Predicted Effects of a Spring Disturbance Flow on LTEMP Resources—a report by the FLow Ad Hoc Group (FLAHG) of the Glen Canyon Dam Adaptive Management Program

I. Background
Disturbance is a critical natural process in streams and rivers (Resh and others 1988, Poff and others 1997). By disrupting ecosystem structure and altering the availability of substrates and resources, flood disturbance helps maintain native biological diversity (Bunn and Arthington 2002, Carlisle and others 2017). Disturbance magnitude, for example the extent of drying at low flow or the proportion of the bed that is mobilized at high flows, can influence ecosystem outcomes by, for example, determining the extent of biomass loss and the quantity of newly scoured habitat patches available for recolonization by algae and aquatic insects (Lake 2000). Disturbance frequency and timing (e.g., spring vs. fall) can also influence the rate and trajectory of ecosystem recovery from disturbance (Figure 1 and Lytle and Poff 2004). The life cycles of many species of algae, insects, and fish are directly tied to flood disturbances (Lytle and Poff 2004) and alterations to river flood regimes can adversely affect ecosystem health. In fact, a national synthesis of flow and biological data from over 700 streams and rivers in the lower 48 states found that healthy communities of native aquatic invertebrates and fish were most often present where flood disturbance still occurred, and where flood timing was seasonally appropriate (i.e., similar to the natural condition; Carlisle and others 2017). Although the Colorado River in Grand Canyon could not be included in this 2017 synthesis owing to the absence of pre-dam ecological data, the mechanisms linking periodic flow disturbance to stream ecosystem health were evaluated in a wide variety of streams and regions (Carlisle 2020). It is therefore reasonable to predict that similar mechanisms linking appropriately timed flow disturbance to ecosystem health also operate in the Colorado River.

Figure 1. Conceptual figure showing the potential role of spring disturbance in enhancing natural processes (e.g., algae and aquatic insect production) of the Colorado River ecosystem.
Outline

- Background (5 slides)
- FLAHG hydrograph (3 slides)
- Knowledge Assessment (14 slides)
- Contingencies, conclusions (5 slides)
Spring floods = healthy ecosystems

“...the apparent nationwide importance of high flows in spring (March, April, May) also indicates that the timing...of high flows is critical.”

Daren Carlisle, June 2020 TWG Presentation
Regular Testing of Fall HFEs

<p>| | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>2001</td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
<td>2005</td>
<td>2006</td>
<td>2007</td>
<td>2008</td>
<td>2009</td>
</tr>
</tbody>
</table>

Preliminary results subject to review and revision
Some benefits of regular Fall HFE testing

Reduced critical uncertainties for HFE → sediment

Sandbar resource improved

Preliminary results subject to review and revision
Why so few Spring HFEs?

- They were prohibited
  - 2011 HFE EA initially prohibited
  - 2016 LTEMP extended thru 2019

- Why prohibit Spring HFE?
  - Study HFE → sandbar w/o creating RBT at LCR
    - Key finding from 2008 spring HFE

- Prohibitions were superfluous
  - Spring sediment trigger not reached in 8 years
    - See Grams and Topping, June 2020 TWG presentation

Preliminary results subject to review and revision
A Path Forward
FLow Ad Hoc Group (FLAHG) formed in 2019
“As a starting point, the FLAHG shall consider the benefits of and opportunities for conducting higher spring releases within power plant capacity” –FLAHG charge
Proposed FLAHG hydrograph

- **Spring disturbance flow (March proposed)**
- **Apron repair is unique opportunity**
  - 5 days at 4,000 ft³/s for dam maintenance
  - **Low flows = disturbance**
- **Combine with spring pulse flow disturbance**
  - low + pulse >> low OR pulse alone

Preliminary results subject to review and revision.
Why March?

- **Keep it simple...**
  - Prior Spring HFEs (‘96 & ’08) were in March
  - Favorable natural process response documented
  - Simplifies comparison of FLAHG & HFE data
  - Avoids commercial motor season in April

---

Down the road....Could explore April, May, or June disturbance flows
But for right now (FLAHG hydrograph) March makes a ton of sense.
Desiccation & scour potential

**Low Flow = Desiccation**

**In a nutshell**
Large area change between 4,000 and 8,000 cubic feet per second (cfs)
- Change in area = metric of drying potential

Cobble hotspots:
27% of habitat exposed to drying
Reach wide:
12% of habitat exposed

Fun fact: Flow of 4000 cfs last occurred in early 90s

**Pulse Flow = Scour**

**In a nutshell**
Shear stress = shearing force of water on bed
- Direct measure of scour potential

Cobble hotspots:
~5% increase in scour at 20,000 vs. 25,000 cfs
Reach wide: ~13% increase in scour

Fun fact: Since '96, flows of 20,000 cfs or greater have occurred just ~7% of the time.

---

Cobble hot spots
- Average: -27%
- Range: -16 to -36%

Range of possible Spring Pulse Flow

USGS

Preliminary results subject to review and revision; pers comm Scott Wright
Why a Knowledge Assessment?

- Stakeholder requested
- Forces communication among scientists
  - Must work in groups, think deeper, get in weeds
- Facilitates communication with stakeholders
  - Translate science with easy-to-understand symbols
- Rubric updated in 2017 & 2019
  - Clear definitions and guidance for scoring
  - Relatively quick and easy to conduct

Preliminary results subject to review and revision
Knowledge Assessment Teams

- **Cultural & Archaeological**: Peter Bungart, Jen Dierker, Jakob Maase, Joel Sankey
- **Natural Process**: Ted Kennedy, Jeff Muehlbauer, Bridget Deemer, Jess Gwinn, Larry Stevens
- **Humpback chub**: Charles Yackulic, Kirk Young, Mike Yard, Maria Dzul
- **Hydropower & Energy**: Craig Ellsworth, Leslie James, Lucas Bair
- **Other Native Fish**: Brian Healy, Melissa Trammel, Bob Schelly, Charles Yackulic, Mark McKinstry
- **Recreational Experience**: Lucas Bair, Kim Dibble, Jim Strogen, David Brown, Leslie James, Craig Ellsworth, David Rogowski
- **Sediment**: Paul Grams, David Topping, Lucas Bair, Matt Kaplinski, Joe Hazel, David Brown, Ben Reeder
- **Tribal Resources**: Peter Bungart, Jakob Maase
- **Rainbow Trout Fishery**: Kim Dibble, Charles Yackulic, Mike Yard
- **Nonnative Invasive Species**: David Ward, David Rogowski
- **Riparian Vegetation**: Emily Palmquist, Brad Butterfield, Barb Ralston, Larry Stevens

33 participants from 12 different agencies:
Specific Measures = bookends

- Cultural & Archaeological: 5 measures
- Natural Process: 4 measures
- Humpback chub: 1 measure
- Hydropower & Energy: 5 measures
- Other Native Fish: 2 measures
- Recreational Experience: 7 measures
- Sediment: 3 measures
- Tribal Resources: 1 measure
- Rainbow Trout Fishery: 2 measures
- Nonnative Invasive Species: 2 measures
- Riparian Vegetation: NA

Example: Rainbow Trout Fishery
1) RBT at Lees Ferry
2) RBT at LCR

Lowest performing measure
Highest performing measure

Preliminary results subject to review and revision
Knowledge Assessment

- Used rubric from 2019
- Evaluated 3 management actions
  - Spring disturbance flow (FLAHG hydrograph)
  - Spring HFE
  - Fall HFE

Preliminary results subject to review and revision
Old KA Symbols

<table>
<thead>
<tr>
<th>Strength of Effect</th>
<th>Direction of Effect</th>
<th>Confidence in Strength &amp; Direction Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong Effect</td>
<td>Positive (Beneficial) Effect</td>
<td>High</td>
</tr>
<tr>
<td>Moderate Effect</td>
<td>No Effect</td>
<td>Medium</td>
</tr>
<tr>
<td>Weak Effect</td>
<td>Negative (Detrimental) Effect</td>
<td>Low</td>
</tr>
<tr>
<td>Strength of Effect Unknown</td>
<td>Direction of Effect Unknown</td>
<td>(n/a)</td>
</tr>
</tbody>
</table>

- Distaste for term 'confidence'
- Not intuitive what colors mean
- Distaste for arrows
- Not intuitive what outline means

Hard to visualize data, see patterns

Preliminary results subject to review and revision
New KA Symbols

Goals of Redesign:
1) Make symbols more intuitive,
2) Improve data visualization (i.e., quickly compare +/- of actions)

Dumbbell Size = Weight of evidence

Y-axis = strength

Stronger Effects

Fall HFE

Direction Unknown
Strengt Unknown
No Effect

Decreasing
Increasing

Preliminary results subject to review and revision
Lowest Performing Measure

Appears to be relatively low risk

Preliminary results subject to review and revision
Potential Decreases identified in KA

- **Hydropower & Energy**
  - Small decrease in ‘load following capability’ predicted

- **Other Native Fish**
  - Razorback spawning period, eggs may dry at 5d low flow

- **Recreational Experience**
  - Crowding and navigation risk during low flow

- **Sediment**
  - Small decrease in ‘total sand volume’ predicted

- **Nonnative Invasive Species**
  - Pierce Ferry may be barrier, low flow may allow greater movement

*Preliminary results subject to review and revision*
Highest Performing Measure (1)

Because sometimes ‘No Effect’ is a Win

Preliminary results subject to review and revision
No Effects identified in KA

- **Hydropower and Energy**
  - Electric generation not affected, no bypass, shoulder month

- **Other Native Fish**
  - No effect predicted, outside of spawning window for FMS/BHS

- **Sediment**
  - Volume of deposition/erosion small, bc pulse flow small

- **Nonnative Invasive Species**
  - Unknown effects, low confidence

Preliminary results subject to review and revision
Highest Performing Measure (2)

Some intriguing potential upsides

Preliminary results subject to review and revision
Potential Increases identified in KA

- **Cultural and Archaeological Resources**
  - Potential increase in available sand for aeolian transport

- **Natural Processes**
  - Potential increase in production & diversity of algae and insects

- **Humpback chub**
  - Potential indirect effect on HBC via food base

- **Tribal Resources**
  - Potential increase in ecosystem health

- **Rainbow Trout Fishery**
  - Potential indirect effects on RBT via food base, spawning

- **Nonnative Invasive Species**
  - Spring disturbance disfavors Brown Trout

Preliminary results subject to review and revision
Spring timing **does not** align with brown trout spawning calendar

From Dibble et al. 2015, *Ecological Applications*.

Preliminary results subject to review and revision.
FLAHG Hydrograph
Essential Context

- Provides ‘contrast’ to last 5 fall HFES
  - Key biology projects are poised to study

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>2001</td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
<td>2005</td>
<td>2006</td>
<td>2007</td>
<td>2008</td>
<td>2009</td>
</tr>
</tbody>
</table>

- 2009-Juvenile chub monitoring (JCM) starts
- 2010-Gross primary production monitoring starts
- 2012-Citizen science insect monitoring starts

Preliminary results subject to review and revision
FLAHG hydrograph will reduce uncertainties in particular, critical uncertainties for fish and aquatics will be reduced if FLAHG hydrograph tested and Project O funded.

Preliminary results subject to review and revision.
What about Bug Flows?

- Complementary? Yes
  - Bug Flows: Egg stage
  - FLAHG flow: Larval stage

- Complicating? Yes
  - Will make data analysis harder

- Confounding? No
  - Effects can be disentangled

**Bug Flows**
- Sine wave pattern
- Grand Canyon focus

**FLAHG flow**
- Insect, NZ mudsnail count
- Lees Ferry focus

*No (scientific) issues with FLAHG flow + Bug Flows in 2021*
FLAHG hydrograph qualitative narratives

### Tribal Resources
- Spring timing aligns with Father Earth's calendar

### Natural Processes
- Spring timing aligns with Mother Nature's calendar

### Recreational Experience
- Spring timing aligns with human calendar

Preliminary results subject to review and revision
Contributors

- USGS/GCMRC- Ted Kennedy, Lucas Bair, Bridget Deemer, Kimberly Dibble, Helen Fairley, Paul Grams, Jeff Muehlbauer, Emily Palmquist, Joel Sankey, Dave Topping, David Ward, Charles Yackulic, Mike Yard;
- USGS/CAWSC-Scott Wright
- Hualapai Department of Cultural Resources-Peter Bungart
- Western Area Power Administration-Craig Ellsworth
- Northern Arizona University-Brad Butterfield
- National Park Service-Brian Healy
- Grand Canyon Wildlands Council-Larry Stevens
- Colorado River Commission of Nevada-Peggy Roefer
Questions?

Preliminary results subject to review and revision.