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Hydrogeologic Investigation of Several Public Water-Supply Sources at Lake Roosevelt National Recreation Area

The National Park Service (NPS) operates 17 public water-supply systems at Lake Roosevelt National Recreation Area (LARO). All of the water systems are classified as transient non-community systems. They provide water for campgrounds, picnic areas, and administrative use. Washington Department of Health (WA-DOH) has identified several of the wells that supply water for these systems as potentially being *Groundwater Sources Under the Direct Influence of Surface Water*.

This report will provide an assessment of the degree of hydraulic connectivity between the groundwater pumped from the wells and the adjacent surface water in Lake Roosevelt. The water systems in question and their Water System ID are;

Haag Cove Campground	WA53NP330
Cloverleaf Campground	WA53NP110
Gifford Campground	WA53NP300
Hawk Creek Campground	WA53NP335
Kamloops Campground	WA53NP460
Keller Ferry Campground	WA53NP470
Hunters Campground	WA53NP380

Locations for each of these water sources at Lake Roosevelt are shown in Figure 1.

The water system at Kettle River Campground (WA53NP495) was previously evaluated and determined to be groundwater that is hydraulically connected with the adjacent surface water. Park staff are developing a plan for installation of a disinfection system for the Kettle River water system that will meet the WA-DOH requirements.

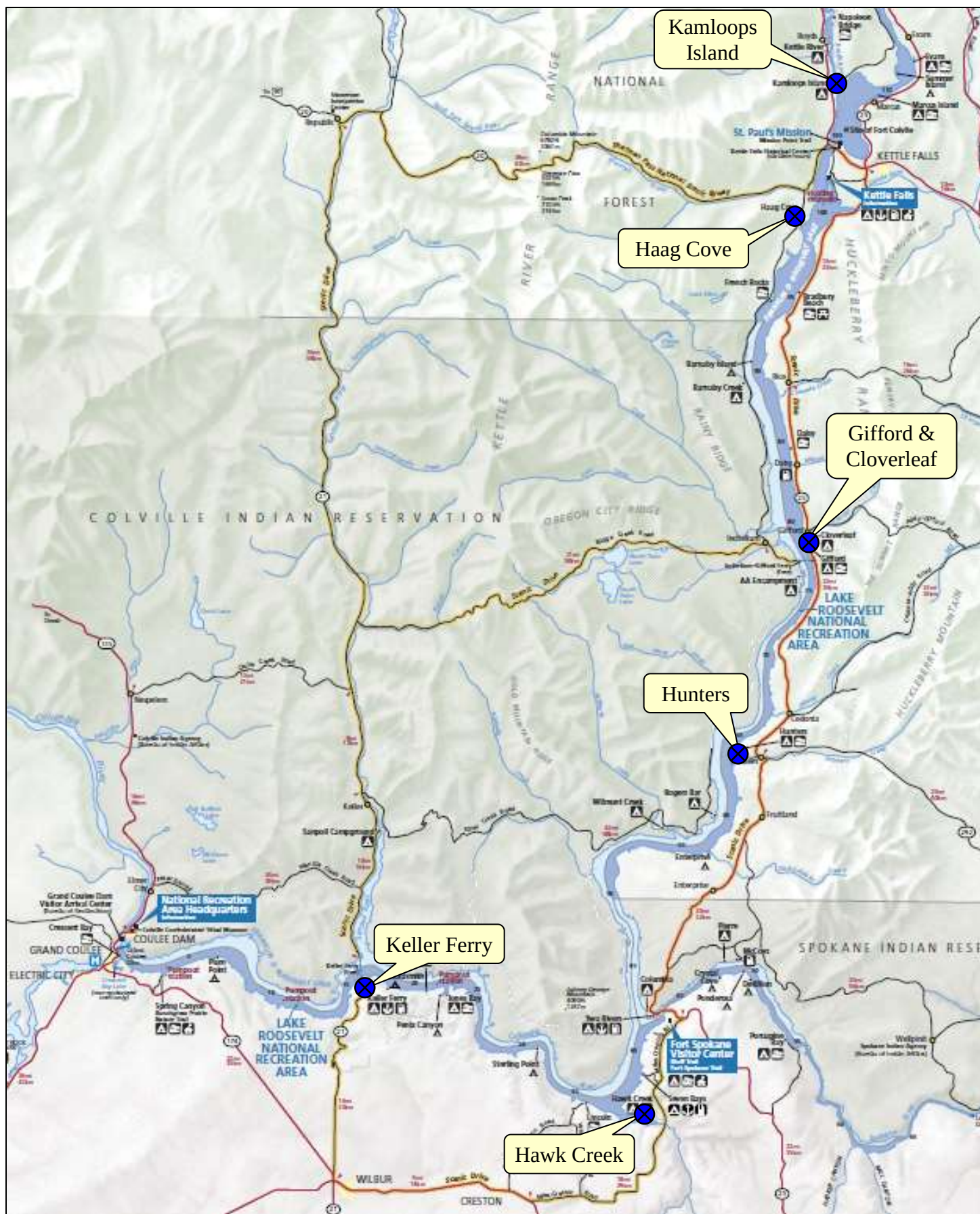


Figure 1. Locations of selected wells at Lake Roosevelt National Recreation Area.

Discussion

All of the sites in this investigation have a similar hydrogeologic setting (Figure 2). Generally, the campgrounds are located on terraces adjacent to the reservoir. The sediments underlying the terraces include clay, silt, sand, and gravel. Deposits of various materials tend to be discontinuous in three dimensions. At some locations, the sediments underlying a terrace are mostly clay, silt, and fine sand deposited in a lake environment. At other locations the sediments are mostly sand and gravel deposited as stream sediments in deltaic environments where streams flowed into the ancestral lake. Some sites contain sedimentary deposits of glacial origin. Landslide deposits occur where a block of sediment slumped into the ancestral lake or river valley. Although the depositional nature of the sediments varies from place to place, they are still largely comprised of some mixture of clay, silt, sand, and gravel.

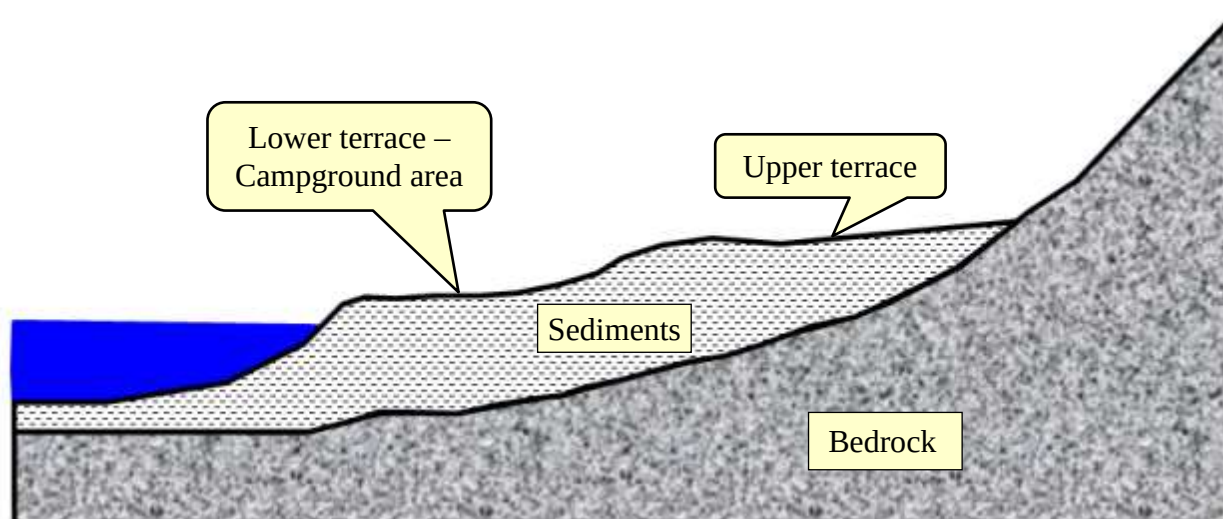


Figure 2. Typical geologic cross-section of a campground area.

A well drilled at one location may encounter a lens of sand and gravel that yields a usable amount of water and a well a few hundred feet away might not encounter any sand or gravel. At most (if not all) of the wells it has been observed that water levels in the wells fluctuate in the same manner as water levels in the reservoir.

The surface elevation of Lake Roosevelt is generally between 1280-1290 feet through most of the year. The elevation is drawn down in spring to make room for snowmelt runoff. The drawdown can be as much as 60-70 feet (Figure 3).

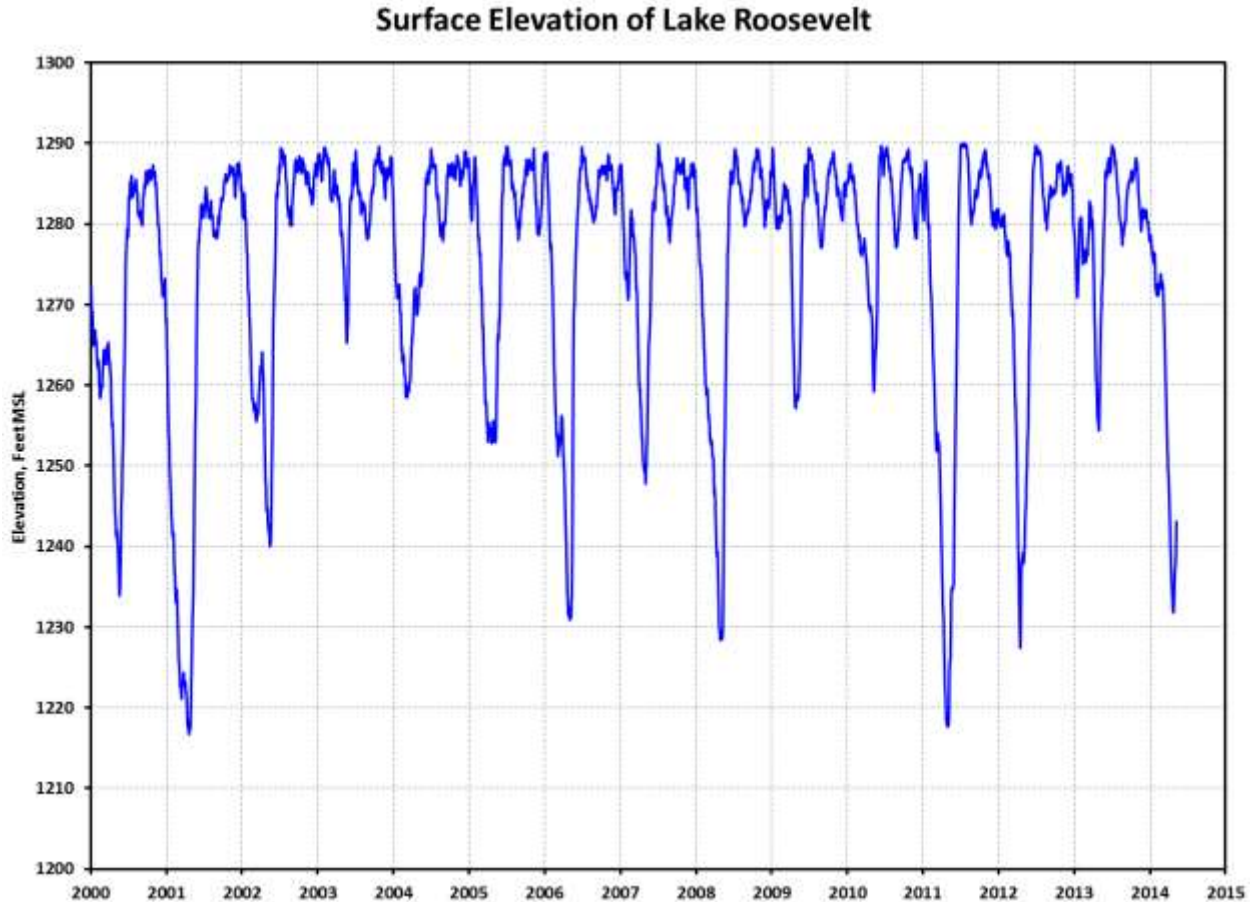
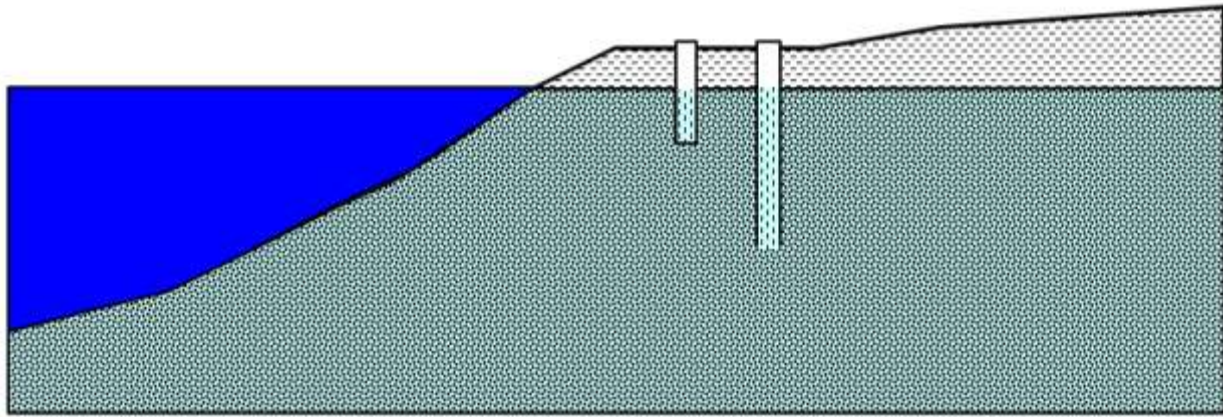
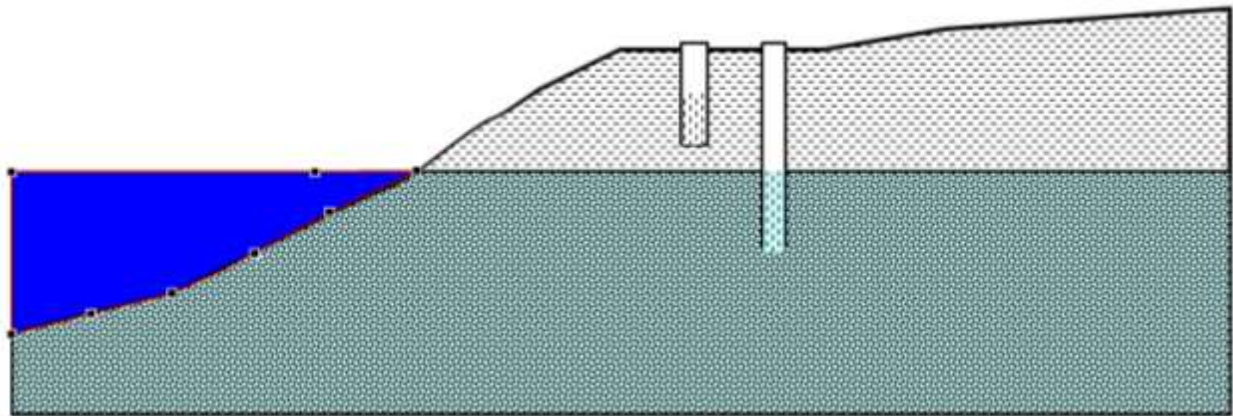


Figure 3. Surface elevation of Lake Roosevelt.

When the water level in the lake is lowered in spring, groundwater in the sediments underlying the terraces adjacent to the lake will drain to the reservoir, causing the water table to lower. The amount of water table lowering at any particular site is a function of the permeability of the sediments (more permeable sediments will drain faster) and the distance from the reservoir (the water table will decline faster closer to the reservoir). A shallow well close to the reservoir will likely go dry during the spring drawdown. A deeper well, or a well farther from the shoreline, is less likely to go dry, but the water level may be lowered several feet (Figure 4).



High or “Normal” water level conditions



Water level conditions during the spring drawdown

Figure 4. Comparison of water levels in the reservoir and water table in the adjacent terraces during high or “normal” water conditions and the spring drawdown.

Shallow wells close to the reservoir that go dry during the spring drawdown and then refill as the reservoir level rises are obviously hydraulically connected with the surface water. Additional testing (MPA test) will be required to determine the degree of risk from biological contaminants.

The potential risk for deep wells is less clear. If a well is deep enough that the entire screened interval is lower than the range of water table fluctuation during the spring drawdown and recovery and there is a low permeability confining layer providing continuous coverage throughout the terrace area, then we could have some assurance that the groundwater pumped from the well was not hydraulically connected with surface water in the reservoir. Lacking compelling evidence showing those conditions, MPA tests should also be conducted on the deep wells to determine the degree of risk from biological contaminants.

Routine bacteriological sampling of the wells has shown no significant contamination issues. Occasionally there is a positive test result, but the follow-up testing has always been negative, indicating that the positive test result was probably not due to contamination of the groundwater aquifer.

Estimating Travel Time to a Well

The normal method to assess the potential risk of wells that might be in hydraulic connection with an adjacent surface water source is to estimate the time of travel for groundwater to each well. Various analytical models exist that could be used to estimate time of travel zones around each well. It would be incorrect to apply that methodology to the analyses of most of these water-supply wells. Analytical models assume that hydrologic conditions, such as the water table elevation, gradient, etc., are static over time. If we made a travel time analysis for one of the wells with a hand pump, we would find that the zone of contribution to the well would encompass a very small area around the well, perhaps a few tens of feet. We would then have a false sense of security about whether the well was drawing water from the reservoir. We know from observing water levels in the wells that there is a great deal of water movement between the groundwater underlying the terraces and the reservoir during the spring drawdown and subsequent refilling of the reservoir.

Analytical element models are often used to estimate the travel time of groundwater flowing to a well, or to estimate the capture zone for various time periods, e.g., 2-year or 5-year capture zones. Kraemer et.al. (2007) show that results from WhAEM modeling for the case where the water table gradient is zero or near zero (flat water table), are essentially the same as the capture zone calculated using the calculated fixed radius method.

When the groundwater gradient in the vicinity of the well is small, the calculated fixed radius (CFR) centered on the well, including a 15% safety factor for a non-zero ambient flow field, is given by:

$$R = 1.1543\sqrt{(QT/\pi Hn)}$$

where R is the travel-time distance,
Q is the pumping rate of the well,
H is the aquifer saturated thickness,
n is the aquifer porosity,
and T is the travel time associated with the well capture.

This method is referred to by Kraemer et.al. (2007) as the “centric circular capture zone” to distinguish it from the simple model for the calculated fixed radius method.

If we use this equation to calculate the capture zone typical of a well at a campground, we find that it is only a few tens of feet. For example, assume the following parameters for a typical hand-pumped well at a campground;

$Q = 2,500$ gallons per day ($334 \text{ ft}^3/\text{day}$)

$T = 120$ days (4 months)

$H = 50$ feet (aquifer thickness)

$n = 0.2$ (porosity)

Then the calculated distance for the contributing area to the well is 41 feet. We get slightly different distances by changing the values of the variables, but for the expected range of values the capture zone ranges from about 20-60 feet for a 120-day season.

Summary

Water-supply wells at campgrounds at Lake Roosevelt National Recreation Area are generally constructed in sedimentary deposits adjacent to the lake. Water levels in wells close to the lake are known to mimic the rise and fall of water level in the lake, demonstrating that surface water in the lake is a source of recharge to the local aquifers adjacent to the lake. Microscopic particulate analysis testing (MPA) should be completed at each of the wells investigated to determine whether groundwater pumped from the wells is under the direct influence of surface water.

Separate hydrogeologic assessment reports for each of the wells and water-supply systems have been prepared and are included with this report.

References

Kraemer, Stephen R., Henk Haitjema, and Victor A. Nelson, 2007, *Working with WhAEM2000 Capture Zone Delineation for a City Wellfield in a Valley Fill Glacial Outwash Aquifer Supporting Wellhead Protection*, EPA/600/R-05/151, 84 pp.