PREDICTIVE MODELING OF DOWNGRADIENT CONCENTRATIONS AND OVERALL CLOSURE TIMEFRAME RESULTING FROM BIOREMEDIATION

Fritz Krembs, P.E., P.G., George Mathes, P.E.,
Mitchell, R. Olson, Ph.D., P.E., Michael G. Sweetenham, P.G.

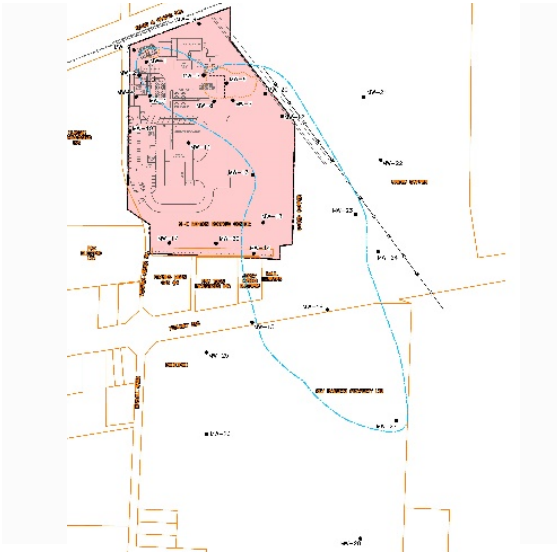
Project Overview

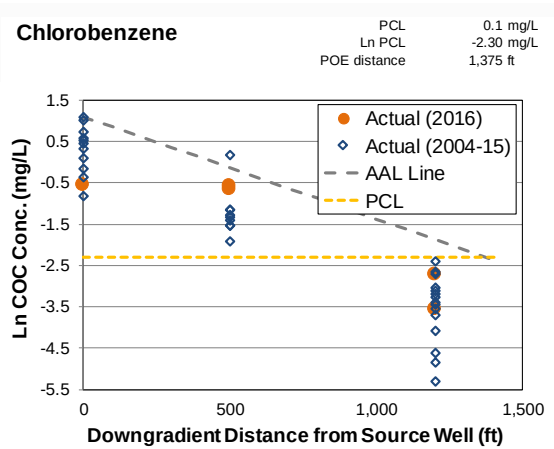
- Industrial facility since 1975
- RCRA program / TCEQ oversight / TRRP
- Groundwater impacts 10-25 ft
  - PCE + degrad. products
  - TCA + degrad. products
  - Chlorinated benzenes (CBs)
- Impacts from 1970s era former stormwater pond

Conceptual Site Model

- Large, dilute plume
- Cis-DCE and vinyl chloride indicate reductive dechlorination
- Thin fine sand bounded above and below by fine-grained strata

Site Strategy



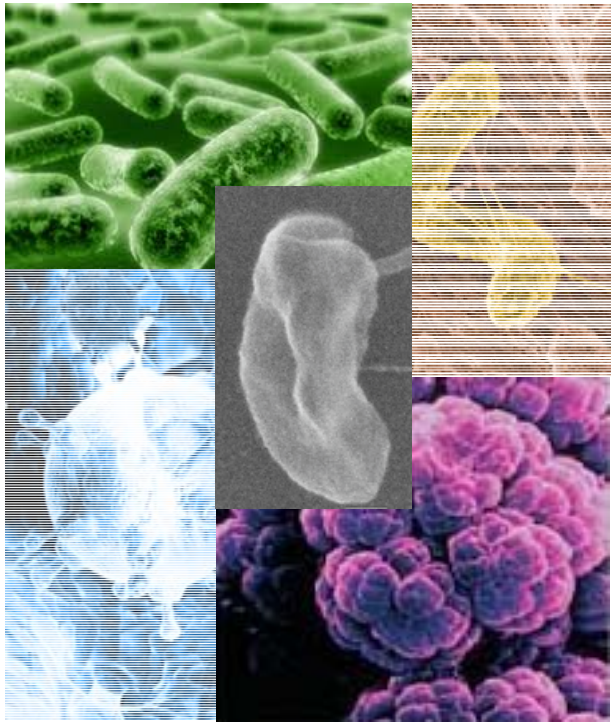


	PLUME MANAGEMENT ZONE (PMZ)	MONITORED NATURAL ATTENUATION (MNA)	ACTIVE REMEDIATION
On-Site	PCE, TCA, CBs (ACLs)	TCA, CBs (AALs)	PCE (ACLs/MCLs)
Off-Site	na	PCE (MCLs)	PCE (MCLs)

Remediation Technology Selection

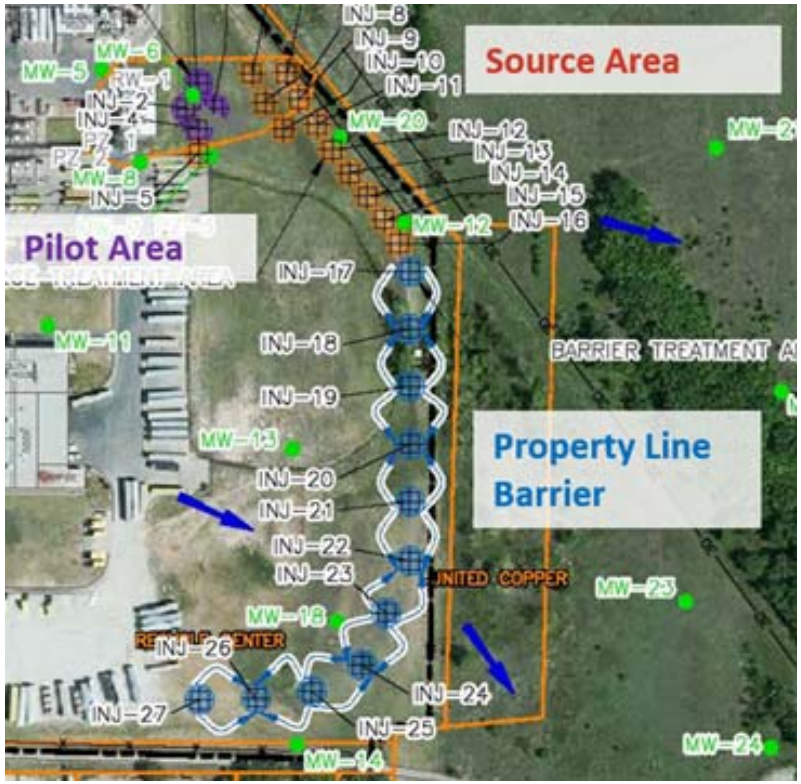
- Economical reagents required for large plume
- Expanding footprint of treatment needed for large plume with access restrictions
- Persistent process needed for middle/late stage plume
- Cis-DCE and vinyl chloride indicated reductive dechlorination ongoing

In-Situ Bioremediation (ISB) most compatible with above criteria



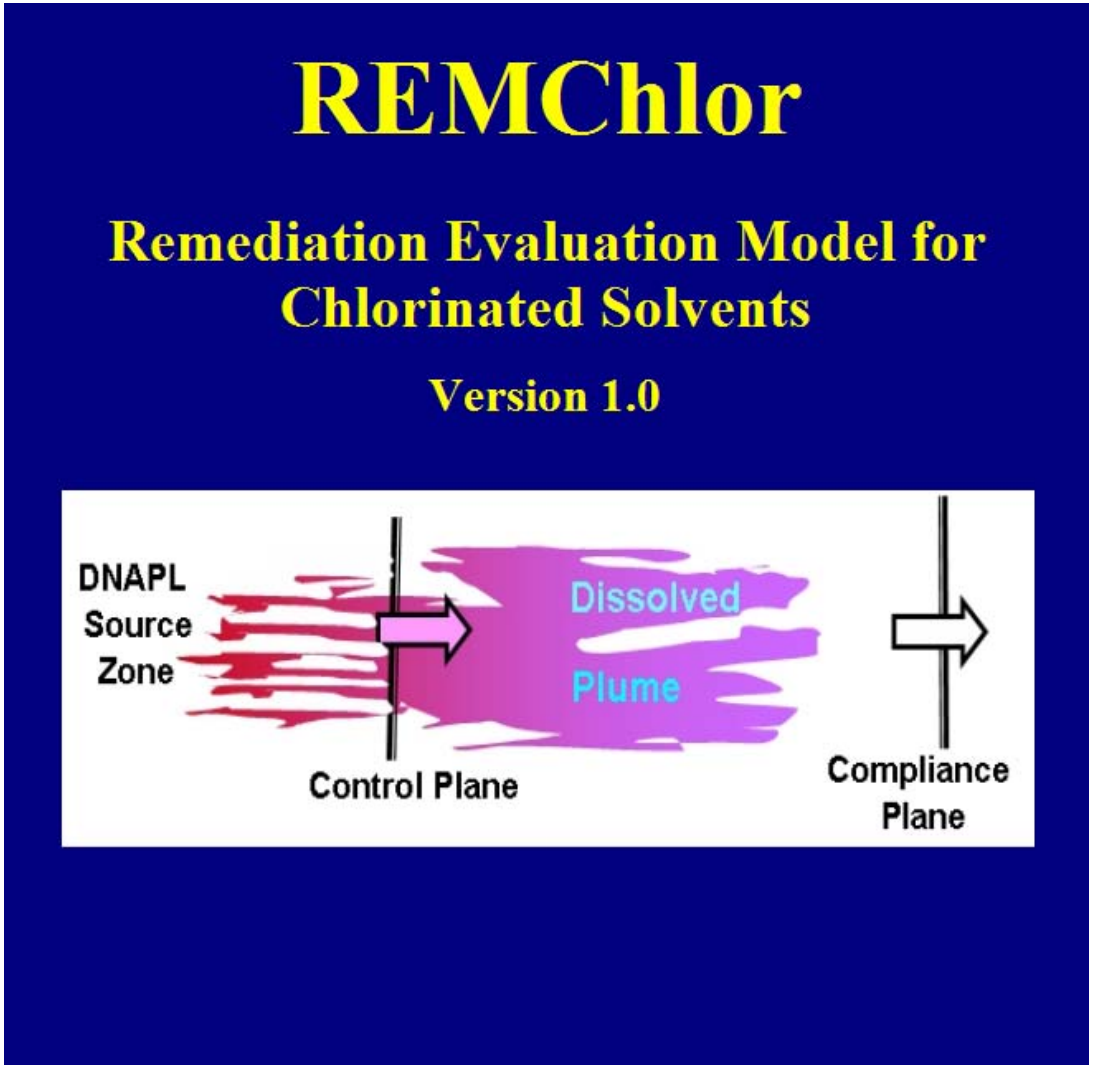
Modeling and ISB Design

- Response Action Plan (RAP) submitted to TCEQ
- Conceptual design
  - Source area treatment
  - Client property line treatment
- Per TCEQ: State proposed ‘reasonable time frame’ and provide justification
- *Use model to assess when ISB attains MCLs off-site*



Step 1: Model Selection

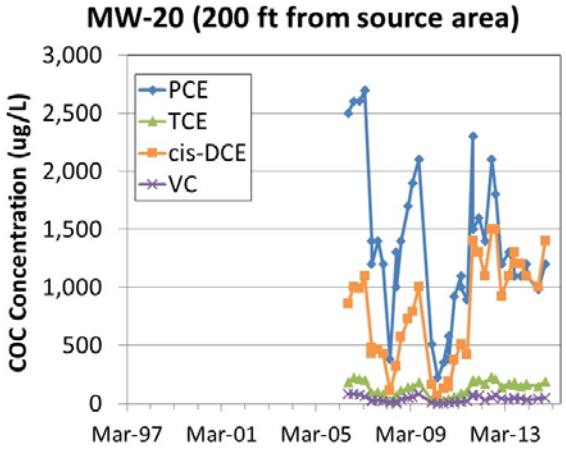
- Remediation
- EPA-vetted
- Biodegradation
- Back-diffusion
- Analytical model

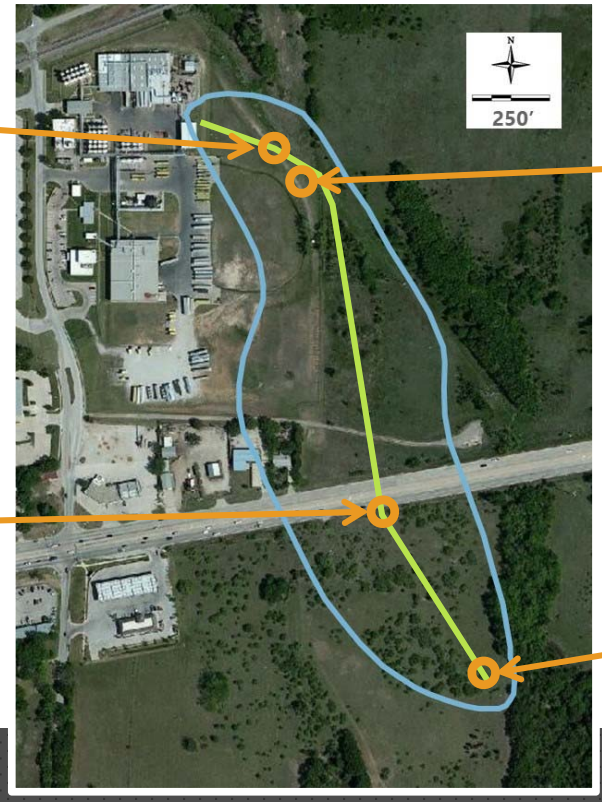


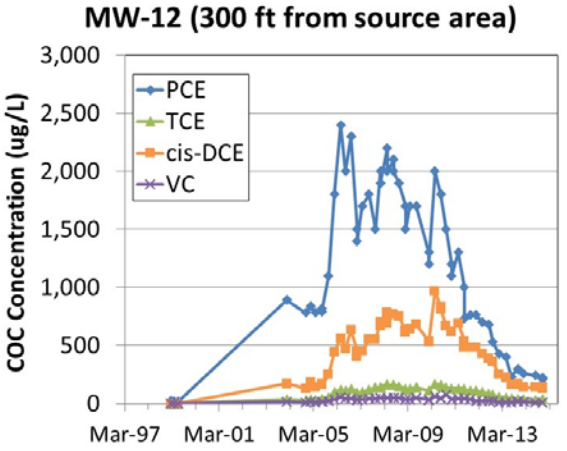
Step 2: Model Calibration

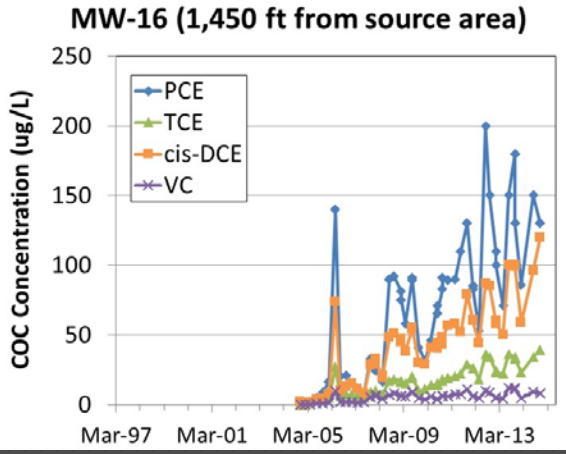
- Calibrate to historical data
  - Multiple time points
  - Multiple locations
- Capture plume-scale behavior
  - Rapid concentration increase upon plume arrival
  - PCE ≥ cis-DCE > TCE > VC

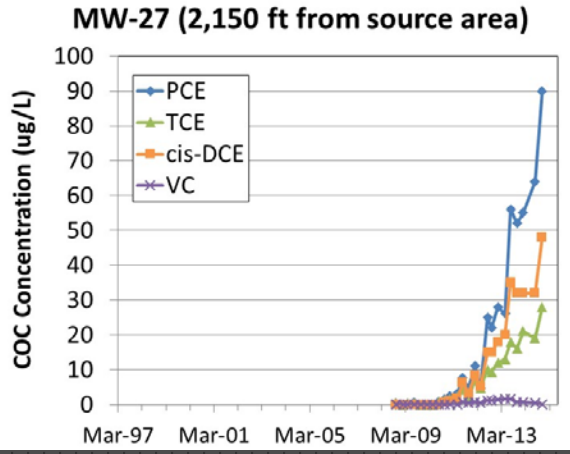
Model Calibration: Historical Data







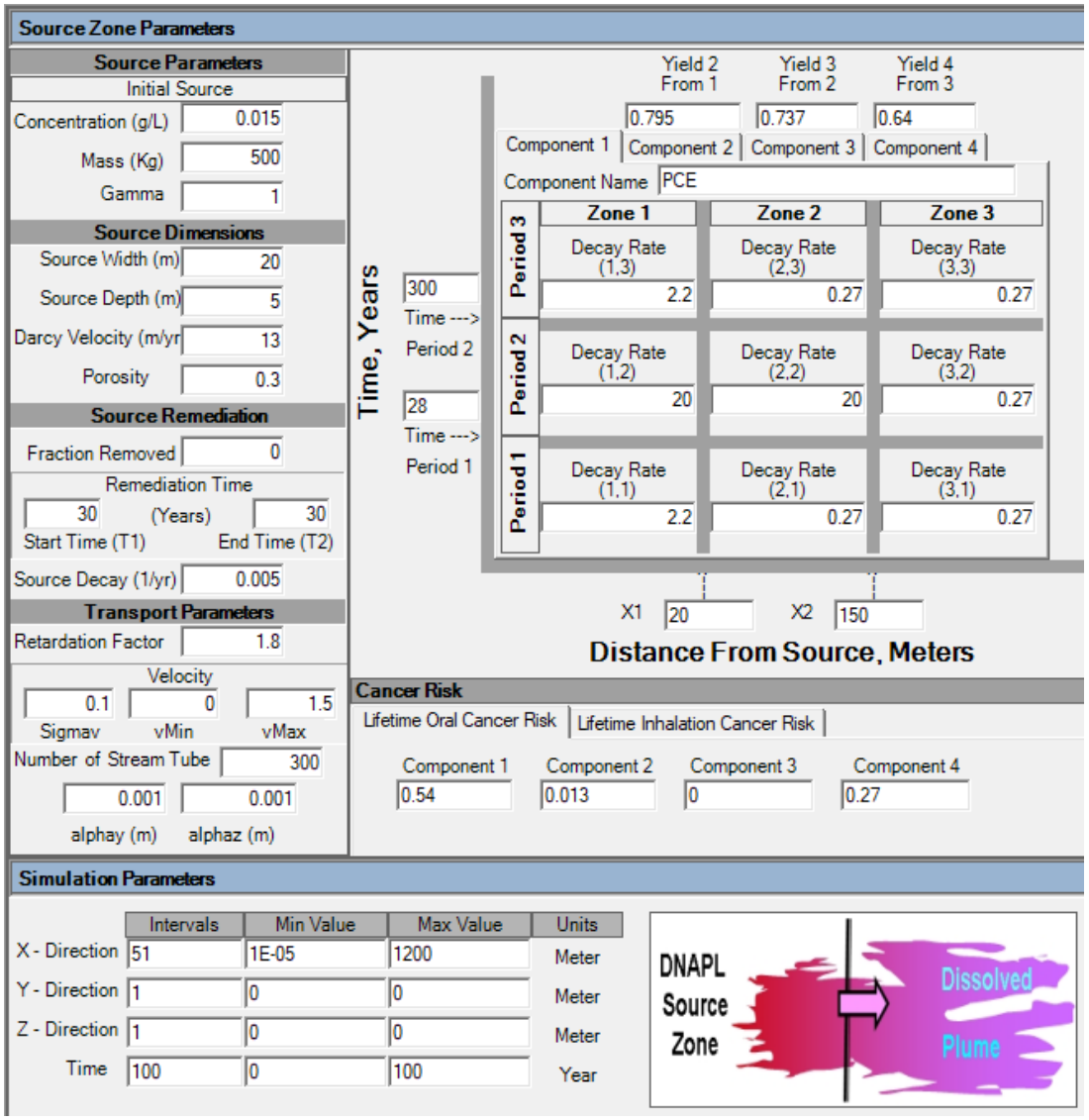




6 time points 2005 to 2014

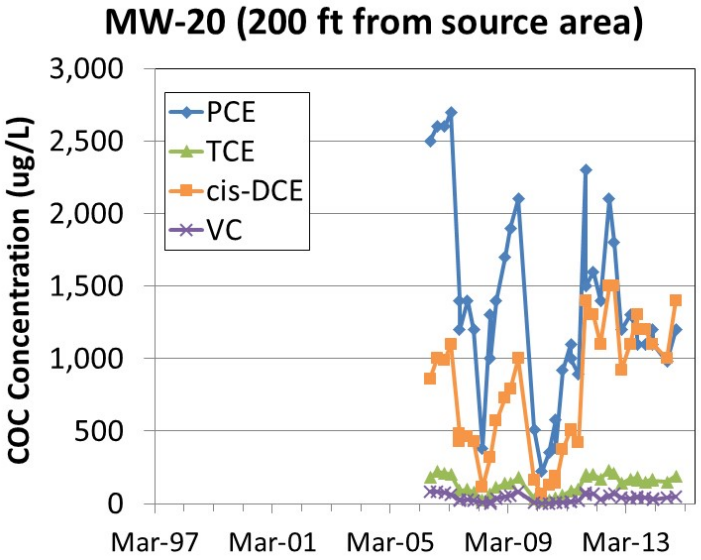
Model Calibration: Parameters

- 54 parameters
  - 11 source
  - 7 groundwater
  - 36 decay
- Constrain number of options
  - Direct measurements
  - Plume-scale behavior
  - Fitting parameters

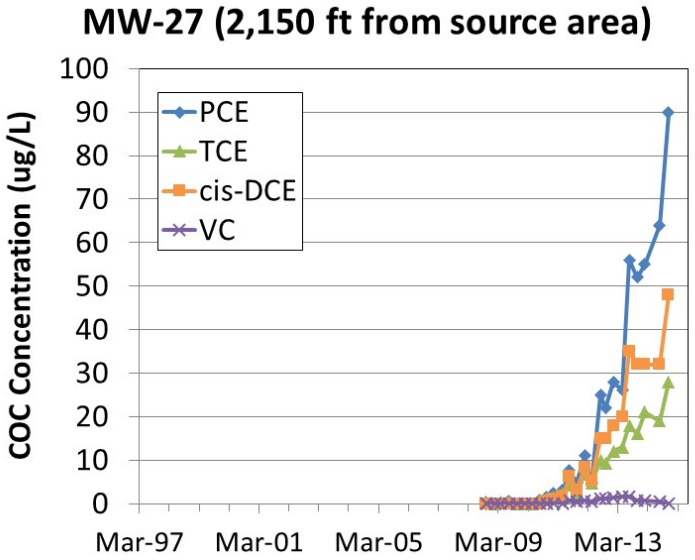


Model Calibration: Plume-Scale Behavior

Decreasing concentrations in source area ->
Source concentration and decay

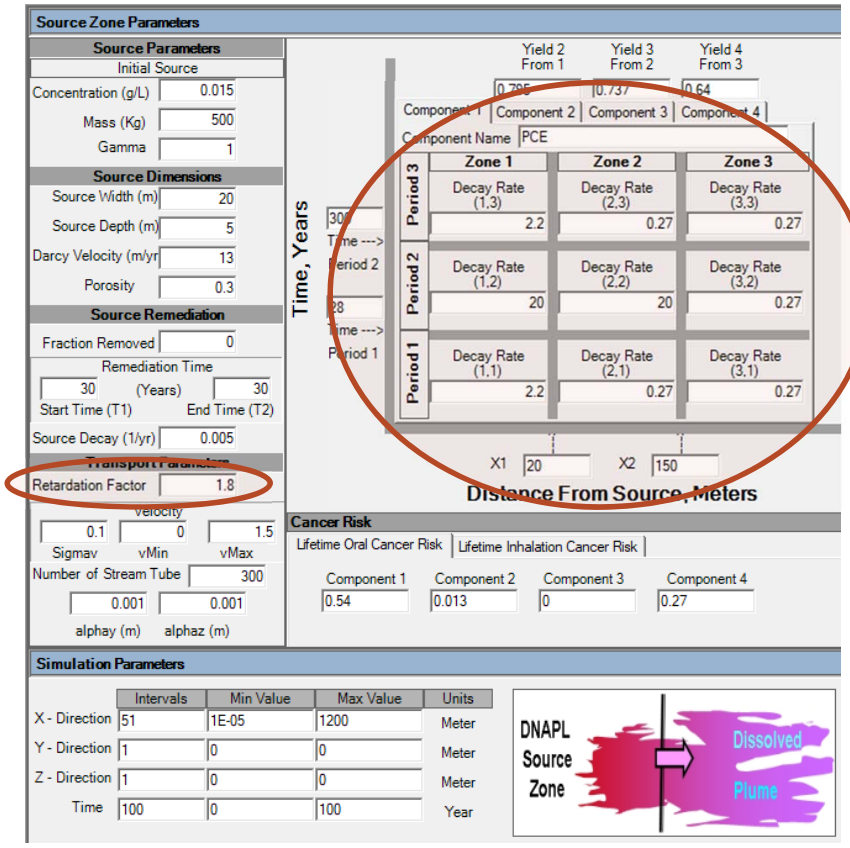


Fast breakthrough ->
Low dispersion velocity profile

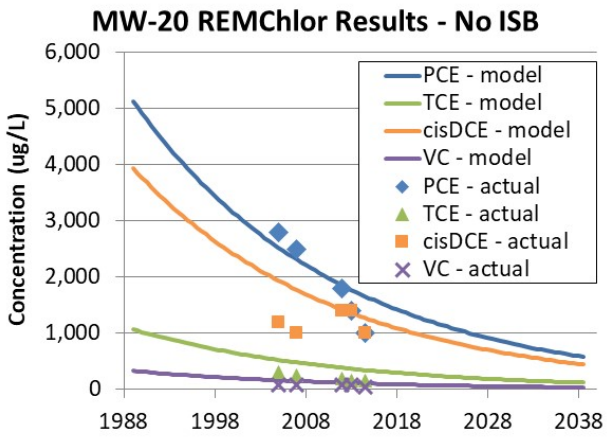


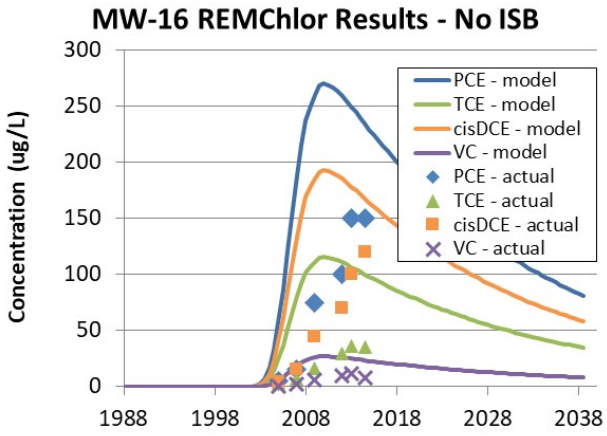
Model Calibration: Fitting Parameters

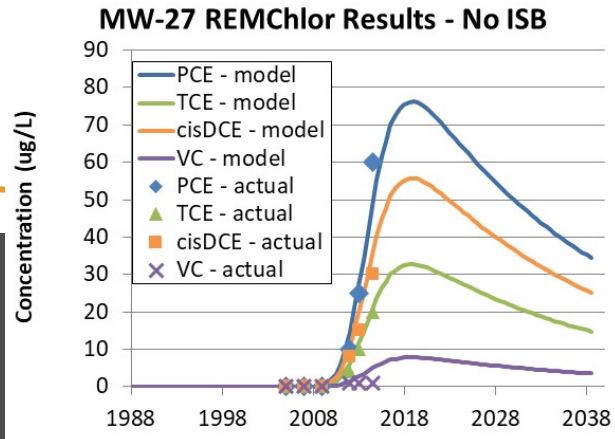
- Retardation
  - One value for 4 constituents
- Decay rates
  - Highest in source area
  - Highest for TCE



Model Calibration: Results

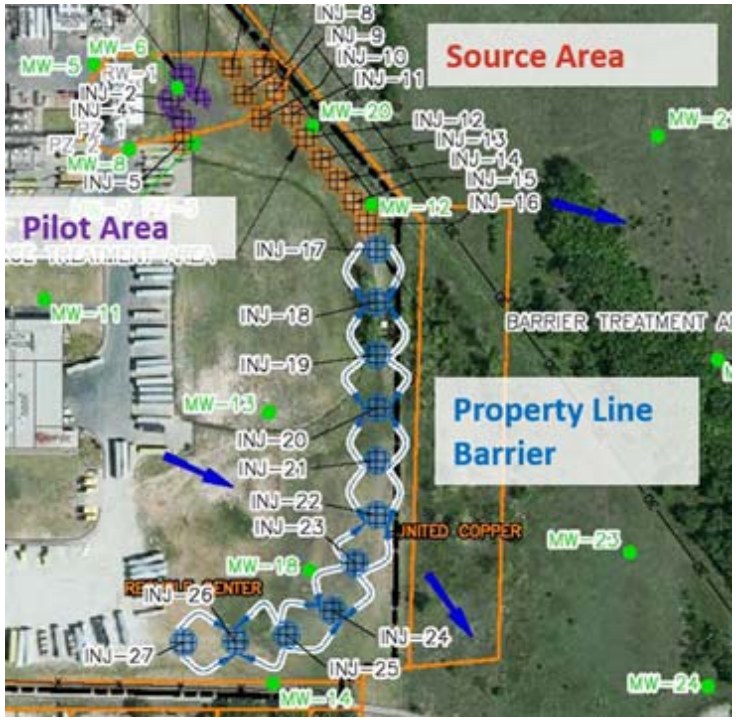




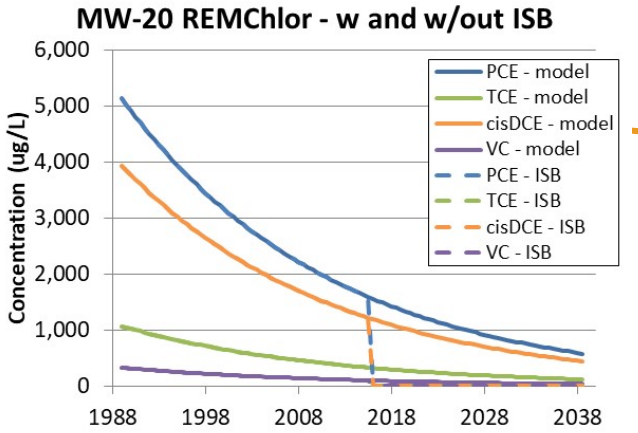


Predictions from Model: Methods

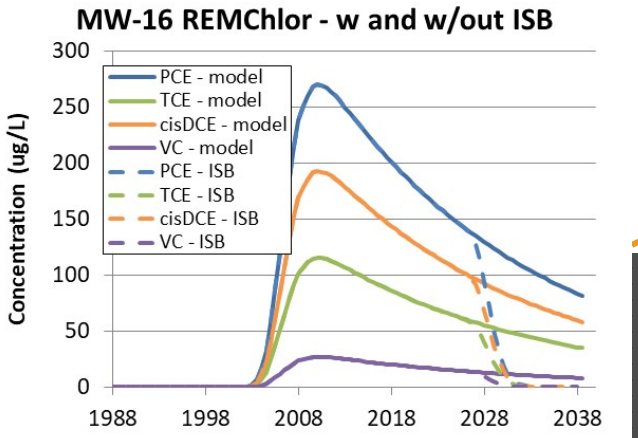
- Goal = Simulate ISB in REMChlor
- Increase degradation rates in on-site ISB footprint
  - 30 /yr for each COC
  - Source to 150m downgradient
  - Starting in 2015
  - Other model inputs constant
- Examine future concentrations downgradient in model

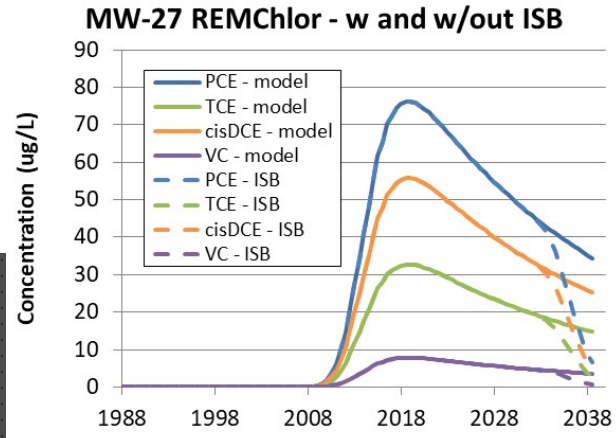


Predictions from Model: Results



Solid lines = model w/out ISB
Dashed lines = model w/ ISB





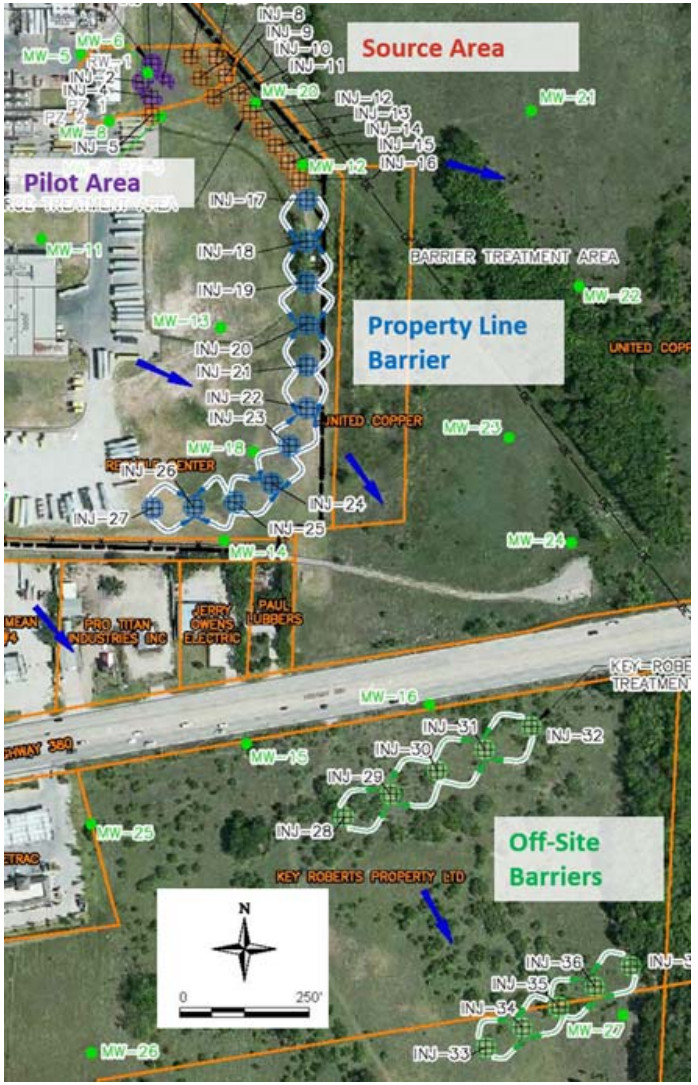
Predictions from Model: Conclusions

Model Results

- Model predicts that ISB on client property results in MCLs
  - 2031 at mid-point (MW-16)
  - 2039 at leading edge (MW-27)
- Longer than acceptable
- 80% longer than GW velocity calculations predict

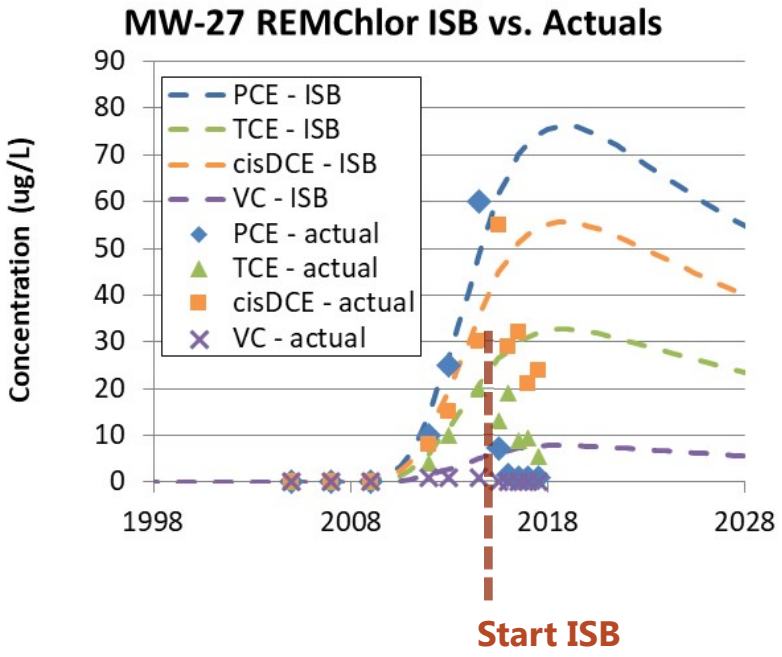
Resulting Actions

- ISB program expanded to off-site area



Post Script: What's New Since 2015

- ISB implemented full-scale in 2015
- Additional injection event 2017
- Analytical data generally supports model results



Summary and Conclusions

- Model assessed predictive results of ISB during design
- Model outcome resulted in expanded ISB footprint
- Remedy timeframe incorporated in decision documents
- ISB program ongoing

Fritz Krembs, P.E., P.G.

fkrembs@trihydro.com

QUESTIONS?

Trihydro