Identifying Sediment Contamination Sources in Watersheds of Austin, Texas

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Abstract: Contaminants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlorinated pesticides, herbicides and heavy metals are hydrophobic, will adsorb onto sediments, and thus are overlooked when water chemistry analysis is performed. However, laboratory costs of sediment analyses can prohibit the number of samples that can be analyzed, limiting the ability to isolate sources. The City of Austin Watershed Protection Department (WPD) has used enzyme linked immunosorbent assays (ELISA) as a fast, cost effective screening method to perform numerous analyses for polycyclic aromatic hydrocarbons (PAHs) in sediments. This method has been used successfully in identifying several localized sources of sediment contamination on four creeks in the Austin area. The contamination had previously been attributed to unknown sources due to lack of spatial resolution when laboratory expenses limited sampling.

Using ELISA as a screening tool has increased WPDs ability to identify sources of pollutants and eliminated the need for costly laboratory analyses for screening. The ability to collect up to 21 samples, run the analyses and obtain results immediately has increased the cost and time efficiency of sampling. The results have subsequently been verified using standard methods of sediment analysis. Verification of the ELISA results at contract laboratories have identified other pollutants such as heavy metals and pesticides at sites that are heavily contaminated with PAHs. These sites are under consideration for remediation and construction of stormwater controls under other WPD programs.

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Introduction: Sediments are an integral part of the benthic environment, providing feeding, habitat, and rearing areas for many aquatic organisms (1). Many contaminants are hydrophobic and will adsorb to the sediments, settle in the creek bed and accumulate at elevated levels in the benthic environment. These contaminants may be found in only trace amounts in the water column (1). Compounds can build up over time as a result of inputs from many sources. Rivers with rapid velocities are able to flush themselves of contaminants if the source is not ongoing; however, lakes and reservoirs act as settling basins and provide long residence times for the sediments in water bodies. The resident time of contaminants in the sediments depends on many biological, chemical and physical factors, such as degree of binding to sediments and degradation rates (2). Sediments serve as both a reservoir and a source for contaminants in the aquatic environment. They are capable of releasing contaminants to the water column and biota over extended periods of time or very quickly due to natural or man made disturbances (2). During a disturbance, toxics can be released back into the water column and become bioavailable. Release stimulated by bacterial decomposition and solubilization can be slow in undisturbed conditions. Peak concentrations in the water column have been correlated with organic matter decomposition, concentrating low flow conditions and storm water flushes (1).

Sediment-sorbed contaminants have been associated with a wide range of impacts on the plants and animals that live within and upon bed sediments. Acute and, in some cases, chronic toxicity of sediment-sorbed contaminants to algae, invertebrates, fish, and other organisms have been measured in laboratory toxicity tests (7). Fin rot, skin and neoplastic lesions and liver tumors have been found in fish living above sediment contaminated with PAHs. The most direct route to humans is consumption of fish tissue that has had the time to bioaccumulate various organic contaminants or metals. (2) The City of Austin's Watershed Protection Department (WPD) used the results of ongoing citywide studies to select creeks in the Austin, Texas area with elevated levels of contaminants in sediments. WPD staff had collected sediment at the mouths of all creeks entering the Town Lake watershed and four creeks of concern were selected from these results for further screening and source location (3). Table 1 shows these initial mouth concentrations prompting more detailed study.

Materials and Methodology:

Initial sites were selected using visual observation, based on availability of sediment and locations of interest. The first sampling run attempted to get a representation of the entire creek from the mouth to the headwaters; pinpointing sites suspected of contamination due to proximity to outfalls, development, or infrastructure. Several creeks have obvious inputs; such as drainage pipes and ditches that proved to be significant sources of contaminants. By sequentially sampling potential sources around sites of contamination, a specific input was located. Sediment was then collected at this site and submitted to a contract laboratory for analysis.

Field Methodology: For sediment screening, samples were collected from bed sediments in the creeks using a Teflon coated scoop or disposable presterilized plastic scoops. Several subsamples (minimum of three) were collected and composited in a glass bowl, prerinsed at each site with native water. The sediment was then transferred to new, sterilized whirlpaks or sterilized glass containers and placed on ice for transport to WPDs laboratory for extraction and screening analysis or transported to a contract laboratory for verification analysis. Samples at the WPD laboratory were then refrigerated (4^{o} C.) and extractions were performed as soon as possible, always within the ELISA manufacturer specified holding time of 14 days. Analyses were performed within 7 days of extractions. Sample handling and preservation for the contract laboratories complied with EPA methodologies.

Laboratory Methodology: The methodology used for sediment screening was the enzyme linked immunosorbent assay (ELISA) procedure for organic constituents. All WPD staff performing immunoassay analyses were trained and certified by Ohmicron Environmental Diagnostics (currently Strategic Diagnostics, Inc, SDI) All immunoassays rely on antibody coupled magnetic particles as the critical analytical reagent (4).The sample extract is added, along with an enzyme conjugate, to a disposable test tube, followed by paramagnetic particles coated with PAH specific antibodies. Both the analyte PAH and the labeled PAH (enzyme conjugate) compete for the antibody binding sites on the paramagnetic particles. At the end of the incubation period, a magnetic field is applied to hold the paramagnetic particles, (which contain the analyte PAH and labeled PAH bound to the antibodies in proportion to their original concentration) in the tube and allow the unbound reagents to be decanted. After decanting, the particles are washed in a washing solution. The presence of PAH is detected by adding an enzyme substrate specific to PAH. The enzyme labeled PAH conjugate bound to the PAH specific antibody catalyzes the conversion of the enzyme substrate mixture to a colored product. After an incubation period, the reaction is stopped and stabilized by the addition of acid. Because the labeled PAH (enzyme conjugate) is in competition with the analyte PAH (in the sample) for the antibody sites, the color development is inversely proportional to the concentration of PAHs in the sample (5).

Sample extractions were performed with the sediment extraction kit provided by SDI. This method employs premeasured vials of 100% methanol. A 10-gram sample is placed in 20 milliliters of methanol and shaken vigorously for one minute. The sample is then allowed to settle for one or more minutes and the liquid is removed and filtered. Filtered extract is then diluted with the appropriate extract diluent, (a buffered saline solution containing preservatives and stabilizers specific to and without detectable levels of analytes). Analyses were performed using ELISA kits for PAH, PCB, 2,4-D and Chlopyrifos. Each immunoassay requires eight standards and one control, multiplication by the appropriate dilution factor and calculations for dry weights for comparison purposes. Due to limited quantities of analysis materials, there were times when further dilutions were not performed if a sample was over range for a particular dilution.

The Elisa method is appropriate for screening and is not an EPA approved method for determining concentrations of specific organics. Therefore when a site was determined through screening to have elevated levels of a contaminant, additional samples were collected and submitted for analysis to a contract laboratory. Contract laboratory analyses for PAHs were performed using EPA Method 8270.

Data Evaluation Methodology: Screening results for sediment were compared to biological effects levels in the National Status and Trends Program produced by the National Oceanic Atmospheric Administration (NOAA) in 1990 (7), and listed in Table 1. Chemical concentrations in this study are reported as effects range-low (ER-L), the lowest 10 percent and effects range-median (ER-M) the median concentration where biological effects were observed. Most of the sites identified from screening results and subsequently submitted to a laboratory had verified concentrations above the ER-M of 35,000 ppb. Due to lack of funding , several sites have not been submitted to contract laboratories for further verification.

Results:

Initially, all sediments were screened using ELISA for PAH, PCB, 2,4-D (chlorinated herbicide) and Chlorpyrifos (an organophosphorous pesticide). The first sampling conducted in December of 1997 resulted in nondetects for PCBs, 2,4-D and Chlorpyrifos. The second screening date in

January of 1998 resulted in two detected values for 2,4-D on East Bouldin Creek. However, when resampled and submitted to a contract laboratory and analyzed for chlorinated herbicides, both samples resulted in nondetects. Subsequently, ELISA screening for 2,4-D, PCBs, and Chlopyrifos was discontinued and remaining screening studies focused on PAHs.

Waller Creek

Table 2 shows the results of ELISA analyses for PAHs in Waller Creek, listed from mouth to headwaters. Upstream of the University of Texas (UT) campus, sites listed in the Table as Skyview through Eastwood, PAHs were detected with ELISA screening but not at elevated levels. The Hemphill Tributary confluence with Waller Creek is located downstream of this area and immediately upstream of 24^{th} Street on the UT campus. This tributary is formed by the discharge of a large water quality wet pond and residential neighborhood runoff. Sampling in the upstream portions of this tributary showed little signs of contamination from PAHs. However, when nearing the confluence of Hemphill with Waller Creek, several drainage pipes are evident on the banks. Sediment samples collected directly downstream of these pipes (Hemphill @ Pipe) showed screening results with somewhat elevated PAH levels. These pipes drain buildings and laboratories affiliated with UT Austin. Downstream of the Hemphill confluence, the sediments in the mainstem of Waller Creek appear to recover, as ELISA screening results are nondetect at the 24^{th} Street dam site. Immediately downstream of this dam is a drainage pipe (Waller @ 24^{th} pipe - although not verified, these pipes appear to drain a parking garage in the vicinity), where screening detected elevated levels of PAHs.

The results, in Hemphill Branch and upstream and downstream of the dam, were verified by laboratory analyses and are provided in Table 3. At the two sites identified with problems in the screening, laboratory analyses confirmed that numerous individual PAHs and total PAHs exceeded biological effects levels. The site with the highest screening levels also had the reported the highest concentrations by EPA methods.

Screening levels of PAHs were consistently elevated downstream in the stretch of creek between 15^{th} and MLK Streets, both upstream and downstream of drainage pipes and ditches. Because of the number of discharge points within a small reach of creek, further investigation of this area is needed to determine possible PAH sources. The information was referred to Austin's Spills and Response group for further action.

East Bouldin Creek

Table 4 shows the results for East Bouldin Creek listed from most upstream site to most downstream site. Elevated screening levels were seen in many areas along the creek. However, lower levels are observed at intermittent sites, indicating that perhaps the creek sediments are recovering or being diluted by erosive sediments along the creek when no new inputs occur. Contamination problems appear to start at the Lightsey site, with the introduction of the diversion tunnel that drains Highway 290 into the creek. The Gillis Park vault, an underground water quality treatment chamber treating the Gillis Park neighborhood, discharges directly into the creek at Gillis Park, and screening levels downstream of this site for PAH were elevated. Several water quality projects have been constructed in this area and subsequent sampling may be used to test their effectiveness.

Downstream of Gillis Park, PAH levels increased; this site is below a major thoroughfare, dry cleaning business and a parking lot drainage ditch, all of which could be contributing to the increase in PAH level at this site. Near the mouth at the Post Oak sites several drainage pipes drain residential sections and apartment complex parking lots. The highest levels found here were below an outfall from the parking area of an apartment complex (EB @ Post Oak Apt pipe) and a pipe draining a residential neighborhood (EB @ Post Oak new pipe). The four highest level sites, were resampled and samples were submitted to the contract laboratories for standard analyses.

PAH results from the laboratory (Table 5) at the Lightsey site exceeded ER-L and ER-M levels for some individual PAHs; total PAHs exceeded the ER-L. The Gillis Park vault outfall and downstream of Gillis Park also showed values above ER-Ls and ER-Ms. This was not unexpected as the inlet filter sediments collected during a previous project (3) had higher levels of PAHs at Gillis Park than found in any of the other sediments collected by inlet filters. In the Post Oak neighborhood, the new pipe also had total PAHs above the ER-L. The Post Oak apartment pipe sediments, however, had many levels of PAH far exceeding the ER-M(7).

Metal contamination varied along the length of the creek corresponding to the site PAH levels. The sites downstream of Gillis Park had the highest lead levels, the Post Oak new pipe lead levels were above the ER-L, and the Post Oak apartment pipe had both lead and mercury levels above their ER-Ls. All results were referred to Water Quality Management (WQM) for consideration of Best Management Practices in the WPD Masterplan.

Shoal Creek
Shoal Creek results are shown in Table 6. Sampling was begun upstream of Highway 183, where PAH screening resulted in nondetects, and proceeded downstream. The next area sampled was downstream of Highway 183 where Shoal Creek Blvd. crosses the creek. The highest screening levels for Shoal Creek PAHs were observed at this location. Levels were much lower downstream above the Steck Ave. crossing, but were still higher than other sites in this study. An additional sample was obtained above this site in the Mopac Steck ponds to check for potential high levels from a land use: residential subwatershed west of MoPac highway. Values for PAHs were somewhat elevated as might be expected in a detention pond, but lower than several other instream sites in this study. This pond is currently being retrofit as a wet pond for water quality control purposes which should assist in reducing toxic levels in the creek sediment below.

The creek is channelized with concrete sideslopes and bed downstream of this site to just upstream of Silverway Avenue, Northcross Mall drains into the creek within this reach, and the site located near the mall showed high levels of PAH contamination. No visible drainage pipes or specific inputs are located in this area. The mall parking areas may drain to this reach as well as Steck Avenue and Anderson Lane. Further investigation by City staff is necessary to determine where the contamination originates. Results were forwarded to WQM for use in planning BMPs through the WPD Masterplan.

A sample was also taken in a channel below, Far West Pond, a detention/water quality pond before it drains to this reach of Shoal Creek. The screening level at this site was high for PAHs and it was noted that in addition to the pond drainage, another storm drain entered the channel above this sample point. The channel was sampled again above that pipe, to represent sediment discharging from the pond, and levels at this site, (Far West Pond outfall), were much lower as shown in Table 6. Despite high levels in this drainage channel, the site directly downstream in the mainstem of the creek (NW Park), appears to recover and had quite low PAH screening levels. The 39th Street site, which mainly drains residential areas, showed high PAH screening levels, but was resampled and found to be much lower at a later date.

When the Shoal Creek Blvd. site was sampled again on a different date for laboratory analyses, the results were not as high as the screening levels might have suggested, but the total PAHs was still above the ER-L. These results are shown in Table 7. All chlorinated pesticides and PCBs, chlorinated herbicides and organophosphorous pesticides for the site at Shoal Creek Blvd. resulted in nondetects. However, arsenic, zinc and lead were all above effects levels. The City is currently completing the design of a very large wet pond/detention facility at the northeast corner of the intersection of Highway 183 and MoPac. This facility will treat some of the MoPac Highway runoff as well as a large portion of the area in the northwest quadrant of that intersection that is currently undergoing rapid development. Later assessment at the Shoal Creek Blvd. site will allow evaluation of the effectiveness of this facility for controlling toxics detected during this study.

Barton Creek

Sampling in Barton Creek was the most intensive of the watersheds studied due to permit requirements of the City of Austin NPDES discharge permit as modified by USFWS Section 7 Consultation Reasonable and Prudent Measures.

Barton Creek showed consistently low levels of PAHs at all sites, except upstream of Barton Springs Pool, near the confluence with Town Lake (Table 8). Sites near Lost Creek Blvd were higher than other Barton Creek sites, but still comparable with lower levels found in other urban creeks.

To focus on the source areas for the high levels in Barton Creek above Barton Springs Pool, the sample 0.25 mile upstream of the pool was screened, but extremely low PAH levels were identified. Two adjacent subareas, which drain to the creek downstream of that site, above the impacted site, are the parking lots at Zilker Park on the north bank of the creek and apartment complexes on the south bank. Sediment from these areas where they appear to drain to the creek were sampled and screened. The site draining Zilker Park parking lot showed elevated screening levels for PAHs, but levels were small compared to extremely high levels of contamination draining from apartments on the opposite bank of the creek. A small watershed containing a private apartment complex has been identified as a source of elevated PAHs with heavy metals such as mercury and pesticides being detected at the problem site. This site has been resampled several times. Both mercury and organic hydrocarbons are well above the Texas Natural Resource Conservation Commission (TNRCC) Screening levels (8). This data has been used to identify concerns for TMDL planning through the Clean Water Act 303(d). These high levels have been verified by contract laboratories as over 655,100 ppb total PAHs (Table 9). This site also showed contamination from chlorinated pesticides, Beta BHC (91.2ppb), Endrin (67.2 ppb) and Heptachlor (20.1ppb). The upstream sample was also analyzed at the laboratory to confirm that contamination did not exist above the site. The parking lot draining Zilker Park has been resampled and eliminated as a source of elevated contaminants. As the sediment of concern originates on private property, and no intervening storm sewers are located between the site and the creek, the City must further investigate possible controls and coordinate with the site landowner. Planning for controls or remediation of sediments is under consideration by WQM.

Continued sampling under the City of Austin's NPDES monitoring programs will assist in determining if there are specific subwatersheds that require Best Management Practices for control of toxic sediments. Subsequent sampling and analysis in Barton Creek between Barton Springs Pool and Loop 360 has detected elevated levels of PAHs in several pools, including the pool at Campbell's Hole. Screening of tributaries and small drainage's upstream of these sites with ELISA was conducted and has identified several sites as potential sources of contaminants. Results of this screen are shown in Table 8. Many more were eliminated as potential sources by this same process.

After priority identification with ELISA, the sites were revisited and samples were submitted to a contract laboratory for verification. When samples from these sites were found to be contaminated with PAHs, they generally were accompanied by additional toxics such as heavy metals and/ or pesticides. Samples from the following sites have been verified as having elevated contaminants. A site directly downstream of Campbell's Hole was identified as contributing elevated PAHs and pesticides (DDT), this site (Waterfall Grotto) drains road runoff from MoPac, although contaminants appear to be entering the system downstream of where the tributary crosses Spyglass Drive. The COA has no access to this area as it is private property and further investigations will be needed to determine the sources of these contaminants. Most parameters are below detection limits when sampled upstream in the tributary close to MoPac drainage. Elevated levels of PAHs have also been detected in a site upstream of the Spyglass access to the greenbelt. This site drains a parking lot to a private apartment complex. Although these sites do not interact with Barton Creek during periods of low rainfall and drought, (levels of contaminants appear to drop in the mainstem creek), these sites discharge into the creek during stormflow and may flow continually during wetter seasons. Additional investigations into the areas upstream of Lost Creek Blvd. have not been successful in identifying contaminant sources. Several laboratory analyses were performed on tributaries in and around the Short Spring Branch Tributary, indicating low levels of contaminants of concern. Additional sampling of these sites in the Lost Creek area may be warranted.

Conclusions: ELISA screening has been useful in helping the City of Austin's WPD to identify sources of contaminants into area creeks. This is a relatively inexpensive and rapid way to perform numerous sediment sample analyses, with a minimum of training. Laboratory costs of sediment analyses by EPA approved methods can prohibit the number of samples that can be analyzed, limiting the ability to isolate sources. WPD has used ELISA as a fast, cost effective screening method to perform numerous screening analyses for polycyclic aromatic hydrocarbons (PAHs) in sediments. This method has been used successfully in identifying several localized sources of sediment contamination on four creeks in the Austin area. The contamination had previously been attributed to unknown sources due to lack of spatial resolution when laboratory expenses limited sampling.
Using ELISA as a screening tool has increased WPDs ability to identify sources of pollutants and eliminated the need for costly laboratory analyses for screening. The ability to collect up to 21 samples, run the analyses and obtain results immediately has increased the cost and time efficiency of sampling. Verification samples in almost all cases corroborated screening results.

Verification of the ELISA results by EPA methods have identified other pollutants such as heavy metals and pesticides at sites that are heavily contaminated with PAHs. In most cases the results acquired by ELISA are not exactly the same or even of the same order of magnitude as results given by method 8270 (see Tables for comparisons), although relative relationships between sites were consistent with laboratory results, even though absolute numbers were not identical. This enabled WPD to accurately screen and select sites for further investigation at a relatively low cost. These sites are under consideration for remediation and construction of stormwater controls under other WPD programs. Access and infrastructure difficulties make correction of sediment contamination difficult. Regardless of funding availability and planning prioritization obtaining the information to direct BMP placement on the basis of sediment data was worthwhile. Final disposition of identified sources has not been determined because of funding priorities of WPD; however, NPDES permitting requirement requires at least one retrofit BMP in the lower Barton Creek watershed as a Reasonable and Prudent Measure for the protection of the Barton Springs salamander, an endangered species.

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Table 1. Results of laboratory PAH analysis for mouths of area creeks

Site	Date	Total PAH in ppb
ER-L (Effects range- Low)		4000
ER-M (Effects range-Median)		35,000
Barton Creek Above Barton Springs Pool	11/21/94	160,892
	4/20/95	56,860
	7/09/96	<DL
East Bouldin @ Town Lake	11/21/94	8,568
	4/20/95	40,298
	07/09/96	<DL
Shoal Creek @ Town Lake	11/21/94	6,466
	4/20/95	31,540
	07/09/96	15,947
Waller below Caesar Chavez	07/10/96	13,334

Table 2. Elisa Screening Results for Waller Creek

Site	PAH Screening Values		
	12/15/97	1/5/98	1/20/98
Skyview		ND	
Koenig			24,467
Koenig pipe			20,541
51st St	22,242		
Eastwood	13,135		
Hemphill	7,714		
Hemphill @pipe		15,147	
Upstream of 24th @ dam		ND	
Upstream of 24th @ pipe		1,930,805	
21st St	31,574		
MLK		51,139	
MLK downstream of pipe			21,333
Trinity St		99,988	
15th St		183,180	20,585
15th St downstream of pipe			7,929
Waterloo	30,175		
Palm Park	15,886		
Over range for test dilution			

Table 3. Laboratory Results for Waller Creek Sites in ppb

Polycyclic aromatic hydrocarbons in Sediment	Waller @ 24th pipe 1/20/98	Waller@ 24 pipe 3/10/98	Hemphill @ pipe 3/10/98	Hemphill @ pipe 3/10/98	Waller @24th ups of dam 3/10/98	Waller @24th ups of dam 3/10/98
	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Anthracene		570		<703		
Benzo (B+K) Flouranthene		2,553		3860		<1,054
Benzo(a) anthracene	<1,310	2,127	1,260	1,936	<600	<527
Benzo(b)flouranthene	13,200		2,550		641	
Benzo(k)flouranthene	5,220		1,570		<600	
Benzo(g,h,I)perylene	<7,640	1,758	1,990	1,390	658	<527
Benzo(a)pyrene	16,200	2,005	5,750	1,559	1,400	<527
Chrysene	14,100	3,160	3,920	2637	1,020	<527
Dibenz(a,h)anthracene	<3,020	1,920	3,170	<703	<1,200	<527
Flouranthene	39,600	6,333	7,120	5,129	1,760	<527
Flourene	<2,120	<566	<600	<703	<600	<527
Indeno(1,2,3-cd)pyrene	7,200	1,705	1,720	1,463	<1,200	<527
Napthalene	<30,200	<566	<3,000	<703	<3,000	<527
Phenathrene	19,800	4,992	2,080	3,400	<600	<527
Pyrene	19,500	5,851	6,860	5,324	1,630	<527
Oil & Grease mg/kg	175	231	447	1,339	63	402
Total Pet. Hydrocarbon	195	220	427	1,054	122	289
Total PAH	134,820	33,063	37,990	26,698	7,109	<527

Table 4. ELISA Screening results for East Bouldin Creek

Sites	PAH Values		
	12/15-16/97	01/05/1998	01/20/1998
EB@Alpine	16,430		
EB@Lightsey		45,717	
EB@Coleman		13,289	
EB upstream of Gillis Park	3,710	ND**	
EB Gillis Park vault outfall		47,383	
EB dwnstream of Gillis Park		144,312	
EB@1st	14,530		
EB@ Upstream of Apartments			10,376
EB@ Post Oak apartments		312,323	
EB@ Post Oak new pipe			66,144
EB@ Post Oak Tunnel			6,983

Over range for test dilution **overrange for Ist dilution ND for 2nd Dilution

Table 5. Laboratory Results for PAH in East Bouldin Creek

Polycyclic aromatic hydrocarbons in Sediment	East Bouldin @ vault 1/20/98	East Bouldin @ Lightsey 1/20/98	East Bouldin @ new pipe 3/10/98	East Bouldin @ new pipe 3/10/98	East Bouldin @ Apt pipe 3/10/98	East Bouldin @ Apt pipe 3/10/98	East Bouldin dwnstrm GP 3/10/98
	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Acenapthene				<1041.3		1,579	
Benzo (B+K) flouranthene				4,257		53,039	
Benzo(a) anthracene	578	584	<600	1,739	9,830	21,171	899
Benzo(b)flouranthene	2,080	1,630	1,660		17,700		1,890
Benzo(k)flouranthene	819	1,190	1,220		10,000		1,250
Benzo(g,h,I)perylene	<1530	<1530	1,580	1,381	10,200	17,615	1,550
Benzo(a)pyrene	2,630	2,640	2,350	1,699	18,700	22,832	2,410
Chrysene	2,770	2,150	2,370	2,676	21,300	31,669	2,270
Dibenz(a,h)anthracene	1,170	1,280	1,880	<1041.3	6,790	4,363	1,860
Flouranthene	2,250	3,580	3,780	3,984	41,900	39,720	5,280
Flourene	<423	<423	<600	<1041.3	<3000	1,588	<600
Indeno(1,2,3-cd)pyrene	1,220	1,130	1,230	1,456	10,800	19,233	1,280
Napthalene	<6030	<6030	<3000	<1041.3	<15000	<1024.2	<3000
Phenathrene	<1290	<1290	926	1,993	12,400	19,745	1,690
Pyrene	1,830	3,100	3,640	4,209	38,200	41,520	5,280
Oil & Grease mg/kg	74	81	118	1,785	68	2,189	133
Total Pet. Hydrocarbon mg/kg	69	47	102	1,055	83	1,141	358
Total PAH	15,347	17,284	20,636	23,394	197,820	274,074	25,659

Table 6. ELISA Screening Results for Shoal Creek

Sites	PAH Values			
	12/15/97	01/05/98	01/20/98	04/17/98
Above Highway 183		ND		
At Shoal Creek Blvd.		128,369		
Mopac-Steck Pond Sediments				302,956
Steck Blvd.	29,772			
Near Northcross Mall		54,995		
Far West Pond Channel		54,853	9,810	
Northwest Park	11,145			
39th St.	16,181			3,065
Pease Park	2,558	ND		
Over range for test dilution				

Table 7. Laboratory Results for PAH for Shoal Creek

Polycyclic Aromatic Hydrocarbons sediments	Shoal Crk. Blvd 1/20/98
	ug/kg
Acenaphthene	
Acenaphthylene	
Benzo(a) anthracene	<261
Benzo(b+k)flouranthene	1,403
Benzo(g,h,I)perylene	<1,530
Benzo(a)pyrene	1,390
Chrysene	982
Dibenz(a,h)anthracene	668
Flouranthene	1,640
Flourene	<423
Indeno(1,2,3-cd)pyrene	<864
Napthalene	<6,030
Phenathrene	<1,290
Pyrene	695
Oil & Grease	28.7
Total Pet. Hydrocarbon	<25
Total PAH	6,778