Salt River Navigability

Presentation to ANSAC

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Definition of Navigability

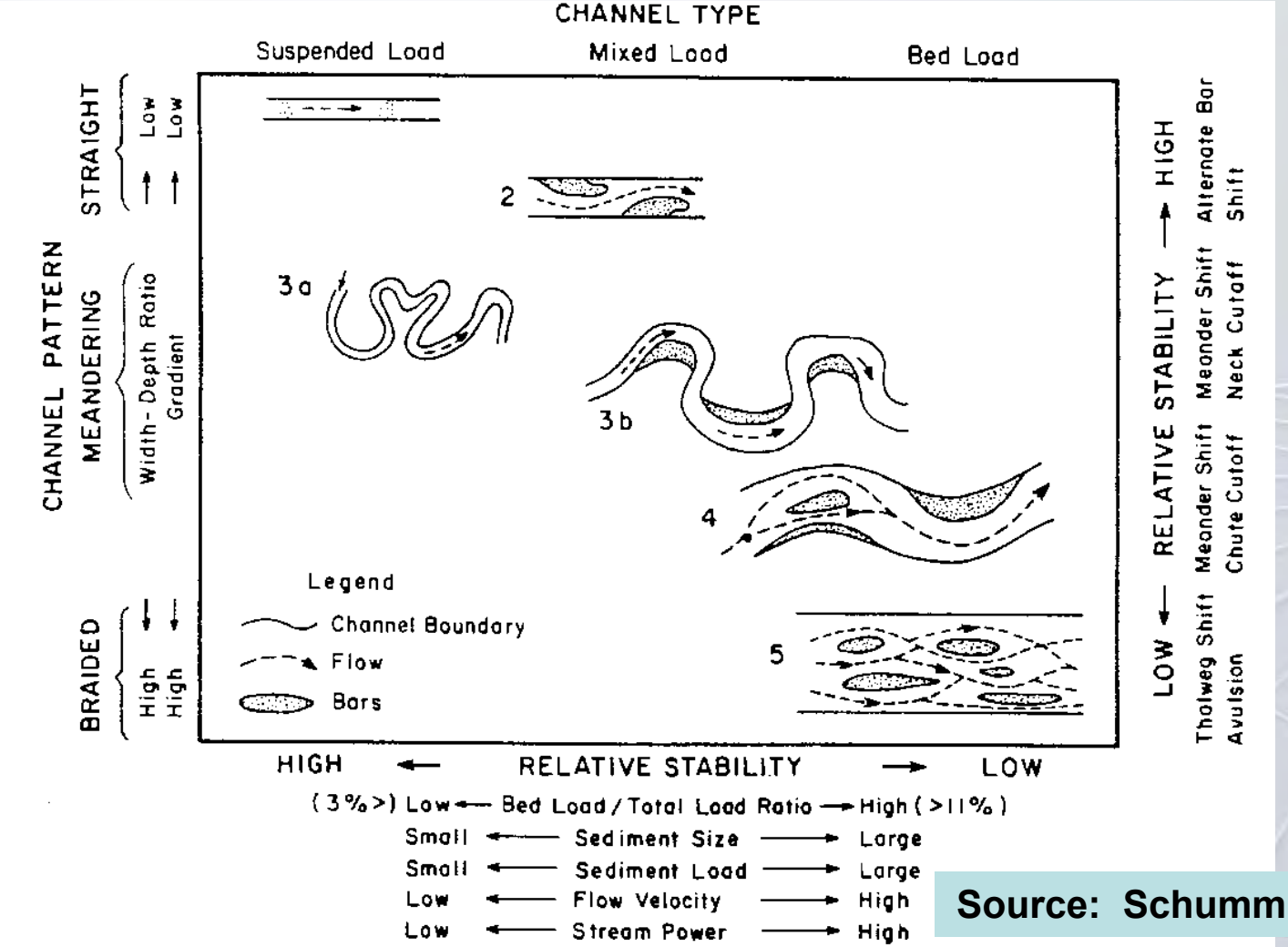
- A.R.S. § 37-1101(5)

"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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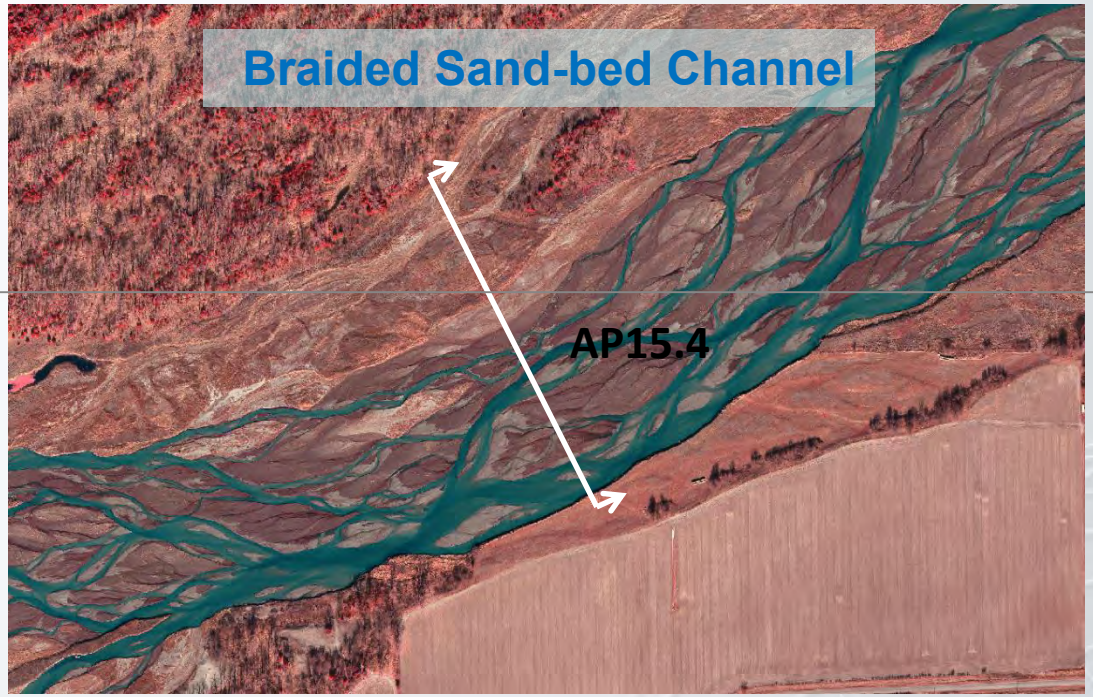
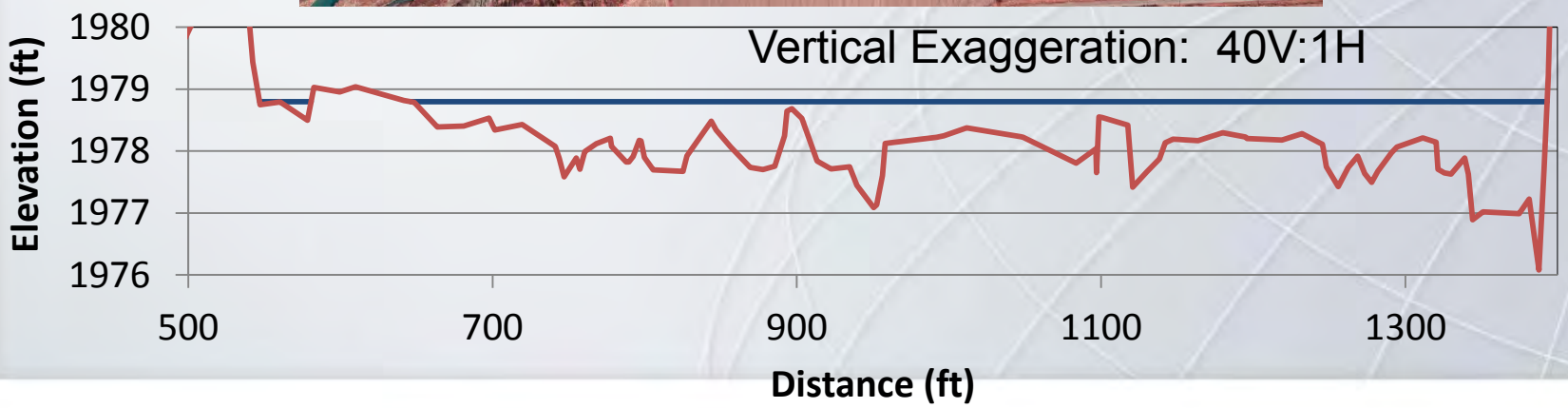


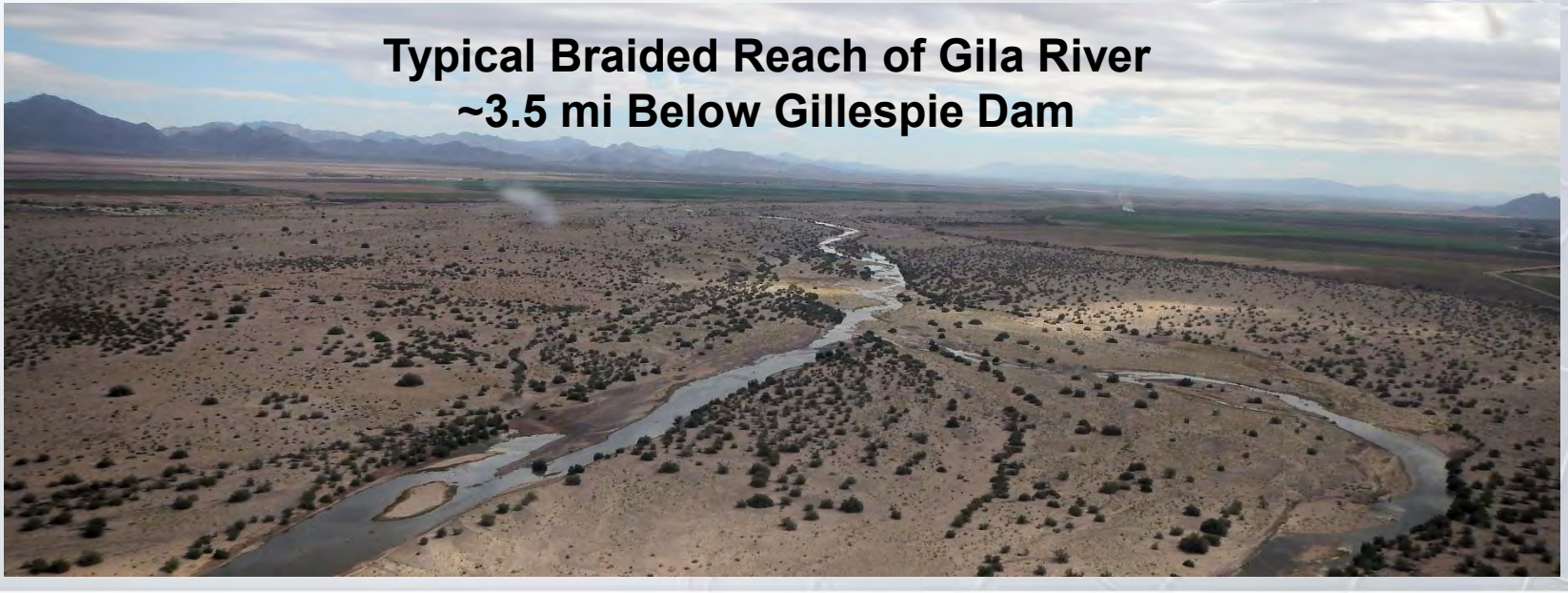


Examples of Channel Types

Examples of Channel Types

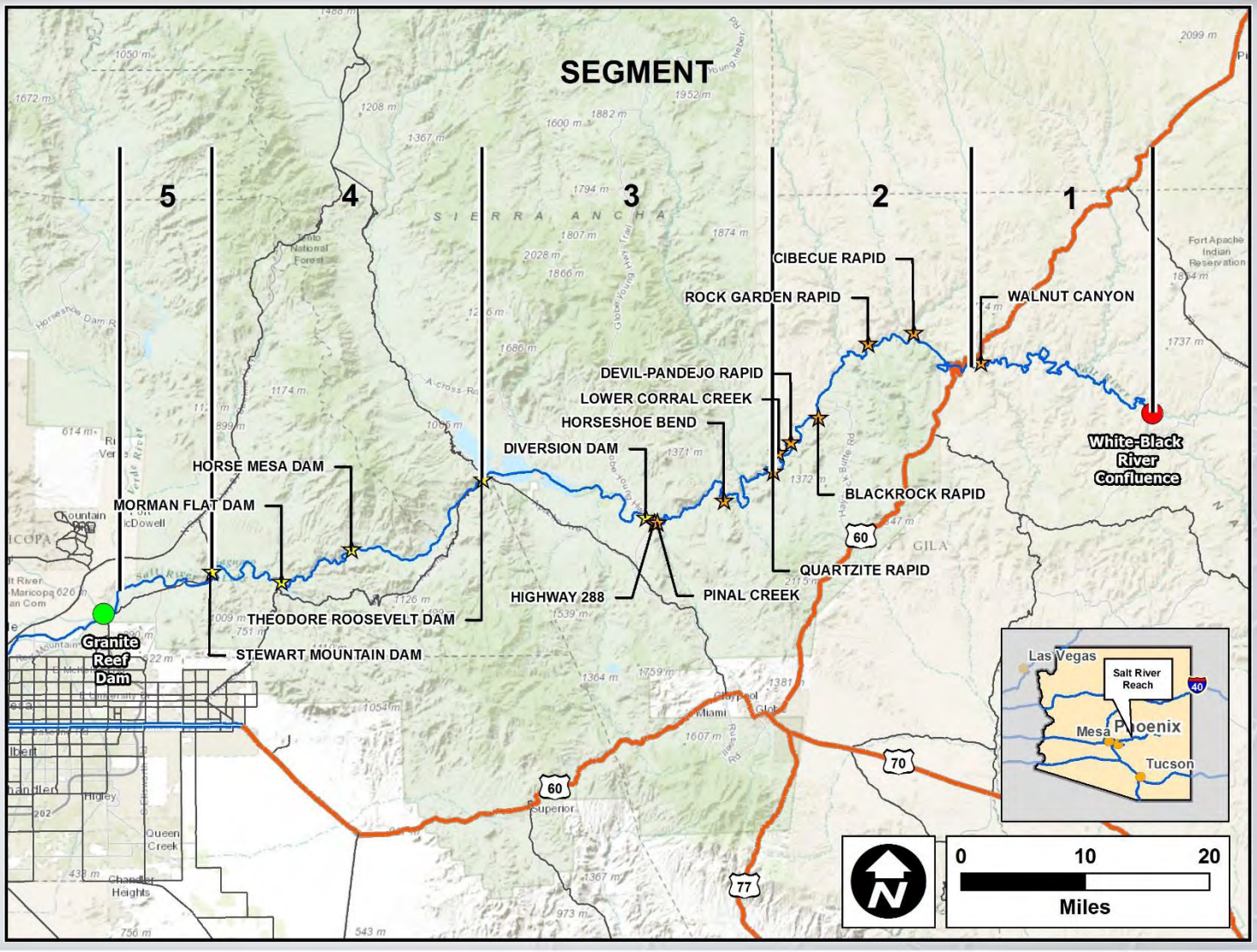
Channel Pattern IS Relevant to Navigability

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

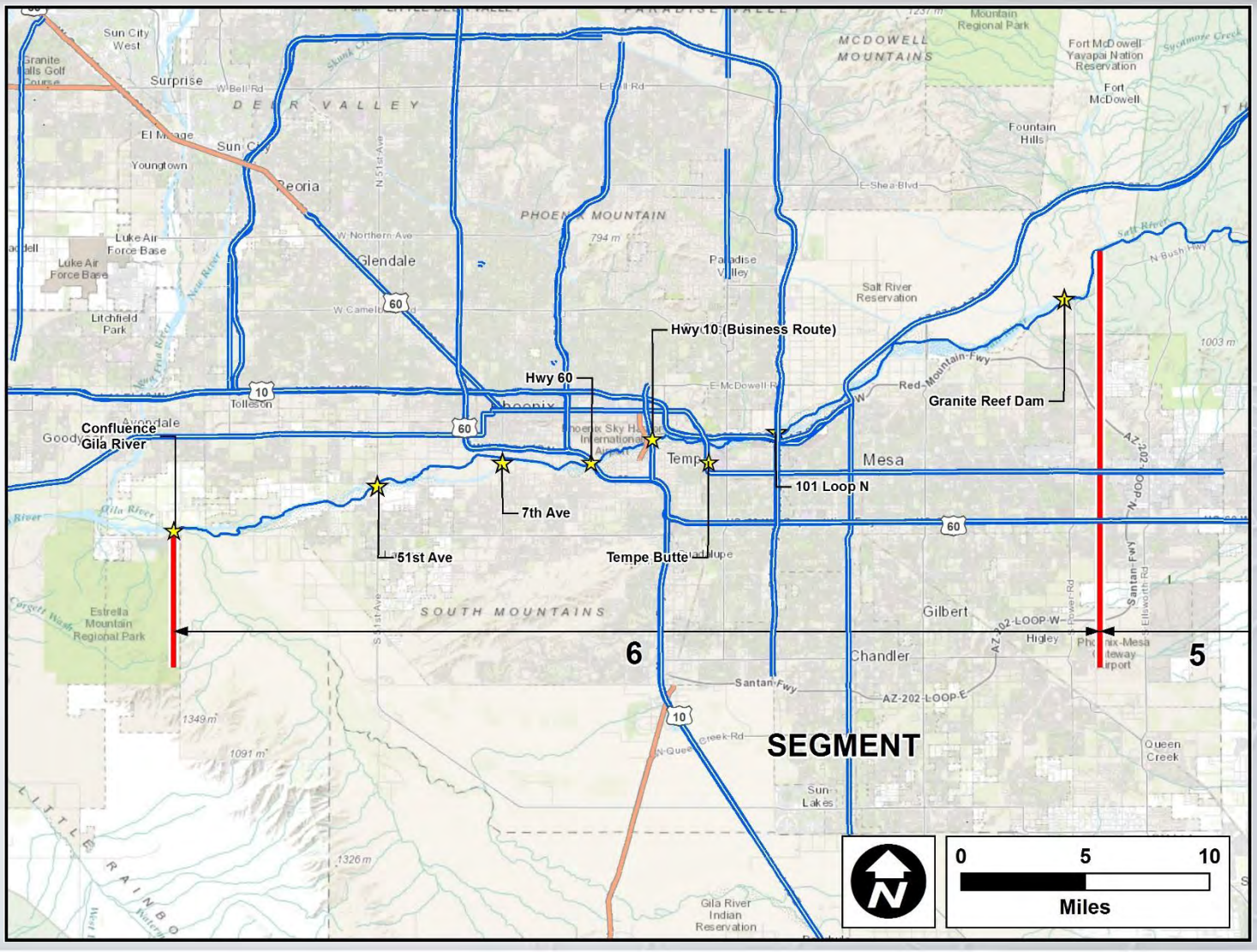


Typical Braided Reach of Gila River ~3.5 mi Below Gillespie Dam

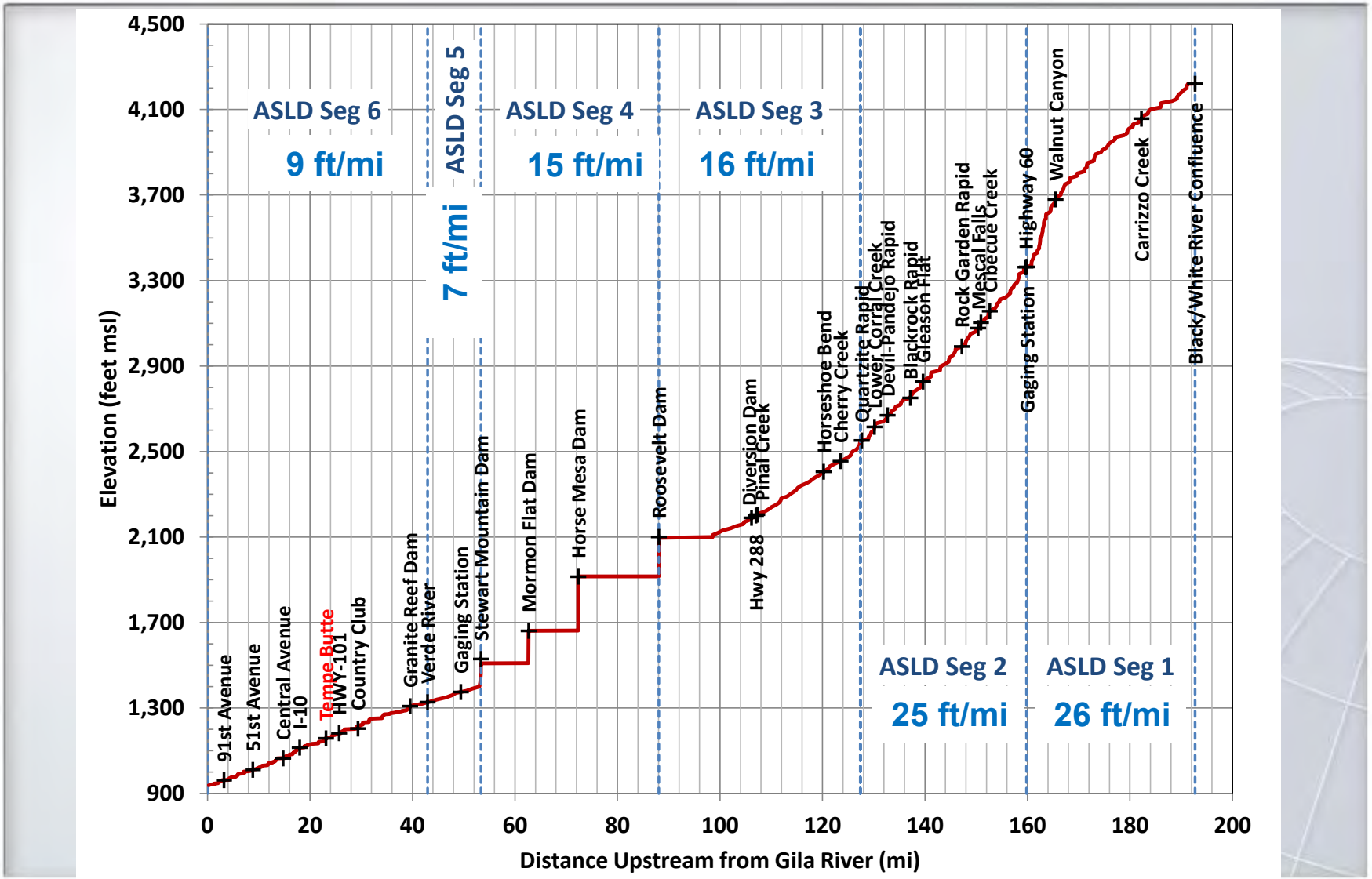
Upper Salt River
Segments and Key Features



Lower Salt River
Segments and Key Features



Longitudinal Profile

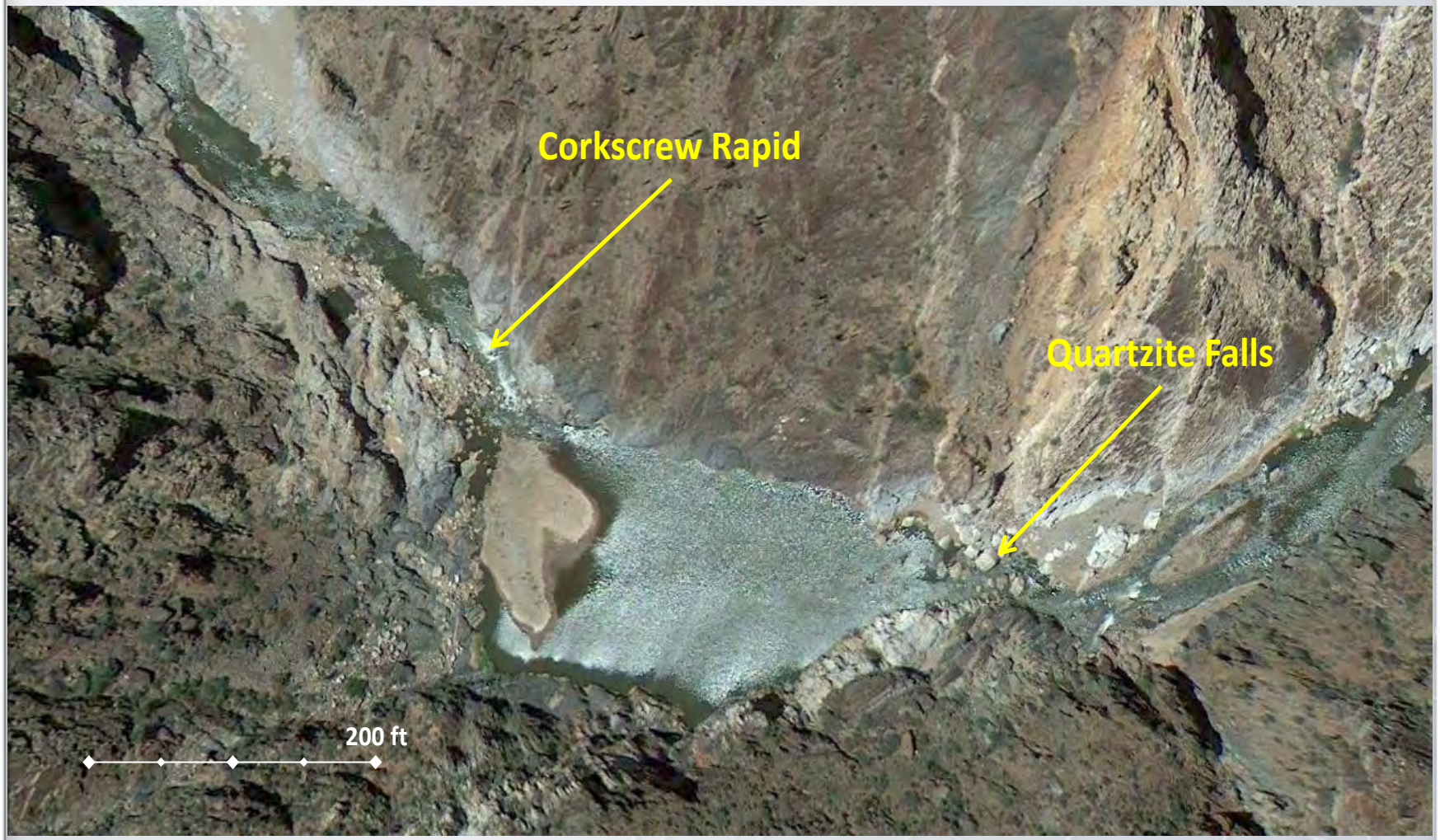


UPPER SALT

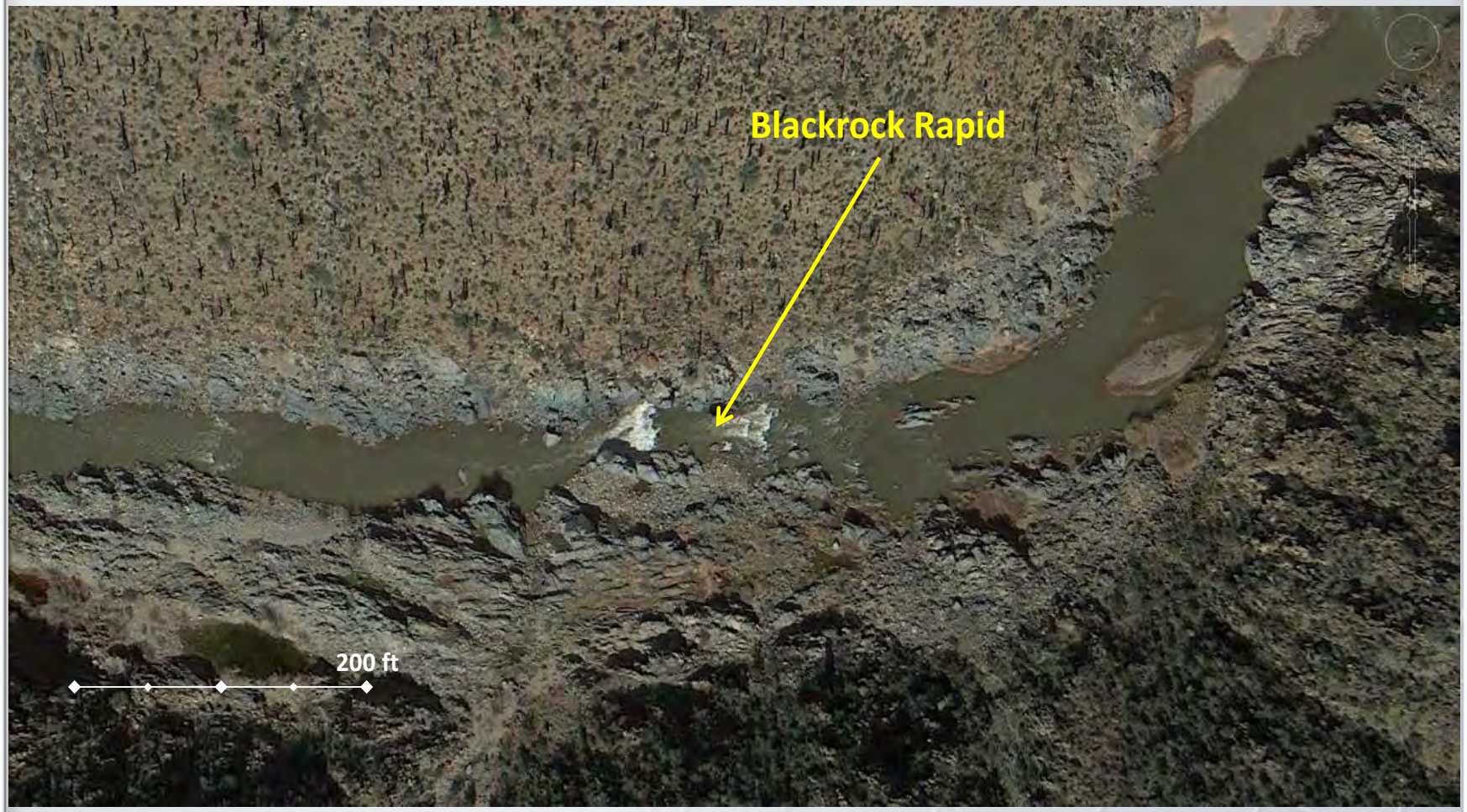
SEGMENT 2

SEGMENT 3
UPSTREAM FROM ROOSEVELT RESERVOIR

Corkscrew Rapid and Quartzite Falls (~RM 80)

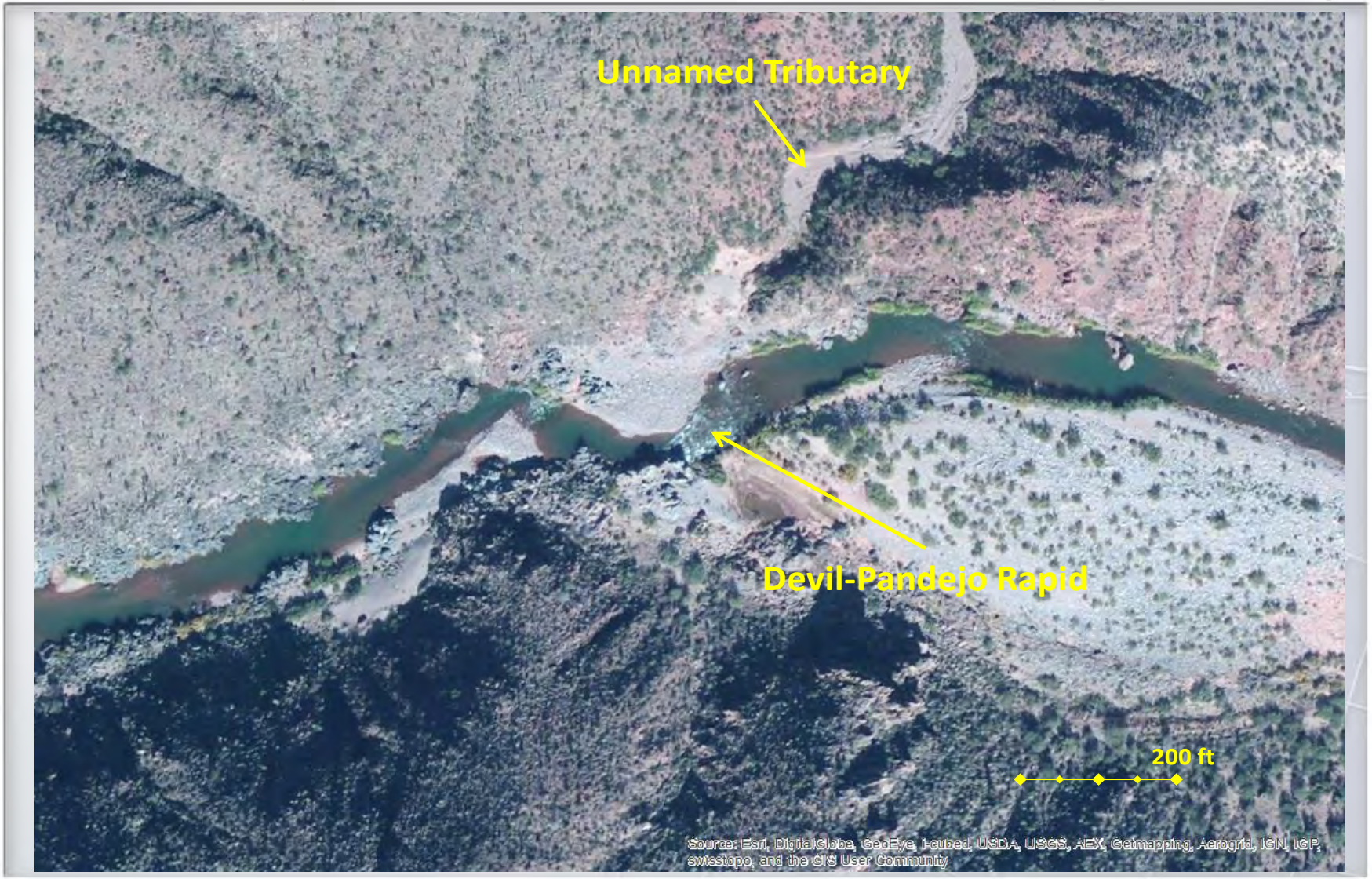


Blackrock Rapid (RM 97.6)



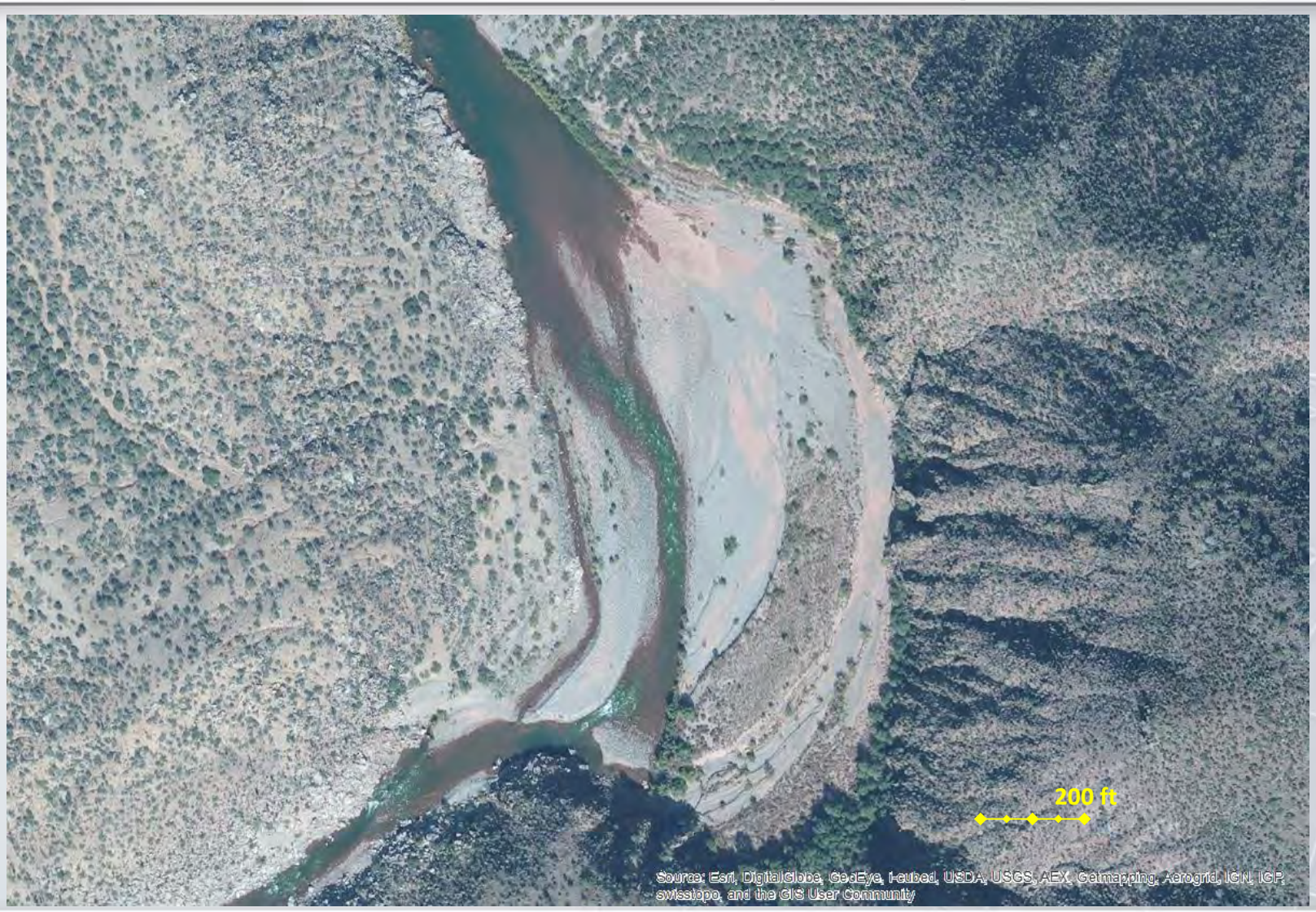
Lower Corral Creek and Rapid (~RM 90.6)

Devil-Pandejo Rapid and Unnamed Tributary (~RM 93.2)



Horseshoe Bend Rapid (~RM 81)

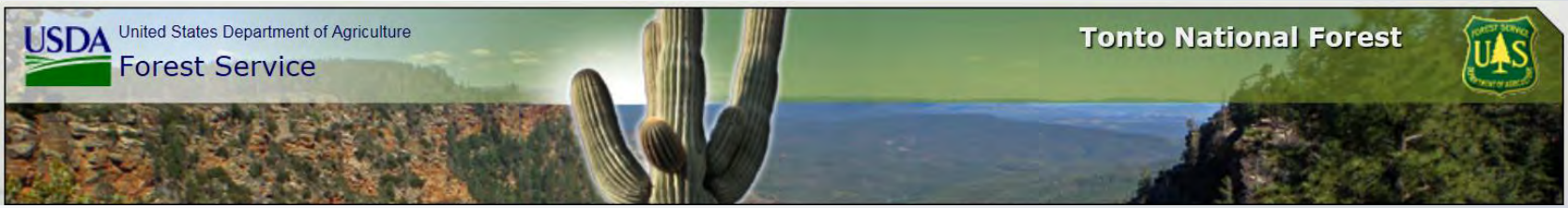
Upper Salt River (RM 105)



Quartzite Falls

Gleason Flats and Gleason Rapid

USFS Salt River Permit Website

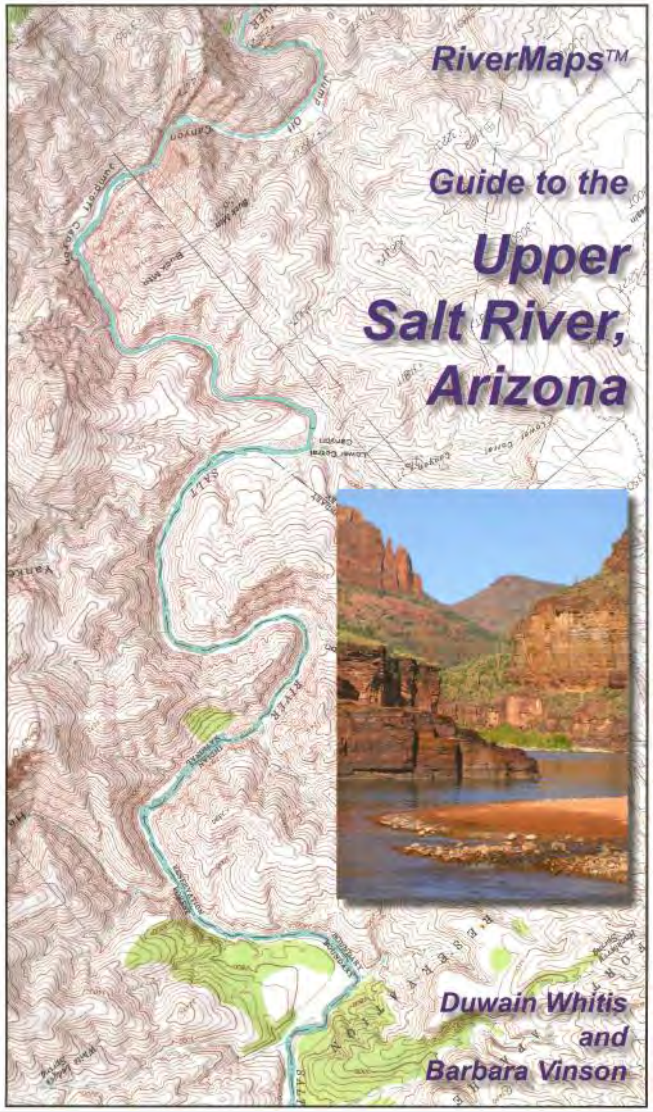


The Salt River Canyon is a very remote and potentially dangerous place. The river is a solid Class III-IV run, and is not recommended for novices and beginners.

(http://www.fs.usda.gov/detail/tonto/passes-permits/?cid=fsbdev3_018757)

Upper Salt River Recreation Opportunity Guide
USFS (1995)

*There are several rapids which can go to a solid Class IV at certain water levels. This river is usually run in small rafts and in kayaks. It is **not** suitable for… open canoes, etc. It is also unsuitable for large rafts.*



General Information

Just a short two and one-half hour drive from central Phoenix is a special river that relatively few boaters get to enjoy, mainly due to its short unpredictable season. The upper Salt River is known for its challenging whitewater, Sonoran desert flora and fauna, and stunning geology. Located north of Globe, Arizona, the section of river described in this guidebook flows through more than 52 miles of canyon scenery with elevations ranging from 2,200 feet near the take-out at State Highway 288 to more than 5,400 feet in the high parts of the canyon near the put-in at U.S. Highway 60. With an average gradient of almost 22 feet per mile, the river tumbles through 33 named rapids, many of which are rated class III or IV. Much of the river is encompassed by the 32,100-acre Salt River Canyon Wilderness on one or both sides.

The river has its headwaters in the White Mountains of eastern Arizona. The White and Black rivers originate on the northwest and southeast slopes, respectively, of Baldy Peak, Arizona's second highest mountain at 11,403 feet. The two streams merge approximately 33 twisting river miles upstream from U.S. Highway 60 to form the Salt River. From the confluence, the river flows free for 93 miles before succumbing to the dead impoundment of Theodore Roosevelt Lake, part of the infrastructure that provides water to the Phoenix metropolitan area. What little water manages to pass through the series of impoundments and diversions below Theodore Roosevelt Dam flows through Phoenix to the Gila River and on to the lower Colorado River at Yuma, Arizona.

The boating season for the Salt typically begins in early March and runs through April with anything from dangerously high water to rock-scraping low water possible. Suggested water levels based on the USGS Chrysotile gage near the put-in at U.S. Highway 60 are 1,200-3,000 cfs for rafts and at least 400 cfs for inflatable kayaks. Experienced boaters can run light rafts as low as 600 cfs and inflatable kayaks as low as 250 cfs, but rafts will be dodging and scraping rocks, and the portages for inflatable kayaks at Black Rock and Corkscrew are strenuous. Higher levels become increasingly hazardous.

The upper Salt River can be divided into two sections. The upper part from U.S. Highway 60 to Mile 9.3 is paralleled by a dirt road on river right with multiple access points to the river. This section is commonly run by commercial and private boaters as a day trip. The remainder of the river is typically run as a multi-day trip even though intermediate access points at Gleason Flat near river mile 19 can shorten the trip and do not require a Forest Service permit (more on this below). The complete run from U.S. Highway 60 to State Highway 288 is commonly run in three to five days depending on the water level and amount of day hiking your group chooses to do.

The upper Salt River through the Salt River Canyon Wilderness (river mile 19.3 to State Highway 288) is administered by the U.S. Forest Service (USFS), Tonto National Forest. USFS regulations require special recreation permits for private boaters taking river trips from March 1 through May 15, the prime boating season. Permits are issued through a lottery, and applications are taken on-line from November 15 through the close of business on January 31. The link to the lottery application and a list of current requirements can be found on the USFS website (a search for "Tonto National Forest Salt River" should allow you to find the website more easily than typing the very cumbersome URL, which is subject to change.) Cancelled permits are available on-line beginning on February 1. Refer to the USFS website for information on how the cancellation system works.

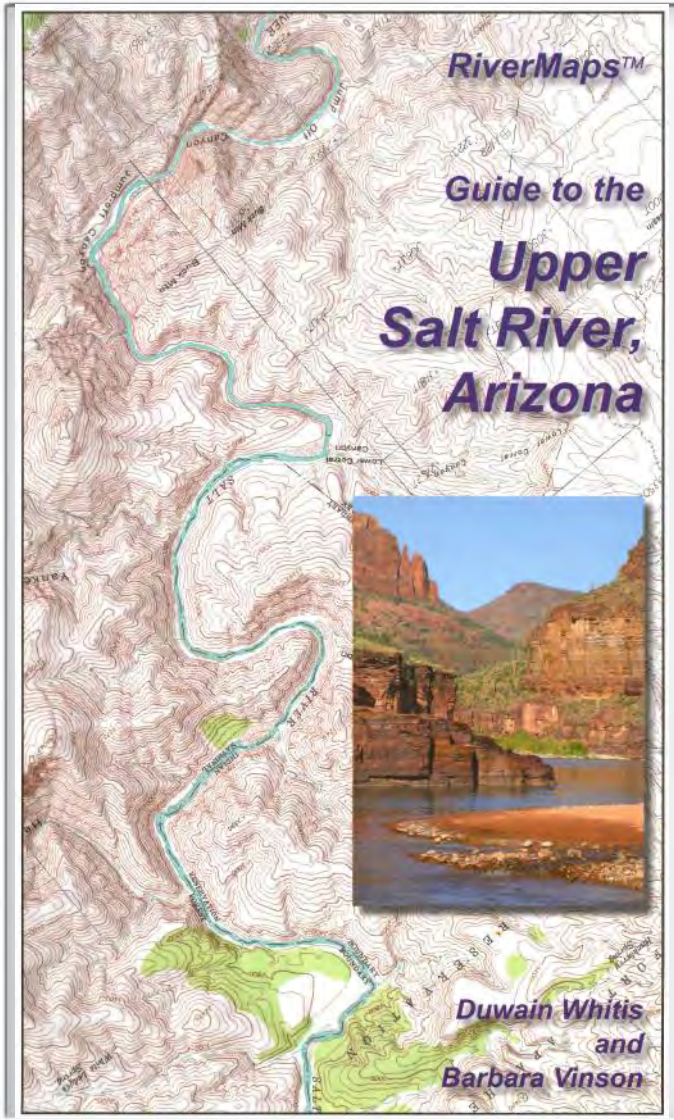
Tonto National Forest currently has the following river trip regulations:

- A boat tag must be attached to every watercraft used.
- Group size is limited to no more than fifteen people in the wilderness section (mile 19.6 to Highway 288) and 25 people from Hoodoo River Access to Gleason Flat (mile 9.3 to mile 19.6). The day section is not limited (mile 0 to mile 9.3).
- Groups must have a fire pan in their possession. Self-supporting kayak trips must have a fire blanket or fire pan in their possession. All fires must be contained within these items.
- Wood collection is limited to dead and down material only. Cutting or stripping limbs from trees is strictly prohibited.
- All trips must possess a portable toilet system to collect all solid human waste for proper disposal at an appropriate waste facility. All solid human waste must be carried out of the river corridor.
- Motorized boats and equipment are prohibited within the Salt River Canyon Wilderness.
- Possession or transportation of any part of native plants is prohibited.
- Littering is strictly prohibited. Pack out all food remains, and trash.

The right side of the river upstream of U.S. Highway 60 to river mile 29.0 is within the White Mountain Apache Tribal Lands. Recreation permits issued by the White Mountain Apache Tribe (WMAT) are required for whitewater boaters utilizing the portion of river flowing through the reservation. Whitewater boating is prohibited by the tribe upstream from the U.S. Highway 60 bridge. During the spring boating season, a self-serve permit kiosk is located next to the access road between the Highway 60 bridge and the put-in, and permits are $20 per person for each day you are within reservation lands. You can also call the tribal recreation office at 928-338-4385 or purchase your permit on-line. WMAT boating regulations are similar to USFS regulations, but no boat tag is required.

Black Rock Rapid at 600 cfs.

The usual put-in and take-out are easily accessed from U.S. Highway 60 and State Highway 288, respectively. The White Mountain Apache Tribe has several campgrounds along the first nine miles of the



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Arizona Daily Star
March 9, 2014

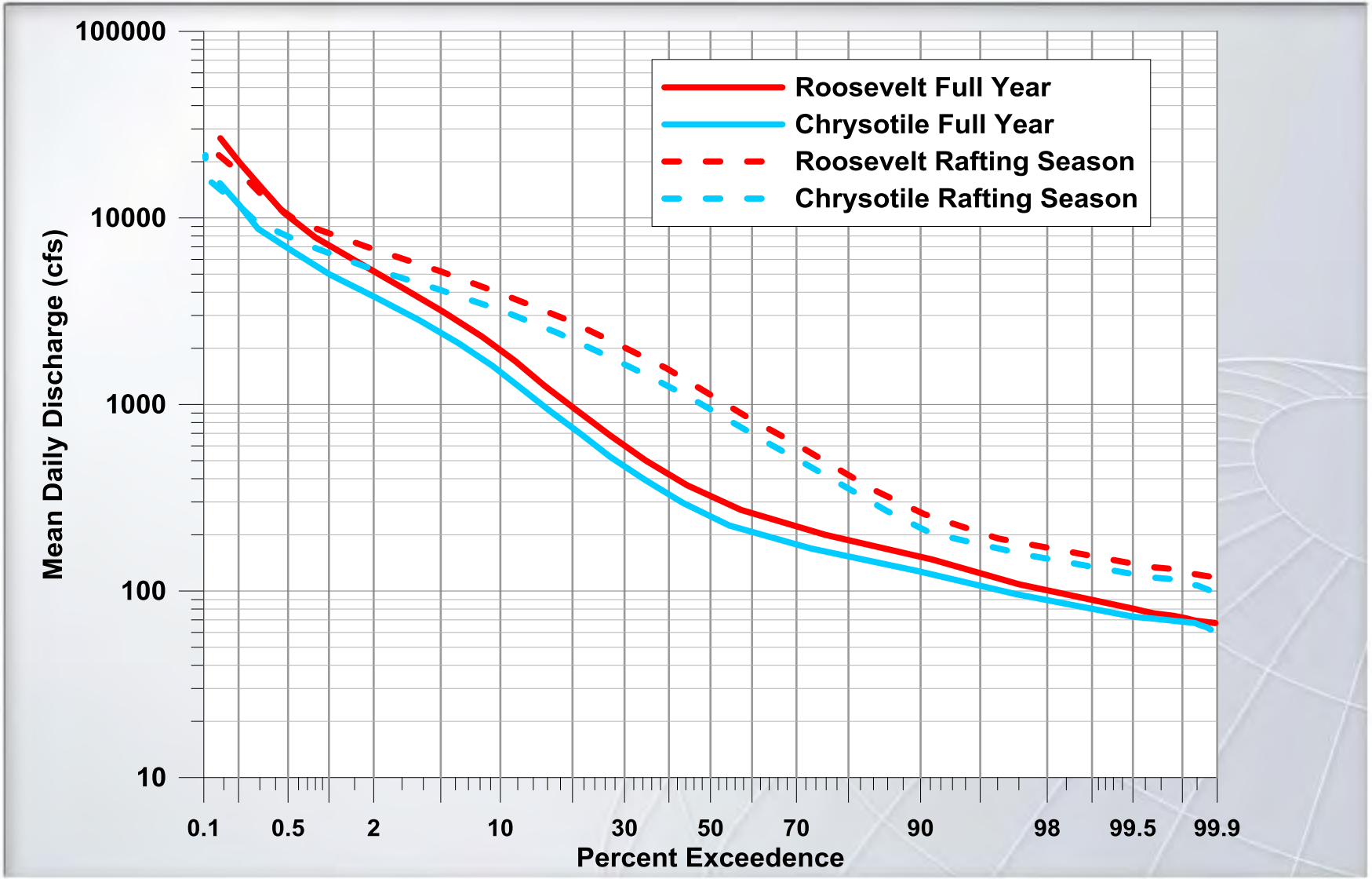
Rafting companies canceling seasons due to dry Arizona winter

"The Salt is a very fickle character," said **Donnie Dove**, owner of Canyon Rio Rafting, one of the four commercial outfitters with an Upper Salt River permit. "She is quite spectacular and quite beautiful, but if there's no water, there's no fun."

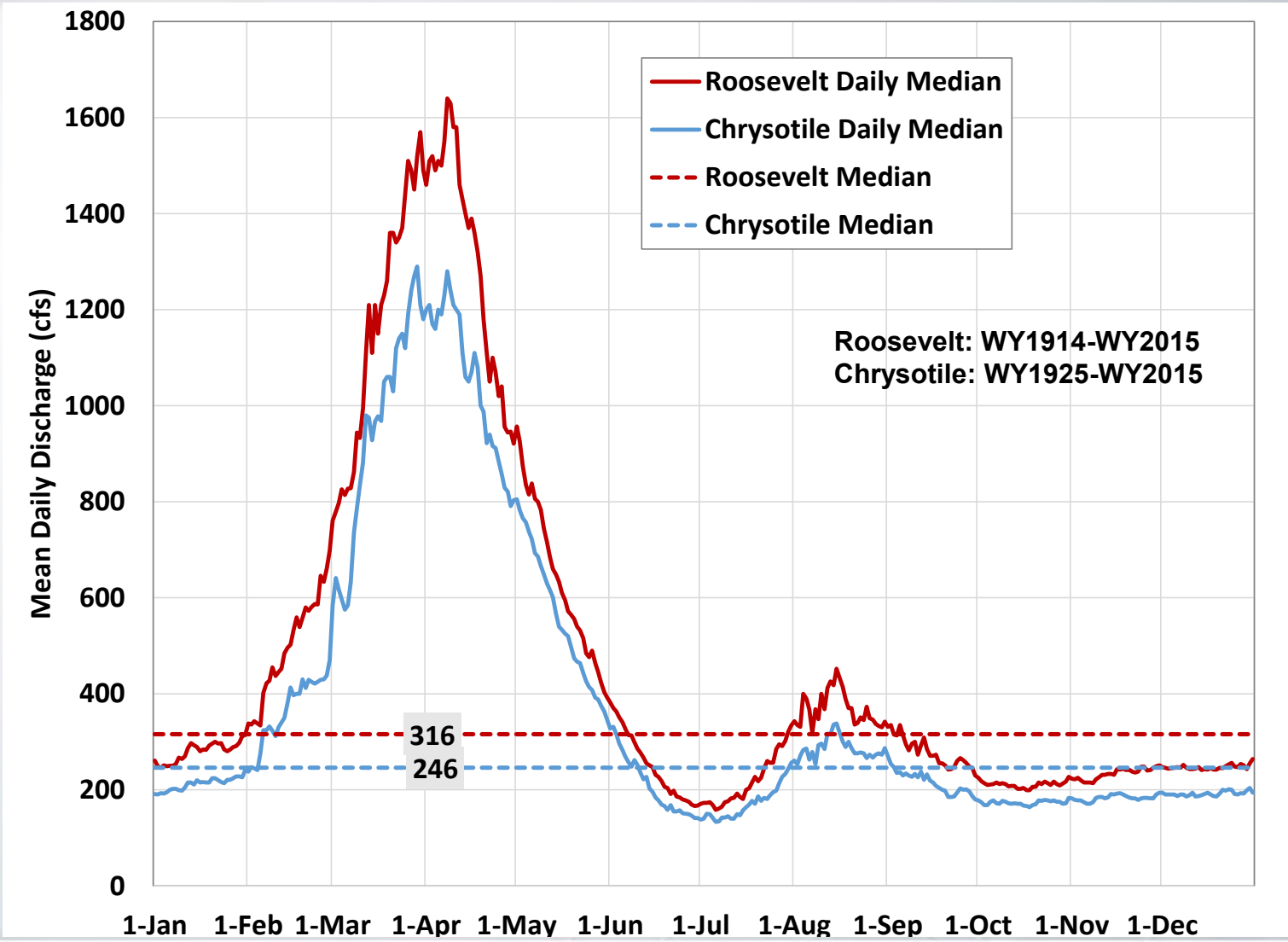
"The higher the flow, the more rocks that are covered and the bigger the waves," said **Joe Greiner**, owner of the company, who anticipates flows of less than 300 cubic feet per second. "We need an absolute minimum of 400 cfs to get the boats out without having to drag it out over the rocks."

http://tucson.com/business/local/rafting-companies-canceling-seasons-due-to-dry-arizona-winter/article_c76c1762-e6f8-5d87-9981-b5537108b628.html

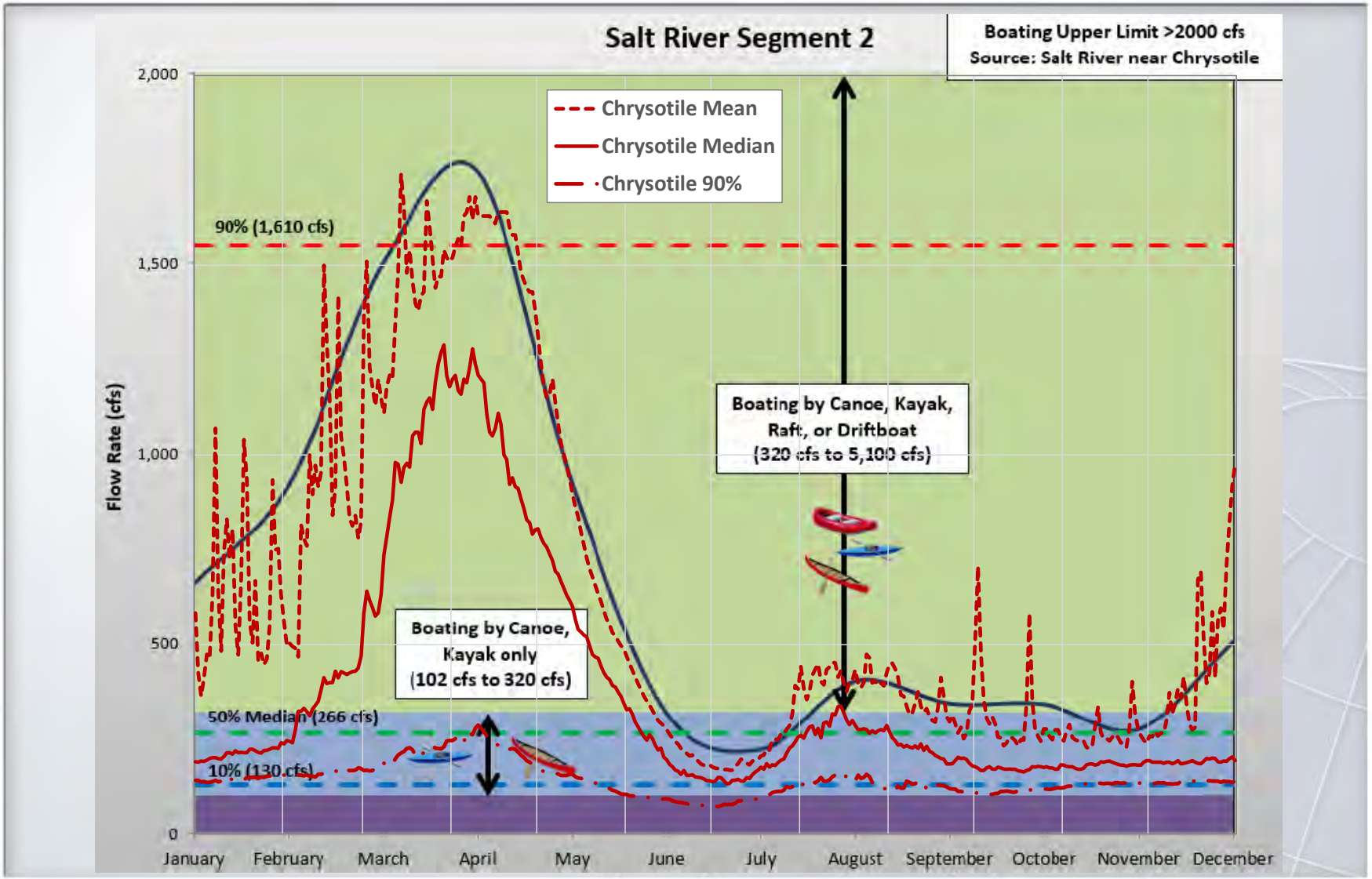
Mean Daily Flow-duration Curves



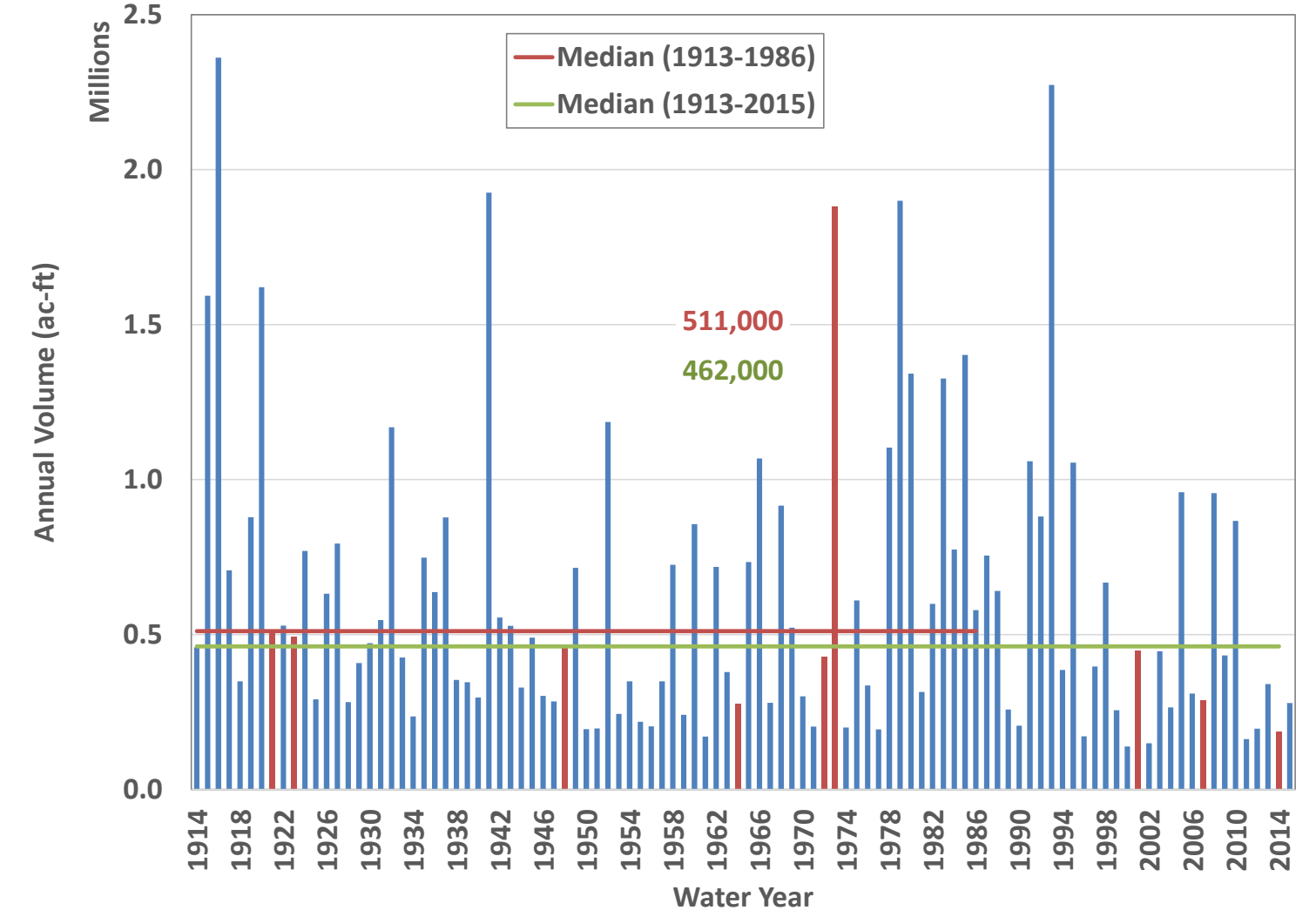
Annual Hydrographs



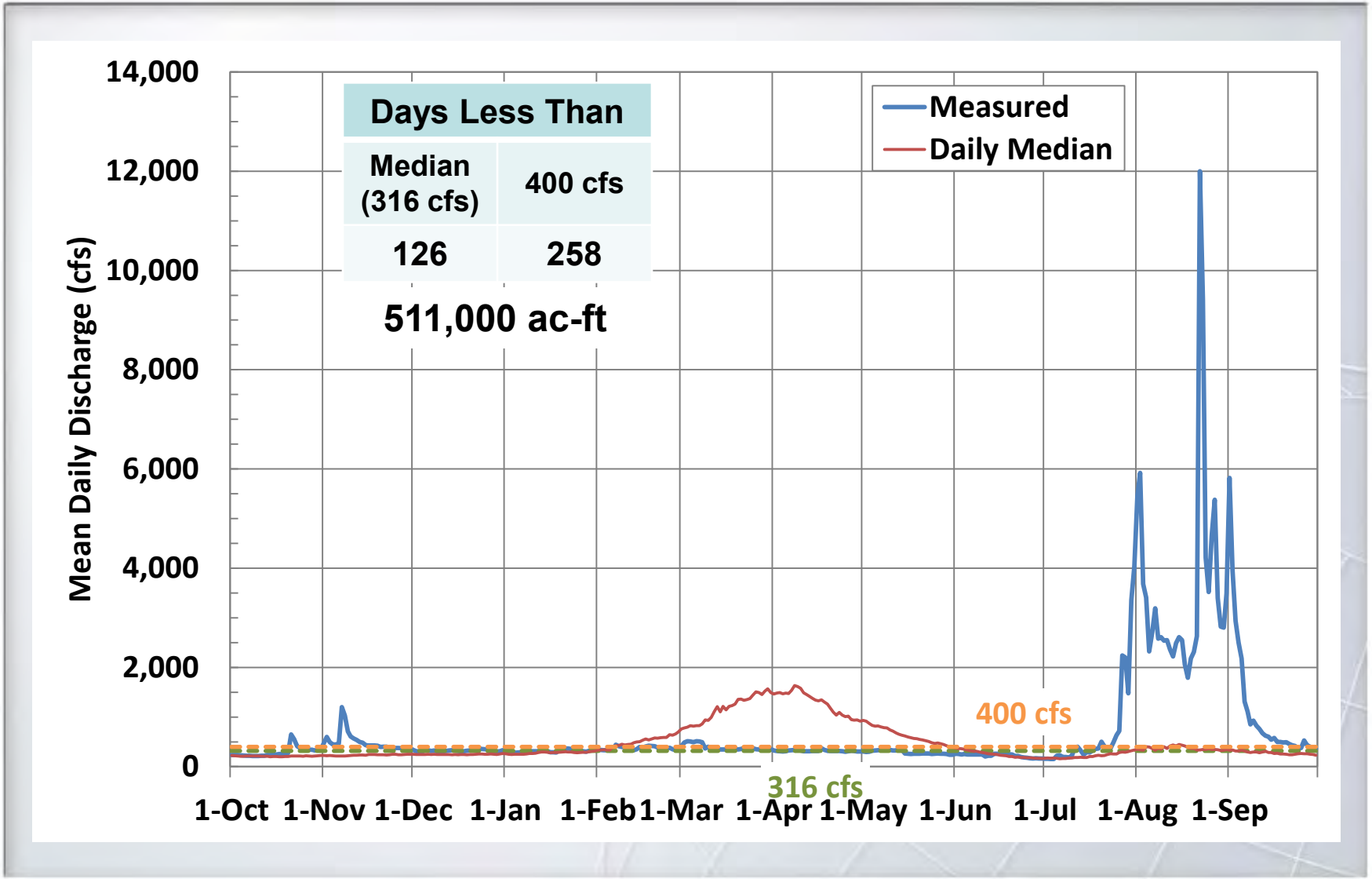
Segment 2 Hydrographs



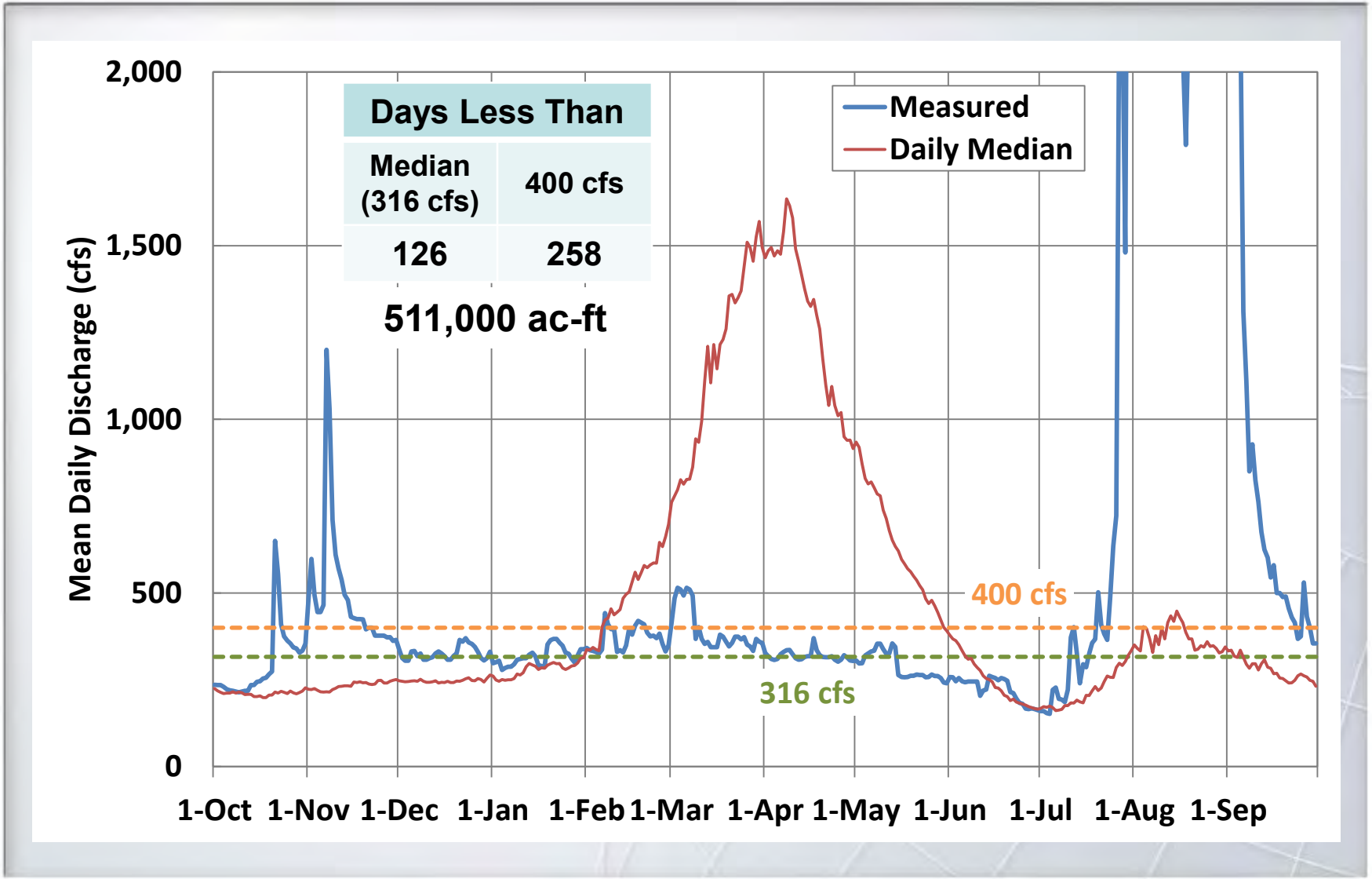
Annual Runoff Volume at Roosevelt Gage



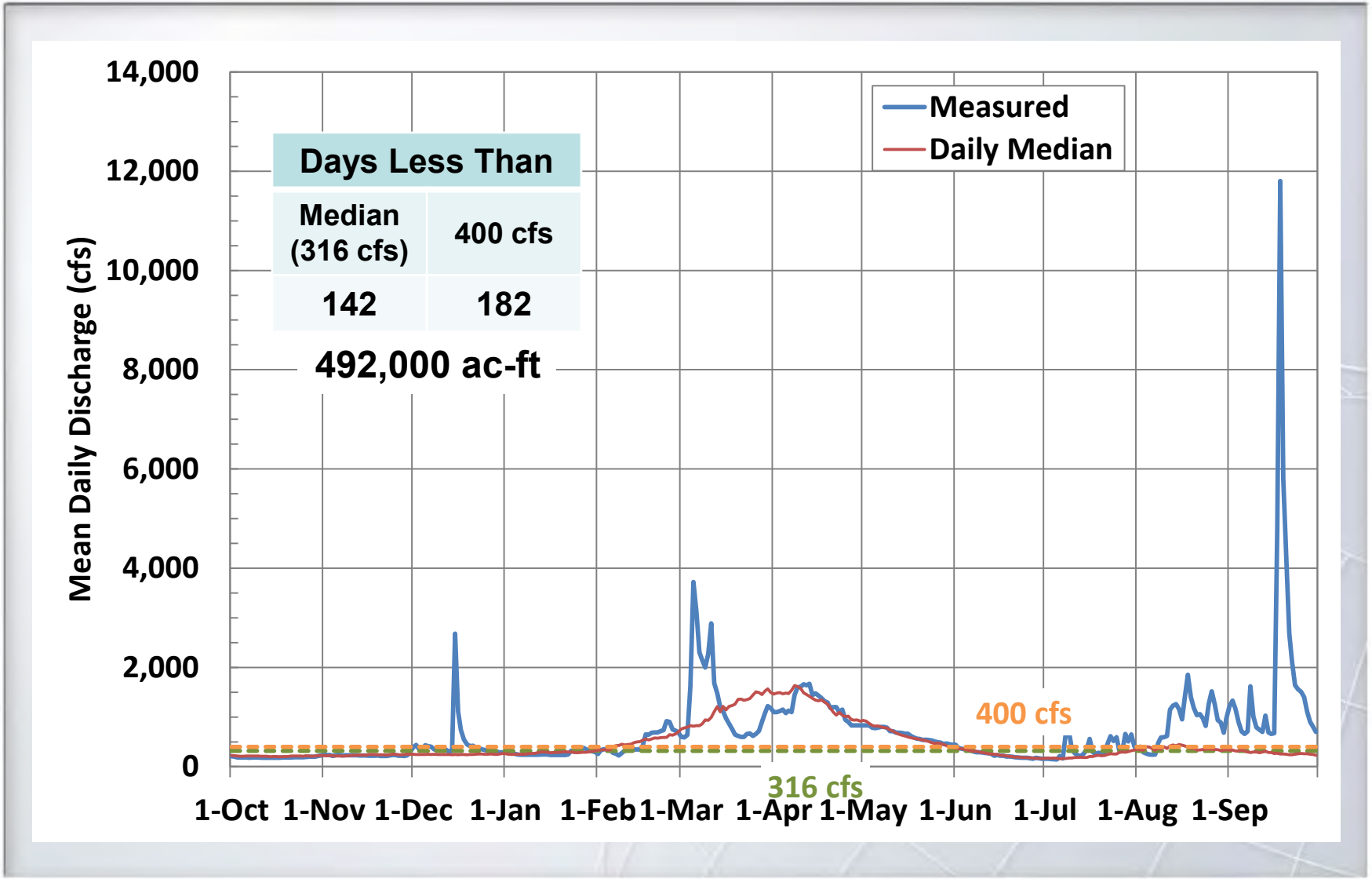
Actual Flows 1921 (46%)



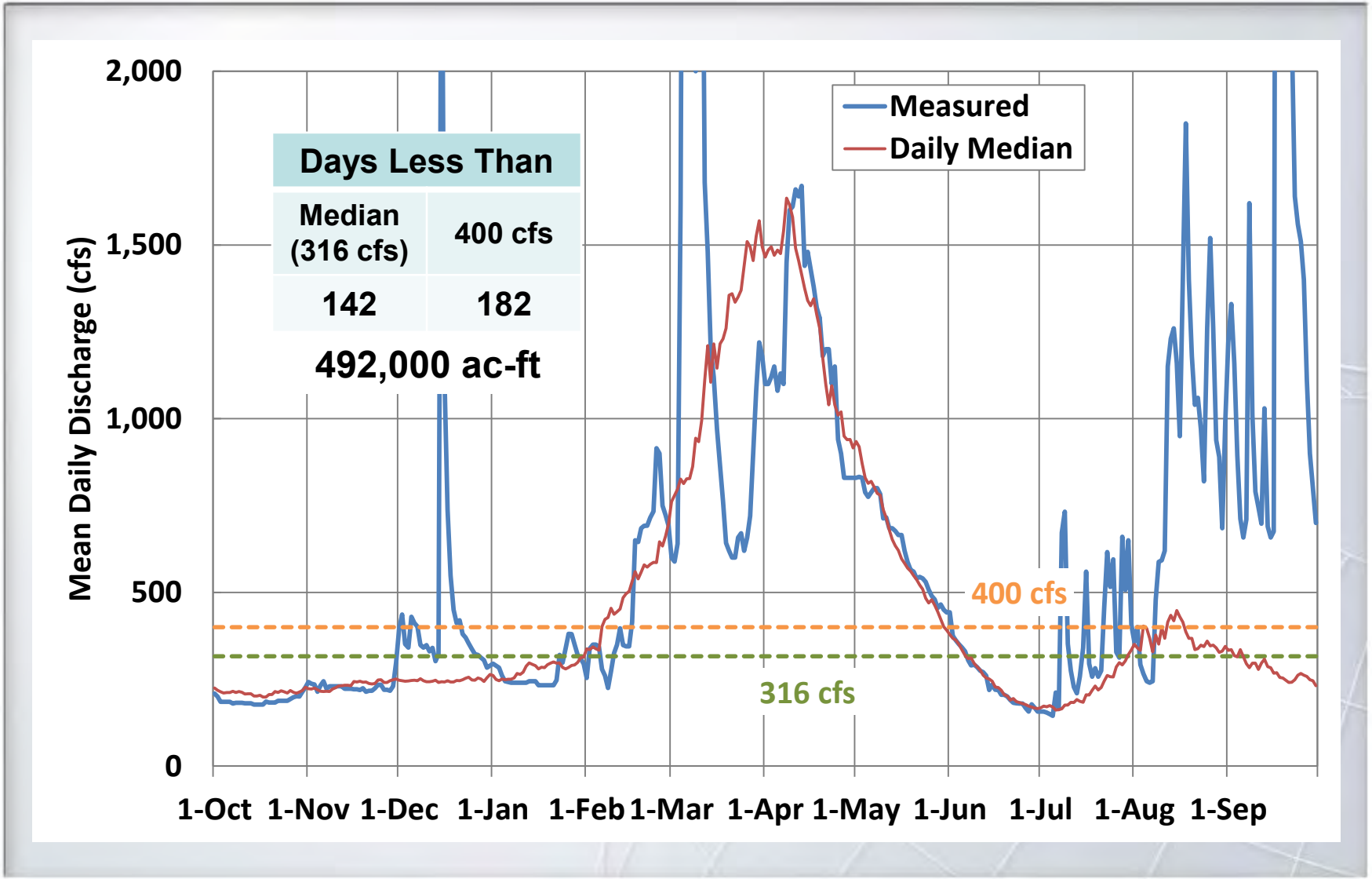
Actual Flows 1921 Zoomed (46%)



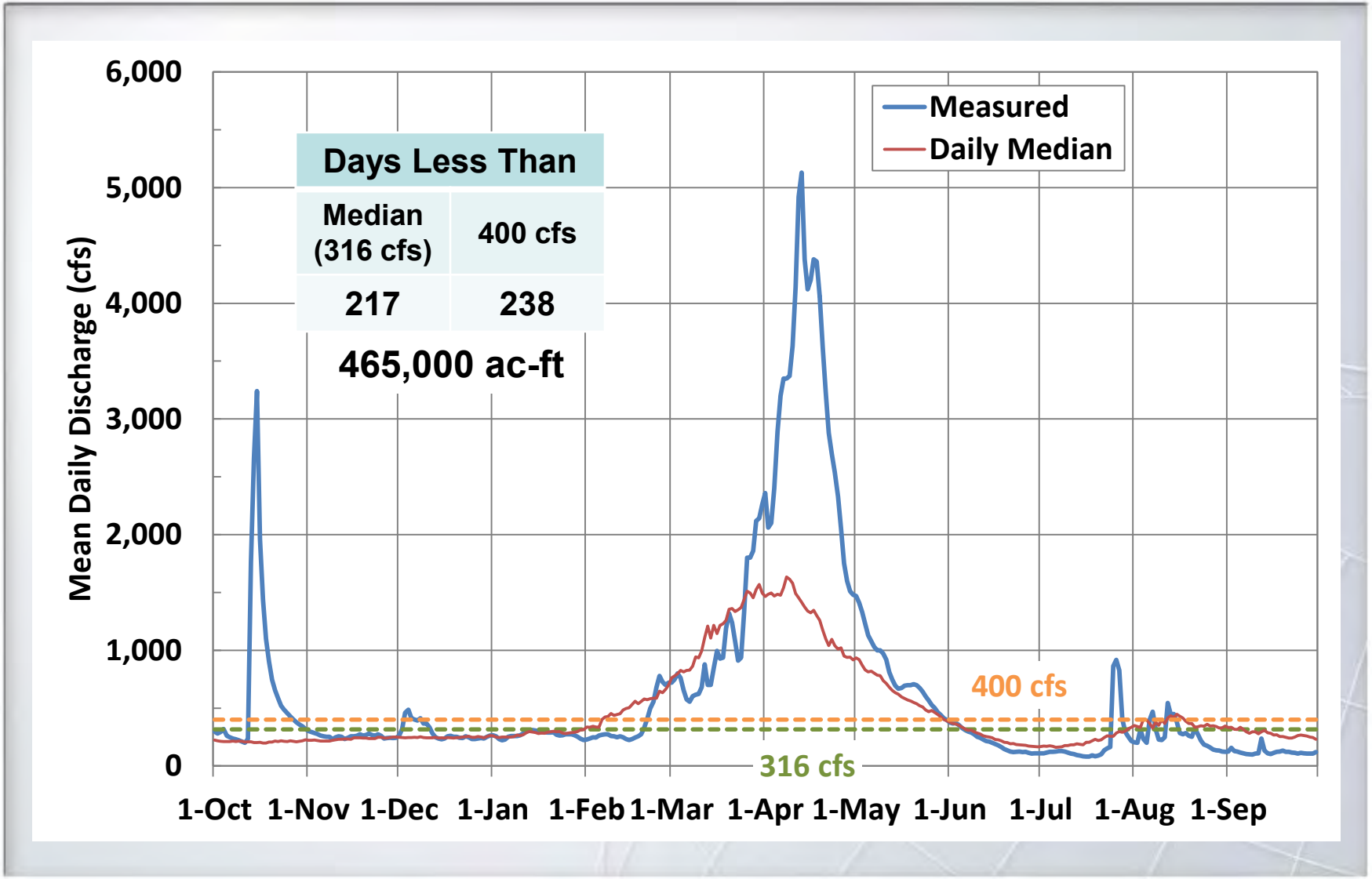
Actual Flows 1923 (47%)



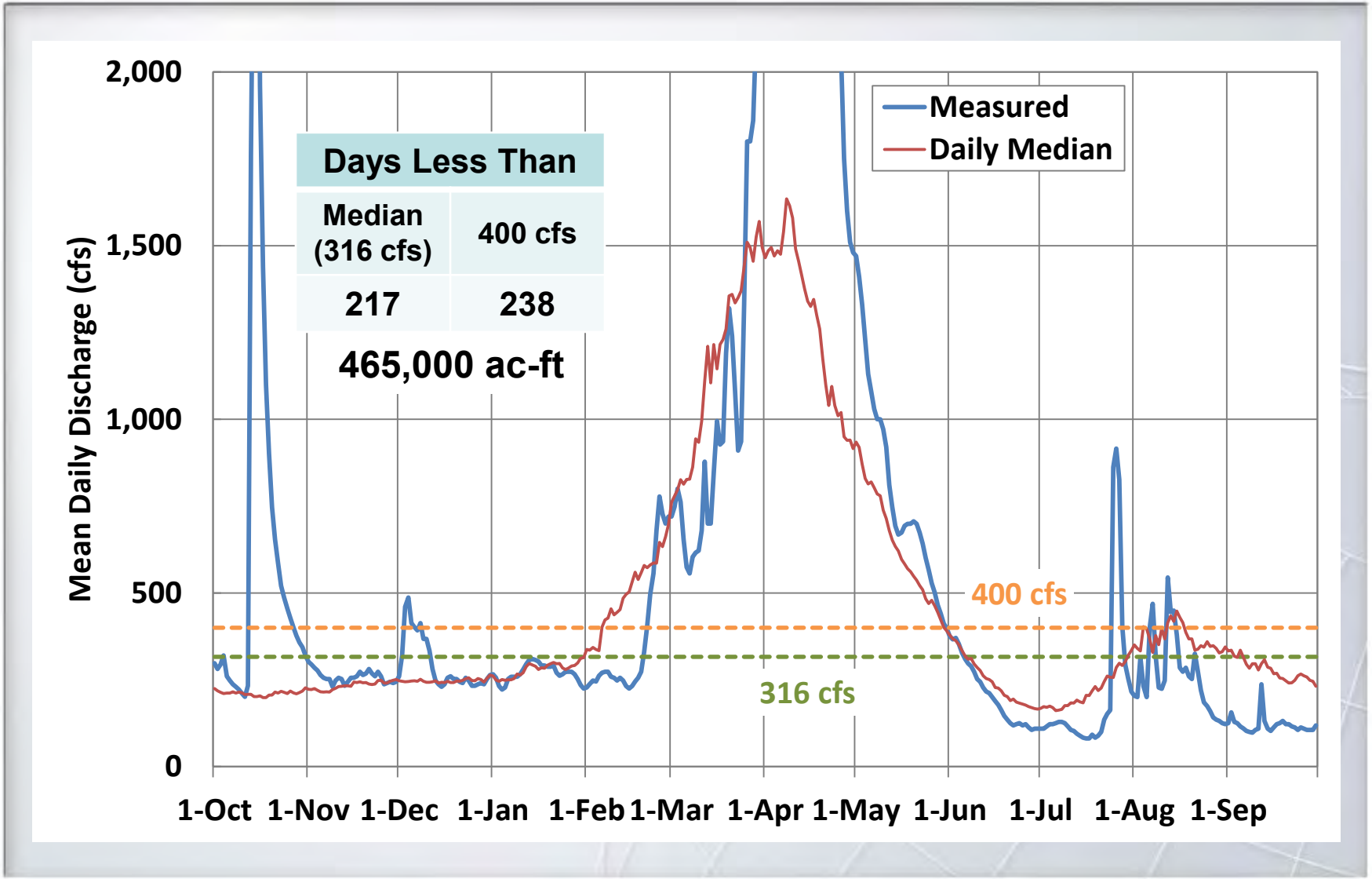
Actual Flows 1923 Zoomed (47%)



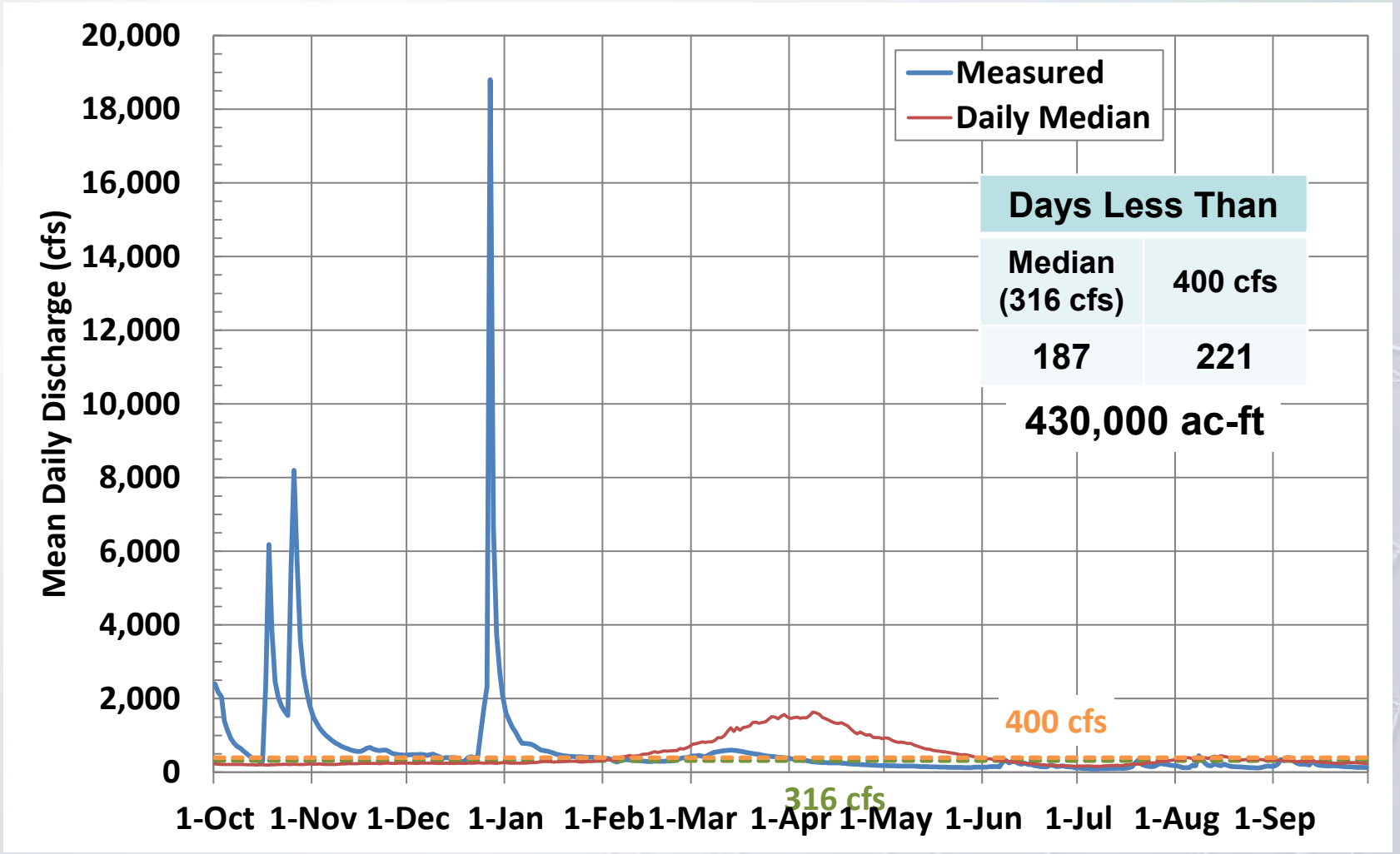
Actual Flows 1948 (50%)



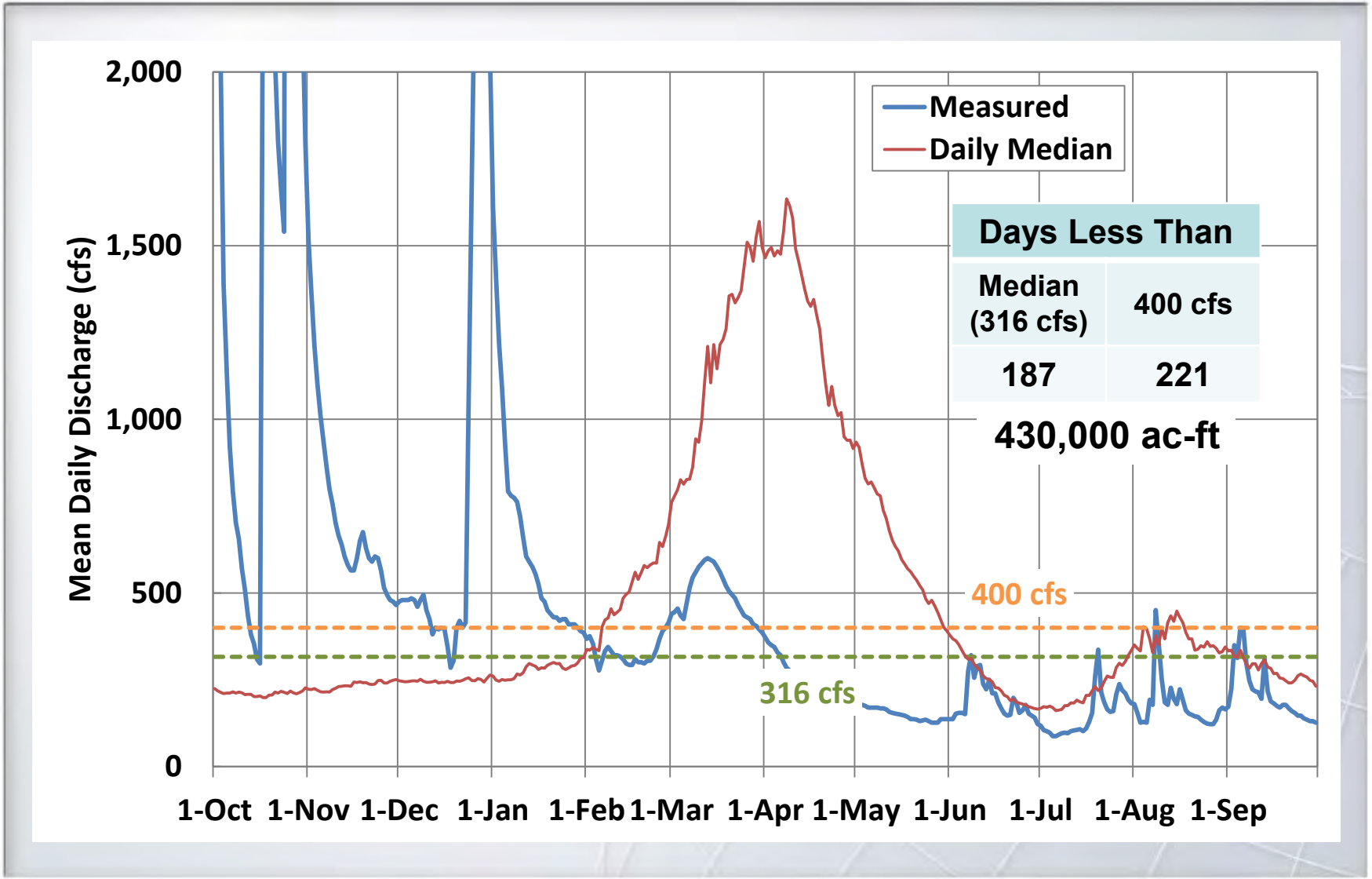
Actual Flows 1948 Zoomed (50%)



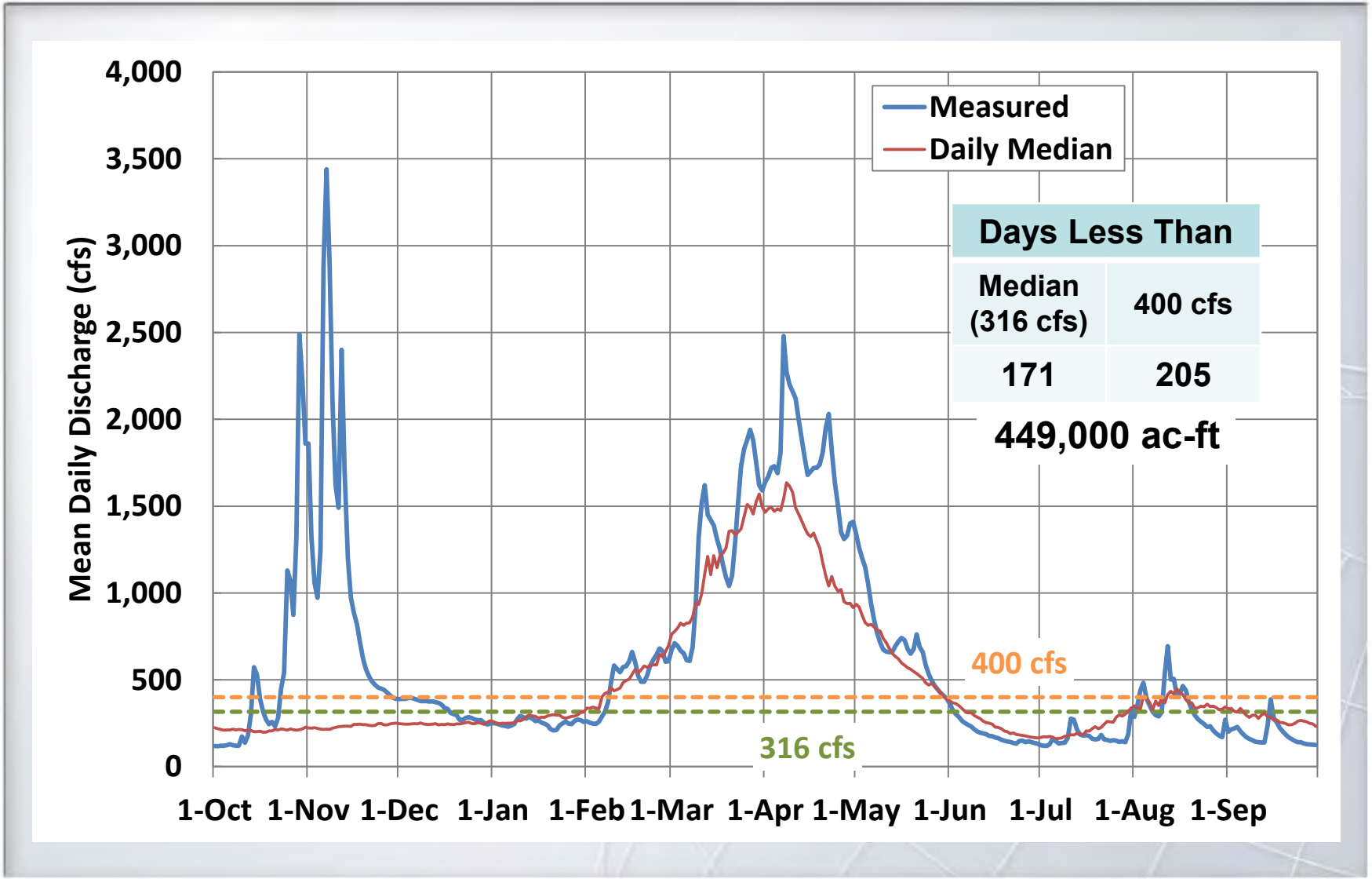
Actual Flows 1972 (55%)



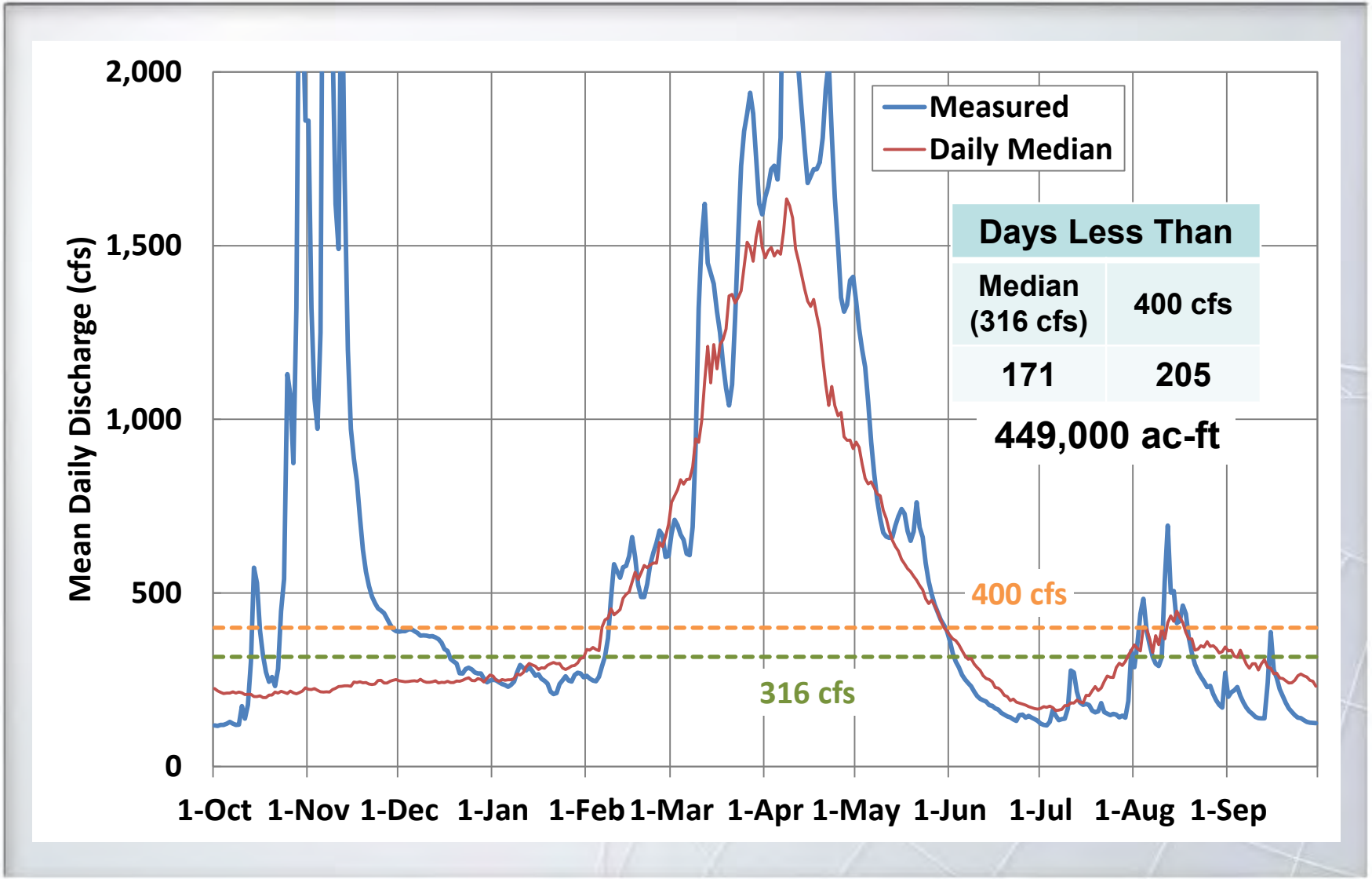
Actual Flows 1972 Zoomed (55%)



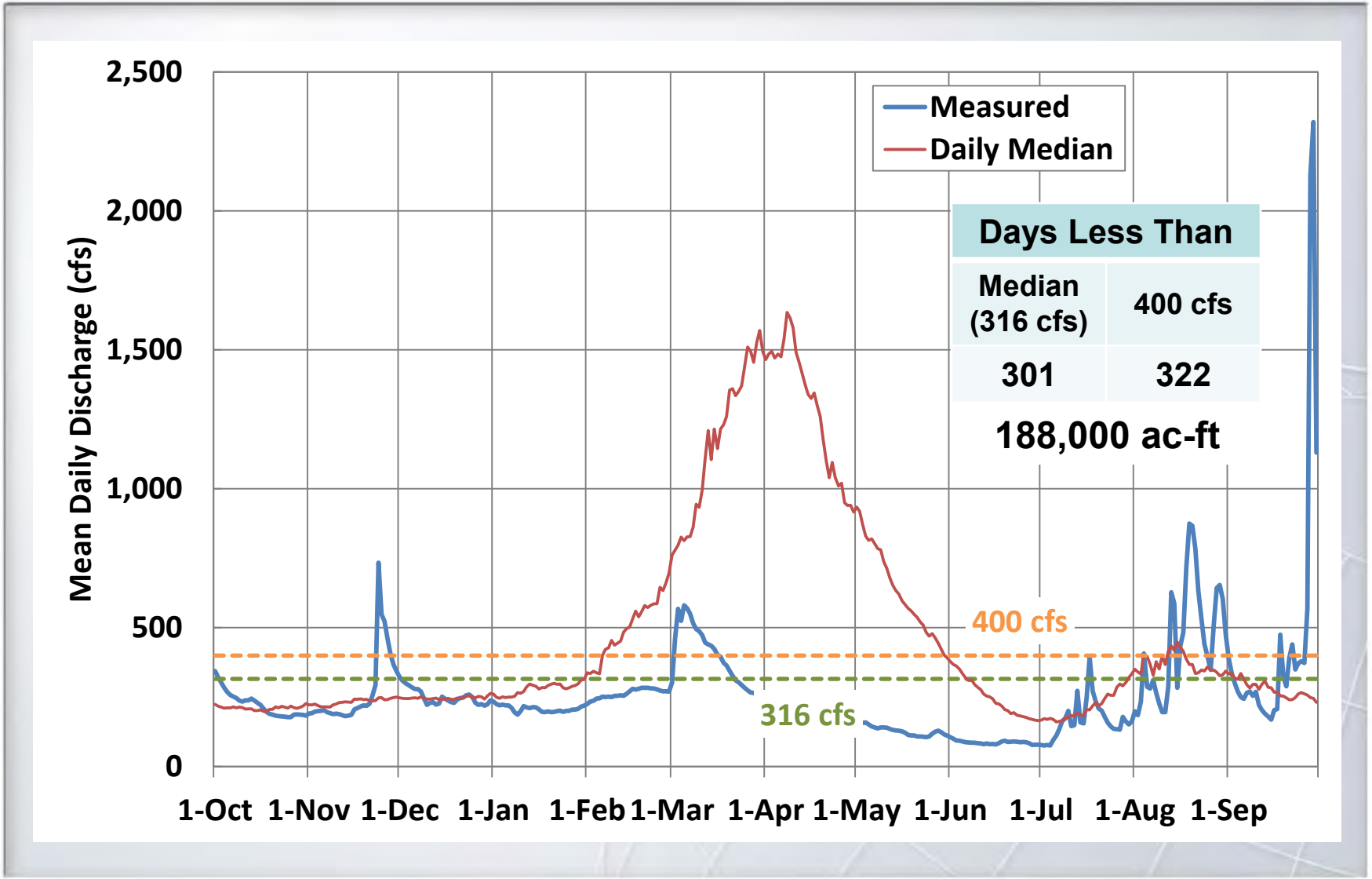
Actual Flows 2001 (52%)



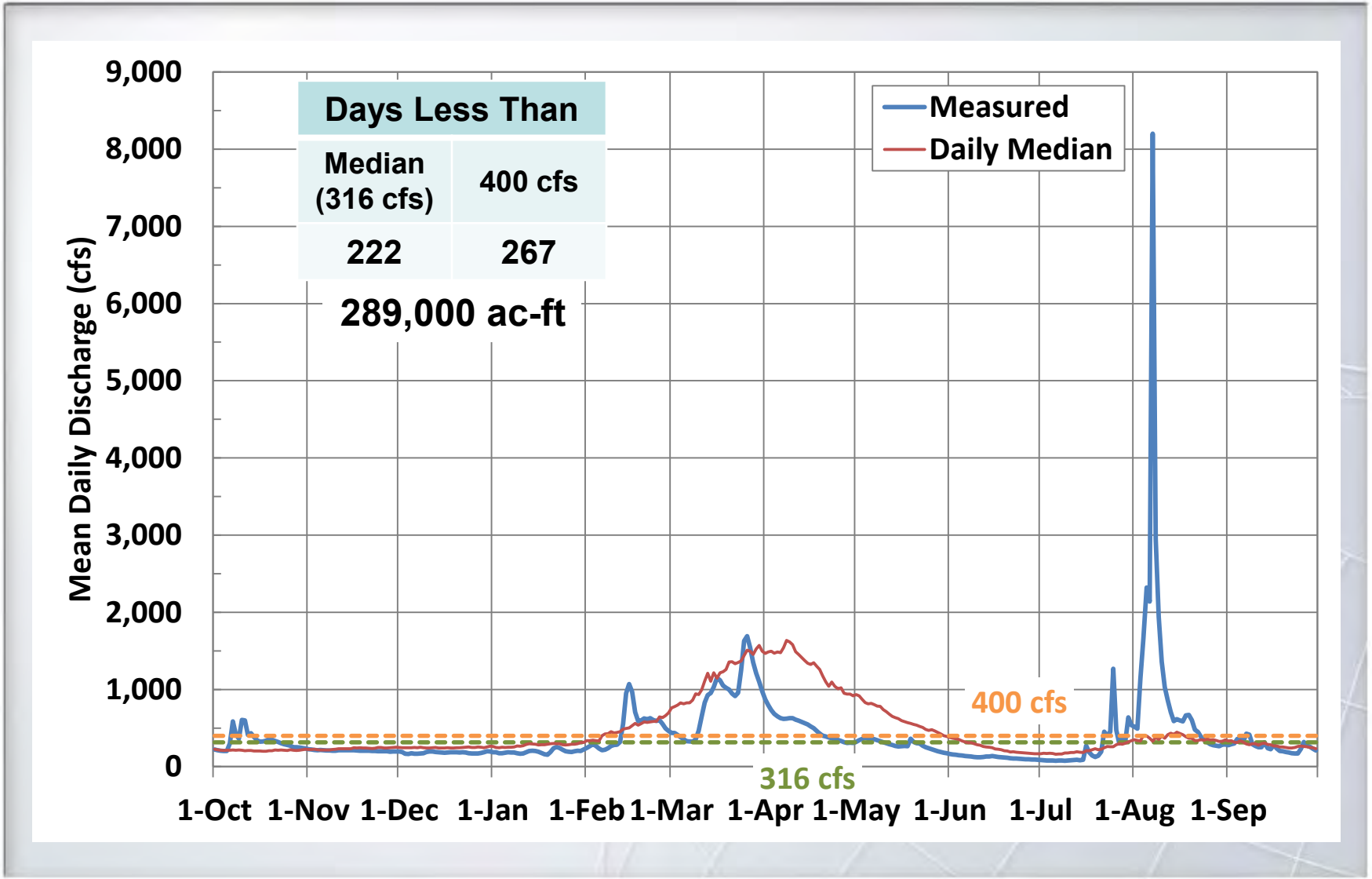
Actual Flows 2001 Zoomed (52%)



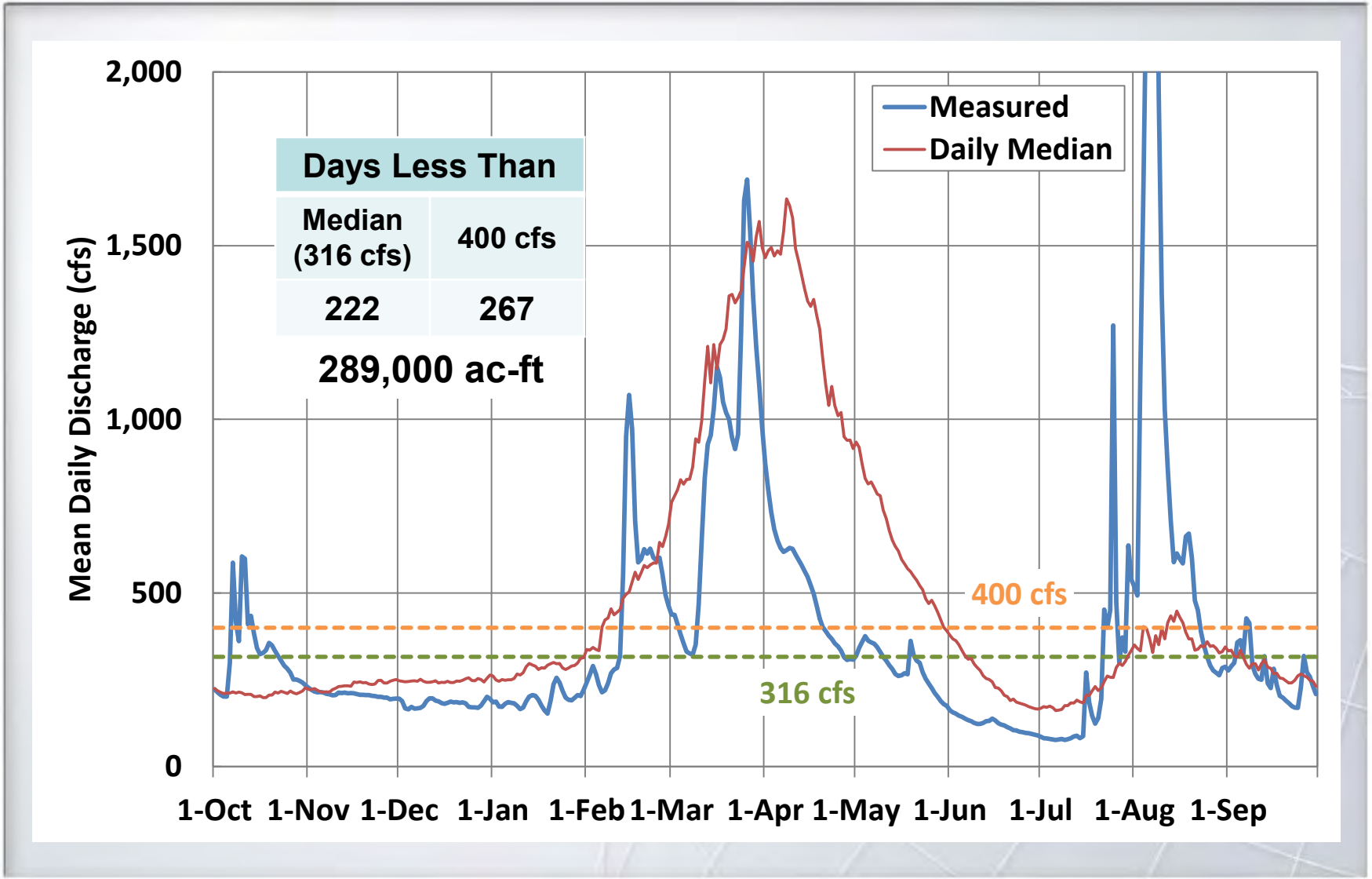
Actual Flows 2014 (95%)



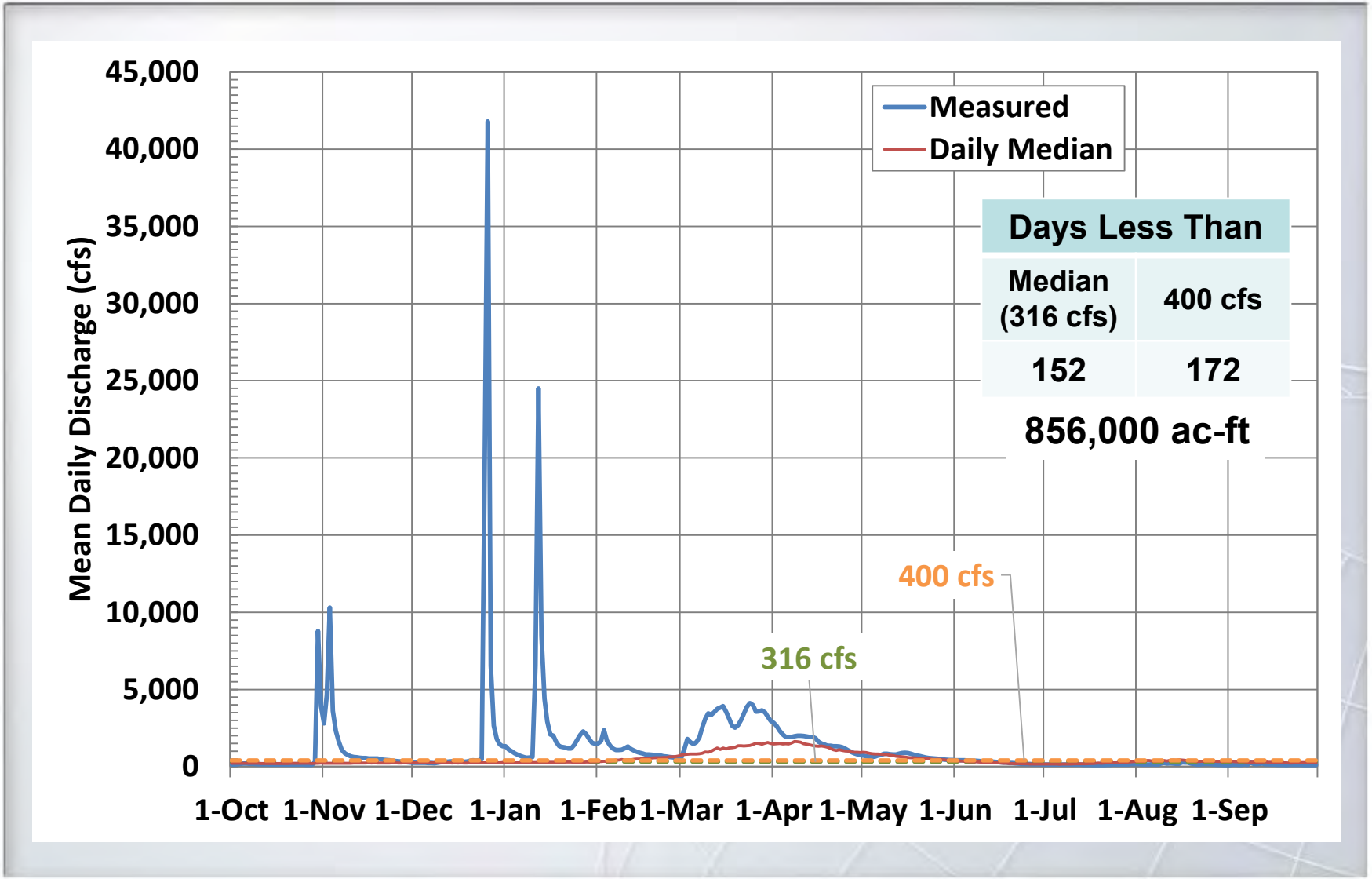
Actual Flows 2007 (75%)



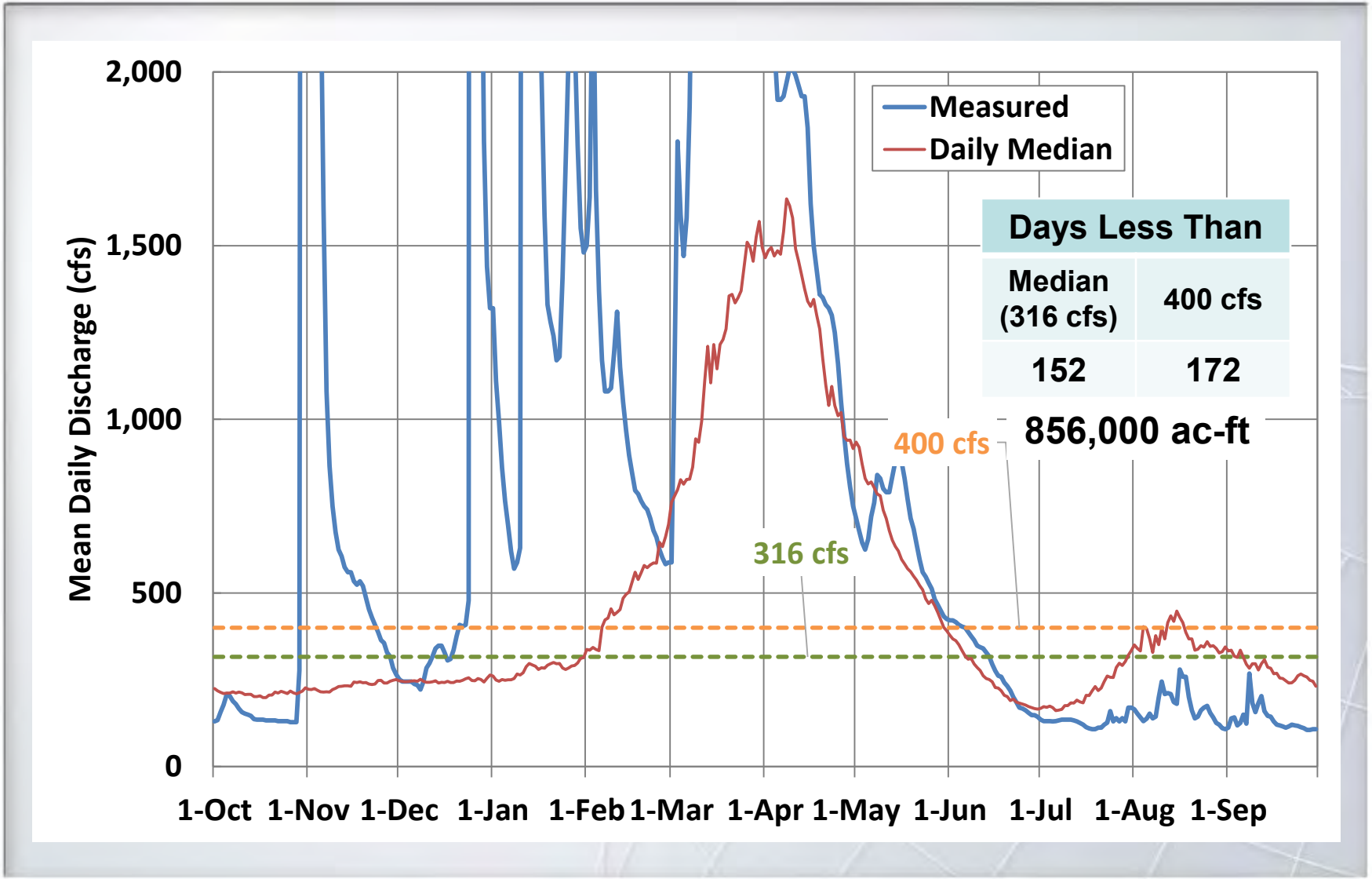
Actual Flows 2007 Zoomed (75%)



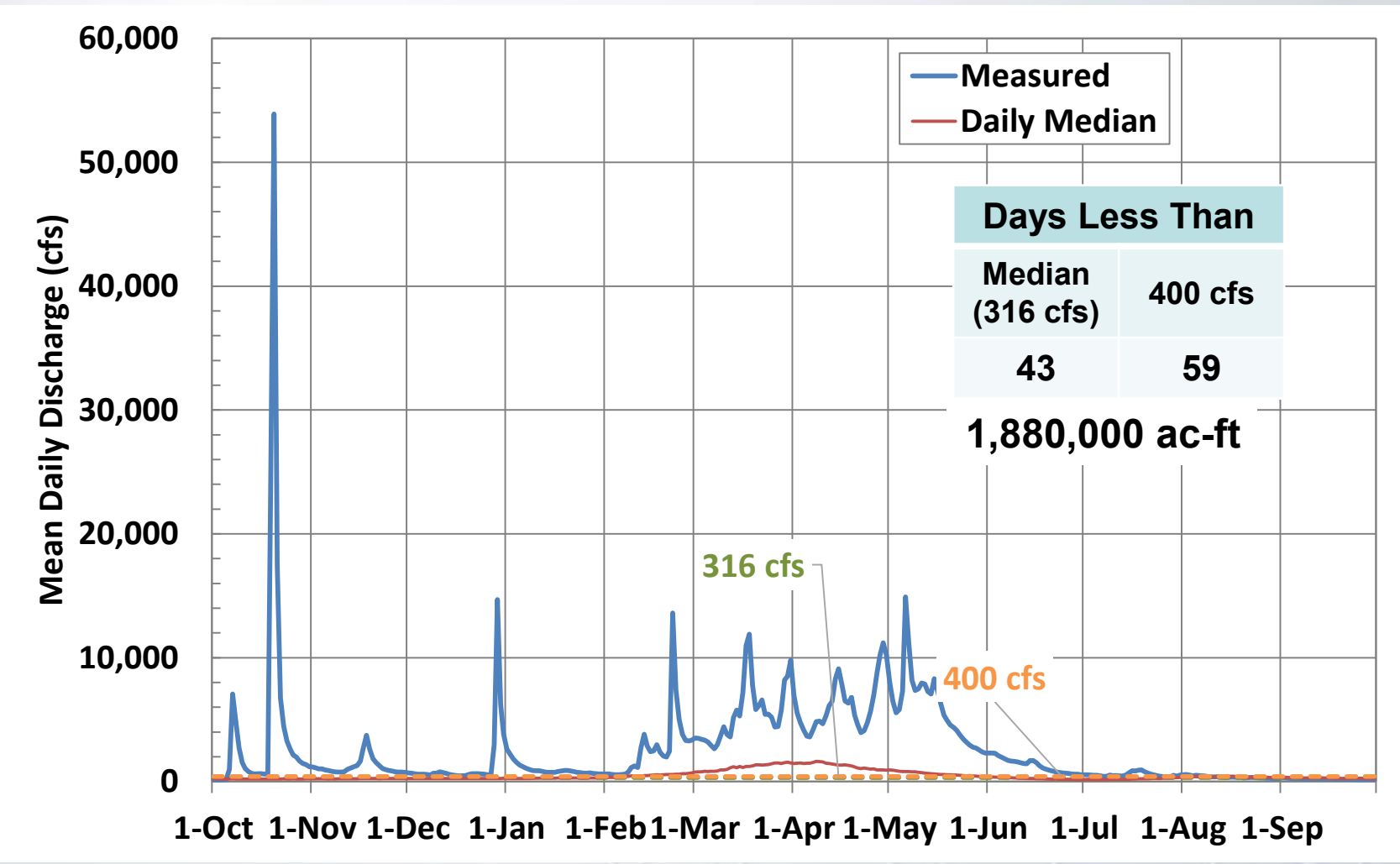
Actual Flows 1960 (25%)



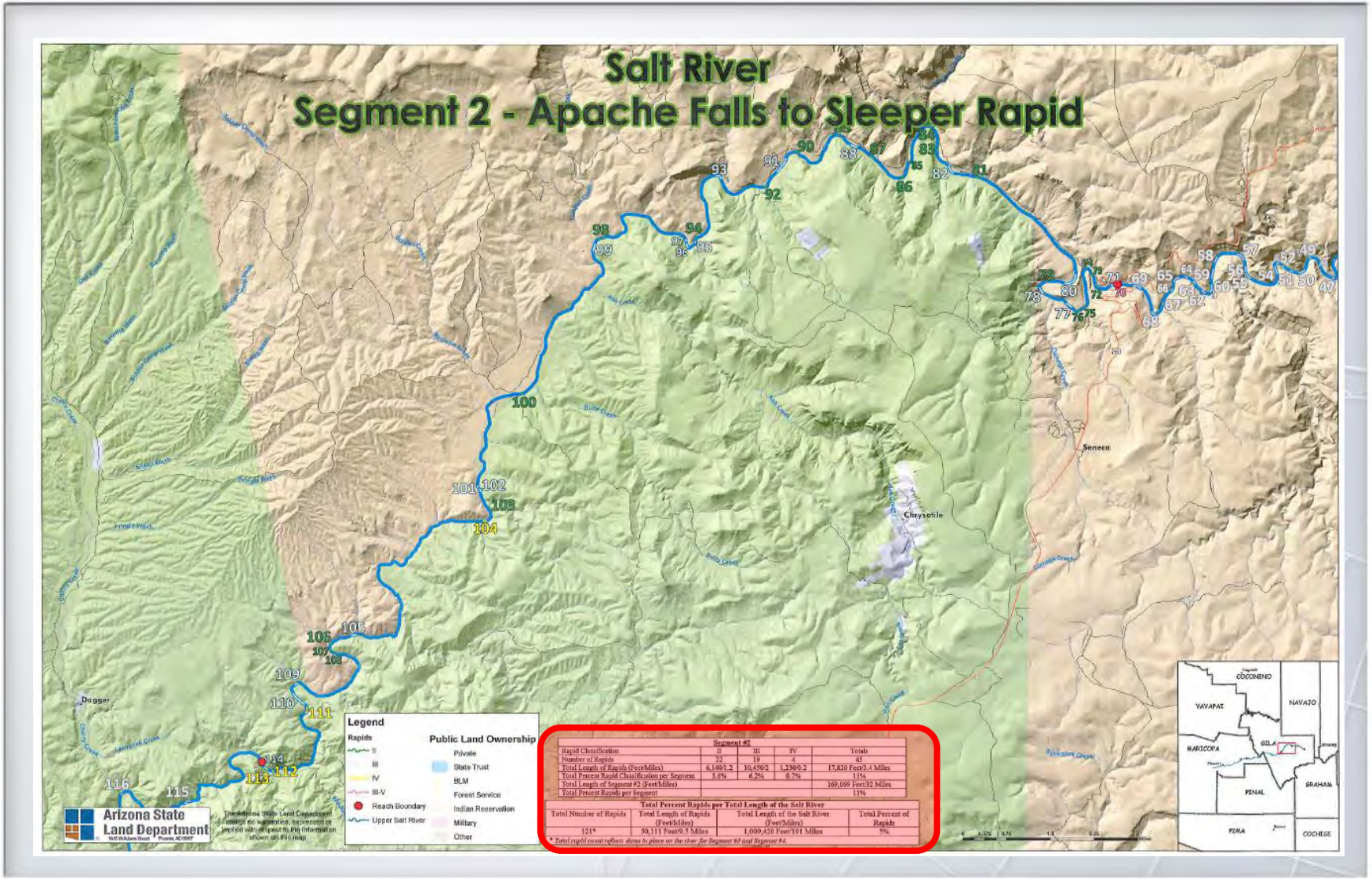
Actual Flows 1960 Zoomed (25%)



Actual Flows 1973 (5%)



ASLD Map



Segment #2				
Rapid Classification	II	III	IV	Totals
Number of Rapids	22	19	4	45
Total Length of Rapids (Feet/Miles)	6,140/1.2	10,450/2	1,230/0.2	17,820 Feet/3.4 Miles
Total Percent Rapid Classification per Segment	5.6%	6.2%	0.7%	11%
Total Length of Segment #2 (Feet/Miles)				169,099 Feet/32 Miles
Total Percent Rapids per Segment				11%

Total Percent Rapids per Total Length of the Salt River			
Total Number of Rapids	Total Length of Rapids (Feet/Miles)	Total Length of the Salt River (Feet/Miles)	Total Percent of Rapids
121*	50,111 Feet/9.5 Miles	1,009,420 Feet/191 Miles	5%

* Total rapid count reflects doubling in place on the river for Segment #3 and Segment #4.

Segment #2				
Rapid Classification	II	III	IV	Totals
Number of Rapids	22	19	4	45
Total Length of Rapids (Feet/Miles)	6,140/1.2	10,450/2	1,230/0.2	17,820 Feet/3.4 Miles
Total Percent Rapid Classification per Segment	3.6%	6.2%	0.7%	11%
Total Length of Segment #2 (Feet/Miles)				169,069 Feet/32 Miles
Total Percent Rapids per Segment				11%

Total Percent Rapids per Total Length of the Salt River			
Total Number of Rapids	Total Length of Rapids (Feet/Miles)	Total Length of the Salt River (Feet/Miles)	Total Percent of Rapids
121*	50,111 Feet/9.5 Miles	1,009,420 Feet/191 Miles	5%

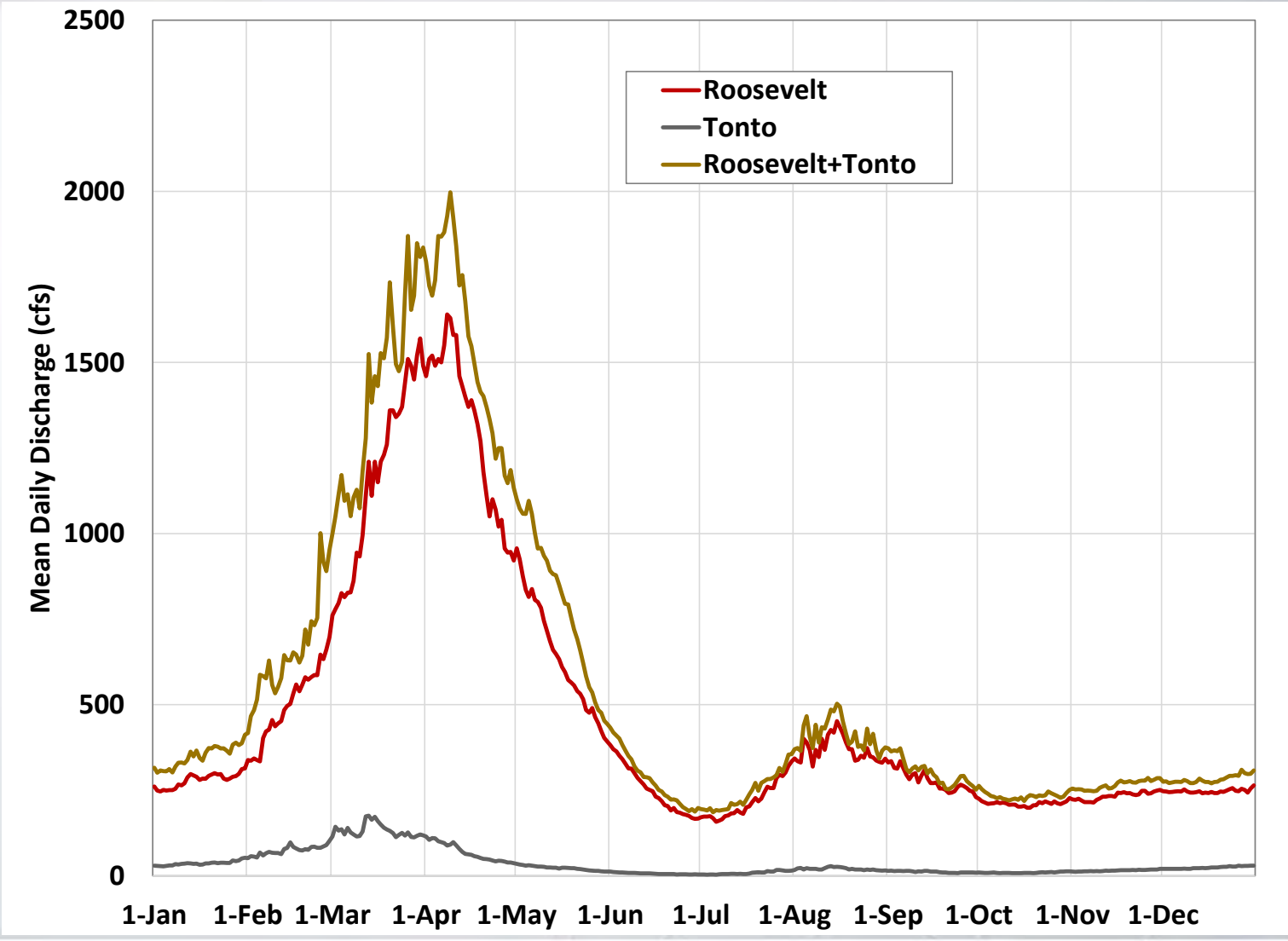
* *Total rapid count reflects dams in place on the river for Segment #3 and Segment #4.*

Would a highway system be open for commerce if bridges were out every 1.4 miles (average spacing of Class III/IV rapids in Segment 2)?

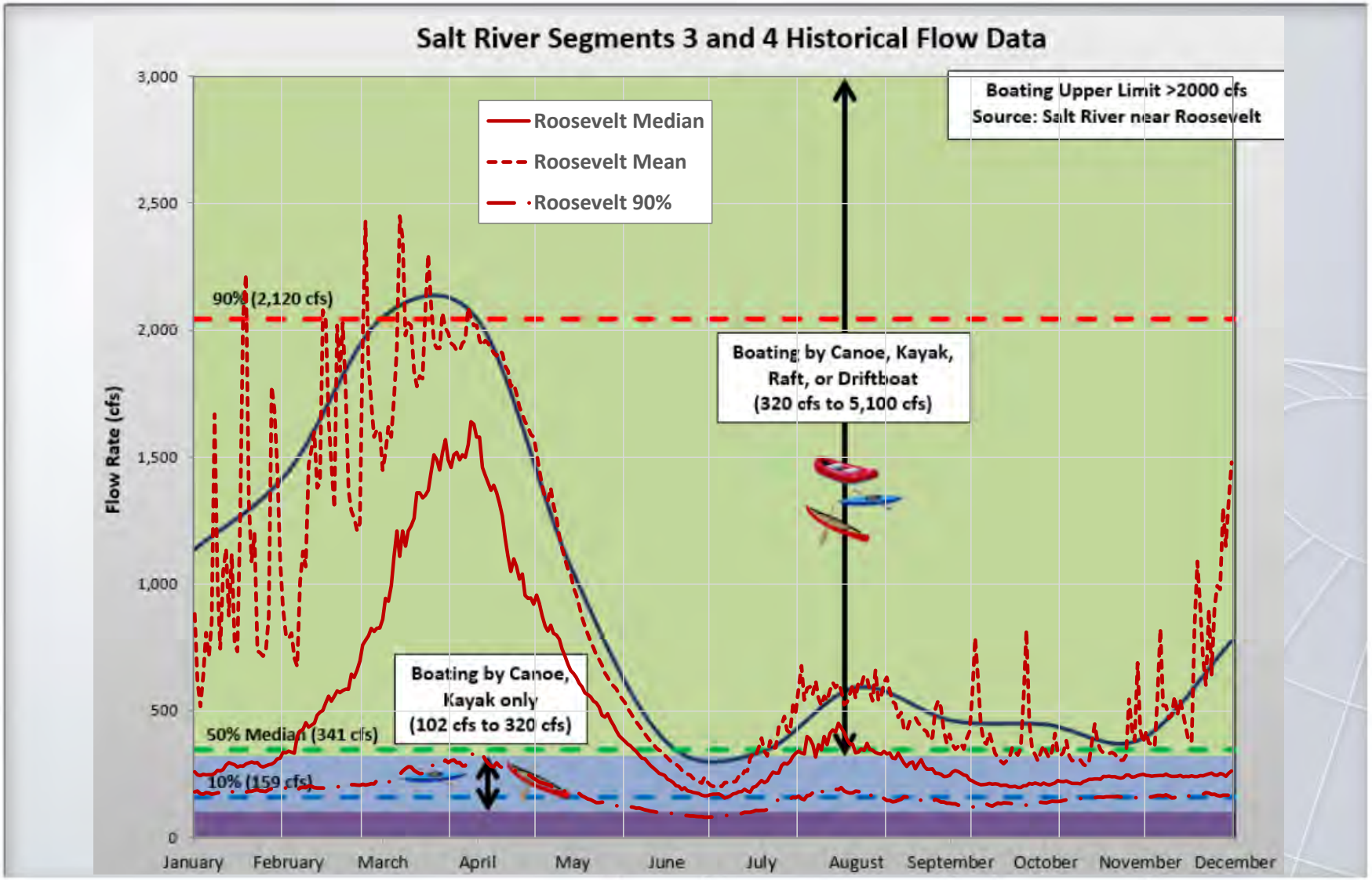
UPPER SALT

SEGMENT 3 ROOSEVELT RESERVOIR

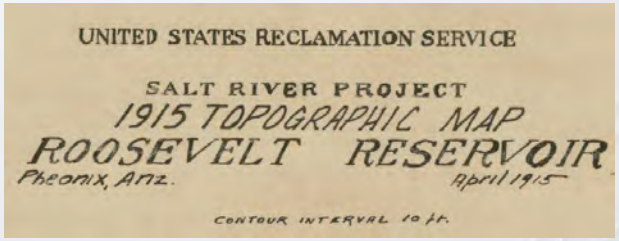
Median Mean Daily Flows



Segment 3 Hydrographs



Roosevelt Lake

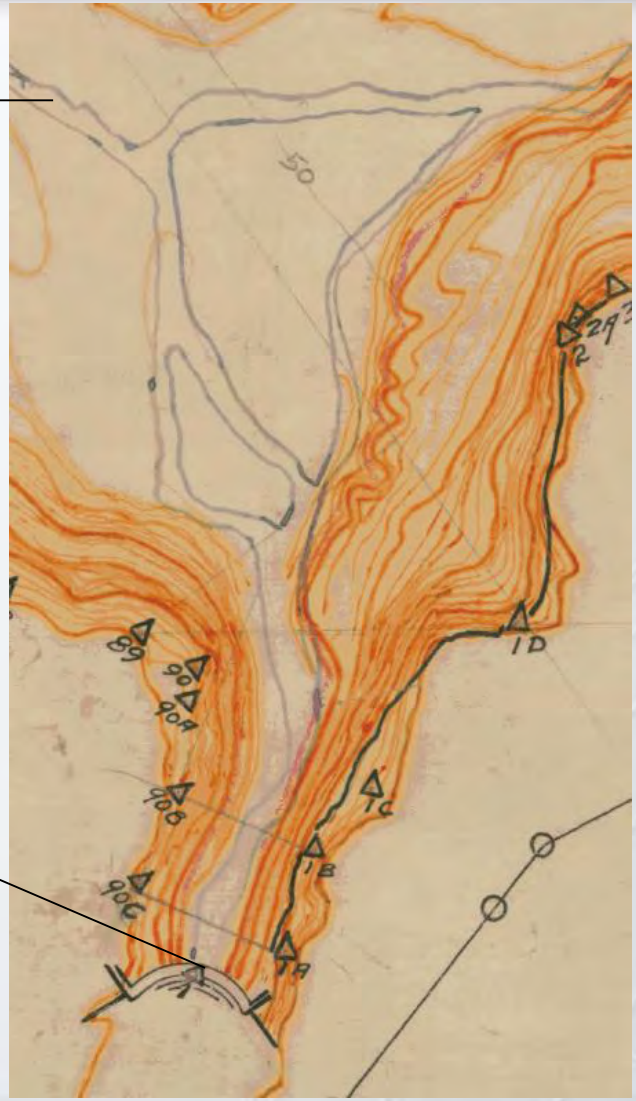


Roosevelt Lake

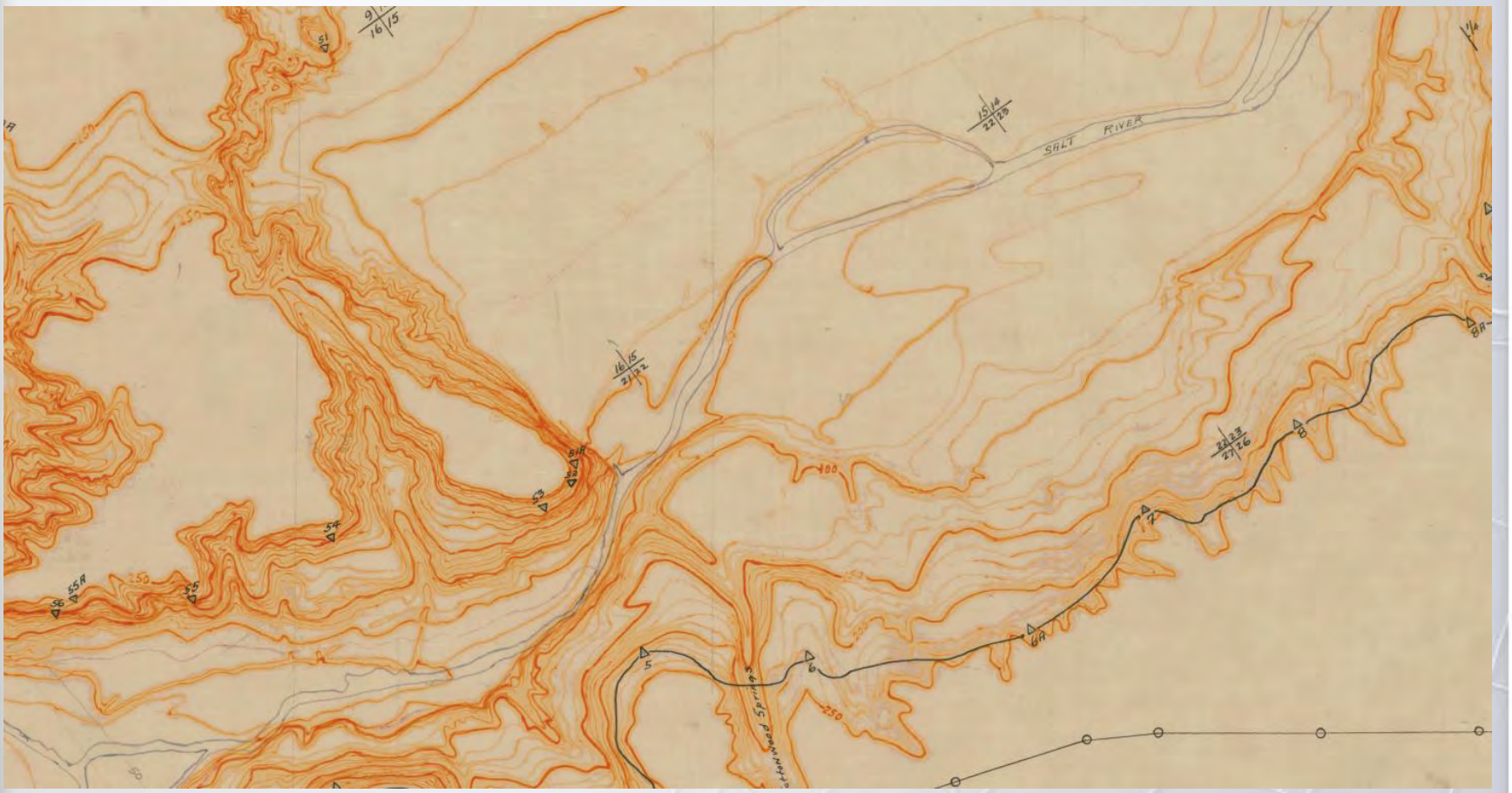
USRS 1915

Tonto Creek

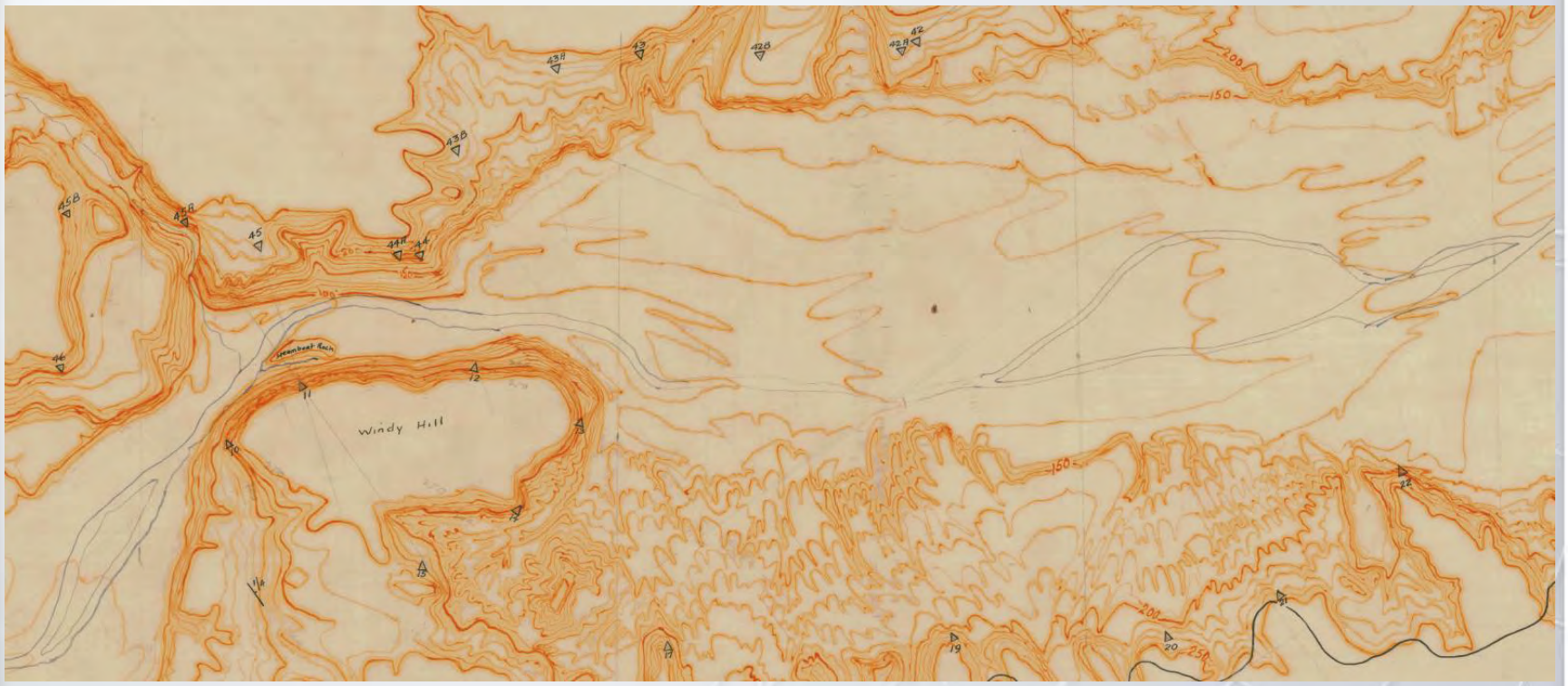
Roosevelt Dam



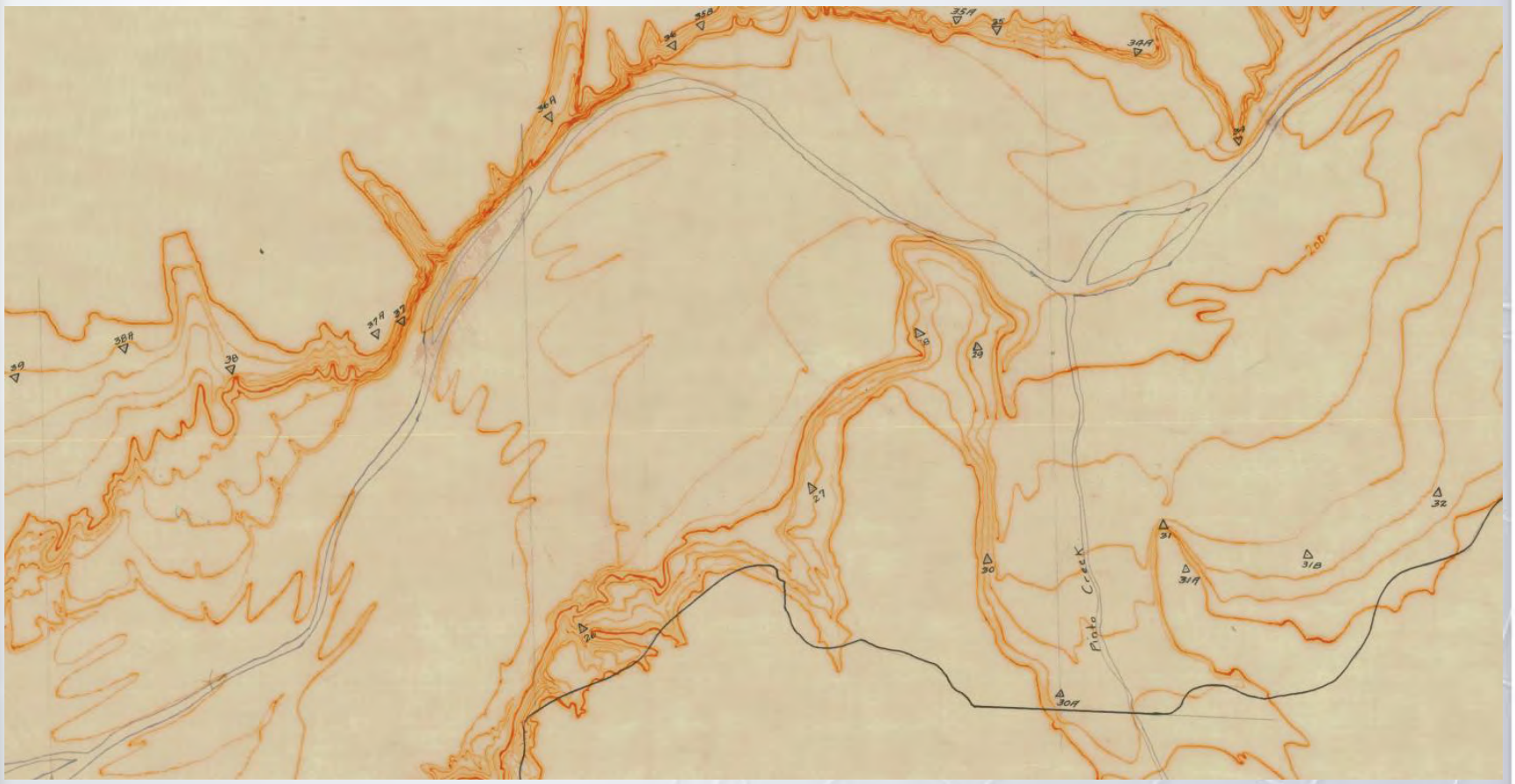
USRS 1915



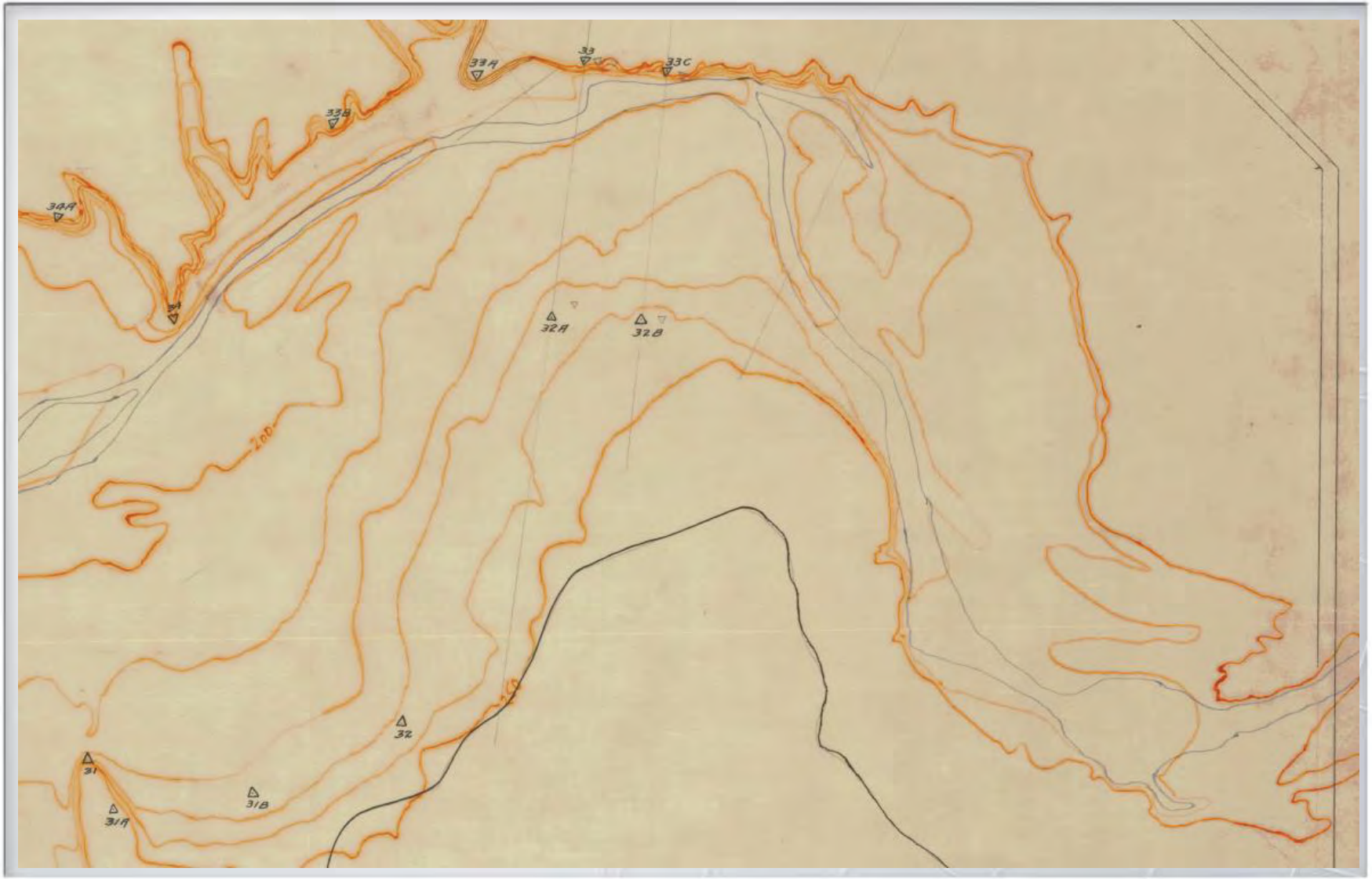
USRS 1915



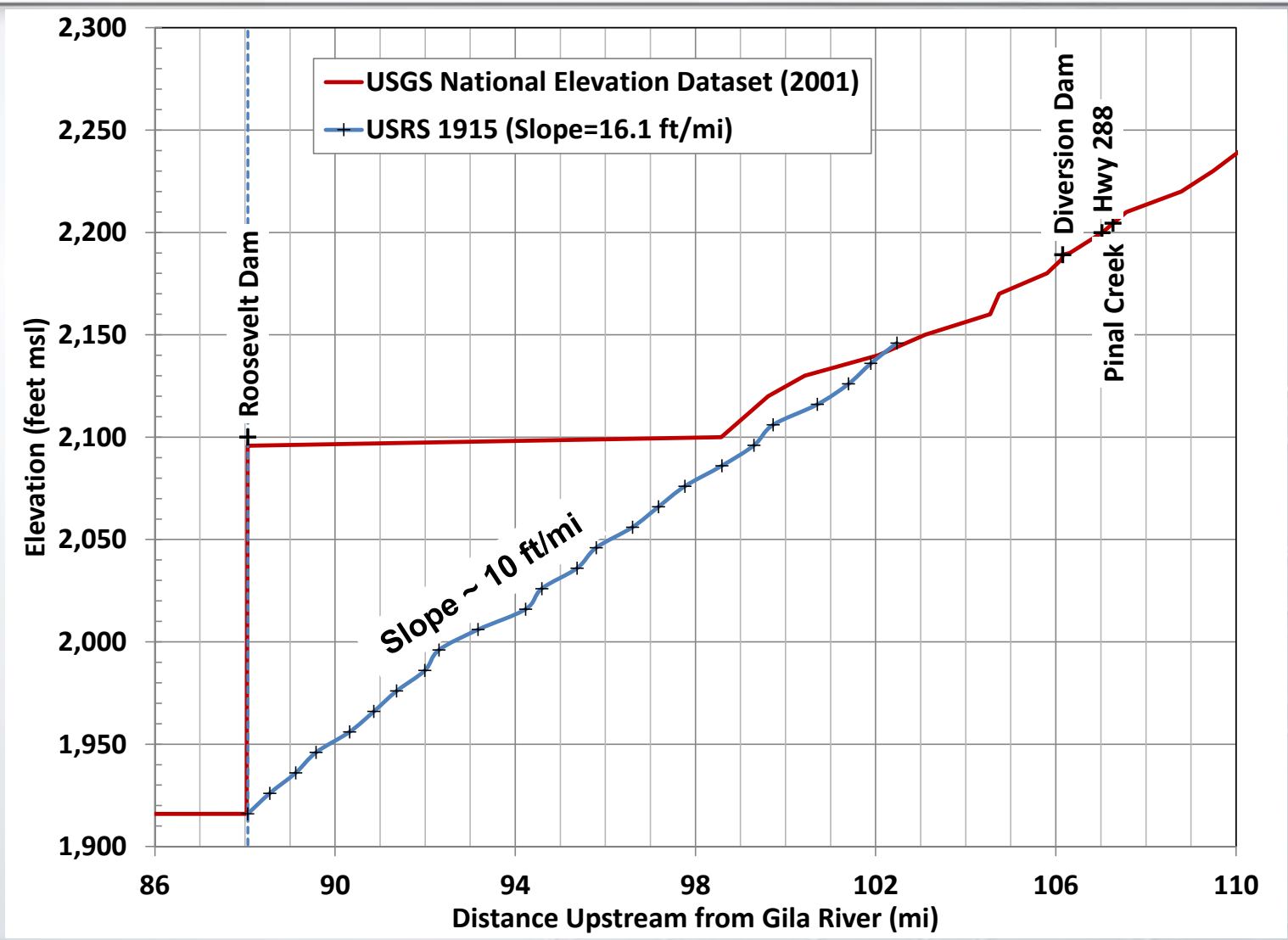
USRS 1915



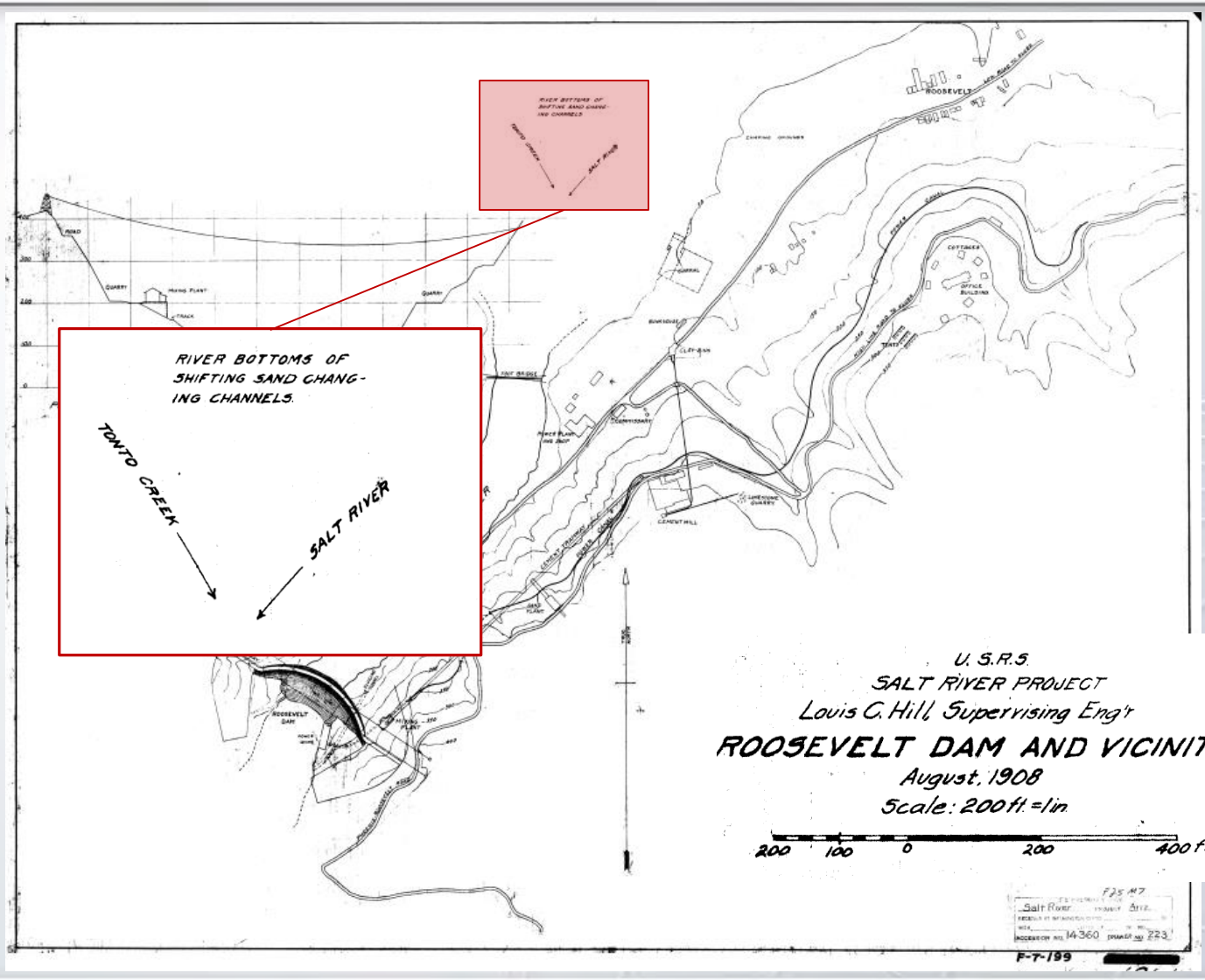
USRS 1915



Longitudinal Profiles



USRS 1908


RIVER BOTTOMS OF SHIFTING SAND CHANG-ING CHANNELS.
TONTO CREEK
SALT RIVER
U. S. R. S.
SALT RIVER PROJECT
Louis C. Hill, Supervising Eng'r
ROOSEVELT DAM AND VICINITY
August, 1908
Scale: 200 ft. = 1 in.
200 100 0 200 400 ft.
Salt River
14360
223
F-7-199

UPPER SALT

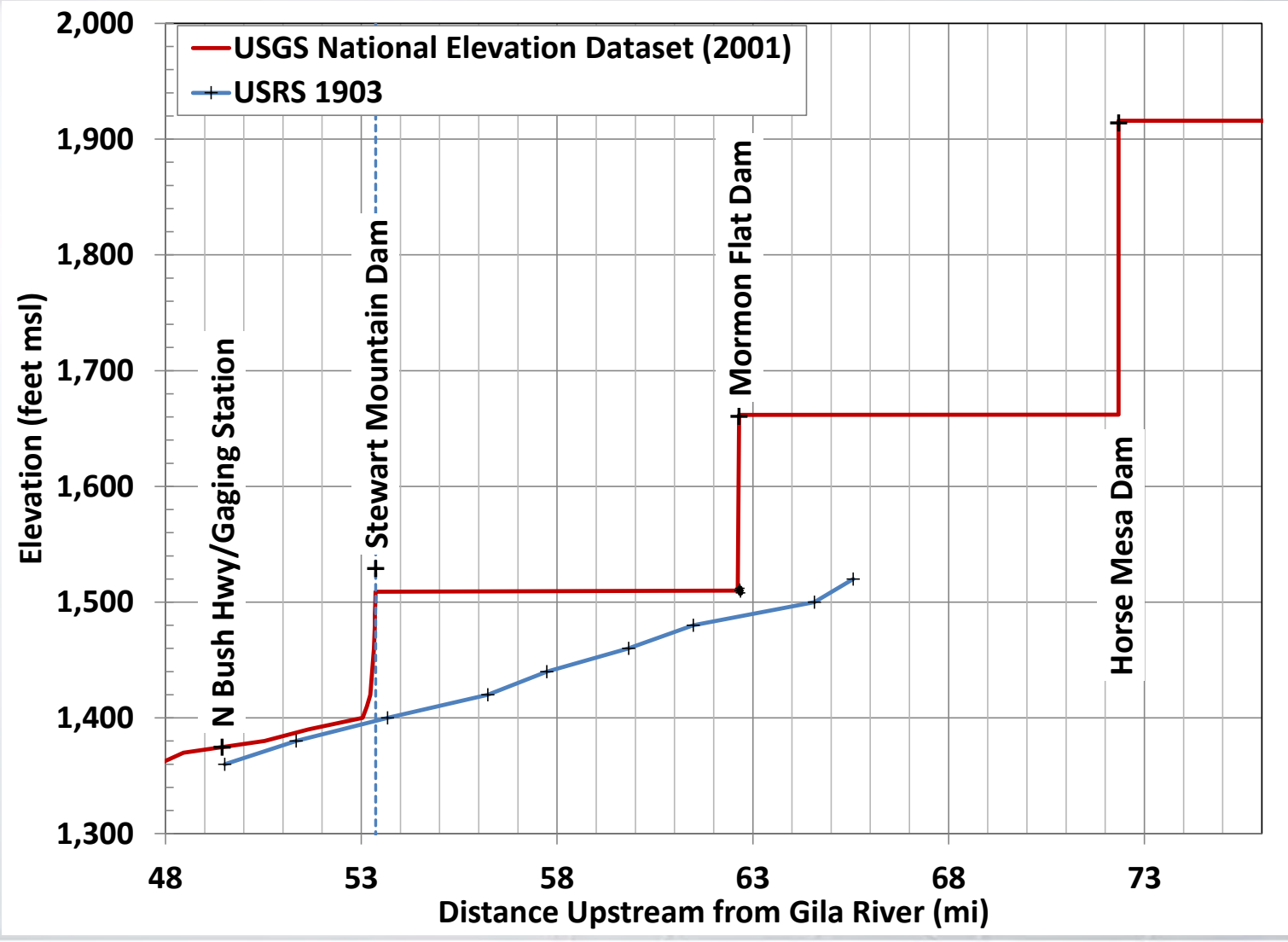
SEGMENT 4

~2 mi Below Roosevelt Dam

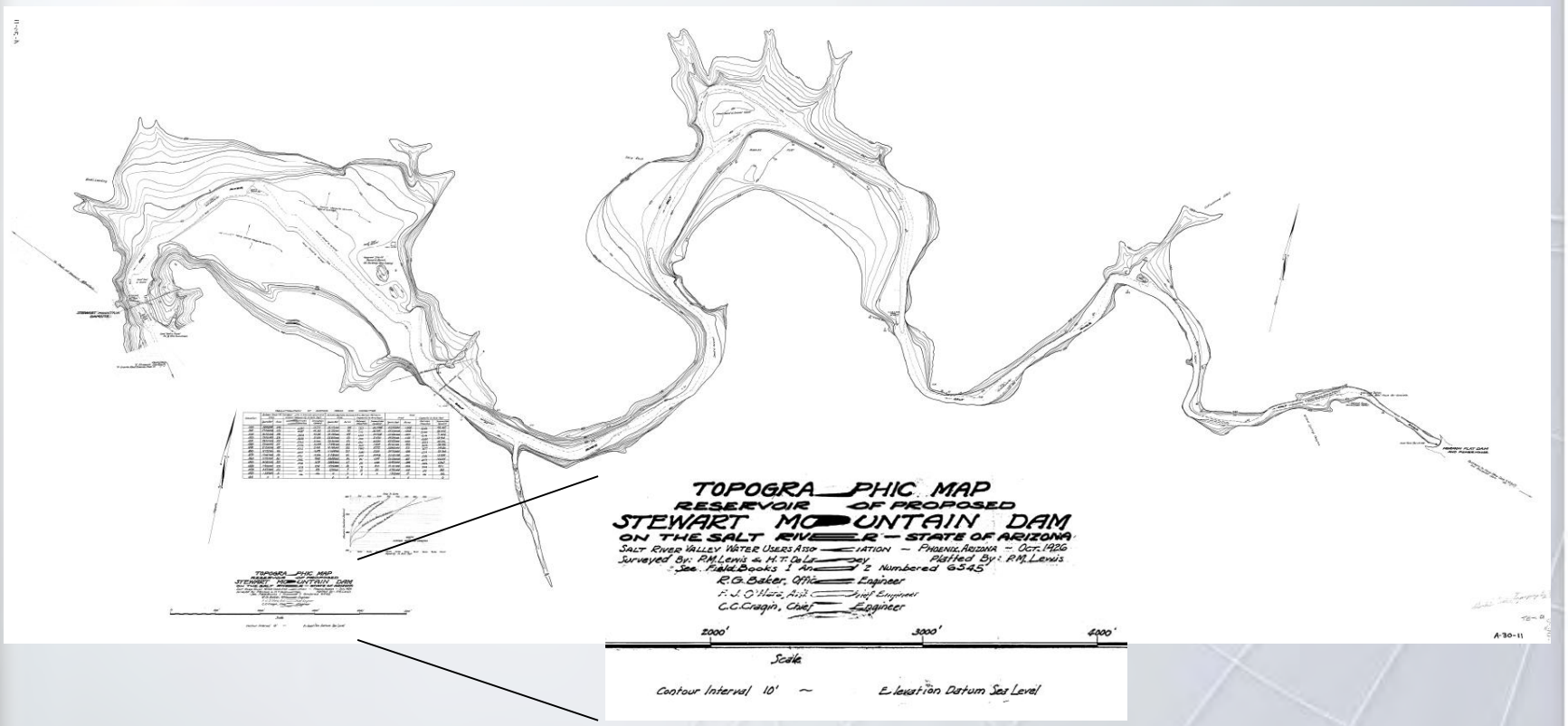
~4 Miles Below Horse Mesa Dam

Mormon Flat Dam

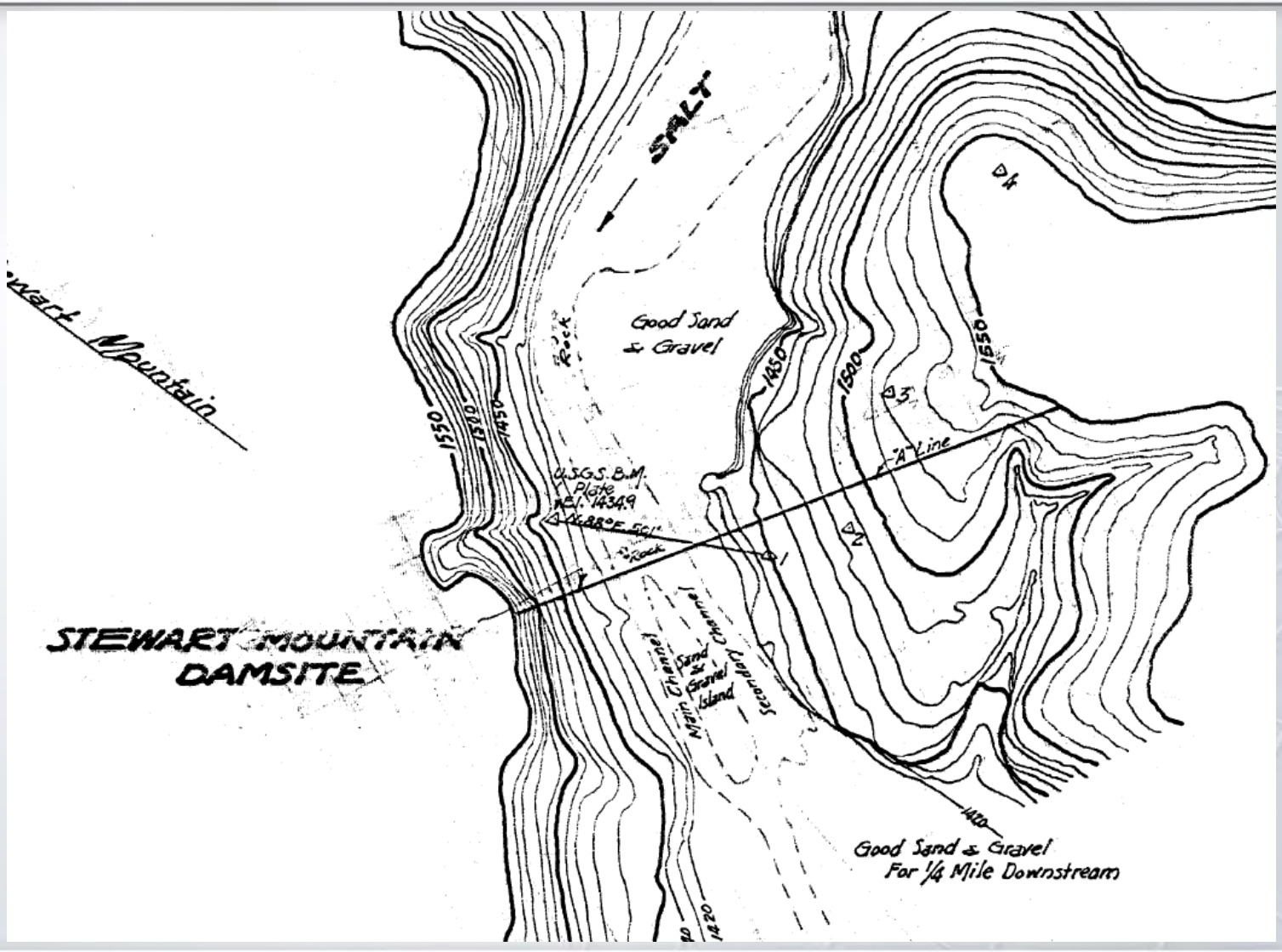
Longitudinal Profiles



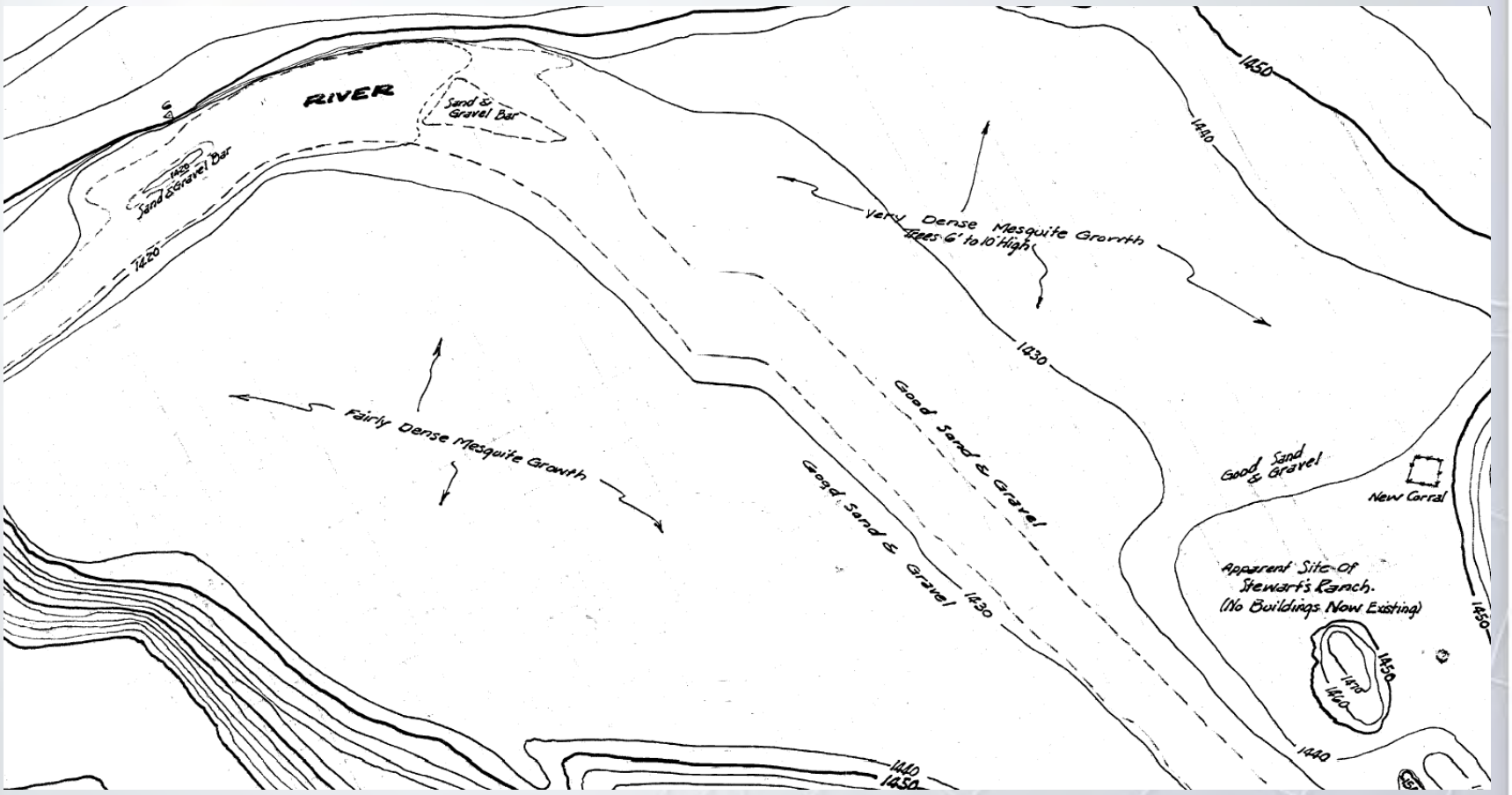
Salt River Valley Water Users Association (1926)



Salt River Valley Water Users Association (1926)

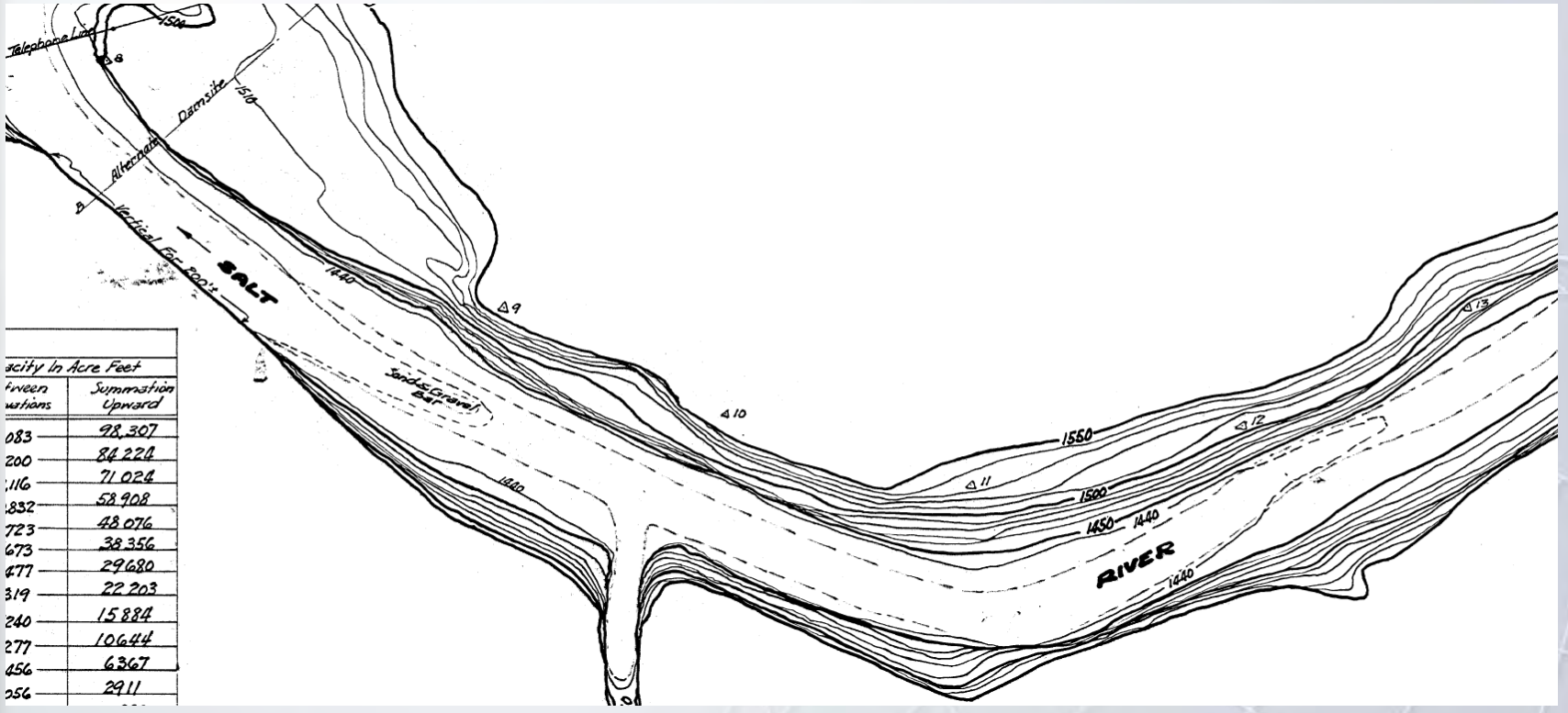


Salt River Valley Water Users Association (1926)



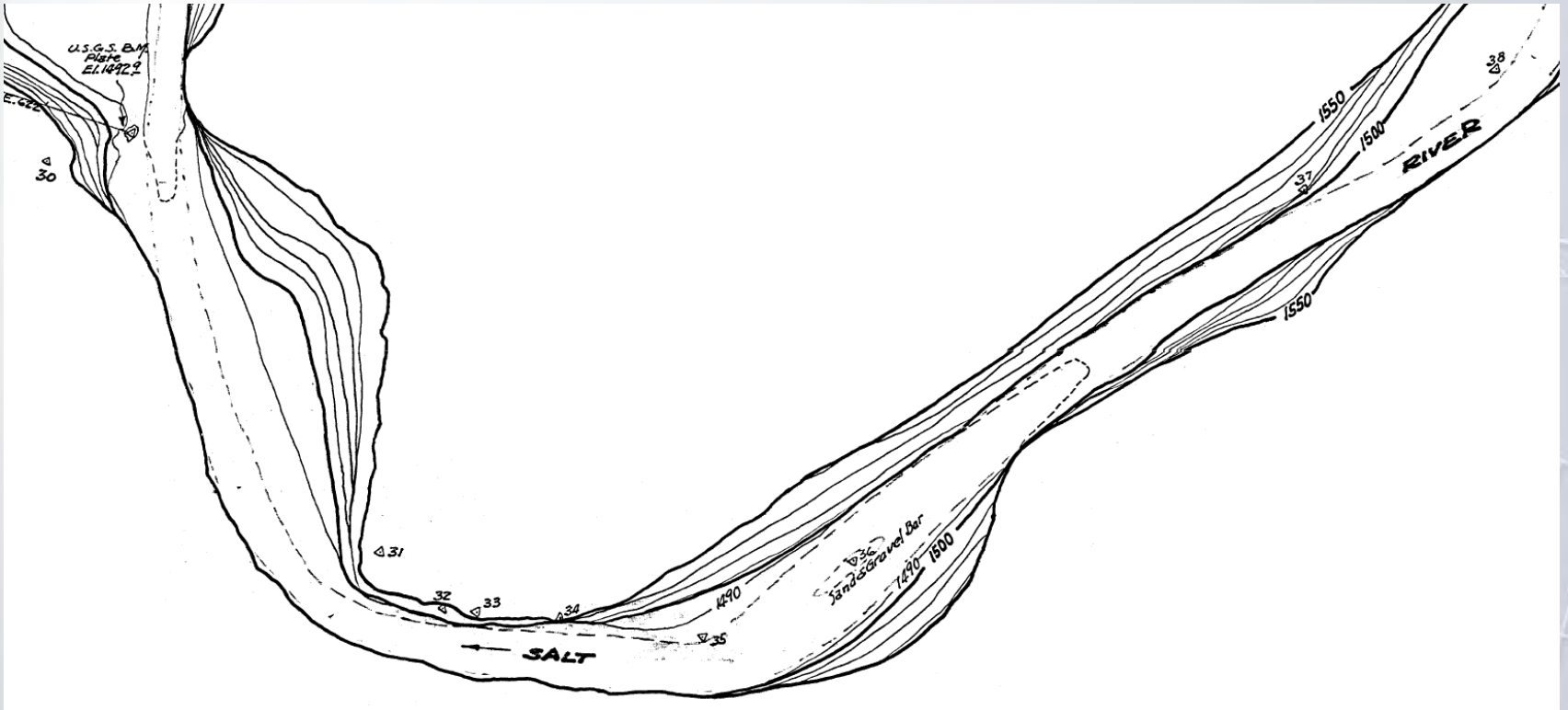
Salt River Valley Water Users Association (1926)

Salt River Valley Water Users Association (1926)

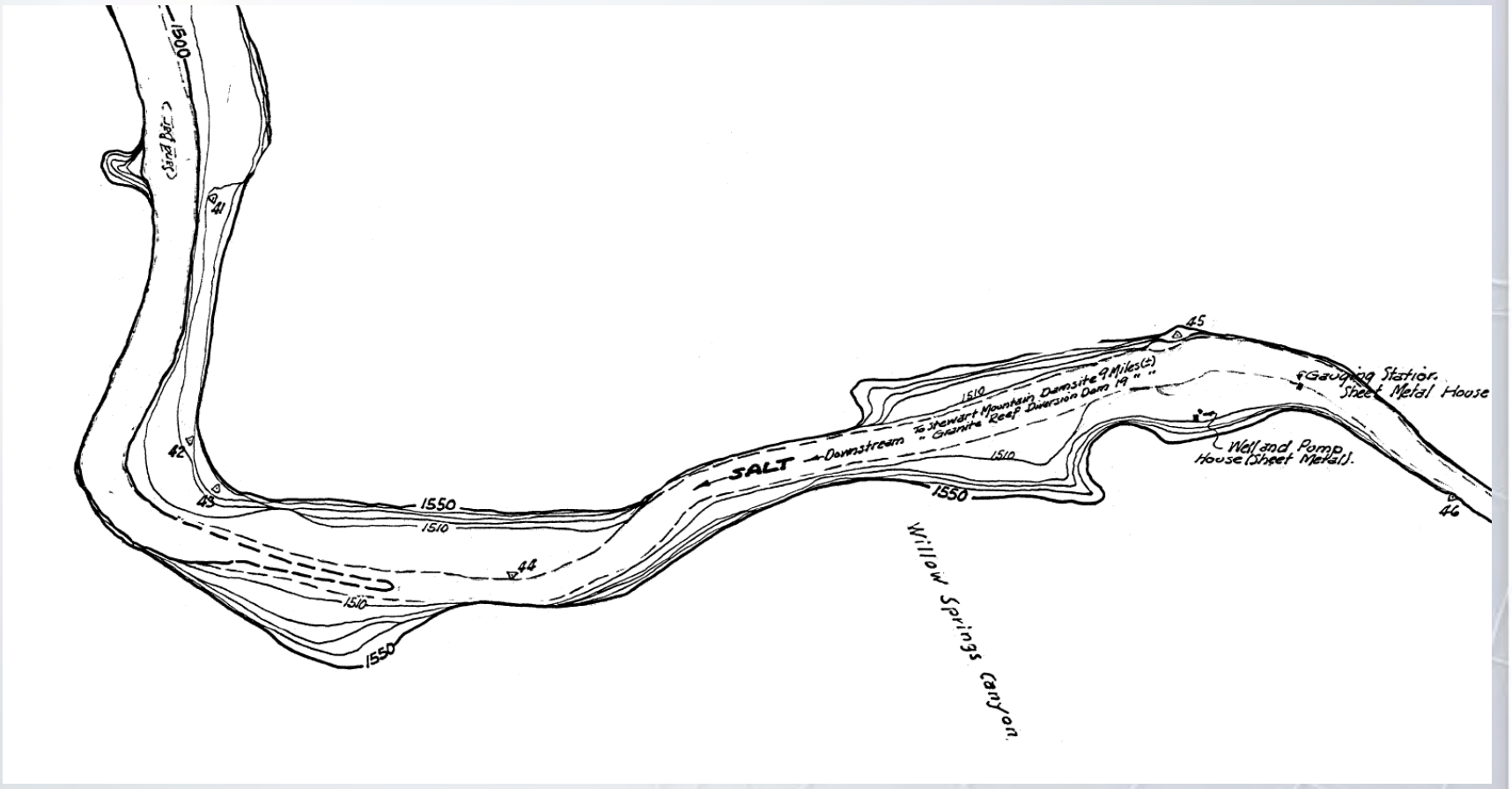


acity In Acre Feet	
ween ustions	Summation Upward
083	98,307
200	84 224
,116	71 024
832	58 908
723	48 076
673	38 356
477	29680
319	22 203
240	15 884
277	10644
456	6367
056	2911

Salt River Valley Water Users Association (1926)



Salt River Valley Water Users Association (1926)



HISTORICAL PHOTOGRAPHS PPT

LOWER SALT

SEGMENTS 5 & 6

Flow Estimates (JE Fuller, 2003; Pope et. al., 1998; Thomsen & Porcello, 1991)

Gage Station	Seg-ment	Flow Rate (cfs) 90%	Flow Rate (cfs) Median (50%)	Flow Rate (cfs) 10%	Gage Period
White River	-	(35)	(90)	(567)	1958-1996
Black River	-	(39)	(109)	(1230)	1958-1996
White + Black	1	74	~~199~~ 171	1,797	1958-2015
Chrysotile	2	130	~~266~~ 246	1,610	1914-2015
Roosevelt	3, 4	159	~~341~~ 316	2,120	1914-2015
Roosevelt, USGS	5	>159	992 (USGS – VR,Tangle)	>2,120	
USGS	6	277 (Salt + Verde)	1230* (USGS, 1991)	3,062 (Salt + Verde)	-

NOTES:

- Includes post-development (non-natural condition) flow data. Underestimates natural flow rates.
- All flow rates shown are from long-term, modern period gage records.
- Use of Roosevelt gage data for Segments 4 does not include tributaries inflows from Tonto Creek and other downstream perennial tributaries, and therefore underestimates actual historical flow rates.
- Diversions above Roosevelt total 8,560 acres (Table 11, ASLD Report)
- * Pre-development flow estimate by USGS (Thomsen & Porcello, 1991)

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Fuller Median Flow Estimate
Segment 6

PREDEVELOPMENT HYDROLOGY OF THE SALT RIVER INDIAN RESERVATION, EAST SALT RIVER VALLEY, ARIZONA

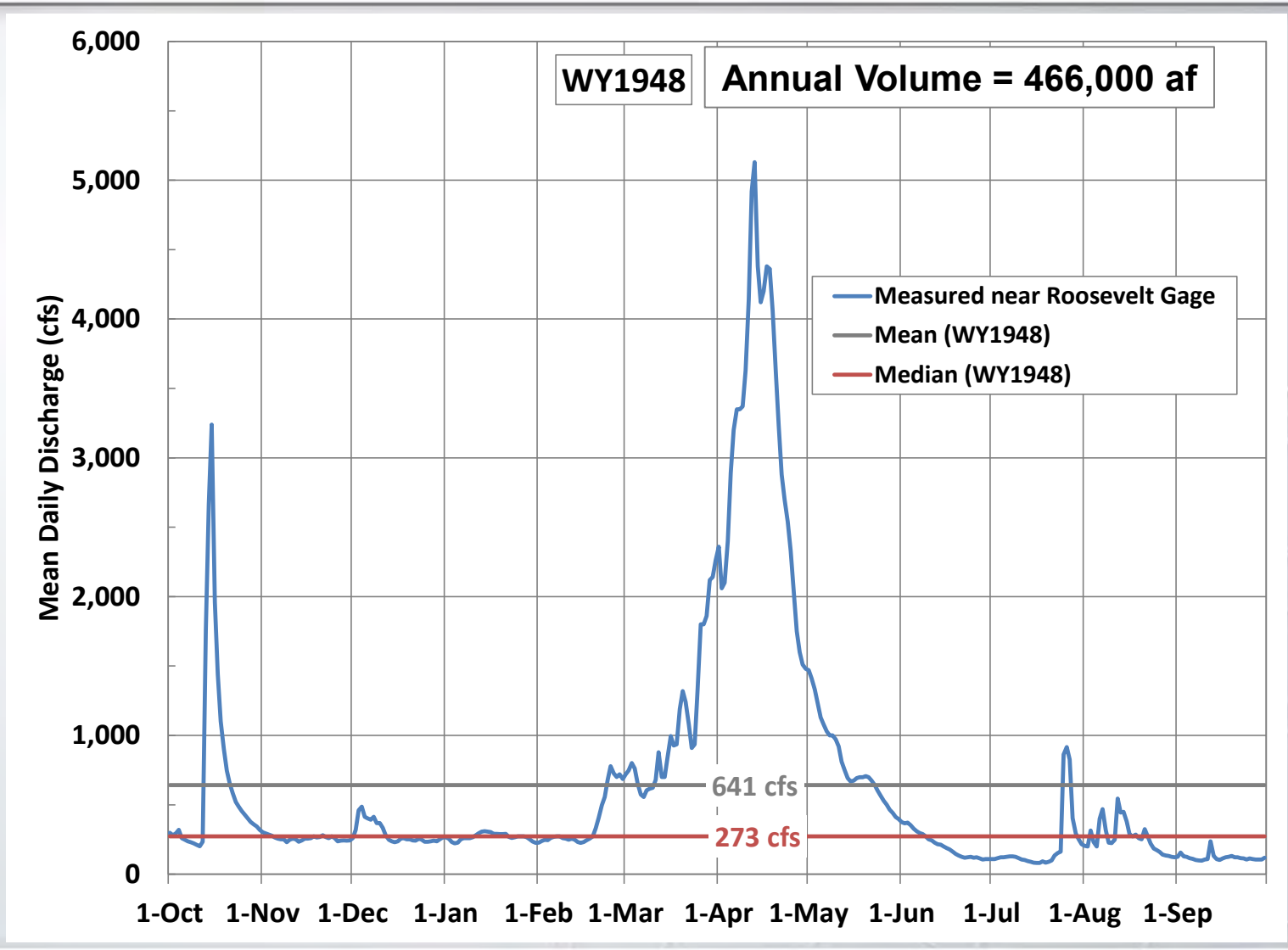
$$889{,}000\ \frac{af}{yr} * \frac{43{,}560\ \frac{ft^3}{ac}}{\left(86{,}400\ \frac{sec}{day}\right) * 365.25\ \frac{days}{yr}} = 1{,}227\ cfs$$

Water–Resources Investigations Report 91–4132

Average discharge during year with median annual volume.
NOT median mean daily flow.

Verde R … and
River b … rde
determine the flow of the Salt River through the study area, and discharge to
values have been adjusted for storage in reservoirs. On the basis of
available records, the combined average discharge of the Salt and Verde
Rivers is 1,223,000 acre-ft/yr; the median discharge is 889,000 acre-ft/yr.
Records for the Verde River date back to 1888 and those for the Salt
River to 1931. For the common period of record, 1931-86, the combined
average discharge is 1,151,000 acre-ft/yr, the median discharge is
873,000 acre-ft/yr, and the annual discharge ranged from 282,000 to
3,832,000 acre-ft. The recorded values reflect the effect of upstream
diversions and reservoir evaporation on the discharge at the confluence of
the Salt and Verde Rivers.

Typical “Near-Median” Year



Thomsen and Porcello (1991)

Table 1.--*Streamflow data at selected streamflow-ga[illegible] stations*

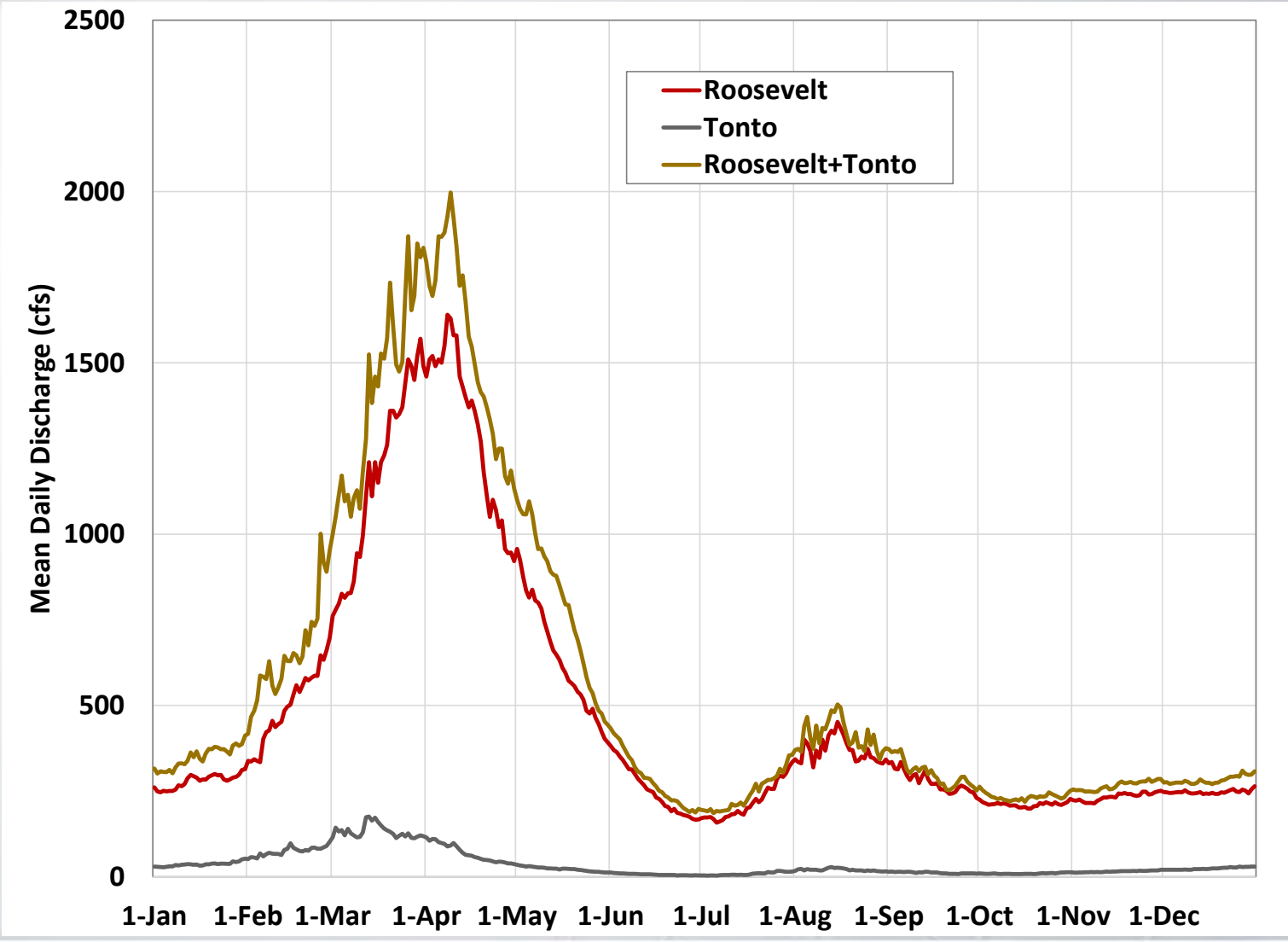
678 cfs

709 cfs

Station number[1]	Station name	Drainage area, in square miles	Wat[illegible] yea[illegible]	Annual runoff Mean [illegible]re-et	Inches[2]	Median Acre-feet
09500500	Salt River at Roosevelt	5,830	1888-1907 1910-13	756,000	2.44	491,000
09498500	[illegible] Roosevelt	[illegible]	[illegible]	[illegible],000	2.84	514,000
09502000	Salt River below Stewart Mountain Dam[3]	6,232	1931-86	730,000	2.20	498,000

Median Mean Daily Discharge = 316 cfs

Median Mean Daily Flows



Flow Estimates (JE Fuller, 2003; Pope et. al., 1998; Thomsen & Porcello, 1991)

Gage Station	Seg-ment	Flow Rate (cfs) 90%	Flow Rate (cfs) Median (50%)	Flow Rate (cfs) 10%	Gage Period
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White + Black	1	74	199	1,797	
Chrysotile	2	130	~~266~~ 246	1,610	1914-2015
Roosevelt	3, 4	159	~~341~~ 316	2,120	1914-2015
Roosevelt, USGS	5	>159	~~992~~ 361	>2,120	1914-1996
		Salt_Roosevelt+Tonto	– VR,) 348		1914-2015
USGS	6	277	~~1230*~~ 573	3,062 (Salt + Verde)	1946-1996
		Salt_Roosevelt+Tonto+Verde	GS, 19 554		1946-2015

NOTES:

- Includes post-development (non-natural condition) flow data. Underestimates natural flow rates.
- All flow rates shown are from long-term, modern period gage records.
- Use of Roosevelt gage data for Segments 4 does not include tributaries inflows from Tonto Creek and other downstream perennial tributaries, and therefore underestimates actual historical flow rates.
- Diversions above Roosevelt total 8,560 acres (Table 11, ASLD Report)
- * Pre-development flow estimate by USGS (Thomsen & Porcello, 1991)

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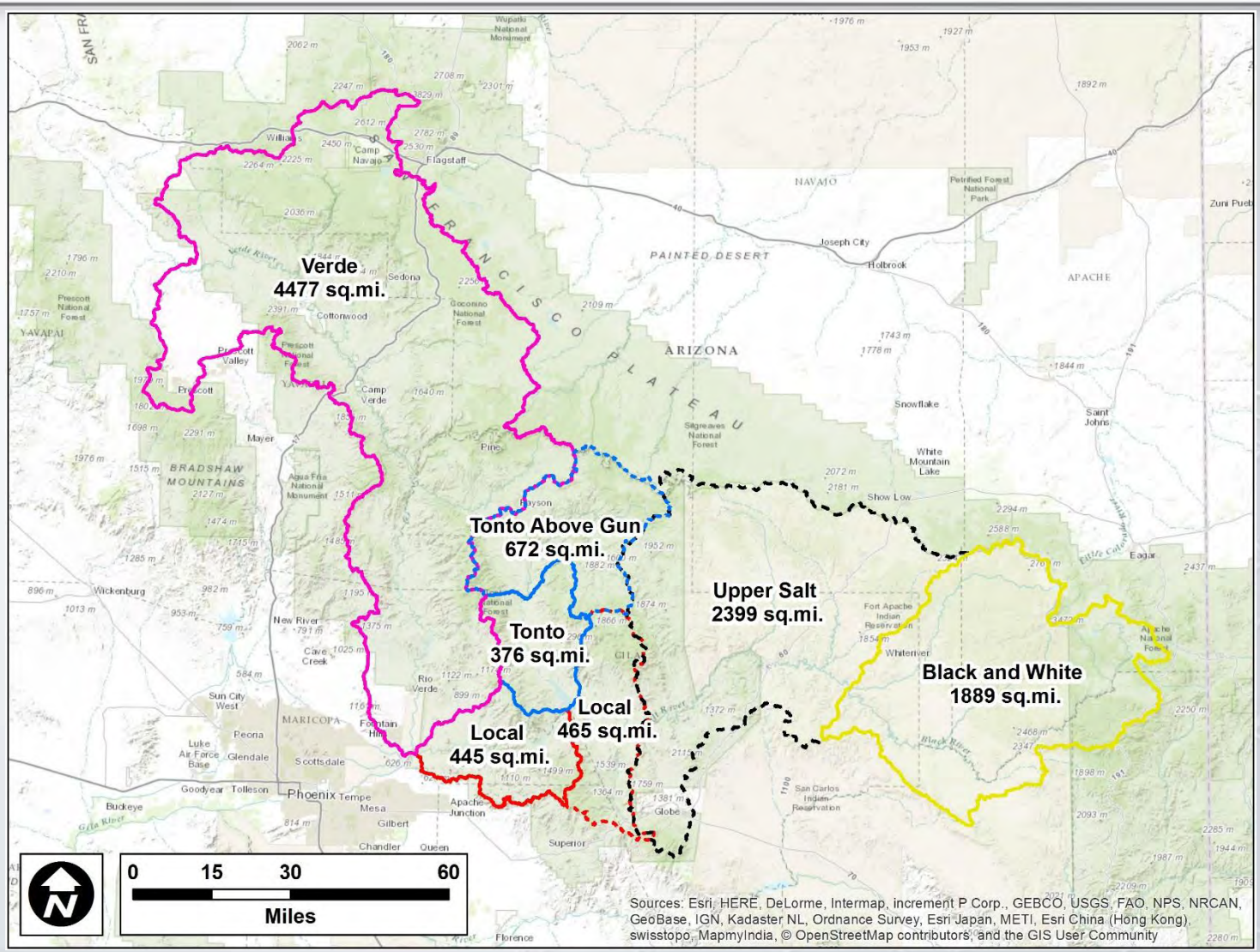
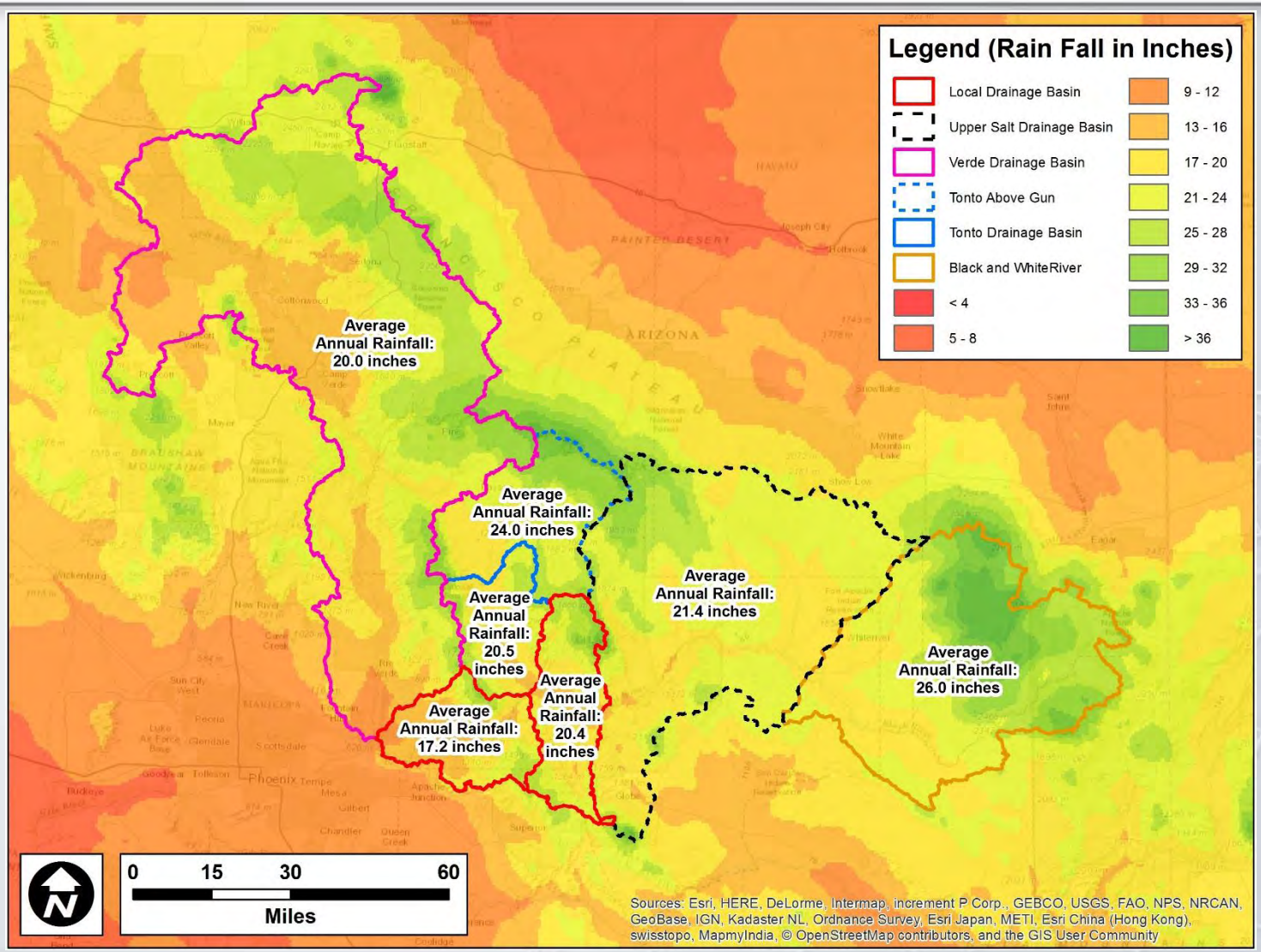
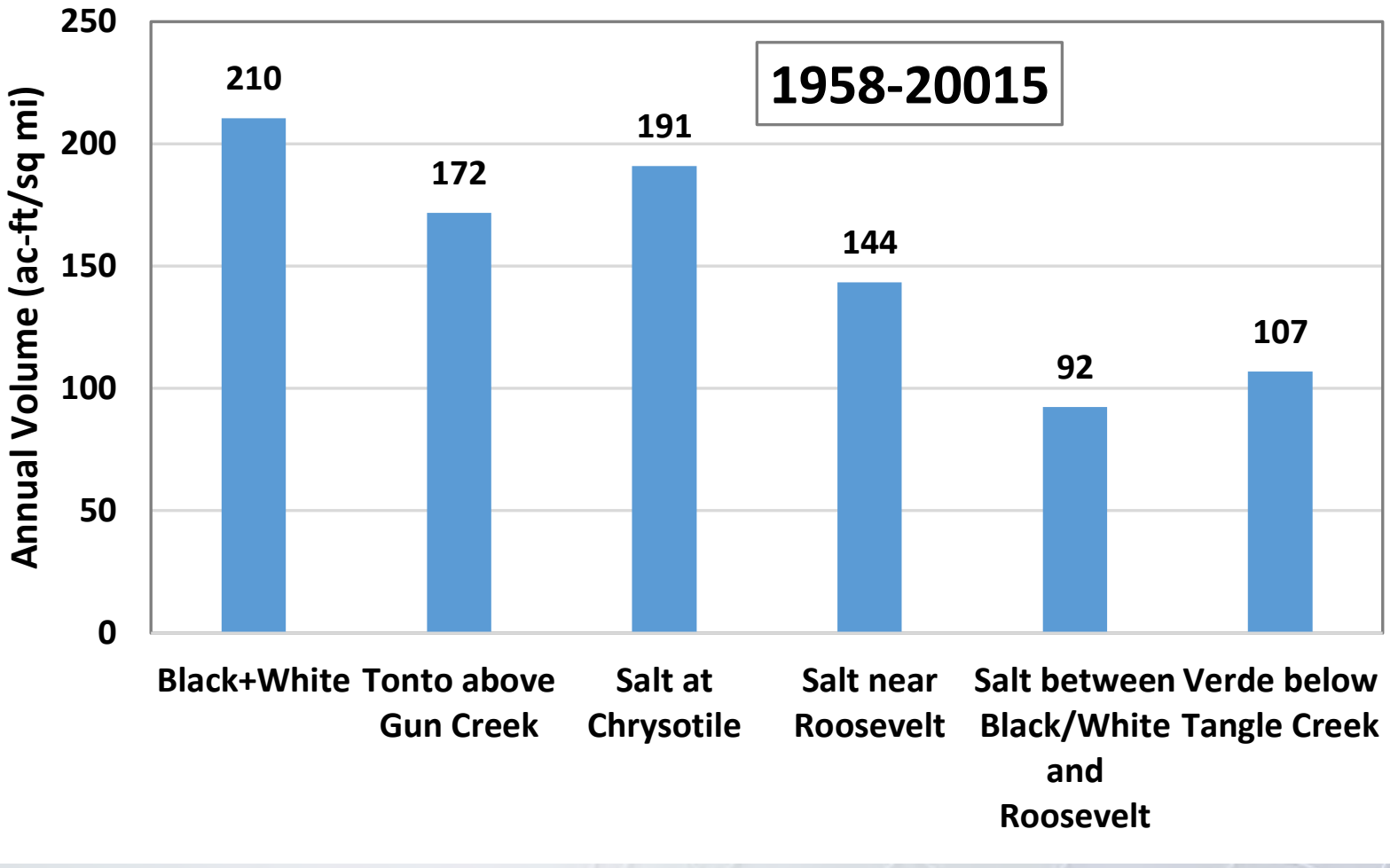
Drainage Areas



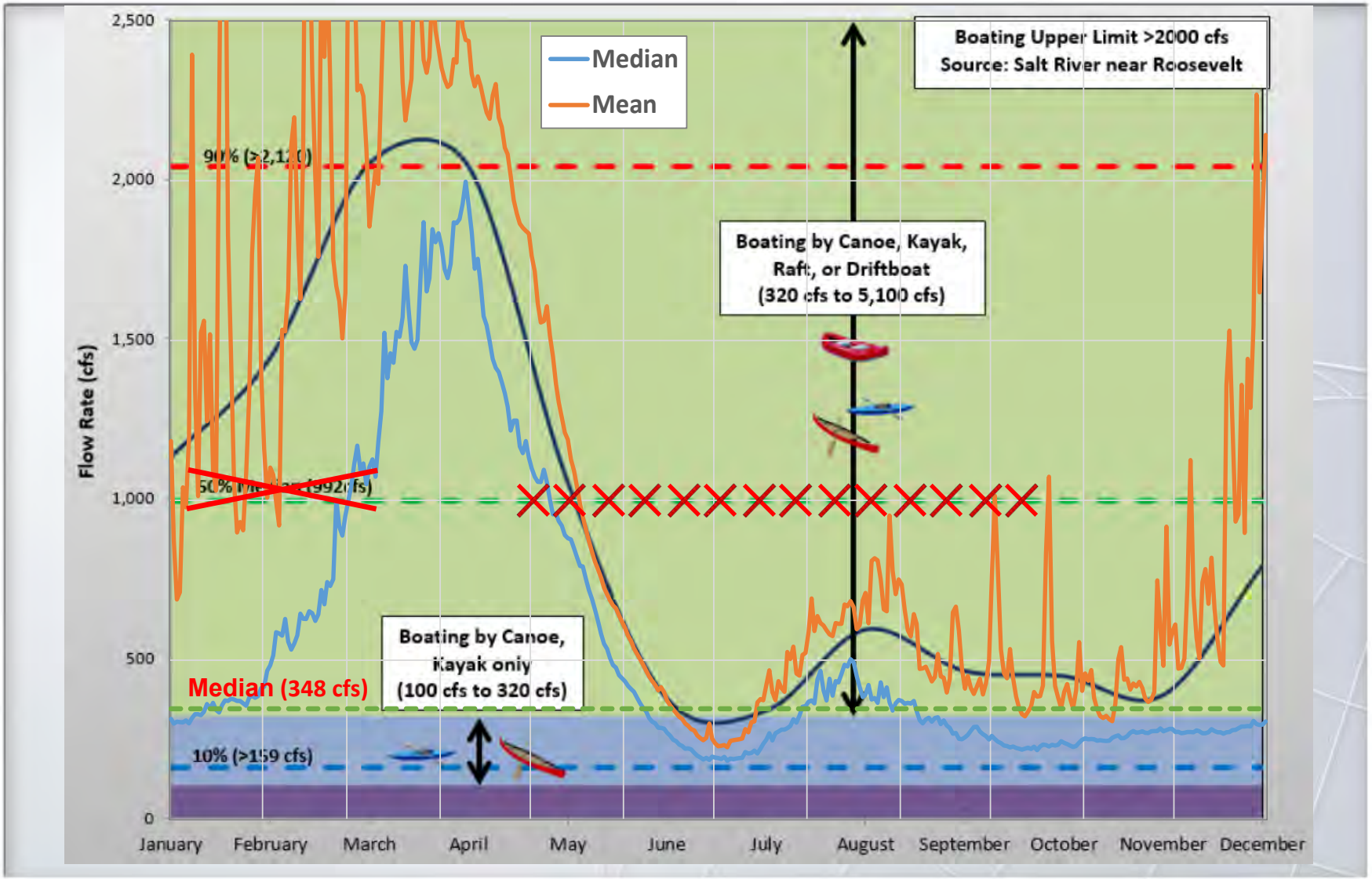
Annual Precipitation



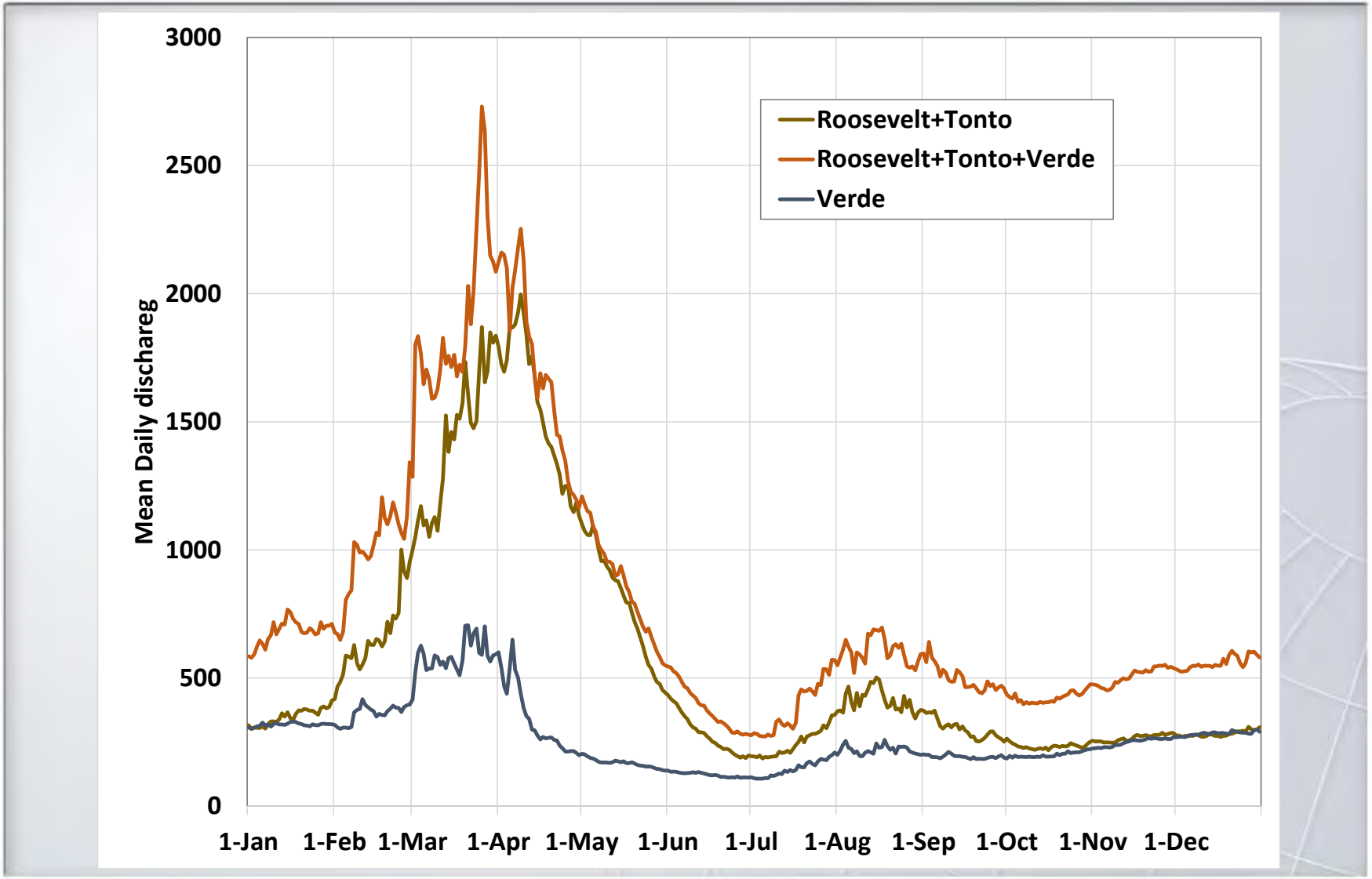
Unit Annual Runoff at Gages



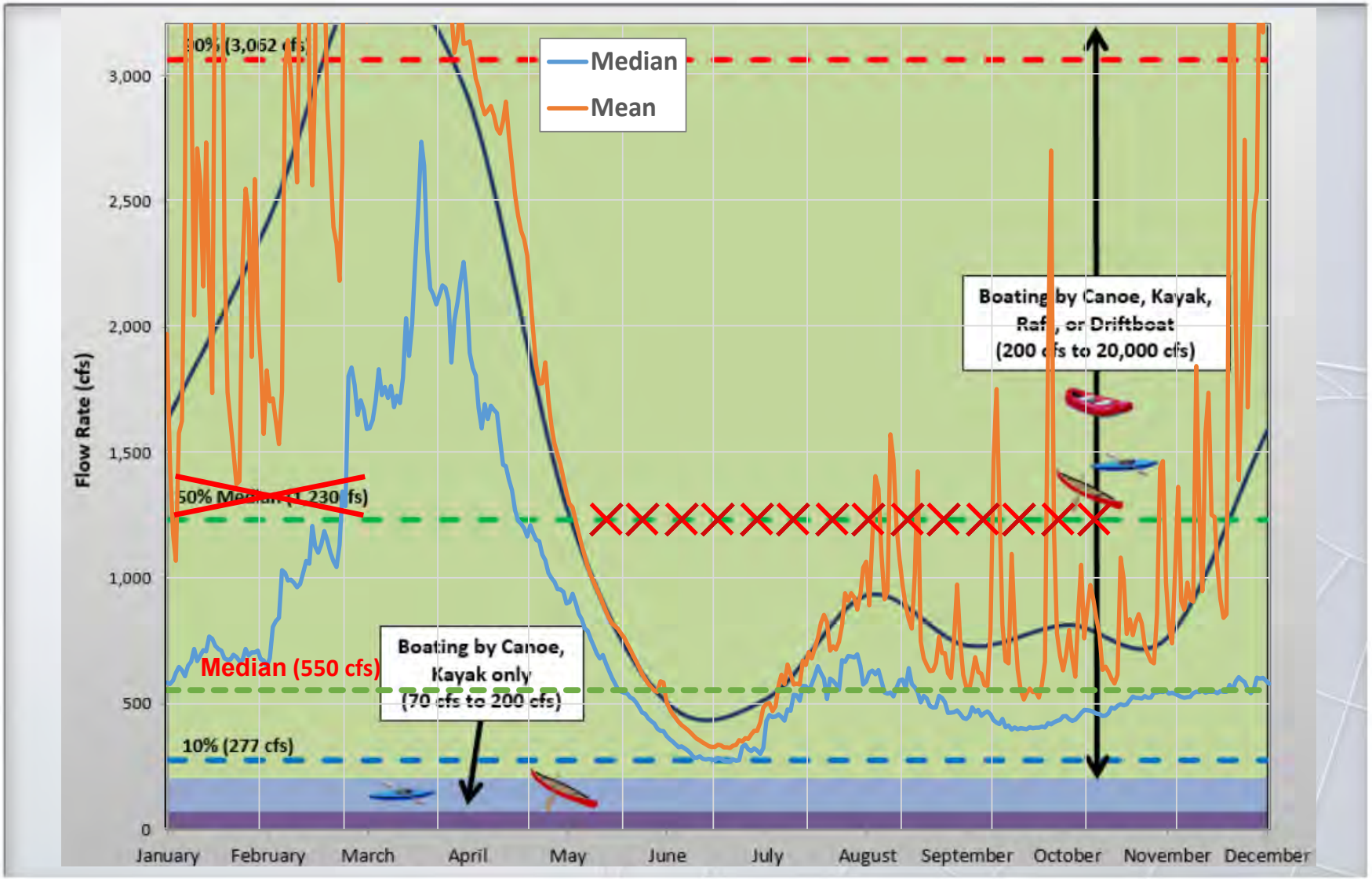
Segment 5 Hydrographs



Median Mean Daily Flows

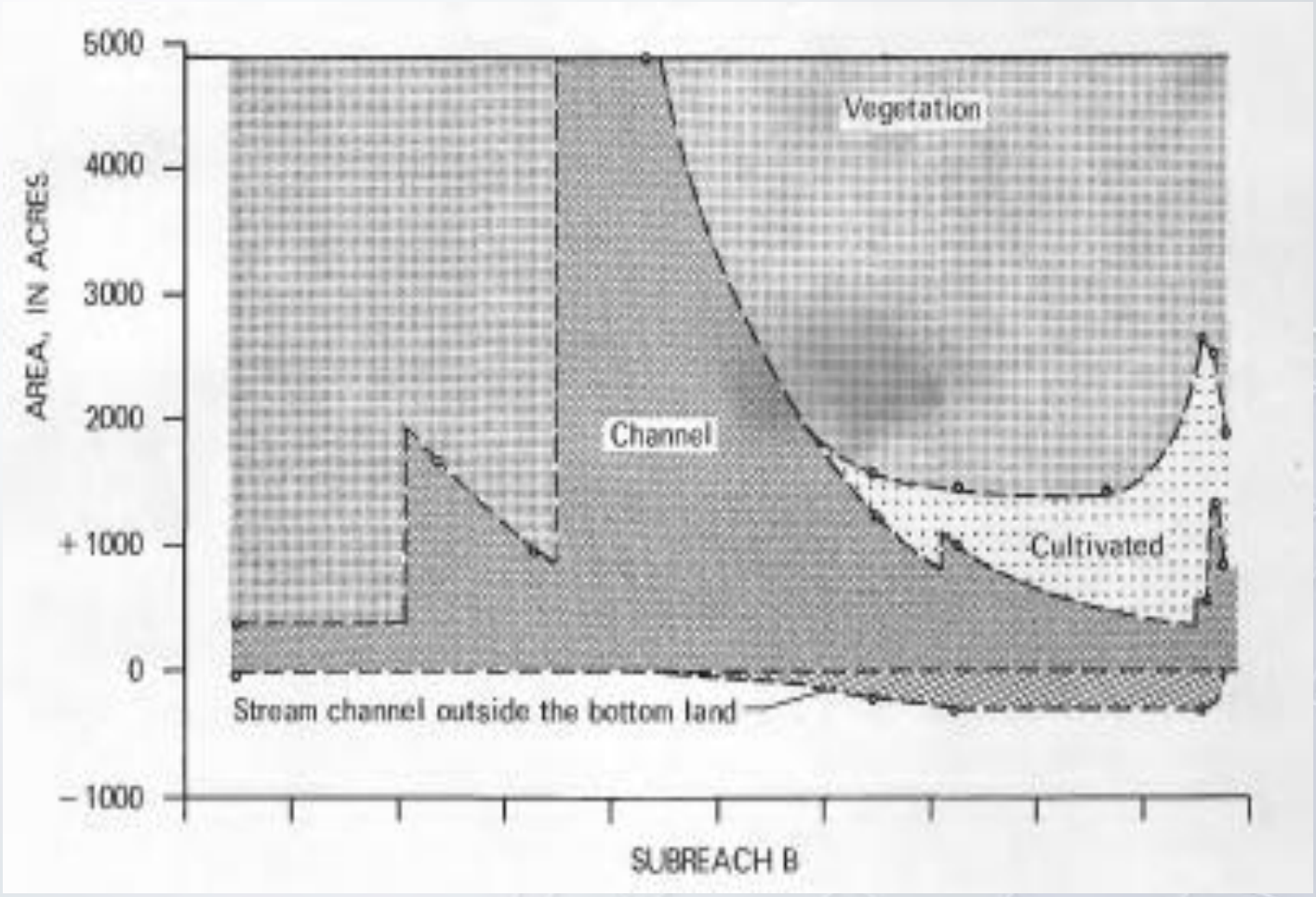


Segment 6 Hydrographs

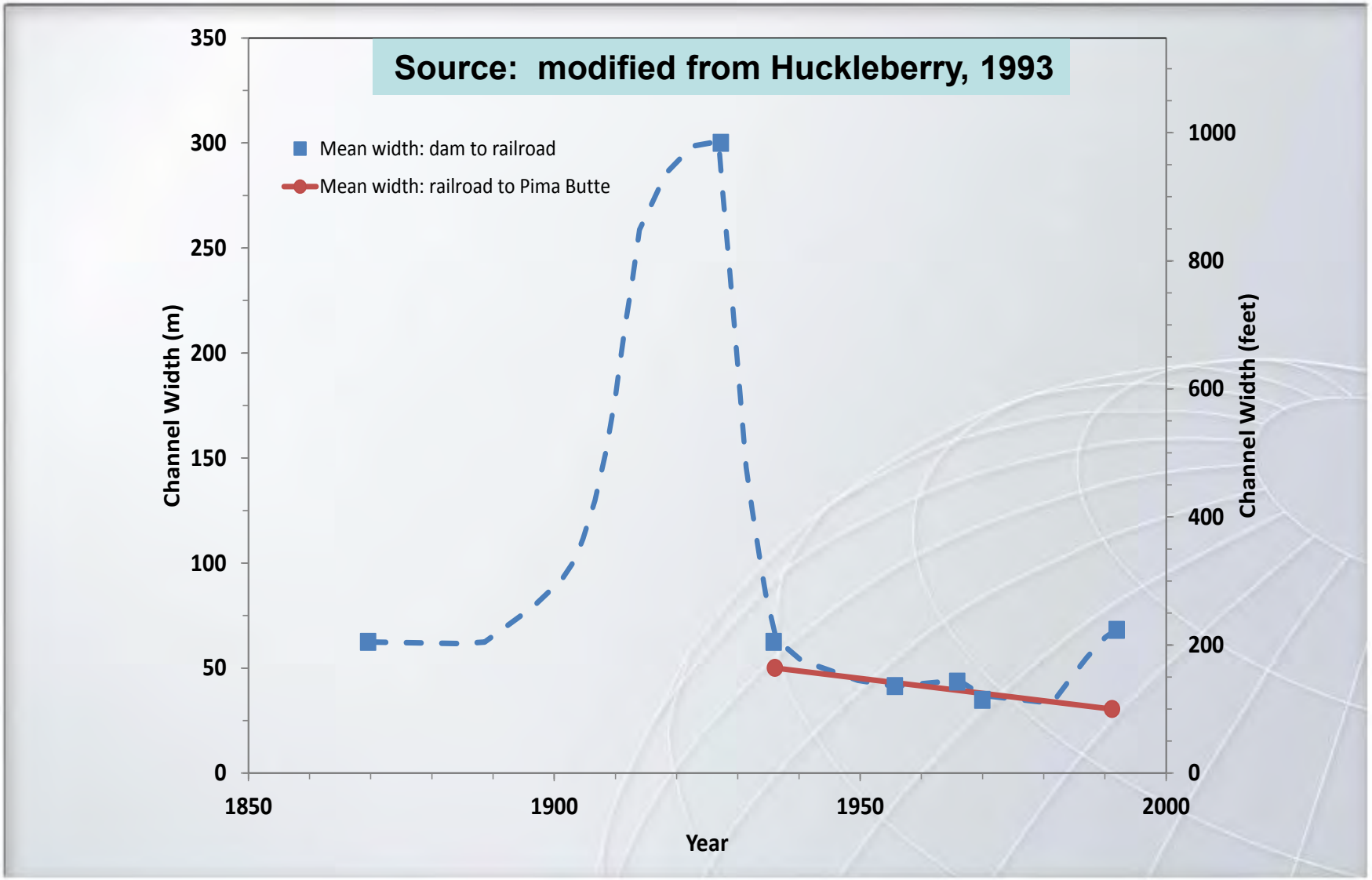


Historical changes in channel area of upper Gila River (San Simon to Pima)

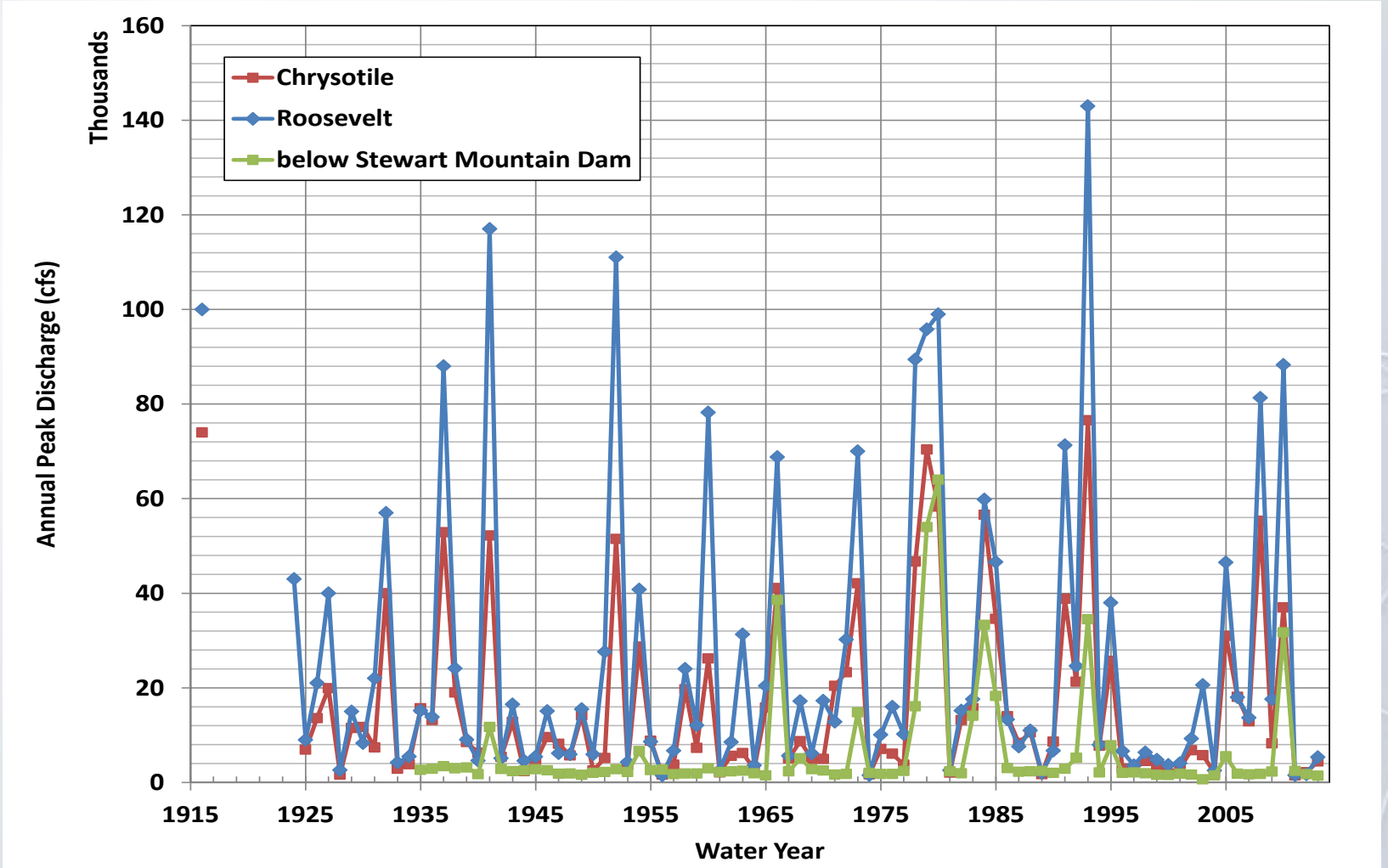
Source: Burkham, 1972



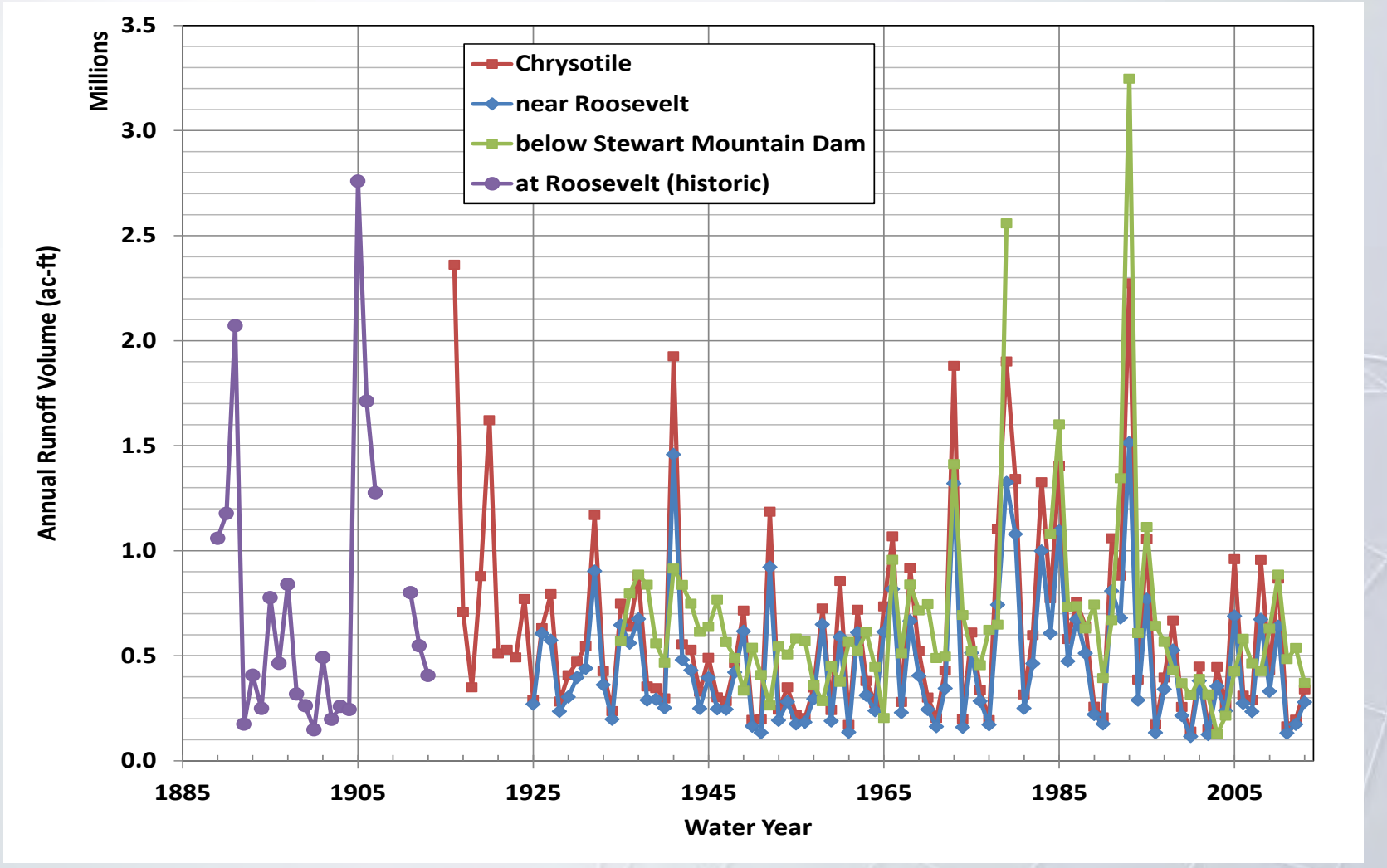
Changes in channel width for the Middle Gila River



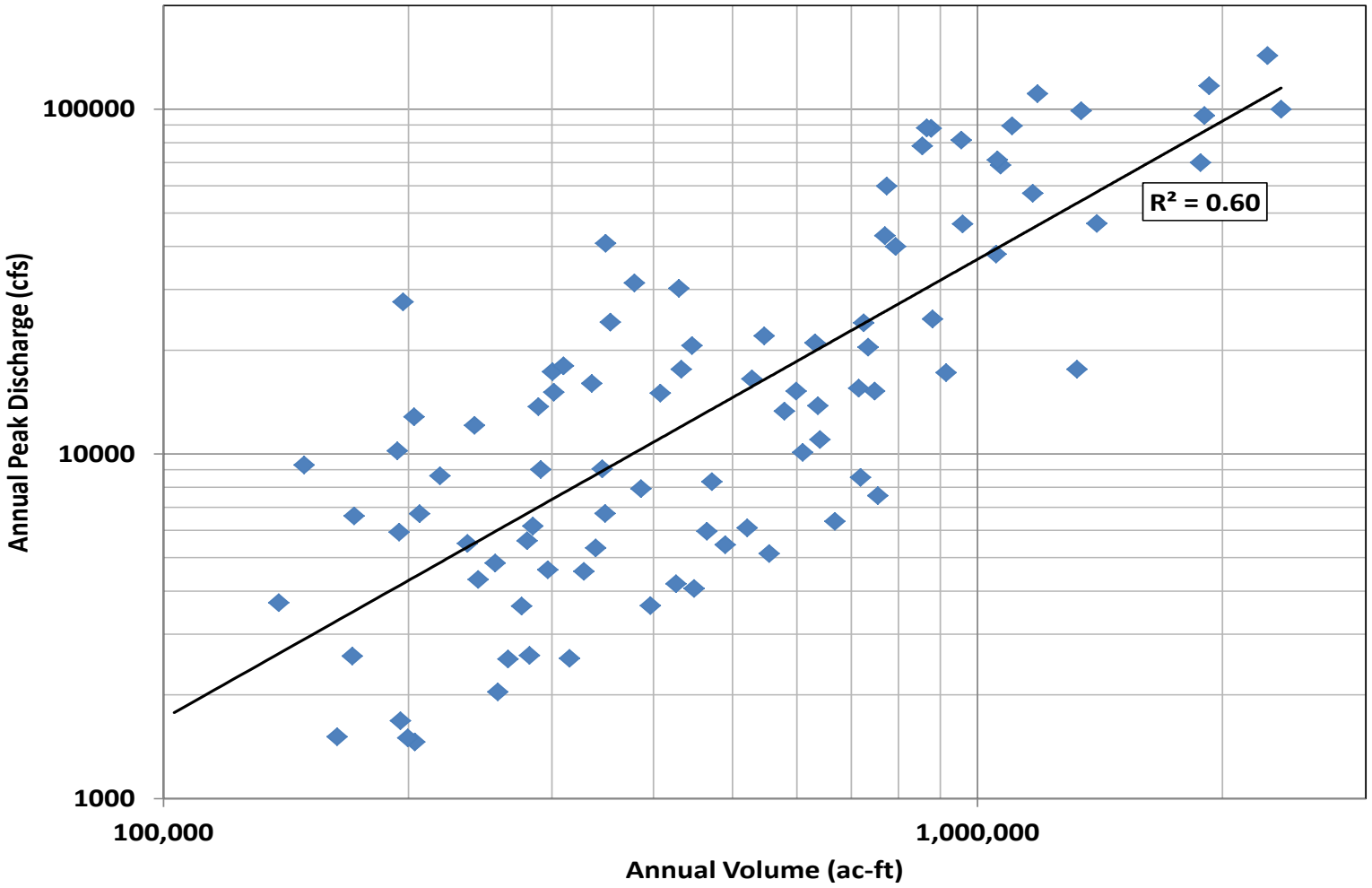
Annual Peak Discharges



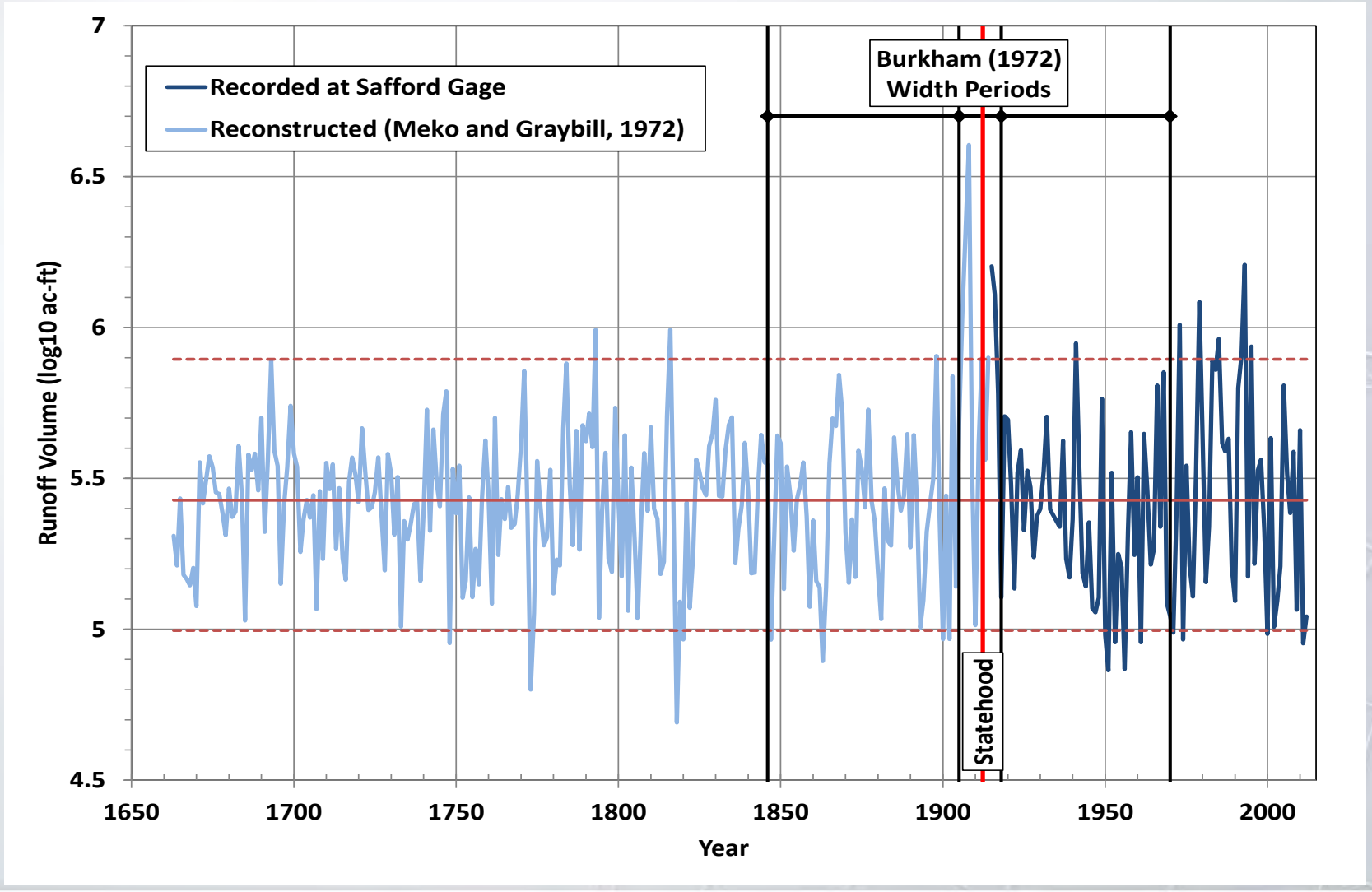
Annual Runoff Volume



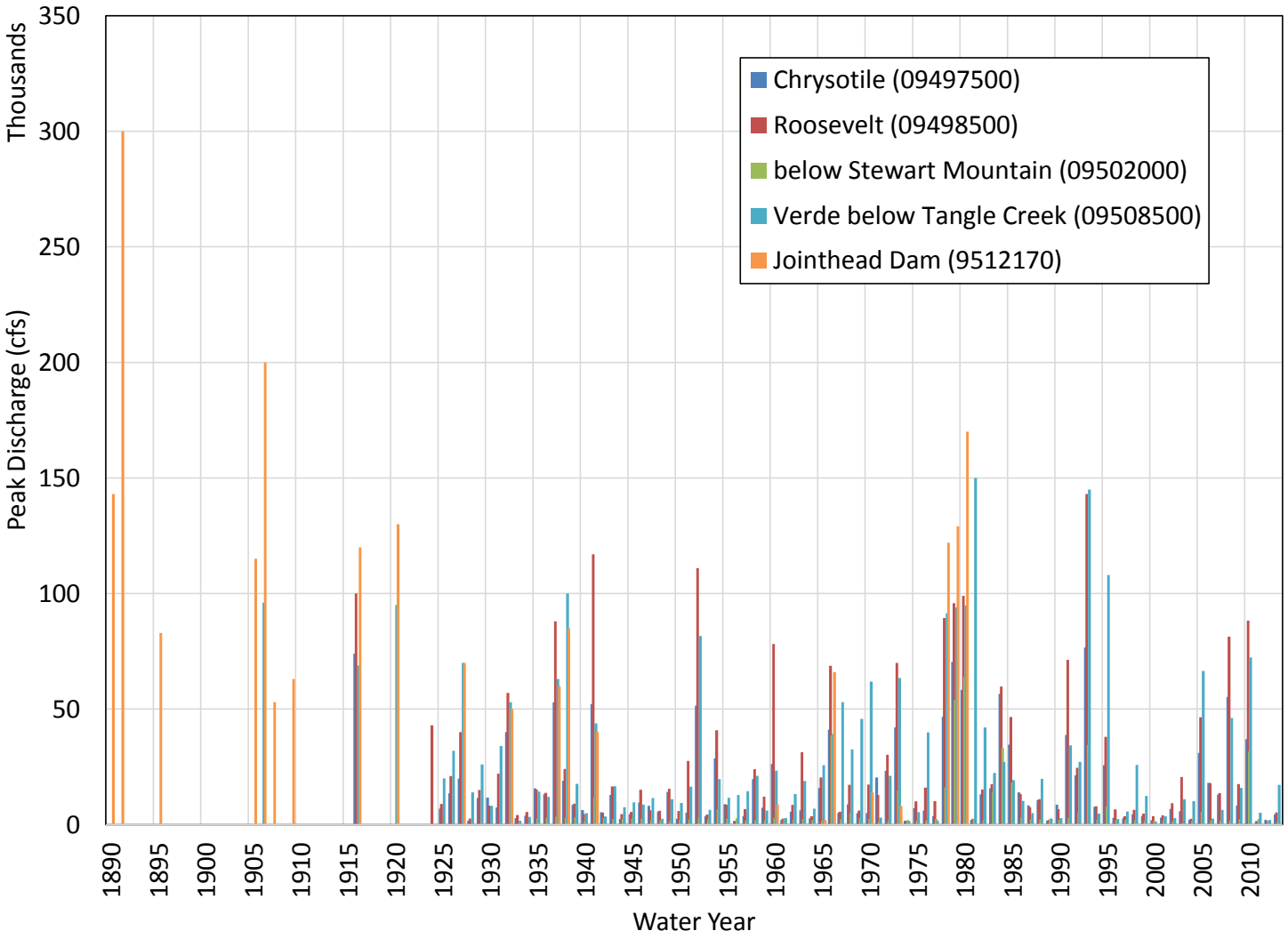
Annual Peak Discharge vs Annual Runoff Volume near Roosevelt



Gila River Annual Discharge



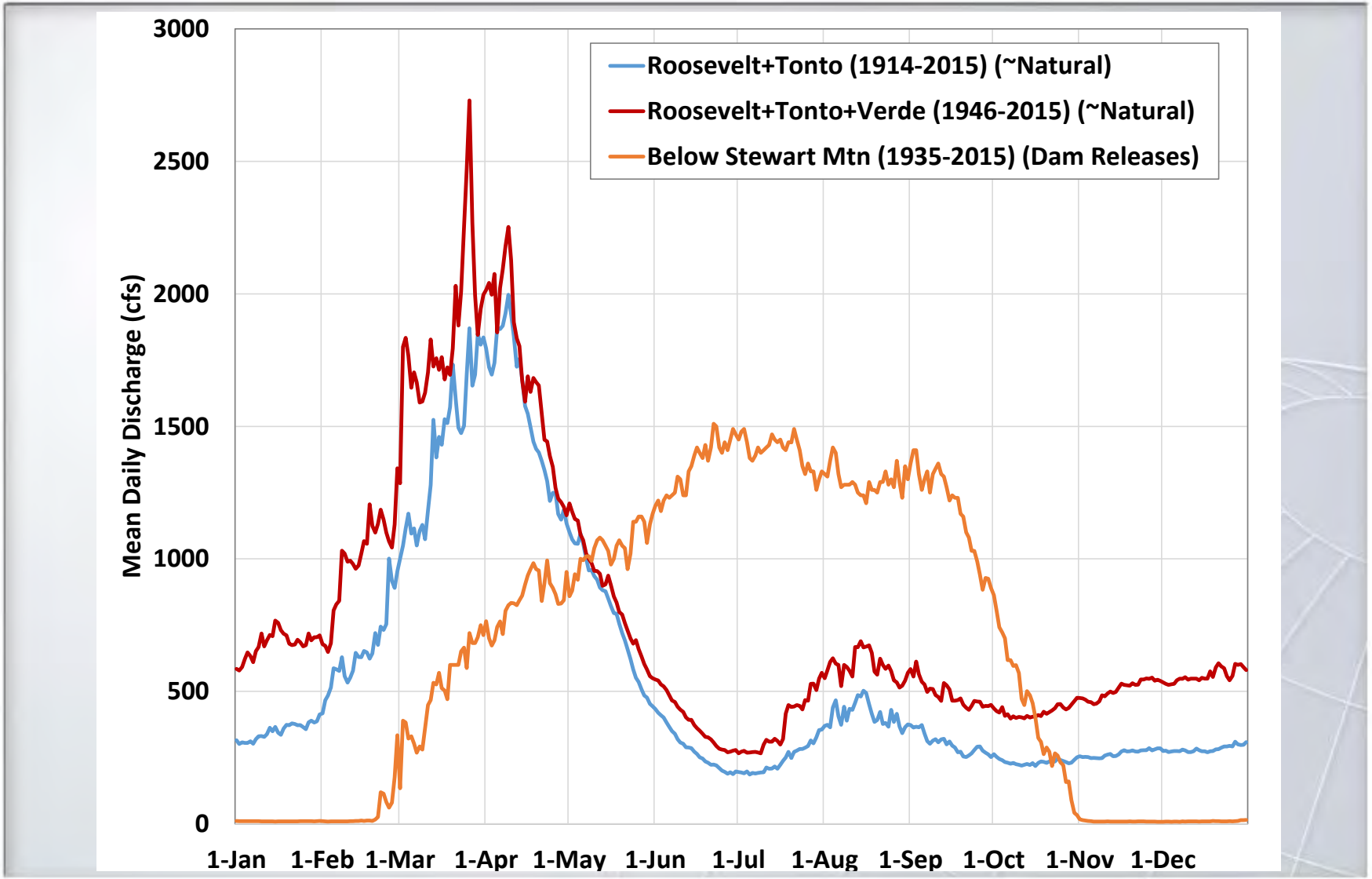
Annual Peak Discharges (1890 – 2014)



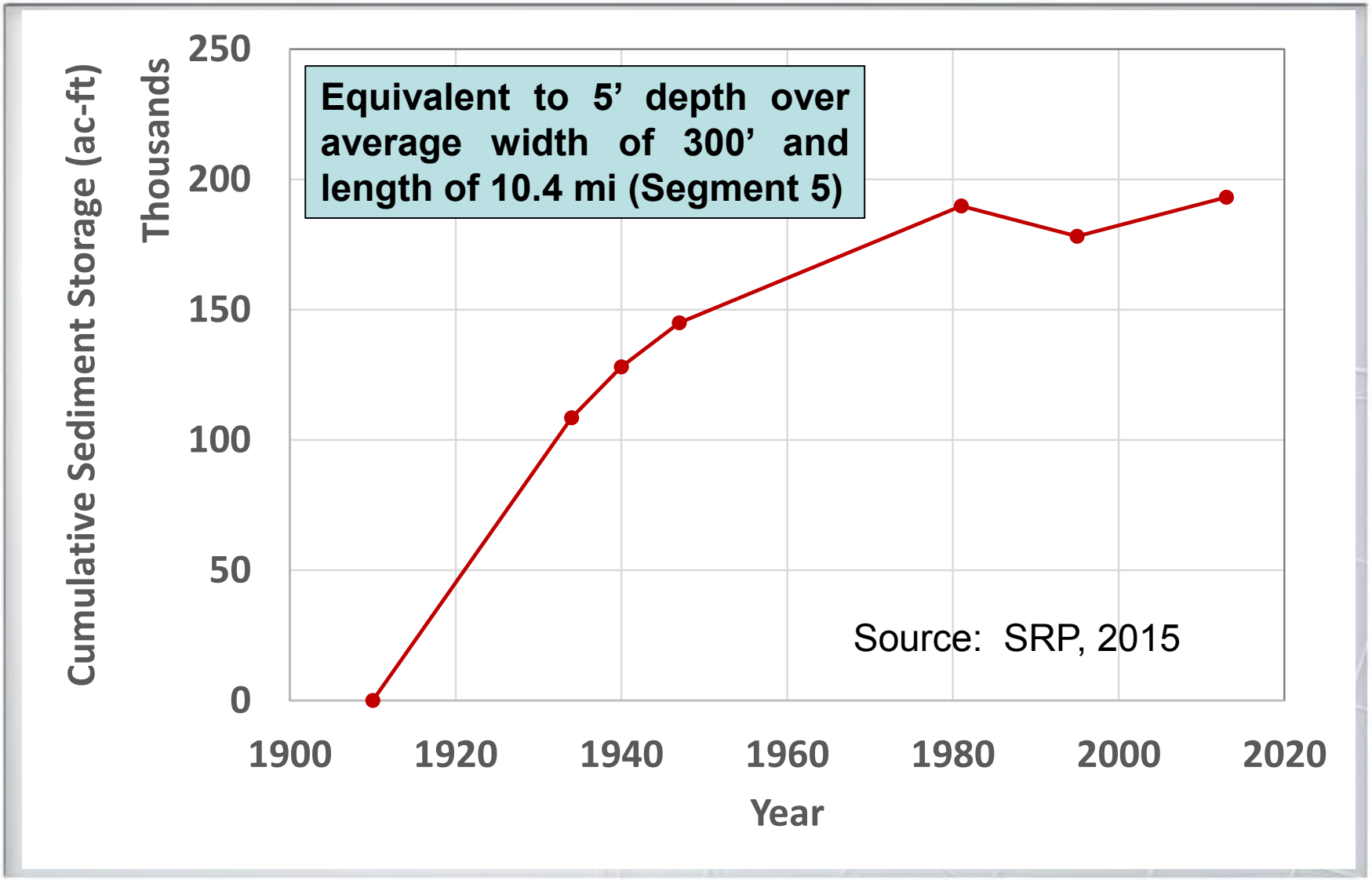
LOWER SALT

SEGMENT 5

Median Mean Daily Flows



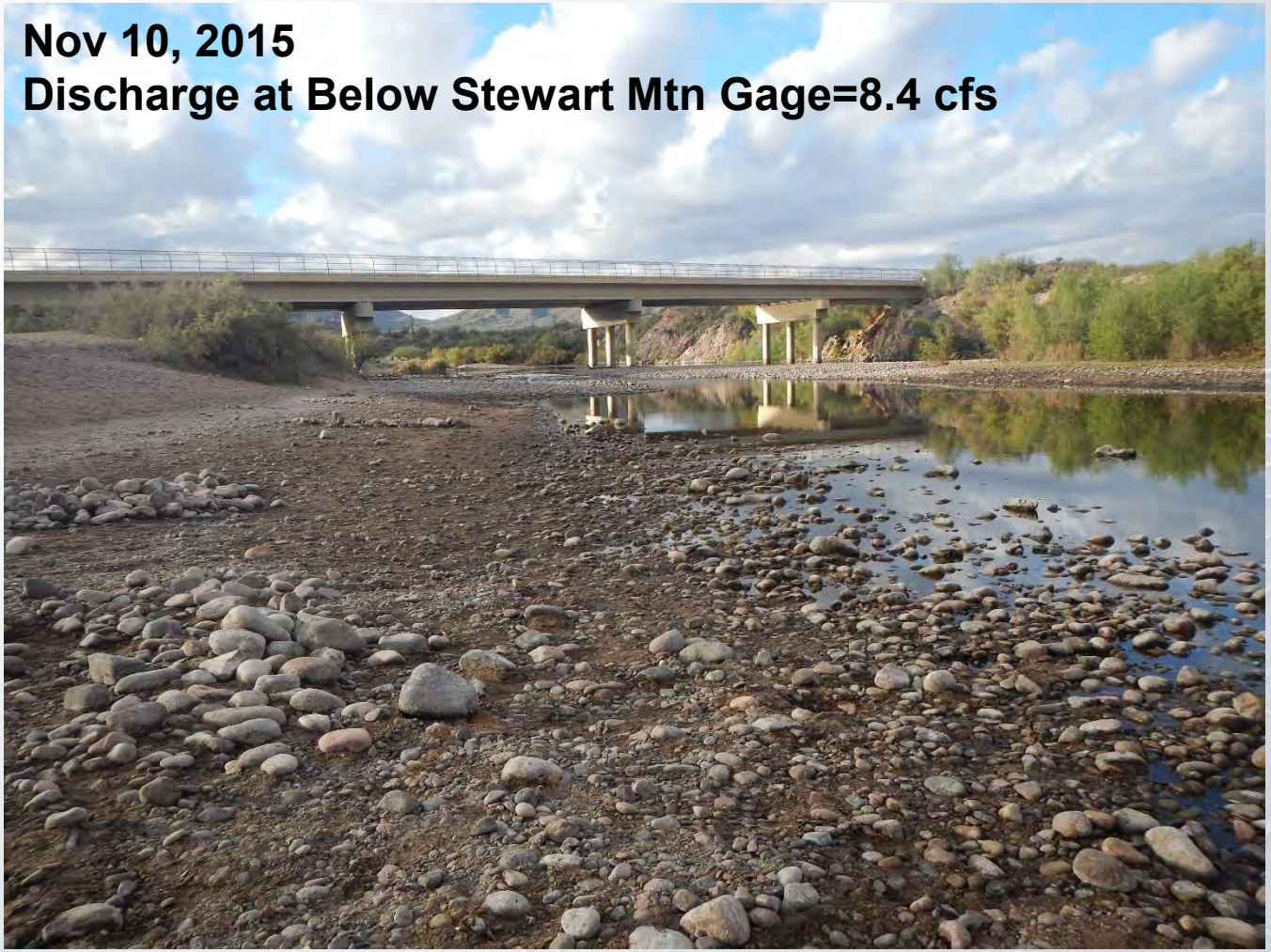
Sediment Storage in Roosevelt Reservoir



Upstream from Verde River (2010)

Upstream from Verde River (1934)

N Bush Highway Bridge
Upstream View



~0.25 mi Upstream from Sheep Bridge
Downstream View

Just upstream from Sheep Bridge
Upstream View

~0.2 mi Downstream from Sheep Bridge
Downstream View

~1.5 mi Downstream from N Bush Highway Bridge Downstream View

Foxtail Takeout
Upstream View

~200 yds Downstream from Foxtail Takeout
Upstream View

Adjacent to Blue Point Ranger Station
Upstream View

~0.5 mi Downstream from Blue Point Ranger Statiton Upstream View

Adjacent to Goldfield Ranch Recreation Site
Upstream View

~1 mi Upstream from Verde River
Downstream View

~0.6 mi Upstream from Verde River
Downstream View

Granite Reef Dam

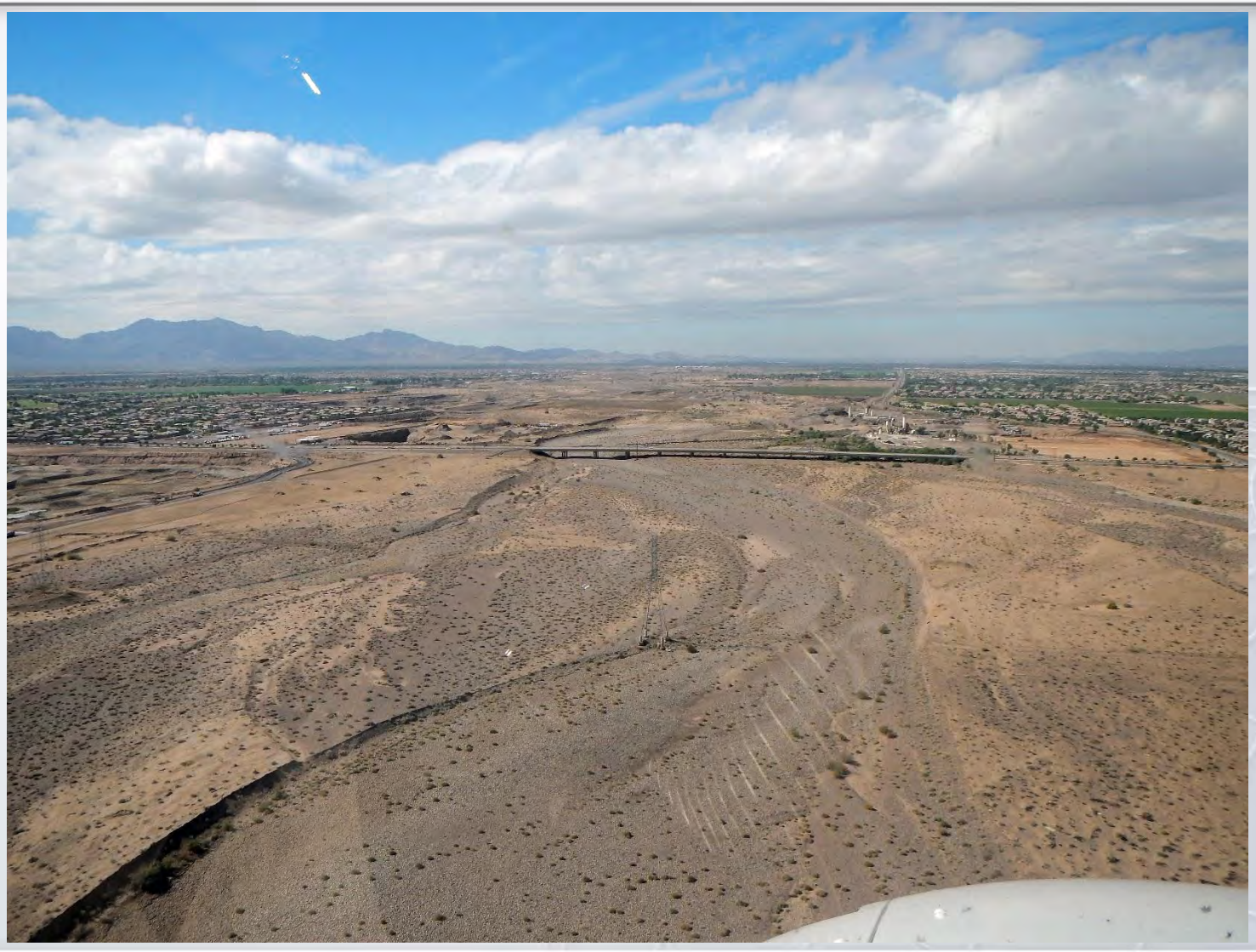
Upstream View (Oct 29, 2013)

Backwater Upstream from Granite Reef Dam
Upstream View (Oct 29, 2013)

LOWER SALT

SEGMENT 6

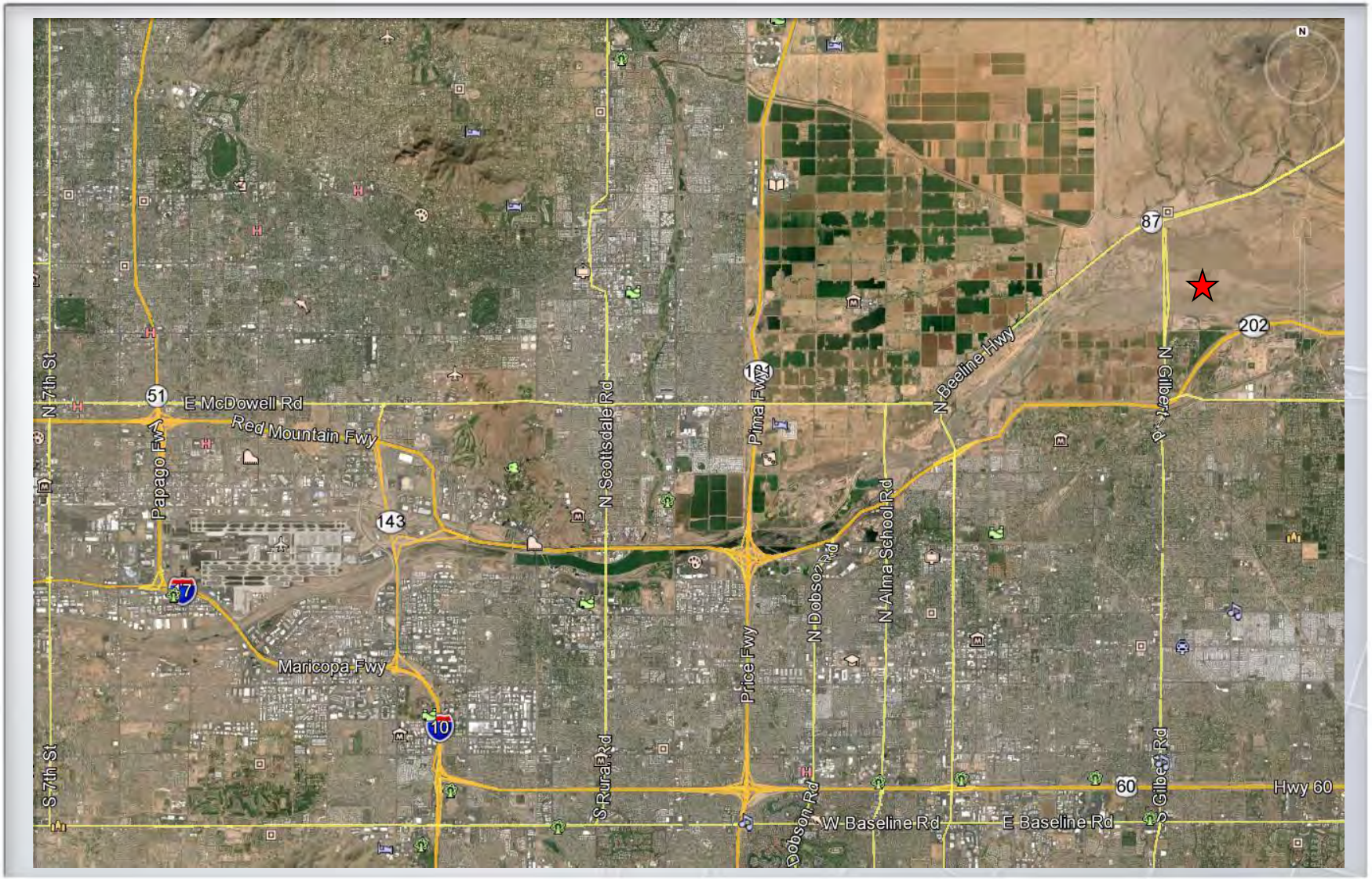
51st Ave
Downstream View (Oct 29, 2013)



51st Ave
Downstream View (Oct 29, 2013)

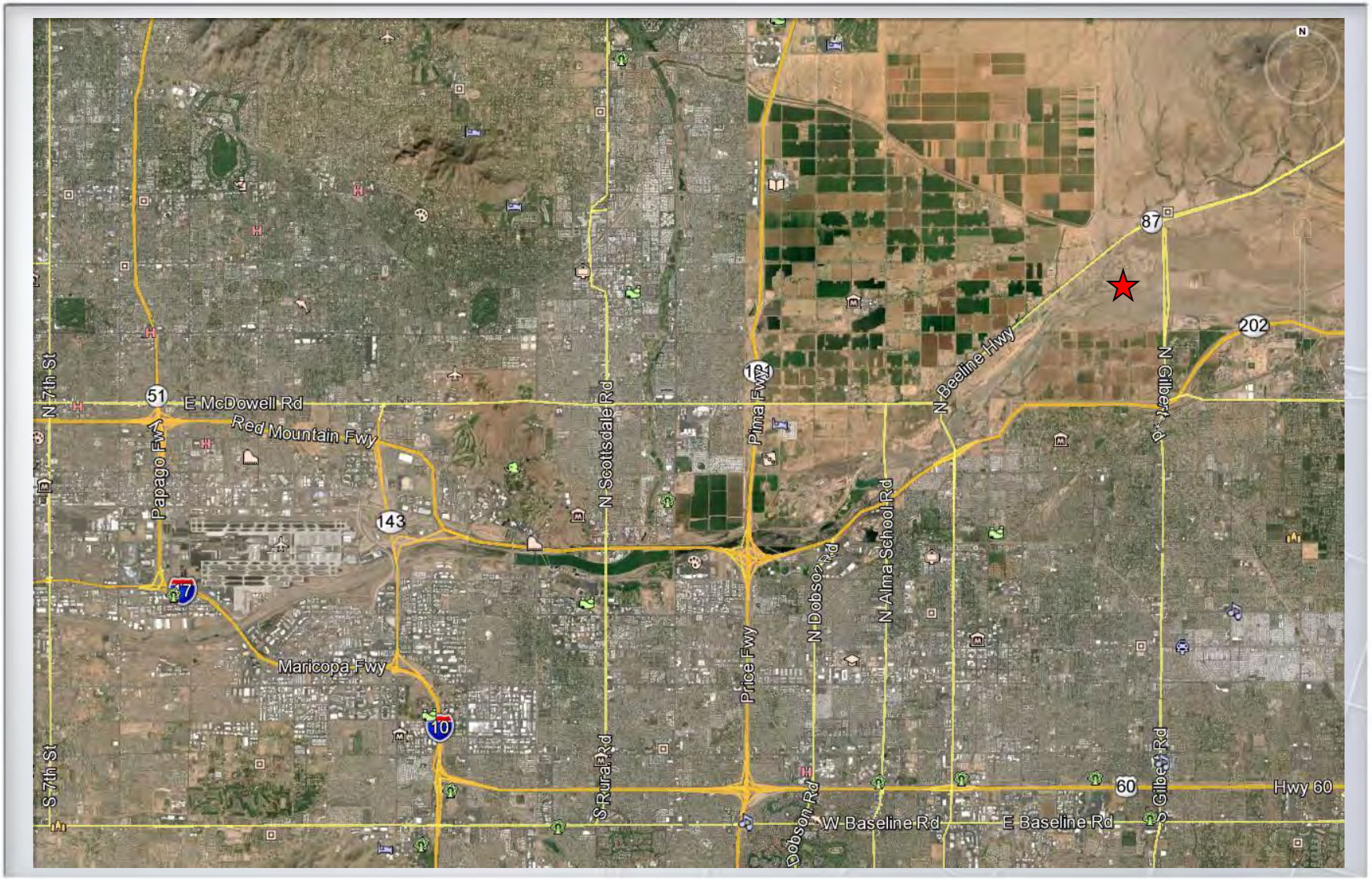
Downstream from 91st Ave
Downstream View (Oct 29, 2013)

Section 30, T2N, R6E (2015)



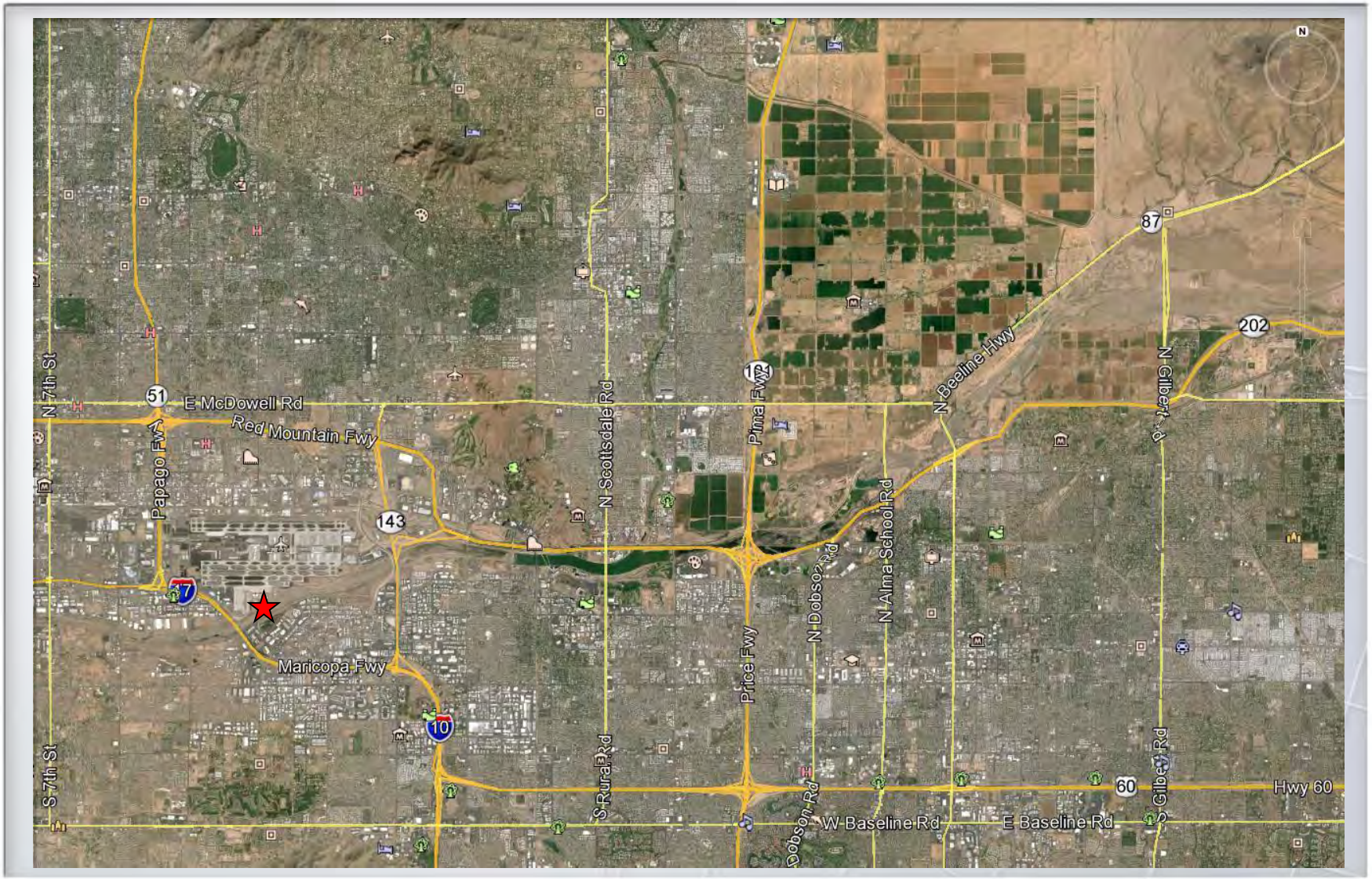
Section 30, T2N, R6E (1934)

Section 25, T2N, R5E (2015)

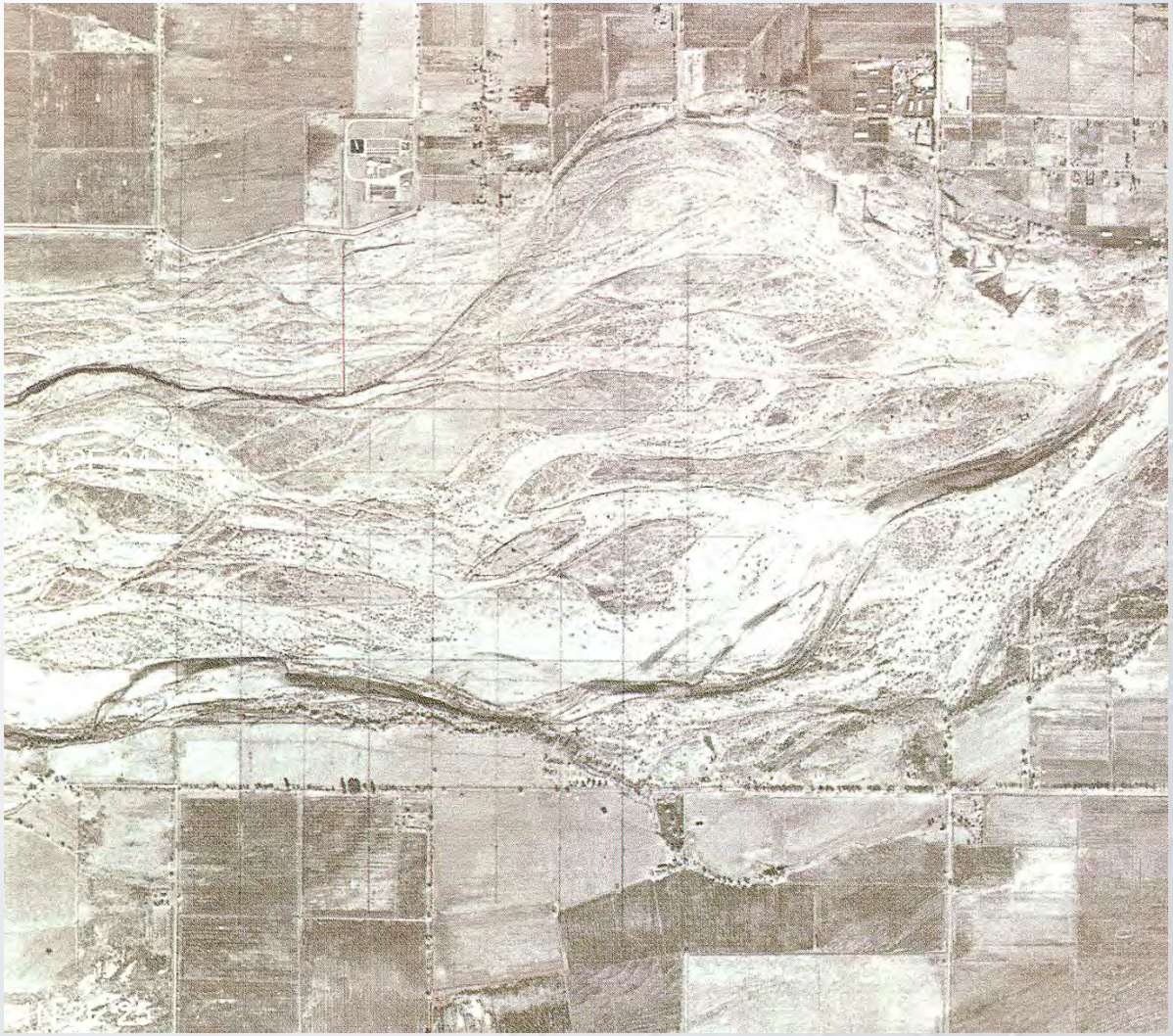


Section 25, T2N, R5E (2002)

Section 24, T1N, R2E (2015)

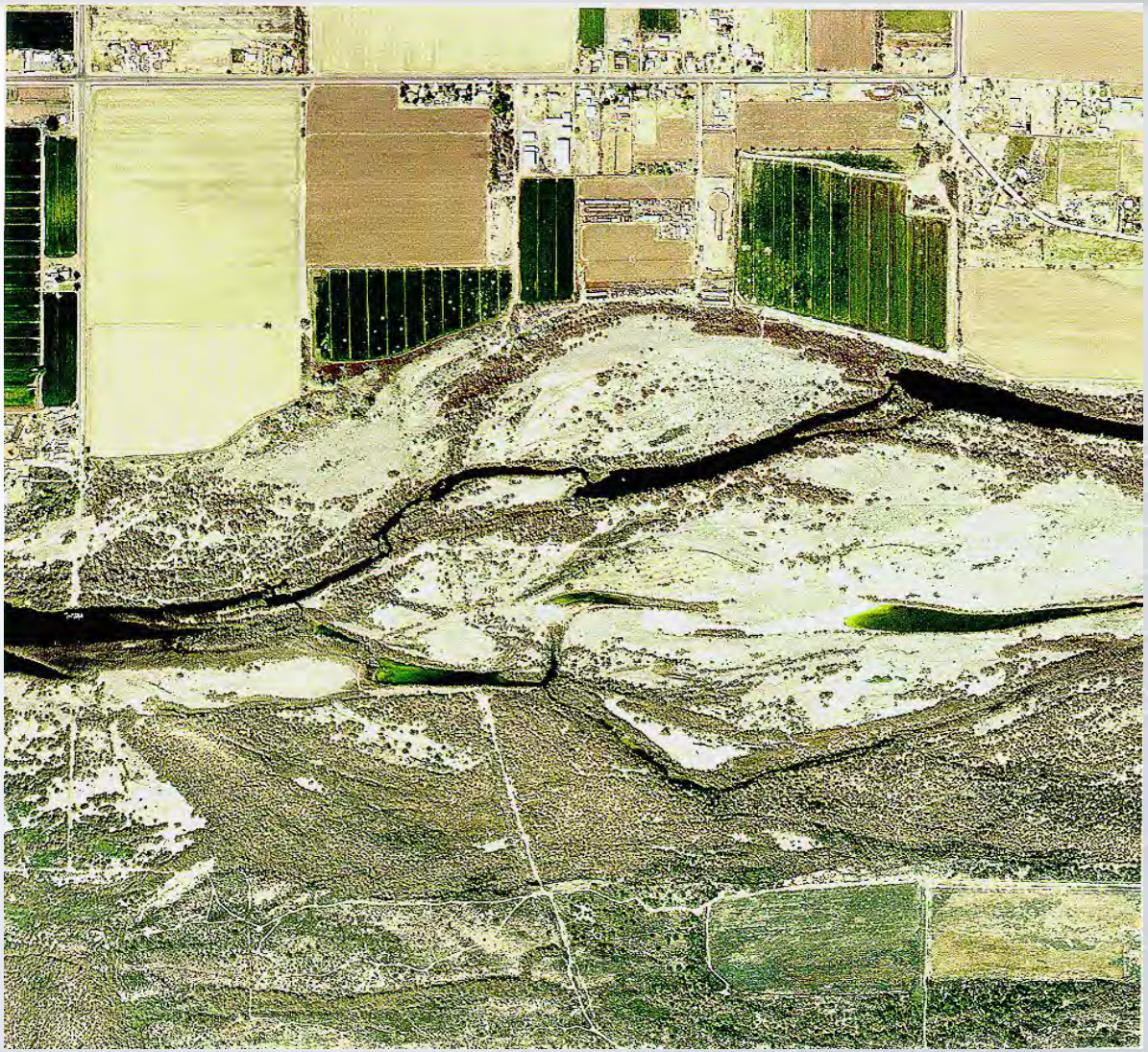


Section 24, T1N, R2E (1934)

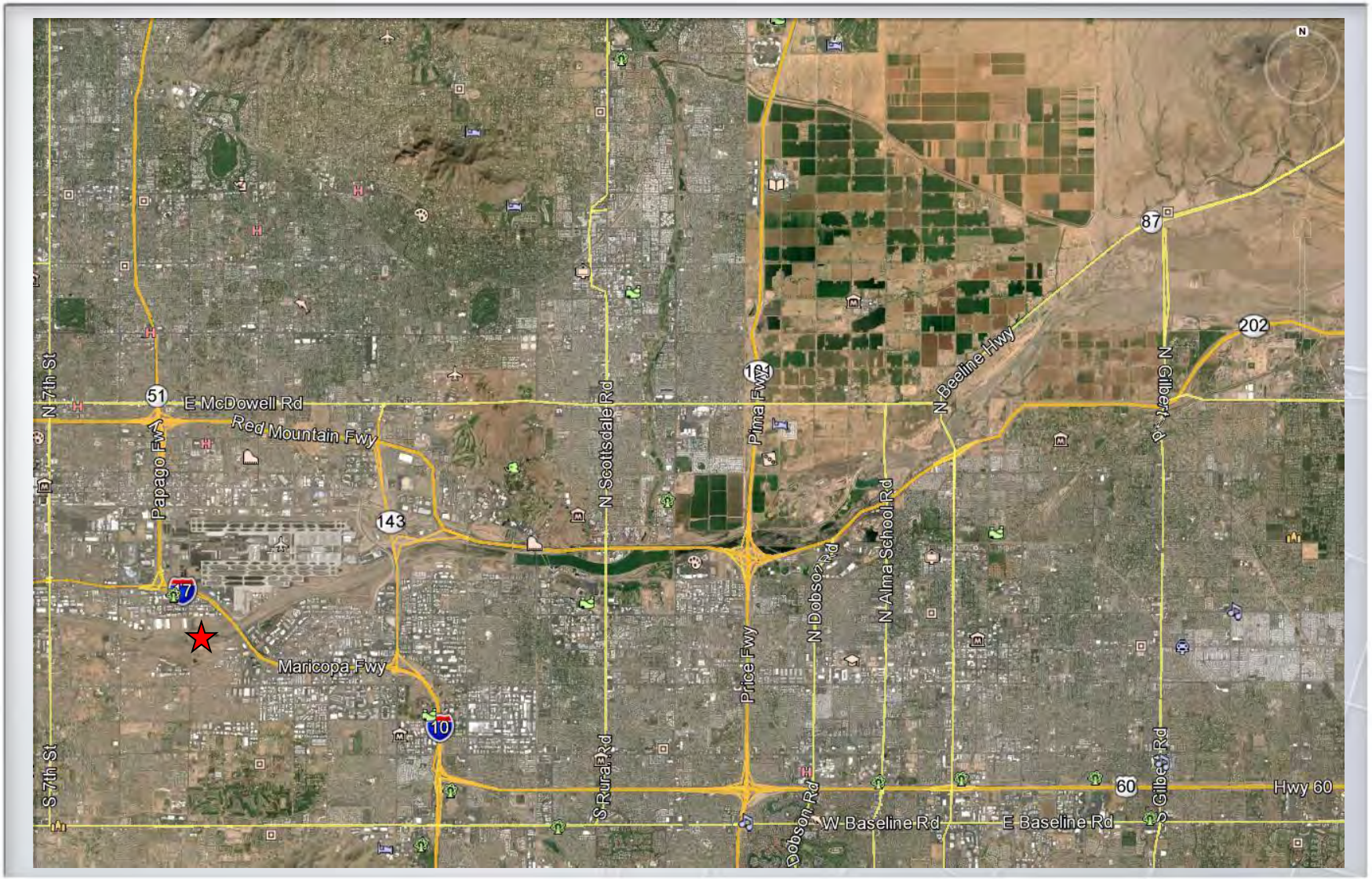


Section 32, T1N, R1E (2015)

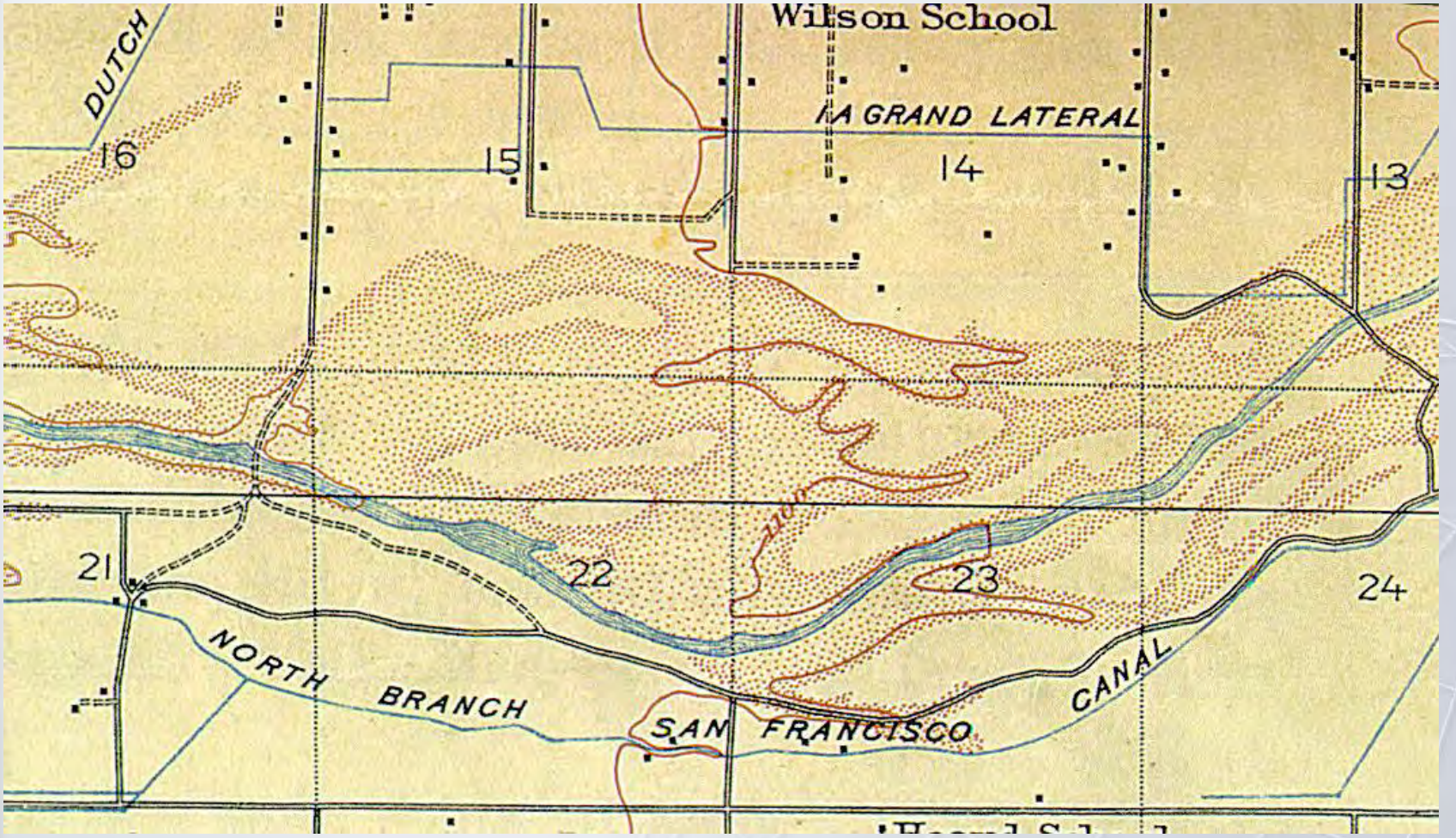
Section 32, T1N, R1E (2002)



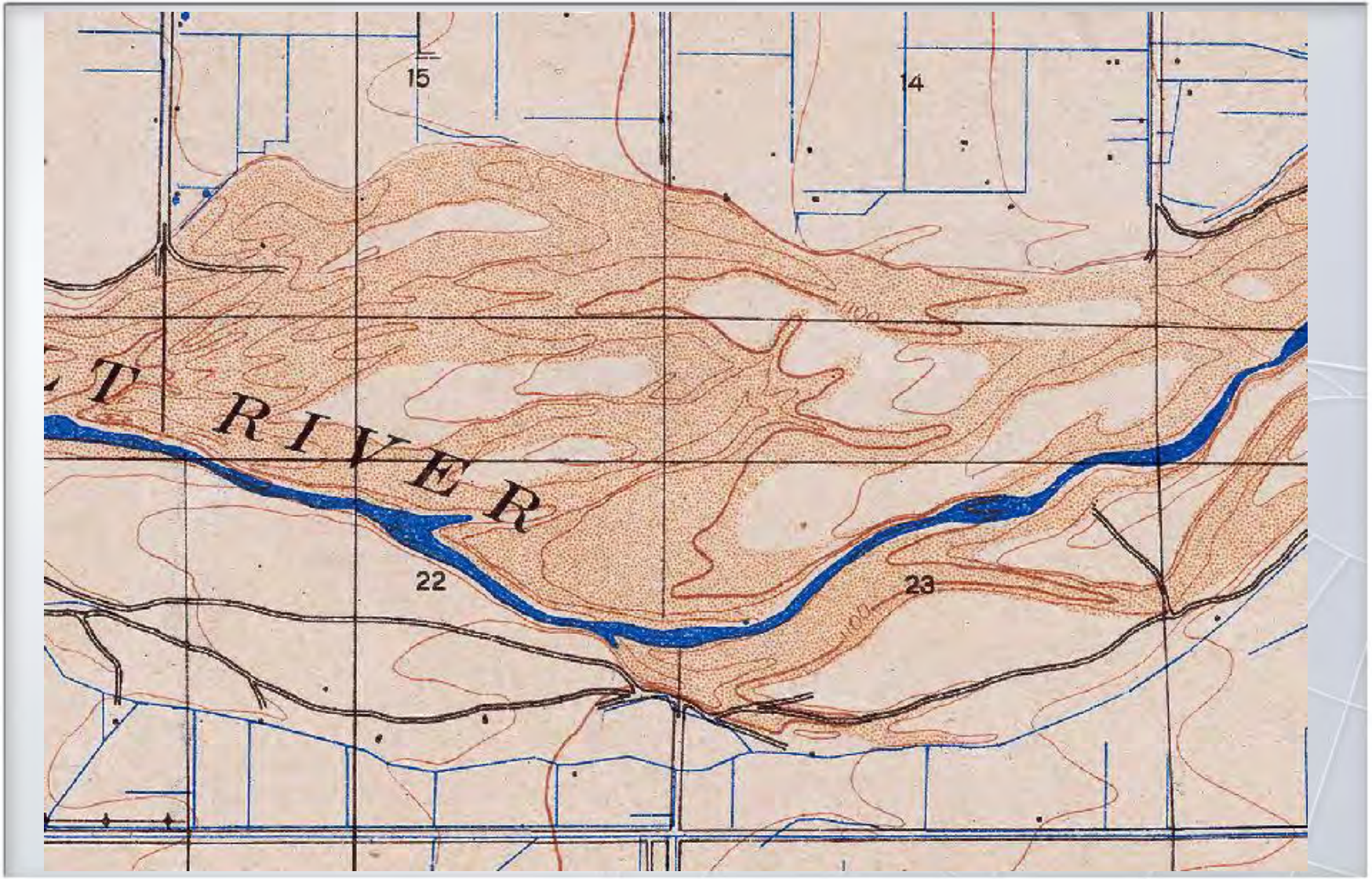
T1N R3&4E (2015)



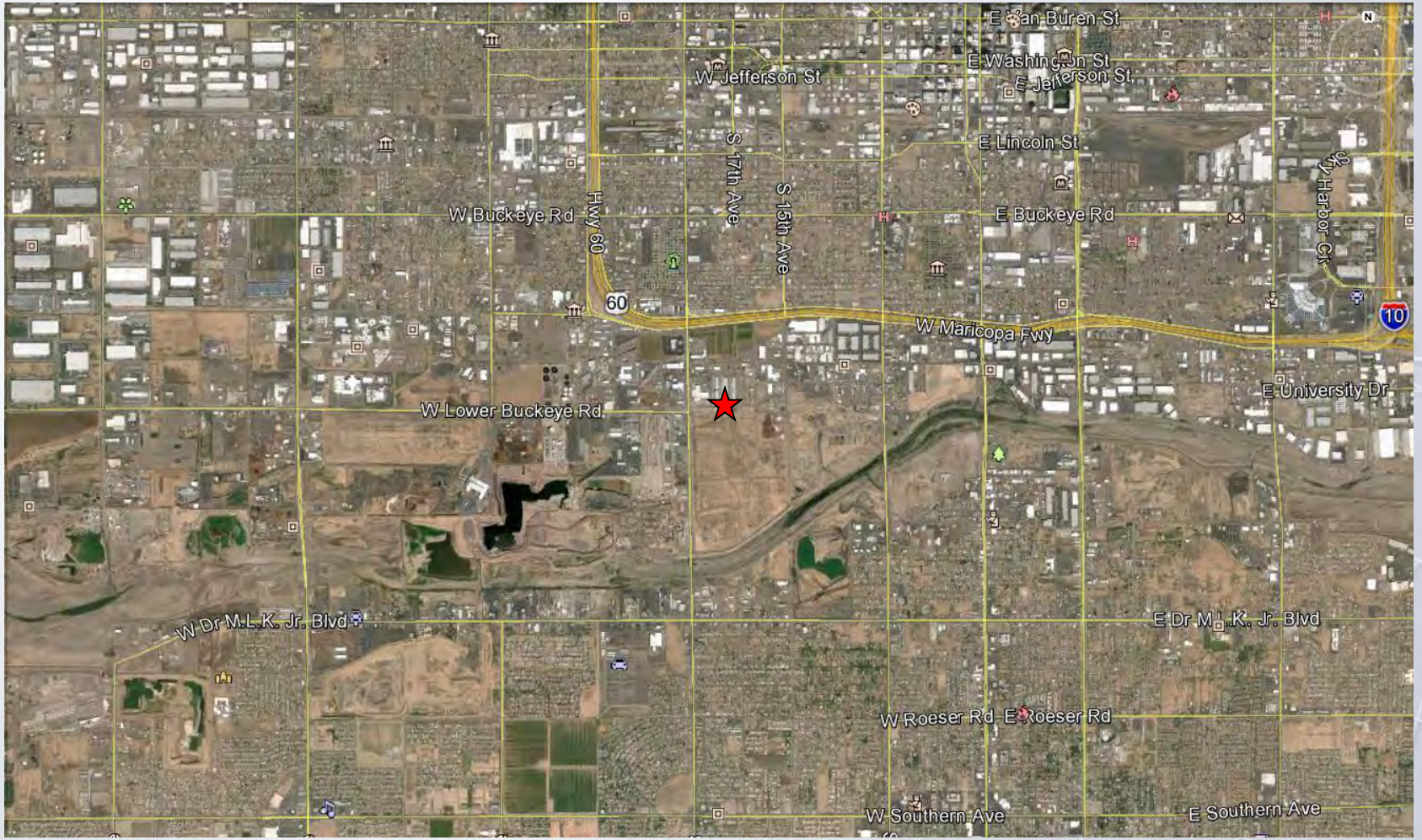
T1N R3E (USGS, 1903-4,1912)



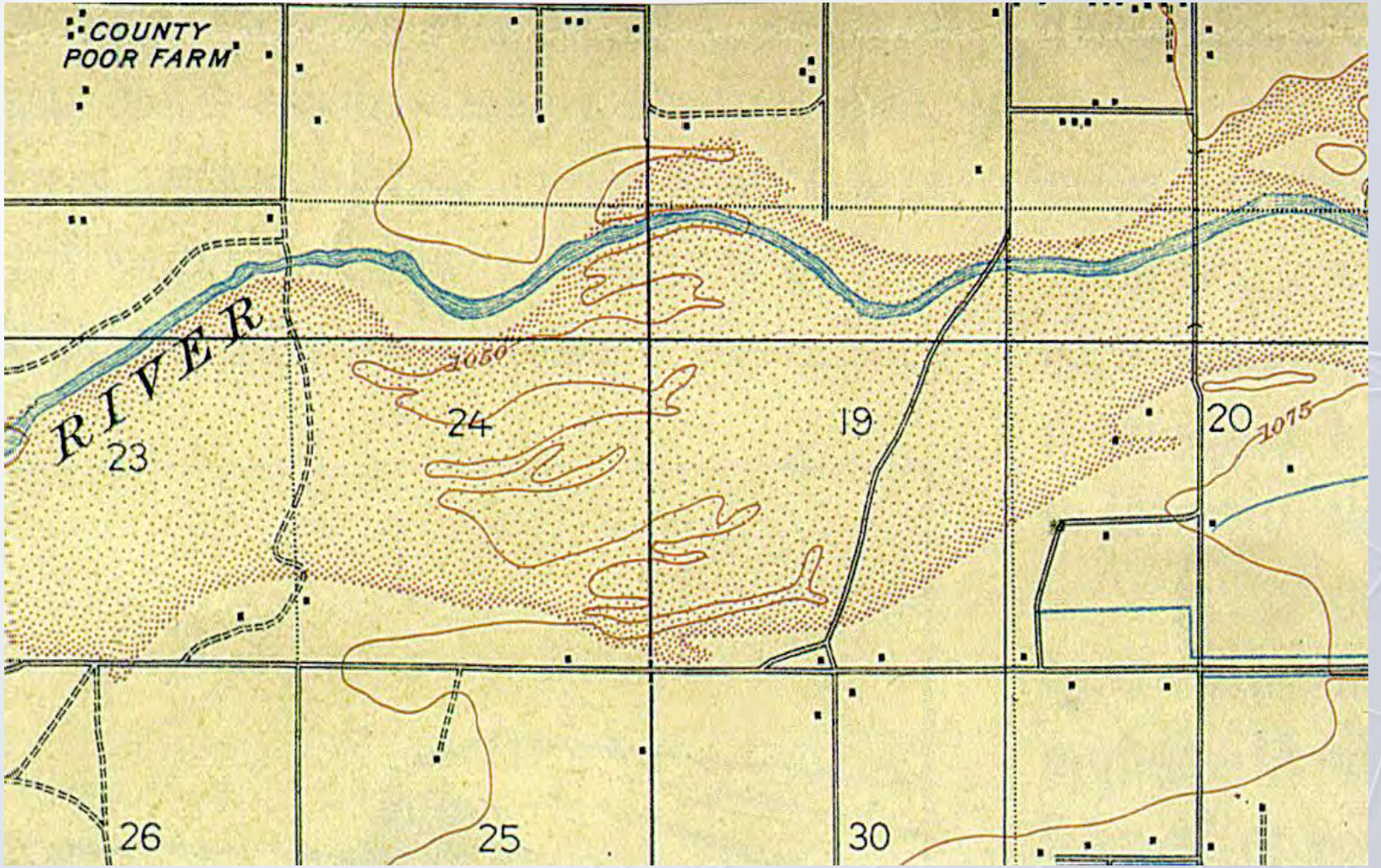
T1N R3E (USGS, 1902-3)



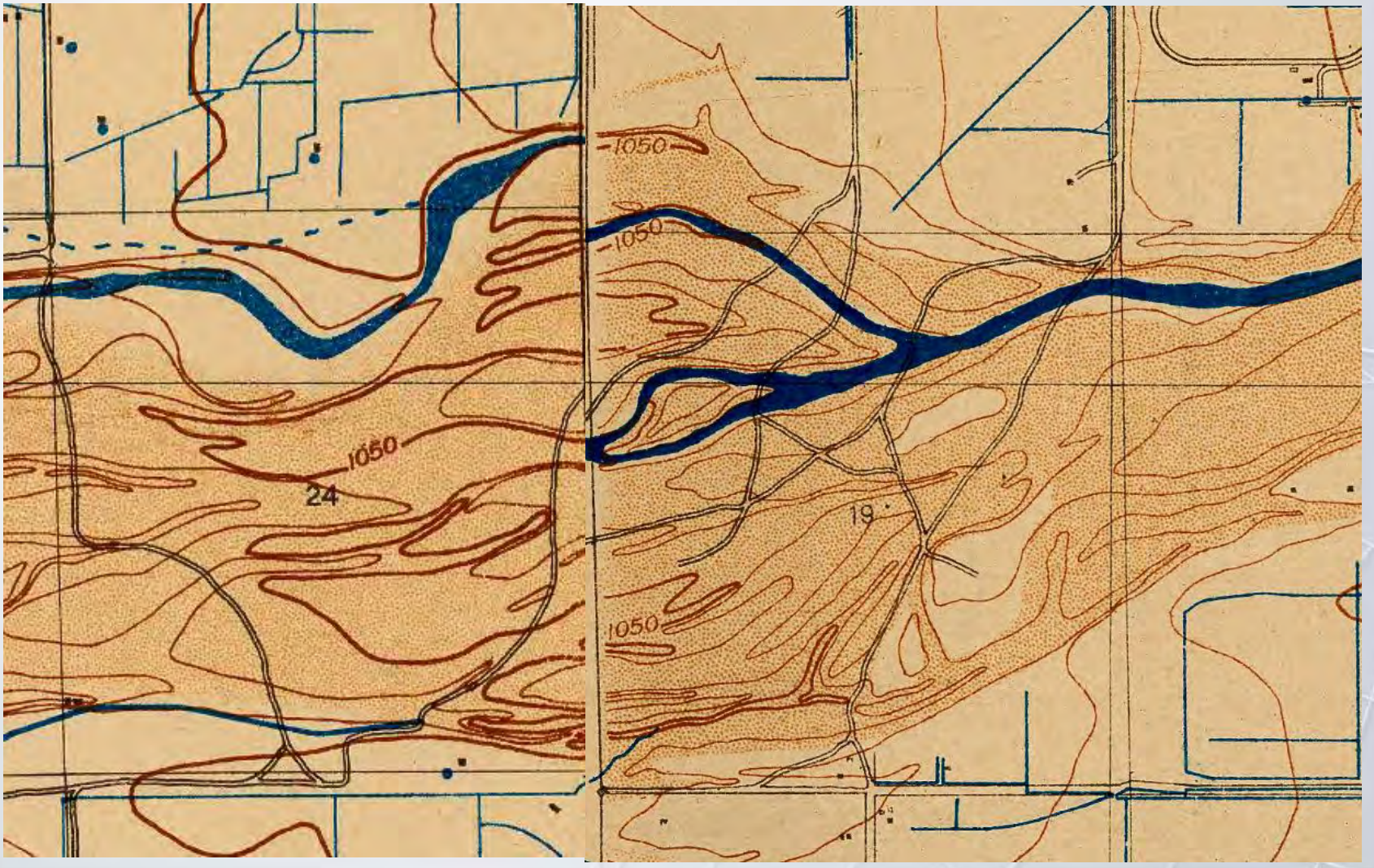
T1N R2&3E (2015)



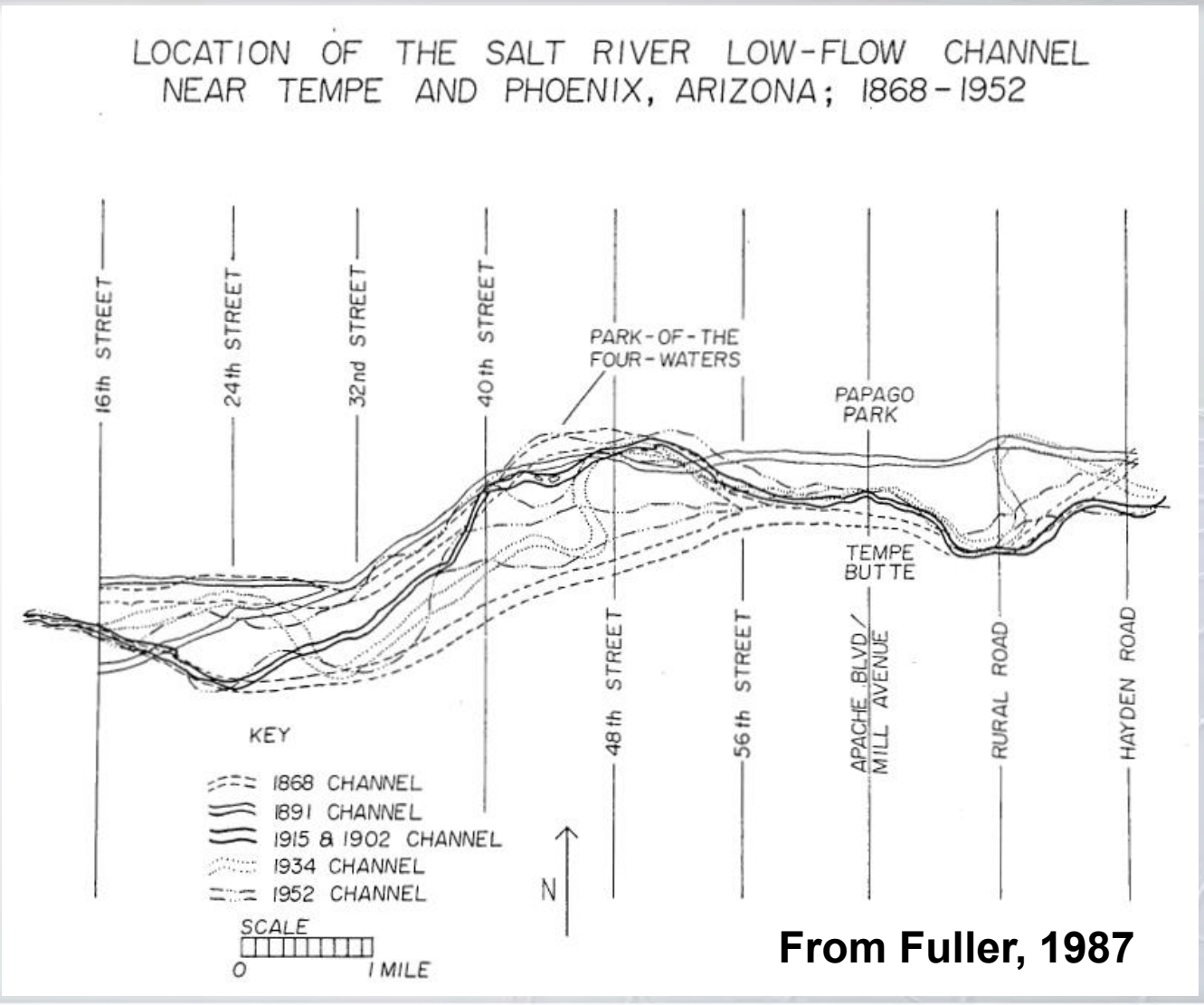
T1N R2&3E (1902-3)



T1N R2&3E (1902-3)



Low-flow Channel Margins (1868 – 1982)



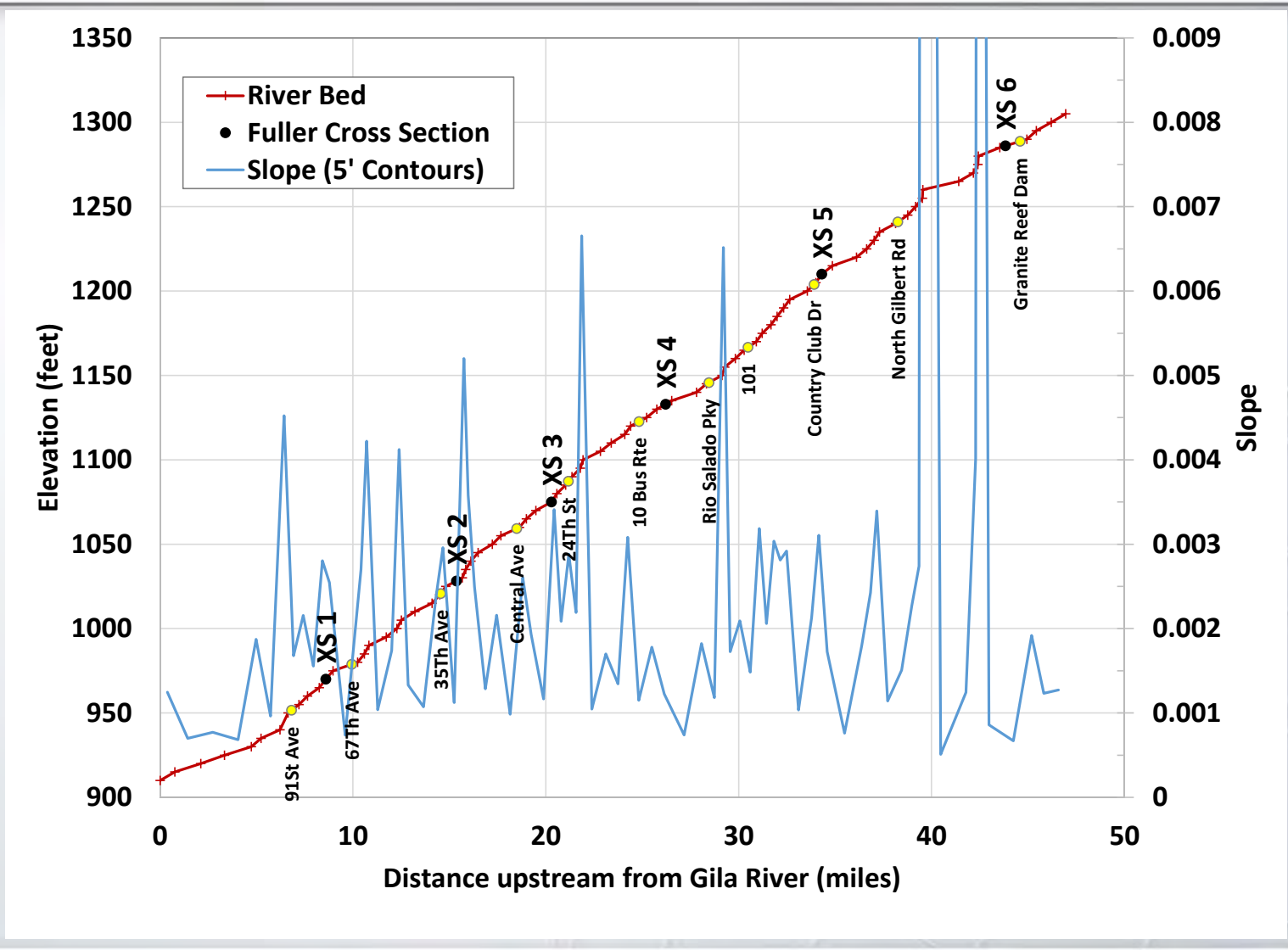
From Fuller, 1987

Fuller Hydraulic Estimates

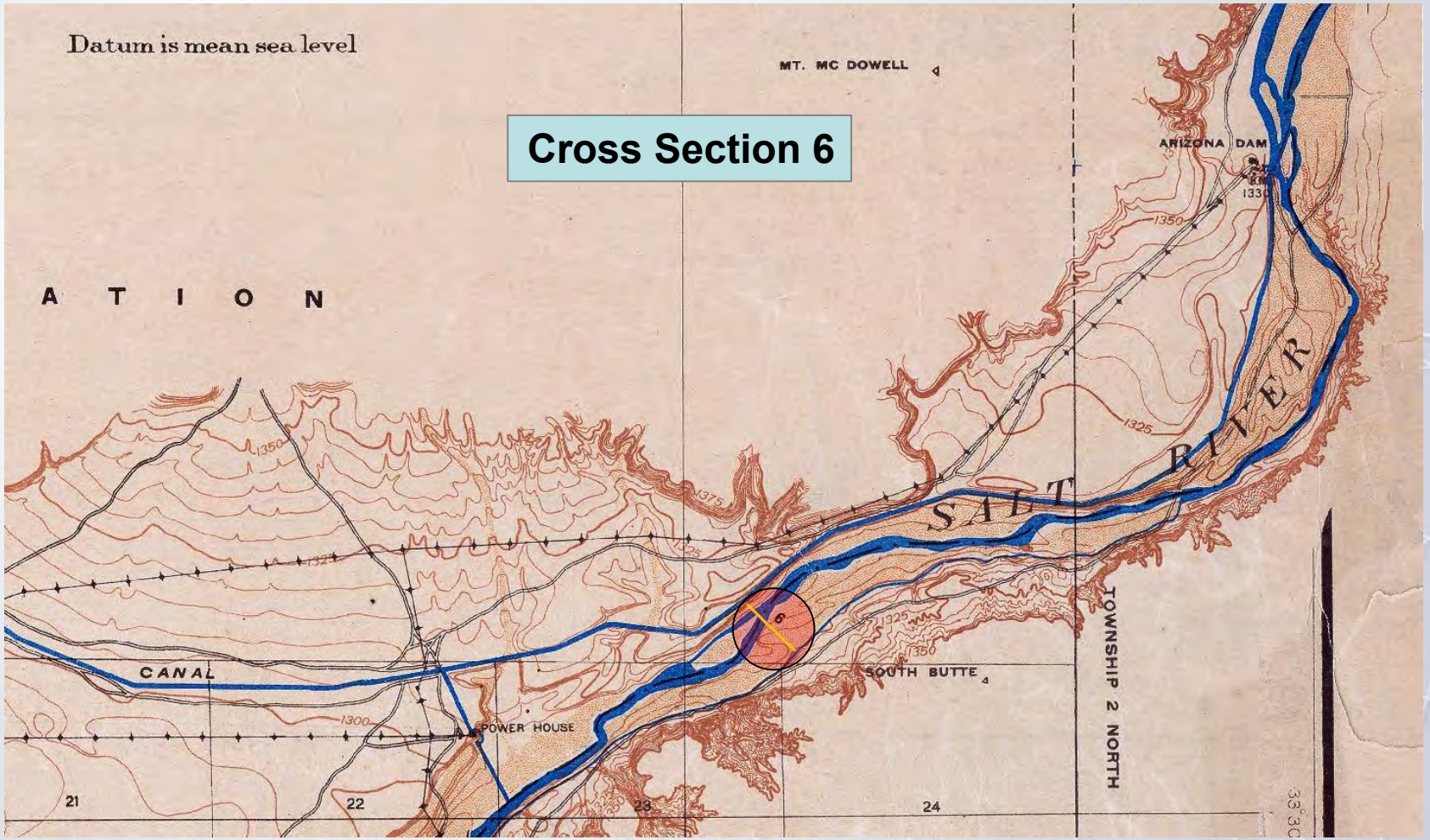
Salt River: Rating Curve Segment 5, Alluvial Channel				
Flow Frequency	Flow Rate (cfs)	Avg Depth (ft)	Average Velocity (ft/s)	Top Width (ft)
90%	>159	1.4	1.4	175
50% (median)	992	3.8	2.5	215
10%	>2120	> 5	> 3	> 300

Salt River: Rating Curve Segment 6, Alluvial Channel				
Flow Frequency	Flow Rate (cfs)	Avg Depth (ft)	Average Velocity (ft/s)	Top Width (ft)
90%	277	0.8	1.7	205
50% (median)	1,230*	5.3	2.1	290
10%	3,062	> 6	> 3	> 300

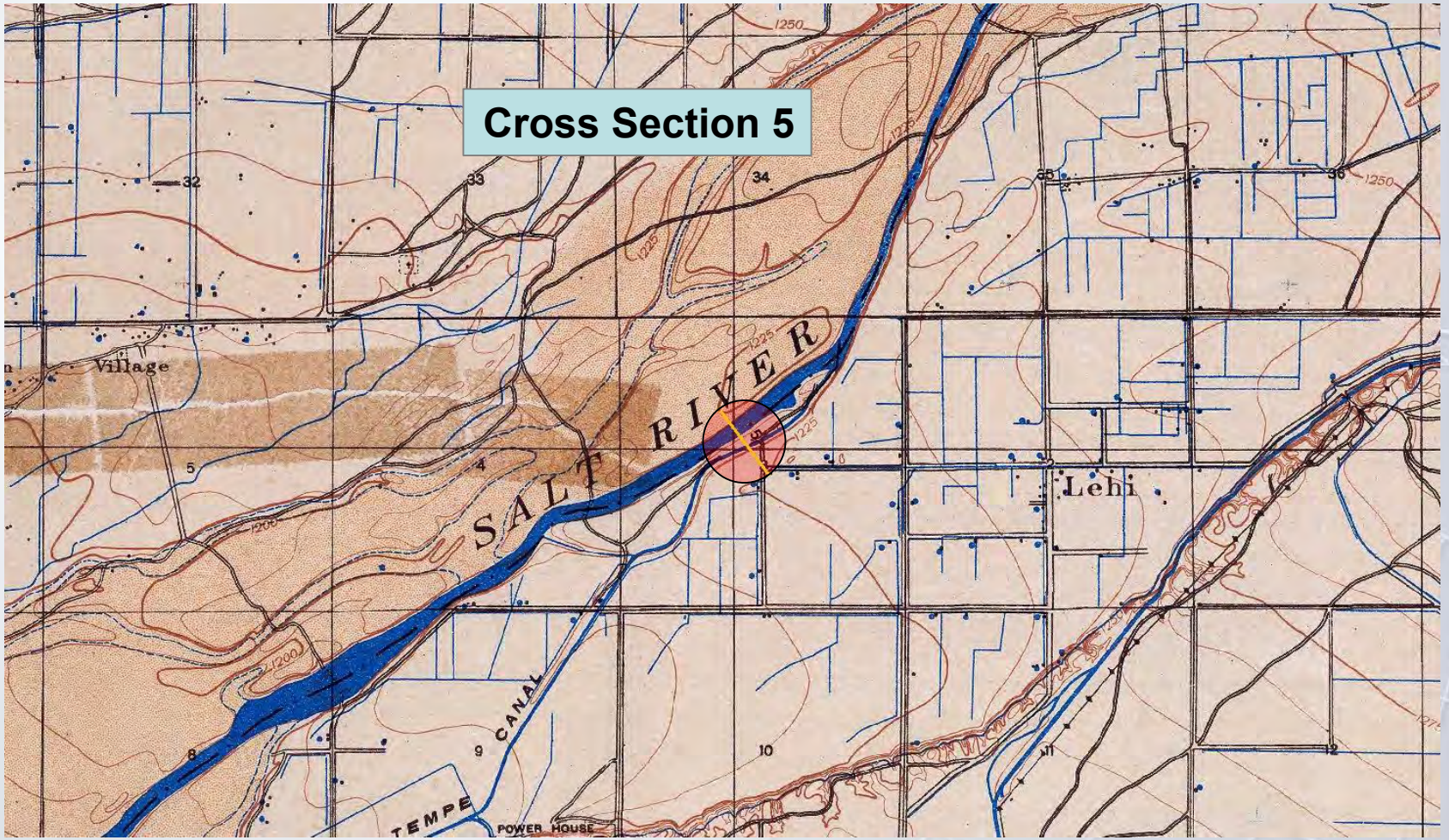
Segment 6 1902-03 Profile and Slopes



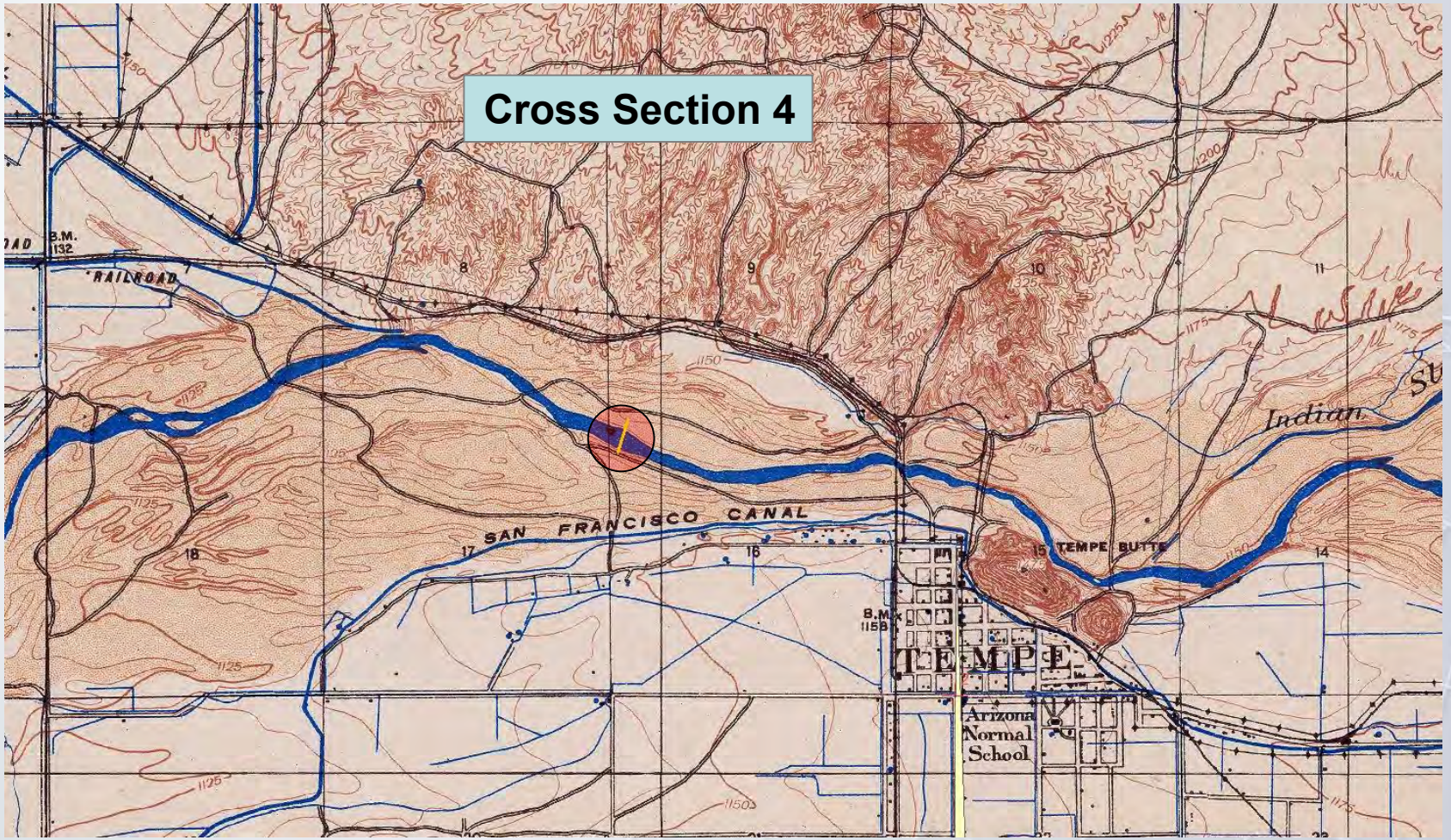
USRS 1902-3 5’ Contour Interval Map



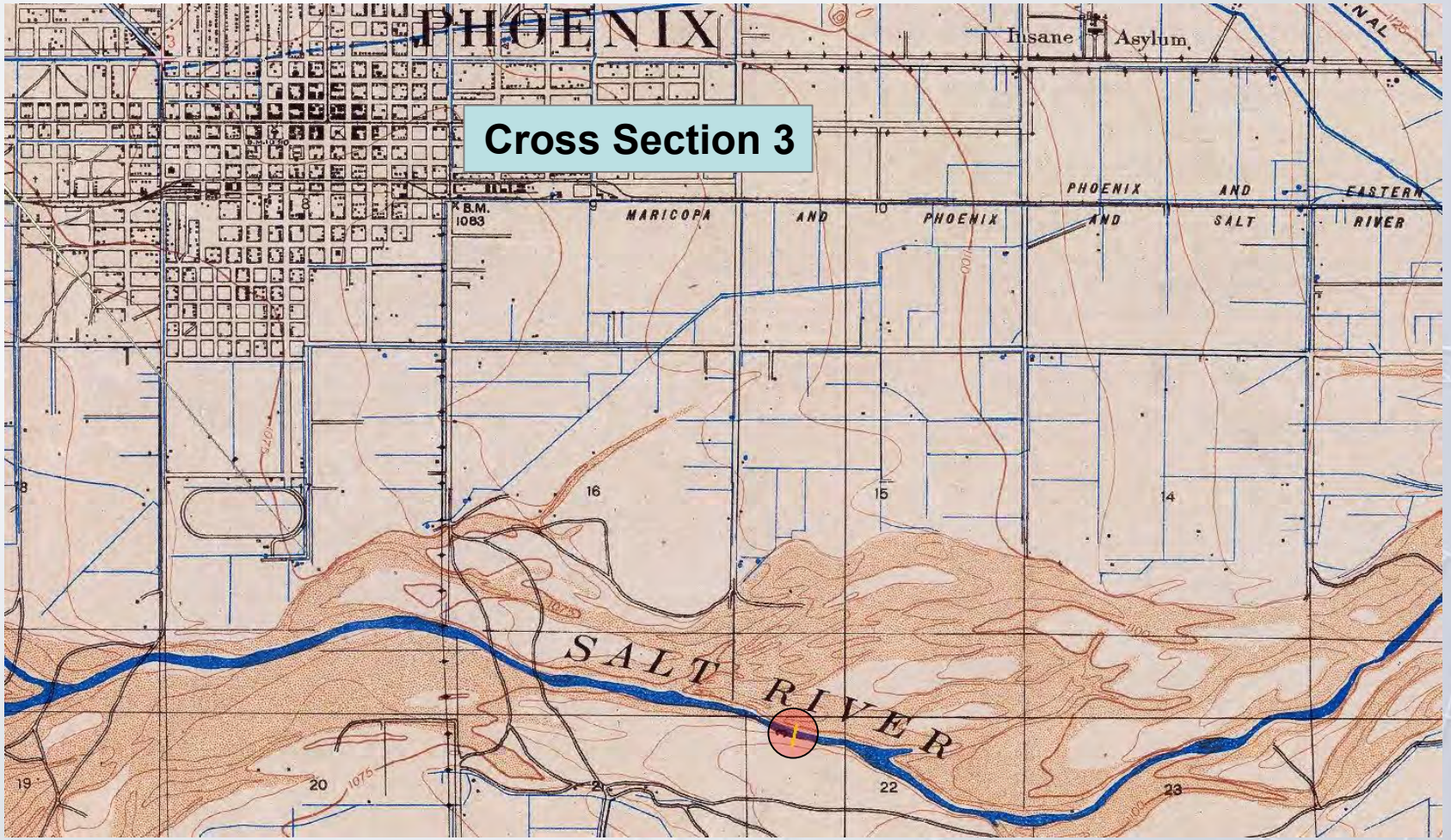
USRS 1902-3 5’ Contour Interval Map



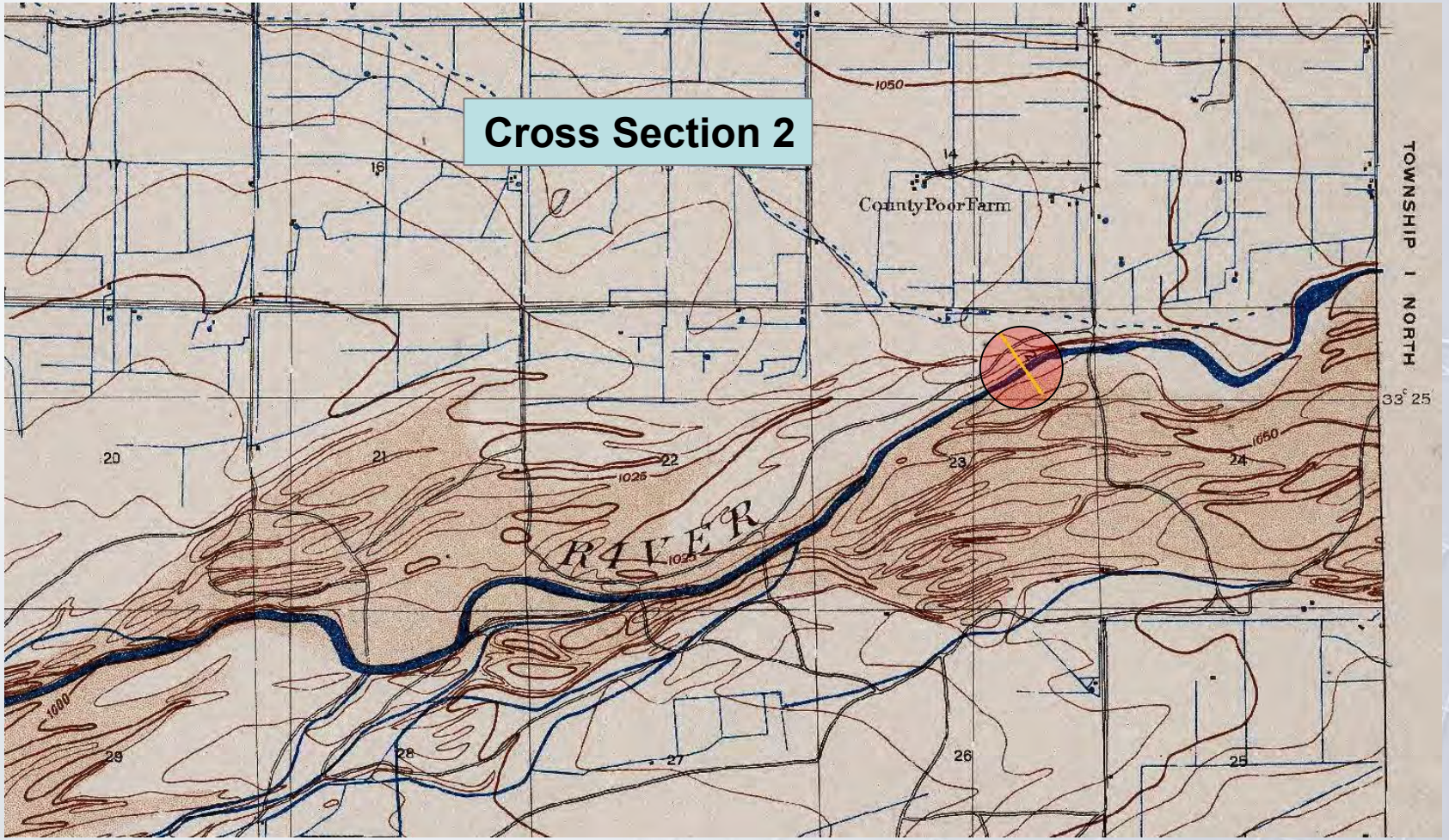
USRS 1902-3 5’ Contour Interval Map



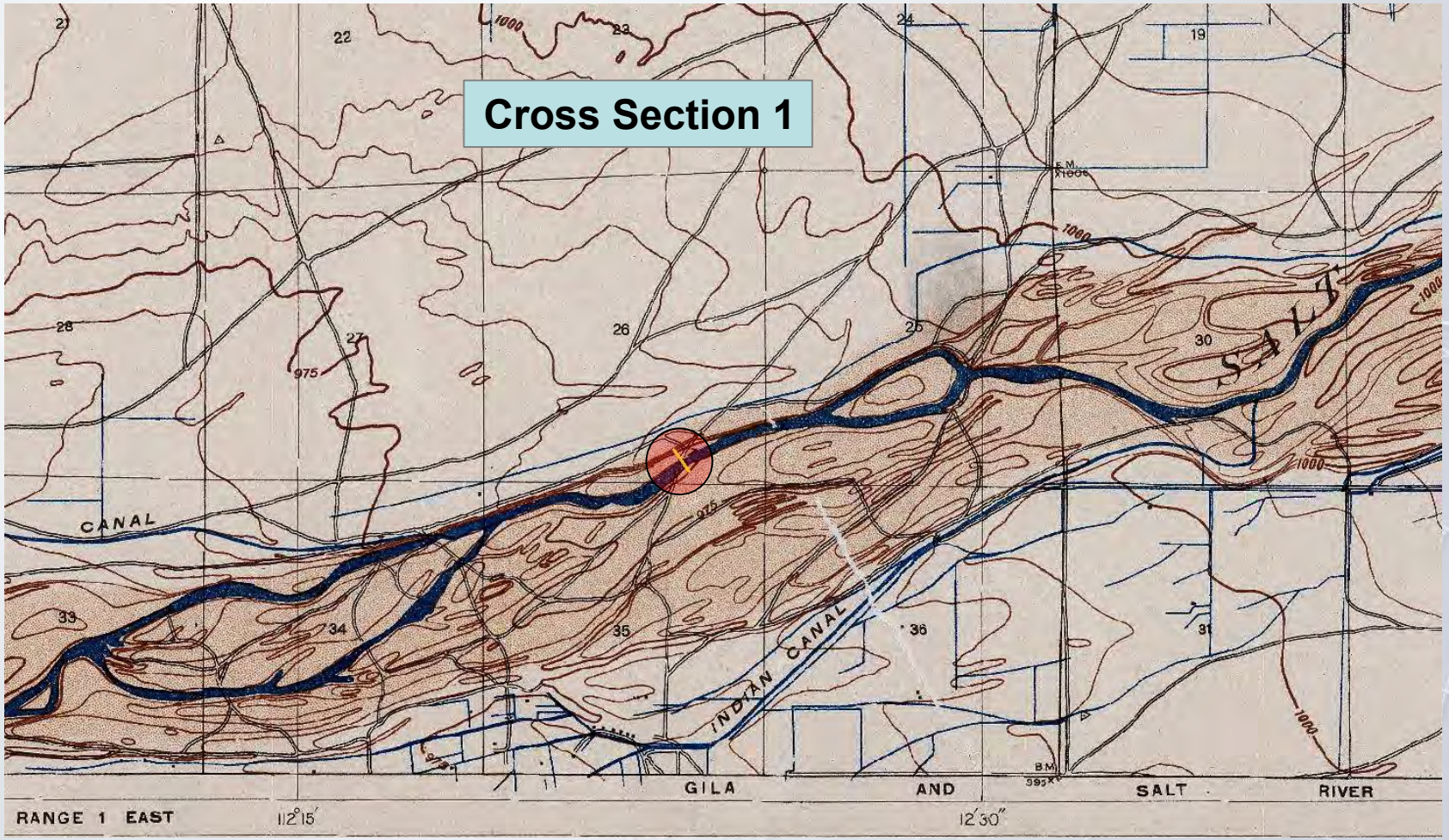
USRS 1902-3 5’ Contour Interval Map



USRS 1902-3 5’ Contour Interval Map



USRS 1902-3 5’ Contour Interval Map



Manning Equation

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Q=Discharge (cfs)

n = Manning Roughness Coefficient

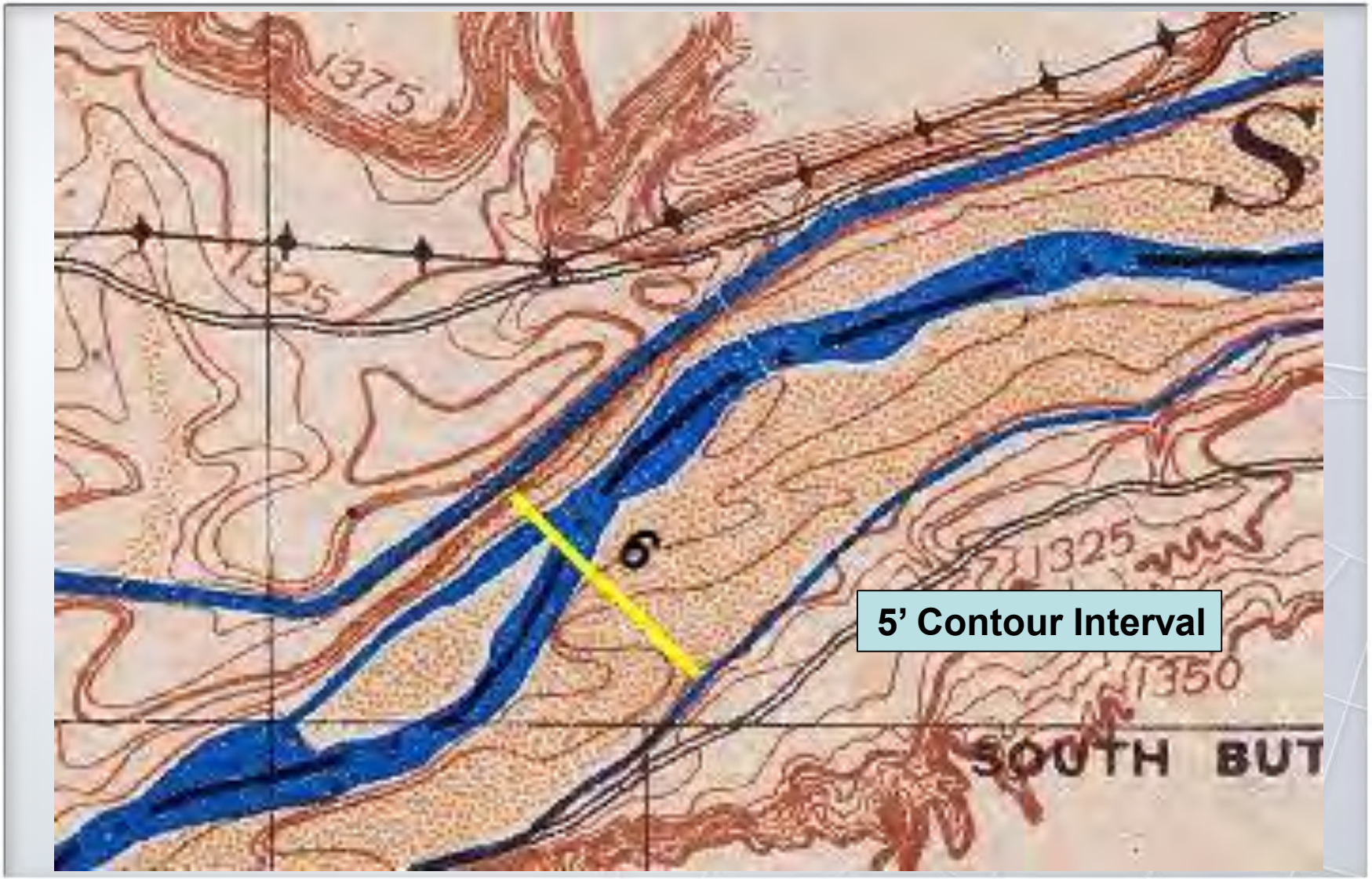
= 0.045 (Fuller, 2003)

A = Cross Sectional Area (ft^2)

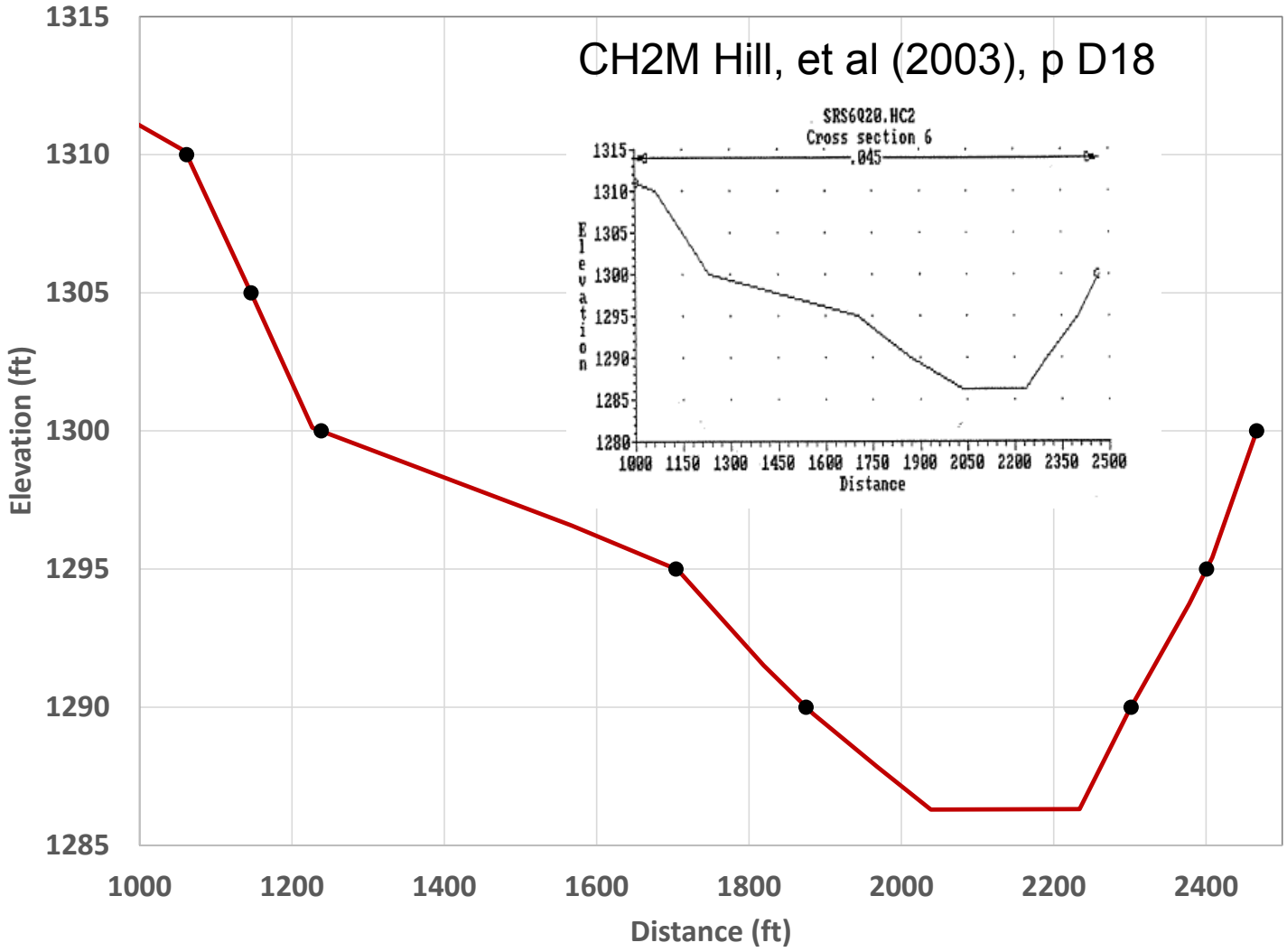
R = Hydraulic Radius = A/Wetted Perimeter (ft)

S = Slope

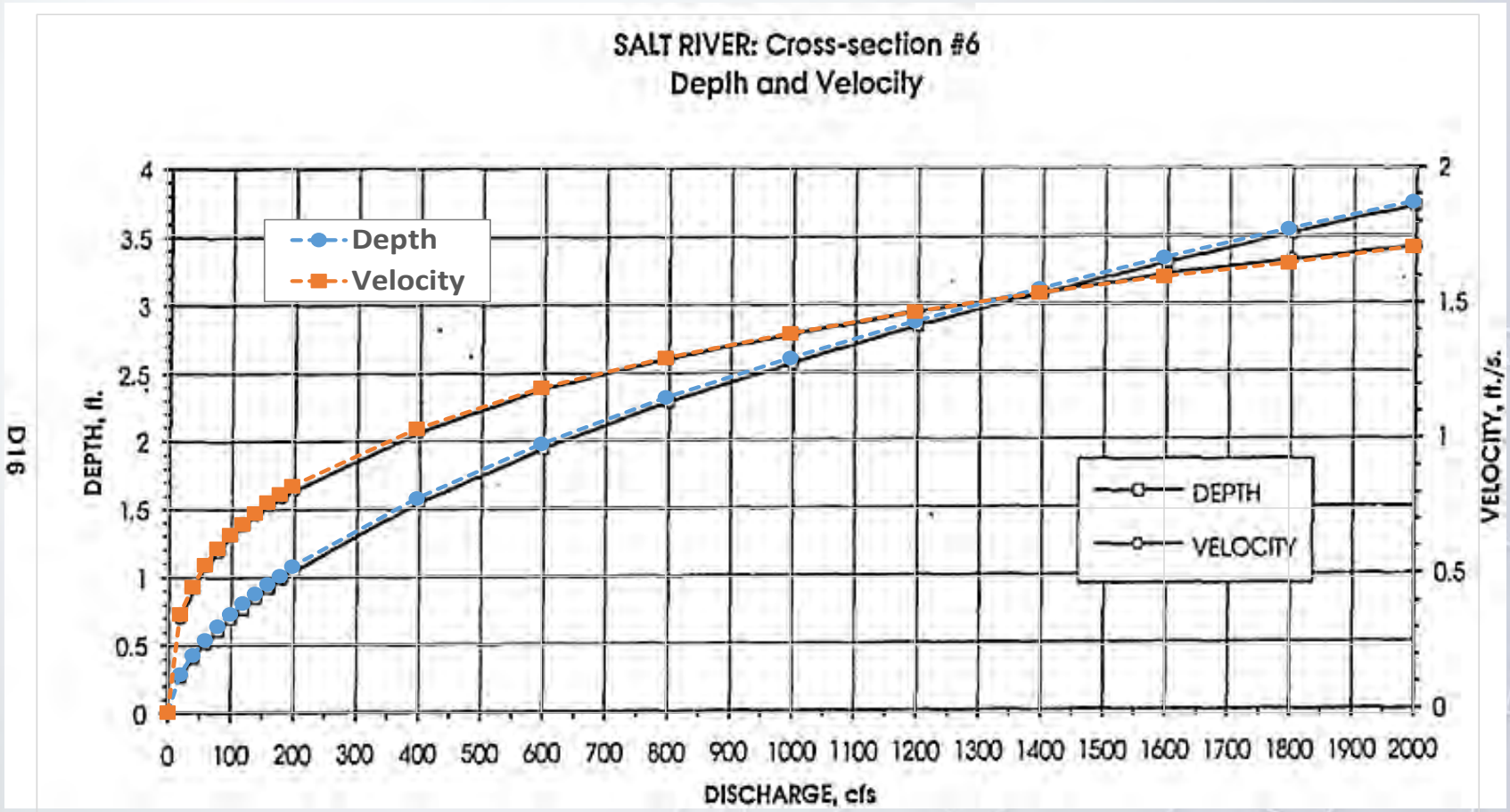
Fuller Cross Section 6



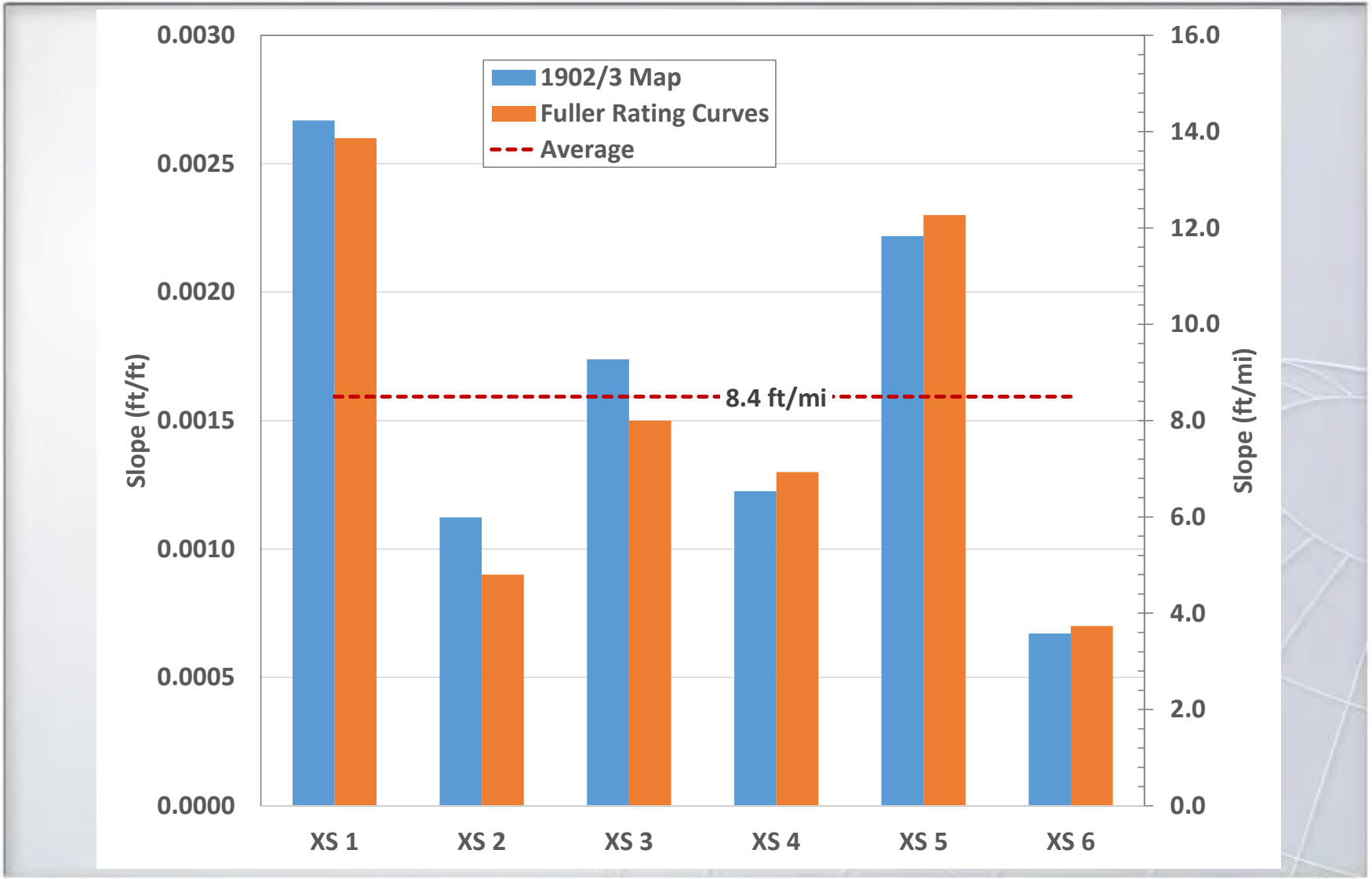
Fuller Cross Section 6



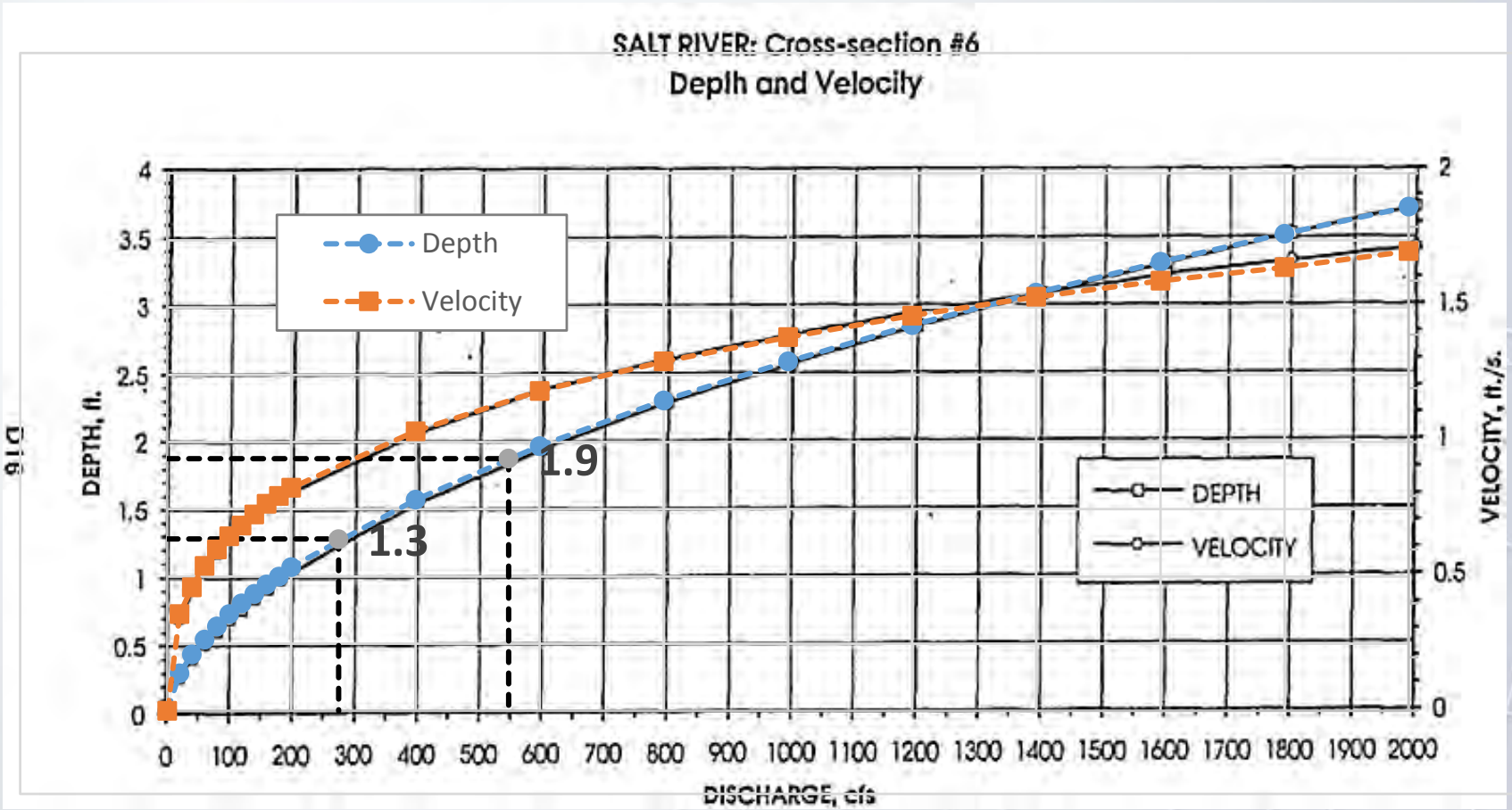
Fuller Cross Section 6

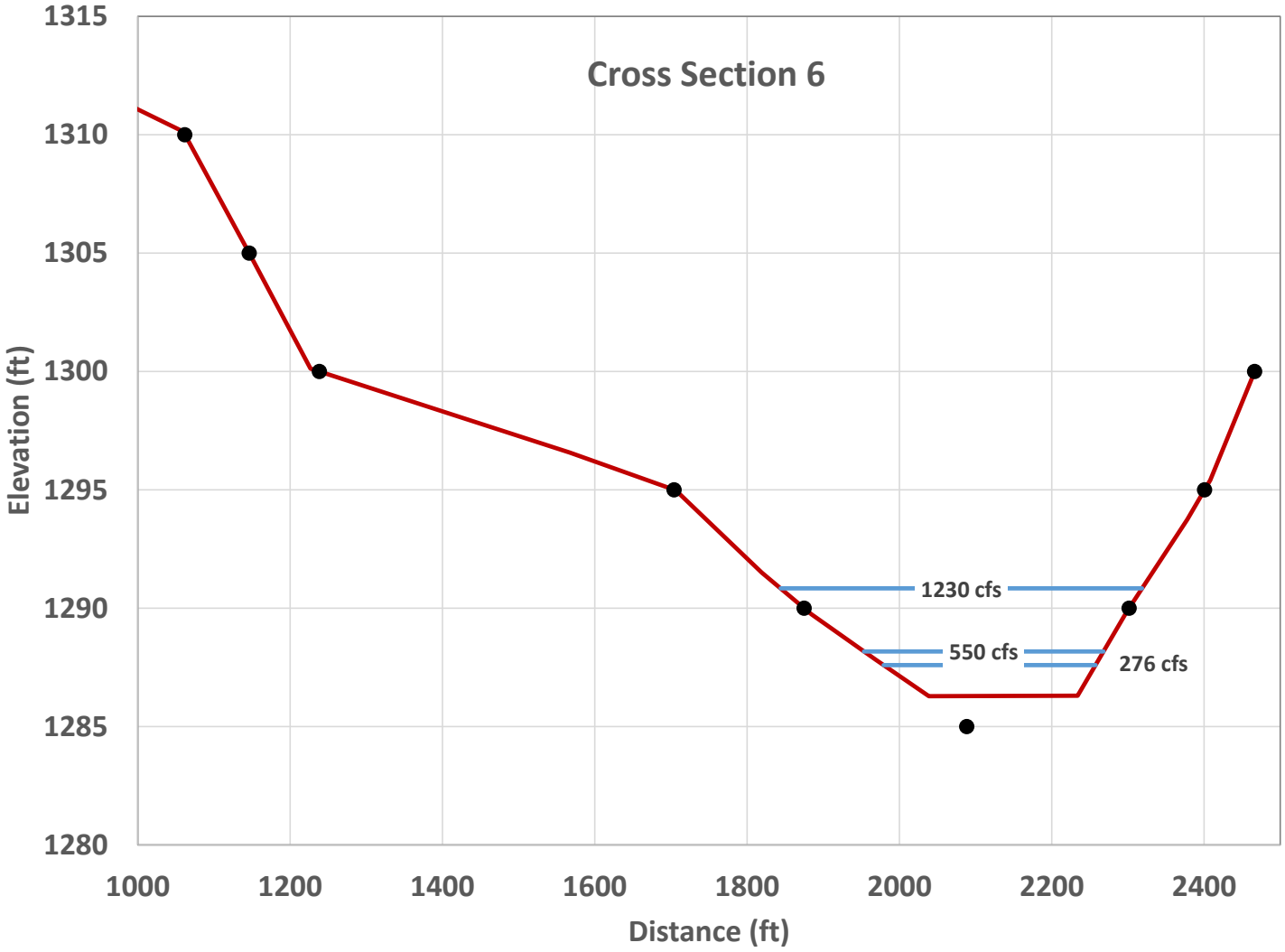


Slopes at Fuller Cross Sections



Fuller Cross Section 6




Cross Section 6
Elevation (ft)
1315
1310
1305
1300
1295
1290
1285
1280
1000
1200
1400
1600
1800
2000
2200
2400
Distance (ft)
1230 cfs
550 cfs
276 cfs

Fuller Hydraulic Estimates

Salt River: Rating Curve Segment 5, Alluvial Channel									
Flow Frequency	Flow Rate (cfs)		Avg Depth (ft)		Average Velocity (ft/s)		Top Width (ft)	
90%	~~>159~~	160	~~1.4~~	1.3	~~1.4~~	0.9	~~175~~	280
50% (median)	~~992~~	348	~~3.8~~	1.5	~~2.5~~	1.0	~~215~~	290
10%	~~>2120~~	2,240	~~>5~~	4.7	~~>3~~	2.0	~~>300~~	480

Segment 5 Values Based on Cross Section 6

Salt River: Rating Curve Segment 6, Alluvial Channel									
Flow Frequency	Flow Rate (cfs)		Avg Depth (ft)		Average Velocity (ft/s)		Top Width (ft)	
90%	277		~~0.8~~	1.3	~~1.7~~	1.4	~~205~~	200
50% (median)	~~1,230~~*	554	~~5.3~~	1.9	~~2.1~~	1.8	~~290~~	230
10%	3,062		~~>6~~	4.7	~~>3~~	2.9	~~>300~~	340

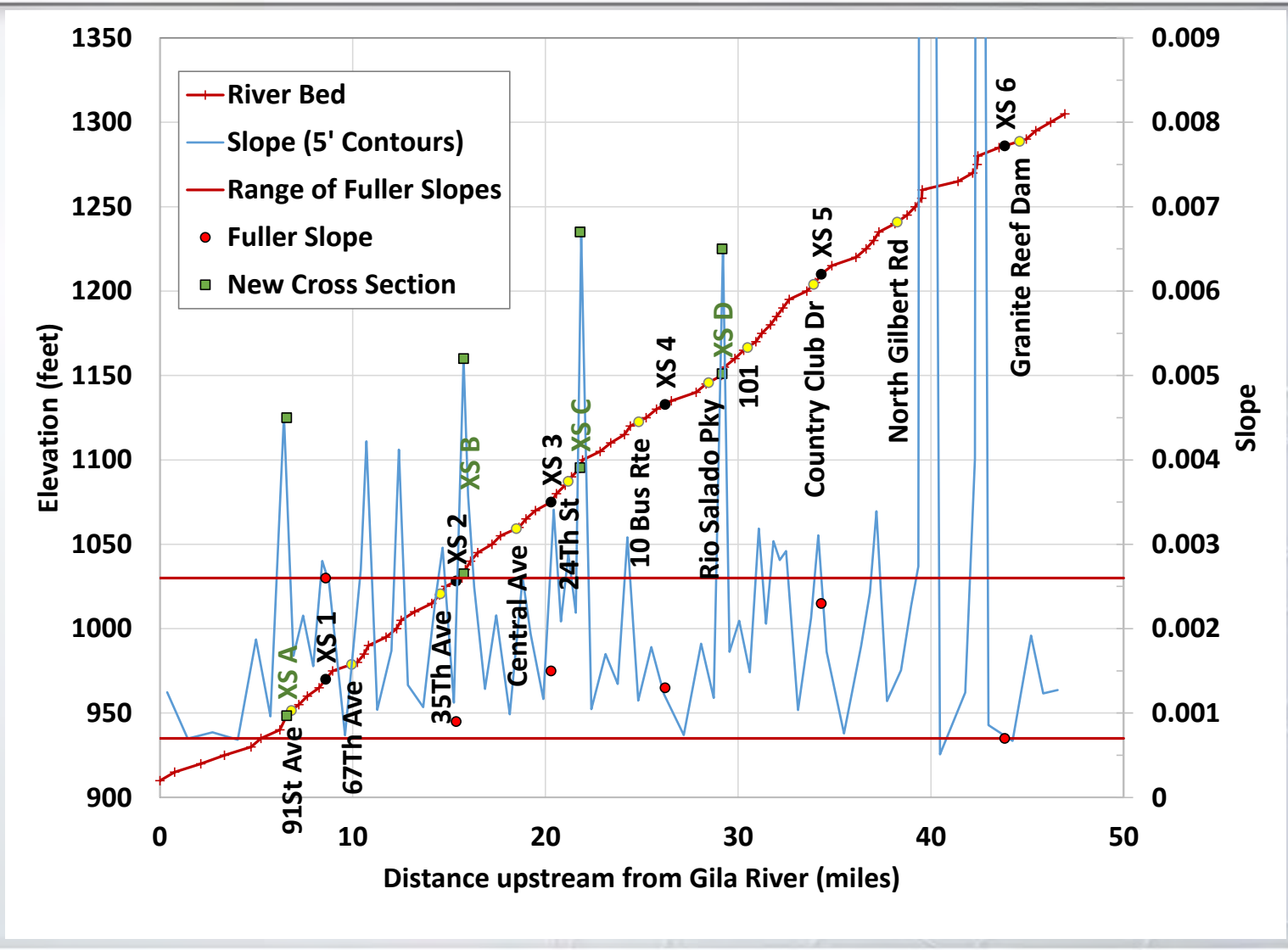
Fuller Hydraulic Estimates

Salt River: Rating Curve Segment 5, Alluvial Channel									
Flow Frequency	Flow Rate (cfs)		Avg Depth (ft)		Average Velocity (ft/s)		Top Width (ft)	
90%	~~>159~~	160	~~1.4~~	1.3	~~1.4~~	0.9	~~175~~	280
50% (median)	~~992~~	348	~~3.8~~	1.5	~~2.5~~	1.0	~~215~~	290
10%	~~>2120~~	2,240	~~>5~~	4.7	~~>3~~	2.0	~~>300~~	480

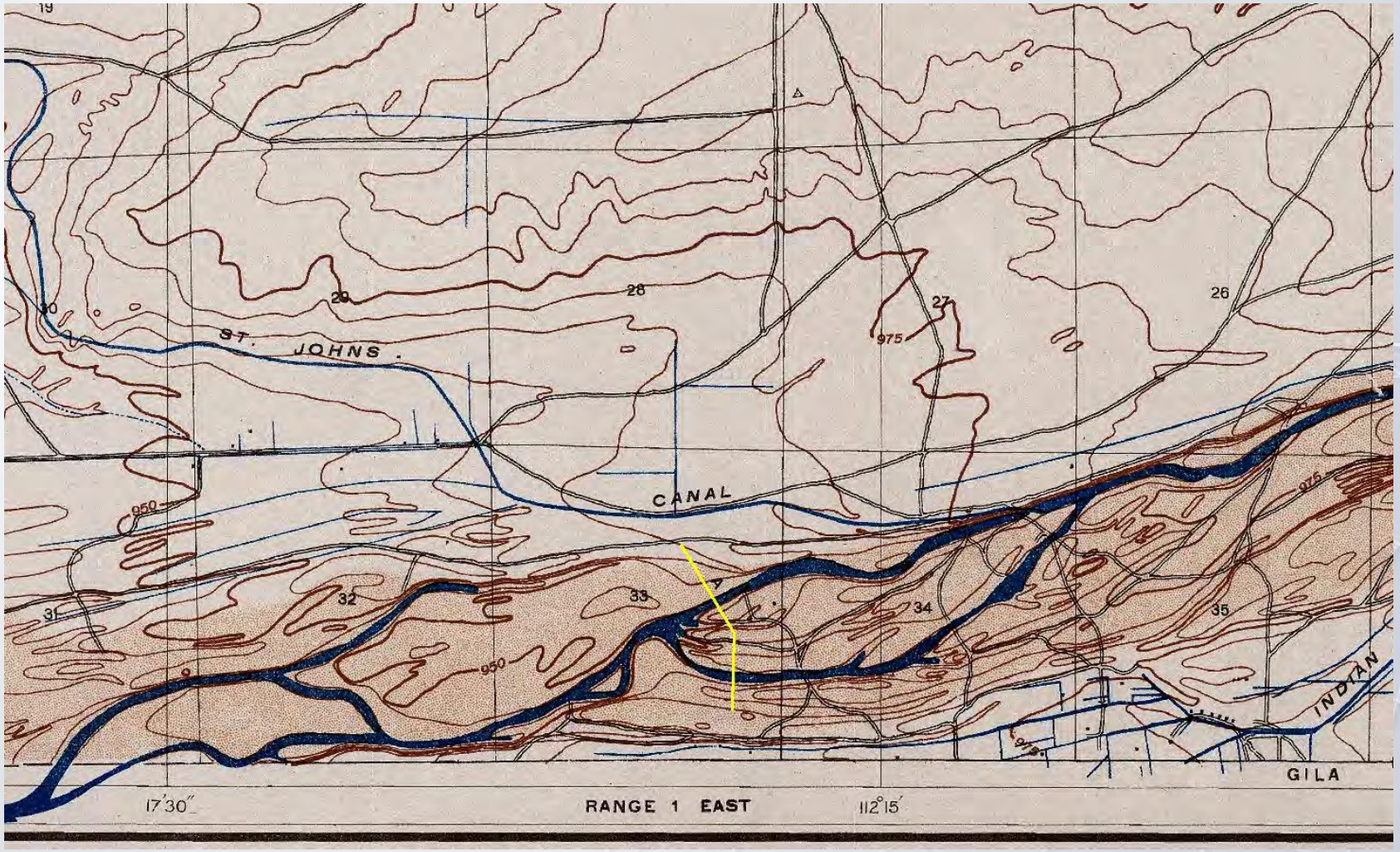
NOTE: These values <u>most likely do not</u> represent the overall average through the segments, and they <u>definitely do not</u> represent the locations most limiting to navigation

Flow Frequency							h (ft)	
90%	277		~~0.8~~	1.3	~~1.7~~	1.4	~~205~~	200
50% (median)	~~1,230~~*	554	~~5.3~~	1.9	~~2.1~~	1.8	~~290~~	230
10%	3,062		~~>6~~	4.7	~~>3~~	2.9	~~>300~~	340

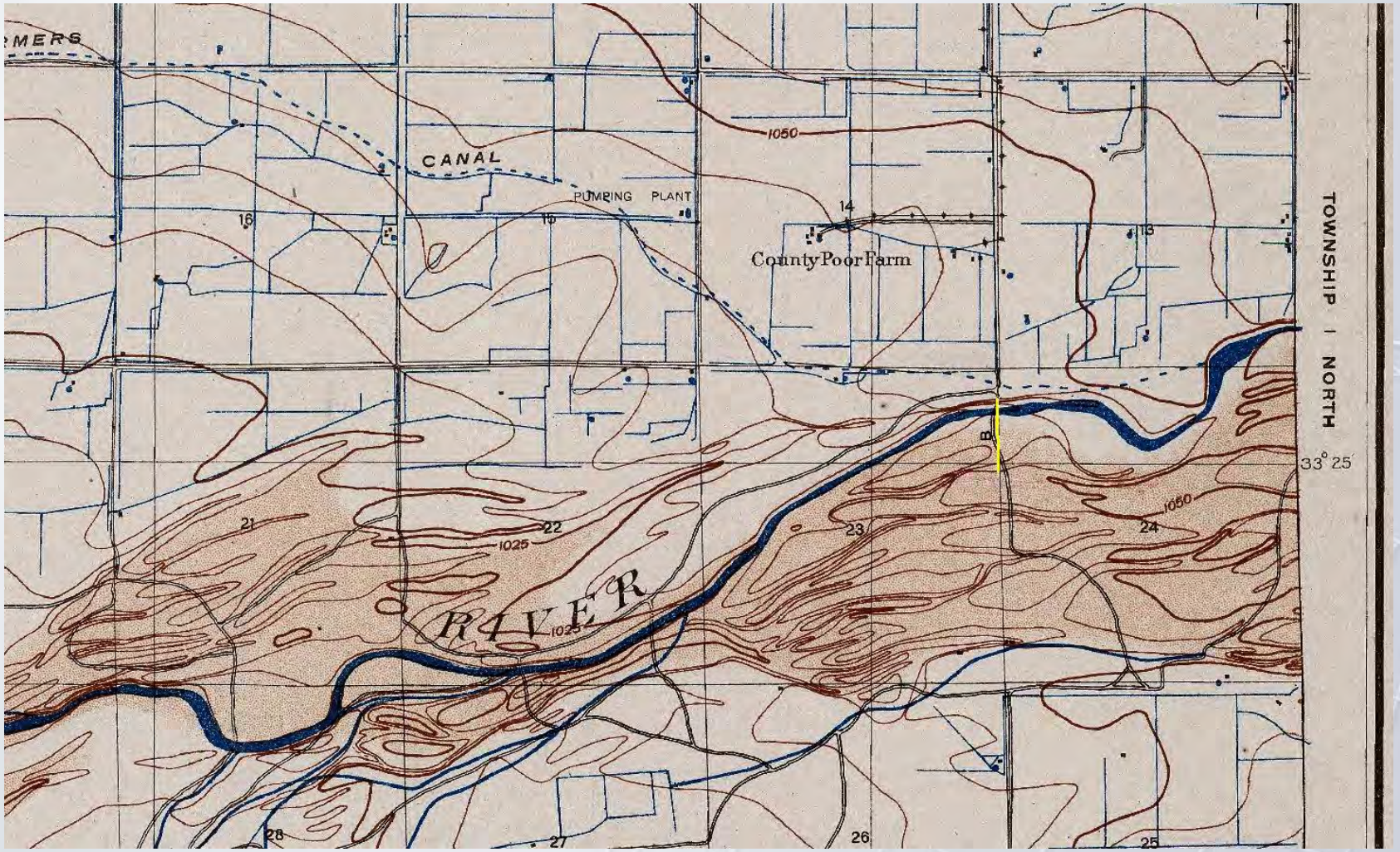
Segment 6 1902-03 Profile and Slopes



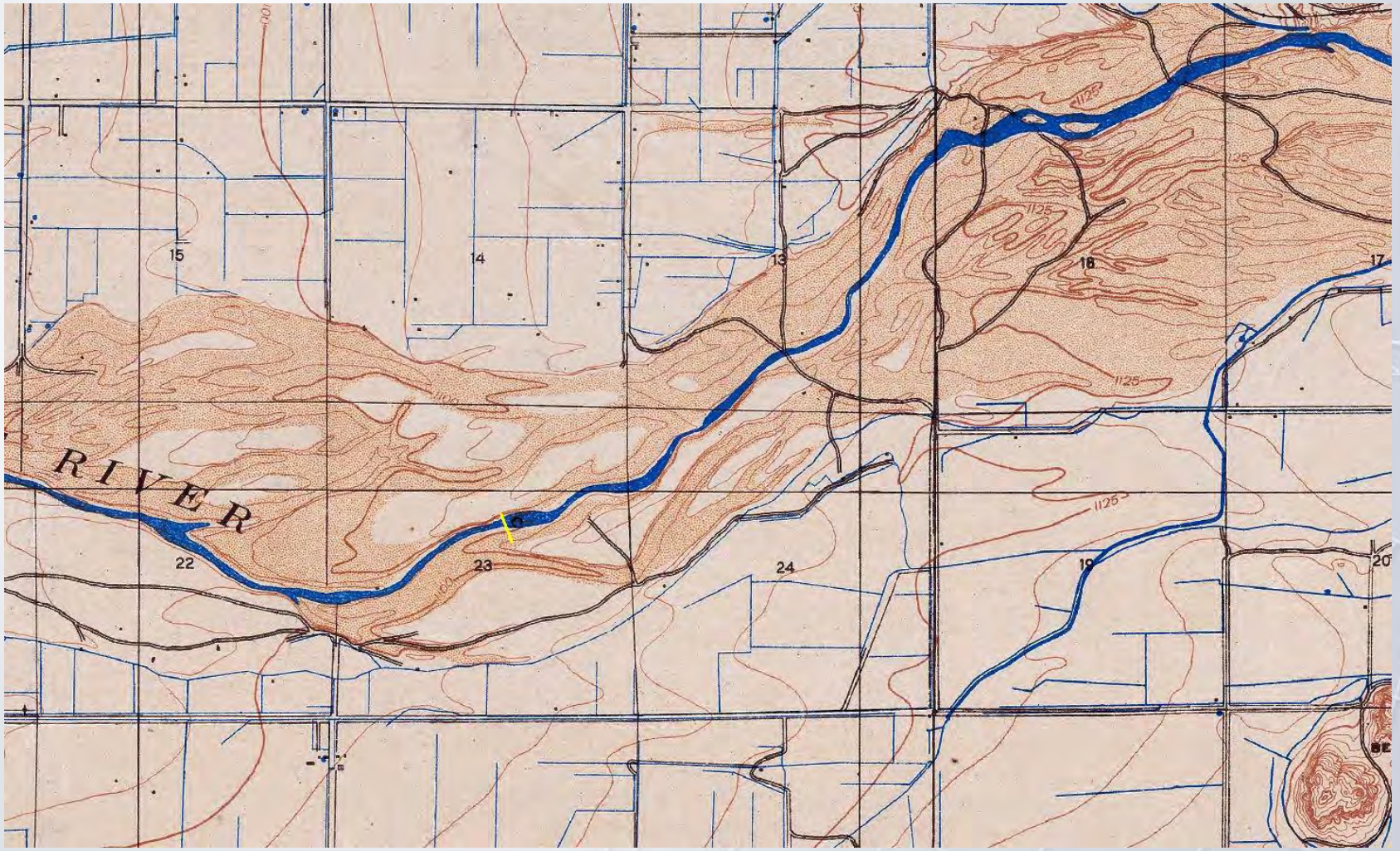
XS A (RM 6.6)


19
30
29
28
27
26
ST. JOHNS
975
CANAL
950
31
32
33
34
35
950
975
INDIAN
GILA
17'30"
RANGE 1 EAST
112°15'

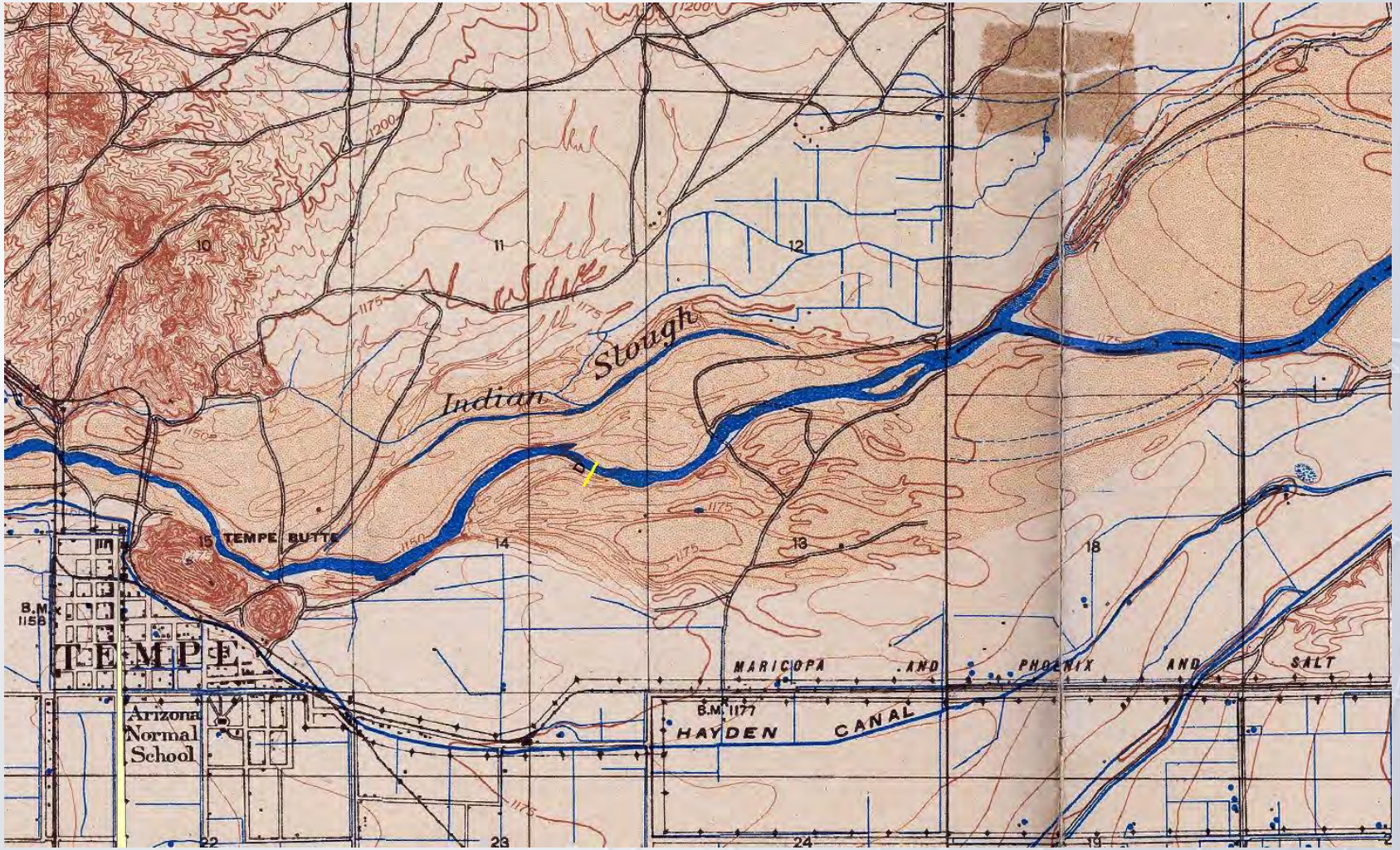
XS B (RM 15.8)


CANAL
PUMPING PLANT
County Poor Farm
1050
1025
RIVER
TOWNSHIP 1 NORTH
33° 25
B
16
15
14
13
21
22
23
24
28
27
26
25

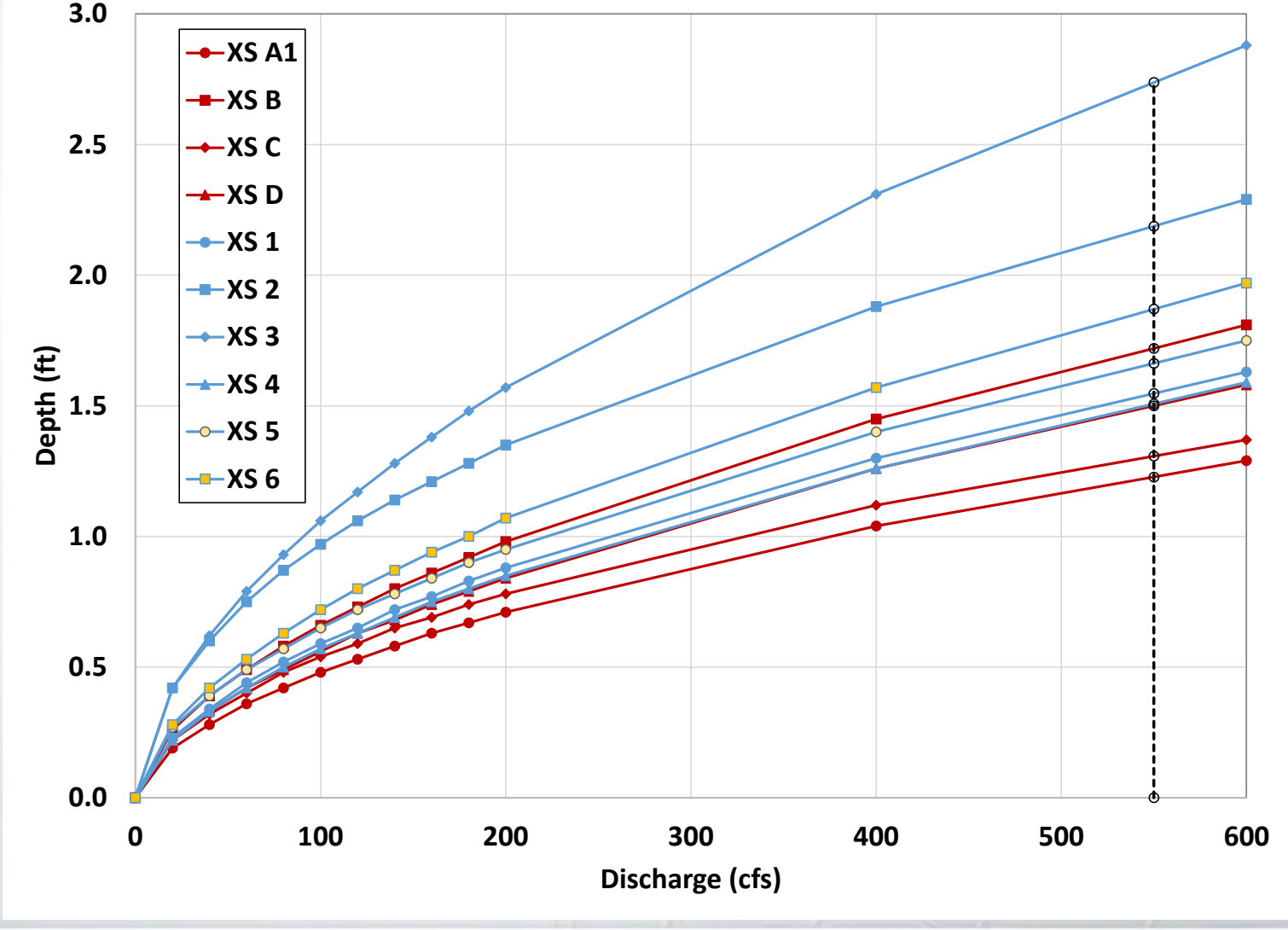
XS C (RM 21.8)



XS D (RM 29.2)


Indian Slough
TEMPE BUTTE
TEMPE
Arizona Normal School
B.M. 1158
B.M. 1177
HAYDEN CANAL
MARICOPA AND PHOENIX AND SALT
10
11
12
13
14
15
18
22
23
24

Depth Rating Curves: Fuller versus Limiting



Summary of Opinions

Neither the Upper or Lower Salt River were susceptible to being used, in their 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.