

October 25, 2005

L54(2380)
SHEN/General

Memorandum

To: Superintendent, Shenandoah National Park

Through: William L. Jackson, Acting Chief, Water Resources Division (WRD)
Gary Rosenlieb, Acting Chief, Water Operations Branch

From: Larry Martin, Hydrogeologist, Water Operations Branch, WRD

Subject: Evaluation of several water systems in Shenandoah National Park

Summary

The park is planning to conduct repair/rehab work for the potable water systems at 4 developed areas in the next couple of years (PMIS 095100). The areas include Dickey Ridge, Piney River/Mathews Arm, Swift Run Entrance Station, and Headquarters. Water sources (springs and wells) for these areas, and several other areas in the park, were inspected and evaluated to determine whether new construction and/or repair-rehab work is needed to continue to collect water from these sources. Recommendations for new well locations are provided, should the park decide that deep wells are preferable to redeveloping springs. Sketches showing recommendations for reconstructing spring collection systems are attached to this report.

A short description of the hydrogeology and history of groundwater exploration and development is provided for each site. Much of this information was obtained from the Water Resources Division files in Fort Collins, CO.

In most cases, I did not provide specific recommendations for a preferred alternative for the repair/rehab work, e.g. recommending construction of a new well vs. reconstruction of a spring collection system. These are site specific decisions that should only be made after considering effects on park resources, economics, and probability of success.

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

General Comments

Most, if not all, of the spring collection systems in the park were constructed by the CCC in the 1930's. These systems are now 70 years old and very little, if any, maintenance has ever been conducted at the springs. Basic maintenance and upgrading of the collection systems at the springs is overdue. At a minimum the collection systems should be improved by installing new perforated pipe and gravel in the collection areas, raising the spring boxes several feet above ground surface and installing tightly fitting covers, and grading the vicinity of the collection areas and spring boxes to route surface flow away from the springs. The area above the collection systems should be kept cleared of woody vegetation to reduce the intrusion of roots into the collection systems, which creates a pathway for surface contamination to enter the water system.

Most of the wells in the park were constructed in the mid-1960s. Generally the wells were constructed by drilling a 10-inch hole into the underlying bedrock to a depth of about 50 feet. Six-inch steel casing was then cemented in place to prevent shallow groundwater in the overburden from entering the well. Drilling then proceeded through the inside of the steel casing to a depth of 200-300 feet, until a few water-bearing fractures were encountered. The yield of each well is dependent on the number, size, and interconnectivity of the fractures that were encountered in the bedrock formations. Generally if water was not encountered within the first 200-300 feet, the hole was abandoned. The wells were completed as open boreholes; there is no screen or perforated casing that might become corroded or plugged with mineral deposits. Additionally, the groundwater is very pure (e.g., the water from the well at Elk Wallow has a total dissolved solids concentration of 67 ppm). There are almost no dissolved minerals in the water, and therefore no potential for scaling or deposition of mineral deposits. All of these factors contribute to the low maintenance needs and longevity of the wells.

Any new wells in the park should be constructed in the same manner. Cement surface casing in place to a depth of about 50 feet to exclude shallow groundwater from the overburden. Drill an open borehole to a depth of 300-400 feet. If sufficient water has not been encountered, the well could be hydrofracked to increase the yield.

Dickey Ridge

In 1963 the Park Service began looking for a new water source for facilities at Dickey Ridge to replace water that was obtained from a spring at Lands Run Gap 3¾ miles to the southeast of Dickey Ridge. Even though a usable well was eventually completed near Dickey Ridge in 1967, the park continued to use the spring at Lands Run Gap until 1999. At that time, the State of Virginia determined that water from the spring was "under the direct influence of surface water" and should be treated as if it were a surface water source. Rather than construct a surface-water treatment system, the park abandoned its use of the spring and began using the well for the water supply at Dickey Ridge. The situation today remains that facilities at Dickey Ridge are dependent on a single source for the water supply, the deep well located about 4000 feet south-southeast of the Visitor Center.

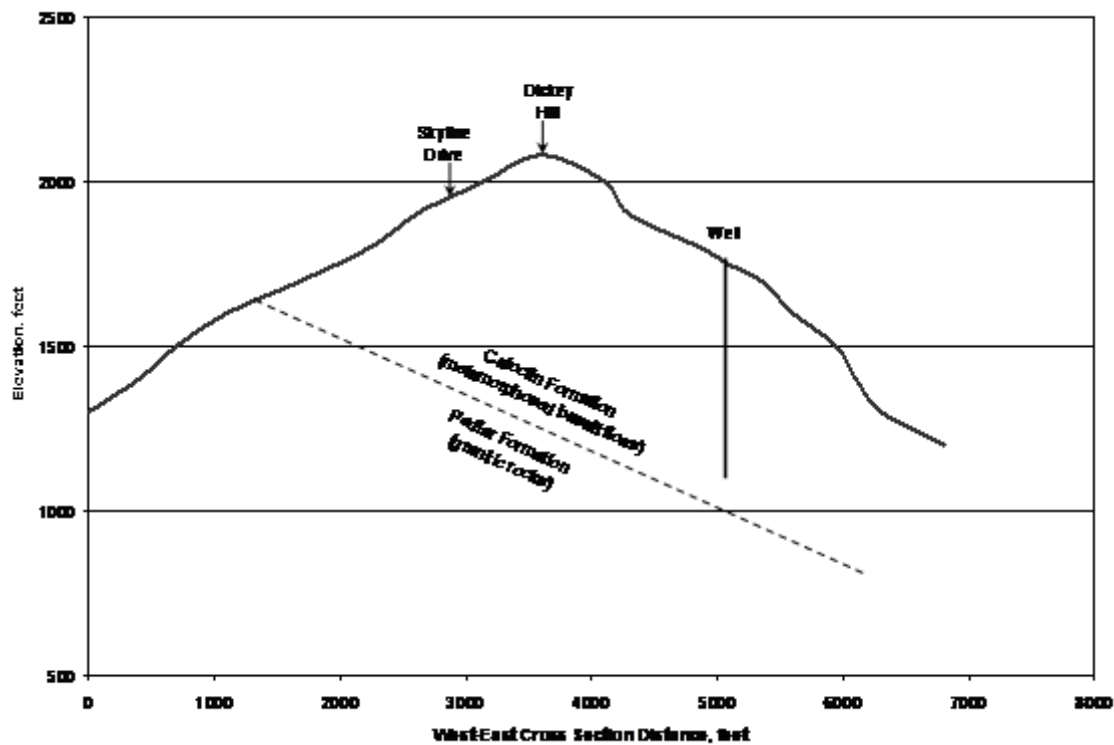
Water is chlorinated at the well and pumped to one of two storage tanks. In summer water is pumped to a 100,000 gallon above ground storage tank. In winter, the above ground tank is

drained and water is stored in a 20,000 gallon underground tank. Water is used to supply the picnic grounds, comfort station, and visitor center at Dickey Ridge. Average water usage at the Dickey Ridge facilities is 2-5,000 gallons per day (per. Comm.. Steve Richards).

During this site visit, the well was pumped at 7-8 gpm for 1½ hours. The water level in the well could not be measured because the measuring tape continually got hung up on obstacles in the well, most likely torque arrestors on the drop pipe. Park staff reports they have never had a problem with the well running dry, even during the spring when the well is pumped continuously for several days to refill the 100,000 gallon tank. So although we could not conduct a drawdown and recovery test of the well, it has proven to be a reliable source based on several years of use. When it was first constructed in 1967 the well was test pumped at 35-60 gpm for 26 hours, resulting in 330 feet of drawdown. As the recovery rate following pumping was rather low, it was recommended that the pumping rate be restricted to 10 gpm. The well is equipped with a 7 gpm pump and pumping is controlled by a timer. The well easily supplies the water needs of NPS facilities at Dickey Ridge. The large storage capacity for the area further provides a buffer for peak demand days.

Prior to successful completion of the deep well in 1967, four “dry” holes were drilled in the area. The first two test holes were drilled to a depth of 250 feet; one of the test holes was at the site of the currently used deep well and produced about 2 gpm. The other test hole was located about 1500 feet south at the Snead House and produced no water. Two test wells were then constructed in the Fox Hollow area about ½ mile northeast of the Visitor Center. These wells were drilled to a depth of 200 and 300 feet. One of these holes produced about 2 gpm from the overburden, the other well was essentially dry. After consultation with geologists from the Virginia Division of Mineral Resources, the Park Service decided to move back to the original site (¾ mile southeast of the Visitor Center) and construct a deep well. The deep well encountered fracture zones at 600-605 and 625-630 feet which produced large amounts of water. Drilling was halted at 650 feet. The well was completed with 6¼-inch steel casing grouted in place to a depth of 51 feet. The well is an open borehole from 51-650 feet. The static water level was 200 feet below ground surface. A 26-hour pump test was conducted at the end of which 41 gallons per minute were being discharged with the water level drawn down to 577 feet. As only 10 gallons per minute were required at the Visitor Center, and an analysis indicated the water to be of good chemical quality, Dickey Ridge Test Hole No. 3 was converted to a water well (Dekay, 1972).

A general schematic cross section of the geology in the vicinity of Dickey Ridge is shown on the following figure. The Catoctin Formation is a series of lava flows that have been metamorphosed and then thrust from the southeast up and over the underlying granite. Throughout the park, wells constructed into the Catoctin Formation are the most reliable source of groundwater, but only where the wells have intersected fractures within the Catoctin. In the Dickey Ridge area, four shallow test wells (200-250 feet deep) either did not intersect fractures or the fracture zones were above the water table. We have learned from experience that wells in this area need to be deep (650 feet or more). Also, future well locations should be as far to the east as possible to place them as far downgradient from recharge areas along the ridgeline. It is probable that more fractures will be found near the base of the Catoctin Formation associated with movement along the thrust fault between the Catoctin and Pedlar Formations.



There is probably enough storage capacity at Dickey Ridge to provide water during periods when maintenance or repair is needed at the well. However, if a new well is desired at Dickey Ridge, it should probably be located in the Snead Farm area. That would place it about as far downgradient of recharge areas as is practical without constructing new roads. The planned depth for a well at the Snead Farm should be 700-800 feet deep. If the granitic rocks are encountered at a shallower depth, drilling should stop when the granite is encountered. Constructing the well at Snead Farm would also place it in the same general area as the existing well and make it a little easier to connect into the existing water line and supply electricity to the new well. The location of the current well and the proposed location of a second well are shown on figure 1.

Mathews Arm – Piney River

Two test holes were constructed in the Mathews Arm area near Jeremys Run in June 1963. One hole produced only a few gpm and was abandoned. The second test hole produced more than 20 gpm and was completed as a water supply well. Both test holes were drilled to 200 feet. The well is cased and grouted to a depth of 24'9" with 6¼" steel casing. The remainder of the hole is a 6¼-inch open borehole. Fracture zones were noted in the drillers log at 42, 47, 73, 109, and 164 feet. The static water level was 1.5 feet below ground surface. The well was test pumped at 23 gpm for 22 hours with the water level stabilizing at 38½ feet below ground surface (Dekay, 1972). The well has not been used as a water source for at least 10 years.

Water for the Mathews Arm campground and facilities at Piney River is supplied from a spring at the head of Piney River, about 1000 feet south of the Hogback Overlook. Water flows by gravity from the spring to a 100,000 gallon storage tank. Water is chlorinated prior to entering the storage tank. Water demand at the campground (based on inflow records at the sewage treatment plant) is about 1000 gpd in midweek, rising to about 3000 gpd on weekends. Water usage rises to about 10-12,000 gpd on weekends during peak visitation periods. The campground at Mathews Arm is open from spring through October. Facilities at Piney River include; the North District Ranger Office with 1 bathroom, the North District Trail Office with 1 bathroom, and a maintenance building with 1 bathroom. Water use for facilities other than the campground does not exceed a few hundred gallons per day.

Currently, the Mathews Arm Campground and NPS facilities at Piney River are supplied by a single water system supplied by the rather distant spring. The water system might be operated more efficiently by splitting it into separate systems; with a large-capacity seasonal system for the campground and a low-capacity, year-round system for NPS facilities at Piney River.

The area at Mathews Arm Campground and Piney River is underlain by Catoctin Formation, metamorphosed lava flows. The Catoctin Formation is the most reliable source of groundwater for wells in the park. The well at the Mathews Arm Campground produces more than 20 gpm from fractures in the Catoctin Formation. The well at Elk Wallow, approximately 6000 feet southwest of Piney River was drilled to a depth of 363 feet in the Catoctin Formation. The well produces 10 gpm from fractures at 70-75 and 140-145 feet below ground surface. Based on successful well construction nearby, we would expect that a well constructed in the vicinity of NPS facilities at Piney River should be capable of providing at least enough water for a low-capacity system.

The spring is about 7000 feet from the storage tank at Piney River. Continued use of the spring will require total rebuilding of the collection system at the spring, regrading of the area to protect the collection system from inflow of surface water and replacement of the water line from the spring to the storage tank. Alternatives to continued use of the spring include; 1) converting the system to rely solely on the well west of the campground, 2) constructing a new well at Piney River to supply facilities at Piney River and use the well at the campground to supply the campground on a separate system, and 3) if a new well at Piney River produces sufficient water, it could be used to supply facilities at Piney River and the campground using the existing storage tank and distribution system.

Success in constructing wells into the Catoctin Formation at other locations in the park indicates there is a reasonable chance of obtaining water from a well at Piney River. There appears to be a NNW trending linear feature, depicted as an intermittent stream on the topographic map, to the south of the Piney River maintenance area. This linear trend may be an expression of a zone of weakness or fractures in the underlying bedrock. If a new well was constructed at Piney River, it should be located to intercept the extension of this linear feature. Thus, the ideal well location would be along the east side of the maintenance yard, perhaps just south of the road to the ranger station. The location could be anywhere in this general area that is conveniently located with respect to electricity, existing water lines, and that will not interfere with other uses in the area. A well in this area might need to be drilled to 800 feet to insure the bottom of the well is at an

elevation lower than the Piney River Valley about a mile to the east. If a test well at Piney River doesn't initially produce enough water, the yield might be improved by hydrofracking.

Location of the well at Mathews Arm Campground, the Piney River Spring, and a recommended location for a test well at Piney River are shown on figure 2.

Panorama – Thornton Gap

Water for facilities at Panorama and Thornton Gap is supplied from two springs on the mountain about 1200 feet north of the entrance station. Water from the collection systems at the springs is piped to a clear well and then to a chlorinator and storage tanks. The primary storage tank is a 200,000 gallon steel tank above ground. There are also two underground storage reservoirs, 20,000 and 50,000 gallons capacity, which are not currently used. Inflow to the spring collection boxes becomes turbid following rainfall, showing an interconnection with surface water in the area and the potential for contamination.

There is another spring and a well that were developed about 1100 feet WSW of the restaurant and 500 feet south of Hwy. 211 at an elevation of 2050 feet. The sustained yield of the well was estimated to be slightly less than 5 gpm (Dekay, 1972). Information regarding past use of the well and spring are not well documented. There was power to the well site and a water line is in place, so it is clear that the water was pumped to the restaurant at an elevation of about 2300 feet at some time in the past. Based on the state of disrepair observed during the 2005 site visit, it is obvious that the spring and well below the restaurant have not been used for many years.

Currently water use in this area is limited to the entrance station and a single toilet for public use at Panorama. There are plans to rehabilitate the buildings at Panorama as a Visitor/Learning Center. This use would greatly increase the water demand for the system.

Alternative water sources for the area include; 1) repair and reconstruction of the well and spring WSW of Panorama and reconstruction of the water line, 2) reconstruction of the spring collection systems on the mountain north of the entrance station, and 3) drill a new well near the storage tanks, north of the entrance station. Options 1 and 2 are the reliable alternatives. Option 3 has a large risk of failure. The springs can not continue to be used as a potable water supply in their current condition as they are highly susceptible to contamination from surface sources.

Locations of wells, springs, and facilities at Panorama are shown on figure 3.

Swift Run Gap

Water for facilities at Swift Run Gap is supplied from a spring about 1000 feet WSW of the entrance station. Water flows from the spring through a chlorinator to an underground storage tank. Water is used at the maintenance shop and the entrance station. There are no public facilities in the area. The entire system operates by gravity flow. The spring collection system, in its current condition, is susceptible to contamination from surface sources. No test wells have been constructed at Swift Run Gap.

Alternatives for improving the water system at Swift Run Gap include;

1. Reconstructing the spring box and collection system to provide a safe water system that is not as susceptible to contamination from surface sources.
2. Drill a well at the maintenance area. The recommended site for a well is anywhere along the eastern side of the parking area at the maintenance yard. This location is closely aligned with the trend of an intermittent stream trending SSW. Target depth of a well should be at least 400 feet. If an adequate water supply has not been obtained it may be necessary to hydrofrack the well.
3. Continue to use the existing spring and collection system and provide bottled water or a small under-the-counter reverse osmosis unit to treat water for drinking.

The location of the currently used spring and a proposed location for a well at Swift Run Gap are shown on figure 4.

Headquarters

Two wells were drilled in 1963 in the headquarters area. Prior to this, water was supplied from a spring a mile to the east. The wells are about $\frac{3}{4}$ mile southeast of the visitor center. The test holes were drilled to 280 and 220 feet. Both wells produce groundwater from fractures in the metamorphosed basalt bedrock (Catoclin Formation). The spring continued to be used for many years after the wells were constructed.

Well No. 1 (the west well) was drilled in the northwest corner of the Headquarters area and encountered water-bearing fractures at depths of 56, 89, 107, 117, and 150 feet. The well is 280 feet deep and is cased with 6¼-inch steel casing to a depth of 50 feet. The annular space between the casing and borehole was grouted to seal the well from surface contamination. The remainder of the hole is a 6¼-inch open borehole. The static water level was 59 feet below ground surface. The well was test pumped at 9 gpm for 20½ hours causing the water level to be drawn down to 108 feet below ground surface. The pumping rate was then increased to 25 gpm causing the water level to drop another 100 feet in the next 1½ hours. The safe yield for this well is about 10 gpm.

Well No. 2 (the east well) was drilled about 400 feet east of Well No. 1. The well penetrated metamorphosed basalt from 20-220 feet, encountering water-bearing fracture zones at 60 and 189 feet below ground surface. The well is 220 feet deep and is cased with 6¼-inch steel casing to a depth of 50 feet. The annular space between the casing and borehole was grouted to seal the well from surface contamination. The remainder of the hole is a 6¼-inch open borehole. The static water level was 40 feet below ground surface. The well was test pumped at 15-23 gpm for 24 hours causing the water level to be drawn down to 174 feet below ground surface (134 feet of drawdown). The safe yield for this well is about 20 gpm.

Well No. 2 has been the only water source for the Headquarters area for about the last 10 years, since use of the spring was discontinued. Park staff do not recall ever having used Well No. 1 (the west well) to supply water for the area.

The production of both wells at Headquarters was tested to determine if there had been significant change since they were constructed in 1963. Hydrographs showing the data from these tests are shown on figures 5 and 6, attached to this report. Location of the wells is shown on figure 7.

The hydrograph for Well No. 2 (the current production well) shows a typical drawdown and recovery pattern. Well No. 2, as equipped, could supply the Headquarters area with up to 10,000 gpd using a schedule of 12 hours on and 12 hours off each day. If additional water is needed for the Headquarters area, Well No. 1 could be used as a supplemental supply, or additional testing could be conducted at Well No. 2 to determine if a larger pump could be installed. Dekay (1972) estimated the safe yield of well No. 2 at 20 gpm.

Water level measurements in Well No. 1 were affected by water cascading into the well from fractures in the rock about 56-57 feet below ground surface. Accurate measurements of drawdown and recovery in response to pumping the well were unobtainable. The 2005 test was conducted at an average pumping rate of 11-12 gpm. Dekay (1972) estimated the safe yield of Well No. 1 at 10 gpm. The well could probably be pumped for several hours a day using the current pump (11-12 gpm). The 2005 test of this well was conducted with the water being discharged at the surface a few hundred feet from the well. If the well were connected to the water system, the increased head associated with pumping the water to the storage tank would likely decrease output from the well to about 10 gpm.

The potable water supply for the Headquarters area should incorporate both wells, perhaps alternating between wells on a weekly basis. That would insure that park staff knew that both wells were operating properly and provide alternative sources. The wells should not be pumped for more than 12 hours per day, allowing time for recovery of water levels in the aquifer between pumping periods. If the water demand for the area increases beyond the capacity of either well individually, both wells could be used with one well scheduled to pump at night and one during the day.

Water supplies in other areas of the park

Potential future rehab projects for water supplies at several other areas of the park were briefly discussed with park staff. These areas were not visited and site-specific conditions are only generally discussed.

Two successful test wells were constructed in the area known as Comers Deadening near Old Rag Road (Dekay, 1972). Well W-869, south of Old Rag Road has an estimated safe yield of 10 gpm. Well W-1136, north of Old Rag Road has an estimated safe yield of 20 gpm. Either or both of these wells could be developed as supplemental sources for the Skyland area and/or as a supply for the White Oak Ranger Station.

Water for the Camp Hoover area is supplied from springs. The collection systems at these springs probably need to be rebuilt to reduce the potential of surface contamination.

Water for the Pinnacles Picnic ground is obtained from a spring that is probably in need of reconstruction. The area near Pinnacles is completely underlain by granite, which is generally a poor prospect for obtaining groundwater. Two unsuccessful test wells were constructed at Pinnacles in 1970. Unfavorable hydrogeologic conditions, unsuccessful test wells, and a reliable spring source makes for a rather obvious choice for water supplies for facilities in this area.

Facilities at Lewis Mountain are supplied from a single well with an estimated safe yield of 12 gpm (Dekay, 1972). A formerly used spring on the west side of Skyline Drive has been abandoned. Additional, or supplemental supplies could be obtained by redeveloping the formerly used spring or drilling a second well.

References

Dekay, Richard H., 1972, Development of Ground-Water Supplies in Shenandoah National Park, Virginia, Mineral Resources Report 10, Virginia Division of Minerals, Charlottesville, VA, 158 pp.

Gathright, Thomas M. III, 1976, Geology of the Shenandoah National Park, Virginia, Bulletin 86, Virginia Division of Minerals, Charlottesville, VA, 93 pp.

Wooten, Kathleen M., Christopher M. Bailey, Adam M. Forte, Brian A. Hasty, Catherine Shrivell, and Cristofer S. Coppinger, 2005, Bedrock Geologic Map of the Swift Run Gap 7.5' Quadrangle, Virginia: Virginia Division of Mineral Resources Open-File Report

cc:

SHEN – Terry Bell, Steve Richards, Shane Spitzer
REGION – John Karish

Attachments: 8 figures

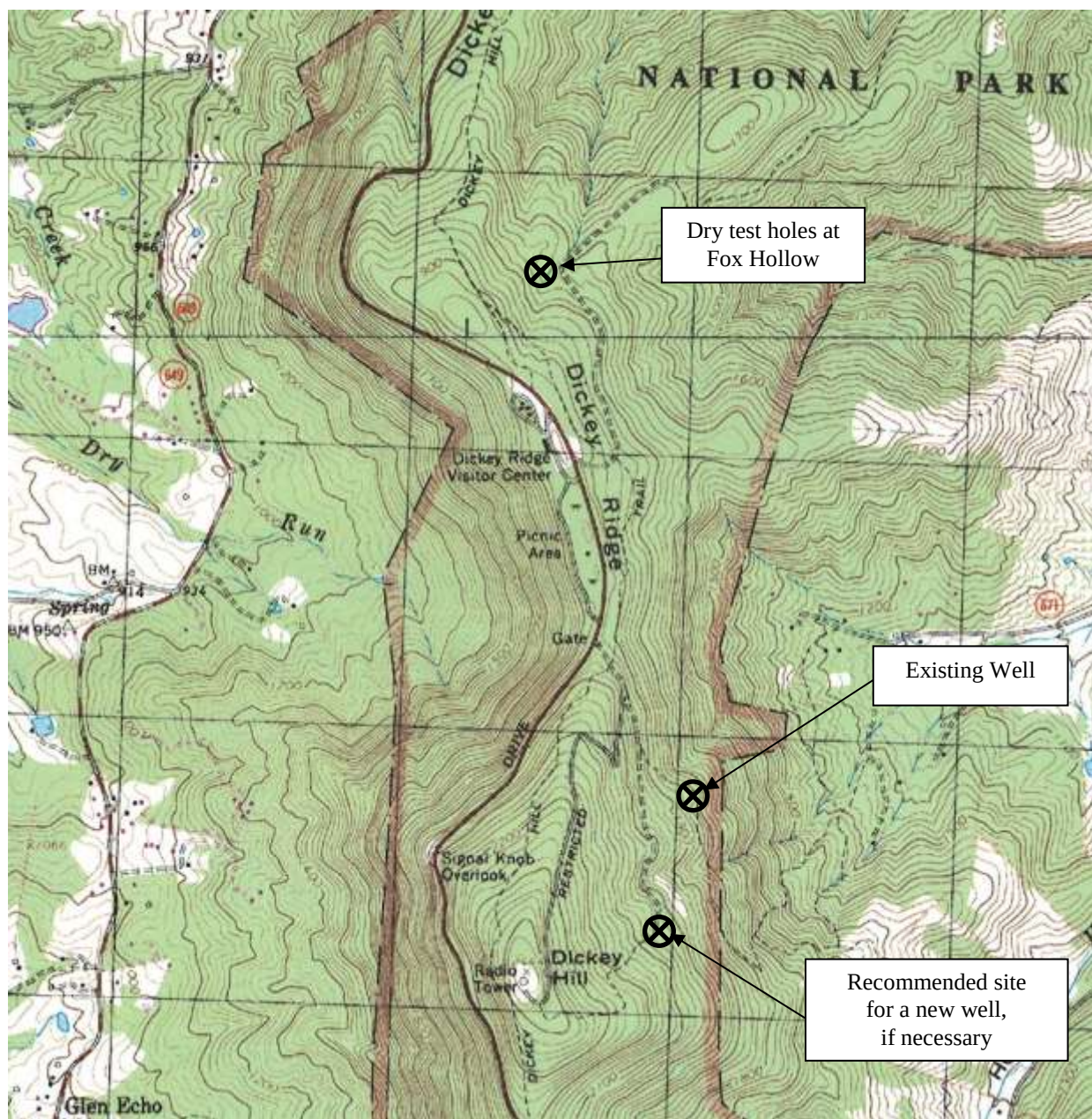


Figure 1. Well locations near Dickey Ridge

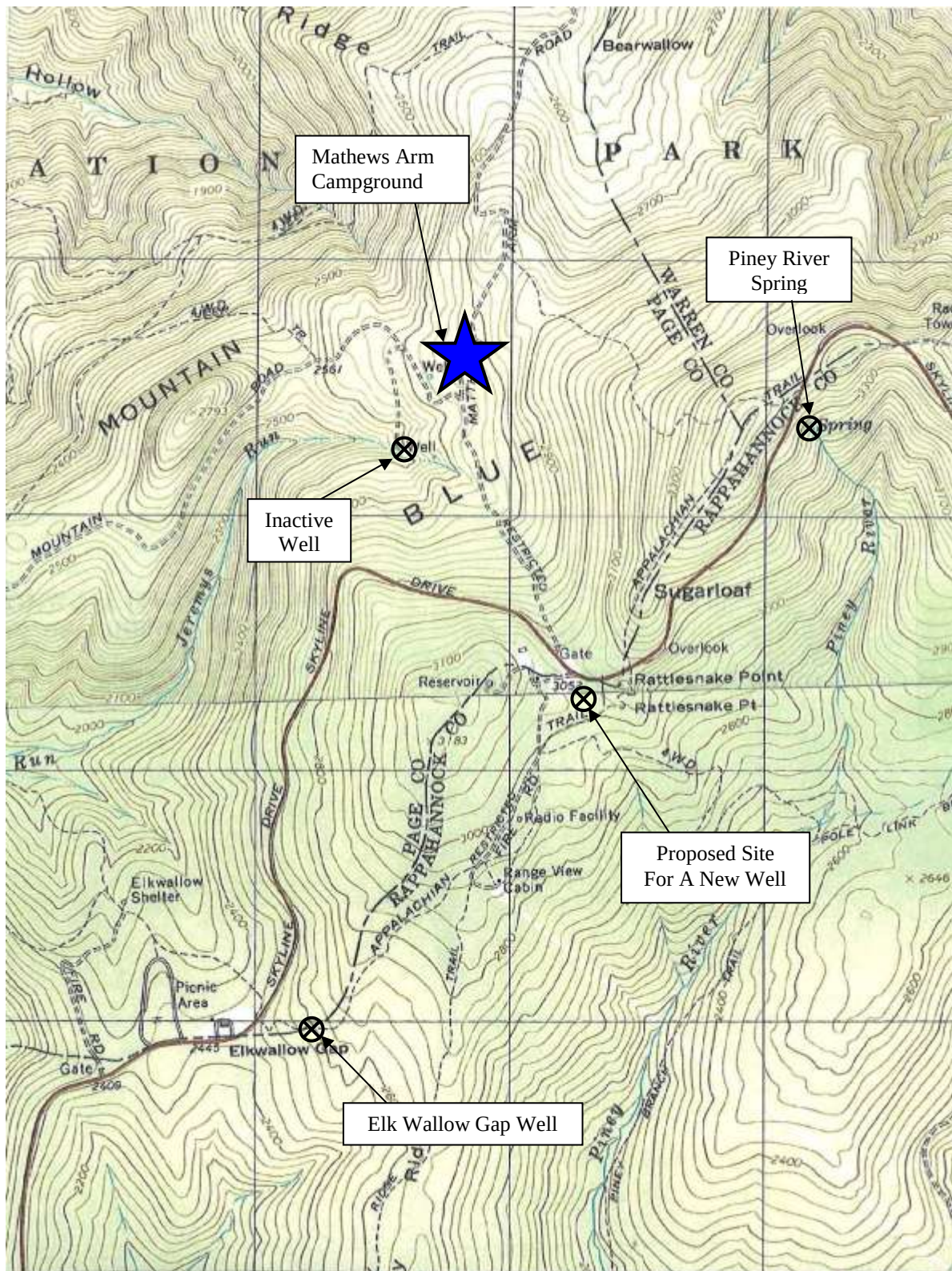


Figure 2. Location of wells and springs in the vicinity of Mathews Arm, Piney River, and Elk Wallow

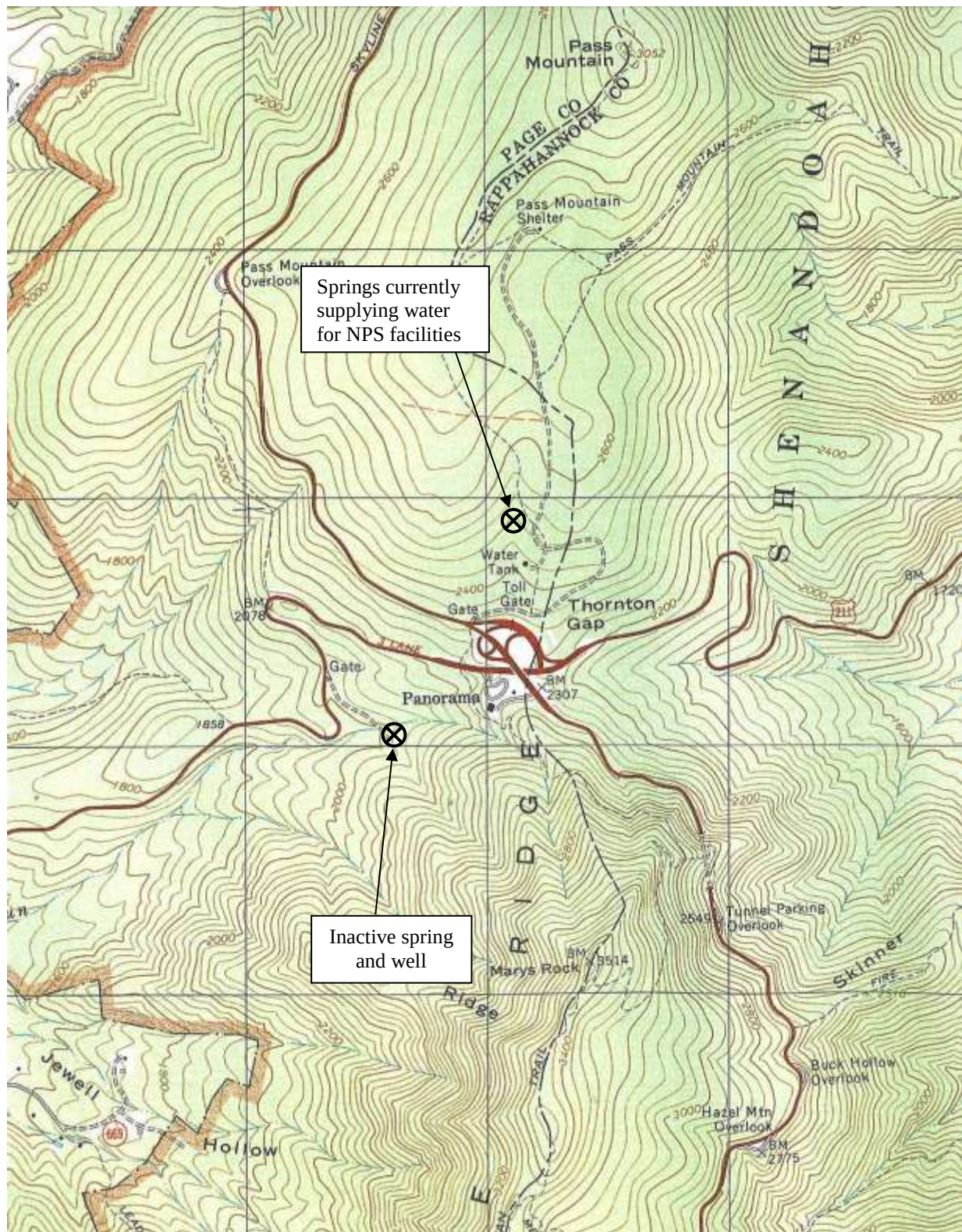


Figure 3. Location of springs and wells in the Thornton Gap – Panorama area.

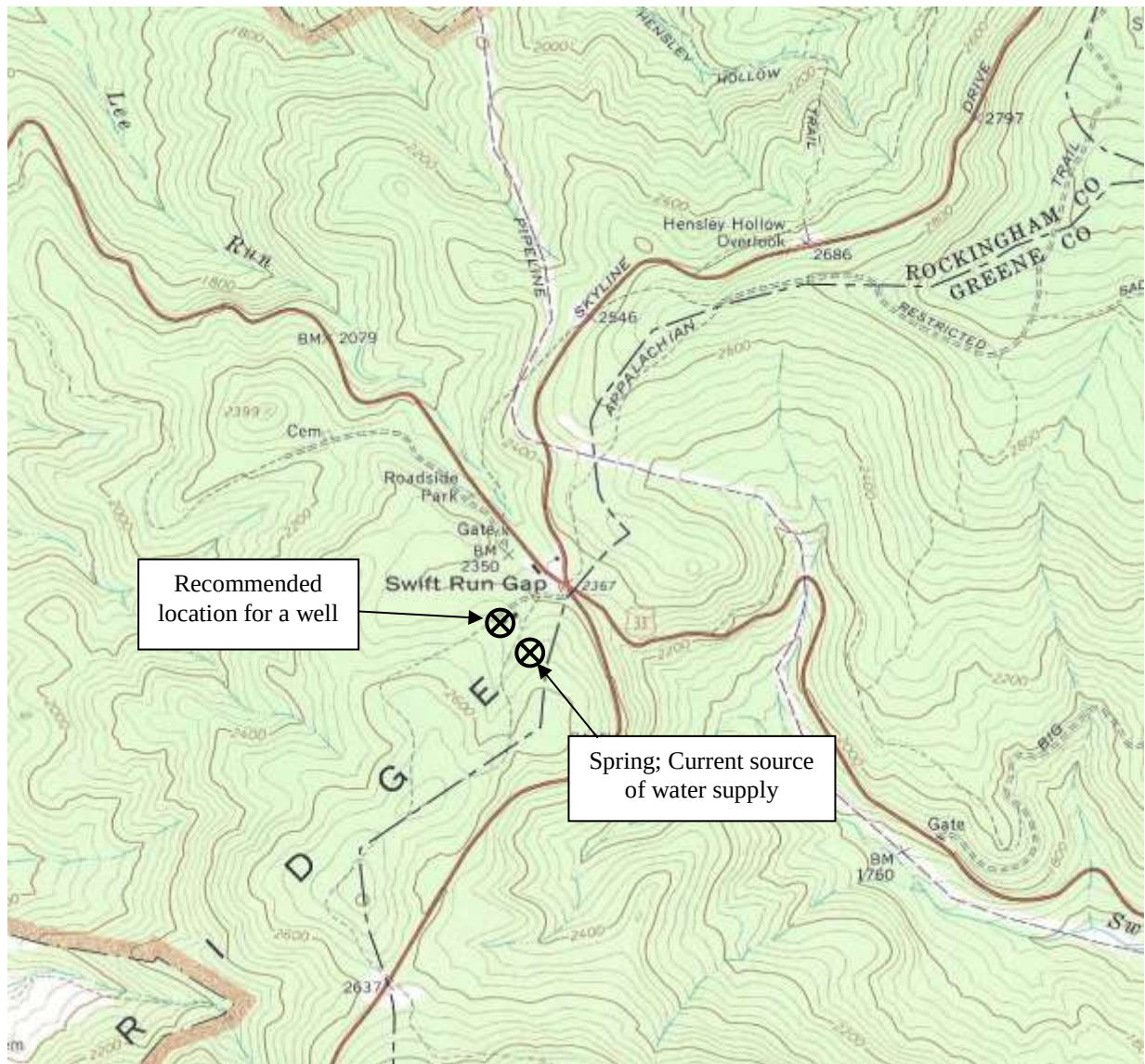


Figure 4. Location of the currently used spring and potential location for a well at Swift Run Gap

**Shenandoah National Park
Headquarters Area Well 1 (West Well)**

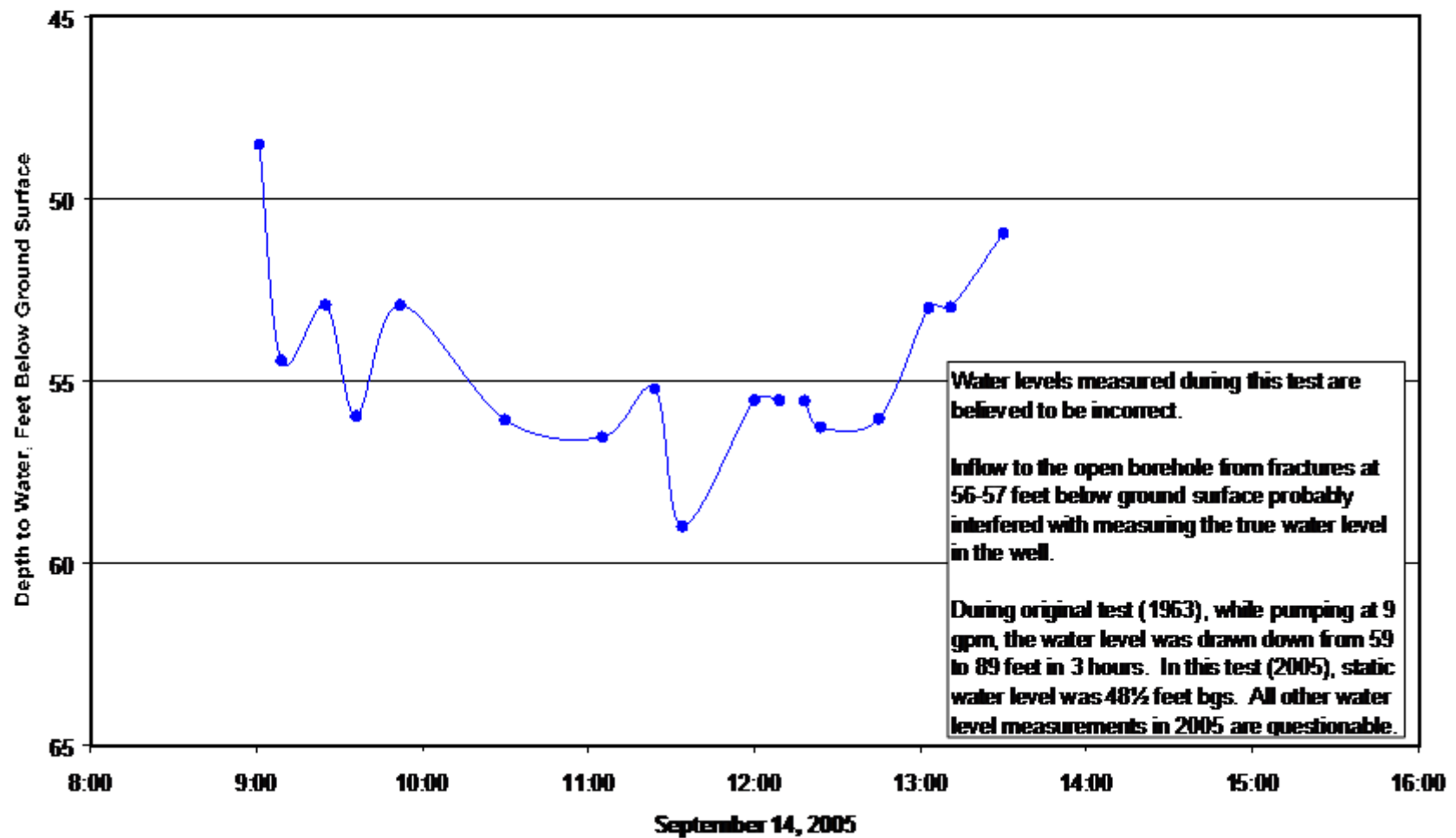


Figure 5. Hydrograph of drawdown and recovery in Well No. 1 in the headquarters area.

**Shenandoah National Park
Headquarters Area Well 2 (East Well)**

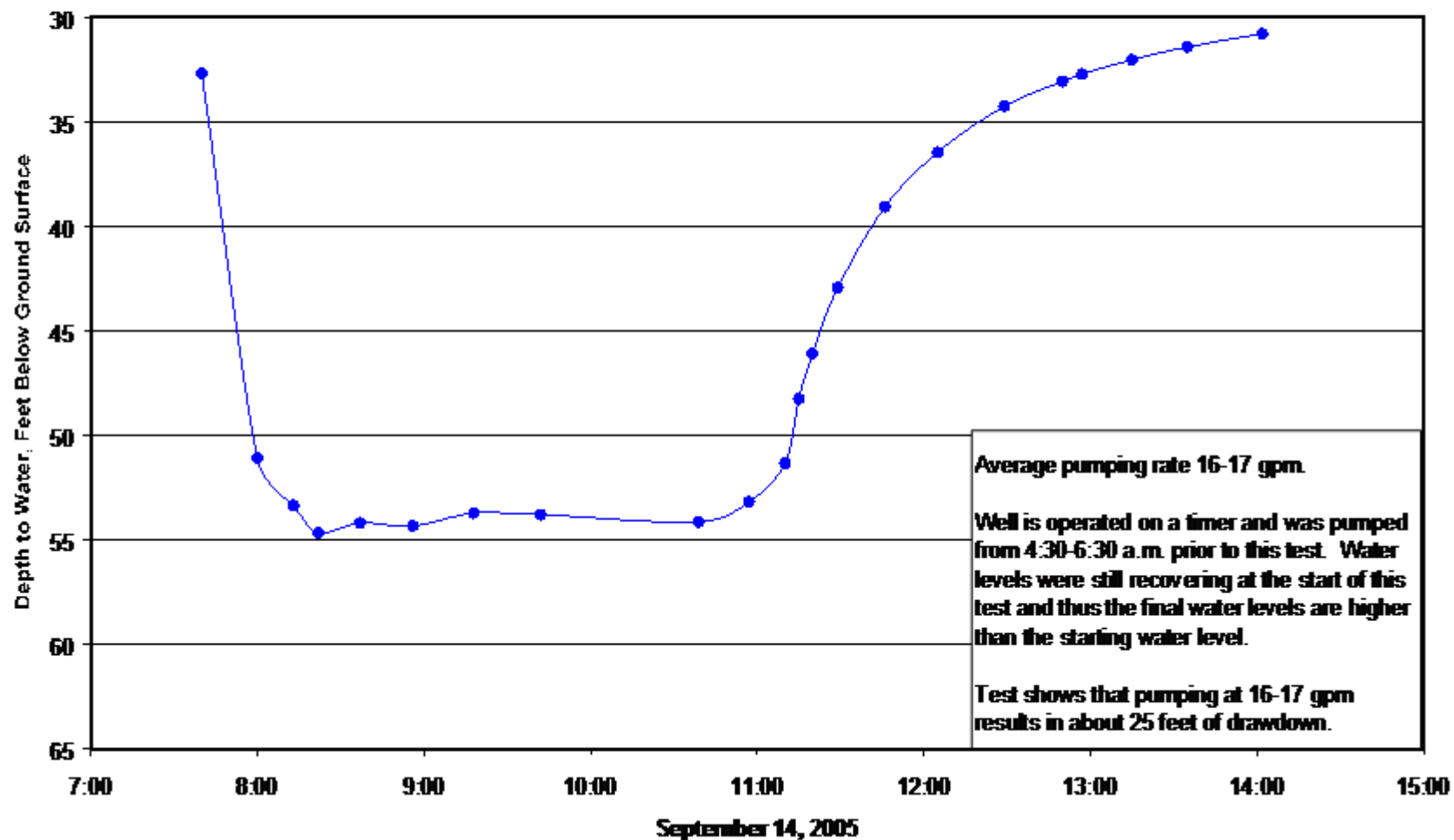


Figure 6. Hydrograph of drawdown and recovery in Well No. 2 in the headquarters area.

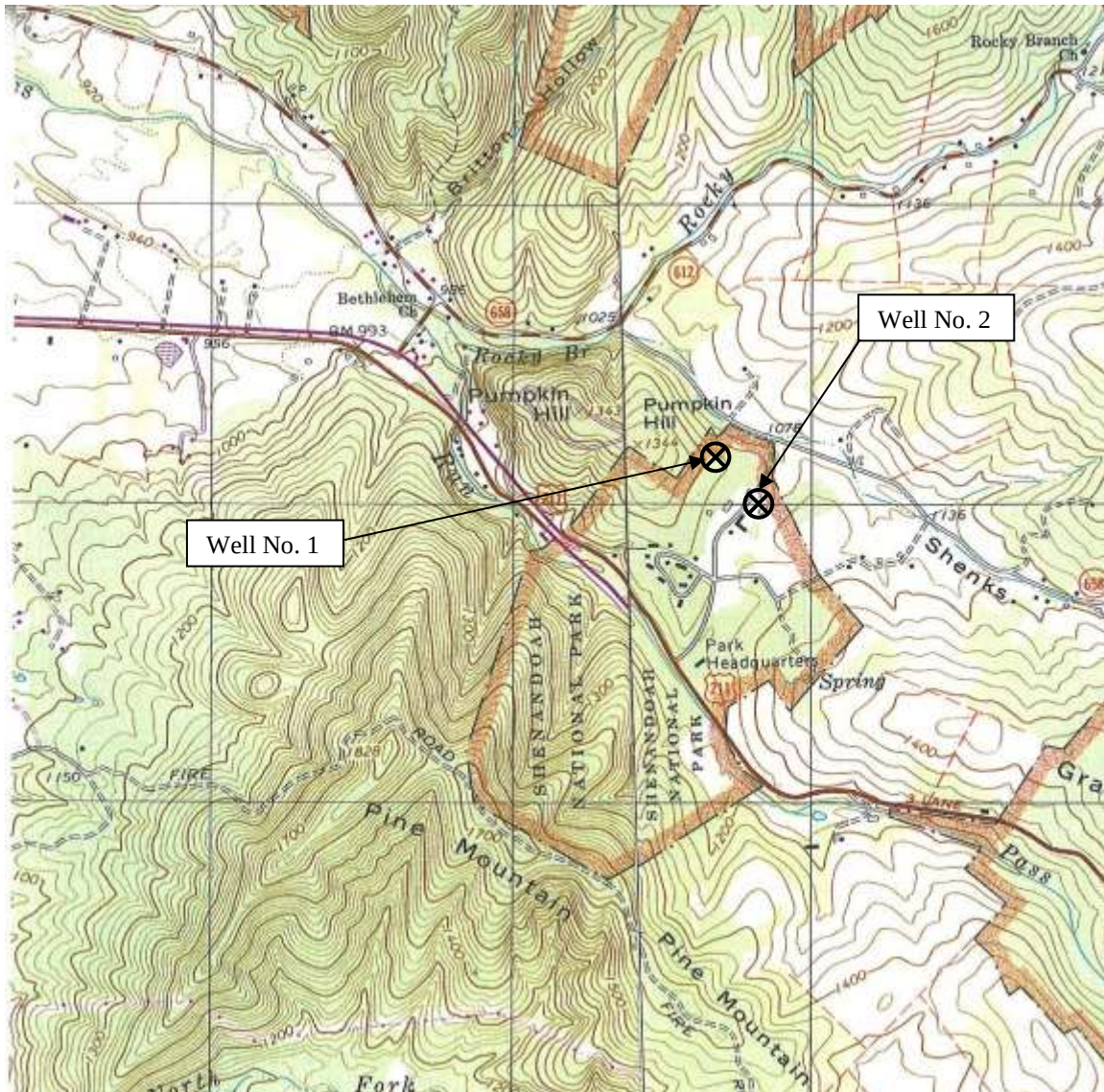


Figure 7. Location of Wells at Headquarters area

Typical Design for Reconstruction of a Spring Water Collection System

Excavate trenches about 2 feet wide by 20-40 feet long and 2-3 feet below the water level. Backfill the trench with pea gravel and perforated pipe. Place geotextile over the pea gravel and backfill with compacted soil from the excavation. Mound the backfill over the trenches to cause surface water to flow away from the collection trenches. Construct a drainage ditch around the perimeter to divert surface water away from the collection systems. Construct wingwalls extending out from the collection box to help back up water into the collection pipes. Raise the elevation of the top of the collection boxes about 2 feet above ground surface and fit the collection boxes with a tight cover to keep the bugs and rodents out. Initiate a regular program of mowing and brush clearing over the collection system to prevent plant roots from entering the collection pipes.

