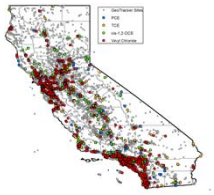
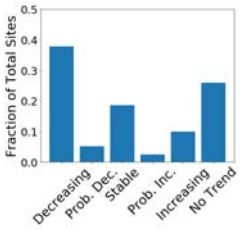
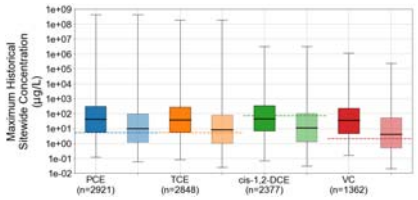
TRACKING CLEANUP OF CHLORINATED SOLVENTS: Development of Benchmark Decay Rates







Kenneth Walker, PE; Travis McGuire, PE; David Adamson, PhD, PE; and Charles Newell, PhD, PE

GSI Environmental Inc., Houston, TX

PROBLEM STATEMENT

Problem:

- ESTCP Project ER-201429
- Overarching Goal: quantify sustained treatment and MNA in low-K zones
  - What do we compare measured MNA rates at 8 field sites to?
  - "Big Data" Component: Develop benchmark decay rates for evaluating sustained treatment and MNA in low-K zones

Approach:

- "Data Mining" California GeoTracker Database
- Evaluate historical sampling data from thousands of sites over 15+ years
- Consistent with recent studies by Adamson et al. (2015, 2016), McHugh et al. (2014), Kulkarni et al. (2017), and McGuire et al. (2016)

PERFORMANCE ASSESSMENT

- **Methodology**
- **Long-term CVOC Trends**
- **Chlorinated solvents and daughter products: potential relationships**
- **Development of benchmark decay rates**

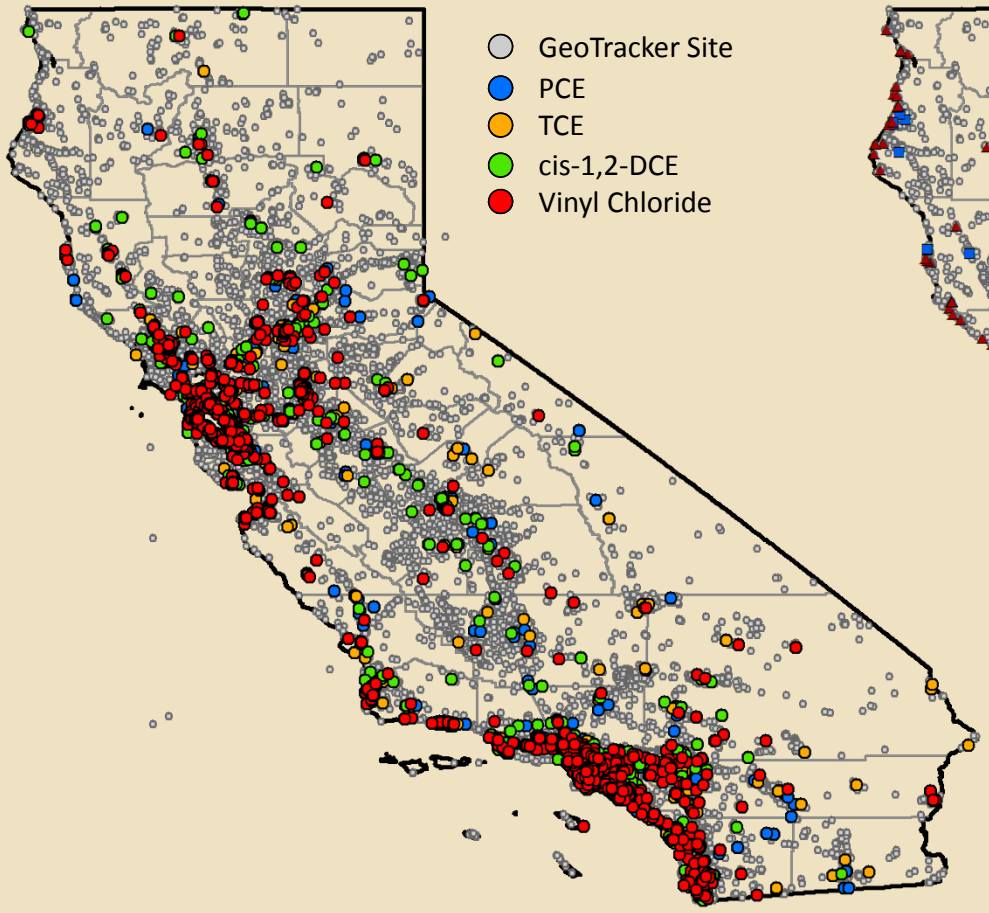
DATA MINING: METHODOLOGY

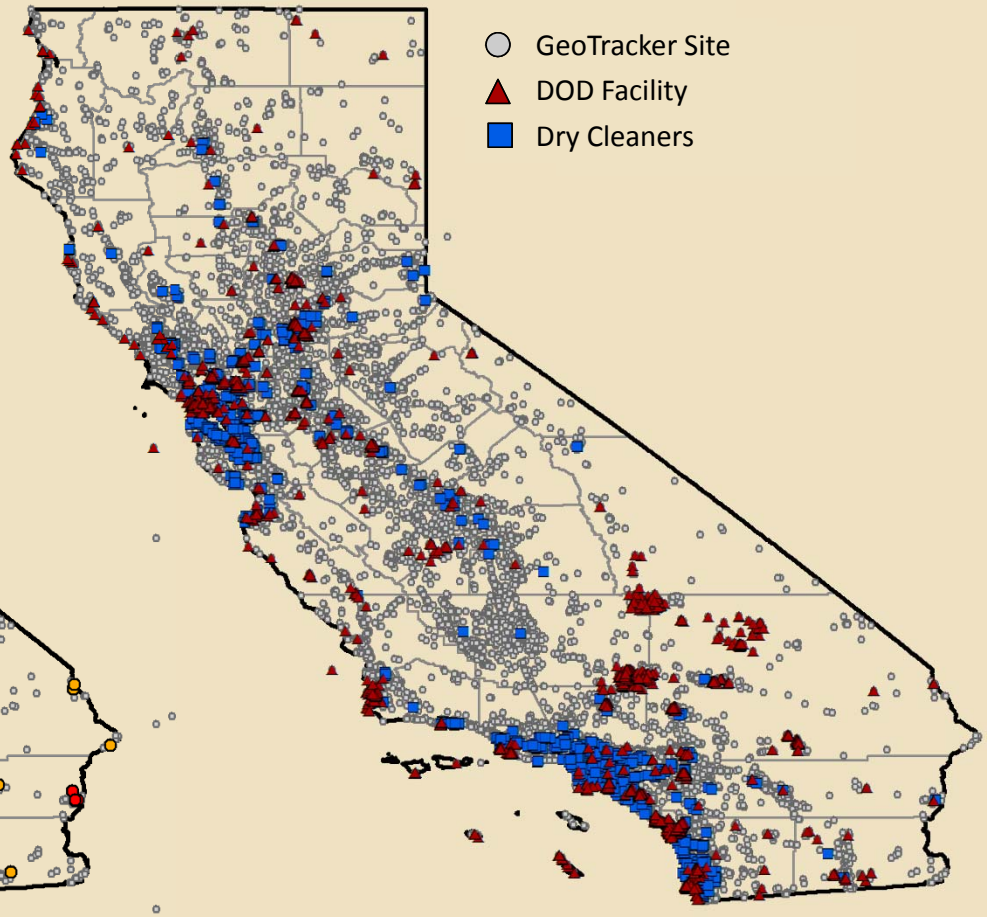
- California GeoTracker database (through 2017)
- Divide monitoring record into six-month periods
  - Max. conc. at each well
  - Max. conc. at each site ("source")
- Criteria for inclusion:
  - Max. conc. > 50 µg/L
    - (1 OoM above MCL for PCE and TCE)
  - < 75% non-detect
  - > 5 years monitoring history
    - Mann-Kendall trends
    - 1st-order decay rates

DATA MINING: GEOTRACKER STATISTICS

Analyte	Sites Sampled	Sites Detected	Wells Sampled	Wells Detected	Sites Meeting Criteria	Wells Meeting Criteria
PCE	7,176	2,922	37,966	27,125	621	1,751
TCE	7,320	2,848	38,066	32,609	652	2,752
cis-1,2-DCE	7,052	2,377	37,642	25,564	594	1,906
Vinyl Chloride	7,075	1,362	37,241	11,151	301	669

CALIFORNIA GEOTRACKER: SITES





PERFORMANCE ASSESSMENT

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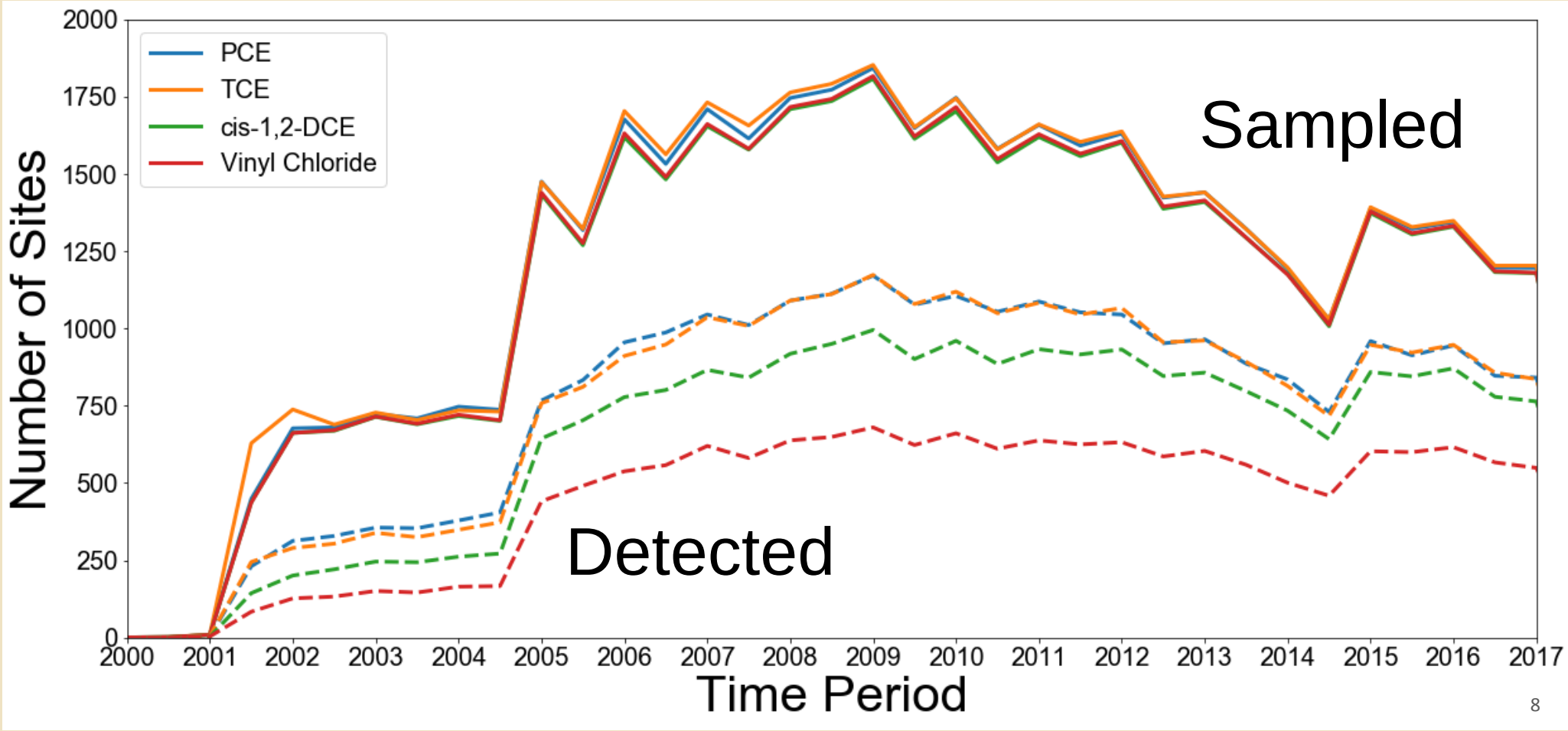
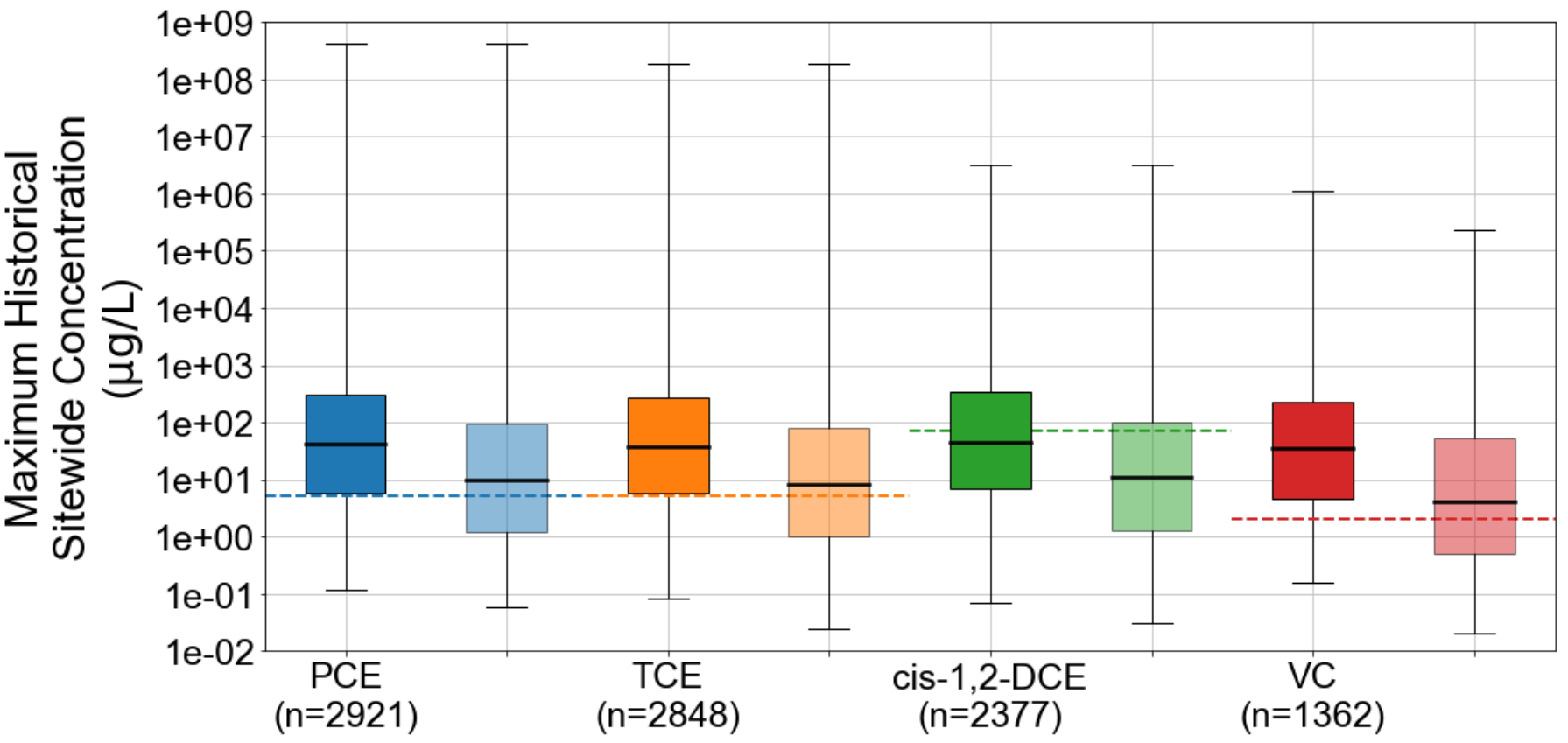
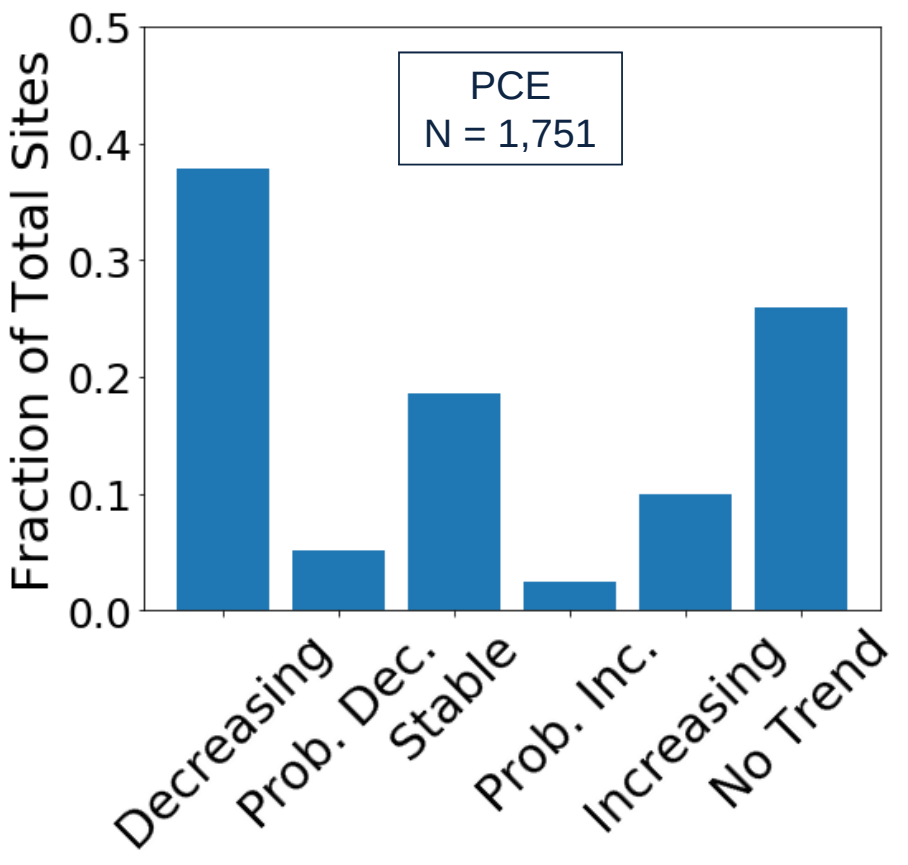
GEOTRACKER: NUMBER OF SITES SAMPLED EACH PERIOD

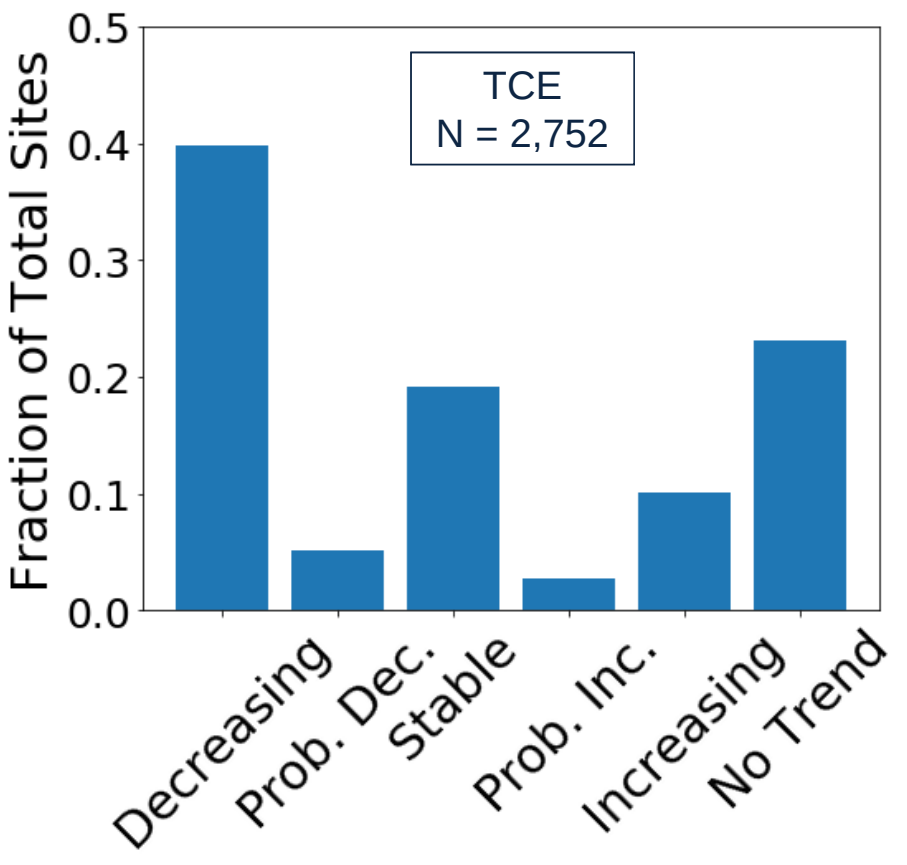


HISTORICAL MAXIMUM SITE CONCENTRATIONS VS. RECENT MAXIMUM SITE CONCENTRATIONS



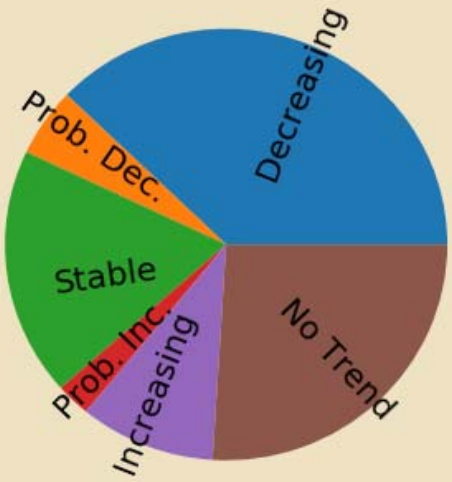
MANN-KENDALL: PCE & TCE IN MONITORING WELLS



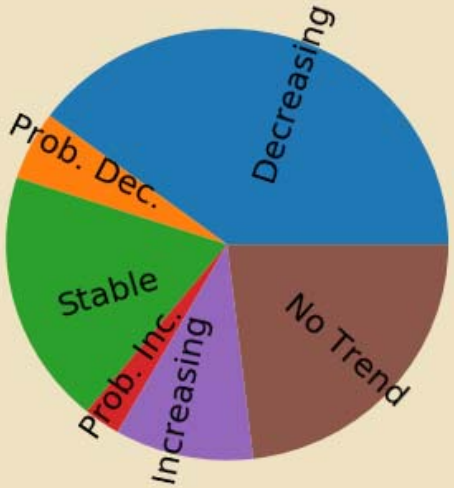


MANN-KENDALL: INDIVIDUAL MONITORING WELLS

PCE (n=1,751)

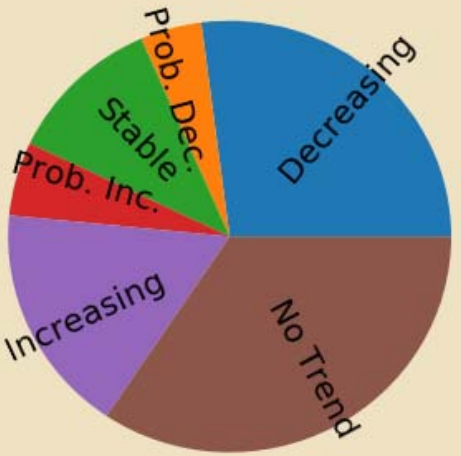


TCE (n=2,752)



cis-1,2-DCE (n=1,906)

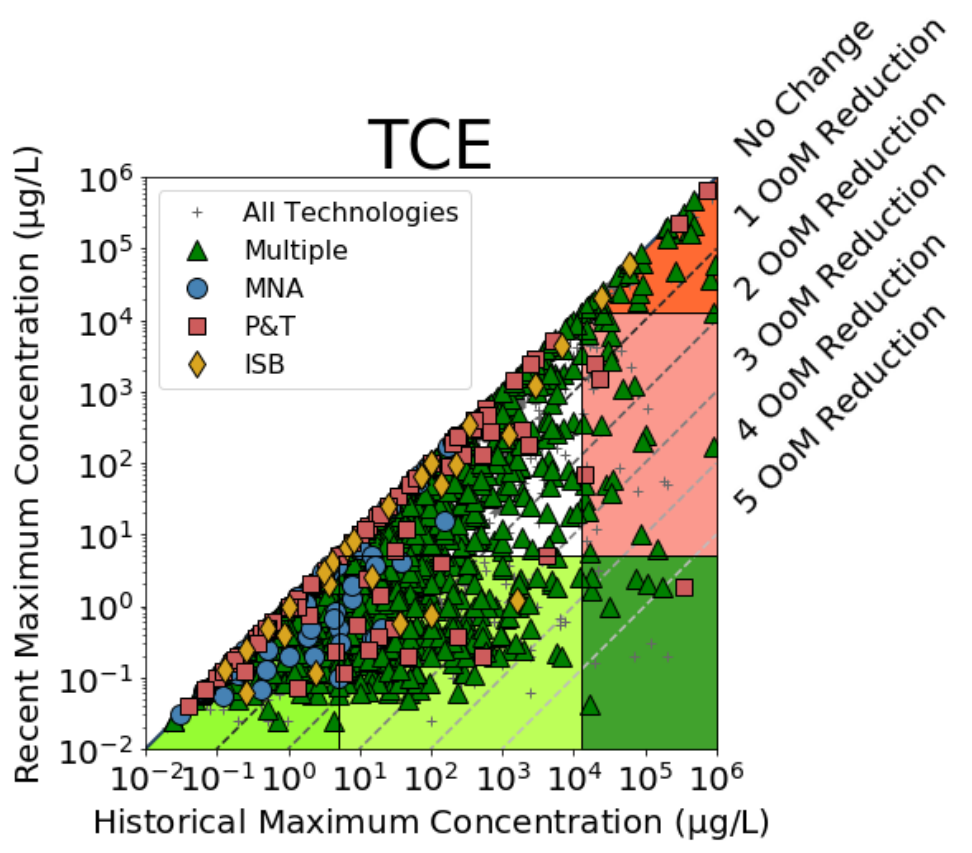
Vinyl Chloride (n=669)



GEOTRACKER REMEDIAL TECHNOLOGIES

- GeoTracker maintains a list of site "actions":
  - In Situ Thermal Treatment
  - Dual Phase Extraction
  - Soil Vapor Extraction (SVE)
  - Excavation
  - Ex Situ Physical/Chemical Treatment (not SVE, P&T, excavation)
  - Capping
  - "Other"
  - Monitored Natural Attenuation (MNA)
  - In Situ Bioremediation (ISB)
  - Permeable Reactive Barrier
  - Pump & Treat
  - Free Product Removal
  - In Situ Physical/Chemical Treatment
  - "Multiple" -> any combination of 2 or more of these technologies

IMPACT OF TECHNOLOGIES?



- **OoM Reductions**
  - **n=2,848 sites**
  - **0-1 OoM: 76%**
  - **1-2 OoM: 16%**
  - **2-3 OoM: 6%**
  - **3-4 OoM: 2%**
  - **4-5 OoM: <1% (12 sites)**
  - **>5 OoM: <1% (6 sites)**
- **Median OoM:**
  - **PCE: 0.22**
  - **TCE: 0.22**
  - **Cis-1,2-DCE: 0.21**
  - **Vinyl Chloride: 0.45**

PERFORMANCE ASSESSMENT

- Methodology
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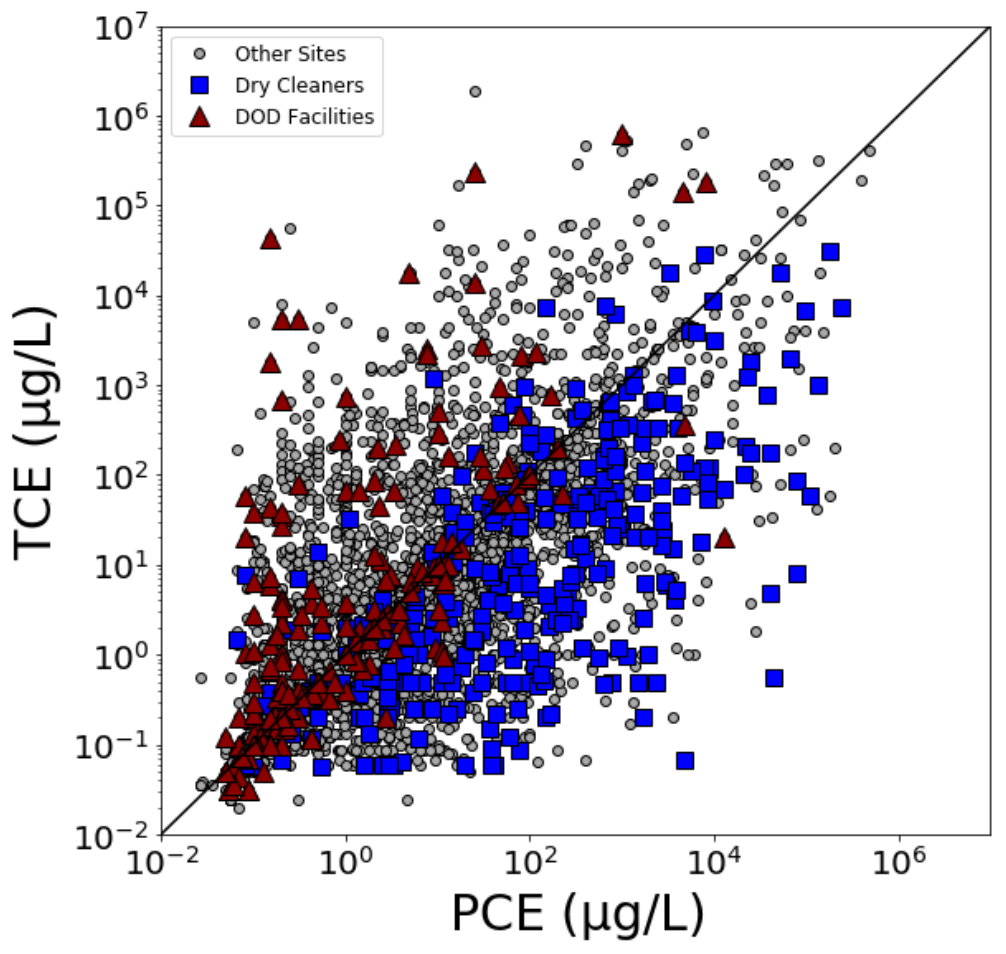
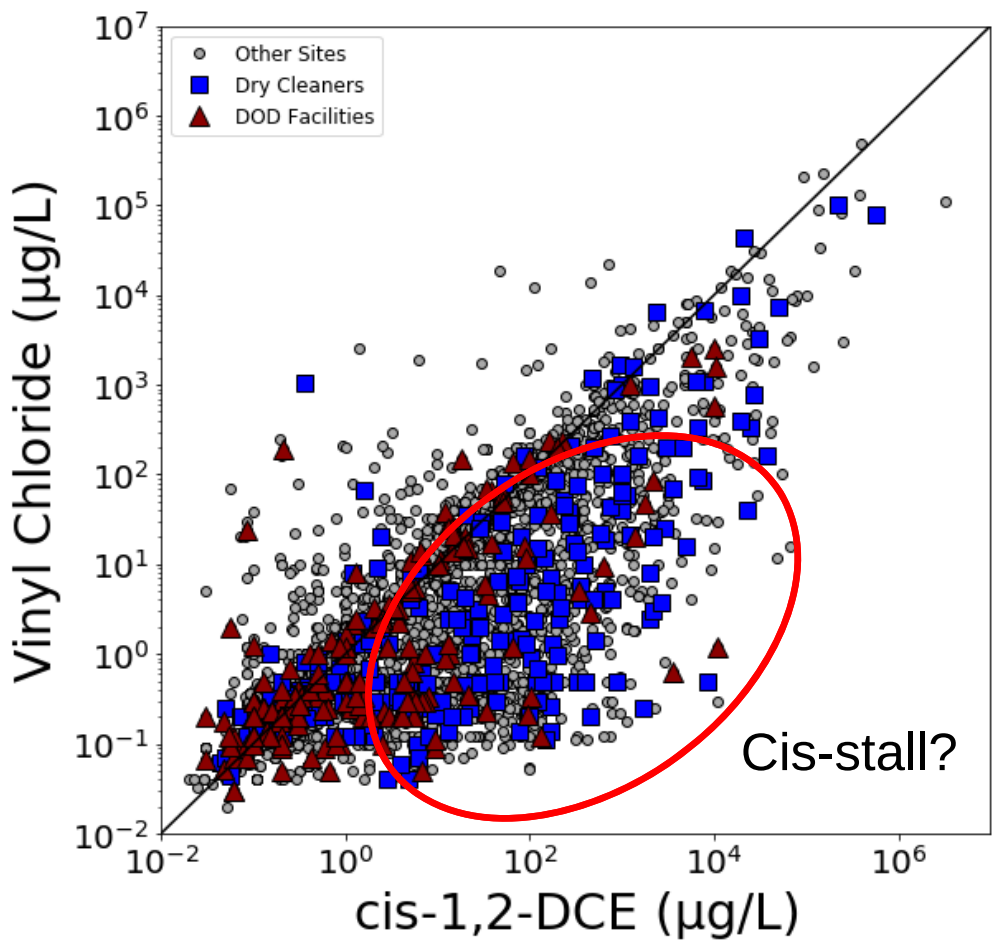
PCE VS. TCE CONCENTRATIONS – MOST RECENT SITE MAXIMUMS



CIS-1,2-DCE VS VC CONCENTRATIONS – MOST RECENT SITE MAXIMUMS



PERFORMANCE ASSESSMENT

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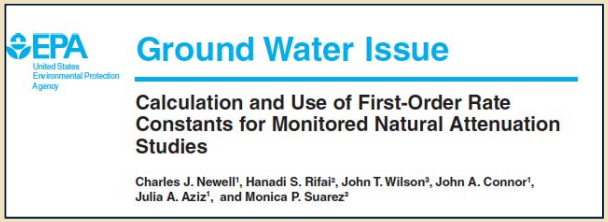
- Chlorinated solvents and daughter products: potential relationships
- **Development of benchmark decay rates**

METRICS: SOURCE ATTENUATION RATES


EPA United States Environmental Protection Agency

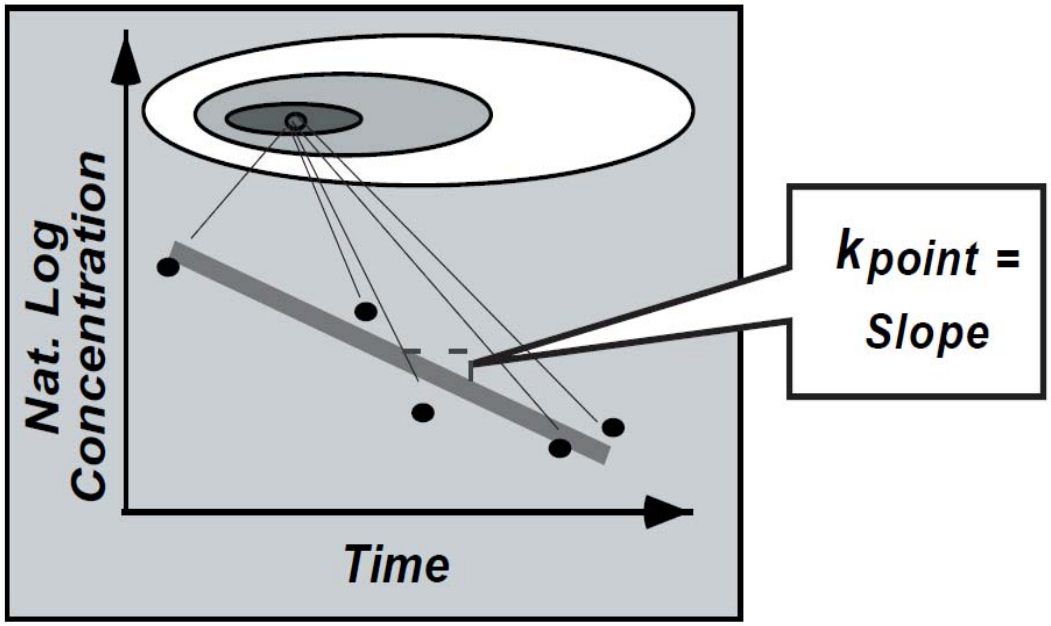
Ground Water Issue

Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies

Charles J. Newell[1], Hanadi S. Rifai[2], John T. Wilson[3], John A. Connor[1], Julia A. Aziz[1], and Monica P. Suarez[2]

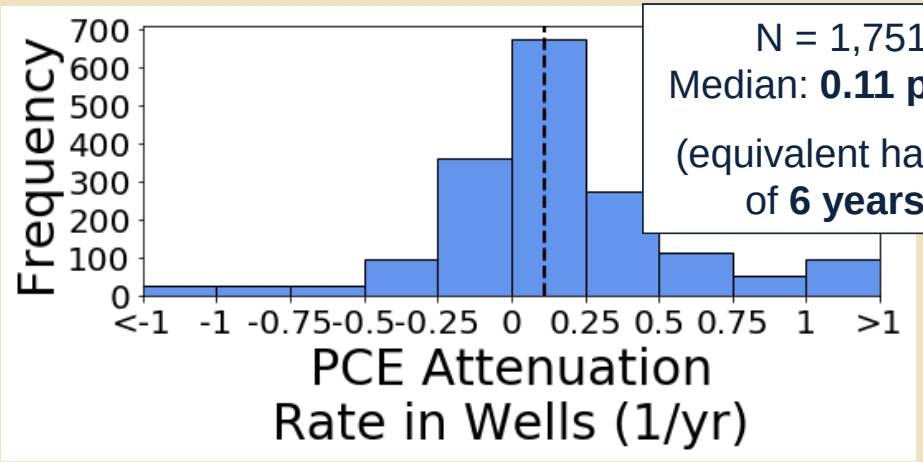
Process the Data

- **Extract the maximum sitewide concentrations for six-month periods**
- **Calculate the source attenuation rate k_{source}**
- **What Impacts k_{source} ?**



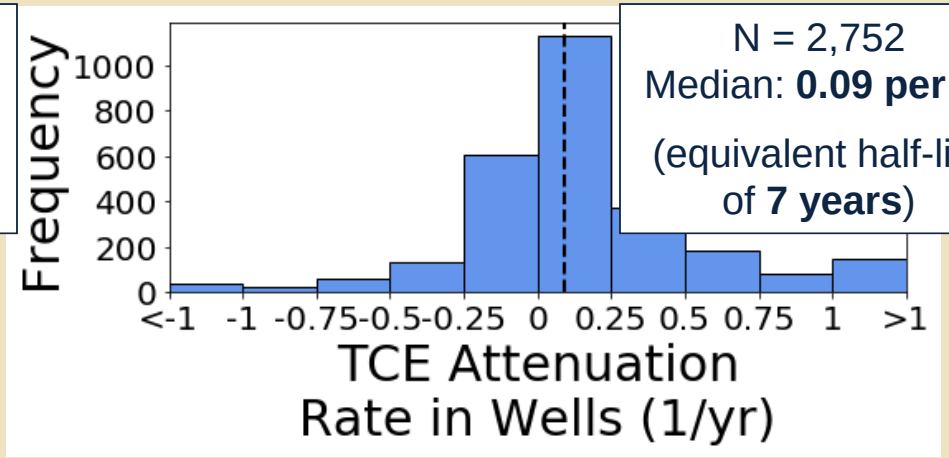
$$C = C_0 e^{-K_{source} t}$$

WELL ATTENUATION RATES: PCE



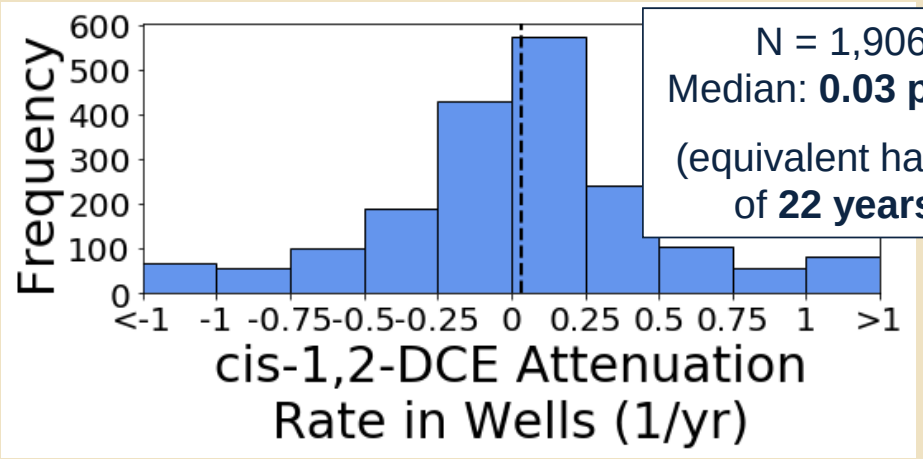
N = 1,751
Median: **0.11 per yr**

(equivalent half-life of **6 years**)



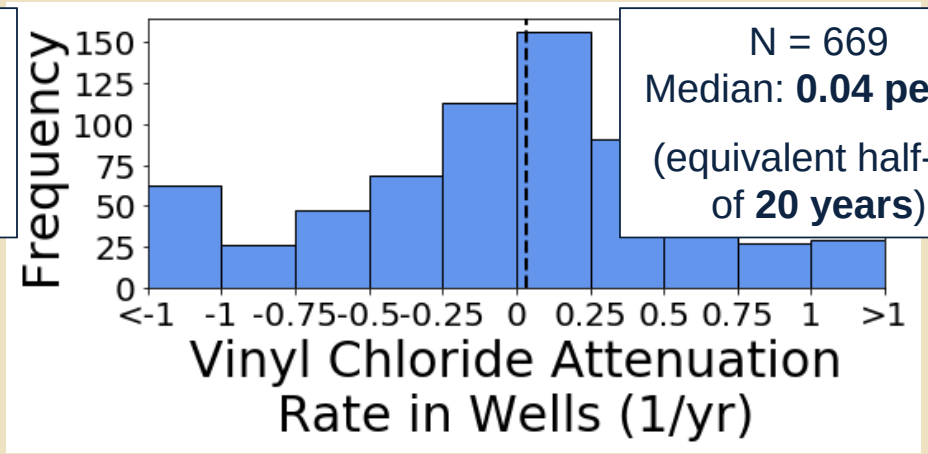
N = 2,752
Median: **0.09 per yr**

(equivalent half-life of **7 years**)



N = 1,906
Median: **0.03 per yr**

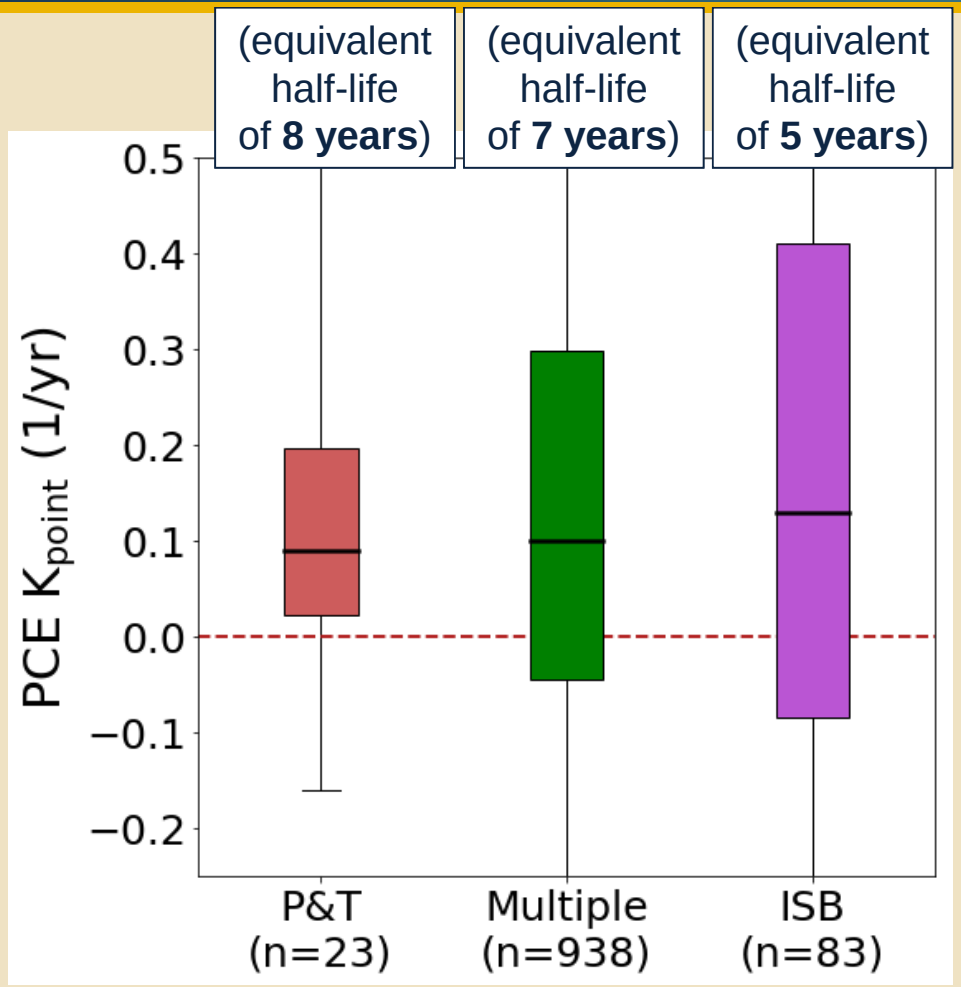
(equivalent half-life of **22 years**)

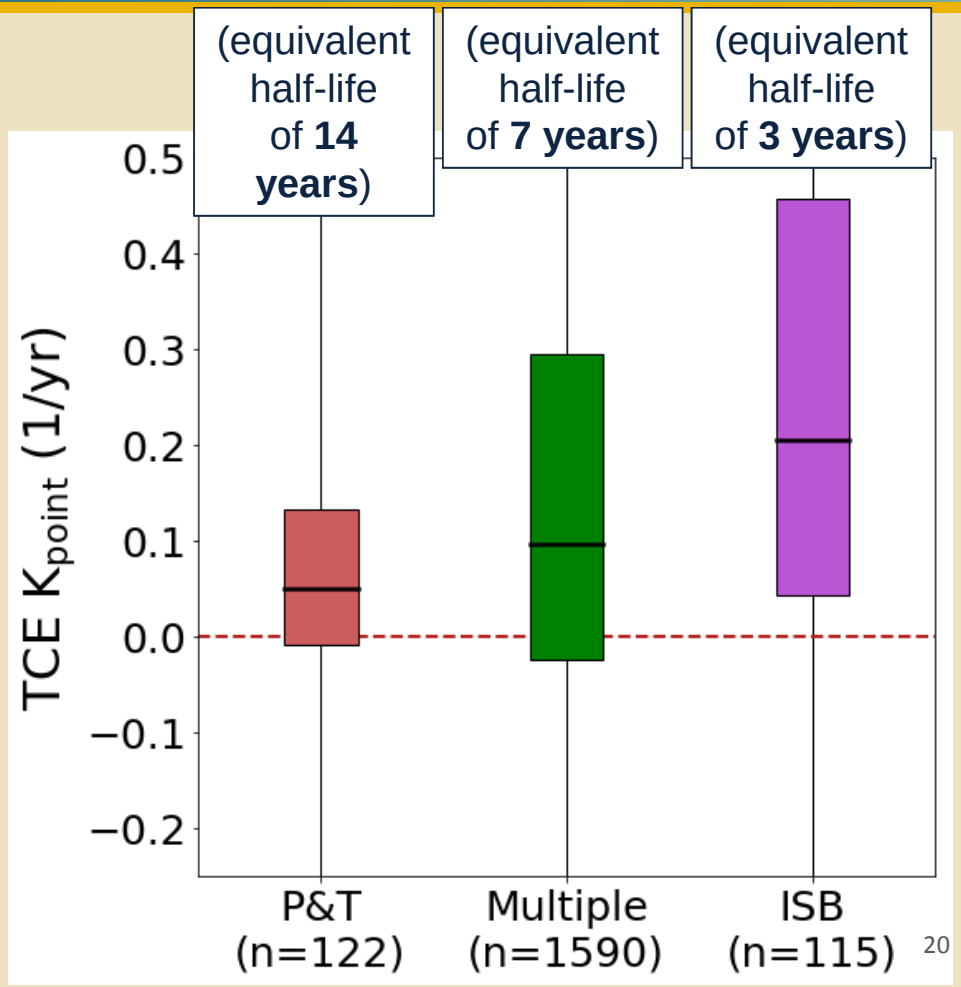


N = 669
Median: **0.04 per yr**

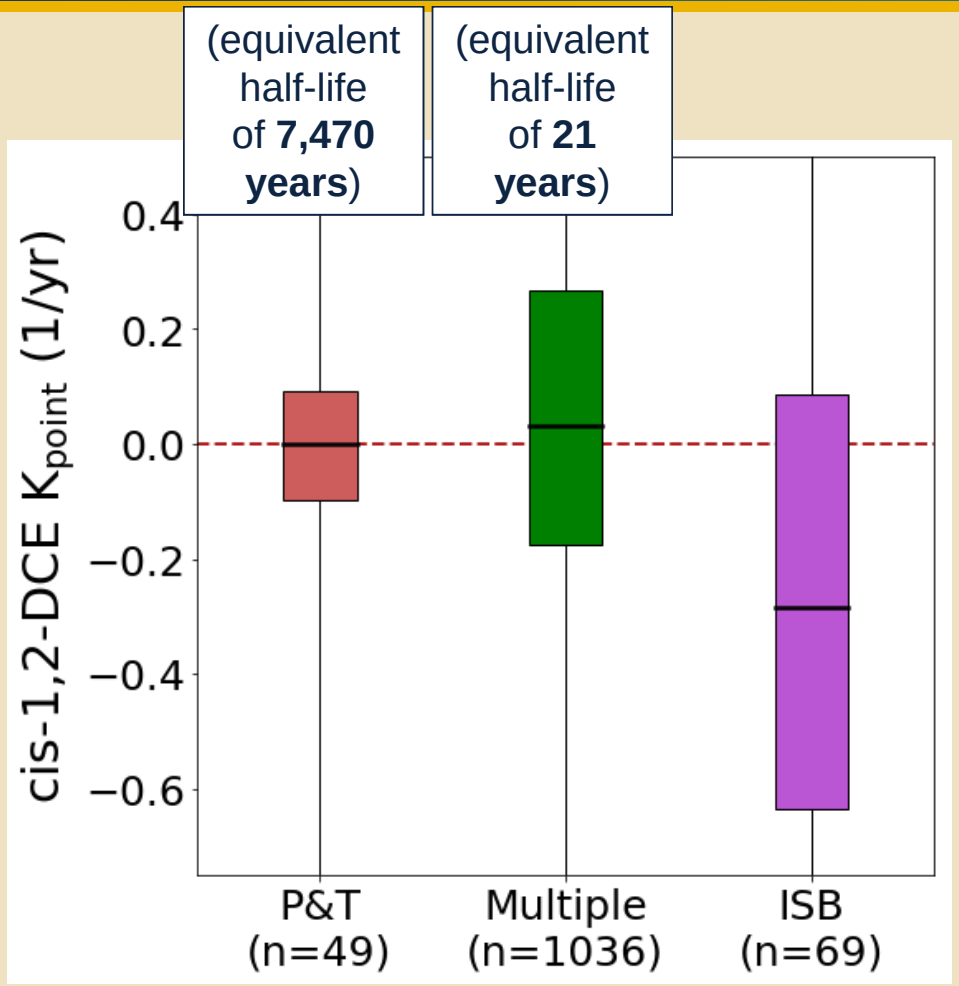
(equivalent half-life of **20 years**)

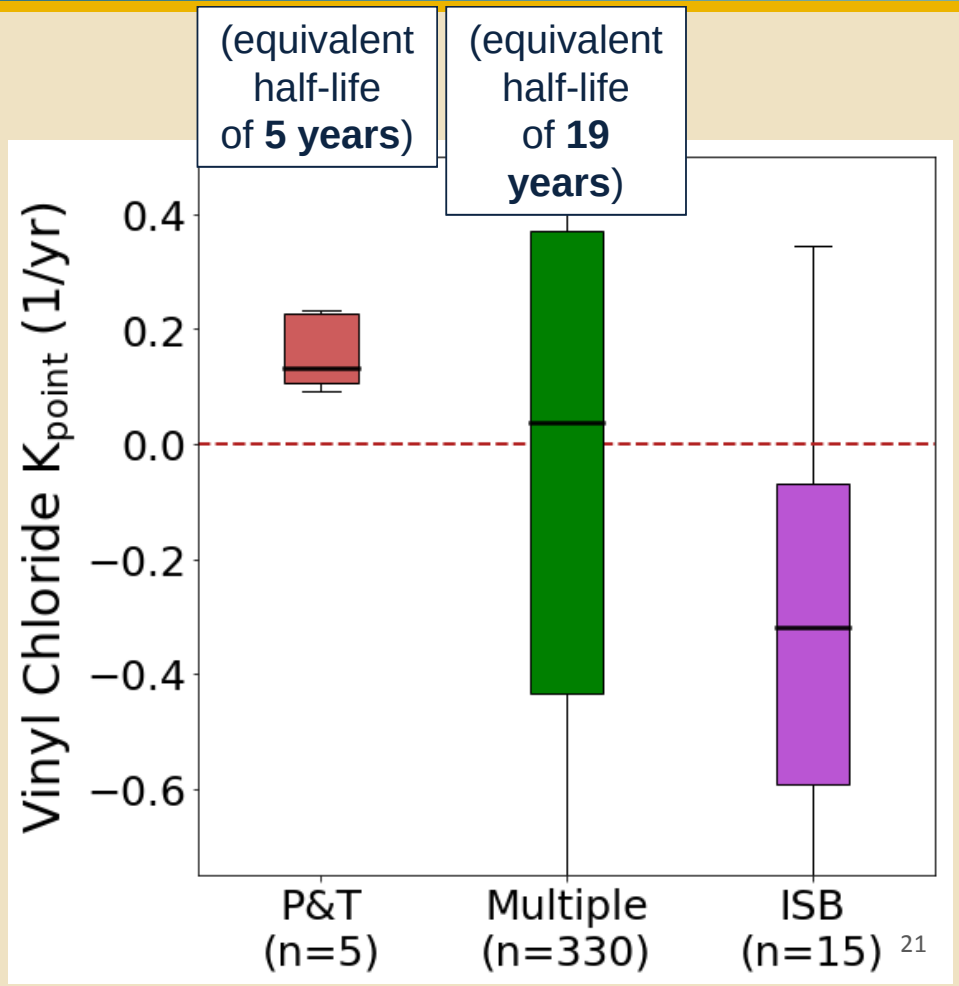
WELL ATTENUATION RATES: IMPACT OF TECHNOLOGIES





WELL ATTENUATION RATES: IMPACT OF TECHNOLOGIES





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- **Hunter Anderson – AFCEC**
- **Sharon Rauch – GSI**

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