Quantifying trade-off between number of bug flow days and hydropower objectives for Glen Canyon Dam, Arizona, USA

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ABSTRACT

U.S. Geological Survey's Grand Canyon Monitoring and Research Center (GCMRC) with inputs from Western Area Power Authority (WAPA) has been conducting summer flow experiments at Glen Canyon dam since 2018. Those experiments ensure low steady weekend releases, which encourages bug-eggs hatching process, and are known as "Bug Flow Experiment". Nevertheless, the exact benefits from the experiments are still unknown and the project is in trial phase. Here, we share results of a linear optimization model that helps quantify the effects of number of steady low bug flow days on hydropower revenue generation. The model runs for one month with two sub-daily timesteps and is subject to daily release limits, ramp rates, maximum energy generation, storage limits, and an exogenously specified monthly release volume. We used constraint method to identify the trade-off between the bug and energy revenue generation objectives. We tested scenarios that vary the month of the year, monthly flow volume, and energy price differential. Preliminary results show: 1) Increasing the monthly release volume simultaneously improves the bug and hydropower revenue generation objectives. 2) With current pricing template and price differential (i.e. weekends rate equals off-peak weekday price and almost 35$ or so price differential between on-peak and off-peak prices in June), low steady weekend releases generates maximum monthly revenues (existing release scheme) followed by decrease of almost 90 thousands dollars with each added steady bug flow day. This is a working document and materials will be updated over time based on work with GCMRC, WAPA, and others.

Release scheme of a dam is mostly driven by hydropower demands. For instance, the releases from Glen Canyon Dam, Arizona, USA fluctuates as much as 8000 cfs in a day. During daytime, the energy demand and prices remain high forcing more releases in comparison to nighttime. The

practice is known as hydropeaking, and widely applied these days throughout the world. Conversely, this artificial change in daily flow regime has affected most of the downstream eco-systems. For example, Stoneflies, Mayflies, Caddisflies, and Midges (affectionately "bugs") are food for the endangered native and non-native fishes of the Colorado River between Glen Canyon dam and Lake Mead, Nevada. These bugs lay their eggs at dusk on rocks and other strata just below the water surface and require days of inundation to hatch. But low hydropeaking releases during night desiccates them to death. During summer 2018, steady weekend releases experiment (Bug Flows experiment) was carried out by U.S. Geological Survey's Grand Canyon Monitoring and Research Center (GCMRC) to encourage bug egg hatching. However, still GCMRC and Western Area Power Authority (WAPA) are evaluating the effects of that experiment. Here we share results of a linear optimization model that helps quantify the effects of steady low bug flow days on hydropower revenue generation. The model runs for one month with two sub-daily timesteps and is subject to daily release limits, ramp rates, maximum energy generation, storage limits, and an exogenously specified monthly release volume. We used constraint method to identify the tradeoff between the energy revenue generation and bug objectives. We tested scenarios that vary the month of the year, monthly flow volume, number of steady bug flows days, and energy pricing templates. Preliminary results show: 1) Increasing the monthly release volume simultaneously improves the bug and hydropower revenue generation objectives. 2) With existing pricing template, making all weekends as steady low flow days will generate maximum monthly revenue. This is a working document and materials will be updated over time based on work with GCMRC, WAPA, and others.