# Discriminating High Natural Background and Contaminant Sources at the Fry Canyon Uranium Upgrader and Copper-Uranium Heap Leach Site, Southeastern Utah, U.S.A.

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Discriminating background uranium (U) concentrations from U contamination is important in establishing the extent of contamination at sites of historic U mining or processing and for assigning reasonable cleanup standards at such sites. The Fry Canyon project site in San Juan County, southeastern Utah, was affected by processing of uranium and copper-uranium ores from 1957-1968. Relict uranium tailings and related pits occupy a bench adjacent to the modern channel of Fry Creek, and a large copper heap-leach pile sits on bedrock just south of this bench.

Bedrock at the site in Fry Canyon, consisting of the Cedar Mesa Sandstone Member of the Permian Cutler Formation (U < 1 ppm), is covered by reddish-brown eolian sand, colluvium, and alluvium. Surface and ground-water samples collected upvalley from the site are Na-$H_2CO_3$-$SO_4$ waters that range from 44-70 μg/L U (USEPA drinking water standard for U is 30 μg/L). These high natural background levels may result from the leaching of uranium from the eolian sediments and from mudstones of the Triassic Chinle Formation exposed along the valley walls. Ground water beneath the ponds on the bench ranges from 770-18,700 μg/L U. These contaminated waters become more dilute as they move downvalley and enter the waters and modern alluvium of adjacent Fry Creek, its surface water, as well as the broader, deeper alluvial paleochannel that underlies the modern creek channel and adjacent terraces and benches. Water from monitoring wells at one terrace approximately 0.4 km downstream contains from 380-578 μg/L U. Contaminated surface water ranges from 150 μg/L near the site to ~250 μg/L near the highway bridge 3.3 km downvalley. The increase is likely due to evaporative concentration. Evidence of uranium contamination based on U concentrations can be further confirmed and quantified using U isotope measurements. The $^{234}U/^{238}U$ isotope

activity ratios for background water (seven upstream water samples) average 1.235±0.069, and for site water samples (four wells) the average is 0.939± 0.011. Mixing calculations show that the downstream monitoring wells contained 78-87% site-derived U, and in downstream surface water U was ~67% site-derived regardless of the degree of evaporative concentration.

The most U-rich (18,700 ug/L) well water on the site displays distinctive Ca-Mg-$SO_4$-dominant chemistry, indicating that some uranium may have been derived from heap leaching of Cu-U ores with sulfuric acid. This same water has strongly negative $\delta^{34}S$ of sulfate (-13.3 ‰) compared to most local waters of -2.4 to -5.4 ‰. Stream sediments show dispersion of particulate contaminants; for example, particles of chalcopyrite (CuFeS) and variably weathered pyrite ($FeS_2$) were identified in tailings at the site and also in stream sediments 1.3 km downstream based on inspection of polished grain mounts of magnetic mineral separates.

The methods used in this study to characterize and trace contamination are applicable at other sites of uranium mining, ore stockpiling, and processing. Measurements of U isotopes can be particularly useful for waters that are marginally contaminated in U compared to natural background (baseline) concentrations or where the presence of uranium-contaminated wastes (uranium ore or mill tailings) is alleged but not established.