

January 2010

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Recommended Citation

Teaf, Christopher M.; Covert, Douglas J.; and Kothur, Srikant R. (2010) "Urban Polycyclic Aromatic Hydrocarbons (PAHS): A Florida Perspective," *Proceedings of the Annual International Conference on Soils, Sediments, Water and Energy*: Vol. 13 , Article 23. Available at: <https://scholarworks.umass.edu/soilsproceedings/vol13/iss1/23>

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Part X: Regulatory

Chapter 22

URBAN POLYCYCLIC AROMATIC HYDROCARBONS (PAHS): A FLORIDA PERSPECTIVE

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ABSTRACT

Over the past decade, polycyclic aromatic hydrocarbons (PAHs) have steadily climbed in importance on the CERCLA list of hazardous substances. Though the listing does not necessarily imply that these chemicals exhibit the greatest degree of toxicity, such recognition by ATSDR and USEPA is predicated at least in part on their overwhelming ubiquity in association with many very common sources, coupled with toxicity considerations. Regulatory agencies increasingly are under pressure to define and interpret data describing urban background levels, and to appropriately determine the relative importance of waste-producing activities and concentrations resulting from typical natural and/or human activity. Three case studies from Florida are presented that confirm the ubiquity of the PAHs at low levels, and that demonstrate the need for more sophisticated and transparent treatment by regulatory agencies. We discuss assessment and risk assessment activities related to two urban redevelopment projects, as well as one property transaction project. In each case, considerable sampling of surficial soils and sediment identified total benzo(a)pyrene-equivalent concentrations in the range of less than one ppm to about 5 ppm. Although those concentrations frequently exceeded the default Florida cleanup target level for both residential and commercial/industrial land use by a wide margin, it was concluded that they are completely consistent with levels reported in a great many urban settings. There is an ongoing need to consider the development of a default urban background level for PAHs in areas characterized by busy roadways or multiple industrial facilities, in much the same way that geological or anthropogenic background levels are established for some inorganics.

Keywords: Polycyclic aromatic hydrocarbons, soil, sediments, water, background, health risk assessment, urban, toxicology, PAH

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1. INTRODUCTION

Over the past decade, polycyclic aromatic hydrocarbons (PAHs) have climbed towards the top of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) list of hazardous substances (ATSDR, 2006). In the biennial ranking comprised of chemicals deemed to pose the greatest possible risk to human health, PAHs placed a meager tenth before moving to fifth in 2001 and settling in at seventh in 2005. Both the Agency for Toxic Substances and Disease Registry (ATSDR) and US Environmental Protection Agency (EPA) recognize the potential importance of PAHs due to their ubiquity in many urban and rural environments. Acknowledgment of their burgeoning presence means regulatory agencies must define and interpret urban background levels to appropriately determine whether industrial facilities or contaminated sites are damaging the environment beyond concentrations resulting from typical natural and human activity.

PAHs are a collection of over 100 different fused benzene ring chemical compounds with varying prevalence and regulatory concern. Background is defined as concentrations in a common area, such as a road, residential yard or non-industrialized locale, due to sources independent of a known waste site (IEPA, 2005b). The multitude of non-point, diffuse, and mobile sources of PAHs ranges from automobile exhaust to road asphalt to cigarette smoke (NPI, 2004). In tandem, they create an urban background concentration that often exceeds health based regulatory recommendations for generally accepted PAH-producers (Delgado, 2000). This paradox undermines environmentalists' desires to contain carcinogenic PAHs, the true threat to public safety. Heightened awareness of this potentially costly inconsistency has increased the vigor of efforts to determine local background levels before targeting sites for remediation. Local and state agencies like the Illinois EPA have begun to more actively rely on background as a means to establish risk-based objectives to determine realistic goals (IEPA, 2005).

In Florida, the Department of Environmental Protection (FDEP) is increasingly aware of and potentially receptive to site-specific demonstrations of urban background, rather than site-related activities, being the cause of observed PAH impacts. However, at this point, procedural constraints, political climate, or financial considerations dictate a strict adherence to the much lower default cleanup guidelines.

1.1 Human Health Effects

The potential carcinogenicity of seven common PAH list compounds [benzo(a)anthracene (B(a)A), benzo(a)pyrene (B(a)P), benzo(b)fluoranthene (B(b)F), benzo(k)fluoranthene (B(b)F), chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene] warrant reasonable regulation and remediation. Due to their ubiquity, PAH exposure occurs constantly whether an individual breathes roadside air, comes into contact with a hazardous waste site, eats grilled food, or drinks contaminated water (NPI, 2004). In the US, lifestyle considerations represent the greatest exposure potential to carcinogenic PAHs for an individual, with general population estimates indicating daily intake averages of 0.207 ug from air, 0.027 ug via water, and 0.16-1.6 ug through food (ATSDR, 1995). Inhalation of tobacco and wood smoke, and residence near a hazardous waste site may increase the 2 to 3 ug/day of total carcinogenic PAHs an adult male encounters (ATSDR, 1995). Significant time spent in metropolitan areas boosts risk since

several studies indicate PAHs in urban ambient air exceed rural air by ten times (ILDPH, 2005). Once PAHs have entered the body, the kidneys, liver, fat, spleen, adrenal glands and ovaries can store them until they are released in urine and feces within a few days (ATSDR, 1995; Grosenheider et al. 2005). Short-term effects have yet to be determined since other chemicals that commonly co-occur with PAHs (e.g., volatile hydrocarbons) often cause immediate symptoms such as eye irritation, nausea, diarrhea, and confusion (ILDPH, 2005). Detrimental long-term, high-level exposure may lead to consequences including cataracts, kidney and liver damage, jaundice, and skin irritation and redness, specifically for naphthalene contact. The immune system also is vulnerable and B(a)P in large doses suppresses the system and damages erythrocytes. Moreover, sufficient doses may cause developmental and reproductive deficiencies in animal studies (BCERF, 2001).

The above effects, though more likely, seem inconsequential in most literature because of the overwhelming focus on cancer from long-term exposure. Laboratory research on female rats indicates breast tissue injection and consistent high dose ingestion of B(a)P and dibenzo(a,l)pyrene caused a significant increase in the development of breast cancer (BCERF, 2001). However these results have not been proven with any consistency in human studies. One of the pioneering PAH cancer studies began in the early 1980's after Long Island, New York appeared to have a 30% higher breast cancer rate than the national average (NBCC, 2002). The first of the 12 studies forming the Long Island Breast Cancer Study Project considered PAHs since these compounds bind to DNA and form DNA adducts, the sites of tissue damage. Detectable adducts increased the chance of breast cancer by 35%, a statistically significant figure; however, a threshold effect was observed in the observed endpoints.

1.2 Sources of PAHs in Urban Environments

1.2.1 Natural Sources

Petroleum and coal formations contain PAHs, and forest fires, volcanic eruptions, and plant and animal pigments (Delgado, 2000) also release PAHs. Volcanoes and forest fires are by far the most common means by which natural producers release PAHs into a given environment (ATSDR, 1995). Coal tar, crude oil, and shale oil are all important repositories of PAHs, and human conversion and incomplete combustion of fuels increases their abundance in the contemporary environment (NPI, 2004). Products, including creosote and asphalt, derived from these fossil fuels also contribute (ILDPH, 2005).

1.2.2 Anthropogenic Sources

Although readily identifiable point sources garner the wealth of federal and government attention and budget, diffuse and mobile sources strongly influence total PAH concentrations in a given medium (NPI, 2004). Non-point sources are unavoidable with virtually every citizen culpable. Common daily anthropogenic contributions include cigarette smoke, internal combustion engines, oil-based heating, indoor and outdoor grilling, jet engines, acetylene torches, and road paving (Delgado, 2000).

PAH concentrations, especially indoors, can rise significantly as a result of smoking. One study conducted in Durham, North Carolina observed that smoking increased indoor levels to alarming heights in smoking households, ranging from 0.08 to 3,600 ng/m³, while outdoor levels in Durham were between 0.03 and 1,700 ng/m³ (USEPA, 1997). Fire production resulting from agricultural, home heating and cooking purposes also causes widespread PAH emissions. These are difficult to control since nearly every urban edifice contributes (NPI, 2004). In fact, the largest anthropogenic source is reportedly residential wood combustion (Grosenheider et al., 2005). Motor vehicle exhaust, the main mobile source, supplements PAHs' expanding presence alongside several vital consumer products. However, US mobile sources such as vehicular emissions contribute only a small quantity, estimated to be 25% in the 1980's, of total PAH emissions (Li, 2003).

Regardless of the source type, PAHs behave similarly in the environment. Once discharged, most enter the air before atmospheric deposition deposits them in other notable mediums. Surface water receives its share primarily from airborne deposition, but other major contributors include urban runoff, effluents from industrial plants, petroleum processing, and occasionally oil spills. Urban runoff, a common non-point source of residential communities, accounted for an estimated 36% of the total PAH input into Rhode Island's Narragansett Bay, as well as an atypical 71% of all high molecular weight toxins found (McCarthy, 2003; LBNL, 2004). Heavy hydrocarbons in water environments tend not to venture far from their anthropogenic source, and thus, aquatic areas near extensive human activity have a propensity to be excessively taxed (ATSDR, 1995).

Soil is the most complex in regard to principal source determination (Delgado, 2000; Hellmann, 1999). Local and long-range transport follows initial atmospheric entrance; therefore, areas seemingly unfettered by direct industrial activity could harbor significant baseline PAH concentrations. Soils adjacent to roadways and parking lots tend to have higher concentrations than rural soil due to auto and asphalt emissions and associated stormwater runoff (Mahler et al., 2005; Wagrowski and Hites, 1997). Additional contributors include public sewage treatment plants, bituminous coal leachate from storage sites, and compost-based fertilizers (ATSDR, 1995). Furthermore, higher organic carbon content and sorbent particle surface area have been associated with increased absorption and accumulation in sediments. For example, Karckhoff (1979) and Gardner (1979) established that silt and clay are twice as likely to amass B(a)P and B(a)A than a sand composition (ATSDR, 1995).

1.3 Reported Ambient Levels of PAHs

Establishing a universal baseline has occupied numerous researchers over the course of the past three decades. Intra-town levels can vary two or three-fold depending on different prevailing sources (traffic vs. domestic coal burning), heating fuels (coal vs. oil), and position relative to an industrial zone (downwind vs. upwind; EU, 2001). Urban and industrial land-use adjacent to river systems is just one example of the complications associated with source attribution and risk assessment (Costa and Gensky, 2001). Another hurdle in standardizing literature relates to whether individual or total PAHs are measured and reported. Furthermore, some researchers utilize BaP_{eq} to create values based on carcinogenic potency in relation to B(a)P, the most often measured and regulated PAH (Grosenheider et al., 2005).

1.3.1 Air

In the ATSDR's 1995 toxicological profile for polycyclic aromatic hydrocarbons, ambient air's unique role as a feeder to soil and water is identified and background ranges are provided. Rural ambient air for some individual PAHs ranged between 0.02-1.2 ng/m³, and urban background fluctuated between 0.15-19.3 ng/m³ (ATSDR, 1995). The extent of this urban-rural discrepancy is once again noted in a New Jersey project from 1981 and 1982. This study showed a 3-5 times higher concentration for urban air and also discovered a 5-10 times higher concentration in winter as opposed to summer. Another early 1980's project found that B(a)P had an urban baseline of 0.64 ng/m³ in Los Angeles. B(g,h,i)PER, a byproduct of automobile emissions on LA's notorious freeways, had a mean geometric concentration of 3.27 ng/m³. Legzdins et al., and Tan and Ku independently determined in 1994 that B(g,h,i)PER was the highest individual PAH concentration among hydrocarbons measured in Hamilton, Ontario and New York City. The specific values, 4.3 ng/m³ in Hamilton and 4.05 ng/m³ in New York City, furthered the notion that urban ambient air levels follow a general pattern when free of point source contributions.

Other research efforts have had more specific goals that were reached by focusing on select media. Addressing urban air pollution is a frequently attempted task that requires PAH background information. A worldwide study of 60 towns in the mid-1970's determined the range of B(a)P in European and US ambient air. For Europe, a range of 1-20 ng/m³ was reported and the US appeared to contain approximately 1 ng/m³ (Menichini, 1992). However, Europe in the 1990's exhibited significantly improved the value ranges for B(a)P (EU, 2001). Rural background varied between 0.1 and 1 ng/m³, and urban baselines ranged from 0.5 to 3 ng/m³. The EU reported 30 ng/m³ as the commonly accepted background in zones close to industrial processes.

1.3.2 Soil

PAH compounds found in soil have been an increasing problem since the Industrial Revolution's promotion of PAH-producing anthropogenic behavior. A compilation of data by the ATSDR confirms the expected: urban background concentrations are greatest, followed by agricultural and rural soil (ATSDR, 1995). Thomas' 1986 survey indicated that even remote Wyoming woods contained 210 ug/kg of total PAHs; whilst, Black et al. (1989) later in the 1980's provided a counterpoint by measuring New York City's Fountain Avenue Landfill, which contained concentrations between 400 and 10,000 ug/kg.

Several of the studies conducted allow a general understanding of urban baseline levels through analysis of samples from several locations throughout an urban domain. The lowest observed levels were in rural soil located far from major highways (Lagoy and Quirk, 1994). According to the IARC, these concentrations were between 0.01-10 mg/kg for all PAHs, while urban background ranged from 1-100 mg/kg. Among the more volatile carcinogenic PAHs, Menzie et al. (1992) noted a variation of 0.01 to 1.3 mg/kg in forest and rural soil. Based on the 15 samples used in this determination, urban soils ranged from 0.06 to 5.8 mg/kg with a median of 1.1 mg/kg.

A mid-90's analysis in New England focused on the relationship between proximity to pavement and toxicity in conjunction with background range determinations (Bradley, 1994). The study found state regulatory standards difficult to reconcile, with background levels of urban surface soils dwarfing the cleanup levels for the weighted total concentration of carcinogenic PAHs [B(a)P-T], which commonly ranges from 0.1 to 0.66 mg/kg. As suggested by the EPA, a 95% confidence interval was utilized to serve as the baseline value. The values were 12.4 mg/kg for total carcinogenic PAH value, and 3.3 mg/kg for B(a)P-TE. The B(a)P-TE at urban background was 30 times greater than the 0.1 mg/kg target level advocated by the CERCLA risk assessment guidance of 1993. Statistical analysis of pavement proximity involved tests for homogeneity of variance and equality of means. The mean for near pavement was 21.9 ppm total PAHs and 2.9 ppm B(a)P-TE, while samples away from pavement had means of 8.3 ppm total PAHs and 1.1 ppm B(a)P-TE. These tests proved there is statistical significance at the 0.05 level on all accounts, but emphasized that ppm levels of PAHs were ubiquitous.

The Massachusetts DEP in 1995 attempted to interpret background concentrations in "natural soil," a term used to denote the 90th percentile value (MADEP, 2002). Lower than 90th percentile values were commonly applied when site-specific background information was absent. A general stipulation when establishing literature background is consideration for the nature of the soil and past uses, but the MADEP's 1996 background levels identified still serve as a solid foundation. Notable "natural" concentrations identified were B(a)P at 3 mg/kg, B(g,h,i)PER at 1 mg/kg, and chrysene at 2 mg/kg (MADEP, 2002).

Subsequently in 2005, the Illinois EPA, as part of their risk-based tiered remediation, established their own carcinogenic PAH background in soil (IEPA, 2005b). Their study separated locales based on population. Areas with over 50,000 residents were branded "Metropolitan Statistical Areas (MSA)," the equivalent of an urban area. Since they deemed the data lognormally distributed, a lognormal 95th percentile concentration, shown on Table 1, represented their conclusions regarding background.

Table 1. Background concentrations of carcinogenic PAHs in IL (mg/kg)

Individual PAH	Chicago	MSA	Non-MSA
B(a)A	1.1	1.8	0.72
B(b)F	1.5	2.0	0.70
B(k)F	1.0	1.7	0.63
B(a)P	1.3	2.1	0.98
Chrysene	1.1	2.7	1.1
Dibenzo(a,h)A	0.20	0.42	0.15
Indeno(1,2,3-c,d)P	0.86	1.6	0.51

*Derived from IEPA, 2005b

1.3.3 Watershed/Sediment

Emissions from a host of mechanisms including stormwater runoff, direct deposition, surface runoff from roadways, and discharges from boats contribute heavily to aquatic sediment contamination (US Navy, 2003; Abrajano and Bopp, 2001). A US Navy review of properties along the Elizabeth River in Virginia examined 20 sediments, and concluded that urban

background was 16 mg/kg for a 16-PAH list of priority pollutants and 26 mg/kg for all detectable PAHs. With those statistics in hand, the researchers proposed that 30 mg/kg of priority pollutants should be the cutoff above which urban background alone cannot account for the PAH concentration. Conversely, Stout et al (2004) reported on surficial sediments and reiterated the lack of one representative urban baseline value. Regardless, there was general consistency, with 96% of the 280 sampled sediments containing below 20 mg/kg of the 16-PAH list of pollutants.

Low solubility and high organic carbon affinity in particulate matter makes sediments a major player, often with a total concentration in the “parts per billion” (ug/kg) or “parts per million” (mg/kg). Water usually only musters a measly “parts per trillion” (ng/kg) concentration due to low water solubility.

Surface water, however, can be a major sink for PAHs. Total PAHs in drinking water, a final destination for PAHs via effluents, was shown to have background between 4 and 24 ng/L. However, in 1978, Basu and Saxena found total mean background concentrations in Pittsburg, Pennsylvania to be 600 ng/L. Additionally, Basu and Saxena (1978) identified groundwater levels between 3-20 ng/L in the bordering states of Ohio, Indiana, and Illinois. A 1986 analysis of the Mississippi River acknowledged that phenanthrene was the highest individual PAH with a high of 34 ng/L. The New Orleans industrial zone sample supports the notion that effluents and surface runoff are some of the most significant contributors to water background (McCarthy, 2003). Several studies presented by the ATSDR have uniformly shown the importance of urban runoff's role.

The United States Fish and Wildlife Service's (USFWS) 1987 report on PAHs is another comprehensive attempt to compile and evaluate cross-generational and cross-geographic background data to form remediation plans. Lee and Grant's 1981 development of the idea that total PAHs in air are approximately 10 times higher than B(a)P levels is a helpful barometer to estimate total PAH concentrations, even with the observed statistical variation (USFWS, 1987).

Coal tar road sealants, 10-18% PAH in weight, have had 500 to 600 times greater quantities of PAHs than asphalt sealant (Mahler et al., 2005). Coal tar sealant's high PAH composition yields direct effects in river sediments near asphalt parking lots sealed with coal tar (Grosenheider et al., 2005). This knowledge fostered research of asphalt runoff because of the known severity of runoff particulates being caught by sediment traps. The United States Geological Survey determined PAH concentrations using 13 parking lots in Austin, Texas, where 600,000 gallons of coal tar sealant were applied each year (USGS, 2005a). Particles in runoff from unsealed lots, serving as the control, contained 54 mg/kg, a concentration 65 times lower than the 3,500 mg/kg resulting from coal tar-based sealants (Mahler et al., 2004). The study also found asphalt-sealed parking lots produced 620 mg/kg in runoff. Due to vehicle exhaust, tire particles, motor oil, and atmospheric deposition, all values surpassed the 22.8 mg/kg sediment Probable Effects Concentration (PEC) used to assess risks from sediment. This hazard prompted Austin officials to ban coal tar sealants and penalize violators with \$2,000 fines (Richardson, 2006).

According to a stormwater analysis in coastal Massachusetts, fluoranthene, phenanthrene, pyrene, and chrysene were the most pervasive PAH compounds (McCarthy, 2003). The authors then deciphered the source of origin by associating the various land uses capable of producing

such a composition. Researchers concluded that “localized bulk increases” of PAHs in coastal sediment were primarily due to stormwater discharges (McCarthy, 2003). Additionally, a long-term study of the Lower Hudson Watershed found the highest PAH concentrations near the Western NY/NJ Harbor in Newark Bay occurred during the early 1950’s, a period marked by petroleum’s prevalence and use in the area (Abrajano and Bopp, 2001). By the mid-1960’s, the 180 ppm of total PAHs in sediments in the 1950’s dropped to 25 ppm.

In 2003, the Ohio EPA conducted a detailed assessment on the Mad River Basin in order to shed more light regarding PAH concentrations in the State’s aquatic environments (OH EPA, 2005). The results varied, but a large proportion of the samples were greater than measured above PEC values suggested by McDonald et al. (2000). Samples, summarized in Table 2, below, were collected at various junctions and tributaries in the Massachusetts River ecosystem.

Table 2. PAH concentrations in Mad River Basin sediments (mg/kg)

PAH name	Moore Run	Dugan Run	St. Paris Tributary	Buck Creek
B(a)A	1.62	3.18	1.27	2.22
B(a)P	2.04	2.99	1.38	2.39
B(b)F	2.81	3.09	1.55	2.67
B(g,h,i)PER	1.75	2.04	1.09	1.81
B(k)F	2.31	2.96	1.45	2.10
Chrysene	2.57	3.84	1.77	2.94
Fluoranthene	5.41	6.98	3.31	5.92
Indeno[1,2,3-cd]pyrene	2.08	2.20	1.15	2.04
Phenanthrene	2.07	3.60	1.43	2.91
Pyrene	4.24	5.75	2.64	4.60
Total PAH	26.90	37.26	17.04	29.60

***Bolded values indicate a level above the PEC.**

**Derived from OH EPA (2005).

Chrysene, fluoranthene, phenanthrene, and pyrene all were above PEC levels in all four locations in the Mad River area. B(a)P crossed the threshold in three of the sites, and passed the TEC in the St. Paris Tributary (1.38 mg/kg). Similarly, the total PAHs were above the PEC in all but the aforementioned tributary where it did exceed the TEC. Values higher than the TEC indicate harmful effects for benthic-dwelling organisms being more likely, but not quite probable (WI DNR, 2003). These levels are not novel to urban watersheds since effluents from anthropogenic activity inevitably enter these aquatic environments.

The main stressors impacting the Lewis Creek Watershed in a Virginia study were lead, total PAHs and sediments (VADEQ, 2006). Sediments often accumulate PAHs due to surface runoff, streambank erosion, and other natural erosion; however, human activity catalyzes these natural processes. This sediment movement transferred a significant amount of PAHs into previously uncontaminated areas in the watershed. With direct contamination a minor threat, the majority of hydrocarbons entered via urban areas such as the city of Staunton and point sources like the

Beverly Exxon site. In 2001, an initial sampling of only one site showed several PAHs above PEC guidelines. During the subsequent 2005 sampling sweep, all except one of the 13 sites showed concentrations above the PEC, and more of them exceeded the TEC. Though none of the PAHs at the other sites posed a threat individually, their toxicity has an additive effect that warrants interest since four sites showed greater than a 1.0 Hazard Index (VADEQ, 2006). The hazard index equals the sum of the hazard quotients (measured result/ PEC or screening level), and a score above 1.0 signifies a potentially toxic condition. Unfortunately, measurements taken five months later showed that half of the impending problem areas experienced statically significant reduction in biological survival or reduction in growth.

1.4 Florida Perspective

1.4.1 Florida Case Study #1

During investigations related to a former manufactured gas plant destined for urban redevelopment project in north-central Florida, PAHs were discovered in soils and roadside ditch sediments at levels that exceeded the site-specific park user scenario soil cleanup target level (SCTL) of 0.35 ppm, as well as the default Florida SCTL for industrial/commercial sites of 0.7 ppm. The 95% upper confidence limit on the mean benzo(a)pyrene-equivalent concentration for on-site soil samples was approximately 1.2 ppm. Site impacts were observed to be sporadic and not specifically associated with historical activities that may have resulted in PAH releases. Further, upstream roadside ditch samples contained higher levels of PAHs than those observed on the site, implicating general urban conditions.

The consultant demonstrated through literature review and site-specific data analysis that the observed concentrations were quite consistent with urban background for PAHs in such a setting. The federal and state agencies involved with the site concurred in principle, but procedurally required the enactment of an institutional control to notify future property owners of the presence of impacted soil and to prevent exposure.

1.4.2 Florida Case Study #2

A local housing authority in central Florida undertook the redevelopment of a decades old urban neighborhood bracketed by major roadways and an interstate highway. Surface soil investigations detected PAHs in excess of default residential SCTLs (0.1 ppm for B(a)P-eq) over most areas of the site. A statistical analysis of the data revealed a mean concentration of 0.6 ppm and a 95% UCL of the mean concentration of 1.1 ppm for 68 surface soil samples.

A background study was proposed by the consultants, and encouraged by the state, to support the literature-based and site-specific evidence of an urban background phenomenon. However, out of an abundance of caution, and in light of available funding for the remediation, it was decided to excavate, and or cap with two feet of clean soil, the exposed areas of the site (i.e., those areas not covered by roads, driveways or buildings).

1.4.3 Florida Case Study #3

As part of the due diligence involved in a property transaction in west-central Florida, PAH impacts were discovered in soils adjacent to and beneath an asphalt parking lot of a former retail shopping center. The investigation was expanded multiple times in an attempt to delineate the impacts. No clear delineation was evident for samples beneath the asphalt, but concentrations adjacent to the parking lot decreased with increasing distance from the parking lot. This was a fairly obvious example of the ubiquity of PAHs, and, specifically was concluded to be related to vehicle emissions and parking lot runoff causing low level impacts.

With a maximum benzo(a)pyrene-equivalent concentration of 2.1 ppm, and mean and 95% UCL concentrations of 0.4 ppm and 0.8 ppm, respectively, site concentrations were well within the widely published range of urban background PAH levels (i.e., typically 1-10 ppm, with some areas as high as 100 ppm). Once again, even though all parties agreed that historical site-related activities were not likely the cause of the observed PAH impacts, in order to facilitate the property transaction process, it was decided that soils adjacent to the parking lot would be excavated and replaced with clean fill. The soils beneath the parking lot were left in place, but an institutional control was enacted to notify future property owners of the presence of impacted soils.

2. DISCUSSION

- Stationary and mobile sources account for as much as 80% of PAHs. Let's worry about the other 20% (background).
- Remediation should not commence without establishing a site-specific background, if possible.
- "While natural events cannot be controlled they do contribute to the background and can have an important local impact. They may therefore affect the ability of a member state to meet any emission limit." (EU, 2003)
- Due to incongruity of nature and the variability in activity among people inhabiting a given area, background values vary a great deal.
- CERCLA [Section 104(3)(A)] addresses the impracticality and unfeasibility of remediation to guideline levels if naturally occurring background exceeds the maximum allowable value. It deems remediation unnecessary and unproductive in such scenarios.
- Those monitoring health risks and PAH concentrations should first identify and control the principal point sources contributing to ambient levels.
- Urban background may be detrimental to human health, but the inability to directly control diffuse and mobile sources makes the threat difficult to manage.
- The main goal is returning a site to urban background, which is relatively stable throughout a city. For this reason, baseline measurements should be determined by utilizing samples from an assortment of locations (parks, roadside, suburbia) throughout a city.
- A tier-based guideline system such as the Illinois TACO or ALARA is often ideal since minor contamination can be addressed with through a nominal response.
- ALARA system: "A tier 1 level of 1 mg/kg of PAHs measured as B(a)P eq. is recommended as a remediation goal; if PAHs are below this level, no further action is

required. A tier 2 level of 10 mg/kg of PAHs measured as B(a)P eq. is recommended as well; if PAHs are below this level, a subjective evaluation of likely current and potential future land use is required. If it appears unlikely that frequent exposure would occur, no further action is required.” (Lagoy and Quirk, 1994)

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