

Potential for developing a groundwater source for facilities at Kalaloch, Olympic National Park

Summary

Two sites are identified for drilling a test well at Kalaloch. Although the prospects for obtaining the necessary quantity of good quality water are not great, it is probably worth drilling a test well, given the potential cost savings compared to constructing a new surface water treatment plant. Either site is equally good, as the expected results are the same for either site. The second site should only be drilled if the water quality from the first site is acceptable but doesn't produce a large enough volume to meet the demand, i.e., if the first test well doesn't produce good water, there's no reason to expect the second site to be any different.

Bedrock underlying the area generally has low permeability. However, groundwater may be available from fractures or fault zones within the bedrock. Glacial outwash and stream deposits overlying the marine terrace may (or may not) be thick enough or permeable enough to provide a sustained yield to meet the demand for water at Kalaloch. Previous test wells in the alluvium associated with Kalaloch Creek produced sufficient water, but it was poor quality and would have required treatment to meet drinking water standards. There is a strong possibility that if a sufficient quantity of water is found from a well drilled into the terrace deposit or bedrock, it will need to be treated to lower the concentration of iron and manganese.

The bedrock underlying the Kalaloch area is geologically similar to Hurricane Ridge, where a well was successfully constructed in 2007. So while we wouldn't normally target this type of bedrock for construction of a well, previous success at Hurricane Ridge might justify construction of a test well into the bedrock underlying Kalaloch.

Test wells constructed in the alluvium of Kalaloch Creek in 1966-67 showed that the alluvium would produce limited amounts of water (probably less than 20 gpm) and that the water would still require treatment to meet drinking water standards.

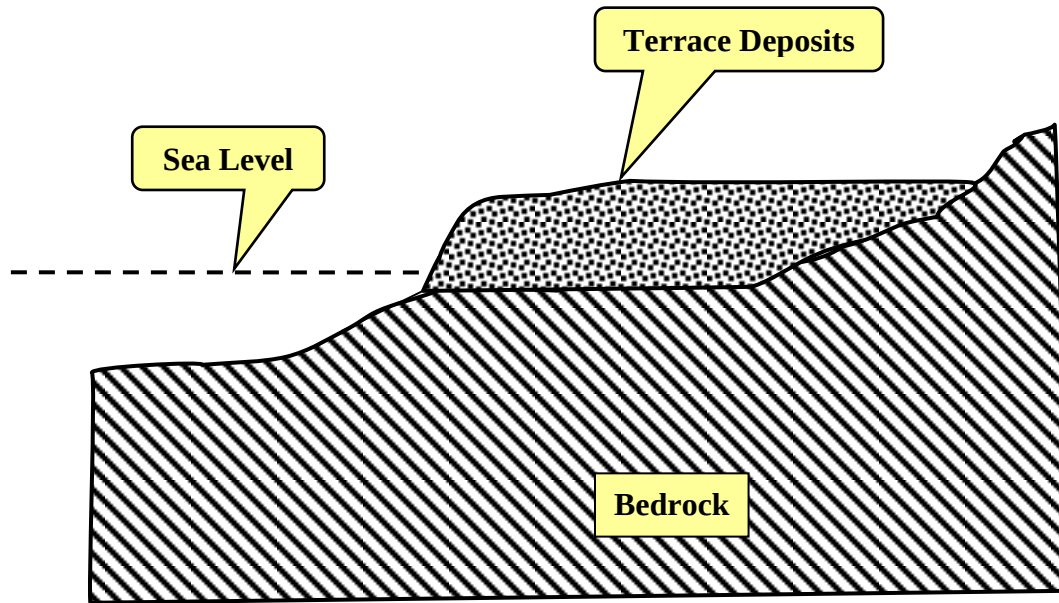
An economic analysis of the alternatives should include:

- cost of constructing and operating a surface-water treatment plant.
- cost of drilling test wells (contact a local well driller to get an estimate).
- potential cost savings of using groundwater as the raw water source.

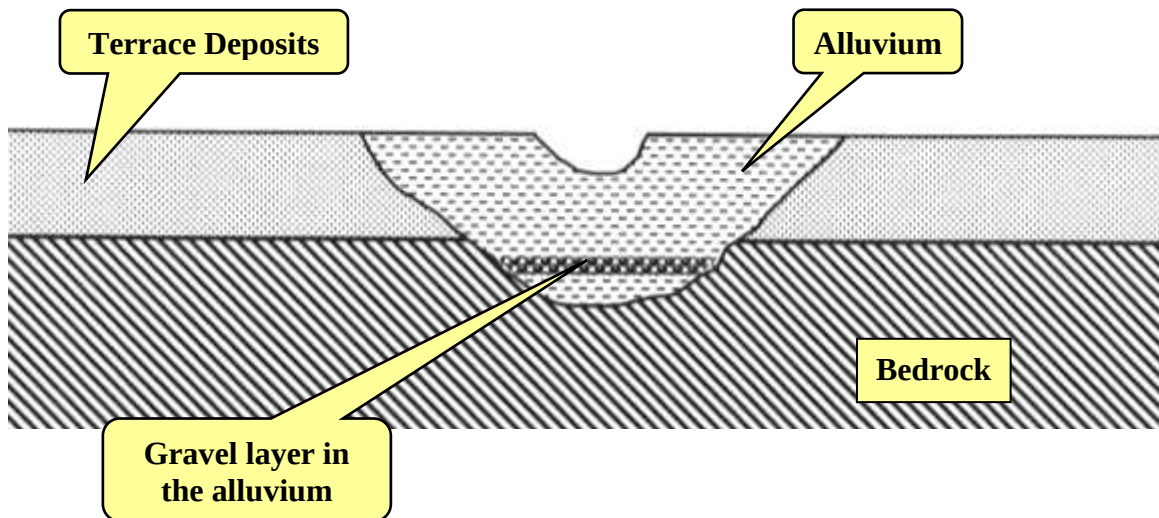
Geology and Hydrogeology of the Kalaloch Area

There are three geologic units that could be considered for development of groundwater supplies at Kalaloch. Those units are the bedrock underlying the area, unconsolidated sediments (sand and gravel) on the marine terrace, and alluvium associated with Kalaloch Creek. The following

figures may help in understanding the relationship of geologic units to one another and provide a mental image to go with the geologic descriptions of the units.



Simplified West-East geologic cross-section at Kalaloch



Simplified North-South geologic cross-section through the mouth of Kalaloch Creek

The recent geologic history of the area is that a wave-cut terrace formed by erosion in the near-shore area, similar to the shallow bedrock outcropping just offshore now. During the last glacial period, sea level was lower and the shoreline was further to the west. During that time, large amounts of sediment were being washed down the rivers and creeks and being deposited in the areas where the rivers exited their steep, mountainous canyons on the former wave-cut terrace. The remnants of these sediments comprise the modern day terrace deposits. Alluvium was deposited (and continues to be deposited) in the stream channels and immediate vicinity.

Origin of bedrock formations

About 200 million years ago, the North American plate began moving to the west. The oceanic plate began moving eastward and was forced under the North American plate at a subduction zone. As the plates moved past one another, some of the uppermost sediments were scraped off the oceanic plate and plastered onto the leading front of the North American plate; much like a bulldozer scraping the upper layers of earth. The layers scraped off the oceanic plate included sandstone, siltstone, and shale. Some of the crustal slices were shoved beneath others, some were bent into folds, and some were shattered into smaller pieces of crust. The continuing movement of the two plates relative to each other caused the slices of sediment shaved off the oceanic plate to pile up against one another until they were near vertical, and in some places turned beyond vertical so that the younger sediments underlie older sediments. Figure 3-6 from Kiver and Harris (1999) helps illustrate the accretion of sediments from the oceanic plate to the leading edge of the North American plate and the origin of bedrock formations along the Olympic coast.

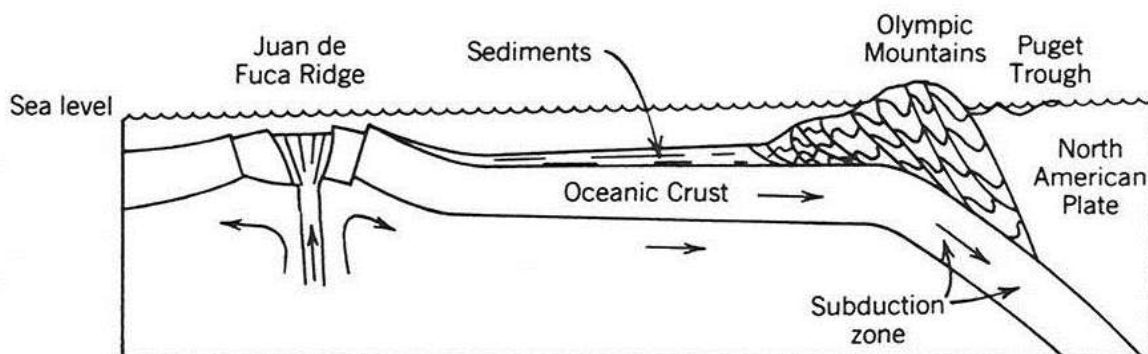


Figure 3-6 (from Kiver and Harris, 1999) Collision of the Juan De Fuca and North American plates “scrapes off” and deforms sedimentary rocks, forming the Olympic Mountains.

Iron and manganese minerals are associated with the basalt rocks and sediments of the oceanic crust. As groundwater interacts with these rocks and their component minerals, iron and manganese are leached out. Groundwater from test wells constructed in the Kalaloch area in 1966-67 had iron and manganese concentrations exceeding secondary drinking water standards.

Harris et al (1997) refer to the sedimentary rock of the ocean crust as turbidites, formed by the settling of sediments flowing along a sloping ocean floor. The term for the sediment-laden flow is turbidity current. Turbidity currents may be started by storm waves, earthquakes, undersea landslides, or rivers pouring massive amounts of sediment into the ocean during floods. As the turbidity current slows down, the sediments settle out; with the larger grains sizes being deposited first. In this manner, we get a sedimentary sequence of gravel or conglomerate, sandstone, and siltstone or clay. Repeated events result in a repeating sequence of layers. This layering can be observed in outcrops of sedimentary rocks, such as in the Kalaloch area.

Groundwater potential of bedrock formations

Conventional wisdom would dictate that the type of bedrock formation underlying the Kalaloch area would be a poor prospect for obtaining groundwater. The bedrock is made up of thin alternating layers of clay, silt, sand, and gravel. Normally we would expect the numerous clay and silt layers to impede groundwater flow to wells. However, the bedrock has been extensively faulted and fractured as pieces of oceanic crust were scraped off and accreted to the North American plate. Abundant rainfall may provide a source of groundwater recharge in the area. Hydrogeologically, the setting is similar to Hurricane Ridge where a water supply well was successfully constructed in 2007. There are no records of wells constructed into this type of bedrock in the coastal area. It is impossible to predict the chemistry of groundwater that might be produced from a well completed in bedrock at Kalaloch.

Test Well No. 1 at Kalaloch (1966) was drilled through alluvium and continued 10 feet into the underlying bedrock formation, from 68-78 feet. The drillers log of this section of the borehole describes the rock as, “very fine-grained sandstone or mudstone, greenish-gray, contains veinlets of calcite, not water-bearing.” This doesn’t bode well for constructing a test well into the bedrock formation underlying the Kalaloch area, however the well was only drilled 10 feet into the bedrock. If a test hole were to be drilled into the bedrock formation, it should be drilled to at least 200-300 feet deep. Nevertheless, preliminary indications are not a cause for optimism.

Terrace Deposits

The near coastal area from the Kalaloch campground, and continuing south past the Queets River is a marine terrace that is as much as a mile wide in places. The terrace is underlain by unconsolidated and stratified sand, gravel, silt, and clay. These sediments are primarily glacial outwash. The terrace deposits in the immediate vicinity of Kalaloch were deposited as outwash from the Hoh and Queets rivers. The outwash deposits have been assigned to two geologic units; the Lyman Rapids outwash and the Hoh Oxbow outwash (Thackray, 1998).

Walters (1970) opined that these sediments seemed to be thicker south of Kalaloch (as evidenced by the wells at the South Beach campground). He thought that in the immediate vicinity of

Kalaloch there would only be a thin mantle of clay and peaty material overlying fine-grained sandstone and siltstone, and therefore it would not be a very productive aquifer in this area.

Lack of previous test drilling in the terrace deposits makes it difficult to make any real assessment of the potential yield for a well in the terrace deposits. It appears that south of Kalaloch (at South Beach campground) there is a sufficient thickness of sediment overlying bedrock to facilitate construction of at least low-yield wells. Yield of a well constructed into the sediments overlying bedrock on the wave-cut terrace is dependent on the permeability and thickness of sediments encountered at any particular location, both of which are largely undocumented.

Rau (1973) stated that the unit of Pleistocene sand, gravel, and clay deposits that outcrops south of the Queets River also forms much of the low-lying bluffs on the marine terrace between Queets and Kalaloch. He speculated that the layer of sand and gravel becomes thinner and occurs deeper toward the north. At Kalaloch, most of the exposure at the creek is composed of silt and clay. Test drilling would be required to determine whether there is a gravel layer at Kalaloch, and whether it is thick enough to provide sufficient groundwater.

The sediments comprising the terraces can be observed in the cliff face from the beach at Kalaloch. The sediments exposed on the beach face are mostly sand and gravel. If these sediments are typical of the terrace deposits for some distance back (east) from the beach, then they could be the source of a productive aquifer. The depth (thickness) of the sediments in this area, or at potential well sites, is unknown.

Kalaloch Creek Alluvium

The valley of Kalaloch Creek and the shoreline where the creek enters the Pacific Ocean is filled with alluvial sediments that have been deposited by the creek. These sediments are derived from erosion of the bedrock of the upland areas. Since the bedrock is primarily composed of marine sediments, the resultant alluvial sediments are primarily fine-grained sediments, mostly clay, silt, and fine-grained sand. There are some gravelly layers which were likely deposited during large flood events that moved large volumes of coarser-grained sediments down the stream. The gravel layers are interbedded and intermixed with the silt and clay sediments. Previous test wells constructed in the alluvium of Kalaloch Creek were not able to obtain clear water. The wells continued to produce turbid and discolored water for the duration of the test pumping.

Previous test wells at Kalaloch, 1966-67

In July 1966, a well was drilled at Kalaloch to replace the surface-water supply from Kalaloch Creek. The well was located in the NW¼ of the SW¼, Section 3, T24N, R13W, about 200 yards north of the creek and about ¾ mile east of the ocean. The well was drilled to 78 feet. The primary water-bearing zones were in gravelly zones from 24½ to 27 and 56 to 66¼ feet below ground surface. Pumping tests determined that the well could probably produce up to 20 gpm as a sustained yield. The water was turbid and somewhat colored and had iron and manganese concentrations in excess of Public Health Service recommended standards.

Apparently it was thought that better water well construction, including well screen and a gravel pack, might allow better development of the aquifer and therefore clearer water.

A second test well was constructed at Kalaloch in 1967 about 200 yards north of the first test well. Well No. 2 was drilled as an 18-inch borehole. Temporary casing (18-inch) was installed as drilling proceeded to prevent the borehole from collapsing. The well was completed with 8-inch Johnson well screen opposite the water-bearing zones at 30-32 feet and 57-65 feet below ground surface. The annular space between the 8-inch casing and well screen and the 18-inch temporary casing was filled with gravel as the temporary casing was withdrawn. The well was then developed by surging and pumping to flush the fine-grained sediment from the gravel pack and develop an efficient flow of water to the well. The well was then pumped at various rates while monitoring the water level in the well.

It was concluded that the well could produce 16 gpm for “a great length of time.” The well could probably produce 25-30 gpm if the pumping time was limited to about 8 hours or less.

Unfortunately, the water chemistry from Well No. 2 was similar to Well No. 1 and efforts to procure a groundwater source were apparently abandoned as there is no further information, discussion, or documentation in the files.

Wells at South Beach

Review of the well construction and hydrogeology at South Beach may provide some insight to anticipated conditions at Kalaloch. South Beach is about 2½ miles south of Kalaloch and has a similar geologic setting. Both Rau (1973) and Walters (1970) opined that the terrace deposits (which are the aquifer at South Beach) would not be as thick or as permeable at Kalaloch and therefore less likely to be a reliable source of water.

The original well at South Beach was 30 feet deep and constructed with 2-foot diameter concrete pipe. The well was located in the SE¼ of the SW¼, Section 22, T24N, R13W, on the east side of the highway. In 1948, the well was deepened by drilling to 115 feet and installing 6-inch steel casing. The annular space between the old 2-foot diameter concrete pipe and the steel casing was filled to prevent contamination of the well. The 6-inch steel casing was slot-perforated from 106-112 feet. The yield of the well was estimated to be 5 gpm. Materials encountered in drilling the well were described as alternating layers of gravel, clay and gravel, and clay. The well drew water from gravel deposits at 100-115 feet below ground surface. Drilling stopped before reaching bedrock.

A second well was constructed at South Beach in 1981. A detailed location for the well was not provided. The well was drilled to 97 feet. The driller’s log describes the sediments as clay or hard pan. (Hard pan is a common term for compacted clay layers.) Steel casing was installed to 51 feet. The well completion report states that there were no perforations and no well screen. If we are to believe the report, the well was completed as an open borehole from 51-97 feet. The well reportedly produced 7 gpm during an 8 hour pumping test.

Water from the well is slightly saline, due to its proximity to the ocean. Water from the well is used for toilets at the picnic area. Potable water is not provided at that location.

General Water Chemistry in Olympic National Park

Walters (1970) investigated the potential for development of several areas in the park. He provided general observations about the water chemistry of surface and groundwater sources and their suitability as drinking water sources.

Water quality in the major rivers of the park is generally very good. Turbidity and color are a problem at certain times of the year.

Groundwater quality is generally good, probably owing to the abundant rainfall and attendant high recharge rates which tend to cause the groundwater to be flushed quickly through the system. There is little residence time for the leaching of minerals from the aquifer matrix.

Iron and manganese concentrations in groundwater in some areas of the park exceed Public Health Standards for drinking water. The recommended limits of 0.3 mg/l for iron and 0.05 mg/l for manganese are based on aesthetic and taste considerations rather than health hazards. High concentrations of iron and manganese have similar effects. They impart a metallic or astringent taste, may stain food during cooking, and stain and discolor laundry and plumbing fixtures.

Potential Well Sites at Kalaloch

Constructing wells in the alluvium of Kalaloch Creek is not recommended. That's been tried and failed. The alluvium associated with Kalaloch Creek contains a large portion of clay and silt size sediment. Test wells were constructed in the alluvium of Kalaloch Creek in 1966-67. These wells were completed in sand or gravel layers at shallow depths, less than 100 feet deep. Apparently, the abundance of clay-size sediments limited the production from the wells. The wells continued to produce colored or turbid water after extensive pumping, probably because the clay sediments were being drawn into the well through the gravel layers. There's no reason to believe that constructing new wells in the alluvium would yield different results.

If the terrace deposits are thick enough, they may be a viable source of groundwater for wells. The wells would need to be located back from the shoreline (east) to reduce the potential for saltwater intrusion from the ocean. The terrace deposits overlie a wave-cut surface on the underlying bedrock. At Kalaloch, the wave-cut surface is below sea level. The thickness of the terrace deposits, depth to bedrock and composition of the sediments in the terrace deposits are all unknown. However, observations of the terrace deposits from the Kalaloch beach show the presence of layers of sand and gravel. If these coarse-grained sediments persist for some distance east of the shoreline, they may be a source of groundwater for wells.

Bedrock underlying the terrace deposits is a repeating sequence of fine-bedded siltstone and fine-grained sandstone. Rock of this type is exposed at Beach 4, a few miles north of Kalaloch. The potential for obtaining groundwater from a water well drilled into bedrock is unknown. There may be enough fracturing to yield a good supply of groundwater to a well, or the fractures may be filled with fine-grained sediments and yield very little water.

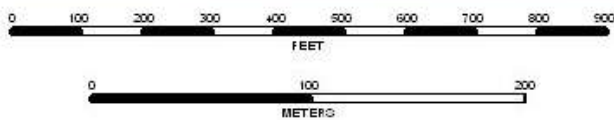
Two sites for test wells are identified in the housing area, approximately 1500 feet east of the ocean shore. These sites are in cleared areas at the easternmost part of the housing area, with one site north of the houses and one site south of the houses (see attached figure). Test wells at either

of these locations would first test the thickness and potential yield from terrace deposits. If needed, the test wells could be continued into the underlying bedrock to test the potential yield from the bedrock. If the results of drilling the first test well are promising, but additional water is needed, then the second well could be drilled. If the first test well is not at least partially successful, then there's no point in drilling a second test well a few hundred feet away. We'd expect similar results from test drilling at both proposed sites.

Maximum depth for a test well at Kalaloch should be about 250 feet. A deeper well might potentially penetrate into underlying saltwater. Also, the potential for obtaining groundwater from fractures in the bedrock decreases with deeper drilling. If groundwater hasn't been obtained from fractures in bedrock by 250 feet, it probably won't happen.

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**Proposed locations for
test wells at Kalaloch,
Olympic National Park**