

FILL MEAD FIRST:

a technical assessment

John C. Schmidt

with contributions from
Maggi Kraft, Daphnee Tuzlak, and Alex Walker

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Quinney College of Natural Resources
Utah State University

Executive Summary

The Fill Mead First (FMF) plan would establish Lake Mead reservoir as the primary water storage facility of the main-stem Colorado River and would relegate Lake Powell reservoir to a secondary water storage facility to be used only when Lake Mead is full. The objectives of the FMF plan are to re-expose some of Glen Canyon's sandstone walls that are now inundated, begin the process of re-creating a riverine ecosystem in Glen Canyon, restore a more natural stream-flow, temperature, and sediment-supply regime of the Colorado River in the Grand Canyon ecosystem, and reduce system-wide water losses caused by evaporation and movement of reservoir water into ground-water storage. The FMF plan would be implemented in three phases. Phase I would involve lowering Lake Powell to the minimum elevation at which hydroelectricity can still be produced (called minimum power pool elevation): 3490 ft asl (feet above sea level). At this elevation, the water surface area of Lake Powell is approximately 77 mi², which is 31% of the surface area when the reservoir is full. Phase II of the FMF plan would involve lowering Lake Powell to dead pool elevation (3370 ft asl), abandoning hydroelectricity generation, and releasing water only through the river outlets. The water surface area of Lake Powell at dead pool is approximately 32 mi² and is 13% of the reservoir surface area when it is full. Implementation of Phase III would necessitate drilling new diversion tunnels around Glen Canyon Dam in order to eliminate all water storage at Lake Powell. In this paper, we summarize the FMF plan and identify critical details about the plan's implementation that are presently unknown. We estimate changes in evaporation losses and ground-water storage that would occur if the FMF plan was implemented, based on review of existing data and published reports. We also discuss significant river-ecosystem issues that would arise if the plan was implemented.

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²For more information, contact Jack Schmidt
at jack.schmidt@usu.edu or 435-797-1791

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<https://qcnr.usu.edu/coloradoriver/futures>



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Implementation of Phase I of FMF would allow the flow regime of the Colorado River in Grand Canyon to be more natural, but only if hydropower generation does not follow daily and weekly demands. Implementation of Phase II of FMF would unavoidably create a less natural flow regime. The primary limitation to re-establishing a natural flow regime is the capacity of the facilities that release reservoir water downstream to the Grand Canyon ecosystem. The capacity of the penstocks that route water to the power plant have a capacity of ~31,500 ft³/s (cubic feet per second), and an additional ~15,000 ft³/s can be released

through the river outlets when the reservoir is at minimum power pool. However, the penstocks cannot be used when the reservoir is below minimum power pool, and the capacity of the river outlets decreases as reservoir elevation drops; the capacity of the river outlets is less than 5000 ft³/s when the reservoir is near dead pool elevation. Thus, the largest releases from Lake Powell could only be ~45,000 ft³/s during Phase I, even though typical incoming floods to Lake Powell exceed 50,000 ft³/s in most years. If Phase II was implemented and an attempt was made to maintain the reservoir at dead pool, releases downstream could be

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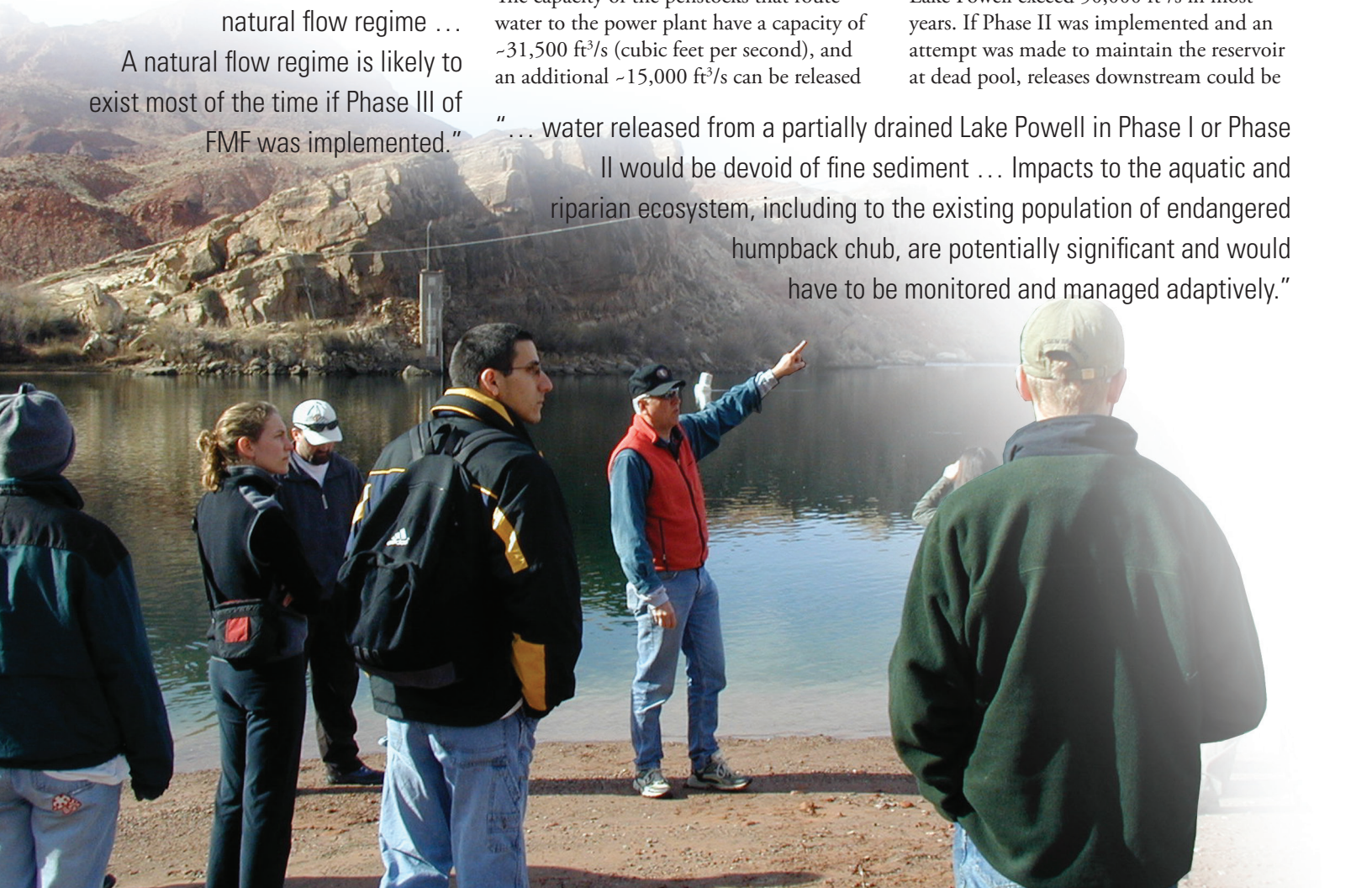




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only 5000 ft³/s. Whenever incoming floods to Lake Powell exceeded this flow rate, the temporarily drained reservoir would partially refill, especially during each year’s spring snowmelt season. In wet years, reservoir elevation would rise more than 100 ft to minimum power pool elevation, and floods of 45,000 ft³/s could occur, but only for as long as the reservoir remained above 3490 ft asl. A natural flow regime is likely to exist most of the time if Phase III of FMF was implemented.

A renewable supply of fine sediment is necessary to maintain Grand Canyon’s eddy sandbars that are used by river runners, create the architecture of aquatic habitat, and serve as a source of fine sediment to be redistributed by winds upslope to help protect archaeological sites. However, Phase I or Phase II would not change the existing condition of fine-sediment deficit that exists in Grand Canyon today, because water released from a partially drained Lake Powell in Phase I or Phase II would be devoid of fine sediment. Sediment eroded from the existing deltas in the Colorado River and San Juan River arms of Lake Powell would be re-deposited within the smaller Lake Powell, creating new, lower-elevation deltas in Glen Canyon. In Phase III, fine-sediment delivery into the Grand Canyon would probably be very large and would cause significant ecosystem adjustments associated

with the sudden change from relatively clear water to a very turbid river. Impacts to the aquatic and riparian ecosystem, including to the existing population of endangered humpback chub, are potentially significant and would have to be monitored and managed adaptively.

We estimate that there would be a small net decrease in total reservoir evaporation if Phase I or Phase II were implemented in comparison to present conditions. Implementation of FMF would decrease the combined surface area of the water stored in both reservoirs, and the evaporation rate from Lake Mead is not much more than from Lake Powell. However, the magnitude of the savings is less than the natural range in variability in evaporation. The rate of evaporation loss from Lake Mead has been measured by the U. S. Geological Survey (USGS) in a state-of-the-science program since 2010 (Moreo, 2013, 2015), and these measurements show that the annual evaporation loss rate is ~6.0 ft/yr and has varied between 5.5 and 6.4 ft/yr. There are no recent state-of-the-science measurements at Lake Powell; the average evaporation rate between 1965 and 1979 was 5.7 ft/yr and varied between 4.9 and 6.5 ft/yr. For purposes of public policy discussion, we conclude that there would be no change in evaporation losses if FMF was implemented.

Movement of reservoir water into the ground-water system that surrounds Lake Powell is inevitable. Most of the ground water that has already moved into storage would return to the Colorado River during a period of decades to centuries after FMF was implemented. A small proportion of the reservoir water that has moved into

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the surrounding bedrock has been a true loss from Lake Powell, but this water has seeped around Glen Canyon Dam and returned to the Colorado River immediately downstream from the dam. Only a small proportion of ground-water storage immediately moves out of the surrounding bedrock when the reservoir is drawn down. Extrapolation of the results of Thomas’ (1986) study concerning ground-water movement and storage north and west from Glen Canyon Dam and Wahweap Marina yields an estimate that between 2.1 and 9.0 million af moved into the bedrock surrounding Lake Powell between 1963 and 1983. Myers (2013a) estimated that ~12 million af moved into ground-water storage during that same period. Thomas’ (1986) study was based on analysis of data from wells and a numerical model that was state-of-the-science at the time the study was published, but this model has coarse resolution by today’s standards. Although there is large uncertainty in extrapolating Thomas’ (1986) results to estimate of the total amount of reservoir water that moved into ground-water storage in the entire Lake Powell region, it is unlikely that this water has irreversibly moved elsewhere in the region. Myers’ (2013a) study was based on a water-budget approach that also has large uncertainty. There is also very large uncertainty in estimating how long into the future reservoir water will continue to move into the surrounding bedrock. Thomas (1986) estimated that some movement of reservoir water into the surrounding bedrock would occur for a period of between 80 and 700 years, assuming that the reservoir stays full most of the time. Based on the best estimates of Thomas (1986), the long-term future rate of movement of



Photo by Michael Collier

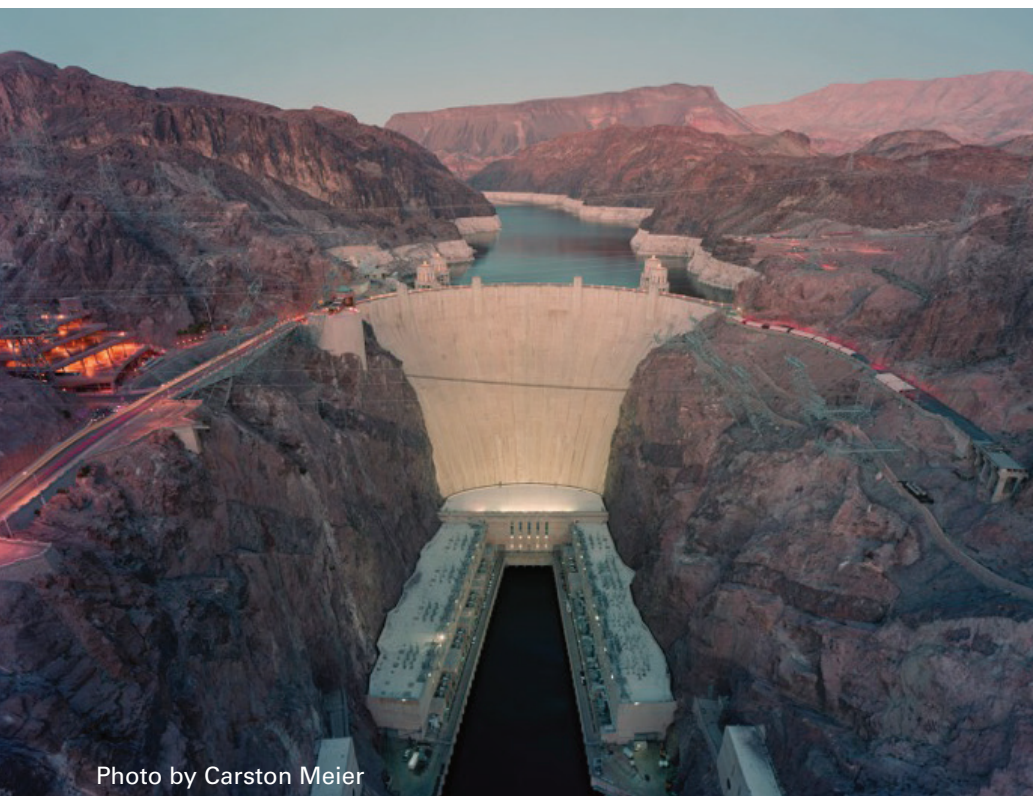


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be less than ~ 0.05 million af/yr ($\sim 50,000$ af/yr). It is a matter of public policy debate whether or not this magnitude of savings is sufficiently large to justify immediate reconsideration of many administrative and legal agreements concerning storage of water in Lake Powell and Lake Mead. At some time in the future, however, this magnitude of water savings might be viewed as sufficiently large to be worth serious engineering and scientific analysis and policy discussion. Now is the time to initiate new measurement programs of losses at Lake Powell and Lake Mead so that future policy discussions have access to less uncertain data regarding evaporation and ground-water storage. Initiation of a new measurement program of evaporation at Lake Powell, continuation of the present evaporation measurement program at Lake Mead, and initiation of a new phase of ground-water monitoring and modeling at Lake Powell and perhaps at Lake Mead would inform these discussions. Establishment of new observation wells further and to the south from Lake Powell, coupled by development of modern, state-of-the-science numerical models of ground-water flow, would allow more precise estimates of future movement of reservoir water into the surrounding ground-water system. Establishment of a new gaging station to reduce uncertainty in estimating the amount of unmeasured inflow to Lake Powell would allow a more accurate water budget to be developed. In addition, implementation of FMF would have to be preceded by predictive modeling of fine-sediment redistribution within a partially drained Lake Powell so that reservoir releases would not further degrade the Grand Canyon ecosystem. Collectively, these data, analyses, and modeling tools would empower future water resource decision-makers to make informed decisions about management of Lake Powell and Lake Mead.

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Assuming that movement of reservoir water into ground-water storage surrounding Lake Mead is small – an estimate suggested by water balance calculations but not yet verified by independent measurements of ground-water flow at wells – the projected water savings by implementing FMF would

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