BUREAU OF RECLAMATION

Water Resource Planning

Sustainable Cities Network

November 7, 2019

Organizational Structure

Secretary of the Interior
David Bernhardt

Asst. Secretary of Indian Affairs

- Bureau of Indian Affairs

Asst. Secretary of Land & Minerals

- Bureau of Land Management
- Office of Surfacing Mining Reclamation & Enforcement

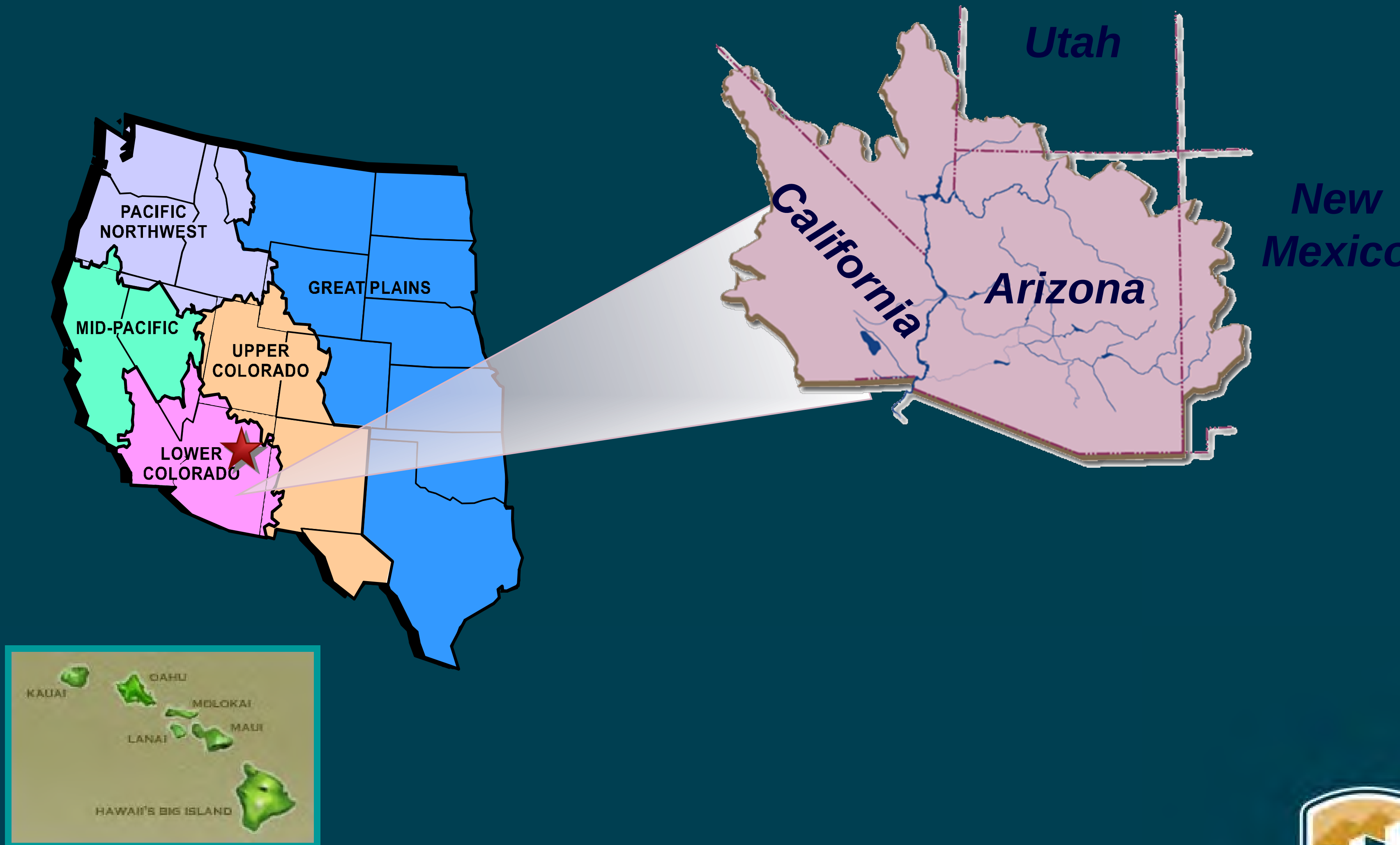
Asst. Secretary of Water & Science

- Bureau of Reclamation
  - Commissioner Brenda Burman
- U.S. Geological Survey

Asst. Secretary of Fish, Wildlife & Parks

- National Park Service
- U.S. Fish and Wildlife Service

Lower Colorado Region



Phoenix Area Office Boundaries

Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Overview

- Largest water provider in the 17 western States (479 dams and 348 reservoirs)
- Nation's second largest producer of hydroelectric power
- Develops authorized facilities to store and convey new water supplies

Recharge

Xeriscape

Water Treatment

Wetlands

Irrigation Efficiencies

Drought Contingency Plan (DCP)

- Consensus-based drought contingency plans were developed
  - each basin state
  - American Indian tribes
  - Mexico

- DCP includes
  - Basin state voluntary reductions and other actions
  - Mexico agreed to implement a Binational Water Scarcity Contingency Plan after the United States adopted the DCP

Colorado River Basin Overview

- 16.5 million acre-feet (maf) allocated annually
  - 7.5 maf each to Upper and Lower Basins
  - 1.5 maf to Mexico
- 14.8 maf average annual "natural" inflow into Lake Powell over past 110 years
- Inflow is highly variable year-to-year
- 60 maf of storage
  - 4 times the annual inflow
- Operations and water deliveries governed by the "Law of the River"

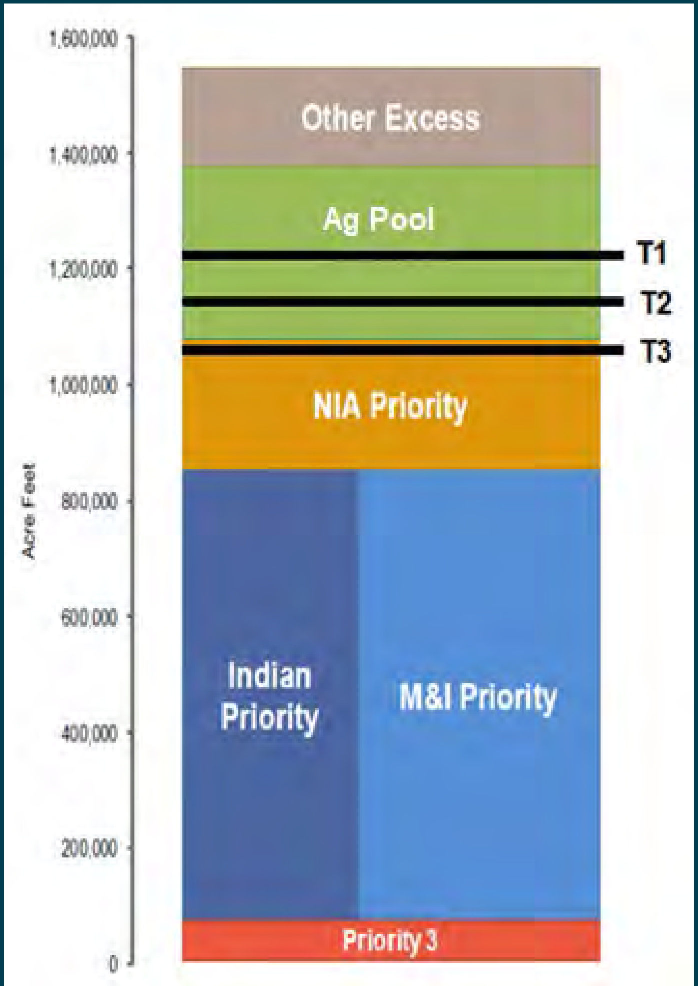
Lower Basin DCP (LBDCP) 2007 Interim Guidelines

Lake Mead Elevation	Arizona Reduction	Nevada Reduction	Mexico Reduction
1075'	320,000 AF	13,000 AF	50,000 AF
1050'	400,000 AF	17,000 AF	70,000 AF
1025'	480,000 AF	20,000 AF	125,000 AF

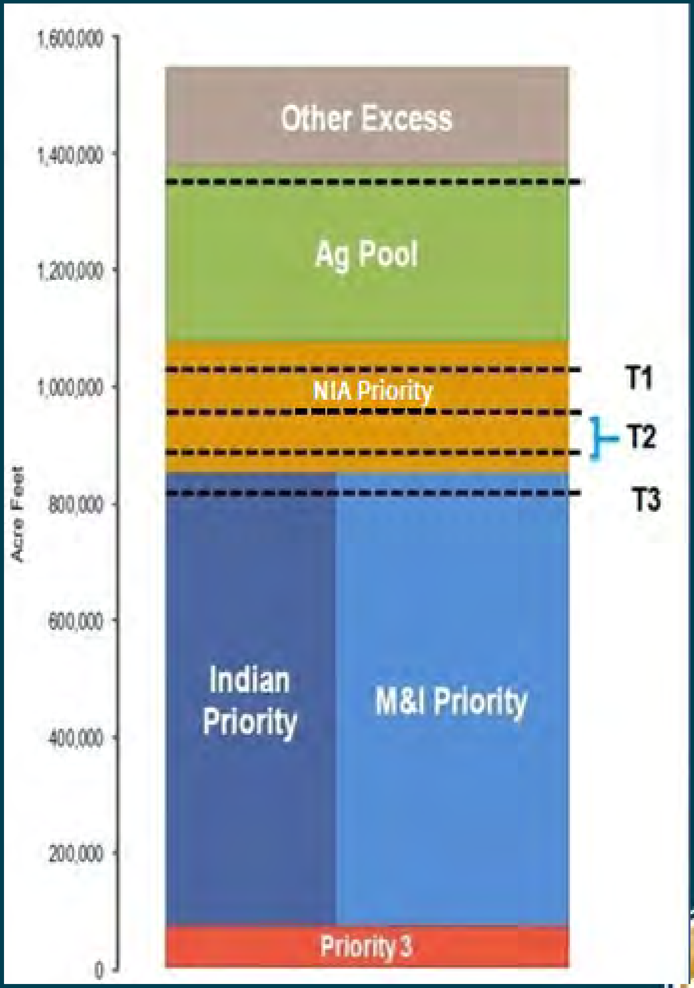
- Arizona and Nevada share Lower Basin shortages under the 2007 Guidelines
- Mexico voluntarily agreed in Minute 319 to accept reductions in its deliveries at the same elevations
- No additional reductions to California under 2007 Guidelines

CAP Priority Pools & Shortage

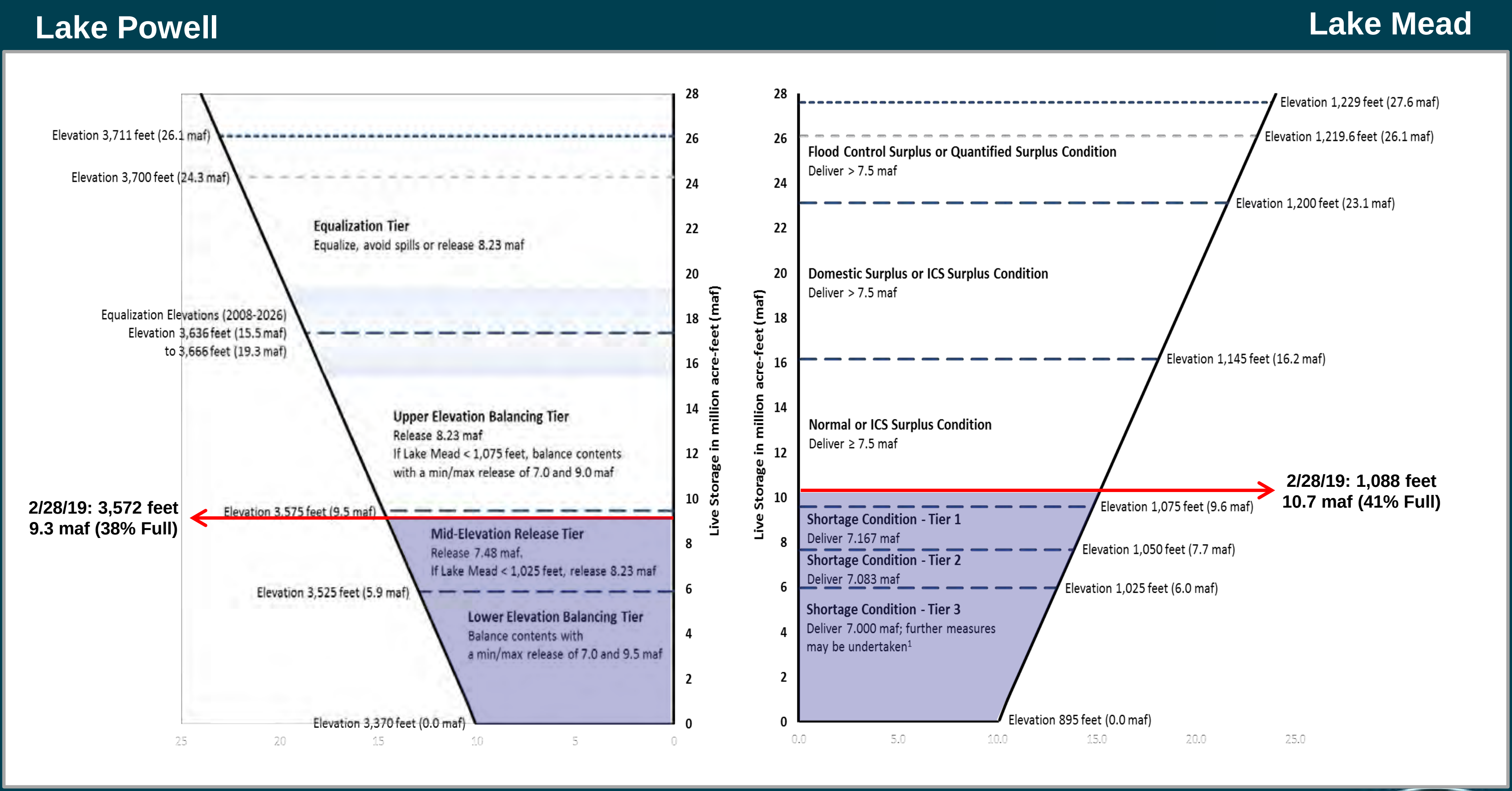
2007 Guidelines



LBDCP

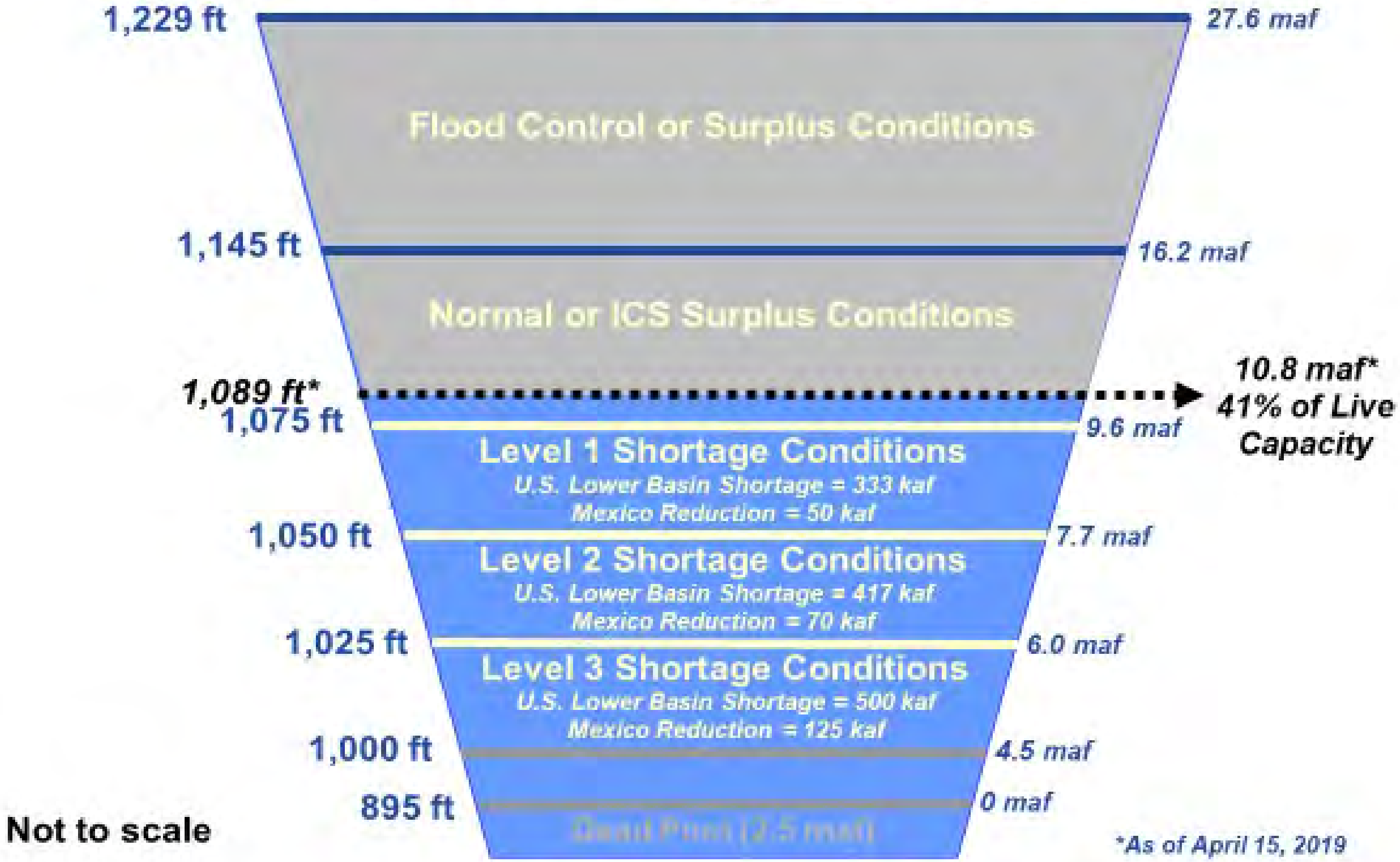


Lake Powell and Lake Mead Operational Diagrams (According to the 2007 Interim Guidelines)



[1] Whenever Lake Mead is below elevation 1,025 feet, the Secretary shall consider whether hydrologic conditions together with anticipated deliveries to the Lower Division States and Mexico is likely to cause the elevation at Lake Mead to fall below 1,000 feet. Such consideration, in consultation with the Basin States, may result in the undertaking of further measures, consistent with applicable Federal law.

Lake Mead – Key Elevations[1,2]

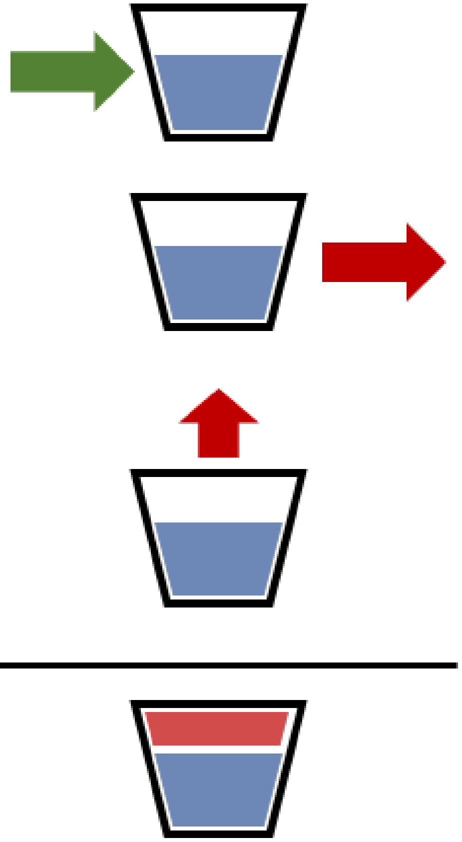


[1] U.S. Lower Basin shortage volumes based on the 2007 Interim Guidelines (in place 2007-2026).
[2] Mexico reductions based on Minute 323 (in place 2017-2026).

Water Budget at Lake Mead

Given current water demands in the Lower Basin and Mexico, and a minimum objective release from Lake Powell (8.23 maf), Lake Mead storage declines by about 1.2 maf annually (equivalent to about 12 feet in elevation).

Inflow *Powell release + side inflows above Mead*	9.0 maf
Outflow *Lower Basin State apportionments and Mexico Treaty allocation, plus balance of downstream regulation, gains, and losses*	-9.6 maf
Mead evaporation loss	-0.6 maf
Balance	-1.2 maf

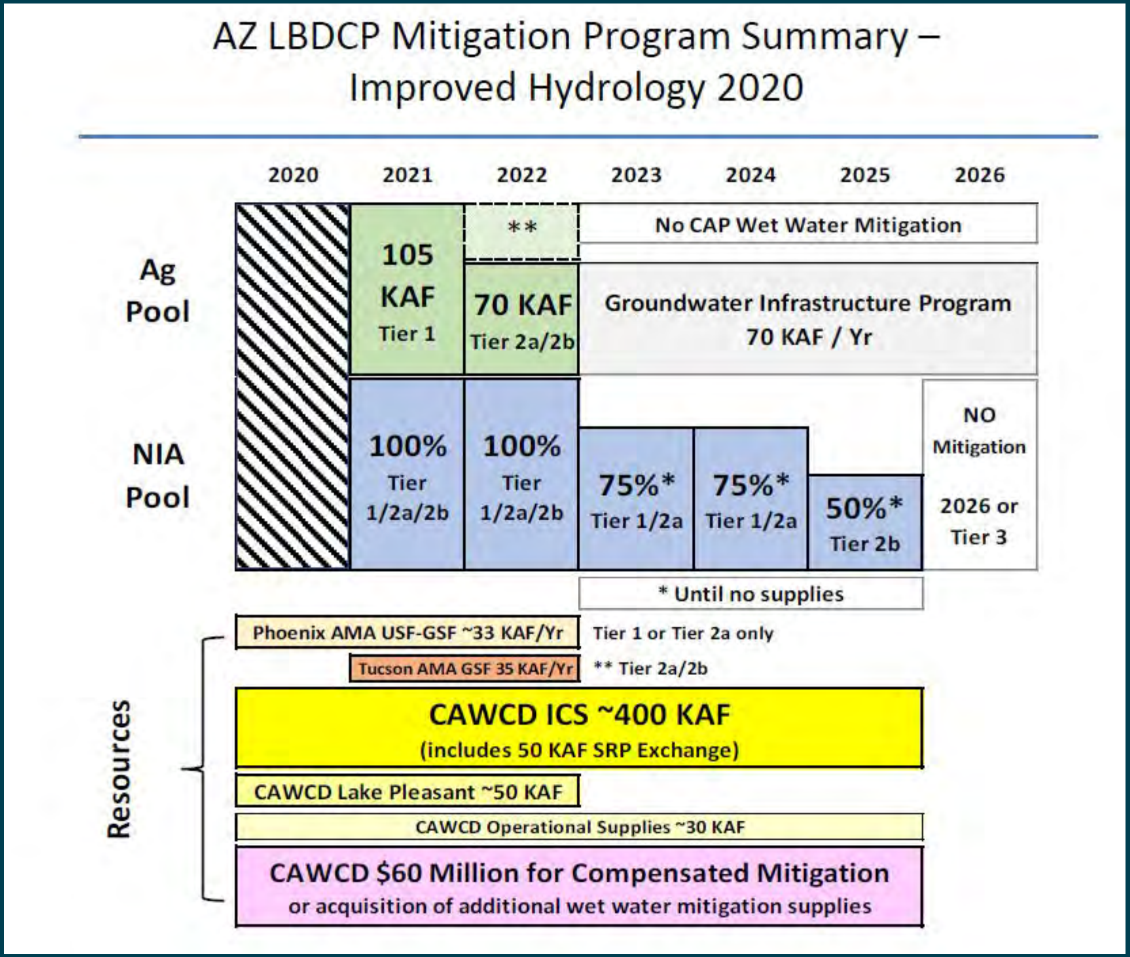


Potential Lake Powell Release Scenarios Water Years 2019 and 2020

Lake Powell			Lake Mead	
Powell WY 2019 Unregulated Inflow (% of average)	WY 2019 Release Volume (maf)	WY 2020 Release Volume (maf)	End of CY 2019 Elevation (feet)	End of CY 2020 Elevation (feet)
>78%	9.00	8.23 or greater	1,075	1,065 or higher
70% - 77%	9.00	7.48	1,070	1,056
64% - 70%	8.23 to 9.00	7.48	1,061 to 1,070	1,041 to 1,056
< 64%	8.23	7.48	1,061	1,041 to 1,047

Based on scenarios developed with the September 2018 Most Probable 24-Month Study, including most probable assumptions for Upper Basin reservoir operations (Flaming Gorge, Aspinall, and Navajo) and Lower Basin water use and intervening flows in 2019 and 2020.

Intra- Arizona



WaterSMART Program

- Managed out of Reclamation's Denver Office
- Reclamation Wide programs

Quantifiable Water Savings
- Canal Lining/Piping
- Municipal Metering
- Irrigation Flow Measurement
- Landscape Irrigation Measures

Energy-Water Nexus
- Renewable energy related to water management and delivery
- Increased energy efficiency

WaterSMART Grants

Water and Energy Efficiency Grants

Increasing Water Supply Reliability
- Water Access and Conveyance System Improvements
- Aquifer Storage and Recovery
- Development of alternative water sources

Improved Water Management
- Modeling
- Decision support tools
- Measurement and Monitoring

Drought Response Program

Drought Resiliency Projects

WaterSMART Grants

Small-Scale Water Efficiency Projects

Small-scale efficiency and water management projects
- Canal Lining/Piping
- Municipal Metering
- Irrigation Flow Measurement.
- Supervisory Control and Data Acquisition (SCADA) and Automation.
- Landscape Irrigation Measures

Cooperative Watershed Management Program

Watershed Management Projects

- Improving Stream Channel Structure and Complexity
- Restoring or Enhancing Floodplains and Riparian Vegetation
- Invasive Species Prevention/Control
- Water Conservation/Management to Improve Ecological Resilience

WaterSMART Construction Opportunities

Technical Assistance to States (TATS)

- Provides data, technical knowledge, and expertise to aid in conservation and allocation of natural resources.
- Assistance in the technical, evaluation, and management phases of water resource program efforts and projects.
- Including environmental, economics, engineering, sedimentation, planning, recreation and public land use, and social analysis.

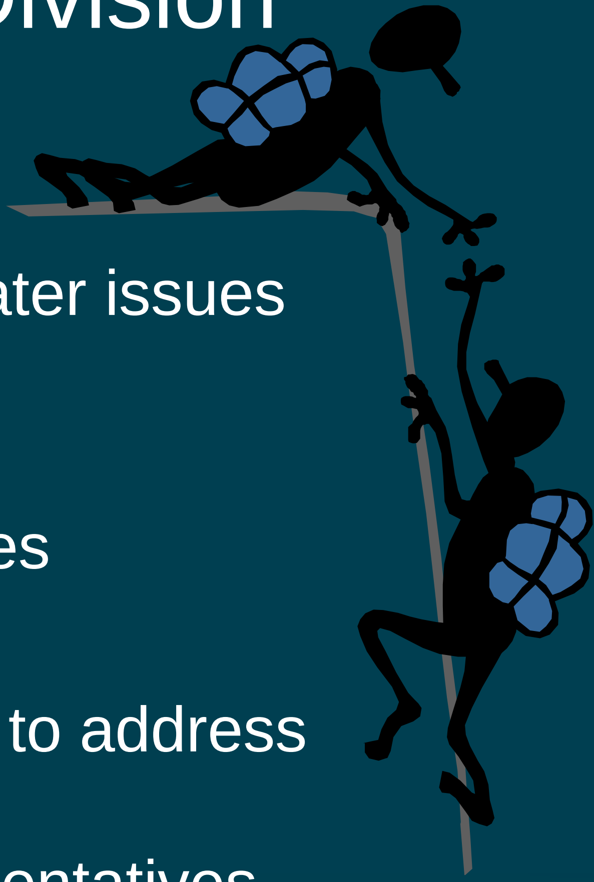
Science and Technology (S&T)

- Competitive funding for BOR staff for innovative research
- Coordinated, interdisciplinary research and technology development
- Collaborate with customers, stakeholders, and other water resource agencies
- Funding provided for pilot studies

Water Resource Planning Authorities

- **Central Arizona Project – Planning**
- **Salt River Project – Planning**
- **Lower Colorado Operations Program**
- **General Planning Activities**
- **Planning Investigations Program**
- **Southern Arizona Water Rights Settlement Act (SAWARSA)**

Program Development Division



- Reclamation
  - stay informed of local and regional water issues
  - establish relationships
  - identify potential need
  - inform partners of funding opportunities
- Community
  - request assistance from Reclamation to address water issues
  - submit letters to congressional representatives to communicate needs and request assistance

Budget Planning Process

- 3 year budget cycle
- New FY budget prepared three years out. E.G. In Oct 2008, FY 2011 program and budget planning
- Reclamation receives funding from Congress under the Energy and Water Development Appropriations bill

Water Development Studies

Congressional Authority

- Reclamation Act of 1902 authorized Appraisal Studies, Special Studies and Technical Investigations.

- Feasibility Studies require expressed Congressional authorization.

- Construction Authority requires Congressional authorization.

Agreements

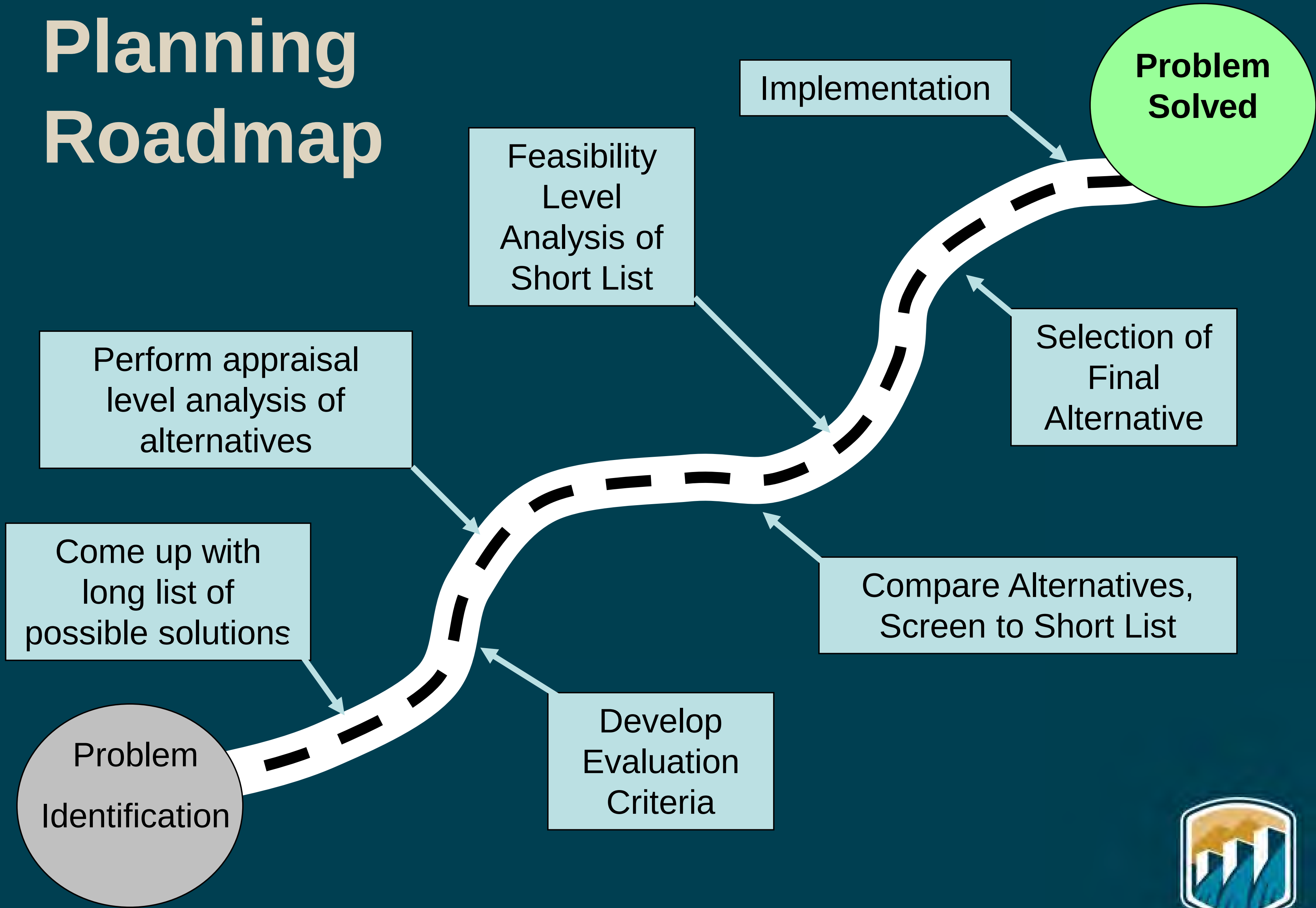
- IGA between partners
- 25 to 50% match-of-study costs
- Accounting and reporting

Types of Studies

- **Appraisal Study** - existing data and information.
- **Special Studies** - existing and new information.
- **Feasibility Study** - detailed investigation; authorized by Congress.

- **National Environmental Policy Act (NEPA)** – mandated for Federally funded projects.

Planning Roadmap



Appraisal - Evaluation Process

Evaluate long list of alternatives based on:

- Implementability
- Effectiveness
- Cost

RECLAMATION

Managing Water in the West

West Salt River Valley Basin Study

West Valley Water Association
Board of Directors

January 23, 2019

John Rasmussen, Study Manager
USBR Phoenix Area Office

U.S. Department of the Interior
Bureau of Reclamation

West Valley Water

Eloy and Maricopa-Stanfield Basin Study

The EMS Basin Study will first assess the current quantity, location, and timing of current water supply including:

- Central Arizona Project (CAP) water
- Surface water
- Recycled water
- Stormwater
- Groundwater

and demands including:

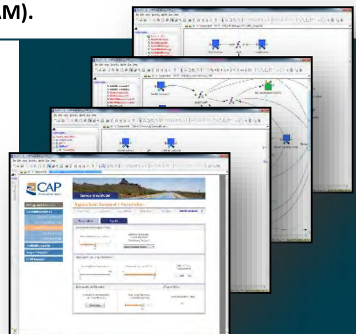
- Municipal
- Industrial
- Agricultural
- Tribal
- Other uses

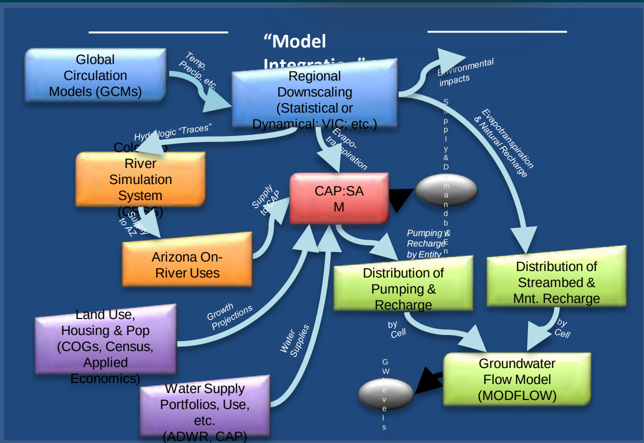
The second step assess the future supply and demands to determine any imbalances using the **Central Arizona Project's Service Area Model (CAP:SAM).**

CAP:SAM

Tool for projecting supply and demand in CAP's three county service area.

- Accounts for complex legal and physical characteristics of users and supplies
- Designed to easily generate "what-if" scenarios





Three year, $1,360,000 partnership between Reclamation and the Pinal Partnership to:

- Project supply & demand imbalances (due to climate and other factors), now through 2060
- Evaluate existing and proposed water infrastructure
- Develop and investigate adaptation strategies (structural and non-structural)
- Perform trade-off analysis

Groundwater Model

- Update Arizona Department of Water Resources' Pinal Active Management Area (**AMA**) Regional Groundwater Flow Model to include future water supply and demand assessments
- Run updated model to include Climate Model Scenarios
- Use groundwater model for adaptation strategies

Schedule

Section 5 Tasks	Description	Year 1				Year 2				Year 3			
		Nov 2018	Feb 2019	May 2019	Aug 2019	Nov 2019	Feb 2020	May 2020	Aug 2020	Nov 2020	Feb 2021	May 2021	Aug 2021
1	Climate Change Analysis		X	X									
2	Supply and Demand Assessment	X	X	X	X								
3 & 4	Groundwater Model			X	X	X	X			X			
5	Conduct Infrastructure Analysis				X			X	X				
6	Adaptation & Mitigation Strategies								X	X			
7	Conduct Economic Analysis									X	X		
8	Basin Study Report			X	X		X		X		X	X	X
9 - 11	Project Management / Admin	X	X	X	X	X	X	X	X	X	X	X	X

- Eloy and Maricopa-Stanfield Basin Study area includes two of the five sub-basins within the Pinal AMA
- Pinal AMA has a statutory management goal to preserve existing agricultural economies for as long as feasible, while considering the need to preserve groundwater for future non-irrigation uses
- Agriculture and Agribusiness contribute $2.3 billion to Pinal Counties economy
- Significant population growth in the near future
- Potential for water demand to outpace supply
- Colorado River water shortage will cause imminent reductions in surface water and CAP Agricultural Settlement Pool
- Increase in groundwater pumping to make up for loss of surface water supply may lead to an increase potential for land subsidence

Central Arizona Canal, north of Florence on AZ-79

Planning for Alternatives

Although the EMS Basin Study is a technical assessment and will not offer policy recommendations or commitments, the development of adaptation strategies to address water supply vulnerabilities is a critical outcome of the study. As these findings could incentivize future adaptation efforts, community input will be strongly sought in this stage of the Basin Study, so as to encourage a wide array of structural and non-structural water management alternatives.

Stay Informed, Get Involved

pinalpartnership.com/ems-basin-study/

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Pinal Partnership
Jake Lenderking
Global Water Resources
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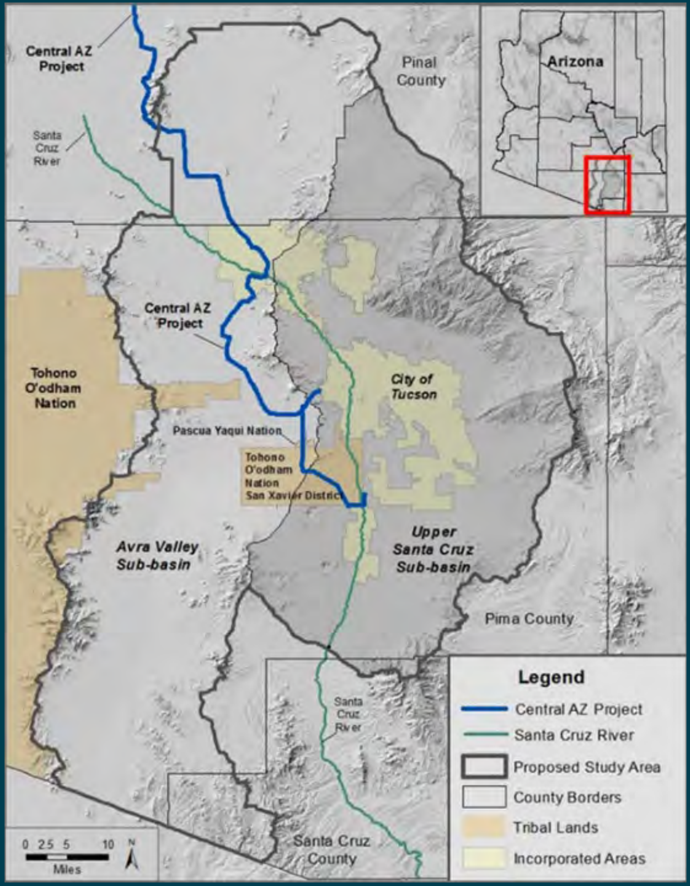
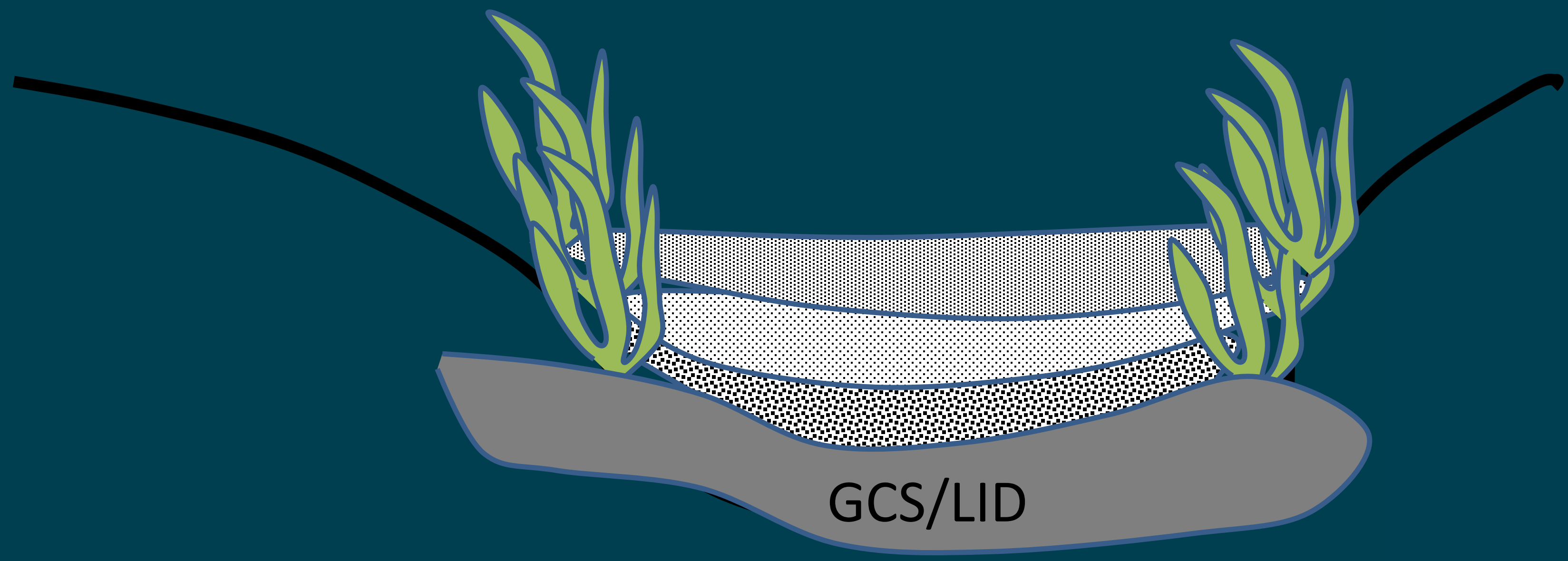
Water Supply/Demand Imbalance in the Face of Climate Change: How will we prepare?

An Overview of the Lower Santa Cruz River Basin Study



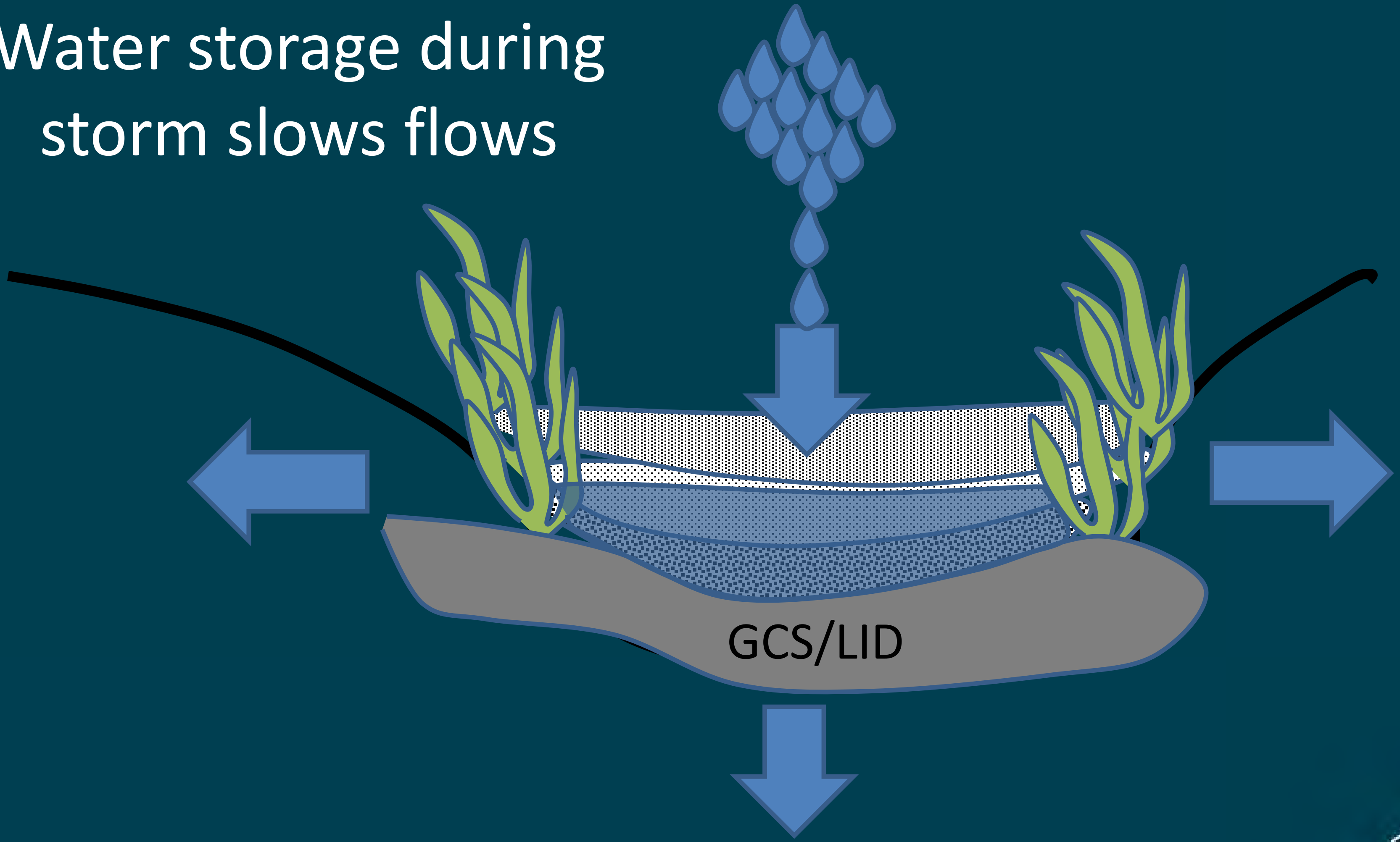
Stormwater Management using Grade Control Structures / Low Impact Development



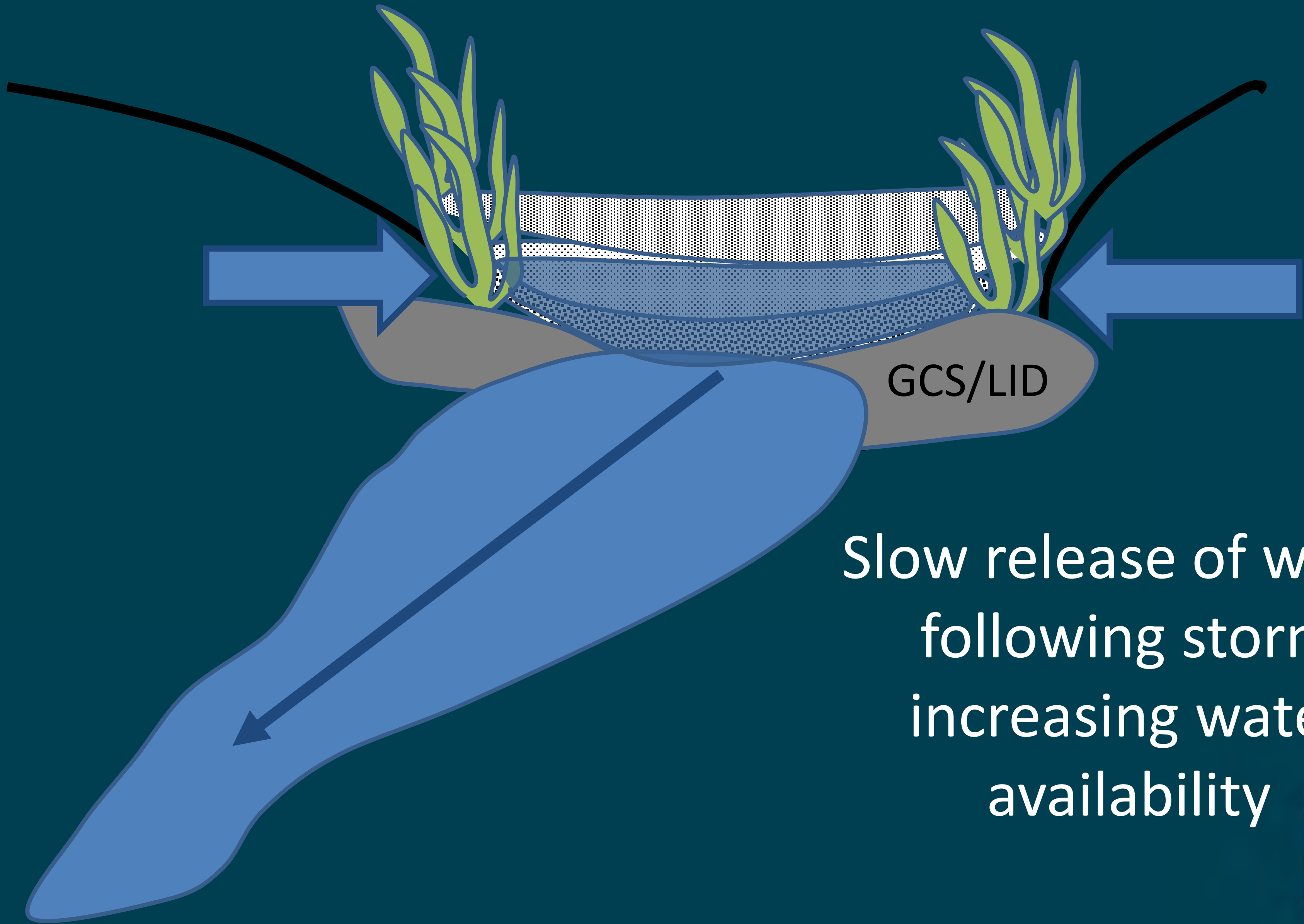
Sedimentation after storm and plant establishment

Stormwater Management using GCS / LID

Water storage during storm slows flows



Stormwater Management using GCS / LID



Slow release of water following storm increasing water availability

Arizona Surface Water Code

Doctrine of prior appropriation governs use (ARS § 45-151 A)

- ✓ "First in Time, First in Right"
- ✓ Beneficial Use
- ✓ Senior Water Right Holders' must be fully satisfied before water is available to Junior Rights

The Law requires that a person must apply for and obtain a permit in order to appropriate surface water. (ARS §§ 151-153)

Arizona Water Protection Fund – Example of funded projects that have included erosion control structures

Double Circle Ranch
Erosion Control Projects, Phase II

Reduction in sediment flow
towards Eagle Creek: benefitting aquatic habitat,
increasing water infiltration/water table, and an increase of productive soil
improving forage for wildlife and livestock.

LID Installation Examples

USBR Gunnison Basin Climate Vulnerability Assessment & Resiliency Strategies for Gunnison Sage-grouse

2012 - 41% Bare Ground and Litter

2015 - 12% Bare Ground and Litter

http://southernrockieslcc.org/project/gunnison-climate/

LID Installation Examples

USBR Gunnison Basin Climate Vulnerability Assessment & Resiliency Strategies for Gunnison Sage-grouse

2012 - 12% Wetland Species Coverage

2015 - 48% Wetland Species Coverage

http://southernrockieslcc.org/project/gunnison-climate/

LID Installation Examples
USBR Muddy Creek, Montana

Muddy Creek near Vaughn, Montana, ca 1930's. Prior to irrigation return flows.

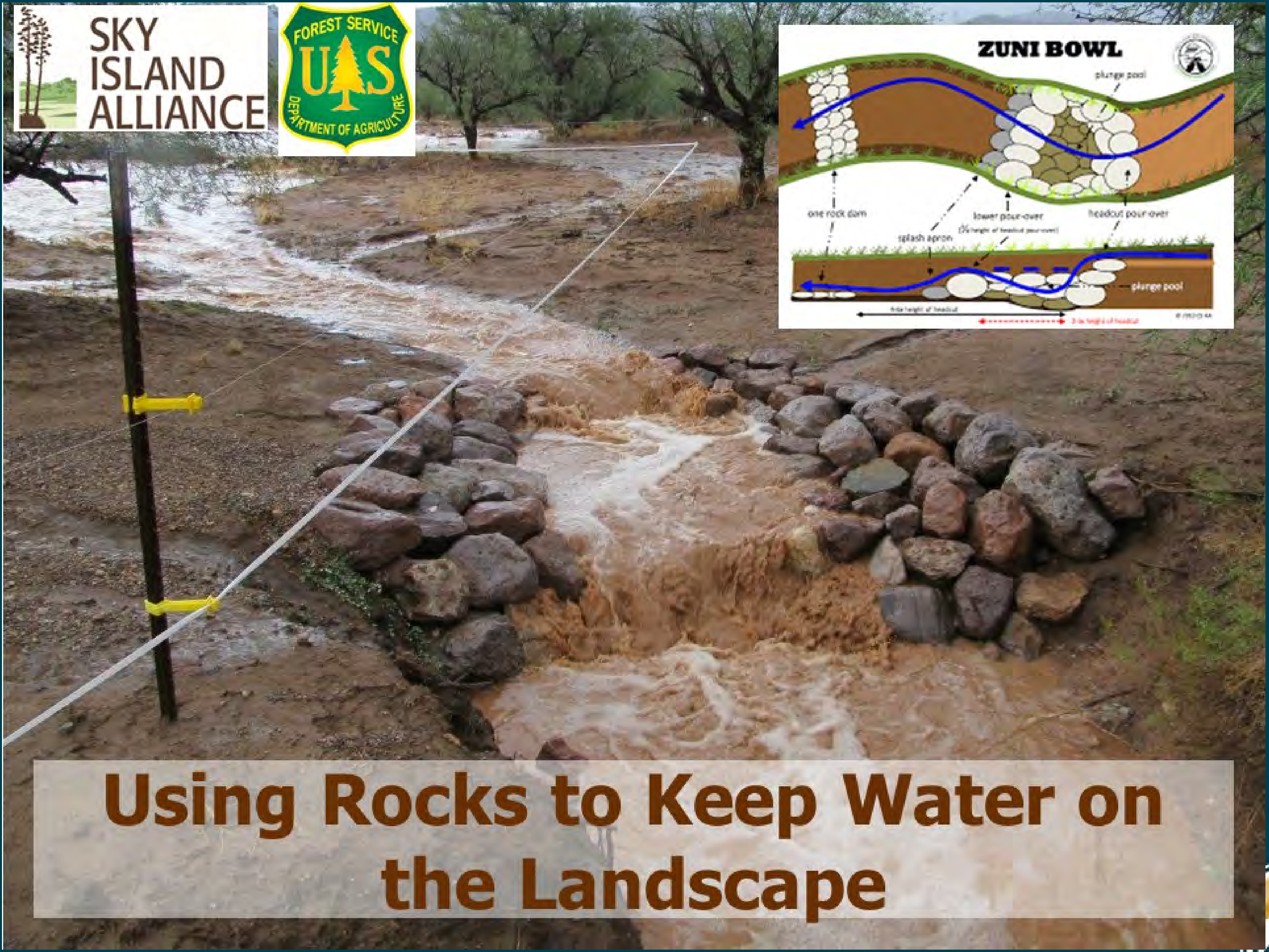
LID Installation Examples
USBR Muddy Creek, Montana 1993

Grade control structure on Muddy Creek near Vaughn, Montana. Flow is right to left. Note cut bank on river right. The channel has incised that amount since return flows from a nearby irrigation district were introduced to Muddy Creek.

LID Installation Examples
USBR Muddy Creek, Montana

Upstream from a grade control structure on Muddy Creek near Vaughn, Montana. The restored grade allowed the recruitment of a new riparian zone on the heavily incised stream. This photo taken ~10 years following installation of the grade control.

LID/GCS Installation Examples



LID Installation Examples
Atturbury Wash Riparian Stewardship Project

Barboot

SKY ISLAND ALLIANCE

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Installation of LID for Restoration Examples

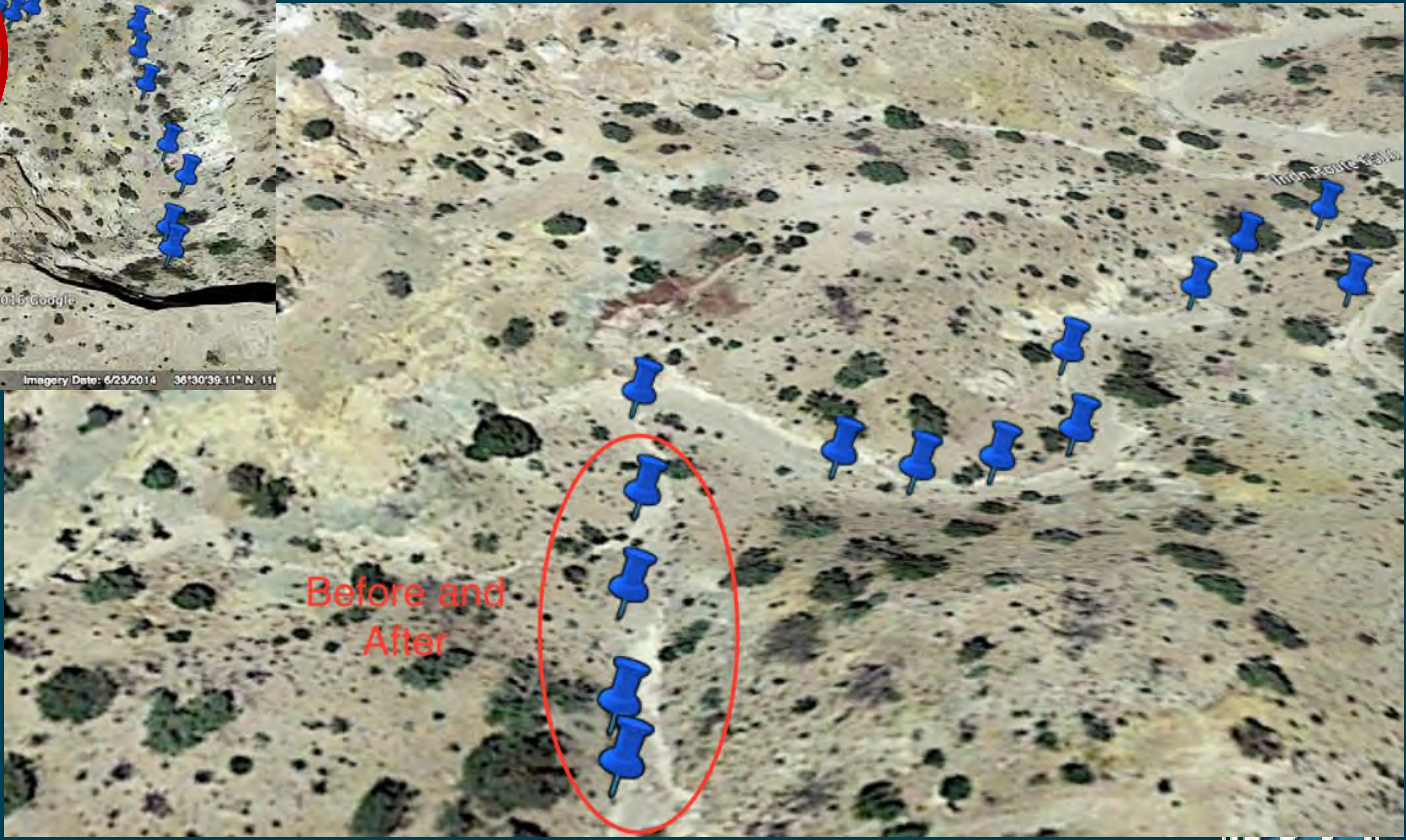
Babocomari River Restoration Project

Installation of LID for Restoration Examples Hopi - Keam's Canyon Flow Restoration

Ancient Hopi check dams

Installation of LID for Restoration Examples

Navajo Nation Chilchinbeto Trincheras



Installation of LID for Restoration Examples

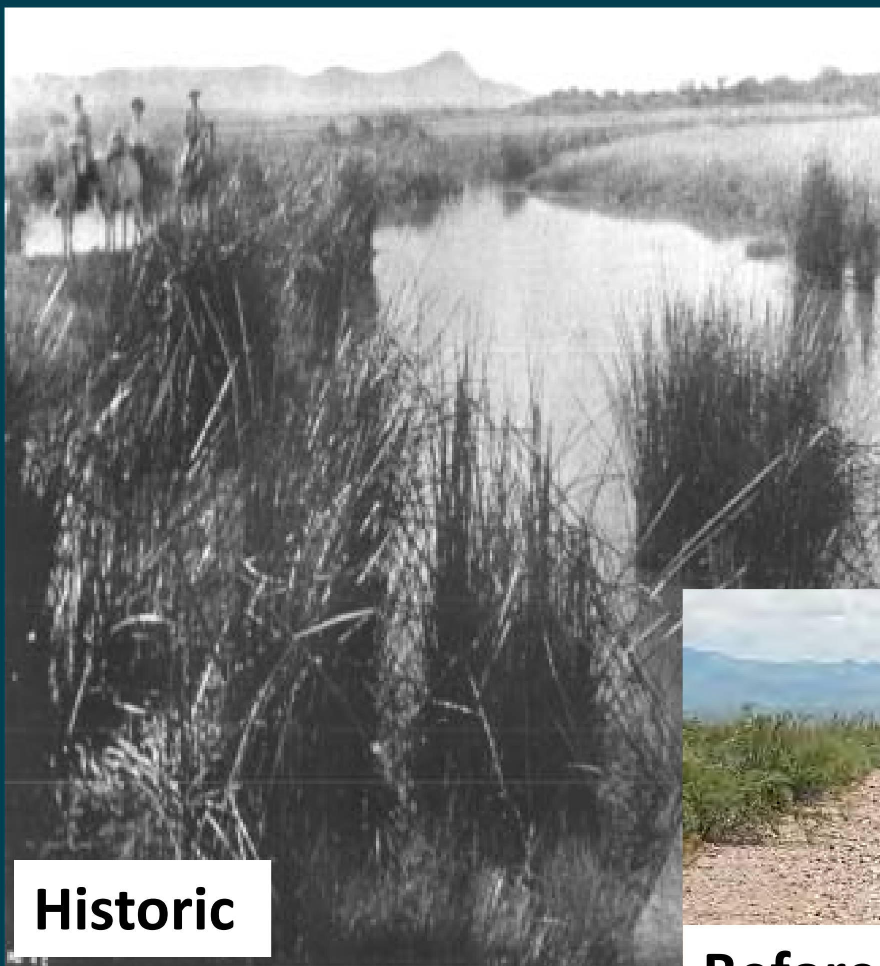
Navajo Nation Chilchinbeto Trincheras

Sedimentation

Installation of LID for Restoration Examples

Rio San Bernardino Headwaters Restoration & Recharge

Cuenca los Ojos http://cuencalosojos.org/

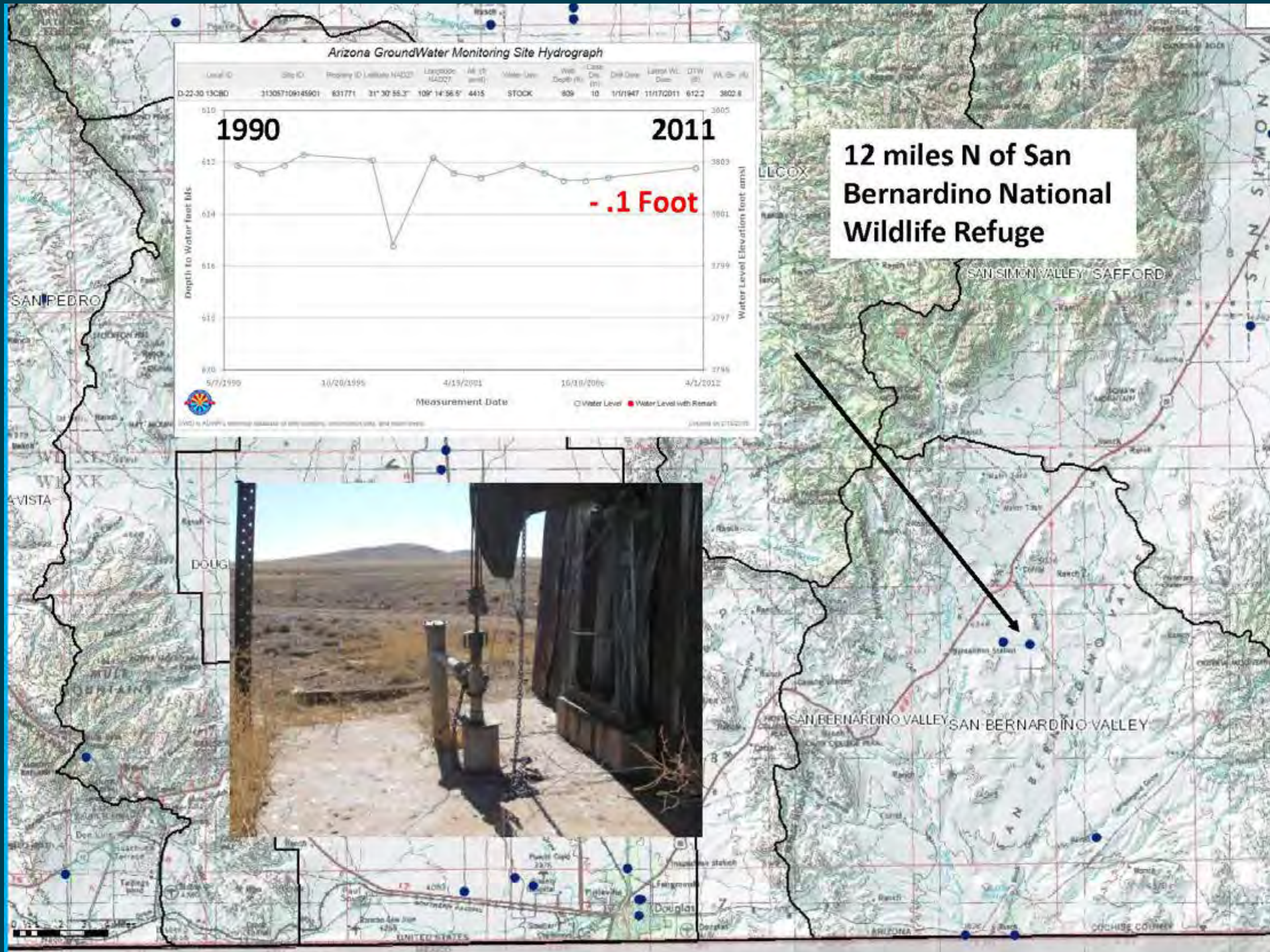


LID Installation Examples

Installation of LID for Restoration Examples

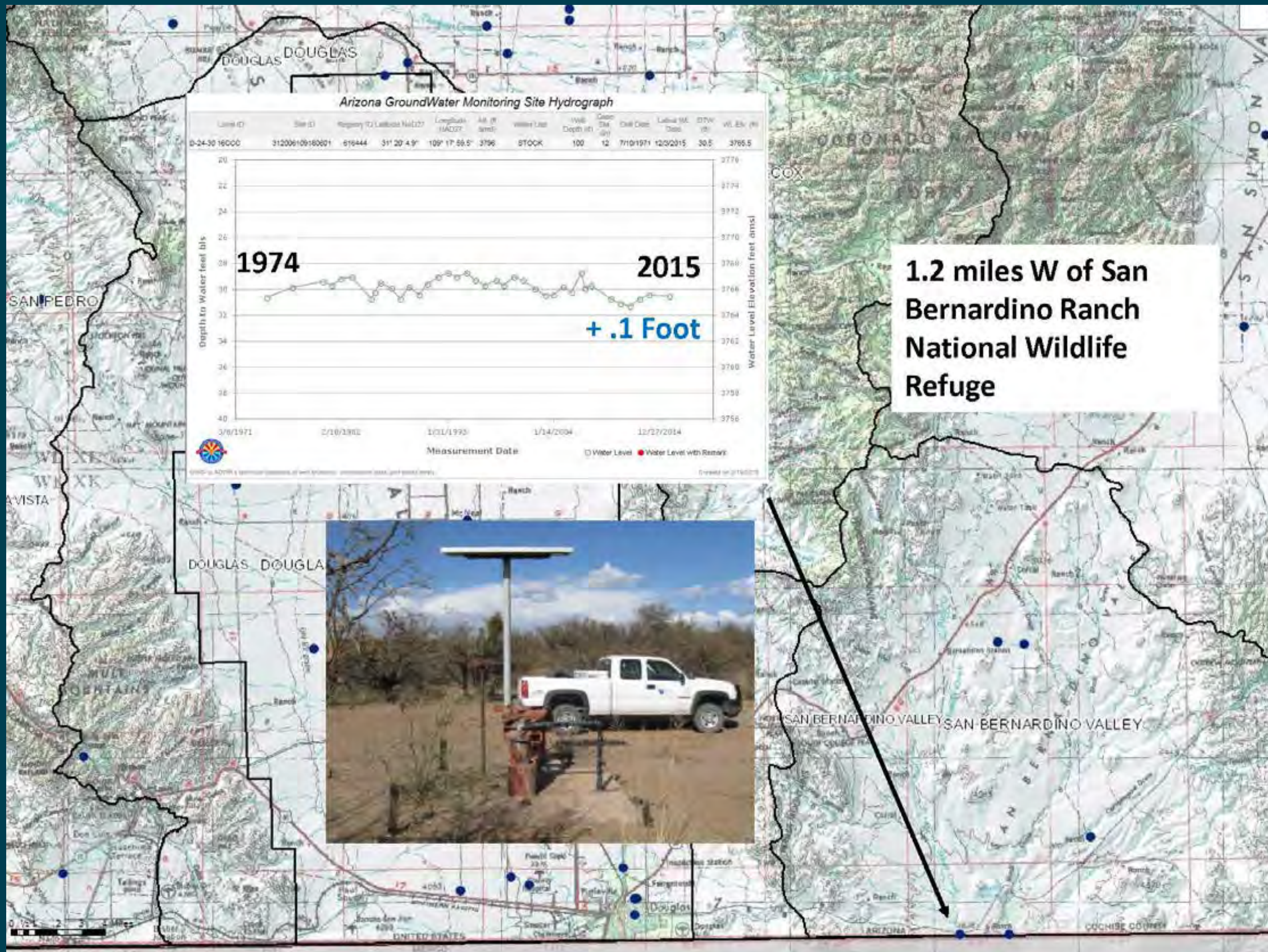
Rio San Bernadino Headwaters Restoration & Recharge

Installation of LID for Restoration Examples
Rio San Bernardino Headwaters Restoration & Recharge



Installation of LID for Restoration

Rio San Bernardino Headwaters Restoration & Recharge



LID and Watershed Management USGS Research

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Remote sensing analysis of riparian vegetation response to desert marsh restoration in the Mexican Highlands

Laura Norman[a,*], Miguel Villarreal[a], H. Ronald Pulliam[b], Robert Minckley[c], Leila Gass[a], Cindy Tolle[d], Michelle Coe[e]

RIVER RESEARCH AND APPLICATIONS

River Res. Applic. (2015)

Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/rra.2895

HYDROLOGIC RESPONSE OF STREAMS RESTORED WITH CHECK DAMS IN THE CHIRICAHUA MOUNTAINS, ARIZONA

L. M. NORMAN[a*], F. BRINKERHOFF[b], E. GWILLIAM[c], D. P. GUERTIN[d], J. CALLEGARY[b], D. C. GOODRICH[e], P. L. NAGLER[f] AND F. GRAY[g]

Ecohydrology & Hydrobiology

journal homepage: www.elsevier.com/locate/ecohyd

Original Research Article

Model analysis of check dam impacts on long-term sediment and water budgets in Southeast Arizona, USA

Laura M. Norman[a,*], Rewati Niraula[b]

USGS Research Monsoon Season 2013

Control: Rock Creek

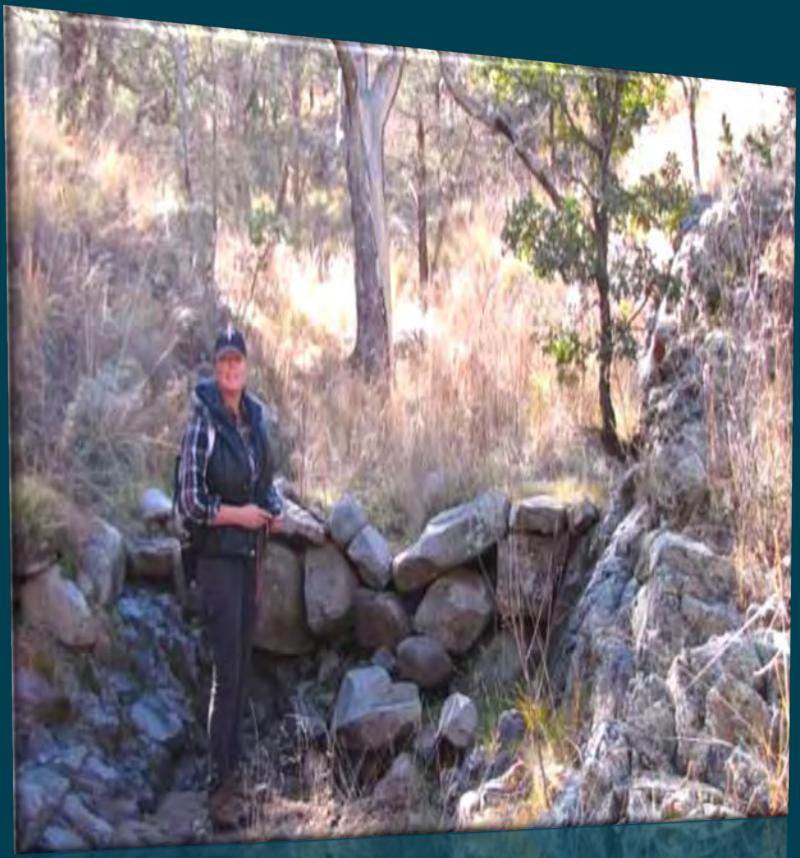
- 24.1 km^2
- 2,404.9 ha
- 5,942.7 acres

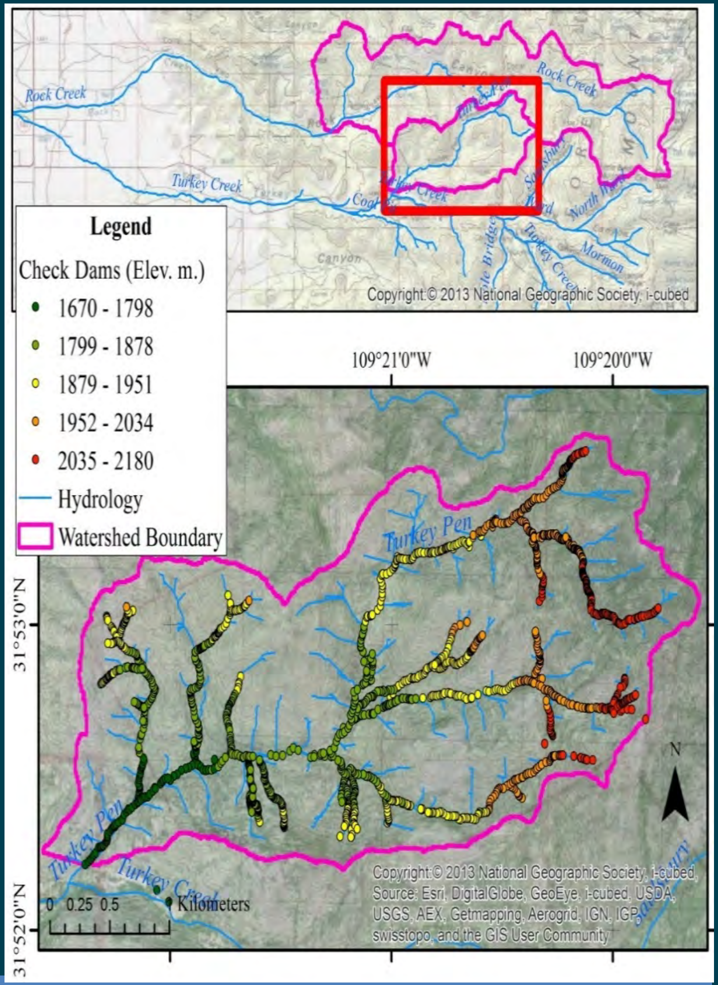
Treated: Turkey Pen

- 7.7 km^2
- 769 ha
- 1,900 acres

USGS science for a changing world
Land Change Science Program

USGS LID Research Results

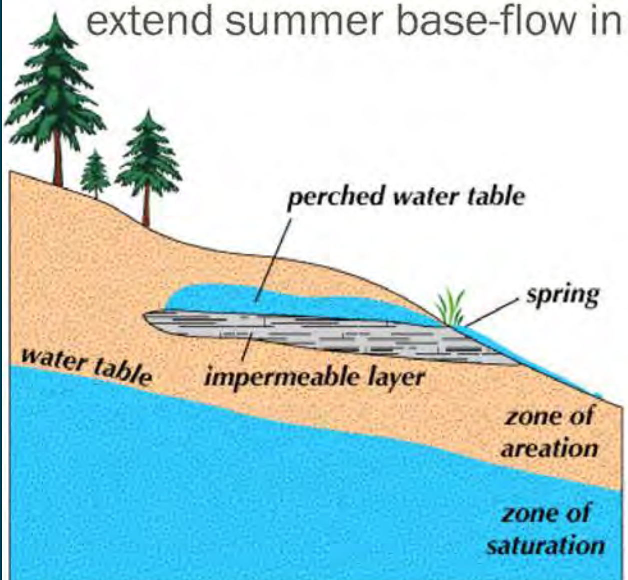




Mapped **1,579** check dams using GPS; The paired sub-watersheds portray one Treated and one Control, where Turkey Pen (769 ha) has >2000 check dams and the adjacent Rock Creek (2405 ha) has none.

USGS LID Research Results

- ✓ The rock detention structures reduce the average rate of flow by more than half.
- ✓ The treated watershed has ~28% more flow volume than the untreated watershed.
- ✓ Management using check dams can extend summer base-flow in arid lands.



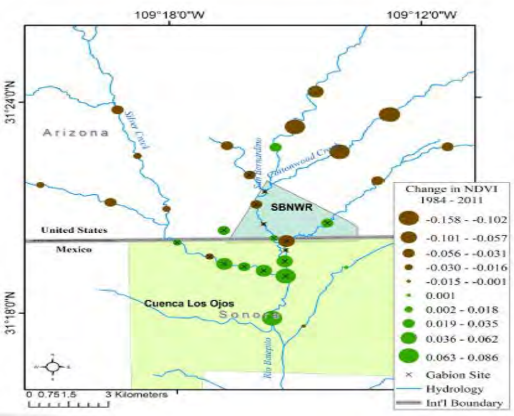
	Untreated/Control (RC)		
	Q Volume (Total Cubic Meters)	Precipitation (Monthly total * Watershed Size, in Cubic Meters)	% Runoff
July	12,959	3,878,490	0.33
August	58,139	3,468,960	1.68
September	34,264	1,011,780	3.39
October	1,720	0	0
	Treated (TP)		
	Q Volume (Total Cubic Meters)	Precipitation (Monthly total * Watershed Size, in Cubic Meters)	% Runoff
July	0	1,238,090	0
August	18,561	1,107,360	1.68
September	27,560	322,980	8.53
October	855	0	0

Norman, L. M., Brinkerhoff, F., Gwilliam, E., Guertin, D. P., Callegary, J., Goodrich, D. C., Nagler, P.L., and Gray, F. (2015). Hydrologic Response of Streams Restored with Check Dams in the Chiricahua Mountains, Arizona. *River Research and Applications*, http://doi.org/10.1002/rra.2895

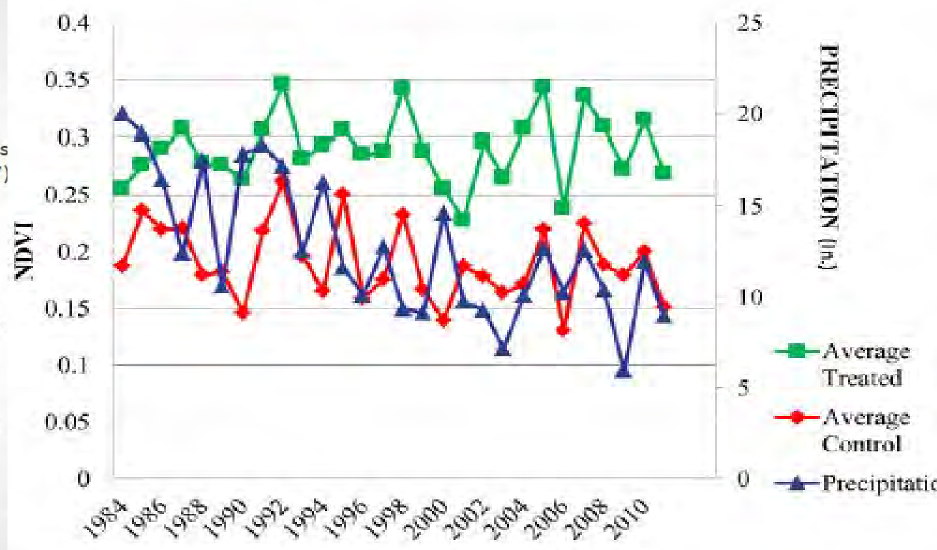
USGS Research LID and Vegetation Changes

Analysis & Results

Normalized Difference Vegetation Index (NDVI)



- Satellite Imagery: Multispectral Landsat Thematic Mapper (TM) images (30 m) for the years 1984-2011 (n = 27) from either May or June (a generally dry period)
- A ratio of reflectance in the near infrared (NIR) and red spectral bands was applied: NDVI = (NIR band – Red band) / (NIR band + Red band), where resulting values range from -1 to +1.
- We extracted the mean NDVI values (for each year) for all 30 m pixels contained in the buffer strips (treated and control) and used results as a proxy for plant biomass.
- We compared changes in vegetation greenness around the gabions and control points over time.



Norman, L. M., Villarreal, M. L., Pulliam, H. R., Minckley, R., Gass, L., Tolle, C., & Coe, M. (2014). Remote sensing analysis of riparian vegetation response to desert marsh restoration in the Mexican Highlands. Ecological Engineering, 70C, 241–254. doi:10.1016/j.ecoleng.2014.05.012

Installation of LID for Restoration ARS Santa Rita Experimental Station

RESEARCH SECTION

doi:10.2489/jswc.69.5.414

Effect of check dams on runoff, sediment yield, and retention on small semiarid watersheds

V.O. Polyakov, M.H. Nichols, M.P. McClaran, and M.A. Nearing

often employed across large areas. For example, sediment trapped by check dams built since the 1960s created a substantial amount of land area (68,000 ha [168,031 ac]) in the Yellow River basin (Xu 2005).

Check dams have been shown to be an effective sedimentation mitigation technique. A 4.5-fold reduction of sediment yield from a 826 km^2 (513 mi^2) watershed in southeast Spain was reported after installation of 400 check dams in an effort to reduce reservoir sedimentation (Romero-Diaz et al. 2007). A

Catena 98 (2012) 104–109

Contents lists available at SciVerse ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

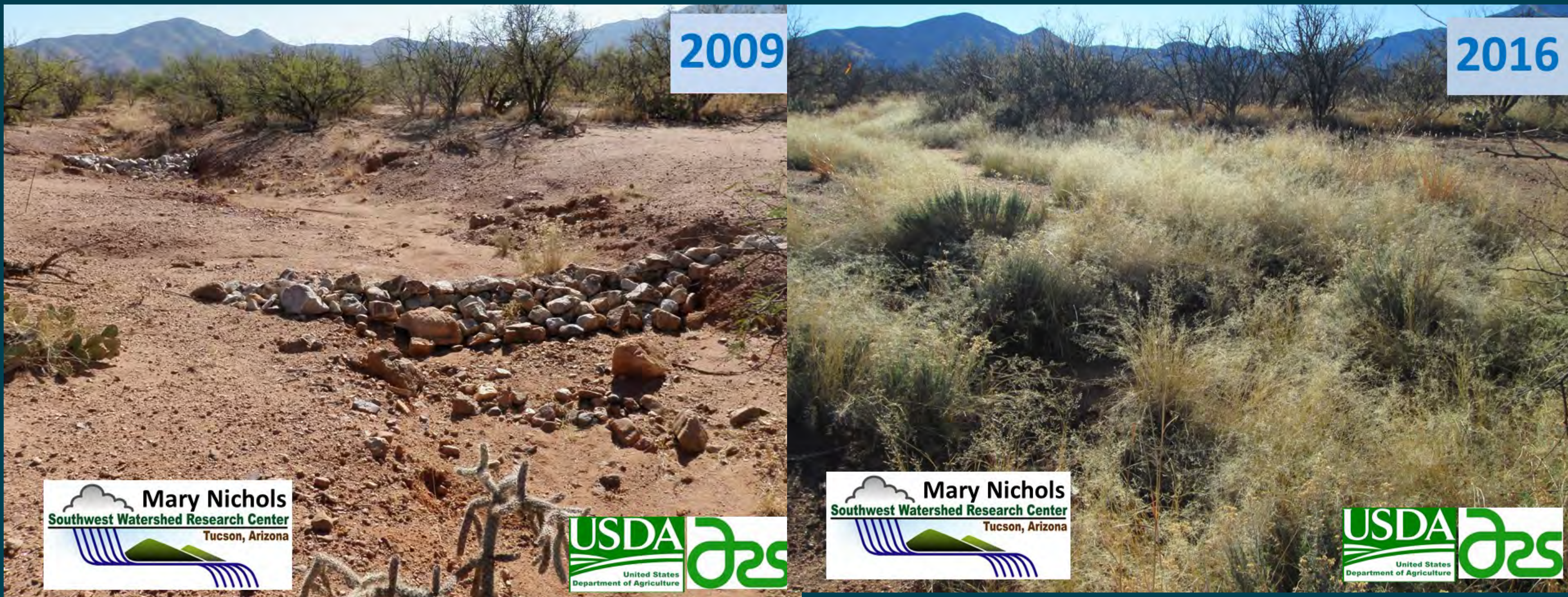
ELSEVIER

Short-term soil moisture response to low-tech erosion control structures in a semiarid rangeland ☆

M.H. Nichols [a,*], K. McReynolds [b], C. Reed [c]

[a] USDA Agricultural Research Service, Southwest Watershed Research Center, Tucson, AZ, USA
[b] University of Arizona Cooperative Extension, Willcox, AZ, USA
[c] University of Arizona, AZ, USA

USDA Research
Santa Rita Research Station



GCS research conducted by the U.S. Department of Agriculture–Agricultural Research Service (USDA-ARS) includes pre- and post-installation monitoring which provides a great foundation to build on; however, there is “lack of (and need for) data to quantify their (GCS) impacts” (Nichols, M.H., et al., 2012).

Bureau of Reclamation – S&T

RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Research & Development Office | Science & Technology Program

FY 2017 Proposal Submission Form

TITLE

The project title should be descriptive enough so that someone not familiar with the project will understand the objective of the work and any location information about where the work is conducted.

Impacts of Grade Control Structure Installations on Hydrology and Sediment Transport as an Adaptive Management Strategy during Climate Change

Impacts of Grade Control Structures Study Partners

The Nature Conservancy

Arizona Department of Water Resources EST. 1980

Forest Service U.S. Department of Agriculture

Flood Control District of Maricopa County

U.S. Fish & Wildlife Service

U.S. Department of the Interior Bureau of Reclamation

The Hopi Tribe

USDA United States Department of Agriculture ARS

Maricopa County Parks and Recreation Department

USGS science for a changing world Land Change Science Program

PAG Pima Association of Governments

Boy Scouts of America

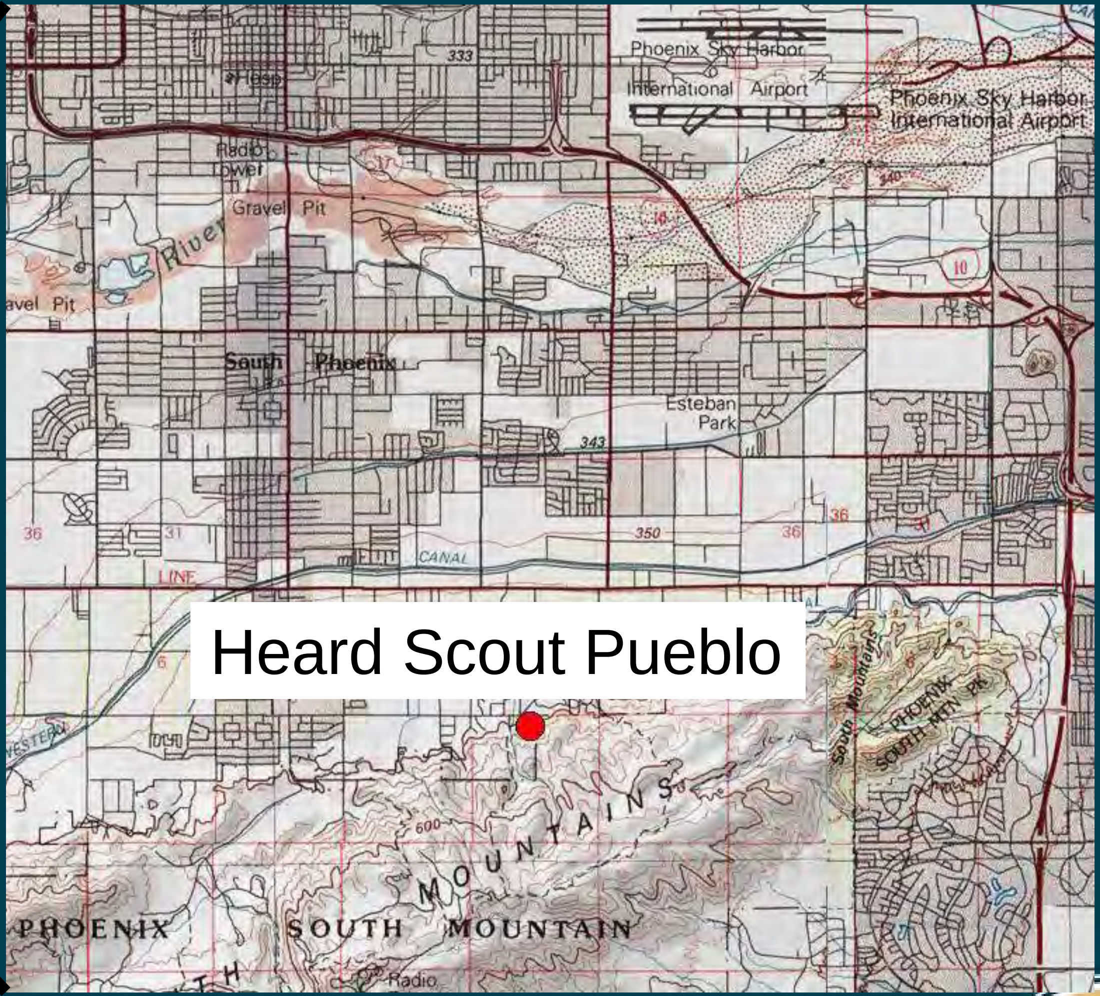
AZGS

Northern Arizona University

Impacts of Grade Control Structures Study Details

- Reclamation's Science and Technology Program
  - http://www.usbr.gov/research/programs/science-technology/
- S&T 1751 from FY2017 through FY2019 – extended through FY2020
  - 3 year research project
  - 1 year pre-GCS installations
  - 2 years post-GCS installations
  - Assess impacts to ephemeral drainage

HSP LID/GCS Research
Boy Scouts of America, Heard Scout Pueblo



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GRAND CANYON COUNCIL

HSP LID/GCS Research
Heard Scout Pueblo Ephemeral Channels

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HSP LID/GCS Research Boy Scouts of America, Heard Scout Pueblo

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EXPLANATION

○ **WS** — WeatherHawk Station locations. These weather stations collect air temperature, barometric pressure and precipitation. **WS-N**, north location

□ **SW** — USGS Surface Water monitoring location
Go to https://water.usgs.gov/osw/data.html and use 332153112022300 to search "Unnamed Creek at Heard Scout Pueblo Near Phoenix"
SW-USGS Station 332153112022300
SW-DS, Downstream pressure transducer to calculate stream elevation
SW-US, Upstream pressure transducer measures stream height to calculate stream elevation

△ **HSP** — Heard Scout Pueblo groundwater monitor well location
HSP-1 ADWR Well Registry 55-227363 Cased to 50 feet, below land surface (ft, bls);
HSP-2 ADWR Well Registry 55-227500 Cased to 20 ft, bls; has six soil moisture sensors attached from 3 to 20 ft, bls;

■ **USGS** — Housing for surface water monitoring equipment

● **SC** — US Geological Survey (USGS) Sediment Chain location, used to monitor sediment transport conditions

U.S. Department of the Interior
Bureau of Reclamation
Science & Technology Program

Hydrologic Research Pre- and Post-Grade Control Structure Installations

Hydrologic monitoring is being conducted at the Heard Scout Pueblo site under Science and Technology Program study #1751

Impacts of Grade Control Structure (GCS) Installations on Hydrology and Sediment Transport as an Adaptive Management Strategy

ONE ROCK DAM
= 1 rock high + uniform surface

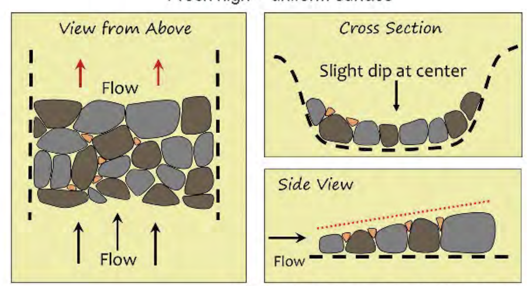

Illustration Credit: Albuquerque Wildlife Federation

Grade Control Structure Installation

Photo Credit: Andy Bennett, Tucson Audubon

The study will assess the hydrologic impact of GCS installations on storm flows, soil moisture, and sediment transport. Hydrologic monitoring began in 2017. GCS installations are planned for 2018. Research results will be used to inform water management policy regarding techniques used to optimize integrative management of surface water, groundwater, and eco-hydrologic resources.

For more information: https://go.usa.gov/xQQNQ

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LID/GCS Research

Heard Scout Pueblo

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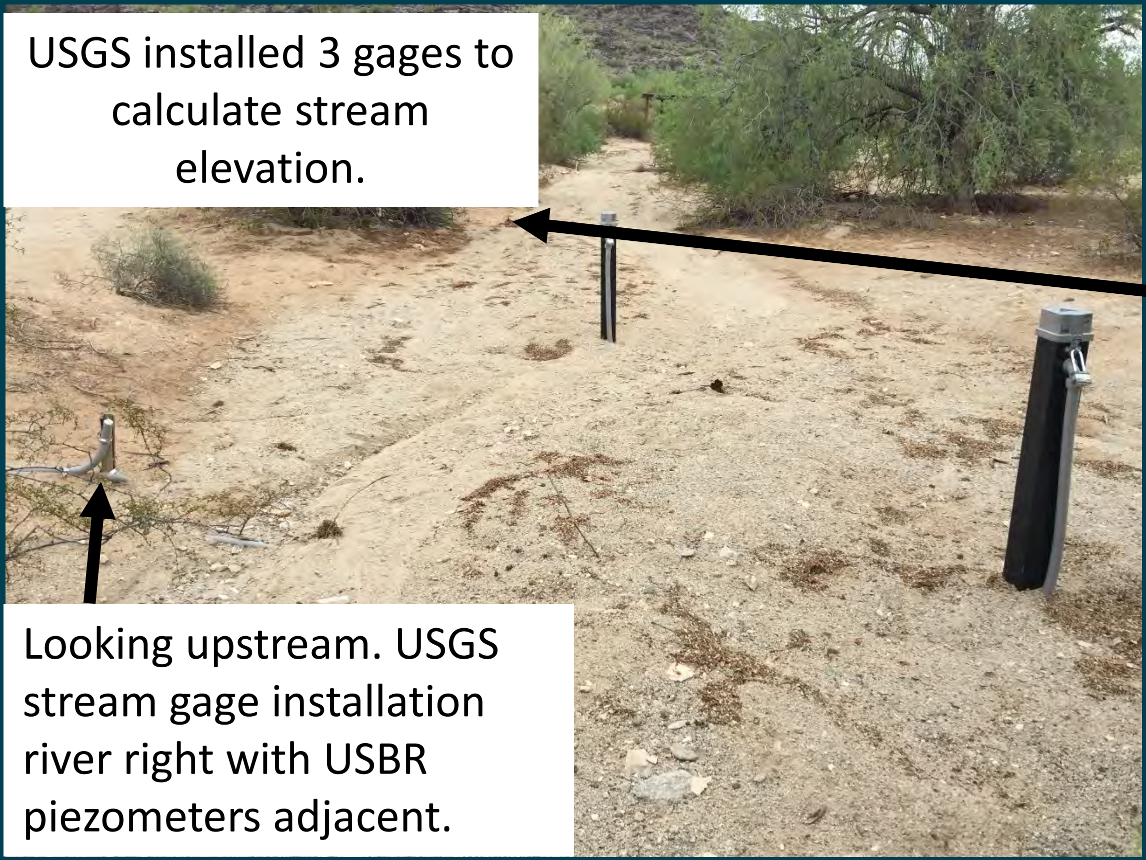
HSP LID/GCS Research
USGS Stream Gaging Station



USGS installed 3 gages to calculate stream elevation.

Looking upstream. USGS stream gage installation river right with USBR piezometers adjacent.

Upstream recording gage

Downstream recording gage

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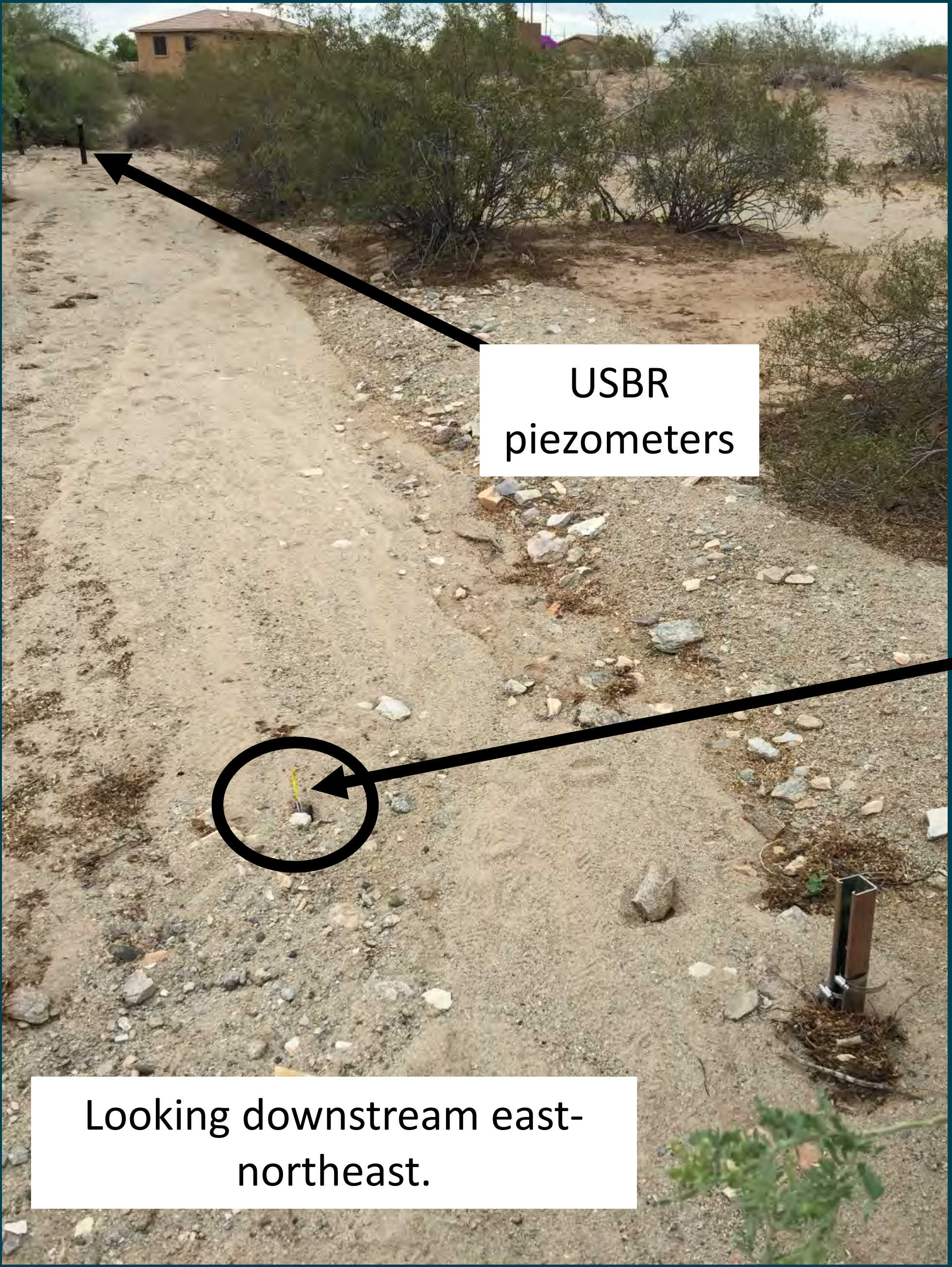
HSP LID/GCS USGS Sediment Scour Chain



USGS sediment scour chain

USGS upstream recording stream gage

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LID/GCS Research

Heard Scout Pueblo – Unmanned Aircraft Survey (UAS)

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HSP LID/GCS Monitor Wells

USBR Auger Drill Rig.

USBR LC Regional Geologist logging cuttings.

USBR Drill Crew

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HSP LID/GCS Monitor Wells

Looking south-southwest. Drill rig, Surface Water and Weather Stations.

USGS Stream Gage Station.

WeatherHawk Weather Station – North.

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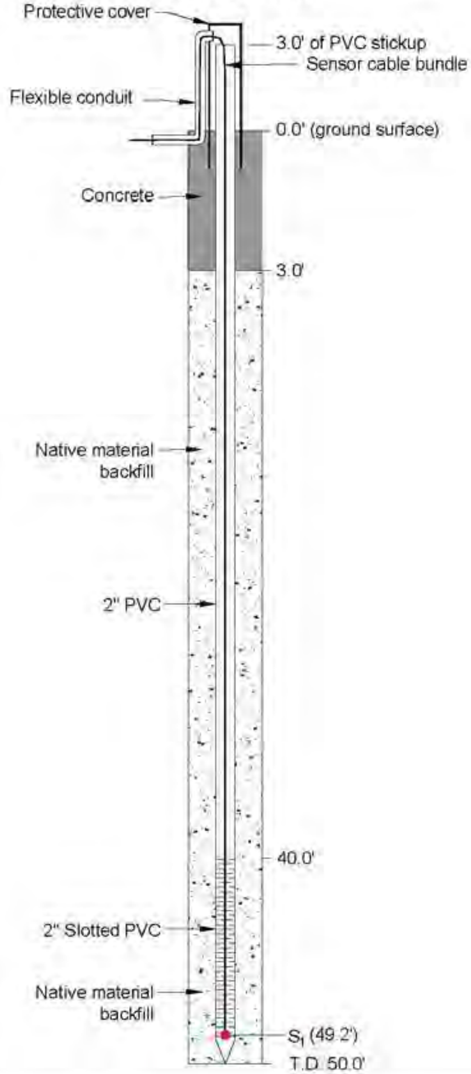
GEOLOGIC LOG OF DRILL HOLE NO. DH-HSP-1

FEATURE: GRADE CONTROL STRUCTURES
LOCATION: WASH
BEGUN: 7/7/2017 FINISHED: 7/7/2017
DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED: DRY

PROJECT: HEARD SCOUT PUEBLO
COORDINATES: N. E.
NAD83, AZ STATE PLANE GRID, EAST ZONE
TOTAL DEPTH: 20.5'
DEPTH TO BEDROCK: N/A

STATE: ARIZONA
GROUND ELEVATION (NAVD88):'
ANGLE FROM HORIZONTAL: 90°
LOGGED BY : M. MILLER
BUREAU OF RECLAMATION

HOLE COMPLETION

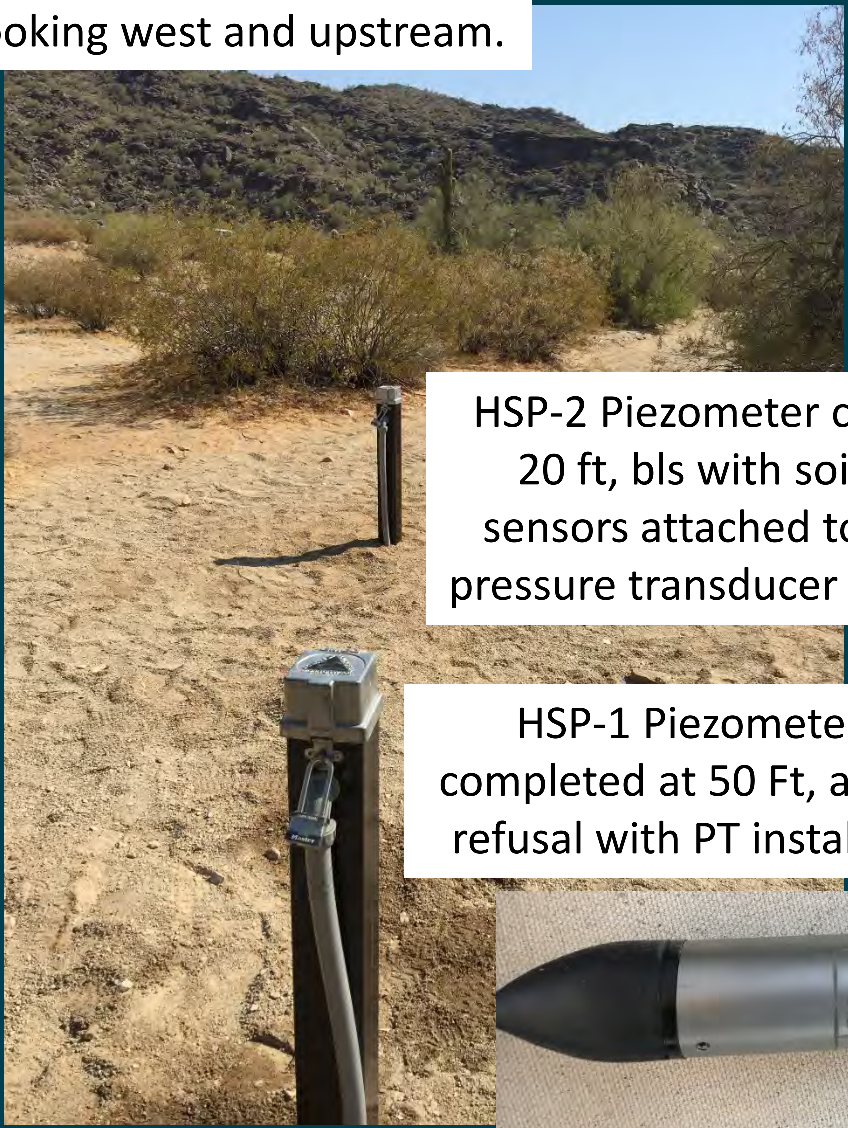


COMMENTS:
All measurements are from ground surface unless otherwise noted.

BOY SCOUT
GRAND CANYON

HSP LID/GCS Monitor Wells

Looking west and upstream.



HSP-2 Piezometer completed at 20 ft, bls with soil moisture sensors attached to casing and pressure transducer (PT) installed.

HSP-1 Piezometer completed at 50 Ft, auger refusal with PT installed.

Looking south.

USGS Stream Gage Station.

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HSP LID/GCS Weather Stations

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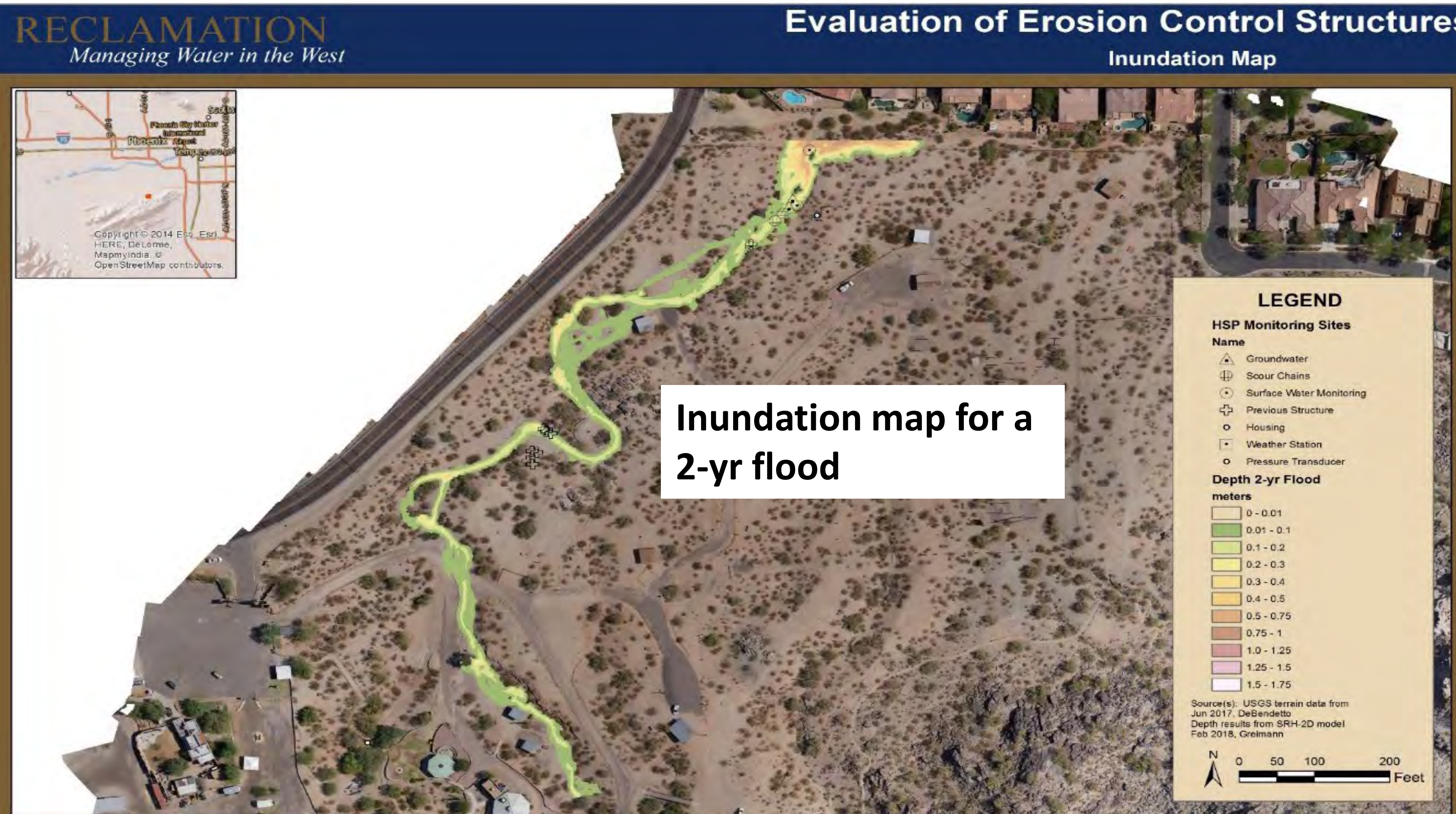
HSP LID/GCS Research
Reclamation Modeling



Inundation map for a 2-yr flood

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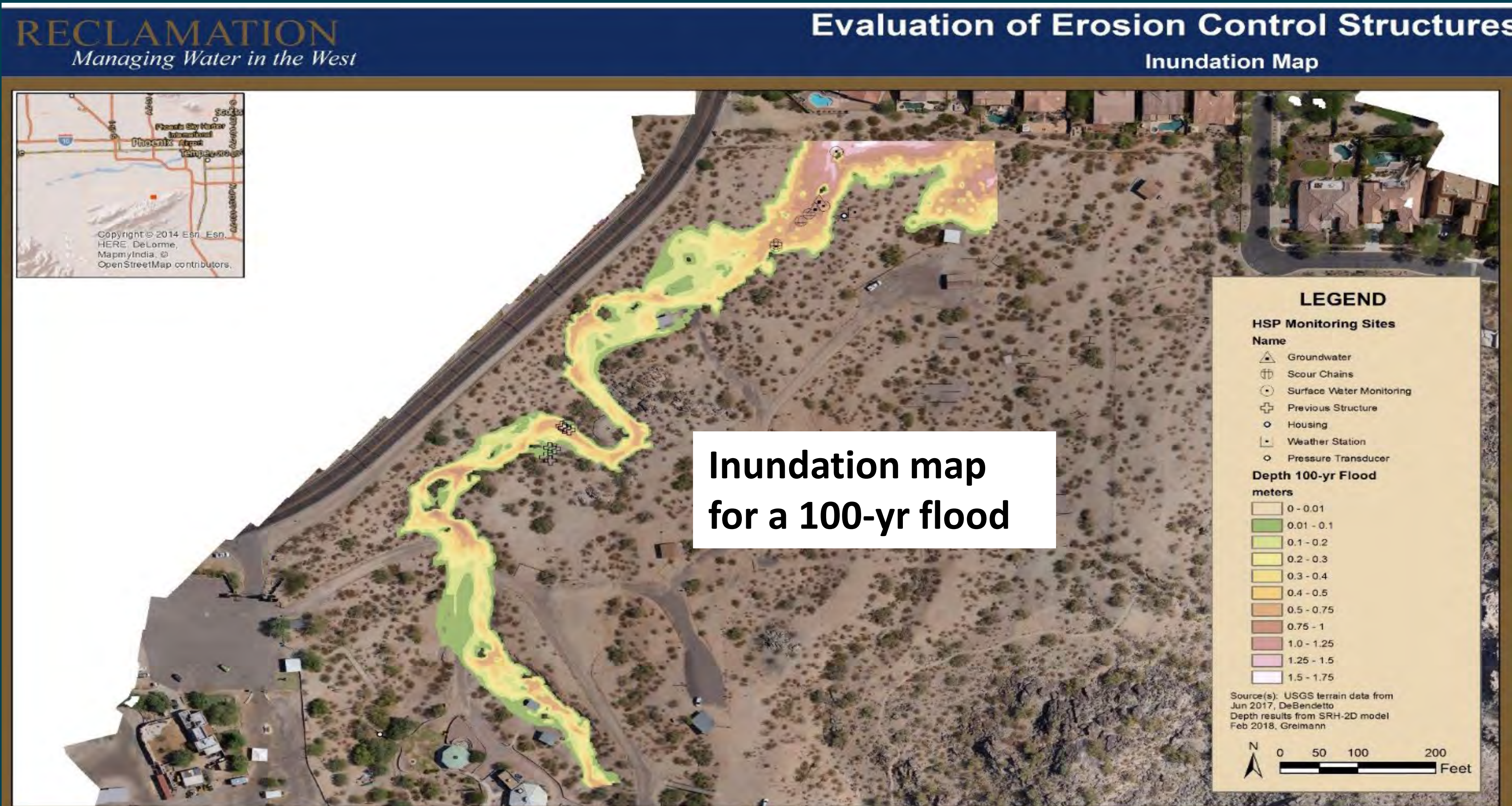
GRAND CANYON COUNCIL

HSP LID/GCS Research
Reclamation Modeling



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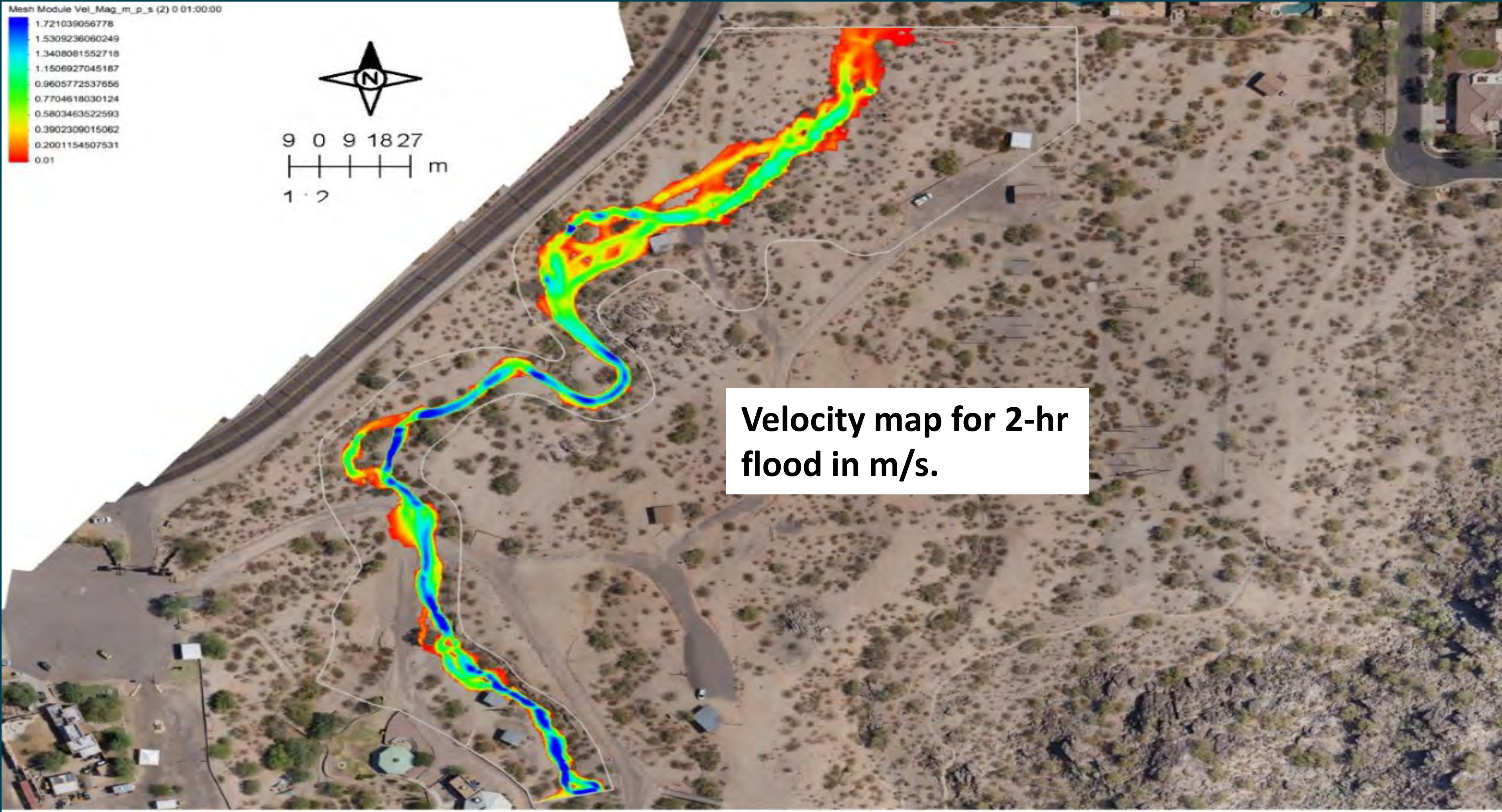
GCS Research
Reclamation Modeling



Velocity map for 2-hr flood in m/s.

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RECLAMATION

Managing Water in the West

Evaluation of Erosion Control Structures

Proposed Grade Control Structure Layout

last revised: February 6, 2018 by Sedimentation and River Hydraulics Group

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HSP LID/GCS Research

Reclamation procurement:

- Natural Channel Designs Inc.
- Installed GCS's at HSP December 2018
- Monitor through 9/30/2020

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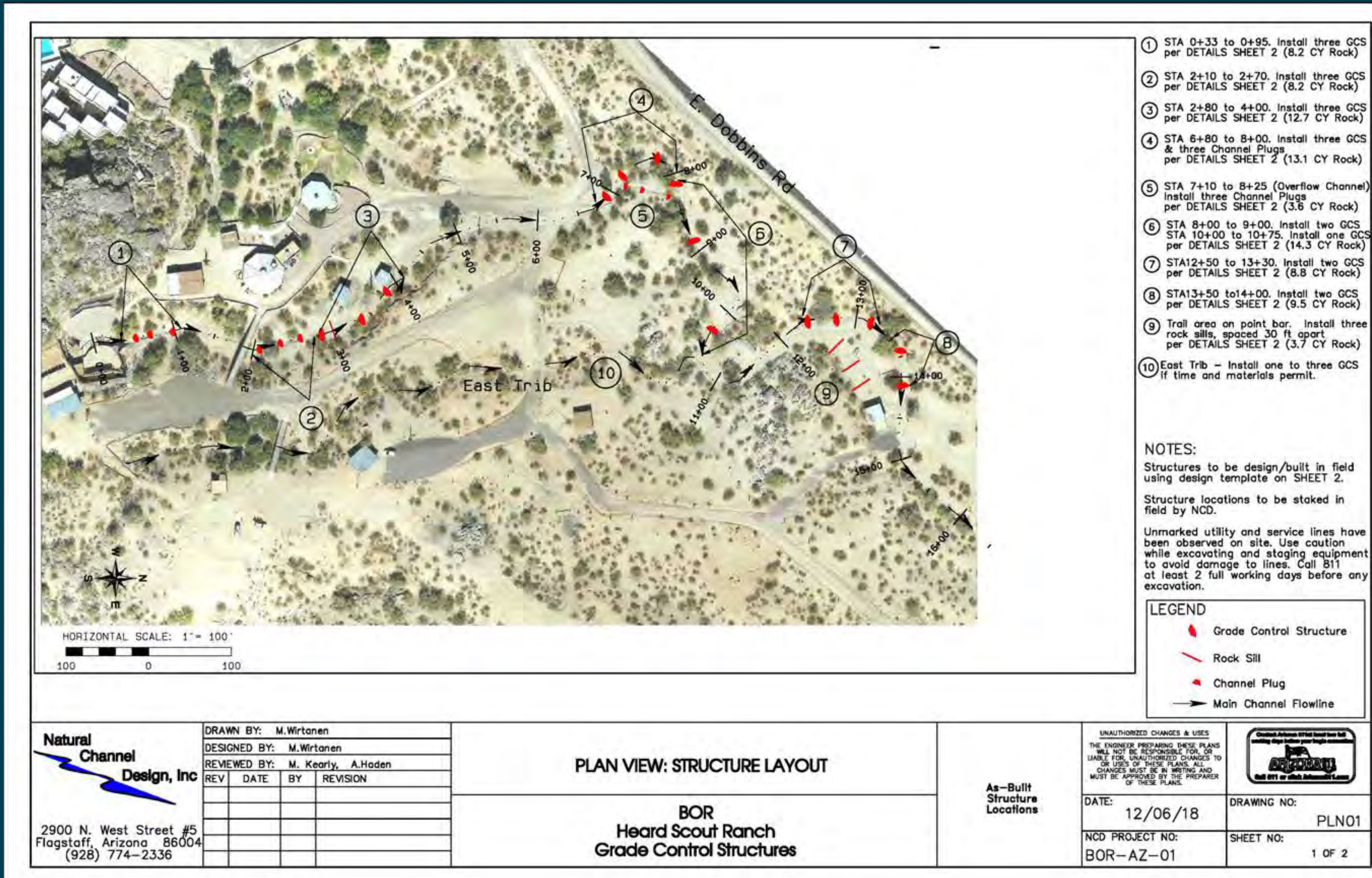
HSP LID/GCS Research



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BOR Heard Ranch GCS

- Project ~1800 ft long
- Reaches broken out based on average stream slope and presence of incoming tributaries
- The number of structures in each reach and approximate spacing was based upon methods outlined in an Army Corp paper: Design Considerations for Siting Grade Control Structures.

NSS - WS area = 0.1 sq mi	Return Interval (year)	Q (cfs)
	1.5	14
	2	20
	5	41
	10	60
	25	90
	50	113
	100	136

- Watershed area appx. 70 acres. Design goal was to maintain the channel capacity of the 2 yr flow event (20 cfs) before water flowed out onto the floodplain.
- Cross sections were created in each reach utilizing topography provided by BOR. Each cross section was modeled utilizing a cross section hydraulic analyzer developed by the NRCS to ensure channel would maintain the design capacity.
- Rock sizing was calculated following the Shields relation and modified using Colorado field data gathered by Dave Rosgen. Design discharge was the 25 year flow event (approximately 90 cfs). A 12 inch average size rock was determined to be needed.
- Grade control structure design is a hybrid of a rock cross vane weir designed by Dave Rosgen, and a one-rock dam developed by Bill Zeedyk. Based on the potential flows this channel can receive, a more substantial design was needed to prevent bed and bank scour. The cross vane weir is designed to protect banks by reducing flow velocities along the bank and focusing energy towards the center of the channel.
- Actual structure location was determined in the field based on channel shape, presence of scour or bank erosion and vegetation.

HSP LID/GCS Research

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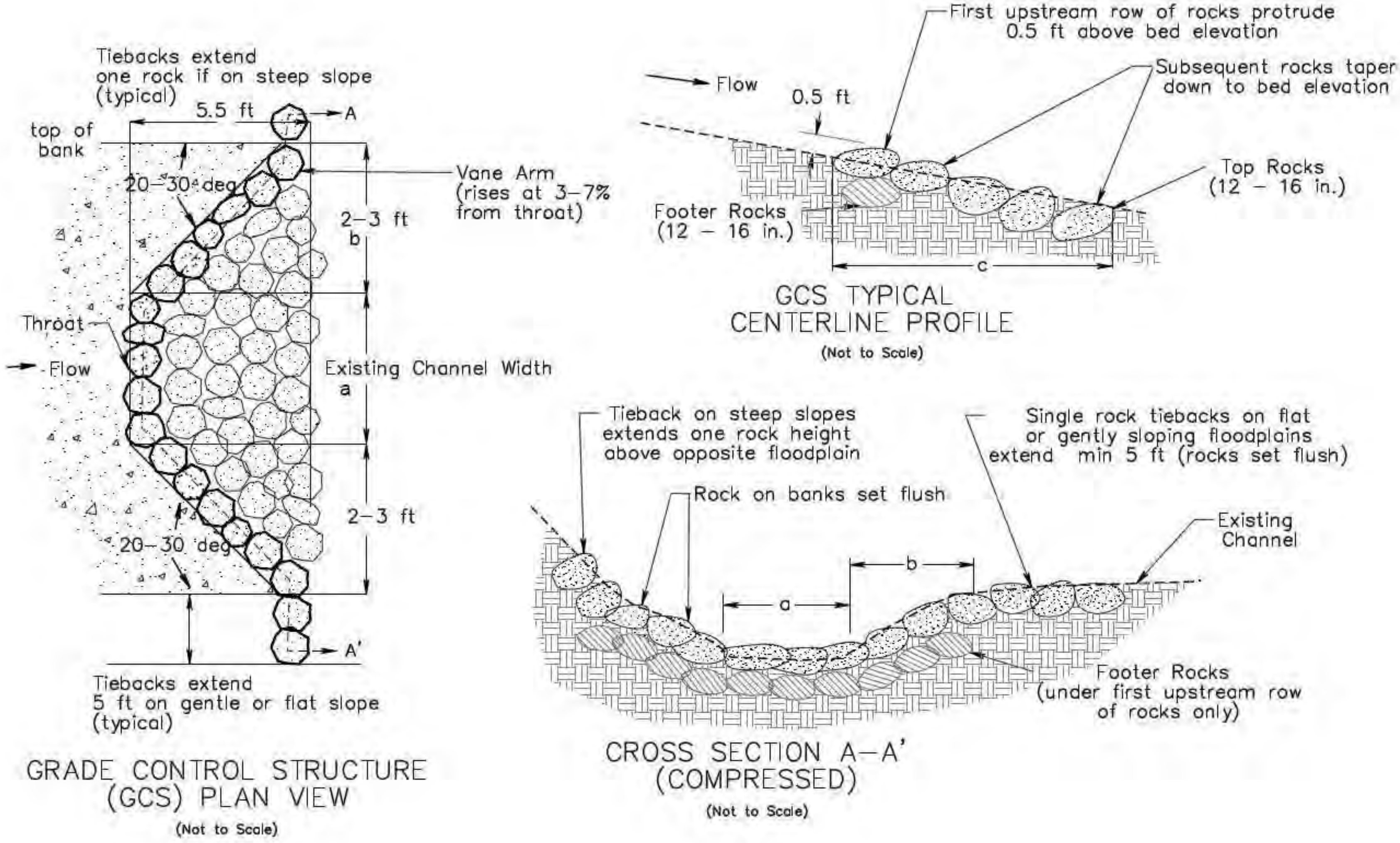
HSP LID/GCS Research Installations



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HSP LID/GCS Research Installations

American Conservation Experience (ACE) staff

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Identifying Key Areas in the City of Phoenix for Stormwater Infiltration & Retention using Low Impact Development

Partner Agencies and Organizations:

Bureau of Reclamation

City of Phoenix

The Nature Conservancy

Flood Control District of Maricopa County

Maricopa County Air Quality Department

The Nature Conservancy
Protecting nature. Preserving life.

LID Floodplain - Study Details

- **Special Study**
  - – utilize existing data
  - – GIS spatial analysis
  - – surface water model
- **Duration: 3-years**
  - – start May 2018
- **Cost-share:** 50% non-federal and 50% federal

LID Floodplain Study
Auxiliary Staffing

Reclamation – Denver Technical Services Center for modeling

TNC – Contractor to assist with data compilation, modeling support, and framework for future use

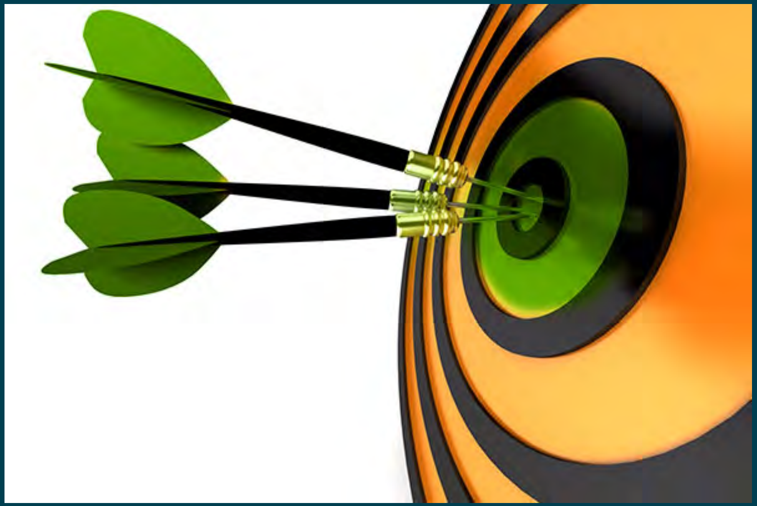
COP – Contractor to supplement work on all Study tasks

ASU – Knowledge Exchange for Resilience Fellowship for literature review and shepherding prioritization methodology

LID Floodplain Study - Objectives

Identify areas with:

- Favorable conditions for LID
- Potential for improving:
  - Water conservation
  - Flood risk
  - Air and water quality
  - Urban heat



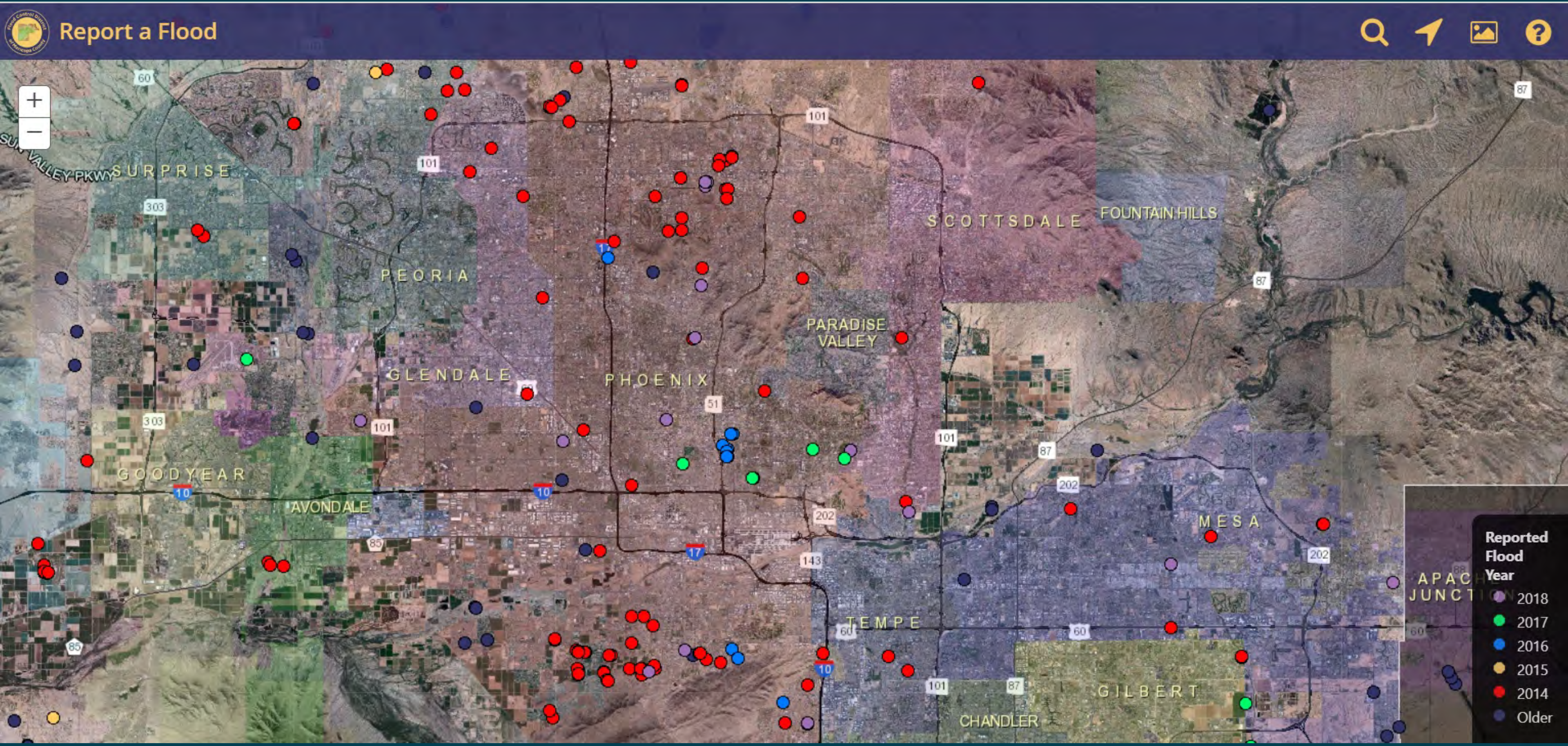
Determine:

- Repeatable approaches to optimize stakeholder-identified benefits: water conservation, infiltration, urban heat, and air and water quality.

LID Floodplain Study
Phoenix Flood September 2014

Michael Chow/The Arizona Republic/AP Photo

LID Floodplain Study
Localized Flooding

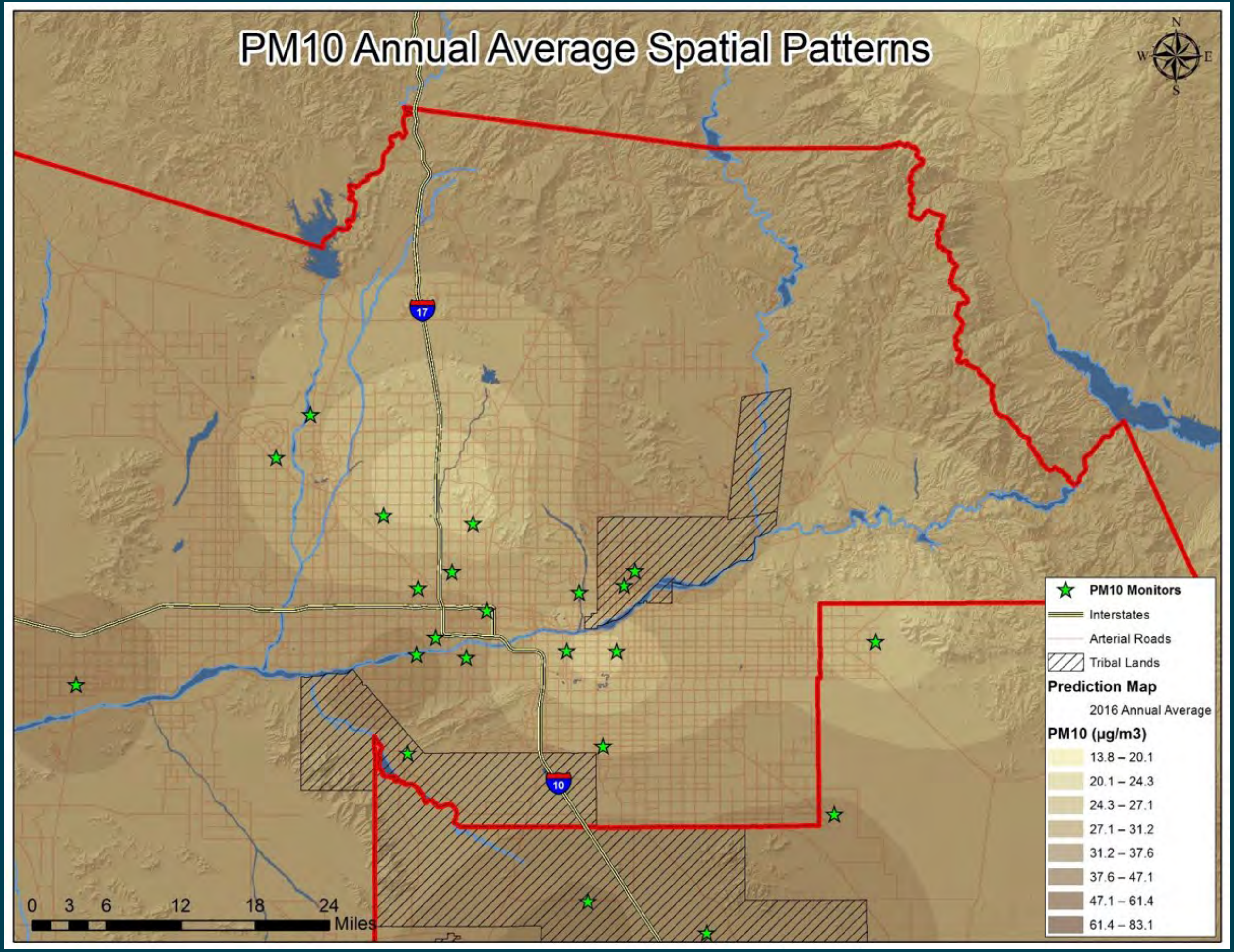


FCDMC, 2018

LID Floodplain Study

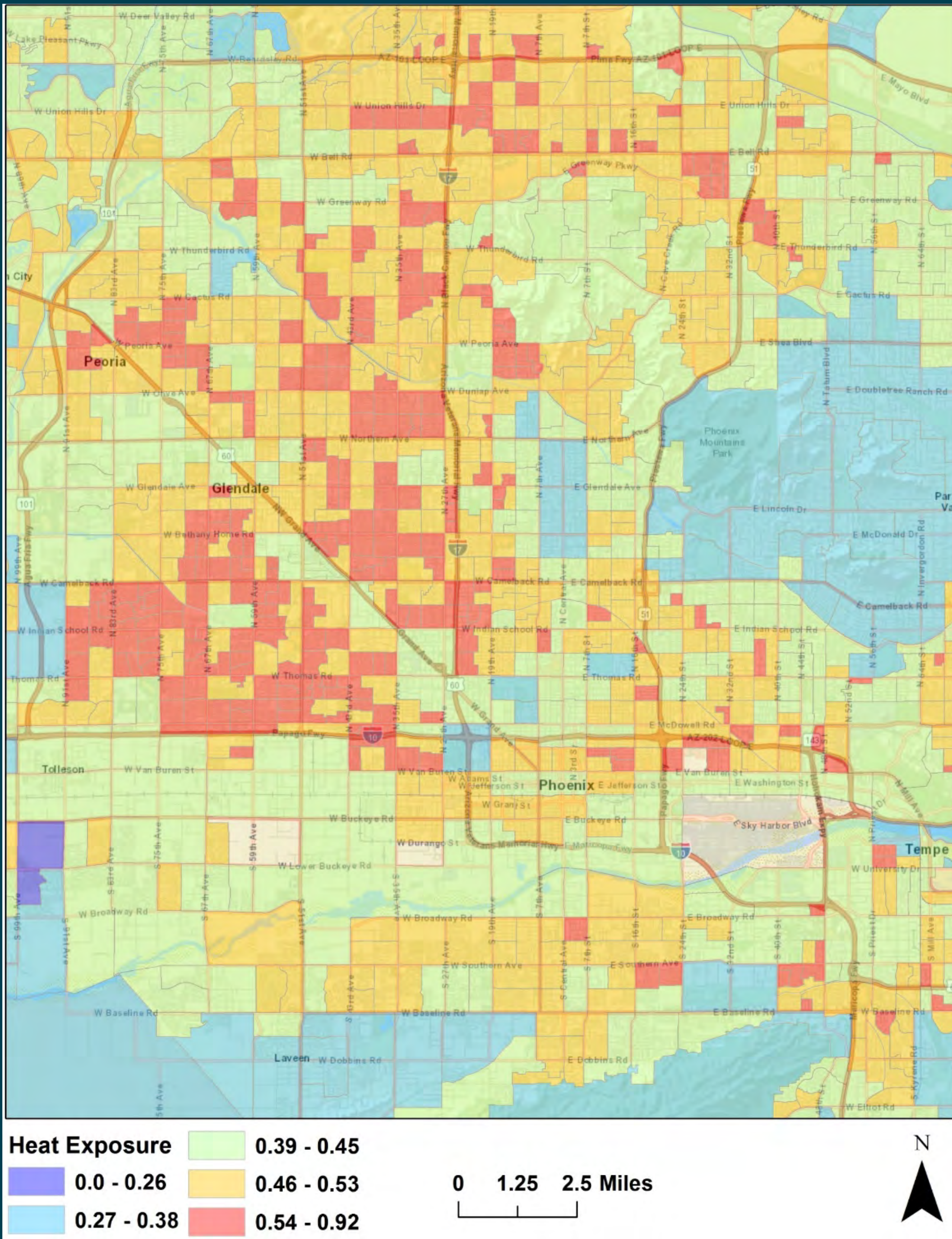
Air Quality: Annual Particulate Matter <10 microns (PM_{10})

Phoenix Metropolitan Region



MCAQD, 2018

LID Floodplain Study
Urban Heat



Heat Exposure – temperature plus population density.

Urban Resilience to Extremes Sustainability Research Network 2018

LID Floodplain Study
Problem Statement

The identified need is to prioritize the implementation of Low Impact Development (LID) / Green Stormwater Infrastructure (GSI) to produce multiple, quantifiable benefits.

The objectives are:

1) identify areas to maximize GSI benefits, including increased stormwater infiltration, flood hazard mitigation, and water conservation; reduced urban heat island impacts, and improved air and water quality; and
2) provide the tools to make long-term decisions regarding placement of GSI through the development of a repeatable prioritization method.

LID Floodplain Study – Literature Review
Assessing Effectiveness

Hydrological Performance	Stormflow peak reductions, infiltration, water availability for irrigation/irrigation offsets.
Urban Heat	radiant and air temperature surface temperature
Air Quality	PM2.5 PM10 Ozone CO
Water quality	Metals (Lead, copper, zinc) e. Coli sediment transport reduction

LID Floodplain Study - LID Features

PCSWMM
https://www.pcswmm.com/

- Permeable Pavement
- Curb openings
- Sediment traps
- Stormwater harvesting basins
- Vegetated or rock swales
- Bioretention systems
- Curb extensions
- Bioretention planter
- Domed overflow structure
- Grade Control Structures
- Tree pits

LID Floodplain Study – LID Features

Permeable Pavers right-of-way

Vegetative Swales Rain Garden

Curb Cuts

City of Phoenix - Taylor Mall ASU
Walter Cronkite School of Journalism and Mass Communication

LID Floodplain Study - LID Features

Pervious concrete at Phoenix Manzanita Park Parking Lot

Curb Core for Street Run-off

Vegetative Swale – Primera Iglesia, Phoenix

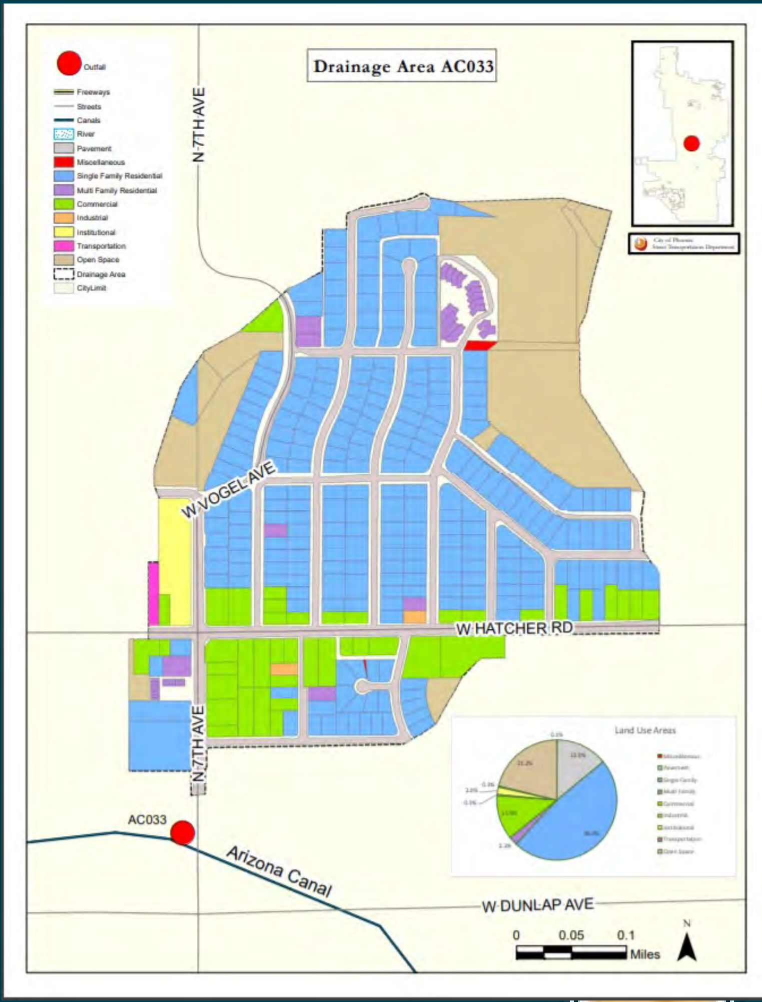
City of Phoenix

LID Study
GIS Catchment Suitability Analysis

Urban Catchment Definition

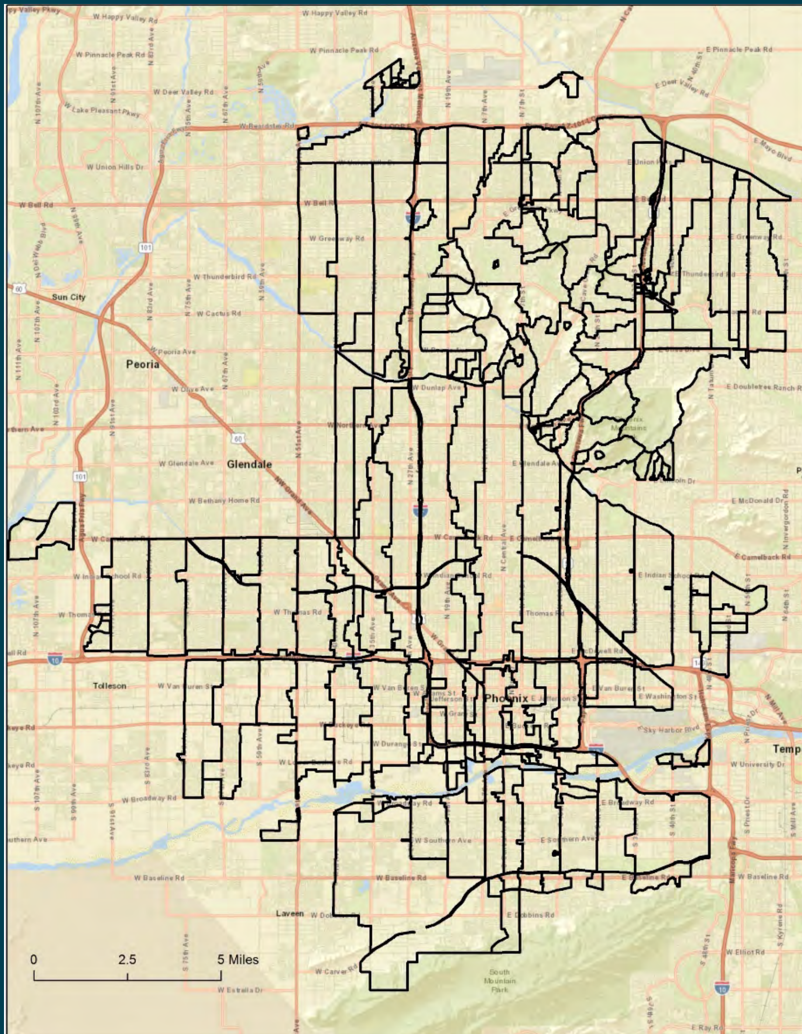
An area of land from which all rainwater drains, overland or through pipes and drainage networks, toward a body of water.

Also known as an urban basin, urban watershed, drainage area, or stormwater drainage system.



City of Phoenix

LID Floodplain Study
GIS Catchment Suitability Analysis



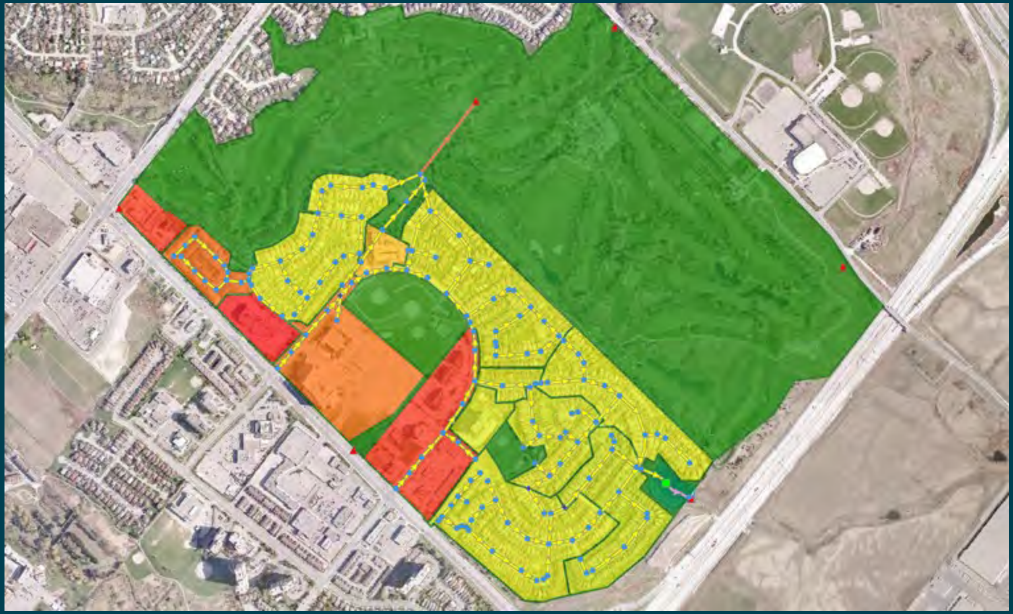
City of Phoenix

GIS Spatial Analysis:
Identify suitable COP stormwater catchments with most potential to improve:

- storm flow management
- infiltration
- urban heat conditions
- water and air quality

LID Floodplain Study
PCSWMM – Personal Computer Stormwater Management Model

PCSWMM:
- used for master planning
- provides quick analysis of multiple LID's and treatment areas
- compares hydrologic and water quality benefits of LID scenarios
- scenario comparison tools



PCSWMM; https://www.pcswmm.com/

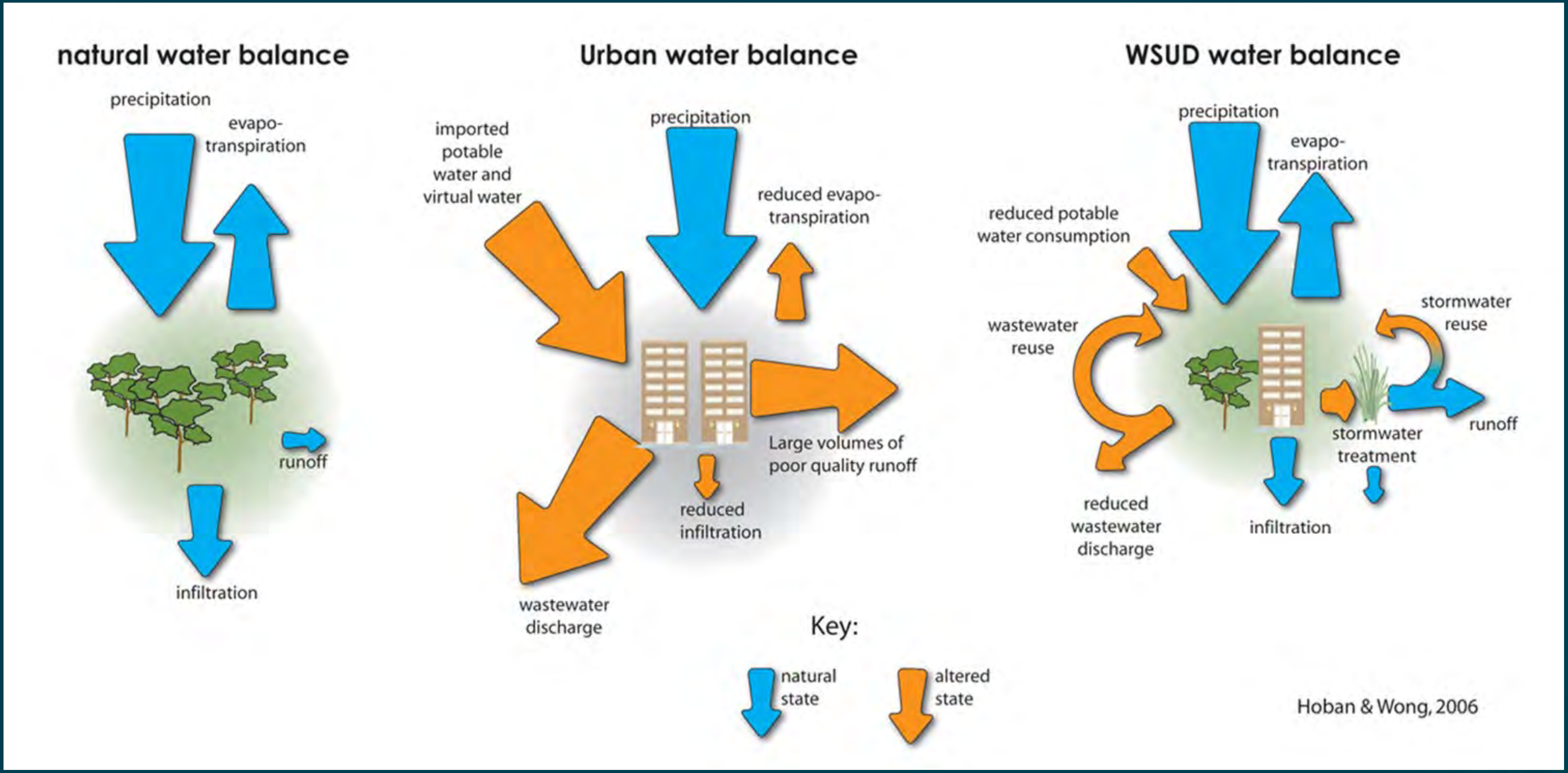
LID Floodplain Study
Develop Model and Identify Scenarios

- Develop LID feature arrangement scenarios.
- Compare types, sizes, and number of LID features.
- Utilize flexible scenario analyses to compare LID arrangements to optimize benefits.
- Assess tradeoffs between scenarios.
- Adjust scenarios according to analysis.
- Select scenario with optimum results.

LID Floodplain Study
Why LID/GSI

- Arizona Department of Water Resources reports that up to 70% of residential water use is outdoors. (https://new.azwater.gov/conservation/landscaping)
- Residential outdoor water (except SRP irrigation areas) primarily consists of water treated to primary drinking water standards.
- Right Water - Right Use
- “green infrastructure is perhaps even more relevant in arid and semi-arid climates” (www.epa.gov/ow/eparecovery)

LID Floodplain Study – Why LID/GSI Water Balance Pre and Post Urban



LID Floodplain Study - LID/GSI Examples

Street median curb cut and bioswale

FCDMC – *Durango Campus*

LID Floodplain Study More Examples

FCDMC – *Durango Campus*

LID Floodplain Study More Examples

City of Phoenix

Bioretention system

7th St. & Filmore

LID Floodplain Study More Examples

Pervious pavement
Taylor Mall

City of Phoenix

LID Floodplain Study More Examples

Pervious pavement
Central Station

LID Floodplain Study More Examples

Greater Phoenix Green Infrastructure & LID Handbook
January 2019
https://sustainability.asu.edu/sustainable-cities/resources/lid-handbook/

FCDMC – *Durango Campus*

LID Floodplain Study
Future Use of Study Tools

The Nature Conservancy

- A shared vision for investment and implementation of green infrastructure
- Assess effectiveness of hybrid approaches to stormwater management
- Combine siloed resources towards shared goals and outcomes

LID and Watershed Management

- Low Impact Development may be used to manage storm flows in a watershed.
- Reduce storm peak flows close to the source
- Reduce land erosion and sediment transport.
- Improve water quality.
- Extend post-storm flows spatially and temporally enhancing local water availability.

LID Benefits

- Slowing flows may increase aquifer recharge.

- GCS installations are flow through and do not retain flows.

- Increases moisture to support native vegetation to support ecosystems, interconnectivity, optimize watershed function and water collection capacity.

- Projections indicate fewer and stronger storms.

- Optimize water resources before storm flows leave watershed.

Hassayampa River Study
Assessing the use of Low Impact Development to Manage Storm Flows

Hassayampa River Study
Study Details

- Partner: City of Buckeye
- Stakeholders: White Tank Mountains Conservancy, Sonoran Institute, Flood Control District of Maricopa County, Walton Family Foundation
- 3-year Special Study
  - projected start Spring 2020
  - special study, existing data, prepare surface water-groundwater model
- 50/50 federal and non-federal cost-share
- Staff:
  - Reclamation's Phoenix Area Office (PXAO)
  - Reclamation's Denver Technical Services Center (TSC)
  - US Geological Survey; Arizona Water Science Center, Tucson Office

Hassayampa River Study
Stormwater Management

Conventional stormwater management

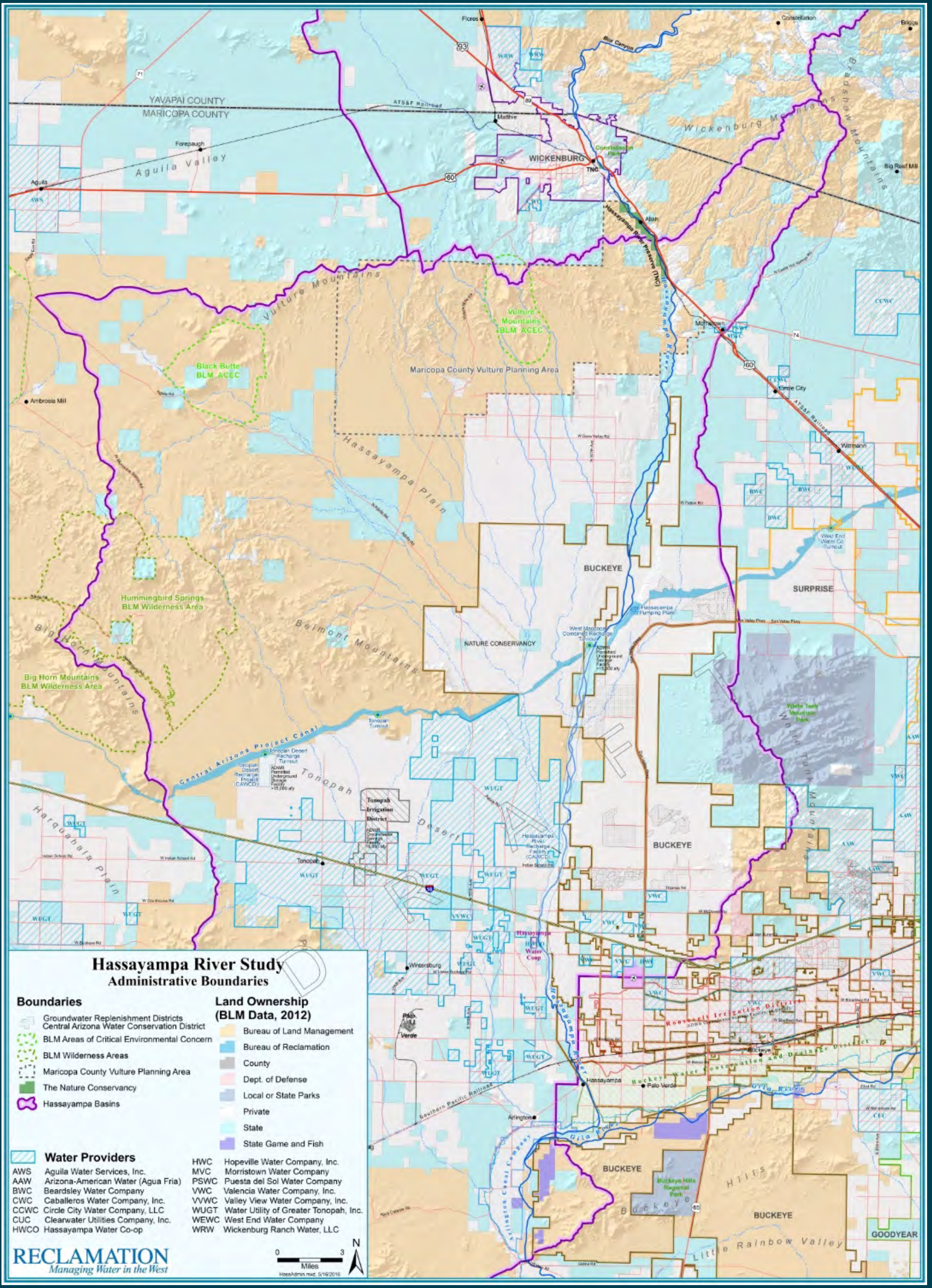
- centralize and concentrate storm flows
- straighten, oversize, soil-cement/impervious channels
- large detention basins and flood controls
- convey flows with outflows at nearby rivers or basins

Hassayampa River Study
Stormwater Management

Low Impact Development (LID) for stormwater management

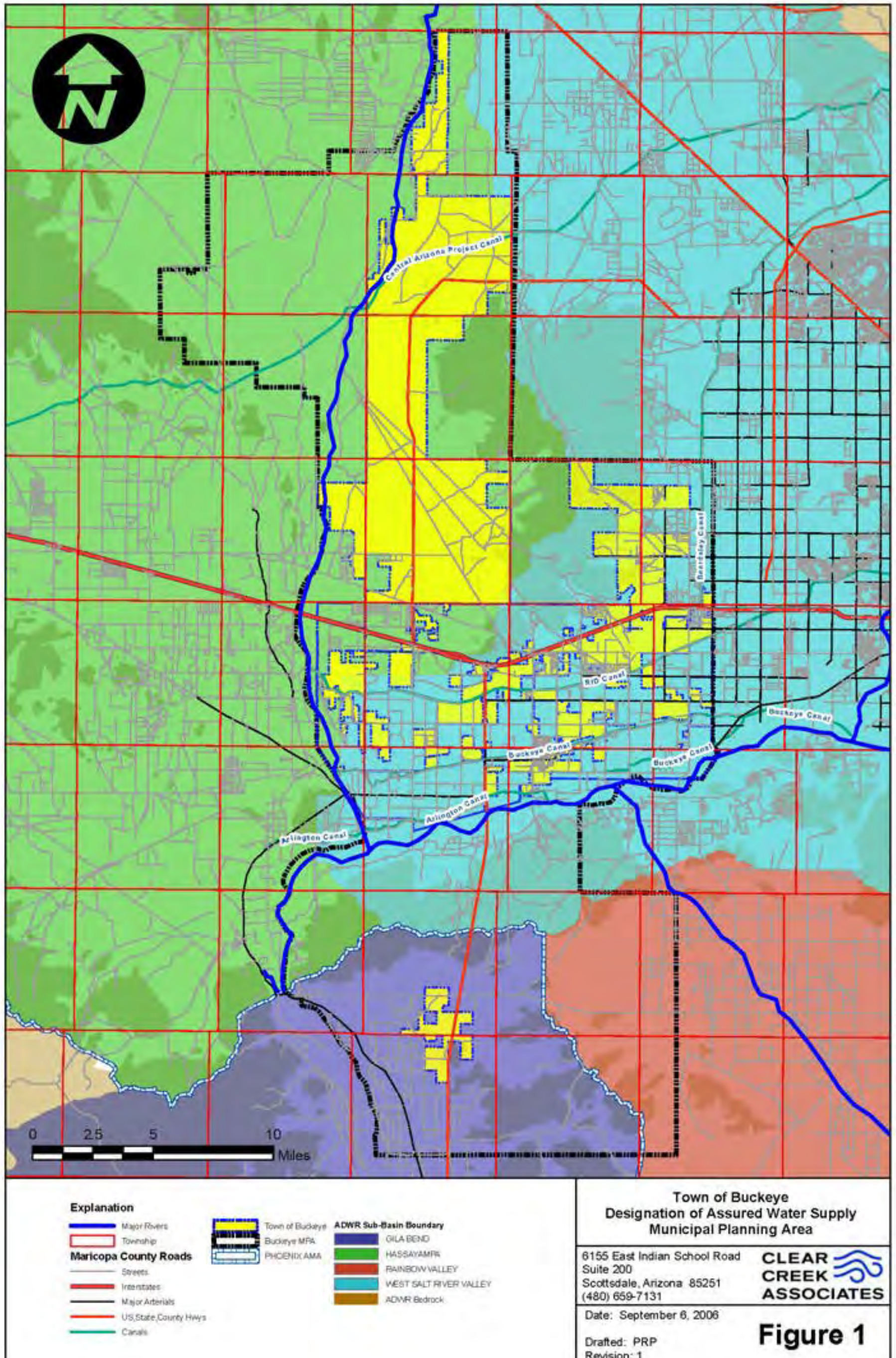
- reduce runoff and sediment transport
- mimic predevelopment hydrology
- reduce disturbed areas and impervious covers
- infiltrate, filter, store, and detain stormwater runoff close to its source
- increase the spatial and temporal availability of water following a storm event
- reduce pollutant loading and stream bank erosion associated with peak flows
- provide a visual amenity
- flexible site designs
- potentially lower cost less than conventional techniques

Hassayampa River Study Objectives



- Investigate use of Low Impact Development (LID) to manage stormwater
- Integrative management of surface water, groundwater, and eco-hydrology
- Optimize water resources while ensuring that entitled developments maintain legal uses, intensities and densities of development.

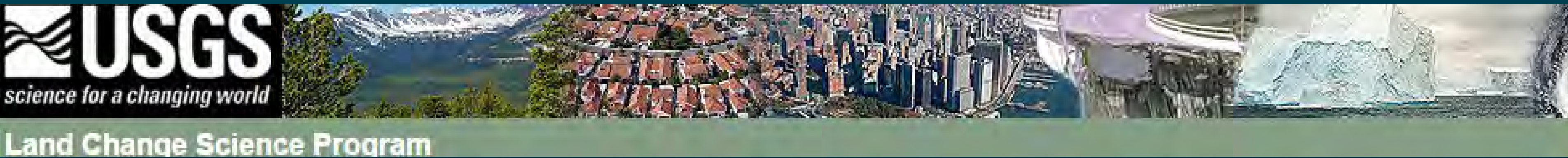
Hassayampa River Study Boundaries



Generally north from Black Mountain Road to confluence with Gila River includes west side of White Tank Mountains and Hassayampa River floodplain

Hassayampa River Study
EPA Healthy Watershed Consortium Grant

- Regional Open Space Strategy
- Continued wildlife connectivity
- Most critical threat - urbanization
- Top Priority - Funding for planning and conservation at watershed scale
- Hassayampa appears to meet definition of a “healthy watershed”
- Maricopa County Flood Control District will update the Sun Valley ADMP in the to-be-urbanized portion of the Hassayampa from the CAP down to I-10
- Unique opportunity to tackle these issues across multiple studies and with a uniquely collaborative approach



Modeling Stormflow Management Alternatives in the Arid Southwest

Laura M. Norman, PhD, Research Physical Scientist,
U.S. Geological Survey, Western Geographic Science Center, Tucson, AZ

Hassayampa River Study
Proposed Process

- Develop scope of work and cost share agreement
- Develop Problem Statement
- Identify stormwater management alternatives
- Assess capacity of alternatives to
  - Reduce surface water flow volume
  - Reduce sediment transport
  - Increase infiltration
  - Increase groundwater recharge
  - Enhance or establish habitat
  - Support wildlife corridors

Hassayampa River Study Proposed Process (continued)

- Compare standard stormwater management practices with alternatives
  - Cost
  - Implementability
  - Effectiveness
- Rank and identify top alternatives
- Report

Deborah Tosline, R.G.
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Phoenix Area Office
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