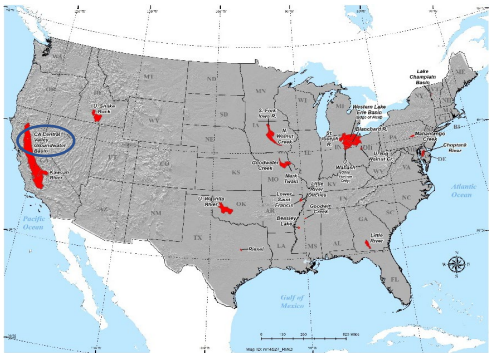
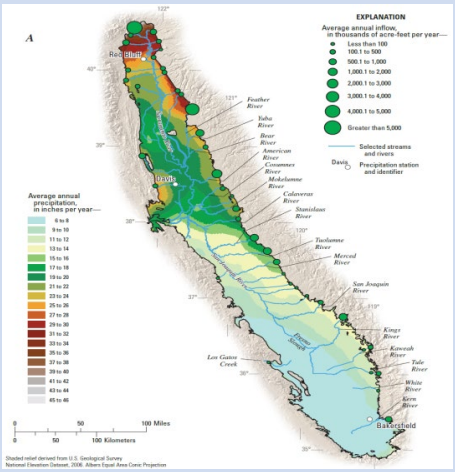
California Central Valley Groundwater Basin: Nonpoint Source Pollution Assessment Tool



Location

This assessment project encompasses the entire 20,000-mi^2 Central Valley groundwater basin in California.

Temperature and Precipitation



Mediterranean climate with dry summers (May-Oct). Average winter precipitation increases south to north from 6 to 30 inches per year. Average lows/highs: January 38°F/56°F and July 66°F/98°F.

Major land uses

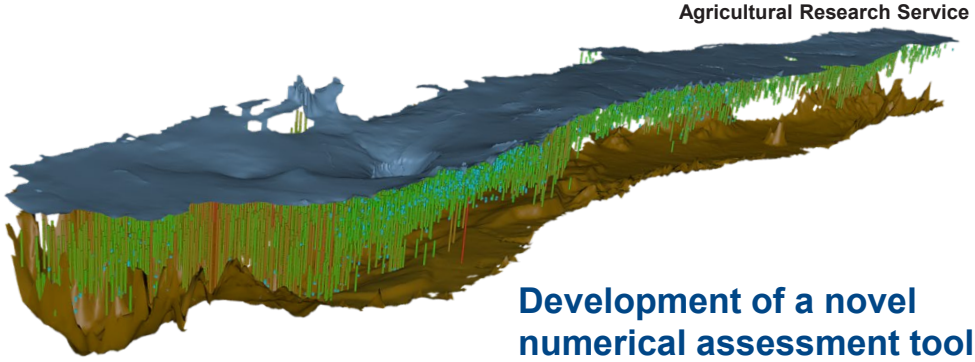
Agriculture: ~$45B with ~250 irrigated crops on ~ 8M acres. Largest acreage is in nuts, tree-fruit, citrus, grapes, rice, vegetables, forage (corn, grain, alfalfa); dairy farming (~20% of US).

Data Tool Being Evaluated

The novel NSPAT tool we developed expands on existing numerical models:

- USGS Central Valley Hydrologic Model (CVHM)
- CDWR Groundwater Model "C2VSim"
- UC Davis Groundwater Nitrogen Loading Model (GNLM)

A Conservation Effects Assessment Project (CEAP) Watershed Assessment Study: A collaboration between the University of California–Davis, the Natural Resources Conservation Service, and the Agricultural Research Service

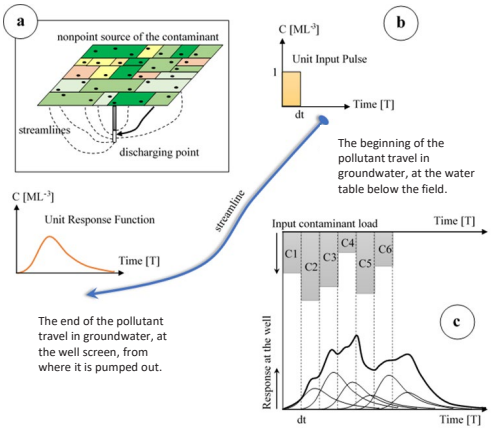


Concerns

Nitrate nonpoint source contamination of groundwater is widespread across the globe and is the leading cause of water quality degradation in California.

Due to the considerable time lag between management actions and groundwater system response (baseflow, well water quality) - often on the order of several decades - decision makers must rely on simulation models to evaluate future water quality improvements from proposed practices.

Existing contaminant simulation approaches are often ill-suited for simulating nonpoint source (NPS) pollution at sufficient resolution of source and aquifer variability across large regions, and too expensive as decision-support tools.



Development of a novel numerical assessment tool

A novel groundwater modeling framework was developed to assess and evaluate the dynamic, spatio-temporally distributed linkages between nonpoint sources above a groundwater basin and groundwater discharges to wells, streams, or other compliance discharge surfaces (CDSs) within a groundwater basin. The framework, the Nonpoint Source Pollution Assessment Tool (NSPAT), allows for computationally efficient evaluation of NPS pollution scenarios and of their effects on improving pollution at CDSs.

The core of NSPAT is a detailed physically based groundwater flow and contaminant transport simulation model. Under the assumption of steady state flow, the flow and transport processes can be tackled separately. An adaptively resolved flow simulation accounts for detailed flux variations near flow sources and sinks (e.g., wells, streams) and due to aquifer heterogeneity is used to identify the pathways of contaminants to wells. The transport simulation is divided into multiple 1D transport computations, each solving for a unit input contaminant mass over one year ("unit source loading function"). The output of the pollutant simulation is a database library ("unit response functions"). The library is used to compute hundreds of years of pollutant breakthroughs at receiving wells and streams from salt and nitrate loading scenarios across a region, also accounting for historic pollutant loading (legacy contamination).

Central Valley Nonpoint Source Pollution Tool

Outcomes/Findings

Application of the numerical tool to local scale basins

- Tule River Basin, 770 mi^2 sub-basin: 9,000 individual nitrate sources were linked to 2,000 agricultural and public water supply wells for statistical assessment of future water quality.
- Modesto, 1,000 mi^2 sub-basin: NSPAT simulated pollution levels over several decades in 3,900 wells and provided statistic measures of nitrate contamination in individual stream segments.
- Tulare Lake Basin, 8,220 mi^2 sub-basin: NSPAT simulated nitrate transport to 7,800 wells and found good agreement with actual historic nitrate data.
- The NSPAT online tool is in development for the entire Central Valley and will allow for prediction of future nitrate at various spatial scales: township, county, sub-basin, management zone, region, study area.

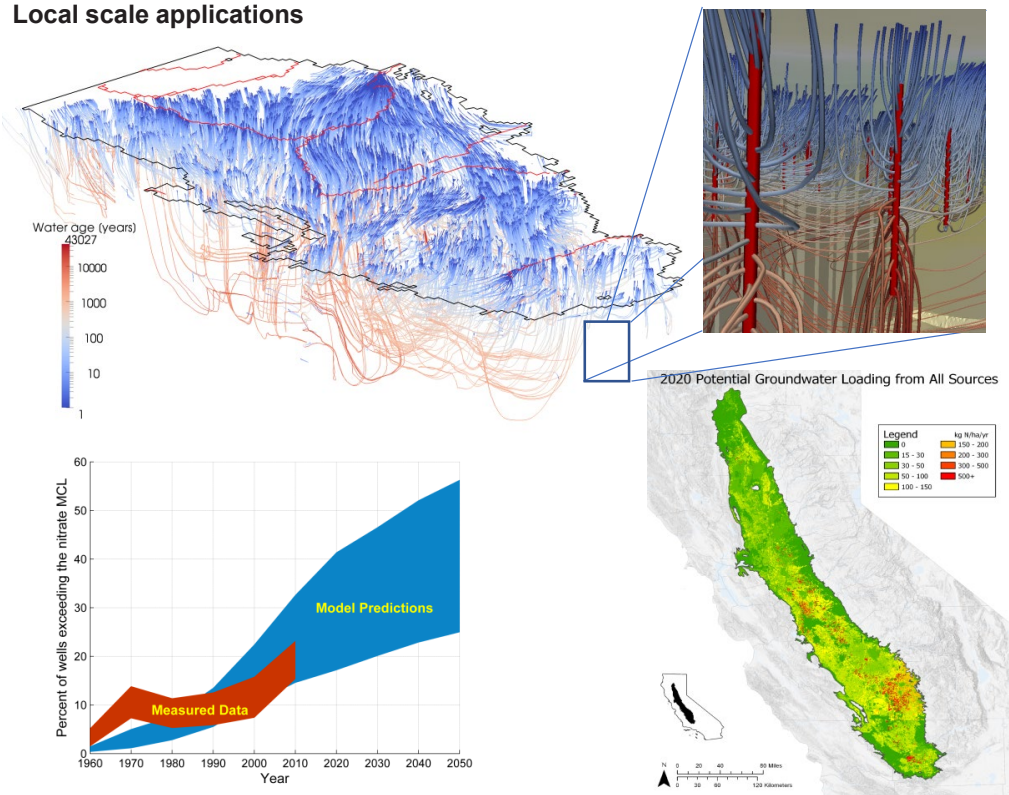
Validation of modeling framework

- We developed extensive "teaching and understanding" examples of nonpoint source pollution in fully 3D, heterogeneous alluvial aquifers.
- The modeling approach was validated against standard modeling tools (MODFLOW-MT3D).
- Evaluation of time and spatial scales was performed to obtain accurate nonpoint source simulation results.
- A web-based user interface is being developed: User-defined scenarios of future agricultural practices and prediction of nitrate distribution in domestic, public, and irrigation supply wells of an area can be quickly assessed over the next 200 years.

Next steps

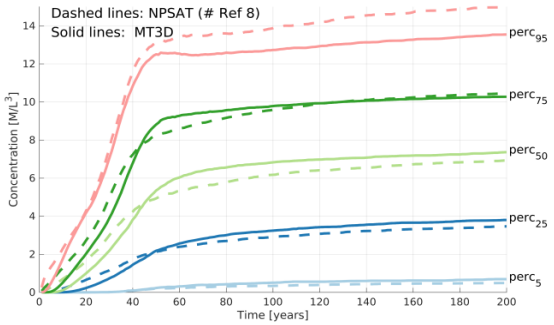
- Simulate the entire Central Valley using NSPAT.

Local scale applications



Clockwise from top left: Contaminant pathways in the 8,220 mi^2 southern Central Valley, close-up of simulated flow paths from the land surface (mostly irrigated agriculture) to well screens (red) with age of the flowpath since recharge (blue = young, red = over 100 years old), potential nitrate loading to groundwater (kg N/ha/year), excess nitrate predicted by NSPAT vs. measured in wells in the southern Central Valley.

- Develop a library of representative flow and transport models based on CVHM and C2VSim for different hydrologic conditions (typical, wet, arid).
- Develop an online platform to be used for predictions by stakeholders.



Comparison of assessment tool against the standard USGS software (MODFLOW with MT3D).

Collaborators and Stakeholders

More Information

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CEAP website: nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap/