

Water Well Construction and Test Drilling for the Utah Valley University Capitol Reef Field Station

The 2001 General Management Plan for Capitol Reef National Park evaluated several alternatives for future use of the Sleeping Rainbow Ranch, a former guest ranch. The preferred alternative was to develop an education facility at the Ranch. Subsequently, the park entered into an agreement with Utah Valley University to allow the University to develop and operate the site as a long-term educational and research facility. The Capitol Reef Field Station was opened in October 2008.

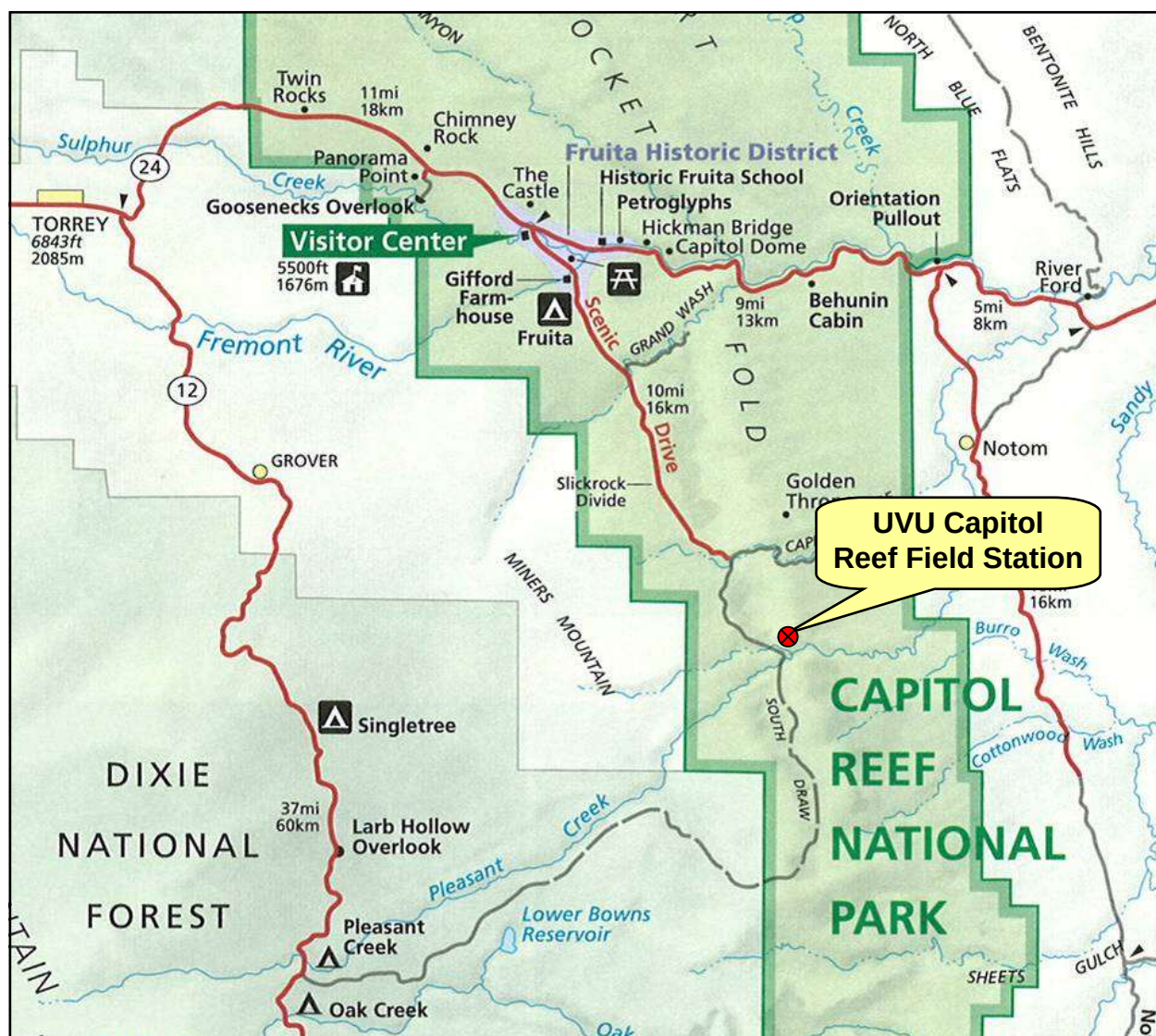


Figure 1. Location of Utah Valley University's Capitol Reef Field Station.

History

A shallow dug well on the north bank of Pleasant Creek provided water for the Sleeping Rainbow Ranch. Since this would not meet modern standards for public drinking water supplies, a 100-foot test well was constructed in 2001. This was followed by construction of a second 100-foot well in 2008. The 2008 well obtains water from the shallow alluvial aquifer. Utah DEQ classifies this as a surface-water source. In August 2010, a test hole was drilled to 860 feet to test the potential for obtaining groundwater from the Sinbad Limestone Member of the Moenkopi Formation and the Kaibab Limestone. All of the wells have been constructed in the same general area (Figure 2). It is about 2000 feet straight-line distance from the wells to the field station.

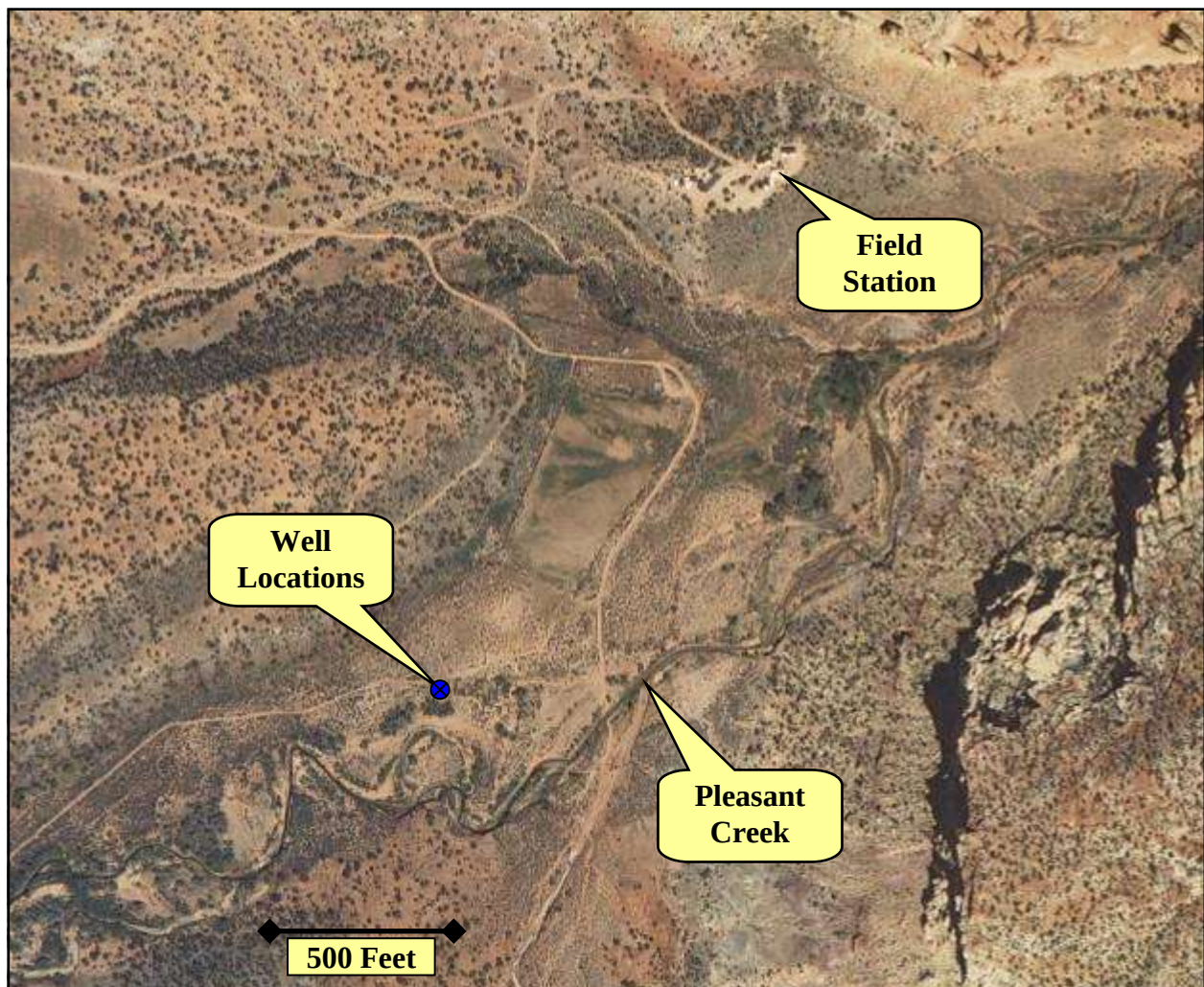


Figure 2. Location of wells relative to the field station and Pleasant Creek.

2001 Well

A 100-foot deep well was constructed in July 2001. Apparently the well was constructed without oversight by either NPS or the University. The well was originally drilled to 300 feet, but the bottom 200 feet were backfilled prior to installation of well screen and casing.

There is conflicting information for the geologic log of the well. The geologic log in the records of the Utah Division of Water Rights shows;

0-9 feet	Sand
9-25 feet	Sand, gravel, cobbles
25-35 feet	Silt, sand
35-75 feet	Sand, gravel
75-90 feet	Water-bearing gravel
90-300 feet	Red Moenkopi shale

This log was provided to the Division of Water Rights by the drilling contractor.

However, another handwritten form that was prepared by the drilling contractor and provided to the University shows the following log.

	Water table at 18 feet
20-60 feet	Red clay and gravel
60-70 feet	Sand, gravel; small layers of gravel interbedded with clay one foot thick
70-115 feet	Clay
115-140 feet	Moenkopi at 110 feet
140-300 feet	Red Moenkopi

These discrepancies created some confusion and doubt in 2009-10 when we were trying to decide how to construct a well that would meet Utah standards for a public water supply. We were unsure whether there was a water-bearing gravel layer from 75-90 feet, or if it was clay. Because of the conflicting information, we couldn't be certain of what depth we would find water-bearing strata. To add to the confusion, the 2001 well was completed by installing 5-inch steel casing to 100 feet and perforating the casing from 80-100 feet. Usually, perforations are placed opposite the most productive water-bearing layers. A bentonite surface seal was installed from 0-30 feet in the annular space between the 8-inch borehole and the steel casing.

In retrospect, and with the benefit of information from two later wells constructed at the site, it appears that both geologic logs were incorrect. The well was probably obtaining water from the shallow alluvial aquifer and that water was flowing down in the annular space and entering the well through the slots in the casing between 80-100 feet. A schematic drawing of this well is shown in figure 3.

A pumping test was conducted at this well in May 2004. The well was pumped at 22 gpm for 4½ hours, resulting in 35 feet of drawdown. The static water level in the well was 20 feet below the top of the casing. The final pumping water level was 55 feet below the top of the casing. The water level recovered to within 2 feet of the pre-pumping static level within 1 hour after pumping stopped. It was concluded that the well was capable of providing the amount of water that would be needed for facilities at the field station.

The conductivity of water pumped from the well was monitored and stabilized at about 2000 µS/cm. Water samples were collected for laboratory analyses. The water was very hard and had

high concentrations of iron, manganese, and sulfate. Water from the well requires treatment to make it potable and to meet drinking water standards.

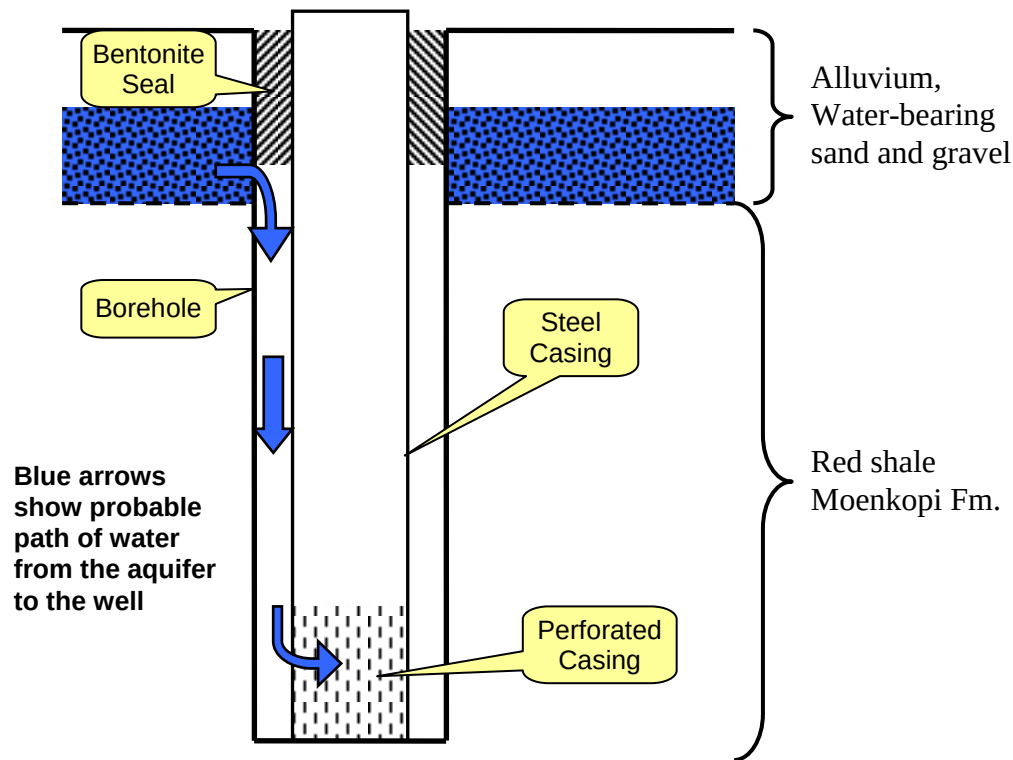


Figure 3. Probable hydrogeology of the 2001 well.

2008 Well

In May-June 2008 a second well was constructed at the site. The well was drilled to 100 feet. The geologic log for this well shows;

0-20 feet	Silt and sand
20-37 feet	Gravel and cobbles
37-100 feet	Red Moenkopi Formation; sandstone, shale layers, mudstone layers

The well was completed by installing 6-inch casing and well screen. The well screen is a stainless steel Johnson screen with 0.050" slot size. The screen is placed from 20-40 feet below ground surface. The surface seal is cement from 0-20 feet. A schematic drawing of the well is shown in Figure 4. The lower part of the well is just dead space. It doesn't contribute water to the well.

The well was test pumped at 25 gpm for 4 hours, resulting in 30 feet of drawdown. The static water level was 18 feet. The well was equipped with a 6 gpm solar-powered pump. This well is the current water supply for facilities at the Field Station.

The 2001 well was abandoned by filling it with bentonite and cement. The casing was cut off three feet below ground surface.

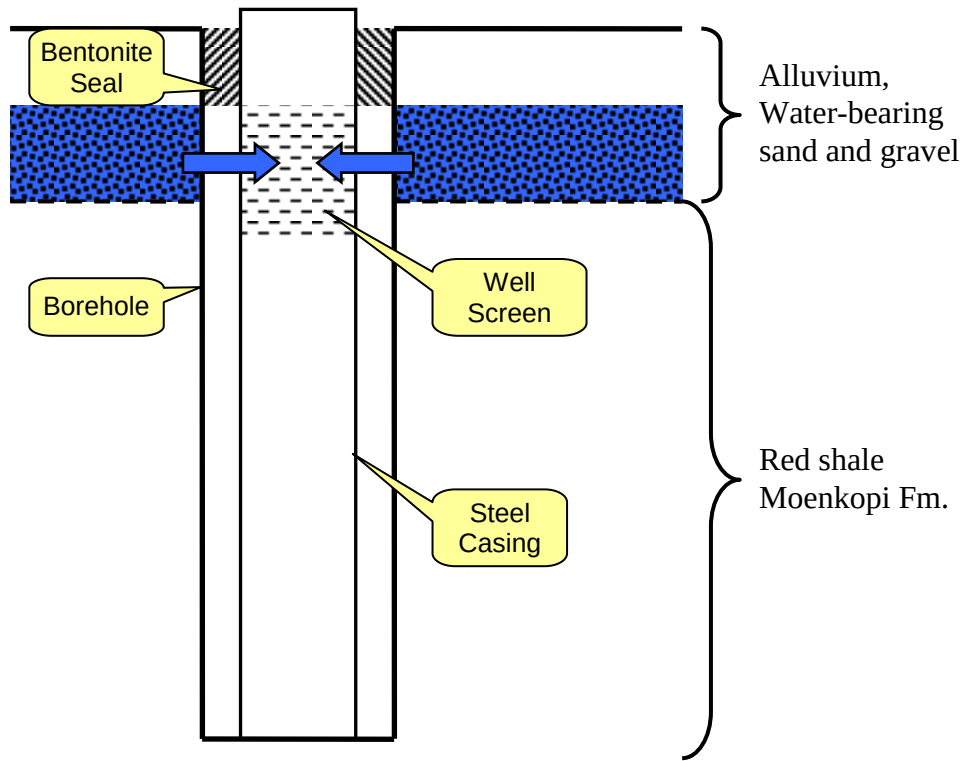


Figure 4. Schematic drawing of the 2008 well.

Planning for the 2010 Well

Utah DEQ requires a 100-foot surface seal on all public water-supply wells. In lieu of a 100-foot seal, water from the well is by default considered to be under the influence of surface water. This requires a higher level of treatment and additional testing and a higher level of certification for the water treatment plant operator. The treatment system in place at the field station does not meet state standards for a surface water source. The University, Utah-DEQ, and NPS staff met several times in the past two years to discuss options for bringing the water system into compliance. Two options emerged from these discussions;

1. Utah-DEQ approved a variance for construction of a new well with a 75-foot surface seal. This design was based on the premise that the log from the 2001 well showed water bearing sand and gravel to a depth of 90 feet.
2. NPS preferred construction of a well to test the water-producing potential from deeper formations. In particular, NPS targeted the Sinbad Limestone Member of the Moenkopi and the Kaibab Limestone underlying the Moenkopi.

From a hydrogeologic perspective, the deep test well would be similar to the well in the Fremont River Gorge that supplies the headquarters area of the park. The Fremont River Gorge well was tested at rates exceeding 100 gpm. At both locations the geologic formations are dipping toward the east-northeast, such that formations that outcrop in the western part of the park can be tapped by drilling a well east of the outcrop area (Figure 5).

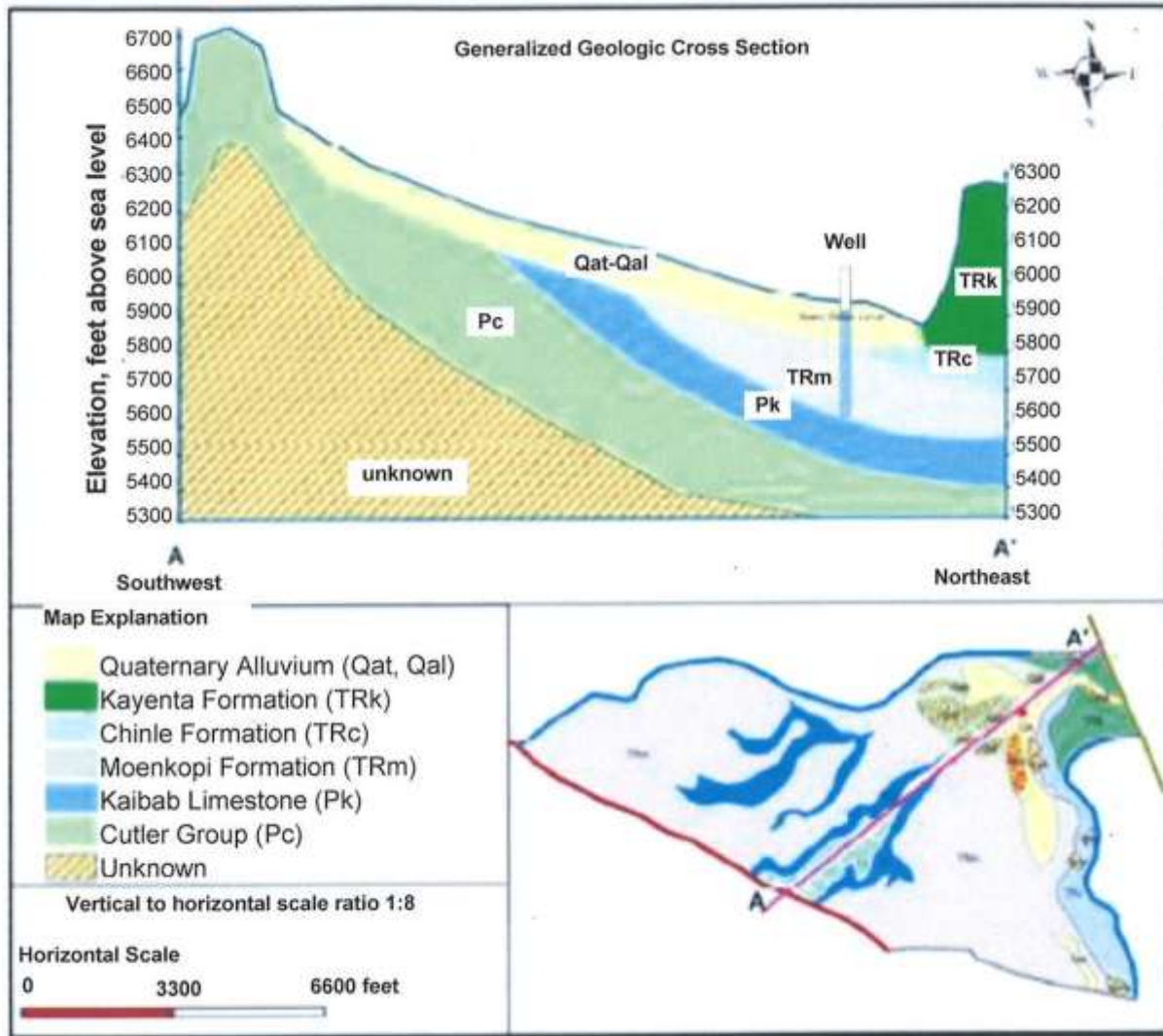


Figure 5. Southwest-northeast geologic cross-section and geologic map of the well site.

2010 Test Hole

A deep test hole was constructed at the site in August 2010. The well was drilled using mud-rotary methods to a depth of 100 feet. Six-inch steel casing was installed and the annular space was filled with cement grout by pumping cement through a tremie pipe to the bottom of the hole and filling it from the bottom up. The DEQ district engineer was on site to witness and approve the installation of the surface seal. Drilling then continued using air-rotary methods to a depth of 860 feet. The hole was essentially dry. It might have produced a quart per minute. The hole was plugged and abandoned.

The geologic log of the 2010 test hole shows;

0-37 feet	Alluvium; sand, gravel, and cobbles.
37-535 feet	Moenkopi Formation; alternating layers of red siltstone, mudstone, and minor amounts of fine-grained sandstone. Minor amount of dampness around the 400-foot depth.
535-588 feet	Sinbad Limestone Member of the Moenkopi Fm.; gray limestone and dolomite with minor interbeds of siltstone and sandstone. Dense, hard drilling, dry.
588-675 feet	Black Dragon Member of the Moenkopi Fm.; alternating layers of red mudstone, siltstone and minor amounts of fine-grained sandstone. Dry.
675-860 feet	Kaibab Limestone; alternating layers of gray-to-white limestone, shale, dolomite, and minor amounts of sandstone or oolitic limestone. Dense, hard drilling, dry.

Particular attention was paid to the drill cuttings from 0-100 feet. The geologic log for the 2001 well had indicated there might be water-bearing sand and gravel to a depth of 90 feet. If that was the case, then the alternative well design with the 75-foot surface seal could be a viable option if the deep test hole was dry. The drill cuttings clearly showed that there was essentially no sand or gravel deeper than about 37 feet. The predominant material in the cuttings below 37 feet was clay or silt. Because this part of the hole was drilled with mud-rotary methods, the siltstone and claystone that predominate in the Moenkopi were pulverized to fine particles and become mixed in with the drilling mud. The drillers need to continually add water to the drilling mud in this part of the hole because the clay from the geologic formations was causing the drilling mud to thicken. The Moenkopi Formation between 37-100 feet is unlikely to produce any water because it is mostly claystone and siltstone; essentially the same material as was encountered all the way to 535 feet with no indication of water.

The Sinbad Limestone and the Kaibab Limestone were both dry throughout the entire section penetrated by the test hole.

After reaching the target depth of 860 feet, we blew large volumes of air through the drill pipe to the bottom of the hole to cause water to blow out of the hole; a procedure commonly referred to as an airlifting test. Airlifting continued for about 15 minutes after clearing the hole of drilling fluids and materials. The estimated yield of the well was perhaps one quart per minute, or less.

Samples of the drill cuttings were bagged, labeled, and stored in a cardboard box in the old cinder-block building on the west side of the field station.

Conclusions

The shallow alluvium associated with Pleasant Creek is the only source of groundwater within 860 of land surface in the vicinity of the UVU Field Station. The Moenkopi Formation is dry. The test well penetrated 185 feet into the Kaibab Limestone and it was dry also.

The 2008 well at this site obtains water from the shallow alluvium. It produces an adequate volume of water for facilities at the field station. Additional testing and treatment of water will be required by Utah DEQ to meet standards for a public water supply.



Photo during drilling of the test hole. The dry dust provides evidence of the lack of water.



Photo during the airlifting test at the end of drilling. Air was circulating through the drill pipe at $400 \text{ ft}^3/\text{min}$. Only a few drips of water are being produced.