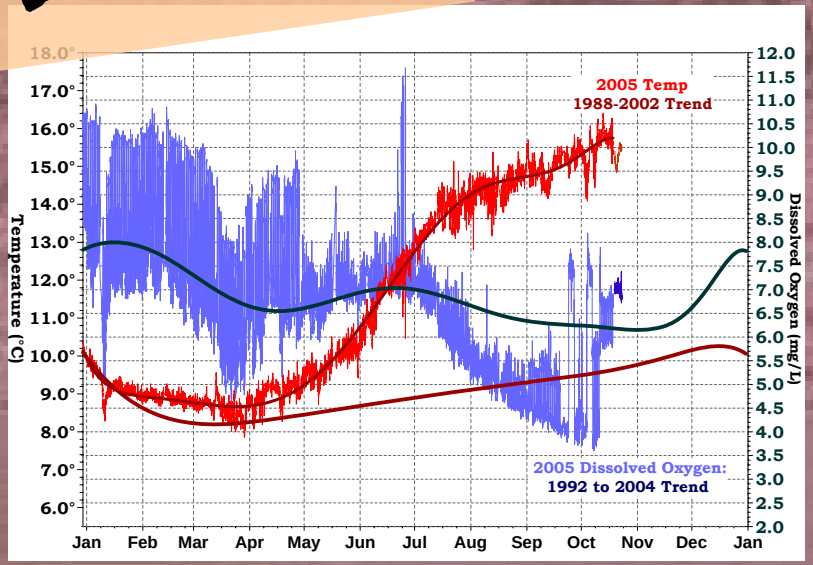
The Climatic Command & Control Lake Stage Experiment

Effects of Drought & 2005 Recovery on Lake Powell and its Tailwaters



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Grand Canyon Monitoring & Research Center

Southwest Biological Science Center

U.S. Department of the Interior
U.S. Geological Survey

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Effects of Drought & Recovery on Lake Powell and its Tailwaters

- Effects of climate on the hydrograph
- Climatic effects to Lake Powell stratification & dynamics
  - Low lake elevation
  - Oxygen demand from influx of organics and deltaic sediments
- Lake influences on Glen Canyon Dam releases
  - Tailwater & downstream warming
  - Decreasing dissolved oxygen

→A microcosm of adaptive management

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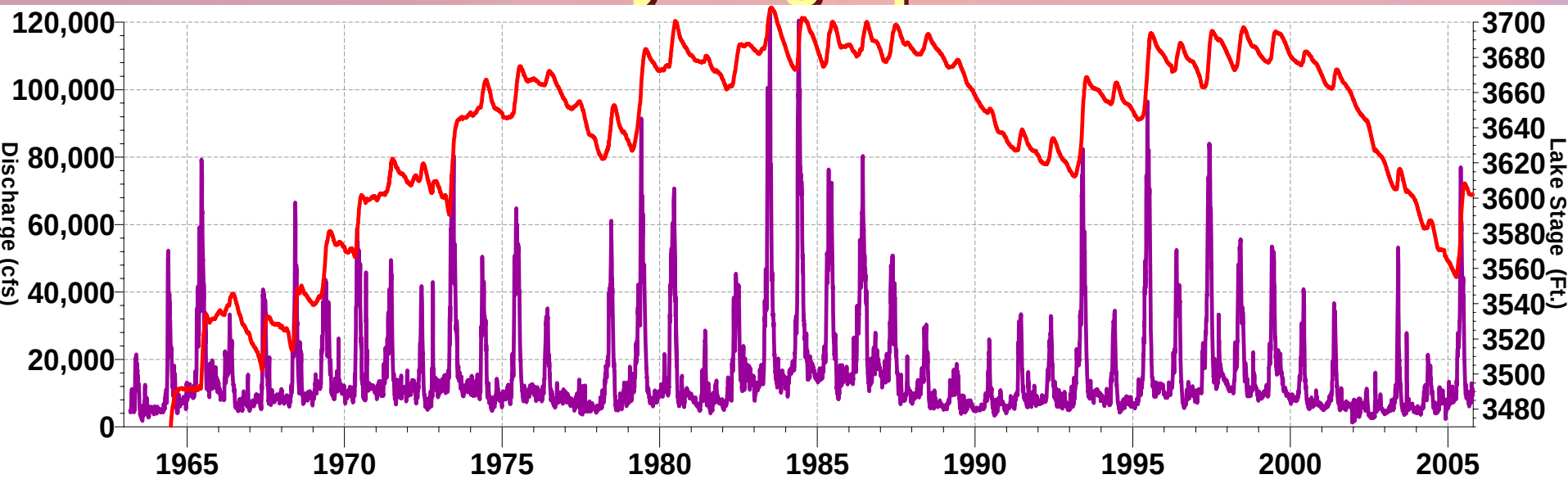
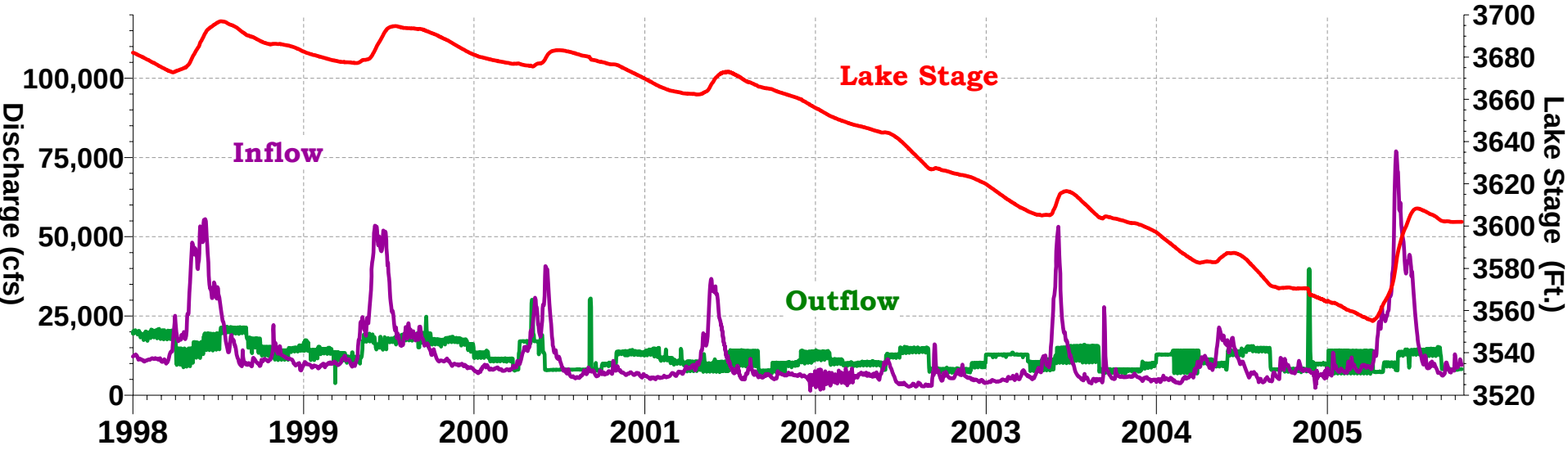
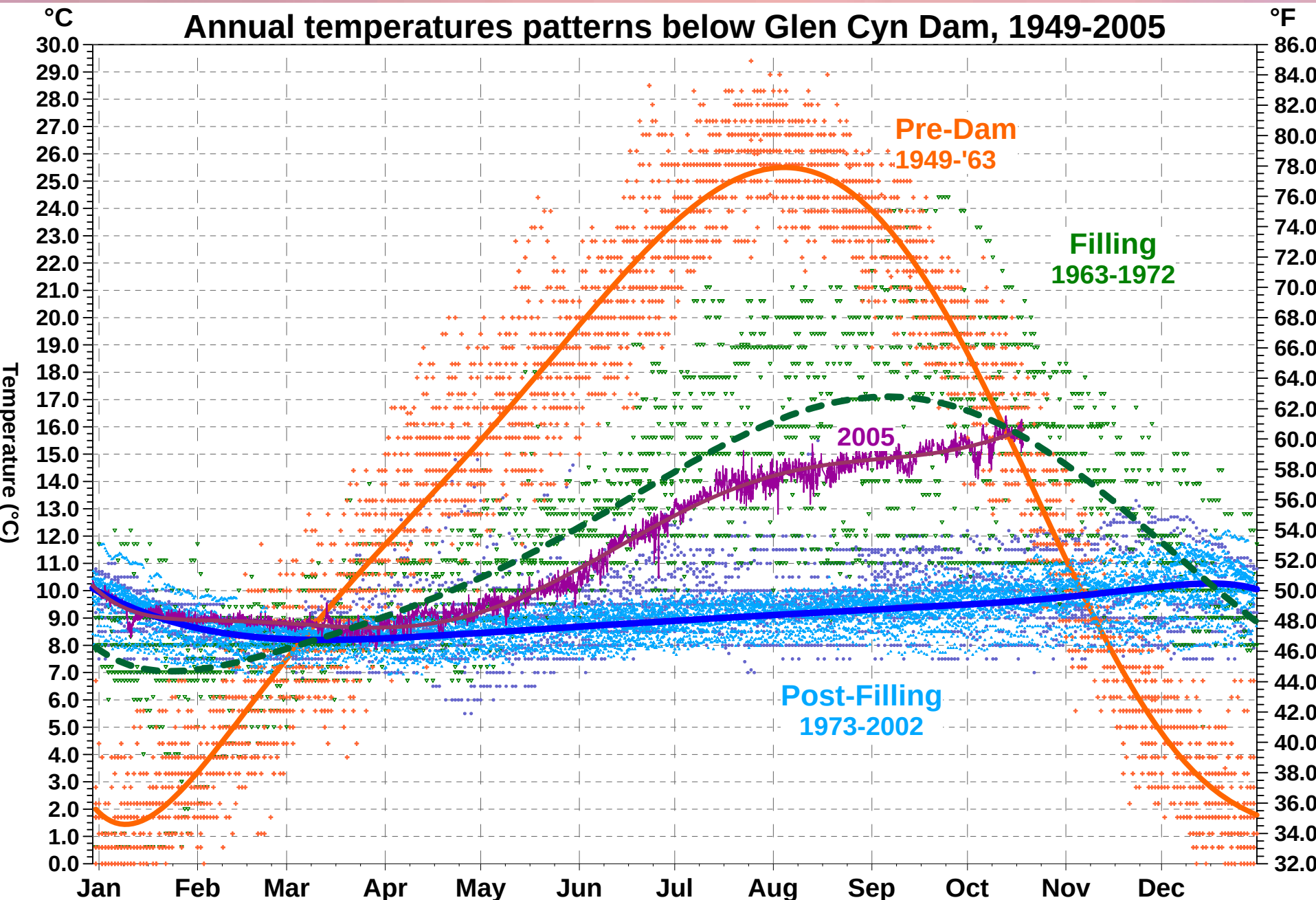
Climate and the Hydrograph

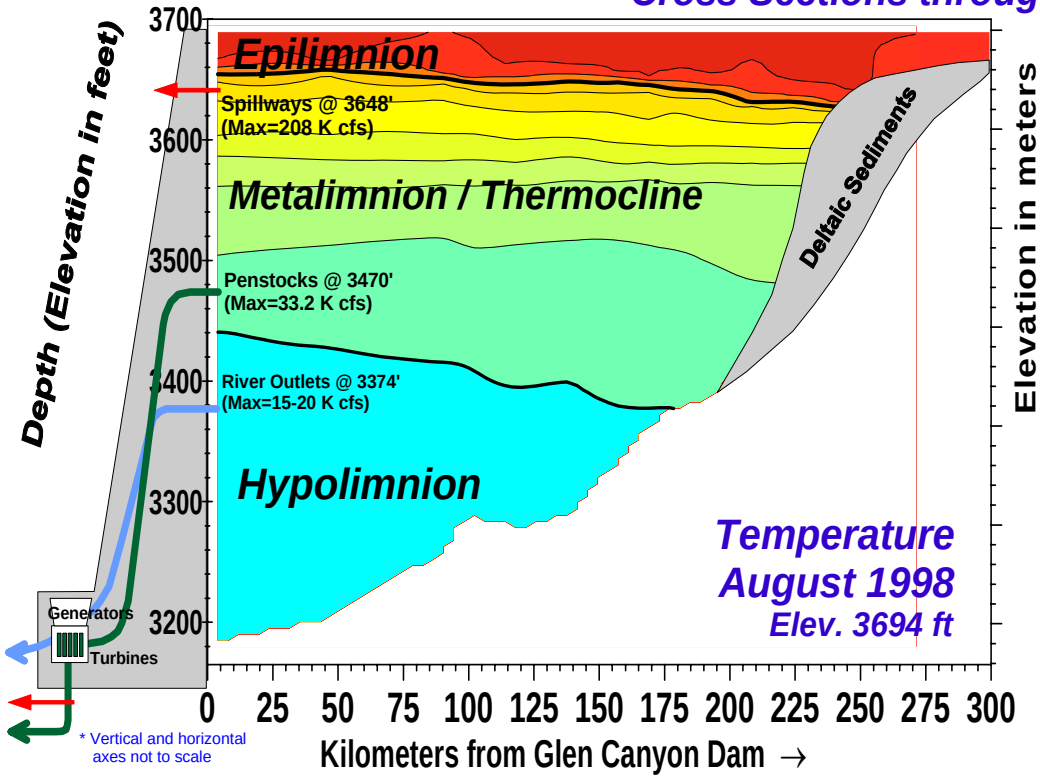




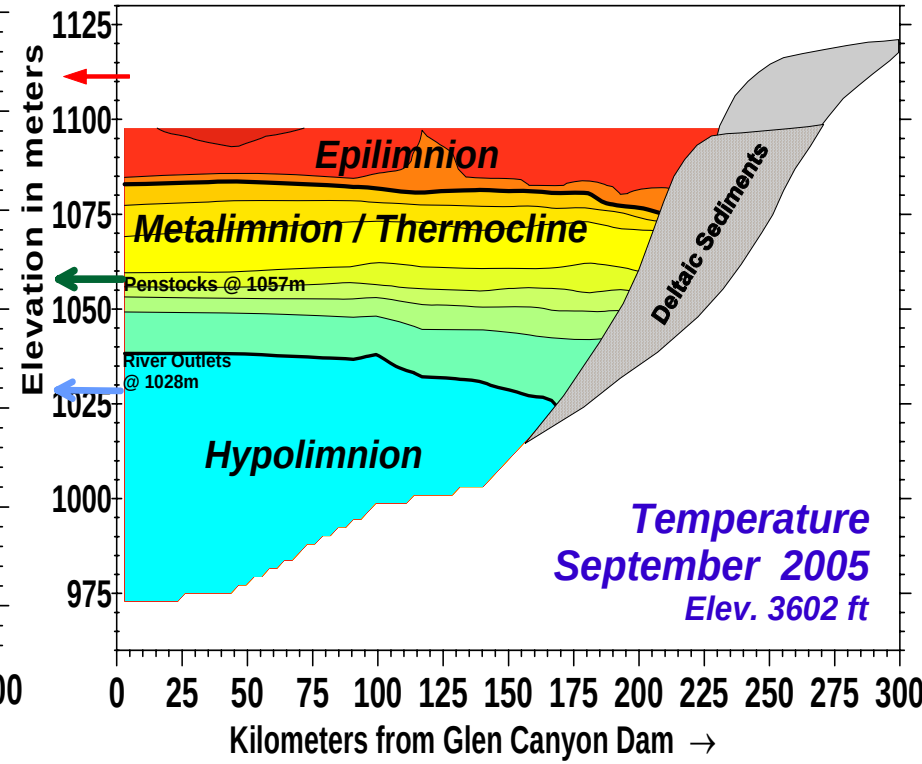
Historic Tailwater Temperature & Effects from the Drought:

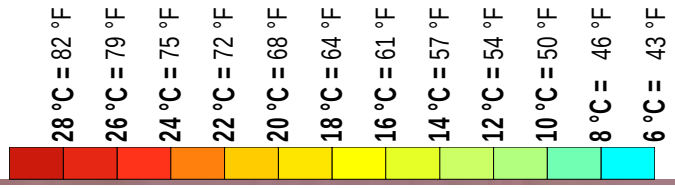


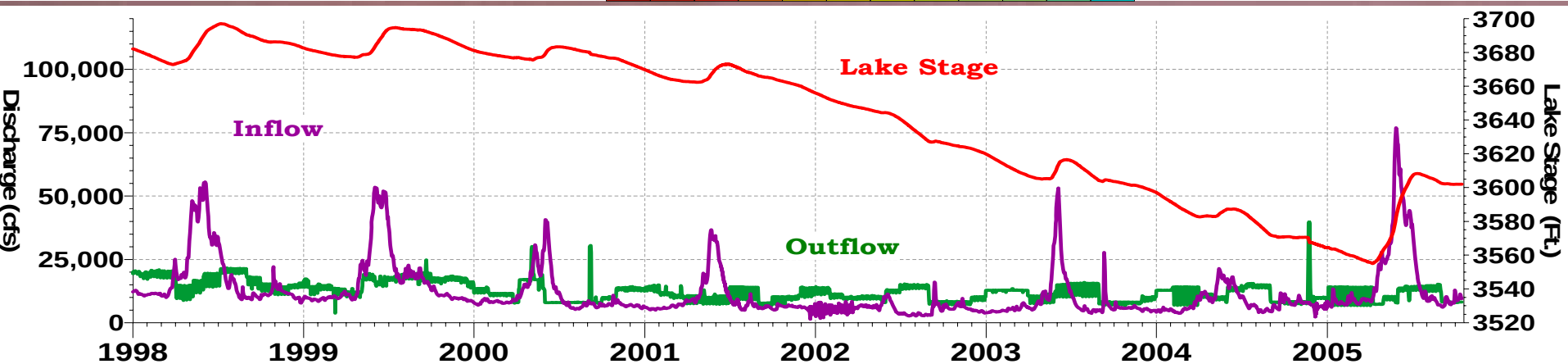
Cross Sections through Lake Powell *



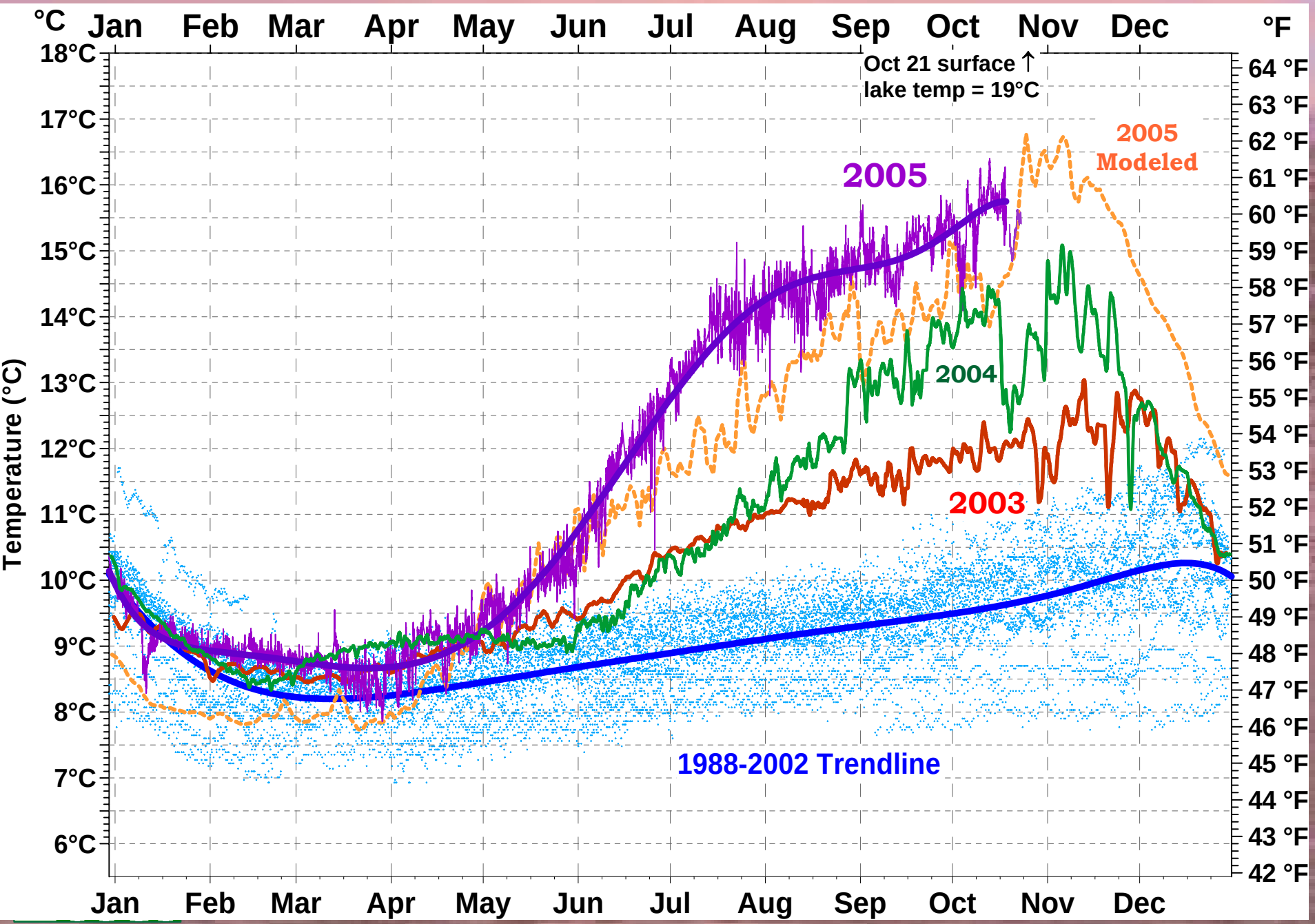
* Vertical and horizontal axes not to scale



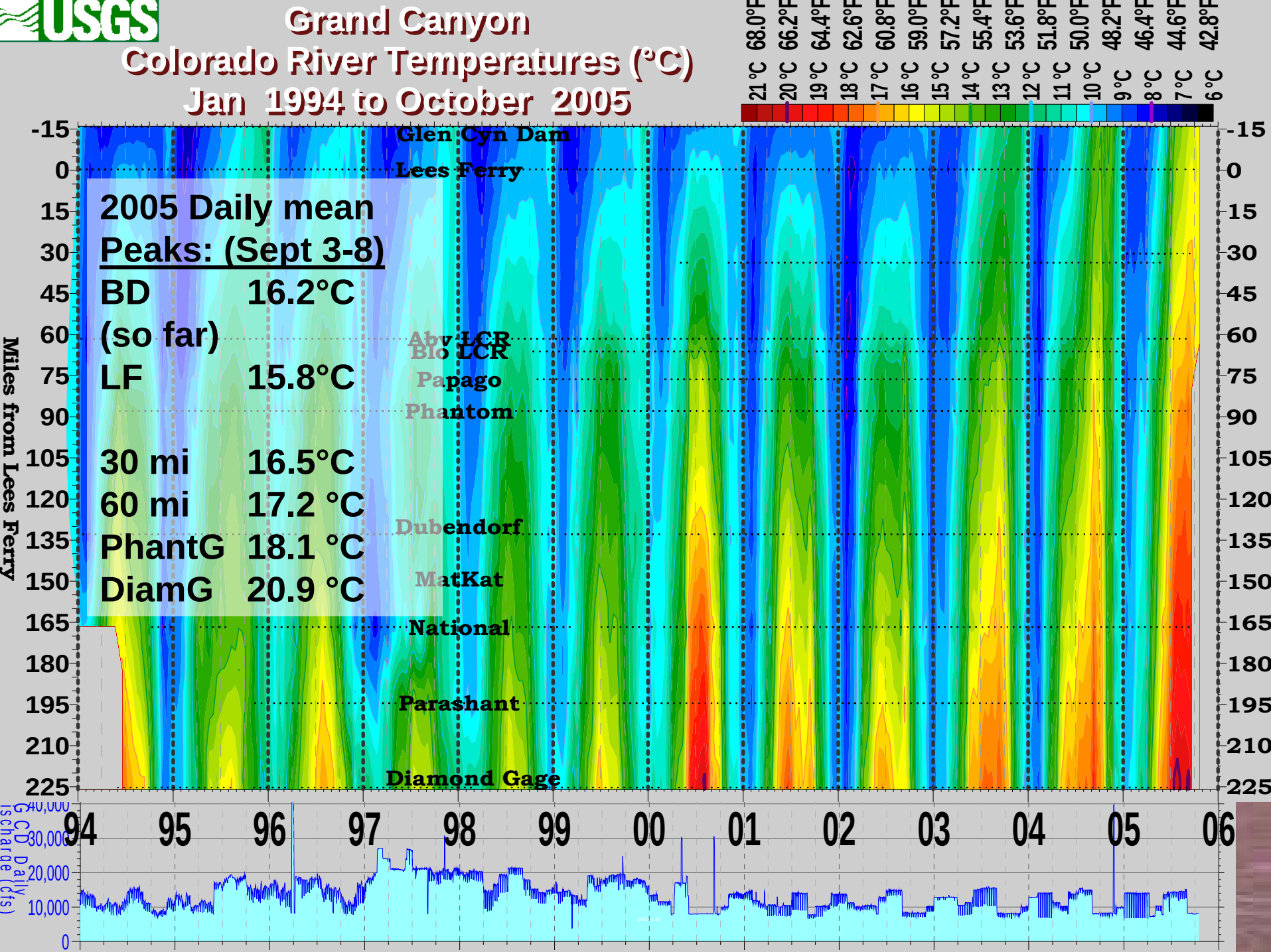




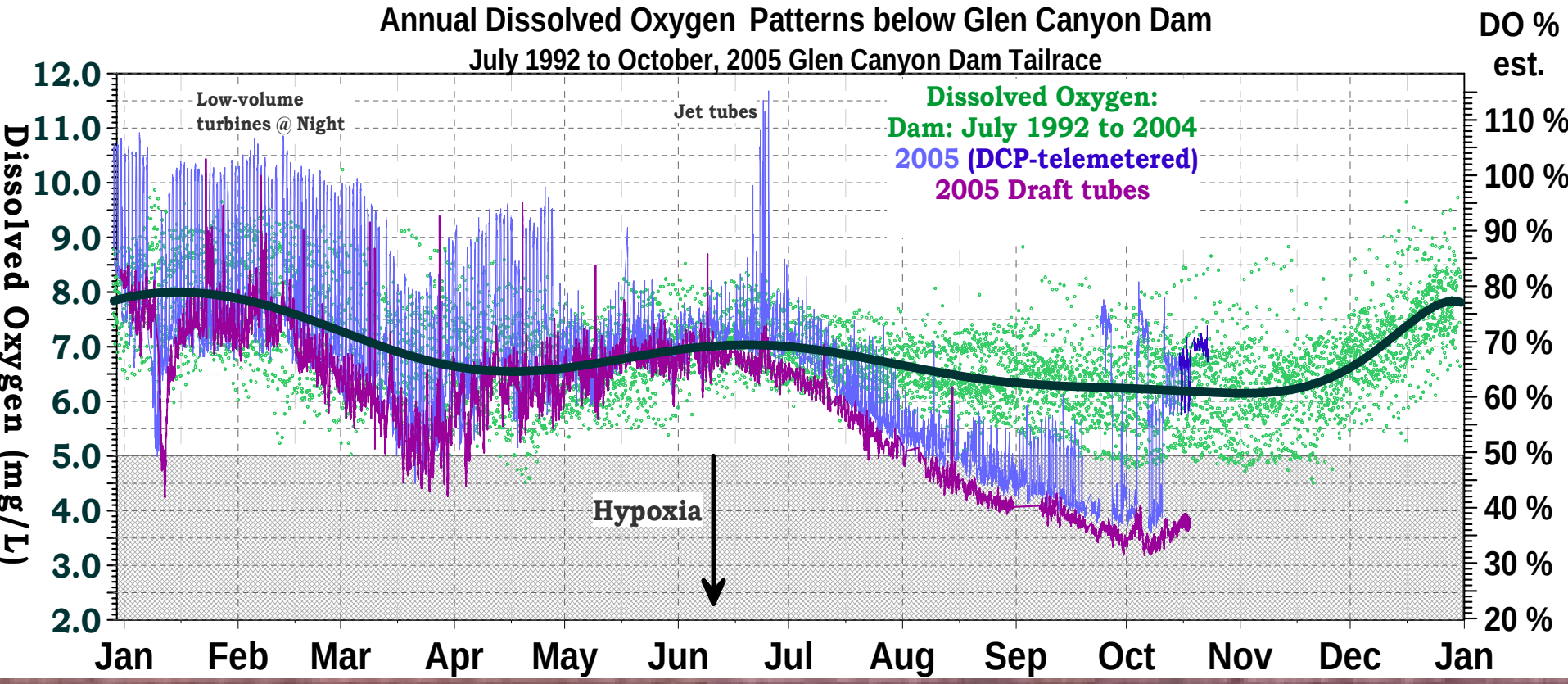
Release Temperature Patterns from Glen Cyn Dam: 1988-2005



Grand Canyon
Colorado River Temperatures (°C)
Jan 1994 to October 2005



Dissolved oxygen in the tailwaters



- Released dissolved oxygen levels have been dropping lower than any measured since 1992
- Warmer water increases system metabolism
- Lees Ferry fishers were concerned with damage to the tailwater trout fishery
- Ecosystem effects unknown

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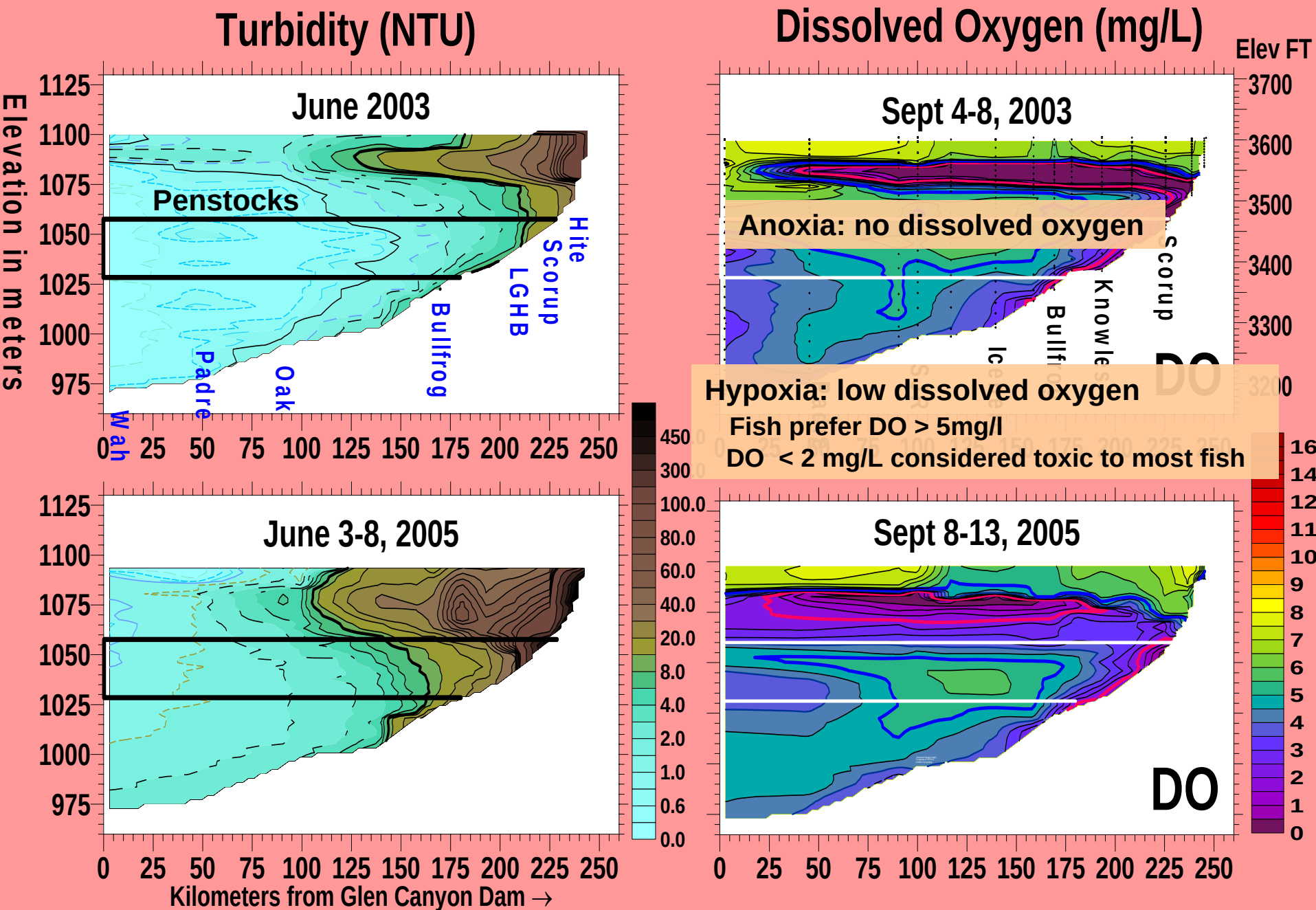
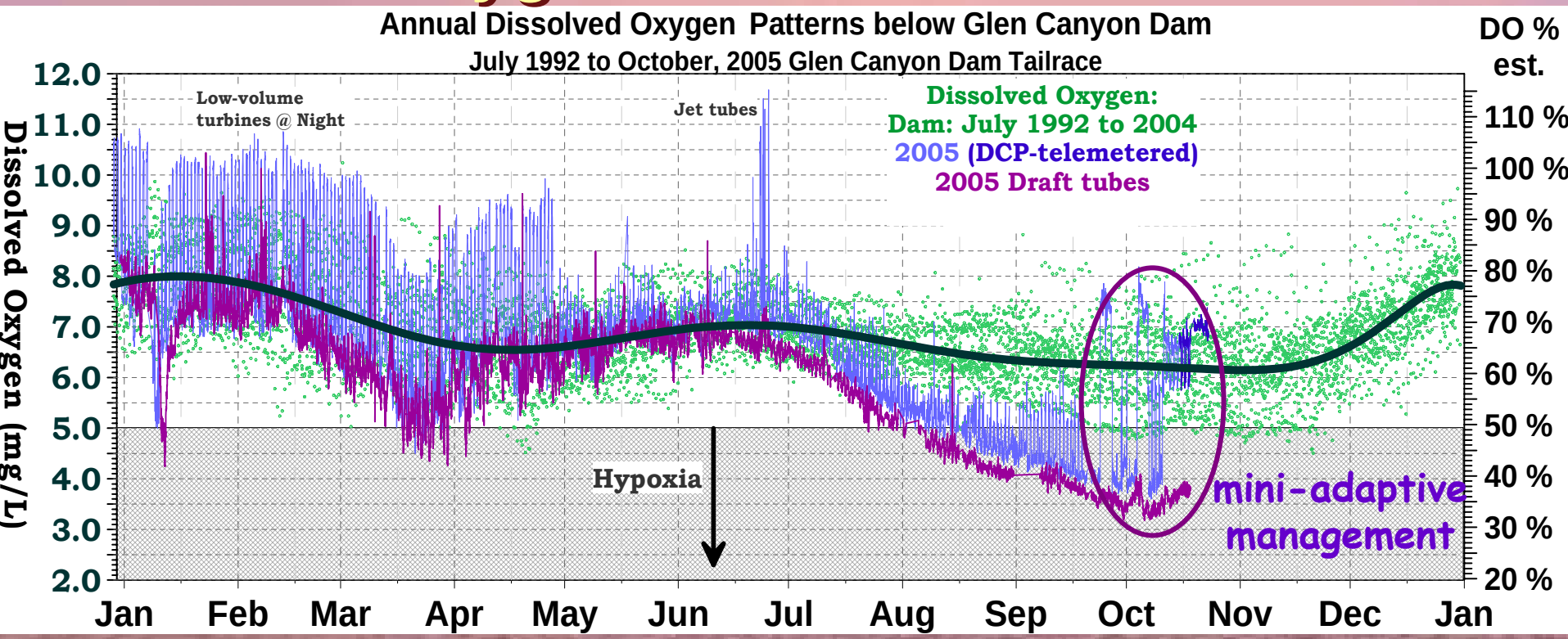
What conditions create low DO?



Dissolved oxygen in the tailwaters



- Dam operations appear to alleviate hypoxia, using either the powerplant or jet-tube bypasses
- Annual mixing of surface lake water from late October to December will eventually resolve tailwater hypoxia

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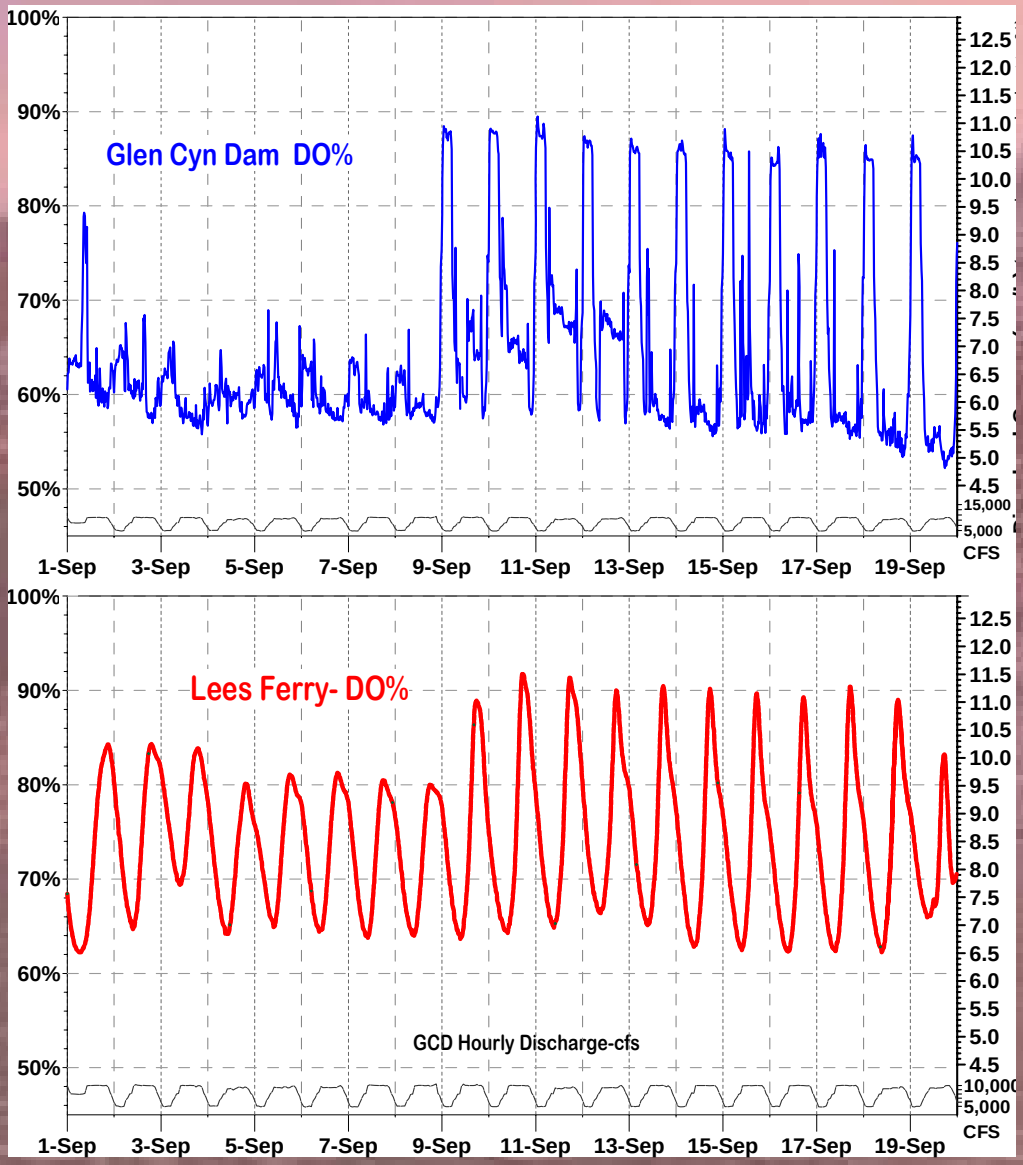
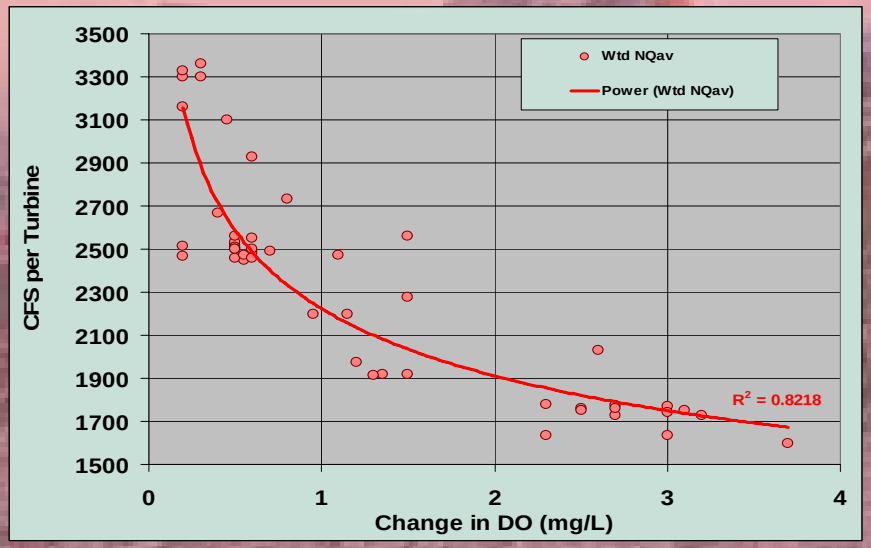
Tailwater dissolved oxygen, Sept 2004



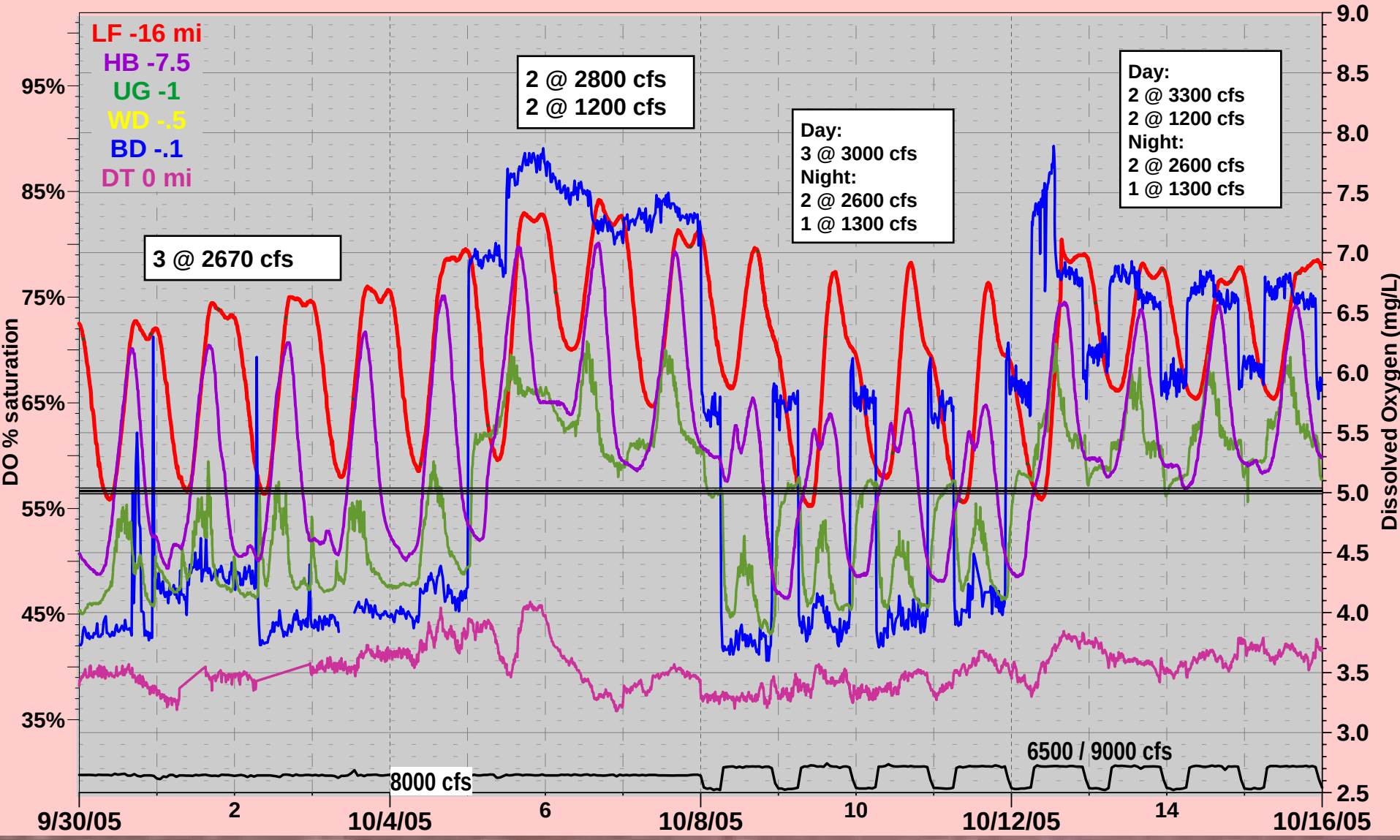
- Elevated spikes in dissolved oxygen have been observed at both the dam and Lees Ferry.
- Powerplant operations were implicated in aeration of the releases.

Change in released dissolved oxygen below the dam vs. Turbine discharge

- Using individual turbines at lower discharges (<~1700 cfs) appeared to aerate release water.
- Interested parties proposed to use more turbines at lower levels to increase downstream oxygen & reduce jeopardy to the tailwater ecosystem.
- However, “restricted gate” operations coincide with inefficient turbine use and damage to turbine components



Aeration of the tailwater using powerplant operations:



Effects of Drought on Lake Powell and its Tailwaters: the Future...

- Q: Will warming occur next year?
- A: Likely: the degree of warming will depend on elevation of the lake, and the warm surface water's access to the penstocks. I.e..
  - Lower lake elevations
  - Low lake elevations with another larger inflow event; or
  - Much lower lake elevations

- Q: Will oxygen diminish in the future?
  - Yes, in March - April when hypoxic water upwells from the hypolimnion.
  - Likely again with another large influx of organic matter and deltaic sediments, depending on the proximity of the hypoxic plume to penstocks

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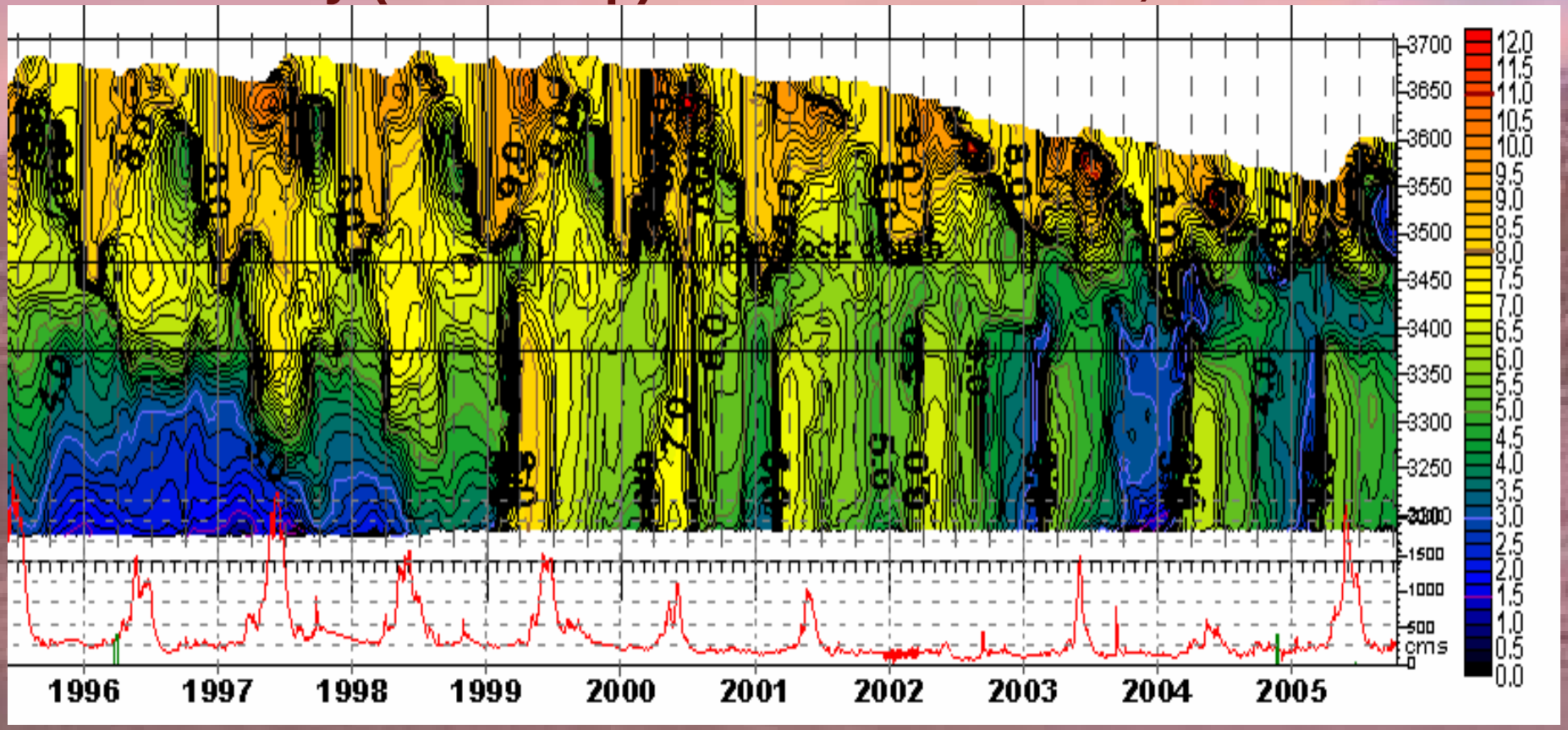
Dissolved oxygen (mg/L) patterns at Glen Canyon Dam forebay (Wahweap) 1996- October 12, 2005



- Hypoxia occurs annually the near the surface and at depth
- 2005 hypoxia impinging on penstock depth
- Fall-winter mixing refreshes surface oxygen.
- Fall surface hypoxia contributes to winter hypolimnetic hypoxia

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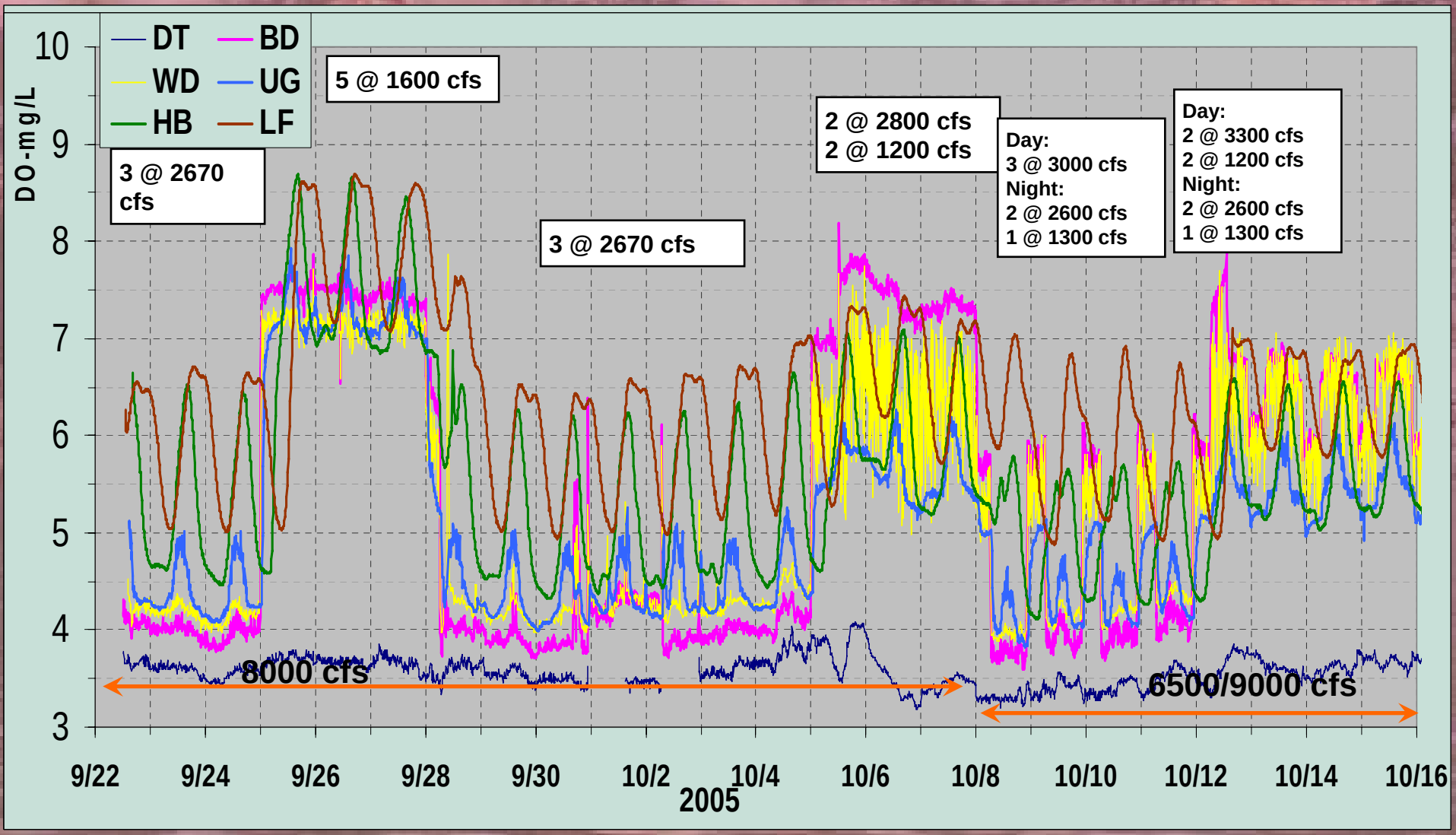
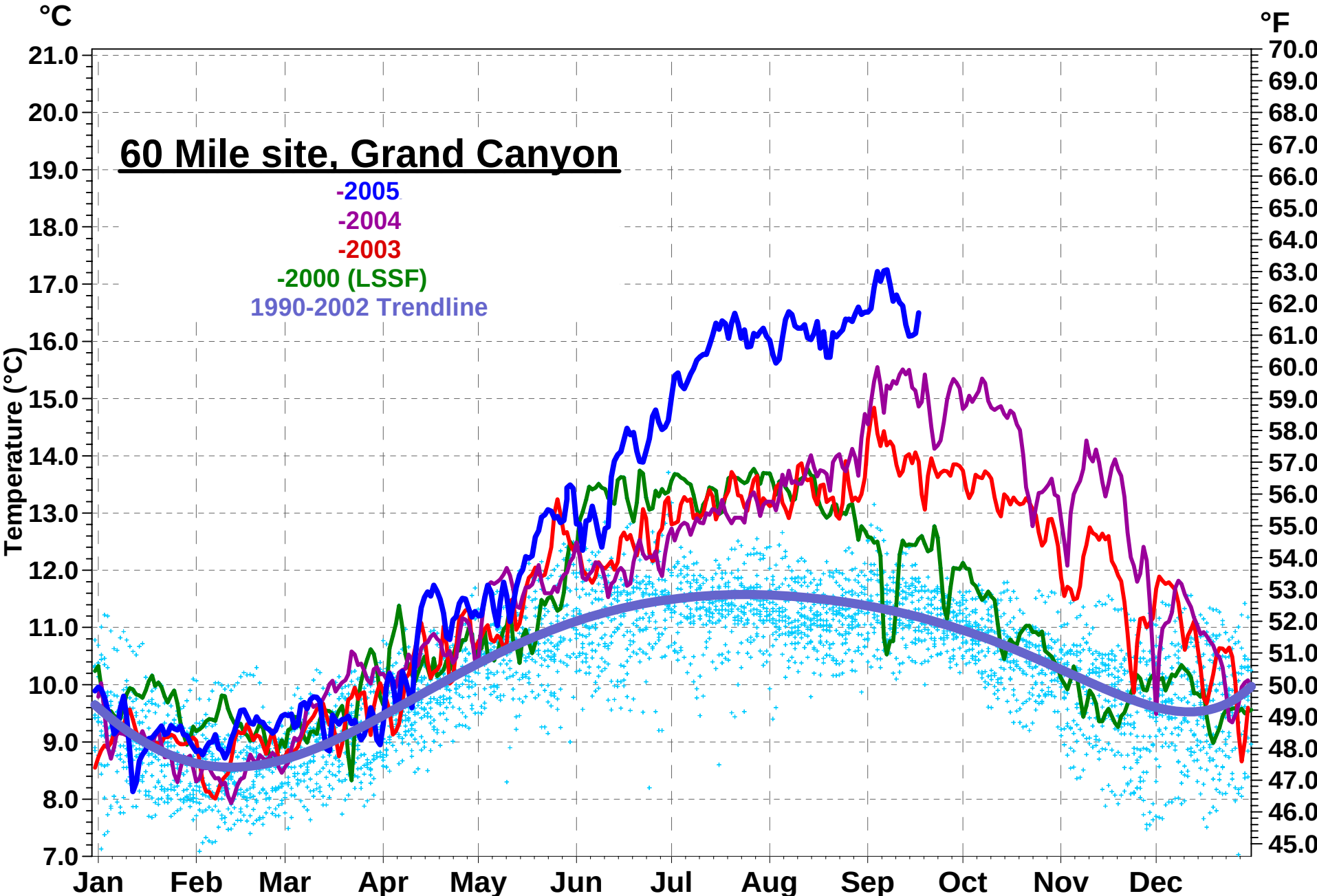
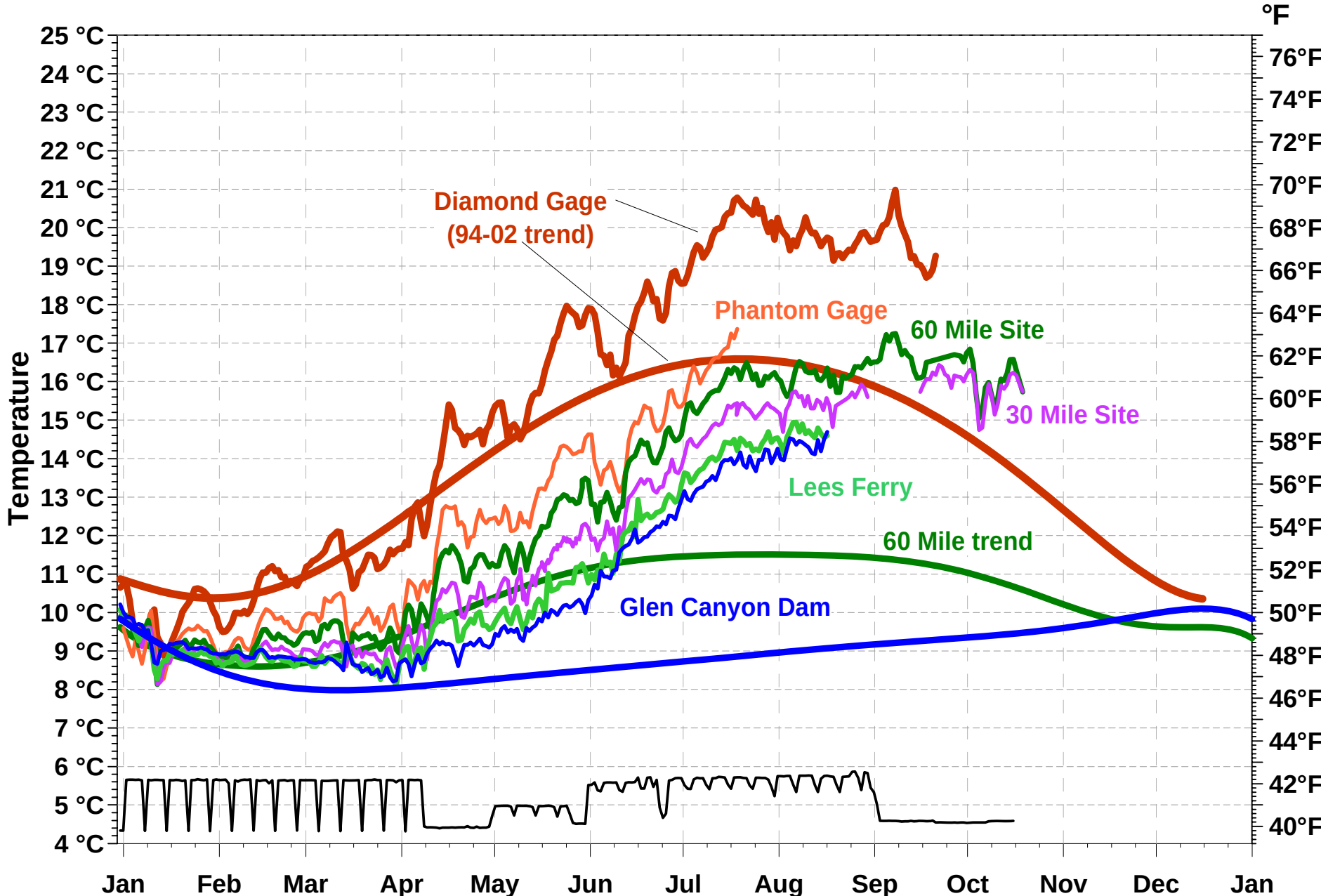
Adaptive management of the dam for aeration



Mean Daily Temperatures in the Colorado River in Grand Canyon 1990 to 2005



Daily Mean Temperature from G.C. Dam to Diamond Gage, 2005