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Polynuclear Aromatic Hydrocarbons Evaluation

January 2013

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Polynuclear Aromatic Hydrocarbons Evaluation

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Acronyms and Abbreviations

ACE	acenaphthene
ANY	acenaphthylene
BaA	benzo(a)anthracene
BaP	benzo(a)pyrene
BbF	benzo(b)fluoranthene
BMP	Best Management Practices
CHR	chrysene
cm	centimeters
DBA	dibenzo(a,h)anthracene
Ft bgs	feet below ground surface
FLU	fluorene
IP	indeno(1,2,3-c,d)pyrene
m/s	meters per second
$\mu g/m^2/s$	micrograms per square meter per second
$\mu g/m^3$	micrograms per cubic meter
MCA	multivariate cluster analysis
mg/kg	milligrams per kilograms
MKC	Madison-Kipp Corporation
NAP	naphthalene
NATA	National-Scale Air Toxics Assessment
NIST	National Institute of Standards and Technology
PAH	polynuclear aromatic hydrocarbons
PC	principal components
PCA	principal component analysis
PCB	polychlorinated biphenyls

PHE	phenanthrene
ppm	parts per million
PYR	pyrene
r	correlation coefficient
$\mathbf{R^2}$	coefficient of determination
RCL	Residual Contaminant Levels
U.S. EPA	United States Enviormental Protection Agency
VOCs	volatile organic compounds
WDNR	Wisconsin Department of Natural Resources

Expert Report

It is our opinion that the polynuclear aromatic hydrocarbons (PAHs) found in the yards surrounding the Madison-Kipp Corporation (MKC) facility (Site) are part of the normal background concentrations of PAHs found in Madison, Wisconsin and other urban areas in the United States. It is also our opinion that the source of PAHs found in the yards surrounding the Site are not from MKC.

These opinions, as well as all of the opinions and conclusions stated herein, are to a reasonable degree of scientific certainty, based on our knowledge, background, experience and site-specific research including the following:

- Total PAHs at the Site
- Specific PAH compounds identified in each sample
- Mixtures of PAH compounds found in each sample
- Potential sources of PAHs from the MKC manufacturing facility
- Transport mechanisms for PAHs including deposition of particulate matter from air or possible overland flow associated with water runoff
- Potential sources of PAHs from areas other than the Site

In rendering these opinions, we surveyed research regarding 'background' PAH concentrations.[1] The Wisconsin Department of Natural Resources' published policy documents on background PAHs were reviewed by ARCADIS. The published materials clearly show that it is widely known that, in Wisconsin, there are statewide sources of PAHs from coal-fired powered plants and other heating systems, dust from asphalt, and many other sources that combine to form a small mass of airborne PAHs that settle on all surfaces including non-covered soils in residential areas. The same type of policy documentation has been prepared in several other states across the country and all of these documents were confirmed by several policies on background

[1] The information and opinions presented in this report may be modified as additional information is reviewed or becomes available.

PAHs written by the United States Environmental Protection Agency (U.S. EPA). Background PAHs are found throughout the country and are expected in any urban, non-covered soil.

Furthermore, we completed a statistical analysis of the 341 PAH samples collected as part of the site investigation activities conducted on and around the Site. Based upon this analysis, the PAHs found in the backyards (off Site) were comprised of background mixtures of PAHs, not PAHs attributable to sources at MKC. During this study a statistical evaluation was completed to separate the PAH data into 6 groups. The individual groups were designated based upon the relative proportions of various PAHs and the ratios of the types of PAHs found in the samples. All samples from residential locations were associated with PAH profiles that are indicative of combustion sources including coal and cinders, urban dust or asphalt, as defined by two PAH profile groups identified during the statistical evaluation. Samples from the Site were represented by all six PAH profile groups, which were dominated by combustion related PAHs or had varying contributions from potential petroleum related PAH sources.

All of the samples that were collected from the Site itself (on Site) were represented by all six of the PAH profile groups. Many of the samples had a similar pattern to the combustion related PAHs identified in the residential yards. However, the other PAH groups that were found exclusively on the Site consisted of a lighter (lower molecular weight) PAH mixture with a higher naphthalene content that likely represents PAHs from potential petroleum related PAH sources. These PAHs are associated with petroleum hydrocarbons that could be the result of normal truck and car traffic at the facility, and the types of petroleum products that were likely used at the Site.

This clear distinction between the on-Site and off-Site samples was then further analyzed. The data demonstrates that the PAHs found on Site did not travel to the surrounding properties. The transport potential of PAHs off Site by water and airborne deposition was studied. The storm water permit for the Site was used as a basis for determining the exit point for water from the site. This clearly showed that most of the water runoff from the Site would end up at the north end of the property. While single events like floods may have a different pattern than normal storm runoff, the preponderance of runoff material over the years would be with the normal storm water flows. Despite this, it was very clear that the off-Site samples in the north consisted of the same background concentrations and mixtures found on the rest of the off-Site properties. There was no evidence that the lower molecular weight PAHs found on the Site were found in the northern off-Site properties.

Local wind data was used to determine the preferential wind flow pattern at the Site. This data set was used to evaluate general air discharges and point source (exhaust fans) air discharges from the property. The preferential air flow pattern is to the north. The offsite samples in the north were compared to the PAHs samples found on Site. Once again, all of the northern off-Site samples were comprised of background PAHs. There was no evidence that the lower molecular weight PAHs found on Site or the lower molecular weight PAHs found in the petroleum products used at the Site traveled to the northern off-Site properties. Further, there is no evidence of a correlation between PAHs detected off-Site and the locations of the exhaust fan air discharges.

The known potential sources of PAHs that were historically used at the Site were petroleum-based products. The only PAHs associated with these products were the lower molecular weight PAHs. While evidence of lower molecular weight PAHs was indicated in the on-Site samples, there was no evidence of these compounds in the off-Site samples. The PAHs from the facility were not the source of PAHs found in the neighbors' backyards, but rather the off-Site samples are consistent with general PAH mixtures found in urban areas (a.k.a. "background").

The Madison-Kipp facility did use coal fired boilers over many decades. However, this potential source is not responsible for PAHs identified in the neighbors' backyards for the following reasons:

- The coal used at the Madison-Kipp facility was a minor proportion of the total coal used in the area for homeowners and businesses. Coal was the predominant historic fuel source for homeowners and businesses throughout East Madison.

- The airborne discharge of PAHs from coal combustion historically at the Madison-Kipp facility would have been from stacks at the Site. While this discharge may have become a small part of the overall background PAHs in Madison, the stacks were specifically designed to move and disperse atmospheric emissions.

Based on this information, an evaluation was completed for potential sources of the PAHs found in the backyards. The U.S. EPA has completed very specific studies on PAHs in the air of various urban areas. These studies included the airborne PAH concentrations for Dane county for several years. The U.S. EPA also provided a method to calculate the amount of PAHs expected to settle onto the soil based upon

the concentrations found in the air. Based upon these calculations, the PAHs found in the backyards are within the expected concentrations for urban areas.

The evaluation methods used in this assessment are consistent with the state of the science as practiced in source identification studies. All methods used, including multivariate cluster analysis, principal component analysis, diagnostic ratio analysis and source correlation, indicate that the PAHs found in the backyards are consistent with background sources[2].

It is our opinion that, to a reasonable degree of scientific certainty, the following conclusions can be drawn from the forensic PAH evaluation presented herein:

1) Statistical analysis of PAH distributions within individual samples clearly indicates that several PAH profiles are present in the data set.

2) The majority of samples meeting the inclusion criterion for the forensic evaluation cluster are in a single group (Group 1) and represent 86.8% of the data set, with the remaining samples being separated into five additional groups.

3) The remaining five groups are differentiated from the main Group 1 profile based on the relative proportion of light 2-ring PAHs or heavier 6-ring PAHs.

4) Residential samples tend to be associated with the primary Group 1 type of PAH profile, with 63 of 65 residential samples being in this group. The remaining two samples were associated with the group having a slightly heavier PAH assemblage, but in any case unassociated with the lighter ring PAHs identified on the MKC facility.

5) When compared to representative PAH source materials, the PAH profiles for Group 1 samples are consistent with PAH assemblages derived from combustion related sources such as coal fines, cinders, urban dust or asphalt. The PAH profile for this group is not consistent with PAH sources from cutting oil, waste oil, diesel contaminated soils, coal tar or coal tar pitch.

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[2] MCA Murakimi et al., 2005; PCA Stout et al., 2003; Diagnostic Ratios Yunkers, 2002; source correlation Burns et al., 2006

6) The spatial distribution of Group 1 shows that these samples are evenly distributed among all locations without a strong preference for clustering in a given area.

7) Group 2 samples are similar to Group 1 with the exception of having a high relative proportion of 6-ring PAHs. The PAH profile for this group is also consistent with combustion related sources including asphalt, urban dust and coal tar pitch.

8) Groups 3, 4, 5 and 6 have greater relative proportions of light 2- and 3-ring PAHs. Based on comparisons with PAH reference material profiles from known sources, these groups most likely are influenced by PAH sources with higher naphthalene proportions including diesel contaminated soils or waste oils superimposed on combustion related PAH sources and are more indicative of the types of PAH source materials utilized at the MKC facility.

1. Introduction

ARCADIS has been retained to assist the Madison-Kipp Corporation (MKC) with environmental investigation and remediation activities at the facility located at 201 Waubesa Street in Madison, Wisconsin (Site). As part of the investigation activities, Site and off-Site residential backyard soil samples were collected for analysis of polynuclear aromatic hydrocarbons (PAHs). The Site data set consists of 341 soil samples analyzed for PAHs from both on- and off-Site locations.

Based on the results of the investigation activities completed, the *Off-Site Residential Polycyclic Aromatic Hydrocarbon (PAH) Results Summary* letter, dated September 11, 2012 was submitted to the Wisconsin Department of Natural Resources (WDNR) to present the PAH results and recommendations. The PAHs detected in soil were compared to the WDNR Non-Industrial Direct Contact Residual Contaminant Levels (RCLs) as calculated using the U.S. EPA's Regional Screening Level web calculator. As previously communicated to WDNR, at most of the sample locations, one or more PAHs from 0 to 2 ft below ground surface (ft bgs) exceeded WDNR's RCL at a cancer risk level of 1×10^{-6} or a non-cancer hazard index of 1. At only a few sample locations, PAH results from 2 to 4 ft bgs also exceeded the RCLs. U.S. EPA has determined the acceptable range for RCLs for PAHs to be between $1x10^{-6}$ and $1x10^{-4}$ [40 CFR **§** 300.430 (e)(2)(i)(A)(2)] and WDNR's Soil Cleanup Standards in Wis. Admin. Code Ch. NR 720 applies 10^{-5} as the cumulative acceptable risk for all sites throughout the state. U.S. EPA has established preliminary remediation goals at various sites in Wisconsin utilizing $1x10^{-5}$ to $1x10^{-4}$ risk.

The September 11, 2012 letter included the following summary regarding the PAHs on the Site:

> PAHs are common industrial compounds, as indicated by their presence on properties such as Madison Kipp and the nearby Goodman Center. However, PAHs are also associated with a broad range of sources unrelated to industrial activity. Based on this information, there is insufficient evidence to establish that PAHs in residential soil are associated with the Madison Kipp property and are anything other than typical background PAHs present in an urban setting. In addition, the concentrations of PAHs present off-site are less than the risk-based levels developed for similar sites in Wisconsin. Therefore, there is no need to implement remedial measures for these constituents at off-site locations. PAHs are ubiquitous in an urban environment from many different activities, the majority of

which have no relation to activities at Madison Kipp. As a result, PAHs should not be a driver for off-site remediation in relation to the Madison Kipp site.

The WDNR issued a letter dated December 7, 2012 directing MKC to submit a work plan "either…for determining whether any of the health-based direct contact exceedances can be attributed to background concentrations or…a remedial action plan to be employed by MKC…". On December 14, 2012, ARCADIS, on behalf of MKC, submitted the *Polynuclear Aromatic Hydrocarbons (PAH) Work Plan, Determination of Whether Health-Based Direct Contact Exceedances Can Be Attributed to Background Concentrations* (Work Plan). The Work Plan presented an evaluation methodology designed to determine whether any of the health-based direct contact exceedances can be attributed to background concentrations. This methodology was aimed at data analyses, the objective of which is to better understand the source, fate and transport concerning the PAHs present at the Site and on adjoining residential properties.

1.1 Site Description

The Site is approximately 7.5 acres in size. A 130,000-square foot building occupies much of the Site. Asphalt parking lots are located in the northeastern, southwestern and southeastern portions of the Site. The building has a 25,000-square foot second floor and a 25,000-square foot basement. Figure 1-1 depicts the layout of the Site. The Site is zoned M-1 (industrial/manufacturing). The Site is currently used as a metals casting facility.

The Site is located in the eastern portion of Madison, in a mixed use area of commercial, industrial and residential land use. The Site is bounded by a bicycle trail (Capital City Trail) constructed on a former railroad line to the north, Atwood Avenue to the south, and Waubesa Street to the west. Residences are located adjacent to the east and west sides of the Site, and further west (across Waubesa Street) and east (across Marquette Street). Commercial properties are located to the south (across Atwood Street) and further east. The Goodman Community Center is located to the north (across the Capital City Trail) and was the site of former industrial activities.

The Site is also located at the northeast end of the Madison isthmus, approximately 1,500 feet north of Lake Monona and approximately 6,800 feet east of Lake Mendota. The topography of the Site is relatively flat, with an elevation ranging from approximately 870 to 880 feet above mean sea level. The Site and surrounding area is serviced by municipal water supply and sewerage systems.

1.2 Site History

In the late 1800s, the United States Navy constructed a foundry at the Site for the purpose of casting cannon barrels. Although no barrels were ultimately cast at the Site, the facility has been used for casting metals since that time. Originally two separate buildings (one on Atwood Avenue and one to the north on Waubesa Street) were located on the Site. Various construction activities over the years joined the buildings, resulting in the current facility configuration (Figure 1-1).

Multiple industrial products have been used during the history of the facility, including cutting oils, lubrication oils, degreasing chemicals and miscellaneous other products. These products contained various petroleum compounds, chlorinated volatile organic compounds (VOCs), and polychlorinated biphenyls (PCBs).

2. General Discussion Of PAH Background Sources In Urban Areas

PAHs in urban soils have many natural and anthropogenic sources. Natural sources include PAHs resulting from forest fires, volcanic eruptions, and petroleum and tar seeps. Anthropogenic sources include fireplaces, wood burning stoves, home heating boilers, cars, trucks, busses, trains, backyard garbage and brush burning, accidental building fires, wood and coal ash, electric power generation plants, industrial boilers, coke ovens, petroleum refineries, road and roofing tar, driveway sealers, petroleum fuels and lubricating oils, oil spills, and many others, including individual industrial plants and waste disposal or spill sites (ATSDR, 1995).

Today many anthropogenic PAH sources are controlled as point sources under various regulatory programs. For instance, a coke oven or a petroleum refinery has emission limitations it must adhere to in accordance with a government issued permit. Historically, such sources were not controlled, however, and emissions that occurred decades ago from such point sources are important sources of current anthropogenic background levels of PAHs.

Background PAH sources consist of both of these groups of natural and anthropogenic sources. PAHs that cannot be traced to a specific source are defined as background PAHs from one or many sources. It is generally recognized that in areas that have been heavily urbanized for decades or even hundreds of years, there are many anthropogenic background sources of PAHs.

2.1 Discussion of Wisconsin Regulations and Guidance Regarding Background Sources

Wisconsin regulations for Soil Cleanup Standards (Wis. Admin. Code Ch. NR 720) specifically address the issue of background levels of constituents, such as PAHs in soils in urban areas. Specifically, NR 720.11(5)(b) states:

> "(b) If the background concentration for a substance in soil at a site or facility is higher than the residual contaminant level for that substance listed in Table 2 or determined using the procedure in s. NR 720.19 (3), the background concentration in soil may be used as the residual contaminant level for that substance. The background concentration for a substance in soil shall be determined using a department-approved and appropriate method."

WDNR (2005) also published a guidance document entitled *Guidance for Determining Soil Contaminant Background Levels at Remediation Sites*. It specifically cites PAHs

as “ubiquitous organics…from widespread atmospheric deposition” that are candidates for background soil determinations because they cannot be traced to a specific source. In fact, the definition of “background soil quality” refers to "lead, polynuclear aromatic hydrocarbons or polychlorinated biphenyls attributable to atmospheric deposition” according to NR 700.03(2).

In addition, WDNR (2011) in its *Soil Residual Contaminant Level Determinations Using the U.S. EPA Regional Screening Level Web Calculator*, specifically states that the Regional Screening Level web calculator does not address soil background levels, and that the soil background levels must be addressed separately when deriving Residual Contaminant Levels.

2.2 Discussion of Other State Regulations and Guidance Regarding Background Sources

WDNR is not alone in considering the widespread atmospheric deposition of PAHs to constitute background. For instance, Massachusetts (1995) defines “background” in the following manner:

> “Background means those levels of oil and hazardous material that would exist in the absence of the disposal site of concern which are:
>
> a) Ubiquitous and consistently present in the environment at and in the vicinity of the disposal site of concern; and
>
> b) Attributable to geologic or ecologic conditions, atmospheric deposition of industrial processes or engine emissions, fill materials containing wood or coal ash, releases to groundwater from a public water supply system, and/or petroleum residues that are incidental to the normal operation of motor vehicles.”

Massachusetts specifically names engine emissions, wood ash, coal ash and petroleum residues associated with motor vehicle operation as anthropogenic sources of PAHs to the environment.

Further, Massachusetts recently released a document entitled *Best Management Practices For Controlling Exposure To Soil During The Development Of Rail Trails* that explicitly recognizes that historical contamination has occurred along railways, but because historical contamination is considered background, it is excluded from the

Massachusetts Contingency Plan, which governs site release investigations and clean ups.

Specifically, the document defines Best Management Practices (BMPs) that were "developed to eliminate or minimize potential exposures to residual oil or hazardous materials commonly found along railroad rights-of-way being converted to rail trails." These BMPs do not require constituent characterization and remediation as noted below:

> "Some historic railroad operations involved the use of chemicals that may have resulted in presence today of contamination…. Lubricating oil and diesel that dripped from the trains are likely sources of the petroleum product found along the lines. Other sources of contaminants associated with historic railroad operation may include coal ash from engines, creosote from ties, and polynuclear aromatic hydrocarbons ("PAHs") from the diesel exhaust. The BMPs outlined in this document are specifically designed to be protective of public health and provide a practical alternative to extensively testing for and possibly removing these "typical" residues expected from the historic operation of a rail line."

In the Illinois Tiered Approach to Corrective Action program, "Area Background" is defined to incorporate anthropogenic sources of constituents:

> ""'Area Background" means concentrations of regulated substances that are consistently present in the environment in the vicinity of a site that are the result of natural conditions or human activities, and not the result solely of releases at the site."

California (2009) incorporates anthropogenic sources in their definition of "ambient conditions" for organics, such as PAHs, as noted below:

> "Polynuclear aromatic hydrocarbons (PAHs) are associated with the combustion of fossil fuels, industrial and commercial activities, and natural sources such as wildfires and volcanic activity. PAHs are found in soils within both rural and urban areas, reflecting the many natural and anthropogenic sources of PAHs in the environment. PAHs that are not attributable to a specific point source are referred to as "ambient". PAHs are typically found at higher ambient concentrations in urban areas, near more heavily traveled roadways, in areas that have had longer human occupation, in areas receiving runoff from surface soils containing PAHs, and areas downwind of urbanized areas (Wang et al., 2008; Nam et al. 2008).

> Some studies have found that higher ambient concentrations can also be associated with soils having higher organic matter and/or clay content."
>
> "For sites where PAH-impacted soils have been identified and require cleanup, it may be necessary to evaluate ambient concentrations of PAHs in soil. This assessment may be needed because the calculated health-based or ecologically-based cleanup goal for PAHs can be one to two orders of magnitude below ambient PAH concentrations in developed areas. In general, DTSC does not require cleanup of sites to concentrations that are less than ambient. In these instances, the cleanup approach can be developed based on ambient PAH concentrations. This approach ensures that the health risks associated with exposure to the PAHs do not pose a health risk greater than that posed by ambient concentrations of PAHs. (California DTSC, 2009)".

Kentucky (2004) also defines background to include anthropogenic sources:

> "Background, as defined in 401 KAR 42:005 (definitions codified to support the Underground Storage Tank regulations), means the concentration of substances consistently present in the environment at, or regionally proximate to, a release but outside the influence of the release. There are two types of background:
>
> a) Natural background is the amount of naturally occurring substances in the environment, exclusive of that from anthropogenic sources.
>
> b) Ambient background means the concentrations of naturally occurring inorganic substances and ubiquitous anthropogenic inorganic substances in the environment that are representative of the region surrounding the site and not attributable to an identifiable release."

Another state that includes anthropogenic sources in its definition of background is West Virginia, as noted below:

> "The Rule specifies that where the De Minimis Standard is below natural background and where the Uniform and Site-Specific Risk-Based Standards are below anthropogenic background, that natural background may be used in place of the De Minimis Standard, and natural or anthropogenic background may be used in place of the Uniform and Site-Specific Risk-Based Standards."

> "Anthropogenic background refers to concentrations of elements that occur over a widespread area as a result of human activities."

2.3 Discussion of Federal Regulations and Guidance Regarding Background Sources

Like many states, the Federal government has a detailed policy on background levels of chemicals in urban soils that recognizes the important role of widespread aerial deposition of chemicals like PAHs in determining the background levels of chemicals in soils. EPA's *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA, 2002) defines background to include both naturally occurring and anthropogenic substances in site media, such as soil. Specifically, EPA states:

> "For the purposes of this policy, the following definitions are used.
>
> Background refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic (EPA, 1989; EPA, 1995a):
>
> 1) Anthropogenic - natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question); and,
>
> 2) Naturally occurring - substances present in the environment in forms that have not been influenced by human activity."

According to EPA, both types of background substances can be treated the same way in a background investigation: "Generally, the type of background substance (natural or anthropogenic) does not influence the statistical or technical method used to characterize background concentrations." EPA is clear that site clean-up decisions should focus on substances released by the site or facility and not on substances present at levels that constitute natural or human-induced historic background. Specifically, EPA (2002) states:

> "Background information is important to risk managers because the CERCLA program, generally, does not clean up to concentrations below natural or anthropogenic background levels. (Page B-3)

> Generally, under CERCLA, cleanup levels are not set at concentrations below natural background levels. Similarly, for anthropogenic contaminant concentrations, the CERCLA program normally does not set cleanup levels below anthropogenic background concentrations (EPA, 1996; EPA, 1997b; EPA, 2000). The reasons for this approach include cost-effectiveness, technical practicability, and the potential for recontamination of remediated areas by surrounding areas with elevated background concentrations. In cases where area-wide contamination may pose risks, but is beyond the authority provided under CERCLA, EPA may be able to help identify other programs or regulatory authorities that are able to address the sources of area-wide contamination, particularly anthropogenic (EPA, 1996; EPA, 1997b; EPA, 2000). (Page B-6)".

EPA's *Risk Assessment Guidance for Superfund* (EPA, 1989) gives an almost identical definition of background as noted below:

> "There are two different types of background levels of chemicals:
>
> 1) Naturally occurring levels, which are ambient concentrations of chemicals present in the environment that have not been influenced by humans (e.g., aluminum, manganese); and
>
> 2) Anthropogenic levels, which are concentrations of chemicals that are present in the environment due to human-made, non-site sources (e.g., industry, automobiles)"

EPA's definition of background levels of PAHs in soils specifically includes all "area-wide contamination" including that from industrial emissions and automobiles.

2.4 Summary

It is our opinion to a reasonable degree of scientific certainty that the Site and surrounding area would be expected to be impacted by naturally occurring and anthropogenic levels of PAHs. As such, the next step in our analysis was to evaluate the specific PAHs found in the soil samples collected from on-Site and residential areas and determine if the PAHs detected in these samples are from the background PAHs or activities at the Site.

3. Forensic Evaluation of PAH Distribution in On-Site and Residential Samples

An essential element of our analysis was identifying potential sources for the PAHs identified both on-Site and in residential samples. Because PAHs are derived from a variety of natural, industrial and general anthropogenic sources, it is possible to evaluate the relative proportions of PAHs in a sample to gain information related to these various sources (Costa and Sauer, 2005; Jansen et al., 2007; Kaplan et al., 1997; Kaplan et al., 2001; Lima et al., 2005; Mitra et al., 1999; Manoli et al., 2004; Nam et al., 2008; Teaf, 2008; EPA, 2007; Uhler and Emsbo-Mattingly, 2006; Zemo, 2009). PAH forensic evaluation methods are well established in the peer-reviewed literature (Burns et al., 1997; Iqbal et al., 2008; Kimbrough and Dickhut, 2006; Kose et al., 2008; Lee, 1999; Liu et al., 2010; Larsen and Baker, 2003; McGregor et al., 2012; Stout et al, 2001a; Stout et al., 2001b: Yunkers et al., 2002). Several of these methods have been employed to evaluate both the nature of the PAHs present both on-site and on residential properties, and to identify how the project-specific distribution of PAHs compares to distributions from known PAH source reference materials.

3.1 Analytical and Statistical Methods for PAH Evaluation

PAHs are ubiquitous in the terrestrial environment (Stout et al., 2001a; Yunkers, et al., 2002; Neff et al., 2005; Lima, et al., 2005). PAHs occur as complex mixtures in sediments and soils that are derived from multiple natural and anthropogenic sources, which may subsequently be subject to a variety of physical, biological and chemical processes that further modify the relative proportion of specific PAH compounds within a given location. An extensive body of work is available in the peer-reviewed literature that describes various PAH sources and transformational processes, as well as presents analytical and statistical methods that have been applied to identify the dominant initial PAH sources within various settings (Douglas et al., 1996; Christensen et al., 2005; Diblasi et al., 2009; Kose et al., 2008; Lima et al., 2005; Mitra et al., 1999; Pies et al., 2008; Stout et al., 2003; Walker et al., 2005; Wang et al., 2009). The fundamental purpose of a forensic PAH evaluation is to apply these methods to gain an understanding of these sources based on the sample-specific distributions of PAHs from a given study area, as compared to empirical and experimental data sets for known source materials as described in the literature, from references cited above.

Forensic PAH evaluations rely on the relative distribution or assemblages of multiple PAHs within a sample, rather than the absolute concentration of these compounds (Bzdusek et al., 2004; Stout et al., 2003). Early research on the source of PAHs in the environment identified three principal classifications of sources based on the

distribution patterns recognized in various environments. These include diagenetic (or biogenic), petrogenic and pyrogenic (Boehm and Farrington, 1984; Yunkers et al., 2003). Diagenetic assemblages arise from the biological transformation of natural organic matter within sediments. Petrogenic assemblages are generated through geological processes of elevated pressure and temperature that transform organic matter in sediments into a variety of PAH compounds that give rise to crude petroleum as well as various ranks of coal. Pyrogenic assemblages are created during the combustion or pyrolysis of organic matter that can include wood, coal, petroleum or other forms of biomass (Stout et al., 2001b).

A basic knowledge of PAH chemistry is important for the understanding of forensic evaluations (Lima et al., 2005). PAHs considered in most forensic evaluations consist of 2- to 6-fused aromatic rings, along with their alkylated homologues, that contain only carbon and hydrogen. These structures are illustrated on Figure 3-1. Parent PAHs include compounds that consist of only the fused aromatic rings, whereas their alkylated homologues have between one and four alkyl groups substituting for hydrogen along the boundary of the molecule. Naphthalene (NAP) and 2-methylnaphthalene (2mNAP) are examples of a parent and alkylated 2-ring PAH. (Note that in the current evaluation, the only alkylated PAHs measured were 1mNAP and 2-methylnaphthalene (2mNAP), although additional alkylated PAHs can be analyzed in other forensic applications.) Alkylated homologues are typically identified by their parent PAH name and the number of additional methyl groups on the structure. Thus, C3-phenanthrene has the basic structure of phenanthrene (PHE) with three methyl groups (or one methyl and one ethyl groups). For PAHs having three or more rings, PAH isomers are compounds that have the same chemical formula, yet have different structures. Fluorene (FLU) and pyrene (PYR) are examples of 4-ring PAH isomers. Table 3-1 provides a summary of chemical names and acronyms used throughout this report.

Over the past 20 years, significant advances have been made in improving analytical detection limits and the differentiation of various PAH compounds that can be analyzed (Wait, 2000; Douglas et al., 2004; Planas et al., 2006). Concurrently with advancement in laboratory analytical methods, several qualitative, quantitative and statistical methods have been developed to evaluate PAH distributions in a variety of sample types. PAH profiles are qualitative illustrations of the distribution of PAHs within a sample or group. PAH profiles illustrate either absolute concentrations within a sample or PAH proportions normalized to the total PAH concentration. Mean PAH profiles for a group are calculated as the average proportion of specific PAHs for samples within

that group. A profile is ordered with low molecular weight 2-ring PAHs to the left and high molecular weight 6-ring PAHs to the right.

Several multivariate statistical methods are typically employed to evaluate the complex relationships in PAH data sets. Principal component analysis (PCA) is the most common multivariate approach used in forensic evaluations (Burns et al., 1997; Stout et al., 2001b; Kimbrough and Dickhut, 2006). Given that multiple PAHs are available for interpretation, PCA is a statistical technique that explains the dispersion or variance in the data by calculating linear combinations of parameters (PAHs) as "principal components" (PC). The first PC (PC1) explains the greatest amount of variance in the data, with the second, third, fourth, etc. explaining sequentially lesser amounts of the variance. PCA results are illustrated on scatter plots that provide the distribution of PCA scores for samples against two different principal components (e.g. PC1 vs. PC2).

Where PCA is a statistical method for illustrating the variability in the PAH data, multivariate cluster analysis (MCA) is a statistical method used to classify samples based on their similarity to create groups of samples that have similar PAH distributions. MCA has been applied to PAHs and combustion materials in a variety of environments (Arditsoglou et al., 2004; Dreyer et al., 2005; Murakami et al., 2005; Morgan and Bull, 2006; Ribeiro et al., 2010). MCA results are presented on dendograms or branching diagrams that group samples together based on their similarities. By analogy, MCA techniques are used to identify "genetic families" of samples that have similar characteristic patterns of PAHs based on the relative distribution of PAHs within individual samples. MCA techniques are used in a variety of genetic, biological, medical research applications, and also have direct application to environmental chemistry and forensics. A full discussion of PCA and MCA techniques is beyond the scope of this report, however, Davis (2002) or Romesburg (2004) and the references cited above provide for a more complete treatment of these techniques.

Quantitative evaluation methods include evaluation of diagnostic ratios of specific PAHs (Douglas et al., 1996; Mitra et al., 1999; Yunkers et al., 2002; Yunkers and Macdonald, 2003; Countway et al., 2003; Costa et al., 2004; Costa and Sauer, 2005, Fernandes and Brooks, 2003; Stout et al., 2004; Stout and Emsbo-Mattingly, 2008). These diagnostic ratios have been empirically linked with either general source classifications (e.g. petrogenic or pyrogenic) or specific PAH sources (e.g. vehicle emissions, petroleum combustion, wood/coal combustion, creosote, coal tars, etc.). Diagnostic ratios are typically presented as cross-plots showing the variability of samples for two separate ratio pairs. Diagnostic ratio plots provide a perspective on

the relative consistency or variability of sample results within or between groups identified using PCA and MCA techniques.

Least-squares regression methods have been used to evaluate the PAH distributions between individual samples, samples and potential source materials, and mean group PAH distributions and source materials (Burns et al, 1997; Burns et al., 2006, Lee, 1999). Applications range from simple comparisons between two samples, to more complex mixing models where the relative contribution from multiple potential PAH sources is estimated to predict contributions in source apportionment studies. Least-squares regression involves comparing two data sets, where the pair-wise proportions of various PAHs represent the X and Y coordinates of the regression with X representing one sample for a given PAH and Y representing the second sample for the sample PAH. Hence, on the scatter plot, the various data points may represent the relative proportions of naphthalene for the two samples, or benzo(a)pyrene, and so on. Two parameters are considered in this type of regression analysis. The primary parameter is the Pearson product-moment correlation coefficient, **r**, which is a measure of the strength of the direct linear relationship between the two samples. The second parameter is the Coefficient of Determination, $\mathbf{R^2}$, which is a statistical estimate of the relative amount of variation in one sample that can be explained by the variation in the second sample. The Coefficient of Determination is calculated as the square of the correlation coefficient. The closer that **r** or $\mathbf{R^2}$ is to 1, the stronger the correlation between the two samples. The statistical significance of either **r** or $\mathbf{R^2}$ is determined from the p-value of the coefficient and the number of data points used in the regression.

3.2 Data Evaluation

A forensic evaluation following the methodologies detailed above has been conducted on soil samples from the Site and in the nearby area to characterize the distribution of PAHs and to identify patterns that may indicate potential sources of PAHs. The objective of this evaluation was to identify the similarities and differences between individual samples utilizing forensic methodologies from the published literature described above, and subsequently to identify the most likely types of PAH source materials that have similar characteristics to these samples.

It is our opinion that, to a reasonable degree of scientific certainty, the following conclusions can be drawn from the forensic PAH evaluation presented herein:

1) A large data set consisting of 341 samples was available for forensic evaluation, with 152 samples having a sufficient number of PAH compounds (10 or more) per sample to meet inclusion criteria for statistical analysis (See Section 3.3 for a summary of the inclusion criteria). Of these samples, 87 samples (57.2%) were from on the facility and 65 (42.8%) were from adjacent residential properties.

2) The methods used in the forensic evaluation were consistent with methods employed by multiple researchers as published in the peer-reviewed scientific literature, as previously cited. Methods included correlation analysis (least-squares), MCA, PCA, and diagnostic ratio analysis. Least-squares correlation analysis was also employed to compare results of the forensic evaluation against PAH profiles for known PAH source materials. Analysis was completed without regard to the source of the sample (i.e. on-Site or off-Site).

3) Six representative PAH profiles were identified using the MCA method. Group 1 includes 132 samples representing 86.8% of the data set. This group includes 63 of the 65 samples (96.9%) collected from the residential properties. Group 2 was broadly similar to Group 1, with a greater relative proportion of 6-ring PAHs. Group 3 was the most unique in comparison with the main body of data and included only two samples (1.3%). Both of these samples were collected on-Site, from depth, and were characterized by higher relative naphthalene proportions. The remaining three groups had PAH profiles that were intermediate between the dominant Group 1 PAH profile and the more naphthalene-rich Group 3 profile.

4) Diagnostic ratios were used to differentiate between PAH contributions from combustion related and petroleum related sources. This evaluation indicated that the vast majority of samples were derived from mixed combustion sources or wood/coal combustion sources. Where lighter PAHs are included in the ratio being evaluated, a small number of samples are shown to plot in areas designated as petroleum or petroleum combustion superimposed on the mixed or wood/coal combustion signal.

5) Based on least-squares regression analysis against PAH distributions from known sources, the majority of samples (Groups 1 and 2) were derived from materials similar to coal fines, cinders, urban dust or asphalt. Group 3 samples were similar to PAH profiles derived from diesel contaminated soils or low-naphthalene coal tars. Groups 4, 5 and 6 had PAH profiles that were consistent with mixtures of combustion-derived PAHs similar to Group 1 and PAH source

materials having a greater proportion of naphthalene such as waste oil or low-naphthalene coal tars.

6) The spatial distribution of samples (Figure 3-2) from the different PAH groups does show some degree of clustering where more than two samples are in a group. All samples from groups 3, 4, 5 and 6 are located on the industrial site. Group 1 is widely dispersed across the project area with samples occurring both on the industrial site and on residential properties. Group 2 is clustered with 3 of 4 samples located in fairly close proximity in the east central portion of the project area. Group 5 is primarily clustered in the east central portion of the industrial, whereas all of the Group 6 samples are situated along the northern margin of the industrial property near the former railroad tracks.

7) Based on the forensic evaluation conducted on this data set, we concluded that the majority of the samples for both the industrial site and residential properties are associated with combustion related PAH sources including coal, cinders and urban dust (i.e. background). Samples that may have some petroleum-derived constituents (e.g. greater naphthalene proportions) are all located on the industrial site and therefore, are determined to be source-related; these petroleum-derived constituents were not identified on any of the residential properties. Therefore, we concluded that PAH sources that are unique to the Site did not contribute to the PAH profiles at the off-Site residential properties in any detectable concentration. Although both the MKC facility and the off-Site residential soils contain PAHs attributable to urban background, the source-derived PAHs from petroleum constituents present on the MKC site are wholly absent from the off-Site residential samples.

3.3 Data Sources, Inclusion Criteria and Forensic Approach

The initial data set included 341 soil analyses of U.S. EPA Priority Pollutant PAH compounds (16 PAHs plus 1- and 2-methylnaphthalene) in total collected from both on- and off-Site. This sample set was differentiated into two groups, including surface samples (mean sample depth less than 1 foot below grade) and subsurface samples (mean sample depth greater than 1 foot). A total of 141 (41.3%) samples were from surface locations and 200 (58.7%) samples were from depth. A total of 213 of the 341 samples (62.5% of all samples) had one or more PAH detected.

Based on our experience and standard practice, an inclusion criterion was established for the forensic evaluation to ensure sufficient information content in the sample results

for statistical assessment. In order for samples to be included in the statistical assessment, a minimum of 10 of the 18 PAHs were required to have positive detections (i.e. results greater than the method detection limit, including J-flag estimated concentrations). A total of 152 samples (44.6% of all samples) met this inclusion criterion. Of these samples, 87 samples were collected from on-site locations (57.2%) and 65 samples were collected from adjacent residential properties (42.8%). Of the 152 samples meeting the inclusion criterion, 122 (80.3%) were surface samples and 30 (19.7%) were subsurface samples. The majority of the samples that did not have any PAHs detected (126 of 128 samples) were from subsurface locations. The relative distribution of samples meeting the inclusion criterion vs. having insufficient detections or no detections of PAHs is shown on Figure 3-3.

121 samples were collected off Site. Of these, 65 (53.7%) of the samples met the minimum number of 10 PAHs present. 35 (28.9%) of the off-Site samples had no PAHs present. Only 21 off-Site samples had some but less than 10 PAHs present. The samples that did not meet the inclusion criteria were further evaluated. None of these off-Site samples had increased levels of low molecular weight PAHs indicative of on-Site samples. Furthermore, samples with fewer than 10 PAHs detected tended to have significantly lower concentrations than those samples meeting the inclusion criteria, with consequently lower concentrations of benzo(a)pyrene(BaP) and other risk drivers. In total 98.3% of the samples from the residential properties either showed PAH assemblages that are characteristic general anthropogenic PAH sources (Group 1), had no PAHs detected, or when fewer than 10 PAHs were detected, had characteristics similar to the other residential samples.

The forensic evaluation followed a step-wise approach consistent with the scientifically accepted methodologies cited above. PAH profiles were calculated for each sample meeting the inclusion criterion, which served as the primary database. Correlation analysis was conducted by least-squares to evaluate the internal consistency of the data set. Statistical analyses were subsequently completed using MCA and PCA. MCA was utilized to identify PAH groups having similar distributions, and PCA was utilized for illustration purposes to show the relationships between these groups on a sample-specific basis. Diagnostic ratios were calculated to evaluate the general source characteristics in terms of combustion (pyrogenic) or petroleum-based (petrogenic) source associations. Finally, least-squares regression analysis was conducted to compare the MCA groups against several characteristic PAH source materials (Burns et al., 1997; Burns et al., 2006).

As an *a priori* element of the MCA statistical evaluation, it was decided to differentiate sample results into six MCA groups in order to identify the major types of PAH distributions. This approach is capable of identifying either individual samples that may be outliers or to identify unique groups within the data sets (Romesburg, 2004). As a cross-check, MCA was performed with more and fewer groups to determine whether or not different number of groups would provide improved resolution of the relevant PAH profiles in the data set. However, it was determined that six groups provided sufficient differentiation of the various PAH profiles. The initial statistical evaluation was conducted using a "single blind" approach, where the investigator did not have knowledge of the specific sample geographic locations. This approach minimizes potential bias in the statistical evaluation.

The six final MCA groups were subsequently compared to ten different PAH source materials that were obtained from the peer-reviewed literature or were developed from empirical measurements from known source materials (Bzdusek et al., 2004; Stout et al., 2003; Yunkers and Macdonald, 2003). Source materials included cutting oil, diesel fuel contaminated soils, National Institute of Standards and Technology (NIST) coal tar standard, coal tar, cinder fill, NIST urban dust, coal, waste oil, asphalt and coal tar pitch (Arditsoglou et al., 2004; Brown et al., 2006; Domeño and Nerin, 2003; Dominguez et al., 1996; Iwrin et al., 1997; Khalili et al., 1995; Li and Kaplan, 2008; Lima et al., 2005; Manoli et al., 2004; NIST, 1992; NIST, 2000; NIST, 2001; Riberio et al., 2010; Stout et al., 2003; Stout and Emsbo-Mattingly, 2008).

3.4 Fate and Transport

Potential fate and transport mechanisms have been evaluated for the PAH content of samples from the off-Site residential areas. Air deposition and overland flow with runoff are identified as the two possible mechanisms for transport of PAHs from the MKC facility to residential locations. Air deposition (from exhaust fans and any other air discharges) from the facility would be affected by the prevailing wind direction, if it is assumed that the site would be a source. Prevailing wind direction obtained from the Wisconsin State Climatology Office for the period 1948 to 2009 (http://www.aos.wisc.edu/~sco/clim-history/stations/msn/madwind.html) indicated that the dominant annual prevailing wind direction is from the south to the north at 12.4 miles per hour (mph), with winds during the December to March period having a prevailing component from the west-northwest (Figure 3-4). Based upon the 1994 topographic map, an evaluation of topography and possible overland surface runoff flow was performed (Figure 3-4). Based upon that evaluation, surface water movement would also be toward the north. Daily air and water flow could be in alternate

directions, but the evaluation clearly showed that the dominant anticipated affect from the Site, were it to be a source of PAHs to off-Site areas, would have been to the north and northeast.

It is our opinion that if the releases from the Site have impacted residential properties, then it would be reasonable to expect that samples collected from the residential properties on the northern portion of the sampling area would have PAH profiles that are similar to the more unique PAH profiles originating from the Site. It would also be expected that total PAH concentrations would be greater to the north as compared with other residential samples. A total of 21 samples having 10 or more PAHs were analyzed from this area. These samples include 102-1, 102-1-34, 102-2, 106-1, 106-2, 110-1, 110-1-34, 110-2, 110-2-34, 114-1, 118-1, 118-2, 126-1, 126-2, 128-1, 128-2, 130-1, 134-1, 134-2, 138-1, and 138-2. It is noted that all of these samples are associated with Group 1 PAH profiles, and none of the samples exhibit the characteristics of PAH profiles from the MKC facility containing the higher proportions of low molecular weight PAHs. In terms of the concentration of total PAHs in these samples, the geometric mean concentrations for this group of 21 samples is 1.23 milligrams per kilograms (mg/kg), which is slightly lower than the geometric mean concentration of 1.54 mg/kg for other Group 1 residential samples from south and west of this area. Furthermore, the geometric mean concentrations for samples from this area is lower than other Group 1 samples from the facility (3.83 mg/kg) and other non-Group 1 samples from the facility (4.86 mg/kg). Given that this area is both down wind and down flow from the facility, and that the PAH signatures for samples from these residential properties is not similar to the samples having profiles exclusive to the facility, we concluded that the residential properties have not been impacted by PAH releases that could be source-derived from the MKC facility.

In addition, the PAH particles present in any air emissions from any coal combustion processes at the MKC facility would have been emitted from stacks. In 1991, the heights of these stacks ranged from 68 to 78 feet above ground level (Kipp-Neighborhood Group Report, 1991). Based on experience and general knowledge of air dispersion principles and processes, the PAHs present in the hot exhaust gases (199 to 358 degrees Fahrenheit) (Kipp-Neighborhood Group Report, 1991) would rise vertically to a significant height from the stacks before dispersing with the winds (EPA, 2004). The particles from these stacks would travel a considerable horizontal distance before falling to the ground by dry and wet deposition processes (EPA, 2004). They would not deposit in the residential yards immediately adjacent to the facility. Instead, they would become part of the overall background levels such as those reported by the EPA National-Scale Air Toxics Assessment (EPA, 2012c).

3.5 Findings

Summary statistics for the number of detections and the relative detection frequency are provided in Table 3-2. This table differentiates between all samples available for analysis, and the samples included in the forensic evaluation. Four PAHs were detected in all samples used in the forensic evaluation, including fluoranthene (FLA), PYR, chrysene (CHR), and (BaP). PAHs having detection frequencies of approximately 80% or greater include benzo(b)fluoranthene (BbF 99.3%), benzo(a)anthracene (BaA 98.7%) phenanthrene (PHE, 98.7%), benzo(g,h,i)perylene (BPE 96.7%), indeno(1,2,3-c,d)pyrene (IP 95.4%) and dibenzo(a,h)anthracene (DBA 79.6%). PAHs that had the lowest detection frequencies included fluorene (FLU 59.9%), naphthalene (NAP 55.9%), acenaphthene (ACE 44.7%), acenaphthylene (ANY 32.9%), 1-methylnaphthalene (1mNAP 33.6%) and 2-methylnaphthalene (2mNAP 17.8%). It is noted that the forensic evaluation is based on the relationship between various PAHs within a given sample, and is not dependent on the total concentration of individual PAHs. Therefore, this discussion focuses on the relevant patterns of PAHs within individual samples and in PAH groups identified using statistical methods.

The MCA approach was able to successfully differentiate between multiple groups within the data set. PAH profile plots were constructed for each group identified by MCA representing the mean PAH proportion for each group. PCA plots were evaluated to visually inspect the distribution of individual samples within each MCA group as compared to the overall distribution of data points. The MCA dendogram for the PAH data set is provided on Figure 3-5, and the corresponding PAH profiles for each group are shown on Figure 3-6. PCA plot for PC1 vs. PC2 and PC1 vs. PC3 are shown on Figure 3-7. Figure 3-8 illustrates the relative loading of different PAHs on the PC1 vs. PC2 plots, which facilitates the interpretation of the relative sample-specific locations in the multiple PAH evaluation.

The following provides a descriptive summary of the six groups derived from the MCA modeling of the data set. PAH profiles are color coded to indicate the number of aromatic rings in the structures as follows: a) orange/yellow, 2-ring PAHs; b) green, 3-ring PAHs, c) blue, 4-ring PAHs; d) purple, 5-ring PAHs; and e) dark red, 6-ring PAHs.

Nearly all MCA cluster group profiles indicated that combustion related sources are the primary contributors to the PAHs in the samples. Diagnostic ratios indicate that the relative contribution from petrogenic (petroleum or coal) and pyrogenic (petroleum combustion, wood/coal combustion, creosote/coal tar) sources varies between the

different MCA groups, as shown on Figure 3-9. The MCA Groups presented below are ordered following in accordance with the specific group number derived from the Minitab analysis (MiniTab is one of several commercially available statistical software package that is commonly used for advanced statistical analysis, Minitab, 2010). The six forensic PAH profiles are described as follows:

Group 1 (n=132, 86.8% of samples); Predominantly composed of 4- and 5-ring PAHs that are consistent with combustion sources such as wood/coal combustion source contribution. This group includes all except for two of the residential samples. Samples cluster in a fairly confined region in the PCA diagrams. Of the Group 1 samples, 111 samples (84.1%) were from surface locations, 18 samples (13.6%) were from the 1 to 6 foot interval, and 3 samples (2.3%) were from 10 feet or more below grade.

Group 2 (n=4, 2.6% of samples); Predominantly composed of 5- and 6-ring PAHs with lower proportions of 4-ring PAHs than Group 1. This group also contains a low relative proportion of 2- and 3-ring PAHs that is slightly greater than Group 1. The PAH profile is consistent with combustion sources such as wood/coal combustion source contribution. This group includes the only two residential samples that are not in Group 1. Group 2 samples cluster in near Group 1 on the PCA diagrams, yet are pulled in the direction of 6-ring PAHs relative to Group 1. Two of the Group 2 samples were from surface locations and two were from the 2 to 4 feet below grade.

Group 3 (n=2, 1.3% of samples); Predominantly composed of 2-ring PAHs that are consistent with a petroleum source such as diesel, with less abundant 3- and 4-ring PAHs, and negligible 5- and 6-ring PAHs. This group is the most unique as compared to the main body of samples represented by Group 1, and is pulled in the direction of 2-ring PAHs relative to Group 1 on the PCA diagrams. Both samples in Group 3 were collected from on-Site sub-surface zones between 7 to 9.4 feet below grade.

Group 4 (n=2, 1.3% of samples); Predominantly 3- and 4-ring PAHs with modest contribution from 2-ring PAHs. The PAH distribution includes fairly low proportions of 5- and 6-ring PAHs. The PAH profile is consistent with a weathered petroleum source that includes a component of petroleum or wood/coal combustion. This group is also unique as compared to the main body of samples represented by Group 1, and is pulled in the direction of 2- and 3-ring PAHs relative to Group 1 on

the PCA diagrams. Both samples in Group 4 were collected from on-Site subsurface zones between 1 to 15 feet below grade.

Group 5 (n=8, 5.3% of samples); Predominantly 3- and 4-ring PAHs with modest contribution from 5-, 6-, and 2-ring PAHs. The PAH profile is consistent with a combustion related PAH source that may include a minor petroleum component. This group is situated between the main Group 1 samples and the Group 4 samples on the PCA diagrams. Six of the Group 5 samples were from on-Site surface locations with the two remaining samples being from 2 to 11 feet below grade.

Group 6 (n=4, 2.6% of samples); Predominantly 2-, 3- and 4-ring PAHs with modest contribution from 5- and 6-ring PAHs. The PAH profile is consistent with mixture of petroleum and combustion related PAH source. This group is situated between the main Group 1 samples and the Group 2 samples on the PCA diagrams. Three of the Group 6 samples were from on-Site surface locations and one sample was from the 2 to 4 feet below grade.

Diagnostic ratios were evaluated for all samples where both PAHs in a given ratio were detected in a sample. Five different ratios were evaluated including light PAH to heavy PAH ratio (LPAH:HPAH ratio of 2- and 3-ring PAHs to 4-, 5- and 6-ring PAHs), ANT:[ANT+PHE] (mass 178) ratio, FLA:[FLA+PYR] (mass 202) ratio, BaA:[BaA+CHR] (mass 228) ratio, and IP:[IP+BPE] (mass 278) ratio. Each of these ratios focuses on a different mass range for the PAHs depending on the ring structures. The LPAH:HPAH ratio provides an indication of the relative contribution of light PAHs that are indicative of petroleum or coal tar sources to heavy PAHs that are more indicative of combustion sources. The remaining diagnostic ratios are the relative proportion of one PAH to the sum of two PAHs of a given mass. These ratios are then compared to “cut points” that can be used to differentiate between PAH sources such as petroleum, petroleum combustion, mixed combustion sources and predominantly coal/wood combustion (Yunkers et al., 2002). The cut points have been presented in the peer-reviewed literature, and have been established on the basis of empirical observations from known sources and thermodynamic principles related to the stability of different PAHs at various formation temperatures. Diagnostic ratios are plotted either on single axis plots, or on cross-plots where two ratios are shown on a scatter diagram.

The LPHA:HPAH ratio plot clearly shows the differentiation between MCA Groups 1 and 2 from Groups 3, 4, 5 and 6. The former groups clearly overlap with fairly low ratios that are indicative of heavy PAHs being dominant in the PAH assemblage.

Group 3 has the highest ratios, which can be indicative of a naphthalene-based PAH source such as diesel or a high naphthalene coal tar. Groups 4, 5 and 6 have ratios that fall between those of Group 1 (combustion dominated) and Group 3 (naphthalene dominated), suggesting the influence of both PAH source types. Cross-plots for PAH proportions indicate that most samples fall in regions dominated by mixed combustion sources or wood/coal combustion sources. In general, there is a broad overlap of the different MCA groups, with Groups 1, 2, 4 and 5 consistently plotting in the same regions. Where lighter PAHs are included in the ratios, a small number of samples are shown to plot in areas designated as petroleum or petroleum combustion.

Regression analysis was conducted to identify potential correlations between the different MCA groups and between MCA Group 1 and Group 3 against selected PAH source materials. Input data for each MCA group was the mean proportion for each of the 18 PAHs for that group. When comparing the MCA groups to the PAH source materials, the two methylnaphthalene compounds were dropped because these compounds were not reported for the reference source materials and the PAH profile was re-normalized to the remaining 16 PAHs which were also available for the reference materials. Selected source materials used for comparison included cutting oil, waste oil, diesel contaminated soils, high-naphthalene coal tar (NIST reference material), low-naphthalene coal tar, coal tar pitch, asphalt, coal fines, cinder fill material and urban dust (NIST reference material), as cited previously. Least-squares regression was used to calculate the correlation coefficient, **r**, Coefficient of Determination, $\mathbf{R^2}$, and slope of the regression line. It is noted that it is important to consider both the correlation coefficient and the slope of the regression line when evaluating the linear relationship between two data sets. The correlation coefficient reflects the relative amount of scatter around the regression, whereas a slope of approximately 1 indicates similar overall trends in relative composition between the two profiles being compared (Davis, 2004).

In general, the different MCA groups showed some degree of correlation with each other, with the exception of Group 3, which was dominated by high naphthalene content. This suggests that there is an underlying common source for most PAH distributions except for Group 3. When comparing the $\mathbf{R^2}$ values for Group 1 vs. the remaining groups, it is determined that 38% to 68% of the variability in Groups 2, 5 and 6 can be explained by the PAH distribution in Group 1, whereas only 4% to 11% of the variability in Groups 3 and 4 can be explained by the PAH distribution in Group 1. In comparison, the $\mathbf{R^2}$ value for Group 3 comparisons indicates that very little of the variation in Groups 1 and 2 can be explained by (1% and 5%, respectively) the

variability in Group 3. However, the distribution of PAHs in Group 3 can explain 25% to 52% of the variability in Groups 4, 5 and 6.

In summary, Group 1 is the dominant type PAH mixture in the data set, representing 86.8% of the samples. Group 3 is the most unique group in comparison to Group 1, representing 1.3% of the samples. There are distinct similarities between Groups 1 and 2, which are not consistent with the other MCA groups. The remaining two groups show characteristics that may be a mixture of Group 1 and Group 3 type signatures.

Each MCA group was compared to the ten PAH source material profiles by least-squares regression. PAH profiles for reference source materials are shown on Figure 3-10. The regression plots are shown for Groups 1 and 3 as compared to selected PAH source materials on Figure 3-11. We conclude to a reasonable degree of scientific certainty that the regression evaluation for the various MCA groups shows the following:

1) Group 1 showed the strongest correlation with coal fines and cinder materials based on both $\mathbf{R^2}$ and slope values, with urban dust and asphalt also showing strong correlations. Group 1 did not show any correlation with cutting oil, waste oil, diesel contaminated soil, coal tar or coal tar pitch.

2) Group 2 showed the strongest correlation with asphalt, urban dust and coal tar pitch (a common precursor for asphalt used as a binder). This group did not show a significant relationship with any of the remaining PAH source materials.

3) Group 3 showed the strongest correlation with diesel contaminated soils and high-naphthalene coal tar, and also a strong correlation with waste oil and low-naphthalene coal tar. This group was not correlated with cutting oil, coal tar pitch, asphalt, coal, cinders or urban dust.

4) Group 4 showed the strongest correlation with low-naphthalene coal tar and had a strong correlation with waste oil. This group is not correlated with cutting oil, high naphthalene coal tar, diesel contaminated soil, coal tar pitch, coal, cinders, asphalt or urban dust.

5) Group 5 shows the strongest correlation with coal fines, low-naphthalene coal tar and cinders, with urban dust and asphalt also showing a fairly strong correlation. This group is not correlated with cutting oil, diesel contaminated soil, high naphthalene coal tar or coal tar pitch.

6) Group 6 shows the strongest correlation with coal fines and cinders, with urban dust and low-naphthalene coal tar also showing relatively strong correlation. This group is not correlated with cutting oil, waste oil, diesel contaminated soil, high-naphthalene coal tar or asphalt.

A final PCA run was conducted that included all samples and the ten PAH source materials. Figure 3-12 shows the relationships between sample values and these PAH source materials as plotted on PC1 and PC2. This figure clearly shows the similarity between the coal and cinder materials and the main body of Group 1 samples. Group 2 samples are pulled in the direction of urban dust and coal tar pitch, whereas Group 3 is pulled in the direction of diesel contaminated soils or high-naphthalene coal tar. Groups 4, 5 and 6 are generally pulled in the direction of waste oil.

It is noted that the least-squares regression and final PCA plot are intended to show the relative location of the various samples and PAH source materials in the context of complex chemical mixtures. It is clearly evident that the majority of the samples in the data set correspond with the PAH signature of coal, cinders, asphalt and urban dust. There are a few samples that are pulled in the direction of PAH source materials with higher naphthalene content, such as diesel fuel. The PAH source material that is least similar to any of the samples is cutting oil.

3.6 Conclusions

The following conclusions can be drawn from the forensic PAH evaluation presented above:

1) Statistical analysis of PAH distributions within individual samples clearly indicates that several PAH profiles are present in the data set.

2) The majority of samples meeting the inclusion criterion for the forensic evaluation cluster are in a single group (Group 1) and represent 86.8% of the data set, with the remaining samples being separated into five additional groups.

3) The remaining five groups are differentiated from the main Group 1 profile based on the relative proportion of light 2-ring PAHs or heavier 6-ring PAHs.

4) Nearly all residential samples are associated with the primary Group 1 type of PAH profile, with 63 of 65 residential samples being in this group. The remaining

two samples were associated with the group having a slightly heavier PAH assemblage.

5) When compared to representative PAH source materials, the PAH profiles for Group 1 samples are consistent with PAH assemblages derived from combustion related sources such as coal fines, cinders, urban dust and/or asphalt. The PAH profile for this group is not consistent with PAH sources from cutting oil, waste oil, diesel contaminated soils, coal tar or coal tar pitch.

6) The spatial distribution of Group 1 shows that these samples are evenly distributed among all locations without a strong preference for clustering in a given area.

7) Group 2 samples are similar to Group 1 with the exception of having a high relative proportion of 6-ring PAHs. The PAH profile for this group is also consistent with combustion related sources including asphalt, urban dust and coal tar pitch.

8) Groups 3, 4, 5 and 6, which contain samples collected exclusively from on-Site, have greater relative proportions of light 2- and 3 ring PAHs. Based on comparisons with PAH reference material profiles from known sources, these groups most likely are influenced by on-Site derived PAH sources with higher naphthalene proportions including diesel contaminated soils or waste oils superimposed on combustion related PAH sources.

4. Discussion of PAH Background Sources Related to the Site

Based on the results of the forensic analysis, we conclude that the sources of PAHs in the residential backyards are background sources. More specifically, we conclude that the PAH mixtures in the soils chemically match combustion sources. This section summarizes the investigation into specific PAH sources in Madison that are the likely sources of the PAHs in these residential soils.

4.1 Discussion of PAH Background Sources In East Madison, Wisconsin

A review of historical sources of PAH emissions into the air was undertaken to determine if there were a significant number of sources that might explain the presence of background PAHs measured in residential soils in the neighborhood surrounding the Site. The area around the Site has been heavily urbanized for decades and there are multiple background sources.

In fact, most of East Madison in the area of the Site is an area that was industrialized for the better part of a century. A 1931 map (University of Chicago, 2012) shows industrial zoning along both sides of Waubesa Street from Atwood Street up to La Follette Avenue, both sides of Corey Street and Ohio Street, from Atwood Street up to the railroad tracks, all along both sides of Atwood Street throughout East Madison, along both sides of Winnebago Street from First Street to Milwaukee Street, and throughout other areas of Madison. About one-half of the land area in East Madison was zoned for commercial or industrial use in 1931(University of Chicago, 2012).

Madison had many coal fired power plants over the decades that emitted PAHs into the atmosphere. For instance, the Capitol Heat and Power Plant operated for over a century in downtown Madison (Wisconsin State Journal. 2010a). It ceased burning coal in 2010. The University of Wisconsin at Madison also operated a coal fired power plant since the mid 1950's in downtown Madison (Wisconsin State Journal. 2010b). This plant used coal and used tires as fuel. Both fuels cause the emission of PAHs from stacks. A large coal fired power plant also has operated since 1975 in nearby Dekorra, Wisconsin, supplying power to Madison (Madison Gas and Electric, 2012a). Also, Madison is the home to the Blount Generating Station, which burned coal from 1902 to 2011 (Madison Gas and Electric, 2012b). From 1979 to 1993, this Madison Power Plant also burned refuse-derived fuel. The Blount Generating Station is two miles southeast of the Site. Although the current and historic power plants were several miles from the Site location, they have been a significant source of PAH deposition onto nearby residential soils because emissions from power plant smoke stacks can

travel several miles before they deposit by dry and wet deposition processes (EPA, 2004).

According to EPA (1985), the Madison Gas Light and Coke Company operated manufactured gas plant sites in Madison from 1898 to 1950 producing $1{,}012x10^{12}$ cubic feet of gas per year at its peak in 1950. Manufactured gas plant sites made gas from coal in a manner similar to a coke oven, emitting PAHs in the process. These PAHs were emitted from stacks that were elevated, and the emissions dispersed widely in the local environment before depositing onto soils (EPA, 2004).

There were also several industrial facilities in East Madison very near the Site (EDR, 2012). The Theo Kupfer Iron Works, 149 Waubesa Street, 350 feet from the Site, operated an iron foundry from 1940 to 1985 (Goodman Community Center, undated). Prior to the iron works, the American Shredder Company operated from 1903 to 1906 (Goodman Community Center, undated). In 1906, the Steinle Turret Lathe Machine Company occupied the building until 1934. In 1990, the Durline Scale Company occupied the building until 2001 (Goodman Community Center, undated). Madison Brass Works at 214 Waubesa Street (100 feet from the Site) was a foundry that produced brass, bronze, aluminum, nickel and white metal castings (EDR, 2012). Berntsen Brass and Aluminum Foundry at 2334 Pennsylvania Avenue was established in 1946 and is 1 mile to the east of Site (EDR, 2012). Theo Kupfer Iron Works, Madison Brass Works, and Berntsen Brass and Aluminum Foundry all had smoke stacks that emitted PAHs into the atmosphere for many decades while in operation.

Consolidated Paving, Inc. operated at 2318 Atwood Avenue, 0.4 miles from the Site making asphalt paving mixtures and blocks (EDR, 2012). Four Lakes Paving was located at 3030 Gateway Place, 0.6 miles from the Site (EDR, 2012). Clark Refining and Marketing was located at 2801 Atwood Street, also less than a mile from the Site (EDR, 2012). Rayovac Corporation at 2317 Winnebago Street manufactured batteries about 0.5 miles from the Site (EDR, 2012). Asphalt paving manufacturers and oil terminals all emitted PAHs over the years within a mile of the MKC facility (ATSDR, 1995).

Releases of PAHs into the air near the Site have been reported by EPA. EPA's Toxic Release Inventory (EPA, 2012) reports that 9,605 pounds of PAHs were released to the environment from 2000 to 2011. Of this, 400 pounds were released to the air. The major PAH emitters in Dane County were the ExxonMobil Terminal about 6 miles to the south of the Site (EPA, 2012b). Madison Gas & Electric's Blount Generating Station was another major emitter, located 2 miles to the southwest of the Site (EPA, 2012b).

Also emitting PAHs were Safety-Kleen Systems 4 miles to the southeast and Flint Hills Resources Pine Bend terminal 6 miles to the south east (EPA, 2012b). MKC is not listed on EPA's Toxic Release Inventory as an emitter of PAHs (EPA, 2012b).

PAHs have also been released to the air for decades from residential properties all over Madison, Wisconsin, including the residences abutting MKC. According to the U.S. Census (2012), 63% of homes in Wisconsin in 1940 were heated by coal or coke and 27% were heated by wood. In 1950, 49% were heated by coal or coke and 12% were heated by wood. Statistics for the years prior to 1940 were not listed in the U.S. Census report, but it is common knowledge that wood and coal were the main fuels used for home heating prior to 1940 throughout the United States.

Bottom ash from coal and coke burning is not classified as a hazardous waste at the present time, and it was certainly not handled or disposed in any special way in the early half of the twentieth century. Much of the bottom ash from home heating was disposed on the residential property itself. In many northern locations, coal and coke ash was routinely used for ice and snow control on roadways (EPRI, 1998). EPA (2012a) states that 30% of coal bottom ash is used for snow and ice control and other miscellaneous applications even today. Thus, it is likely that bottom ash from home heating systems were one source of PAHs in soils in the residential lots.

Other sources of PAHs in soils in East Madison are combustion emissions from the transportation sector. The Chicago, Milwaukee, St. Paul and Pacific Railroad and the Chicago and North Western Railroad lines both run very close to the MKC facility. The former started operation in 1847 and the latter in 1859 (American-Rails, 2012). Railroad spurs entered the MKC property itself. In addition, the 1931 map (University of Wisconsin, 2012) shows that major roadways present in East Madison today were present as early at 1931, if not earlier. Major roadways near the Site that have been present for decades include Washington Street, Atwood Avenue, Milwaukee Street, Winnebago Street, and others. It is our opinion that vehicle emissions from millions of cars and trucks that have traveled the East Madison roadways for a century contribute to the PAH levels in residential soils throughout East Madison.

Backyard trash burning is also a source of PAHs in East Madison soils. According to the Wisconsin Division of Public Health (2001), backyard trash burning was historically quite common: "Before scientists learned about the dangers of burning trash, it was commonly burned at homes and landfills." According to WDNR (2003), "open burning and backyard dumping is a significant problem in Wisconsin and is difficult to enforce." Also, "Open Burning is the number one source of citizen complaints to the DNR Bureau

of Air Management." PAHs are emitted from the open burning of trash (Great Lakes Binational Toxics Strategy, 2004).

In conclusion, soils throughout Madison, Wisconsin and the residential neighborhood around the Site contain urban background levels of PAHs from many sources, as they do in all cities in America. For East Madison soils, the sources of PAHs include over a hundred years of deposition from coal fired power plants, home and commercial heating systems, railroads, motor vehicles, iron and brass foundries, asphalt production plants, backyard burning, and miscellaneous industries with industrial boilers. These numerous sources of PAH emissions into ambient air explain the low levels of PAHs in the residential soils, as discussed in the next section.

4.2 Comparison of PAH Background Levels In Different Urban Settings

The levels of PAHs in the residential soils at properties abutting the Site are very low and, in fact, are lower than the typical levels seen in other urban settings (see Table 4.1). Thus, the PAHs at the residential properties are entirely consistent with background levels and background sources. Specifically, the 95th Upper Confidence Limit on the mean of total PAH levels and benzo(a)pyrene-toxic equivalent levels [B(a)P-TE] whether calculated using all surface data or by using data that was averaged by property and then averaged over all properties, are all about ten times *less* than the typical urban background levels reported in several comprehensive PAH background sampling efforts (see Table 4.1). In addition, the highest property average was also about ten times *less* than typical urban background levels (see Table 4.1).

Urban background studies in other areas of the United States have focused on urban areas with long histories of industry, power generation and vehicle traffic. The fact that the residential samples near the MKC Site are so much lower than the urban background samples collected elsewhere unquestionably demonstrates that the PAHs in the residential soils have ubiquitous urban background sources from widespread atmospheric deposition rather than a specific, nearby source-derived contributor.

Table 4.1. Comparison of Residential PAH Levels and Typical Urban Background Levels

Citation	95th UCL Total PAH (ppm)[1]	95th UCL B(a)P-TE [2] (ppm)
Madison, Wisconsin		
Residential Properties, 63 samples	2.2	0.3

Table 4.1. Comparison of Residential PAH Levels and Typical Urban Background Levels

Citation	95th UCL Total PAH (ppm)[1]	95th UCL B(a)P-TE [2] (ppm)
Residential Properties, 32 yards	1.4	0.2
Worst Case Residential Property	3.6	0.4
Published Urban Background Studies		
Magee, et al. (1994) New England	24.8	3.3
MADEP (2002) Massachusetts	24.5	3.0
IEPA (2007) Chicago	14.2	1.9
IEPA (2007) Metro Areas	24.8	3.1
USGS (2003) Chicago	133.2	19.1
EPRI (2003) Western New York	30.5	4.3
EPRI (2008) Urban Soil	23.2	3.4

[1]ppm = parts per million (mg/kg)

[2] B(a)P-TE, benzo(a)pyrene toxic equivalents (EPA, 1993)

4.3 Quantitative Estimation of Residential PAH Background Concentrations in Dane County, Wisconsin

There is additional strong evidence to support our conclusion that the PAHs in the residential soils at the properties abutting the Site are present due to the deposition of PAHs from the air from background sources near and far. EPA performed its National-Scale Air Toxics Assessment (NATA) in 1996, 1999, 2002 and 2005 (EPA, 2012c). Total PAH average ambient air concentrations were estimated by EPA for Dane County, Wisconsin. As noted in Table 4.2, the estimated air concentrations vary from 0.016 micrograms per cubic meter (µg/m^3) in 2002 and 2005 in Dane County to 0.049 µg/m^3 in Dane County in 1996.

Table 4.2. Estimated Total PAH Background Ambient Air Concentrations (µg/m^3) that Deposit onto Dane County Soils

Year	Dane County
1996	0.049
1999	0.024
2002	0.016
2005	0.016

PAHs are present in air as fine particulate material which settles to the ground by gravity (dry deposition) and by rainfall (wet deposition.) Dry deposition can be estimated using a standard EPA equation:

Dry deposition flux (µg/m^2/s) = Concentration (µg/m^3) X Deposition velocity (m/s)

(µg/m^2/s) = micrograms per square meter per second

(µg/m^3) = micrograms per cubic meter

(m/s) = meters per second

A regulatory default deposition velocity (SCAQMD, 2011) is 0.02 m/s. Estimated background soil deposition rates can be calculated from the background air concentrations and the default deposition velocity. This will underestimate total background deposition, because it estimates dry deposition only and ignores wet deposition. Soil concentrations can then be estimated using the EPA guidance document for estimating soil concentrations from emissions of particulate matter from combustors. According to EPA (2005), particulate matter that is deposited onto soil will become incorporated into the top 2 centimeters (cm) of the soil. The estimated background soil concentrations after 30 and 100 years of deposition are shown in Tables 4.3 and 4.4.

Table 4.3. Estimated Total PAH Ambient Background Soil Concentration Assuming 30 Years of Deposition (µg/g, ppm)

Year	Dane County
1996	31
1999	15
2002	10
2005	10

Table 4.4. Estimated Total PAH Ambient Background Soil Concentration Assuming 100 Years of Deposition (µg/g, ppm)

Year	Dane County
1996	103
1999	50
2002	34
2005	34

As demonstrated by the tables above, it is our opinion to a reasonable degree of scientific certainty that background levels of PAHs in the ambient air throughout Madison, Wisconsin, can entirely explain the surface soil PAH levels observed in the residential yards near the Site, which are summarized in Table 4.1. The 95th Upper Confidence Limit on the mean total PAH concentration in the surface soil of residential yards is 2.2 ppm, and the worst case residential property had a total PAH concentration of 3.6 ppm (see Table 4.1). Estimated soil concentrations based on background ambient air concentrations of total PAHs range from 10 to 103 ppm depending on the data set year used and the number of years of deposition assumed (see Tables 4.3 and 4.4).

It is likely that these soil concentrations are underestimates, because emissions of particulate matter have declined significantly over the twentieth century. In earlier decades, there were more coal fired power plants, more homes heated with coal, coke, and wood, more vehicle emissions, and more industrial emissions of all sorts. Accordingly, the total PAH levels in the air were undoubtedly much higher from 1900 to 1996 than they were in and after 1996 when EPA initiated the NATA program.

The PAHs that deposited onto residential soil on these properties abutting the Site from 1908 onward in time would have become incorporated into the surface soil as modeled using the EPA (2005) method. According to the Sanborn Map from 1908 (EDR, 2012), most of these properties were vacant lots in 1908, with several homes present. By 1942 almost all of the lots had houses on them. Thus, none of these lots were covered by paving or large buildings. They were all open lots. Thus, the EPA (2005) approach to estimating deposition in soils is scientifically reasonable.

Over the course of the 30 to100 years, some of the deposited PAHs could have been incorporated by physical mixing into the soil column to a depth deeper than EPA's default assumption of 2 cm. If so, then the estimated soil concentrations from background PAHs in the air could have been diluted by 5 to10 fold compared to the estimates shown in Tables 4.3 and 4.4. Even so, the estimated soil concentrations are still equal to or higher than the measured surface soil concentrations in these residential yards.

The estimated total PAH concentrations are not for any specific location in Dane County, Wisconsin. Instead, the estimates are based on EPA's average total PAH concentrations in the air throughout all of Dane County. Thus, it is expected from EPA's NATA dataset that the total PAH concentration in residential soil at any location in Dane County would be at least 10 ppm and could be higher. This is not surprising because the typical measured urban background PAH concentrations published in several comprehensive studies varies from 14 ppm to 133 ppm as shown in Table 4.1.

4.4 Summary of Historical Sources of PAH Emissions in the Area of the MKC Facility

Several lines of investigation have been presented to determine if the concentrations of PAHs in residential soils near the Site are unusually high compared to the expected levels in any urban area with a history of multiple sources of PAH emissions into the ambient air or whether they are typical of urban background sources. All lines of inquiry conclude that the PAH concentrations are neither elevated nor unexpected. The measured concentrations are entirely consistent and are, in fact, *lower* than expected for urbanized areas with a history of commercial and industrial development based on the sources cited above. The results are also consistent with the soil concentrations that would be predicted from the aerial deposition from the average PAH concentrations in air reported by EPA in its NATA Assessments for Dane County, Wisconsin. Further historical research identified many sources of PAH emissions to ambient air that, collectively, explain the presence of PAHs in soils at residential

properties adjacent to the MKC facility. Similar levels are predicted for all of East Madison and Dane County. PAH emission sources include, but are not limited to:

- Capitol Heat and Power Plant
- University of Wisconsin at Madison Power Plant
- Blount Generating Station
- Madison Gas Light and Coke Company Manufactured Gas Plants
- Theo Kupfer Iron Works
- Madison Brass Works
- Berntsen Brass and Aluminum Foundry
- Consolidated Paving, Inc.
- Four Lakes Paving
- Clark Refining and Marketing
- Rayovac Corporation
- ExxonMobil Terminal
- Safety-Kleen Systems
- Flint Hills Resources Pine Bend terminal
- Residential wood, coal and coke burning for heating and cooking
- Wood, coal and coke bottom ash disposal
- Chicago, Milwaukee, St. Paul and Pacific Railroad
- Chicago and North Western Railroad

- Motor vehicle emissions
- Backyard burning.

5. Review of Expert Report of Dr. Lorne Everett

The expert report of Dr. Lorne Everett has been reviewed for insights into the alleged sources, fate and transport of the PAHs at the Site. The review comments are provided below and listed in the order found in the expert report, starting with the page number where they can be located:

Page 12 - Contamination also spreads into surficial soil by windblown dust, exhaust fallout and by sediment transport during rain and flooding events. The PAH, PCB and metal contamination spreads away from the Madison-Kipp property primarily by these methods. The PAHs, PCBs and metals now being found in neighbors' soil has migrated from the highly contaminated soil on Madison-Kipp property and/or has been discharged directly from Madison-Kipp's vents and stacks and contaminated particulate matter subsequently settled out of the air onto the neighbors' yards.

There are no facts or figures referenced in this statement and no data analysis was performed.

Page 20 - Mr. Schmoller succinctly summarized this interpretation: "If you just look at the distribution of PCE all around the site, it makes sense that -- and you look at it in conjunction with the PCB data and the on-site PAH data, I think the three of those together give a pretty clear picture that whatever fluids were spread for dust suppressant in the northeast or southwest, had those components" (Schmoller Deposition, 2012, p. 283).

This quote is Mr. Schmoller's opinion. We are aware of no independent analysis of the PAH data performed by the WDNR.

Page 21 - ***Madison-Kipp is a source of PAH's on Madison-Kipp and surrounding Class Area Properties*** *PAHs are present in fuel oil and petroleum combustion products. The location of the former above ground fuel oil storage tank (AST) was identified in the northern most part of the building and noted in Exhibit 2. Madison-Kipp used fuel oil for heating and released PAH's through its smoke stacks and vents. WDNR agrees with my interpretation that Madison-Kipp is the source of PAH's found in the environment on and around the facility: PAHs have been identified in many soil samples (both onsite and offsite) often at levels that exceed the Wisconsin PAH cleanup criteria. Mr. Schmoller indicates that in his opinion both the VOC's and the PAHs are coming from Madison-Kipp (Schmoller Deposition, 2012, p.100).*

MKC did use fuel oil and other petroleum based products at their facility Section 3.5, (Figure 3-11). Section 3.5 reviews the types of PAHs that would be associated with the products used at the facility. Our analysis of the off-site data (Section 3.5) shows that the PAHs found off-Site are not related to petroleum products used at the MKC facility.

Page 43 - There can be no dispute that the industrial chemicals used and released at Madison-Kipp such as PCE, PCBs, and PAHs are hazardous wastes, within the meaning of RCRA. Madison-Kipp engaged in the handling, storage, transportation and disposal of this hazardous waste. 9 U.S. EPA, October 20, 1997, Memorandum, Subject: Transmittal of Guidance on the Use of Section 7003 of RCRA. The contaminants PCE, PCBs and PAHs - - emanating from Madison-Kipp's property - - have been found throughout the Class Area (and beyond) in soil, soil gas, subslab vapor and, for some homes, in the indoor air. PCE from Madison-Kipp likewise contaminates the shallow groundwater just 20 or so feet below these homes, and the deeper groundwater aquifer below that. In short, toxic chemicals from Madison-Kipp contaminate, or threaten to contaminate, virtually every dimension of the surrounding neighborhood, including the Class Area.

There is no evidence that the PAHs were a hazardous waste generated or stored on the site. PAHs were a minor portion of petroleum products used at the Site. The data analysis in this report shows that the PAHs that were part of these petroleum products were not the source of PAHs at the adjoining residential properties. (Section 3.5)

Page 53 - The on-site soil investigation for PAHs needs to be expanded in the southern parking lots (impacts resulting from oil spreading for dust suppression and also from PAHs likely emitted from Madison-Kipp's exhaust fans and stacks). In my opinion, this phase of the on-site investigation will require approximately 50 sample locations with samples collected from at least two depths at each location: one surface sample in the upper 6 inches of soil and one sample at a depth of 1 to 2 feet.

The 50 sample locations suggested here seem to be based upon a random number. Dr. Everett does not explain how he arrived at this number, his rationale or his methodology. He presented no statistical analysis to predict how many samples would be needed for a statistically significant sample size. He did not present a surface analysis to determine the amount of open land available in the area that he wanted to sample. He did not present an analysis of the data from the 341 PAH samples that have already been collected as we have done here.

Page 55 - As of September 2012, PAHs have been found at every off-site property sampled (see Exhibit 7). Madison-Kipp almost certainly released PAHs to the environment. Petroleum-based lubricants used on die-cast molds are partly combusted each time molten metal is injected into a mold. PAHs are formed during this combustion process and would have been vented to the atmosphere. Madison-Kipp's current consultant, ARCADIS, has recommended that cleanup in the neighborhood not be driven by the widespread PAH contamination because the PAHs can originate from numerous sources (including backyard grilling), not just Madison-Kipp. If one wanted to identify the source of the PAHs, there are well known forensic techniques such as hydrocarbon fingerprinting which could have provided insight into the source of the PAHs. It has been known for at least 50 years that benzo(a)pyrene is a potent chemical carcinogen. This is one of the PAHs identified in the soil at neighboring properties. Since PAHs are a substantial human health risk, it is unacceptable that ARCADIS would find elevated PAHs everywhere it looked, yet try to trivialize the issue by suggesting the PAHs are the result of back yard grilling activity or otherwise blaming the neighbors. Clearly further forensic inquiry was required in this situation before ARCADIS could reach such a conclusion, especially in the light of compelling evidence showing that Madison-Kipp is the source of the PAHs. For example, ARCADIS could have looked at the Madison-Kipp oil and gas purchases on a year-round basis to determine if the PAHs released from the stacks and vents at Madison-Kipp were cyclic. The PAHs were identified nearly everywhere they were sampled and the distribution of PAHs can be attributed to emissions from Madison-Kipp's die cast operations and spreading of hydraulic fluids containing the PAHs, PCE and PCBs on the gravel topped parking lots towards the north central part of the facility and the (yet to be characterized) old parking lot in the southwest part of the facility (bearing in mind however that the southwest part of the facility parking lot has been partially covered over by a building). I personally walked along the very narrow walkway between the Madison-Kipp facility and homes at 269-233 East Waubesa Street. While standing behind the home at 233 E. Waubesa Street, I took photos of large exhaust fans at Madison-Kipp (see Photo 22) which clearly showed they were dripping with petroleum residues. I further looked at the concentrations of PAHs in the backyards of the homes immediately adjacent to these exhaust fans. The highest concentrations of PAHs are located in the yards directly adjacent to the exhaust fans, strongly suggesting that emissions from the fans were a source of the PAHs. ARCADIS, as an advocate for Madison-Kipp, is trying to avoid addressing the PAH problem, which would reduce the cost of further investigation and remediation. After completion of the off-site soil testing program referenced earlier in this report, all residential yards with PAH above WDNR's action level, should be excavated to remove the impacted soil and replaced with clean backfill.

Once again Dr. Everett mentions the use of forensic techniques to determine the origin of PAHs at the Site but fails to apply those techniques in this expert report as we have done here. Section 3.5 of this report applies those techniques to show that the PAHs found in the surrounding properties did not originate from MKC.

Dr. Everett states that benzo(a)pyrene is a major contributor to the human health risk and a significant reason for addressing the PAHs at this Site. Our analysis shows that benzo(a)pyrene was not part of the PAHs found in products used at the manufacturing facility (Section 3.5). Our analysis also showed that benzo(a)pyrene was more prevalent off-Site than it was on-Site (Section 3). Further, this compound was part of the background concentrations found at the Site and not related to the activities at the MKC facility (Sections 3 and 4)

Finally, Dr. Everett states that he witnessed the exhaust fans "*dripping with petroleum residues",* however produced no data that showed what was in the condensate allegedly coming from the fans. Since he does not even state that he found a petroleum odor associated with these fans, we do not understand the basis of this opinion. He then goes on to say that the concentrations found in the yards closest to these fans had the highest concentrations of PAHs. This is not true. The highest concentrations at the site were found at samples B-56(0-2), B-54(0-2), B-21(0-2), B-55(0-2), B-22(0-2), and B-19(0-2), and these samples are on opposite sides of the building (three on the east side and three on the west side of the building). This clearly shows that there is no correlation between the location of exhaust fans and the highest concentrations of PAHs found in the adjacent residential properties.

Page 59 - Shallower on-site soils are more likely to be impacted with multiple contaminants. This is because both PCBs and PAHs have an affinity to strongly sorb to soil grains and organics in soil, thus are generally restricted to surficial soil 17 and usually do not leach deeply into the soil profile. For this reason, I believe excavation and off-site disposal at a licensed treatment or disposal facility is the most appropriate approach for on-site shallow soil. For off-site shallow soil, excavation is the appropriate remediation technique because accomplishing cleanup rapidly should be a high priority for contaminated soil in residential yards where the risk of dermal contact and incidental ingestion are so great.

We agree with the statement that we would only expect to find PAHs in the shallow soil due to strong adsorption to the soil particles. This report shows that the PAHs in the backyard are associated with background sources of PAHs and that removing them by excavation is, therefore, not supportable and would be inconsistent with regulatory precedent.

6. Expert Summary of Findings

It is our opinion to a reasonable degree of scientific certainty that the PAHs found at the residential properties surrounding the MKC facility are part of the normal background concentrations of PAHs found in Madison, Wisconsin and other urban areas in the United States. It is also our opinion to a reasonable degree of scientific certainty that the sources of PAHs found at the residential properties surrounding the Site are not from MKC. We developed these opinions based upon a thorough review of the regulations, published papers and peer reviewed scientific literature, and the execution of a statistical evaluation of the data from the Site. We specifically found that:

- Several states, including Wisconsin, accept the reality of PAH background concentrations
- U.S. EPA accepts the reality of PAH background concentrations
- Forensic analysis showed that the off-Site PAHs were background – MKC was not the source of off-Site PAHs
- Forensic analysis showed that the PAHs on Site had a higher contribution from the lower molecular weight PAHs found in petroleum hydrocarbons. These mixtures were not found off Site showing that MKC was not the source of off-Site PAHs
- Group 1 showed the strongest correlation with coal fines and cinder materials based on both $\mathbf{R^2}$ and slope values, with urban dust and asphalt also showing strong correlations. Group 1 did not show any correlation with cutting oil, waste oil, or diesel contaminated soil
- Fate and transport analysis showed that the PAHs from the Site would have been deposited North and Northeast of the Site. Data from that specific geographic sample set showed that the PAHs were at background concentrations and that MKC was not the source of off-Site PAHs.
- U.S. EPA and local data specified several sources of PAHs in the area around MKC – MKC was not listed as a PAH source by U.S. EPA

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potwmetl&fld=m71&fld=m72&fld=m73&fld=m79&fld=m90&fld=m94&fld=m99&fld=RELLBY&fld=on

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ARCADIS

Tables

ARCADIS

Table 3-1 Chemical Names and Abbreviations

Abbreviation	Chemical Name	CAS No.	Rings
NAP	Naphthalene	91-20-3	2
1mNAP	1-Methylnaphthalene	90-12-0	2
2mNAP	2-Methylnaphthalene	91-57-6	2
ANY	Acenaphthylene	208-96-8	3
ACE	Acenapthene	83-32-9	3
FLU	Fluorene	86-73-7	3
ANT	Anthracene	120-12-7	3
PHE	Phenanthrene	85-01-8	3
FLA	Fluoranthene	206-44-0	4
PYR	Pyrene	129-00-0	4
BaA	Benzo(a)anthracene	56-55-3	4
CHR	Chrysene	218-01-9	4
BbF	Benzo(b)fluoranthene	205-99-2	5
BkF	Benzo(k)fluoranthene	207-08-9	5
BaP	Benzo(a)pyrene	50-32-8	5
DBA	Dibenzo(a.h)anthracene	53-73-3	5
IP	Indeno(1,2,3-c,d)pyrene	53-70-3	6
BPE	Benzo(g,h,I)perylene	191-24-2	6

ARCADIS

Table 3-2 PAH Detection Frequency

PAH Designation	Detections in Full Data Set (n=341)	Detection Frequency in Full Data Set (%)	Detections in Forensic Data Set (n=341)	Detection Frequency in Forensic Data Set (%)
NAP	96	28.2%	85	55.9%
1mNAP	58	17.0%	51	33.6%
2mNAP	28	8.2%	27	17.8%
ANY	52	15.2%	50	32.9%
ACE	68	19.9%	68	44.7%
FLU	94	27.6%	91	59.9%
ANT	128	37.5%	124	81.6%
PHE	166	48.7%	150	98.7%
FLA	183	53.7%	152	100.0%
PYR	180	52.8%	152	100.0%
BaA	178	52.2%	150	98.7%
CHR	179	52.5%	152	100.0%
BbF	186	54.5%	151	99.3%
BkF	157	46.0%	148	97.4%
BaP	190	55.7%	152	100.0%
DBA	122	35.8%	121	79.6%
IP	151	44.3%	145	95.4%
BPE	161	47.2%	147	96.7%

% Percent

PAH abbreviations are provided in Table 3.1

ARCADIS

Figures

LEGEND

PARCELS

BUILDING FOOTPRINTS

0 100 200

Feet

NOTES:
1. AERIAL IMAGERY OBTAINED FROM BING IMAGERY SERVICE THROUGH ESRI ONLINE MAPPING, ACCESSED 1/11/13

MADISON-KIPP
201 WAUBESA STREET
MADISON, WI

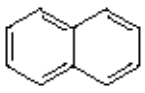
SITE LAYOUT

ARCADIS

FIGURE 1-1

CITY: MPLS DIV/GROUP: IM DB: MG LD: CK
MADISON-KIPP
Path: G:\GIS\Projects\Madison_Kipp\ArcMap\Site_Layout_20130111.mxd

2-Ring PAHs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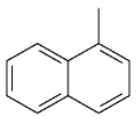
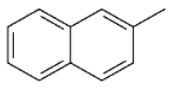
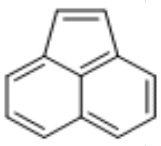
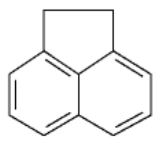
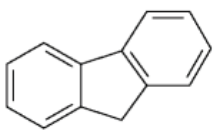

1-Methylnaphthalene 90-12-0

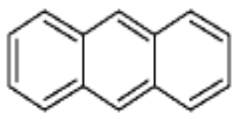

2-Methylnaphthalene 91-57-6

3-Ring PAHs


Acenaphthalene 208-96-8


Acenapthene 83-32-9


Fluorene 86-73-7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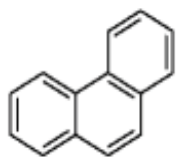
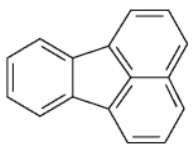
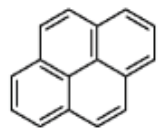
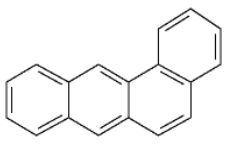

Phenanthrene 85-01-8

4-Ring PAHs


Fluoranthene 206-44-0


Pyrene 129-00-0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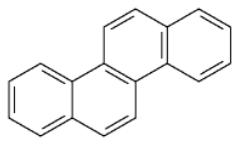
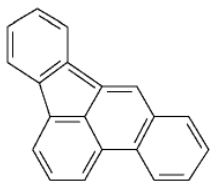

Chrysene 218-01-9

5-Ring PAHs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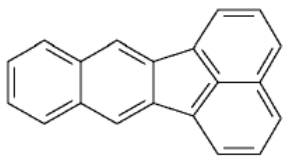
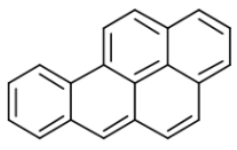
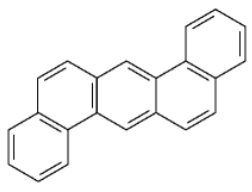
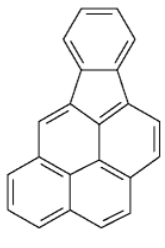

Benzo(k)fluoranthene 207-08-9


Benzo(a)pyrene 50-32-8


Dibenzo(a,h)anthracene 53-73-3

6-Ring PAHs


Indeno(1,2,3-c,d)pyrene 53-70-3


Benzo(g,h,I)perylene 191-24-2

LEGEND

PAHs	Polynuclear Aromatic Hydrocarbons
53-70-3	Chemical Abstract Service (CAS) Number

MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

SUMMARY DIAGRAM OF PAH STRUCTURES

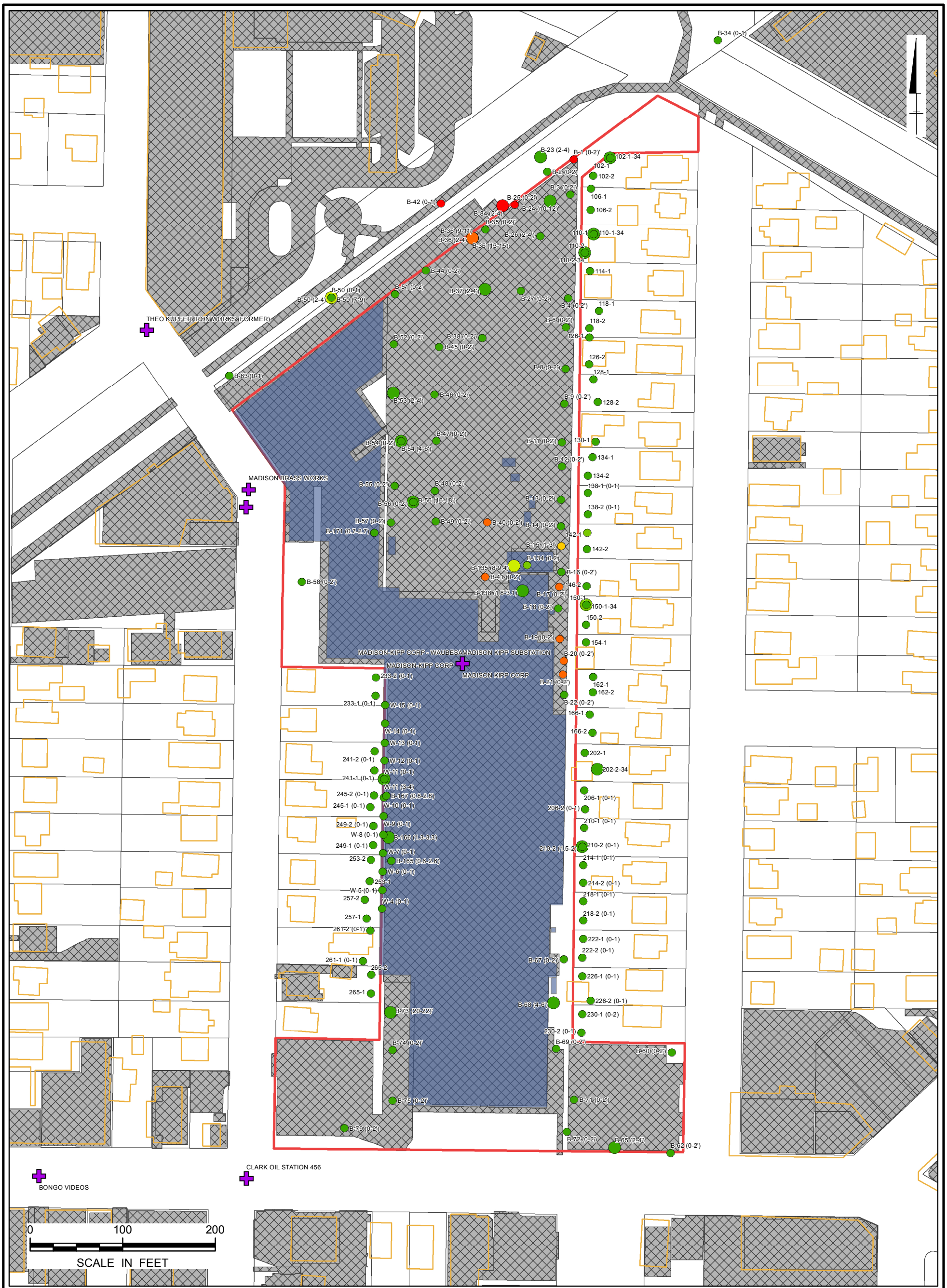
ARCADIS

FIGURE
3-1

17JAN13\ENVIRONMENT\CK\LMB
MADISONKPPWI001283\GRAPHICS\FIGURE 1 PAH STRUCTURES.AI

PROJECT: MADISON KIPP

CITY:(CLEVELAND) DIV/GROUP:(ENV/GIS) DB:L.GREENE LD: PIC: PM: TM:



LEGEND

SURFACE SAMPLE LOCATIONS
- GROUP 1
- GROUP 2
- GROUP 3
- GROUP 4
- GROUP 5
- GROUP 6

SUBSURFACE SAMPLE LOCATIONS
- GROUP 1
- GROUP 2
- GROUP 3
- GROUP 4
- GROUP 5
- GROUP 6

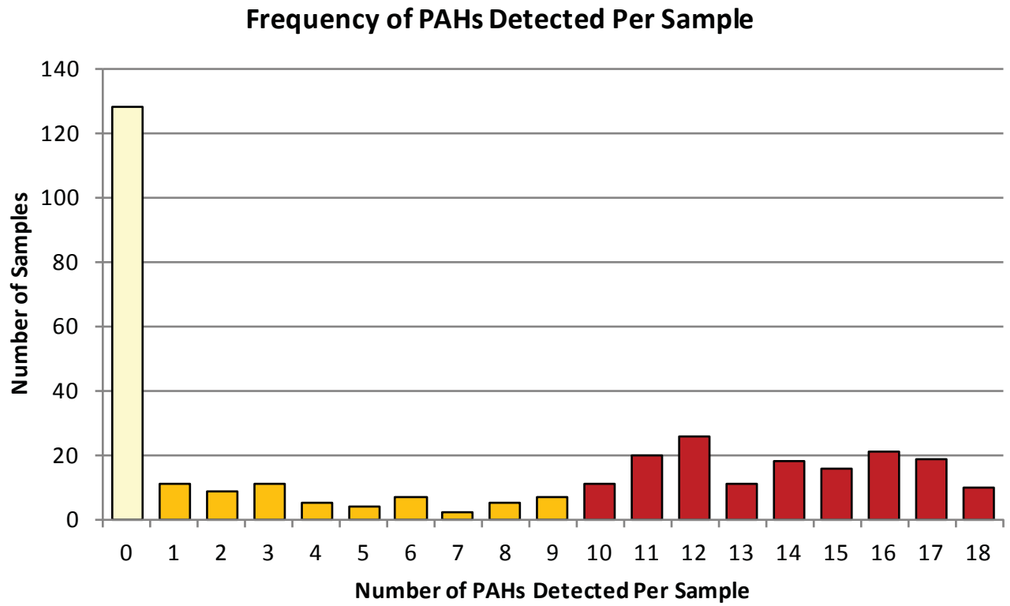
- SITES OF INTEREST (EDR 1 MILE SEARCH)
- SITE STRUCTURES
- OFFSITE BUILDING FOOT PRINTS
- PROPERTY BOUNDARY
- PARCEL BOUNDARIES
- IMPERVIOUS FEATURES IN IMMEDIATE AREA (5.9 ACRES)
- IMPERVIOUS AREAS

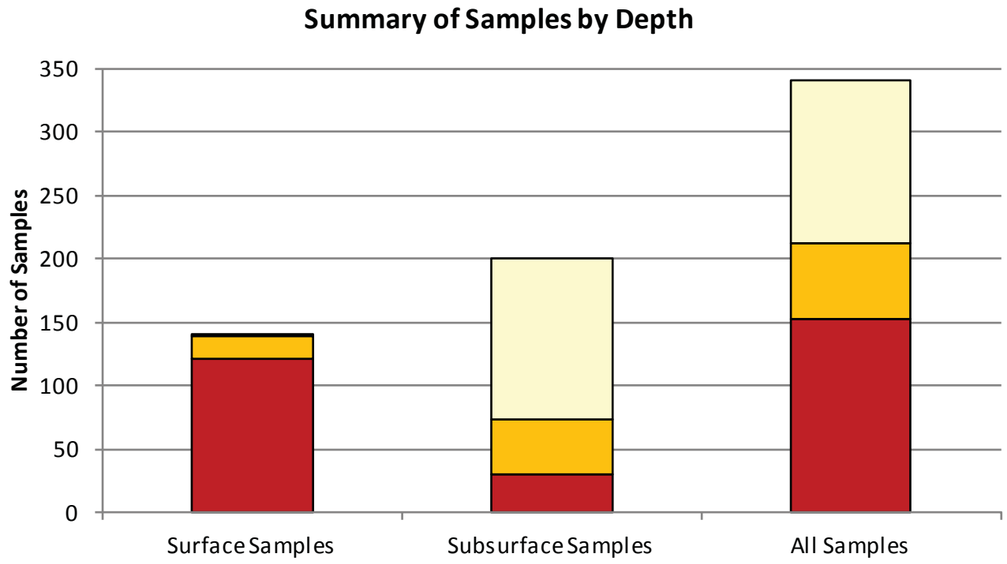
MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

SAMPLE GROUPS

ARCADIS

FIGURE
3-2





10 or more PAHs detected 1 to 9 PAHs detected PAHs not detected

LEGEND

Surface Sample - mean sample depth less than 1 foot below grade.

Subsurface Sample - mean sample depth greater than 1 foot below grade.

PAHs - Polynuclear Aromatic Hydrocarbons.

MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

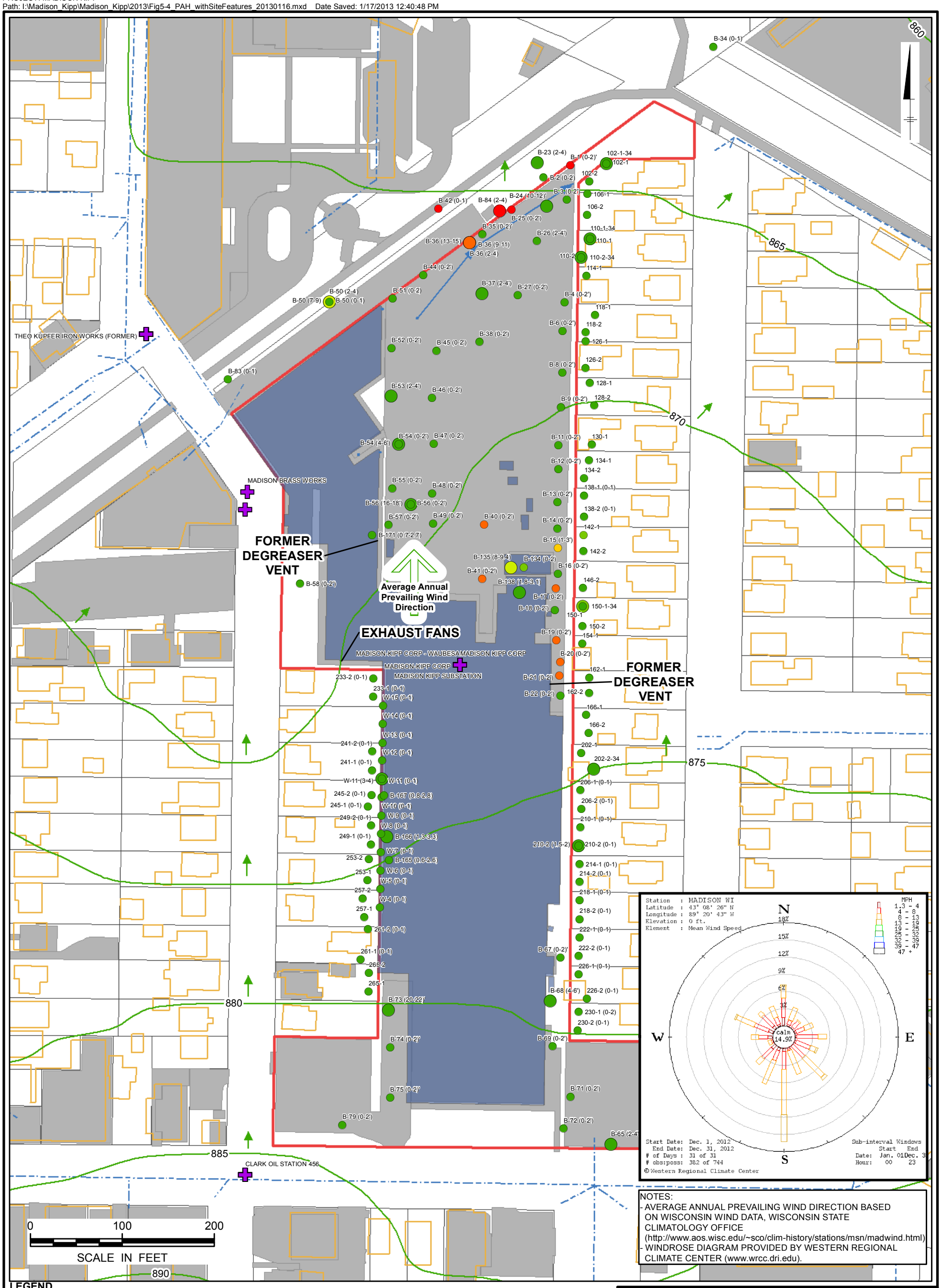
SUMMARY OF DATA SET BY INCLUSION CRITERIA AND DEPTH ZONE

ARCADIS

FIGURE
3-3

17JAN13\ENVIRONMENT\CK\LMB
MADISONKPP\WI001283\GRAPHICS\FIGURE 2 SUMMARY OR DATA SET.AI

CITY:(CLEVELAND) DIV/GROUP:(ENV/GIS) DB:L.GREENE LD: PIC: PM: TM:
PROJECT: MADISON KIPP
Path: I:\Madison_Kipp\Madison_Kipp\2013\Fig5-4_PAH_withSiteFeatures_20130116.mxd Date Saved: 1/17/2013 12:40:48 PM



NOTES:
- AVERAGE ANNUAL PREVAILING WIND DIRECTION BASED ON WISCONSIN WIND DATA, WISCONSIN STATE CLIMATOLOGY OFFICE (http://www.aos.wisc.edu/~sco/clim-history/stations/msn/madwind.html)
- WINDROSE DIAGRAM PROVIDED BY WESTERN REGIONAL CLIMATE CENTER (www.wrcc.dri.edu).

LEGEND

SURFACE SAMPLE LOCATIONS
- GROUP 1
- GROUP 2
- GROUP 3
- GROUP 4
- GROUP 5
- GROUP 6

SUBSURFACE SAMPLE LOCATIONS
- GROUP 1
- GROUP 2
- GROUP 3
- GROUP 4
- GROUP 5
- GROUP 6

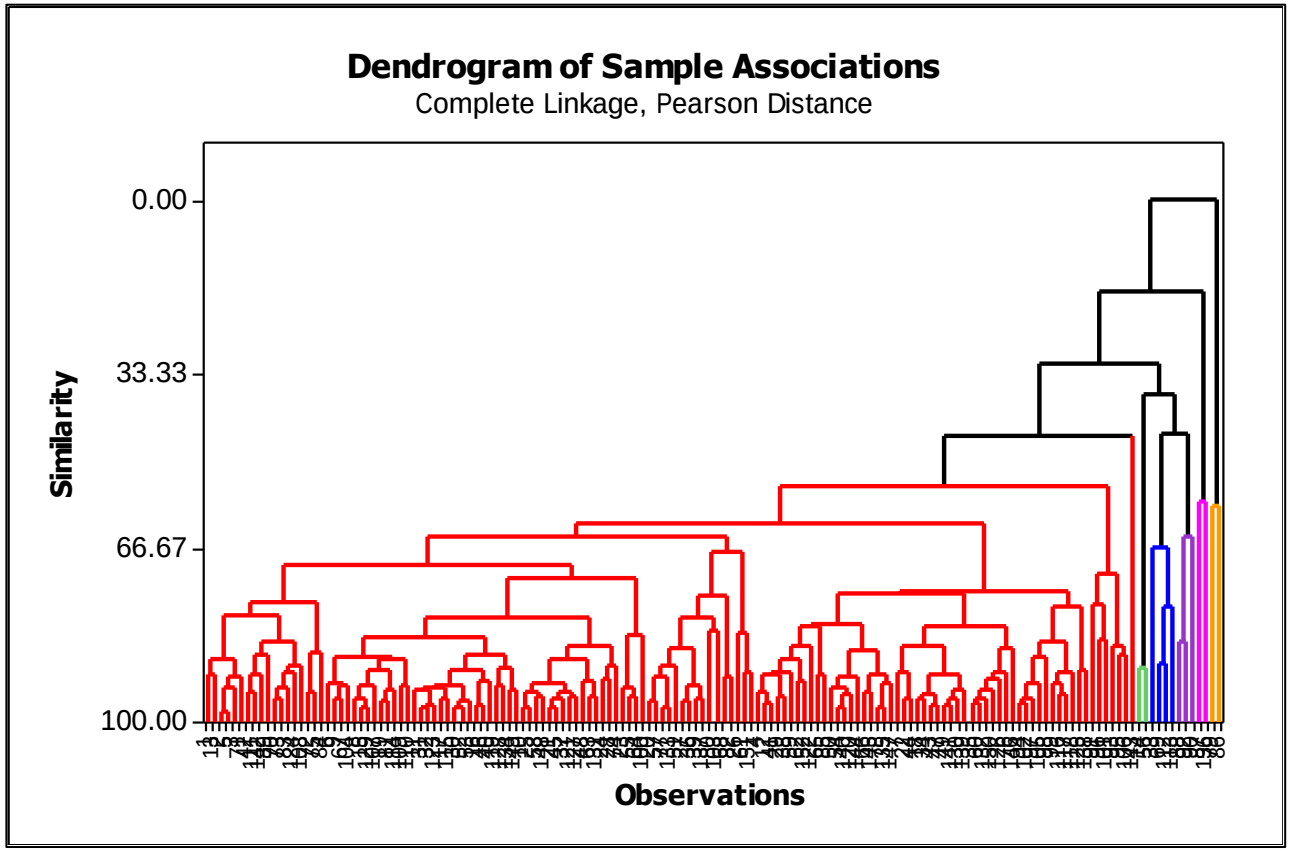
- SITES OF INTEREST (EDR 1 MILE SEARCH)
- PARTICLE TRACKING
- TOPOGRAPHIC CONTOURS (5FT INTERVAL)
- STORMWATER PIPES
- ONSITE STORM WATER DISCHARGE
- SITE STRUCTURES
- OFFSITE BUILDING FOOT PRINTS
- IMPERVIOUS AREAS
- IMPERVIOUS FEATURES IN IMMEDIATE AREA
- PARCEL BOUNDARIES

MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

SITE TRANSPORT

ARCADIS

FIGURE
3-4



The various colors of the lines indicate the six different cluster groups identified by the analysis. Each vertical line represents an individual sample or subsequent group of related samples. The height of the horizontal connecting lines indicates the relative degree of similarity between groups of samples. Sample identification numbers are linked to statistical software used for the forensic evaluation.

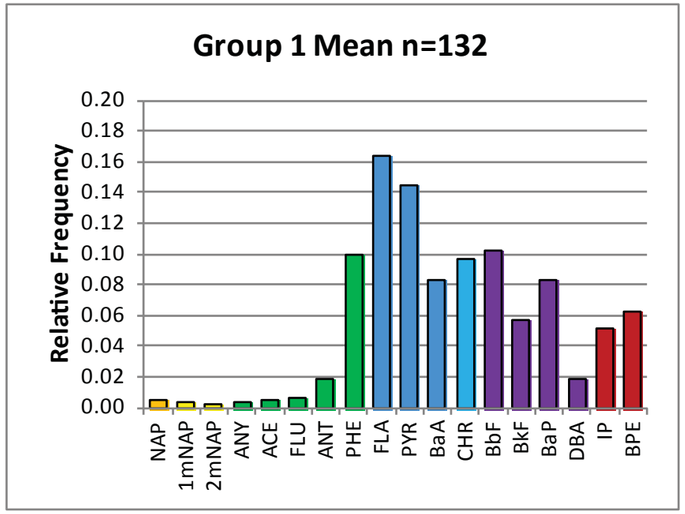
MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

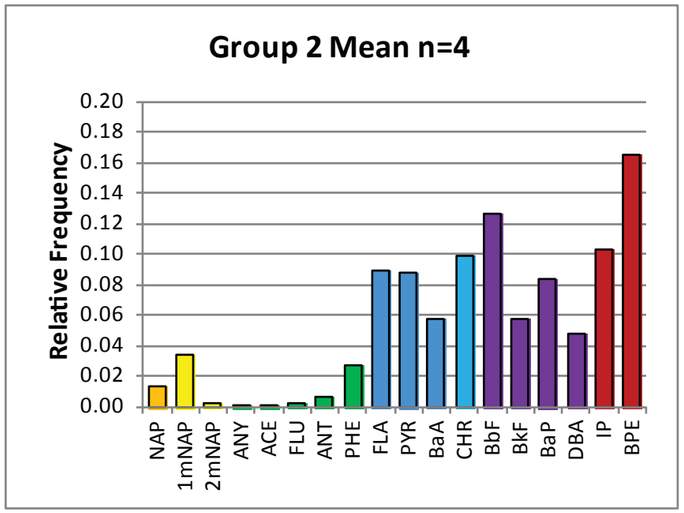
SUMMARY DENDOGRAM OF MULTIVARIATE CLUSTER ANALYSIS RESULTS

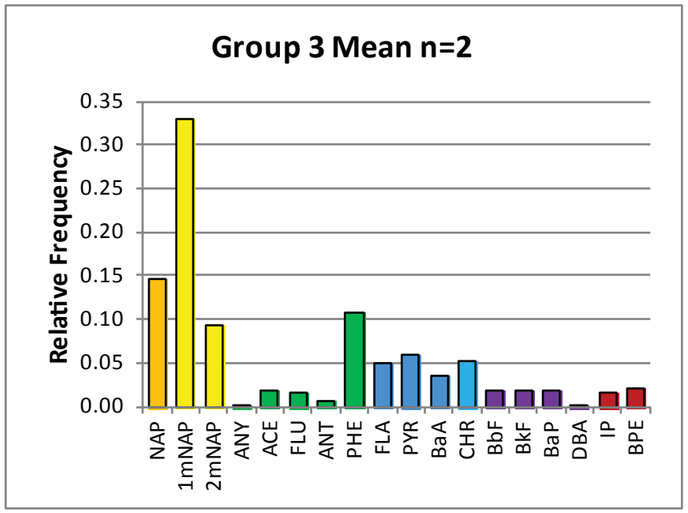
ARCADIS

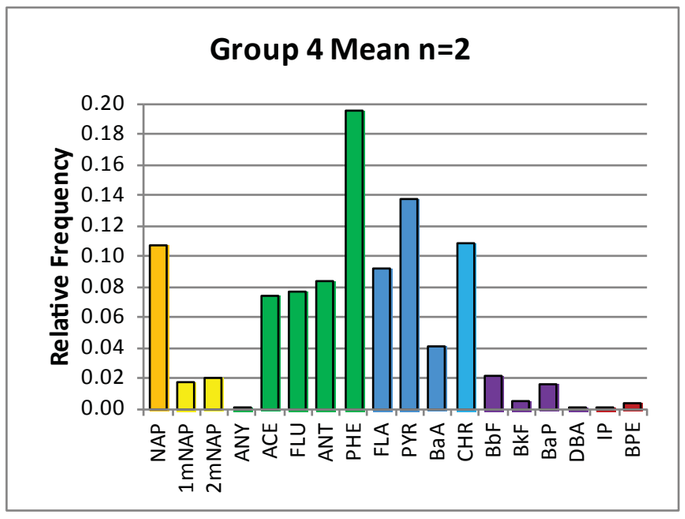
FIGURE
3-5

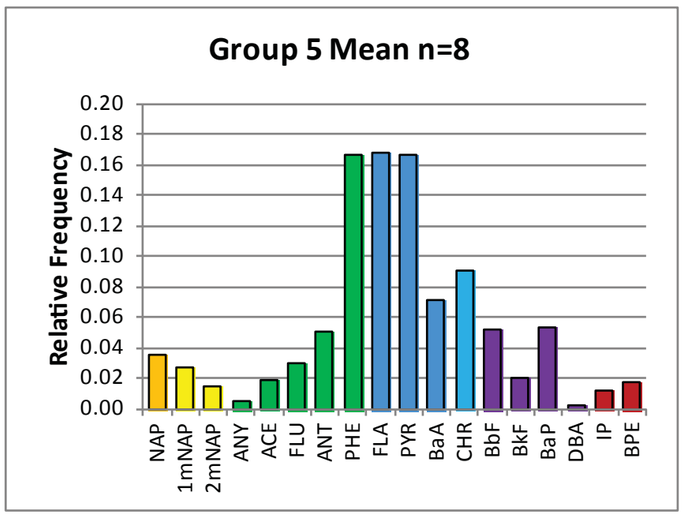
17JAN13\ENVIRONMENT\TSL\MB
MADISONKPP\WI001283\GRAPHICS\FIGURE 3 SUMMARY DENDOGRAM.AI

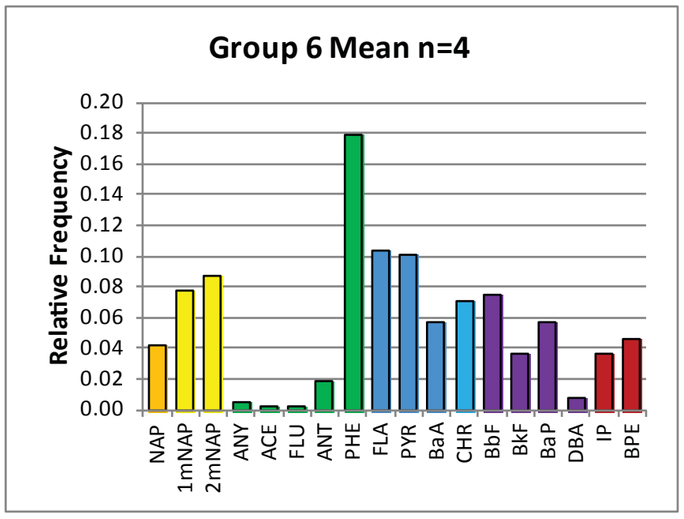












The vertical bars of each profile indicate the relative proportion of each individual PAH in the different group. Colors represent 2-ring (orange and yellow), 3-ring (green), 4-ring (blue), 5-ring (purple) and 6-ring (dark red) PAHs. Abbreviations for PAHs are described in the text. The number of samples in each cluster group is indicated.

MADISON KIPP CORPORATION
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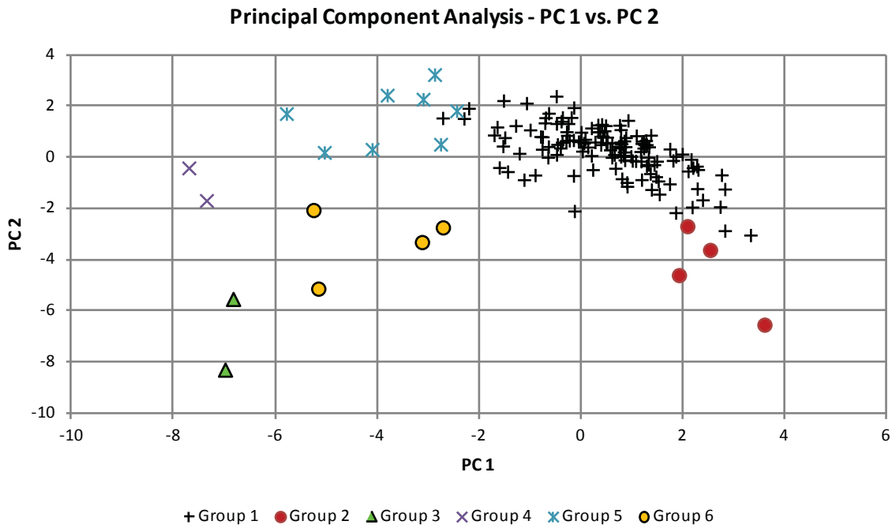
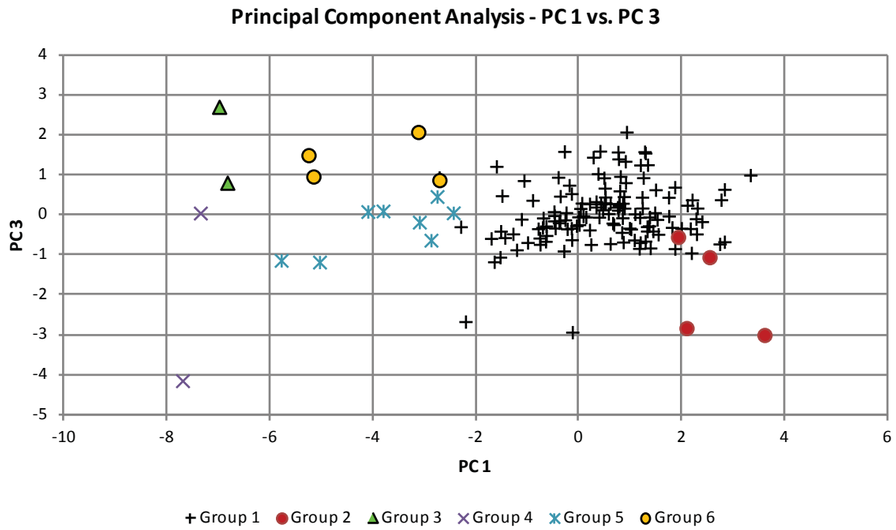
PAH PROFILES FOR MEAN PAH PROPORTIONS IN EACH MULTIVARIATE CLUSTER GROUP

ARCADIS

FIGURE
3-6

17JAN13\ENVIRONMENT\CK\LMB
MADISONKPPW\001283\GRAPHICS\FIGURE 4 PAH PROFILES.AI





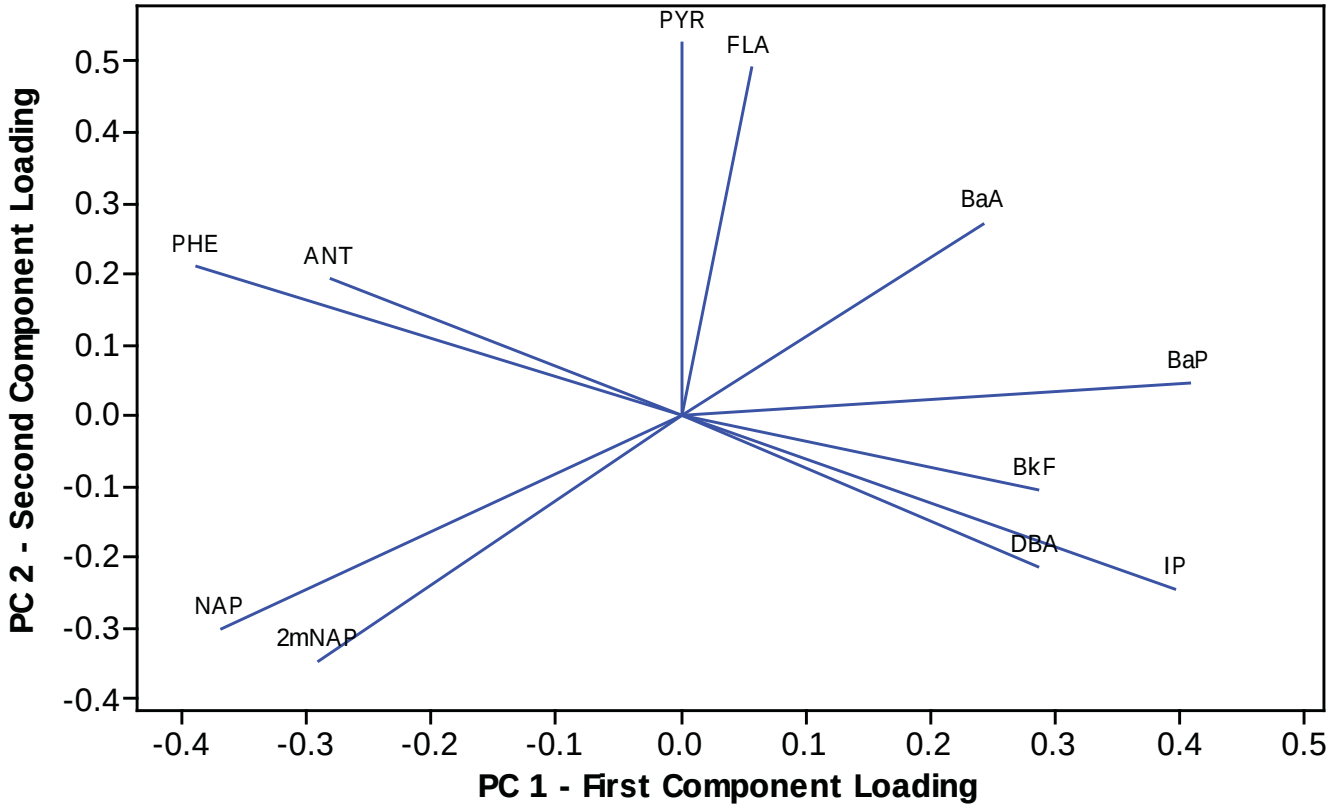
17JAN13\ENVIRONMENT\CK\LMB
MADISONKPPWI001283\GRAPHICS\FIGURE PRINCIPAL COMPONENT ANALYSIS.AI

MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

PRINCIPAL COMPONENT ANALYSIS

ARCADIS

FIGURE
3-7



MADISON KIPP CORPORATION
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MADISON, WISCONSIN

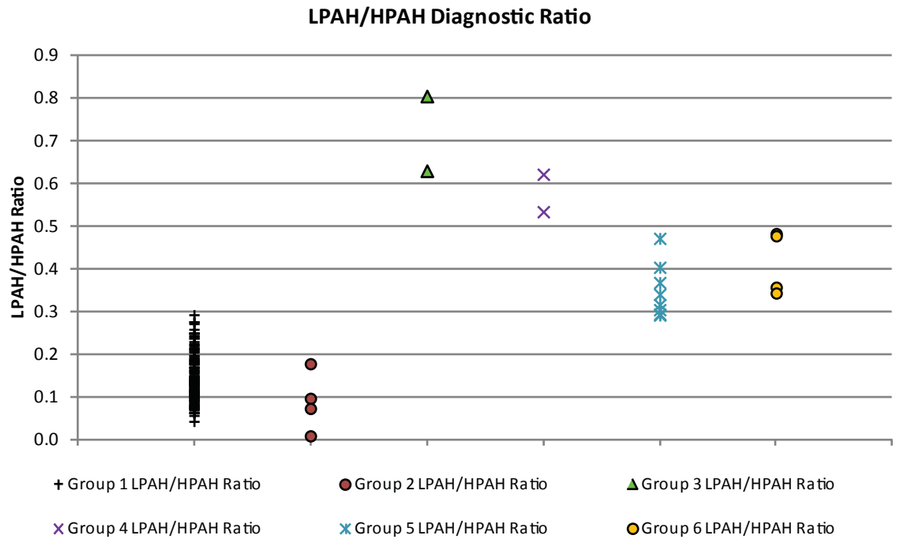
LOADING FACTORS FOR PRINCIPAL COMPONENT ANALYSIS PC1 VS PC2

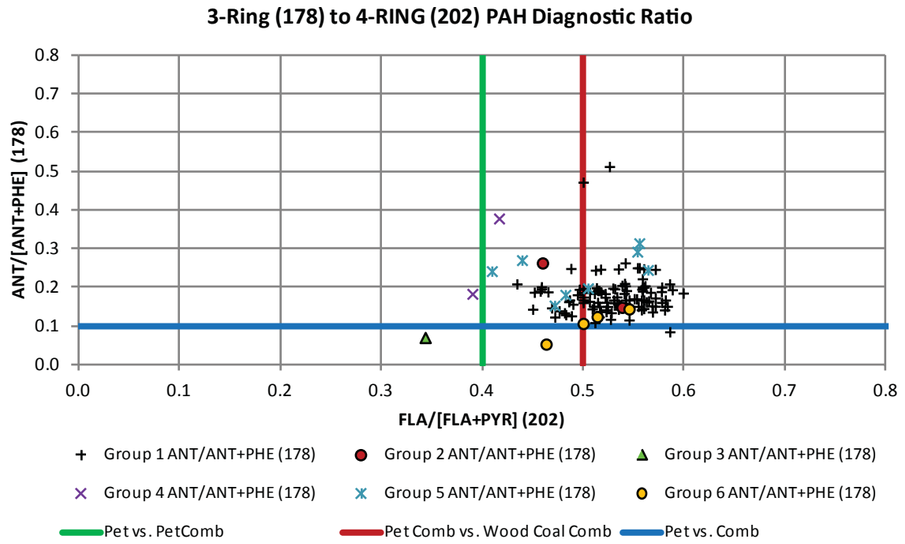
ARCADIS

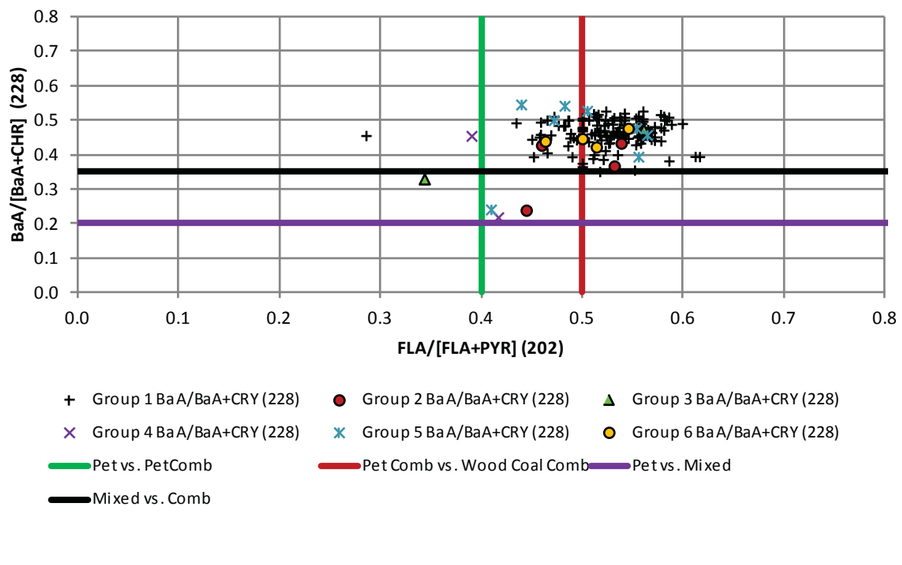
FIGURE
3-8

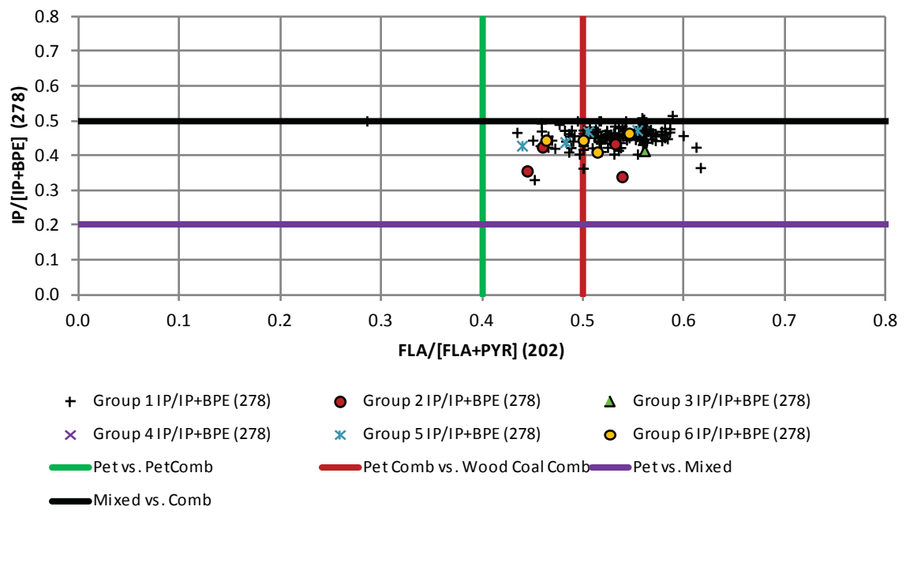
Abbreviations for PAHs are described in the text

17JAN13\ENVIRONMENT\CK\LMB
MADISONKPP\WI001283\GRAPHICS\FIGURE 6 PCA WEIGHTING FACTORS.AI









LEGEND

PAH	Polynuclear Aromatic Hydrocarbons
LPAH	Light PAH
HPAH	Heavy PAH
Pet	Petroleum
Pet Comb	Petroleum Combustion
Wood Coal Comb	Wood Coal Combustion
Mixed	Pet Comb and Wood Coal Comb

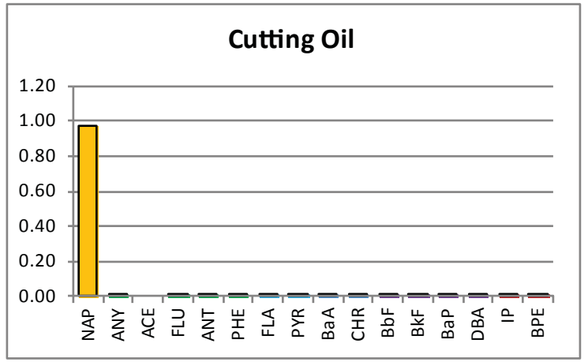
MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

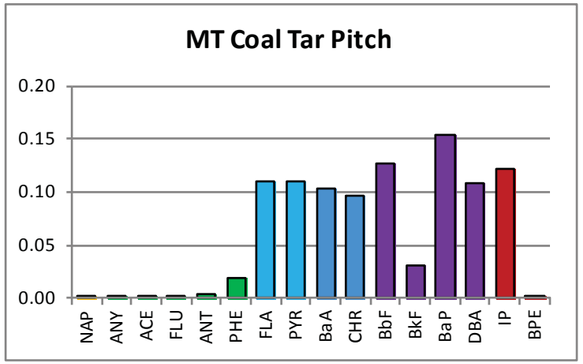
DIAGNOSTIC RATIOS

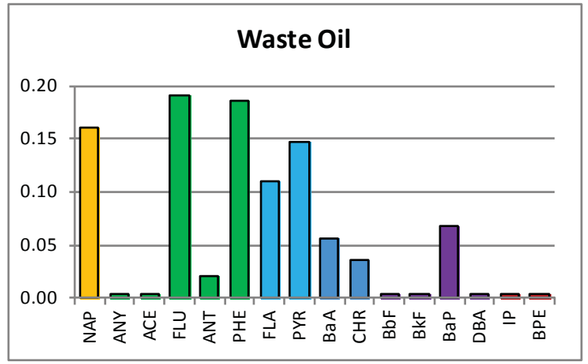
ARCADIS

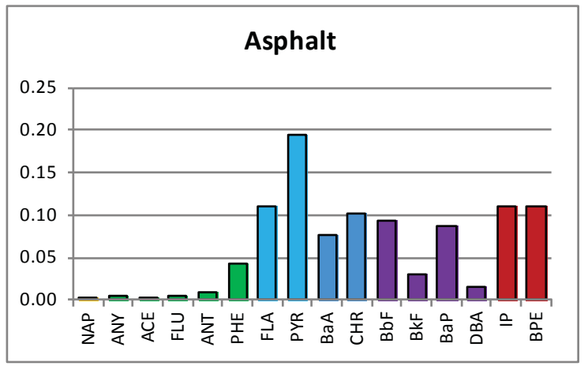
FIGURE
3-9

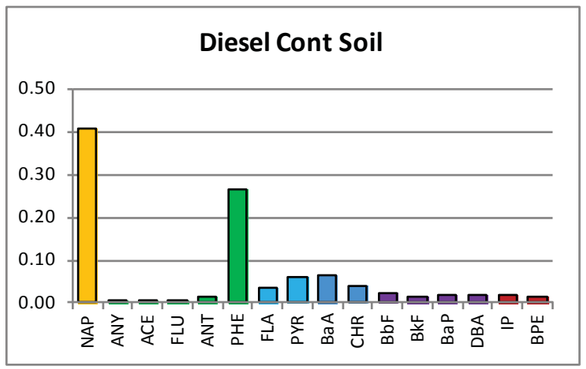
17JAN13\ENVIRONMENT\CK\LMB
MADISONKPPWI001283\GRAPHICS\FIGURE 7 DIAGNOSTIC RATIOS.AI

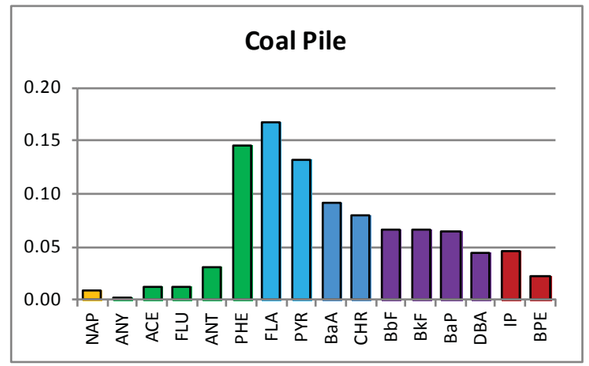


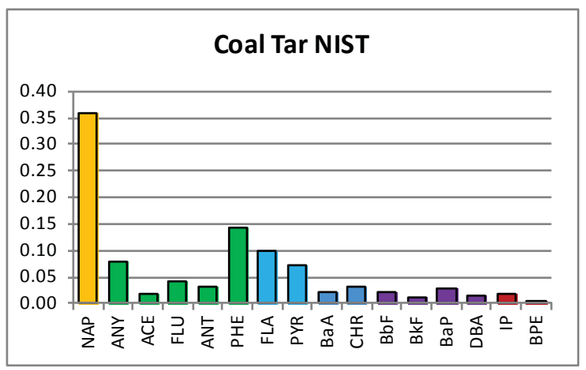


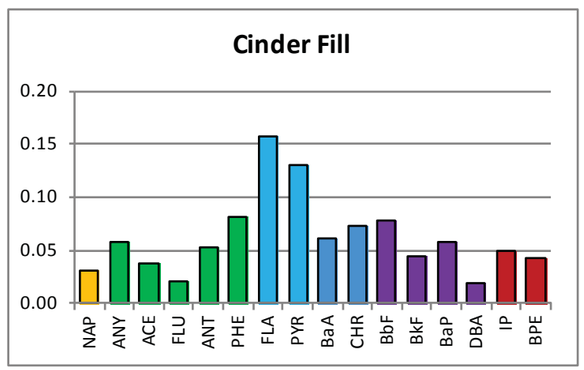


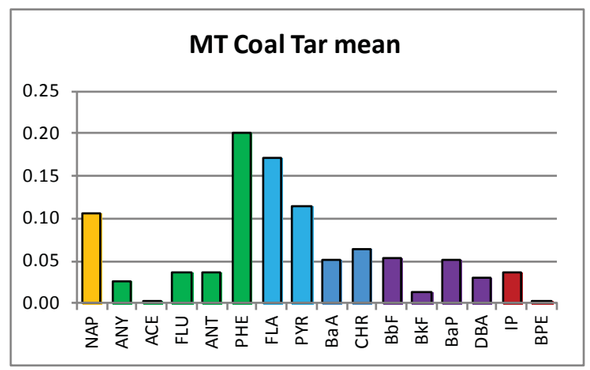


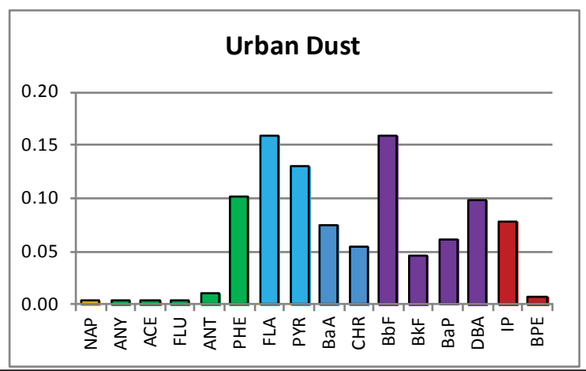












Abbreviations for PAHs are described in the text.

MADISON KIPP CORPORATION
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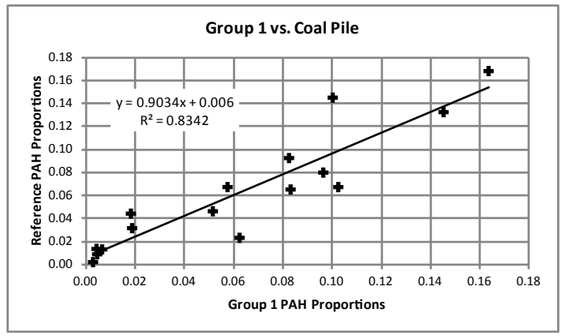
MADISON, WISCONSIN

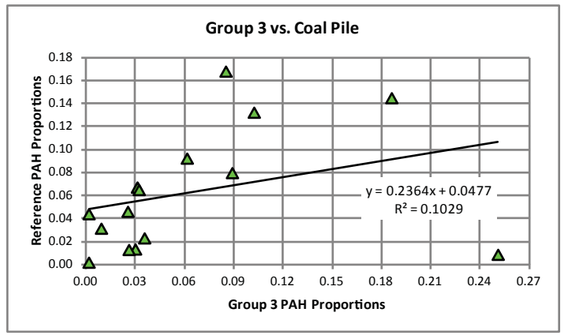
PAH PROFILES FOR REFERENCE SOURCE MATERIALS

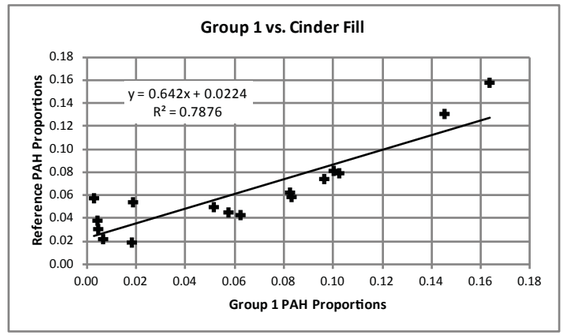
ARCADIS

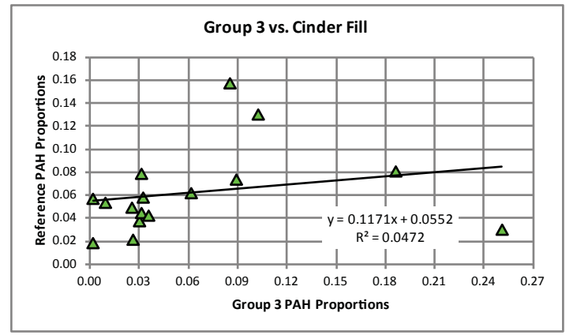
FIGURE
3-10

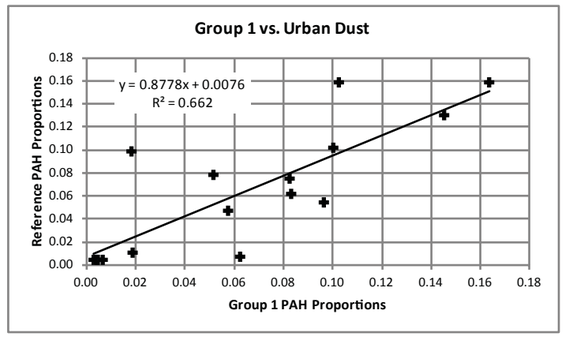
17JAN13\ENVIRONMENTCK\LMB
MADISONKPPWI\001283\GRAPHICS\FIGURE 8 REFERENCE PAH PROFILES.AI

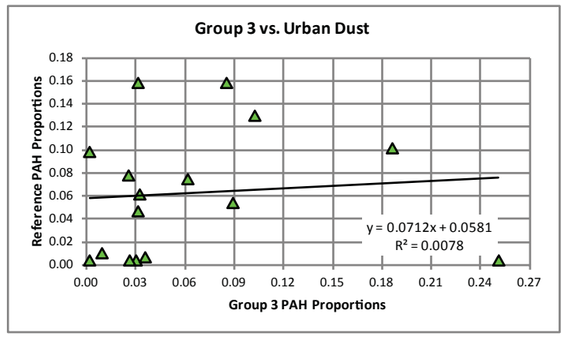


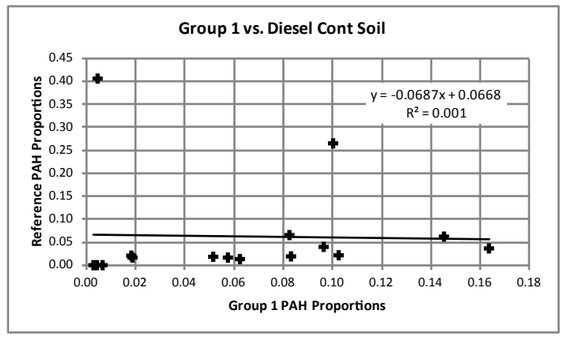


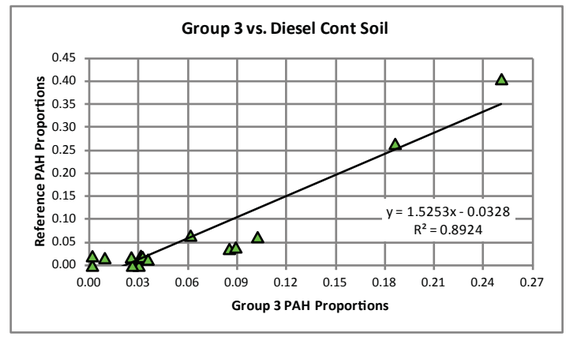


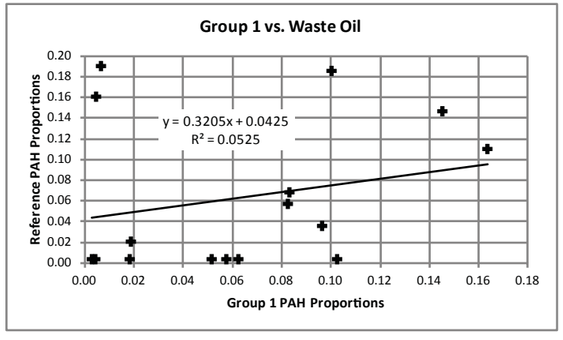


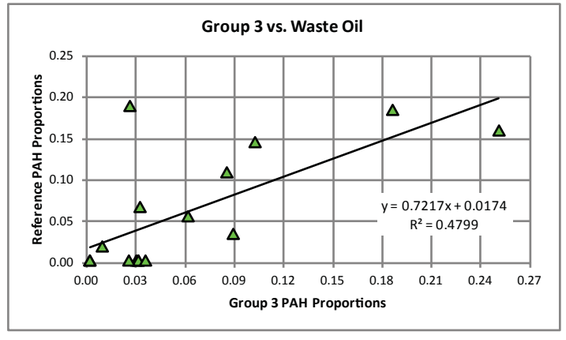












LEGEND

PAH	Polynuclear Aromatic Hydrocarbons
Cont	Contaminated

MADISON KIPP CORPORATION
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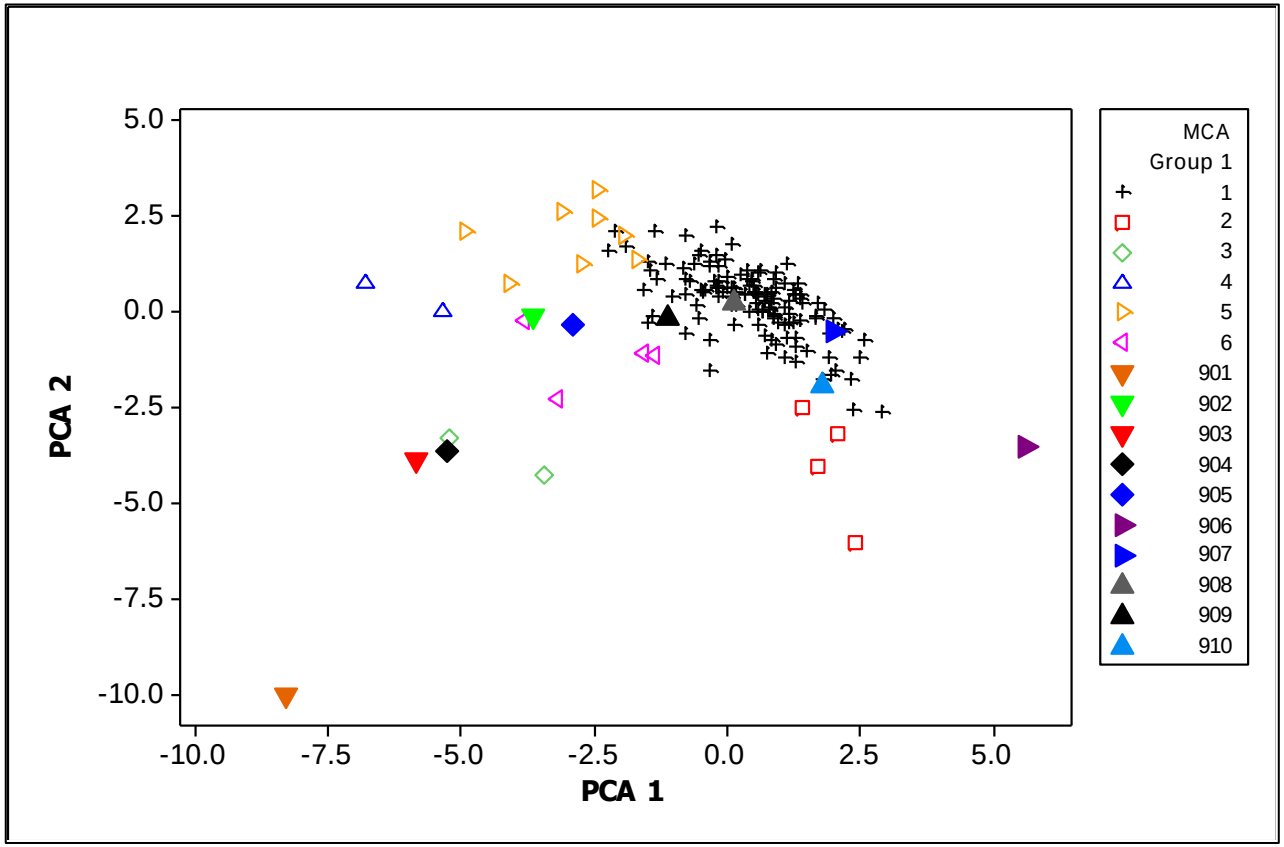
MADISON, WISCONSIN

REGRESSION RESULTS

ARCADIS

FIGURE
3-11

17JAN13\ENVIRONMENT\CK\LMB
MADISONKPPWI001283\GRAPHICS\FIGURE 9 REGRESSION RESULTS.AI



901 - Cutting Oil
902 - Waste Oil
903 - Diesel Contaminated Soil
904 - Coal Tar (high-naphthalene)
905 - Coal Tar (low-naphthalene)
906 - Coal Tar Pitch
907 - Asphalt
908 - Coal Fines
909 - Cinder Fill
910 - Urban Dust

MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

SCATTERPLOT OF PCA 2 VS PCA 1 WITH PAH SOURCE MATERIAL

ARCADIS

FIGURE
3-12

17JAN13\ENVIRONMENT\SLMB
MADISONKPP\WI001283\GRAPHICS\FIGURE 10 PCA VS PAH.AI

ARCADIS

Education

Ph.D., Toxicology, Massachusetts Institute of Technology, Cambridge, 1986

M.P.A., Science and Public Policy, University of Washington, Seattle, 1978

M.S., Chemistry, University of California, San Diego, 1975

B.S. Chemistry, University of Virginia, Charlottesville, 1973

Years of Experience

Total - 32

With ARCADIS - 3

Professional Qualifications

Member, Governor's Pesticide Board

Member, Ontario Minister of the Environment's Advisory Committee on Transboundary Science

Member, Society of Toxicology

Member, American College of Toxicology

Member, International Society for Regulatory Toxicology and Pharmacology

Member, Society for Risk Analysis

Member, Society for Environmental Toxicology and Chemistry

Member, Society of the Sigma XI

Brian Magee, Ph.D.

Vice President/Principal Toxicologist

Dr. Magee has over 30 years' experience in toxicology and risk assessment. Dr. Magee directs risk assessment projects for a wide range of industrial and governmental clients and provides senior technical review of projects in which the critical evaluation of toxicological and pharmacokinetic data is essential. Dr. Magee has performed risk assessments of former manufactured gas plants, petroleum refineries, operating chemical plants, landfills, and petroleum spill sites. In addition, he has derived risk-based clean-up criteria for numerous CERCLA, RCRA, and state-listed sites. Dr. Magee has also performed risk assessments for over 20 combustion facilities, which include municipal solid waste combustors, hazardous waste combustors, petroleum- and petroleum coke-fired power plants, coal-fired power plants, cement kilns, and industrial boilers. Additionally, Dr. Magee has provided expert testimony regarding the risks posed by exposure to chlorinated solvents, petroleum mixtures, including creosote, diesel fuel, and fuel oils, chlordane, lead, complexed cyanides, formaldehyde, and other chemicals.

Summary of Core Skills

Risk Assessment

Dr. Magee has performed hundreds of risk assessments for Superfund, RCRA, and state-lead waste sites. These include baseline risk assessments, derivation of risk-based clean-up levels, risk assessments to evaluate the efficacy of proposed corrective actions, development of risk-based sampling plans for site investigations, risk calculations in support of litigation, and risk assessments are requirements for permitting activities.

Toxicological Evaluations/Investigations

Dr. Magee has performed numerous toxicological evaluations in support of regulatory compliance activities, risk assessments, and litigation support. These activities include the design, execution, and evaluation of primary toxicological research, such as the derivation of toxicologically relevant analytical method development and the design of animal experiments to support bioavailability adjustment factors. Toxicological research also involves summarization and evaluation of primary literature to determine health-based dose levels and evaluate the ability of a chemical to cause specific adverse effects.

Expert Witness and Litigation Support

Dr. Magee has performed courtroom testimony, prepared affidavits, undergone depositions, prepared written testimony for submission to courts, and provided strategic consulting for litigation regarding toxic torts and regulatory compliance cases with respect to chlorinated solvents, combustor emissions, heavy metals, creosote, coal tar, naphthalene, metal-cyanide complexes, formaldehyde, and other chemicals.

Regulatory Toxicology

Dr. Magee has written and evaluated environmental laws and regulations. He has prepared regulatory comments on many proposed rules, guidance manuals, and proposed methodologies that affect his clients. These comment documents are submitted to the relevant regulatory agency and become part of the docket for the proposed legal action.

Representative Project Experience

Risk Assessment and Regulatory Toxicology

PAH and Related Risk Assessment Projects

Department of Public Works, Sydney, Nova Scotia – Performed Environmental Impact Analysis for environmental remediation of the Tar Ponds and Coke Ovens sites, which comprise over 100 hectares of industrial property containing 560,000 tonnes of soil contaminated with petroleum hydrocarbons, PAHs, and metals, 1,300 tonnes of PAH-contaminated sediments, 25,000 tonnes of coal-tar contaminated soil, 700,000 tonnes of sediments contaminated with PAHs and metals, and 35,000 tonnes of PCBs in excess of 50 ppm. Evaluated air monitoring program and health-based air criteria. Attended public consultation meetings, meetings with local medical specialists, and meetings with public health officials. Performed a multipathway risk assessment of emissions from a proposed PCB combustor, which included PCBs, dioxins/furans, PAHs, and selected metals as Constituents of Potential Concern. Performed a worker and off-site resident risk assessment of the remediation of pond sediments containing PCBs, PAHs, other organic constituents and metals as well as similar risk assessments for the remediation of soils, groundwater, stream sediments, and surface waters in other areas of the sites.

Department of Public Works, Sydney, Nova Scotia – Performed dust and volatile chemical emission modeling and risk assessment of coke, coal, and coal tar in support of the definition of exclusion zones for demolition of a former coke oven facility and coal tar distillery. Used EPA-approved models for estimation of PM10 emission factors associated with excavation, trucking, and storage activities and for estimation of volatile chemical emissions. Derived health-based

criteria that were protective for nearby residents for short-term and long-term emissions of respirable particles, naphthalene, other volatile and semivolatile chemicals and selected metals. Performed risk assessment of deposited dust onto soil and garden produce. Derived emission factors for volatile chemicals for sludge excavation, dewatering, and stockpile storage associated with sewer pipe installation activities.

Castle and Cooke, HI – Performed risk assessment of commercial property adjacent to a property on which a former manufactured plant site and benzene production facility were sited and on which a large commercial retail establishment was planned. Chemicals of concern included PAHs, aromatic solvents, and petroleum hydrocarbons. Direct contact risks and risks due to volatilization of solvents from soil, soil gas, and groundwater were evaluated. Assisted developers by performing risk assessment calculations assuming various remediation scenarios.

Castle & Cooke, HI – Performed human health risk assessment of volatile organic compounds from a former manufactured gas plant facility migrating from the site into retail buildings built on adjacent land. Performed indoor air modeling from measured concentrations in soil vapor, in soil and in groundwater. Performed soil risk assessment on PAHs.

Confidential Client, HI – Performed risk assessment evaluation in support of litigation regarding a commercial property on which there were historical releases of benzene, toluene, ethylbenzene, naphthalene, and coal tar residues. Advised attorneys of risk assessment issues during settlement conferences.

United States Air Force, TX – Performed historical population cancer risk assessment of naphthalene exposures to assess the scientific robustness of a Unit Risk Factor proposed by the U.S. EPA. Tested the hypothesis that rodent toxicology data is relevant to the assessment of human health risk. Presented findings at three international scientific meetings (US, Canada, Italy), prepared manuscript for publication in Regulatory Toxicology and Pharmacology, and responded to journal reviewer comments.

Toxicology Excellence in Risk Assessment, Cincinnati, OH – Served on expert panel to review and evaluate a toxicological evaluation of coal tar shampoo that derived a No Significant Risk Level in accordance with California Proposition 65. Risk assessment was performed in support of litigation by coal tar shampoo manufacturers.

Honeywell International Inc., Morristown, NJ – Conceived, planned, and managed a site-specific PAH bioavailability study for soils in a residential neighborhood adjacent to a former coal tar waste site in Region V. Soils and organic soil extracts were fed to mice for 14 days. PAH metabolites were measured in urine, and chemical:DNA adducts were measured in lung tissue. Absorption Adjustment Factors were derived for use in risk assessment. Negotiated the study protocol with the Region V EPA toxicologist, who accepted the results for use in the risk assessment.

PACIFIC Division Naval Facilities Engineering Command, CLEAN; Hawaii. (Red Hill Bulk Fuel Farm) – Performed senior technical review of screening level risk assessment of petroleum hydrocarbons, including PAHs, released from Red Hill Storage Tanks in the mountainside which overlies the Pearl Harbor Aquifer. Developed recommendations for future potential risk assessment and/or exposure prevention management tasks.

PACIFIC Division Naval Facilities Engineering Command, CLEAN; Hawaii – Prepared and submitted comments to the National Toxicology Program regarding their proposal to list naphthalene as "reasonably anticipated to be a human carcinogen" in the Eleventh Edition of *Report on Carcinogens.*

Honeywell International Inc., Morristown, NJ – Prepared detailed responses to EPA comments on a One Dimensional Monte Carlo risk assessment of ingestion and dermal exposure to potentially carcinogenic PAHs in soils in a residential neighborhood in the vicinity of a coal tar distillation facility that was previously prepared by another consultant

Honeywell International Inc., Morristown, NJ – Performed Two Dimensional Monte Carlo risk assessment of ingestion and dermal exposure to potentially carcinogenic PAHs in soils in a residential neighborhood in the vicinity of a coal tar distillation facility. Submitted study to Region V EPA, responded to EPA comments, and revised to study to meet all of their concerns

Reilly Industries, Inc., Indianapolis, IN – Managed Superfund risk assessment as part of Remedial Investigation for a Region V site that is part of an operating coal tar-based chemical manufacturing plant. Wrote detailed toxicological profiles for PAH and pyridine compounds. Derived Bioavailability Adjustment Factors for 20 chemicals. Successfully negotiated with EPA Region V to allow usage of a comparative potency approach for PAHs and several more realistic approaches that varied from conservative EPA guidance. Prepared risk-based remediation goals for the site Feasibility Study. Attended Region V EPA meetings with client. Responded to Agency comments.

Reilly Industries, Inc., Dover, Ohio – Performed senior technical oversight on a Superfund risk assessment for a former coal tar refinery in Region V. Provided dose-response profiles and bioavailablity adjustment factors for PAH and other chemicals. Performed quality assurance on all aspects of the project. Attended EPA Region V meetings with client.

Confidential Petroleum Refinery, IL – For this operating petroleum refinery, in response to an EPA Region V order, prepared risk-based clean closure criteria for storm water basins that contained petroleum sludge and process water. Used simple extraction assays to derive site-specific absorption factors that were favorable to the client. Negotiated realistic risk assessment assumptions with EPA Region V staff.

Colonial Gas Company, Lowell, MA – Prepared Method 3 risk characterization for cyanide and PAHs pursuant to Massachusetts Contingency Plan requirements for a former Manufactured Gas Plant waste disposal area that was being considered for redevelopment as a pre-school and day care center. Risk assessment calculations focused on young children as sensitive receptors. Information was provided to the potential property buyer to guide a purchase decision.

Boston Gas Company, Boston, MA – Performed a Method 3 Phase II Risk Characterization of a former MGP site currently used as a gas storage and distribution center. Chemicals evaluated included PAHs, TPH, cyanide, and lead. Receptors included on-site workers, construction and utility workers, visitors, and recreational users of an adjacent park.

National Grid, Northborough, MA – Performed Substantial Hazard Analysis of former manufactured gas plant site to determine if risks posed by exposures for a short period of time would exceed state risk management benchmarks.

Boston Gas Company and Massachusetts Electric Company, MA – Prepared Phase II Risk Characterization pursuant to the Massachusetts Contingency Plan for a former Manufactured Gas Plant site currently used as a Boston Gas Company maintenance facility. Chemicals evaluated included PAHs, TPH, cyanide, and lead. Developed absorption adjustment factors for PAHs. Developed acute risk assessment approach and acute toxicity benchmarks for hot spot analyses. Modeled air concentrations for volatile chemicals in subsurface soil.

ThermoRetec, Concord, MA – Prepared iterative Method 3 risk characterization pursuant to Massachusetts Contingency Plan requirements for a former Manufactured Gas Plant that was planned for redevelopment as mixed land use that included underground parking, office space, a hotel, and residential housing. Performed risk calculations according to several potential development scenarios. Informed developer that certain areas were acceptable for development and others were not. Estimated the risks due to volatilization of site-related constituents into current off-site buildings and into a potential underground parking garage.

Boston Gas Company, Boston, MA – Performed a Method 3 Phase II Risk Characterization of a former Manufactured Gas Plant site currently used as a private membership yacht club and marina. gas storage and distribution center. Chemicals evaluated included PAHs, TPH, cyanide, and lead. Receptors included on-site workers, construction and utility workers, and club members.

Massachusetts Electric Company, Westborough, MA – Prepared Phase III Risk Characterization pursuant to the Massachusetts Contingency Plan for a former Manufactured Gas Plant site currently used as a city park. Chemicals evaluated included PAHs, TPH, cyanide, and lead. Developed absorption adjustment factors for PAHs. Developed acute risk assessment approach and acute toxicity benchmarks for hot spot analyses. Modeled air concentrations for volatile chemicals in subsurface soil.

Colonial Gas Company, Lowell, MA – Provided senior technical oversight on five risk assessments developed pursuant to the state Superfund law. Wrote detailed toxicological profiles on PAHs and cyanide. Derived Bioavailability Adjustment Factors for 25 chemicals. Negotiated risk assessment policy issues with regulatory agency. Presented results at public meeting.

Bay State Gas Company, Westborough, MA – Performed Phase II Risk Characterization for a former manufactured gas plant site in Taunton, MA. Chemicals of potential concern included PAHs and physiologically available cyanide. Assisted in designing sampling plan. Performed hotspot analysis in accordance with DEP guidance. Attended meetings with DEP staff and presented risk assessment plan.

Consolidated Edison, NY – Prepared risk communication course for workers at Consolidated Edison's Astoria, Queens facility to discuss the RCRA RFI process in the areas previously used as a Manufactured Gas Plant facility. Discussed toxicological information regarding PAHs, coal tar, complexed cyanides, and other MGP-related chemicals.

Northern Utilities, NH – Performed risk assessment of volatiles entering sewer pipes at a former manufactured gas plant site by the use of volatilization modeling approaches. Assisted in drafting scope of work for additional sample collection.

New York State Electric and Gas Company, Binghamton, NY – Managed and provided technical guidance on the human health risk assessment of several former manufactured gas sites. Negotiated scopes of work with NYSDEC. Developed toxicokinetic factors for PAH-contaminated soils taking into consideration differences in absorption, distribution and metabolism specific to the route of exposure and the matrix in which the contaminant was found.

New York State Electric and Gas Company, Binghamton, NY – Reviewed and critically evaluated a computerized risk assessment model developed by EPRI for this public utility client. The model was used to prioritize manufactured gas plant sites according to PAH, BTEX, and cyanide risks. It assesses uncertainty in the risk assessment process by performing multiple calculations using assigned values for the probability distribution for critical input parameters.

Massachusetts Electric Company, Northborough, MA – Performed toxicological literature review, evaluated studies, and derived acute toxicity benchmarks for ten chemicals of potential concern for use in human health risk assessment of a former manufactured gas plant site.

Boston Gas Company, MA – Prepared toxicological evaluation of ferric ferrocyanide for presentation to workers at a former MGP site. Performed risk characterization of site groundwater to determine if volatile chemicals present in water in building basements could volatilize into the building.

Bowditch & Dewey, MA/National Grid, MA – Designated as a fact witness regarding the risk assessment of a former manufactured gas plant site. Deposition was taken.

Pepper, Hamilton & Sheetz, MI – Named as expert witness in toxic tort litigation associated with CERCLA former MGP site containing metal-complexed cyanides. Evaluated EPA Region V- and ATSDR- prepared toxicological reports and public health investigations. Assisted attorneys in deposing opposing witnesses.

UCAR Carbon, Nashville, TN – Evaluated coal tar pitch volatile emission data from various carbon anode preparation unit activities and toxicology literature on PAH-containing mixtures. Prepared recommendations concerning monitoring protocols for coal tar pitch volatiles and fence-line concentrations that are protective of human health.

Beazer East, Inc., Pittsburgh, PA – Conducted human health risk assessment for an operating coke facility as part of a RCRA Facilities Investigation. Derived Absorption Adjustment Factors for PAHs. Executed Monte Carlo Analysis for the ingestion and dermal contact with PAHs. Performed screening ecological investigation.

Koppers Industries, Inc., PA – Performed a critical evaluation of the ATSDR draft toxicological profile on Creosote. Argued that data on coal tar creosote, wood creosote, coal tar, coal tar pitch, coal tar pitch volatiles, and emissions from coke ovens and aluminum smelters were significantly different and were not relevant to the toxicological evaluation of coal tar creosote.

People's Gas Light & Coke Company, IL – Provided expert assistance on the toxicology and risk assessment of cyanide compounds found in soils near a residential neighborhood adjacent to a Region V site. Assisted in the preparation of public information fact sheets and briefing documents for company staff, and served as company's expert in public meetings. Designed and executed a laboratory bench experiment to simulate the accidental formation of hydrogen cyanide gas subsequent to the release of concentrated sulfuric acid from a railcar derailment in an area with metal cyanide compounds in the soil.

Beazer East, Inc., Pittsburgh, PA – Performed evaluation of literature on dermal exposures to PAHs via coal tar shampoo and derived permeability constant for PAHs in aqueous solution for use in risk assessment for a CERCLA site.

Confidential Client – For a manufacturer of creosote located in a European country, performed evaluation of scientific information presented in support of a ban on the manufacture and use of creosote by the government of Denmark and a proposed ban on creosote proposed by member governments of the European Union. Information evaluated included a recent mouse skin study on creosote performed by the Fraunhofen Institute of Germany and risk assessment calculations on dermal exposures to PAHs from contact with creosote-treated lumber.

Confidential Client – Performed comprehensive literature evaluation of toxicity and toxicokinetics literature on coal tar, coal tar pitch, and creosote. Evaluated epidemiology studies on users of coal tar pharmaceuticals, workers who contact coal tar and coal tar distillates, and wood treatment workers who are exposed to creosote. Prepared comparison of doses of PAHs predicted from risk assessment of PAHs in soils to doses obtained from clinical use of coal tar pharmaceuticals.

Powell, Goldstein, Frazer & Murphy, Atlanta, GA/Beazer East, Inc., PA – Prepared affidavit regarding the toxicology and PAH composition of creosote and related petroleum-based mixtures for CERCLA courtroom proceedings. Assisted attorney in examining opposing toxicology witness. Prepared toxicological summaries on creosote and related mixtures.

Wildman, Harrold, Allen & Dixon, IL/Jones, Day, Reavis & Pogue, OH – Provided litigation support regarding the state of the art in toxicology and risk assessment and in toxicological knowledge on a number of industrial chemicals and products from 1900 to present time. Chemicals included creosote, coal tar, and other PAH-containing mixtures.

Honeywell International Inc., Morristown, NJ – Prepared and submitted comments to the National Toxicology Program regarding their proposal to list naphthalene as “reasonably anticipated to be a human carcinogen” in the Eleventh Edition of *Report on Carcinogens.* Presented evidence that rat nasal tumors are not relevant to human health and recommended that NTP not list naphthalene.

Beazer East, Pittsburgh, PA – Prepared comments on EPA proposed Drinking Water Standards for PAHs. Evaluated the technical basis for the proposed rules and submitted comments for inclusion in the public record.

Powell, Goldstein, Frazer & Murphy, Atlanta, GA/Beazer East, Inc., PA – Served as expert witness for a jury trial involving claims of adverse health effects and environmental risks associated with PAHs at a CERCLA site that was a former wood treating facility using creosote and other formulations. In courtroom proceedings, showed that levels of naphthalene in groundwater were below health and regulatory levels of concern; showed that naphthalene was present in many products used and disposed on- and off-site that were unrelated to client; and showed that it was not possible to attribute the chemical in the groundwater to the client's past activities. Received kudos from client for clear and persuasive courtroom testimony.

Wildman, Harrold, Allen & Dixon, IL – Provided litigation support regarding the significance of air monitoring results for creosote constituents in the residential neighborhood in the vicinity of an operating wood treating plant in defense of a class action suit brought by a citizen’s group alleging adverse health effects. Evaluated and assisted in the design of the residential air monitoring program that analyzed for naphthalene, other semivolatile chemicals, volatile chemicals, and selected metals.

Babst, Calland, Clements, and Zomnir, PA/Beazer East, Inc., PA – Designated as a fact witness regarding the risk assessment of PAHs an operating coke oven facility. Deposition was taken. Performed site-specific risk assessment of the facility which is adjacent to a residential neighborhood.

Confidential Client, Pittsburgh, PA – Served as expert witness for a jury trial involving claims of adverse health effects and environmental risks associated with PAHs at a CERCLA site. In courtroom proceedings, showed that levels of naphthalene in groundwater were below health and regulatory levels of concern; showed that naphthalene was present in many products used and disposed on- and off-site that were unrelated to client; and showed that it was not possible to attribute the chemical in the groundwater to the client's past activities. Received kudos from client for clear and persuasive courtroom testimony.

Confidential Client, HI – Developed risk assessment site conceptual model for a large commercial area along the Honolulu harbor that has been historically affected by releases of petroleum hydrocarbons. Chemicals of concern included PAHs and petroleum hydrocarbons. Assisted in quality control evaluation of historical data.

Beazer East Inc., Pittsburgh, PA – Critically evaluated and prepared formal comments on the PAH risk assessment policy prepared by the State of Wisconsin. Prepared risk assessment scope of work for an operating wood treatment facility.

U.S. Navy, HI – Performed senior technical review of screening level risk assessment of petroleum hydrocarbons, including PAHs, released from Red Hills Storage Tanks in the mountainside above Pearl Harbor. Made recommendations to the Navy concerning follow-on risk assessment activities.

Commonwealth of Pennsylvania, Pittsburgh, PA – Evaluated risk assessment of PAHs in a freshwater pond prepared by a steel mill in support of a no action alternative.

Confidential Petroleum Refinery, IL – For this operating petroleum refinery, in response to an EPA Region V order, prepared risk-based clean closure criteria for storm water basins that contained petroleum sludge and process water. Used simple extraction assays to derive site-specific absorption factors that were favorable to the client. Negotiated realistic risk assessment assumptions with EPA Region V staff.

Cliffs-Dow PRP Group, Detroit, MI – Assisted PRP group in negotiating with MDNR and EPA Region V. Prepared risk assessment work plans and risk-based sampling plans for PAHs in coal tar affected media. Derived probable target clean-up goals using various approaches. Prepared memoranda for submission to agencies outlining the most reasonable approaches.

CITGO Petroleum Corporation, Fairfax, VA – Conducted a human health and environmental risk assessment of the CITGO bulk storage terminal in Fairfax, VA. Used fate and transport modeling to determine on- and off-site concentrations of compounds in soils and water due to the presence of an on-site plume of free product. Developed site-specific exposure scenarios, such as wading in a local stream and maintenance work on the local golf course, which were used to estimate potential risks to the surrounding community. Developed target cleanup levels for the fuel constituents. Demonstrated that State's TPH criteria were unrealistically low based on human health risk assessment.

Sun Refining Company, Philadelphia, PA – Prepared risk-based action levels for a petroleum refinery to accompany a RCRA Facilities Investigation in Region III. Strategically presented proposed Media Cleanup Levels in the RFI in addition to RFI Action Levels. Argued that industrial site use exposure scenarios were more appropriate than residential scenarios for ultimate cleanup levels. Evaluated Region III Risk-Based Concentrations for client technical and legal staff. Compared action levels to site data and made risk-based recommendations for limited further investigation in specific areas of the site. Attended meetings with Agency toxicologists and argued client's positions.

Boston Edison Company, Boston, MA – Prepared clean closure criteria pursuant to RCRA for the closure of waste impoundments at two operating oil-fired electric power generation facilities. Estimated exposure to contaminants posed by inhalation of volatile materials escaping from soil piles and by direct contact with and incidental ingestion of soil.

Beazer East, Inc., Nashua, NH – Performed site investigation, risk assessment, and public involvement activities for a 90 acre former wood treating site that is proposed for redevelopment as a City park having contact and non-contact recreational uses. Wood treating chemicals include PAHs (creosote), pentachlorophenol, arsenic and chromium. All activities are being performed according to the New Hampshire Department of Environmental Services (NHDES) Risk Characterization and Management Policy. The goal of risk assessment activities is to determine if certain future land uses are consistent with NHDES policy. Risk assessment activities, remedial design activities and landscaping activities for land use planning are being performed iteratively so that the site reuse potential and protection of public health can simultaneously be optimized. Designed and executed two NHDES-approved pre-grading soil sampling programs to support the proposal that site regrading activities could be safely performed before risk assessment surface soil sampling and analysis was undertaken. Designed and executed a NHDES-approved air monitoring program to ensure that public health was adequately protected against exposure to respirable dust, volatile & semivolatile constituents, and metals during site regrading activities. Designed, obtained State approval form and executed a comprehensive post-grading soil sampling program to gather data required for human health risk assessment. Prepared a risk assessment scope of work. Served as the site owner's environmental and risk assessment consultant in numerous meetings with State and City officials. Prepared for and attended several public meetings on the progress of site

environmental work and the proposed site redevelopment plan. Prepared brochures and briefing materials for City officials and the public. Participated in a live call-in local television program concerning the site development plans.

Air Impacts Health Risk Assessment Projects

Department of Public Works, Sydney, Nova Scotia – Performed Environmental Impact Analysis for air emissions associated with the environmental remediation of the Tar Ponds and Coke Ovens sites, which comprise over 100 hectares of industrial property containing 560,000 tonnes of soil contaminated with petroleum hydrocarbons, PAHs, and metals, 1,300 tonnes of PAH-contaminated sediments, 25,000 tonnes of coal-tar contaminated soil, 700,000 tonnes of sediments contaminated with PAHs and metals, and 35,000 tonnes of PCBs in excess of 50 ppm. Airborne constituents of concern included SOx, NOx, CO, and particulate matter from construction vehicles, particulate matter from excavation and grading activities, and site-related VOCs from excavation and stabilization activities. Evaluated air monitoring program and health-based air criteria. Attended public consultation meetings, meetings with local medical specialists, and meetings with public health officials. Performed a multipathway risk assessment of emissions from a proposed PCB combustor, which included PCBs, dioxins/furans, PAHs, and selected metals as Constituents of Potential Concern. Performed a worker and off-site resident risk assessment of the remediation of pond sediments containing PCBs, PAHs, other organic constituents and metals as well as similar risk assessments for the remediation of soils, groundwater, stream sediments, and surface waters in other areas of the sites.

New Brunswick Power, Fredericton, New Brunswick – Performed multipathway human health risk assessment of emissions from the combustion of Orimulsion© (Venezuelan bitumen product) as fuel in the proposed refurbishment of an existing heavy fuel oil-fired power generation facility in Lorneville, New Brunswick. The risk assessment was a component study used to prepare an Environmental Impact Assessment required for a governmental operating permit. Approximately fifty epidemiology studies and government documents allegedly linking quantifiable cases of health effects with respirable particulate matter were evaluated and critiqued. These documents included the Canadian “National Ambient Air Quality Objectives for Particulate Matter,” the U.S. “Air Quality Criteria for Particulate Matter,” and dozens of scientific papers from the primary literature. In addition, several computer models allegedly estimating quantifiable cases of health effects were evaluated and critiqued. These include the Illness Costs of Air Pollution (ICAP) model developed for the Ontario Medical Association and the Air Quality Valuation Model (AQCM) developed by Health Canada/Environment Canada. Evaluated criteria and noncriteria chemical emissions. Chemicals evaluated included sulfur dioxide, nitrogen oxides, particulate matter, metals, polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds. Indirect risk assessment was performed in accordance with U.S. EPA combustor risk assessment guidance and included residents, farmers and fishers. Pathways included inhalation, ingestion of soil, ingestion of backyard produce, ingestion of drinking water, ingestion of fish, and ingestion of farm products. Attended meetings with and presented results

to regulatory officials, members of the public and members of intervener groups. Risk assessment results were well received and did not precipitate any adverse comments from any members of the governmental Technical Advisory Committee, which accepted and approved the report as written.

New Brunswick Power, Fredericton, New Brunswick – Performed multipathway human health risk assessment of emissions from the combustion of a mixture of Heavy Fuel Oil and Petroleum Coke. Pathways included inhalation, ingestion of soil, ingestion of backyard produce, ingestion of drinking water, ingestion of fish, and ingestion of farm products.

Department of Public Works, Sydney, Nova Scotia – Performed dust and volatile chemical emission modeling and risk assessment of coke, coal, and coal tar in support of the definition of exclusion zones for demolition of a former coke oven facility and coal tar distillery. Used EPA-approved models for estimation of PM10 emission factors associated with excavation, trucking, and storage activities and for estimation of volatile chemical emissions. Derived health-based criteria that were protective for nearby residents for short-term and long-term emissions of respirable particles, naphthalene, other volatile and semivolatile chemicals and selected metals. Performed risk assessment of deposited dust onto soil and garden produce. Derived emission factors for volatile chemicals for sludge excavation, dewatering, and stockpile storage associated with sewer pipe installation activities.

Covanta Energy, Inc., Haverhill, MA (MSW Combustion Ash) – Prepared a Scope of Work for the multipathway human health risk assessment of a landfill disposal area for municipal solid waste combustion ash in accordance with MADEP guidance using EPA combustor risk assessment guidance. Designed and performed a site-specific monitoring program to measure total and respirable suspended particulates with Hi-Vol samplers and NIOSH personal monitors and to measure PM10 levels with a Personal DataRAM real-time monitor. In addition, total metals, such as arsenic, nickel and mercury, were analyzed, as was diesel particulate (organic and elemental carbon). Prepared report arguing that dust levels attributable to ash disposal were caused by diesel exhaust and not ash dumping or compacting.

Covanta Energy, Fairfield, New Jersey – Currently managing the preparation of an Environmental Impact Statement and Clean Air Act PSD permit application for the expansion of the City and County of Honolulu's H-POWER Energy-from-Waste facility. The current proposed project involves the addition of a new Mass Burn boiler and a new electric generation turbine. Constituents of concern include SOx, NOx, PM10, PM2.5, dioxins/furans, mercury, and others.

Covanta Energy, Fairfield, New Jersey – Performed human health risk assessment for and provided senior technical oversight of an Environmental Impact Statement and Clean Air Act PSD permit application for the expansion of the City and County of Honolulu's H-POWER Energy-from-Waste facility. The proposed project involved the addition of a third Refuse Derived

Fuel boiler unit to the currently operating facility. The project was not built due to the decision of the City Council in 2005.

Covanta Energy, Fairfield, New Jersey – Performed human health risk assessment of PM10 and PM2.5 from Covanta's Marion County, Oregon Energy-from-Waste facility using published concentration-response functions. Estimated levels of increased mortality and morbidity from all causes and from selected specific causes. Demonstrated that not one person would die or become ill from emitted fine particulate matter due to the facility expansion even using conservative concentration-response functions from epidemiological studies that have debatable scientific soundness.

Covanta Energy, Fairfield, New Jersey – Performed human health risk assessment of PM10 and PM2.5 from Covanta's Minneapolis, Minnesota Energy-from-Waste facility using published concentration-response functions. Estimated levels of increased mortality and morbidity from all causes and from selected specific causes. Demonstrated that not one person would die or become ill from emitted fine particulate matter due to the facility expansion even using conservative concentration-response functions from epidemiological studies that have debatable scientific soundness.

City and County of Honolulu, Honolulu, Hawaii – Performed a multipathway human health risk assessment of emissions from the combustion of municipal solid waste at the City's combustor facility in advance of a permit application to build and operate a third boiler unit. Chemicals evaluated included lead, other heavy metals, polycyclic aromatic hydrocarbons and dioxin and furan congeners. Indirect risk assessment was performed in accordance with U.S. EPA combustor risk assessment guidance and included residents, farmers and fishers. Pathways included inhalation, ingestion of soil, ingestion of backyard produce, ingestion of drinking water, ingestion of fish, and ingestion of farm products. Using site-specific data the algorithms for the fate and transport of mercury were modified from EPA default values.

Belt Collins Hawaii Ltd., Honolulu, HI – For the Mamalahoa Highway – Kawaihae Road Connector Project in Waimea, HI, performed a human health and environmental assessment of the impacts of the proposed roadway with regards to both the road's impact on adjacent agriculture and the impact of agricultural practices on individuals using the road. Constituents of concern were SOx, NOx, CO, and particulate matter from vehicles using the roadway and selected pesticides and herbicides from the farm operations.

Westinghouse, Pittsburgh, PA – Prepared a protocol document for a multipathway risk assessment of a proposed PCB incinerator in Bloomington, IN. Derived absorption adjustment factors for PCBs. Attended meetings with and negotiated approaches and assumptions with EPA Region V.

Beazer East, Inc., Nashua, NH – Designed and executed a NHDES-approved air monitoring program to ensure that public health was adequately protected against exposure to respirable particulates, volatile & semivolatile constituents, and metals during site regrading activities at a former wood treating site which had historical releases of naphthalene, creosote, and other constituents. Monitors included Hi-Vol sampling and analysis for metals, SVOCs and VOCs using EPA approved methods. Real time PM10 monitoring was also performed using fixed location and hand-held monitors. Derived health-based fence line criteria that were protective of nearby residents' health for respirable particles and for individual chemicals present in site soils.

City and County of Honolulu, Honolulu, HI – Prepared a scope of work for a field sampling program to measure respirable particulate generation during asphalt roadway demolition using cold planer machines by cold planing. Executed a field sampling program for particulate monitoring using NIOSH total and respirable dust methods and real-time PM10 monitors during roadway demolition. Concluded that respirable particulate generation from asphalt road demolition does not pose a significant risk to people adjacent residents or to workers. Prepared a report entitled "Air Monitoring of Roadway Demolition Activities, Beneficial Use of H-POWER Municipal Solid Waste Ash as an Aggregate for Road Materials.

City and County of Honolulu, Honolulu, HI – Designed and performed sampling for total particulates and respirable particulates and analyzed for metals, crystalline silica, and particle-bound and vapor phase mercury in ambient air at an operating municipal solid waste landfill adjacent to a residential development during a demonstration project in which municipal solid waste ash was used as daily landfill cover. Evaluated and validated laboratory data. Prepared risk assessment reports that addressed the health of landfill workers, members of the public that visited the landfill, and nearby residents. Concluded that use of ash as alternate daily landfill cover does not pose significant adverse human health risks. Provided technical support on issues raised during the public hearing process with regard to a proposal to extend the landfill operating permit.

NiSource, Merrillville, IN – Provided risk assessment and toxicology consulting to gas utility concerning elemental mercury vapor because of Region V regulatory actions. Predicted indoor air mercury levels at various times assuming various spill scenarios using EPA models. Evaluated levels of mercury vapor commonly detected in dentists' offices and in locations of historical mercury spills. Evaluated health based criteria for mercury vapor exposure. Evaluated mercury vapor detection instruments.

Gas Research Institute, Pittsburgh, PA – Performed detailed review of a computer-based model developed to evaluate exposures and risks posed by mercury in surface and subsurface soils. Evaluated fate and transport, exposure assessment, and toxicity aspects of this model.

Confidential Client, New Brunswick, Canada – Critically evaluated report prepared for a medical waste combustor in support of an argument than a carbon injection air pollution control

system to control mercury emissions was not required for government approval to increase the waste combustor operating conditions.

Dominion Energy, Richmond, VA (Coal Combustion) – Managed multipathway risk assessment for proposed coal fired power plant permit. Selected contaminants of concern, relevant receptors, and exposure pathways. Oversaw calculations and prepared documentation.

Hilo Coast Power Company, HI (Coal Combustion Ash) – Performed risk assessment consulting on risks posed by leaching of metals from coal combustion ash. Evaluated laboratory methods and reporting limits. Evaluated the need to sample ash for additional metals based on the probability that such metals are present in coal ash. Performed fate and transport modeling and human health risk assessment. Participated in meeting with Hawaii Department of Health concerning beneficial reuse permit.

AES, HI (Coal Combustion Ash) – Performed risk assessment consulting on risks posed by leaching and surface runoff of metals from coal combustion ash. Commented on proposed beneficial use permit. Performed fate and transport modeling and human health risk assessment.

Ogden Projects, Inc., Stanislaw, CA – Performed technical oversight of air dispersion modeling of a hypothetical accidental release of anhydrous ammonia. Conducted toxicological evaluation of acute toxicity data on ammonia. Determined appropriate health-based benchmarks for various exposure times.

American Ref-Fuel, New York – Provided peer review for a multipathway risk assessment prepared by another company for a proposed municipal solid waste combustor. Provided strategic risk assessment consulting. Chemicals of potential concern included dioxins/furans and metals.

American Ref-Fuel, New York – Provided strategic risk assessment consulting services by critiquing and modifying a previously prepared protocol for a hazardous waste combustor. Chemicals of potential concern included dioxins/furans and metals. Met with NYSDOH and NYSDEC on numerous occasions. Negotiated innovative and more realistic approaches with the agencies.

Hazardous Waste Treatment Council, American Industrial Health Council, Chemical Manufacturer's Association, Washington, D.C. – Prepared comprehensive comments on EPA's draft indirect risk assessment guidance for submission to the Agency. Evaluated EPA's proposed approach for evaluating uptake of dioxin vapor directly into plants and developed an alternative method.

Hazardous Waste Treatment Council, Washington, DC – Presented a seminar on multipathway risk assessments for incinerators and industrial furnaces to the Thermal Treatment Committee. Discussed the implications of the EPA's 1993 risk assessment initiative and critical strategic issues in performing risk assessments for these facilities.

Covanta Energy, Inc., Salinas, CA – Performed screening level air dispersion modeling of emissions from an internal combustion engine burning landfill gases. Evaluated risk assessment methodology used to determine compliance with State regulations.

American Envirotech, Inc., Houston, Texas – Prepared indirect pathway risk assessment for proposed hazardous waste incinerator in accordance with major aspects of EPA's draft Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions. Prepared a detailed protocol document in negotiation with the Texas Natural Resources Conservation Commission. Developed alternate approach for assessing direct uptake of dioxin vapor into plants. Evaluated risks for six different receptors and performed risk zone analysis per EPA and TNRCC requests.

Environmental Technology Council, Washington, D.C. – Submitted Affidavit, Supplemental Affidavit, and Expert Report to Federal District Court in Louisiana in support of litigation against GTX, Inc. Hazardous Waste Combustor, Morgan City, Louisiana (formerly Marine Shale, Inc.). Chemicals of potential concern included dioxins/furans and mercury. Evaluated risk assessments prepared for GTX, Inc. using the 1998 *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (1998)* with a commercial risk assessment program, IRAP-h, sold by Lakes Environmental. Evaluated the IRAP-h model for consistency with documentation requirements that are standard in the field of risk assessment and with the 1998 EPA guidance. Programmed and executed a side-by-side risk assessment using all of the same input parameters to test the accuracy of the IRAP-h model. Discovered many errors and flaws in the GTX risk assessments, including the inability of the IRAP-h program to allow reviewers to verify the correctness of the internal code. Prepared detailed summary report that outlined deficiencies in the GTX risk assessments and prepared a comprehensive risk assessment document using the EPA guidance.

Environmental Technology Council – Prepared comments on 1998 *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (1998)* for submission to EPA. Protocols and methodologies were taken from a more generic document that has not yet been released to the public: *Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions.* Major aspect of the evaluation focused on the treatment by USEPA of mercury emissions from combustion facilities, including the vapor/particle partitioning, the valence state interactions, and the methylation processes.

ENSCO, El Dorado, AR – Prepared a Scope of Work for the multipathway human health risk assessment of the emissions from a hazardous waste combustor facility in accordance with U.S.

EPA combustor risk assessment guidance and in accordance with comments from state regulators.

Municipal Solid Waste Combustor, Pennsylvania – Performed a multiple exposure pathway, multiple compound, multiple media risk assessment for permitting a new combustor in accordance with Pennsylvania and state-of-the-art guidelines. Projected emissions dispersion and performed deposition modeling to provide ground-level ambient concentrations and accumulation of emitted materials in solids, dusts and food chains. Chemicals of potential concern included dioxins/furans and metals. Although food chain exposures posed the largest potential risks, no unacceptable risks were identified by the assessment. Attended public meetings.

UCAR Carbon, Nashville, TN – Evaluated coal tar pitch volatile emission data from various carbon anode preparation unit activities and toxicology literature on PAH-containing mixtures. Prepared recommendations concerning monitoring protocols for coal tar pitch volatiles and fence-line concentrations that are protective of human health.

Energy Answers, Rochester, MA (MSW Combustion Ash) – Performed risk assessment of the use of aggregate material produced from municipal solid waste combustor bottom ash in asphalt roadway construction. Evaluated leaching of lead and other metals from ash-aggregate-amended asphalt. Performed human health and environmental risk assessment of surface runoff and groundwater leachate. Participated in negotiations with MADEP. Assisted in preparation of Beneficial Use Permit.

Norlite Light Aggregate Kiln, NY (Fossil Fuel Ash Aggregate) – Performed risk assessment consulting to light aggregate kiln that was co-firing fuel oil and hazardous waste solvents and was producing an aggregate material that was mixed with combustion ash. Assisted in decision-making regarding the marketability of the product. Risk assessment activities focused on lead.

Ogden Projects, Fairfield, NJ (MSW Combustion Ash) – Performed critical evaluation of risk assessment documents addressing the beneficial reuse of municipal solid waste combustor ash from two municipal waste combustors. Risk assessment activities focused on the presence of lead in the combustor ash. Prepared a technical memorandum and participated in client conferences with the document authors.

Confidential Client, Washington, D.C. – Prepared generic multipathway risk assessment for lead emissions from 21 cement kilns permitted by RCRA to combust hazardous waste according to EPA's 1994 Screening Level Risk Guidance. Compared estimated child blood lead levels and estimated lifetime cancer risk associated with baseline emissions levels and proposed MACT standards. Direct and indirect pathways were evaluated, including beef, pork, chicken, egg, dairy product, and fish ingestion.

City and County of Honolulu, Honolulu, HI (MSW Combustion Ash) – Prepared three human health risk assessments of the beneficial use of municipal solid waste combustion ash from the City and County of Honolulu's H-Power facility. One project considered the proposed use of the ash *in lieu* of clay as part of the final cover in the closure of a city-owned landfill. The risk assessment considered risks from lead, other heavy metals, and dioxin and furan congeners. Risks during and after the closure were evaluated under several potential scenarios using EPA's IEUBK model and California's LeadSpread model. Receptors included workers, on-site trespassing children, and off-site children. Affected media included the ash, ash leachate, ash-derived dust, surface water and sediment, and fish. Dust generation and dispersion modeling was performed as well as modeling of surface runoff of ash into nearby surface water and sediment. Ash-specific absorption adjustment factors were derived for lead and other metals. A second project considered the proposed use of combustor ash as alternate daily cover at the City's operating municipal solid waste landfill. A third project considered the use of combustor ash as aggregate in road materials.

City and County of Honolulu, Honolulu, HI (MSW Combustion Ash) – Prepared a work plan for the environmental testing of a test roadway that would contain municipal solid waste combustion ash as a partial substitute for aggregate in the asphalt preparation. Prepared an operations plan for the manufacture of the ash-amended asphalt and the construction of the test roadway. Prepared a draft and final work plan for the evaluation of the leachate quality from the roadway materials containing ash. Constituents of concern were lead and other heavy metals. Provided oversight of the manufacture of ash-amended asphalt and the construction of the test roadway. Executed the four-year field sampling program for environmental testing of the test and control roadways. Summarized the environmental testing of municipal solid waste ash-amended asphalt. Test results included wash water analyses, analyses of the soil at the location of surface water runoff from the test and control roadways, and analysis of SPLP leachate of test cores of test and control asphalt. Prepared a plan for long-term testing of ash-amended asphalt.

City and County of Honolulu, Honolulu, HI (MSW Combustion Ash) – Performed risk assessment, air sampling, and legislative testimony in Senate committee hearing to address emergency concerns by the State, environmental activists, and local citizens concerning some unpermitted waste disposal activities at a former municipal solid waste incinerator. Disposal activities included disposal of solid waste combustion ash on the facility site and disposal on the adjacent ash landfill. Prepared a Human Health Risk Assessment of the City and County of Honolulu's Refuse Division and Department of Parks and Recreation workers who currently work at the closed Waipahu Incinerator complex, children and adults who use the adjacent Waipio Peninsula Soccer Complex, nearby residents, and hypothetical trespassers at the Waipahu Ash Landfill. Constituents of concern were lead, other heavy metals, and dioxins and furans.

City and County of Honolulu, Honolulu, HI (MSW Combustion Ash) – Prepared Closure Plan for Subtitle D closure of a unused municipal solid waste incinerator. Performed facility

inventory and wipe sampling of internal facility surfaces for lead and other metals present in deposited ash-like material. Responded to State Department of Health (DOH) questions and attended meeting with DOH on client's behalf. Closure Plan includes plans for soil sampling and analysis, equipment cleaning, removal and recycling, building surface wipe sampling and risk assessment, groundwater modeling, ecological reconnaissance, and site wide risk assessment.

Confidential MSW Ash Landfill (MSW Combustion Ash) – Provided risk assessment consulting services concerning the permitting requirements for expanding a municipal landfill that accepts municipal solid waste combustor ash, which contains lead, other heavy metals, and dioxins/furans. The landfill wished to gain state permission to use MSW combustor ash as landfill daily cover.

Confidential MSW Facility (MSW Combustion Ash) – Provided litigation support regarding a personal injury case in which plaintiffs alleged that they were been harmed by heavy metals, such as lead and cadmium, from a municipal solid waste combustor's stack emissions and/or fugitive dust from the municipal solid waste combustor ash. Evaluated plaintiff's medical data, identified various potential sources of heavy metal exposures, and performed various risk assessment calculations. Assisted in preparing interrogatories and responses to interrogatories.

City and County of Honolulu, Honolulu, HI – Prepared a scope of work for a field sampling program to measure dust generation during asphalt roadway demolition using cold planer machines by cold planing. Executed a field sampling program for dust generation monitoring using NIOSH total and respirable dust methods and real-time PM10 monitors during roadway demolition. Constituents of concern included lead and other heavy metals. Concluded that dust generation from asphalt road demolition does not pose a significant risk to people adjacent residents or to workers. Prepared a report entitled "Air Monitoring of Roadway Demolition Activities, Beneficial Use of H-POWER Municipal Solid Waste Ash as an Aggregate for Road Materials.

Confidential Polymer Processor, CT – Performed toxicological evaluation of numerous chemicals to determine the cause of alleged health symptoms reported by people living near the facility. Focused on eye and lung irritation and delayed sensitization effects. Derived toxicological benchmarks for use in a human health risk assessment. Interfaced with client lawyers and negotiated with the state toxicologist.

Confidential Tannery, MN – Conducted toxicological investigation of products and formulations to determine the cause of alleged respiratory sensitization symptoms in workers in one department. Evaluated ambient air monitoring reports and analytical methodologies. Performed literature searches and critical reviews of scientific papers.

NiSource, Merrillville, IN – Provided risk assessment and toxicology consulting to gas utility concerning elemental mercury vapor because of Region V regulatory actions. Predicted indoor

air mercury levels at various times assuming various spill scenarios using EPA models. Evaluated levels of mercury vapor commonly detected in dentists' offices and in locations of historical mercury spills. Evaluated health based criteria for mercury vapor exposure. Evaluated mercury vapor detection instruments.

Ogden Projects, Inc., Stanislaw, CA – Performed technical oversight of air dispersion modeling of a hypothetical accidental release of anhydrous ammonia. Conducted toxicological evaluation of acute toxicity data on ammonia. Determined appropriate health-based benchmarks for various exposure times.

Expert Witness and Litigation Support Projects

Marshall, Dennehey, Warner, Coleman & Goggin, PA; Chiumento, McNally & Shockley, NJ; Hoagland, Longo, Moran, Dunst & Doukas, LLP, NJ; Slowinski Atkins, LLP, NJ – Served as expert witness in a wrongful death case involving alleged benzene exposure from vapor intrusion of gasoline into a commercial building. Evaluated and critiqued plaintiff's expert reports, estimated potential exposures to benzene, reviewed and evaluated human epidemiology studies of benzene, and prepared expert report.

Schwartz Campbell, PA – Served as a defense expert witness in a lawsuit in which two individuals alleged that their chronic myeloid leukemias were cause by formaldehyde exposures in their workplace in a foundry that used phenol-formaldehyde resin-coated sand in their operations. Prepared expert report and testified at hearing. Lawsuit was dismissed based on expert testimony.

Confidential Client, Pittsburgh, PA – Served as expert witness for a jury trial involving claims of adverse health effects and environmental risks associated with PAHs at a CERCLA site. In courtroom proceedings, showed that levels of naphthalene in groundwater were below health and regulatory levels of concern; showed that naphthalene was present in many products used and disposed on- and off-site that were unrelated to client; and showed that it was not possible to attribute the chemical in the groundwater to the client's past activities. Received kudos from client for clear and persuasive courtroom testimony.

Wildman, Harrold, Allen & Dixon, IL – Performed litigation support regarding a personal injury case in which a worker was alleged to have contracted liver cancer from exposure to coal tar and related workplace chemicals at a creosote manufacturing plant. Comprehensively evaluated and summarized the literature on selected chemicals and PAH mixtures regarding liver injury and liver cancer.

Confidential Client, HI – Performed risk assessment evaluation in support of litigation regarding a commercial property on which there were historical releases of benzene, toluene,

ethylbenzene, naphthalene, and coal tar residues. Advised attorneys of risk assessment issues during settlement conferences.

Powell, Goldstein, Frazer & Murphy, Atlanta, GA/Beazer East, Inc., PA – Served as expert witness for a jury trial involving claims of adverse health effects and environmental risks associated with PAHs at a CERCLA site that was a former wood treating facility using creosote and other formulations. In courtroom proceedings, showed that levels of naphthalene in groundwater were below health and regulatory levels of concern; showed that naphthalene was present in many products used and disposed on- and off-site that were unrelated to client; and showed that it was not possible to attribute the chemical in the groundwater to the client's past activities. Received kudos from client for clear and persuasive courtroom testimony.

Bowditch & Dewey, MA/National Grid, MA – Designated as a fact witness regarding the risk assessment of a former manufactured gas plant site. Deposition was taken.

Wildman, Harrold, Allen & Dixon, IL – Provided litigation support regarding the significance of air monitoring results for creosote constituents in the residential neighborhood in the vicinity of an operating wood treating plant in defense of a class action suit brought by a citizen's group alleging adverse health effects. Evaluated and assisted in the design of the residential air monitoring program that analyzed for naphthalene, other semivolatile chemicals, volatile chemicals, and selected metals.

Powell, Goldstein, Frazer & Murphy, Atlanta, GA/Beazer East, Inc., PA – Prepared affidavit regarding the toxicology and PAH composition of creosote and related petroleum-based mixtures for CERCLA courtroom proceedings. Assisted attorney in examining opposing toxicology witness. Prepared toxicological summaries on creosote and related mixtures.

Wildman, Harrold, Allen & Dixon, IL/Jones, Day, Reavis & Pogue, OH – Provided litigation support regarding the state of the art in toxicology and risk assessment and in toxicological knowledge on a number of industrial chemicals and products from 1900 to present time. Chemicals included creosote, coal tar, and other PAH-containing mixtures.

Pepper, Hamilton & Sheetz, MI – Named as expert witness in toxic tort litigation associated with CERCLA former MGP site containing metal-complexed cyanides. Evaluated EPA Region V- and ATSDR- prepared toxicological reports and public health investigations. Assisted attorneys in deposing opposing witnesses.

Babst, Calland, Clements, and Zomnir, PA/Beazer East, Inc., PA – Designated as a fact witness regarding the risk assessment of PAHs an operating coke oven facility. Deposition was taken. Performed site-specific risk assessment of the facility which is adjacent to a residential neighborhood.

Bumgardner & Ellis, P.A., NJ – Performed detailed toxicological evaluation of dichloromethane and prepared expert report for submission to the court. The report evaluated reproductive and developmental toxicological data to determine if a single, short-term exposure might have caused a miscarriage as alleged by a worker at a warehouse for a national company that manufactures cleaning products.

Jones Day; Bartlit Beck Herman Palenchar & Scott; Timothy Hardy, Esq. – Serving as a defense expert witness on matters of exposure assessment and risk assessment in two Wisconsin lawsuits in which two persons have alleged that their current health problems are due, in whole, to exposure to the client's lead-based paint.

Bartlit Beck Herman Palenchar & Scott; Timothy Hardy, Esq. – Serving as a defense expert witness on matters of exposure assessment and risk assessment in a Chicago lawsuit in which a person has alleged that her learning disabilities are due, in whole, to exposure to the client's lead-based paint.

Bartlit Beck Herman Palenchar & Scott; Timothy Hardy, Esq.; Jones Day – Served as a defense expert witness on matters of exposure assessment and risk assessment in a lawsuit in which the City of Milwaukee sued two paint and pigment companies regarding lead-based paint in residential buildings. Evaluated scientific literature and government reports regarding current and historical blood lead levels in children; lead blood levels of concern as defined by various regulatory agencies; lead-based paint hazards as defined by various regulatory agencies; lead levels in household dust and children's blood following various remedial intervention strategies, such as paint remediation, paint stabilization, routine maintenance/cleaning, window replacement, window stabilization, etc.; EPA and HUD regulations concerning lead-based paint; the efficacy of simple maintenance and cleaning in managing lead-based paint risks; the sources of lead in urban soils in Milwaukee and elsewhere; and the many sources of childhood lead exposure, including deteriorated lead-based paint, lead in soil from historical emissions of lead from vehicles using leaded gasoline, and lead in soil from current and historical industrial emissions. Prepared an expert report, testified at deposition and testified at trial. Received kudos from the clients and the clients' attorneys for clear and persuasive courtroom testimony. The jury decided on behalf of the clients, and potential damages in excess of $40,000,000 were avoided.

Timothy Hardy, Esq.; Bartlit Beck Herman Palenchar & Scott; Alder Pollock & Sheehan P.C., Arnold & Porter; Higgins, Cavanaugh & Cooney; Halleland Lewis Nilan Sipkins & Johnson P.A.; Carroll, Kelly & Murphy; Jones Day; Cetrulo & Capone; McGuire, Woods, Battle & Boothe LLP; Vetter & White; Orrick, Herrington & Sutcliffe; Hinckley, Allen & Synder LLP; Petrarca and McGair, Inc.; McGrath North Mullin & Kratz P.C. – Served as a defense expert witness on matters of exposure assessment and risk assessment in a lawsuit in which the Attorney General sued the paint and pigment industry regarding lead-based paint in residential buildings in the State of Rhode Island. Evaluated scientific literature and government reports regarding current and historical blood lead levels in children; lead blood levels of concern

as defined by various regulatory agencies; lead-based paint hazards as defined by various regulatory agencies; lead levels in household dust and children's blood following various remedial intervention strategies, such as paint remediation, paint stabilization, routine maintenance/cleaning, window replacement, window stabilization, etc.; EPA and HUD regulations concerning lead-based paint; the efficacy of simple maintenance and cleaning in managing lead-based paint risks; and the many sources of childhood lead exposure, including deteriorated lead-based paint, lead in soil from historical emissions of lead from vehicles using leaded gasoline, and lead in soil from current and historical industrial emissions.. Testified at deposition three times.

Schultheis Tabler and Wallace, Ephrata, WA – Performed detailed toxicological evaluation of ammonia and prepared expert report for submission to the court. The report evaluated respiratory toxicological data to determine if a single, short-term exposure might have caused chronic respiratory effects as alleged by a railway worker who was working near a site from which ammonia fumes were alleged to have been released into the atmosphere. Attended deposition.

Hanley & Patch Attorneys, CA – Provided litigation support for lawsuit in which perchloroethylene was alleged to have been released by the client and to have decreased property values and caused unacceptable risks. Provided expert advice and courtroom testimony on the toxicity of perchloroethylene and the potential risks posed by their presence. Modeled volatilization into ambient and indoor air. Compared estimated exposures to typical exposures at dry cleaning facilities. Client won lawsuit based in large part on risk assessment testimony.

Massachusetts Attorney General's Office – Prepared an affidavit for Federal Court demonstrating that an imminent threat to public health was posed by the presence of chlorinated solvents in a residential area adjacent to a former electronics manufacturing facility. Prepared a supporting appendix, which was a detailed risk assessment. Gave courtroom testimony concerning the risk assessment approach.

Bourland, Heflin, Alvarez & Minor, TN; Sullivan & Worchester, MA; Tupperware, FL. – Serving as a defense expert witness with regard to allegations that solid and hazardous wastes were historically disposed on the site of an existing building and that constituents from those alleged disposals are causing unreasonable human health and environmental risks. Prepared expert report proving scientifically that the allegations were baseless.

Andrews Kurth, Dallas, Texas – Performing strategic consulting to Jacuzzi Brands, Inc. which is responsible to resolving all PCB issues at an operating facility that was sold to another entity. Evaluated TSCA regulations, investigated risk-based closure approaches, and developed strategies to minimize EPA oversight and maximize total site closure. Attended meeting with

EPA Region IV TSCA coordinator with client (seller) and buyer's consultants. Developed a site sampling plan in accordance with TSCA Subpart N and remediation options for the site.

Mounce, Green, Myers, Safi & Galatzan, TX/Jobe Concrete Products, Inc., El Paso, TX – Provided litigation support, expert witness services, and field sampling and analysis activities in support of a lawsuit in which plaintiffs' alleged that particulate matter from a quarry facility caused specific adverse health effects. Performed indoor dust and outdoor soil sampling for elements, minerals, fungi, bacteria, and specific allergens. Performed detailed literature searches. Evaluated reports of plaintiffs' experts. Evaluated medical records of plaintiffs. Assisted in deposing plaintiff's expert. Prepared field sampling report and expert opinion report.

Matsubara, Lee and Kotake, HI – Named as expert witness in litigation regarding a property that was the site of an automobile dealership, a warehouse and a former wood treatment site. Chemicals of concern include pesticides used in wood preservation: arsenic, chromium, dioxins/furans, and pentachlorophenol. Evaluated site characterization documents, performed *de novo* risk calculations, prepared expert reports and memoranda, prepared supplemental sampling plan, and attended meetings with plaintiffs' attorneys and regulatory agencies.

Hanley & Patch Attorneys, CA – Named as expert witness in a toxic tort case in California in which plaintiffs' alleged that chlordane and heptachlor applied to a home ten years earlier rendered their home uninhabitable. Designed and managed air quality sampling, analysis, and interpretation of data. Prepared Declaration regarding toxicology of chlordane and heptachlor and acceptable levels in homes. Critically evaluated laboratory data presented by plaintiffs. Prepared Rebuttal Declaration critically evaluating statements and conclusions of opposing expert witness. Evaluated Plaintiffs' residential sampling and analysis. Assisted attorneys in deposing opposing witnesses.

People's Gas Light & Coke Company, IL – Provided expert assistance on the toxicology and risk assessment of cyanide compounds found in soils near a residential neighborhood adjacent to a Region V site. Assisted in the preparation of public information fact sheets and briefing documents for company staff, and served as company's expert in public meetings. Designed and executed a laboratory bench experiment to simulate the accidental formation of hydrogen cyanide gas subsequent to the release of concentrated sulfuric acid from a railcar derailment in an area with metal cyanide compounds in the soil.

Dykema Gossett, MI – Named as expert witness in litigation. Critically evaluated risk-based cost allocation analysis for a client who was one of several PRPs at a former landfill that was a Region V Superfund site. Concluded that the analysis was erroneous in identifying client's perchloroethylene as the major risk contributor at the site. Identified major technical errors in opposing expert's analysis. Argued that it is inappropriate to base cost allocation on risk assessment results exclusively.

Waste Disposal Site Risk Assessment

SACO Tannery Waste Pits, ME – For EPA, conducted risk assessment for a CERCLA site that was used as a disposal area for tannery process wastes such as chromium sludges, acid wastes, methylene chloride, and caustic substances. Site media evaluate included groundwater, sediment and soil. Chemicals of potential concern included chromium, arsenic, and chlorinated solvents. Derived Absorption Adjustment Factors for chromium and other metals to allow the phenomenon of bioavailability to be included in the quantitative risk assessment.

Nyanza Chemical Company Superfund Site, Ashland, MA – For EPA, prepared the work plan for and managed the conduct of the human health and environmental risk assessment for the remedial investigation/feasibility study at former dye manufacturing plant. Chemicals of concern included benzidine, dichlorobenzidine, nitrobenzene, aniline, and various metals. Evaluated human health risks for ingestion of contaminated groundwater, direct contact with contaminated water in surface streams and marshes and in basement seepage, direct contact with marsh sediments, and inhalation of volatilized organics emanating from basement seepage water and groundwater used for showering and bathing. Critically evaluated the available literature on skin permeability constants and developed a suitable approach for this project.

Yaworski Landfill CERCLA Site, Hartford, CT – For EPA, prepared human health criteria for a CERCLA Alternate Concentration Limit Demonstration. Human health criteria were based on ingestion of fish, contact with surface water, contact with sediment, and ingestion of groundwater. Prepared a comprehensive document responding to all EPA Region I comments. Negotiated with EPA regarding appropriate approaches and methodologies. Prepared revised human health criteria based on outcome of negotiations.

Industri-Plex Site, MA – For EPA, performed risk assessment on CERCLA site used as a disposal site for tannery wastes. Chemicals of potential concern included chromium, arsenic, lead and other heavy metals. Derived Absorption Adjustment Factors for chromium and other metals to allow the phenomenon of bioavailability to be included in the quantitative risk assessment.

U.S. EPA, Washington, DC – Prepared Absorption Adjustment Factors for use in risk assessment for several metals commonly found at waste sites. Evaluated and summarized scientific literature on the bioavailability and absorption of these metals from various media, including water, food, and soil, and by various routes of exposure, including dermal and oral.

Pennsylvania Department of Environmental Protection – Evaluated risk assessment protocol, air dispersion protocol, and risk assessment reports for risk assessment of proposed re-grading of a 700 acre steel slag pile that was planned for residential development. Slag contained lead, manganese, chromium, and other heavy metals. Performed estimation of emissions of respirable particulates associated with excavation, trucking, and storage activities.

Derived health-based criteria that were protective of nearby residents' health for respirable particles and for individual chemicals present in site soils.

Dykema Gossett, MI – Named as expert witness in litigation. Critically evaluated risk-based cost allocation analysis for a client who was one of several PRPs at a former landfill that was a Region V Superfund site. Concluded that the analysis was erroneous in identifying client's perchloroethylene as the major risk contributor at the site. Identified major technical errors in opposing expert's analysis. Argued that it is inappropriate to base cost allocation on risk assessment results exclusively.

City of Detroit Legal Department – Provided expert testimony regarding a legal case in which PCBs from a Region V Landfill Superfund site were alleged to have caused specific adverse health effects. Prepared a written interrogatory and gave an oral deposition regarding the significance of specific PCB serum levels as an indicator of site-specific exposure versus general background exposure.

Public Works Government Services Canada – Assisting in implementation of air monitoring program for multiple mining and mineral processing sites in Nova Scotia, Canada. Prepared criteria for soil lead and other metals to determine health protectiveness of non-specific Total Suspended Particulate (TSP) and Particulate Matter 10 (PM10). Assessed whether ambient air standards for lead and other metals will be met if soil derived dust is present in the air at levels that do not exceed TSP and PM10 standards during site remediation work.

NIPSCO, IN – Performing a RCRA Facilities Investigation of an operating coal-fired power plant situated on Lake Michigan and the Indiana Dunes National Lakeshore Park under an accelerated consent order. Solid Waste Management Units include uncontrolled coal fly ash and bottom ash landfills, storage areas, and surface impoundments. Impacts of fly ash and bottom ash on the wetlands in the National Lakeshore and Lake Michigan are major concerns of the regulators. Negotiated with EPA Region V regarding scope of the investigation, sampling and analysis program, analyte lists, and screening criteria.

Haskon Corporation, Taunton, MA – For this aerospace manufacturing company, provided expert risk assessment consulting services regarding lead frit in soil. Evaluated extraction procedure to determine the bioavailability of specific lead species (lead frit) by the mammalian gastrointestinal tract to be used in a health risk assessment of the presence of the compounds in soil.

Princess House Inc., Taunton, MA – Performed risk assessment for lead frit in soil in accordance with the Massachusetts Contingency Plan.

Department of Public Works, Sydney, Nova Scotia – Performed dust and volatile chemical emission modeling and risk assessment of coke, coal, and coal tar in support of the definition of

exclusion zones for demolition of a former coke oven facility and coal tar distillery. Used EPA-approved models for estimation of PM10 emission factors associated with excavation, trucking, and storage activities and for estimation of volatile chemical emissions. Derived health-based criteria that were protective for nearby residents for short-term and long-term emissions of respirable particles, naphthalene, other volatile and semivolatile chemicals and selected metals. Performed risk assessment of deposited dust onto soil and garden produce. Derived emission factors for volatile chemicals for sludge excavation, dewatering, and stockpile storage associated with sewer pipe installation activities.

Department of Public Works, Sydney, Nova Scotia – Performed dust and volatile chemical emission modeling and risk assessment of coke, coal, and coal tar in support of the definition of exclusion zones for demolition of a former coke oven facility and coal tar distillery. Used EPA-approved models for estimation of PM10 emission factors associated with excavation, trucking, and storage activities and for estimation of volatile chemical emissions. Derived health-based criteria that were protective for nearby residents for short-term and long-term emissions of respirable particles, arsenic, lead, other metals, naphthalene, PAHs, and other volatile and semivolatile chemicals. Performed risk assessment of deposited dust onto soil and garden produce. Derived emission factors for volatile chemicals for sludge excavation, dewatering, and stockpile storage associated with sewer pipe installation activities.

AES, HI (Coal Combustion Ash) – Performed risk assessment consulting on risks posed by leaching and surface runoff of metals from coal combustion ash. Commented on proposed beneficial use permit. Performed fate and transport modeling and human health risk assessment.

Dykema Gossett, MI – Named as expert witness in litigation. Critically evaluated risk-based cost allocation analysis for a client who was one of several PRPs at a Region V Superfund site in Michigan (Boors Nobel Site). Concluded that the analysis was erroneous in identifying client's perchloroethylene as the major risk contributor at the site. Identified major technical errors in opposing expert's analysis. Argued that it is inappropriate to base cost allocation on risk assessment results exclusively.

New Bedford Harbor Superfund Site, MA – Provided quality assurance/quality control for the human health and environmental risk assessment for the New Bedford Harbor Superfund site in Massachusetts. Critically evaluated the methodology for estimating human exposures to PCBs and metals due to ingestion of fish and contact with surface water and sediments and the toxicity profiles for all contaminants. Performed a detailed evaluation of the pharmacokinetics of PCBs to develop a technically sound basis to assess the human health risks posed by dermal exposures to PCB-contaminated sediments.

Pennsylvania Department of Environmental Protection, Harrisburg, PA – Provided human health risk assessment support in reviewing documents regarding the NRC closure of a mixed

waste shallow land disposal area at an operating nuclear facility. Radionuclides present include uranium, thorium, and americium. Chemicals present include chlorinated solvents, metals, and uranium solubilizing agents. Materials disposed in the area include radionuclide contaminated laundry, gloves, laboratory wipes, glassware, and equipment. Critically evaluated both the radiological (RESRAD code) and chemical risk assessments previously prepared. Critically evaluated the adequacy of site characterization database. Suggested additional sampling for a Phase II field program. Derived acceptability criteria for evaluating down-hole gamma logging of sample borings within the waste trenches. Performed *de novo* risk assessment calculations. Performed failure risk assessment of proposed trench cap for a remedial option that called for stabilizing the waste in place.

Charles George Landfill Superfund Site, MA – Estimated exposure to and evaluated the human health effects of contaminants known to be present in groundwater, surface water, sediments, and ambient and landfill vent air. Relative absorption factors for all routes of exposure were derived for arsenic and other contaminants. Presented the results of this assessment to federal, state, and local officials and citizens at a public meeting. As part of the Feasibility Study for this site, derived health-protective cleanup levels for all media. Also assessed the public health benefits or liabilities posed by several alternative approaches considered for a site remediation.

United Technologies Corporation, Winthrop, ME – Developed Public Health Criteria as part of an Alternate Concentration Limit demonstration pursuant to CERCLA for a former municipal landfill. Estimated potential exposure to contaminants in a lake posed by direct contact with and ingestion of water during swimming and ingestion of fish. Developed relative absorption factors for 30 chemicals for three matrix/route situations.

Fort Indiantown Gap Military Reservation, Annville, PA – Performed risk-based prioritization of Potential Areas of Interest on 18,500 acre military reservation as part of the Preliminary Assessment and Site Inspection of the facility. Developed site-specific ranking tool based on EPA PreScore and PA-score software and Hazard Ranking System regulations and utilizing a site wide Geographical Information System (GIS).

CARY Chemicals, Farmingdale, NJ – Prepared risk-based soil cleanup levels for two phthalate esters: bis(2-ethylhexyl)phthalate and di(n-octyl)phthalate. Cleanup levels were derived for restricted and unrestricted land use scenarios and for both surface and subsurface soil conditions. The risk analysis was submitted to the NJ Department of Environmental Protection and Energy in support of a cost effective remediation strategy.

Cottman Avenue PRP Group, Richmond, VA – For the Cottman Avenue PRP Group, which consists of Virginia Power, Potomac Electric Power Company, and five other major middle Atlantic utilities, prepared a Pre-Design Work Plan for an EPA-mandated Remedial Design for a CERCLA site. Risk assessment was used as a tool to focus the soil and river sediment work

plan with the goal to limit the remedial action to the minimum effort required to be adequately protective of human health and the environment. Site-related constituents included PCBs and petroleum products.

Worker Risk Assessment Projects

Rite Aid Pharmacy, PA –Performed a critical evaluation of an Industrial Hygiene report on indoor air quality at an operating pharmacy building in New Jersey that was located adjacent to property that formerly housed a service station and a dry cleaner. Performed risk assessment calculations on chlorinated solvents and petroleum hydrocarbons. Made presentations to Rite Aid workers concerning indoor air quality.

Rite Aid Pharmacy, NC – Evaluated indoor air quality data on several warehouse buildings in North Carolina that were situated atop groundwater containing chlorinated solvents, including TCE and PCE, presumably released from former occupants of the buildings and other adjacent buildings. Planned and executed additional air quality sampling in several buildings. Performed risk assessment calculations and prepared a report.

Confidential Polymer Processor, CT – Performed toxicological evaluation of numerous chemicals to determine the cause of alleged health symptoms reported by people living near the facility. Focused on eye and lung irritation and delayed sensitization effects. Derived toxicological benchmarks for use in a human health risk assessment. Interfaced with client lawyers and negotiated with the state toxicologist.

City and County of Honolulu, Honolulu, HI – Performed indoor surface wipe testing of dust in a former municipal solid waste incinerator that is currently used as a maintenance shop and office space for employees of two City departments. Tested collected dust samples for lead and other heavy metals. Evaluated dust loading standards for the definition of lead-based paint as defined by EPA and HUD in residential buildings. Evaluated OSHA workplace floor dust criteria. Performed risk assessment calculations for workers using standard practices.

Confidential Client, Nationwide – Prepared risk-based lead wipe sample criteria for commercial buildings for a company that was vacating buildings and cleaning them for commercial re-use.

ENSCO, El Dorado, AR – Evaluated the scientific literature and prepared a toxicological evaluation of 2,4-dichlorophenol, phenol, and other chlorophenols to assist ENSCO in setting waste acceptance criteria that would be protective of worker's health.

New Brunswick Power, Fredericton, NB – Performed detailed toxicological evaluation of vanadium and prepared report that was submitted to potential clients of synthetic gypsum (flue gas desulfurization residue) who use it to manufacture wallboard. The report evaluated

respiratory toxicological data to determine if vanadium released in the manufacture and use of synthetic gypsum wallboard might have the potential cause certain respiratory effects that are known to be associated with a specific vanadium compound, vanadium pentoxide, which serves as the basis of the US EPA Reference Concentration for vanadium. Designed in vivo inhalation toxicology study to directly determine inhalation toxicity of both natural and synthetic gypsum. Designed in vitro toxicology study to determine the bioavailability of both natural and synthetic gypsum. Designed exposure study to measure the amount of dust released during the cutting of wallboard during use in construction activities.

3M Company, Minneapolis, MN – Conducted toxicological investigation of 70 chemicals and chemical mixtures, including solvents, dyes and pigments, and plastic resins and additives. Determined presence of chemicals on various regulatory lists and evaluated primary toxicological information. Chemicals were then prioritized to assist 3M in pollution prevention planning.

NiSource, Merrillville, IN – Provided risk assessment and toxicology consulting to gas utility concerning elemental mercury vapor because of Region V regulatory actions. Predicted indoor air mercury levels at various times assuming various spill scenarios using EPA models. Evaluated levels of mercury vapor commonly detected in dentists' offices and in locations of historical mercury spills. Evaluated health based criteria for mercury vapor exposure. Evaluated mercury vapor detection instruments.

Boston Gas Company, Medford, MA – Performed risk assessment consulting regarding a building formerly used for chemical manufacturing and formulating that was being considered for redevelopment as an office building. Performed a site inspection, a toxicological investigation of site-related chemicals, and risk assessment calculations.

Confidential Client, NY – Evaluated chemical composition data from an off-specification caulk product that was present in an office building. Prepared a toxicological evaluation of the constituents and evaluated potential risk to office workers.

Confidential Client, NM – Performed strategic consulting to client on indoor air quality sampling and data evaluation for an office building above a former TCE plume associated with a former Superfund site in Albuquerque, NM.

Confidential Tannery, MN – Conducted toxicological investigation of products and formulations to determine the cause of alleged respiratory sensitization symptoms in workers in one department. Evaluated ambient air monitoring reports and analytical methodologies. Performed literature searches and critical reviews of scientific papers.

Goodwin Proctor, UniFirst Corporation, MA ¬– Performed risk assessment for one of the largest and most complex chlorinated solvent site in Massachusetts. Tetrachloroethylene was

released from the site of a former dry cleaning warehouse facility and migrated beneath 40-50 homes and businesses in a residential neighborhood in Somerville, MA. Provided technical assessment of a State-proposed Unit Risk Factor (URF) for PCE and succeeded in convincing regulators to allow use of a realistic URF. Participated in Massachusetts Department of Environmental Protection Indoor Air Workgroup, attended meetings, and provided critical comments to draft Indoor Air Guidance documents. Attended public meetings, meetings with regulators, and meetings with staff and teachers at an affected school. Performed risk assessment calculations for PCE, TCE and other solvents and prepared multiple reports.

Confidential Client, NJ – Prepared a toxicological evaluation of tetrachloroethylene in an office building formerly used as a dry cleaning facility. Evaluated reported health symptoms associated with PCE exposure and evaluated specific symptoms and health effects reported by building staff. Prepared memorandum summarizing findings and briefed client and client legal staff.

Bank of America, NJ – Evaluated site data and assisted in work plan development for White Swan Superfund Site downgradient from a former dry cleaning facility. Tetrachloroethylene and other solvents had migrated beneath a large residential neighborhood. Attended meetings with US EPA and participated in scoping of RI/FS process.

Duke Energy, IN – Evaluated indoor air quality data from an office building adjacent to and on top of a former manufactured gas plant site. Performed Peer Review of risk assessment calculations and report. Advised client of significance of detected constituents.

Payette Company, MA – Performed indoor air quality assessment of an office building in which people were complaining about headaches and subjective symptoms. Evaluated the building, chemicals used, and staff complaints. Prepared memorandum summarizing findings.

Boston Gas Company, Boston, MA – Performed a Method 3 Phase II Risk Characterization of a former Manufactured Gas Plant site currently used as a private membership yacht club and marina. gas storage and distribution center. Chemicals evaluated included PAHs, TPH, cyanide, and lead. Receptors included on-site workers, construction and utility workers, and club members.

Consolidated Edison, NY – Prepared risk communication course for workers at Consolidated Edison's Astoria, Queens facility to discuss the RCRA RFI process in the areas previously used as a Manufactured Gas Plant facility. Discussed toxicological information regarding PAHs, coal tar, complexed cyanides, and other MGP-related chemicals.

Boston Gas Company, MA – Prepared toxicological evaluation of ferric ferrocyanide for presentation to workers at a former MGP site. Performed risk characterization of site groundwater to determine if volatile chemicals present in water in building basements could volatilize into the building.

Confidential Manufacturing Client, US – For a confidential electronic manufacturing client, provided senior oversight and technical review of a summary of information pertaining to radioactivity from the long -term releases from the malfunctioning Fukushima nuclear reactor complex located in Fukushima Prefecture, Japan. This summary discussed the potential for adverse worker safety-related impacts to workers at the client's facilities that received electrical components from suppliers located in Japan.

GEMCORE Site, CA - For Chevron Environmental Management Company, provided senior oversight and peer review of a risk assessment that evaluated the potential for adverse human health effects from exposure to arsenic, lead, and naturally occurring radioactive material (NORM) in soil at the Former Unocal/GEMCOR Geothermal Facility in Calipatria, California. The risk evaluation considered the hypothetical future exposure of solar power facility maintenance workers. For NORM, human exposures were estimated and radiological doses and cancer risks were calculated using RESRAD, Version 6.5.

City and County of Honolulu, Honolulu, HI – Performed indoor surface wipe testing of dust in a former municipal solid waste incinerator that is currently used as a maintenance shop and office space for employees of two City departments. Tested collected dust samples for lead and other heavy metals. Evaluated dust loading standards for the definition of lead-based paint as defined by EPA and HUD in residential buildings. Evaluated OSHA workplace floor dust criteria. Performed risk assessment calculations for workers using standard practices.

Solvent Risk Assessment/Indoor Air Risk Assessment

Confidential Client – Prepared Comments on EPA's *Proposed Classification of Trichloroethylene and Proposed Unit Risk Factor, February 2010*. Prepared 50 page scientific comment document and concluded that EPA's proposals were deficient because the implications of the proposal were not discussed, and no validation exercise was performed to determine if cancer incidence predictions made with the proposed Unit Risk Factor match the known incidence rates of RCC, liver and biliary cancer and NHL in the context of the many well characterized risk factors for these cancers.

Timex, AK – Evaluated groundwater and indoor air quality data from office buildings adjacent to and on top of former manufacturing facilities. Constituents of concern included TCE and other chlorinated and non-chlorinated solvents. Performed senior review and oversight of risk assessment calculations and report.

Goodwin Proctor, UniFirst Corporation, MA – Performing risk assessment consulting for a UniFirst –owned commercial building, a building containing a day care center, and a residential neighborhood at the Wells G&H Superfund site. Constituents of concern include TCE and PCE. Commented on EPA vapor intrusion

criteria, participated in workplan development, reviewed site data, prepared risk assessments, prepared reports, and attended meetings with EPA project managers. Planned and executed indoor air and subslab soil vapor sampling in numerous buildings and prepared sampling and analysis reports and human health risk assessment reports. Attended meetings with USEPA and parents of children at the day care center.

Confidential Client, NM – Performed strategic consulting to client on indoor air quality sampling and data evaluation for an office building above a former TCE plume associated with a former Superfund site in Albuquerque, NM.

Rite Aid Pharmacy, PA –Performed a critical evaluation of an Industrial Hygiene report on indoor air quality at an operating pharmacy building in New Jersey that was located adjacent to property that formerly housed a service station and a dry cleaner. Performed risk assessment calculations on chlorinated solvents and petroleum hydrocarbons. Made presentations to Rite Aid workers concerning indoor air quality.

Goodwin Proctor, UniFirst Corporation, VT – Performed risk assessment for a chlorinated solvent site in Vermont. Tetrachloroethylene was released from the site of a former dry cleaning operation and migrated beneath residential dwellings. Attended meetings with regulators. Performed risk assessment calculations for PCE, TCE, and other solvents.

Goodwin Proctor, UniFirst Corporation, NC – Performed risk assessment for a chlorinated solvent site in North Carolina. Tetrachloroethylene was released from the site of a former dry cleaning operation and migrated beneath the building which is now used as a warehouse for dry cleaning operations. Attended meetings with regulators. Performed risk assessment calculations for PCE, TCE, and other solvents and prepared multiple memoranda. Evaluated site data and made recommendations regarding site sampling and remedial options. Performed site-specific modeling of indoor air quality.

Goodwin Proctor, UniFirst Corporation, CA – Performed risk assessment for a chlorinated solvent site in Stockton, CA. Tetrachloroethylene was released from the site of a former dry cleaning operation and migrated beneath the building. Evaluated site data and made recommendations regarding site sampling and remedial options. Performed third party review of site-specific modeling of indoor air quality.

Confidential Client, NY – Prepared a toxicological evaluation of tetrachloroethylene in an office building adjacent to a former dry cleaning facility. Evaluated reported health symptoms associated with PCE exposure and evaluated specific symptoms

and health effects reported by building staff. Prepared memorandum summarizing findings and briefed client and client legal staff.

IBM, NY – Provided peer review of a toxicological analysis of perchloroethylene. Analysis was prepared to apprise IBM corporate staff of current developments in the toxicology and pharmacokinetic modeling of PCE. Topics presented included epidemiology, animal carcinogenicity bioassays, potential mechanisms of carcinogenicity, physiologically-based pharmacokinetic modeling, and relevance to human risk of PCE carcinogenicity in experimental animals.

Confidential Client, TX – Provided senior review and oversight of a risk assessment of perchloroethylene in groundwater associated with an industrial laundry. Risk assessment was prepared for litigation support and included a critical evaluation of the EPA's current cancer slope factor. Evaluated current pharmacokinetic modeling studies and presented alternate cancer slope factors based on best available science.

Boise Cascade Corporation, International Falls, MN – Prepared a critique of EPA's cancer slope factor for chloroform that was published in the Journal of the Technical Association of the Pulp and Paper Industry. Prepared comprehensive evaluation of the metabolism and bioavailability metabolism of chloroform.

Hanley & Patch Attorneys, CA – Provided litigation support for lawsuit in which perchloroethylene was alleged to have been released by the client and to have decreased property values and caused unacceptable risks. Provided expert advice and courtroom testimony on the toxicity of perchloroethylene and the potential risks posed by their presence. Modeled volatilization into ambient and indoor air. Compared estimated exposures to typical exposures at dry cleaning facilities. Client won lawsuit based in large part on risk assessment testimony.

Massachusetts Attorney General's Office – Prepared an affidavit for Federal Court demonstrating that an imminent threat to public health was posed by the presence of chlorinated solvents in a residential area adjacent to a former electronics manufacturing facility. Prepared a supporting appendix, which was a detailed risk assessment. Gave courtroom testimony concerning the risk assessment approach.

Texas Commission on Environmental Quality, TX – Performed strategic consulting to TCEQ on indoor air quality sampling and data evaluation for residences and schools above a petroleum plume associated with a historical release in McAllen, TX.

ThermoRetec, Concord, MA – Prepared iterative Method 3 risk characterization pursuant to Massachusetts Contingency Plan requirements for a former Manufactured Gas Plant that was planned for redevelopment as mixed land use that included underground parking, office space, a

hotel, and residential housing. Performed risk calculations according to several potential development scenarios. Informed developer that certain areas were acceptable for development and others were not. Estimated the risks due to volatilization of site-related constituents into current off-site buildings and into a potential underground parking garage.

Northern Utilities, NH – Performed risk assessment of volatiles entering sewer pipes and homes at a former manufactured gas plant site by the use of volatilization modeling approaches. Assisted in drafting scope of work for additional sample collection.

Solid Waste Risk Assessment

City and County of Honolulu, Honolulu, HI – Prepared and implemented Closure Plan for Subtitle D closure of a former municipal solid waste incinerator. Performed facility inventory and wipe sampling of internal facility surfaces for lead and other metals present in deposited ash-like material. Responded to State Department of Health (DOH) questions and attended meetings with DOH on client's behalf. Closure Plan includes plans for soil sampling and analysis, equipment cleaning, removal and recycling, building surface wipe sampling and risk assessment, groundwater modeling, ecological reconnaissance, and site wide risk assessment. Currently implementing Closure Plan.

City and County of Honolulu, Honolulu, HI – Designed and performed long-term environmental sampling, analysis and evaluation of test pavement containing solid waste combustion ash to determine if lead and other metals from the ash could be used beneficially in asphalt pavement without adverse effects to human health and the environment. Results from pavement wash, soil, and asphalt leachate samples demonstrate that there are no adverse environmental impacts from use of ash in asphalt from the pavement in use.

American Ref-Fuel, New York – Prepared a multipathway risk assessment for a municipal solid waste combustor for which air pollution control devices were being upgraded. Risk assessment was performed according to previously negotiated protocols for several different potential engineering configurations. Chemicals of potential concern included dioxins/furans, lead and other heavy metals.

City and County of Honolulu, Honolulu, HI – Prepared a Work Plan for the closure of a former municipal solid waste incinerator that is planned for redevelopment as an indoor soccer training center for children. The major constituents of concern are lead and other heavy metals in incinerator residues that cover equipment and indoor surfaces. The Work Plan includes cleaning, decommissioning, and recycling of piping, ductwork, equipment, etc., cleaning of building surfaces, wipe sampling of surfaces, and risk assessment assuming recreational use by children. Other aspects of the work plan include sampling and analysis of soil, groundwater, and surface water and sediment in drainage ways.

City and County of Honolulu, Honolulu, HI – Performed indoor surface wipe testing of dust in a former municipal solid waste incinerator that is currently used as a maintenance shop and office space for employees of two City departments. Tested collected dust samples for lead and other heavy metals. Evaluated dust loading standards for the definition of lead-based paint as defined by EPA and HUD in residential buildings. Evaluated OSHA workplace floor dust criteria. Performed risk assessment calculations for workers using standard practices.

City and County of Honolulu, Honolulu, HI – Designed and performed long-term environmental sampling, analysis and evaluation of test pavement containing solid waste combustion ash to determine if lead and other metals from the ash could be used beneficially in asphalt pavement without adverse effects to human health and the environment. Results from pavement wash, soil, and asphalt leachate samples demonstrate that there are no adverse environmental impacts from use of ash in asphalt from the pavement in use.

American Ref-Fuel, New York – Prepared a multipathway risk assessment for a municipal solid waste combustor for which air pollution control devices were being upgraded. Risk assessment was performed according to previously negotiated protocols for several different potential engineering configurations. Chemicals of potential concern included dioxins/furans, lead and other heavy metals.

Energy Answers, Rochester, MA – Performed risk assessment of the use of aggregate material produced from municipal solid waste combustor bottom ash in asphalt roadway construction. Evaluated leaching of lead and other metals from ash-aggregate-amended asphalt. Performed human health and environmental risk assessment of surface runoff and groundwater leachate. Participated in negotiations with MADEP. Assisted in preparation of Beneficial Use Permit.

Norlite Light Aggregate Kiln, NY – Performed risk assessment consulting to light aggregate kiln that was co-firing fuel oil and hazardous waste solvents and was producing an aggregate material that was mixed with combustion ash. Assisted in decision-making regarding the marketability of the product. Risk assessment activities focused on lead.

Ogden Projects, Fairfield, NJ – Performed critical evaluation of risk assessment documents addressing the beneficial reuse of municipal solid waste combustor ash from two municipal waste combustors. Risk assessment activities focused on the presence of lead in the combustor ash. Prepared a technical memorandum and participated in client conferences with the document authors.

City and County of Honolulu, Honolulu, HI – Prepared three human health risk assessments of the beneficial use of municipal solid waste combustion ash from the City and County of Honolulu's H-Power facility. One project considered the proposed use of the ash *in lieu* of clay

as part of the final cover in the closure of a city-owned landfill. The risk assessment considered risks from lead, other heavy metals, and dioxin and furan congeners. Risks during and after the closure were evaluated under several potential scenarios using EPA's IEUBK model and California's LeadSpread model. Receptors included workers, on-site trespassing children, and off-site children. Affected media included the ash, ash leachate, ash-derived dust, surface water and sediment, and fish. Dust generation and dispersion modeling was performed as well as modeling of surface runoff of ash into nearby surface water and sediment. Ash-specific absorption adjustment factors were derived for lead and other metals. A second project considered the proposed use of combustor ash as alternate daily cover at the City's operating municipal solid waste landfill. A third project considered the use of combustor ash as aggregate in road materials.

City and County of Honolulu, Honolulu, HI – Prepared a work plan for the environmental testing of a test roadway that would contain municipal solid waste combustion ash as a partial substitute for aggregate in the asphalt preparation. Prepared an operations plan for the manufacture of the ash-amended asphalt and the construction of the test roadway. Prepared a draft and final work plan for the evaluation of the leachate quality from the roadway materials containing ash. Constituents of concern were lead and other heavy metals. Provided oversight of the manufacture of ash-amended asphalt and the construction of the test roadway. Executed the four-year field sampling program for environmental testing of the test and control roadways. Summarized the environmental testing of municipal solid waste ash-amended asphalt. Test results included wash water analyses, analyses of the soil at the location of surface water runoff from the test and control roadways, and analysis of SPLP leachate of test cores of test and control asphalt. Prepared a plan for long-term testing of ash-amended asphalt.

City and County of Honolulu, Honolulu, HI – Performed risk assessment, air sampling, and legislative testimony in Senate committee hearing to address emergency concerns by the State, environmental activists, and local citizens concerning some unpermitted waste disposal activities at a former municipal solid waste incinerator. Disposal activities included disposal of solid waste combustion ash on the facility site and disposal on the adjacent ash landfill. Prepared a Human Health Risk Assessment of the City and County of Honolulu's Refuse Division and Department of Parks and Recreation workers who currently work at the closed Waipahu Incinerator complex, children and adults who use the adjacent Waipio Peninsula Soccer Complex, nearby residents, and hypothetical trespassers at the Waipahu Ash Landfill. Constituents of concern were lead, other heavy metals, and dioxins and furans.

Confidential MSW Ash Landfill – Provided risk assessment consulting services concerning the permitting requirements for expanding a municipal landfill that accepts municipal solid waste combustor ash, which contains lead, other heavy metals, and dioxins/furans. The landfill wished to gain state permission to use MSW combustor ash as landfill daily cover.

Confidential MSW Facility – Provided litigation support regarding a personal injury case in which plaintiffs alleged that they were been harmed by heavy metals, such as lead and cadmium, from a municipal solid waste combustor's stack emissions and/or fugitive dust from the municipal solid waste combustor ash. Evaluated plaintiff's medical data, identified various potential sources of heavy metal exposures, and performed various risk assessment calculations. Assisted in preparing interrogatories and responses to interrogatories.

City and County of Honolulu, Honolulu, Hawaii – Performed a multipathway human health risk assessment of emissions from the combustion of municipal solid waste at the City's combustor facility in advance of a permit application to build and operate a third boiler unit. Chemicals evaluated included lead, other heavy metals, polycyclic aromatic hydrocarbons and dioxin and furan congeners. Indirect risk assessment was performed in accordance with U.S. EPA combustor risk assessment guidance and included residents, farmers and fishers. Pathways included inhalation, ingestion of soil, ingestion of backyard produce, ingestion of drinking water, ingestion of fish, and ingestion of farm products. Using site-specific data the algorithms for the fate and transport of mercury were modified from EPA default values.

City and County of Honolulu, Honolulu, HI – Prepared a scope of work for a field sampling program to measure dust generation during asphalt roadway demolition using cold planer machines by cold planing. Executed a field sampling program for dust generation monitoring using NIOSH total and respirable dust methods and real-time PM10 monitors during roadway demolition. Constituents of concern included lead and other heavy metals. Concluded that dust generation from asphalt road demolition does not pose a significant risk to people adjacent residents or to workers. Prepared a report entitled "Air Monitoring of Roadway Demolition Activities, Beneficial Use of H-POWER Municipal Solid Waste Ash as an Aggregate for Road Materials.

Covanta Energy, Fairfield, New Jersey – Currently managing the preparation of an Environmental Impact Statement and Clean Air Act PSD permit application for the expansion of the City and County of Honolulu's H-POWER Energy-from-Waste facility. The current proposed project involves the addition of a new Mass Burn boiler and a new electric generation turbine. Constituents of concern include SOx, NOx, PM10, PM2.5, dioxins/furans, mercury, and others.

Covanta Energy, Fairfield, New Jersey – Performed human health risk assessment for and provided senior technical oversight of an Environmental Impact Statement and Clean Air Act PSD permit application for the expansion of the City and County of Honolulu's H-POWER Energy-from-Waste facility. The proposed project involved the addition of a third Refuse Derived Fuel boiler unit to the currently operating facility. The project was not built due to the decision of the City Council in 2005.

Covanta Energy, Fairfield, New Jersey – Performed human health risk assessment of PM10 and PM2.5 from Covanta's Marion County, Oregon Energy-from-Waste facility using published

concentration-response functions. Estimated levels of increased mortality and morbidity from all causes and from selected specific causes. Demonstrated that not one person would die or become ill from emitted fine particulate matter due to the facility expansion even using conservative concentration-response functions from epidemiological studies that have debatable scientific soundness.

Covanta Energy, Fairfield, New Jersey – Performed human health risk assessment of PM10 and PM2.5 from Covanta's Minneapolis, Minnesota Energy-from-Waste facility using published concentration-response functions. Estimated levels of increased mortality and morbidity from all causes and from selected specific causes. Demonstrated that not one person would die or become ill from emitted fine particulate matter due to the facility expansion even using conservative concentration-response functions from epidemiological studies that have debatable scientific soundness.

City and County of Honolulu, Honolulu, Hawaii – Performed a multipathway human health risk assessment of emissions from the combustion of municipal solid waste at the City's combustor facility in advance of a permit application to build and operate a third boiler unit. Chemicals evaluated included lead, other heavy metals, polycyclic aromatic hydrocarbons and dioxin and furan congeners. Indirect risk assessment was performed in accordance with U.S. EPA combustor risk assessment guidance and included residents, farmers and fishers. Pathways included inhalation, ingestion of soil, ingestion of backyard produce, ingestion of drinking water, ingestion of fish, and ingestion of farm products. Using site-specific data the algorithms for the fate and transport of mercury were modified from EPA default values.

Covanta Energy, Inc., Haverhill, MA –- Prepared a Scope of Work for the multipathway human health risk assessment of a landfill disposal area for municipal solid waste combustion ash in accordance with MADEP guidance using EPA combustor risk assessment guidance. Designed and performed a site-specific monitoring program to measure total and respirable suspended particulates with Hi-Vol samplers and NIOSH personal monitors and to measure PM10 levels with a Personal DataRAM real-time monitor. In addition, total metals, such as arsenic, nickel and mercury, were analyzed, as was diesel particulate (organic and elemental carbon). Prepared report arguing that dust levels attributable to ash disposal were caused by diesel exhaust and not ash dumping or compacting.

City and County of Honolulu, Honolulu, HI –Prepared a scope of work for a field sampling program to measure respirable particulate generation during asphalt roadway demolition using cold planer machines by cold planing. Executed a field sampling program for particulate monitoring using NIOSH total and respirable dust methods and real-time PM10 monitors during roadway demolition. Concluded that respirable particulate generation from asphalt road demolition does not pose a significant risk to people adjacent residents or to workers. Prepared a report entitled "Air Monitoring of Roadway Demolition Activities, Beneficial Use of H-POWER Municipal Solid Waste Ash as an Aggregate for Road Materials.

City and County of Honolulu, Honolulu, HI – Designed and performed sampling for total particulates and respirable particulates and analyzed for metals, crystalline silica, and particle-bound and vapor phase mercury in ambient air at an operating municipal solid waste landfill adjacent to a residential development during a demonstration project in which municipal solid waste ash was used as daily landfill cover. Evaluated and validated laboratory data. Prepared risk assessment reports that addressed the health of landfill workers, members of the public that visited the landfill, and nearby residents. Concluded that use of ash as alternate daily landfill cover does not pose significant adverse human health risks. Provided technical support on issues raised during the public hearing process with regard to a proposal to extend the landfill operating permit.

American Ref-Fuel, New York – Provided peer review for a multipathway risk assessment prepared by another company for a proposed municipal solid waste combustor. Provided strategic risk assessment consulting. Chemicals of potential concern included dioxins/furans and metals.

American Ref-Fuel, New York - Provided strategic risk assessment consulting services by critiquing and modifying a previously prepared protocol for a hazardous waste combustor. Chemicals of potential concern included dioxins/furans and metals. Met with NYSDOH and NYSDEC on numerous occasions. Negotiated innovative and more realistic approaches with the agencies.

American Envirotech, Inc., Houston, Texas – Prepared indirect pathway risk assessment for proposed hazardous waste incinerator in accordance with major aspects of EPA's draft Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions. Prepared a detailed protocol document in negotiation with the Texas Natural Resources Conservation Commission. Developed alternate approach for assessing direct uptake of dioxin vapor into plants. Evaluated risks for six different receptors and performed risk zone analysis per EPA and TNRCC requests.

Municipal Solid Waste Combustor, Pennsylvania – Performed a multiple exposure pathway, multiple-compound, multiple media risk assessment for permitting a new combustor in accordance with Pennsylvania and state-of-the-art guidelines. Projected emissions dispersion and performed deposition modeling to provide ground-level ambient concentrations and accumulation of emitted materials in solids, dusts and food chains. Chemicals of potential concern included dioxins/furans and metals. Although food chain exposures posed the largest potential risks, no unacceptable risks were identified by the assessment. Attended public meetings.

Energy Answers, Rochester, MA (MSW Combustion Ash) – Performed risk assessment of the use of aggregate material produced from municipal solid waste combustor bottom ash in asphalt roadway construction. Evaluated leaching of lead and other metals from ash-aggregate-

amended asphalt. Performed human health and environmental risk assessment of surface runoff and groundwater leachate. Participated in negotiations with MADEP. Assisted in preparation of Beneficial Use Permit.

Ogden Projects, Fairfield, NJ – Performed critical evaluation of risk assessment documents addressing the beneficial reuse of municipal solid waste combustor ash from two municipal waste combustors. Risk assessment activities focused on the presence of lead in the combustor ash. Prepared a technical memorandum and participated in client conferences with the document authors.

City and County of Honolulu, Honolulu, HI – Prepared three human health risk assessments of the beneficial use of municipal solid waste combustion ash from the City and County of Honolulu's H-Power facility. One project considered the proposed use of the ash *in lieu* of clay as part of the final cover in the closure of a city-owned landfill. The risk assessment considered risks from lead, other heavy metals, and dioxin and furan congeners. Risks during and after the closure were evaluated under several potential scenarios using EPA's IEUBK model and California's LeadSpread model. Receptors included workers, on-site trespassing children, and off-site children. Affected media included the ash, ash leachate, ash-derived dust, surface water and sediment, and fish. Dust generation and dispersion modeling was performed as well as modeling of surface runoff of ash into nearby surface water and sediment. Ash-specific absorption adjustment factors were derived for lead and other metals. A second project considered the proposed use of combustor ash as alternate daily cover at the City's operating municipal solid waste landfill. A third project considered the use of combustor ash as aggregate in road materials.

City and County of Honolulu, Honolulu, HI – Prepared a work plan for the environmental testing of a test roadway that would contain municipal solid waste combustion ash as a partial substitute for aggregate in the asphalt preparation. Prepared an operations plan for the manufacture of the ash-amended asphalt and the construction of the test roadway. Prepared a draft and final work plan for the evaluation of the leachate quality from the roadway materials containing ash. Constituents of concern were lead and other heavy metals. Provided oversight of the manufacture of ash-amended asphalt and the construction of the test roadway. Executed the four-year field sampling program for environmental testing of the test and control roadways. Summarized the environmental testing of municipal solid waste ash-amended asphalt. Test results included wash water analyses, analyses of the soil at the location of surface water runoff from the test and control roadways, and analysis of SPLP leachate of test cores of test and control asphalt. Prepared a plan for long-term testing of ash-amended asphalt.

City and County of Honolulu, Honolulu, HI – Performed risk assessment, air sampling, and legislative testimony in Senate committee hearing to address emergency concerns by the State, environmental activists, and local citizens concerning some unpermitted waste disposal activities at a former municipal solid waste incinerator. Disposal activities included disposal of solid waste

combustion ash on the facility site and disposal on the adjacent ash landfill. Prepared a Human Health Risk Assessment of the City and County of Honolulu's Refuse Division and Department of Parks and Recreation workers who currently work at the closed Waipahu Incinerator complex, children and adults who use the adjacent Waipio Peninsula Soccer Complex, nearby residents, and hypothetical trespassers at the Waipahu Ash Landfill. Constituents of concern were lead, other heavy metals, and dioxins and furans.

City and County of Honolulu, Honolulu, HI – Prepared Closure Plan for Subtitle D closure of a unused municipal solid waste incinerator. Performed facility inventory and wipe sampling of internal facility surfaces for lead and other metals present in deposited ash-like material. Responded to State Department of Health (DOH) questions and attended meeting with DOH on client's behalf. Closure Plan includes plans for soil sampling and analysis, equipment cleaning, removal and recycling, building surface wipe sampling and risk assessment, groundwater modeling, ecological reconnaissance, and site wide risk assessment.

Confidential MSW Ash Landfill – Provided risk assessment consulting services concerning the permitting requirements for expanding a municipal landfill that accepts municipal solid waste combustor ash, which contains lead, other heavy metals, and dioxins/furans. The landfill wished to gain state permission to use MSW combustor ash as landfill daily cover.

Confidential MSW Facility – Provided litigation support regarding a personal injury case in which plaintiffs alleged that they were been harmed by heavy metals, such as lead and cadmium, from a municipal solid waste combustor's stack emissions and/or fugitive dust from the municipal solid waste combustor ash. Evaluated plaintiff's medical data, identified various potential sources of heavy metal exposures, and performed various risk assessment calculations. Assisted in preparing interrogatories and responses to interrogatories.

City and County of Honolulu, Honolulu, HI – Prepared a scope of work for a field sampling program to measure dust generation during asphalt roadway demolition using cold planer machines by cold planing. Executed a field sampling program for dust generation monitoring using NIOSH total and respirable dust methods and real-time PM10 monitors during roadway demolition. Constituents of concern included lead and other heavy metals. Concluded that dust generation from asphalt road demolition does not pose a significant risk to people adjacent residents or to workers. Prepared a report entitled "Air Monitoring of Roadway Demolition Activities, Beneficial Use of H-POWER Municipal Solid Waste Ash as an Aggregate for Road Materials.

City and County of Honolulu, Honolulu, HI – Developed a facility Closure Plan for a former municipal waste incinerator that contains a large PCB transformer bank. Evaluated TSCA regulations, investigated risk-based closure approaches, and developed strategies to minimize EPA oversight and maximize total site closure. Participated in conference calls with Hawaii Department of Health.

Heavy Metals Risk Assessment

New Brunswick Power, Fredericton, New Brunswick – Performed third party critique of human health risk assessment plan and site-specific bioavailability test plan for lead and arsenic in residential soil in properties downwind from coal fired power plant.

Confidential Client, Nationwide – Prepared risk-based lead wipe sample criteria for commercial buildings for a company that was vacating buildings and cleaning them for commercial re-use.

City of El Paso, TX – Served as the Mayor's office and the City Health Department's expert on the exposure assessment and risk assessment of lead in soil in ten residential neighborhoods near a smelter site that EPA was considering listing as CERCLA sites. Made presentations to EPA, TDOH, TNRCC, and ATSDR on City's behalf and served on working groups with the above agencies as the City's designated representative. Evaluated and commented on work plans for and results of residential soil sampling, site-specific testing for model parameterization of EPA's Integrated Exposure Uptake Biokinetic Model for lead in children, site-specific bioavailability studies, and heath surveys attempting to identify the principal causes of children's lead levels in those with levels higher than 10 ug/dL in the study area. Compiled and evaluated historical and current children's blood lead levels in the study area, other areas in El Paso County, and other jurisdictions. investigated other sources of children's blood lead levels besides residential soil. Participated in derivation of site-specific action levels and identification of potential remedial approaches.

Home of the Innocents, Louisville, KY – Prepared risk assessment pursuant to KY regulations on a currently operating stockyard and slaughterhouse that was being considered for redevelopment as a home for orphans. Site-related chemicals of concern included lead and arsenic. Risk assessment calculations focused on young children as sensitive receptors. Served as potential buyer's risk assessment consultant in meetings with State environmental regulators.

Pennsylvania Department of Environmental Protection – Critically evaluated risk assessment supporting a site-specific clean-up standard for lead in soil at a metal reclamation facility. Attended site and client meetings.

Plympton PRP Group, Plympton, MA – Prepared detailed technical memorandum addressed to the Massachusetts DEP arguing that lead soil cleanup levels need not be set lower than the state's promulgated standard of 300 mg/kg. No public health benefits were shown to result from designation of the background concentration as a site-specific cleanup standard.

Confidential Client, Washington, D.C. – Prepared generic multipathway risk assessment for lead emissions from 21 cement kilns permitted by RCRA to combust hazardous waste according to EPA's 1994 Screening Level Risk Guidance. Compared estimated child blood lead levels and

estimated lifetime cancer risk associated with baseline emissions levels and proposed MACT standards. Direct and indirect pathways were evaluated, including beef, pork, chicken, egg, dairy product, and fish ingestion.

California Dept. of Health Services – Prepared a comprehensive human health effects assessment of inorganic nickel. Derived health-related limits and goals for use in emergency and remedial actions at California hazardous waste sites. This project required a critical evaluation of scientific reports regarding all aspects of the toxicology of nickel compounds. An important aspect of this assessment was the derivation of toxicokinetic factors from comparisons of the absorption, metabolism, and elimination of the contaminant by humans and the experimental animals that were used in the quantitative toxicity studies.

Regulatory Toxicology

Resorcinol Task Force, Gloucestershire, United Kingdom – Attended various annual meetings, discussed the derivation of the Reference Dose (RfD) for resorcinol derived by AMEC and approved by a review panel convened by TERA, and participated in discussions about RTF's draft report of the guideline-compliant full two generation reproductive study in rats. Assisted in the evaluation of the WHO CICAD and in the preparation of the recent SIAR as a toxicology reviewer.

Babst, Calland, Clements, and Zomnir, PA – Derived and documented an oral health-based toxicological criterion (Reference Dose) for resorcinol based on newly available data from a range finding study of a guideline compliant two-generation reproduction and developmental toxicity study in rats sponsored by the Resorcinol Task Force. Evaluated the published literature. Prepared a comprehensive toxicological evaluation. Presented proposed Reference Dose at expert panel meeting arranged by Toxicology Excellence in Risk Assessment (TERA). Evaluated and responded to panel comments. Presented updated findings to TERA panel. Presented Reference Dose at meeting of Pennsylvania Science Advisory Board.

Babst, Calland, Clements, and Zomnir, PA – Critically evaluated and prepared comments on the EPA's High Production Volume Data Summary and Test Plan for resorcinol.

Babst, Calland, Clements, and Zomnir, PA – Critically evaluated and prepared comments on an ATSDR Public Health Assessment on the Bear Creek Waste Disposal Area. Evaluated and prepared comments on the toxicological evaluations of resorcinol, benzene sulfonate, meta benzene disulfonate, and para hydroxyl benzene sulfonate.

Farchemia, Milan, Italy – Derived and documented human health risk-based guidelines for drinking water consumption for two pharmaceuticals, carbamazepine and dimetridazole, using standard risk assessment methods and procedures. For carbamazepine and dimetridazole, no Tolerable Daily Intake (TDI) or an Acceptable Daily Intake (ADI) values were available in the

published literature. AMEC risk assessors searched the published toxicology literature, summarized the literature on adverse effects and the dose levels at which they occurred, and derived a TDI using the methods and procedures that are in normal use by regulatory agencies. From the TDIs, groundwater remedial goals for the two pharmaceuticals were derived and documented.

Confidential Client, PA – Provided product registration services to a client who filed a Premanufacture Notice under the Toxic Substances Control Act with incorrect information about the identify of a reactant, which was supplied as a confidential trade mark reactant. Prepared amendment to the Premanufacture Notice and investigated the potential legal liability associated with supplying incorrect information to the USEPA.

Babst, Calland, Clements, and Zomnir, PA – Derived and documented oral health-based toxicological criteria (Reference Doses) for benzene sulphonate, meta benzene disulphonate, and para hydroxyl benzene sulphonate from toxicological studies designed, placed, managed, and evaluated for the client. Toxicological studies for the three constituents included: mutagenicity studies in bacteria and mammalian cells, 17-day range finding studies in rats, and 13-week studies in rats.

Beazer East, Inc., PA – Designed, placed, managed, evaluated and summarized dermal irritation toxicological studies in rabbits for benzene sulphonate, meta benzene disulphonate, and para hydroxyl benzene sulphonate. Results were published in a peer-reviewed journal.

Schultheis Tabler and Wallace, Ephrata, WA – Performed detailed toxicological evaluation of ammonia and prepared expert report for submission to the court. The report evaluated respiratory toxicological data to determine if a single, short-term exposure might have caused chronic respiratory effects as alleged by a railway worker who was working near a site from which ammonia fumes were alleged to have been released into the atmosphere. Attended deposition.

Osaka Gas Company, Japan – Evaluated toxicology and risk assessment laws and regulations for UK, US, Canada, Germany, Netherlands, and other European countries, prepared report comparing approaches to waste site management among countries, and made recommendations concerning the best approach for a waste site in Japan.

Beazer East, Inc., PA – Designed, placed, managed, evaluated and summarized dermal penetration studies in human skin for benzene sulphonate, meta benzene disulphonate, and para hydroxyl benzene sulphonate. Results were published in a peer-reviewed journal.

Confidential Tannery, MN – Conducted toxicological investigation of products and formulations to determine the cause of alleged respiratory sensitization symptoms in workers in one

department. Evaluated ambient air monitoring reports and analytical methodologies. Performed literature searches and critical reviews of scientific papers.

Commonwealth of Pennsylvania, Pittsburgh, PA – Evaluated toxicological evaluation of TPH from diesel fuel prepared by Conrail in support of a state-wide clean-up standard for TPH. Presented alterative approach that was incorporated into the document.

U.S. EPA, Washington, DC – Assessed the suitability of using the EPA RQ scheme for ranking chronic toxic effects for the purpose of Emissions Inventory Reporting. Prepared additional toxicity criteria for implementation of Section 313 of the Superfund Amendments.

Hawaii Department of Health, Honolulu, HI – Served as toxicology consultant to HDOH in addressing the concerns of a community group who alleges abnormally high rates of birth defects and learning disabilities in their children due to pesticide residues from former agricultural use of the land upon which their community was built. Performed toxicological evaluation of 50 chemicals of potential concern, which included organic herbicides, chlorinated hydrocarbons, arsenic, chromium and dioxins/furans. Risk assessment calculations demonstrated that the chemicals detected in residential soils could not have been causally related to any effects alleged by community members. Made presentations to members of the public and attended meetings with HDOH.

Massachusetts Natural Gas Council, MA – Performed toxicological evaluation of ferric ferrocyanide for submission to the U.S. Environmental Protection Agency to assist them in determining if ferric ferrocyanide should be listed as a CERCLA Hazardous Substance.

California Dept. of Health Services – Prepared a comprehensive human health effects assessment of inorganic nickel. Derived health-related limits and goals for use in emergency and remedial actions at California hazardous waste sites. This project required a critical evaluation of scientific reports regarding all aspects of the toxicology of nickel compounds. An important aspect of this assessment was the derivation of toxicokinetic factors from comparisons of the absorption, metabolism, and elimination of the contaminant by humans and the experimental animals that were used in the quantitative toxicity studies.

American Red Cross, Washington, DC – Served on expert panel of toxicologists that evaluated the use of bis(2-ethylhexyl)phthalate (BEHP) and a new citrate based plasticizer in blood bags. Because BEHP, which has a history of safe use in blood bags, has been shown to cause tumors in rodents who are fed large doses over their lifetime, alternative plasticizers were developed by blood bag vendors. Upon comparison of the toxicological data from both chemicals, the panel recommended that use of BEHP be continued.

U.S. EPA, Washington, DC – Prepared a critical evaluation of the available information on the carcinogenicity, mutagenicity, reproductive effects and developmental effects caused by

inorganic fluorides. U.S. EPA used this report in making decisions regarding the merit of a petition to have inorganic fluoride added to the SARA Section 313 list.

IBM, NY – Provided peer review of a toxicological analysis of perchloroethylene. Analysis was prepared to apprise IBM corporate staff of current developments in the toxicology and pharmacokinetic modeling of PCE. Topics presented included epidemiology, animal carcinogenicity bioassays, potential mechanisms of carcinogenicity, physiologically-based pharmacokinetic modeling, and relevance to human risk of PCE carcinogenicity in experimental animals.

Confidential Client, TX – Provided senior review and oversight of a risk assessment of perchloroethylene in groundwater associated with an industrial laundry. Risk assessment was prepared for litigation support and included a critical evaluation of the EPA's current cancer slope factor. Evaluated current pharmacokinetic modeling studies and presented alternate cancer slope factors based on best available science.

Boise Cascade Corporation, International Falls, MN – Prepared a critique of EPA's cancer slope factor for chloroform that was published in the Journal of the Technical Association of the Pulp and Paper Industry. Prepared comprehensive evaluation of the metabolism and bioavailability metabolism of chloroform.

Boston University School of Medicine – Served as Adjunct Assistant Professor of Toxicology, 1989-1992. Taught graduate level course in toxicology to medical doctors and graduate students in public health.

City of Detroit Legal Department – Provided expert testimony regarding a legal case in which PCBs from a Region V Superfund site were alleged to have caused specific adverse health effects. Prepared a written interrogatory and gave an oral deposition regarding the significance of specific PCB serum levels as an indicator of site-specific exposure versus general background exposure.

New Brunswick Power, Fredericton, New Brunswick – Performed toxicological evaluation of respirable particulate matter. Approximately fifty epidemiology studies and government documents allegedly linking quantifiable cases of health effects with respirable particulate matter were evaluated and critiqued. These documents included the Canadian “National Ambient Air Quality Objectives for Particulate Matter,” the U.S. “Air Quality Criteria for Particulate Matter,” and dozens of scientific papers from the primary literature. In addition, several computer models allegedly estimating quantifiable cases of health effects were evaluated and critiqued. These include the Illness Costs of Air Pollution (ICAP) model developed for the Ontario Medical Association and the Air Quality Valuation Model (AQCM) developed by Health Canada/Environment Canada.

Beazer East Inc., Pittsburgh, PA – Critically evaluated acute toxicity data on arsenic and derived acute toxicity benchmark for use at a former wood treatment site. Benchmark was used to determine if one-time exposures to soil hotspots would be protective of acute toxicity endpoints.

Ogden Projects, Inc., Stanislaw, CA – Performed technical oversight of air dispersion modeling of a hypothetical accidental release of anhydrous ammonia. Conducted toxicological evaluation of acute toxicity data on ammonia. Determined appropriate health-based benchmarks for various exposure times.

PACIFIC Division Naval Facilities Engineering Command, CLEAN, HI – Prepared and submitted comments to the National Toxicology Program regarding their proposal to list naphthalene as “reasonably anticipated to be a human carcinogen” in the Eleventh Edition of *Report on Carcinogens.*

Confidential Client – Performed critical review of dioxin toxicology literature. Identified and critically reviewed the key historical and recent papers on the potential toxicity of dioxin and related compounds in support of possible litigation. Human and animal studies investigating reproductive and developmental effects, immunologic effects, carcinogenic effects, and mechanism of action and pharmacokinetics were included in the review.

Massachusetts Natural Gas Council – Developed and validated a Physiologically Available Cyanide Method for measuring cyanide in soil samples from hazardous waste sites. The method was developed under strict supervision of the Massachusetts DEP and is used to implement an agency-derived "imminent threat" benchmark concentration.

Massachusetts Natural Gas Council, MA – Critically evaluated and prepared formal comments on Massachusetts Department of Environmental Protection proposed policy on risk assessment of PAHs. Demonstrated that experimental data on naphthalene and other PAHs were not sufficient to classify them as potentially carcinogenic PAH. Presented information showing that literature on PAH interactions does not support a conclusion that PAH given together result in synergistic effects.

New England Power Company, Westborough, MA – Evaluated health effects of electromagnetic fields associated with high voltage power lines for an Environmental Impact Statement. Briefed NEP management on state of the science regarding potential health effects.

Confidential Client, MT – For this rail yard site, performed a detailed toxicological evaluation of diesel fuel. Evaluated state and federal clean-up level precedents for total petroleum hydrocarbons. Proposed a risk-based sampling plan for site soils. Derived groundwater action levels for three groundwater use scenarios: ingestion, incidental contact, and watering of produce.

Atochem, Tacoma, WA – Reviewed and evaluated data showing that EPA's cancer slope factor for arsenic is inappropriate. Current information demonstrates that low doses of ingested arsenic are efficiently metabolized to a nontoxic form in the body. At the high doses at which toxic effects are seen, this process is saturated and is inefficient. Thus, linear low dose extrapolation models are inappropriate. Also, performed laboratory experiment to estimate the site-specific bioavailability of arsenic, which was less than the default value assumed by Washington state regulators.

ThermalKEM, SC – Served as ThermalKEM's representative on Advisory Committee for a University of South Carolina epidemiology study around a hazardous waste incinerator.

American Paper Institute, Washington, DC – Evaluation of body weight versus surface area dose scaling for dioxin. Critically evaluated the appropriate method for scaling laboratory animal dioxin doses to humans. Documented in a written report that body weight scaling was scientifically appropriate and that EPA's cancer slope factor was an overestimate.

Georgia-Pacific, NC – Critically evaluated the North Carolina Department of Health's use of toxicity data to derive a fish advisory for dioxin. Recommended to DOH that pathology data from EPA's animal study using current NTP pathology guidelines be used, as well as body weight dose scaling.

DuPont, Wilmington, DE – Critically evaluated the primary toxicity studies from which EPA derived RfC's for CrVI and CrIII. While the value was not unreasonable for CrVI, it was scientifically inappropriate to use the same data from chromate workers to derive a RfC for CrIII. Data were presented to demonstrate that CrIII is much less toxic than CrVI. EPA subsequently removed both values from its IRIS database, but a RfC for total chromium, regardless of speciation, was proposed using the same CrVI data.

American Ref-Fuel, Houston, TX – Critically evaluated the state's derivation of a cancer slope factor for chromium that is four times higher than EPA's value. Presented dosimetry arguments to demonstrate that EPA's value adequately health protective.

American Ref-Fuel, Houston, TX – Prepared scientific arguments that municipal solid waste combustor emitted CrVI would significantly transform to CrIII before reaching an exposure point and that absorbed CrVI would significantly transform to CrIII in the human body before reaching target tissues. Cited EPA reports that document such processes. Presented arguments to New York and Texas regulators, respectively, that such processes should be quantitatively modeled. Both regulators agreed with the conceptual arguments and agreed to carefully consider quantitative estimates, if presented.

Pesticide Risk Assessment

Department of Food and Agriculture, MA – Serving as Massachusetts' Governor's appointed toxicologist to the Department of Food and Agriculture's Pesticide Board since 1998.

Opryland Hotel, TN – Performed risk assessment of herbicide and pesticide residues in soils on commercial land that had formerly been used as agricultural land and that was being developed for a hotel expansion. Pesticides included DDT, DDE, DDD and others. Designed air monitoring program to measure pesticide emissions during soil excavation and transfer activities. Evaluated site data.

Confidential Client, MD – Provided expert consulting to attorneys defending a toxic tort case in Maryland in which plaintiffs' alleged that chlordane and heptachlor applied to their home before purchase made their home uninhabitable. Evaluated plaintiffs' data, designed defendants'' sampling and analysis program, and performed risk assessment calculations on chlordane, heptachlor and chlorpyrifos.

Hawaii Department of Health – Served as toxicology consultant to HDOH in addressing the concerns of a community group who alleged abnormally high rates of birth defects and learning disabilities in their children due to herbicide and pesticide residues from former agricultural use of the land upon which their community was built. Chemicals of potential concern included chlorinated hydrocarbons, such as DDT, DDE, DDD, chlordane, heptachlor, 2,4-D, 2,4,5-T, 2,4,5-TP, lindane and others, organic herbicides, arsenic, chromium and dioxins/furans. Risk assessment calculations demonstrated that the chemicals detected in residential soils could not have been causally related to any effects alleged by community members. Made presentations to members of the public and attended meetings with HDOH.

Hanley & Patch Attorneys, CA – Named as expert witness in a toxic tort case in California in which plaintiffs' alleged that chlordane and heptachlor applied to a home ten years earlier rendered their home uninhabitable. Detected chemicals included chlorinated hydrocarbons, such as DDT, DDE, DDD, chlordane, heptachlor, 2,4-D, 2,4,5-T, 2,4,5-TP, lindane and others. Designed and managed air quality sampling, analysis, and interpretation of data. Prepared Declaration regarding toxicology of chlordane and heptachlor and acceptable levels in homes. Critically evaluated laboratory data presented by plaintiffs. Prepared Rebuttal Declaration critically evaluating statements and conclusions of opposing expert witness. Evaluated Plaintiffs' residential sampling and analysis. Assisted attorneys in deposing opposing witnesses.

Confidential Tannery, MN – Conducted toxicological investigation of products and formulations, including fungicides, to determine the cause of alleged respiratory sensitization symptoms in workers in one department of an operating facility. Evaluated ambient air monitoring reports and analytical methodologies. Performed literature searches and critical reviews of scientific papers.

The World Bank, United Nations, Washington, DC – Prepared reports and memoranda on a variety of topics germane to Third World development, including the effects of U.S. pesticide regulations on marketability of pyrethrum pesticides produced in Tanzania and the role of the World Bank as a technology transfer institution.

Matsubara, Lee and Kotake, HI – Named as expert witness in litigation regarding a property that was the site of an automobile dealership, a warehouse and a former wood treatment site. Chemicals of concern include pesticides used in wood preservation: arsenic, chromium, dioxins/furans, and pentachlorophenol. Evaluated site characterization documents, performed *de novo* risk calculations, prepared expert reports and memoranda, prepared supplemental sampling plan, and attended meetings with plaintiffs' attorneys and regulatory agencies.

Other Risk Assessment Projects

New Brunswick Power, Fredericton, NB – Performed an assessment of vanadium in ash from Orimulsion (c) and petroleum coke, typical levels of vanadium in human blood and urine, and human exposure indicators. Prepared a report and briefed workers and quarterly safety meeting.

New Brunswick Power, Fredericton, N.B. – Prepared a White Paper on the toxicology of petroleum coke, a fuel that is being used at an electric generation power plant, to address worker concerns about exposures during routine operations.

Hawaii Department of Transportation, HI – Prepared human health risk assessment of natural and depleted uranium for the Environmental Assessment for the Saddle Road extension project located on the island of Hawaii, Hawaii. The roadway project was planned to transverse a parcel of land recently deeded from the U.S. Army, on which depleted uranium was suspected to be present. Planned sampling and analysis, evaluated data, and performed risk assessment calculations for people who may construct or use the roadway.

Covanta Energy, NJ – Prepared a State-of-the-Science White Paper on the toxicology and risk assessment of dioxin and furan congeners.

PACIFIC Division Naval Facilities Engineering Command, CLEAN; Hawaii. (COMNAVMARIANAS, Guam, Orote Landfill) Performed senior technical oversight of a preliminary human health risk evaluation and baseline human health risk evaluation from the consumption of seafood caught near the Orote Landfill Site. Represented the Navy's interest in meetings with EPA Region IX, Guam EPA, ATSDR, and others. Briefed decision-makers on PCB toxicity. Project is on-going.

Duke Energy, IN – Served on the Indiana Department of Environmental Management Expert Panel on background levels of metals and PAHs in soils to provide stakeholder input into the revision of state guidelines for the performance of site-specific background studies.

AlliedSignal Corporation, Morristown, NJ – Prepared risk-based soil cleanup levels for PCB containing soils for a site in New Jersey. Used and documented alternate cancer slope factors derived from recent scientific literature

AlliedSignal Corporation; James River Corporation, Beazer East Inc. – Critiqued New Jersey soil protection & indoor surface standards and prepared document for the regulatory docket. Chemicals of concern included PCBs, PAHs, volatile organics, and metals.

James River Corporation, Richmond, VA – Prepared human health risk assessment for PCBs in soil, air, and building materials at a site in New Jersey. Performed fate and transport modeling of PCBs from concrete block walls into building air. Developed approach for evaluating PCBs present on the surfaces of walls in the building.

AlliedSignal Corporation, Morristown, NJ – Prepared risk-based soil cleanup levels for PCB containing soils for a site in New Jersey. Used and documented alternate cancer slope factors derived from recent scientific literature.

Pennsylvania Department of Environmental Protection, Harrisburg, PA – Prepared risk evaluation of PCBs in a pond adjacent to a gas pipeline compressor station using EPA's 1996 PCB risk assessment policy. Performed screening level risk assessment of human health, wildlife, and benthic organisms. Made recommendations comparing various remedial options, including no action and limited sediment removal.

AlliedSignal Corporation; James River Corporation, Beazer East Inc. – Critiqued New Jersey PCB soil & indoor surface standards and prepared document for the regulatory docket.

Confidential Client, MA – Provided radionuclide risk assessment support to a nuclear laundry regarding an accidental release of facility water to an adjacent pond. Evaluated pond water and sediment sampling plan. Evaluated data summarization methods, including treatment of nondetects. Compiled and summarized natural background data for soil, sediment, surface water, and groundwater. Evaluated regulatory benchmarks, such as NRC effluent limits, drinking water standards, and unrestricted release criteria for suitability as benchmarks for pond data. Designed site-specific risk assessment for recreational exposures to pond water, sediment, and pond fish using the RESRAD code and EPA methods.

Semiconductor Manufacturer, ME – Performed a comparative health assessment of three gold electroplating baths for a semiconductor manufacturer. The goal of the analysis was to determine if two cyanide-free baths provided significant human health and environmental benefits due to their replacement of cyanide with other agents. The baths were assessed based on their acute toxicity to humans, their potential to produce acutely toxic gases upon acidification, their chronic toxicity to humans, and their persistence in the environment. Human exposure to these baths were considered for routine uses (dermal contact) and for accident

situations (inhalation of gaseous constituents). Prepared toxicological evaluations and dose/response assessments of numerous constituents including PCBs, PAHs, lead, nickel, cadmium, arsenic, thallium, and bis-(2-ethylhexyl)phthalate.

Gas Research Institute, Pittsburgh, PA – Performed detailed review of a computer-based model developed to evaluate exposures and risks posed by mercury in surface and subsurface soils. Evaluated fate and transport, exposure assessment, and toxicity aspects of this model.

Confidential Client, New Brunswick, Canada – Critically evaluated report prepared for a medical waste combustor in support of an argument than a carbon injection air pollution control system to control mercury emissions was not required for government approval to increase the waste combustor operating conditions.

Environmental Technology Council, Washington, D.C. – Critically evaluated the EPA's multipathway risk assessment model for defining exit levels for the Hazardous Waste Identification rule under RCRA. Major deficiencies in the model were in its treatment of mercury transport and fate and exposure assessment. Detailed discussion of mercury issues was prepared.

PACIFIC Division Naval Facilities Engineering Command, CLEAN; Hawaii. (Aiea Laundry) Performed senior technical review of a risk assessment prepared for the Aiea Laundry site by another consultant.

PACIFIC Division Naval Facilities Engineering Command, CLEAN; Hawaii (Confidential Site) Performed senior technical review of a screening level risk assessment performed for the site. Assisted AMEC risk assessment project manager in addressing toxicological issues for PCB risk assessment. Project is on-going.

Confidential Client, HI – Performed screening level risk assessment of fungi and bacteria from soil, wipe sample and water data collected in a commercial warehouse. Advised attorneys of results in support of litigation.

New York City Department of Environmental Protection, New York, NY – Prepared risk-based decision criteria for determining the appropriate disposition of excavated soils from two water pollution control plants, Hunt's Point and Bowery Bay. Evaluated soil sampling data, evaluated the appropriateness of NYC Soil Action Criteria. Performed human health risk assessment and concluded that the soils were not suitable for off-site disposal as residential fill. However, off-site disposal in a municipal landfill or on-site disposal as backfill did not pose an unacceptable health risk.

Confidential Client – Performed critical review of dioxin toxicology literature. Identified and critically reviewed the key historical and recent papers on the potential toxicity of dioxin and

related compounds in support of possible litigation. Human and animal studies investigating reproductive and developmental effects, immunologic effects, carcinogenic effects, and mechanism of action and pharmacokinetics were included in the review.

Bay State Gas Company, Westborough, MA – Provided consulting services regarding chemical and toxicological aspects of various, proposed cyanide destruction technologies. Critically evaluated Institute of Gas Research (IGT) feasibility study proposal. Served on Massachusetts Natural Gas Council/Gas Research Institute/IGT advisory panel.

Hoffman-LaRoche, NJ – Performed chemical evaluation of client's process data to determine the probable source of cyanide detected in a sewage drain samples. Designed and recommended bench scale experiments to confirm study conclusions.

Integrated Waste Services Association – Prepared comments on *Estimating Exposure to Dioxin-Like Compounds (1994)* for submission to EPA. Focused on exposure assessment methodologies and assumptions that could be applied to MSW combustor risk assessments.

Environmental Technology Council, Washington, D.C. – Prepared risk assessment comments on EPA's Delisting Risk Assessment Software. AMEC was retained by the Environmental Technology Council to review the DRAS program and determine if it appropriately evaluates hazardous wastes for delisting. Various hypothetical risk assessment evaluations were performed to determine if the EPA software was operating properly. A summary report was prepared and submitted to EPA.

United Oil Products, New Jersey – Prepared risk-based soil cleanup levels for PCB containing soils for a Superfund site in New Jersey. Used and documented alternate cancer slope factors derived from recent scientific literature.

Confidential Client – Managed development of a mathematical model that predicts vaporization rates of PCBs from soil.

Confidential Client (1), FL – After EPA performed a CERCLA Site Inspection, was retained on a sole source basis by a pulp and paper industry client to evaluate the Hazard Ranking System (HRS) Rule, the HRS Guidance Manual, and the EPA's PREscore software to determine what data and information were necessary to properly score their mill. Directed client's staff to obtain the requisite data. Performed preliminary runs to determine the HRS score for the mill if the most accurate data were used as input. A report was prepared that presented data and information in four topic areas: (1) policy issues requiring discretion and professional judgment, (2) site-specific data and information required for HRS scoring, (3) toxicological errors in the HRS, and (4) logical flaws in the HRS Rule. Calculated an HRS score for the mill that was well below the EPA criterion for NPL listing. The report was submitted to U.S. EPA Region IV, and Made a formal presentation of its contents to EPA staff.

Confidential Client (2), FL – Before EPA performed a CERCLA Site Inspection, was retained on a sole source basis by a pulp and paper industry client to assist them in preparing for the Inspection. Assisted the client by reviewing existing data, viewing aerial photographs, drawings, and maps, performing a site walk-over and presenting a tutorial on the Hazard Ranking System (HRS) scoring process. Apprised the client of the implications of site-specific data and information on the ultimate HRS score. Advised the client of specific information that they should provide to EPA's contractors. After completion of the Site Inspection and receipt of split sample results, the client has taken a pro-active stance and requested technical support to determine the implications of the inspection on the HRS scoring process.

Association for the Environmental Health of Soils, Amherst, MA – Presented course in risk assessment to 100 staff members of the Louisiana Department of Environmental Quality. Focused on petroleum contaminated soils and the risk assessment of PAHs and BTEX. Discussed the limited utility of TPH analysis results.

Pennsylvania Department of Environmental Protection, Harrisburg, PA – Provided technical support to the Science Advisory Board (SAB) charged with developing generic, state-wide soil clean-up standards pursuant to PA's new hazardous waste statute. On an aggressive schedule, critically evaluated 15 fate and transport models capable of deriving soil levels that are protective of groundwater. Presented results to the SAB and responded to requests for additional information.

Massachusetts Dept. of Environmental Protection – Evaluated the public health and environmental risk components of the existing hazardous waste site ranking models for the Commonwealth of Massachusetts in implementing its State Superfund law. Developed several innovative approaches for categorizing and ranking hazardous waste sites according to relative hazard for the State of Massachusetts.

U.S. EPA, Washington, DC – Participated in EPA's assessment of the Hazard Ranking Scheme as required under SARA by ranking selected sites with several different ranking schemes.

U.S. EPA, Washington, DC – Assessed the suitability of using the EPA RQ scheme for ranking chronic toxic effects for the purpose of Emissions Inventory Reporting. Prepared additional toxicity criteria for implementation of Section 313 of the Superfund Amendments.

EPA Region I, Risk Assessment Workgroup – Participated in the EPA-sponsored Region I Risk Assessment Workgroup, whose goal is to discuss and resolve critical scientific issues in risk assessment. Presented discussions on the bioavailability of metals for contaminated soils, approaches to assessing risks from less-than-lifetime exposures to contaminants, and approaches for estimating human exposures to contaminants from dermal contact. Co-authored "Supplemental Superfund Risk Assessment Guidance (1989) ".

U.S. EPA, Office of Emergency and Remedial Response, Washington, DC – Reviewed and prepared technical comments on the draft Superfund Exposure Assessment Manual.

U.S. EPA, Washington, DC – Prepared a critical evaluation of the available information on the carcinogenicity, mutagenicity, reproductive effects and developmental effects caused by inorganic fluorides. U.S. EPA used this report in making decisions regarding the merit of a petition to have inorganic fluoride added to the SARA Section 313 list.

Science Policy/Science Communication

Boston University School of Medicine – Served as Adjunct Assistant Professor of Toxicology, 1989-1992. Taught graduate level course in toxicology to medical doctors and graduate students in public health.

U.S. EPA, Washington, DC – Participated in policy development and rulemaking for the Toxic Substance Control Act at the Office of Toxic Substances. Developed technical aspects of rules to monitor significant new uses of chemicals. Prepared strategy documents, program plans, and briefing reports regarding these and other rules. Assisted in managing a technical contract regarding chemical use patterns.

Environmental Law Institute, Washington, DC – Served as Staff Scientist. Edited Environmental Law Reporter reports and other Institute documents for scientific accuracy. Prepared and submitted to EPA comments on proposed Resource Conservation and Recovery Act regulations. Gained familiarity with Federal databases concerning air and water quality and chemical exposure assessment methodologies.

The World Bank, United Nations, Washington, DC – Prepared reports and memoranda on a variety of topics germane to Third World development, including the effects of U.S. pesticide regulations on marketability of pyrethrum pesticides produced in Tanzania and the role of the World Bank as a technology transfer institution.

U.S. EPA, Seattle, WA – Participated in the formulation of a regional water quality strategy as an Environmental Protection Specialist at EPA Region X. Gained familiarity with Federal water pollution laws and regulations and the Environmental Impact Statement review process.

WGBH, Boston, MA – Served as a AAAS Mass Media Fellow. Research, directed and produced ten radio reports on scientific and environmental issues. Reports broadcast on "All Things Considered" included a three-part series on the technical and policy issues surrounding the saccharin ban and a report on sickle cell anemia.

University of Washington – Served as a Teaching Assistant in the Graduate School of Public Affairs for a course in statistical methods.

Seattle Community College – Designed and co-taught a course in environmental issues.

University of California – Served as a Lecturer. Managed the undergraduate general chemistry laboratory course, including design of experiments, publication of a revised lab manual, direction and production of a series of six instructional videotapes concerning experimental techniques, and supervision of three graduate teaching assistants.

Toxicology Research

Toxicology Program, Massachusetts Institute of Technology – Performed toxicology research and received training that focused on biochemical toxicology, genetic toxicology, chemical dosimetry, and molecular mechanisms of mutagenesis/carcinogenesis.

Toxicology Program, Massachusetts Institute of Technology – Characterized a previously unknown role of human hemoglobin in the metabolic transformation of xenobiotic substances, including numerous environmental contaminants. Determined the effects of point mutations in human hemoglobin on the enzymatic activity.

Toxicology Program, Massachusetts Institute of Technology – Developed methods to identify and quantitate foreign compounds and their metabolites in biologic fluids. Gained extensive experience in the techniques of bioanalytical chemistry, including HPLC, GC/MS, FPLC, electrophoresis, ultrafiltration, and others.

Selected Publications/Presentations

Magee, B., K. Connor, D. Chin, V. Houck. 2012. SETAC NA. Long Beach, CA. Critical Evaluation of USEPA's Toxicological Assessment of Benzo(a)pyrene.

Magee, B. S. Evert. 2012. SETAC NA. Long Beach, CA. PAH Mixtures: Additivity, Synergism or Antagonism?

Magee, B, Chin, D. 2012. Manufactured Gas Plants 2012. Chicago, IL; Proposed Increases in PAH Relative Potency Factors Will Greatly Increase Risks at All PAH Sites. Derivatives of sulfolane, a new class of antiinflammatory compounds

http://link.springer.com/article/10.1007%2FBF00770776?LI=true *(see excerpt, attached – appears to contain some tox info)*

Magee, B, Chin, D. 2012. SETAC Europe. Berlin, Germany; Proposed Increases in PAH Relative Potency Factors Will Greatly Increase Risks at All PAH Sites.

Magee, B. and Hoeger, G. 2012. Manufactured Gas Plants 2012. Chicago, IL; Bioavailability Studies: The Last Available Tools for Evaluating PAH Risks Realistically.

Magee, B. and Hoeger, G. 2012. SETAC Europe. Berlin, Germany; Bioavailability Studies: The Last Available Tools for Evaluating PAH Risks Realistically.

Magee, B. 2011. Environment, Safety, and Occupational Health (ESOH). Nashville, TN. Evaluation Of A Proposed EPA Unit Risk Factor For Naphthalene Using Screening-Level Population Risk Assessment Of Nasal Tumors In The United States.

Magee, B. and G. Hoeger. 2011. Environment, Safety, and Occupational Health (ESOH). Nashville, TN.. Evaluation Of Polycyclic Aromatic Hydrocarbons In Clay Target Fragments And Surface Soil At Shot Gun Range Sites.

Magee, B. and G. Hoeger. 2011. Environment, Energy Security, and Sustainability. Evaluation Of Polycyclic Aromatic Hydrocarbons In Clay Target Fragments And Surface Soil At Shot Gun Range Sites.

Chin, D, Anderson, P, Magee B. 2011.Society for Environmental Chemistry & Toxicology (North Atlantic Chapter). 2011. RME: Exploring the Upper Bounds of Upper-Bound Exposure Parameters in Deterministic Human Health Risk Assessments.

Chin, D, Anderson, P, Magee B. 2011. Society for Environmental Chemistry & Toxicology: RME: Exploring the Upper Bounds of Upper-Bound Exposure Parameters in Deterministic Human Health Risk Assessments.

Magee, B, Chin, D. 2011. Society for Environmental Chemistry & Toxicology:. Proposed Increases in PAH Relative Potency Factors Will Greatly Increase Risks at All PAH Sites.

Baker, K., J. White and B. Magee. 2011. Society for Environmental Chemistry & Toxicology. Pharmaceuticals At Sites Affected By Contamination: A UK Approach To Assessing Risk To Human Health.

Magee, B. and G. Hoeger. 2011. Society for Environmental Chemistry & Toxicology. Evaluation Of Polycyclic Aromatic Hydrocarbons In Clay Target Fragments And Surface Soil At Shot Gun Ranges.

Locey, B., Magee, B. 2011. Society for Environmental Chemistry & Toxicology: Locey, B., Magee, B. 2011. Update on the Toxicology of 1,4-Dioxane.

Magee, B. 2011. Society for Environmental Chemistry & Toxicology. Human Health Risks of Petroleum Coke as Fuel for Electric Power Generation.

Magee, B., Hoeger, G., Locey, B, Connor, K. 2011. Society for Environmental Chemistry & Toxicology Bioavailability Studies: The Last Available Tools For Evaluating PAH Risks Realistically.

Magee, B., Weaver, A. 2011. Society for Environmental Chemistry & Toxicology. Risks of Intact Residential Lead Based Paint Versus Risks of Remediation.

Magee, B., Keating-Connolly, J. , Chew, B. 2011. Society for Environmental Chemistry & Toxicology. Comprehensive Risk Assessment of a Proposed $30M Cleanup Plan at Sydney, Nova Scotia. Magee, B, Samuelian, J, Haines, K, Chappel, M, Penn, I, **Chin, D**, Anders, D, Hinz, J. 2010. Screening-level population risk assessment of nasal tumors in the US due to naphthalene exposure. Regulatory Toxicology and Pharmacology 57: 168-180.

Magee, B. et al. 2010. Screening Population Validation Exercise Of EPA's Proposed Reference Dose. Presented at DIOXIN2010, San Antonio, Texas, October 2010.

Huntley, S., P. Anderson and B. Magee. 2010. Application Of Dioxin Epidemiology Data For Deriving Toxicity Values For 2,3,7,8-TCDD For Use In Risk Assessments. Presented at DIOXIN2010, San Antonio, Texas, October, 2010.

Nadine Weinberg, Brian Magee, Nancy Bonnevie, Margaret Bartee. 2010. Weight of Evidence Evaluations: A Comparative Analysis of Human and Ecological Approaches. Presented at Society for Risk Analysis Annual Meeting. Salt Lake City, UT, December 2010.

Magee, B. et al. 2010. Bioavailability Testing: Human Health & Ecological Risk Harmonization. Presented at Society for Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2010.

Magee, B., et al. 2010. Screening-level population risk assessment of nasal tumors in the US due to naphthalene exposure. *Regul. Toxicol. Pharmacol*. 57:168-180.

Magee, Brian H., John Hinz and Doris Anders. 2010. Probabilistic Screening-Level Population Risk Assessment Of Naphthalene Exposure. Society of Toxicology Annual Meeting. Salt Lake City, UT. March 8-11, 2010.

Magee, Brian H., John Hinz and Doris Anders. 2010. Evaluation Of A Proposed EPA Unit Risk Factor For Naphthalene Using Screening-Level Population Risk Assessment Of Nasal Tumors In The United States. EPRI MGP 2010. San Antonio, TX., January 27-29, 2010.

Magee, Brian H., Patrick Gwinn, Wilfred Kaiser, and Dawn Macneil. 2010. Derivation Of Stop-Work Air Criteria For Benzene And Naphthalene For The Sydney Tar Ponds And Coke Ovens Clean-Up Project. EPRI MGP 2010. San Antonio, TX., January 27-29, 2010.

Magee, Brian H. 2009. India: Environmental & Chemical Regulatory Developments. ORC Worldwide, International Safety and Health Forum. Washington, D.C., November 12, 2009.

Magee, Brian H. 2009. European Environmental Regulations: REACH. Pennsylvania Bar Institute. Environmental Law Forum. Harrisburg, PA. April, 2009.

Magee, Brian H. Strategies and Experiences of a Fortune 500 Global Appliance Company. REACH USA 2009. Houston, TX.

Magee, Brian, et al. 2009. Screening-level population risk assessment of nasal tumors in the US due to naphthalene exposure. *Regulatory Toxicology and Pharmacology.* Manuscript submitted.

Magee, Brian H. et al. 2008. Population Screening-Level Risk Assessment Of Nasal Tumors Due To Naphthalene Exposure. Presented at CONSOIL International Conference, Milan, Italy, June, 2008

Magee, Brian H., et al. 2008. Drinking Water Remedial Goals For Two Pharmaceuticals In Groundwater. Presented at CONSOIL International Conference, Milan, Italy, June, 2008

Magee, B.H. 2008. Population Screening-Level Risk Assessment Of Nasal Tumors Due To Naphthalene Exposure. USAFE Remediation & Spill Workshop. 6 May 2008. Bitburg, Germany

Magee, B.H., et al. 2008. Typical Levels Of Tetrachloroethylene And Trichloroethylene In Residential Indoor Air. Presented at CONSOIL International Conference, Milan, Italy, June, 2008

Magee, Brian H. and Chris Mackay. Analysis of Alternatives: Substitution Requirements Under REACH. REACH USA 2008. Boston, MA.

Magee, B.H. Risk Assessment Provisions in the European REACH Regulation. Presented at the University of Massachusetts Conference. Amherst, MA. October, 2008.

Wolfson, Timothy and Brian Magee. New European Chemicals Legislation as a Source of Scientific Information for Toxic Tort Litigators. PBA Civil Litigation Section Newsletter Spring 2007.

Magee, Brian H., Julia Osborne, and William Vaughan. European chemicals regulation to affect water treatment industry. World Water and Environmental Engineering May/June 2007.

Magee, B.H., Okoji, R.O, C.M. Jones, and J.L. Hahn. 2004. Environmental Monitoring During Resource Recovery Combustion Ash Reuse Demonstration Projects. Presented at 2004 International Conference on Resource Recovery of Incineration Ash, Taipei County, Taiwan. September 2004.

Magee, B.H., Okoji, R.O, C.M. Jones, and J.L. Hahn. 2004. Use of Quantitative Risk Assessment Techniques to Establish Environmental Acceptability of Resource Recovery Combustion Ash Reuse Projects. Presented at 2004 International Conference on Resource Recovery of Incineration Ash, Taipei County, Taiwan. September 2004.

Magee, B.H., C.M. Jones, and J.L. Hahn. 2004. Air Monitoring of Dust from Roadway Demolition. Society of Risk Analysis. Palm Springs, CA. December 2004.

Tay, Chin H., B.T. Pugh, S.R. Clough, and Brian H. Magee. 2004. Dermal Irritation Assessment of Three Benzene Sulfonate Compounds. International Journal of Toxicology 23:11-16.

Magee, B.H., S.R. Clough, and T.A. Roy. 2004. An In Vitro Evaluation of Human Dermal Exposure to Benzene Sulfonate, m-Benzene Disulfonate and p-Phenol Sulfonate. Bulletin of Environmental Contamination and Toxicology 73:2.

Jones, Colin M., Hahn, Jeffrey L., Magee, Brian H., Yuen, Nathan Q.S., Sandefur, Kealohi, Tom, Jefferson N., and Yap, Clinton. 1999. Utilization of Ash from Municipal Solid Waste Combustion. Final Report. Phase II. NREL Subcontract No XAR-3-1322. August 1999.

Magee, B.H., J.L. Hahn, C.M. Jones, and G. Murata. 1999. Environmental Testing of Municipal Solid Waste Ash-Amended Asphalt. Proceeding of the Seventh Annual North American Waste-to-Energy Conference, Tampa, Florida, May, 1999 (GR-WTE 0107).

Magee, B.H., D.G. Dolan, D.A. Paley, and E. Weyand. 1999. Benzo(a)pyrene Bioavailability from Residential Soils. Society of Toxicology Annual Meeting, New Orleans, LA, March, 1999.

Magee, B. and E. Weyand. 1998. New Study: Benzo[a]pyrene Bioavailability in Soil. Contaminated Soils Conference, Amherst, MA, October, 1998.

Magee, B.H. 1997. Quantitative Use of Bioavailability in Risk Assessment. IBC's International Congress of Human Health Bioavailability. Scottsdale, AZ., December, 1997.

Magee, B.H. 1997. Oral and Dermal Absorption Adjustment factors for Risk Assessment of Soils Containing PAHs, Pentachlorophenol, and Dioxins. Society of Environmental Toxicology and Chemistry. San Francisco, CA., November, 1997.

Magee, B.H., A.C. Miller, J.L. Hahn, and C.M. Jones. 1997. Ambient Air Monitoring of the Beneficial Use of Municipal Waste Combustor (MWC) Ash as Daily Landfill Cover. Proceeding of the Fifth Annual North American Waste-to-Energy Conference, Research Triangle Park, N.C., April, 1997 (GR-WTE 0105).

Magee, B.H., P.A. Anderson, and D. Burmaster. 1997. Absorption Adjustment Factor Distributions (AAFs) for PAHs. Fundamental and Applied Toxicology 36:1:2.

Magee, B.H., 1996. Quantitative Use of Bioavailability Data in Risk Assessment. Presented at the Society for Risk Analysis Annual Meeting. New Orleans, LA., December, 1996.

Magee, B.H., A.C. Miller, J.L. Hahn, and C.M. Jones. 1996. Human Health Risk Assessment of the Beneficial Use of Municipal Waste Combustor (MWC) Ash. Presented at the Society for Risk Analysis Annual Meeting. New Orleans, LA., December, 1996.

Magee, B., A. Taft, W. Ratliff, J. Kelley, J. Sullivan, and O. Pancorbo. 1996. Physiologically Available Cyanide (PAC) in Manufactured Gas Plant Waste and Soil Samples. Prepared for 11th Annual Conference on Contaminated Soils, Amherst, MA., October, 1996.

Magee, B., A. Taft, W. Ratliff, J. Kelley, J. Sullivan, and O. Pancorbo. 1996. Physiologically Available Cyanide (PAC) in Manufactured Gas Plant Waste and Soil Samples. Presented at Society for Environmental Toxicology and Chemistry Annual Meeting, Washington, D.C., November, 1996

Magee, B., P. Anderson, and D. Burmaster. 1996. Absorption Adjustment Factor (AAF) Distributions for Polycyclic Aromatic Hydrocarbons (PAHs). Human and Ecological Risk Assessment 2:841-873.

Magee, B. 1996. New Developments in PAH Risk Assessment. Presentation to Boston Area Risk Group.

Magee, B. 1995. Risk-Based Remediation of Waste Sites, Presentation to Society of American Military Engineers, Rhein Main Post, Germany.

Magee, B. and Smith, D. 1995. Risk Assessment of Dioxin Congeners Via Plant Uptake. Human and Ecological Risk Assessment, Volume 1, Number 3.

Magee, B.H. 1995. Comparative Risk Assessment of Polynuclear Aromatic Hydrocarbons (PAH): Environmental Exposure to Contaminated Soil and Clinical Exposure to Coal Tar Pharmaceuticals. Invited speaker: National Conference on Hydrocarbon Contaminated Soils-Expediting Cleanups in USEPA/Region 6, January, 1995.

Magee, B.H. 1994. Indirect Risk Assessment: The Facility Experience. Invited Presentation to the RCRA Policy Forum, Washington, D.C.

Magee, B.H. 1994. Use and Misuse of Risk Assessment in the Courtroom. Invited Presentation to the 1994 Annual Convention Environmental Law Program, Colorado/Kansas Trial Lawyers Association.

Smith, D.G. and B.H. Magee. 1994. Critique of the Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions. Presentation at Air and Waste Management Association Conference, Kansas City, MO.

D. Smith, A. Yuhas, and B. Magee. 1994. Incinerator risk assessments: Change is in the air. In Press. Chemical Engineering.

Bradley, L.J.N., B.H. Magee, and S.L. Allen. 1994. Background Levels of Polycyclic Aromatic Hydrocarbons and Selected Metals in New England Urban Soils. J. Soil Contamination 3:349-361.

Magee, B.H. and L.J.N. Bradley. 1994. Absorption Adjustment Factors for Use in Risk Assessment. In Press. Proceedings of International Congress on the Health Effects of Hazardous Waste.

Magee, B.H. and L.J.N. Bradley. 1994. Background Levels of Polycyclic Aromatic Hydrocarbons. Presentation at Annual Conference on Contaminated Soils, Long Beach, CA.

Magee, B.H. et al. 1992. Risk Based Target Cleanup Levels for TPH in Soils. In Hydrocarbon Contaminated Soils. Lewis Publishers, Chelsea, MI.

Magee, B.H. et al. 1992. Human Health Risk Assessment of Hydrocarbon Contaminated Soils. Workshop presented to the Seventh Annual Conference on Hydrocarbon Contaminated Soils, Amherst, MA.

Magee, B.H. et al. 1992. Urban Background Levels of Polycyclic Aromatic Hydrocarbons. Presentation at Society for Risk Analysis Annual Conference, San Diego, CA.

Magee, B.H. and P.D. Anderson. 1992. Understanding the Major Steps in the Risk Assessment Process. Executive Enterprises Conference on Risk Assessment as a Corporate Management Tool, Washington, DC.

Magee, B.H. et al. 1991. Physiologically Available Cyanide Method for Risk Assessment of Metal Complexed Cyanides. Toxicologist 11:715.

Ruffle, B. and B. Magee. 1991. Risk Levels Implicit in States' Ambient Levels. Air Toxics Issues in the 1990s: Policies, Strategies, and Compliance. (Air & Waste Management Association, Pittsburgh, PA).

Magee, B.H. and H.A. Barton. 1990. Evaluation of the Chloroform Inhalation Cancer Potency Factor. Proceedings of the 1990 Environmental Conference on the Technical Association of the Pulp and Paper Industry.

Magee, B.H. 1990. Risk Assessment of Air Emissions. Executive Enterprises Conference on Air Toxics Compliance, Washington, DC.

Magee, B.H. and M.A. Marletta 1989. Sulfoxidase Activity of Hemoglobin. Toxicologist 9:1.

Magee, B.H. and M.A. Marletta 1988. Sulfoxidase Activity of Hemoglobin. Paper presented at 18th Northeast Regional Meeting, American Chemical Society.

Ryan E., B. Magee, and S. Santos 1987. Assessing Risk from Dermal Absorption at Hazardous Waste Sites. Presentation at Superfund '87, November.

Magee, B. 1986. The Sulfoxidase Activity of Hemoglobin: Mechanistic Characterization. Ph.D. Dissertation, Massachusetts Institute of Technology.

Magee, B., H. Barton, and M. Marletta 1986. Hemoglobin as a Monooxygenase. Paper presented at the American Chemical Society Annual Meeting.

Glass, G., B. DeLisle, P. Detogni, T. Gabig, B. Magee, M. Markert, and B. Babior 1986. The Respiratory Burst Oxidase of Human Neutophiles: Further Studies of the Purified Enzyme. Journal of Biological Chemistry, 261:13247 13251.

Magee, B.H. 1978. Decision Making for the Governmental Regulation of Chemical Substances. M.P.A. Thesis in Science Policy, University of Washington.

Magee, B. 1975. The Effect of Anthropogenic Halocarbon Emissions on Stratospheric Ozone Depletion. Presentation for M.S. Degree in Chemistry, University of California.

Billing Rate: $250.00 per hour

**COURTROOM TESTIMONY, DEPOSITIONS, AFFIDAVITS,
AND EXPERT REPORTS
BRIAN HARRISON MAGEE, Ph.D.**

Expert Report - Toxic Tort Case - Gasoline Vapor Intrusion Into Retail Pharmacy Building (leukemia; benzene)	Marshall, Dennehey, Warner, Coleman & Goggin (Eric A. Weiss) Chiumento, McNally & Shockley; Hoagland, Longo, Moran, Dunst & Doukas, LLP; Slowinski Atkins, LLP New Jersey
Public Meetings ***Expert Report*** - Commercial Gasoline Vapor Intrusion Site (benzene)	Manko, Gold, Katcher, & Fox LLP (Jill Kaplan) New Jersey
Potential Litigation Support ***Public Meetings*** - Three residential chlorinated solvent vapor intrusion sites (PCE)	Goodwin Proctor (Gregory A. Bibler, Nathan J. Brodeur) Massachusetts
Expert Report ***Site Investigation*** - Former Plastics Manufacturing Site	Bourland, Heflin, Alvarez & Minor (John J. Heflin) Tennessee Sullivan & Worchester Massachusetts
Expert Report - 3 Personal Injury Product Liability Cases (Chicago, Illinois; Milwaukee, Wisconsin) (lead-based paint)	Bartlit Beck Herman Palenchar & Scott Colorado (Donald Scott, Andre Pauka) Timothy Hardy, Esq. (Timothy Hardy) Colorado Jones Day (Laura E. Ellsworth, Thomas S. Jones, Charles H. Moellenberg Jr., Leon F. DeJulius Jr.) Pennsylvania

Courtroom Testimony ***Deposition*** ***Expert Report*** - Class Action Product Liability Case (Milwaukee, Wisconsin) (lead-based paint)	Bartlit Beck Herman Palenchar & Scott Colorado (Donald Scott, Andre Pauka) Timothy Hardy, Esq. (Timothy Hardy) Colorado Jones Day (Laura E. Ellsworth, Thomas S. Jones, Charles H. Moellenberg Jr., Leon F. DeJulius Jr.) Pennsylvania
Depositions (3) ***Expert Report*** - Class Action Product Liability Case (Rhode Island) (lead-based paint)	Bartlit Beck Herman Palenchar & Scott Timothy Hardy, Esq. Alder Pollock & Sheehan P.C. Arnold & Porter Higgins, Cavanaugh & Cooney Halleland Lewis Nilan Sipkins & Johnson P.A. Carroll, Kelly & Murphy Jones Day Cetrulo & Capone McGuire, Woods, Battle & Boothe LLP Vetter & White Orrick, Herrington & Sutcliffe Hinckley, Allen & Synder LLP Petrarca and McGair, Inc. McGrath North Mullin & Kratz P.C.
Courtroom Testimony ***Expert Report*** - Two Personal Injury Product Liability Cases (leukemia; formaldehyde)	Swartz Campbell, LLC Pennsylvania

ARCADIS

Education
MS, Environmental Engineering, Purdue University, 1974
BS, Environmental Engineering, Purdue University, 1973

Years of Experience
Total - 40
With ARCADIS – 23

Professional Registrations

None

Professional Qualifications
National Groundwater Association

Evan K. Nyer

Principal Scientist

Mr. Nyer is responsible for maintaining and expanding the company's technical expertise in geology/hydrogeology, engineering, modeling, risk assessment and bioremediation. He has extensive experience as a groundwater treatment engineer and has designed and installed more than 500 groundwater treatment systems, including biological, in-situ biological, air stripping, activated carbon, inorganic, advanced oxidation, soil-venting, sparging systems, vacuum enhanced remediation, and reactive zones. In addition to being responsible for technical designs and strategies, he has published and presented numerous works on groundwater treatment and other aspects of waste management and remediation. Mr. Nyer has taught courses on groundwater cleanup and treatment technologies around the world and is the author of four books, In-Situ Treatment Technology now in its second edition, Groundwater & Soil Remediation Practical Methods and Strategies, Practical Techniques for Groundwater and Soil Remediation, and Groundwater Treatment Technology, now in its third edition. He was also a principal author of Bioremediation from the American Academy of Environmental Engineering. Mr. Nyer is a regular contributor to Groundwater Monitoring and Remediation in which he has had his own column, "Treatment Technology" from 1987 to 2007.

For many years, Mr. Nyer has been active in the development of new treatment technologies. His main area of research interest is in the development and application of new technologies in the fields of biological treatment and in-situ methods. Before concentrating on groundwater, Mr. Nyer worked extensively with treatment plant managers in troubleshooting the operation of biological treatment systems and has been involved with more than 50 different biological treatment systems. His latest work on biological systems include a high concentrated anaerobic bioreactor for methane production and an algae harvester. Mr. Nyer also has extensive experience with inorganic treatment technologies, solid/liquid separation, UV-ozone, UV-peroxide, ultrafiltration and reverse osmosis processes.

Dispute Resolution Changes in RODs, RAPs, and other Agreements with Regulators

Biscayne Landing, North Miami Beach, FL
Design a treatment system to capture and treat the groundwater under a landfill. Negotiated a compromise design with the regulators.

Thermo Chem Superfund Site
PRPs, Michigan
Negotiated a change in remedial system design from the original ROD. Used air sparging, VES and natural attenuation to replace a pump and treat in the source area. Capital savings were over $2 million. Was responsible for process design and overseeing implementation of the complete system.

Tibbets Road
PRPs, New Hampshire
Designed a vacuum enhanced recovery to replace a pump and treat at a Superfund site. The Federal and State regulators accepted the new design as a change to a signed ROD. The original design would have taken 25 years and cost over $30 million. The new design took less than 3 years to fully implement and cost less than $5 million.

Seymour Superfund Site
PRPs, Indiana
Was the principal designer on a federal superfund project that used natural remediation as a method to eliminate organic compounds from an aquifer. The project was successful in changing a signed ROD that originally required pumping and treating of the area below the cap. The new design saved $1.3 million in capital costs over the original ROD design.

Technical Review
U.S. EPA Region 8
Performed technical review on an innovative treatment system for creosote wastes. The review lasted several years and covered all phases of the project including planning, laboratory testing, pilot tests and final implementation.

Mercier Site
Quebec, Canada
Was member of an international team of experts that designed a remediation system for the Mercier site.

TCE Remediation
Ford Land, California
Project leader for the design, installation and operation of a VER that remediated a TCE plume in one year. Had to negotiate with the local Water Board to get them to accept fast approvals - implementation.

ARCADIS

Evan K. Nyer
Principal Scientist

Application of New and/or Innovative Remediation Technology to Significantly Reduce the Cost of Site Remediation

Remediation System
Confidential Client, Tennessee
Designed a remediation system for a State Superfund site that included biological treatment for groundwater and liquid wastes, and an in-situ system for the contaminated soil.

NASA
JPL, Pasadena, California
Part of the team that led the design efforts for treatment of perchlorate in the aquifer and drinking water of the City of Pasadena.

Wright Patterson Air Force Base
U.S. Air Force, Ohio
Designed and installed a groundwater treatment system for chlorinated hydrocarbons. The 2,000 gpm system uses air stripping as the treatment technology.

McClellan Air Force Base
U.S. Air Force, California
Designed and installed a low concentration biological treatment system to treat acetone and MEK. The biological unit followed a high temperature air stripper and triple phase activated carbon.

Enhanced Biological Remediation
Florida Hydrocarbon Program, Florida
Used $N0_3$ and H_20_2 to enhance the rate of biological degradation at a gas station site in order to reduce the time for Natural Attenuation.

Modular System
Confidential Petroleum Company, California
Designed a standard modular system for gasoline stations in states that regulate air emissions from air strippers. System included biological treatment, filtration and carbon system. System was automatic, needing no operator attention, and fit into less than one parking space. This design has been used in over 10 installations across the country.

Natural Biological Attenuation
Amoco, Florida
Lead a project team that used four gasoline stations in Florida to prove to the State that natural biological attenuation could remediate a site without pump and treat.

Remediate
Syntex, Bahamas
Developed a design to remediate a site that had 30,000 ppm H_2S in the vadose zone. The design included a scrubber for the VES, in-situ biological remediation, and bioventing.

Chemical Plant WWTS
Union Carbide, West Virginia
Designed an upgrade to an existing wastewater treatment system for a specialty chemical plant. Work included laboratory and pilot studies and a full scale design.

Wastewater System Design
Union Carbide, Louisiana
Designed a degassing system for a pure oxygen biological treatment system. The degasser was required in order for the clarifier to work properly.

Solvent Refinery
Confidential Industrial Client, California
Designed a treatment system for high concentration wastewater from a solvent refinery in California. Biological treatment was used.

Methane Remediation
Kingsford Products, Michigan
Project leader for the investigation and remediation of methane under the entire town. Source was biological degradation of organics dissolved in the groundwater. Project includes a 500 gpm biological treatment system.

Brine Aquifer
U.S. Ecology, Texas
Designed a treatment system for a contaminated brine aquifer in Texas. The main contaminants were high TOC and arsenic. System included two stage biological treatment, arsenic precipitation, filtration and carbon adsorption.

Biological Treatment
Upjohn, Michigan
Designed innovative treatment system for low concentrations of Tetrahydrofuran, t-butanol, chlorobenzene and 13 other compounds. All influent concentrations were less than 2 ppm each.

Used biological treatment to produce effluent levels less than 5 ppb or below detection limits for each compound.

Groundwater Treatment System
Confidential Industrial Client, Florida
Was the principal designer for a groundwater treatment system for total dissolved solids including sulfates and nitrates. The system included pretreatment and reverse osmosis.

Training, Review of Project

Tiger Team
U.S. Navy, South Carolina, California, Virginia, Pennsylvania
Part of a review team that helped Navy project managers optimize the remediation designs at the sites that they managed.

Naval Training
U.S. Navy, South Carolina, California, Washington, Hawaii
Part of the training team for project managers. Provided education on strategies and several remediation methods.

Brazil EPA
San Paulo, Brazil
Presented a course for Brazil EPA to train industry and regulators how to remediate hydrocarbon sites.

Base Realignment and Closure (BRAC) Training
U.S. Navy, Missouri, California
Part of the BRAC training course. Taught strategies for quick closures of contaminated sites and advanced technologies for contaminant removal.

Alternative Energy

High Concentration Anaerobic Bioreactor
Part of a team that developed an anaerobic bioreactor for organic wastes. Retain runs at 25 – 33 percent solid and produces methane from the waste.

Energy Independence for DOD Base

Produced a White Paper that showed how an anaerobic biological reactor, combined with an electrical generator, could supply most of the power needed for a DOD Base and provide a

continued source of power, even if the base was attacked.

Algae Harvester

Developed a new type of filter that can remove low concentrations of algae from an algae growth tank.

Algae Development Project

Part of a team headed by a financial company to review and develop a business plan for an Algae company.

Tire Recycling

Led a team to review the current technology of a tire recycling operation. The plan is to improve the current operation and then expand the technology to 25 new plants.

Expert Witness

Expert Witness
Worthington, Florida
Worked out compromise with water district regarding dry cleaner contamination of drinking water aquifer. No court

Expert Witness
Collier Development, Miami, Florida
Serving as an expert witness for Collier Development. Individuals affected by creosotes released in 1950's. Was able to show that the contaminants were not the client's and case settled.

Expert Witness
City of Delray Beach, Delray Beach, Florida
Served as an expert witness involving the city's attempt to recover costs for treatment of a contaminated municipal well field. Provided trial testimony.

Expert Witness
Confidential Industrial Client, United States
Served as an expert witness on PCBs. Client wanted to prevent a class action suit being filed. No depositions and no testimony. Judge ruled against class formation.

Expert Witness
Murphy Oil Corporation, Louisiana
Served as an expert witness to help client prove they were not responsible for contamination at an oil terminal. Provided trial testimony.

Expert Witness
Washington Gas, Maryland
Served as an expert witness on rate case in front of the Public Commissioners. Helped prove money spent on remediation of MGP site was proper and should be part of their rate base.

Expert Witness
Confidential Industrial Client, Louisiana
Served as an expert witness regarding the cost of remediation from a paint plant and pesticide operation. No deposition and no testimony.

Expert Witness
Litton, California
Served as an expert witness on the cost of remediation and the source of original chlorinated hydrocarbon contamination. After expert report submitted, plaintiff withdrew their suit.

Expert Witness
Worthington, Florida
Worked out compromise with water district regarding dry cleaner contamination of drinking water aquifer. No court.

Expert Witness
Kingsford, Michigan
Served as expert witness on fate and transport of methane. No deposition and no testimony.

Expert Witness
City of Fresno, California
Served as an expert witness for treatment and remediation of DBCP and EDP in groundwater and soil. Lead the defense during a mock trial where lawyers were not allowed to make direct argument. Original suit was for $750 million. Case settled for $25 million.

Selected Publications

Nyer, E.K., et al., Groundwater Treatment Technology, 3rd Edition, John Wiley & Sons, Hoboken, New Jersey, 2009

Fierro Jr., Pedro and Nyer, Evan K., The Water Encyclopedia, 3rd Edition Hydrologic Data and Internet Resources, 2008, CRC Press Taylor & Francis Group

Nyer, E.K., et. al., In-Situ Treatment Technologies, 2nd Edition. Lewis Publishers, Inc. Boca Raton, FL, 2000

Nyer. E.K., et. al., Groundwater and Soil Remediation, Practical Methods and Strategies, Ann Arbor Press, Inc., Chelsea, Michigan, 1998

Nyer, E.K. Practical Techniques for Groundwater and Soil Remediation. Lewis Publishers, Inc., Chelsea, Michigan, 1992

Advanced Treatment Technologies – 16 papers

Biological Design – 22 papers

Groundwater Design – 46 papers

In Situ Design – 13 papers

Technical Instruction

Instructor for the Summer 2004 Harvard Executive Education Seminars, Harvard University, Cambridge, MA , "Profitable Design, Development, and Construction on Contaminated Land".

Instructor, "The Princeton Remediation Course" a group of seminars presented by Princeton Groundwater, 1997 to 2000.

Instructor at the "BRAC Cleanup Team Workshop," 1998, San Diego, CA, St. Louis, MO.

Instructor for the Navy Tiger Team Workshops, 1997 - 1998.

Instructor, "The Princeton Course Groundwater Pollution and Hydrology" seminar presented by Princeton Groundwater, 1994 to 2000.

Chief Instructor, "Encontro Tecnico Sobre Questoes Ambientais Em Postos De Servicos" seminar presented in Brazil, 1993.

Instructor, "Bioremediation, The State of Practice In Hazardous Waste Remediation Operations", a teleconference sponsored by Air & Waste Management Association, 1992.

Instructor, "Bioremediation of Hazardous Waste Sites", a workshop presented by US EPA, 1989.

ARCADIS

Evan K. Nyer
Principal Scientist

Chief Instructor, "Ground-water Treatment Technology", a short course presented by the National Water Well Association, 1985-1989.

Chief Instructor, "Groundwater Treatment Technology", a short course presented by UCLA, 1987-1990.

Instructor, "Alternative Treatment Technology Workshop", a workshop for US EPA Superfund personnel, 1987 - 1989.

Instructor, "Corrective Action for Containment and Control of Ground-water Contamination", a short course presented by the National Water Well Association, 1985-1987.

Instructor, "Industrial Biological Wastewater Treatment Systems", a short course presented by Center for Professional Advancement, New Brunswick, NJ, 1980-82, 1985.

Billing Rate: $250.00 per hour