Geohydrologic Properties of Fractured Bedrock Aquifer Systems: A Review and Application to Ester Dome, Alaska

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"Principal" aquifers of the United States consist of unconsolidated sedimentary deposits. Other "less common" aquifers, which occur in much of the western and northeastern United States, are composed of fractured igneous, metamorphic, and sedimentary bedrock. Increasing residential and industrial development into upland and mountainous regions is putting increased pressure on these fractured aquifer systems.

Ground-water dynamics of fractured bedrock aquifers are not well understood and it is challenging to solve water-resources problems in bedrock settings. Flow and storage occurs primarily in bedrock fractures, joints, and foliation planes. The matrix porosity and permeability is very low or close to zero, with higher permeability in the fractures.

We are examining an upland aquifer system located approximately 11 km (7 miles) west of Fairbanks, Alaska. A ground-water monitoring network at Ester Dome includes approximately 50 wells, of which 7 are continuous-recording, data-collection stations. Ground-water levels are monitored at all sites on a monthly basis. Water levels, summer precipitation, water temperature, and air temperature are monitored at the continuous recording sites.

The geology at Ester Dome consists of metamorphic schists of varying grades, igneous intrusions, and surficial gravels and silts. A series of high angle northeast trending fault zones cut across Ester Dome, where gouge material and mineral deposits occur. The principal aquifer at Ester Dome is the metamorphic schist, where most wells are drilled into the schist.

The primary recharge is from snowmelt and occurs through weathered bedrock at the higher elevations of Ester Dome where there is the greatest snowpack and no overburden or permafrost. Ground water is preferentially flowing toward the valley bottoms and discharging into streams, lakes, and wetlands. Runoff occurs on the steeper slopes, particularly after snowmelt. Springs and seeps are common on Ester Dome. We also see aufeis in the winter, which indicates ground-water outflow. The water-table surface, in general, mimics the topography of the dome. Water levels in water-supply wells fluctuate dramatically at the highest elevations, in response to snowmelt and pumping. Water levels in wells located at the lower slopes of the dome are more stable, with fewer daily and annual fluctuations. Reported well yields in the fractured aquifer system vary from less than 3.78 L/min (1 gpm) to over 760 L/min (200 gpm).

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