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Managing Water in the West

Bighorn River Side Channel Investigation:

Hydraulic and Sediment Transport Analysis

U.S. Department of the Interior
Bureau of Reclamation

Presentation Outline

- Acknowledgements
- Review of Bighorn River geomorphic study
- Past hydrology
- Hydraulic model results
- Sediment tracers
- Repeat surveys
- Conclusions
- Recommendations

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Acknowledgements

- **Thanks to:**
  - **Earl Radonski (MT-FWP), Travis Bauer (Reclamation, TSC), Jeanne Godaire (Reclamation, TSC) for assistance during the bathymetric survey in 2009**
  - **Earl Radonski (MT-FWP), Brad Olszewski (MT-FWP), Jim Forseth (Reclamation, MTAO), and Dan Stremcha (Reclamation (Reclamation, MTAO) for assistance during the pebble counts**
  - **Earl Radonski (MT-FWP) and Dave Gaeuman (Reclamation, TRRP) for assistance with placing and locating the gravel tracers**
  - **Dennis Fischer for several conversations throughout the study**

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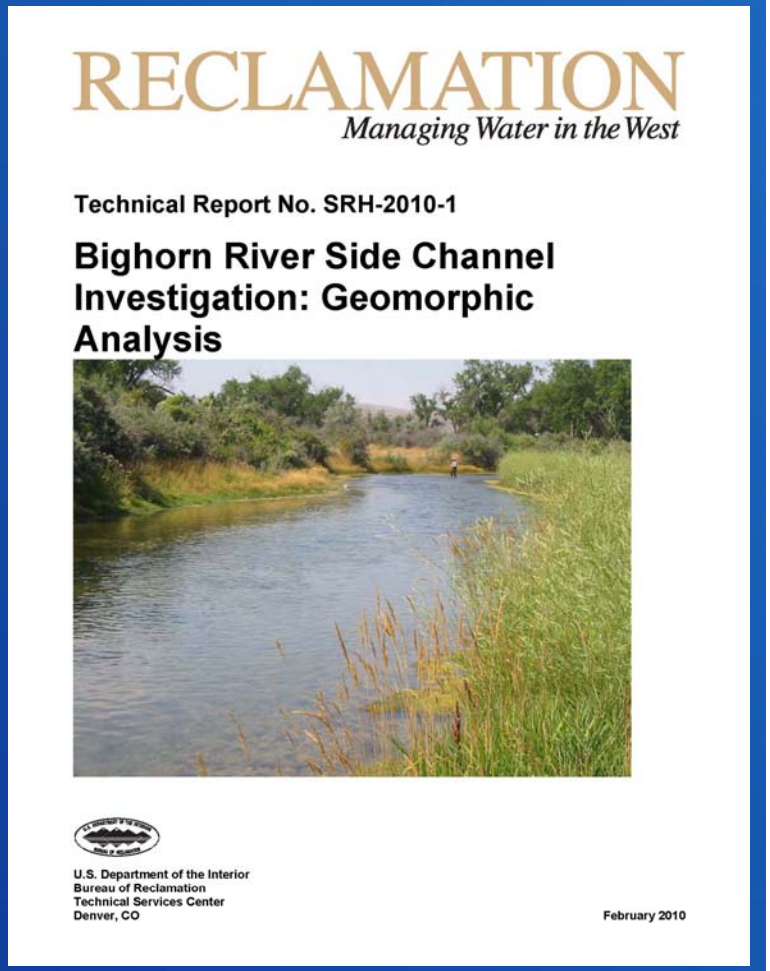
Bighorn River Geomorphology

- **Jeanne Godaire (Reclamation, TSC) completed the geomorphic study in Feb. 2010**
  - **Bed elev. In the main channel has remained relatively stable**
  - **Channel positions have maintained a similar position since 1980**
  - **Geomorphic complexity has been decreasing since 1961**
  - **Several ecologically critical side channels are becoming disconnected from the main channel**
  - **Several side channels were abandoned betw. 1961 and 2009**



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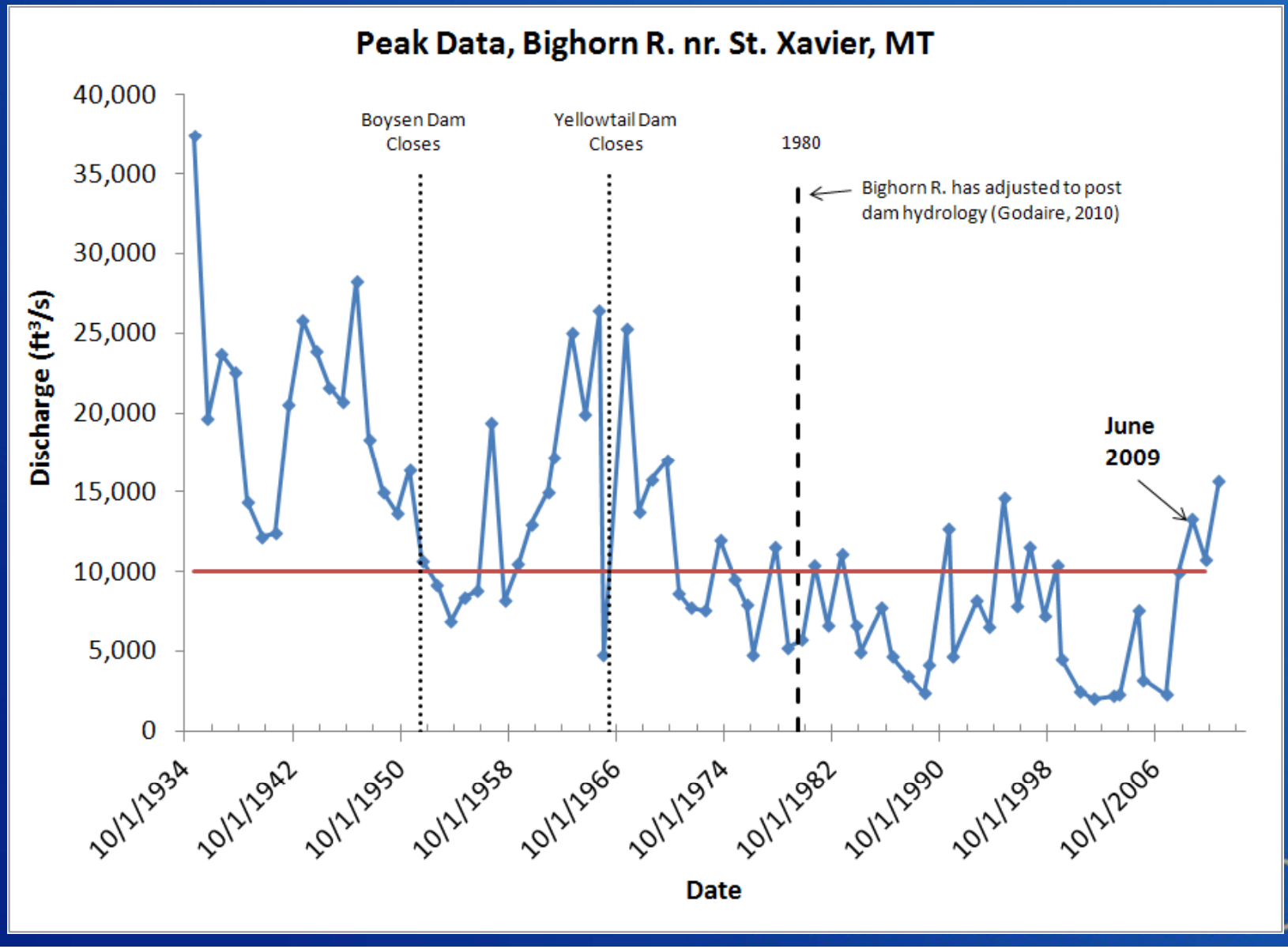
Past Hydrology



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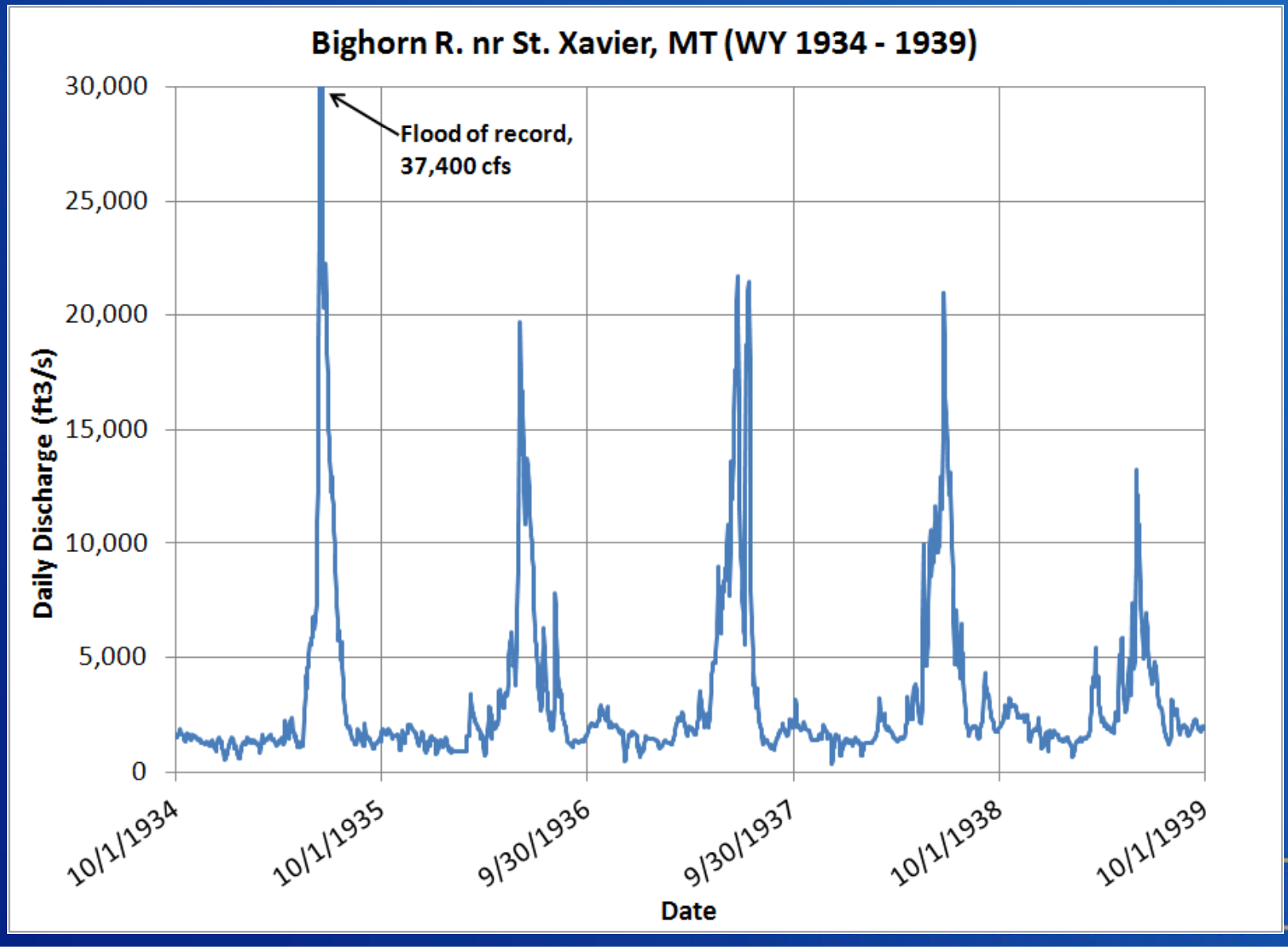

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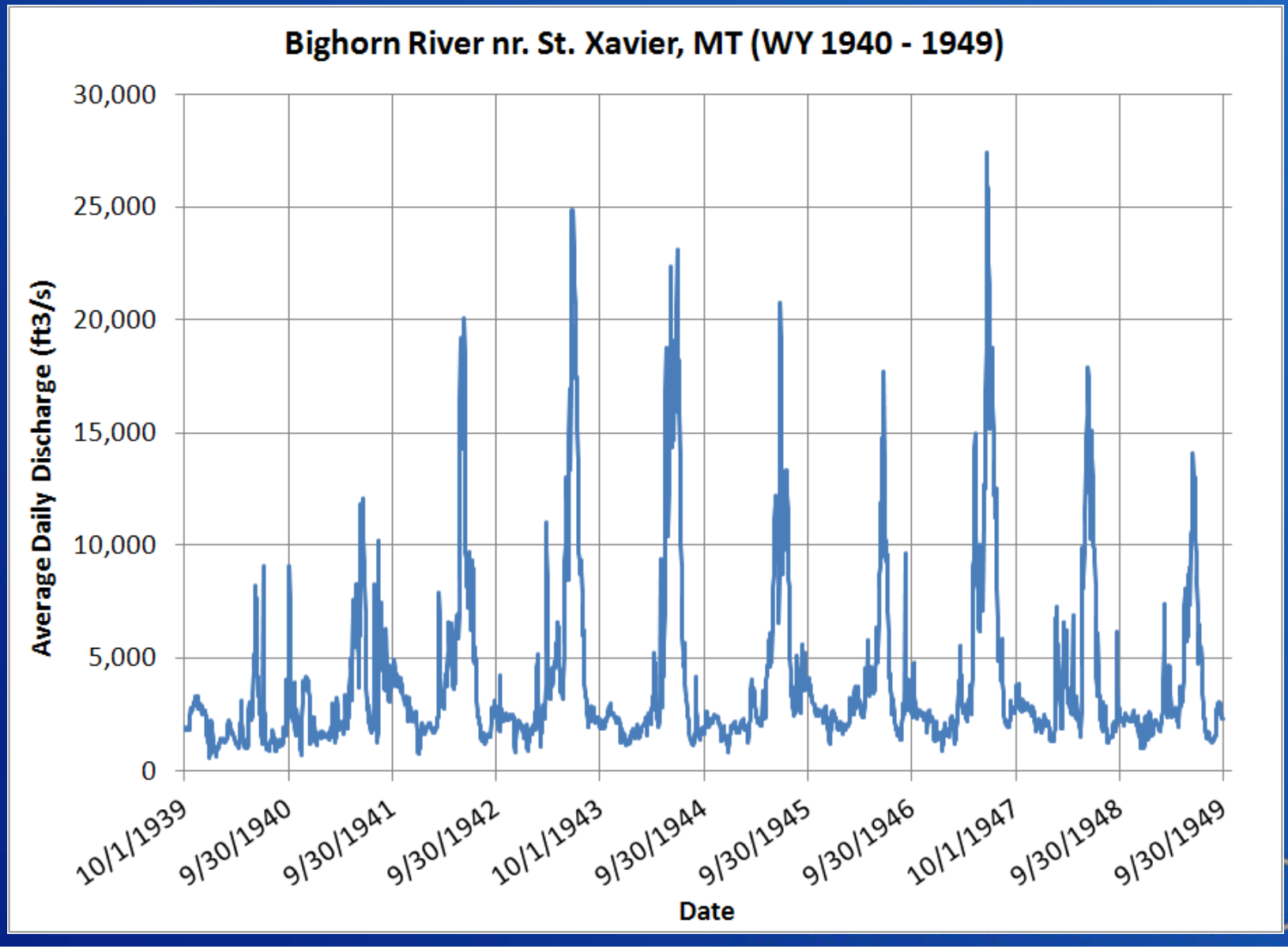

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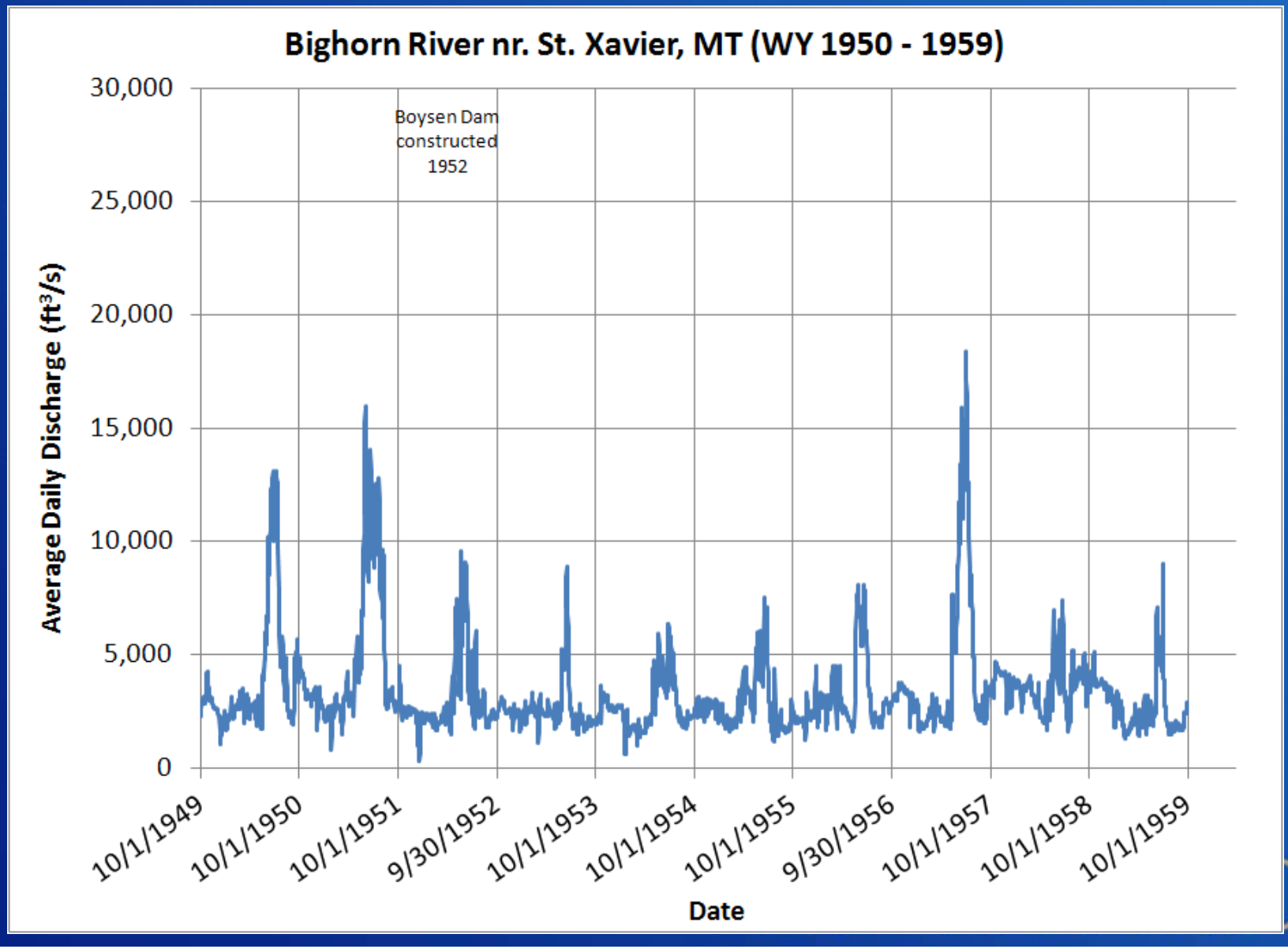

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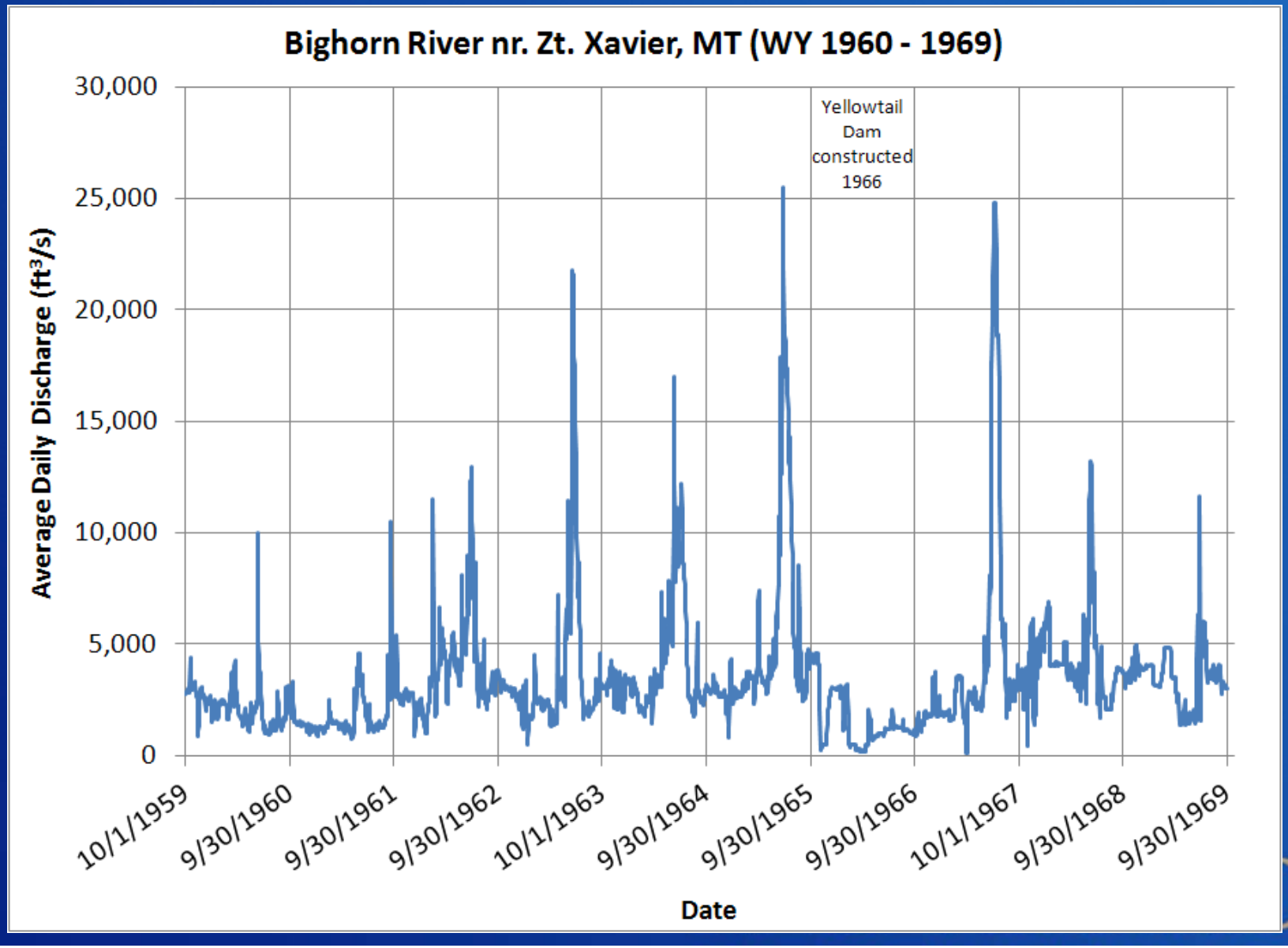

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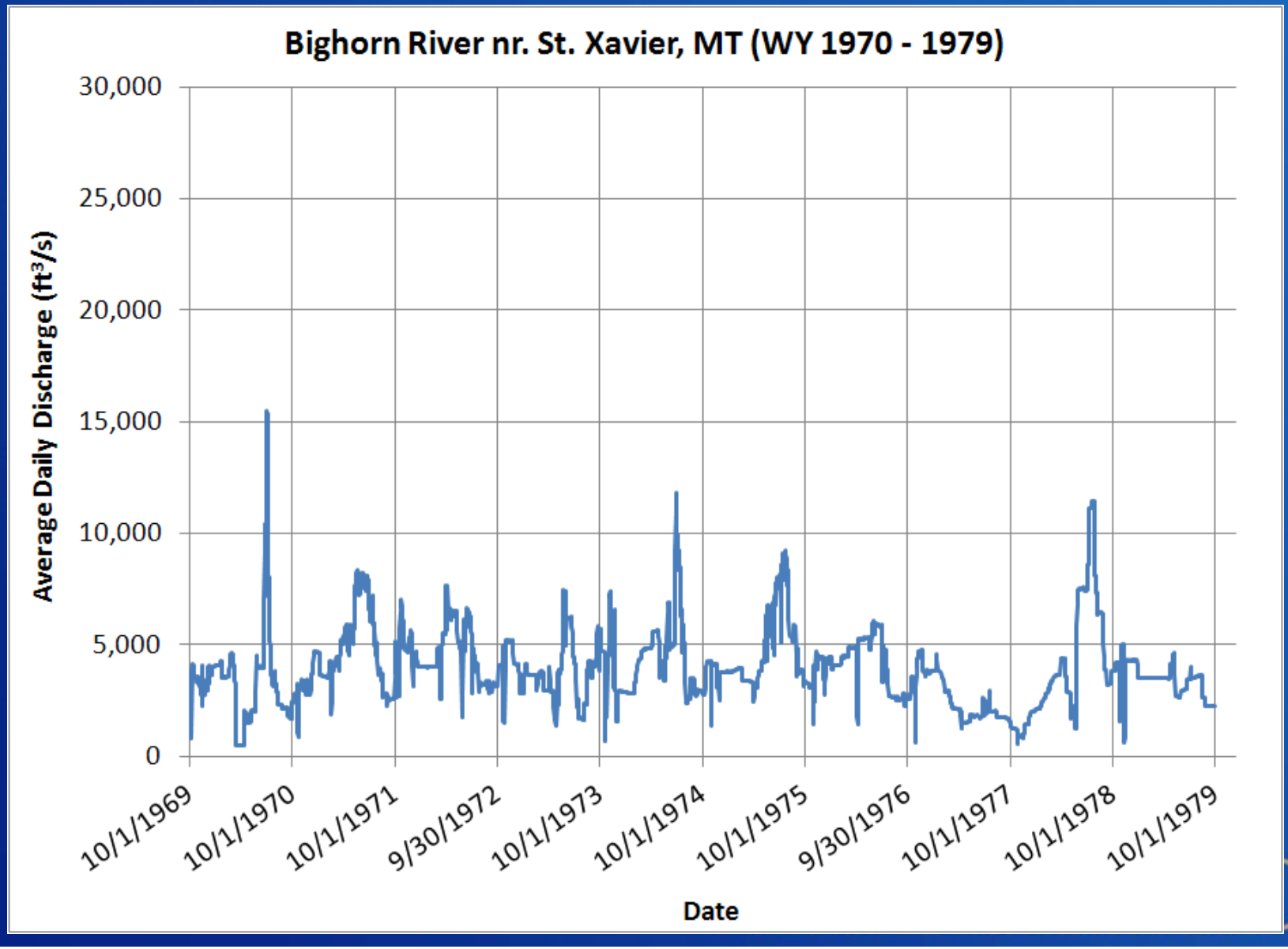

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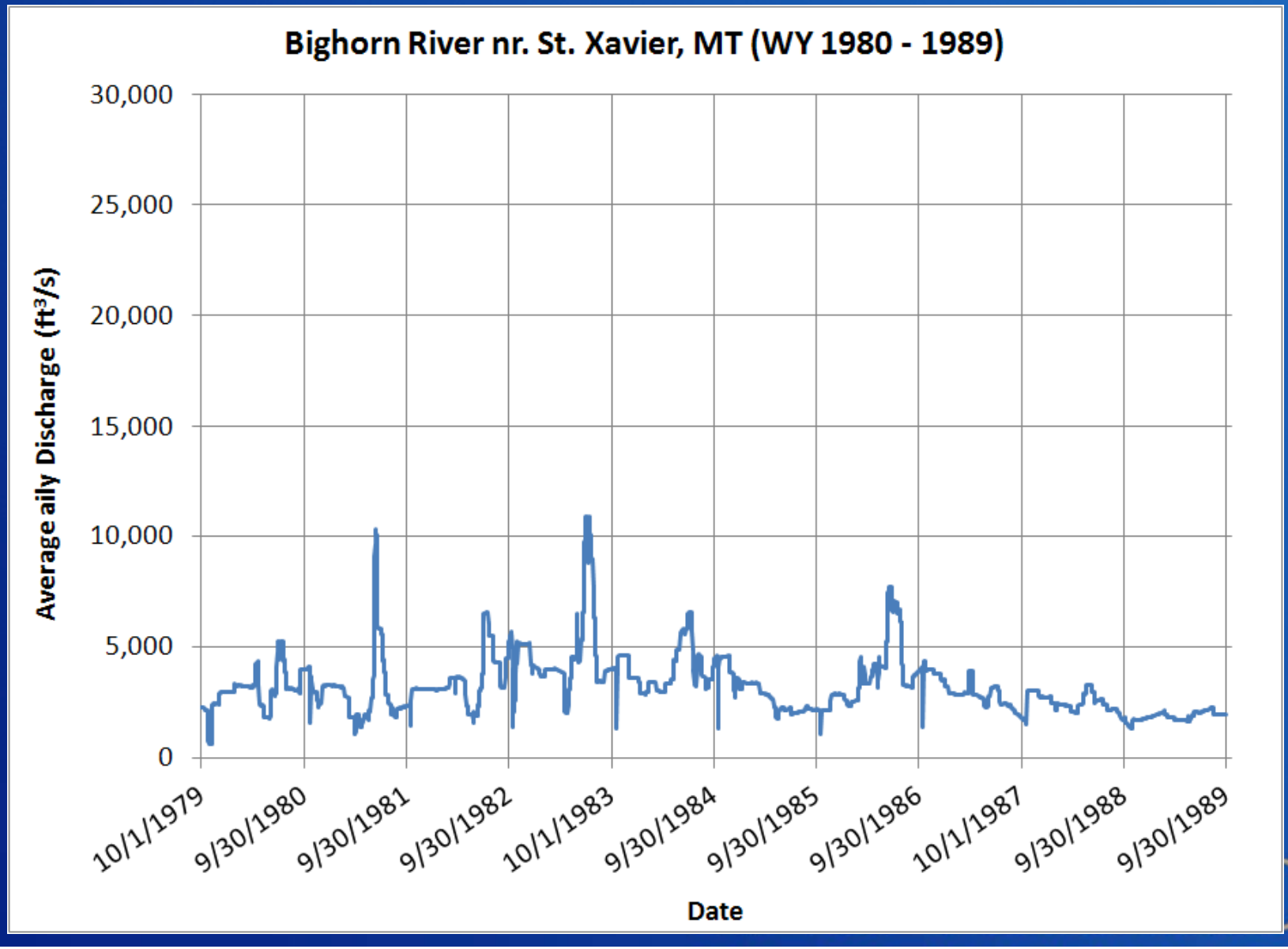

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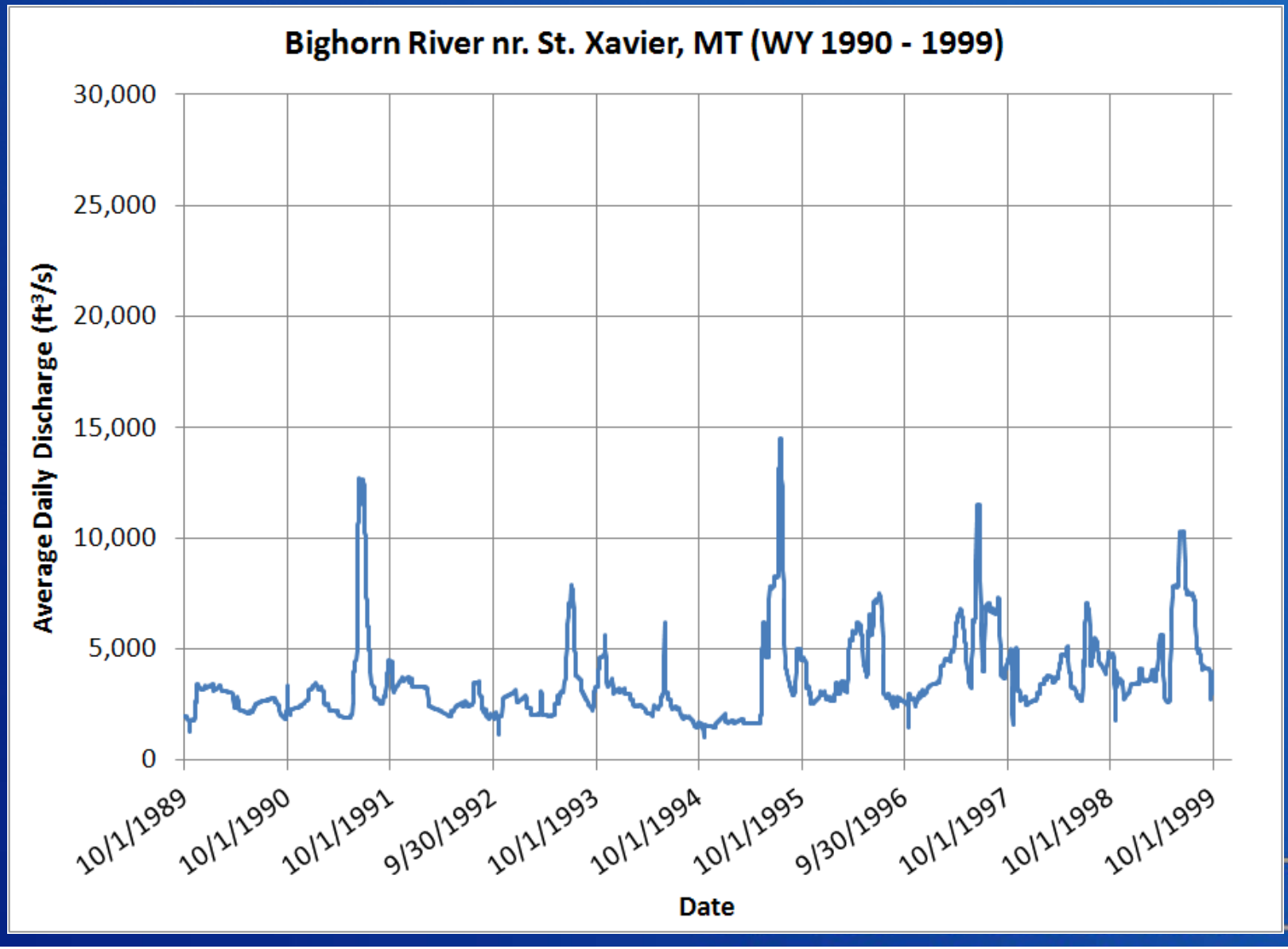

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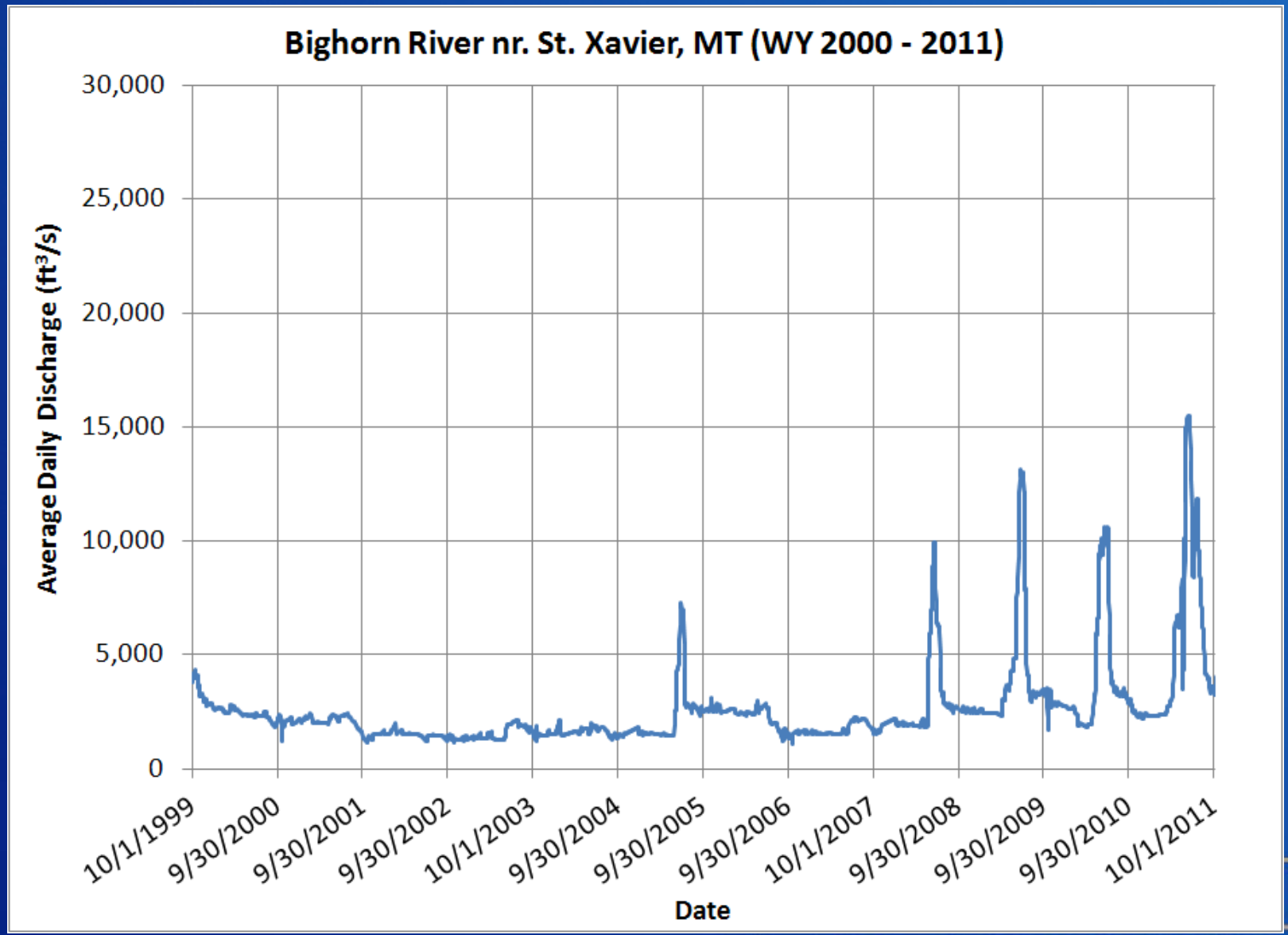
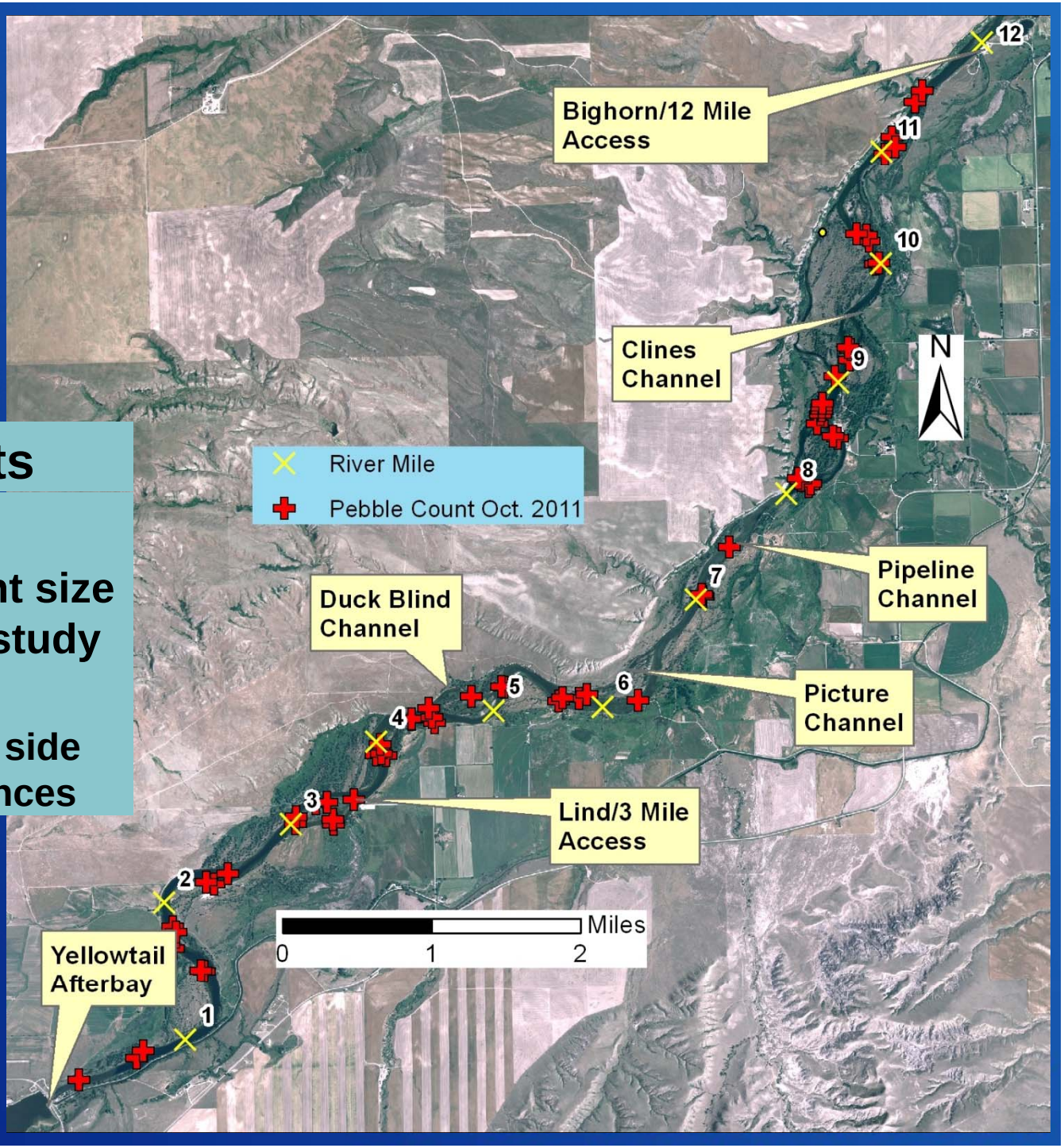


Hydraulic Modeling

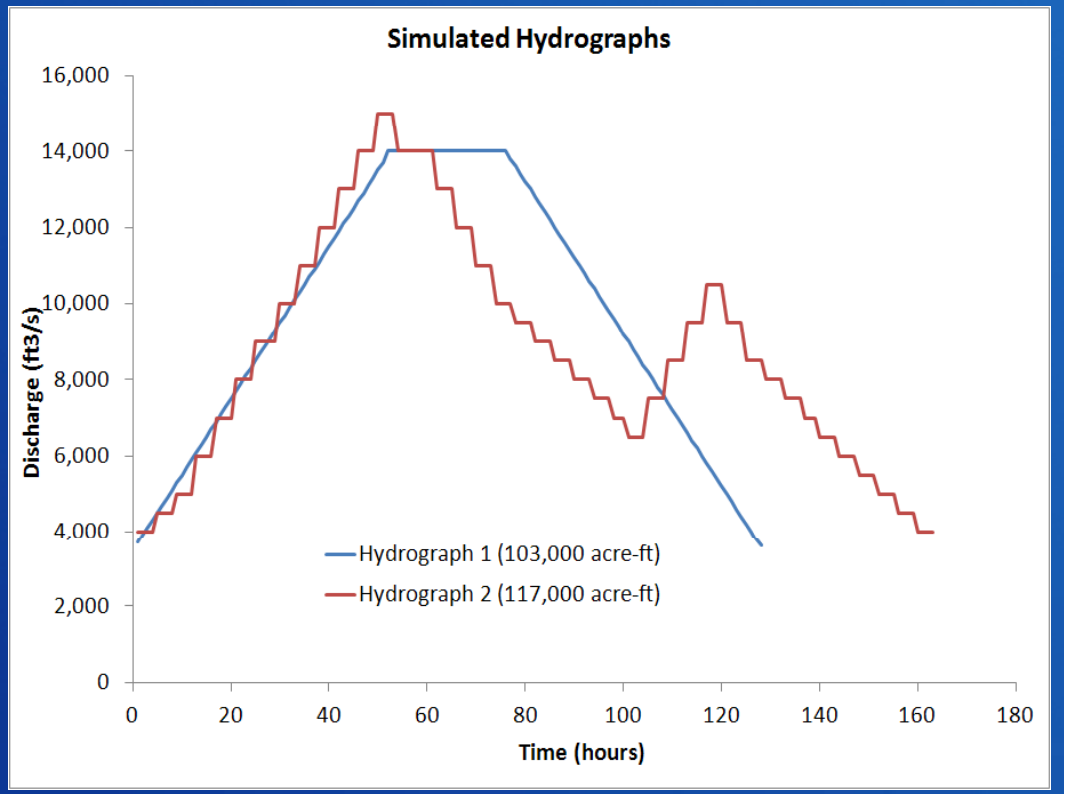
- **64 Pebble Counts**
  - **Oct. 2012**
  - **Identify sediment size throughout the study reach**
    - **Particularly in side channel entrances**



Hydraulic Model

- **Steady State Discharges (ft^3/s)**
  - 2,500
  - 3,574
  - 5,500
  - 8,000
  - 10,000
  - 12,000
  - 14,000
  - 15,500

- **Unsteady Discharges**



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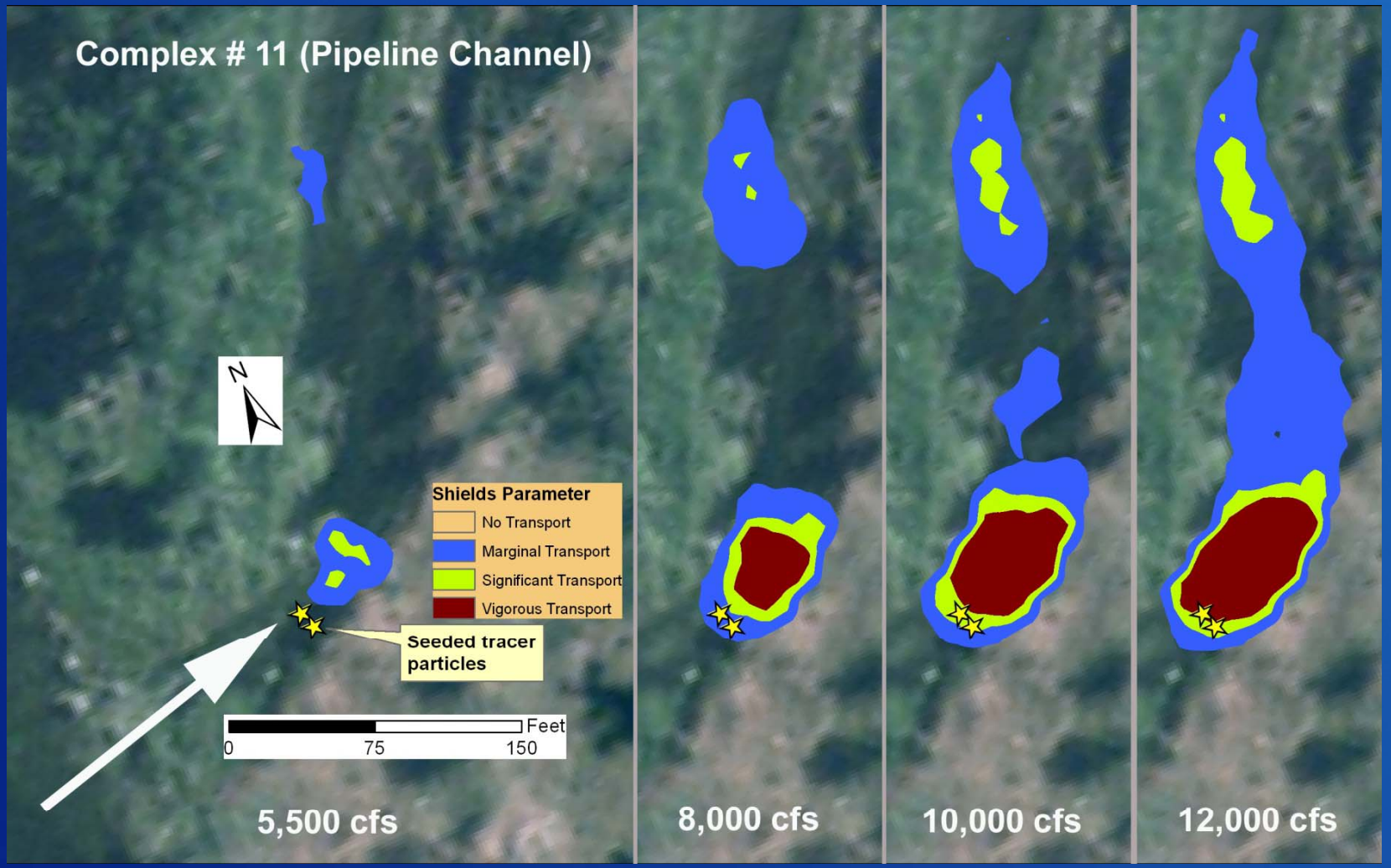
Hydraulic Model

- **Incipient Sediment Motion using Shield's Criteria**
  - **Buffington and Montgomery, 1997; Andrews, 1994; Pitlick and Van Steeter, 1998**
- $\tau_c^* = \tau / (\rho_s - \rho) g d_i$
  - where: τ_c^* = critical dimensionless Shields stress/parameter
  - τ = shear stress = $\rho g h S_f$ (h = flow depth, S_f = friction slope)
  - ρ and ρ_s are densities of water and sediment, respectively
  - g is the acceleration due to gravity; and d_i is the sediment size
- **Four categories of sediment motion**

No Sediment Transport	Marginal Sediment Transport	Significant Sediment Transport	Vigorous Sediment Transport
$0 < \tau_c^* \leq 0.03$	$0.03 < \tau_c^* \leq 0.047$	$0.047 < \tau_c^* \leq 0.06$	$\tau_c^* > 0.06$

Hydraulic Modeling Results



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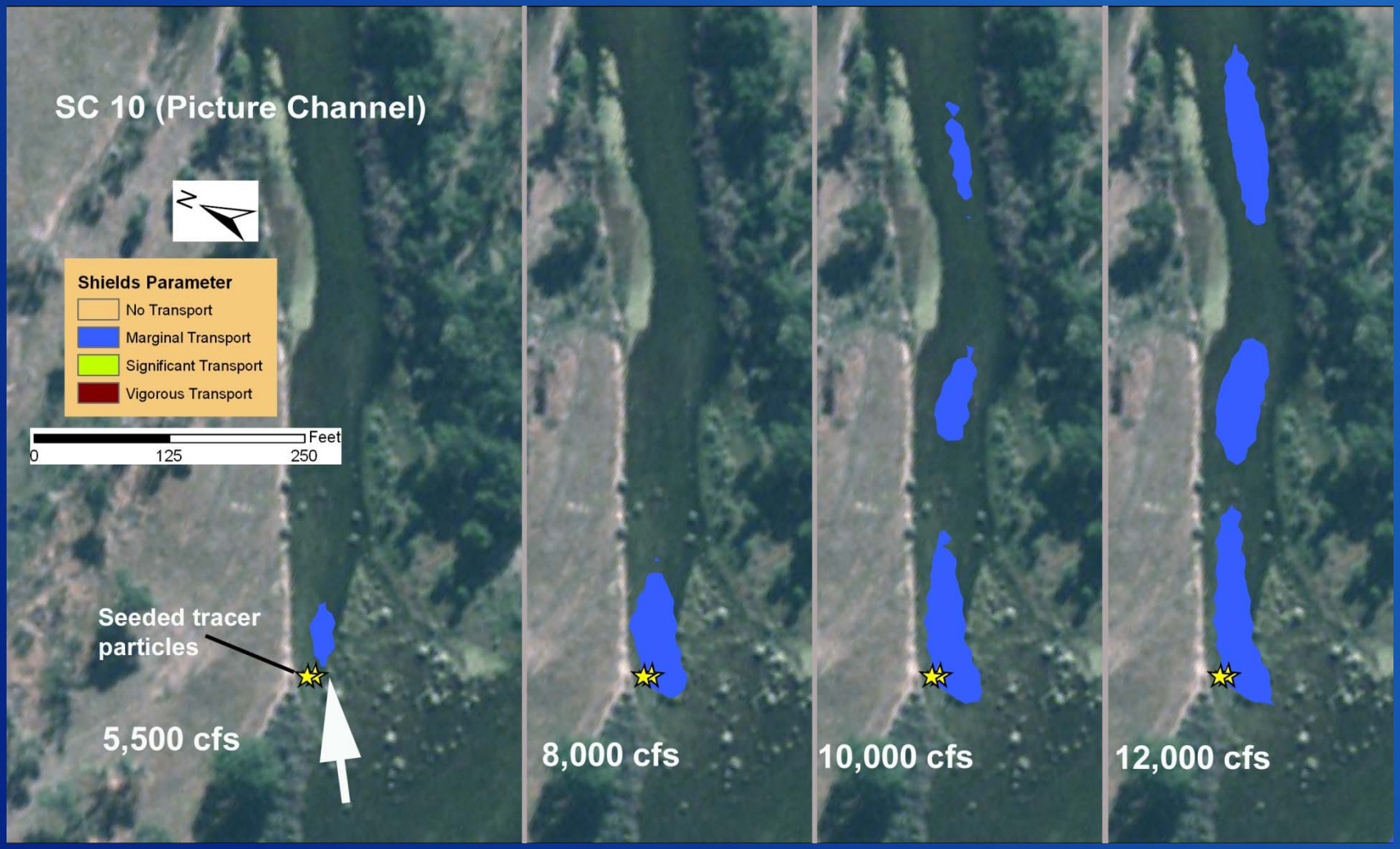
Hydraulic Model Results



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Tracer Particles

- Cooperative effort with Dave Gaeuman (BOR)
  - Funded last year (2012) with Reclamation research program
- Specially tagged particles have been seeded in four side channels of the study reach of the Bighorn R.
  - 100 particles in each of the four channels
- Marked with Radio Frequency Identification (RFID) tags and paint
- Purpose – track movement of three different size classes of gravel through four side channels
  - What discharge does it take to initiate motion?
    - Marginal? Significant? Vigorous?
  - How far does a particle travel in a single event?
  - How long does it take for a particle to move from the entrance to the outlet of a side channel?

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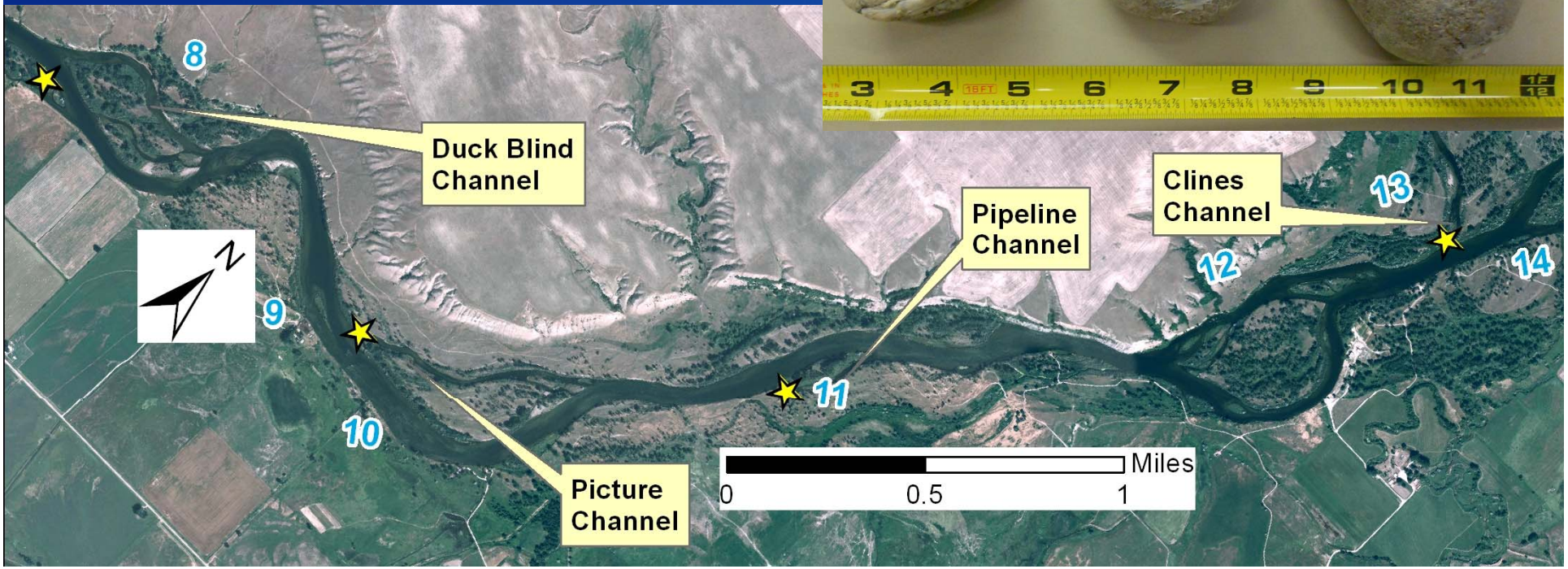
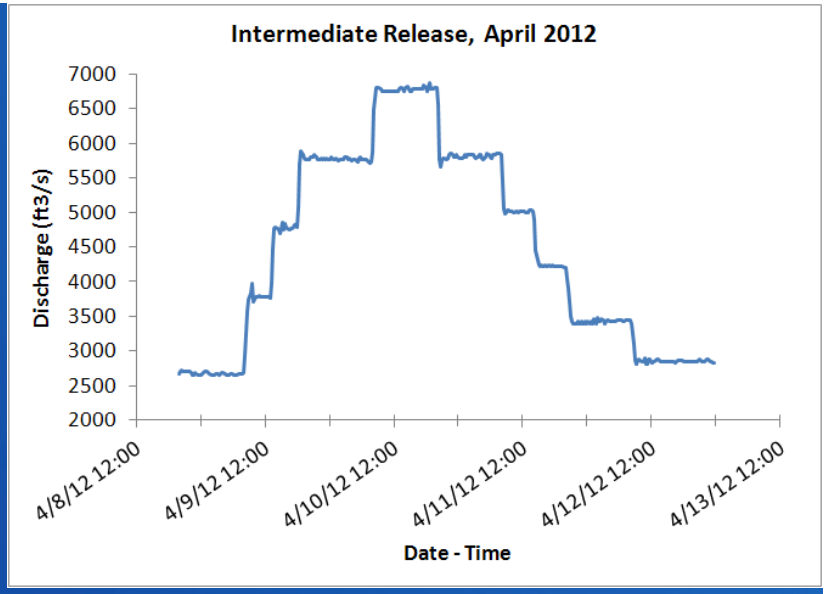
Tracer Particles



Tracer Particles



- Side Channel 8b:
  - 2 particles moved 90 ft.
  - 6 particles moved 55 ft.
  - 7 particles moved 45 ft
  - 12 particles moved 35 ft
  - Remaining particles remained in the seeded location or moved only a short distance
- Side Channel 10 (Picture channel)
  - 1 particle moved 18 ft.
  - 15 particles moved 6 ft.
  - All other particles remained in the seeded location
- Side channel 11 (Pipeline/Juniper channel)
  - 1 particle moved 21 ft
  - 3 particles moved 10 ft
  - 1 particle moved 5 ft
  - No other particles moved

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Repeat Surveys

- **Side Channel 8a**
  - **River right across from the Duck Blind channel**
  - **Survey 2009 and 2012**

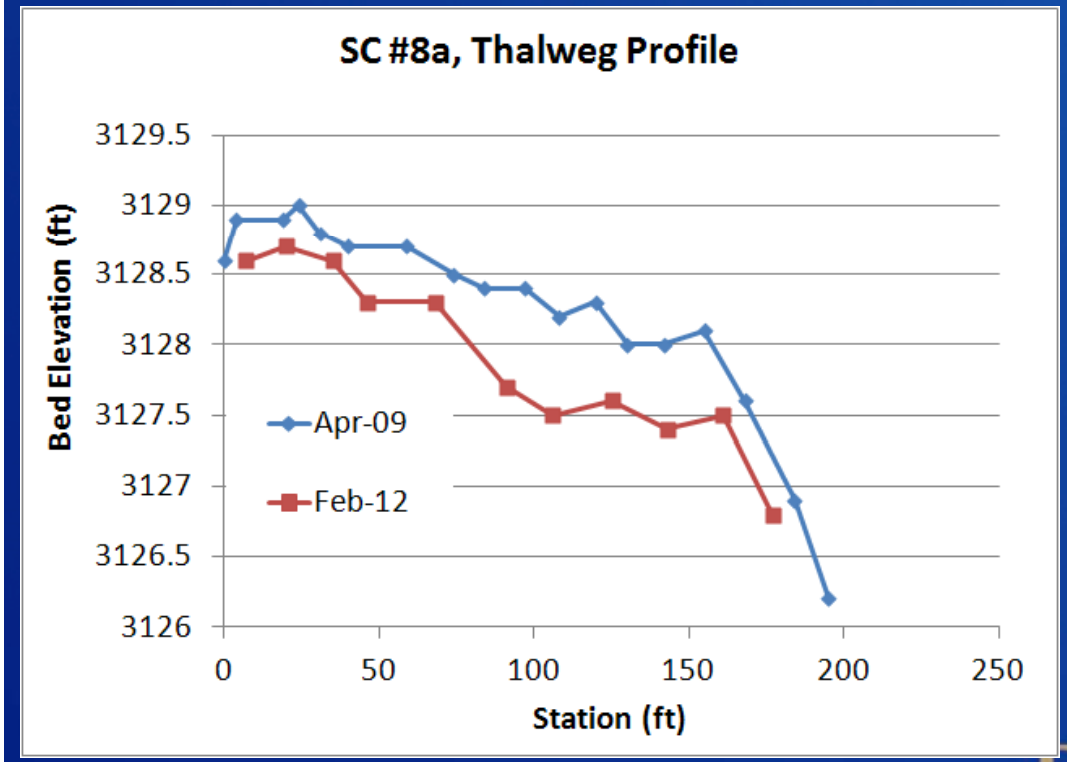
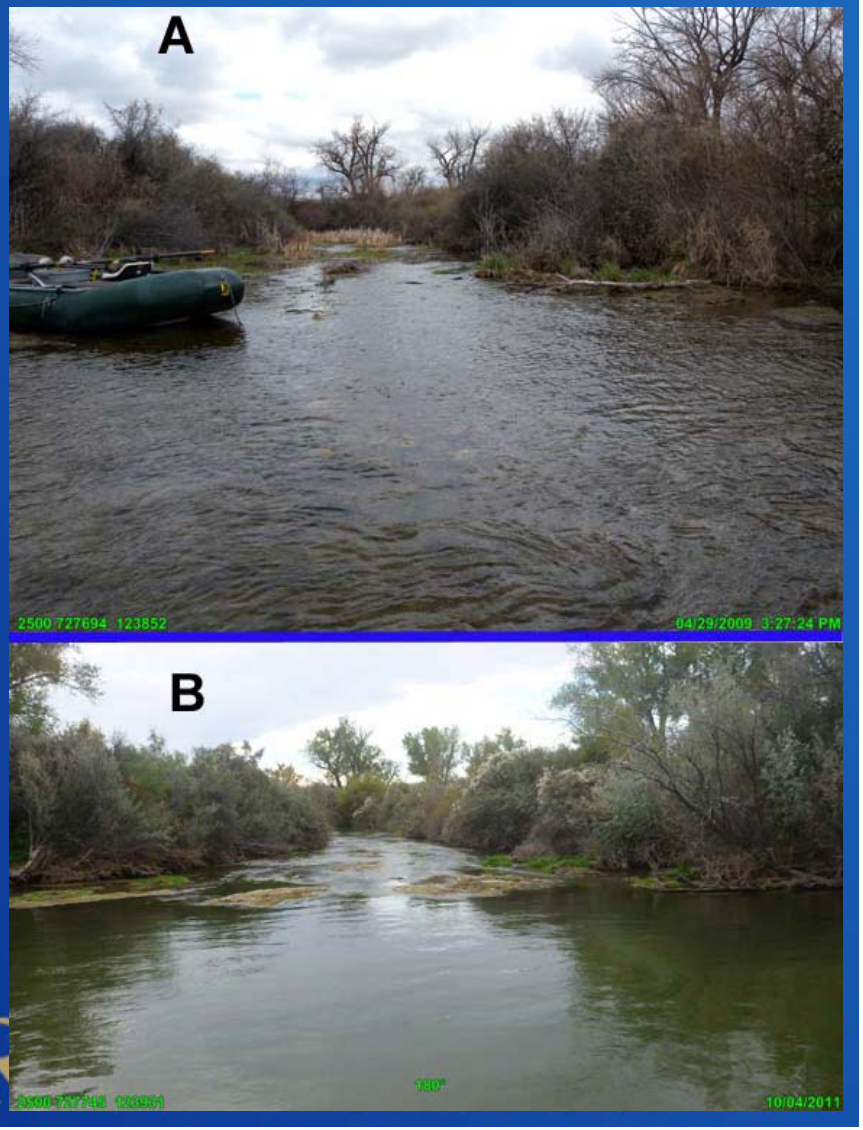
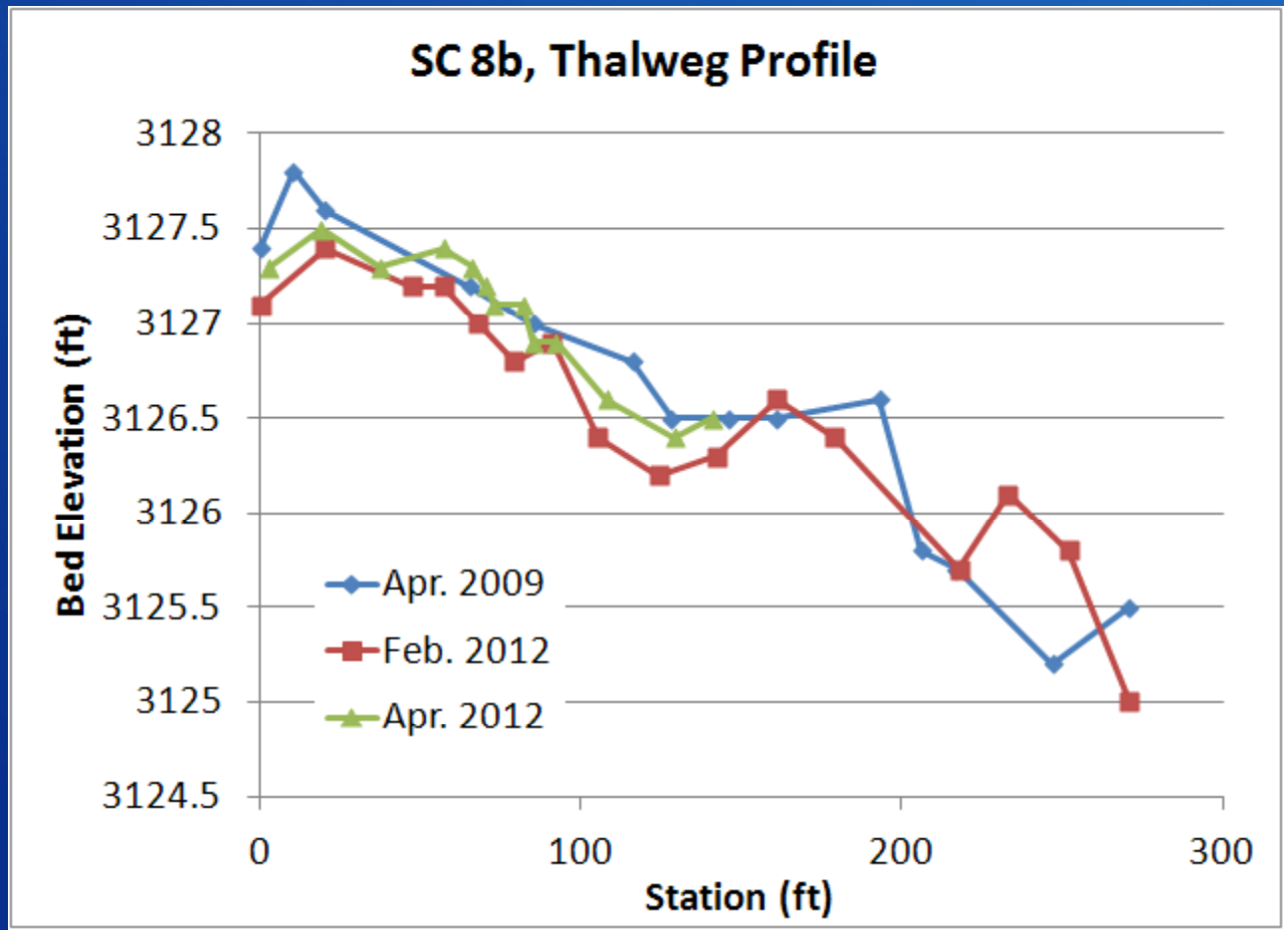


Photo 2009 and 2011
(3,574 AND 3,250 CFS)



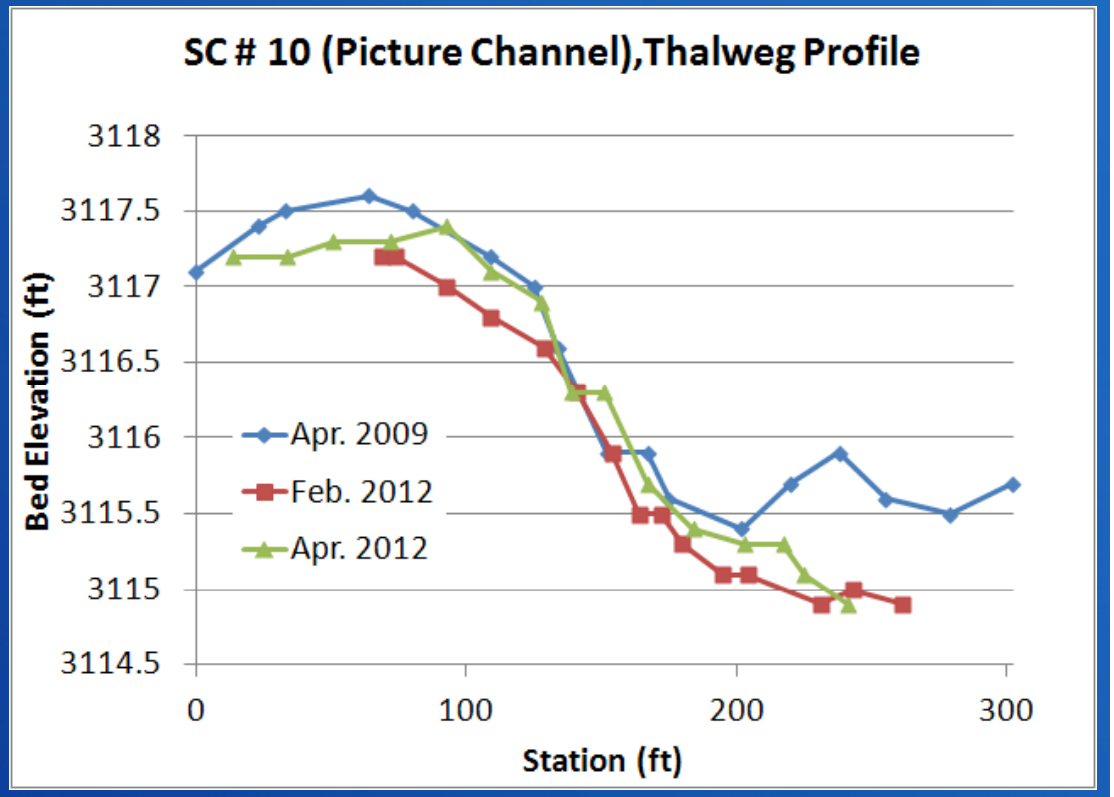
Repeat Surveys

- **Side channel 8b**
  - **Survey 2009 and 2012**



Repeat Surveys

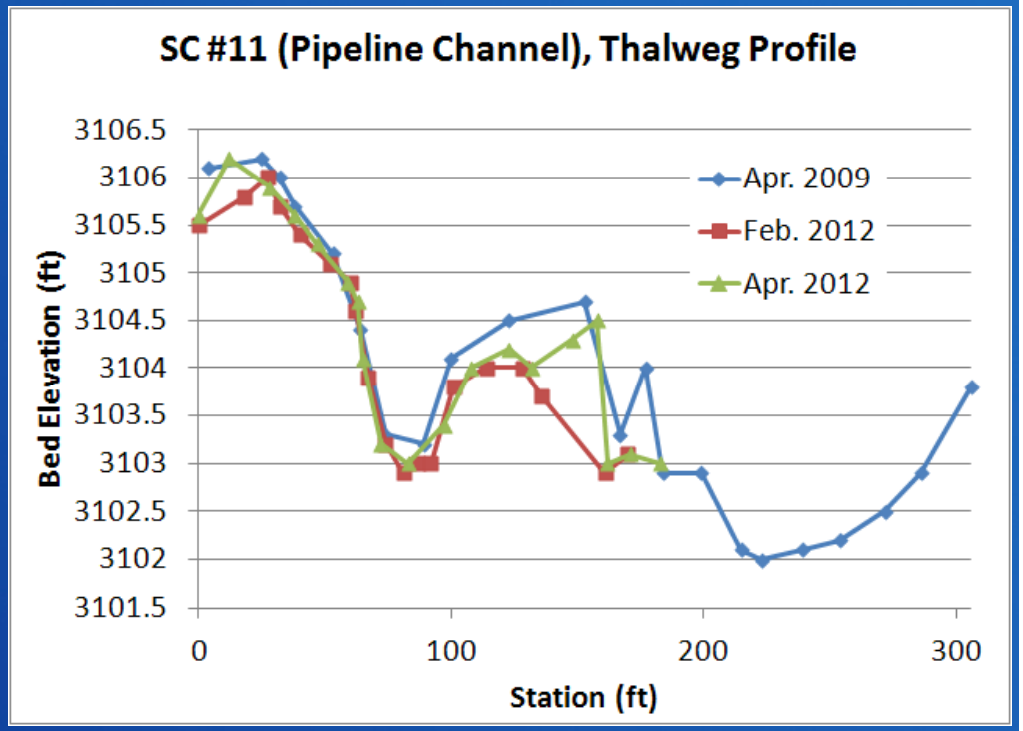
- Side channel #10 (Picture channel)
  - Surveys 2009, 2012
  - Photo A – 2009
  - Photo B – 2012
  - (3,115 AND 3,250 CFS)

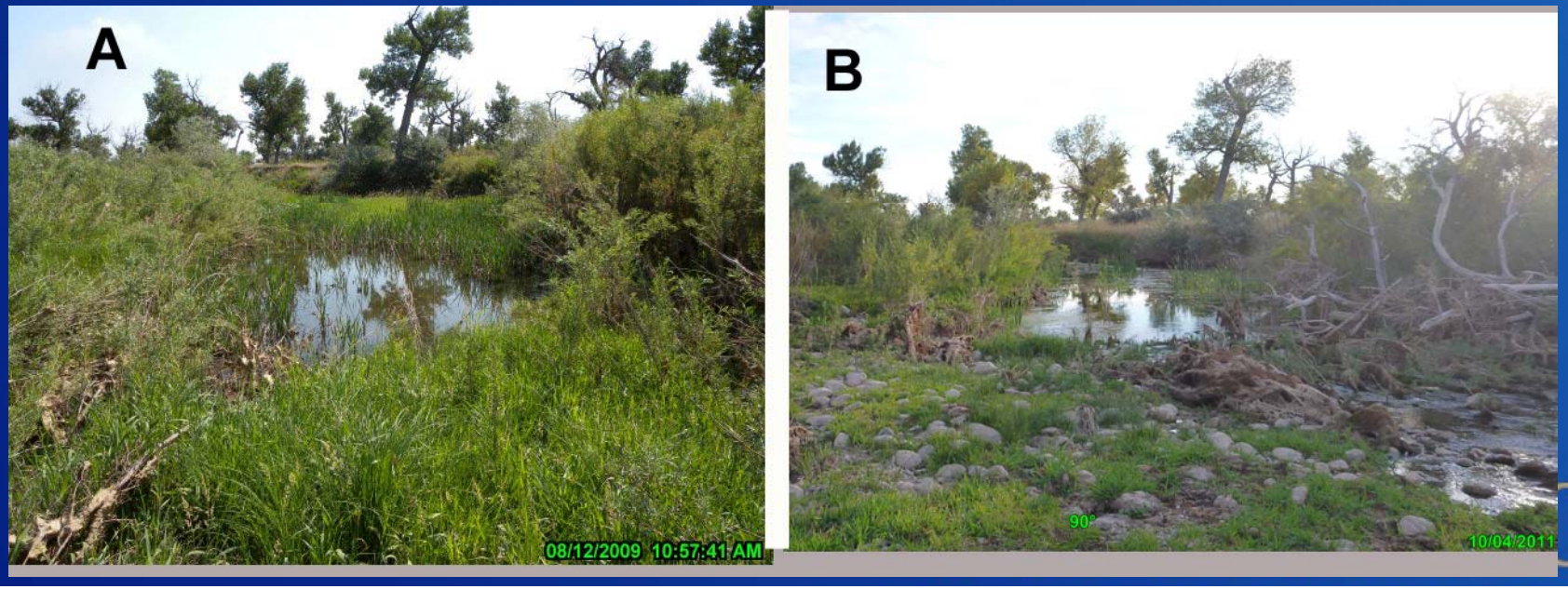


Repeat surveys

- **Side channel #11 (Pipeline/Juniper channel)**
  - **Survey 2009 and 2012**
  - **Photos 2009 and 2011**

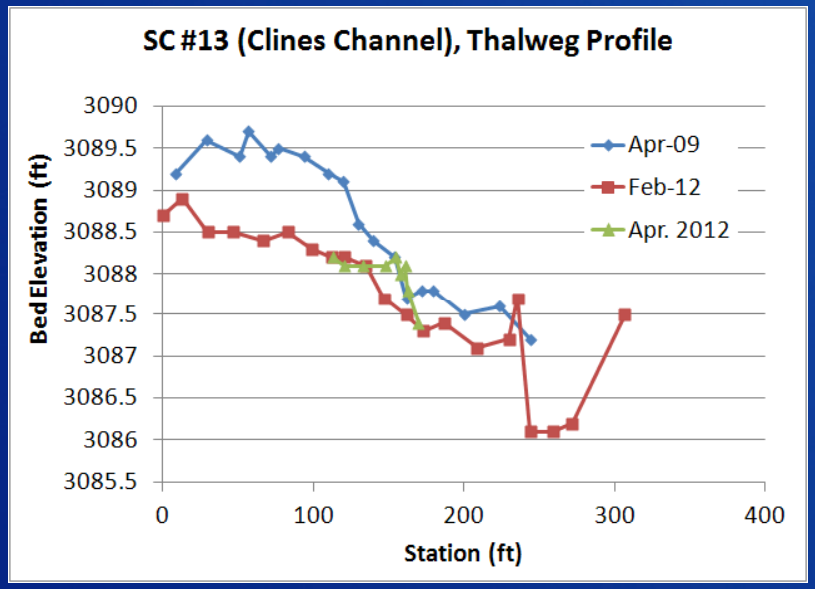
  (3,115 and 3,250 cfs)





Cline's channel

- **Side channel #13**



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Cline's Channel

- **Sediment tracer results**
  - **Significant sediment transport occurred in this channel during the 7,000 cfs release in April 2012**
  - **All particles were transported from their seeded location**
  - **Some particles were located 180 ft. downstream of the seeding location**
  - **Many tracer particles were buried, indicating significant motion of the native sediment**

Conclusions of the Study

- **Releases from Yellowtail Dam:**
  - **are capable of clearing vegetation on gravel bars and in side channels**
  - **are capable of flushing fine sediment from side channels**
  - **are likely capable of stopping the trend of side channel aggradation, perhaps very slowly reversing the trend**
  - **Are *not* likely to reverse the trend of side channel aggradation in a timely manner**
- **Mechanical removal of accumulated sediment, in addition to well conceived releases from Yellowtail Dam, is likely the only means by which select side channels can become active at a lower discharge than present conditions**

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Recommendations

- **Releases from Yellowtail Dam**
  - **Intermediate releases of 6,000 to 10,000 cfs are recommended for vegetation and fine sediment removal**
    - **Recommended frequency – annually**
      - **Not to exceed 3 years**
  - **High flow releases of 10,000 to 15,000 cfs are recommended for maintaining existing conditions in side channels, maintain new excavations, and increase habitat diversity**
    - **Recommended frequency – biannually**
      - **Not to exceed 5 years**
  - **Smaller magnitude, more frequent changes to discharge during drawdown**

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Recommendations

- **Ecological releases should vary from year to year**
  - **There is no single discharge that benefits all ecological functions**
  - **Varying release peak and duration will increase the diversity of the river**

Recommendations

- Monitoring
  - Continue repeat surveys
    - Establish more cross sections similar to the WAPA cross sections established in the 1990's
    - Continue to monitor Cline's channel for function
  - Establish photo-points and continue monitoring with frequent photographs of select side channels
  - Continue to monitor sediment tracer particles
- Excavation
  - Consider excavating sediment at select side channel entrances
    - Design these excavations for sediment transport, not aesthetics or habitat

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Questions?

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