Modeling Land Application of Food-Processing Wastewater in the Central Valley, CA

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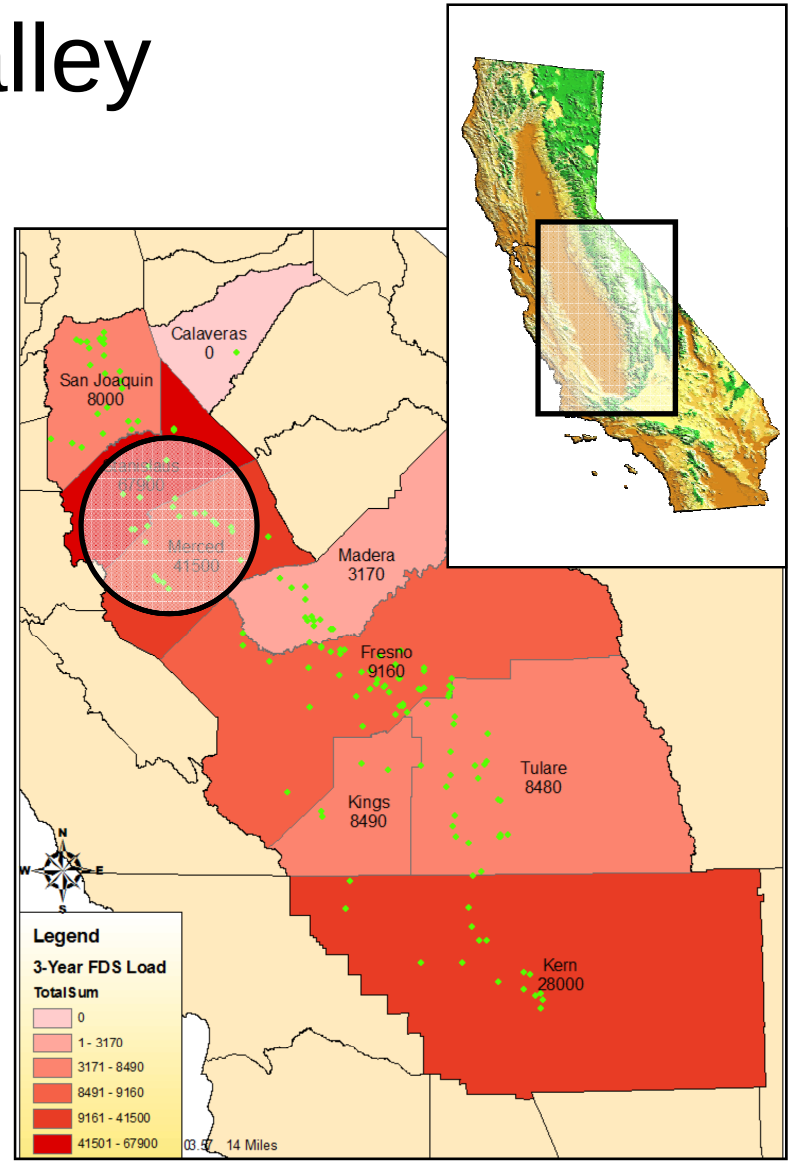
Food Processing Wastewater in the Central Valley

- Over 600 facilities
- >$62 billion in revenue
- Water use: 80 million $m^3\ yr^{-1}$
- High in salinity (FDS), organic carbon, and nitrogen
- Typical disposal method: land application for irrigation
- Discharged to alluvial fan and floodplain deposits

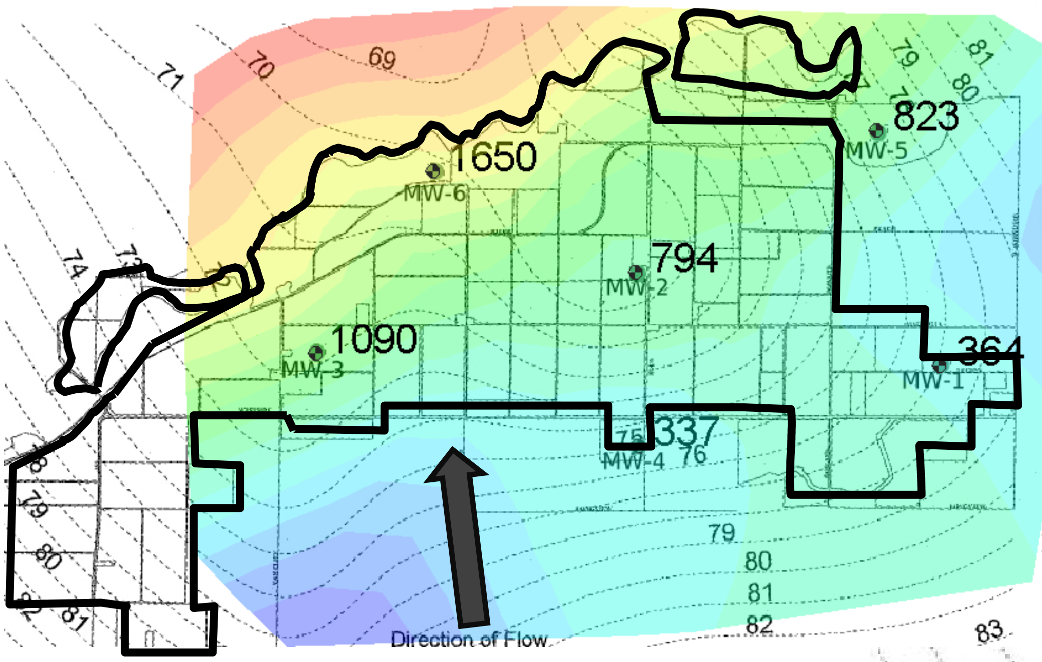


An Environmental Threat?

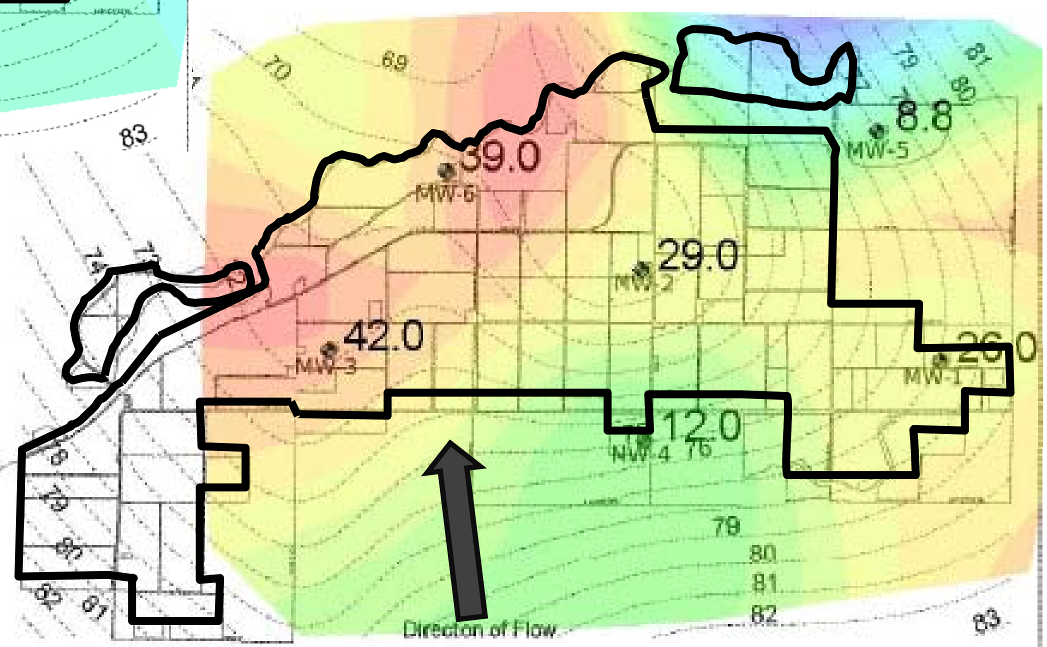
Metric	Municipal Waste	Tomato Canner
BOD (mg-O_2 L^{-1})	450	820
FDS (mg L^{-1})	720	1680
pH	6.7	5.4
Nitrogen (mg-N L^{-1})	25	51
Flow Rate (gal d^{-1})	2.6×10^7	1.5×10^6
Pathogens present?	Virtually certain	Very unlikely
Sources: food, disinfectants, processing chemicals		

Groundwater Degradation?

Winery Example
1300 acres



Fixed Dissolved Solids (mg/L)



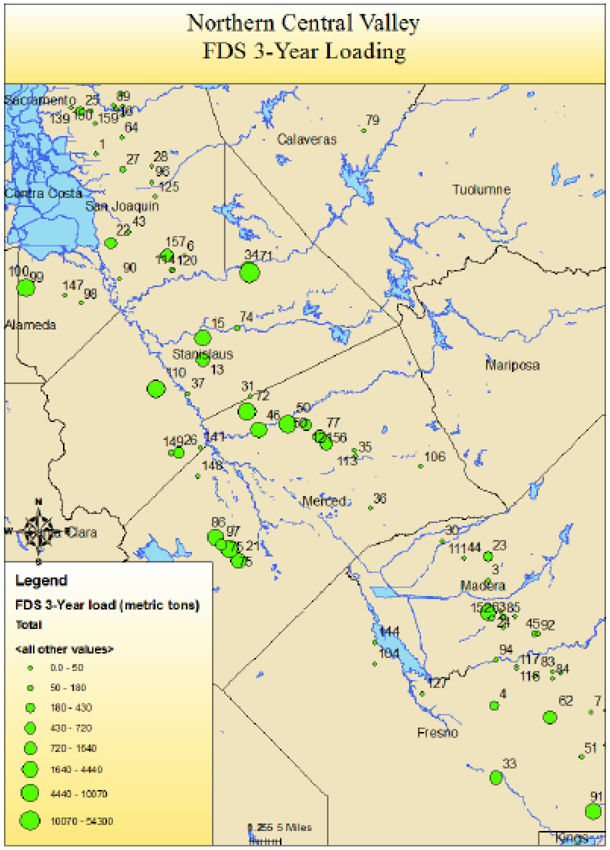
Nitrate (mg/L)

Regulating Food Processing Waste

- Study itself product of legal settlement
- Protect California's environment, economy, or both?
  - Regulators vs. industry?
  - Water resources vs. economy? (Porter-Cologne Act)
- All agree on need for regulations based on science
  - What is the natural attenuation capacity of the soil?
  - Is there a safe agronomic rate for salinity application?
  - What discharge management processes are effective?
  - How do the economic costs of land application compare to those of the alternatives?

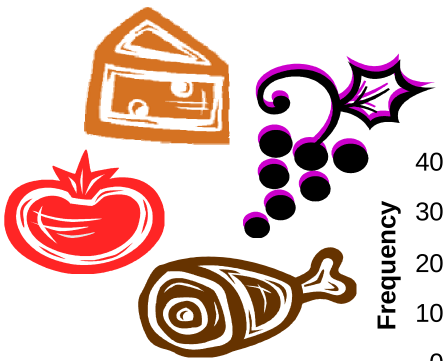
Modeling Challenges

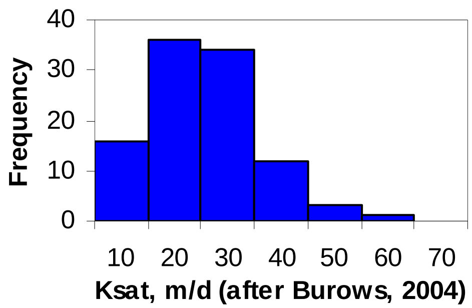
- Very Large Scale
  - 600+ producers with a diversity of wastewater characteristics and application site hydrogeology
- Attenuation Processes
  - Condition specific rates, strong potential for interaction
- Data Deficiency
  - Few measurements in vadose zone, none long-term
- Disparate systems
  - Required complexity different for vadose and saturated zones



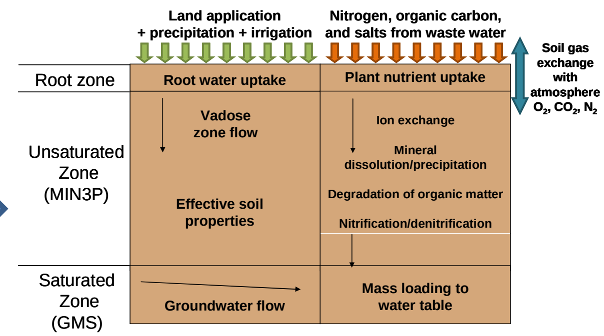
Modeling Strategy

Address diversity of sites and waste streams

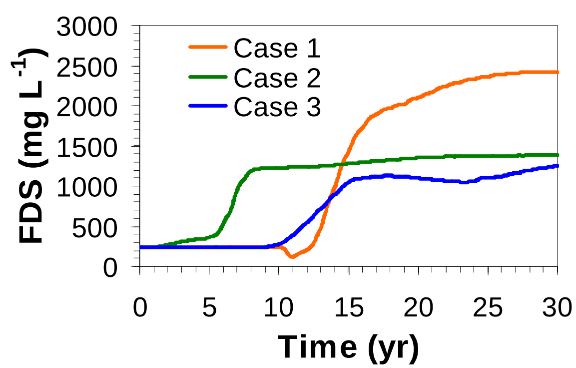




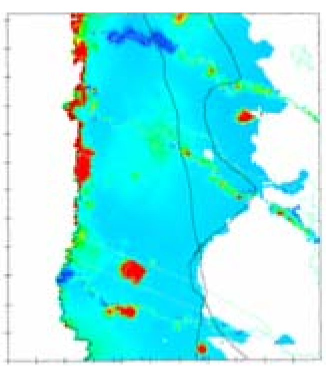
Develop and implement model of waste attenuation



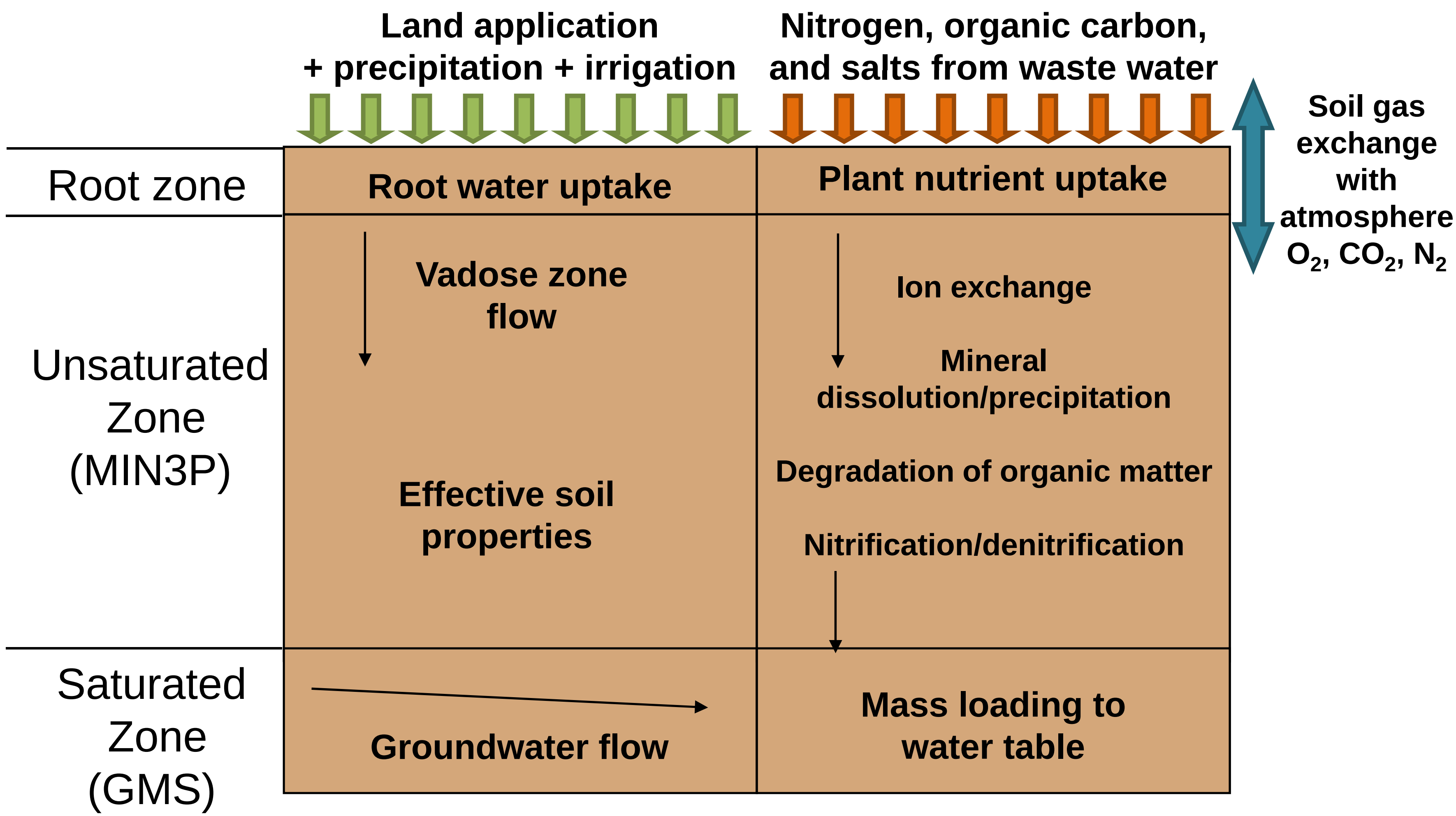
Use “transfer functions” to describe UZ/SZ connection



Run groundwater model to determine extent of degradation



Land Application Conceptual Model



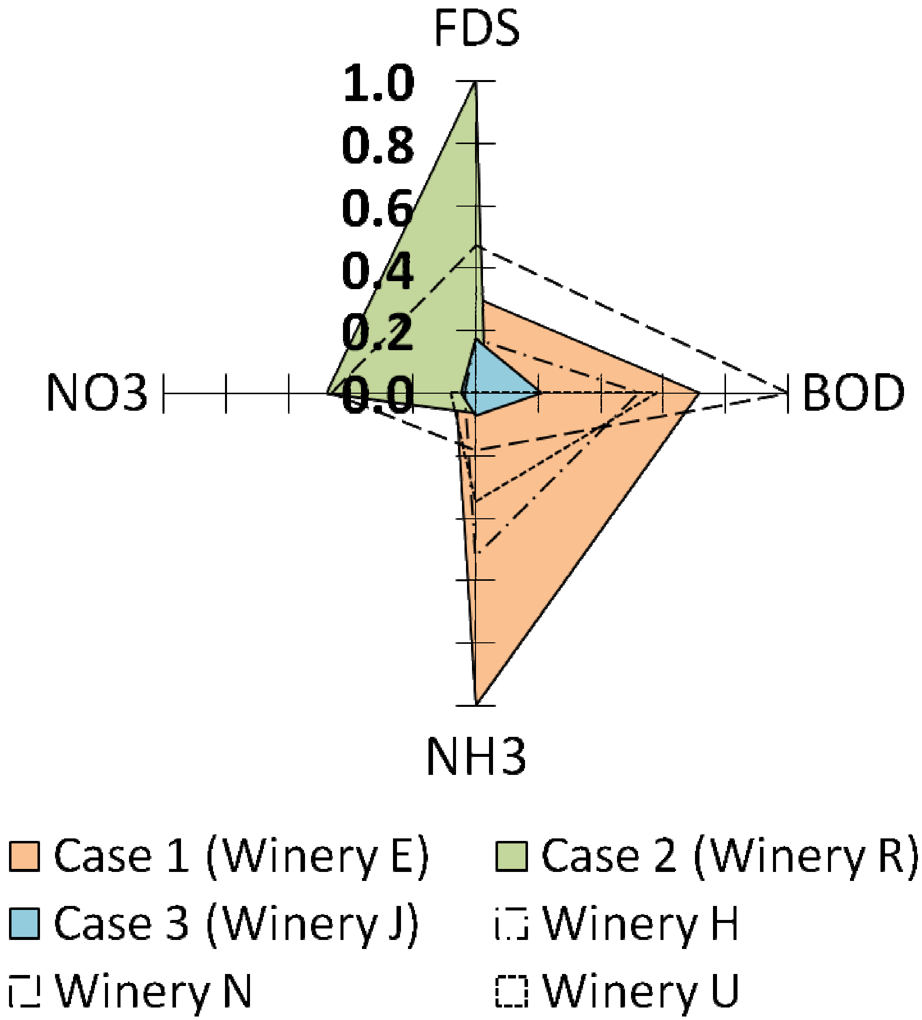
Vadose Zone Model Scenarios

- 12 scenarios – 4 industries, 3 cases
- Best/worst case for nitrogen, saturation dependent
- Simulations implemented in MIN3P numerical code

Case	Soil Saturation	Waste water composition	Best/worst?
1	High for anaerobic (0.9 – 0.99)	High: NH_4^+, CH_2O, FDS Low: NO_3	Worst for NH_4^+
2	Low for aerobic (0.4 – 0.5)	High: NO_3+NH_4^+, FDS Low: CH_2O	Worst for NO_3^-
3	Moderate for mixed (0.8 – 0.9)	Low: CH_2O, FDS, NH_4^+, and NO_3 low relative to CH_2O	Best for both

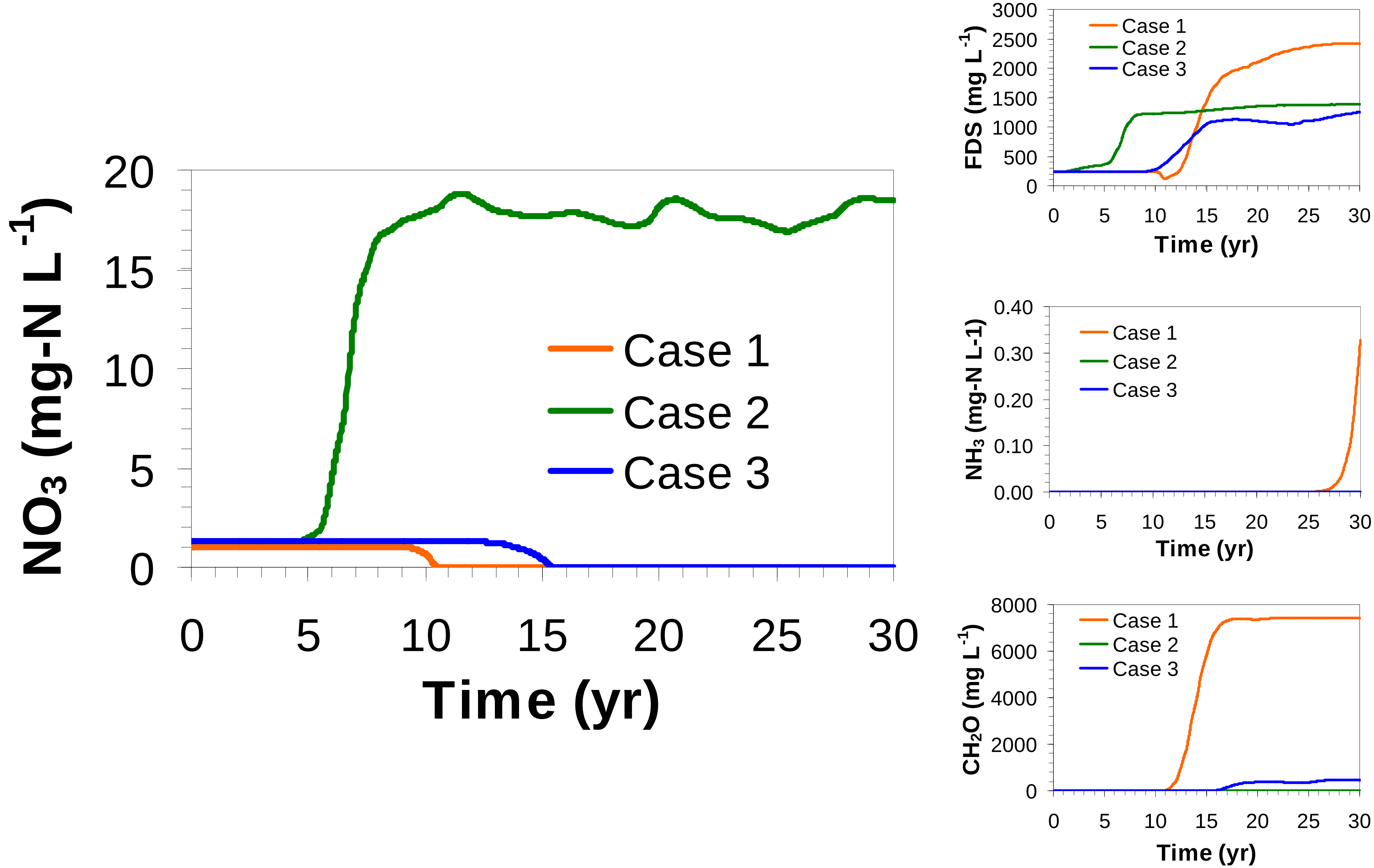
Applied Waste Concentrations

Winery Waste Water Footprint

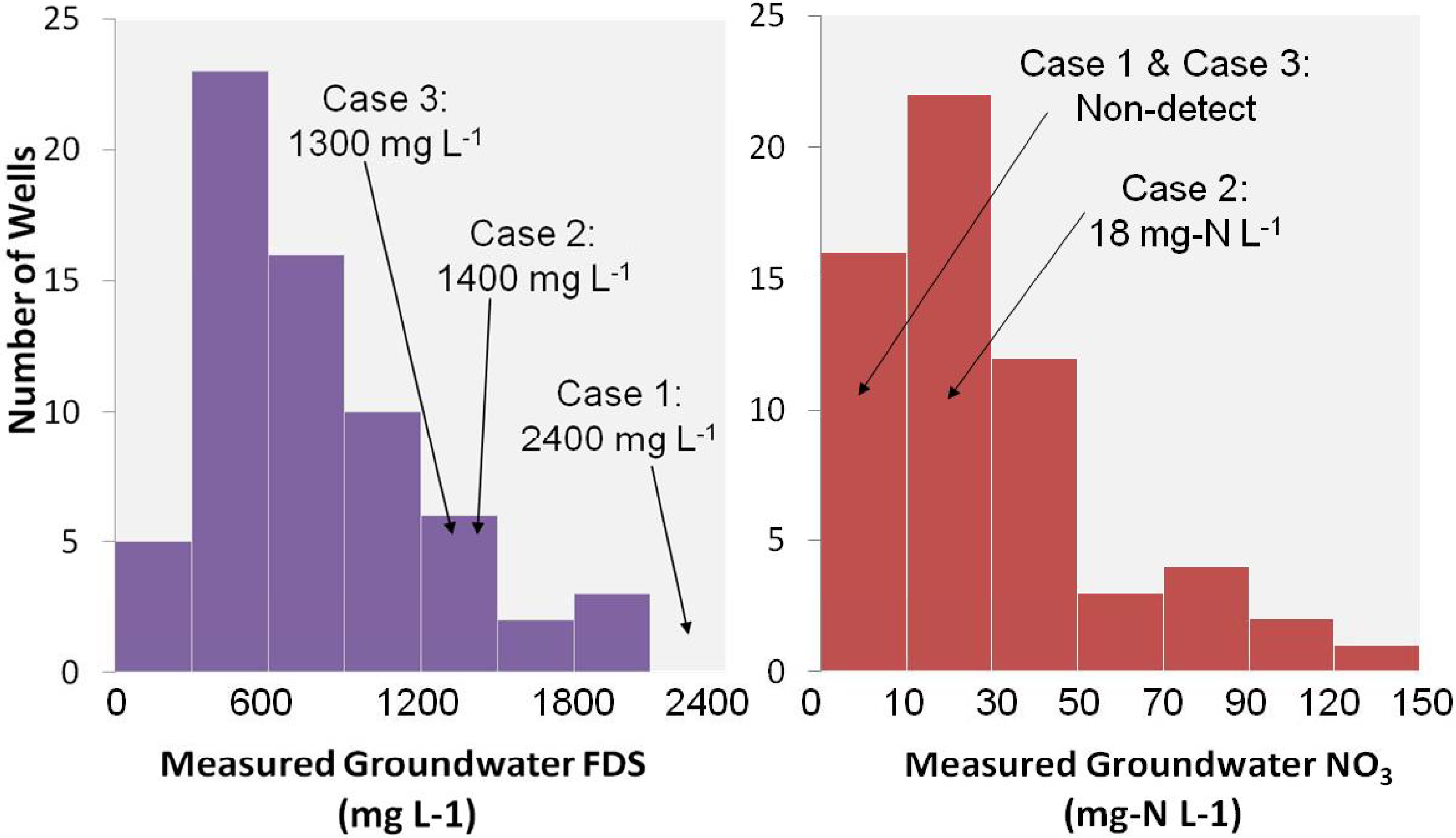


Waste Components
Calcium (Ca^{2+})
Magnesium (Mg^{2+})
Potassium (K^{+})
Sodium (Na^{+})
Ammonium (NH_4^{+})
Manganese (Mn^{2+})
Zinc (Zn^{2+})
Copper (Cu^{2+})
Iron (Fe^{2+})
Carbonate (CO_3^{2-})
Phosphate (PO_4^{3-})
Sulfate (SO_4^{2-})
Chloride (Cl^{-})
Nitrate (NO_3^{-})
pH
Labile organic carbon(CH_2O)

Example Transfer Functions

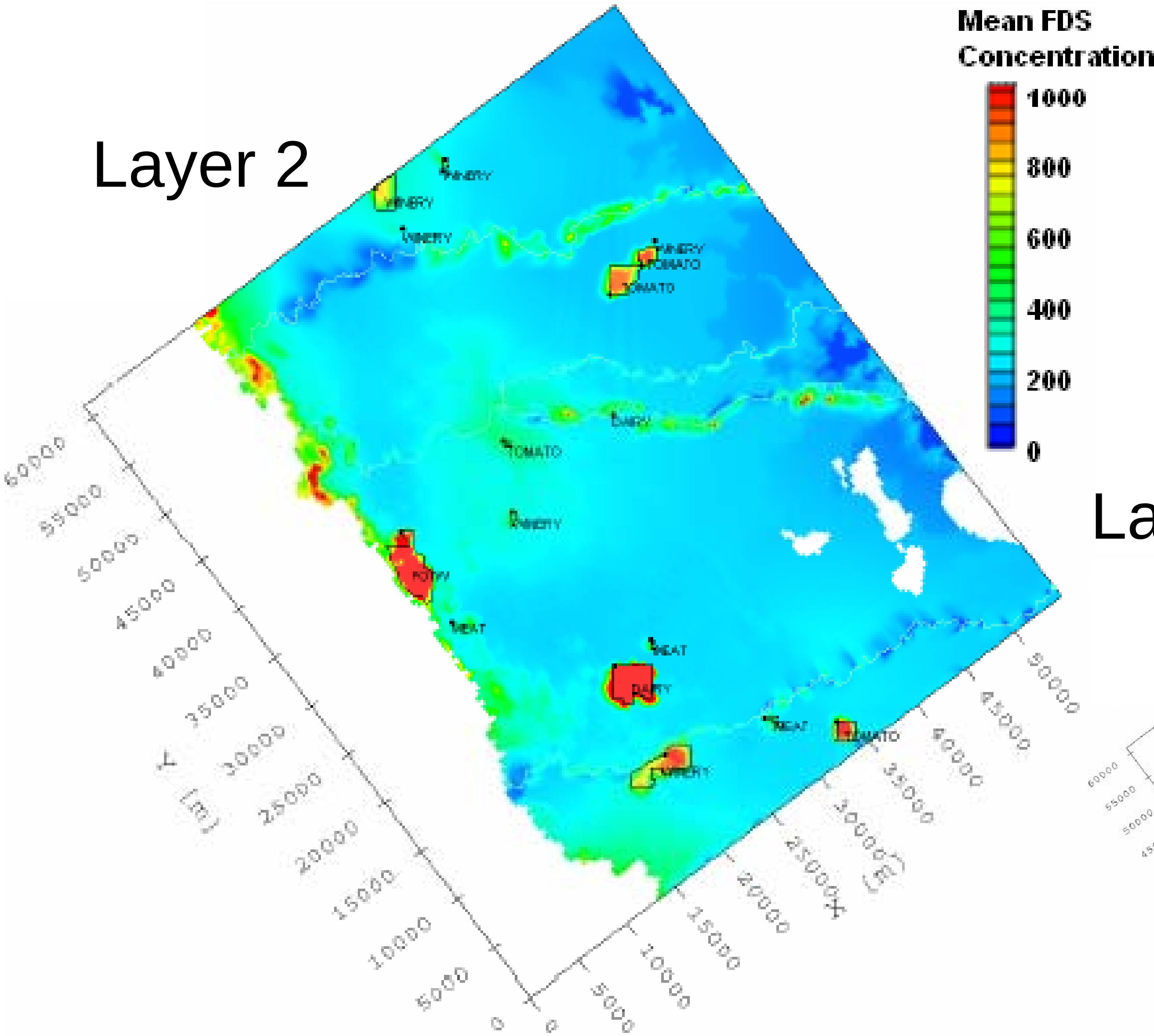


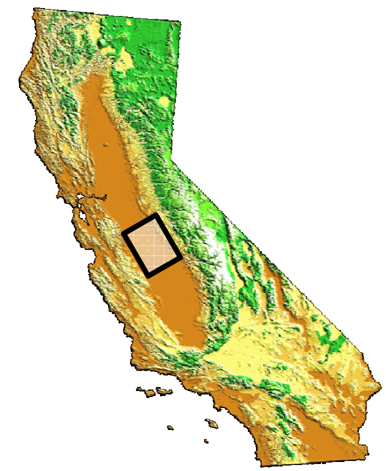
Comparison to Groundwater Data



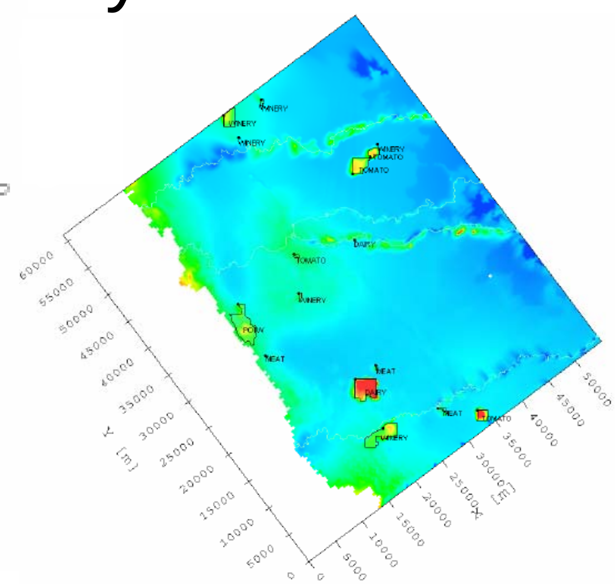
Degradation of Groundwater

Layer 2





Layer 3



Conclusions

- Attenuation condition dependent, not necessarily sustainable
- Attenuation processes contributing most were dependant on the contaminant
- “Safe agronomic rate” questionable for FDS
- Lateral migration in groundwater limited
- Need for increased vadose zone monitoring and characterization
- Modeling can provide tool for policy makers, but does not offer definitive solution