Low flows in Glen Canyon: preliminary geomorphic analysis of the potential effects on fish and food base

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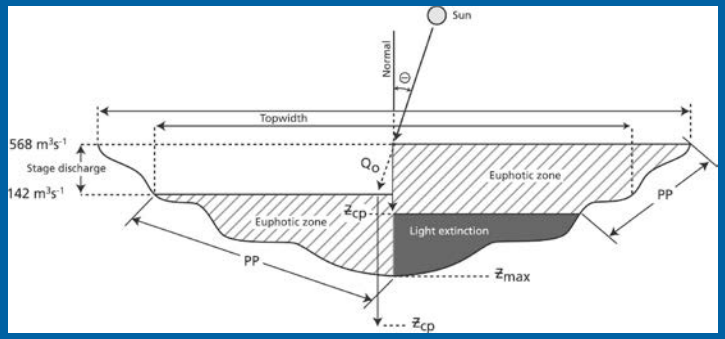
QUESTION:

HOW MUCH DO MINIMUM *MLFF* DAM RELEASES REDUCE AQUATIC HABITAT?



OR

Recall: Water Depth Limits Light Penetration to the Bed - influencing aquatic food production (from Yard, 2003) & that channel geometry controls depth, wetted area, etc.

How much shoreline area gets dewatered in the Glen Canyon Tailwater when dam releases are reduced from

8,000 to 5,000 cfs?

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<u>Stakeholder Concern:</u> about whether HFEs and low minimum flows under the 1996 ROD of 5,000 cfs (142 m^3/s) between 07:00 p.m. and 07:00 a.m. (versus 8,000 cfs (227 m^3/s) <u>might</u> negatively affect the Lees Ferry fishery and foodbase?

Initially addressed by GCMRC (Kennedy & VanderKooi, 2012)

"**It is our professional judgment that the effects on food base and rainbow trout of the two alternative flow regimes described above would be indistinguishable.** Our judgment about minimal ecological effects is based largely on estimates of how much additional streambed is exposed when flows drop from 8,000 to 5,000 cfs. There are more than 20 cross-sections in Glen Canyon that have been monitored for geomorphic characteristics; the lower flows of 5,000 cfs **<u>only reduce the inundated area</u>** of the stream bed at these measured cross-section by **<u>an average of 5 percent</u>** (USGS unpublished data)."

PRELIMINARY DATA
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So, What's Changed Since October 2012… ?

…the minimum area estimated increase by 2X

stream bed at these measured cross-section by **an average of 10 percent** (USGS unpublished data)."

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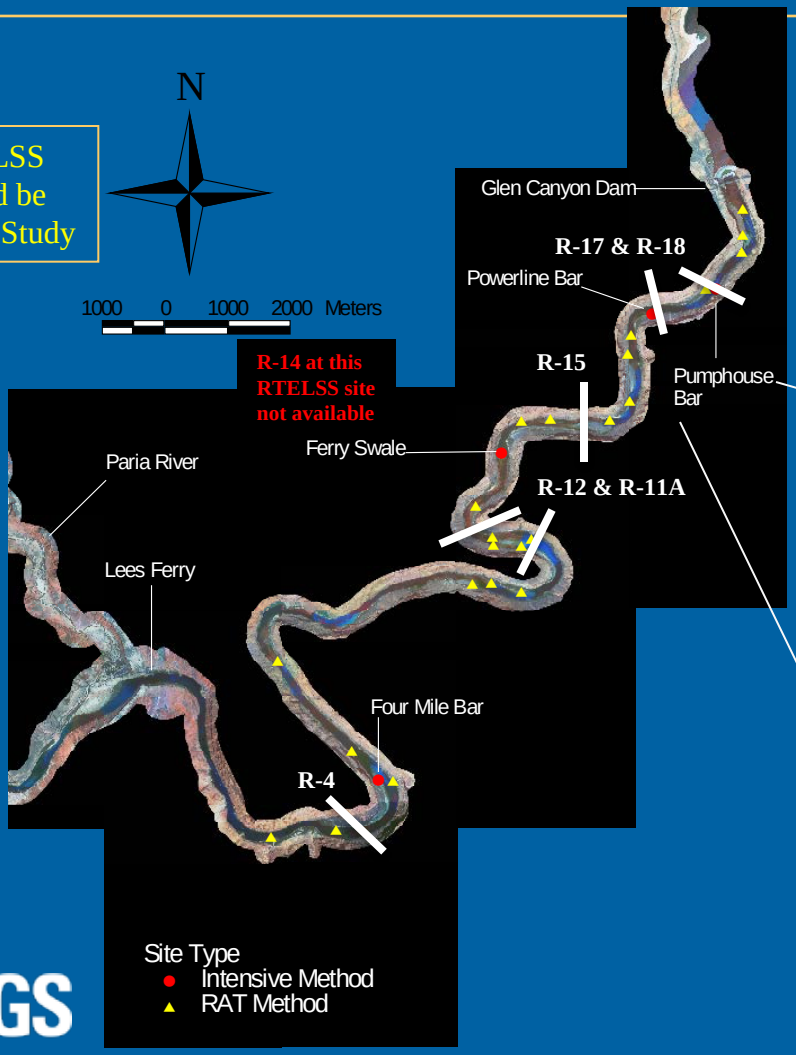
Only a limited subset of the existing channel cross sections are located across such low-angle shorelines as seen below, but those that do, such as at -14.4 (below Pumphouse Bar), show much greater than a 5% wetted width reduction between 8,000 and 5,000 cfs.

Only 2 of 4 RTELSS Study Sites Could be Evaluated in this Study



6 of the 24 Existing Cross Sections were deemed to be representative of low-angle channel habitats and were assessed for habitat area dewatering in 5 study segments between river miles -03.1 and -14.4 [total subsample of 4 km]

-14-Mile Bar (-14.4-Right), below Pumphouse

Many Factors May Influence Aquatic Productivity in the Tailwater

- Canyon/Channel Geometry (Water Depth & Aspect [light])
- Lake Powell Quality of Water (nutrients, DO, Temp)
- Annual Thermal Regime (variations related to above)
- Turbidity (total suspended sediment & dissolved organics)
- Channel Bed Substrate (bedrock or gravel vs. sand or finer)
- Dam Operations (monthly to seasonal high & low-flow patterns)
- Wetted Channel Area (and its variations related to above)

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Many Factors May Influence Aquatic Productivity in the Tailwater




- Canyon/Channel Geometry (Water Depth & Aspect [light])

These three elements might be important, but not *<u>the</u>* most important parameters to consider regarding questions about what primarily limits aquatic invertebrate diversity & abundance?

- Dam Operations (monthly to seasonal high & low-flow patterns)
- Wetted Channel Area (and its variations related to above)

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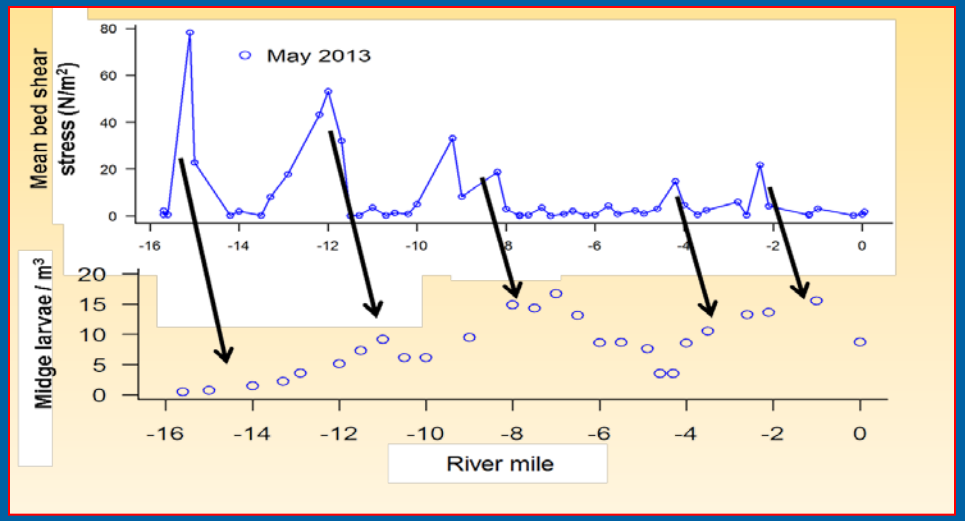
There are Clear Longitudinal Variations in Aquatic Resources

(likely related, in part, to channel characteristics)

Drifting midge larvae concentrations ~ 8,000 cfs, May 2013 relative to channel-bed shear stress

Data: Muehlbauer & Kennedy et al. unpublished



Chironomidae

Why are "Hot Spots" hot…

…and why are others not?

Rainbow trout catch per 250-m shoreline segment Pre- vs. Post-2012 HFE below Glen Canyon Dam

Data: Yard & Korman et al. unpublished

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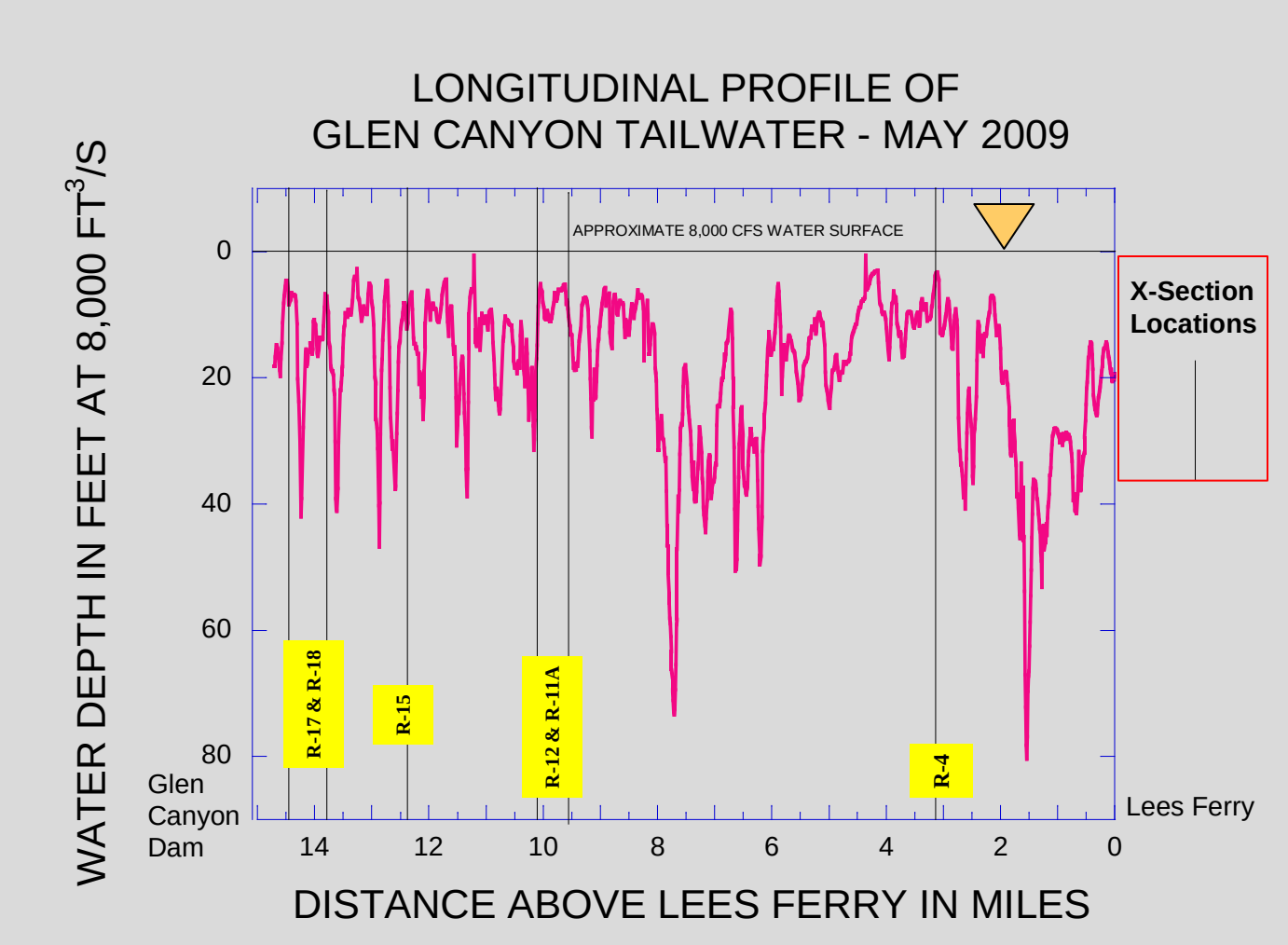
Longitudinal Channel Depth Profile

[Glen Canyon Dam to Lees Ferry]



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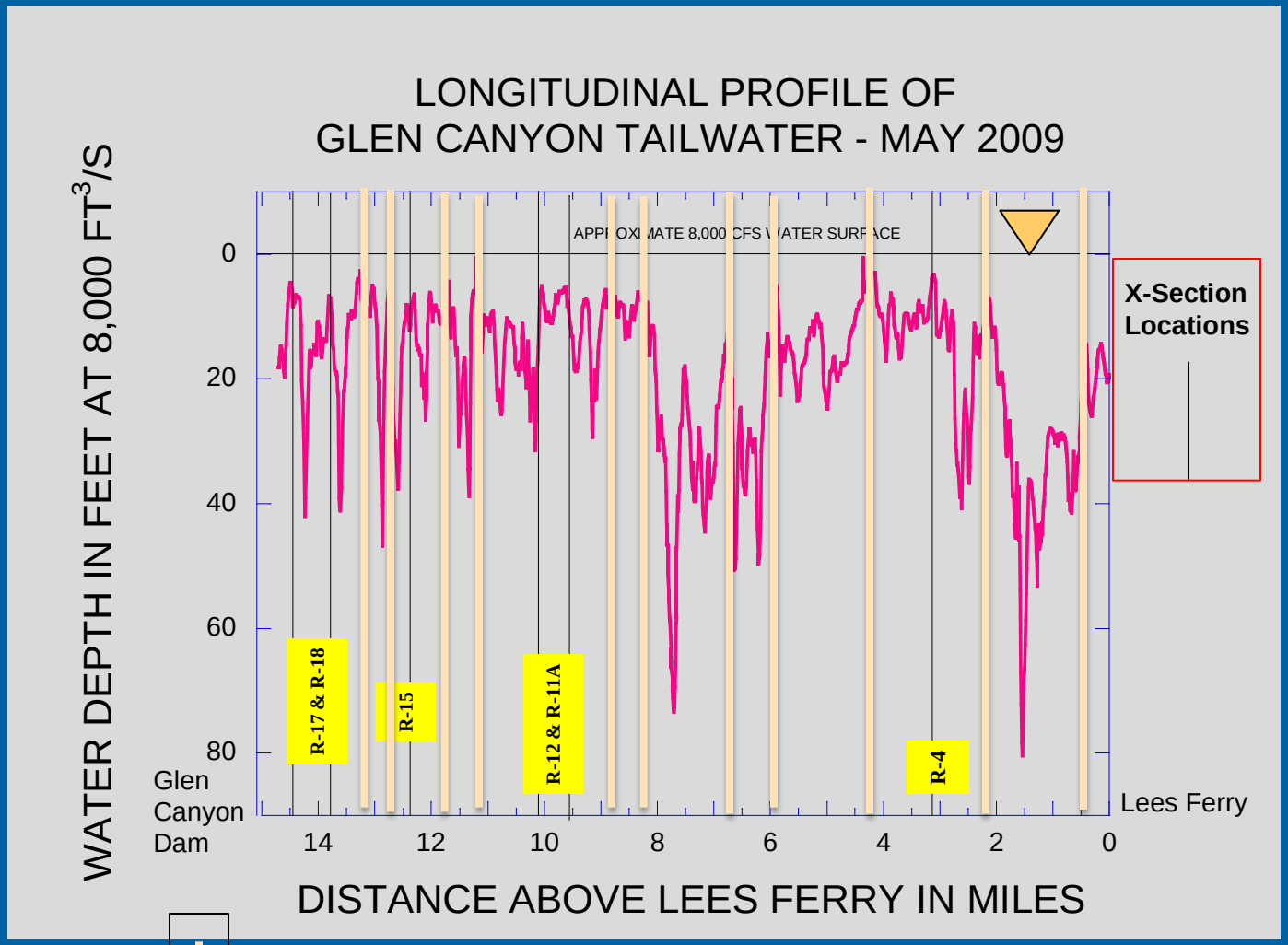
Recall that Depth Matters in Light Attenuation & GPP

Longitudinal Channel Depth Profile

[Glen Canyon Dam to Lees Ferry]



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X-Sections that Would Ideally Represent some of the Other Low-Angle Habitats in Glen Canyon

Site Characteristics for Five Segments Evaluated (Δ's in shoreline area inundated from 8,000 to 5,000 cfs)

The 6 X-Sections used in the assessment were not optiamally located over

"low-angle" [11 percent slopes]

habitats of most interest, but were all that exist at present

STUDY SITE NAME	FOUR-MILE BAR (-04.1 to -03.1)	9-MILE DRAW & HORSESHOE BEND (-10.6 to -09.1)	PROP BAR (-12.4 to 11.8)	POWERLINE BAR (-13.9 to 13.5)	FOURTEEN-MILE BAR (-14.5 to -14.0)
Approximate Site Length (m)	1000	1500	600	400	500
X-Section(s) & (River Miles) for study of low-angle shorelines	R-5 (-04.4) **R-4 (-03.2)**	R-13 (-10.6) **R-12 (-10.2)** **R-11A (-09.6)** R-11 (-09.1)	**R-15 (-12.4)**	**R-17 (-13.8)**	**R-18 (-14.4)**
Vert. Elev. Δ from 227 to 142 m^3/s (2000 era) in meters	R-5 (0.39 m) **R-4 (0.20m)**	R-13 (0.30 m) **R-12 (0.30 m)** **R-11A (0.34 m)** R-11 (0.33 m)	**R-15 (0.36 m)**	**R-17 (0.38 m)**	**R-18 (0.41 m)**
Historic Vertical Scour 1965-2000 (m) ~ 150 m^3/s stage	R-5 (0.70 m) **R-4 (0.60 m)**	R-13 (2.20 m) **R-12 (2.15 m)** **R-11A (1.30 m)** R-11 (2.0 m)	**R-15 (2.05 m)**	**R-17 (2.20 m)**	**R-18 (2.25 m)**
Study Segment Aspect (annual solar insolation)	**NW-SE & E-W (less variable)**	**E-W & N-S (less variable)**	**E-W (more variable)**	**E-W (more variable)**	**NE-SW (less variable)**

~49% (12 km) of tailwater has "low-angle" habitat – (4 km of that was subsampled)

Preliminary Low-Flow Habitat Area Assessment Results (Δ's in shoreline area inundated from 8,000 to 5,000 cfs)

16 hectars is an Area Equal to ~35 NFL Football Fields…

Again, this is about 2X the area initially estimated by Kennedy & VanderKooi in 2012…

It is still not possible to estimate what low-flows to 5,000 cfs mean relative to fish and food base…

Operations in fall months have already been as low as 6,000 cfs...

Summer 2013 sand inputs & NOV HFE might also be confounding influences

STUDY SITE NAME	FOUR-MILE BAR (-04.1 to -03.1)	9-MILE DRAW & HORSESHOE BEND (-10.6 to -09.1)	PROP BAR (-12.4 to 11.8)	POWERLINE BAR (-13.9 to 13.5)	PUMPHOUSE BAR (-14.5 to -14.0)
Changes (Δ) in	Wetted	Cross-Section	Width at the	Five Low- Flow	Study Sites
Δs in wetted channel width (WCW) & Elev. 227 - 142 m^3/s (m) for area Δs	R-4 (4.7)	R-12 (16.2) R-11A (15.9)	R-15 (9.6)	R-17 (6.0)	R-18 (32.3)
DIFF. 227 - 142 m^3/s Wetted Area	[based on R-4] ~0.47 ha	[based on AVE. of R-12 & R-11A] ~2.41 ha	[based on R-15] ~0.58 ha	[based on R-17] ~0.24 ha	[based on R-18] ~1.62 ha
				(5.32 ha/4 km)=	1.33 ha/km
Total Change in	Low-Angle	Wetted Shore	Area (m^2)	Glen Canyon	Tailwater
(25 km of Glen Canyon) Total estimated Wetted Channel Area at 227 m^3/s stage elev.				~327 ha (derived from 2009 digital imagery for 25 km at 227 m^3/s)	
Low-Angle (~48% or 12 km)	Shoreline	Habitat of main	Focus in Study	~160 ha (327*0.49)	(see Korman et al. 2005)
(12 km of Glen Canyon) Estimated total low-angle habitat area Δ between 227 – 142 m^3/s stages	Dewatered (Extrapolated	Shoreline From Five Study	Area Sites [4 km])	~16 ha (1.33 ha/km*12 km) or about 1,700,000 sq. ft.	GCD - Lees Ferry at 142 m^3/s about ~10% of total wet area at 227 m^3/s stage

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This Estimate is about 10X larger than one made by Yard Initially - 1994

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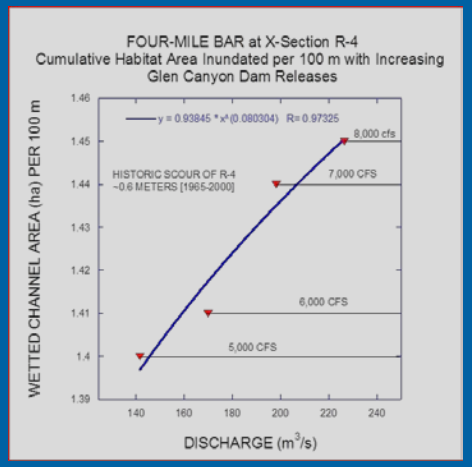
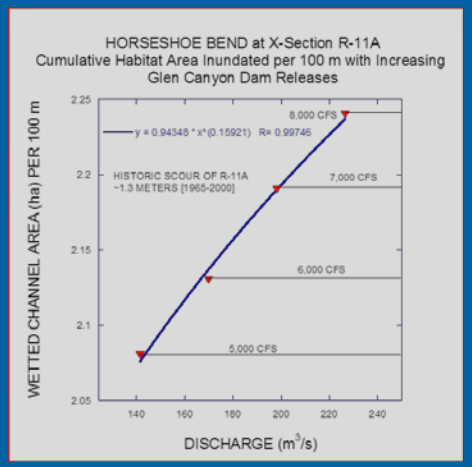
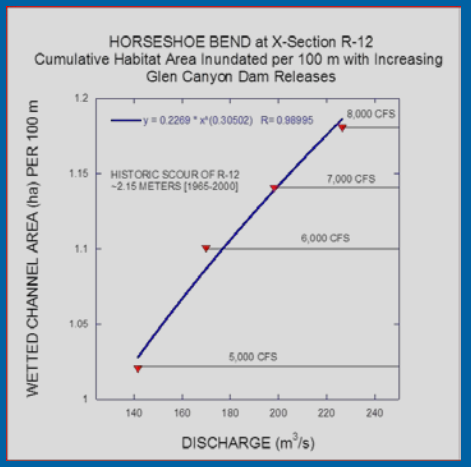
Low-Flow Inundation - Site Responses

(Δ's in area/unit length (100 m) - 8,000 to 5,000 cfs)

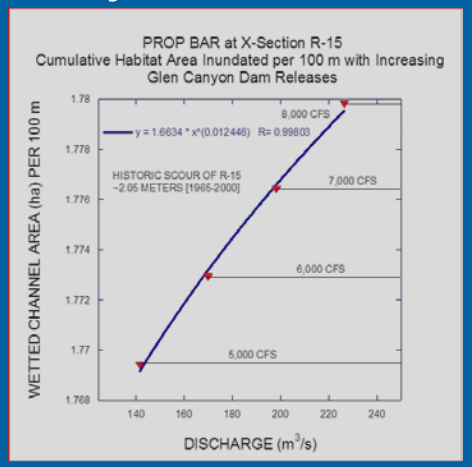
1/7th Effect

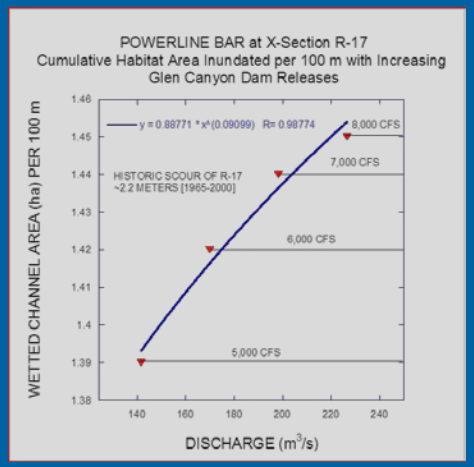


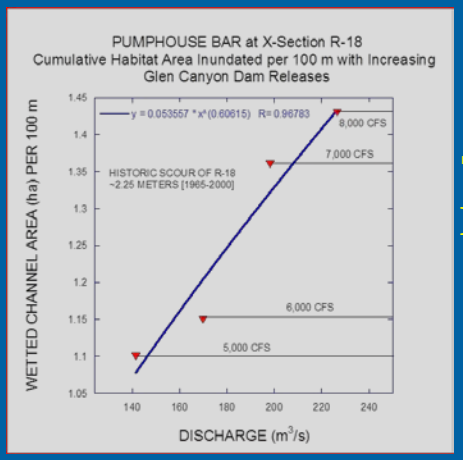




Lees Ferry ← DOWNSTREAM →







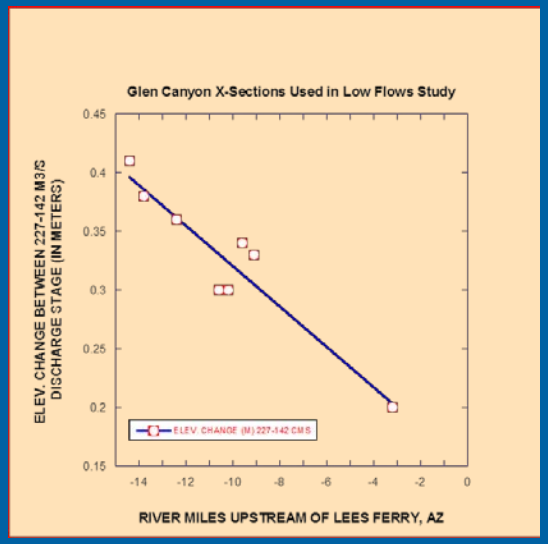
7X Effect

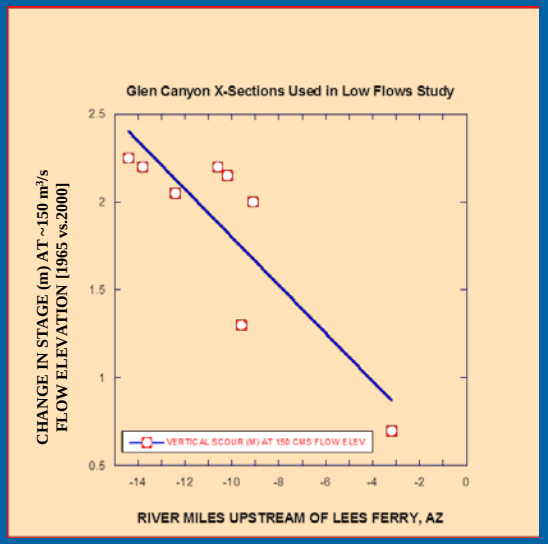
USGS ← UPSTREAM → Dam

Responses Vary by Site - Most Low-Flow Sensitive Sites Upstream – Most Robust Downstream

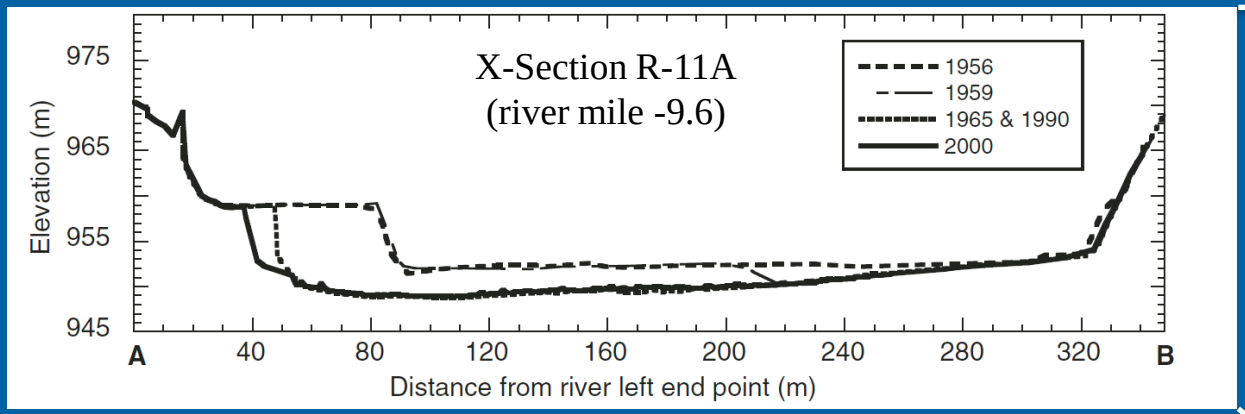
Historical Channel Incision in Response to Dam Operations Increased Low-Flow Areas Upstream

Vertical Δ from 5-8 kcfs is a 2X larger near dam than at Four-Mile Bar (from Grams et al. 2007)





Fourteen Mile Bar (14.4-R)

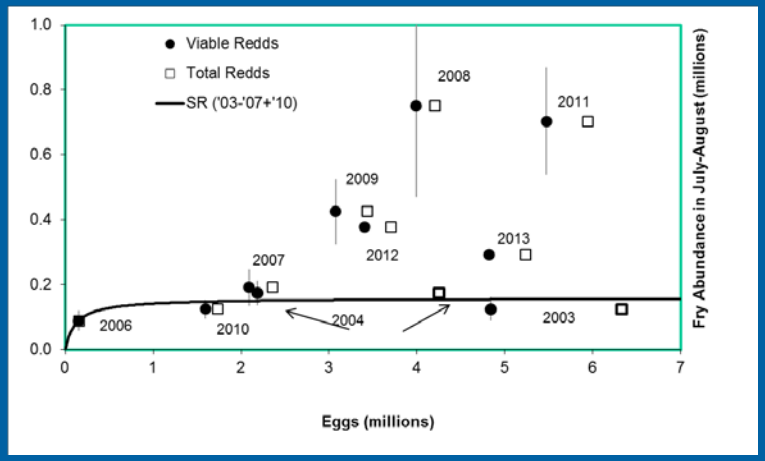


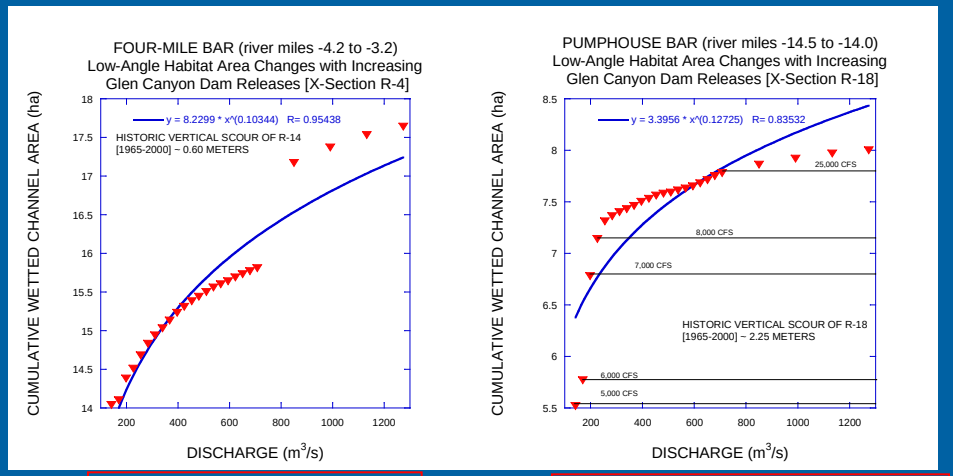
Vertical & Lateral Erosion Expanded Width of X-Sectional Low-Flow Area

Cross-Section Just Below Duck Island – 9.9-I

Consider Implications of Higher Flows on Habitat (Δ's in shoreline area inundated Above 8,000 cfs)

WY 2008 Spring HFE & Equalization Operations in WY 2011 Increased Trout Survival (after Korman et al. 2011)





Four-Mile Bar
X-Section R-4
River mile -3.2

Fourteen Mile Bar
X-Section R-18
river mile -14.4

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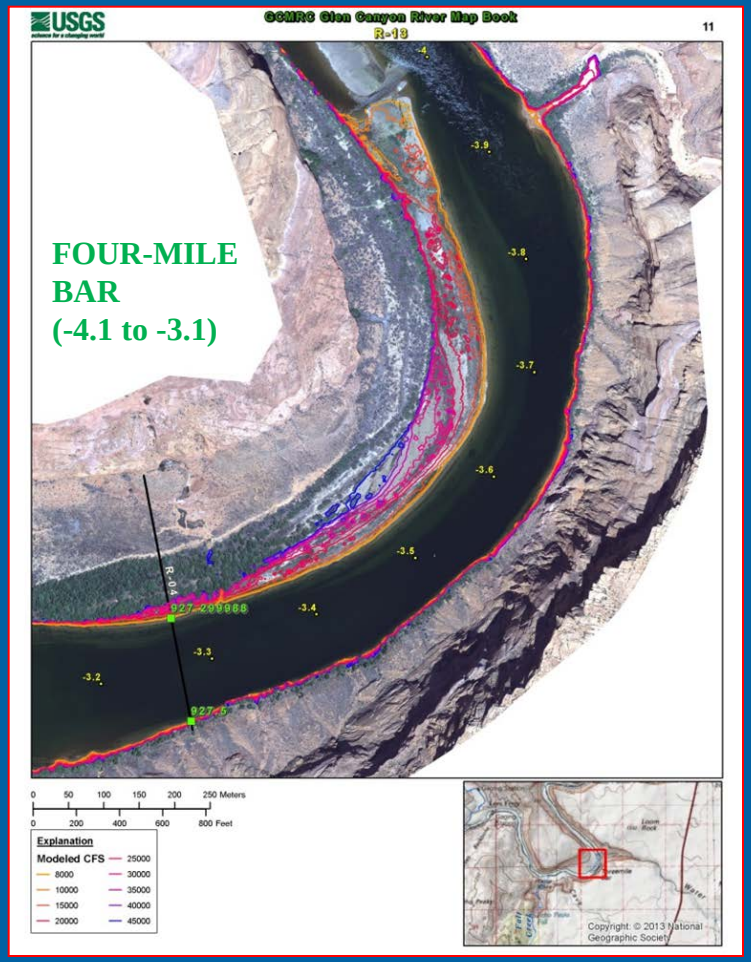
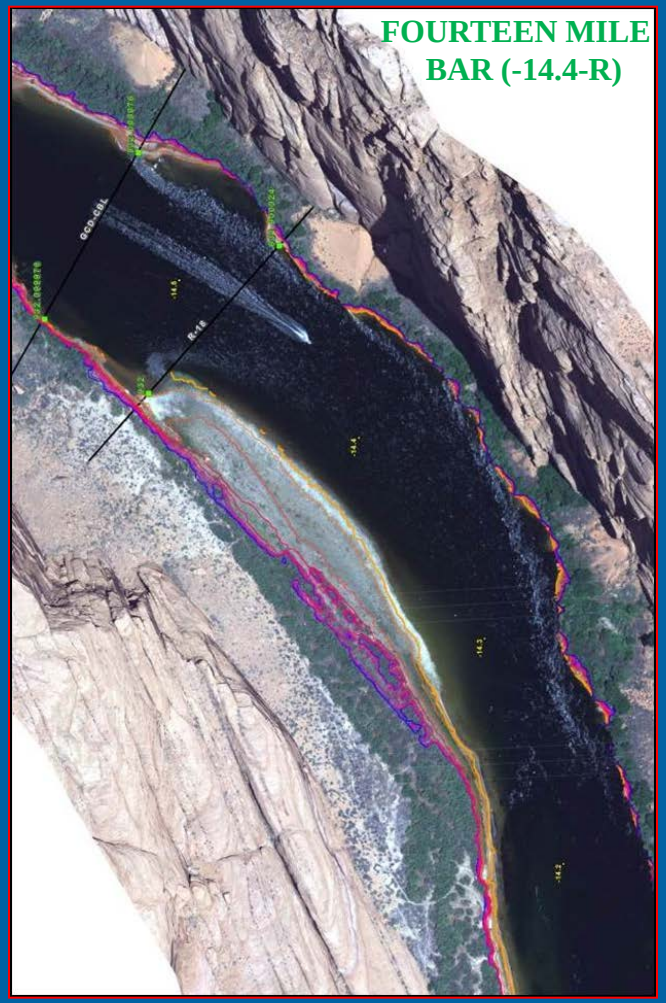
Perhaps Aquatic Habitats (cobble bars) could also be Individually Evaluated for Flows above 8,000 cfs?

Estimating Shorelines w/o a Flow Model

8,000 to 45,000 cfs



Estimating shorelines over range of releases may be critical to planning future managed flows & experiments?



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Higher Elevation Bars have become More Vegetated under Lower Volumes?

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Preliminary Concluding Thoughts

- Flows at 5,000 cfs have rarely occurred since 1996 (mostly 2003-6 testing)
- No food base monitoring data were collected when they did occur (ugh)
- Wet channel area is reduced in low-angle habitats by ~10% (8 to 5 kcfs)
- This area reduction consists of about 16 hectares or 1,700,000 sq. ft.
- Habitat sensitivity to low-flow changes is highly site dependent
- Sites nearer to the dam appear to be most sensitive to these changes
- More detailed channel geometry data is needed for areas not assessed
- Scientists unlikely to detect effects of daily flows at 8,000 vs. 5,000 cfs

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Perhaps Seasonal Timing of Low vs. Higher Flows & Temperature is the ???