

June 21, 2013

L54(2380)
SEKI/General

Memorandum

To: Superintendent, Sequoia Kings Canyon National Parks

Through: Ed Harvey, Chief, Water Resources Division (WRD)
Gary Rosenlieb, Chief, Aquatic Systems Branch (ASB)

From: Larry Martin, Hydrogeologist, Aquatic Systems Branch (ASB)

Subject: Trip Report to investigate potential water-supply well sites at Cedar Grove, Kings Canyon National Park

Summary: An area near the entrance to Sentinel campground and southwest of the bridge at Cedar Grove is identified as the optimal location for a water-supply well to provide a supplemental source for the Cedar Grove water system (Figure 5). Drilling to assess subsurface conditions for the design of the bridge showed the presence of high-permeability to at least 90 feet deep at the bridge. Electrical power and connection to existing water lines are fairly accessible from this location. The area should be far enough from the river to avoid classification as “groundwater under the direct influence of surface water.”

Discussion: The Cedar Grove water system provides water to four campgrounds, a visitor center, administrative buildings, NPS housing for approximately 70 residents, and a concession area with a restaurant, lodge, store, and showers. The area is open from late-April to mid-November with the peak season from late-June to Labor Day. There is no occupancy and no water use during the winter months.

Average daily demand for the water system is about 19,000 gallons per day (gpd) or 13 gallons per minute (gpm) and the peak demand is about 56,000 gpd or 39 gpm (Hatch, Mott, MacDonald, 2012).

The water system is supplied with groundwater from two deep bedrock wells near the heliport and the Sheep Creek water treatment plant (Figure 1). The wells are capable of providing a sustained yield of 20 gpm (28,000 gpd), but that requires pumping 24 hours per day. When production from the wells cannot keep up with the demand, an emergency backup surface-water

supply from a diversion on Sheep Creek is used. The surface water is filtered and chlorinated but does not meet California Department of Public Health standards for public water supplies. Boil water notices must be posted when the supplemental water supply is used.

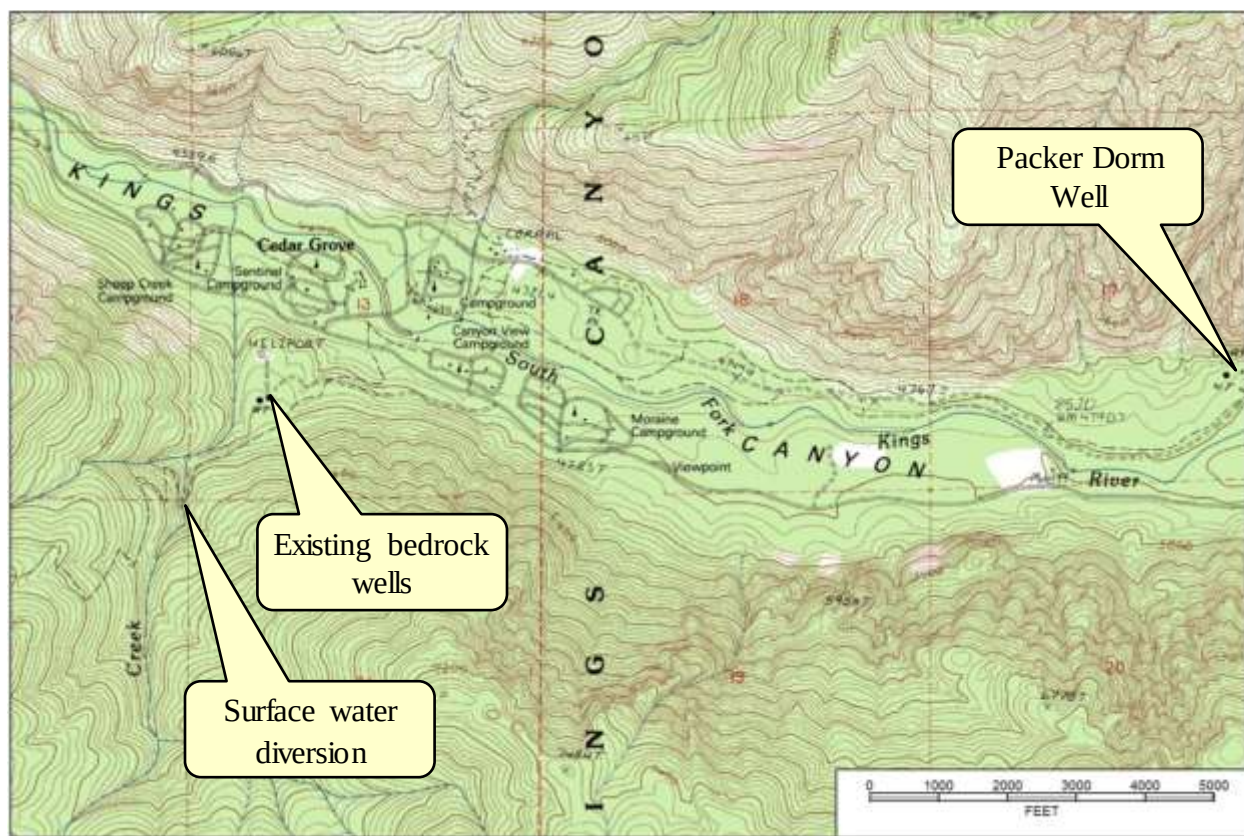


Figure 1. Locations of existing water-supply sources at Cedar Grove.

Several alternatives are being considered to provide a permanent solution to meet the water demand during the peak season. Surface water diversions from Sheep Creek could be increased and the surface water treatment brought up to State standards. Additional bedrock wells could be constructed near the existing water treatment plant and heliport. Shallow wells could be constructed in the alluvial aquifer of the valley.

Surface water diversions from Sheep Creek would easily meet current and future demand, but the cost of bringing a surface water treatment plant into compliance is estimated to be about \$1.5 million. Additionally, annual operation and maintenance costs for a surface water treatment system are substantially greater than for a groundwater system.

Construction of additional bedrock wells near the water treatment plant or heliport is unlikely to provide the desired quantity of water. Bedrock in the area is granodiorite which is essentially impermeable. Groundwater can sometimes be obtained from fractures in the bedrock, but the occurrence and reliability of yield from bedrock wells is both highly variable and unpredictable. The existing wells near the heliport provide a good example of expected results from bedrock wells. Three deep wells have been constructed to depths of 700, 740, and 800 feet. The wells

initially produced 9, 20, and 3 gpm respectively. Long-term sustained yield is less because as the water level in the wells is drawn down, some fracture zones are dewatered and no longer contribute water to the well. The 3 gpm well is not equipped with a pump as it would not produce enough water to justify the expense. The long-term sustained yield of the other two wells is 5-6 gpm and 12-15 gpm.

There is only limited area for construction of new wells near the water treatment plant and heliport. Any new well in the area would, by default, be in within a few hundred feet of the existing wells. Topography and wilderness boundaries limit access to potential drilling sites. Based on general hydrogeologic principles and past drilling results, it would be unreasonable to expect to obtain the desired quantity of water from a single new bedrock well or even 2-3 additional bedrock wells.

A shallow well in the alluvial sediments of the valley has the greatest potential to provide the desired amount of water for the Cedar Grove system. A properly constructed well in the alluvium would reasonably be expected to produce in excess of 100 gpm of good-quality groundwater.

Hydrogeology of the alluvial aquifer

The valley of Kings Canyon was scoured to some depth by Pleistocene glaciers that extended down the South Fork of the Kings River to about a mile west of Cedar Grove. As the glaciers melted and retreated, they deposited their load of glacial sediments which have been subsequently reworked by the river and added to by the deposition of alluvial sediments transported by the river. The thickness of these sediments at Cedar Grove is unknown, but test drilling at the bridge showed that the sediments extend to at least 90 feet below ground surface, to an elevation of about 4510 feet. We would anticipate the water table in the vicinity of the bridge to be at an elevation of near 4600 feet, approximately coincident with the elevation of the river bed.

A test well at Packer Dorm, about 2½ miles east (upstream) from Cedar Grove penetrated 260 feet of sediments before reaching the underlying bedrock.

A schematic geologic cross-section of the valley at Cedar Grove is shown in Figure 2. The thickest, most-permeable alluvial sediments would be expected to be found in the middle of the valley where the flowing water of the river has reworked the sediments, flushing the fine-grained sediments downstream and leaving behind the coarse-grained sand, gravel, cobbles, and boulders. Sediments at the margins of the valley would be expected to be less well-sorted and therefore less permeable.

Several test holes were constructed at the Cedar Grove bridge to evaluate conditions for design of the new bridge. These holes were drilled to depths of 60-90 feet. The sediments through the entire depth of the holes were described as, “coarse-gravel and boulders in a coarse-sand to gravel matrix” (Haramy and Dodson, 2009). That is typical for alluvial sediments where the fine-grained fraction has been flushed downstream by the swift moving water of the river.

One of the unknown factors in selecting a test well location is the distribution of the coarse-grained alluvial sediments in relation to the glacial deposits that underlie the alluvium. This may,

or may not, be important as the glacial deposits may be permeable enough to yield an adequate water supply to a well.

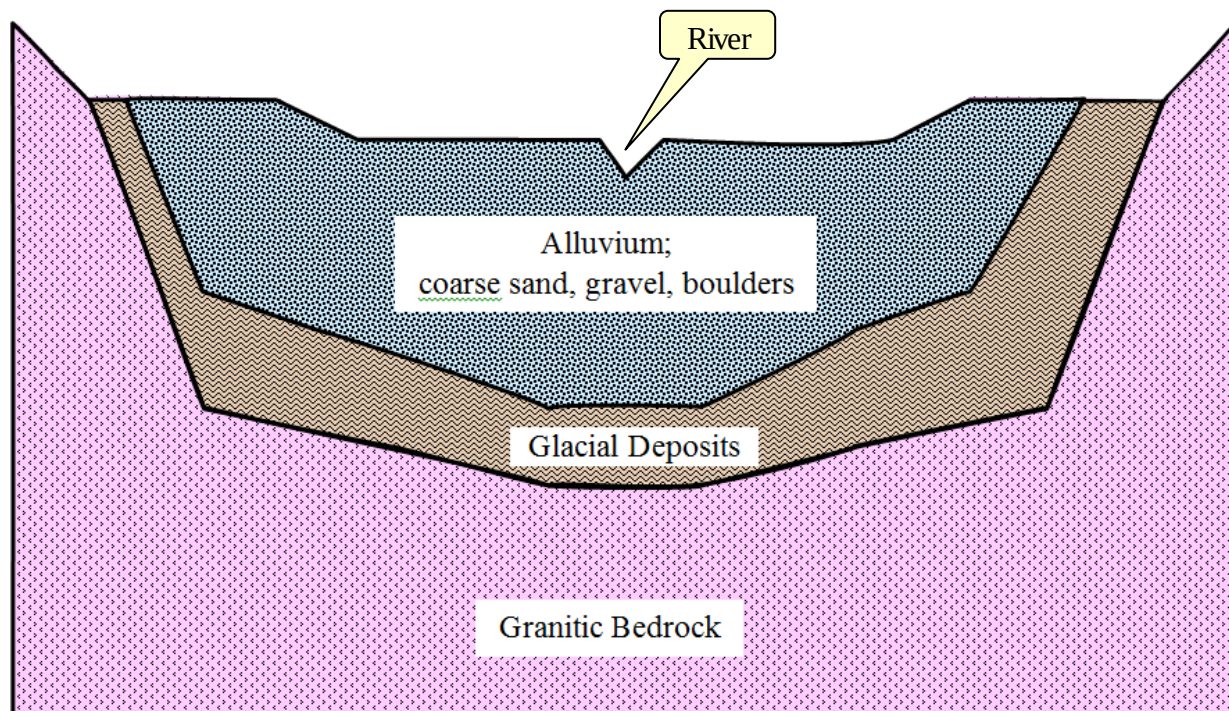


Figure 2. Schematic geologic cross-section across the valley at Cedar Grove showing the general relationship of the permeable alluvial deposits overlying the glacial deposits, filling the valley that was carved in the bedrock by glaciers.

Groundwater under the direct influence of surface water

A well that is located close to the river might draw much of its pumped water from the river without adequate filtration, requiring that the water be treated as if it came from a surface-water source. The California Department of Health does not explicitly evaluate a groundwater source with respect to being under the direct influence of surface water. Rather, the well and groundwater source are evaluated to assess the “Physical Barrier Effectiveness” as an indicator of the potential for contaminant sources to affect the water supply. Each well is evaluated on a case-by-case basis. If the groundwater supply is deemed to be potentially vulnerable to direct infiltration of surface water, then additional testing may be required; such as a microparticulate analysis (MPA) test.

There is a balance to be achieved in selecting a location for a test well in the alluvial aquifer of the valley. The well should not be too close to the margins of the valley where it would be more likely to encounter the low-permeability glacial sediments or bedrock at shallow depths. The well should also not be too close to the river because it would then be more likely to be classified as “under the influence of surface water.” Adequate filtration of groundwater in the alluvial aquifer should be achieved by locating the well 150-200 feet from the river and placing the screened interval some distance below the elevation of the river.

Packer Dorm Well

A test well was constructed at Packer Dorm in 2008 (Figure 1). The well penetrated 259 feet of alluvial, glacial, and lacustrine sediments before encountering bedrock. A diagram of the completed well and geologic log is shown in Figure 3. The geologic log shows mostly clay from 113-259 feet. These clay layers are likely lacustrine (lakebed) sediments that were deposited following the retreat of the glaciers. Normally we wouldn't expect clay sediments to yield water to a well, but there must be intermittent beds of sand or gravel in the interval from 207-259 feet (labeled as "quartz/gray clay") to yield water to the well. Otherwise there would be no reason to place the well screen at that depth.

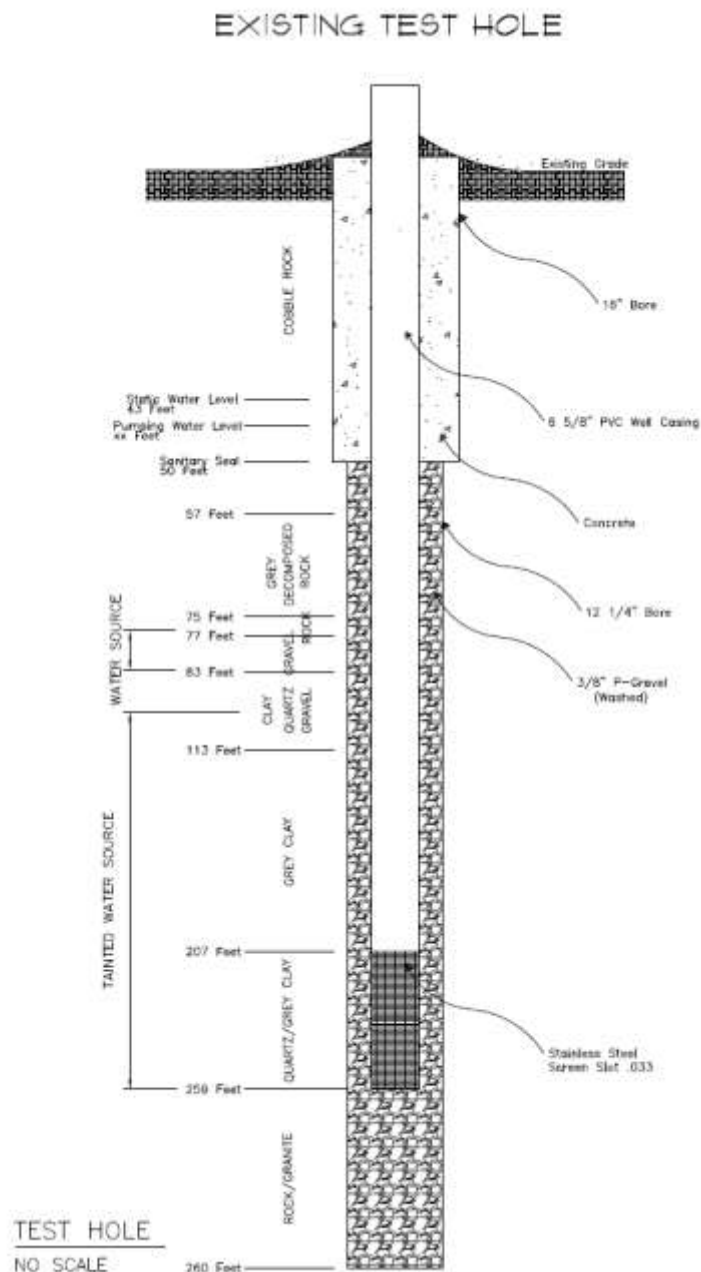


Figure 3. Schematic of test well constructed at Packer Dorm, November 2008.

The well log notes the presence of a “tainted water source” coinciding with the clay layers in the well. In hindsight, this is not entirely unexpected as the clay layers would have low permeability and thus a long residence time for groundwater to leach minerals from the clay. Anaerobic or anoxic conditions in the clay layers may facilitate chemical reactions that contribute to the poor water quality from this test well. As examples, water from the test well had an arsenic concentration of 620 ppb, hardness of 8,000 mg/l, turbidity of 52,000 NTU, and high concentrations of lead copper, and zinc.

It is likely that this would have been a good well if drilling had terminated at 83 feet when the first clay layer was encountered, or if the borehole had been backfilled to that depth prior to installing the screen, casing, and gravel pack. The gravel and decomposed rock layers above the clay are very permeable and receive abundant recharge from infiltration of snowmelt and precipitation. The resultant fast movement of groundwater through the shallow alluvial aquifer would help insure good water quality.

The lesson to be learned from the Packer Dorm well is to stop drilling when the clay layers are encountered.

Recommendations for test well locations

Many factors influence the final site selection for a test well in the alluvial aquifer of the valley. These factors include;

1. Locate the well some distance from the valley wall. Alluvial sediments are more likely to be thicker and more permeable near the middle of the valley. Drilling near the margins of the valley is more likely to encounter lower permeability glacial deposits and bedrock at shallower depths.
2. Locate the well some distance from the river. A well too close to the river will be designated as groundwater under the direct influence of surface water, requiring treatment as a surface water source.
3. Proximity to existing electrical power and water mains to facilitate incorporating the new source into existing infrastructure.
4. Required setback distances from sewer lines (50 feet) and roads.
5. Protection of natural resources.

The most important tenet in site selection is to locate the well where it is most likely to encounter a good source of groundwater. Figure 4 outlines a general area in the valley near Cedar Grove that is most likely to provide a successful test well for this project. The area outlined in Figure 4 focuses only on identifying the area where a test well is likely to produce the necessary amount of good-quality water. The general strategy in identifying this area is to maintain a 200-300 foot buffer from the margins of the valley where a well would be more likely to encounter lower-permeability glacial sediments or granitic bedrock at shallower depths. Most of the area along the center of the valley should have high-permeability alluvial sediments with a sufficient thickness to yield an abundant amount of groundwater to a well.

As a practical matter, potential locations for a well to provide a supplemental source of water for the existing water system are limited to the area south of the river and between the Sentinel campground and the Canyon View campground to avoid potential conflicts with visitor use in

the campgrounds and the lodge area. This area provides accessibility to connect to existing water lines, electricity is readily available, and test drilling at the bridge shows that high-permeability alluvial sediments extend deep enough to provide a good source of groundwater to a well. Within this general area, we still need to maintain a setback from the margin of the valley, a setback from the river to avoid classification of the water source as “under the influence of surface water”, and a 50-foot setback from existing sewer lines. With these factors in mind, we are left with a very small area southwest of the bridge, near the entrance to the Sentinel campground as the potential well site (Figure 5).

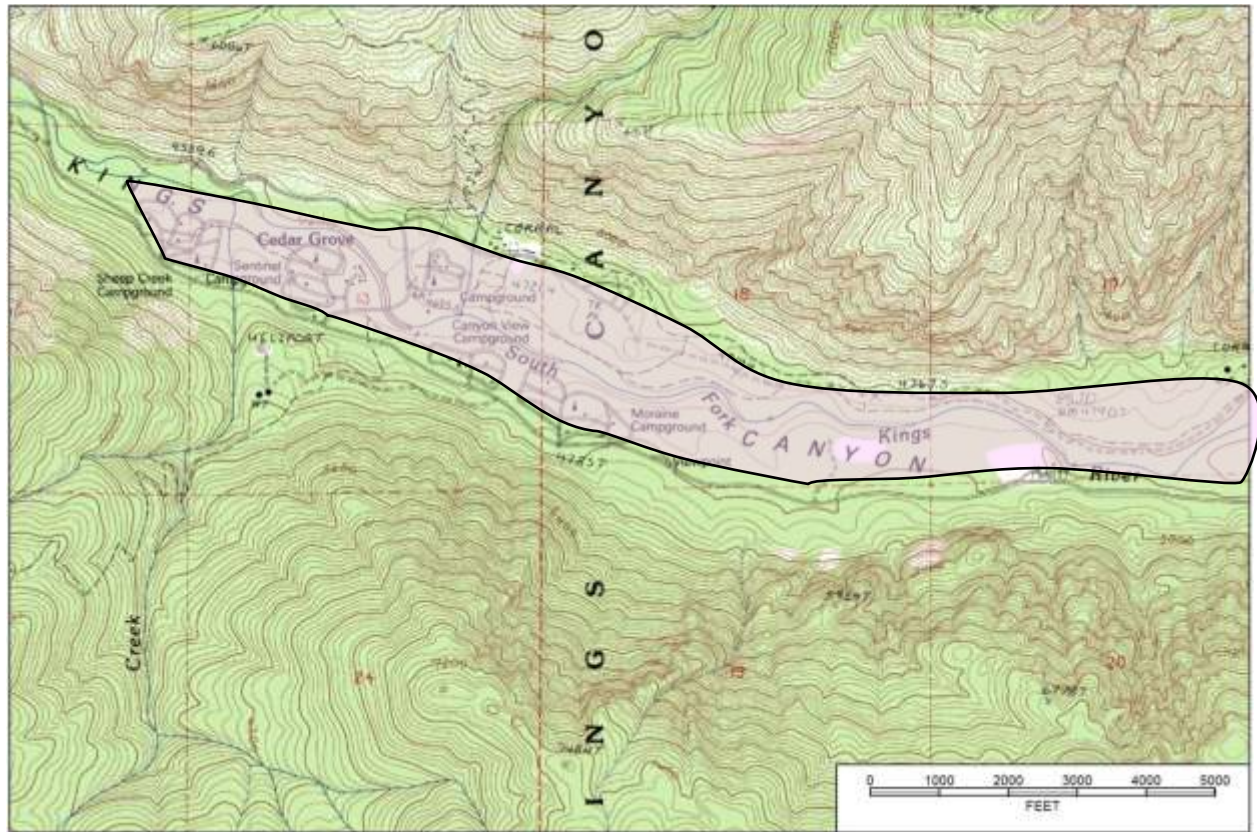


Figure 4. General area in the vicinity of Cedar Grove where a well constructed in the alluvial aquifer would be expected to produce at least 50 gpm.



Figure 5. Recommended location for a test well in the alluvial aquifer near Cedar Grove.

Well design

An example of the general design for a water well constructed in the alluvial aquifer is shown in Figure 6. Design details might change depending on conditions encountered during drilling. The main features of the well design include;

1. Drill a 10-inch borehole to 50 feet and install 10-inch ID temporary casing to facilitate installation of the surface seal.
2. Drill a 6-inch borehole to 125 feet. Drive 6-inch casing to prevent borehole collapse and facilitate collection of geologic samples as drilling proceeds. It is very likely that the well would only need to be 80-100 feet deep, but initial plans should be for a deeper well in case it's needed.
3. Select a permeable interval for the well screen based on geologic interpretation of drilling samples.
4. Well screen size will be dependent on the grain-size analysis of sediments from the interval selected for the well screen. We will not be able to develop a natural gravel pack around the screen if the openings in the screen are too large or too small,
5. Install well screen by telescoping and pulling back the casing to expose the screen to the geologic formation.

6. Install the surface seal as the 10-inch casing is removed.
7. Develop the well. Conduct a pumping test. Collect samples for water quality analyses.

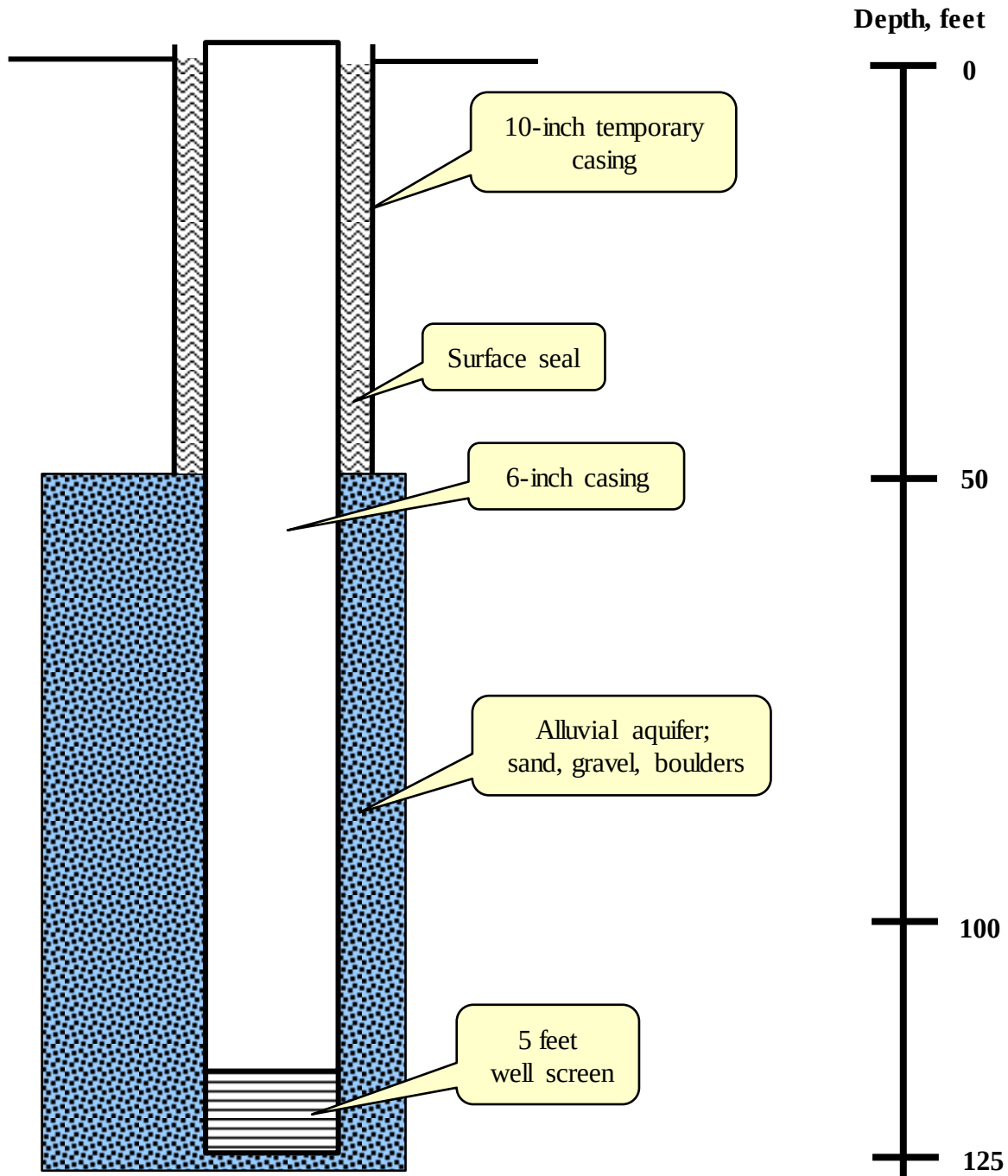


Figure 6. Example of the design for a test well in the alluvial aquifer near Cedar Grove.

If there are any questions regarding this trip report, please call me at (970)-225-3515.

References

Haramy, Khamis Y., and Dodson, Marilyn D., 2009, *Cedar Grove Bridge Replacement*, Geotechnical Report CA-PX-SEKI-06-01

Hatch, Mott, MacDonald, 2012, *Title I – Preliminary Design Assessment – FINAL*, Cedar Grove Water System, technical memorandum

cc:

SEKI – Chris Carpenter – Project Manager/Engineer
Justin Pattison - Project Manager/Engineer
Jack Vance - Facility Manager
Dan Blackwell - Chief of Facilities and Construction
Duane Smythe - Chief Plant Operator (Kings Canyon NP)

PWRO – Ray Sauvajot – Chief, PWR Natural Resource Programs
Mietek Kolipinski – Water Resources Program Lead