Verde River Navigability

Presentation to ANSAC

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February 2015

Definition of Navigability

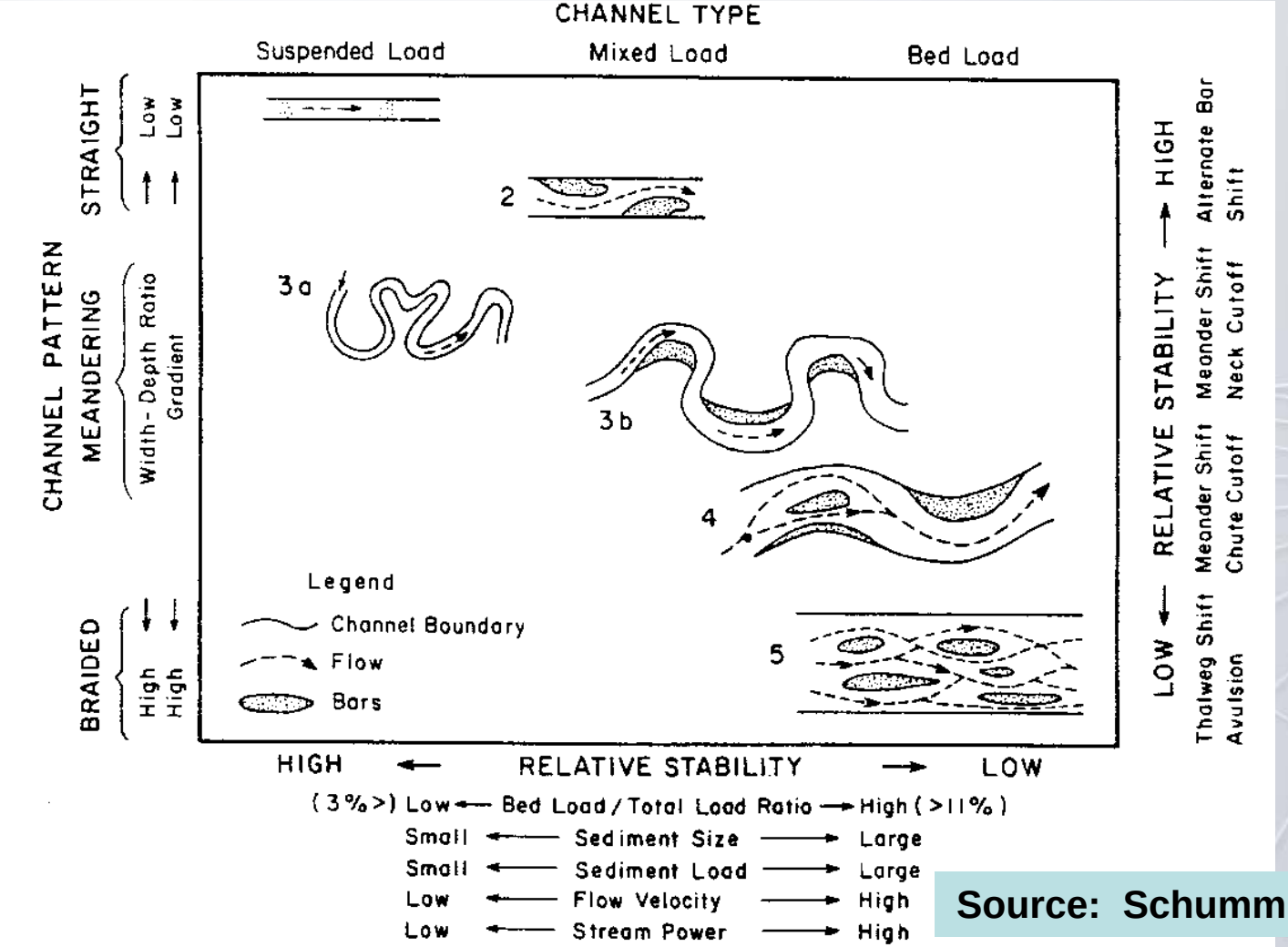
- A.R.S. § 37-1101(5)

"Navigable" or "navigable watercourse" means a watercourse that was in existence on February 14, 1912, and at that time was used or was susceptible to being used, in its ordinary and natural condition, as a highway for commerce, over which trade and travel were or could have been conducted in customary modes of trade and travel on water.

Definition of Navigability

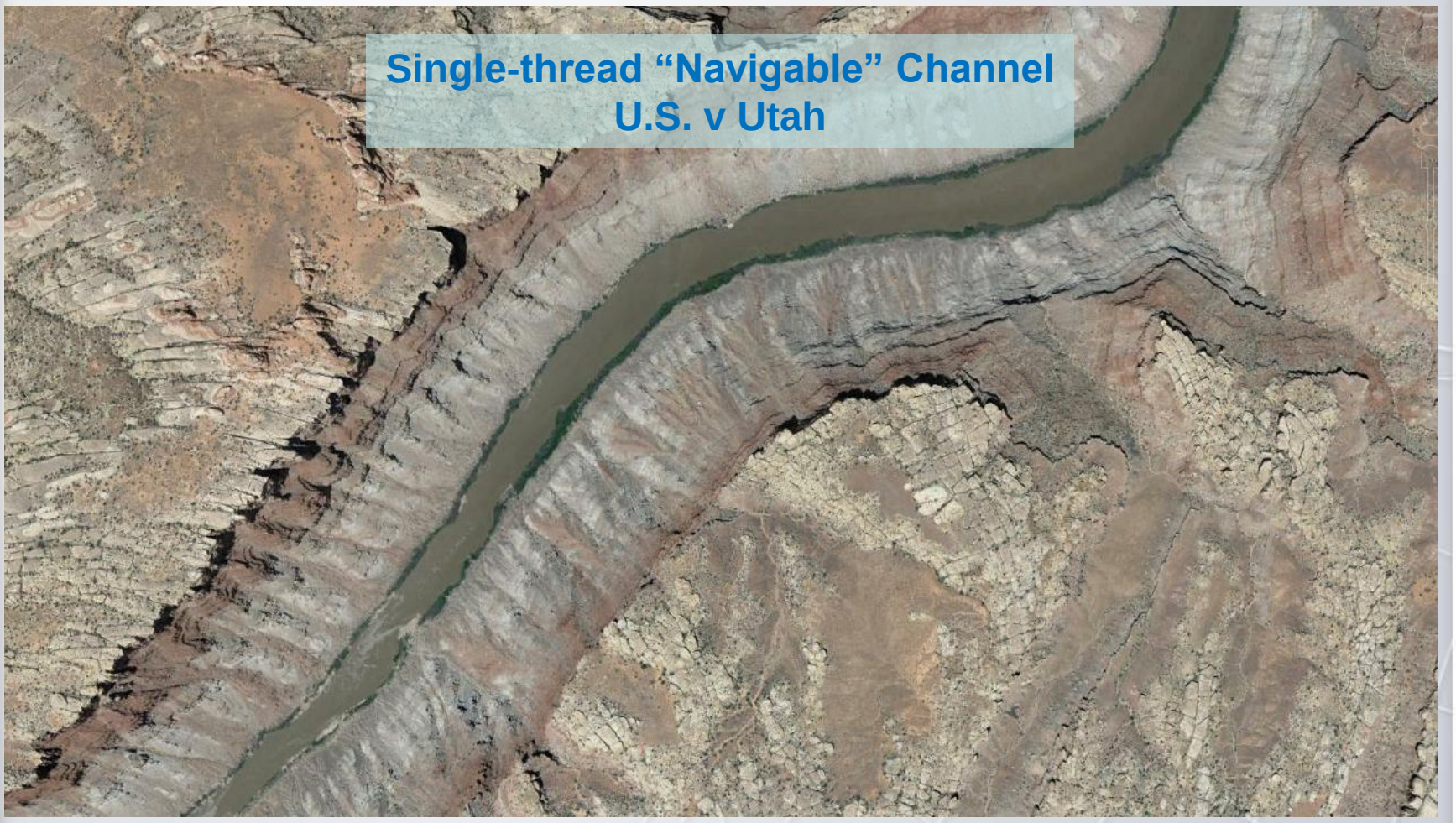
- PPL Montana
  - …ev*idence* [of present-day, primarily recreational use] *must be confined to that which shows the river could sustain the kinds of commercial use that, as a realistic matter, might have occurred at the time of statehood.*

Channel Classification Relevant to Gila River Navigability



Source: Schumm (1981)

Examples of Channel Types



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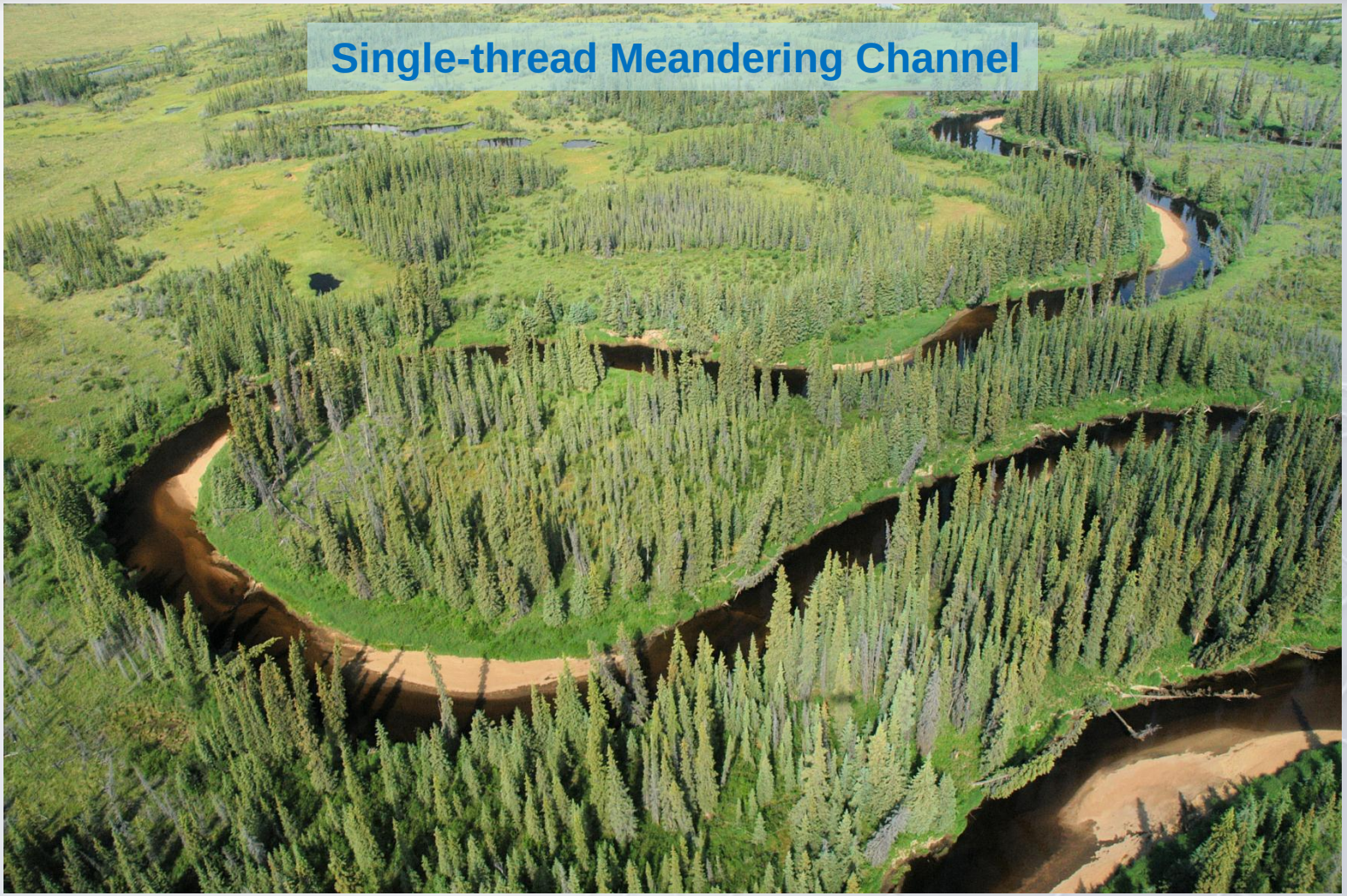
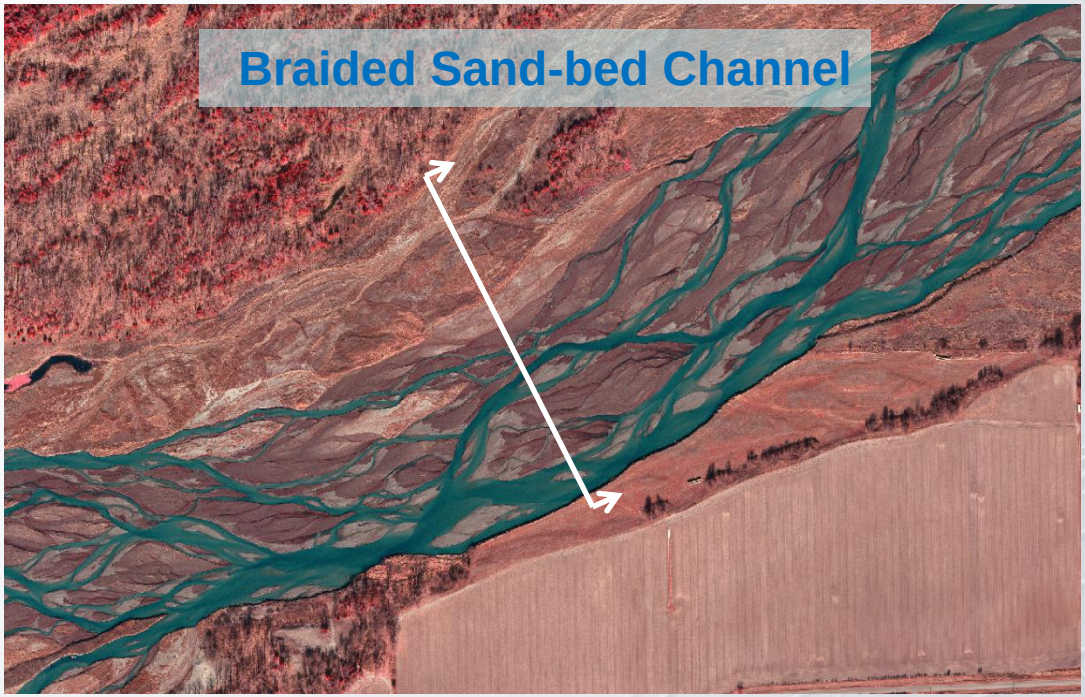
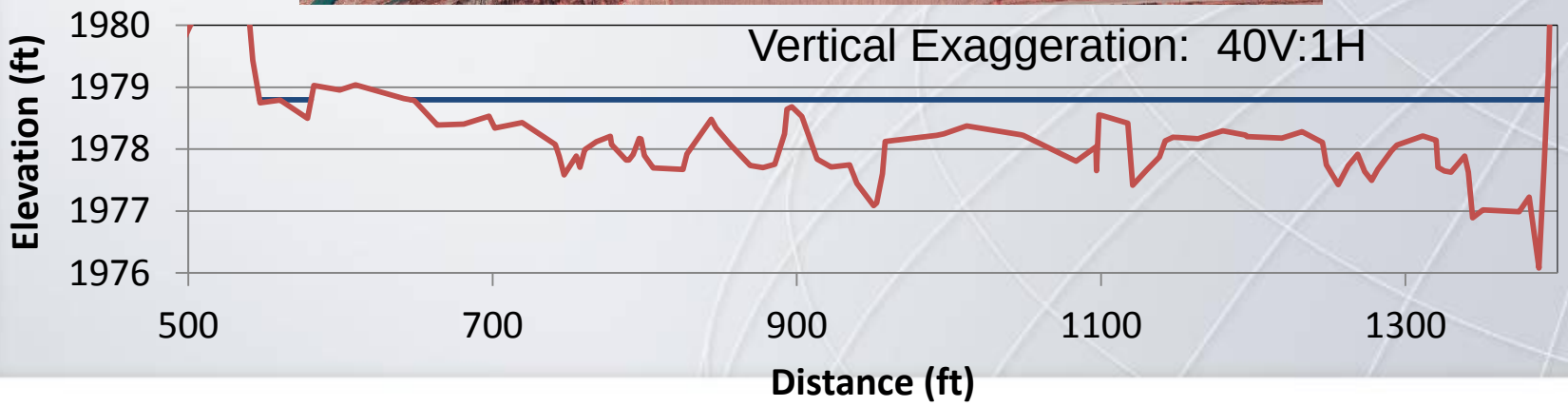


Examples of Channel Types





Examples of Channel Types

Examples of Channel Types

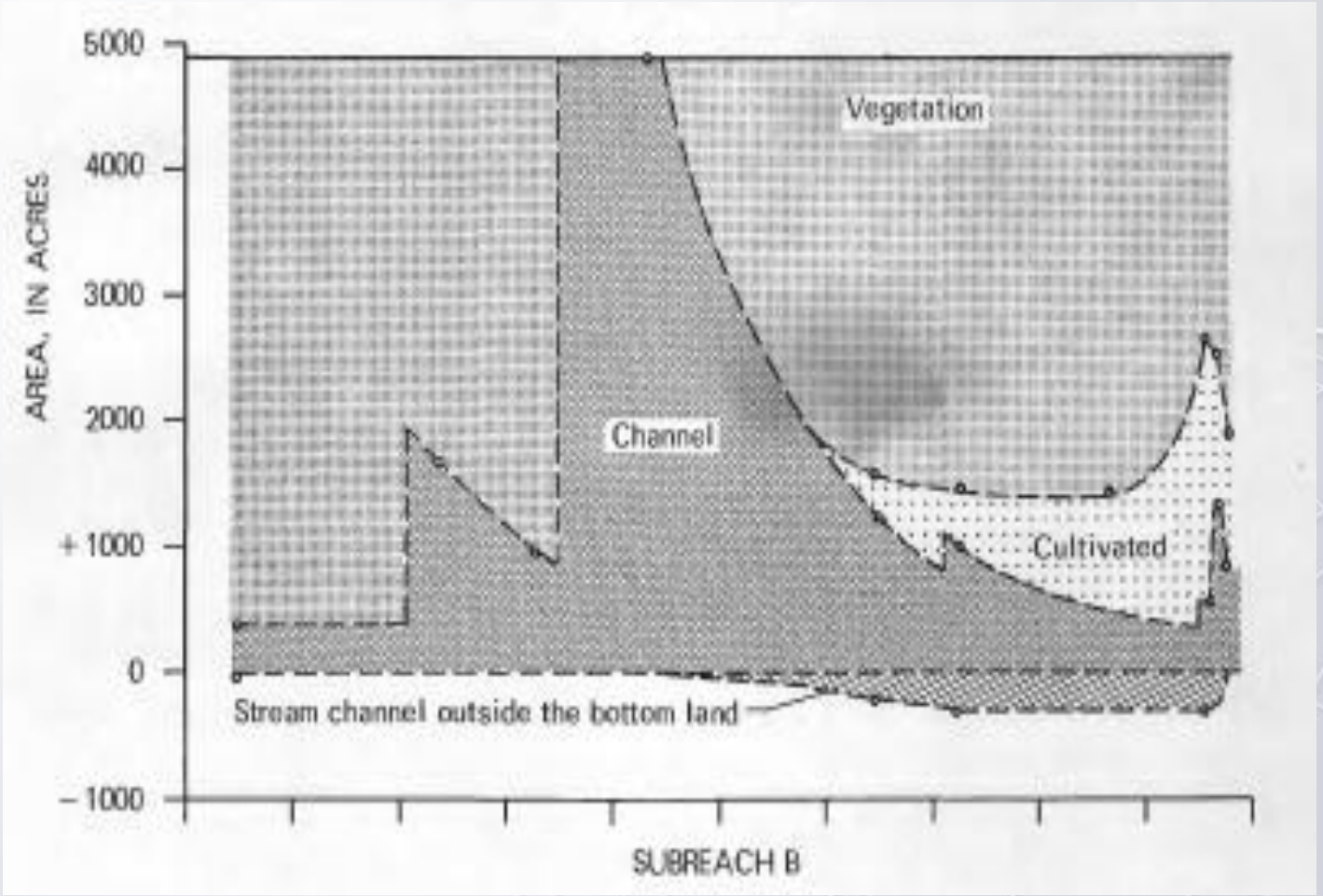
Channel Pattern IS Relevant to Navigability

- Braided channels:
  - Wide, shallow cross section
  - Multiple, unstable (i.e., shifting) channels
  - NOT conducive to boating

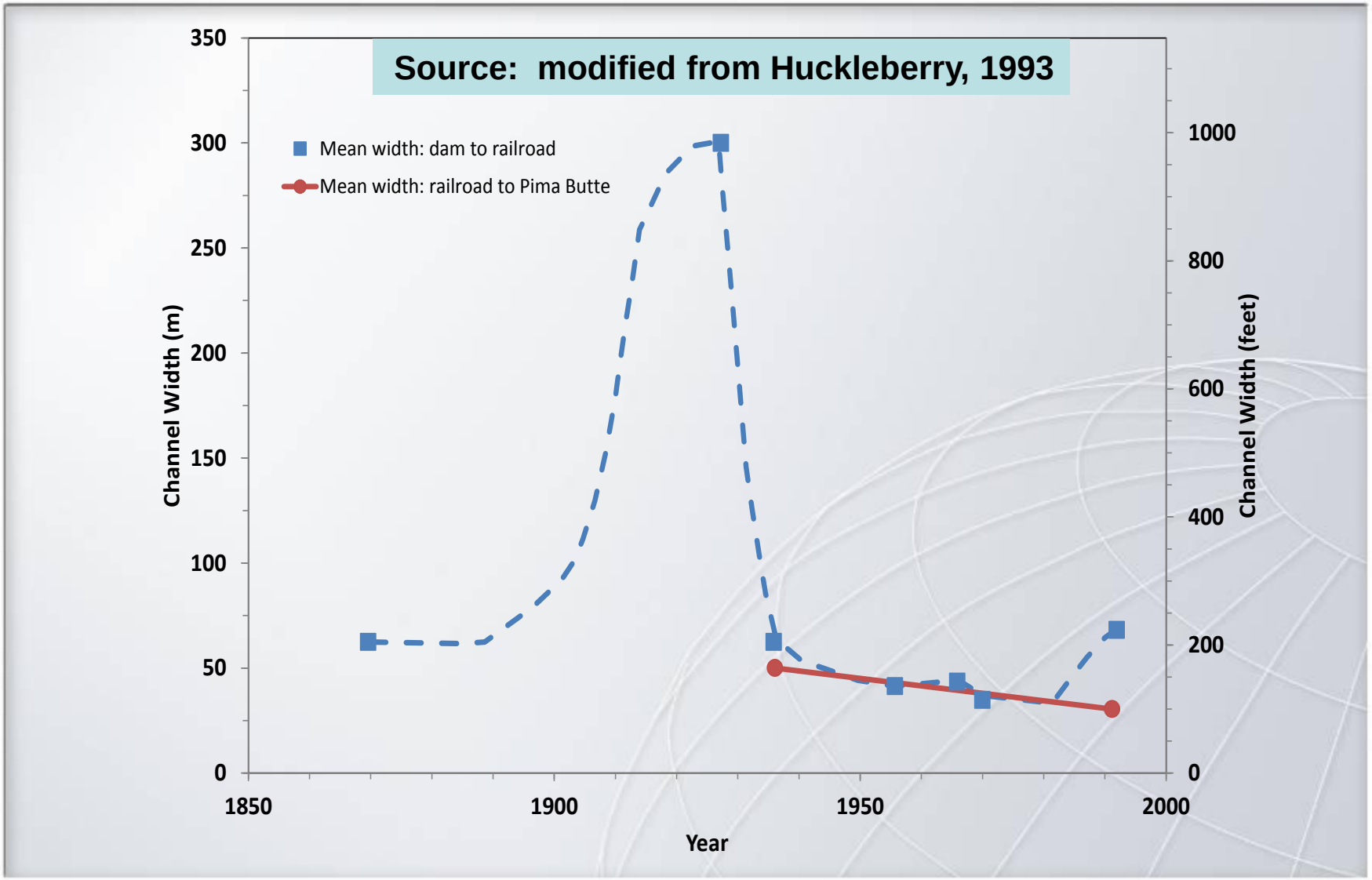
Typical Braided Reach of Gila River ~3.5 mi Below Gillespie Dam

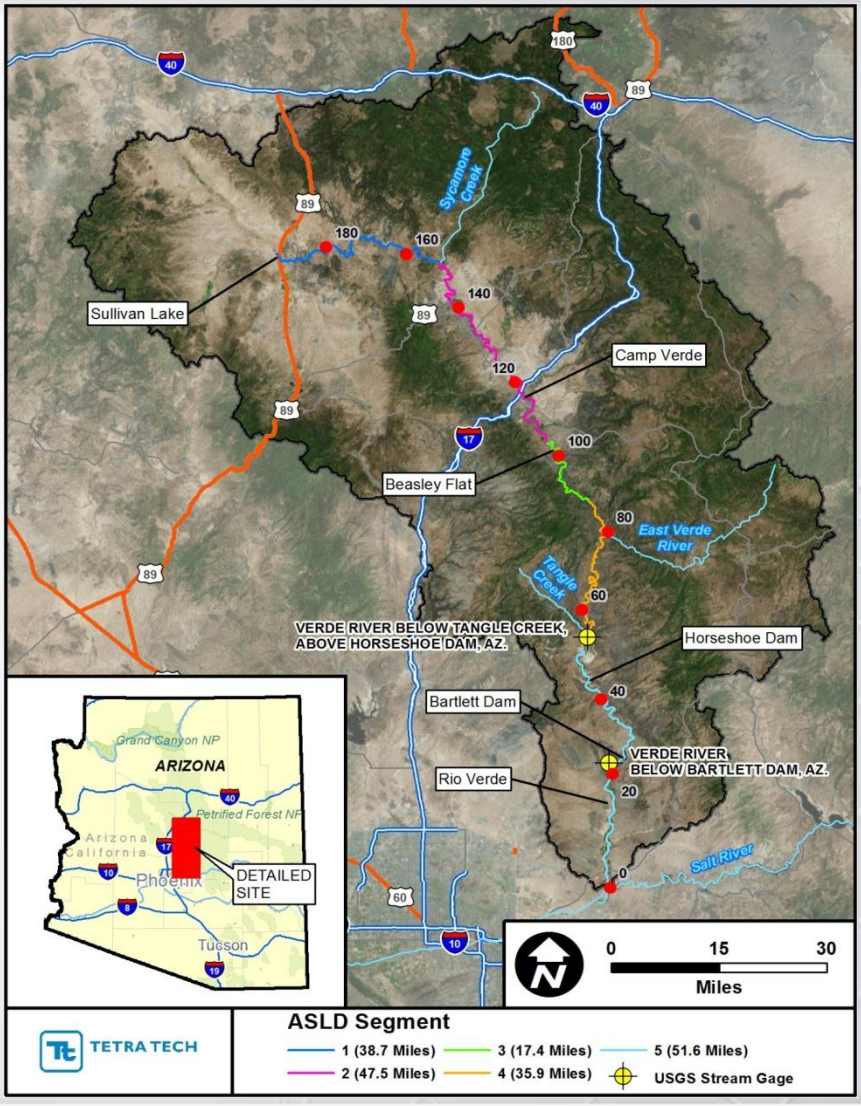
Historical changes in channel area of upper Gila River (San Simon to Pima)

Source: Burkham, 1972

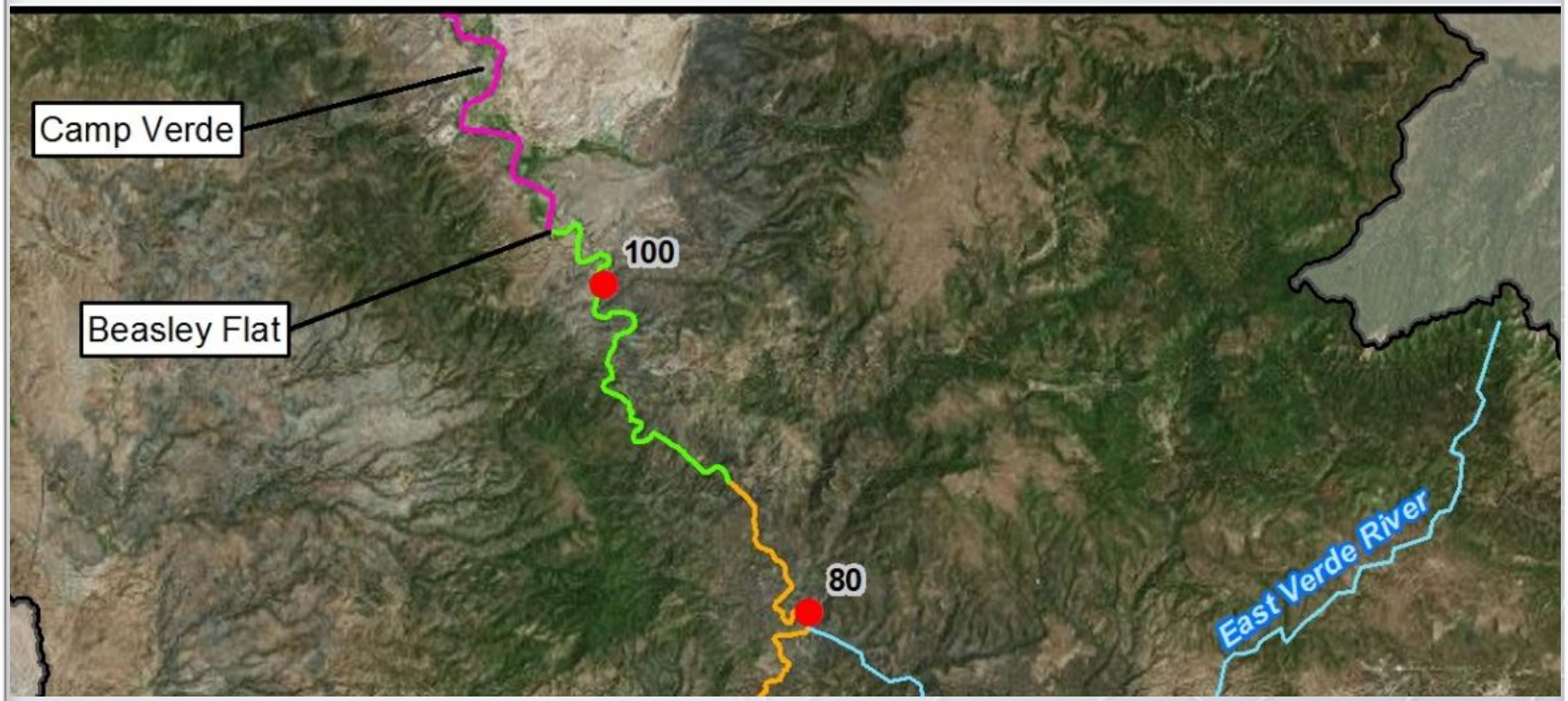


Changes in channel width for the Middle Gila River

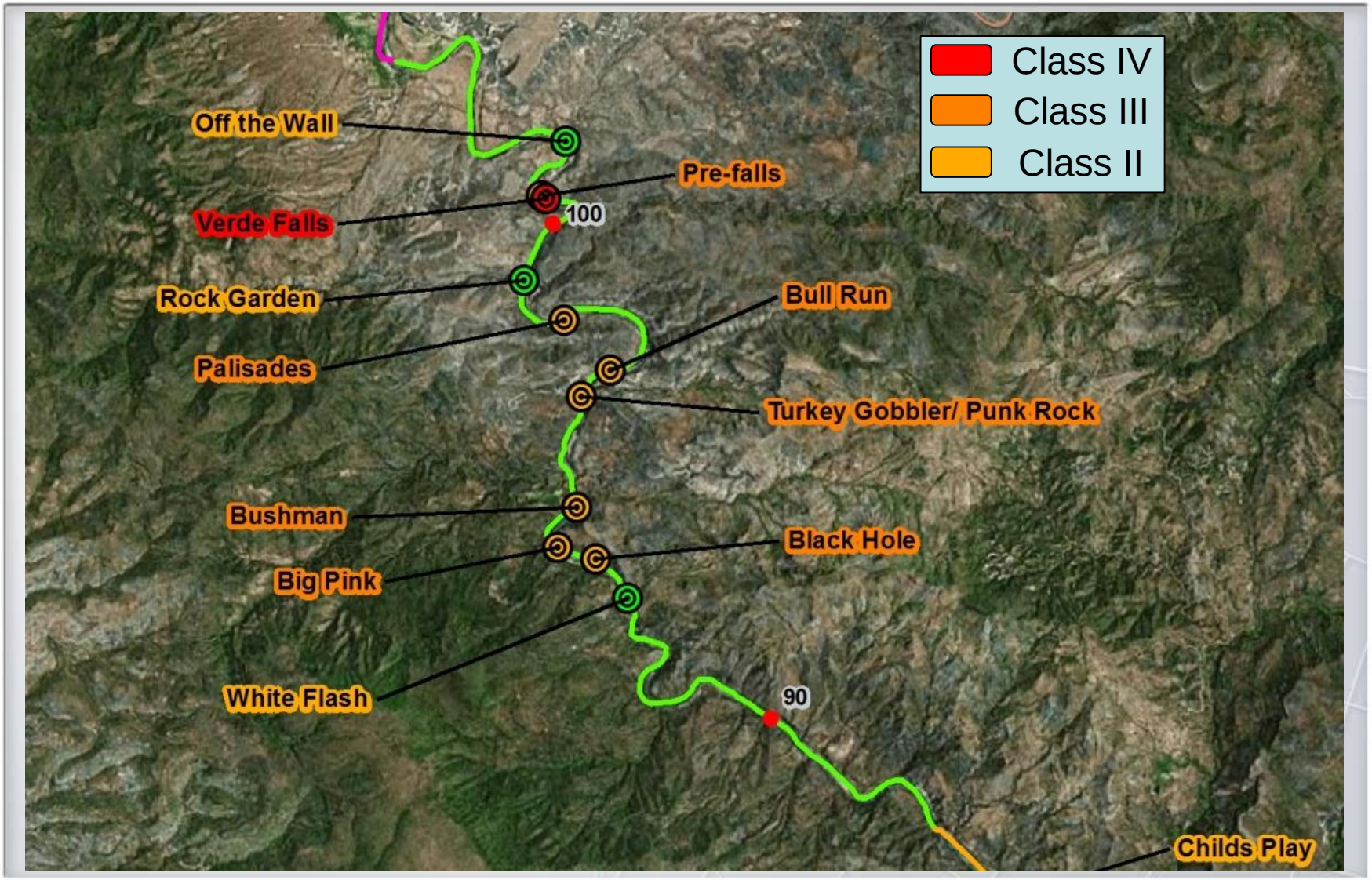



Sullivan Lake
Camp Verde
Beasley Flat
Horseshoe Dam
Bartlett Dam
Rio Verde
VERDE RIVER BELOW TANGLE CREEK, ABOVE HORSESHOE DAM, AZ.
VERDE RIVER BELOW BARTLETT DAM, AZ.
Sycamore Creek
East Verde River
Tangle Creek
Salt River
180
160
140
120
100
80
60
40
20
0
89
40
17
10
60
Grand Canyon NP
ARIZONA
Petrified Forest NP
Arizona
California
Phoenix
Tucson
DETAILED SITE
0
15
30
Miles
TETRA TECH
ASLD Segment
1 (38.7 Miles)
2 (47.5 Miles)
3 (17.4 Miles)
4 (35.9 Miles)
5 (51.6 Miles)
USGS Stream Gage

Segment 3



Segment 3


Class IV
Class III
Class II
Off the Wall
Pre-falls
Verde Falls
100
Rock Garden
Bull Run
Palisades
Turkey Gobbler/ Punk Rock
Bushman
Black Hole
Big Pink
White Flash
90
Childs Play

Verde Falls and Pre-falls

Pre-Falls Rapid

2.4

Pre-Falls rapid, class III, appears suddenly, making it hard to scout. Supposedly you can stop well upstream and scout left. In any case, it is steep but not tricky.

Pre-Falls rapid from below

Photo of Pre-Falls that guy took

http://cacreeks.com/verde.htm

Verde Falls Rapid

2.5

Verde Falls, class IV, scout left

The no-stopping zone for eagle habitat starts just upstream, but you must stop to scout or portage this rapid, so the sign seems out of place. Different guidebooks say the falls is either 5 feet or 8 feet high. Both statements might be true at different water levels. At ultra low flows the falls is too rocky to run. At minimum recommended flows, far right is relatively straightforward. As flow increases, alternate routes become available on the left. At high flows (see YouTube videos) the holes are truly monstrous.

Verde Falls rapid from above left

Verde Falls run by boat emptied of gear

http://cacreeks.com/verde.htm

Rock Garden Rapid

4.1

Rock Garden rapid, a long series of moderate rock slaloms. The no-stopping zone for eagle habitat ends shortly below this rapid. A USFS recommended campsite is at mile 4.5 on the left.

Camp on left above Palisades rapid

Palisades rapid above sandy beach camp

http://cacreeks.com/verde.htm

Punk Rock, AKA Turkey Gobbler

7.1

Punk Rock rapid, AKA Turkey Gobbler, class III+

At low flows this rapid is very rocky, making it hard to work left. At high flows the water moves strongly into a midstream trap rock. Supposedly the scout is from the right bank, but from the top this looks like any other generic class II rapid on the Verde. If you neglect to stop and scout, just make sure to go far left.

Swimmer narrowly misses Punk Rock!

It's a nasty rapid with sharp pointy rocks

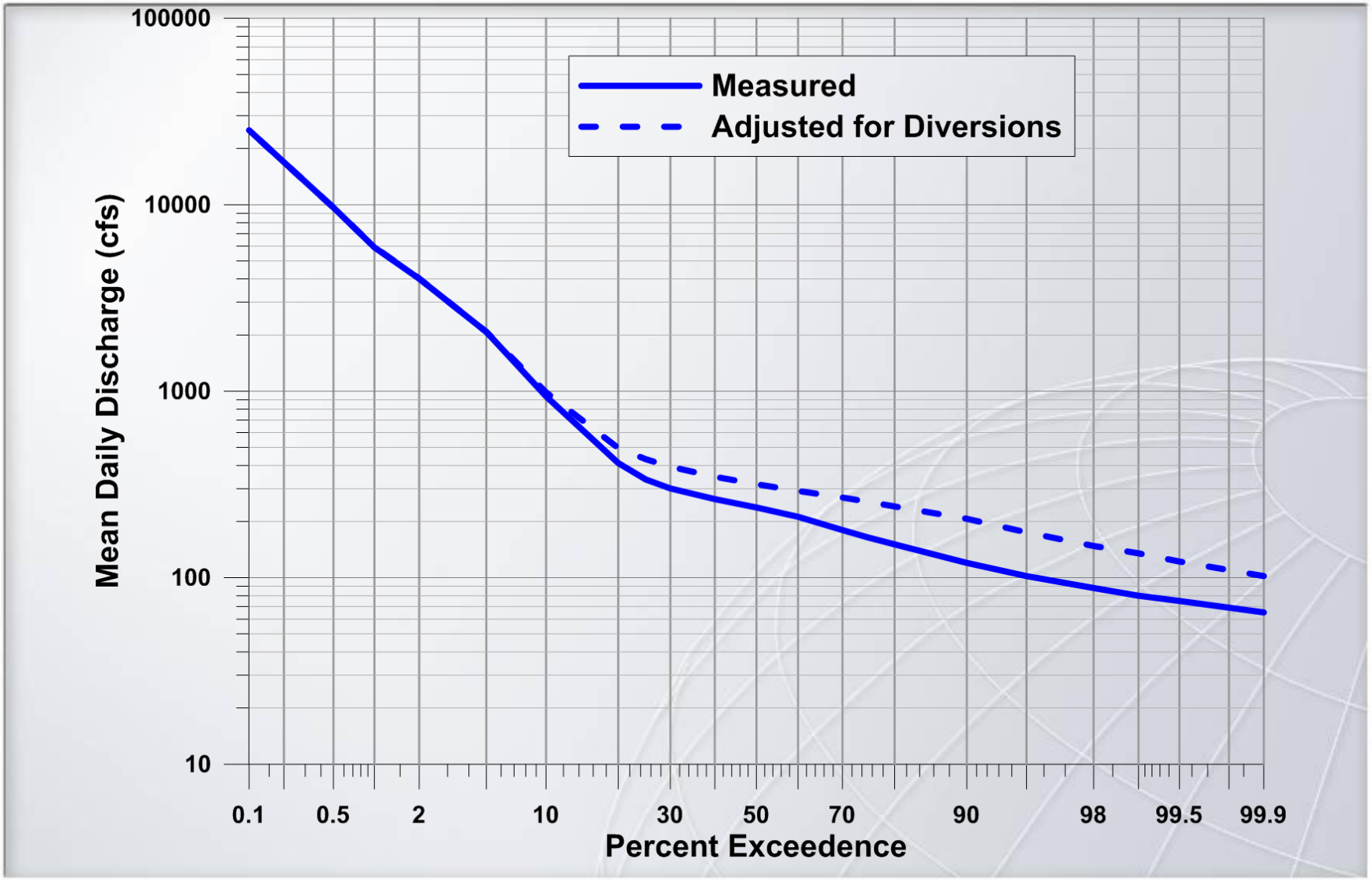
http://cacreeks.com/verde.htm

Black Hole Rapid

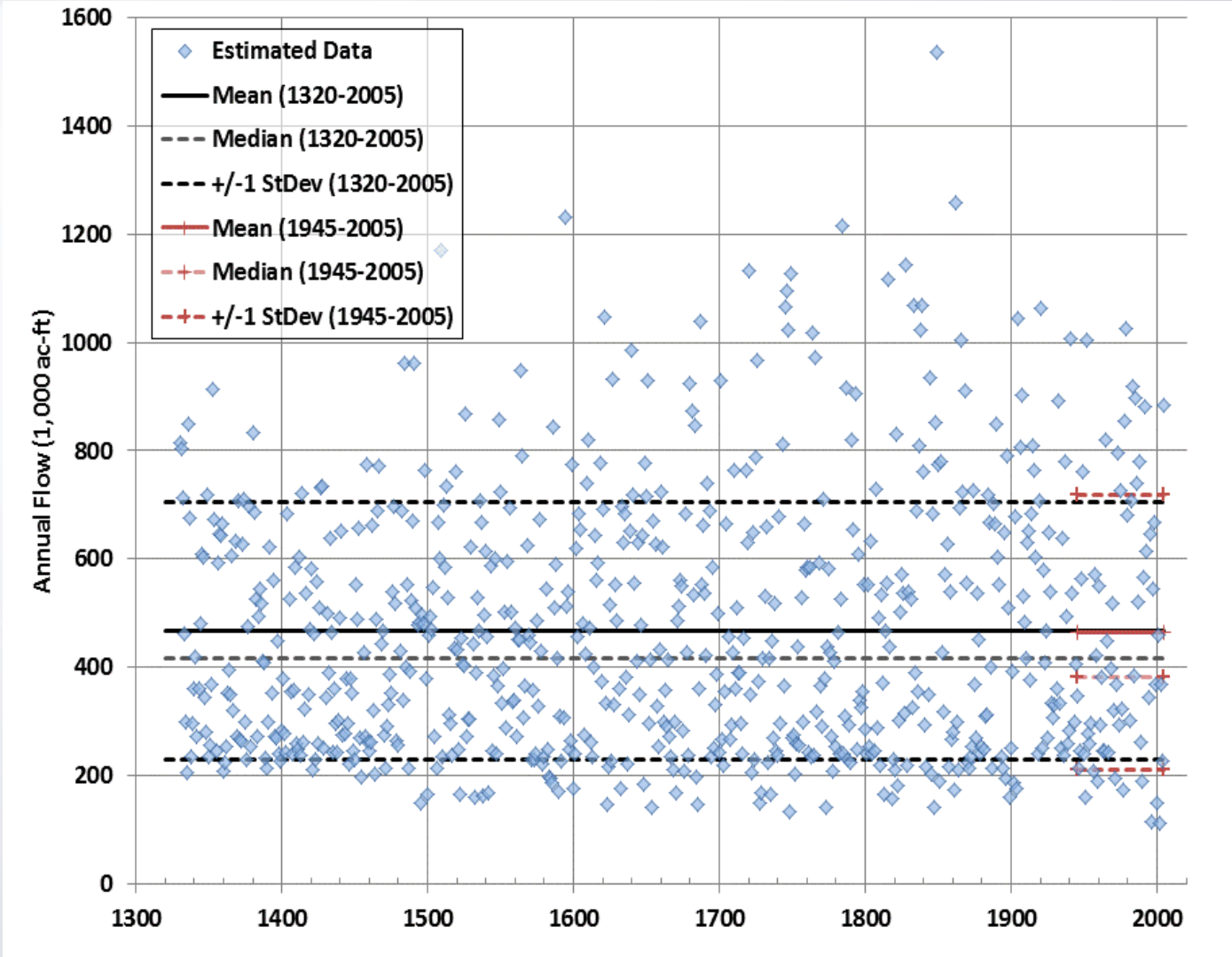
Between Beasley Flat and Verde Falls

~0.8 miles upstream from Verde Hot Spring

Verde Below Tangle Creek Flow Duration Curve



Estimated annual flow volumes from Meko and Hirschboeck (2008)



Segment 4


Childs Play
Baby Snaggle-Tooth
Little Drop
Nasty Little Dog Leg
Gnarly Little Rock Bar
80
Rockin' Center
Dogs Foot
East Verde River
Shoot and Ladders
Red Wall
70
Red Creek
Tangle Creek
60
Dry Run
Junk Yard
Honey Chute

Shoots and Ladders Rapid (Class III)

Gnarly Rock Bar Rapid

21.6

Gnarly Rock Bar rapid, class III, possibly line right

Maybe the river changed, or we took the wrong (left) channel, because this was the only class III we encountered below Childs. It is not marked class III in the USFS pamphlet, though many others are. One boater in our group took the right channel and said it wasn't very easy, either: two class IV moves to avoid a pin and a headwall, he said. The Verde must change a lot year-to-year.

First section of Gnarly Rock Bar

Second section of Gnarly Rock Bar rapid

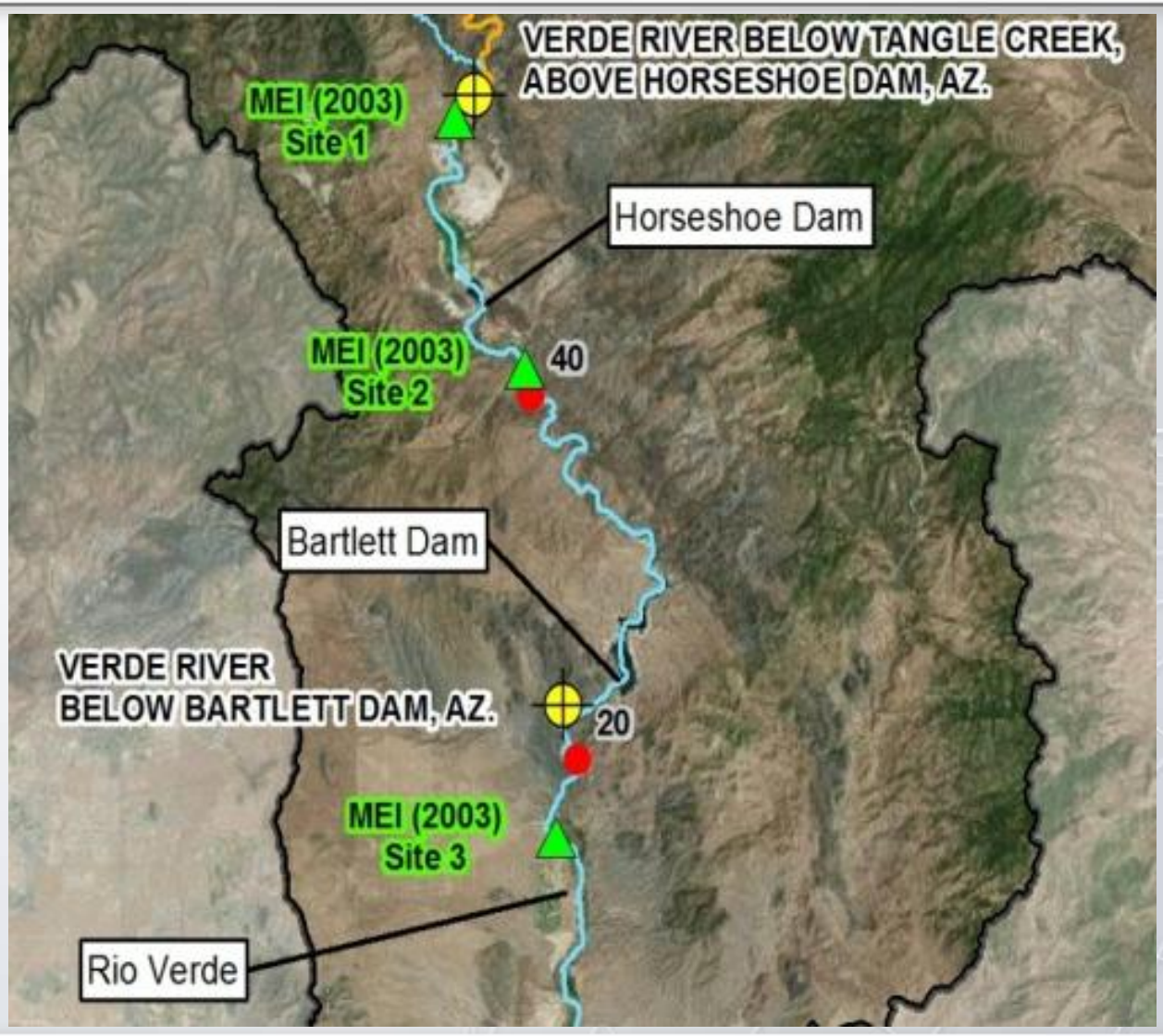
http://cacreeks.com/verde.htm

Gnarly Little Rockbar Rapid (Class II)

Shallow, boulder-strewn riffle near the Tangle Creek confluence

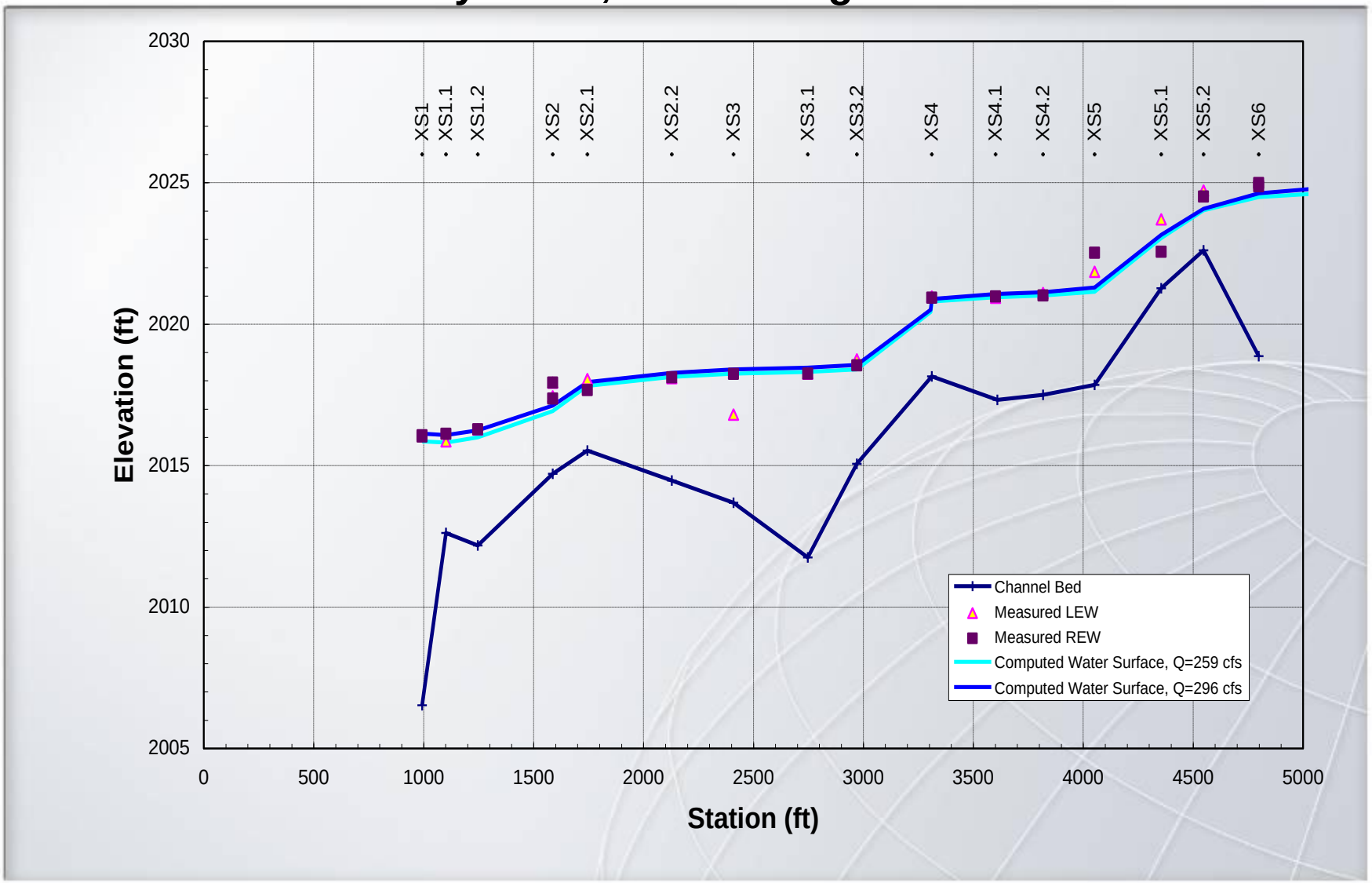
Tree-choked cobble/boulder bar just upstream from the Fossil Creek

MEI (2003) study sites

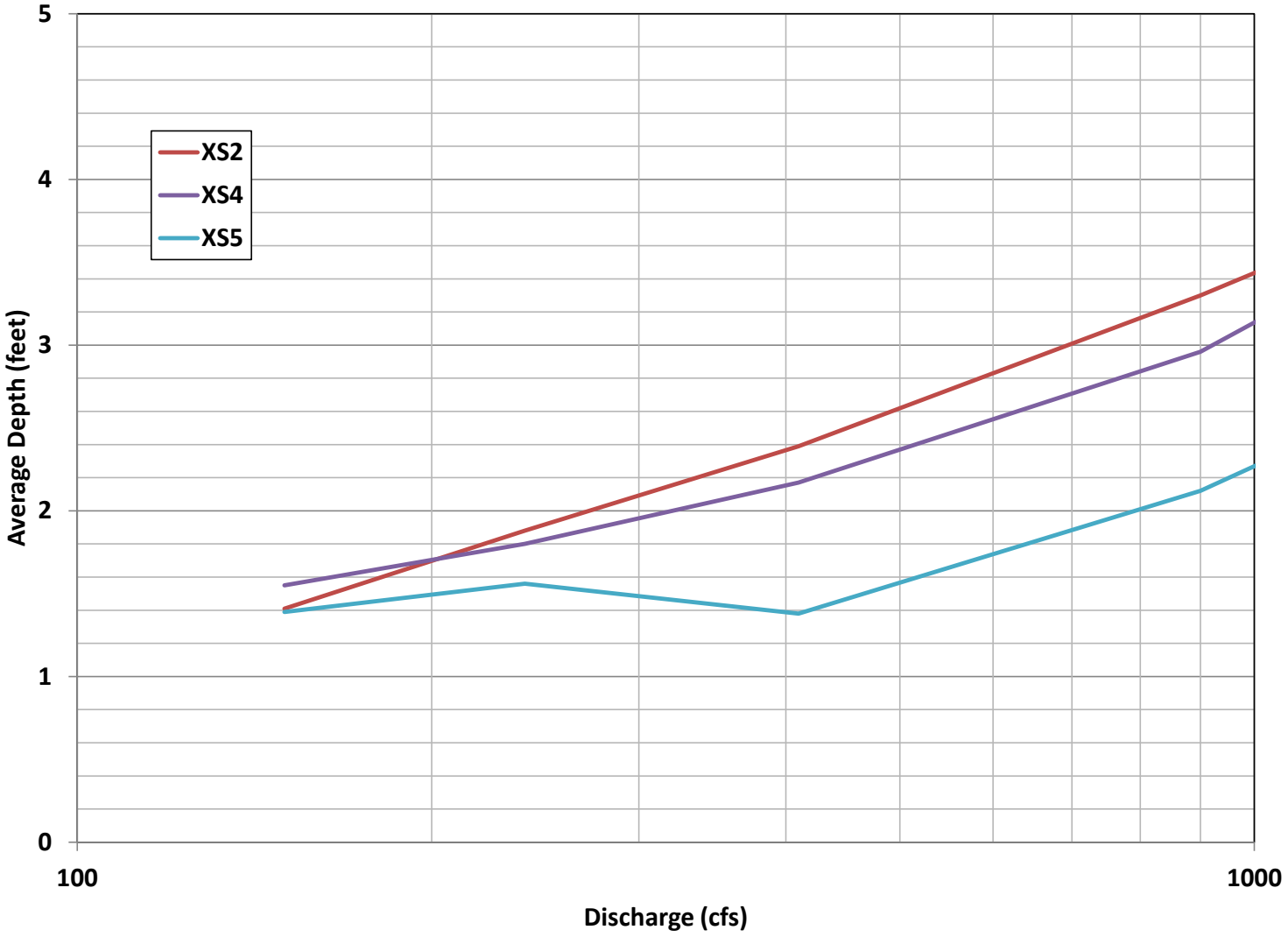


View looking upstream of MEI (2003) Study Site 1, below Tangle Creek

Thalweg and water-surface profiles at the MEI (2003)
Study Site 1, below Tangle Creek



Average depth at MEI (2003) Site 1 XS2, XS4 and XS5



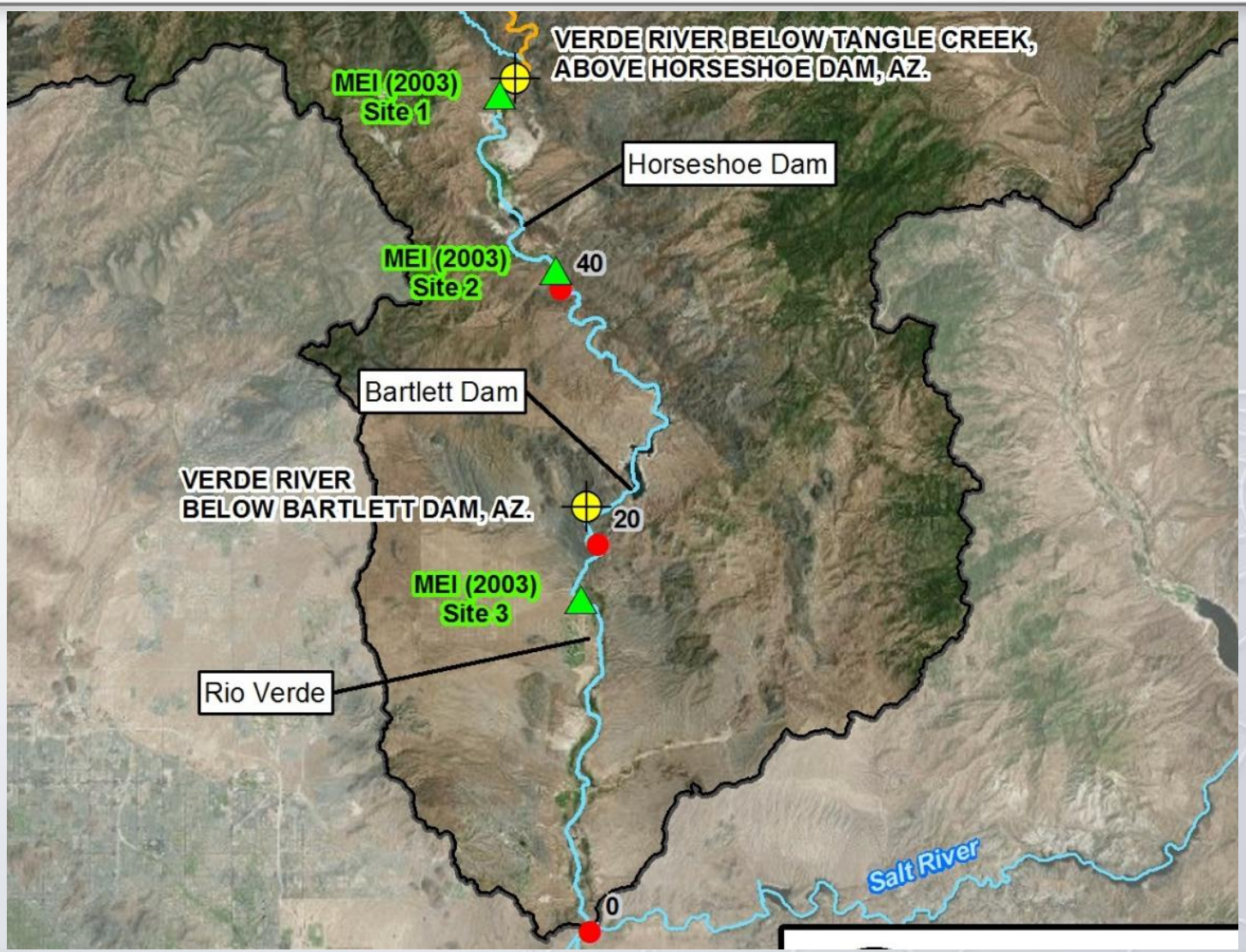
AMERICAN WHITEWATER

VERDE R BLW TANGLE CREEK, ABV HORSESHOE DAM, AZ. [USA-ARZ]

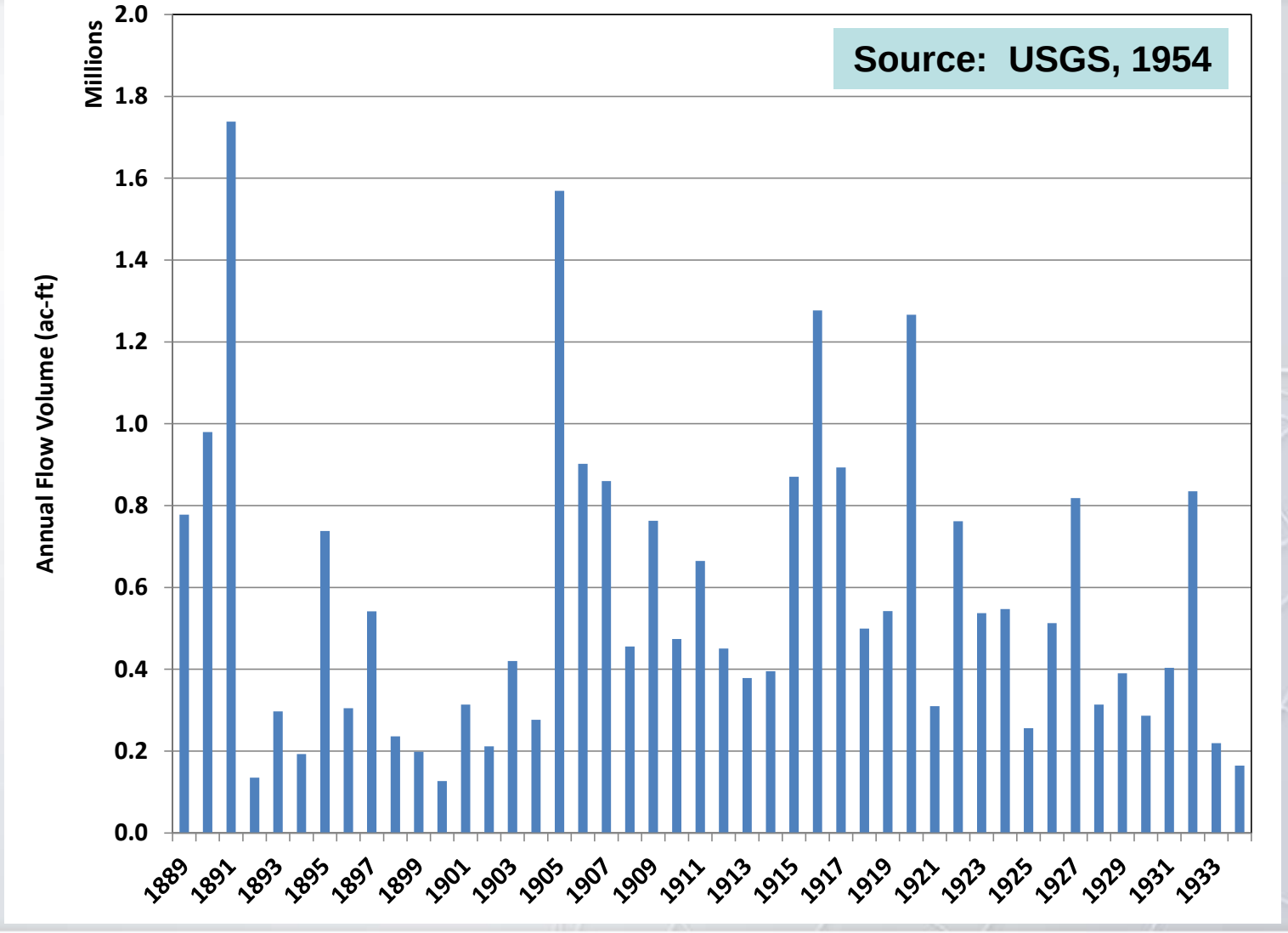
Gauge Information

Name	Range	Difficulty	Updated	Level
VERDE R BLW TANGLE CREEK, ABV HORSESHOE DAM, AZ.				
usgs-09508500	500 - 50000 cfs	I-III	20h46m	252 cfs (too low)
	Flow range for best boatability uncertain. Please help your fellow boaters with a comment or report.			

Segment 5


VERDE RIVER BELOW TANGLE CREEK, ABOVE HORSESHOE DAM, AZ.
MEI (2003) Site 1
Horseshoe Dam
MEI (2003) Site 2
40
Bartlett Dam
VERDE RIVER BELOW BARTLETT DAM, AZ.
20
MEI (2003) Site 3
Rio Verde
Salt River
0

Annual flow volume below Bartlett Dam



Horseshoe Dam Site 1934

“bottom of Fort McDowell Indian Reservation” 1934

Verde and Salt River confluence 1934

~2.5 miles downstream from Horseshoe Dam

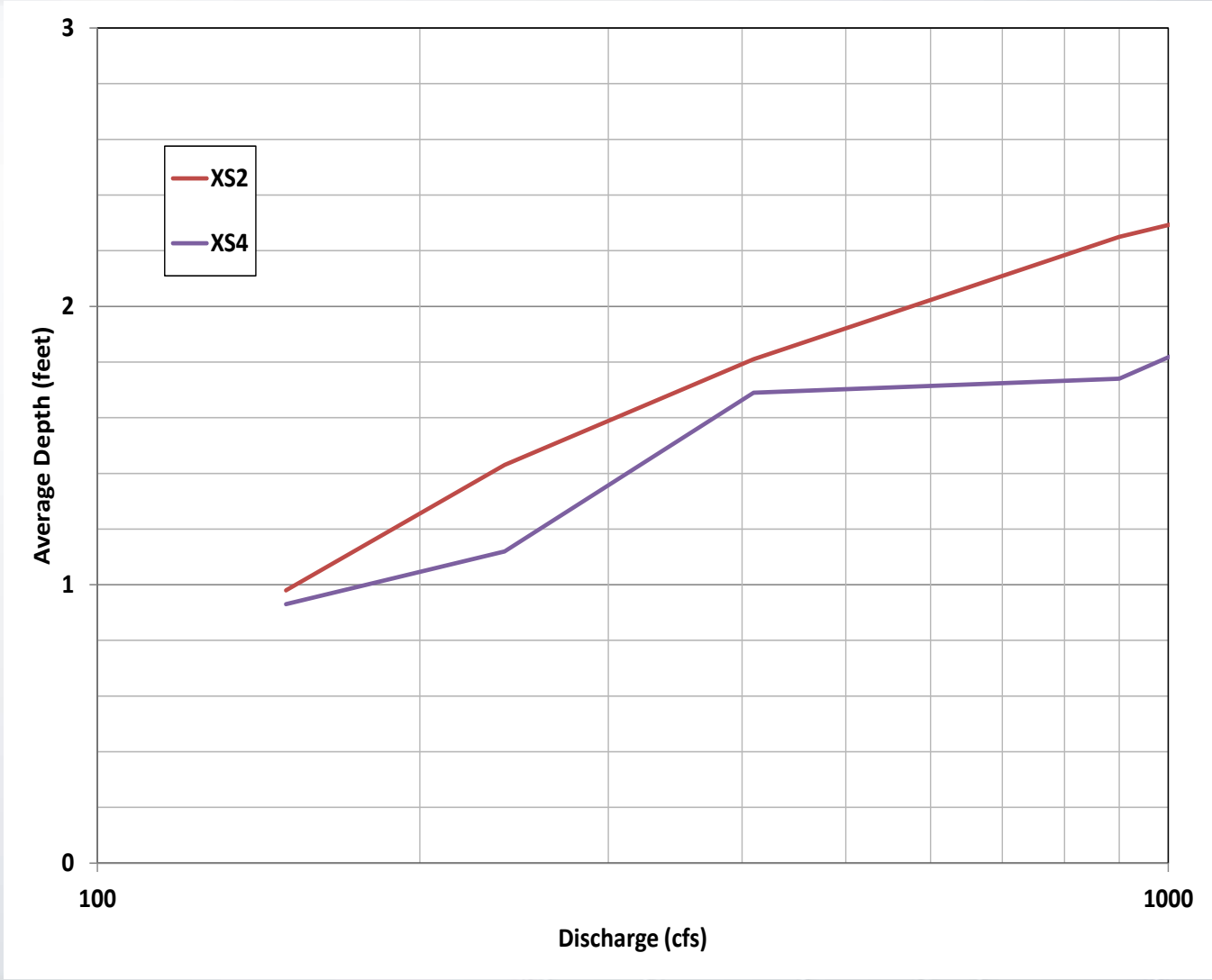
~4.5 miles downstream from Bartlett Dam

Near Rio Verde

MEI (2003) Study Site 2

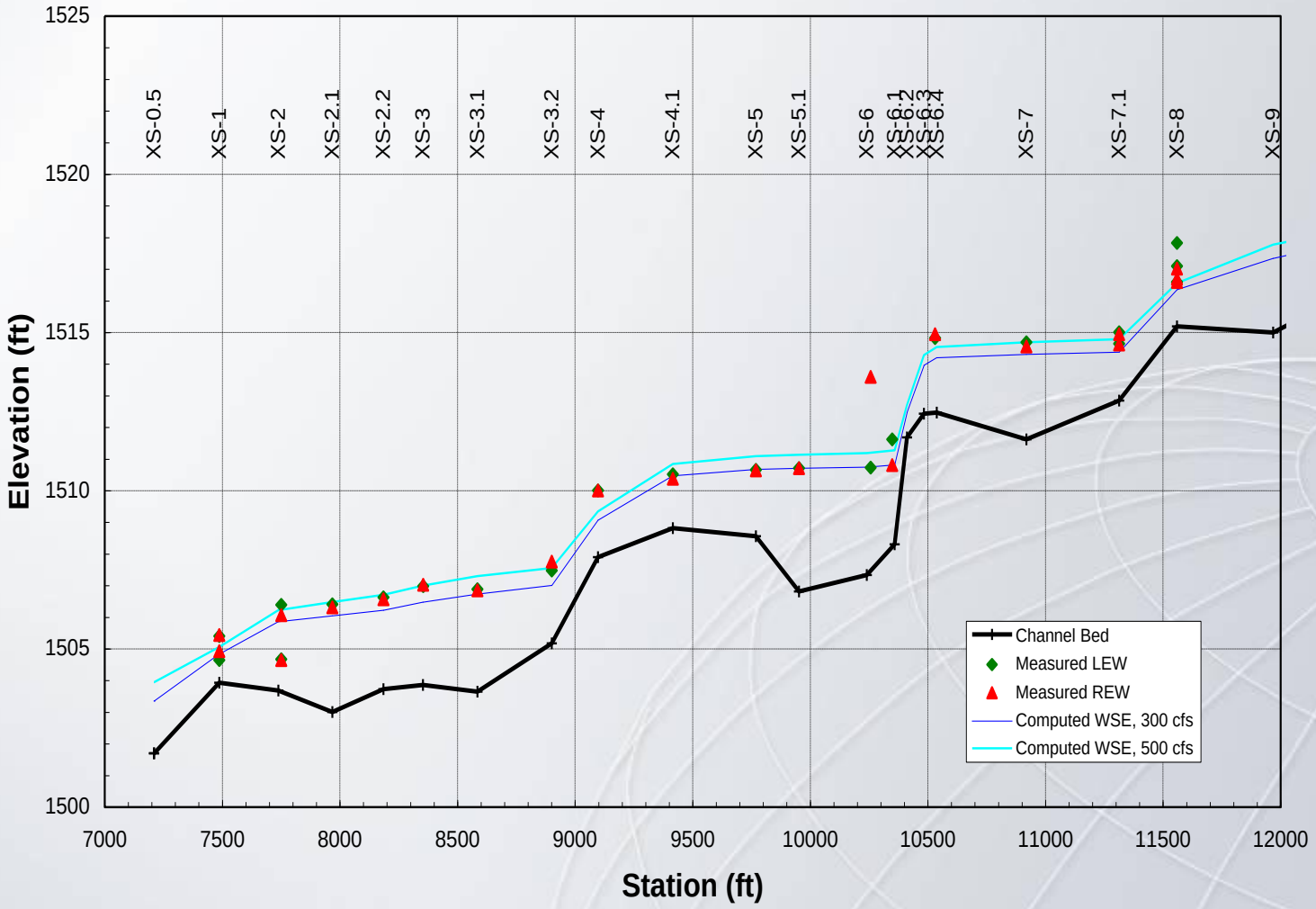
MEI (2003) Study Site 2

MEI (2003) Site 2 XS2 and XS4

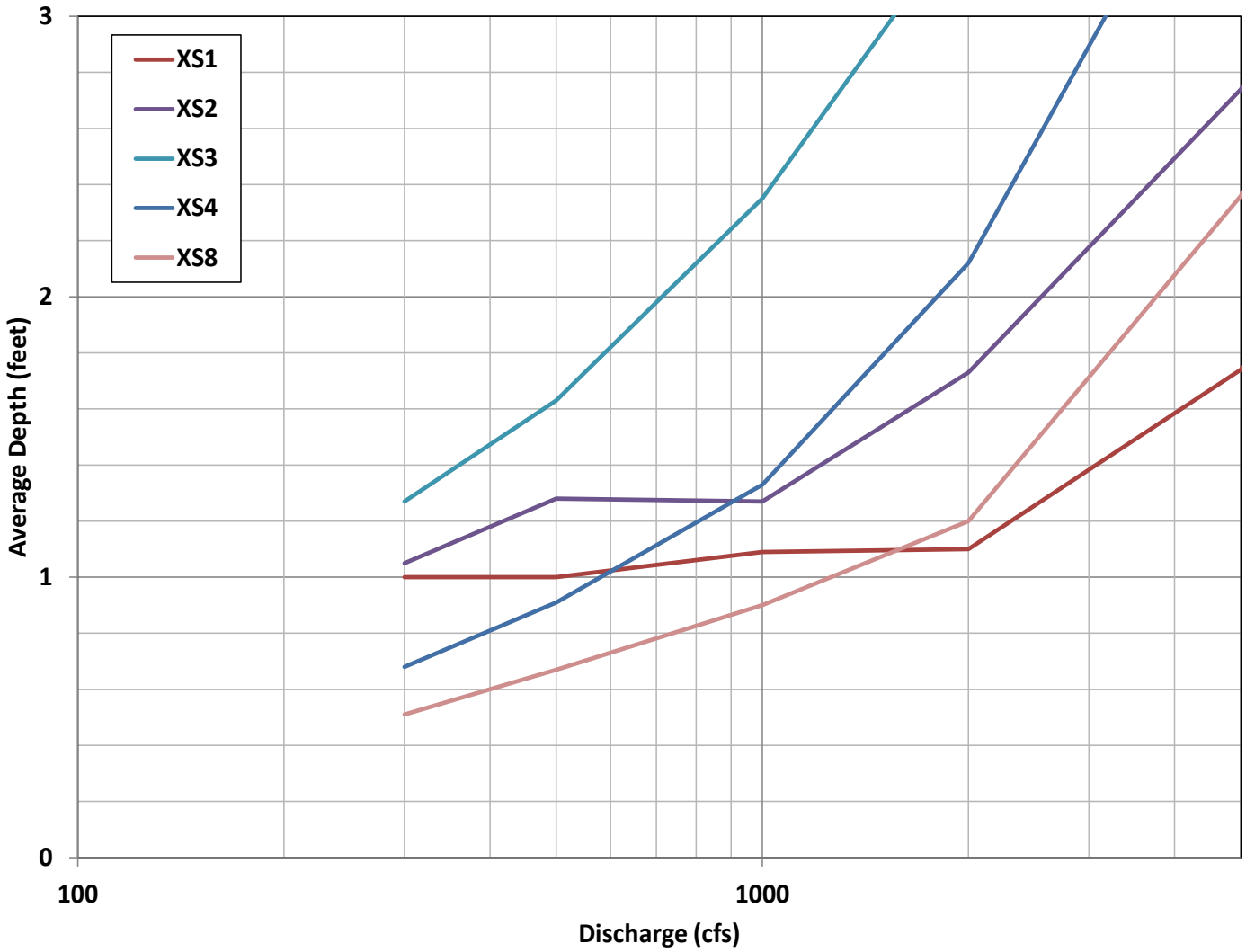


MEI (2003) Study Site 3

MEI (2003) Study Site



MEI (2003) Site 3



Summary of Opinions

- ASLD Segments 1 and 2
  - Based on evidence presented by others, **not navigable using boats in customary use for commerce at date of statehood**

"Duff Drop" (River Mile 14.8)

"USGS Rapids" (River Mile 40.3)

Photos from Burtell (2014)

Summary of Opinions

- ASLD Segments 3 and 4
  - Narrow, bed-rock confined canyon
  - Numerous rapids
  - **Not navigable using boats in customary use for commerce at date of statehood**

Summary of Opinions

- ASLD Segment 5
  - Wider valley bottom bounded by alluvial terraces
  - Island-braided character under modern (post-statehood) conditions
  - Braided and highly-responsive to large floods under pre-statehood conditions
  - Unstable, multi-channel character would have precluded reliable navigation with boat in customary use for commerce at statehood
  - **Not navigable using boats in customary use for commerce at date of statehood**

Summary of Opinions

The Verde River was NOT susceptible to being used, in its ordinary and natural condition, as a highway for commerce, using customary modes of trade and travel on water at the time of Arizona's statehood.

Hjalmarson Appendix J, Oct 4, 2014, p6

In his January 8, 2014 Declaration Navigability of the Gila River Between the Arizona-New Mexico Stateline and the Confluence with the Colorado River presented to ANSAC at the Gila River hearing in Phoenix, AZ on Aug. 20, 2014, Dr. Mussetter stated "As is true for most dryland rivers, there is strong correlation between the annual flood peak and the annual runoff in the Gila River (Figure 5 below); thus, the low flow period in the mid-1800s also very likely corresponded to with an absence of major flooding."

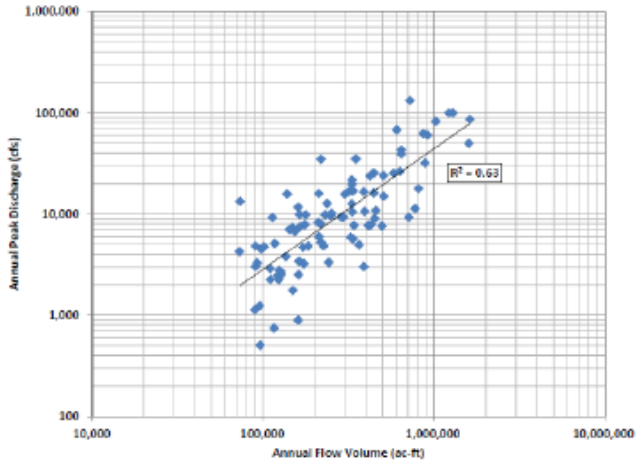
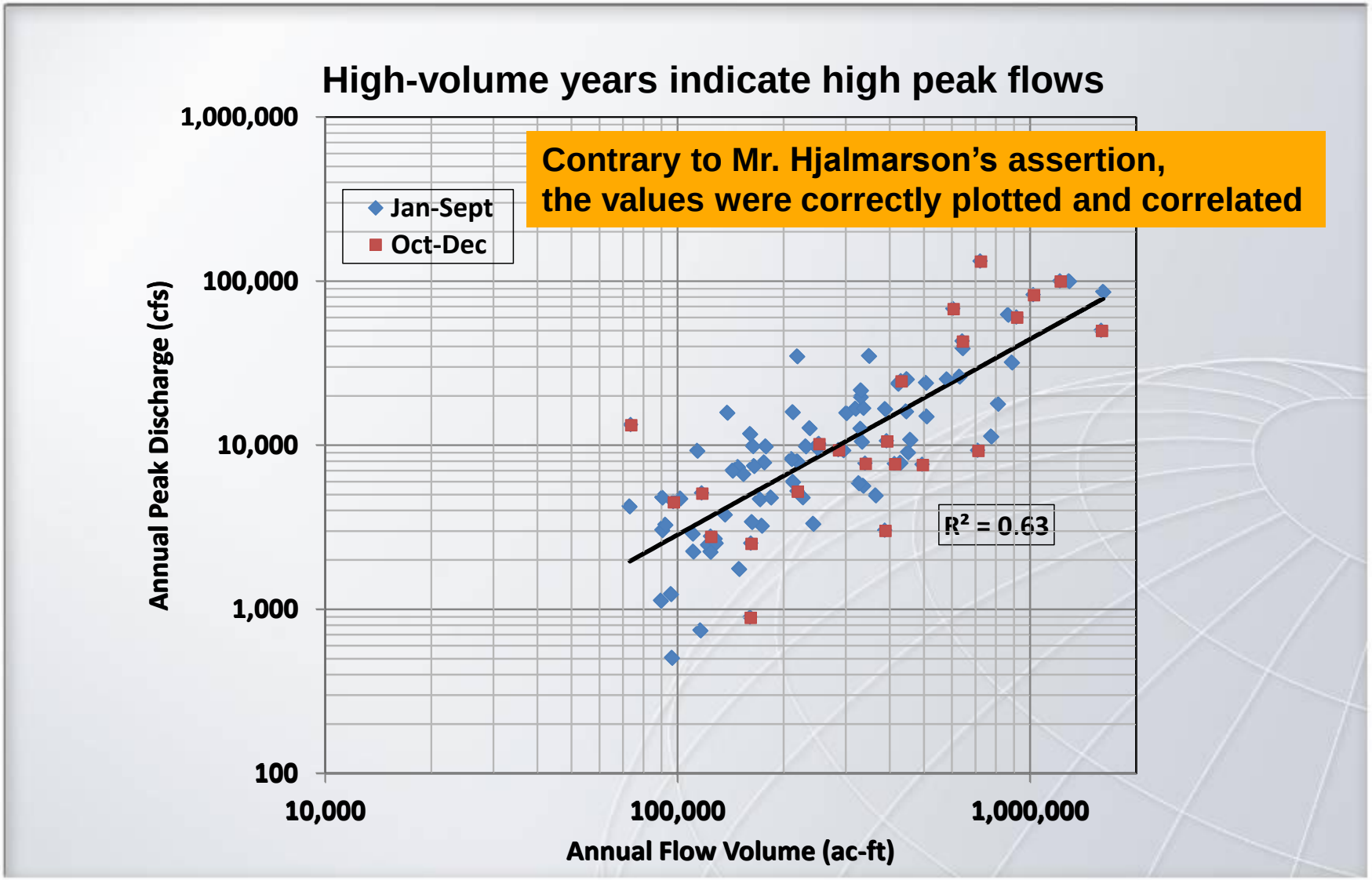


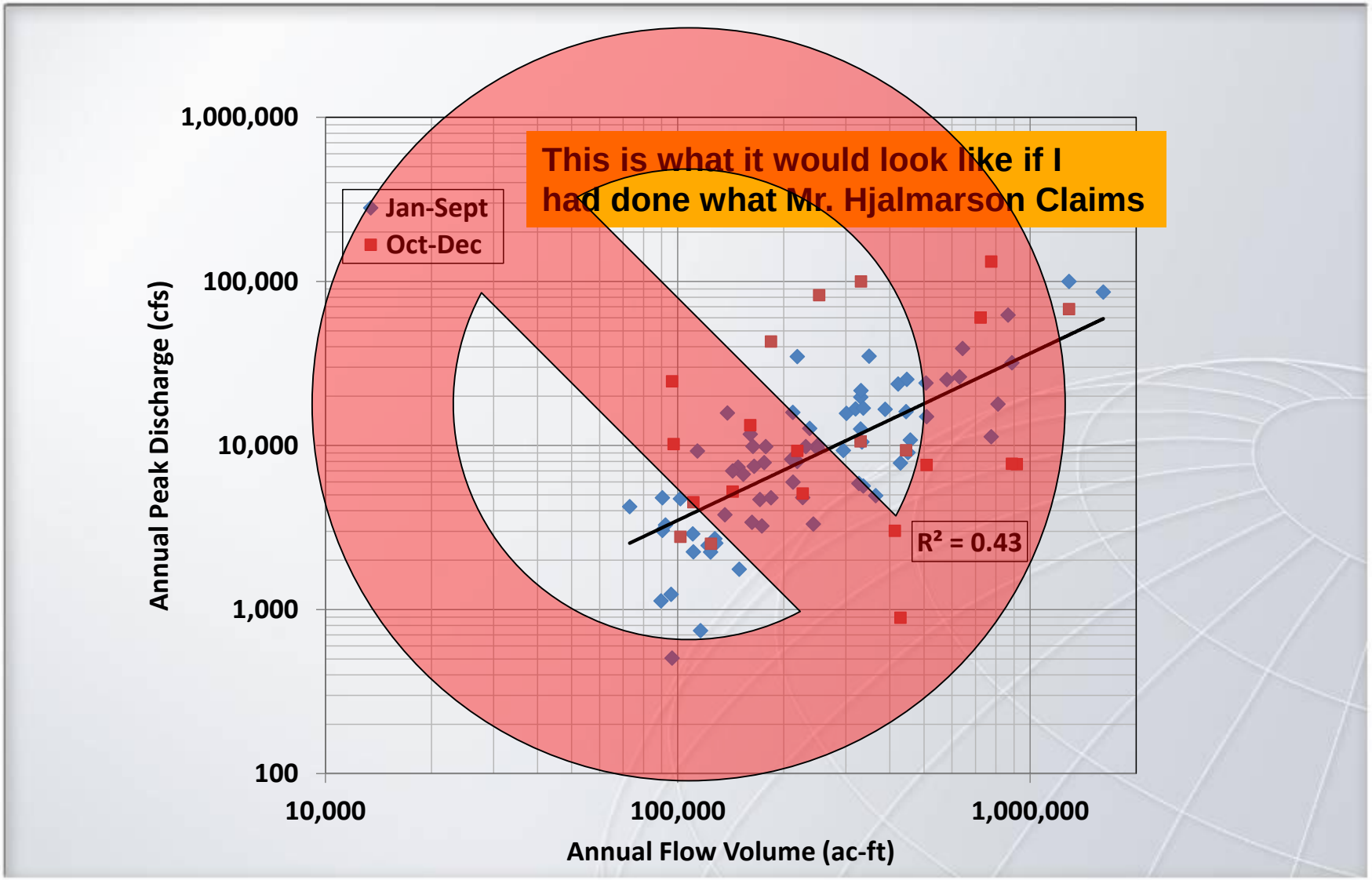
Figure 5. Annual peak discharge and corresponding annual flow volume for the period of record from 1915 through 2012 at the Gila River at Head of Safford Valley gage (USGS Gage No. 09448500).

However, there is an error with the regression in Dr. Mussetter's Figure 5 shown above which suggests that he may be unfamiliar with retrieving USGS data from its website. His annual flows (x axis) are for water years (Oct 1-Sept 30) but his annual peaks are for calendar years (Jan. 1-Dec. 31). There is only a 9 month period common to the annual pairs of data and 3 important months of Oct. 1-Dec. 31 are not common to the data pairs. Thus, a water-year data pair can have a large volume of annual flood flow but the peak discharge corresponding to that flow is in another water-year data pair. Large floods are known to occur during Oct. 1-Dec. 31 and neglecting this period of flood record renders the analysis meaningless. As a result, this relation presented to ANSAC by Dr. Mussetter is fatally flawed.

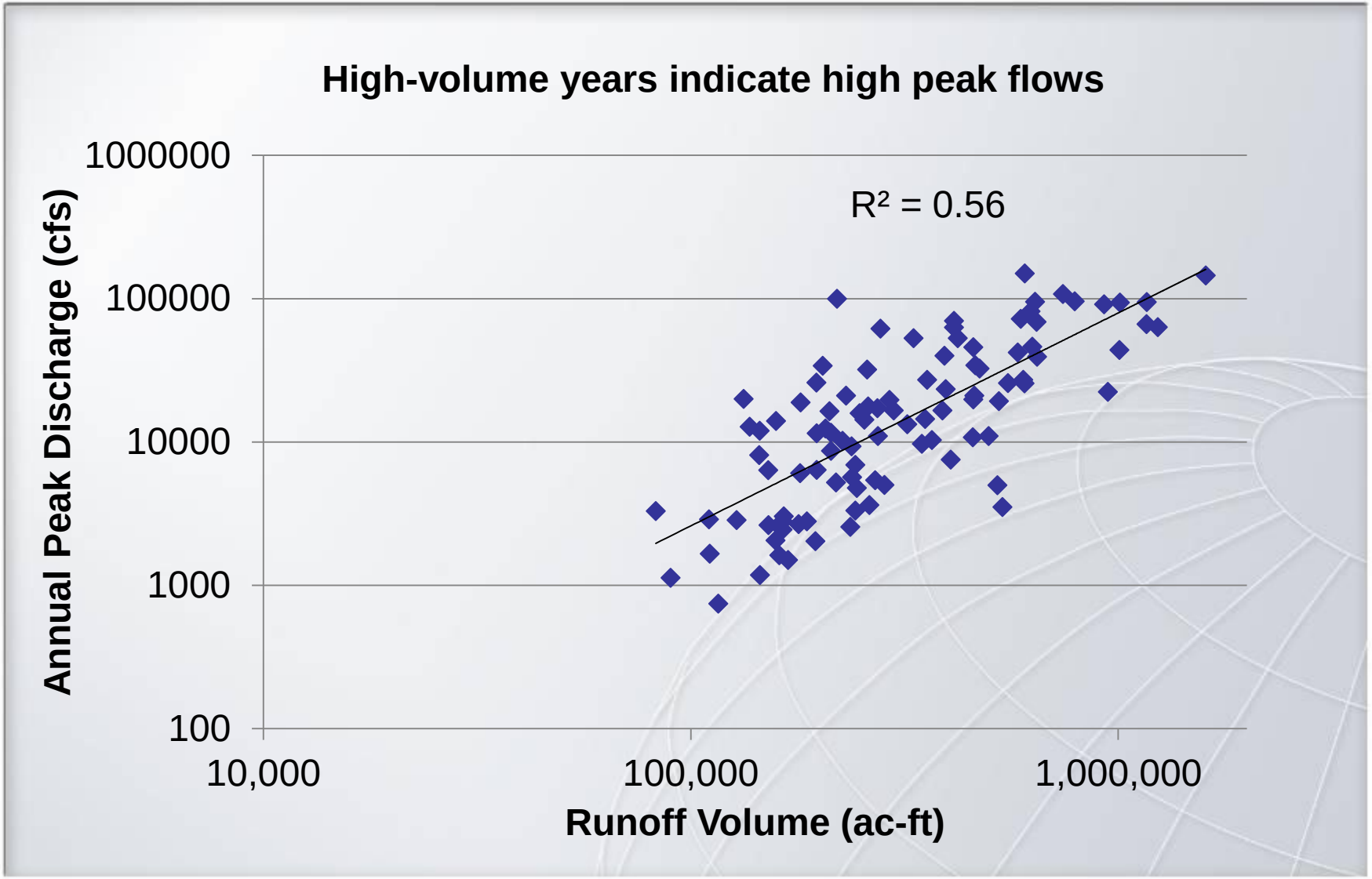
Gila River at Safford Valley



Gila River at Safford Valley



Verde River Below Tangle Creek Gage



Hjalmarson Appendix, Oct 4, 2014, p18

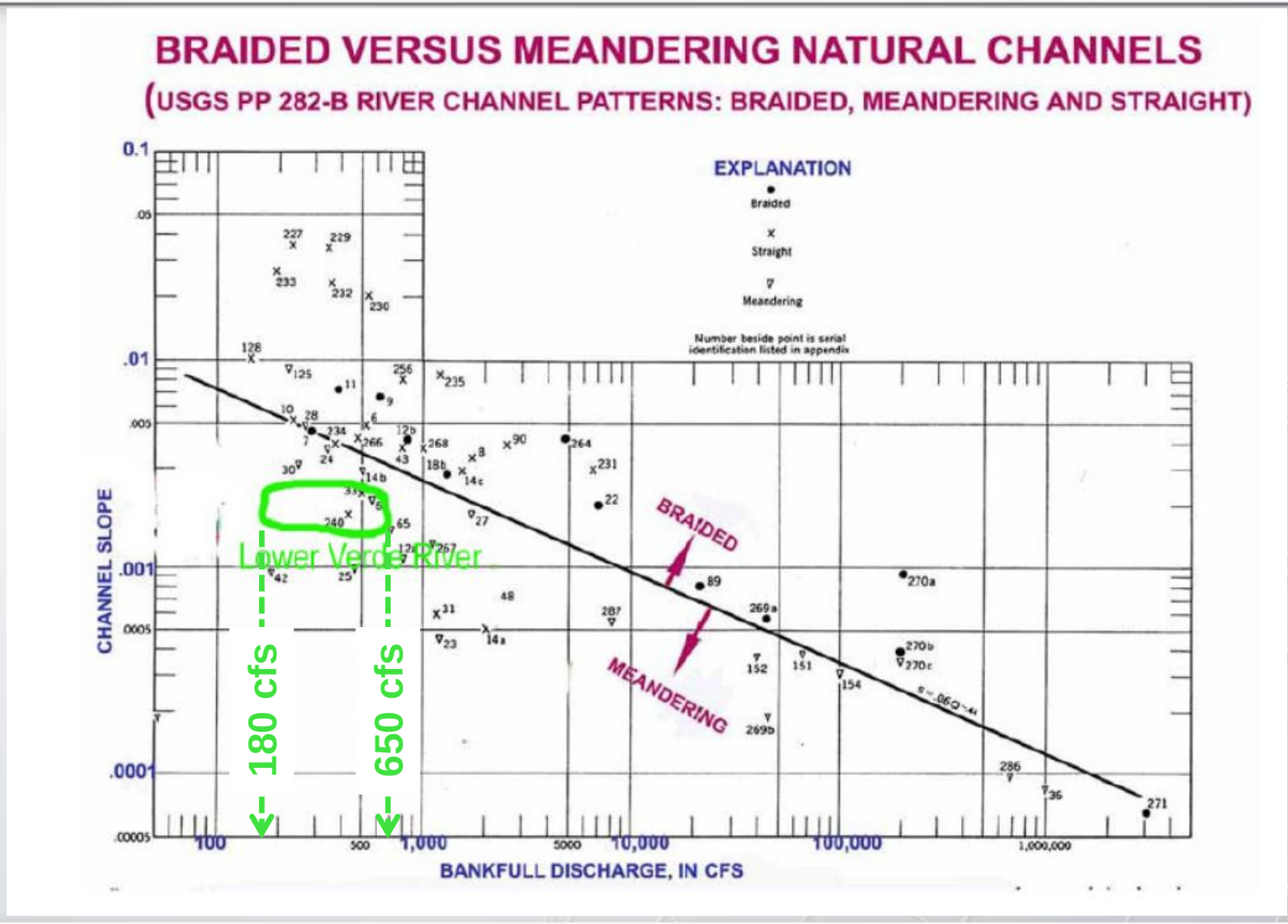
H7a. (Fremont River of Utah)

In his testimony before ANSAC on the Gila River, Dr. Mussetter recently relied upon work by W. L. Graf (Graf, W.L., 2002. *Fluvial Processes in Dryland Rivers*. The Blackburn Press, Section 5.4, pp. 196-218.) Specifically, he referred to Graf's discussion of channel change from "catastrophic" floods and applied that to the Gila River. Graf uses the Fremont River in Utah (p. 207-208) to argue his catastrophic theory of changing channel pattern. He attributes the change of channel pattern of the Fremont River to a large flood (in 1896) while ignoring human effects. On p. 207 Graf states that the original meandering Fremont River changed to a braided channel during a large flood event but he ignores human activity as a related cause.

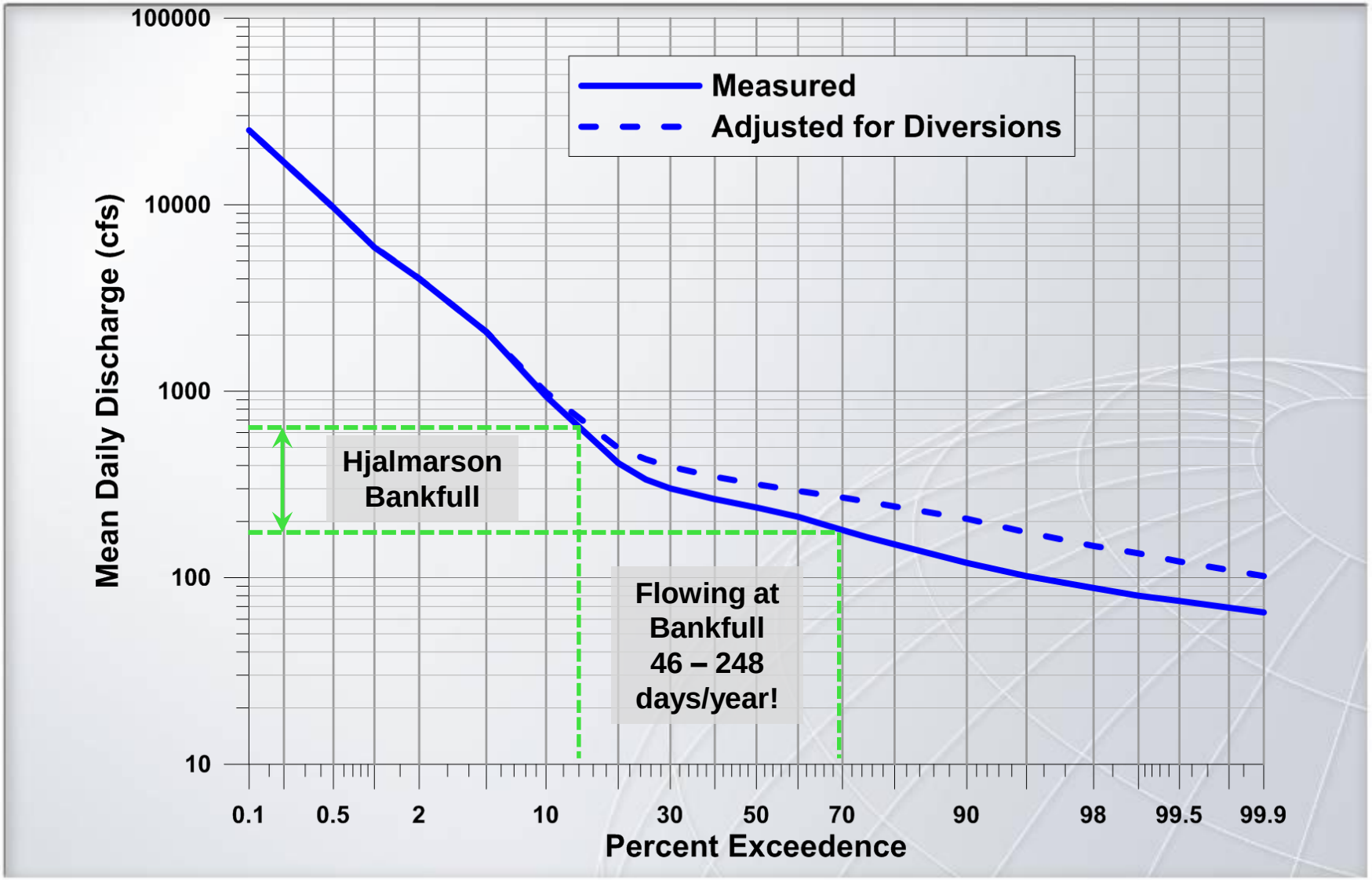
Hjalmarson Addendum, Nov 14, 2014, p36

Item 3.--For the same discharge, rivers like the Verde River with low slopes tend to have meandering channels (Leopold, L.B., Wolman, M.G., and Miller, J.P, 1964, Fluvial processes in geomorphology: New York, Dover Books on Earth Sciences, 503 p.). The plot below is the result of a scientific study where characteristics of many natural river channels were examined. The USGS scientists found a distinction between meandering and braided channels based on slope. This distinction shown below has withstood the test of time. Thus, why would Dr. Mussetter expect braiding? Surely Dr. Mussetter isn't basing his opinion on a single aerial photo in 1934 of local flood debris at the mouth of the Verde River.

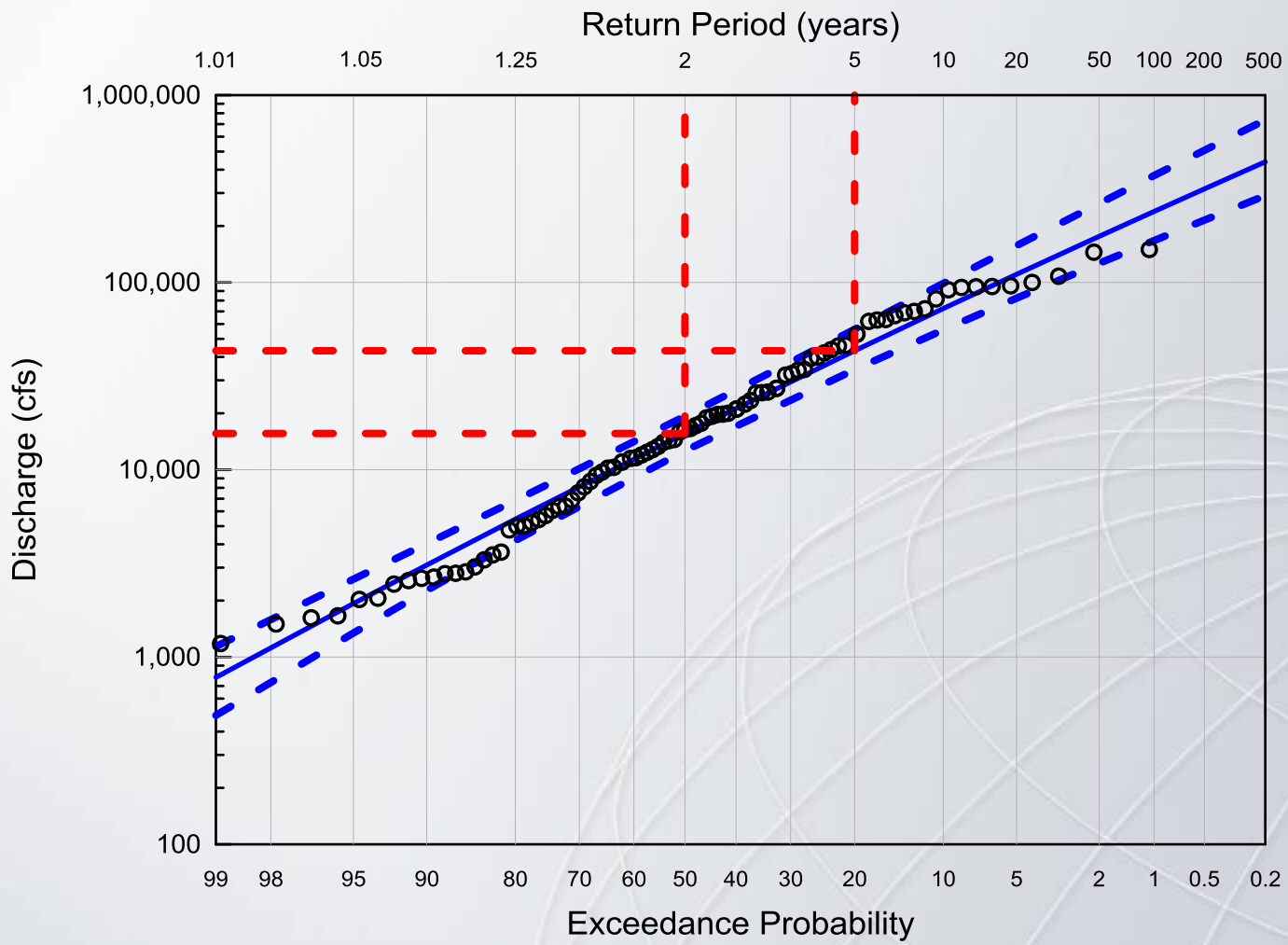
Braiding versus Meandering



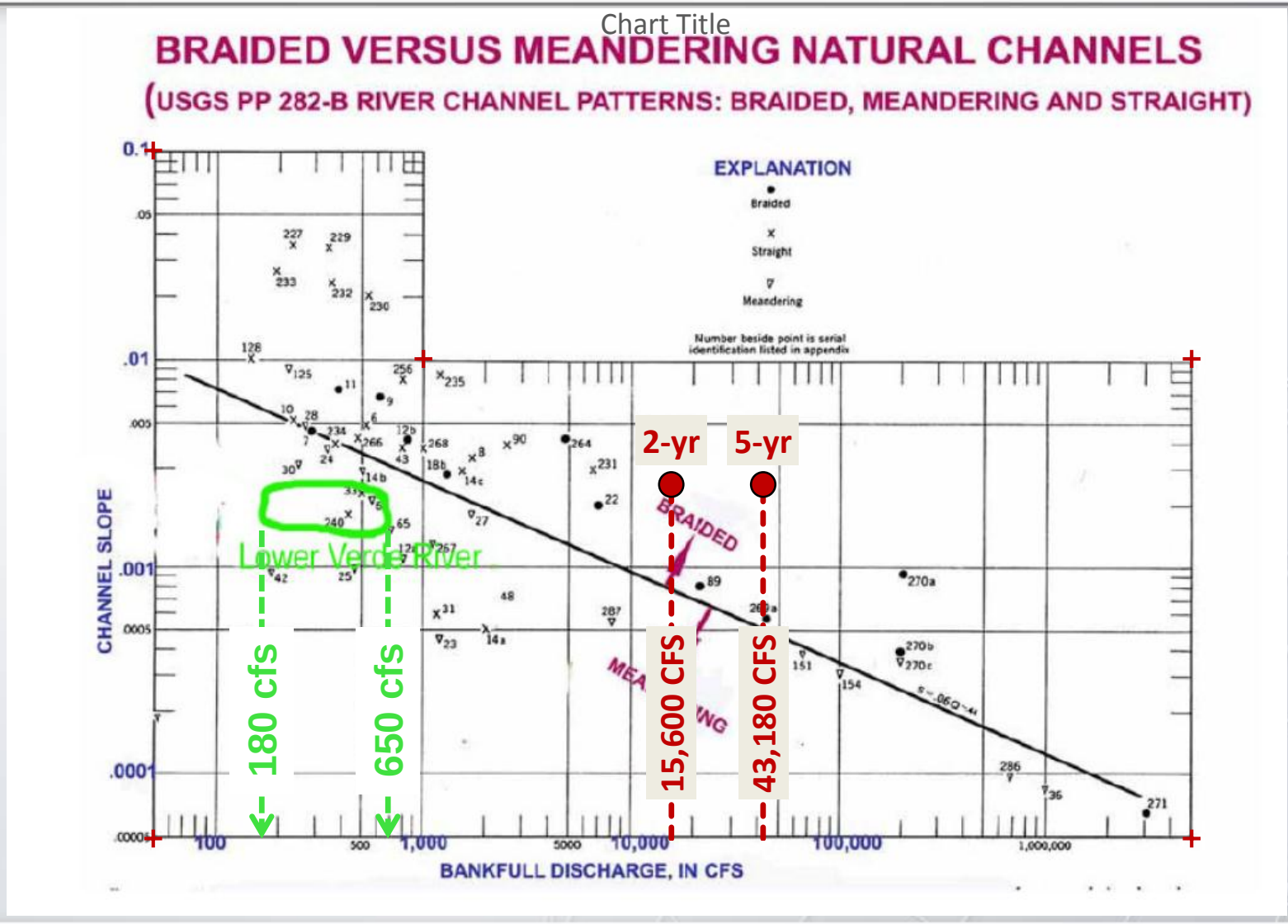
Verde Below Tangle Creek Flow Duration Curve



Verde Below Tangle Creek Peak Flood Frequency Curve



Braiding versus Meandering



Hjalmarson Addendum, Nov 14, 2014, p42

(4) Downstream of Bartlett

Immediately below Bartlett, the floodplain is narrow and was frequently scoured (Figure III-22). About 6 miles downstream of Bartlett, below Needle Rock near Box Bar Ranch (Figure III-23), the Verde Valley changes character from a relatively high-gradient, bedrock-restricted, steep-sided channel with a narrow floodplain to a lower gradient, more braided channel with a broader floodplain. Topographically, there is more opportunity for riparian vegetation to establish and develop from this point to the mouth of the river. Historically, the river floodplain in this reach was periodically scoured bare, and did not support extensive stands of woody riparian vegetation. From 1934 aerial photographs, it appears that most areas of woody vegetation were relatively sparse (less than 50 percent vegetation cover). Human impacts, such as livestock grazing and irrigation diversions, pre-date the dam and likely impacted vegetation cover and establishment in some areas.

Hjalmarson Addendum, Nov 14, 2014, p42

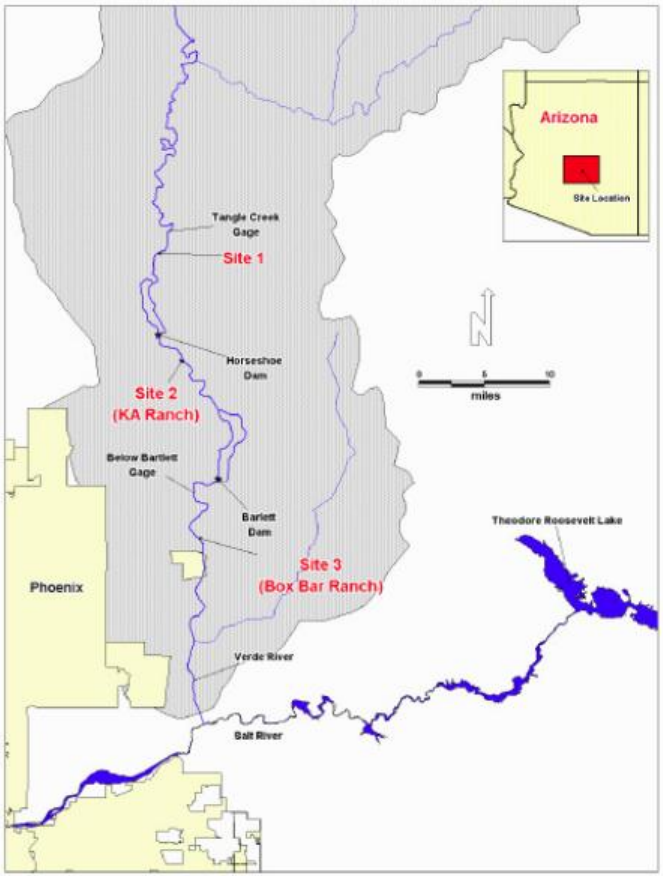
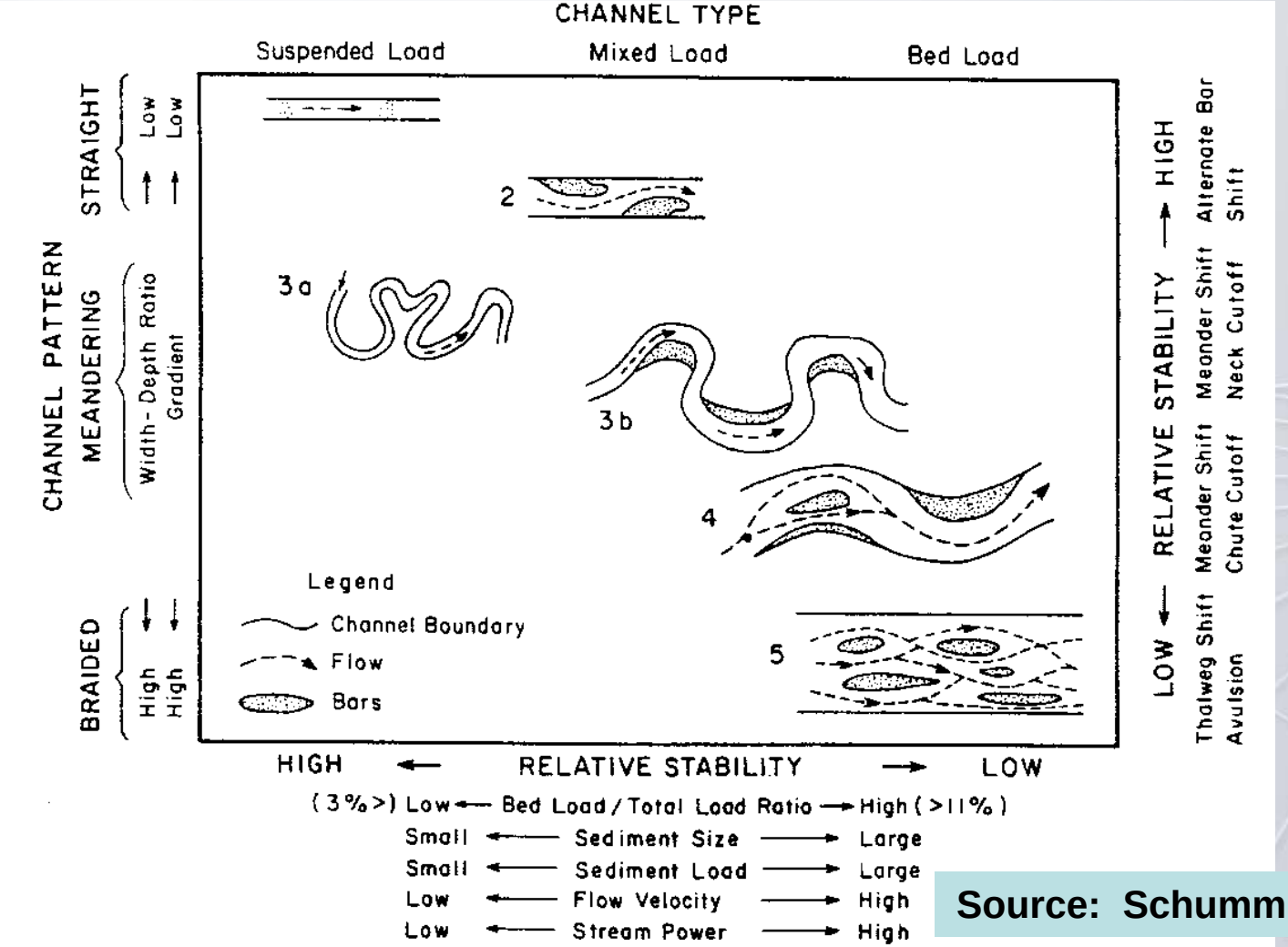


Figure 1.1. Location map.

Sites 2 and 3 obviously are impacted by regulated flow below Horseshoe and Bartlett Dams. Impacts include altered streamflow and sediment discharge that are discussed in my report. Dr. Mussetter neglects to show that the hydrologic and hydraulic conditions at sites 2 and 3 do not represent natural and ordinary conditions. The simple fact is sites 2-3 are affected by humans.

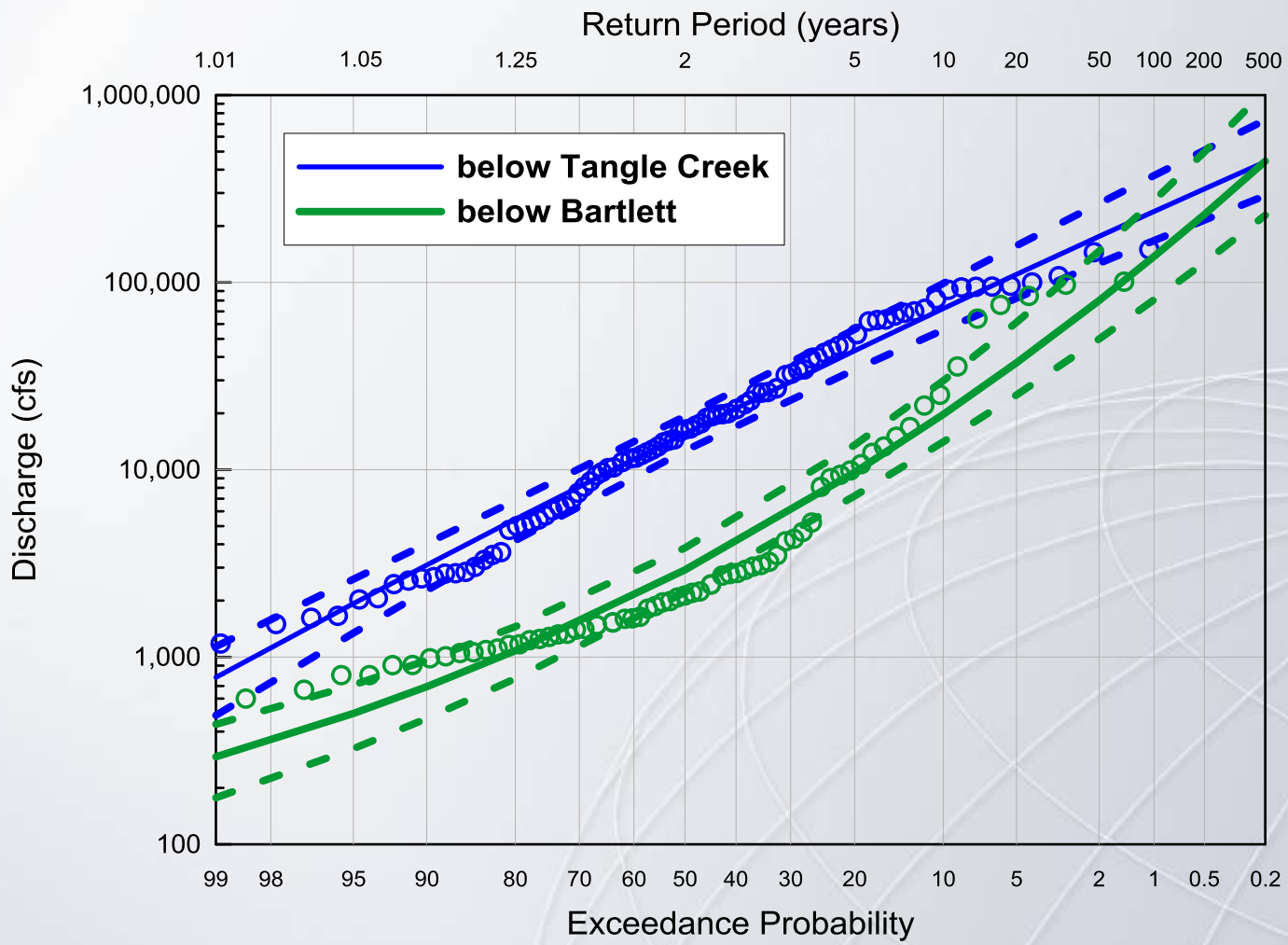
Channel Classification Relevant to Gila River Navigability



Source: Schumm (1981)

Sedimentation at Head of Horseshoe Reservoir

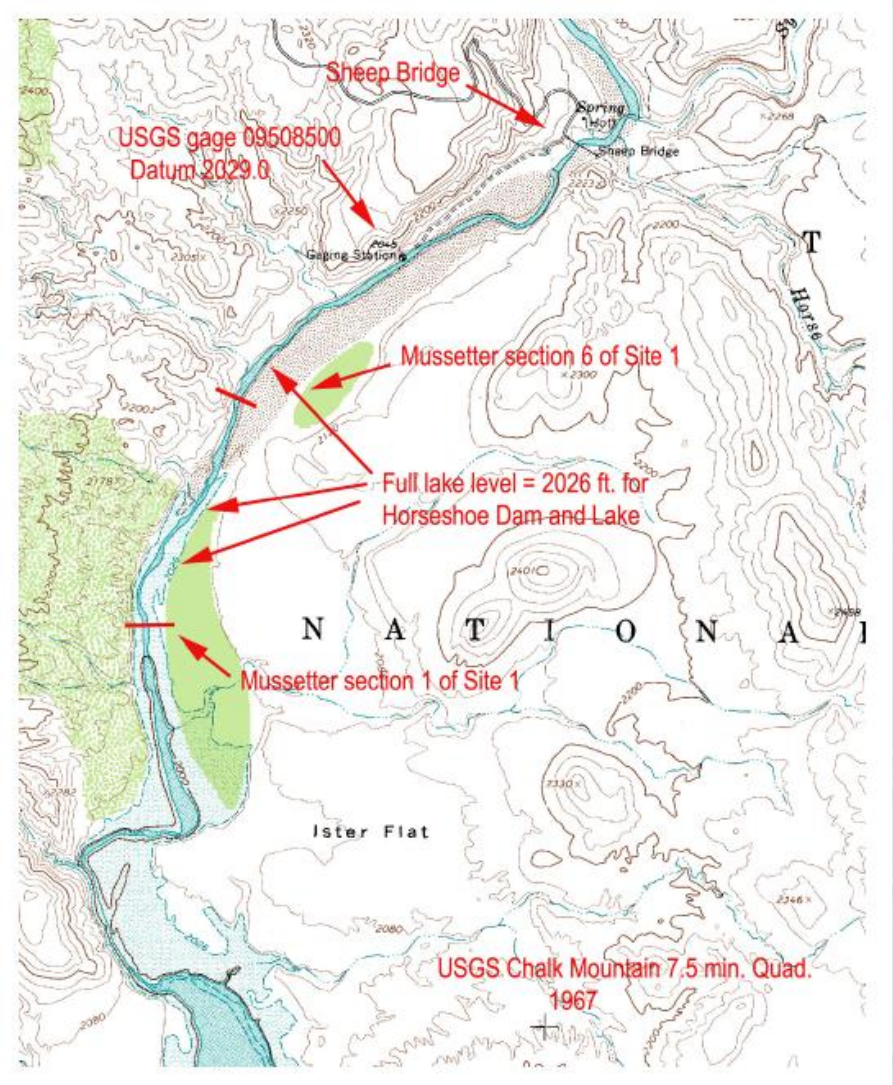
Verde River Flood Frequency Curves

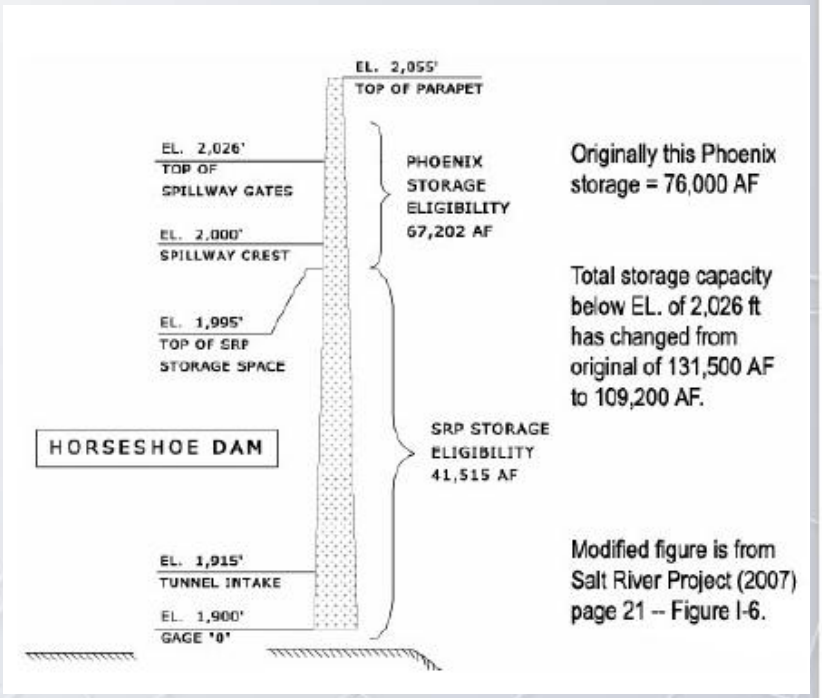


Hjalmarson Addendum, Nov 14, 2014, p43

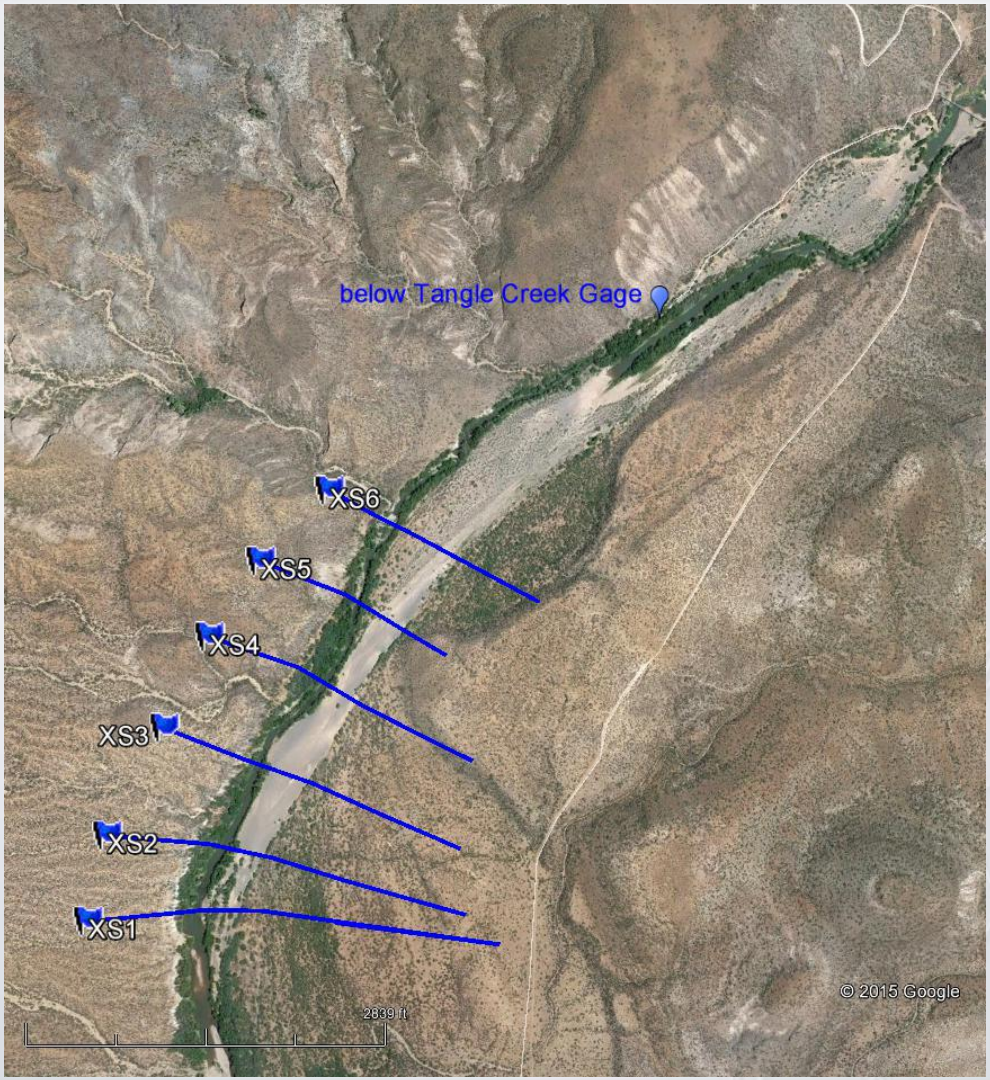
Site 1 is interesting because Dr. Mussetter neglects to mention that it lies within the normal water surface elevation of Horseshoe Reservoir (see map below) and has been inundated a few times by water stored behind Horseshoe Dam. Also, site 1 has been subjected to backwater and associated deposition of river transported sediment during large floods especially when storage in Horseshoe Reservoir was large. The amount of reduction in reservoir storage by deposited sediment captured by Horseshoe Dam is on the order of 620 AF per year (SRP 2007, p. 90). The relatively recent (historically speaking) deposited sediment along the Verde River in and along Site 1 is easily scoured, especially during storm runoff, and is quite variable in amount and location because of the influence of fluctuations in lake levels. Site 1 is located in one of the most unstable areas along the human impacted Verde River.

Hjalmarson Addendum, Nov 14, 2014, p43

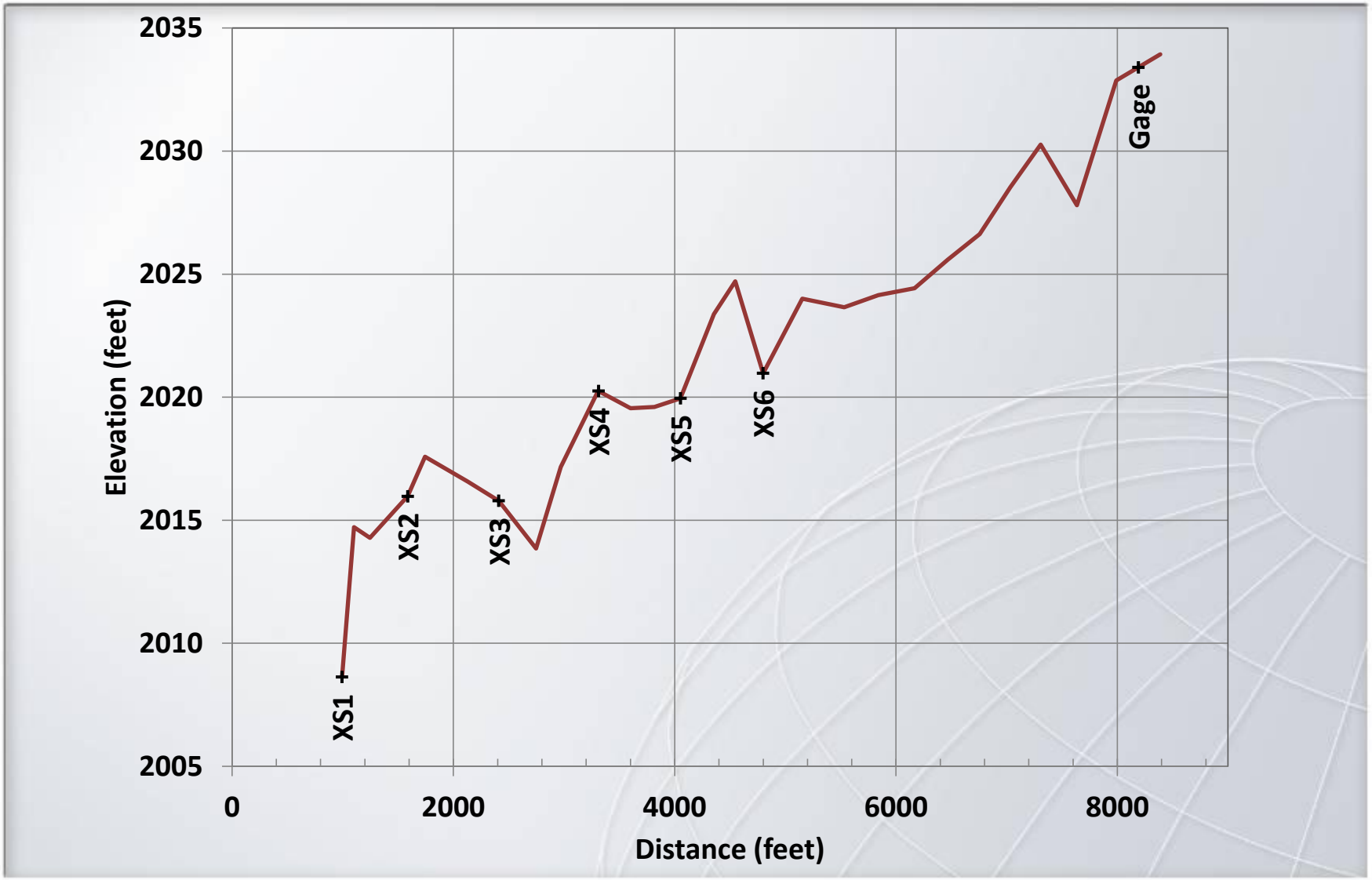




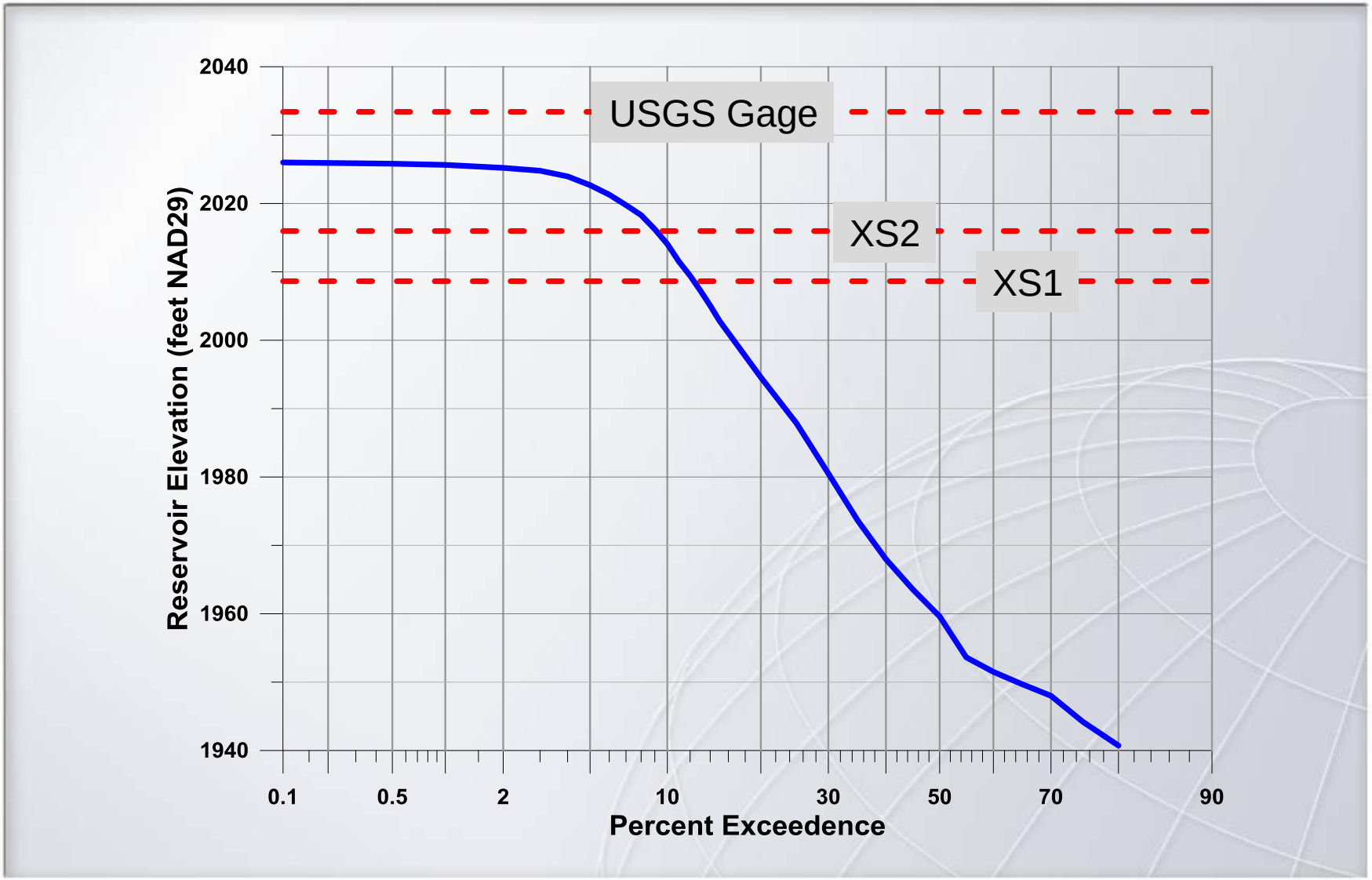
MEI (2003) Site 1



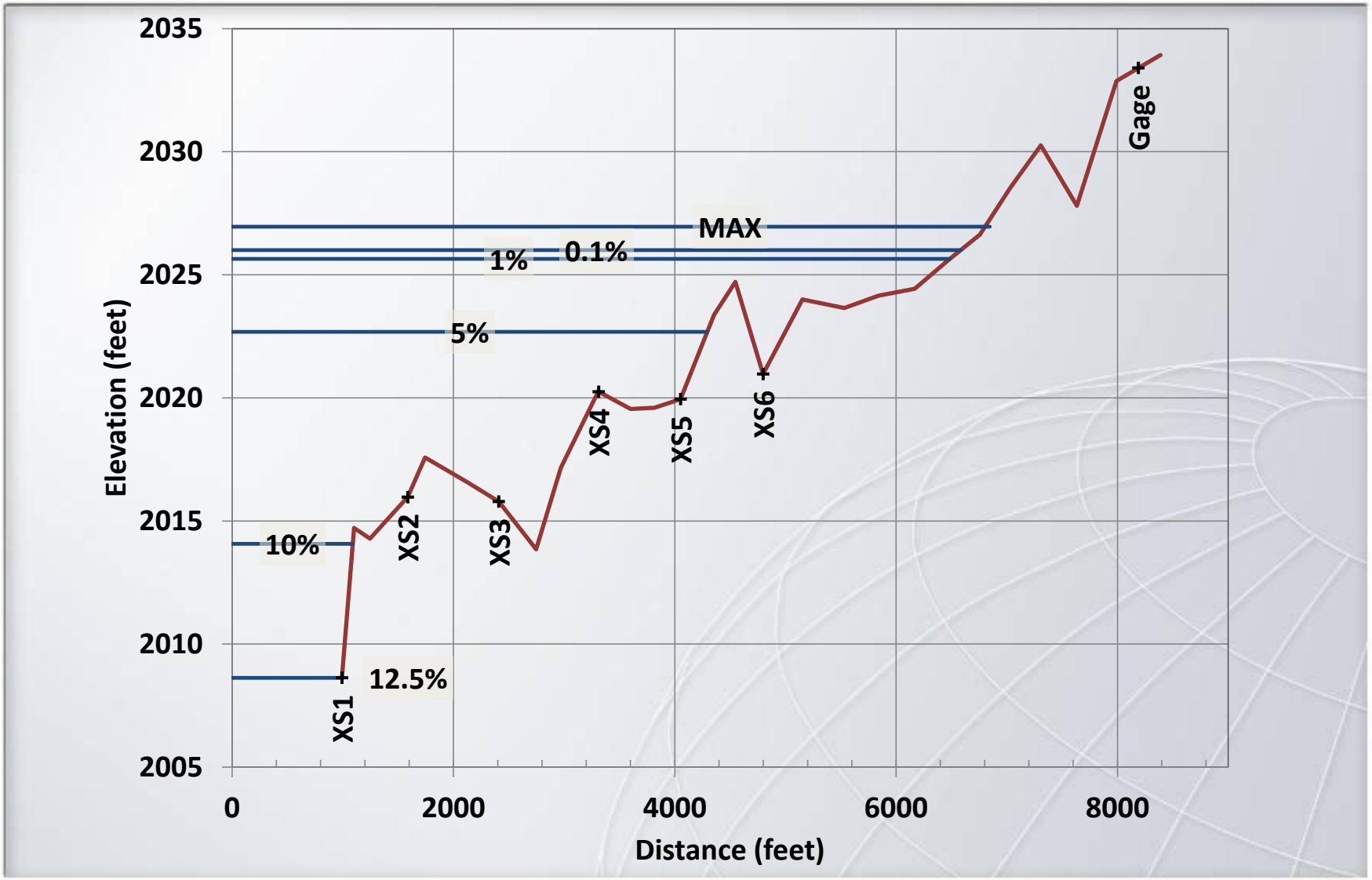
MEI (2003) Site 1 Profile



Horseshoe Reservoir Elevation-Duration



MEI (2003) Site 1 Profile



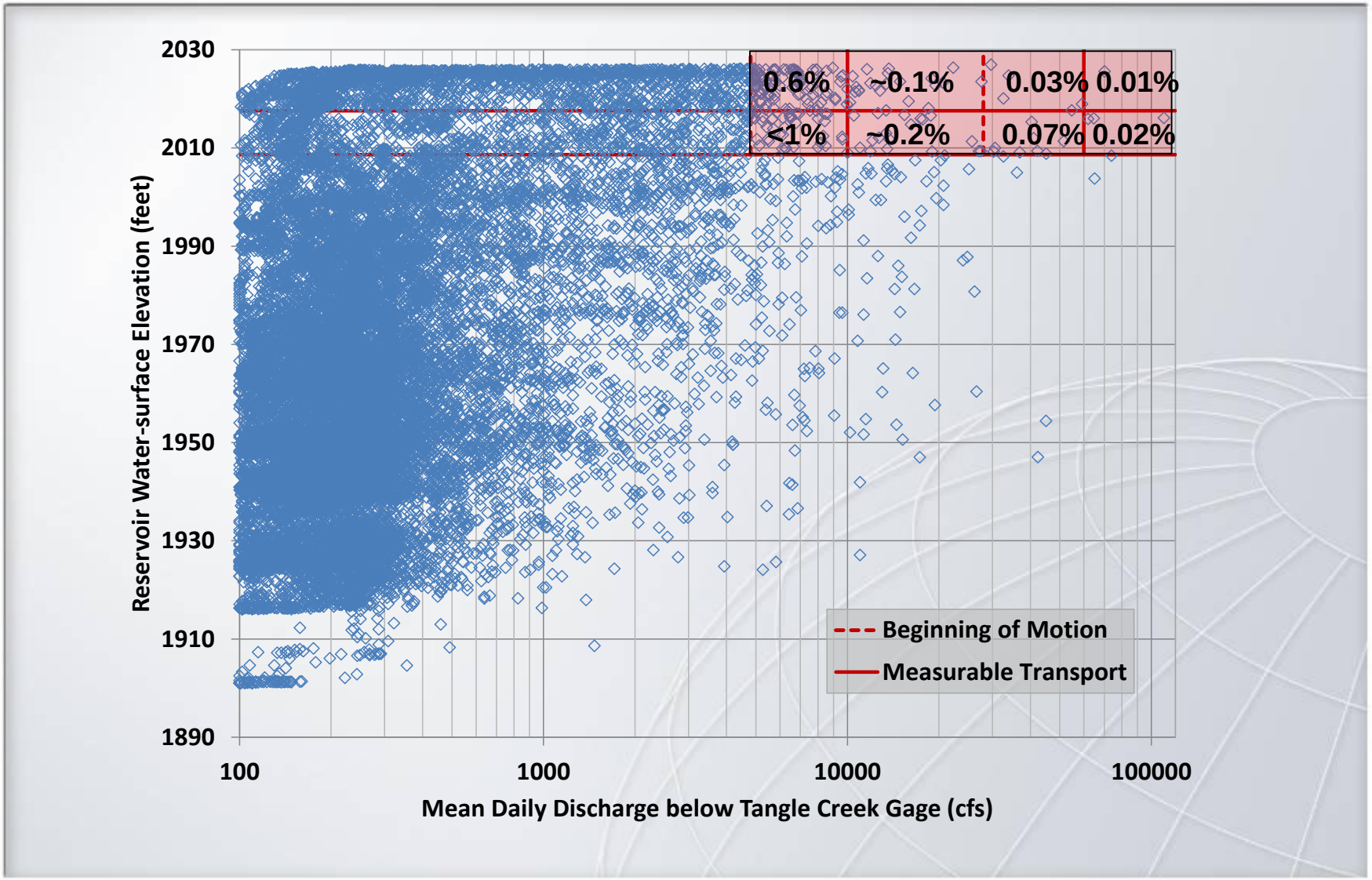
MEI (2003) Critical Discharge for Bed Mobilization

Table 5.2 provides a summary of the typical main channel characteristics for each of the sites.

Table 5.2. Summary of main channel characteristics for the three sites.

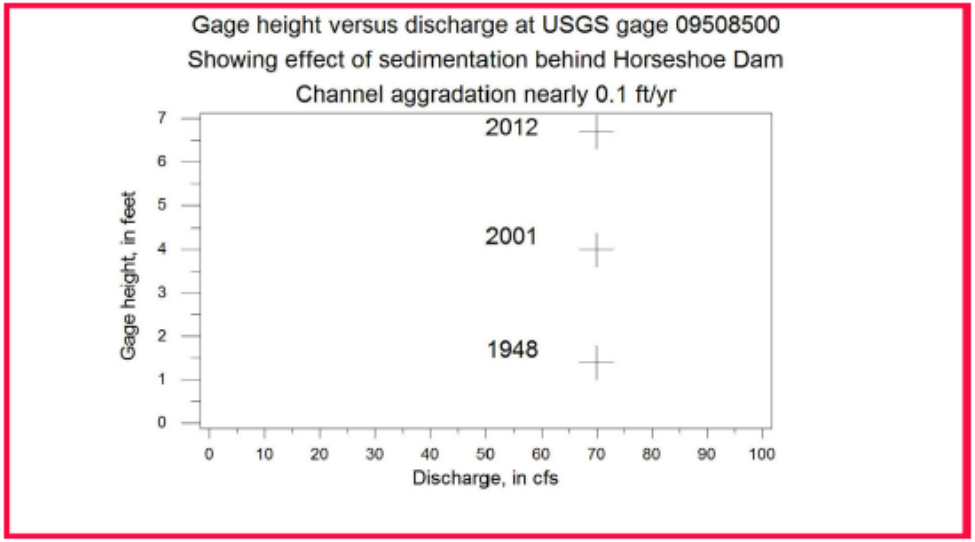
Characteristic	Site 1	Site 2	Site 3
Slope (ft/ft)	0.0027	0.0041	0.0023
Bed Material D_{50} (mm)	80.5	146	95
Main Channel Capacity (cfs)	16,000	20,000	20,000
Recurrence Interval (yrs)*	2.1	4	8.4
Critical Discharge (cfs)	4,600—28,000	2,400—55,000	2,200—16,000
Recurrence Interval (yrs)*	1.3—3.5	1.1—10	1.9—7.7
Discharge for Measurable Sediment Transport (cfs)	10,000—60,000	3,200—120,000	5,000—90,000
Recurrence Interval (yrs)	1.6—7.1	1.3—>57	3.5—>22.6

Horseshoe Reservoir versus *below Tangle Creek* Discharge

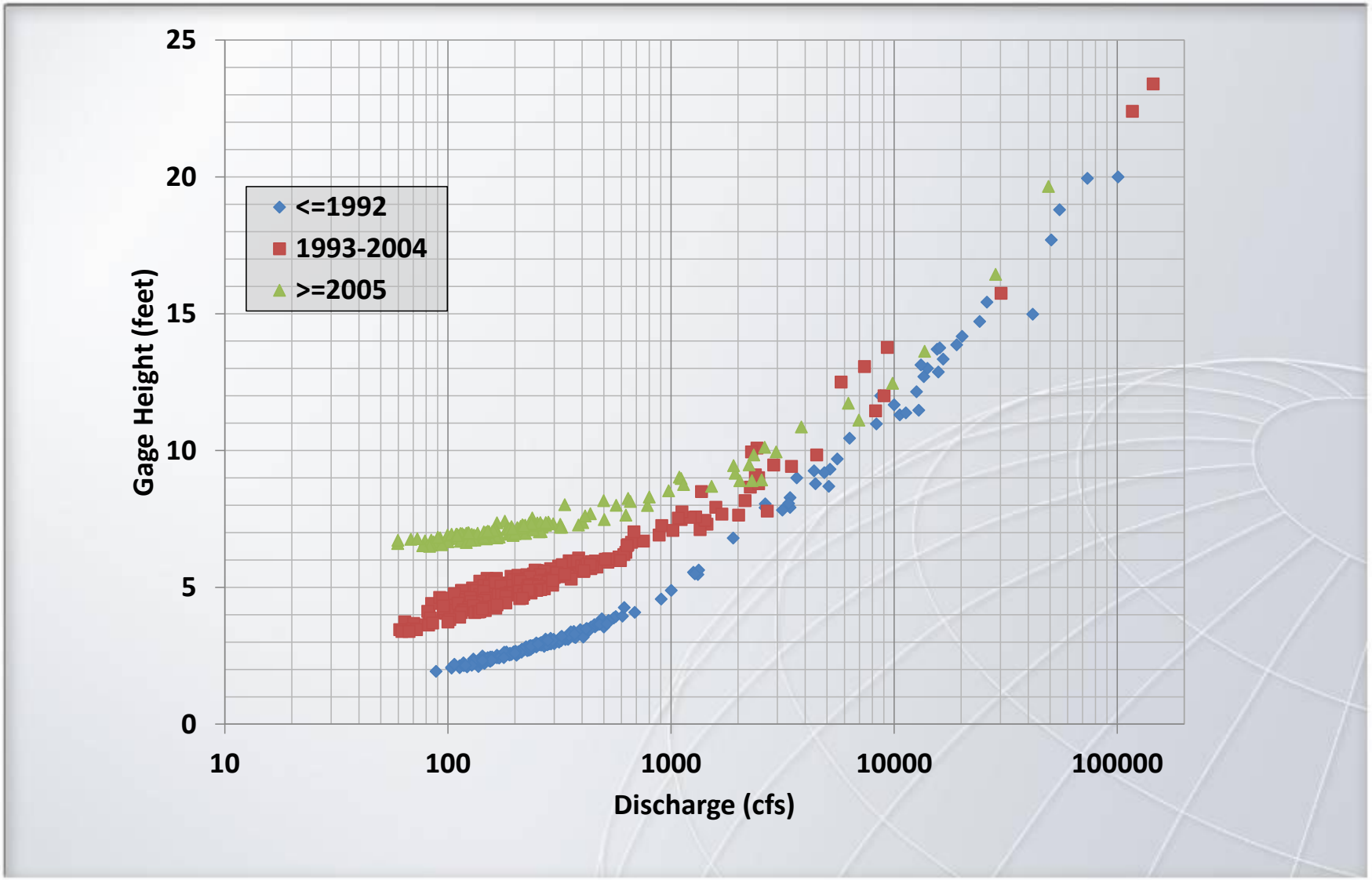


Hjalmarson Addendum, Nov 14, 2014, p44

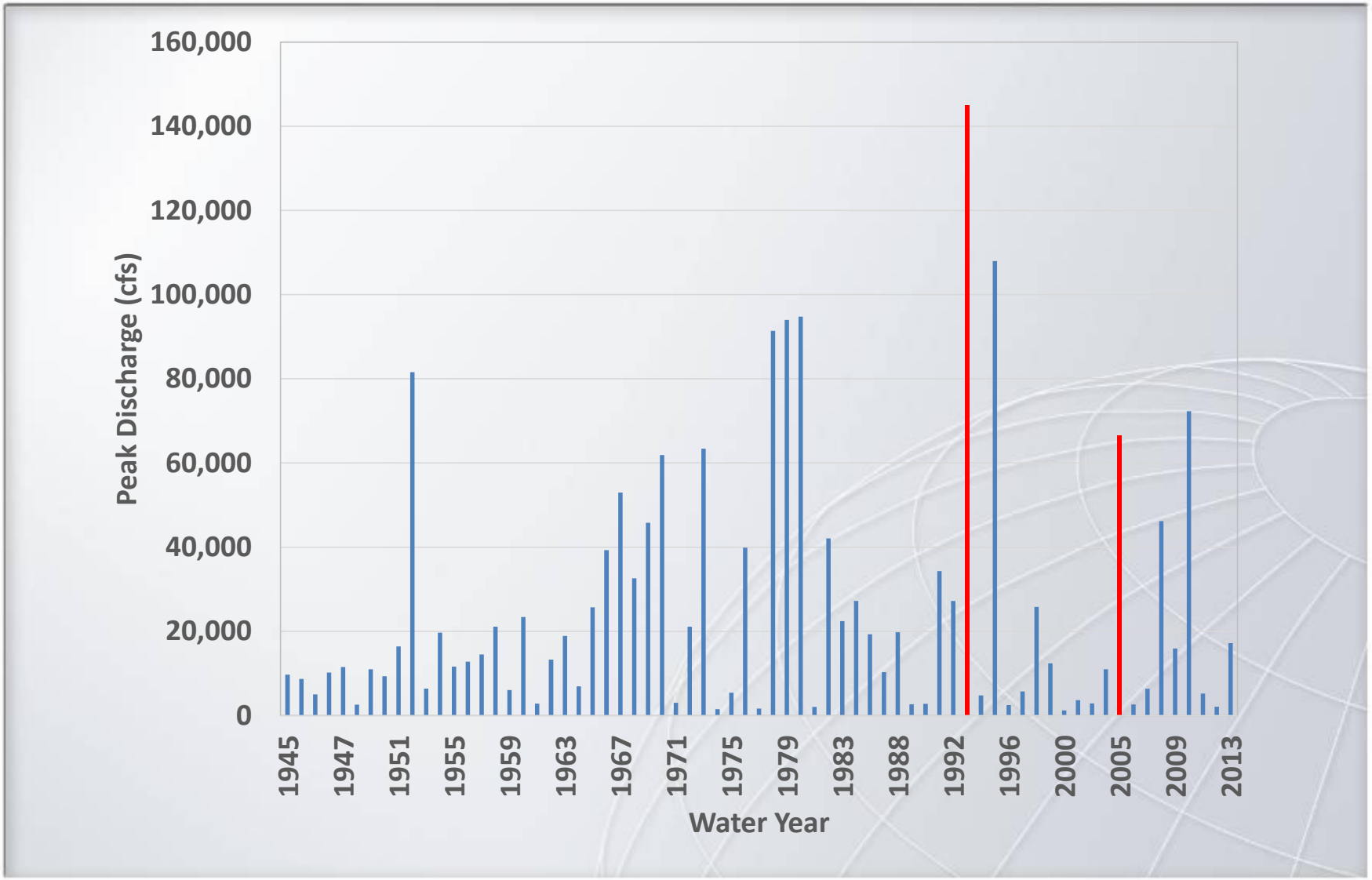
The relation below shows the effect of the aggrading channel of the Verde River at gage 09508500 where a delta like environment has been created by backwater and associated sediment deposition at the USGS gage and cableway above Horseshoe Dam and reservoir. On the right side of the cableway the flow is perpendicular to the cable but on the left side the flow is parallel to the cable. A small small human caused delta has formed at the cableway. The channel geometry is ever changing in this human caused unstable environment. Site 1 is downstream of the USGS gage, (see map on previous page)



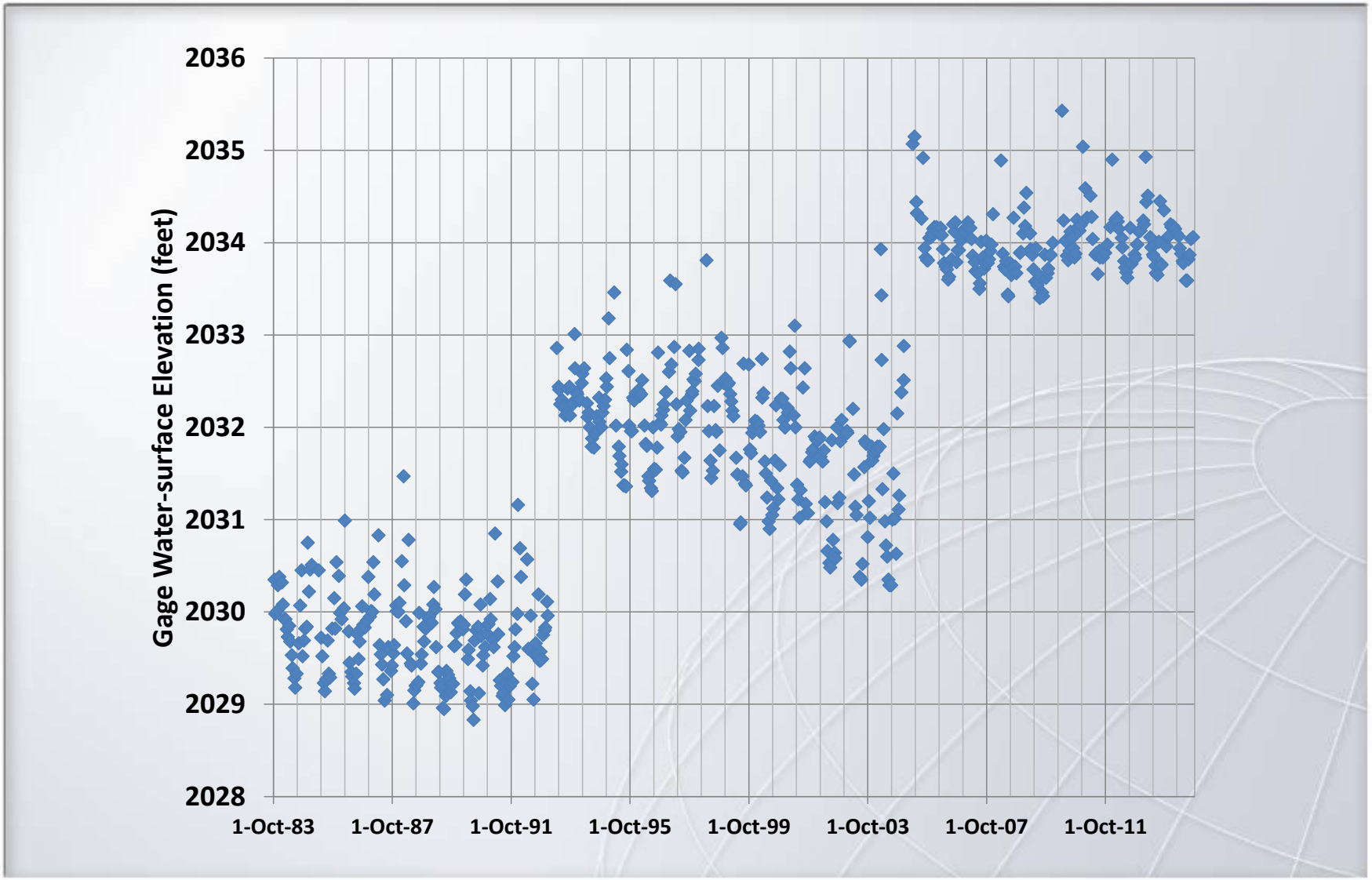
Below Tangle Creek Gage Height v Discharge



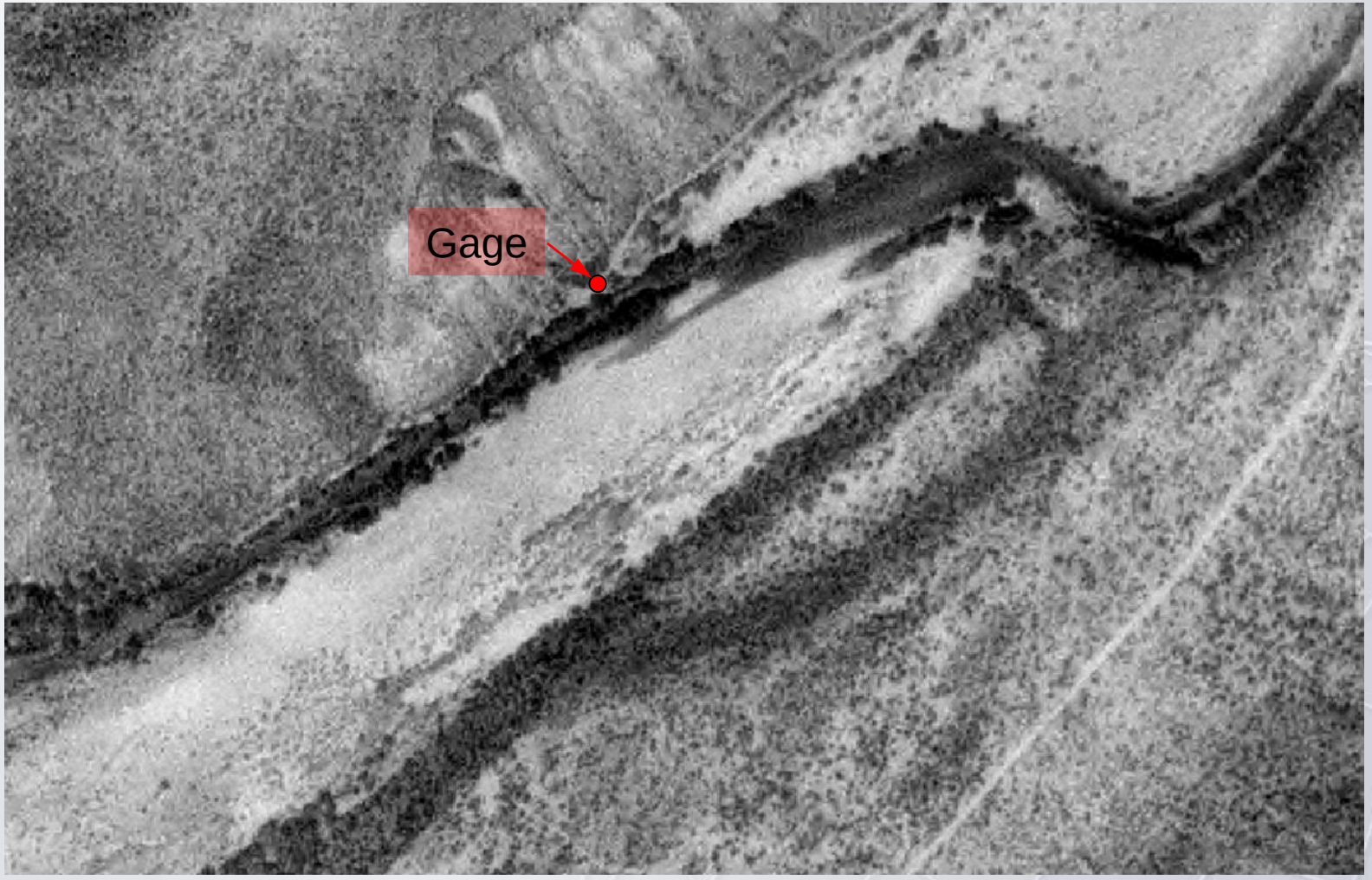
Below Tangle Creek Gage Annual Peak Discharge



Below Tangle Creek Gage Height v Discharge



Below Tangle Creek Gage (1992)



Below Tangle Creek Gage (1997)

Below Tangle Creek Gage (2002)

Below Tangle Creek Gage (2006)

Below Tangle Creek Gage (2013)

Summary of Opinions

The Verde River was NOT susceptible to being used, in its ordinary and natural condition, as a highway for commerce, using customary modes of trade and travel on water at the time of Arizona's statehood.