Unexpected Contaminant Transport Pathways Can Be Explained By "Hidden" Stratigraphy

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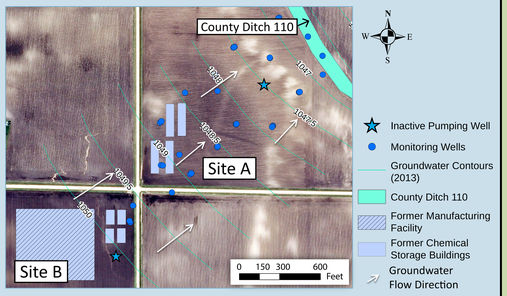
Group 1

Site Layout

Site A consists of former chemical storage buildings. Historically, there were chemical releases to the soil which migrated to the groundwater. Groundwater flows northeast towards County Ditch One Hundred Ten. Site B consists of former chemical storage buildings and a manufacturing facility. There were no known chemical releases on Site B which had not been remediated.

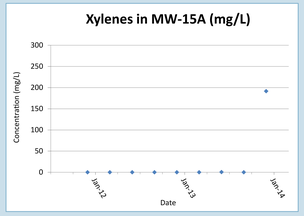
Following remediation of Site A, a pumping well was installed to prevent off-site migration of any residual contamination. Quarterly groundwater monitoring continued in boundary wells to confirm the effectiveness of the remedy at protecting groundwater and the adjacent waterbody.



Problem Statement

In September 2013, total xylenes were measured at a very high concentration, almost 200 mg/L, in Site A boundary well MW-15A. The measurement was anomalous because xylenes had not been detected in MW-15A before (see time series graph on right), and were not contaminants of concern at Site A.

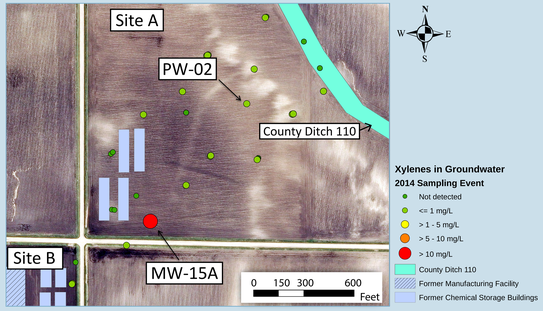
Another unusual characteristic of this measurement: MW-15A was screened in the intermediate depth interval (>10 ft below water table) and xylenes, having a lower specific gravity than water, would be expected to travel in the shallow depth interval.



Initial Investigation

A site-wide monitoring event took place in 2014 to determine the source of the xylenes. Permission was gained to sample upgradient wells on Site B. Wells that had not been sampled in several years were redeveloped for use in this sampling event.

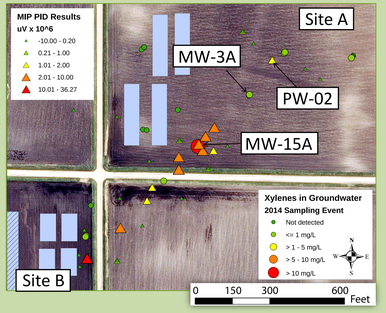
The 2014 event found negligible concentrations of xylenes in all wells sampled except for MW-15A (see map on right).

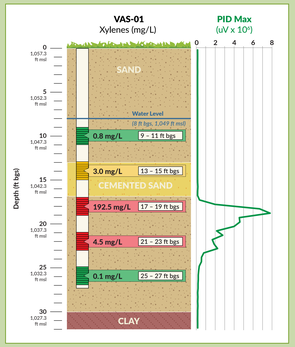


Profiling – Comparing VAS to MIP

Vertical aquifer sampling (VAS) adjacent to MW-15A confirmed the high xylene concentrations were ten feet below the water table. Membrane interface probes (MIPs) with photo-ionization detectors (PID) were used to determine the plume source. The PID detected volatile organic compounds (VOCs) above 1,000 ppm. The figure below shows that the PID results accurately aligned with the VAS xylene results.

Because multiple MIPs can be advanced each day, and the results are instantaneous, decision makers could meet each evening, view the day's results in cross-section and 3-D, and plan the next day's MIP locations. The PID data accurately identified the horizontal and vertical extent of the VOCs, and revealed that the xylenes came from Site B. The figure below shows a plan view of the PID and initial total xylenes results.



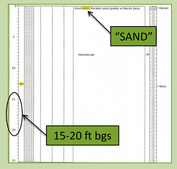


Historic Data Source Review – Discovery of Cemented Sand Layer

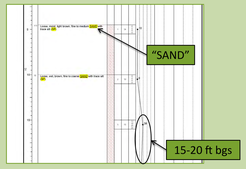
The process of placing the MIPs at the site revealed a very dense stratigraphic layer within an aquifer previously classified uniformly as "sand." Why didn't we know about this very dense, or "cemented," sand layer, aside from the fact that it is a lens that pinches out in the floodplain?

1. Data collection error: Some boring logs (specifically hollow stem auger borings) communicated no difference in the sand density in the cemented sand depth interval (Example 1 below).
2. Data recording error: Other logs did not note increased sand density in the soil description, although an increase in blow counts corresponded with the cemented sand depth interval (Example 2).
3. Data entry error: Boring logs which noted a "very dense" or "cemented" sand were keyed into the site database as USCS codes. USCS codes do not distinguish sand density (Example 3).

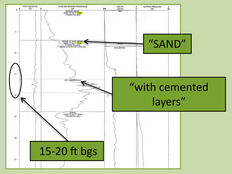
Example 1



Example 2



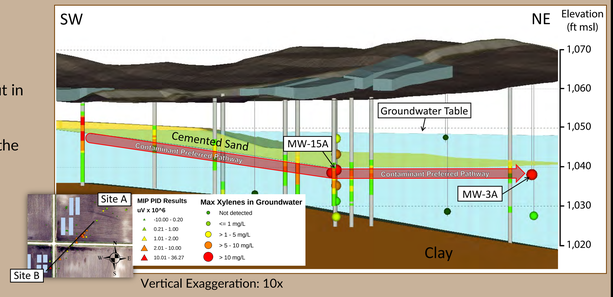
Example 3



Unusual Migration – Trapped Under Cemented Sand Layer

A more thorough review of site boring logs, combined with lithologic information gathered by the MIPs, revealed a cemented sand layer which began above the groundwater table upgradient of the site, sloped downward below the groundwater table beneath the subject site, and pinched out in the floodplain.

Combining the PID data with the refined understanding of the site boring logs revealed that the xylene remained trapped under the cemented sand layer as it traveled downgradient with the groundwater flow.



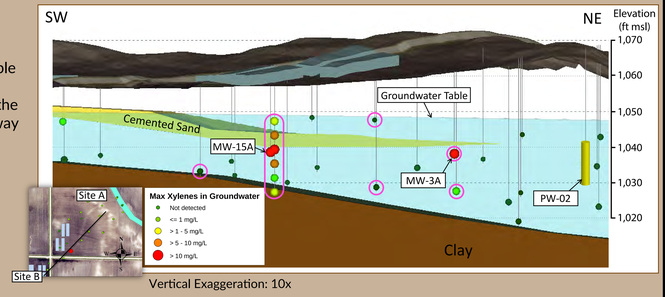
Vertical Exaggeration: 10x

Evaded Detection – Narrow Width and Depth Interval

The plume went undetected in upgradient and downgradient wells during the 2014 site-wide sampling event due to the narrow depth interval of the plume. The plume passed above or below multiple well screens along the transport pathway. In the cross-sectional view of the 3-D model to the right, the wells along the cross-section of the transport pathway are circled in pink.

In a 2015 quarterly sampling event, elevated concentrations of xylenes were detected downgradient in a well screened in the correct depth interval (MW-3A).

A pumping well (PW-02) previously used to remediate Site A was able to control the migration of xylenes off site.

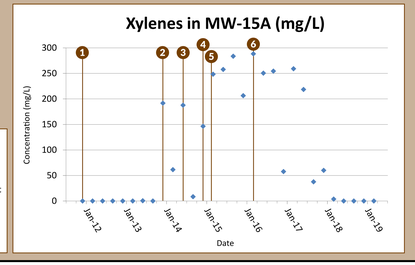


Vertical Exaggeration: 10x

Problem Resolution

The investigation revealed that the xylenes in groundwater originated in the cemented sand beneath Site B. Discussions with the operators of Site B revealed that a Site B pumping well, PW-01, had ceased production about two years prior to the appearance of xylenes in MW-15A.

The cessation of pumping in PW-01 either caused the groundwater table to rise into the contaminated cemented sand beneath Site B, or it no longer hydraulically contained/controlled flow, allowing impacted groundwater to migrate downgradient.

Responsible parties were able to target the soil requiring treatment with maximum efficiency. Two years following source remediation at Site B, xylene levels in MW-15A decreased to non-detect.

Applicability: MIP results may not be able to pinpoint one source as easily on a site with multiple contaminants and sources. However, revisiting boring log information and further evaluating site stratigraphy allows optimization of sampling and remediation.