Sources and travel times of groundwater recharge and groundwater dependent ecosystems in the Livermore Valley Basin

Using Isotopes to Optimize Managed Aquifer Recharge with Zone 7 Water Agency


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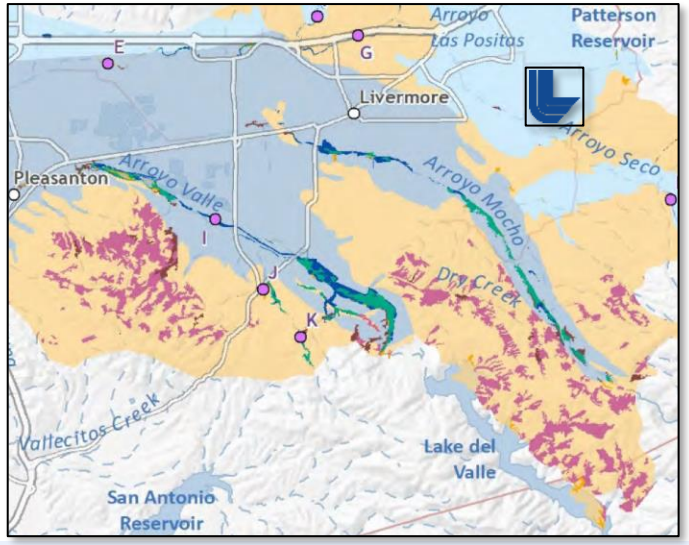
Prepared by LLNL under Contract DE-AC52-07NA27344.

Context: Laboratory Directed Research

- unique expertise in isotope tracing of water flows in the environment
  - 3-year study (2022-2025)
  - Funded internally by LLNL
  - Demonstrate and develop novel isotopic tracer techniques
  - Advance understanding of Livermore Valley basin recharge via Arroyos



LLNL collaboration with Zone 7

- Zone 7 provides water management in the Livermore Valley Groundwater Basin (DWR Basin No. 2-10)
  - “Deliver safe, reliable, efficient, and sustainable water and flood protection services.”
- Strategic Plan initiatives:
  - #7 - Manage as the GSA and implement the groundwater management plan
  - #8 - **Study and refine knowledge of the groundwater basins**
- Study focus:
  - Zone 7’s “recharge operations to augment instream and mining pond aquifer recharge”
  - Interconnected Surface Water (ICSW): Impact on GDEs and protected species
- Special thanks to Ken Minn and Jacob Danielsen

Practical research questions:

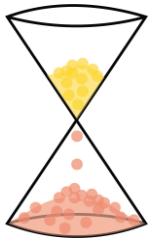
- Groundwater recharge:
  - What are the sources of water recharging the basin?
  - Where does groundwater recharge the basin?
  - What is the contribution of 2023 and 2024 recharge?
  - What are the groundwater recharge rates?

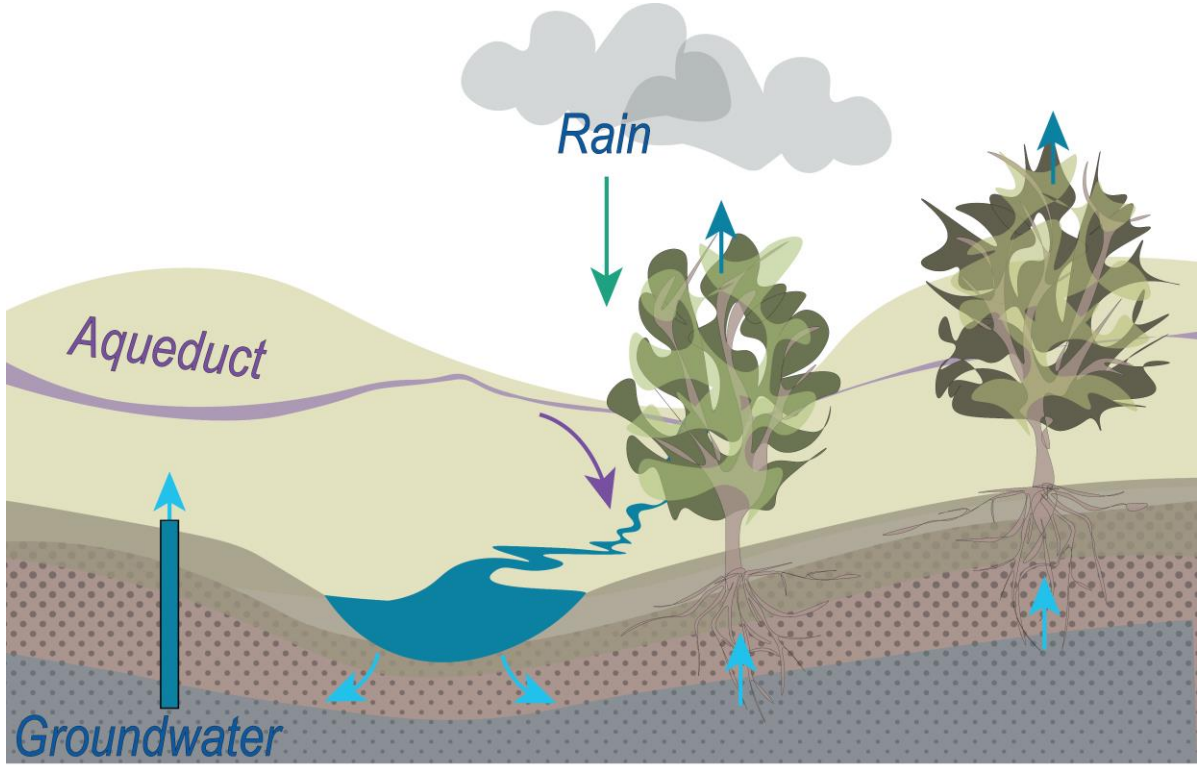
- Groundwater dependent ecosystems (GDEs):
  - What sources of water are used by GDEs in Sycamore Grove ?

Isotope chemistry tracks water sources and velocities

- Like fingerprints, stable isotopes track water source
  - Flood waters, light rains, or imported water

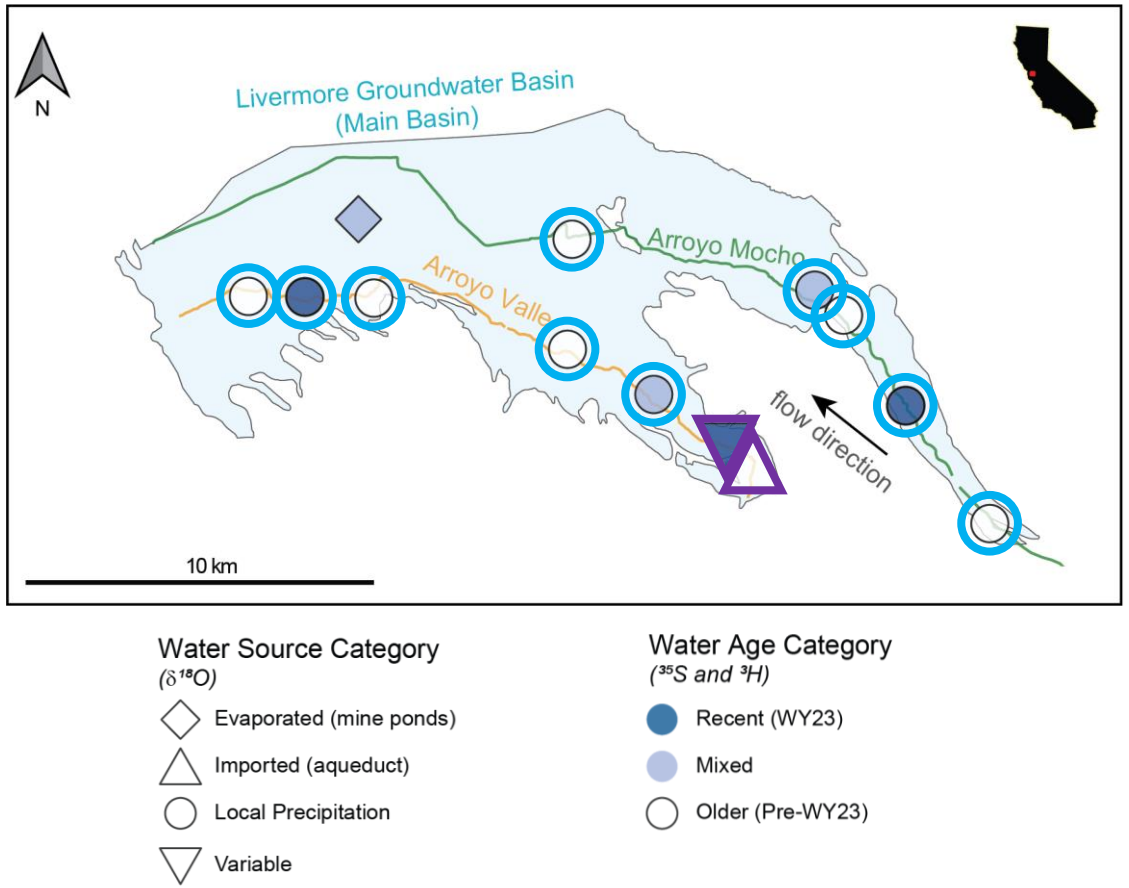
- Radioactive isotopes act as a timer from source (rain) to receptor (groundwater well)
  - naturally occurring isotopes





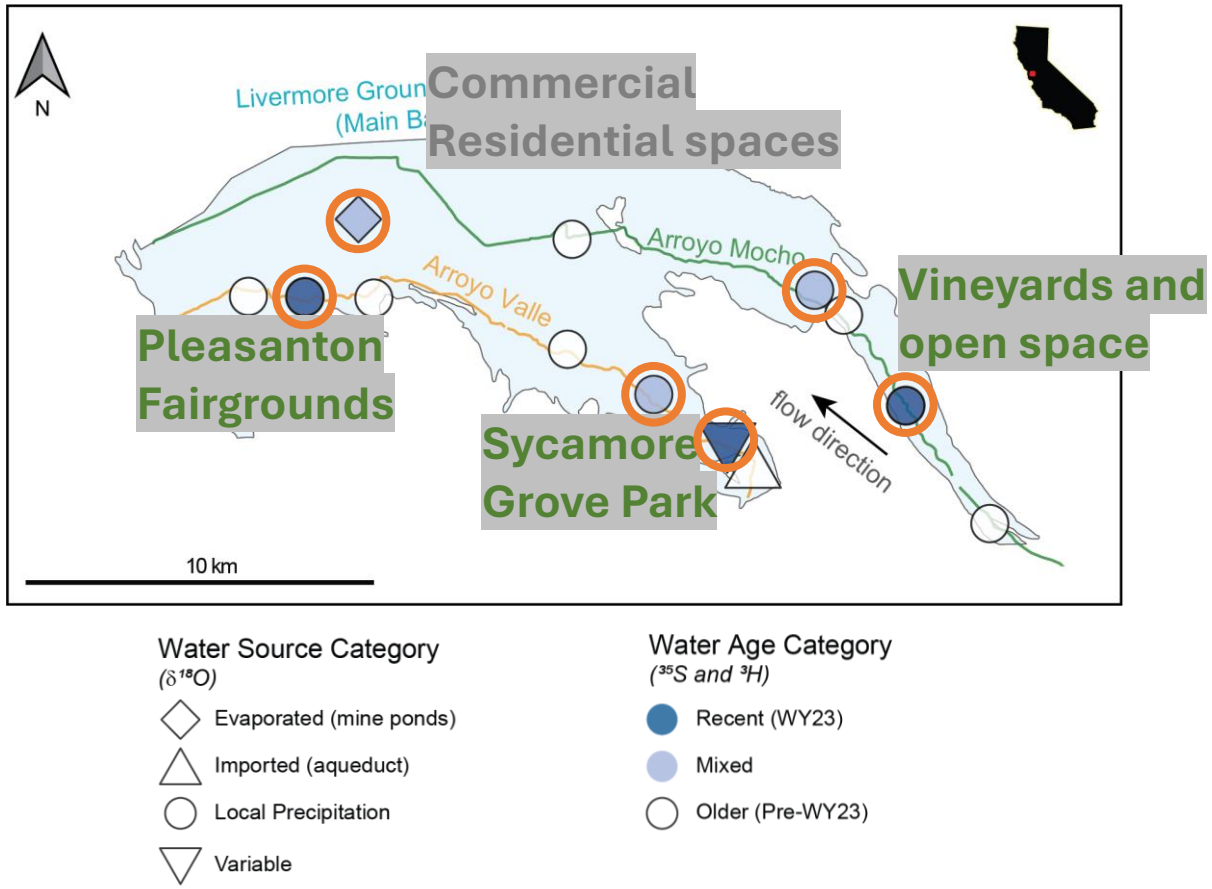
What are the sources of water recharging the basin?

- Most recharge from local winter storms and flooding events (blue circles: 10/13 wells)
- Very little groundwater sampled was imported from the South Bay Aqueduct (purple triangles: 2/13 wells)



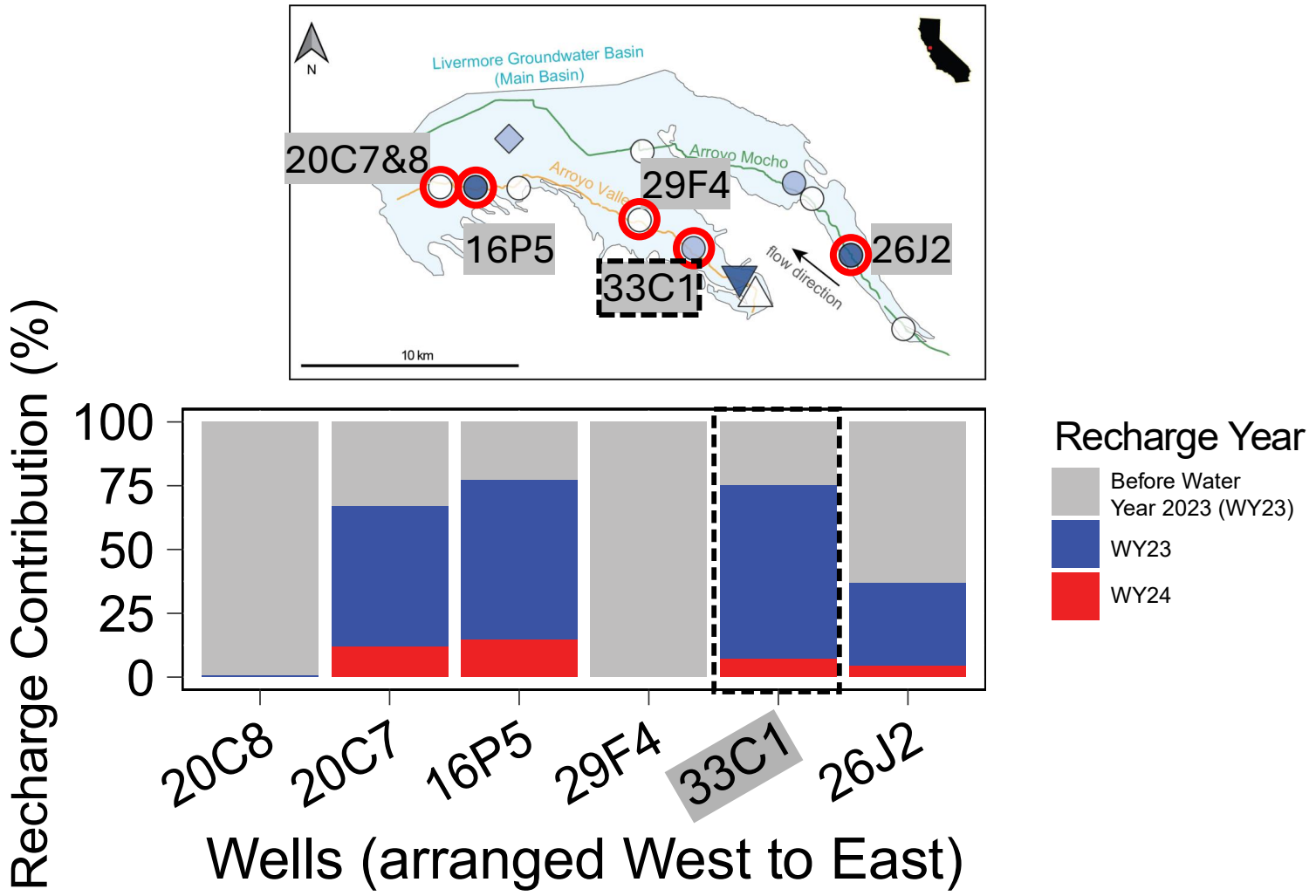
Where does groundwater recharge the basin?

- 6 out of 13 wells tested had evidence of rapid recharge (orange circles).
- Rapid recharge found in green spaces
  - No clear association with lithology



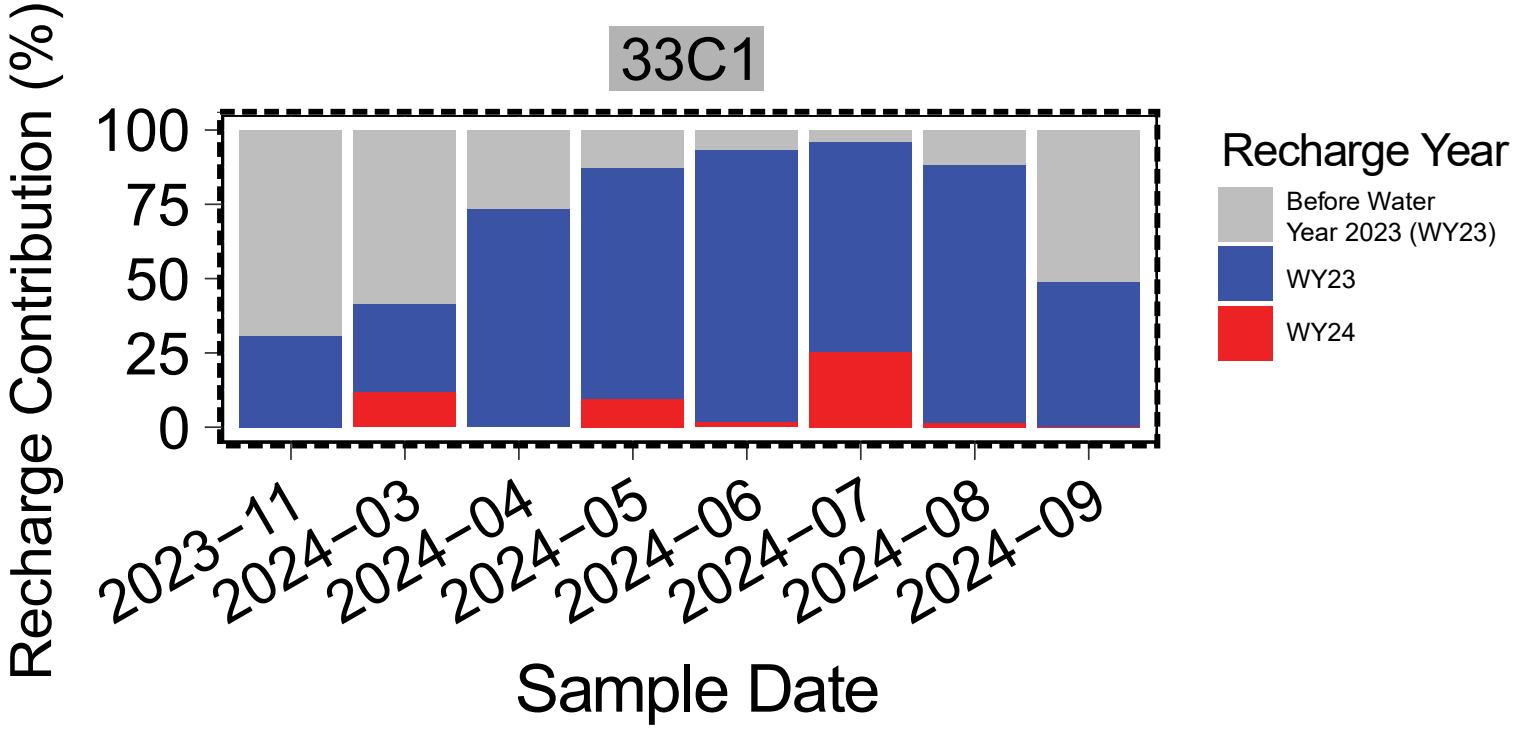
What is the contribution of 2023 and 2024 recharge?

- New recharge contribution investigated in 6 wells
- New recharge ranged from 0-75% of water
- Findings based on age model + isotopic tracers:
  - Sulfur-35
  - Tritium
  - Helium-3 (from tritium decay)



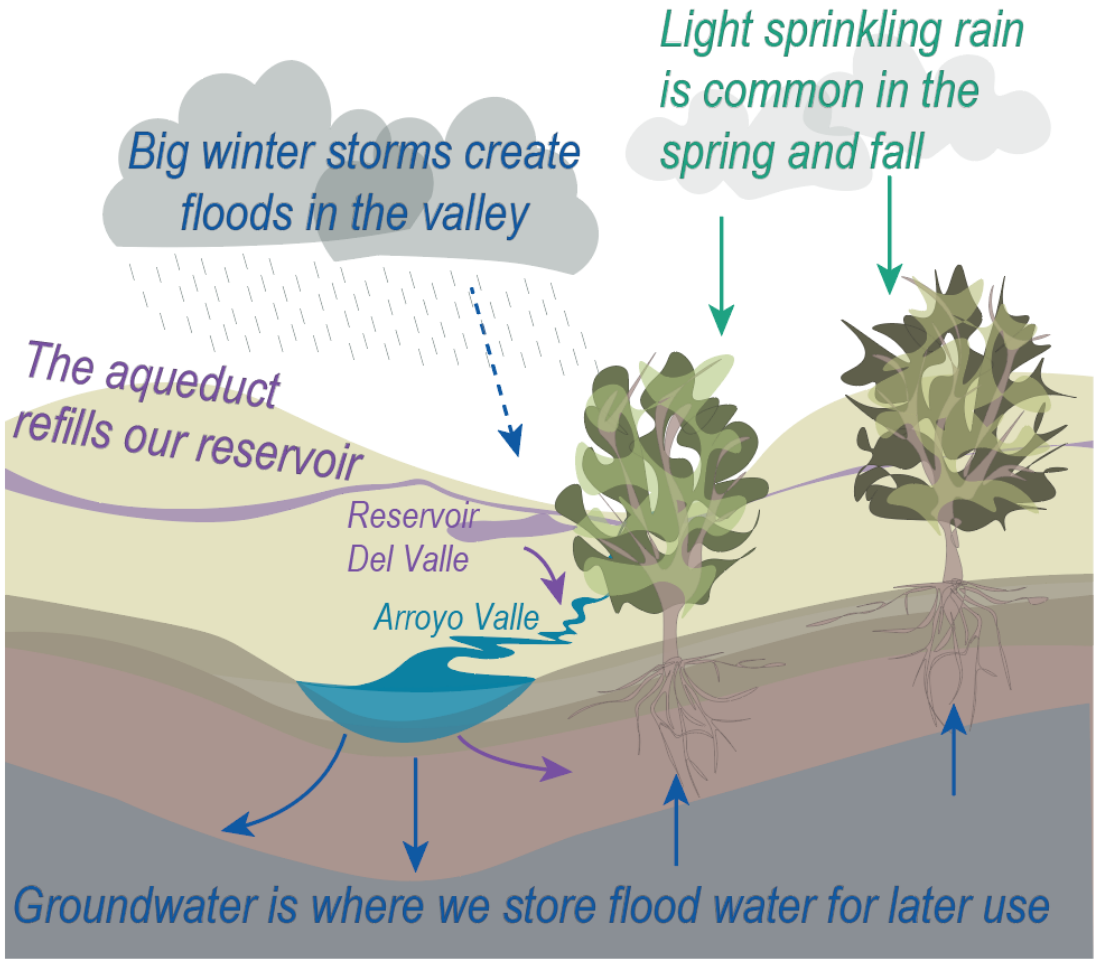
New water contributions are seasonally variable

- Quantified monthly recharge rates range from 0.1-6.9 ft/yr
- Rates can be implemented as particle tracking constraints in updated numerical flow models
- Reduces uncertainty for more informed management decisions

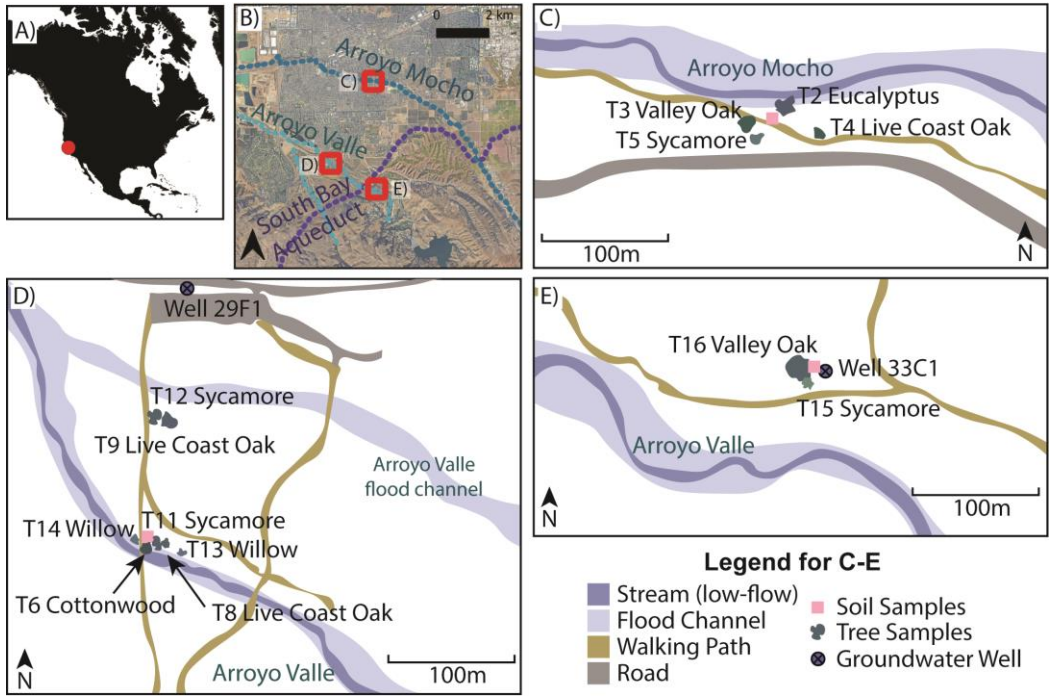


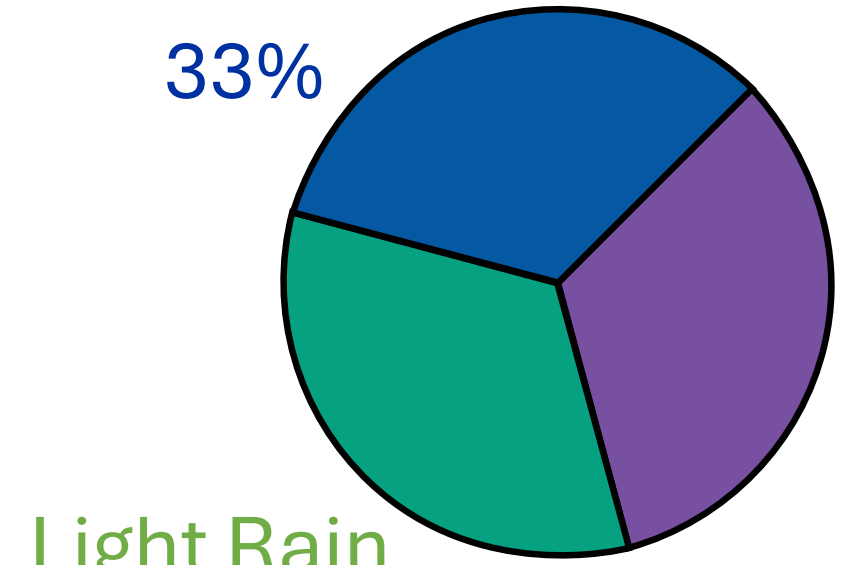
What sources of water are used by GDEs?

- Groundwater
  - Water stored underground, refilled by winter flooding
- Light Rain Events
  - Light showers that most people barely notice
- Imported Water
  - Water from the South Bay Aqueduct, delivered through Reservoir Del Valle



Isotopes show that MAR operations support GDEs

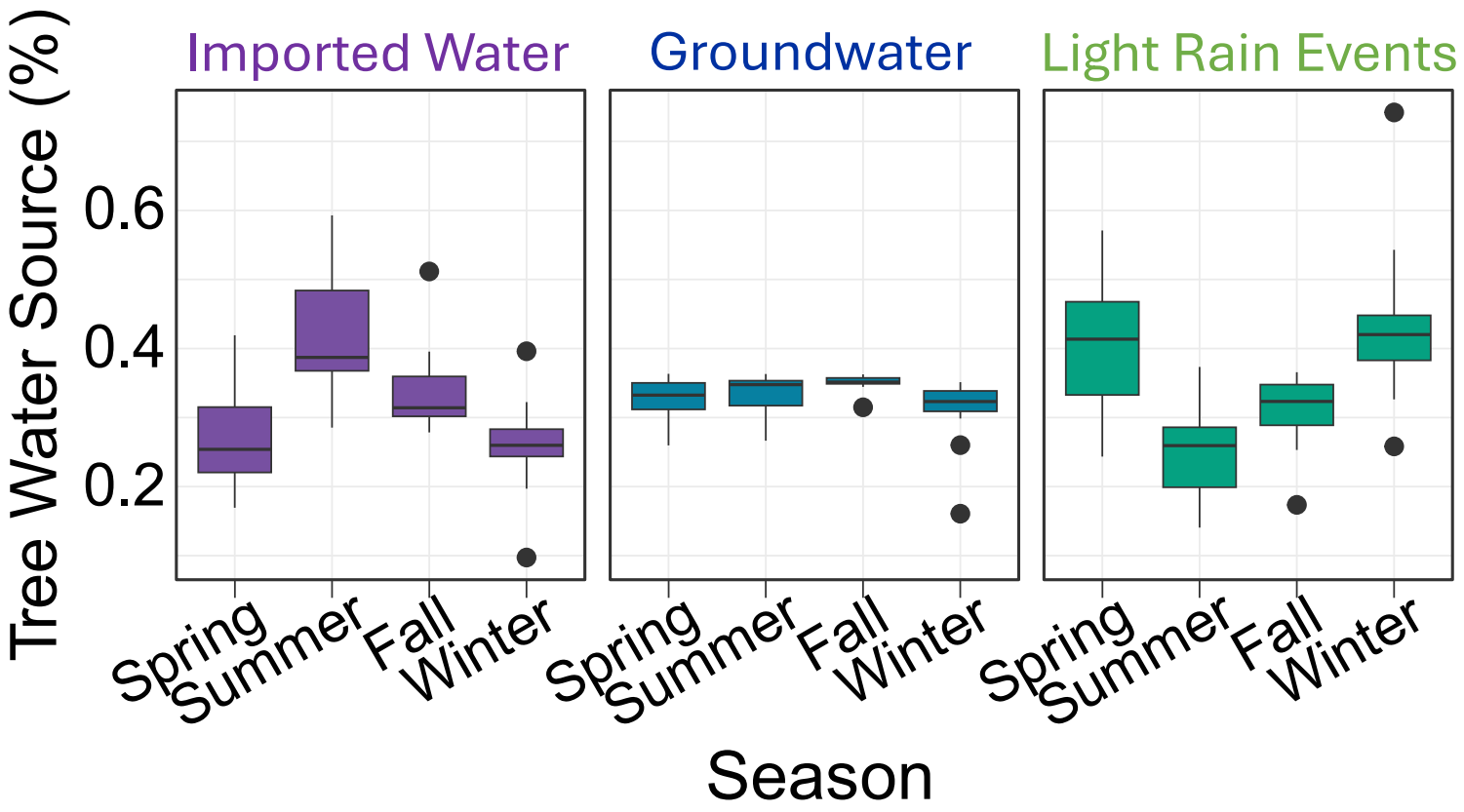




- 87 tree samples from 13 trees
- April 2024 through April 2025

Contributions of water sources vary seasonally

- Imported water supports GDE demand, particularly in summer.
- While light rains only contribute 10% of rain volume, they are important for GDEs.
- Method demonstrates SGMA compliance.



Isotope research answered these three questions:

- Identified 6 wells with rapid recharge (recommendations for MAR efficiency)
- Quantified recharge rates for decision-risk reduction (model integration)
- Demonstrated that imported MAR water is used by GDEs (SGMA compliance)

Hydrological Processes

RESEARCH ARTICLE

How Rains and Floods Become Groundwater: Understanding Recharge Pathways With Stable and Cosmogenic Isotopes

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Received: 22 July 2024 | **Revised:** 3 October 2024 | **Accepted:** 21 November 2024

In review 2026

Quantifying groundwater recharge rates with cosmogenic isotopes and an age-ranked storage selection model.
Submitted to Water Resources Research.
Lerback, Visser, Harm, Grande, Moran, Minn, and Danielsen.

Ecohydrology

RESEARCH ARTICLE | Full Access

California Trees Seasonally Use Augmented Water Sources: Water Isotope Tracking in a Groundwater-Dependent Ecosystem

Jory Chapin Lerback, Erik Oerter, Ate Visser, A. Jake Harm

First published: 08 January 2026 | https://doi.org/10.1002/eco.70166 |

Key Findings (1/2): Groundwater Recharge

- Sources, locations, and rates of groundwater recharge
  - most recharge to wells is locally sourced
    - based on the similarity between well samples and the oxygen-18 signature in rain
  - green spaces allow for rapid recharge
    - based on the detection of short-lived radioactive sulfur-35 in wells in open spaces
  - water year 2023 caused significant recharge across the basin
    - based on groundwater age models and isotope age tracers in six wells

- Monthly recharge rates greater than the annual precipitation total indicates focused recharge of local runoff

Key Findings (2/2): Groundwater Dependent Ecosystems

- Water used by GDEs in Sycamore Grove
  - composed of 1/3 groundwater, 1/3 rain, and 1/3 imported water
    - based on analyses of deuterium and oxygen-18 in plants and sources
  - source contributions vary seasonally
    - contribution of imported water increases in summer
    - rain contribution decreases in summer
    - groundwater contribution remains constant

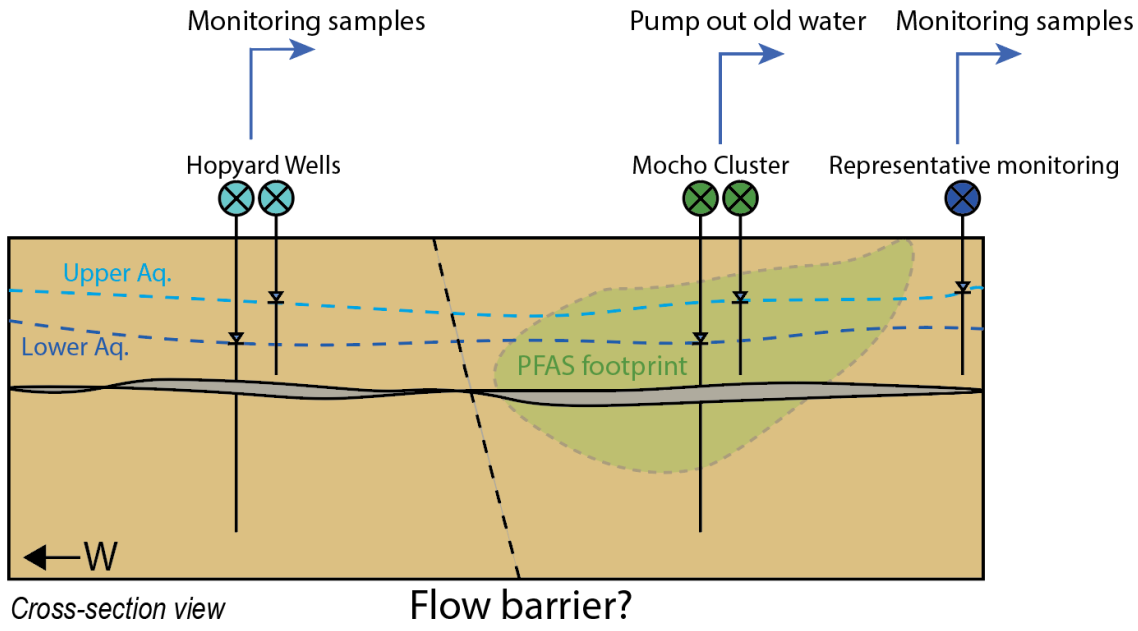
- MAR operations support groundwater dependent ecosystems

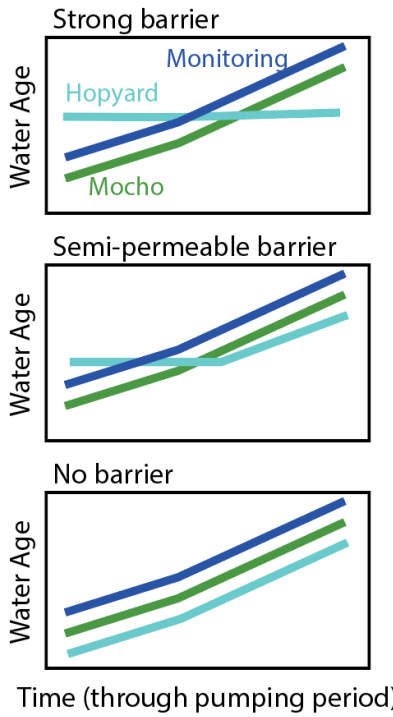
Why partner with LLNL

- Growing reliance on MAR to secure long-term water supplies.
- Regulatory pressure under SGMA to protect GDEs.
- Need to ensure each recharge dollar is used efficiently.
- **Isotope data gives us hard evidence on where recharge goes and how fast.**

Opportunities for Future Collaboration

- Estimate recharge rates from Lake I with isotope tracers:
  - Recharge rates estimates can justify purchase and diversion of flood waters
  - Proposal to Google Water Initiative (led by Livermore Lab Foundation)
- Hydrodynamics for PFAS management
  - Examine flow barrier between Hopyard and Mocho well fields
  - Potential WaterSMART Bureau of Reclamation Applied Science Grant application





Thank you

- As climate changes, water resources will be increasingly variable
- Managed aquifer recharge can be optimized as a water security solution
- More isotopic research can help inform management decisions

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