



# **Transport of Agricultural Chemicals: Unsaturated Zone to Ground Water to Surface Water, San Joaquin Valley, California**

**Joseph Domagalski**

**and**

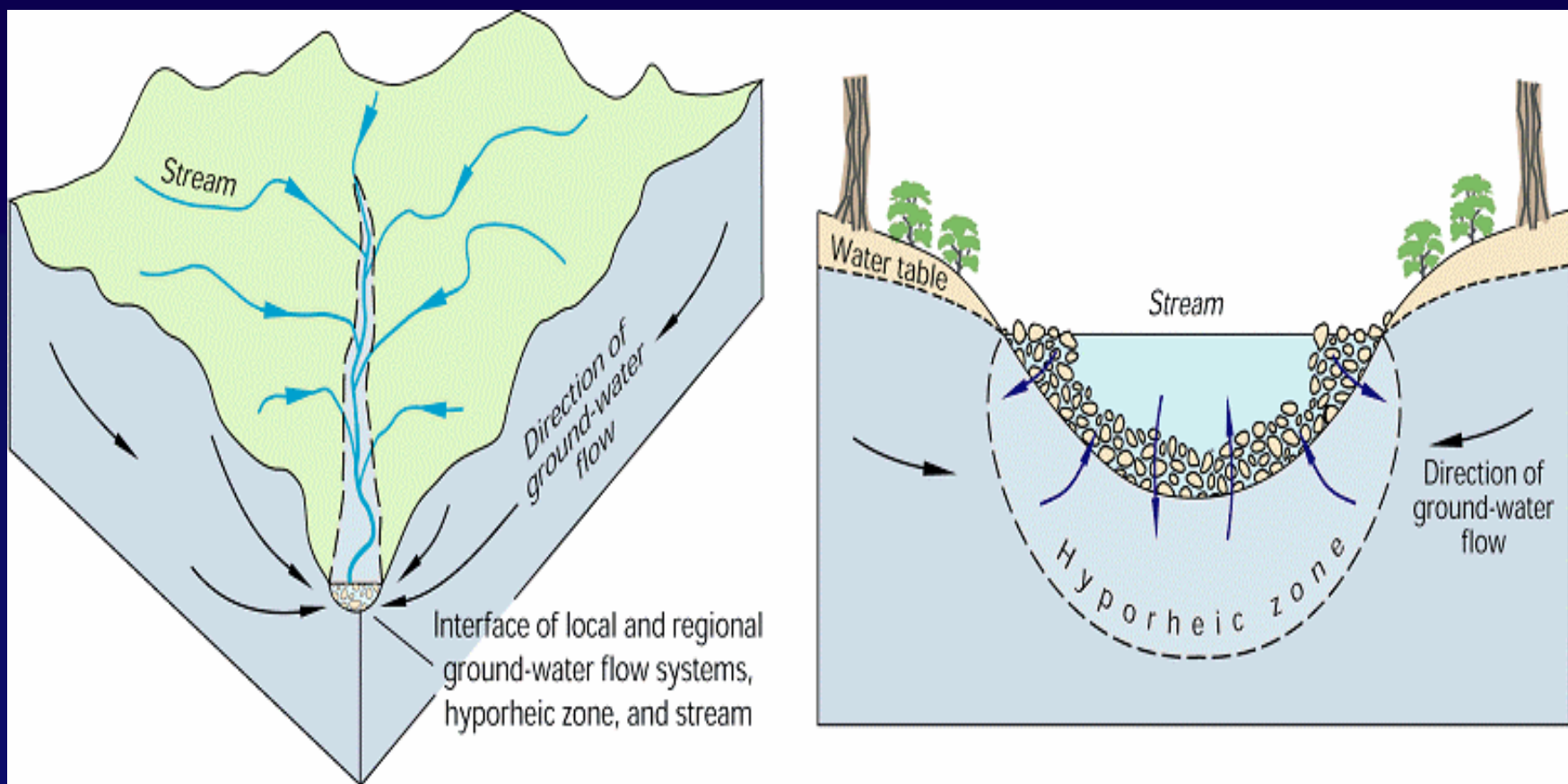
**Steven Phillips**

# Purpose and Goals of Study

---

- How do agricultural chemicals move through hydrologic compartments? (rain, soil, ground water)
- How does the movement of water affect the transport, concentrations, and fate of agricultural chemicals?
- Can we track these processes in the environment?-- Focus on processes happening in small watersheds, or short flow paths--What are the implications for agricultural management?

# Schematic of Water Movement In A Small Watershed



# Design Requirements of Flow Path Study

---

- The focus of the study was on a one-kilometer flow path--Almond orchard to the Merced River
- The unsaturated zone and ground-water chemistry had to be monitored at the top of the flow path
- Two additional locations along the ground-water flow path had to be monitored.
- Ground-water discharge to the Merced River had to be quantified, and analyses for agricultural chemicals were required.
- Cooperation from growers and landowners had to be secured

# Design of Study in the San Joaquin Valley, continued

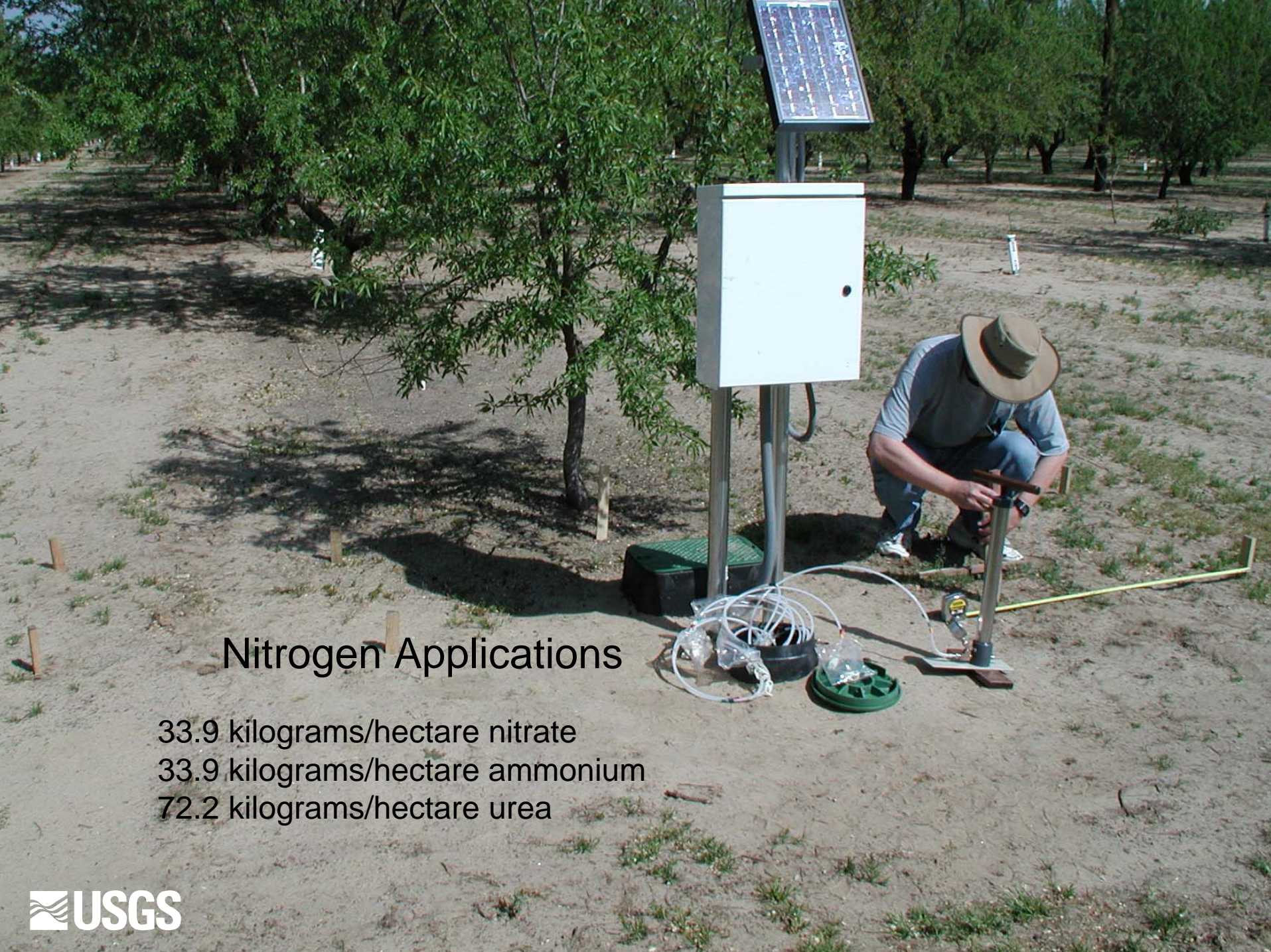
---

**Requirements of study: Compute water balance from irrigation, rain, and meteorological data**

**Follow the movement of water and chemicals into soil to ground-water table and to a stream interface (lower Merced River)**

**Measure chemicals, and model water movement along ground-water flow path**





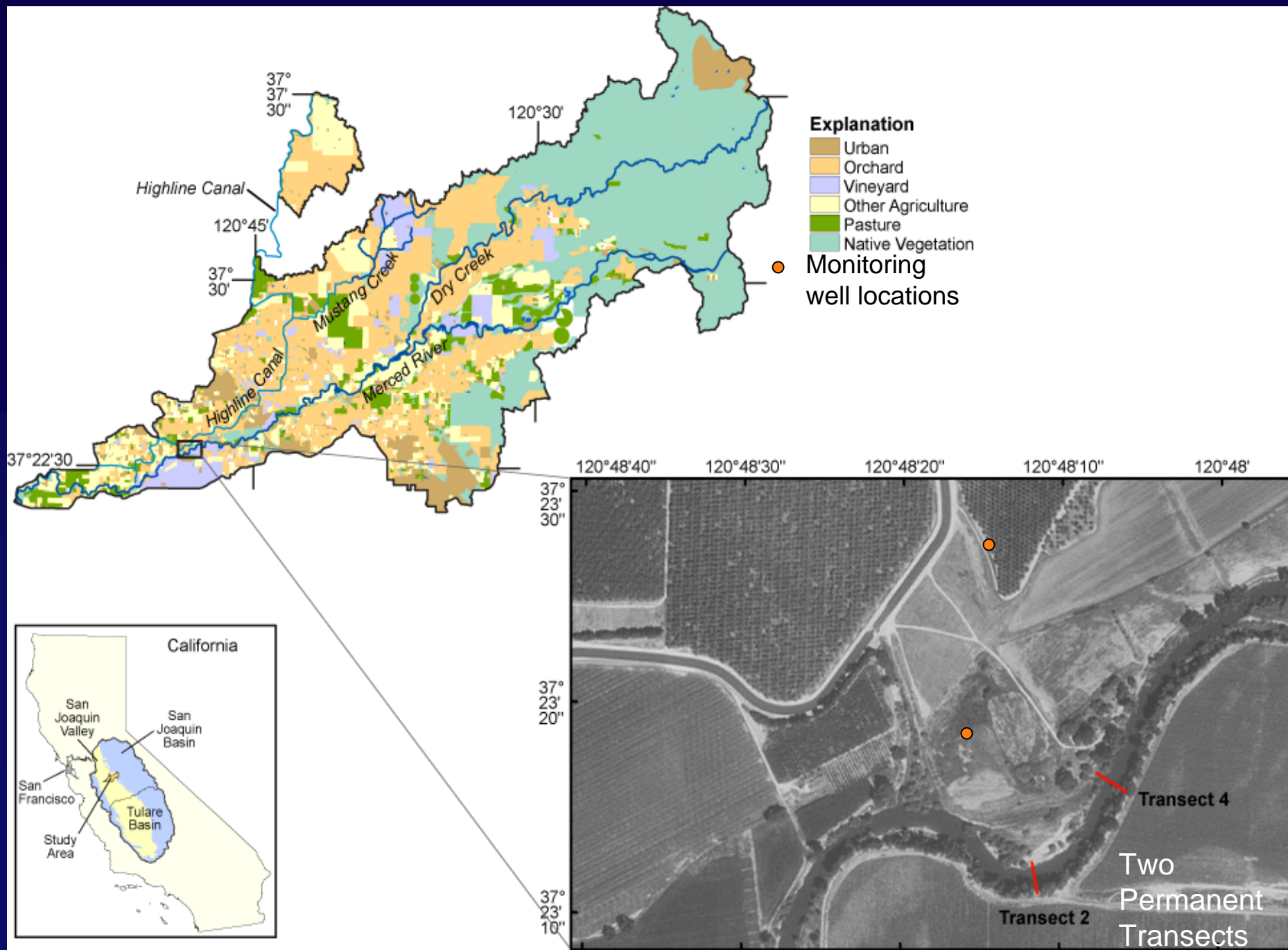
## Nitrogen Applications

33.9 kilograms/hectare nitrate

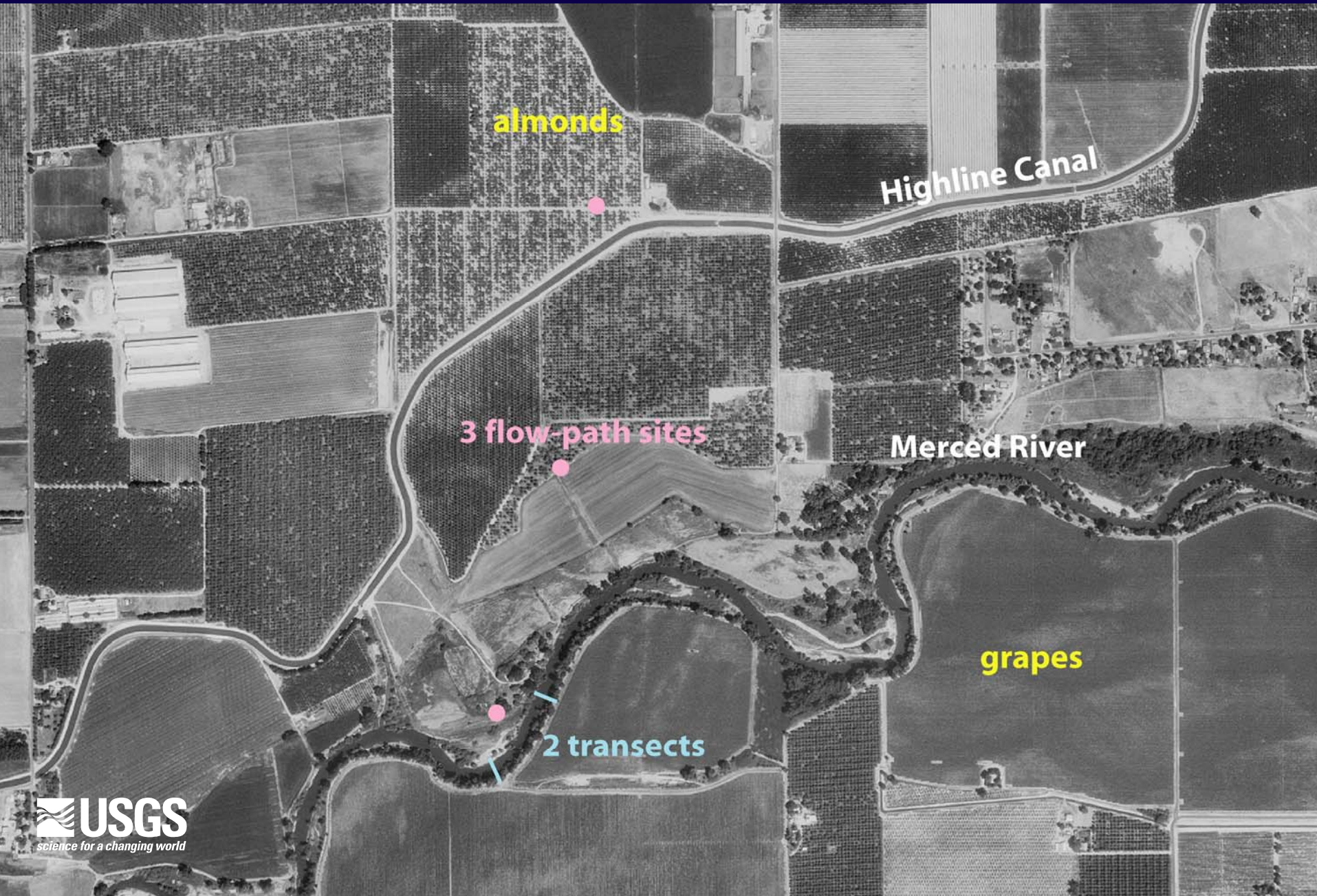
33.9 kilograms/hectare ammonium

72.2 kilograms/hectare urea





# Overview of Flow Path and GW/SW sites





# Top of Flow Path Site - Almonds Everywhere





# Related Data



Temperature &  
humidity



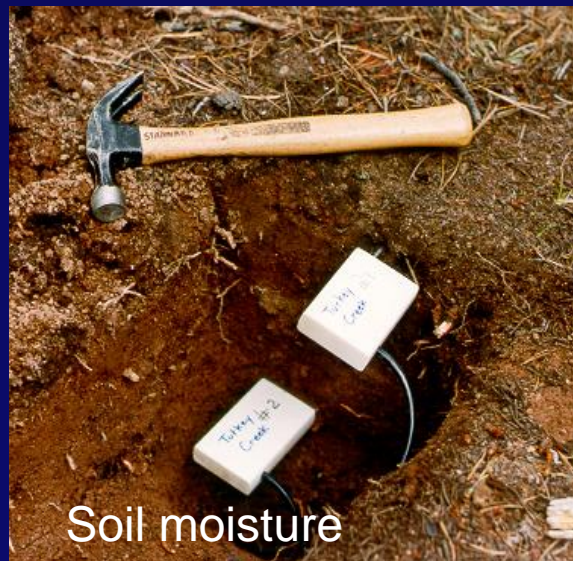
Rainfall



Solar radiation



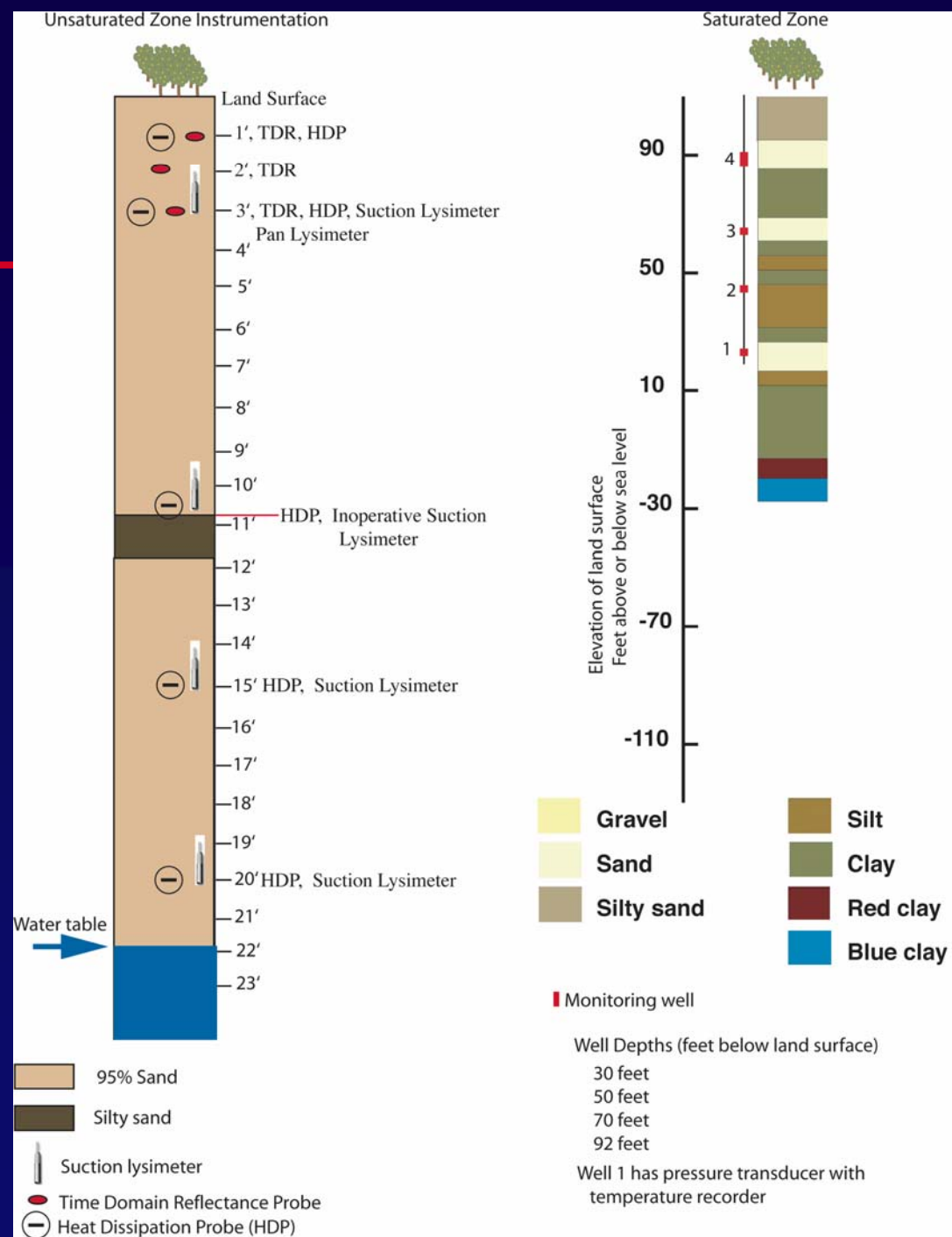
Wind speed & direction



Soil moisture

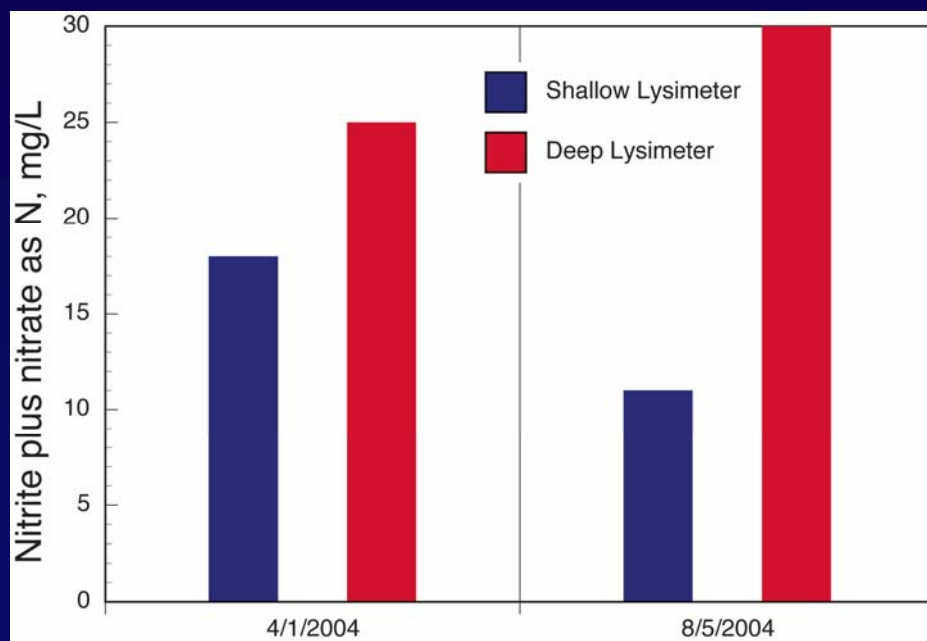
Instrumentation in the unsaturated zone consisted of lysimeters for water sampling and probes for tracking water movement.

Wells were drilled to various depths to determine changes in water chemistry



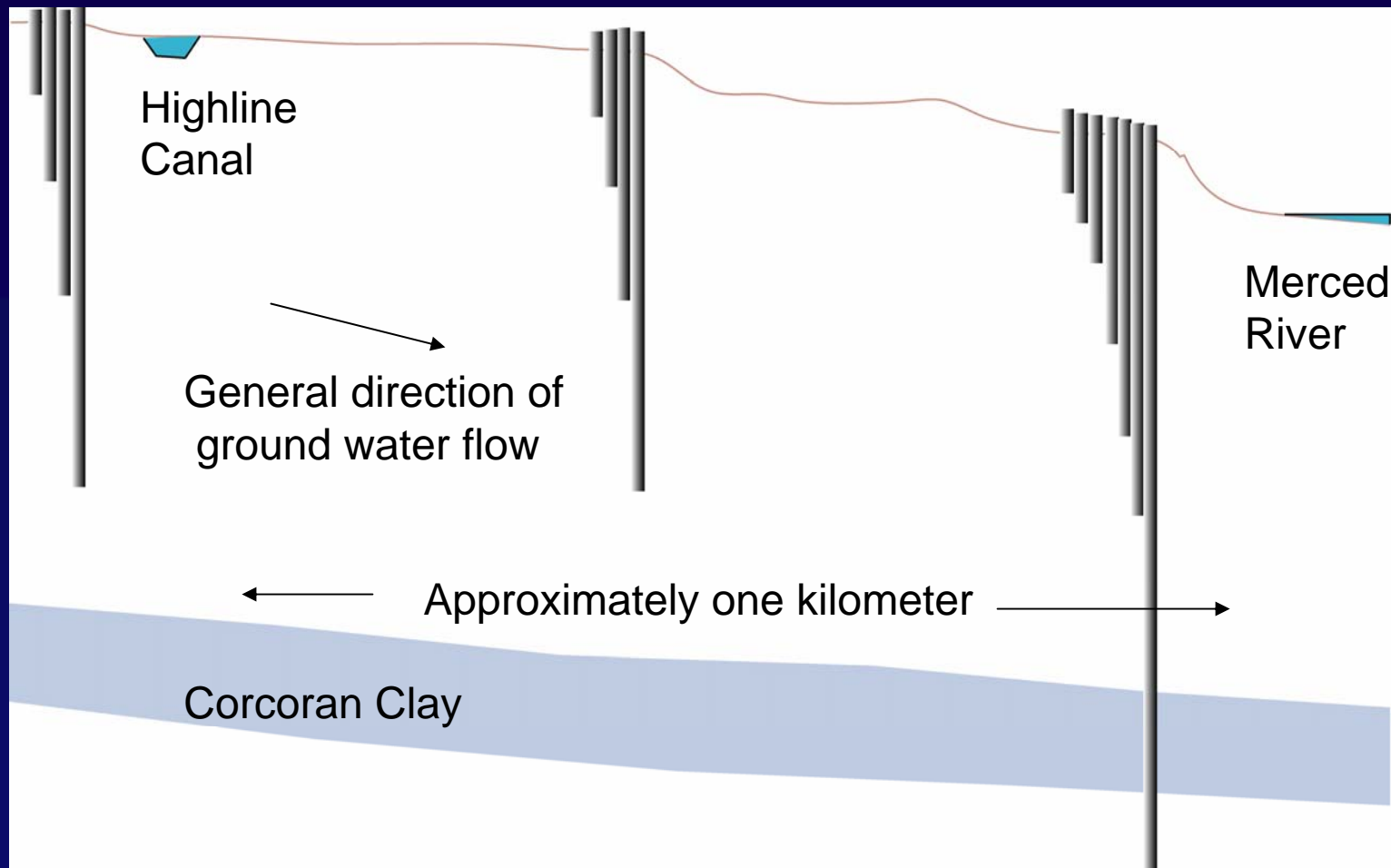


# Nitrate Concentrations in the Unsaturated Zone

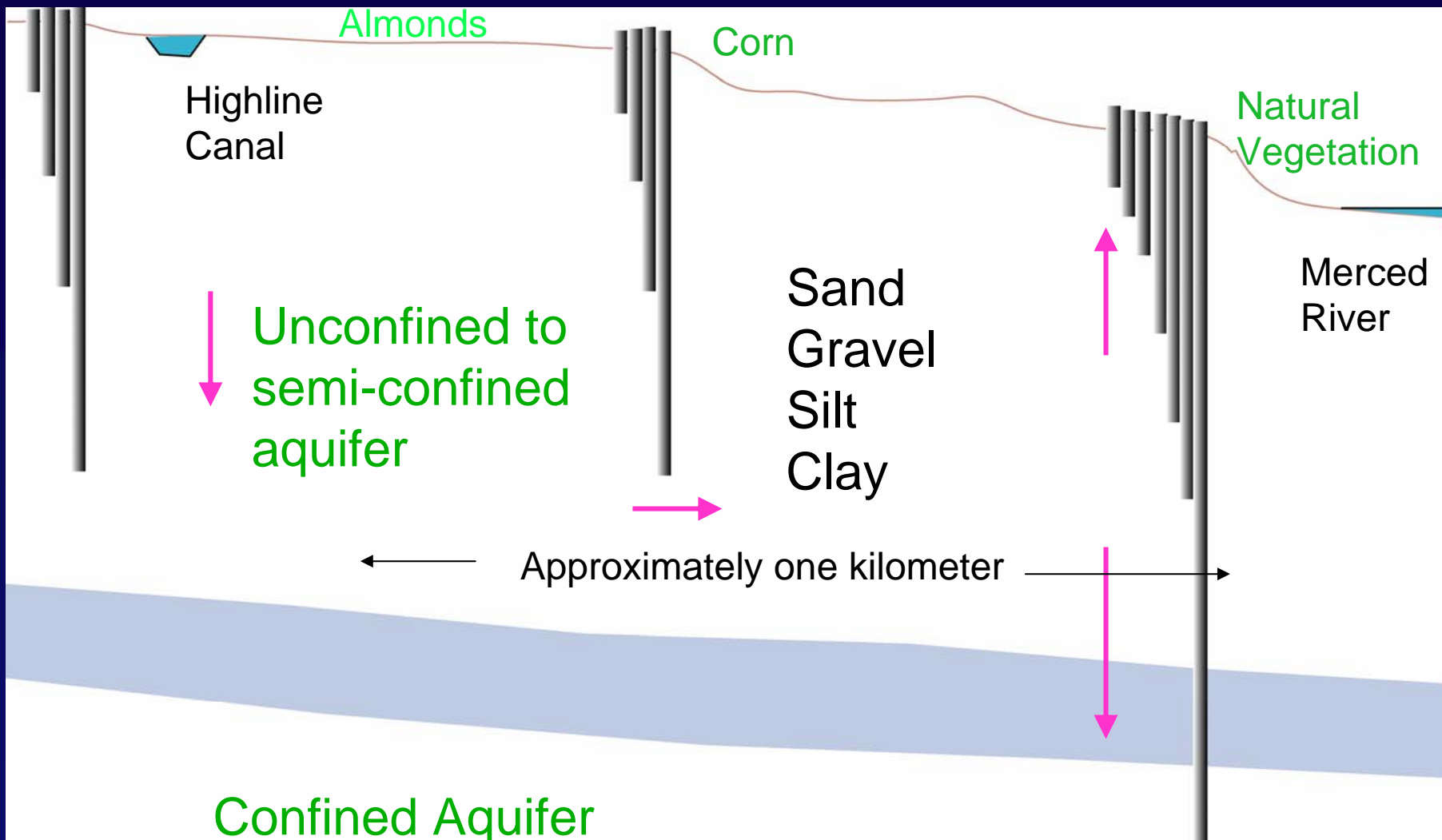


- Nitrate concentrations were consistently high in the unsaturated zone. This sampling at beginning and end of the growing season demonstrates the movement of nitrate from upper to lower horizons.
- Modeled load of nitrate to water table: 73 kg  $\text{NO}_3$  per hectare per year <sup>12</sup>

# Array of Monitoring Wells Along Flow Path

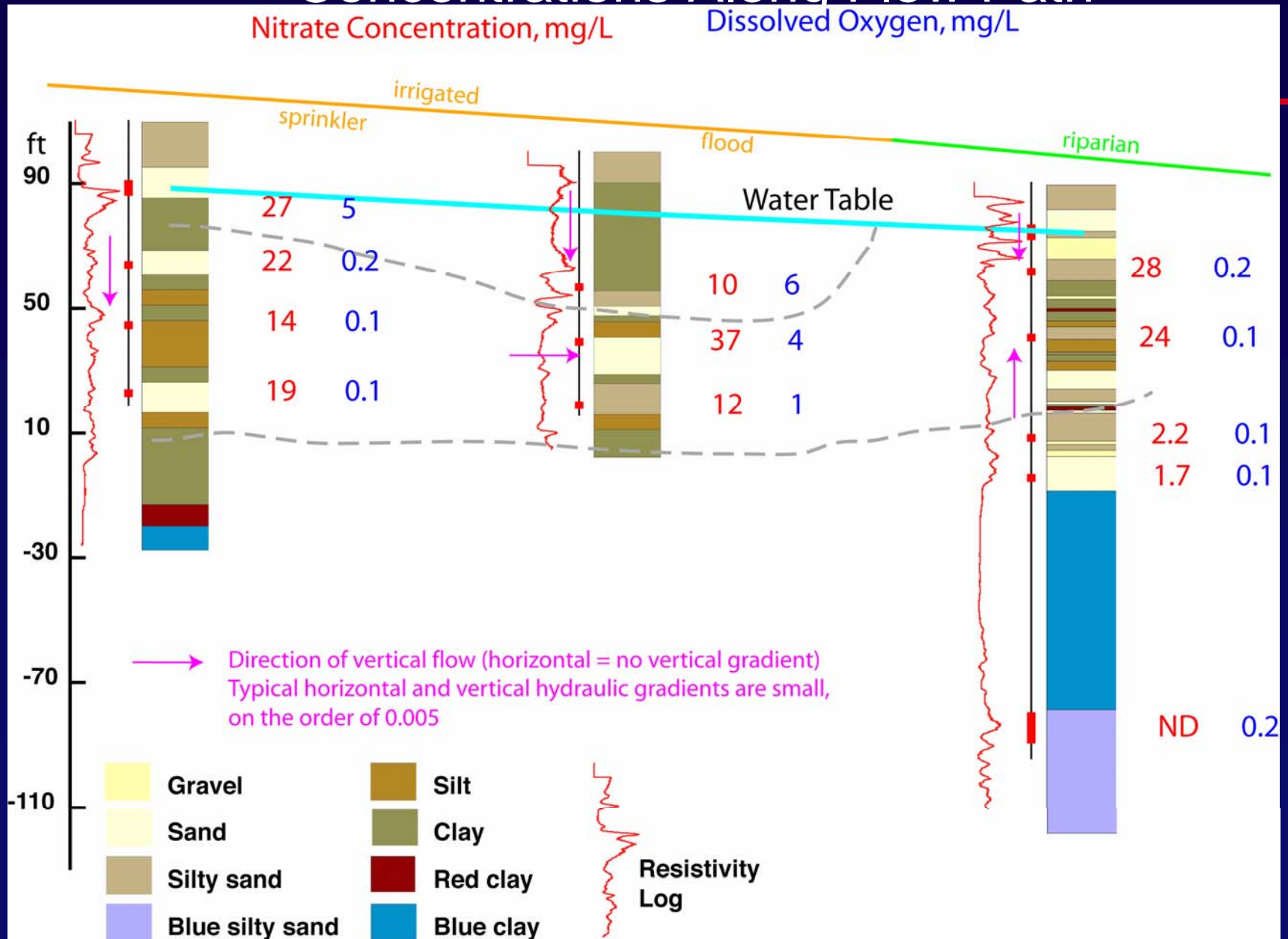


# Actual Directions of Ground-Water Flow





# Nitrate and Dissolved Oxygen Concentrations Along Flow Path

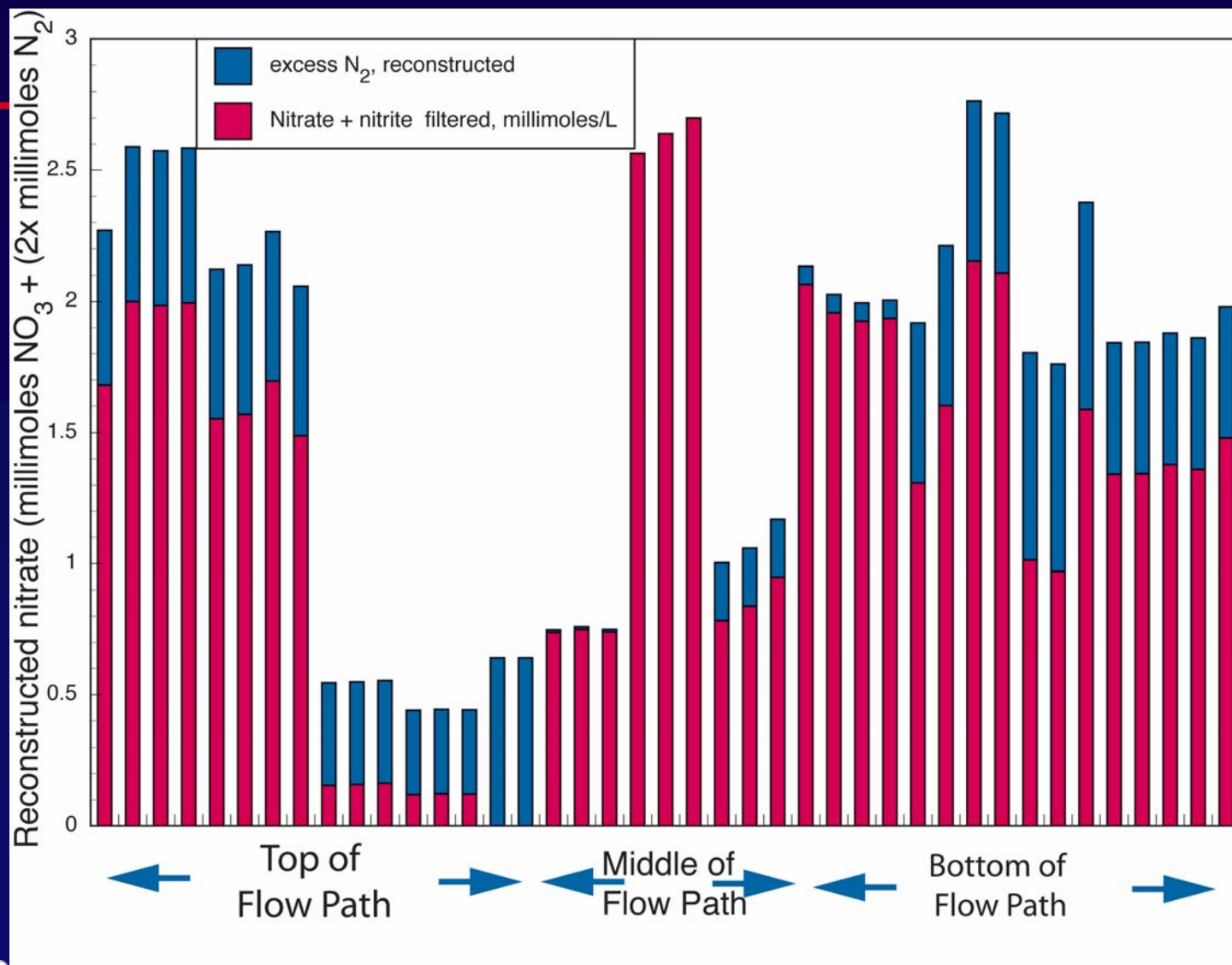


# Is the Measured Nitrate the Whole Story?

---

- **Measured nitrate only tells what is currently present in the aquifer.**
- **It is important to know how much de-nitrification has taken place or may take place.**
- **This can be accomplished by measuring atmospheric gases, such as nitrogen, and determining if an excess of nitrogen (from nitrate) is present.**

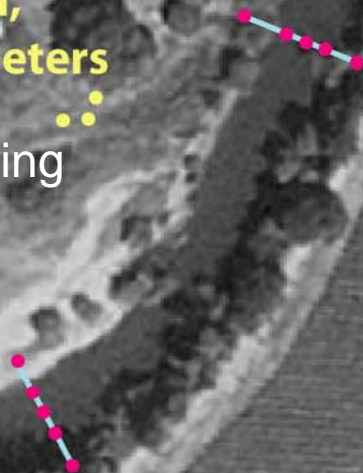
# Reconstructed Nitrate: Merced Flow Path Wells



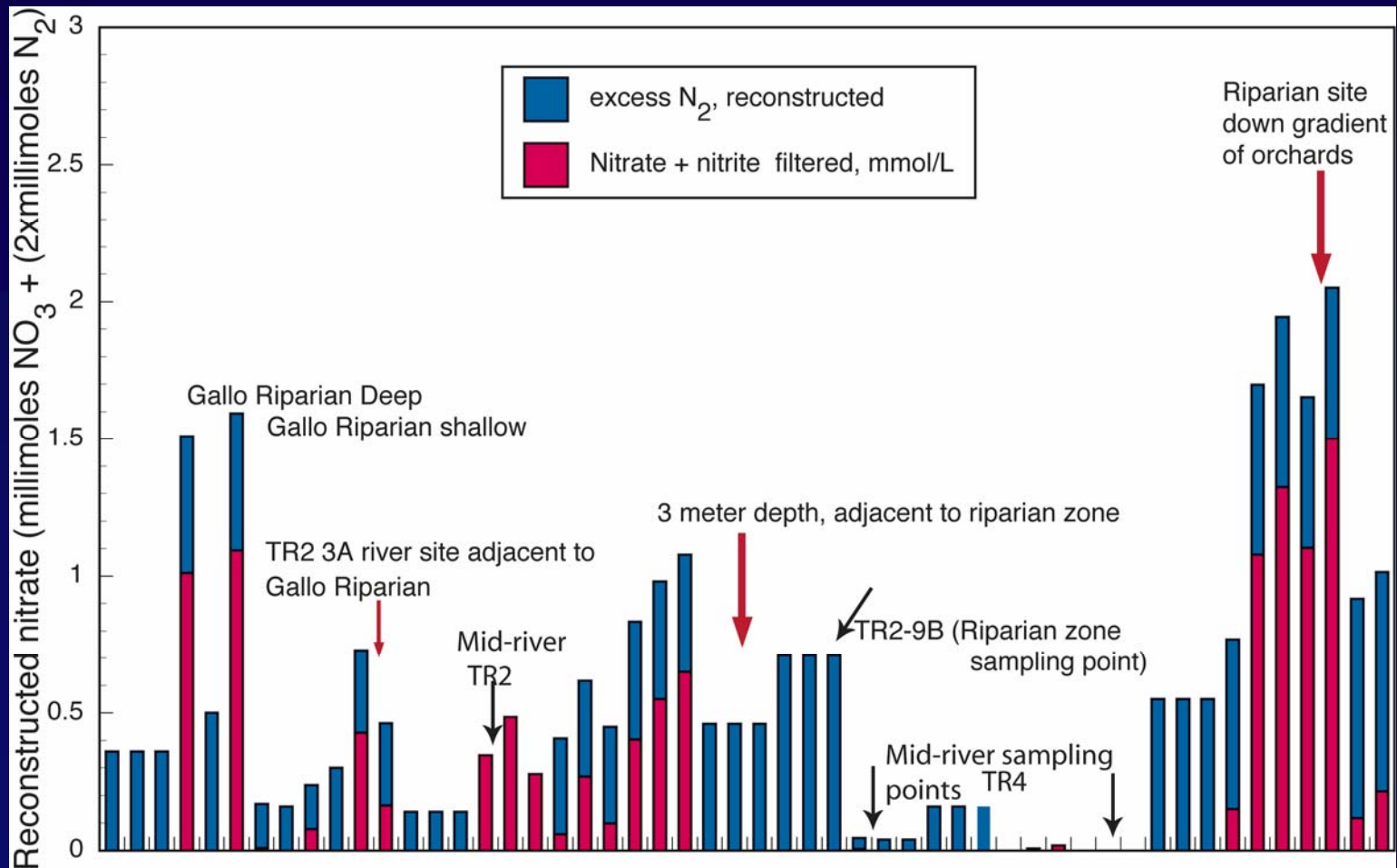


# Toe of Flow Path and GW/SW Sites

toe of  
flow path,  
8 piezometers  
15-195 ft  
(Monitoring  
Wells)



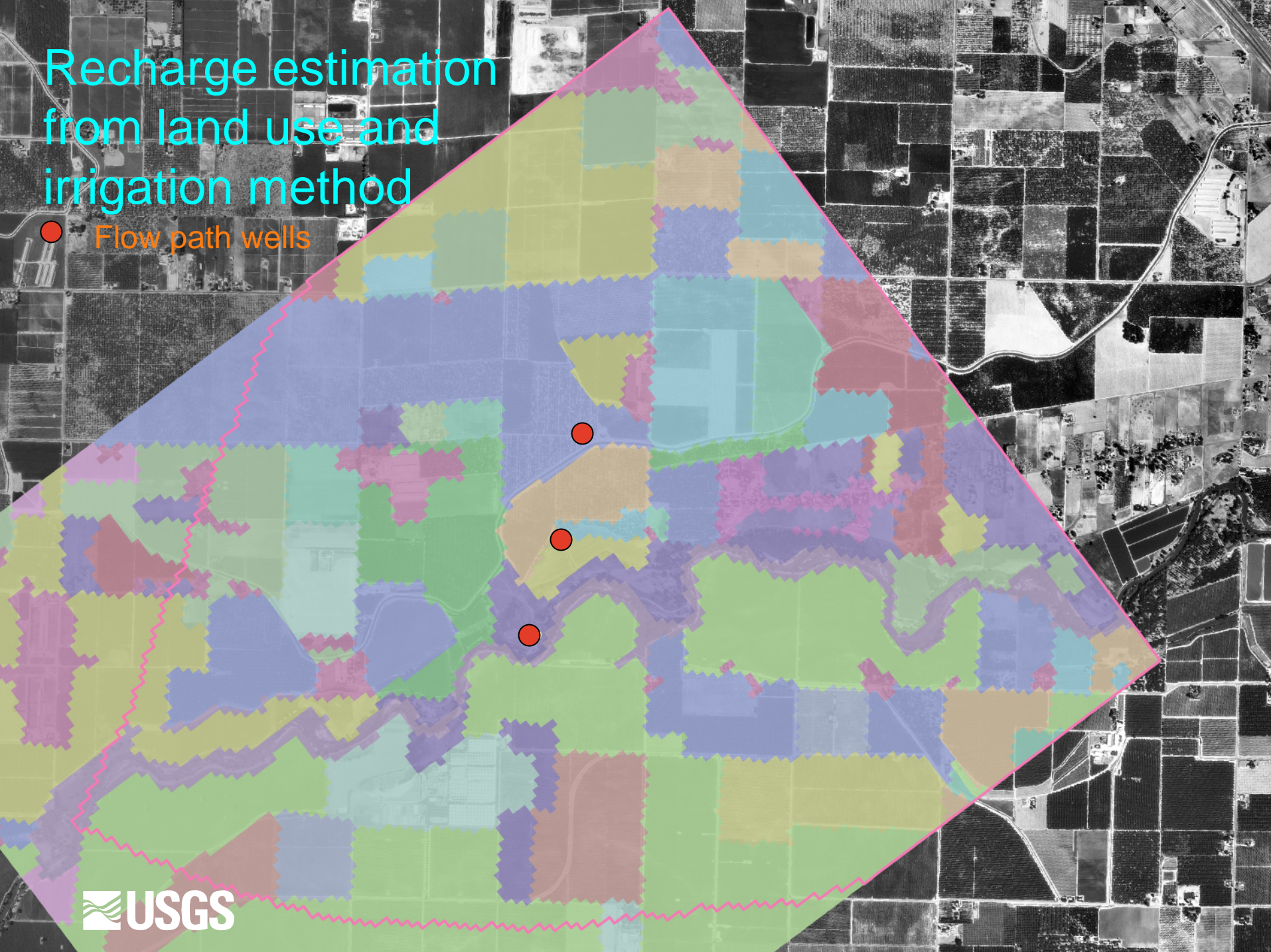
# Reconstructed Nitrate Below or Adjacent to Merced River





# Recharge estimation from land use and irrigation method

● Flow path wells



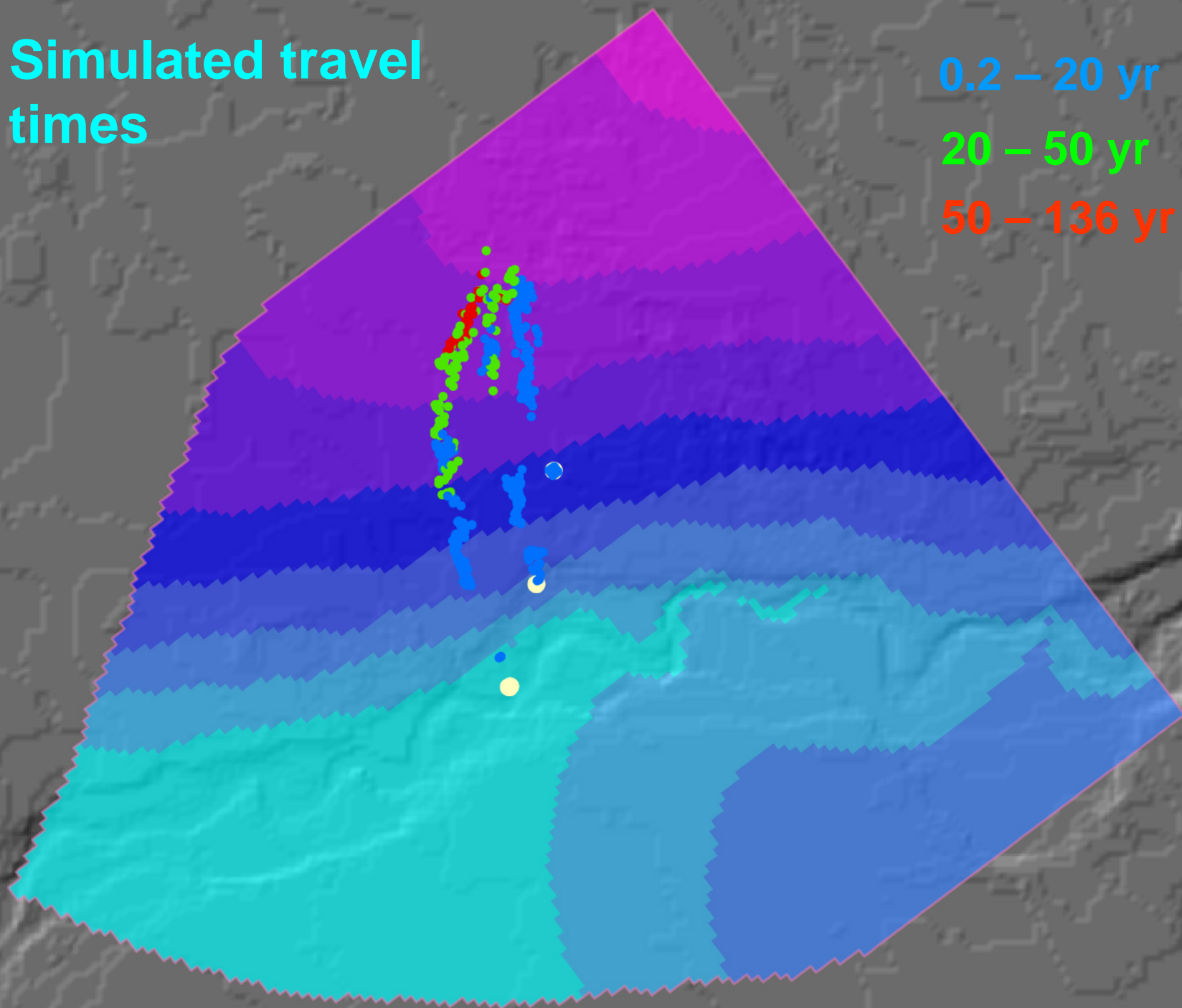


# Simulated travel times

0.2 – 20 yr

20 – 50 yr

50 – 136 yr

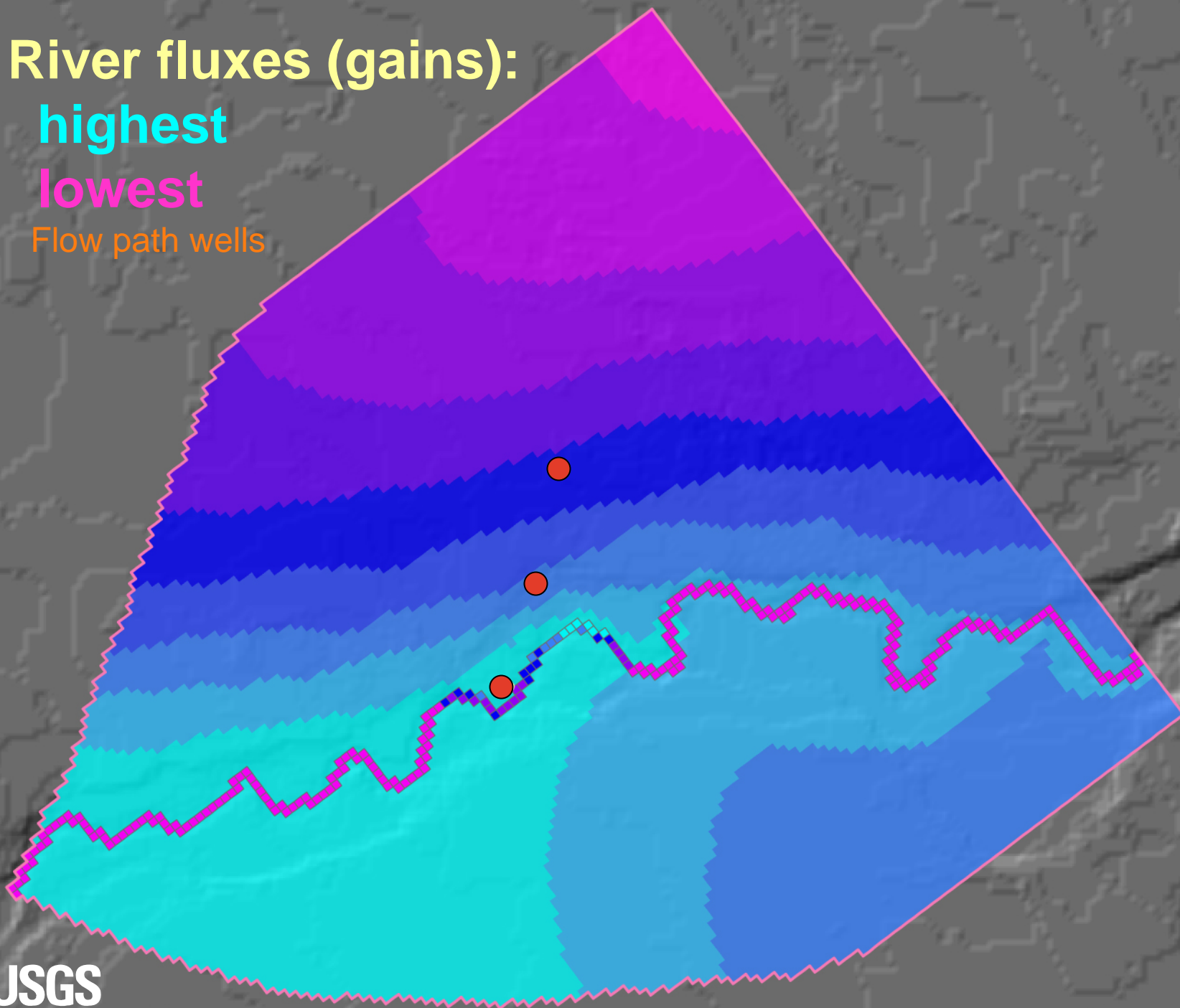


# River fluxes (gains):

highest

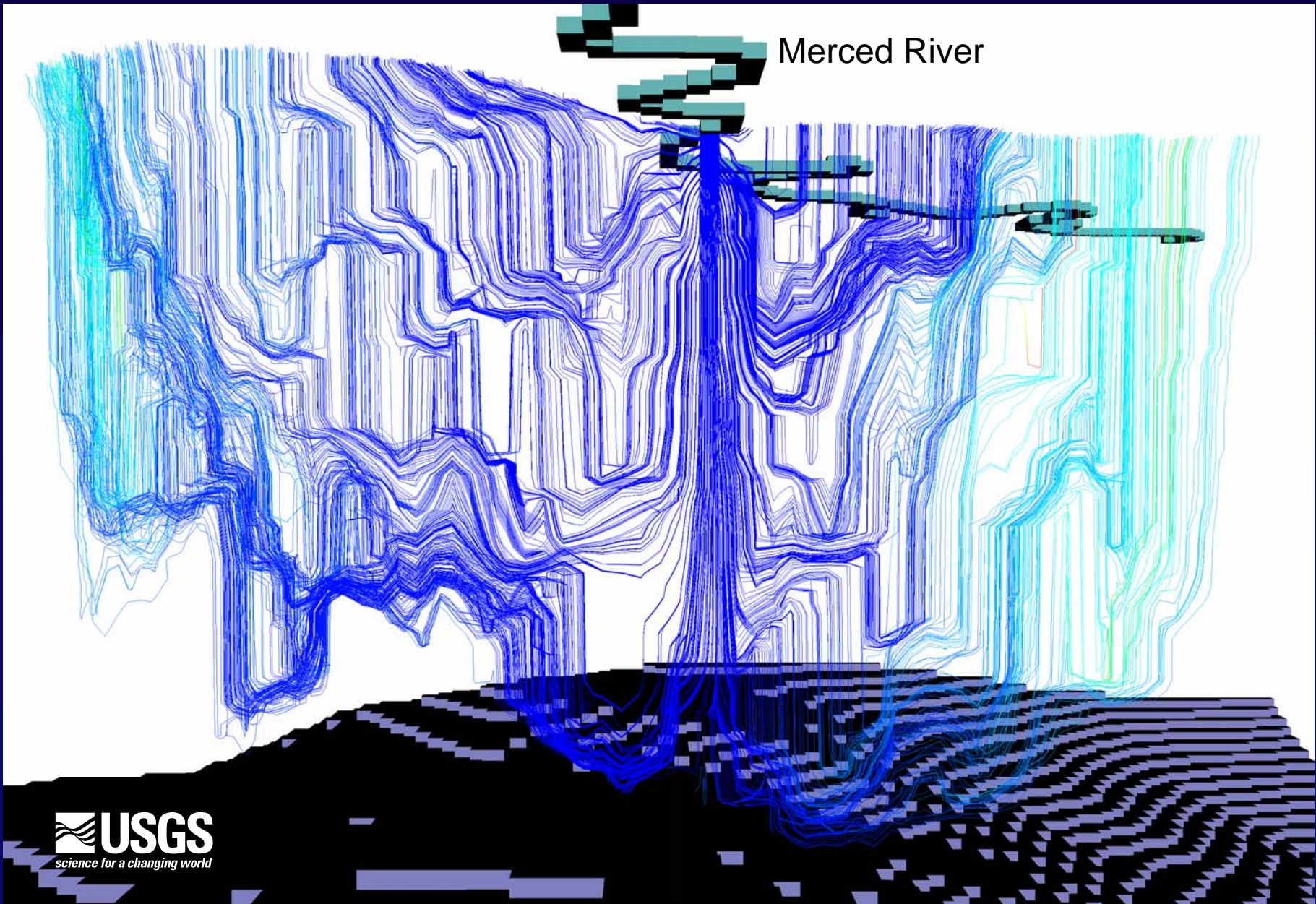
lowest

● Flow path wells





# Modeled Flow Lines of Ground Water Movement





# Summary: Nitrate Removal Across Riparian Zone

---

- **Analysis of dissolved gases, age dates, etc. indicate rapid removal of nitrate across the riparian buffer between the river and the agricultural fields**
- **Movement of water and associated nitrate load into or out of Merced River streambed is dependent on river stage, irrigation, and rainfall**
- **Modeled flow paths indicate shallow and deep sources of water discharging into the river**

# Contact Information

---

- Joseph Domagalski
- Hydrologist
- U.S. Geological Survey, Placer Hall, 6000 J Street, Sacramento, CA 95819
- 916 278 3077
- [joed@usgs.gov](mailto:joed@usgs.gov)
- <http://ca.water.usgs.gov/sanj/>