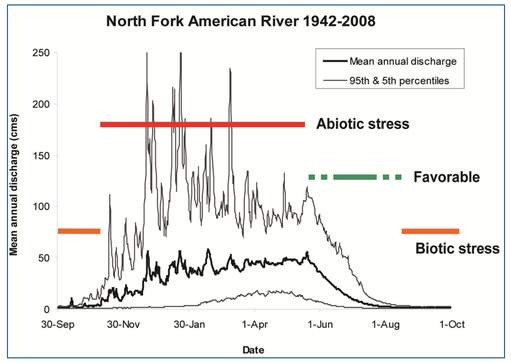
Environmental Flow Measures in FERC Relicensing of Sierra Nevada Hydropower Projects: Concepts and Case Studies

Amy Lind[1], Carol Purchase[1], Sarah Yarnell[2]

1– USDA Forest Service, Tahoe National Forest, California; 2– Center For Watershed Sciences, University of California, Davis

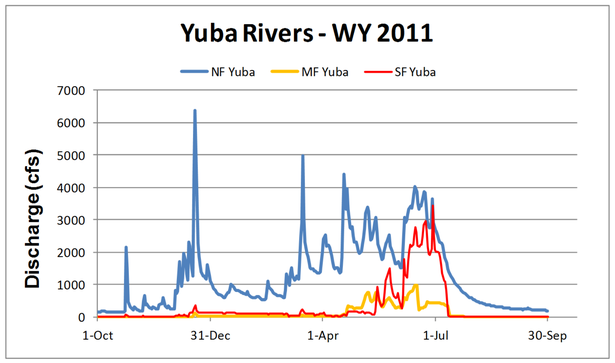
Background - Natural Flow Regime Paradigm and Snowmelt Recession

* In Mediterranean climates, spring is the one time annually where high resources are coupled with predictable river flows.
* High biodiversity results (*Gasith & Resh 1999*).



Yarnell et al. 2010

* Many regulated rivers lack a spring snowmelt recession.
*In this figure, the NF Yuba is unregulated and the MF and SF are regulated at different levels.



FERC Hydropower Project Relicensing

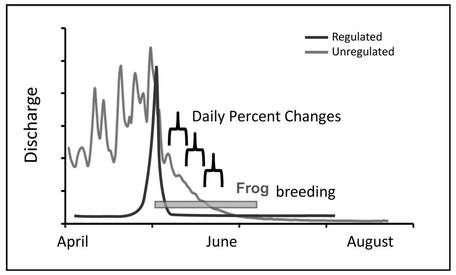
* Hydroelectric projects are licensed for 30-50 years by the Federal Energy Regulatory Commission (FERC)
* Major Steps in the Integrated Licensing Process (ILP):

Studies → Negotiations → Licensee Application →
Negotiations → Stakeholder Terms and Conditions →
NEPA / CEQA → New License Monitoring

Case Studies

Foothill yellow- legged frog laying eggs.

* Frogs attach eggs to substrate in shallow water (average depth of 30cm) during spring flow recession period (*Bondi et al. 2013).*
* Eggs take ~ 3 weeks to hatch
* Gradual spring flow recession is protective of eggs/ early tadpoles if the max stage change is no more than 30cm over 3 weeks.
* Many riparian tree species also require no more than 1-2cm stage per day for root follow (*Rood and Mahoney 1992*).
* Both frogs and riparian needs are consistent with <10% per day rate of flow change.
* Gradual flows can also provide recreational boating opportunities (e.g., see NF Feather graph).

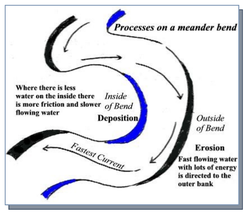


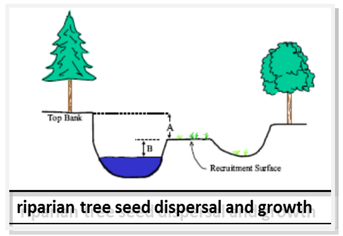
Simplified hydrograph for regulated and unregulated rivers with daily percent change and frog breeding time period (Lind and Yarnell 2011)

Environmental Flow Measures

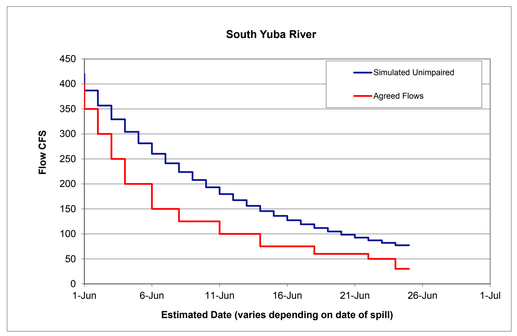
* Focus on restoration of spring snowmelt recession:
  - Sediment transport and redistribution - point bar formation
  - Riparian vegetation recruits and establishes
  - Stream amphibians lay eggs and tadpoles develop
  - Salmonid spawning and egg development in gravels
  - Recreational whitewater boating
* Also include measures on:
  - Summer minimum flows for water temperature
  - Fall/winter "pulse" flows for sediment flushing / transport

Rainbow Trout

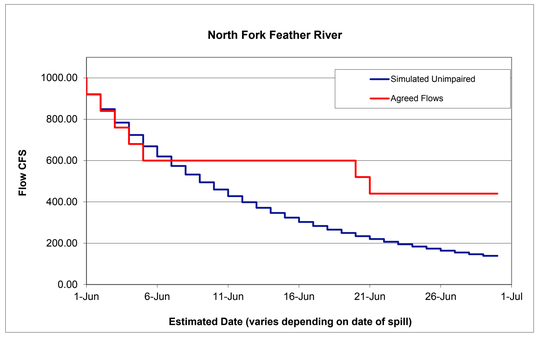




Spring Spill Management - Modified Snowmelt Recession



South Yuba River flows agreed to during relicensing, compared to un-impaired gradual recession rate. Required for any spills after May 1.

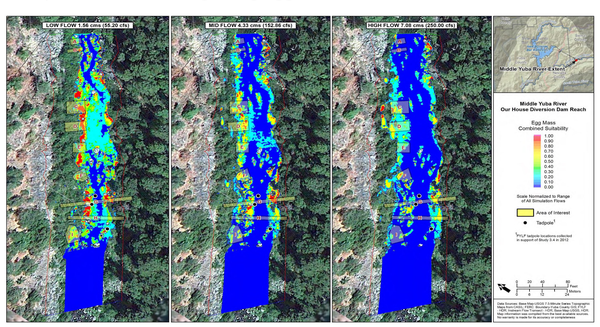


North Fork Feather River flows agreed to during license test flow period (2015-2020), compared to unimpaired gradual recession rate. Bench out at 600 cfs for 15 days is for recreational boating. Required for any spills after May 1.

Tools

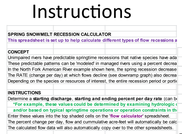
* Relicensing studies - geomorphology, riparian, aquatic species, recreation, water balance models.

* Hydrodynamic modeling (1D, 2D):
  Quantitative and visual relationship of flows to species for specific aquatic habitats - e.g., frog egg mass habitat.



'Recession Flow Calculator' tool - Excel spreadsheet
- Instructions plus 3 sheets of calculators

Instructions

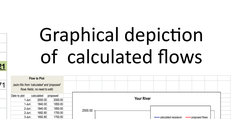


Flow calculator

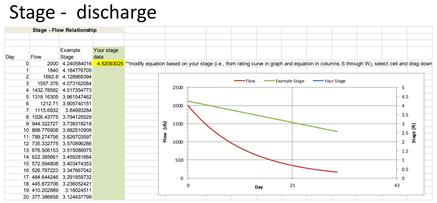
Calculator Variables are Underlined		
Start =	2000	
Start %	8%	
Recession Period in days		21
End %	5%	
Daily Increment		0.001428571

Day	Percent Change	Flow	Cumulative AF
0	8.00%	2000	3960
1	7.86%	1842.857143	7,609
2	7.71%	1700.693878	10,976
3	7.57%	1571.927055	14,089
4	7.43%	1455.155331	16,970
5	7.29%	1349.136871	19,641
6	7.14%	1252.769952	22,122

Graphical depiction of calculated flows



Stage - discharge



Lessons Learned

* Restoring spring snowmelt hydrology provides multiple geomorphic and ecological benefits.
* Water availability is typically high and power generation demands are usually low during the spring.
* Focusing on the spring flow element of the natural flow regime can provide a balance between ecological resources and power generation needs.
* Collaboration among stakeholders can result in innovative solutions to meet multiples needs - e.g., resource agencies and recreationists.
* Use all available tools to understand relationships between flows, geomorphic, ecological, and recreational resources. Some tools have been developed specifically for hydropower relicensing to compare different flow regimes (e.g., 'Recession Flow Calculator').

See handout for References and more information on the Recession Calculator Tool.