Wisconsin Closure Protocol Study

Authors: Theresa Evanson, Aristeo Pelayo, Jean Bahr

Overview & Summary

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WGWA Luncheon
November 12, 2009

Study Partners

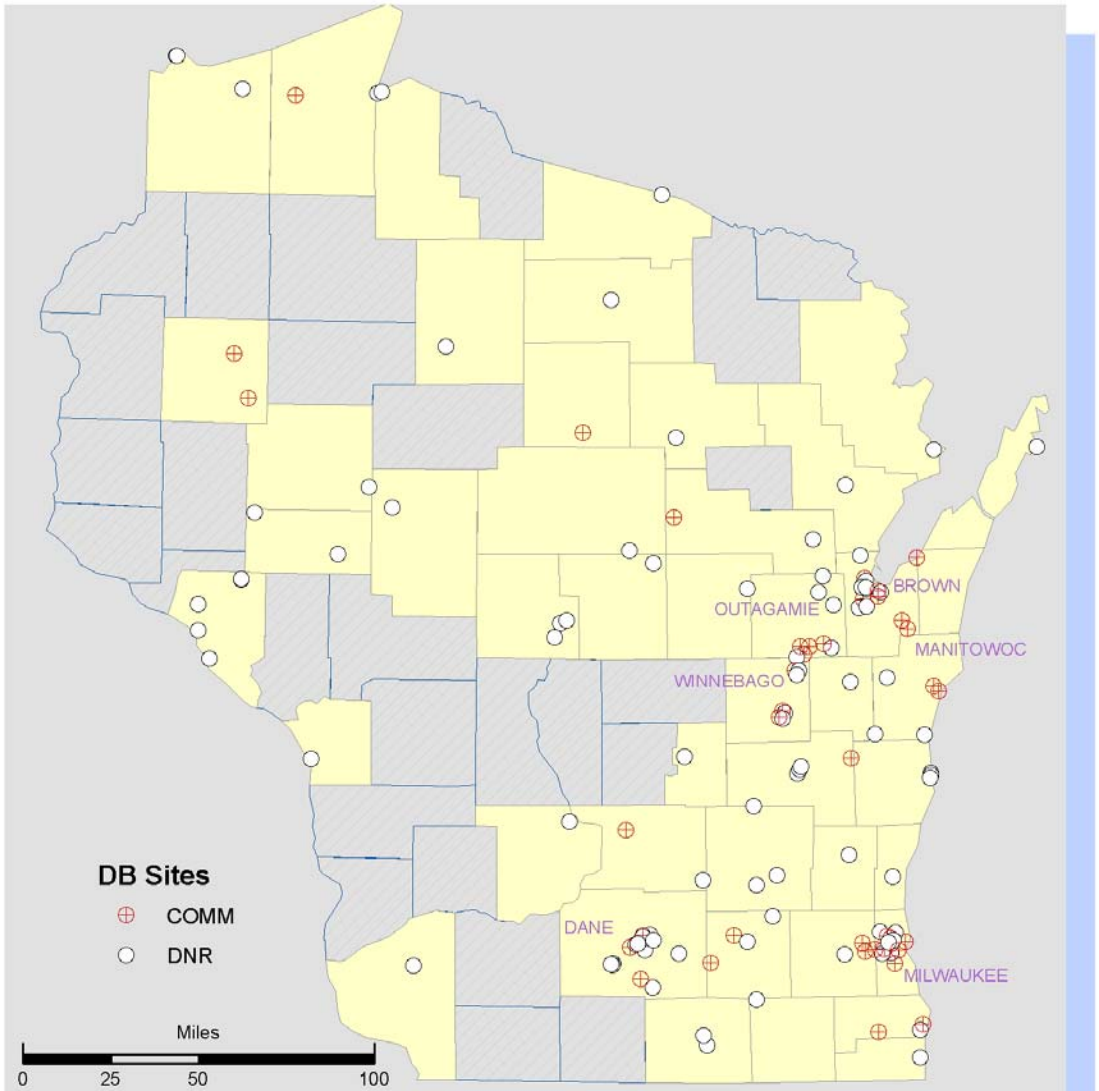
- Jean Bahr, UW-Madison Professor, Geology & Geophysics, co-author
- Jennifer Skinner, Dept of Commerce
- Bruce Bauman, Am Petroleum Institute
- Jim Rauman, USGS
- US EPA R.S. Kerr Lab, lab analysis
- Peer Reviewers: John Wilson, EPA; Ryan DuPont, Utah State University, Mark Malander, Exxon-Mobile

Study Goals

1. Was sufficient information collected during the site investigation to determine if NA was effective?
2. Did contaminants behave as predicted after closure?
3. Were established protocols effective in helping staff make closure decisions?
4. What site characteristics indicate a need for a modified closure protocol and/or post-closure monitoring?

Site Selection for Database

- GIS Registry of 1,378 sites
  - 967 (70%) Closed by DNR, 1999 – 2000
  - 411 (30%) Closed by COMM, 2000
- Stratified-Random Sampling of sites to review for inclusion in database
  - Maintain ratio of sites by county
  - Maintain ratio of sites by Agency
- Ultimately included 133 sites in database, or ~10% of closed sites



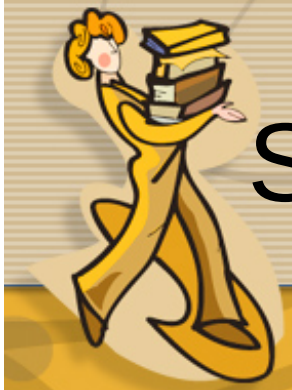
Sites in the Wisconsin Natural-Attenuation Closure Protocol Study Database.

Total Sites: 133 (100%)

COMM Sites: 40 (30%)
DNR Sites: 93 (70%)

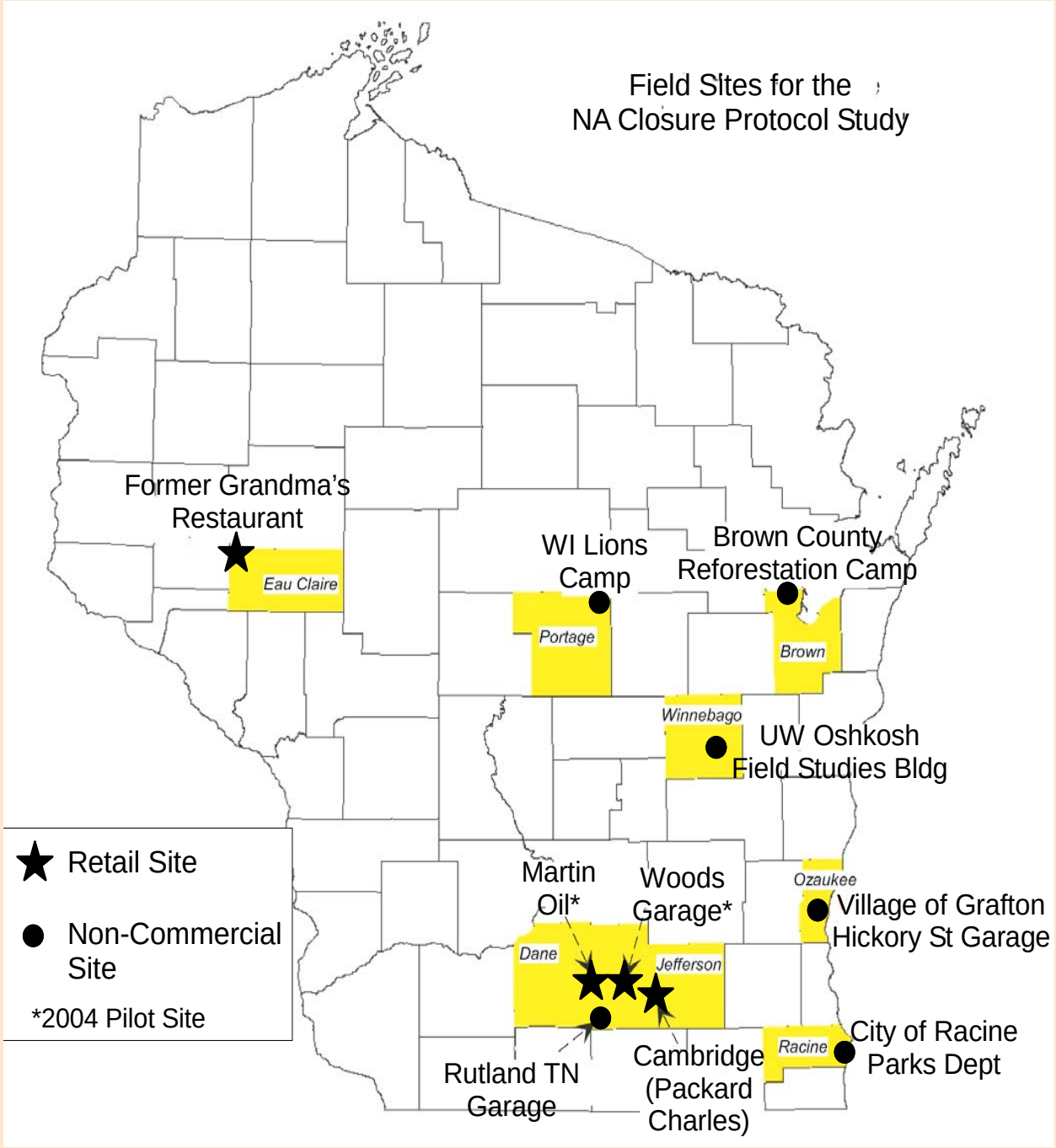
Database Information

- General site information
  - Land use, # USTs, dimensions, address
- Contaminant setting
  - Spill description, # soil borings, source zone concentrations, #monitoring wells, remediation type
- Hydrogeologic setting
  - Flow direction, aquifer characteristics, water level fluctuation, gw monitoring



Selection Criteria for Field Sites

- Fairly well characterized so that closure data can be compared with WCPS data
- Include sites representing a variety of geologic settings
- Access to original source zone
- No existing UST system
- Travel time from Madison
- Ability to obtain access agreement


Field Sltes for the
NA Closure Protocol Study
Former Grandma's
Restaurant
Eau Claire
WI Lions
Camp
Portage
Brown County
Reforestation Camp
Brown
Winnebago
UW Oshkosh
Field Studies Bldg
Retail Site
Non-Commercial
Site
*2004 Pilot Site
Martin
Oil*
Woods
Garage*
Dane
Jefferson
Ozaukee
Village of Grafton
Hickory St Garage
Racine
City of Racine
Parks Dept
Rutland TN
Garage
Cambridge
(Packard
Charles)

Geologic Setting

- Database of closed petroleum sites
  - Clay - 40%
  - Non-clay – 45%
  - Bedrock – 15%
- Field sites
  - Clay – 3 sites
  - Non-clay – 6 sites
  - Bedrock – 1 site

Use of Remedies

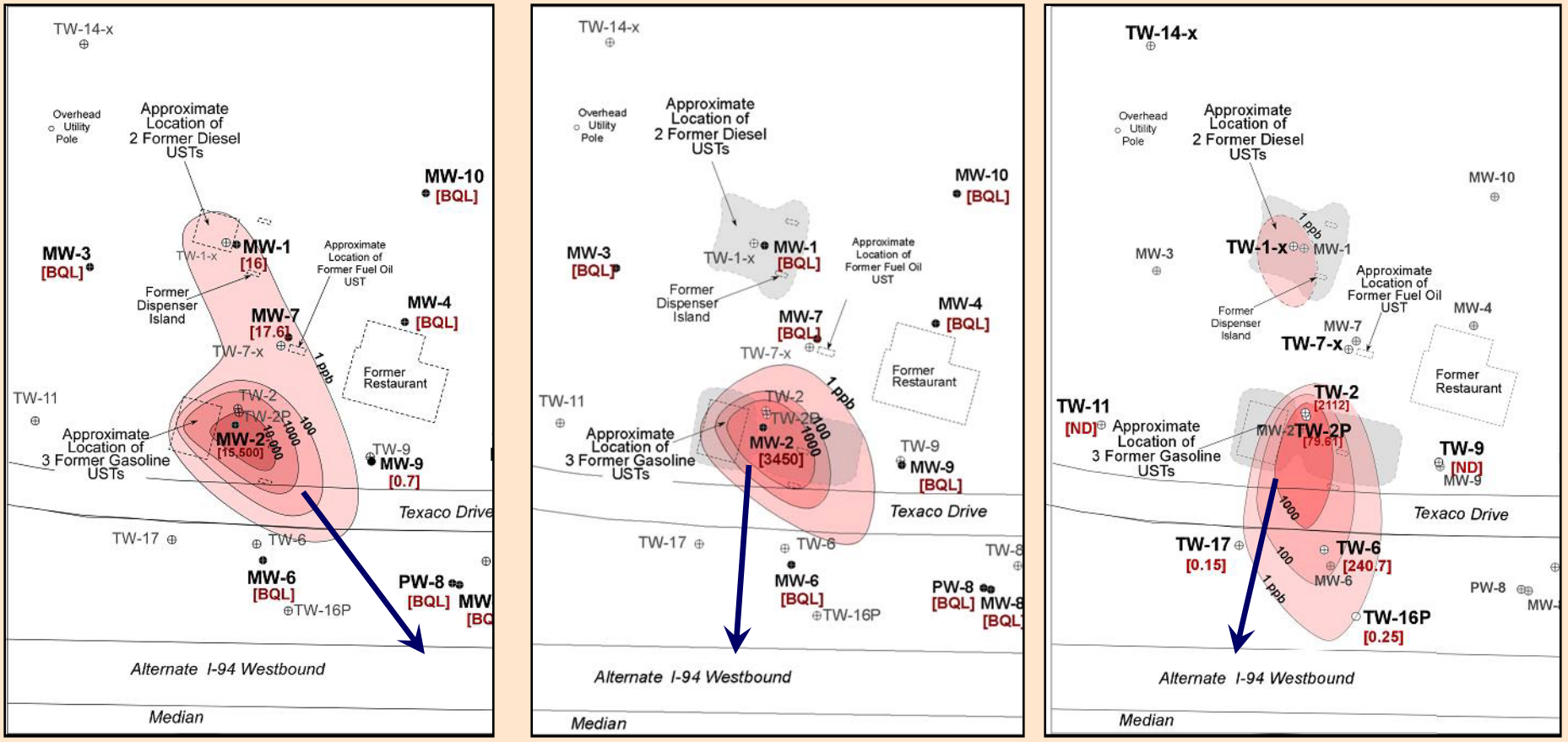
132 sites where remedy was defined in the database:

- 94 sites had an active remedy
- 38 were MNA only

Use of Piezometers

- Piezometers installed at 25% (34) sites in database.
- 5 field sites had piezometers installed during the SI.
- Reflects our 3-dimentional understanding of the groundwater plume.

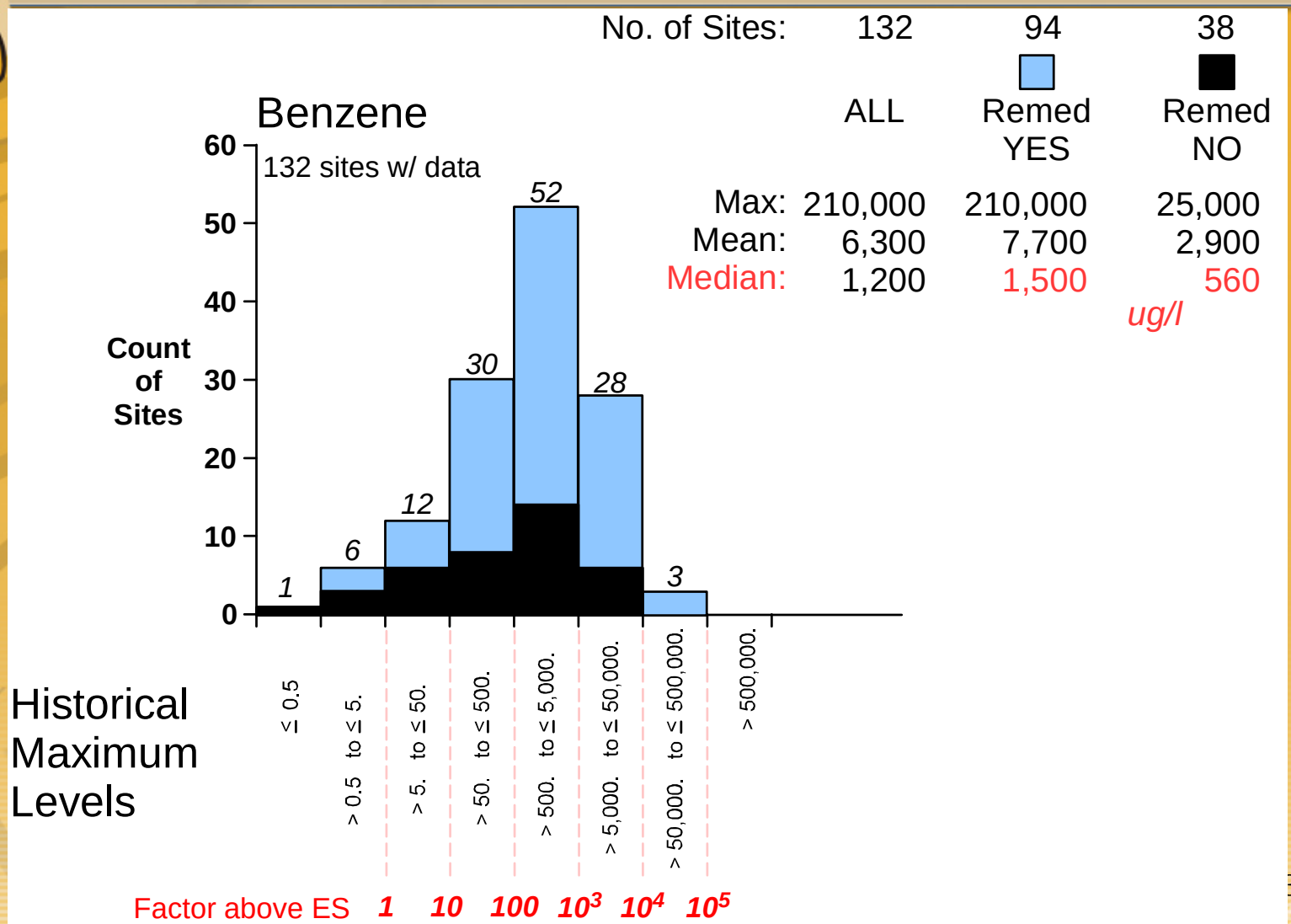
Variability in Groundwater flow direction: Example of plume axis shift of roughly 40°.



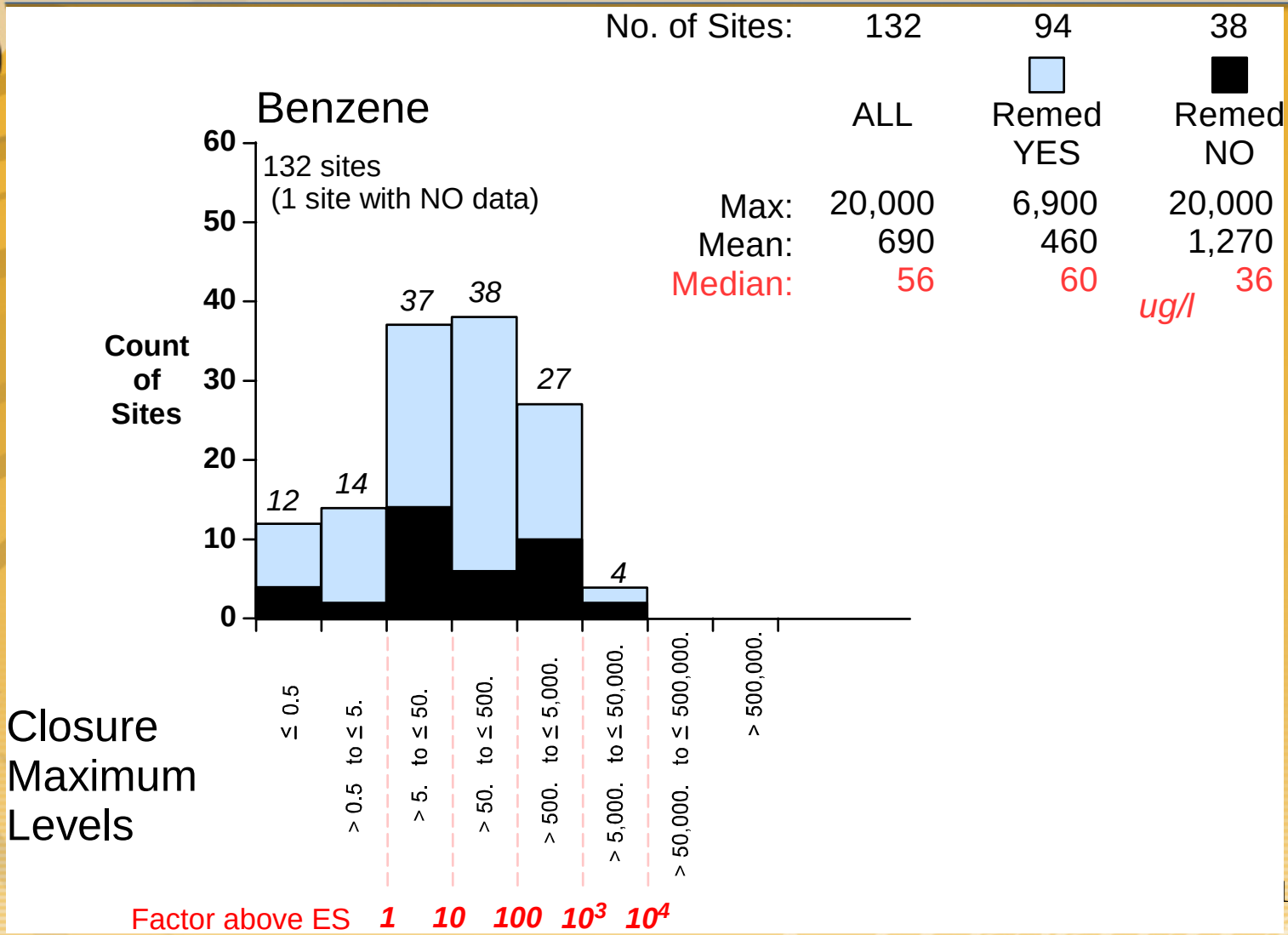
Groundwater flow variability

(Rachel Greve's 2007 Thesis Defense Total BTEX Figure)

Historical Maximum & Remedy

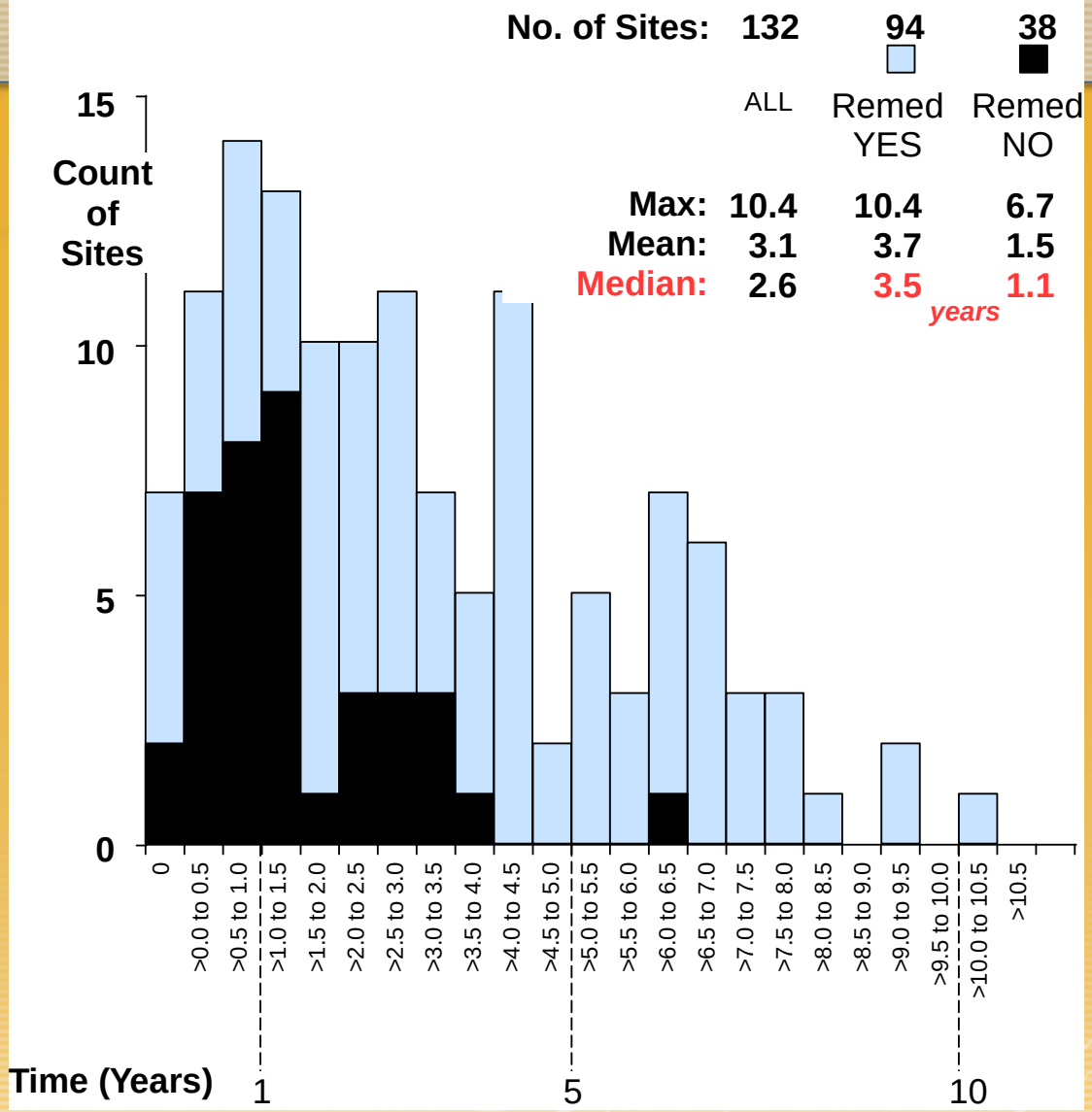


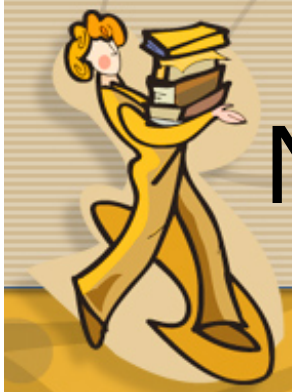
Closure Maximum & Remedy



Time between Historical Benzene Maximum & Closure Benzene Maximum

Time Interval Between Historical Benzene Maximum and Most-Recent "Closure" Benzene Maximum





Non-parametric Statistical Tests

- Of 106 database sites, 23 (or 20%) fail the "stable or decreasing" standard of the Mann-Kendall test for Benzene.
- Mann-Kendall test is significantly biased by the addition of the coefficient of variation (CV) test.
- Need alternate assessment tool if declining trends can not be established at the end of 8 rounds of monitoring.

Synopsis – Database Study

- Significant groundwater flow direction change is almost a certainty
- Collectively, a factor of 10 reduction in maximum benzene concentration, but smaller reduction for clay sites that were not remediated
- Short monitoring period, and even shorter for sites that were not remediated

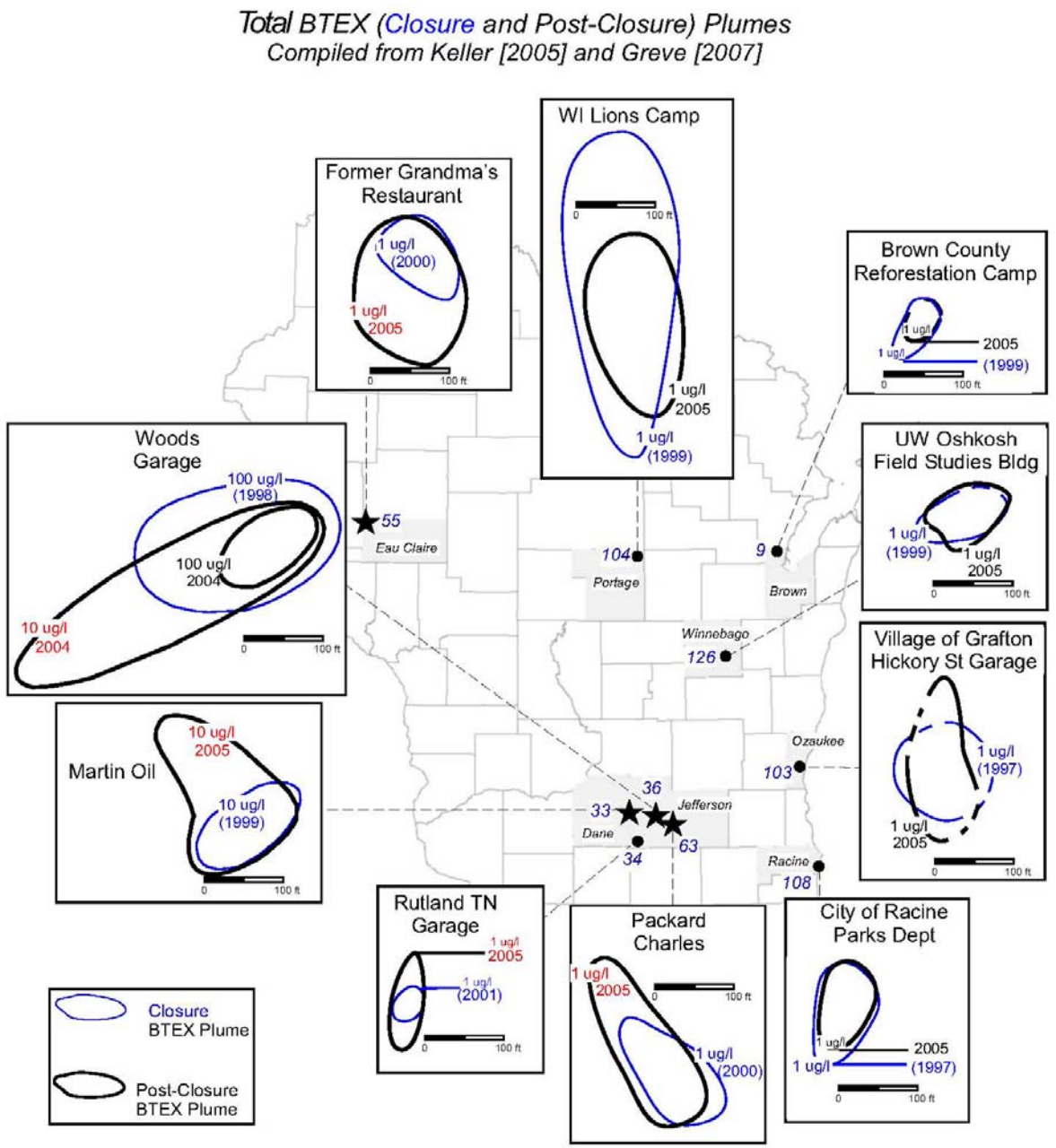
Will we see similar decrease 5 years post closure?

Groundwater Plumes – Field Study

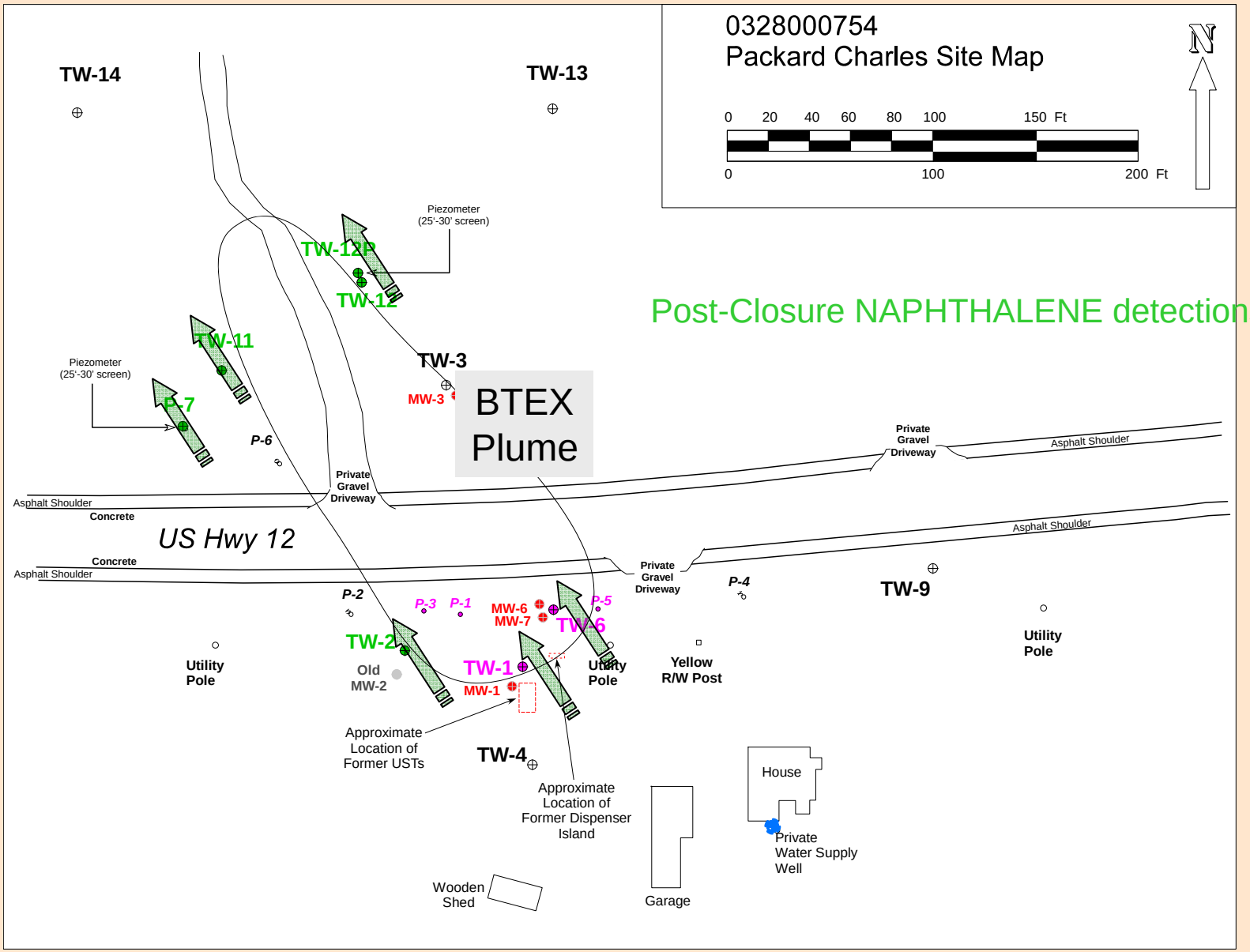
- Area of benzene plume has decreased post-closure
- BTEX plume has remained the same or increased somewhat in size.
- Naphthalene plume has increased, sometimes beyond the location of the original benzene plume.

Comparison of Total BTEX Plumes –

Closure vs. Post-Closure



Naphthalene plume enlarged



Source Zone Concentrations

Recap on Benzene from Database Study

- Contaminant concentrations in the Source Zone (SZ) declined, on average, by a factor of 10 prior to site closure.
  - Benzene declines from an average historical maximum of 6,300 ppb to to an average closure concentration of 690 ppb.
  - MNA only & Clay sites showed considerably less decline in SZ at time of closure.

Did we see similar decline 5 years post closure?

Benzene Maximums:

Historical

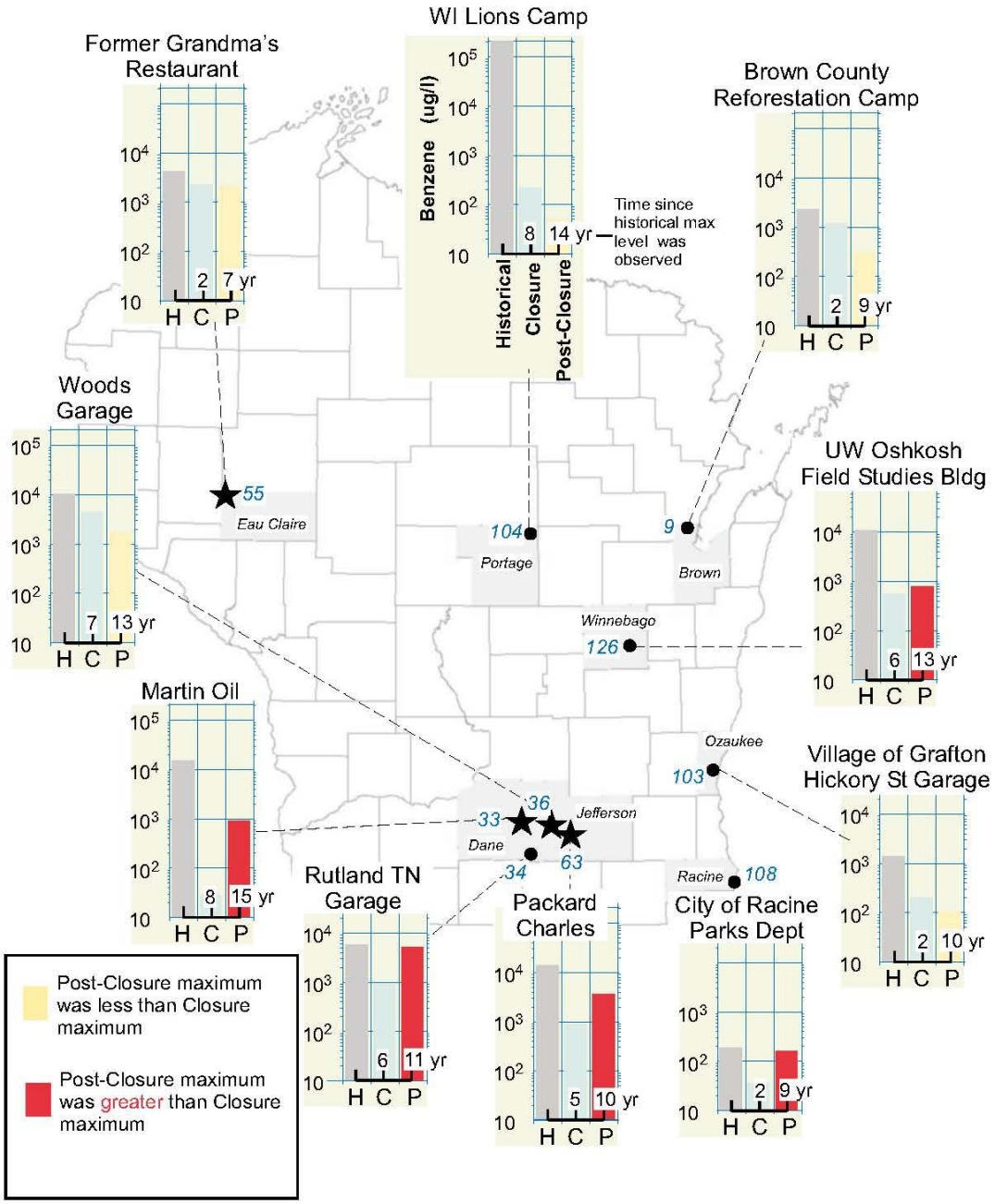
Closure

Post-closure

Red

Post-Closure **>** **C**losure

Benzene Data Maximum from Water-Table Monitoring Well Samples

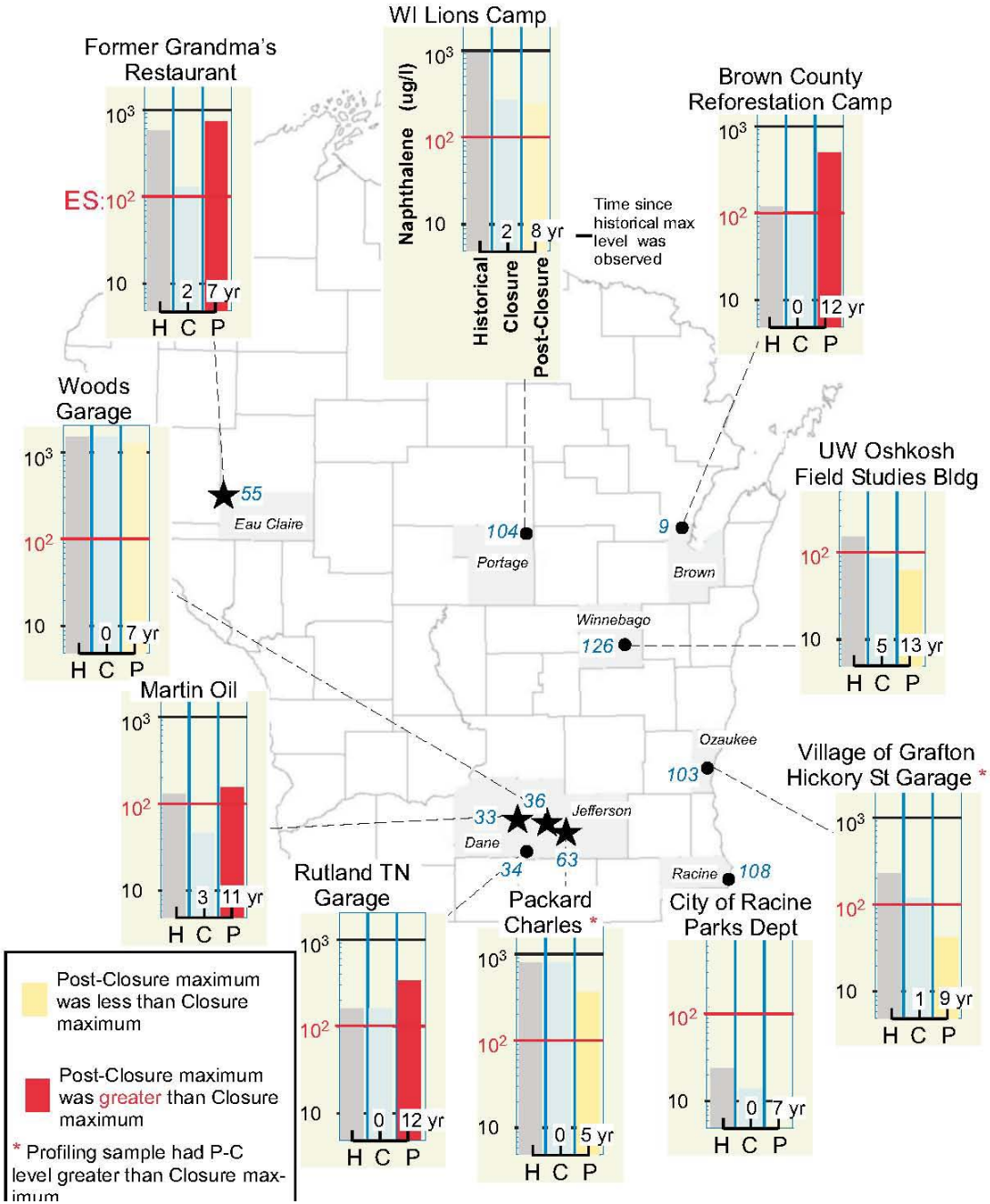


Naphthalene Maximums: **H**istorical **C**losure **P**ost-closure

Red

Post-Closure **>** **C**losure

Naphthalene Data Maximum from Water-Table Monitoring Well Samples



Recommendations: Source Zone

- Natural attenuation of source zone contaminants could not be documented in this study.
- We are unable to project a time when contaminants may reach State groundwater standards.
- Recommend better balance between source actions and monitoring.

Recommendation: Length of GW Monitoring

- Recommend a minimum of 8 quarterly rounds of data to assess natural attenuation.
- If clear declining trends are not evident, do site-specific assessment of whether additional actions are needed to support the effectiveness of natural attenuation.

Recommendation: Nonparametric Statistics

- Mann-Kendall and Mann-Whitney tests, as currently defined in code, have limited usefulness in closure decision-making.
- Recommend dropping the Mann-Kendall test altogether and requiring better assessment of seasonality of data for the Mann-Whitney.

Recommendation: Analysis of Groundwater Data

- Variability in water table elevation and groundwater flow affects decision-making on natural attenuation, especially over a short period of monitoring.
- Recommend moving away from single well analysis to more robust analytical approaches (such as spatial integration of groundwater concentration data).

Recommendation: Better 3-D Definition of Plume

- Recommend that piezometers be installed at sites with hydraulic conductivity ≥ 10^{-4} cm/sec.
- Discrete vertical profiling when possible to better define the plume in 3 dimensions

Recommendation: Plume Maturity & Monitoring for PAHs

- Dominant contaminants in groundwater plumes change with time
- Specific contaminant plumes (*e.g.*, benzene) may shrink while another (*e.g.*, naphthalene) increase.
- Recommend that naphthalene monitoring be included as a routine parameter and PAHs be monitored at diesel and fuel oil sites.

Future Work

- Methods to determine presence of LNAPL and how source weathering affects groundwater contamination
- Whether mass flux needs to be assessed at LUST sites
- How the accuracy of field measurements affects the estimate of time to meet environmental standards

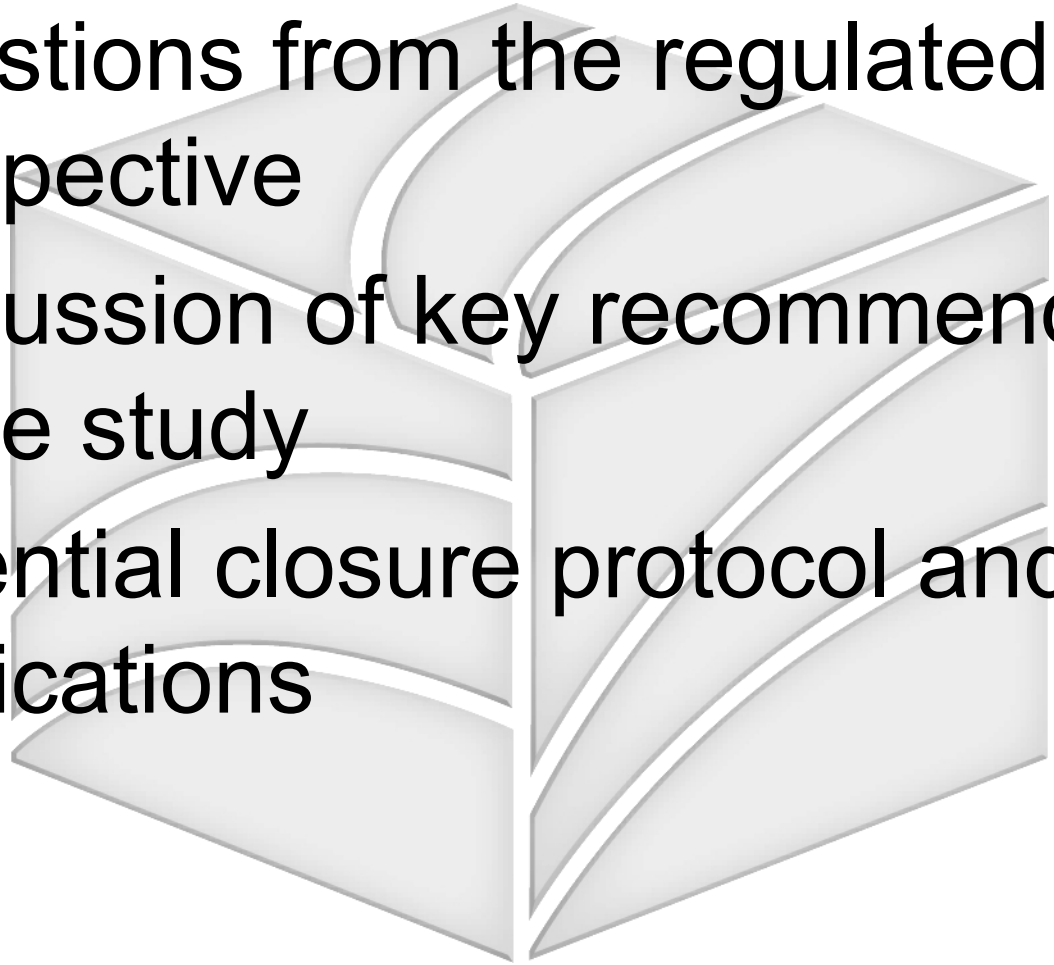
Wisconsin Closure Protocol Study:
Industry and Regulated Community Perspective

Laurie Parsons, Lparsons@Naturalrt.com

Wisconsin Groundwater Association Lecture Series
November 12, 2009

Overview

- Questions from the regulated perspective
- Discussion of key recommendations of the study
- Potential closure protocol and policy implications



NATURAL RESOURCE TECHNOLOGY

Questions (and Discussion)

- Will closed cases be reopened?
  - Not as a result of this study
- Is the use of MNA “at risk” for Wisconsin sites?
  - No, scientific community agrees that NA occurs -- it must remain a viable closure option
  - Changes in specific requirements and continued work on guidance may be warranted

NATURAL RESOURCE TECHNOLOGY

Questions (and Discussion)

- Can we expect policy changes with broader reach than just petroleum sites?
  - Yes, but policy revisions were already under evaluation and may not be specific to the closure study
  - Maintain flexibility where appropriate
- How will this study affect timing of closures and ability to redevelop impaired properties?
  - Stay tuned….

NATURAL RESOURCE TECHNOLOGY

Recap of Study Recommendations

- Need a Better Balance Between Source Control and Continued Monitoring
- Retool Our Data Analysis Techniques
- Refine Site Characterizations

NATURAL RESOURCE TECHNOLOGY

Options on Source Control

- Implement source control early in the process, even before groundwater assessment is fully complete
- Make greater use of field screening tools for source delineation (MIP, LIF, Targost™)
- Conduct groundwater characterization and MNA assessment concurrent with “removal actions”
- Might lead to more timely closures?

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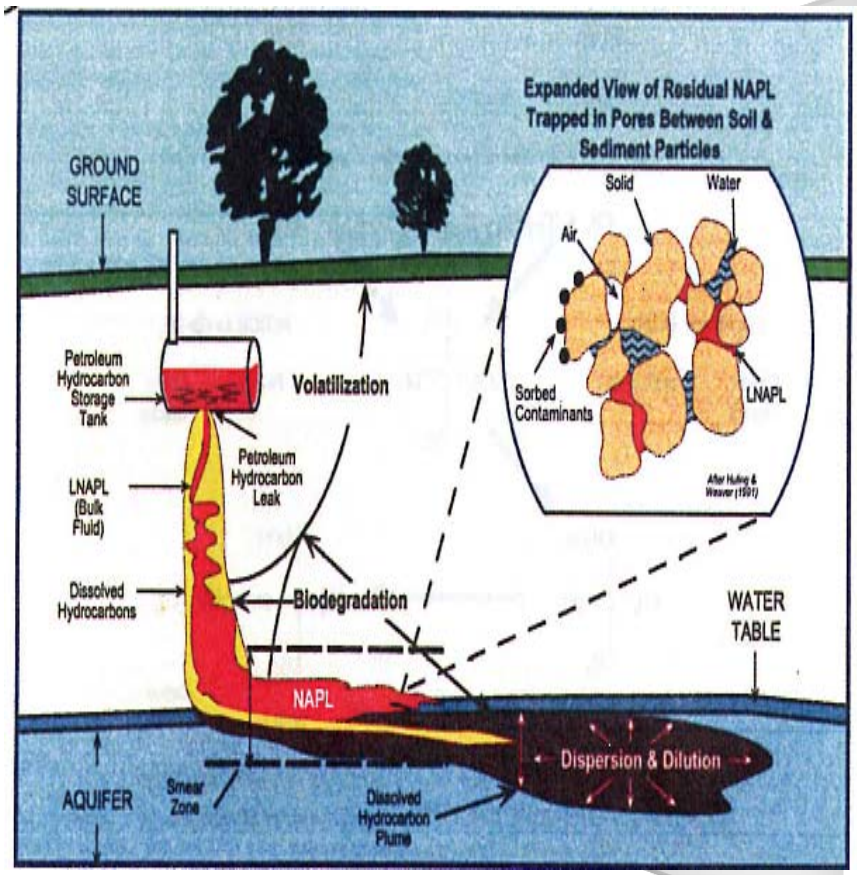
Early Source Control Concerns



- Risk of not achieving closure after significant cost and effort
- Fear of reliving the early 90's (dig and haul days)
- Issues with secondary sources

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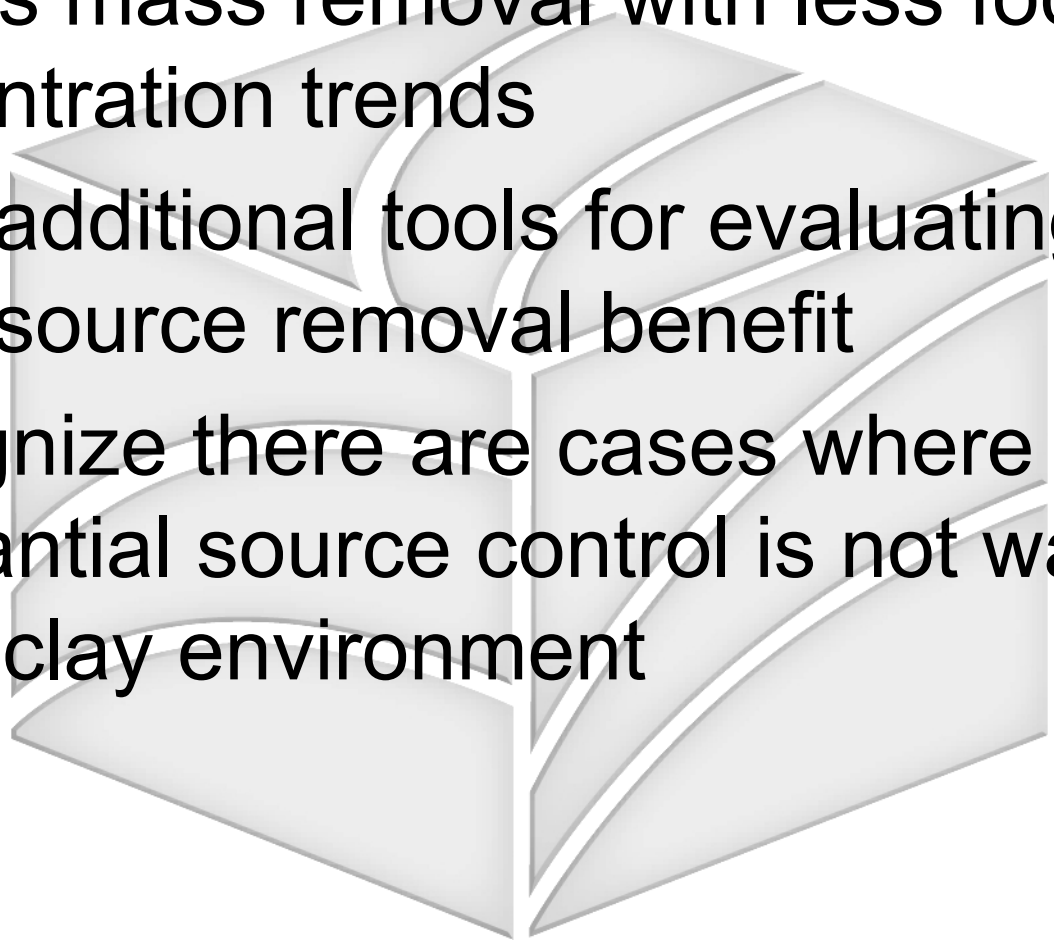
Possible Solutions for Better Balancing Source Control and Monitoring

- Assess mass removal with less focus on concentration trends
- Need additional tools for evaluating mass/source removal benefit
- Recognize there are cases where substantial source control is not warranted – e.g. clay environment



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Retooling Data Analysis

- Evaluating "stable" plumes: If clear declining trends are not evident, MNA should not be excluded, may need longer timeframe
- Importance of site-specific assessments: Multiple lines of evidence are critical for review of closure potential (exposure pathway analysis, hydrogeologic setting, distance to water supply wells, etc.)
- Monitoring timeframe: 8 rounds of data might be reasonable in certain cases, but timeframe should be a function of site-specific conditions

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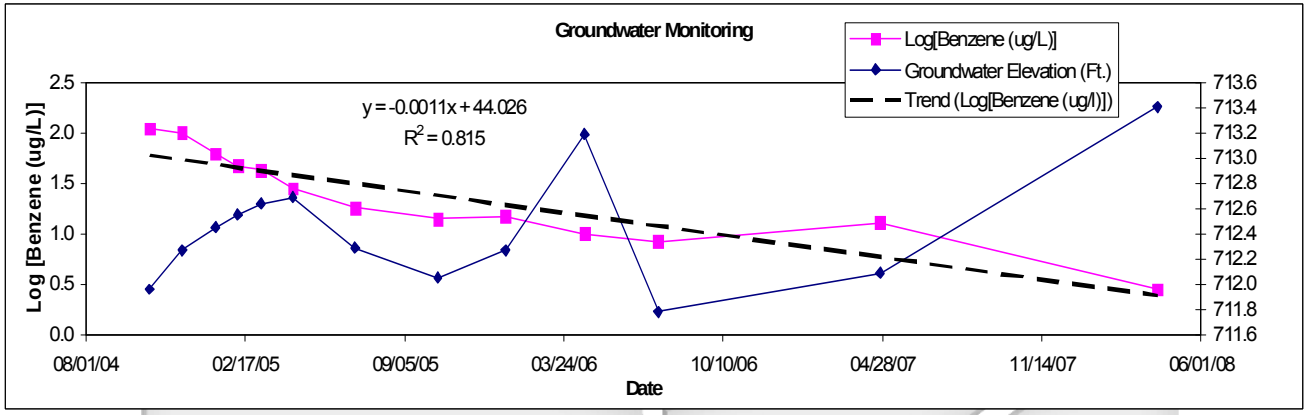
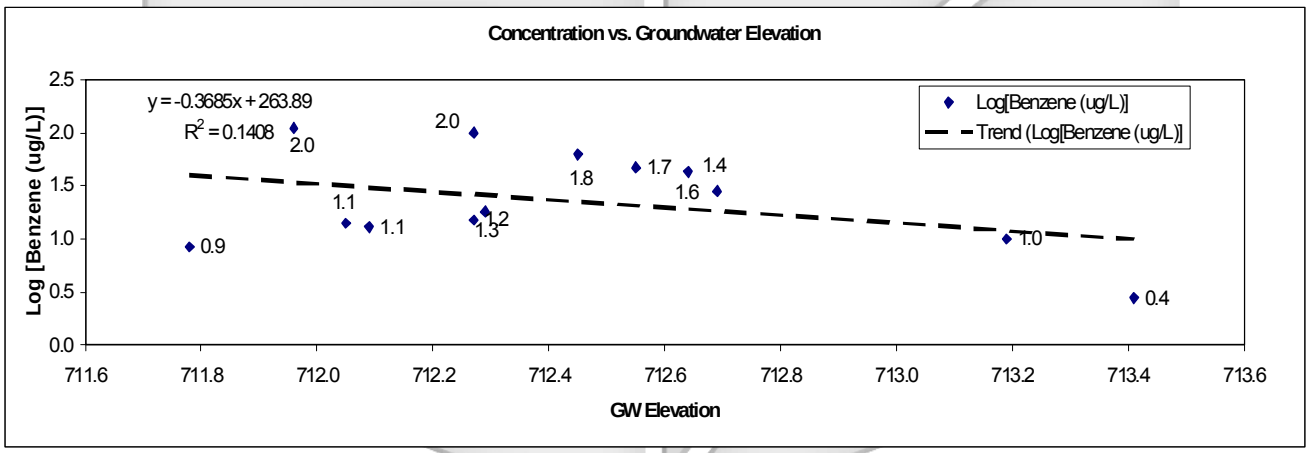
Retool Statistical Evaluations





Assessing seasonal variability

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More on Groundwater Data Analysis

- Single well analysis has a place with limited data sets
- Concurrence with eliminating the Coefficient of Variation (CV) test:
  - Overstates the low concentrations
  - Understates higher concentrations
- Focus more on spatial integration analysis

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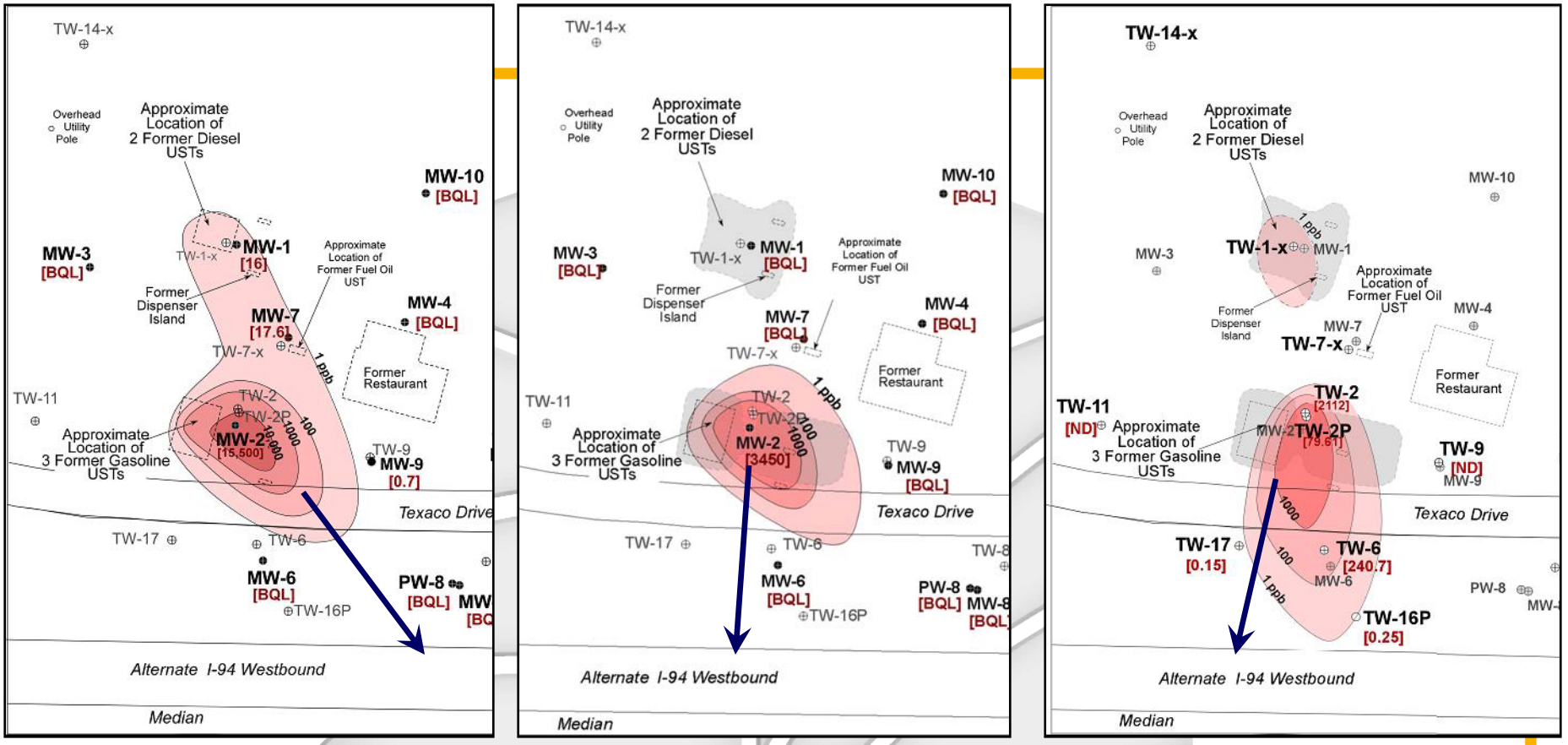
The Ideal Plume Representation



Source: T. Evanson, WDNR, November 2009 WGWA Meeting
(Rachel Greve's 2007 Thesis Defense Total BTEX Figure)

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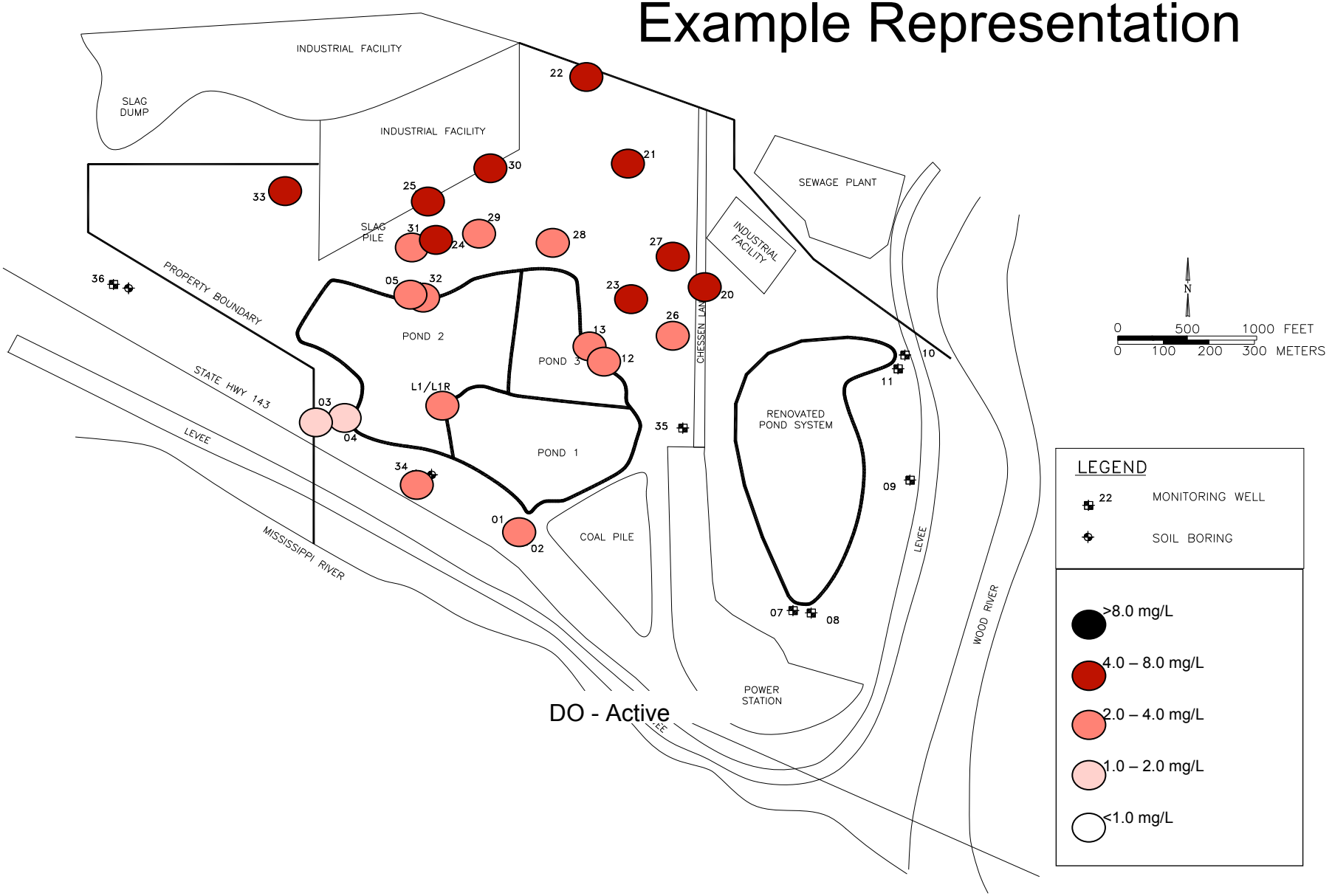
Example Representation



DO - Active

Vertical Plume Definition

- Consider weight of evidence approach rather than linking the need for deeper piezometers to hydraulic conductivity ≥ 10^{-4} cm/sec
- Is there a transmissive zone that warrants assessment?
- Discrete vertical profiling is probably underused and can be cost effective

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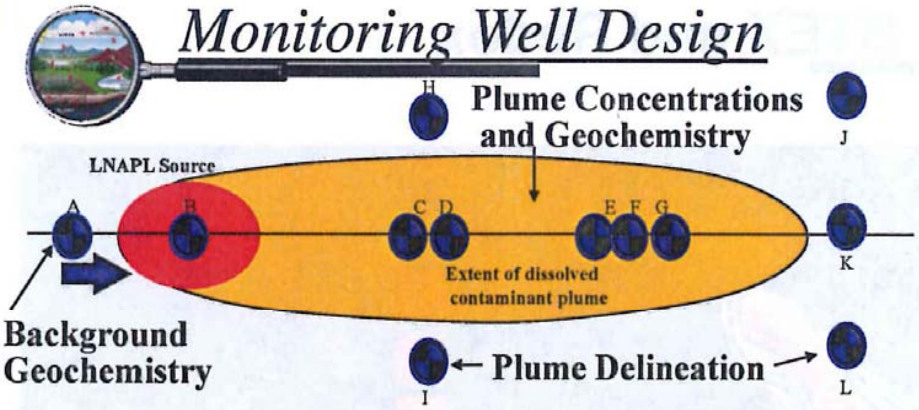
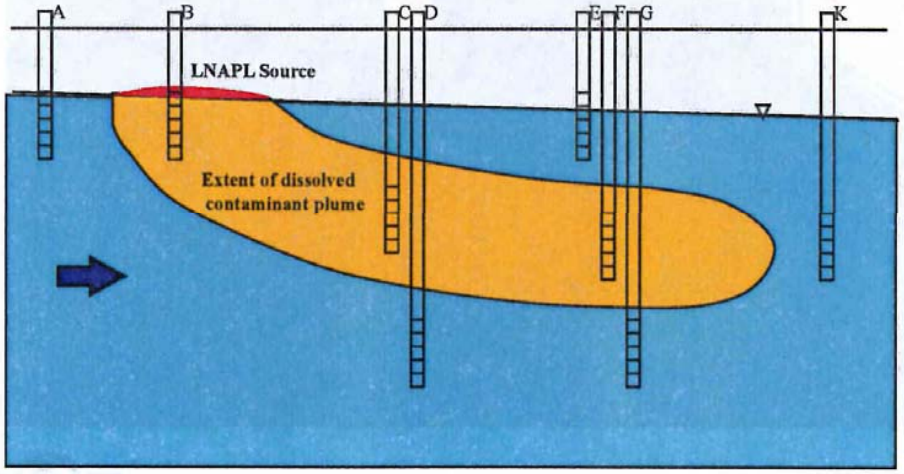
Monitoring Well Design





Monitoring Wells:

- *Background (A)*
- *Source (B)*
- *Plume (C-G)*
- *Sentinel (H-L)*

Design considers

- *receptor location*
- *travel times*
- *stratigraphy & hydrogeology*
- NO *minimum number of wells*

EOS ALLIANCE

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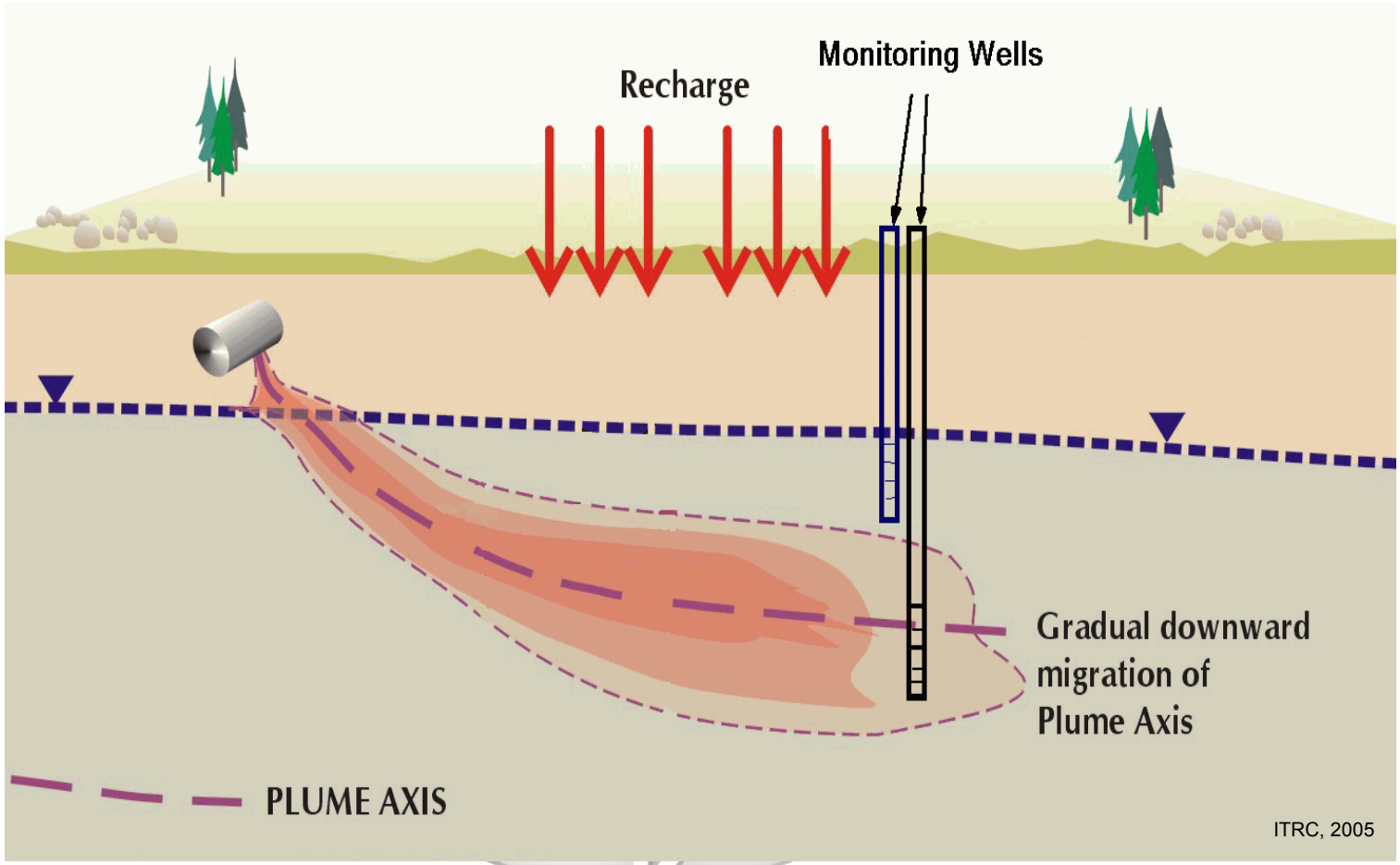

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On Monitoring for PAHs

- Requiring PAH monitoring at diesel/fuel oil sites may have confounding results:
  - Urban/anthropogenic sources are an issue
  - PAHs associated with particulates – low flow methods help mitigate problems with false positives but do not solve the problem
  - May delay closure even though unrelated to site specific release
- Consider PVOCs + Naphthalene when appropriate in lieu of full SVOC/PAH scans

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Policy Changes?

- Should “closure” be redefined or have a tiered structure to better address the reality of ongoing obligations?
- Can we create incentives for cleanup and avoid the disincentives?
  - e.g. better balance between source control and monitoring → could streamline closure

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NR 700 Closure Rules

Revisions are in progress:

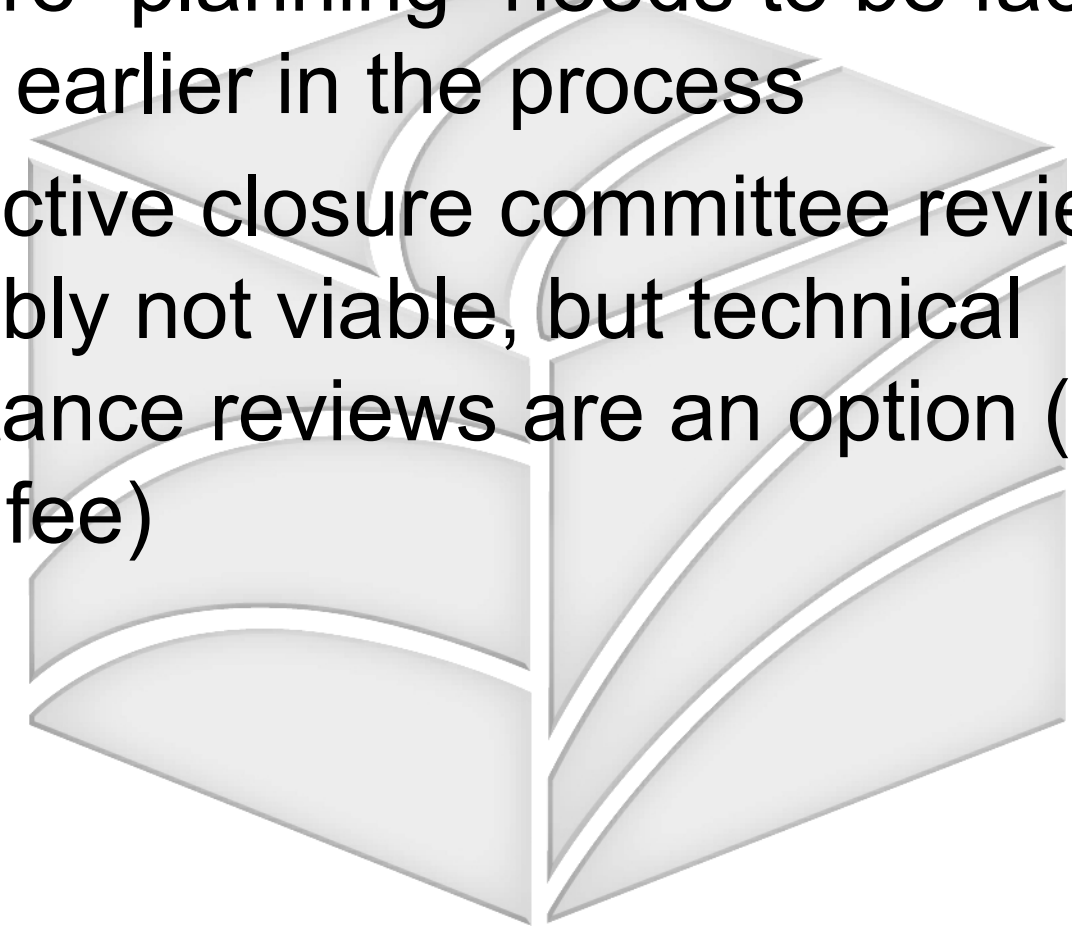
- **NR 725 (New):** *Notification Requirements for Residual Contamination and Continuing Obligations*
- **NR 726:** *Case Closure*
- **NR 727 (New):** *Continuing Obligation Requirements and Reopening Closed Cases*

http://dnr.wi.gov/org/aw/rr/wi_regs/index.htm#changes.

Natural Resource Technology

Process Changes

- Closure “planning” needs to be factored in much earlier in the process
- Interactive closure committee reviews - probably not viable, but technical assistance reviews are an option (for a small fee)



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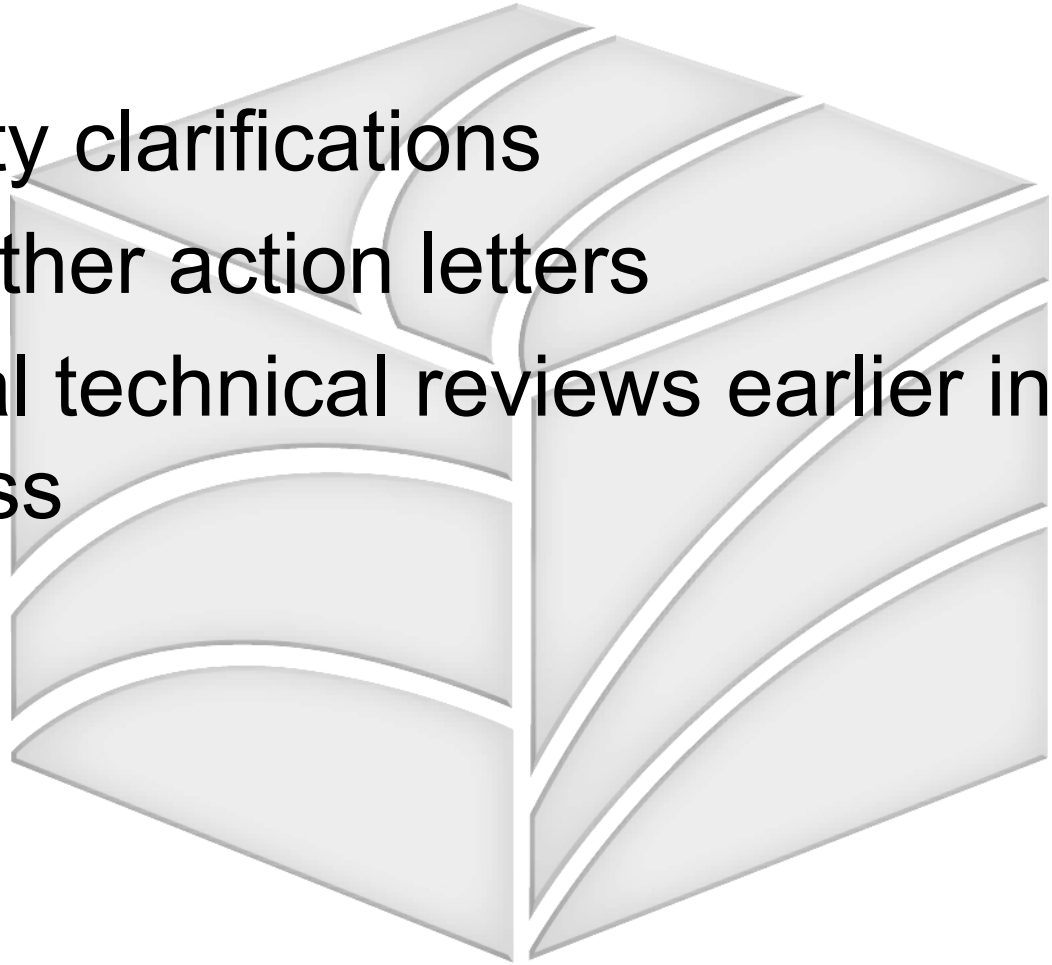
Other Tools for Achieving Project Goals

- Liability clarifications
- No further action letters
- Formal technical reviews earlier in the process



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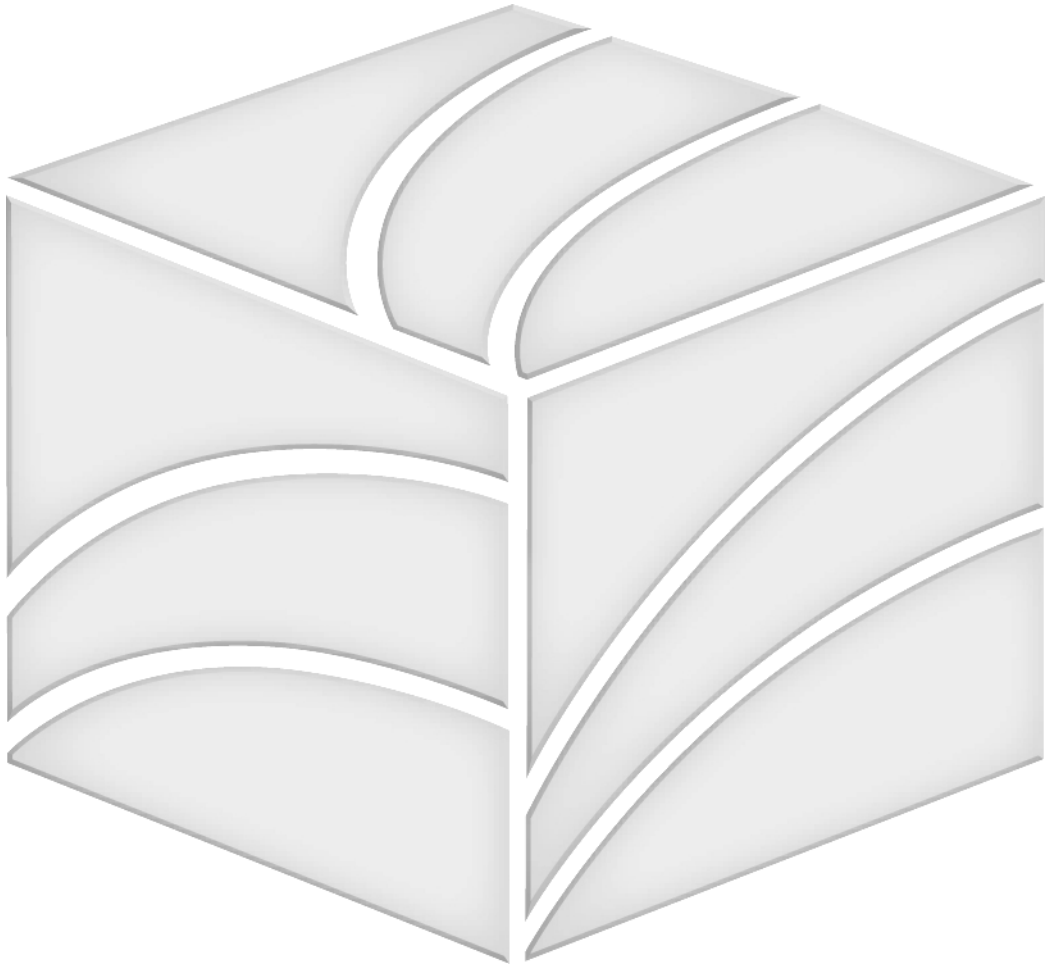
Discussion



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