Riverbank Filtration

An Old Solution to a New Problem

Jack Wittman
Layne Hydro

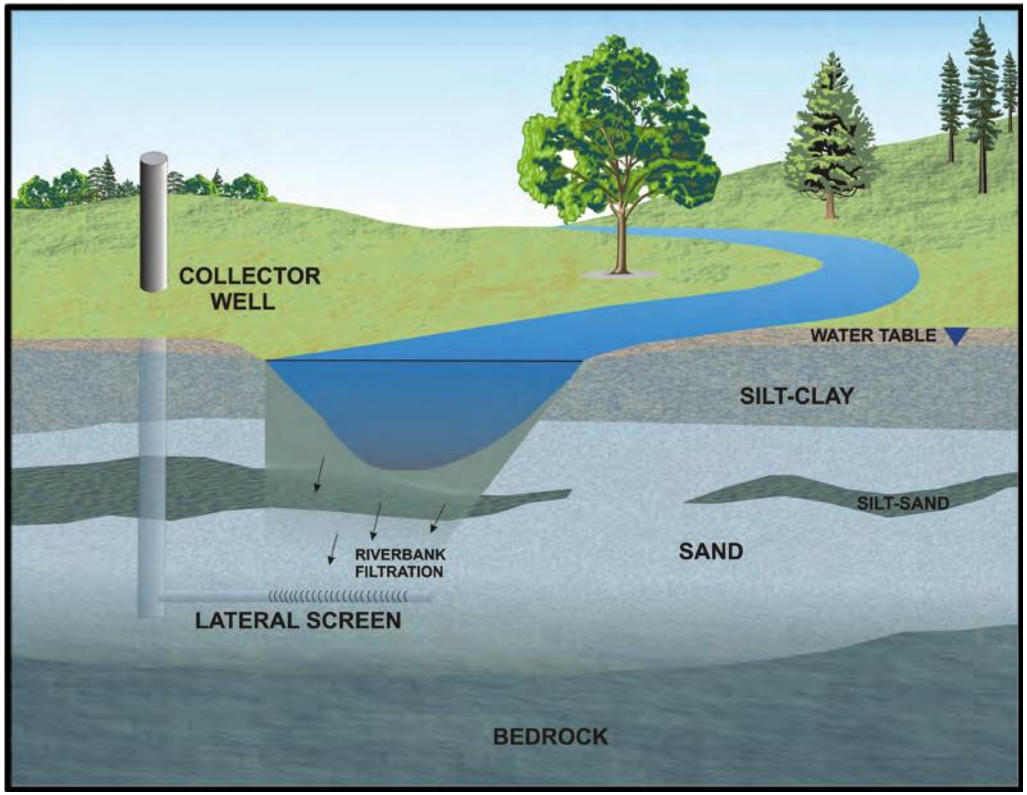
Outline

- History of River Bank Filtration (RBF)
- Alternative Well Field Designs
  - collector/angle/vertical wells, infiltration galleries
- Water Quality Benefits: pathogens, inorganics
- Predicting Yield
- Lessons from 3 sites
  - Sonoma County, California
  - Des Moines, Iowa
  - Pine Bluff, Arkansas

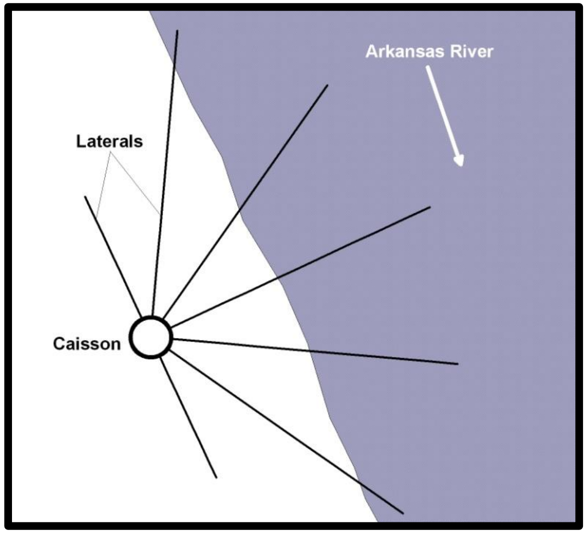
History of RBF

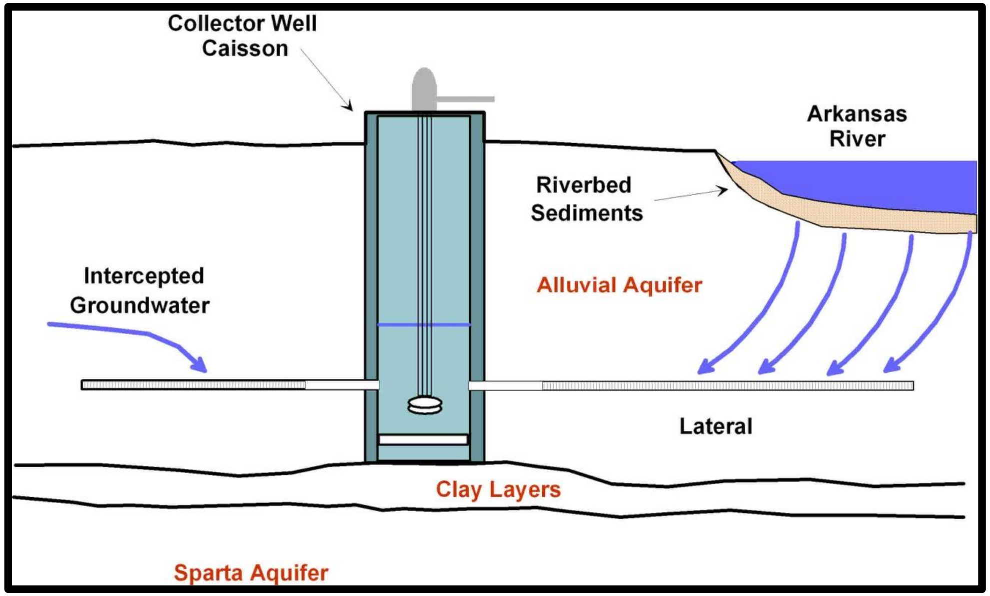
- European RBF (1800s)
  - Line of wells along shoreline
  - Vertical wells pumping ~500 gpm
  - **Primary purpose is treatment**
  - Long history (>100 yrs)
  - Belgrade, Berlin, Amsterdam
- USA RBF (1940s)
  - Clusters of vertical wells angle wells or collector wells (Ranney wells)
  - Many Ranney wells with very high yields
  - **Purpose has been high capacity intake**
  - Relatively short history (1940s)
  - Cincinnati, Louisville, Terre Haute, Sonoma County

What is River Bank Filtration? (RBF)



What is River Bank Filtration? (RBF)





Example from Arkansas

WHY USE RBF?

- Improve upon raw surface water quality
- Lower cost than "direct" SW treatment
- Treatment effects are credited in LT2ESWTR
- Effective on pharmaceutically active compounds,
- RBF enhances well yield <u>and</u> improves water quality

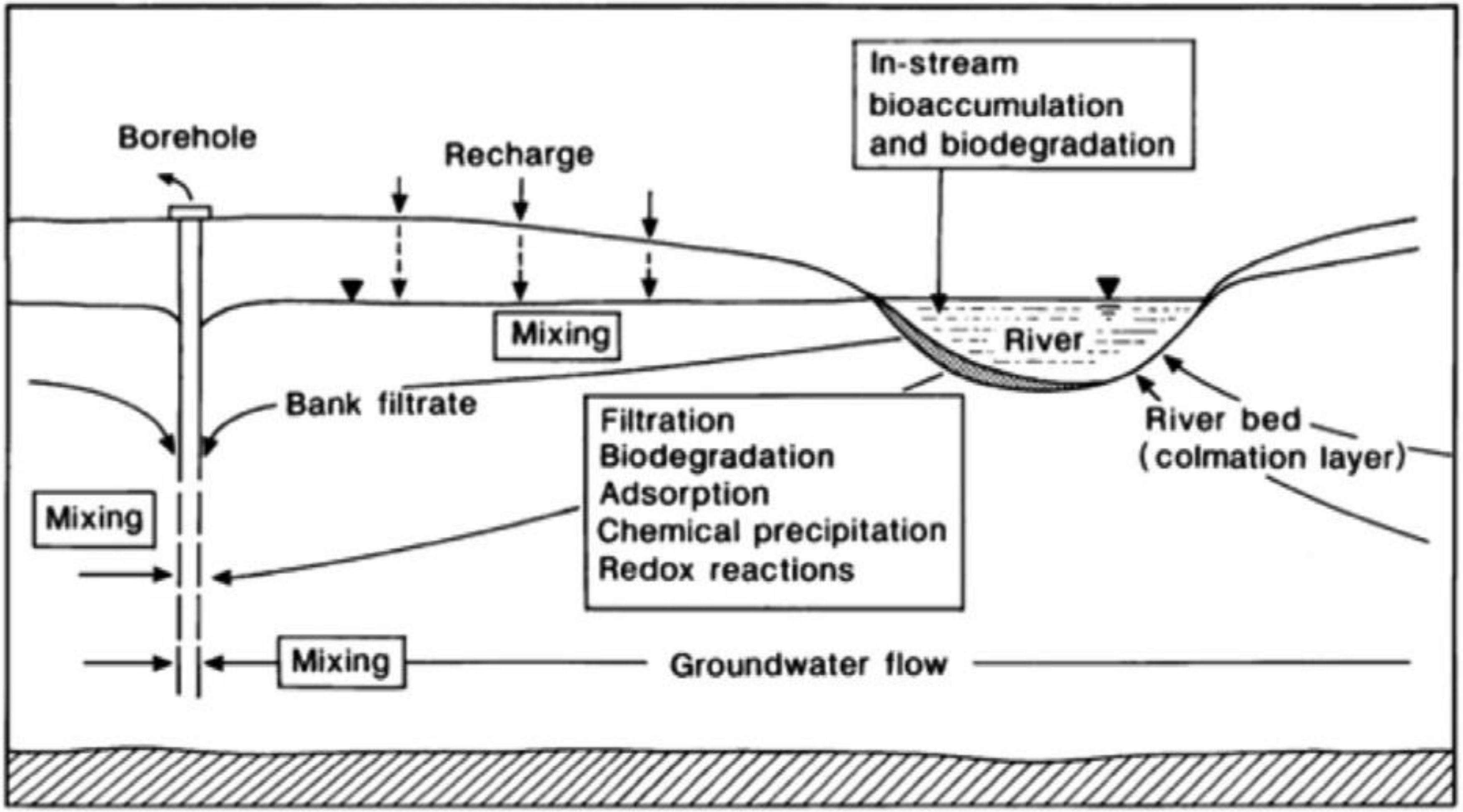
Literature Review

- Water Research Foundation (AwwaRF)
  - #3121, 3136, 3180
- Gollnitz – Great Miami River
  - Found that quality improved most at stream-aquifer interface
- Hubbs – Ohio River
  - Possible to over-pump
- Bouwer - national
  - RBF effective pretreatment
- Jasperse and Constanz – Russian River
  - Heat is a good tracer
- Verstraeten – Platte River
  - PAC can move to wells
- Massman – Berlin
  - Mix of ages found in wells
- Levy and others
  - Quality improved when stream detached

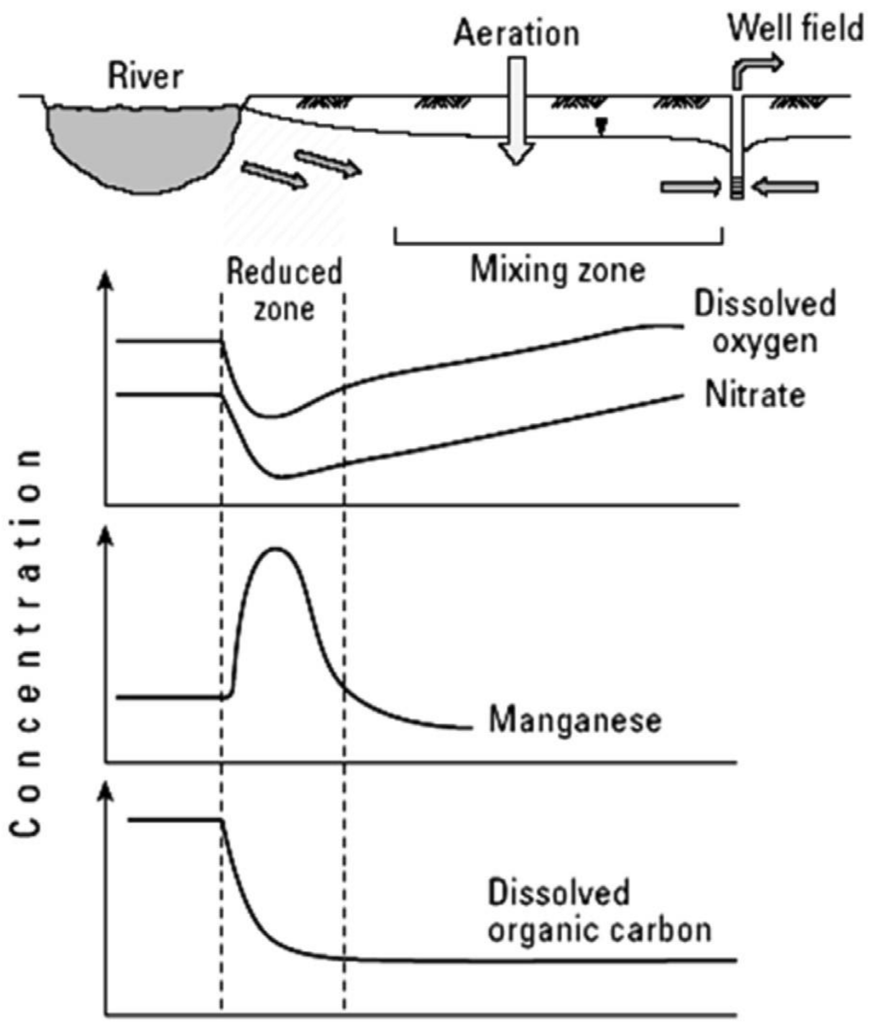
What have we learned by using this technology?

WATER QUALITY BENEFITS OF RBF

RBF Processes



Effects on Water Quality



RBF REMOVAL AND LIMITATIONS

parameter	RBF removal	limitations
Sediment	Good	travel time
Algal toxins	Good	texture
Nutrients	Moderate	anoxic
Anions Cations	Poor	TDS – salinity
Heavy metals	Depends	Site
pesticides	Depends	Site
Endocrine distruptors	Good	missing oxic zone
Pharmaceuticals	Depends	?
DBP	Good	anoxic zone
Chlorinated hydrocarbons	Moderate	oxic zone

Ground **w**ater **U**nder the **D**irect **I**nfluence (GWUDI)

REGULATORY ISSUES

Utilities want to limit regulations while assuring reliability, quality and low cost

Regulatory Objectives

Safety

Pathogens

Impacts

Water Quality

Regulatory effectiveness

Example at St. Joseph, MO

Abandoned sw plant

New well field near Missouri River

1 Ranney well + 7 vertical wells (30 MGD)

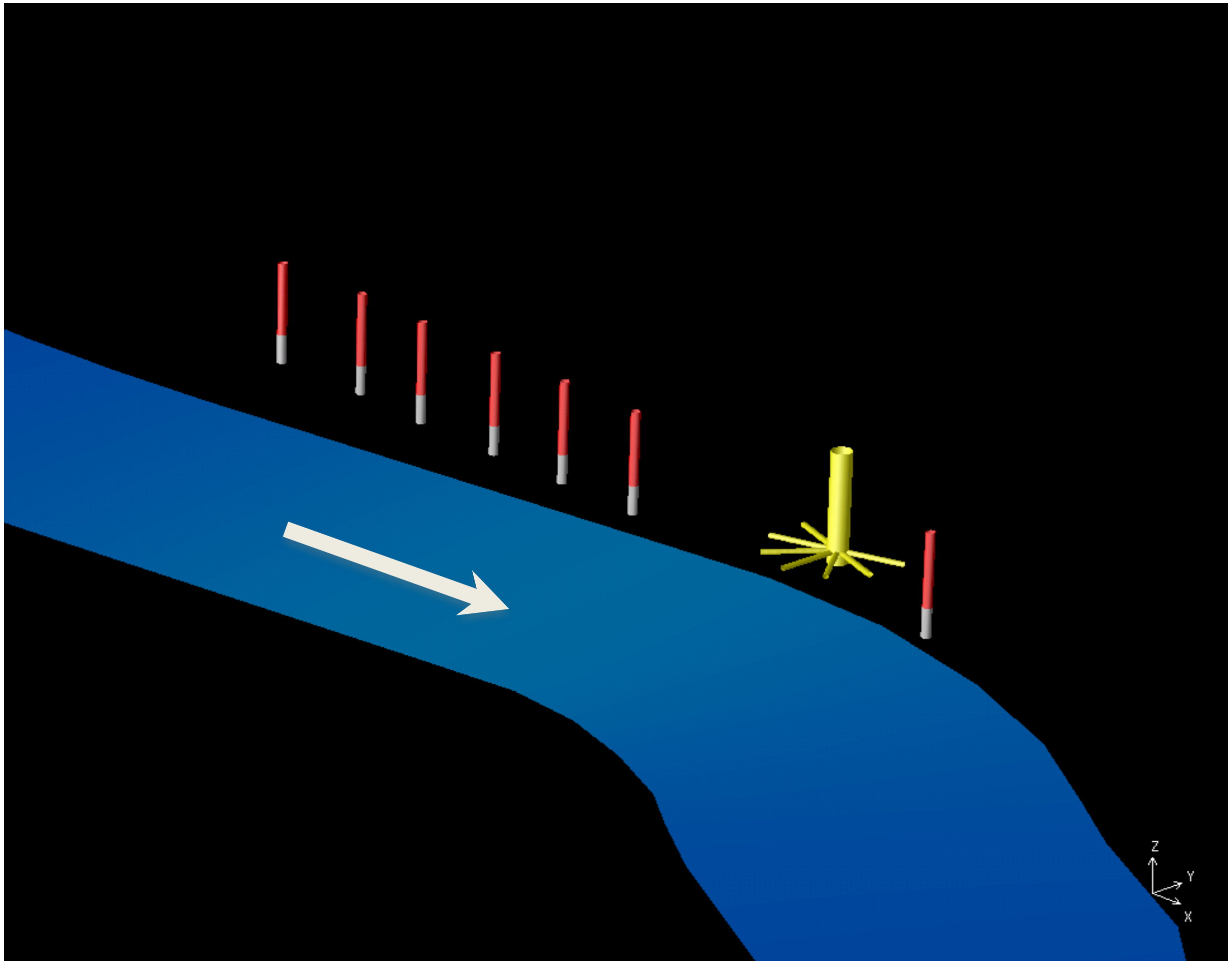
Example at St. Joseph, MO

water quality (soft-> hard)

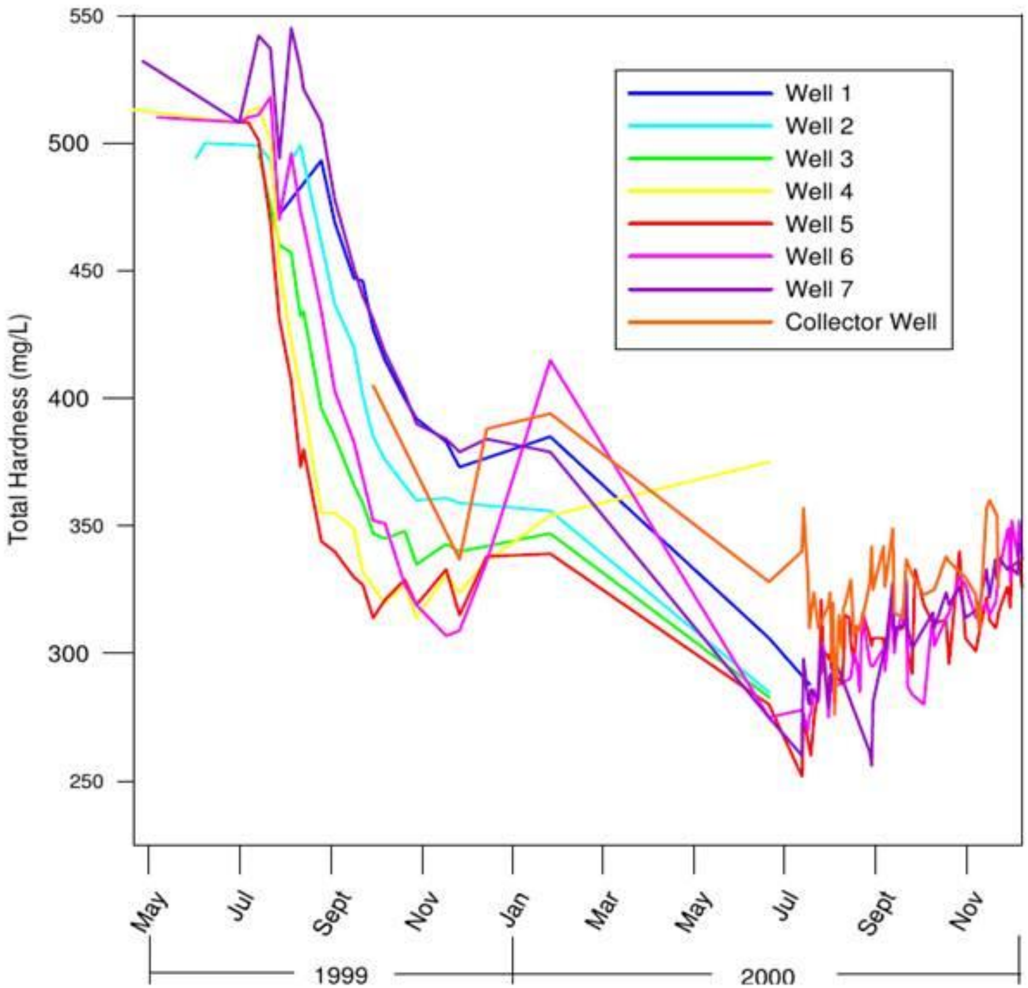
Promise of RBF?

Cost for sludge removal

Layout of the Well Field

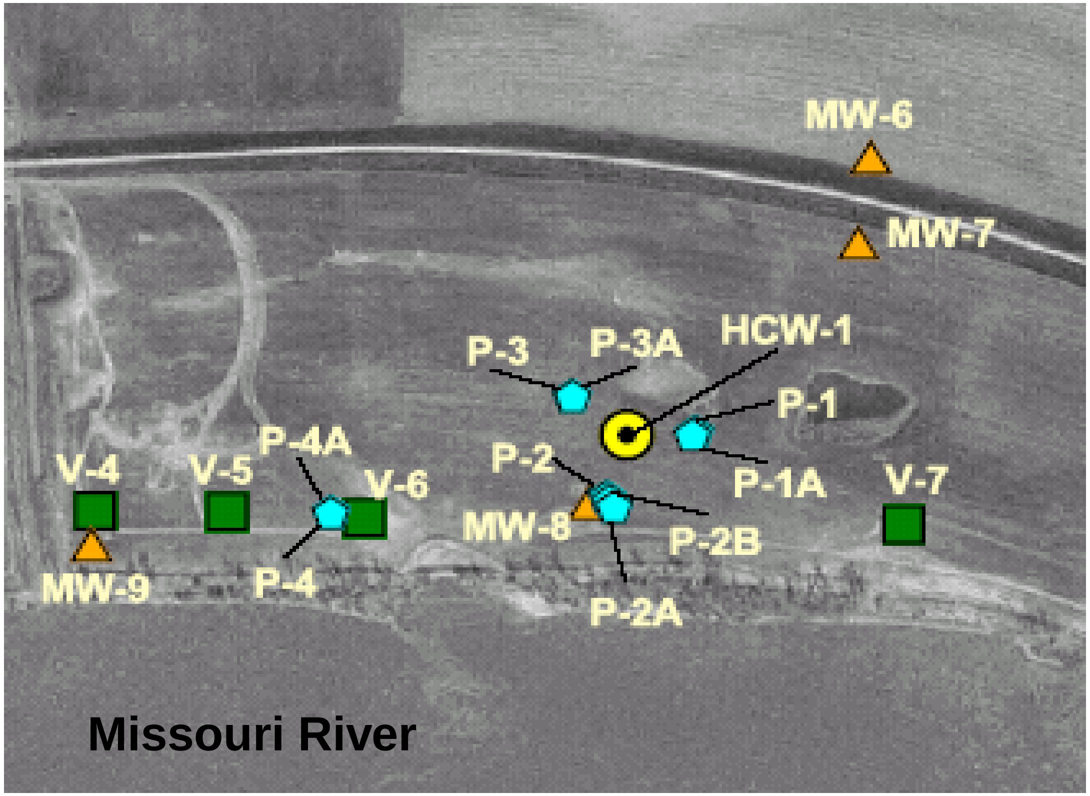


HARDNESS AFTER STARTUP



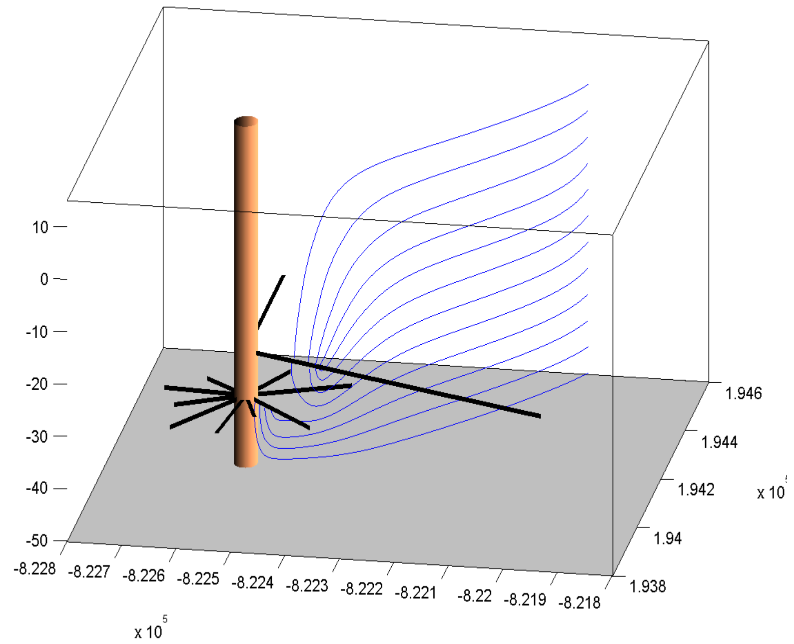
Layout of the Well Field

- How does quality vary around the collector well?
- Softer water near vertical wells?



Modeling RBF Hardness in Ranney Well

- 3-D vector geometry
- Aquifer layering
- Explicit interaction between arms
- 3-D pathline tracing, residence time calculations



Modeling Residence Time

- Assume:

  1) Hardness - mixing sw and groundwater

  2) Affected by the choice of operational wells
- Use calibrated model
  - Determine the fraction of river water pumped by the wells for many pumping configurations
- Choose configuration -> largest fraction of river water for any pumping rate

SW/GW Mixing Ratio

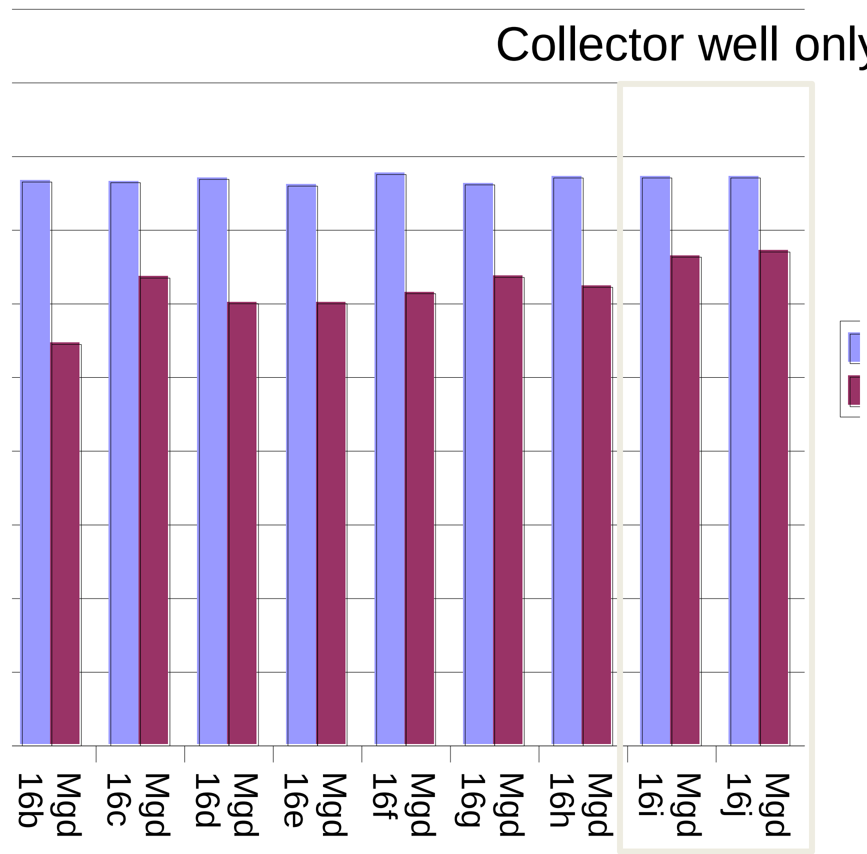
- Based on 16 MGD models:
  - Average fraction of river water: **76.7%**
  - Estimated hardness from mixing: 295 ppm
- Actual influent hardness averages ~340 ppm
- **Why the discrepancy?**

- Hypothesis: distribution of travel times
  - Short travel time → low hardness
  - Long travel time → higher hardness

MODELING ST. JOSEPH WELLS

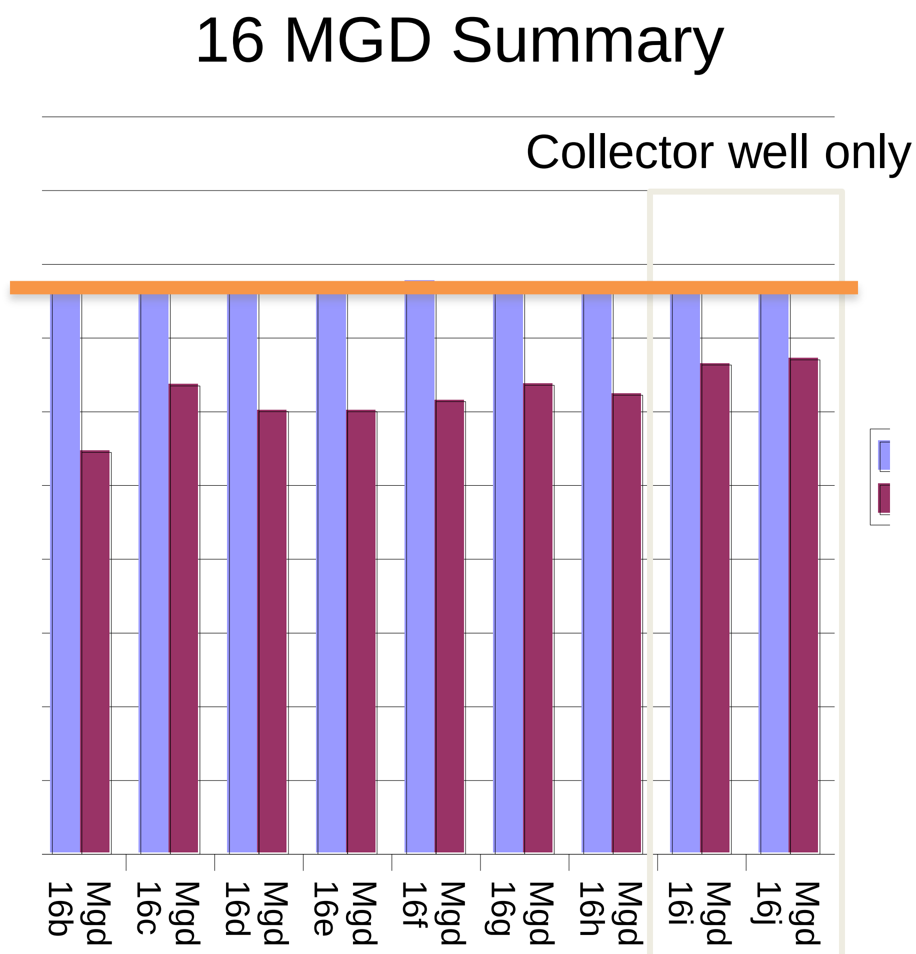
- 10 model runs were performed
- Total water pumped from the river (blue bars) insensitive to configuration

16 MGD Summary



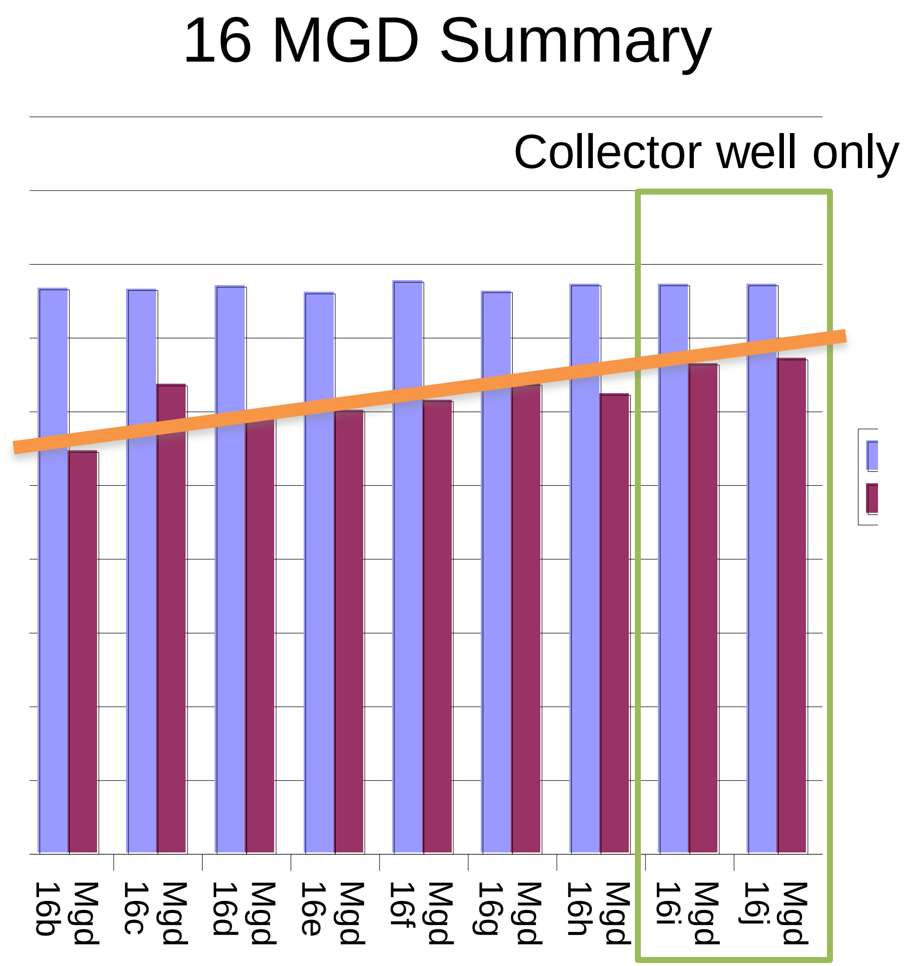
Modeling St. Joseph Wells

- 10 model runs were performed
- Total water pumped from the river (blue bars) insensitive to configuration
- What happened?



Modeling St. Joseph Wells

- Water pumped from the river in less than two years (purple bars) is quite sensitive to the configuration



Groundwater Under the Direct Influence

What are the rules?

Problem of Pathogens

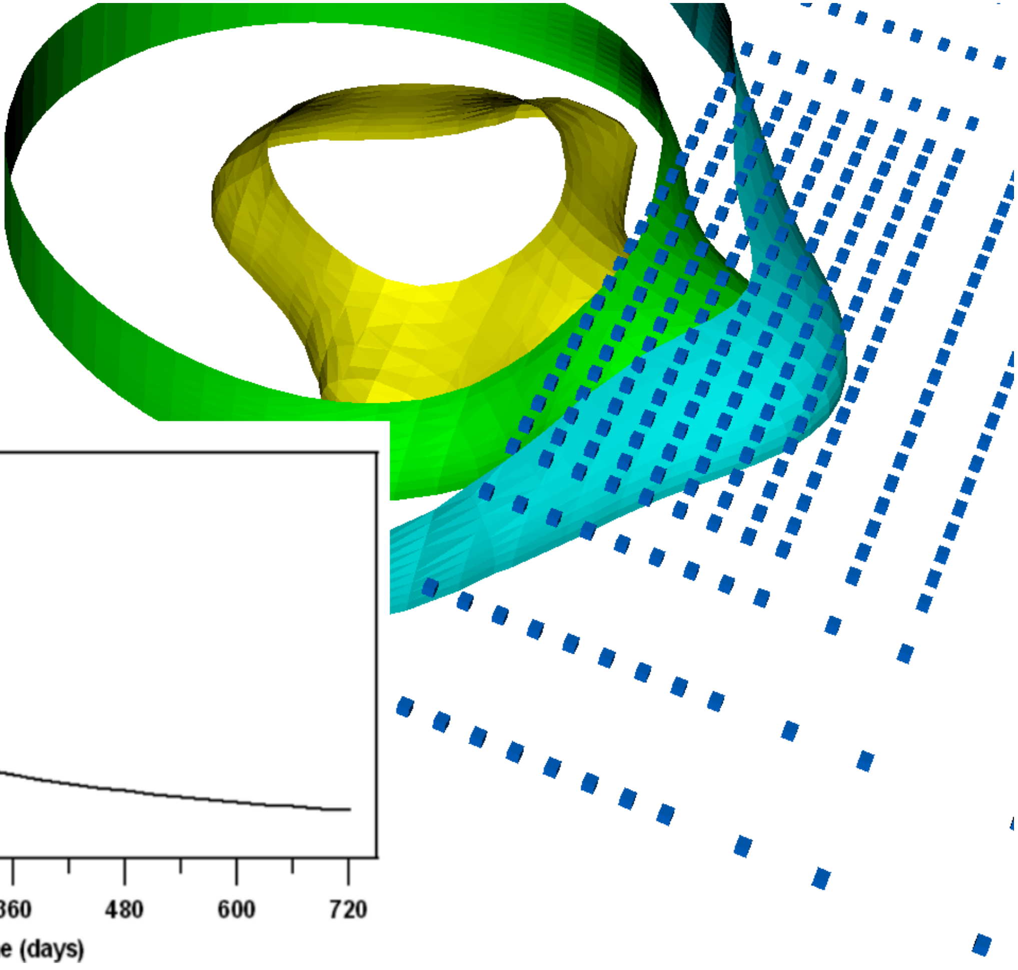
- Short residence times = more pathogens?
  - NOT SO FAST!
    - Gollnitz, Verstraeten, Clancy, Hubbs, Weiss, Ray
- How do the states manage GWUDI?
  - Some examples

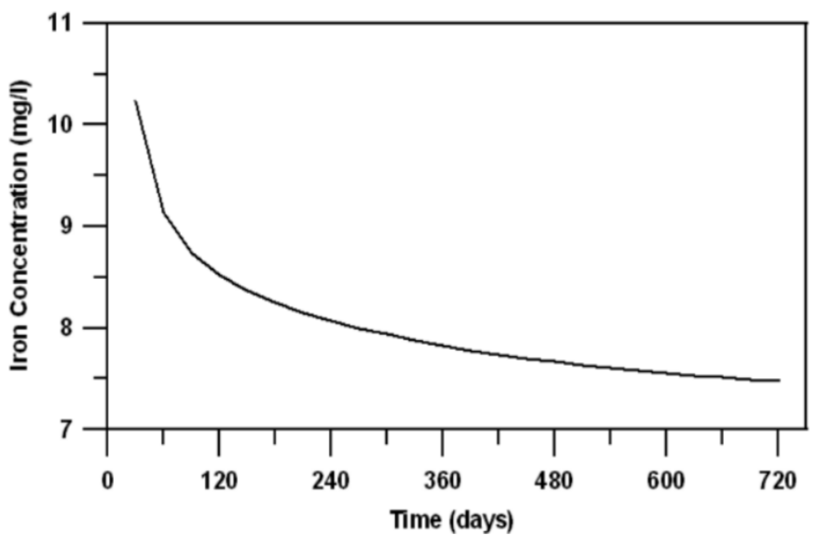
APPROACHES TO GWUDI: COMPARISON

- Indiana
  - 200 ft setback *or* chemistry + performance (MPA)
- Iowa
  - Performance (sampling)
- Arkansas
  - Performance (sampling)
- Missouri
  - 200 ft setback for the lateral arm tips

RECONSIDERING RBF

Engineering groundwater systems





RBF IS CRITICAL TO FUTURE

- Supplies need to be diversified
  - Drought, impacts, sustainability, quality

- Regulations need to reflect research
  - Pathogens
  - DWBP
  - Endocrine disruptors

Layne

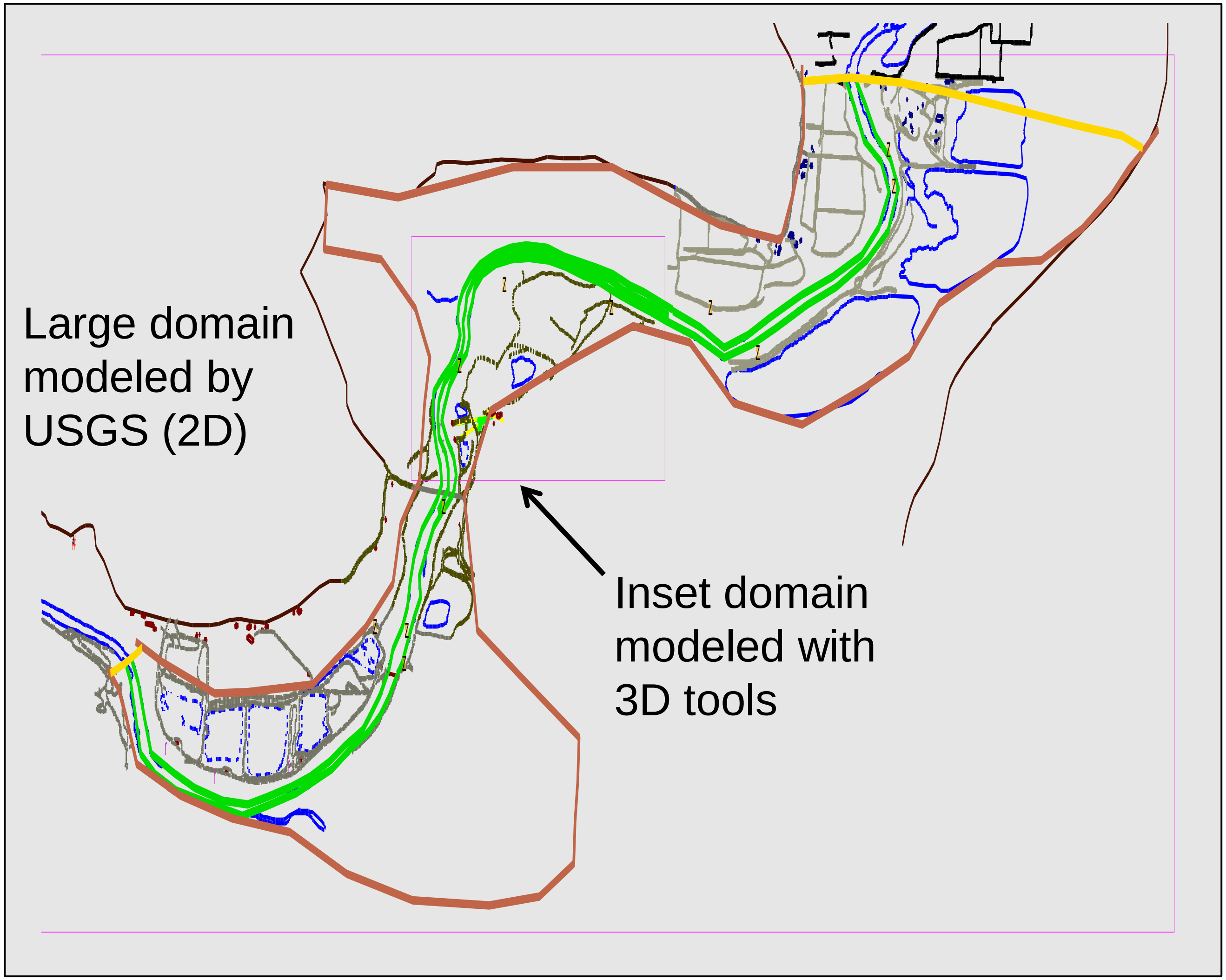
Design considerations of RBF systems

PREDICTING YIELDS OF RBF SYSTEMS

Sonoma County, California

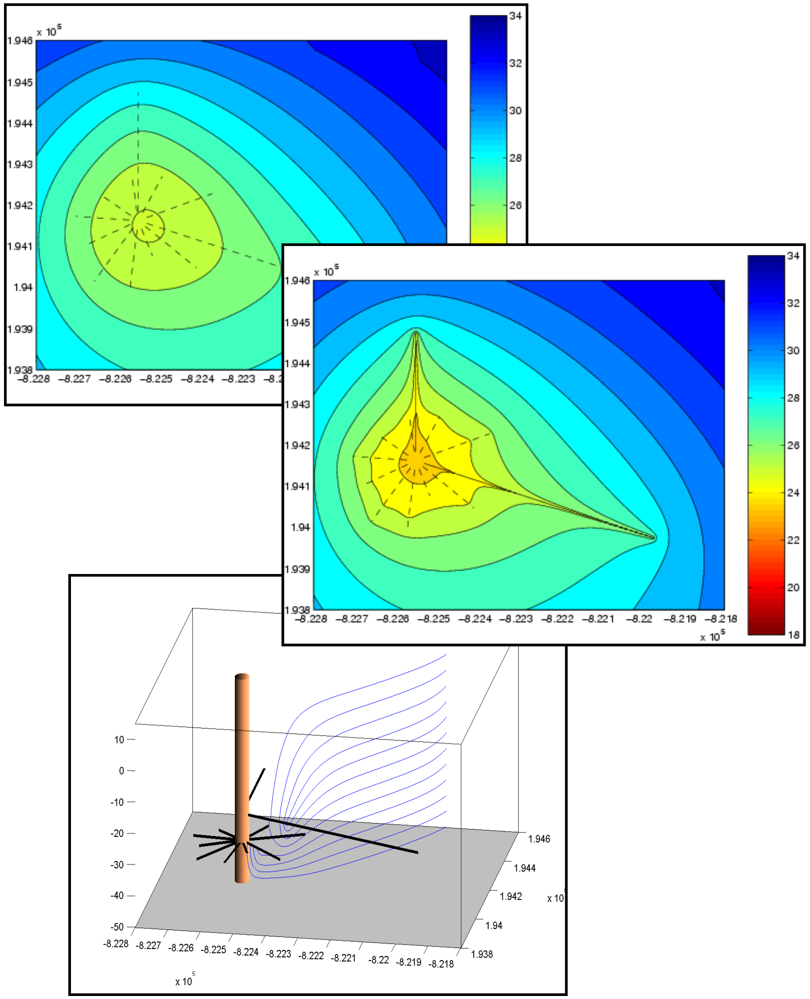
- Collector wells along the Russian River
- Population growth suggested additional capacity
- Not much land in a limited area
- Evaluate new construction techniques

Sonoma County

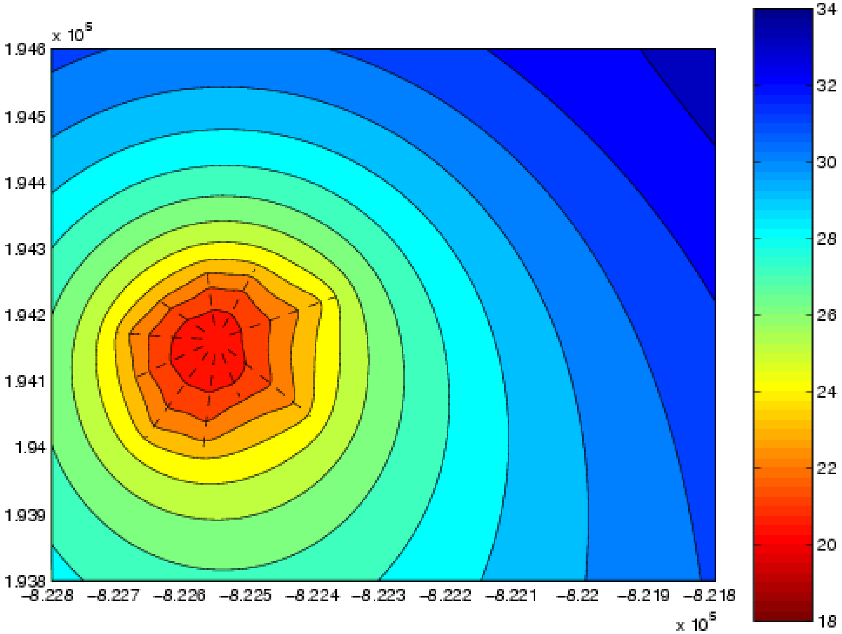


Applied Collector Well Modeling

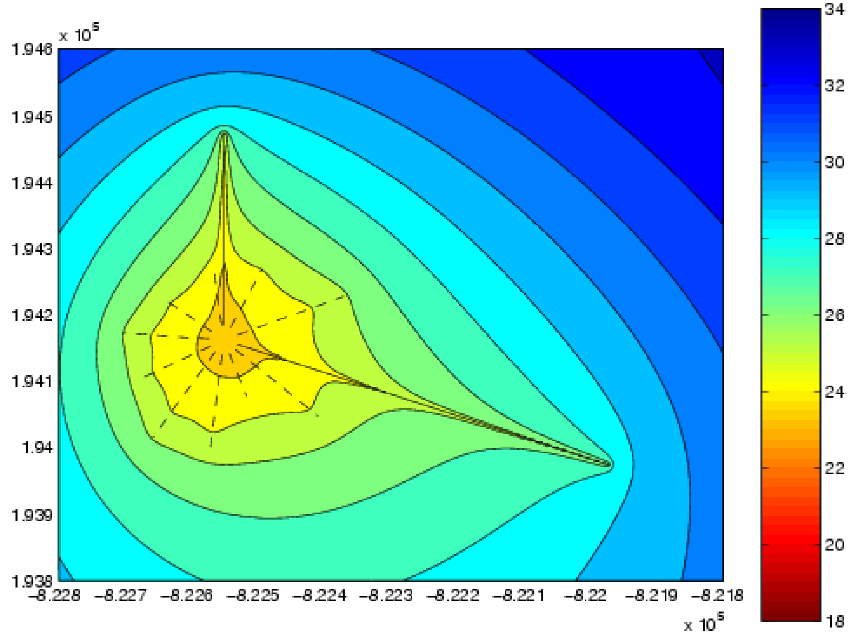
- Specialized models for collector wells
- Need to capture the complex flow near the well and the regional impacts
- Used by Sonoma Co.
- Helps determine options and make good decisions



Sonoma County Lateral Extension



Original

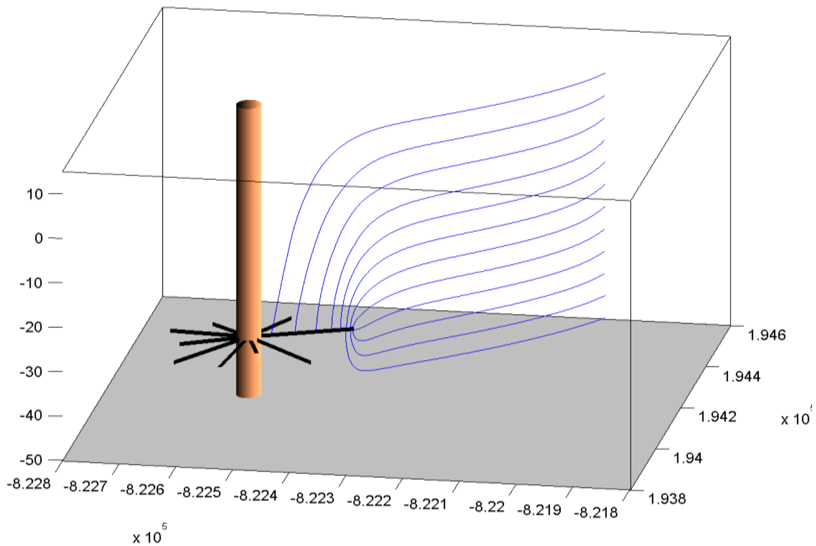


Proposed

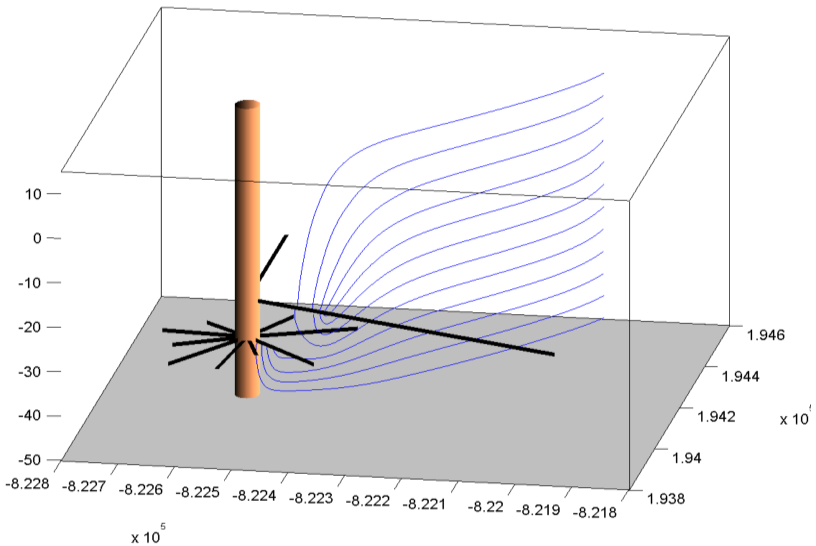
Same pumping rate in each but *diminishing* returns on additional length

Sonoma County

changes in yield and travel time



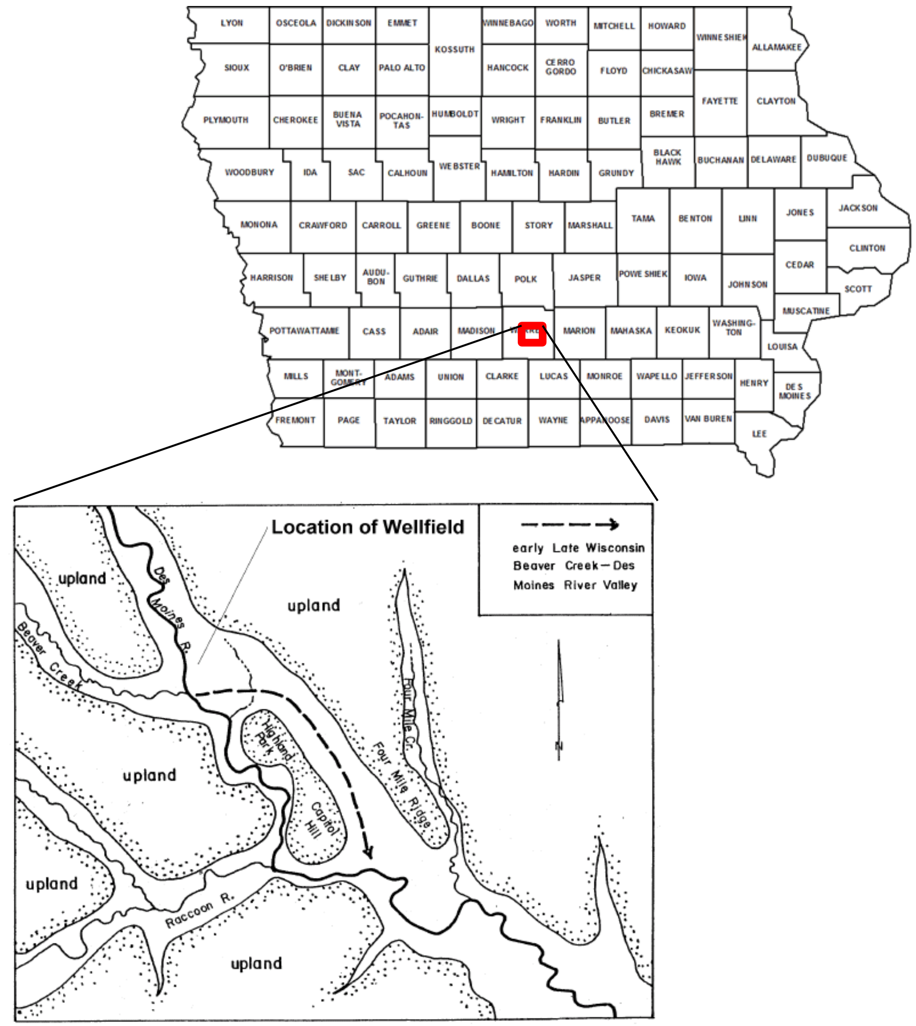
Original



Proposed

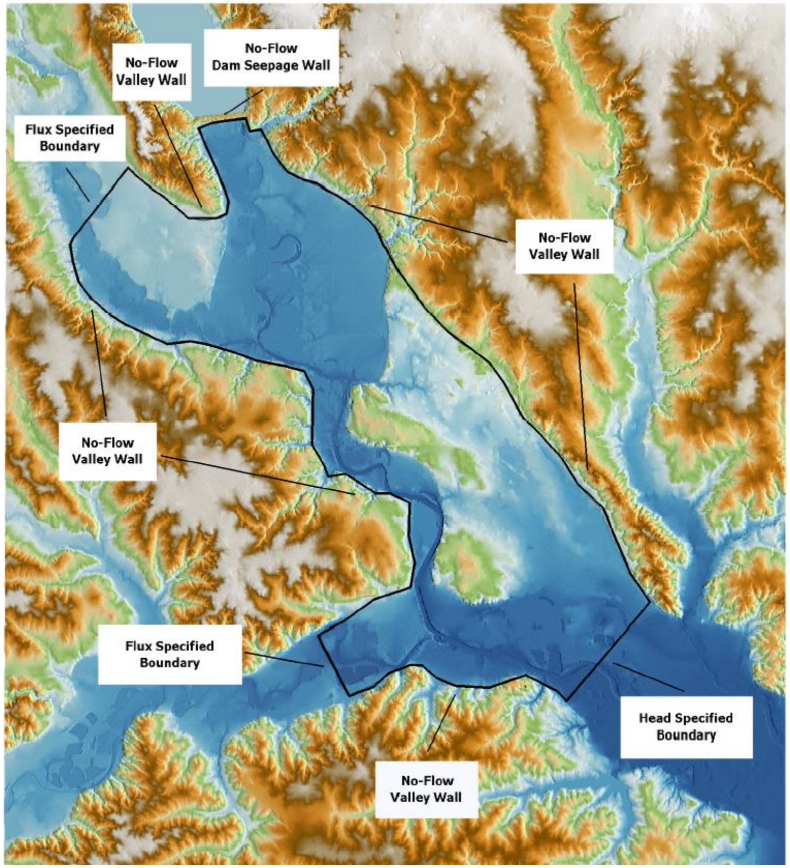
Des Moines, Iowa

- New well field needed to add 10 MGD
- Des Moines has several Ranney wells
  - How many new wells to produce 10 MGD?
  - How much water was possible from the thin 30 ft sand aquifer?
  - Could we optimize water quality for treatment plant?

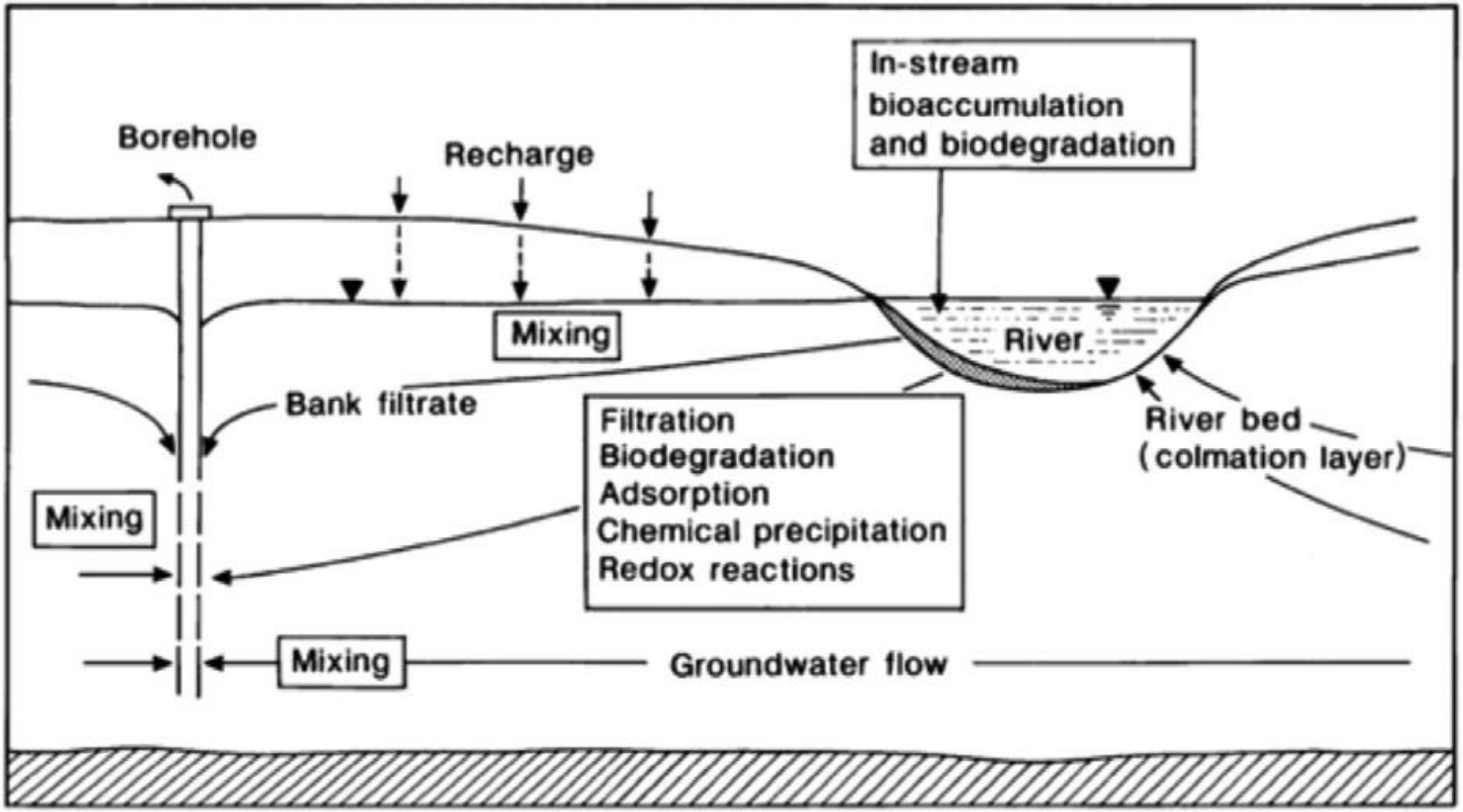


Des Moines, Iowa

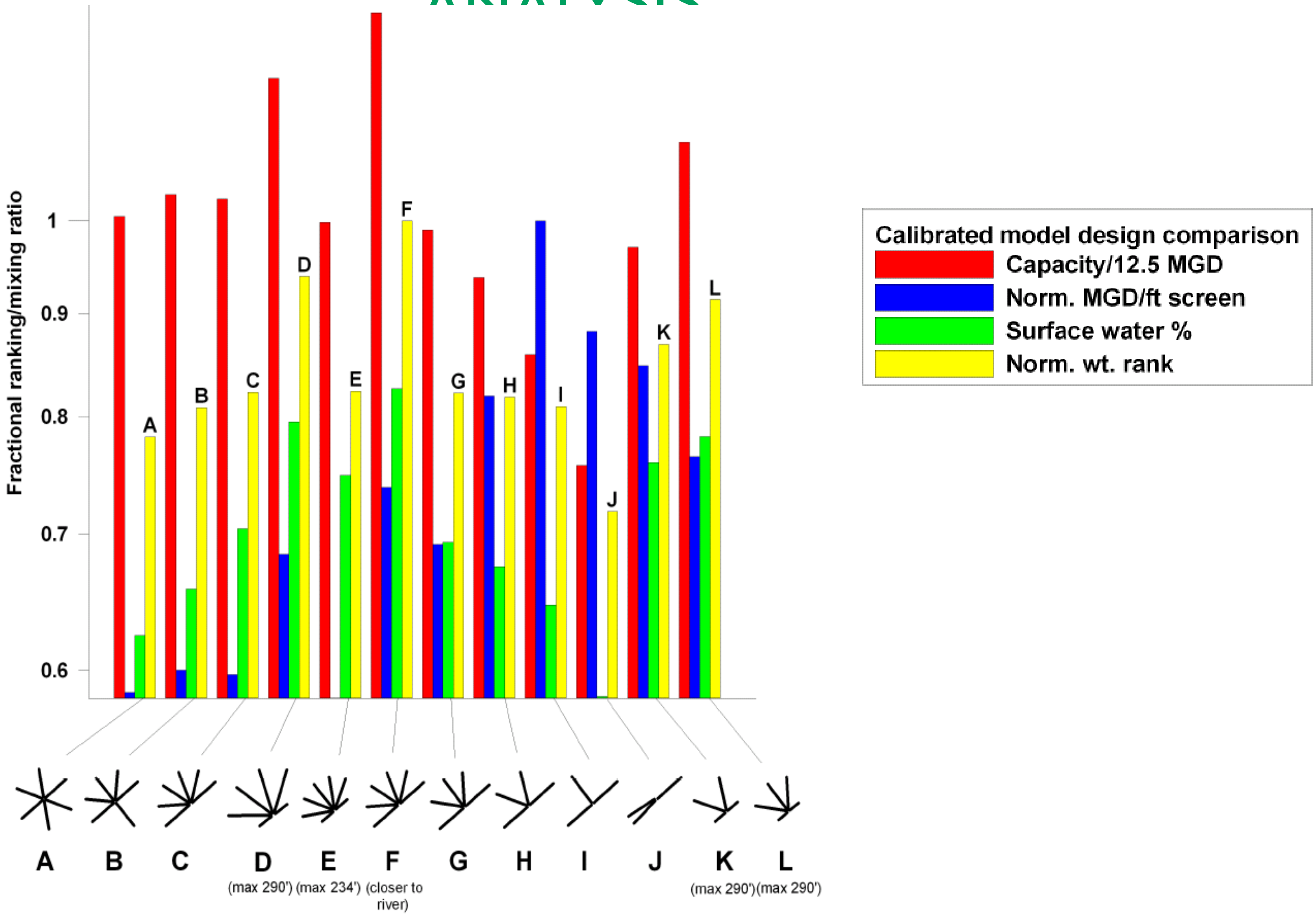
- DMWW coordinated the hydrogeologic investigation
- Layne conducted aquifer tests and did interpretation of the results
  - Regional 2-D models
  - Local 3-D models
  - Aquifer yield
  - Water quality



RBF Processes



DES MOINES – LATERAL DESIGN ANALYSIS



Conclusions and Summary

- Minimize costs of treatment
- Remove new contaminants
- Add capacity by using available surface water
- Removes pathogens and increases the safety of the supply
- Drought-proof supplies on large rivers
- Limits impact to the smallest possible area
- Important for developing countries