351

Arizona State Land Department
October 9, 2015

Presentation to ANSAC: Salt River Navigability

Introduction

- Federal Standard for Title Navigability (Daniel Ball Test)
  - Ordinary & Natural
  - Used or Susceptible
  - Trade & Travel on Water
- Recent Court Decisions
  - AZ: Prior to dam & diversions
  - US: River Segments

"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 the customary modes of trade and travel on water.

A.R.S. § 37-1101(5)

ASLD Reports Background

- Prepared as Directed by AZ Legislature
  - HB 2594 (1992) ➔ A.R.S. §§ 37-1106 -1156
- ASLD provided technical support to ANSAC
  - Collect & present facts re. navigability
- Reports for all watercourses (30,000+) in AZ
  - ASLD Advocated for Navigability on the Salt, Gila, and Verde

ASLD Reports Background

- Reports for the Upper & Lower Salt River were updated after previous legislative changes to A.R.S. § 37-1101-1156
  - Not updated after Montana v. PPL or Winkleman v. ANSAC
  - This presentation provides that update for
    - Upper Salt Report
    - Lower Salt Report

- ASLD Report Team
  - Jon Fuller/CH2M Hill, JEF – Upper & Lower Salt
    - Hydrology, Geomorphology
  - Brian Iserman/JEF – Upper Salt
    - Hydrology
  - Pat Quinn/Stantec Consulting – Upper Salt
  - Dennis Gilpin/SWCA – Upper & Lower Salt
    - History & Archaeology

Presentation Overview

- Note on Evidence
  - Not all evidence submitted by ASLD will be discussed today
  - Incorporate evidence from previous hearings and filings by reference
  - AZAGO Submittals & ASLD Reports (all rivers)

Speaker Resume

- Navigability Studies
  - Arizona: 1992-2014
    - All Major River Systems
    - 30,000+ Small & Minor Watercourses
  - Alaska, Rocky Mountain States, East Coast
- Professional Experience (30 yrs in Arizona)
  - Hydrologist (PH)
  - Civil Engineer (PE)
  - Geomorphologist (RG)

Presentation Overview

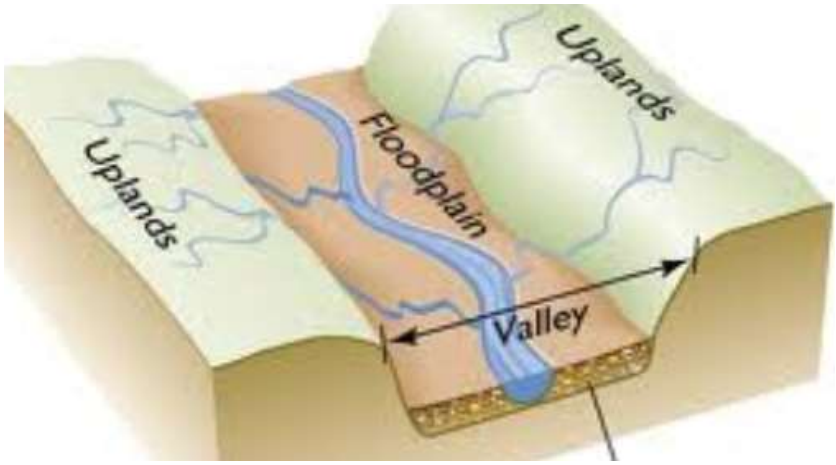
- Speaker Resume – Salt River
  - Flood History
    - Graduate Work 1984-86 – Paleoflood Studies
    - M.S. Thesis (Univ. of AZ) – Salt River Flood History
    - 1993 Flood Reports
  - Previous Navigability Studies
    - Salt River & Major/Minor Tributaries
  - Engineering Studies
    - Main stem – floodplain, erosion, restoration, sediment
    - Tributaries – master plans, hydrology, floodplain, environmental studies, many others

Presentation Overview

- Speaker Resume – Salt River
  - Field Experience
    - Paddled Canoe, Rafted or Boated
      - US60 Bridge to Lake Roosevelt
      - All Salt River Lakes
      - Stewart Mountain Dam to Granite Reef Dam
      - Parts of Segment 6 (aka Lower Salt)
      - Lowest flow rate: 8 cfs @ Stewart Mtn
      - Highest flow rate: 8,000 cfs @ Chrysotile
      - Summer, Winter, Spring, Fall trips at ordinary flows (90-2,200 cfs)
    - Every road crossing & river access point
    - Several helicopter & small plane tours

Terminology

- Floodplain *
  - Areas in a **<u>watercourse</u>** which have been or may be covered partially or wholly by flood water (See A.R.S. § 48-3601).
  - Includes a low flow or main channel that is ordinarily inundated, and elevated areas that are less frequently inundated.



* Not defined in ARS § 37-1101

Terminology

- Flood
  - Water flowing beyond its normal confines, especially onto usually dry land.
  - Flow above the ordinary high water mark.
  - Flow above the 95% flow duration.
  - Not ordinary seasonal high flow

- Drought ("unusual drought")
  - A protracted period of deficient runoff or precipitation
  - Determined by comparing current precipitation over some time period to the long-term average (e.g., 75% of average for two years)
  - Flow below the 5% flow duration

Terminology

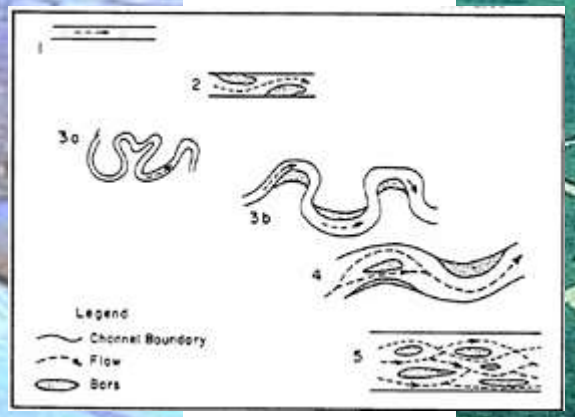
- Braided River
  - "A river that divides and rejoins around bars of width similar to the channel width and with a sinuosity of 1-1.3"
- Meandering River
  - "A stream with sinuosity > 1.3"

Source: Dictionary of Geology

Terminology

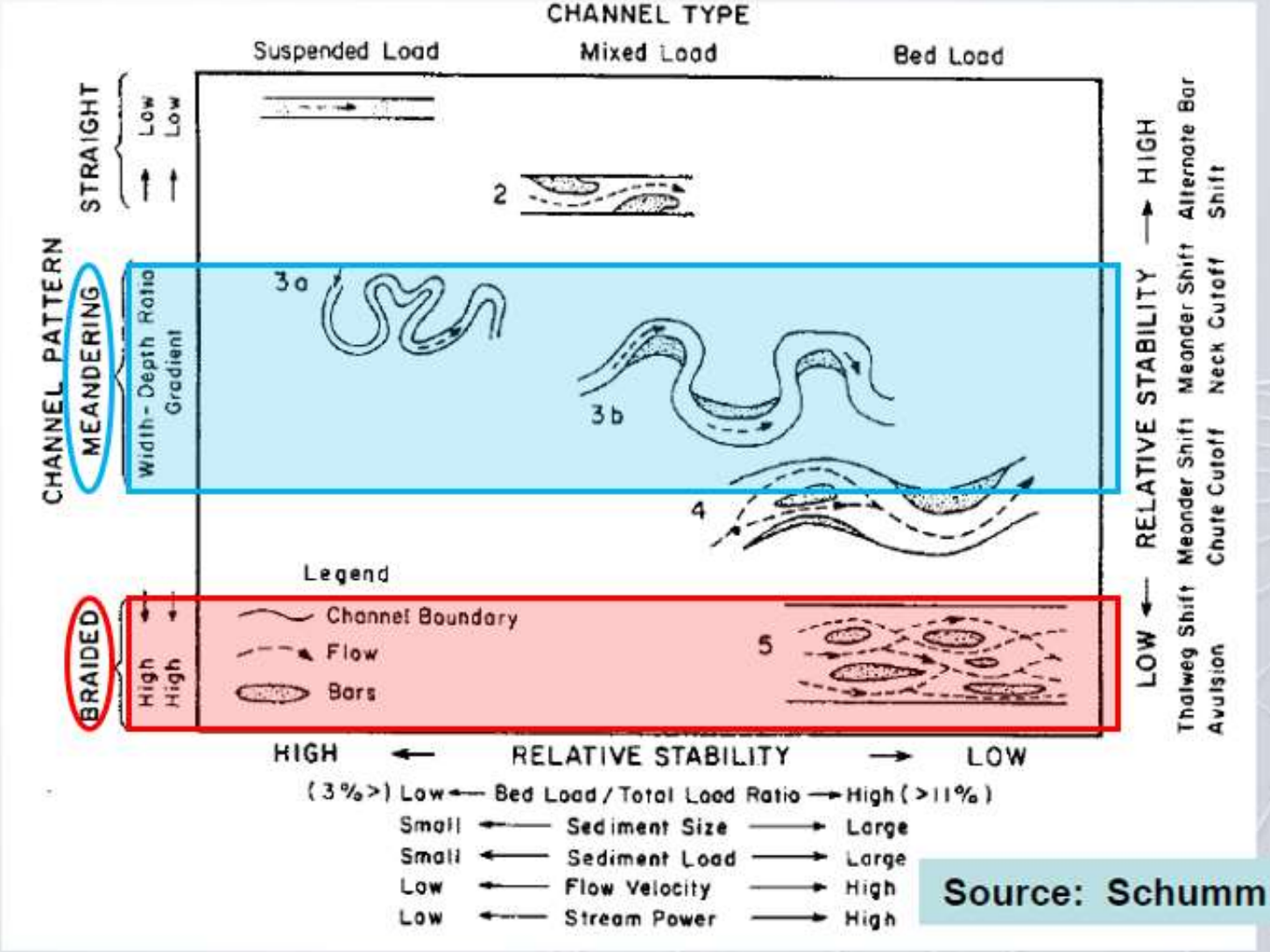
- Common Channel Patterns

Braided



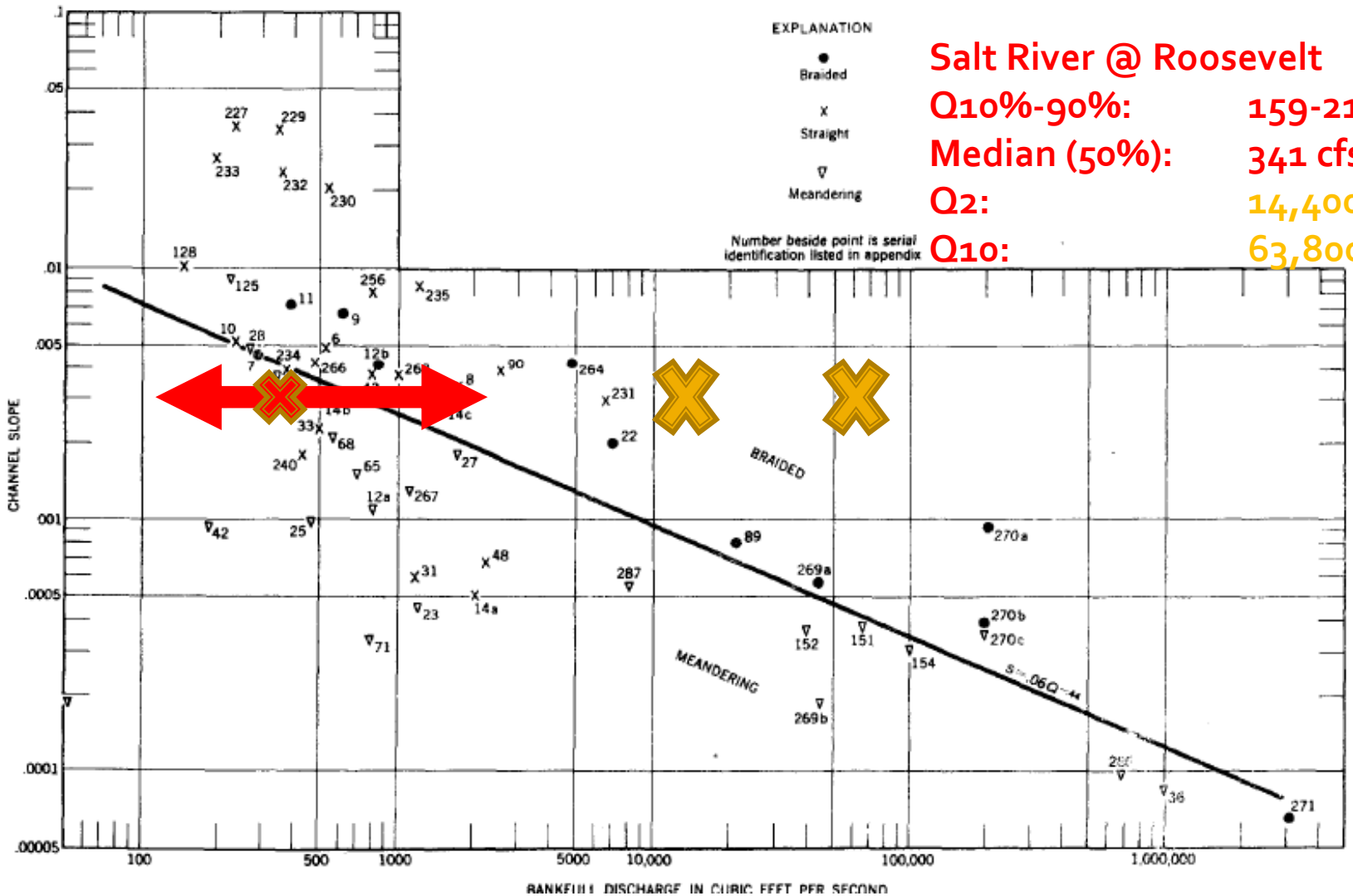
Meandering

Terminology



Source: Schumm (1981)

Terminology



Salt River @ Roosevelt

Q10%-90%:	159-2120 cfs
Median (50%):	341 cfs
Q2:	14,400 cfs
Q10:	63,800 cfs

Is this stream segment braided?
Salt River, Segment 5
Downstream of Blue Point

Terminology

Is this river segment braided?

Terminology

- Channel *
  - An open conveyance of surface water having a bottom and sides in a linear configuration.
  - Low Flow (Main) Channel. A channel within a larger channel which typically carries low and/or normal flows. The area within the ordinary high watermark.
  - Watercourse (A.R.S. § 37-1101.11) – the main body or portion or reach of any lake, river, creek, stream, wash , arroyo, channel or other body of water.

* Not defined in ARS 37-1101

Terminology

- Channel
  - Flood Channel. The portion of the floodplain that carries floods that exceed the main channel capacity.
  - Compound Channel. A stream type that has both a low flow channel and a flood channel(s). Each may have a different stream pattern.

Compound Channels

Salt River d/s Verde River

< < Braided Flood Channel

Non-braided main channel > >

Boating occurs on ordinary flows in the main channel, not on the flood channel.

Terminology

- US Army Corps of Engineers:

  "…the most common channel type in dry regions, compound channels are characterized by a single, low-flow meandering channel inserted into a wider braided channel network."

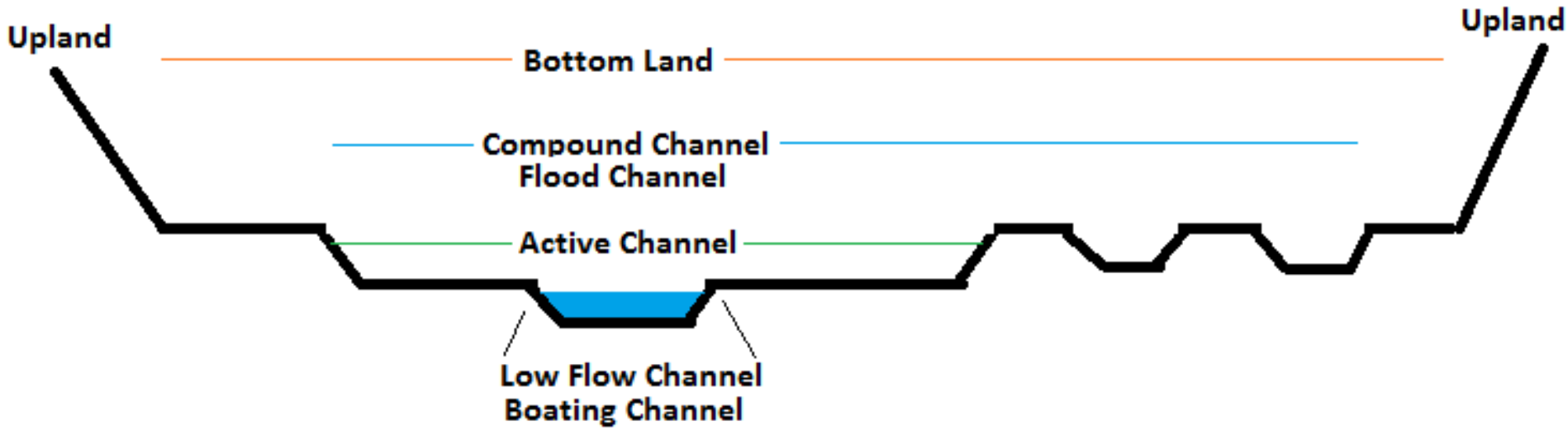
Source: Lichvar & McColley, p. 8, as cited in Gookin, 2014, p. 12

Terminology

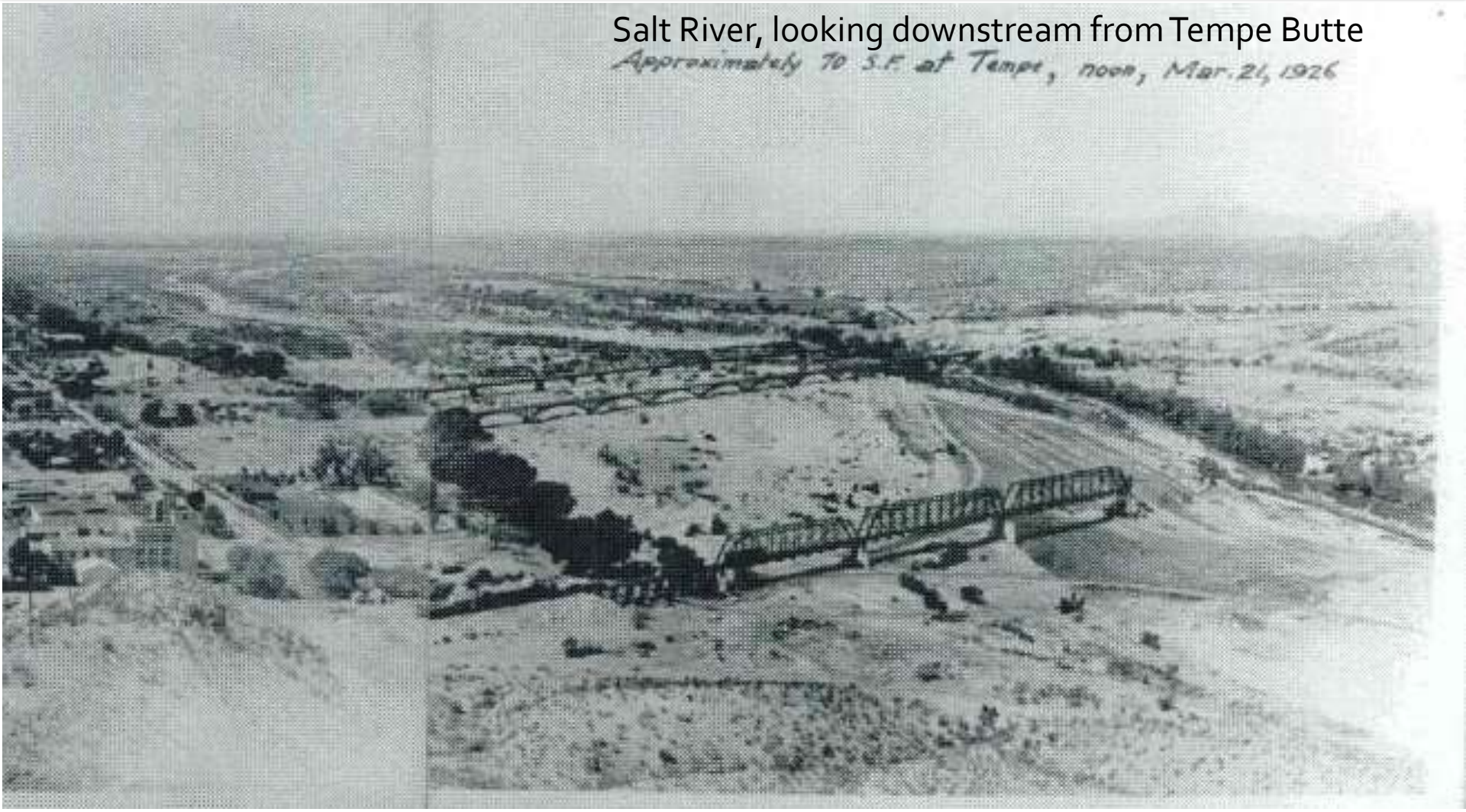
- So…What is the "Channel?"
  - It depends – objective, intent, speaker
  - Navigable channel vs. flood channel
  - Characterizing river corridor or low flow conveyance
  - Flood impact study vs. boating guide

  - The terminology is easily confused

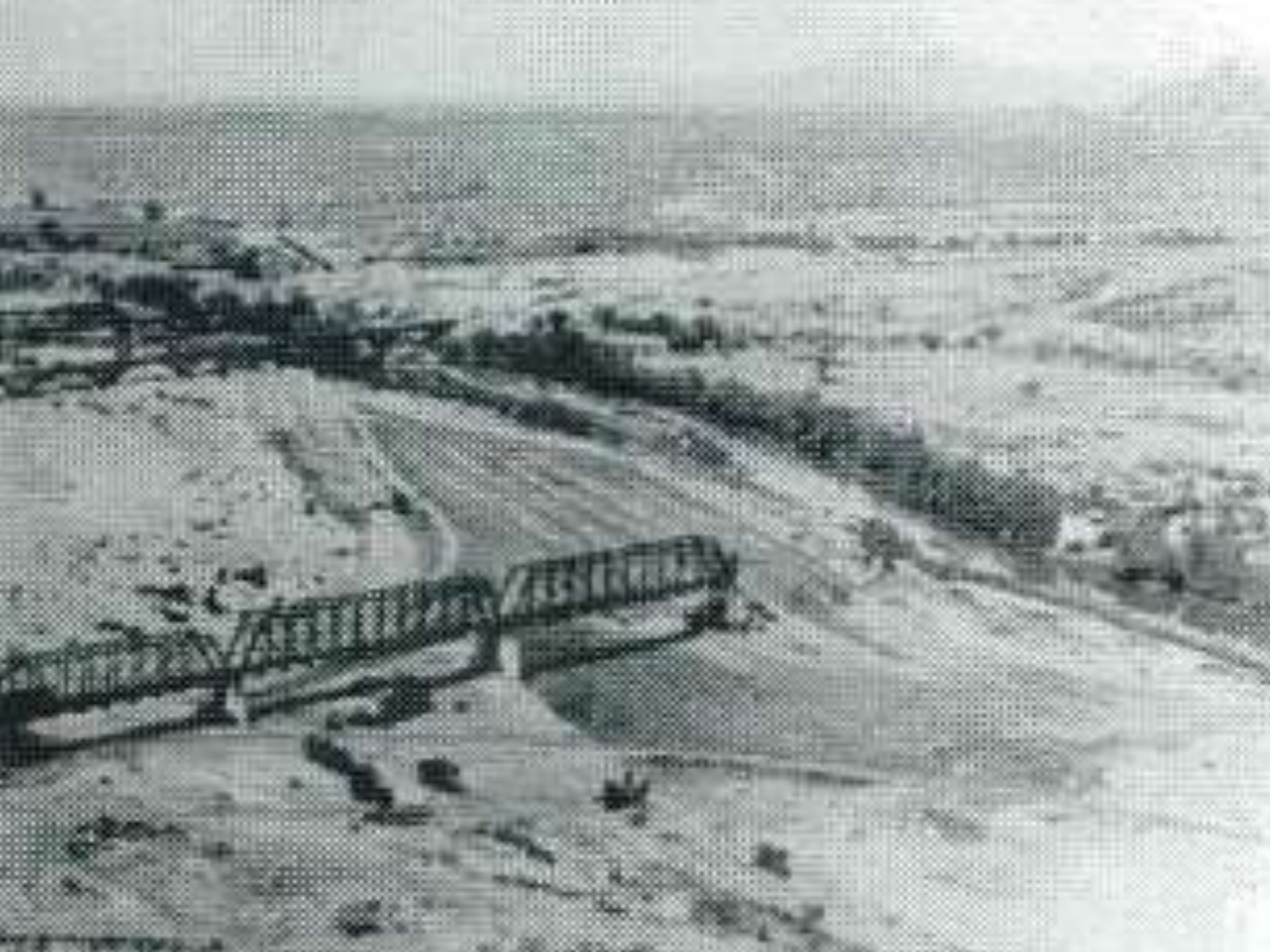
Terminology



Terminology



Salt River, looking downstream from Tempe Butte



Terminology

- Example: Burkham, 1972 Study of Gila
  - Phreatophyte study – water use by floodplain vegetation
  - "Stream channel" = area devoid of vegetation
    - Not = boating channel, except in high flow
    - "Active channel" – recent erosion, deposition, water flow
  - "Bottom land" = 1914 flood channel (inclusive)
  - "Flood plain" = outside stream channel, inside bottom land, densely vegetated

Compound Channels

Salt River d/s Verde River

< < Braided Flood Channel

Non-braided main channel > >

Boating occurs on ordinary flows in the main channel, not on the flood channel.

Terminology

- Channel Pattern: Relevance to Navigability
  - Minimal
  - Braided, Meandering, Compound rivers can all be navigated if…
- The Real Question:
  - Is the flowing part of the river deep & wide enough to float boats?

Terminology

- Channel Response to Flooding
  - Flood dominated arid region streams
  - Floods leave a persistent mark on the floodplain
    - Widening
    - Erosion of flood channel
    - Remove vegetation
    - Special case: Geomorphic Thresholds
  - Ordinary flows shape the low flow channel
    - Low flow channel returns after floods recede
    - May be relocated within floodplain

Terminology

- Channel Response to Flooding – Salt River
  - Salt River Segments 1-4
    - Minimal in bedrock canyons
  - Salt River Segments 5-6
    - Typical alluvial river response
      - Widening, possible braiding during flood
      - Scouring, deposition & reshaping of floodplain possible
      - Low flow channel returns after flood recedes
      - Migration of low flow channel within floodplain likely
    - Burkham; Huckleberry

Channel Response to Flooding

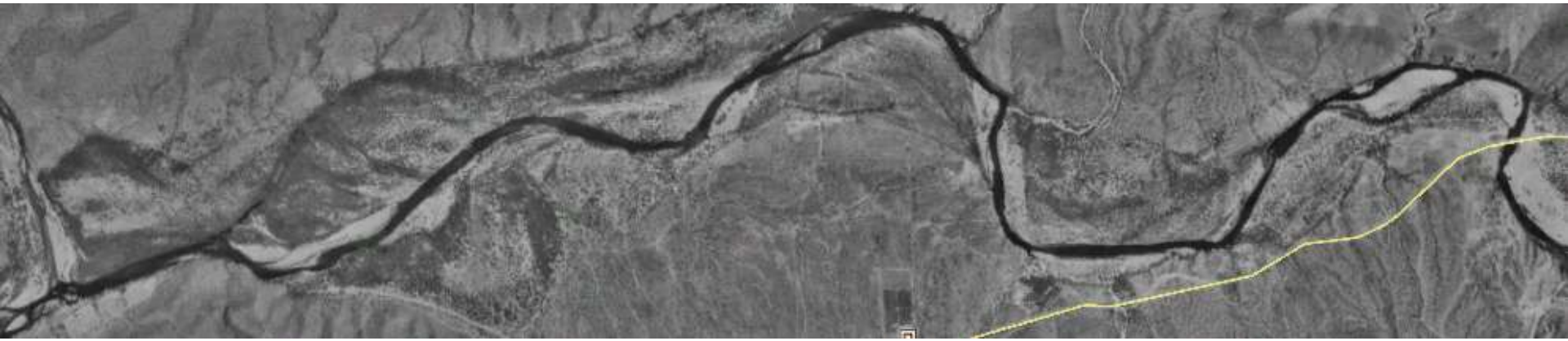
2013

Salt River: Stewart Mtn Dam area to Verde River confluence (Seg 5)

1905

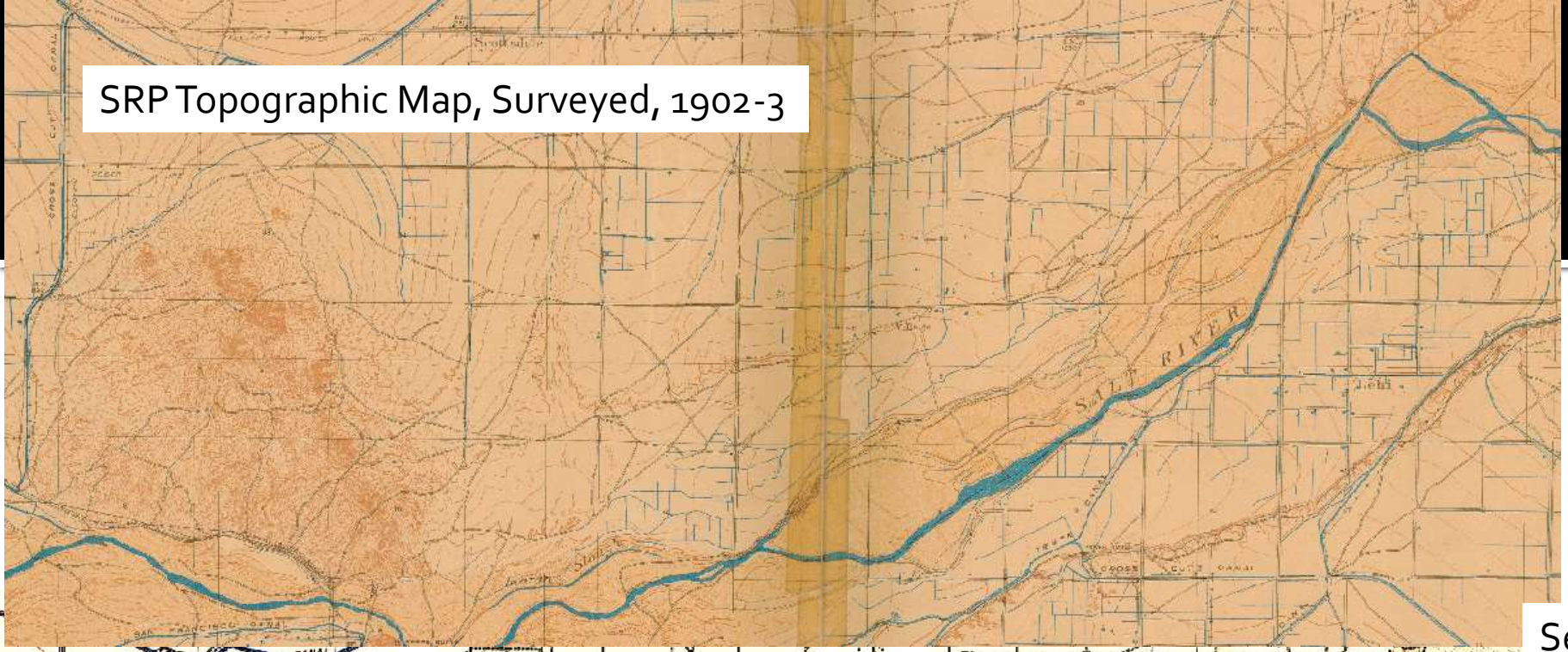
Channel Response to Flooding

October 11, 2003

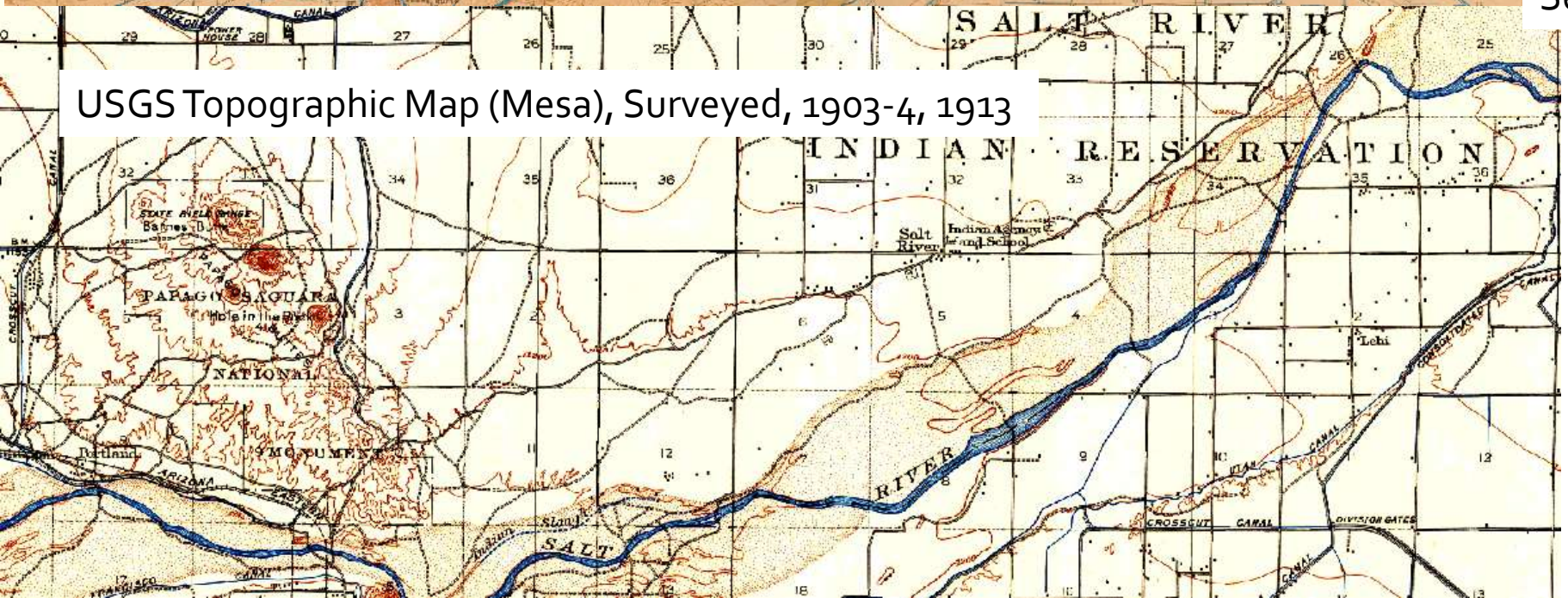


July 26, 1992

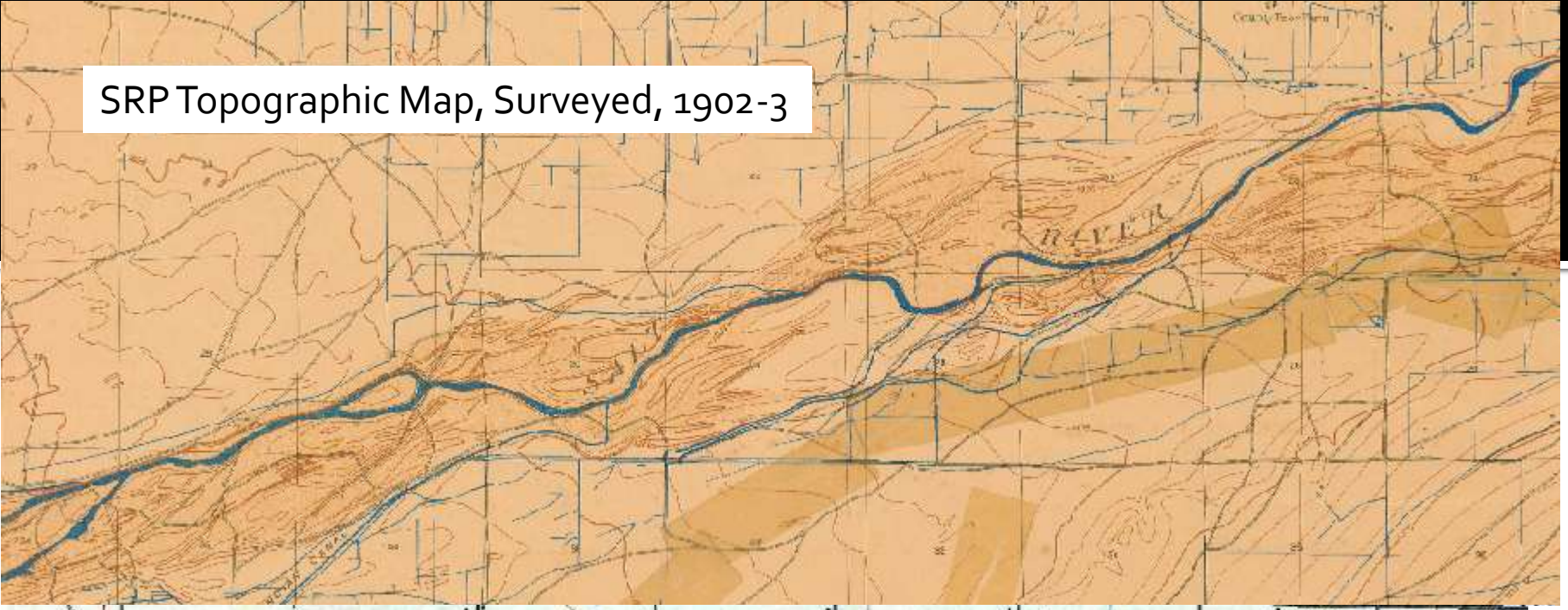
Salt River: Verde River confluence to Blue Point (Seg 5)


SRP Topographic Map, Surveyed, 1902-3
SALT RIVER
Lehi

Seg 6

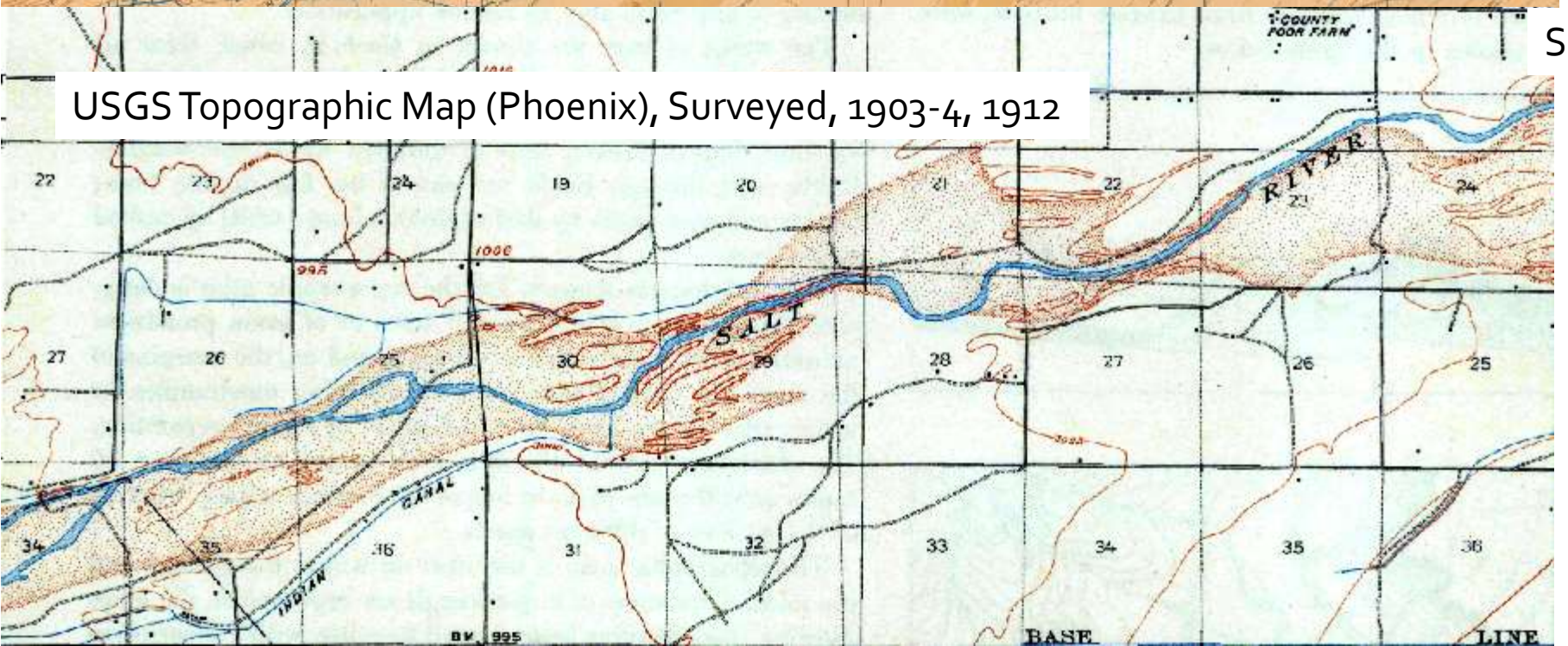

USGS Topographic Map (Mesa), Surveyed, 1903-4, 1913
SALT RIVER
INDIAN RESERVATION
Salt River
Indian Agency and School
PAPAGO SAGUARO
NATIONAL
MONUMENT
Portland
ARIZONA
EASTERN
Lehi
CROSSCUT CANAL
DIVISION GATES
SALT RIVER

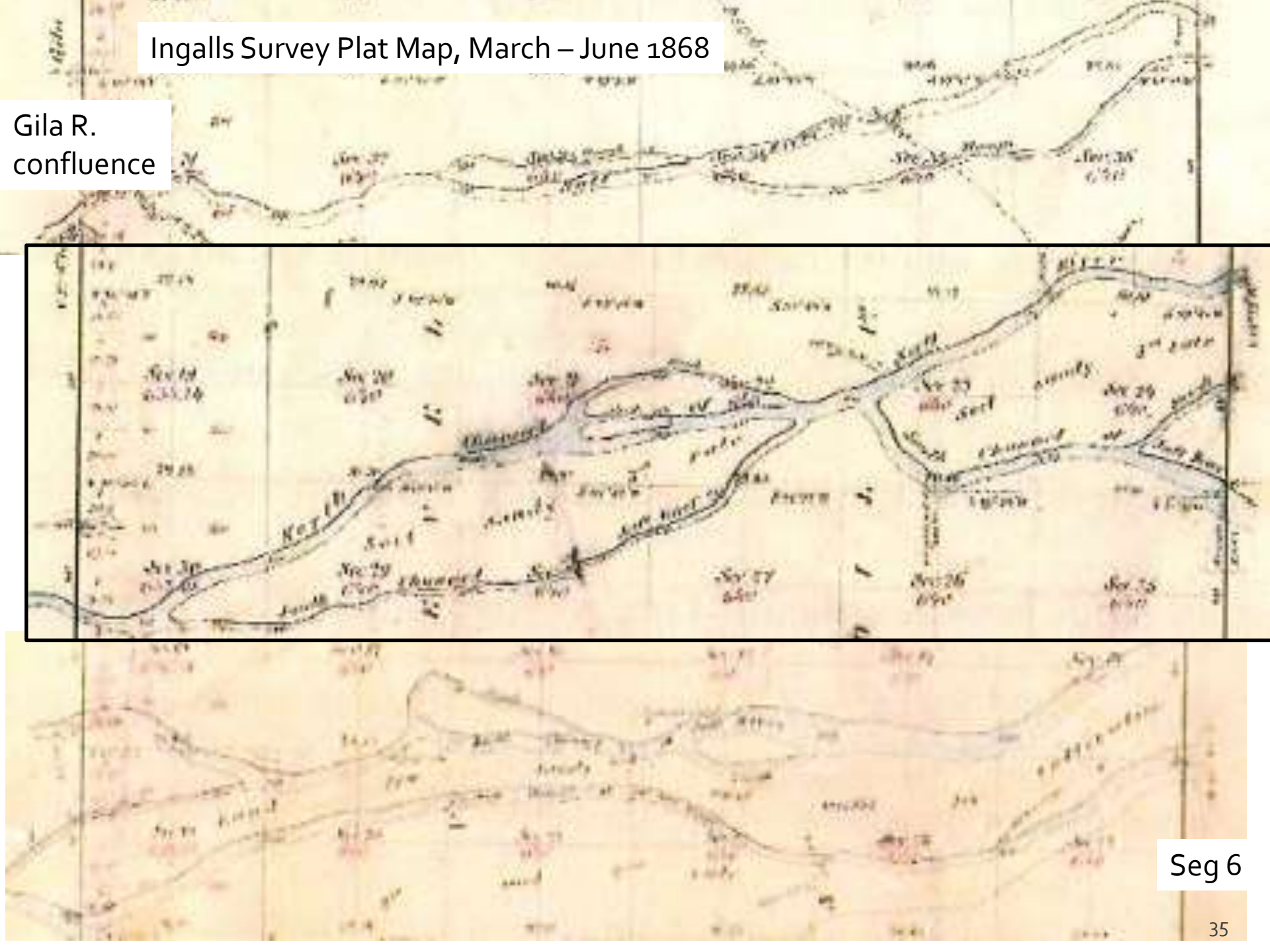
SRP Topographic Map, Surveyed, 1902-3



Seg 6

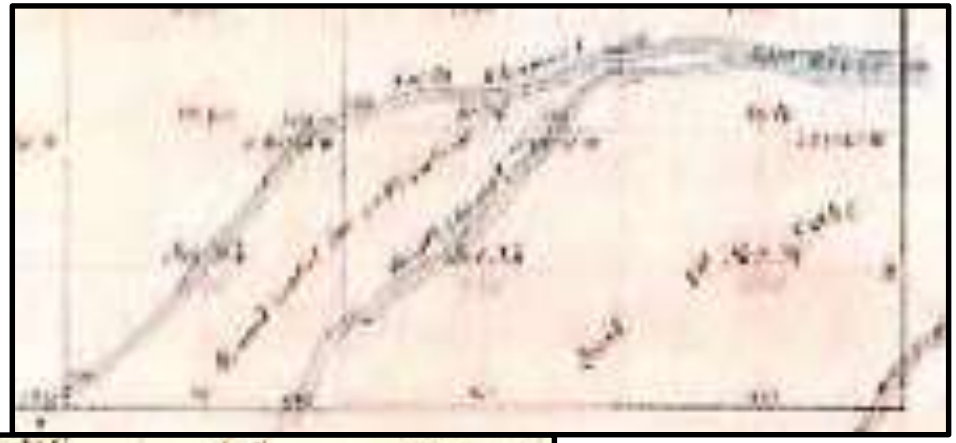
USGS Topographic Map (Phoenix), Surveyed, 1903-4, 1912




Ingalls Survey Plat Map, March – June 1868
Gila R. confluence
Seg 6

Ingalls Survey Plat Map, March – June 1868

Seg 6



Verde R. confluence

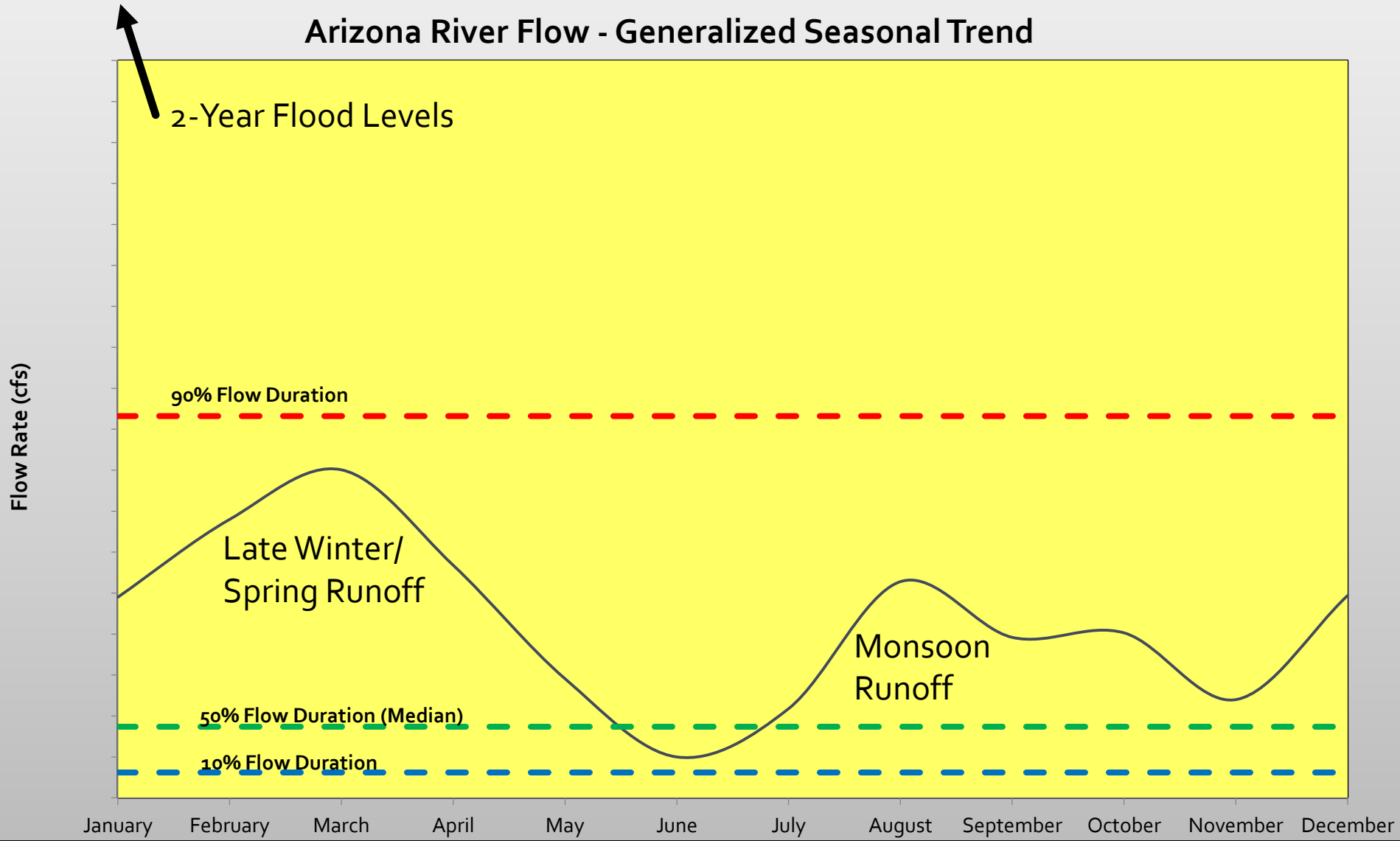
Terminology

- Streambed A.R.S. § 37-1101(2)
  - Bed – the land lying between the ordinary high watermarks of a watercourse.
  - Ordinary high watermark: the line on the banks of a watercourse established by fluctuations of water and indicated by physical characteristics… (topography, vegetation, soils)… Ordinary high watermark does not mean the line reached by unusual floods. (A.R.S. § 37-1101(6))

Ordinary & Natural Condition

- Ordinary
  - Normal, expected flow rate (i.e., median)
    - Median monthly range
  - By Definition
    - Not flood (Also, A.R.S. § 37-1101(6), OHWM)
    - Not drought
  - May Vary Seasonally
    - Spring runoff (e.g., "*Ordinary* High Water")
    - Winter freeze
    - Summer low flow

Terminology: Non-Erratic Seasonal, Ordinary Flow Fluctuation



Ordinary & Natural Condition

- Natural
  - The condition without human impact
  - Not possible to determine condition with zero human impact
  - Is possible to determine condition with no human impacts that significantly reduce or enhance navigability
  - Natural means: without damming & diversion
  - For Arizona Navigability:
    - Winkleman: (Best Evidence: 1800's-1860's)
      - After Hohokam diversions cease
      - Before modern era settlement

Terminology

- Unstable
  - Not defined in ARS or ANSAC's statutes
  - Webster's Dictionary
    - Likely to change, not firm or fixed, not constant
  - Meaning depends on perspective
    - Irrigation vs. boating
    - Building bridges vs. boating rivers
  - **All** natural rivers change with time
    - Meandering, sand bars, flood erosion
    - Irrelevant to navigability in ordinary & natural conditions

Terminology

- Erratic
  - Not defined in ARS or ANSAC's statutes
  - Webster's Dictionary:
    - Acting, moving, or changing in ways that are not expected or usual : not consistent or regular
  - Meaning depends on perspective
    - Irrigator vs. Boater
    - Crops & diversion dams vs. boatability
  - Does NOT mean:
    - Ordinary seasonal changes in flow rates
    - Occasional floods
  - Montana PPL
    - "River need not be susceptible at every point during the year"
    - Not "so brief that is not a commercial reality."

Ordinary & Natural Condition

- For the Salt River
  - Identify the major changes to the river system
    - Minimal change upstream of Lake Roosevelt
      - Changes don't significantly impact navigability
      - Some decrease in natural flows
    - Substantive Change Below Lake Roosevelt
      - Reservoirs – river valley inundated
      - Water Supply Management – altered hydrology

Terminology

- Obstructions (to Navigability)
  - Not Defined in ANSAC statutes
  - Depends on the Type of Boat
    - River Barges vs. Trapper Canoes
  - Depends on Boater's Experience
  - Depends on Flow Rate
  - Obstruction, Obstacle, Challenge

Obstruction?	Barges	Canoes
Sand Bars	Only if river wide	No
Rapids	Yes	No (I-V)
Waterfalls	Yes	Some
Beaver Dams	No	No
Shallow Flow	< 10 ft.	< 0.5 ft.

The Federal Test is based on more than just obstructions.

Terminology

- Sand Bars
  - Raised area of sand at or near the water surface
  - Occupies part of the stream bed channel
  - Salt River: point bars more likely than in-channel bars

Salt River
Pre-Roosevelt near Dam Site

Colorado River
near Bullhead City

Cimarron River
Oklahoma

Terminology

- Waterfalls:
  - Definition: River flow over a vertical drop.
  - Not drowned out at high flow
  - Permanent feature
  - Rapids are less steep, may be drown out
  - None on Gila, Salt, or Verde River in AZ
    - Some Rapids are named "falls"

Great Falls, Missouri River, MT

Terminology

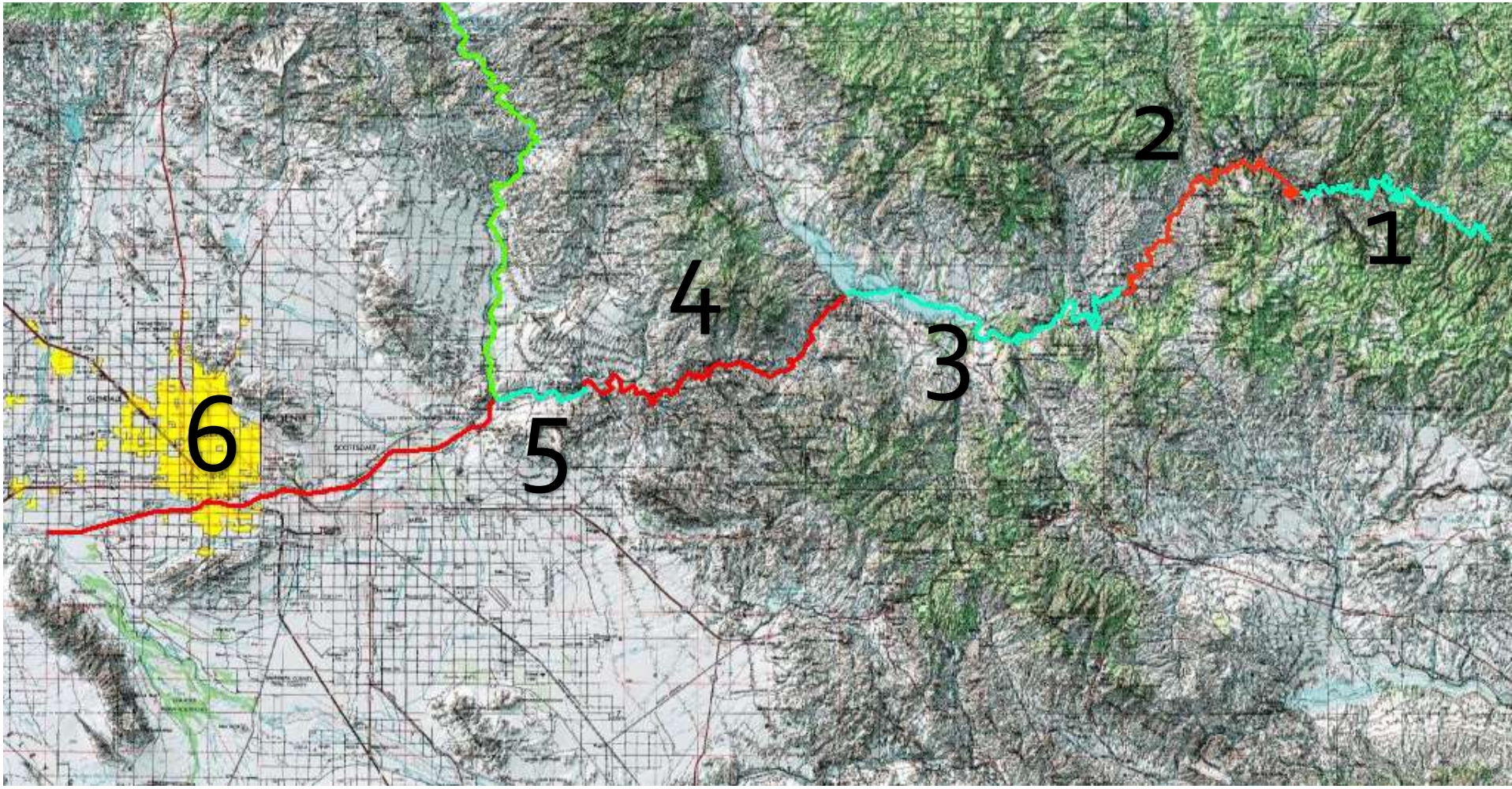
- Fords:
  - Definition: A **ford** is a shallow place with good footing where a river or stream may be crossed by wading or inside a vehicle.
  - May occur naturally
  - Implies most reaches not ford-able

Presentation Overview

- Preview of State's Findings & Conclusions:

- Salt River
  - Segments 2-6 were navigable in ordinary & natural condition
  - Has a history of navigation
  - Was and is susceptible to navigation
  - Extensive modern recreational boating
  - Existing commercial boating activity

Segmentation



Salt River Segmentation

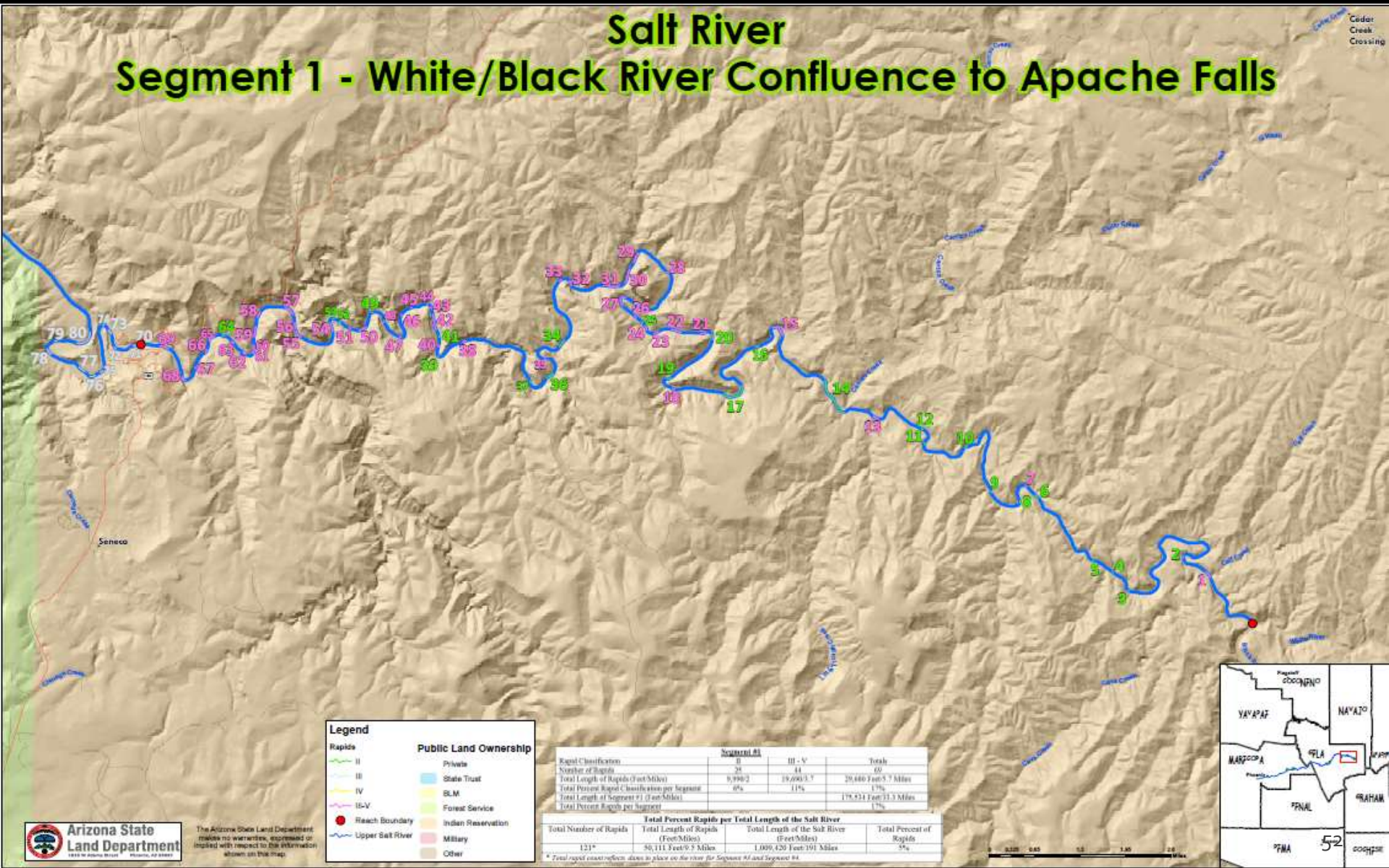
- Salt River is Variable Over its Course
  - Changes in Channel Characteristics
    - Rapids – density, rating
    - Susceptibility to Navigation
  - Changes in Hydrology
    - Flow Rate Increases in Downstream Direction
  - Changes in Physiography
    - Bedrock Canyons & Flats, Alluvial Valley
- Justification for Considering River in Segments
  - Navigability Characteristics

Salt River Segmentation

- Previous Segmentation
  - Not Ordinary & Natural Condition
  - Based on Modern Human Geography
    - Reach 1 – Upstream of Roosevelt Reservoir
    - Reach 2- Reservoirs
    - Reach 3 – Stewart Mountain to Granite Reef Dams
    - "Lower" Salt – Granite Reef to Gila River Confluence

- Proposed Segmentation
  - Reflects Navigability Characteristics
  - Hydrology, Geology, Ordinary & Natural Condition

Salt River Segment #1



Segment #1

Rapid Classification	II	III - V	Totals
Number of Rapids	25	44	69
Total Length of Rapids (Feet/Miles)	9,990/2	19,690/3.7	29,680 Feet/5.7 Miles
Total Percent Rapid Classification per Segment	6%	11%	17%
Total Length of Segment #1 (Feet/Miles)			175,934 Feet/33.3 Miles
Total Percent Rapids per Segment			17%

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 dates in place on the river for Segment #1 and Segment #4.

Salt River Segment #1

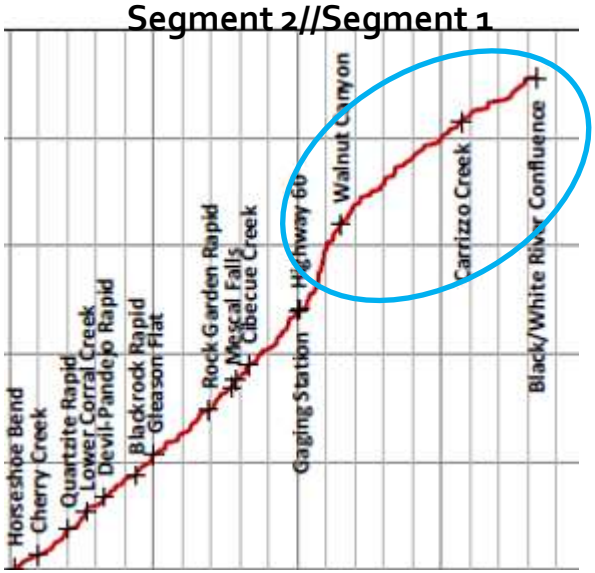
- Salt River Segment #1
  - White/Black River Confluence to Apache Falls
    - San Carlos & White Mountain Apache Tribal Lands (100%)
  - Perennial River Flow
  - Channel Characteristics
    - Pool & Riffle / Pool-Drop Pattern
    - Sinuous to Straight Channel
    - Narrow Bedrock Canyon (No Flats)
  - Changes in Hydrology since 1912
    - Some diversions from White & Black Rivers
  - Boating Not Currently Permitted by Tribes

Salt River Segment #1

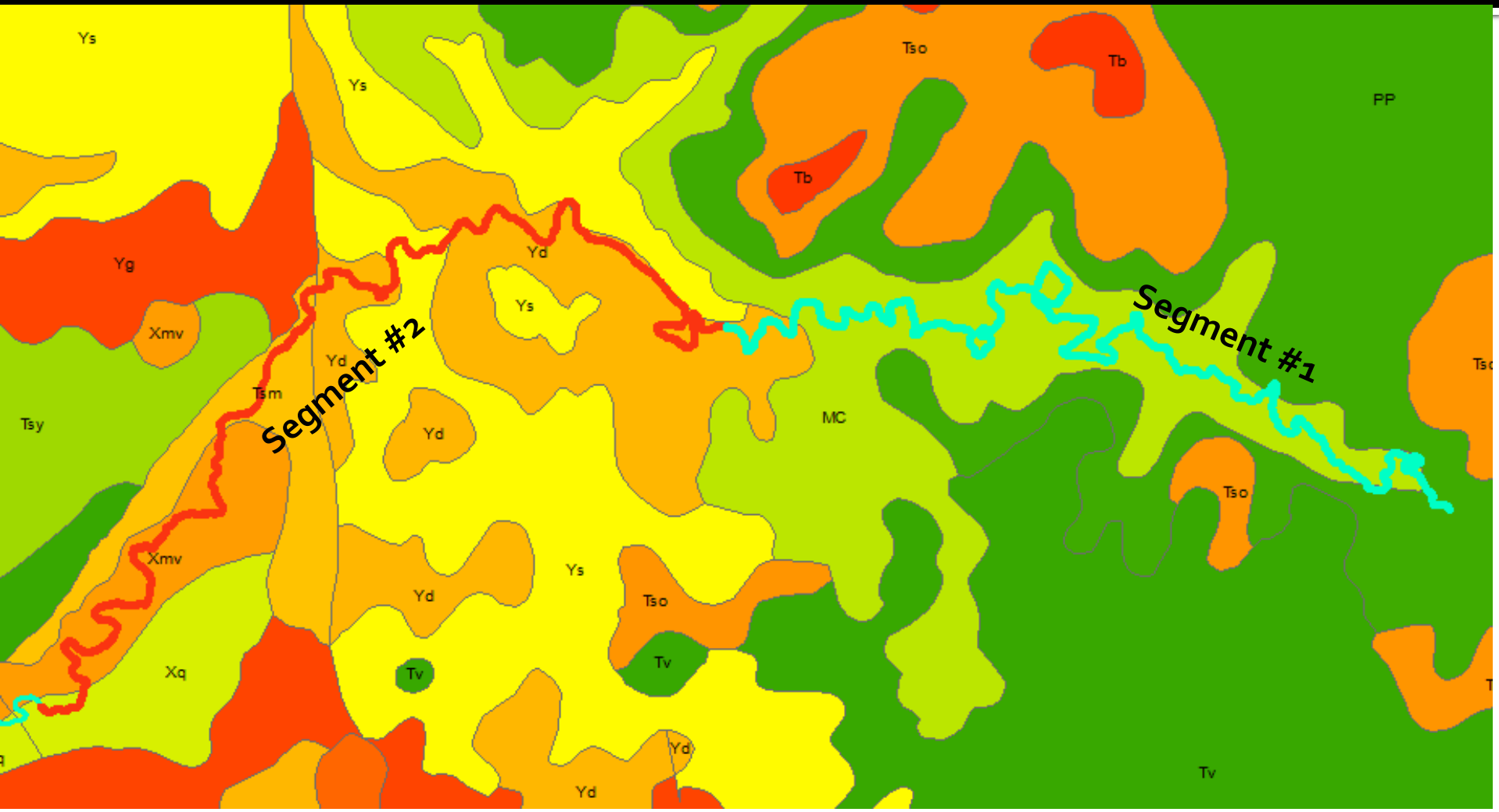
- Many Rapids
  - Class II-III-IV-V
    - ~17% of Segment Length
    - 44 rapids are III-V
  - Rapids not officially classified – may be III-VI
  - 69 Significant Rapids in 34 miles
  - Most Rapids in Lower Half of Segment

- Unique Geology – Different from Segments 2-4 or 5-6
  - Segment #1 – All One Rock Unit
  - Rock Type & Channel Slope

- Major Tributaries
  - White/Black Rivers
  - Carrizo Creek
  - Sawmill Canyon



Salt River Segment #1: Geologic Map



MC = Mississippian/Cambrian Sedimentary Rocks

Yd, Ys, Xmv, Xq = Metamorphic & Igneous Rock Types

Google Earth Flyover

- Salt River, Segment 1

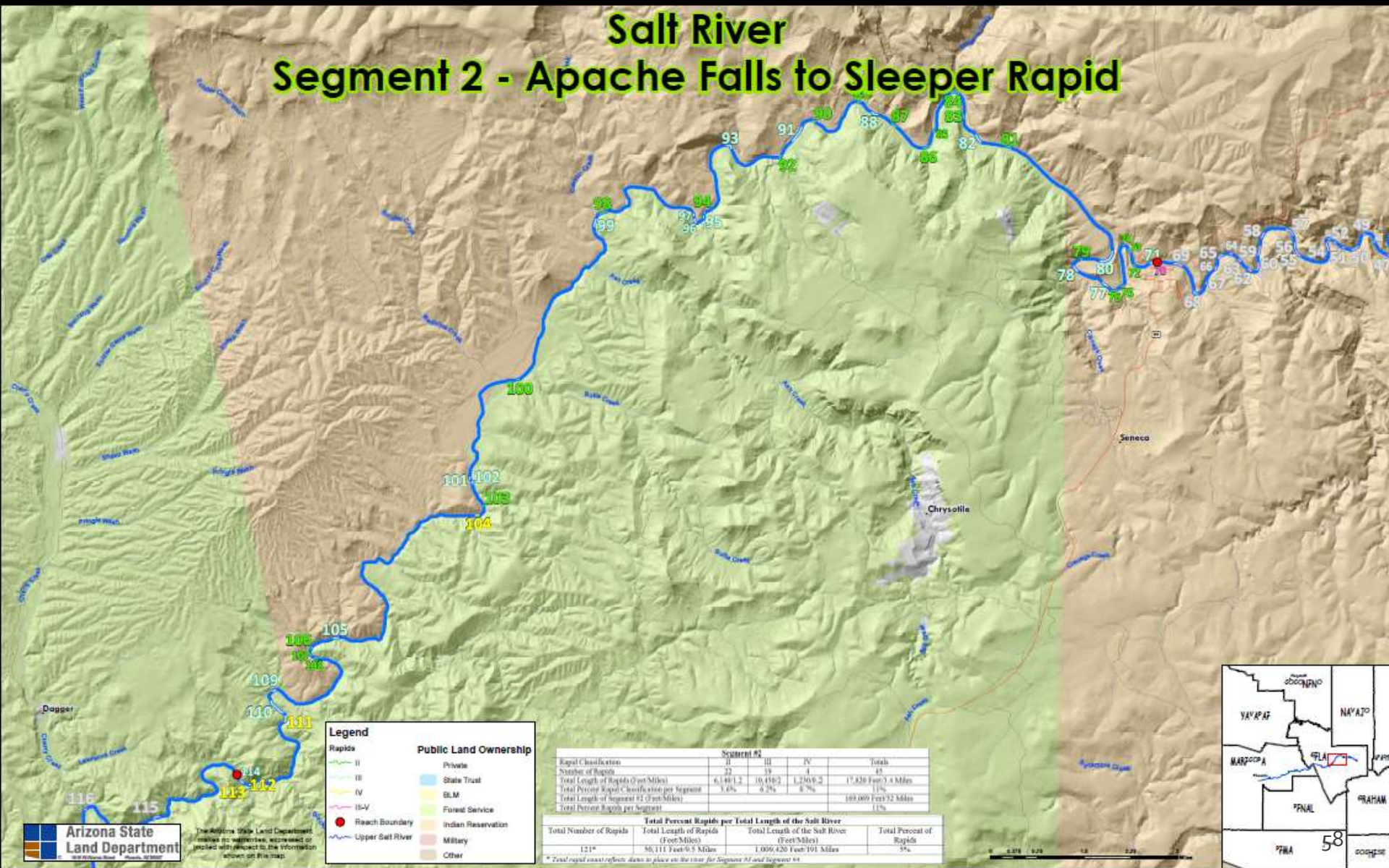
Salt River: Segment 1

- Field Photographs

Aug 16, 2013
~90 cfs

May 18, 2013
~240 cfs

Salt River Segment #2



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	10,416/2	1,216/0.2	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)				169,009 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.

Salt River Segment #2

- Salt River Segment #2
  - Apache Falls to Sleeper Rapid
    - San Carlos & White Mountain Apache Tribal Lands
    - Tonto National Forest
  - Perennial Flow
  - Channel Characteristics
    - Pool & Riffle Pattern
    - Sinuous to Straight
    - Bedrock Canyons, Gleason Flat
  - Modern Commercial & Recreational Boating
  - Some Upstream Diversions from White & Black Rivers

Salt River Segment #2

- Rapids
  - Class II-III-IV
    - ~10% of Segment Length
    - Clusters of Rapids, Long Stretches of Class I & Flat Water
    - Most are Class II or Lower
    - 19 Class III Rapids*
    - 4 Class IV Rapids*
  - 45 Rapids in 33 miles

- Major Tributaries
  - Cibecue Creek
  - Canyon Creek

*Rapid ratings reflect rafting season conditions, not normal low flow. At low flow, rapids are rated lower.

Google Earth Flyover

- Salt River, Segment 2

November 8, 2014 @ 193 cfs

Segment #2 Field Photos

Segment #2 Field Photos

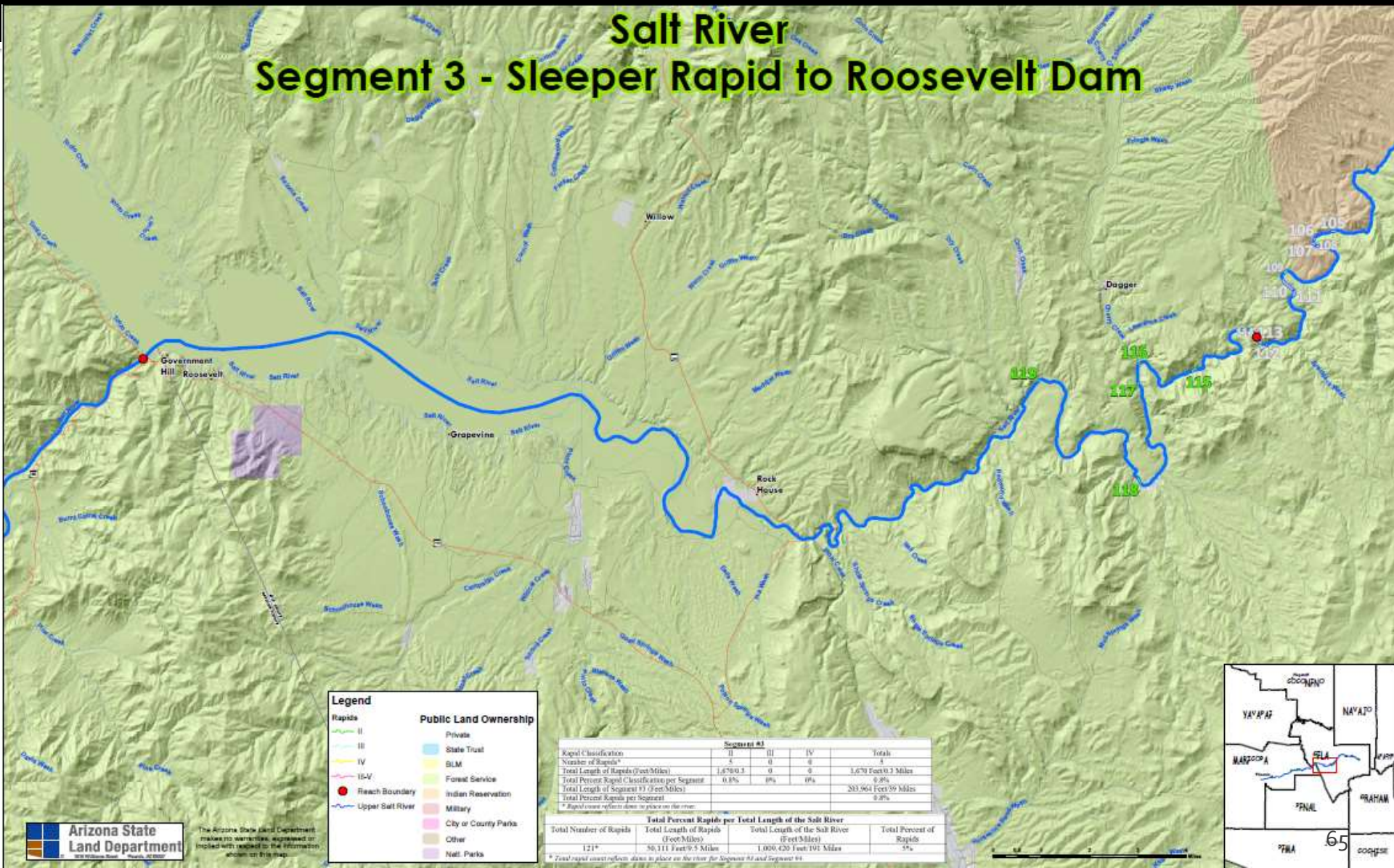
- Additional photos provided digitally

Segment #2 Field Photos

GoPro Videos of Canoeing Rapids in Segment 2

Provided digitally

Salt River Segment #3



Segment #3				
Rapid Classification	II	III	IV	Totals
Number of Rapids*	5	0	0	5
Total Length of Rapids (Feet/Miles)	1,670/0.3	0	0	1,670 Feet/0.3 Miles
Total Percent Rapid Classification per Segment	0.8%	0%	0%	0.8%
Total Length of Segment #3 (Feet/Miles)				203,964 Feet/39 Miles
Total Percent Rapids per Segment				0.8%

* Rapid count reflects dams in place on the river.

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	1,000,420 Feet/191 Miles	5%

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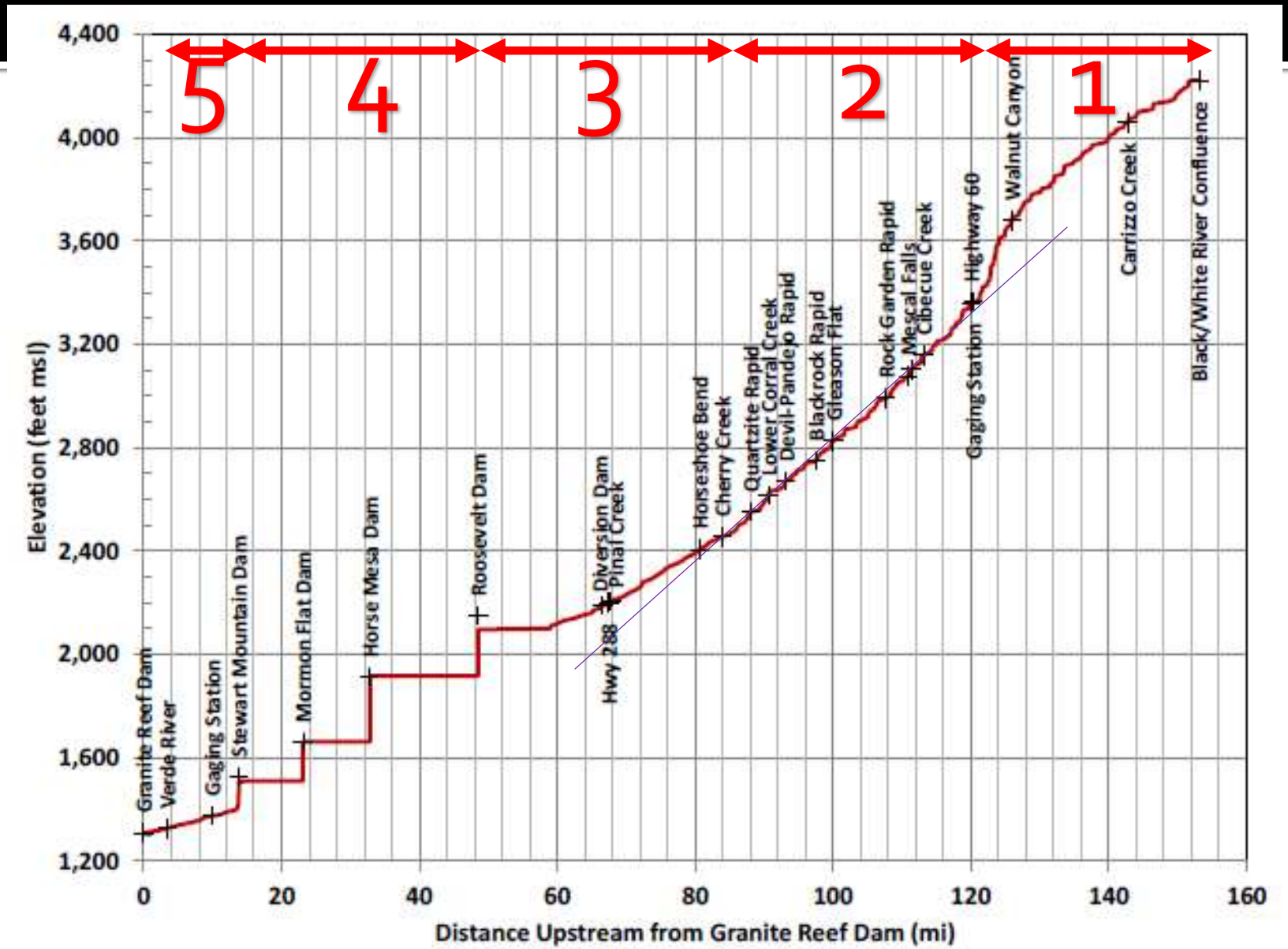
Salt River Segment #3

- Salt River Segment #3
  - Sleeper Rapid to Roosevelt Dam*
    - Tonto National Forest
    - Minor Private Inholdings @ Horseshoe Bend & Livingstone
  - Perennial Flow
  - Channel Characteristics
    - Pool & Riffle Pattern
    - Sinuous to Straight
    - Bedrock Canyons & Flats (Horseshoe, Redman, Tonto)
  - Some Diversion from White & Black Rivers Upstream
    - Roosevelt Reservoir Impoundment Inundates Tonto Basin

*Note: Segment boundary located at mouth of bedrock canyon just upstream of actual location of Roosevelt Dam.

Segment #3


5
4
3
2
1
Elevation (feet msl)
4,400
4,000
3,600
3,200
2,800
2,400
2,000
1,600
1,200
0
20
40
60
80
100
120
140
160
Distance Upstream from Granite Reef Dam (mi)
Granite Reef Dam
Verde River
Gaging Station
Stewart Mountain Dam
Mormon Flat Dam
Horse Mesa Dam
Roosevelt Dam
Hwy 288
Diversion Dam
Pinal Creek
Horseshoe Bend
Cherry Creek
Quartzite Rapid
Lower Corral Creek
Devil-Pandejo Rapid
Blackrock Rapid
Gleason Flat
Rock Garden Rapid
Mescal Falls
Cibecue Creek
Gaging Station
Highway 60
Walnut Canyon
Carrizo Creek
Black/White River Confluence

Salt River Segment #3

- No Major Rapids
  - Five (5) Class II
    - No Class III, IV, or V Rapids
  - ~1% of Segment Length
  - 5 Rapids in 40 miles

- Major Tributaries
  - Cherry Creek
  - Pinal Creek
  - Pinto Creek
  - Tonto Creek

Google Earth Flyover

- Salt River, Segment 3

Salt River – Segment #3

- Field Photos (to be provided digitally)

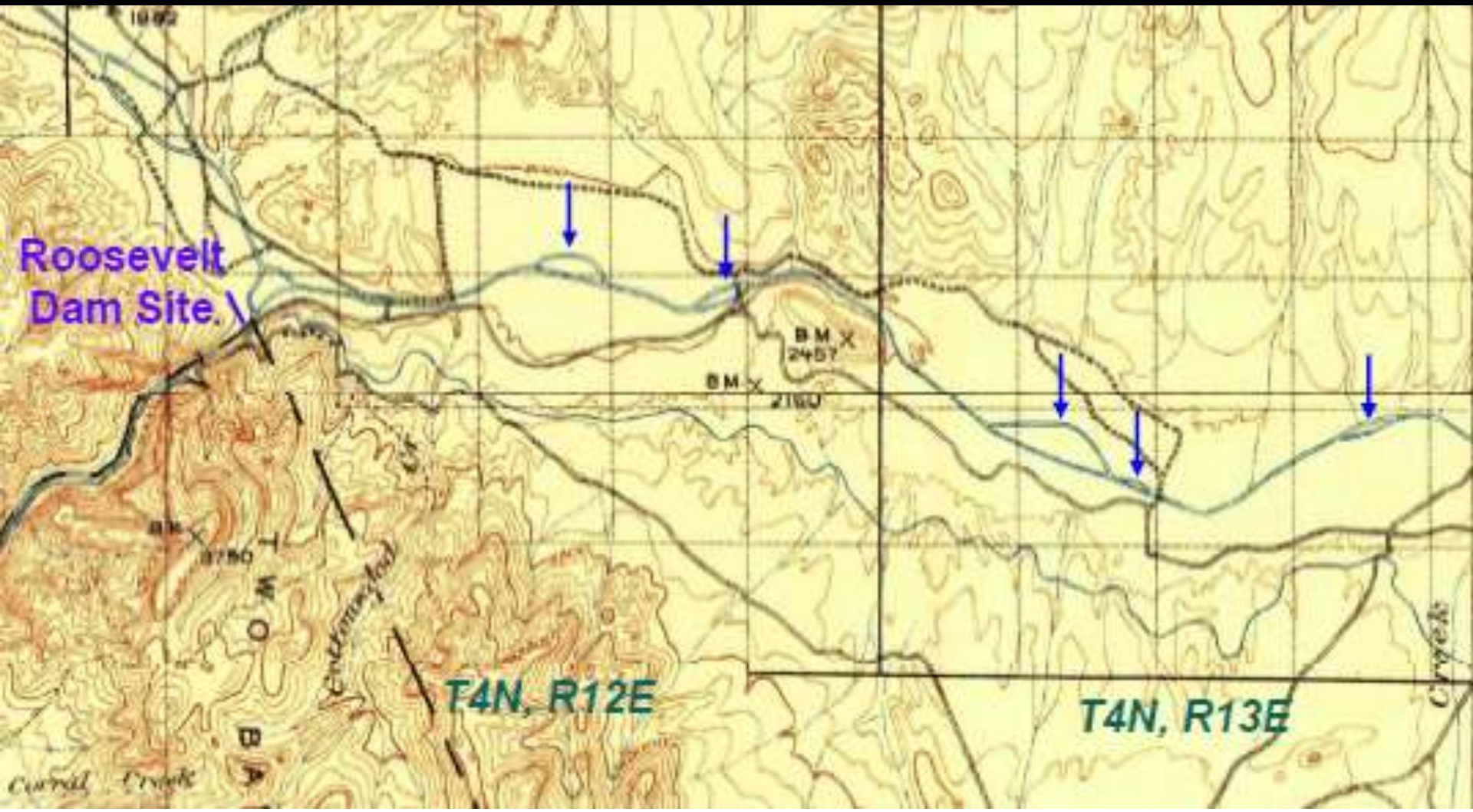
Salt River – Segment #3

- Field Photos

Salt River Segment #3

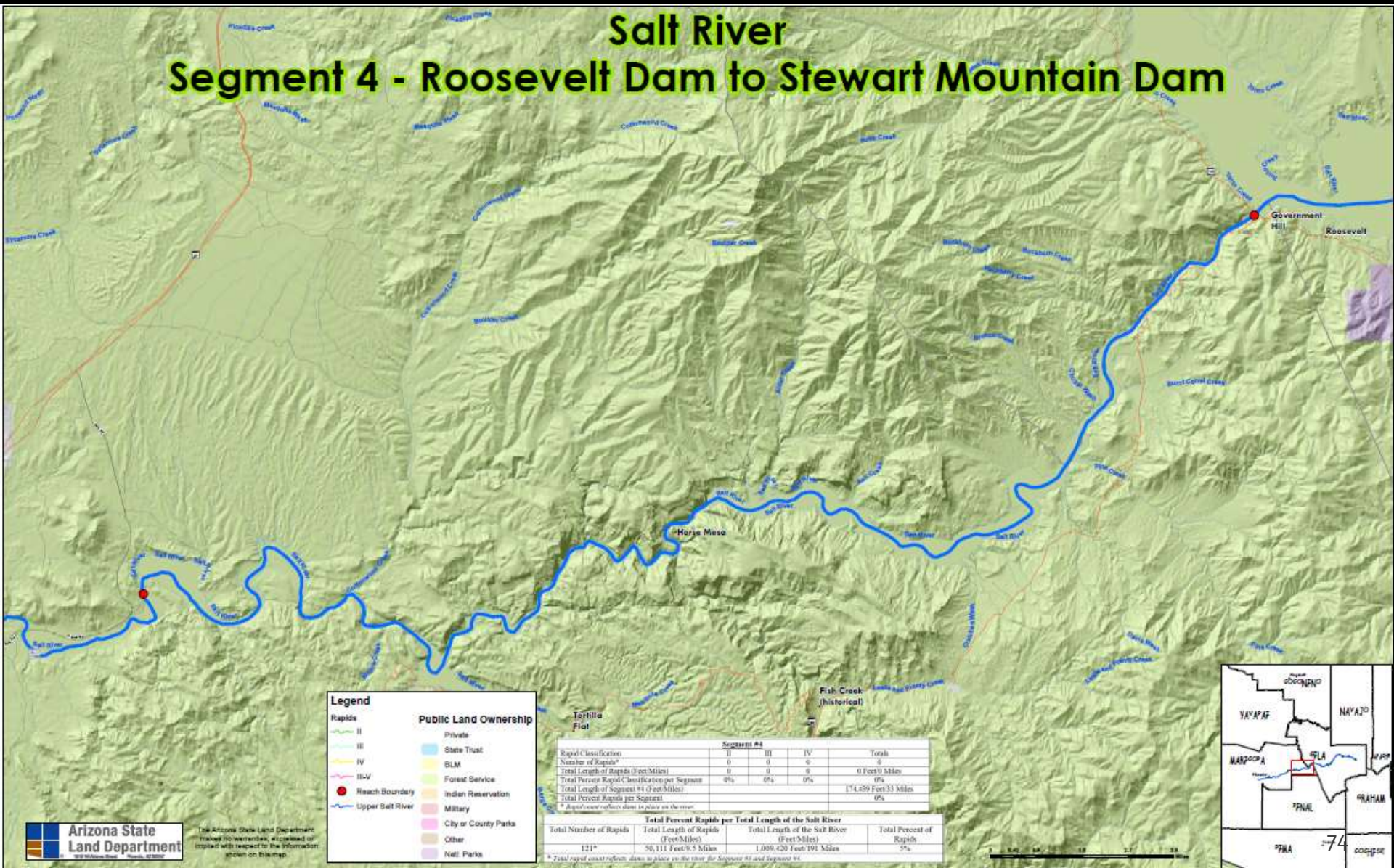
- River Conditions Under Lake Roosevelt (O&N)
  - Compare to Other Flats on the Salt River (Seg 1-4)
    - Gleason, Redmon, Horseshoe Bend
  - Historical Accounts
    - No Significant Rapids or Braiding Mentioned
    - Some Photos of Class I-II near Roosevelt Dam Site
  - Geomorphology
    - Small Tributaries
    - Tributaries Set Back From Main Stem & Flatter
    - Similar Slope to Rest of Segment 3
    - Underlain by Alluvium
    - Valley Morphology Not Conducive to Large Rapid Formation

Salt River Segment #3



Source: USGS Quad Roosevelt, 1909

Salt River Segment #4



Segment #4				
Rapid Classification	II	III	IV	Totals
Number of Rapids*	0	0	0	0
Total Length of Rapids (Feet/Miles)	0	0	0	0 Feet/0 Miles
Total Percent Rapid Classification per Segment	0%	0%	0%	0%
Total Length of Segment #4 (Feet/Miles)				174,489 Feet/33 Miles
Total Percent Rapids per Segment				0%

* Rapid count reflects dams in place on the river.

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 #1 and Segment #4.

Salt River Segment #4

- Salt River Segment #4
  - Roosevelt Dam to Stewart Mountain Dam*
    - Tonto National Forest
  - Perennial Flow
  - Probable Channel Characteristics
    - Pool & Riffle
    - Sinuous to Straight
    - Bedrock Canyons, Small Flats
  - Hydrology Altered by Reservoir Impoundment

*Notes

Upstream segment boundary located at mouth of bedrock canyon just upstream of actual location of Roosevelt Dam.
Downstream segment boundary located at mouth of bedrock canyon just below actual location of Stewart Mtn Dam.

Salt River Segment #4

- Rapids
  - Now submerged by Reservoirs
  - Existence of Rapids inferred from geology, canyon morphology, and historical boating accounts
  - Discussed in more detail later
- Historical Boating Accounts
- Major Tributaries
  - Fish Creek
  - Tortilla Canyon/La Barge Canyon
  - Cottonwood Creek

Google Earth Flyover

- Salt River, Segment 4

Segment #4 Field Photos

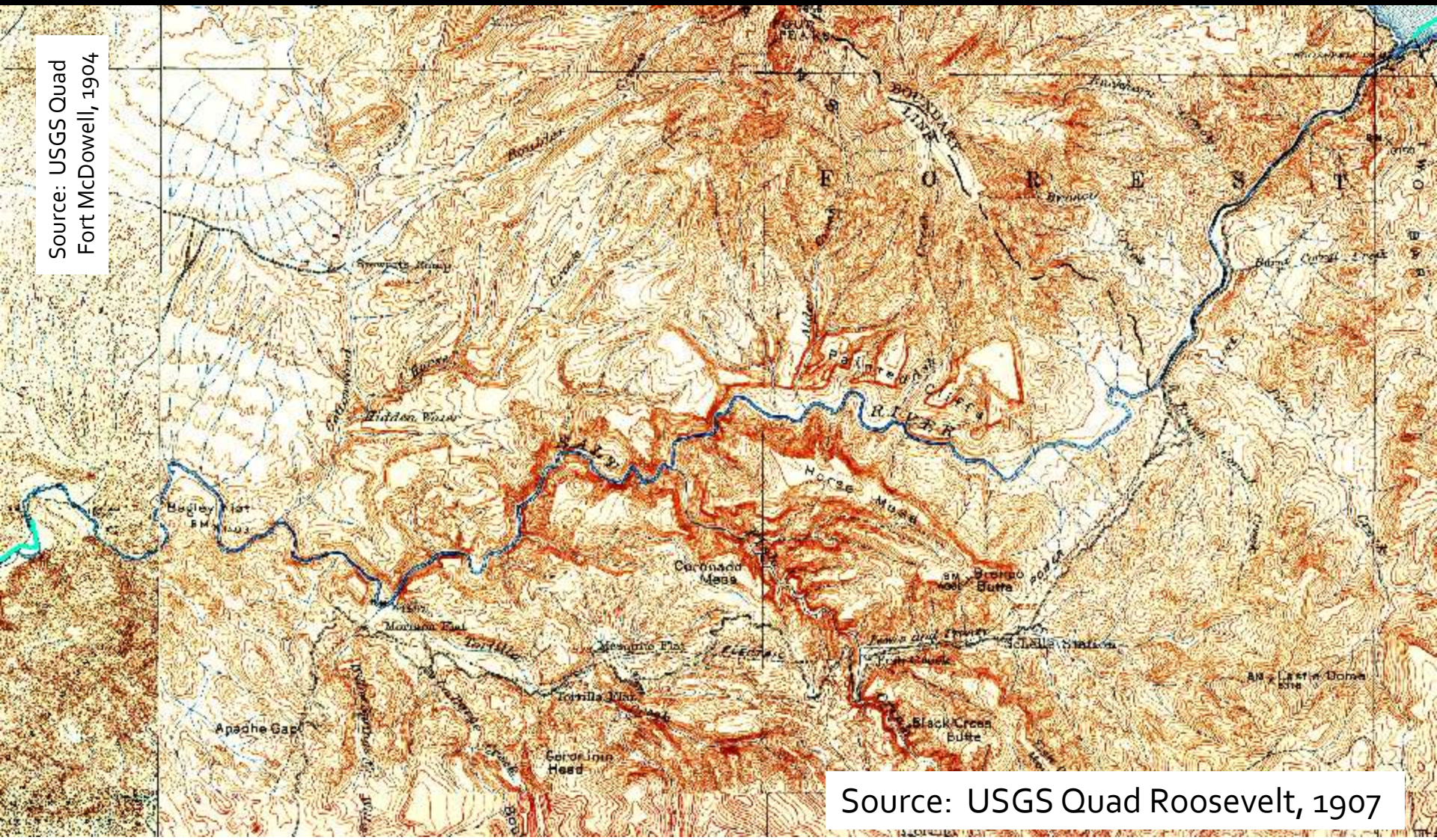
Boat tour of lakes, focusing on side tributaries and canyon morphology.

Additional photos provided digitally

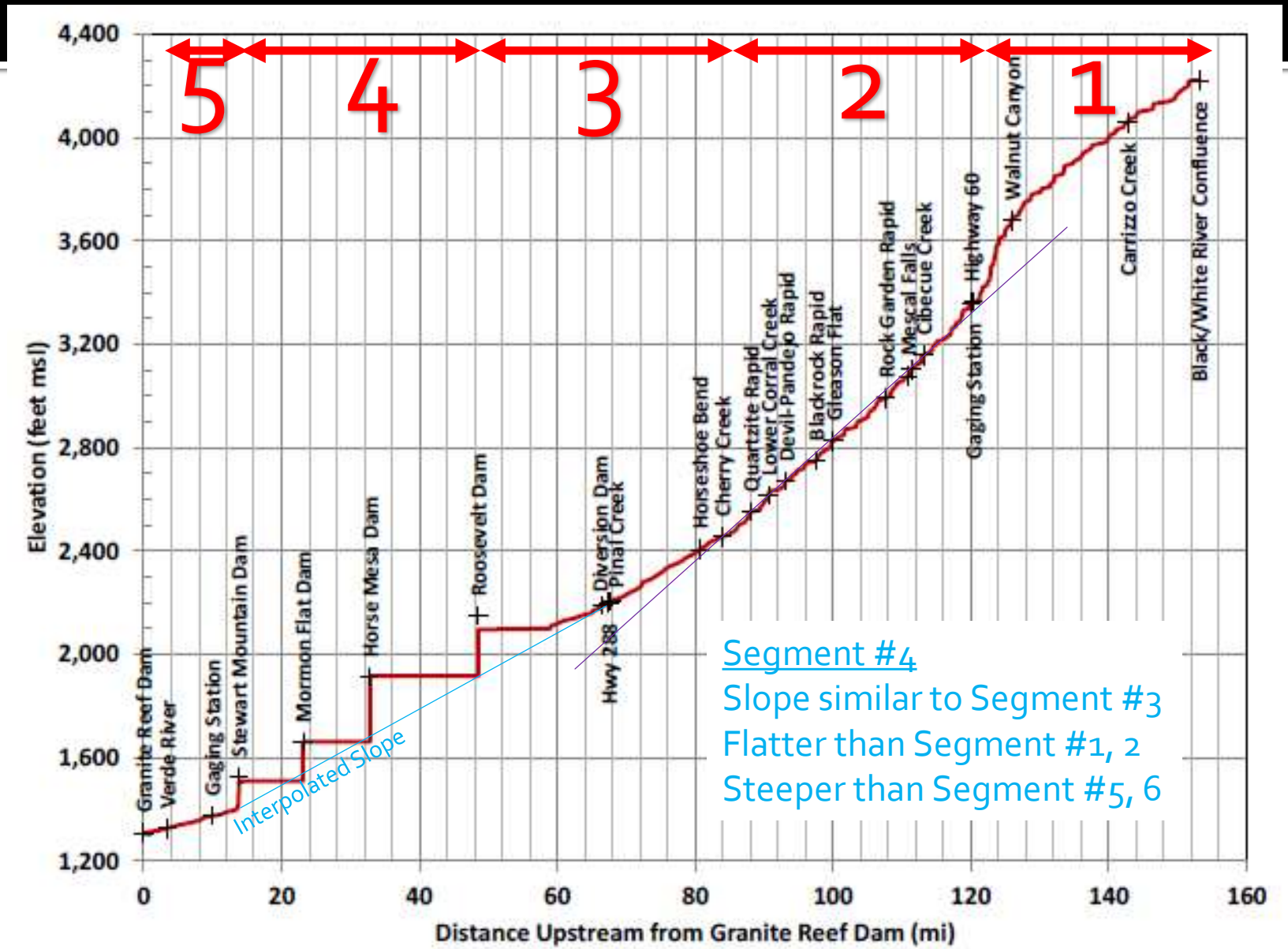
Salt River Segment #4

- Analysis of Potential for Rapids in Segment #4
  - Historical Maps (pre-date dams)
  - Historical Boating Accounts
  - Comparison to Undammed Reaches
    - Slope Profile
    - Tributary Characteristics
    - Bedrock Geology
    - Canyon Morphology

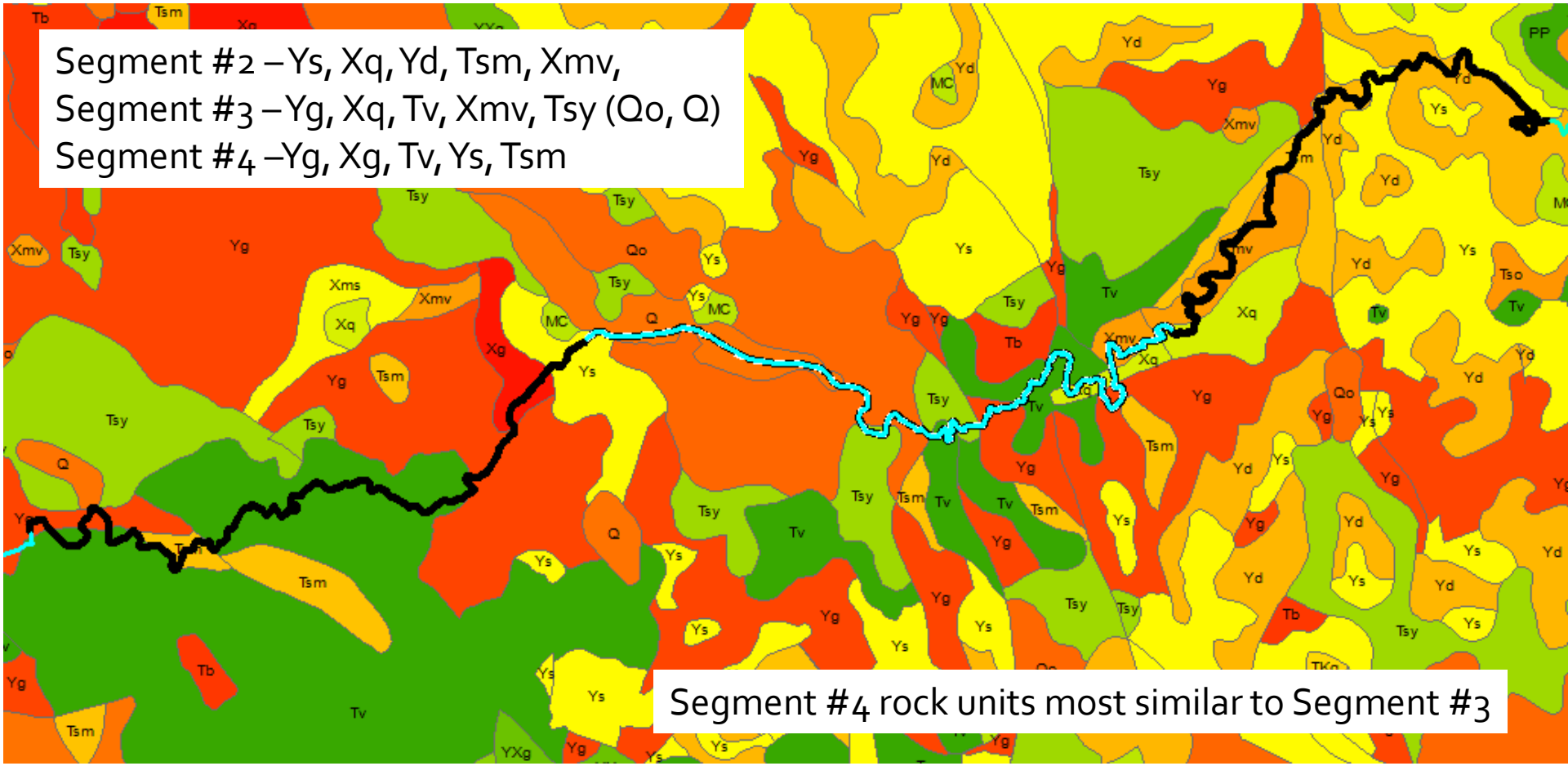
Historical Maps: Segment #4



Segment #4: Pre-Dam Conditions



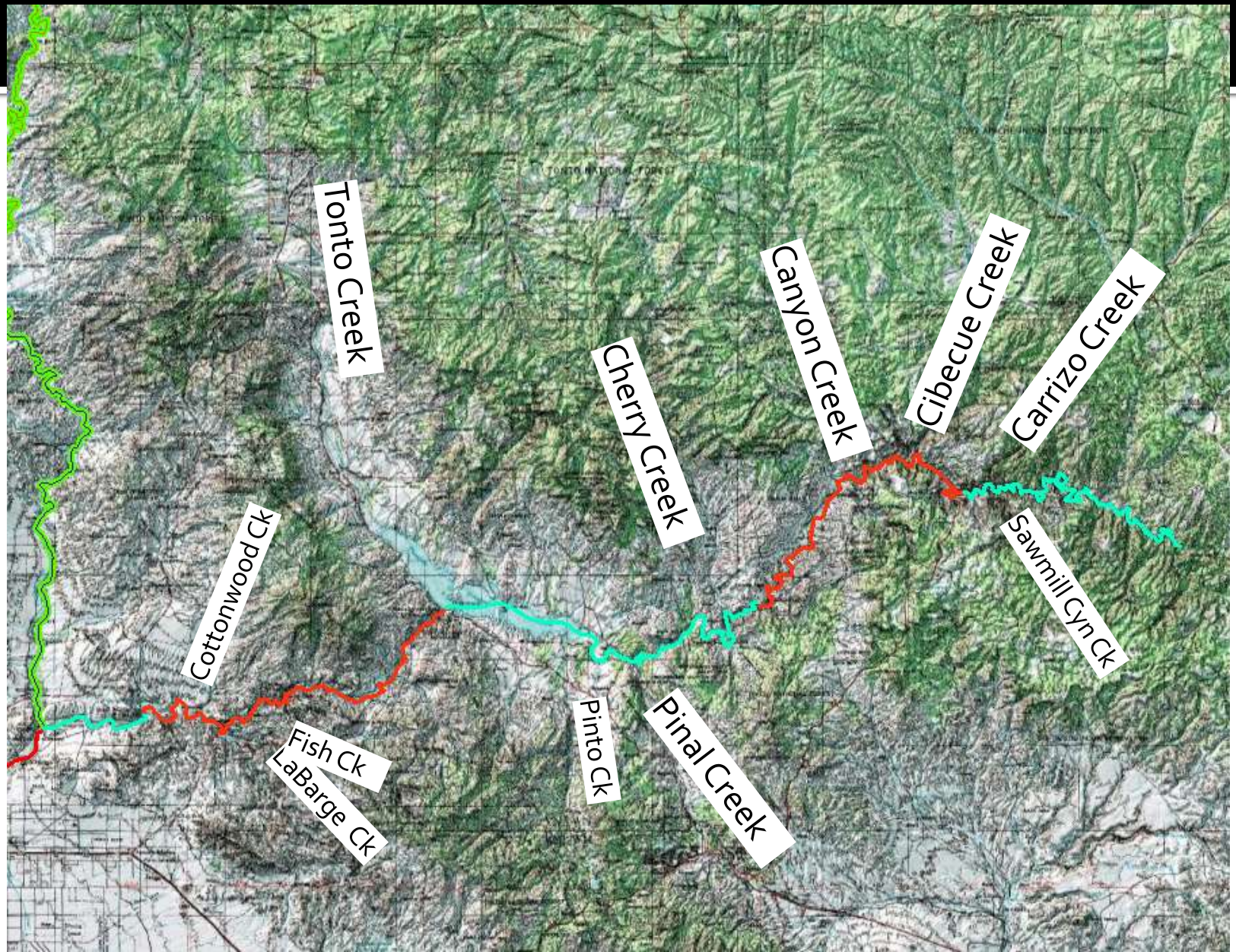
Segment #4: Pre-Dam Conditions



Segment #4: Pre-Dam Conditions

Salt River Rapids & Geology							
Unit	**Rock Type**	**Segment**					**Rapid**
MC	Mississippian/Cambrian sedimentary	1					No named rapids in Segment #1, but many unnamed Class III-V.
Tsm	Miocene/Oligocene sedimentary		2		4		All Class II or lower in this unit
Tsy	Pliocene/Miocene sedimentary			3			All Class II or lower in this unit
Tv	Miocene/Oligocene volcanics			3	4		All Class II or lower in this unit
Xmv	Proterozoic metavolcanic		2	3			Eye of Needle (III), Black Rock (IV), Devil's Pendejo (III), Lower Corral (III), Pinball (III), Maze (IV)
Xg	Proterozoic granites				4		Similar lithology to Yg, but different weathering pattern
Xq	Proterozoic quartzite		2	3			Quartzite (IV), Corkscrew (IV), Sleeper (III)
Yd	Proterozoic diabase		2				Bridge (III), Maytag (III), Grummon (III), Overboard (III), Exhibition (III), Mescal (III), Ledges (III), Cheese/Rat Trap (III), White Rock (III)
Yg	Proterozoic granites			3	4		Granite (III)
Ys	Proterozoic sedimentary		2		4		Rock Garden (III)
Q	Alluvium			3	4	5	All Class II or lower in this unit

Segment #4: Pre-Dam Conditions



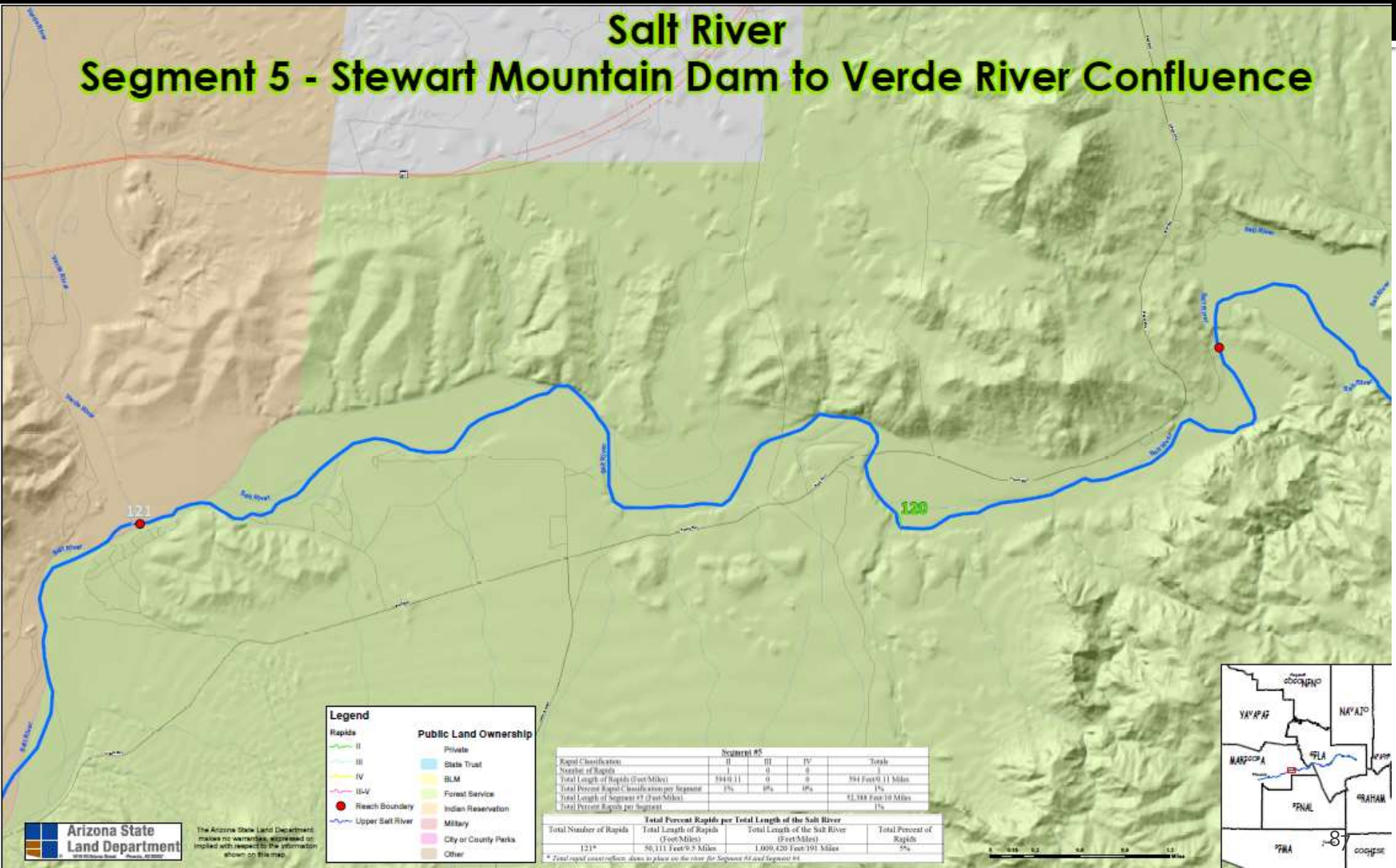
Salt River Segment #4

- Canyon Morphology Analysis
  - Occurrence & Class of Rapids (Segments 1-3)
  - Causes of Rapids
    - Geologic – fault, sills
    - Tributary Confluence/Sediment Supply
    - Rock fall
    - Pool/Riffle Sediment Distribution
  - Implications for Segment 4

Salt River Segment #4

- Rapids in Segment #4
  - Greatest Similarity to Segment 3 (Geology)
    - Geology
    - Slope
  - Rock Units with Large (Class III-IV) Rapids Not Present
  - Slope Flatter Than Segments 1-2
  - No Major Tributaries
    - Larger tributaries set back from main channel
    - Not conducive to debris flow
  - Canyon Morphology
    - Rock fall in some reaches
  - Historical Descriptions
    - Some rapids
    - Some fast current
    - Some easy floating
- Conclusion: Class II most likely

Salt River Segment #5



Segment #5				
Rapid Classification	II	III	IV	Totals
Number of Rapids	1	0	0	1
Total Length of Rapids (Feet/Miles)	594/0.11	0	0	594 Feet/0.11 Miles
Total Percent Rapid Classification per Segment	1%	0%	0%	1%
Total Length of Segment #5 (Feet/Miles)				52,388 Feet/10 Miles
Total Percent Rapids per Segment				1%

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 #4 and Segment #6

Salt River Segment #5

- Salt River Segment #5
  - Stewart Mountain Dam* to Verde River
    - Tonto National Forest
    - Salt River Pima Maricopa Indian Community
  - Perennial Flow
  - Channel Characteristics
    - Pool & Riffle
    - Sinuous to Straight
    - Narrow Alluvial Valley, Some Local Bedrock Control
  - Hydrology Altered by Dam Releases & Storage

*Note: Segment boundary located at mouth of bedrock canyon just downstream of actual location of Stewart Mtn Dam. Downstream boundary just above Verde River confluence.

Salt River Segment #5

- Historical Boating Accounts
- Extensive Modern Boating
  - Recreational & Commercial Recreation
- Rapids
  - Two Class II- Rapids
    - Less than 2% of Segment Length
    - Two rapids in 10 miles
  - No Class III, IV, or V Rapids
- Major Tributaries
  - None

Google Earth Flyover

- Salt River, Segment 5

August 23, 2014 – 631 cfs

Segment #5 Field Photos

March 15, 2014 – 8 cfs

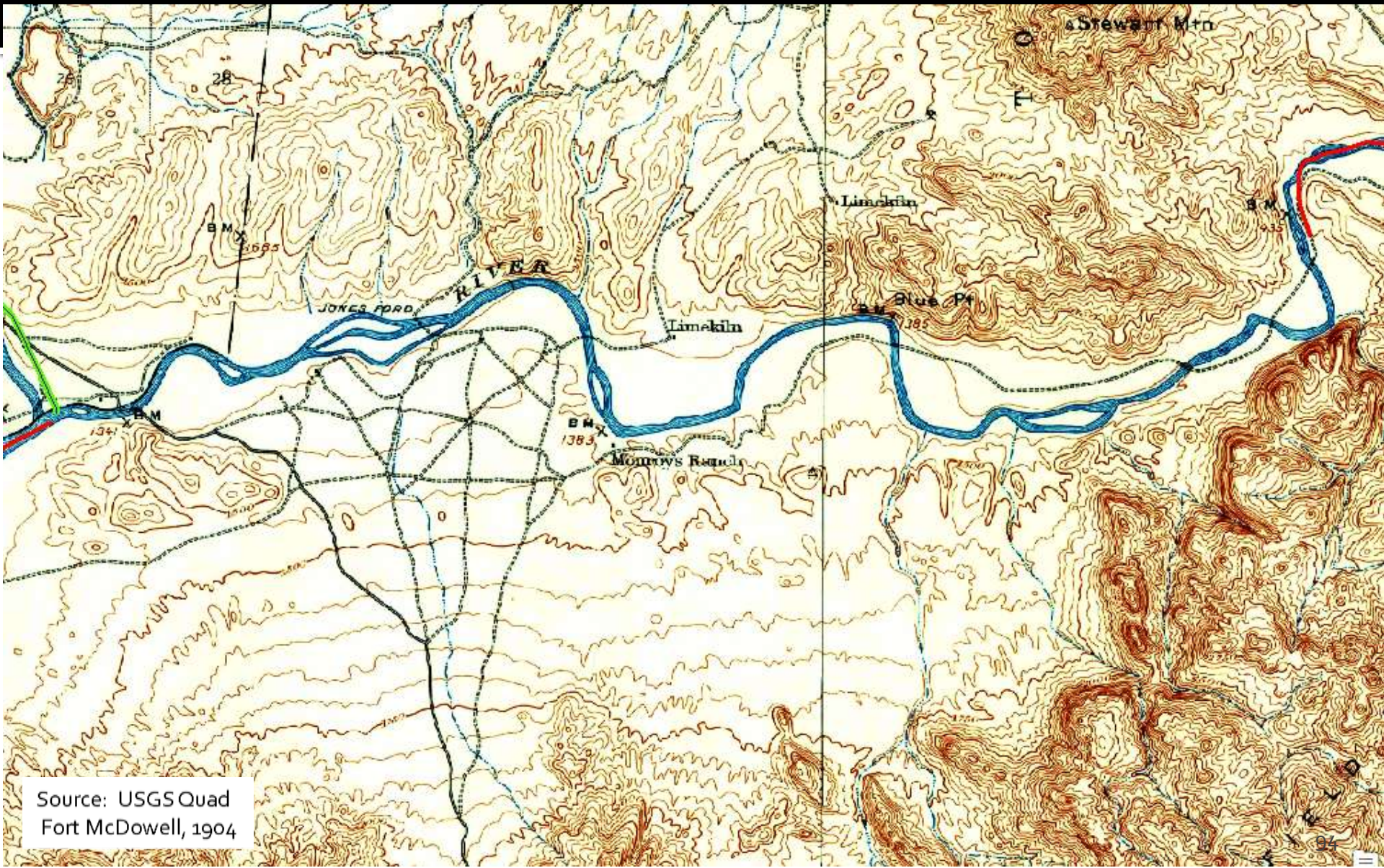
Segment #5 Field Photos

82% of Segment 5 was pools, with depths > 1 ft at 8 cfs

Segment #5 Field Photos

Additional photos to be provided digitally

Historical Maps: Segment #5



Source: USGS Quad
Fort McDowell, 1904

Historical Maps: Segment #5

2011

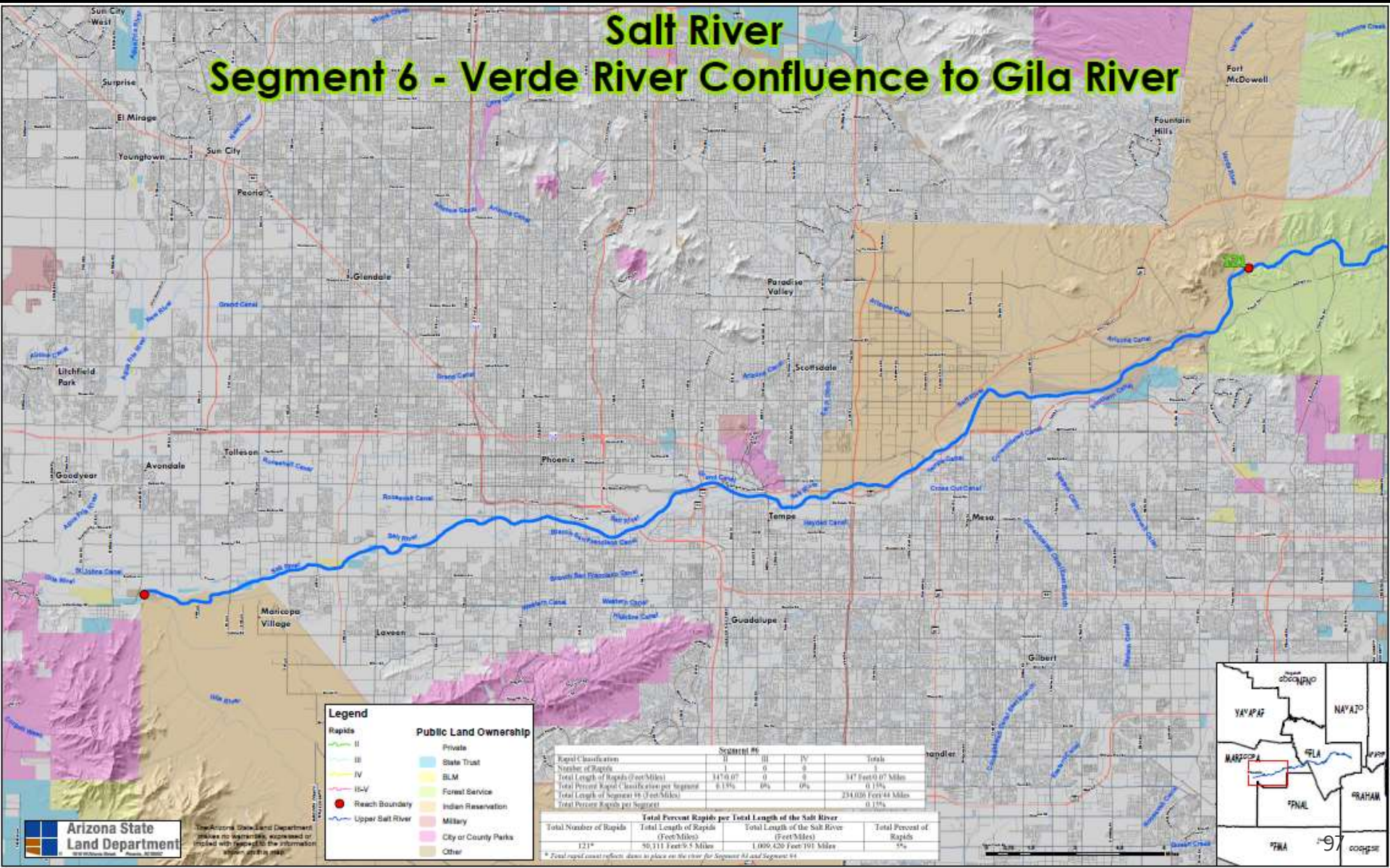
1904

Historical Maps: Segment #5

2013

1904

Salt River Segment #6



Salt River Segment #6

- Salt River Segment #6
  - Verde River to Gila River
    - Tonto National Forest
    - Fort McDowell Apache Tribe
    - Salt River Pima Maricopa Indian Community
    - Gila River Indian Community
  - Perennial (historically)
  - Channel Characteristics
    - Pool & Riffle
    - Sinuous to Straight
    - Local Braiding, Compound Channel
    - Broad Alluvial Valley
  - Hydrology Controlled by Dam Releases

Salt River Segment #6

- Historical Boating Accounts
- Modern Boating
  - During floods & in effluent discharge
- No Rapids
- Major Tributaries
  - Verde River
  - Indian Bend Wash (ephemeral)

Google Earth Flyover

- Salt River, Segment 6

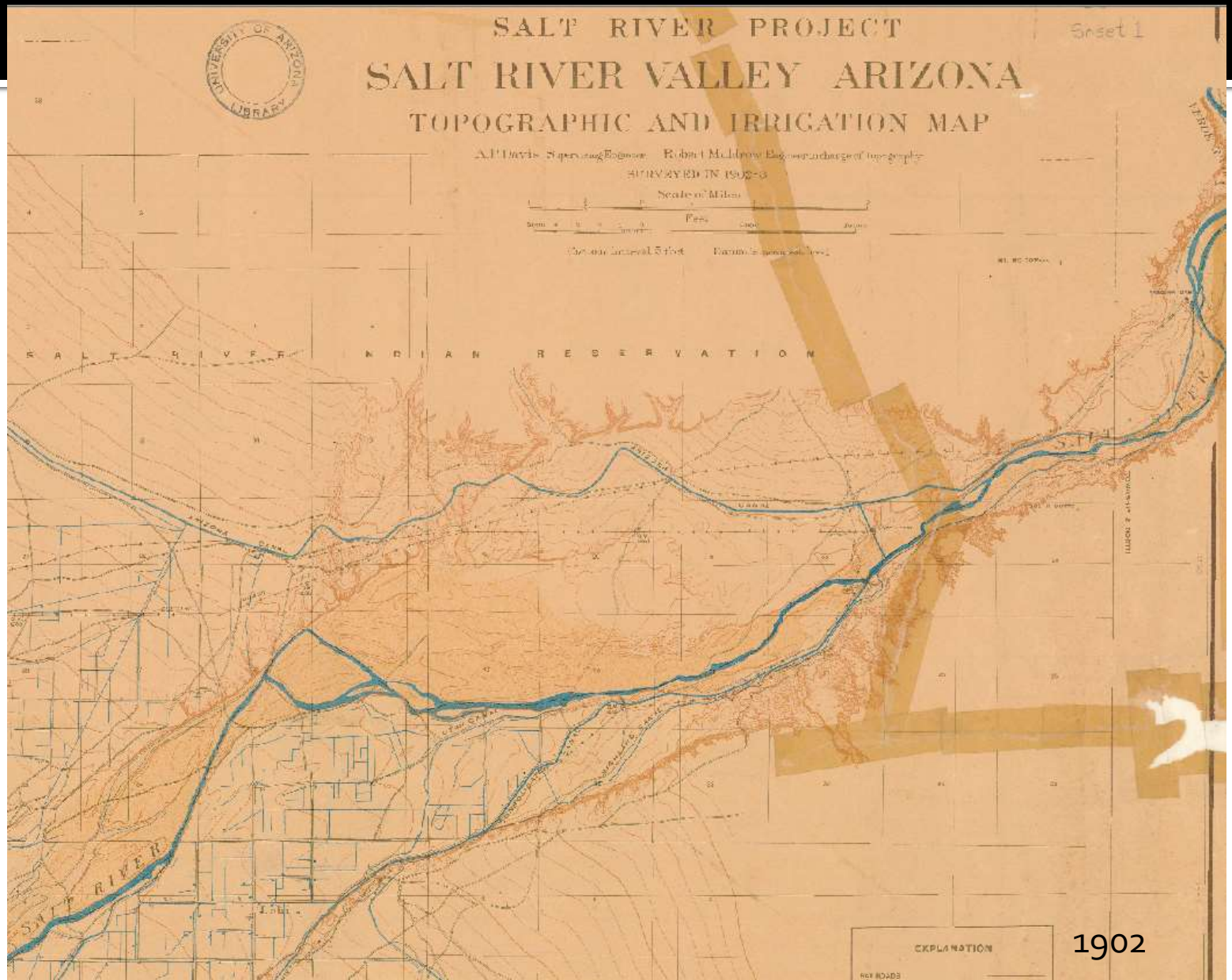
Salt River Segment #6

March 15, 2014
@ 283 cfs

Salt River Segment #6

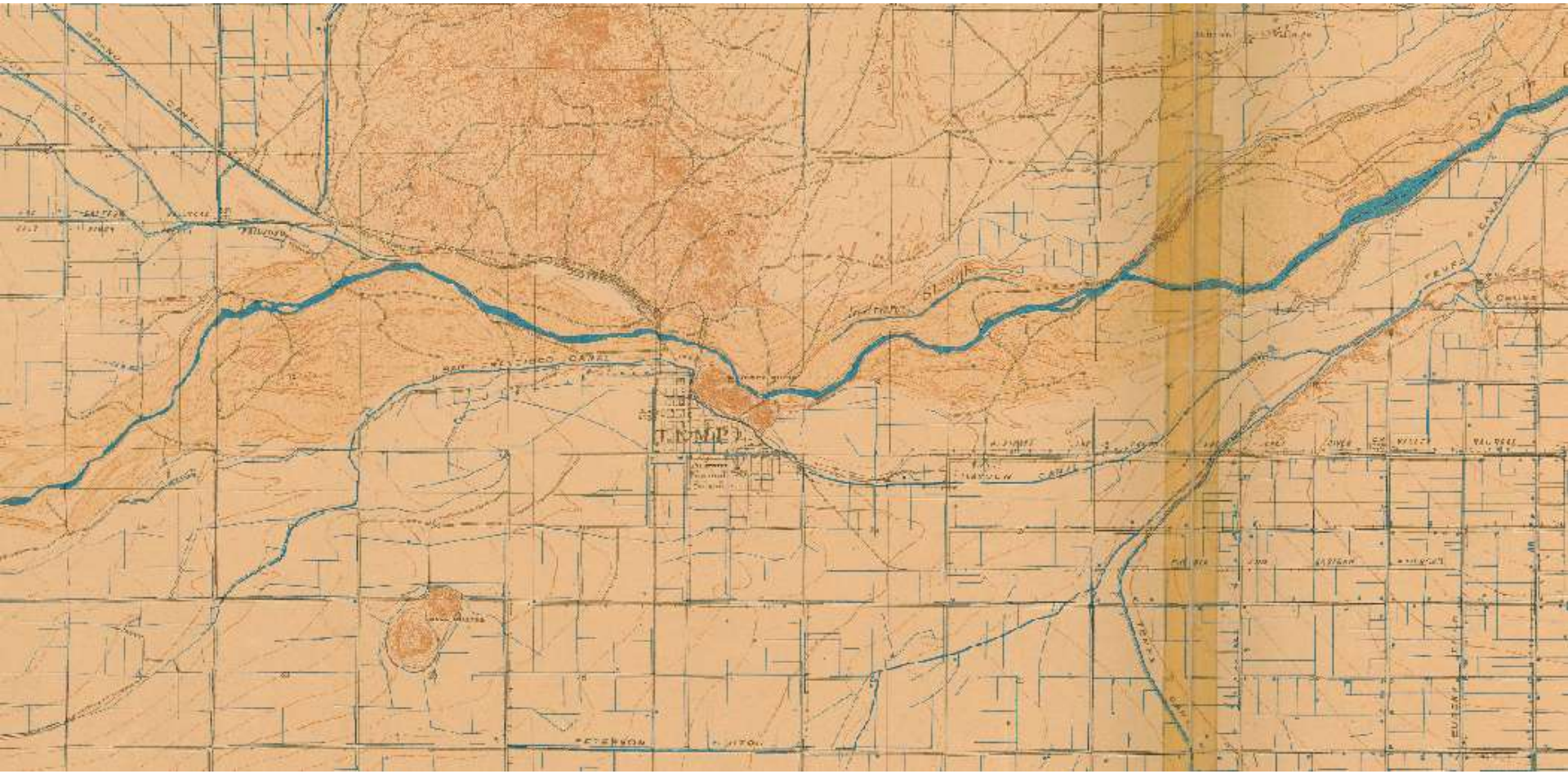
February 11, 2014
@ 370 cfs

Historical Maps: Segment #6

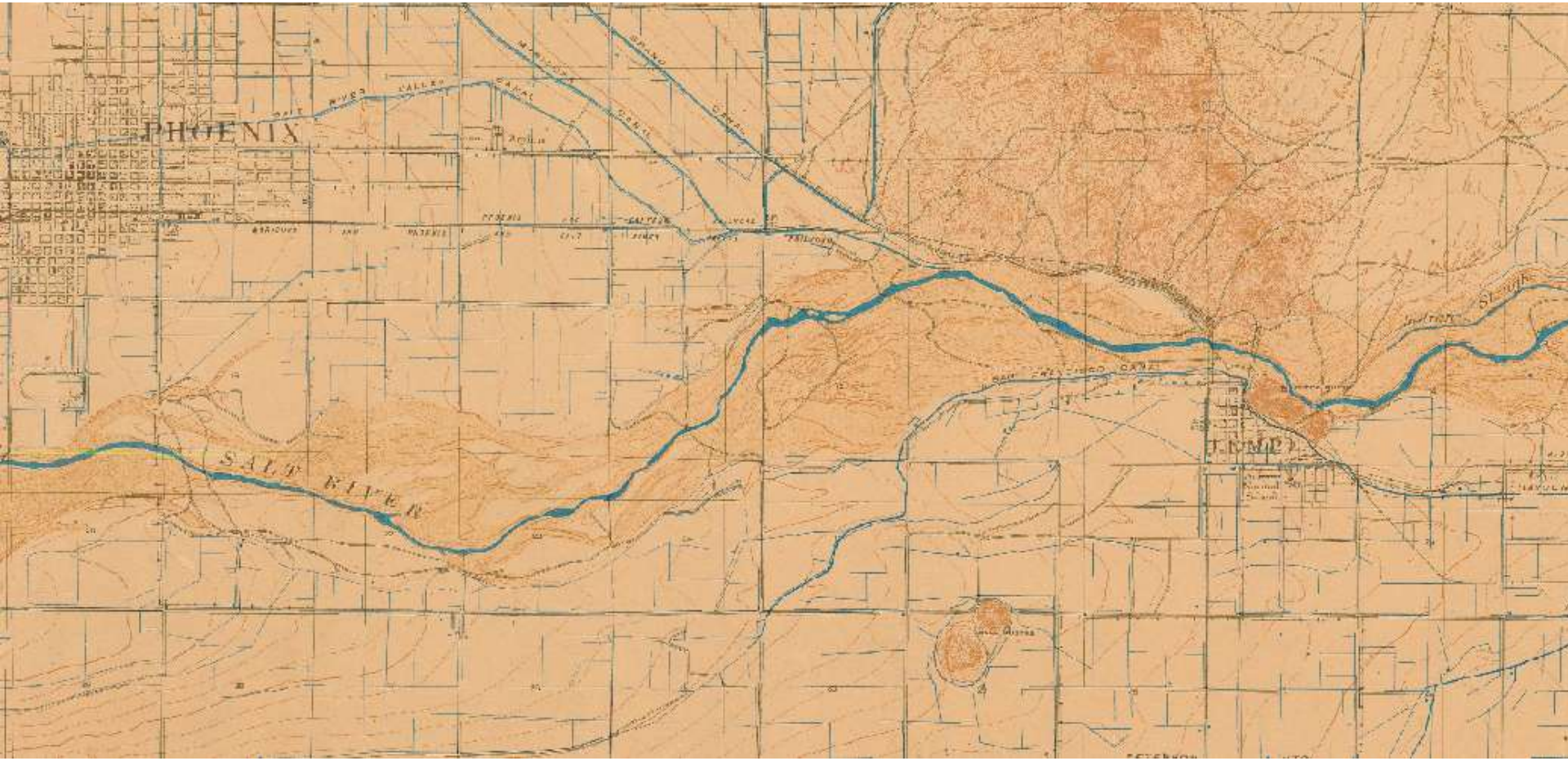


1902

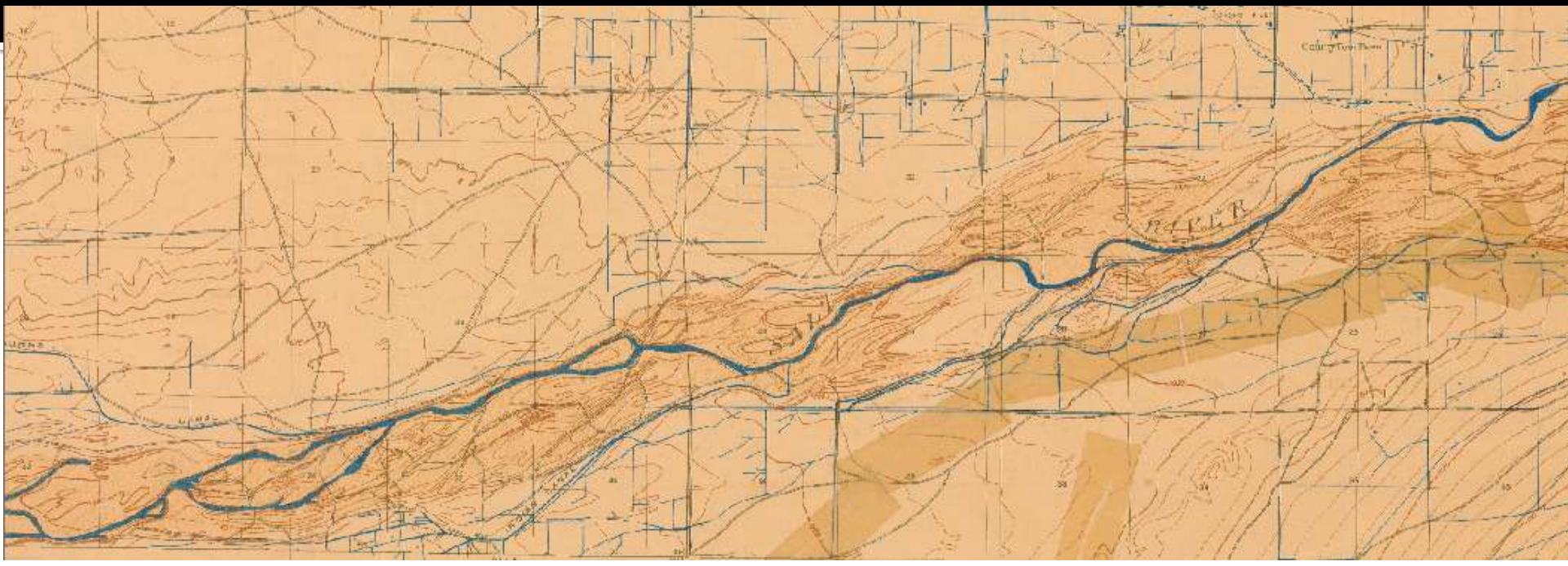
Historical Maps: Segment #6



Historical Maps: Segment #6



Historical Maps: Segment #6



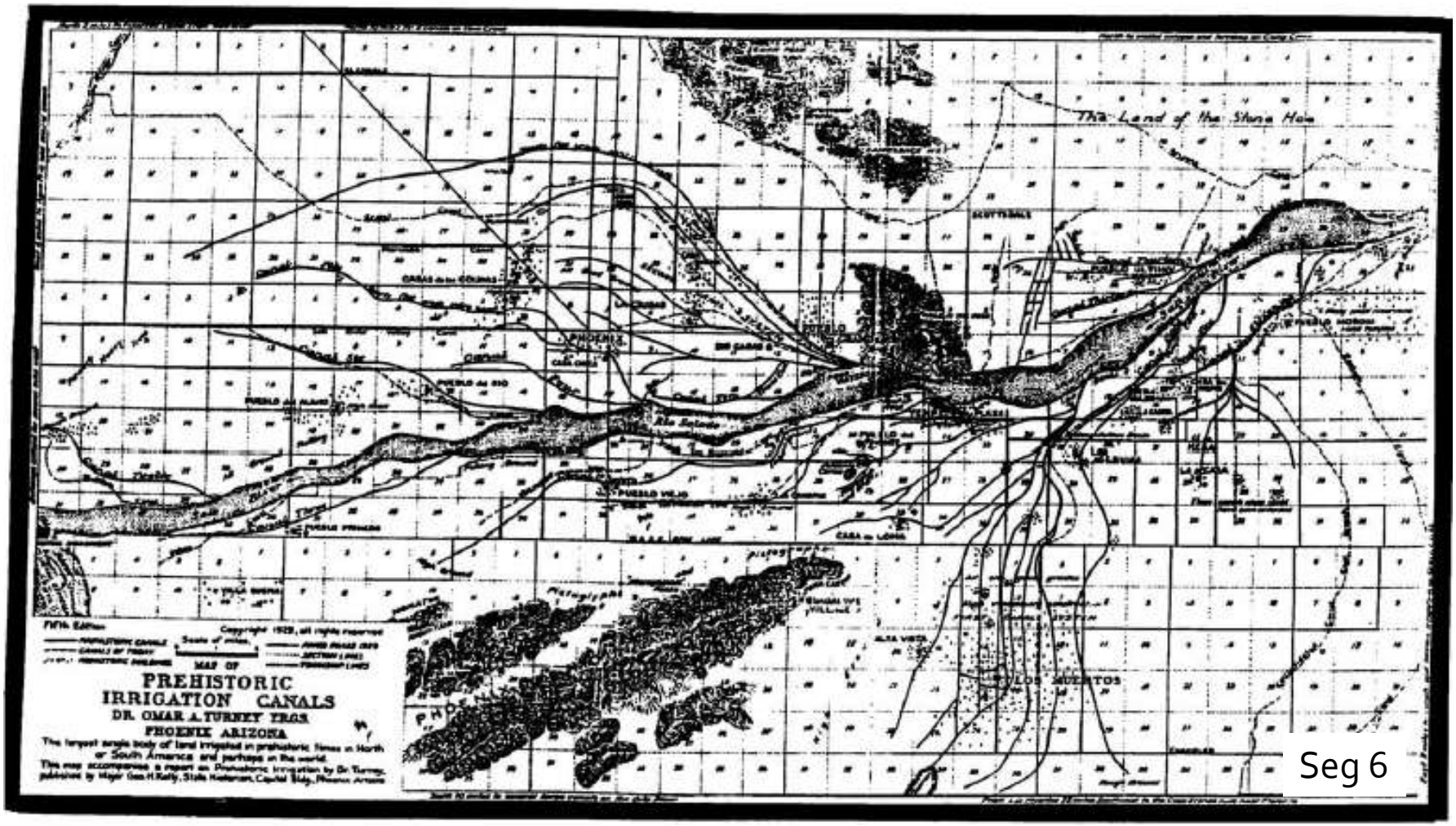
Navigability of the Salt River

- Information Provided in ASLD Reports
  - Archaeology
  - History
  - River Descriptions
  - Historical Boating Accounts
  - Geology
  - Hydrology
  - Rating Curves (Flow Depths)
  - Modern Boating

Archaeology: Key Findings

- Canal Systems
  - 1,000+ years of irrigation-based civilization
  - 300+ miles of canals (Segment 6)
  - 140,000 acres irrigated
  - Single canal capacity up to 240 cfs
  - 250-1450 A.D
  - 80,000-200,000 people along canal systems
  - Minimal irrigation along Salt River Segments 1-4
    - Segment 3 – Tonto Basin (now under Roosevelt Lake)

Archaeology: Segment 6 Canals



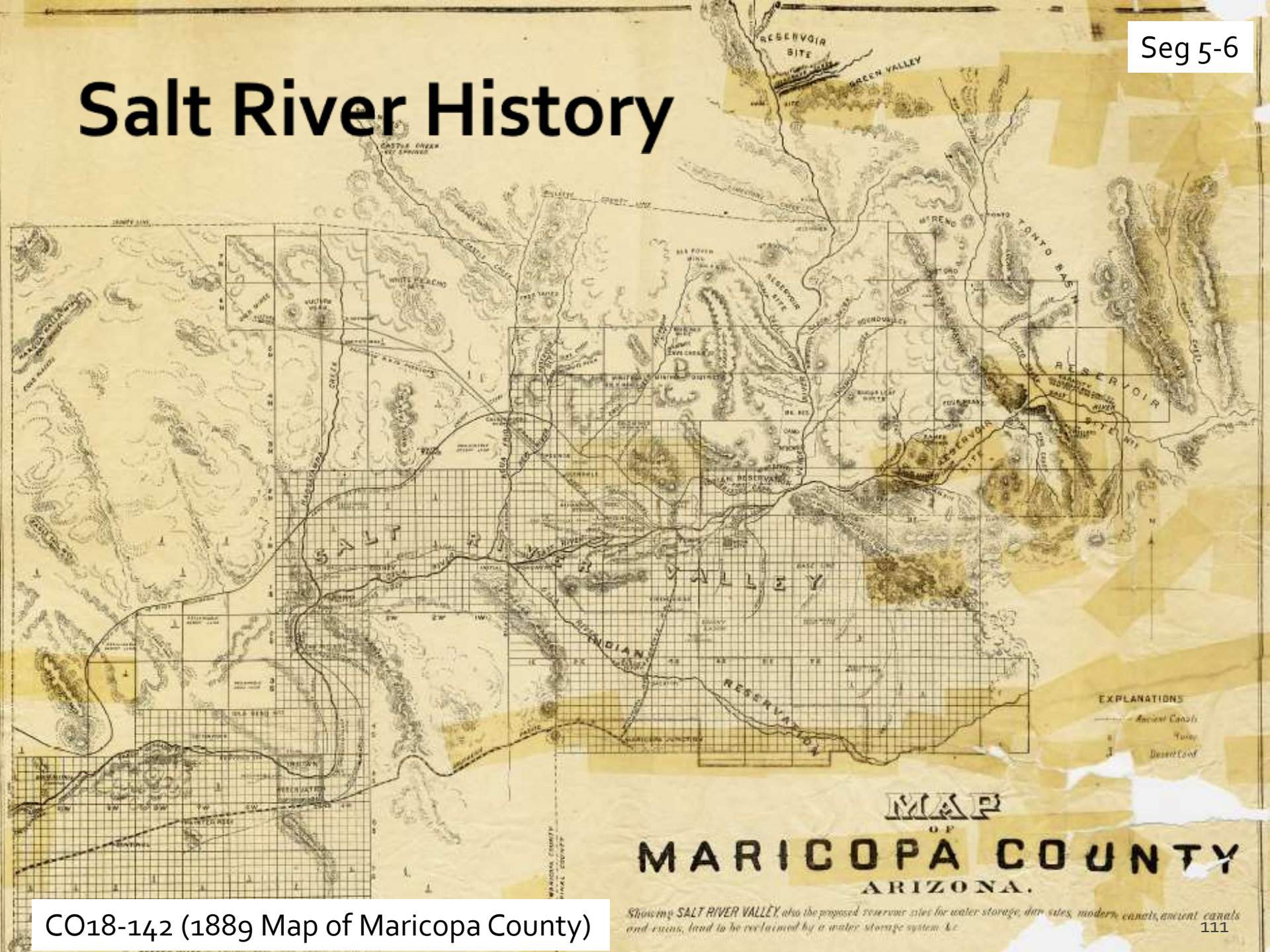
Turney, 1929 as cited in ASLD, p. 2-4

Archaeology: Key Findings

- Archaeological Evidence of Boating
  - Hohokam boats (Cushing, 1890; USBR, 2000)
  - Balsa rafts in canals (Wilcox, 1993)
  - Boat ramps on canals (Henderson, 2015)
  - Boat building materials (Henderson, 2015)
- Fish
  - Big river fish (chub, squawfish, etc.)
  - 5 ft long, 40 lbs
- Perennial Stream Flow

Salt River History

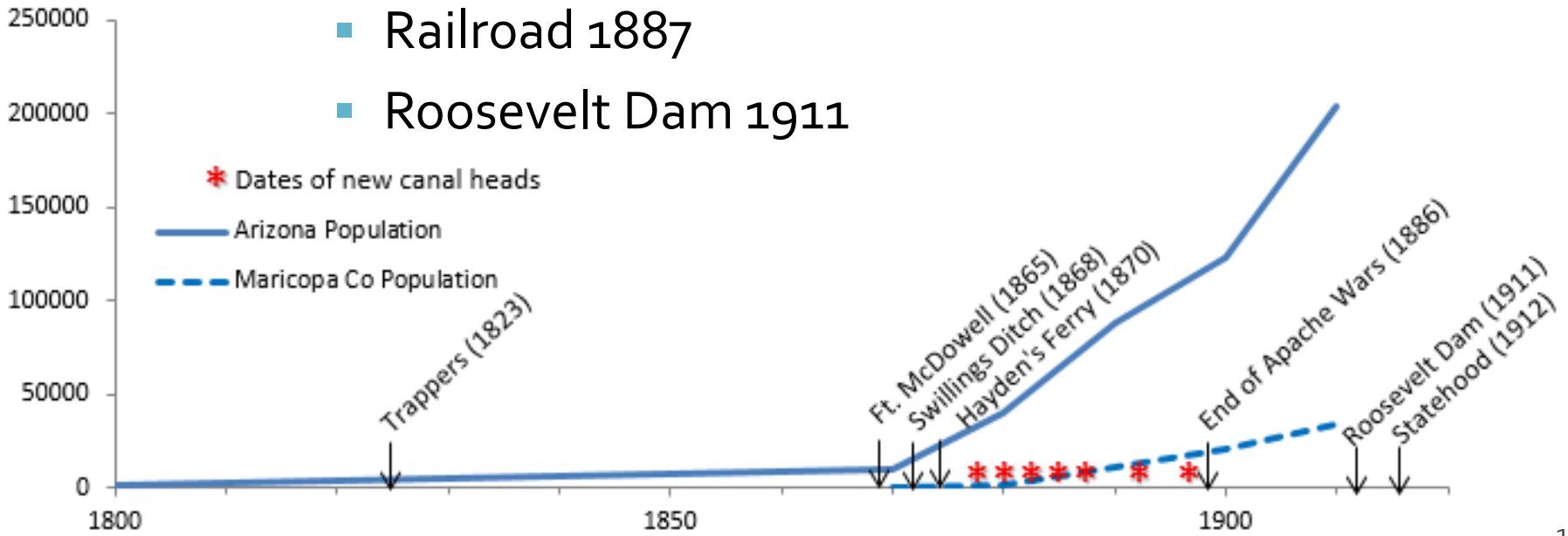
Seg 5-6



CO18-142 (1889 Map of Maricopa County)

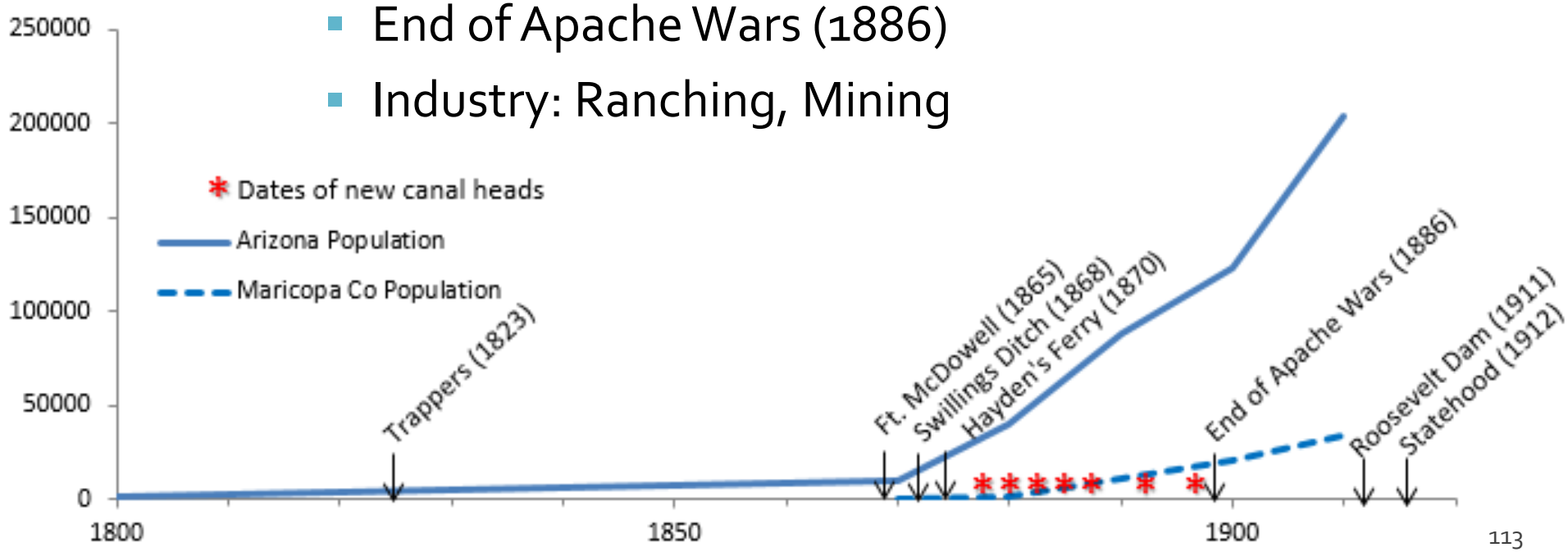
History: Key Findings

- Key Events in Salt River History (Seg 5-6)
  - Explorers 1500's-1800's
  - Trappers 1820's
  - Euro-American Settlement 1860's, Agriculture
  - Canals 1867+
  - Railroad 1887
  - Roosevelt Dam 1911



History: Key Findings

- Key Events in Salt River History (Seg 1-4)
  - Explorers 1500's-1800's
  - Trappers 1820's
  - Apache/Yavapai <1870's
  - End of Apache Wars (1886)
  - Industry: Ranching, Mining



History: Key Findings

- Population along the Salt River

	1890	1900	1910		Segment
Phoenix (1868)	3,152	5,544	11,134		6
Maricopa County	10,986	20,457	34,498		4-6
Salt River Valley			21,589		5-6
Tempe (1868)		885	1,473		6
Mesa (1878)		722	1,602		6
Gila County	2,021	4,973	16,348		1-3
Globe-Miami			9,361		-
Roosevelt area			707		3

History: Key Findings

- Towns Located on the Salt River ca. 1912

Segment	Town	Population 1910	Segment	Town	Population 1910
1	None	0	5	None	0
2	None	0	6	Marysville	*
3	Livingston	*	6	Lehi	*
3	Roosevelt	707	6	Mesa+	3,330
3	Grapevine	*	6	Tempe+	3,073
4	Tortilla Flat	*	6	Phoenix+	11,134

* Community is not listed in 1910 census.
+ Includes "precinct" around town.

Population Centers on Salt River above the Verde River

- Tonto Basin Ranching & Farming
  - Roosevelt (@ dam site)
  - Livingstone, Grapevine (@ Pinto Creek)
  - Armer, Catalpa, Cline (@ Tonto Creek)
  - Small irrigation ditches
- King Woolsey Salt Works
  - Segment 2; 1876-1879; Salt packed out by mule
  - Salt supplied to mines at McMillanville
  - Mormon Flat – Ranch
- Isolated pioneer ranches on tributaries

History: Key Findings

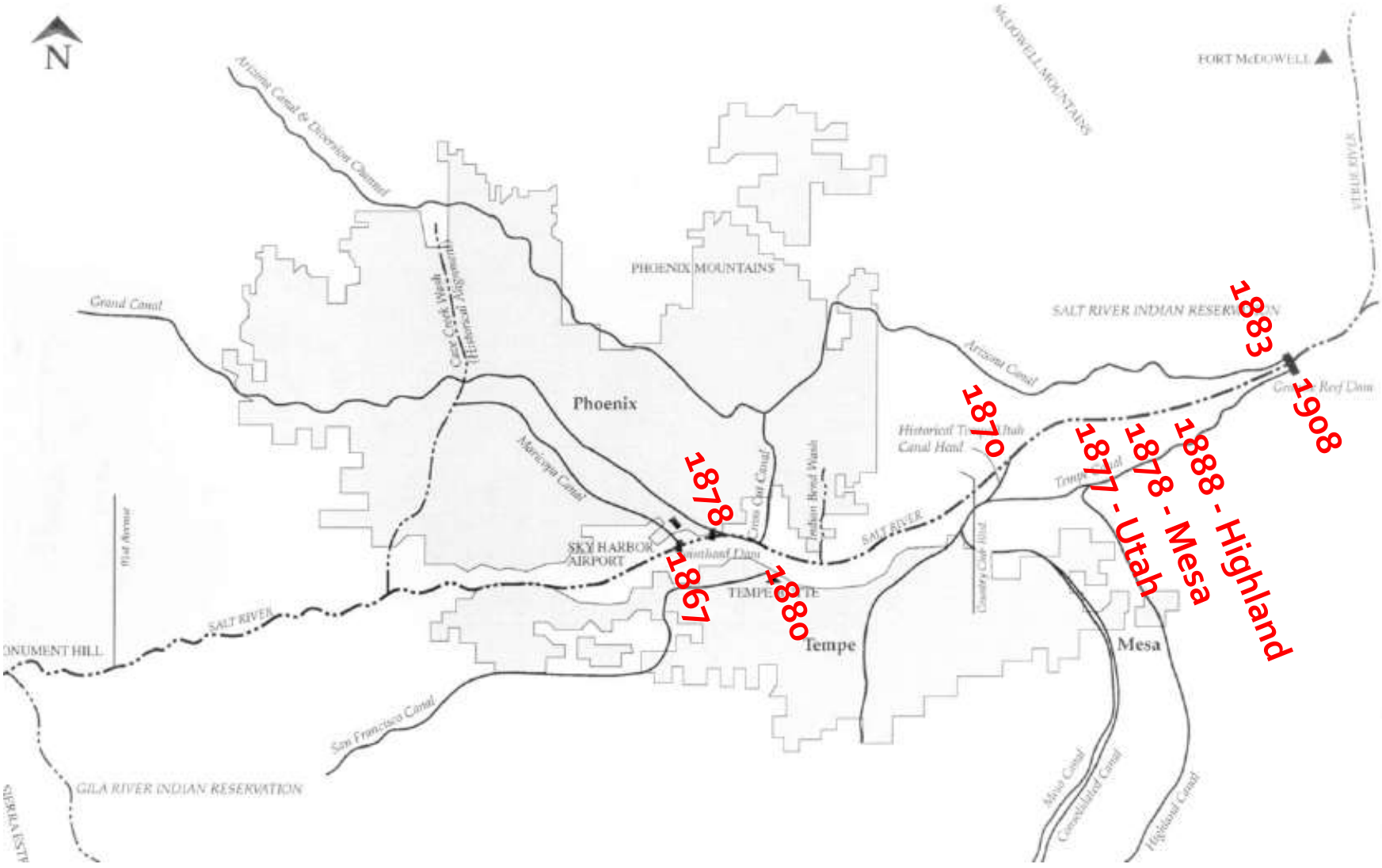
Canals

Swilling's (Salt R Canal)	1867	Jointhead Dam
Maricopa Canal	~1870	Jointhead Dam
Tempe Canal	1870	9 mi. upstream JD
Broadway Canal	1870	4 mi. upstream JD
Utah Canal	1877	14 mi. upstream JD
Mesa Canal	1878	16 mi. upstream JD
Grand Canal	1878*	3 mi. upstream JD
San Francisco Canal	1880	Tempe Canal
Arizona Canal	1883	Arizona Dam
Highland Canal	1888	8 mi. upstream JD
Consolidated Canal	1891	Arizona Dam

ASLD, Table 7-8 (Lower Salt)

History: Key Findings

Seg 6



History: Key Findings

- Dams
  - Arizona (1885) – Segment 6 Diversion
  - Granite Reef (1908) – Segment 6 Diversion
  - Roosevelt (1911) – Segment 4 Roosevelt Lake
  - Stewart Mtn (1930) – Segment 4 Saguaro Lake
  - Horse Mesa (1927) – Segment 4 Apache Lake
  - Mormon Flat (1925) – Segment 4 Canyon Lake
  - Verde River Dams (Influences Segment 6)
    - Bartlett (1939) & Horseshoe (1945)

History: Key Findings

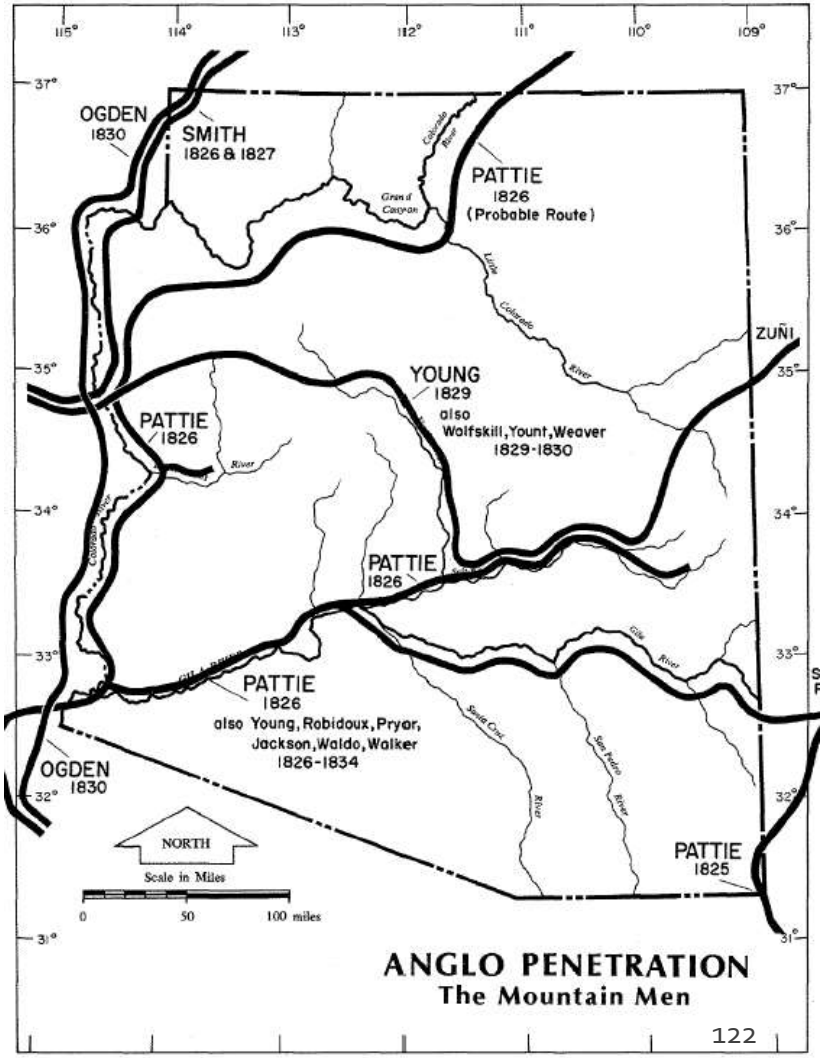
- Spanish Explorers (1700's)
  - Salt River Segments 1-4
    - May have crossed Salt River
    - Mostly went east or west of River
  - Salt River Segments 5-6
    - Visited Pima Villages @ Salt/Gila Confluence
    - Crossed Salt
  - Did Not Establish Missions along Salt River

History: Key Findings

- Native American
  - Salt River Segments 1-4
    - Apache/Yavapai Tribes
    - Seasonal Occupation of River Valleys & Canyons
    - Flood Irrigation, Small Scale
    - Some Irrigation Canals in Tonto Basin
  - Salt River Segments 5-6
    - Pima @ Salt/Gila Confluence
    - Maricopa - mostly on Gila River
    - Mostly unoccupied in 18th century – buffer zone
    - Irrigated agriculture

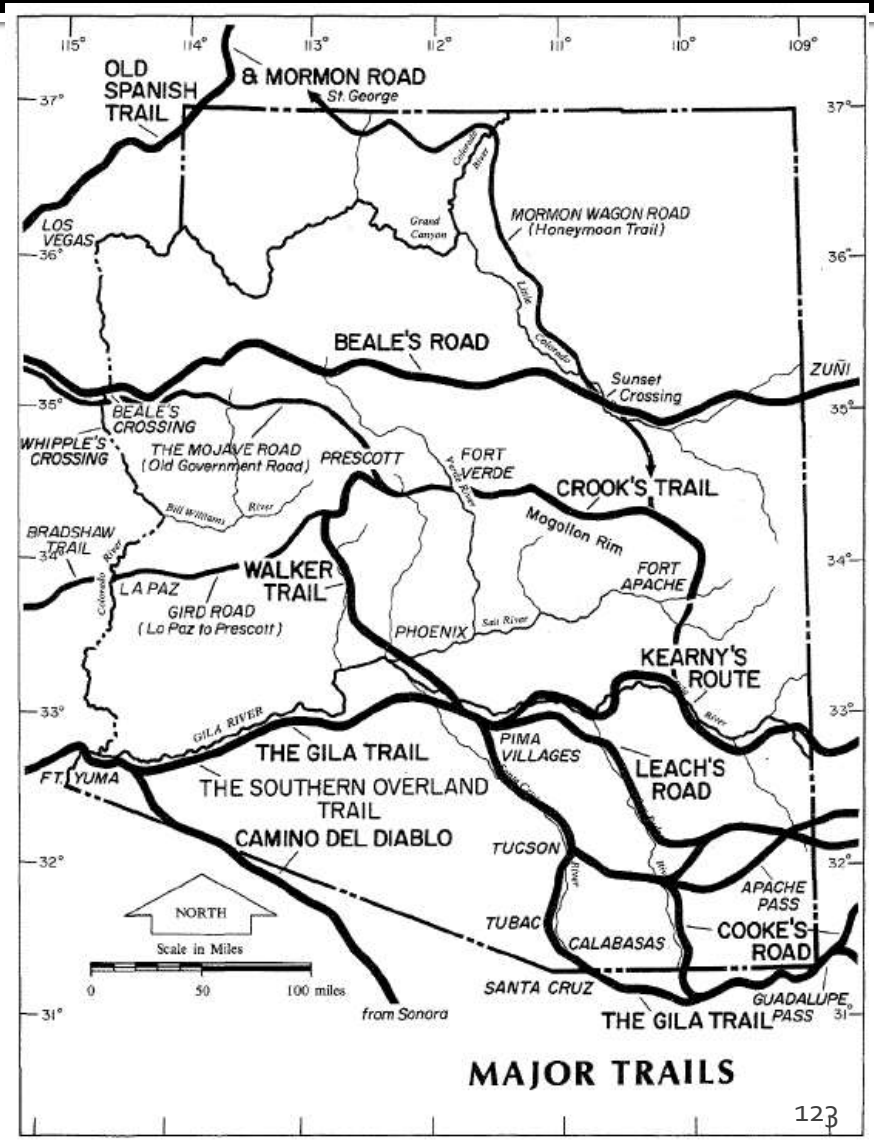
History: Key Findings

- Early Exploration & Trappers
  - James Ohio Pattie, 1820's
  - Ewing Young, 1829
  - Travelled upstream
  - Market furs in New Mexico
    - Overland travel required
  - No boats mentioned on Salt
  - No descriptions of Salt River above Verde River



History: Key Findings (Segments 1-4)

- Major Trails & Railroads
  - Did Not Cross Salt River above Tempe
  - Reached Globe in 1898
- Wagon Road (1870's)
  - Tonto Creek to Salt River
  - Salt River to Pinal Creek
  - Pinal Creek to Globe
- US60 Bridge (1934)

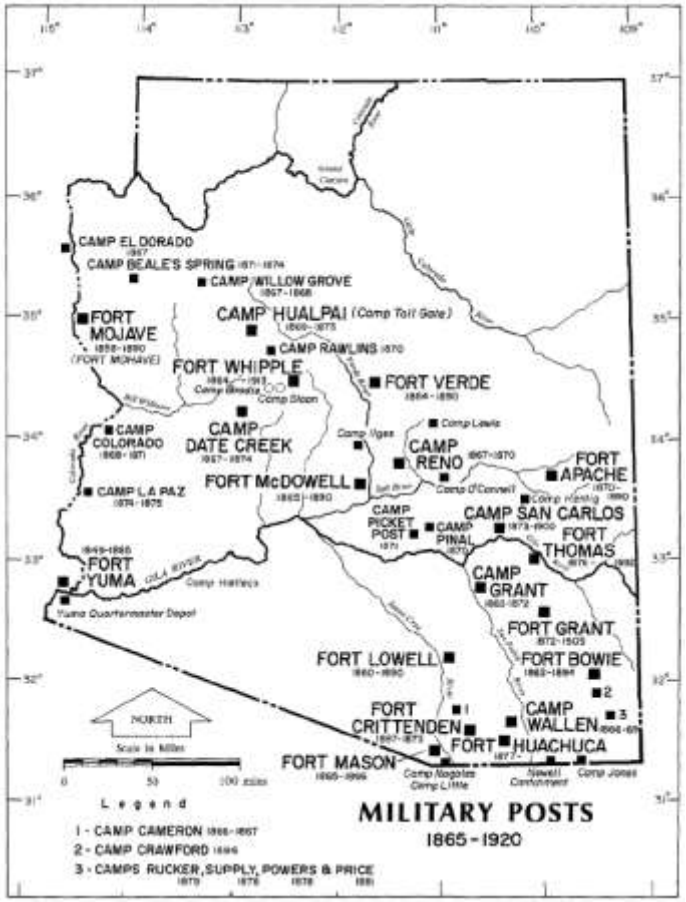


History: Key Findings (Segment 5-6)

- Major Trails & Railroads
  - Railroad to Phoenix 1887
- Wagon Roads (1870's)
  - Followed Gila River

History: Key Findings

- Military Posts
  - Camp Reno (1867-1870)
    - Ft. McDowell Outpost
    - On Tonto Creek
  - Camp O'Connell
    - Near Livingston
  - Fort Apache (Camp Ord)
    - On White River
  - Camp Hentig
    - On Black River
  - Fort McDowell (Verde River)



Descriptions of the Salt River

- Questions to Ask When Reading Historical River Descriptions
  - What River Segment?
  - What Time of Year?
  - Flood/Drought/Ordinary Condition?
  - When Relative to Man-Caused Depletion?
  - Point of View & Attitude of Observer

- The following historical descriptions are excerpted from the ASLD Report.
  - See Report for citations

River Descriptions: Segment 6

- Father Luis Velarde (1716)
  - "Salado"…salty (Wyllys, 1931)
- Father Jacobo Sedelmayr (1744)
  - Salt/Gila confluence (Dunne, 1955)
  - "marshes…fields of reeds…alders & cottonwoods"
- James Ohio Pattie (Feb, 1826)
  - "as much water as the [Gila]" (Davis, 1982)
  - "abounds with beavers"

River Descriptions: Segment 6

- John Bartlett (July 1852)
  - Salt River, 12 miles above Gila

The bottom, which we crossed diagonally, is from three to four miles wide. The river we found to be from eighty to one hundred and twenty feet wide, from two to three feet deep, and both rapid and clear. … The water is perfectly sweet, and neither brackish nor salty, as would be inferred from the name. We saw from the banks many fish in its clear waters, and caught several of the same species as those taken in the Gila. The margin of the river on both sides, for a width of three hundred feet, consists of sand and gravel, brought down by freshets when the stream overflows its banks; and from the appearance of the drift-wood lodged in the trees and bushes, it must at times be much swollen, and run with great rapidity. … [A]long the immediate margin of the stream large cotton-wood trees grow.

River Descriptions: Segment 6

- Elliot Coues (1867) (Davis, 1982)
  - Beaver "very abundant" (Salt & Verde)

- Hiram Hodge (1877)
  - "At low water it is a clear, beautiful stream, having an average width of two hundred feet for a distance of one hundred miles above its junction with the Gila, and a depth of two feet or more."

River Descriptions

- WF Ingalls, December, 1868 Segment 6
  - "low & swampy" (near Tempe)
  - "a large stream"

River Descriptions

- Lt. Beckwith & A.W. Whipple, 1849
  - Salt River Between Canyon & Tonto Creek
    - Segment 2

The Salinas also, according to the accounts of Lieutenant Beckwith and Dr. Randall, who tried to follow its course, on their way from Zuñi to the Gila, in 1849, treads a chasm of the same nature, and is as impassable with pack-mules as that near Mount Turnbull. They were obliged to leave the stream, and make their way over high and rough mountains [Foreman 1941a:220].

    - Canyons Not Passable for Pack Mule
      - Does not discuss boat passage

River Descriptions

- King Woolsey, 1864 (Segment #3)
  - Vigilante Campaigns vs. Apaches
  - Mostly Travelled Overland
  - Tonto Creek confluence
    - Indian fields along tributaries
    - Salt River water brackish
  - Pinal Creek confluence
  - Mentions Crossing Salt River
    - No details except date (June 1864) & salty water

River Descriptions

- Mike Burns, Yavapai (~1872; Segment #4)
  - Segment #4 (Salt River above Fish Creek)

    about 10 miles long and 3 miles wide, high, and surrounded by rocks and precipices on all sides, with only two places where it can be climbed on foot, but not on a horse. One path was on the west and the other on the northeast side...From the neck we could see the che-wa-kees [camps] on the other side of the river, but it took all day to get to them, as the country was rough, the canyons deep and the rocks in the river very slippery. In winter the river was very difficult to cross on account of the high water from White River and Tonto Creek, tributaries of Salt River into which also comes Fish Creek [Corbusier 1971:62].

  - Deep canyon
  - Winter flows difficult to cross

River Descriptions

- Dr. William Corbusier, February 1874 (Segment #3)
  - Salt River in Tonto Basin

When we reached the Salt River, the water was so high and turbulent that we could not cross, and it was some time before we found a fording place. We camped about a mile above the present site of the Roosevelt Dam in a grove of cottonwoods, now many feet under the water of the artificial lake [Corbusier 1971:25].

  - Deep water in places, forded in others
  - Difficult to cross (on foot / horse)
    - BUREC depth threshold

River Descriptions

- Indian Commissioner LE Dudley, March 1875
  - Segment #5 or 6, near Verde confluence

No further matter of particular interest occurred until Saturday the 3rd of March when we reached the Salt River. We fortunately found that the stream could be forded, but running as swiftly as it does in the month of March, it was a sad duty to compel men, women and children to wade through cold water, even though they were Indians. The water was about waist deep to a tall man, and the crossing was a pitiful sight [Dudley 1875-6 cited by Corbusier 1971:262].

  - Waist deep water @ ford
  - Swift water

River Descriptions

- Adolph Bandelier, May/June 1883
  - Tonto Basin (Segment #3)
    - Broad, blue rushing stream…clear & alkaline
    - Finest large river in the Southwest
    - Alive with trout
  - Pinto Creek Area (Segment #3)

Chico did not like to cross Salt River, which is very swift, and as broad as the Gila at San Carlos, but only "belly deep." The bottom on the other side is not as wide as that of the south bank, and it rises more rapidly. There is also a dense growth of mesquite, and the foothills, higher and more steep, are studded with Cactus pitahaya as with huge pillars [Lange and Riley 1970:115].

  - Above Pinal Creek: Uninhabitable deep canyons

River Descriptions

- From Webb, Ribbon of Green
  - p. 314. Citing Minckley, 1973 (p. 121). Commercial fishery on lower Salt (Segment 6)
  - p. 318. USR Segment #5 – dams deprived reach of sediment, making it more cobbly and less vegetated than before dams.

River Descriptions

- Summary of Descriptions
  - Few Descriptions Recorded
  - Perennial
  - Moderate depths
    - Not shallow
    - Deep in floods
  - Single channel
  - Rugged & Remote
  - Deep Bedrock Canyons
  - Beaver, Fish

Historical Photographs

Seg 2

A. (November 26, 1935.) This upstream view from the old, two-lane bridge that crosses the Salt River in Salt River Canyon shows a relatively small discharge of 277 ft^3/s. Scattered native shrubs, including willows and brickellbush, appear to occupy the floodplain at right center. The road leading to Show Low (the combined U.S. Highway 60 and Arizona Highway 77) appears as a one-lane cut through the hillslope at center. (R. E. Cook 2280, courtesy of the U.S. Geological Survey.)

B. (June 25, 1964.) The water is low (about 97 ft^3/s), exposing the bedrock that forms the channel bed and the low-water control downstream from the gaging station. In the intervening twenty-nine years, three floods with peaks of greater than 50,000 ft^3/s passed through this reach. At this time, tamarisk is interspersed with the native shrubs on the floodplain and lines river left, which was mostly devoid of woody vegetation in 1935. Fan palms *(lower right)*, which are not native to this area, were planted as part of a roadside park well before this photograph was taken. The roadcut on the skyline has been widened. (R. M. Turner.)

C. (October 25, 2000.) The water level is only slightly higher in 2000 than it was in 1964. In the intervening thirty-six years, two floods have exceeded 70,000 ft^3/s, and four have exceeded 50,000 ft^3/s. Despite these floods, riparian vegetation along the banks has increased, in particular nonnative tamarisk. The palms have grown considerably. (D. Oldershaw, Stake 363.)

Ribbon of Green, Webb et. al., 2007
Salt River nr Chrysotile

Historical Photographs

Seg 3

Date: pre-1910
Location: Roosevelt Reservoir
ASU Special Collections

Historical Photographs

Seg 3

A. (April 22, 1937.) In this upstream view, the Salt River is flowing at 4,000 ft^3/s. The long-term gaging station in this reach is associated with the bridge in the distance, and a diversion dam is present just downstream from the camera station. Two months before this photograph was taken, the brush-covered island at right center was submerged during a February flood; most floods on the Salt River occur during the winter months. This camera station is several miles upstream from the top of Roosevelt Lake, the first of the major flood-control and water-supply structures on the Salt River upstream from Phoenix. (W. E. Dickinson 2166, courtesy of the U.S. Geological Survey.)

B. (February 3, 1979.) The brush-covered island is now densely covered with mostly nonnative tamarisk, although many native species also occur in this reach, including cottonwood, coyote willow, black willow, and various species of brickellbush. The bar in the left foreground was scoured during large floods in both 1978 and 1979. (R. M. Turner.)

C. (November 25, 2000.) Flood frequency on the Salt River did not change significantly in the twentieth century, as it did on other rivers in the region, although four one-hundred-year floods did occur in a fifteen-year period. The 1993 flood, which had a peak discharge of 143,000 ft^3/s at the gaging station on the bridge visible in the distance, did little to slow the advance of riparian vegetation—in particular tamarisk—at this site. Native species, notably carrizo grass, have also increased, although they are difficult to distinguish from the tamarisk in this view. (D. Oldershaw, Stake 955.)

Ribbon of Green, Webb et. al., 2007
Salt River nr Roosevelt

Historical Photographs

Looking upstream at site of Roosevelt Dam on the Salt River, April 16, 1906.

Seg 4

Date: April 16, 1906
Location: Salt River @ Roosevelt Dam Site

Historical Photographs

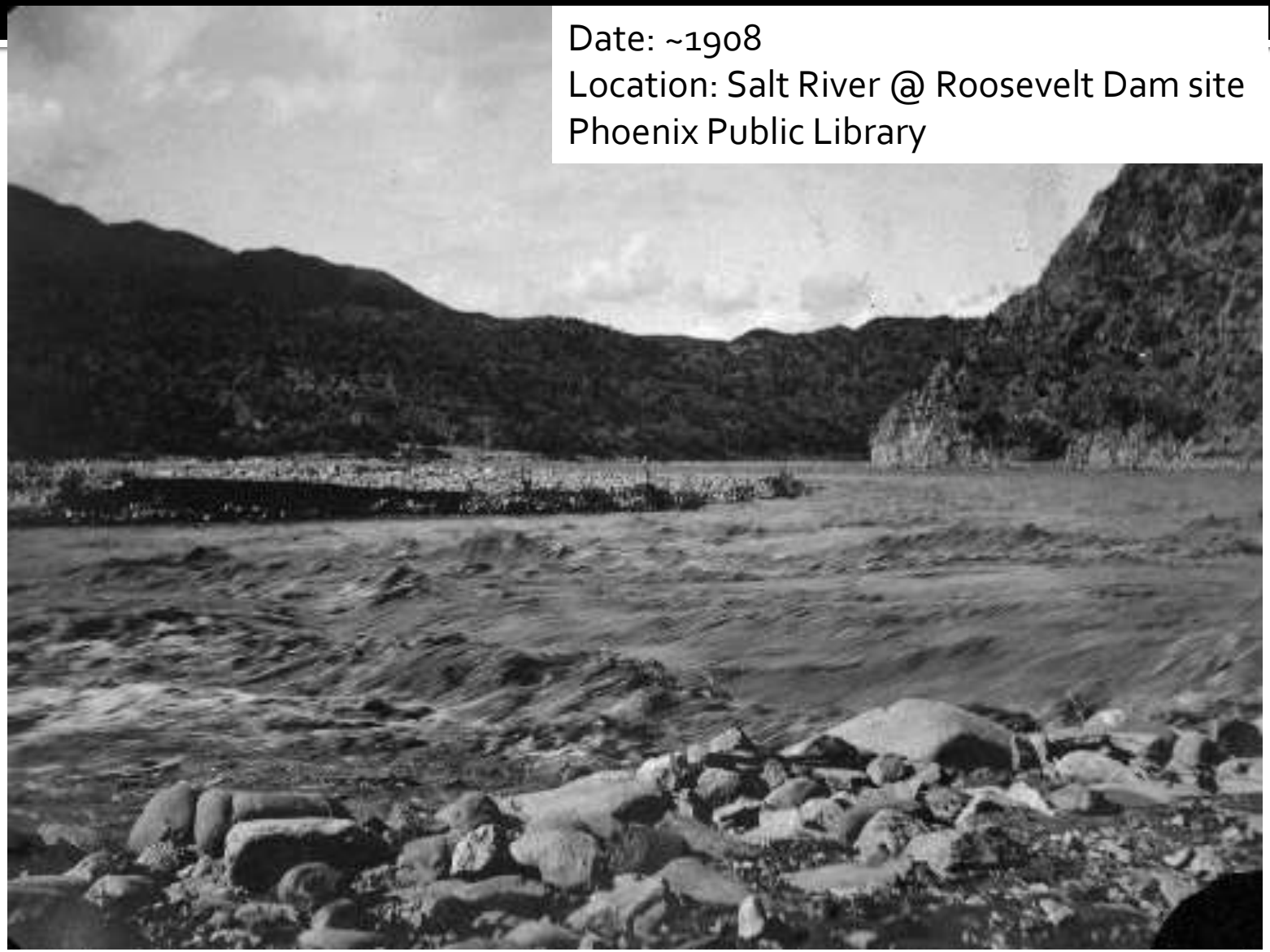
Date: January 14, 1904
Location: Salt River
BUREC Archives

Looking up Salt River, showing junction of Salt and Tonto River and location of camp at dam site. Jan. 14-1904.

Seg 3

Historical Photographs

Seg 3



Date: ~1908
Location: Salt River @ Roosevelt Dam site
Phoenix Public Library

Historical Photographs

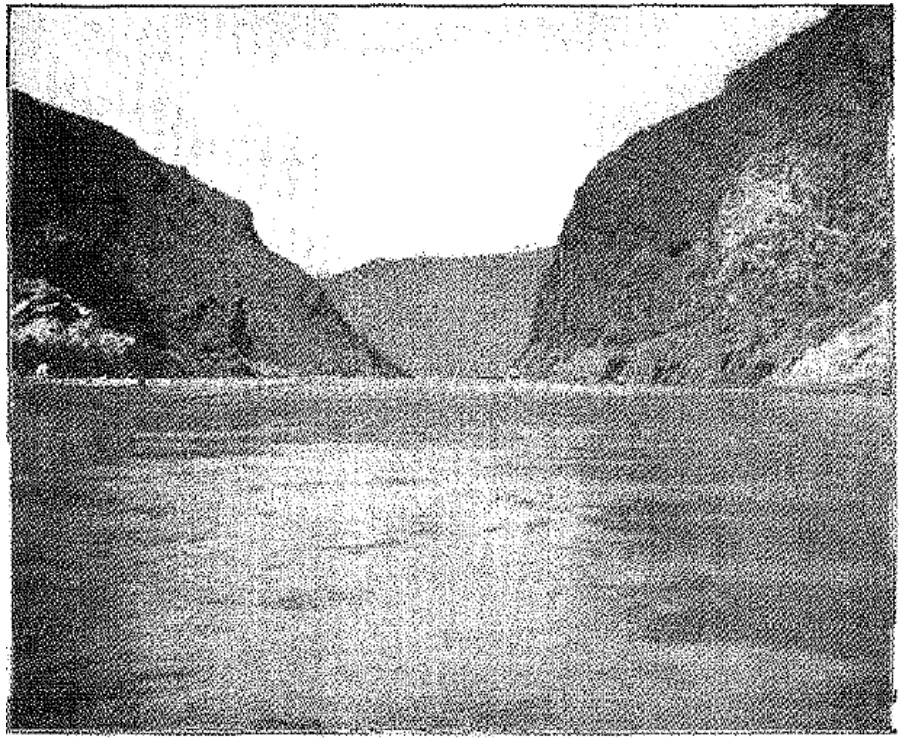
Seg 3

Date: ~March 6, 1906
Location: Salt River @ Camp Roosevelt
Zarbin, 1985

Historical Photographs

Date: 1904
Location: Salt River
AZ Historical Society

Historical Photographs



B. SALT RIVER DAM SITE, LOOKING DOWNSTREAM.

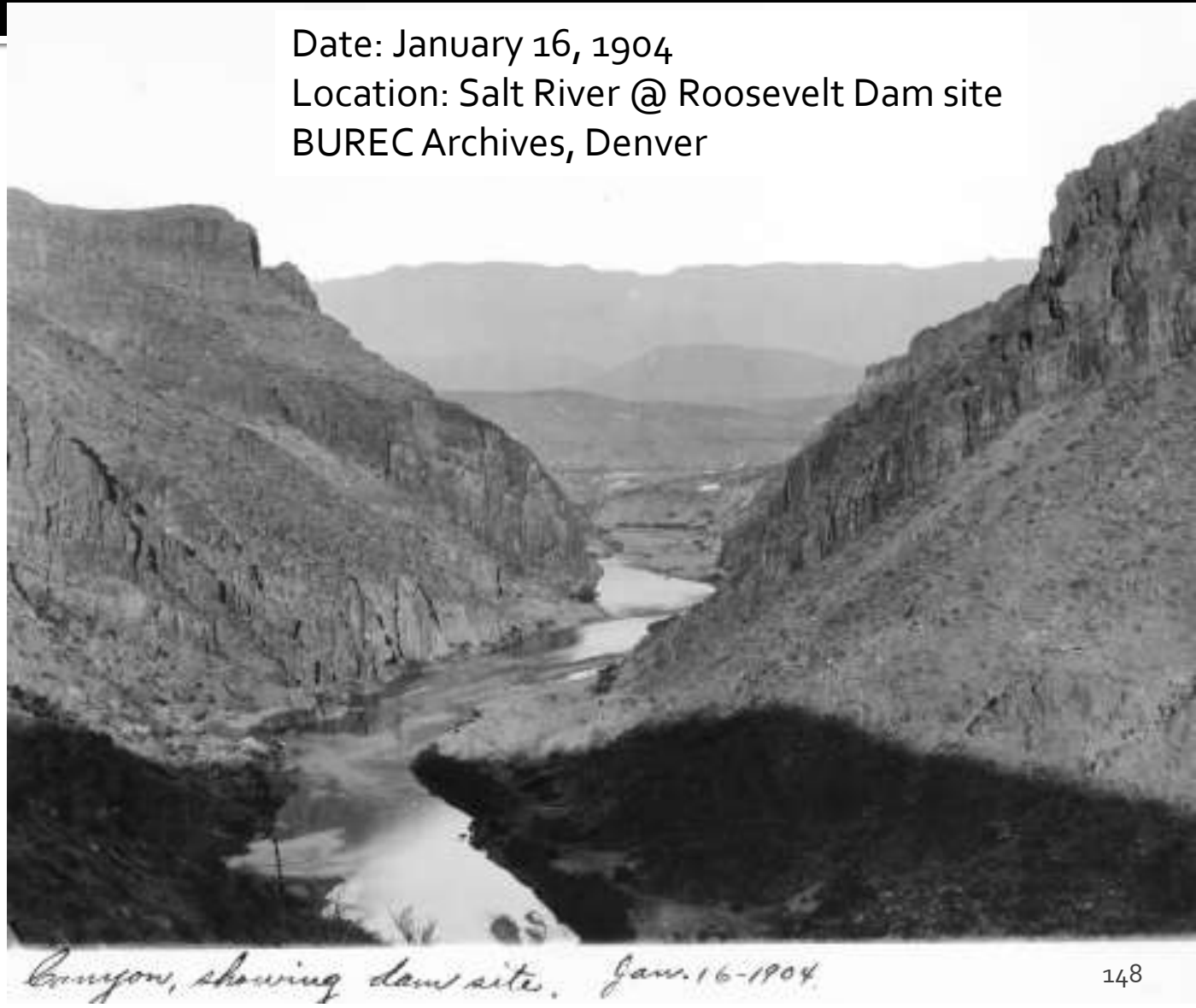
Date: < 1903
Location: Salt River @ Roosevelt Dam Site

Date: March 6, 1906
Location: Salt River @ Roosevelt Dam Site
BUREC Archives

Seg 4

Historical Photographs

Seg 4



Seg 4

Salt River @ Horse Mesa Dam Site
1924
Library of Congress

Historical Photographs

Date: 1916
Location: Near Mormon Flat, Salt River
National Archives

Seg 4

Historical Photographs

Date: ca. 1910
Location: Sheep Bridge on Salt River
ASU Special Collections CP MCL 34967.A3

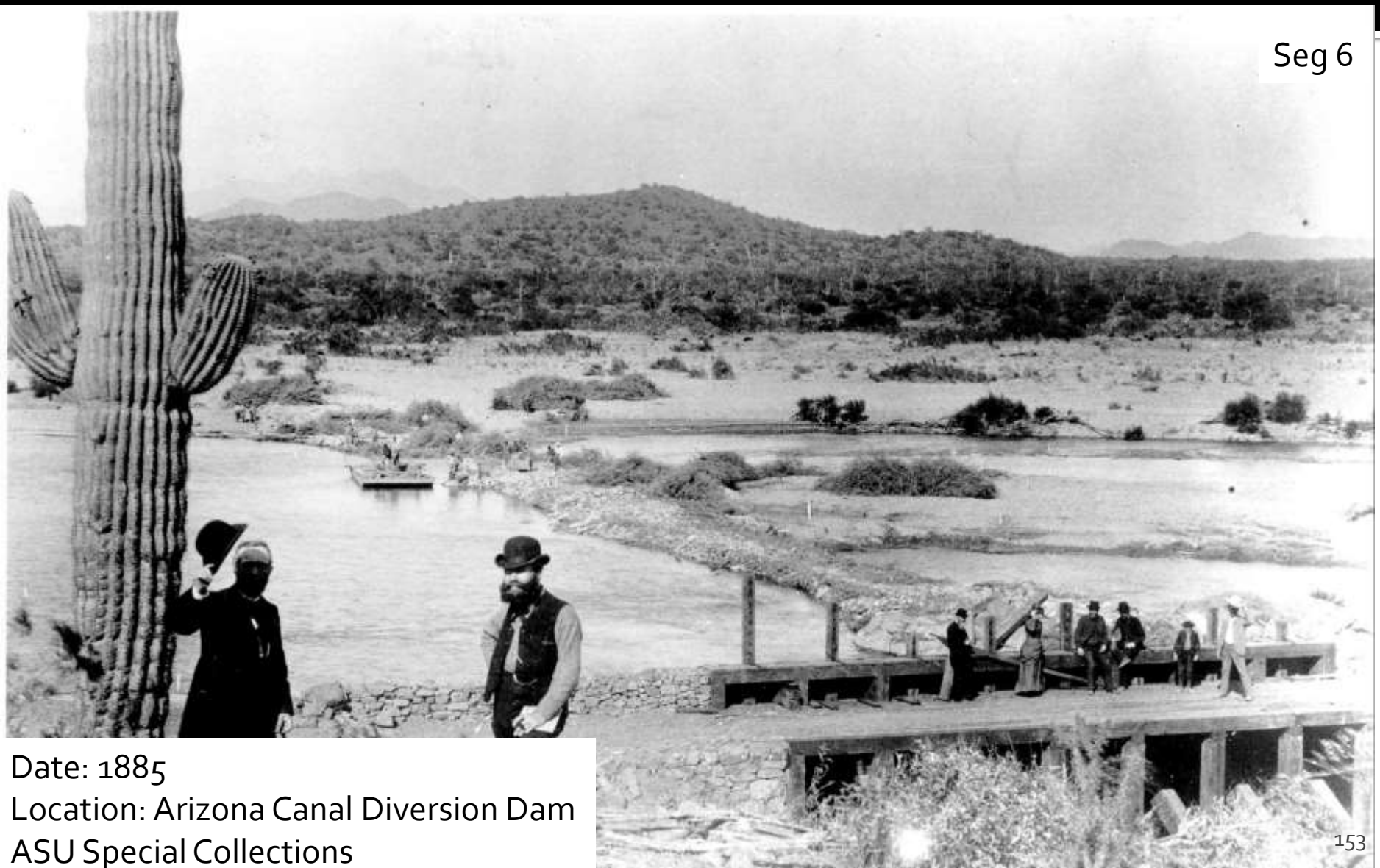
Seg 5

Historical Photographs

Date: pre-1908
Location: Salt/Verde Confluence
Source: Beasley, 1908

Junction of the Verde and the Salt.

Historical Photographs



Date: 1885
Location: Arizona Canal Diversion Dam
ASU Special Collections

Historical Photographs

Seg 6

Date: ca. 1890
Location: Hayden's Ferry
ASU – Hayden Library

Historical Photographs

Date: March 21, 1926 (70 cfs)
Location: Mill Avenue, Tempe
Fuller, 1987 – SRP Archives

Plate 1. Photograph of the Salt River, 1926. From SRP Archives. Perspective looking west from Tempe Butte. Compare to Plate 2.

Seg 6

Historical Photographs

Seg 6

Boating on Salt River.

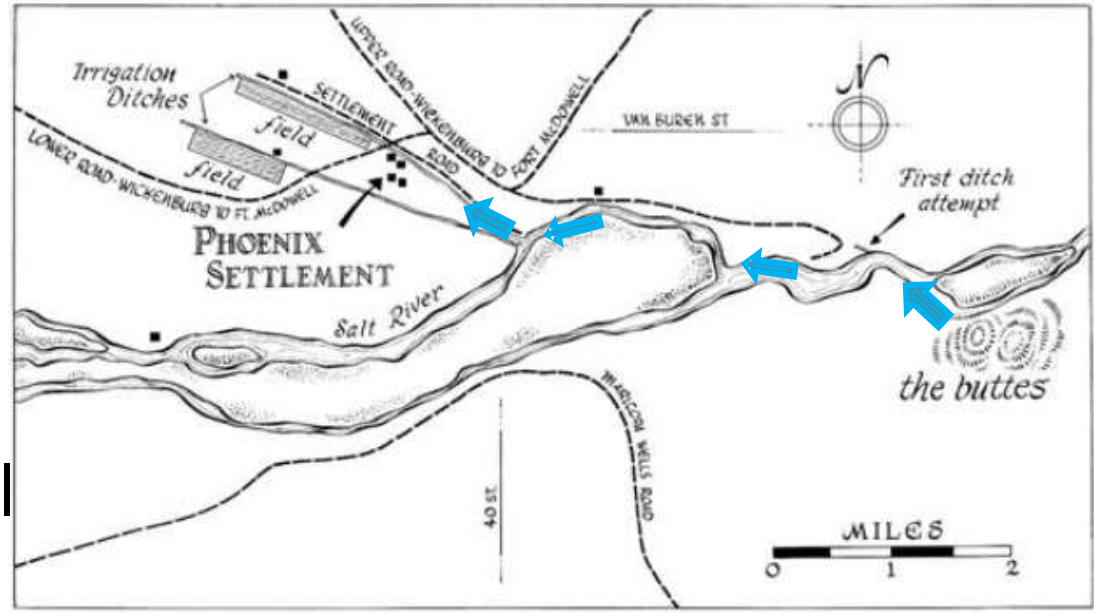
Date: Unknown
Location: Salt River
Seargeant, H.H., 1960

Historical Boating Accounts

- Source Information
  - Newspaper Articles
  - USGS / USRS Water Supply Papers (Flow Data)
  - Photographs

Historical Boating Accounts

- Flat Boat (May 1873)
  (Segment 6)
  - L. Vandermark & W. Kilgore
  - "Salt is navigable for small craft"
  - Five tons wheat
  - Flat boat
  - Hayden's Ferry to Swilling Canal
  - Canal to Helling's Mill



Sources: Weekly AZ Miner, 5-3-1873
Map: AZPCP.org

Historical Boating Accounts

- Charles Hayden – Log Floating Experiment
  - Segment 1? Probably on White or Black River
  - Initial Reconnaissance (6-14-1873)
    - "Headwaters" of Salt River Trip
    - Maine lumberman – Salt R. superior to Maine rivers
  - Canoe Trip (6-21,28-1873)
    - Made canoe from a tree
    - Six men, logs for log drive
    - Abandoned boat
    - Difficulty with rapids & boulders, lost gear
    - Log jam in narrow canyons
  - Hayden's Conclusion: Log floating was a failure

Sources: AZ Citizen, 6-14-1873; AZ Weekly Miner, 6-21,28-1873

The "Forest" in Segments 1(below) & 2(above)

Historical Boating Accounts

- Hamilton, Jordan, & Halesworth (Jan 1879)
  - Segment 6
  - Skiff
    - Built for $10
  - Phoenix to Yuma Trip
    - "river (is) perfectly practicable for navigation"
      - (one spot on Gila narrowed by rocks)
    - Would easily float a loaded flat boat, drawing 2 ft. of water
    - "Successful"

Sources: Arizona Sentinel 1-25-1879

Historical Boating Accounts

- James Stewart (October 1880)
  - Segment 6
  - Superintendent of Stage Company
  - "Will launch his boat on Salt River tonight"

Sources: Arizona Republican 10-2-1920

Historical Boating Accounts

- Cotton & Bingham Trip (February 1881)
  - Phoenix to Yuma (Salt River Segment 6)
  - 18 ft skiff, flat-bottomed
  - Very low draft boat, sturdy
  - Article announces intended launch

AZ Gazette, 2.17.1881

Historical Boating Accounts

- "Yuma or Bust," November 1881
  - Segment 6 (Phoenix to Gila River)
    - Then Gila River to Yuma
  - 20 x 5 ft flatboat
  - Shallow flow, sand bars
    - Knee deep flow
  - Buckey O'Niell

Source: ASLD Report, Phoenix Gazette (11.30, 12.3.1881)

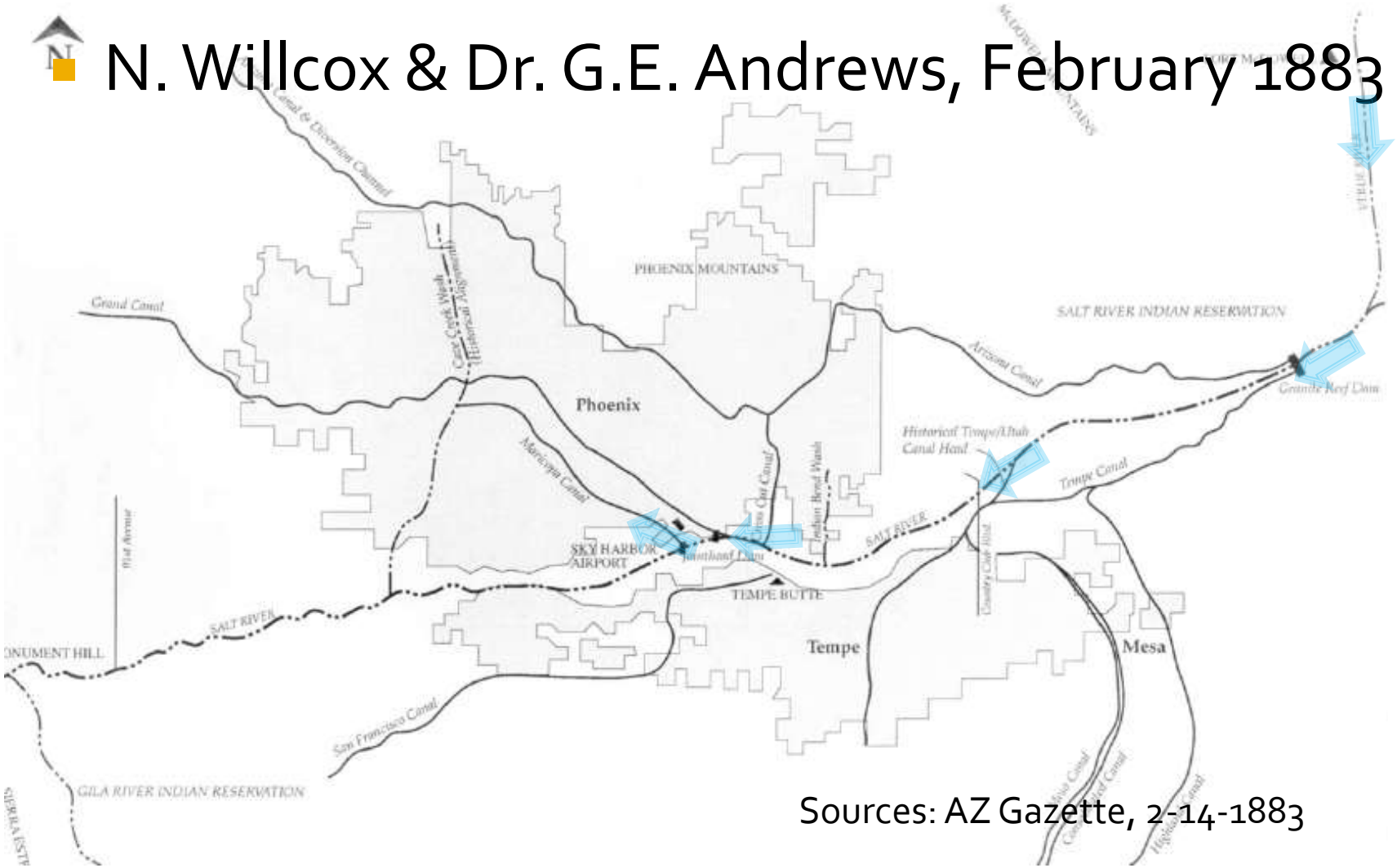
Historical Boating Accounts

- N. Willcox & Dr. G.E. Andrews, February 1883
  - Segment #6
  - Canvas skiff
  - Pleasant except for rain while camping
  - Fort McDowell to Barnum's Pier (Salt River Canal)
    - aka, Swilling's Ditch
  - "Salt River is navigable stream and should be included in the River & Harbor Appropriation Bill"

Sources: AZ Gazette, 2-14-1883

Historical Boating Accounts

- N. Willcox & Dr. G.E. Andrews, February 1883



Sources: AZ Gazette, 2-14-1883

Historical Boating Accounts

- Jim Meadows, 1883
  - Livingston to Tempe (Segment 3-6)
  - Four men, one boat
  - First descent, not reported in papers until 1909
  - "Success"
    - One boater was scared
    - Boat got stuck once on rocks – floated off

Sources: AZ Republican, 10-4-1909

Historical Boating Accounts

- William Burch, June 1885
  - Tonto Creek Confluence to Phoenix (Segments 3-6)
    - Began @ Judge Eddy's Ranch, 4 mi. above Tonto Creek mouth
    - Purpose: Determine if log floating was feasible
  - 18x5 flatboat – 4 or 5 men
  - Hazards:
    - "Numerous projecting boulders"
    - Upset the boat once, lost some gear
  - Success
    - "Undisputed conclusion" that logs can be floated
    - "Exciting & interesting trip"
    - Main difficulty is getting logs to the river (10 mi. from banks)
  - Stream: "6-20 ft. deep"

Sources: AZ Gazette, 6-3,5,6,8-1885

Historical Boating Accounts

- William Burch, June 1885
  - Day 1: Eddy's Ranch to Roosevelt area
    - 4-5 smooth rapids
  - Day 2: Roosevelt into Canyon
    - Several swift & dangerous rapids (no problems reported)
    - Steep walled canyons
  - Day 3: (Canyon Lake footprint)
    - River more winding
    - Occasional large rocks mid-channel
    - Rapid current
    - 4-6 ft cascades and falls, boat shot over, bumping rocks occasionally
    - Sailing was grand, needed to look out for rocks

Sources: AZ Herald, 1885

Historical Boating Accounts

- William Burch, June 1885
  - Day 3 (con't):
    - Got stuck on mid-channel rock they didn't see
    - Swam ashore and slept the night
    - Meadows went downstream 2 miles to cut poles, pried off boat
  - Day 4:
    - Floated quietly to Jones' Ranch, layover day
  - Day 5:
    - Carried boat over Arizona Dam
    - Floated over two other dams
    - Tempe Canal to near Tempe
    - Boat "slightly chafed by rocks"

Sources: AZ Herald, 1885

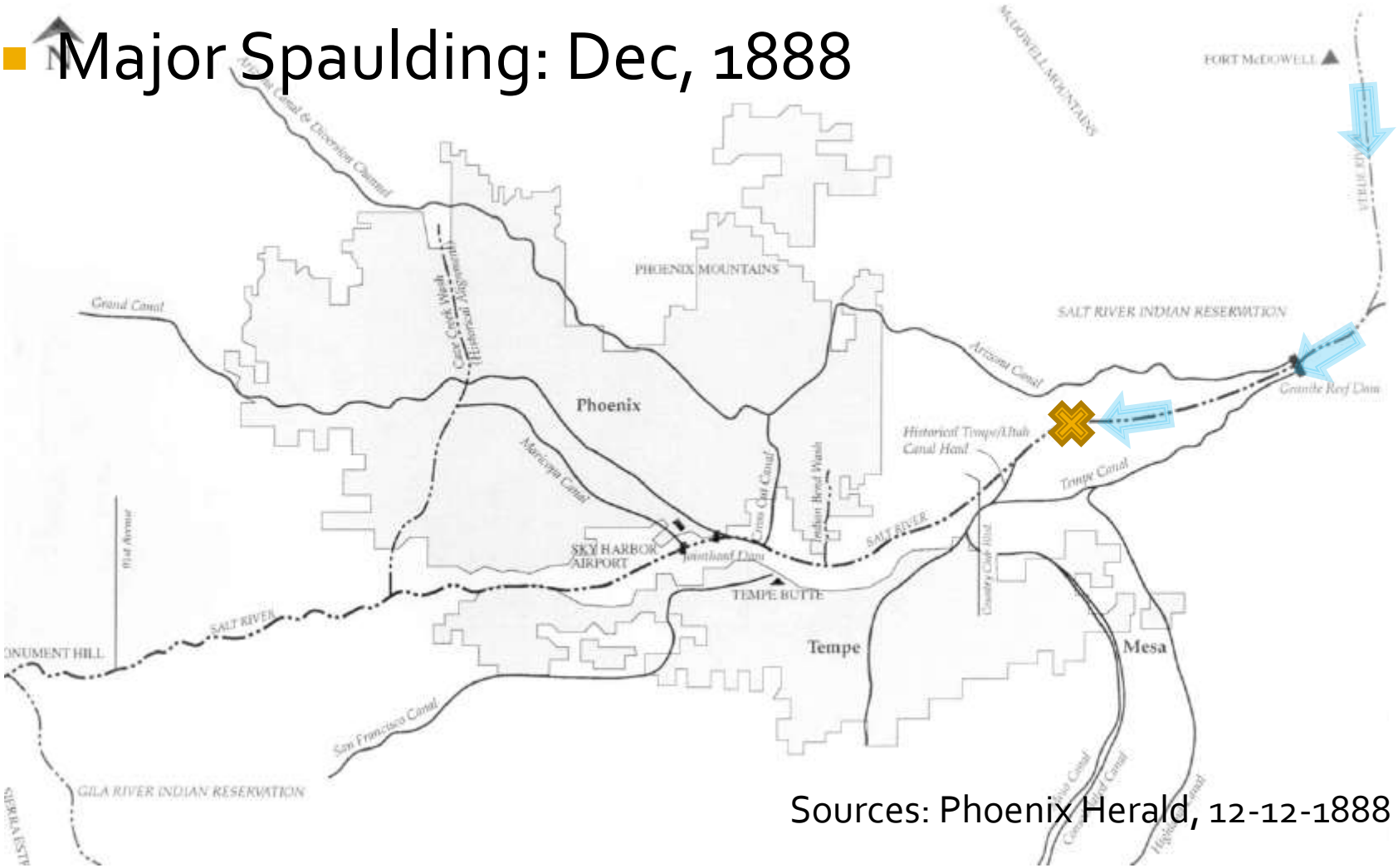
Historical Boating Accounts

- Major E.J. Spaulding, December 1888
  - Ft. McDowell to Mesa Dam (Segment #6)
  - Canoe – 2 men (Capt. Hatfield)
  - Major Spaulding killed by accidental gun fire during portage over dam
  - No boating problems reported

Sources: Phoenix Herald, 12-12-1888

Historical Boating Accounts

- Major Spaulding: Dec, 1888



Sources: Phoenix Herald, 12-12-1888

Historical Boating Accounts

- Major Spaulding: Dec, 1888

Source: USGS, 1897, p. 35

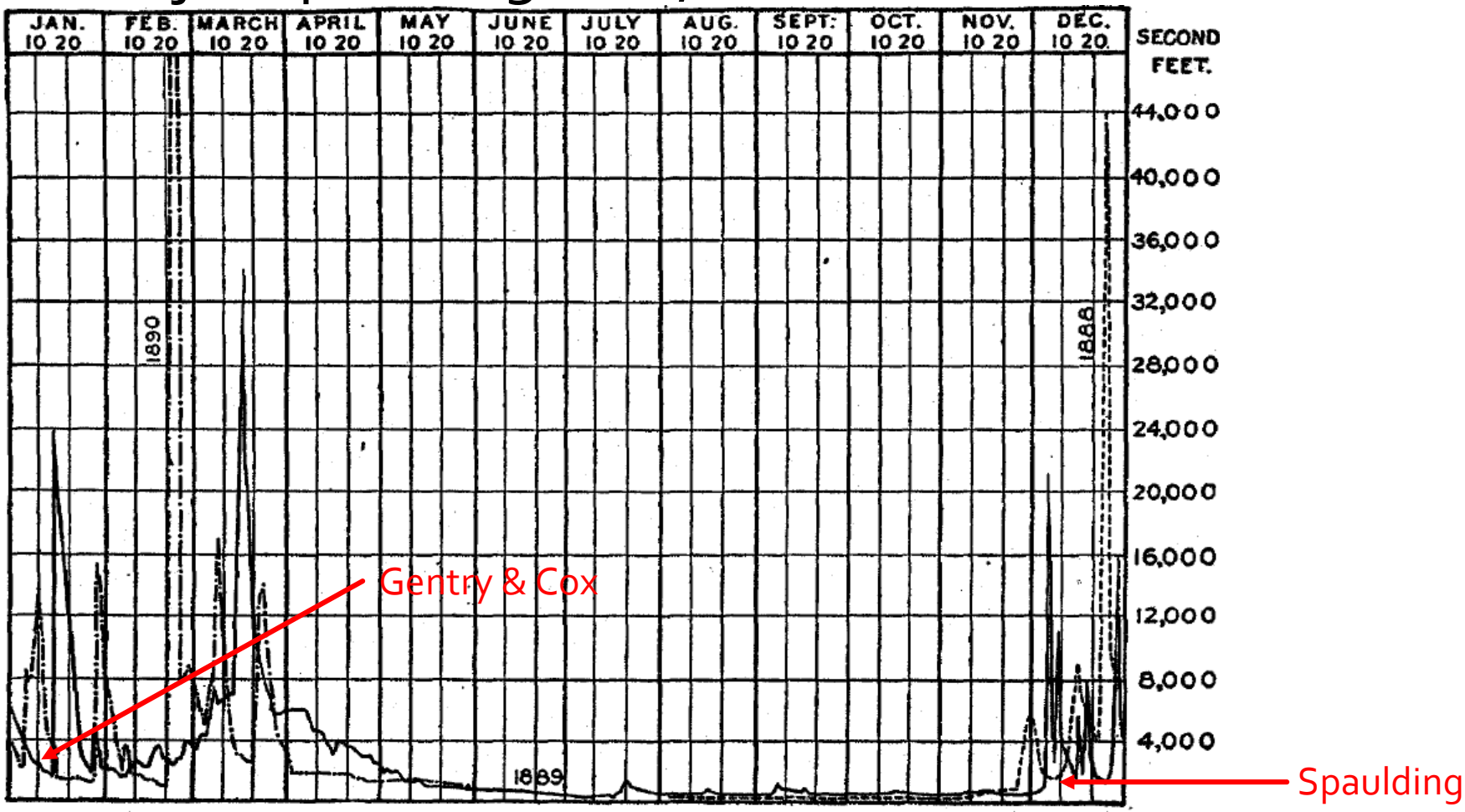
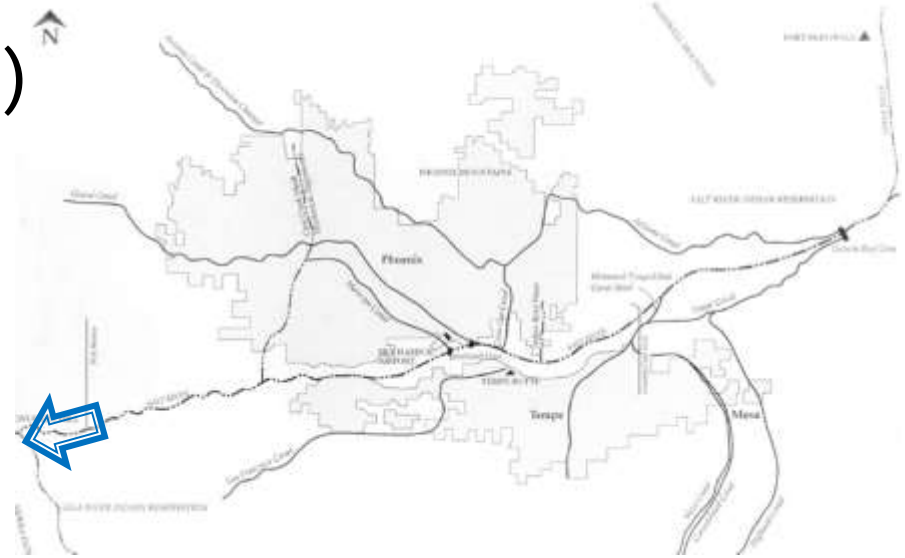


FIG. 3.—Daily discharge of Salt River at Arizona dam, 1888-1891.

Historical Boating Accounts

- Gentry & Cox (Jan 9, 1889)
  - Segment 6
  - Large Ferry Boat, Five men
  - Maricopa Crossing
    - Intended to go to Gila Bend
  - After reaching Gila River
    - 40 miles downstream of Phoenix
    - Boat snagged in high current & broke apart



Sources: Tombstone Daily Prospector, Jan 24, 1889

Historical Boating Accounts

- Stanley Sykes & Charlie McLean (Winter, 1890's)
  - Segment 6 (Phoenix to Yuma)
  - Canvas over wood frame, painted
  - Salt River at put in: 15-20 ft wide, 1 ft deep
  - Dry reaches until the Gila Confluence
    - Walked beside loaded boat in depleted flow areas
    - River 20 feet wide & 1-2 ft deep.
  - Flow depleted due to irrigation diversions
  - Story recounted ~50 years after the fact

Source: Coconino Sun, 9.7.1945

Historical Boating Accounts

- JK & George Day: Camp Verde to Yuma (1892)
  - Segment 6
  - Small boat
  - September to April
  - Trapping – "large quantity of furs"
  - 5th trip
  - Returned to Prescott by railroad
  - Plan to repeat trip next September

Note: Previous trips not in newspapers

Sources: Arizona Sentinel 4-2-1892

Historical Boating Accounts

Estimated monthly discharge of Verde River at McDowell.—

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1890.[a]				
September	1,769	348	1,123	66,802
October	3,733	377	1,384	80,116
November	15,252	383	2,359	140,331
December	15,183	555	3,130	192,464
The year	64,480	119	1,666	1,186,843
1891.[a]				
January	7,193	445	1,435	88,244
February	135,000	371	17,467	970,051
March	3,460	525	1,928	118,535
April	606	459	534	31,775
May	361	365	458	28,190
June	539	280	401	23,849
July	405	252	314	19,291
August	[illegible]	[illegible]	[illegible]	17,113
September	631	220	395	23,478
October	310	231	258	15,833
November	314	231	256	15,233
December	346	294	328	20,168
The year	135,000	229	2,004	1,371,760
1892.[a]				
January	360	257	284	17,458
February				[b]11,046
March				[b]9,832
April				[b]5,213
May				[b]5,608
June				[b]3,106
July	215	136	152	9,374

Estimated monthly discharge of Salt River at reser

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1891.[a]			
September	605	220	378
October	273	203	227
November	283	207	230
December	311	264	295
The year	150,000	203	2,529
1892.			
January	445	318	352
February[b]	234	204	221
March[b]	268	206	230
April[b]	[illegible]	[illegible]	[illegible]
May[b]	760	185	365
June[b]	157	76	110
July	267	168	189
August	259	152	186
September	180	150	157
October	770	144	196
November	392	203	231
December	266	236	253
The year	770	76	234

Sources: AP Davis, 1903

Historical Boating Accounts

- Hudson River Reservoir & Irrigation Co (June 1893)
  - Segment 4 – "Salt River Through Canyon"
  - Canvas boats
  - Boats used in commercial survey of river bed
    - "One of the boats"
  - Boat flipped
    - Occupants thrown into river
    - Two boat ribs damaged, boat nearly unserviceable
    - Difficult to find camping spot due to steep, narrow canyon

Sources: Arizona Republican 6-2-1893

Historical Boating Accounts

- Lieutenant Robinson (1893)
  - Segment 6
  - Salt River by boat
    - Phoenix to Yuma
    - Three soldiers, in boat(s)
  - Article recalls a previous trip
  - No details re. boat type or events during trip
    - Boated safely to Yuma & beyond

Sources: Bisbee Daily Review 10-6-1909

Historical Boating Accounts

- Adams & Evans (Jan 20-Feb 17 1895)
  - Segment 6
  - 18 x 3.5 ft homemade wooden flat boat with cabin
  - Clifton to Sacaton (Gila River)
  - Tempe to Yuma (Segment 6 of Salt River)
  - Hauled the boat from Sacaton to Phoenix
    - Visited for several days in Phoenix
  - Boated Phoenix to Yuma
  - Jan-Feb is beginning of high water season.
    - No records of unusually high flows in Feb 1895

Sources: Phoenix Herald (2.18,25.1895), AZ Sentinel (3.9.1895)

Historical Boating Accounts

- Floating Logs, May 1894
  - Lumber from Ft. McDowell post retirement
  - 300 cords of lumber placed in river
  - Scheme abandoned due to threat to Arizona Dam in Salt River Segment 6

Sources: The Salt Lake Herald, 5-3-1894
Cited to Scott Soliday in ASLD Reports

Historical Boating Accounts

- Jacob Shively & "Capt." Schreiver (March 1905)
  - Segment 6
  - Shively/Shibely
    - 76 years old
  - Built a boat to travel Phoenix to Yuma
    - Keeled wooden boat
  - Launched Phoenix 3/23
  - Sited at Arlington (3/24) & Buckeye (on Gila)
  - Boated a moderate sustained flood ~21,000 cfs
  - Modified boat design en route
    - Added freeboard
  - Reported no problems on Salt River (Day 1)

Sources: AZ Republican 3-24,29, 4-3-1905

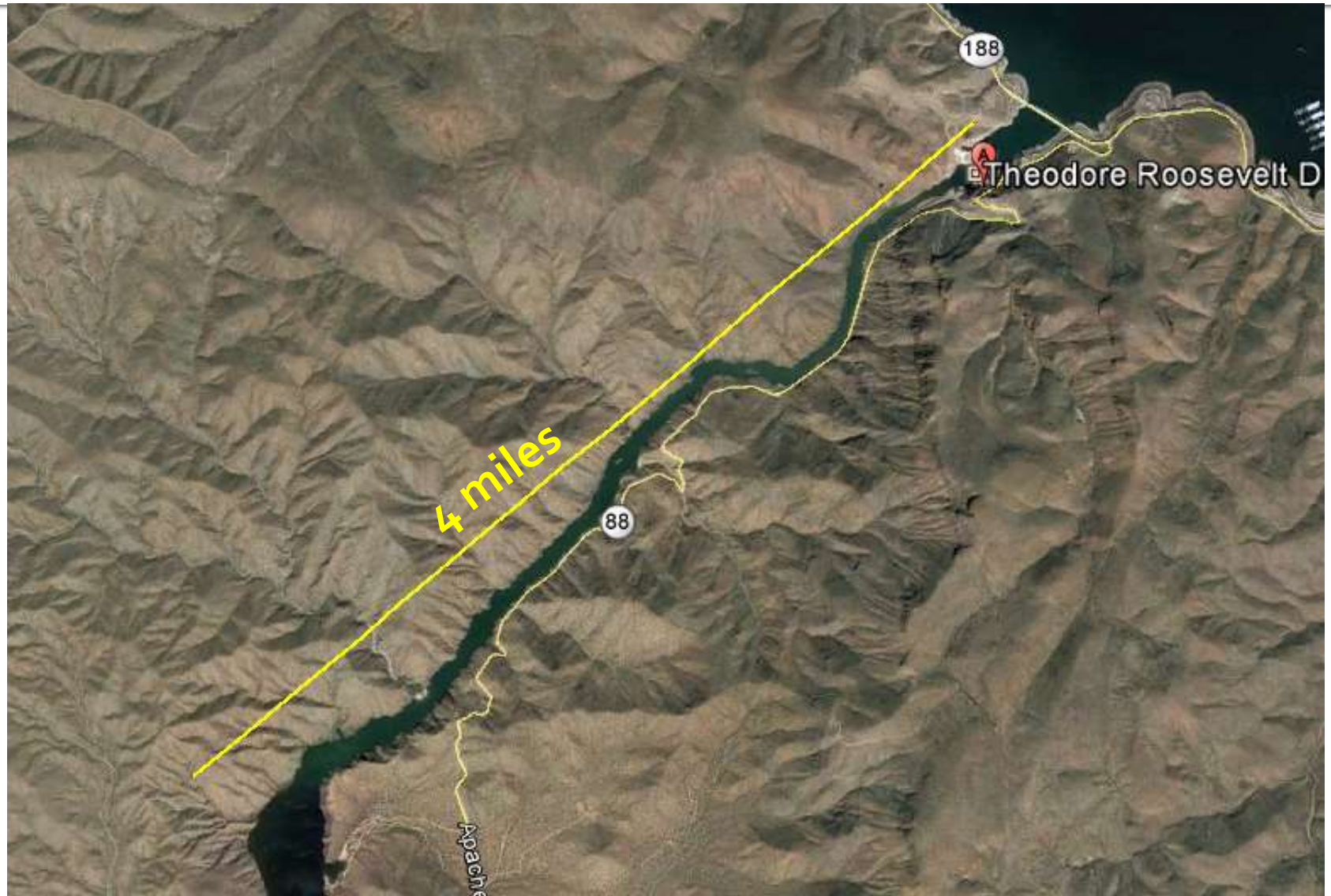
Historical Boating Accounts

- Hauling Freight to Roosevelt (Segment 4)
  - "hauled up river in a boat"
  - 4 miles up canyon
  - Botticher's Camp to Roosevelt
  - When road washed out.

The High Line road, which has been under construction for some months, is now rapidly approaching completion, the Mesa stage making its first trip across it on Monday, the 24th. The completion of this road will solve the big transportation problem for the government, as before its completion, and at the time of the heavy rains and floods, the nearest the Mesa stage could get to Roosevelt was Botticher's camp, some four miles down the canyon, the balance of the distance being over trail, and all freight came over via the pack train, or else was hauled up the river in a boat, both modes of transportation of but little comfort to the traveler and expensive.

Sources: AZ Republican, April 30, 1905

Modern View of Narrow Canyon Four Miles Below Roosevelt Dam



190x USGS Topographic Map of Four Miles Downstream of Roosevelt

Historical Boating Accounts

- Flatboat Trip Advertisement (May 23, 1905)
  - Seeking participants for hunting, boat trip
  - Phoenix to Yuma (Segment 6 of Salt River)
  - Leaving Wednesday or Thursday (May 23rd = Tuesday)

Sources: Arizona Republican 5-23-1905

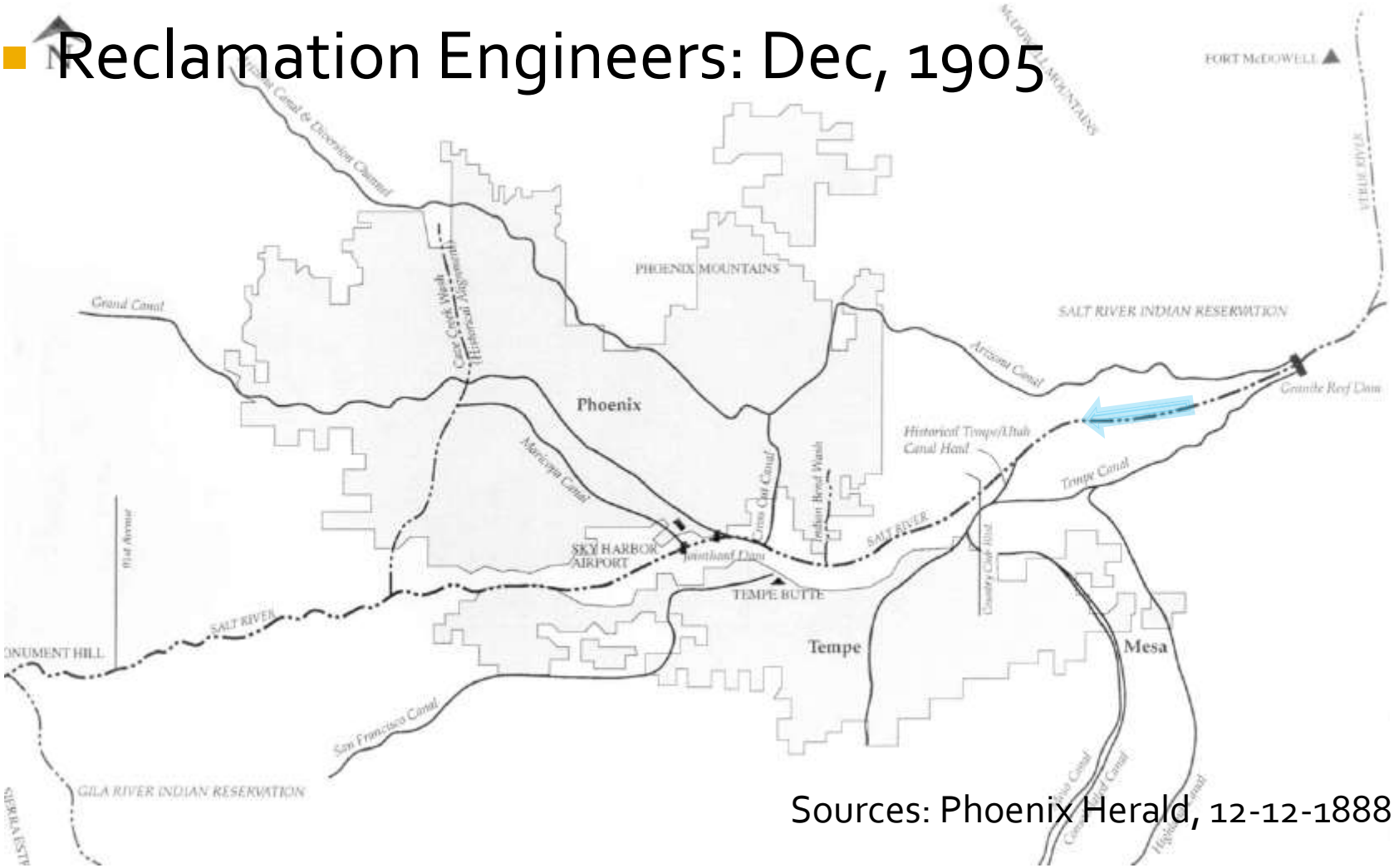
Historical Boating Accounts

- Reclamation Service Engineers (Dec, 1905)
  - Fowler, McDermott & McClung
  - Arizona Dam to Consolidated Canal
    - Segment 6
  - "Shipwrecked twice" in a mile, no loss
    - "Hit on a rock in a rapid"
    - "Stuck on a sandbar"
  - Once, "threatened to turn over," (but didn't)

Sources: AZ Republican 12-9-1905

Historical Boating Accounts

- Reclamation Engineers: Dec, 1905



Sources: Phoenix Herald, 12-12-1888

Historical Boating Accounts

- Tom Rains, Boat Theft (April 28, 1909)
  - Segment 6
  - Mr. Rains "keeps a boat on the river near 7th Avenue."
  - Boat was stolen by children (~ 10 yrs old)
  - Boated 9 miles downstream
  - Boat tied up on river bank

Sources: Arizona Republican 4-29-1909

Historical Boating Accounts

- Louis Selly, Boat Builder 1909
  - Master boat-builder
    - Recently completed two boats
    - Orders for "two or three" more
    - "Apt to be kept busy for some time"

Sources: Arizona Republican 6-27-1909

Historical Boating Accounts

- Thorpe & Crawford, June 1910
  - Roosevelt Dam to Granite Reef Dam (Segment 4-6)
  - Rowboat
    - Boat bottom damaged by rocks (June low water trip)
    - Dragged boat "many times"
    - Well pleased with the trip
    - Not a fast trip
    - Couldn't compete with the stage line
  - Below average flow (145 cfs @ McDowell)
    - Less than 10% flow duration

Sources: AZ Republican, 6-28-1910

Historical Boating Accounts

- Herbert Ensign & Donald Scott (June, 1919)
  - Segments 4-6: Roosevelt Dam to Phoenix
    - Granite Reef to Phoenix on Arizona Canal
  - Canoe
    - Built extra strong, but light for easy transport around rapids
  - Good Trip Description
    - Flipped in rapid early on Day 1, no gear lost (strapped in)
      - Flipped again. After that, portaged some rapids
    - Few pictures because both paddlers needed to control boat
    - Flipped in Arizona Canal, lost some gear not strapped in

Sources: Arizona Republican 6-28-1919

Historical Boating Accounts

- Herbert Ensign & Donald Scott (June, 1919)
  - Trip Log
    - Day 1: Roosevelt Dam to Where Road Leaves River (~3.5 mi.)
    - Day 2: Road to 2 mi. Past Fish Creek (~13 mi)
    - Day 3: Fish Creek to Granite Reef Dam
      - Fish Creek to Mormon Flat (8 mi. took 3.5 hrs, no portages)
      - Reached Granite Reef Dam @ 9:30 pm (partial night float, 23 mi.))
    - Day 4: Granite Reef to Phoenix via Arizona Canal

Sources: Arizona Republican 6-28-1919

Historical Boating Accounts

- Ferries & Navigability
  - Used for Crossing River (Segments 3, 5, 6)
    - Not Upstream or Downstream Trade & Travel
    - Is Trade & Travel on Water
  - Indicates River is Deep Enough for Boats
    - Typically Flatboats
    - Often Heavily Loaded
    - Can't Be Forded
  - Replaced by Bridges Eventually
  - Use During "High" Water Conditions
    - Higher than Fording Depth
    - Seasonal Use
    - Usually for Several Months

Historical Boating Accounts

- Ferries
  - 1867 – US Army (Segment 6), Salt River Crossing
  - 1867 – Gen. Rusling borrowed boat from German settler
  - 1874-1909 – Hayden's Ferry
  - 1884-1919 – Salt & Gila Ferry (downstream Phoenix)
  - 1898 – Haws & Finch Ferry (3 miles above Maricopa Dam)
  - 1889 – Gentry & Cox (Maricopa Crossing)
  - 1884 – Shureman & Singletary Ferry (above Tempe)
  - 1868-1874 – Marysville Ferry on Maricopa-Ft. McDowell Rd
  - 1890 – Robertsons Crossing (Gila County)

ASLD, Table 3-3 (Original Sources Cited in Table), AZ Silver Belt 1-11-1890

Historical Boating Accounts

- Roosevelt Ferry (Segment #3)
  - Probably used by dam construction crews
  - Ferried 600 teams, 1400 people in January 1909
  - Hampered by changing water stage

Source: Tombstone Epitaph, 2-21-1909

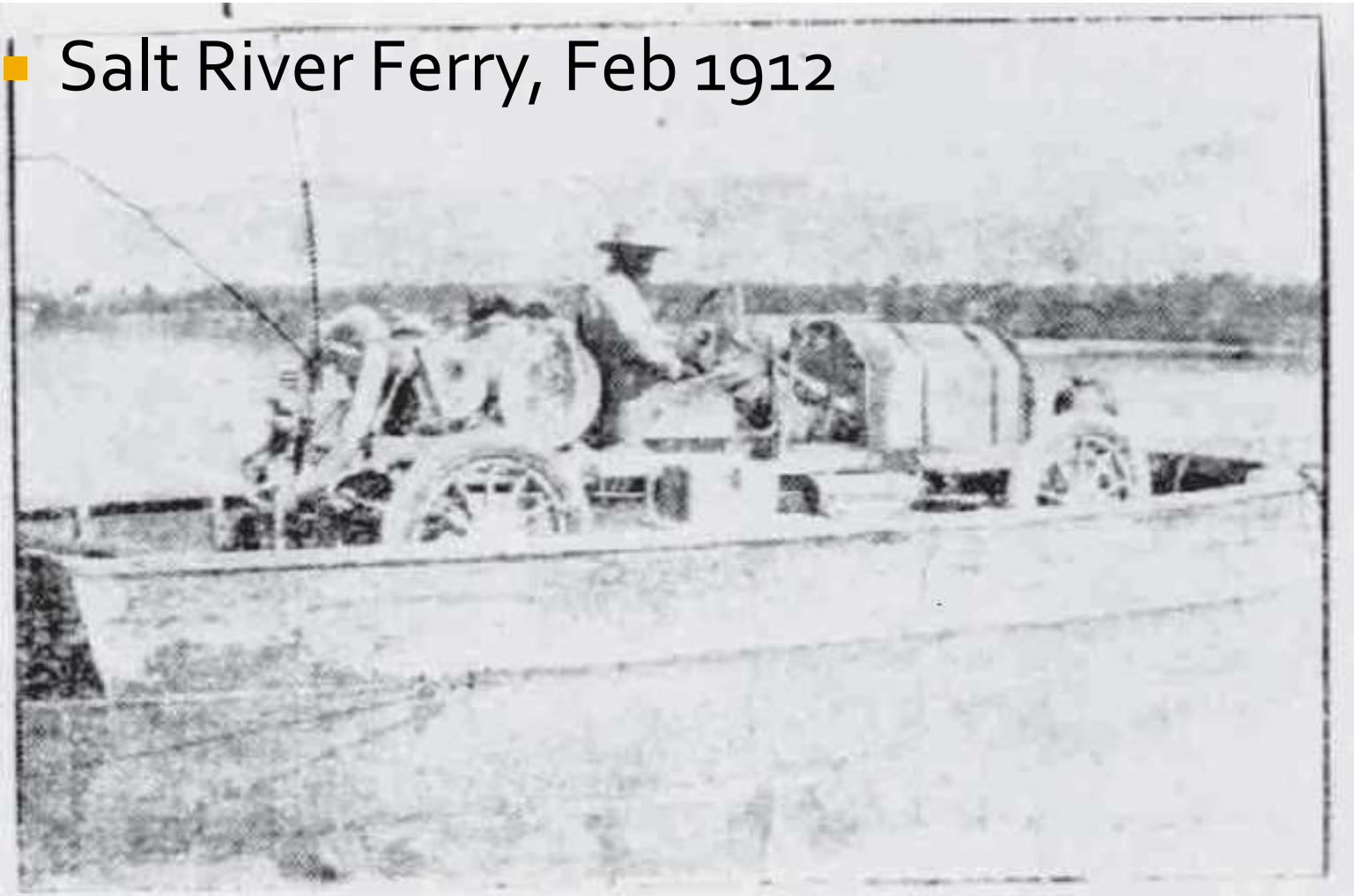
- Livingstone Ferry (Segment #3)

Source: AZ Silver Belt, 5-4-1905

Historical Boating Accounts

- Salt River Ferry, Feb 1912

Seg 6



W. F. Brong Ferrying the Salt River.

Source:
AZ Republican
2-19-1912

Swimming & Fishing – Segment 6

CP MCL 97844.TAX 70

The "Ole Swimmin Hole" in 1917 was in the Salt River west of town. Boys dove under banks to catch fish in bare hands.

^

Rev. Fred McNeil Collection
ASU Hayden Library, Special Collections
CP MCL 97725.T3

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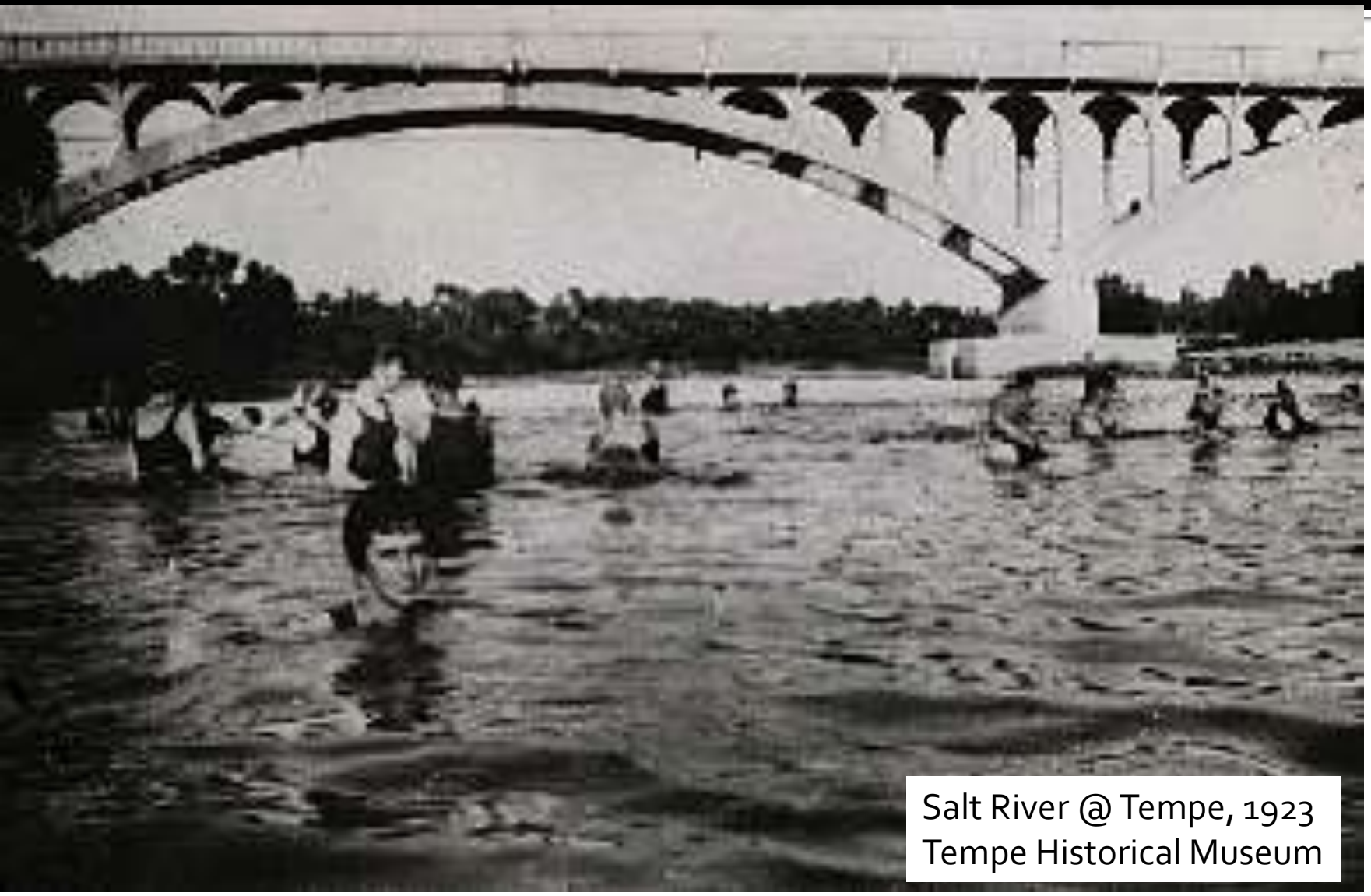
ASU Archives
UP UPC ASUG S882 1930:13

Swimming & Fishing – Segment 6



Salt River @ Tempe, 1923
Tempe Historical Museum

Construction of Roosevelt Dam

Seg 3/4

- Dams: Not Ordinary & Natural
- Use of Boats
  - Some construction use (on impoundment)
  - Logs floated to dam site
  - Ferries across river & impoundment
  - Recreational (AZ Repub, 4-12-1912)
    - Motor boats going "upriver"

Historical Boating Accounts

- George Greenwald, February 1908
  - "Raft of Lumber" on Salt River (Segment 3)
  - Floating on river current to dam
  - Swept into current around dam construction
  - Greenwald Drowned trying to save lumber

- Two Engineers, 1909
  - One Drowned in Tunnel Impoundment

Sources: Rogge et. al., 1994
AZ Republican 2-14-1908
Zarbin, 1984

Historical Photographs

Feb 1, 1909

July 31, 1909

May 2, 1910

Date: Pre-1912
Location: Downstream of Roosevelt Dam
BUREC Archives, Denver

Construction of Roosevelt Dam

- Why Weren't Dam Construction Activities Supplied Up- & Down-River on the Salt?
  - Salt River conditions above Verde River (rapids/riffles, flow velocity, flow depth) not conducive to heavily loaded, deep draft boats.
  - River was going to be shut off – alternative modes of transportation would be required eventually after completion of the dam.
  - Sometimes, they were (AZ Republican 4-30-1905)
  - Logs, lumber were floated downstream to dam

Historical Boating Accounts

Summary of Historical Boating Accounts

Account	Boat Type	Date	Success?	Segment	Purpose
5 Tons of Wheat	Flat boat	May 1873	Yes	6	Commercial
Hayden	Canoe, Logs	June 1873	No	1*	Commercial
Hamilton	Skiff	Jan 1879	Yes	6	Travel
Stewart	Boat	Oct 1880	Unknown	6	Boat builder
Cotton & Bingham	Skiff	Feb 1881	Unknown	6	Travel
Yuma or Bust	Flat boat	Nov 1881	Yes	6	Travel
Willcox & Andrews	Canvas Skiff	Feb 1883	Yes	6	Travel

Historical Boating Accounts

Summary of Historical Boating Accounts

Account	Boat Type	Date	Success?	Segment	Purpose
Meadows	Boat	1883	Yes	3-6	Commercial
Burch	Flat boat	June 1885	Yes	3-6	Commercial
Spaulding	Canoe	Dec 1888	Yes	6	Travel
Sykes	Canvas boat	1890's	Yes*	6	Travel
JK Day	Boat	Spring '92	Yes	6	Commercial
JK Day	Boat	Spring Pre-1892	Yes	6	Commercial 4 trips
Hudson River Co.	Canvas boat	June 1893	Yes	4	Commercial

Historical Boating Accounts

Summary of Historical Boating Accounts

Account	Boat Type	Date	Success?	Segment	Purpose
Robinson	Boat	1893	Yes	6	Travel
Adams & Evans	Flat boat	Jan 1895	Yes	6	Travel – Recreation
Gentry & Cox	Large Ferry	Jan 1889	Yes (on Salt)	6	Commercial
Roosevelt Freight	Boats	April 1905	Yes	4	Commercial
Advertise-ment	Boat	May 1905	Unknown	6	Hunting
USRS	Boat	Dec 1905	No*	6	Travel
Shively	Boat	Mar 1905	Yes	6	Travel

Historical Boating Accounts

Summary of Historical Boating Accounts

Account	Boat Type	Date	Success?	Segment	Purpose
Rains	Boat	April 1909	Yes	6	Travel
Selly	Boat	1909	Unknown	6?	Boat builder
Thorpe & Crawford	Rowboat	June 1910	Yes	3-6	Travel – Recreation
Ensign & Scott	Canoe	June 1919	Yes	3-6	Travel - Recreation

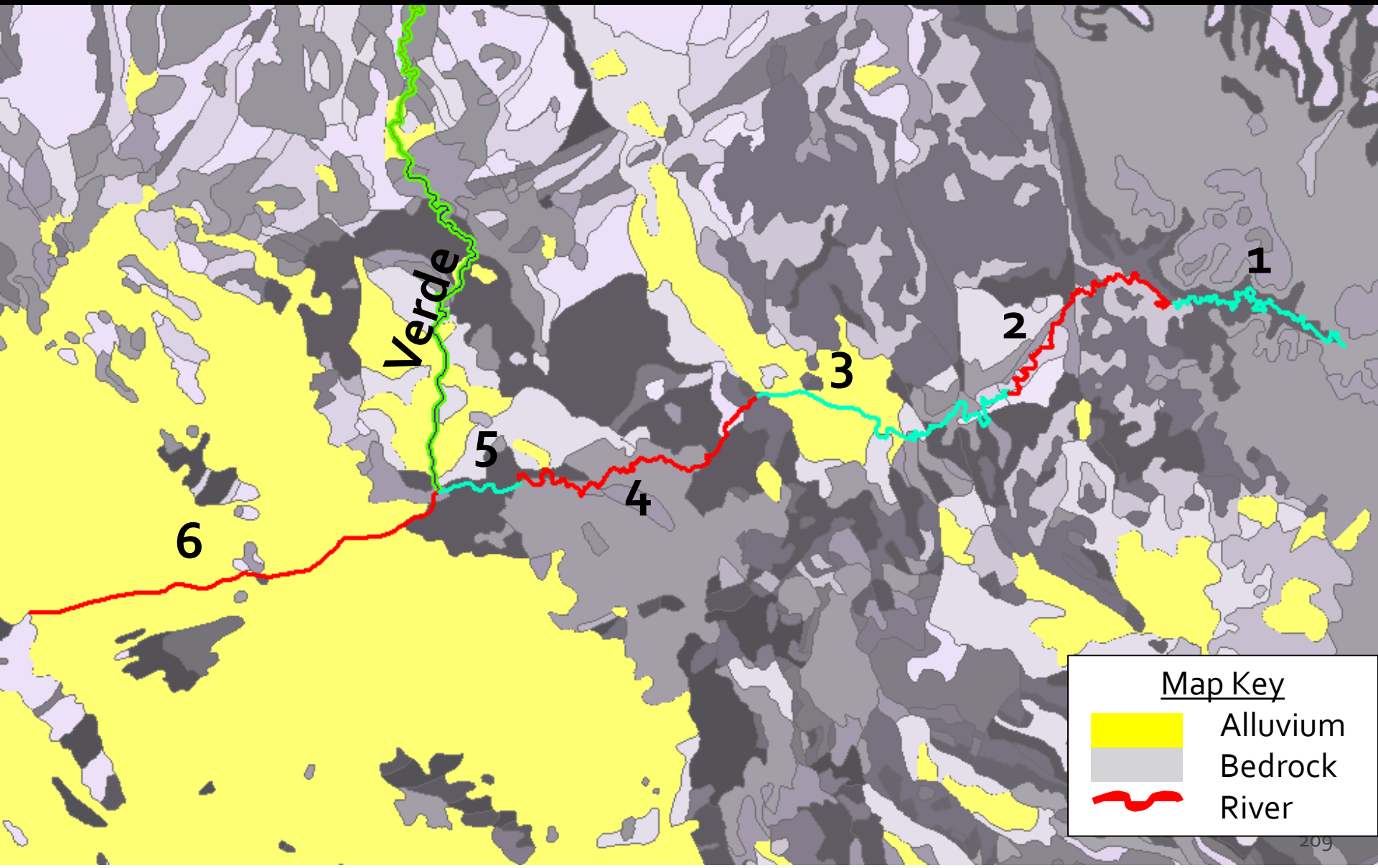
Not Counted in Summary:

1. Boats used in construction of dams (Roosevelt, irrigation dams)
2. Boats used during floods
3. Boats used on canals
4. Ferry trips across river (~ commercial ferries, multiple locations, 1,000's(?) of trips)

Historical Accounts: Summary

- 28Trips
  - 2 Unsuccessful (only 1 failure in Segment 2-6)
  - 4 Insufficient information (e.g., launch only)
- No Flood Accounts Included
- Canoes, Flatboats, Canvas Boats, Skiffs
- Downstream & Upstream Direction
  - Most trips went downstream only
- No Problems with Beaver Dams Noted
- Rapids Noted (Seg 4 only), Did Not Stop Trips
- Includes Trade & Travel
- Throughout Year (June most frequent)

Geology: Key Findings

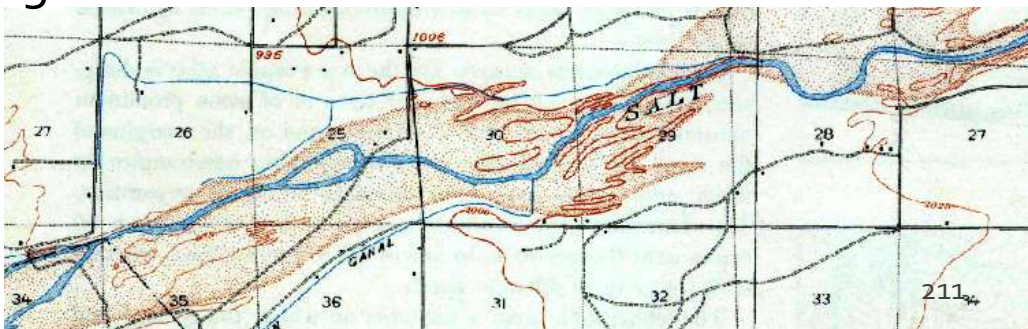


Geology: Key Findings

- Bedrock Canyons (Segments 1-4)
  - Intervening Flats (broader alluvial valley reaches)
  - No Significant Change in Channel Morphology
- Alluvial Valley (Segment 5-6)
  - Minimal bedrock (Granite Reef, Tempe Butte)
- Affects of Floods
  - Segments 1-4: Minimal due to Bedrock Control
  - Segments 5-6: Reshaping of Flood Channel
    - Ordinary, Low-Flow Channel Recurs After Flood
    - Low Flow Channel Can Move During Large Floods
  - Floods Aren't "Ordinary"

Geology: Key Findings

- Channel Pattern
  - Single Channel (Segments 1-4)
    - Some split channels locally
      - > 95% single channel
      - Main channel is obvious
  - Compound Channel (Segment 5-6)
    - Single low flow channel
      - Some double channel reaches on low flow
      - USGS map (ca. 1912): 85% single channel
    - Braided flood channel



Geology: Key Findings

- Rapids
  - Bedrock Ledges
    - Very few
  - Canyon Tributaries
    - Debris Flows & Delta Deposits – most are riffles
  - Difficulty Varies by Reach
    - Segment 1: Numerous Class IV rapids
    - Segment 2: Some Class III-IV rapids
    - Segments 3-6: Class II or lower
      - Insignificant to Low Draft Boats
    - Segment 6: No known rapids, probably some riffles

Geology – Other Factors

- Waterfalls
  - No Actual Waterfalls on Salt River
  - Apache (Segment #1) & Quartzite (Segment #2)
    - "Falls" are challenging, but runnable rapids (Class IV)
    - Often portaged or lined
  - Mescal "Falls" is a mild Class III rapid in Segment #2
- Springs
  - Many named & unnamed, adds flow to river
- Tributaries
  - Some perennial tributaries in Segments 1-5
  - Ephemeral tributaries in Segment 6

Modern Boating on the Salt River

- What About Quartzite Falls Rapid?
  - Narrow Canyon, Small Drop, Turbulent
    - 100 ft long rapid, Large pool below rapid
  - Dynamited in 1993
    - Removed part of the ledge, frustrations with queue
    - Still Class IV at high flow
  - Why Portage?
    - Was Class V @ High Water, with Recirculating Keeper Hole
    - Commonly boated at lower water pre-blasting
  - Short Portage Made by 100's to 1000's of Boaters
    - Did Not Stop or Prevent Boating Trips pre-blast
    - Today it is normally boated without a portage

Quartzite "Falls" Rapid

- Class III-V (Pre-Dynamite)
  - Characteristics
    - Short (~100-150 ft. long whitewater)
    - Constriction
    - Boulders & Bedrock Sill
    - Portage – normally on river left
    - Pool immediately below rapid

Quartzite "Falls" Rapid

Google Earth Aerial, June 5, 2012 @ 94 cfs Yellow bar = 100 ft.

Quartzite "Falls" Rapid

Google Earth Aerial, June 5, 2012 @ 94 cfs Yellow bar = 100 ft.

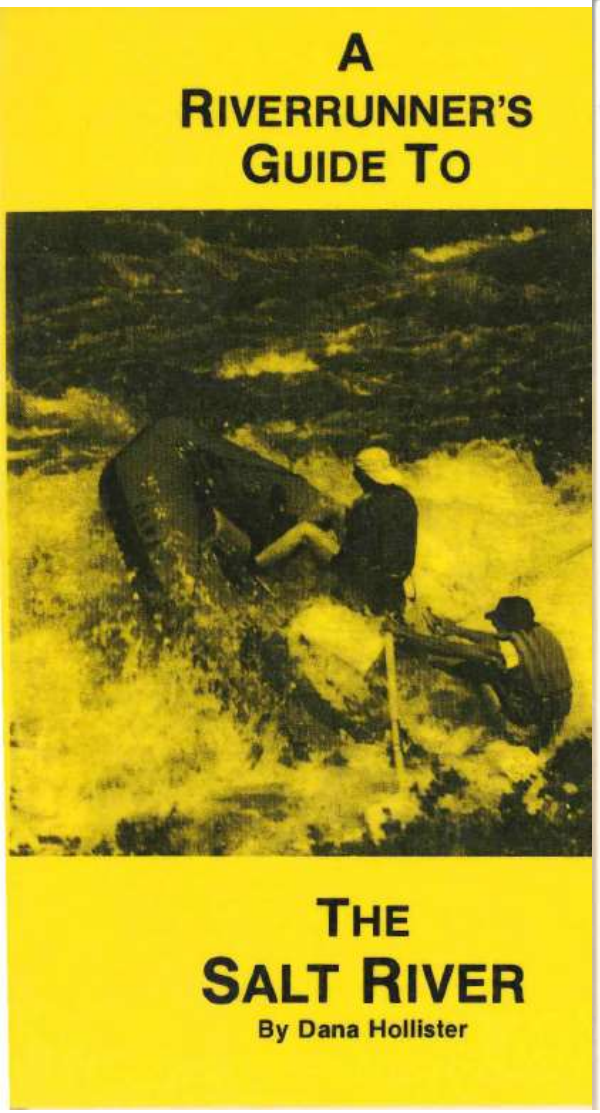
Quartzite "Falls" Rapid

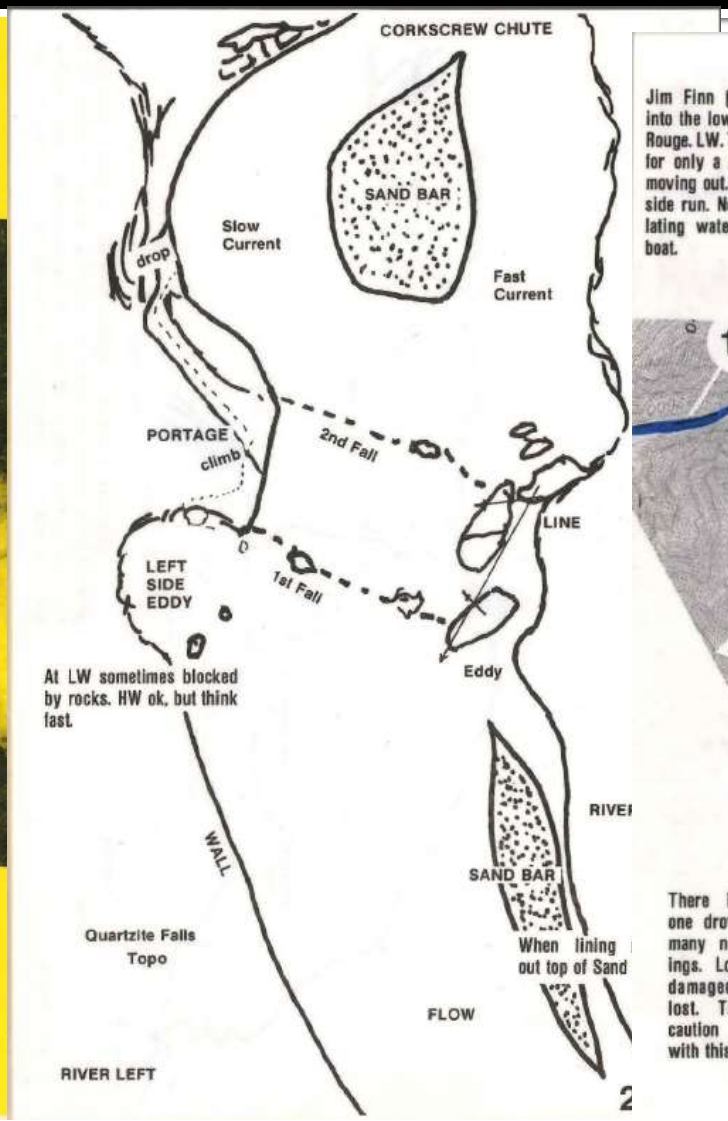
AZGFD, 1996 Fish Survey

Quartzite "Falls"

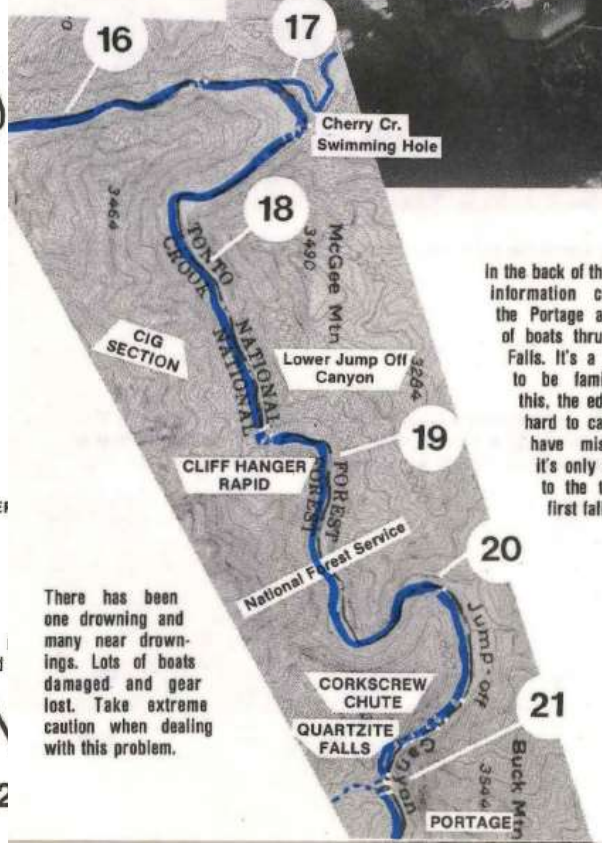
AZGFD, 1996 Fish Survey

Quartzite "Falls" Rapid





Jim Finn (right) punches into the lower fall in a 15' Rouge. LW. The boat pauses for only a moment before moving out. This is the left side run. Note the recirculating water right of the boat.



In the back of this guide is information concerning the Portage and Lining of boats thru Quartzite Falls. It's a good idea to be familiar with this, the eddy can be hard to catch. Boats have missed, and it's only a few feet to the top of the first fall.

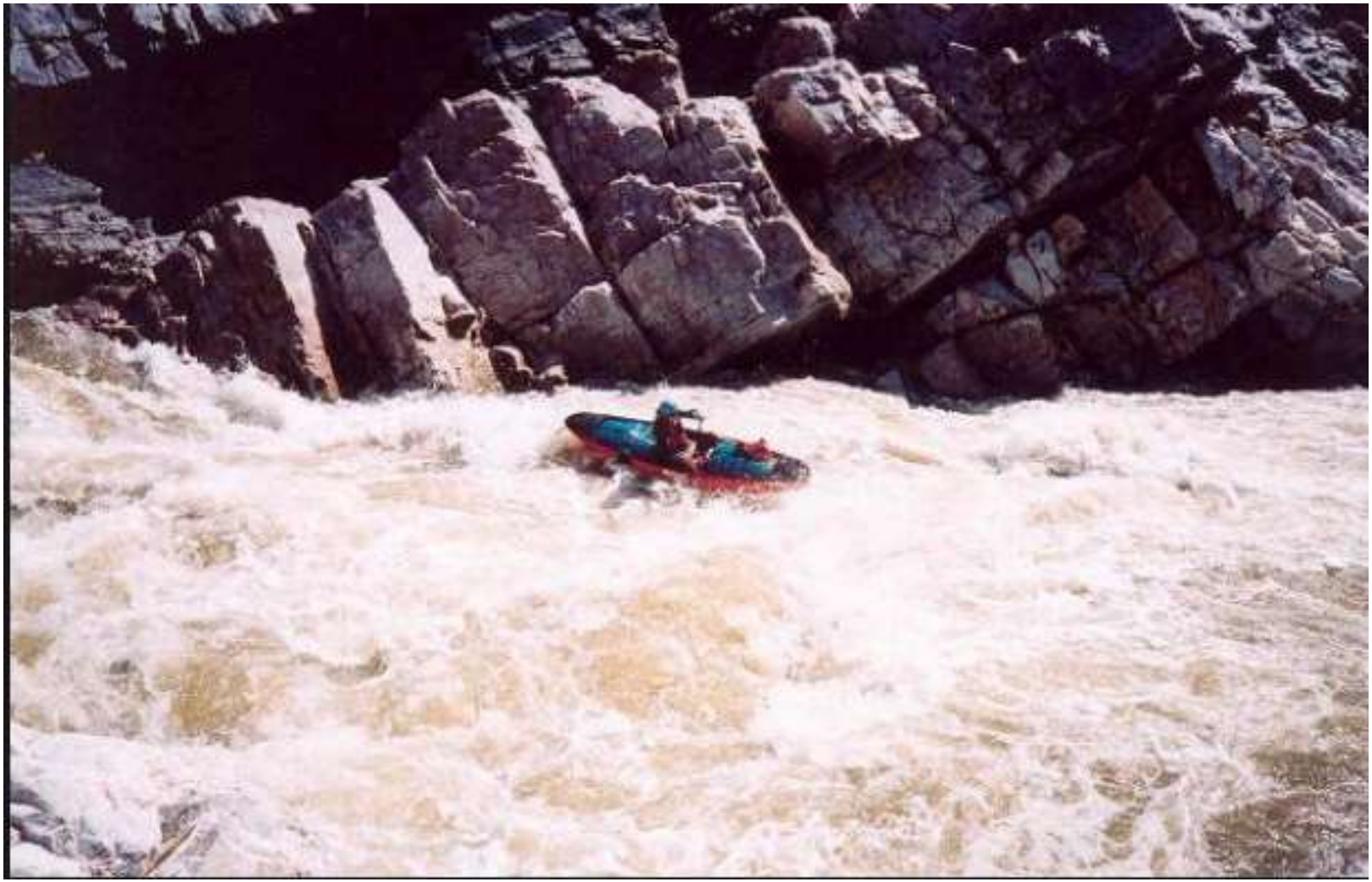
There has been one drowning and many near drownings. Lots of boats damaged and gear lost. Take extreme caution when dealing with this problem.

Quartzite "Falls" Rapid

Quartzite, Pre-Dynamite

Quartzite, Pre-Dynamite

Quartzite "Falls" Rapid



Canoeing Quartzite at High Flow

Geology – Other Factors

- Gaining/Losing Reaches
  - Gaining: Segments 1-5 – Springs, Tributaries
  - Losing: Segment 6
    - Shallow water table pre-settlement
    - Tempe Butte forces some ground water to surface
- Bars
  - Gravel & cobble (Segments 1-6)
    - Channel margins
  - Sand bars (Segment 6)
    - Channel margins, in-channel
  - Many navigable rivers have bars
    - Navigate around the bars

Hydrology: Key Findings

- Flow Rate Data Provided in ASLD Reports
  - Pre- and Post-Statehood
  - Mean, Monthly, Median, Range
  - Seasonality of Runoff
  - Floods & Droughts (Rare, Not Ordinary)
  - Estimates from Multiple Sources
  - Primary Reliance on Modern USGS Gage Data
    - 1800's-Present

Salt River Hydrology

- Nature of Flow Data Provided
  - Mean vs. Median
    - Both were/are provided
    - Mean is more commonly used
    - Median more reflective of "ordinary" condition
  - Seasonal Variation
    - Occurs Within Predictable, Ordinary Range
    - 90% Range Presented
    - Seasonal Variation Normal on Navigable Rivers
      - Ice, Low/High Flow, Flood Season

Salt River Hydrology

- Nature of Flow Data Provided
  - Floods & Droughts
    - All Rivers Experience Floods & Droughts
    - Floods & Droughts Are Rare
      - i.e., not "Ordinary"
    - Irrelevant to Determination of Navigability

Salt River Hydrology

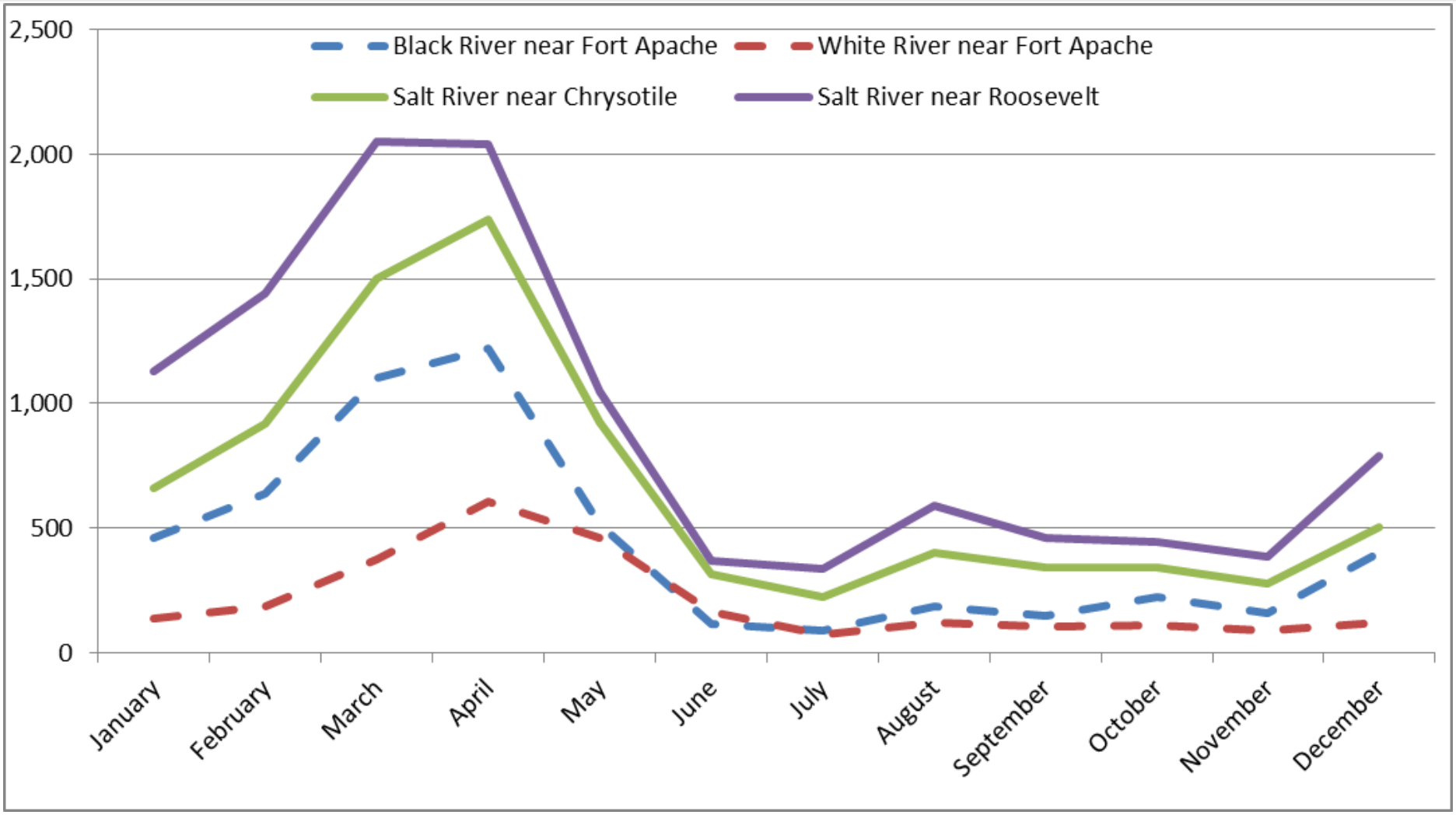
- Reliability of Flow Data Cited
  - Best available
  - Based on actual measurements
  - Routinely used for court decisions
  - Routinely relied on for:
    - Water Supply
    - Water Rights
    - Recreational Boating Permitting

Salt River Hydrology

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 Black River	- -	(35) (39)	(90) (109)	(567) (1230)	1958-1996 1958-1996
White + Black	1	74	199	1,797	
Chrysotile	2	130	266	1,610	1925-1996
Roosevelt	3, 4	159	341	2,120	1914-1996
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)

Salt River Seasonal Flow Variation



Salt River Hydrology

- Other Flow Estimates
  - Segment 5 (upstream of Verde)
    - Tree Ring Data (Graybill, 1989): 796 cfs (mean)
    - Aldridge (USGS, 1981): 732 cfs (mean)
  - Segment 6
    - Kent Decree 1576 cfs (mean)

Note: Estimates are for the Salt River above the Verde confluence (Segment #5)

Salt River Hydrology

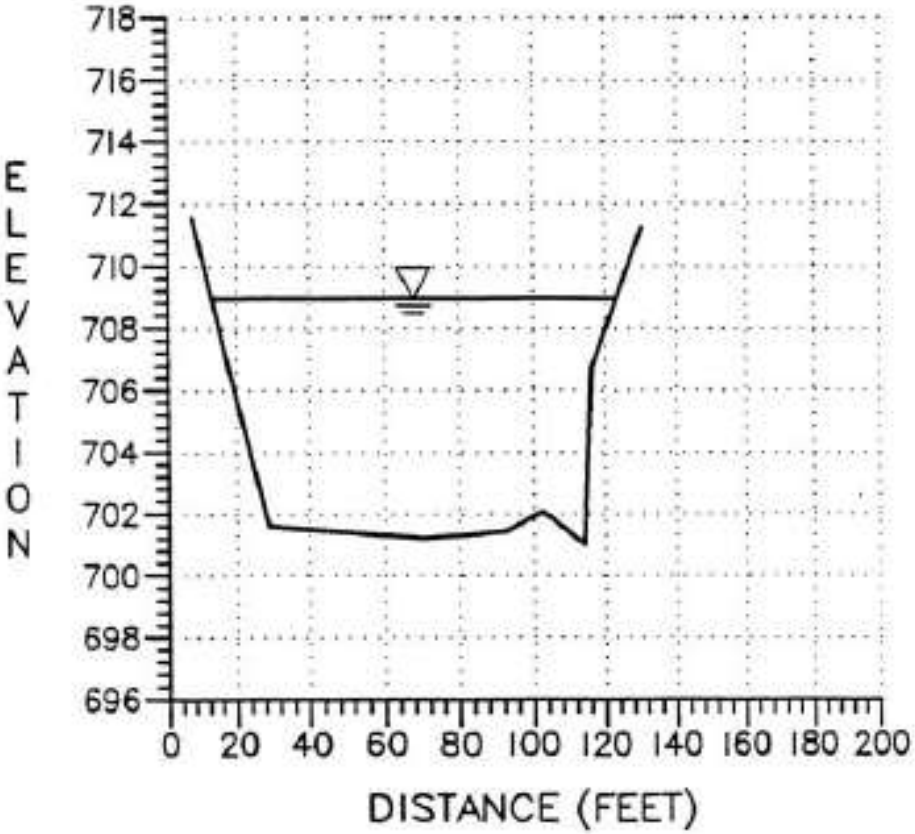
- Summary
  - Best Available Data
  - Flow is Predictable
  - Flow is Reliable
  - Flow is Perennial
  - Flow is Significant
    - Late Winter/Spring Flows Ordinarily Highest

Salt River Rating Curves

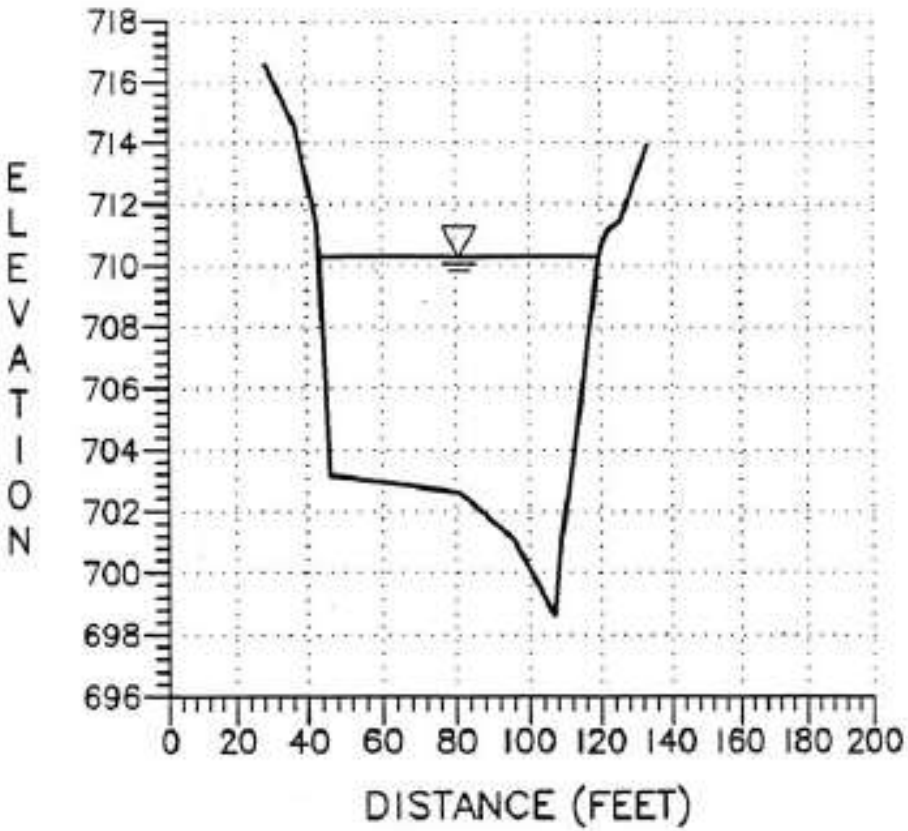
- Rating Curves: Flow Depth & Width Estimates
  - Segments 1-4
    - From USGS Rating Curves & Field Sections
    - Broadly Representative of Segments
    - Actual Measurements & Observations
    - Consistent with Historical Observations
    - Representative of Ordinary & Natural River Condition
  - Two "Typical Sections"
    - Sheer Canyon
    - Gravel Bar

Typical Channel Sections Segments 1-4

Sheer Canyon Section



Gravel Bar Section



Salt River Rating Curves

- Rating Curves: Flow Depth & Width Estimates
  - Segments 5-6
    - 1907 Topographic Mapping (5 ft. contour interval)
    - Interpolated Low Flow Geometry
    - HEC-2 Modeling - Depth
    - Consistent with Historical Observations

Salt River Rating Curves

Salt River: Rating Curve – Segment 2, Sheer Canyon (Chrysotile Gauge)				
Flow Frequency	Flow Rate (cfs)	Avg Depth (ft)	Average Velocity (ft/s)	Top Width (ft)
90%	130	1.8	1.2	170
50% (median)	266	2.1	1.5	210
10%	1610	3.6	2.9	280

Salt River: Rating Curve – Segment 2, Gravel Bar (Chrysotile Gauge)				
Flow Frequency	Flow Rate (cfs)	Avg Depth (ft)	Average Velocity (ft/s)	Top Width (ft)
90%	130	3.9	2.9	25
50% (median)	266	5.0	3.5	30
10%	1610	10.0	5.0	80

Salt River Rating Curves

Salt River: Rating Curve – Segment 3-4, Sheer Canyon (Roosevelt Gauge)				
Flow Frequency	Flow Rate (cfs)	Avg Depth (ft)	Average Velocity (ft/s)	Top Width (ft)
90%	159	1.8	1.3	180
50% (median)	341	2.3	1.7	220
10%	2,120	4.0	3.3	280

Salt River: Rating Curve – Segment 3-4, Gravel Bar (Roosevelt Gauge)				
Flow Frequency	Flow Rate (cfs)	Avg Depth (ft)	Average Velocity (ft/s)	Top Width (ft)
90%	159	4.0	3.0	25
50% (median)	341	5.5	3.7	35
10%	2,120	10.7	5.2	90

Salt River Rating Curves

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

Typical Channel Sections Segments 5-6

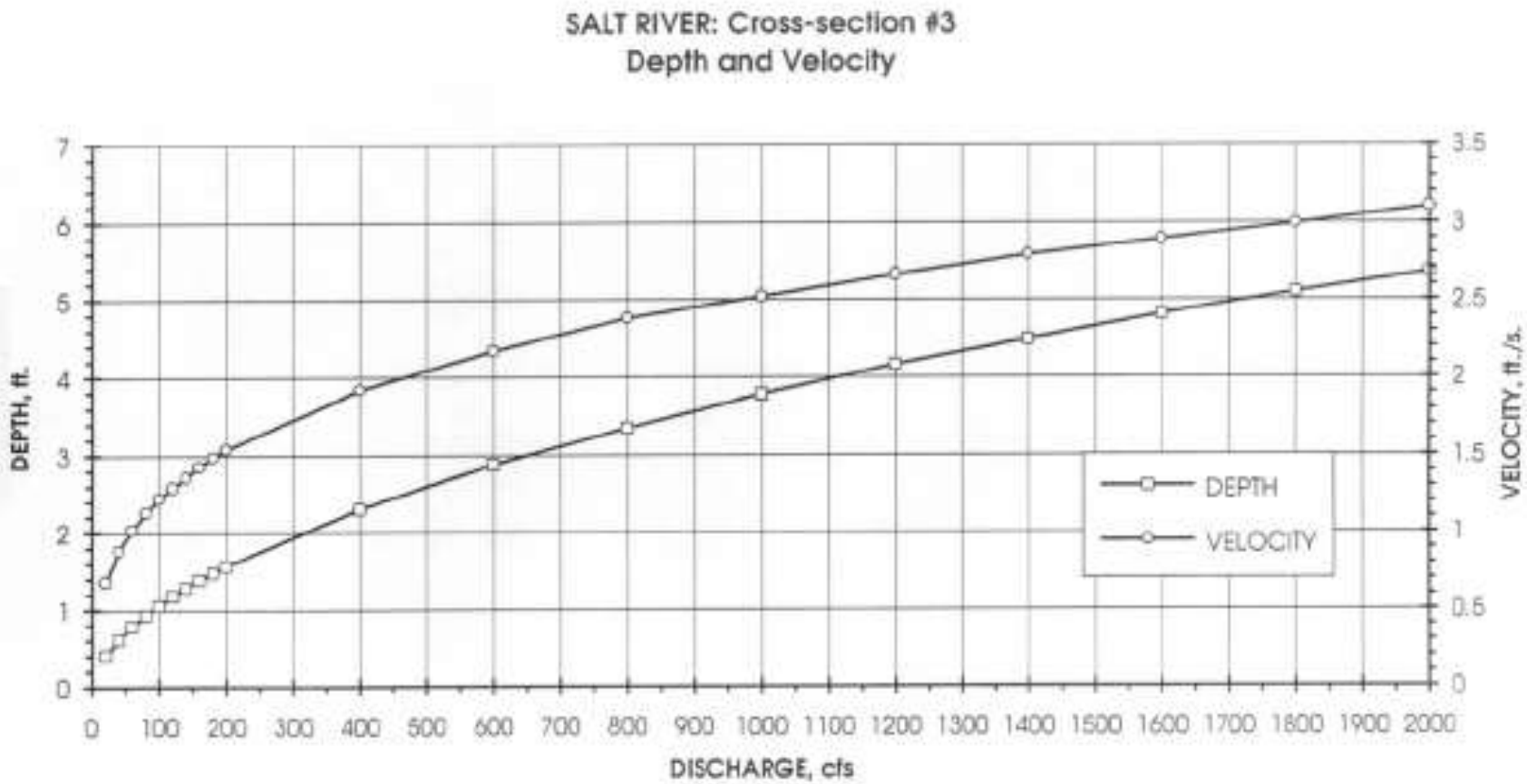


Figure 7-4. Typical Historic Salt River Low-Flow RatingCurve.

ASLD Report, p. 7-25
Representative of Ordinary & Natural Condition, ca. 1905

Depth Estimate Verification

- Segments 2-3, 5
  - Field visits
  - Boating trips
  - Historical descriptions
- Segment 6
  - Historical descriptions
  - GLO survey notes
    - Ingalls, March-June, 1868
    - Width estimates by triangular: too deep to cross on foot

Salt River Rating Curves
USGS Gaging Stations: Chrysotile

October 6, 2015 @ 330 cfs

Salt River Rating Curves
USGS Gaging Stations: Chrysotile

October 6, 2015 @ 330 cfs

Salt River Rating Curves
USGS Gaging Stations: Chrysotile

June 5, 2012 @ 88 cfs

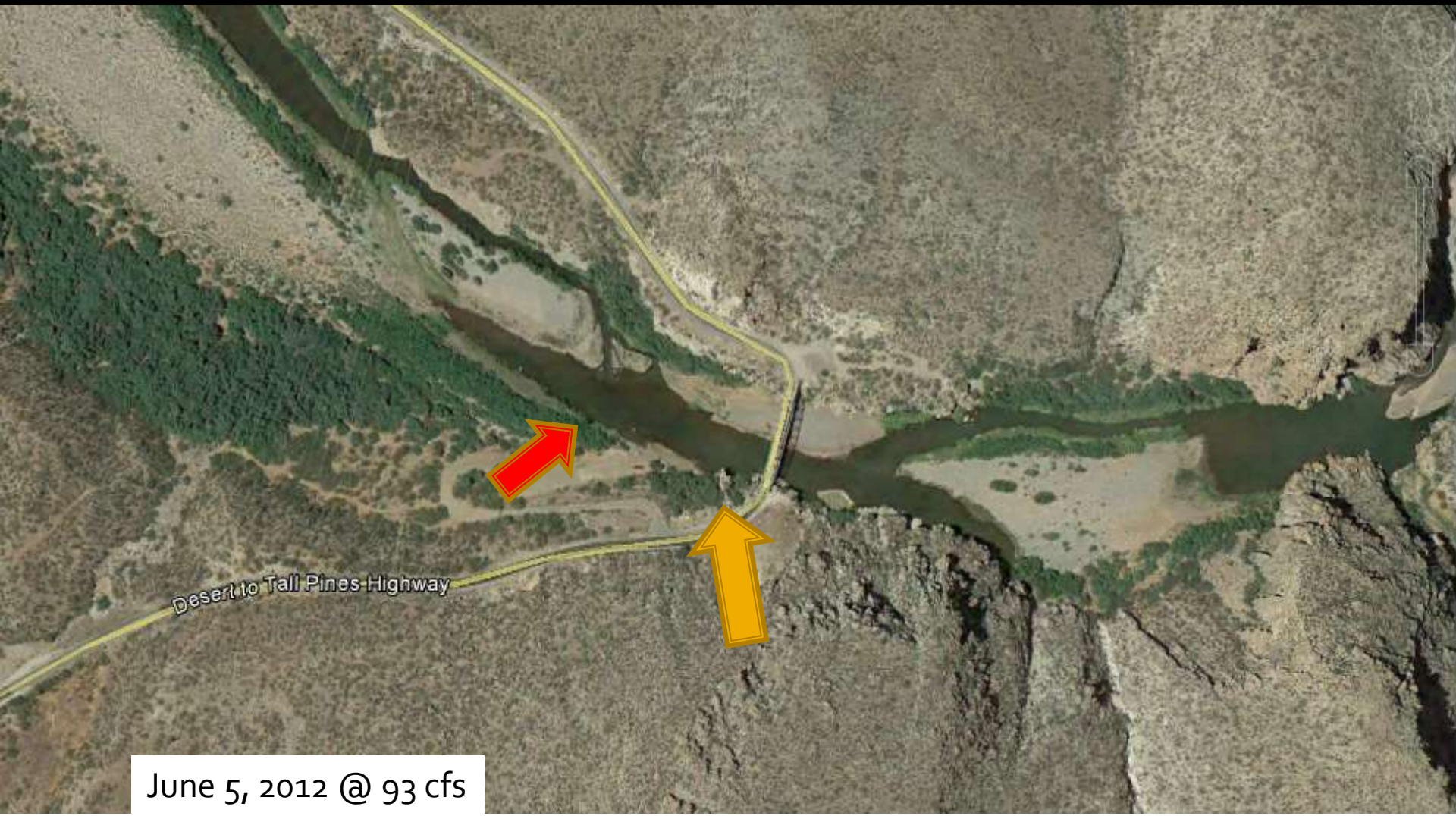
Salt River Rating Curves
USGS Gaging Stations: Roosevelt

October 6, 2015 @ 550 cfs
Photo taken from USFS boat ramp

Salt River Rating Curves
USGS Gaging Stations: Roosevelt

October 6, 2015 @ 550 cfs

Salt River Rating Curves
USGS Gaging Stations: Roosevelt



June 5, 2012 @ 93 cfs

Salt River Rating Curves
USGS Gaging Stations: Stewart Mtn

February 11, 2014 @ 8 cfs

Salt River Rating Curves
USGS Gaging Stations

August 13, 2015 @ 840 cfs

Salt River Rating Curves
USGS Gaging Stations: Stewart Mtn

May 26, 2012 @ 1200 cfs

Salt River Rating Curves

- Rating Curves vs. Reality
  - At the Control Section
    - Rating Curves Reasonable Accurate (+/- 5-25%)
    - Measurement Error
    - Channel Change
    - Periodic Adjustment
    - Range of Measurements
  - Away from the Control Section
    - Pool & Riffle Stream System Characteristics
    - Rapids, Obstacles, Pools
    - Importance of Field Experience
  - The Ultimate Test: A Boat in the River

Susceptibility to Boating

- Requirements for Boating
  - In Boating Presentation
- Summarized Below by Segment
  - Flow Data (Seasonal, Median, 10-90%)
  - Boating Range

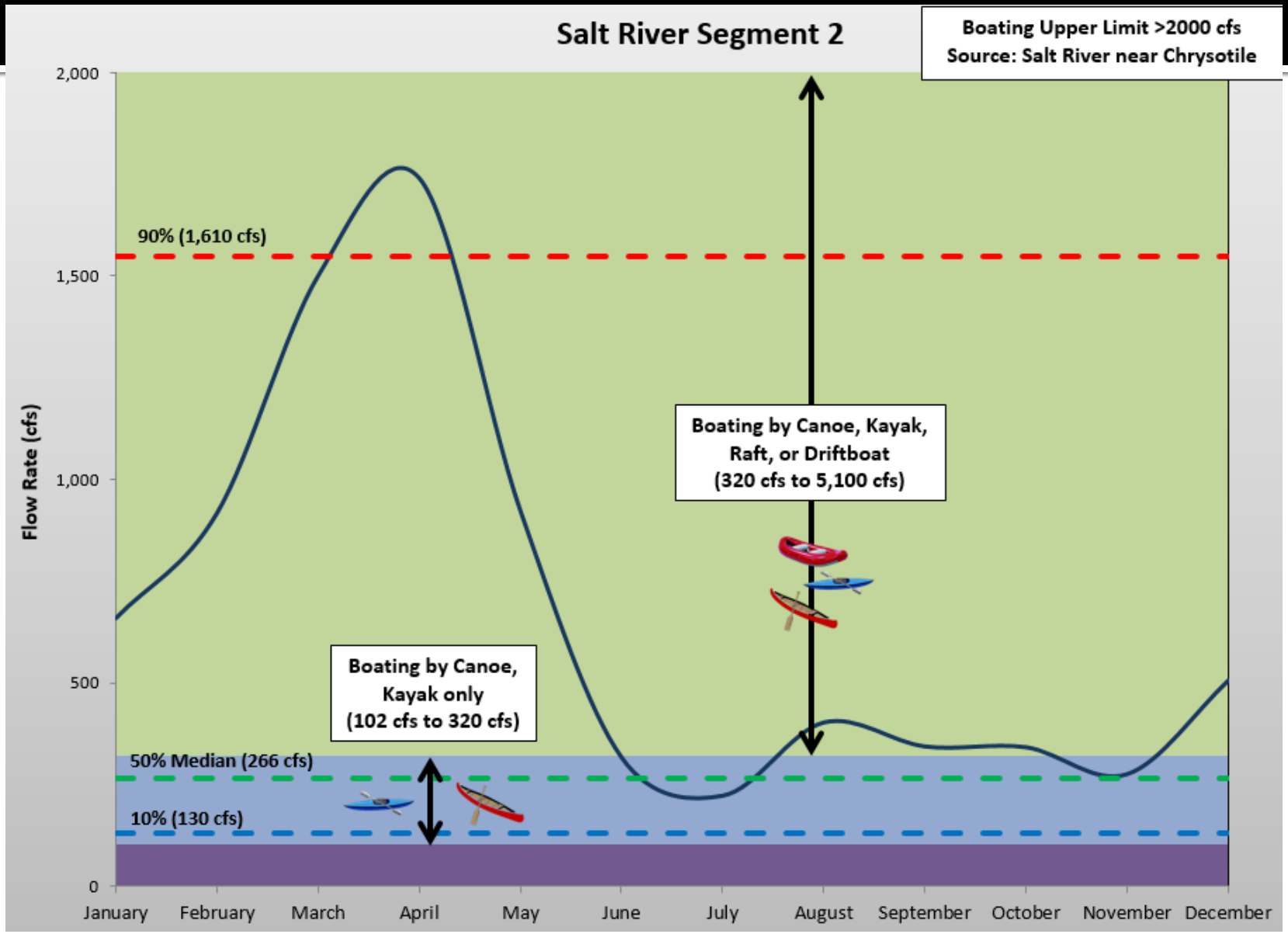
Salt River Segment #1

- Not Normally Boatable by 1912-Era Watercraft
  - Sufficient Flow Most of Year
    - Perennial
  - Rapids
    - Too many-Too big (Class IV+)
    - Low flow/high flow
  - Minimal Historical Boating
    - Hayden's failed log float / canoe trip
  - No Legal Modern Boating
    - Difficult trip

Salt River Segment #1

- Summary
  - Boatable by canoes: <10% of the time
    - Occasionally (<30 days/yr)
  - Boatable by flatboats: <10% of the time
    - Occasionally (<30 days/yr)
  - Modern Boating
    - No permitted recreational use
    - Significant rapids
  - Ordinary & Natural Condition
    - Similar to existing condition

Salt River Segment #2



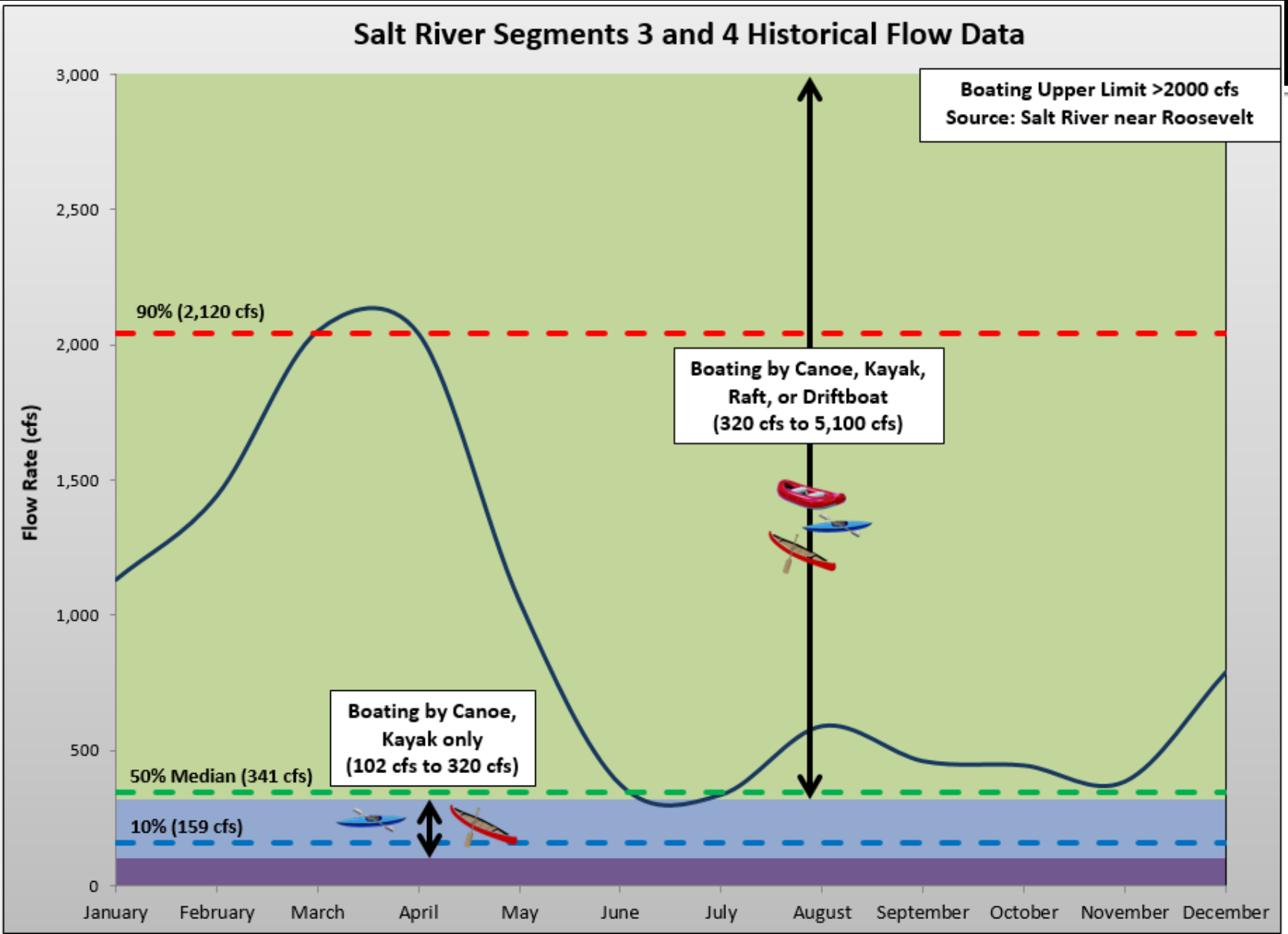
Salt River Segment #2

- Modern Boating
  - Frequently Boated for Recreation
    - Permit System by US Forest Service
    - Permit System by White Mountain Apache Tribes
- Changes Since Statehood
  - Minor flow removed for irrigation & municipal use
  - Minimal change in character of river
    - Bridge at US60

Salt River Segment #2

- Summary
  - Boatable by canoes: ~90% of the time
    - Year Round (330 days/yr)
  - Boatable by flatboats: <50 % of the time
    - Seasonally (Winter, Monsoon) (180 days/yr)
  - Modern Boating
    - Frequent recreational use
    - Several significant rapids
  - Ordinary & Natural Condition
    - Similar to existing condition

Salt River Segment #3



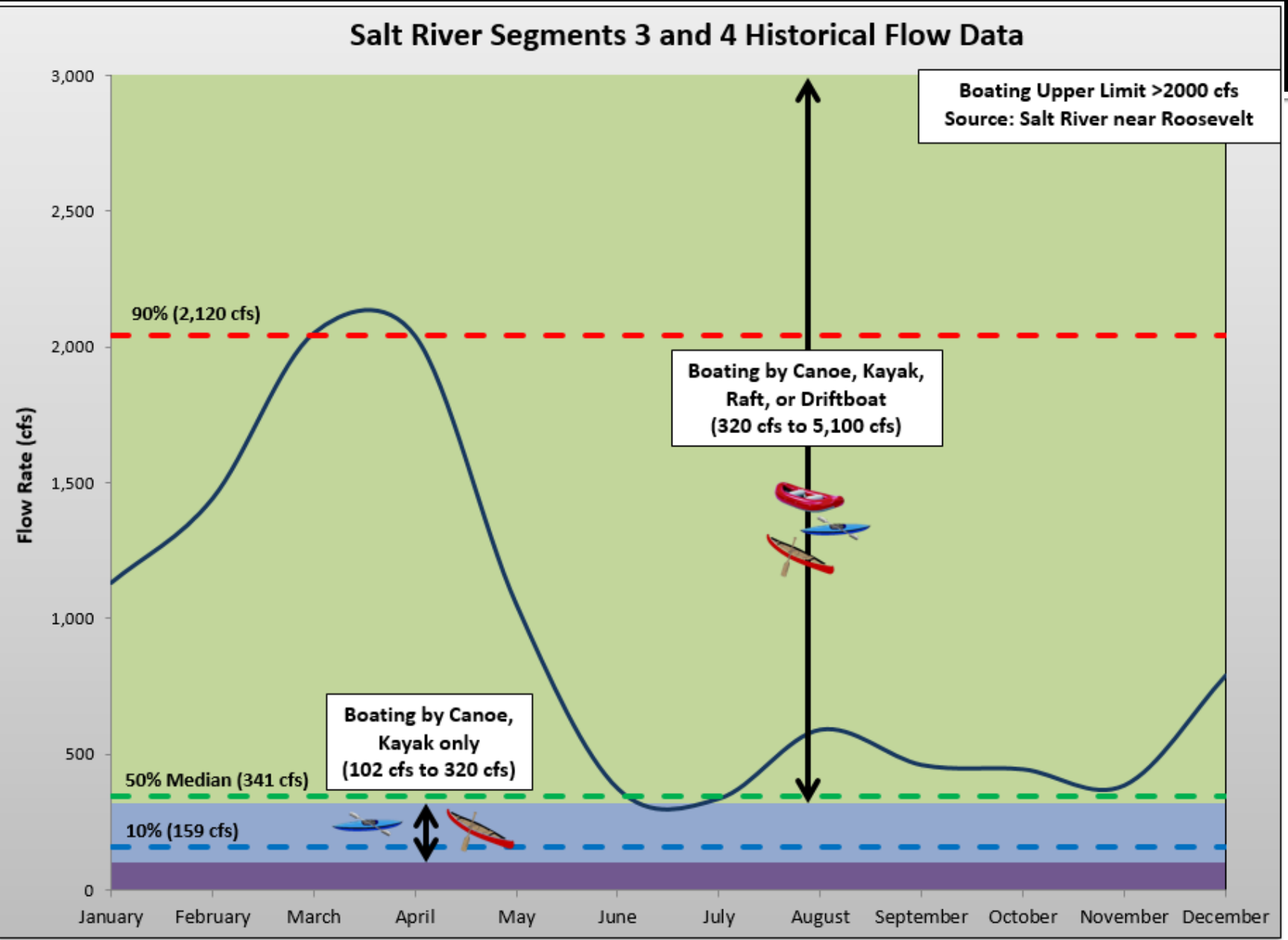
Salt River Segment #3

- Modern Boating
  - Frequently Boated for Recreation
    - Permit System by US Forest Service
- Changes Since Statehood
  - Minor flow removed for irrigation & municipal use
  - Minimal change in character of river
    - Bridge at SR288
  - Roosevelt Lake Inundation (pre-dates 1912, fluctuates)
    - Diversion Dam downstream of SR288

Salt River Segment #3

- Summary
  - Boatable by canoes: ~90% of the time
    - Year Round (330 days/yr)
  - Boatable by flatboats: > 50 % of the time
    - Seasonally (Winter, Monsoon) (180 days/yr)
  - Boating
    - Frequent modern recreational use
    - No significant rapids
    - Historical boating accounts in lower reaches
  - Ordinary & Natural Condition
    - Similar to existing condition until Roosevelt Lake
    - Diversion dam at Livingstone area (Modern Hazard)
      - Mentioned in boating guides

Salt River Segment #4



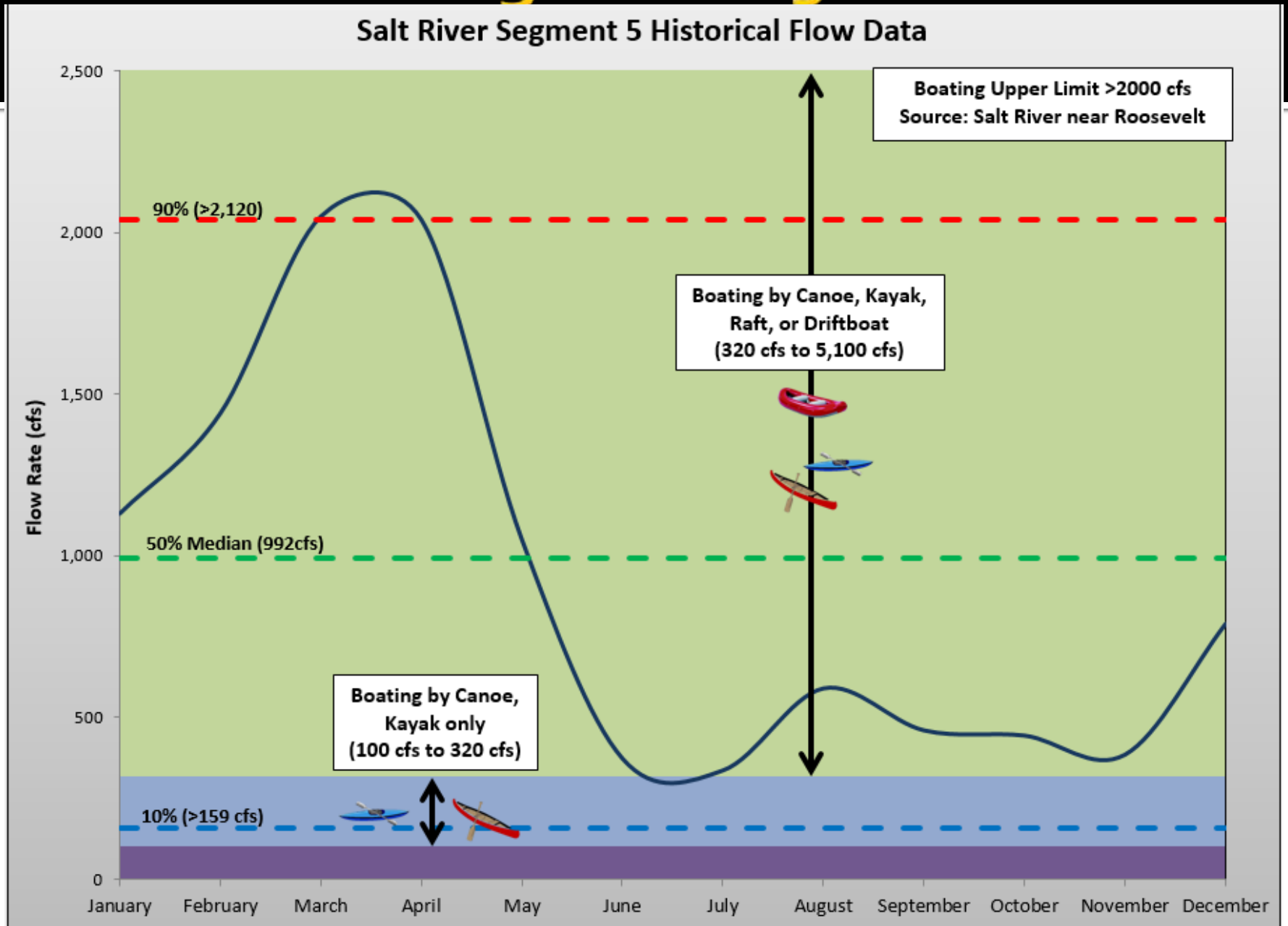
Salt River Segment #4

- Modern Boating
  - Popular boating on Reservoir system
  - Ordinary & natural river condition submerged
- Changes Since Statehood
  - Flow impoundment submerges river
  - Flow regulated for water supply & flood control

Salt River Segment #4

- Summary
  - Boatable by canoes: ~90% of the time
    - Year Round (330 days/yr)
  - Boatable by flatboats: > 50 % of the time
    - Seasonally (Winter, Monsoon) (180 days/yr)
  - Boating
    - Numerous historical boating accounts
    - No significant rapids likely
    - Frequent modern recreational use (on reservoirs)
  - Ordinary & Natural Condition
    - Similar to existing condition until Roosevelt Lake

Salt River Segment #5



Salt River Segment #5

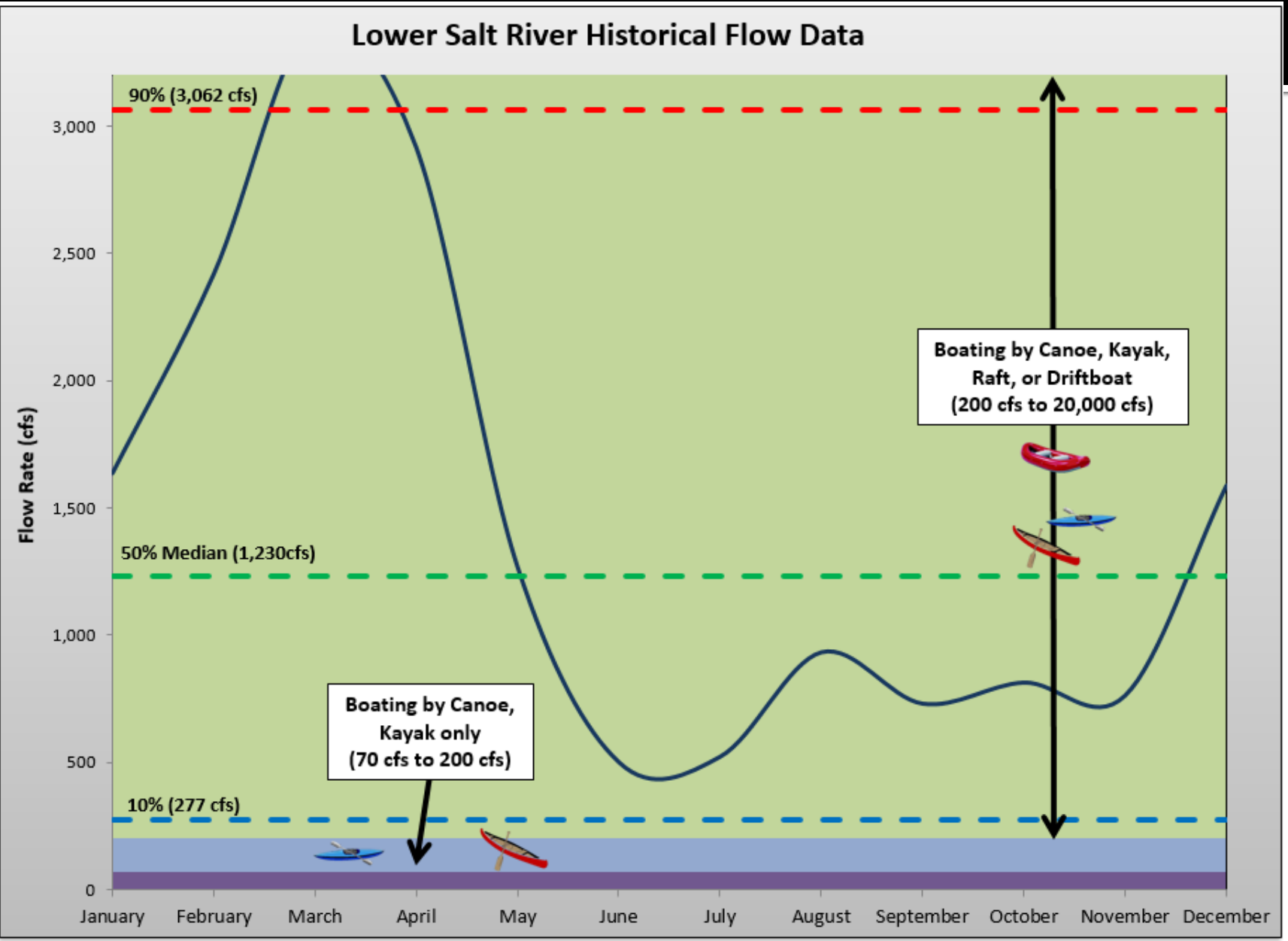
- Modern Boating
  - Popular boating during reservoir releases
  - Commercial kayak rental, shuttles, rafting
  - Salt River Tubing

- Changes Since Statehood
  - Flow regulated for water supply & flood control
  - Channel conditions essentially unchanged
    - Bridge at Blue Point
    - River access parking outside of floodplain

Salt River Segment #5

- Summary
  - Boatable by canoes: ~90% of the time
    - Year Round (330 days/yr)
  - Boatable by flatboats: > 70 % of the time
    - Most of year except very low flow (260 days/yr)
  - Boating
    - Frequent modern recreational use
    - No significant rapids
    - Numerous historical boating accounts
  - Ordinary & Natural Condition
    - Similar to existing condition
    - Flow rates changed due to water supply management

Salt River Segment #6



Salt River Segment #6

- Modern Boating
  - Some boating during floods & dam releases
  - Some boating in effluent releases

- Changes Since Statehood
  - Flow regulated for water supply & flood control
  - Channel conditions highly altered
    - In-stream mining
    - Channelization
    - Urbanization
    - Encroachment

Salt River Segment #6

- Summary
  - Boatable by canoes: ~95% of the time
    - Year Round (350 days/yr)
  - Boatable by flatboats: > 85% of the time
    - Most of year, except very low flow (310days/yr)
  - Boating
    - Numerous historical boating accounts
    - No significant rapids
    - Infrequent recreational use due to flow removal
  - Ordinary & Natural Condition
    - Reconstructed from historical photos, maps & accounts
    - Flow rates changed due to water supply management

Modern Boating

Modern Boating

- Private Recreation
  - Segment 2-3 (all year, most in Spring)
  - Segment 5 (Spring-Summer-Fall)
  - Segment 6 (all year, effluent)
- Seasonal Commercial Recreation
  - Rafting Companies (Segment 2-3-5)
  - Kayak rental (Segment 5)
  - Tubing (Segment 5)
  - Shuttle Services (Segments 2-3-5)
- Other Commercial Boating

Modern Boating on the Salt River

- Paddler's Clubs
  - Central Arizona Paddler's Club Poll
    - All of Segment 1-6 have been boated
    - Segment 2 & 5 are most frequently boated
    - Segment 4 boating is on Reservoirs
    - Segment 5 boating is on Reservoir releases
      - Typical release rates are below natural median flow rate
    - Segment 6 boating is on Reservoir releases, floods or effluent discharge
  - All seasons

Modern Boating on the Salt River

- Previous ANSAC Testimony (1997, Globe)
  - Jim Slingluff, Canoeist – Segments 2,3,5
    - Beginning to intermediate boating skills required
  - Jerry Van Gasse, Commercial Rafting – Segments 2,3
    - 20 trips per year
  - George Marsik, Commercial Rafting – Segments 2,3
    - Year round trips, 100 per year
  - Dorothy Riddle, Commercial Boating – Segments 2,3,5

Modern Boating on the Salt River

- Current Commercial Operations – Segments 2-3
  - Permit Season: March 1-May 15 (76 days)
  - Four Commercial Companies
    - Allowed 2 launches per day (total)
    - User Days

User Days	Daily (Seg 2)	Wilderness (Seg 2-3)
Wet Year (2010):	6,950	570
Dry Year (2015):	850	190

"The Government's assertion as to lack of commercial possibilities fails to recognize one source of commerce which in the future will undoubtedly develop to a considerable extent-the use of these Rivers for the transportation of tourists for hire, to view the natural scenic wonders and explore the archaeological features of these regions"

Utah Special Masters Report, p. 117).

Source: D. Sullivan, USFS Tonto River Ranger, 2015

Modern Boating on the Salt River

- USFS Permitted Private Trip Data: Segments 2-3
  - Permit Season: March 1-May 15 (76 days)

Private Trips

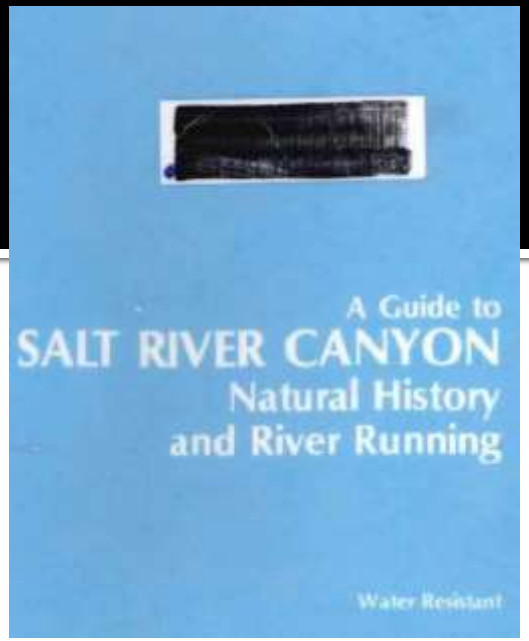
Allowed 4 launches per day (304 total)

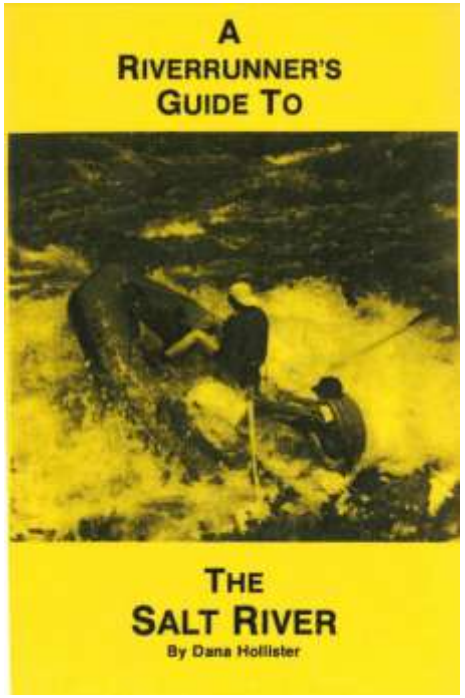
User Days	Wilderness (Seg 2-3)	Daily
Wet Year (2010):	292 trips (2600 people)	~3,000
Dry Year (2015):	15 permits	~400

Source: D. Sullivan, USFS Tonto River Ranger, 2015

Modern Boating on the Salt River

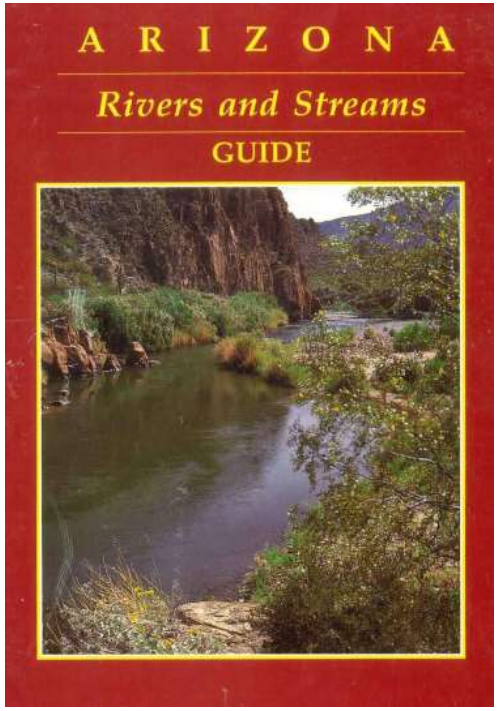
- Paddling Guides
  - Arizona State Parks Boating Guide
    - Segment 1-2 (Canoe, Kayak, Raft)
  - Southwest Boating Guide
    - Segment 1-2 (Canoe, Kayak, Raft)
  - Guide to the Upper Salt River
    - Segment 2-3
  - Paddling Arizona
    - Segment 2-5



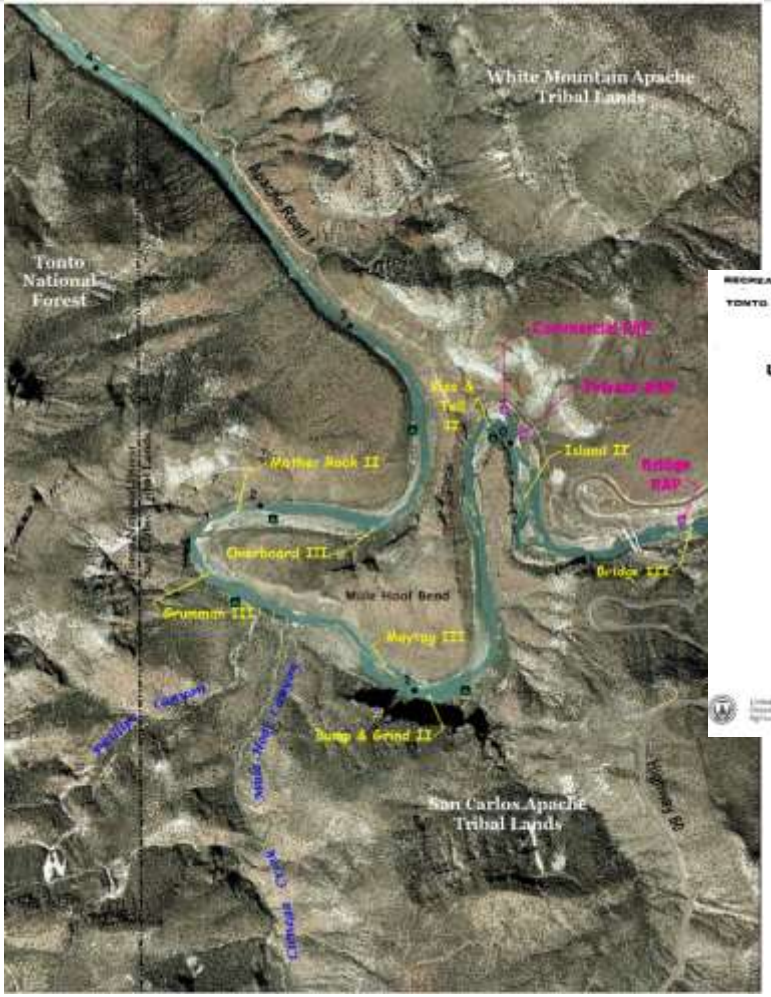


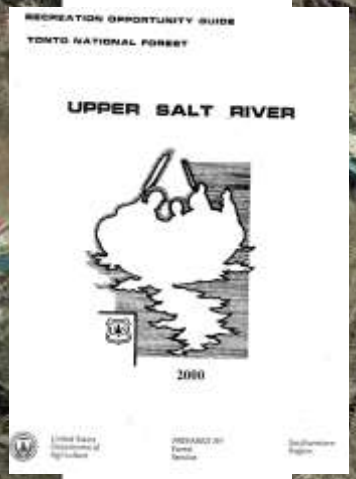
Modern Boating on the Salt River

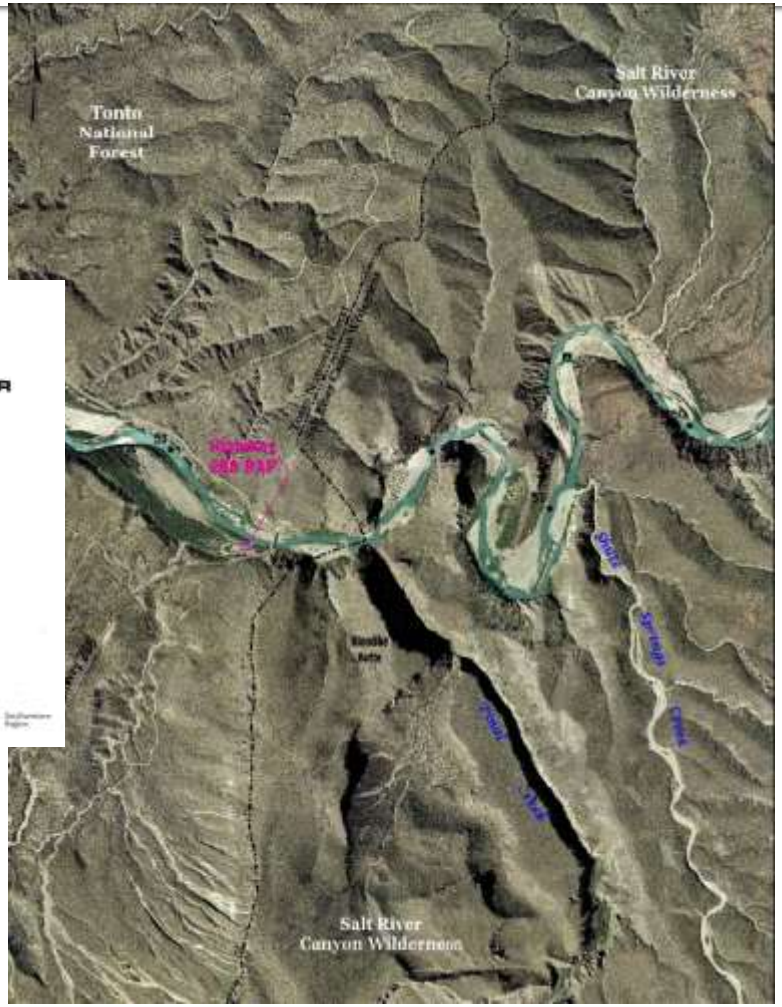
- River Guides
  - National Park Service:
    - "One of the best whitewater streams in the Southwest"
  - Arizona State Parks Rivers & Streams Guide
    - Year round boating
  - USFS Forest Service Guide & Maps
    - River Rangers
    - Winter/Spring Permitting



Modern Boating on the Salt River







US60 Bridge (Segment 2)

Roosevelt/SR288 (Segment 3)

Modern Boating on the Salt River

- Websites re. Salt River Boating (Segments 2,3,5)
  - Paddleon.net:
    - Segments 2-4-5 – Trip reports & photos
  - Southwestpaddler.com
    - Year round, 300+ cfs
  - Sites for Commercial Vendors
    - Mild to Wild
    - Wilderness Aware
    - Salt River Rafting
    - Salt River Canoe Kayak & Raft Rentals

Modern Boating on the Salt River

- Other Commercial Use
  - Game & Fish Surveys (Segment 2, 3) – Canoe
  - Maricopa County Sheriff's Office River & Lake Patrol (5)
  - White Mountain Apache Permits (2)
  - USFS Permits (2-3)

Modern Boating on the Salt River

- AZ Game & Fish Dept Fish Surveys (Seg 2-3)
  - Canoes & Rafts
  - Electofisher Equipment

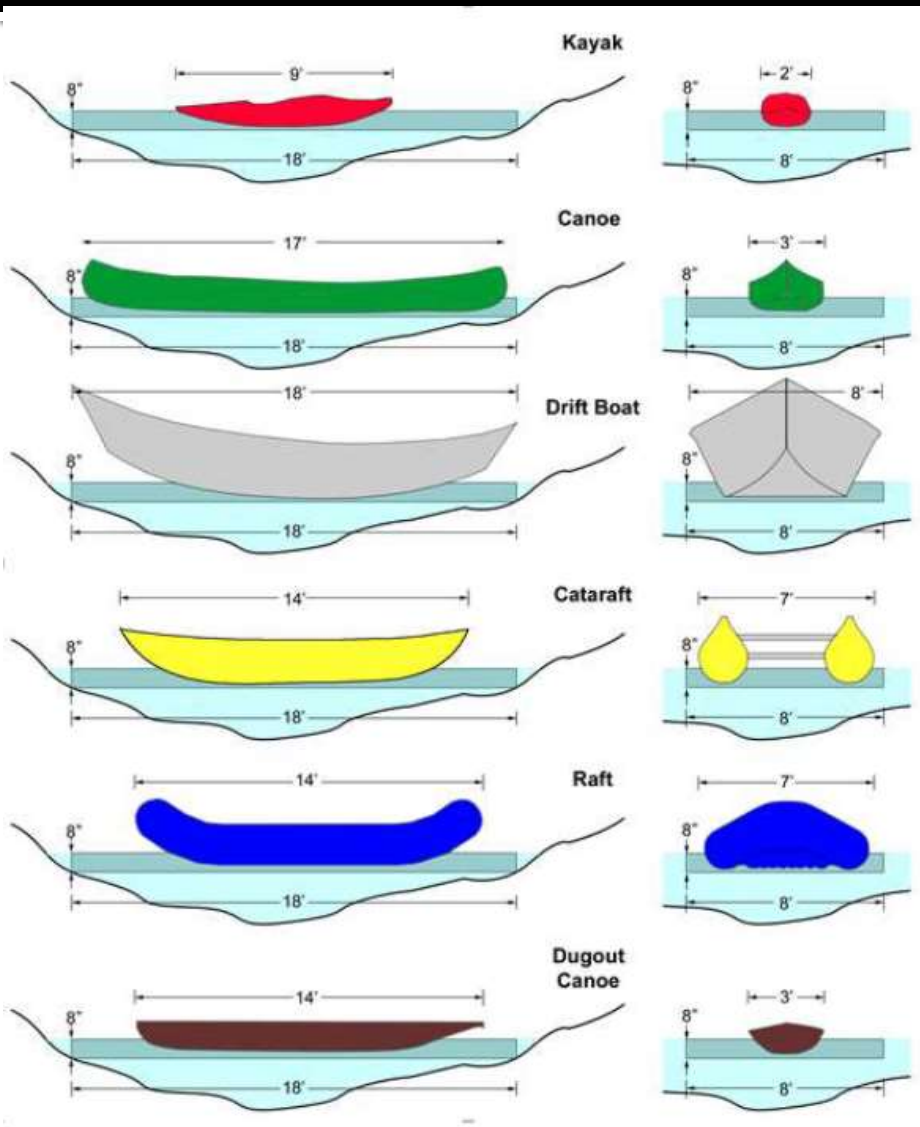
Date	Reach	Flow Rate	Boat
June 19-21, 2001	Segment 3	122-137 cfs	Canoes
April 8-12, 2002	Segments 2-3	186-233 cfs	Canoes
June 9-13, 2003	Segments 2-3	135-175 cfs	Raft
July 31, 2003	Segment 3	500-700 cfs	Raft
May 17-21, 2004	Segment 2-3	280-310 cfs	Raft

Modern Boating on the Salt River

Modern Boating on the Salt River

Modern Boat Types Commonly Used on the Salt River			
Type	**Segments**	**Season**	Flow
Inflatible Raft	2, 3, 5	Year	> 300 cfs
Inflatible Cataraft	2, 3, 5	Year	> 300 cfs
Inflatible Kayak or Canoe	1, 2, 3, 5	Year	> 100 cfs
Hard-Shell Kayak	1, 2, 3, 5	Year	> 100 cfs
Hard-Shell Canoe	1, 2, 3, 4, 5, 6	Year	> 100 cfs
Jet-Boat	5	S-Su-F	> 550 cfs
Air Boat	5	S-Su-F	> 500 cfs
Rowboat	5, 6	S-Su-F	> 200 cfs
Motorboat	5	S-Su-F	> 500 cfs

Modern Boating on the Salt River

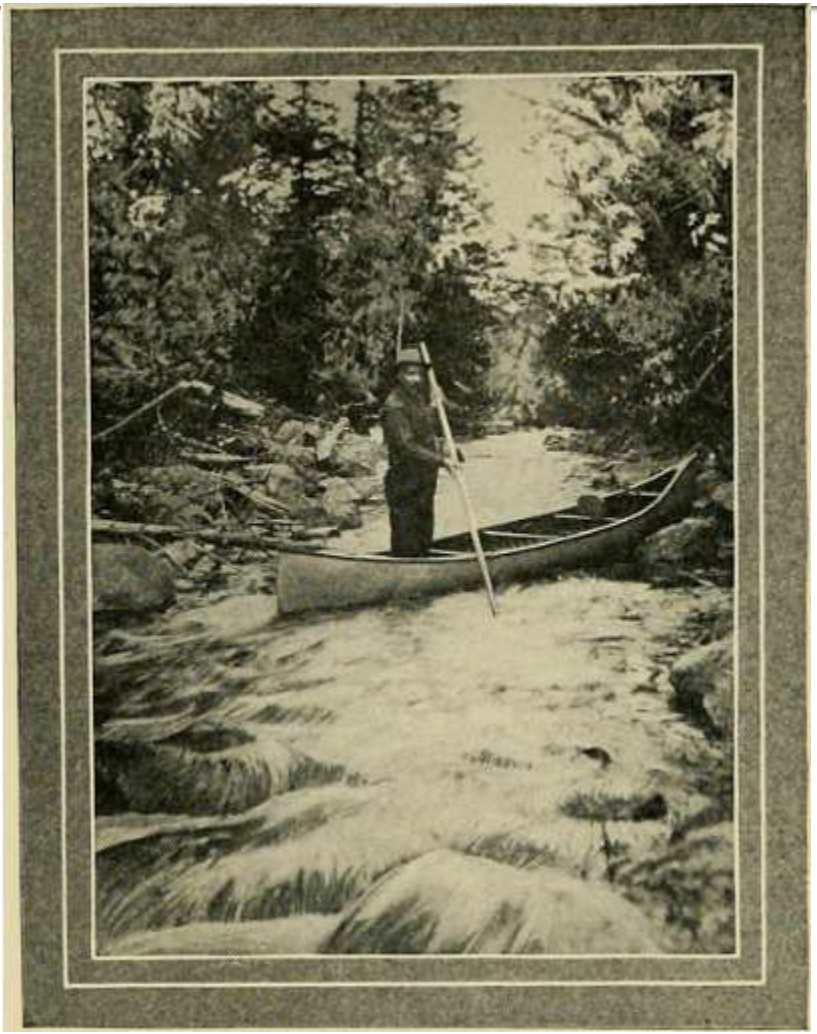


Utah Special Master – Boat Draw	
Rowboat (16-18 ft)	6-12"
Rowboat (18-22 ft)	14-18"
Steel Rowboat (18 ft)	7-19"
Motor Boats (20-27 ft)	10-24"
Scow (32x8 ft)	8"
Canoe	Not provided

^ From Boating Powerpoint, Slide 11

< From Boating Powerpoint, Slide 117

Historical Boats on Shallow Rivers



1904, In The Maine Woods (Magazine)

Frank Poling up the Rapids

1910, In The Maine Woods (Magazine)

Historical Boats on Shallow Rivers

Going downstream
is called snubbing,
in birch bark canoe

Keewaydin Photo Archives

Historical Boats on Shallow Rivers

In cedar canvas canoe, going upstream
From Paddlemaking blogspot

Paul J. Fournier poles his canoe up Allagash Stream in Maine

Modern Boating vs. Historical Boats

- Conclusion: Meaningfully Similar
  - Boat Function Same
  - Boat Design Same
  - Boat Use Same: Trade & Travel
  - Boat Draw / Required Water Depth Same
  - Main Difference is Improved Durability
    - Wooden/Canvas Boats Were Routinely Used on Rocky, Shallow Rivers
- Refer to Fuller Boating Presentation
- Refer to Other Boating Expert Presentations
  - Brad Dimock, Don Farmer, Jim Slingluff

Modern Boating vs. Historical Boats

- The "Edith" on Salt River Segments 5-6
  - Wooden Replica of Kolb Brothers Dory (ca. 1910)
    - Load: 850 lb + Dimock + water > 1,000 lbs
  - Canvas Klepper Kayak (ca. 1900 design)
  - Fiberglass & Wood McKenzie Replica (ca. 1960)
  - Three Plastic Canoes (1 tandem, 2 solo)
  - One Neoprene Raft (16 ft, 3 passengers)
  - One Neoprene Cataraft
  - Three Plastic Kayaks

Modern Boating vs. Historical Boats

- The "Edith" on Salt River Segments 5-6
  - August 31, 2015
    - Launch ~ 6:30 am
    - Take-out ~ 10:30 am
  - Flow Rate:
    - 653 cfs (746 cfs below Verde confluence)

      Median Flow = 992 cfs upstream of Verde

      = 1230 cfs downstream of Verde
  - Reach: Saguaro Ranch to Granite Reef
    - ~12 miles

Modern Boating vs. Historical Boats

Modern Boating vs. Historical Boats

Modern Boating vs. Historical Boats

Modern Boating vs. Historical Boats

- Go to Slide Show of Edith Trip

Modern Boating vs. Historical Boats

- Edith Trip Summary
  - All Boats & Boaters completed the trip
  - No boat damage
- Success!

- Conclusion: Salt River Segment 5 Boatable by Historical Boats

Technical Summary

- Permanent, perennial flow
- Predictable, reliable flow range
- Sufficient to float shallow draft boats all year
- Sufficient for larger, flat bottom boats seasonally
- Well-defined boating channel that conveys the ordinary, normal flow of the Salt River

Conclusion: Lessons from the Colorado River

- Colorado River is Affirmed to be Navigable
  - A.R.S. §§ 37-1123.A
  - Arizona v. California, 283 U.S. 423 (1931)

Conclusion: Lessons from the Colorado River

- Characteristics
  - Subject to Flood & Drought
    - Subject to "disastrous floods"
  - Subject to Flash Floods
  - Large Seasonal Flow Variations
    - "widely varying river…fast current in summer and minimal flow in winter"

Conclusion: Lessons from the Colorado River

- Characteristics
  - Many Rapids
  - Compound Channel, some "braiding"
  - Channel Position Changes due to Flood Erosion & Meandering
  - Sand Bars & Islands
    - "ever changing sand bars that hindered navigation"
  - Tidal bores, high tides
- Not Listed in Rivers & Harbors Act of 1899

Navigable Lower Colorado River, UC Riverside Collection, Lippincott 1880-1920

Conclusion: Lessons from the Colorado River

- Conclusion:
  - Those characteristics are **NOT** definitive evidence of non-navigability.

- What is evidence of non-navigability?
  - Scientific & Historical Evidence that
    - Not deep enough for boating
    - Not wide enough for boating
    - Natural obstructions prevent boating over long reaches

Conclusion

- Federal Standard for Title Navigability (Daniel Ball Test)
  - Ordinary & Natural
  - Used or Susceptible
  - Trade & Travel on Water

"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 the customary modes of trade and travel on water.

A.R.S. § 37-1101(5)

Conclusions

- Salt River* is a Navigable Watercourse

  * Segment 2-6

  - Existed in February 1912
  - Was used as highway of commerce
  - Was susceptible to use as highway of commerce
    - For trade and travel on water
    - By customary modes of travel on water

"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 the ***customary modes*** of trade and ***travel on water***. **A.R.S. § 37-1101(5)**