Texas Tech Lecture

October 14, 2020

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Texas Water Development Board

Innovative Water Technologies

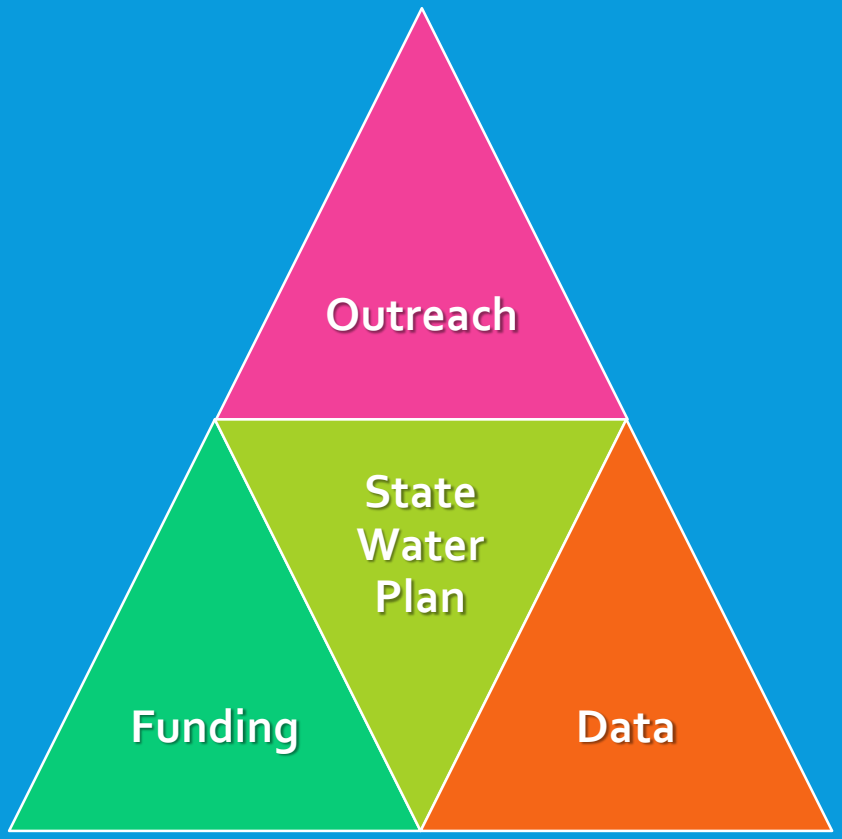
ASR & MAR

(aquifer storage and recovery & managed aquifer recharge)

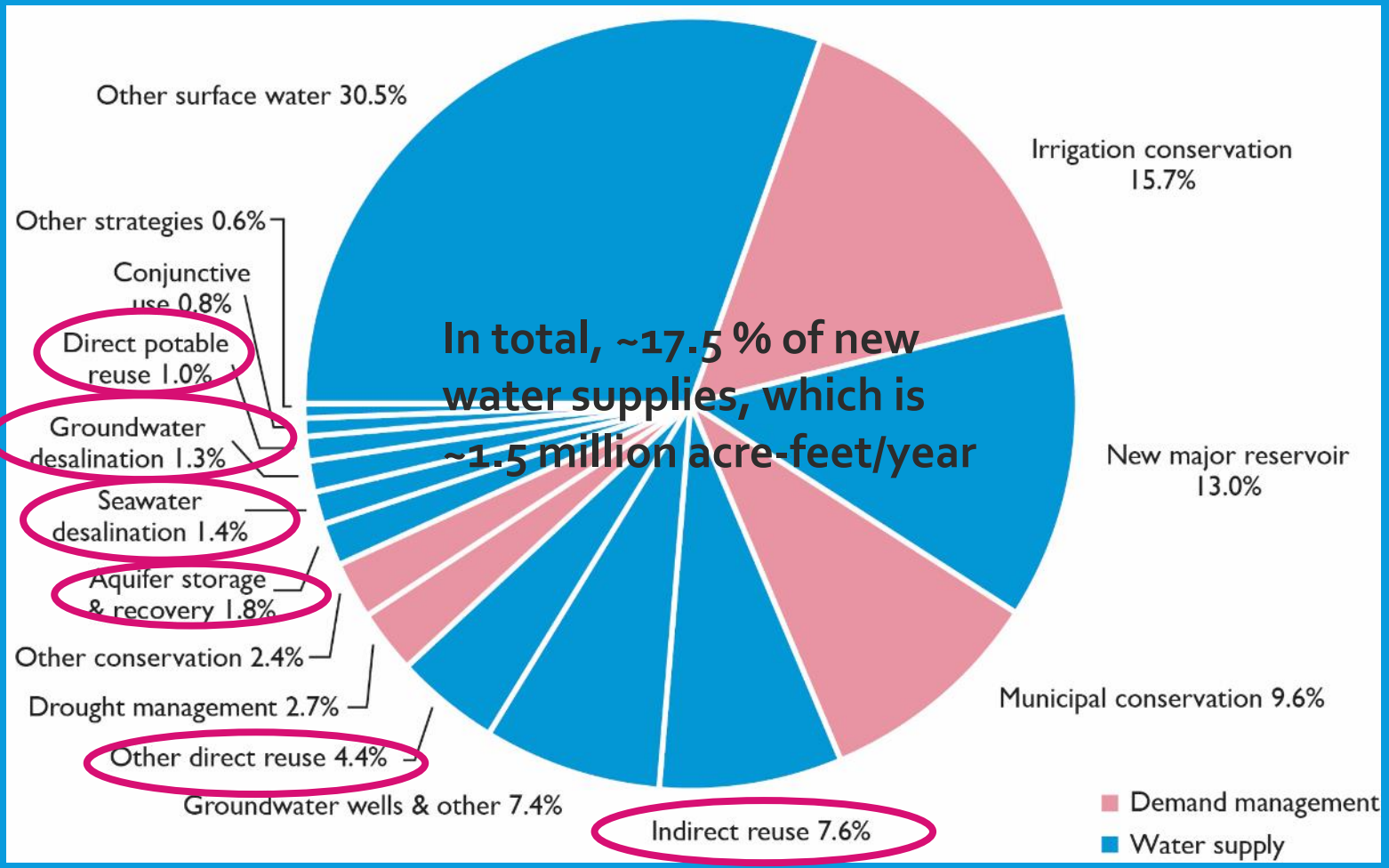
OUTLINE

A. What is the Texas Water Development Board?
B. What is ASR & MAR?
C. What is TWDB doing to support ASR & MAR?
D. Examples of ASR & MAR in Texas
E. Discuss topics of interest for the class

TEXAS WATER DEVELOPMENT BOARD (TWDB)



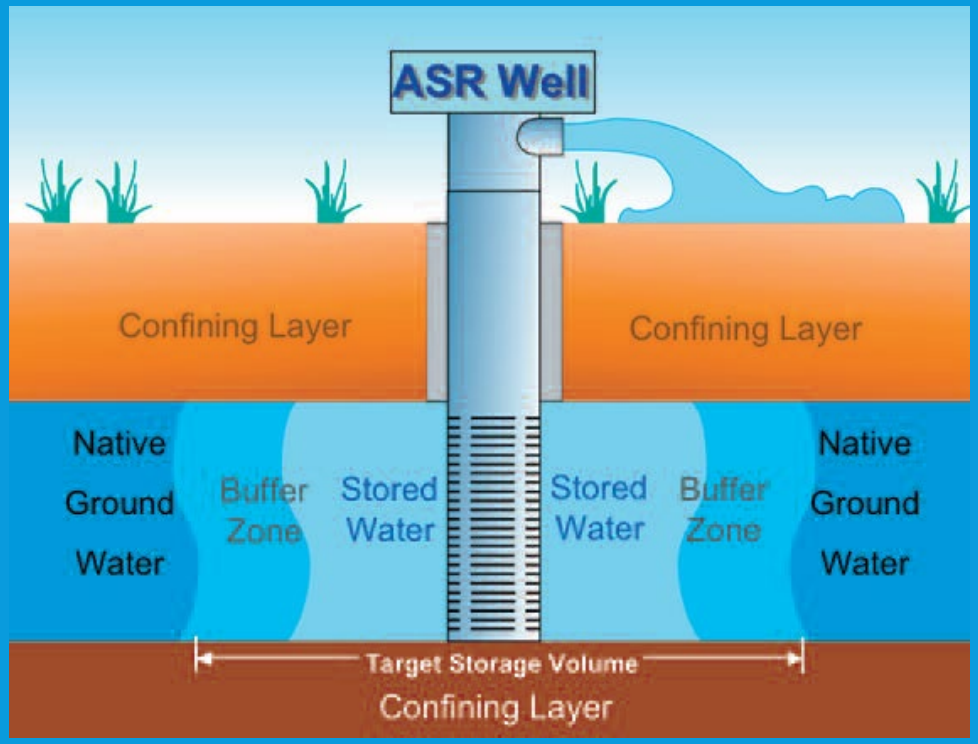
2017 STATE WATER PLAN 2070 SUPPLY STRATEGIES



WHAT IS ASR?

Aquifer Storage and Recovery (ASR)

- Generally defined as the storage of water in a suitable aquifer and recovery of that water during times of need for beneficial use
- Source water can be reclaimed, groundwater, or surface water; surface is most prevalent
- You can use the same well to retrieve the water or use another well at different location.



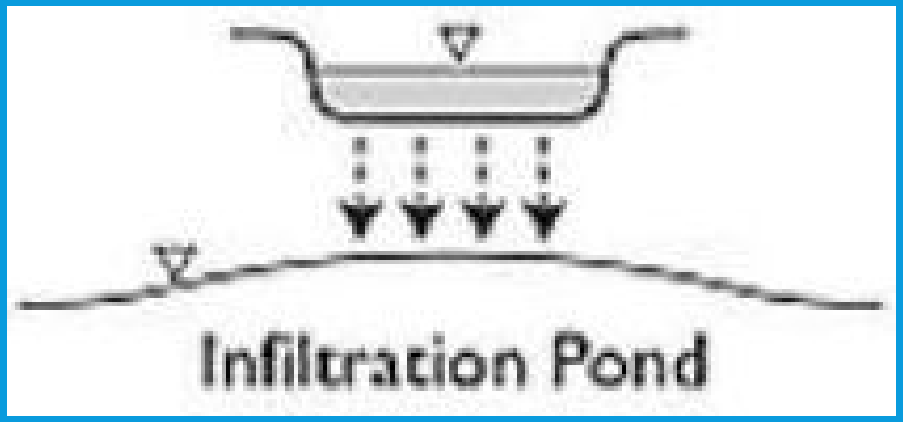
Source: NGWA

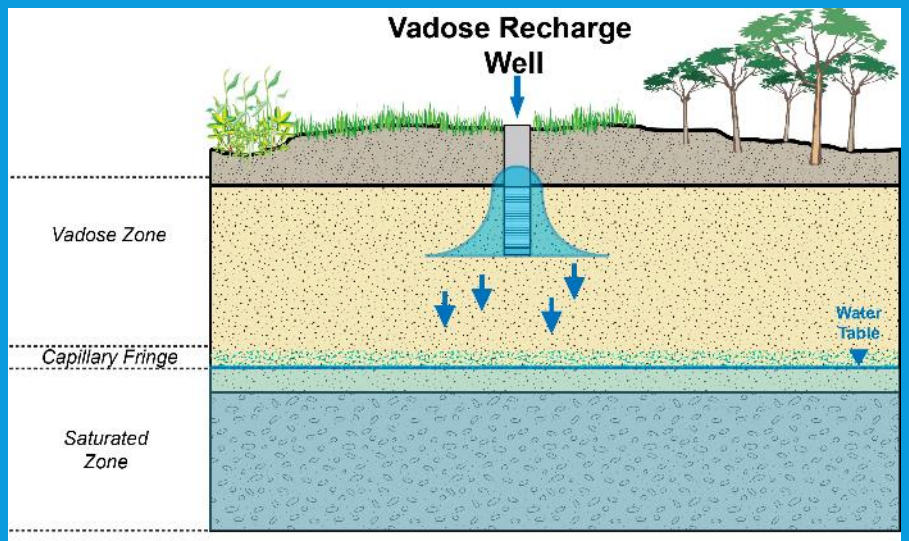
WHAT IS MAR*?

*MAR and AR are used interchangeably

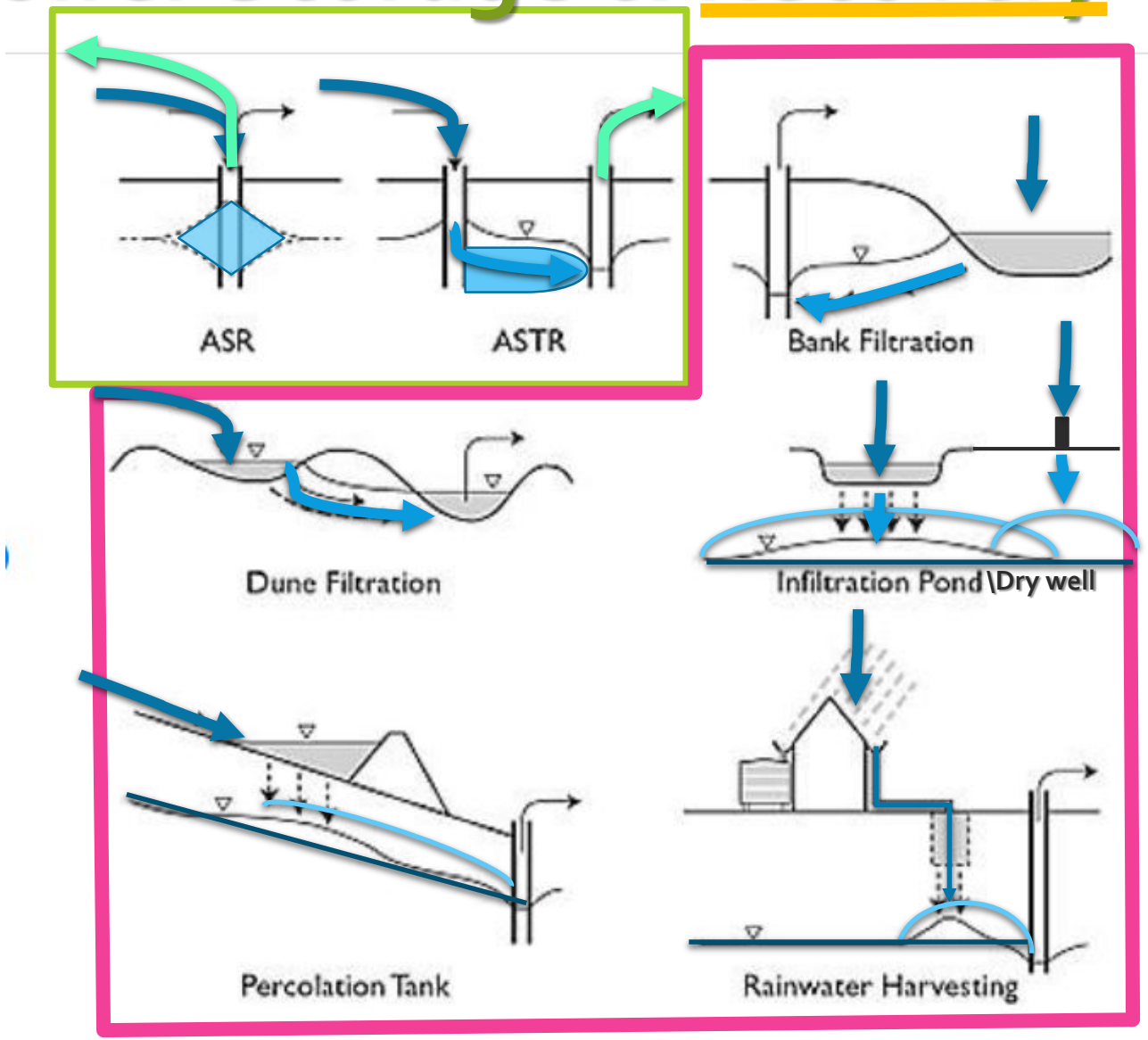
Managed Aquifer Recharge (MAR or AR)

- Generally defined as intentional recharge without an injection well or the intention of recovery
- Often uses infiltration basins or gravity-fed vadose wells
- Goals vary more than ASR





Aquifer Storage & Recovery

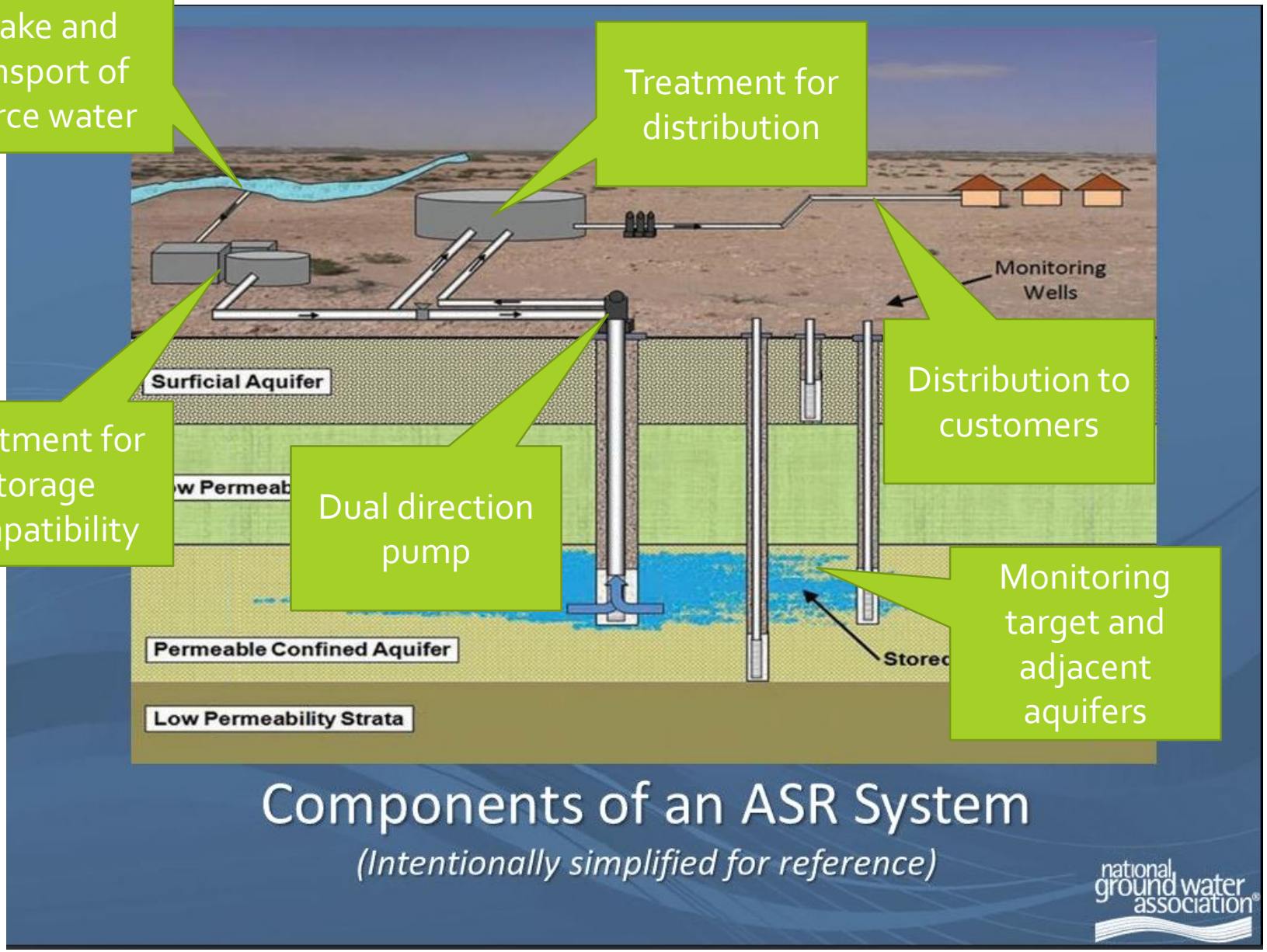


Most common MAR techniques (Gale and Dillon 2005) ASR: Aquifer Storage and Recovery; ASTR: Aquifer Storage Transfer and Recovery

Aquifer Recharge (AR)

THE BASICS

- Need
  - Water supply, environmental, other
- Excess water
  - Availability
    - seasonally, intermittently, constant
- Aquifer
  - in the right location with the right hydrogeological properties
- ASR does not create “new” water.


Intake and transport of source water
Treatment for distribution
Monitoring Wells
Distribution to customers
Surficial Aquifer
Treatment for storage compatibility
Dual direction pump
Permeable Confined Aquifer
Monitoring target and adjacent aquifers
Low Permeability Strata
Components of an ASR System
(Intentionally simplified for reference)
national ground water association

OTHER CONSIDERATIONS

- Source and native water compatibility
- Volume of water needed to establish the storage zone
- Infrastructure
- Economics
- Regulatory issues
- System goals & expectations

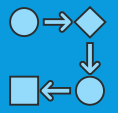
BENEFITS OF ASR & MAR

ASR*

- Eliminate evaporative loss

- Reduce inundation

- Maximize resources



- Maximize Infrastructure

- Modulate peaking

- Defer expansions

MAR

- reduce water level declines
- supplement quantity of groundwater
- improve water quality
- improve groundwater-surface water interactions
- mitigate subsidence

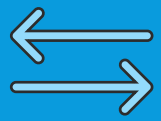
* When comparing ASR to surface reservoirs

CHALLENGES OF ASR & MAR

- Appropriate geology

- Available excess water

- Pretreatment requirements



- Hydraulic migration

- Chemical interactions

- Regulations and permits

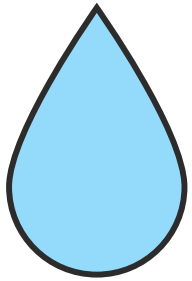
AQUIFER PROPERTIES

Gather data:

- Porosity and permeablility
- Confining layers
- Storage zone thickness
- Transmissivity
- Dispersivity
- Vertical and horizontal gradients
- Water quality
- Mineralogy

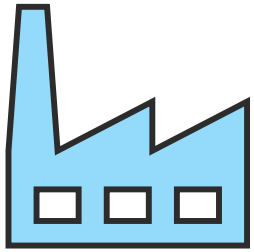
- Homogeneous storage zone
- Confined (ASR)
- Vadose zone with good vertical infiltration (MAR)
- Transmissivity sufficient for injection and recovery
  - Reduce energy to inject/recover
  - Limit "bubble migration"
  - Limit mixing
- Storage zone sufficient for storage volume and time
- Geochemistry should not deteriorate water quality or system efficiency

AVAILABLE "EXCESS" WATER



- Volume, frequency, duration, and water quality
- Permits, regulations, laws

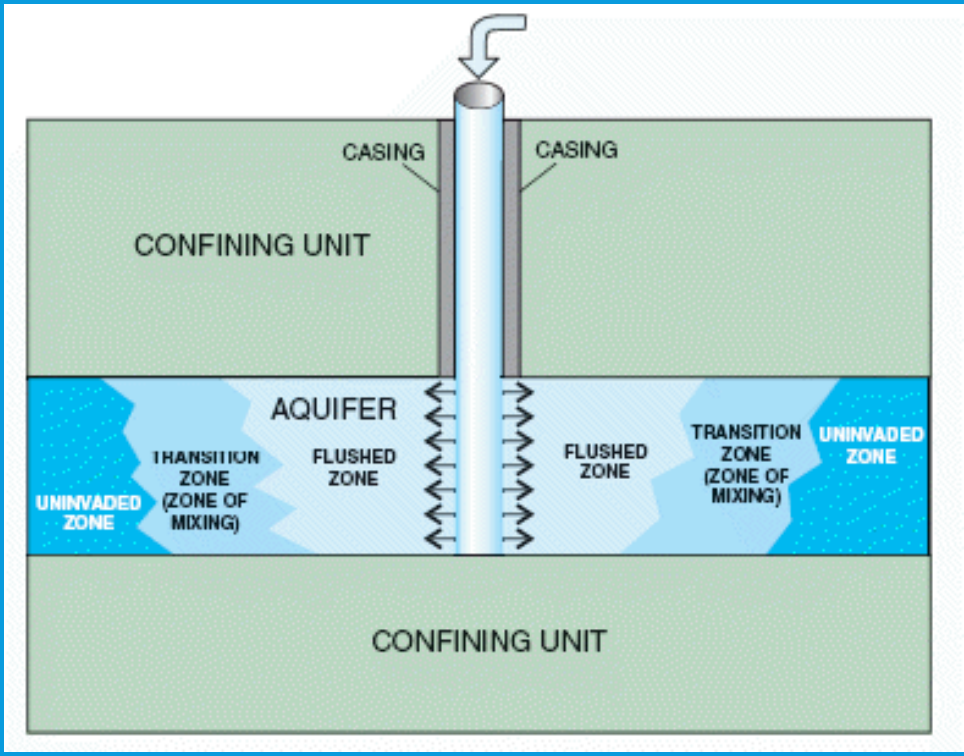
PRETREATMENT



- Protect the Aquifer!
- Federal laws require protecting Underground Sources of Drinking Water (USDW) from Underground Injection (UIC)
  - https://www.epa.gov/uic
- All 3 of the existing ASR facilities in Texas treat injected water to drinking water standards
- Treatment adds a considerable expense
  - Source-native water compatibility
  - pH
  - Dissolved oxygen
  - organics
- MAR is a different story if it is an infiltration basin instead of a well

HYDRAULIC MIGRATION

- Protect your "bubble"!
- Texas groundwater is rule of capture
- How?
  - Land ownership
  - City ordnances
  - Well field operations

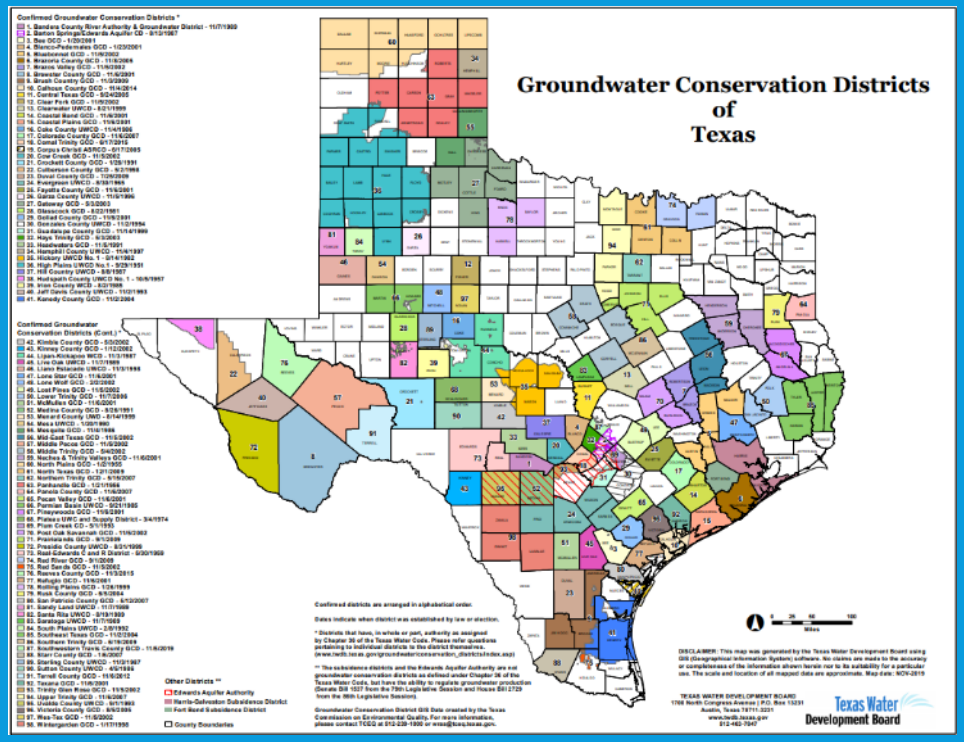


CHEMICAL INTERACTIONS

- Example: Arsenic Mobilization
- Minerals with arsenic exist in some aquifers
- It can be released in groundwater by:
  - shifts in redox
  - Increases in pH
  - Introduction of organics?
    - See work by Dr. Sarah Fakhreddine in Orange County, California
- Data collection and planning can minimize this impact

REGULATIONS AND PERMITS

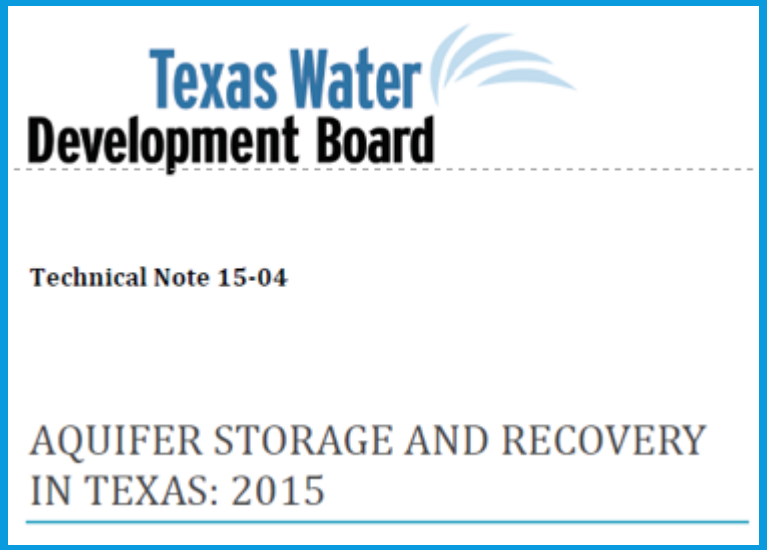
- Not regulated by TWDB
- Injection is overseen by the TCEQ Underground Injection Program (UIC)
  - Authorization for a Class V well is needed
    - https://www.tceq.texas.gov/permitting/radmat/uic_permits/UIC_Guidance_Class_5.html
- Water rights and rules depend on the source
  - Surface water rights are granted by TCEQ
    - https://www.tceq.texas.gov/permitting/water_rights/wr-permitting/water_rights.html
  - Groundwater depends on if there is a Groundwater Conservation District
    - https://www.twdb.texas.gov/groundwater/conservation_districts/index.asp
  - Reclaimed water requires written approval from TCEQ
    - https://www.tceq.texas.gov/assistance/water/reclaimed_water.html



EXAMPLES OF ASR & MAR

- Historic projects
- Current projects and facilities
  - Texas karst MAR
  - Houston stormwater MAR experiment
  - Current Municipal facilities
    - El Paso
    - Kerrville
    - SAWS
  - Kansas Equus Beds

TECHNICAL NOTE 15-04



- Published in June 2015
- Discusses 27 historical, current, and proposed ASR programs

http://www.twdb.texas.gov/publications/reports/technical_notes/doc/TechnicalNote15-04.pdf

VERY EARLY DAYS IN TEXAS…

- Early "Artificial Recharge" experiments by the USGS, Texas Board of Water Engineers, and partner cities
- City of El Paso; 1947 to 1952
  - Alleviate declines in the Hueco Bolson Aquifer
  - Source was treated Rio Grande
  - Four recharge/recovery cycles
  - Good aquifer response and no well clogging
- City of Amarillo; 1954/1955
  - Mitigate need for pipeline expansion
  - Source was distant Ogallala well field
  - Target was Ogallala field near the city
  - Single season, two-well experiment
  - Good aquifer response and no well clogging
  - No known additional actions taken by the cities

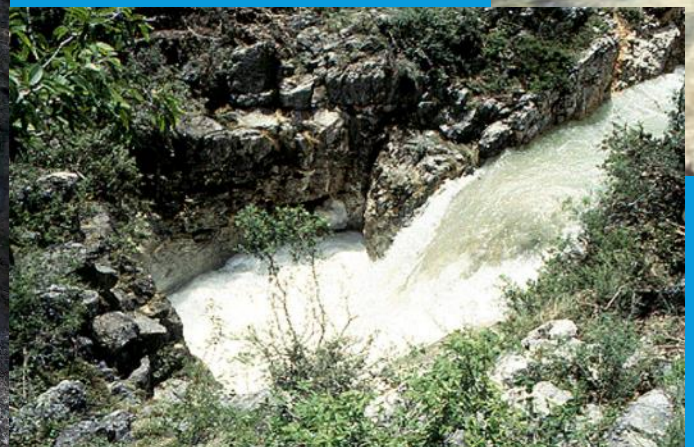
EARLY PROJECTS

- Colorado River Municipal Water District; 1963 to 1970
  - Utilize excess transmission capacity from J.B Thomas reservoir
  - Store in the Ogallala; recover to meet Odessa peak demand
  - Injected raw water
  - Distribution system redesign in 1969 removed excess capacity
- High Plains; early 1970's to mid-1980's
  - Maximize purchased Lake Meredith water
  - Store in the Ogallala
  - Growth eventually outstripped excess contracted supply
- Midland; early 1970's to mid-1990's
  - Increase well yield near Midland to seasonally meet peak demands
  - Sources vary somewhat in description but perhaps from a productive but remote Ogallala well field
  - Store in nearby well field (Ogallala or Antlers?) that was less productive
  - Stopped for contamination or reduced efficiency, hard to say

TEXAS KARST MAR

Edwards Aquifer Authority – Valdina Farms Sinkhole

- dam on Seco Creek, diversion channel excavated to the sinkhole, floodwaters recharge Edwards Aquifer



Barton Springs – Onion Creek Recharge Enhancement

- Antioch Cave structure

HOUSTON STORMWATER MAR

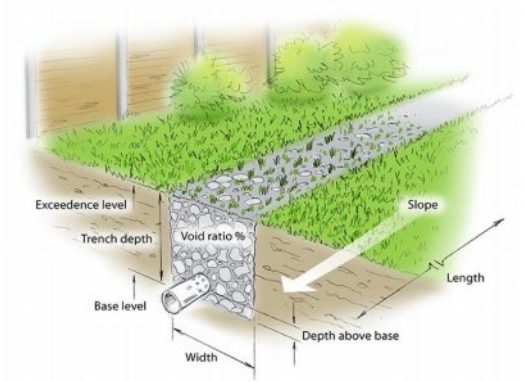
https://gmiller.tamu.edu/project-archive/harris-county-drainage-reuse-initative

From the presentation "Prospects for Managed Aquifer Recharge Using Stormwater: Harris County and Beyond," Gretchen Miller, Ph.D., P.E., ENV SP Zachry Department of Civil and Environmental Engineering, http://gmiller.tamu.edu, gmiller@tamu.edu

DRI Phase II: Pilot Enhanced Infiltration

Parjana EGRP®

Infiltration Trenches



Soil Amendments

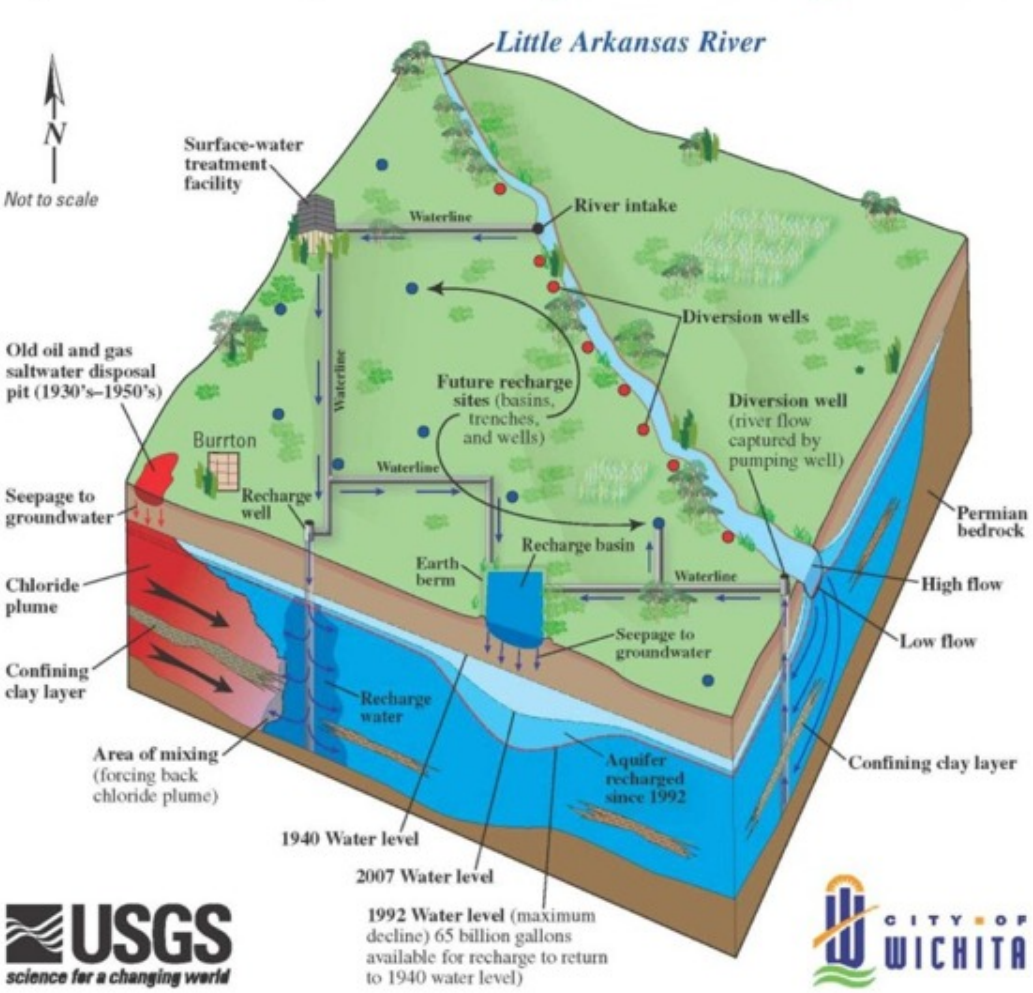
Looked at 3 options:

1. **Enhance natural infiltration**
2. **Dry well infiltration**
3. **ASR injection**
4. **Deep aquifer injection**

TEXAS ASR FACILITIES

- El Paso (also MAR)
  - Began operation in 1985 with ten injection wells
  - Highly treated reclaimed source water
  - Storage/transport in the Hueco-Mesilla Bolsons Aquifer
- Kerrville
  - Operational in 1998 with two-well system; expansion planned to three
  - Guadalupe River source water
  - Storage in the Lower Trinity Aquifer
- San Antonio
  - Operational since 2004, second largest in the U.S.; over 150,000 acre-feet in storage, 29 well system; 60 MGD capacity
  - Edwards Aquifer source water is stored in Carrizo-Wilcox Aquifer
  - SAWS: H2Oaks ASR, Southern Bexar County, purchased 3200 acres, Leases land back to ranchers

EQUUS BEDS, KANSAS



- An example of MAR to improve water quality

DISCUSS TOPICS OF INTEREST

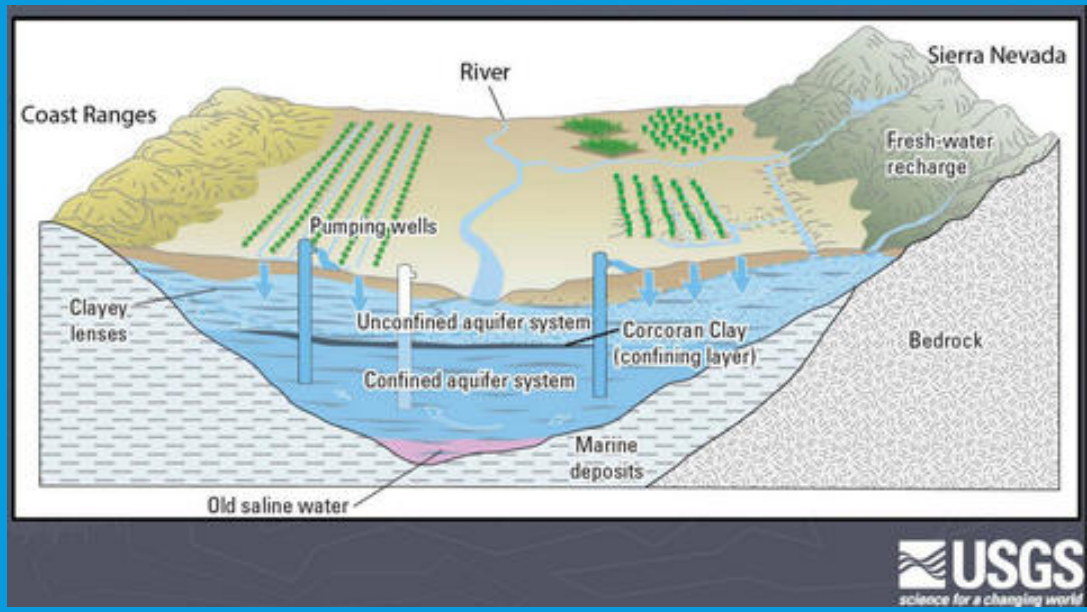
- Technologies that facilitate ASR
- Scale of projects
- Ecosystems
- How much can you increase groundwater in an aquifer?

FACILITATING TECHNOLOGIES

- UIC Class V wells
- Conjunctive use
- Two-way transmission pipes
  - SAWS infrastructure
- Water Treatment
  - Pretreatment
  - Desalination
  - Treated water and distribution system compatibility
- Energy-Water Nexus
  - Pumped storage
  - Example: Use nighttime generated wind turbine energy to inject water
- Rainwater harvesting
  - At least one residential scale in Texas

CONJUNCTIVE USE

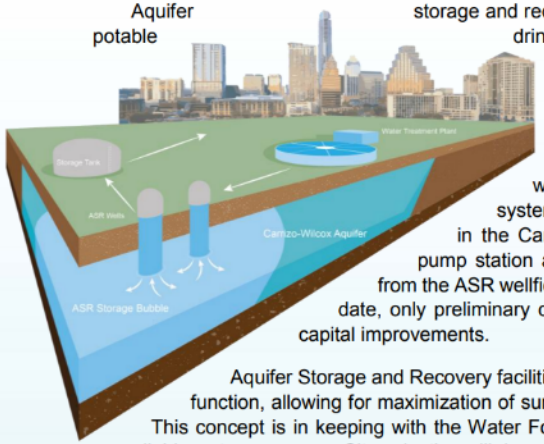
- Coordinated use of ground- and surface water to maximize or sustain yields
- ASR adds agility
  - Flexibility
  - Max water rights
  - Capture excess water for later use
  - Use surface water when it is high, switch to groundwater when it is dry
  - Improve water quality
  - Improving economic costs
  - Irrigation
  - Flexible infrastructure can be more expense



PAIRING WITH WTP OR WWTP

- Meet water quality requirements for injection
- Utilize reclaimed water
- Prepare recovered water for distribution

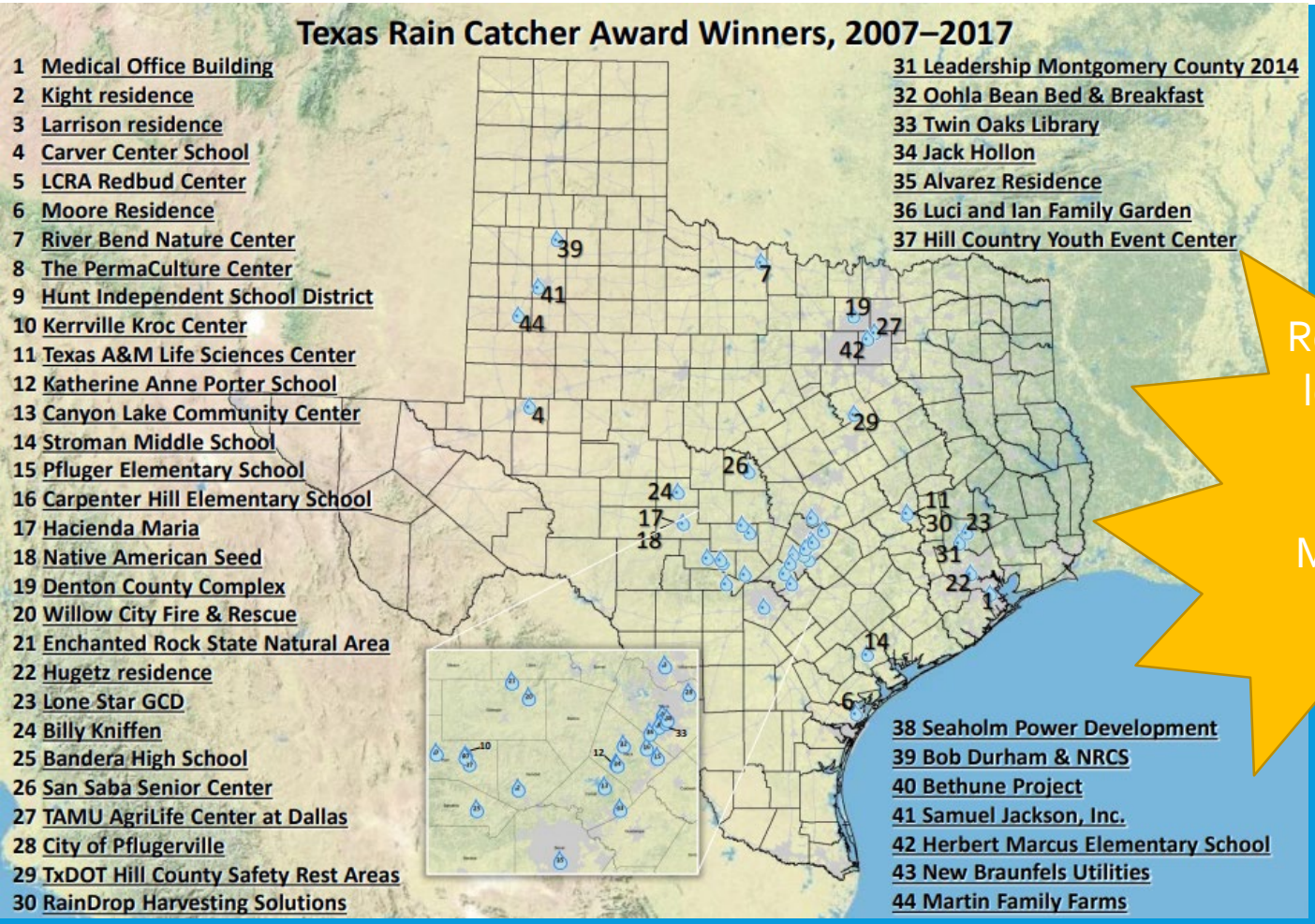
9.1.3.1 Aquifer Storage and Recovery – S1



Aquifer storage and recovery (ASR) is a strategy in which water (ex: potable drinking water) can be stored in an aquifer during wetter periods and recovered for use during drier periods. The Carrizo-Wilcox ASR strategy recommended in Water Forward for implementation by the 2040 planning horizon includes facilities to pipe treated drinking water from the City of Austin's distribution system to an ASR wellfield for injection and storage in the Carrizo-Wilcox aquifer. Facilities also include a pump station and storage tank to convey recovered water from the ASR wellfield to the City of Austin distribution system. To date, only preliminary costs for an ASR pilot are include in the AW capital improvements.

Aquifer Storage and Recovery facilities would be planned to serve solely a storage function, allowing for maximization of surface water resources during drought periods. This concept is in keeping with the Water Forward guiding principle of maximizing locally available water resources. Site selection will depend on favorable hydrogeology to fulfill the ASR facility's intended storage purpose. In implementing this option, Austin Water would work to develop and

RAINWATER HARVESTING



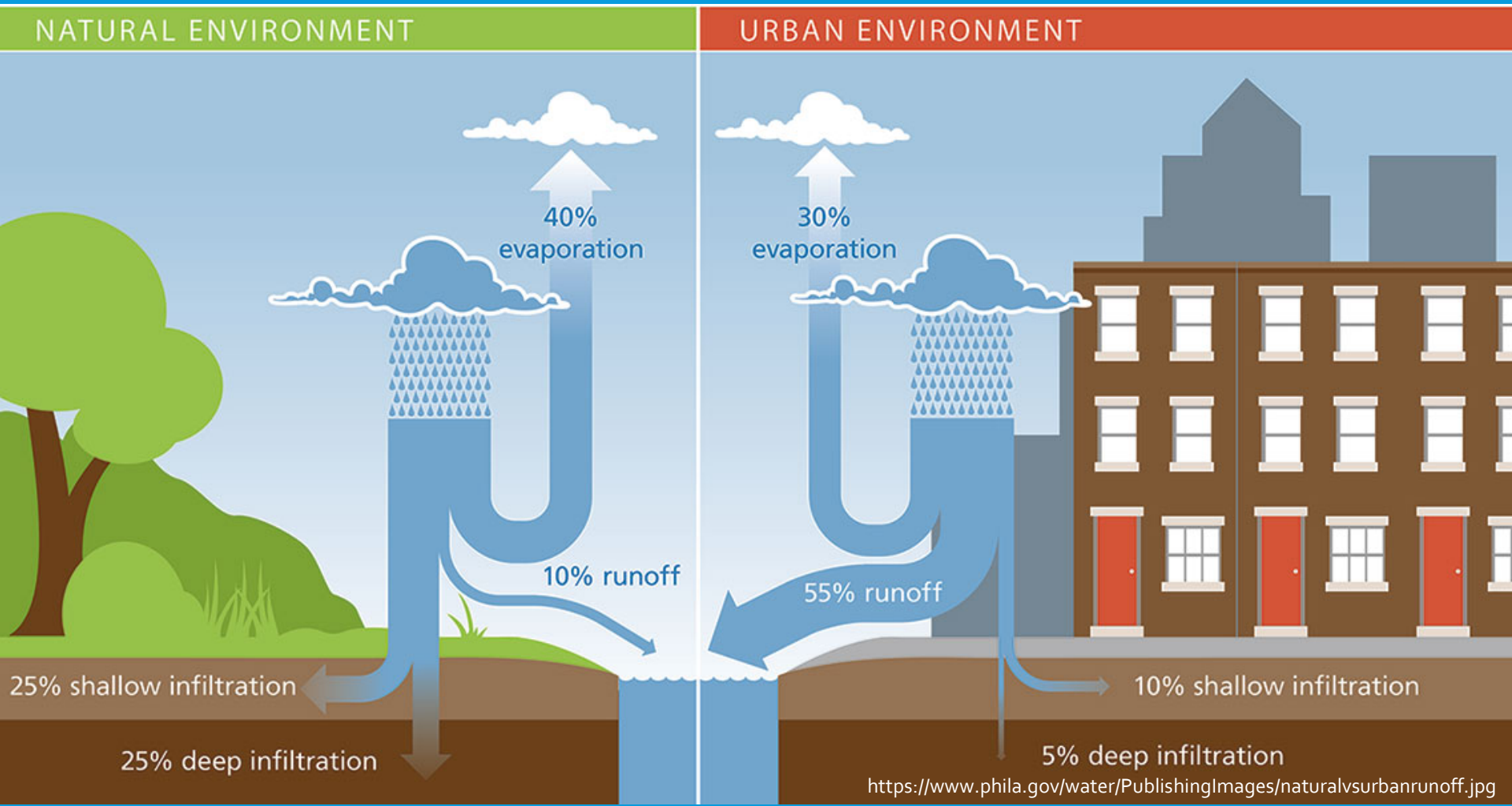
Recent winner local winner: TTU Home Utility Management System

https://www.twdb.texas.gov/innovativewater/rainwater/raincatcher/index.asp

SCALE

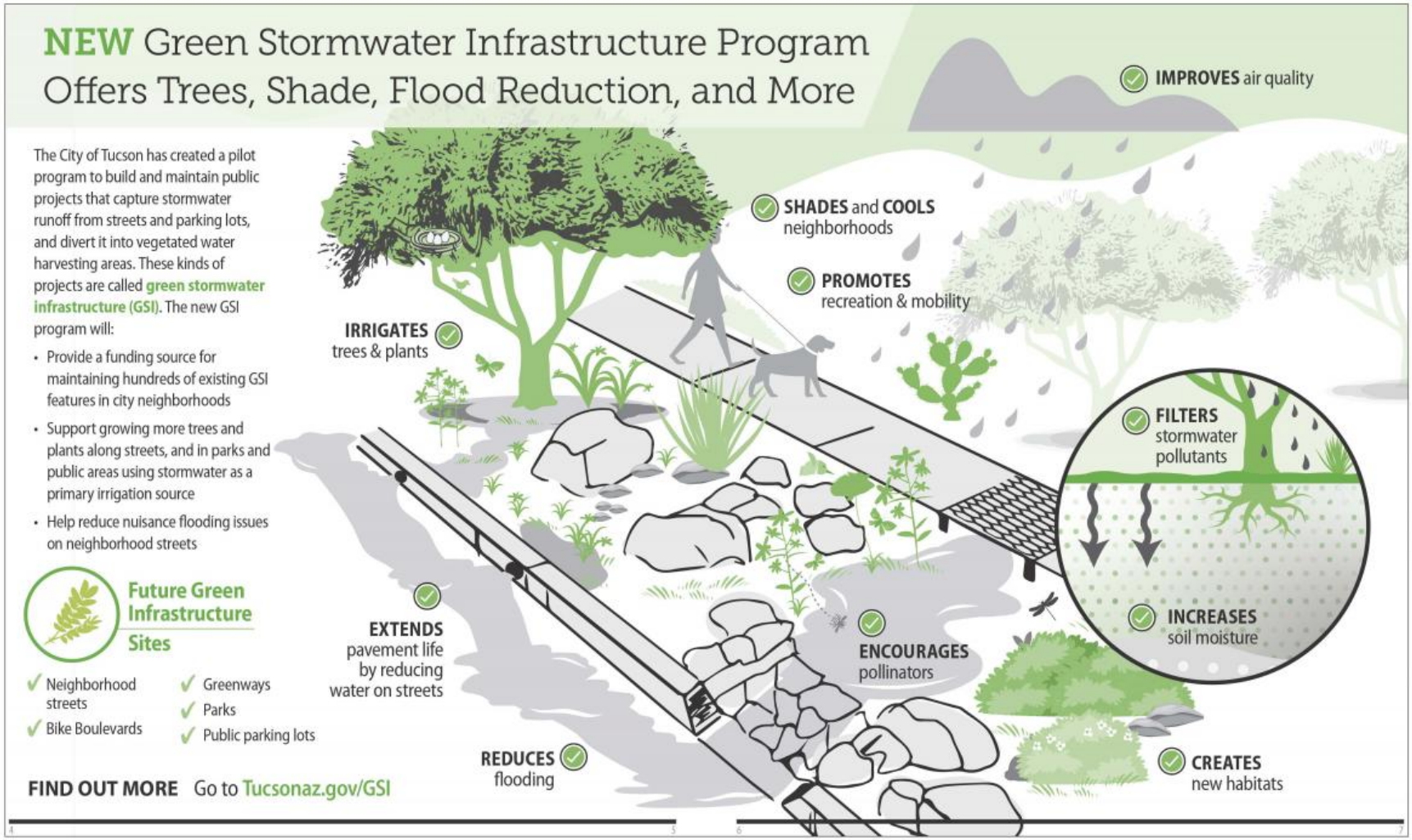
- Residential/Property
  - Ruby Ranch ASR
  - Green Infrastructure
    - Infiltration basins
    - Paid for by stormwater management fees
    - Philadelphia "Green City, Clean Water"
    - Tucson "Green Stormwater Infrastructure"
- Municipal
  - This is the most common scale due to economics, infrastructure, water rights
  - Needs to integrate with existing water infrastructure
  - El Paso, Kerrville, San Antonio…
- Groundwater Conservation District
  - EAA and BSEACD MAR
- State
  - Idaho Snake River
  - California agriculture MAR

PHILADELPHIA
"GREEN CITY, CLEAN WATER"

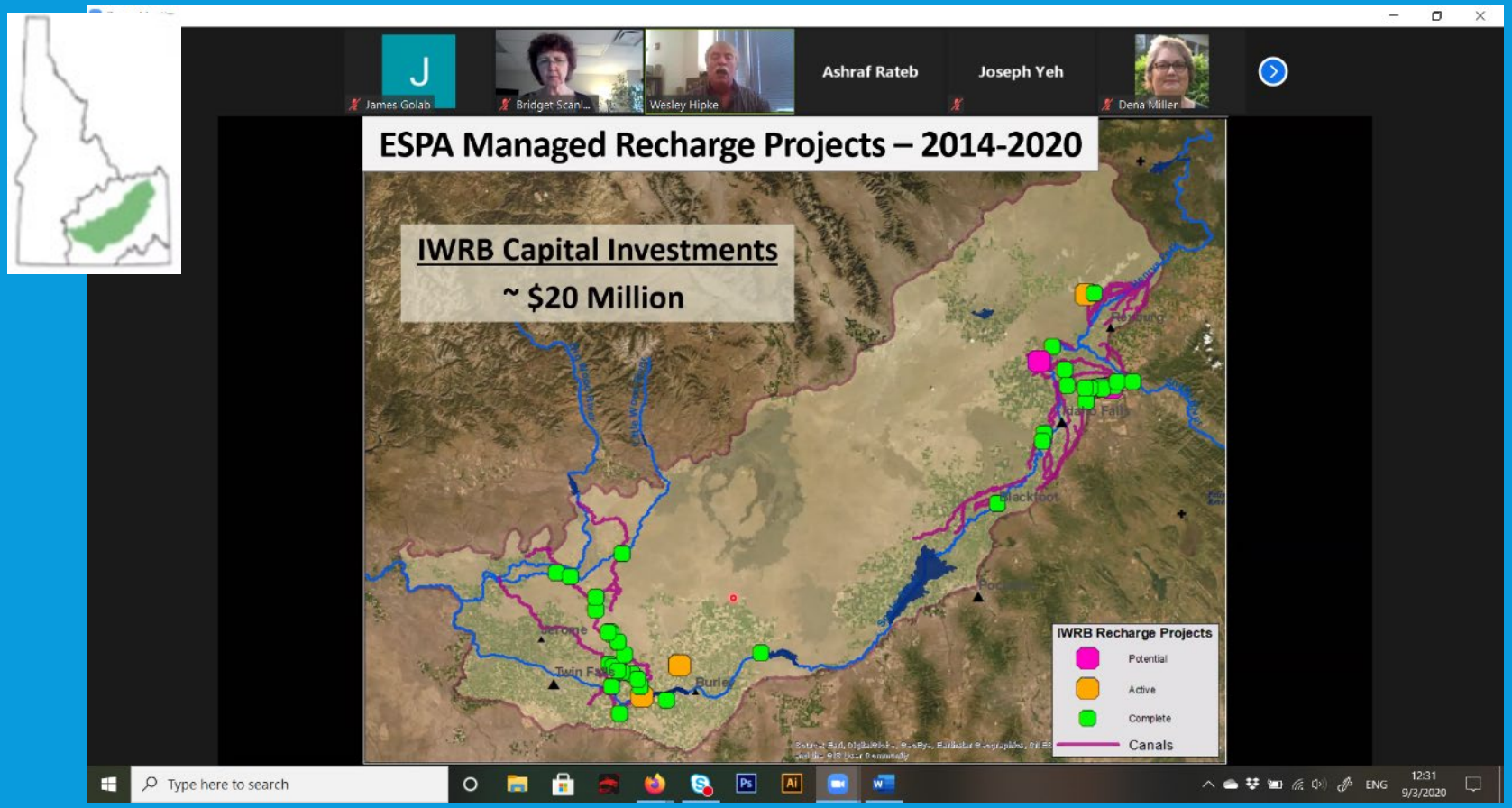


https://www.phila.gov/water/PublishingImages/naturalvsurbanrunoff.jpg

TUCSON
"GREEN STORMWATER INFRASTRUCTURE"



EASTERN SNAKE PLAIN AQUIFER, IDAHO



https://www.usbr.gov/pn/studies/henrysfork/meetings/2011-02-15/hf-espa-recharge-feb2011.pdf

FLOOD-MAR, CALIFORNIA

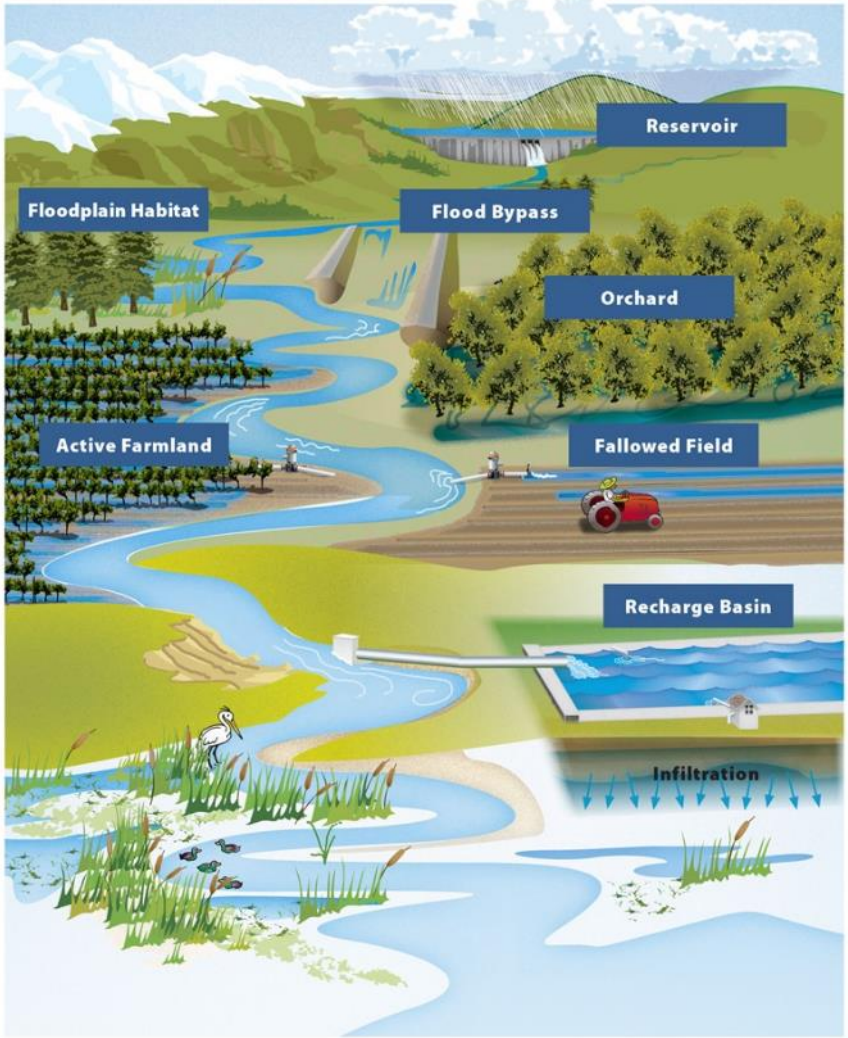
https://water.ca.gov/Programs/All-Programs/Flood-MAR

"Flood-MAR" - resource management strategy using flood water (rainfall or snow melt) for MAR

Scales

- individual landowners diverting flood water with existing infrastructure
- extensive detention/recharge areas
- Basins, using modern flood management infrastructure/operations

Sustainable Groundwater Management Act (SGMA) - requires governments and water agencies of high and medium priority basins to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge



SHIFTS IN ECOSYSTEMS

- Aquifers as habitat
  - Endangered species of the Edwards Aquifer
  - Wetlands
  - Pollinators
- Groundwater-Surface water interactions
  - Sinks and Springs
- Frequency-Duration-Volume of source water supplies
  - Environmental base flows
  - Inflows to bays and estuaries
  - Sediment transport

HOW MUCH INCREASE THE AQUIFER VOLUME?

- Availability of storage space in the aquifer
  - Distribution in 3D
- Infiltration rate of the aquifer
- Evaporation rate
- Volume, frequency, and duration of source water
- Storage for source water while injecting or infiltrating
- Volume, frequency, and duration of use

QUESTIONS AND DISCUSSION

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Innovative Water Technologies
http://www.twdb.texas.gov/innovativewater/index.asp

2017 Water Plan
http://www.twdb.texas.gov/waterplanning/swp/2017/index.asp