Comprehensive Review of the Fill Lake Mead First Initiative

Trevor Carey
ECL 290
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Lake Powell

- Commissioned in 1966, full pool 1980

- 2nd largest man-made reservoir in United States (24.3 MAF)

- Important for water storage and power generation for the Western United States
Impacts of Lake Powell and Glen Canyon Dam

Fish

**Mollie & Aviva:** Showed the dam almost eliminated sediment flows, decreased river temp. and allowed for a more hospitable environment for non-native fish. **Vanessa:** Discussed how dams contributed the extirpation of native fish.

Water Rights

**Jesse & Jennifer:** Native American’s access to water rights in the upper and lower basin, (Navajo water rights are in the Lake Powell watershed).

Sediment

**Jeff:** Sediment regime of the lower basin has been completely altered by impoundment of Lake Powell. **Sarah:** How dams contributed to changes to riparian ecosystems. **Jasmin:** Using high flow experiments to redistribute sediment and create beaches.

Dam Operation

**Marisa:** Citizen science program looking at tidal effects caused by the dam.

Other

**Ann:** Habitat destruction of the Kanab Ambersnail from high flows.
Fill Lake Mead First Initiative

- Reservoir levels of both Lake Mead & Powell have been hovering around 50% full
  - Recent studies Barnett and Pierce (2008) and Kirk et al. (2017) showed reservoir levels will continue to decline, and hot drier conditions will be more common

- Drain water from Lake Powell to fill Lake Mead

- Glen Canyon dam would become a run of the river dam, with additional flood control capacity if needed

Data courtesy of water-data.com
Goals of FLMF

• First proposed by Glen Canyon Institute in 2013

• Identified 3 goals of the initiative:

  1. Save water by consolidating to one reservoir (300,000-600,000 AF/yr)
     • Water losses associated with seepage and evaporation
  2. Glen Canyon Recovery
     • How does accumulated sediment affect Glen Canyon recovery
  3. Colorado River restoration to pre-dam flows
     • Is it possible to restore the Colorado river to pre-dam flows, and sediment regime
Schmidt et al. (2016) summarizes the three stages of the FLMF.

- Goal was to determine if the proposed plan would restore the Colorado river to a pre-dam flow regime.
• Phase I:
  - Water is lowered to Elevation, 3490’
  - Minimum power pool elevation
    - Only can release 45,000 cfs
    - Cannot release expected inflows in high flow (normal?) years
FLMF Implementation Details

• Phase II:
  • Water is lowered to Elevation, 3370’
  • Dead pool elevation
    • Only can release 15,000 cfs
    • Almost impossible to control reservoir elevation, and does not restore flows to pre-dam conditions
Capacity of will outflow will be quickly exceeded

Reservoir elevation will rise significantly

Water level reaches Penstocks

Water level doesn’t reach starting elevation at year end

Schmidt et al. (2016)
• Phase III:
  • Diversion tunnels drilled, bypassing GCD
  • Pass expected peak flows
    • >25,000, 30,000, 50,000 cfs?
  • A 1978 USBR report concluded new tunnels would be costly
Water Loss of Lake Powell and Mead

• Change in reservoir storage ($\Delta S$) can be expressed with a water budget

\[
\Delta S = I + P \pm E \pm G - R - D
\]

GCI: Estimated 300,000-600,000 AF/yr water saving
Water Loss: Evaporation

- Background:
  - Difficult to measure
  - Significant year-to-year variation

- Evaporation = (Surface Area)(Evaporation Rate)

- Multi-year studies have been conducted to determine the evaporation rates of both reservoirs
Water Loss: Evaporation

• Evaporation Rate Studies

• Lake Mead:
  • Anderson and Prichard (1951) = 5.3 ft/yr
  • Harbeck et al. (1958) = 7.1 ft/yr (in 1953)
  • Harbeck et al. (1958) = 7.0 ft/yr (1941-1953)
  • Westenberg et al. (2006) = 6.7 ft/yr (1953-1973)
  • Westenberg et al. (2006) = 7.5 ft/yr (1997-1999)
  • Lake Mead (2010-2015) most probable average annual rate = 6.2 ft/yr

• Lake Powell:
  • Jacoby et al. (1977) = 5.8 ft/yr (1962-1975)
  • Reclamation (1986) = (using Jacoby et al. data) 5.7 ft/yr
  • Lake Powell (1965-1979) average annual rate = 5.7 ft/yr
Water Loss: Evaporation

- Schmidt et al. (2016) incorporating the uncertainty of measurements provided estimates of evaporation

<table>
<thead>
<tr>
<th>Evaporation</th>
<th>Current</th>
<th>Phase I</th>
<th>Phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Powell</td>
<td>570,000 (±80,000)</td>
<td>280,000 (±40,000)</td>
<td>120,000 (±15,000)</td>
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<tr>
<td>(AF)</td>
<td></td>
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<tr>
<td>Lake Mead</td>
<td>560,000 (±40,000)</td>
<td>820,000 (±60,000)</td>
<td>870,000 (±70,000)</td>
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<tr>
<td>(AF)</td>
<td></td>
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<tr>
<td>Total (AF)</td>
<td>1,100,000 (±200,000) (±100,000)</td>
<td>1,100,000 (±100,000)</td>
<td>1,000,000 (±100,000) (±200,000)</td>
</tr>
</tbody>
</table>
Water Loss: Seepage

• Background:
  • Porous (Navajo) sandstone beneath Lake Powell
  • Beneath Lake Mead is volcanic rock

• Lake Powell GW Studies:
  • Jacoby et al. (1977)
    • 0.85 MAF (1963-1966)
    • 0.69 MAF (1968-1971)
    • 0.68 MAF (1971-1976)
  • Thomas (1986)
    • 0.37 MAF (1963-1983)
    • **0.05 MAF (1983-2033)**
    • 0.032 MAF (2033-2083)
Water Savings of FLMF

• Best Estimate:
  • Evaporation (100,000 AF) + Seepage (50,000 AF) = 150,000 AF
  • It should be known that the best estimate contains uncertainty

• Glen Canyon Institute estimated a potential water savings of about 300,000-500,000 AF per year
  • Assumes similar evaporation rates
  • Estimates much larger seepage losses in Lake Powell
Glen Canyon Recovery: Sediment Remobilization

- No estimate of the amount of sediment flowing into Lake Powell
  - Topping et al. (2000) estimated that 54–60 million mt/yr was transported through Glen Canyon to Lees Ferry (1949-1962)
- Concern with Phase I and II is sediment will be remobilized closer to the dam, into Glen Canyon
Sediment Remobilization

• Between 1999-2005 Lake Powell was lowered 55 m
• 84,000 AF sediment in the Colorado delta eroded.
  • 35% directly at the down of the delta, the rest much closer to the dam
• Similar conditions can be expected during drawdown of FLMF

Majeski, 2009
Ecological Concerns

• Only after Phase III is implemented would the river return to a natural flow regime

• The river would remain sediment deficient during Phase I and II
  • Under Phase III sediment will fill the Grand Canyon

• The river temperature would return to natural conditions in Phase II and III

• No known benefit or harm of native and non-native fish in the upper basin
Conclusion and Policy Discussion

• FLMF would save approximately 150,000 AF
  • Seepage into the surrounding at Lake Powell will only decrease with time.
  • More data is always better
  • Does the 150,000 AF saving warrant an overhaul ~100 years of policy?

• Unless Phase III is implemented, the river, and sediment regime will not be restored to pre-dam conditions

• Sediment will remobilize into Glen Canyon under Phase I & II. Under Phase III it could take decades to clear all sediment
References (In order of appearance)


References (In order of appearance)

- [12]: Reclamation. 1986. Lake Powell evaporation. Salt Lake City, Upper Colorado Regional Office report, 27 p. This estimate is based on the mass transfer method.
Required Energy for Pumping

• 9.81 J to lift 1 liter of water 1 m

Details:
• Elevation difference between Hoover and Glen Canyon Dam, 775 m
• A 2012 USBR report estimated the upper basin used 3.7 MAF in 2010

Total energy can be estimated:

\[
\left(\frac{1000 \text{ liters}}{1 \text{ m}^3}\right) \left(\frac{9.81 \text{ J}}{1 \text{ liter}}\right) \left(775 \text{ m}\right) \left[\frac{3.7 \text{ MAF}}{1 \text{ AF}}\right] \left[\frac{1233 \text{ m}^3}{1 \text{ AF}}\right] = 3.5 \times 10^{16} \text{ J}
\]

\[
\left[3.5 \times 10^{16} \text{ J}\right] \left[\frac{1 \text{ kwh}}{3.6 \times 10^6 \text{ J}}\right] = 9.7 \text{ Billion kwh} > 9 \text{ Billion kwh produced by the basin}
\]