Evaluating the Frequency of Triggered Spring High Flow Experiments (HFE's) Assumed in the Long-Term Experimental and Management Plan

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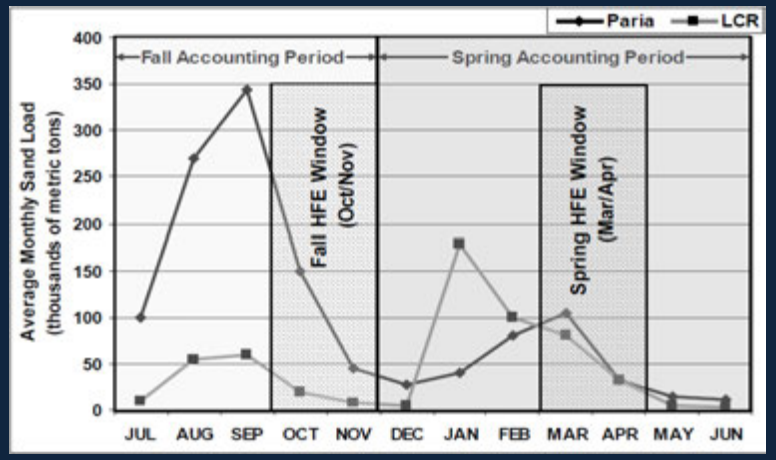
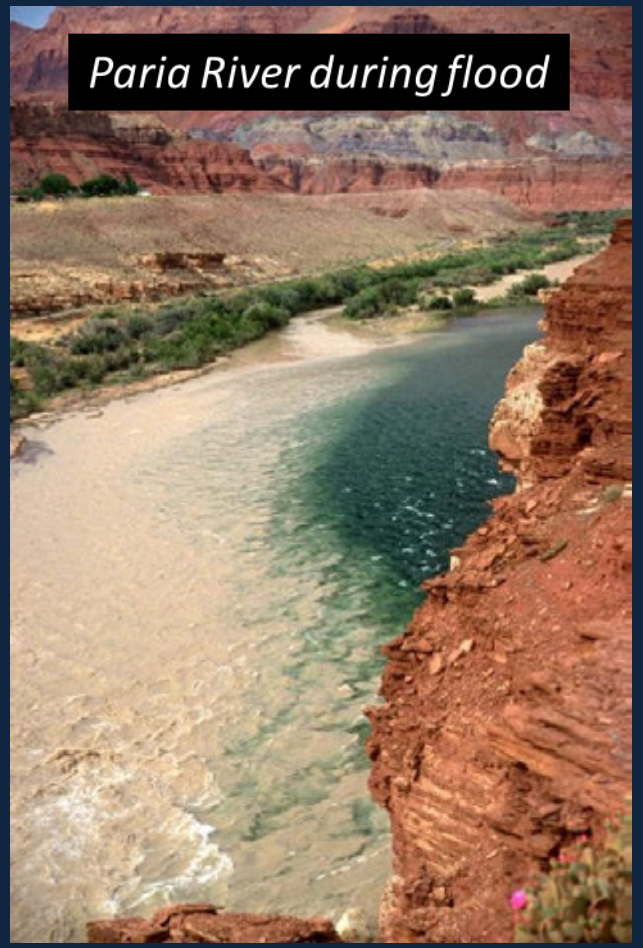
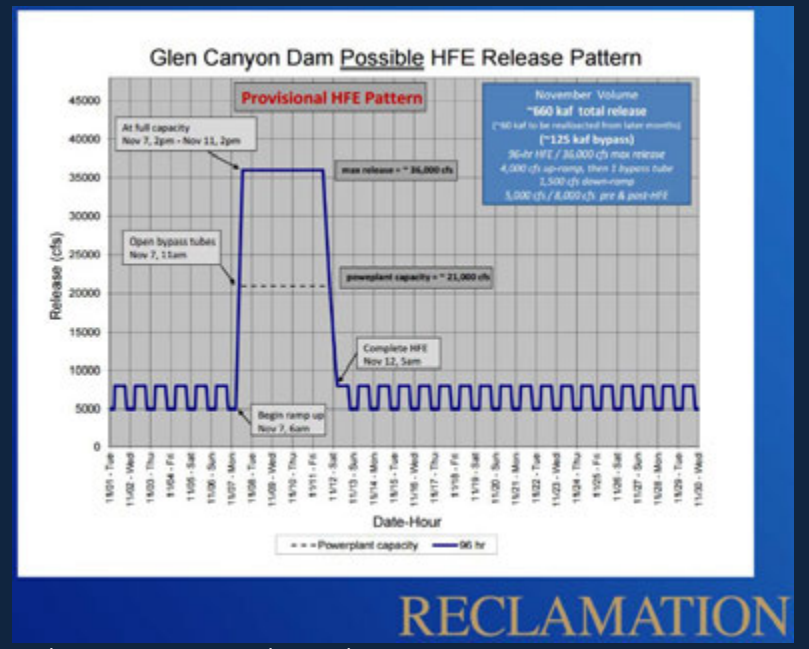
The HFE Protocol:

- Track sand inputs from Paria River and model sand budget during designated accounting periods
  - July 1 – Dec. 1
  - Dec. 1 – Jun. 30
- Find the magnitude and duration of HFE that "fits" the amount of sand available
- Schedule HFE

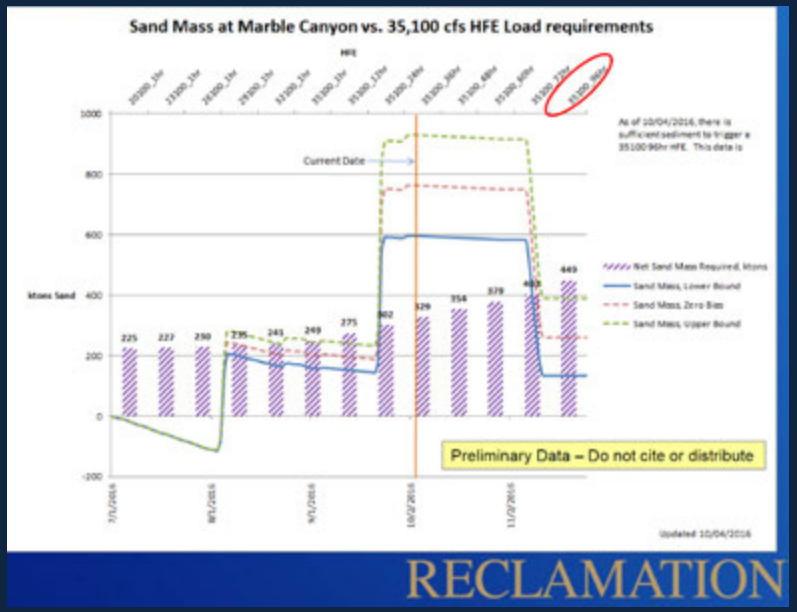


Wright and Kennedy (2011)





Glen Canyon Dam Hydrograph, USBR

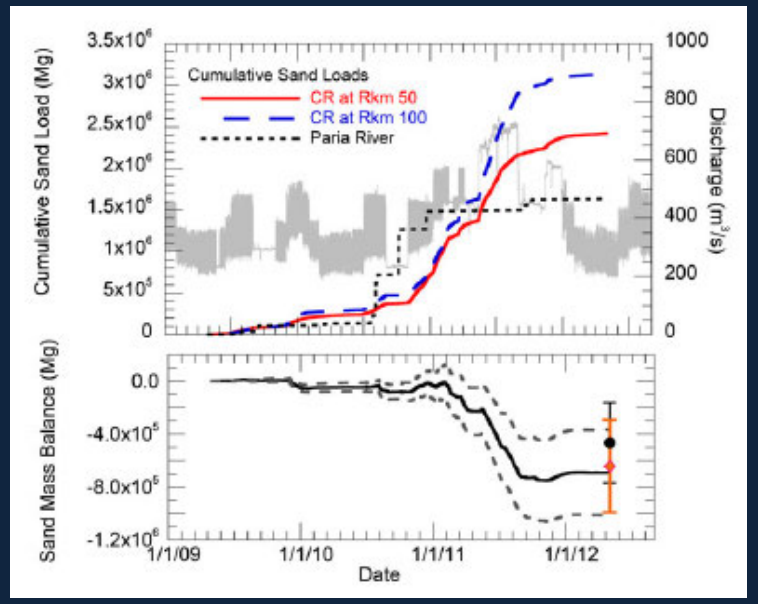


Preliminary data, do not cite

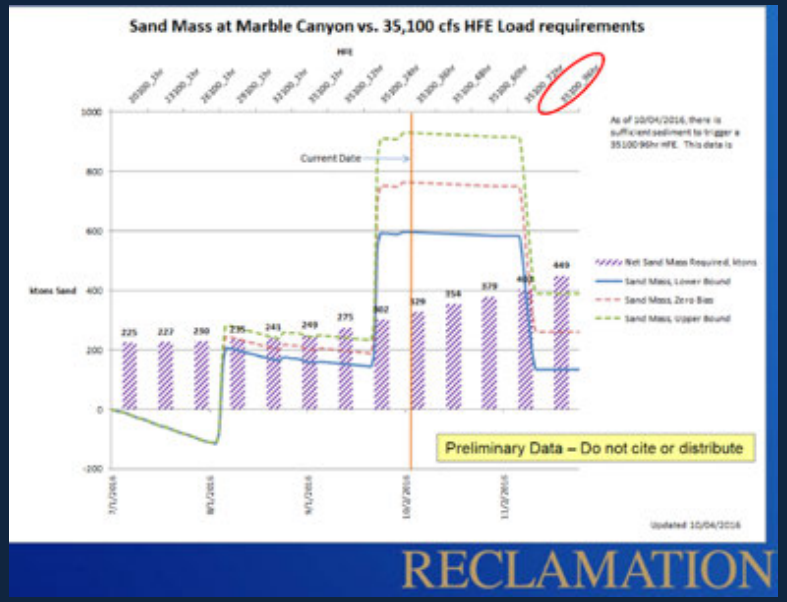
USGS

Sand accounting periods

- The objective of the HFE Protocol in the LTEMP is to achieve sandbar building while retaining a positive sand mass balance.
- Sand mass balance is a relative measure and depends on the period over which it is computed.
  - For LTEMP alternative analysis, sand mass balance was evaluated over the duration of 20-year simulations.
    - This long-term evaluation will be the ultimate test of the HFE Protocol and is being monitored in Project B.2
  - For HFE implementation, we evaluate the mass balance over short accounting periods.
    - These accounting periods were chosen to coincide with the periods of most likely sediment inputs from the Paria River



Example of long-term sand mass balance for evaluation of dam operations over periods of many years (Grams and others, 2019)



Example of short-term sand mass balance over fall accounting period for HFE implementation

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Sand accounting periods, cont.

Short-term mass balance accounting windows:

- Distinct Spring and Fall accounting periods:
  - Can design HFE to “use” only recent sand inputs.
  - HFEs are implemented when storage in Upper Marble Canyon is highest
  - Simple decision process

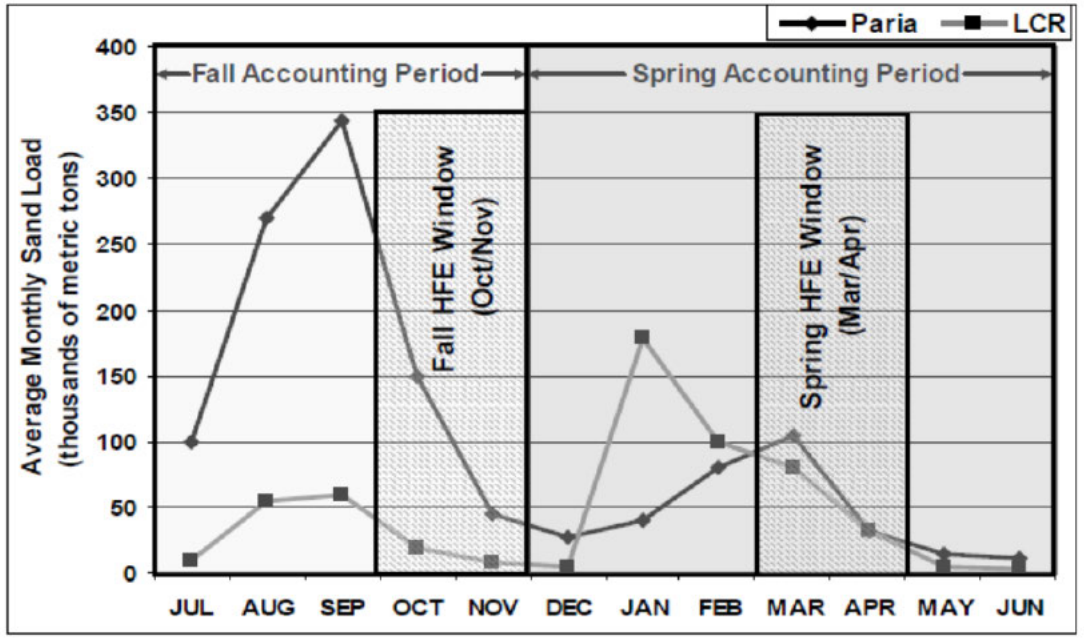

FIGURE P-1 Average Monthly Sand Load from the Paria River and Little Colorado River Showing the Fall and Spring HFE Accounting Periods and Implementation Windows

Plot from LTEMP EIS, Appendix P

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Frequency of Spring HFEs

As estimated in LTEMP

- Simulations designed to represent the full range of historical conditions:
  - 21 hydrologic traces
  - 3 sediment traces (low, median, high)

➢ May be sufficient sediment input to trigger Spring HFEs in “26% of the years in the LTEMP period”

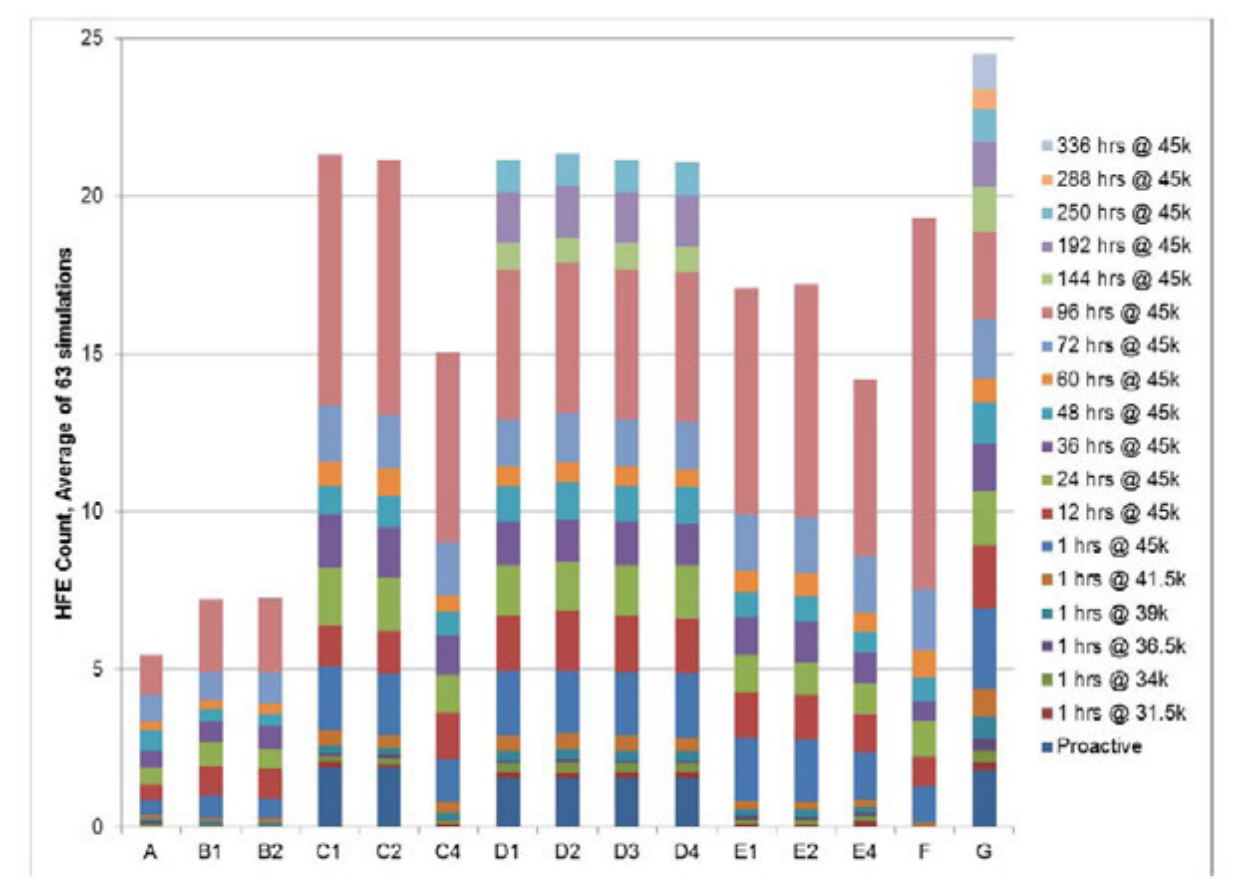


FIGURE E-8 Average Sediment and Hydrology Triggered HFE Count by Type for Each Long-Term Strategy (long-term strategies C3, E3, E5, and E6 by definition have no HFEs)

Estimated number of HFEs to occur during 20-year implementation of LTEMP
(“D” was selected alternative)

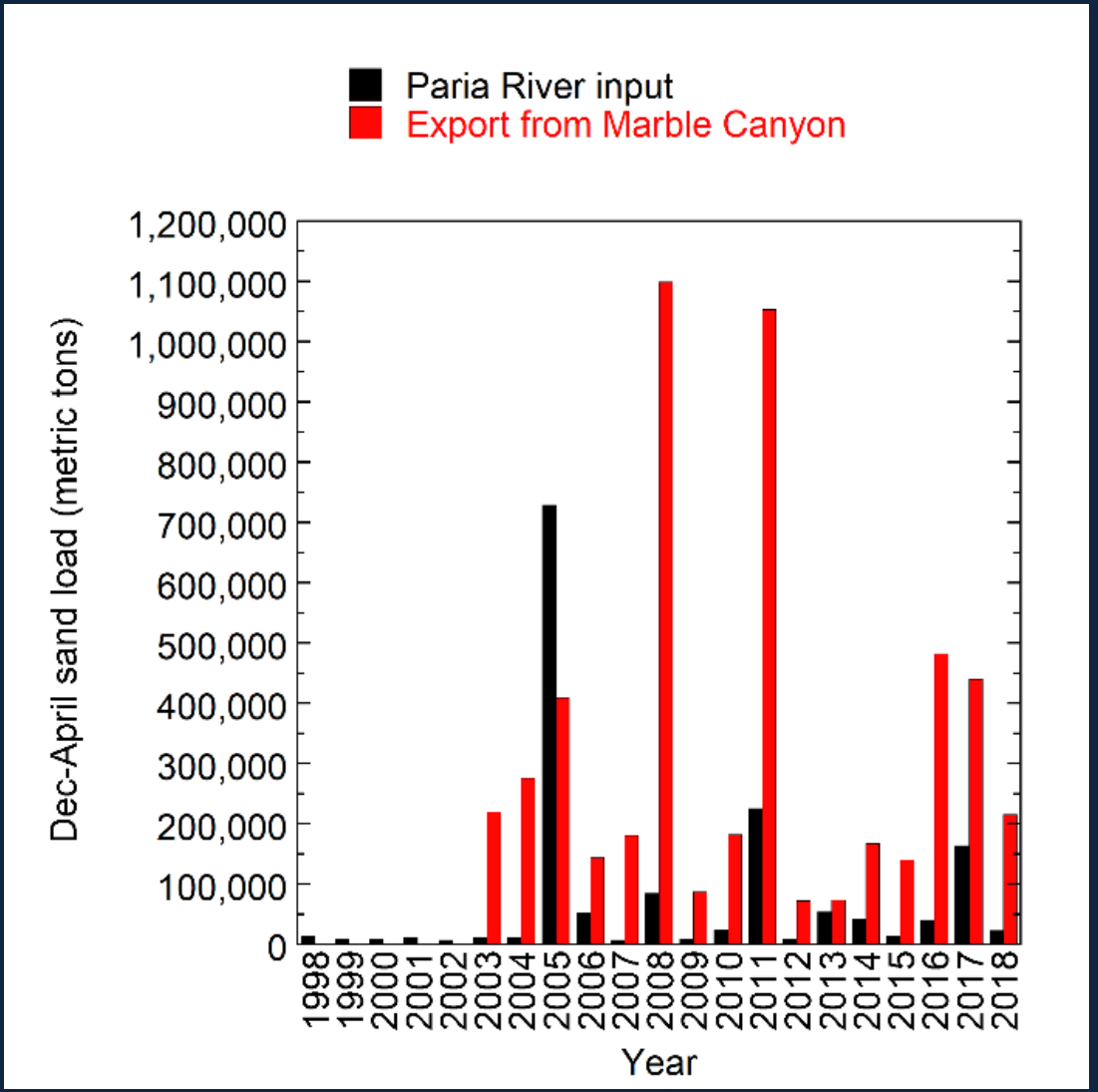
Plot from LTEMP EIS, Appendix E

USGS

Frequency of Spring HFEs, cont.

Based on observations of past 20 years:

- Compare December – April Paria sand inputs with December to April sand export from Marble Canyon
- ➢ May have been sufficient sediment input to trigger Spring HFE: “Once since 1998”



Annual Paria River sand input (black) compared with Marble Canyon sand export (red)

Data from: https://www.gcmrc.gov/discharge_qw_sediment

USGS

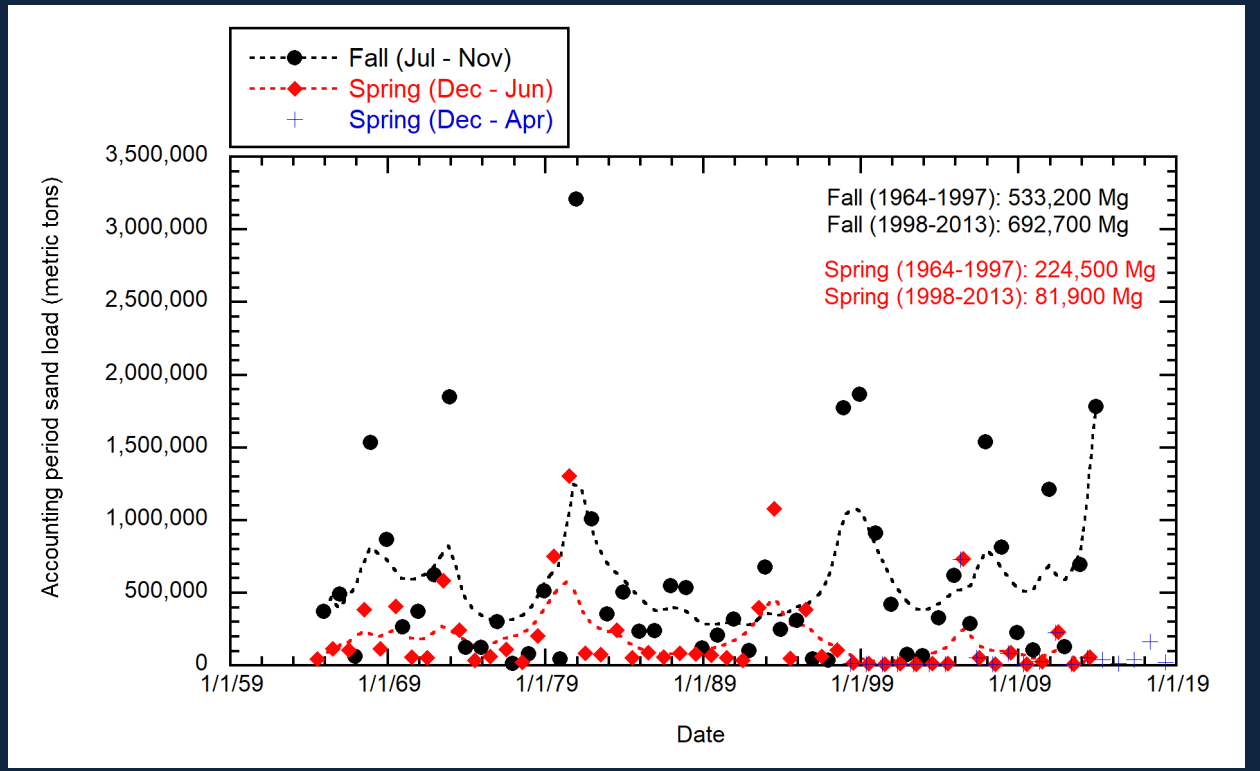
Frequency of Spring HFEs, , cont. 2

Why the difference between the two analyses?

- The LTEMP simulations considered Paria River sand inputs since 1963
- Fall (summer) sand inputs from Paria have been relatively consistent
- Spring (winter) sand inputs were at least 3 times greater between 1964 and 1997 than between 1998 and present

➢ Summer sand inputs have been consistent, but winter sand inputs have not been consistent

Maybe there will be a return to larger winter floods, or maybe there has been a shift towards less winter precipitation.



- *Black circles (summer/fall inputs) and red diamonds (winter/spring inputs) are data used in LTEMP*
- *Blue "+" are 1998 – 2018 data we looked at (same)*

Data from: https://www.gcmrc.gov/discharge_qw_sediment

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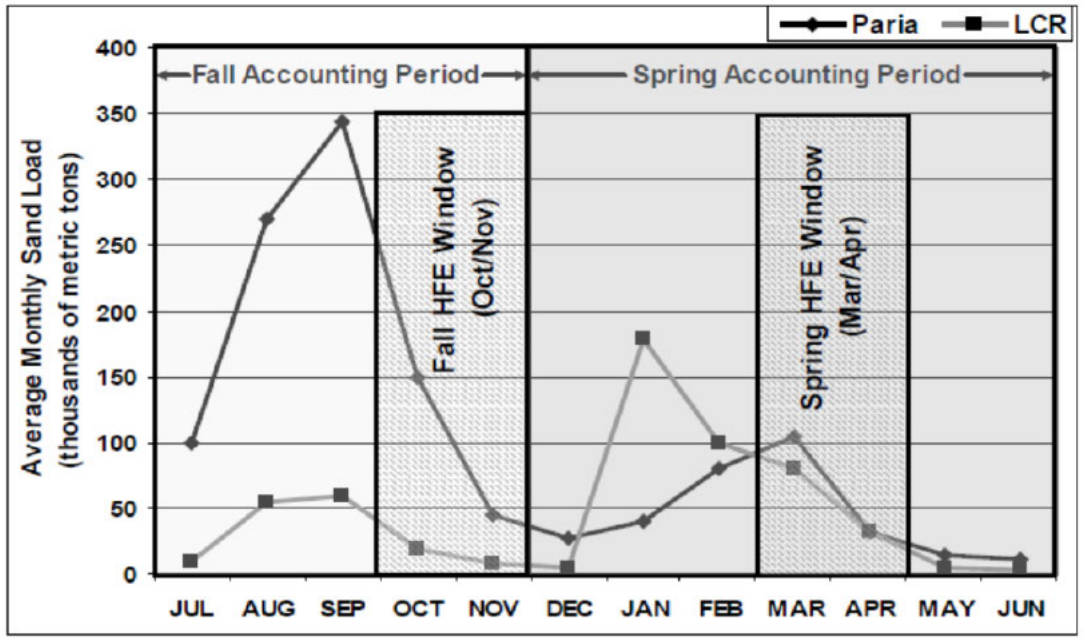
How to trigger a Spring HFE:

- Merge the separate fall and spring accounting periods to one annual accounting period:
  - Could design to implement HFE in fall or spring
  - Would need a process for deciding whether to implement HFE in Fall or Spring
  - Would likely end up with more sand export before implementing spring HFE
    - Lower dam releases in winter would result in more sand left for spring HFE
    - Can evaluate this with sand mass balance model
- Although a single annual accounting period is not the process that was described in LTEMP, it is fully consistent with the scientific basis for the "store-and-release" HFE approach that was adopted in LTEMP.



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Plot from LTEMP EIS, Appendix P

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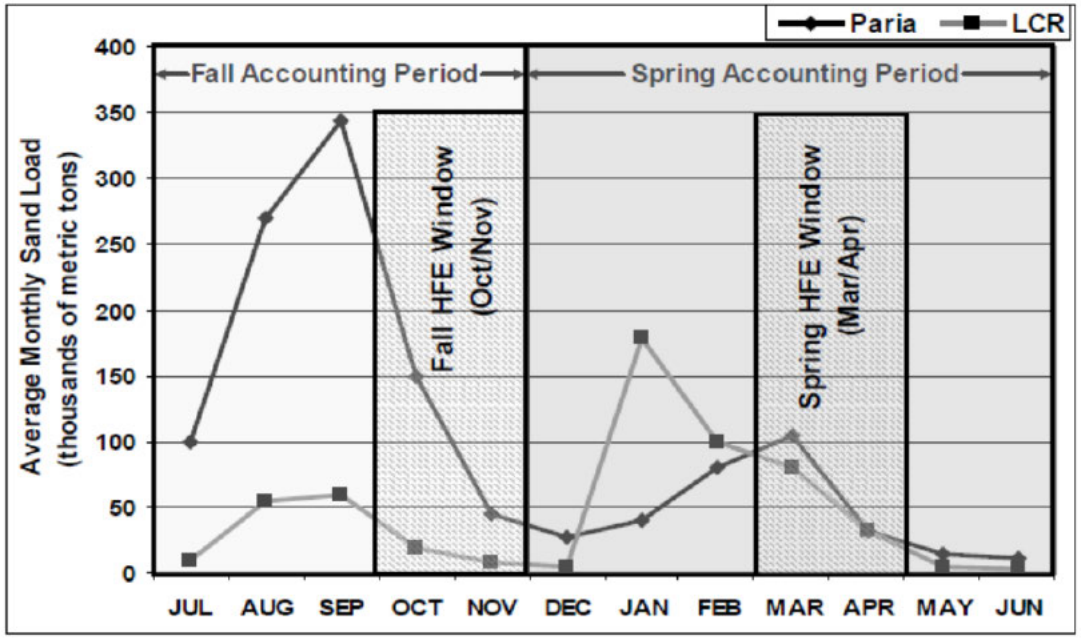
How to trigger a Spring HFE, cont:

Looking back at sand budgets for Marble Canyon from 2002 to 2017:

- 9 years with fall sediment triggers:
  (> 300,000 metric tons of accumulation)
  - 1 year with winter inputs resulted in greater sand enrichment for the next spring
  - 5 years where winter inputs meant fall and spring sand enrichment in Marble Canyon were about the same
  - 2 years where sand enrichment in fall was much larger than in spring
  - 1 year where there was sand enrichment in fall and no sand enrichment in spring



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