Discussion of the Bug Flows Synthesis and Review & Opportunities for Spring and Summer Flow Experiments

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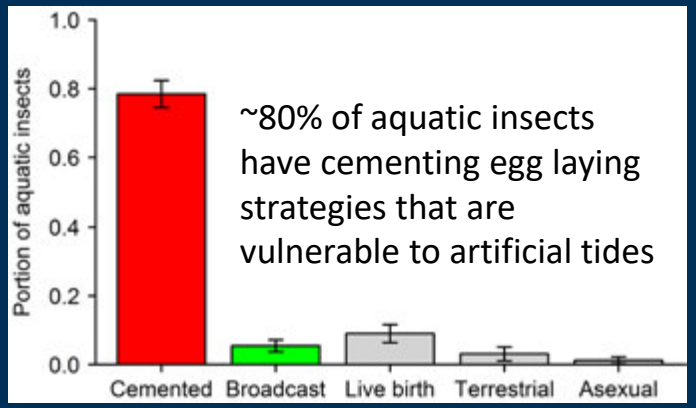
U.S. Geological Survey

Why Bug Flows?



~80% of aquatic insects have cementing egg laying strategies that are vulnerable to artificial tides

From Kennedy and others 2016, Bioscience

Year-round hydropower fluctuations do not support natural processes essential to diverse and resilient invertebrate assemblages

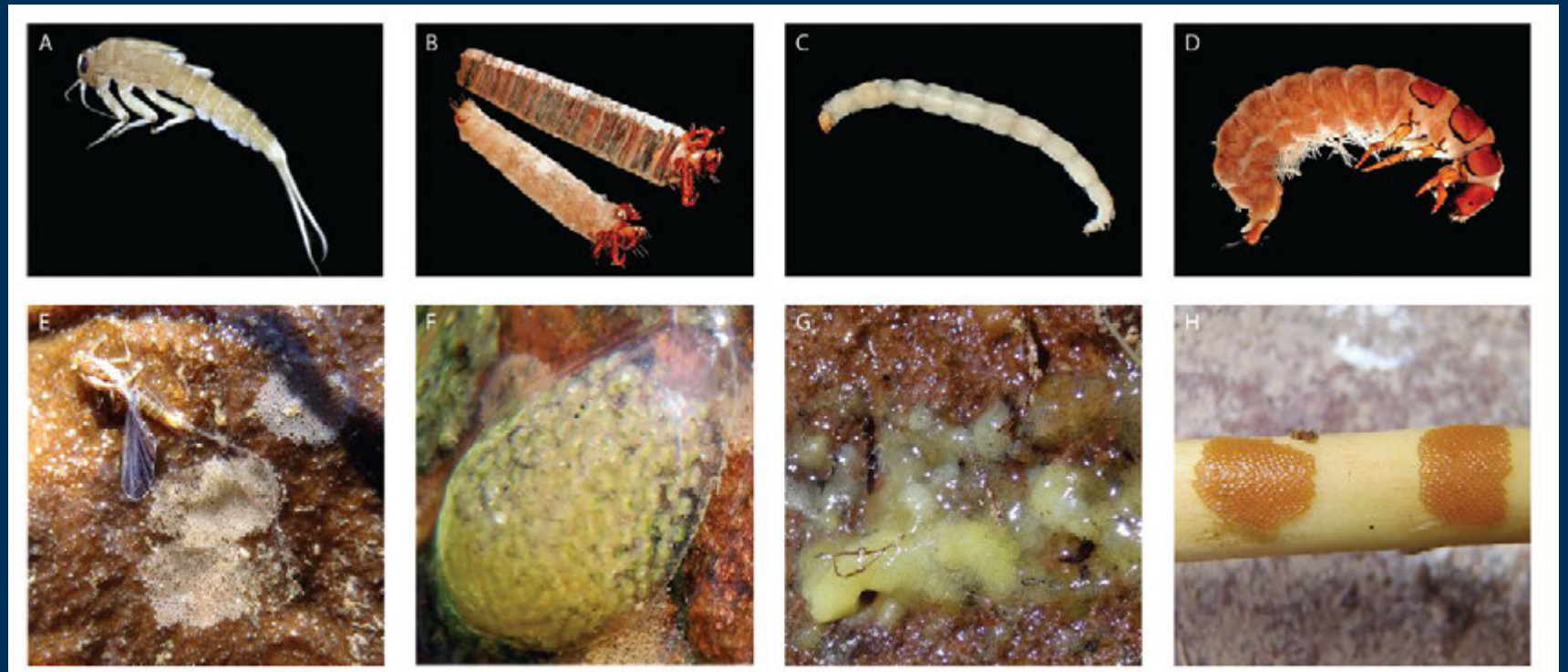


Figure 2. Larval and egg mass photos of *Baetis* spp. (Ephemeroptera) (A, E), *Brachycentrus occidentalis* (Trichoptera) (B, F), Chironomidae (Diptera) (C, G), and *Hydropsyche occidentalis* (Trichoptera) (D, H). Photo credits: Morgan Ford (A), Greg Wada (B, C, D), and Matt Schroer (E, F, G).

Photos of aquatic insects (top) and eggs cemented on various substrates (bottom).
From Miller and others 2020, Freshwater Science

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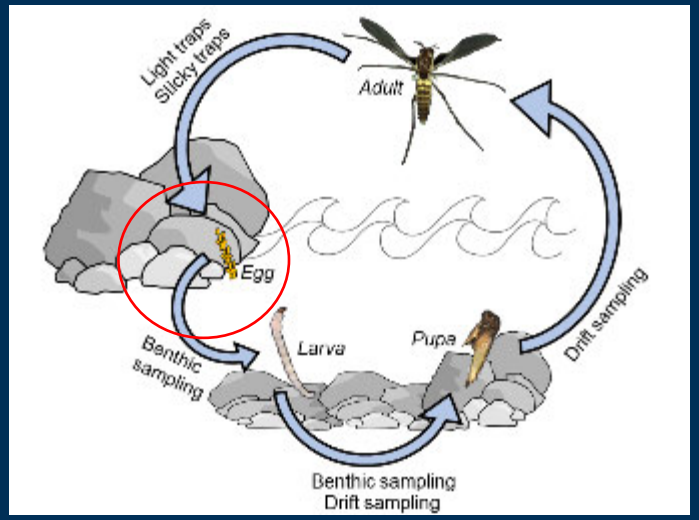
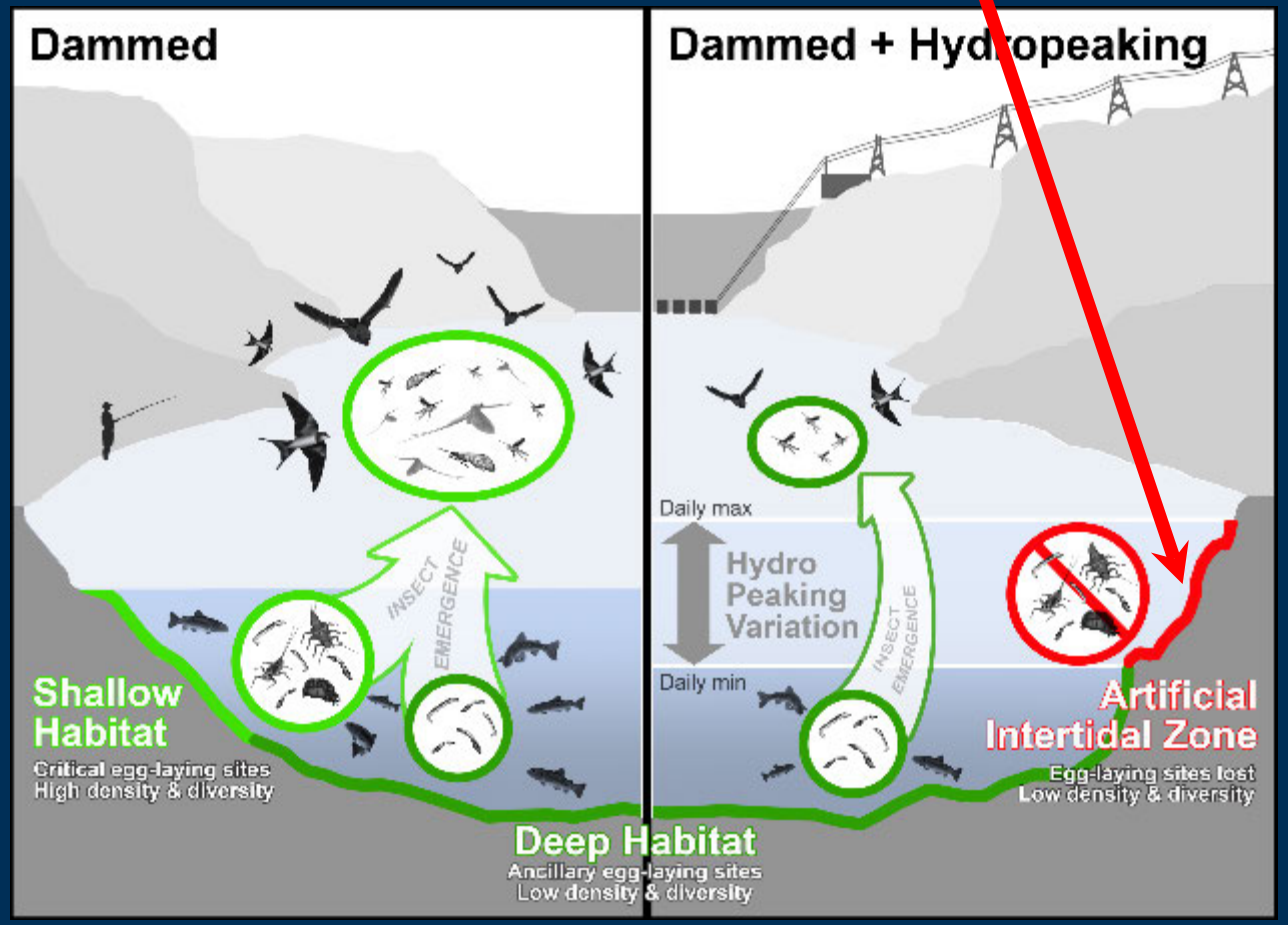
Why Bug Flows?

- Daily hydropower fluctuations create “tides”
- Insects lay eggs at water line at dusk
- When tide drops, eggs dry, die



Bug Flows seeks to mitigate this



From Kennedy and others 2016, Bioscience

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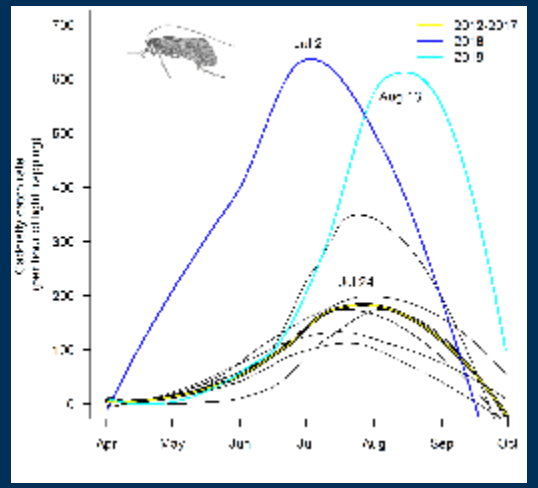
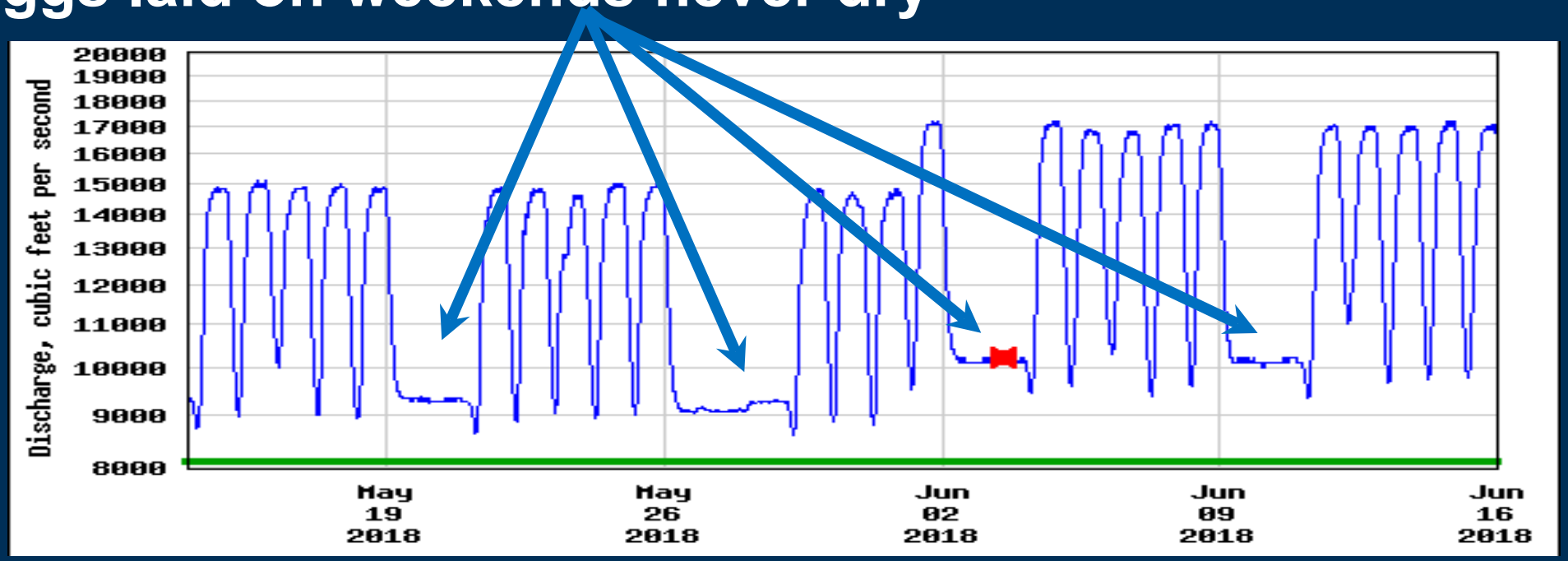
What is a Bug Flow?

- Give bugs the weekends off
- Weekend stable low flows from May-August
  - 34-36 days/years
  - Tested 2018-2020
- Eggs laid on weekends never dry



May-August



Unpublished data, subject to change, do not cite.

https://waterdata.usgs.gov/az/nwis/uv?site_no=09380000

Goals of Bug Flows

- **Proximate Objective**
  - Improve egg laying conditions for aquatic insects
- **Ultimate Objective**
  - "Improve food base productivity and abundance or diversity of mayflies, stoneflies, and caddisflies"

Table 4, LTEMP EIS

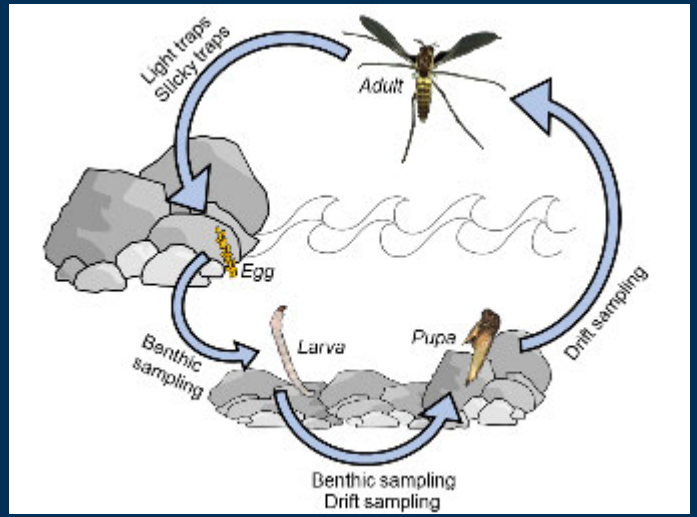


TABLE 4 (Cont.)

Experimental Treatment	Trigger[a] and Primary Objective	Replicates	Duration	Annual Implementation Considerations[b]	Long-Term Off-Ramp Conditions[c]	Action if Successful
Aquatic Resource-Related Experiments (Cont.)						
Macroinvertebrate production flows	Trigger: None Objective: Improve food base productivity and abundance or diversity of mayflies, stoneflies, and caddisflies	Target two to three replicates	Up to 4 months (May–Aug.)[g]	Potential short-term unacceptable impacts on resources listed in Section 1.3; coordinate planning with other experiments to avoid confounding conditions or results	Steady weekend flows have little or no benefit on food base, trout fishery, or native fish; increase in warmwater nonnative species or trout at the Little Colorado River; or long-term unacceptable adverse impacts on the resources listed in Section 1.3 are observed	Implement as adaptive treatment in target months when conditions allow

[g] The duration and other characteristics of experimental macroinvertebrate production flows could be adjusted based on the results of initial experiments.

From Attachment B: Table 4, p. B-14, LTEMP-Record of Decision

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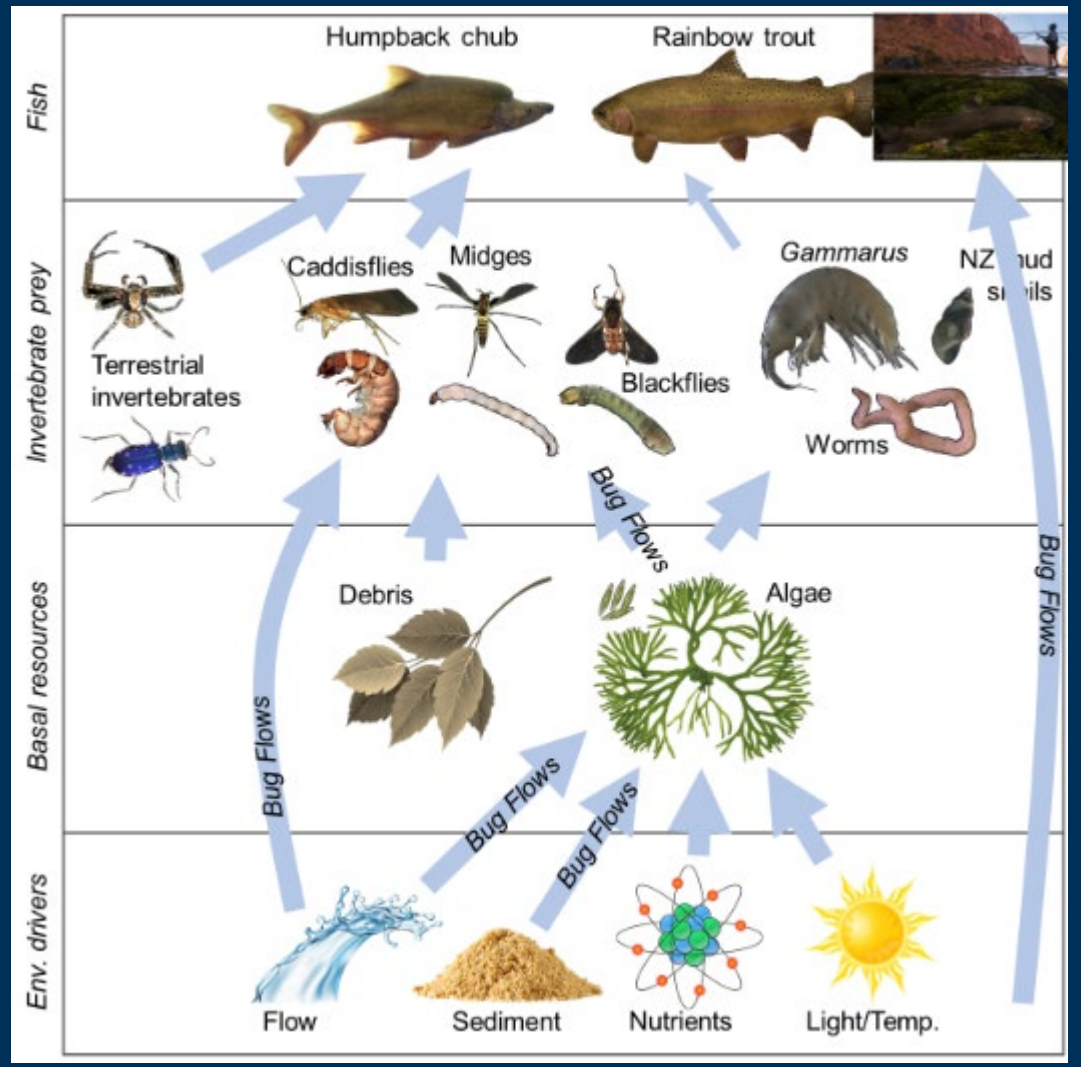
Bug Flows-Key Findings

- Enhanced natural processes and improved food base
  - More egg laying substrates
  - More insect emergence
  - More caddisflies (but not midges)
  - More GPP
    - Condition of native fish & humpback chub positively related to GPP
- Enhanced rainbow trout fishery
  - Higher catch rates



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Science Advisor Review Timeline

- October 12-GCMRC submits Bug Flow report
- October 28-Bug Flow workshop #1
- November 4-Bug Flow workshop #2
- January 4-Science Advisor review received
- January 11-ARM presentation w/ 2021 light trap data
- January 13-TWG meeting (today)

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Take Homes from Science Advisors

- **Bug Flows was successful**
  - Ruhi: "…Bug Flows were successful, overall, in enhancing natural processes…"
  - Downes: "Experiment successfully met proximate and ultimate objectives"
  - Kroll: "…high likelihood the experiment has worked…"
  - Colvin: "The Bug Flows are meeting primary and proximate objectives and the science being conducted is cutting edge."

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Take Homes from Science Advisors

- **Report should include more details**
  - **More statistics**
  - **Include summary table**
  - **Better link to hypotheses and objectives**
  - **Separate direct vs. indirect effects**

• Summary table of research question, hypotheses, and expectations is needed	Michael Colvin
• A table summarizing all data available would be useful. Adding basic metadata would be valuable for the reader and could spur research synthesis	Albert Ruhi
• Present hypotheses and their associated predictions in the introduction, unexpected results should not be considered "failures"	Barbara Downes

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Take Homes from Science Advisors

- **More analyses and modeling would be informative**
  - **Dynamic ecosystem models**
  - **Species-level analysis of abundance**
  - **Trait analysis**

• System of dynamics models could show connections between experiments	Michael Colvin
• Invertebrate trait analysis and species-level response due to traits	Albert Ruhi
• Species-level abundance data and differences in egg-laying strategies would bring clarity to the effects of Bug Flows	Barbara Downes
• Species-level sampling would provide more data and confirmation on experiment results • Benthic sampling once per year at low flows is recommended	Stephanie Kroll

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Take Homes from Science Advisors

- **Thoughts about Future Experiments**
  - Add months
  - Shifting months could be informative
  - Opportunity cost of changing design

1. Changing the experimental design potentially creates opportunity costs. By altering the way the hypotheses are tested, you run the danger of further complicating a scientific story that is complex and not yet fully understood. Indeed, an opportunity cost has arguably already

Barbara Downes

- Longer block of steady flows (i.e., more months within a year) could help reduce the uncertainty regarding the role of flows

Albert Ruhi

- Mar/April-July experiments might show which times of year are most beneficial to bugs

Stephanie Kroll

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Take Homes from Science Advisors

- **Quantifying environmental benefits**
- **Compensating hydropower**

Obviously, the power company can measure its losses very precisely and in dollars; how is this weighed up against the environmental benefits of experiments like Bug Flows? A difficulty is that many environmental benefits do not lend themselves to measurement using dollars. Sure, we can price up the cost of running an experiment like Bug Flows, or we can calculate how much people might pay for the privilege of angling for Rainbow Trout in an improved fishery, but the value of gaining knowledge that prevents ecosystem collapse or extinctions is arguably priceless.

Barbara Downes

An agreed method for balancing costs—however they are measured— gives everyone clarity, sets some ground rules, acknowledges that repairing decades of environmental damage costs money and can be expensive, and potentially gives everyone an incentive to work for the best solution overall. Such a formula might explore options for the power company to seek tax write-offs or to gain environmental credits that deliver benefits back to the company.

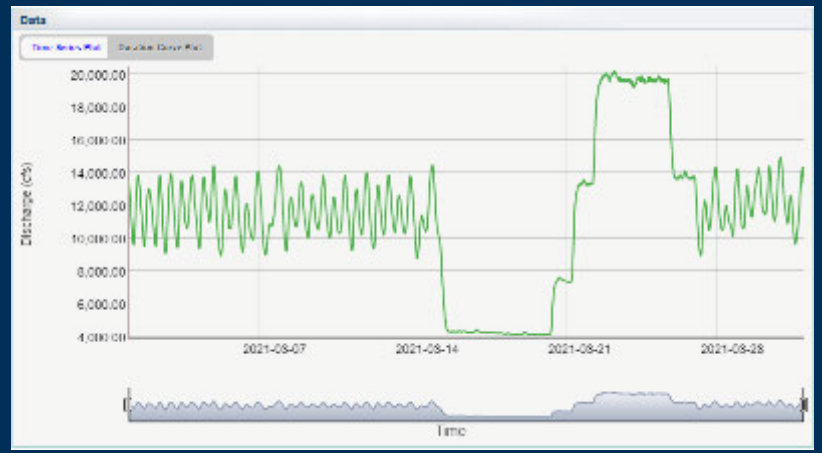
Barbara Downes

Opportunities for Spring and Summer Flow Experiments

Testing Flow Experiments	GCD Experimental Flow	Duration	Implementation Window
1996, 2008	Spring HFE$^{\Delta}$	up to 96 hours	March – April
Not yet tested	Proactive Spring HFE$^{\Delta\Diamond}$	24 hours**	April – June
Not yet tested	Trout Management Flows	up to 3 cycles/month for 4 months	May – August
2018, 2019, 2020	Macroinvertebrate Flows	target 2-3 replicates	May – August
2004, 2012, 2013, 2014, 2016, 2018 (2015, 2021)	Fall HFE	up to 96 hours	October - November
Not yet tested	Extended Duration Fall HFE	97- 192* or 97-250 hours***	October - November

LTEMP Flow Experiments

Δ no Spring HFE in same WY as extended duration Fall HFE
◊ no proactive Spring HFE in same WY as sediment-driven Spring HFE



Spring or summer disturbance flow?

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* First test not to exceed 192 hours
** First test 24 hours
*** After first test, up to 250 hours

Preliminary data, do not cite.