



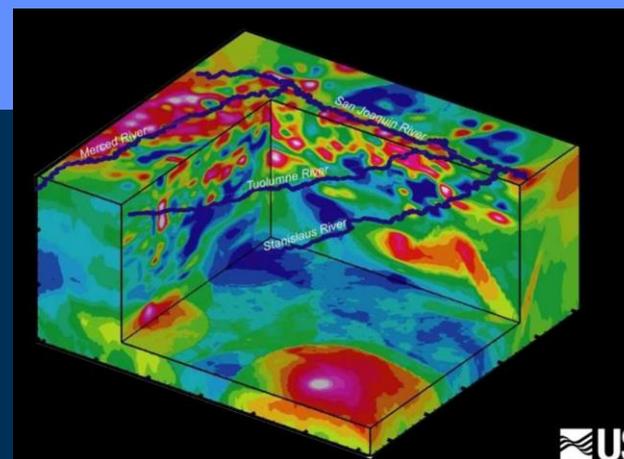
Oil, Gas, and Groundwater Quality in California—a discussion of issues relevant to monitoring the effects of well stimulation at regional scales

Kim Taylor, PhD, USGS California Water Science Center

US Geological Survey California Water Science Center



Mission is to collect, analyze and disseminate the impartial hydrologic data and information needed to wisely manage water resources for the people of the United States and the State of California



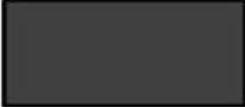
CAWSC Team

- Miranda S. Fram, PhD, GAMA Program Chief
- Matthew K. Landon, Program Chief for Groundwater and Geochemistry
- Justin T. Kulongoski, PhD, geochemist
- Claudia C. Faunt, PhD, Program Chief for Groundwater and Applied Modeling
- Kim Taylor, PhD, Program Officer

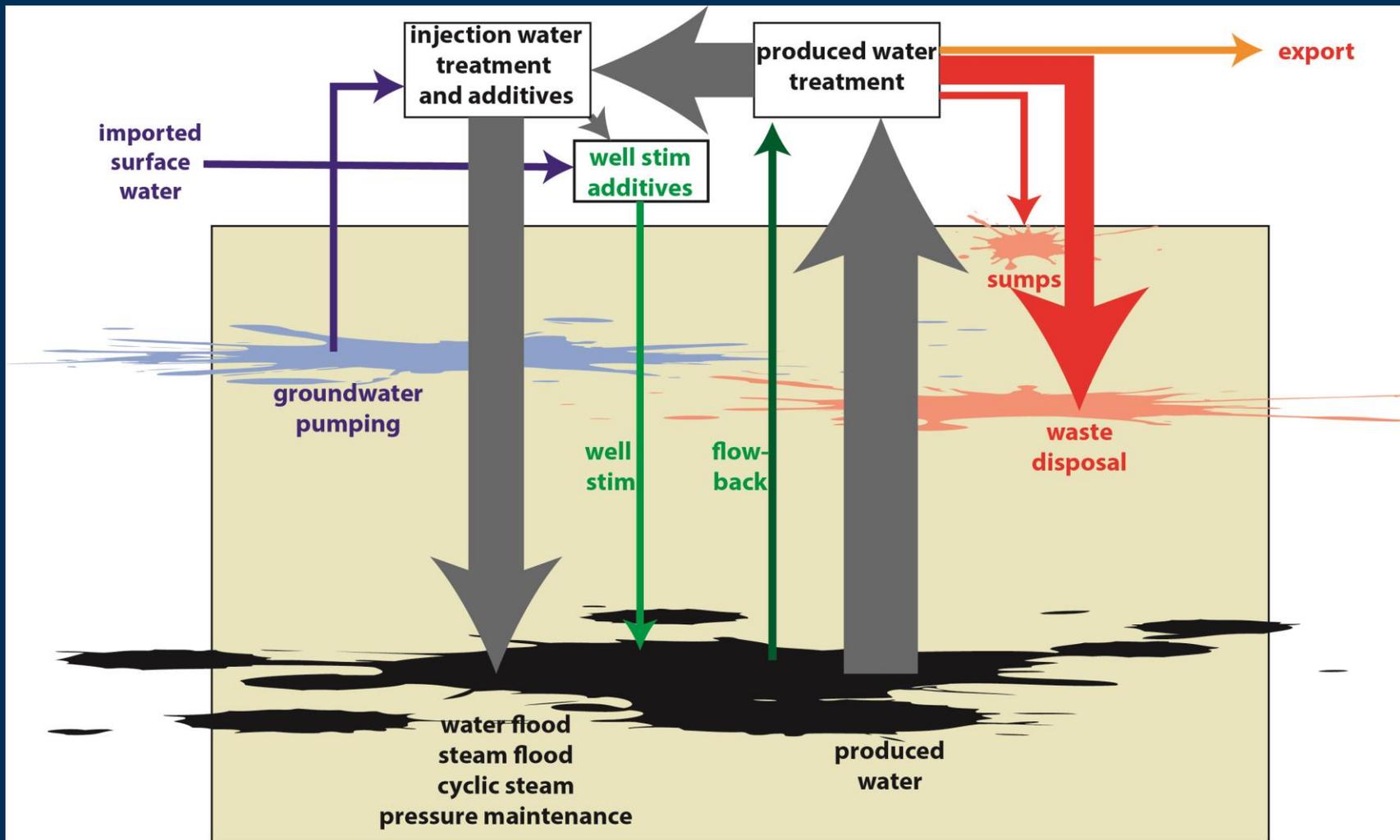
Key Policy Questions for the SWRCB

- What groundwater resources are to be protected?
- How should areas that have already been affected by oil and gas development be managed?
- How should the programs address the fact that potential effects of well stimulation on groundwater resources are occurring in the context of effects from other oil and gas development practices?

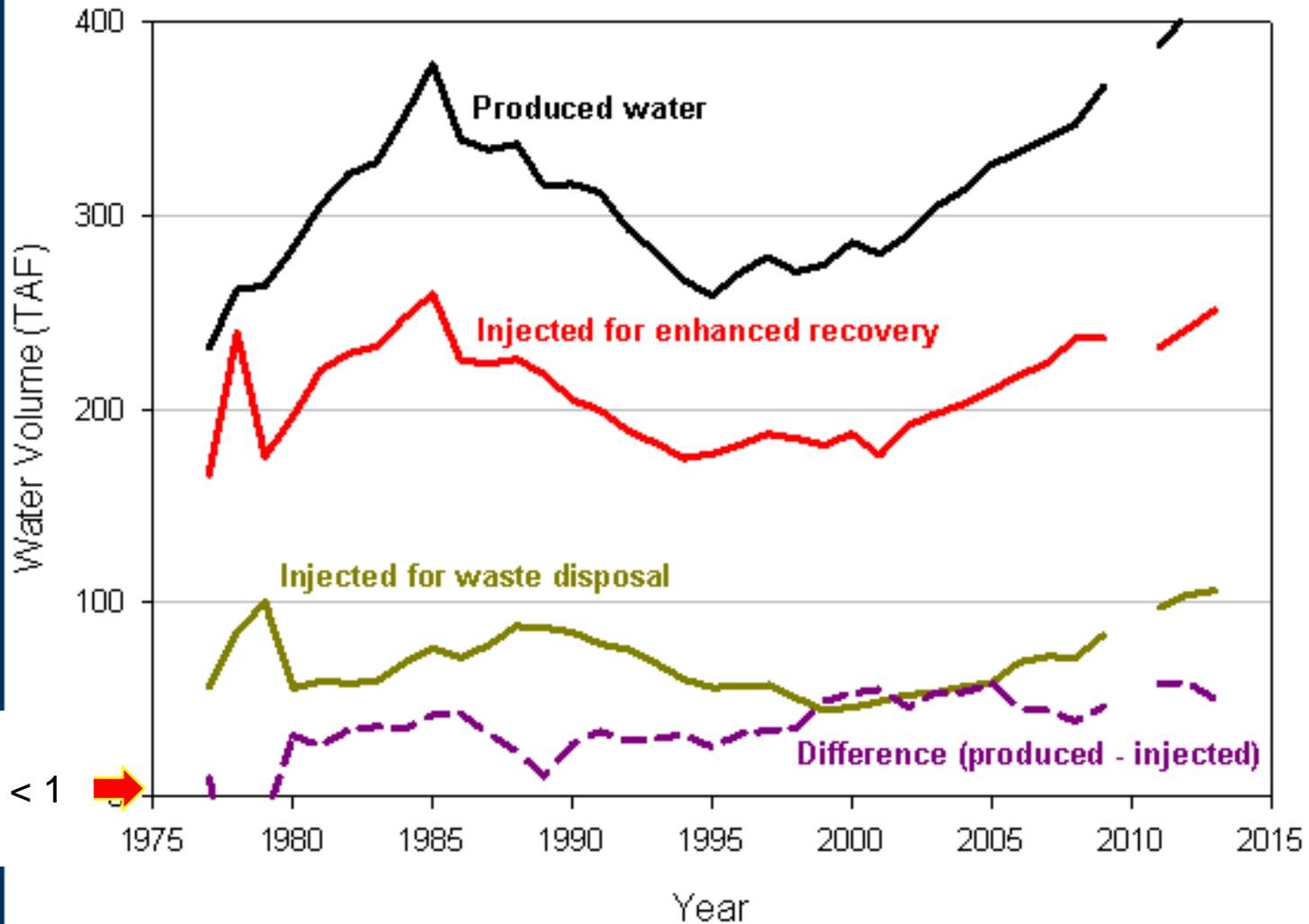
Source + Pathway + Useable Resource

	Zone		Data Availability
depth 	near-surface		mixed: data associated with specific contamination & waste disposal sites, shallow public supply wells, some broader assessments in some places
	zones currently used for public water supply		extensive baseline data from GAMA and DDWR: raw data available but not synthesized and pathways not identified
	lowest quality irrigation source water/ supply for brackish desalination projects	----- 3,000 mg/l TDS ----- 10,000 mg/l TDS	extremely limited information including lack of location and extent of resources, boundaries of zones defined by TDS levels
	characteristics of zones between groundwater resources and oil and gas activities		raw data available but not synthesized and pathways identified
	hydrocarbon producing zones		extensive information held by oil and gas operators

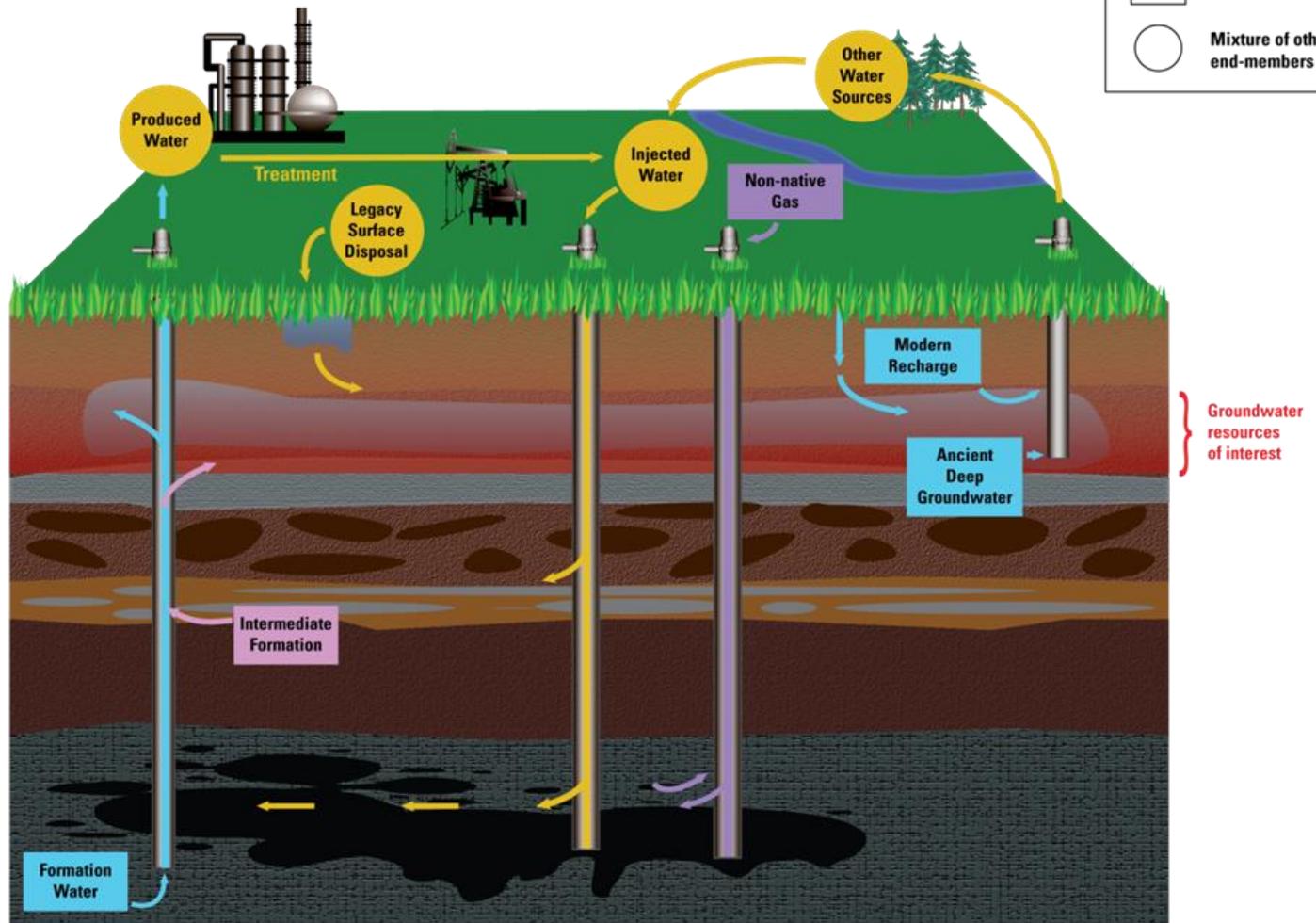
Distinguishing the environmental effects of one human activity from another is always a significant scientific challenge



Annual Total Water Volumes Reported for California Onshore Oil and Gas Fields

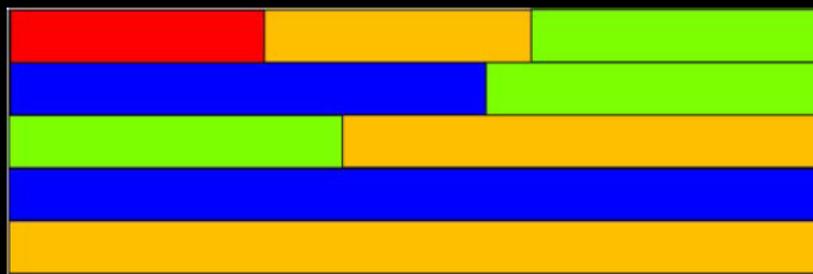


Geochemical End-member Mixing Model

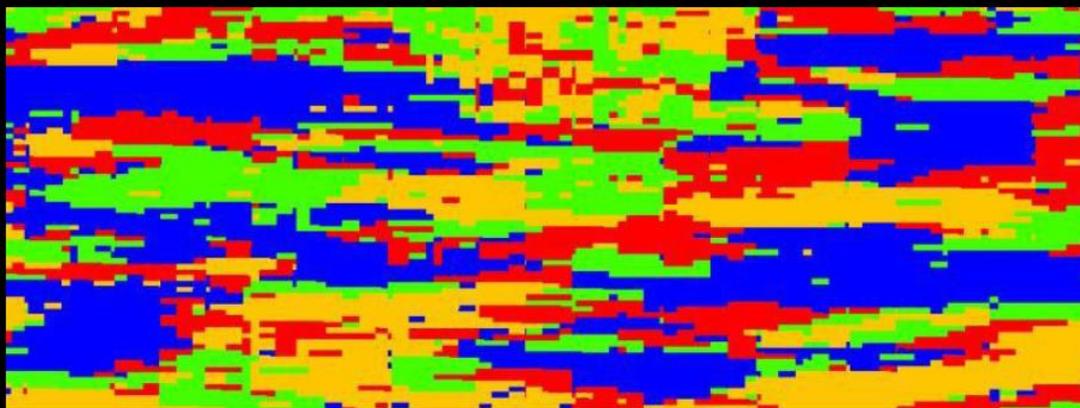


Geologic Framework Models

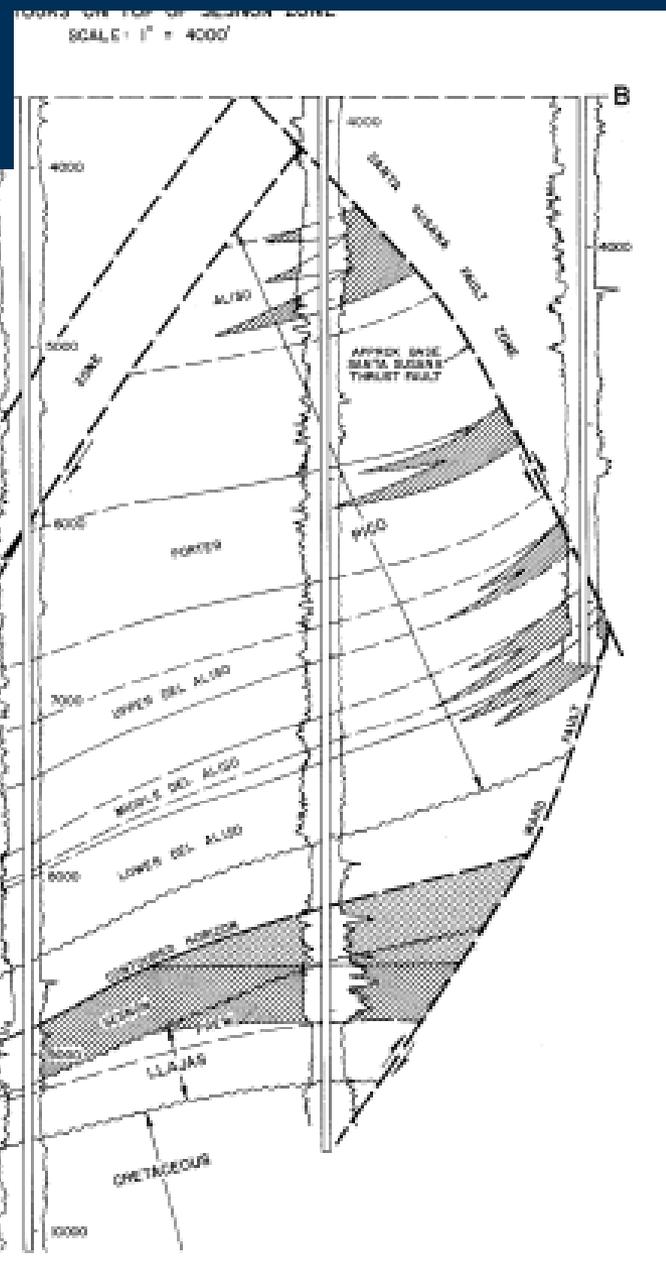
Typical "layer-cake" model construction



More realistic model construction

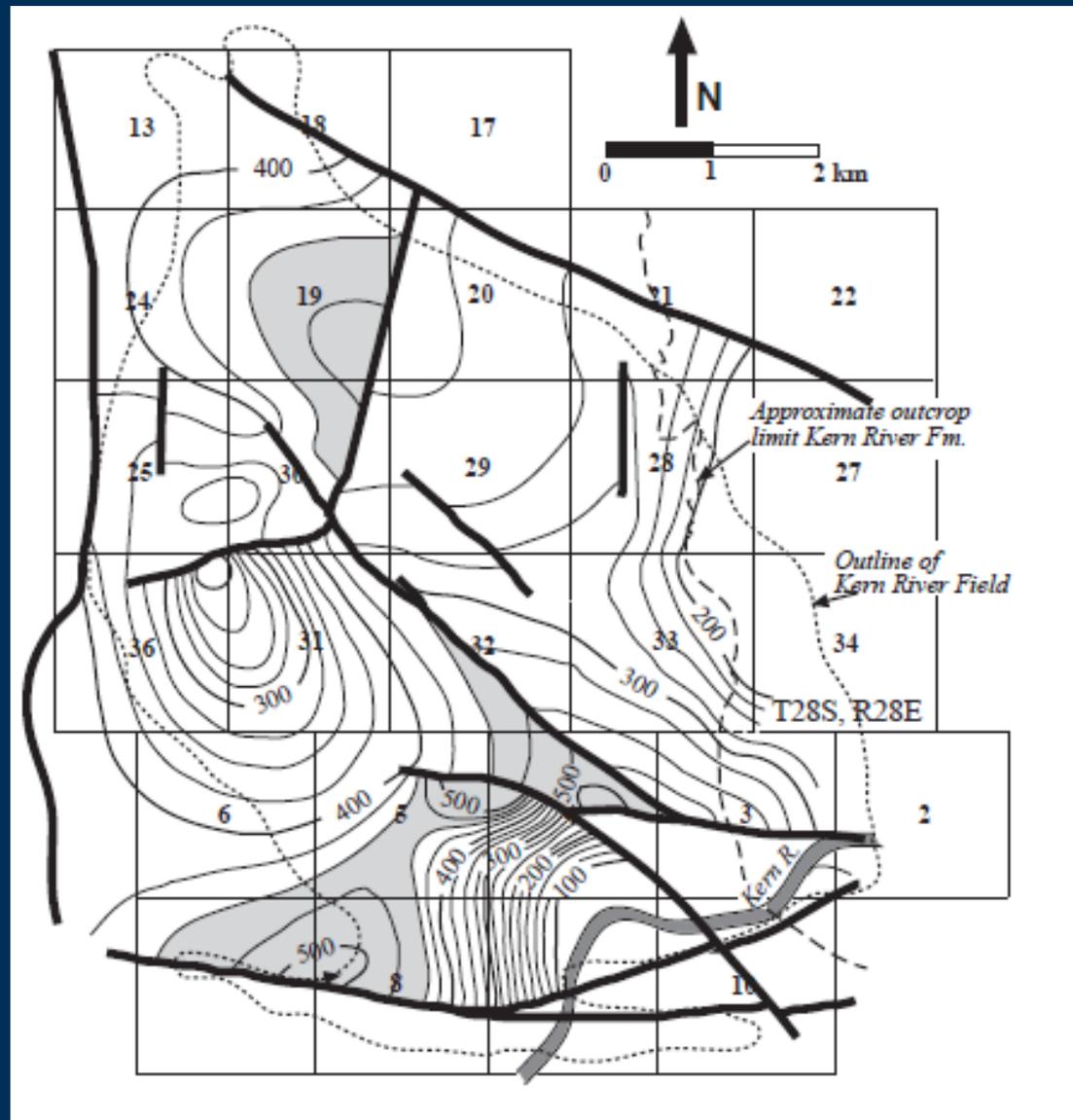


- Flow is not strongly controlled by modeler's decisions
- Solute transport not as dependent on assigned dispersion

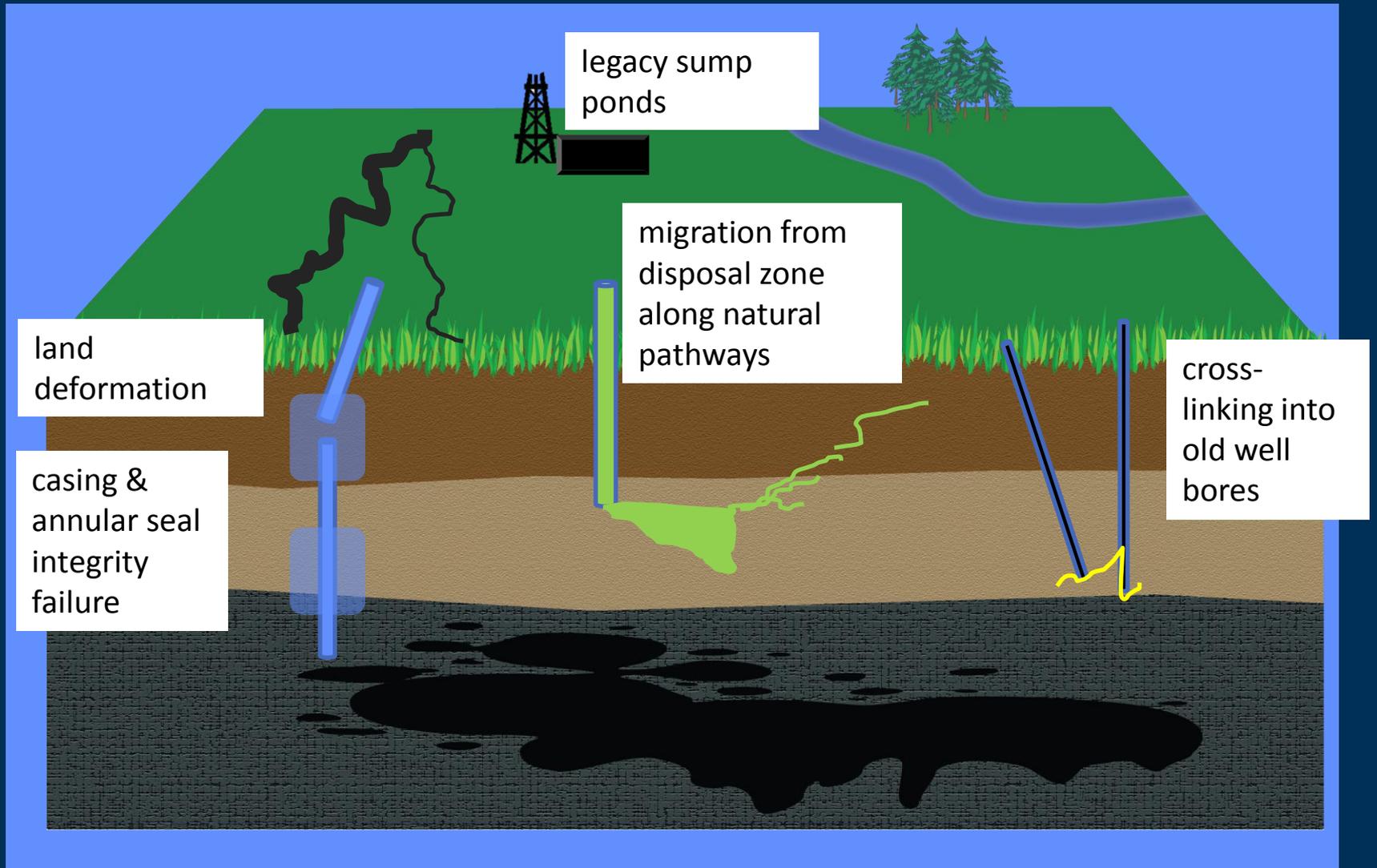


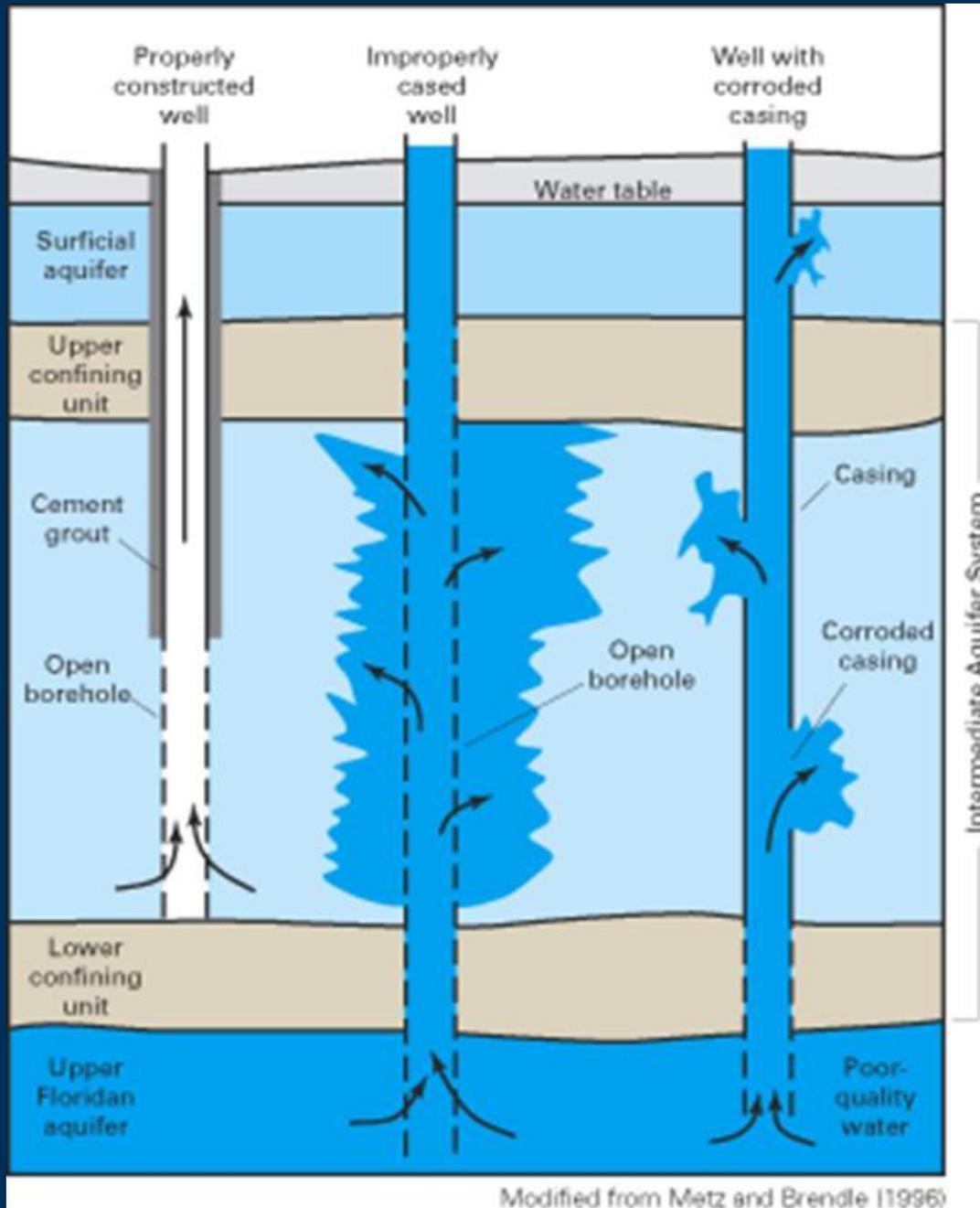
Hydraulic Gradients

Potentiometric surfaces in Santa Margarita Formation, Kern River oil field (Coburn and Gillespie, 2002)



Pathways of Specific Concern in California

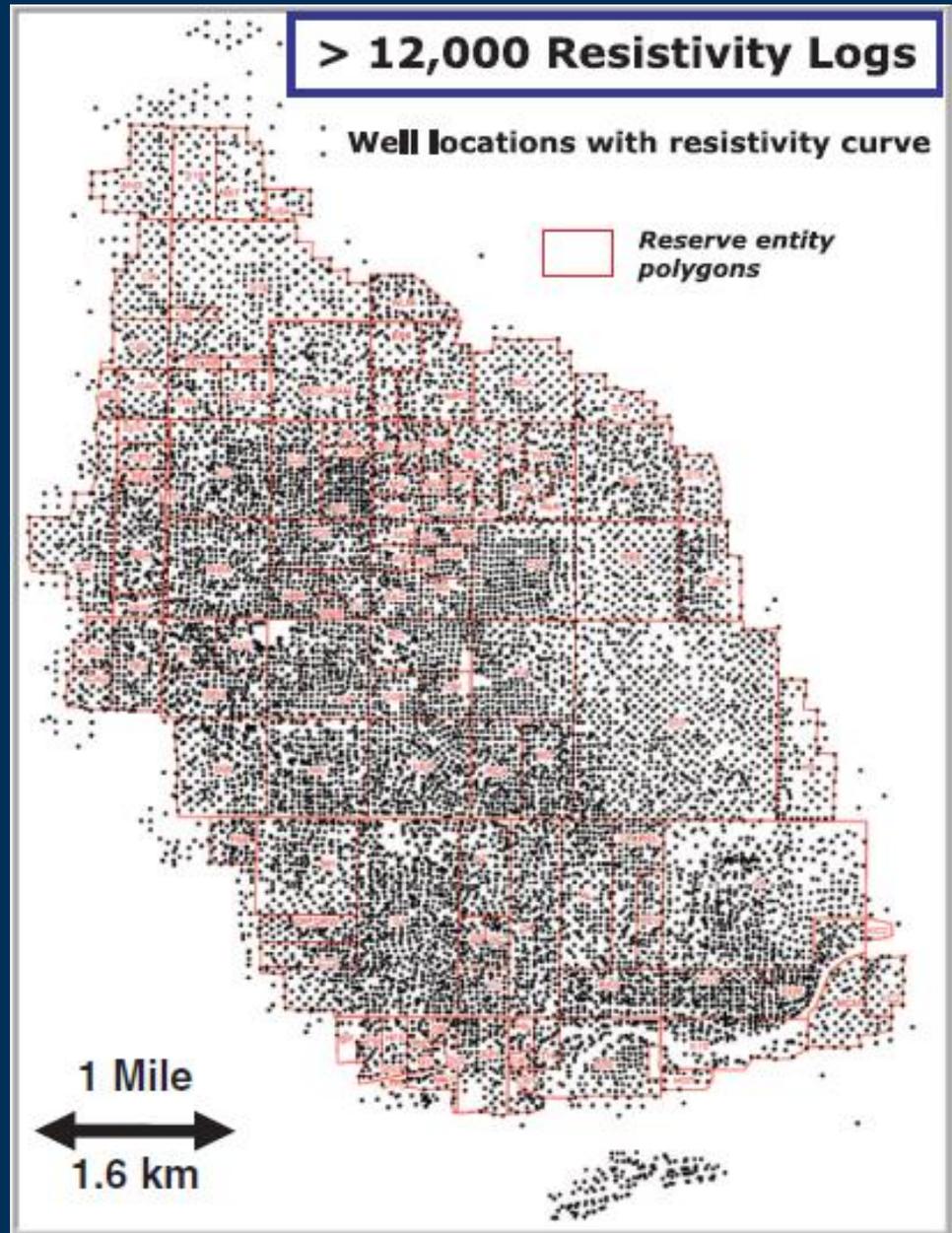




Modified from Metz and Brendle (1996)

Wells in Kern River Oil Field with resistivity logs (Beeson and others, 2014)

Of the 168 currently active oil fields greater than 2 mi² in size, 31 contain more than 100 known wellbores per square mile



USGS Discussion Paper

- http://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/docs/usgs_discussion_paper.pdf