

Evidence for the Natural Attenuation of PAH: Acenaphthene: the Last PAH Standing

Abstract

PAH compounds are biodegradable, and several researchers have published the mechanisms, rates, and other details of PAH biodegradation in groundwater (Fraser, et al. 2008, Zamfirescu and Grathwohl, 2001). The researchers have shown that aerobic degradation removes most of the lighter, two-ring and three-ring PAH compounds. Heavier PAH compounds, especially carcinogenic PAH, are more generally resistaznt to biodegradation and are less mobile in the environment.

The pattern of groundwater PAH concentrations at the Reilly Site is similar to the biodegradation pattern described in the literature. This is illustrated by naphthalene and acenaphthene concentrations in groundwater samples. Near the source areas at the Reilly Site, naphthalene is the dominant PAH compound found in the groundwater and is the primary energy (food) source for biodegrading microorganisms. The mass of acenaphthene becomes greater than the mass of other PAH compounds downgradient from the source due to acenaphthene's relative resistance to biodegradation compared to naphthalene, and its greater mobility compared to heavier PAH compounds.

Isoconcentration maps and other data presentations illustrate that acenaphthene represents 80% or more of the total PAH present in groundwater samples collected downgradient from the Reilly Site.

Site History





- Reilly operated a coal tar refinery and wood treating plant on 80 acres in St. Louis Park from 1917 to 1972.
- A multiaquifer well on site allowed PAH to migrate from shallow to deep aquifers.
- Taste and odor problems were encountered in 1932 when the City drilled its first well in the Prairie du Chien – Jordan Aquifer half a mile from the Reilly Site.
- PAH and coal-tar-like materials are present in soils and drift to the top of Platteville bedrock 65 feet deep.
- Clean soil was used to cover contamination, but a long-term source of PAH is present at the Site.
- Drinking water is treated using granular activated carbon.

- PAH

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Coal Tar and PAH: Fun Facts to Know and Tell

• There are approximately 10 gallons of tar per ton of coal coked (or converted to gas at your neighborhood manufactured gas plant)

• Coal tar contains approximately 11% naphthalene

• Coal tar contains approximately 1.4% acenaphthene

• Typical coal tar is mostly pitch that contains high molecular weight

 North Carolina "Tar Heels" were workers at underground wood coking operations for tar, turpentine, and charcoal production.

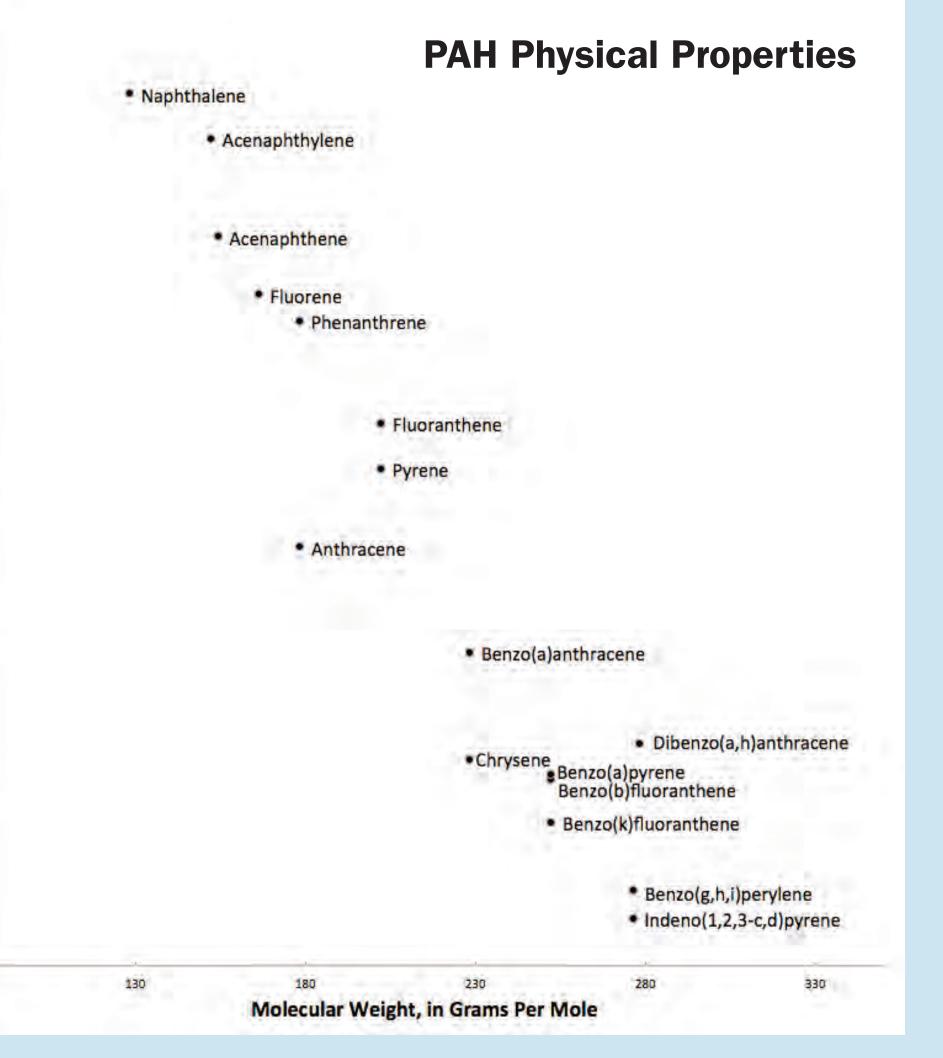
• There are over 100 different PAH compounds, 16 of which are priority pollutant PAH chosen to be representative of the entire group.

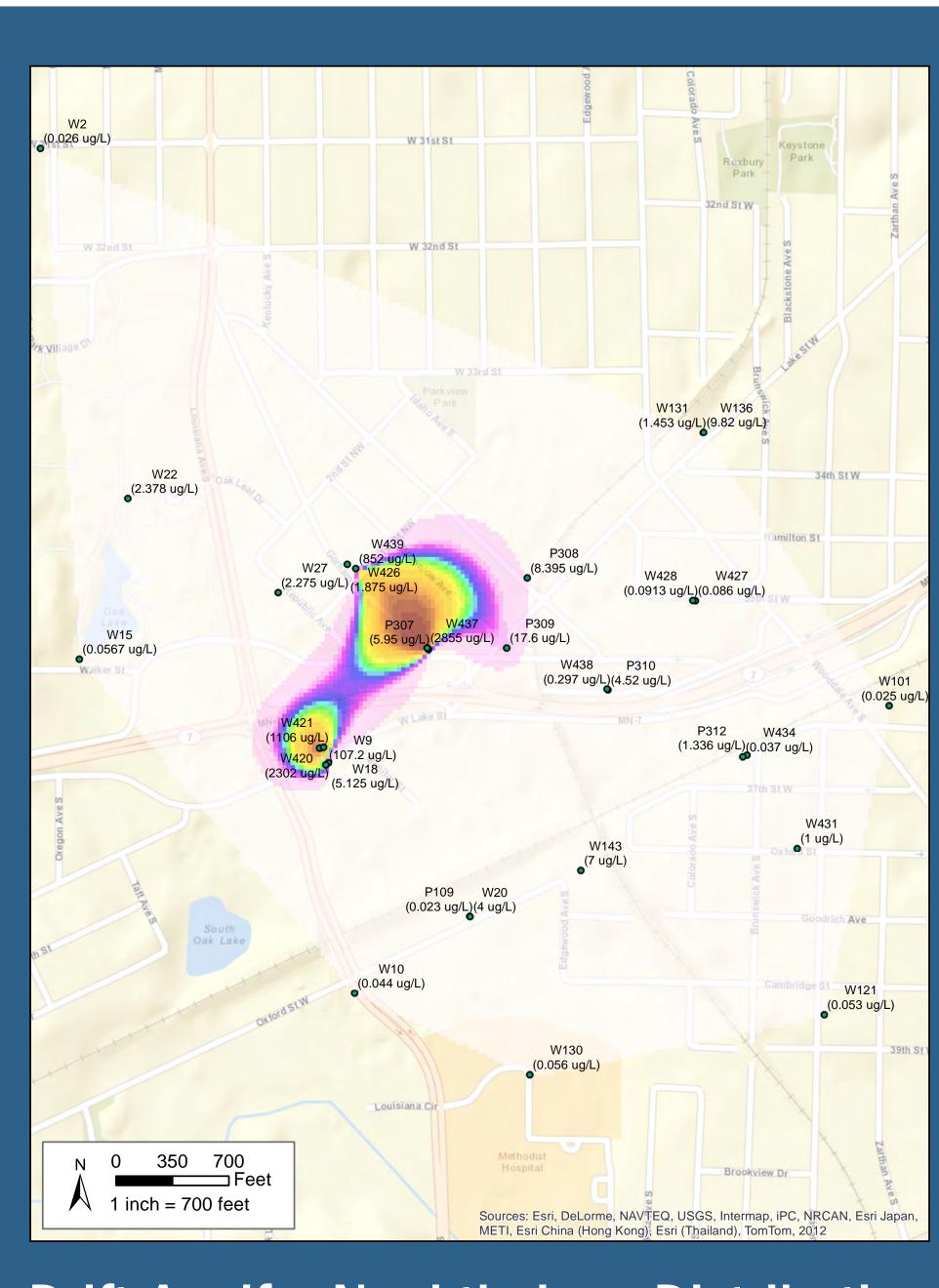
Drinking Water Criteria for PAH (PPB)

	MDH HBV ¹	MDH HRL ²	U.S. EPA, MCL ³	Reilly Site Consent Decree ⁴
ogenic PAH (sum)				0.028
o(a)pyrene (BaP)			0.2	
Equivalents (sum)	0.060			
PAH (sum)				0.280
aphthene		400		
acene		2,000		
anthene		300		
ene		300		
thalene		70		
1e		200		

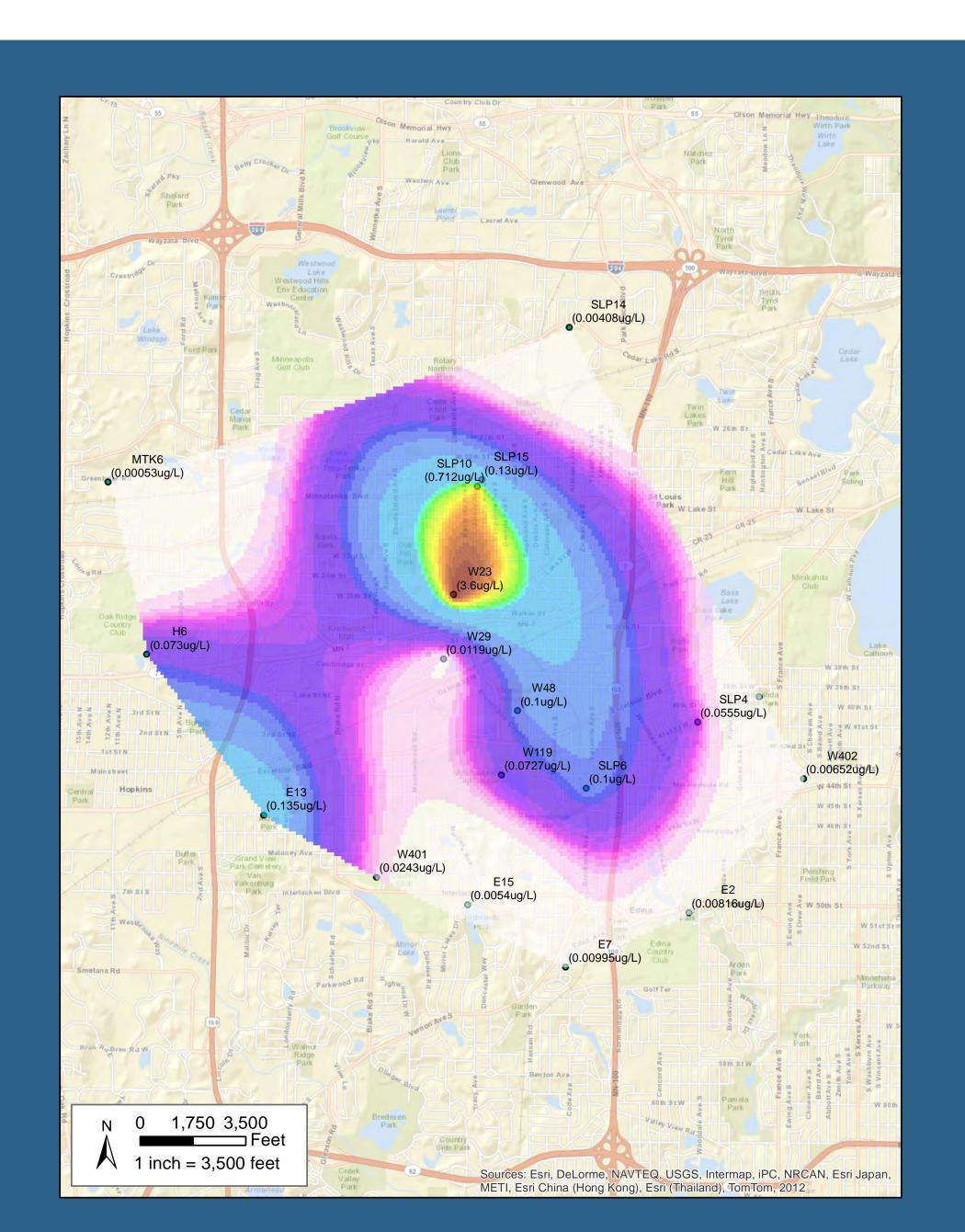
lue for up to 25 carcinogenic PAH (potency related to BaP). This CPAH policy is currently under review for the only priority pollutant PAH listed by the MDH. ant Level for the only PAH listed by the U.S. EPA.

nsent Decree lists 32 compounds, nine of which were considered carcinogenic.

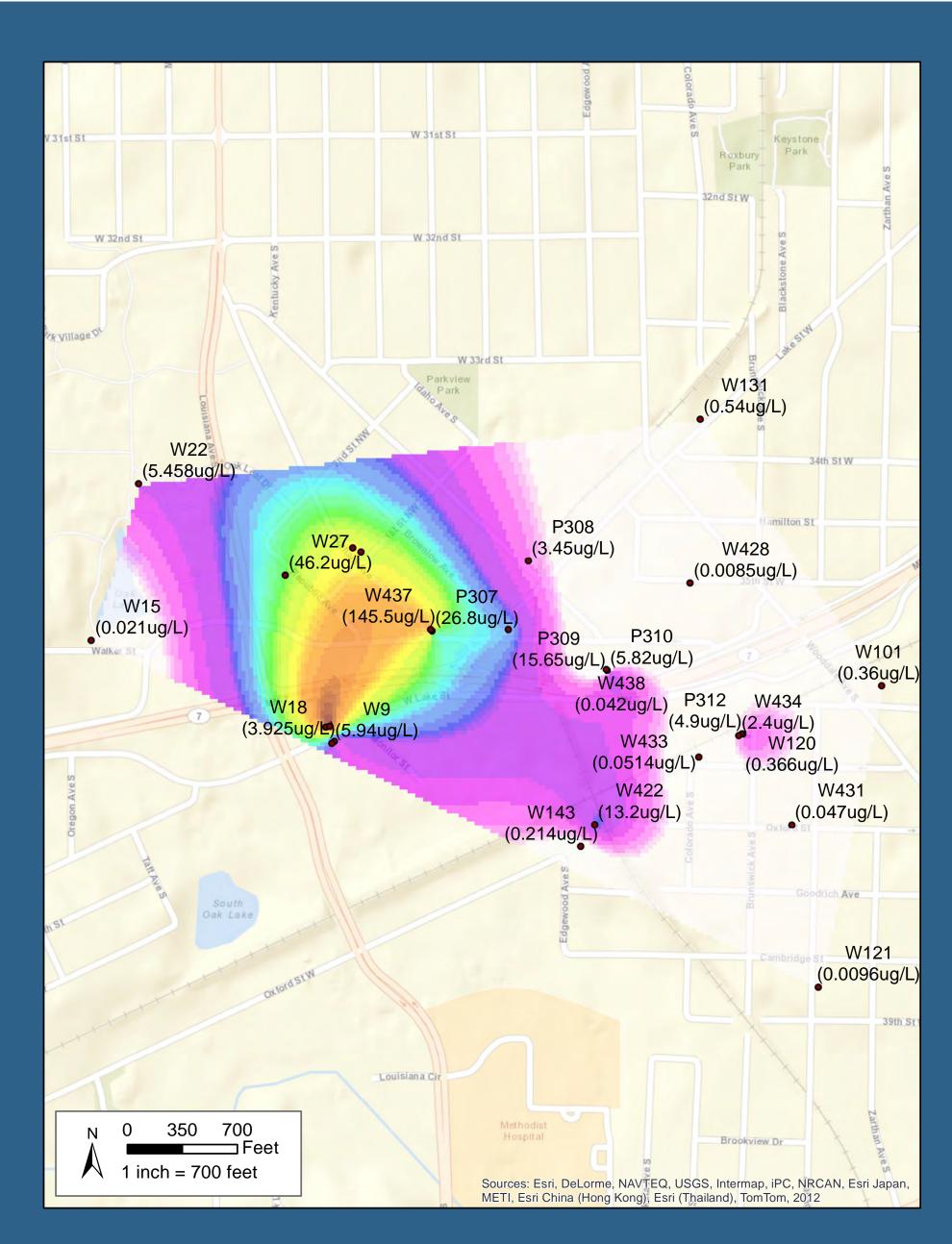




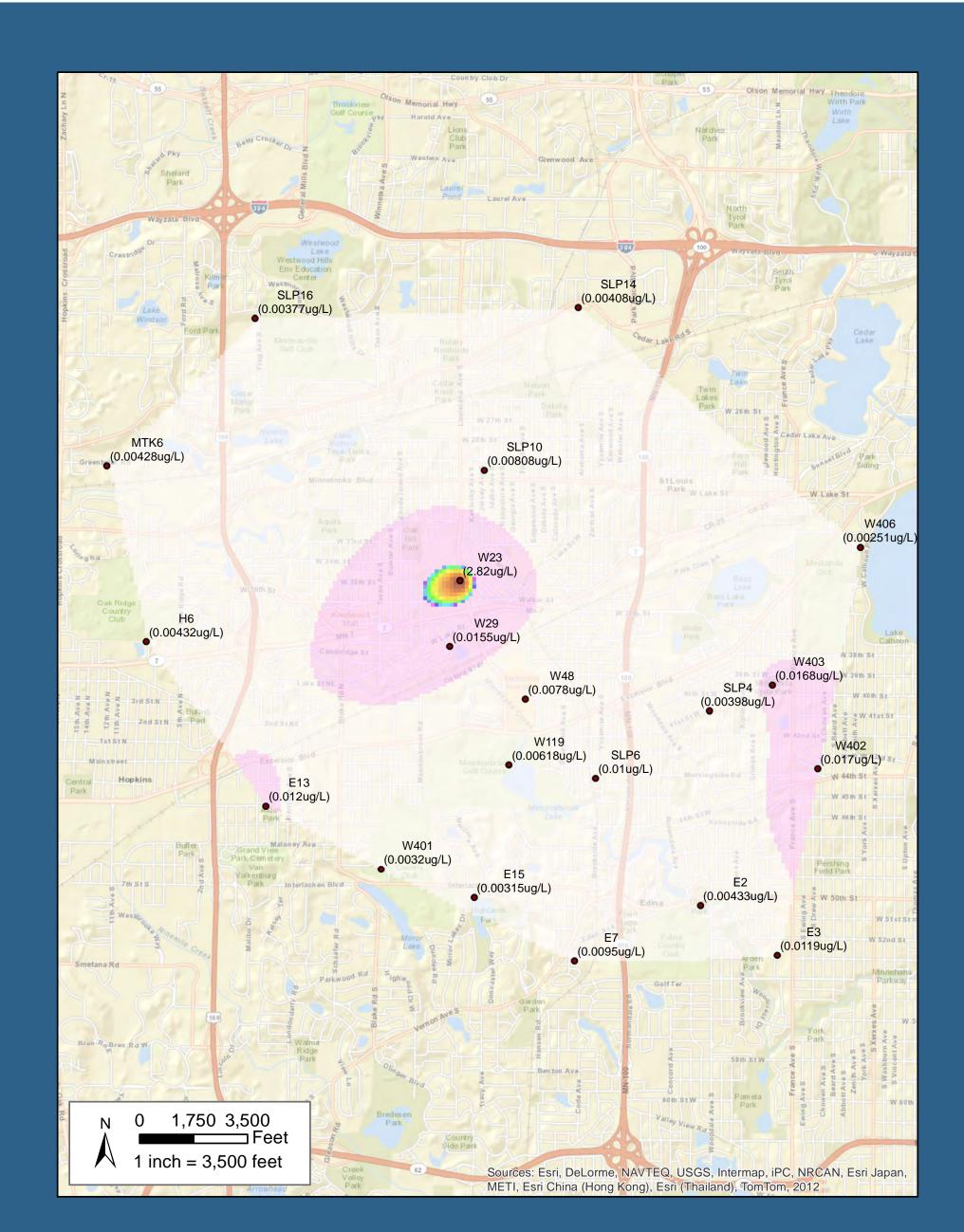
Drift Aquifer Naphthalene Distribution



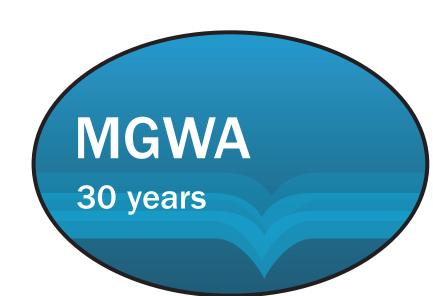
Prairie du Chien – Jordan Aquifer Acenaphthene Distribution

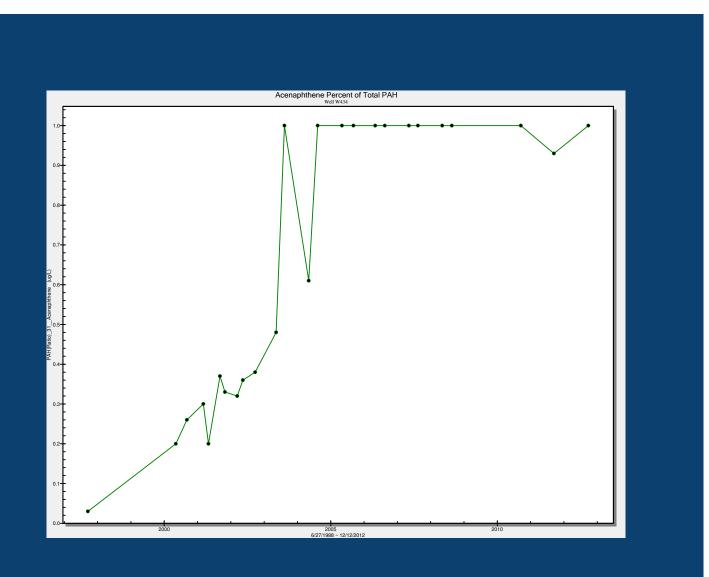


Drift Aquifer Acenaphthene Distribution

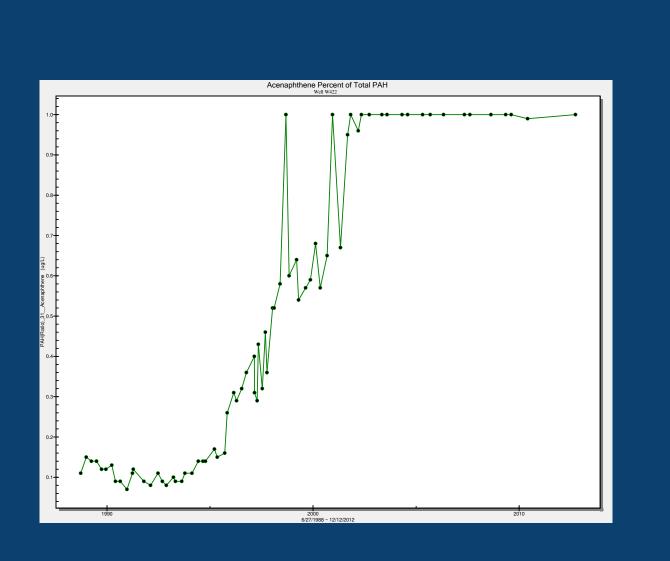


Prairie du Chien – Jordan Aquifer Naphthalene Distribution

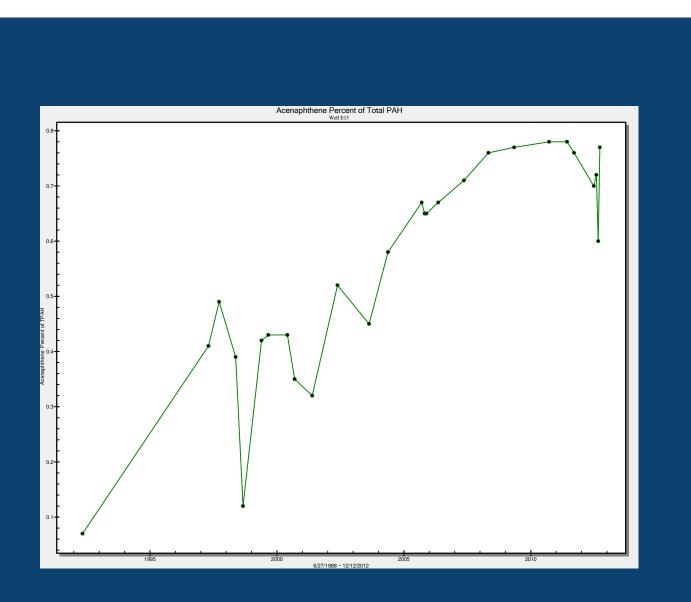




Well W434 Acenaphthene Percentage



Well W422 Acenaphthene Percentage



Well E13 Acenaphthene Percentage



Source Area Naphthalene History

Summary & Conclusion

Near the source areas at the Reilly Site, naphthalene is the dominant PAH compound found in the groundwater

- Acenaphthene is the dominant PAH compound found in downgradient groundwater
- In an idealized biodegradation setting, as distance from the source increases, all PAH concentrations decrease in downgradient areas due to various natural attenuation phenomena and naphthalene is removed below detection limits.
- The pattern of groundwater PAH concentrations at the Reilly Site is similar to the biodegradation pattern described in the literature
- Biological degradation removed naphthalene and a portion of the other more easily degraded PAH compounds in the source area. Higher molecular weight PAH that were not biodegradable were sorbed to the soils and aquifer matrix, especially the peat and organic soils in the bog area
- Acenaphthene and other PAH are attenuated by sorption and dispersion in the downgradient areas where biodegradation is largely absent

References:

Fraser, M., Barker, J.F., Butler, B., Blaine, F., Joseph, S., Cooke, C., 2008. "Natural attenuation of a plume from an emplaced coal tar creosote source over 14 years". Journal of Contaminant Hydrology 100, pp101-115, June 1, 2008.

Gregg, W., 2007. "The Role of Multiaguifer Wells in Coal Tar Migration". Presentation at MGWA Spring Conference. April 19,

Zamfirescu, D., Grathwohl, P., 2001. "Occurrence and attenuation of specific organic compounds in the groundwater plume at a former gasworks site". Journal of Contaminant Hydrology 53, pp 407-427, May 30,