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Hydrogeology and Water-Supply Wells

Grand Teton National Park

Natural Resource Report NPS/NRPC/WRD/NRTR—2008/091



ON THE COVER

Simulated view of Grand Teton National Park and surrounding area looking to the southwest.

Photograph by: Landsat 7 Team at NASA Goddard Space Flight Center

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Natural Resource Report NPS/NRPC/WRD/NRTR—2008/091

Larry Martin
National Park Service
Water Resources Division
1201 Oak Ridge Drive, Suite 250
Fort Collins, CO 80525

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Executive Summary

Vertical movement of crustal blocks along the Teton Fault resulted in uplifting of the block on the west side of the fault and creation of the Teton Range. Downward movement of the block on the east side of the fault formed a deep basin that has filled with sediments, resulting in the broad, flat valley known as Jackson Hole. Advance and retreat of glaciers in the last 10,000-150,000 years resulted in deposition of several hundred feet of glacial and alluvial sediments over the surface of the valley. These unconsolidated sedimentary aquifers are the source of groundwater for public water-supply wells at facilities in Grand Teton National Park.

There are numerous low-yield domestic wells in the park. Some of these wells were constructed by NPS to provide water for single-family residences, ranger stations, entrance stations, etc. Some of the low-yield wells were acquired with private parcels that were purchased and incorporated into the park. A well drilled almost anywhere in the valley will produce enough water for domestic use at residences.

Locating groundwater sources for large-volume public water supply wells can be more problematic. Deposits of glacial outwash, areas where glacial deposits have been reworked by streams, and areas where streams have deposited alluvium are generally very permeable and can produce large volumes of water from wells. In areas where the glacial deposits have not been reworked by running water (glacial till and moraines), abundant amounts of clay and silt mixed with sand and gravel result in relatively low permeability sediments, and well yields will be too low to supply public water-supply systems.

Many of the wells in the park were completed with perforated steel casing. This is an inexpensive, but also inefficient, method of well construction. Wells constructed with perforated casing are susceptible to “sand pumping”. Wells completed with properly-sized well screen are more efficient and, when properly developed, are not likely to produce sand.

Successful construction of high-yield wells is more likely if the wells are located in areas underlain by glacial outwash or alluvium. Wells constructed in areas underlain by glacial till or moraines are likely to yield only small quantities of water.

Introduction

Prior to 1961, there were very few public water-supply wells in Grand Teton National Park. Most public water supplies were obtained from springs or surface water sources. The need for larger volumes of water to support increasing park visitation and the need to provide water meeting public health criteria caused the park to begin exploration and development of groundwater sources. Much of the information and data obtained during construction and testing of wells and test holes is scattered throughout files at the park and the Water Resources Division in Ft. Collins. Some of the information resides only in the memories of park staff. This report is an effort to collect and compile this information in one document for the benefit of future investigators.

A general location map for Grand Teton National Park and the surrounding area is provided as Figure 1.

Scope of Investigation

This report provides a summary of the hydrogeology of Grand Teton National Park with respect to availability of groundwater for large-yield public water supplies. It is not meant to be a comprehensive report of the hydrogeology of the entire park. The report also provides a summary of construction of public water-supply wells in the park.

The descriptions of test drilling and well construction are mostly limited to public water-supply systems. There are numerous private, domestic wells that were acquired with the transfer of private property to the park; discussion of these wells is not included in this report. It is possible to drill a well almost anywhere in the Jackson Hole Valley and obtain enough water for a private, domestic water supply. The park is more concerned with where large-yield water-supply wells can be constructed to provide water for large developments within the park, such as the Jackson Lake Lodge.

This report does not attempt to inventory or assess the numerous monitoring wells constructed in the park. Monitoring wells tend to be shallow wells constructed only a short distance below the water table to provide access for water quality sampling. They generally do not provide much useful information regarding hydrogeology or potential well yield.

Previous Investigations

McGreevy and Gordon (1964) reported on the results of test well drilling at several localities along the east side of Jackson Lake. Their work included hydrogeologic investigations of the area to identify potential areas for construction and development of water-supply wells to replace surface water sources at several areas. There was also a need to provide supplemental water supplies for facilities at Colter Bay and Jackson Lake Lodge, which were being supplied with water from a spring.

Behrendt et al. (1968) reported on the results of geophysical investigations in the park conducted to provide a better understanding of the structural geology of the park and surrounding area.

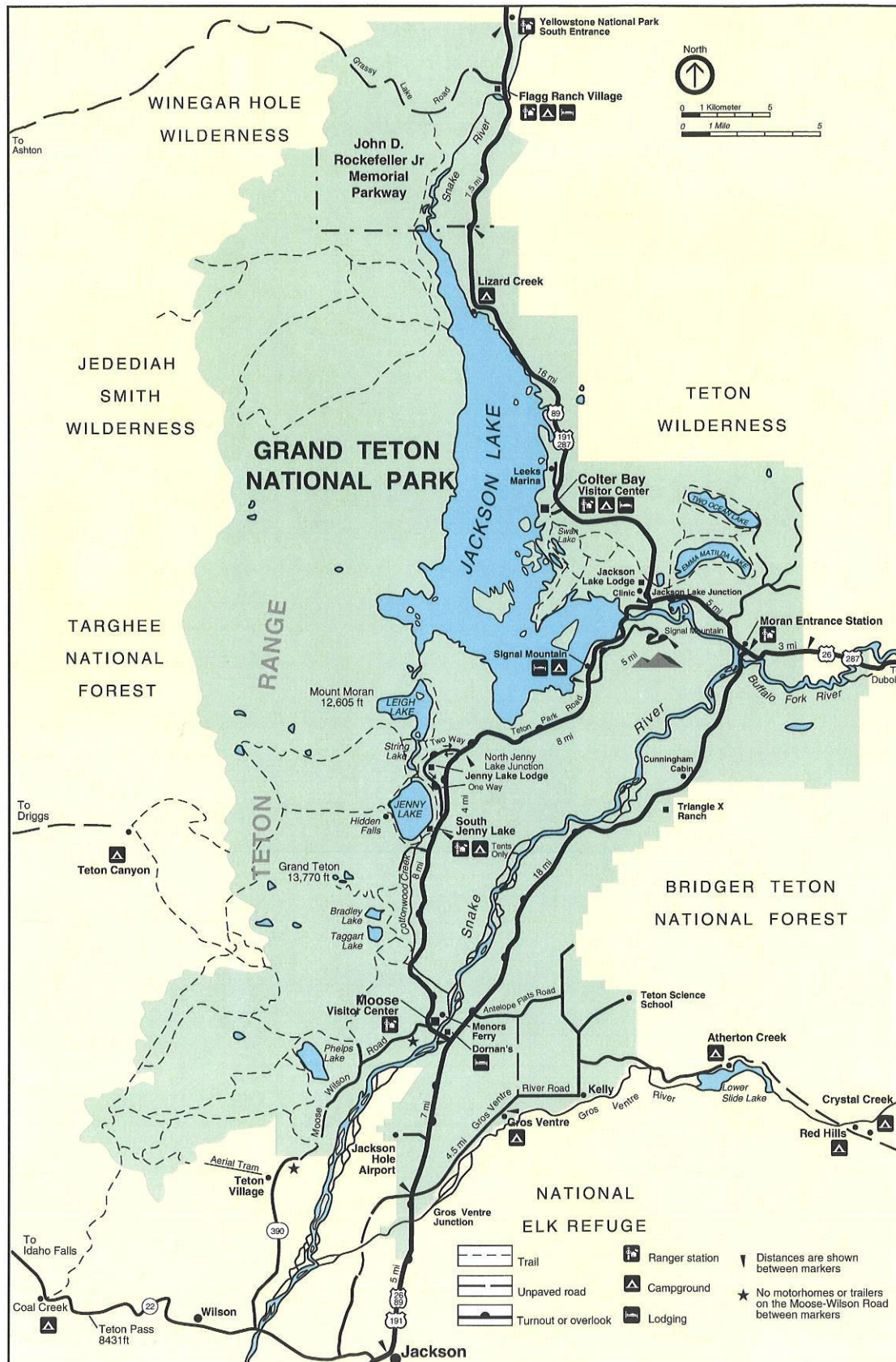


Figure 1. General location map for Grand Teton National Park and vicinity.

Mekeel (1972) provides a general overview of park water resources. His master's thesis was a compilation of information obtained during his seasonal work at the park during the summers of 1964 through 1968.

Cox (1974) conducted a summary appraisal of water resources in the park. He included an inventory of wells and water quality data for both surface and groundwater in the area. At the time of Cox's study (1967-73), most facilities in the park were being supplied with water from springs or surface water sources. Wells were used to supply water for the Gros Ventre and Lizard Creek campgrounds, the Signal Mountain Lodge and Campground, and as a supplemental source to the springs that supplied Colter Bay Village and Jackson Lake Lodge.

Chronic (1984) provides a general overview of the geology and geologic history of the park.

Love et al. (1992) published a geologic map of Grand Teton National Park. J.D. Love spent more than 50 years of his career conducting geologic investigations and mapping in Wyoming, with an emphasis on the Jackson Hole area.

Nolan and Miller (1995) compiled and analyzed water resources data for Teton County south of Yellowstone National Park. The study area included Grand Teton National Park and John D. Rockefeller, Jr. Memorial Parkway.

Harris et al. (1997) provide another summary of the geology and geologic history of the park and surrounding area.

Mott (1998) authored a water resources scoping report for the park which describes the hydrologic and related physical processes in and around Grand Teton National Park, how those processes interact with biological resources, and issues potentially affecting the water resources of the park.

Hedmark and Young (1999) investigated the hydrogeology and water quality near four wastewater-treatment facilities in the park.

Kiver and Harris (1999) provide a general overview of the park geology and geologic history. They also provide insight into the relationship between the physical geology and physiographic features of the park and the geologic structure and glaciology that have produced these features.

Love et al. (2007) provide a concise explanation of the geologic history of the area and explain how the structural geology and geologic processes have combined to create the landscape of the park. In particular, they provide an explanation of the recent glacial geology of the Jackson Hole valley and how it has shaped the topography, vegetation distribution, and drainage patterns in the valley. Their work is an invaluable aid to understanding the hydrogeology of the near-surface sediments, which are the source of groundwater for public water-supply wells in the park.

Geology

The geology of Grand Teton National Park is defined by the Teton Fault. The block on the west side of the fault has been uplifted and eroded to form the Teton Range. The block on the east side of the fault has been downdropped and subsequently filled with sediments, forming the broad open valley of Jackson Hole. Movement of the fault blocks is similar to a set of swinging doors, with the hinge of the fault block underlying the Jackson Hole valley located some distance east of the valley and the hinge of the fault block underlying the mountain range located some distance to the west of the mountains. Movement along the fault is as if the swinging doors had been opened in opposite directions (Figure 2).

The lower part of the basin underlying the Jackson Hole Valley has been filled with lakebed sediments and volcanic rocks from eruptions at the north end of the park. Closer to the surface, the valley-fill sediments are comprised of glacial deposits and alluvium. The shallow valley-fill sediments comprised of glacial deposits and alluvium are the source of groundwater for water-supply wells in the park.

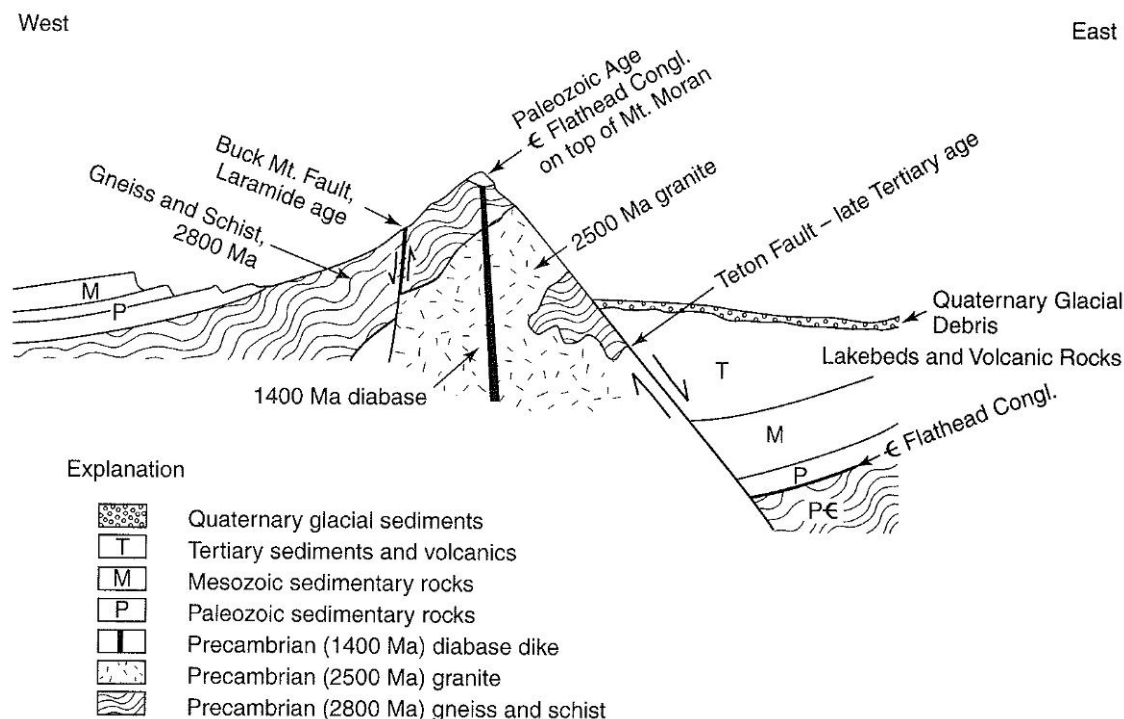


Figure 2. Generalized geologic cross section of the Teton Range and part of Jackson Hole.
From Kiver and Harris (1999)

Glacial Geology

There may have been as many as twenty major glaciations in the past 2.5 million years (Love et al., 2007). There is little, if any, remaining evidence of any but the last two glacial events in the Jackson Hole area. The Bull Lake glaciation occurred from about 160,000 to 130,000 years ago when glaciers covered the entire Jackson Hole valley to within a few miles north of Hoback

Junction. The Pinedale glaciation occurred from about 30,000 to 12,000 years ago when the ice covered Jackson Lake and Leigh Lake, but not Jenny Lake. On the east side of the valley, glaciers extended to about Deadmans Bar. The approximate extents of glacial ice advances during these two periods of glaciation are shown on Figure 3.

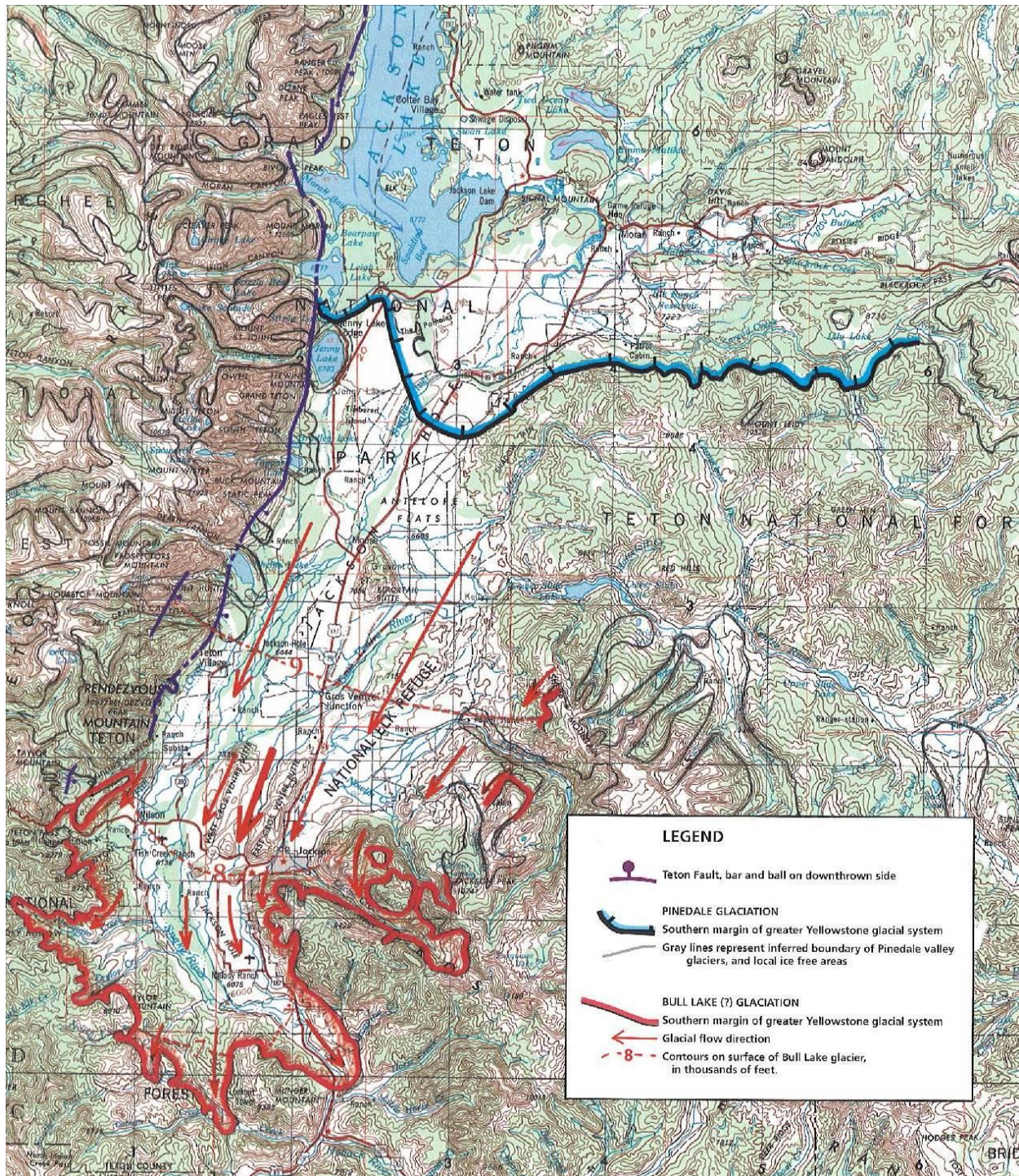


Figure 3. Map showing the approximate extent of glacial ice during the Bull Lake and Pinedale glaciations. From Love et al. (2007)

During the Bull Lake glaciation, ice from the Yellowstone glacial system flowed south through the Jackson Hole Valley, filling the entire valley to within 2 miles of Hoback Junction (Love et al, 2007). The glacier scoured the sides of the valley and the Gros Ventre Buttes near Jackson. Tributary valleys were dammed by ice, creating lakes and, subsequently, thick deposits of lake sediments. The Bull Lake glaciation scoured deep basins in the valley, which were later filled with glacial sediments. Much of the record of the Bull Lake glaciation has been obscured by weathering, erosion, and the subsequent Pinedale glaciation.

The Pinedale glaciation was the most recent glacial advance in the Jackson Hole Valley. The current estimate is that the glaciation occurred from about 30,000 to 12,000 years ago. During the Pinedale glaciation, three primary ice lobes flowed into the northern part of the Jackson Hole Valley from the Yellowstone ice field to the north. Most of the flow of glaciers into the valley was from the east via the Buffalo Fork ice lobe, from the northeast via the Pacific Creek ice lobe, and from the north via the Snake River ice lobe. Different lobes were dominant at different times during the glaciation, as the most productive source area of snow and ice shifted in the ice field. The changes in glacial activity complicated interpretation of events, but Love et al. (2007) appear to have worked out the sequence of events. As each of the ice lobes advanced (at different times), they scoured deep basins, which were subsequently filled with lake sediments and glacial outwash. Jackson Lake was scoured by the most recent ice advance and was not entirely filled with sediment as there was no subsequent glacial advance and retreat.

Ice flowing from the Teton Range was not the primary source of glaciers in the Jackson Hole valley. However, during the Pinedale glaciation, mountain glaciers from the Teton Range flowed east out of the mountains to the valley along the west side of Jackson Hole. These glaciers formed moraine deposits at their terminus just beyond the mouths of the canyons (Figure 4). The moraines act as dams, resulting in the formation of Jenny Lake, Bradley Lake, Phelps Lake, and Taggart Lakes. These prominent lakes were clearly formed by glacial processes, which led to the early speculation that glaciers flowing from the Teton Range were the primary source of ice for glaciation of the entire valley. Leigh Lake and String Lake were covered by the main ice field flowing south from Yellowstone during the Pinedale glaciation and owe their existence to other geologic processes, perhaps earlier glacial events.

Most of the southern Jackson Hole valley has been a depositional environment for the past 130,000 years, since the end of the Bull Lake glaciation. Pinedale glaciation did not extend south of the Jenny Lake/Deadmans Bar areas. Thus, during the Pinedale glaciation the valley to the south was being filled with glacial outwash sediments from the glaciers which had their terminus in the Jackson Lake/Moran areas. Outwash deposits in the southern Jackson Hole valley are many tens or hundreds of feet thick and are generally a prolific source of groundwater for wells.

The hydrogeology of the northern part of the Jackson Hole valley, north of Jenny Lake and Deadmans Bar, is more complicated due to the repeated advances and retreats and associated changes in depositional environments during the Pinedale glaciation. Wells drilled in this part of the valley might encounter glacial till, lake sediments, glacial outwash, and alluvial fan deposits, or any combination and sequence of these sediments. It is difficult to predict what will be encountered at any particular area until at least one exploratory well has been drilled.

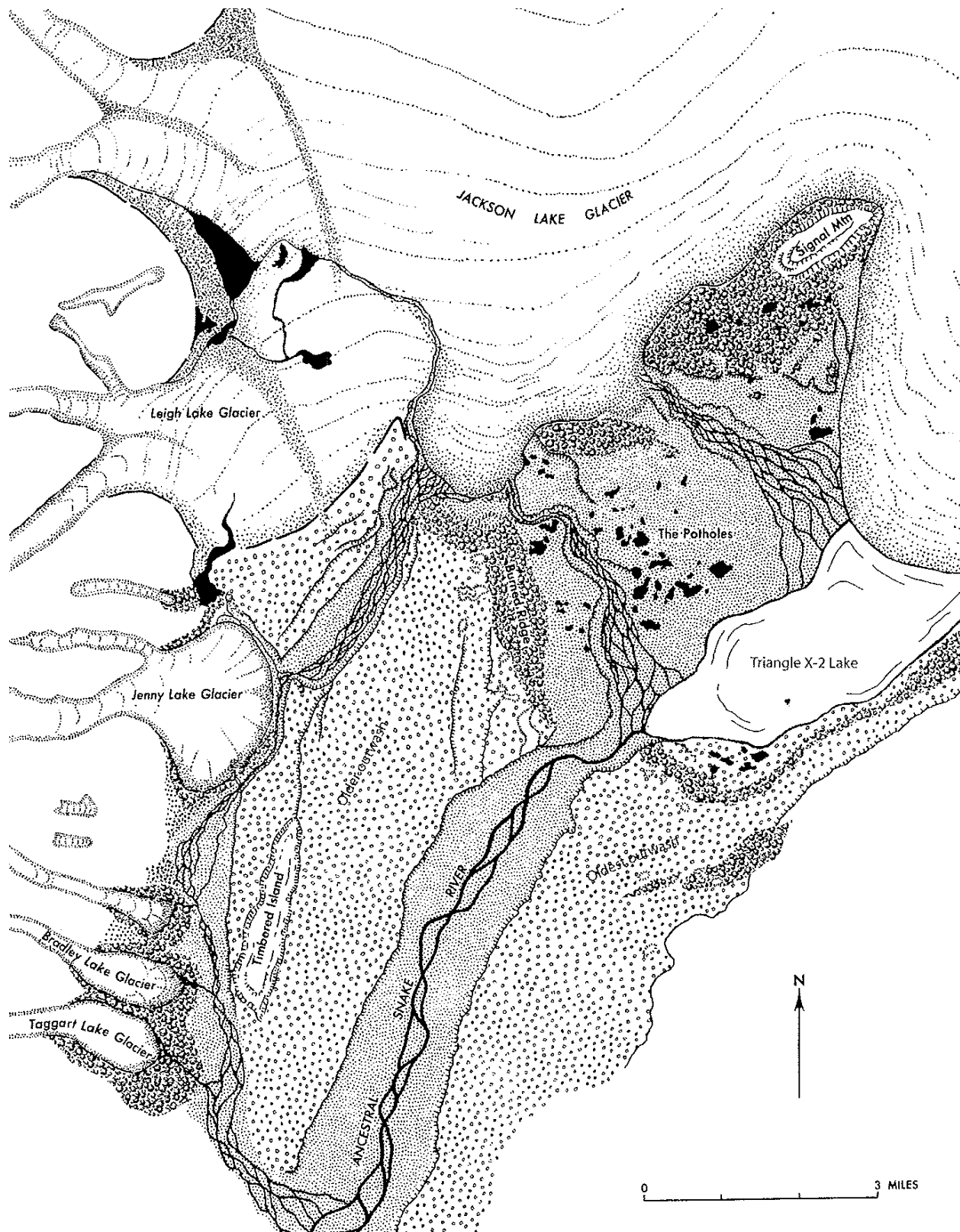


Figure 4. Sketch map of areas covered by glaciers and outwash during the recessional phase of the Pinedale glaciation. From Love et al. (2007).

Glacial deposits are of three types: moraines, till, and outwash. Moraines and till are similar in that they both contain a mixture of sediment sizes from clay to boulders. The presence of significant amounts of clay and silt result in low permeability and make these deposits poor targets for construction of water-supply wells. Outwash and alluvium are similar in that the sediments have been deposited or reworked by flowing water and are mostly lacking the fine-grained silt and clay sediments. Outwash and alluvium generally have high permeability and are good targets for construction of water-supply wells. All of the facilities, and therefore all of the water-supply wells, at Grand Teton National Park are located in the valley. Identifying good locations for wells to supply these facilities is largely a matter of deciphering the history of the glacial geology of the valley to identify areas of outwash and alluvium where large amounts of groundwater are more likely to occur.

Alluvium occurs as floodplain deposits and alluvial fans emanating from tributary valleys. The alluvium is generally comprised of well-sorted deposits of sand and gravel. Much of the alluvium is glacial outwash material that has been reworked by modern streams. Alluvial fans occur along the margins of the Jackson Hole valley where tributary streams entering the valley from the surrounding uplands have deposited their sediment load. Large amounts of groundwater occur within the alluvium (Cox, 1974).

Modern-day streams in the valley continue to rework sediments, flushing the fine-grained particles downstream and leaving the coarse sediments as alluvium. Generally, the alluvial sediments associated with the major streams are prolific aquifers that will easily yield 100s of gallons per minute to properly designed wells.

Vegetation in the Jackson Hole valley is influenced by the distribution of Pinedale glacial moraines and outwash deposits. The moraines are generally forested, whereas the outwash plains sustain only a sparse covering of sagebrush. The moraines contain large amounts of silt and clay and, therefore, retain water and have higher soil moisture content than the outwash deposits. The moraine deposits also retain chemical elements in the fine-grained sediments and are, therefore, more fertile than the porous quartzite sand and gravel that comprise the outwash plains.

Water well and test hole construction

1961 Test Well Drilling

The first records of well construction by the National Park Service in Grand Teton National Park were for several test wells constructed in 1961. Prior to that, water supplies for most facilities in the park were obtained from either surface water sources or springs. Most of the test drilling in 1961 was near Jackson Lake to identify potential groundwater supplies for NPS facilities at/near Jackson Lake. The investigations were limited to the alluvium and lacustrine sediments along Jackson Lake and the area immediately east of Jackson Lake. Additionally, a test well was constructed near the Buffalo Fork Ranger Station at Moran. Results and interpretation of information obtained from the 1961 test drilling program are provided by McGreevy and Gordon (1964). Locations of the 1961 test wells are shown on Figure 5.

Table 1. Test wells constructed at Grand Teton National Park in 1961.

Well Name	Depth	Yield	Disposition
Lizard Point No. 1	101 ft	97 gpm	Supply well for Lizard Creek Campground
Lizard Point No. 2	83 ft	25 gpm	Abandoned
Colter Bay Reservoir Well	200 ft	---	Abandoned
Pilgrim Creek No.1	151 ft	150 gpm	Abandoned
Pilgrim Creek No.2	100 ft	130 gpm	Abandoned
Pilgrim Creek No.3	97 ft	150 gpm	Abandoned
Buffalo Fork Ranger Station (Moran Junction)	55 ft	30 gpm	Supply well for facilities at Moran Jct., replaced in 2002
Signal Mountain No. 1	152 ft	20 gpm	Abandoned
Signal Mountain No. 2	205 ft	115 gpm	Supply well for facilities at Signal Mt., replaced ca. 1991

One of the test wells at Lizard Point became the supply well for the Lizard Creek Campground and remains in use today. The test well near the Snake River at the Buffalo Fork Ranger Station provided water for facilities at Moran Junction until a new well was constructed there in 2002. One of the test wells at Signal Mountain provided water for facilities there until a new well was constructed on top of the hill, near the underground storage reservoir for facilities at Signal Mountain. The remainder of the test wells constructed in 1961 were plugged and abandoned.

Two test holes were constructed in the Lizard Point area near the north end of Jackson Lake. The holes were drilled through unconsolidated deposits that included clay, silt, fine sand, coarse sand, and gravel. Lizard Point No. 1 was drilled to 101 feet and completed with 6-inch steel casing that was perforated from 68-87 feet. The well was test pumped for 24 hours at 97 gpm resulting in 5 feet of drawdown. The Lizard Point No. 1 well remains in use as the water supply well for the Lizard Creek campground. Lizard Point No. 2 encountered more fine sand and clay than Lizard Point No. 1. Lizard Point No. 2 was bailed at 25 gpm, but the openings in the perforated casing were too large to prevent inflow of the fine-grained sand and silt. Lizard Point No. 2 was plugged and abandoned.

A test well was drilled near the Colter Bay reservoir (water storage tank) about a mile northeast of Colter Bay Village. The well was drilled to 200 feet and encountered mostly clay and silt, sometimes mixed with sand and gravel. The well did not produce a useable amount of water and was abandoned.

Three test wells were drilled in the upper part of the Pilgrim Creek valley, approximately 2 miles north of Hwy 89/287. These wells were called Pilgrim Creek No. 1-3, but those names should not be confused with subsequent well drilling that resulted in construction of production wells that were also named Pilgrim Creek No. 1, No. 2 & No. 3. In the fall of 1962, a new production well was constructed a few feet from the Pilgrim Creek No. 1 test hole. This production well

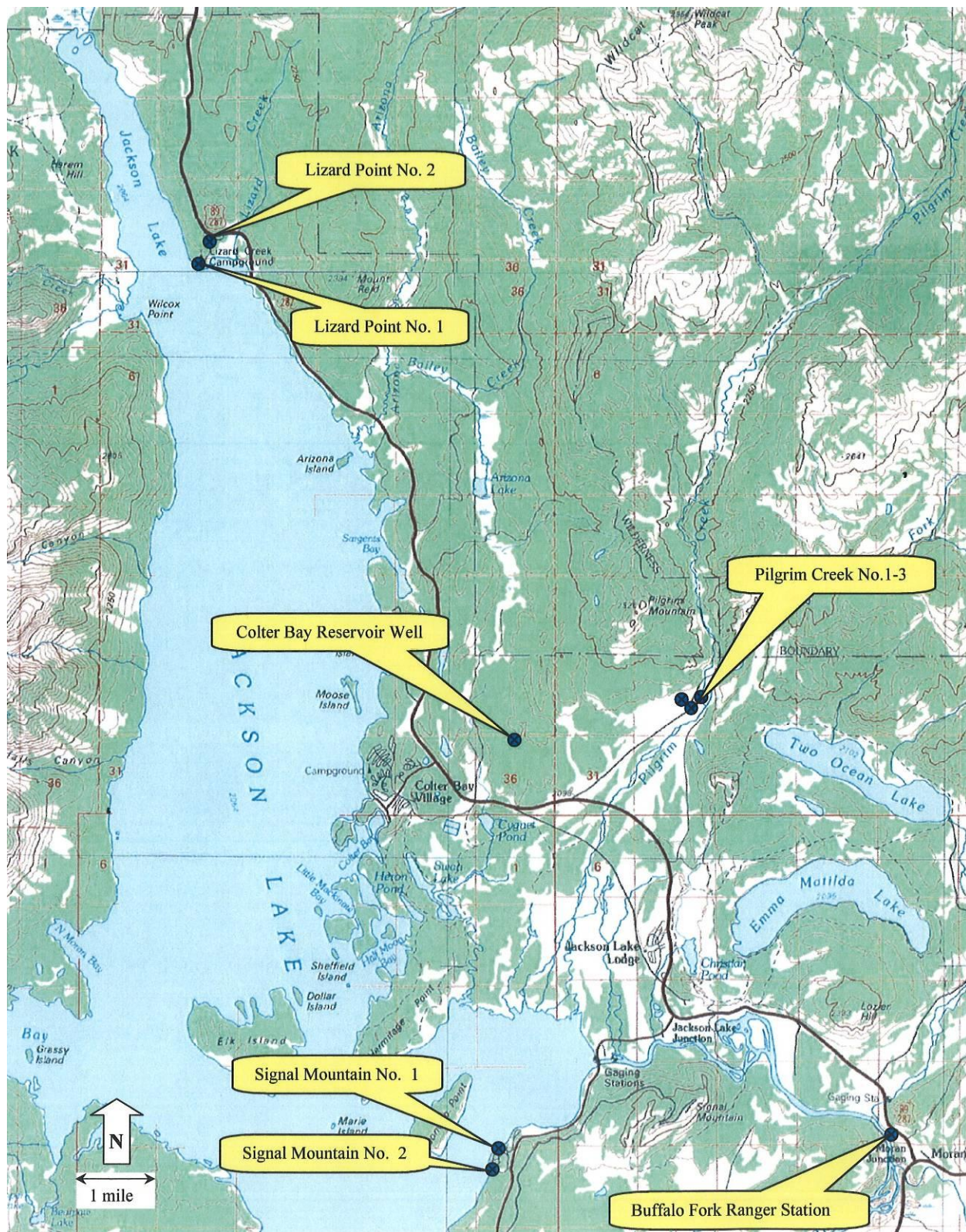


Figure 5. Locations of test wells constructed in 1961.

was named Pilgrim Creek No. 1. Subsequently, two more production wells were constructed in the Pilgrim Creek valley; Pilgrim Creek No. 2 in 1975 and Pilgrim Creek No. 3 in 1985. All three of the original test holes, constructed in 1961, were plugged and abandoned.

Pilgrim Creek No. 1 (1961 test well) was drilled to 151 feet and was completed with 6-inch casing that was perforated at various intervals between 31-134 feet below ground surface. The well was test pumped for 26 hours at 150 gpm, resulting in 1½ feet of drawdown. Most of the sediments encountered during drilling were coarse-sand to coarse-gravel size.

Pilgrim Creek No. 2 (1961 test well) was drilled to 100 feet. Steel casing (6 inch) was installed with perforations at various intervals between 36-56 feet below ground surface. The 6-inch casing was later removed and replaced with a ¾-inch pipe for use as a water-level observation well. The well was test pumped for 26 hours at 130 gpm, resulting in 4.4 feet of drawdown. Several lenses of sand and coarse-gravel were encountered during drilling, but the much of the well passed through deposits of fine-grained sand.

Pilgrim Creek No. 3 (1961 test well) was drilled to 97 feet. Steel casing (6 inch) was installed to 70 feet with perforations at various intervals between 26-55 feet below ground surface. The 6-inch casing was later removed and replaced with a ¾-inch pipe for use as a water-level observation well. The well was test pumped for 26 hours at 150 gpm, resulting in 4.4 feet of drawdown. The well encountered lenses of coarse sand and gravel to a depth of 55 feet. Below 55 feet the well encountered “mushy” sand that would “heave” into the bottom of the casing. Bedrock was encountered at 73 feet.

The test well at the Buffalo Fork Ranger Station was drilled to a depth of 55 feet. The well was completed with 6-inch casing that was perforated from 28-30 feet below ground surface, corresponding with a water-bearing gravel layer. Lake sediments (clay) were encountered at a depth of 44 feet. The well was test pumped for 31 hours at 30 gpm, resulting in 12 feet of drawdown. The well remained in use as the water supply well for facilities at Moran Junction until a new well was constructed in 2002.

Two test wells were constructed at the Signal Mountain campground. Signal Mountain Well No. 1 was drilled to 152 feet and encountered mostly clay, silt, and fine sand. The well was test pumped for 26 hours at 20 gpm with an estimated drawdown of 42 feet. Well No. 1 did not meet the desired production needs and was plugged and abandoned. Signal Mountain Well No. 2 was drilled near the boat ramp, south of the campground. It was drilled to 205 feet and was completed with 6-inch casing with perforations at various intervals from 59-68 feet and 159-160 feet below ground surface. The perforated intervals corresponded with more permeable sand and gravel layers. The well was test pumped for 24 hours at 115 gpm, resulting in 10½ feet of drawdown. Signal Mountain Well No. 2 was the water supply well for facilities at Signal Mountain until about 1991, when a new well was constructed on top the hill near the underground water storage reservoir.

Domestic Water-Supply Wells

There are many water-supply wells and water systems in Grand Teton National Park that provide water for a single building, or possibly two buildings. In most cases, these are single family homes or small ranger stations that use only a small amount of water per day. Many of them are seasonal residences. Very little, if any, information was found regarding construction of low-yield domestic wells for single-family residences and ranger stations. The locations of low-yield domestic wells currently being used are provided in Table 2.

Table 2. Low-yield domestic wells at facilities in Grand Teton National Park.

Bldg. # and Location	Description
#67 Kelly	Ranger Station
#1210 Kelly	Johnson House
#1225 Kelly	Paul Residence
#1121 S. Boundary, Hwy. 191	Stewart Residence
#1094 S. Boundary, Hwy. 191	Green Residence
#1095 A/B Moose/Wilson Rd. #1096 Moose/Wilson Rd.	Tanke Residence (Main) Tanke Residence (Single)
#1456 A/B, Moose/Wilson Rd.	Whitty Residence
#1359 Antelope Flats	Reimer/ Hultman Residence
#356 Shadow Mountain	Roskam Residence

Public Water-Supply Wells

There are many public water-supply wells and water systems in Grand Teton National Park. They range in size from low-demand wells that are a seasonal supply for an entrance station to municipal supply wells providing tens of thousands of gallons per day for large developments such as Jackson Lake Lodge. The location and use of public supply wells in the park is summarized in Table 3.

Table 3. Public water-supply wells at Grand Teton National Park.

Location	Water source	Uses
Flagg Ranch	3 wells	NPS residences, lodge, restaurant, campground
Snake River Picnic Area	1 well	Inactive. Well supplied water for the campground that formerly occupied this area.
Lizard Creek	1 well	Seasonal use at campground
AMK/ University of Wyoming field station	2 wells	Cabins and lodge facilities for university research scientists and field station staff
Leeks Lodge & Marina	1 well	Marina and restaurant
Pilgrim Creek	3 wells	All facilities at Jackson Lake Lodge and Colter Bay Village; restaurants, lodges, cabins, campgrounds, marinas
Moran Junction	1 well	Ranger station, NPS residences, and an elementary school
Signal Mountain	1 well	All facilities at Signal Mountain; restaurant, lodge, campground
Brinkerhoff House	1 well	Inactive. Water supplied from the system at Signal Mountain
Triangle X Ranch	Spring	Cabins and restaurant
Jenny Lake Lodge & String Lake picnic area	1 well	Lodge, restaurant, picnic area
South Jenny Lake	1 well	Campground and Jenny Lake Visitor Center
Lupine Meadows	1 well	NPS cabins (climbing ranger residences)
Highlands	1 well	NPS housing (seasonal)
Climbers Ranch	1 well	Cabins operated by the American Alpine Club
Taggart Creek	2 wells	NPS housing and offices at Beaver Creek and Moose, and the Main Visitor Center at Moose
White Grass	1 well	Cabins for the cultural preservation center at the historic White Grass Dude Ranch
Granite	1 well	Granite Canyon Entrance Station
Gros Ventre Campground	1 well	One well supplies all facilities. The second well is inactive.
Teton Science School	1 well	Lodge, dining facility, and cabins for a private environmental science school

Flagg Ranch

Facilities at Flagg Ranch are currently (2007) supplied water from two wells located about one mile north of the ranch (Figure 6). Water from the wells contains arsenic and fluoride at concentrations slightly above drinking water standards. The water was also about 10°C warmer than water from monitoring wells near the sewage lagoons. It was hypothesized (Martin, 2005) that the source of arsenic and fluoride was geothermally-influenced groundwater in contact with volcanic bedrock a short distance north of the wells.

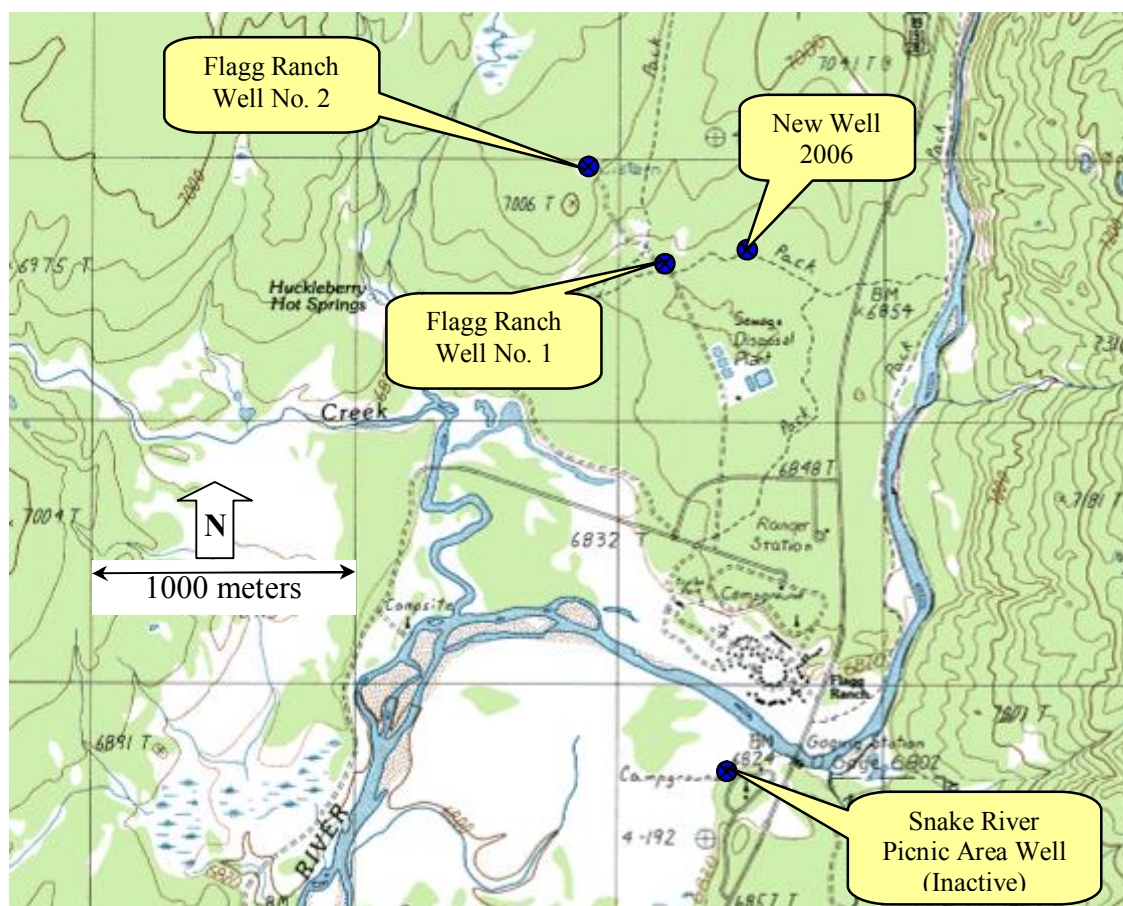


Figure 6. Locations of wells at Flagg Ranch and Snake River Picnic Area.

Flagg Ranch Well No. 1 was drilled to a total depth of 95 feet and was completed with well screen from 60-83 feet below ground surface. The well obtains water from alluvium and glacial outwash deposits, primarily sand and gravel. The well was test pumped (1978) for 24 hours at rates from 100-175 gpm, resulting in 48 feet of drawdown. The driller recommended limiting pumping to less than 165 gpm.

Flagg Ranch Well No. 2 was drilled to a total depth of 100 feet and was completed with well screen from 80-100 feet below ground surface. The well obtains water from alluvium and glacial outwash deposits, described on the driller's log as sand and coarse gravel. The well was test pumped (1979) for 25 hours at 225-230 gpm, resulting in 62 feet of drawdown.

Another well was constructed in 1978 to supply water for the sewer plant. The well was drilled to a total depth of 106 feet and was completed with well screen from 67-80 feet below ground surface. The well was test pumped for 24 hours at 35 gpm with no drawdown. The well obtains water from alluvium and glacial outwash.

A new well was drilled closer to the Snake River in 2006 to obtain better quality groundwater from the alluvial deposits associated with the Snake River. The new well has lower concentrations of arsenic and fluoride but has not yet been connected to the water supply system. The well was drilled to a total depth of 90 feet, with the last 5 feet penetrating basalt bedrock. The well was completed with well screen from 70-80 feet below ground surface. The well obtains water from sand and gravel sediments, either alluvium or glacial outwash.

Snake River Picnic Area

The well at the Snake River picnic area (Figure 6) is no longer operated. The picnic area is a dry site. The well is 101 feet deep and was constructed in 1974. The well is completed in alluvium of the Snake River valley. The well has perforated casing from 88-94 feet below ground surface. The well was test pumped (in 1974) for 2 hours at 40 gpm, resulting in 44 feet of drawdown. The site was formerly a campground, but it has been reduced to a day-use only picnic area.

Lizard Creek

Two test wells were drilled at Lizard Creek in 1961 (Figure 7). Lizard Creek No. 2 encountered mostly clay and silt and was dry its entire depth. It was plugged and abandoned. Lizard Creek No. 1 was drilled to a total depth of 101 feet and encountered mostly sand and gravel, described by Cox (1974) as alluvium. The well was completed with perforated casing from 68-87 feet below ground surface. It was test pumped for 60 hours at 98 gpm, resulting in 5 feet of drawdown.

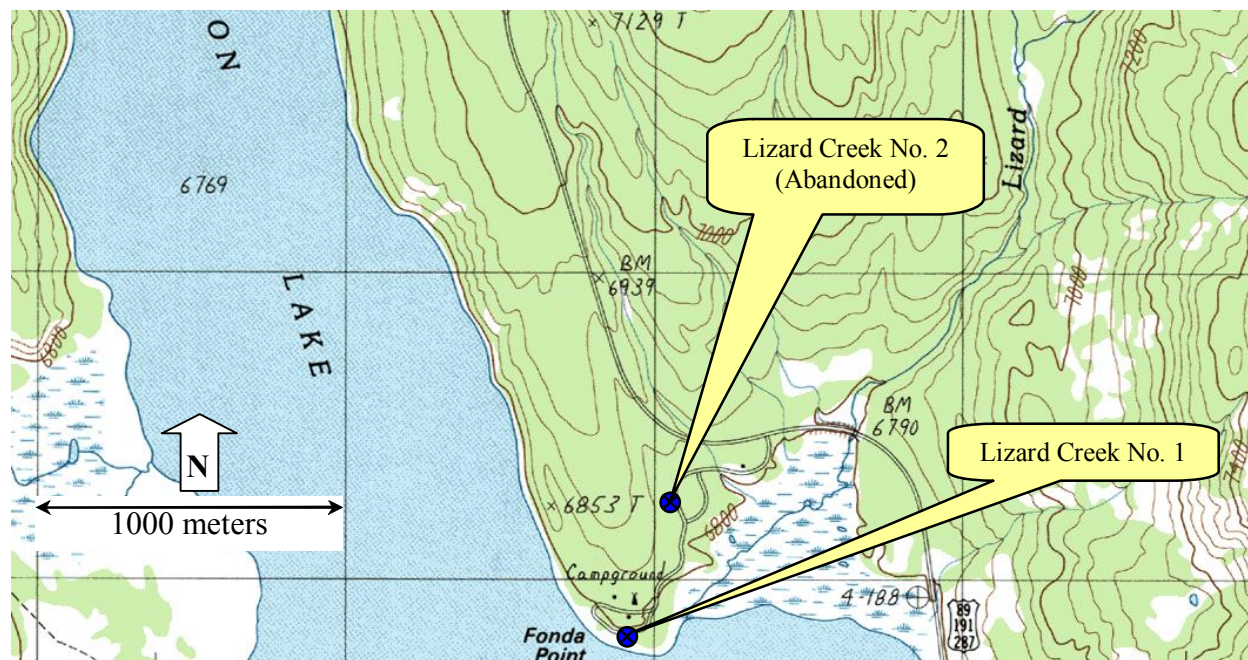


Figure 7. Locations of wells at Lizard Creek Campground.

Leeks Lodge & Marina and AMK Ranch

Leeks Lodge and Marina are located on the eastern shore of Jackson Lake about 1½ miles northwest of Colter Bay (Figure 8). NPS facilities there are supplied with water from a single well. The well was drilled to a total depth of 131 feet and was completed with perforated casing from 111-120 feet below ground surface. The well was test pumped for 2 hours at 40 gpm, resulting in 10 feet of drawdown. The well obtains water from quartzite gravel, probably glacial outwash.

Cox (1974) lists another well at Leeks Lodge that was reportedly constructed in 1937. The well is 41 feet deep, but no other information is provided.

The AMK Ranch is a research station operated by the University of Wyoming. McGreevy and Gordon (1964) provide driller's logs for two wells at AMK Ranch (Figure 8). Both wells are constructed into unconsolidated sand and gravel deposits, probably glacial outwash. The wells were drilled to a total depth of 149 and 170 feet. No other information is available for these wells.

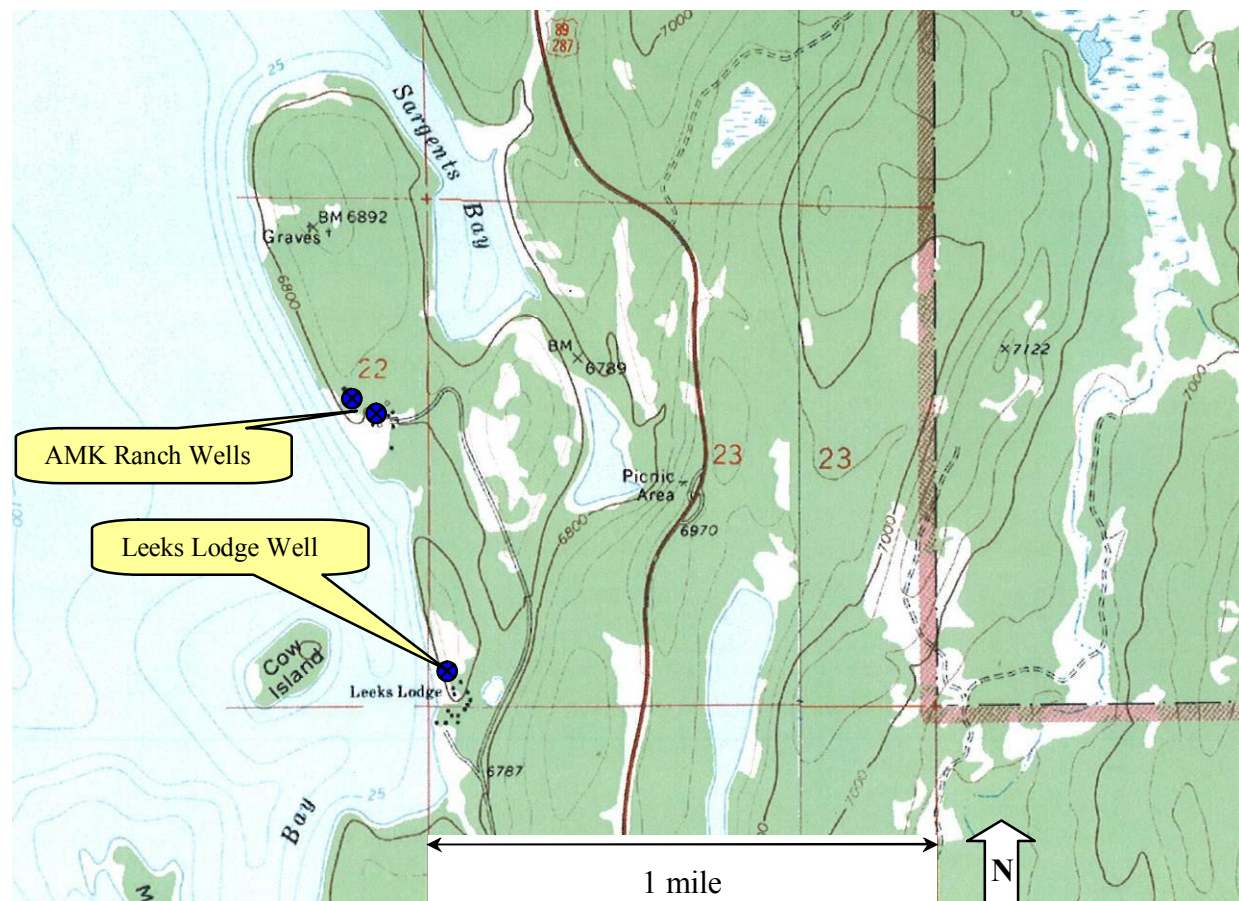


Figure 8. Locations of wells at Leeks Lodge & Marina and the AMK Ranch.

Pilgrim Creek

Three test wells were constructed in the upper part of the Pilgrim Creek valley in 1961. Information obtained from the test drilling was used to design and construct Pilgrim Creek No. 1 in the area in 1962-63. Pilgrim Creek No. 2 was constructed in 1975, and Pilgrim Creek No. 3 was constructed in 1985. The three wells in the Pilgrim Creek valley (Figure 9) provide water for NPS facilities at Colter Bay and Jackson Lake Lodge. Pilgrim Creek No. 1 is located furthest upstream and can pump water to the storage tanks for either Colter Bay or Jackson Lake Lodge. Pilgrim Creek No. 2 is closest to the highway and pumps water only to the storage tank for Colter Bay. Pilgrim Creek No. 3 is the middle well in the valley and pumps water only to the storage tank for Jackson Lake Lodge.

Upstream of the park boundary, the forks of Pilgrim Creek flow on bedrock. Downstream of the park boundary, the valley of Pilgrim Creek was scoured during Pinedale glaciation and subsequently filled with alluvium and glacial outwash as the glaciers receded, resulting in formation of a very thick, permeable aquifer. Further downstream, in the approximate area of the highway, permeability of the sediments decreases due to the presence of glacial till deposits along the eastern margin of Jackson Lake.

Pilgrim Creek No. 1 was completed in 1962. It was drilled to a total depth of 201 feet and was completed by perforating the casing from 69-134 feet below ground surface, corresponding with the gravelly sediments. Below 140 feet, the well was drilled through fine sand, and there was no attempt to develop water from the sand. The well was test pumped for 24 hours at 150 gpm, resulting in 0.1 foot of drawdown.

Pilgrim Creek No. 2 was constructed in 1975. It was drilled to a total depth of 175 feet and was completed by perforating the casing between 77-140 feet below ground surface, corresponding with the most permeable interval of the aquifer. The well was test pumped for 4 hours at 200 gpm, resulting in 3 feet of drawdown.

Pilgrim Creek No. 3 was constructed in 1985. It was drilled to a total depth of 250 feet and completed by perforating the casing from 138-225 feet below ground surface, corresponding with the gravelly sediments encountered during drilling. The well was test pumped for 25 hours at 370 gpm, resulting in 6 feet of drawdown.

Moran Junction

Moran Junction is at the confluence of the Buffalo Fork and Snake Rivers, about 5 miles downstream from Jackson Lake. The upland areas adjacent to Moran Junction are underlain by bedrock of the Harebell Formation, which is generally low-permeability due to the presence of clay intermixed with the gravel and sand sediments. The valleys of the Buffalo Fork and Snake River in this area were deeply scoured by glaciers and subsequently filled with lacustrine (lake) sediments when the flow in the rivers was dammed by glaciers. The lacustrine sediments are primarily clay and silt and can be very thick. In many places, there is a thin (few tens of feet)

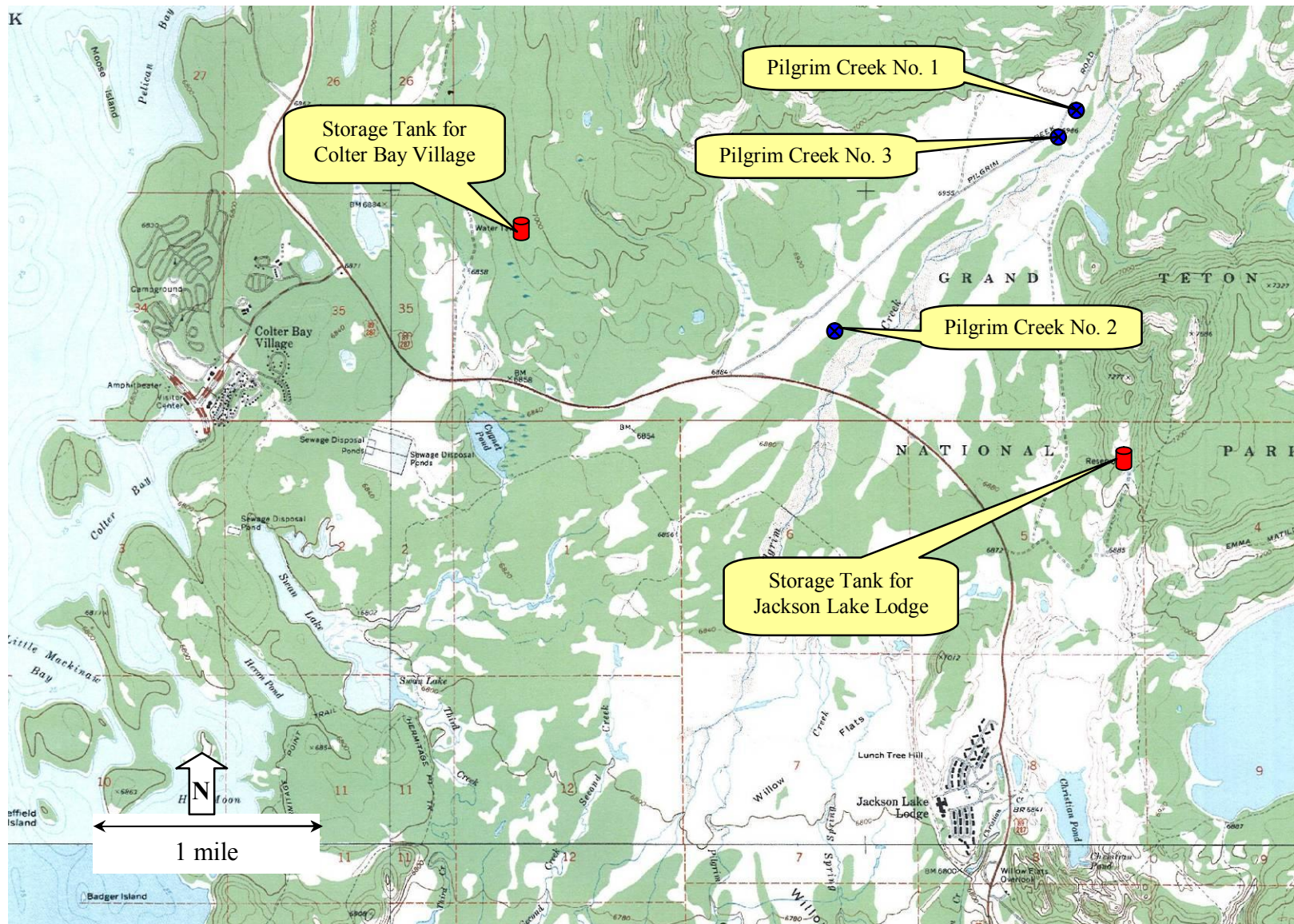


Figure 9. Locations of Pilgrim Creek wells.

veneer of alluvium or glacial outwash overlying the lacustrine sediments. Where the permeable alluvium or outwash occurs at an elevation lower than the adjacent rivers, the sediments will be saturated and wells can be constructed to obtain water from this aquifer. However, where the contact between the alluvium/outwash and the lacustrine sediments occurs at an elevation higher than the adjacent rivers, the water will have been drained from the permeable sediments.

The original well (Moran No. 1) at Moran Junction was constructed in 1961 adjacent to the Snake River (Figure 10). This is the same well that is labeled “Buffalo Fork Ranger Station” on Figure 5. The well was drilled to a total depth of 55 feet and was completed by perforating the casing between 28-30 feet below ground surface to obtain water from a corresponding gravel layer. Fine-grained lacustrine sediments were encountered at a depth of about 36 feet. The well was test pumped for 31 hours at 30 gpm, resulting in 12 feet of drawdown. The well began to pump sand in the late-1990s and a new well (Moran No. 2) was constructed east of the highway in 1999. Geologic conditions at the new site were not favorable. The yield of the well was only about 1 gpm due to a large amount of silt in the sediments. The well was abandoned.

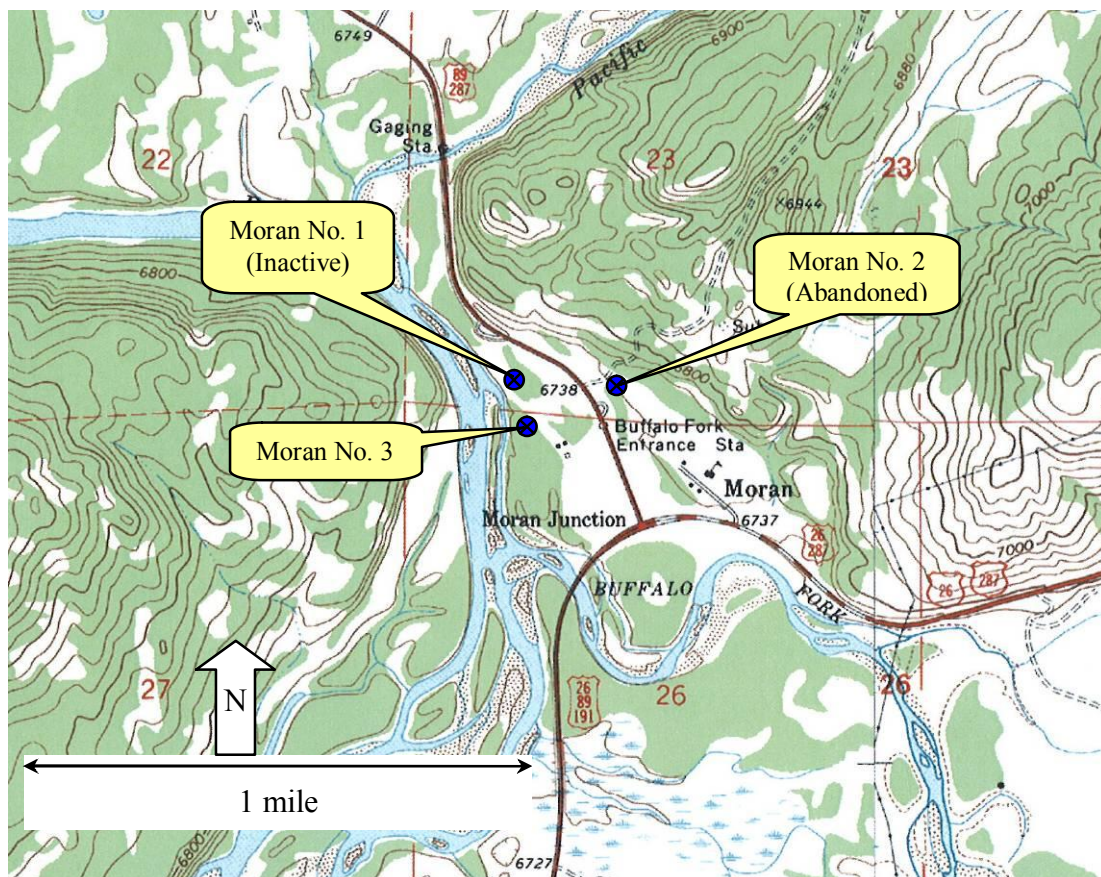


Figure 10. Locations of wells at Moran Junction.

Moran No. 3 was constructed south of Moran No. 1, near the Snake River, in 2002. The well was drilled to a total depth of 40 feet and was completed by installing a telescoping well screen from 32-37 feet below ground surface. The well was tested by pumping for 26 hours at 75 gpm, resulting in 8 feet of drawdown.

Signal Mountain

Two test holes were drilled at the Signal Mountain campground in 1961 (Figure 11). The test hole at the boat ramp, Signal Mountain Well No. 2, was converted to a public water-supply well. The total depth of the well is 205 feet. The casing is perforated from 59-68 and 159-160 feet below ground surface. The well was tested by pumping at 115 gpm for 24 hours, resulting in 10½ feet of drawdown. The well is no longer actively operated, having been replaced by the well near the reservoir on Signal Mountain.

A well was constructed near the underground water storage tank on Signal Mountain in 1991. The well was drilled to a total depth of 260 feet and reportedly obtains water from sand and gravel deep in the well. The static water level was 230 feet below ground surface when the well was drilled in 1991. This well is currently the sole source of water for all NPS facilities in the Signal Mountain area.

A test well was constructed at the Brinkerhoff House in 1992. The well was drilled to a total depth of 238 feet and appears to have penetrated glacial moraine deposits for its entire depth. There is no well screen and no perforations; all of the water enters the well through the open end at the bottom of the casing (238 feet). The well was test pumped at various rates and will produce 5 gpm in its current condition. It would likely produce more water if the casing was perforated opposite the water-bearing gravel zones. Currently the Brinkerhoff House is connected to the Signal Mountain water system and the 1992 test well has never been used as a supply well. The well could be a viable source of water for the Brinkerhoff House if there was a desire to separate it from the Signal Mountain water system.

Triangle X Ranch

The Triangle X Ranch is a dude ranch operated by a concessioner. Water is provided from a developed spring/seep area (Figure 12). The source of water for the spring/seep area is probably groundwater draining from the glacial outwash deposit comprising the bench immediately southeast of the spring/seep area.

A test well was drilled at the ranch in 1991. The well was drilled to a total depth of 91 feet and penetrated a layer of clean, well-sorted, fine-grained sand from 52-88 feet. Steel casing was installed to a depth of 83 feet. There was no well screen and no perforations in the casing. All of the water entering the well came through the opening at the bottom of 6-inch casing. The well produced 12 gpm during test pumping. A properly constructed screened well at this site would likely yield more than 20 gpm. The driller's log for the test well shows that shale was encountered at a depth of 88 feet. If this was indeed shale, it is probably the top of the Teewinot Formation. Alternatively, the "shale" might be lacustrine sediments that were deposited in one of the glacial lakes that occurred in this area. Subsequent burial of the lacustrine sediments may have caused them to compact into semi-consolidated rocklike material that could have been mistakenly identified as shale. The fine-grained, clean sand that was encountered may have been

a deltaic deposit formed where the unnamed creek flows from the southeast into the Snake River valley during a time when a glacial lake filled the valley.

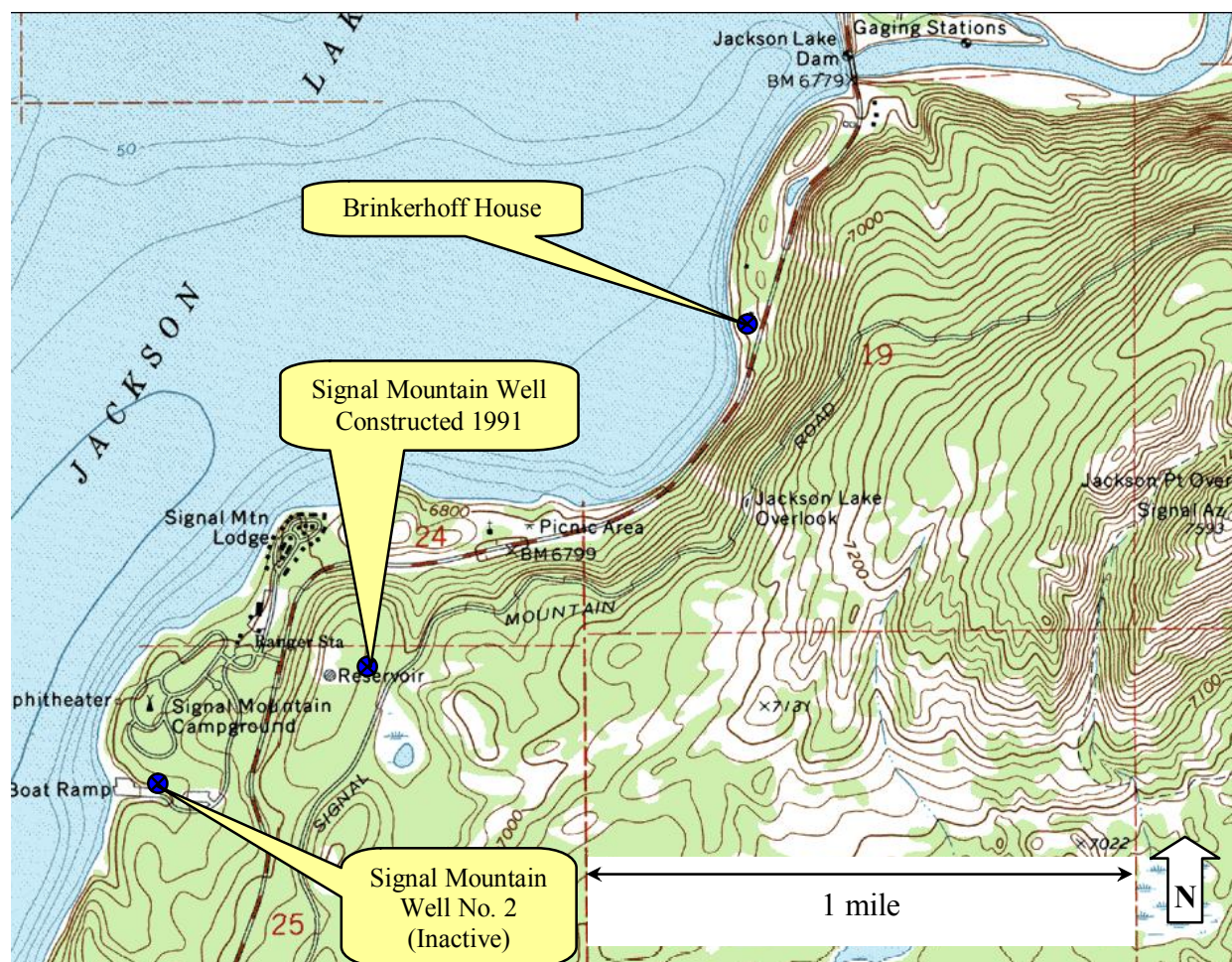


Figure 11. Locations of wells at Signal Mountain.

Jenny Lake Lodge and String Lake Area

The Jenny Lake Lodge No. 1 well was constructed near the water storage tank in 1982 (Figure 13). The well was drilled into the glacial moraine ringing the perimeter of Jenny Lake. Most of the material encountered during drilling is described on the driller's log as, "gravel, clay, and sand", typical of moraine deposits. The well was originally drilled to a total depth of 290 feet and completed with perforated casing from 160-270 feet. It was test pumped for 24 hours at 55 gpm, resulting in 2 feet of drawdown. By 1986, production from the well had decreased, and drawdown during pumping increased, to the point where it was necessary to attempt rehabilitation of the well. Attempts to redevelop the well by surging were unsuccessful. The well was then deepened to 327 feet, but did not result in increasing the yield of the well. It appears, from reading notes in the files, that the fine-grained portion of the moraine deposits migrated into the well and filled about the lower 50 feet of the well and plugged the aquifer adjacent to the well. A well constructed at this site with properly designed well screen might have performed better, but it's also possible that the abundant clay in the formation might have

continually migrated toward the well and been a continuous source of trouble, i.e., “sand pumping”.

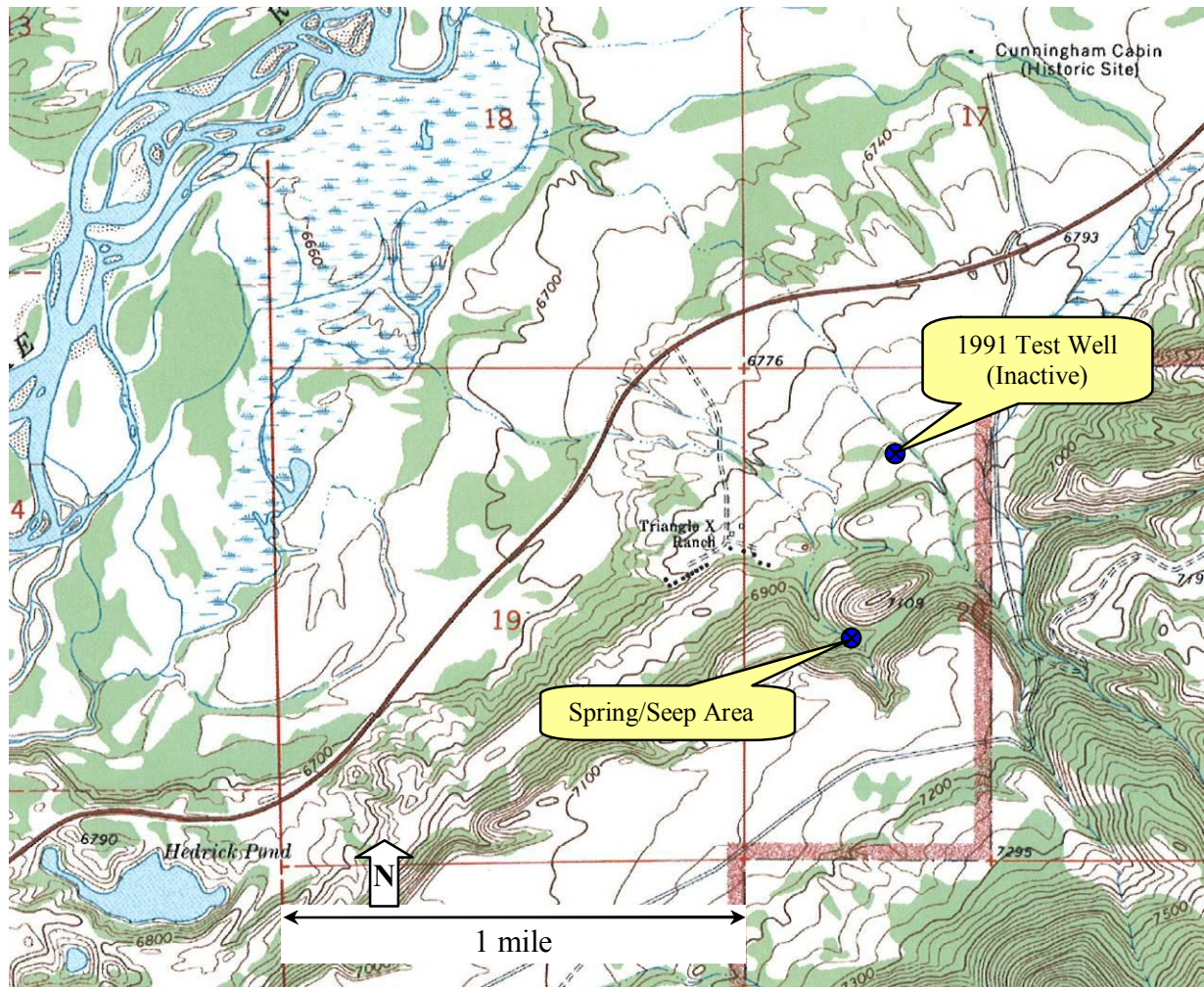


Figure 12. Locations of existing and potential water sources at Triangle X Ranch.

The Jenny Lake No. 2 well was constructed by the U.S. Bureau of Reclamation in August 1986 about 1000 feet north of the Jenny Lake Lodge. The well was drilled to a total depth of 177 feet, approximately 70 feet below the surface of Jenny Lake. The well did not produce significant amounts of water, and the water level remained at 167 feet below ground level, about 60 feet lower than the surface of the lake. The drill rod broke and could not be retrieved. Because of the problems with drilling and retrieval of the broken drill rods at the bottom of the hole, unfavorable geologic conditions, and the lack of water; the hole was plugged and abandoned.

The Jenny Lake No. 3 well was constructed by the U.S. Bureau of Reclamation in August-October 1986 approximately ½ mile northeast of the Jenny Lake Lodge. The well was drilled to a total depth of 377 feet. Sediments encountered during drilling were glacial outwash, mostly sand and gravel, lacking the clay-size fraction found in the moraine deposits around the perimeter of Jenny Lake. Depth to water in the well was about 240 feet below ground surface.

The well was completed with 100 slot telescoping well screen from 331-371 feet below ground surface. The well was test pumped for 22 hours at 50 gpm with no drawdown.

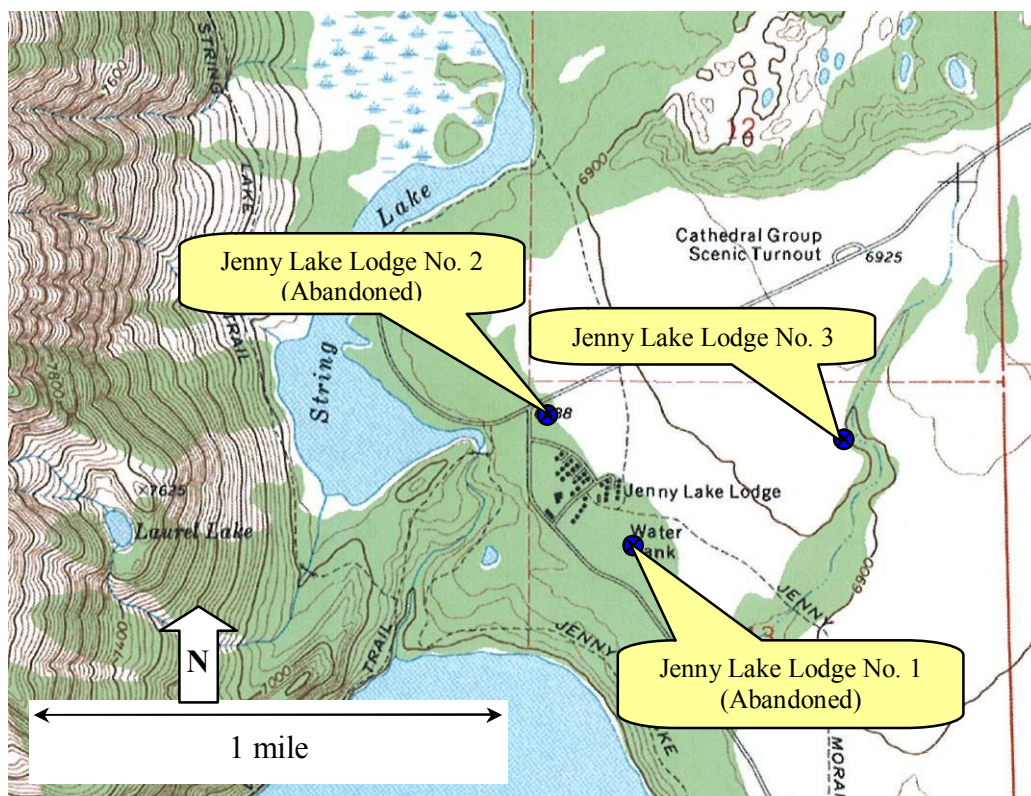


Figure 13. Locations of water-supply wells near Jenny Lake Lodge and String Lake Picnic Area.

South Jenny Lake

The South Jenny Lake Well supplies water for facilities at the Jenny Lake campground and visitor center (Figure 14). It was drilled in 1982 to a total depth of 250 feet and was completed with perforated casing from 200-240 feet below ground surface. Most of the well was drilled through glacial moraine deposits, as evidenced by the inclusion of clay or silt in the lithologic log of the well driller's report. The driller's log notes an interval of pea gravel and sand from 210-235 feet, and it is that interval that was developed as the source of water for the well. The well was test pumped for 24 hours at 65 gpm, resulting in 17 feet of drawdown.

Lupine Meadows

The Lupine Meadows Well provides water for several cabins that provide seasonal housing for NPS climbing rangers (Figure 14). The well was drilled in 1978 to a total depth of 103 feet. The well was test pumped for 24 hours at 176 gpm resulting in 2 feet of drawdown. In 1982, the well was deepened to 150 feet. The lithologic log on the well completion report notes only sand and gravel for the entire interval from 100-150 feet. The well was then test pumped for 15 hours at 45 gpm resulting in no drawdown.

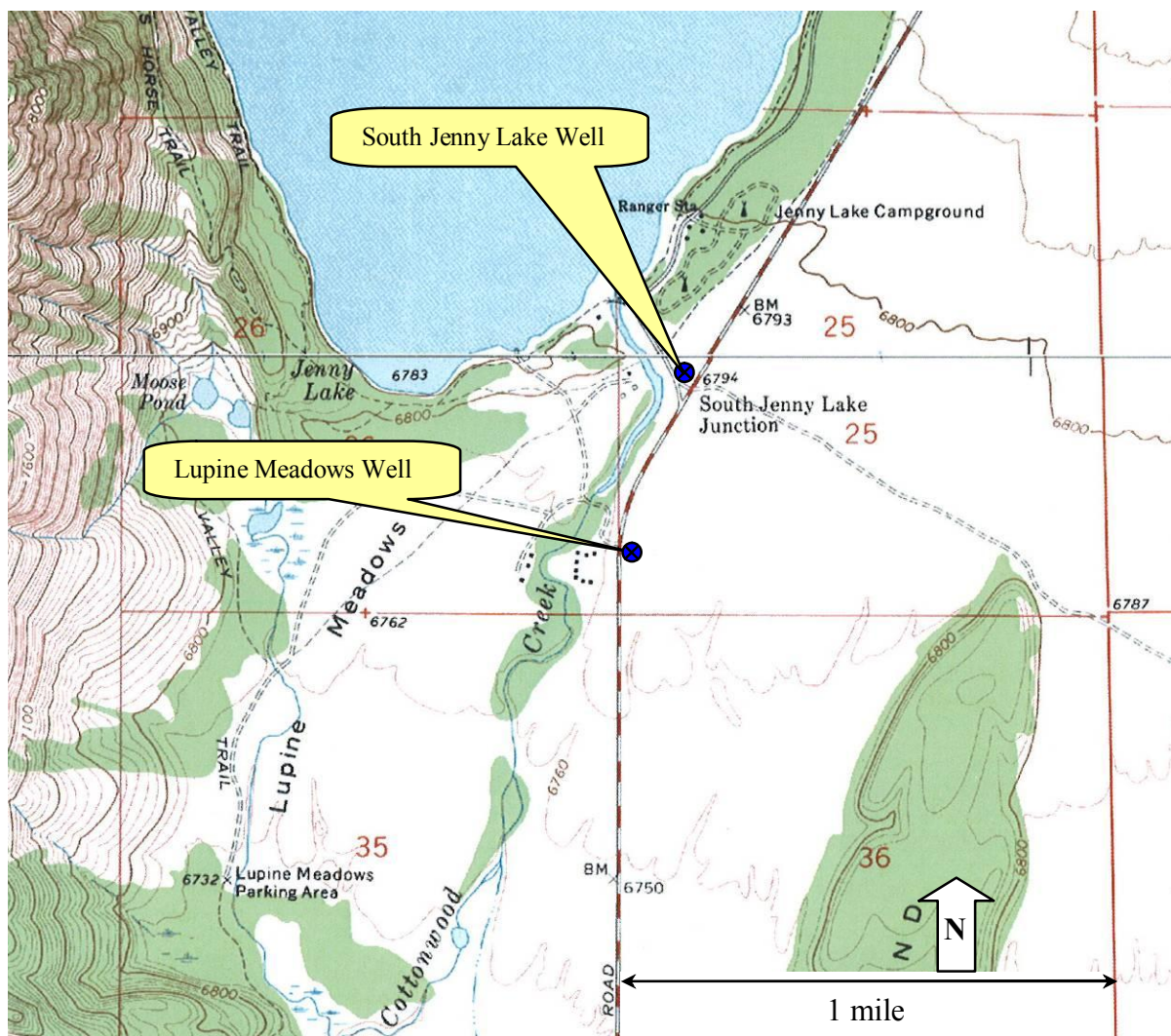


Figure 14. Location of the South Jenny Lake and Lupine Meadow Wells.

Climbers Ranch and Highlands

The Climbers Ranch well provides water for seasonal housing at Climbers Ranch (Figure 15). The ranch is a collection of cabins and dormitory accommodations operated by the American Alpine Club to provide affordable housing for park visitors. It was formerly the Double Diamond Guest Ranch. The well is reportedly 88 feet deep, but no other information is available.

The Highlands well provides water for seasonal housing at an NPS residential area (Figure 15). The well was drilled in 1974 to a total depth of 151 feet. It was completed with perforated casing from 118-130 feet below ground surface. The well was test pumped at 15 gpm for 48 hours with no drawdown. The driller's log for this well mentions only sand and gravel to a depth of 132 feet. Below 132 feet the lithology changes to green clay with gravel.

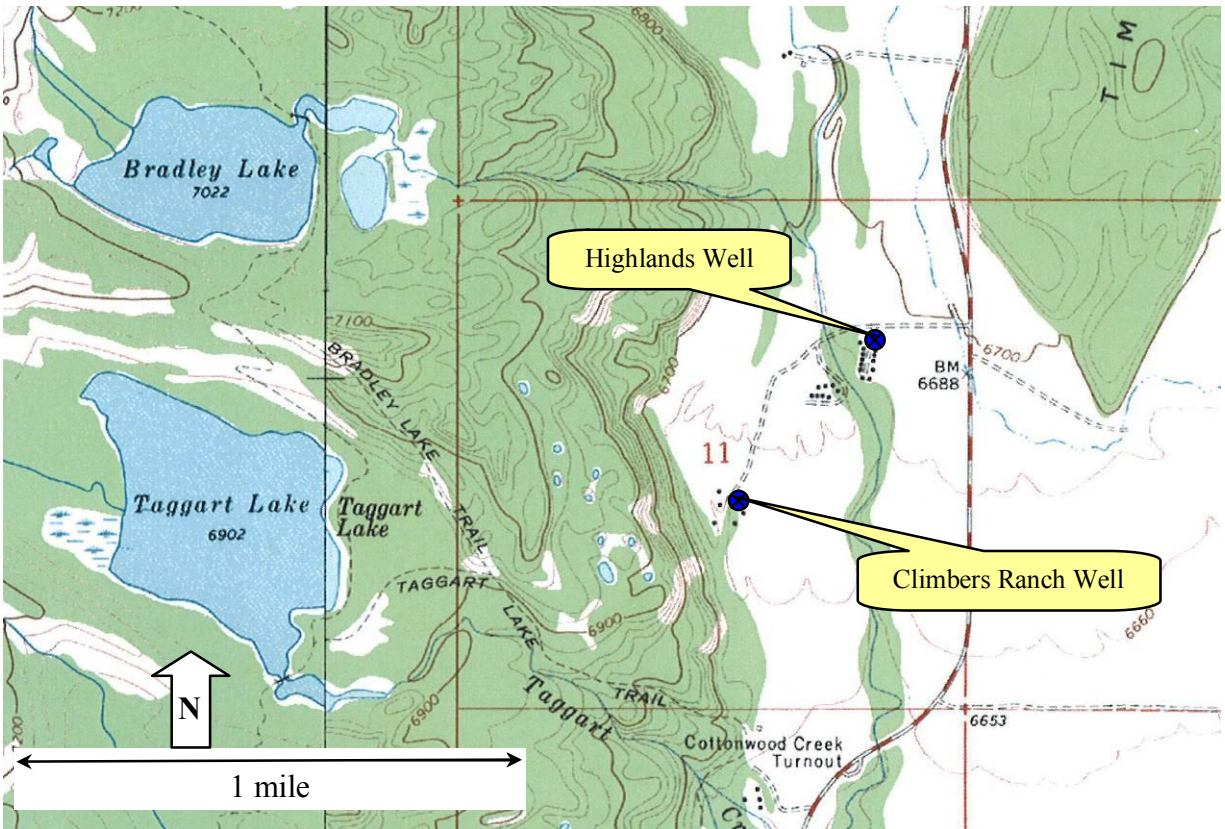


Figure 15. Locations of wells at Climbers Ranch and Highlands.

Taggart Creek

There are two wells near Taggart Creek which provide water for the NPS residential area at Beaver Creek and all NPS facilities at Moose, including the visitor center, administrative offices, maintenance facility, and residential area (Figure 16). Production is typically alternated between the two wells, but they can be pumped simultaneously when demand is high.

Taggart Creek No. 1 was drilled in October 1981 to a total depth of 160 feet. The well driller's report states that no well screen was installed and that no perforations were made. If that is correct, then all of the water enters the well through the open end at the bottom of the casing. The well was test pumped at 60 gpm for 24 hours, resulting in 12 feet of drawdown. The lithologic log shows only sand and boulders from 20-160 feet. The well, as currently equipped, produces about 70 gpm.

Taggart Creek No. 2 was drilled in September 1999 to a total depth of 160 feet. The well was completed with 60-slot well screen from 150-160 feet. There is no record of a pump test for this well, but a 100-gpm pump was installed. The lithologic log for this well was primarily sand, gravel, and cobbles. The well, as currently equipped, produces about 120 gpm.

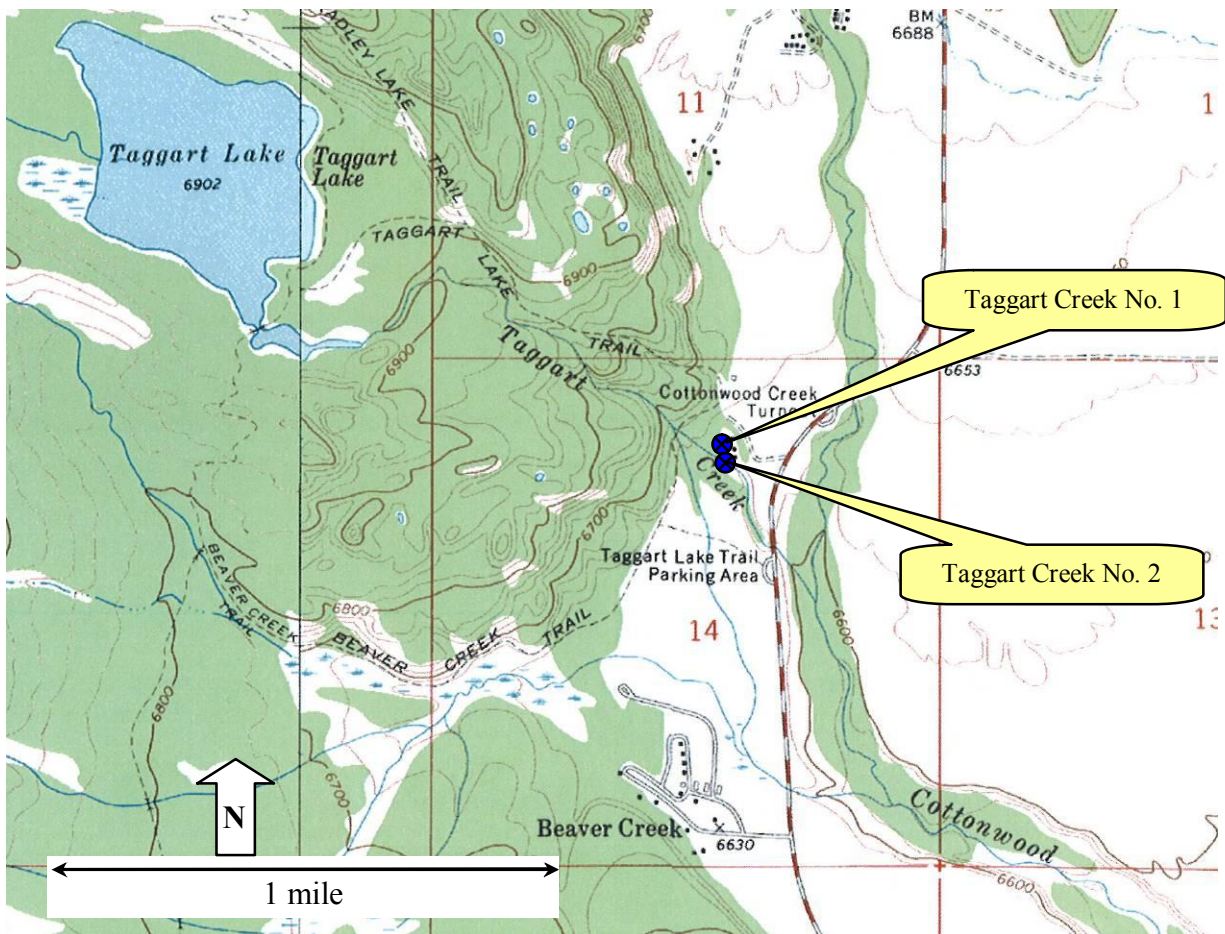


Figure 16. Locations of Taggart Creek Wells.

White Grass Ranch

White Grass Ranch is the site of a former dude ranch near the Death Canyon trailhead (Figure 17). A well was drilled at the ranch in 2004 to determine the availability of water for a planned historic preservation training facility. The well was drilled to a total depth of 98 feet and completed with perforated casing from 75-90 feet. The well was test pumped at 50 gpm for 24 hours, resulting in 30 feet of drawdown. The test hole was drilled through a heterogeneous mixture of sand, gravel, silt, and clay to a depth of about 75 feet. From 75-95 feet the formation was primarily sand and gravel with only small amounts of silt or clay. Runny clay, saturated with water, was encountered below 95 feet.

JY Ranch

The JY Ranch was donated to the park in 2001 by Laurance S. Rockefeller. The JY Ranch was the Rockefeller family retreat since 1932. The Wyoming State Engineer's Office has record of two wells at the ranch (Figure 17). JY No. 1 is 90 feet deep and can produce 5 gpm from a gravel zone from 70-90 feet below ground surface. JY No. 2 is 160 feet deep and has a "very good" yield from a gravel zone from 70-180 feet below ground surface. All of the buildings have been removed from the ranch site and the wells are inactive.

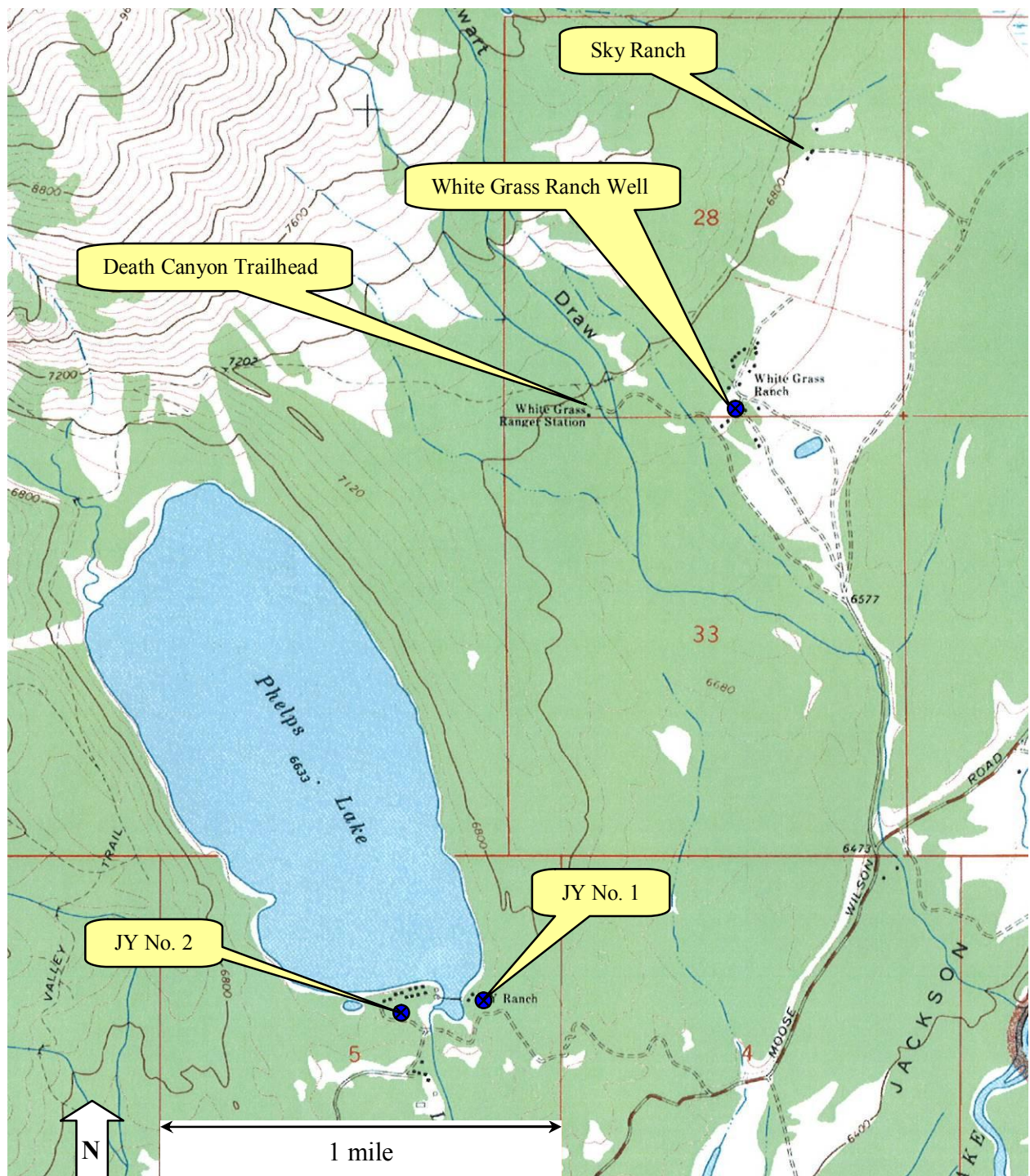


Figure 17. Location of the wells at White Grass Ranch, JY Ranch, future well at Sky Ranch.

Granite Creek

The Granite Creek well was constructed in Fall 2000 to provide water for the Southwest Entrance Station on the Moose-Wilson Road (Figure 18). The well was drilled to a total depth of 60 feet and was completed with 60-slot well screen from 50-60 feet. There is no record of a pumping test for this well, but the driller's log indicates it was producing 20-30 gpm during drilling. The driller's log shows that the well penetrated mostly sand, gravel, cobbles, and boulders.

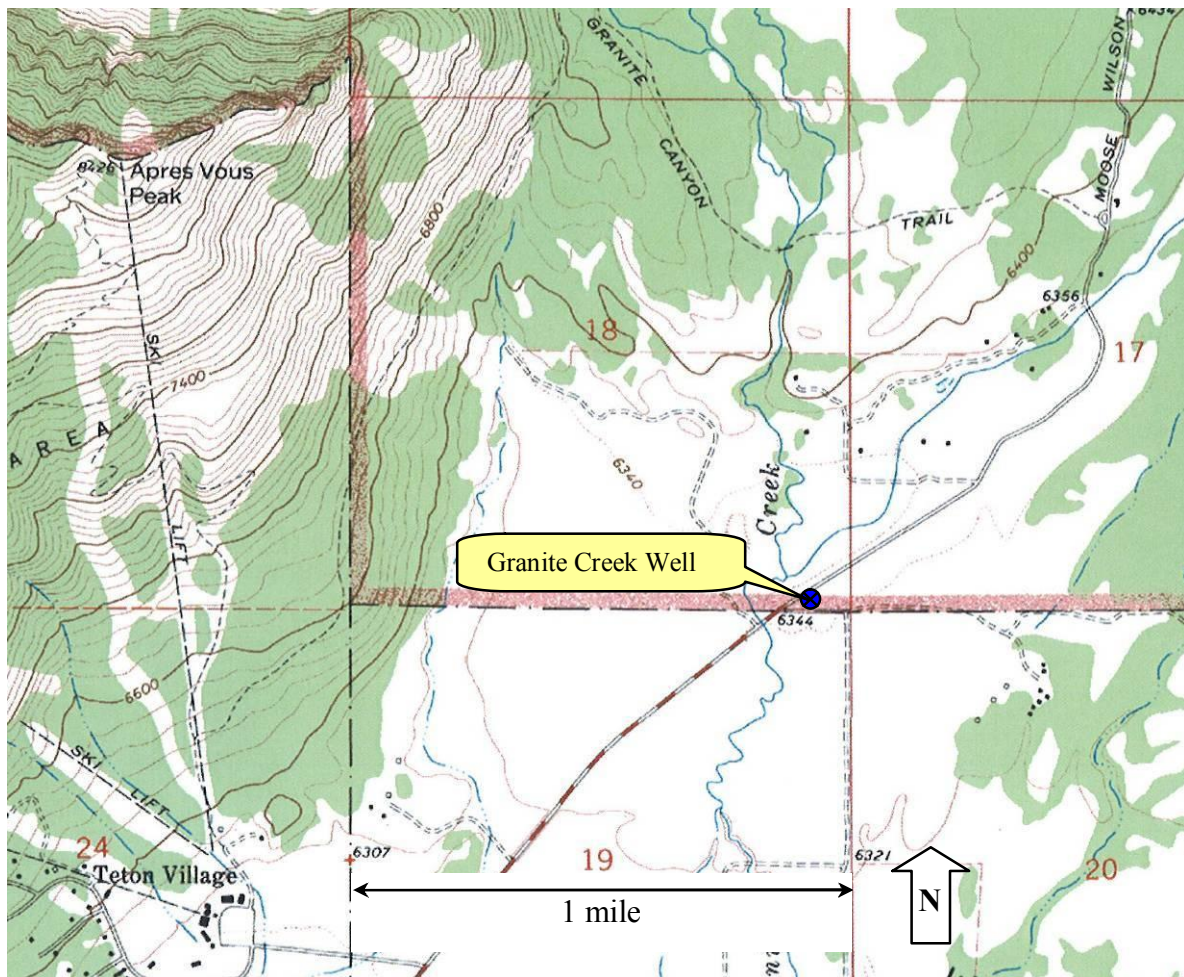


Figure 18. Location of the Granite Creek Well at southwest park entrance.

Gros Ventre Campground

Water for use at the Gros Ventre Campground is supplied from one well near the eastern end of the campground (Figure 19) about 1½ miles west of Kelly. The well was drilled in 1964 to a total depth of 150 feet. The well was completed with perforated casing from 120-150 feet below ground surface. The well was test pumped for 30 hours at rates between 200-300 gpm, resulting in 9 inches of drawdown. The driller's log indicates mostly sand and gravel with small amounts of clay or silt in some intervals.

There is a second well near the entrance to the campground, but it is inactive. That well was constructed in 1975 and is 62 feet deep. Depth to water was 23 feet below ground surface when the well was constructed. Water is obtained from alluvial sediments, sand and gravel, from 23-62 feet below ground surface. No data were found regarding yield or drawdown for this well.

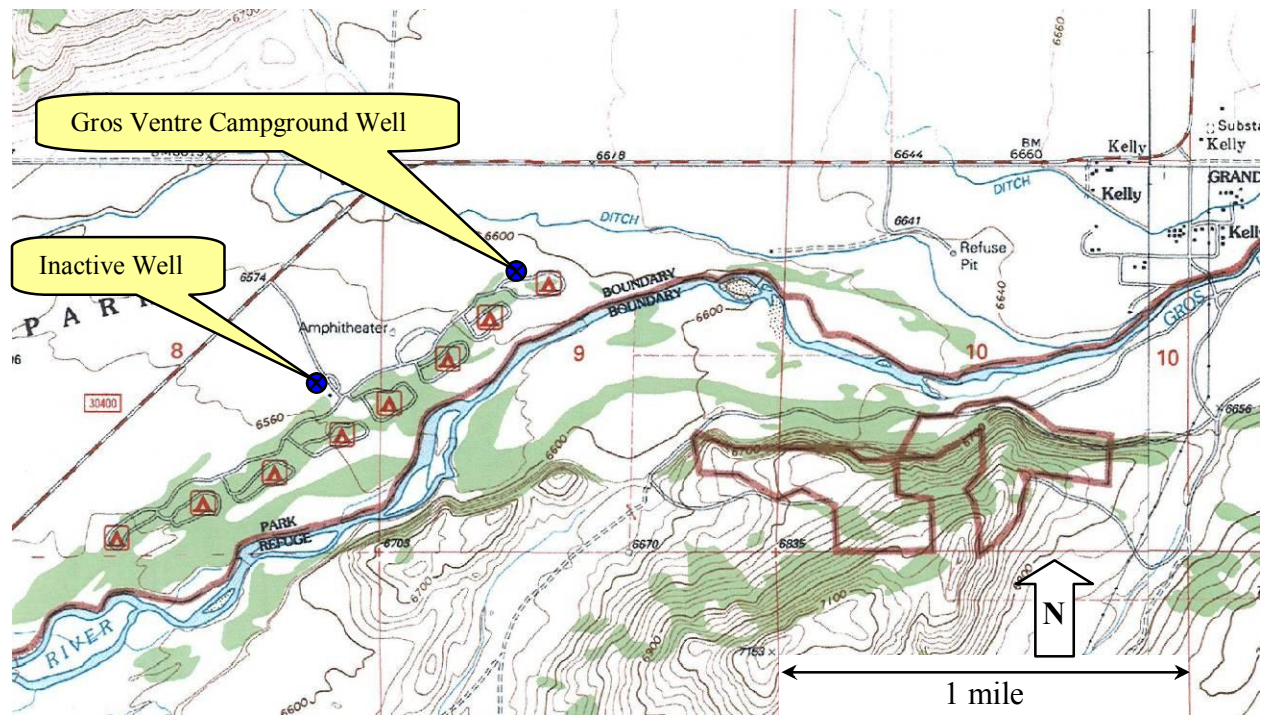


Figure 19. Location of wells at Gros Ventre Campground.

Teton Science School

Water for facilities at the Kelly Campus of the Teton Science School was obtained from a “spring” in the center of the campus until late-summer 2007. The spring was susceptible to contamination from surface runoff. A well was drilled in 2007 to a total depth of 200 feet (Figure 20). The well was completed with 60-slot screen from 185-195 feet. The well was test pumped for 24 hours at 90 gpm, resulting in 8 feet of drawdown. The well penetrates primarily bedrock of the Teewinot Formation. Water is obtained from limestone layers within the Teewinot. This is the only well in Grand Teton National Park that obtains water from an aquifer other than alluvium or glacial sediments.

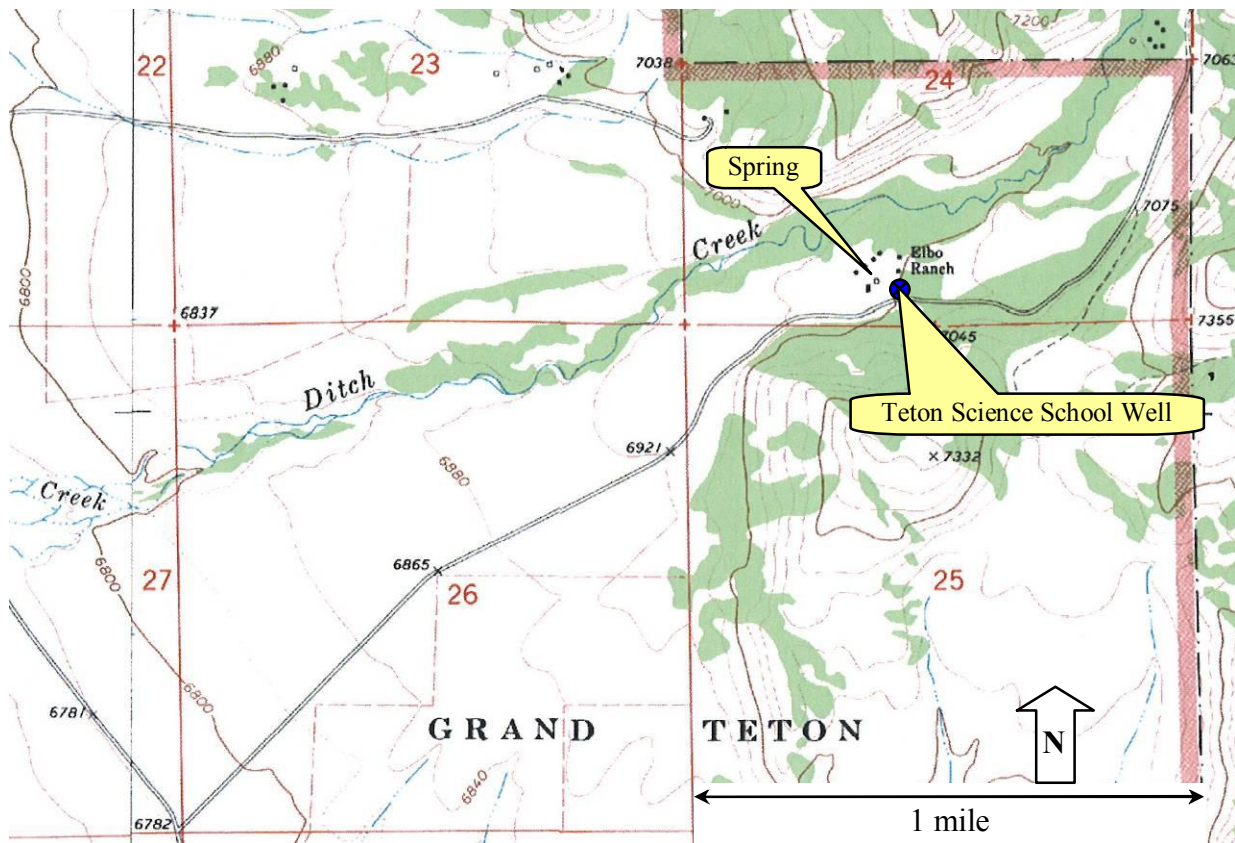


Figure 20. Location of well at Teton Science School.

Future Water Supply Issues/Needs

There are several developments in the park that need additional water supplies, backup wells, or new sources of water for public use. These needs include a backup well at Taggart Creek and Signal Mountain, construction of new wells at Triangle X Ranch and Sky Ranch, and protection of well sites along Pilgrim Creek from encroachment by the meandering stream.

Taggart Creek

There may be a need for additional supplies or a backup well for the Taggart Creek water system. The system supplies water for the NPS housing area at Beaver Creek and all NPS facilities in the Moose area: including administrative offices, the maintenance facility, employee housing, and the visitor center. There are two existing wells at Taggart Creek (Figure 16). The wells are located along Taggart Creek, a short distance west of Cottonwood Creek.

Figure 4 shows the probable drainage patterns near the end of the last glacial period. At that time, Cottonwood Creek was a major outlet for meltwater from the Jackson Lake Glacier. Taggart Creek probably had larger flows from meltwater from the Taggart Lake Glacier. Larger volumes of surface-water flow in these streams likely resulted in reworking glacial deposits and deposition of alluvium, resulting in very permeable sand and gravel deposits along these drainages. The high productivity of the existing Taggart Creek wells provides evidence of the

permeable nature of these sediments. Additional water supplies could be developed in this area by construction of additional wells either along Taggart Creek or Cottonwood Creek. Yields exceeding 100 gpm should be very easily obtained from a properly designed and constructed well.

Sky Ranch

The park recently acquired possession of the buildings at Sky Ranch, about a half mile north of White Grass Ranch (Figure 17). Sky Ranch consists of a main house, several adjacent cabins, and a barn. The existing water system collects surface water west (uphill) of the buildings and diverts it to a cistern and a distribution system to the buildings.

The hydrogeologic setting of Sky Ranch is identical to that of White Grass Ranch. Precipitation and snowmelt runoff from the granitic rocks of the mountains to the west of the ranch flows down numerous streams and infiltrates the unconsolidated sediments along the entire mountain front. The areas to the west of the buildings (at both White Grass Ranch and Sky Ranch) have many small springs and seeps, evidence of the abundant groundwater recharge along the mountain front.

The test well at White Grass Ranch showed that the sediments underlying the area are likely a heterogeneous mix of alternating and discontinuous glacial and alluvial deposits. A well drilled almost anywhere in the vicinity of the buildings at Sky Ranch would be likely to encounter a zone of permeable sand or gravel which would be likely to yield sufficient water for use at the ranch. If a well is constructed, sediment samples from the well cuttings should be carefully analyzed and logged to identify the most permeable zone. The well should be completed with a "Johnson" type well screen and rigorously developed to remove fine-grained sediments from the area adjacent to the screened interval.

Signal Mountain

All of the water for facilities at Signal Mountain is supplied from a single well adjacent to the underground storage reservoir on Signal Mountain (Figure 11). The well (as equipped with the current pump) is barely able to meet the demand during the peak summer season. Data are not available to determine whether the well could be equipped with a larger pump to produce more water. Regardless, a backup well for this system would be prudent.

Facilities at Signal Mountain are located on the southeast shore of Jackson Lake. The underlying sediments, in the immediate vicinity of the lakeshore, are moraine deposits from the last stage of the Pinedale glaciation. The moraine deposits contain abundant clay and are therefore poor aquifers. The moraine deposits along the southeast shore of Jackson Lake essentially act as a leaky dam, impounding water in the lake. Previous test drilling along the shoreline resulted in wells that did not produce enough water to warrant completion as a water-supply well. The well at the boat ramp was productive for many years, but eventually production was reduced by movement of fine-grained sediments into the well and plugging the aquifer adjacent to the well.

The most obvious location for a new well to provide additional water for facilities at Signal Mountain is near the existing well on Signal Mountain. A new well should be 200-300 feet from the existing well to reduce interference between the wells, but not so far away as to risk drilling

into different geologic strata or result in long distances for water and electrical hookups to the new well. A new well in this area should be planned to go at least 300 feet deep. The existing well was drilled to 260 feet, with no indication that it had fully penetrated the permeable gravel aquifer.

Pilgrim Creek

Pilgrim Creek has a braided stream channel that actively meanders and migrates across the valley. Migration of the channel has the potential to encroach on the existing wells and wellhouses, or to disrupt vehicular access to the well sites. Wellhouses might be protected by strategic placement of large boulders as a barrier to encroachment by the stream. Providing vehicular access might be more problematic, as is protecting underground water and electrical lines. Bulldozers might be used to redirect streamflow away from the wellhouses or to encourage the stream to migrate in another direction. New well sites could be selected toward the margins of the valley, but eventually the stream might migrate to these new locations also.

The area underlying Pilgrim Creek valley was deeply scoured during the Pinedale glaciation. The basin was later filled with glacial outwash, resulting in the formation of a large valley-fill aquifer. Toward the lower end of the valley, near Jackson Lake, the permeable outwash deposits are truncated by a late-stage advance of the Jackson Lake Glacier and deposition of glacial till at the terminal moraine of the glacier. These geologic processes limit the area for construction of high-yield wells in the Pilgrim Creek valley to the area between the highway and the park boundary. Well sites closer to the gravel road in the Pilgrim Creek valley would probably be just as productive as the existing well sites near the creek.

Triangle X Ranch

Currently (2007) the public water supply for facilities at the Triangle X Ranch is obtained from a shallow collection system in a seep/spring area along an unnamed creek southeast of the ranch buildings (Figure 12). The collection system is susceptible to surface contamination and occasionally exceeds turbidity limits after rainstorms. A well is desired to provide the ranch with a safe, reliable source of groundwater.

A test well was constructed about ¼ mile northeast of the ranch in 1991 (Figure 12). The well penetrated a permeable sand aquifer between 58-88 feet below ground surface that would probably yield sufficient water to meet the demand at the ranch. Unfortunately the test well was not constructed very efficiently; there was no well screen and no perforations in the casing, so the potential capacity of a well at this location is uncertain.

Another alternative location for a test well is a short distance upstream from the spring/seep area, adjacent to the water storage tank. There have been no test wells in the area, so the underlying geologic formations are unknown. Examination of geologic maps of the area indicates that a well at this location might penetrate glacial outwash, or bedrock of the Teewinot or Cutler Formations. Glacial outwash would potentially be a good source of water, if it is thick enough. The new well (2007) at the Teton Science School was constructed in the Teewinot Formation and produces an abundant supply of groundwater from limestone beds. The water-producing potential of the Cutler Formation is unknown as no wells have been constructed into the Cutler Formation in the Jackson Hole area.

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Natural Resources Program Center
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

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