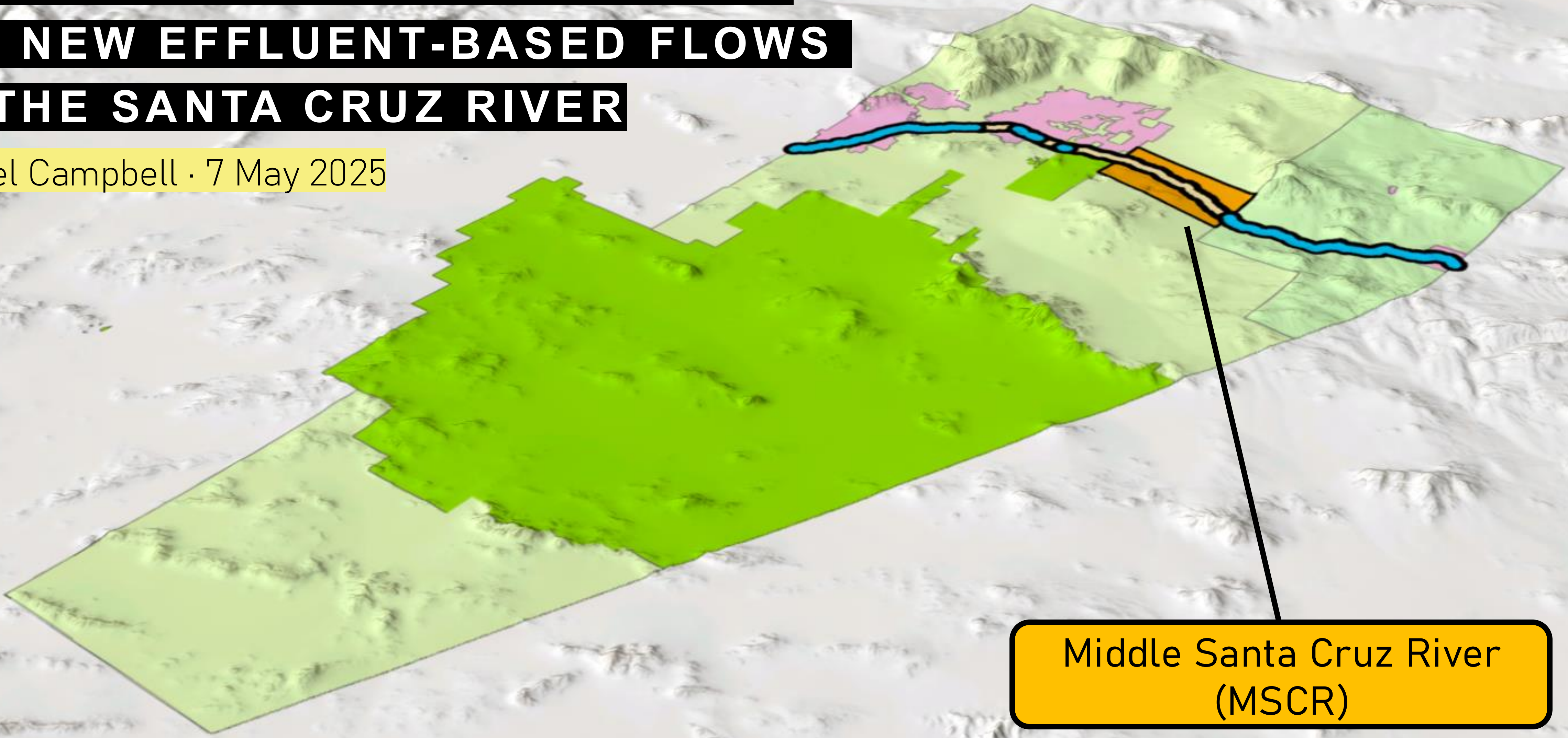
OPPORTUNITIES, CONCEPTS, AND PROPOSED MANAGEMENT TOOLS FOR NEW EFFLUENT-BASED FLOWS ON THE SANTA CRUZ RIVER

Michael Campbell · 7 May 2025



HOW MIGHT WE BEST IMPLEMENT EFFLUENT-BASED FLOWS ON THE MIDDLE SANTA CRUZ RIVER?

1

Riparian habitat in the Santa Cruz River watershed has been harmed by development pressure, climate change, and (especially) cessation of intermittent and perennial surface flows due to groundwater extraction.

1904 (USGS)

2000 (USGS)

Repeat photography via Watershed Management Group (WMG).
Learn more: Search for "Tucson's rivers then and now."

HOW MIGHT WE BEST IMPLEMENT EFFLUENT-BASED FLOWS ON THE MIDDLE SANTA CRUZ RIVER?

2

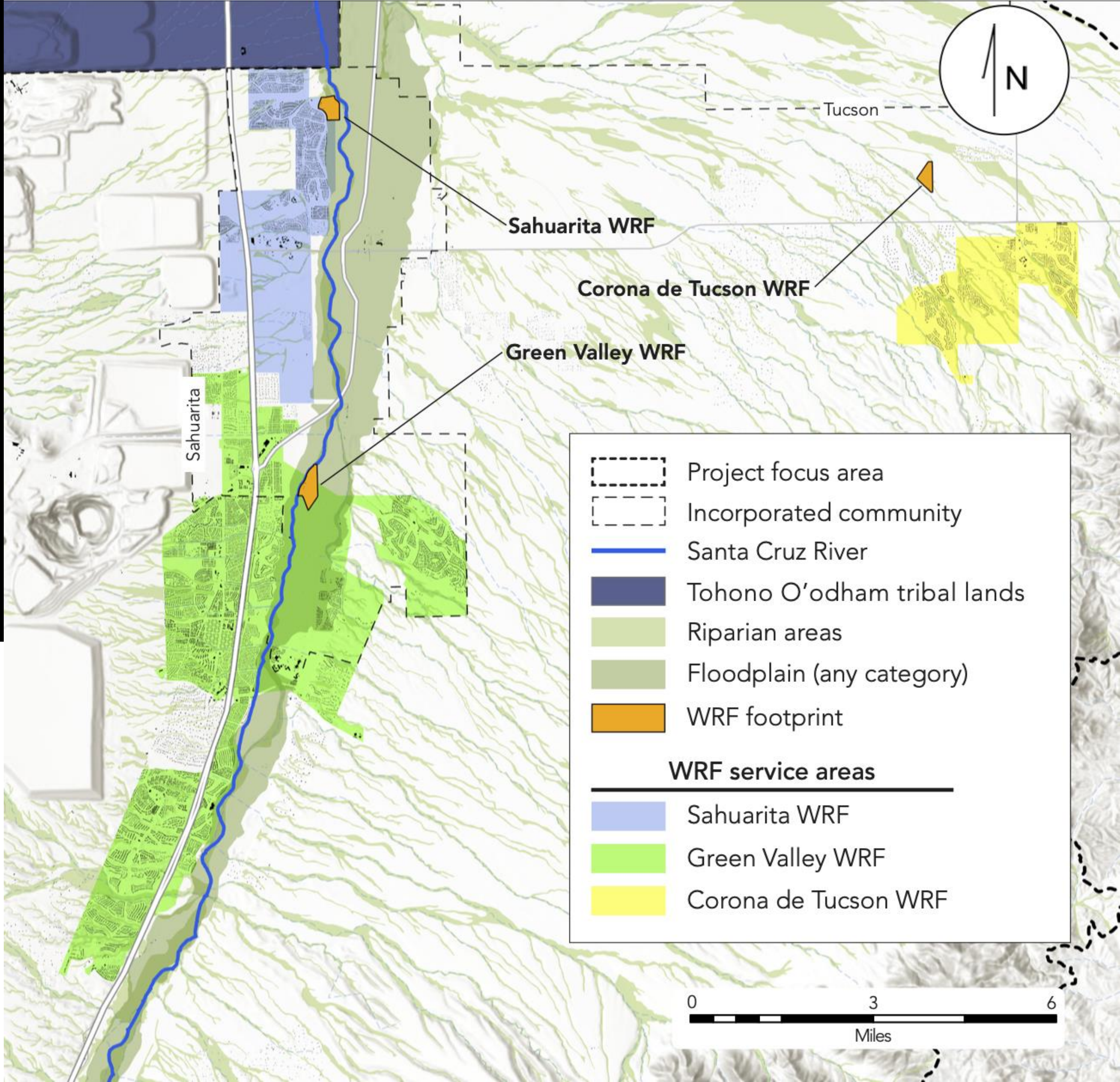
Effluent-based flows are a viable and valuable tool for restoring dewatered streams in arid lands (Bogan et al., 2020; Eppehimer et al., 2020, Hamdhani et al., 2020; Luthy et al., 2015).

Aerial photos by Rudy Malusa (unless otherwise noted)

HOW MIGHT WE BEST IMPLEMENT EFFLUENT-BASED FLOWS ON THE MIDDLE SANTA CRUZ RIVER?

3

Wastewater reclamation facilities (WRFs) near the Middle Santa Cruz generate thousands of acre feet of treated wastewater ("effluent") per year. This effluent is mostly sent to infiltration basins.



HOW MIGHT WE BEST IMPLEMENT EFFLUENT-BASED FLOWS ON THE MIDDLE SANTA CRUZ RIVER?

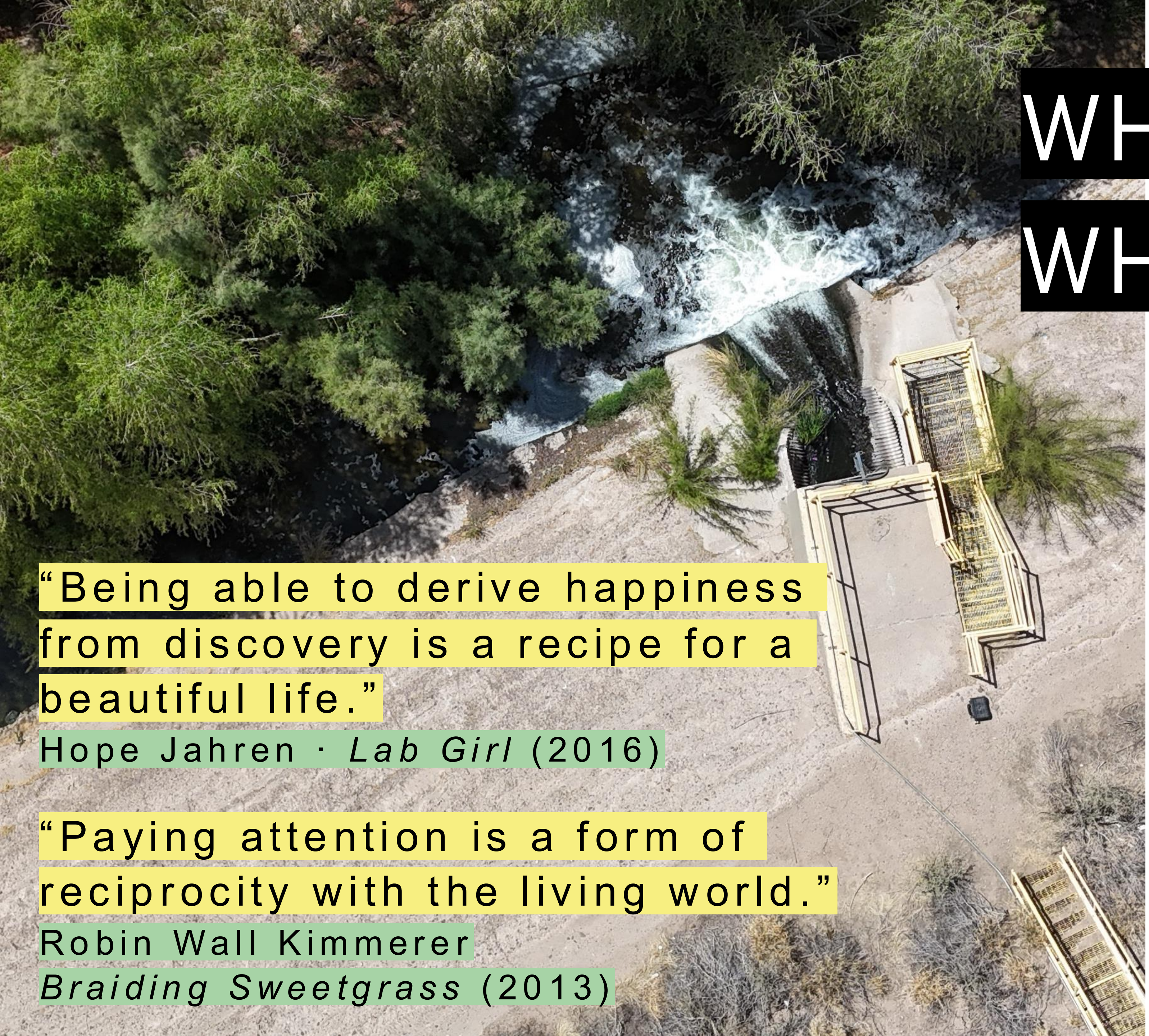
4

This leads me to ask: **What might effluent-based flows look like on the Middle Santa Cruz River?**

How might they be informed by current restoration projects, and how might they differ?

WHO AM I AND WHY DO I CARE?

- Dual-degree program (MS Urban Planning / Water, Society, and Policy).
- Professional background in computational chemistry and wilderness guiding.
- We need water to live.
  We need nature to live well.



"Being able to derive happiness from discovery is a recipe for a beautiful life."
Hope Jahren · *Lab Girl* (2016)

"Paying attention is a form of reciprocity with the living world."
Robin Wall Kimmerer
Braiding Sweetgrass (2013)

Today's journey

Basic outline of the problem space

Why does Tucson put effluent in the river?

Linked, Local, and Leveraged:
A framework for planners evaluating riparian restoration projects

Concepts for effluent-based flows and their management

Hasn't the river always been dry?

Factors affecting long-term viability

WHY DOES TUCSON PUT TREATED WASTEWATER IN THE RIVER?

A YOUNG MAN RECEIVES A HORSE.

IS IT GOOD FORTUNE?

“WE’LL SEE.”

HE FALLS FROM THE HORSE AND BREAKS HIS LEG.

IS IT BAD FORTUNE?

“WE’LL SEE.”

WHEN WAR BREAKS OUT, HE CAN NOT FIGHT AND SO ESCAPES CERTAIN DEATH.

– Retelling of a parable from the Huainanzi (2^{nd} Century BCE)

THE CITY SELLS ITS EFFLUENT.
IS IT GOOD FORTUNE?
"WE'LL SEE."
THE RECIPIENT REFUSES DELIVERY. THE CITY MUST DUMP ITS EFFLUENT IN THE RIVER.
IS IT BAD FORTUNE?
"WE'LL SEE."
A LIVING RIVER NOW FLOWS IN THE DESERT.

– The parable of Pima County wastewater

WE LOVE A SIMPLE STORY.

OUR SIMPLE STORY:
A FLOWING DESERT STREAM WAS DRIED BY PRIVATE INTERESTS AND REWATERED FOR COLLECTIVE CONVENIENCE

the ONION

Thirsty Mayor Drinks Town's Entire Water Supply

Published: May 4, 2007

ARDMORE, OK—Saying he was "just really thirsty," Mayor Earl Moore apologized to his constituents Tuesday after drinking the entire 1.5-million-gallon water supply housed in the town's water tower.

"I apologize that my actions today have left all of you without water, and I will do everything in my power to make sure we have water tomorrow," a visibly bloated Moore told reporters. "I woke up in the middle of the night and my mouth was dry. I thought I just needed a sip of water, but I was obviously thirstier than that."

Responding to criticism that he deeply mismanaged city resources, Moore promised to drive to nearby Marietta next time.

A FLOWING DESERT STREAM DRIED BY PRIVATE INTERESTS AND REWATERED FOR COLLECTIVE CONVENIENCE

30 May 1927 (Norman Wallace collection, via *Requiem for the Santa Cruz*)

A FLOWING DESERT STREAM DRIED BY PRIVATE INTERESTS AND REWATERED FOR COLLECTIVE CONVENIENCE

6 October 1987 (RM Turner, via *Requiem for the Santa Cruz*)

A FLOWING DESERT STREAM DRIED BY PRIVATE INTERESTS AND REWATERED FOR COLLECTIVE CONVENIENCE

SANTA CRUZ DAILY RECEIVES SEWAGE OUTFLOW WORTH SOME $30

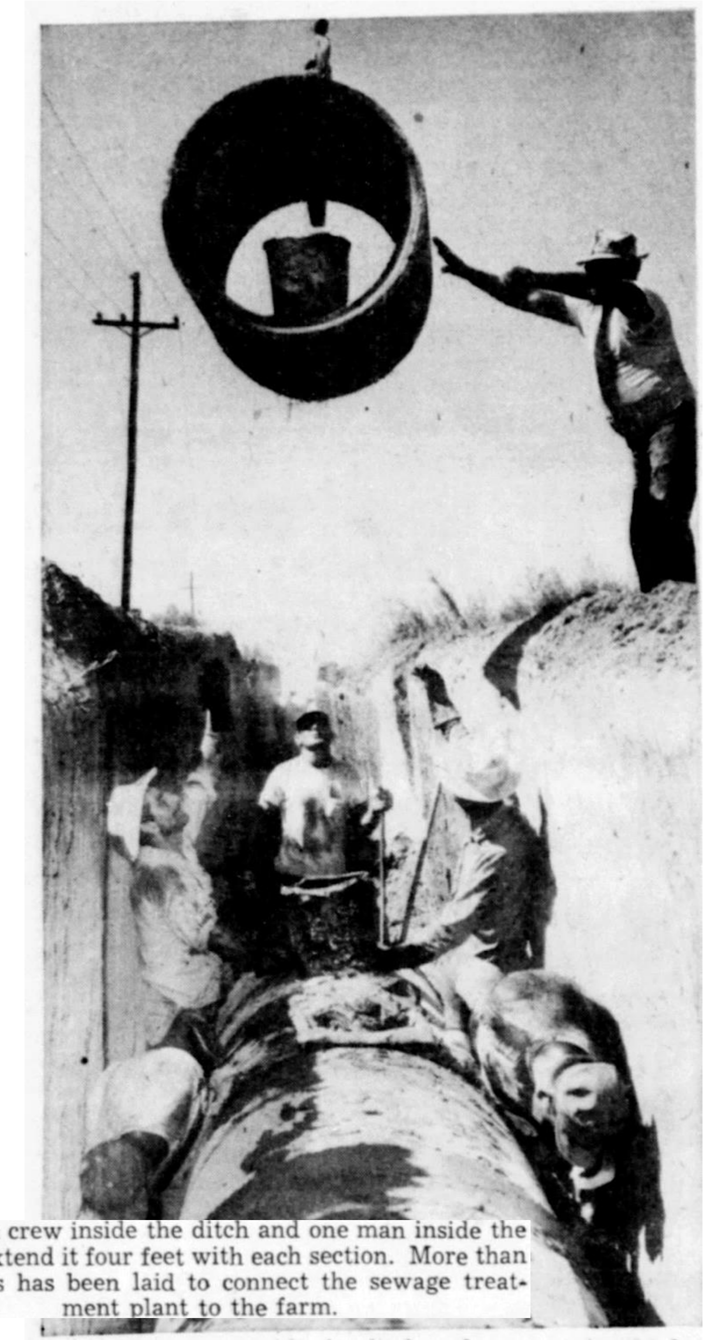
The point where outflow from the city's sewage treatment plant is dumped into the Santa Cruz river at the rate of approximately 15 acre-feet daily. It is valued at upwards of $2 per acre-foot for irrigation purposes. The Sanitary district has taken issue with the city for not marketing the treatment plant's waste products—water and fertilizer. The city has been trying for nearly two years to complete arrangements for sale of the outflow. Bids on the water, some for only a portion of the outflow, have ranged from $1 to $2.65 per acre-foot. The council in March voted to delay sale of the outflow to study use of part of the water for reactivation of the city farm on Silver Bell road.

—Sedley-Hopkins Photo

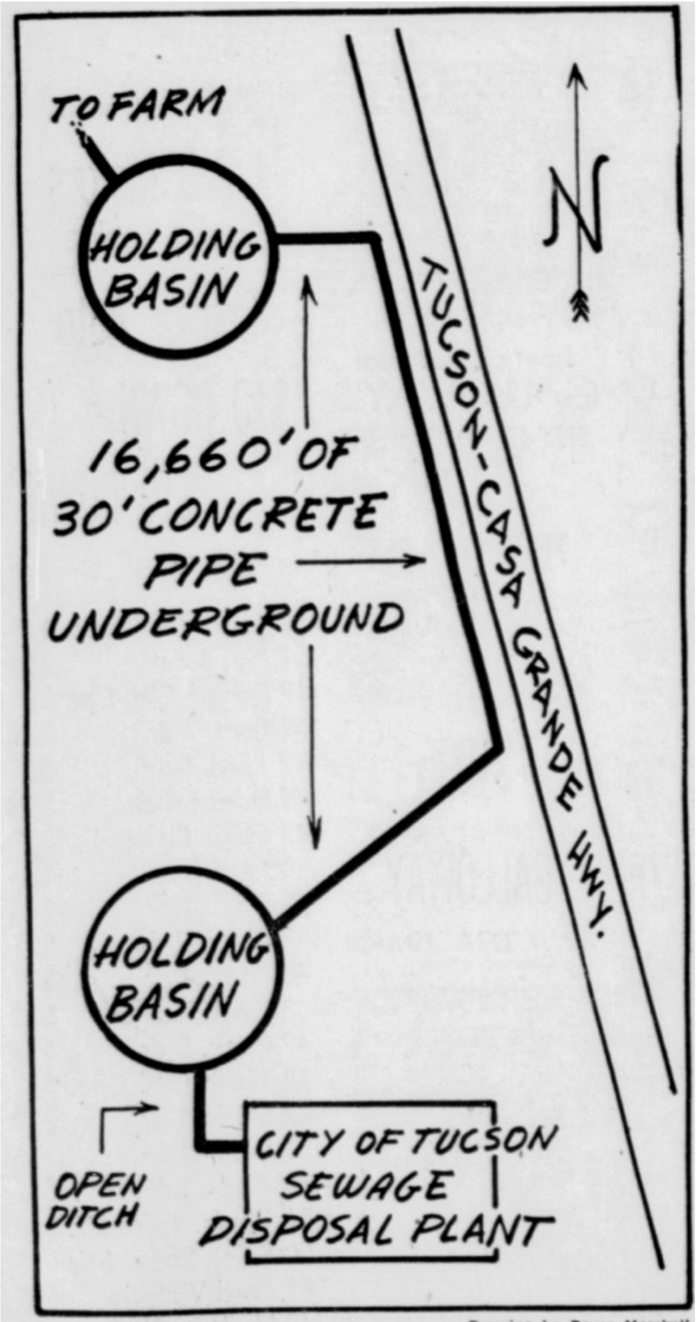
27 June 1952 (Photo credited to "Sedley-Hopkins" appearing in the *Tucson Daily Citizen*)

A FLOWING DESERT STREAM DRIED BY PRIVATE INTERESTS AND REWATERED FOR COLLECTIVE CONVENIENCE

15 September 1955
(Uncredited photo and map by Bruce Marshall appearing in the *Tucson Daily Citizen*)



A five-man crew inside the ditch and one man inside the pipe line extend it four feet with each section. More than three miles has been laid to connect the sewage treatment plant to the farm.

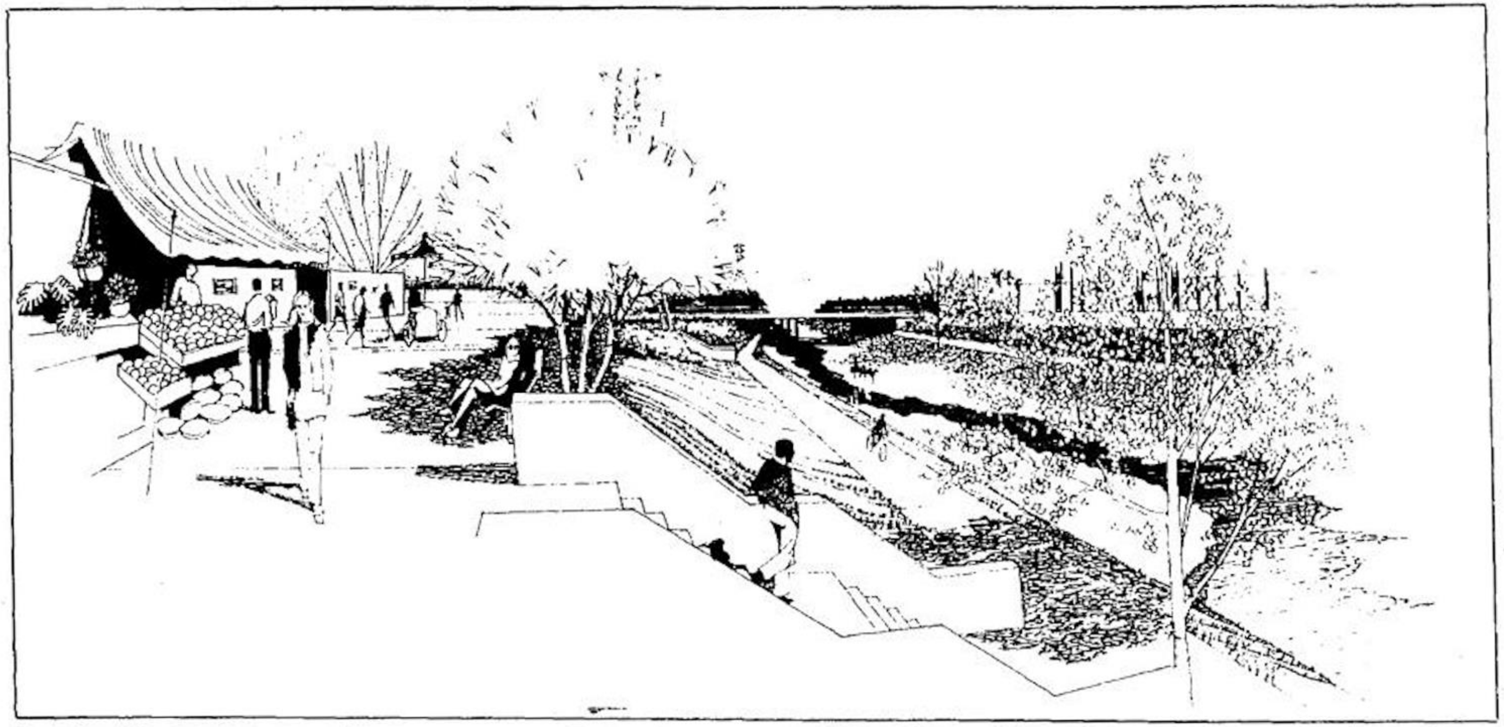


— Drawing by Bruce Marshall

A FLOWING DESERT STREAM DRIED BY PRIVATE INTERESTS AND REWATERED FOR … LOTS OF REASONS, ACTUALLY

15 September 1971
(*Tucson Daily Citizen* article)
19 May 1972
(USGS photo)

A FLOWING DESERT STREAM DRIED BY PRIVATE INTERESTS AND REWATERED FOR … LOTS OF REASONS, ACTUALLY



An emerald for downtown Tucson

Through the eye of an artist, this is how a four-mile section of the Santa Cruz River would look under a proposal to turn the dry washbed into a park. The park would feature sidewalk shops along a year-round river.

New face for a wasteland

Trees, grass, trails, golf courses, housing and commercial areas are among the uses proposed for a 14-mile stretch of the Santa Cruz River now often used as a graveyard for rusting autos. The plan recommends a facelift that would spur development of the inner city.

Riverpark concept art (*Tucson Daily Citizen* article, 26 August 1976)

BASIC OUTLINE OF THE PROBLEM SPACE

HOW MIGHT WE BEST IMPLEMENT EFFLUENT-BASED FLOWS ON THE MIDDLE SANTA CRUZ RIVER?

TWO BIG CONSTRAINTS:

1. Cannot discharge more effluent than is produced.
2. Flows must not encroach onto tribally governed lands of the Tohono O'odham Nation.

WE NEED TO KNOW:

How much water do we have to work with?

How best to work with that volume of water?

How to ensure the long-term viability of these flows?

WHY HERE?

Long-standing desire for effluent-based flows in this region (PCRWRD 2007 ROMP, 2022 SCWC WRP)

Anticipated population growth suggests effluent is a reliable water source for conservation projects.

SDCP (and other sources) identify southernmost reaches of the MSCR as an important location for habitat connectivity.

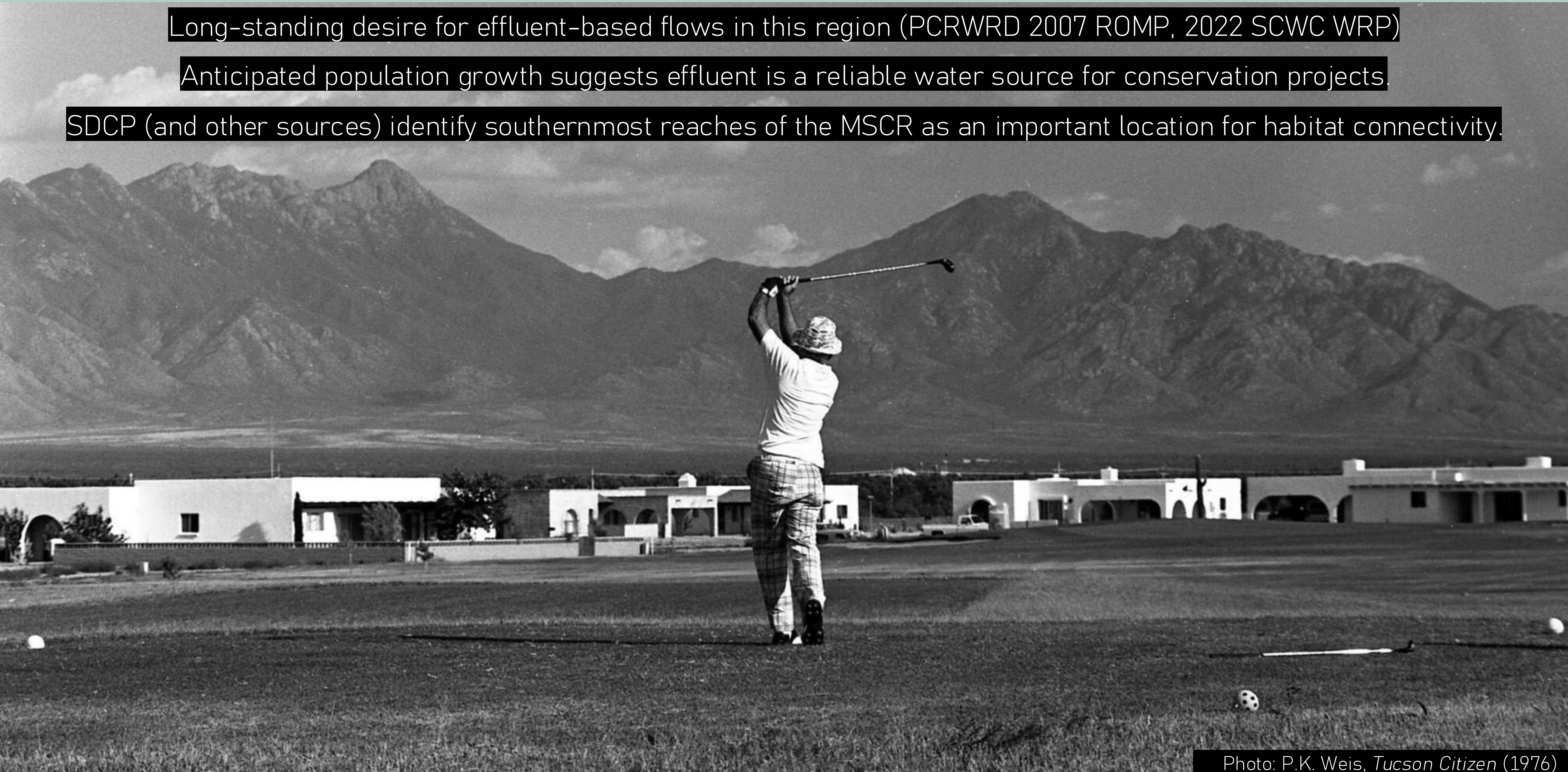


Photo: P.K. Weis, *Tucson Citizen* (1976)

IMPORTANT BACKGROUND

"WATER BANKING"

1

If you are in an Active Management Area (AMA), adding water to the aquifer can earn you the right to take it out later. Even with effluent.

Recovery rights are earned by accruing "long-term storage credits (LTSCs).

2

Regular water turns into groundwater when it soaks through the soil beneath it (infiltration).
You can do this in a constructed basin (underground storage facility, or USF).
You can do this in a natural watercourse (managed underground storage facility, or MUSF).

3

If you do this with effluent in a constructed basin (USF):

You can recover 95% of what you put in the ground.

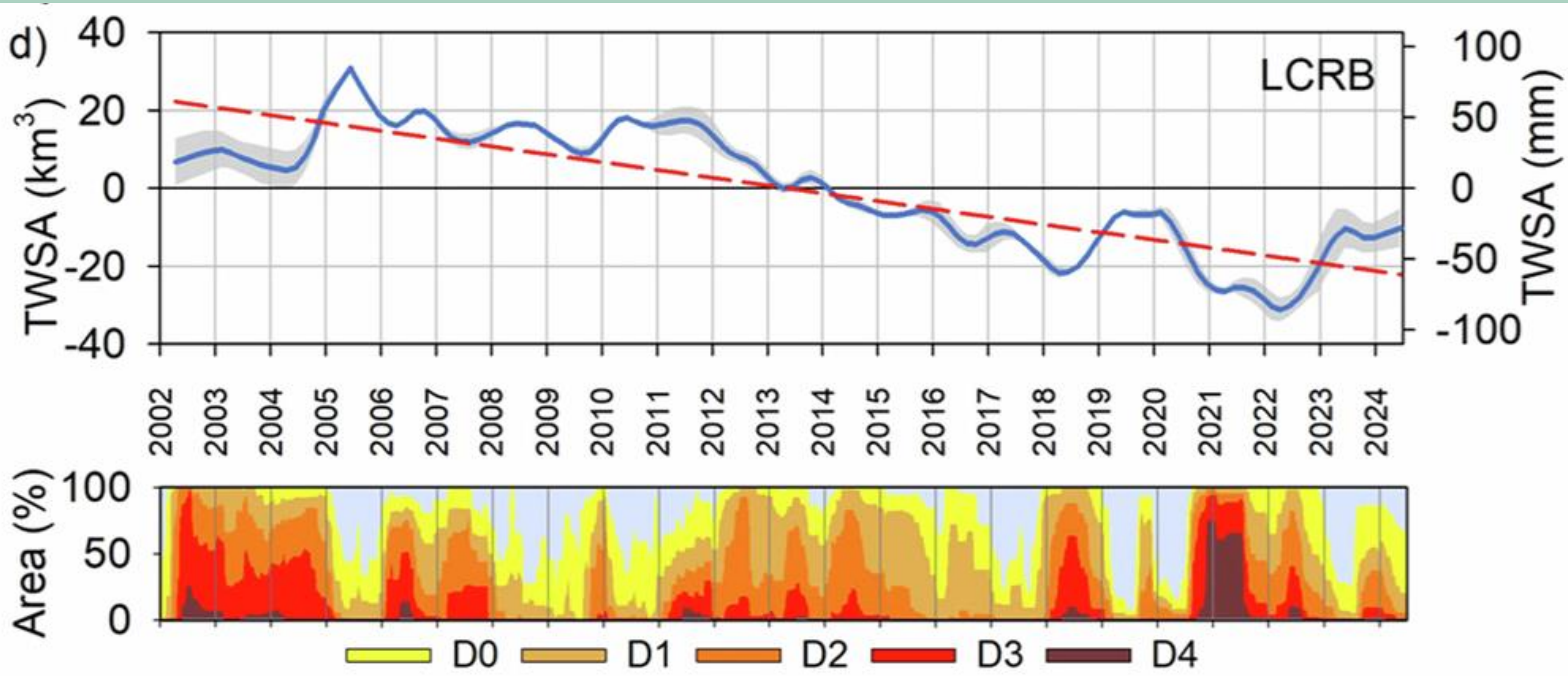
TERMS AND CONDITIONS APPLY

4

If you do this with effluent in a natural watercourse (MUSF):

You can recover 50% of what you put in the ground.

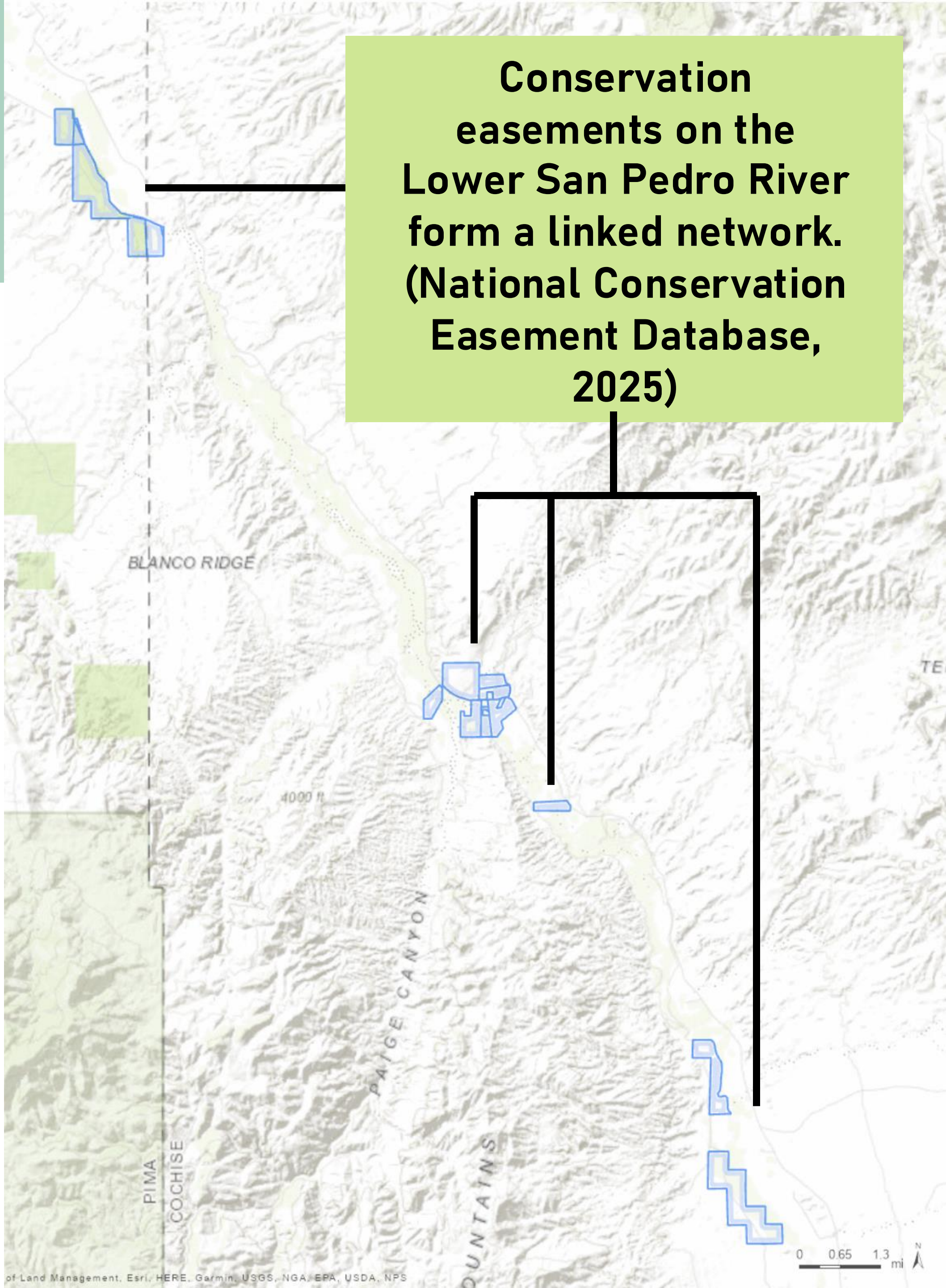
THE BIG PICTURE, BASIN-WIDE



"Supply-demand imbalance" (We use more than we get)	Modified groundwater inputs (Meixner et al., 2016)	Large-scale groundwater decline (Scanlon et al., 2025)

THE BIG PICTURE, BASIN-WIDE

- Basin-scale problems require multi- and interdisciplinary solutions (Cosens et al., 2012; Jury and Vaux, 2005; USBR, 2012).
- Macro-scale restoration success and ecological resilience is achieved through linked, local-scale projects (Anderson et al., 2023; Fremier et al., 2015; Ralston & Starr, 2007).
- Small-scale riparian habitat conservation tends to develop into linked networks, even with conservation easements (Fremier et al., 2015).



LARGE-SCALE RIPARIAN CONSERVATION IS LINKED, LOCAL, AND LEVERAGED (L3)

- I describe the projects that contribute to basin-scale success as "linked, local, and leveraged" (L3).
- Planning professionals can better allocate and maximize return on limited resources by evaluating prospective projects for habitat linkage, locality, and ability to leverage co-benefits.
- L3 distills concepts from conservation ecology and climate adaptation that have been developed over the last twenty years and refined within the last decade (Anderson et al., 2023; Fremier et al., 2015; Ralston & Starr, 2007).

L3: NEWLY STATED BUT NOTHING NEW

LINKED SITES

"To increase resilience through connectivity, riparian networks should be an important component."

LEVERAGED CO-BENEFITS

"Restoration actions, including reactivating floodplains, build upon existing efforts that protect valuable ecosystem services, such as water filtration, recreation, and flood control … [and] can serve human needs."

LOCAL-SCALE IMPLEMENTATION

"A riparian connectivity network could take advantage of … an existing suite of administrative, state, and federal policies."

Anderson et al. (2015)

WHERE DOES OUR EFFLUENT GO?

Recharge basins

“Purple pipe” system

On-site reuse

Coming soon: Advanced water purification

IN-CHANNEL FLOWS

Marana and Tres Rios WRFs

Lower Santa Cruz River MUSF

Agua Nueva WRF

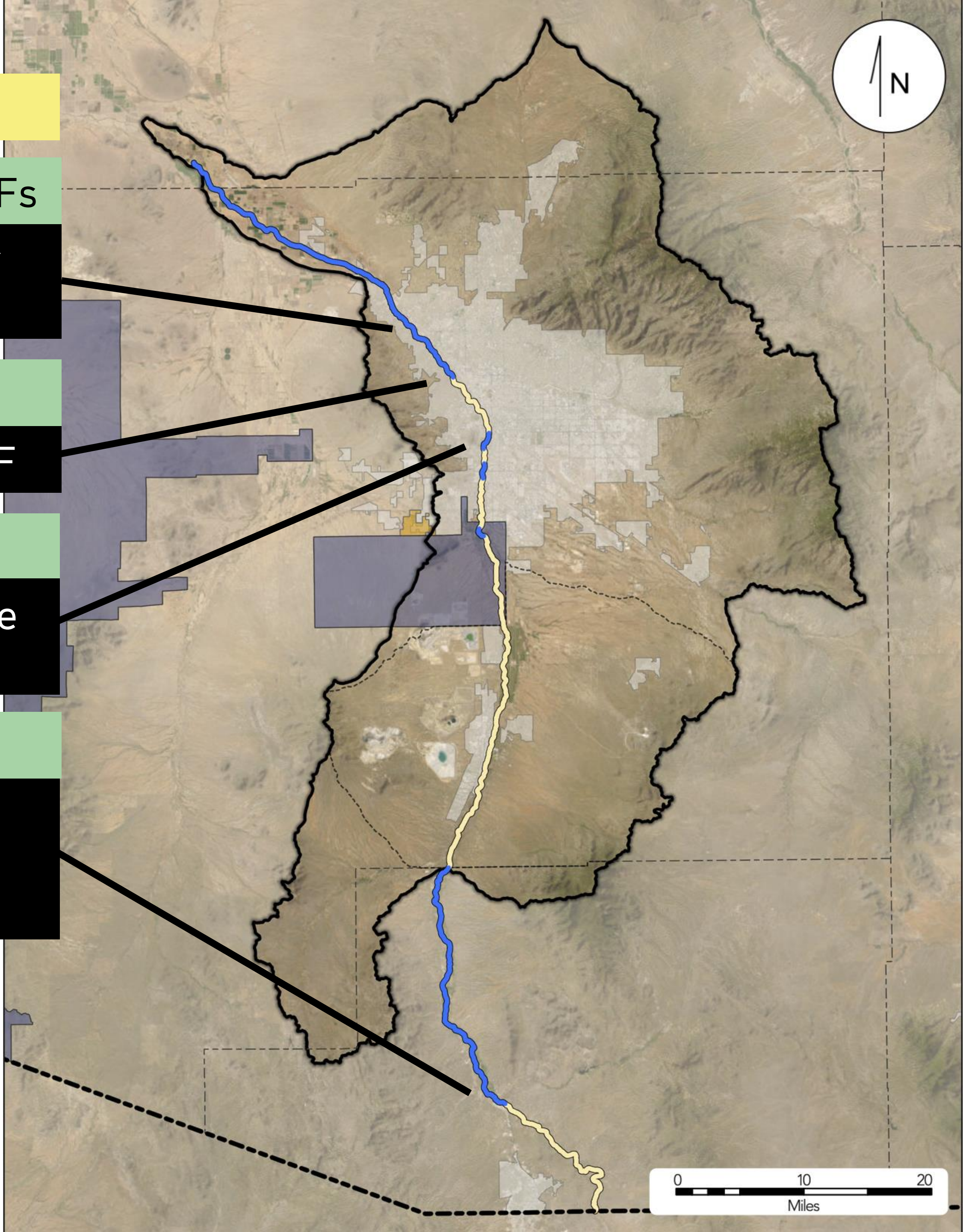
Santa Cruz Managed USF

Agua Nueva WRF

Santa Cruz River Heritage Project

Nogales Int. WTP

Downstream reaches in Santa Cruz County (No formal MUSF)



Project context area
Project focus area
County line
US-Mexico boundary

Tohono O’odham tribal lands
Pascua Yaqui tribal lands
Urbanized areas

Santa Cruz River
Flowing reachs (extent can vary)
Ephemeral reaches

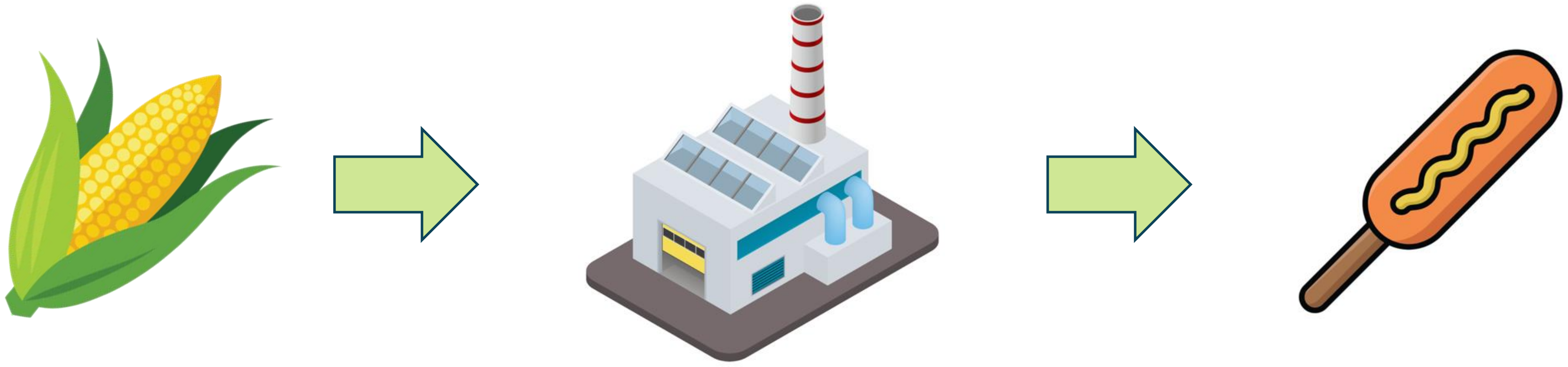
THE SANTA CRUZ RIVER: 1935

Photo: Emergency Relief Administration (1935)

THE SANTA CRUZ RIVER: 2025

WRFs ARE “WEIRD FACTORIES”

PERSPECTIVE: PUBLIC AND PRIVATE GOODS

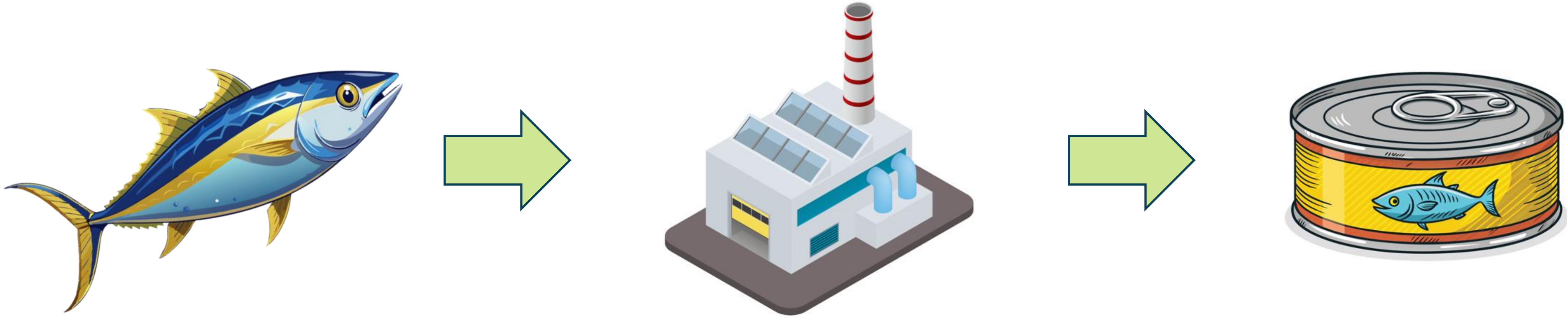


Regular factories convert private goods into value-added private goods.

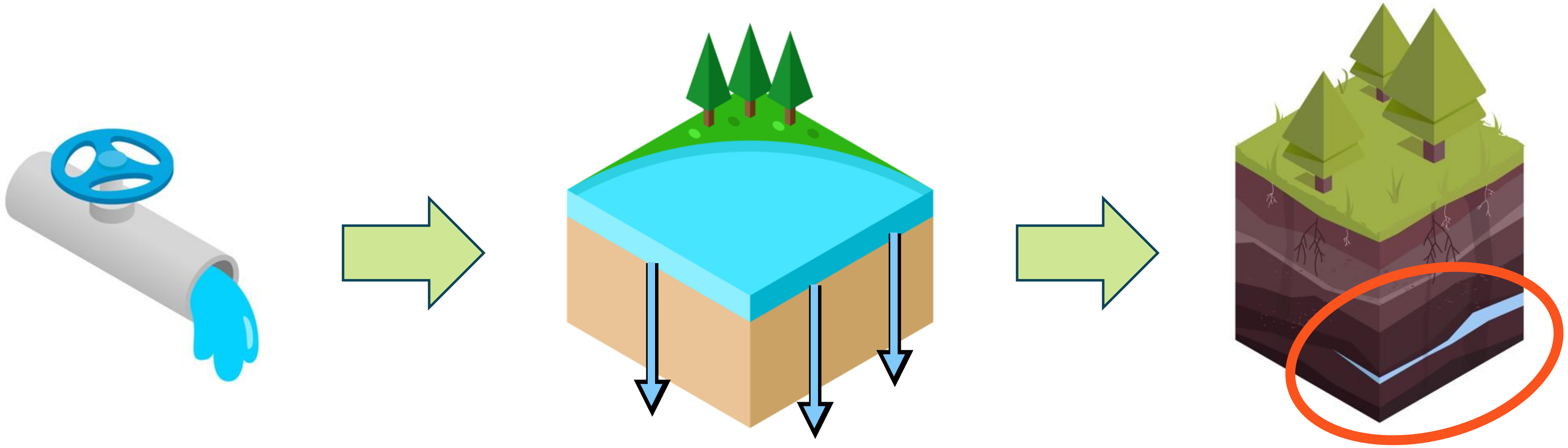
“Weird factories” convert public bads into public “less bads,” public goods, or private goods.

USFs AND MUSFs ARE "WEIRD FACTORIES"

PERSPECTIVE: COMMON-POOL RESOURCES



Regular factories convert appropriated common pool resources into value-added private goods.



"Weird factories" convert value-added inputs into common pool resources.

CONCEPTS FOR EFFLUENT-BASED FLOWS AND THEIR MANAGEMENT

EXISTING WRFs AND SERVICE AREAS

2023 annual effluent production:

Green Valley WRF: 2,027 AF

Sahuarita WRF: 1,028.5 AF

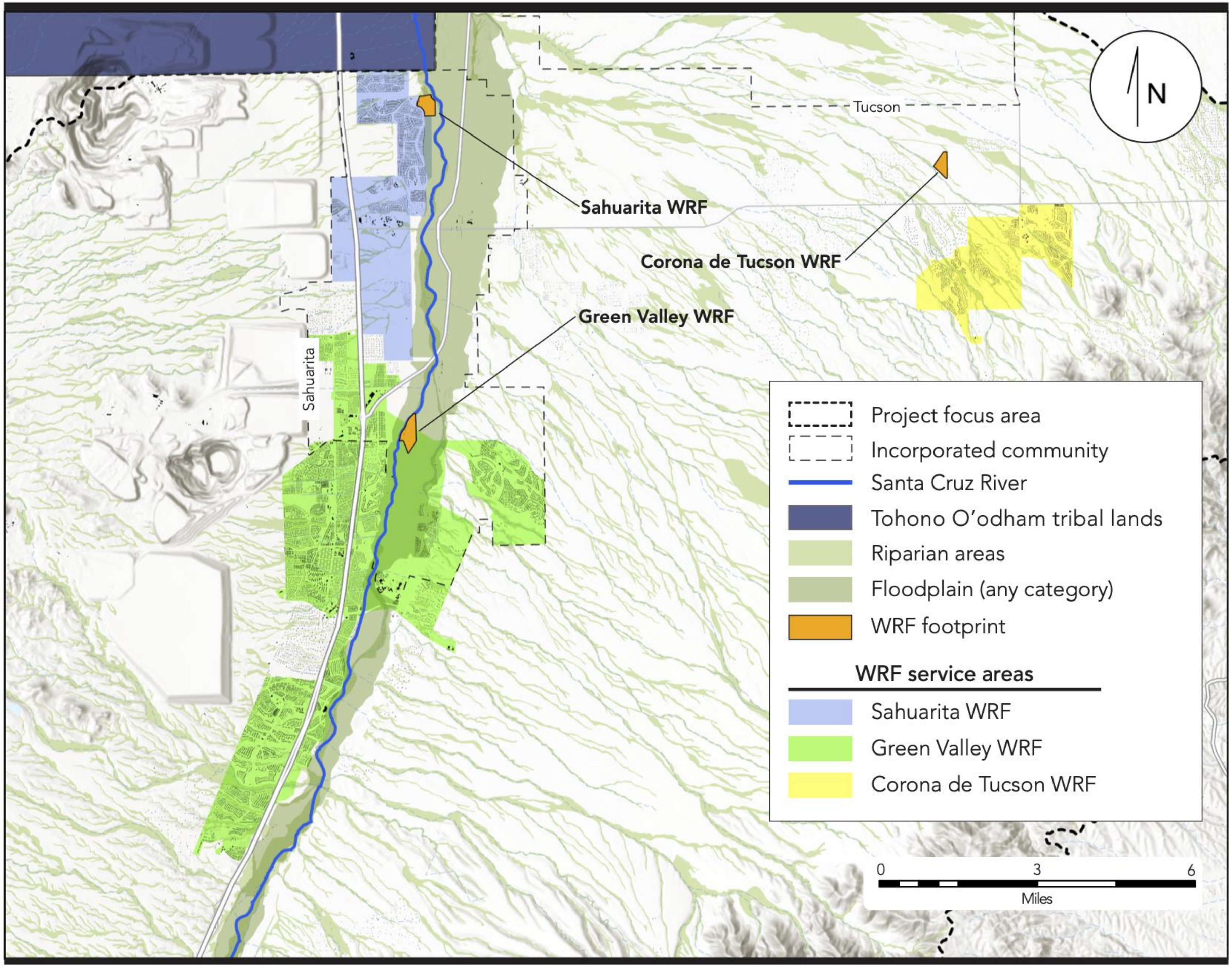
Corona de Tucson WRF: 429 AF

Projected annual effluent production in 2045, regional facility consolidation scenario:

Regional facility: 6,745 AF

Current annual effluent delivery obligations from Green Valley WRF:

Delivery to Robson: 1,120 AF/yr



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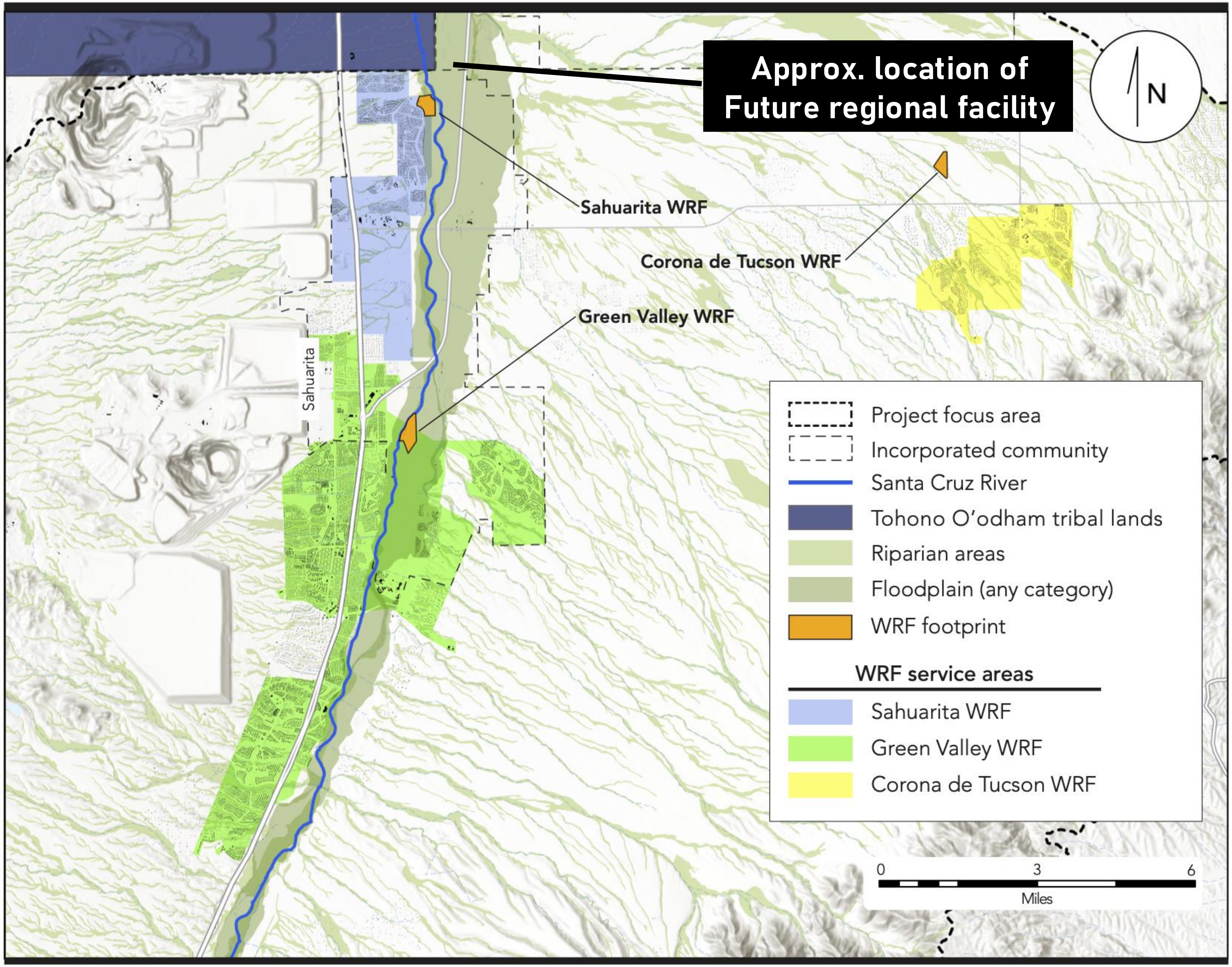


CONCEPT DEVELOPMENT

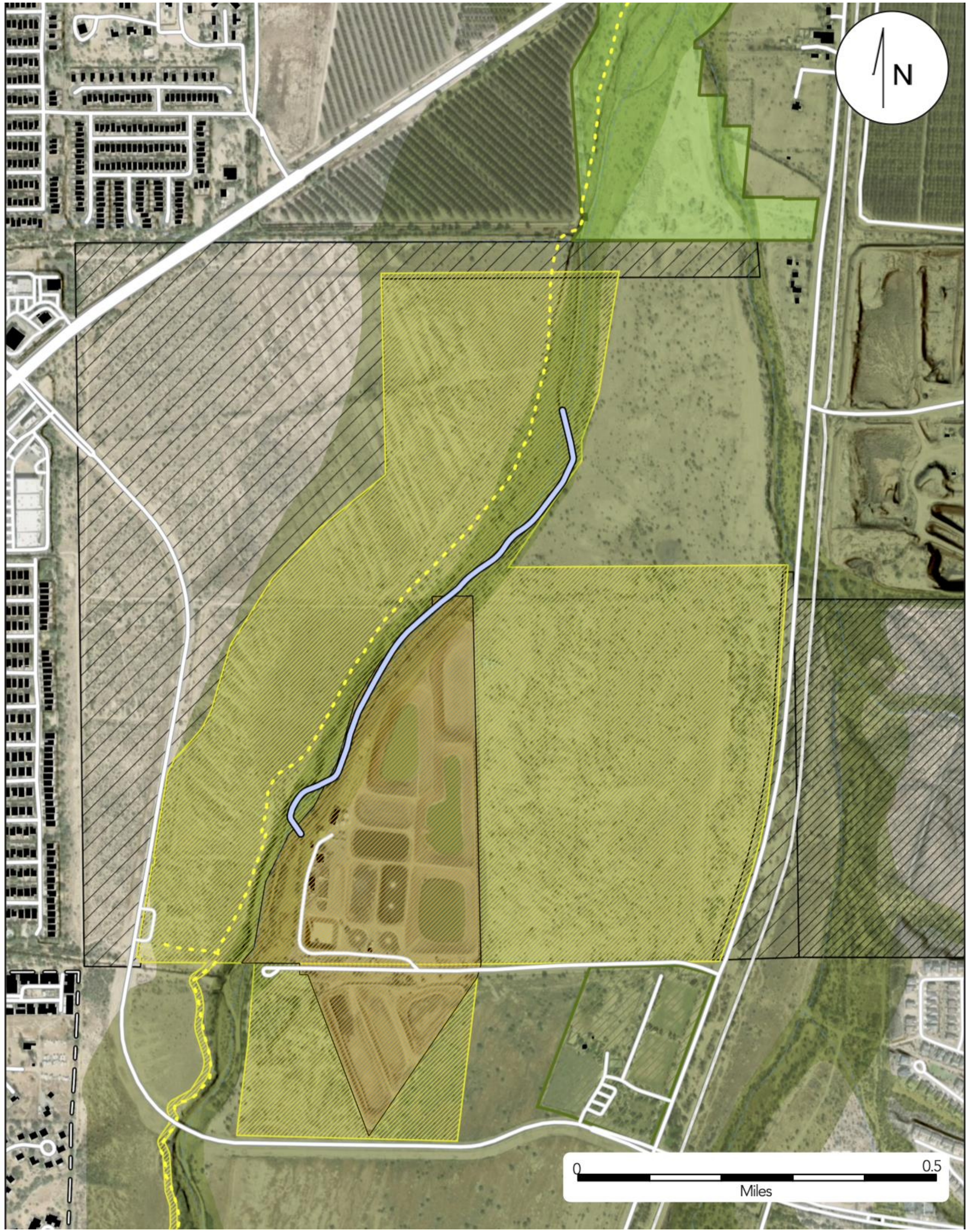
Concept	Scenario overview	Description	Timeframe	Effluent volume (AF/yr)	Extent of flow (mi)
1	Current GVWRF effluent availability	Present day production from Green Valley WRF, minus existing delivery obligations, discharged from current GVWRF outfall	Near term	873.75	0.78
2	Intermediate effluent availability	Full future production output from Green Valley WRF discharged from GVWRF outfall, or partial effluent production from future regional facility, conveyed to and discharged from GVWRF outfall	Intermediate (2025-2045)	3027	2.7
3	Full future availability	Full production output from regional WRF, conveyed to and discharged from current GV WRF outfall point	Far future (~2045)	6745	6.0
4	Full future availability	Full production output from regional WRF, conveyed to a distributed distribution system with multiple outfall points	Long-term (~2045)	6745	Roughly six miles, distributed across multiple outfalls

CONCEPT 1:

CURRENT EFFLUENT AVAILABILITY FROM GREEN VALLEY WRF

EXISTING EFFLUENT PRODUCTION, LESS DELIVERY OBLIGATIONS

Incorporated community
Tohono O'odham tribal lands
Riparian areas
Floodplain (any category)
SDCP CLS lands
WRF footprint
Other Pima County parcels
State trust parcels (unleased)
State trust parcels (leased)
Modeled extent of surface flow
Juan Bautista de Anza National Historic Trail (planned and completed segments)



CONCEPT 2:

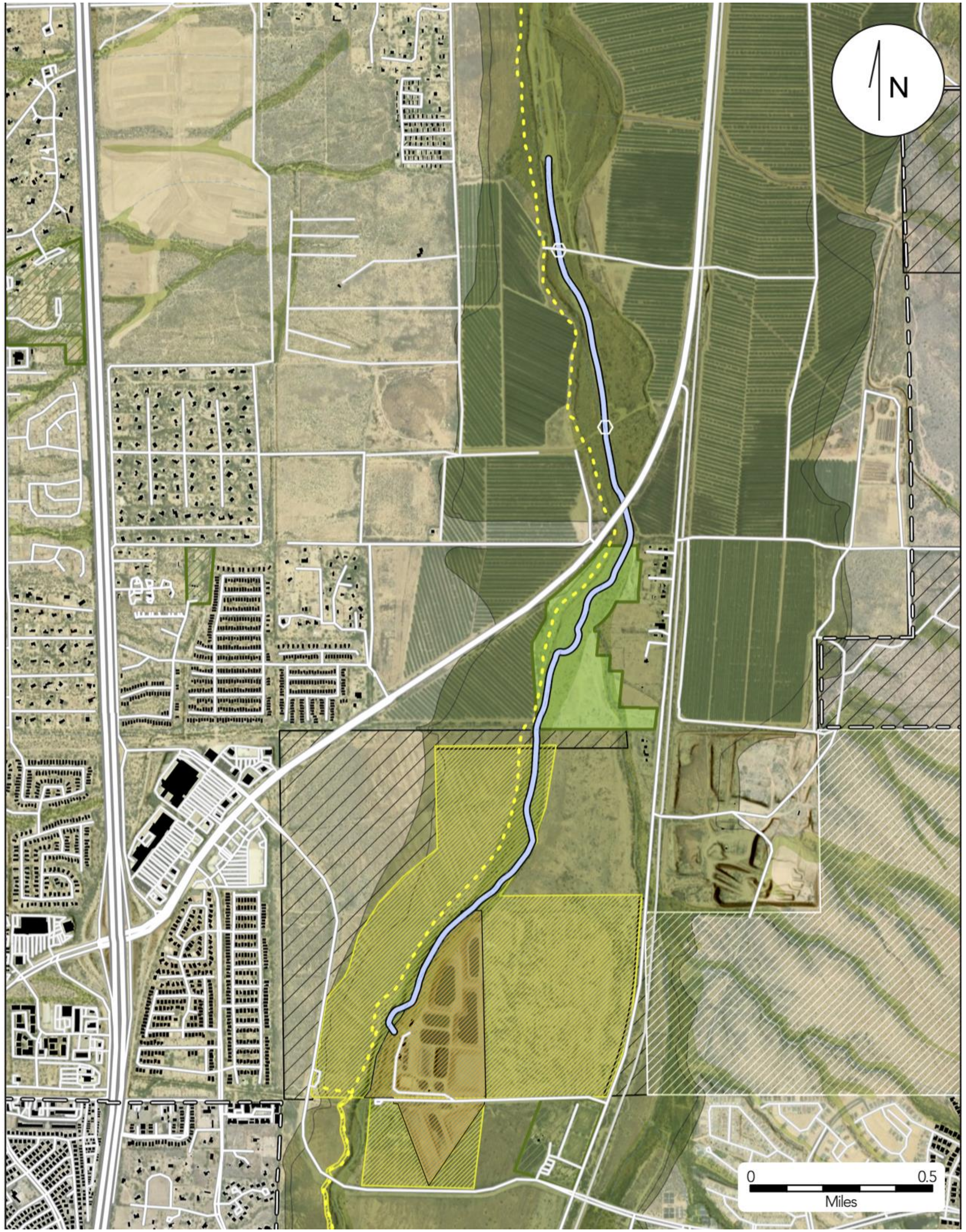
INTERMEDIATE EFFLUENT AVAILABILITY

TWO PATHWAYS TO THIS SCENARIO:

1.) Discharge all effluent produced at GVWRF into MSCR (present-day)

2.) Convey roughly half of all effluent produced at a future regional facility to the existing GVWRF outfall point, and discharge into MSCR (2045).

- Incorporated community
- Tohono O'odham tribal lands
- Riparian areas
- Floodplain (any category)
- SDCP CLS lands
- WRF footprint
- Recreational parcels outside SDCP CLS
- Other Pima County parcels
- State trust parcels (unleased)
- State trust parcels (leased)
- Modeled extent of surface flow
- Unbridged crossing
- Juan Bautista de Anza National Historic Trail (planned and completed segments)



CONCEPT 3:

FULL FUTURE EFFLUENT AVAILABILITY

EFFLUENT PRODUCTION IS CONSOLIDATED AT A FUTURE REGIONAL WRF (LIKELY ON OR NEAR PIMA MINE ROAD), AND FULL PRODUCTION OUTPUT IS CONVEYED UPGRADIENT TO EXISTING GVWRF OUTFALL TO AVOID ENCROACHMENT OF FLOW ONTO TRIBALLY GOVERNED LANDS OF THE TOHONO O'ODHAM NATION.

- Incorporated community
- Tohono O'odham tribal lands
- Riparian areas
- Floodplain (any category)
- SDCP CLS lands
- WRF footprint
- Recreational parcels outside SDCP CLS
- Other Pima County parcels
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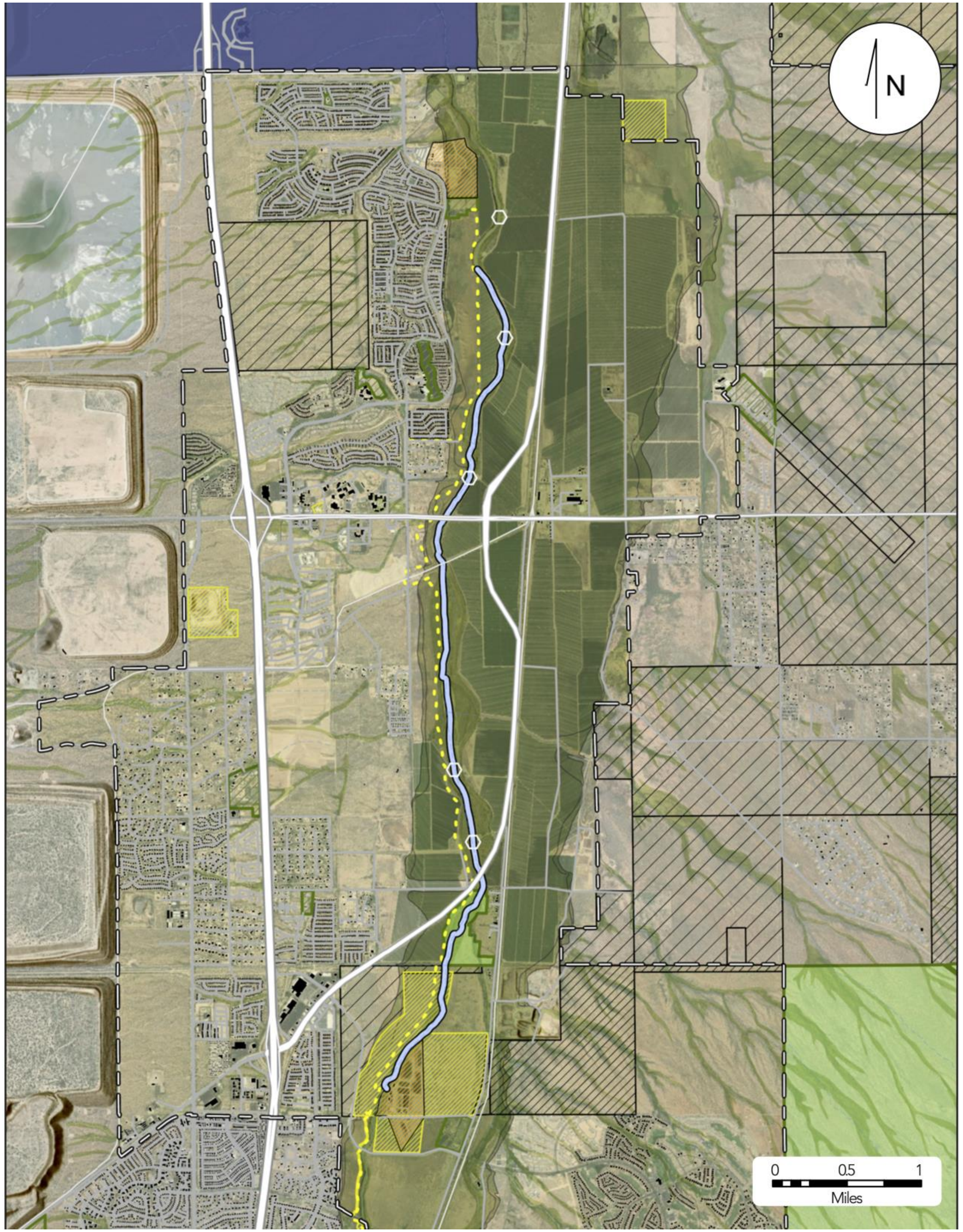
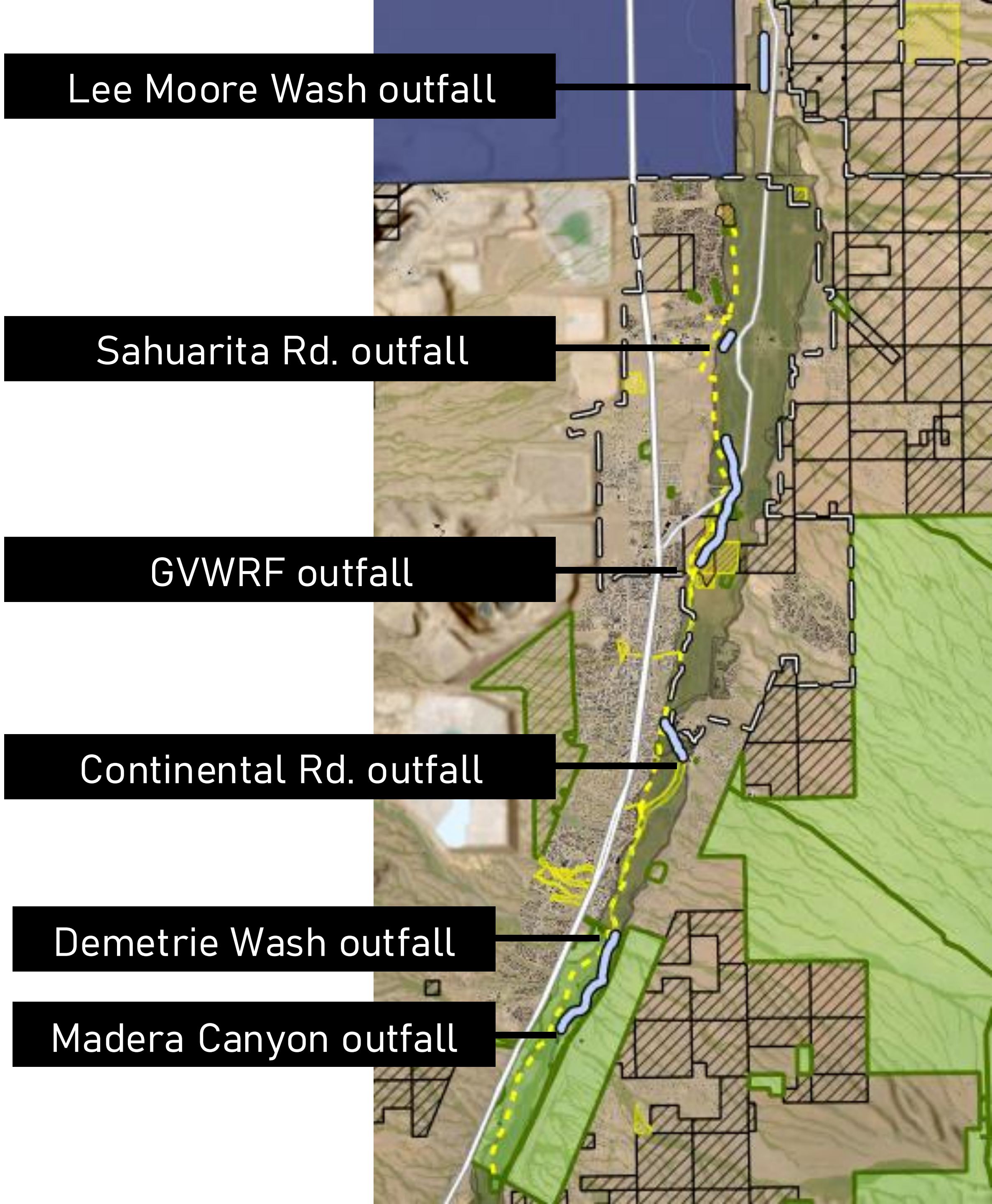


CONCEPT 4:

FULL FUTURE AVAILABILITY, MULTIPLE OUTFALLS

EFFLUENT PRODUCTION IS CONSOLIDATED AT A FUTURE REGIONAL WRF (LIKELY ON OR NEAR PIMA MINE ROAD).
EFFLUENT IS CONVEYED UP- AND DOWNAGRADIENT THROUGHOUT THE MIDDLE SANTA CRUZ VALLEY AND DISCHARGED THROUGH MULTIPLE OUTFALLS.



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- Tohono O'odham tribal lands
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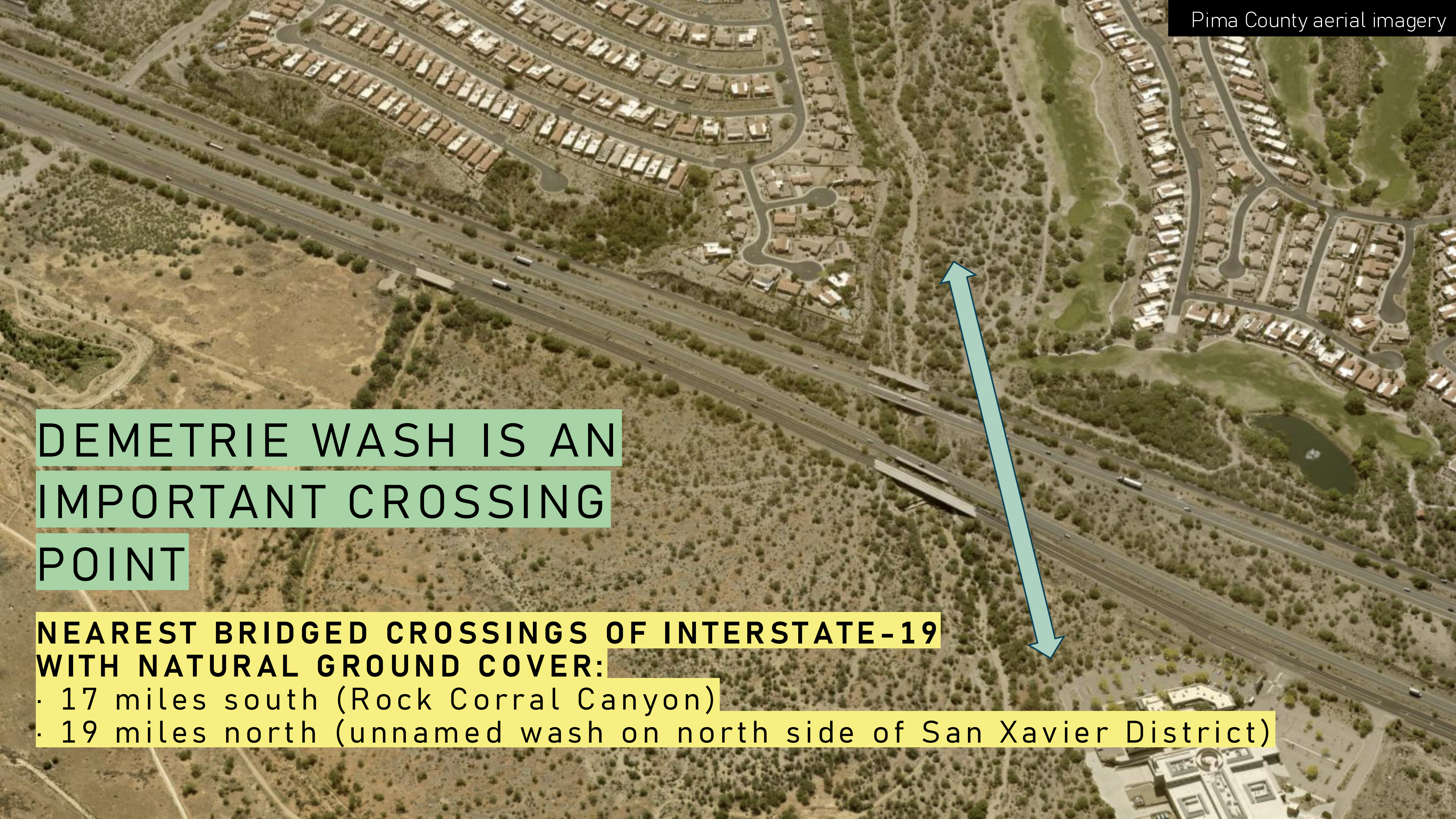
SOME REMARKS ON CONCEPT 4

- Multiple outfalls allow variable in-stream flows even with a constant effluent production rate.
- Some low-volume outfalls discharge at a more constant rate, mimicking baseflow regime from a reliable seep or spring.
- A fraction of the effluent production is allocated to "peak flows" that are cycled between outfall points on a seasonal or annual basis — this mimics seasonal and interannual variations in baseflow.
- Outfalls are strategically located to maximize habitat value and reduce distances between refugia.

IMPORTANCE OF THE CANOA RANCH OUTFALLS (MADERA CANYON AND DEMETRIE WASH)

- Anderson et al. (2023) and SDCP identify these lands as important for habitat connectivity, especially with respect to climate change.
- Did Canoa Ranch have historic flow? Unlikely that the first land grant in the area was for an ephemerally flowing river.
- Existing land uses to the north present significant barriers to east-west movement



DEMETRIE WASH IS AN IMPORTANT CROSSING POINT

NEAREST BRIDGED CROSSINGS OF INTERSTATE-19 WITH NATURAL GROUND COVER:

- 17 miles south (Rock Corral Canyon)
- 19 miles north (unnamed wash on north side of San Xavier District)

MANAGEMENT CONCEPT: DRAM CREDITS

How it works

1.) Reserve 20% of LTSCs accrued at an MUSF for **drought response and adaptive management (DRAM)**.

2.) "Spend" these credits on DRAM needs. Spending can be direct (through groundwater withdrawals) or indirectly (trading LTSCs for CAP delivery).

3.) Recover a significant fraction of these spent credits through infiltration and conversion of DRAM flows to groundwater.

Example use case

Increased outflows during hot and otherwise dry conditions where riparian vegetation is subject to water stress.

A 20% DRAM reserve is only a 3% net credit spend

Suppose a DRAM flow is released at an MUSF with a 95% crediting rate for groundwater storage (5% cut to the aquifer). Suppose also that evapotranspirative use is 10% (90% infiltration).

A 20% increase in flow would consume only 2% of the stored water volume. The remaining 18% of water volume would infiltrate the channel and accrue LTSCs at a 95% crediting rate.

With a 20% DRAM reserve, the net loss of LTSCs is less than 3%.

A plausible-sounding objection

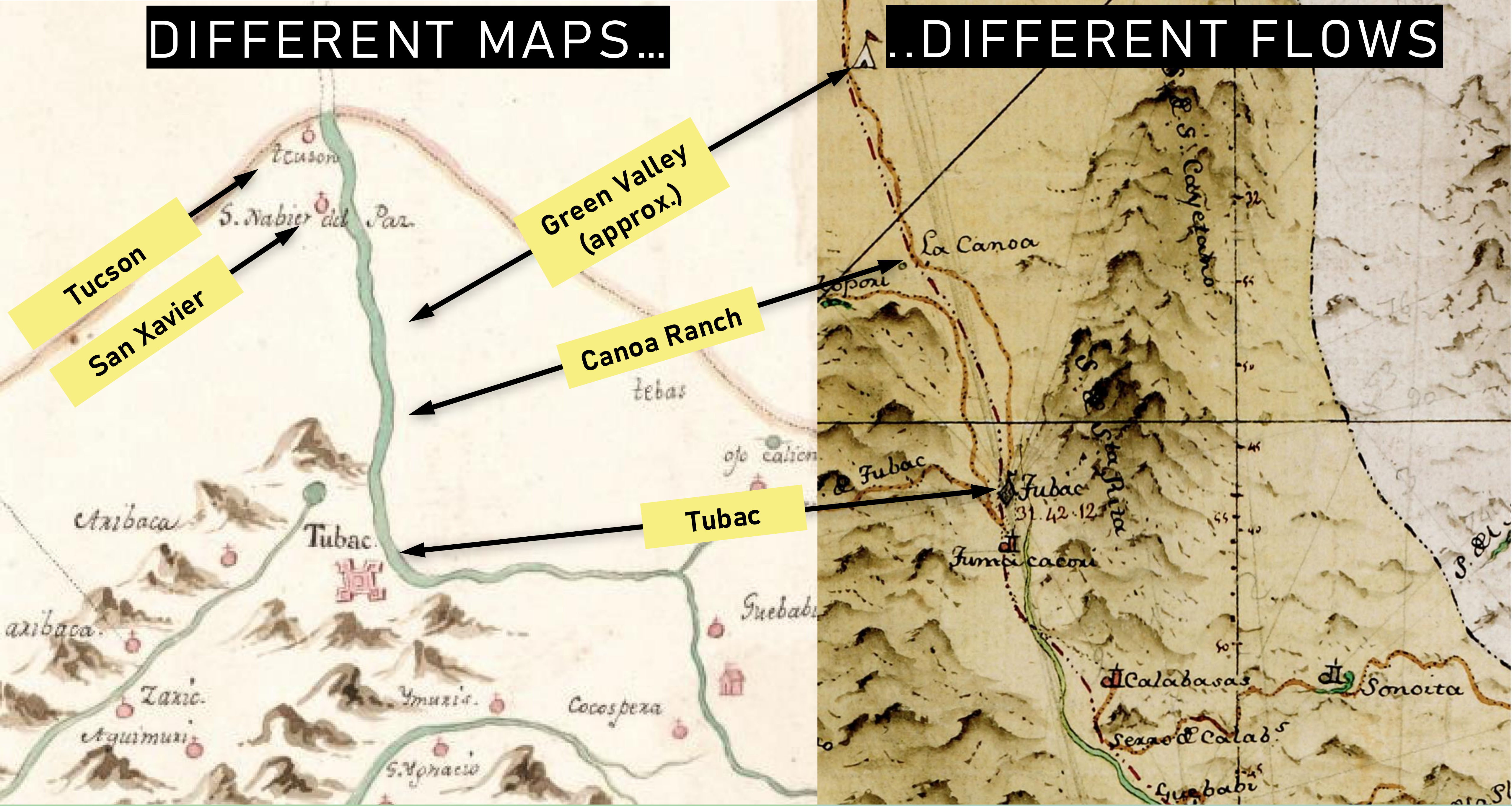
HASN'T THE RIVER ALWAYS BEEN DRY?

"THE RIVER HAS ALWAYS BEEN DRY HERE"

- "If you hear the word 'restoration' applied, immediately ask: 'Restore to what and when?'" —Webb et al. (2014)
- Reasonably good evidence for variable flow regimes on the MSCR over sufficiently long timescales:
  - Historic record
  - Physical / archaeological record
  - Deep bedrock … but perched aquifer

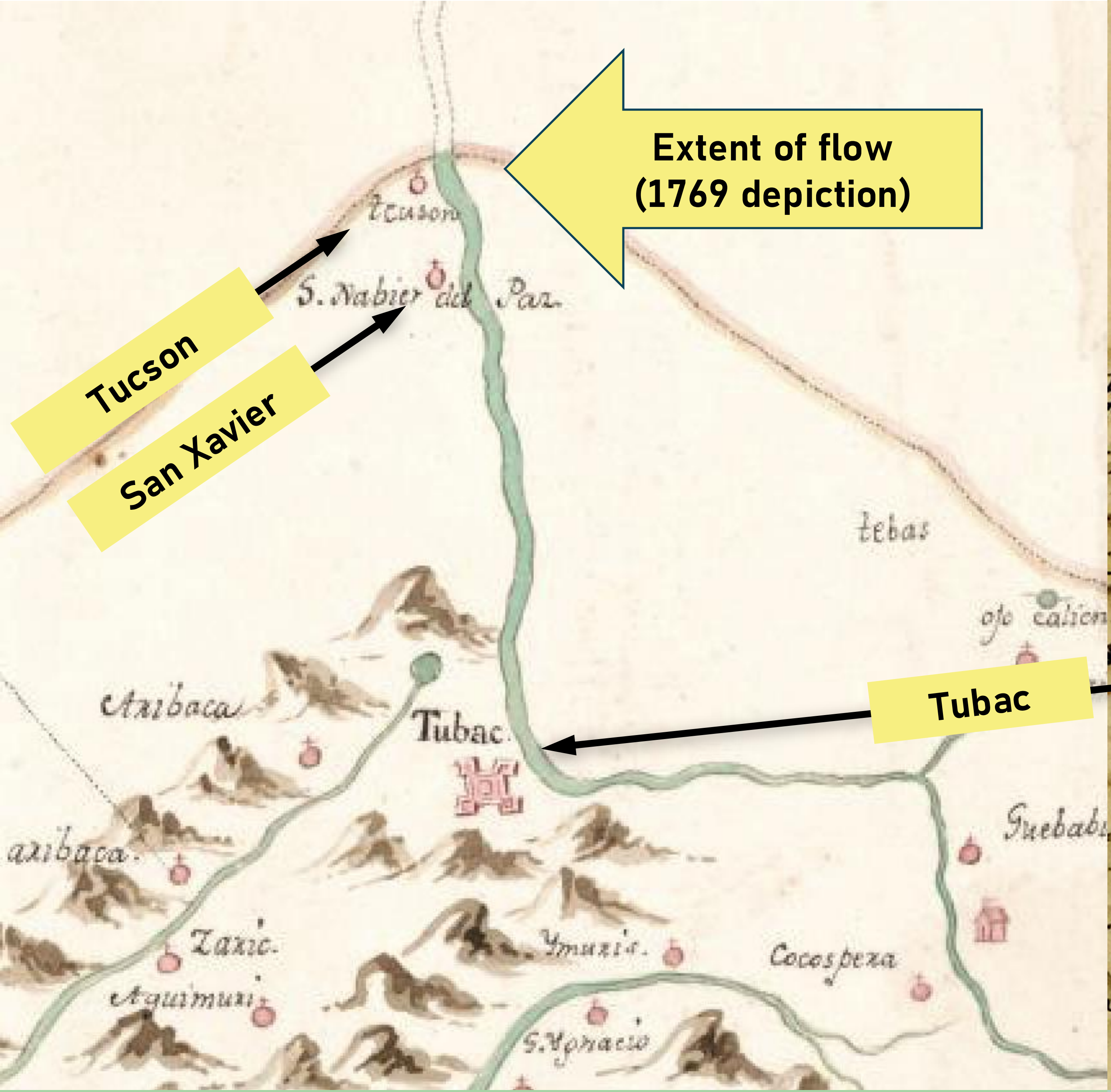
Map by de la Rocha (1780)

DIFFERENT MAPS… ..DIFFERENT FLOWS



Map by Urrutia and de la Fora (1769)

Map by de la Rocha (1780)



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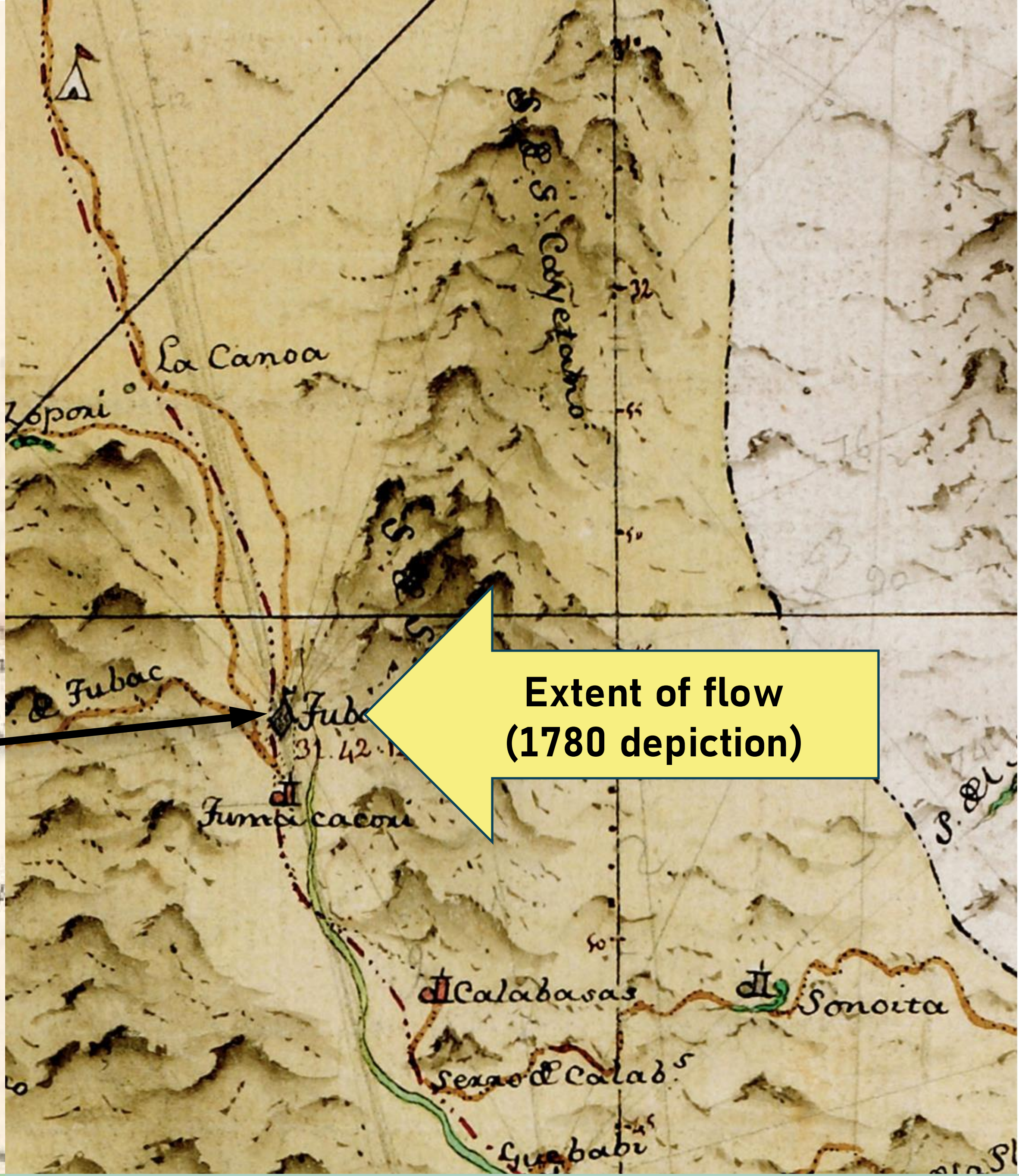
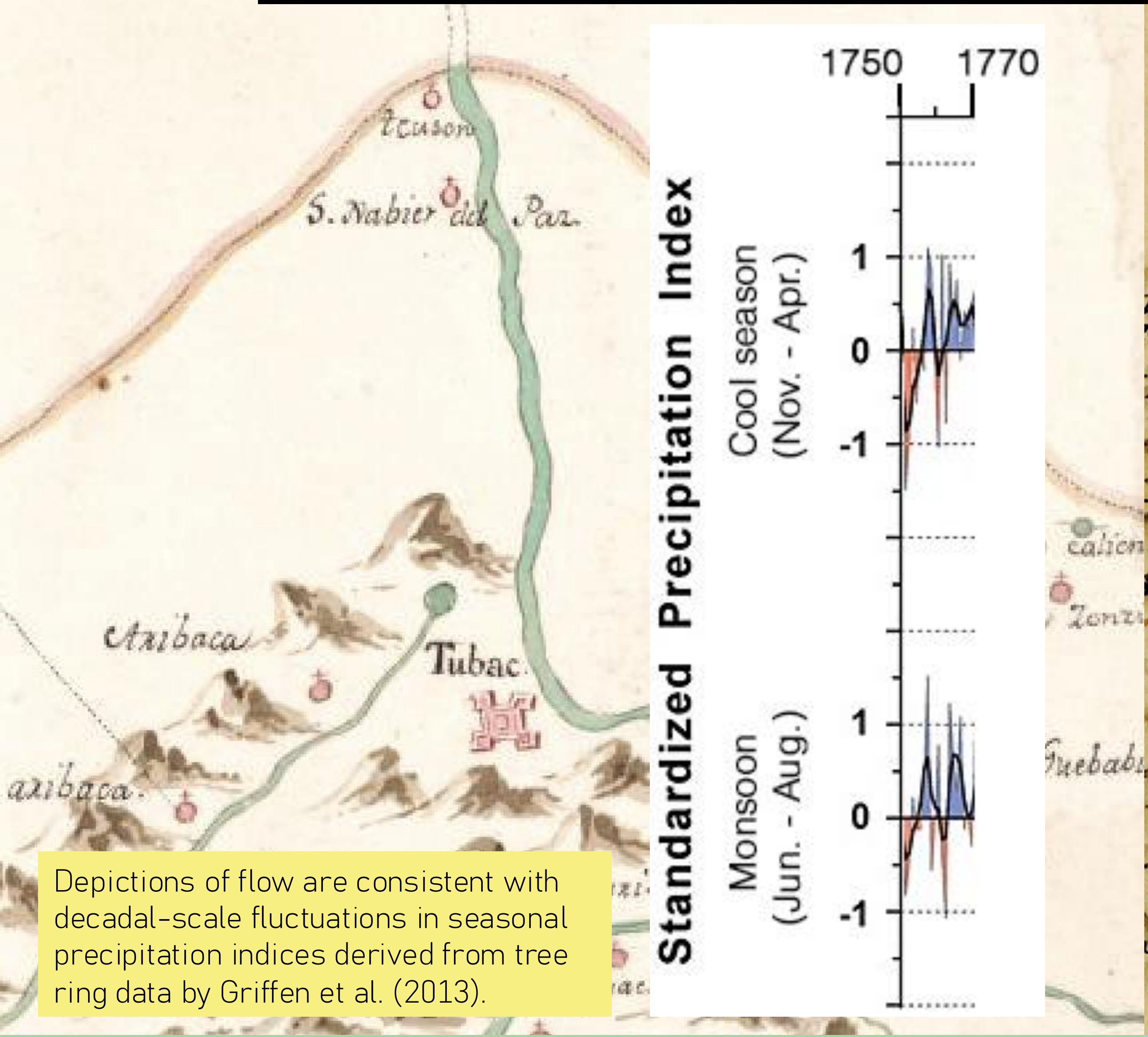


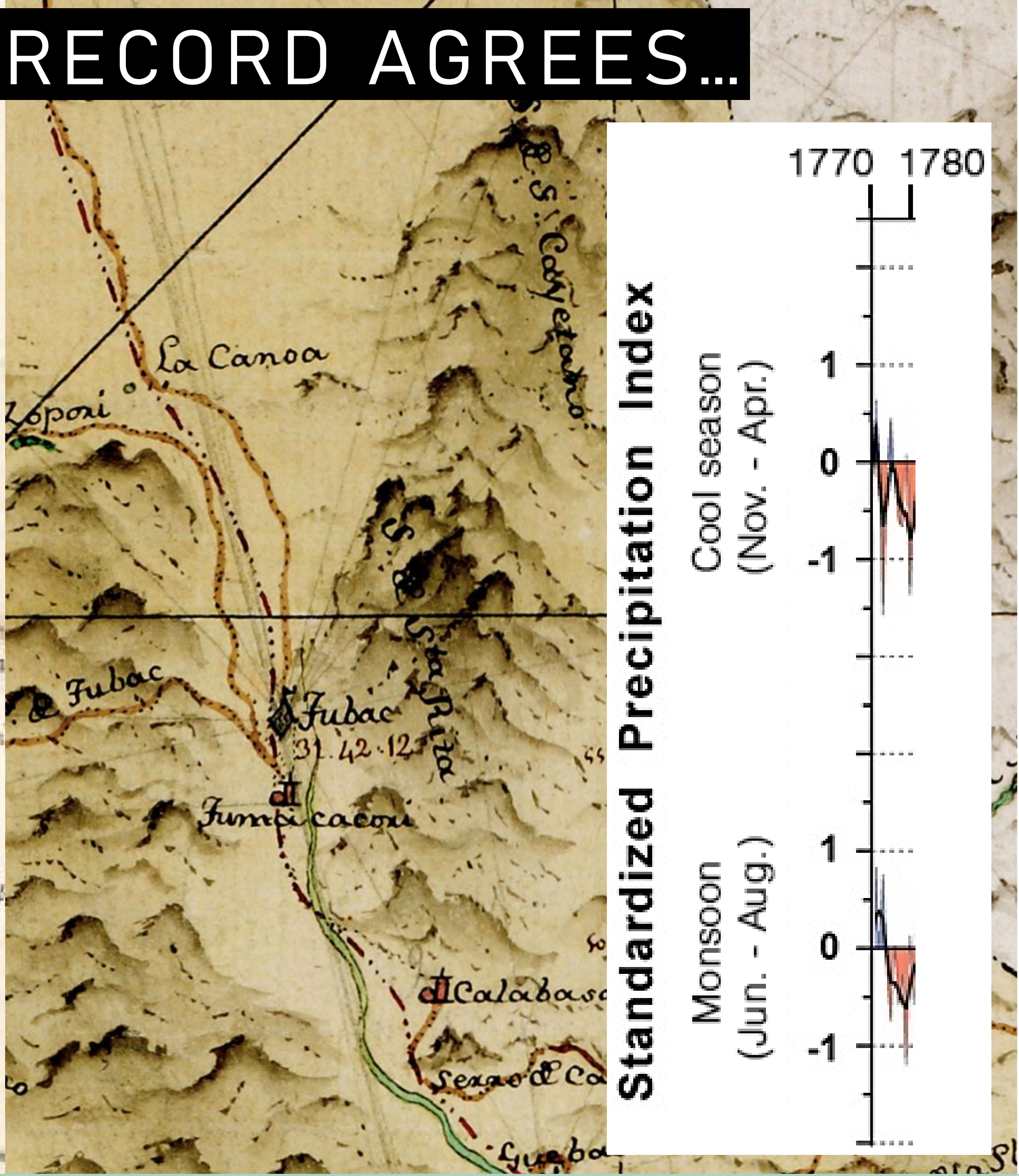
Map by de la Rocha (1780)

THE CLIMATOLOGICAL RECORD AGREES…



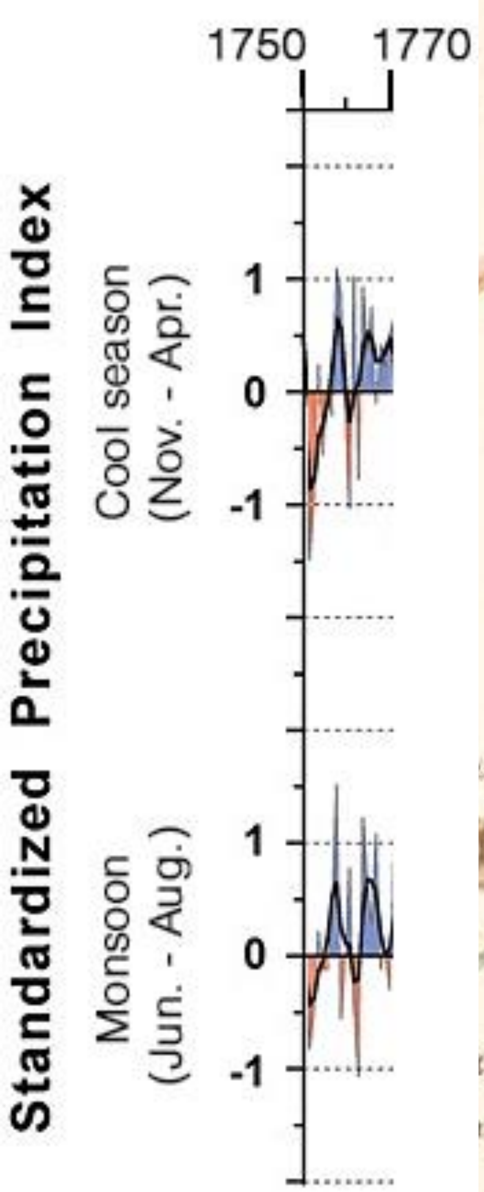
Depictions of flow are consistent with decadal-scale fluctuations in seasonal precipitation indices derived from tree ring data by Griffen et al. (2013).

Map by Urritia and de la Fora (1769)



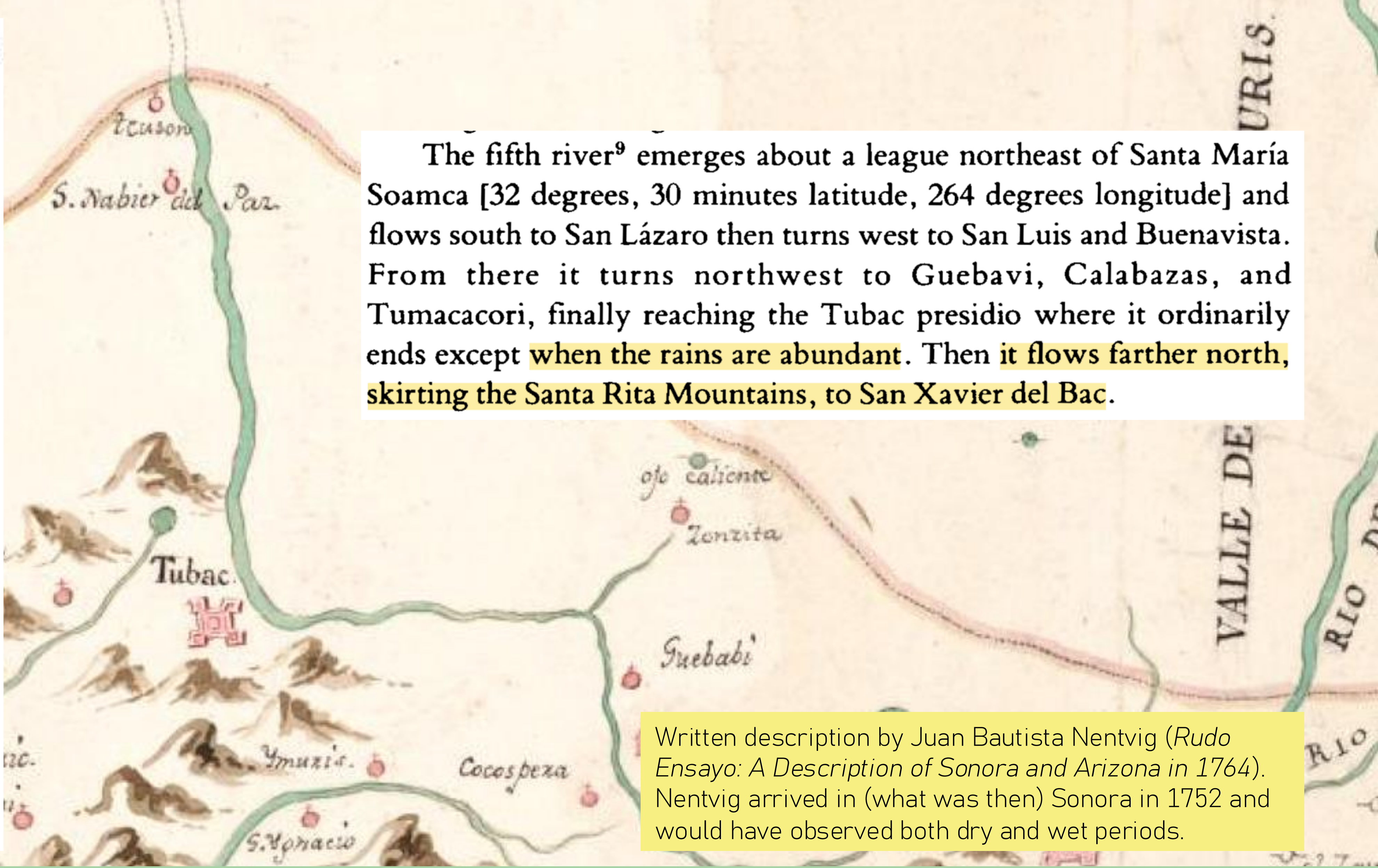
Map by de la Rocha (1780)

… AND THE WRITTEN RECORD ALSO AGREES



> The fifth river[9] emerges about a league northeast of Santa María Soamca [32 degrees, 30 minutes latitude, 264 degrees longitude] and flows south to San Lázaro then turns west to San Luis and Buenavista. From there it turns northwest to Guebavi, Calabazas, and Tumacacori, finally reaching the Tubac presidio where it ordinarily ends except when the rains are abundant. Then it flows farther north, skirting the Santa Rita Mountains, to San Xavier del Bac.

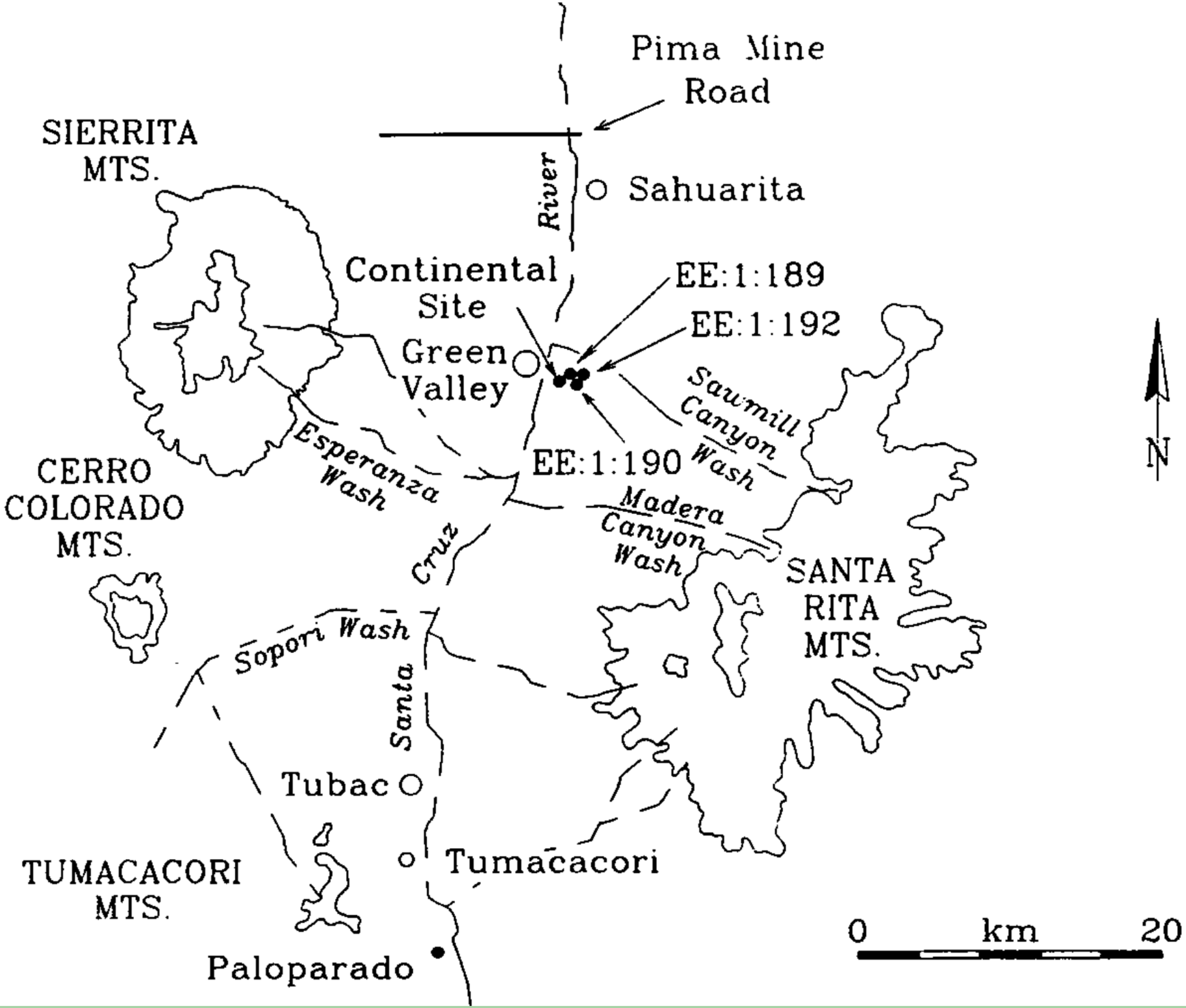
Written description by Juan Bautista Nentvig (*Rudo Ensayo: A Description of Sonora and Arizona in 1764*). Nentvig arrived in (what was then) Sonora in 1752 and would have observed both dry and wet periods.



Map by Urrutia and de la Fora (1769)

PHYSICAL EVIDENCE OF WATER RESOURCE USE

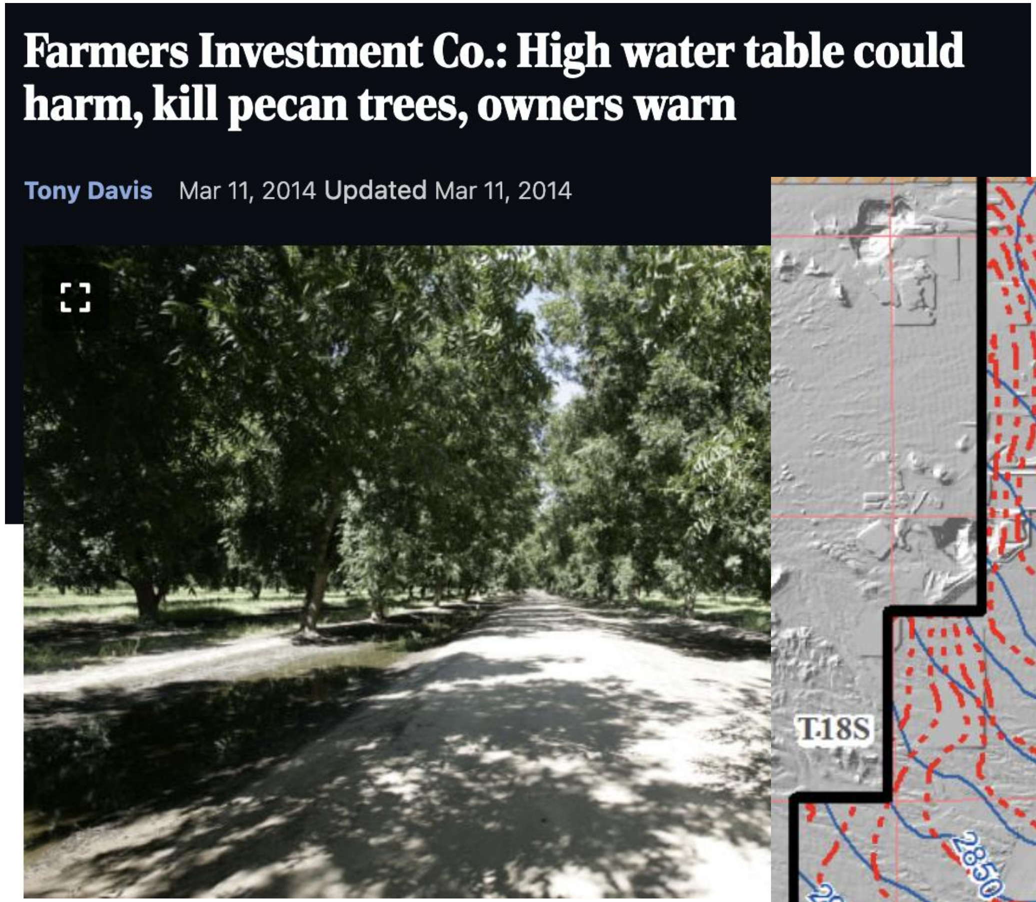
- The Continental Site contains (AP, 2009; Dart 2014):
  - At least one irrigation canal and evidence of irrigated agriculture
  - Woven reed material
  - Remains of mud turtles
  - Acorns
  - "Abundant cattail pollen"
- Long human presence. Peak population c. 1150-1300.
- No evidence of persistent human use after 1300.

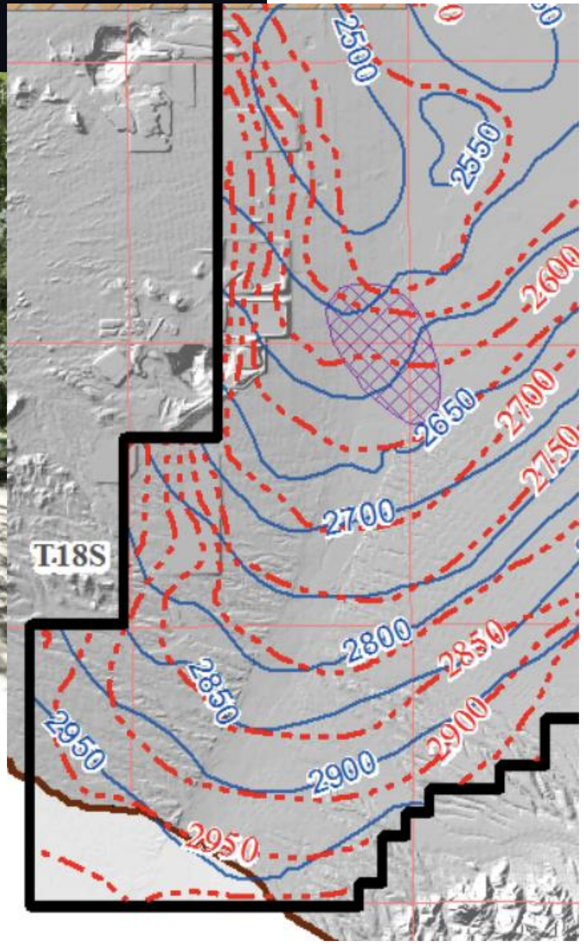


Map by Jones (1998)

DEEP BEDROCK … AND A PERCHED AQUIFER

- ADWR reports show perched groundwater in the Green Valley area (Mason and Bota, 2006; Mason and Hipke, 2013).
- Concern that groundwater recharge over perched aquifer could damage pecan trees (Davis, 2014)
- A perched aquifer, recharged by seasonal flows, is consistent with riparian cottonwood-willow habitat (see e.g. Fonseca and List, 2012)





Map from Mason and Hipke (2013)

LONG-TERM CHALLENGES

LTSC CREDITING RATES: A PERSISTENT ISSUE

Put **a hundred gallons in** the aquifer.
Get **fifty gallons out**.

Put **a hundred gallons in** the aquifer.
Get **ninety-five gallons out.**

LTSC CREDITING RATES: A PERSISTENT ISSUE

The disincentive for flow

Recall that effluent can be converted to groundwater for later re-use.

Recovery rights to stored groundwater are based on the number of accrued long-term storage credits (LTSCs).

Recovery of groundwater from underground effluent storage is *typically* credited at 50% for in-channel flows that recharge groundwater in an MUSF. This compares poorly to 95% crediting for storage in a constructed basin (USF).

Grandfathered MUSFs

MUSFs approved or submitted for approval before January 2019 are grandfathered, and effluent flows there receive 95% crediting.

Possible solutions

The best and most obvious solution is to amend state law to achieve MUSF/USF crediting parity.

Failing that, infiltration from effluent-based flows can be credited at 100% if the MUSF could "add value" to a state park, national park, or national monument. This requires that the park or monument include "any portion of a natural channel of a stream or adjacent floodplain that would benefit from the [managed underground storage facility."

- The law does not say *how* the MUSF must add value, only that it *must.*
- The law does not say *how* the stream must benefit, only that it *must*.
- The law does not specify whether *portion* refers to a portion that benefits, or a portion that crosses.

ADVANCED WATER PURIFICATION IS (FINALLY) COMING TO TUCSON

HAYDEN SAYS: THE STATE SUPREME COURT'S RULING THAT WATER CAN'T BE PUMPED FROM ONE BASIN TO ANOTHER OVER STATE LAND OUGHT TO bring things to a head, come next leg. session. Sooner or later cities and their people are going to be given priority, on basis of highest beneficial usage; over farmers, who will have to be compensated for their loss of water. Not long ago we talked about the fact that the Colo. River was split up during a time of extremely high flow. We got another slant at that last week, when a geologist pointed out that the glaciers and snowfields of Colorado started to melt rapidly about 20 yrs ago, and that when this melt is gone, there'll be even less water in the River. Maybe by then we'll have the wit and courage and sense to cleanup the 28 million gals of effluent going down the Santa Cruz each day, and turn it back through the city mains. It's acoming, for sure, has to. The best and briefest comment on the practicability of the liberal pacifists' love and disarm viewpoint was made in Phx the other day. A young lovin feller said to another man, Peace, I love you. The other guy whomped him with a tire iron! One sentence sermon, which pleased us no end. Lime-Sulphur promotes peace and harmony in the garden, cuts down root competition by opening the soil and letting em all have water!

HAYDEN EXCAVATION SERVICE 327-6029

Explicit discussion of direct potable reuse in local media **as early as 1962**. Pilot plant / project under discussion in 1963.

City studied the possibility of effluent delivery to mining operations in the 1970s.

Above: Local ad supporting direct potable reuse (1969)

PRICE SIGNALS FOR WATER CONSERVATION

Year	Cost per AF	Project / agreement	Water volume
2018	$250	Colorado River Indian Tribes (CRIT) Drought Contingency Plan (DCP) compensated transfer	150,000 AF (50k AF/yr over 3 years)
2022	$260	Compensated reduction in CAP deliveries to Tucson (rejected by M&C)	30,000 AF
2023	$400	Compensated reduction in CAP deliveries to Tucson, funded by Inflation Reduction Act (IRA)	110,000 AF (multiyear through 2025)
2025	$1,554	Funding for Advanced Water Purification (AWP) plant in exchange for CAP delivery reductions to Tucson	56,000 AF (over ten years)
2025	$2,000	Funding for infrastructure and metering to support water conservation, in exchange for CAP delivery reductions to Gilbert	8,500 AF (over ten years)
2025	$3,080	Funding for CAP/Salt River Project (SRP) interconnects, in exchange for CAP delivery reductions	50,000 AF (over fifty years)

PRICE SIGNALS FOR WATER CONSERVATION

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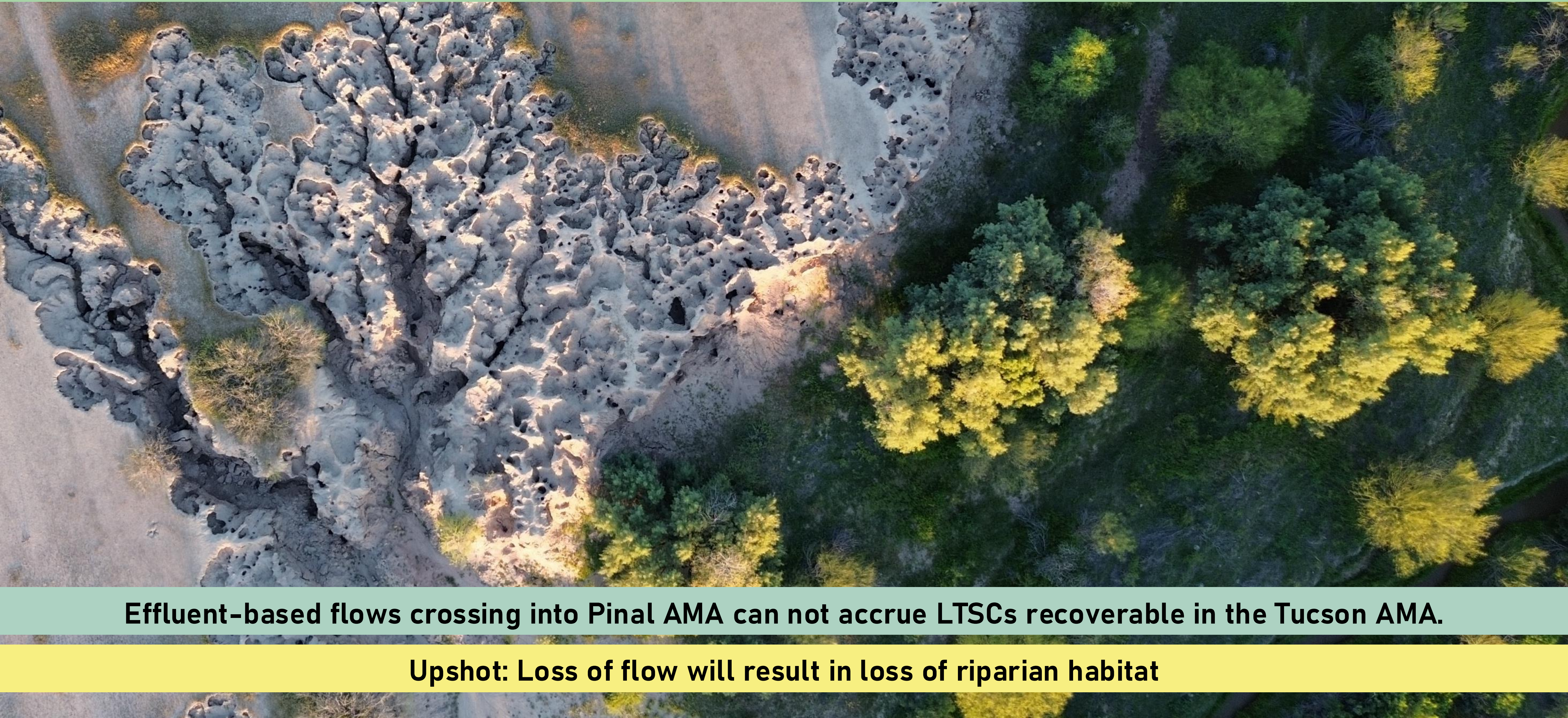
2025	$1,554	Funding for Advanced Water Purification (AWP) pl exchange for CAP delivery reductions to Tucson	0 AF (over ten)
2025	$2,000	Funding for infrastructure and metering to suppor conservation, in exchange for CAP delivery reduct Gilbert	AF (over ten years)
2025	$3,080	Funding for CAP/Salt River Project (SRP) interconnects, in exchange for CAP delivery reductions	50,000 AF (over fifty years)

Wholesale purchase price for desalinated water in San Diego:
2022: $2,815
2024: $3,400
2026: $3,736 (projected)

MOTIVATION FOR AWP PROJECT: REDUCE EFFLUENT FLOWS INTO PINAL AMA



Effluent-based flows crossing into Pinal AMA can not accrue LTSCs recoverable in the Tucson AMA.

Upshot: Loss of flow will result in loss of riparian habitat

AN ALTERNATE MECHANISM TO AVOID WET WATER LOSSES FROM OUT-OF-AMA FLOW

- Install flow metering at Tucson/Pinal AMA boundary.
- Establish new MUSF in Pinal to accrue LTSCs in Pinal AMA
- MUSF floodplain falls within Ironwood National Monument Boundary, making it eligible for 100% LTSC accrual (45 ARS 811, 45 ARS 852).
- Trade recoverable groundwater for CAP water from CAIDD
- Import CAP water

FUTURE RESEARCH QUESTIONS

- What is the full spatial extent of effluent-dependent flow in Arizona, and how do the flow regimes vary across sites?
- Closely related: What does a complete inventory of effluent generation and use look like at the state level?
- What range of benefits (social, cultural, ecological) are these engineered flows responsible for?
- How do flow regime and L3 elements (linkages, locality/scale, collocated assets) affect those benefits?
- What would an updated and more complete local inventory of riparian restoration projects reveal?
- Is it possible to locally induce groundwater perching (e.g., via permeation grouting to spread infiltrated water in selected areas) and better reproduce certain elements of naturally occurring riparian habitat?
- What would a more complete survey of the archaeological literature reveal about human and natural history on the MSCR?
- What species should be introduced and monitored on rewatered rivers?
- What species are currently crossing under I-19 at Demetrie Wash? (Baseline conditions assessment)
- What would an update inventory of local or regional riparian restoration projects look like?
- What is the smallest scale at which in-channel releases of effluent are useful?

TAKE-HOME MESSAGES

Planning

- Evaluate riparian restoration projects using a "linked / local / leveraged" framework.
- Alternatives with multiple outfalls and adaptive management strategies can mimic natural flow regimes and hedge against drought
- Increased competition for effluent is very likely

Ecology

- Contemporary flow gauges on the MSCR do not offer a complete history
- Canoa Ranch area has high value for species movement, especially in response to climate change
- Long-term planning is important, but so are "happy accidents"

Policy

- LTSC crediting rates hinder the ability of jurisdictions to realize the benefits of effluent-based in-channel recharge.
- Unambiguous crediting parity for effluent stored in-channel and effluent stored in-basin will require new legislation.
- Lack of crediting parity threatens the possibilities for new in-channel flows
- Failing that, there are potential workarounds (based on various interpretations of MUSFs that "benefit a park or monument"). But ambiguity is bad.

THANK YOU FOR YOUR TIME AND ATTENTION

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WHY HERE?

- Long-standing desire for effluent-based flows in this region (PCRWRD 2007 ROMP, 2022 SCWC WRP)
- Anticipated population growth suggests effluent is a reliable water source for conservation projects.
- SDCP (and other sources) identify southernmost reaches of the MSCR as an important location for habitat connectivity.

Photo: Joan Rennick, *Tucson Citizen* (1979)

WHY NOT?

Photo: H. Darr Beiser, *Tucson Citizen* (1981)

A FLOWING DESERT STREAM DRIED BY PRIVATE INTERESTS AND REWATERED FOR COLLECTIVE CONVENIENCE

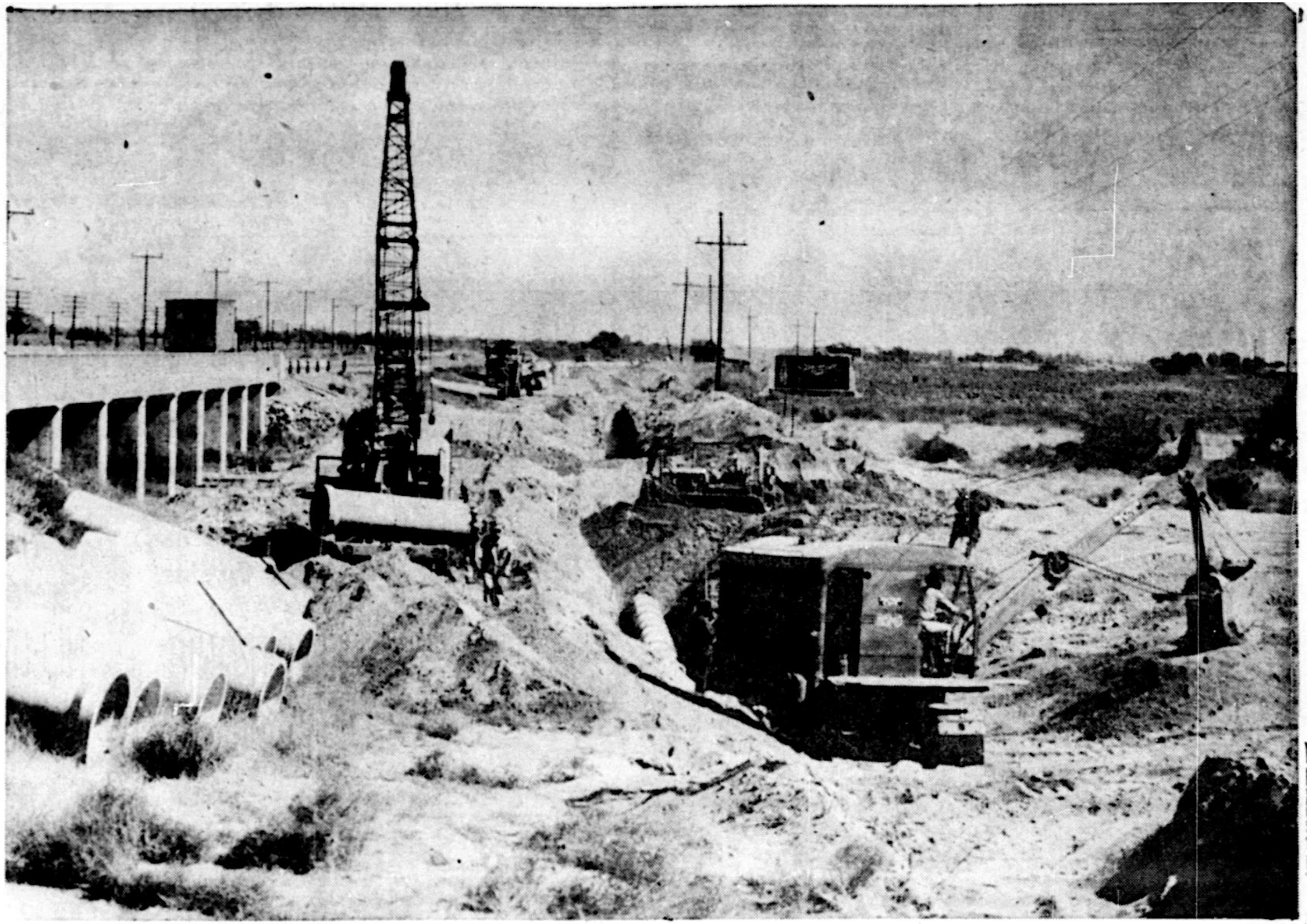
20 August 1954 (*Tucson Daily Citizen*)

—Citizen Photos

CITY TO SELL THIS SEWAGE PLANT OUTFLOW

Ray Drain, sewage plant superintendent, watches outflow from disposal plant into Santa Cruz at 9.8 million gallons per day. Contracts to city farm and local power plant use about half present supply. Remainder of flow will be let by bid for private farm use. Amount of outflow is increasing each month.

A FLOWING DESERT STREAM DRIED BY PRIVATE INTERESTS AND REWATERED FOR COLLECTIVE CONVENIENCE



—Citizen Photos

The 30-inch pipe line, which will transport sewage water from the city's disposal plant to the Cortaro Cotton & Cattle Co. farm, goes under three rivers in three miles. First, comes the Rillito, then the Canada del Oro and finally the Santa Cruz. This shot taken at the Canada del Oro crossing shows the line being buried 12 feet below the streambed. All rivers were crossed by the same method.

15 September 1955 (*Tucson Daily Citizen*)