



The Kern Water Bank and Oil Fields

Oil, Gas, and Groundwater in California



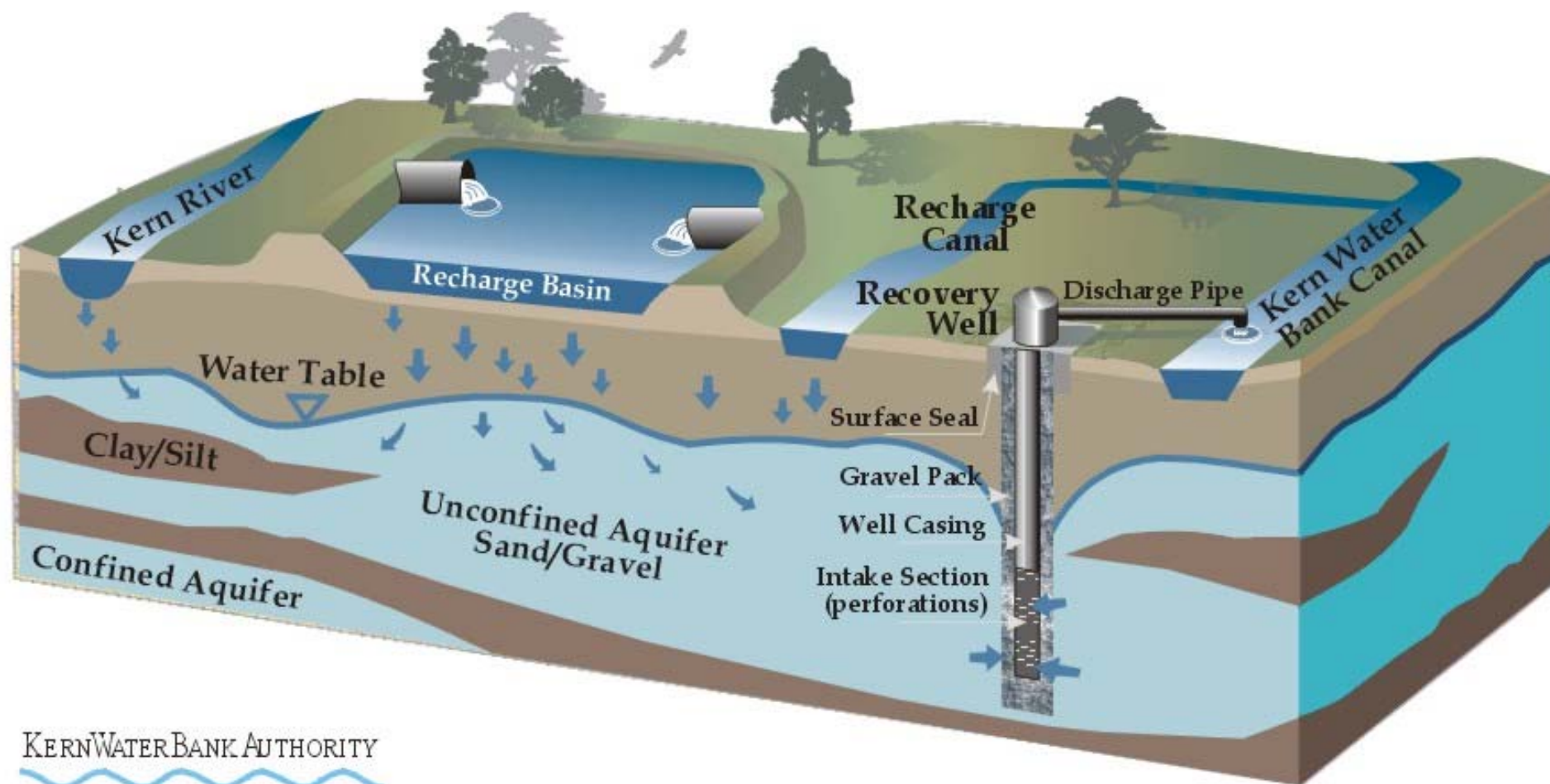
Presentation Outline

- What is water banking?
- The Kern Water Bank
 - Infrastructure and capacities
 - Groundwater levels and quality
- The KWB and oil fields
 - Legacy problems
 - SB-4, UIC, and the KWB
 - Summary
- But first...



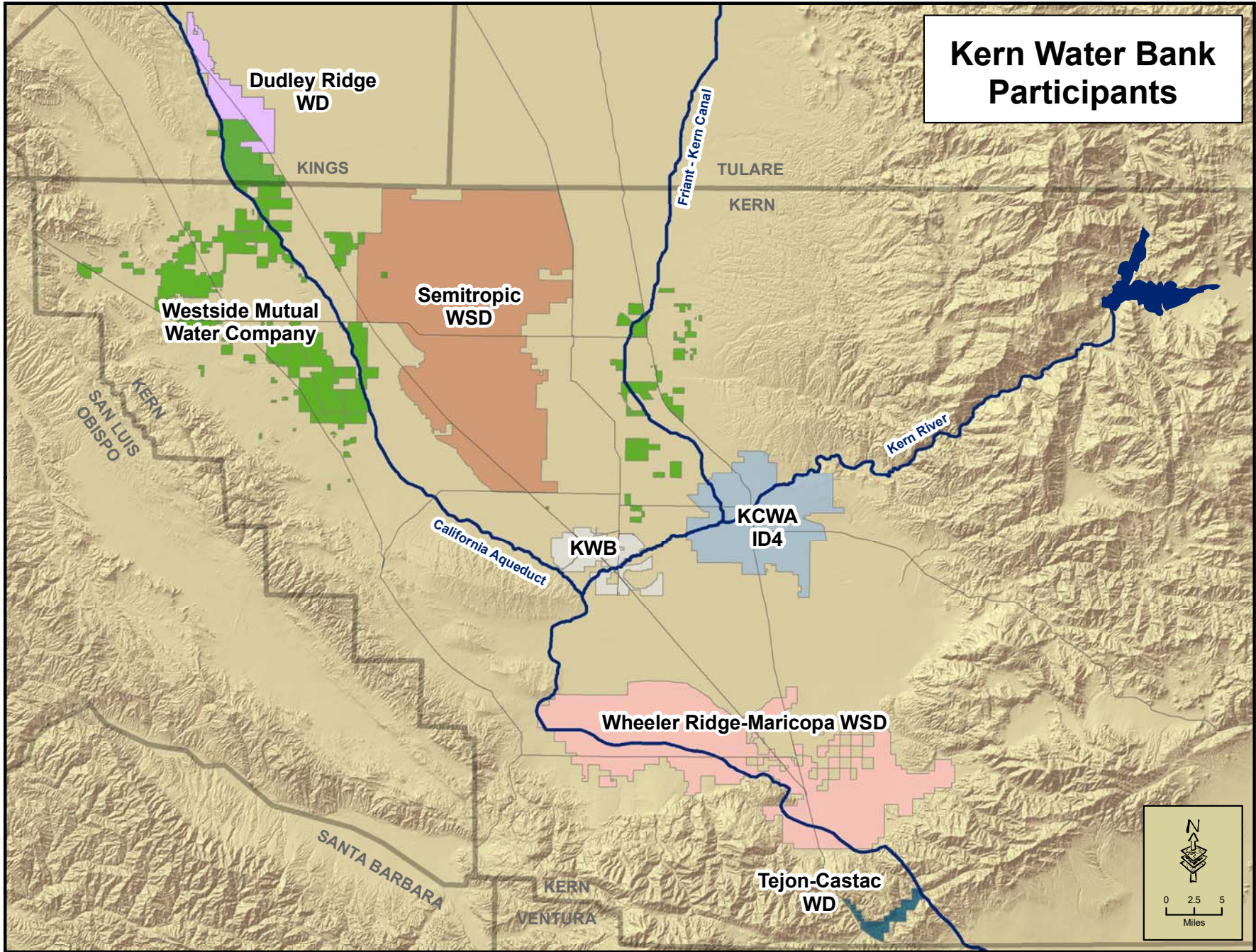
Some Early Perspectives on Oil and Groundwater, circa 1915

- SEC. 15. It shall be the duty of the owner of any well ... to properly case such well ... and to use every effort and endeavor ... to effectually shut off all water **overlying** or underlying the oil or gas-bearing strata, and to effectually **prevent any water from penetrating such oil or gas-bearing strata**.
- SEC. 16. It shall be the duty of the owner of any well ... before abandoning the same, to use every effort to shut off and **exclude all water from entering oil-bearing strata encountered in the well**.



KERN WATER BANK AUTHORITY

Kern Water Bank Participants





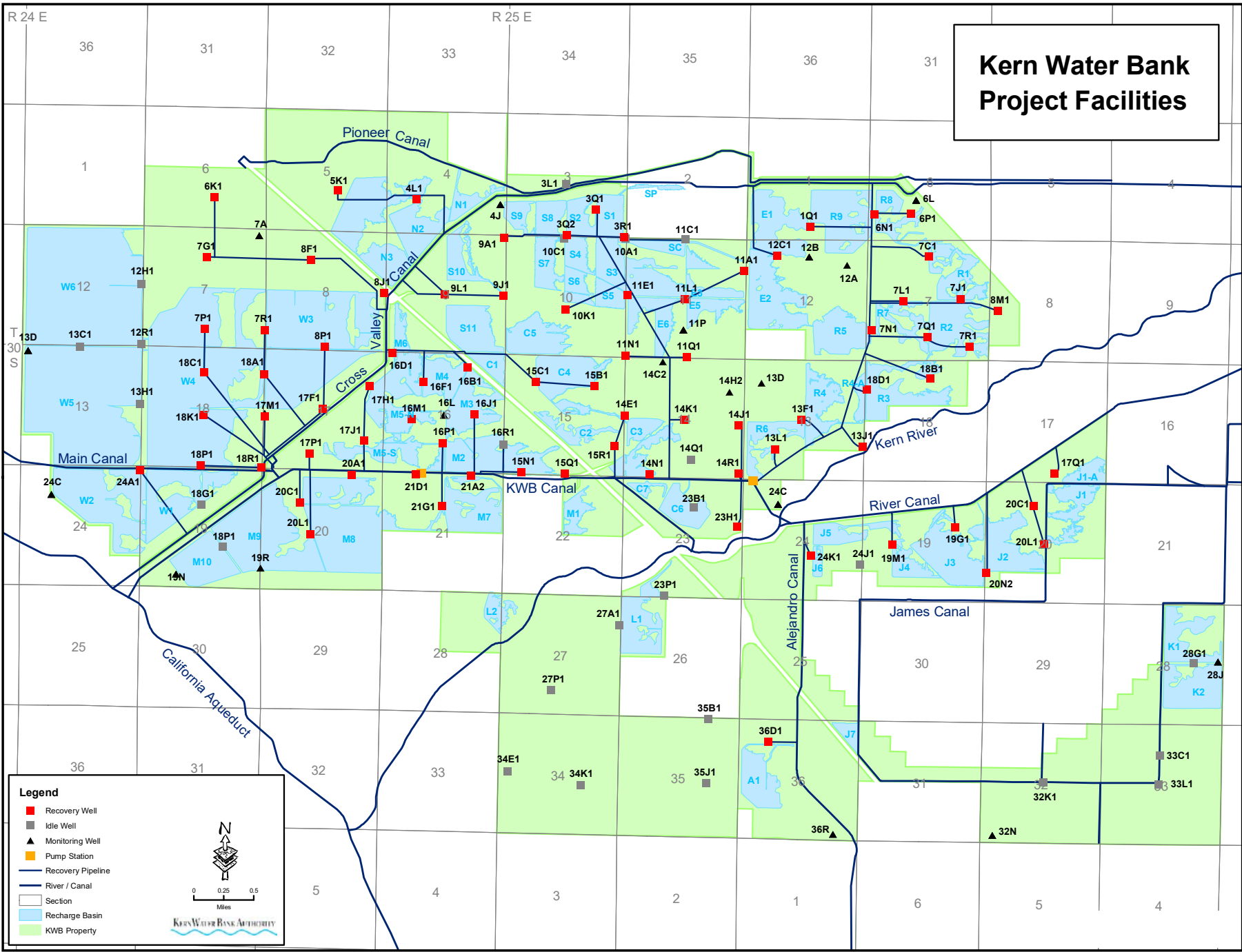
Infrastructure & Capacities


➤ Recharge

- Shallow recharge basins occupy 11 square miles
- Can recharge up to 60,000 AF/month (465 million bbls)
- 500,000 AF maximum annual recharge capacity (3.9 billion bbls)
- ~1.5 MAF storage capacity (11.5 billion bbls)

➤ Recovery

- 85 wells with an average depth of 750 feet; deepest ~900 feet
- 33 miles of pipelines (18" – 60" diameter)
- Annual recovery capacity ranges from ~240,000 AF (1.9 billion bbls) to 125,000 AF (1 billion bbls)
- Average well 5 cfs (77,000 bbls/day)
 - Enough water in 1 day to serve 10 households for one year

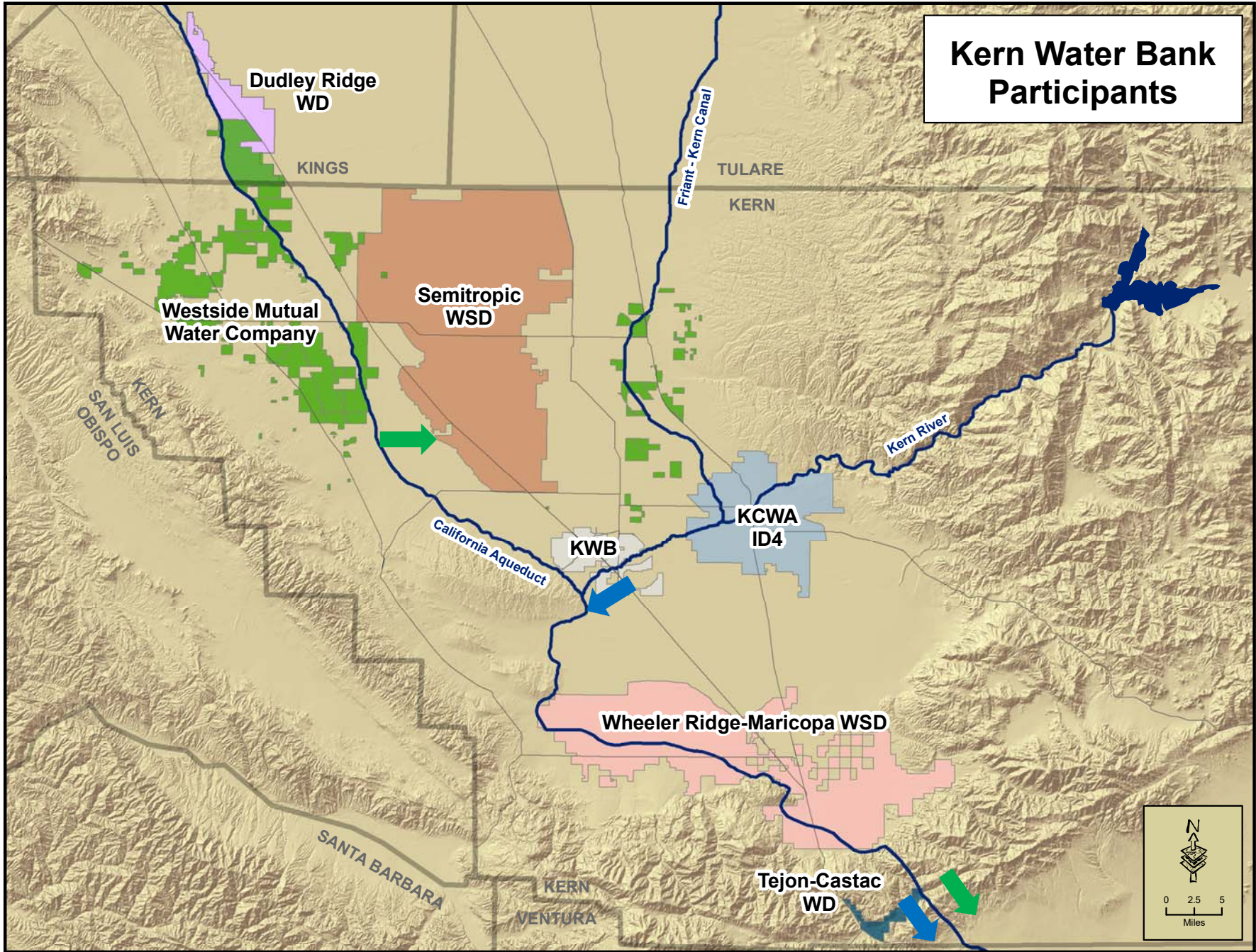




Groundwater Levels and Quality

- ▶ Groundwater levels have ranged from 20 to 280 feet
- ▶ Groundwater quality
 - ▶ Sample 85 recovery wells for Title 22 constituents every 3 years
 - ▶ Sample 57 monitoring wells for constituents of concern twice a year
 - ▶ No pesticides or other organic chemicals
 - ▶ Overall water quality excellent
 - ▶ **Extremely critical aspect of groundwater banking**

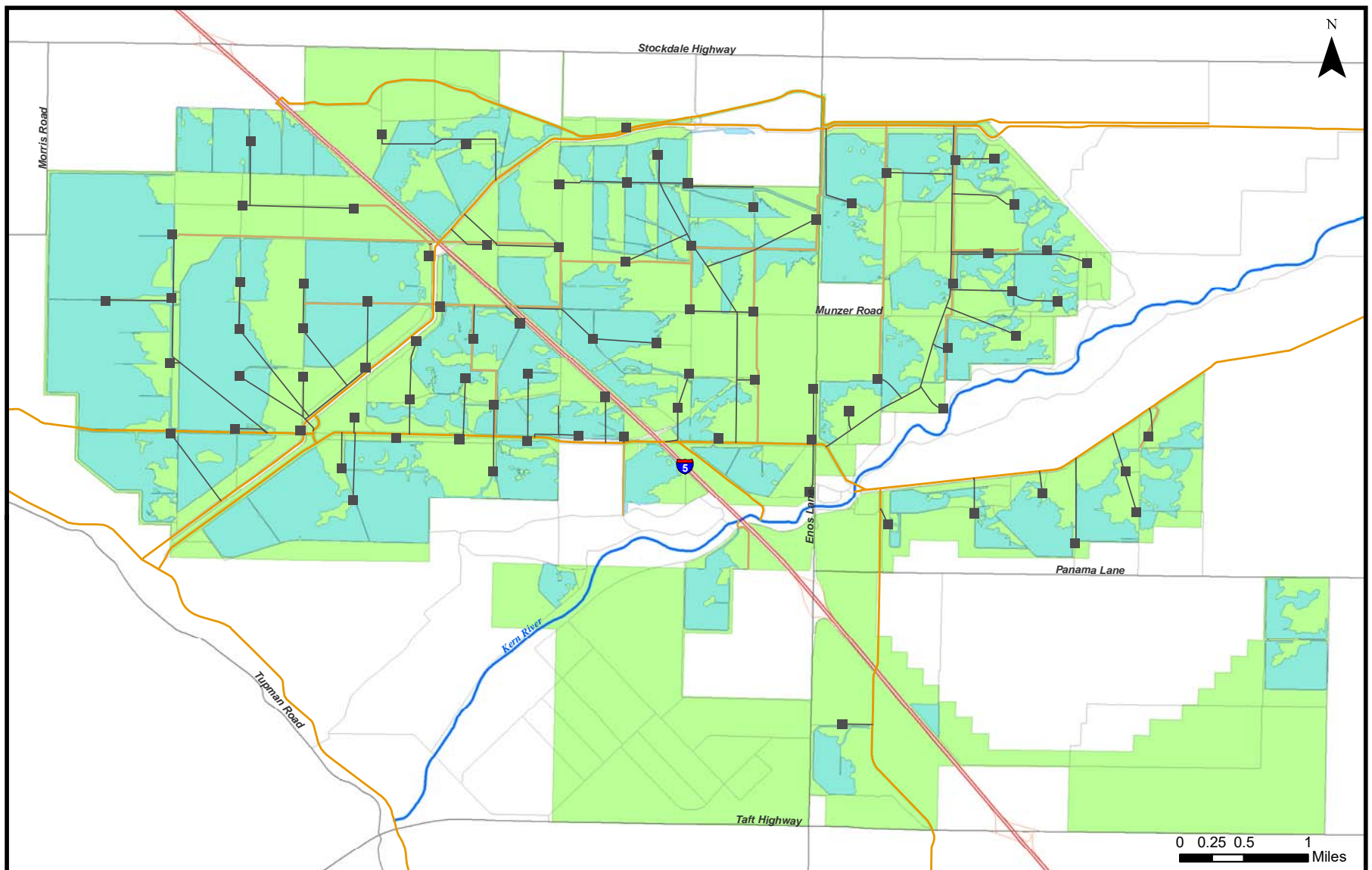
Kern Water Bank Participants





The KWB and Oil Fields

- Several oil fields adjacent and underlying the KWB
- Production dates back to 1936; mostly from the late Miocene Stevens sands
- Gas from 3,100 to 5,900 ft; oil below 8,000 ft
- 35° API or greater
- “Base of fresh water” 1,200 to 2,000 ft



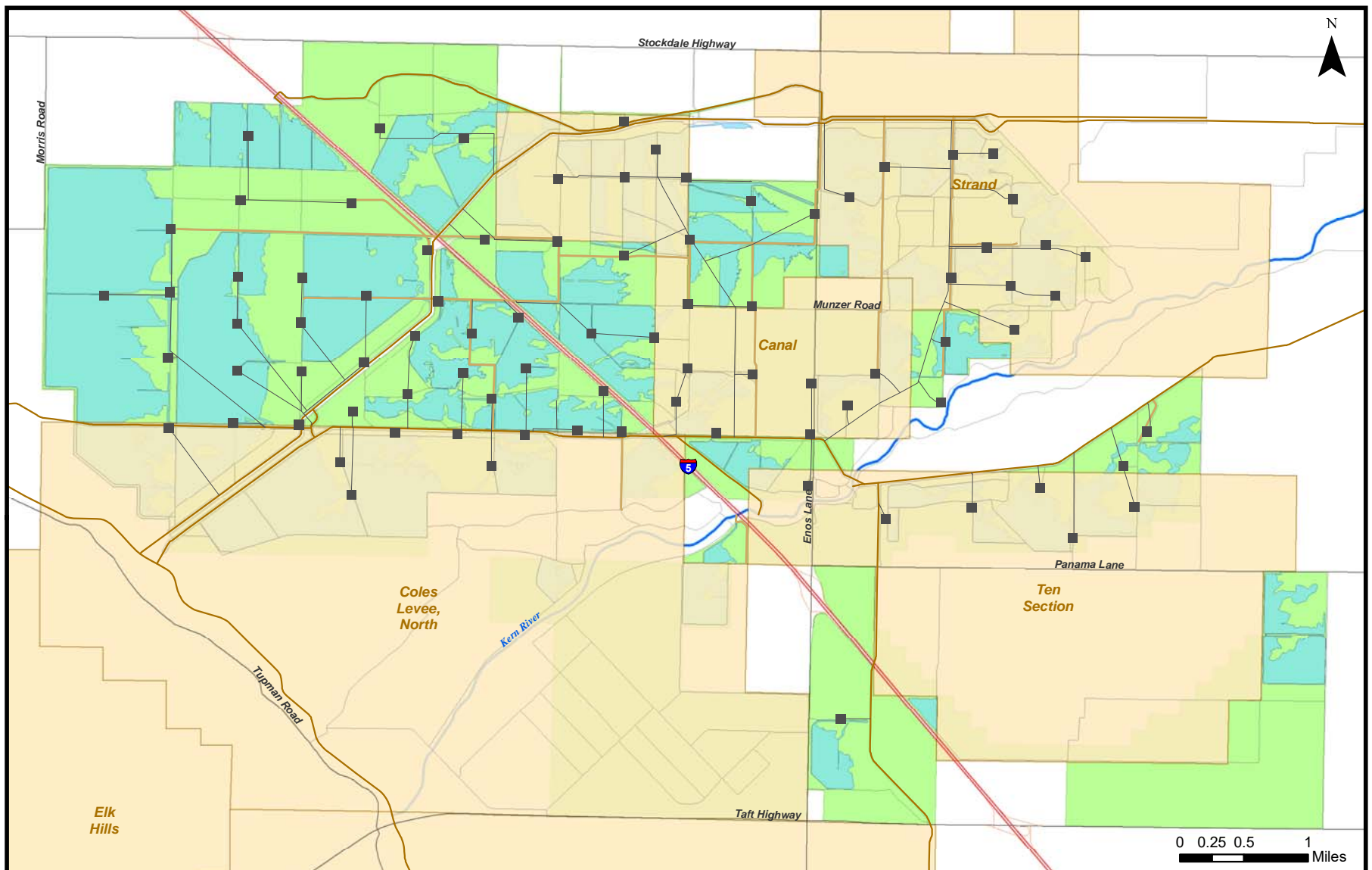
DOGGR - Administrative Boundaries

KERN WATER BANK AUTHORITY

Date: 2/13/2015

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- Existing Wells
- Canals
- Recovery Pipelines
- Rivers / Major Canals
- Existing Recharge Basins
- KWB Property



DOGGR-Administrative Boundaries

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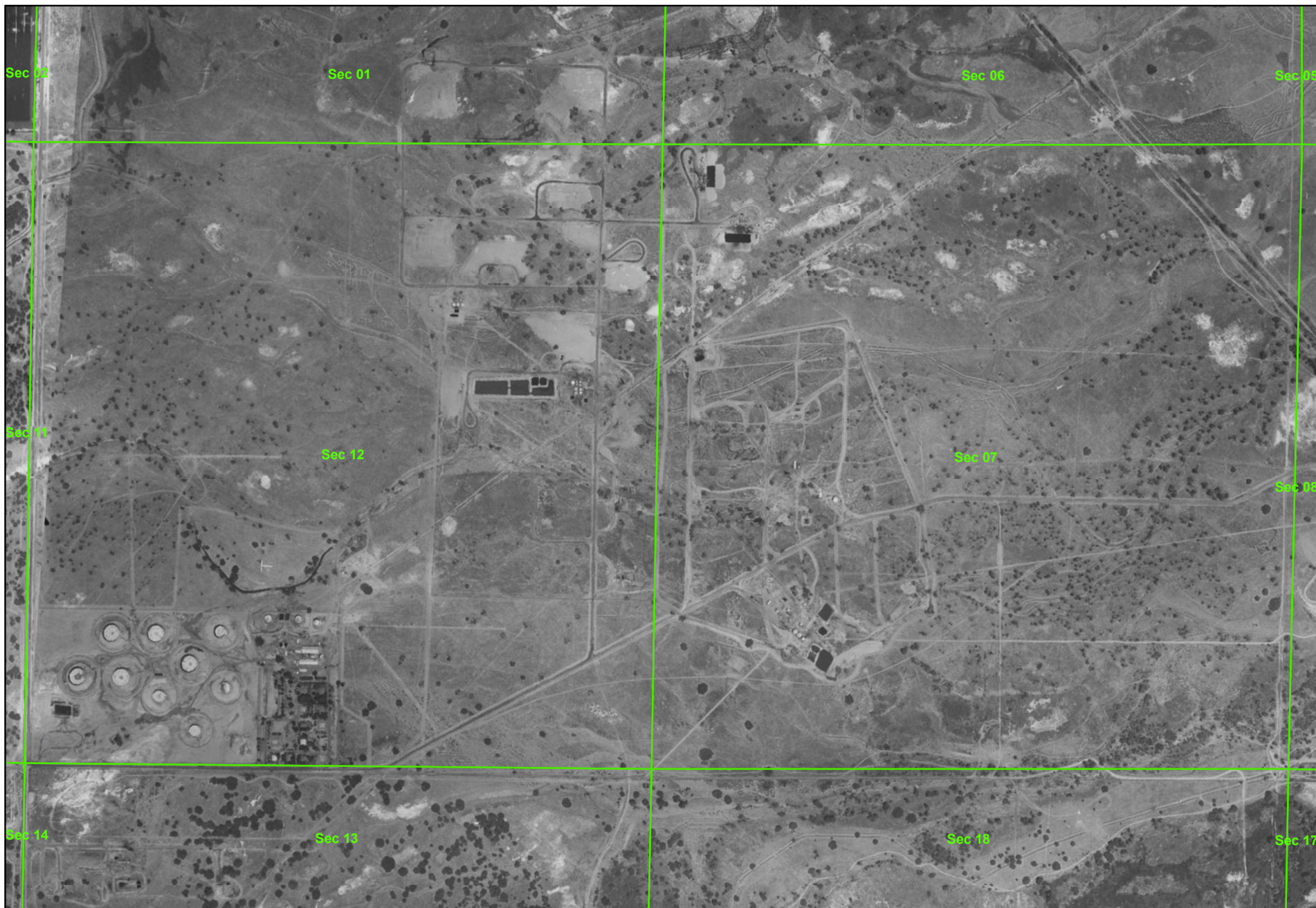
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- Existing Wells
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- Existing Recharge Basins
- Administrative Boundaries - Department of Conservation (DOGGR) Updated 01/15/14



Legacy Issues

- Pipelines
- Tanks
- Vacuum trucks discharging to roads
- Sumps
- Dumps



Aerial Photos - May 18th, 1956

























Well TDS Levels

Legend

Existing KWB Recovery Wells per Interval	
0 - 100	1 Well
100 - 200	26 Wells
200 - 300	23 Wells
300 - 400	18 Wells
400 - 500	2 Well
500 - 1000	3 Wells
1000 +	0 Wells
No Data	
U	Production Wells
T	Monitoring Wells

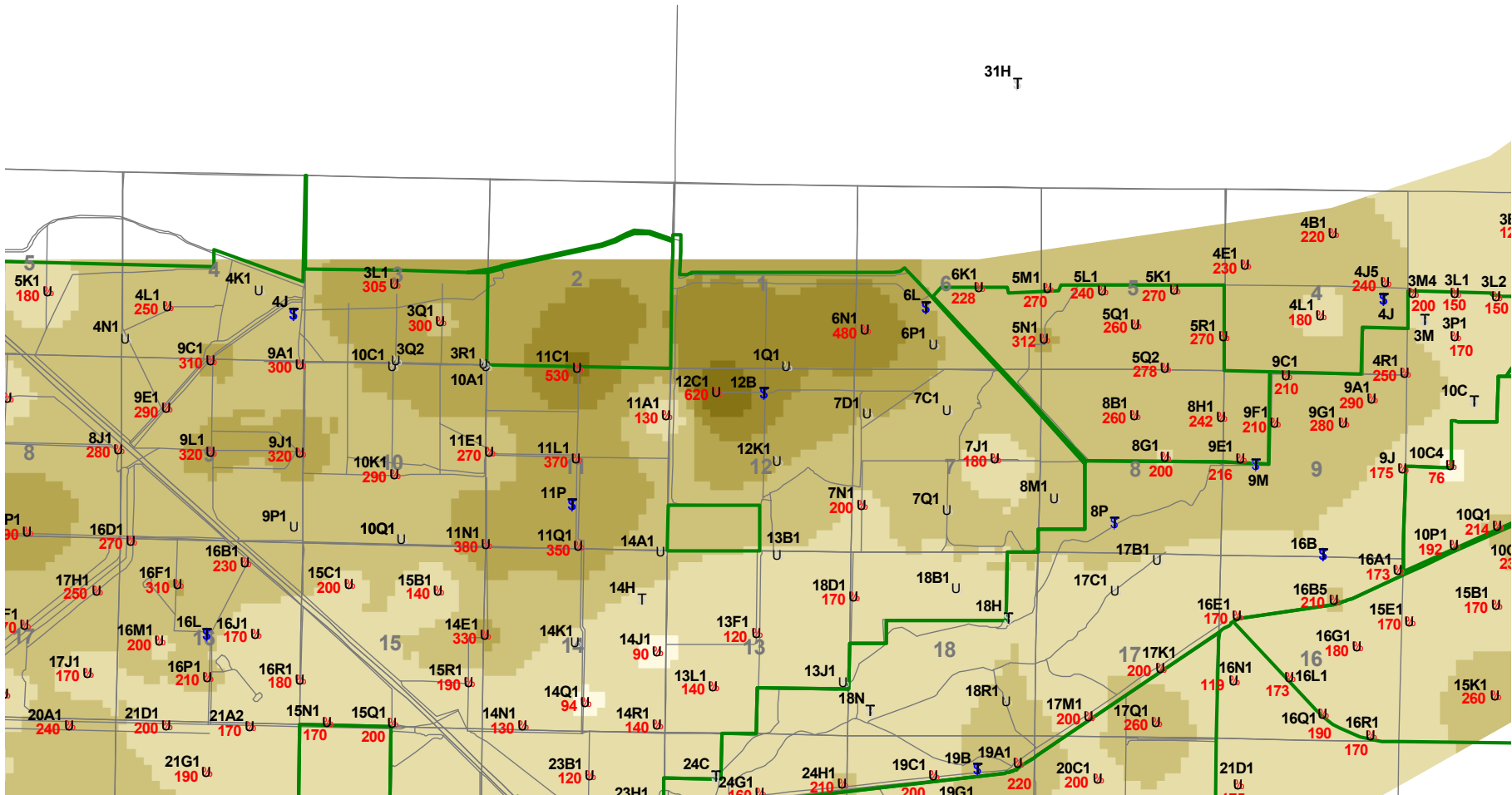
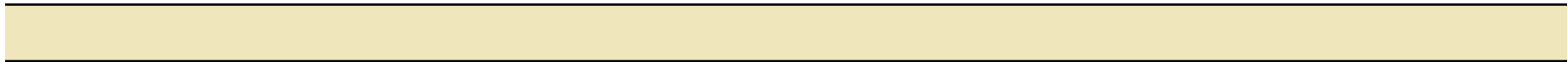
Note: MCL = 500 mg/L

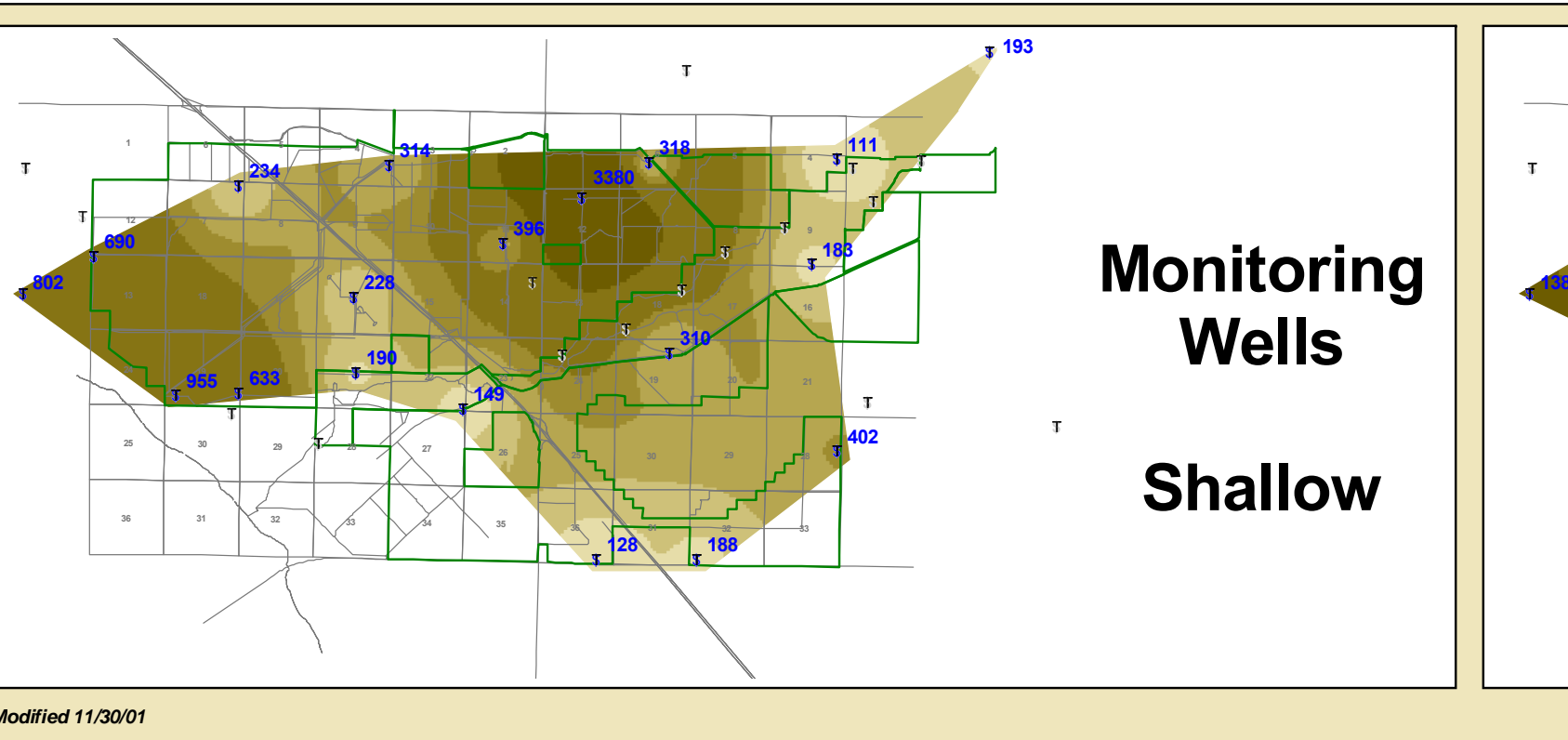
Recovery Wells

Monitoring Wells Shallow


Monitoring Wells Deep

KERN WATER BANK AUTHORITY









SB4 Model Criteria for GW Monitoring

- The Model Criteria has three main components:
 - Area Specific groundwater monitoring near stimulation wells
 - Requirements for Designated Contractor Sampling and Testing
 - Regional scale groundwater monitoring to be implemented by the State Water Board
- "The area-specific requirements described in this document are not designed for early detection of impacts to groundwater from well stimulation, but rather are designed to characterize baseline water quality conditions and detect potential impacts to beneficial use waters from well stimulation treatments."



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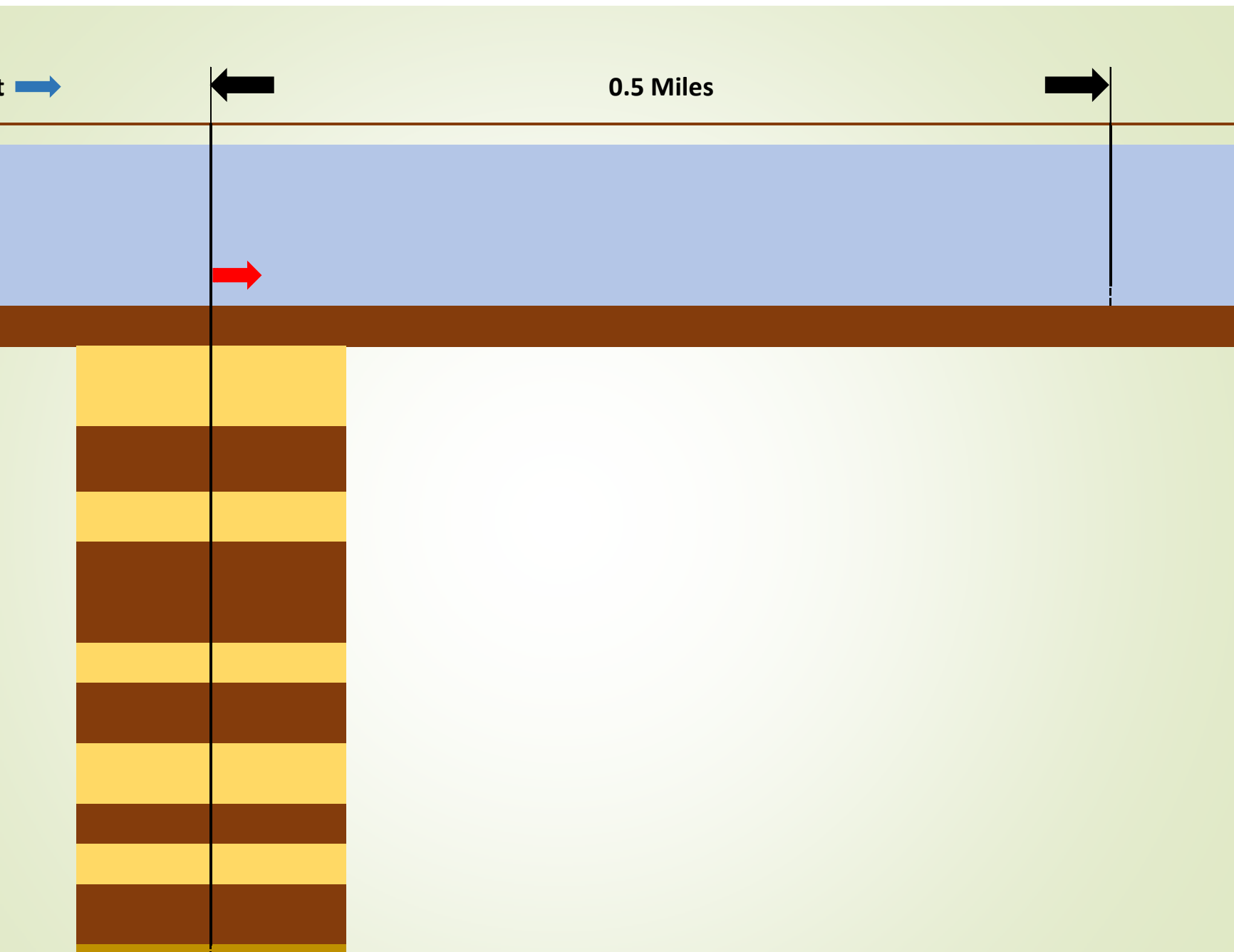
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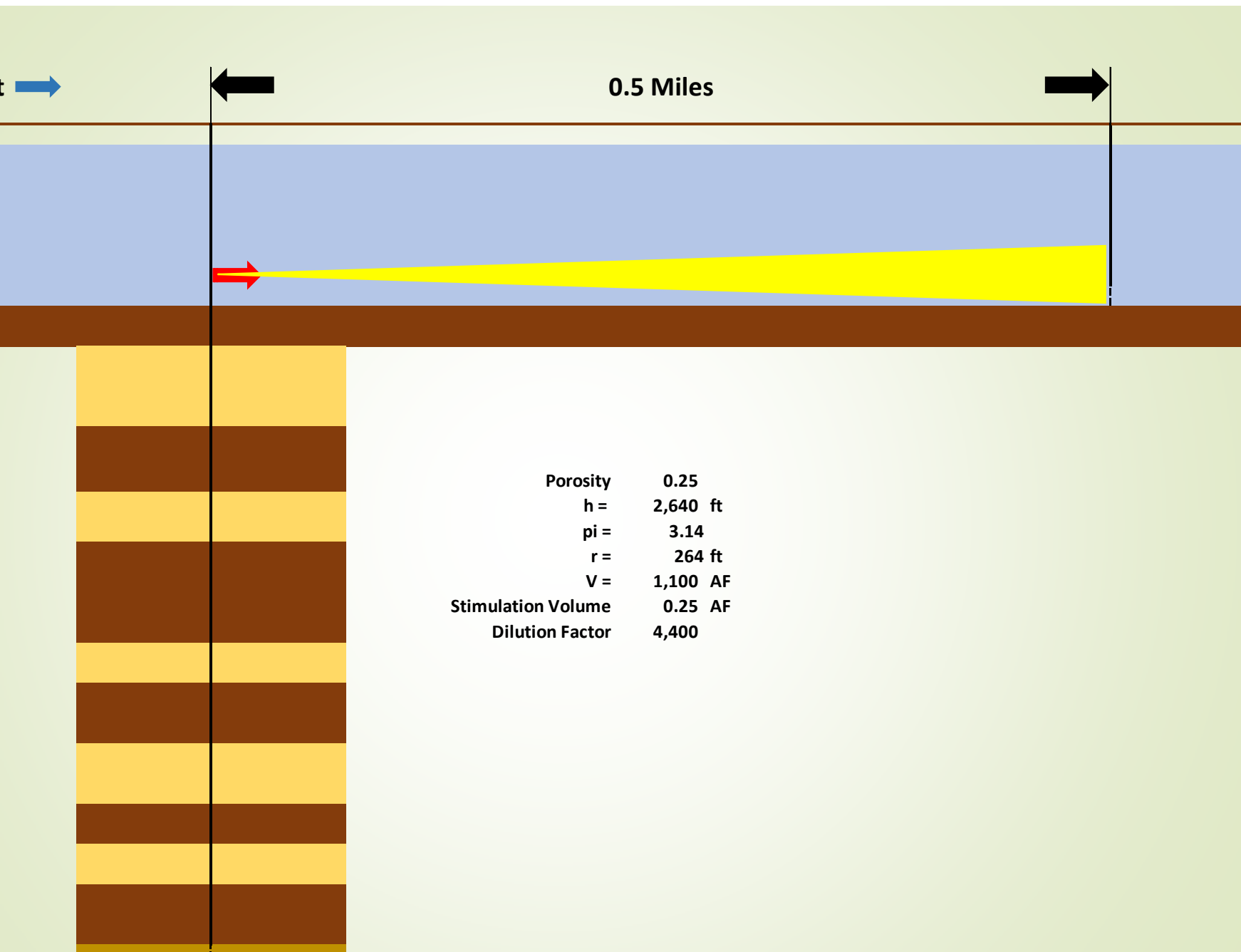
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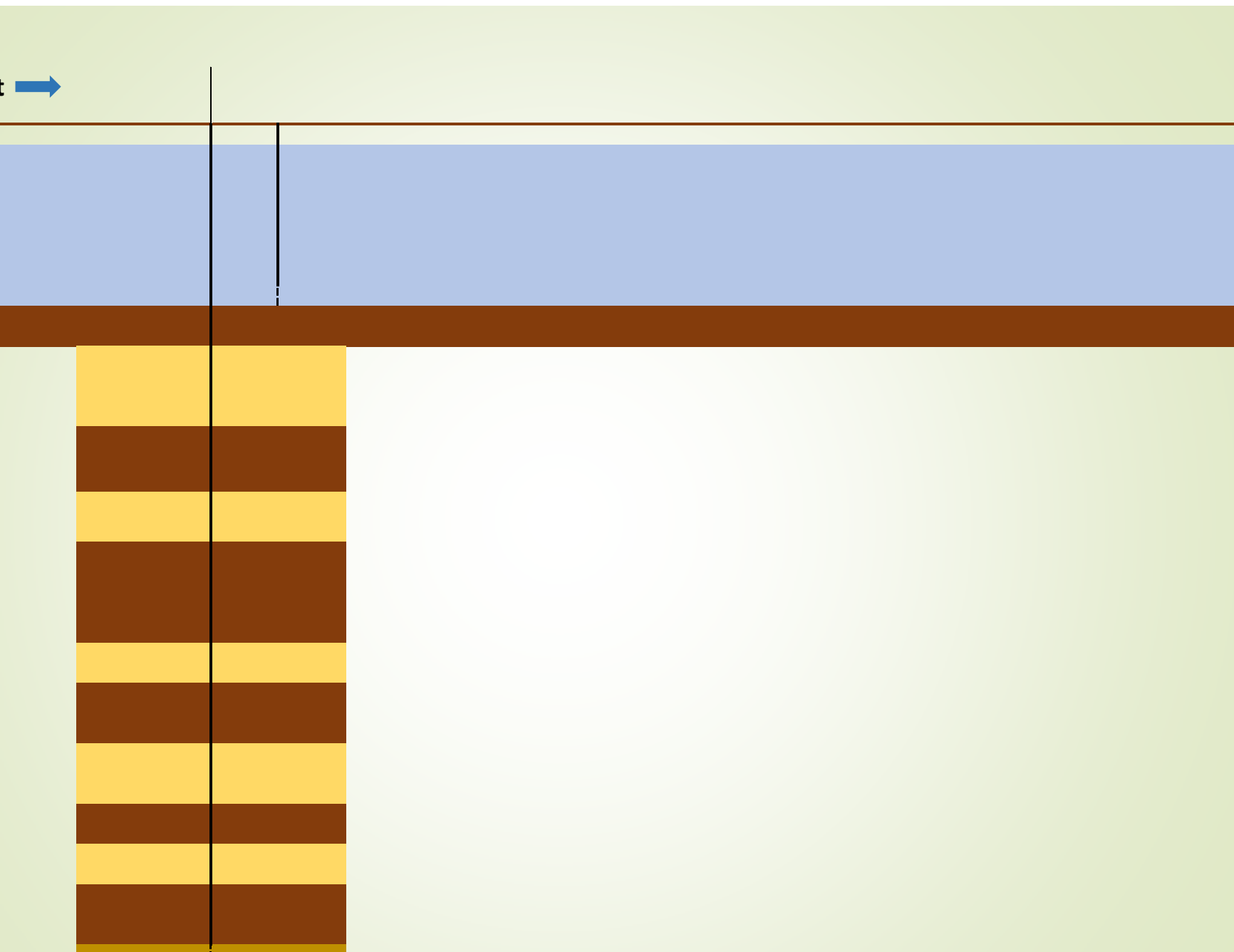
Required Monitoring Wells

- One upgradient and two downgradient monitoring wells
- Located within 0.5 mile of the surface projection of the zone(s) of stimulation.
- Sentry wells between any drinking water supply well within one mile and downgradient of the zone(s) of stimulation.
- Begs the question: "What is the volume of water that could be impacted before detection?"





Porosity	0.25
h =	2,640 ft
pi =	3.14
r =	264 ft
V =	1,100 AF
Stimulation Volume	0.25 AF
Dilution Factor	4,400





SB4 Monitoring Near the KWB

- North Coles Levee well 32-30 to be stimulated at a depth of 9,665 feet
- Volume of fluids: 85,000 gallons (about 0.25 AF)
- Fractures about 400 feet long and extending upward about 100 feet
- One groundwater well to be monitored
 - Screened from 485 to 555 feet
 - Located >4,000 feet to the northeast



SB4 Monitoring Near the KWB

- Direct distance between stimulation zone and monitored gw about 10,000 feet, with many overlying aquitards
- Volume of cone in the direction of the monitoring well about 4,000 AF
- Simulation volume was about 0.25 AF
- Dilution factor about 16,000
- Monitoring conducted before stimulation and 12 days after stimulation, then semi-annually
- GW velocity is about 1 ft/day; total travel time for 4,000 feet is about 11 years
- So... how can GW monitoring ever detect impacts to groundwater?



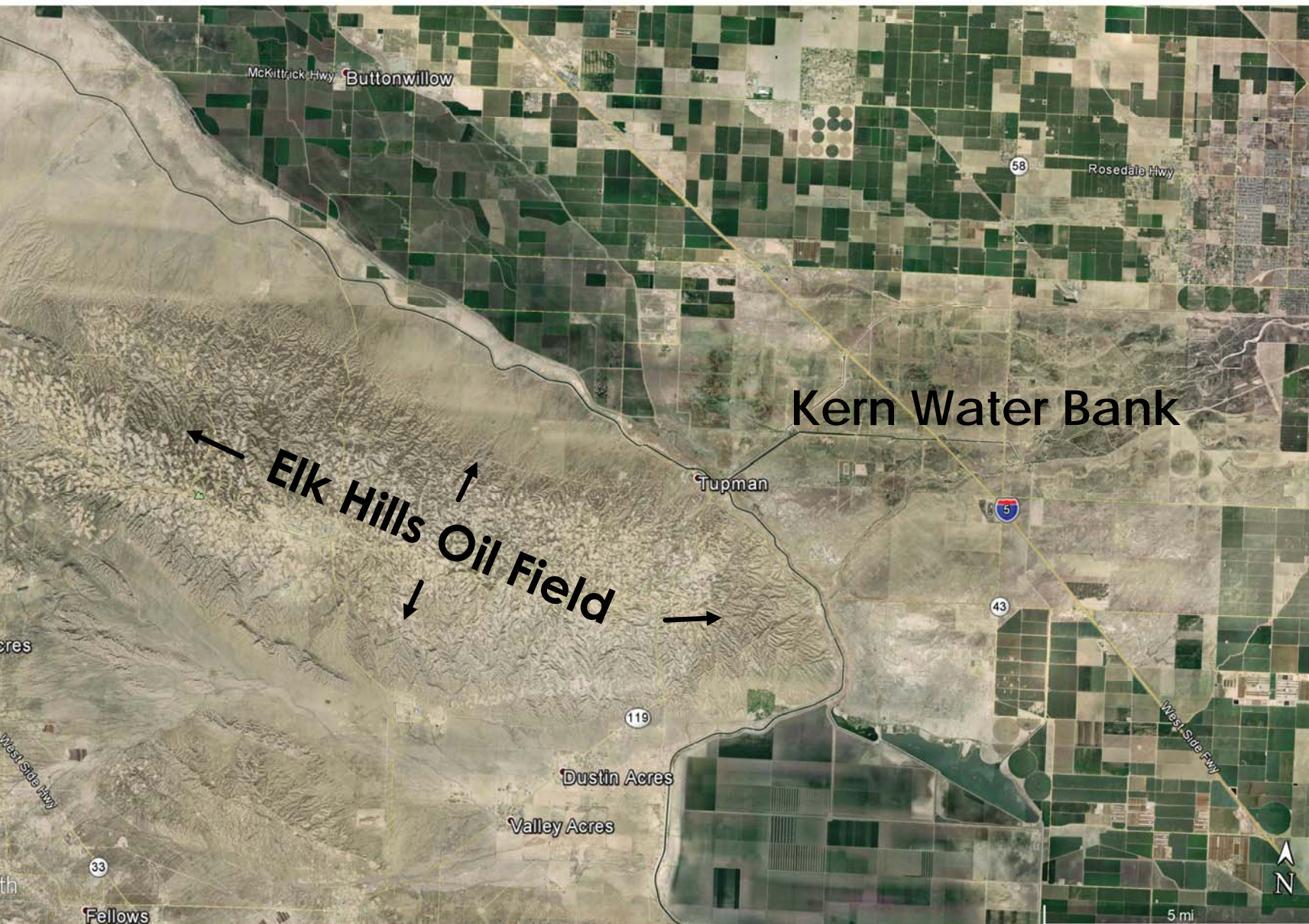
UIC and Aquifer Exemptions

- The aquifer is not a source of drinking water (or other beneficial uses).
- The aquifer cannot now, and will not in the future, serve as a source of beneficial water because:
 - The aquifer is oil producing or expected to be oil producing.
 - Groundwater recovery impractical.
 - The aquifer is severely contaminated.
 - TDS above 3,000 mg/l and other water quality constituents are such that it is not reasonably expected to be used for beneficial uses.

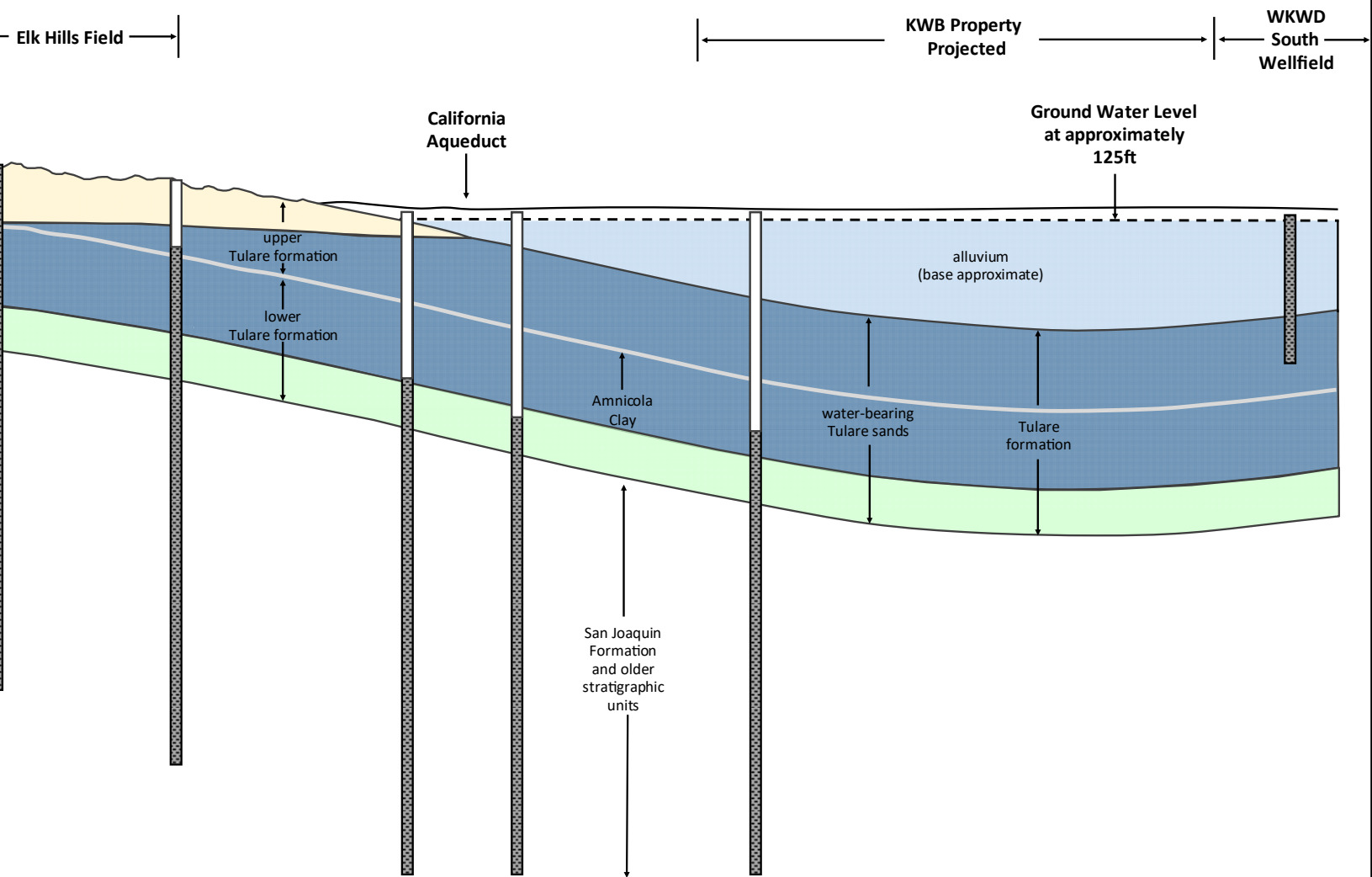


UIC and Aquifer Exemptions

- The Tulare and Kern River Formations, and the overlying alluvium, form the Kern County Sub-basin aquifer
- The Tulare Formation and the Kern River Formation both produce oil – so, where do you draw the exemption line?
- To further complicate matters, SB4 requires groundwater monitoring unless there are no USDWs in the area
- The onus of SB-4 groundwater monitoring is an incentive to have aquifers deemed “exempt”
- Case in point – the Elk Hill Oil Field
 - Tulare Fm. “was” considered exempt
 - Injection into the Tulare for several decades near the top of the anticline and on the southern flank of the anticline



Cross Section of Elk Hills to WKWD South Wellfield



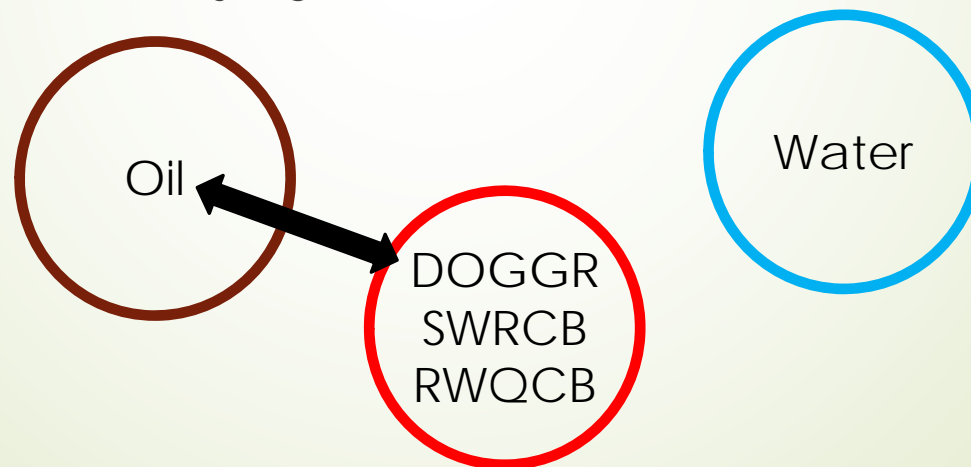


Exemption Problems

- Significant geologic data gaps between Tulare oil sands and the Tulare aquifer
- Proprietary unavailable seismic will be viewed with skepticism
- Virtually no groundwater monitoring data between the Tulare oil sands and the Tulare aquifer

Communication Issues

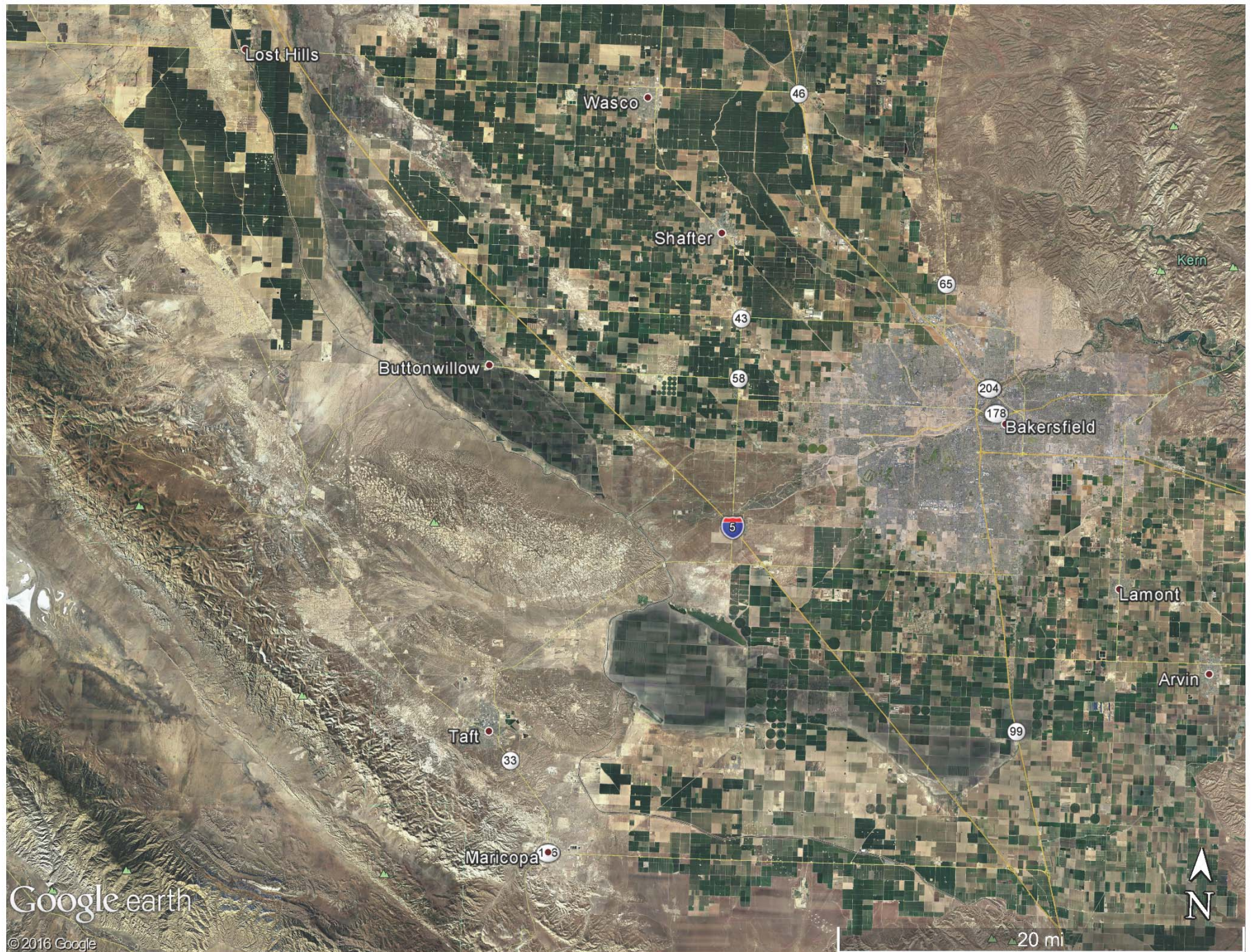
- Oil industry and DOGGR seem to communicate
- Water community seems out of the loop, but the jury is still out






Mistaken Generalizations

- From the 2011 Horsley Group Report:
 - *How are USDWs identified in District 4 fields...?*
 - The District has a lot of water quality data available from produced water analyses. Swabbing of formation water in new zones is an option if other data are not available for that zone. Electric log calculations are also an option. **In general terms, fresh groundwater is absent west of Highway I-5** and is present to the east of I-5 in the Central Valley sediments due to recharge from the Sierra Mountains to the east of the Valley.



Google earth

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Monitoring Report Misinformation

- The report says there are no public drinking water wells in the area -*when there are eight municipal supply wells in the area*
- The report says groundwater analytical results indicate a well contains poor quality groundwater – *when the well meets all drinking water standards*
- The report says constituent levels, that could be related to stimulation activities, are “trace levels” – *when the levels actually exceed MCLs*
- The lab reports use TLCs as reference levels – *when the analyses are for characterizing drinking water*



Summary

- KWB and groundwater are critical resources to the Southern San Joaquin Valley
- Groundwater quality is extremely important to this resource
- The legacy of oil field development has impacted both soil and groundwater – especially with respect to salts
- The purpose of SB4 monitoring is frankly puzzling
- SB4 monitoring may create pressure to exempt some aquifers
- Much more information is needed to fully understand the relationship between oil bearing formations and groundwater
- The groundwater community must be included in the discussion of UIC exemptions and SB4 monitoring, and reporting should be unbiased and truthful