DAVIS, CA - Groundwater-fed springs provide unique contributions, and some unexpected hazards, to Grand Canyon water systems, explained Lauren Foster, a graduate student researcher at the Colorado Schools of Mines (CSM). Foster, whose research focuses on hydro-climate interactions in alpine environments, presented remotely from CSM to a group of University of California, Davis (UCD) graduate students as part of an interdisciplinary Ecogeomorphology class offered through UCD's Center for Watershed Sciences. The course brings together graduate students from diverse disciplinary backgrounds to study and present on aspects of the Grand Canyon that fall within each student's area of expertise. The course culminates with a rafting trip down the Colorado River through the Grand Canyon, a unique opportunity to experience in-person, and with the guidance of fellow students' knowledge, the unique region that students spend the quarter studying.

Foster's presentation, "Hidden Waters: Groundwater Pathways to Springs in the Grand Canyon," focused on the role of ground-fed spring waters in the Grand Canyon riverine system. The presentation summarized the major springs entering the Grand Canyon and their importance. It touched on the human relationships to and effects on these subterranean water features, and also explained the current scientific understanding of the water pathways to and from these groundwater systems.

While springs account for only a tiny proportion of Grand Canyon tributaries, their confluences with the Colorado River "host over 36% of [Grand Canyon] flora and fauna." To put that in perspective, spring confluences hold several hundred times greater species diversity than anywhere else in the Grand Canyon. Three of the largest and best known springs, Blue Spring, Roaring Springs, and Havasu Spring, enter the canyon at the Little Colorado Confluence, Bright Angel Creek, and Havasu Canyon respectively (listed upstream to downstream). Because these springs are mostly fed by confined aquifers - that is, they are not heavily influenced by precipitation - their flow to the Colorado River is year-round and generally consistent in magnitude. Blue Spring, the largest of the three, contributes 223 cubic-feet/second (cfs) to the Colorado River, enough flow to cover a football field in a foot of water in four to five minutes. While this may seem like a lot of water, consider that the average flow of the Colorado River is around 15,000 cfs, about seventy times greater than the contribution of Blue Spring. Roaring Springs, farther downstream, is tapped by the National Park Service to provide water to Grand Canyon National Park facilities; the Transcanyon Pipeline lifts water several thousand feet out of the canyon to ensure that park staff and visitors can stay clean, happy, and hydrated.

While human development around the canyon is sparse compared to other regions of the United States, human use of spring water around the canyon is an area of concern. The aquifers that feed Grand Canyon springs have seen reduced water storage due to increased human pumping. The near-surface Coconino Aquifer has seen mild impact due to pumping at Tusayan Village, near the canyon. But more significantly, the deeper Redwall-Muav aquifer, connected over a broad region by a network of porous limestone, has seen water-storage reductions due to more distant pumping around the rapidly developing Flagstaff, AZ area. Research has shown that pumping of the Redwall-Muav may be the cause of the 8-9% reduction in flow observed at Havasu Springs.

Springs around the Grand Canyon are important for more than aesthetic appreciation and ecology. Foster explained that these springs served as sacred places of worship to the Hopi people who once inhabited the canyon. She quoted author John Donahue: "The land is a living organ, it breathes… the Hopis say that it is the underground water that sucks in, that breathes the rain."

The closing slides of Foster's presentation offered an unexpected conclusion to the presentation. While we may ascribe purity to sacred blue springs pouring out of ancient stone, "old water," now believed to be a major contributor to many Grand Canyon springs, can have dangerously high levels of naturally occurring toxins. Scientists previously believed that the high carbon-dioxide

(CO2) levels in some spring water, known to create the renowned terracing at spring confluences, were due to atmospheric interactions. Foster explained that more recent research has shown that some of these waters have actually gained CO2 through ancient interactions with elements deep in the earth's crust. These "old waters" carry dangerous levels of arsenic and uranium. No need to cancel the rafting trip, but "don't drink it [the spring water] when you visit," concluded Foster; most of the contributing springs are exceptionally pure, but better not to guess which ones might carry "old water."