our analytical calculations (Figure 3) suggests that there could be 72 feet of drawdown 1,000 feet from the quarry wall at maximum pumping level in the future pit, but that estimate is theoretical and does not include effects of natural hydrologic boundaries that would be encountered as the cone of influence expands. During initial stages of mining to a depth of 100 feet, GMA does not expect any adverse drawdown impacts to occur off the quarry property. However, to be cautious, the initial estimate of the zone of influence that will be used during the initial stages of mining will assume a maximum of 22 feet of drawdown 1,000 feet from the quarry pit, during the period when the mine depth is 100 feet or less. Figure 6 shows the location of that estimated initial zone of influence. Based on our experience, GMA believes that limit is a conservative estimate of the zone of influence, meaning that we expect that it represents a worse-case estimate of the location of the zone of influence.

GMA noted earlier that we expect streams and changing characteristics of the rock will be limiting factors to the expansion of the cone of influence. As the quarry grows, Alamance Aggregates Inc.'s consultant could model the site using historic water level data, mined depth and area, and rate of withdrawal to project characterize the actual zone of influence. An updated map showing the actual zone of influence would be developed after 5 years of data have been collected. This map will be used to guide the mitigation plan for potential impacts to surrounding water-supply wells.

As the quarry is developed deeper, we expect only minor additional volumes of water to be produced. This is supported by the fact that deeper fractures in the on-site wells appear to represent only about 10% of the transmissivity determined from the full thickness of the unit. GMA has experience working with similar quarry operations in the region that supports these expectations. There are generally no adverse impacts to water-supply wells located more than 1,000 feet from a typical quarry pit boundary. So GMA believes that the map in Figure 6 is a conservative starting point to estimate the zone of influence around Snow Camp Quarry. There are no residential water-supply wells outside the quarry permit boundary and located within the estimated initial zone of influence. Therefore, we do not anticipate adverse impacts to surrounding wells as a result of the initial quarry operations.

6.0 MONITORING PLAN FOR QUARRY DEVELOPMENT

Reinhardt (2018b, 2019) proposed a groundwater monitoring plan for the Snow Camp Quarry involving the designation of up to four well locations. Each well location would be near the quarry property boundary, generally to the northeast, southeast, southwest, and northwest. That plan included having two wells at each location, one shallow well 50 to 100 feet deep, and one deeper well drilled to the proposed depth of the quarry (330 feet).

The new observation wells constructed for this project (Figure 5) are located just north of the proposed quarry pit in a general orientation from northeast to southwest, which is the same trend as the magnetic anomaly and foliation of the bedrock. Foliation of the bedrock is likely the preferred direction or pathway for groundwater flow, so data collected along that orientation using wells OW-1, OW-2, OW-3, and OW-4 could be used to monitor preferential flow directions of groundwater. Therefore, GMA suggests that the new observation wells (OW-1, OW-2, OW-3, and OW-4) constructed for this investigation should be added to the monitoring plan as monitoring wells.

GMA suggests that Well OW-1 should be used as the northeastern deep monitoring well and existing WSW-2 could be used as the shallow monitoring well. Existing WSW-4 could be used as the deep monitoring well and existing WSW-1 could be used as the shallow monitoring well for the southwestern monitoring station. New well pairs would need to be constructed to the southeast and northwest. See Figure 7 for the existing well locations and proposed well locations suggested for the monitoring plan.

Water levels should be periodically recorded for all monitoring wells. These wells will serve as sentinel wells to document water-level changes as the quarry expansion progresses. Regular water-level measurements in these wells will document the impact of groundwater withdrawals on groundwater levels through time. Graphs of these water level changes will help the Alamance Aggregates and NCDEQ determine if groundwater withdrawals are the cause of any problems that may arise in residential wells beyond the quarry property. Those data will be used to periodically modify the projected zone of influence as the quarry develops.

7.0 MITIGATION PLAN FOR RESIDENTIAL WATER-SUPPLY WELLS

This plan is developed specifically to address concerns relative to residential water-supply wells located near the proposed Alamance Aggregates Inc. – Snow Camp Quarry located in the vicinity of Snow Camp, North Carolina. This Mitigation Plan has been developed to address how Alamance Aggregates Inc. will respond, upon notification that a water-supply well within the zone of influence may have been adversely impacted due to declining groundwater levels.

Adverse water-level declines are those that impact the usefulness of the well to provide water. A small water-level decline will not adversely impact the vast majority of wells. Alamance Aggregates Inc. will establish the zone of influence based on current conditions and periodically update that zone of influence based on the monitoring plan data. Our analytical calculations (Figure 3) provide a predicted zone of influence to be used during initial quarry operations.

Water Well Inventory

As part of the original permitting effort for this quarry location, Reinhardt (2019) conducted a water-supply well survey of the area. The water-supply well survey was conducted within a 1,500 foot radius of the proposed permit boundary. No residential properties were identified within 500 feet of the proposed mining limit.

Reinhardt (2019) identified 81 properties zoned as residential within the search area and determined that 21 of those properties were undeveloped. A review of County records, and the responses received from a mailed questionnaire to property owners, revealed there are at least 42 residential water-supply wells within 1,500 feet from the proposed quarry permit boundary. Water-supply wells in this area ranged in depth from 105 feet to 415 feet. Well yields for those wells ranged from 1.5 gpm to 100 gpm. Reinhardt (2019) also included the names of well owners, coordinates, and addresses for each property. GMA proposes to use this existing well inventory as part of the initial database for the mitigation plan.

As mentioned above, GMA believes that the initial zone of influence map shown in Figure 6 is a conservative estimate of the zone of influence around the Snow Camp Quarry. There are no active residential water-supply wells located within the 1,000 foot radius around the proposed pit boundary.

Response Plan

Should a problem occur with a residential water-supply well, the property owner should notify Alamance Aggregates Inc. or NCDEQ of the water-supply well issue. The proposed procedures to address the complaint are outlined below:

a) An analysis will be made to determine whether or not the water supply well in question is located within the Zone of Influence as it exists at the time of the notice.

b) An Alamance Aggregates Inc. representative, or a designated agent (a qualified well repair/installation specialist), will evaluate the condition of the water-supply well to determine the cause of the failure.

c) If a determination is made that the water-supply well in question has failed due to mechanical reasons not related to drawdown from the quarry, the NCDEQ will be notified and the procedures outlined in this Mitigation Plan will not be applicable. The property owner will be notified of the findings of this determination and will be responsible for any necessary repairs.

d) If a determination is made that the water-supply well in question has failed due to a decline of groundwater level that has been caused or is a direct result of mining activities or dewatering of the pit, then Alamance Aggregates Inc., at its expense, will proceed as quickly as is reasonable to provide a functioning, permanent water supply to the property owner, either by rehabilitation, repair, or deepening of the existing water supply well; or drilling of a new water-supply well of the same diameter; or by connecting the residence to a public water supply, if available. Alamance Aggregates Inc., or a designated agent (a qualified well repair/installation specialist), will evaluate the existing water-supply system to determine the most reasonable method available to restore the permanent water supply. The options available must be capable of meeting the minimum volume used or needed by the property owner before the disruption of water-supply occurred.

e) Based on the time necessary to re-establish a permanent supply to the property, it may be necessary to arrange with a licensed and reputable water distributor to provide the affected user with a temporary water supply. This water supply will be for use in normal household activities, such as bathing, washing, and sanitary facilities. This supply will be in the form of a clean-water tanker or container that will be refilled as needed, all at the expense of Alamance Aggregates Inc.

This Mitigation Plan relies on the use of qualified outside vendors to satisfy the needs of a temporary water supply and to develop a permanent water source. As licensed reputable companies, they are expected to accomplish and carry out their assigned duties in a manner that ensures that all work is completed within a predetermined time period. If for any reason, this work is not completed to an acceptable level of quality and/or within the time frame agreed upon by all parties, the outside vendor will be replaced by another company designated by Alamance Aggregates Inc.

8.0 CONCLUSIONS

GMA supervised the installation of four new observation wells on the quarry property, to supplement information that could be obtained from four existing former water-supply wells. The four observation wells were constructed on the northern side of the property. All of these wells are also located within the magnetic anomaly identified by Clark (2019). A 6-hour variable rate step-drawdown test and a 24-hour constant rate aquifer pumping test were conducted, using observation well OW-2 as the pumping well. The drilling contractor, Derry's Well Drilling constructed these wells with GMA supervision. Derry's Well Drilling also performed the following: estimated well yields for each existing water-supply well and new wells, performed video logging of each new observation and existing water-supply well, and operated the pump for the 6 hour step test. Rorie's Well Repair operated the pumping equipment and collected water levels for the 24-hour aquifer test. Using data gathered from the site, GMA prepared a site conceptual model of the area and performed predictive analytical calculations.

Aquifer testing revealed several characteristics of the fractured rock at the quarry site. All of the wells tested on the quarry property have low yields, ranging from 1 gpm to 10 gpm. The specific capacity of the pumping well was 0.08 gpm/ft. of drawdown. Transmissivity of the aquifer was higher (12 ft^2/day) in the shallower portions of the pumping well where shallow fractures are more abundant and can tap water stored in the overlying saprolite. Estimated transmissivity dropped to 2 ft^2/day in the deeper portions of the aquifer where fractures are less abundant and are less productive. The aquifer at the site is unconfined. The calculated storage coefficient values from the site are small, indicating that the fractured rock has very low porosity in the proposed mine area. The rock material that is to be mined by this quarry operation will produce very low volumes of groundwater.

GMA prepared a map showing the initial zone of influence for drawdowns resulting from quarry withdrawals. The map shows a limit of 22 feet of drawdown 1,000 away from the quarry pit boundary when the quarry pit is expected to have a maximum of 100 feet of drawdown. This map is intended to be the initial map to be used to determine if a well is within an area where it could possibly be impacted by quarry withdrawals. This map should be updated every 5 years using periodic water level measurements obtained from the observations wells mandated by NCDEQ to be installed at the four compass points around the quarry. GMA strongly suggests that the four new observation wells installed for this project, along with the four former water-supply wells existing on the site, be incorporated in that monitoring plan and used to periodically update the zone of influence map during active mining.

A mitigation plan has been prepared by GMA to address any problems arising with a residential well after the quarry has begun operation. The homeowner must contact Alamance Aggregates Inc., or NCDEQ, to report the problem. Alamance Aggregates will then contact their consultant to evaluate whether it is possible that the problem is caused by groundwater withdrawals from the quarry or by equipment malfunction in the well. It is the responsibility of the homeowner to repair their well if the problem is due to equipment malfunction or deterioration of the well (e.g., scale or bio-fouling of the borehole, lightning strikes, power surge, holes in casing, etc.). If the consultant determines that the problem could be result of quarry groundwater withdrawals, Alamance Aggregates will notify the homeowner and NCDEQ and indicate what steps will be taken at Alamance Aggregates' cost to mitigate the problem. Possible solutions could include: 1) lower the pump intake in the affected well; 2) if the pump cannot be lowered, the pump and piping will be removed and the well drilled deeper to connect to deeper fractures; 3) and if necessary, a new well may be drilled to sufficient depths to provide potable water.

9.0 REPORT CERTIFICATION

I, William L. Lyke, a Licensed Geologist for Groundwater Management Associates, Inc. (GMA), do certify that the information contained in this report is correct and accurate to the best of my knowledge. GMA is a professional corporation licensed to practice geology (Greenville and Apex, NC #C-121) and engineering (Apex, NC #C-0854) in the state of North Carolina.

Richard K. Spruill, PhD, P.G.
Principal Hydrogeologist

James K. Holley, P.G.
Senior Hydrogeologist
Water-Resources Director

William L. Lyke, P.G., P.E.
Senior Hydrogeologist/Civil Engineer

NORTH CAROLINA
LICENSED
12/17/19
SEAL
0408
GEOLOGIST
WILLIAM L. LYKE

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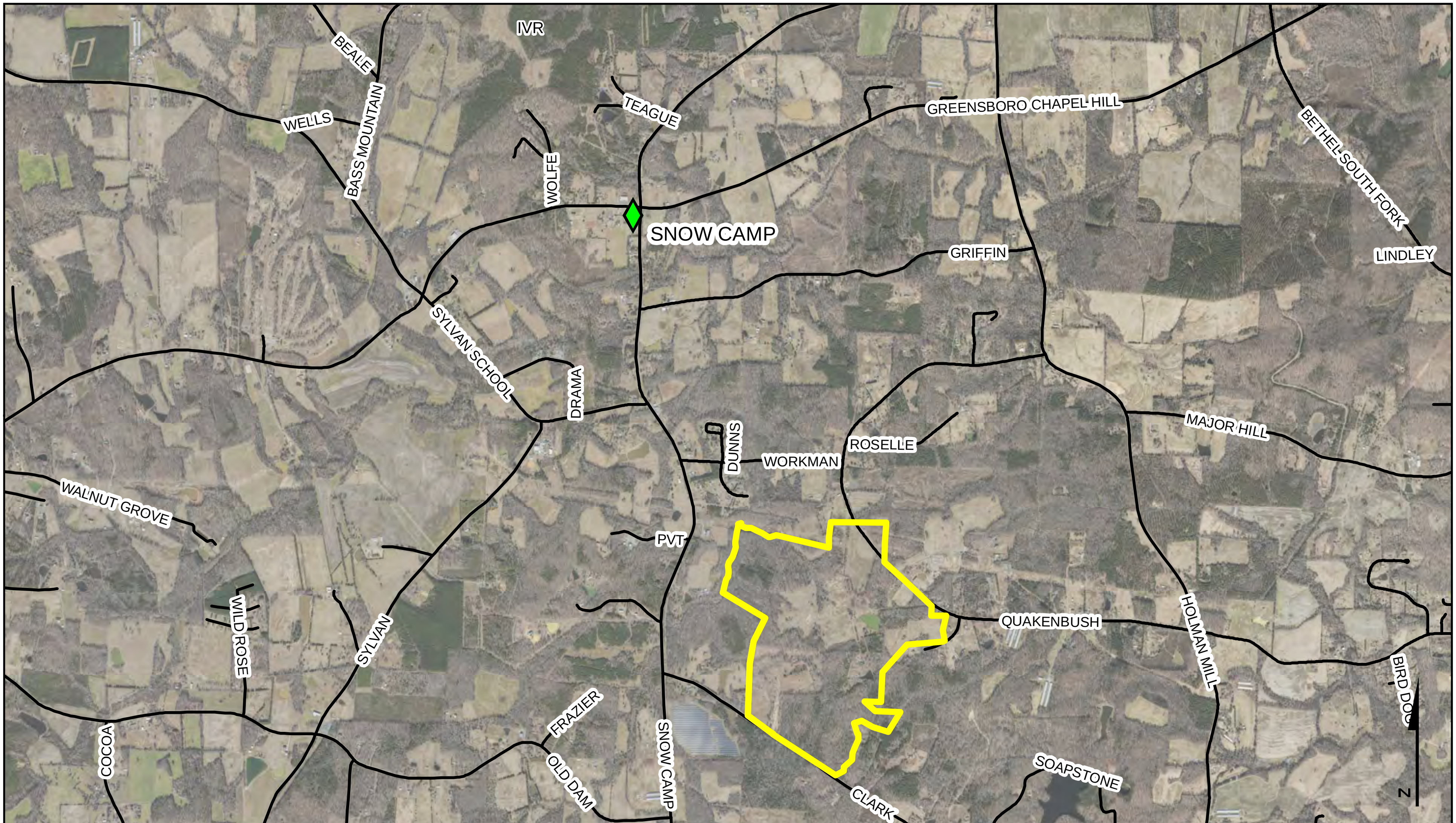
FIGURES



LEGEND

TOWN OF SNOW CAMP

APPROXIMATE PERMIT BOUNDARY

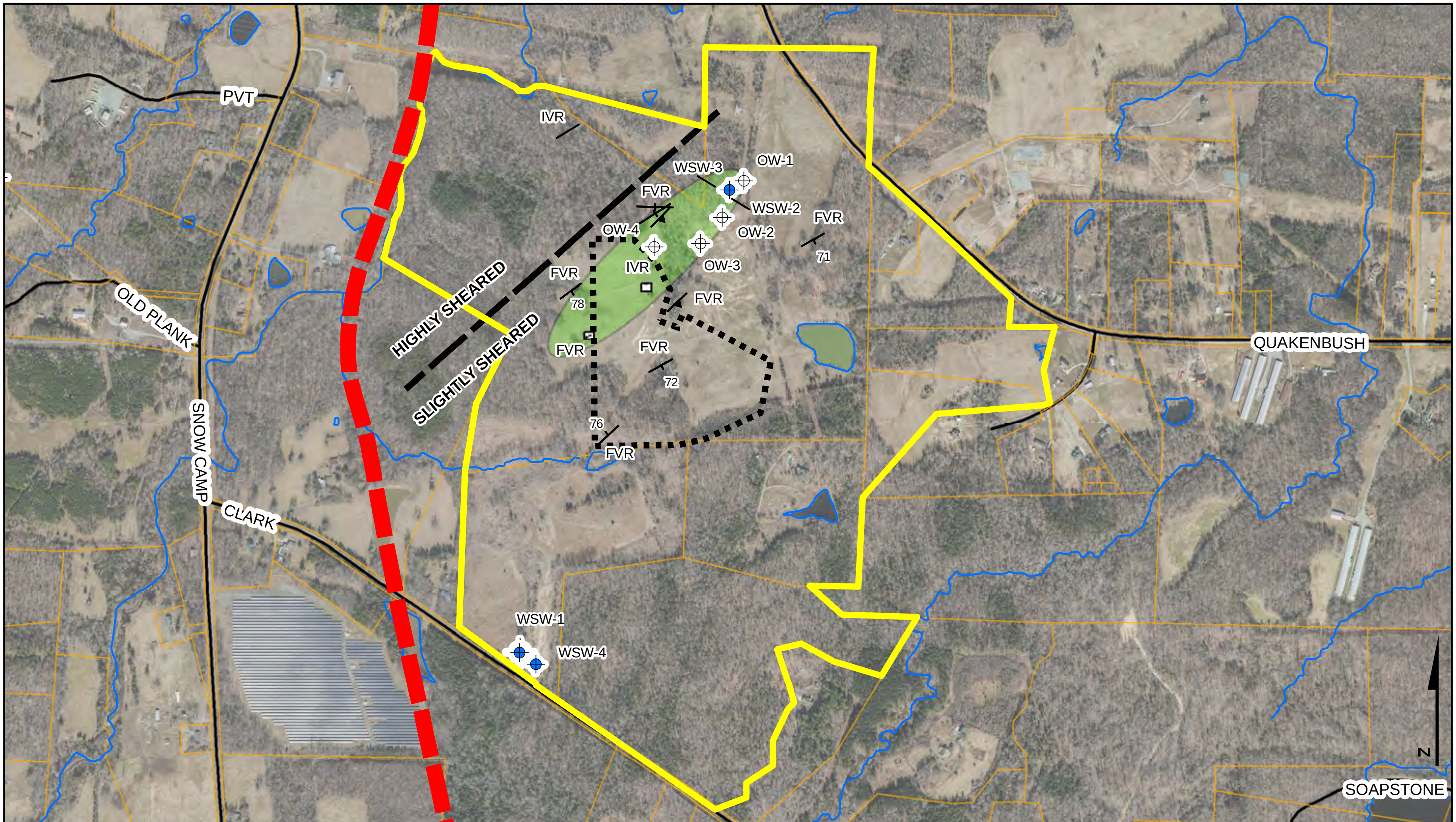
ROADS

SCALE IN FEET

0 1,500 3,000

GMA

File: DRAWINGS/163101/ FIG1_SITE_LOCATION_MAP	SITE LOCATION MAP	DATE: 12/12/2019
PROJECT NO. 163101	ALAMANCE AGGREGATES SNOW CAMP QUARRY SITE	FIGURE 1



LEGEND

WATER-SUPPLY WELL
OBSERVATION WELL
DIABASE DIKE (CLARK 2019)
MAGNETIC ANOMALY (CLARK 2019)
OUTCROP
SHEAR ZONE CONTACT (SCHMIDT ET AL. 2006)
FOLIATION
VERTICAL JOINT
STRIKE AND DIP OF JOINT
APPROXIMATE PERMIT BOUNDARY
APPROXIMATE PIT BOUNDARY
SURFACE WATER
ROADS
PARCEL BOUNDARY

SCALE IN FEET
0 500 1,000

File: DRAWINGS/163101/ FIG2_Site_Map_201912	SITE MAP SHOWING WELL LOCATIONS AND SITE GEOLOGY	DATE: 12/12/2019
PROJECT NO. 163101	ALAMANCE AGGREGATES SNOW CAMP QUARRY SITE	FIGURE 2

Figure 3. Distance Drawdown Analysis of Pumping Test Data

Corrected Drawdown Values at 1200 minutes of pumping - Snow Camp Quarry Pumping Test from well OW2.

Well	Distance	Drawdown
OW2	0.25	30.51
OW3	181	4.85
OW4	436	0.2
OW1	377	0.02
WSW2	258	0.32

$T = 70Q/\Delta s$

$\Delta s = 9.51$ feet

$Q = 2.5$ gpm

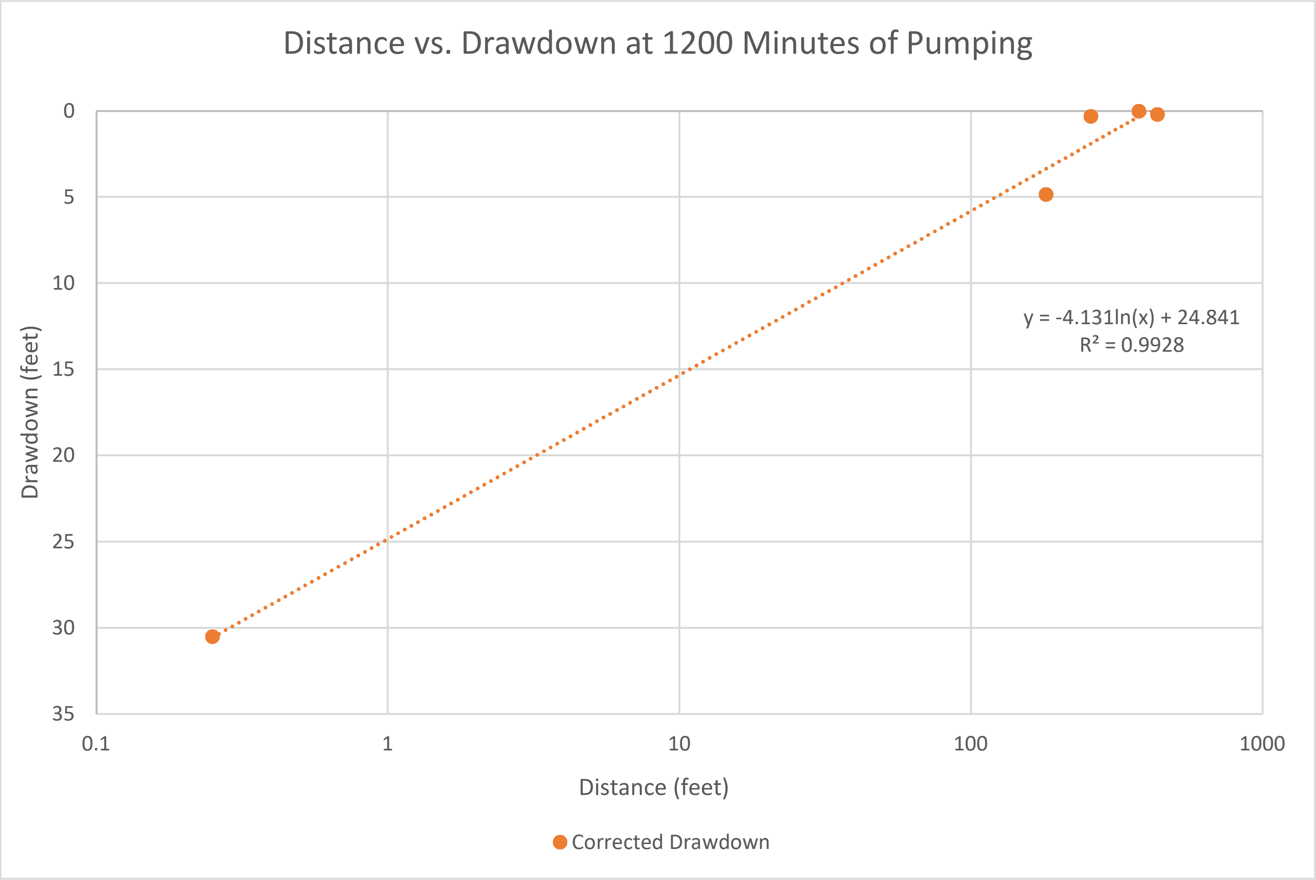
$T = 18.4\ ft^2/day$

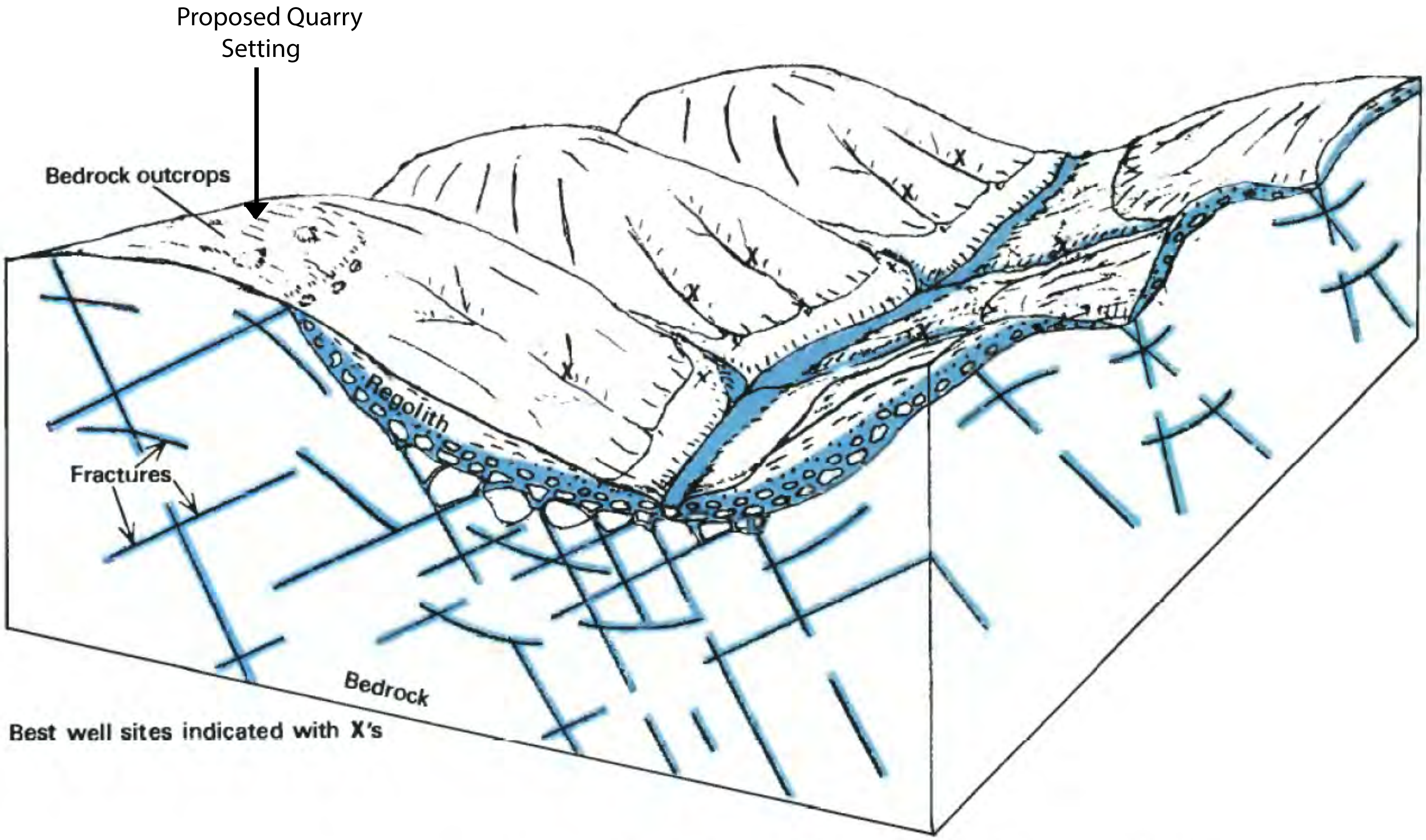
$S = Tt/640\ r_0^2$

$t = 1200$ minutes

$r_0 = 409$ feet

$S = 0.0002$

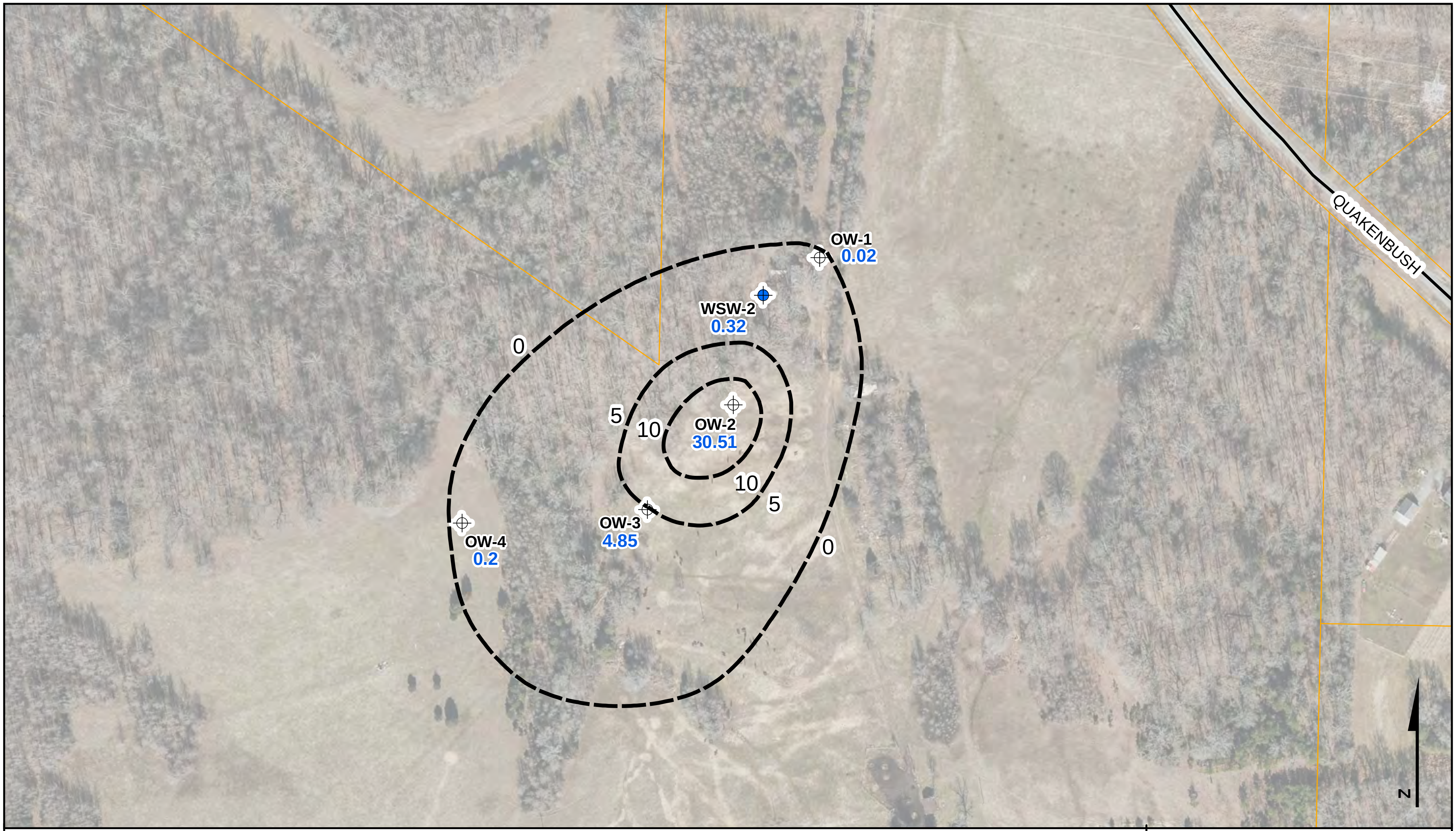




Modified from Heath, 1984

GMA
GROUNDWATER MANAGEMENT ASSOCIATES, INC.

File: Drawings/163101/ Figure4	SITE CONCEPTUAL MODEL OF THE SNOW CAMP QUARRY SETTING	Date:12/16/2019
PROJECT 163101	ALAMANCE AGGREGATES SNOW CAMP QUARRY SITE	FIGURE 4



LEGEND

WATER-SUPPLY WELL
OBSERVATION WELL
ROADS
PARCEL BOUNDARY

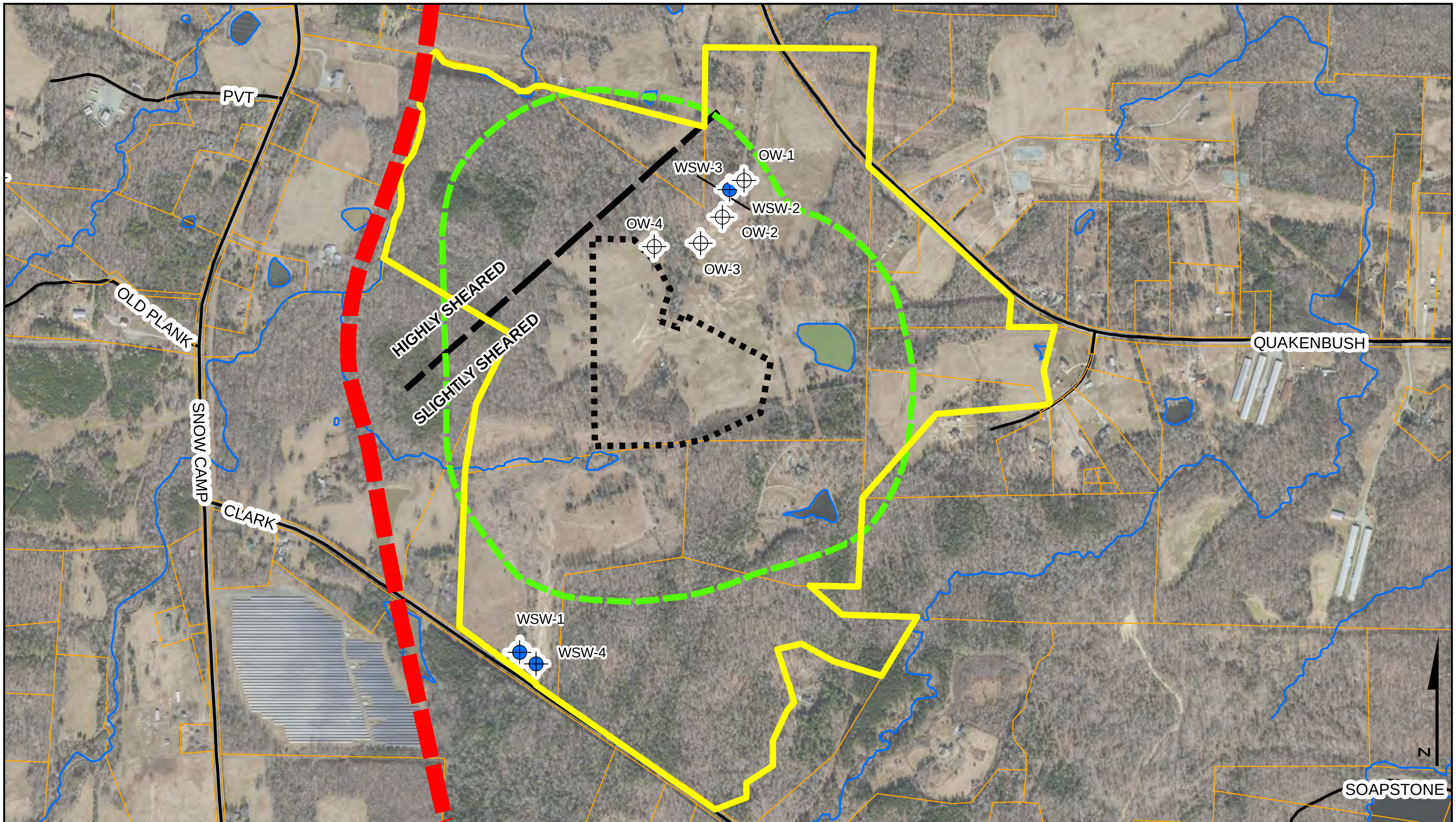
10 FEET OF DRAWDOWN (CORRECTED)

4.85 CORRECTED DRAWDOWN VALUES

SCALE IN FEET
0 125 250

GMA
GROUNDWATER MANAGEMENT ASSOCIATES, INC.

File: DRAWINGS/163101/ CONEOFDEPRESSION	CONTOUR MAP OF DRAWDOWN FROM THE CONSTANT RATE PUMPING AQUIFER TEST	DATE: 12/13/2019
PROJECT NO. 163101	ALAMANCE AGGREGATES SNOW CAMP QUARRY SITE	FIGURE 5



LEGEND

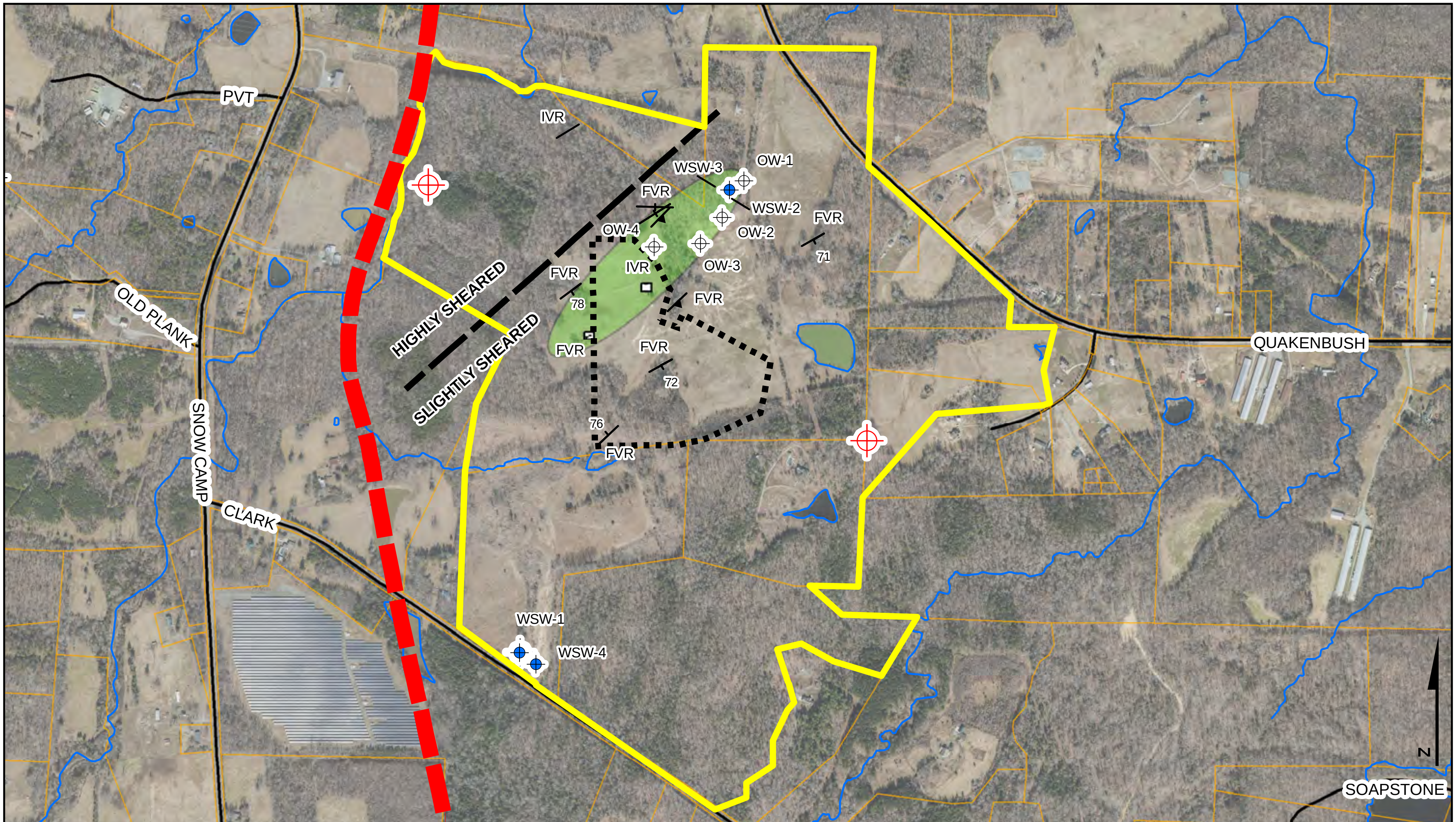
- WATER-SUPPLY WELL
- OBSERVATION WELL
- DIABASE DIKE (CLARK 2019)
- SHEAR ZONE CONTACT (SCHMIDT ET AL. 2006)
- APPROXIMATE PERMIT BOUNDARY
- APPROXIMATE PIT BOUNDARY
- PRELIMINARY ZONE OF INFLUENCE (FROM 100-FT DEPTH INITIAL PIT)
- PARCEL BOUNDARY
- SURFACE WATER
- ROADS

SCALE IN FEET

0 500 1,000

GMA

File: DRAWINGS/163101/ FIG6_ZONEOFINFLUENCE	ESTIMATED INITIAL ZONE OF INFLUENCE RESULTING FROM QUARRY WITHDRAWALS	DATE: 12/16/2019
PROJECT NO. 163101	ALAMANCE AGGREGATES SNOW CAMP QUARRY SITE	FIGURE 6



LEGEND

WATER-SUPPLY WELL

OBSERVATION WELL

DIABASE DIKE (CLARK 2019)

MAGNETIC ANOMALY (CLARK 2019)

OUTCROP

SHEAR ZONE CONTACT (SCHMIDT ET AL. 2006)

FOLIATION

VERTICAL JOINT

STRIKE AND DIP OF JOINT

PROPOSED MONITORING WELL LOCATION

APPROXIMATE PERMIT BOUNDARY

APPROXIMATE PIT BOUNDARY

SURFACE WATER

ROADS

SCALE IN FEET

0 500 1,000

GMA

File: DRAWINGS/163101/ FIG7_PROPOSEDMWS	PROPOSED MONITORING WELL LOCATIONS FOR GROUNDWATER MONITORING PLAN	DATE: 12/16/2019
PROJECT NO. 163101	ALAMANCE AGGREGATES SNOW CAMP QUARRY SITE	FIGURE 7

APPENDIX I

GEOLOGIC LOGS OF OBSERVATION WELLS

WELL CONSTRUCTION RECORD

This form can be used for single or multiple wells

1. Well Contractor Information:

John W. Huneycutt

Well Contractor Name

2465-A

NC Well Contractor Certification Number

Derry's Well Drilling, Inc.

Company Name

2. Well Construction Permit #: ____________________

List all applicable well permits (i.e. County, State, Variance, Injection, etc.)

3. Well Use (check well use):

Water Supply Well:

- ☐Agricultural
- ☐Municipal/Public
- ☐Geothermal (Heating/Cooling Supply)
- ☐Residential Water Supply (single)
- ☑Industrial/Commercial
- ☐Residential Water Supply (shared)
- ☐Irrigation

Non-Water Supply Well:

- ☐Monitoring
- ☐Recovery

Injection Well:

- ☐Aquifer Recharge
- ☐Groundwater Remediation
- ☐Aquifer Storage and Recovery
- ☐Salinity Barrier
- ☐Aquifer Test
- ☐Stormwater Drainage
- ☐Experimental Technology
- ☐Subsidence Control
- ☐Geothermal (Closed Loop)
- ☐Tracer
- ☐Geothermal (Heating/Cooling Return)
- ☐Other (explain under #21 Remarks)

4. Date Well(s) Completed: 10/23/19 **Well ID#** OW-1

5a. Well Location:

Alamance Aggregates, LLC

Facility/Owner Name

Facility ID# (if applicable)

Quakenbush Rd., Snow Camp 27349

Physical Address, City, and Zip

Alamance

County

Parcel Identification No. (PIN)

5b. Latitude and Longitude in degrees/minutes/seconds or decimal degrees:
(if well field, one lat/long is sufficient)

35.873380 **N** 79.415460 **W**

6. Is (are) the well(s): ☑**Permanent** or ☐**Temporary**

7. Is this a repair to an existing well: ☐**Yes** or ☑**No**

If this is a repair, fill out known well construction information and explain the nature of the repair under #21 remarks section or on the back of this form.

8. Number of wells constructed: 1

*For multiple injection or non-water supply wells **ONLY** with the **same construction**, you can submit one form.*

9. Total well depth below land surface: 350 **(ft.)**

For multiple wells list all depths if different (example- 3@200' and 2@100')

10. Static water level below top of casing: 32 **(ft.)**

If water level is above casing, use "+"

11. Borehole diameter: 6 **(in.)**

12. Well construction method: Rotary

(i.e. auger, rotary, cable, direct push, etc.)

FOR WATER SUPPLY WELLS ONLY:

13a. Yield (gpm) 10 **Method of test:** Air

13b. Disinfection type: Granular **Amount:** 1/2 lb.

For Internal Use ONLY:

14. WATER ZONES

FROM	TO	DESCRIPTION
77 ft.	80 ft.	2 gpm
145 ft.	165 ft.	2 gpm (185'-205'=2gpm, 247'-255'=4gpm)

15. OUTER CASING (for multi-cased wells) OR LINER (if applicable)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
0 ft.	49 ft.	6 1/8 in.	SDR-21	PVC

16. INNER CASING OR TUBING (geothermal closed-loop)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
ft.	ft.	in.		
ft.	ft.	in.		

17. SCREEN

FROM	TO	DIAMETER	SLOT SIZE	THICKNESS	MATERIAL
ft.	ft.	in.			
ft.	ft.	in.			

18. GROUT

FROM	TO	MATERIAL	EMPLACEMENT METHOD & AMOUNT
0 ft.	3 ft.	Bent. Chips	Gravity
3 ft.	20 ft.	Bentonite	Pumped
ft.	ft.		

19. SAND/GRAVEL PACK (if applicable)

FROM	TO	MATERIAL	EMPLACEMENT METHOD
ft.	ft.		
ft.	ft.		

20. DRILLING LOG (attach additional sheets if necessary)

FROM	TO	DESCRIPTION (color, hardness, soil/rock type, grain size, etc.)
0 ft.	25 ft.	Red Dirt
25 ft.	38 ft.	Lighter Red Dirt (Moist)
38 ft.	43 ft.	Sandy Shale Rock
43 ft.	103 ft.	Lighter More Consolidated Shale Rock
103 ft.	350 ft.	Blue Rock (Some White Quartz)
ft.	ft.	Seams: 77'=2g, 145-165'=2g, 185-205'=2g
ft.	ft.	247-255'=4g

21. REMARKS

22. Certification:

John W. Huneycutt 10/22/19

Signature of Certified Well Contractor Date

By signing this form, I hereby certify that the well(s) was (were) constructed in accordance with 15A NCAC 02C .0100 or 15A NCAC 02C .0200 Well Construction Standards and that a copy of this record has been provided to the well owner.

23. Site diagram or additional well details:

You may use the back of this page to provide additional well site details or well construction details. You may also attach additional pages if necessary.

SUBMITTAL INSTUCTIONS

24a. For All Wells: Submit this form within 30 days of completion of well construction to the following:

Division of Water Resources, Information Processing Unit,
1617 Mail Service Center, Raleigh, NC 27699-1617

24b. For Injection Wells ONLY: In addition to sending the form to the address in 24a above, also submit a copy of this form within 30 days of completion of well construction to the following:

Division of Water Resources, Underground Injection Control Program,
1636 Mail Service Center, Raleigh, NC 27699-1636

24c. For Water Supply & Injection Wells:
Also submit one copy of this form within 30 days of completion of well construction to the county health department of the county where constructed.

WELL CONSTRUCTION RECORD
This form can be used for single or multiple wells

For Internal Use ONLY:

1. Well Contractor Information:

John W. Huneycutt
Well Contractor Name

2465-A
NC Well Contractor Certification Number

Derry's Well Drilling, Inc.
Company Name

2. Well Construction Permit #: ____
List all applicable well permits (i.e. County, State, Variance, Injection, etc.)

3. Well Use (check well use):

Water Supply Well:
☐Agricultural ☐Municipal/Public
☐Geothermal (Heating/Cooling Supply) ☐Residential Water Supply (single)
☑Industrial/Commercial ☐Residential Water Supply (shared)
☐Irrigation

Non-Water Supply Well:
☐Monitoring ☐Recovery

Injection Well:
☐Aquifer Recharge ☐Groundwater Remediation
☐Aquifer Storage and Recovery ☐Salinity Barrier
☐Aquifer Test ☐Stormwater Drainage
☐Experimental Technology ☐Subsidence Control
☐Geothermal (Closed Loop) ☐Tracer
☐Geothermal (Heating/Cooling Return) ☐Other (explain under #21 Remarks)

4. Date Well(s) Completed: 10/26/19 **Well ID#** OW-2

5a. Well Location:

Alamance Aggregates, LLC
Facility/Owner Name

Facility ID# (if applicable)

Quakenbush Rd., Snow Camp 27349
Physical Address, City, and Zip

Alamance
County

Parcel Identification No. (PIN)

5b. Latitude and Longitude in degrees/minutes/seconds or decimal degrees:
(if well field, one lat/long is sufficient)

35.872490 **N** 79.416110 **W**

6. Is (are) the well(s): ☑**Permanent** or ☐**Temporary**

7. Is this a repair to an existing well: ☐**Yes** or ☑**No**
If this is a repair, fill out known well construction information and explain the nature of the repair under #21 remarks section or on the back of this form.

8. Number of wells constructed: 1
For multiple injection or non-water supply wells ONLY with the same construction, you can submit one form.

9. Total well depth below land surface: 350 **(ft.)**
For multiple wells list all depths if different (example- 3@200' and 2@100')

10. Static water level below top of casing: 15 **(ft.)**
If water level is above casing, use "+"

11. Borehole diameter: 6 **(in.)**

12. Well construction method: Rotary
(i.e. auger, rotary, cable, direct push, etc.)

FOR WATER SUPPLY WELLS ONLY:

13a. Yield (gpm) 2.5 **Method of test:** Air

13b. Disinfection type: Granular **Amount:** 1/2 lb.

14. WATER ZONES

FROM	TO	DESCRIPTION
25 ft.	45 ft.	1/2 gpm
70 ft.	75 ft.	1/2 gpm (272'=1.5gpm)

15. OUTER CASING (for multi-cased wells) OR LINER (if applicable)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
0 ft.	20 ft.	6 1/8 in.	SDR-21	PVC

16. INNER CASING OR TUBING (geothermal closed-loop)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
ft.	ft.	in.		
ft.	ft.	in.		

17. SCREEN

FROM	TO	DIAMETER	SLOT SIZE	THICKNESS	MATERIAL
ft.	ft.	in.			
ft.	ft.	in.			

18. GROUT

FROM	TO	MATERIAL	EMPLACEMENT METHOD & AMOUNT
0 ft.	3 ft.	Bent. Chips	Gravity
3 ft.	20 ft.	Bentonite	Pumped
ft.	ft.		

19. SAND/GRAVEL PACK (if applicable)

FROM	TO	MATERIAL	EMPLACEMENT METHOD
ft.	ft.		
ft.	ft.		

20. DRILLING LOG (attach additional sheets if necessary)

FROM	TO	DESCRIPTION (color, hardness, soil/rock type, grain size, etc.)
0 ft.	11 ft.	Red Dirt
11 ft.	350 ft.	Blue Rock
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	Seams: 17', 25-45'=1/2g, 44', 50', 56',
ft.	ft.	70'=1/2g, 272'=1.5g

21. REMARKS

22. Certification:

John W. Huneycutt 11/22/19
Signature of Certified Well Contractor Date

By signing this form, I hereby certify that the well(s) was (were) constructed in accordance with 15A NCAC 02C .0100 or 15A NCAC 02C .0200 Well Construction Standards and that a copy of this record has been provided to the well owner.

23. Site diagram or additional well details:
You may use the back of this page to provide additional well site details or well construction details. You may also attach additional pages if necessary.

SUBMITTAL INSTUCTIONS

24a. For All Wells: Submit this form within 30 days of completion of well construction to the following:

**Division of Water Resources, Information Processing Unit,
1617 Mail Service Center, Raleigh, NC 27699-1617**

24b. For Injection Wells ONLY: In addition to sending the form to the address in 24a above, also submit a copy of this form within 30 days of completion of well construction to the following:

**Division of Water Resources, Underground Injection Control Program,
1636 Mail Service Center, Raleigh, NC 27699-1636**

24c. For Water Supply & Injection Wells:
Also submit one copy of this form within 30 days of completion of well construction to the county health department of the county where constructed.

WELL CONSTRUCTION RECORD

This form can be used for single or multiple wells

For Internal Use ONLY:

1. Well Contractor Information:

John W. Huneycutt
Well Contractor Name

2465-A
NC Well Contractor Certification Number

Derry's Well Drilling, Inc.
Company Name

2. Well Construction Permit #: ______
List all applicable well permits (i.e. County, State, Variance, Injection, etc.)

3. Well Use (check well use):

Water Supply Well:
- ☐Agricultural
- ☐Municipal/Public
- ☐Geothermal (Heating/Cooling Supply)
- ☐Residential Water Supply (single)
- ☑Industrial/Commercial
- ☐Residential Water Supply (shared)
- ☐Irrigation

Non-Water Supply Well:
- ☐Monitoring
- ☐Recovery

Injection Well:
- ☐Aquifer Recharge
- ☐Groundwater Remediation
- ☐Aquifer Storage and Recovery
- ☐Salinity Barrier
- ☐Aquifer Test
- ☐Stormwater Drainage
- ☐Experimental Technology
- ☐Subsidence Control
- ☐Geothermal (Closed Loop)
- ☐Tracer
- ☐Geothermal (Heating/Cooling Return)
- ☐Other (explain under #21 Remarks)

4. Date Well(s) Completed: 11/16/19 **Well ID#** OW-3

5a. Well Location:

Alamance Aggregates, LLC
Facility/Owner Name

Facility ID# (if applicable)

Quakenbush Rd., Snow Camp 27349
Physical Address, City, and Zip

Alamance
County

Parcel Identification No. (PIN)

5b. Latitude and Longitude in degrees/minutes/seconds or decimal degrees:
(if well field, one lat/long is sufficient)

35.87213 **N** 79.41653 **W**

6. Is (are) the well(s): ☑**Permanent** or ☐**Temporary**

7. Is this a repair to an existing well: ☐**Yes** or ☑**No**
If this is a repair, fill out known well construction information and explain the nature of the repair under #21 remarks section or on the back of this form.

8. Number of wells constructed: 1
For multiple injection or non-water supply wells ONLY with the same construction, you can submit one form.

9. Total well depth below land surface: 350 **(ft.)**
For multiple wells list all depths if different (example- 3@200' and 2@100')

10. Static water level below top of casing: 8.5 **(ft.)**
If water level is above casing, use "+"

11. Borehole diameter: 6 **(in.)**

12. Well construction method: Rotary
(i.e. auger, rotary, cable, direct push, etc.)

FOR WATER SUPPLY WELLS ONLY:

13a. Yield (gpm) 4 **Method of test:** Air

13b. Disinfection type: Granular **Amount:** 1/2 lb.

14. WATER ZONES

FROM	TO	DESCRIPTION
56 ft.	61 ft.	1 gpm
97 ft.	103 ft.	3 gpm

15. OUTER CASING (for multi-cased wells) OR LINER (if applicable)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
0 ft.	21 ft.	6 1/8 in.	SDR-21	PVC

16. INNER CASING OR TUBING (geothermal closed-loop)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
ft.	ft.	in.		
ft.	ft.	in.		

17. SCREEN

FROM	TO	DIAMETER	SLOT SIZE	THICKNESS	MATERIAL
ft.	ft.	in.			
ft.	ft.	in.			

18. GROUT

FROM	TO	MATERIAL	EMPLACEMENT METHOD & AMOUNT
0 ft.	3 ft.	Bent. Chips	Gravity
3 ft.	20 ft.	Bentonite	Pumped
ft.	ft.		

19. SAND/GRAVEL PACK (if applicable)

FROM	TO	MATERIAL	EMPLACEMENT METHOD
ft.	ft.		
ft.	ft.		

20. DRILLING LOG (attach additional sheets if necessary)

FROM	TO	DESCRIPTION (color, hardness, soil/rock type, grain size, etc.)
0 ft.	11 ft.	Red Dirt
11 ft.	350 ft.	Blue Rock
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	Seams: 56'=1g, 97'=3g
ft.	ft.	

21. REMARKS

22. Certification:

John W. Huneycutt — 12/10/19
Signature of Certified Well Contractor — Date

By signing this form, I hereby certify that the well(s) was (were) constructed in accordance with 15A NCAC 02C .0100 or 15A NCAC 02C .0200 Well Construction Standards and that a copy of this record has been provided to the well owner.

23. Site diagram or additional well details:
You may use the back of this page to provide additional well site details or well construction details. You may also attach additional pages if necessary.

SUBMITTAL INSTUCTIONS

24a. For All Wells: Submit this form within 30 days of completion of well construction to the following:

Division of Water Resources, Information Processing Unit,
1617 Mail Service Center, Raleigh, NC 27699-1617

24b. For Injection Wells ONLY: In addition to sending the form to the address in 24a above, also submit a copy of this form within 30 days of completion of well construction to the following:

Division of Water Resources, Underground Injection Control Program,
1636 Mail Service Center, Raleigh, NC 27699-1636

24c. For Water Supply & Injection Wells:
Also submit one copy of this form within 30 days of completion of well construction to the county health department of the county where constructed.

WELL CONSTRUCTION RECORD
This form can be used for single or multiple wells

1. Well Contractor Information:

John W. Huneycutt
Well Contractor Name

2465-A
NC Well Contractor Certification Number

Derry's Well Drilling, Inc.
Company Name

2. Well Construction Permit #: ______
List all applicable well permits (i.e. County, State, Variance, Injection, etc.)

3. Well Use (check well use):

Water Supply Well:
- ☐Agricultural
- ☐Municipal/Public
- ☐Geothermal (Heating/Cooling Supply)
- ☐Residential Water Supply (single)
- ☑Industrial/Commercial
- ☐Residential Water Supply (shared)
- ☐Irrigation

Non-Water Supply Well:
- ☐Monitoring
- ☐Recovery

Injection Well:
- ☐Aquifer Recharge
- ☐Groundwater Remediation
- ☐Aquifer Storage and Recovery
- ☐Salinity Barrier
- ☐Aquifer Test
- ☐Stormwater Drainage
- ☐Experimental Technology
- ☐Subsidence Control
- ☐Geothermal (Closed Loop)
- ☐Tracer
- ☐Geothermal (Heating/Cooling Return)
- ☐Other (explain under #21 Remarks)

4. Date Well(s) Completed: 11/14/19 **Well ID#** OW-4

5a. Well Location:

Alamance Aggregates, LLC
Facility/Owner Name

Facility ID# (if applicable)

Quakenbush Rd., Snow Camp 27349
Physical Address, City, and Zip

Alamance
County

Parcel Identification No. (PIN)

5b. Latitude and Longitude in degrees/minutes/seconds or decimal degrees:
(if well field, one lat/long is sufficient)

35.87193 **N** 79.41741 **W**

6. Is (are) the well(s): ☑**Permanent** or ☐**Temporary**

7. Is this a repair to an existing well: ☐**Yes** or ☑**No**
If this is a repair, fill out known well construction information and explain the nature of the repair under #21 remarks section or on the back of this form.

8. Number of wells constructed: 1
*For multiple injection or non-water supply wells **ONLY** with the **same construction**, you can submit one form.*

9. Total well depth below land surface: 350 **(ft.)**
For multiple wells list all depths if different (example- 3@200' and 2@100')

10. Static water level below top of casing: 18.5 **(ft.)**
If water level is above casing, use "+"

11. Borehole diameter: 6 **(in.)**

12. Well construction method: Rotary
(i.e. auger, rotary, cable, direct push, etc.)

FOR WATER SUPPLY WELLS ONLY:

13a. Yield (gpm) 3 **Method of test:** Air

13b. Disinfection type: Granular **Amount:** 1/2 lb.

For Internal Use ONLY:

14. WATER ZONES

FROM	TO	DESCRIPTION
39 ft.	40 ft.	1 gpm
80 ft.	85 ft.	1 gpm (290-300'=1g)

15. OUTER CASING (for multi-cased wells) OR LINER (if applicable)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
0 ft.	22 ft.	6 1/8 in.	SDR-21	PVC

16. INNER CASING OR TUBING (geothermal closed-loop)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
ft.	ft.	in.		
ft.	ft.	in.		

17. SCREEN

FROM	TO	DIAMETER	SLOT SIZE	THICKNESS	MATERIAL
ft.	ft.	in.			
ft.	ft.	in.			

18. GROUT

FROM	TO	MATERIAL	EMPLACEMENT METHOD & AMOUNT
0 ft.	3 ft.	Bent. Chips	Gravity
3 ft.	20 ft.	Bentonite	Pumped
ft.	ft.		

19. SAND/GRAVEL PACK (if applicable)

FROM	TO	MATERIAL	EMPLACEMENT METHOD
ft.	ft.		
ft.	ft.		

20. DRILLING LOG (attach additional sheets if necessary)

FROM	TO	DESCRIPTION (color, hardness, soil/rock type, grain size, etc.)
0 ft.	14 ft.	Red Dirt
14 ft.	350 ft.	Blue Rock
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	Seams: 39-40'=1g, 80-85'=1g, 290-300'=1g
ft.	ft.	

21. REMARKS

22. Certification:

John W. Huneycutt — 12/10/19
Signature of Certified Well Contractor — Date

By signing this form, I hereby certify that the well(s) was (were) constructed in accordance with 15A NCAC 02C .0100 or 15A NCAC 02C .0200 Well Construction Standards and that a copy of this record has been provided to the well owner.

23. Site diagram or additional well details:
You may use the back of this page to provide additional well site details or well construction details. You may also attach additional pages if necessary.

SUBMITTAL INSTUCTIONS

24a. For All Wells: Submit this form within 30 days of completion of well construction to the following:

Division of Water Resources, Information Processing Unit,
1617 Mail Service Center, Raleigh, NC 27699-1617

24b. For Injection Wells ONLY: In addition to sending the form to the address in 24a above, also submit a copy of this form within 30 days of completion of well construction to the following:

Division of Water Resources, Underground Injection Control Program,
1636 Mail Service Center, Raleigh, NC 27699-1636

24c. For Water Supply & Injection Wells:
Also submit one copy of this form within 30 days of completion of well construction to the county health department of the county where constructed.

Groundwater Management Associates, Inc.
2205-A CANDUN DRIVE, APEX, NC 27523

SNOW CAMP QUARRY

BORING LOG OW-1

PROJECT : Snow Camp Quarry
DRILLING CONTRACTOR : Derry's Well Drilling
DRILLING METHOD AND EQUIPMENT USED : Air Rotary
BORING DIAMETER: 6 inches START: 10/22/2019 END : 10/23/2019 LOGGER : WLL for GMA

GRAPHIC	INTERVAL DEPTH (FT BLS) TOP	BOTTOM	DESCRIPTION
	LAND SURFACE		
	0	15	Overburden; red loam.
	15	25	Overburden; brown loam.
	25	25	Overburden; brown loam.
	25	35	Overburden; brown loam.
	35	45	Overburden; brown loam, damp; well casing set at 49 feet.
	45	55	Felsic Volcanic Rock (FVR) fragments, brown.
	55	65	FVR fragments, brown.
	65	75	FVR fragments, brown.
	75	85	FVR fragments, brown; well yield is 2 gallons per minute (gpm) at 77 feet.
	85	95	FVR fragments, gray.
	95	105	Intermediate Volcanic Rock (IVR) and FVR fragments some quartz and pink feldspar, dark gray.
	105	115	IVR and FVR fragments some quartz and pink feldspar, dark gray.
	115	125	IVR fragments, greenish gray.
	125	135	IVR fragments, greenish gray.
	135	145	IVR fragments, greenish gray.
	145	155	IVR fragments, greenish gray.
	155	165	IVR fragments, greenish gray; 2 gpm more yield from 145-165. .
	165	175	IVR fragments, greenish gray; total well yield at 170 feet was 4 gpm.
	175	185	IVR fragments, greenish gray.
	185	195	IVR fragments, greenish gray.
	195	205	FVR fragments, light gray; 2 gpm more yield from 185 -205 feet. Total well yield at 205 feet is 6 gpm.
	205	215	FVR fragments, gray.
	215	225	FVR fragments, gray.
	225	235	FVR fragments, some quartz, light gray.
	235	245	FVR fragments, some quartz, light gray.
	245	255	FVR with felsic phenocrysts, gray; 4 gpm more yield at 248 feet..
	255	265	FVR with felsic phenocrysts, gray; large crack at 255 feet.
	265	275	FVR with felsic phenocrysts, gray.
	275	285	FVR with felsic phenocrysts, gray.
	285	295	FVR with felsic phenocrysts, gray.
	295	305	FVR with felsic phenocrysts, gray.
	305	315	FVR with felsic phenocrysts, gray.
	315	325	FVR with felsic phenocrysts, gray.
	325	335	FVR with felsic phenocrysts, gray.
	335	351	FVR with felsic phenocrysts, gray. Total well yield is 10 gpm.

COMMENTS: Boring was converted to an Observation Well (#1) with open-hole construction. Casing is 8 inch diameter PVC set at 49 feet BLS. Boring is 6 inch diameter. Total Well depth is 351 feet BLS. Total Well Yield is 10 gpm. Felsic Volcanic Rock (FVR) and Intermediate Volcanic Rock (IVR) are defined in Carpenter (1982).

GMA

Groundwater Management Associates, Inc.

2205-A CANDUN DRIVE, APEX, NC 27523

SNOW CAMP QUARRY

BORING LOG OW-2

PROJECT : Snow Camp Quarry

DRILLING CONTRACTOR : Derry's Well Drilling

DRILLING METHOD AND EQUIPMENT USED : Air Rotary

BORING DIAMETER: 6 inches START: October 2019 END : October 2019 LOGGER : WLL for GMA

GRAPHIC	INTERVAL DEPTH (FT BLS) TOP	BOTTOM	DESCRIPTION
	LAND SURFACE		
	0	10	Overburden; btown loam.
	10	20	Rock at 11 feet, Felsic Volcanic Rock (FVR) fragments, light tan, dry; hit crack at 17 feet; most of sample is FVR fragments, gray, wet.
	20	30	FVR fragments, gray; casing set at 20 feet.
	30	40	FVR fragments, gray; 1/2 gpm yield between 25-45 feet.
	40	50	FVR fragments, gray; crack at 44 feet.
	50	60	FVR fragments, gray; crack at 50 feet and 56 feet..
	60	70	FVR fragments, gray' crack around 70 feet.
	70	80	FVR fragments, gray.
	80	90	FVR fragments, gray.
	90	100	FVR fragments, gray.
	100	110	FVR fragments, gray.
	110	120	FVR fragments, gray.
	120	130	FVR fragments, gray; total well yield 2 gpm.
	130	140	FVR fragments, gray.
	140	150	FVR fragments, gray.
	150	160	FVR fragments, gray.
	160	170	FVR fragments, gray.
	170	180	FVR fragments, gray.
	180	190	FVR fragments, gray.
	190	200	FVR fragments, gray.
	200	210	FVR fragments, gray.
	210	220	FVR fragments, gray.
	220	230	FVR fragments, gray.
	230	240	FVR fragments, gray.
	240	250	FVR fragments, gray.
	250	260	FVR fragments, gray.
	260	270	FVR fragments, gray. Total well yield at 265 feet is 2 gpm (unchanged from yield at 125 feet).
	270	280	FVR fragments, gray; hit water at 272 feet, total well yield is 6 gpm.
	280	290	FVR fragments, gray.
	290	300	Predominantly Intermediate Volcanic Rock (IVR) with some FVR, greenish dark gray.
	300	310	Predominantly Intermediate Volcanic Rock (IVR) with some FVR, greenish dark gray.
	310	320	Predominantly Intermediate Volcanic Rock (IVR) with some FVR, greenish dark gray.
	320	330	Predominantly Intermediate Volcanic Rock (IVR) with some FVR, greenish dark gray.
	330	340	Predominantly Intermediate Volcanic Rock (IVR) with some FVR, greenish dark gray.
	340	350	Predominantly FVR with some IVR, gray; total well yield is 2.5 gpm.

COMMENTS: Boring was converted to an Observation Well (#2) with open-hole construction. Casing is 8 inch diameter PVC set at 20 feet BLS. Boring is 6 inch diameter. Total Well depth is 350 feet BLS. Total Well Yield is 2.5 gpm. Felsic Volcanic Rock (FVR) and Intermediate Volcanic Rock (IVR) are defined in Carpenter (1982).

Groundwater Management Associates, Inc.
2205-A CANDUN DRIVE, APEX, NC 27523

SNOW CAMP QUARRY

BORING LOG OW-3

PROJECT : Snow Camp Quarry
DRILLING CONTRACTOR : Derry's Well Drilling
DRILLING METHOD AND EQUIPMENT USED : Air Rotary
BORING DIAMETER: 6 inches START: END : 11/16/2019 LOGGER : WLL for GMA

GRAPHIC	INTERVAL DEPTH (FT BLS) TOP	BOTTOM	DESCRIPTION
	LAND SURFACE		
	0	5	Overburden; btown loam.
	5	15	Rock at 11 feet, Felsic Volcanic Rock (FVR) fragments, light tan, dry.
	15	25	FVR fragments, gray; casing set at 21 feet.
	25	35	FVR fragments, gray, some dark gray gragments.
	35	45	Intermediate Volcanic Rock (IVR), dark gray, some feldspar.
	45	55	IVR, dark gray, some feldspar.
	55	65	IVR, dark gray, some feldspar; fracture 56 feet yeild about 1 gpm.
	65	75	IVR, dark green gray, minor feldspar.
	75	85	IVR, dark green gray, minor feldspar.
	85	95	IVR, dark green gray, minor feldspar and quartz.
	95	105	IVR, dark green gray, minor feldspar and quartz; fracture 97 feet adds 2 gpm, total well yield 3 gpm.
	105	115	IVR, dark green gray, minor feldspar and quartz.
	115	125	IVR, dark green gray, minor feldspar and quartz.
	125	135	IVR, dark green gray, minor feldspar and quartz.
	135	145	IVR, dark green gray, more feldspaar and quartz
	145	155	IVR, dark green gray, minor feldspar and quartz.
	155	165	IVR, dark green gray, minor feldspar and quartz.
	165	175	IVR, dark green gray, minor feldspar and quartz.
	175	185	IVR, dark green gray, minor feldspar and quartz.
	185	195	IVR, dark green gray, minor feldspar and quartz.
	195	205	IVR, dark green gray, minor feldspar and quartz.
	205	215	IVR, dark green gray, minor feldspar and quartz.
	215	225	IVR, dark green gray, minor feldspar and quartz.
	225	235	IVR, dark green gray, minor feldspar and quartz.
	235	245	IVR, dark green gray, minor feldspar and quartz.
	245	255	IVR, dark green gray, minor feldspar and quartz.
	255	265	IVR, dark green gray, more quartz at 257 feet.
	265	275	IVR, dark gray, no feldspar and quartz.
	275	285	IVR, dark gray, no feldspar and quartz.
	285	295	IVR, dark gray, no feldspar and quartz.
	295	305	IVR, dark gray, no feldspar and quartz.
	305	315	IVR, dark gray, no feldspar and quartz.
	315	325	IVR, dark gray, some feldspar and quart, and epidote (light green).
	325	335	IVR, dark gray, some feldspar and quart, and a lot of epidote (light green) from 330-335 feet.
	335	345	FVR, gray with felsic phenocrysts and some quartz and epidote (light green).
	345	350	FVR, gray with felsic phenocrysts; total well yield is 4 gpm.

COMMENTS: Boring was converted to an Observation Well (#3) with open-hole construction. Casing is 8 inch diameter PVC set at 21 feet BLS. Boring is 6 inch diameter. Total Well depth is 350 feet BLS. Total Well Yield is 4 gpm. Felsic Volcanic Rock (FVR) and Intermediate Volcanic Rock (IVR) are defined in Carpenter (1982).

GMA

Groundwater Management Associates, Inc.

2205-A CANDUN DRIVE, APEX, NC 27523

SNOW CAMP QUARRY

BORING LOG OW-4

PROJECT : Snow Camp Quarry

DRILLING CONTRACTOR : Derry's Well Drilling

DRILLING METHOD AND EQUIPMENT USED : Air Rotary

BORING DIAMETER: 6 inches START: 11/8/2019 END : 11/11/2019 LOGGER : WLL for GMA

GRAPHIC	INTERVAL DEPTH (FT BLS) TOP	BOTTOM	DESCRIPTION
	LAND SURFACE		
	0	10	Overburden.
	10	14	Overburden to 14 feet, rock at 14 feet.
	14	25	Felsic Volcanic Rock (FVR) with felsic phenocrysts, gray; well casing set at 22 feet.
	25	40	FVR with felsic phenocrysts, gray; fracture at 39-40 feet yields about 1 gallon per minute (gpm).
	40	55	FVR with felsic phenocrysts, gray.
	55	65	FVR with felsic phenocrysts, gray.
	65	75	FVR with felsic phenocrysts, gray; fracture zone around 70 feet yields about 1 gpm.
	75	85	FVR with felsic phenocrysts, gray.
	85	95	FVR with felsic phenocrysts, gray.
	95	105	FVR with felsic phenocrysts, gray.
	105	115	FVR with felsic phenocrysts, gray.
	115	125	FVR with felsic phenocrysts, gray.
	125	135	FVR with felsic phenocrysts, gray.
	135	145	FVR with felsic phenocrysts, gray.
	145	155	FVR with felsic phenocrysts, gray.
	155	165	Intermediate Volcanic Rock (IVR), dark greenish gray; black fragments in dark green matrix.
	165	175	IVR, dark greenish gray; black fragments in dark green matrix.
	175	185	IVR, dark greenish gray; black fragments in dark green matrix; total well yield is 2-3 gpm.
	185	195	IVR (dark gray) and FVR with felsic phenocrysts (gray).
	195	205	FVR with felsic phenocrysts, gray.
	205	215	FVR with felsic phenocrysts, gray.
	215	225	FVR with felsic phenocrysts, gray.
	225	235	FVR with felsic phenocrysts, gray.
	235	245	FVR with felsic phenocrysts, gray; total well yeild is 2-3 gpm.
	245	255	FVR with felsic phenocrysts, gray.
	255	265	FVR with felsic phenocrysts, gray.
	265	275	FVR with felsic phenocrysts, gray.
	275	285	FVR with felsic phenocrysts, gray.
	285	295	FVR with felsic phenocrysts, gray; total well yield is 5 gpm adding 2 gpm over last 10 feet.
	295	305	FVR with felsic phenocrysts, gray.
	305	315	FVR with felsic phenocrysts, gray.
	315	325	FVR with felsic phenocrysts, gray.
	325	335	FVR with felsic phenocrysts, gray.
	335	345	FVR with felsic phenocrysts, gray.
	345	350	FVR with felsic phenocrysts, gray; total well yield is 3 gpm.

COMMENTS: Boring was converted to an Observation Well (#4) with open-hole construction. Casing is 8 inch diameter PVC set at 22 feet BLS. Boring is 6 inch diameter. Total Well depth is 350 feet BLS. Total Well Yield is 3 gpm. Felsic Volcanic Rock (FVR) and Intermediate Volcanic Rock (IVR) are defined in Carpenter (1982).

APPENDIX II

AQUIFER TEST DATA SHEETS

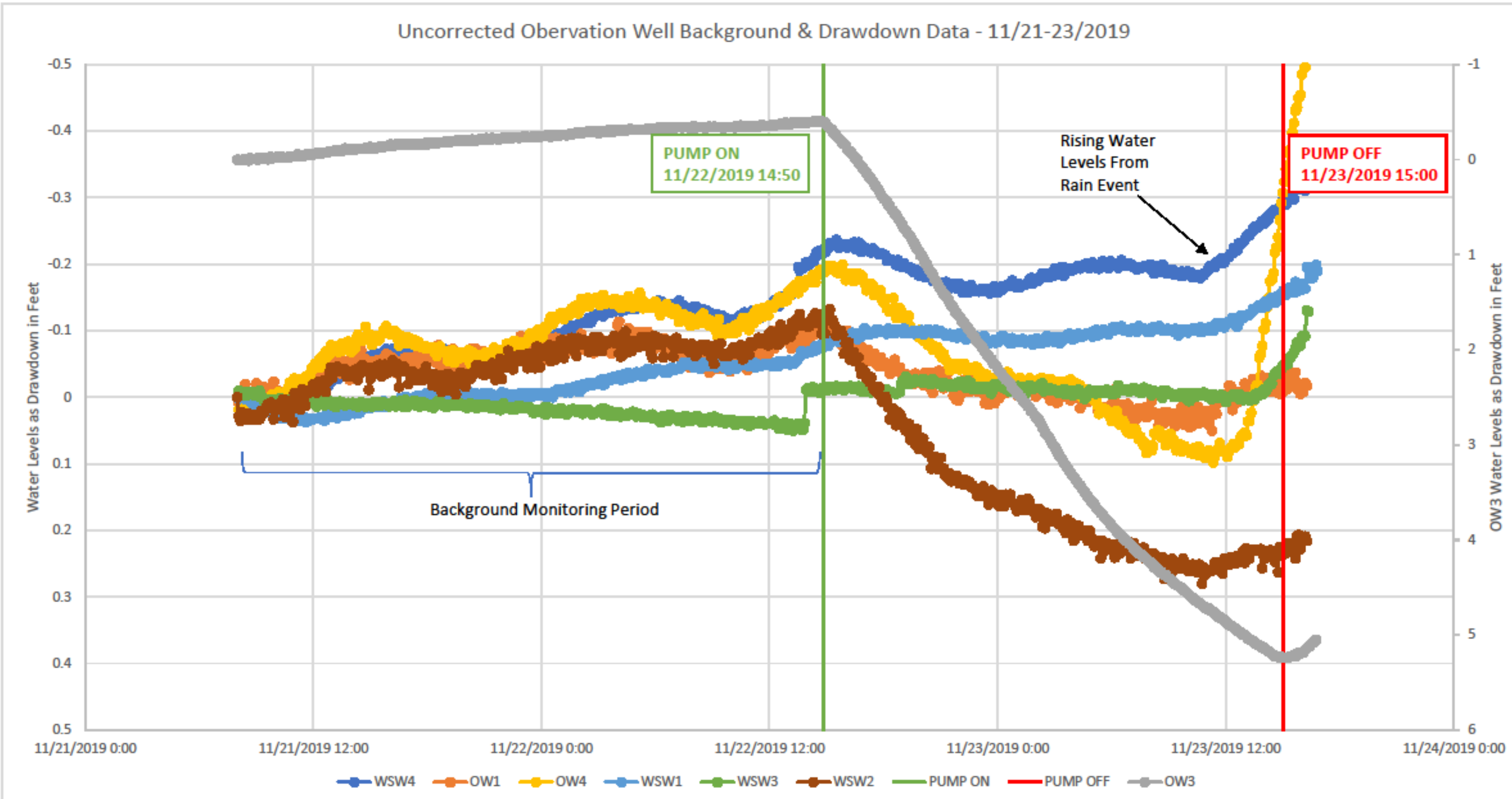
Pumping Test Monitoring Log Form------HAND MEASUREMENTS					
Project Number & Location: 163101 Snow Camp Quarry Site					Well#: OW-2 Pumping Well
Date: 11/22/2019	Start Time: 1450				Static Water Level: 15.33 ft. at 1404 hr on 11-22-2019
Latitude: N35.87249°		Longitude: W79.41611°			Final Pumping Rate: 2.5 GPM
minutes	**Time**	**Water Level (ft)**	**Drawdown (ft)**	**Spec. Cap. (Q/s)**	**Comments**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
12					
14					
16					
18					
20					
25					
29		20.90	5.57	0.45	
35					
39		21.82	6.49	0.39	
44		22.13	6.80	0.37	
49		22.55	7.22	0.35	
54		22.78	7.45	0.34	
64		23.40	8.07	0.31	
74		23.94	8.61	0.29	
84		24.60	9.27	0.27	
94		25.25	9.92	0.25	
104		25.81	10.48	0.24	
114		26.35	11.02	0.23	
130		27.18	11.85	0.21	
Project Number & Location: 163101 Snow Camp Quarry Site					Well#: OW-2 Pumping Well
Date: 11/22/2019	Start 1450				Static Water Level: 15.33 ft.
minutes	**Time**	**Water Level (ft)**	**Drawdown (ft)**	**Spec. Cap. (Q/s)**	**Comments**
160		28.70	13.37	0.19	
190		30.13	14.80	0.17	
220		31.50	16.17	0.15	
250		32.91	17.58	0.14	
280		34.68	19.35	0.13	
310		36.48	21.15	0.12	
340		37.94	22.61	0.11	
370		38.58	23.25	0.11	
400		38.56	23.23	0.11	
430		38.74	23.41	0.11	
460		38.80	23.47	0.11	
490		38.60	23.27	0.11	
520		38.93	23.60	0.11	
550		39.12	23.79	0.11	
580		39.20	23.87	0.10	
610		39.40	24.07	0.10	
640		39.78	24.45	0.10	
670		39.92	24.59	0.10	
700		40.08	24.75	0.10	
730		40.33	25.00	0.10	
760		40.70	25.37	0.10	
790		41.00	25.67	0.10	
820		41.40	26.07	0.10	
850		42.55	27.22	0.09	
880		41.83	26.50	0.09	
910		42.00	26.67	0.09	
940		42.08	26.75	0.09	
970		42.18	26.85	0.09	
1000		42.30	26.97	0.09	
1030		42.31	26.98	0.09	
1060		43.22	27.89	0.09	

1090		43.77	28.44	0.09	
1120		44.25	28.92	0.09	
1150		44.87	29.54	0.08	
1180		45.60	30.27	0.08	
1210		46.06	30.73	0.08	
1240		46.83	31.50	0.08	
1270		47.32	31.99	0.08	
1300		47.45	32.12	0.08	steady rain began falling at 9:30 am on 11-23-2019, about 1120 minutes into test.
1330		47.59	32.26	0.08	
1360		47.78	32.45	0.08	
1390		48.25	32.92	0.08	
1420		48.08	32.75	0.08	
1450		48.08	32.75	0.08	
					pump off in pumping well OW-2 at 1450 on 11-23-2019
Distance from Pumping Well to Observation well = 0 feet This is the Pumping Well					
GMA Project #: 163101					
Measuring Point Description: Top of PVC casing					
MP Height above Land Surface: ~2.0 ft. for hand measurments.					
Target Q: 2.5 GPM					
Pumping Equipment Contractor: Rorie Well Repair					
Person Recording Data: WLL (GMA) and Rorie Well Repair Crew overnight					

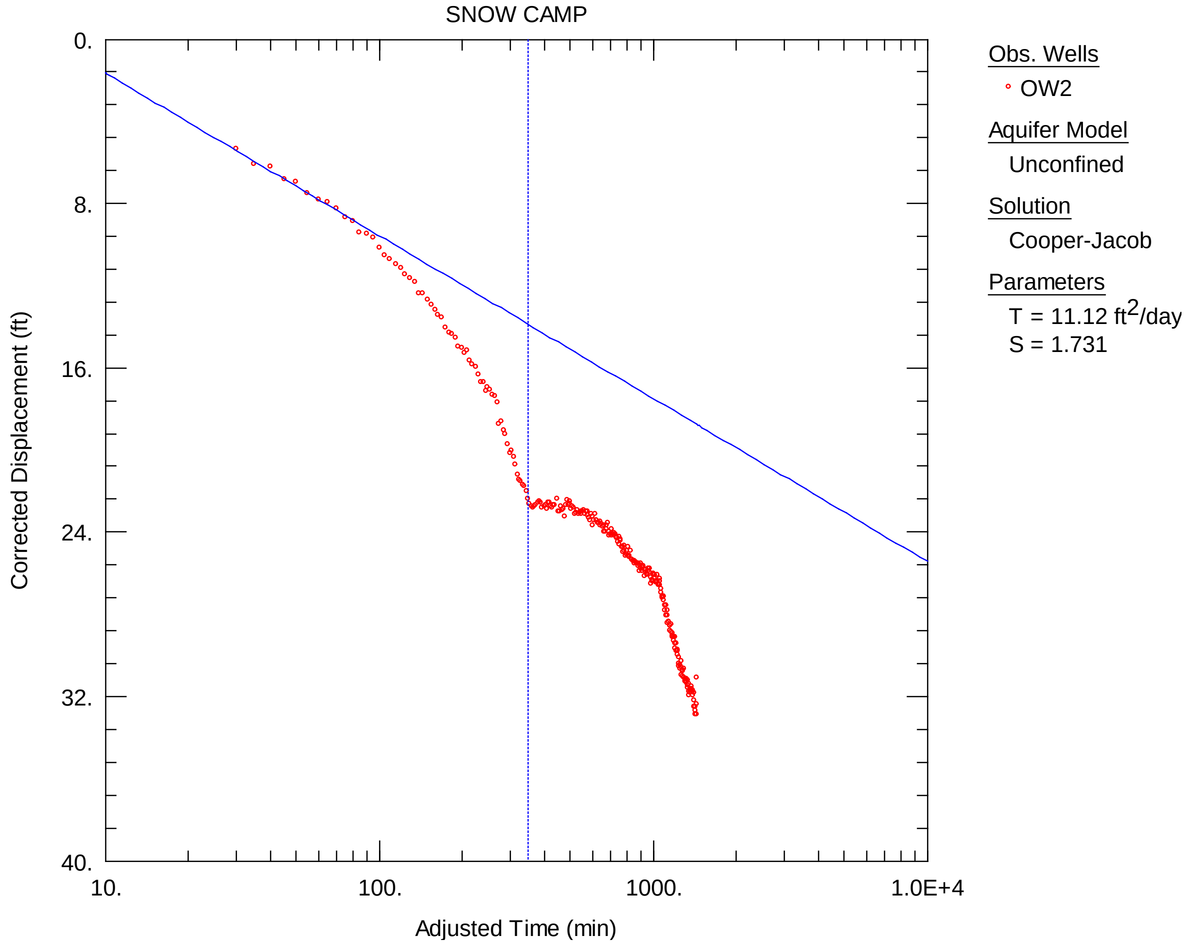
Pumping Test Monitoring Log Form------HAND MEASUREMENTS					
Project Number & Location: 163101 Snow Camp Quarry Site					**Well#: OW-2 Pumping Well**
Date: 11/22/2019	**Start Time: 1450**				**Static Water Level: 15.33 ft. at 1404 hr on 11-22-2019**
Latitude: N35.87249°		**Longitude: W79.41611°**			**Final Pumping Rate: RECOVERY**
minutes	**Time**	**Water Level (ft)**	**Drawdown (ft)**	**Spec. Cap. (Q/s)**	**Comments**
1		47.50	32.17		Pumping Rate = 2.5 gpm
2		47.42	32.09		
3		47.38	32.05		
4		47.23	31.90		
5					
6		47.38	32.05		
7					
8		47.00	31.67		
9		46.70	31.37		
10					
11		46.20	30.87		
15		46.80	31.47		
17		46.78	31.45		
19		46.61	31.28		
20					
25		46.30	30.97		
30		45.98	30.65		
35		45.56	30.23		
40		44.96	29.63		
45		44.48	29.15		
50		44.06	28.73		
55		43.79	28.46		
60		43.36	28.03		
70		42.65	27.32		
80		42.22	26.89		
90		41.15	25.82		
100		40.14	24.81		
110		39.03	23.70		
120		38.10	22.77		
Distance from Pumping Well to Observation well = 0 ft.					
GMA Project #: 163101					
Measuring Point Description: Top of Casing for hand measurements					
MP Height above Land Surface: ~2.0 ft. for hand measurements					
Pumping Equipment Contractor: Rorie Well Repair					
Person Recording Data: WLL (GMA) and Rorie Well Repair Crew overnight					

APPENDIX III

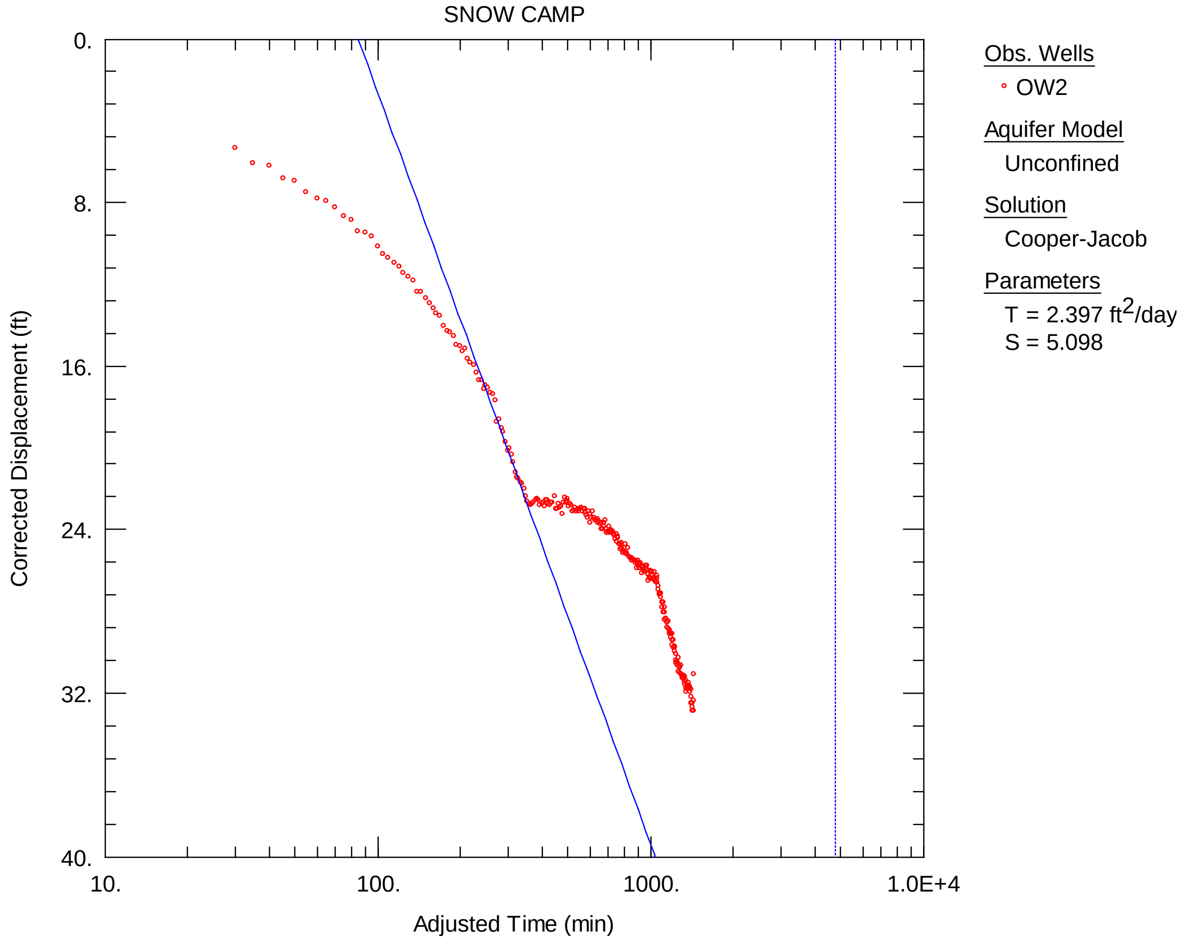
AQUIFER TEST DATA PLOTS AND ANALYTICAL MODELING CALCULATIONS



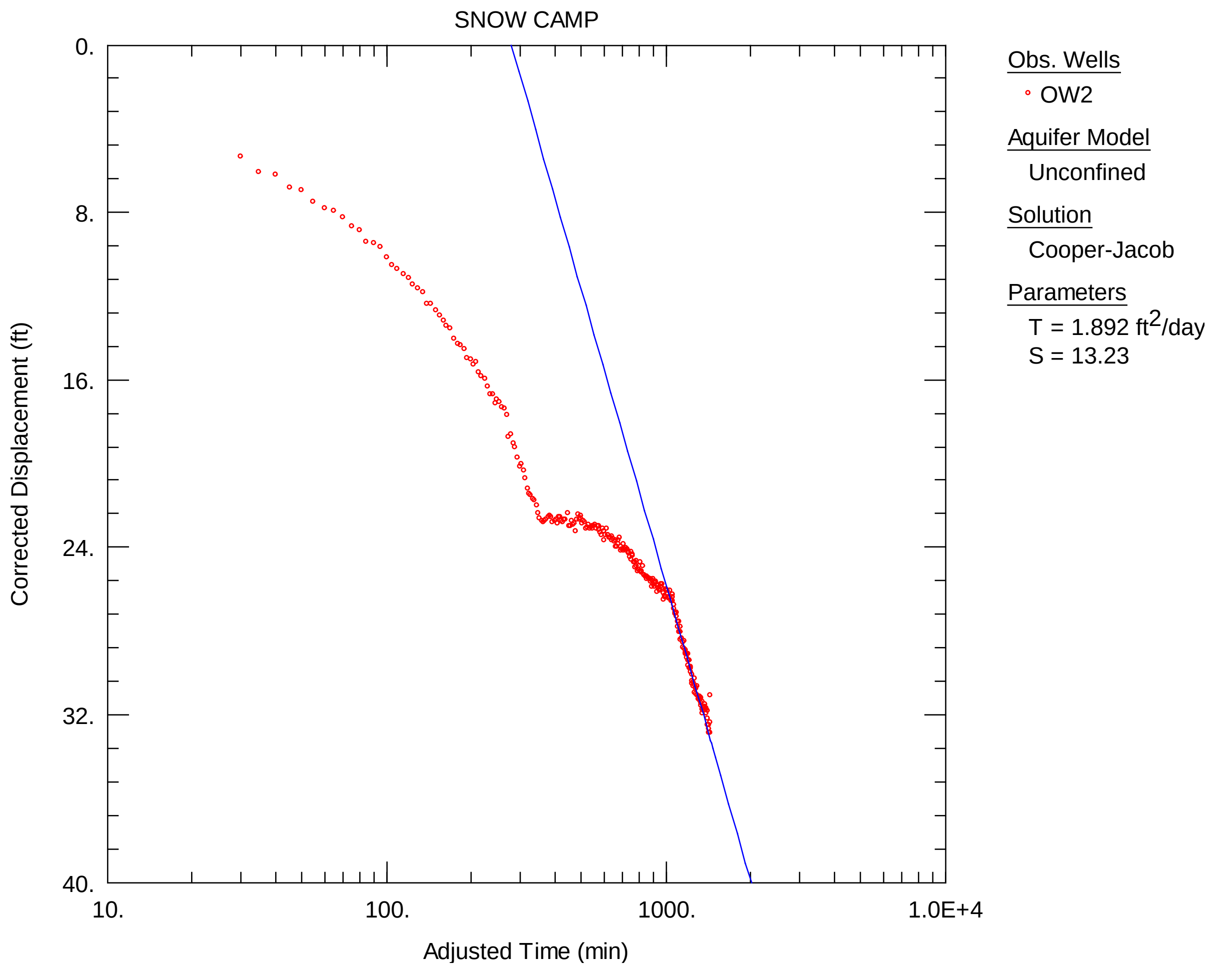
Uncorrected Pressure Transducer Water-Level Data from Observation Wells Expressed as Drawdown Values in Feet.
Note that wells WSW1, WSW3, WSW4 show no discernible drawdown effects from the pumping well. Also note that drawdown in well OW1 was so small that it is virtually indiscernible from the background water-level fluctuations. Only wells OW3, WSW2 and OW4 exhibited sufficient drawdown to warrant use in aquifer property analyses.



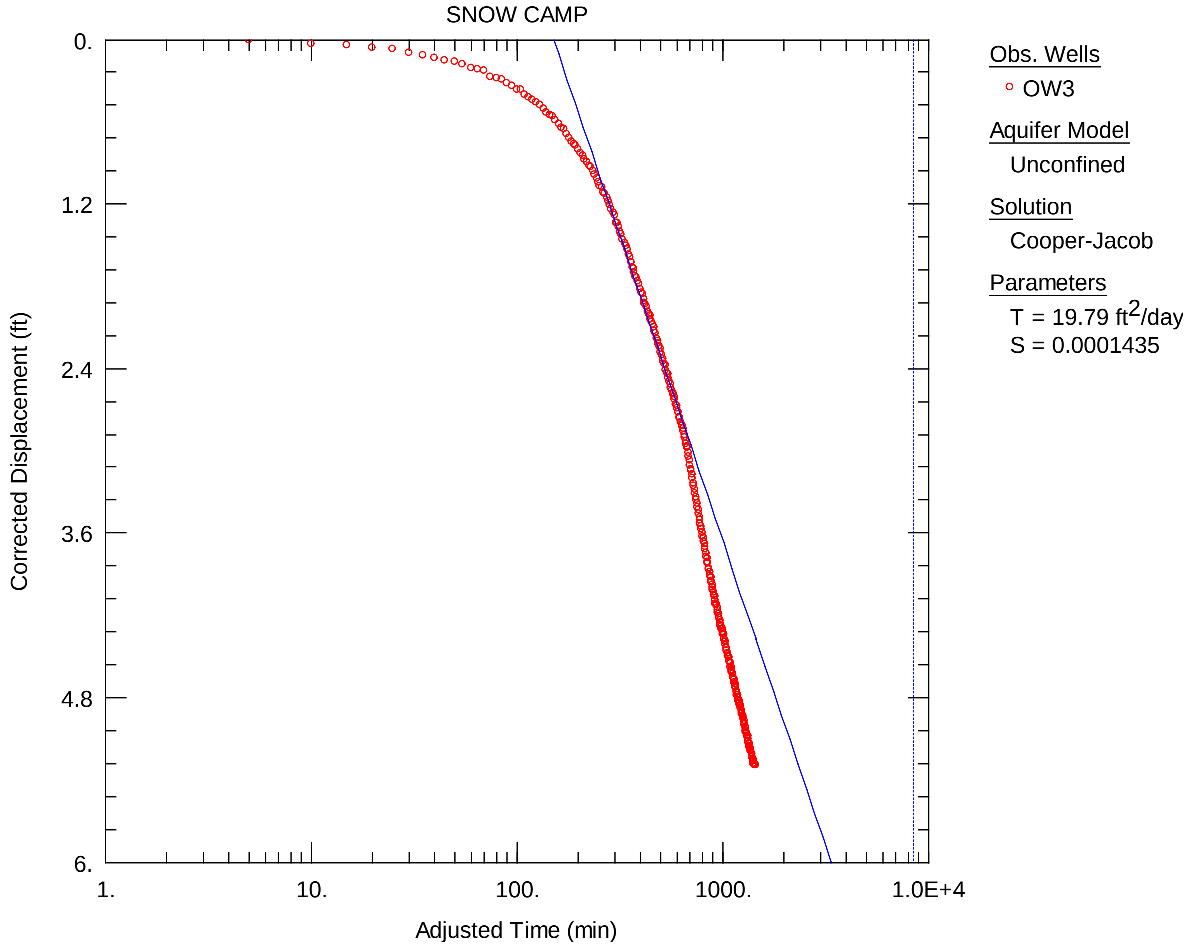
Cooper-Jacob Analysis of early drawdown data from the pumping well (OW2). This match approximates the total transmissivity of all significant water-producing fractures open to the pumping well. Note that unsteady-shape drawdown conditions occurred during this initial time period, so the transmissivity (T) value may be an over-estimate. Also note that the storage coefficient (S) value is not valid for a pumping well, so that value listed above should be ignored. A significant steepening of the drawdown response occurred after approximately 80 minutes of pumping, indicating that shallow water-producing zones were being dewatered after that duration of pumping.



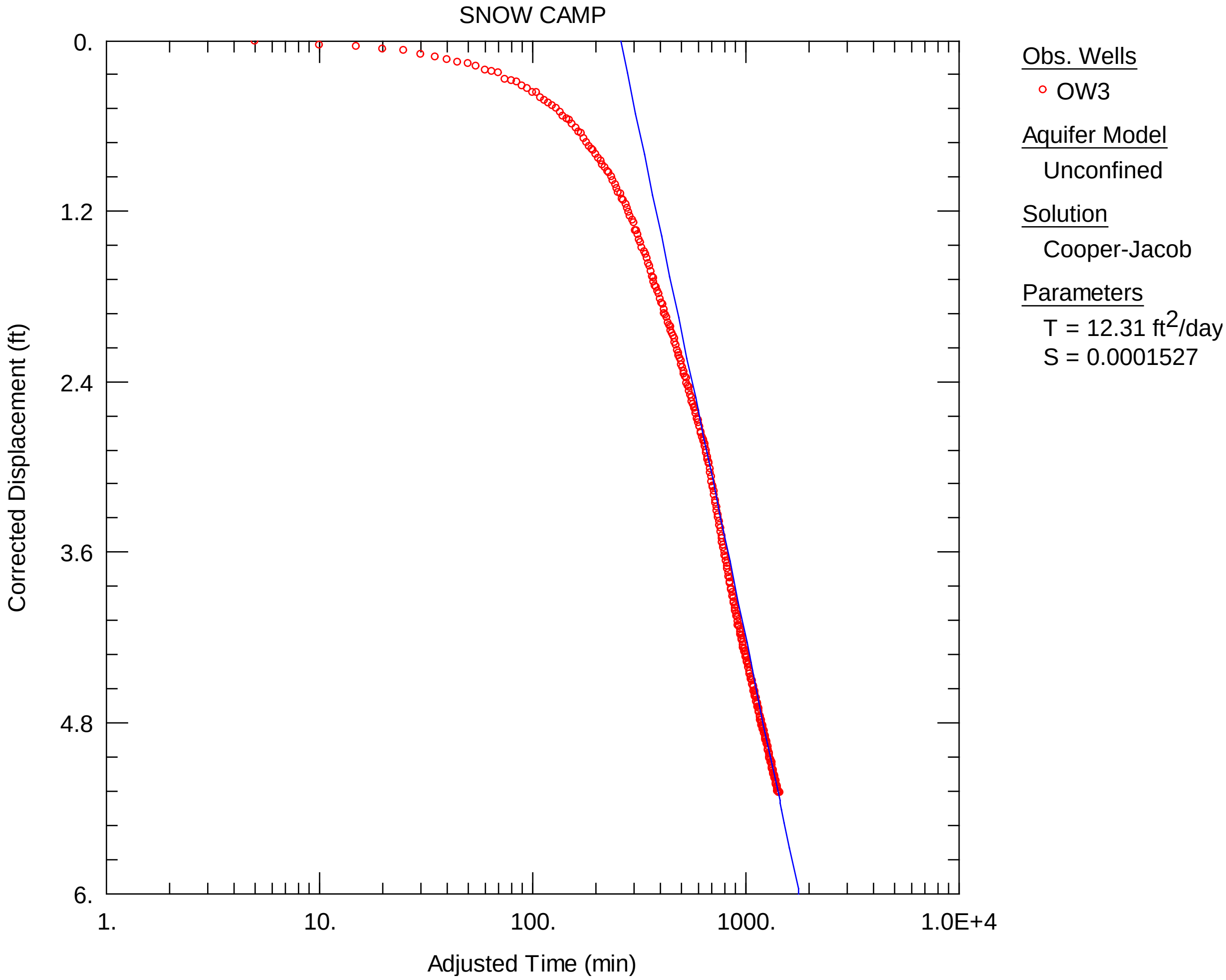
Cooper-Jacob Analysis of the middle section of drawdown data from the pumping well (OW2). Note the significantly lower transmissivity value derived from this portion of the drawdown data as compared to the T derived from the early data. The lower transmissivity is indicative of dewatering of upper fractures. The steepening of drawdown response occurs at approximately 23 feet of drawdown. This drawdown equates to a depth of approximately 36 feet below land surface. Also note that the storage coefficient (S) listed above is not valid for a pumping well and should be ignored.



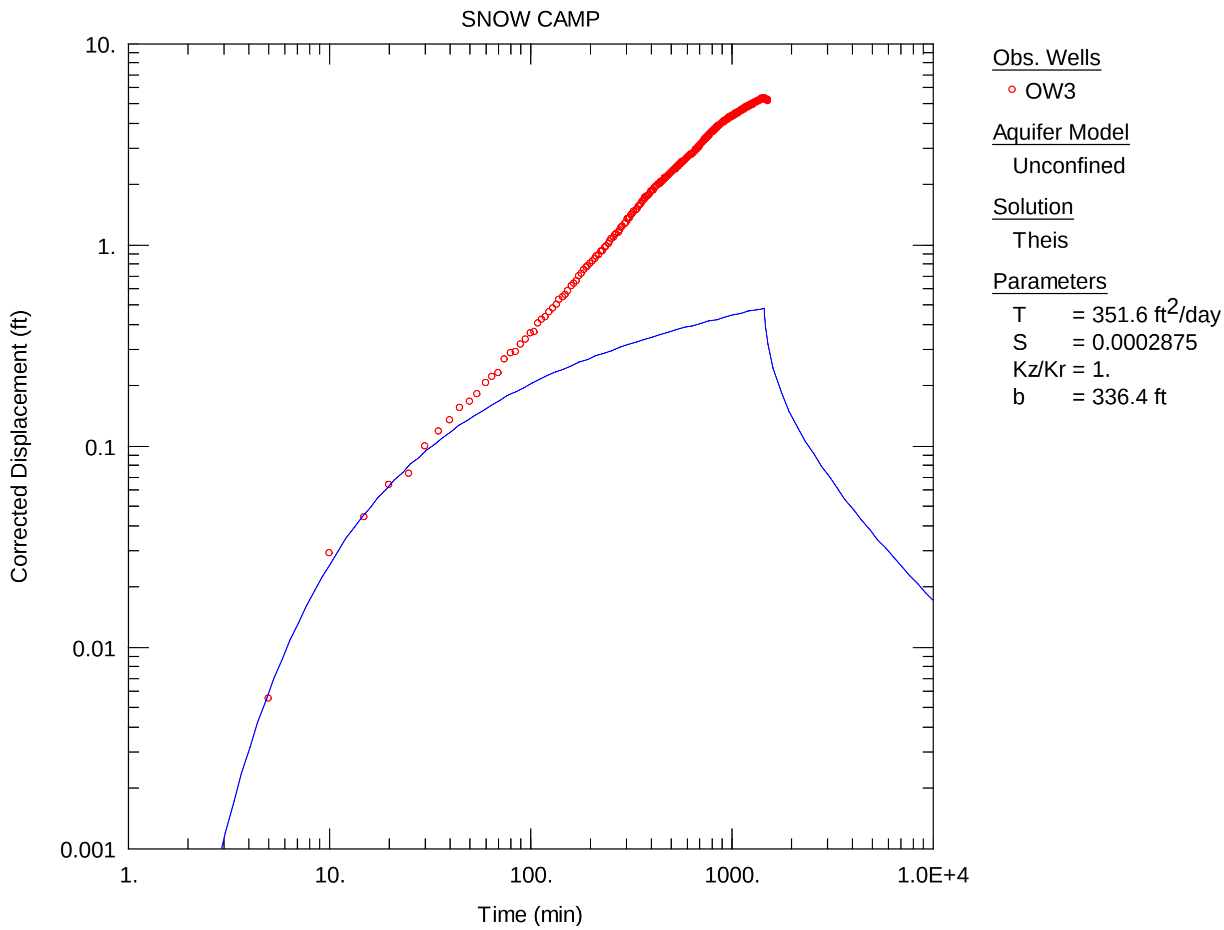
Cooper-Jacob Analysis of the late drawdown data from the pumping well (OW2). Note that the transmissivity match for the later data are indicative of the hydraulic properties of the deeper portions of the aquifer. It appears that dewatering of some fractures occur at approximate drawdown values of 23.5 to 26.5 feet (approximately 36 to 40 feet below land surface). The data from well OW2 indicates that the bedrock below 40 feet depth has very low permeability. Also note that the storage coefficient (S) listed above is not valid for a pumping well and should be ignored.



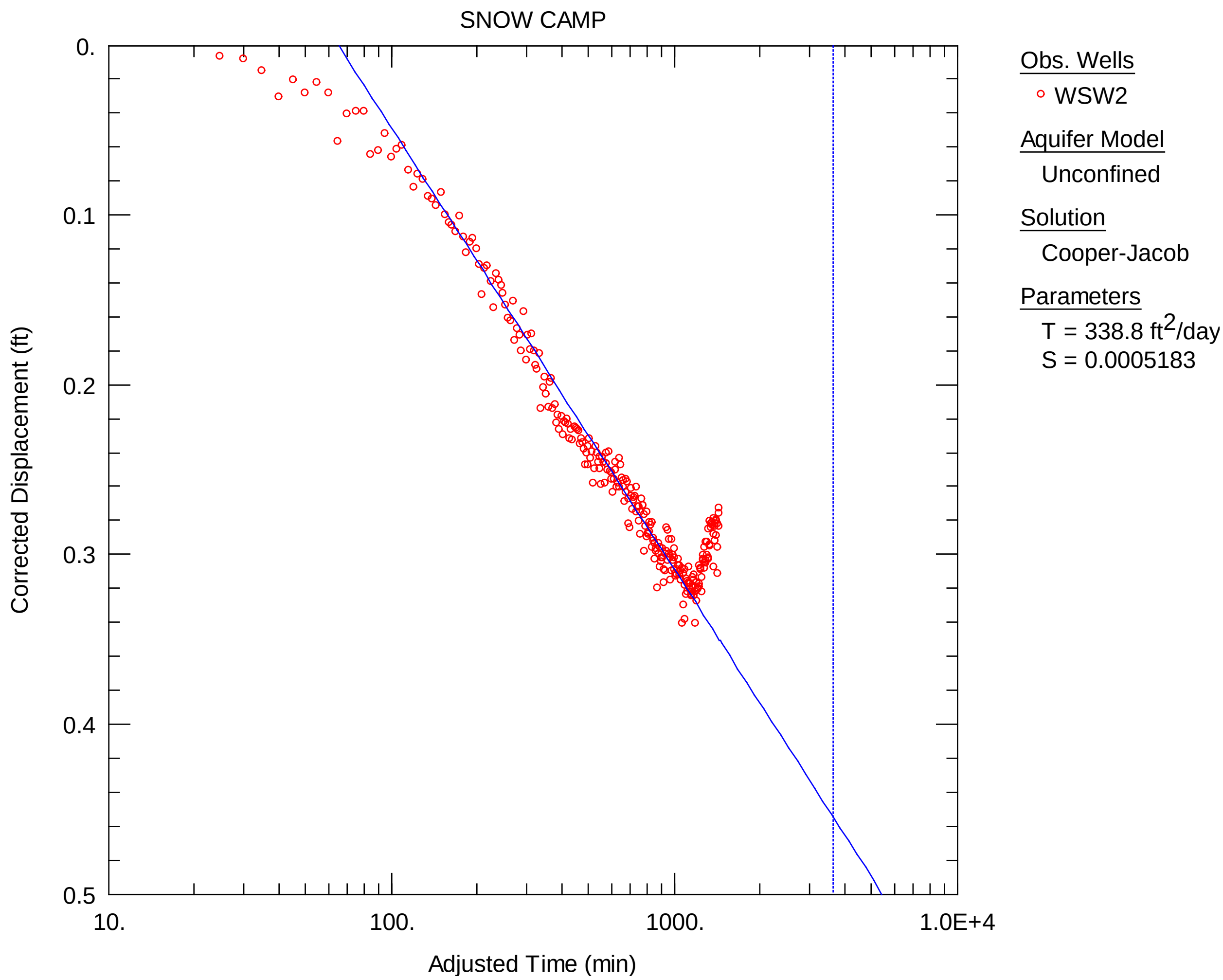
Cooper-Jacob Analysis of the corrected drawdown data from well OW3. The transmissivity calculated is similar to the early-drawdown data solutions from the pumping well (OW2). The steepened drawdown response at approximately 800 minutes of pumping is an impermeable boundary response that is likely a result of dewatering of shallow fractures at the pumping well. The storage coefficient indicates that there is a very small amount of water in storage in the rock, as would be expected for a unconfined fractured bedrock with little to no regolith above the rock.



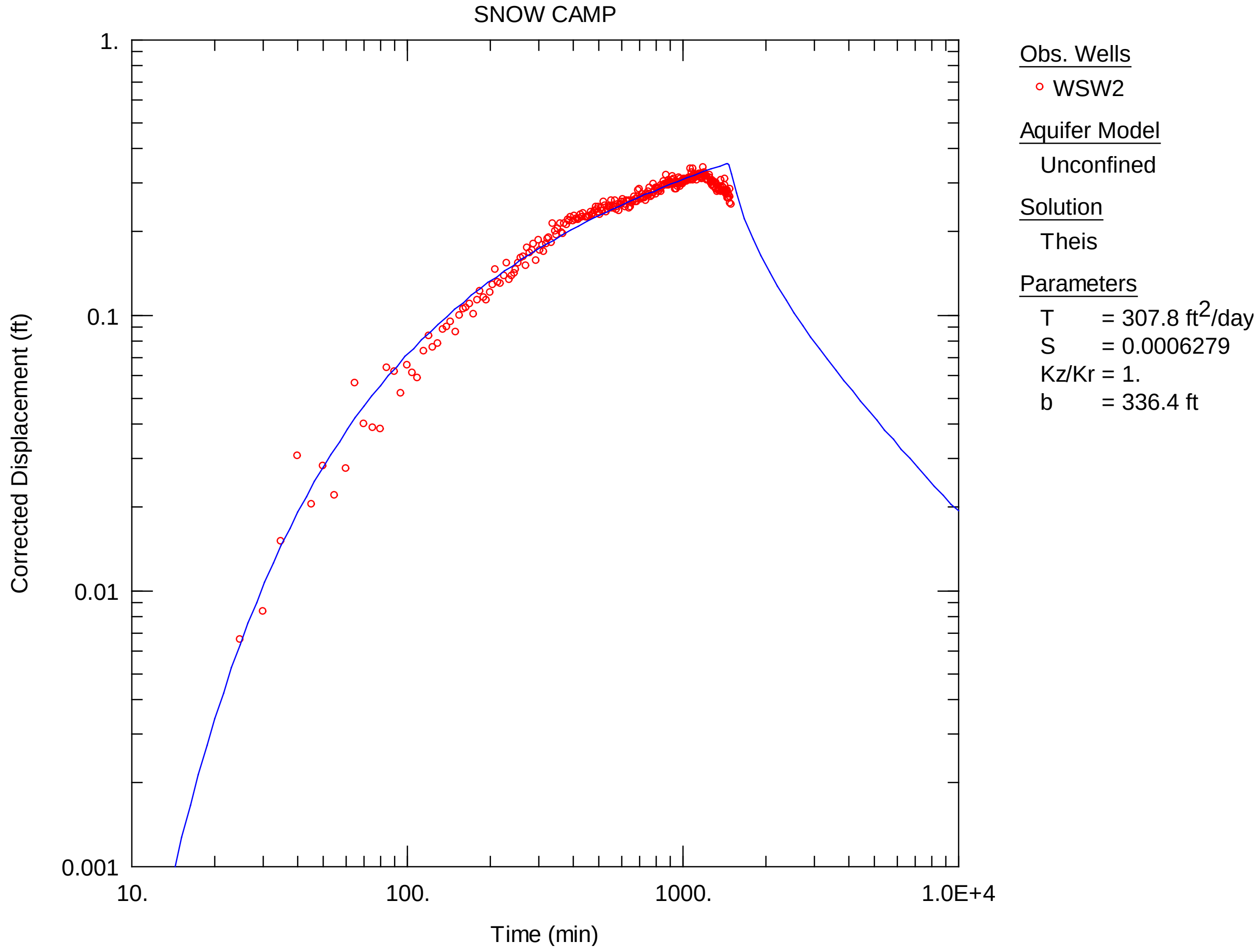
Cooper-Jacob solution for the corrected later drawdown data from well OW3.



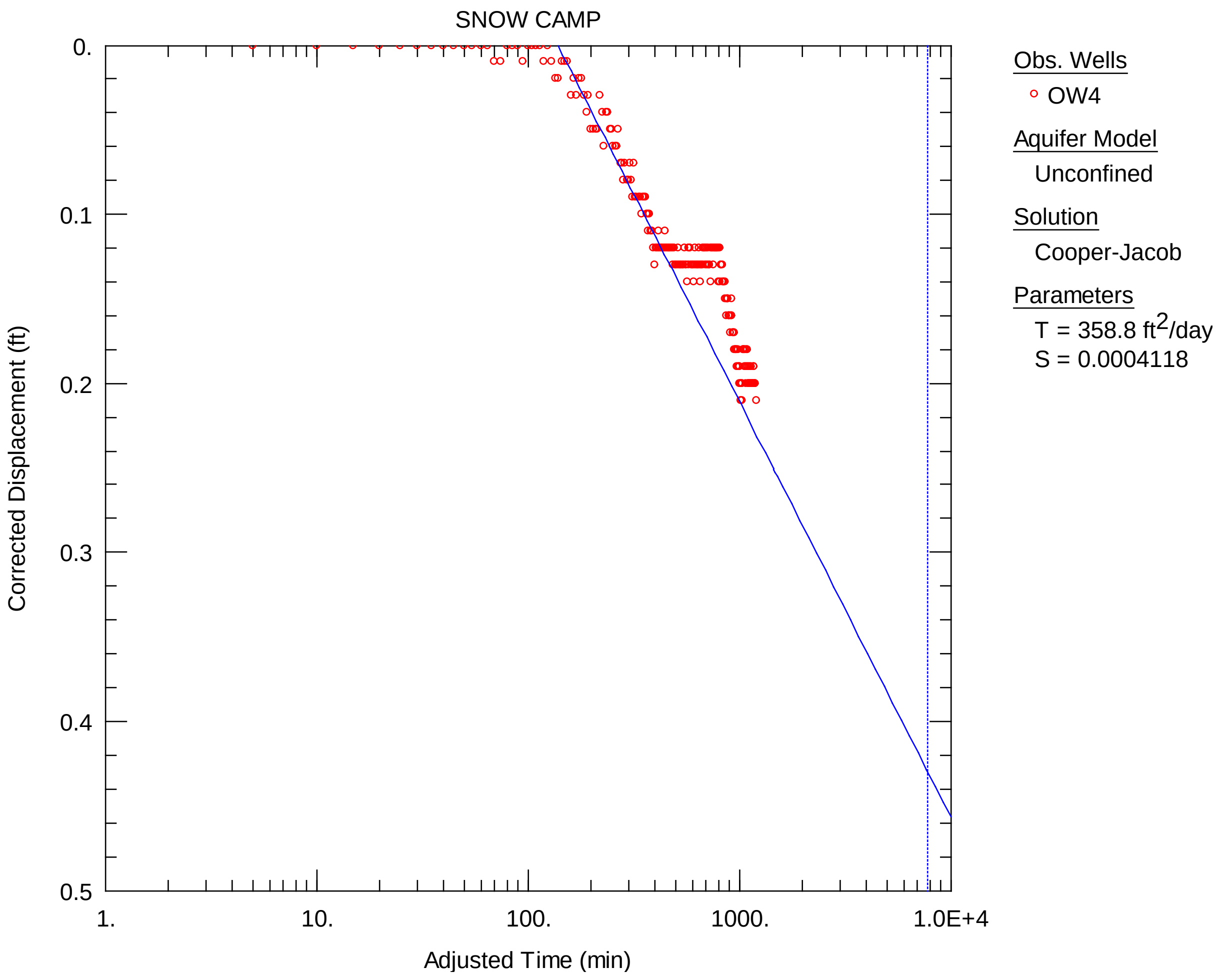
Theis Analysis of corrected drawdown data from well OW3. Note the strong impermeable boundary effect after approximately 20 minutes of pumping. This response likely represents dewatering of the regolith and upper fractures near the pumping well.



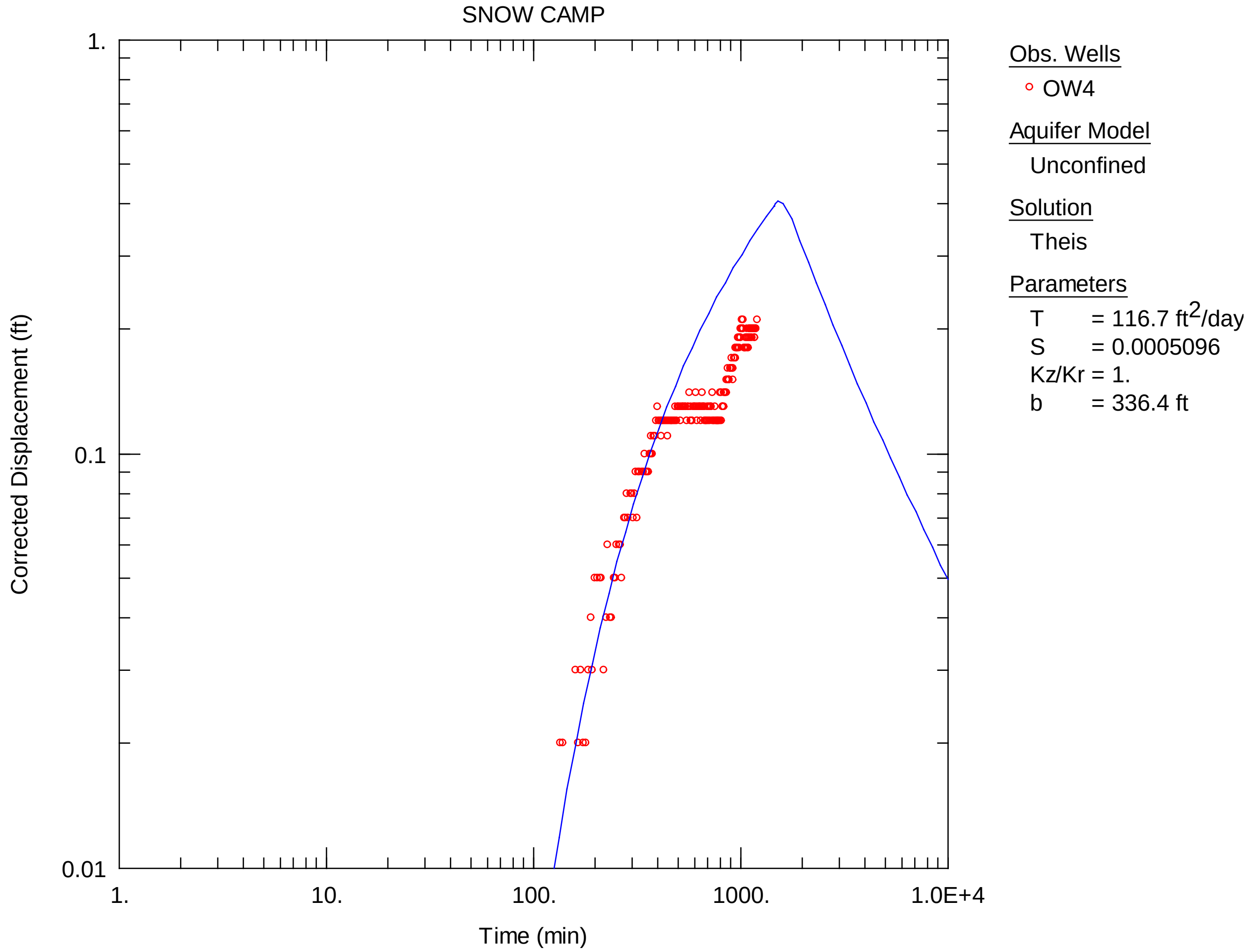
Cooper-Jacob Analysis of Corrected Drawdown Data from well WSW2. Note that WSW2 does not fully penetrate the bedrock section open at the pumping well (OW2). Also note the rising water levels due to rainfall recharge after approximately 1200 minutes of pumping.



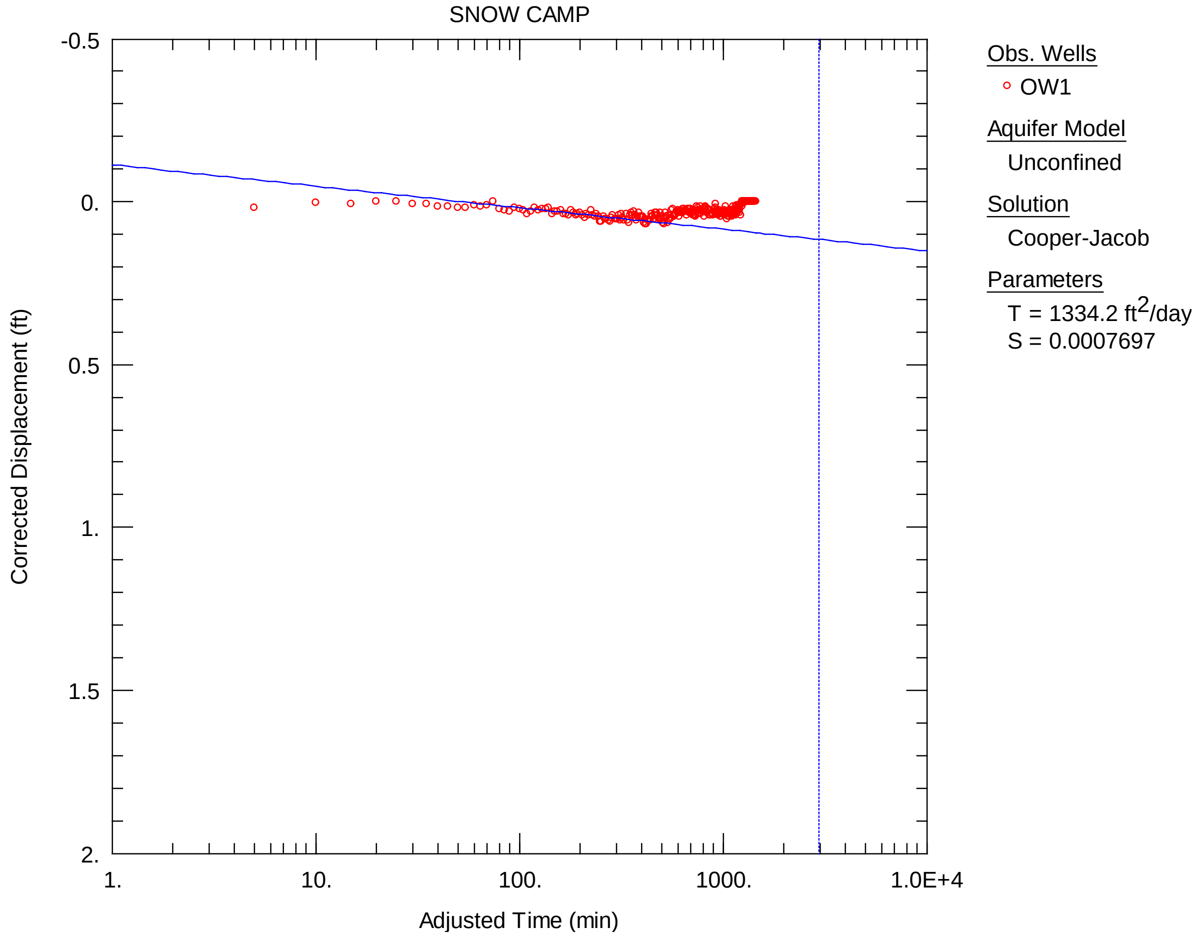
Theis Analysis of Corrected Drawdown Data from well WSW2. Note that WSW2 does not fully penetrate the bedrock section open at the pumping well (OW2). Also note the rising water levels due to rainfall recharge after approximately 1200 minutes of pumping. WSW2 indicates higher transmissivity and storage coefficient than the pumping well (OW2) and the closest observation well (OW3). The higher T likely is associated with a thicker regolith in the vicinity of WSW2 than at the pumping well where regolith is virtually absent.



Cooper-Jacob Analysis of corrected drawdown data from well OW4. Note that total drawdown observed at well OW4 is limited to approximately 0.2 feet. A linear average correction of the data has been applied for the background trend of water-level change. However, the background data indicate complex diurnal fluctuations of up to 0.1 feet that are not accounted for in the average linear correction. These diurnal fluctuations significantly affect the curve matching for such a small quantity of drawdown observed at well OW4. Therefore, GMA believes that the transmissivity solution determined from well OW4 overestimates the aquifer conditions by an order of magnitude. We consider the solution from well OW4 to not reliably represent the hydraulic properties of the bedrock aquifer at the site.



Theis Analysis of the corrected drawdown data from well OW4. Note the poor curve match that is a result of the very limited total drawdown as well as the diurnal background fluctuations that were not accounted for in data corrections. GMA believes that the transmissivity solution from well OW-4 is likely overestimated by an order of magnitude and does not reliably represent the hydraulic properties of the bedrock aquifer at this site.



Cooper-Jacob Plot of Corrected Drawdown Data from well OW1. The magnitude of drawdown observed is so small, and the background water-level fluctuations are significant enough to prevent valid analyses of aquifer hydraulic properties. Thus, the listed "Parameters" should **not** be considered as having any validity. This graph was used for illustration purposes only.