Third Annually

Groundwater Workshop

JANUARY 30, 2025

DIXON Resource Conservation District

SOLANO Resource Conservation District

USDA NRCS U.S. Department of Agriculture Natural Resources Conservation Service

Solano GSA

Luhdorff & Scalmanini Consulting Engineers

UCDAVIS UNIVERSITY OF CALIFORNIA

WELCOME

- SIGN IN
- GRAB A DRINK AND SNACK
- PLEASE SILENCE YOUR PHONES
- A GENTLE REMINDER TO SAVE CONVERSATIONS WITH YOUR NEIGHBOR FOR IN BETWEEN PRESENTERS OR DURING BREAK
- ASK QUESTIONS AFTER EACH PRESENTER
- PLEASE FILL OUT THE EVALUATION FORM

Event Facilitator:
Martha McKeen, Dixon Resource Conservation District

Maritza Flores Marquez, PE

SOLANO COUNTY WATER AGENCY/SOLANO GSA

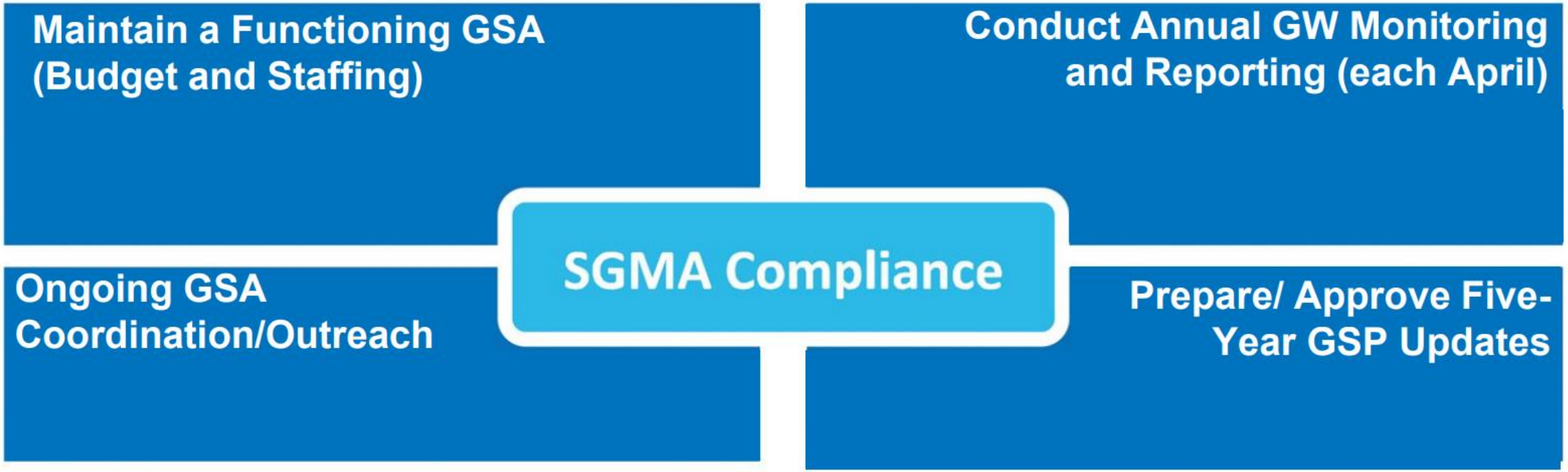
Groundwater Workshop

January 30, 2025

Solano Groundwater Sustainability Plan: An Overview and Updates

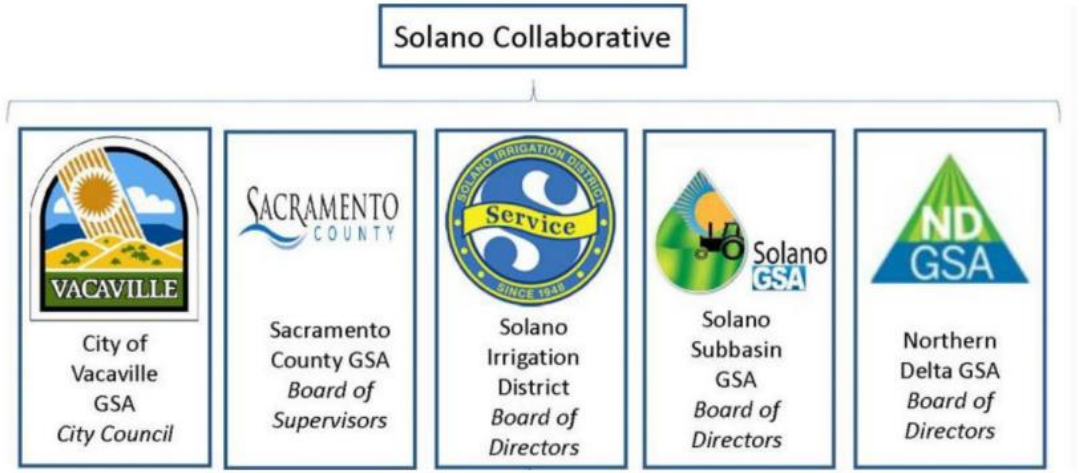
Maritza Flores Marquez, PE
Solano County Water Agency/ Solano GSA

California SGMA Requirements

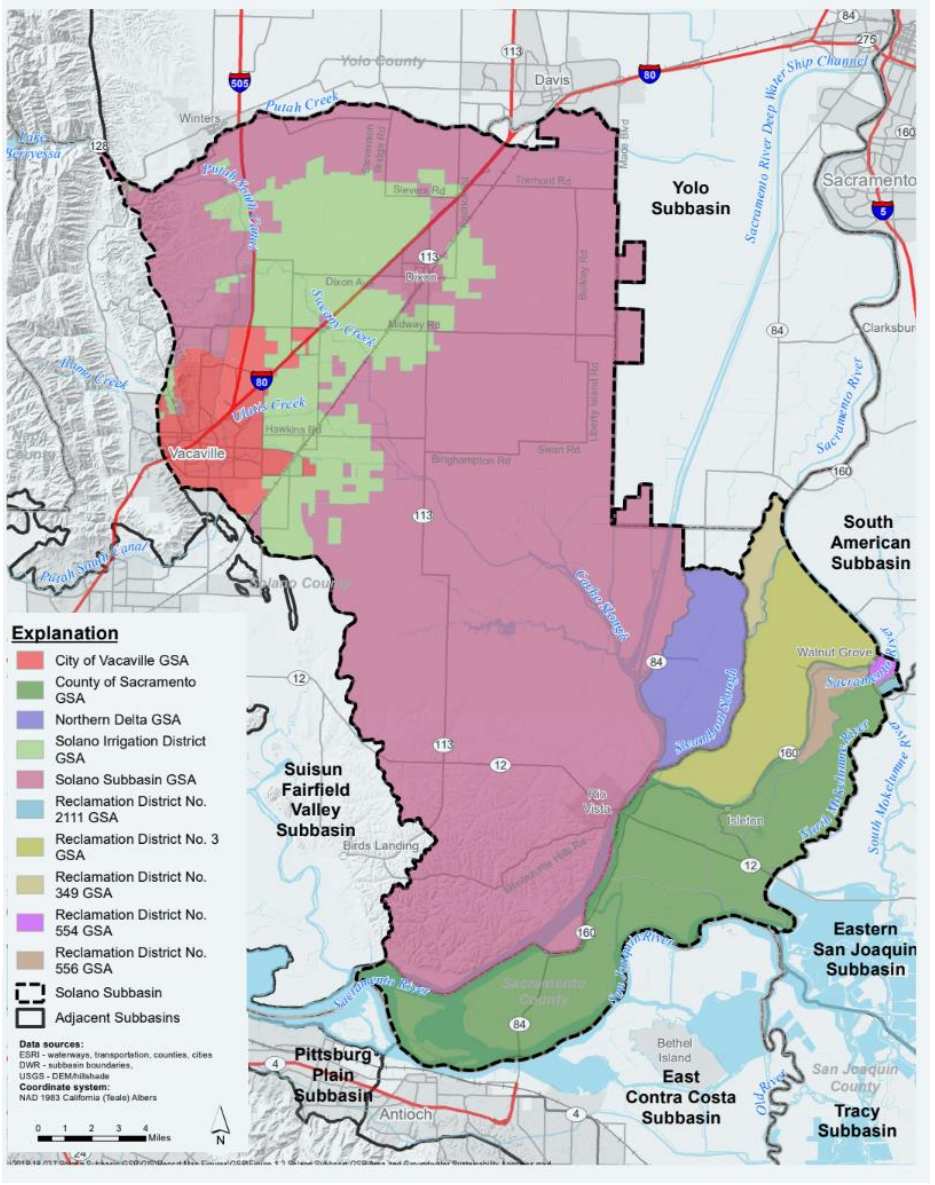


Solano Subbasin

- Solano Collaborative comprises of 5 GSAs that work together to manage subbasin



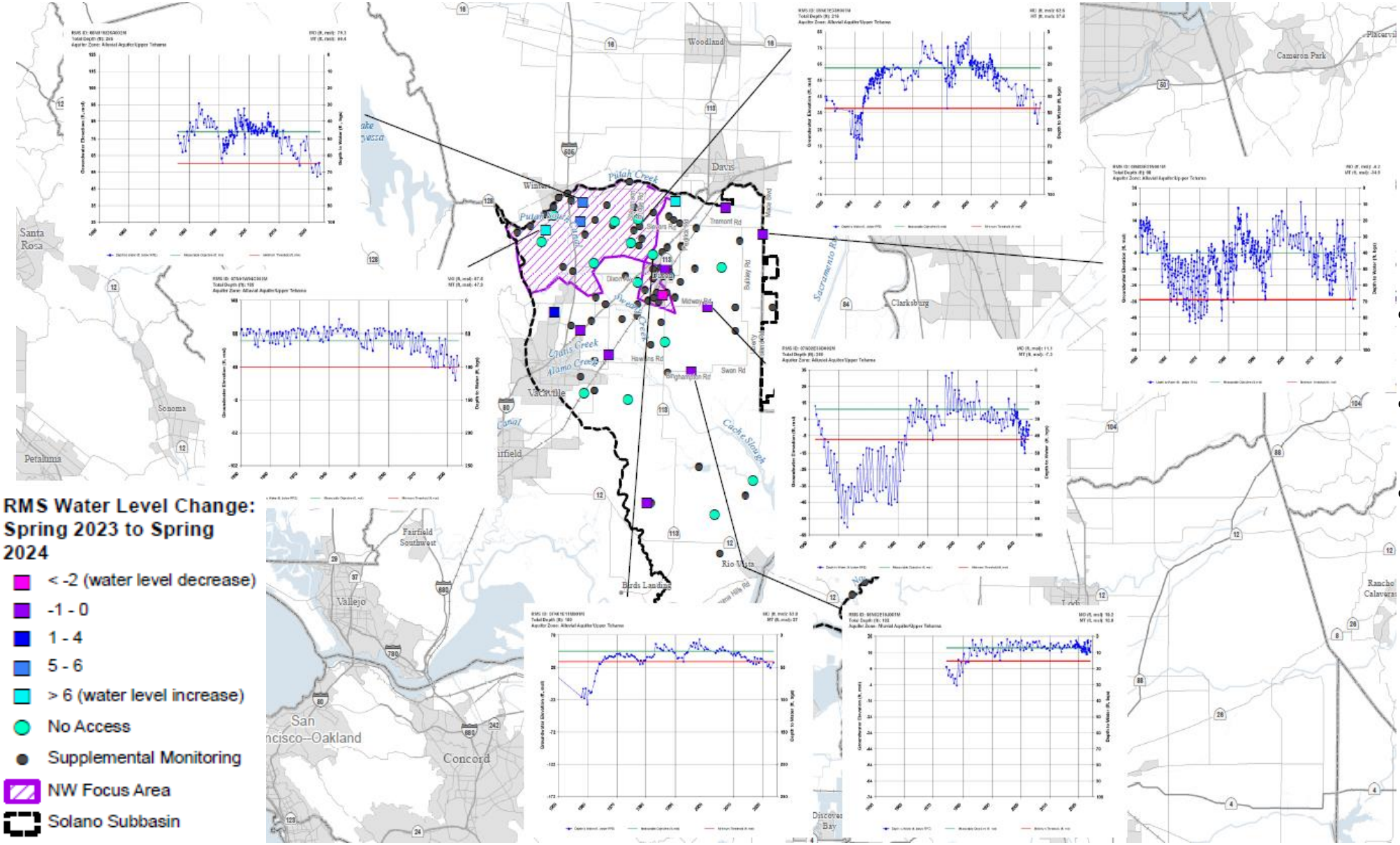
Independent Reclamation District (RD) GSAs; RD 3, RD 349, RD 555, RD 556, RD 2111, RD 317



Overview of Solano Subbasin Conditions and GSP Activities

- Solano Subbasin GSP approved in January 2024
- Emphasis on conditions and activities in the northwestern Subbasin
- Groundwater Conditions:
  - Water year 2023 was a wet year - increases in groundwater levels
- DWR GSP Implementation Grant activities:
  - Ongoing monitoring enhancements and interactive web map development (Solano Subbasin Monitoring Web Map Application)
  - Well and surface water diversion inventory development
  - Cover cropping study and multi-benefit solution planning – enhance recharge and reduce stormwater runoff
  - Outreach and education efforts – workshops, town hall

Spring 2024 Water Level Status

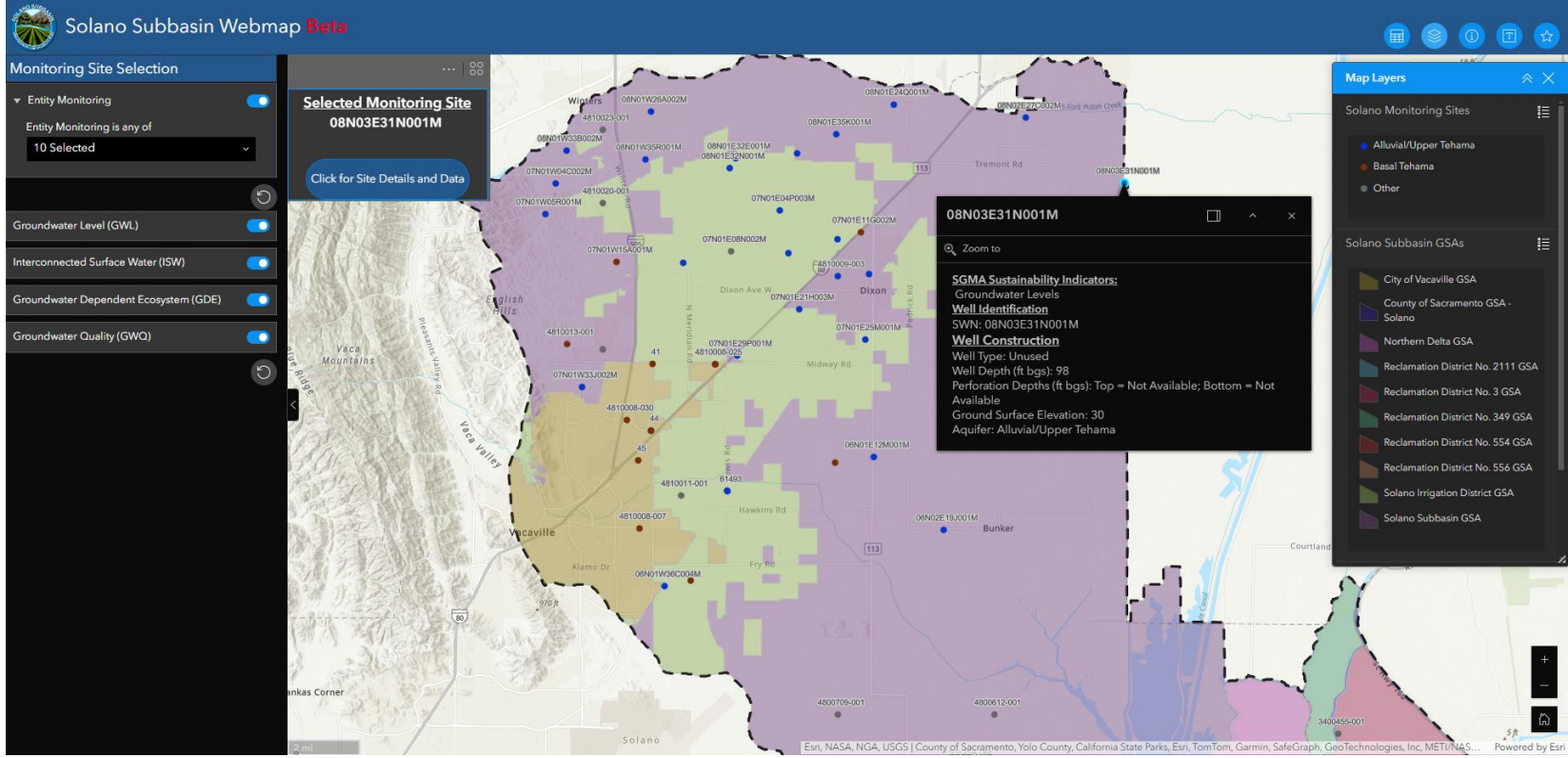


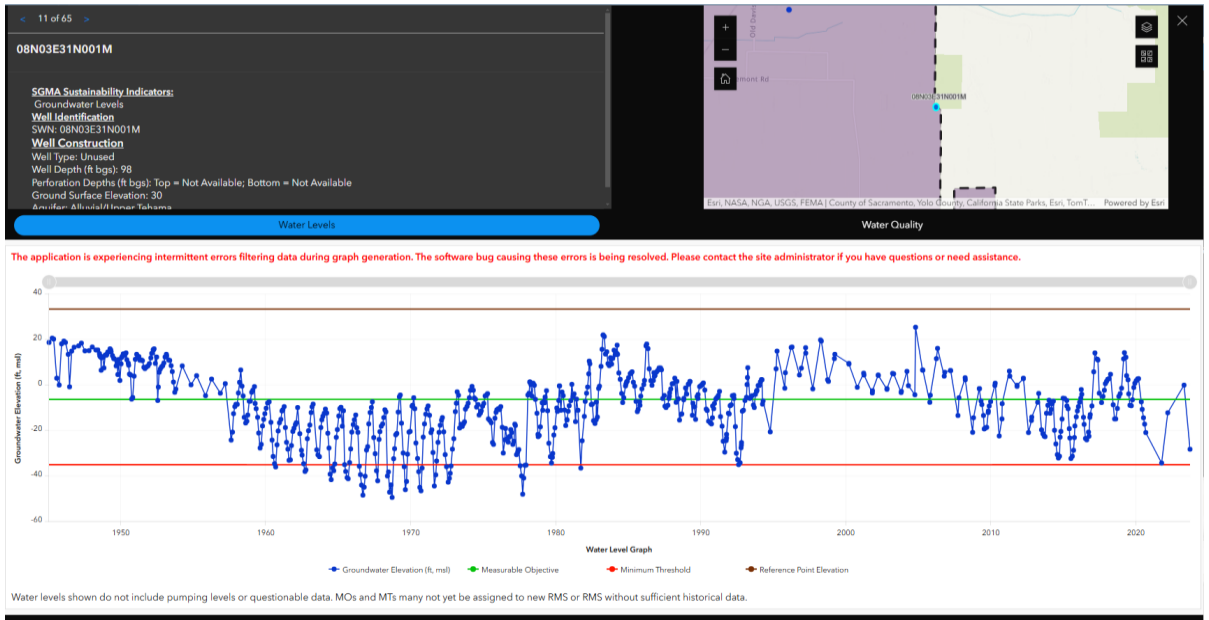
Changes in Water Levels Spring 2023 to 2024:

- Water levels rose in most wells
- Many wells had >5 ft increases
- Potential lagged effects from wet 2023

Web Map Enhancements

- Expanded network of monitoring sites
- Other data layers of interest
  - Groundwater level contours
  - Subsidence
  - Soil and subsurface geologic characteristics





Groundwater Well and Surface Water Diversion Inventory

Groundwater Wells

- DWR Well Completion Reports
- County Well Permits

Surface Water Diversions

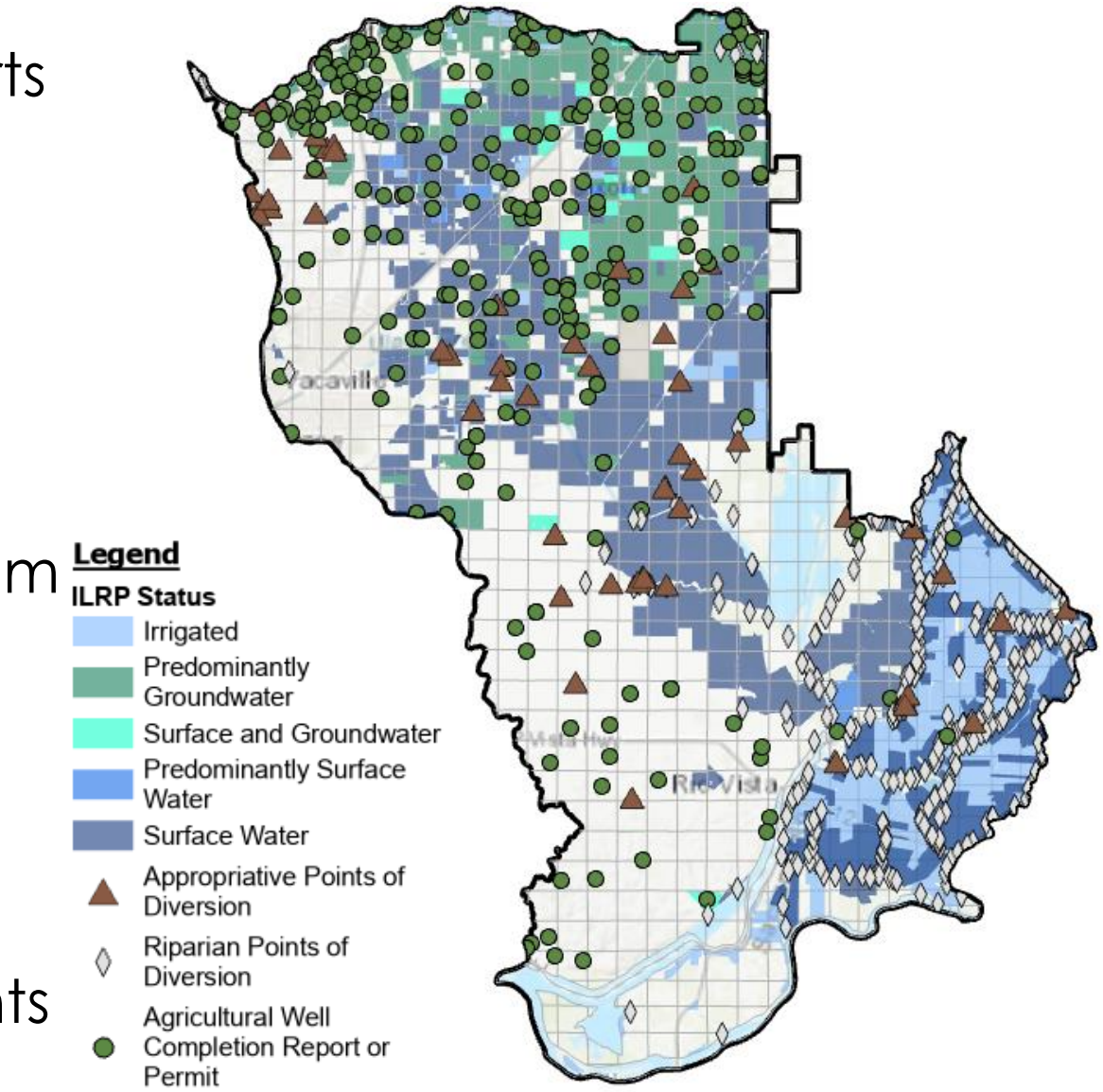
- SWRCB eWRIMS

Irrigated Parcels

- Water source information from Irrigated Lands Regulatory Program

Next Steps

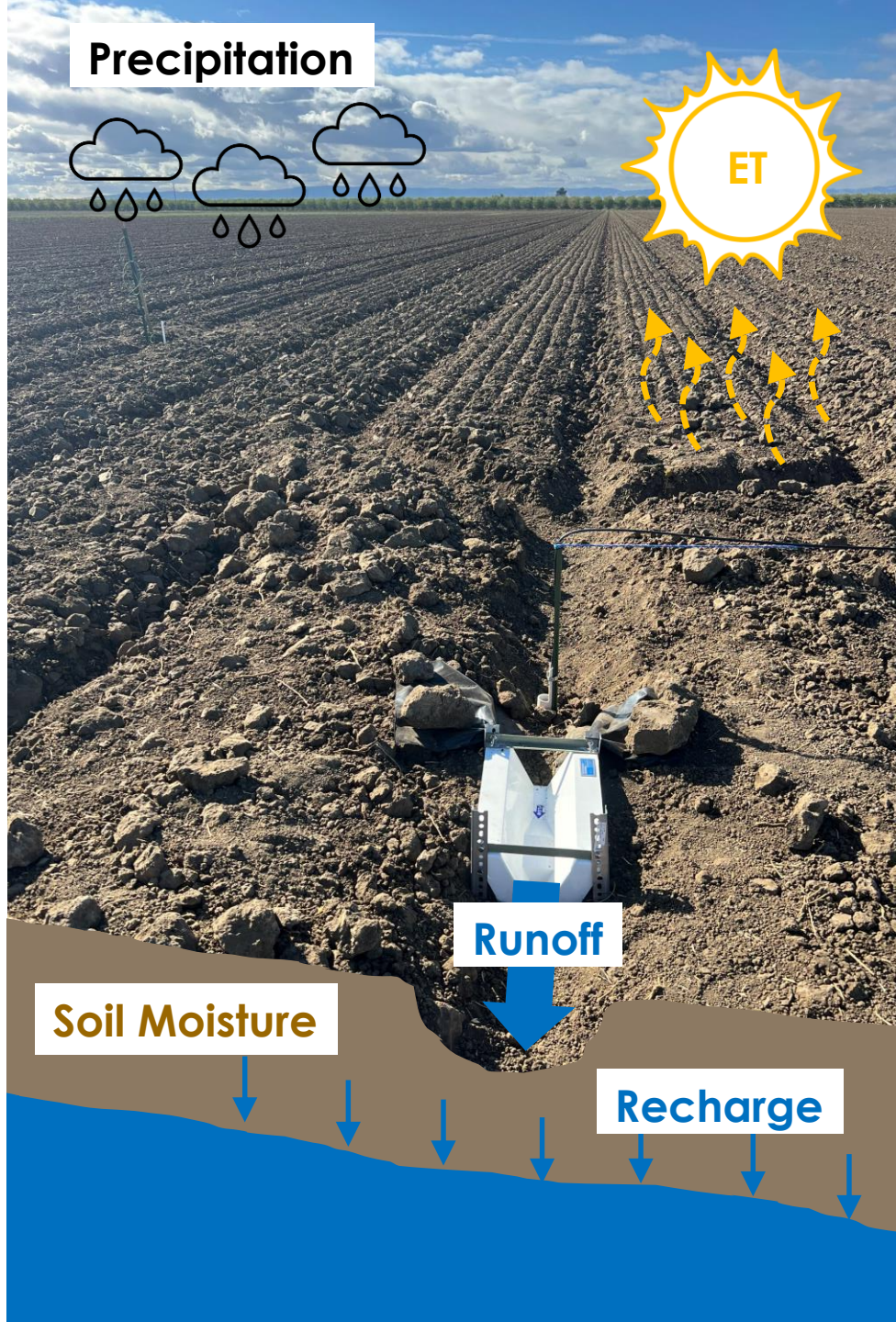
- Targeted well sampling
- Hydrologic model refinements



Cover Crop Study

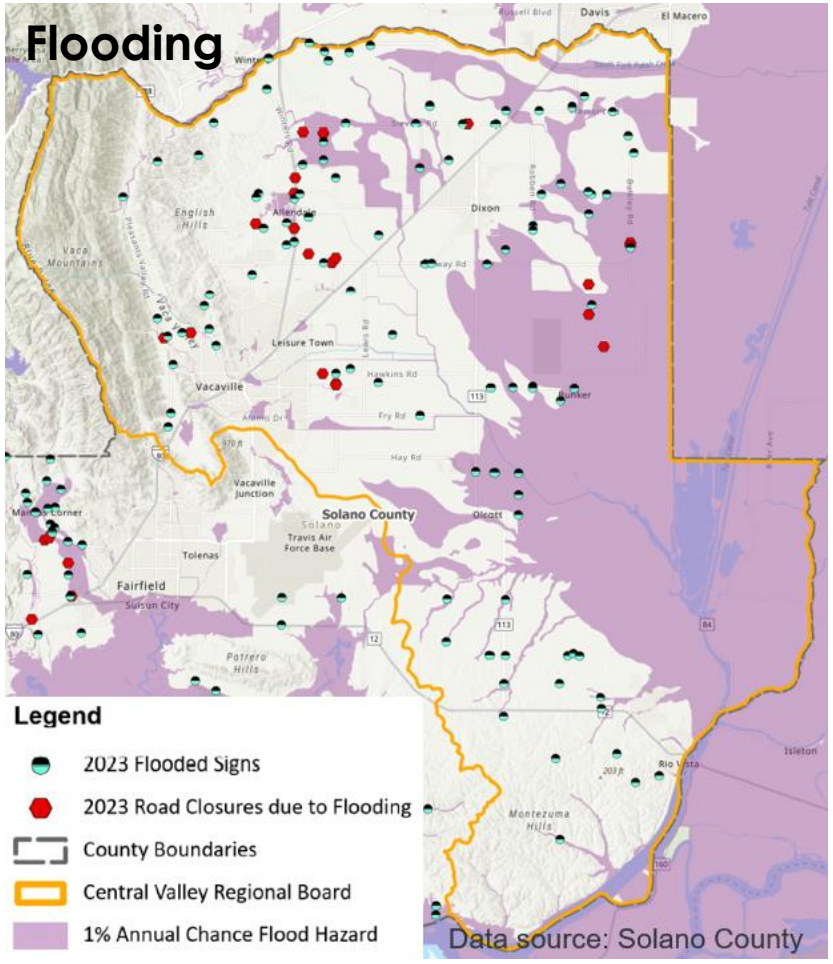
- Assess effectiveness of furrow cover cropping: enhanced rainfall infiltration and reduced stormwater runoff

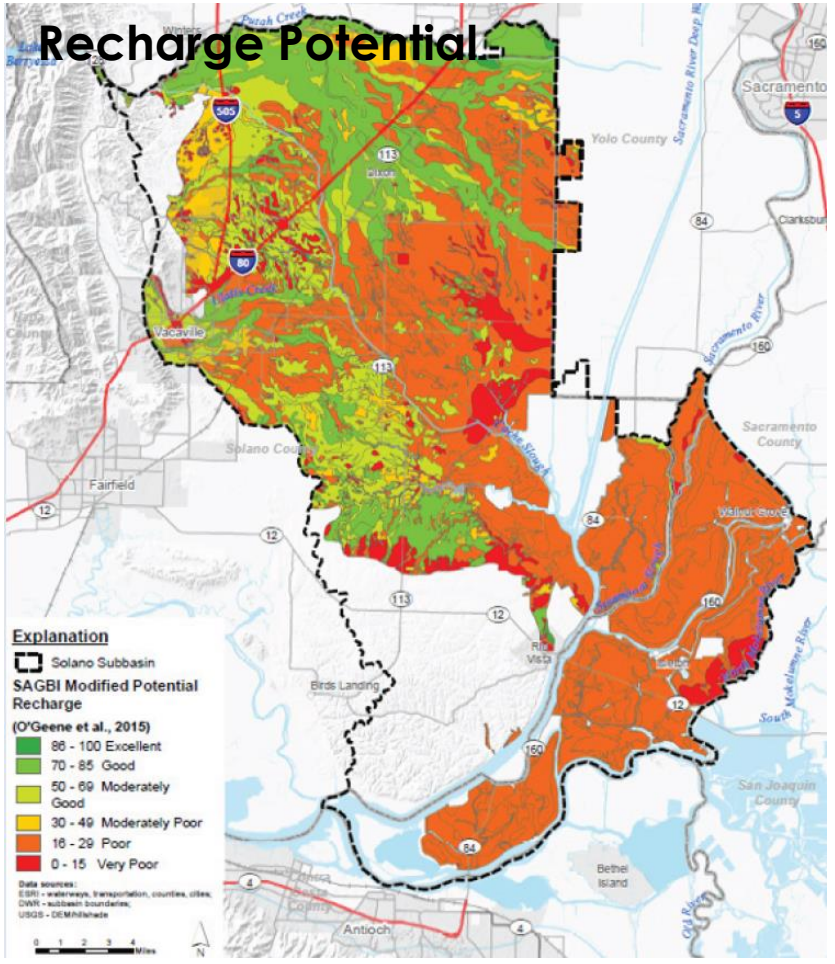
- Monitor water budget components:
  - Precip
  - Runoff
  - Evapotranspiration (ET)
  - Soil moisture
- Estimate infiltration and deep percolation (groundwater recharge)

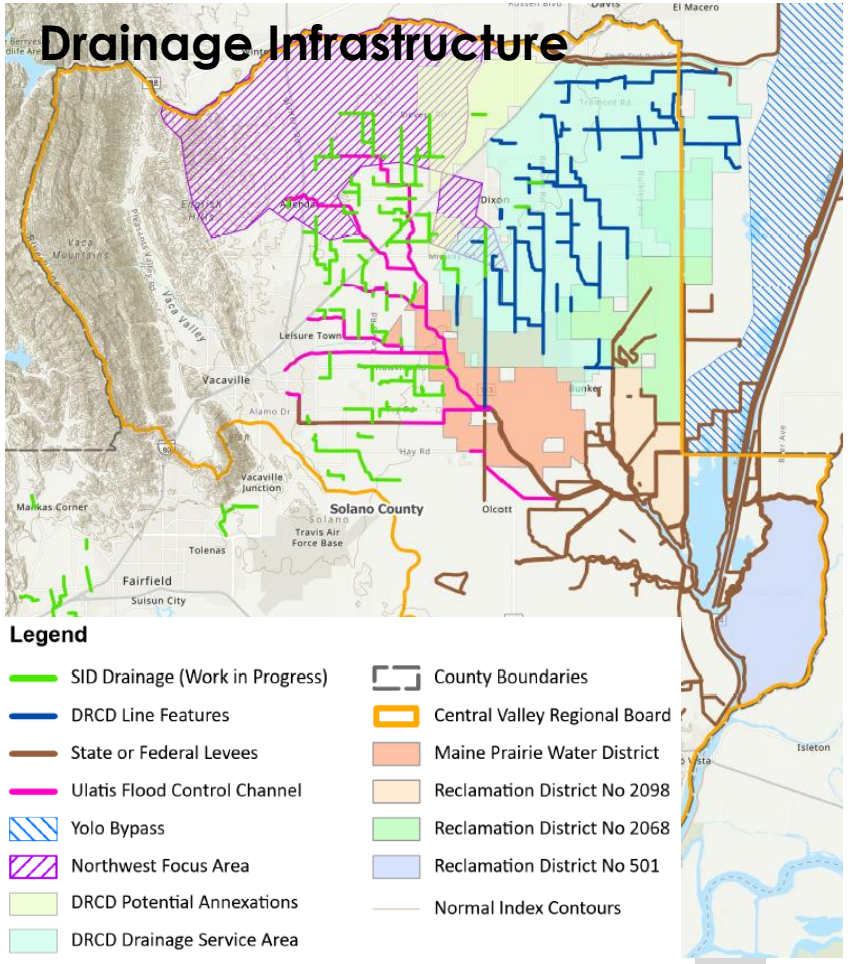


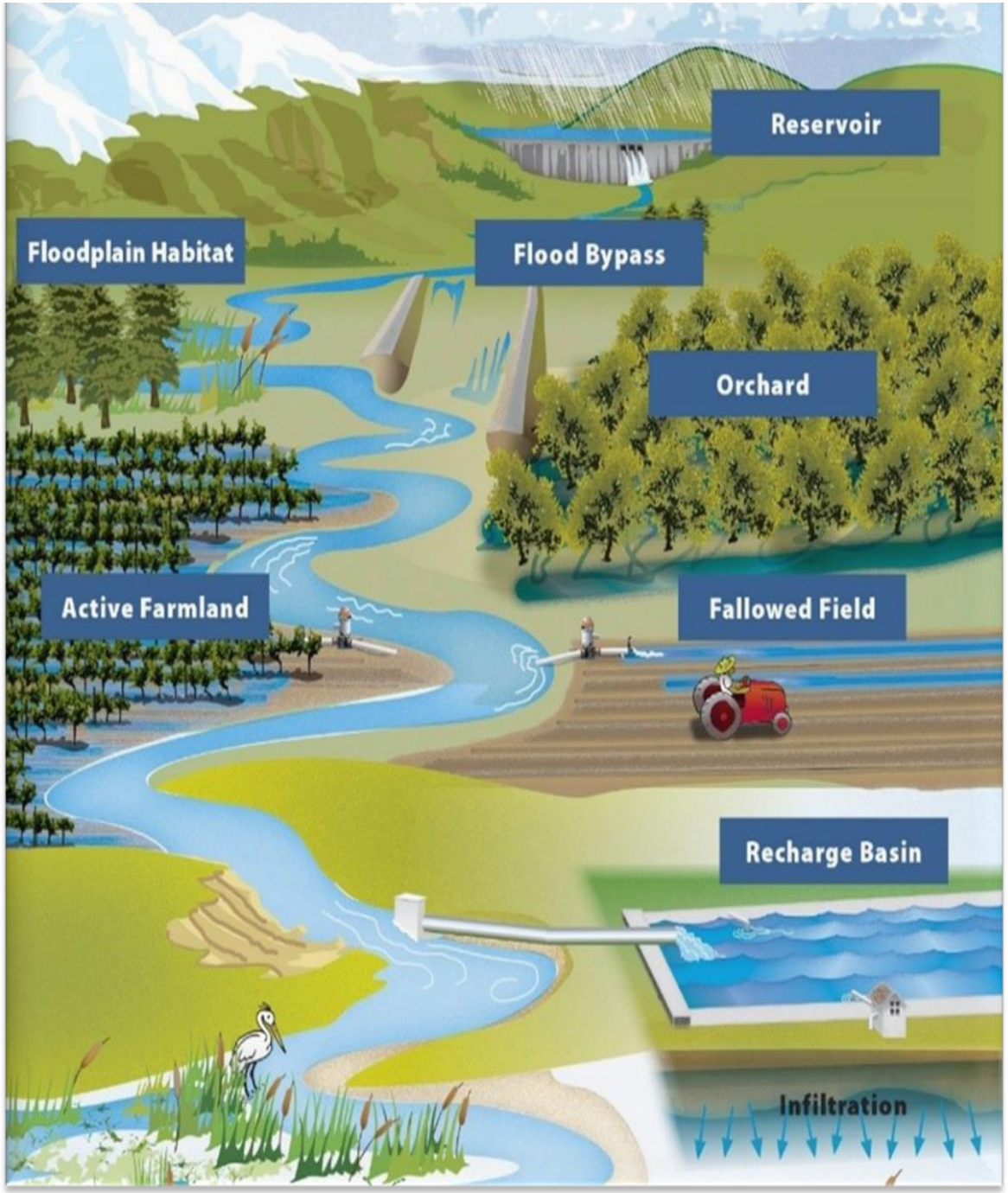
Multi-Benefit Solutions

- GSAs and other stakeholders coordinating on solutions
- Objectives:
  - Enhance groundwater recharge (especially in NW Focus Area)
  - Reduce downstream flooding from stormwater runoff









Incentives and Policies

- Exploring potential incentives and policies to promote actions that will improve Subbasin resilience and sustainability

GSP Implementation Ongoing Grant Activities

Component 1: Grant Administration

- Coordinating grant deliverables and goals with project partners (LSCE, Ag Innovations, Mark Grismer, DRCD, SRCD)
- Tracking budgets and invoice/progress report submissions

Component 2: GSP Monitoring and Data Management Enhancements

- Well inventory efforts with the Solano County well permit database
- Well-monitoring along Putah Creek
- Data Management System updates for remote monitoring and enhancements for water quality
- Interconnected surface and groundwater monitoring development

Component 3: Supporting Groundwater Use Management Actions

- Surface water diversion inventory; refining place of use for diversions
- Solano Integrated Hydrologic Model updates
- Public outreach events to promote water conservation and groundwater recharge

Component 4: Water Supply Replenishment and Reliability Projects

- Multibenefit recharge project coordination for the Northwest Focus Area/Upper Tremont 3 Watershed
- Cover crop study planning and coordination

Component 5: GSP Implementation, Outreach, and Compliance Activities

- Continuous GSA Collaborative Meetings.
- Continuous Project Team Meetings.
- Continuous GSA Technical Advisory Committee Meetings.
- Track and develop outreach materials.
- Prepare for and begin developing the 2024 Water Year Annual Report.

Planned GSP Implementation Activities in 2025

- Water year 2024 (Oct 23-Sept 24) annual report in preparation by April 1, 2025 – close to average precipitation year
- DWR GSP Implementation Grant activities:
  - Continuation of monitoring enhancements and expanding interactive web map information
  - Cover cropping pilot study
  - Emphasis on multi-benefit solution planning to enhance recharge and reduce stormwater runoff
  - Evaluation of policies and incentives to ensure long-term sustainable groundwater management
  - Outreach and education efforts – workshops, town hall

THANK YOU

Nick Watterson

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Solano Subbasin Groundwater Conditions

Groundwater Workshop

January 30, 2025

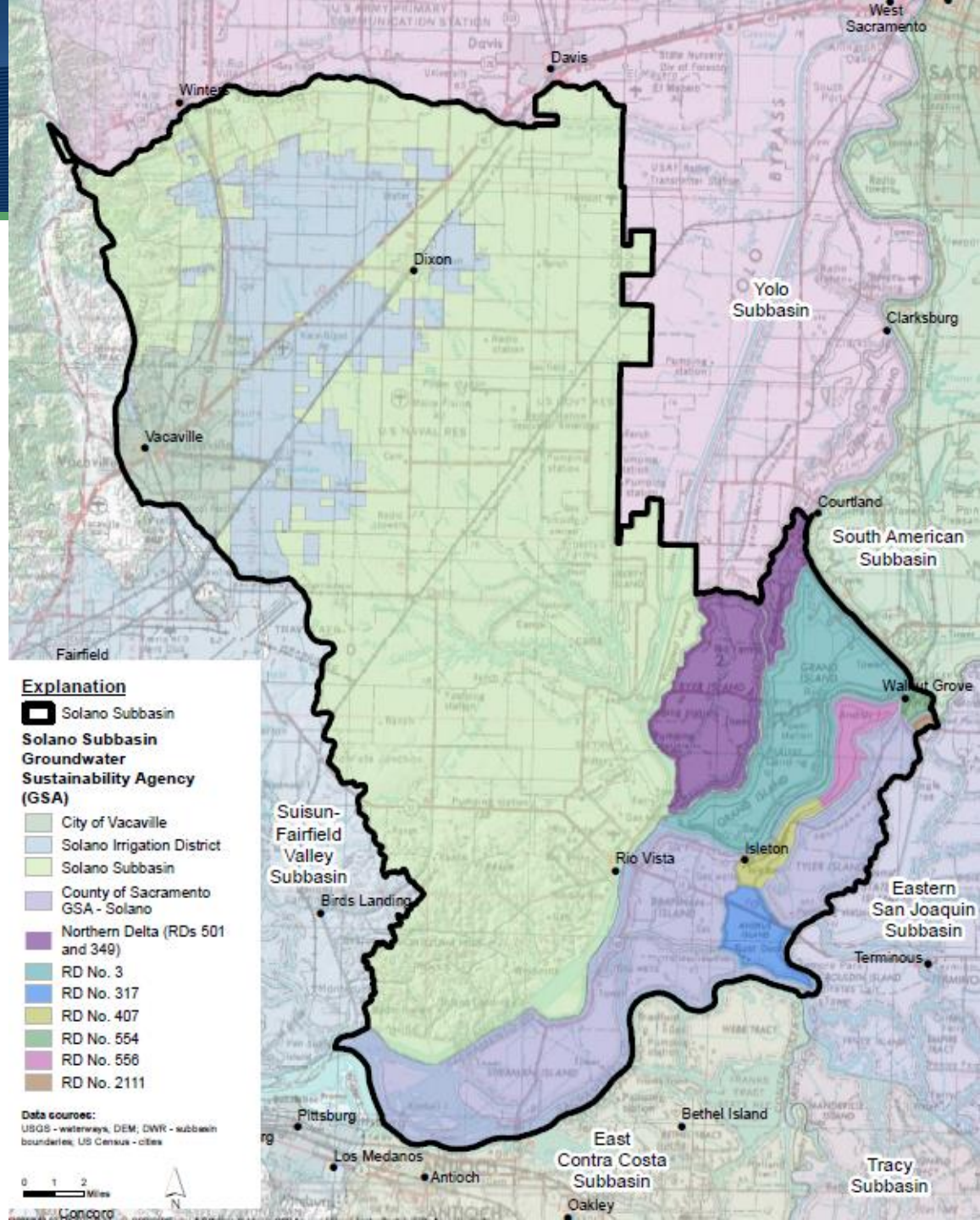
Nick Watterson

Principal Hydrogeologist

Luhdorff & Scalmanini
Consulting Engineers

Outline

- Solano Subbasin GSP Background
- Preview of WY 2024 Groundwater Conditions in the Solano Subbasin
- GSP Implementation Activities



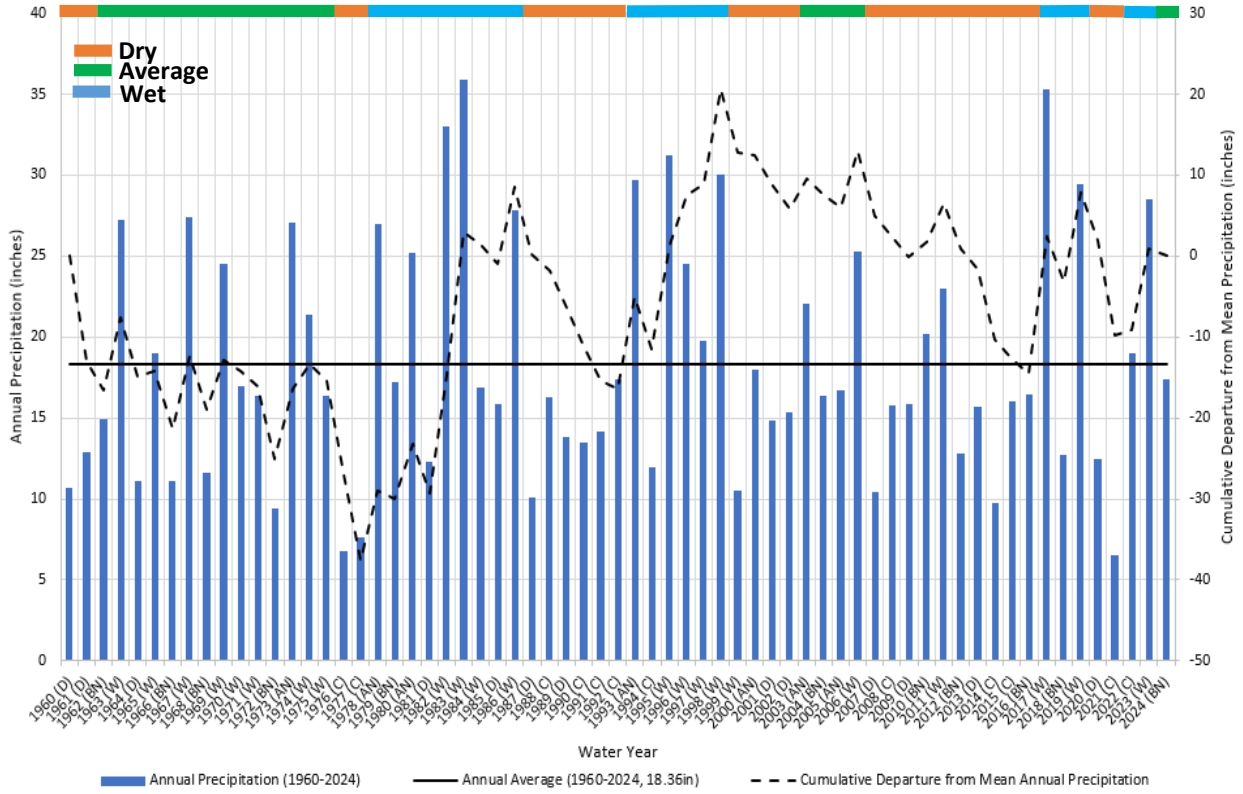
Groundwater Sustainability Plan Background

- Historical sustainable groundwater conditions
- Northwest Focus Area is area of special attention, including for opportunities to enhance recharge
- GSP annual reports to be completed by April 1 – WY 2024 report in progress
  - Document groundwater conditions (e.g., water levels, water quality, subsidence)
  - Water use by source and sector
  - Estimates of groundwater pumping and change in groundwater storage
  - Evaluate conditions relative to sustainable management criteria in GSP
  - Document projects and management actions occurring

LSCE

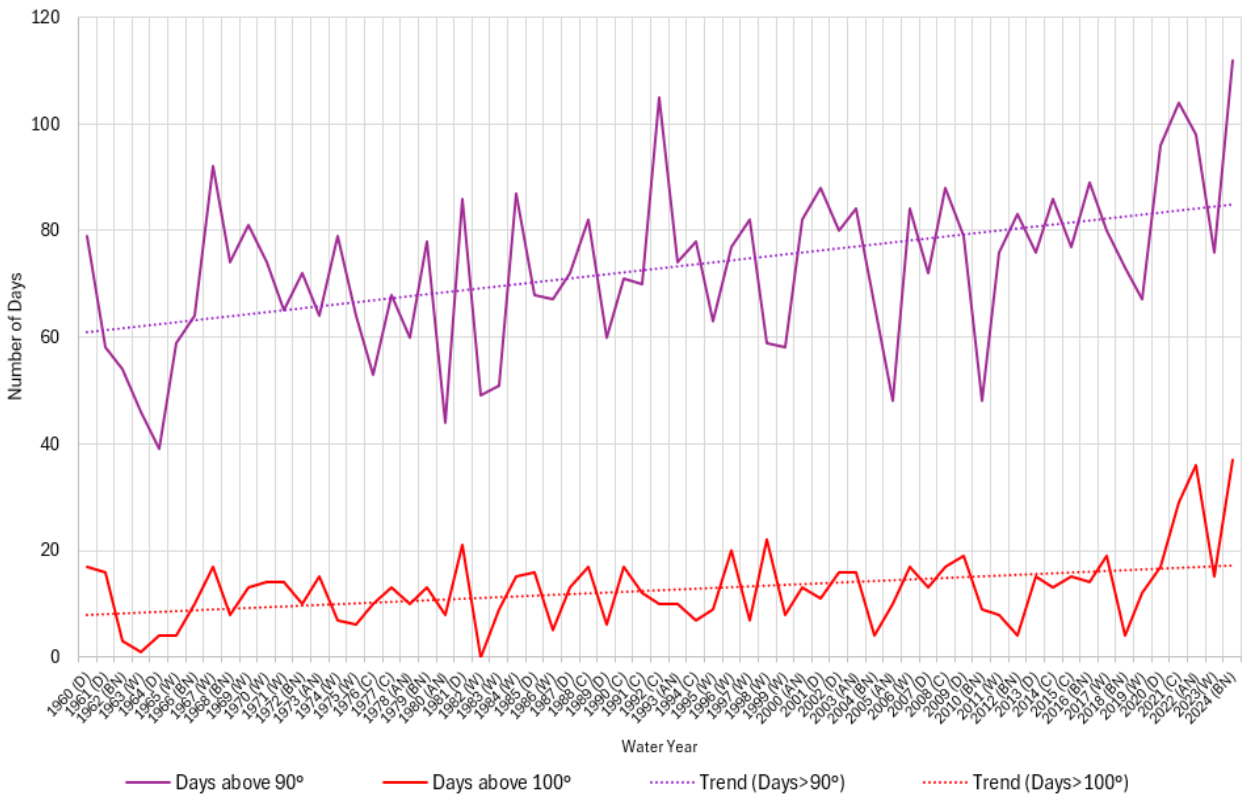
Precipitation and Temperature

Precipitation



- Drier than average in many recent years
- 2024: 17.39 inches, ~1 inch below avg

Temperature



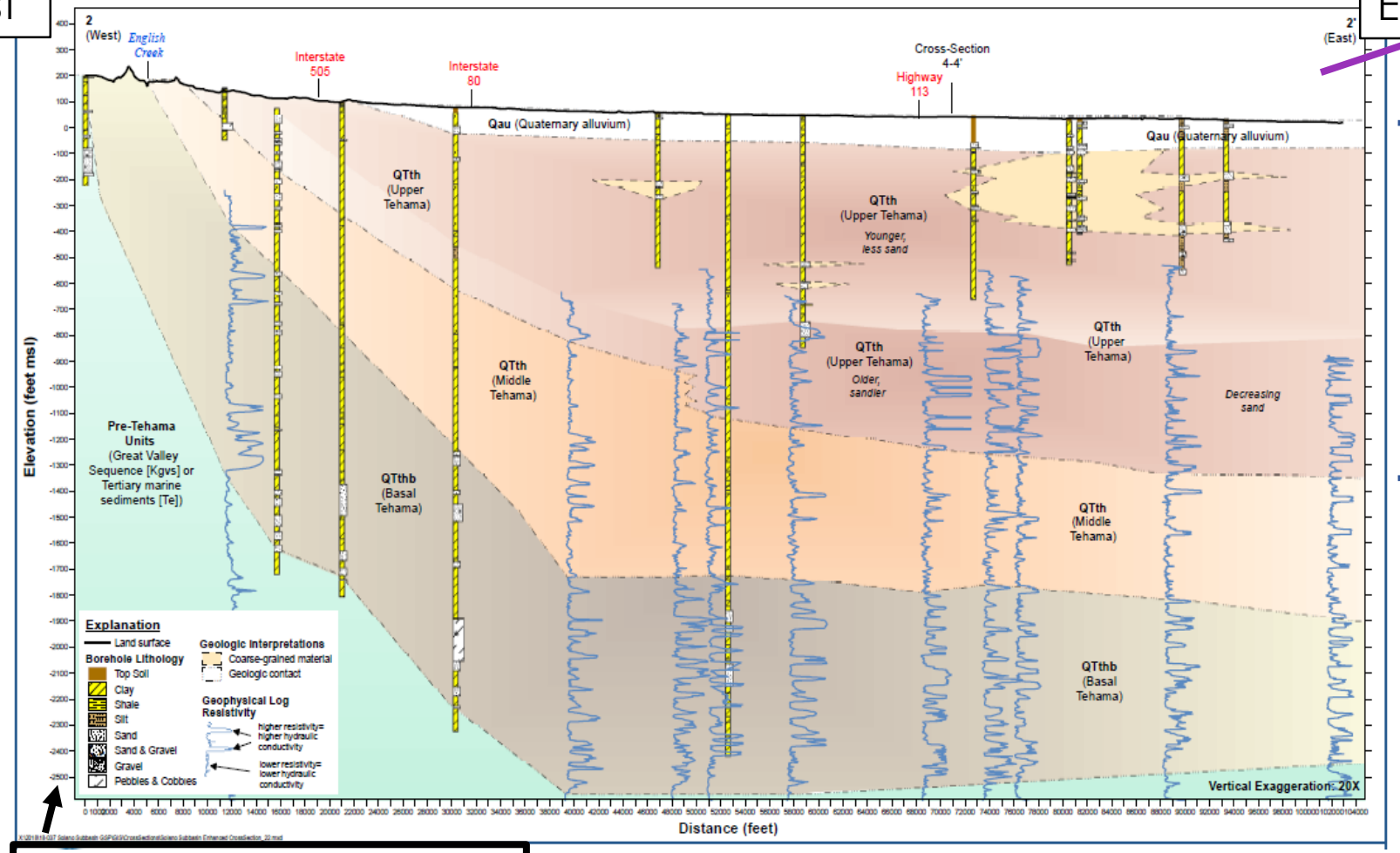
- Increasing number of hot days
- WY 2024: 112 days >90°, 37 days >100°

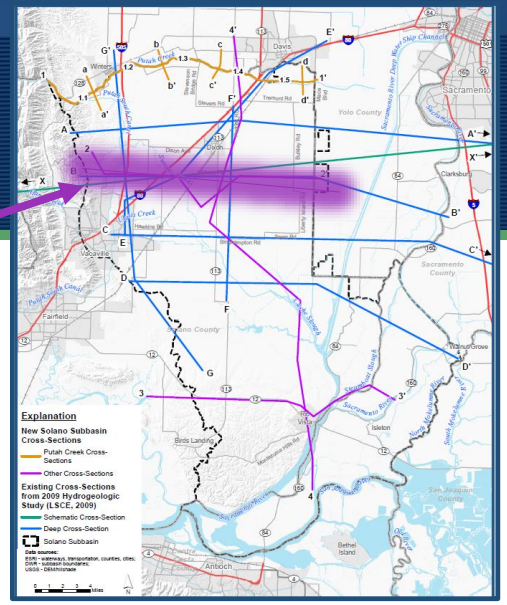
LSCE

Hydrogeology

West

East



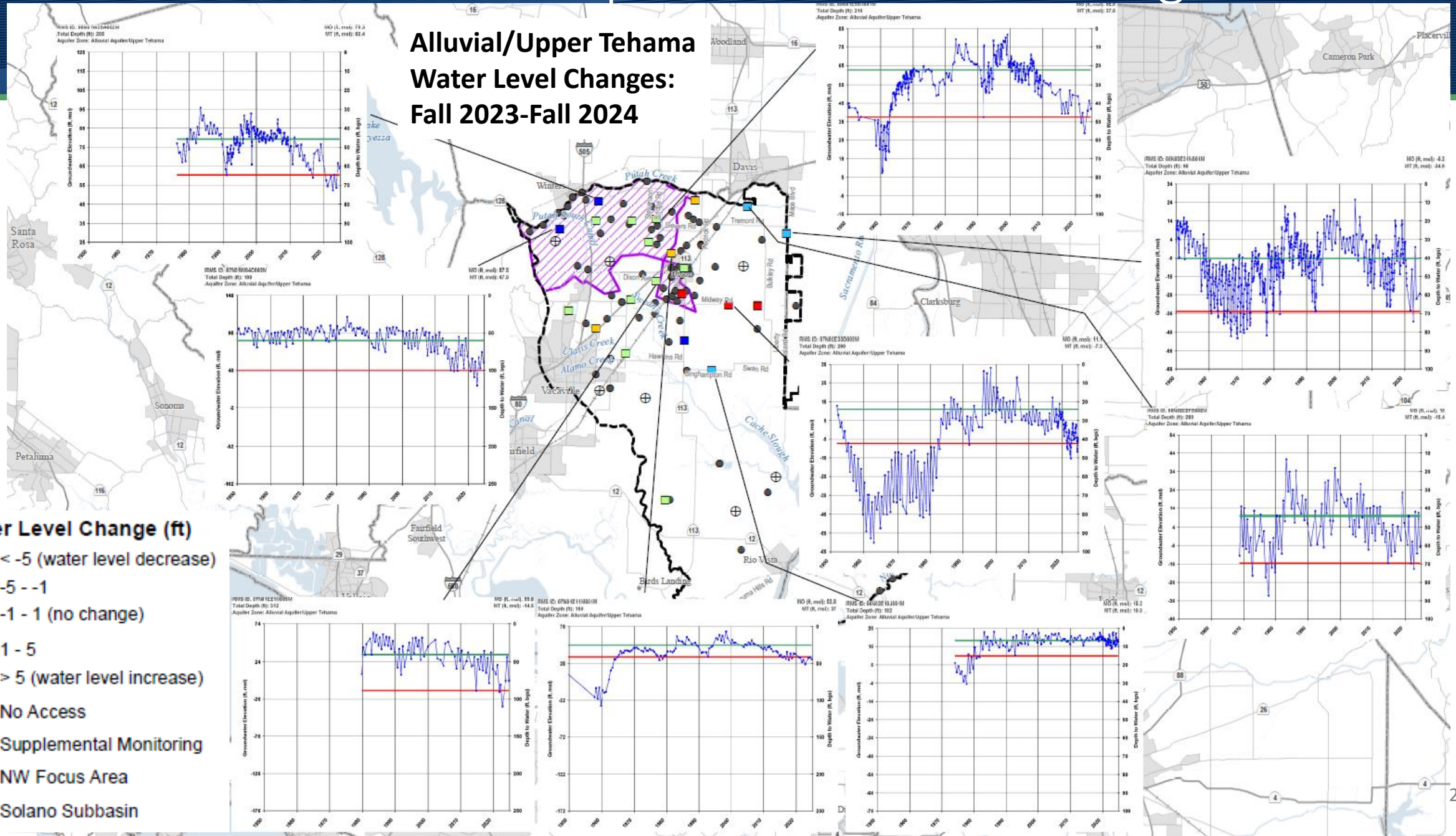


Alluvial/Upper Tehama Zone is primary aquifer for agricultural and small domestic wells

-2500 Ft Elev.;~2,700 Ft. Deep

LSCE

Groundwater Levels – Representative Monitoring Sites



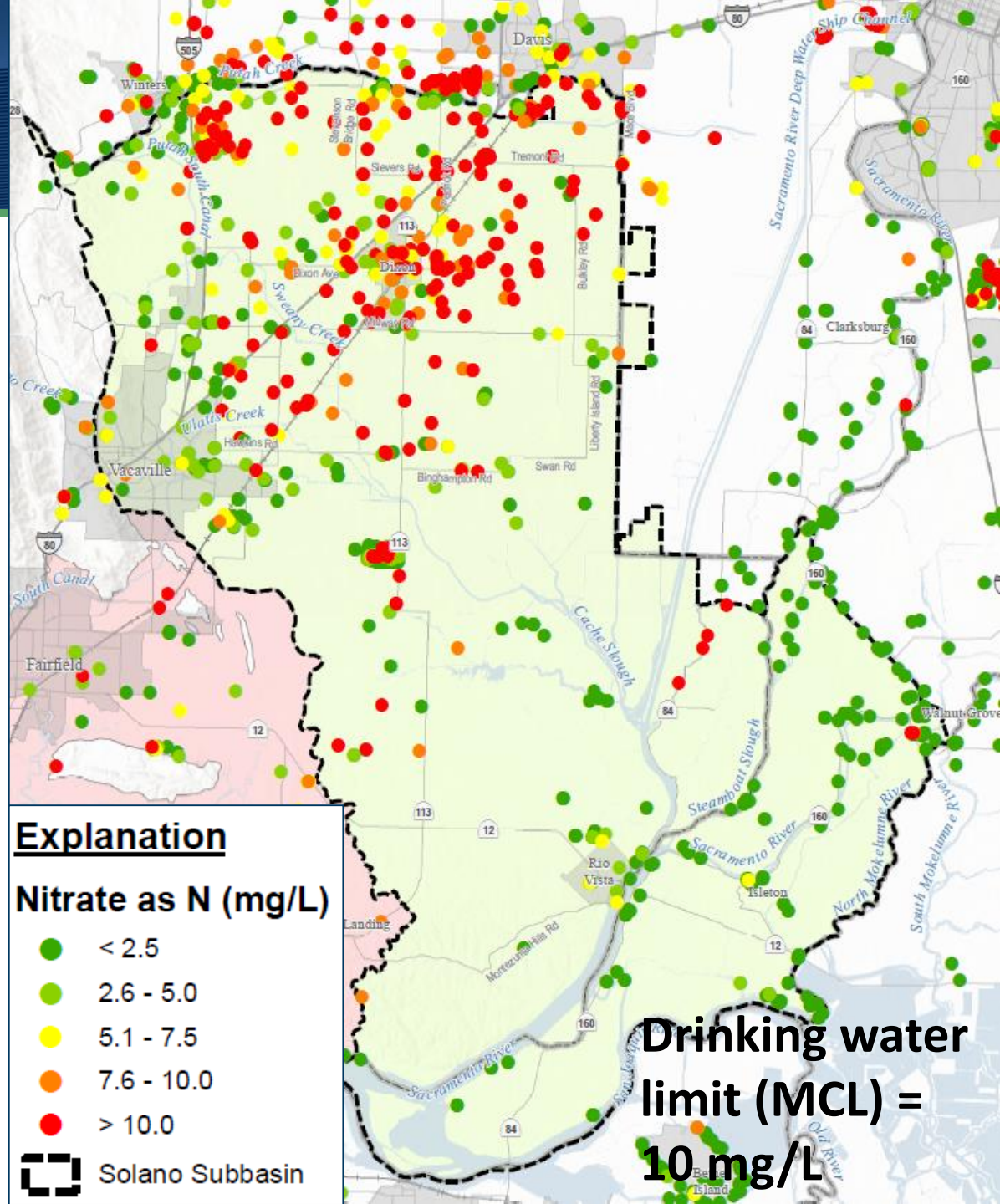
Summary of Recent Water Levels

- Water level recovery evident in many Alluvial/Upper Tehama zone wells since Fall 2022
  - 27 of 30 RMS wells stable or increasing
  - 12 of 30 RMS wells increasing >5 foot
- Wet WY 2023 increased groundwater recharge
- Full benefit to deeper groundwater system from WY 2023 recharge may be delayed
- Decreased groundwater pumping in WY 2023 (estimates for WY 2024 in progress)
- Potential changes in recent water demand from land use/crop transitioning

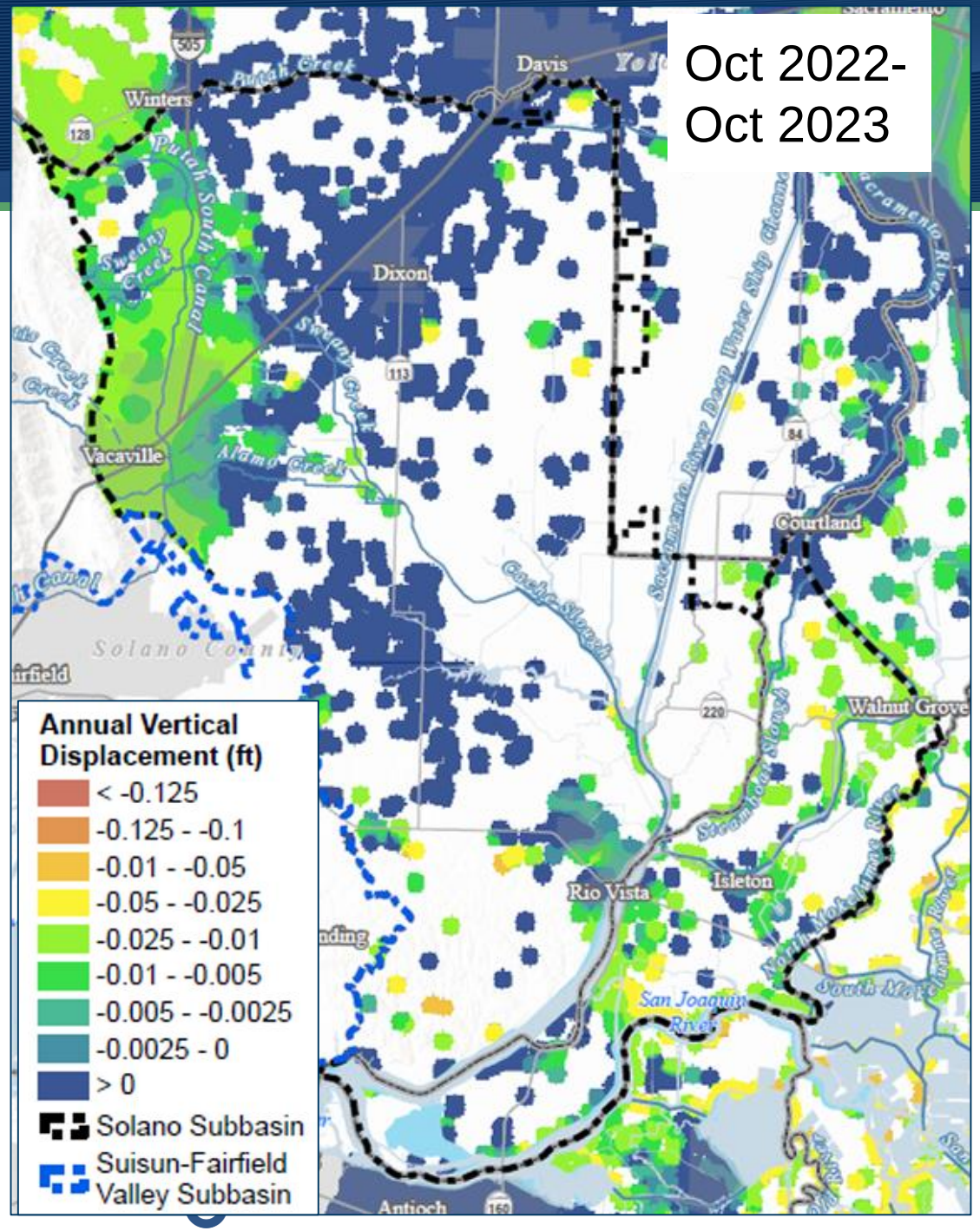
LSCE

Groundwater Quality

- Constituents of interest
  - chloride, total dissolved solids, nitrate, arsenic, chromium-6, boron
- Recent monitoring suggests broader occurrence of elevated nitrate in GW
- Nitrate management challenges:
  - Shallow GW conditions
  - Historical loading/residual nitrogen
- GSP has limited responsibility over management of water quality conditions



Subsidence

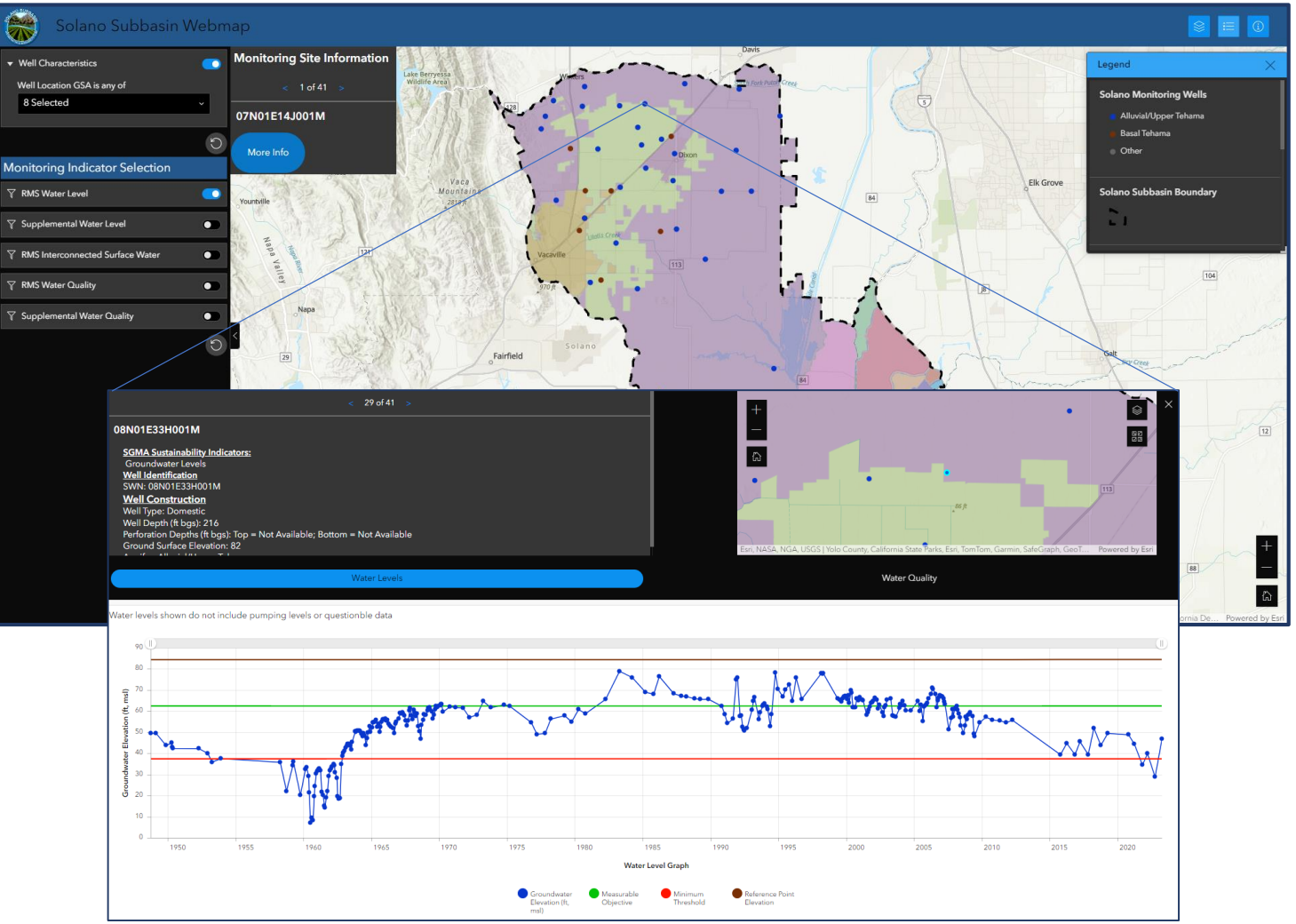


- Tracked with continuous GPS station sites and remote sensing data
- No apparent land subsidence from GW withdrawals
- WY 2024 data still in preparation

Key GSP Implementation Activities

- DWR GSP Implementation Grant funding many activities
- Monitoring enhancements (well network additions and automation)
- Interactive web map enhancements
- Refining data on water sources and uses; hydrologic model refinements
- Projects and management actions to enhance recharge and reduce runoff
- Policies and incentives to ensure sustainable groundwater management

Solano Subbasin Interactive Monitoring Web Map



- Tool for updating water users/managers on conditions
- Current focus on GSP Representative Monitoring Sites (RMS) - groundwater levels and quality
- Future enhancements planned
- No private well information - precise locations not shown
- www.solanogsp.com/subbasin_conditions/

LSCE

GW Well and SW Diversion Inventory

State and County well data

- Well Completion Reports & permits

Surface Water Diversions

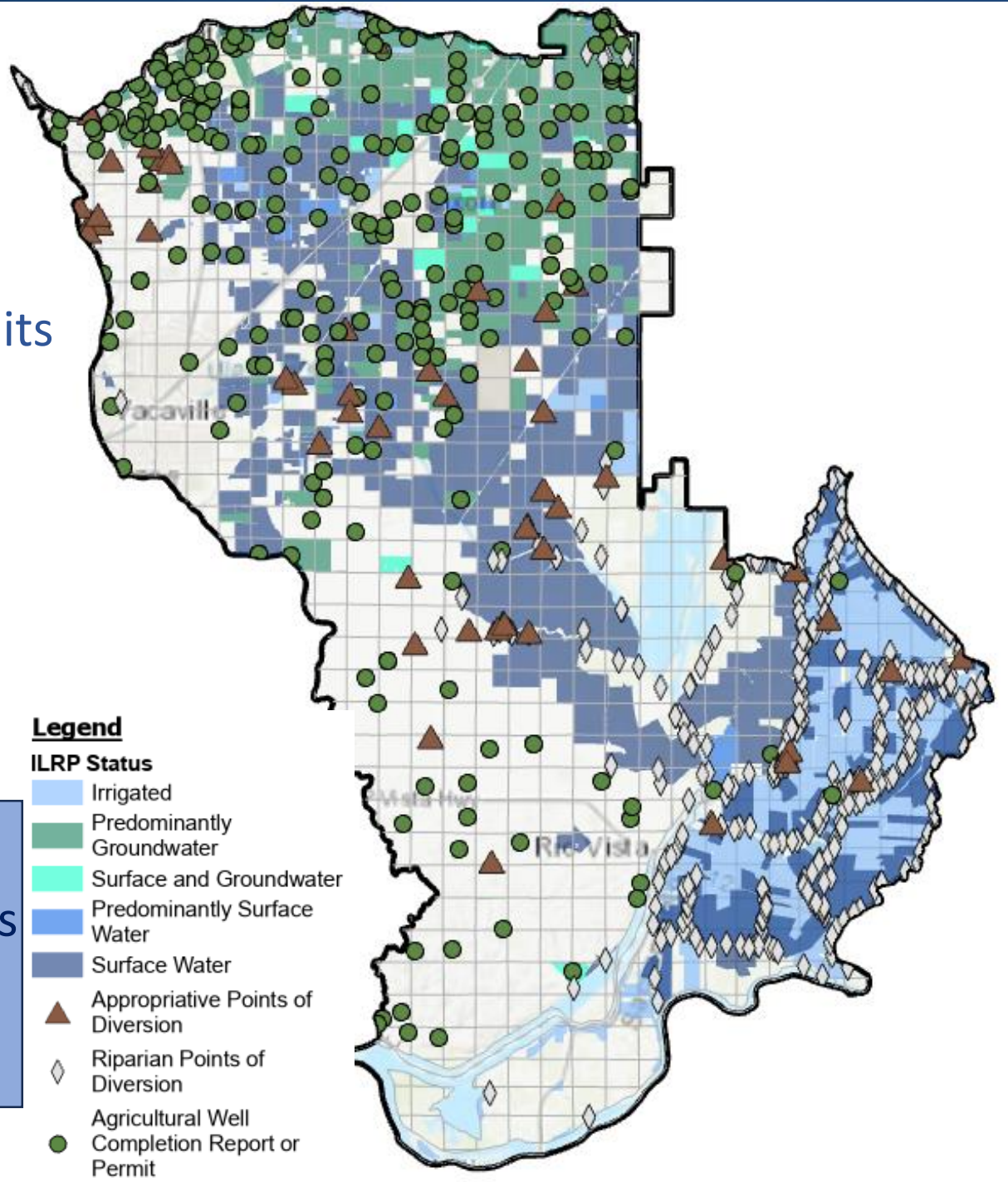
- SWRCB points of diversion and place of use

Irrigated Parcel Water Source

- From ILRP surveys

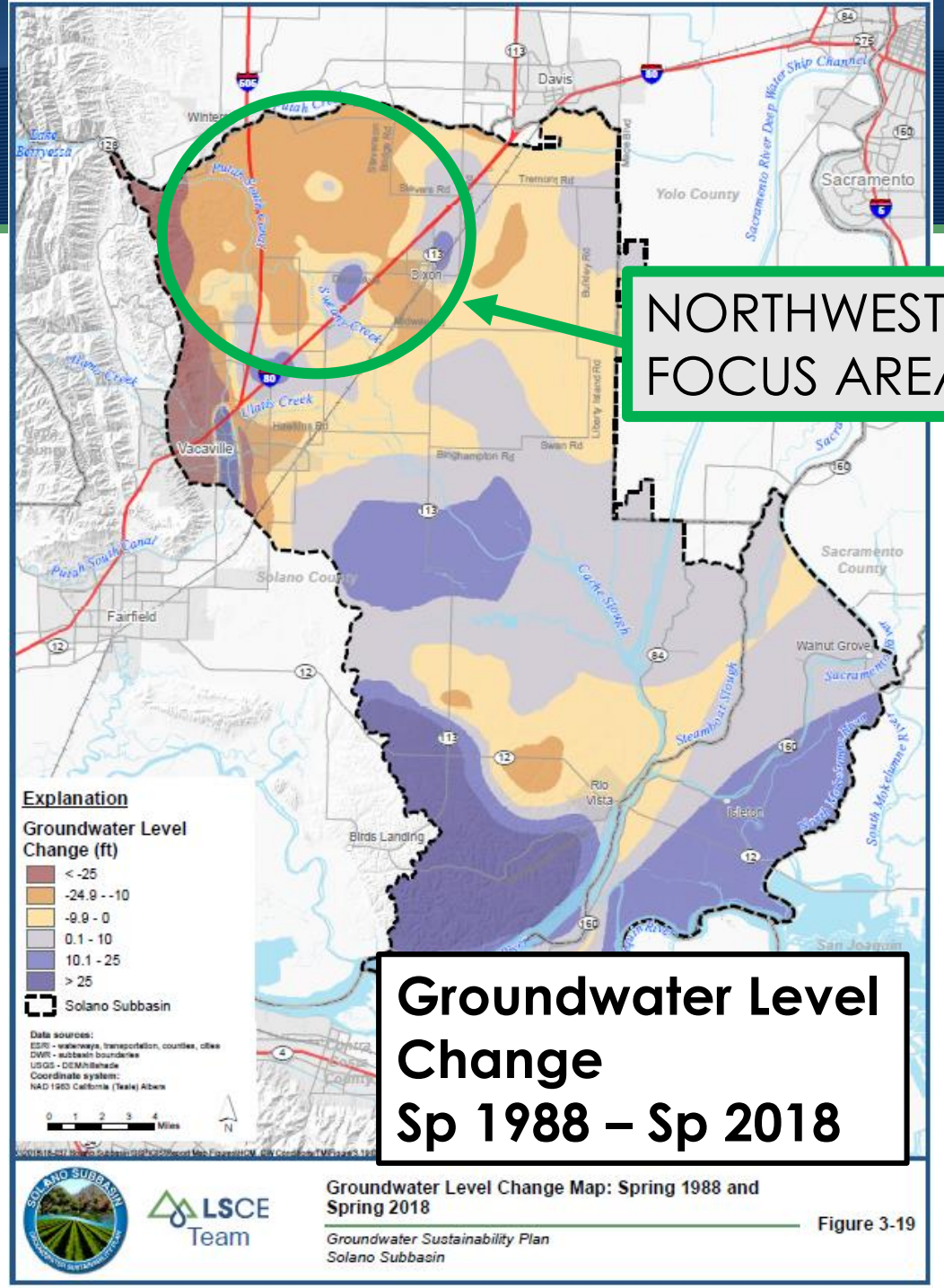
Next Steps

- Targeted well sampling to address WQ data gaps
- Hydrologic model refinements



Enhancing Groundwater Recharge

- Achieve multiple benefits: increase groundwater recharge in NW Focus Area and improve stormwater management
- Interest from land owners/managers in exploring possibilities
- GSAs, in partnership with RCDs, exploring many project concepts for piloting and/or future implementation

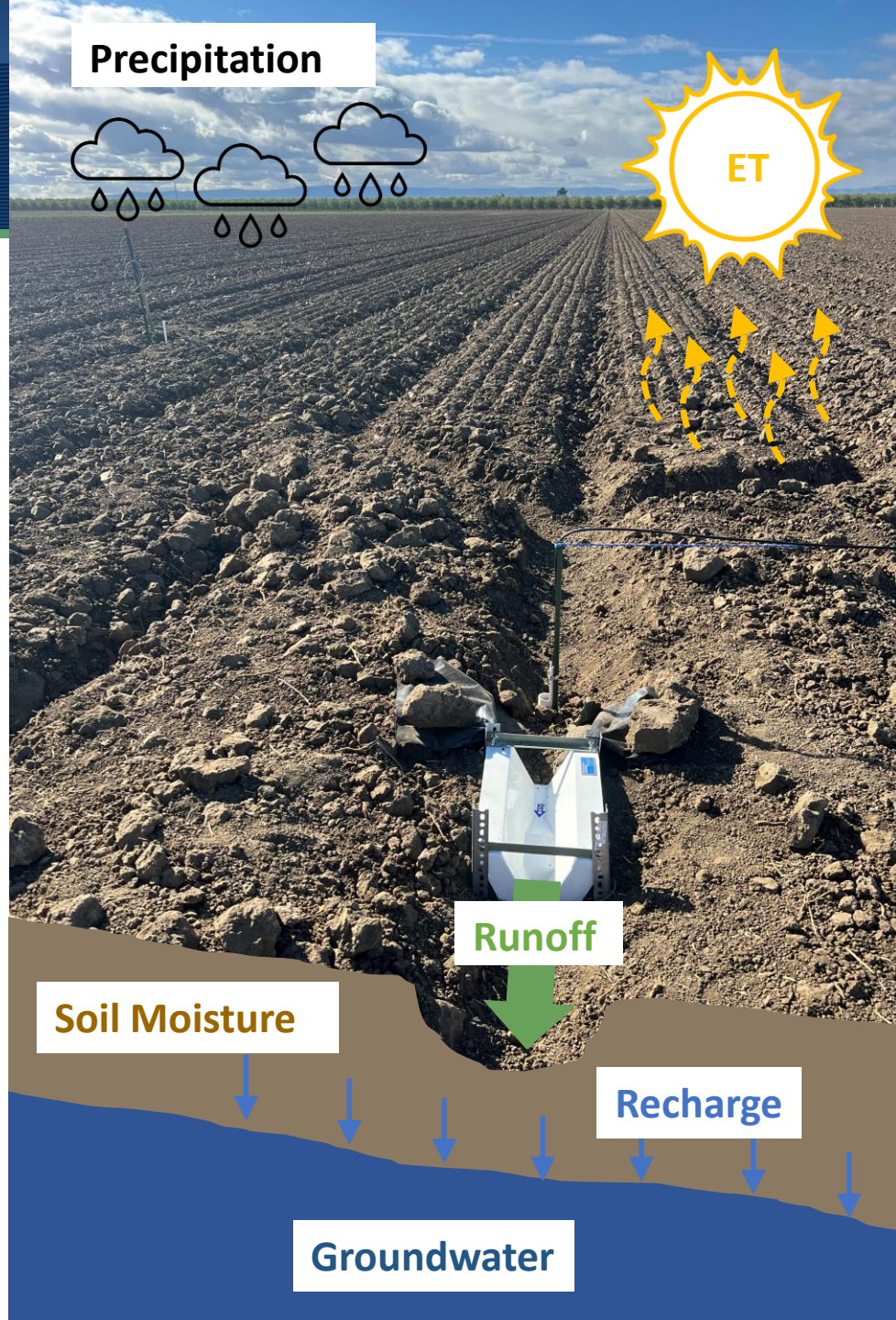


Cover Crop Study

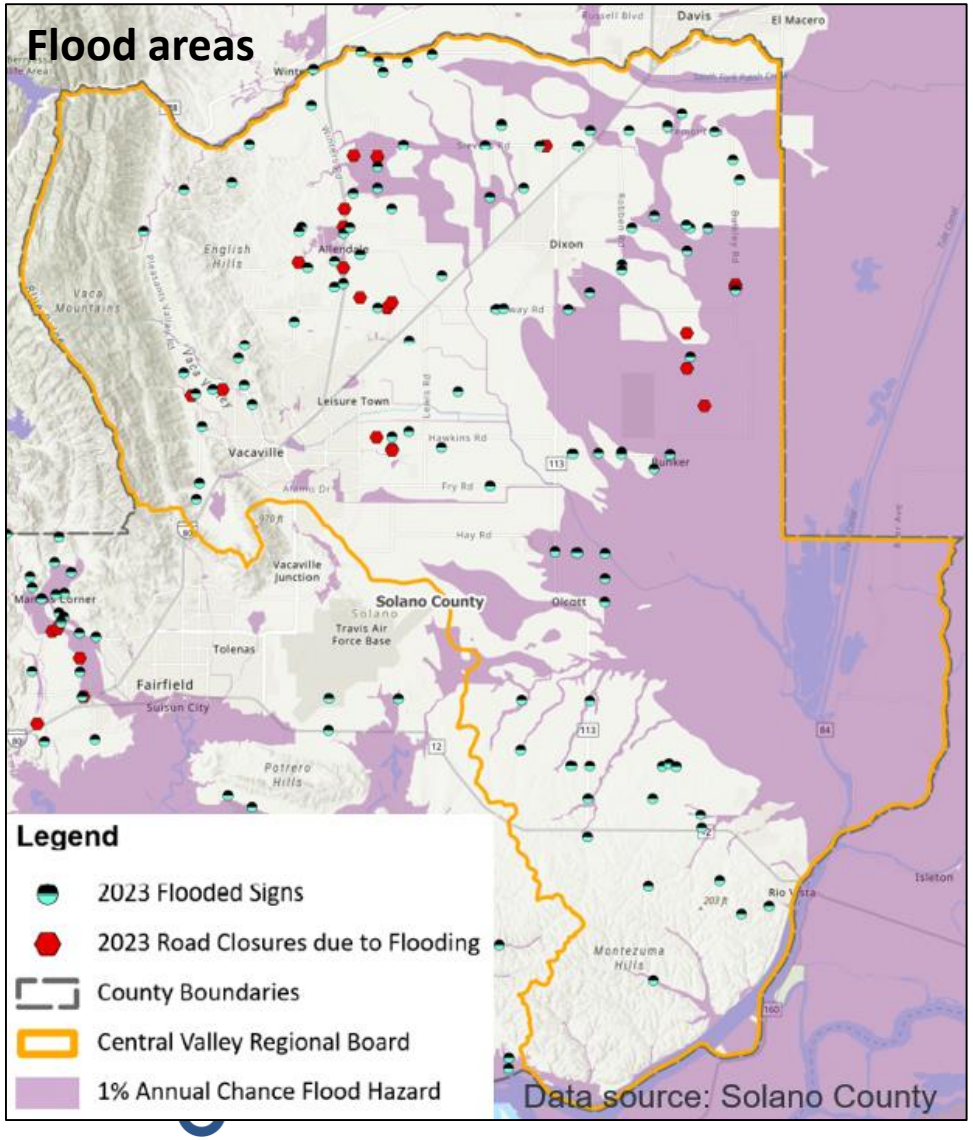
- Assess benefits of furrow cover cropping
- Collaboration with multiple farmers

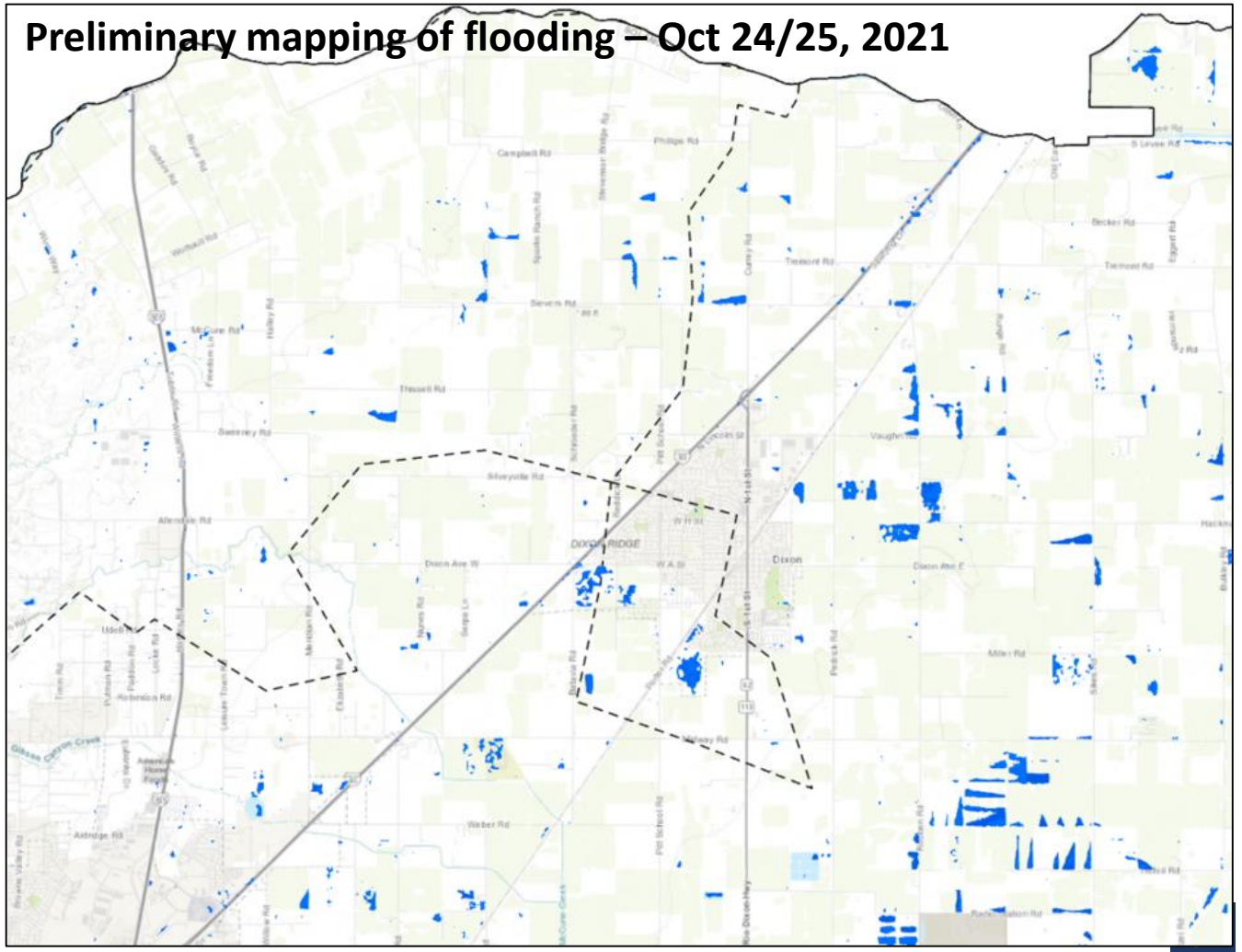
- Monitoring components:
  - Precip
  - Runoff
  - Evapotranspiration (ET)
  - Soil moisture
- Estimate infiltration and deep percolation (groundwater recharge)
- Other observations of benefits or challenges

LSCE

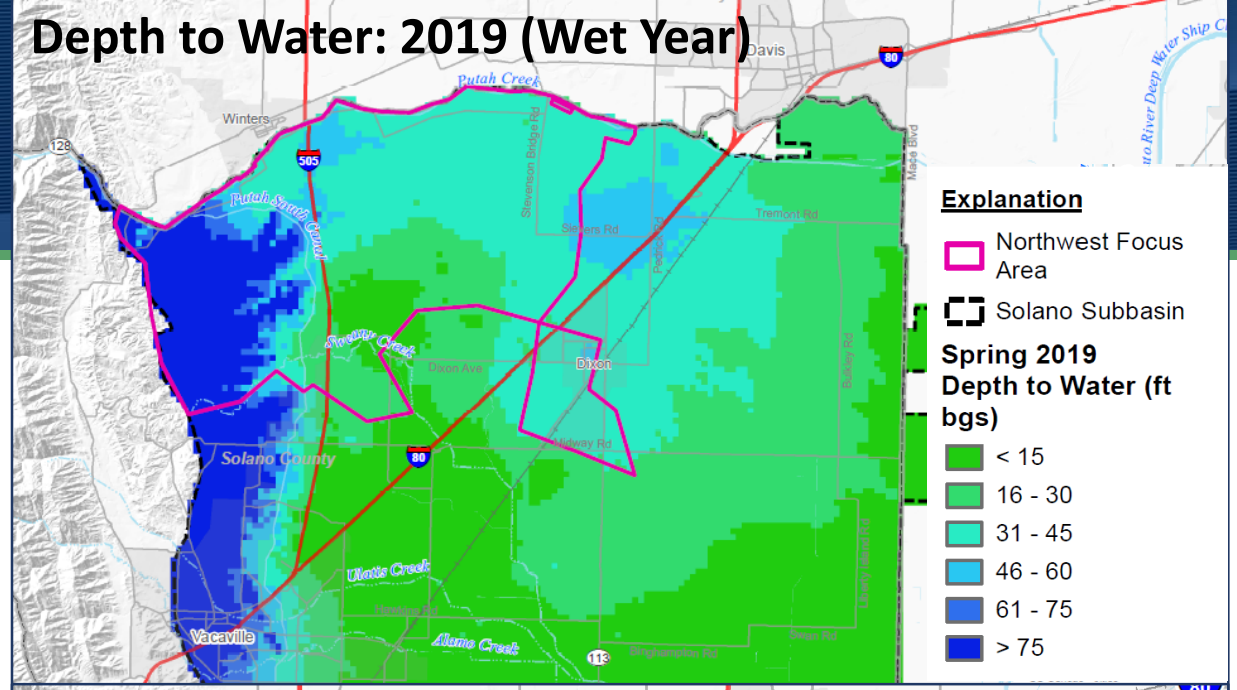


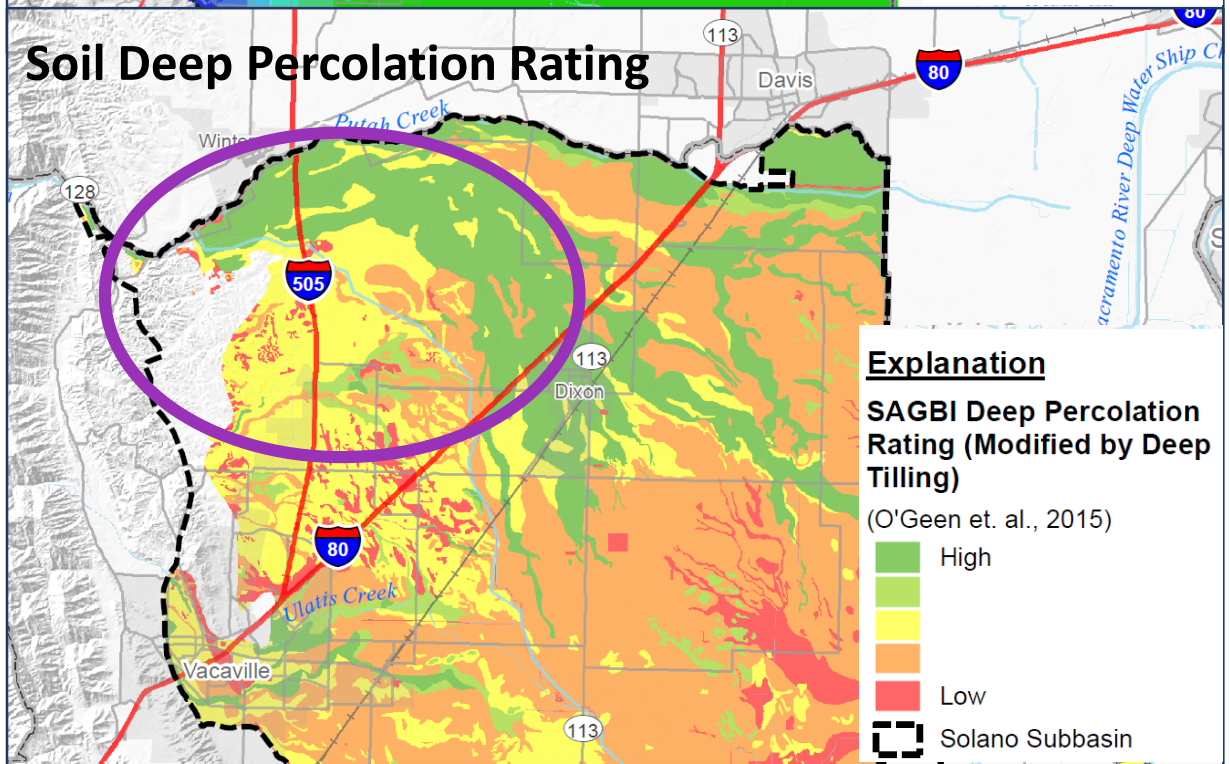
Multi-Benefit Project Planning: Stormwater Runoff



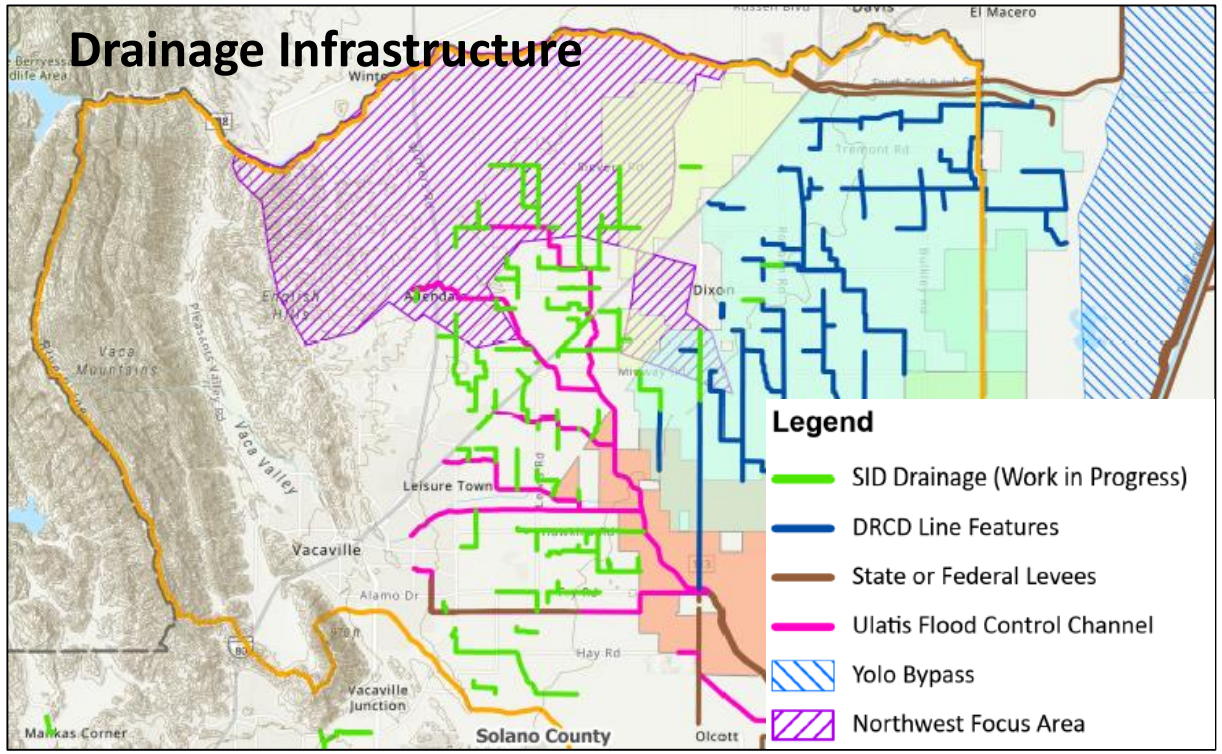


Multi-Benefit Project Planning: Recharge Opportunities

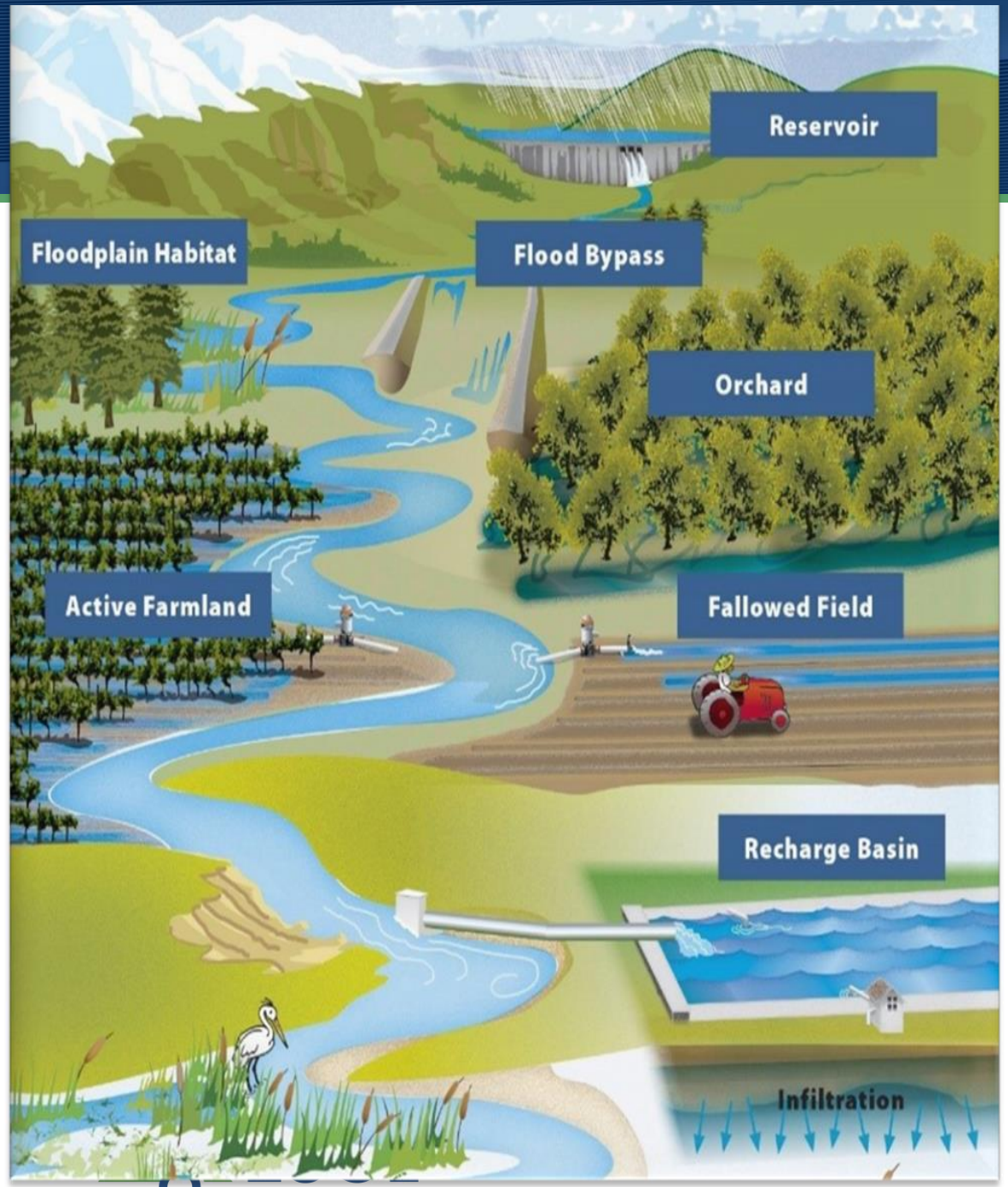




- Solano Subbasin characteristics align with multi-benefit opportunities



Implementation of Actions and Evaluation of Incentives



- Prioritization of areas and concepts for implementation of projects and actions
- Exploring potential incentives and policies to improve Subbasin resilience and sustainability
- Coordination between many stakeholder groups on proactive measures

THANK YOU

Kelly Huff with Local Growers

DIXON RESOURCE CONSERVATION DISTRICT

LOCAL GROWER PANEL

PRACTICES THAT BENEFIT GROUNDWATER

- *Ben Lyons, Lockewood Acres*
- *Seth Cooley, Cooley Enterprises*

- *Last year's panel participants*

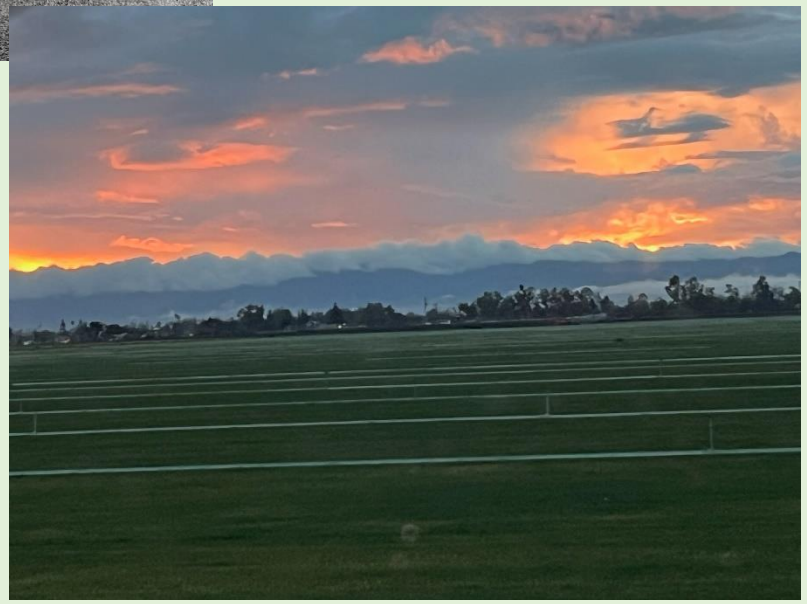
Craig Gnos, E & H Farms; Spencer Bei, Robben Ranch;
Tommy Bottoms, Tremont Farms; Michael Barrett, Casbar Farms

LOCAL GROWER PANEL

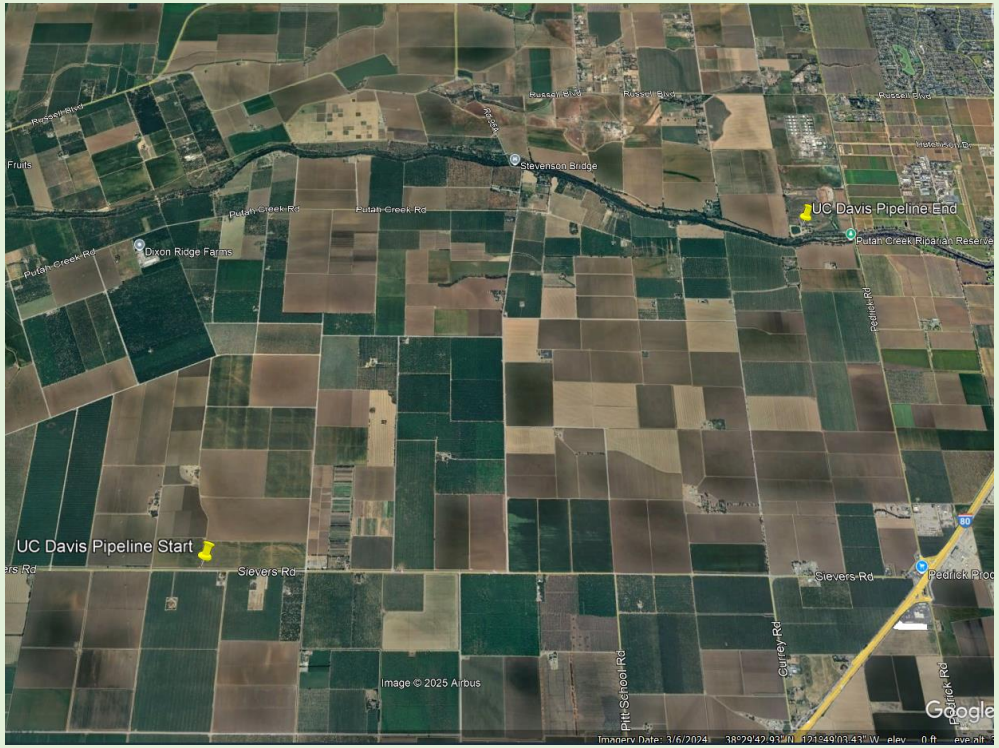
PRACTICES THAT BENEFIT GROUNDWATER

- Must provide benefits to and fit into overall system
- It is not all or nothing
- Can’t add significant new risks or complication to system
- Impacts can’t be evaluated in isolation

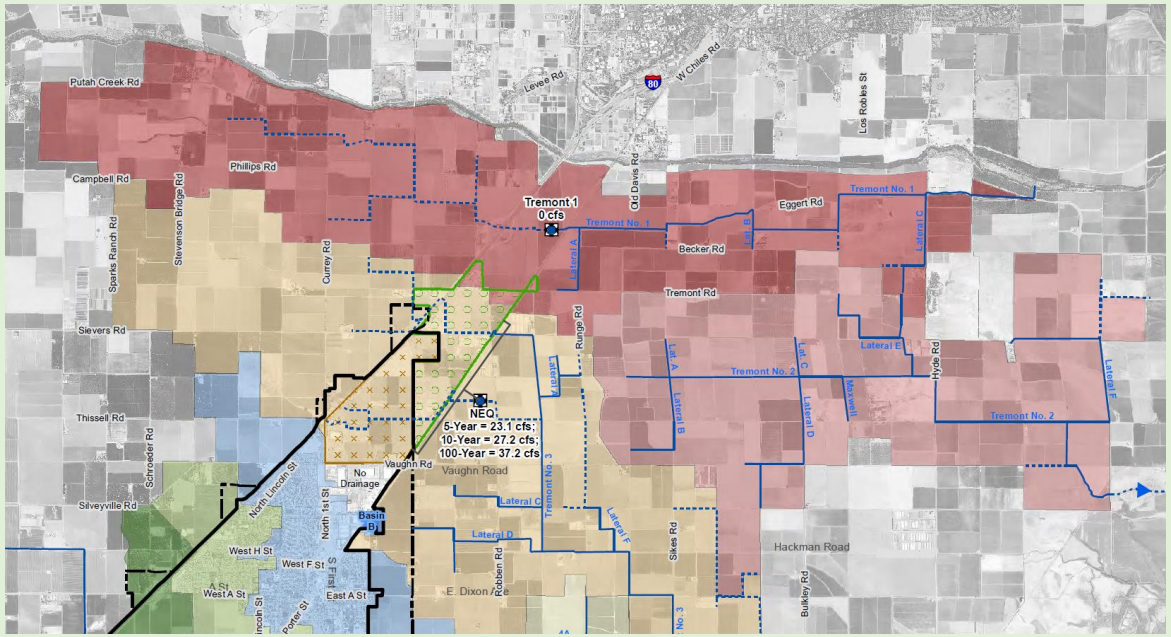
WHAT PERCENTAGE OF OUR LOCAL AG LAND IS VEGETATED CURRENTLY IN THE WINTER SEASON?



Q1:
What groundwater and/or drainage related challenges have you experienced in your operation or observed locally? What have you done or what can we do to address them?



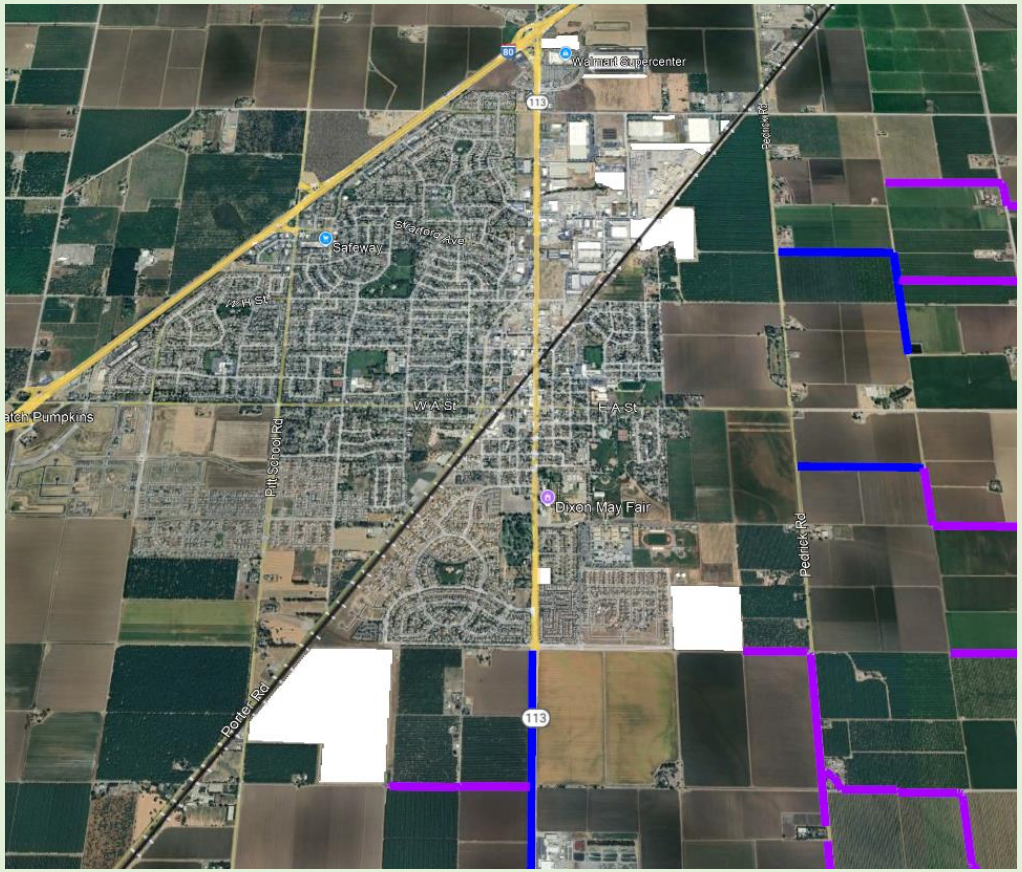
COULD EXCESS SUPPLY IN STORAGE BE APPLIED TO CROPLAND?
OR
COULD SID SERVICE AREA BE EXTENDED IN NW FOCUS AREA?



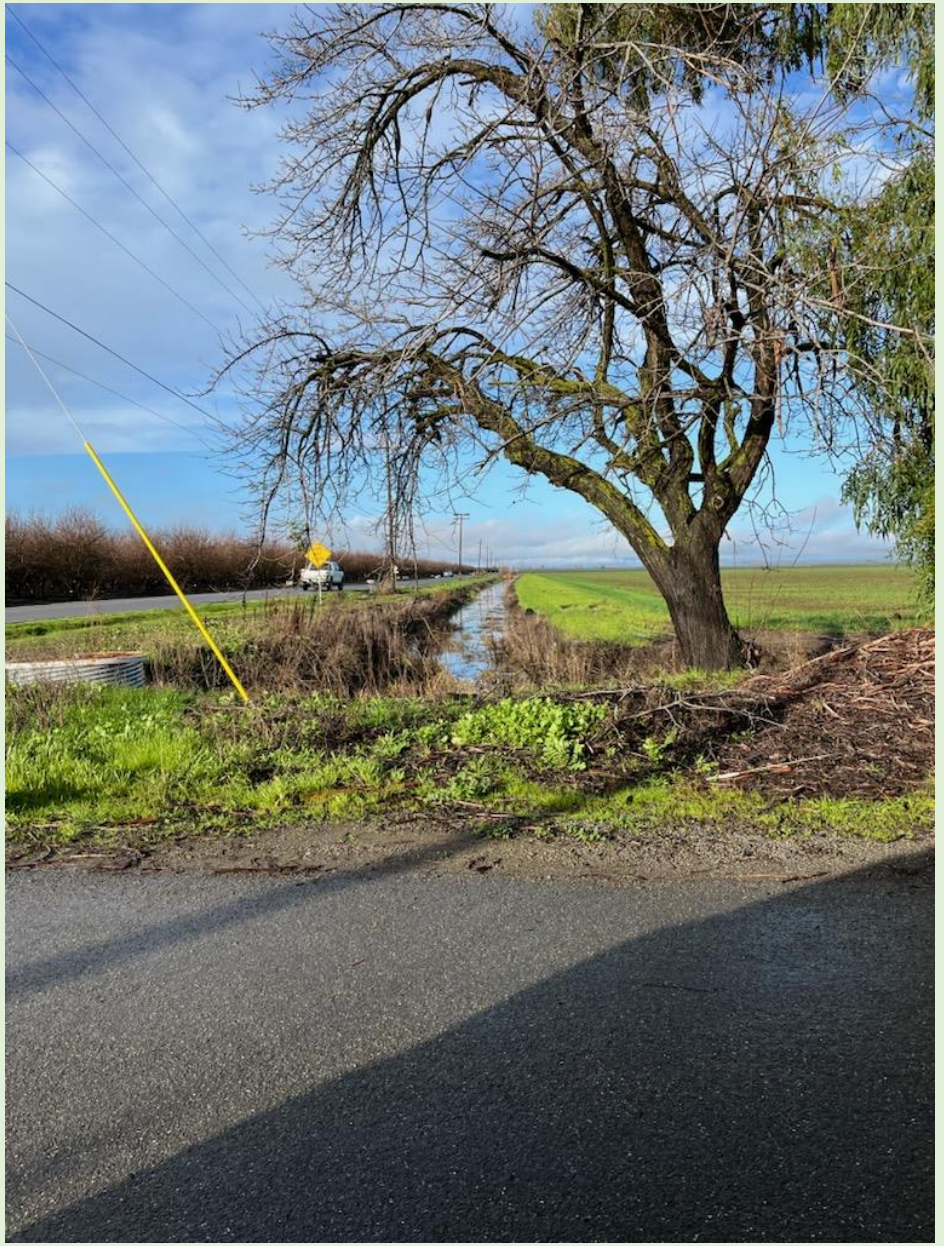
COULD DRAINAGE BE RE-DIRECTED TO SINK AREAS?

Q2:
Any recommendations to local water management agencies on managing our local water resources?

- COULD AGENCIES PROVIDE SUPPORT TO MAINTAIN OR ENHANCE EXISTING BASINS?



CITY OF DIXON/PRIVATE STORMWATER BASINS



LINEAR TAILWATER RETURN SYSTEM
020124 CURREY-SIEVERS ROADS

Q3:
What do you think could be offered as meaningful incentives for increased groundwater recharge in our County?

Break

VISIT THE REPRESENTATIVES FROM:

- AUDUBON-BIRDS RETURN PROGRAM
- DIXON RCD
- LYSTEK- AN ALTERNATE TO NITROGEN APPLICATION
- SOLANO FARM BUREAU
- SOLANO RCD
- SUSTAINABLE CONSERVATION-RECHARGE PROGRAMS
- USDA NRCS

Wendy Rash

NATURAL RESOURCE CONSERVATION SERVICES

Dixon-Solano Water Quality Coalition

January 30, 2025

Wendy Rash, Water Quality Specialist, NRCS

On-Farm Groundwater Recharge

Lessons from NRCS's Pilot Program

United States Department of Agriculture

Natural Resources Conservation Service

In a big water year…

- Does your soil infiltrate heavy rains or does it pond and evaporate or run off?
- Can you take flood water after your ground is saturated?
- Where can you put excess water on your farm?

Types of farm recharge practices

- Developing soil that can absorb and infiltrate water
  - Capturing rainfall
- Utilize surface water instead of groundwater
  - “In-lieu” recharge
- Intentional flooding of fields for infiltration
  - On-Farm Recharge or Agricultural Managed Aquifer Recharge (AgMAR)
- Put flood flows in dedicated non-crop areas to recharge
  - Groundwater Recharge Basin or Trench

NRCS has two interim practices for recharge

Recharge basin or trench

- Permanent feature (15 years) – land dedicated to recharge

On-farm recharge

- Management practice in tandem with agriculture

Recharge Pilot program

- Goal: Field test the interim practices
- Limited area
- Limited funding
- Extra requirements on pilot projects
  - Monitoring well
  - Water source and rights

Site selection factors

- Soil Agricultural Groundwater Banking Index (SAGBI)
  - Soil properties, to 60 inch depth

BI | Soil Agricultural Groundwater Banking Index

Factors | Map Settings

This App

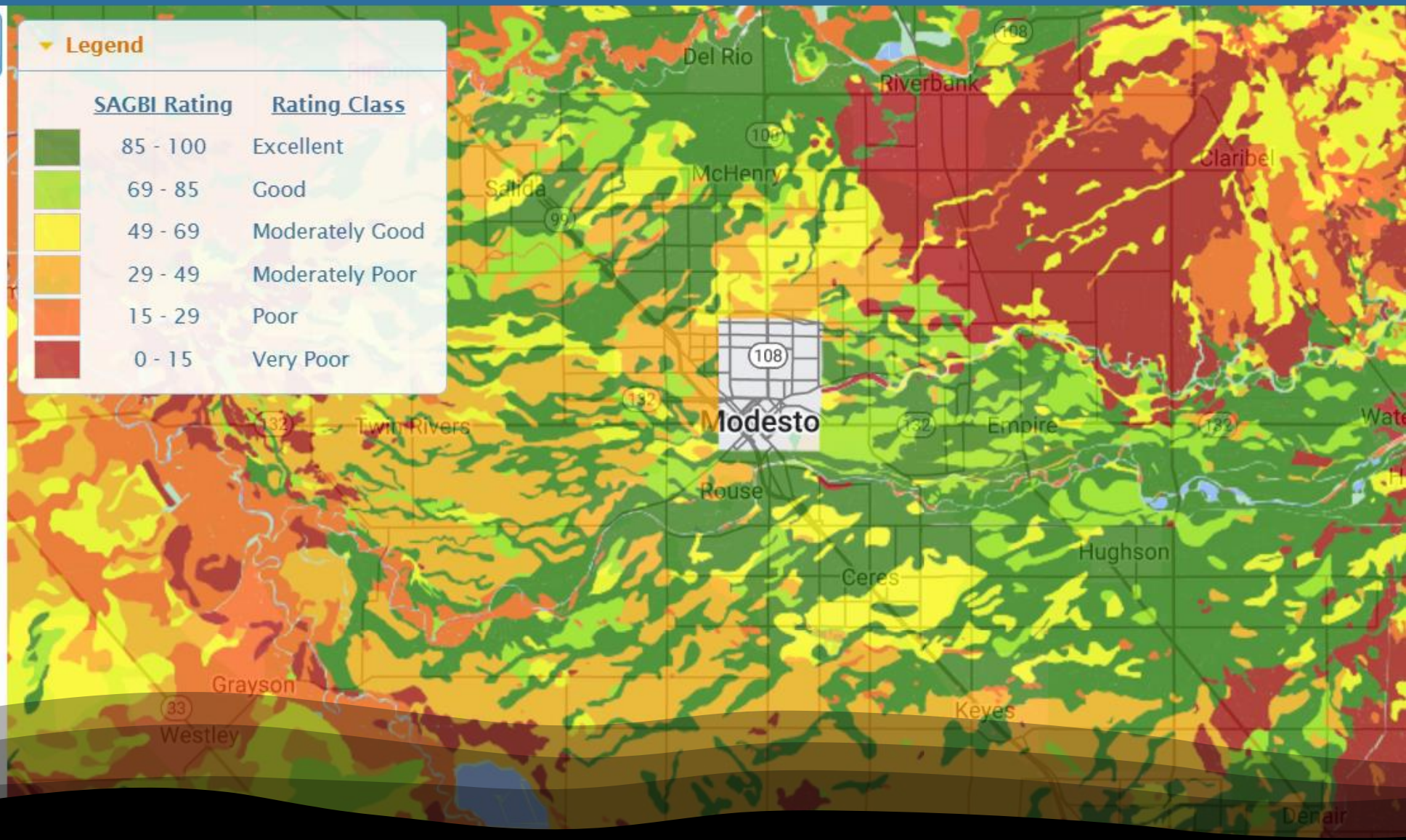
und

Agricultural Groundwater Banking
GBI) is a suitability index for
ater recharge on agricultural land.
I is based on five major factors
ritical to successful agricultural
ater banking: deep percolation,
e residence time, topography,
limitations, and soil surface
. More details can be found in the
icle in *California Agriculture*.

e app

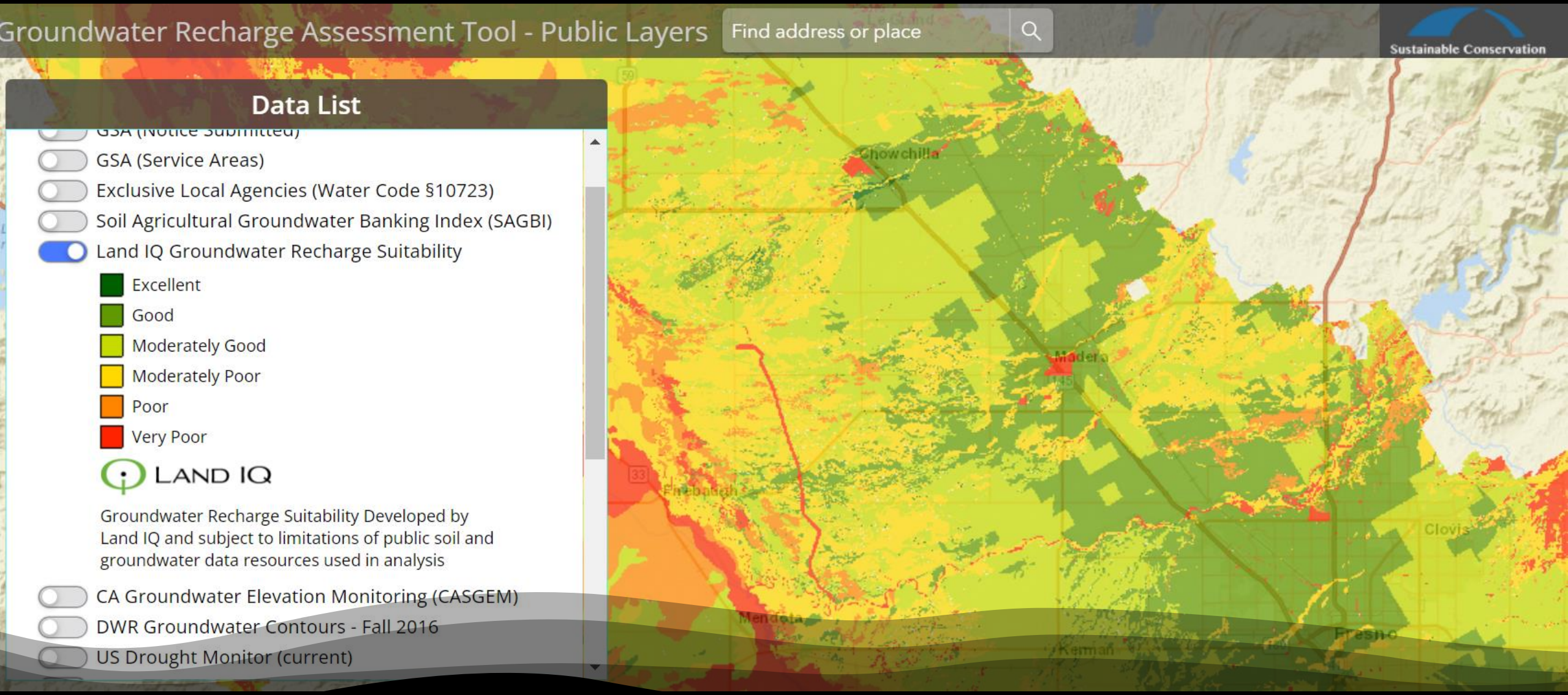
the map to view specific SAGBI
s at that location.
more about each SAGBI factor on
actors' tab.
e 'Map Settings' tab to change the
overlay transparency, or to zoom
pecific area of interest.

was developed by the California
Lab at UC Davis and



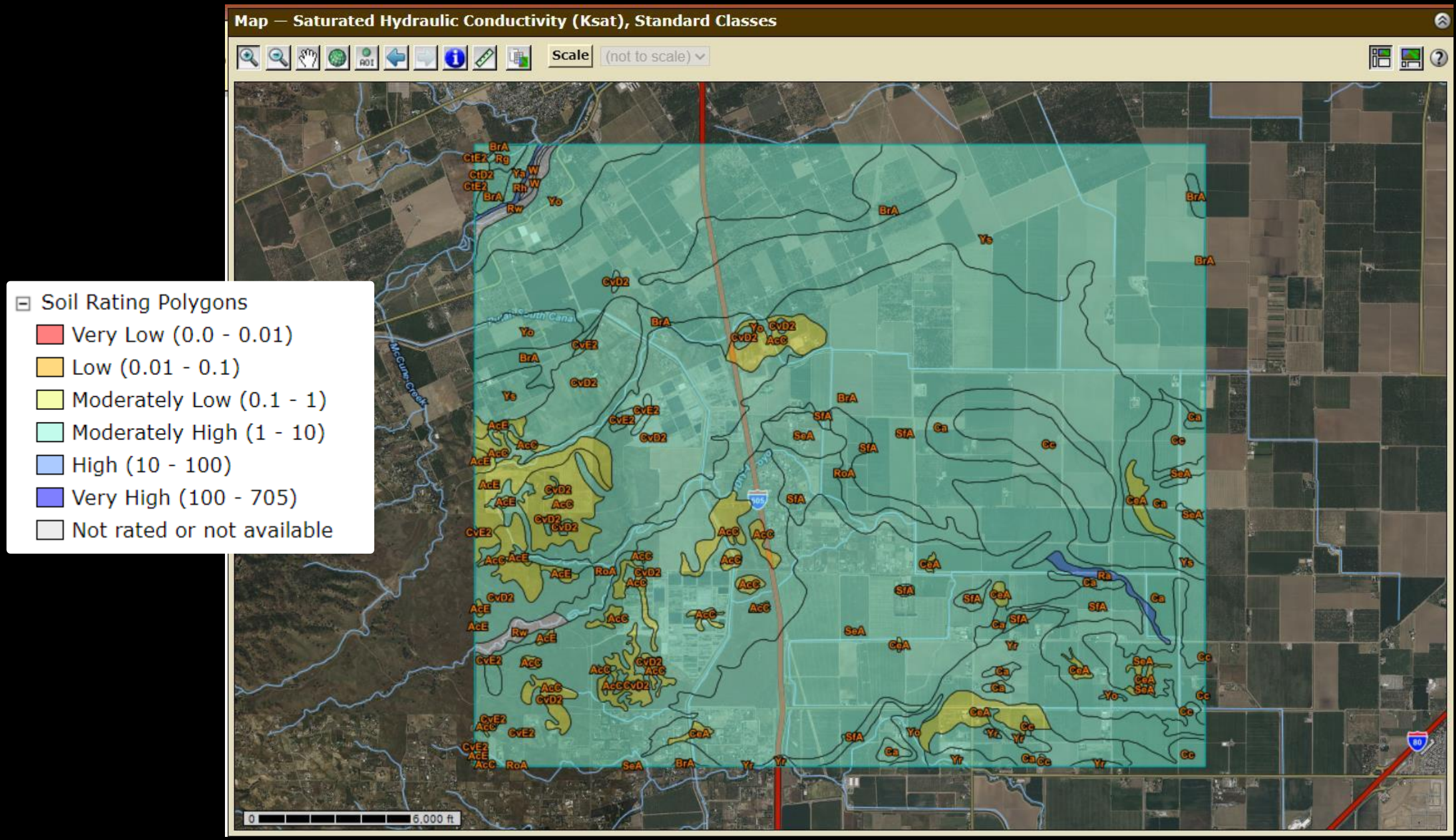
Site selection factors

- Soil Agricultural Groundwater Banking Index (SAGBI)
  - Soil properties, to 60 inch depth
- Groundwater Recharge Assessment Tool (GRAT)
  - Factors for shallow geology, to 120 ft depth


Groundwater Recharge Assessment Tool - Public Layers
Find address or place
Sustainable Conservation
Data List
GSA (Service Areas)
Exclusive Local Agencies (Water Code §10723)
Soil Agricultural Groundwater Banking Index (SAGBI)
Land IQ Groundwater Recharge Suitability
Excellent
Good
Moderately Good
Moderately Poor
Poor
Very Poor
LAND IQ
Groundwater Recharge Suitability Developed by Land IQ and subject to limitations of public soil and groundwater data resources used in analysis
CA Groundwater Elevation Monitoring (CASGEM)
DWR Groundwater Contours - Fall 2016
US Drought Monitor (current)
Chowchilla
Madera
Firebaugh
Mendota
Kerman
Clovis
Fresno

Site selection factors

- Soil Agricultural Groundwater Banking Index (SAGBI)
  - Soil properties, to 60 inch depth
- Groundwater Recharge Assessment Tool (GRAT)
  - Factors for shallow geology, to 120 ft depth
- Saturated hydraulic conductivity (Ksat) for basins


Map — Saturated Hydraulic Conductivity (Ksat), Standard Classes
Scale
(not to scale)
Soil Rating Polygons
Very Low (0.0 - 0.01)
Low (0.01 - 0.1)
Moderately Low (0.1 - 1)
Moderately High (1 - 10)
High (10 - 100)
Very High (100 - 705)
Not rated or not available
0
6,000 ft

Site selection factors

- Water availability- District delivery or water rights for recharge
- Logistics- District cooperation
- Hardware needs
  - Pumps, pipelines, meters
- Water quality considerations

Risk management for water quality

- High-risk sites ruled out
- Source water quality
- Pre-treatment for sediment

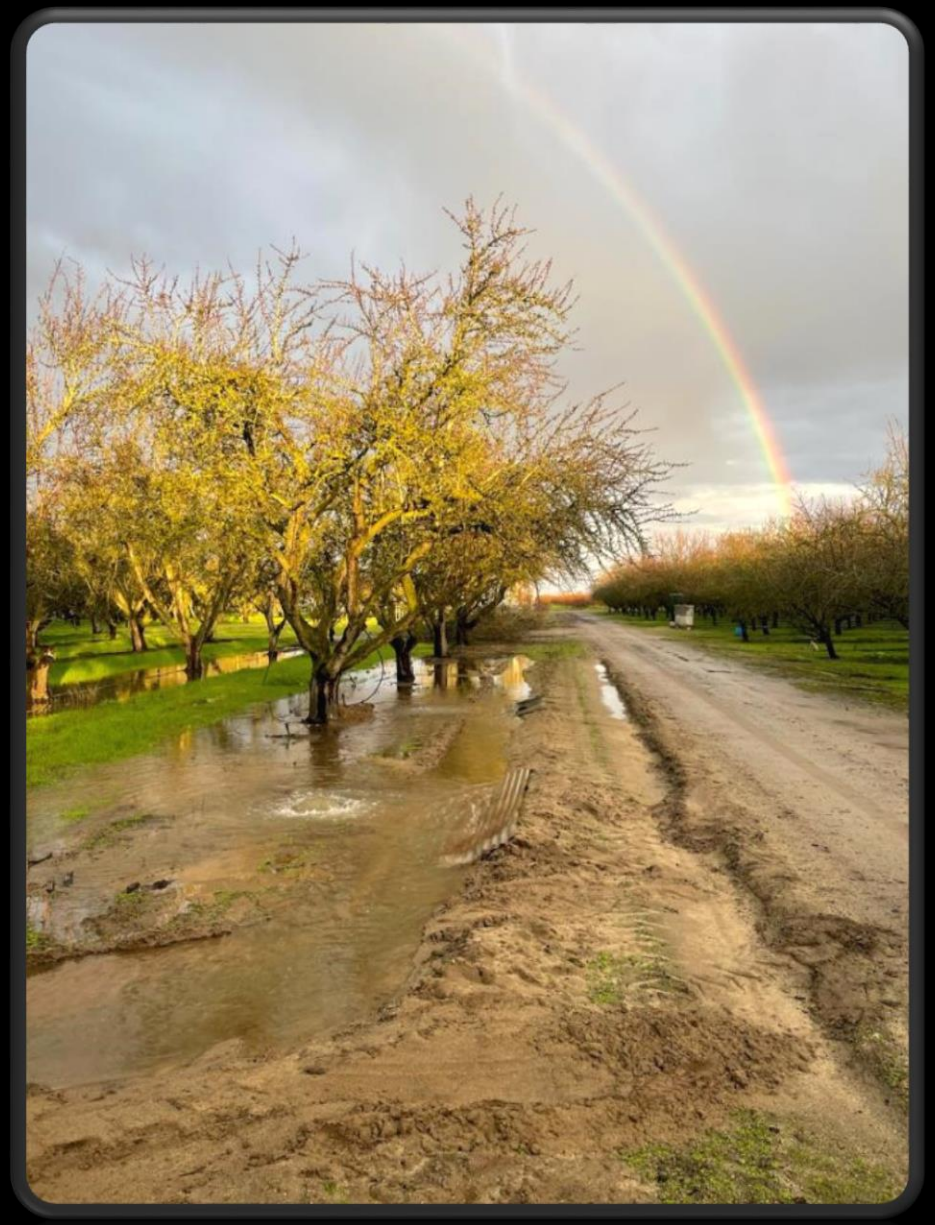
Goal: protect or improve groundwater quality

- Pest management
  - Pesticide leaching risk
  - State regulation- “No-Recharge” materials list
- Nutrient management
  - Nitrate leaching risk
  - Residual nitrate in soil
  - Nitrogen management

Agronomic considerations for crops

Annuals

- Damage to winter crops
- Flooding impacts to soil biology
- Loss of yield



Agronomic considerations for crops

Perennials

- Dormant season field work
- Root or fungal disease
- Root stock flooding tolerance
- Wind-throws-loss of trees
- Loss of yield
- Weed pressure

What did producers do for on-farm recharge?

- Nutrient management plan review
- Pesticide Use Reports for risk assessment
- Field setup plan for flood
- Consider: flood impacts to crops, cultural practices
- Put water on at least once a year when available:
  1 or 2 years in a 3-year contract

What did producers do for basins?

- Review site history
- Need appropriative water rights or recharge water right
- Only Cropland and Associated land, no pasture or range
- Discuss how water would get to the field: need pipe, turnout or flow meters?
- Basins are paid per ac-ft of storage capacity

Monitoring for pilot projects

- Nearby well to monitor for response
- Well Monitoring:
  - NRCS and Sustainable Conservation staff
  - Nov – Dec pre-recharge, 2022 and 2023
  - March 2023 post-recharge
  - water level measurements
  - water analysis for Nitrate and Total Dissolved Solids

Outcomes for NRCS Pilot for 2022-23

Basin or Trench

- Built 1 on-farm basin
- 18 ac footprint, 60 ac-ft capacity
- >200 ac-ft recharged

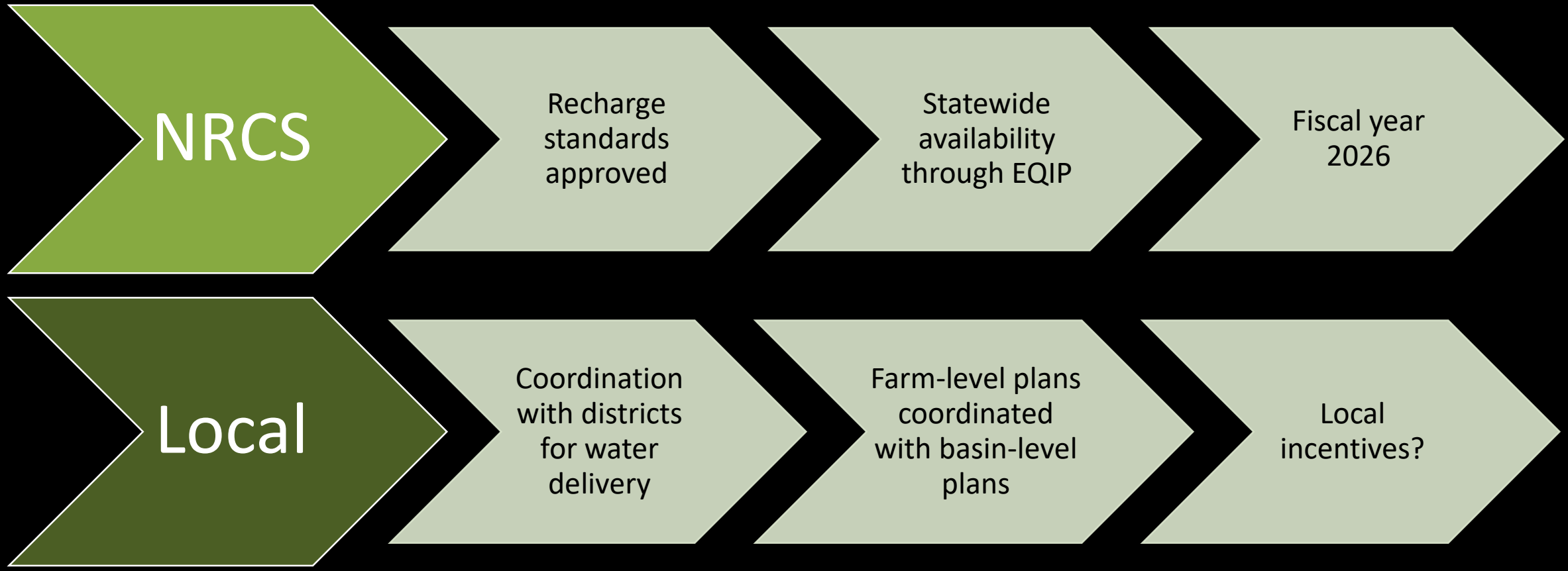
On-farm recharge

- Over 3,000 acres
- Total recharge 4,680 ac-ft
- Averaged 1.7 ac-ft/ac
- Ranged from 0.5 – 3.25 ac-ft/ac

Observations

- Requires skilled management
- Labor costs
- Irrigation vs. Recharge: Minimum application
- Cooperation with agencies- water delivery, water rights
- Incentives
  - NRCS payment rates
  - GSA or ID incentives

Next steps


NRCS
Recharge standards approved
Statewide availability through EQIP
Fiscal year 2026
Local
Coordination with districts for water delivery
Farm-level plans coordinated with basin-level plans
Local incentives?

CA Water Code 1242.1- Flood Emergency Diversions

- State regulation
- Water Resources Control Board, Cal Fish and Wildlife
- Flood flows can be used for groundwater recharge
- No water rights required*
- No CEQA required*

CA Water Code 1242.1- Flood Emergency Diversions

Anyone can divert who:

- Complies with water code conditions
- Owns or has legal access to diversion works
- Owns or has legal access to recharge land

CA Water Code 1242.1- Flood Emergency Diversions

You can divert:

- Floodwater portion of flow
- Surface water in:
  - Rivers
  - Streams
  - Lakes

CA Water Code 1242.1- Flood Emergency Diversions

You can divert when:

- There is flood risk based on local plan
- Active flood emergency declared
- Public notice of flood emergency
- *Delta has special conditions

CA Water Code 1242.1- Flood Emergency Diversions

Where can water go?

☑ Existing facilities

- Basins built for recharge
- Managed wetlands
- Active ag production areas

☒ "No-Recharge" places

- Concentrated animal waste
- Outlier fields for N management
- Risk to levees or water systems
- Areas not in active agricultural production

CA Water Code 1242.1- Flood Emergency Diversions

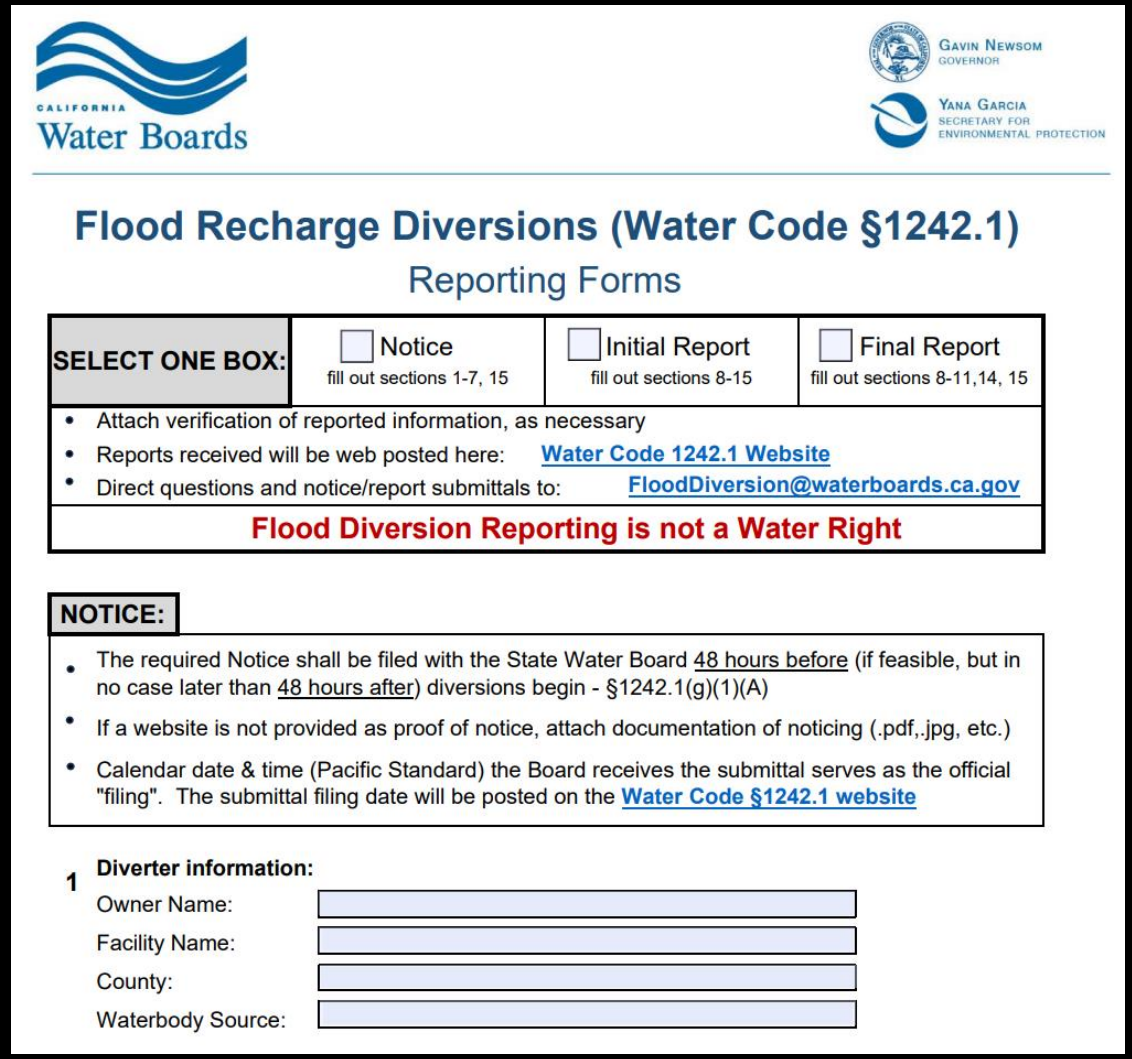
How can water be diverted?

- Temporary or permanent pumps
- No new construction of permanent pumping stations
- Temporary pumps must have simple fish screens

CA Water Code 1242.1- Flood Emergency Diversions

What is in the fine print?

- No water rights are attached to flood diversions
- Reporting to State Water Board is required
- Fish screens approved by Cal Fish and Wildlife



California Water Boards

Gavin Newsom, Governor

Yana Garcia, Secretary for Environmental Protection

Flood Recharge Diversions (Water Code §1242.1)

Reporting Forms

SELECT ONE BOX:	☐ Notice fill out sections 1-7, 15	☐ Initial Report fill out sections 8-15	☐ Final Report fill out sections 8-11,14, 15

- Attach verification of reported information, as necessary
- Reports received will be web posted here: Water Code 1242.1 Website
- Direct questions and notice/report submittals to: FloodDiversion@waterboards.ca.gov

Flood Diversion Reporting is not a Water Right

NOTICE:

- The required Notice shall be filed with the State Water Board 48 hours before (if feasible, but in no case later than 48 hours after) diversions begin - §1242.1(g)(1)(A)
- If a website is not provided as proof of notice, attach documentation of noticing (.pdf,.jpg, etc.)
- Calendar date & time (Pacific Standard) the Board receives the submittal serves as the official "filing". The submittal filing date will be posted on the Water Code §1242.1 website

1 **Diverter information:**

Owner Name:

Facility Name:

County:

Waterbody Source:

CA Water Code 1242.1- Flood Emergency Diversions

- For more details visit Flood Recharge Diversions (Water Code §1242.1.1) | California State Water Resources Control Board
- For technical questions: FloodDiversion@waterboards.ca.gov

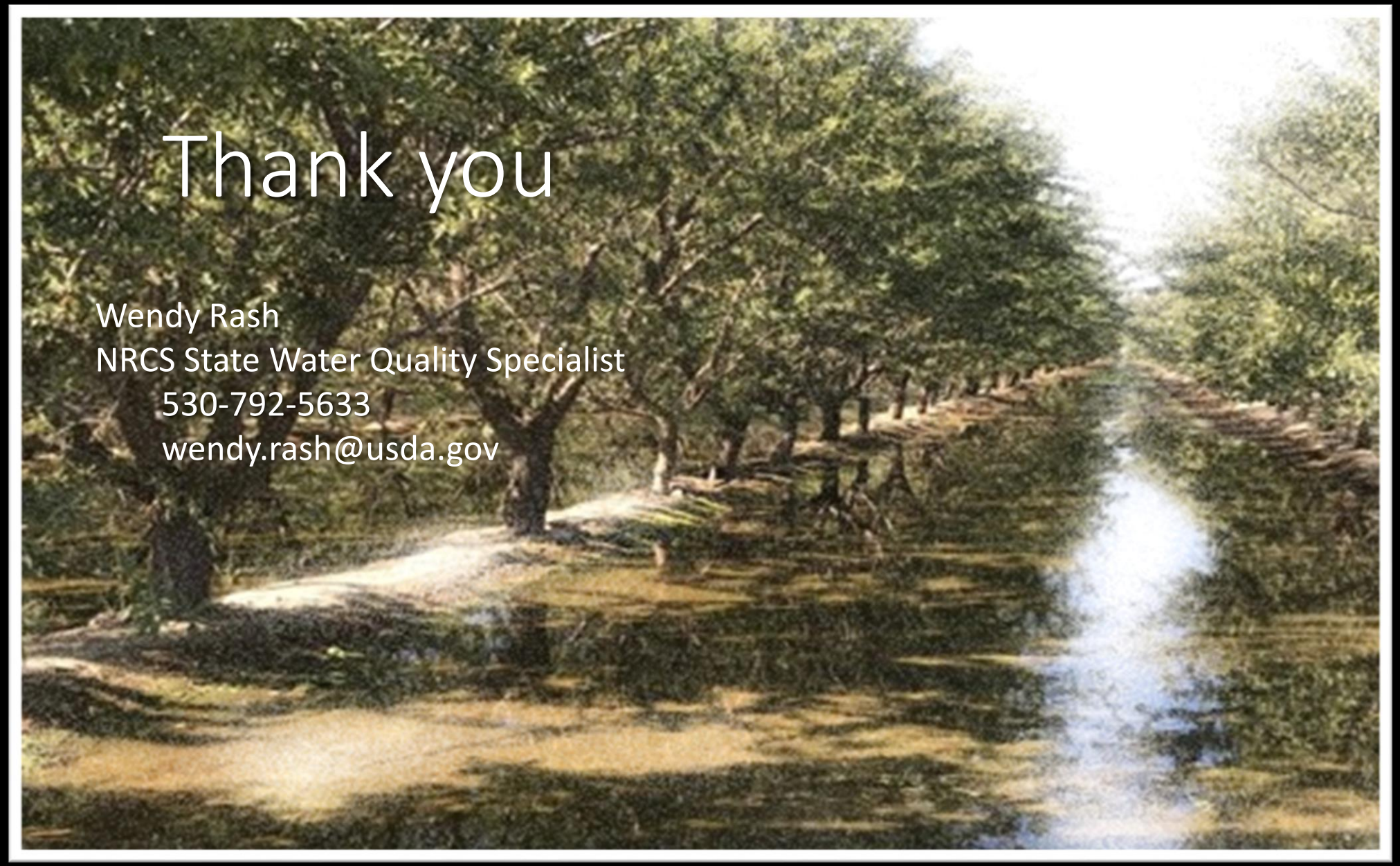
How to get help on groundwater recharge

Funding

- NRCS: EQIP- Coming soon
- Local incentives?
- CA DWR: Flood Diversion and Recharge Enhancement (FDRE) Initiative?

Technical assistance

- NRCS
- Sustainable Conservation
- State Water Resources Control Board (SWRCB)- for flood diversion


Thank you
Wendy Rash
NRCS State Water Quality Specialist
530-792-5633
wendy.rash@usda.gov

Monica Quezada and Amy King

SOLANO RESOURCE CONSERVATION DISTRICT

SOLANO Resource Conservation District

Nurturing Groundwater : The Environmental Benefits of Vegetated Ditches and Ponds

January 30, 2025

Monica Quezada

Agriculture Project Manager

SOLANO
Resource
Conservation
District

- Our Goals
- **Restore** Solano County watersheds and natural resources to health
- **Protect** natural resources through vibrant partnerships, strategic restoration, and effective education programs
- **Educate** children and adults about watershed science and effective stewardship
- **Enhance** our watersheds and their habitats to better serve all beneficial purposes

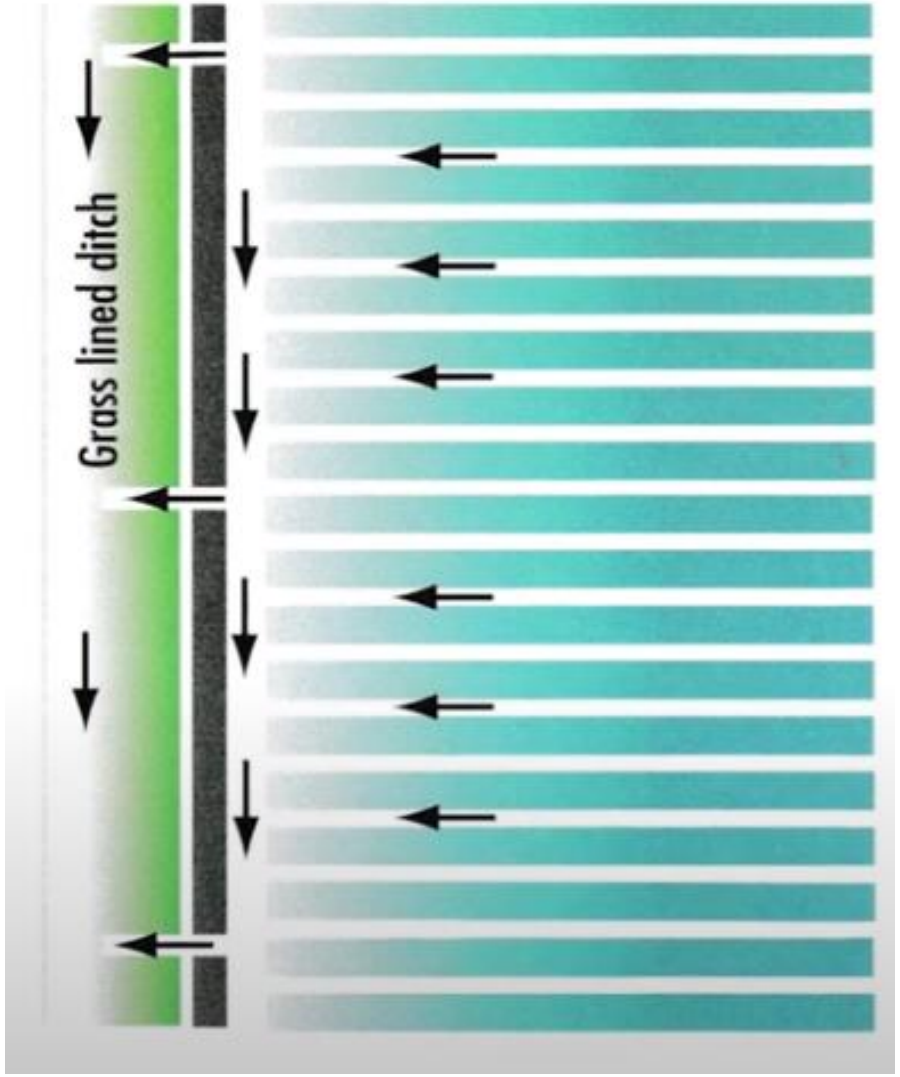
- **Slow It**
  - Provide a rougher, more vegetated surface that slows down water flow.
- **Spread It**
  - Prevent flow accumulation by widening the flow path.
- **Sink It**
  - Create a soil surface that allows water infiltration into unconfined shallow and/or deep aquifers.
- **Store It**
  - Create a healthy, biologically active soil profile with organic matter that acts more as a sponge.

Vegetation options:

- Cover crops
- Tree/shrub hedgerows
- Tree/shrub end caps
- Riparian buffer strips
- Grassed swales or vegetated ditches

Tailwater Ditches

- Ditches at end of field that run perpendicular to crop rows
- Can be planted with grasses and forbs to help filter and slow down agricultural runoff and stormwater
- Began in southeastern U.S. but spread to CA and was tested and proven on tomato and alfalfa fields



Source: East San Joaquin Water Quality Coalition

The Role of Vegetation

- ABOVE GROUND
  - Vegetation helps intercept water and reduce its impact on soil
  - Also works to physically remove sediments
  - Helps filter pollutants
- BELOW GROUND
  - Roots help stabilize slopes
  - Improve infiltration
    - Roots create conduits for water to flow
  - Living roots promote microbial activity which breaks down nutrients and other pollutants

Best Management Practice for Water Quality

- 3 main concerns with runoff and surface water
  - 1. Erosion/sediment
  - 2. Nutrients
  - 3. Pest control products

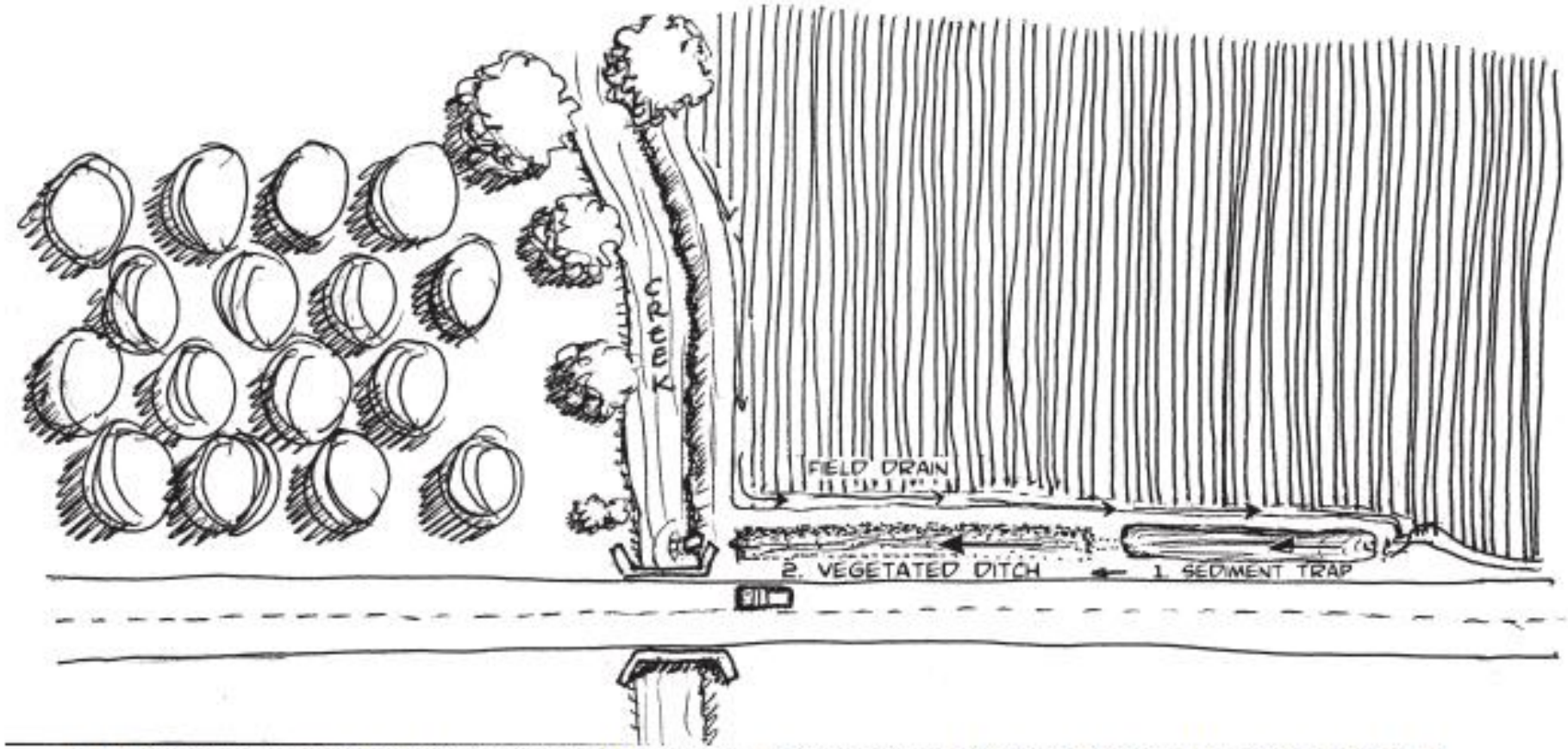
- Vegetated ditches reduce amount of sediment, nutrients and pesticides or herbicides that end up downstream

- One study found a 67% decrease in permethrin concentrations (Moore et al. 2011)

Benefits beyond water quality!

1. Filtration
2. Flood attenuation in winter
3. Living roots stabilize ditch banks & fight erosion
4. Can reduce invasion by weeds
5. Wildlife habitat

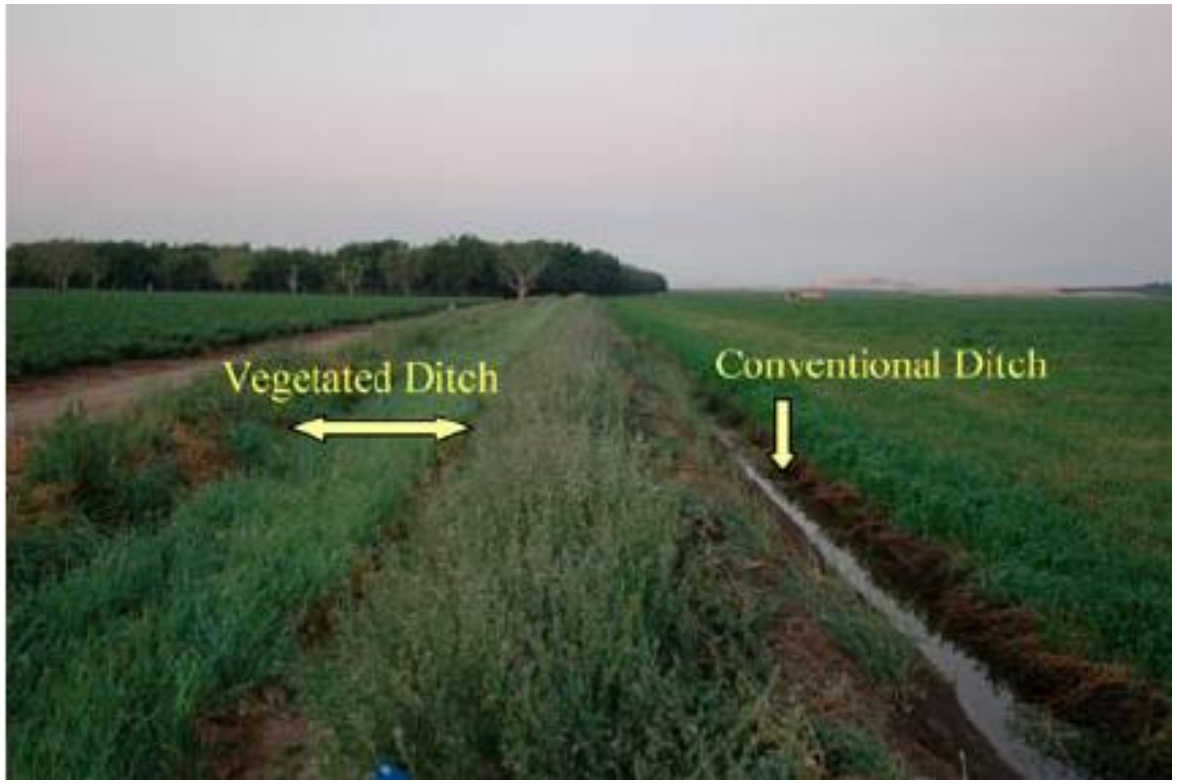
Potential Layout



In this field, furrows drain from top to bottom of the picture. Water is captured in the tail ditch and passes through an up-stream sediment trap from right to left before enering the vegetated ditch enroute to the stream (see arrows).

Possible Designs

- “V” ditches
  - Easiest to excavate and most compact
  - More susceptible to erosion
- Flat bottom or “U”-shaped ditches
  - Most effective
  - Slow water down and increase area over which water can percolate
  - 2 ft bottom width allows for use of lawn mower



Gill, Sheryl & Spurlock, Frank & Goh, Kean & Ganapathy, Carissa. (2007). Vegetated ditches as a management practice in irrigated alfalfa. Environmental monitoring and assessment. 144. 261-7. 10.1007/s10661-007-9988-

Establishing Vegetated Ditches

- New ditches can be excavated with a ditcher, scraper or road grader
- Gentle 3:1 or 2:1 slopes work best for plant establishment
- Ideal time is in the fall
  - Once irrigation season has ended but before start of winter rains
- Ensure blank canvas if seeding natives
  - Allow first flush of weeds to come up and kill them before planting

Species for Perennial vs Annual Ditch

Perennial

- Native plants that can tolerate periods of drought
- Deeper roots of perennials allow more infiltration
  - Red fescue (less attractive to rodents)
  - Creeping wild rye and lupines
  - Sedge and rush species
    - Can be drill seeded (if ditch is wide enough) or plug planted, ideally in mid winter
    - Dense planting: 6-12 inches apart

Annual

- Annual species
  - Barley or annual rye
    - Fast growing grasses that can provide cover in the winter months

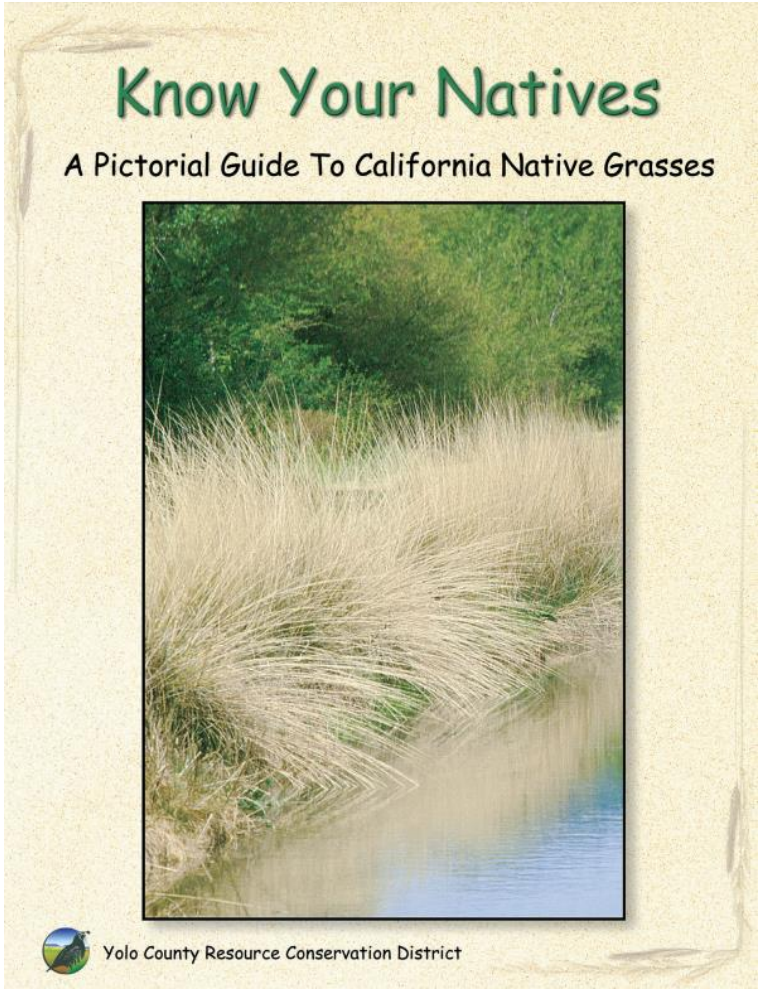
Root Systems of Recommended Species

Figure 10.4. Root systems of four grass cover crops at early stages of growth (two months in a greenhouse). From left: annual ryegrass, barley, triticale (winter biennials) and sorghum-sudangrass (summer annuals). Photos by Joseph Amsili.

Magdoff, F. and Van Es, H. (2021). Building Soils for Better Crops. Sustainable Agriculture Research and Education (SARE) Program, National Institute of Food and Agriculture, U.S. Department of Agriculture.

What Species Should I Choose?

- Know Your Natives handbook from Yolo RCD
- We can also do a site visit and provide you with a recommended species list

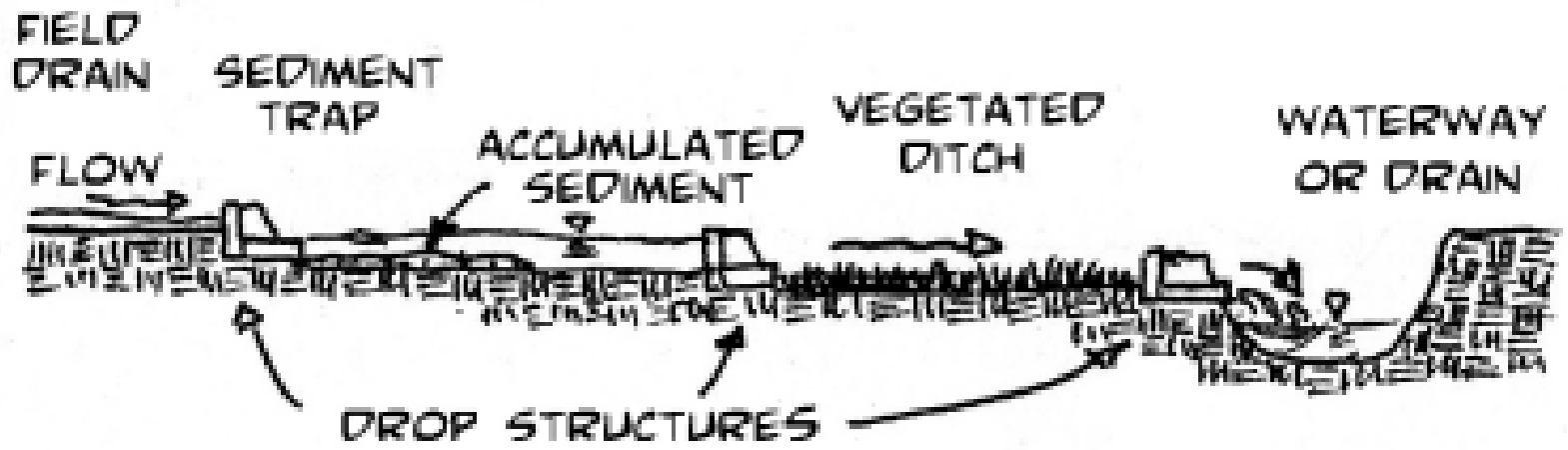


Maintenance

- Periodic excavation or scraping
- Weed control
  - Mowing, spraying and/ or burning
- Reseeding vegetation to repair damage from machinery or erosion
- For mosquito control, limit the length of time there is standing water
  - Reach out to Solano County Mosquito Abatement District (https://www.solanomosquito.com/)

Sediment Traps

- Capture eroded particles from runoff
  - Prevent clogging of vegetated ditches
  - Shallow basin, 2-3 ft deep
  - Upstream of vegetated ditch
  - Can add check dam at end of sediment trap



Vegetated Ditch in Woodland

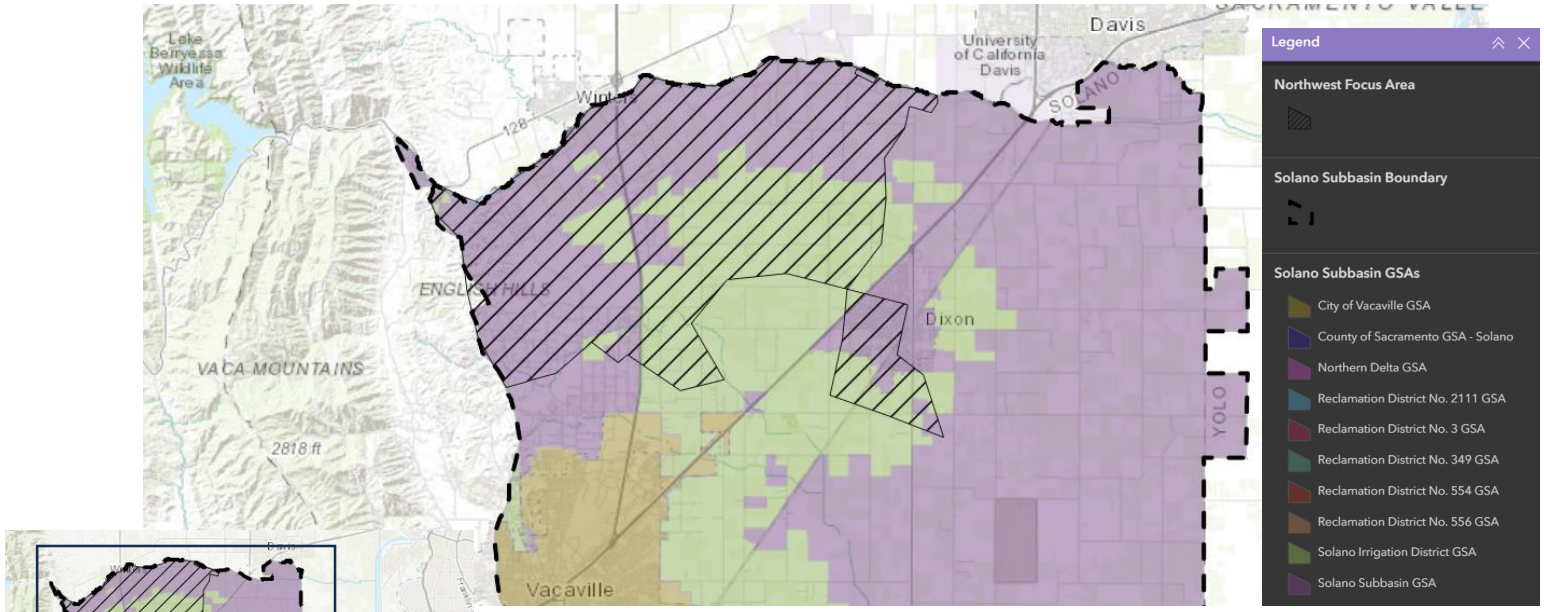
Vegetated Ditch in Woodland

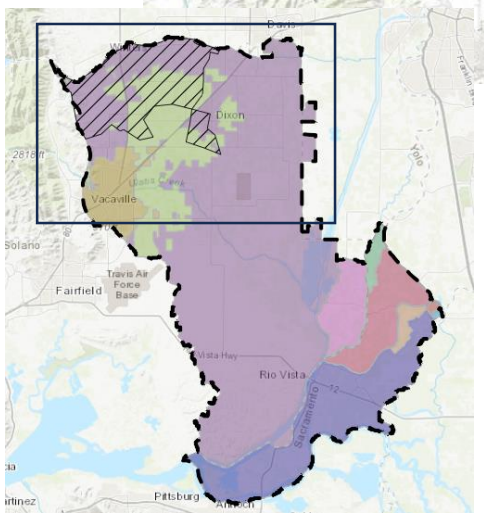
- Lupines in March

Planning for a Pond

2022 Dixon RCD Survey of Landowners in NW Focus Area

- Area where wells have gone dry and where topography creates runoff that floods other areas
- Interest in establishing seasonal ponds





Interactive Solano Subbasin map
solanogsp.com

Preliminary Questions

1. Water Source

2. Soil & Underlying Geology
   - Web Soil Survey is sometimes limited to top 60 inches

3. Topography

Preliminary Questions

1. Water Source

2. Soil & Underlying Geology
   - Web Soil Survey is sometimes limited to top 60 inches

3. Topography

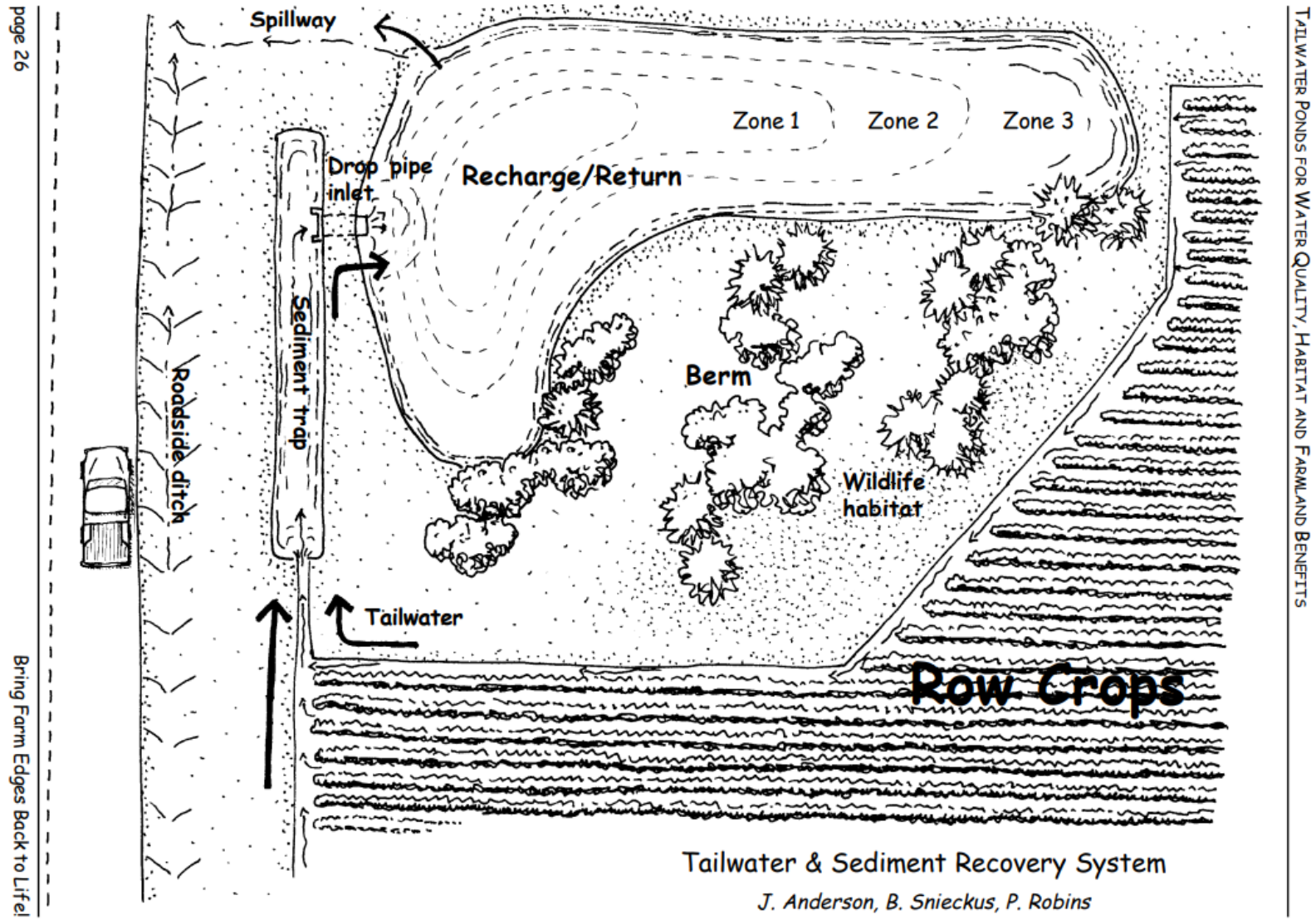
Solano RCD can help recommend a consultant to determine feasibility and design.

Permitting

1. **CA Fish and Wildlife** must be consulted to determine habitat connectivity
2. Make sure to call 811 dig!
3. Active ag operations have exemptions, but grading permit may still be needed
   - Only need a grading permit with the County
     - < 50 cubic yards – No permit required.
   - Grading@solanocounty.com

Two Stage Pond Design

- First small pond works as a sediment trap
- Second, larger pond can be used for infiltration, water storage, water return and for wildlife habitat.
  - Gradual 3:1 or 4:1 slope with deep center
  - Deep center portion (> 5 ft)
- No woody species on embankments



Pond Planting Zones

- No woody species on embankments
- Zone 1
  - deep water, rarely dry
- Zone 2 and 3
  - Moist soil, intermittently under water

Suggested Plant Materials for Tailwater Ponds

Moist Soil Vegetation Zone 1 and 2

Spikerush (*Eleocharis macrostachya*)
Sedges (*Cyperus* species)
Rushes (*Scirpus americanus, Juncus effusus and J. balticus*)

(Establishing short-statured rushes and sedges will keep out unwanted species such as cattails and bulrushes which will dominate a small wetland if allowed to proliferate.)

Moist Soil Vegetation Zone 3

Species listed in Zones 1 and 2
White-root sedge (*Carex barbarae*)
Clustered field sedge (*C. praegracilis)*
Meadow barley (*Hordeum brachyantherum*)
Hairgrass (*Deschampsia caespitosa*)
Bentgrass (*Agrostis exarata*)

Pond Edge

Meadow barley
Bentgrass (*Agrostis exerata*)
Hairgrass
Slender wheatgrass (*Elymus trachycaulus majus*)
Creeping wildrye (*Leymus triticoides*)
Clustered field sedge
White-root Sedge

Dryland Native Grass Mixture

Blue wildrye (*Elymus glaucus*)
Purple needlegrass (*Nassella pulchra*)
Oniongrass (*Melica californica*)
Pine bluegrass (*Poa secunda*)

Trees

Willows (*Salix* spp.)
Valley Oak (*Quercus lobata*)
Sycamore (*Platanus racemosa*)
Black Walnut (*Juglans californica* var. *hindsii*)
Cottonwood (*Populus fremontii*)
Interior Live Oak (*Quercus wislizenii*)
Buckeye *(Aesculus californica*)

Shrubs

Button Willow (*Cephalanthus occidentalis)*
Coyote Brush (*Baccharis pilularis*)
Wild Rose (*Rosa californica*)
California Lilac (*Ceanothus* spp.)
Mulefat (*Baccharis viminea*)
Elderberry (*Sambucus mexicana*)
Toyon (*Heteromeles arbutifolia*)
Redbud (*Cercis occidentalis*)

Source: Yolo County RCD -Bring Farm Edges Back to Life!

Native Plant Lists Available

- Will require irrigation first 2-3 years
- More drought tolerant than non-natives

Plants native to Solano County that are good for pond plantings

H_2O	Species	Common name	Structure	Water needs	Height (ft)	Flower	Fruit/seed
In water	*Eleocharis macrostachya*	Spike rush	grass/sedge/rush	emergent	1-2	nondescript	
	Juncus balticus	Baltic rush	grass/sedge/rush	emergent/riparian	2-3	nondescript	
	Scirpus spp.	Tule	grass/sedge/rush	emergent	6-8	nondescript	
	Typha spp.	Cattail	grass/sedge/rush	emergent	6	nondescript	
Riparian species (need/tolerate lots of water)	*Artemesia douglasiana*	Mugwort	forb	riparian/upland	3-5	nondescript	
	Grindelia camporum	Gumplant	forb	riparian	2-4	yellow	
	Symphyotrichum chilense	CA aster	forb	riparian	3-5	pale purple	
	Carex barbarae	Sedge, Santa Barbara	grass/sedge/rush	riparian	2	nondescript	
	Carex praegracilis	Sedge, slender	grass/sedge/rush	riparian/emergent	1.5	nondescript	
	Leymus triticoides	Creeping wildrye	grass/sedge/rush	riparian/upland	3	nondescript	
	Muhlenbergia rigens	Deer grass	grass, large	riparian/upland	3-5	nondescript	
	Baccharis salicifolia	Mule fat	shrub, mid-sized	riparian	4-8	white	
	Calycanthus occidentalis	Spice bush	shrub, large	riparian	8-10	red	
	Cephalanthus occidentalis	Buttonbush	shrub, large	riparian/emergent	8-20	white	
	Cornus sericea	Dogwood	shrub, mid-sized	riparian	5-7	white	
	Hibiscus californica	CA hibiscus	shrub, mid-sized	riparian	4-6	pink	
	Rosa californica	CA rose	shrub, mid-sized	riparian/upland	4-6	pink	red hip
	Rubus ursinus	CA blackberry	shrub, small	riparian	2-3	white	black berry
	Acer negundo	Box elder	tree	riparian	30-50	nondescript	
	Fraxinus latifolia	Oregon ash	tree	riparian/emergent	40-60	nondescript	
	Platanus racemosa	Sycamore	tree	riparian/upland	80	nondescript	
	Populus fremontii	Cottonwood	tree	riparian	50-75	nondescript	
	Quercus lobata	Oak, valley	tree	riparian/upland	50-75	nondescript	acorn
	Quercus wislizeni	Oak, interior	tree	riparian/upland	30-75	nondescript	acorn
	Salix laevigata	Willow, red	tree	riparian	20-30	nondescript	
	Salix lucida	Willow, shining	tree	riparian	20	nondescript	
	Aristilochia californica	Pipevine	vine	riparian	4-6	green/purple	
	Clematis ligustifolia	Clematis, Western	vine	riparian	up to 20	white/yellow	fluffy seed head
	Vitis californica	CA grape	vine	riparian	up to 30	nondescript	purple fruit
Upland Species (need/tolerate less water)	*Asclepias fascicularis*	Milkweed, narrow leafed	forb	upland	2	white/pink	
	Asclepias speciosa	Milkweed, showy	forb	upland	3	white/pink	
	Festuca idahoensis	Idaho fescue	grass/sedge/rush	upland	2	nondescript	
	Nassella pulchra	Purple needle grass	grass/sedge/rush	upland	1	nondescript	
	Baccharis pilularis	Coyote bush	shrub, mid-sized	upland/riparian	6-8	white	
	Berberis aquifolium	Oregon grape	shrub, mid-sized	upland	2-6	yellow	blue berry
	Ceanothus cuneatus	Buck brush	shrub, mid-sized	upland	6-10	white, pale blue	
	Ceanothus integerrimus	Deer brush	shrub, mid-sized	upland	6-10	white, blue	
	Cercis occidentalis	Redbud	shrub, large	upland	8-15	pink	purple pods
	Epilobium canum	CA fuchsia	shrub, small	upland	2	red	
	*Eriogonum fasciculatum**	CA buckwheat*	shrub, small	upland	2-3	white	
	Heteromeles arbutifolia	Toyon	shrub, large	upland	6-15	white	red fruit
	Mimulus aurantiacus	Sticky monkey bush	shrub, small	upland	3-4	orange	
	Rhamnus californica	Coffeeberry	shrub, mid-sized	upland	5-7	white	blue berries
	Ribes sanguineum	Red-flowered currant	shrub, mid-sized	upland	6-10	pink, red	
	Sambucus mexicana	Elderberry	shrub, large	upland/riparian	8-15	white	blue fruit
	Aesculus californica	CA Buckeye	tree	upland/riparian	20-30	pink	large nut
	*Ceanothus thyrsiflorus**	Blue blossom*	tree	upland	15-20	blue	
	Juglans californica	CA Walnut	tree	upland/riparian	40-50	nondescript	nut
	Pinus sabiniana	Grey pine	tree	upland	40-80	nondescript	
	Quercus douglasii	Oak, blue	tree	upland	30-50	nondescript	acorn
	Umbellularia californica	CA bay	tree	upland	30-75	nondescript	
	Clematis lasiantha	Clematis, pipestem	vine	upland	up to 15	white/yellow	fluffy seed head

* native to nearby counties, but not Solano County

For More Information

- Bring Farm Edges Back to Life!

Bring Farm Edges Back to Life!

Table of Contents

THANK YOU!

Monica Quedaza, Solano RCD
monica.quezada@solanorcd.org

Sources

- https://www.solanorcd.org/images/vegetated-drainage-ditch.pdf
- https://yolorcd.org/wp-content/uploads/Farm-Edges-v5-Full.pdf
- https://agwaterstewards.org/practices/farm-ponds/
- https://www.youtube.com/watch?v=lE8K-Ejhoa4

Solano RCD – current groundwater activity

SOLANO
Resource
Conservation
District

Amy King
Ag and Water Program Manager

Solano RCD – current groundwater activity

1. NW Focus Area pilot projects
2. Technical assistance with financial assistance programs
3. Peddling native plants

NW Focus Area pilot projects

- Winter cover crops in furrows
- Vegetated swales
- Infiltration basins
- Detention basin/pond retrofit
- Upland plantings in the hills

Technical assistance with financial assistance programs

1. **NRCS EQIP, CSP** – we can help with applications or existing contracts
2. **CDFA Healthy Soils Program** – ditto, for both Farm Bureau and Fibershed programs

3. Flood Awareness program with SCWA – we can help you work with agencies, permits, partners to improve drainage and infiltration

Peddling native plants

- SRCD Native Plant Sales (October, sometimes April)
- Wildlife habitat projects – for monarchs, birds, erosion and sediment control, etc.
- Carbon sequestration projects

solanorcd.org

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Thank you

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solanorcd.org

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Dr. Thomas Harter

UNIVERSITY OF CALIFORNIA, DAVIS

Dixon Resource Conservation District

3rd Groundwater Workshop

30 January 2025

Sustainable groundwater quality management in agricultural landscapes - The role of modeling tools

Thomas Harter
University of California Davis
ThHarter@ucdavis.edu

https://groundwater.ucdavis.edu

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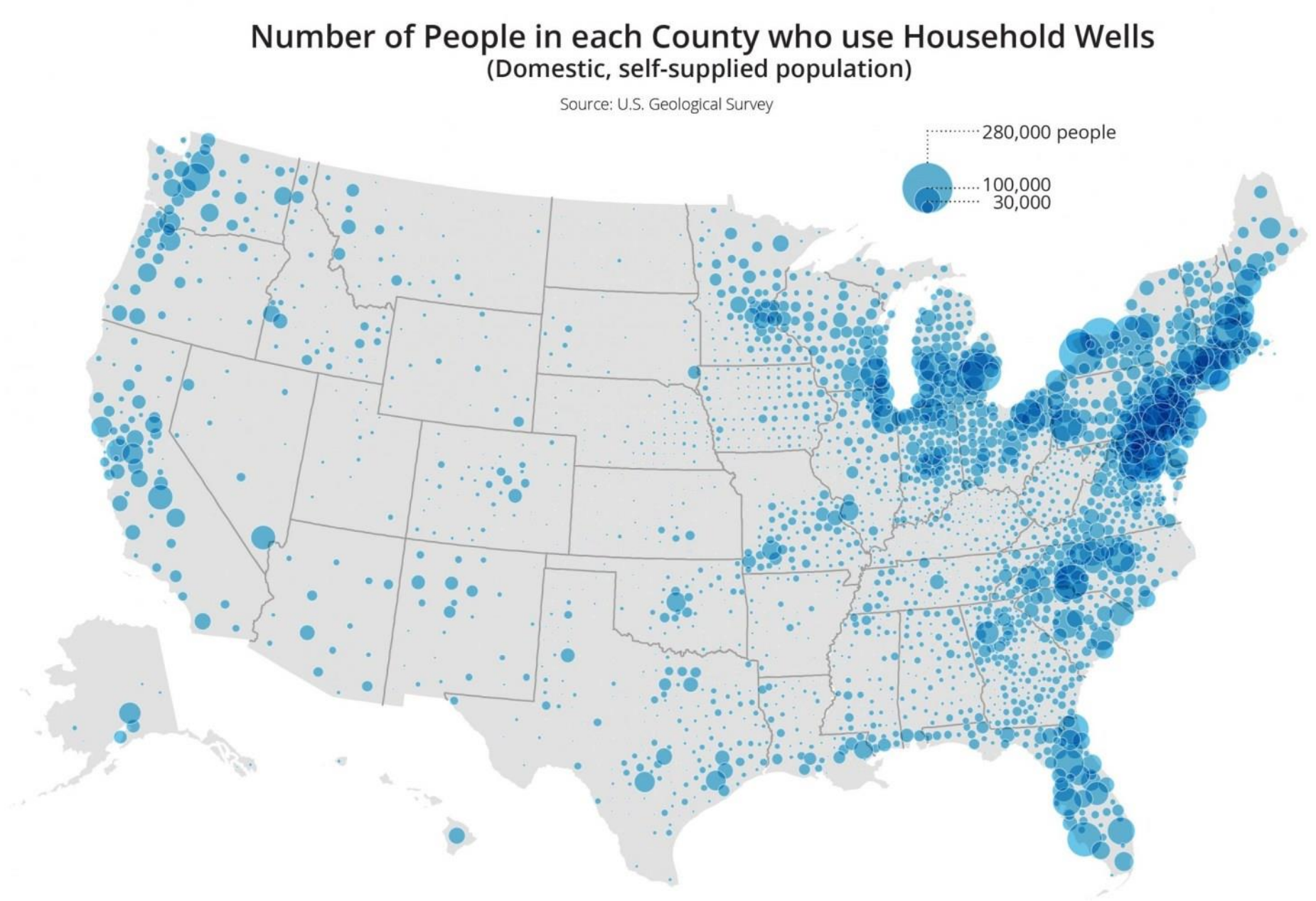
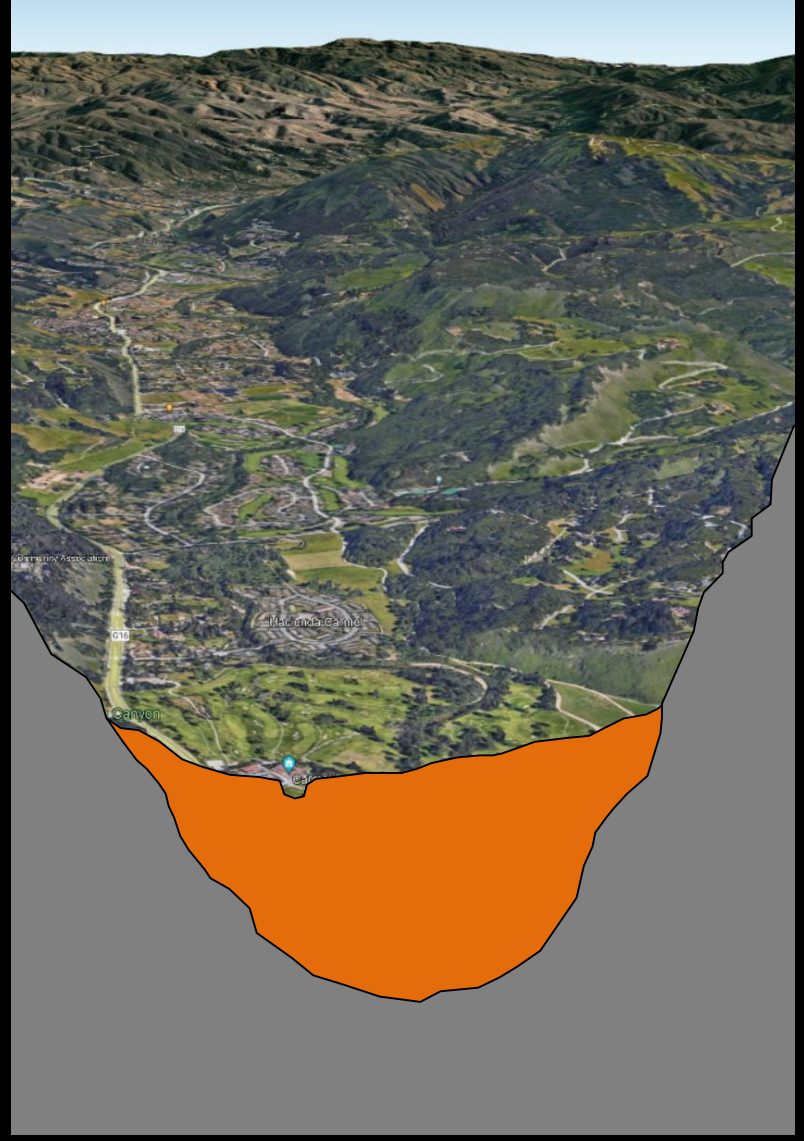
University of California
Agriculture and Natural Resources

Department of
LAND, AIR AND WATER RESOURCES
University of California, Davis
Climate Change • Sustainable Agriculture
Environmental Quality • Landscape Processes



https://www.circleofblue.org/2018/world/infographic-household-wells-in-the-united-states/




WELLS FARGO
Deloitte
ONE WILSHIRE
©Wikipedia

Laura Bliss / Atlantic City Lab

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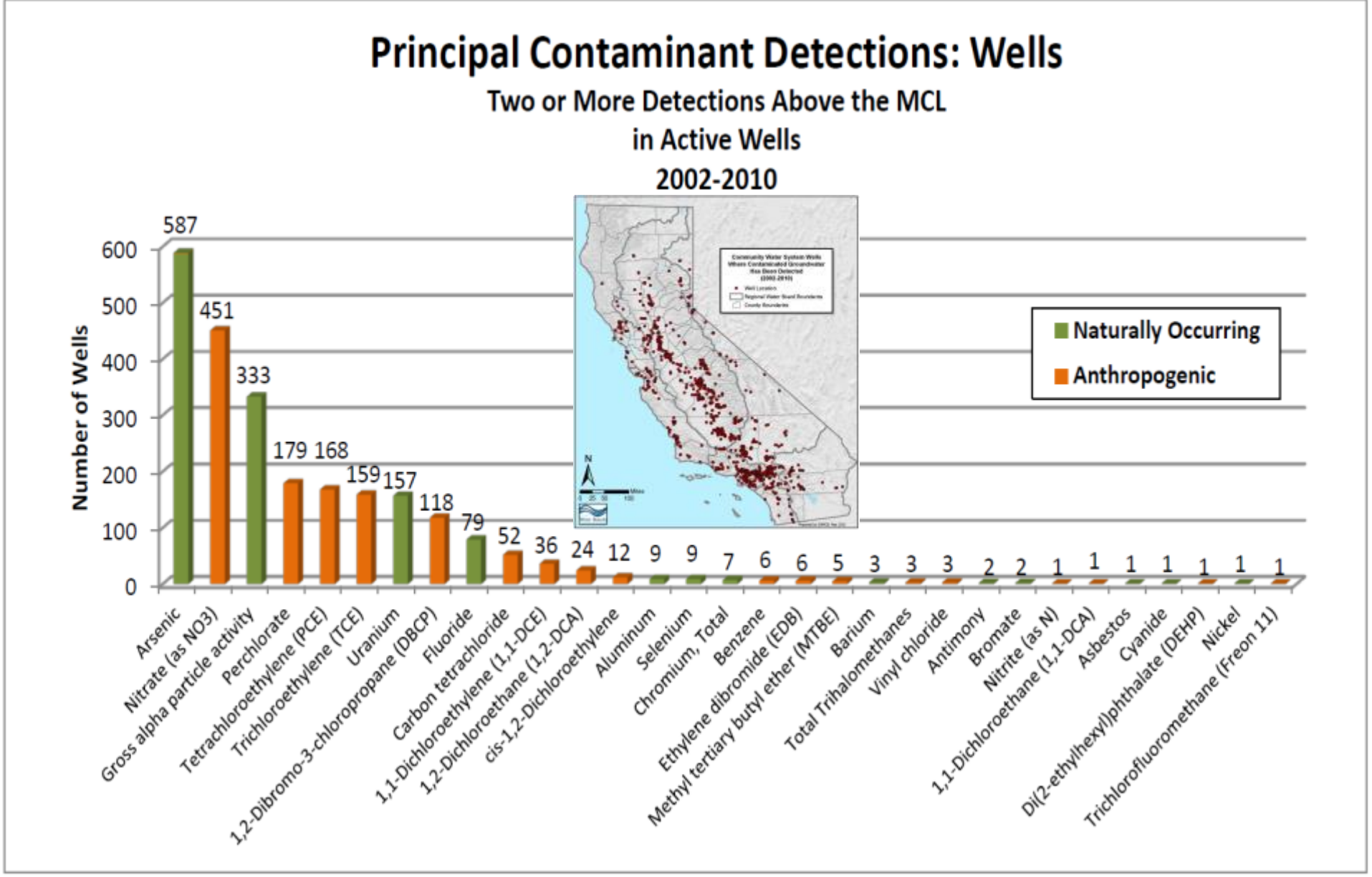
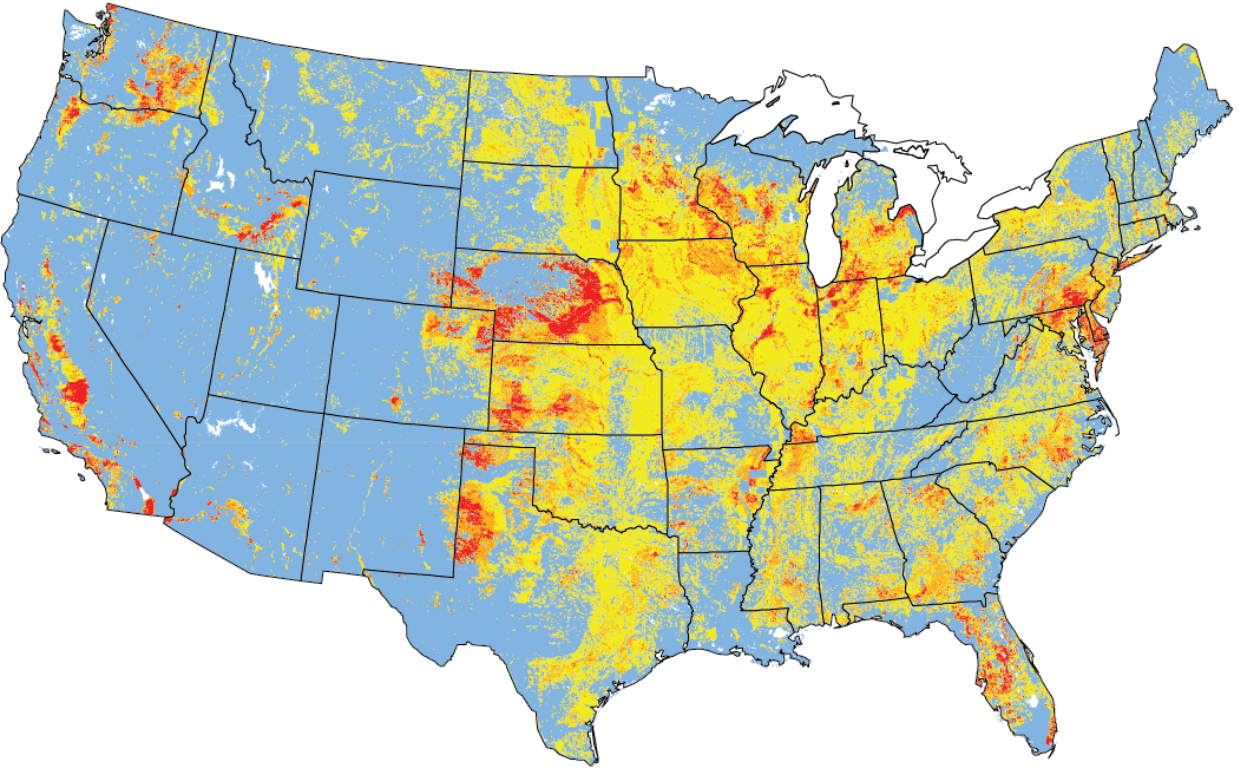


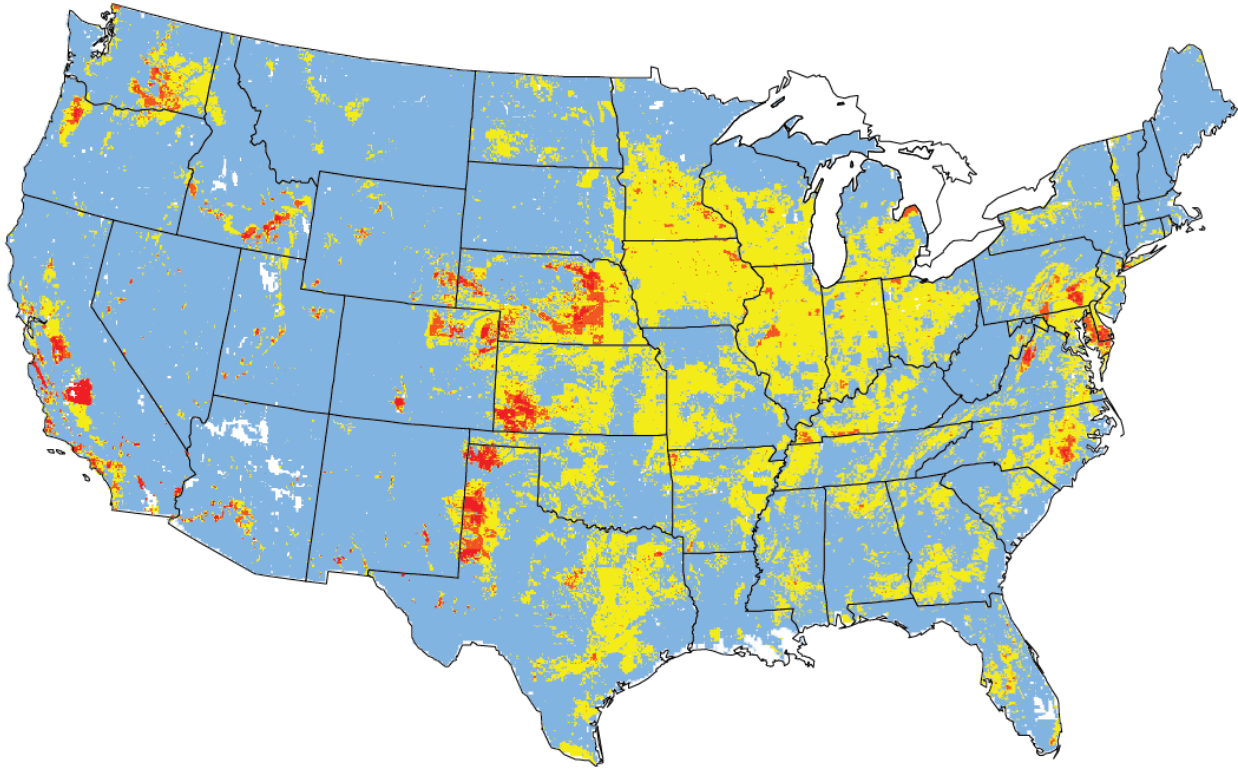
total active public supply wells in California: 8,396
with contaminated groundwater (before treatment): 1,659

State Water Resources Control Board, AB2222 Report to Legislature, January 2013

Predicted nitrate in shallow, recently recharged groundwater



Predicted nitrate in deeper groundwater used for drinking water



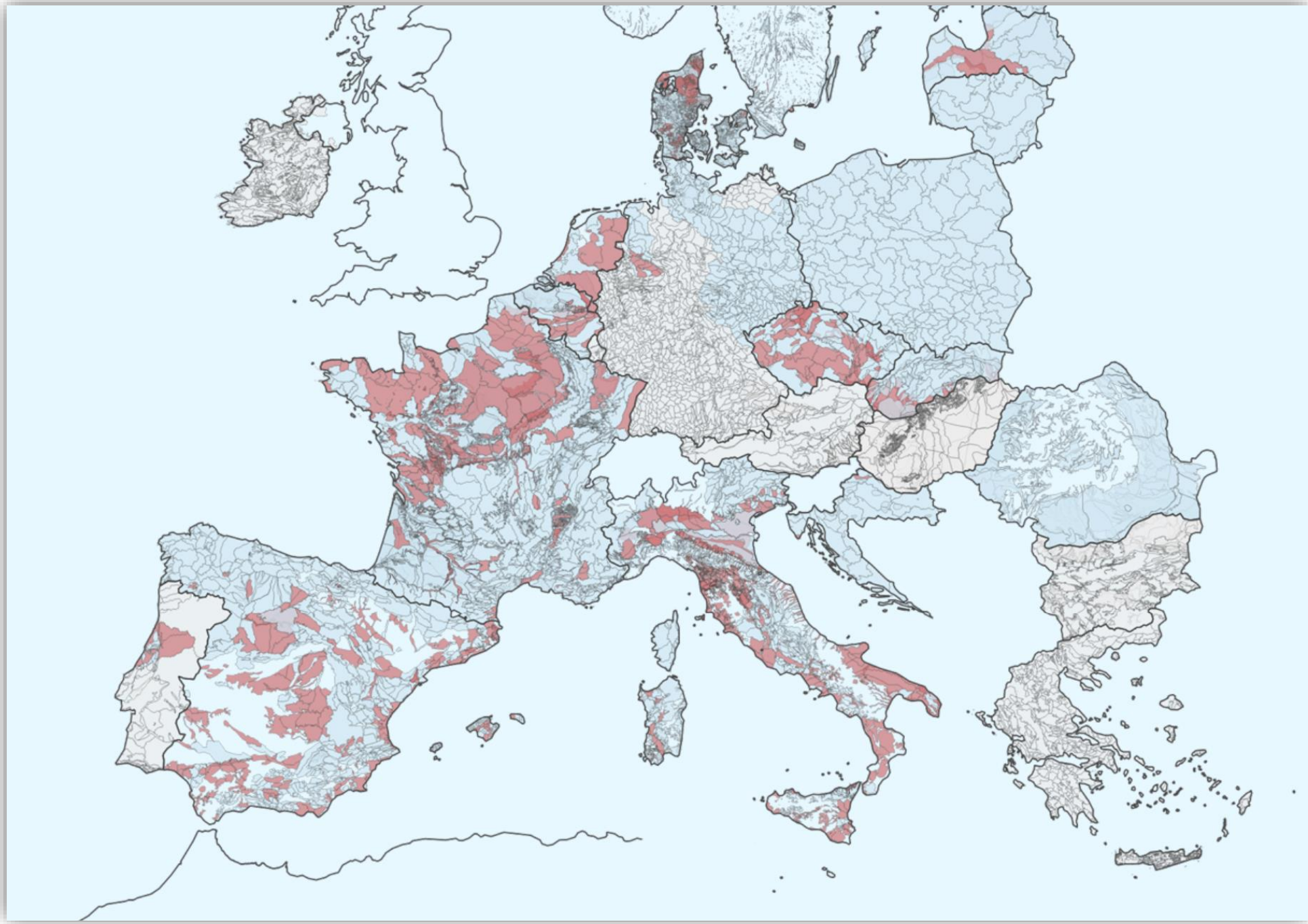
EXPLANATION

Predicted nitrogen concentration, in milligrams per liter as N

- < 1
- 1 to 5
- > 5 to 10
- > 10

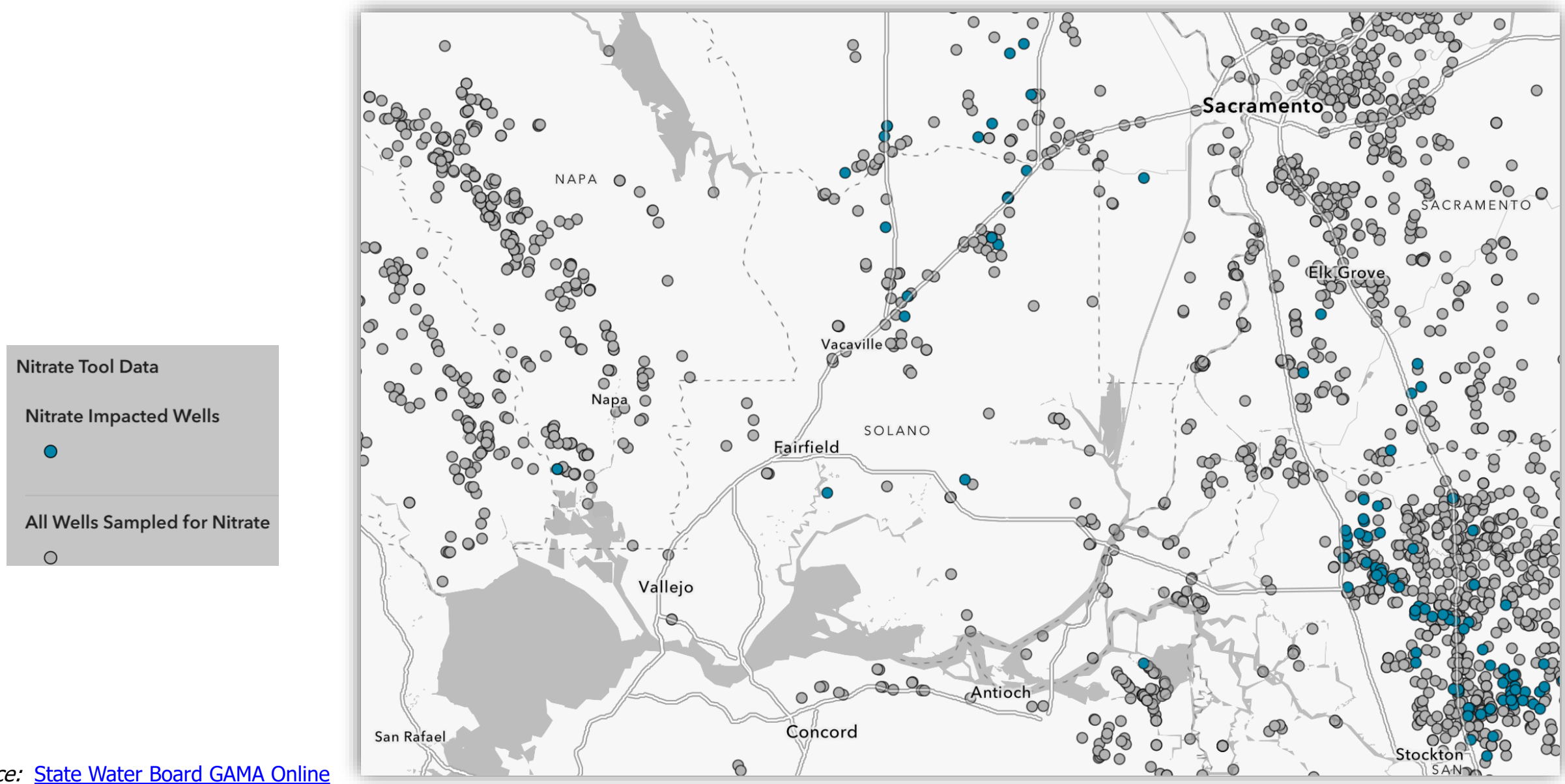
Source: USGS, 2015

Nitrate Pollution of Groundwater is Common in Agricultural Regions around the Globe



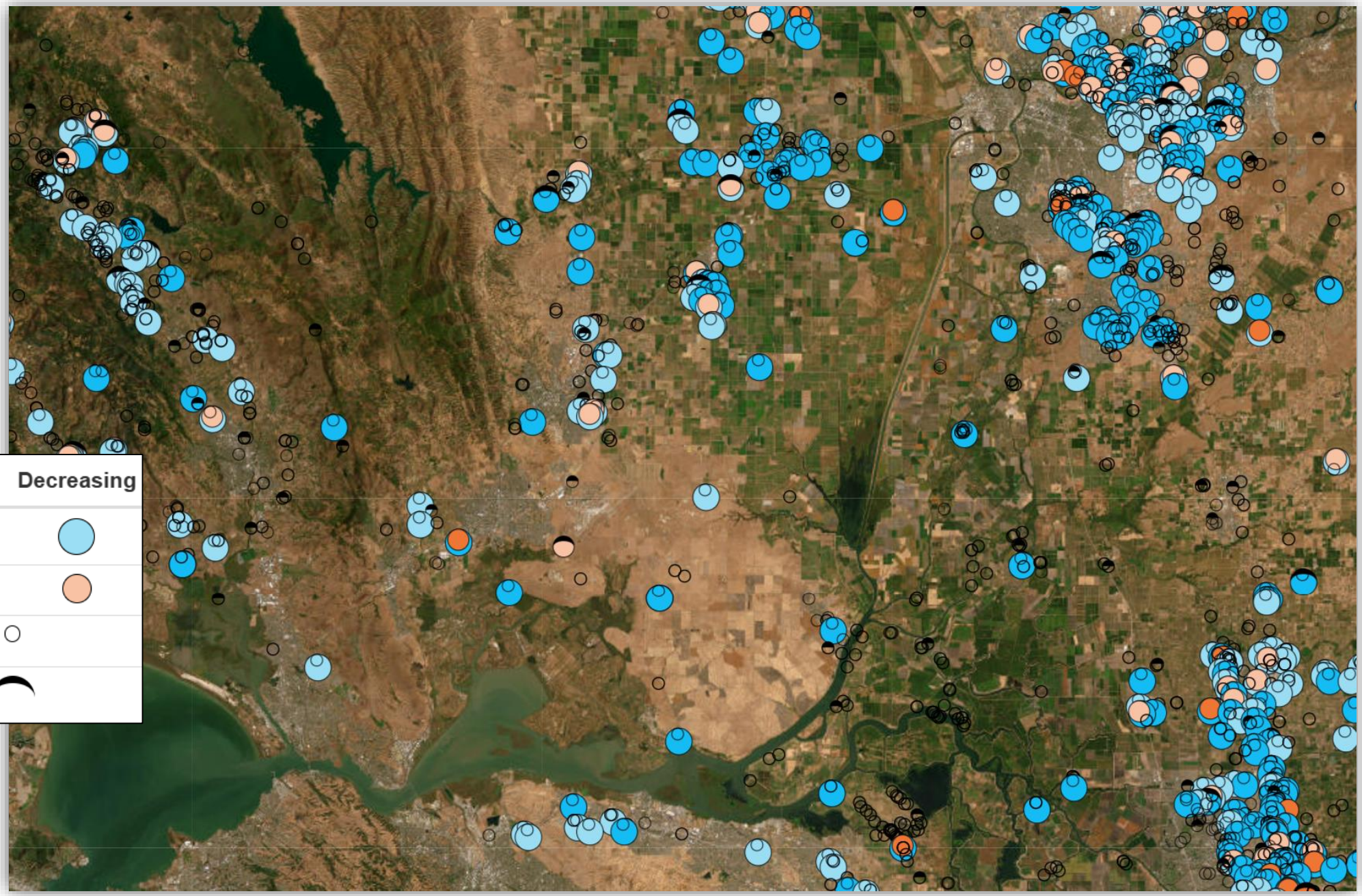
https://EuropeanWaters.eu / European Environment Agency, 2024

Risk of Nitrate Contamination in Domestic Wells and “State Small” Public Water Supply Systems



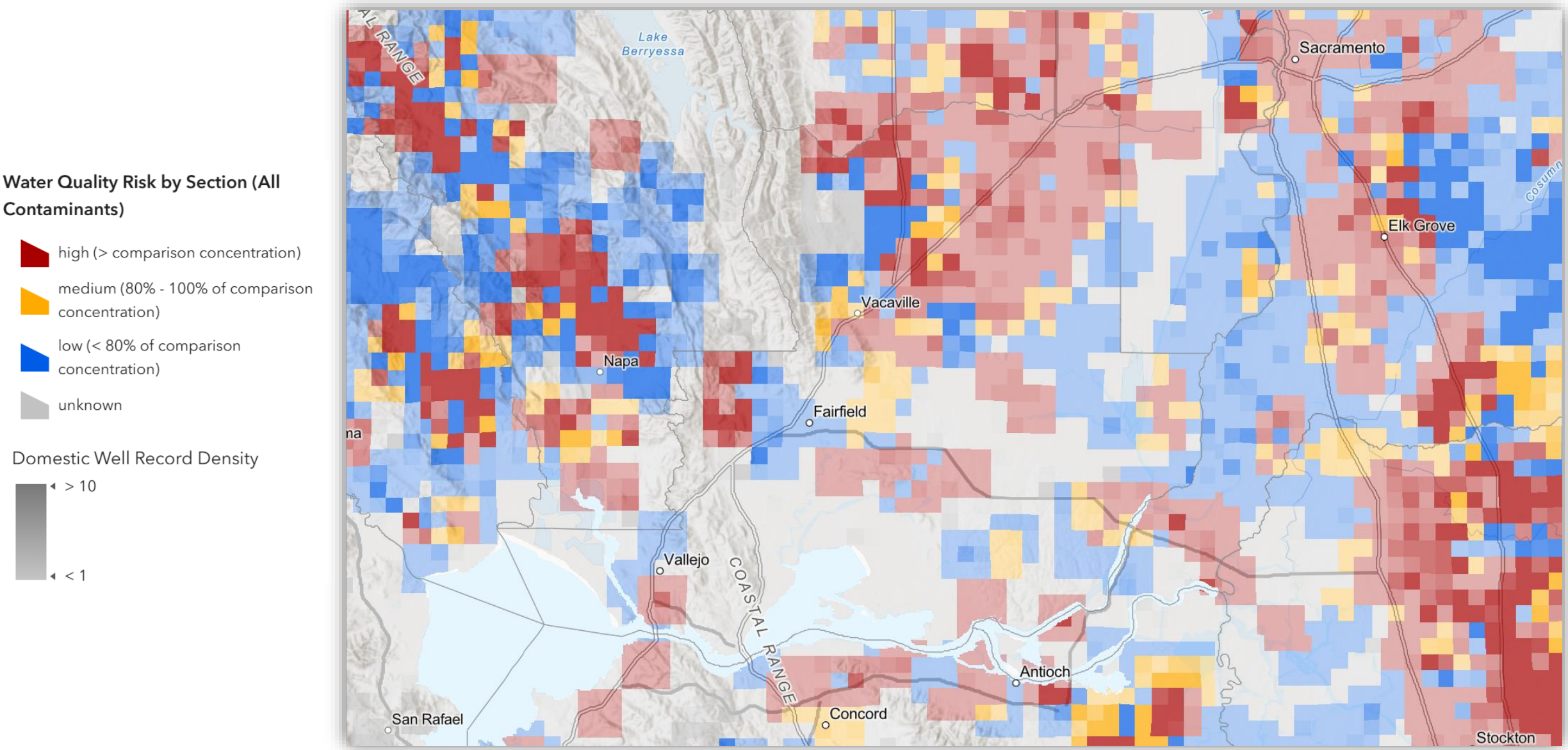
Source: [State Water Board GAMA Online Tools – Is My Well Near a Nitrate-Impacted Well?]

Recent Nitrate Trend



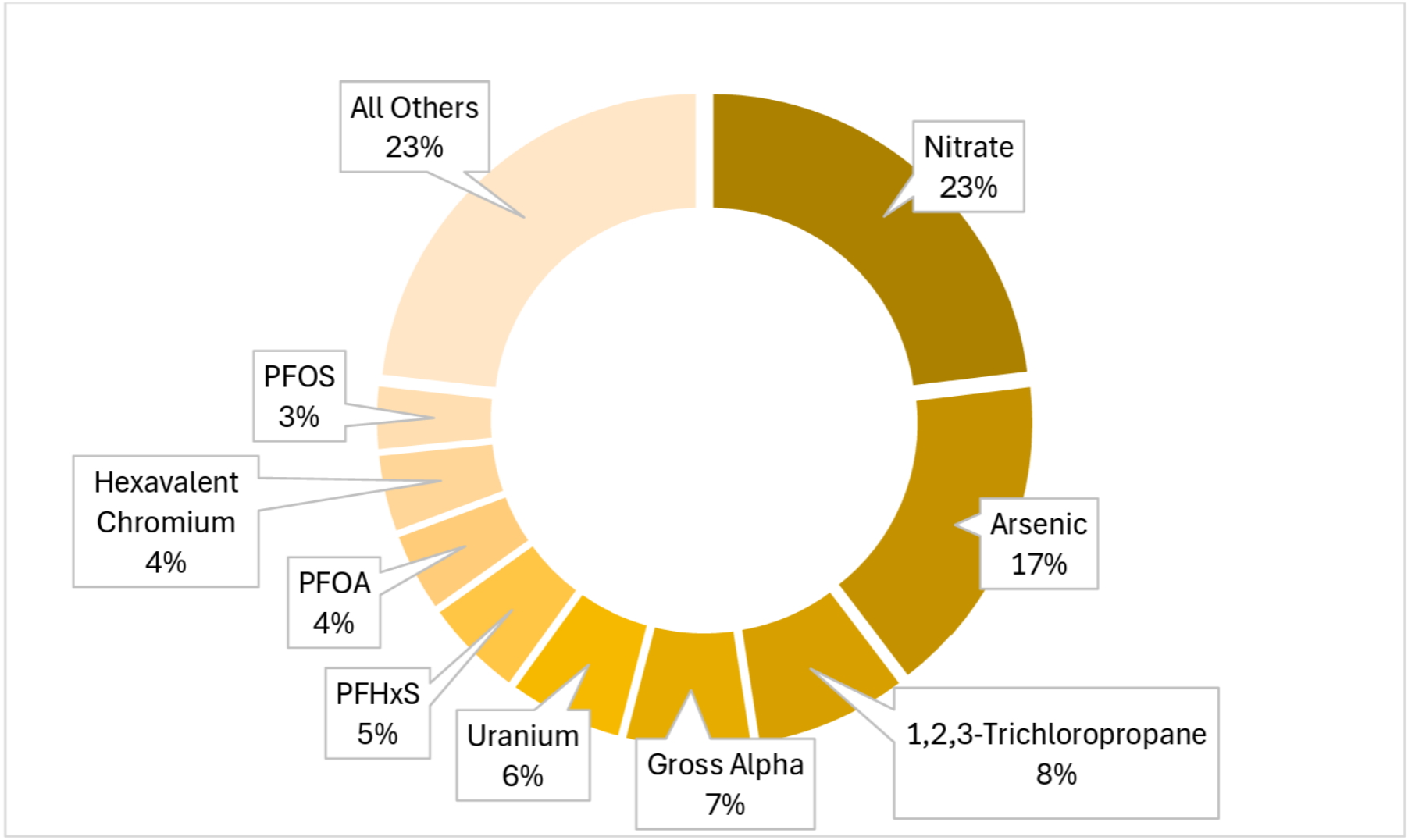
Source: State Water Board GAMA Online Tools –Trend Analysis Tool

Risk of Contamination in Domestic Wells and "State Small" Public Water Supply Systems



Source: [State Water Board GAMA Online Tools – Aquifer Risk Map for Domestic Wells and State Small Systems]

Contaminants in Domestic Wells of High-Risk Aquifer Areas (statewide)

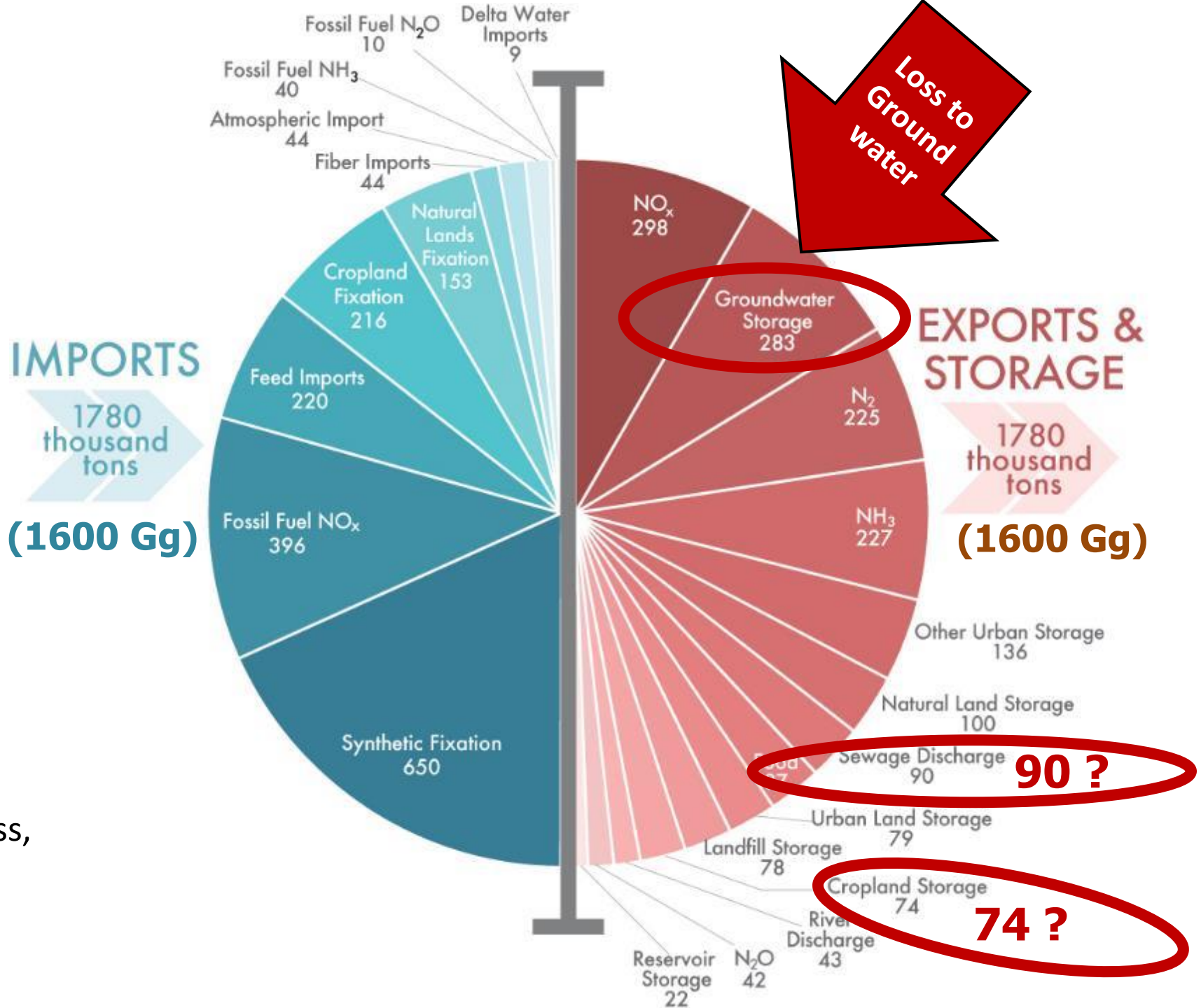


SWRCB, Aquifer Risk Map Methodology, 2025

Nitrate in Groundwater: Where is it from?

California Nitrogen Assessment

1000 short-tons N yr^{-1}



*from:*UC Davis Agricultural Sustainability Institute, UC Press, 2016

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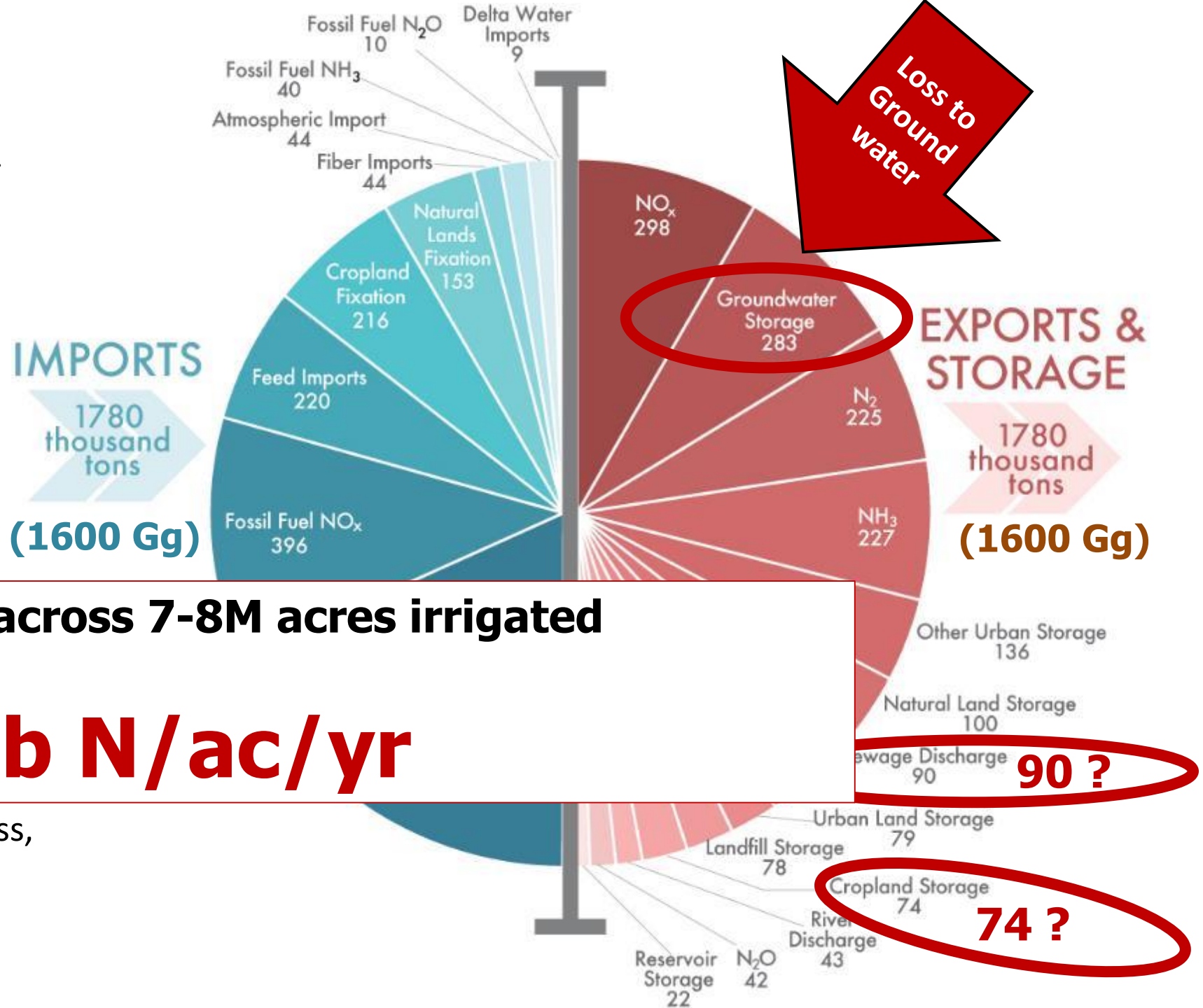
California Nitrogen Assessment

1000 short-tons N yr^{-1}



potential N balance across 7-8M acres irrigated agricultural land:

~75 - 120 lb N/ac/yr

Sustainability Institute, UC Press, 2016

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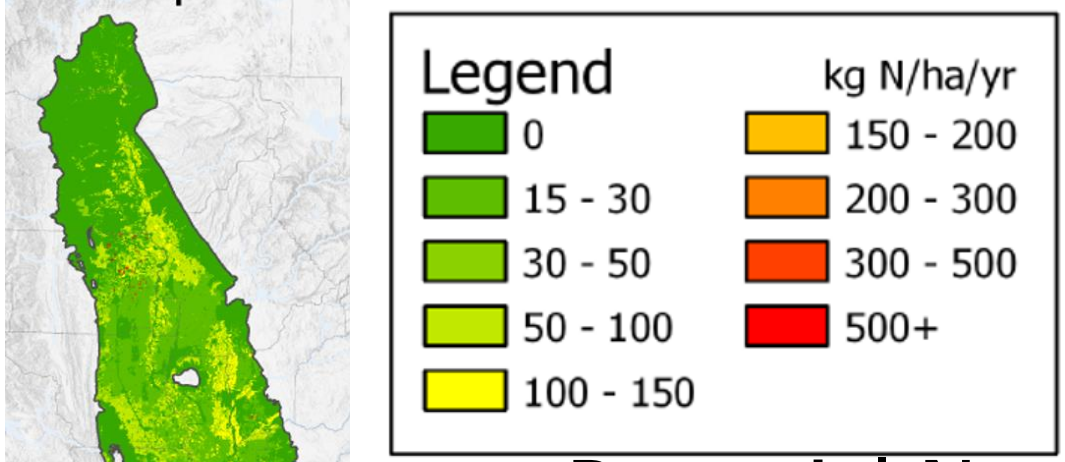
Drinking Water Limit:

45 mg Nitrate /L

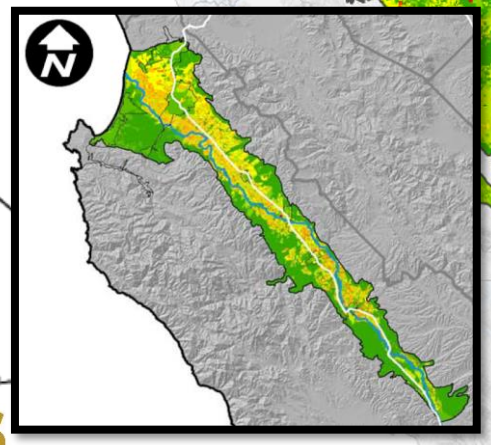
= 10 mg Nitrate-N / L

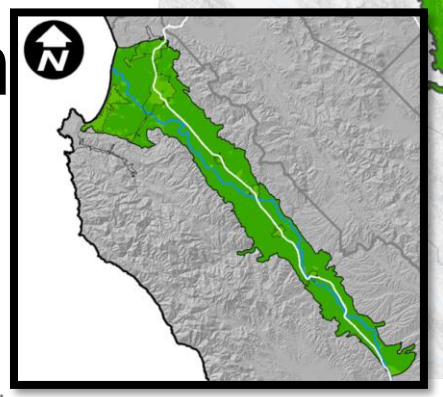
= 27 lb Nitrate-N / acre-foot

Laura Bliss / Atlantic City Lab



Potential N Leaching from Crop and Natural Vegetation





Potential N Leaching from Urban and Industrial Landuse, Dairy Corrals & Lagoons

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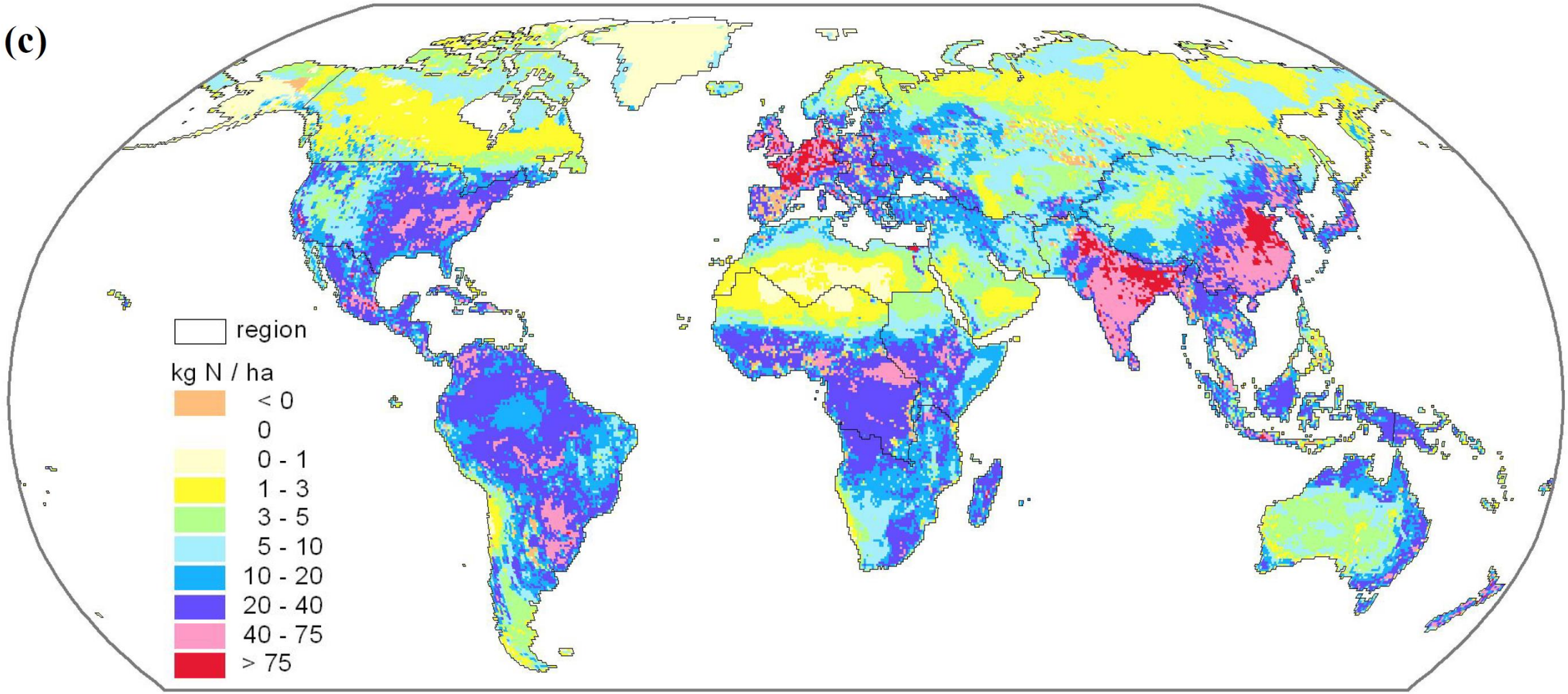
Harter et al., 2017. http://groundwaternitrate.ucdavis.edu

Global Soil Nitrogen Balance at the End of the 20th Century

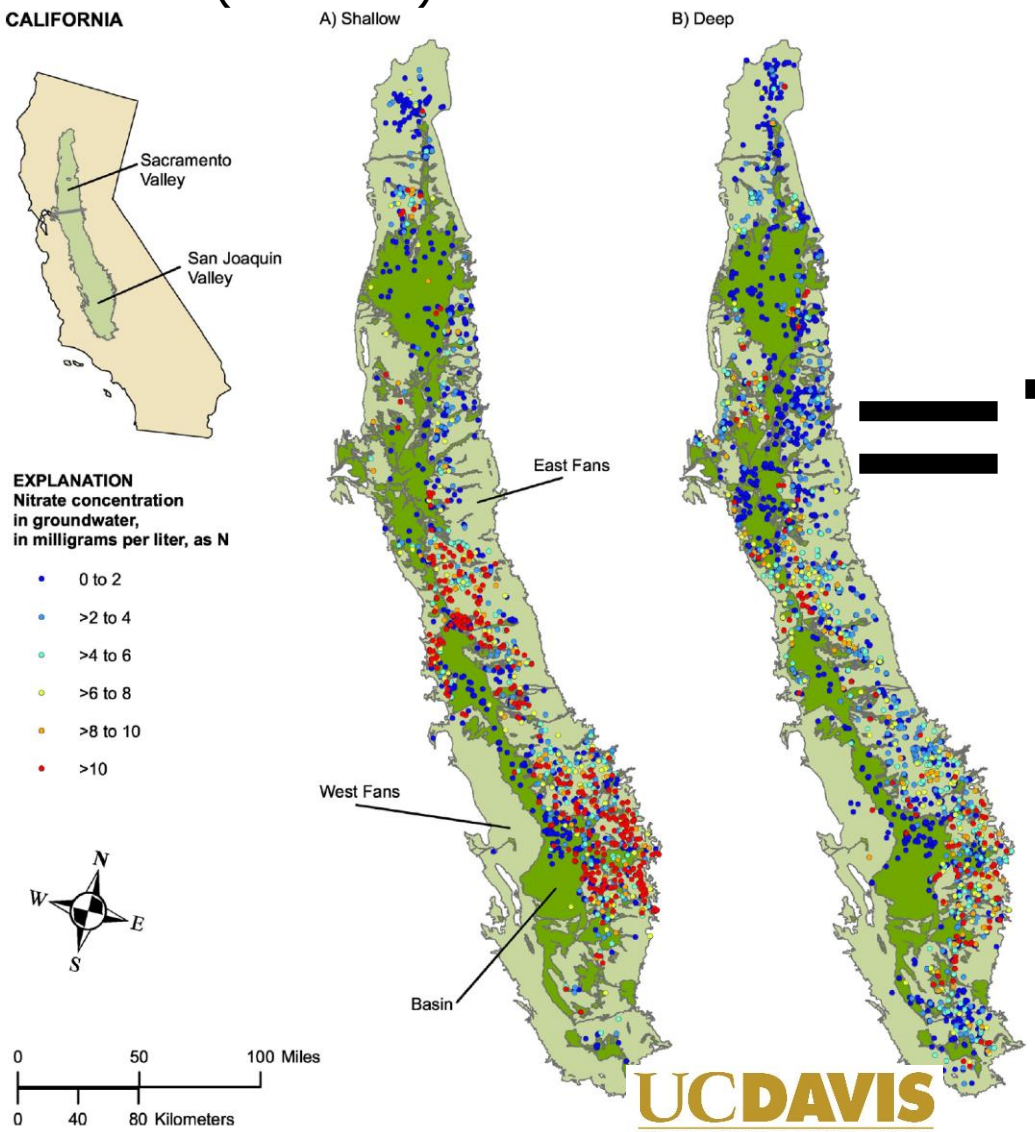


Source: Siebert, 2005

Machine Learning: Well Nitrate(2000 – 2014) as f(Explanatory Variables)

Domestic wells (< 100 m)

Public supply wells (> 100 m)



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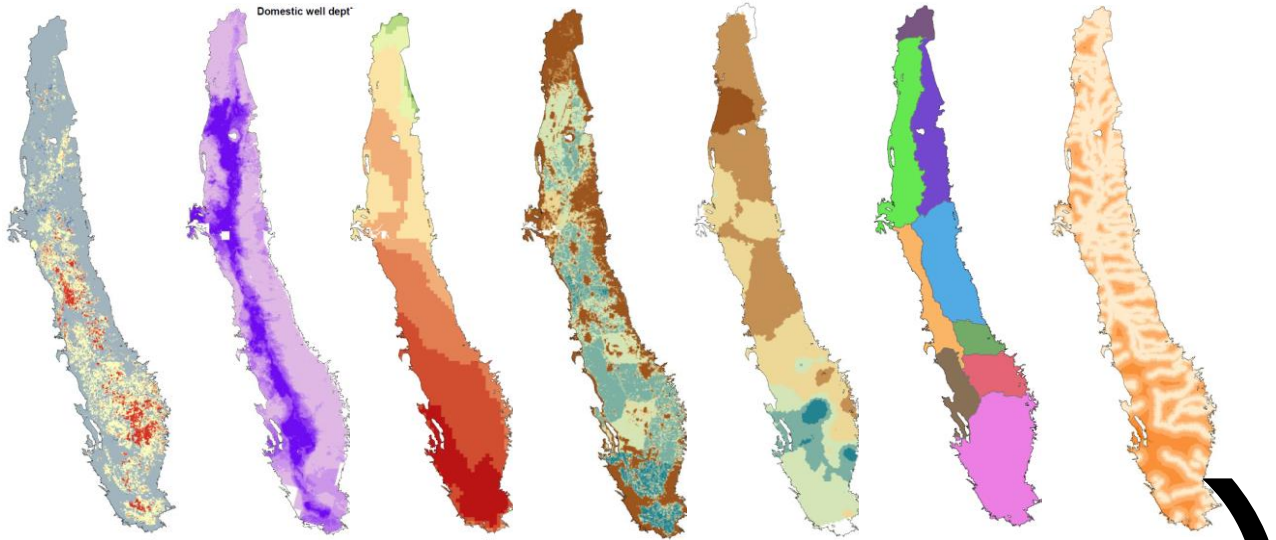
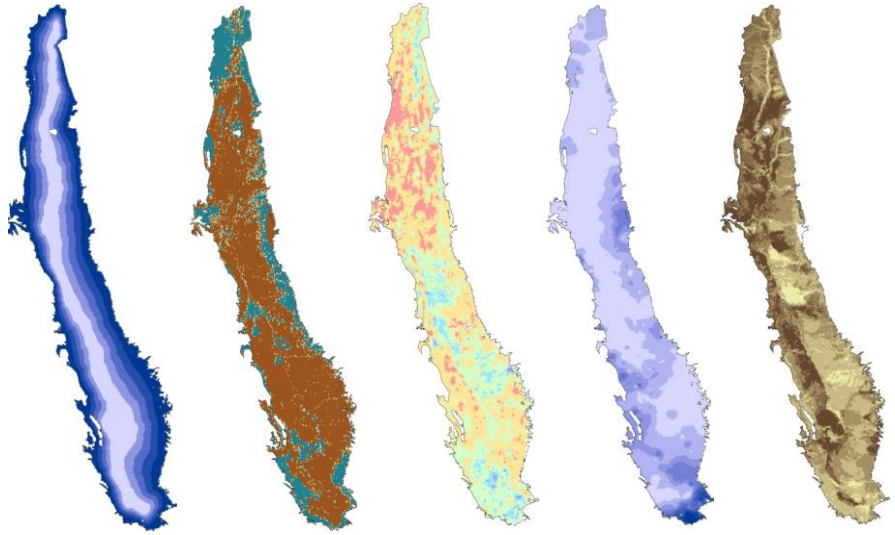


N-Surplus 1975 | DO | P - Etpot | Fertlizer N | Depth to 60a old gw | Soil Texture | Dist. River



Dist. Thalweg | Natural Area | Coarse Soil | Depth to GW | Aquifer Clay

)

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Ransom et al., STOTEN 2017

Machine learning (Boosted Regression Tree) identified major predictors of groundwater nitrate

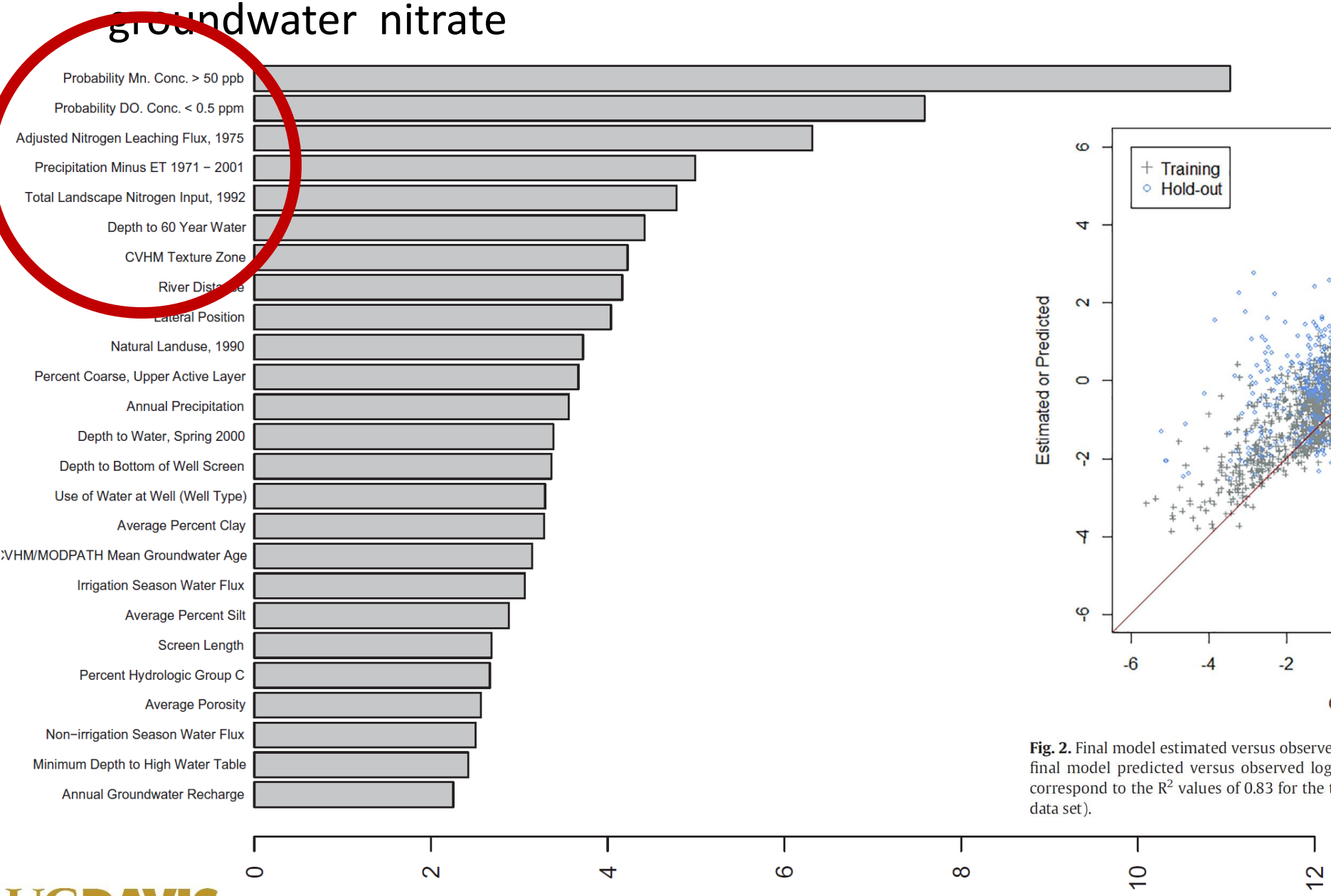

Fig. 2. Final model estimated versus observed log nitrate values (training data set) and final model predicted versus observed log nitrate values (hold-out data set). Plots correspond to the R^2 values of 0.83 for the training data set and 0.44 for the hold-out data set).

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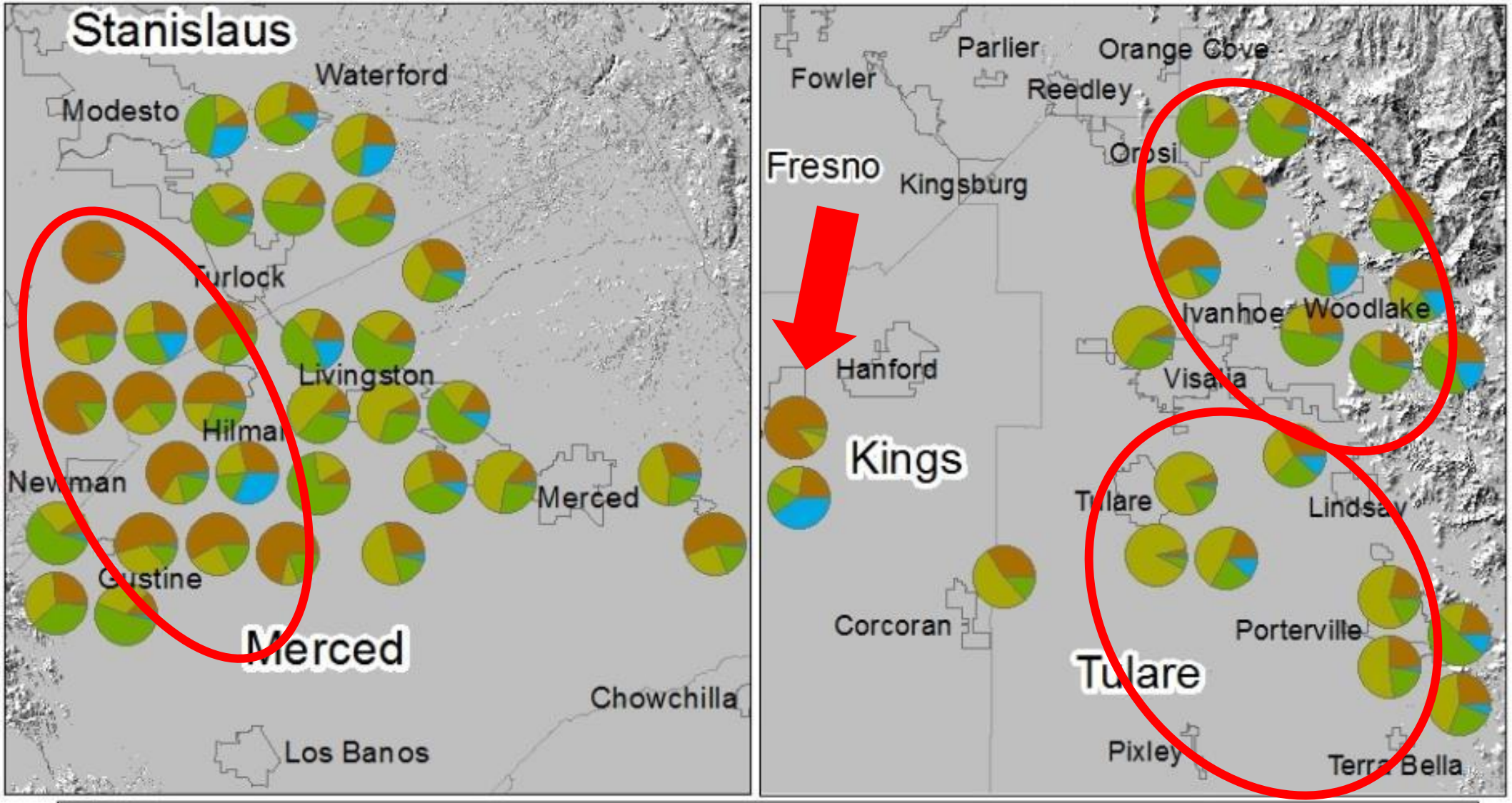
Ransom et al., STOTEN 2017

Nitrate forensics: Bayesian estimation of source fractions

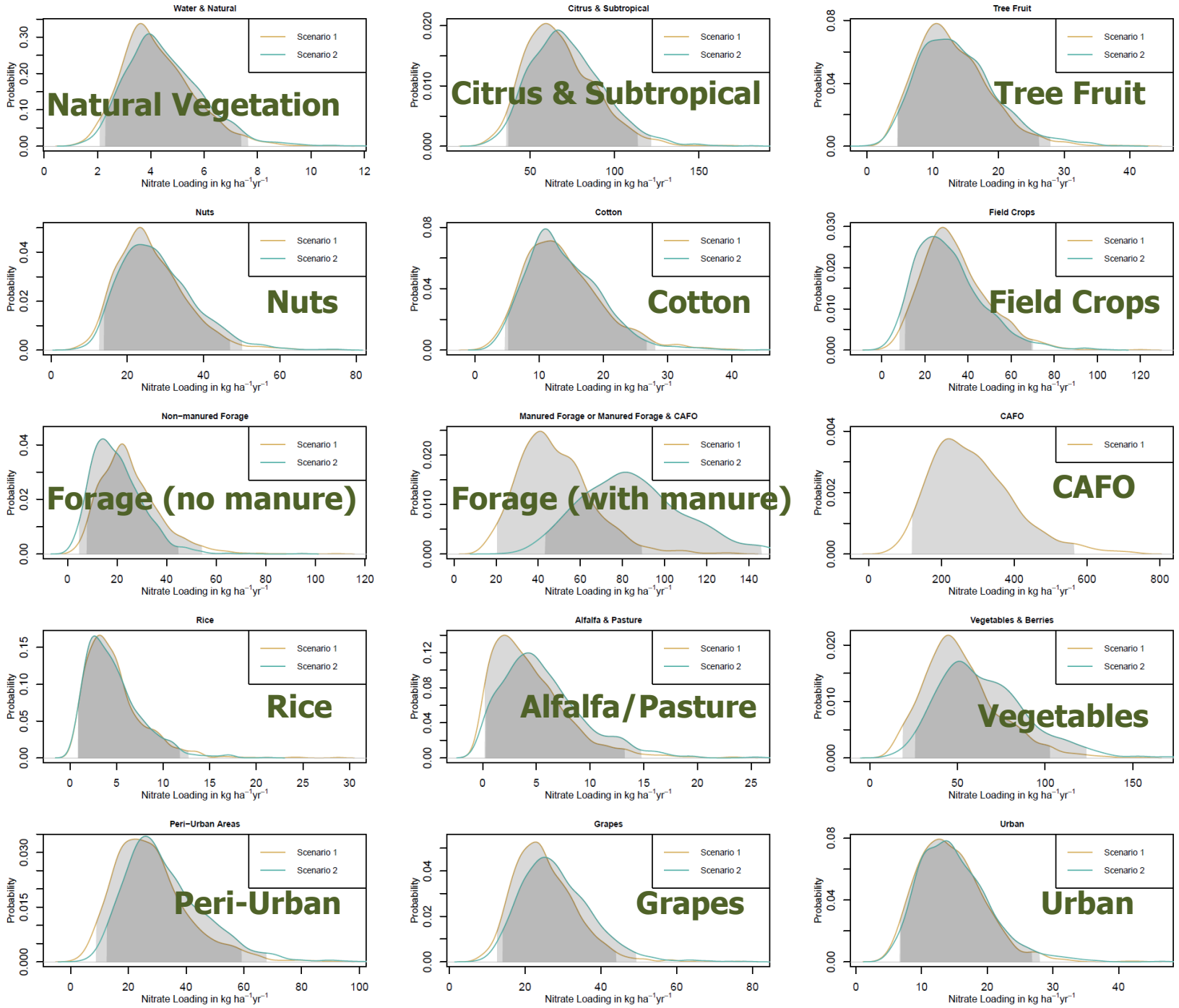


Ransom et al., WRR (2016)

Estimated nitrogen loading pdf at time of recharge
[kg N/ha/yr]

(1970s – 1990s)

by crop / landuse type



Ransom et al., HESS (2018)

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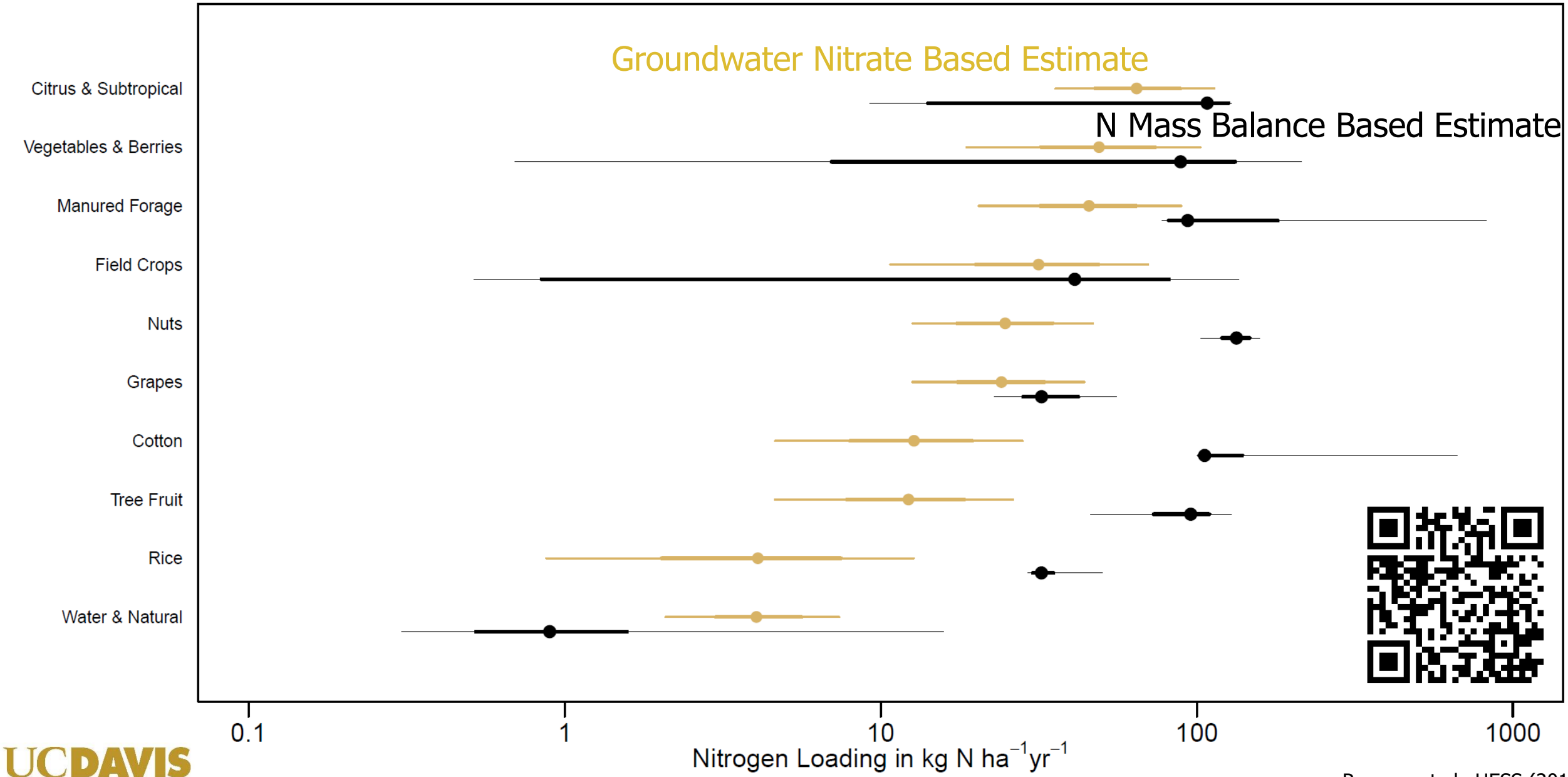
Forensic analysis confirms the mass balance N loading to groundwater for some crops and landuse types



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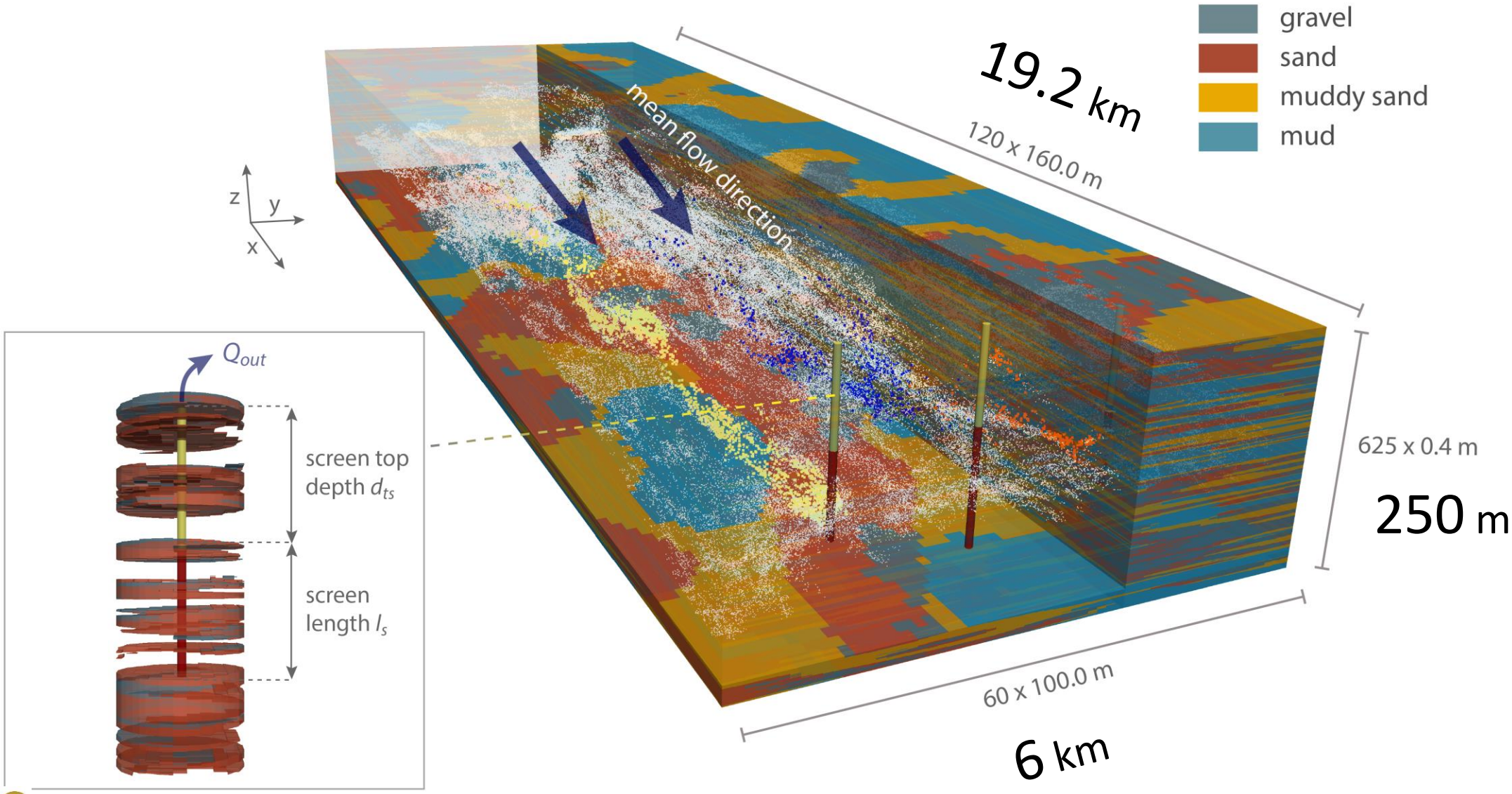
Ransom et al., HESS (2018)

Research programs to develop and assess BMPs: Groundwater Modeling



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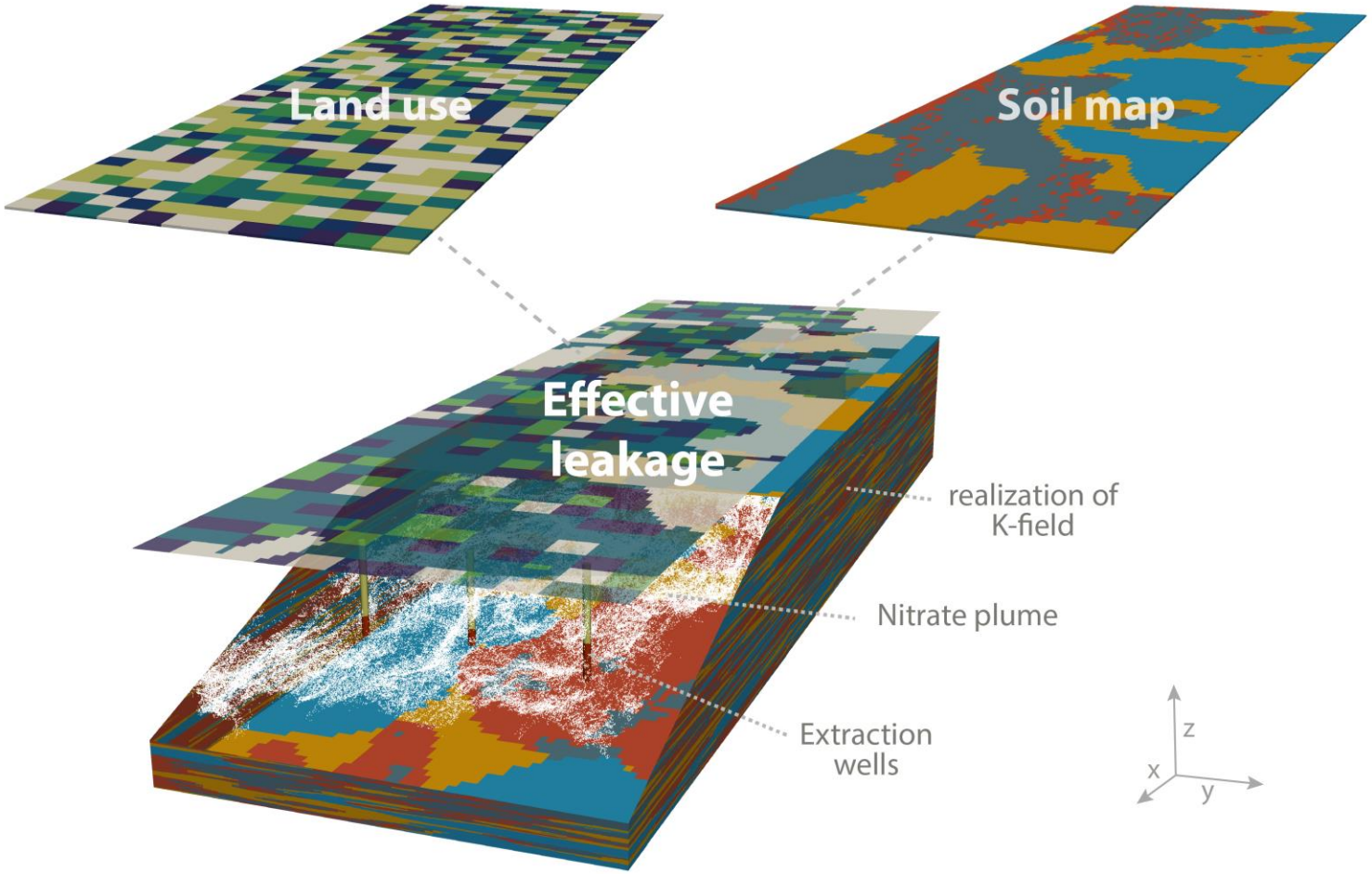
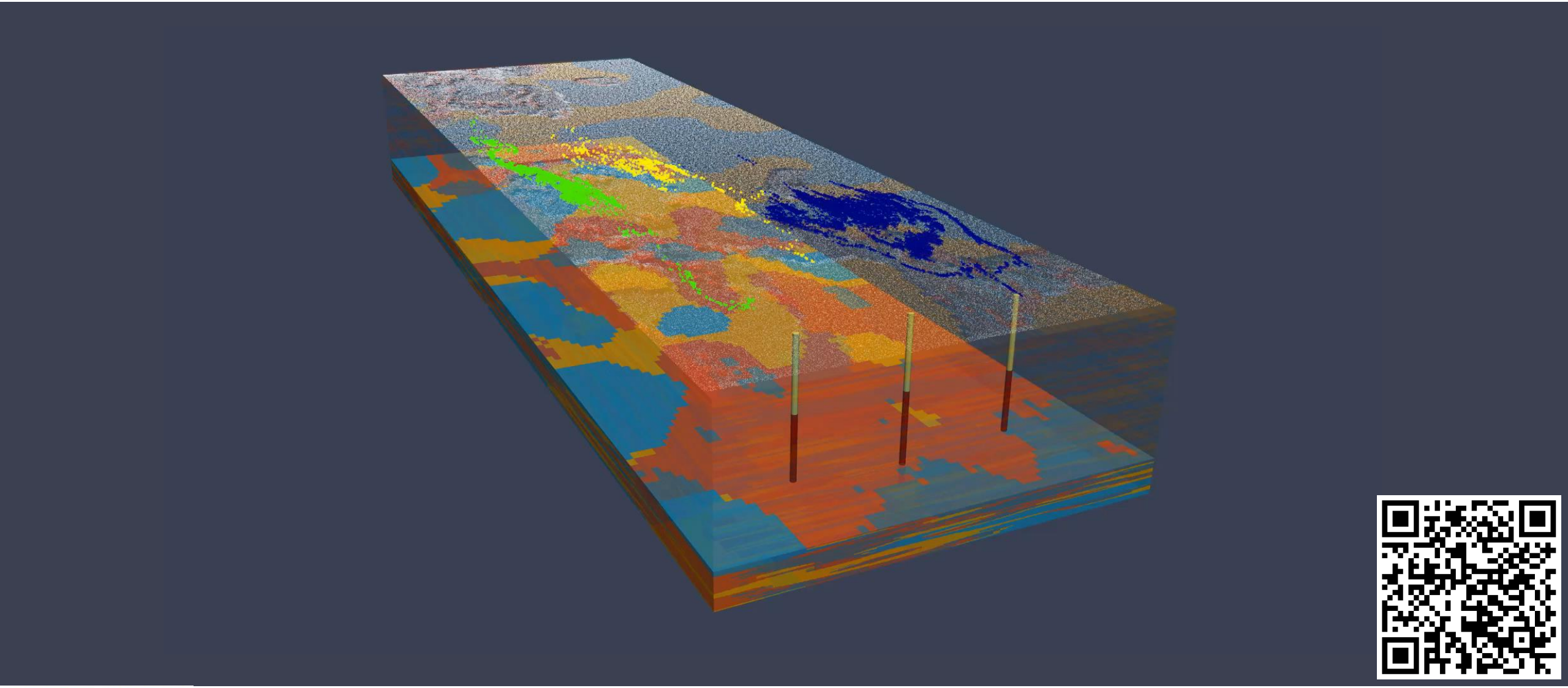
..but we don’t consider just the variability of the aquifer, also that of soils and crop-scape…



Henri and Harter, HESS 2019

What Happens to Nitrogen Surplus When Leached This Year as Nitrate?



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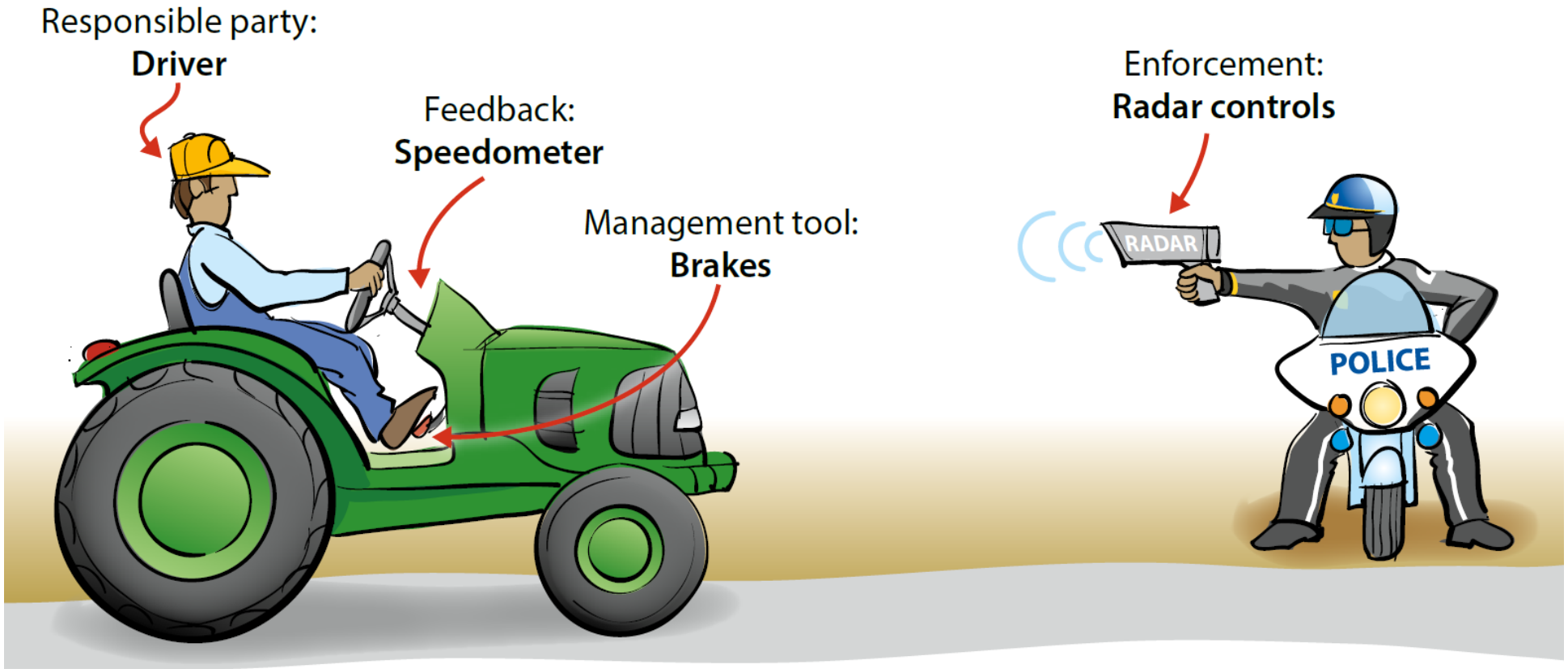
Henri and Harter, WRR 2019

Groundwater Nitrate Sources: What to Do About It?

The Basics of Management Policy & Regulation

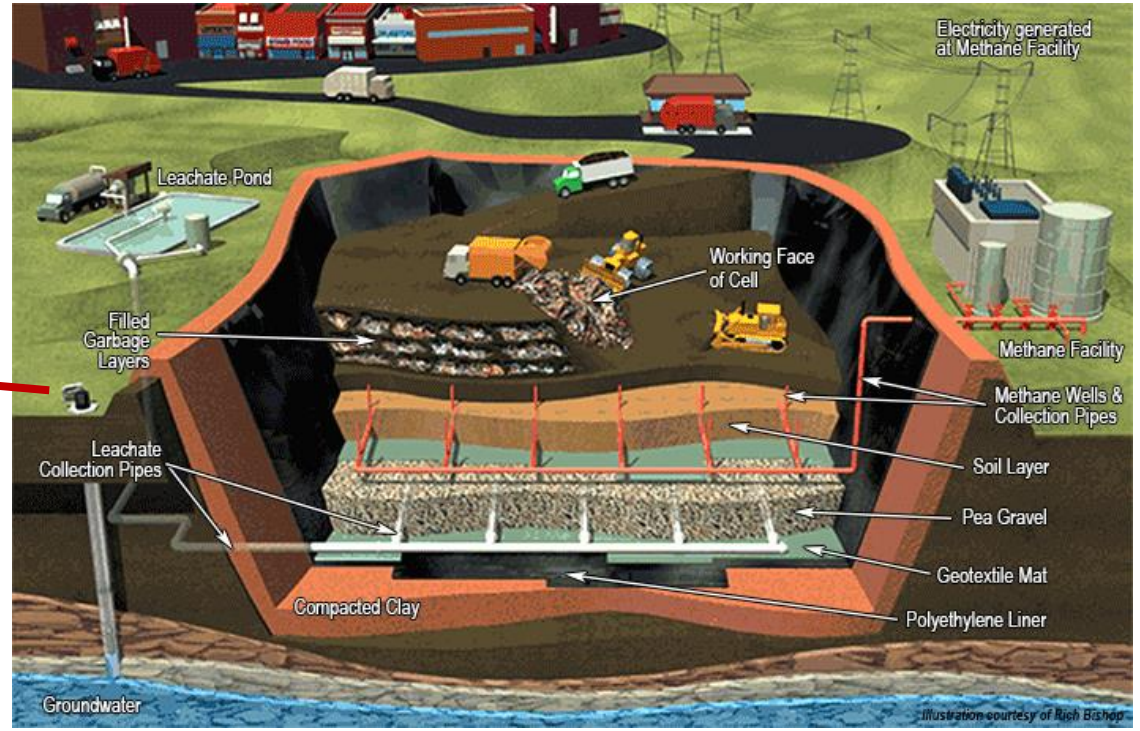
- Identify impacts (human health, environment, economy) and risk drivers
- Identify & prioritize parties to be regulated (universal v structured/categories)



Harter, California Agriculture, 2015

… identify potential polluters, control pollution, remediate, monitor… …

Monitoring Well



California Water Quality Regulations

State Legislation / Statutory Authority:
1969 Porter-Cologne Water Quality Control Act
2002 Sunset of Exemptions for NPS (Agriculture, Urban Stormwater)

State Water Board (Oversight)
9 Regional Water Boards (Planning, Permitting, Policing)

Basin Plan: water bodies (gw & sw), beneficial uses
=> water quality objectives

Discharge Permits
("Orders")

Penalties / Cease and Desist Orders

California – Regulations to curtail groundwater pollution from NPS

Legislative Mandate of the late 1990s:
2002 Sunset of Exemptions for NPS (Agriculture, Urban Stormwater)

new discharge permits / first for agriculture

2000s to current: Surface Water
2007 to current: Groundwater

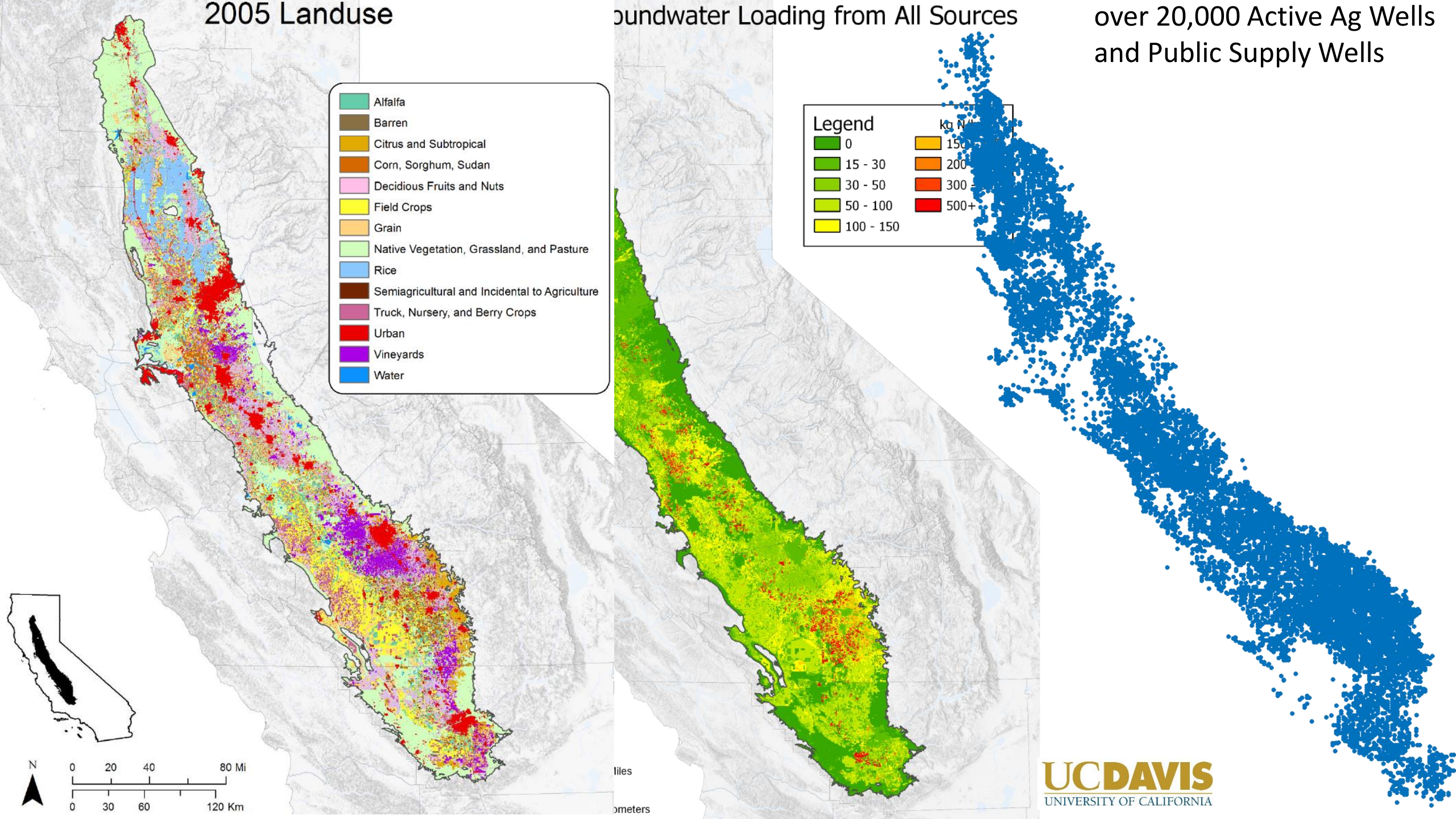
2007 Dairy Order (Central Valley RWB)

2012 Irrigated Lands Regulatory Program (Central Valley RWB)

2012 Agricultural Order (Central Coast RWB)

2018 Revised ILRP (SWB – statewide precedence)

2018 Salt and Nutrient Basin Plan Amendment (Central Valley RWB)


2005 Landuse
Alfalfa
Barren
Citrus and Subtropical
Corn, Sorghum, Sudan
Decidious Fruits and Nuts
Field Crops
Grain
Native Vegetation, Grassland, and Pasture
Rice
Semiagricultural and Incidental to Agriculture
Truck, Nursery, and Berry Crops
Urban
Vineyards
Water
N
0 20 40 80 Mi
0 30 60 120 Km
oundwater Loading from All Sources
Legend
0
15 - 30
30 - 50
50 - 100
100 - 150
150
200
300
500+
over 20,000 Active Ag Wells
and Public Supply Wells
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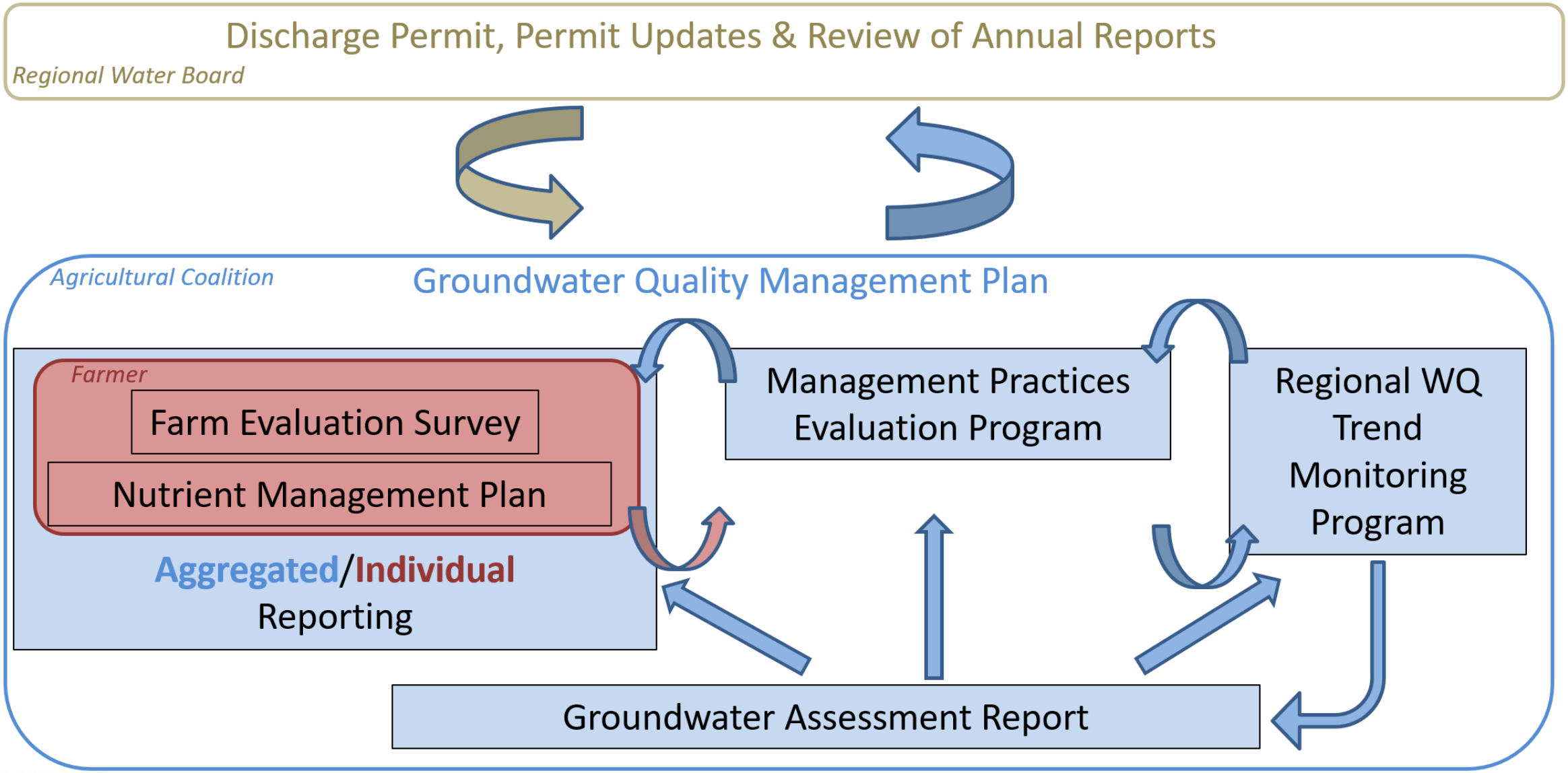
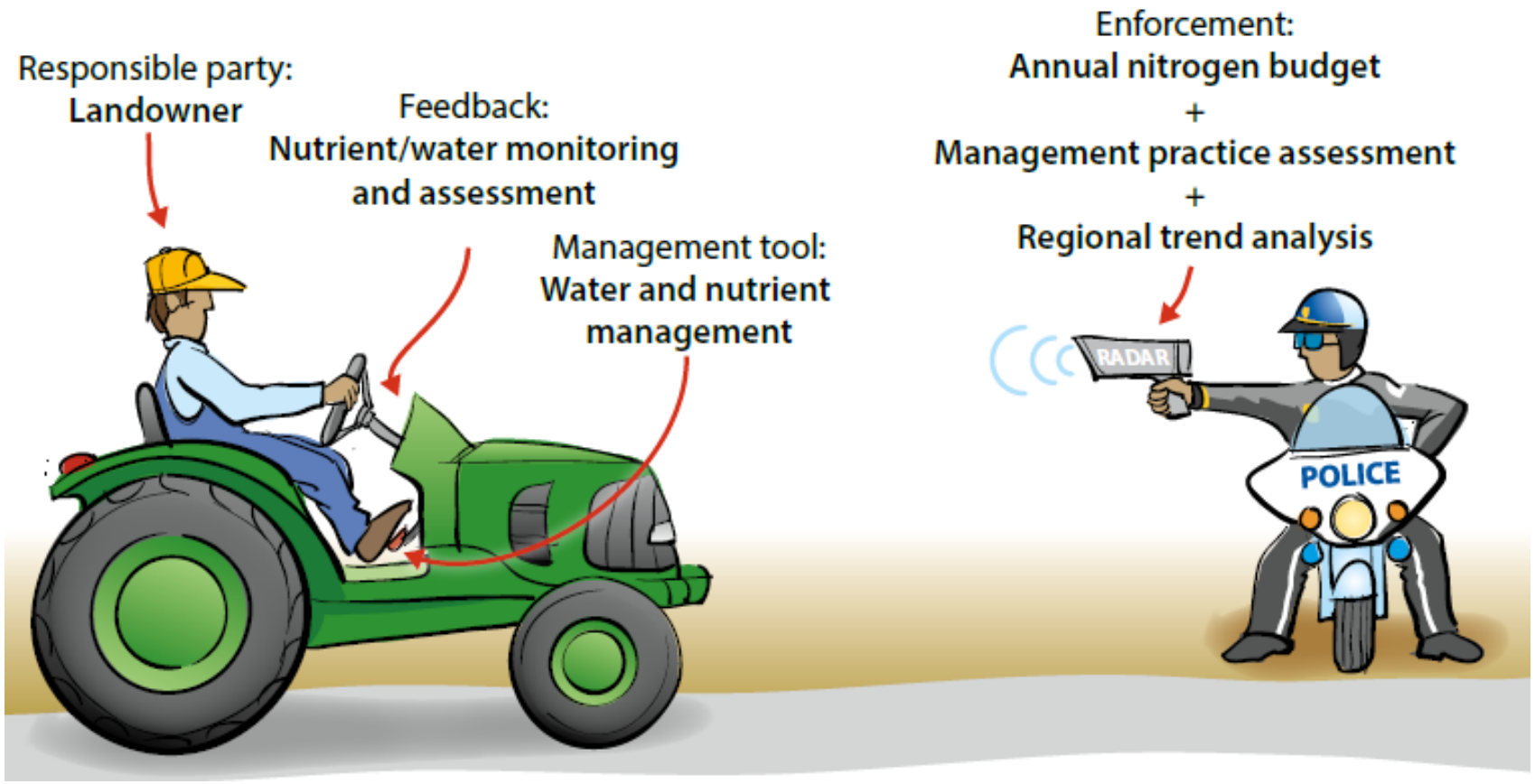
California regulations to curtail groundwater pollution from agriculture: Irrigated Lands Regulatory Program overview



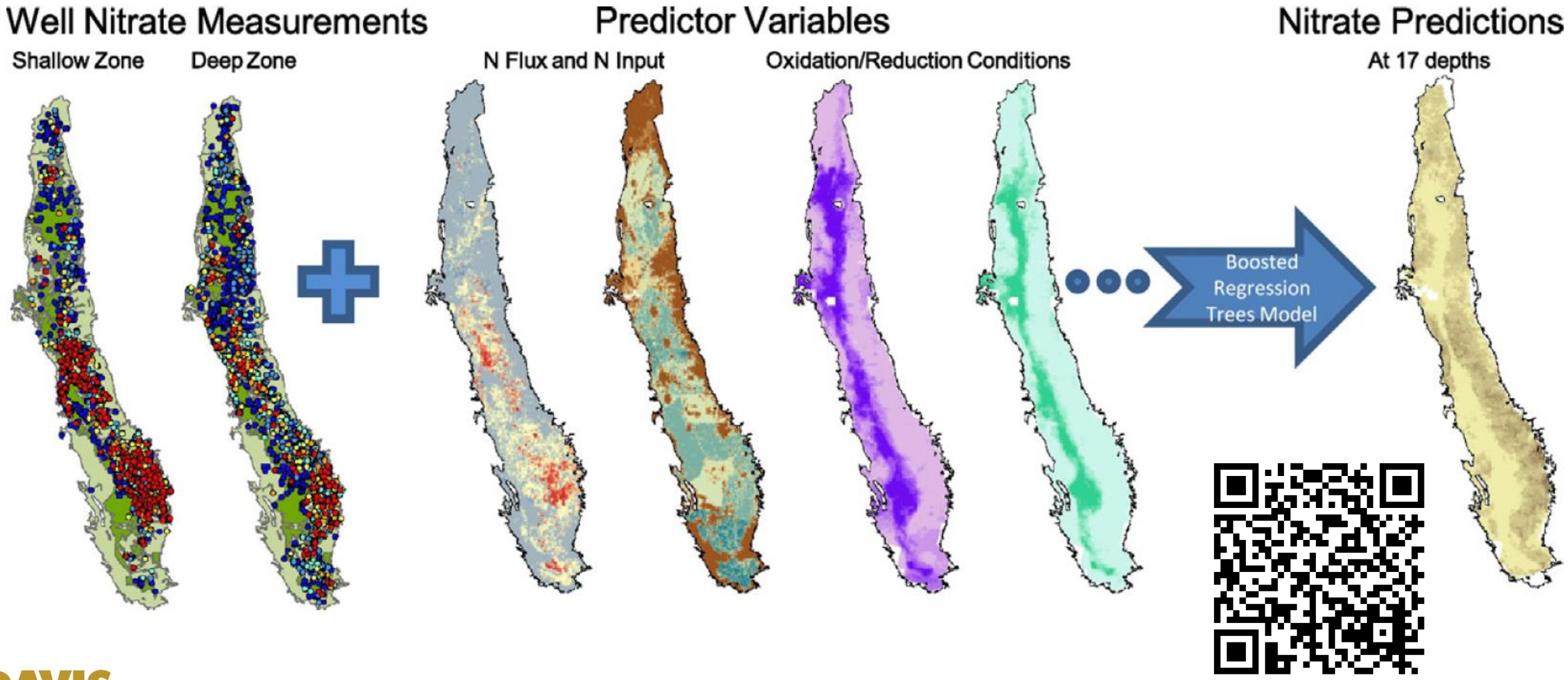
ILRP: Regulating nonpoint sources of nitrate pollution

- Identify impacts and risk drivers: GW Assessment Report
- Identify & prioritize parties to be regulated: high vulnerability areas



Harter, California Agriculture, 2015

Use machine learning to predict nitrate at 1 km scale (Boosted Random Tree)



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Ransom et al., STOTEN 2017

Estimated groundwater nitrate concentration (BRT) at 1 km^2 & 17 depths

Domestic well depth (< 100 m)

Public supply well depth (> 100 m)

EXPLANATION

Nitrate - N (mg/L)

- < 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- > 10

N W E S

0 180 360 Miles

0 160 320 Kilometers

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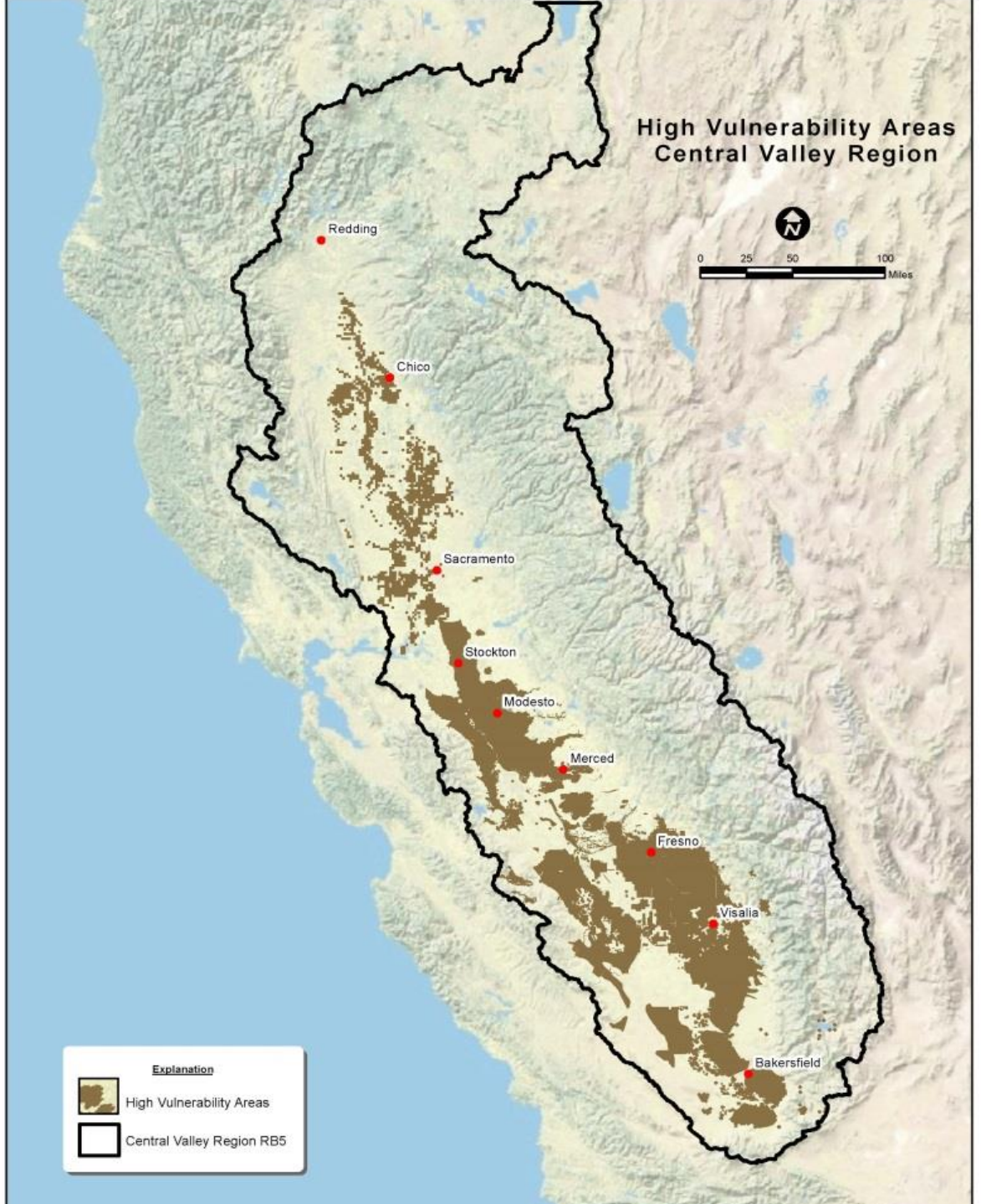
Ransom et al., STOTEN 2017

Overlay measured/predicted nitrate occurrence with community locations

=> High Vulnerability Areas (HVAs) for nitrate

Central Valley, California



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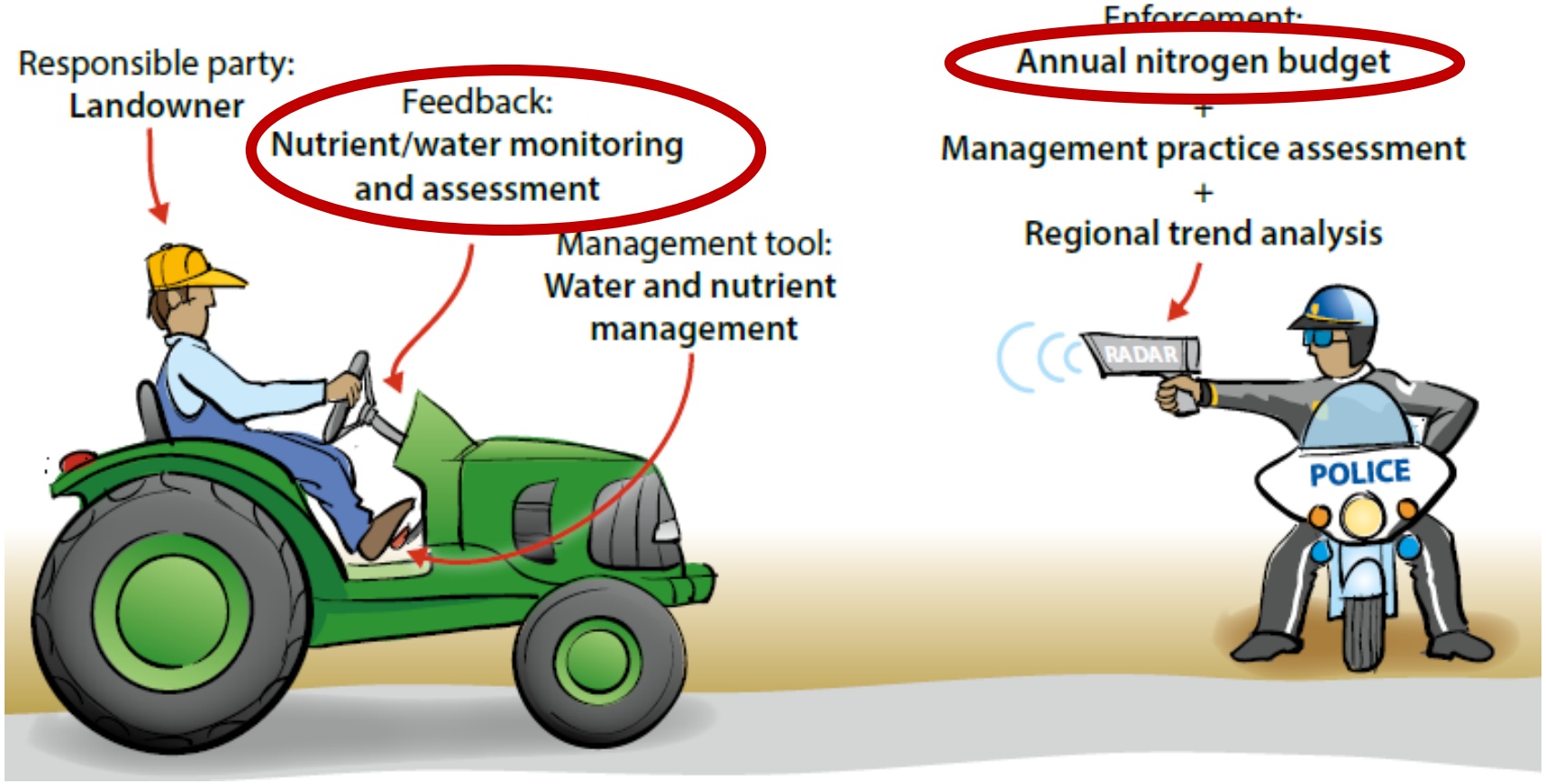
ILRP: Regulating nonpoint sources of nitrate pollution

- Identify impacts and risk drivers: GW Assessment Report
- Identify & prioritize parties to be regulated: high vulnerability areas



Harter, California Agriculture, 2015

Growers are responsible for compliance

- Obtain coverage (initial application)
- Implement management practices
- Prepare plans and reports on practices
  - Template-based
  - Stay on farm/submit to coalitions (HVAs)

From: Central Valley Regional Water Board, Irrigated Lands Regulatory Program

Grower's
Nitrogen Management Plan:

Annual Nitrogen Budget
Reporting (by field)

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: _____

1. Crop Year (Harvested): _____

2. Member ID# _____

3. Name:

4. APN(s):	5. Field(s) ID	Acres

CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
6. Crop		**17. Nitrogen Fertilizers**		
7. Production Unit		18. Dry/Liquid N (lbs/ac)		
8. Projected Yield (Units/Acre)		19. Foliar N (lbs/ac)		
9. N Recommended (lbs/ac)		**20. Organic Material N**		
10. Acres		21. Available N in Manure/Compost (lbs/ac estimate)		
Post Production Actuals				
11. Actual Yield (Units/Acre)		**22. Total Available N Applied** (lbs per acre)		
12. Total N Applied (lbs/ac)		**23. Nitrogen Credits (est)**		
13. ** N Removed (lbs N/ac)		24. Available N carryover in soil; (annualized lbs/acre)		
14. Notes:		25. N in Irrigation water (annualized, lbs/ac)		
		26. Total N Credits (lbs per acre)		
		27. Total N Applied & Available		

PLAN CERTIFICATION		
28. CERTIFIED BY:	**29. CERTIFICATION METHOD**	
	30. Low Vulnerability Area, No Certification Needed	
	31. Self-Certified, approved training program attended	
DATE:	32. Self-Certified, UC or NRCS site recommendation	
	33. Nitrogen Management Plan Specialist	

**Your Coalition will provide the method to be used to estimate N Removed. Approved by the Central Valley Water Board 23 December 2014.

Instruction numbering in this document differs slightly from the NMP template approved by the Water Board to accommodate this publication design.

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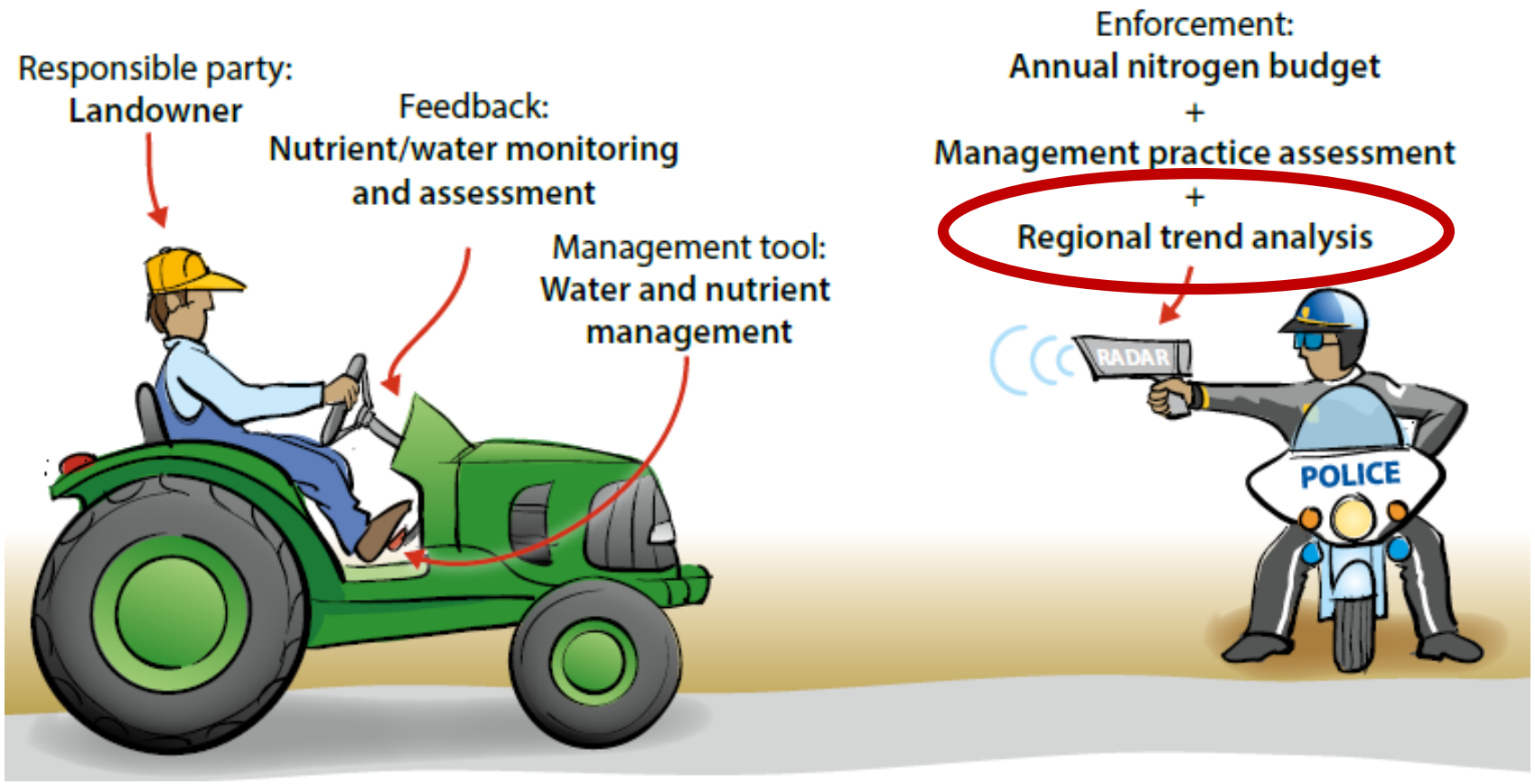
ILRP: Regulating nonpoint sources of nitrate pollution

- Identify impacts and risk drivers: GW Assessment Report
- Identify & prioritize parties to be regulated: high vulnerability areas



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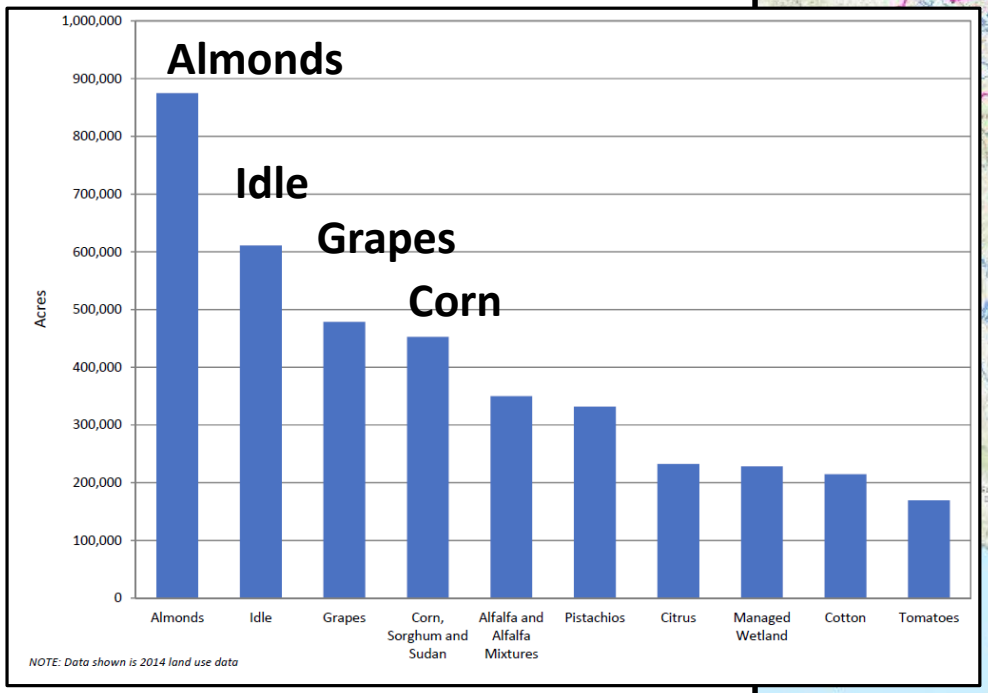
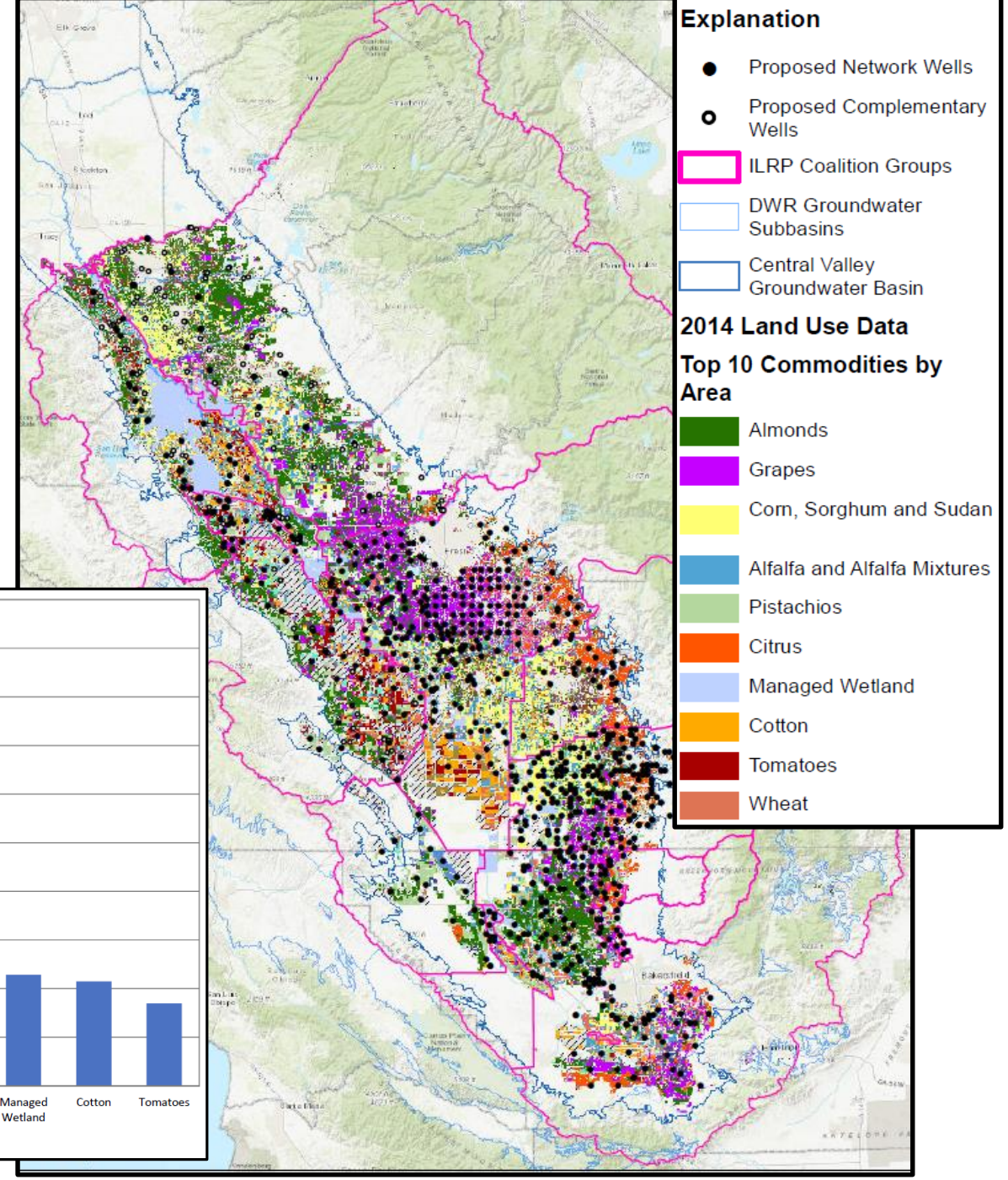
Harter, California Agriculture, 2015

CVGMC Network & Top Commodities

- Almonds: 875,015 ac
- Grapes: 478,751 ac
- Corn: 452,531 ac





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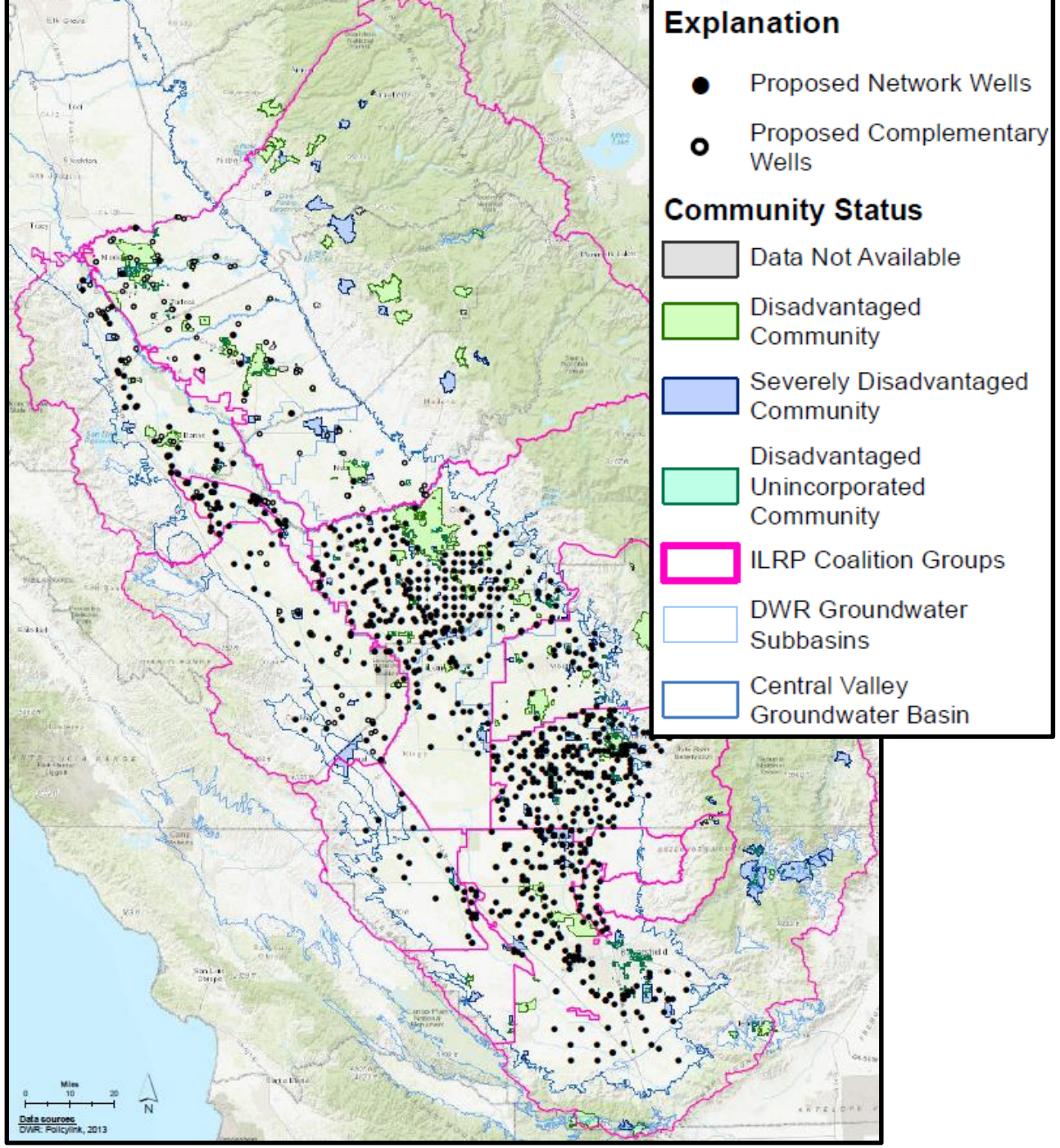
Courtesy of: CVGMC March 27, 2018 Meeting

CVGMC Network and DACs



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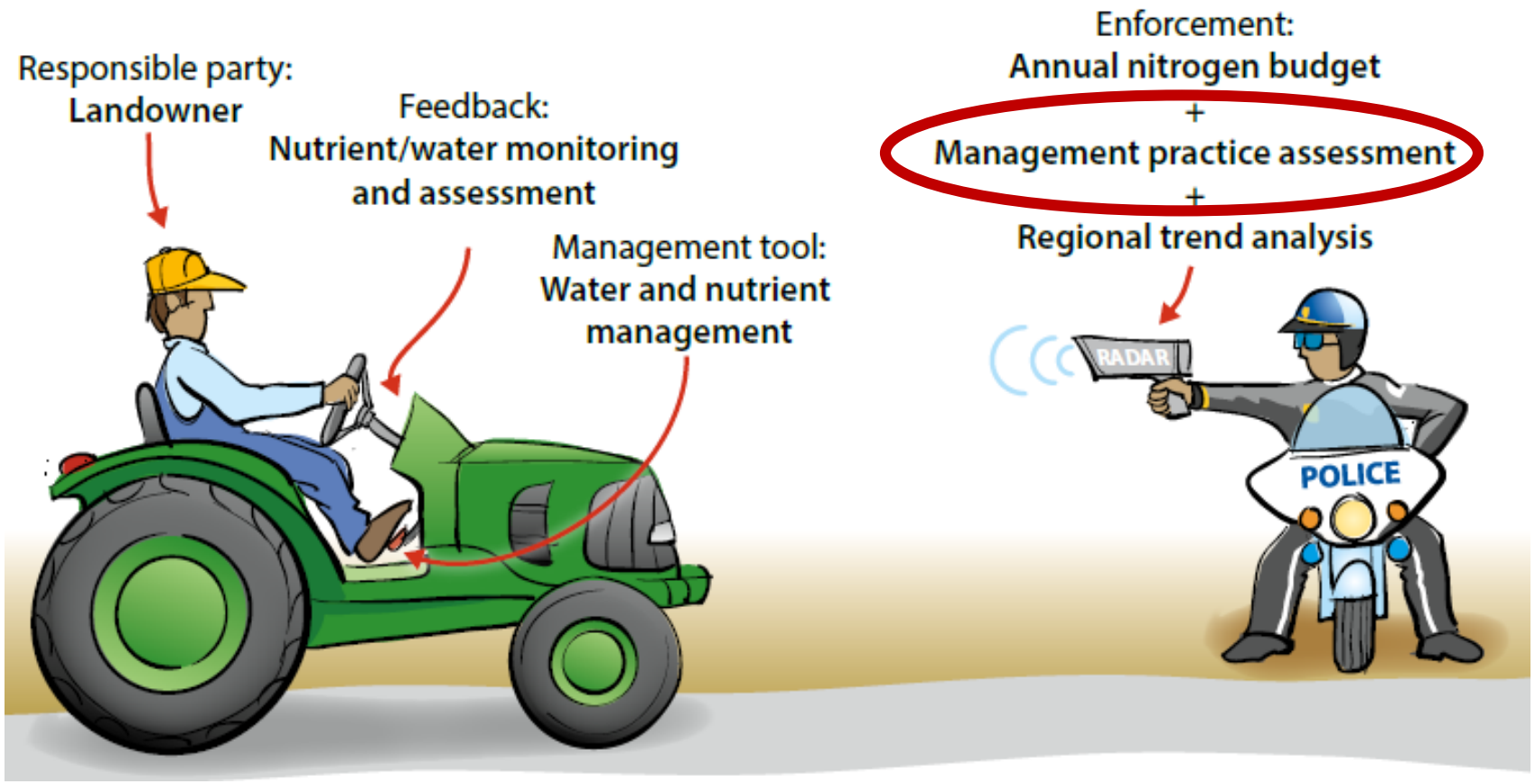
Courtesy of: CVGMC March 27, 2018 Meeting

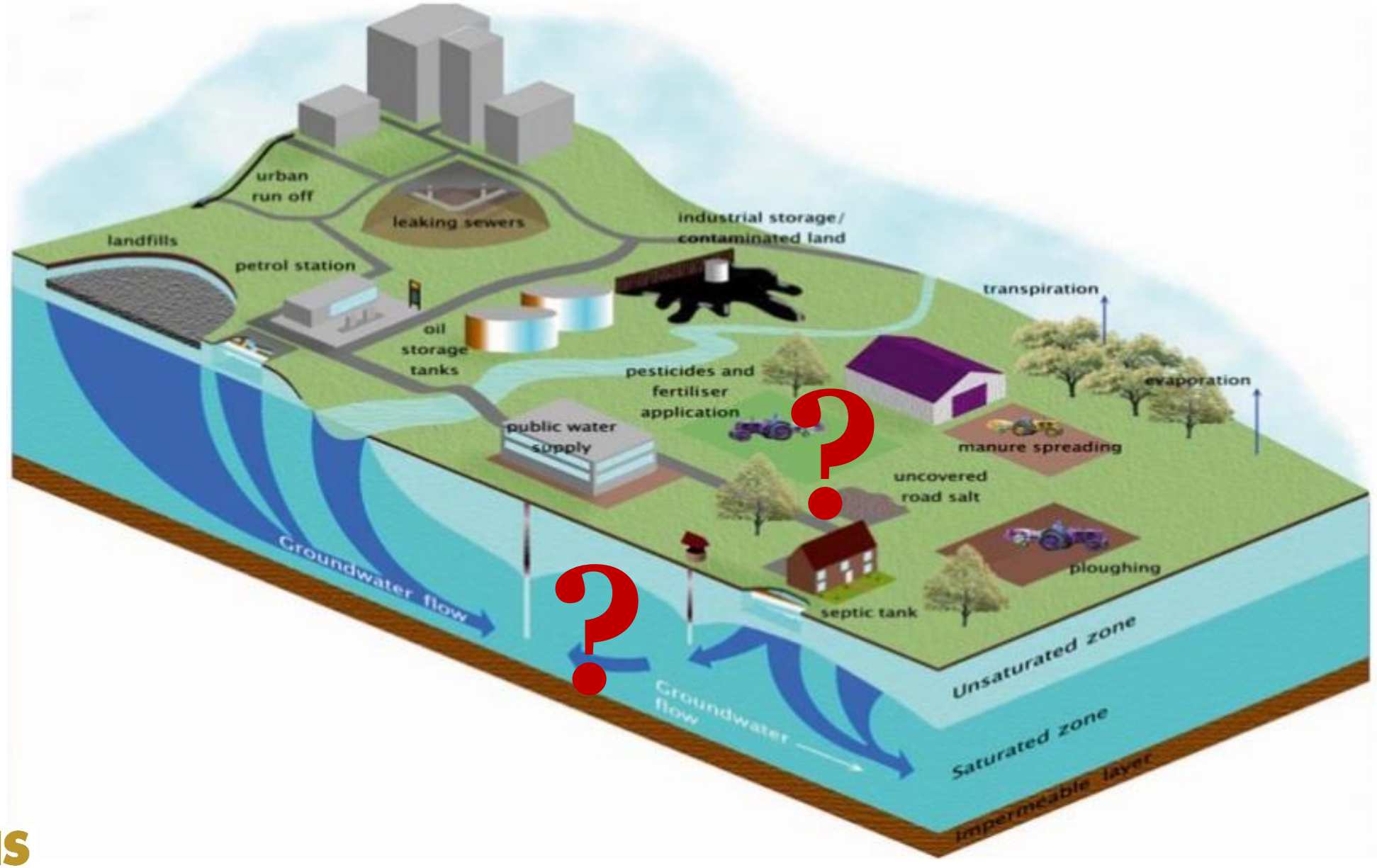
ILRP: Regulating nonpoint sources of nitrate pollution

- Identify impacts and risk drivers: GW Assessment Report
- Identify & prioritize parties to be regulated: high vulnerability areas



Harter, California Agriculture, 2015

Moving forward, two key questions:



… ag's most important pollution control device: water and nutrient management….

Increase crop N-use efficiency -- Decrease deep percolation

Basic Components	Management Measures	50 Practices
Improve irrigation and drainage systems	✓ Perform system evaluation and monitoring	3
	✓ Improve Irrigation scheduling	4
	✓ Improve irrigation system design and operation	13
	✓ Other irrigation infrastructure improvements	2
Improve fertilizer and manure use	✓ Improve rate, timing, and placement	15
Change crop rotation	✓ Modify crop rotation or grow cover crops	4
Improve storage and handling	✓ Avoid fertilizer material and manure spills during transport, storage and application	9

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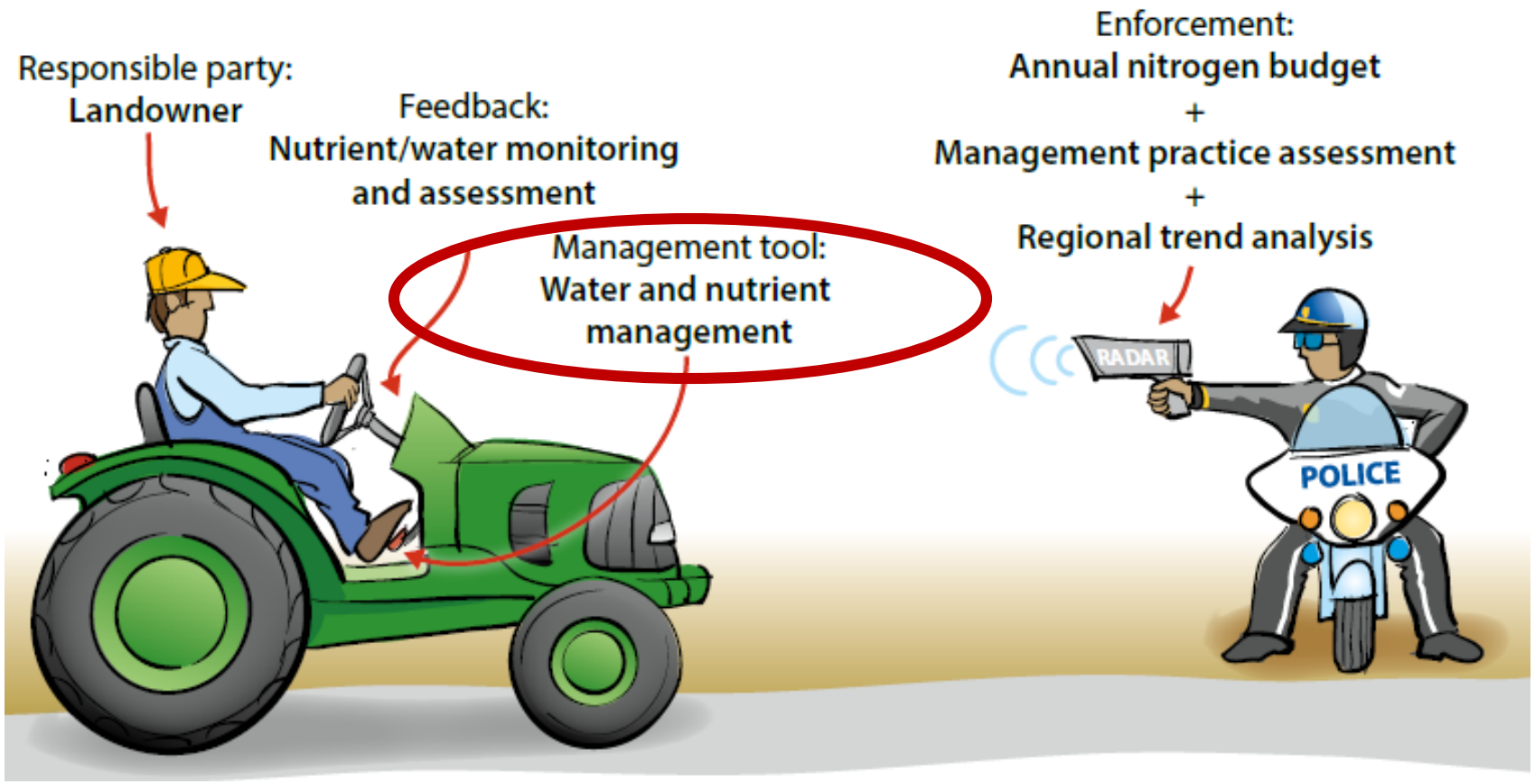
http://groundwaternitrate.ucdavis.edu - Technical Report 3

ILRP: Regulating nonpoint sources of nitrate pollution

- Identify impacts and risk drivers: GW Assessment Report
- Identify & prioritize parties to be regulated: high vulnerability areas



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Harter, California Agriculture, 2015

“FORMULA” in lieu of monitoring device: Soil-Crop Modeling (each field, soil)

Soil & Water Assessment Tool | SWAT

mpepTEAM

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Research programs to develop and assess BMPs: Field Sites

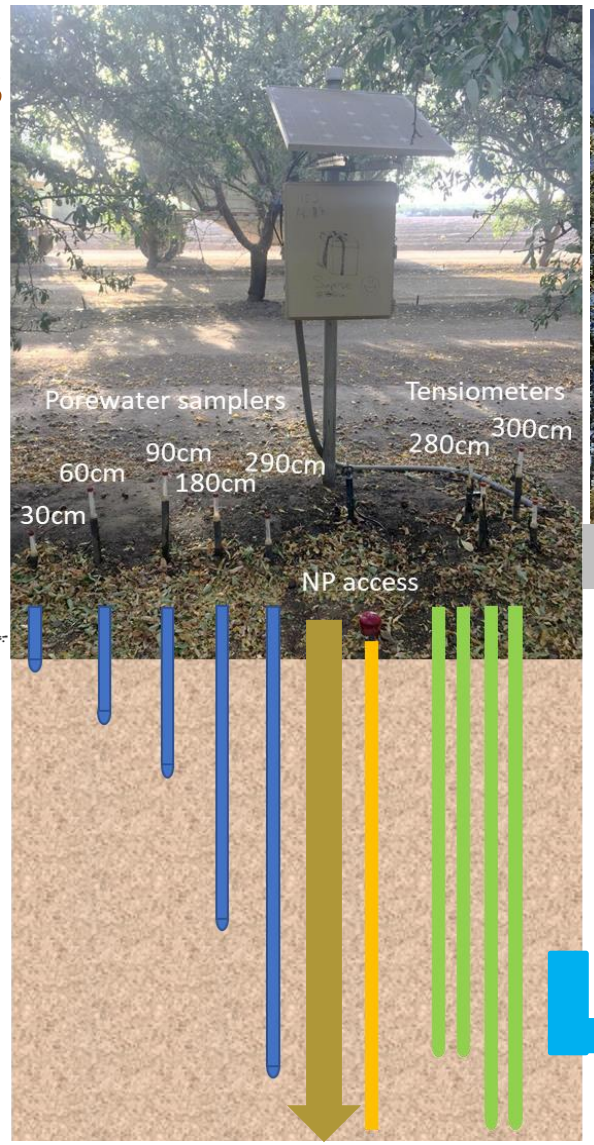
landscape water and N fluxes

(deep) vadose zone water and N fluxes

groundwater N fluxes

N_2O Emission

N Tissue Assimilation



Monitoring NO_3 in root zone

ET

Irrigation & N Fertigation

NO_3 Leaching to Groundwater

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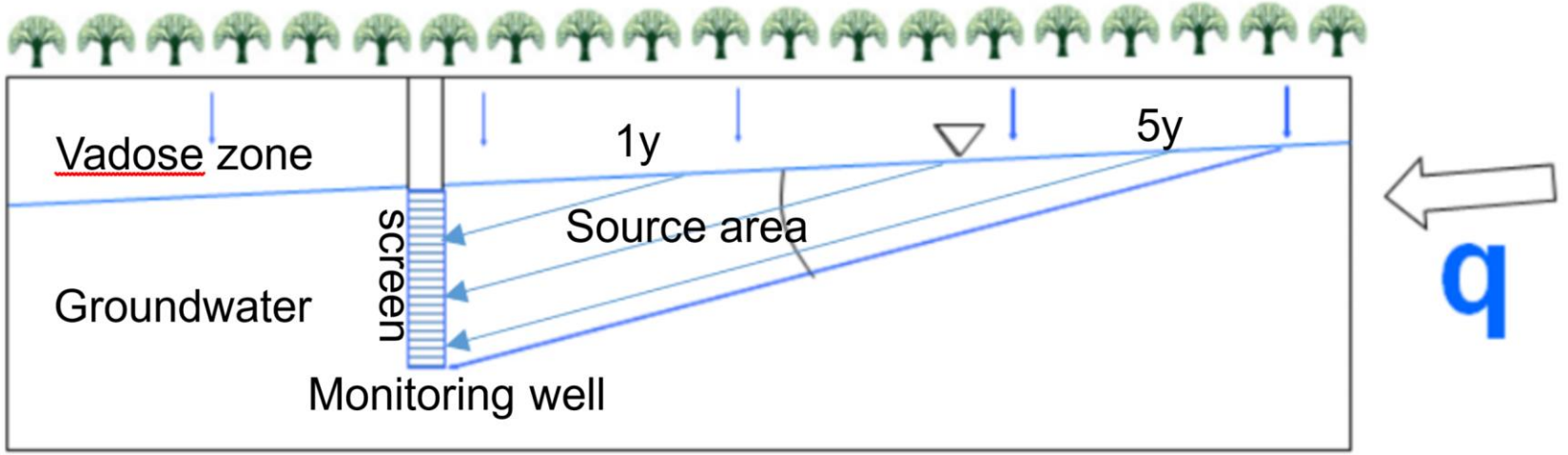
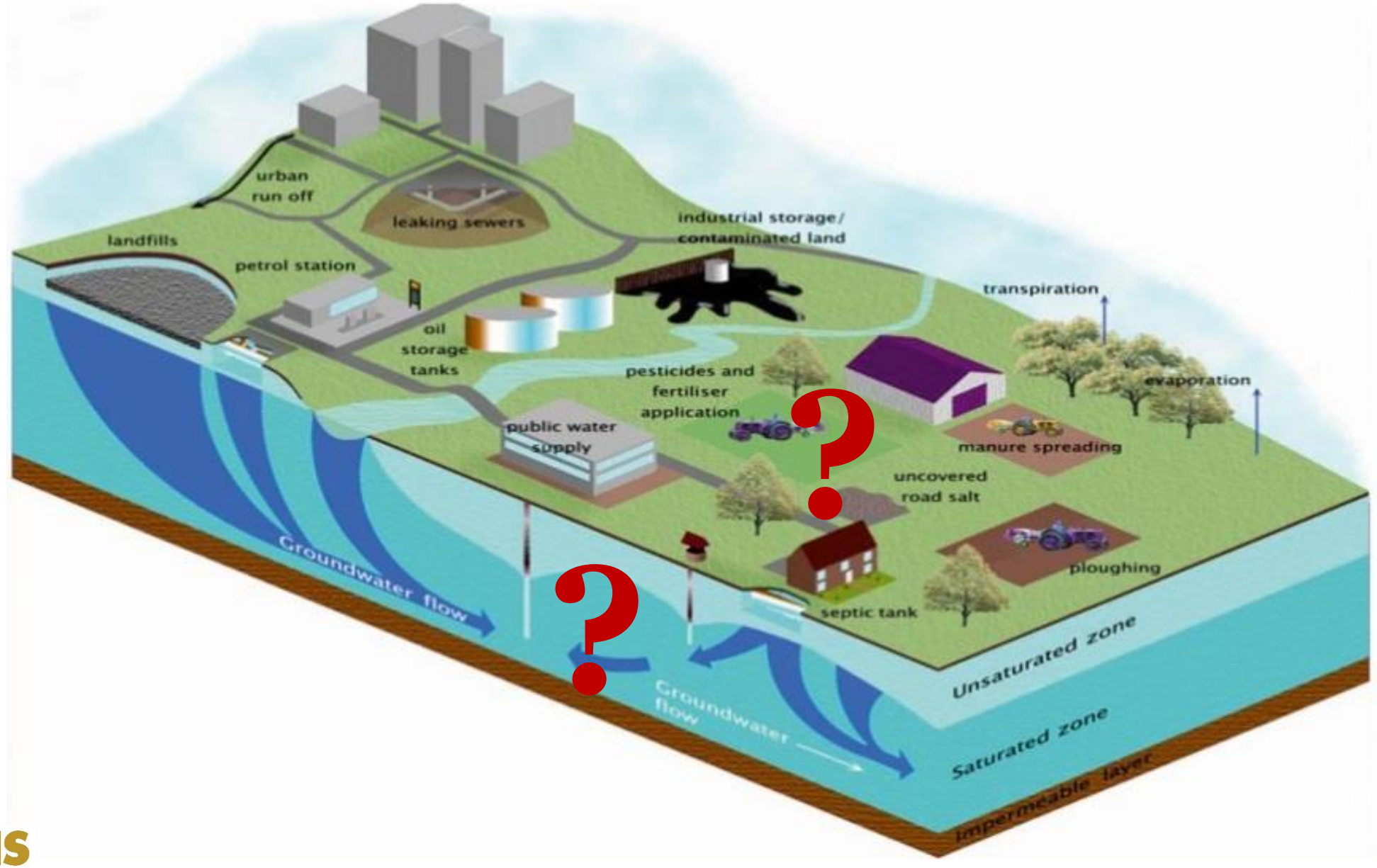
Groundwater monitoring: 20 monitoring wells within top 5 m of groundwater



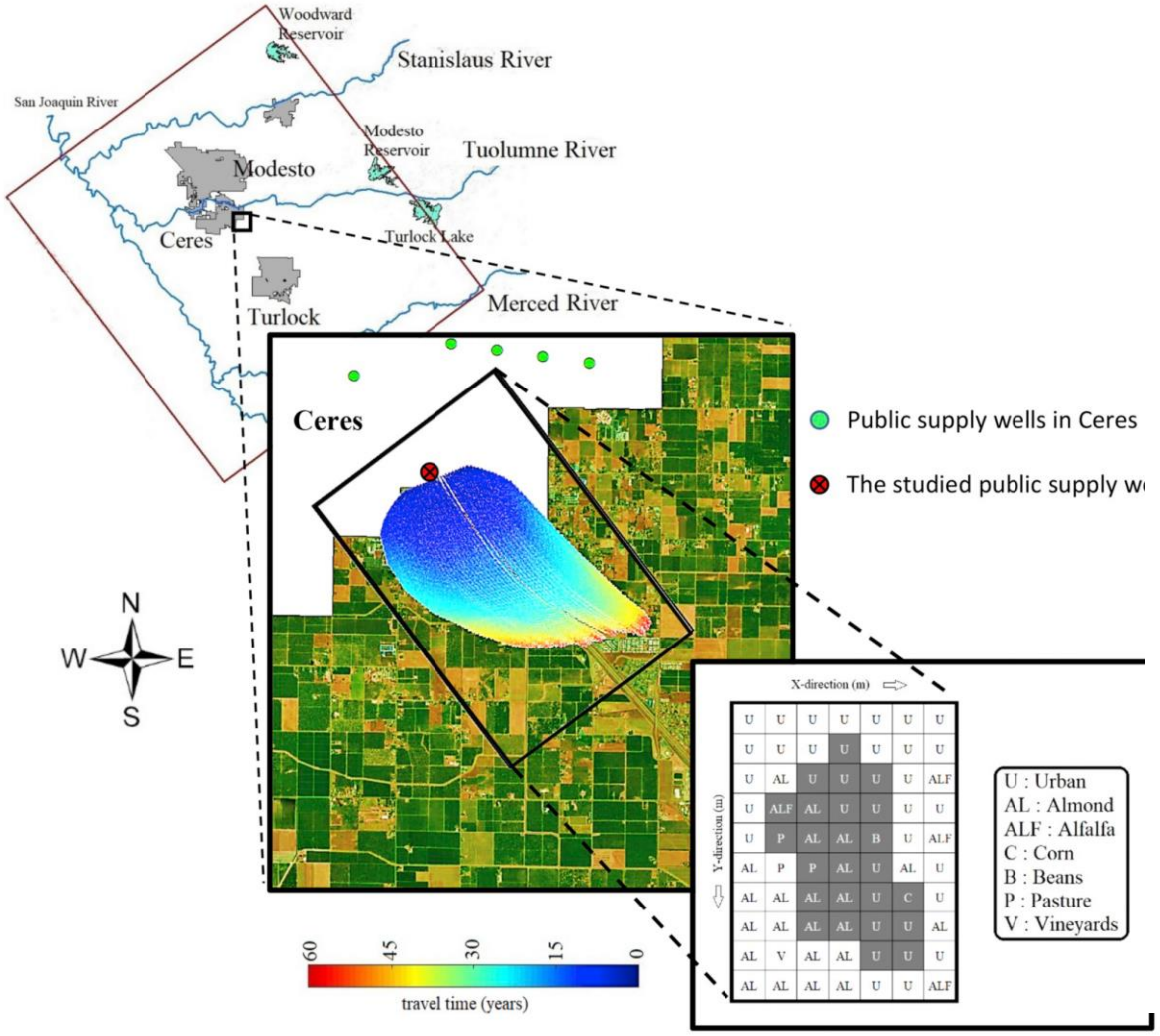
Nitrate in Groundwater:

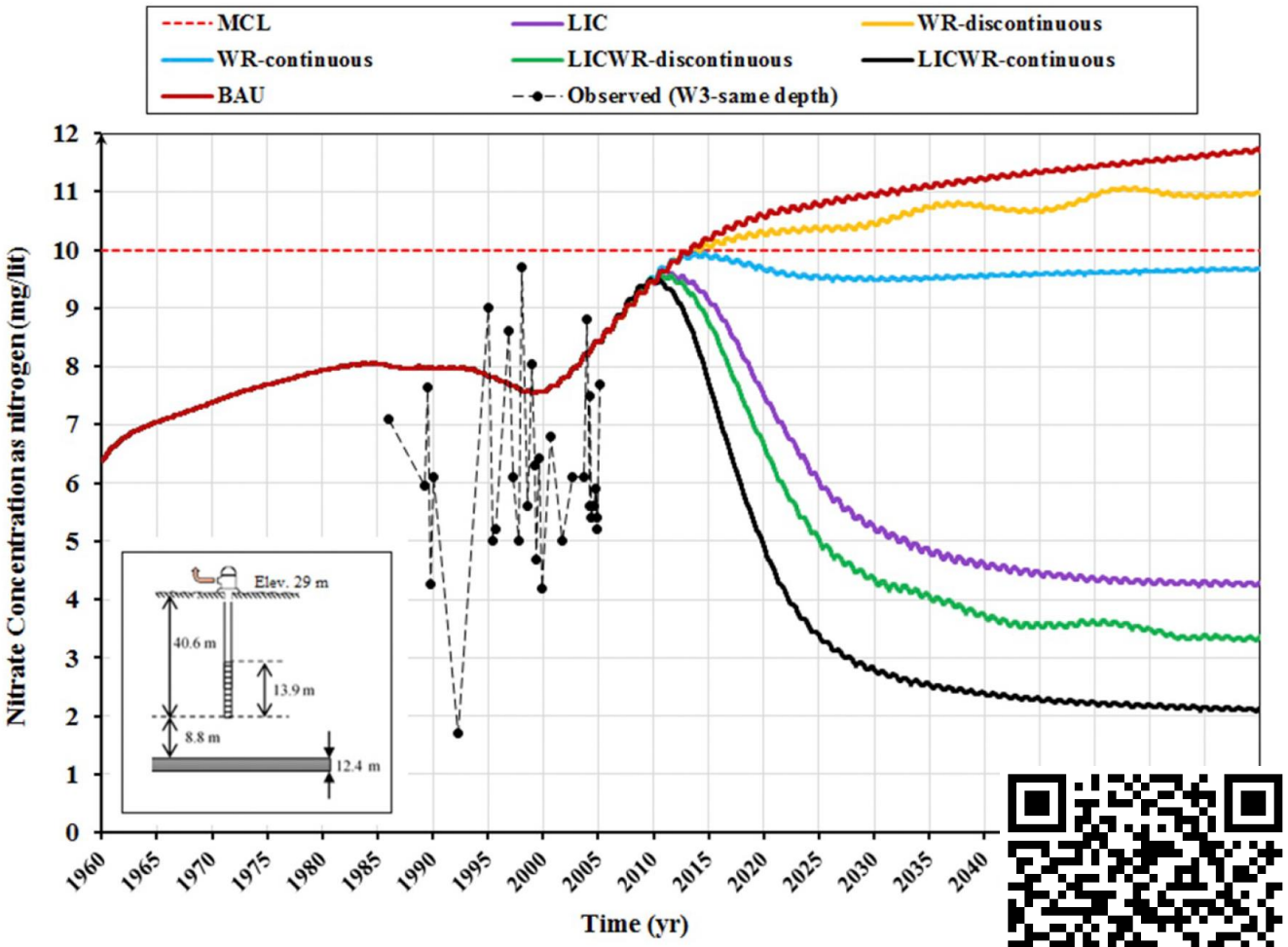
Doing the Best - What Will the Future Bring, When?

Moving forward, two key questions:



Research needs: Assessment of BMP Impacts on Public Supply Well in a Disadvantaged Community





Bastani and Harter, J Contam Hydrol 2019

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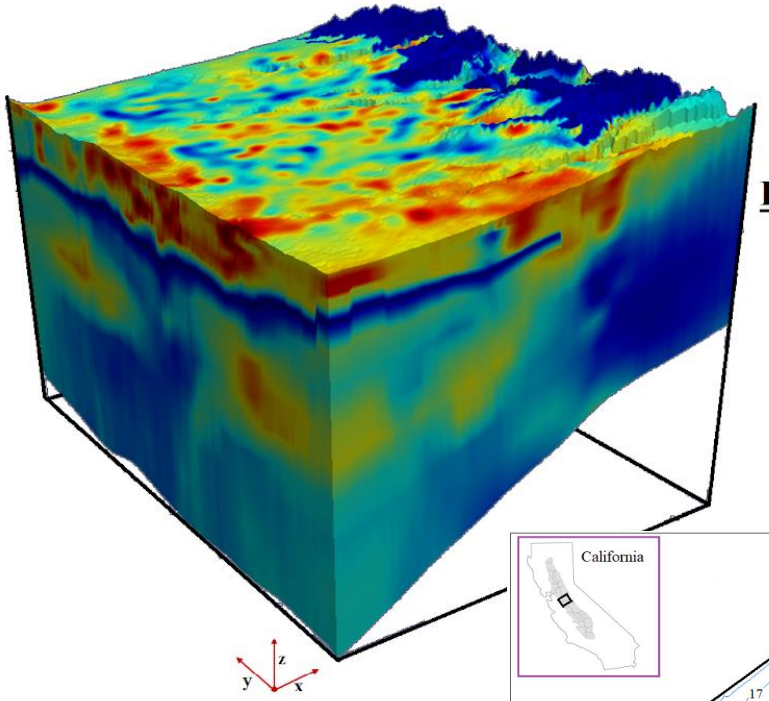
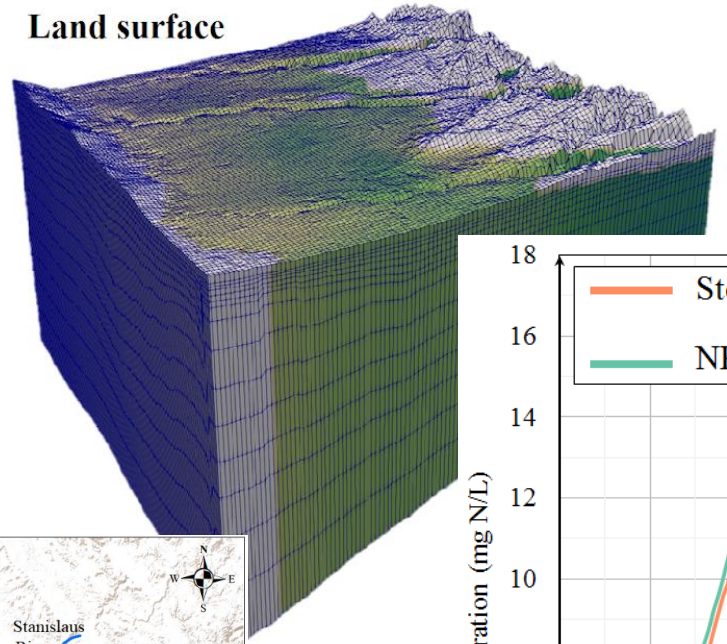
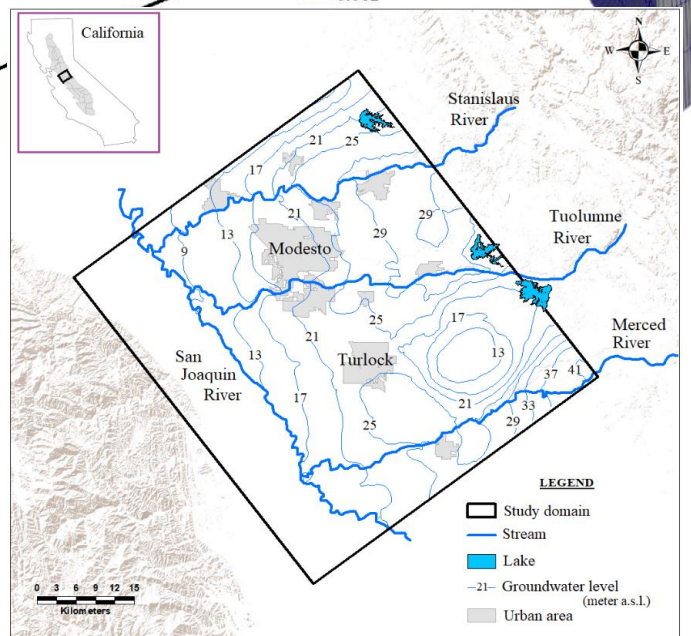
Comparison against most popular (but slow) model software looks good for practical applications

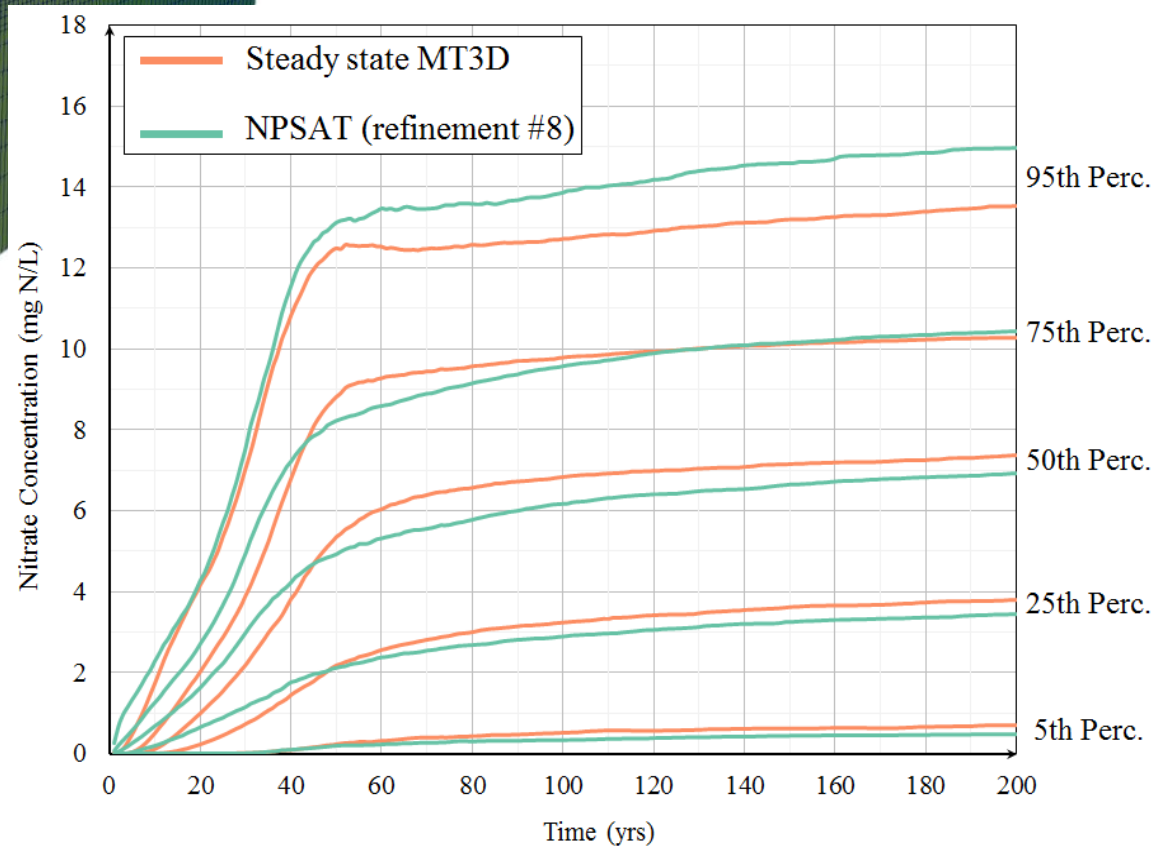






Model Area:
38 miles x 34 miles

MODFLOW-MT3D v NPSAT



Bastani et al, in preparation, 2020

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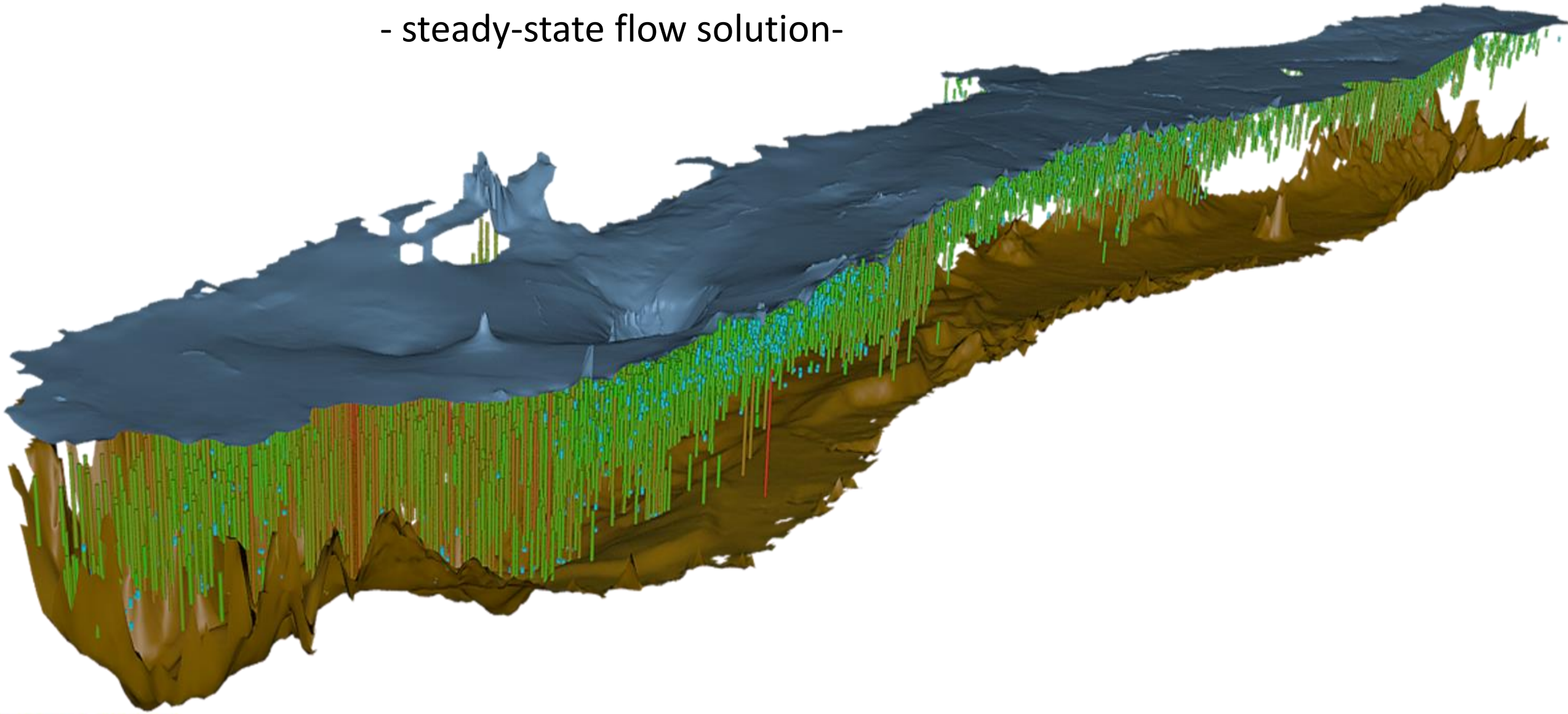
Nonpoint Source Assessment Toolbox (NPSAT):
application to the Central Valley
- steady-state flow solution-



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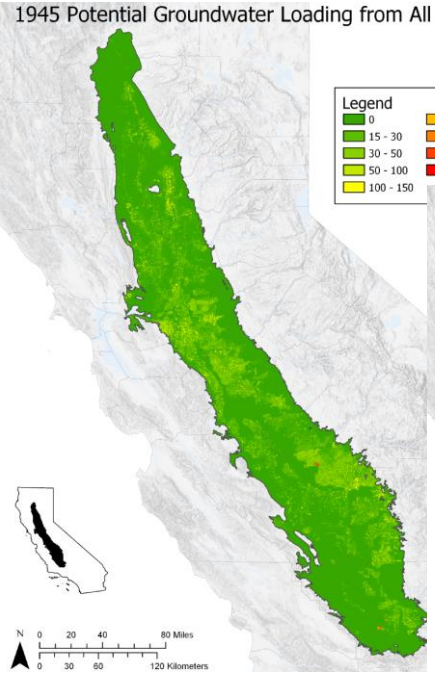
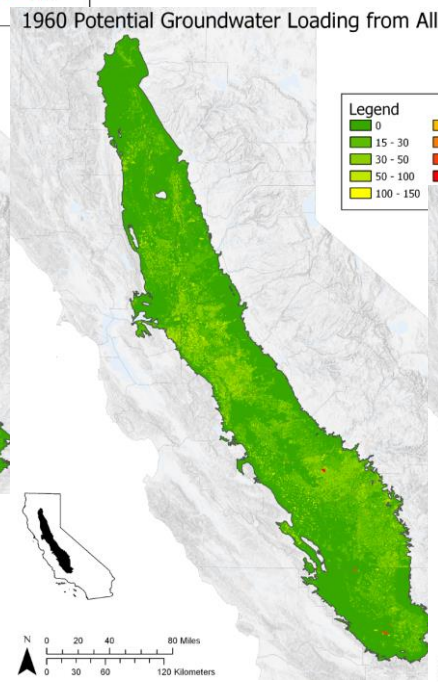
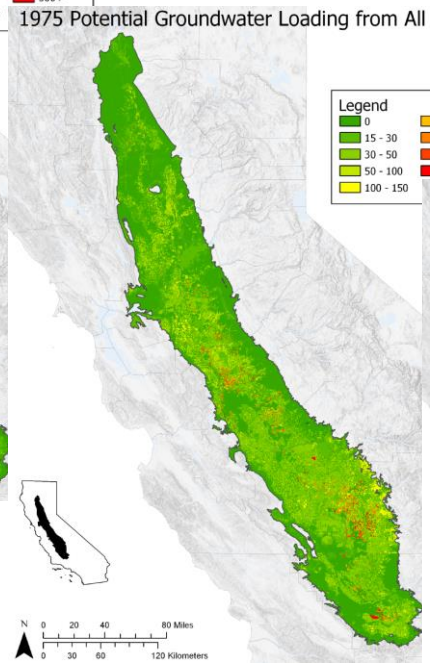
Apply N loading time series at high spatial resolution (50m) to NPSAT



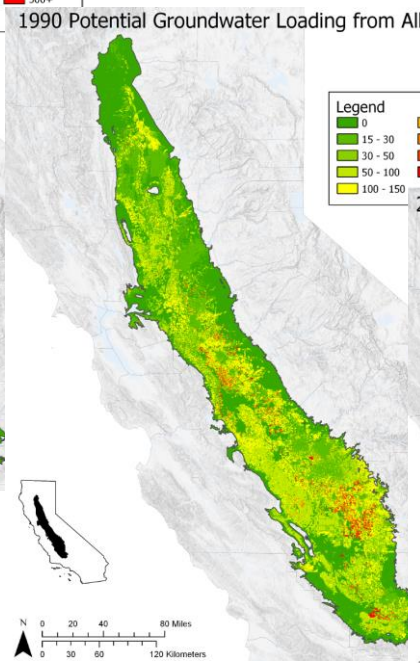
1945



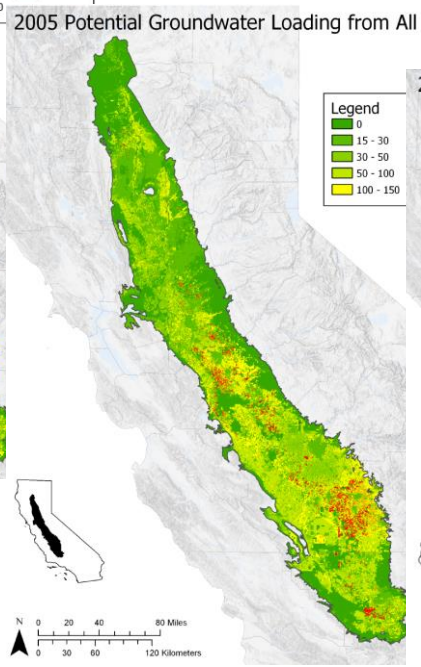
1960



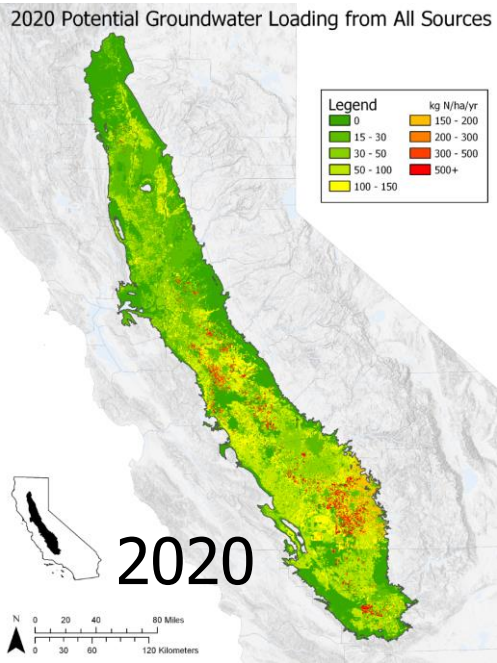
1975



1990



2005

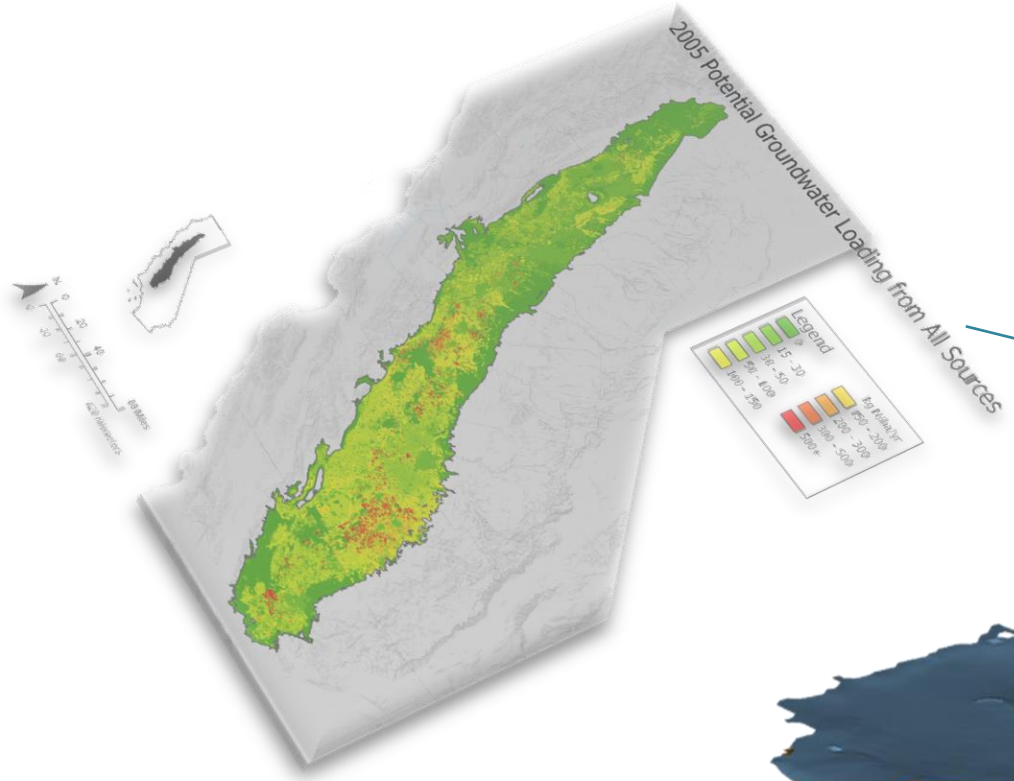


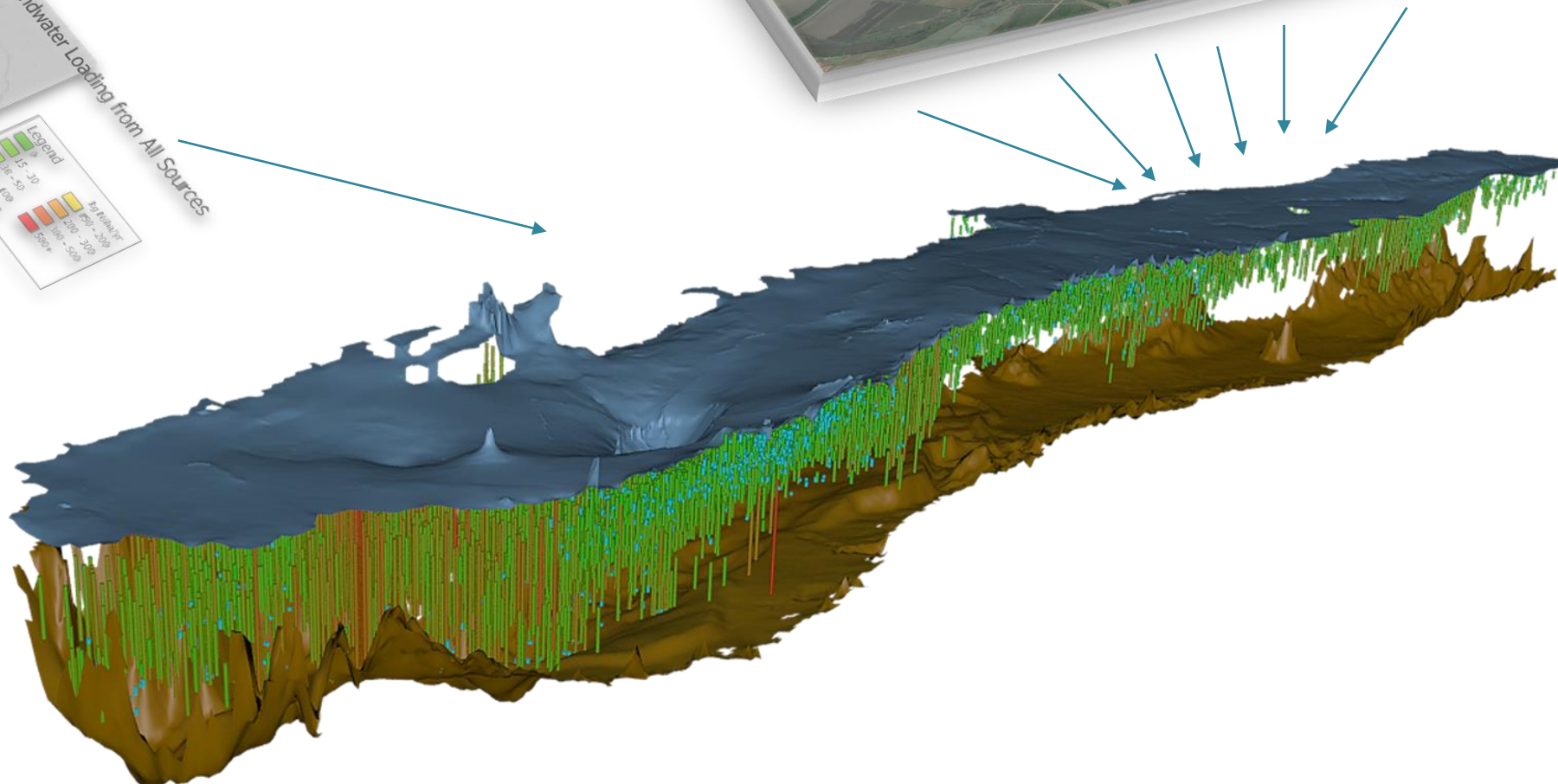
2020

Nonpoint Source Assessment Toolbox (NPSAT):

Couple to SWAT:

nitrate and recharge from bottom of root zone





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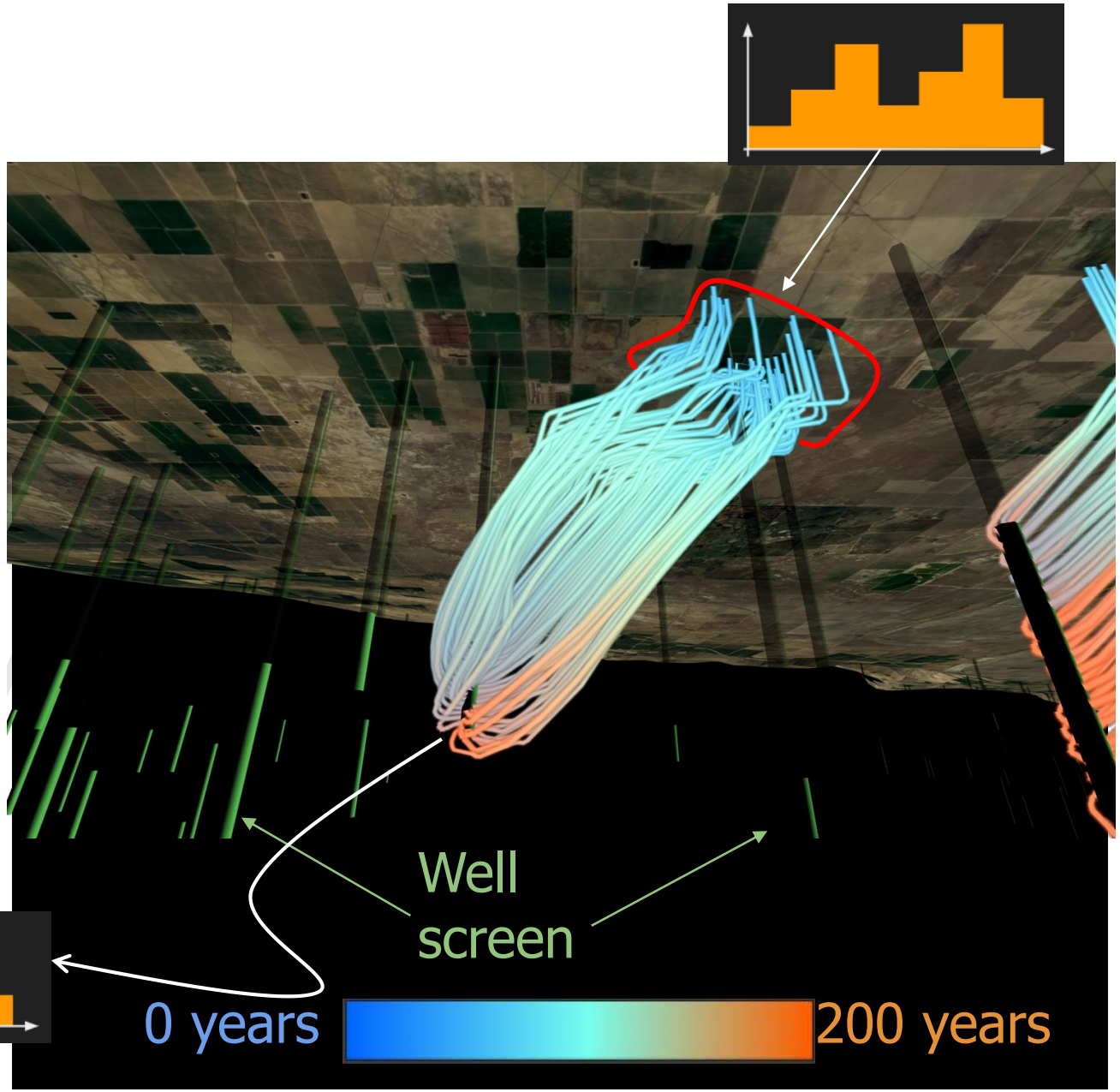
Transport Simulation in the NPSAT Simulation Framework

computationally intensive, but scenario-independent

- 100 particles per well
- Backward particle tracking
  - "Ichnos" software (manuscript in review) – particle tracking in variable meshes
  - Identify the source area for each well
  - Calculate the age of water
  - Porosity is set constant to 10%
- Unit Response functions

- Convolution w/ input history
- Well BTC
- Statistical Summary

computationally fast
input history is user-scenario dependent



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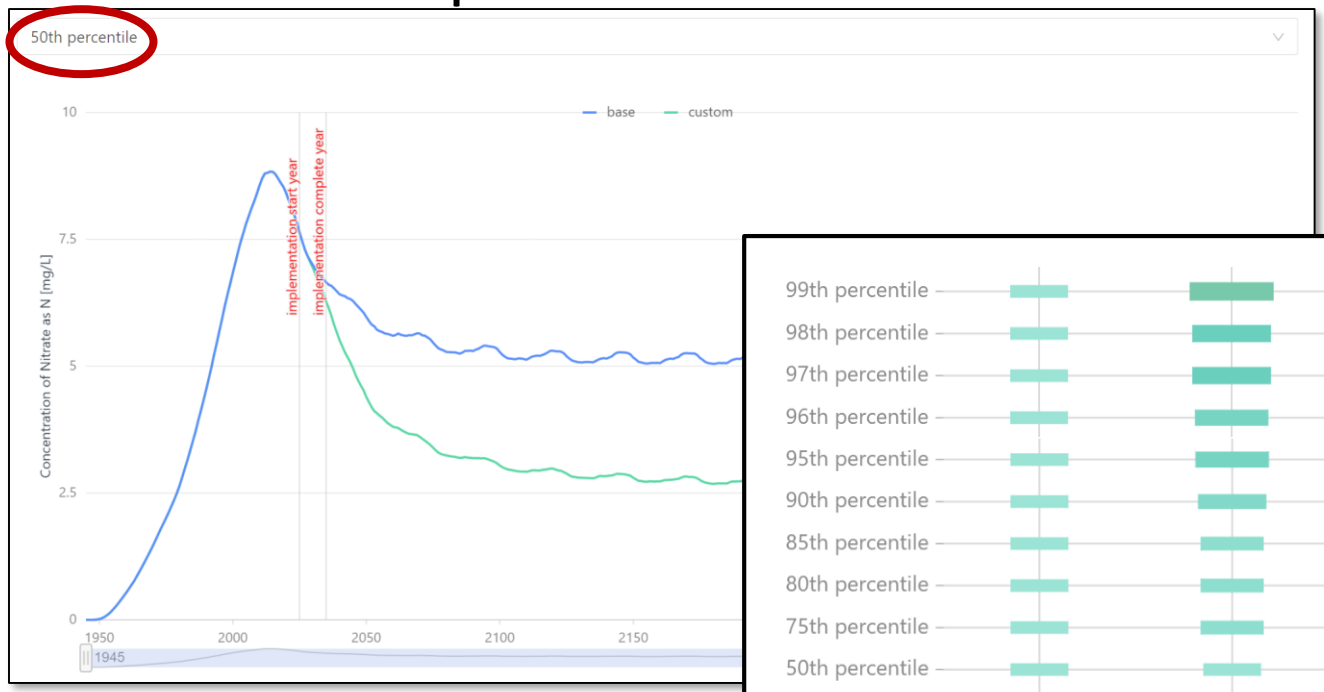
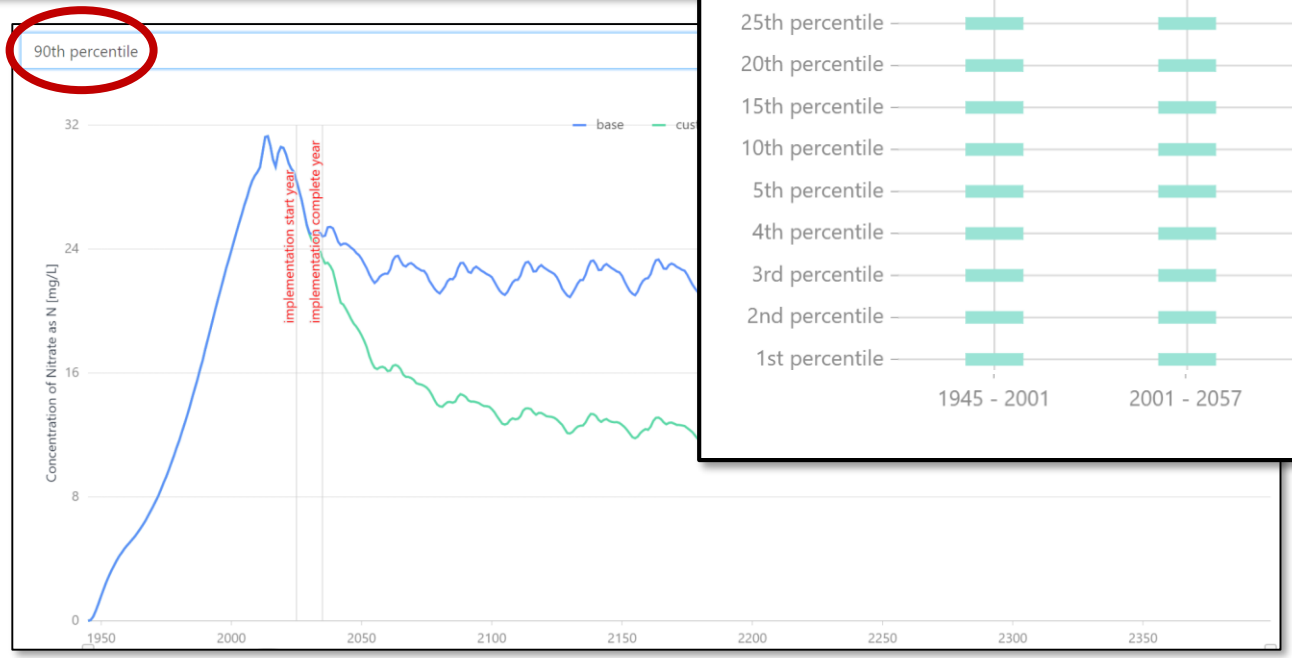
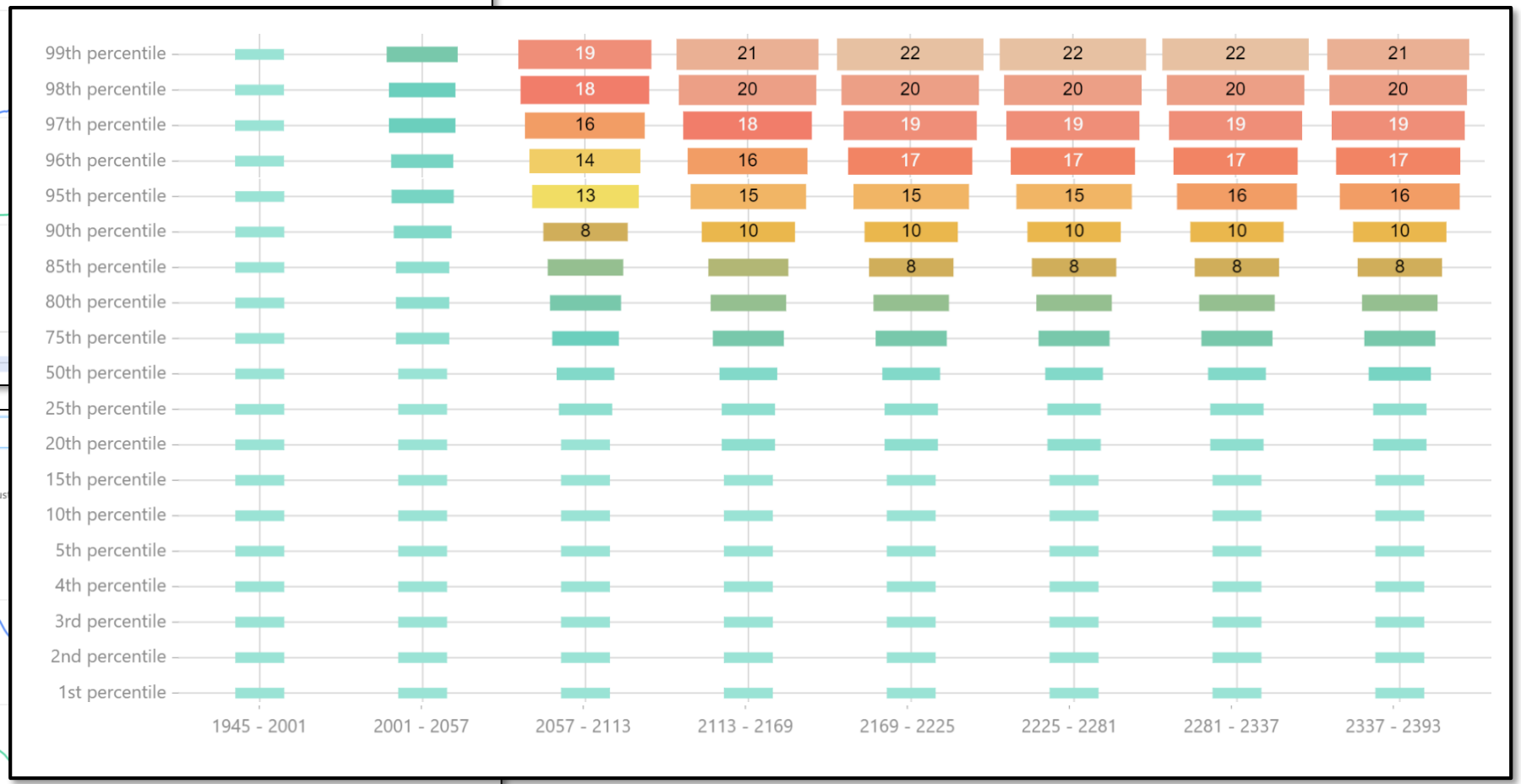
Scenario Comparison

CV-NPSAT web
UCDAVIS





Percentile Distribution of 25-year Reduction in Nitrate-N Concentration



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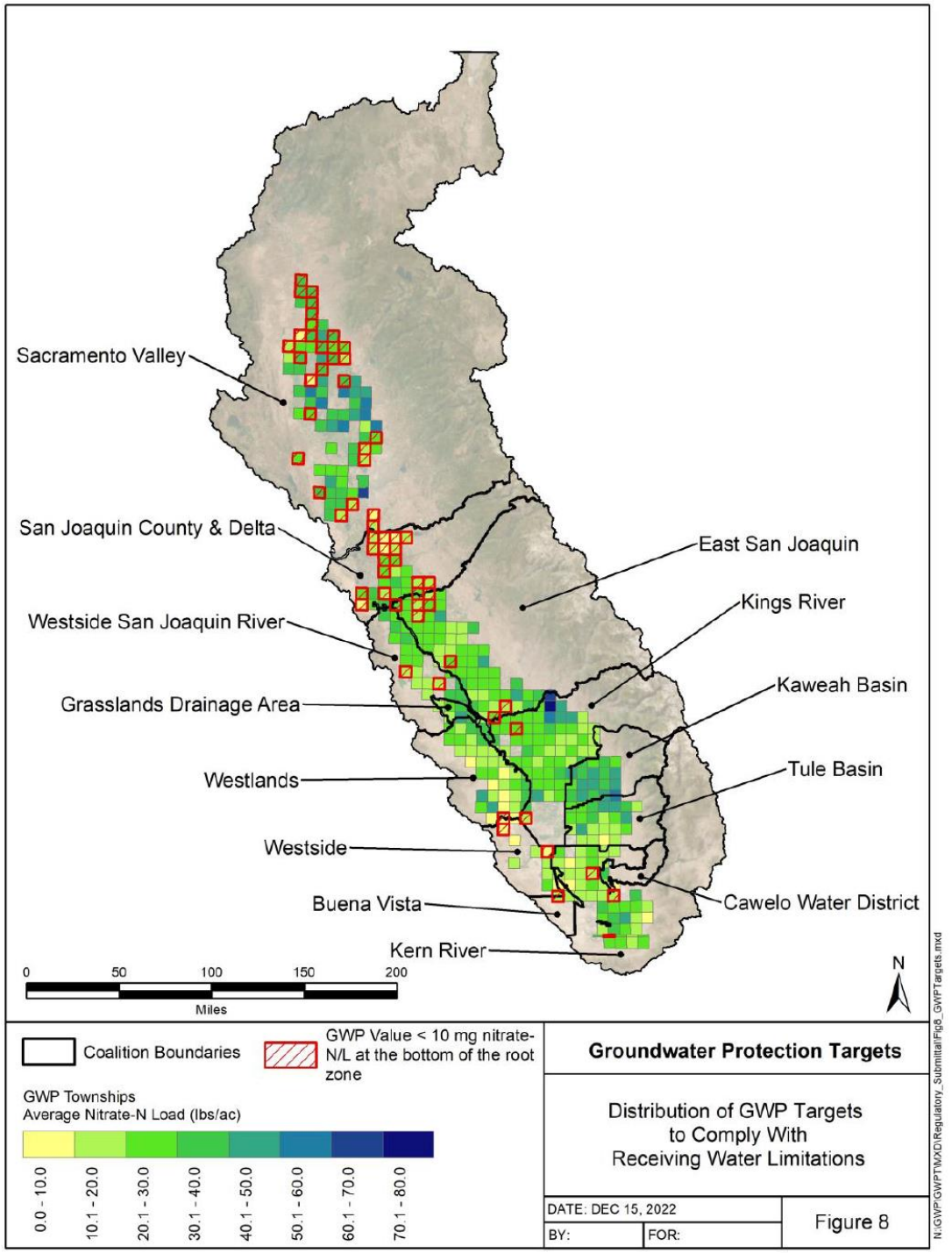
Groundwater Protection Targets



Stakeholder Engagement

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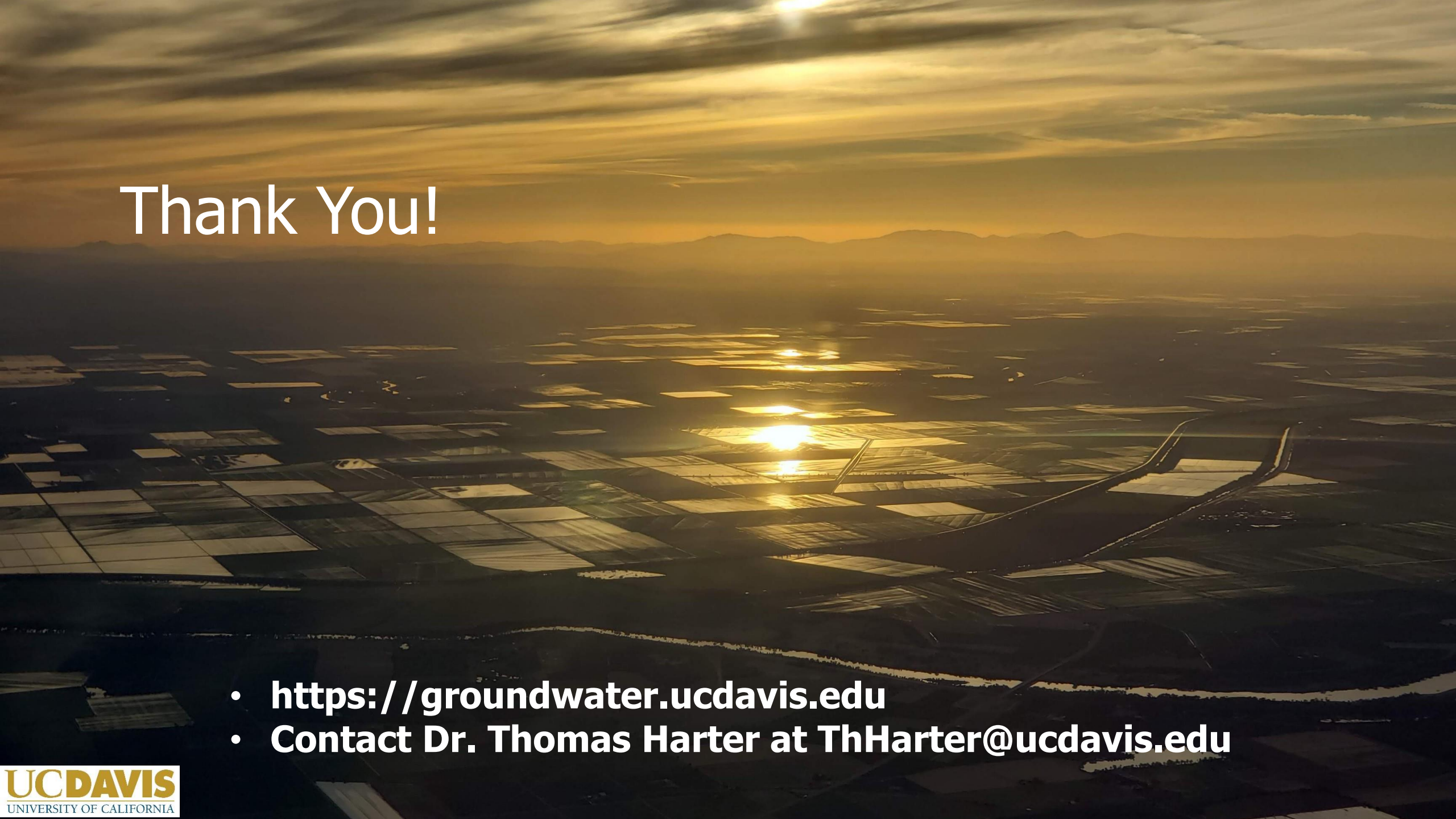

Thank You!

- **https://groundwater.ucdavis.edu**
- **Contact Dr. Thomas Harter at ThHarter@ucdavis.edu**

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Questions?

Please take a moment to fill out the workshop evaluation.

Thank you for attending!