

An aerial photograph of a water treatment facility. The image shows several large, interconnected basins and channels filled with dark water. The surrounding land is a mix of green vegetation and brown, sandy soil. A prominent dirt road or path runs through the center of the facility, connecting different sections. The overall scene depicts a complex system for water management and treatment.

Managed Aquifer Recharge General Overview in California

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Parker Groundwater/Ramboll USA

September 7, 2022

Santa Margarita Groundwater Agency Workshop
Managed Aquifer Recharge - Exploring the Opportunities

Groundwater

- We face huge challenges
- Invisible
- Out of sight
- Out of mind, except when:
 - The well runs dry
 - The tap does not flow
 - Suddenly there is a fee
- Hats off to all that work in it

GROUNDWATER Making the invisible visible

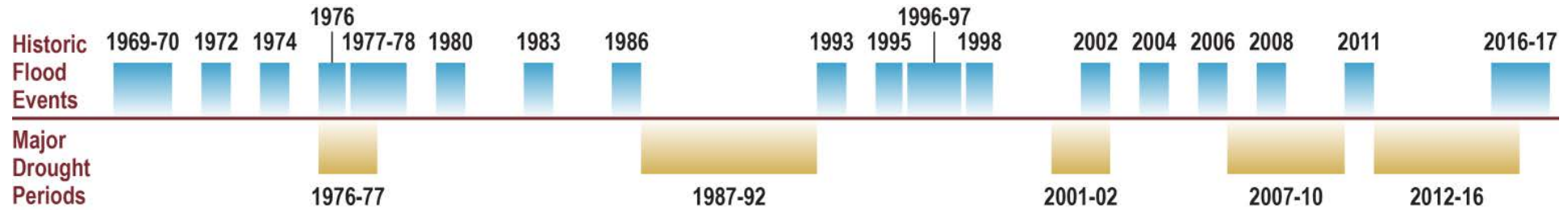


MAR Presentation Outline

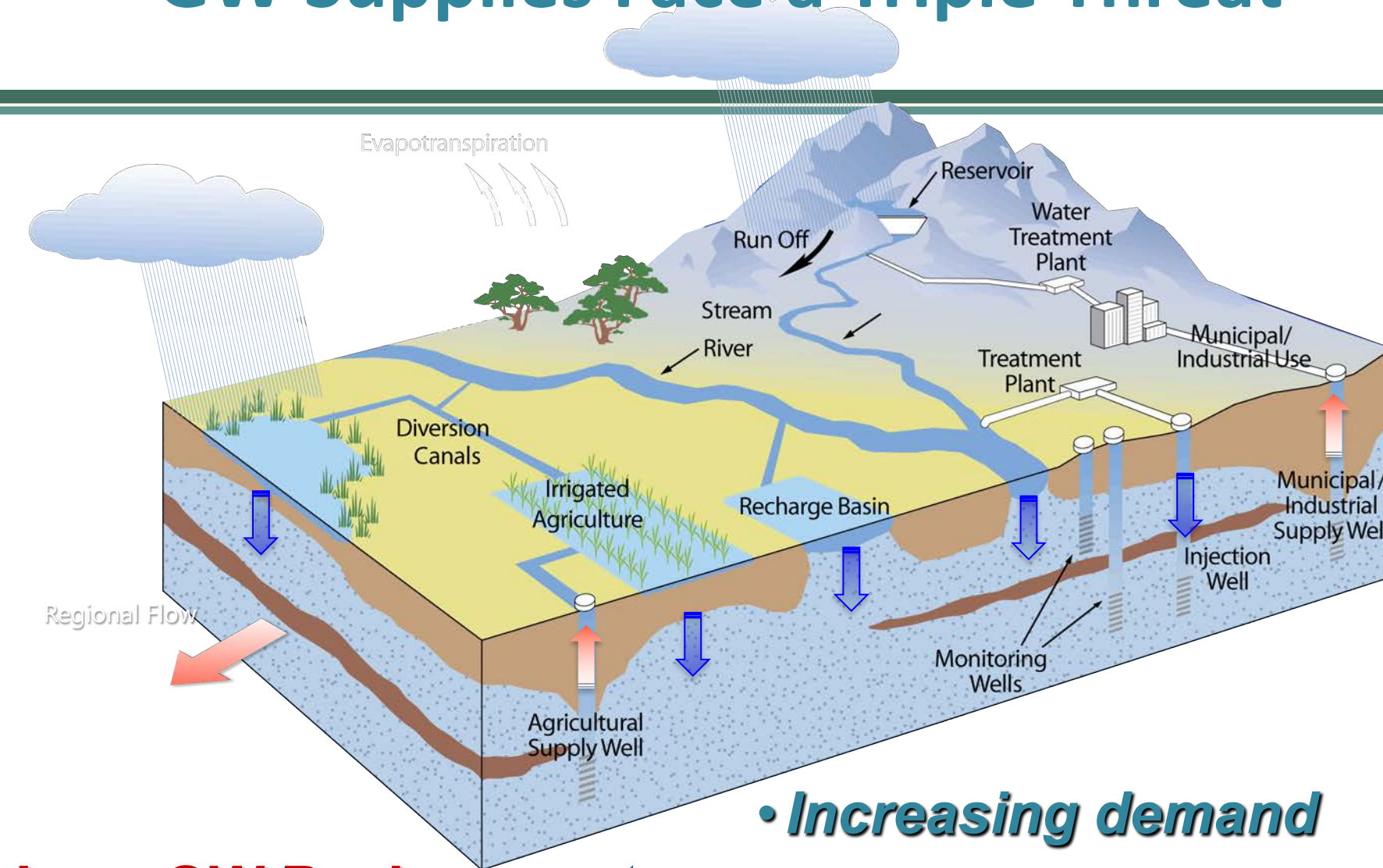
- Overview of MAR
- California Status/Plans
- Definitions/Terminology
- MAR Basics
- California Examples



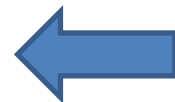
Water Management: A Tale of Two Extremes



GW Supplies Face a Triple Threat



Less GW Recharge

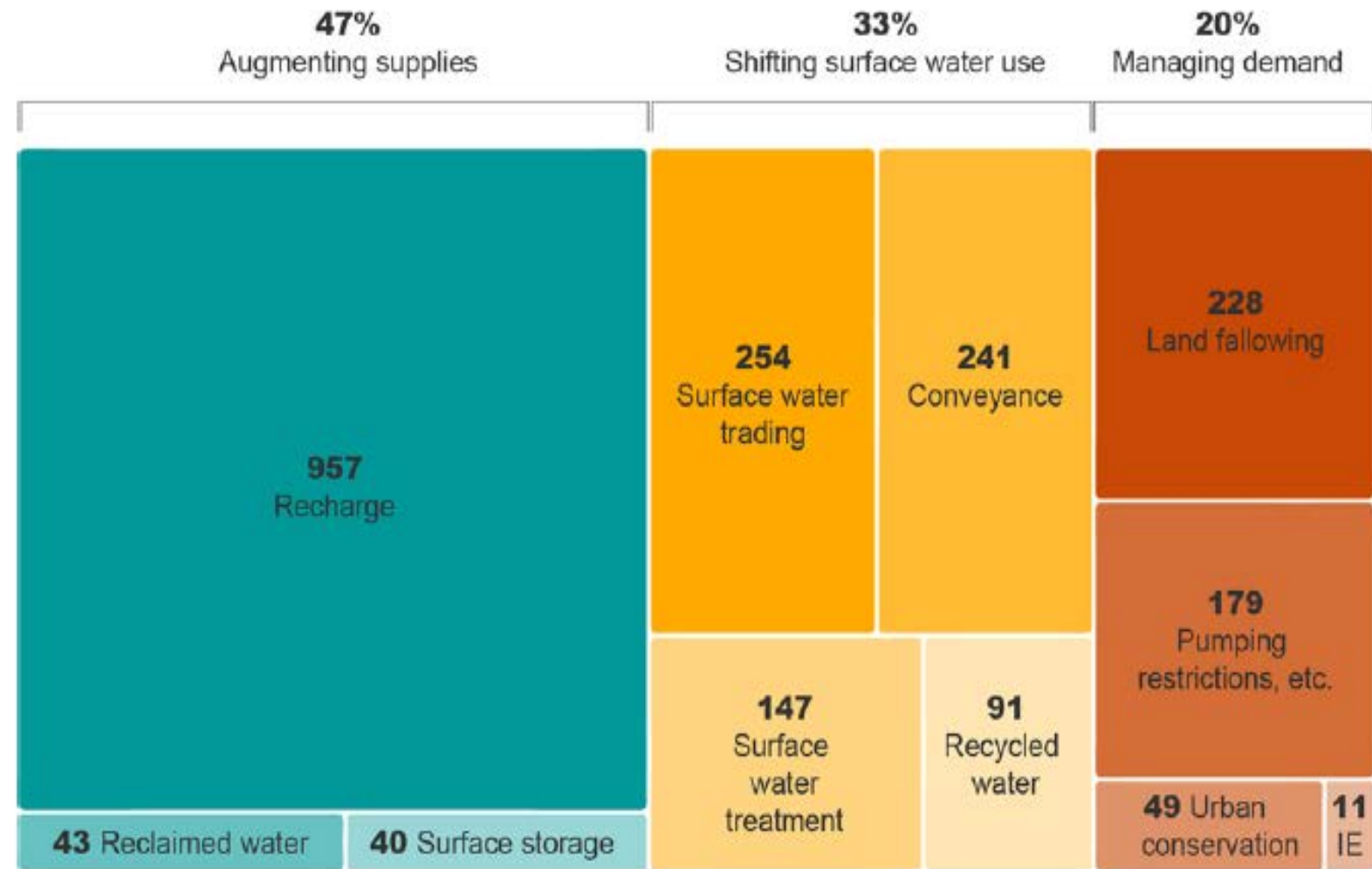


- **Increasing demand**
- **Shifting land use**
- **More intense, episodic rainfall**

Projects and Management Actions San Joaquin Valley COD Basin 2020 GSPs

Public Policy Institute of California - 2021

- 2.2 MAF new supplies and management options to shift use
- ~ 1MAF in MAR
- *Less than half* that surface water and stormwater available



PPIC 2020

Total amount: 2,241 taf/y

Round 2 GSPs - Non-COD SGMA Basins

Managed Aquifer Recharge Projects Proposed

- 75 - Surface water in-lieu
- 55 - Infiltration basins
- 30 - On-farm recharge
- 25 - ASR and injection wells
- 15 - On- and off-stream recharge
- 10 - Mixed projects
- 4 - Recycled water substitution
- 3 - Recharge canals
- 2 - Vegetation removal
- 2 - Dry wells
- 1 - Reservoir reoperation



Managed Aquifer Recharge Round 2 GSPs Estimated Volumes and Costs

- Many projects did not have pre-determined volumes (TBD)
- Also many projects did not have pre-determined costs (TBD)
- So total volumes and costs from the Round 2 GSPs may be underestimated

Reported Volumes

580-700TAF

Extended Volumes

1000TAF



Reported Costs

\$ ~1.5B

Extended Volumes

\$ ~2.5B

2022-23 Round 2 SGMA Grant Funding - \$200M
New Water Supply Strategy - \$ 8.2B Modernize Infrastructure

MAR Definition and Purposes

The purposeful recharge of water to aquifers for subsequent recovery or for environmental benefit

- Manage water supply
- Meet legal obligations
- Restore/protect aquifers
- Maintain minimum flows and levels



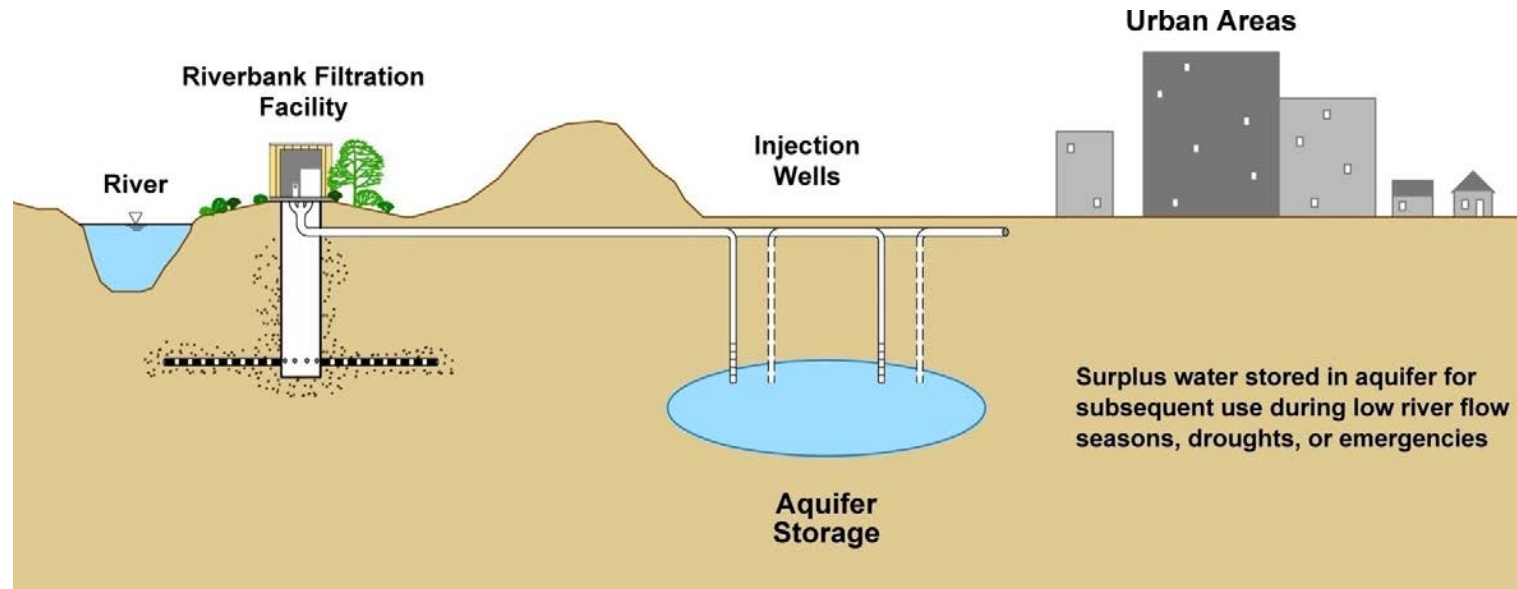
- Flood mitigation
- Water quality enhancement and protection
- Water reuse
- Ecosystem restoration and protection

MAR Terminology - Common Grounds

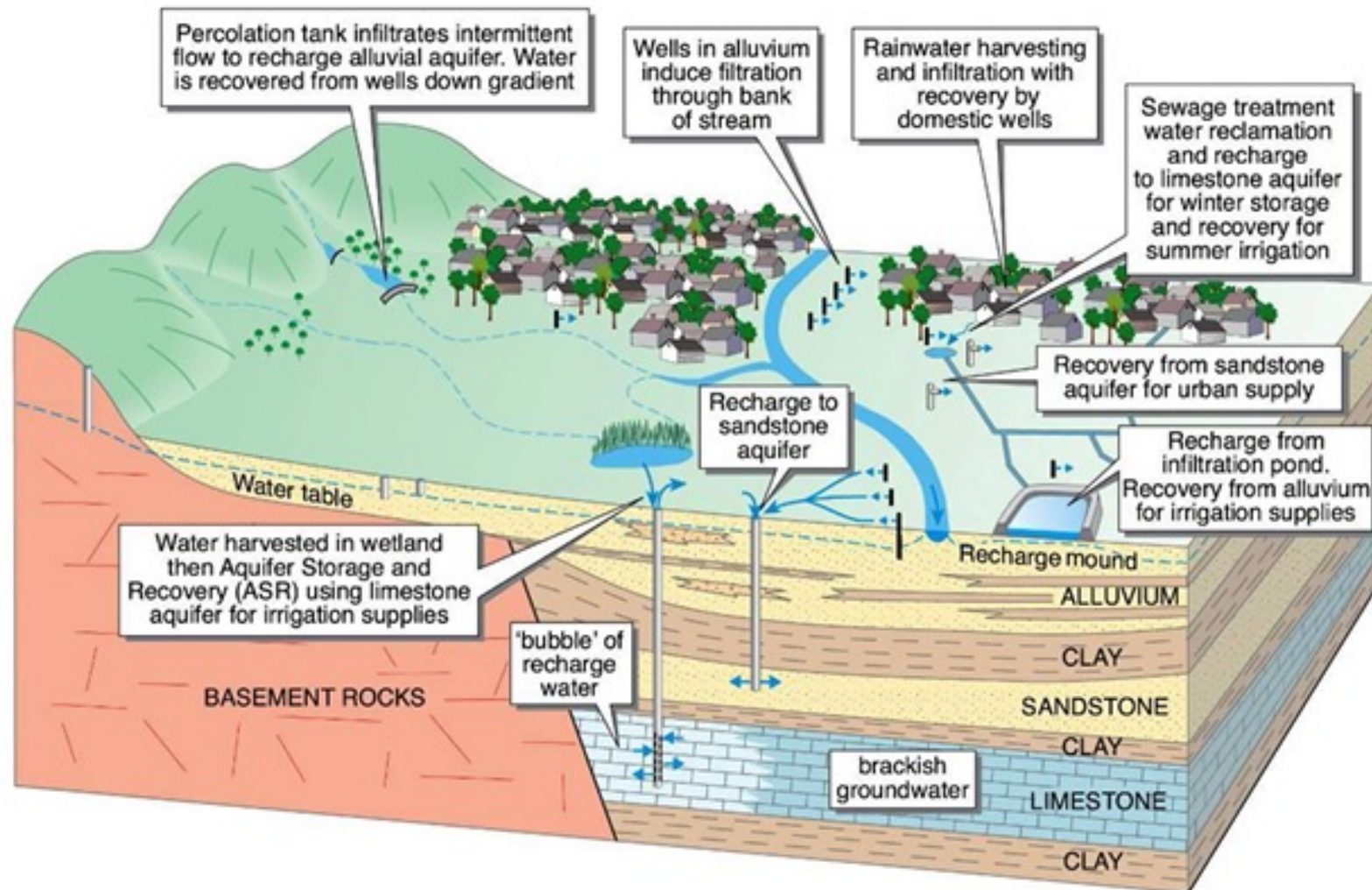
- Aquifer
- Aquifer Storage and Recovery
- Aquifer Storage Transfer and Recovery
- Artificial Recharge (legacy term)
- Bank Filtration
- Buffer Zone
- Cycle Test
- Dry Well
- Groundwater Replenishment
- Infiltration (Recharge) Basin (Pond)
- In Lieu Recharge
- Managed Aquifer Recharge
- Receiving Water
- Recharge Area
- Residence Time
- Soil Aquifer Treatment
- Source Water
- Target Storage Volume
- Underground Injection Control (UIC)

What is Aquifer Storage and Recovery (ASR)?

- Temporary storage of surface water underground
- Used in place of water tanks and reservoirs
- Water is recharged through wells directly into a target aquifer zone during wet or surplus periods and pumped out for beneficial use during dry or peak need periods



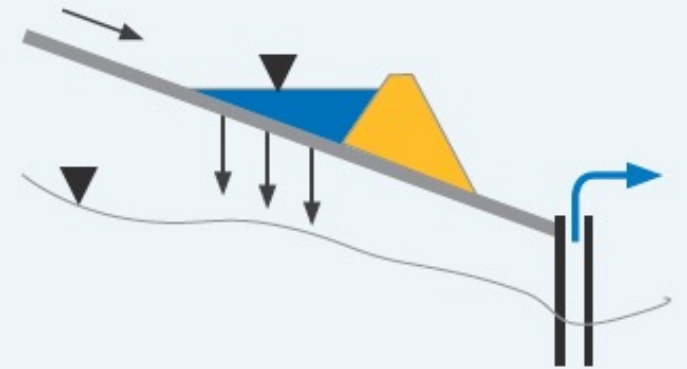
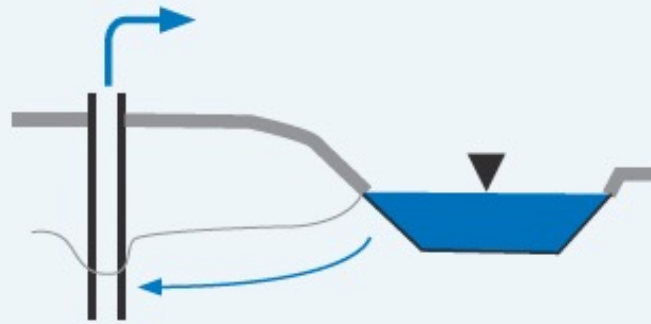
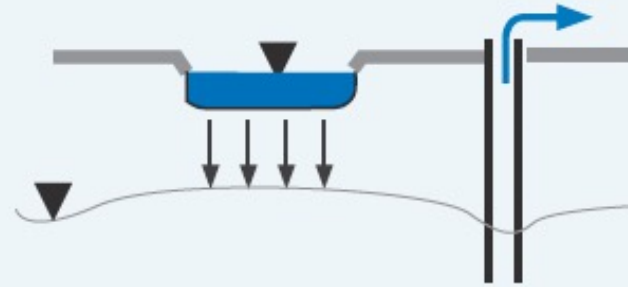
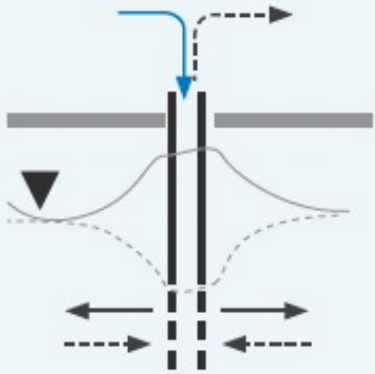
Adapt MAR to Local Conditions



Recharge Categories

Unintentional Recharge Enhancement (incidental)	Unmanaged Recharge (for disposal)	Managed Recharge (for recovery)
<ul style="list-style-type: none">• Clearing of deep rooted vegetation, or soil tillage• Spate irrigation• Leakage from water pipes and sewers• Irrigation deep seepage• Spraying herbicides	<ul style="list-style-type: none">• Stormwater drainage wells and sumps• Septic tank leach fields• Mining and industrial water disposal to sumps	<ul style="list-style-type: none">• Streambed channel modifications• Bank filtration• Water spreading• Recharge wells• Reservoir releases• Soil aquifer treatment• Rainwater harvesting

MAR Types



Different Scales of Managed Recharge





Source Waters for Recharge

- Surface water from rivers or lakes
 - Captured stormwater
 - Disinfected Drinking Water
 - Treated wastewater
 - Desalinated seawater and brackish water
 - Groundwater from other aquifers
- Recharge water compatibility
 - Aquifer matrix materials
 - Receiving groundwater
 - Vadose zone possibly also
 - Pollutants, trace elements, pathogens, emerging constituents

Pilot testing advisable



Stormwater as a Source for Managed Aquifer Recharge (MAR)

Low-impact development (LID)

1-10 af/yr per site

Distributed Stormwater Collection → MAR

(DSC-MAR)

10^2 - 10^3 af/yr per site

Regional spreading grounds

10^4 - 10^5 af/yr per site



Essential Requirements for MAR

- Sufficient demand for recovered water
- Adequate source and quality of source water
- Suitable aquifer to store and recover water
- Sufficient land footprint to harvest and treat water
- Capacity to effectively manage MAR project
- Water rights for source, storage, and recovery
- Satisfy adequately statutes and regulations
- Public Involvement/General Acceptance

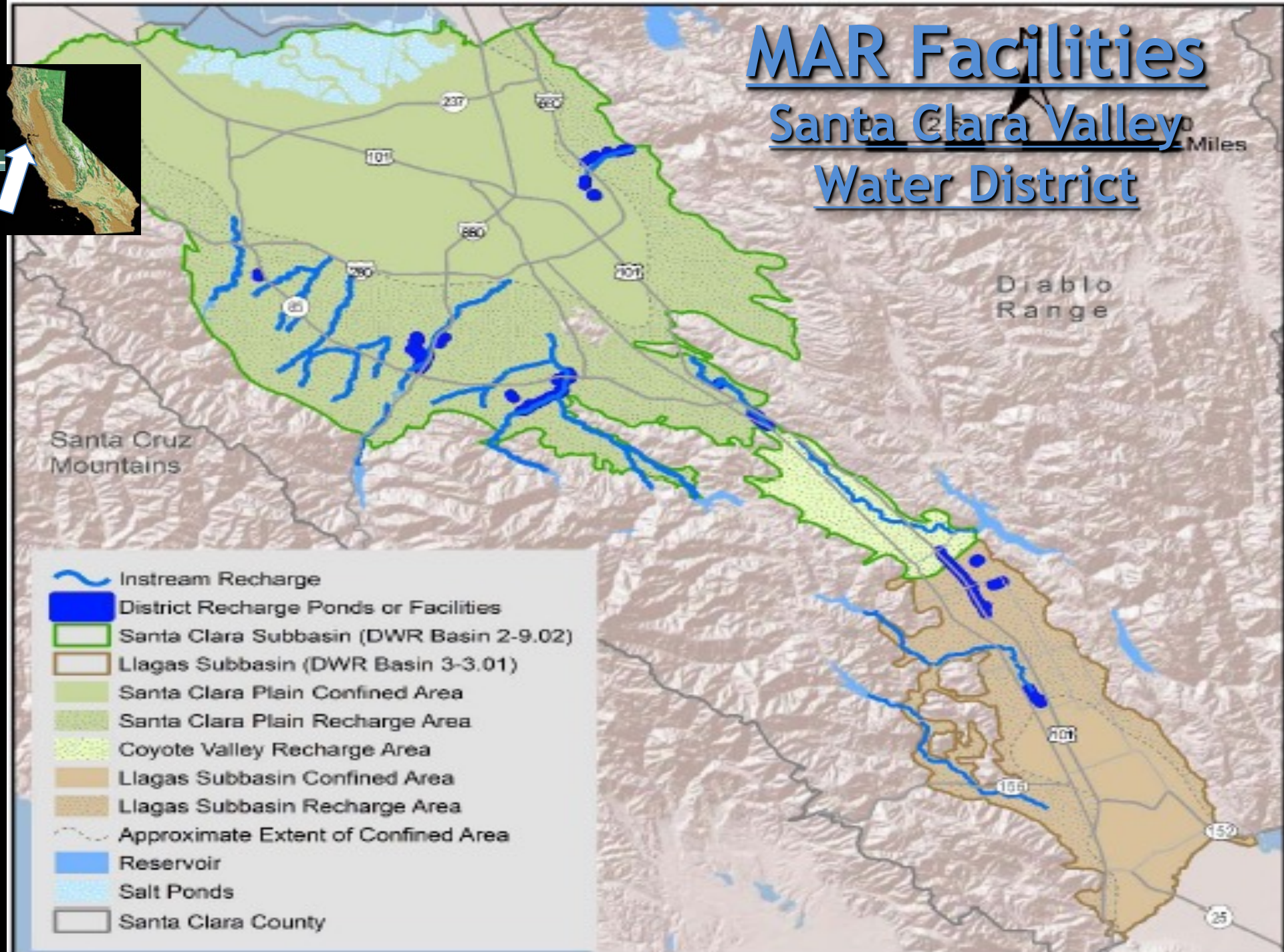


Technical and Regulatory Challenges of MAR

- Adequate hydrogeologic characterizations for water quantity and hydrogeochemical assessments for quality
- Inadequate aquifer knowledge serious impediment
- Consider short- and long-term impacts of both native groundwater and surface water
 - Changes in groundwater recharge, flow and discharge
 - Water quality effects of mixing
 - Chemical interactions with aquifer matrix
 - Monitoring levels and quality key



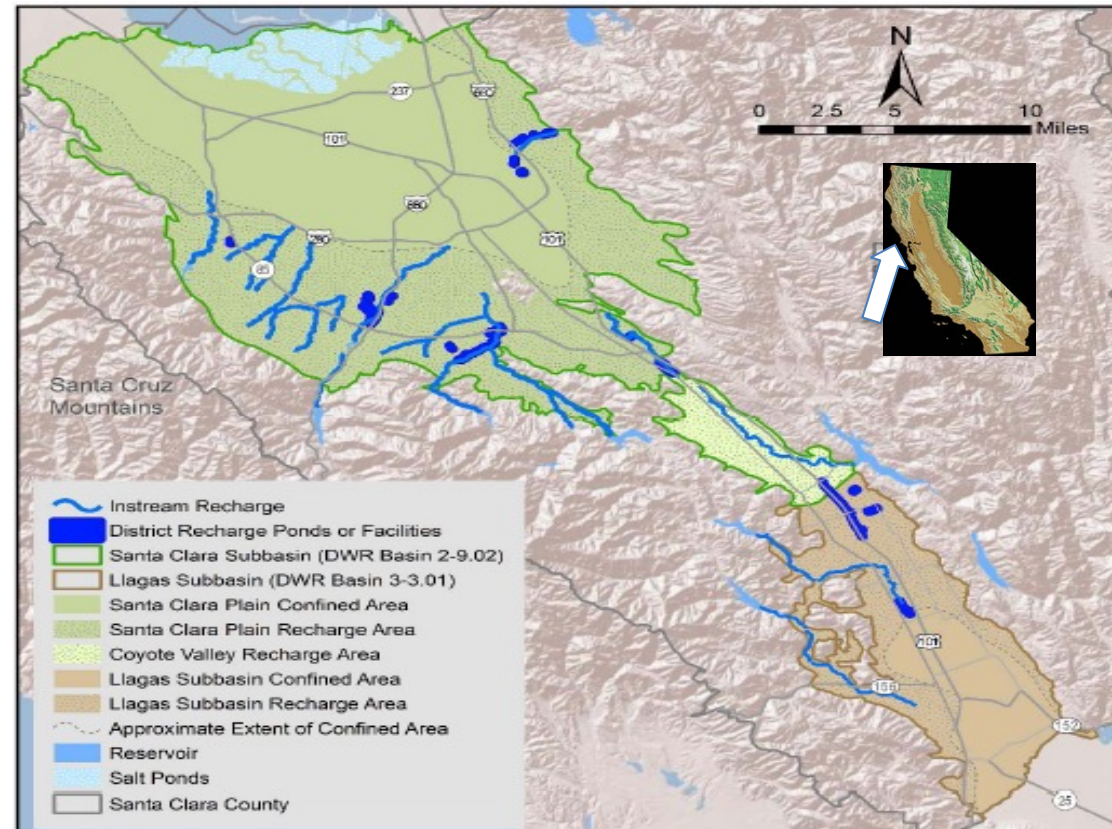
MAR Facilities Santa Clara Valley Water District



Long-Term MAR in California

Santa Clara Valley Water District

- Established in 1930s to address land subsidence and associated flooding from San Francisco Bay
- Land subsidence about 13 feet in San Jose between 1915-1970
- 393 acres of recharge ponds
- 91 miles of controlled in-stream recharge
- Recharge approximately 100,00 acre-feet per year



Long-Term MAR in California

Santa Clara Valley Water District

- Approximately half the supply comes from groundwater
- Direct and in lieu recharge
- Sources of water include stormwater water, recycled water and imported water



Long-Term MAR in California

Leaky Acres - City of Fresno & Clovis, Fresno Irrigation District

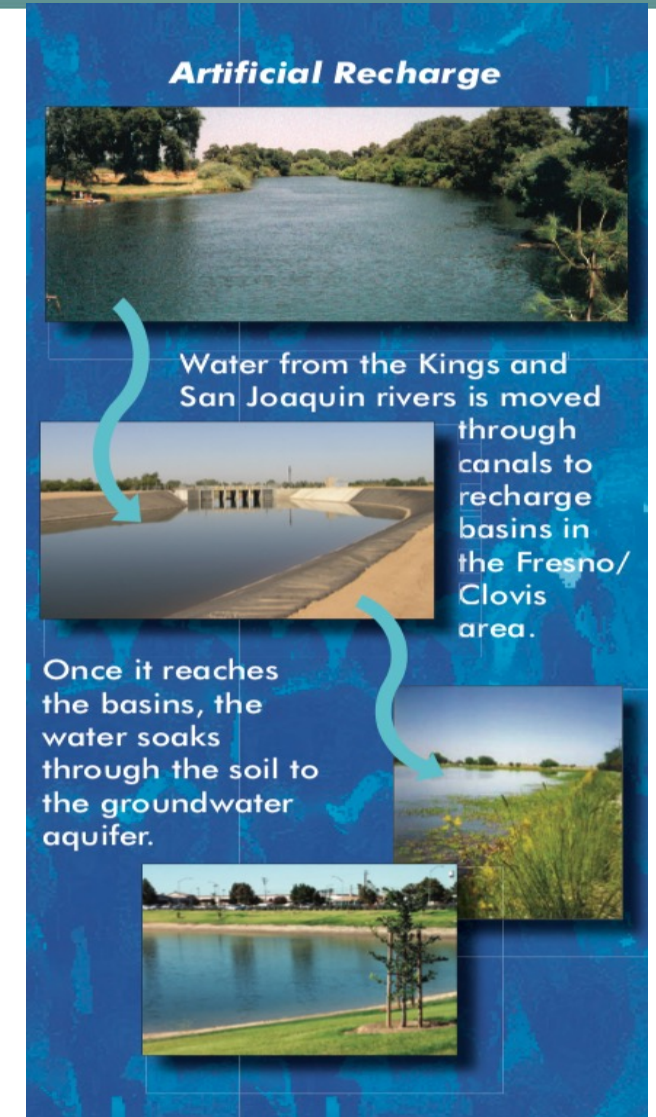
- Initiated in the 1970s to address falling groundwater levels
- Clovis - 85-acre recharge basin
- Fresno - 224 acres of recharge ponds
- Fresno Flood Irrigation District operates 700-mile canal and nearly 600-acres of recharge ponds



Long-Term MAR in California

Leaky Acres - City of Fresno & Clovis, Fresno Irrigation District

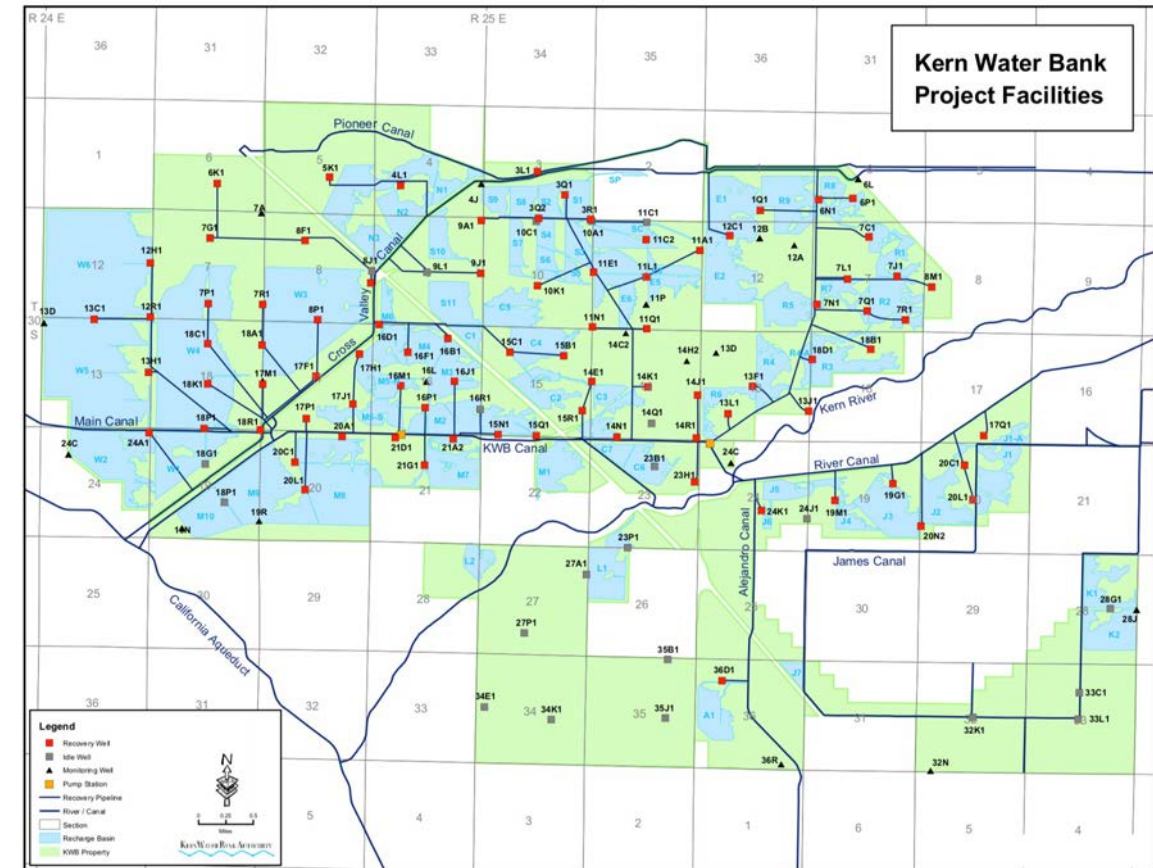
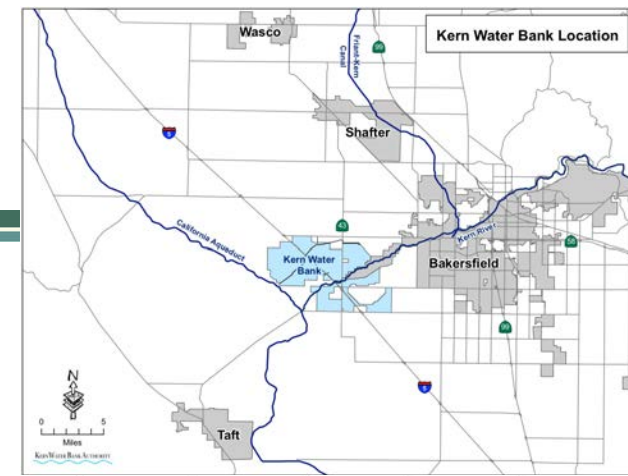
- In the 1930's groundwater was as shallow as 30 feet bgs, but now more on the order of 150 feet bgs
- Approximately 60,000 acre-feet/year recharged
- An additional 20,000 acre-feet stormwater recharged through Flood Control District recharge basins
- Recycled water use has also been increased for supplemental use, and not is over 25% of water supply in Clovis and 15% in Fresno



Long-Term MAR in California

Kern Water Bank

- Established in 1988 by the State - 1994 thru Monterey Agreement became a separate non-state entity
- 20,000 acres of state and federally designated habitat
- Habitat conservation plan / natural community conservation plan
- Bank capacity ~10MAF
- 7,000 acres recharge ponds - recharge rate 0.3 ft/day
- 85 recovery wells - 5 cubic feet/sec
- 36 miles pipeline
- 6-mile canal
- Recharge more than 2.5MAF and recovery 1.5 MAF annually

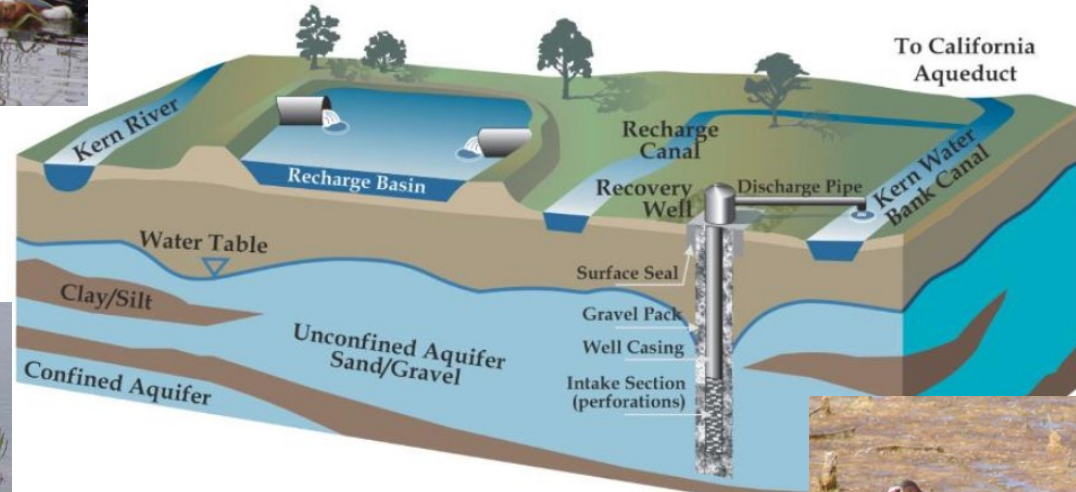


Long-Term MAR in California

Kern Water Bank



Recharge thru Ponds



Recovery thru Wells

Courtesy of Kern County Water Agency

Long-Term MAR in California - WRD

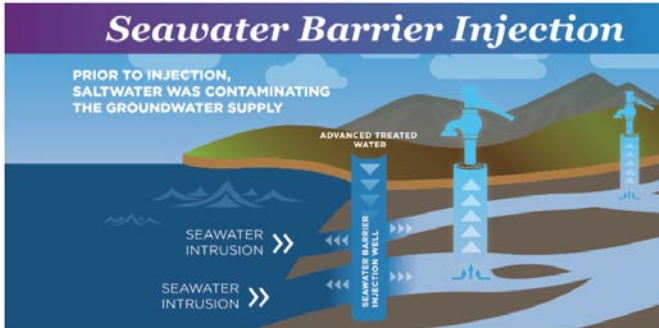
Water Replenishment District of Southern California

- Created by Special Legislation in 1959 to manage, regulate and replenish West Coast and Central Basins
 - 43 Cities
 - Population ~4M
 - ~600,000 AF/Y Water Usage
 - ~250,000 AF/Y Groundwater
 - Over 400 Pumping Wells
- Water Interdependence Now
 - Maximize local stormwater and recycled water for replenishment and resiliency



Long-Term MAR in California - WRD

WRD Leo J. Vander Lans Advanced Water Treatment Facility



1950's Seawater Intrusion Barrier Testing

Long-Term MAR in California - WRD



1937



Rio Hondo



***Facilities owned and operated by Los Angeles
County Flood Control District***

Size Both Basins: 1,000 Acres

Intake Capacity: 2,850 cfs

Storage Capacity: 5,200 af

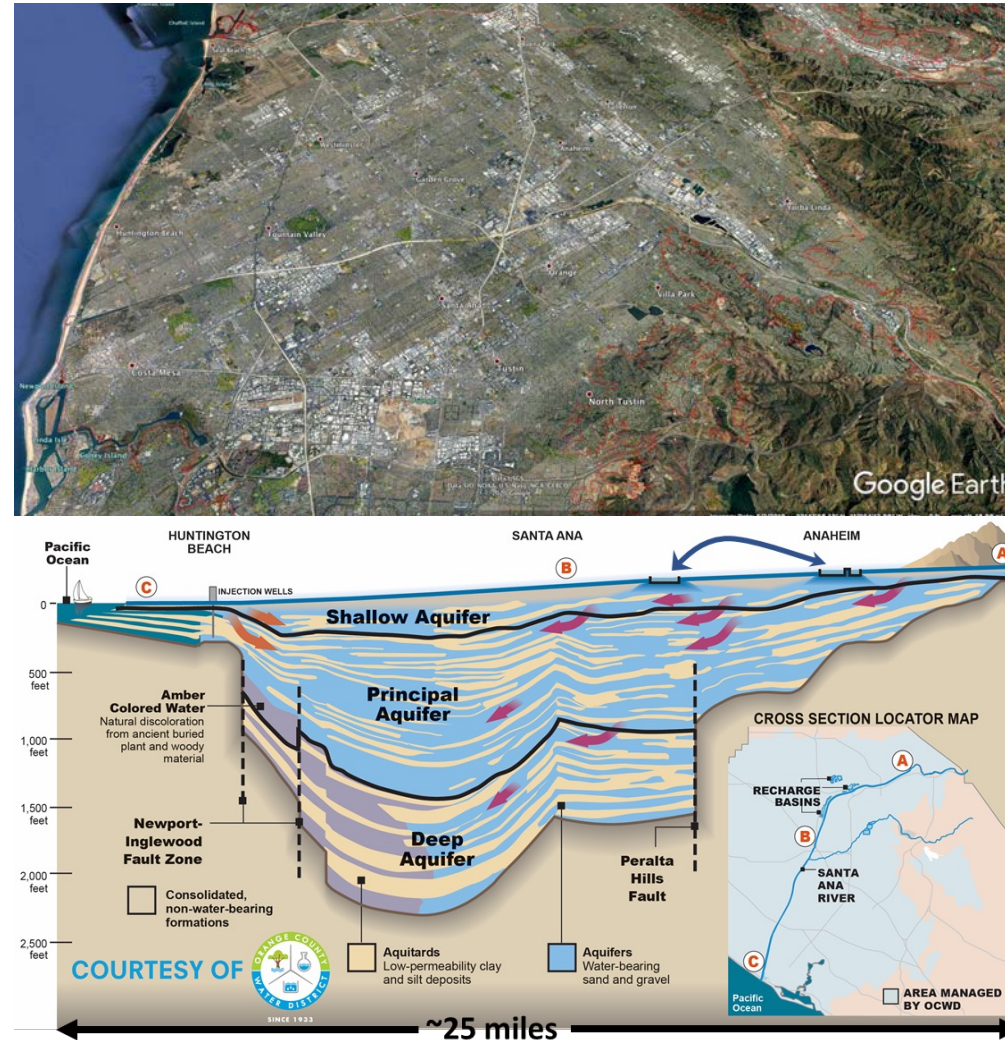
Infiltration Rate: up to 1,200 cfs

(2,400 afd)

Long-Term MAR in California - OCWD

Orange County Water District

- Established in 1933 to
 - Protect rights to Santa Ana River flow
 - Manage OC Groundwater Basin
- Provide groundwater to
 - 19 municipal and sewer districts
 - 2.5 million residents
- Basin provides 77% of the water supply for north and central Orange County, or ~300,000 AF/Y
- Basin capacity ~40MAF



Long-Term MAR in California - OCWD

Main Recharge Sources

- River storm flows
- River base flows (largely treated effluent from Riverside and San Bernardino counties)
- Imported water (decreasing supply)
- Recycled water (increasing supply)



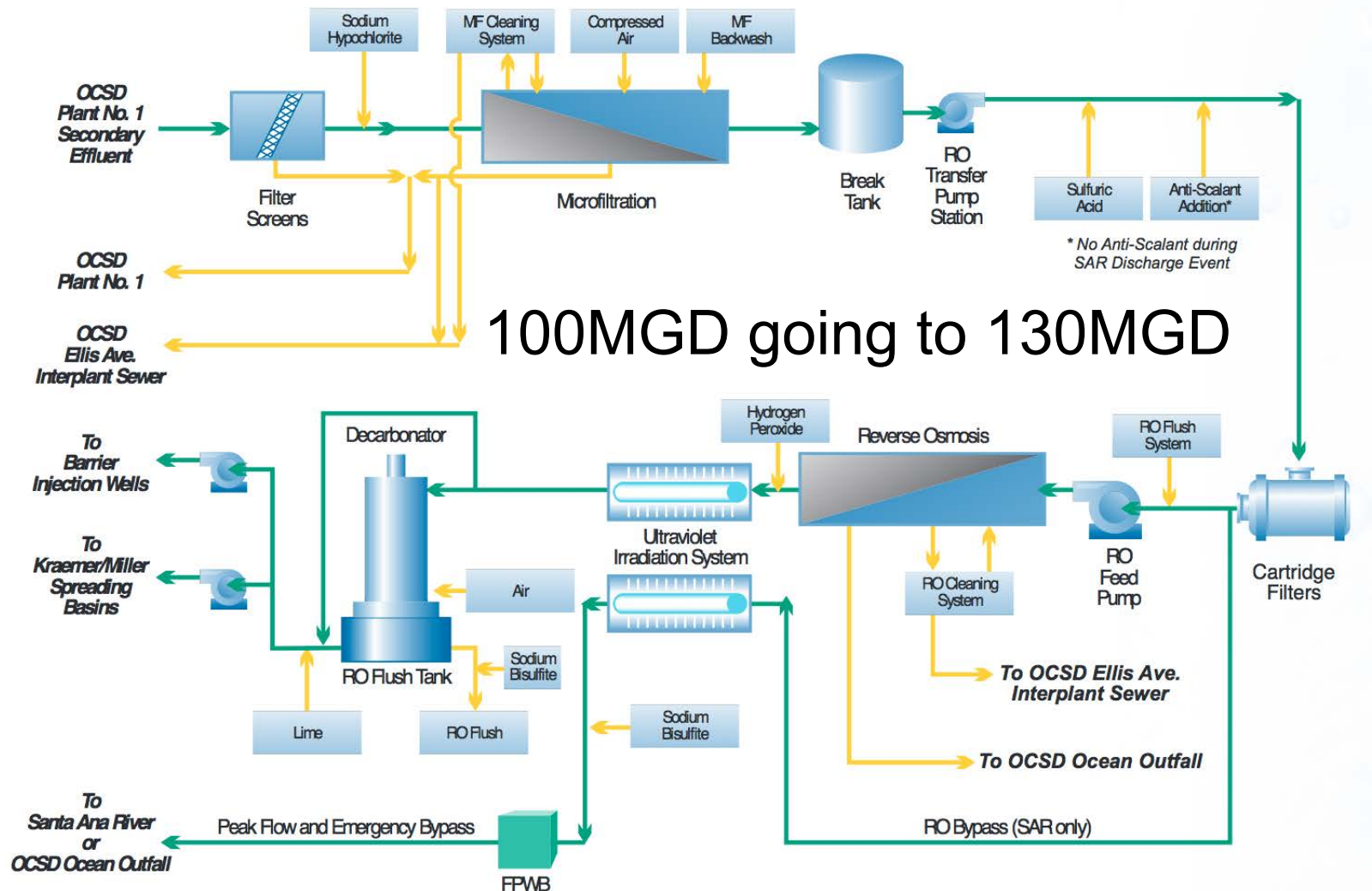
OCWD recharge facilities along Santa Ana River. Warner Basin in center/background.

**Total Recharge:
250,000- 300,000 AFY**

Long-Term MAR in California - OCWD

The Groundwater Replenishment System (GWRs)

- Operating since mid-1990s
- Preliminary/primary treatment – screening, grit chambers, clarifiers, biological sludge treatment
- Microfiltration
- Reverse osmosis
- High intensity ultraviolet light with hydrogen peroxide
- pH adjustment and decarbonation
- Calcium hydroxide stabilization



International Association of Hydrogeologists - Managed Aquifer Recharge Commission
<https://recharge.iah.org/>

ISMAR10 in Madrid, Spain 20-24 May 2019

National Ground Water Association www.ngwa.org

American Groundwater Trust www.agwt.org

Groundwater Resources Association of California

<https://www.grac.org/ismar-speaker-presentations/> ISMAR11 in Long Beach in 2022

Department of Water Resources Sustainable Groundwater Management Program

<https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management>

Santa Clara Valley Water District

<https://www.valleywater.org/your-water/where-your-water-comes-from/groundwater>

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