

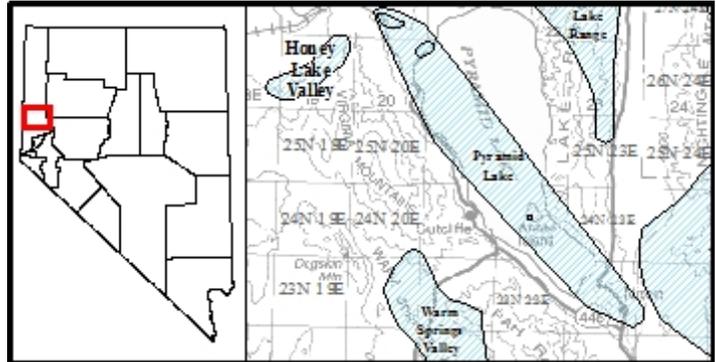
# Site Description

## Pyramid Lake

(Updated 2014)

### Geologic setting:

The Pyramid Lake geothermal site is located on the Pyramid Indian Reservation 48 km northeast of Reno. It forms part of the Walker Lane, a major right-lateral strike slip domain in western Nevada. The Virginia Mountains are located to the west of the Pyramid Lake site while the Lake Range, Fox Range, and Terraced Hills are located to the northeast. Several other geothermal clusters are present in the surrounding area.



At the northern boundary of Pyramid Reservation, the Fox Range abuts a newly-discovered anomaly at Emerson Pass (Kratt et al., 2010) using shallow temperature surveys. The area has no thermal water discharge at the surface. In the fall of 2013, four shallow gradient wells were drilled ranging in depth from 140 to 250 feet, and bottom hole temperatures of 96 to 120.5°C, respectively. A deeper gradient well is planned in late 2013.

The southern Fox Range contains Mesozoic granodiorite stocks overlain by volcanic flows and tuffs, and intercalated with diatomite, sandstone, and conglomerate (Bonham and Papke, 1969; Bonham et al., 1985). The Terraced Hills and Southern Fox Range are composed of Mesozoic metasedimentary and granitic basement rock, Cretaceous plutonic rocks, and Tertiary volcanic and sedimentary rocks. Quaternary deposits such as lacustrine sediments, spring deposits, and alluvium are also observed throughout this region (Anderson and Faulds, 2013).

### Geothermal features:

Nearby geothermal clusters include the Lake Range to the northeast, Honey Lake Valley to the northwest, Warm Springs Valley to the south, and the Truckee Range to the east. Aster Pass, Needle Rock Hot Springs, and Pyramid Island/Anaho Island are all within the larger Pyramid Lake cluster.

Needle Rock Hot Spring, a boiling-temperature tufaceous system in northeastern Pyramid Lake (Sec. 12, T26N, R20E and Sec. 6, 7, T26N, R21E), is located along a series of north-northeast-striking faults (Bonham, 1969). Warm springs are also present in southern Pyramid Lake at Pyramid Island (Sec. 3, T24N, R22E) and Anaho Island (Sec. 16?, T24N, R22E).

In 2005-6, the Pyramid Lake Paiute Tribe initiated the Pyramid Lake Energy Project to develop geothermal resources on the reservation. The project includes geophysical, gravity, and magnetic surveys, and a thermal gradient drill-hole program. Drilling of the gradient holes started in November 2005, and three were completed by March 2006 at Astor Pass (Nevada Geothermal Update, April 2006, Nevada Division of Minerals). Part of the exploration and geophysical work was done in collaboration with the University of Nevada, Reno and the Great Basin Center for Geothermal Energy.

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***Pyramid Island, Anaho Island:*** Pyramid Island, the namesake for Pyramid Lake, is a spectacular mass of tufa deposited when the lake level was higher than at present. The collection of tufa into needles, spires, and pyramids is related to underwater warm springs (Russell, 1885); divers have reported underwater hot springs near the Needle Rocks and The Pyramid. The Pyramid lies along the Lake Range fault zone (Faulds, pers. comm., 2005; formerly called the East Pyramid Lake fault).

Garside and Schilling (1991) report warm springs at Pyramid Island (Sec. 3, T24N, R22E) and Anaho Island (Sec. 16?, T24N, R22E). Benson and others (1995) reported a temperature of 89°C for the spring at Pyramid. In March 2005, there were 2 orifices on the Pyramid, 6 feet apart, from 0.2 to 0.35 m above the lake water level on the west side of the pyramid near the center of the island. One spring is flowing down into the lake (96.2°C) and the other (97.8°C) is spouting up and out, spilling into the lake. This second spring was sampled for water chemistry analysis on 3/15/05 and had a pH of 7.7 and specific conductance of 8120 mS/cm. Steam can be seen above the springs, ~9 m above the lake surface, which was at 1,160 m on 3/15/05.

The spring on Anaho Island is reported by Waring (1965) to be 49°C; however, attempts to locate it on March 15, 2005 failed. An unreferenced web site <http://www.hot Springsenthusiast.com/Nevada.asp> shows a spring just off the coast of the southern point of Anaho island. There was no evidence of a spring on the south or west sides of the island on land during the March 2005 visit, though there may have been a spring(s) offshore. No vents were visible, but green algae occurred in the shallow water off the island on the south side of the island.

***The Needle Rock Hot Springs*** ([Map](#)): Both the Needle Rock Hot Springs and Pyramid Island were deposited in Pyramid Lake when its level was higher than at present. Springs at the Needle Rock Hot Springs are reported to range from 58°C (Benson and others, 1995) or 66°C (Grose and Keller, 1975b) to a maximum of 98°C (Waring, 1965), near-boiling for the elevation. A number of the springs are shown on the Needle Rocks 7.5' Quadrangle map.

In the early 1960s Western Geothermal, Inc. drilled three geothermal wells at the Needle Rock Hot Springs. The deepest of these was 1,795 m, and another was about 1,220 m deep. The maximum recorded temperature was about 116°C. From examination of drill cuttings from the deepest well, it is believed that Tertiary basaltic andesites overlie Mesozoic metamorphic rocks at about 1,540 m (H.F. Bonham, written commun., 1964). This well flowed continuously after its completion, but geysered or pulsed, a complete cycle taking about 1 minute. A 35-second eruption, with hot water reaching 10 m in height above the well, was followed by 32 seconds of diminished activity. During this period the well flowed at a rate of about 450 L/min. A thin film of siliceous sinter (geyserite) collected on the well casing during this time; a slight odor of H<sub>2</sub>S was also noted (H.F. Bonham, Jr., written commun., 1964). Mariner and others (1974) reported that their best estimate of the thermal reservoir temperature is 137°C, using the silica (adiabatic) geothermometer. Na-K-Ca geothermometer temperatures are higher; a sample considered reliable yielded a Na-K-Ca estimated temperature of 213.9°C and a K-Mg estimated temperature of 228.3 (GeothermEx, 2004). Benson and others (1995) reported a temperature of 85.3°C for water flowing from the Needles well.

***Nixon:*** There is a well located at a maintenance shop in Nixon (Southwest quarter of Sec. 25, T23N, R23E 25) that was sampled in 2009 by NBMG staff. The sample was taken at a spigot approximately 100

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feet from the pump house. A temperature of 23°C was recorded and a Na-K-Ca geothermometer of 38.1°C (Fournier, 1981), a quartz geothermometer of 77.3°C (Fournier, 1977), and a chalcedony geothermometer of 45.8°C (Fournier, 1981) were also recorded at this well (Great Basin Groundwater Geochemical Database).

**Astor Pass:** A total of six wells have been noted within the Aster Pass cluster with four being sampled by NBMG staff. Recorded temperatures for these wells range from 15°C up to 76°C. The four wells sampled by NBMG staff were the Northern Solar Well (Northwest quarter of Section 28, T27N R20E), the Southern Solar Well (Northeast quarter of section 34, T27N R20E) and the NTG-3 and NTG-3X wells (Northwest quarter of Section 28, T27N R20E). The remaining two wells, USGS Well 1-N and Fred True Well were recorded as cold wells in the Great Basin Groundwater Geochemical Database.

The Northern Solar Well was reported to be 21.3°C with a Na-K-Ca geothermometer of 79.3°C (Fournier, 1981), a quartz geothermometer of 102.46°C (Fournier, 1977), and a chalcedony geothermometer of 73.6°C (Fournier, 1981). This site showed evidence of cattle and greenish water. Samplers noted that they could not see where water entered the trough (Great Basin Groundwater Geochemical Database).

The Southern Solar Well was reported to be slightly warmer at 26.4°C with a Na-K-Ca geothermometer of 142.6°C (Fournier, 1971), a quartz geothermometer of 71.09 (Fournier, 1977), and a chalcedony geothermometer of 39.3 (Fournier, 1981). The sample was collected where the well pipe entered a cattle trough. The trough water was reported to be brownish with weeds, bird feathers, and dead Mormon crickets in it. Evidence of cattle was also noted (Great Basin Groundwater Geochemical Database).

Wells NTG-3B and NTG-3BX were observed to have a temperature of 76.7°C and 60°C respectively. Well NTG-3B had a Na-K-Ca geothermometer of 131.7°C (Fournier, 1981), a quartz geothermometer of 176.94°C (Fournier, 1977), and a chalcedony geothermometer of 155.4°C (Fournier, 1981). No geothermometer data were recorded for NTG-3BX (Great Basin Groundwater Geochemical Database).

## Leasing information:

The Pyramid Lake energy project received a \$8.5m DOE grant to perform regional stress analysis, geophysical survey, and shallow temperature surveys in the Pyramid Lake Reservation. Two slim holes were drilled at Astor Pass in winter 2010-2011; Preliminary results show Astor Pass can produce 2MW energy production (DOE). Currently Emerson pass is being looked into because of its favorable structural setting, high temperatures, and its steep Calcite and silica veins (DOE). By September 30, 2013 long term viability models of Astor Pass will be completed, seismic analysis of Anderson bay will be completed, 6 temperature gradient wells will be completed at Emerson pass.

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