

FINAL REPORT

**MEASUREMENTS AND LOADINGS OF POLYCYCLIC AROMATIC
HYDROCARBONS (PAH) IN STORM WATER, COMBINED SEWER
OVERFLOWS, RIVERS, AND PUBLICLY OWNED TREATMENT
WORKS (POTWs) DISCHARGING TO MASSACHUSETTS BAYS**

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FOREWORD

The roots of the Massachusetts Bays Program extend back to 1982, when the City of Quincy filed suit against the Metropolitan District Commission and the Boston Water and Sewer Commission over the chronic pollution of Boston Harbor, Quincy Bay, and adjacent waters. Outdated and poorly maintained sewage treatment plants on Deer Island and Nut Island were being overwhelmed daily by sewage from the forty-three communities in the Metropolitan Boston area. Untreated and partially treated sewage were spilling into Boston Harbor.

Litigation over the pollution of Boston Harbor culminated in 1985 when the United States Attorney filed suit on behalf of the Environmental Protection Agency against the Commonwealth of Massachusetts for violations of the Federal Clean Water Act. The settlement of this suit resulted, in 1988, in the creation of the Massachusetts Water Resources Authority, the agency currently overseeing a multi-billion dollar project to repair and upgrade Metropolitan Boston's sewage treatment system. In addition, the settlement resulted in the establishment of the Massachusetts Environmental Trust - an environmental philanthropy dedicated to improving the Commonwealth's coastal and marine resources. \$2 million in settlement proceeds were administered by the Trust to support projects dedicated to the restoration and protection of Boston Harbor and Massachusetts Bay.

The Trust provided \$1.6 million to establish the Massachusetts Bays Program, a collaborative effort of public officials, civic organizations, business leaders, and environmental groups to work towards improved coastal water quality. The funding was used to support both a program of public education and a scientific research program focusing on the sources, fate, transport and effects of contaminants in the Massachusetts and Cape Cod Bays ecosystem. To maximize the efficiency of limited research funding, the sponsored research program was developed in coordination with research funded by the MWRA, the United States Geological Survey, and the Massachusetts Institute of Technology Sea Grant Program.

In April, 1990, following a formal process of nomination, the Massachusetts Bays Program became part of the National Estuary Program. The additional funding provided as part of this joint program of the Environmental Protection Agency and the Commonwealth of Massachusetts is being used to continue a coordinated program of research in the Massachusetts Bays ecosystem, as well as supporting the development of a comprehensive conservation and management plan for the coastal and marine resources of Massachusetts and Cape Cod Bays. The study described in this report addresses revised loading estimates of polycyclic aromatic hydrocarbons (PAHs) in storm water, combined sewer overflows, rivers and publicly owned treatment works discharging to Massachusetts Bays. This information is helping to meet the Massachusetts Bays Program goal of producing an area-wide management plan for water quality enhancement and protection.

The information in this document has been subject to Massachusetts Bays Program peer and administrative review and has been accepted for publication as a Massachusetts Bays Program document. The contents of this document do not necessarily reflect the views and policies of the Management Conference.

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EXECUTIVE SUMMARY

Because PAH compounds can pose a risk to human health and the environment, there is interest in having good estimates of source concentrations and loadings to Massachusetts coastal areas. A 1991 study of pollutant loads (Menzie-Cura, 1991) demonstrated that nonpoint sources may be important contributors to Polycyclic Aromatic Hydrocarbons (PAHs) to near-shore regions of Massachusetts Bay. However, since limited data were available for the Massachusetts coastal region, the 1991 study relied upon extrapolations from data collected in other geographic areas from a variety of studies. This is a source of uncertainty in the 1991 estimates.

The current study was designed to reduce uncertainties in PAH loading estimates by collecting site-specific nonpoint and point source PAH data which would allow more accurate estimation of loadings. By including both point and nonpoint sources in the measurements program, a data set of even analytical quality was established to provide a basis for assessing the relative contributions of each type of source.

The program was also designed to examine relationships among PAH compounds - which are expensive to analyze - and the conventional pollutants total suspended solids (TSS), total organic carbon (TOC), and oil and grease (O&G). Because PAH compounds preferentially partition to particulate organic matter (Mackay et al., 1992), it was anticipated that there may be statistical relationships between PAH concentrations and TSS or TOC for particular source types and land use. Identifying these relationships could assist in predicting PAH loads from analysis of the less expensive conventional pollutants.

The study included:

- Sampling the Deer Island, Nut Island, South Essex Sewerage District, and Lynn Treatment Plant effluents;
- Sampling Combined Sewer Overflows (CSOs) in residential and commercial/industrial areas in the Massachusetts Water Resources Authority (MWRA) system during periods of overflow;

PAH concentrations in the effluent than the POTWs with only primary treatment.

PAH Relationships with TSS, TOC, and O&G

Correlation and linear regression analyses indicated that TSS and TOC can be good predictors of PAH concentrations for specific source types and land use categories. Results show that:

- For the urban POTW NPDES source category, TOC and TSS are significant predictors of Total PAH and LMW PAH.
- For the nonurban storm water source category, TOC, TSS and O&G can be used to predict any of the PAH variables.
- For the urban river source category, TOC can be used to predict total PAH, HMW PAH and carcinogenic PAH concentrations.
- None of the conventional pollutants are significant predictors of urban CSO, urban storm water, or nonurban river PAH concentrations.

Loadings of PAHs

Using the new PAH concentration data, estimates were made of the loads to Massachusetts Bay (Figure ES-1 and ES-2). Total PAH loading to Massachusetts Bay was estimated to be 1.4×10^4 kg/yr (Figure ES-1). This estimate is slightly higher than the higher of two estimates presented in the Menzie-Cura (1991) report. The newer site-specific estimates indicate that the 1991 study slightly *overestimated* the contribution of POTW NPDES discharges but *underestimated* stormwater and river loadings. The calculations show:

- POTWs were the greatest source of low molecular weight PAH compounds as well as total PAH (Figure ES-1 and ES-2); naphthalenes comprise a major portion of the low molecular weight PAH;
- Nonpoint sources including rivers are the greatest sources of high molecular weight PAH compounds which includes the carcinogenic compounds (Figure ES-1 and ES-2);

Massachusetts Bay. On the other hand, urban storm water discharges may have more local effects. The relative magnitude of these effects should be assessed, before instituting controls in one basin over another.

6. This analysis of waterborne PAH loadings should be compared to an analysis of atmospheric loadings directly to the surface of Massachusetts Bay (Golomb et al., 1995).

References for Executive Summary

Golomb, D., D. Ryan, N. Eby, J. Underhill, T. Wade, and S. Zemba. 1995. Atmospheric deposition of contaminants onto Massachusetts and Cape Cod Bays. Massachusetts Bays Program, Boston MA. MBP-95-07.

Mackay, D., W.Y. Shiu, and K.C. Ma. 1992. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. Volume II: Polynuclear Aromatic Hydrocarbons, Polychlorinated Dioxins, and Dibenzofurans. Lewis Publishers, Ann Arbor. 597 p.

Menzie-Cura, 1991. Sources and Loading of Pollutants to Massachusetts Bay. Massachusetts Bay Program, Boston, MA. MBP 91-01.

Menzie-Cura, 1995. Organic Loadings from the Merrimack River to Massachusetts Bay. Massachusetts Bay Program, Boston, MA. MBP 95-04.

**TABLE ES-2
DESCRIPTIVE STATISTICS FOR SOURCES**

NPDES DATA

Parameter	Number of Samples	Minimum	Maximum	Distribution	Log of the				Standard Error of the Mean
					Geometric Mean	Geometric Std. Dev.	Arithmetic Mean	Arithmetic Std. Dev.	
PAH (ng/l)									
Total PAHs	12	179.4	33540	lognormal	3162	4.3	6865	9188	2652
Carcinogenic PAH	12	15.23	534.2	lognormal	75.86	2.7	120.2	143.9	42
LMW PAHs	12	122.9	31700	lognorm J	2951	4.6	6572	8711	2515
HMW PAHs	12	44.70	1835	lognormal	144.5	3.0	292.7	500.9	145
TOC (mg/l)	10	9.0	95	both	33	2.6	47	35	11
TSS (mg/l)	10	2.5	97	normal	32	3.3	47	31	10
O&G (mg/l)	8	1.0	33	neither	5.4	6.0	15	15	5.3

CSO DATA

Parameter	Number of Samples	Minimum	Maximum	Distribution	Log of the				Standard Error of the Mean
					Geometric Mean	Geometric Std. Dev.	Arithmetic Mean	Arithmetic Std. Dev.	
PAH (ng/l)									
Total PAHs	9	1332	17968	lognormal	3388	2.3	4780	5199	1733
Carcinogenic PAH	9	325.4	5300	lognormal	812.8	2.5	1265	1575	525
LMW PAHs	9	594.6	9148	lognormal	1820	2.4	2624	2687	896
HMW PAHs	9	603.6	8820	lognormal	1445	2.3	2157	2604	868
TOC (mg/l)	9	4.0	24	both	9.1	2.0	11	7.5	2.5
TSS (mg/l)	9	8.0	154	both	38	2.5	53	48	16
O&G (mg/l)	9	3.0	25	both	9.1	2.5	12	8.8	2.9

Notes:
Distribution is either normal, lognormal, both, or neither

TABLE ES-2
DESCRIPTIVE STATISTICS FOR SOURCES

RIVER DATA

(urban category)

Parameter	Number of Samples	Minimum	Maximum	Distribution	Log of the				Standard Error of the Mean
					Geometric Mean	Geometric Std. Dev.	Arithmetic Mean	Arithmetic Std. Dev.	
PAH (ng/l)									
Total PAHs	9	205.7	5681	lognormal	933.3	3.0	1578	1182	394
Carcinogenic PAH	9	21.71	747.4	lognormal	154.9	3.0	245.3	255.1	85
LMW PAHs	9	72.00	4000	lognormal	575.4	3.4	1049	1250	417
HMW PAHs	9	46.84	1681	lognormal	316.2	3.0	528.7	581.3	194
TOC (mg/l)	9	1.1	15	lognormal	4.074	2.1	5.2	4	1.3
TSS (mg/l)	9	2.0	12	both	4.467	2.0	5.5	3.7	1.2
O&G (mg/l)	6	1.0	5.0	neither	1.585	2.0	2.0	1.7	0.7

RIVER DATA

(nonurban category)

Parameter	Number of Samples	Minimum	Maximum	Distribution	Log of the				Standard Error of the Mean
					Geometric Mean	Geometric Std. Dev.	Arithmetic Mean	Arithmetic Std. Dev.	
PAH (ng/l)									
Total PAHs	7	121.5	459.4	both	288.4	1.5	308.0	117.0	44
Carcinogenic PAH	7	20.20	149.0	both	72.44	2.0	86.10	47.11	18
LMW PAHs	7	29.00	315.0	both	131.8	2.2	159.9	93.40	35
HMW PAHs	7	29.70	253.0	both	123.0	2.1	147.8	81.21	31
TSS (mg/l)	7	6.0	15	both	9.3	1.4	9.9	3.3	1.3
TOC (mg/l)	7	2.3	5.0	both	3.2	1.3	3.3	0.92	0.3
O&G (mg/l)	1	1.0	1.0	NC	NC	NC	NC	NC	NC

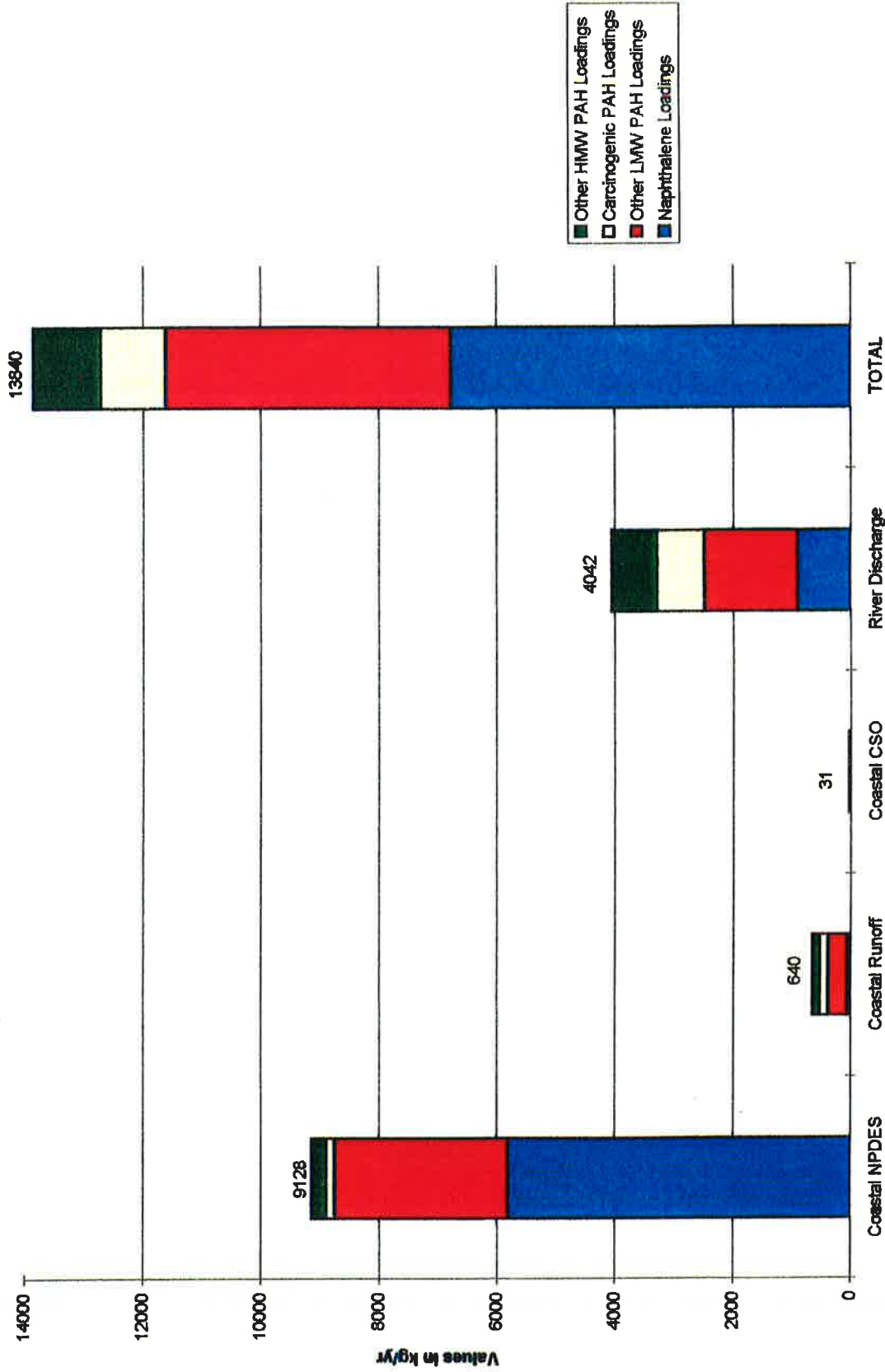
Notes:

Distribution is either normal, lognormal, both, or neither

NC = Not Calculated (only one sample)

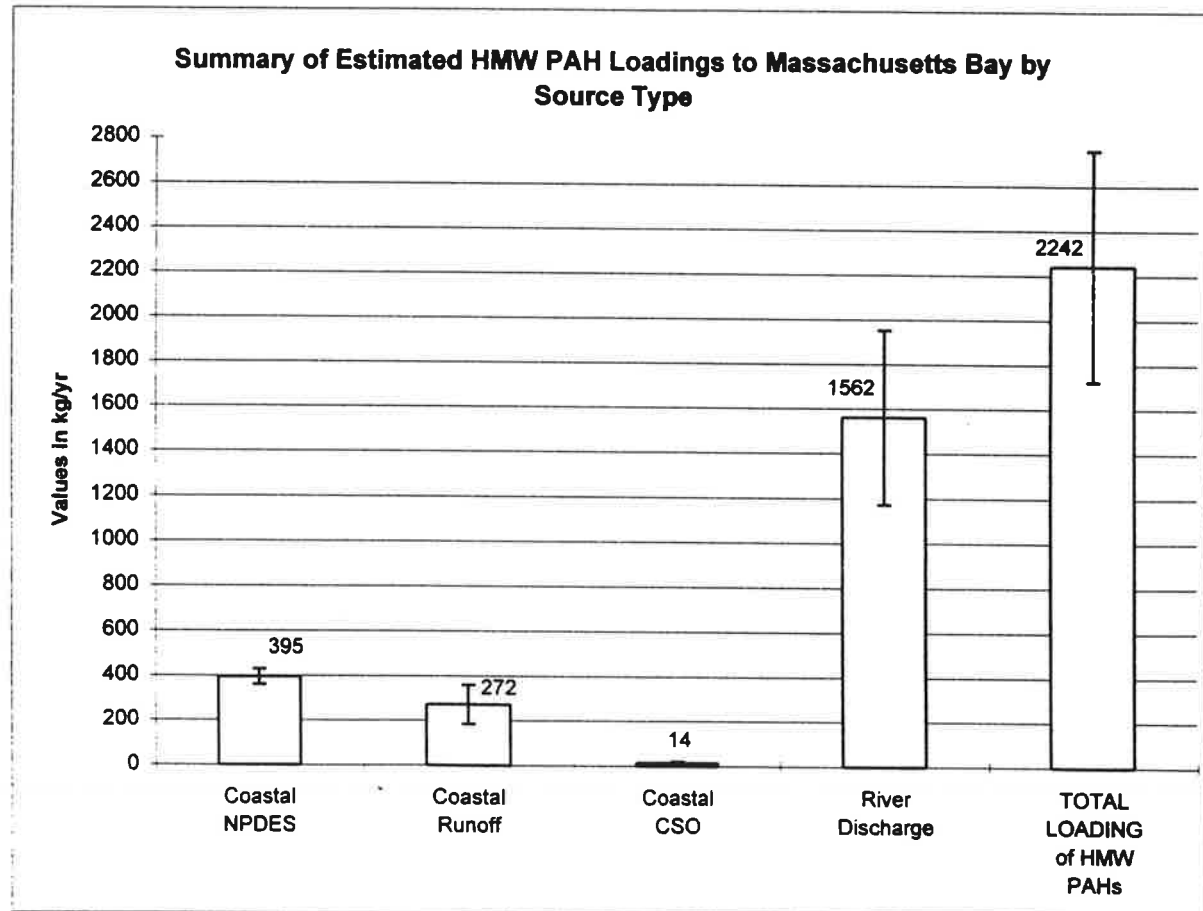
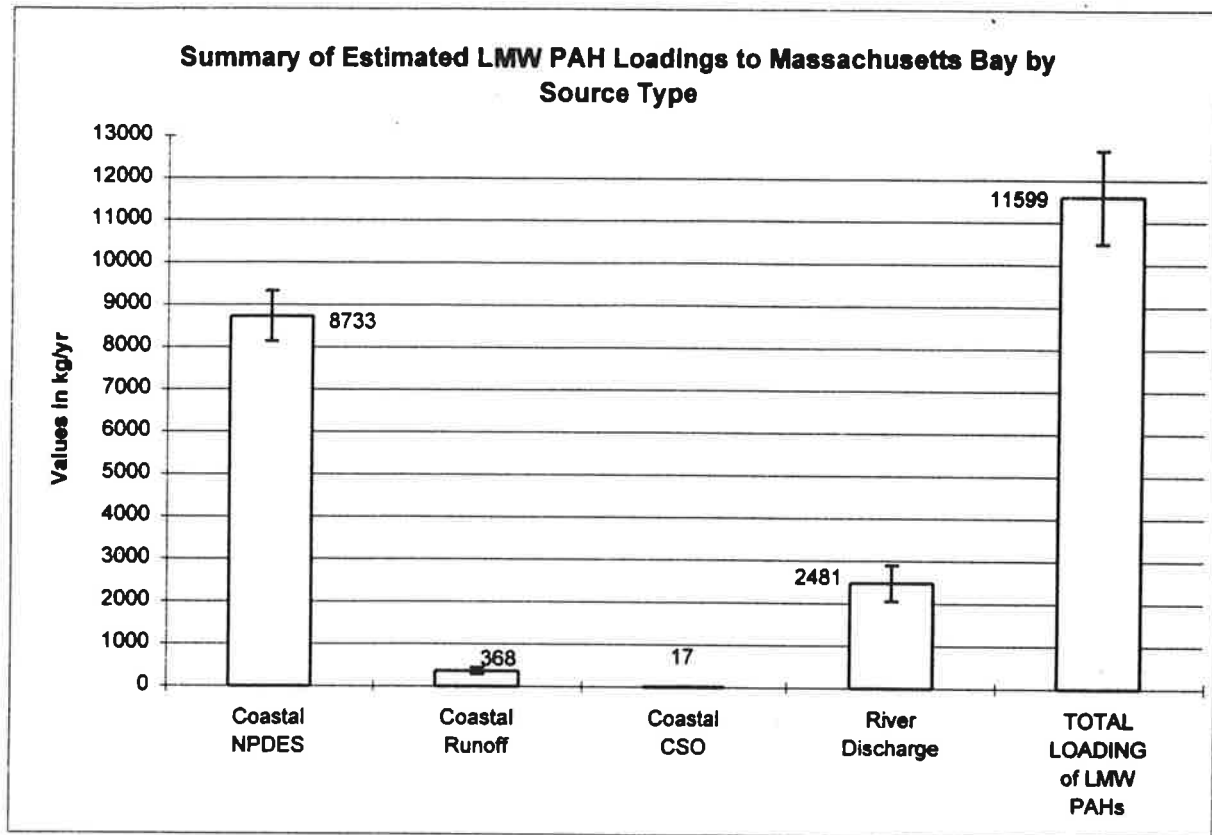
FIGURE ES-1

Summary of Estimated PAH Loadings to Massachusetts Bay by Source Type



Note:
 Carcinogenic Loadings (9 compounds) are a subset of HMW Loadings (17 total compounds)
 Naphthalene Loadings (5 compounds) are a subset of LMW Loadings (22 total compounds)

FIGURE ES-2



1.0 INTRODUCTION

1.1 Objectives

The initial Massachusetts Bays study by Menzie-Cura & Associates, Inc. (Menzie-Cura, 1991) estimated sources and loadings of contaminants to Massachusetts Bay. This study demonstrated that nonpoint sources may be important contributors to Polycyclic Aromatic Hydrocarbons (PAH) loadings in near-shore regions of the Massachusetts Bay system. These compounds have been identified as important with regard to potential human and ecological effects. Therefore, there is interest in having good estimates of source concentrations and loadings. However, since limited data were available for the Massachusetts coastal region, the initial study relied upon extrapolations from data collected in other geographic areas from a variety of studies.

The 1991 study found that very little data were available on PAH compounds in point and nonpoint sources discharging to coastal areas. The authors noted that:

The Nationwide Urban Runoff Program (NURP) carried out by the U.S. Environmental Protection Agency (EPA) did not focus upon the nature of PAH loads in nonpoint sources;

The National Coastal Pollutant Discharge Inventory (NCPDI) developed by the National Oceanographic and Atmospheric Administration (NOAA) provides little information on loadings of PAHs that can be used for the Massachusetts Bay system;

Discharge monitoring for point sources generally does not include PAHs; when they are measured, the detection limits are usually high and PAH loads are not always properly reflected by the data; and,

Studies from the Boston Harbor area on combined sewer overflows (CSO) and other nonpoint sources have either not measured PAHs, or have used analytical methods that have not been sensitive enough.

Recognizing these data gaps, investigators for the Narragansett Bay studies (Hoffman, et al. 1982, 1984 and 1985) completed a series of field studies for

NOAA and EPA to develop information on the characteristics and loads of organic compounds in runoff. They compared estimates generated with their field data to estimates from other sources (e.g., atmospheric and point sources). The work illustrated the importance of obtaining site-specific information on the concentrations of the PAH compounds.

The current study was designed to reduce uncertainties in PAH loading estimates by collecting site-specific nonpoint and point source PAH data which would allow more accurate estimation of loadings. By including both point and nonpoint sources in the measurements program, a data set of even analytical quality was established to provide a basis for assessing the relative contributions of each type of source.

The program was also designed to examine relationships among PAH compounds - which are expensive to analyze - and the conventional pollutants total suspended solids (TSS), total organic carbon (TOC), and oil and grease (O&G). Because PAH compounds preferentially partition to particulate organic matter (Mackay et al., 1992), it was anticipated that there may be statistical relationships between PAH concentrations and TSS or TOC for particular source types and land use.

Correlations between TSS and several organic compounds were observed in storm water runoff data (Hoffman, 1982 and 1984). However, no previous studies have attempted to define relationships between PAHs and TSS, TOC or O&G. If regression models could be developed, then the routinely collected conventional pollutant data could be used to estimate the concentrations of PAHs.

Specifically, the present study had several objectives:

- to measure PAH concentrations from various nonpoint sources - CSOs, storm sewers, and rivers;

- to measure PAH concentrations in the effluent of major point sources to Massachusetts Bay (publicly owned treatment works), for use in comparisons;

2.0 TECHNICAL APPROACH

2.1 Overview

The specific goals of the study were to collect sufficient PAH and conventional pollutant data for the major categories of source type and land use to characterize variability, and to identify statistical relationships between parameters which could be used to estimate PAH concentrations for other source areas, where only conventional pollutant data were available. A separate study (Golomb, et al., 1995) has addressed atmospheric loadings; ultimately the results of both studies will be brought together to provide a more complete picture of overall loadings of PAH compounds.

The analysis had four main components:

- identification of parameter statistical distributions and characterization of the variability of pollutant concentrations;

- identification of statistical relationships between PAHs and conventional pollutants, for the measured nonpoint and point sources;

- recalculation of the loadings of PAHs to Massachusetts Bay from specific land use areas within the Boston Harbor and the Salem Sound drainage basins; and,

- extrapolation of the results to other similar land use areas within the regions of the study, using data from the earlier study (Menzie-Cura, 1991).

With regard to recalculating loadings, the main difference between the initial Menzie-Cura (1991) study and the current study is that this one used region-specific measured concentrations of PAHs; the other assumptions were the same. We recognize that the *assumptions* made in the calculation of loadings result in *estimates* of the PAHs which reach the shoreline of Massachusetts Bay.

This shoreline may include the mouth of an estuary at an open coast, a small embayment, an open coastline, or any combination. Each of these separate

2.2.1 Publicly-Owned Treatment Works

Four Publicly-Owned Treatment Works (POTWs) were selected for National Permit Discharge Elimination System (NPDES) outfall sampling: the City of Lynn's sewerage treatment plant, the Southeast Essex sewerage treatment plant, the Massachusetts Water Resources Authority's Nut Island plant and the Massachusetts Water Resources Authority's Deer Island plant.

The Lynn plant is a secondary treatment plant that discharges into Lynn Harbor. The effluent from this plant was sampled by personnel from Menzie-Cura, from a sluiceway leading to the point of discharge. This sampling point was downstream of all treatment activities, and samples collected from it represented the final effluent entering Lynn Harbor.

The Southeast Essex plant is a primary treatment plant that discharges into Salem Harbor. The effluent from this plant was sampled by personnel from Menzie-Cura from a valve at the plant, upstream of the pipe leading to the point of discharge. This sampling point was downstream of all treatment activities, and samples collected from it represented the final effluent entering Salem Harbor.

Personnel from MWRA sampled the effluents from the Nut Island and Deer Island plants, upstream of their points of discharge. The sampling points were downstream of all treatment activities, and samples collected from them represented the final effluents entering Boston Harbor.

2.2.2 Combined Sewer Overflows

In the study area, CSOs occur in the Boston area. The other communities do not have functioning CSOs. We coordinated CSO sampling with MWRA's CSO sampling program, and selected five CSOs in the MWRA service area:

BOS-080, a CSO with a 47-acre, mixed residential/commercial/industrial tributary area;

BOS-012, a CSO with a 35-acre, mixed residential/commercial tributary area;

had previously installed sampling meters, and were easily accessible. The Boston stations and their various urban land uses were:

Dorchester, a storm sewer at Baker Square representing commercial/residential land use;

Hyde Park, a storm sewer at Walcott Street representing urban residential land use;

West Roxbury, a storm sewer at 51 Hollywood Street representing urban residential land use;

Allston-Brighton, a storm sewer at Guest Street representing urban residential/commercial land use; and,

Charlestown, a storm sewer at Medford Street representing urban residential/commercial land use.

We coordinated sampling of these urban storm drains with the BWSC. The automatic samplers were checked at the beginning of the storm for proper functioning and were set to begin sampling at a given water level in the pipe (the level was unique to each pipe based on the contractor's prior experience sampling these stations). The samplers collected a flow-weighted, 2.5-gallon sample by taking 750 ml for every 40,000 gallons of flow through the pipe. At the end of the storm, the samples were removed from the samplers and the flow data were obtained from the flow meters.

The other three urban storm water stations were in the City of Salem. These did not have automated meters installed in sewer manholes. These were "end-of-pipe" stations, discharging directly into the coastal area. The City of Salem storm water stations were:

Salem Leavitt, a storm water outfall adjacent to Leavitt Street, which drains a mixed residential/commercial area and discharges into Palmer Cove;

Salem MBTA, an elevated (above low tide) storm water pipe adjacent to the Bridge Street Massachusetts Bay Transportation Authority (MBTA)

on their observations of turbulence during flow over the dam. To minimize the potential effects of seasonal stratification behind the dam, we took the depth-integrated sample from top to bottom.

The Charles River sampling station was immediately upstream of the Charles River Dam, adjacent to the largest lock (close to the center of the channel). The lock is not opened frequently; MDC personnel indicated that there is equal mixing across the river at this point. Sampling occurred from a pier next to this lock. We avoided sampling during periods of large-scale water releases from the side spillways, because MDC personnel indicated that these releases affect mixing characteristics and there is no access for sampling in the side spillways.

The selected sampling points for the Danvers and the Merrimack Rivers were downstream of all tributaries or obvious sources. The Danvers River sampling station was downstream of various tributaries to the Danvers River. We sampled the Danvers River from the public pier, opposite the Route 107 Bridge. This sampling location is affected by salt water, but we sampled at outgoing low tide to minimize offshore dilution and to maximize, as much as possible, the contribution from the upstream urbanized watershed.

The Merrimack River freshwater sampling station was immediately downstream of the City of Newburyport, but within the vicinity of the sewage treatment plant. We attempted to sample at low tide, or during the last two hours before slack low tide, to minimize dilution by tidal waters.

We sampled the Mystic, Charles and Danvers Rivers with a "cage sampler" provided by ADL. This sampler holds a four-liter glass sample bottle. The weighted cage is lowered into the water on a one-quarter inch metered line. A second line controls a valve which is opened at depth to fill the bottle. Successful sample collection is indicated by the start and stop of air bubbles from the bottle floating to the surface of the water. The advantage of this sampler is that the sample is collected directly into the bottle, minimizing potential contamination due to sampling equipment. Three sample bottles were collected at each sampling station to ensure sufficient sample volume for all planned analyses. For each bottle, the metered line was lowered and raised at a constant rate until the bottle was filled to ensure collection over the desired

Conventional pollutant analyses were completed by the E³I laboratory in Somerville, Massachusetts. Analyses included: Total Organic Carbon by EPA Method 415.1 (wet chemical oxidation, infrared), Total Suspended Solids by the American Public Health Association's Standard Method 2540D (gravimetric), and Oil & Grease by EPA Method 413.1 (gravimetric).

The laboratory results are provided in Appendix A. PAH and conventional pollutant data are shown by sample location and date.

Results for individual PAH compounds were summed to provide the total PAH (TPAH), low molecular weight PAH (LMW PAH), high molecular weight PAH (HMW PAH), carcinogenic PAH (CPAH) and naphthalene data groups, as shown in Table 2. Pyrene and benzo(g,h,i)perylene were conservatively included in the carcinogenic compound group; the weight of evidence data for carcinogenicity are equivocal with respect to their carcinogenicity. Removing pyrene from this group would reduce the concentration by 1/5 to 1/2 depending on the source.

Non-detected compounds were assumed to be zero. For the conventional pollutants, non-detected results were assigned values equal to one-half their associated method detection limits.

2.4 Statistical Analyses

All statistical analyses were completed using the *SPSS for Windows* software. Analysis of the analytical data began with distributional tests to determine appropriate descriptive statistics and subsequent statistical procedures.

Parameter data for each main source category (NPDES, CSO, storm water and river) and land use type (urban and nonurban) within a source category were tested for fit to the normal and lognormal distribution. Distribution tests were completed using the Shapiro-Wilks normality test, since this test is a powerful test for small samples.

To test for normality, the actual data values were tested. Data sets with normality test probabilities greater than, or equal to, 0.05 were considered to fit the normal distribution. Data sets with probabilities less than 0.05 were

concentrations in NPDES effluents, river loads, storm water loads, and CSO loads; and, high detection limits for PAHs reported in the literature.

The measurements made during the current work reduce some of the uncertainty in the estimation of the range of PAH concentrations associated with various sources of direct discharge to coastal areas. This study used the same methods to calculate Total PAH loadings to the study area as were previously applied (Menzie-Cura, 1991). The general equation used to make these calculations was:

$$\text{Loading (kg/yr)} = Q \text{ (m}^3\text{/s)} \times C \text{ (ng/l)} \times 3.16 \times 10^{-2}$$

where,

Q = average annual flow

C = average PAH concentration (a measured average was used whenever possible; an average of pooled data was used, when direct measurements were not available)

3.16×10^{-2} is a units conversion factor.

We used arithmetic average concentrations and flows to calculate loadings, based on work done by the MWRA demonstrating the appropriateness of this approach (Alber and Chan, 1994). In addition, this report used updated flows into Boston Harbor from Alber and Chan (1994), when appropriate.

2.4.1 Calculation of POTW NPDES Loadings

We used the maximum discharge rates from the Menzie-Cura (1991) report for coastal POTW effluents within the Merrimack River, north shore, and south shore drainage areas. For the Boston Harbor drainage area, we used more recent measured average flow rates from Deer Island and Nut Island (Alber and Chan, 1994). The estimate of the remaining NPDES discharge into Boston Harbor was based on the Menzie-Cura (1991) report, the flows from Alber and Chan (1994) and our best professional judgement. We used a pooled average of total PAHs for a NPDES discharge concentration, where we did not have

For the current study, all of the coastal runoff flow rates used in the Menzie-Cura (1991) were adjusted by a scaling factor of 2.70 ($0.734/0.272$), to incorporate the Alber and Chan (1994) findings. We used average urban and nonurban PAH concentrations for the load calculations.

2.4.4 Calculation of River Loads

The measured average PAH concentrations were used to estimate loads for the rivers. Estimates were developed for nonurban and urban rivers. Designation of a river as either nonurban or urban involved examining the general land use in the river's watershed. Most rivers had a mix of land uses so the designations reflect the degree of urbanization as judged by the assessment team. For example, the Merrimack River was considered a nonurban river even though there are several major municipalities along its upstream reaches. Still, as indicated in Menzie-Cura (1991), the Merrimack River drainage area has a lower percentage of urban land use (28%) compared to the north shore (36%) or the Boston Harbor (51%) drainage areas. In comparison, the Cape Cod drainage area is 30% urban while the south shore has the lowest degree of urbanization (17%). Of the rivers sampled in this program, the Merrimack had the lowest concentrations of PAH compounds and provides the best data we have for estimating the levels that may occur in areas that are only moderately urbanized. We used the results from the Merrimack river to represent other nonurban rivers, and used an average of the measured urban rivers to represent other urban rivers. Using the Merrimack data for other nonurban rivers may overestimate concentrations for some of the nonurban rivers on the south shore but these rivers do not contribute significantly to the freshwater flow into the Massachusetts Bay system.

proportion of carcinogenic and other high molecular weight PAH than do the NPDES wastewater effluents.

Significant differences were detected in PAH levels in storm water as discussed later in this section. Urban storm water exhibited total PAH levels ranging from 530 to 54,452 ng/l with an arithmetic mean of 12,190 ng/l. The carcinogenic component in the urban storm water ranged between 36 and 18,940 ng/l with a mean of 2,934 ng/l. The maximum and mean values for urban storm water exceed those observed in CSO discharges for both total and carcinogenic PAHs.

In contrast, the PAH levels in nonurban storm water are about an order of magnitude less than those observed in urban storm water. Total PAH ranged between 277 and 4,030 ng/l with an arithmetic mean of 1,314 ng/l. Carcinogenic PAH ranged between 25 and 1,366 ng/l with a mean of 364 ng/l.

PAH concentrations in rivers were lower than those observed in storm water, suggesting that PAH compounds entering the rivers from runoff either settle out or are diluted. In addition, the data appeared less variable when surrounding land use was taken into account. Concentrations of PAH in urban rivers were significantly higher than those in nonurban rivers, as discussed further below. Urban rivers exhibited a range in total PAH from 205 to 5,681 ng/l with a mean of 1,578 ng/l. The carcinogenic component ranged from 21 to 747 ng/l. Total PAH in nonurban rivers ranged from 121 to 459 ng/l while carcinogenic PAH ranged from 29 to 315 ng/l.

3.2 Parameter Distributions and Differences by Land Use

Printouts of the *SPSS* analyses for distribution, and differences by land use, are included in Appendices B and C, respectively. These are annotated so that the results of each test can be easily interpreted.

Distributions

Appendix B presents all the tests used to evaluate whether data fit a normal or lognormal distribution. The distributions - normal, lognormal, both, or neither - are summarized in Table 3. Distribution tests indicated that all of the PAH groups and TOC for all of the source types and land use categories fit the lognormal distribution. (The PAH data for the non-urban river category and

the r^2 , the significance of the regression model (as measured by the F test), and the parameters of the regression equation: the calculated intercept, the slope, and the residual mean square error (RMSE).

The correlation and linear regression analyses indicate that conventional pollutants can be good predictors of PAH concentrations for specific source types and land use categories. It should be noted, however, that although significant relationships between PAH concentrations and TSS and TOC were observed, the data are not robust given the small sample size. Therefore, while these functional relationships can be used as predictors of PAH loadings, their limitations should be acknowledged. Results show that:

For the urban NPDES source category, TOC and TSS are significant predictors of total PAH and LMW PAH. Each of these conventional pollutant variables explains about 50% of the variance in the total, or the LWM PAH concentrations.

For the nonurban storm water source category, TOC, TSS and O&G can be used to predict any of the PAH variables. These are the strongest of the models, and can explain up to 79% of the variance in the PAH concentrations.

For the urban river source category, TOC can be used to predict total PAH, HMW PAH and carcinogenic PAH concentrations. TOC explains up to 50% of the variance in the PAH concentrations.

None of the conventional pollutants are significant predictors of urban CSO, urban storm water, or nonurban river PAH concentrations.

3.4 PAH Loadings

Estimates of PAH loadings are provided in Tables 5 through 9 based on data provided in Appendix E. These estimates are provided for total PAHs, carcinogenic PAHs, low molecular weight PAHs, high molecular weight PAHs, and naphthalenes. Estimates are provided for the five major coastal areas identified in the initial Menzie-Cura (1991) study to provide a basis for comparison. While the current study focused on and analyzed specific

these four discharges is 75% of the total POTW NPDES flow to Massachusetts Bay.

Among the various potential sources of total PAH, urban storm water exhibited the maximum total PAH concentration (54,452 ng/l from Hyde Park on July 9, 1992). This indicates that locally, storm water, particularly urban storm water may be an important PAH source. However the total mass of PAH in storm water is low, relative to NPDES discharges.

Table 6 and Figure 3 show that river discharges dominate the input of carcinogenic PAH to coastal areas of Massachusetts (797 kg/yr). Coastal storm water runoff and POTWs contributed approximately the same amount of this PAH component (150 kg/yr). The river contribution reflects a combination of high flow and carcinogenic PAH levels that are somewhat higher than those for POTW NPDES discharges. However, concentrations of carcinogenic PAHs are much higher in storm water and CSO discharges.

Comparison of the calculated loadings for total and carcinogenic PAHs highlights the importance of differences in the composition of total PAH, between the point and nonpoint sources (Figures 2 and 3). The nonpoint sources appear to have a higher proportion of carcinogenic PAHs, relative to total PAHs. The average ratio of carcinogenic PAH to total PAH is about 0.016 for the point sources, and about 0.20 for the nonpoint sources.

Table 7 and Figure 3 show that loadings of high molecular weight PAHs are similar to those of the carcinogenic PAH compounds. This is expected because the carcinogenic PAHs are a subset of the high molecular weight PAH group.

Tables 8 and 9 show the concentrations and calculated loadings for low molecular weight PAH and the naphthalene components, respectively. The coastal POTW NPDES discharges contribute about 75% of the total low molecular weight PAH fraction to Massachusetts Bay, and about two-thirds of this fraction consists of naphthalene compounds (Figures 1 and 2).

When variables are back-transformed, the proper model is:

$$Y = b_{oa} X^{b_1} 10^\epsilon$$

where,

b_{oa} = the antilog of b_o

The exponential model is applicable when logs of the dependent variable (Y) are used with the untransformed independent variable (X):

$$\log Y = \beta_o + \beta_1 X + \epsilon$$

where,

β_o = the regression intercept estimated by b_o

β_1 = the regression slope estimated by b_1

ϵ = the random error term (Mean Square Error/2)

When variables are back-transformed, the proper model is:

$$Y = b_{oa} 10^{b_1 X} 10^\epsilon$$

Unfortunately, the substantial variability observed within source types (particularly the urban sources) and the weak correlations (with high error terms) calculated for most variables, indicate that these models give uncertain estimates. These uncertainties may be compounded when applied to geographic areas other than Massachusetts Bay. Variability seems greatest for urban areas. In addition, we expect that differences in climate between Massachusetts Bay and other areas could be an important variable affecting relationships among PAHs and conventional pollutants.

4.2 Composition of Total PAHs by Source Type and Land Use

The individual compounds which comprise total PAHs vary from one source type to another. Table 10 provides lowest, the average and the highest of the ratios of carcinogenic to total PAH and LMW PAH to HMW PAH. The

4.3.2 Uncertainties Associated with Statistical Analyses

Since most of the data fit the lognormal distribution, the use of arithmetic averages and average flow rates probably results in conservative estimates of loadings. While there is a large standard deviation around the average for certain categories, the maximum concentrations do not appear to be coincident with maximum flows (in most cases, large flows provide more dilution).

The data and analytical methodology used in this study have been carefully documented, so that other investigators may perform alternate calculations.

4.4 Recommendations

Based on this report the following recommendations are offered:

1. **Storm water drains that discharge directly to depositional areas should be identified.** The control of PAH discharges into the environment is a complicated issue. In terms of total mass of PAH, the POTW point source category is dominant. On the other hand, nonpoint sources of carcinogenic PAHs are more important than the point sources. And while the total PAH load from storm water drains is small in comparison, the drains generally discharge into small embayments.

With urban storm water, the concentrations of HMW and carcinogenic PAHs may be high and locally very significant. This may be especially important in depositional areas of Boston Inner Harbor which receive loadings from urban rivers and direct discharges from urban storm water drains. Under such conditions, impacts may occur on spatial scales smaller than Massachusetts Bay generally.

2. **Secondary treatment of sewage would reduce loadings of Total PAH compounds if such loadings are judged to pose an unacceptable risk.** Our observations indicate that secondary treatment may substantially reduce the concentrations of carcinogenic PAHs as well as lighter compounds such as naphthalene. This observation is based on a comparison of several measurements of effluent from the four coastal POTWs. It is possible that the lower observed concentrations in the

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TABLES

TABLE 1
SAMPLING LOCATIONS,
SAMPLING DATES AND PARAMETERS MEASURED

SOURCE	LOCATION	SAMPLING DATES & PARAMETERS
STORM-WATER	Dorchester	05/11/92 - PAH, TSS, TOC, O&G 07/09/92 - PAH, TSS, TOC 07/23/92 - PAH, TSS, TOC
	Hyde Park	05/11/92 - PAH, TSS, TOC, O&G 07/09/92 - PAH, TSS, TOC 07/23/92 - PAH, TSS, TOC
	West Roxbury	05/09/92 - TSS, TOC, O&G 07/09/92 - PAH, TSS, TOC 07/23/92 - PAH, TSS, TOC
	Allston/Brighton	05/11/92 - PAH, TSS, TOC, O&G 07/09/92 - PAH, TSS, TOC 07/23/92 - PAH, TSS, TOC
	Charlestown	05/09/92 - PAH, TSS, TOC, O&G 07/09/92 - PAH, TSS, TOC 07/23/92 - PAH, TSS, TOC
	Salem Levitt Station	03/25/93 - PAH, TSS, TOC, O&G
	Salem MBTA	03/25/93 - PAH, TSS, TOC, O&G
	Salem Conner	03/25/93 - PAH, TSS, TOC, O&G
	Salem MBTA	09/27/93 - PAH, TSS, TOC, O&G
	Salem MBTA	10/12/93 - PAH, TSS, TOC, O&G
	Braintree	03/25/93 - PAH, TSS, TOC, O&G 04/22/93 - PAH, TSS, TOC 05/18/93 - PAH, TSS, TOC 05/20/93 - PAH, TSS, TOC, O&G 06/04/93 - PAH, TSS, TOC, O&G
	Winchester	05/20/93 - PAH, TSS, TOC, O&G 06/28/93 - PAH, TSS, TOC, O&G 07/20/93 - PAH, TSS, TOC, O&G 09/27/93 - PAH, TSS, TOC, O&G

TABLE 2
ANALYTICAL DATA
COMPOUNDS AND DATA GROUPS

PAH COMPOUNDS

Low Molecular Weight PAHs

*Naphthalene
C1-Naphthalene
C2-Naphthalene
C3-Naphthalene
C4-Naphthalene
*Acenaphthylene
*Acenaphthene
Biphenyl
*Fluorene
C1-Fluorene
C2-Fluorene
C3-Fluorene
*Phenanthrene
*Anthracene
C1-Phenanthrene/Anthracene
C2-Phenanthrene/Anthracene
C3-Phenanthrene/Anthracene
C4-Phenanthrene/Anthracene
Dibenzothiophene
C1-Dibenzothiophene
C2-Dibenzothiophene
C3-Dibenzothiophene

High Molecular Weight PAHs

*Fluoranthene
*Pyrene
C1-Fluoranthene/Pyrene
*Benzo(a)anthracene
*Chrysene
C1-Chrysene
C2-Chrysene
C3-Chrysene
C4-Chrysene
*Benzo(b)fluoranthene
*Benzo(k)fluoranthene
Benzo(e)pyrene
*Benzo(a)pyrene
Perylene
*Indeno(1,2,3-cd)pyrene
*Dibenz(a,h)anthracene
*Benzo(g,h,i)perylene

*** Priority Pollutant PAHs**

Total PAH was calculated as the sum of all detected PAH compounds

Carcinogenic PAH was calculated as the sum of the following compounds:
pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene,
benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene and
benzo(g,h,i)perylene.

Total Naphthalenes was calculated as the sum of all detected compounds from
Naphthalene to C4-Naphthalene, inclusive.

LMW PAH was calculated as the sum of all detected Low Molecular Weight
PAH Compounds.

HMW PAH was calculated as the sum of all detected High Molecular Weight
PAH compounds.

CONVENTIONAL POLLUTANTS

Total Suspended Solids

Oil & Grease Analytical Results

Total Organic Carbon

TABLE 3
DESCRIPTIVE STATISTICS FOR SOURCES

NPDES DATA

Parameter	Number of Samples	Minimum	Maximum	Distribution	Log of the				Arithmetic Std. Dev.	Standard Error of the Mean
					Geometric Mean	Geometric Std. Dev.	Arithmetic Mean	Arithmetic Std. Dev.		
PAH (ng/l)										
Total PAHs	12	179.4	33540	lognormal	3162	4.3	6865	9188	2652	
Carcinogenic PAH	12	15.23	534.2	lognormal	75.86	2.7	120.2	143.9	42	
LMW PAHs	12	122.9	31700	lognormal	2951	4.6	6572	8711	2515	
HMW PAHs	12	44.70	1835	lognormal	144.5	3.0	292.7	500.9	145	
TOC (mg/l)	10	9.0	95	both	33	2.6	47	35	11	
TSS (mg/l)	10	2.5	97	normal	32	3.3	47	31	10	
O&G (mg/l)	8	1.0	33	neither	5.4	6.0	15	15	5.3	

CSO DATA

Parameter	Number of Samples	Minimum	Maximum	Distribution	Log of the				Arithmetic Std. Dev.	Standard Error of the Mean
					Geometric Mean	Geometric Std. Dev.	Arithmetic Mean	Arithmetic Std. Dev.		
PAH (ng/l)										
Total PAHs	9	1332	17968	lognormal	3388	2.3	4780	5199	1733	
Carcinogenic PAH	9	325.4	5300	lognormal	812.8	2.5	1265	1575	525	
LMW PAHs	9	594.6	9148	lognormal	1820	2.4	2624	2687	896	
HMW PAHs	9	603.6	8820	lognormal	1445	2.3	2157	2604	868	
TOC (mg/l)	9	4.0	24	both	9.1	2.0	11	7.5	2.5	
TSS (mg/l)	9	8.0	154	both	38	2.5	53	48	16	
O&G (mg/l)	9	3.0	25	both	9.1	2.5	12	8.8	2.9	

Notes:

Distribution is either normal, lognormal, both, or neither

TABLE 3
DESCRIPTIVE STATISTICS FOR SOURCES

RIVER DATA

(urban category)

Parameter	Number of Samples	Minimum	Maximum	Distribution	Log of the				Standard Error of the Mean
					Geometric Mean	Geometric Std. Dev.	Arithmetic Mean	Arithmetic Std. Dev.	
PAH (ng/l)									
Total PAHs	9	205.7	5681	lognormal	933.3	3.0	1578	1182	394
Carcinogenic PAH	9	21.71	747.4	lognormal	154.9	3.0	245.3	255.1	85
LMW PAHs	9	72.00	4000	lognormal	575.4	3.4	1049	1250	417
HMW PAHs	9	46.84	1681	lognormal	316.2	3.0	528.7	581.3	194
TOC (mg/l)	9	1.1	15	lognormal	4.074	2.1	5.2	4	1.3
TSS (mg/l)	9	2.0	12	both	4.467	2.0	5.5	3.7	1.2
O&G (mg/l)	6	1.0	5.0	neither	1.585	2.0	2.0	1.7	0.7

RIVER DATA

(nonurban category)

Parameter	Number of Samples	Minimum	Maximum	Distribution	Log of the				Standard Error of the Mean
					Geometric Mean	Geometric Std. Dev.	Arithmetic Mean	Arithmetic Std. Dev.	
PAH (ng/l)									
Total PAHs	7	121.5	459.4	both	288.4	1.5	308.0	117.0	44
Carcinogenic PAH	7	20.20	149.0	both	72.44	2.0	86.10	47.11	18
LMW PAHs	7	29.00	315.0	both	131.8	2.2	159.9	93.40	35
HMW PAHs	7	29.70	253.0	both	123.0	2.1	147.8	81.21	31
TSS (mg/l)	7	6.0	15	both	9.3	1.4	9.9	3.3	1.3
TOC (mg/l)	7	2.3	5.0	both	3.2	1.3	3.3	0.92	0.3
O&G (mg/l)	1	1.0	1.0	NC	NC	NC	NC	NC	NC

Notes:

Distribution is either normal, lognormal, both, or neither

NC = Not Calculated (only one sample)

TABLE 5
SUMMARY OF TOTAL PAH LOADS IN KG/YR

SOURCE	Merrimack	North Shore	Boston Harbor	South Shore	Cape Cod	Total	1991¹ Estimate
Coastal NPDES	561	346	8126	95		9128	10200
Coastal Runoff	6	308	282	22	24	642	3.3
Coastal CSO			31			31	
River Discharge	1184	253	2523	83		4043	476
TOTAL	1751	907	10962	198	24	13844	10679

¹ See text for discussion of comparability of calculated numbers and 1991 estimates

TABLE 7
SUMMARY OF HMW PAH LOADS IN KG/YR

SOURCE	Merrimack	North Shore	Boston Harbor	South Shore	Cape Cod	Total
Coastal NPDES	24	20	347	4		395
Coastal Runoff	3	129	118	11	12	273
Coastal CSO			14			14
River Discharge	569	99	854	40		1562
TOTAL	596	248	1333	55	12	2244

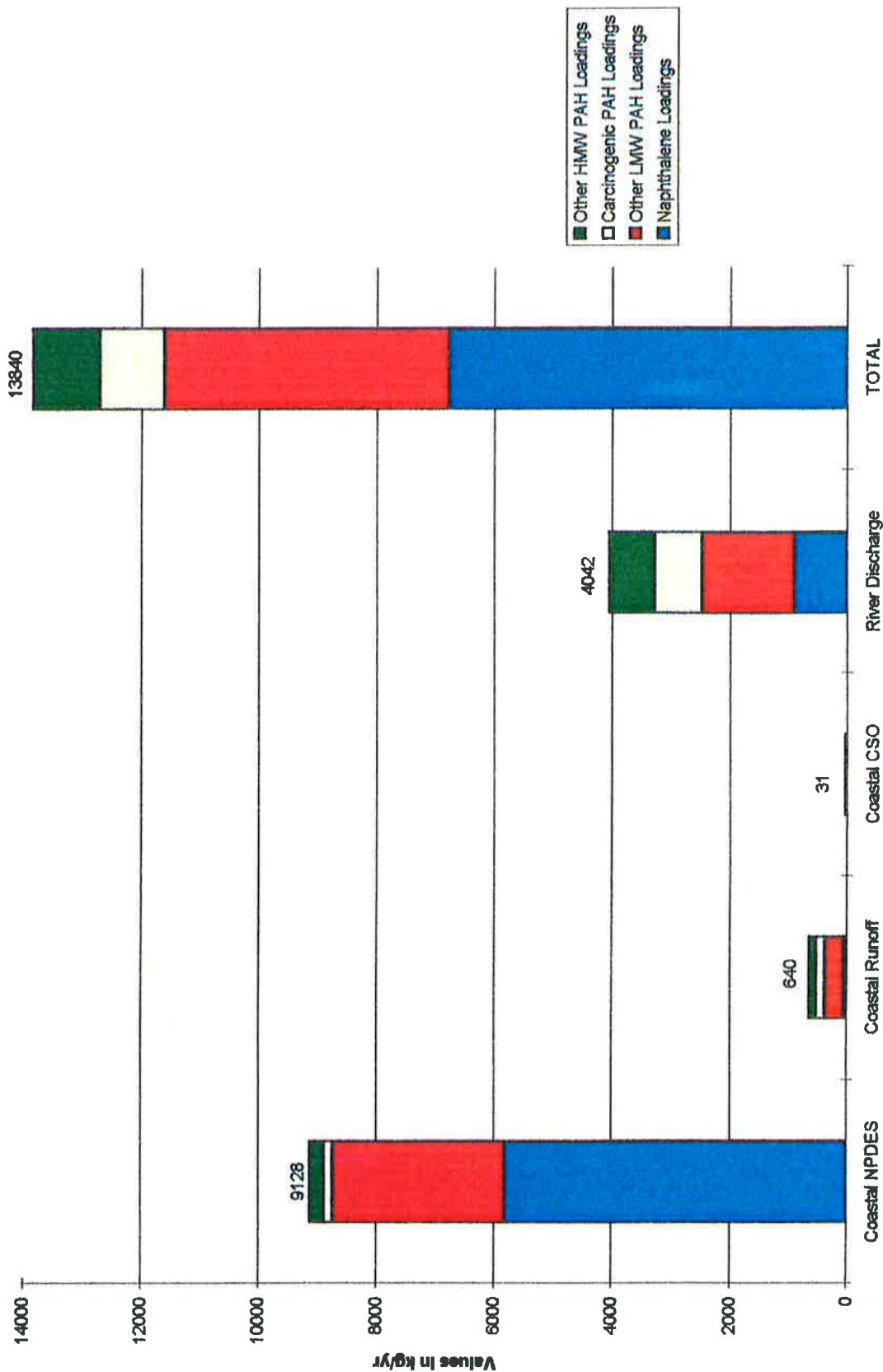
TABLE 9
SUMMARY OF TOTAL NAPHTHALENE LOADS IN KG/YR

SOURCE	Merrimack	North Shore	Boston Harbor	South Shore	Cape Cod	Total
Coastal NPDES	350	202	5203	60		5815
Coastal Runoff	1	24	22	3	3	53
Coastal CSO			6			6
River Discharge	315	57	506	22		900
TOTAL	666	283	5737	85	3	6774

FIGURE

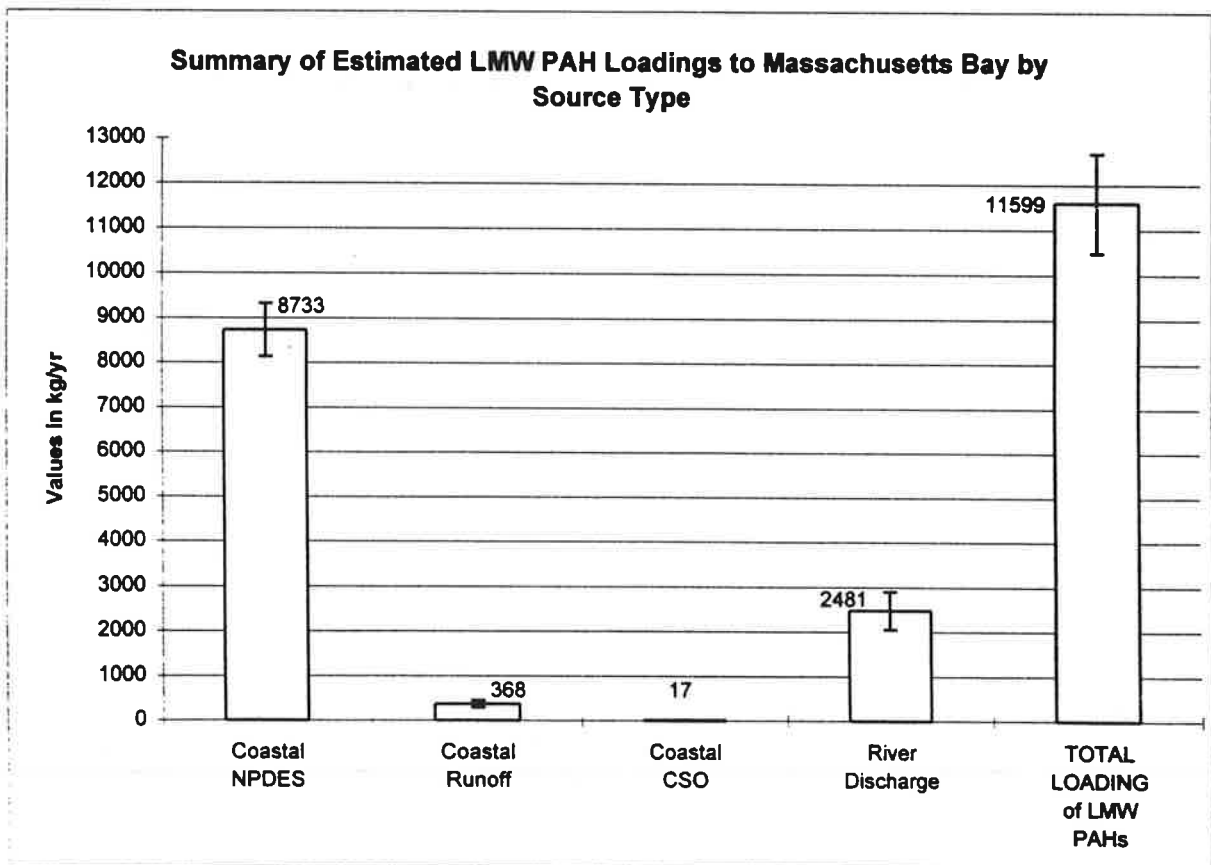
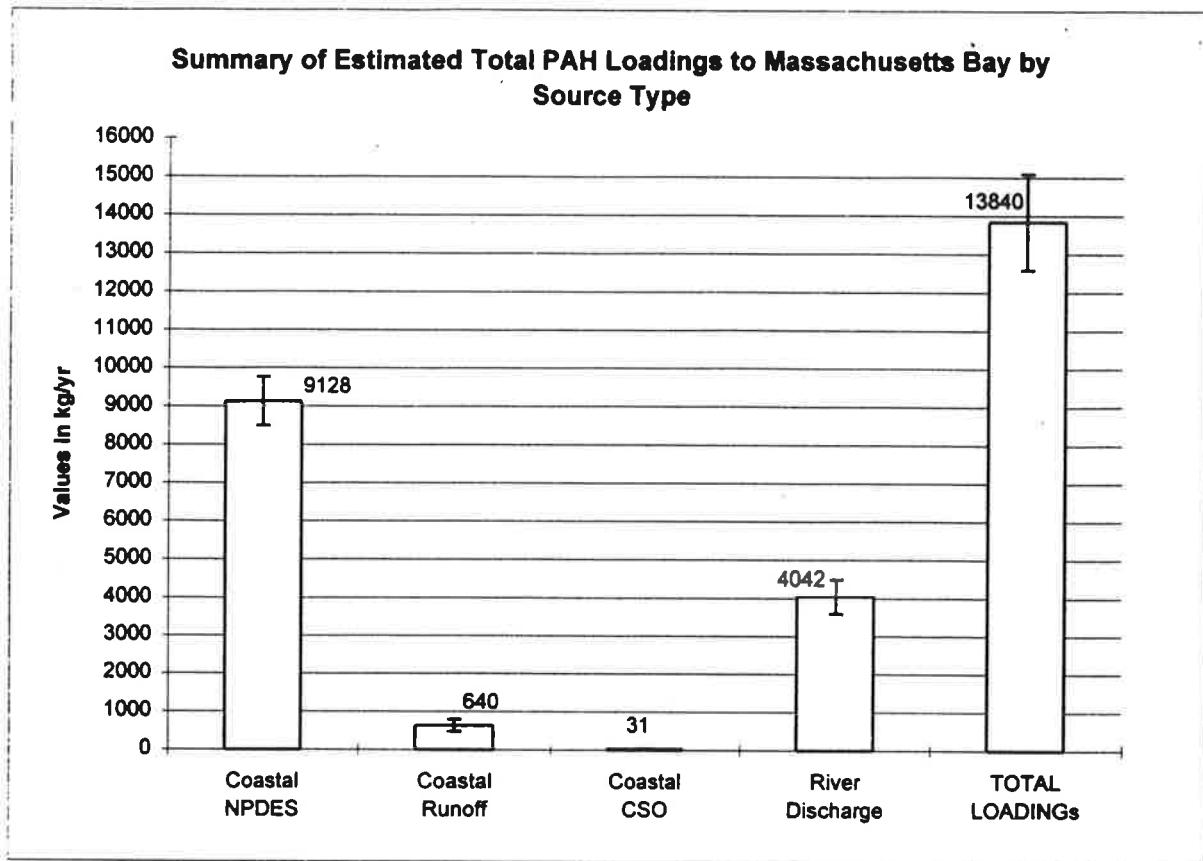
FIGURE 1

Summary of Estimated PAH Loadings to Massachusetts Bay by Source Type



Note:
 Carcinogenic Loadings (9 compounds) are a subset of HMW Loadings (17 total compounds)
 Naphthalene Loadings (5 compounds) are a subset of LMW Loadings (22 total compounds)

FIGURE 2



APPENDIX A
ANALYTICAL RESULTS

Mass Bays Program PAH Loadings Project	Charles River River Water	Mystic River River Water	Danvers River River Water
Sample Collection Date	04/30/92	04/30/92	04/30/92
PAH Analytical Results	07/30/92	07/25/92	07/25/92
Units	ng/L	ng/L	ng/L
Naphthalene	16.21	36.5	44.91
C1-Naphthalene	12.8	23.06	41.56
C2-Naphthalene	23.79	49.85	42.59
C3-Naphthalene	31.35	34.63	15.82
C4-Naphthalene	56.7	41.94	
Acenaphthylene	9.14	14.93	4.01
Acenaphthene		7.4	6.67
Biphenyl	3.06	4.06	4.56
Fluorene	5.2	8.32	4.63
C1-Fluorene			
C2-Fluorene			
C3-Fluorene			
Phenanthrene	23.78	27.28	13.2
Anthracene	8.17	15.44	
C1-Phenanthrene/Anthracene	26.07	30.21	13.81
C2-Phenanthrene/Anthracene	34.43	64.16	21.97
C3-Phenanthrene/Anthracene	69.6	29.07	
C4-Phenanthrene/Anthracene	60.77	70.4	
Dibenzothiophene	7.67	5.81	1.3
C1-Dibenzothiophene	13.06	9.82	
C2-Dibenzothiophene	22.2	29.8	
C3-Dibenzothiophene			
Fluoranthene	32.67	55.27	12.45
Pyrene	43.48	47.23	6.86
C1-Fluoranthene/Pyrene	54.1	51.65	10.34
Benzo(a)anthracene	9.83	10.86	1.61
Chrysene	18.33	21.59	3.86
C1-Chrysene	12.85	13.78	
C2-Chrysene			
C3-Chrysene			
C4-Chrysene			
Benzo(b)fluoranthene	14.53	15.93	2.67
Benzo(k)fluoranthene	10.5	15.09	2.29
Benzo(e)pyrene	11.44	13.34	2.34
Benzo(a)pyrene	8.74	11.55	
Perylene	2.24	3.25	
Indeno(1,2,3-cd)pyrene	6.75	10.13	2.48
Dibenzo(a,h)anthracene			
Benzo(g,h,i)perylene	7.58	11.24	1.94
Total PAHs	657.04	783.59	261.87
Total Carcinogenic PAHs	119.74	143.62	21.71
Low Molecular Weight PAHs	424	502.68	215.03
High Molecular Weight PAHs	233.04	280.91	46.84
Total Naphthalenes	140.85	185.98	144.88

Mass Bays Program PAH Loadings Project	City of Lynn NPDES	S.E. Essex NPDES	Nut Island NPDES	Deer Island NPDES
Sample Collection Date	04/30/92	04/30/92	04/30/92	04/30/92
PAH Analytical Results	07/25/92	07/25/92	07/26/92	07/26/92
Units	ng/L	ng/L	ng/L	ng/L
Naphthalene	9.71	970.86	576.87	1798.79
C1-Naphthalene	8.89	766.54	907.45	5050.51
C2-Naphthalene	56.43	1175.29	1552.5	8230.89
C3-Naphthalene	186.29	544.26	1078.97	4348.51
C4-Naphthalene	161.59	397.98	642.39	1795.61
Acenaphthylene				
Acenaphthene		70.62		205.44
Biphenyl	3.7	138.15	86.89	510.14
Fluorene		44.13	78.64	191.08
C1-Fluorene		138.63		432.78
C2-Fluorene		283.53	257	565.57
C3-Fluorene		255.4	240.12	622.38
Phenanthrene	12.72	98.89	138.85	495.85
Anthracene	7.22	38.73	30.29	125.28
C1-Phenanthrene/Anthracene		491.99	669.74	2118.18
C2-Phenanthrene/Anthracene		855.84	841.85	2531.31
C3-Phenanthrene/Anthracene	39.64	455.95	249.51	1280.63
C4-Phenanthrene/Anthracene	32.29		237.03	386.53
Dibenzothiophene		30.12	43.06	125.41
C1-Dibenzothiophene	7.15	191	176.64	356.65
C2-Dibenzothiophene	11.92		120.16	222.84
C3-Dibenzothiophene			191.87	306.08
Fluoranthene	11.56		42.4	240.7
Pyrene	18.51		46.36	266.2
C1-Fluoranthene/Pyrene	17.76	75.97	63.85	370.82
Benzo(a)anthracene				91.79
Chrysene	5.58			
C1-Chrysene			34.09	230.42
C2-Chrysene				152.06
C3-Chrysene				145.5
C4-Chrysene				161.8
Benzo(b)fluoranthene	3.07		9.69	71.61
Benzo(k)fluoranthene	3.05		10.99	58.91
Benzo(e)pyrene				
Benzo(a)pyrene			12.49	
Perylene				
Indeno(1,2,3-cd)pyrene				
Dibenzo(a,h)anthracene				
Benzo(g,h,i)perylene		15.23	6.25	45.64
Total PAHs	597.08	7039.11	8345.95	33535.91
Total Carcinogenic PAHs	30.21	15.23	85.78	534.15
Low Molecular Weight PAHs	537.55	6947.91	8119.83	31700.46
High Molecular Weight PAHs	59.53	91.2	226.12	1835.45
Total Naphthalenes	422.91	3854.93	4758.18	21224.31

Mass Bays Program PAH Loadings Project	City of Lynn NPDES	S.E. Essex NPDES	Nut Island NPDES	Deer Island NPDES
Sample Collection Date	1/14/93	1/14/23	1/21/93	1/21/93
PAH Analytical Results	05/08/93	05/08/93	05/08/93	05/08/93
Units	ng/L	ng/L	ng/L	ng/L
Naphthalene	20	830	350	1500
C1-Naphthalene	14	690	290	1700
C2-Naphthalene	25	660	370	2300
C3-Naphthalene	100	630	320	1800
C4-Naphthalene	78	270	250	990
Acenaphthylene	4.1	12	8.8	42
Acenaphthene	6.6	64	42	170
Biphenyl	3.6	97	49	240
Fluorene	3.7	54	37	190
C1-Fluorene	6.1	67	53	290
C2-Fluorene	68	120	120	470
C3-Fluorene	130	170	130	390
Phenanthrene	6	110	78	290
Anthracene	2.1	19	5.4	34
C1-Phenanthrene/Anthracene	7.4	100	96	500
C2-Phenanthrene/Anthracene	24	110	110	470
C3-Phenanthrene/Anthracene	50	91	64	310
C4-Phenanthrene/Anthracene	21	77	37	140
Dibenzothiophene		17	11	50
C1-Dibenzothiophene		110	35	140
C2-Dibenzothiophene	17	93	56	240
C3-Dibenzothiophene	33	96	82	210
Fluoranthene	10	78	37	86
Pyrene	30	66	31	95
C1-Fluoranthene/Pyrene	16	42	25	81
Benzo(a)anthracene	6.8	28	8	25
Chrysene	9.6	30	12	32
C1-Chrysene	5.1	17	10	23
C2-Chrysene				
C3-Chrysene				
C4-Chrysene				
Benzo(b)fluoranthene	11	29	12	23
Benzo(k)fluoranthene	5.3	8.7	4.3	13
Benzo(e)pyrene	5.7	13	6.3	12
Benzo(a)pyrene	6.3	11	9.6	9.7
Perylene	1.4	7	2.2	6.8
Indeno(1,2,3-cd)pyrene	4.6	15	8.1	15
Dibenzo(a,h)anthracene				
Benzo(g,h,i)perylene	6.2		6.7	
Total PAHs	737.6	4831.7	2766.4	12887.5
Total Carcinogenic PAHs	79.8	187.7	91.7	212.7
Low Molecular Weight PAHs	619.6	4487	2594.2	12466
High Molecular Weight PAHs	118	344.7	172.2	421.5
Total Naphthalenes	237	3080	1580	8290

Mass Bays Program PAH Loadings Project	Charlestown Stormwater	Dorchester Stormwater	Hyde Park Stormwater	West Roxbury Stormwater
Sample Collection Date	5/9/92	7/9/92	7/9/92	7/9/92
PAH Analytical Results	07/27/92	11/04/91	11/04/91	11/04/91
Units	ng/L	ng/L	ng/L	ng/L
Naphthalene	12.57	40	350	91
C1-Naphthalene	20.28	56	580	170
C2-Naphthalene	63.01	110	620	320
C3-Naphthalene	54.41		560	260
C4-Naphthalene	118.3		550	290
Acenaphthylene	19.81	23	69	91
Acenaphthene		23	290	39
Biphenyl		11	43	67
Fluorene	12.5	50	280	93
C1-Fluorene	10.61		230	110
C2-Fluorene			980	140
C3-Fluorene			2600	
Phenanthrene	83.79	410	2400	740
Anthracene	38.78	95	530	170
C1-Phenanthrene/Anthracene	128.63	430	3100	950
C2-Phenanthrene/Anthracene	346.04	350	3800	1100
C3-Phenanthrene/Anthracene	306.1	390	1800	760
C4-Phenanthrene/Anthracene	357.7	810	3600	1100
Dibenzothiophene	54.14	170	170	170
C1-Dibenzothiophene	163.05	160	230	260
C2-Dibenzothiophene	317.31	270	450	450
C3-Dibenzothiophene	286.26	270	510	420
Fluoranthene	130.5	610	5300	1100
Pyrene	112.23	320	3800	730
C1-Fluoranthene/Pyrene	169.81	250	2800	620
Benzo(a)anthracene	56.99	110	2000	310
Chrysene	96.37	230	2800	530
C1-Chrysene	87.56	90	1000	210
C2-Chrysene	95.77	42	470	120
C3-Chrysene	87.77			99
C4-Chrysene	62.9			
Benzo(b)fluoranthene	92.43	250	3400	600
Benzo(k)fluoranthene	81.57	86	1200	210
Benzo(e)pyrene	76	130	1700	300
Benzo(a)pyrene	55.77	100	1900	280
Perylene	18.06	27	500	70
Indeno(1,2,3-cd)pyrene	68.36	120	1800	280
Dibenzo(a,h)anthracene	12.85	23	440	64
Benzo(g,h,i)perylene	85.72	120	1600	280
Total PAHs	3783.95	6176	54452	13594
Total Carcinogenic PAHs	662.29	1359	18940	3284
Low Molecular Weight PAHs	2393.29	3668	23742	7791
High Molecular Weight PAHs	1390.66	2508	30710	5803
Total Naphthalenes	268.57	206	2660	1131

Mass Bays Program PAH Loadings Project	West Roxbury Stormwater	Allston/Brighton Stormwater	Charlestown Stormwater
Sample Collection Date	7/23/92	7/23/92	7/23/92
PAH Analytical Results	11/04/91	11/04/91	11/04/91
Units	ng/L	ng/L	ng/L
Naphthalene	59	110	240
C1-Naphthalene	37	260	49
C2-Naphthalene	110	860	50
C3-Naphthalene		560	
C4-Naphthalene			
Acenaphthylene	15	150	
Acenaphthene	25	110	17
Biphenyl	27	55	8.7
Fluorene	38	250	10
C1-Fluorene		180	
C2-Fluorene		650	
C3-Fluorene		420	
Phenanthrene	91	1100	30
Anthracene	61	490	11
C1-Phenanthrene/Anthracene	760	860	35
C2-Phenanthrene/Anthracene	230	820	
C3-Phenanthrene/Anthracene		450	
C4-Phenanthrene/Anthracene		3000	
Dibenzothiophene	77	2400	4.9
C1-Dibenzothiophene	210	1000	15
C2-Dibenzothiophene	320	1100	
C3-Dibenzothiophene	240	680	
Fluoranthene	80	2100	20
Pyrene	53	1000	15
C1-Fluoranthene/Pyrene	71	580	
Benzo(a)anthracene	20	230	4.3
Chrysene	35	810	5.7
C1-Chrysene		140	
C2-Chrysene		36	
C3-Chrysene			
C4-Chrysene			
Benzo(b)fluoranthene	29	750	5.5
Benzo(k)fluoranthene	11	230	
Benzo(e)pyrene	15	330	2.8
Benzo(a)pyrene	12	120	
Perylene		33	
Indeno(1,2,3-cd)pyrene	13	270	6.1
Dibenzo(a,h)anthracene		47	
Benzo(g,h,i)perylene	14	240	
Total PAHs	2653	22421	530
Total Carcinogenic PAHs	187	3697	36.6
Low Molecular Weight PAHs	2300	15505	470.6
High Molecular Weight PAHs	353	6916	59.4
Total Naphthalenes	206	1790	339

Mass Bays Program PAH Loadings Project	Boston 080 CSO	Fox Point CSO	Boston 012 CSO	Somerville 003 CSO
Sample Collection Date	11/23/92	11/23/92	11/23/92	11/23/92
PAH Analytical Results	02/24/91	05/08/93	02/24/91	02/24/91
Units	ng/L	ng/L	ng/L	ng/L
Naphthalene	57	310	58	46
C1-Naphthalene	43	480	110	33
C2-Naphthalene	35	950	270	18
C3-Naphthalene	39	920	360	20
C4-Naphthalene	32	600	270	23
Acenaphthylene	16	51	18	8.1
Acenaphthene	22	140	33	5.5
Biphenyl	6.2	78	21	2.3
Fluorene	27	180	48	10
C1-Fluorene	16	200	75	7.9
C2-Fluorene	48	400	200	26
C3-Fluorene	73	490	230	36
Phenanthrene	300	1170	320	98
Anthracene	46	230	45	14
C1-Phenanthrene/Anthracene	150	680	320	48
C2-Phenanthrene/Anthracene	140	620	340	49
C3-Phenanthrene/Anthracene	91	390	210	41
C4-Phenanthrene/Anthracene	170	450	180	57
Dibenzothiophene	19	89	27	5.6
C1-Dibenzothiophene	23	160	63	7.2
C2-Dibenzothiophene	47	280	120	16
C3-Dibenzothiophene	58	280	120	23
Fluoranthene	470	1600	390	140
Pyrene	360	1200	320	91
C1-Fluoranthene/Pyrene	180	580	220	52
Benzo(a)anthracene	160	570	130	37
Chrysene	220	720	190	65
C1-Chrysene	110	300	110	27
C2-Chrysene	72	170	88	20
C3-Chrysene	42	110	39	13
C4-Chrysene	26	150	13	7.5
Benzo(b)fluoranthene	270	890	210	79
Benzo(k)fluoranthene	100	280	90	27
Benzo(e)pyrene	140	470	110	39
Benzo(a)pyrene	170	550	130	44
Perylene	43	140	31	11
Indeno(1,2,3-cd)pyrene	130	450	110	38
Dibenzo(a,h)anthracene	28	110	22	7.4
Benzo(g,h,i)perylene	150	530	120	51
Total PAHs	4129.2	17968	5761	1343.5
Total Carcinogenic PAHs	1588	5300	1322	439.4
Low Molecular Weight PAHs	1458.2	9148	3438	594.6
High Molecular Weight PAHs	2671	8820	2323	748.9
Total Naphthalenes	206	3260	1068	140

Mass Bays Program PAH Loadings Project	Levit St. Salem Stormwater	Braintree Stormwater	MBTA Salem Stormwater	Conner Salem Stormwater
Sample Collection Date	3/25/93	3/25/93	3/25/93	3/25/93
PAH Analytical Results	05/29/93	05/29/93	05/29/93	05/29/93
Units	ng/L	ng/L	ng/L	ng/L
Naphthalene	1050	92	141	410
C1-Naphthalene	669	3.4	135	217
C2-Naphthalene	295		176	150
C3-Naphthalene	196		125	152
C4-Naphthalene	236		104	284
Acenaphthylene	66	1.4	19	216
Acenaphthene	40		15	71
Biphenyl	78	54	88	77
Fluorene	94		39	148
C1-Fluorene	88		23	80
C2-Fluorene	253		50	269
C3-Fluorene	737		270	224
Phenanthrene	852	70	352	1410
Anthracene	91		27	211
C1-Phenanthrene/Anthracene	562	6.5	141	752
C2-Phenanthrene/Anthracene	542		135	626
C3-Phenanthrene/Anthracene	280		70	323
C4-Phenanthrene/Anthracene	275		102	326
Dibenzothiophene	61	2.4	26	94
C1-Dibenzothiophene	129		41	169
C2-Dibenzothiophene	279		92	362
C3-Dibenzothiophene	262		84	310
Fluoranthene	933	22	342	1950
Pyrene	556	9.9	189	1160
C1-Fluoranthene/Pyrene	200	5.8	59	411
Benzo(a)anthracene	153	3.7	60	331
Chrysene	348	11	160	713
C1-Chrysene	102		42	184
C2-Chrysene	88		30	106
C3-Chrysene	86		28	142
C4-Chrysene				
Benzo(b)fluoranthene	364	6.4	167	740
Benzo(k)fluoranthene	103	2.2	47	203
Benzo(e)pyrene	191	3.6	84	373
Benzo(a)pyrene	144		58	274
Perylene	36		13	74
Indeno(1,2,3-cd)pyrene	196		70	393
Dibenzo(a,h)anthracene	42		14	82
Benzo(g,h,i)perylene	204		71	411
Total PAHs	10881	294.3	3689	14428
Total Carcinogenic PAHs	2110	33.2	836	4307
Low Molecular Weight PAHs	7135	229.7	2255	6881
High Molecular Weight PAHs	3746	64.6	1434	7547
Total Naphthalenes	2446	95.4	681	1213

Mass Bays Program PAH Loadings Project	Braintree Stormwater	Winchester Stormwater	Winchester Stormwater	Winchester Stormwater
Sample Collection Date	6/4/93	6/28/93	7/20/93	7/20/93
PAH Analytical Results	12/4/93	12/4/93	12/4/93	12/4/93
Units	ng/L	ng/L	ng/L	ng/L
Naphthalene	30.3	42.9	21.4	20.5
C1-Naphthalene	14.2	23.7	19.5	16.2
C2-Naphthalene	9	24.4	12.9	10.9
C3-Naphthalene	20.1	28.4	27.3	21.7
C4-Naphthalene	4.2	67.3	32.8	28.1
Acenaphthylene	2.3	12.6	3	3
Acenaphthene	2	9.9	5.6	5.6
Biphenyl	4	26.2	1.8	2.3
Fluorene	4.5	15.3	10.4	9.8
C1-Fluorene	3.2	7.2	14.7	13.7
C2-Fluorene	5.4	31.6	22.8	23.3
C3-Fluorene	21	409.2	414.8	422.2
Phenanthrene	26.4	196.8	42	38
Anthracene	3.7	27.4	13.7	13.9
C1-Phenanthrene/Anthracene	17.5	87.9	24.6	22.8
C2-Phenanthrene/Anthracene	10.1	112.7	33	33.9
C3-Phenanthrene/Anthracene	13.3	91.3	26.1	28.2
C4-Phenanthrene/Anthracene	6.9	184.2	29.8	39.8
Dibenzothiophene	2.3	17.9	5.8	5.5
C1-Dibenzothiophene	3.7	27.1	8.4	8.8
C2-Dibenzothiophene	4.1	67.1	14.9	16.9
C3-Dibenzothiophene	2.6	97.9	17.7	18.6
Fluoranthene	35.5	447.1	75.7	77.6
Pyrene	20.1	270.7	40	42.1
C1-Fluoranthene/Pyrene	9	110.7	25.3	27.3
Benzo(a)anthracene	3	62	10.8	9.6
Chrysene	9.6	266.7	33.7	33.8
C1-Chrysene	2.4	99.2	14.4	14.9
C2-Chrysene	1.2	101.2	11.4	12.5
C3-Chrysene	1.1	141.7	12.2	13.4
C4-Chrysene		88.7	8.9	8.4
Benzo(b)fluoranthene	4.3	243.4	26.1	26.5
Benzo(k)fluoranthene	1.55	73.7	7.2	7.5
Benzo(e)pyrene	2.4	135.2	15.1	14.7
Benzo(a)pyrene	1.5	79.4	6.6	7.1
Perylene	0.3	18.1	1.9	2.2
Indeno(1,2,3-cd)pyrene	1.4	112.9	9.4	9.7
Dibenzo(a,h)anthracene	0.4	20.2	1.8	1.7
Benzo(g,h,i)perylene	1.48	150	13.6	14.7
Total PAHs	306.03	4029.9	1117.1	1127.4
Total Carcinogenic PAHs	43.33	1279	149.2	152.7
Low Molecular Weight PAHs	210.8	1609	803	803.7
High Molecular Weight PAHs	95.23	2420.9	314.1	323.7
Total Naphthalenes	77.8	186.7	113.9	97.4

Mass Bays Program PAH Loadings Project	Charles River River Water	Mystic River River Water	Danvers River River Water
Sample Collection Date	03/25/92	03/25/92	03/25/92
TSS Analytical Results	4/1/92	4/1/92	4/1/92
Units	mg/l	mg/l	mg/l
TSS	8	4	2
Oil & Grease Analytical Results	4/1/92	4/1/92	4/1/92
Units	mg/l	mg/l	mg/l
Oil & Grease	<2.0	<2.0	<2.0
TOC Analytical Results	4/1/92	4/1/92	4/1/92
Units	mg/l	mg/l	mg/l
TOC	6.4	15	4.5

Mass Bays Program PAH Loadings Project	Charles River River Water	Mystic River River Water	Danvers River River Water
Sample Collection Date	10/15/92	10/15/92	10/15/92
TSS Analytical Results	11/2/92	11/2/92	11/2/92
Units	mg/l	mg/l	mg/l
TSS	<5	10	<5
Oil & Grease Analytical Results	11/2/92	11/2/92	11/2/92
Units	mg/l	mg/l	mg/l
Oil & Grease	3.0	5.0	<2.0
TOC Analytical Results	11/2/92	11/2/92	11/2/92
Units	mg/l	mg/l	mg/l
TOC	4.6	4.8	1.5

Mass Bays Program PAH Loadings Project	City of Lynn NPDES	S.E. Essex NPDES	Nut Island NPDES	Deer Island NPDES
Sample Collection Date	10/15/92	10/15/92	10/15/92	10/15/92
TSS Analytical Results	11/2/92	11/2/92	11/2/92	11/2/92
Units	mg/l	mg/l	mg/l	mg/l
TSS	<5	84	33	67
Oil & Grease Analytical Results	11/2/92	11/2/92	Not Analyzed	Not Analyzed
Units	mg/l	mg/l		
Oil & Grease	<2.0	27		
TOC Analytical Results	11/2/92	11/2/92	11/2/92	11/2/92
Units	mg/l	mg/l	mg/l	mg/l
TOC	9.4	92	42	28

Mass Bays Program PAH Loadings Project	Dorchester Stormwater	Hyde Park Stormwater	West Roxbury Stormwater	Allston/Brighton Stormwater
Sample Collection Date	5/11/92	5/11/92	5/9/92	5/11/92
	5/21/92	5/21/92	5/21/92	
TSS Analytical Results				5/21/92
Units	mg/l	mg/l	mg/l	mg/l
TSS	95	32	25	13
Oil & Grease Analytical Results	5/21/92	5/21/92	5/21/92	5/21/92
Units	mg/l	mg/l	mg/l	mg/l
Oil & Grease	13	3	7	3
TOC Analytical Results	5/21/92	5/21/92	5/21/92	5/21/92
Units	mg/l	mg/l	mg/l	mg/l
TOC	24	6	16	3

Mass Bays Program PAH Loadings Project	Allston/Brighton Stormwater	Charlestown Stormwater	Dorchester Stormwater	Hyde Park Stormwater
Sample Collection Date	7/9/92	7/9/92	7/23/92	7/23/92
TSS Analytical Results	7/30/92	7/30/92	8/11/92	8/11/92
Units	mg/l	mg/l	mg/l	mg/l
TSS	<5	35	20	224
Oil & Grease Analytical Results	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed
Units				
Oil & Grease				
TOC Analytical Results	7/30/92	7/30/92	8/11/92	8/11/92
Units	mg/l	mg/l	mg/l	mg/l
TOC	5	12	14	36

Mass Bays Program PAH Loadings Project	Boston 080 CSO	Somerville Mrg. CSO	Boston 012 CSO	Somerville 003 CSO
Sample Collection Date	11/3/92	11/3/92	11/3/92	11/3/92
TSS Analytical Results	12/1/92	12/1/92	12/1/92	12/1/92
Units	mg/l	mg/l	mg/l	mg/l
TSS	70	57	65	21
Oil & Grease Analytical Results	12/1/92	12/1/92	12/1/92	12/1/92
Units	mg/l	mg/l	mg/l	mg/l
Oil & Grease	20	19	20	5
TOC Analytical Results	12/1/92	12/1/92	12/1/92	12/1/92
Units	mg/l	mg/l	mg/l	mg/l
TOC	24	20	16	13

Mass Bays Program	Somerville Mrg.
PAH Loadings Project	CSO

Sample Collection Date	11/23/92
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TSS Analytical Results	12/14/92
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Units	mg/l
TSS	20

Oil & Grease Analytical Results	12/14/92
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Units	mg/l
Oil & Grease	4

TOC Analytical Results	12/14/92
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Units	mg/l
TOC	4

Mass Bays Program PAH Loadings Project	Braintree Stormwater	Braintree Stormwater	Winchester Stormwater	Braintree Stormwater
Sample Collection Date	4/22/93	5/18/93	5/20/93	5/20/93
TSS Analytical Results	5/6/93	6/4/93	6/4/93	6/7/93
Units	mg/l	mg/l	mg/l	mg/l
TSS	<5	<5	7	<5
Oil & Grease Analytical Results	Not Analyzed	Not Analyzed	6/4/93	6/7/93
Units			mg/l	mg/l
Oil & Grease			2	<2
TOC Analytical Results	5/6/93	6/4/93	6/4/93	6/7/93
Units	mg/l	mg/l	mg/l	mg/l
TOC	<1	2	18	2

Mass Bays Program PAH Loadings Project	Winchester Stormwater	MBTA Salem Stormwater	MBTA Salem Stormwater	MBTA Salem Stormwater DUPLICATE
Sample Collection Date	9/27/93	9/27/93	10/12/93	10/12/93
TSS Analytical Results	10/15/93	10/15/93	11/4/93	Not Analyzed
Units	mg/l	mg/l	mg/l	
TSS	10	8	7	
Oil & Grease Analytical Results	10/15/93	10/15/93	11/4/93	Not Analyzed
Units	mg/l	mg/l	mg/l	
Oil & Grease	3	2	5	
TOC Analytical Results	10/15/93	10/15/93	11/4/93	11/4/93
Units	mg/l	mg/l	mg/l	mg/l
TOC	5	4	12	11

Mass Bays Program	3rd River Cruise	4th River Cruise	5th River Cruise
Merrimack River Project	Upstream	Upstream	Upstream
	Low Tide	Low Tide	Low Tide
Sample Collection Date	10/10/92	1/8/93	5/1/93
PAH Analytical Results	11/11/93	05/08/93	05/29/93
Units	ng/L	ng/L	ng/L
Naphthalene	23		123
C1-Naphthalene	32		8.9
C2-Naphthalene	27		6.5
C3-Naphthalene			
C4-Naphthalene			
Acenaphthylene			2.8
Acenaphthene			3.2
Biphenyl	3.1		62
Fluorene			3.3
C1-Fluorene			
C2-Fluorene			
C3-Fluorene			
Phenanthracene	5.3	29	72
Anthracene	1.4		2.7
C1-Phenanthracene/Anthracene			10
C2-Phenanthracene/Anthracene			11
C3-Phenanthracene/Anthracene			6.5
C4-Phenanthracene/Anthracene			
Dibenzothiophene			3.1
C1-Dibenzothiophene			
C2-Dibenzothiophene			
C3-Dibenzothiophene			
Fluoranthene	7.6	52	28
Pyrene	5.7	38	17
C1-Fluoranthene/Pyrene			10
Benzo(a)anthracene	3.4		7.1
Chrysene	4		15
C1-Chrysene		11	5.7
C2-Chrysene		22	
C3-Chrysene			
C4-Chrysene			
Benzo(b)fluoranthene	3.1	38	12
Benzo(k)fluoranthene		15	4.7
Benzo(e)pyrene	1.9	19	6.5
Benzo(a)pyrene	2.3	18	7.6
Perylene			2.5
Indeno(1,2,3-cd)pyrene		17	5.6
Dibenzo(a,h)anthracene			1.5
Benzo(g,h,i)perylene	1.7	23	5.4
Total PAHs	121.5	282	443.6
Carcinogenic PAHs	20.2	149	75.9
Low Molecular Weight PAHs	91.80	29.00	315.00
High Molecular Weight PAHs	29.70	253.00	128.60
Total Naphthalenes	82.00	0.00	138.40

Mass Bays Program	3rd River Cruise	4th River Cruise	5th River Cruise
Merrimack River Project	Upstream	Upstream	Upstream
	Low Tide	Low Tide	Low Tide
Sample Collection Date	10/10/92	1/8/93	5/1/93
TSS Analytical Results	11/2/92	1/19/93	5/13/93
Units	mg/l	mg/l	mg/l
TSS	6	8	6
Oil & Grease Analytical Results	11/2/92	Not Analyzed	Not Analyzed
Units	mg/l		
Oil & Grease	< 2.0		
TOC Analytical Results	11/2/92	1/19/93	5/13/93
Units	mg/l	mg/l	mg/l
TOC	2.8	4	5

APPENDIX B
TESTS FOR NORMALITY

River DataNormal**Urban River**CAR_PAHS
By LANDUSE 1

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	245.3211	Std Err	85.0471	Min	21.7100	Skewness	1.4944
Median	143.6200	Variance	65097.02	Max	747.4300	S E Skew	.7171
5% Trim	229.8490	Std Dev	255.1412	Range	725.7200	Kurtosis	.8867
				IQR	323.1850	S E Kurt	1.3997

Frequency	Stem & Leaf
1.00	0 * 2
1.00	0 . 6
3.00	1 * 124
1.00	1 . 5
1.00	2 * 1
2.00	Extremes (615), (747)

Stem width: 100.00
Each leaf: 1 case(s)CAR_PAHS
By LANDUSE 1Hi-Res Chart # 6: Normal plot of car_pahs for landuse: 1
Hi-Res Chart # 7: Detrended normal plot of car_pahs for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.7551	9	< .0100
K-S (Lilliefors)	.3209	9	.0081

No**Non-Urban River**CAR_PAHS
By LANDUSE 2

Valid cases: 7.0 Missing cases: .0 Percent missing: .0

Mean	86.1014	Std Err	17.8073	Min	20.2000	Skewness	.2923
Median	75.9000	Variance	2219.699	Max	149.0000	S E Skew	.7937
5% Trim	86.2683	Std Dev	47.1137	Range	128.8000	Kurtosis	-.8825
				IQR	87.8800	S E Kurt	1.5875

Frequency	Stem & Leaf
1.00	0 * 2
4.00	0 . 5679
2.00	1 * 44

Stem width: 100.00
Each leaf: 1 case(s)CAR_PAHS
By LANDUSE 2Hi-Res Chart # 9: Normal plot of car_pahs for landuse: 2
Hi-Res Chart # 10: Detrended normal plot of car_pahs for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.9251	7	.4871
K-S (Lilliefors)	.1596	7	> .2000

Yes

Hi-Res Chart # 8: Boxplot of car_pahs by landuse

Normality Tests with Untransformed Data

B - 4

River Data

Normal

Urban River

HMM_PAHS
By LANDUSE 1

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	528.7189	Std Err	193.7653	Min	46.8400	Skewness	1.5202
Median	280.9100	Variance	337904.9	Max	1680.610	S E Skew	.7171
5% Trim	491.4960	Std Dev	581.2959	Range	1633.770	Kurtosis	.9355
				IQR	743.9300	S E Kurt	1.3997

Frequency	Stem & Leaf
1.00	0 . 4
1.00	1 . 3
3.00	2 . 238
1.00	3 . 0
1.00	4 . 8
2.00	Extremes (1364), (1681)

Stem width: 100.00
Each leaf: 1 case(s)

HMM_PAHS
By LANDUSE 1

Hi-Res Chart # 16: Normal plot of hmw_pahs for landuse: 1
Hi-Res Chart # 17: Detrended normal plot of hmw_pahs for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.7447	9	< .0100
K-S (Lilliefors)	.3147	9	.0105

No

Non-Urban River

HMM_PAHS
By LANDUSE 2

Valid cases: 7.0 Missing cases: .0 Percent missing: .0

Mean	147.8157	Std Err	30.6941	Min	29.7000	Skewness	.1710
Median	128.6000	Variance	6594.913	Max	253.0000	S E Skew	.7937
5% Trim	148.5341	Std Dev	81.2091	Range	223.3000	Kurtosis	-.7751
				IQR	151.6800	S E Kurt	1.5875

Frequency	Stem & Leaf
2.00	0 . 29
3.00	1 . 126
2.00	2 . 45

Stem width: 100.00
Each leaf: 1 case(s)

HMM_PAHS
By LANDUSE 2

Hi-Res Chart # 19: Normal plot of hmw_pahs for landuse: 2
Hi-Res Chart # 20: Detrended normal plot of hmw_pahs for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.9293	7	.5116
K-S (Lilliefors)	.1650	7	> .2000

Yes

Hi-Res Chart # 18: Boxplot of hmw_pahs by landuse

River DataNormal

Oil and Grease

Urban River

O_G
By LANDUSE 1

Valid cases: 6.0 Missing cases: 3.0 Percent missing: 33.3

Mean	2.0000	Std Err	.6831	Min	1.0000	Skewness	1.5367
Median	1.0000	Variance	2.8000	Max	5.0000	S E Skew	.8452
5% Trim	1.8889	Std Dev	1.6733	Range	4.0000	Kurtosis	1.4286
				IQR	2.5000	S E Kurt	1.7408

Frequency	Stem &	Leaf
4.00	1 .	0000
.00	2 .	
1.00	3 .	0
.00	4 .	
1.00	5 .	0

Stem width: 1.00
Each leaf: 1 case(s)

O_G
By LANDUSE 1

Hi-Res Chart # 26: Normal plot of o_g for landuse: 1
Hi-Res Chart # 27: Detrended normal plot of o_g for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.6998	6	< .0100
K-S (Lilliefors)	.3916	6	.0045

No

Oil & Grease
Non-Urban River

O_G
By LANDUSE 2

Valid cases: 1.0 Missing cases: 6.0 Percent missing: 85.7

>Note # 17570. Command name: EXAMINE
>The number of unique data values for this cell is equal to one. The cell
>will be included in any boxplots produced but other output will be omitted.

Hi-Res Chart # 28: Boxplot of o_g by landuse

Not Calculated

Normality Tests with Untransformed Data

Stormwater Data

B - 8
Normal

Urban Stormwater

TOT_PAHS
By LANDUSE 1

Valid cases: 19.0 Missing cases: 1.0 Percent missing: 5.0

Mean	12193.82	Std Err	2953.901	Min	530.0000	Skewness	2.1062
Median	8414.190	Variance	1.66E+08	Max	54452.00	S E Skew	.5238
5% Trim	10494.14	Std Dev	12875.76	Range	53922.00	Kurtosis	5.7811
				IQR	17225.00	S E Kurt	1.0143

Frequency Stem & Leaf

7.00	0 *	0112233
3.00	0 .	668
4.00	1 *	0234
1.00	1 .	9
2.00	2 *	12
1.00	2 .	5
1.00	Extremes	(54452)

Stem width: 10000.00
Each leaf: 1 case(s)

TOT_PAHS
By LANDUSE 1

Hi-Res Chart # 34: Normal plot of tot_pahs for landuse: 1
Hi-Res Chart # 35: Detrended normal plot of tot_pahs for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.7862	19	< .0100
K-S (Lilliefors)	.1680	19	.1645

No

Non-Urban Stormwater

TOT_PAHS
By LANDUSE 2

Valid cases: 10.0 Missing cases: .0 Percent missing: .0

Mean	1314.602	Std Err	458.5474	Min	277.8000	Skewness	1.4344
Median	772.5000	Variance	2102657	Max	4029.900	S E Skew	.6870
5% Trim	1221.352	Std Dev	1450.054	Range	3752.100	Kurtosis	.6641
				IQR	1742.428	S E Kurt	1.3342

Frequency Stem & Leaf

5.00	0 *	22234
.00	0 .	
3.00	1 *	114
2.00	Extremes	(3860), (4030)

Stem width: 1000.00
Each leaf: 1 case(s)

TOT_PAHS
By LANDUSE 2

Hi-Res Chart # 37: Normal plot of tot_pahs for landuse: 2
Hi-Res Chart # 38: Detrended normal plot of tot_pahs for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.7256	10	< .0100
K-S (Lilliefors)	.2697	10	.0377

No

Hi-Res Chart # 36: Boxplot of tot_pahs by landuse

Normality Tests with Untransformed Data

Stormwater Data

B - 10
Normal

Urban Stormwater

LMW_PAHS
By LANDUSE 1

Valid cases: 19.0 Missing cases: 1.0 Percent missing: 5.0

Mean	7079.981	Std Err	1503.320	Min	470.6000	Skewness	1.1583
Median	4932.000	Variance	42939443	Max	23742.00	S E Skew	.5238
5% Trim	6521.501	Std Dev	6552.819	Range	23271.40	Kurtosis	.6688
				IQR	11675.00	S E Kurt	1.0143

Frequency Stem & Leaf

10.00	0 *	0011222344
4.00	0 .	6677
2.00	1 *	34
2.00	1 .	55
1.00	Extremes	(23742)

Stem width: 10000.00
Each leaf: 1 case(s)

LMW_PAHS
By LANDUSE 1

Hi-Res Chart # 44: Normal plot of lmw_pahs for landuse: 1
Hi-Res Chart # 45: Detrended normal plot of lmw_pahs for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.8589	19	< .0100
K-S (Lilliefors)	.1936	19	.0590

No

Non-Urban Stormwater

LMW_PAHS
By LANDUSE 2

Valid cases: 10.0 Missing cases: .0 Percent missing: .0

Mean	661.4900	Std Err	176.7635	Min	190.2000	Skewness	1.0149
Median	465.7000	Variance	312453.4	Max	1609.300	S E Skew	.6870
5% Trim	635.0167	Std Dev	558.9753	Range	1419.100	Kurtosis	-.3035
				IQR	781.4750	S E Kurt	1.3342

Frequency Stem & Leaf

5.00	0 *	12222
3.00	0 .	688
.00	1 *	
2.00	1 .	66

Stem width: 1000.00
Each leaf: 1 case(s)

LMW_PAHS
By LANDUSE 2

Hi-Res Chart # 47: Normal plot of lmw_pahs for landuse: 2
Hi-Res Chart # 48: Detrended normal plot of lmw_pahs for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.7886	10	.0130
K-S (Lilliefors)	.2730	10	.0333

Hi-Res Chart # 46: Boxplot of lmw_pahs by landuse

No

Normality Tests with Untransformed Data Stormwater Data

B - 12
Normal

Urban Stormwater

TSS
By LANDUSE 1

Valid cases: 20.0 Missing cases: .0 Percent missing: .0

Mean	34.4500	Std Err	11.1879	Min	2.5000	Skewness	3.1874
Median	19.0000	Variance	2503.366	Max	224.0000	S E Skew	.5121
5% Trim	25.6944	Std Dev	50.0336	Range	221.5000	Kurtosis	11.5677
				IQR	35.2500	S E Kurt	.9924

Frequency	Stem &	Leaf
7.00	0	2222788
3.00	1	388
2.00	2	05
3.00	3	258
3.00	4	459
2.00	Extremes (95), (224)	

Stem width: 10.00
Each leaf: 1 case(s)

TSS
By LANDUSE 1

Hi-Res Chart # 54: Normal plot of tss for landuse: 1
Hi-Res Chart # 55: Detrended normal plot of tss for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.6092	20	< .0100
K-S (Lilliefors)	.2856	20	.0002

No

Non-Urban Stormwater

TSS
By LANDUSE 2

Valid cases: 10.0 Missing cases: .0 Percent missing: .0

Mean	5.2500	Std Err	1.6368	Min	2.5000	Skewness	2.0428
Median	2.5000	Variance	26.7917	Max	18.0000	S E Skew	.6870
5% Trim	4.6944	Std Dev	5.1761	Range	15.5000	Kurtosis	3.9754
				IQR	5.2500	S E Kurt	1.3342

Frequency	Stem &	Leaf
7.00	0 *	2222222
1.00	0	7
1.00	1 *	0
1.00	Extremes (18)	

Stem width: 10.00
Each leaf: 1 case(s)

TSS
By LANDUSE 2

Hi-Res Chart # 57: Normal plot of tss for landuse: 2
Hi-Res Chart # 58: Detrended normal plot of tss for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.6279	10	< .0100
K-S (Lilliefors)	.4024	10	.0001

No

Hi-Res Chart # 56: Boxplot of tss by landuse

Normality Tests with Untransformed Data

Stormwater Data

B - 14
Normal

Urban Stormwater

TOC
By LANDUSE 1

Valid cases: 20.0 Missing cases: .0 Percent missing: .0

Mean	11.8000	Std Err	2.0126	Min	3.0000	Skewness	1.6276
Median	9.0000	Variance	81.0105	Max	36.0000	S E Skew	.5121
5% Trim	10.9444	Std Dev	9.0006	Range	33.0000	Kurtosis	2.2149
				IQR	8.7500	S E Kurt	.9924

Frequency	Stem &	Leaf
4.00	0 *	3444
8.00	0 .	56789999
4.00	1 *	2244
1.00	1 .	6
1.00	2 *	4
2.00	Extremes	(31), (36)

Stem width: 10.00
Each leaf: 1 case(s)

TOC
By LANDUSE 1

Hi-Res Chart # 64:Normal plot of toc for landuse: 1
Hi-Res Chart # 65:Detrended normal plot of toc for landuse: 1

No

	Statistic	df	Significance
Shapiro-Wilks	.8088	20	< .0100
K-S (Lilliefors)	.2221	20	.0108

Non-Urban Stormwater

TOC
By LANDUSE 2

Valid cases: 10.0 Missing cases: .0 Percent missing: .0

Mean	10.1500	Std Err	4.7551	Min	.5000	Skewness	2.4740
Median	3.5000	Variance	226.1139	Max	50.0000	S E Skew	.6870
5% Trim	8.4722	Std Dev	15.0371	Range	49.5000	Kurtosis	6.5575
				IQR	10.0000	S E Kurt	1.3342

Frequency	Stem &	Leaf
5.00	0 *	02222
1.00	0 .	5
2.00	1 *	00
1.00	1 .	8
1.00	Extremes	(50)

Stem width: 10.00
Each leaf: 1 case(s)

TOC
By LANDUSE 2

Hi-Res Chart # 67:Normal plot of toc for landuse: 2
Hi-Res Chart # 68:Detrended normal plot of toc for landuse: 2

No

	Statistic	df	Significance
Shapiro-Wilks	.6504	10	< .0100
K-S (Lilliefors)	.3040	10	.0094

Hi-Res Chart # 66:Boxplot of toc by landuse

Normality Tests with Untransformed Data Pooled River Data

B - 16
Normal

Rivers

LMW_PAHS

Valid cases: 16.0 Missing cases: .0 Percent missing: .0

Mean	660.3250	Std Err	255.5854	Min	29.0000	Skewness	2.7271
Median	241.3150	Variance	1045182	Max	4000.300	S E Skew	.5643
5% Trim	509.8444	Std Dev	1022.342	Range	3971.300	Kurtosis	7.9739
				IQR	733.7525	S E Kurt	1.0908

Frequency Stem & Leaf

11.00 0 * 00011222234
2.00 0 . 59
1.00 1 * 0
2.00 Extremes (1967), (4000)

Stem width: 1000.00
Each leaf: 1 case(s)

LMW_PAHS

Hi-Res Chart # 412: Normal plot of lmw_pahs
Hi-Res Chart # 413: Detrended normal plot of lmw_pahs

	Statistic	df	Significance
Shapiro-Wilks	.6160	16	< .0100
K-S (Lilliefors)	.3113	16	.0002

No

Hi-Res Chart # 414: Boxplot of lmw_pahs

Rivers

HMW_PAHS

Valid cases: 16.0 Missing cases: .0 Percent missing: .0

Mean	362.0738	Std Err	117.5105	Min	29.7000	Skewness	2.3163
Median	230.0200	Variance	220939.3	Max	1680.610	S E Skew	.5643
5% Trim	307.2869	Std Dev	470.0418	Range	1650.910	Kurtosis	4.5965
				IQR	183.4875	S E Kurt	1.0908

Frequency Stem & Leaf

3.00 0 . 249
4.00 1 . 1236
5.00 2 . 23458
1.00 3 . 0
1.00 4 . 8
2.00 Extremes (1364), (1681)

Stem width: 100.00
Each leaf: 1 case(s)

HMW_PAHS

Hi-Res Chart # 415: Normal plot of hmw_pahs
Hi-Res Chart # 416: Detrended normal plot of hmw_pahs

	Statistic	df	Significance
Shapiro-Wilks	.6261	16	< .0100
K-S (Lilliefors)	.3585	16	.0000

No

Hi-Res Chart # 417: Boxplot of hmw_pahs

Normality Tests with Untransformed Data

Pooled River Data

B - 18
Normal

Rivers

TOC

Valid cases: 16.0 Missing cases: .0 Percent missing: .0

Mean	4.3750	Std Err	.7908	Min	1.1000	Skewness	2.7138
Median	4.1500	Variance	10.0060	Max	15.0000	S E Skew	.5643
5% Trim	3.9667	Std Dev	3.1632	Range	13.9000	Kurtosis	9.2109
				IQR	2.0750	S E Kurt	1.0908

Frequency	Stem	Leaf
2.00	1	15
3.00	2	388
2.00	3	00
6.00	4	035689
1.00	5	0
1.00	6	4
1.00	Extremes (15.0)	

Stem width: 1.00
Each leaf: 1 case(s)

TOC

Hi-Res Chart # 424:Normal plot of toc
Hi-Res Chart # 425:Detrended normal plot of toc

	Statistic	df	Significance
Shapiro-Wilks	.7014	16	< .0100
K-S (Lilliefors)	.2967	16	.0005

Hi-Res Chart # 426:Boxplot of toc

No

Normality Tests with Untransformed Data

NPDES DATA

B - 20
Normal

NPDES

LMW_PAHS

Valid cases: 12.0 Missing cases: .0 Percent missing: .0

Mean	6572.287	Std Err	2514.784	Min	122.9000	Skewness	2.5037
Median	3701.000	Variance	75889649	Max	31700.46	S E Skew	.6373
5 th Trim	5534.577	Std Dev	8711.467	Range	31577.56	Kurtosis	7.0484
				IQR	6805.900	S E Kurt	1.2322

Frequency Stem & Leaf

7.00	0 *	0002224
3.00	0 .	668
1.00	1 *	2
1.00	Extremes	(31700)

Stem width: 10000.00
Each leaf: 1 case(s)

LMW_PAHS

Hi-Res Chart # 433: Normal plot of lmw_pahs
Hi-Res Chart # 434: Detrended normal plot of lmw_pahs

	Statistic	df	Significance
Shapiro-Wilks	.6944	12	< .0100
K-S (Lilliefors)	.2628	12	.0216

No

Hi-Res Chart # 435: Boxplot of lmw_pahs

NPDES

HMW_PAHS

Valid cases: 12.0 Missing cases: .0 Percent missing: .0

Mean	292.7333	Std Err	144.5882	Min	44.7000	Skewness	3.1213
Median	104.6000	Variance	250869.1	Max	1835.450	S E Skew	.6373
5 th Trim	220.8065	Std Dev	500.8683	Range	1790.750	Kurtosis	10.1936
				IQR	257.7975	S E Kurt	1.2322

Frequency Stem & Leaf

6.00	0 .	455589
2.00	1 .	17
1.00	2 .	2
1.00	3 .	4
1.00	4 .	2
1.00	Extremes	(1835)

Stem width: 100.00
Each leaf: 1 case(s)

HMW_PAHS

Hi-Res Chart # 436: Normal plot of hmw_pahs
Hi-Res Chart # 437: Detrended normal plot of hmw_pahs

	Statistic	df	Significance
Shapiro-Wilks	.5214	12	< .0100
K-S (Lilliefors)	.3152	12	.0017

No

Normality Tests with Untransformed Data
NPDES DATA

B - 22
Normal

NPDES

TOC

Valid cases: 10.0 Missing cases: 2.0 Percent missing: 16.7

Mean	46.6200	Std Err	11.0721	Min	9.0000	Skewness	.4485
Median	41.0000	Variance	1225.906	Max	95.0000	S E Skew	.6870
5% Trim	46.0222	Std Dev	35.0129	Range	86.0000	Kurtosis	-1.4575
				IQR	82.3000	S E Kurt	1.3342

Frequency	Stem &	Leaf
3.00	0 +	000
1.00	0 t	2
3.00	0 f	444
.00	0 s	
3.00	0 .	999

Stem width: 100.00
Each leaf: 1 case(s)

TOC

Hi-Res Chart # 445: Normal plot of toc
Hi-Res Chart # 446: Detrended normal plot of toc

	Statistic	df	Significance
Shapiro-Wilks	.8548	10	.0738
K-S (Lilliefors)	.1729	10	> .2000

Hi-Res Chart # 447: Boxplot of toc

Yes

Normality Tests with Untransformed Data

Stormwater Data

B - 24
Normal

Stormwater

CAR_PAHS

Valid cases: 29.0 Missing cases: 1.0 Percent missing: 3.3

Mean	2047.852	Std Err	668.1392	Min	25.1000	Skewness	3.9401
Median	836.0000	Variance	12945890	Max	18940.00	S E Skew	.4335
5% Trim	1462.411	Std Dev	3598.040	Range	18914.90	Kurtosis	18.2327
				IQR	3082.550	S E Kurt	.0452

Frequency	Stem &	Leaf
12.00	0 *	000001111234
4.00	0 .	6788
3.00	1 *	233
.00	1 .	
2.00	2 *	12
.00	2 .	
2.00	3 *	12
2.00	3 .	66
2.00	4 *	03
1.00	4 .	9
1.00	Extremes	(18940)

Stem width: 1000.00
Each leaf: 1 case(s)

CAR_PAHS

Hi-Res Chart # 451: Normal plot of car_pahs
Hi-Res Chart # 452: Detrended normal plot of car_pahs

	Statistic	df	Significance
Shapiro-Wilks	.5446	29	< .0100
K-S (Lilliefors)	.2525	29	.0001

Hi-Res Chart # 453: Boxplot of car_pahs

No

Normality Tests with Untransformed Data

Stormwater Data

B - 26
Normal

Stormwater

HMM_PAHS

Valid cases: 29.0 Missing cases: 1.0 Percent missing: 3.3

Mean	3572.732	Std Err	1099.760	Min	50.0000	Skewness	3.6707
Median	1390.660	Variance	35074688	Max	30710.00	S E Skew	.4335
5% Trim	2630.823	Std Dev	5922.389	Range	30660.00	Kurtosis	16.2785
				IQR	5414.100	S E Kurt	.8452

Frequency	Stem &	Leaf
12.00	0 .	000001333467
4.00	1 .	2234
3.00	2 .	245
1.00	3 .	7
1.00	4 .	3
2.00	5 .	68
2.00	6 .	59
2.00	7 .	15
.00	8 .	
1.00	9 .	2
1.00	Extremes	(30710)

Stem width: 1000.00
Each leaf: 1 case(s)

HMM_PAHS

Hi-Res Chart # 457: Normal plot of hmw_pahs
Hi-Res Chart # 458: Detrended normal plot of hmw_pahs

	Statistic	df	Significance
Shapiro-Wilks	.5807	29	< .0100
K-S (Lilliefors)	.2415	29	.0002

Hi-Res Chart # 459: Boxplot of hmw_pahs

No

Normality Tests with Untransformed Data
Stormwater Data

B - 28
Normal

Stormwater

O_G

Valid cases: 18.0 Missing cases: 12.0 Percent missing: 40.0

Mean	4.4778	Std Err	.9432	Min	1.0000	Skewness	1.2168
Median	3.0000	Variance	16.0148	Max	13.0000	S E Skew	.5363
5th Trim	4.1975	Std Dev	4.0018	Range	12.0000	Kurtosis	.3940
				IQR	6.2500	S E Kurt	1.0378

Frequency	Stem &	Leaf
5.00	0 *	11111
6.00	0 t	223333
2.00	0 f	45
1.00	0 s	7
2.00	0 .	89
.00	1 *	
2.00	1 t	33

Stem width: 10.00
Each leaf: 1 case(s)

O_G

Hi-Res Chart # 463: Normal plot of o_g
Hi-Res Chart # 464: Detrended normal plot of o_g

	Statistic	df	Significance
Shapiro-Wilks	.8105	18	< .0100
K-S (Lilliefors)	.2551	18	.0030

Hi-Res Chart # 465: Boxplot of o_g

No

Normality Tests with Untransformed Data

CSO DATA

B - 30
Normal

CSO

TOT_PAHS
Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	4780.311	Std Err	1733.083	Min	1331.800	Skewness	2.4794
Median	3288.000	Variance	27032175	Max	17968.00	S E Skew	.7171
5% Trim	4239.246	Std Dev	5199.248	Range	16636.20	Kurtosis	6.6624
				IQR	3818.650	S E Kurt	1.3997

Frequency Stem & Leaf
3.00 1 . 338
1.00 2 . 2
1.00 3 . 2
1.00 4 . 1
2.00 5 . 07
1.00 Extremes (17968)

Stem width: 1000.00
Each leaf: 1 case(s)

TOT_PAHS

Hi-Res Chart # 469:Normal plot of tot_pahs
Hi-Res Chart # 470:Detrended normal plot of tot_pahs

	Statistic	df	Significance
Shapiro-Wilks	.6679	9	< .0100
K-S (Lilliefors)	.3141	9	.0108

No

Hi-Res Chart # 471:Boxplot of tot_pahs

CSO CAR_PAHS

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	1265.144	Std Err	525.0060	Min	325.4000	Skewness	2.5868
Median	765.0000	Variance	2480682	Max	5300.000	S E Skew	.7171
5% Trim	1093.194	Std Dev	1575.018	Range	4974.600	Kurtosis	7.0697
				IQR	1053.150	S E Kurt	1.3997

Frequency Stem & Leaf
4.00 0 * 3344
2.00 0 . 78
1.00 1 * 3
1.00 1 . 5
1.00 Extremes (5300)

Stem width: 1000.00
Each leaf: 1 case(s)

CAR_PAHS

Hi-Res Chart # 472:Normal plot of car_pahs
Hi-Res Chart # 473:Detrended normal plot of car_pahs

	Statistic	df	Significance
Shapiro-Wilks	.6251	9	< .0100
K-S (Lilliefors)	.3077	9	.0140

Hi-Res Chart # 474:Boxplot of car_pahs

No

Normality Tests with Untransformed Data

CSO DATA

B - 32
Normal

CSO

TSS

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	53.1111	Std Err	14.9373	Min	8.0000	Skewness	1.4892
Median	57.0000	Variance	2008.111	Max	154.0000	S E Skew	.7171
5% Trim	50.0123	Std Dev	44.8120	Range	146.0000	Kurtosis	2.8335
				IQR	48.0000	S E Kurt	1.3997

Frequency	Stem & Leaf
2.00	0 * 01
2.00	0 t 22
1.00	0 f 5
3.00	0 s 667
1.00	Extremes (154)

Stem width: 100.00
Each leaf: 1 case(s)

TSS

Hi-Res Chart # 481:Normal plot of tss
Hi-Res Chart # 482:Detrended normal plot of tss

	Statistic	df	Significance
Shapiro-Wilks	.8289	9	.0499
K-S (Lilliefors)	.2420	9	.1368

No

Hi-Res Chart # 483:Boxplot of tss

CSO O_G

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	12.4444	Std Err	2.9350	Min	3.0000	Skewness	.0999
Median	13.0000	Variance	77.5278	Max	25.0000	S E Skew	.7171
5% Trim	12.2716	Std Dev	8.8050	Range	22.0000	Kurtosis	-2.0186
				IQR	16.5000	S E Kurt	1.3997

Frequency	Stem & Leaf
3.00	0 * 334
1.00	0 . 5
1.00	1 * 3
1.00	1 . 9
2.00	2 * 00
1.00	2 . 5

Stem width: 10.00
Each leaf: 1 case(s)

O_G

Hi-Res Chart # 484:Normal plot of o_g
Hi-Res Chart # 485:Detrended normal plot of o_g

	Statistic	df	Significance
Shapiro-Wilks	.8547	9	.0928
K-S (Lilliefors)	.2455	9	.1252

Yes

Hi-Res Chart # 486:Boxplot of o_g

Normality Tests with Log Transformed Data River Data

B - 34
Log Normal

Urban River

LOG_CPAH
By LANDUSE 1

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	2.1857	Std Err	.1552	Min	1.3367	Skewness	-.1815
Median	2.1572	Variance	.2168	Max	2.8736	S E Skew	.7171
5% Trim	2.1946	Std Dev	.4656	Range	1.5369	Kurtosis	.5247
				IQR	.6134	S E Kurt	1.3997

Frequency Stem & Leaf

```

1.00 Extremes (1.34)
1.00 18 . 2
.00 19 .
2.00 20 . 79
2.00 21 . 58
.00 22 .
1.00 23 . 3
2.00 Extremes (2.79), (2.87)

```

Stem width: .10
Each leaf: 1 case(s)

LOG_CPAH
By LANDUSE 1

Hi-Res Chart # 135: Normal plot of log_cpah for landuse: 1
Hi-Res Chart # 136: Detrended normal plot of log_cpah for landuse: 1

Yes

	Statistic	df	Significance
Shapiro-Wilks	.9414	9	.5689
K-S (Lilliefors)	.1685	9	> .2000

Non-Urban River

LOG_CPAH
By LANDUSE 2

Valid cases: 7.0 Missing cases: .0 Percent missing: .0

Mean	1.8631	Std Err	.1116	Min	1.3054	Skewness	-1.0640
Median	1.8802	Variance	.0872	Max	2.1732	S E Skew	.7937
5% Trim	1.8768	Std Dev	.2952	Range	.8678	Kurtosis	1.6170
				IQR	.4038	S E Kurt	1.5875

Frequency Stem & Leaf

```

1.00 Extremes (1.3)
4.00 1 . 7789
2.00 2 * 11

```

Stem width: 1.00
Each leaf: 1 case(s)

LOG_CPAH
By LANDUSE 2

Hi-Res Chart # 138: Normal plot of log_cpah for landuse: 2
Hi-Res Chart # 139: Detrended normal plot of log_cpah for landuse: 2

Yes

	Statistic	df	Significance
Shapiro-Wilks	.9031	7	.3894
K-S (Lilliefors)	.1468	7	> .2000

Hi-Res Chart # 137: Boxplot of log_cpah by landuse

Normality Tests with Log Transformed Data

River Data

B - 36
Log Normal

Urban River

LOG_HPAH
By LANDUSE 1

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	2.5003	Std Err	.1595	Min	1.6706	Skewness	.0206
Median	2.4486	Variance	.2290	Max	3.2255	S E Skew	.7171
5% Trim	2.5061	Std Dev	.4786	Range	1.5549	Kurtosis	.1972
				IQR	.6690	S E Kurt	1.3997

Frequency Stem & Leaf

```

1.00 Extremes (1.7)
5.00 2 * 13344
1.00 2 . 6
1.00 3 * 1
1.00 Extremes (3.2)

```

Stem width: 1.00
Each leaf: 1 case(s)

LOG_HPAH
By LANDUSE 1

Hi-Res Chart # 145: Normal plot of log_hpah for landuse: 1
Hi-Res Chart # 146: Detrended normal plot of log_hpah for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.9493	9	.6541
K-S (Lilliefors)	.1767	9	> .2000

Yes

Non Urban River

LOG_HPAH
By LANDUSE 2

Valid cases: 7.0 Missing cases: .0 Percent missing: .0

Mean	2.0913	Std Err	.1195	Min	1.4728	Skewness	-1.3098
Median	2.1092	Variance	.0999	Max	2.4031	S E Skew	.7937
5% Trim	2.1083	Std Dev	.3160	Range	.9304	Kurtosis	2.3109
				IQR	.4071	S E Kurt	1.5875

Frequency Stem & Leaf

```

1.00 Extremes (1.5)
1.00 1 . 9
5.00 2 * 01234

```

Stem width: 1.00
Each leaf: 1 case(s)

LOG_HPAH
By LANDUSE 2

Hi-Res Chart # 148: Normal plot of log_hpah for landuse: 2
Hi-Res Chart # 149: Detrended normal plot of log_hpah for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.8775	7	.2754
K-S (Lilliefors)	.1619	7	> .2000

Yes

Hi-Res Chart # 147: Boxplot of log_hpah by landuse

Normality Tests with Log Transformed Data River Data

B - 38
Log Normal

Urban River

LOG_TOC
By LANDUSE 1

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	.6134	Std Err	.1110	Min	.0414	Skewness	-.3678
Median	.6628	Variance	.1109	Max	1.1761	S E Skew	.7171
5% Trim	.6139	Std Dev	.3330	Range	1.1347	Kurtosis	.7722
				IQR	.3434	S E Kurt	1.3997

Frequency Stem & Leaf

2.00 Extremes (.041), (.176)

1.00 63 . 3

.00 64 .

1.00 65 . 3

1.00 66 . 2

.00 67 .

1.00 68 . 1

1.00 69 . 0

2.00 Extremes (.806), (1.176)

Stem width: .01
Each leaf: 1 case(s)

LOG_TOC
By LANDUSE 1

Hi-Res Chart # 155:Normal plot of log_toc for landuse: 1
Hi-Res Chart # 156:Detrended normal plot of log_toc for landuse: 1

Yes

	Statistic	df	Significance
Shapiro-Wilks	.8828	9	.2252
K-S (Lilliefors)	.1907	9	> .2000

Non Urban River

LOG_TOC
By LANDUSE 2

Valid cases: 7.0 Missing cases: .0 Percent missing: .0

Mean	.5016	Std Err	.0425	Min	.3617	Skewness	.9230
Median	.4771	Variance	.0126	Max	.6990	S E Skew	.7937
5% Trim	.4984	Std Dev	.1124	Range	.3372	Kurtosis	.5162
				IQR	.1549	S E Kurt	1.5875

Frequency Stem & Leaf

1.00 3 . 6

4.00 4 . 4477

.00 5 .

1.00 6 . 0

1.00 Extremes (.70)

Stem width: .10
Each leaf: 1 case(s)

Hi-Res Chart # 158:Normal plot of log_toc for landuse: 2
Hi-Res Chart # 159:Detrended normal plot of log_toc for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.9025	7	.3865
K-S (Lilliefors)	.3006	7	.0553

Hi-Res Chart # 157:Boxplot of log_toc by landuse

Yes

Normality Tests with Log Transformed Data

River Data

B - 40
Log Normal

Urban River

LOG_OG
By LANDUSE 1

Valid cases: 6.0 Missing cases: 3.0 Percent missing: 33.3

Mean	.1960	Std Err	.1272	Min	.0000	Skewness	1.1824
Median	.0000	Variance	.0971	Max	.6990	S E Skew	.8452
5% Trim	.1790	Std Dev	.3117	Range	.6990	Kurtosis	-.6011
			IQR		.5326	S E Kurt	1.7408

Frequency	Stem	Leaf
4.00	0 *	0000
.00	0 t	
1.00	0 f	4
1.00	0 s	6

Stem width: 1.00
Each leaf: 1 case(s)

LOG_OG
By LANDUSE 1

Hi-Res Chart # 165: Normal plot of log_og for landuse: 1
Hi-Res Chart # 166: Detrended normal plot of log_og for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.6931	6	< .0100
K-S (Lilliefors)	.4020	6	.0030

No

Non Urban River

LOG_OG
By LANDUSE 2

Valid cases: 1.0 Missing cases: 6.0 Percent missing: 85.7

>Note # 17570. Command name: EXAMINE
>The number of unique data values for this cell is equal to one. The cell
>will be included in any boxplots produced but other output will be omitted.

Hi-Res Chart # 167: Boxplot of log_og by landuse

Not Determined

Normality Tests with Log Transformed Data

Stormwater Data

B - 42
Log Normal

Urban Stormwater

LOG_LPAH
By LANDUSE 1

Valid cases: 19.0 Missing cases: 1.0 Percent missing: 5.0

Mean	3.6364	Std Err	.1115	Min	2.6727	Skewness	-.3766
Median	3.6930	Variance	.2362	Max	4.3755	S E Skew	.5238
5% Trim	3.6489	Std Dev	.4860	Range	1.7029	Kurtosis	-.7050
				IQR	.7908	S E Kurt	1.0143

Frequency	Stem & Leaf
2.00	2 . 68
5.00	3 * 00333
7.00	3 . 5667888
5.00	4 * 11123

Stem width: 1.00
Each leaf: 1 case(s)

LOG_LPAH
By LANDUSE 1

Hi-Res Chart # 173: Normal plot of log_lpah for landuse: 1
Hi-Res Chart # 174: Detrended normal plot of log_lpah for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.9599	19	.5548
K-S (Lilliefors)	.0864	19	> .2000

Yes

Non Urban Stormwater

LOG_LPAH
By LANDUSE 2

Valid cases: 10.0 Missing cases: .0 Percent missing: .0

Mean	2.6768	Std Err	.1183	Min	2.2792	Skewness	.3438
Median	2.6117	Variance	.1401	Max	3.2066	S E Skew	.6870
5% Trim	2.6695	Std Dev	.3742	Range	.9274	Kurtosis	-1.7614
				IQR	.6313	S E Kurt	1.3342

Frequency	Stem & Leaf
5.00	2 * 23333
3.00	2 . 899
2.00	3 * 22

Stem width: 1.00
Each leaf: 1 case(s)

LOG_LPAH
By LANDUSE 2

Hi-Res Chart # 176: Normal plot of log_lpah for landuse: 2
Hi-Res Chart # 177: Detrended normal plot of log_lpah for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.8382	10	.0469
K-S (Lilliefors)	.2819	10	.0235

No

Hi-Res Chart # 175: Boxplot of log_lpah by landuse

Normality Tests with Log Transformed Data

Stormwater Data

B - 44
Log Normal

Urban Stormwater

LOG_TSS
By LANDUSE 1

Valid cases: 20.0 Missing cases: .0 Percent missing: .0

Mean	1.2255	Std Err	.1241	Min	.3979	Skewness	-.0638
Median	1.2782	Variance	.3080	Max	2.3502	S E Skew	.5121
5% Trim	1.2090	Std Dev	.5549	Range	1.9523	Kurtosis	-.5054
				IQR	.7679	S E Kurt	.9924

Frequency	Stem & Leaf
4.00	0 * 3333
3.00	0 . 899
5.00	1 * 12233
7.00	1 . 5556669
1.00	2 * 3

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TSS
By LANDUSE 1

Hi-Res Chart # 183: Normal plot of log_tss for landuse: 1
Hi-Res Chart # 184: Detrended normal plot of log_tss for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.9422	20	.3274
K-S (Lilliefors)	.1321	20	> .2000

Yes

Non Urban Stormwater

LOG_TSS
By LANDUSE 2

Valid cases: 10.0 Missing cases: .0 Percent missing: .0

Mean	.5886	Std Err	.1019	Min	.3979	Skewness	1.3890
Median	.3979	Variance	.1038	Max	1.2553	S E Skew	.6870
5% Trim	.5621	Std Dev	.3221	Range	.8573	Kurtosis	.5202
				IQR	.4859	S E Kurt	1.3342

Frequency	Stem & Leaf
7.00	0 * 3333333
1.00	0 . 8
2.00	1 * 02

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TSS
By LANDUSE 2

Hi-Res Chart # 186: Normal plot of log_tss for landuse: 2
Hi-Res Chart # 187: Detrended normal plot of log_tss for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.6618	10	< .0100
K-S (Lilliefors)	.4230	10	.0000

Hi-Res Chart # 185: Boxplot of log_tss by landuse

No

Normality Tests with Log Transformed Data Stormwater Data

B - 46
Log Normal

Urban Stormwater

LOG_TPAH
By LANDUSE 1

Valid cases: 19.0 Missing cases: 1.0 Percent missing: 5.0

Mean	3.8477	Std Err	.1180	Min	2.7243	Skewness	-.4393
Median	3.9250	Variance	.2647	Max	4.7360	S E Skew	.5238
5% Trim	3.8607	Std Dev	.5145	Range	2.0117	Kurtosis	-.2562
				IGR	.8746	S E Kurt	1.0143

Frequency	Stem &	Leaf
1.00	2 .	7
4.00	3 *	1234
5.00	3 .	55779
8.00	4 *	01112334
1.00	4 .	7

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TPAH
By LANDUSE 1

Hi-Res Chart # 193: Normal plot of log_tpah for landuse: 1
Hi-Res Chart # 194: Detrended normal plot of log_tpah for landuse: 1

	Statistic	df	Significance
Shapiro-Wilks	.9736	19	.8161
K-S (Lilliefors)	.0885	19	> .2000

Yes

Non Urban Stormwater

LOG_TPAH
By LANDUSE 2

Valid cases: 10.0 Missing cases: .0 Percent missing: .0

Mean	2.8924	Std Err	.1460	Min	2.4437	Skewness	.5413
Median	2.8397	Variance	.2132	Max	3.6053	S E Skew	.6870
5% Trim	2.8778	Std Dev	.4618	Range	1.1616	Kurtosis	-1.2683
				IGR	.7981	S E Kurt	1.3342

Frequency	Stem &	Leaf
4.00	2 *	4444
1.00	2 .	6
3.00	3 *	001
2.00	3 .	56

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TPAH
By LANDUSE 2

Hi-Res Chart # 196: Normal plot of log_tpah for landuse: 2
Hi-Res Chart # 197: Detrended normal plot of log_tpah for landuse: 2

	Statistic	df	Significance
Shapiro-Wilks	.8504	10	.0655
K-S (Lilliefors)	.2141	10	> .2000

Yes

Hi-Res Chart # 195: Boxplot of log_tpah by landuse

Normality Tests with Log Transformed Data Pooled River Data

B - 48
Log Normal

Rivers

LOG_CPAH

Valid cases: 16.0 Missing cases: .0 Percent missing: .0

Mean	2.0445	Std Err	.1054	Min	1.3054	Skewness	.2050
Median	2.0860	Variance	.1778	Max	2.8736	S E Skew	.5643
5% Trim	2.0395	Std Dev	.4217	Range	1.5682	Kurtosis	.5488
				IQR	.3783	S E Kurt	1.0908

Frequency Stem & Leaf

2.00	1 *	33
5.00	1 .	77889
7.00	2 *	0011113
2.00 Extremes		(2.8), (2.9)

Stem width: 1.00
Each leaf: 1 case(s)

LOG_CPAH

Hi-Res Chart # 301:Normal plot of log_cpah
Hi-Res Chart # 302:Detrended normal plot of log_cpah

	Statistic	df	Significance
Shapiro-Wilks	.9382	16	.3799
K-S (Lilliefors)	.1834	16	.1539

Yes

Hi-Res Chart # 303:Boxplot of log_cpah

Rivers

LOG_LPAH

Valid cases: 16.0 Missing cases: .0 Percent missing: .0

Mean	2.4780	Std Err	.1378	Min	1.4624	Skewness	.3347
Median	2.3800	Variance	.3037	Max	3.6021	S E Skew	.5643
5% Trim	2.4720	Std Dev	.5511	Range	2.1397	Kurtosis	.0797
				IQR	.8065	S E Kurt	1.0908

Frequency Stem & Leaf

1.00	1 *	4
2.00	1 .	89
7.00	2 *	1133344
3.00	2 .	679
2.00	3 *	02
1.00	3 .	6

Stem width: 1.00
Each leaf: 1 case(s)

LOG_LPAH

Hi-Res Chart # 304:Normal plot of log_lpah
Hi-Res Chart # 305:Detrended normal plot of log_lpah

	Statistic	df	Significance
Shapiro-Wilks	.9811	16	.9509
K-S (Lilliefors)	.1103	16	> .2000

Yes

Hi-Res Chart # 306:Boxplot of log_lpah

Normality Tests with Log Transformed Data Pooled River Data

B - 50
Log Normal

Rivers LOG_TOC

Valid cases: 16.0 Missing cases: .0 Percent missing: .0

Mean	.5645	Std Err	.0649	Min	.0414	Skewness	.1577
Median	.6178	Variance	.0675	Max	1.1761	S E Skew	.5643
5% Trim	.5596	Std Dev	.2598	Range	1.1347	Kurtosis	1.6332
				IQR	.2408	S E Kurt	1.0908

Frequency	Stem &	Leaf
1.00	Extremes	(.04)
1.00	1	7
.00	2	
1.00	3	6
4.00	4	4477
.00	5	
7.00	6	0356899
.00	7	
1.00	8	0
1.00	Extremes	(1.18)

Stem width: .10
Each leaf: 1 case(s)

LOG_TOC

Hi-Res Chart # 313: Normal plot of log_toc
Hi-Res Chart # 314: Detrended normal plot of log_toc

Yes

	Statistic	df	Significance
Shapiro-Wilks	.9413	16	.4071
K-S (Lilliefors)	.1773	16	.1917

Hi-Res Chart # 315: Boxplot of log_toc

Rivers

LOG_TPAH

Valid cases: 16.0 Missing cases: .0 Percent missing: .0

Mean	2.7430	Std Err	.1133	Min	2.0846	Skewness	.9246
Median	2.6546	Variance	.2055	Max	3.7544	S E Skew	.5643
5% Trim	2.7234	Std Dev	.4533	Range	1.6698	Kurtosis	.3945
				IQR	.6380	S E Kurt	1.0908

Frequency	Stem &	Leaf
6.00	2 *	033444
6.00	2	566688
2.00	3 *	11
2.00	3	57

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TPAH

Hi-Res Chart # 316: Normal plot of log_tpah
Hi-Res Chart # 317: Detrended normal plot of log_tpah

	Statistic	df	Significance
Shapiro-Wilks	.9274	16	.2861
K-S (Lilliefors)	.1678	16	> .2000

Hi-Res Chart # 318: Boxplot of log_tpah

Yes

Normality Tests with Log Transformed Data NPDES DATA

B - 52
Log Normal

NPDES

LOG_CPAH

Valid cases: 12.0 Missing cases: .0 Percent missing: .0

Mean	1.8757	Std Err	.1228	Min	1.1827	Skewness	.4167
Median	1.9095	Variance	.1810	Max	2.7277	S E Skew	.6373
5% Trim	1.8669	Std Dev	.4255	Range	1.5450	Kurtosis	.1974
				IQR	.6730	S E Kurt	1.2322

Frequency	Stem & Leaf
3.00	1 * 144
6.00	1 . 669999
2.00	2 * 23
1.00	2 . 7

Stem width: 1.00
Each leaf: 1 case(s)

LOG_CPAH

Hi-Res Chart # 322:Normal plot of log_cpah
Hi-Res Chart # 323:Detrended normal plot of log_cpah

	Statistic	df	Significance
Shapiro-Wilks	.9705	12	.8669
K-S (Lilliefors)	.1693	12	> .2000

Yes

Hi-Res Chart # 324:Boxplot of log_cpah

NPDES

LOG_LPAH

Valid cases: 12.0 Missing cases: .0 Percent missing: .0

Mean	3.4688	Std Err	.1917	Min	2.0896	Skewness	-.6766
Median	3.5583	Variance	.4409	Max	4.5011	S E Skew	.6373
5% Trim	3.4881	Std Dev	.6640	Range	2.4115	Kurtosis	.4115
				IQR	.9617	S E Kurt	1.2322

Frequency	Stem & Leaf
1.00	2 * 0
2.00	2 . 77
3.00	3 * 344
4.00	3 . 6789
1.00	4 * 0
1.00	4 . 5

Stem width: 1.00
Each leaf: 1 case(s)

LOG_LPAH

Hi-Res Chart # 325:Normal plot of log_lpah
Hi-Res Chart # 326:Detrended normal plot of log_lpah

	Statistic	df	Significance
Shapiro-Wilks	.9569	12	.6858
K-S (Lilliefors)	.0959	12	> .2000

Hi-Res Chart # 327:Boxplot of log_lpah

Yes

Normality Tests with Log Transformed Data

NPDES DATA

B - 54
Log Normal

NPDES

LOG_TOC

Valid cases: 10.0 Missing cases: 2.0 Percent missing: 16.7

Mean	1.5187	Std Err	.1314	Min	.9542	Skewness	-.4053
Median	1.6127	Variance	.1726	Max	1.9777	S E Skew	.6870
5% Trim	1.5245	Std Dev	.4155	Range	1.0235	Kurtosis	-1.4731
				IQR	.9771	S E Kurt	1.3342

Frequency	Stem & Leaf
3.00	0 . 999
1.00	1 * 4
6.00	1 . 666999

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TOC

Hi-Res Chart # 334: Normal plot of log_toc
Hi-Res Chart # 335: Detrended normal plot of log_toc

	Statistic	df	Significance
Shapiro-Wilks	.8602	10	.0837
K-S (Lilliefors)	.1978	10	> .2000

Yes

Hi-Res Chart # 336: Boxplot of log_toc

NPDES

LOG_TPAH

Valid cases: 12.0 Missing cases: .0 Percent missing: .0

Mean	3.5045	Std Err	.1814	Min	2.2538	Skewness	-.5176
Median	3.5808	Variance	.3947	Max	4.5255	S E Skew	.6373
5% Trim	3.5173	Std Dev	.6282	Range	2.2717	Kurtosis	.1816
				IQR	.9126	S E Kurt	1.2322

Frequency	Stem & Leaf
1.00	2 * 2
2.00	2 . 78
3.00	3 * 344
4.00	3 . 6789
1.00	4 * 1
1.00	4 . 5

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TPAH

Hi-Res Chart # 337: Normal plot of log_tpah
Hi-Res Chart # 338: Detrended normal plot of log_tpah

	Statistic	df	Significance
Shapiro-Wilks	.9683	12	.8375
K-S (Lilliefors)	.0946	12	> .2000

Yes

Hi-Res Chart # 339: Boxplot of log_tpah

Normality Tests with Log Transformed Data

Pooled Stormwater Data

B - 56
Log Normal

Stormwater

LOG_CPAH

Valid cases: 29.0 Missing cases: 1.0 Percent missing: 3.3

Mean	2.7968	Std Err	.1444	Min	1.3997	Skewness	-.2842
Median	2.9222	Variance	.6047	Max	4.2774	S E Skew	.4335
5% Trim	2.8000	Std Dev	.7776	Range	2.8777	Kurtosis	-.8611
				IQR	1.3308	S E Kurt	.8452

Frequency	Stem	Leaf
1.00	1 *	3
4.00	1 .	5566
5.00	2 *	11124
6.00	2 .	568899
5.00	3 *	11133
7.00	3 .	5555666
1.00	4 *	2

Stem width: 1.00
Each leaf: 1 case(s)

LOG_CPAH

Hi-Res Chart # 343:Normal plot of log_cpah
Hi-Res Chart # 344:Detrended normal plot of log_cpah

	Statistic	df	Significance
Shapiro-Wilks	.9484	29	.2568
K-S (Lilliefors)	.0970	29	> .2000

Yes

Hi-Res Chart # 345:Boxplot of log_cpah

Stormwater

LOG_LPAH

Valid cases: 29.0 Missing cases: 1.0 Percent missing: 3.3

Mean	3.3055	Std Err	.1192	Min	2.2792	Skewness	-.0754
Median	3.3531	Variance	.4123	Max	4.3755	S E Skew	.4335
5% Trim	3.3053	Std Dev	.6421	Range	2.0963	Kurtosis	-1.1067
				IQR	.9899	S E Kurt	.8452

Frequency	Stem	Leaf
5.00	2 *	23333
5.00	2 .	68899
7.00	3 *	0022333
7.00	3 .	5667888
5.00	4 *	11123

Stem width: 1.00
Each leaf: 1 case(s)

LOG_LPAH

Hi-Res Chart # 346:Normal plot of log_lpah
Hi-Res Chart # 347:Detrended normal plot of log_lpah

	Statistic	df	Significance
Shapiro-Wilks	.9444	29	.2015
K-S (Lilliefors)	.0965	29	> .2000

Yes

Hi-Res Chart # 348:Boxplot of log_lpah

Normality Tests with Log Transformed Data

Pooled Stormwater Data

B - 58
Log Normal

Stormwater

LOG_TOC

Valid cases: 30.0 Missing cases: .0 Percent missing: .0

Mean	.8655	Std Err	.0793	Min	-.3010	Skewness	-.4375
Median	.9542	Variance	.1887	Max	1.6990	S E Skew	.4269
5% Trim	.8755	Std Dev	.4343	Range	2.0000	Kurtosis	.5772
				IQR	.5441	S E Kurt	.8327

Frequency Stem & Leaf

1.00	Extremes	(-.3)
4.00	0 t	3333
1.00	0 f	4
6.00	0 s	666667
6.00	0 .	899999
6.00	1 *	000011
3.00	1 t	223
2.00	1 f	45
1.00	1 s	6

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TOC

Hi-Res Chart # 355:Normal plot of log_toc
Hi-Res Chart # 356:Detrended normal plot of log_toc

	Statistic	df	Significance
Shapiro-Wilks	.9745	30	.6864
K-S (Lilliefors)	.0698	30	> .2000

Yes

Hi-Res Chart # 357:Boxplot of log_toc

Stormwater

LOG_TPAAH

Valid cases: 29.0 Missing cases: 1.0 Percent missing: 3.3

Mean	3.5183	Std Err	.1249	Min	2.4437	Skewness	-.1573
Median	3.5779	Variance	.4522	Max	4.7360	S E Skew	.4335
5% Trim	3.5160	Std Dev	.6725	Range	2.2923	Kurtosis	-1.0186
				IQR	1.0689	S E Kurt	.8452

Frequency Stem & Leaf

4.00	2 *	4444
2.00	2 .	67
7.00	3 *	0011234
7.00	3 .	5556779
8.00	4 *	01112334
1.00	4 .	7

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TPAAH

Hi-Res Chart # 358:Normal plot of log_tpah
Hi-Res Chart # 359:Detrended normal plot of log_tpah

	Statistic	df	Significance
Shapiro-Wilks	.9480	29	.2513
K-S (Lilliefors)	.0880	29	> .2000

Yes

Hi-Res Chart # 360:Boxplot of log_tpah

Normality Tests with Log Transformed Data

CSO DATA

B - 60
Log Normal

CSO

LOG_CPAH

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	2.9147	Std Err	.1289	Min	2.5124	Skewness	1.1695
Median	2.8837	Variance	.1495	Max	3.7243	S E Skew	.7171
5% Trim	2.8920	Std Dev	.3867	Range	1.2119	Kurtosis	1.2780
				IQR	.5589	S E Kurt	1.3997

Frequency	Stem &	Leaf
6.00	2 .	556689
2.00	3 *	12
1.00	3 .	7

Stem width: 1.00
Each leaf: 1 case(s)

LOG_CPAH

Hi-Res Chart # 364:Normal plot of log_cpah
Hi-Res Chart # 365:Detrended normal plot of log_cpah

	Statistic	df	Significance
Shapiro-Wilks	.8988	9	.3095
K-S (Lilliefors)	.1769	9	> .2000

Yes

Hi-Res Chart # 366:Boxplot of log_cpah

CSO

LOG_LPAH

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	3.2617	Std Err	.1258	Min	2.7742	Skewness	.5849
Median	3.1958	Variance	.1425	Max	3.9613	S E Skew	.7171
5% Trim	3.2499	Std Dev	.3775	Range	1.1871	Kurtosis	-.0719
				IQR	.6218	S E Kurt	1.3997

Frequency	Stem &	Leaf
2.00	2 .	78
4.00	3 *	0112
3.00	3 .	559

Stem width: 1.00
Each leaf: 1 case(s)

LOG_LPAH

Hi-Res Chart # 367:Normal plot of log_lpah
Hi-Res Chart # 368:Detrended normal plot of log_lpah

	Statistic	df	Significance
Shapiro-Wilks	.9611	9	.7822
K-S (Lilliefors)	.1438	9	> .2000

Hi-Res Chart # 369:Boxplot of log_lpah

Yes

Normality Tests with Log Transformed Data

CSO DATA

B - 62
Log Normal

CSO

LOG_TOC

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	.9569	Std Err	.1032	Min	.6021	Skewness	.0073
Median	.9031	Variance	.0959	Max	1.3802	S E Skew	.7171
5% Trim	.9530	Std Dev	.3096	Range	.7782	Kurtosis	-1.7135
			IQR		.6505	S E Kurt	1.3997

Frequency	Stem &	Leaf
5.00	0 .	66699
4.00	1 *	1233

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TOC

Hi-Res Chart # 376: Normal plot of log_toc
Hi-Res Chart # 377: Detrended normal plot of log_toc

	Statistic	df	Significance
Shapiro-Wilks	.8900	9	.2634
K-S (Lilliefors)	.2074	9	> .2000

Yes

Hi-Res Chart # 378: Boxplot of log_toc

CSO

LOG_TPAH

Valid cases: 9.0 Missing cases: .0 Percent missing: .0

Mean	3.5255	Std Err	.1203	Min	3.1244	Skewness	.8838
Median	3.5169	Variance	.1302	Max	4.2545	S E Skew	.7171
5% Trim	3.5073	Std Dev	.3608	Range	1.1301	Kurtosis	.8411
			IQR		.5333	S E Kurt	1.3997

Frequency	Stem &	Leaf
4.00	3 *	1123
4.00	3 .	5677
1.00	4 *	2

Stem width: 1.00
Each leaf: 1 case(s)

LOG_TPAH

Hi-Res Chart # 379: Normal plot of log_tpah
Hi-Res Chart # 380: Detrended normal plot of log_tpah

	Statistic	df	Significance
Shapiro-Wilks	.9259	9	.4519
K-S (Lilliefors)	.1463	9	> .2000

Yes

Hi-Res Chart # 381: Boxplot of log_tpah

APPENDIX C

Mann-Whitney and Analysis of Variance Tests Used to Detect Significant Differences in Concentrations Between Urban and Non-Urban Stormwater and Rivers

Tests for Differences by Landuse (Urban vs Non-Urban)
Stormwater Data

C - 1

----- Mann-Whitney U - Wilcoxon Rank Sum W Test

TSS in Stormwater
By Landuse

Mean Rank	Cases					
18.77	20	LANDUSE = 1				
8.95	10	LANDUSE = 2				
--	--					
	30	Total				
U	W	Exact	Corrected for ties			
		2-Tailed P	Z	2-Tailed P		
34.5	89.5	.0028	-2.9569	.0031		Significant Difference

----- Mann-Whitney U - Wilcoxon Rank Sum W Test

Total PAH in Stormwater
By Landuse

Mean Rank	Cases					
19.05	19	LANDUSE = 1				
7.30	10	LANDUSE = 2				
--	--					
	29	Total				
U	W	Exact	Corrected for ties			
		2-Tailed P	Z	2-Tailed P		
18.0	73.0	.0001	-3.5330	.0004		Significant Difference

----- Mann-Whitney U - Wilcoxon Rank Sum W Test

Carcinogenic PAH in Stormwater
By Landuse

Mean Rank	Cases					
18.63	19	LANDUSE = 1				
8.10	10	LANDUSE = 2				
--	--					
	29	Total				
U	W	Exact	Corrected for ties			
		2-Tailed P	Z	2-Tailed P		
26.0	81.0	.0009	-3.1659	.0015		Significant Difference

----- Mann-Whitney U - Wilcoxon Rank Sum W Test

LMW PAH in Stormwater
By Landuse

Mean Rank	Cases					
19.32	19	LANDUSE = 1				
6.80	10	LANDUSE = 2				
--	--					
	29	Total				
U	W	Exact	Corrected for ties			
		2-Tailed P	Z	2-Tailed P		
13.0	68.0	.0000	-3.7624	.0002		Significant Difference

Tests for Differences by Landuse (Urban vs Non-Urban)
River Data

C - 3

----- **Mann-Whitney U - Wilcoxon Rank Sum W Test**

TSS in Rivers
By Landuse

Mean Rank Cases

6.33 9 LANDUSE = 1
 11.29 7 LANDUSE = 2
 --
 16 Total

U W Exact Corrected for ties
 12.0 79.0 2-Tailed P Z 2-Tailed P
 .0418 -2.0810 .0374

**Significant
 Difference**

----- **Mann-Whitney U - Wilcoxon Rank Sum W Test**

Total PAH in Rivers
By Landuse

Mean Rank Cases

10.78 9 LANDUSE = 1
 5.57 7 LANDUSE = 2
 --
 16 Total

U W Exact Corrected for ties
 11.0 39.0 2-Tailed P Z 2-Tailed P
 .0311 -2.1700 .0300

**Significant
 Difference**

----- **Mann-Whitney U - Wilcoxon Rank Sum W Test**

Carcinogenic PAH in Rivers
By Landuse

Mean Rank Cases

10.22 9 LANDUSE = 1
 6.29 7 LANDUSE = 2
 --
 16 Total

U W Exact Corrected for ties
 16.0 44.0 2-Tailed P Z 2-Tailed P
 .1142 -1.6407 .1009

**Not-Significant
 Difference**

----- **Mann-Whitney U - Wilcoxon Rank Sum W Test**

LMW PAH in Rivers
By Landuse

Mean Rank Cases

11.11 9 LANDUSE = 1
 5.14 7 LANDUSE = 2
 --
 16 Total

U W Exact Corrected for ties
 8.0 36.0 2-Tailed P Z 2-Tailed P
 .0115 -2.4875 .0129

**Significant
 Difference**

Tests for Differences by Landuse (Urban vs Non-Urban)
Log-TPAH by Landuse

C - 5

Total PAH in Rivers

***** Analysis of Variance *****

Log-TPAH
By Landuse

Unique sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	1.031	1	1.031	7.043	.019
LANDUSE	1.031	1	1.031	7.043	.019
Explained	1.031	1	1.031	7.043	.019
Residual	2.050	14	.146		
Total	3.082	15	.205		

16 cases were processed.
0 cases (.0 pct) were missing.

**Significant
Difference**

Total PAH in Stormwater

***** Analysis of Variance *****

Log-TPAH
By Landuse

Unique sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	5.978	1	5.978	24.151	.000
LANDUSE	5.978	1	5.978	24.151	.000
Explained	5.978	1	5.978	24.151	.000
Residual	6.684	27	.248		
Total	12.662	28	.452		

30 cases were processed.
1 cases (3.3 pct) were missing.

**Significant
Difference**

HMW PAH in Rivers

*** Analysis of Variance ***

Log-HPAH
By Landuse

Unique sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	.659	1	.659	3.792	.072
LANDUSE	.659	1	.659	3.792	.072
Explained	.659	1	.659	3.792	.072
Residual	2.432	14	.174		
Total	3.090	15	.206		

16 cases were processed.
0 cases (.0 pct) were missing.

Not-Significant
Difference

HMW PAH in Stormwater

*** Analysis of Variance ***

Log-HPAH
By Landuse

Unique sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	5.915	1	5.915	15.150	.001
LANDUSE	5.915	1	5.915	15.150	.001
Explained	5.915	1	5.915	15.150	.001
Residual	10.543	27	.390		
Total	16.458	28	.588		

30 cases were processed.
1 cases (3.3 pct) were missing.

Significant
Difference

TOC in Rivers

*** Analysis of Variance ***

Log-TOC
By Landuse

Unique sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	.049	1	.049	.715	.412
LANDUSE	.049	1	.049	.715	.412
Explained	.049	1	.049	.715	.412
Residual	.963	14	.069		
Total	1.012	15	.067		

16 cases were processed.
0 cases (.0 pct) were missing.

Not-Significant
Difference

TOC in Stormwater

*** Analysis of Variance ***

Log-TOC
By Landuse

Unique sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	.661	1	.661	3.845	.060
LANDUSE	.661	1	.661	3.845	.060
Explained	.661	1	.661	3.845	.060
Residual	4.810	28	.172		
Total	5.471	29	.189		

30 cases were processed.
0 cases (.0 pct) were missing.

Not-Significant
Difference

Tests for Differences by Landuse (Urban vs Non-Urban)
Log-Oil & Grease by Landuse

C - 11

Oil & Grease in Stormwater

*** Analysis of Variance ***

Log-OG
By Landuse

Unique sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	.088	1	.088	.550	.469
LANDUSE	.088	1	.088	.550	.469
Explained	.088	1	.088	.550	.469
Residual	2.558	16	.160		
Total	2.646	17	.156		

30 cases were processed.
12 cases (40.0 pct) were missing.

Not-Significant
Difference

BIVARIATE CORRELATIONS: NPDES DATA

LANDUSE: 1 Urban

- - Correlation Coefficients - -

	LOG_CPAH	LOG_HPAH	LOG_LPAH	LOG_TPAH	LOG_TOC	TSS
LOG_CPAH	1.0000 (12) P= .	.8845 (12) P= .000	.5738 (12) P= .051	.5910 (12) P= .043	.2271 (10) P= .528	.3598 (12) P= .251
LOG_HPAH	.8845 (12) P= .000	1.0000 (12) P= .	.6659 (12) P= .018	.6884 (12) P= .013	.3192 (10) P= .369	.3460 (12) P= .271
LOG_LPAH	.5738 (12) P= .051	.6659 (12) P= .018	1.0000 (12) P= .	.9991 (12) P= .000	.7289 (10) P= .017	.6886 (12) P= .013
LOG_TPAH	.5910 (12) P= .043	.6884 (12) P= .013	.9991 (12) P= .000	1.0000 (12) P= .	.7203 (10) P= .019	.6836 (12) P= .014
LOG_TOC	.2271 (10) P= .528	.3192 (10) P= .369	.7289 (10) P= .017	.7203 (10) P= .019	1.0000 (10) P= .	.8805 (10) P= .001
TSS	.3598 (12) P= .251	.3460 (12) P= .271	.6886 (12) P= .013	.6836 (12) P= .014	.8805 (10) P= .001	1.0000 (12) P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

REGRESSIONS: NPDES DATA

LANDUSE: 1 Urban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_TPAH

Block Number 1. Method: Enter LOG_TOC

Variable(s) Entered on Step Number

1.. LOG_TOC

Multiple R .72025
R Square .51876
Adjusted R Square .45861
Standard Error .48691

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	2.04455	2.04455
Residual	8	1.89664	.23708

F = 8.62389 Signif F = .0188

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TOC	1.147098	.390615	.720253	2.937	.0188
(Constant)	1.708204	.612867		2.787	.0237

End Block Number 1 All requested variables entered.

REGRESSIONS: NPDES DATA

LANDUSE: 1 Urban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_LPAH

Block Number 1. Method: Enter LOG_TOC

Variable(s) Entered on Step Number
1.. LOG_TOC

Multiple R .72887
R Square .53125
Adjusted R Square .47265
Standard Error .50900

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	2.34900	2.34900
Residual	8	2.07268	.25909

F = 9.06653 Signif F = .0168

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TOC	1.229541	.408341	.728866	3.011	.0168
(Constant)	1.544358	.640678		2.411	.0425

End Block Number 1 All requested variables entered.

REGRESSIONS: NPDES DATA

LANDUSE: 1 Urban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_TPAH

Block Number 1. Method: Enter TSS

Variable(s) Entered on Step Number
1.. TSS

Multiple R .68362
R Square .46734
Adjusted R Square .41407
Standard Error .48088

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	2.02888	2.02888
Residual	10	2.31249	.23125

F = 8.77357 Signif F = .0142

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
TSS	.014066	.004749	.683620	2.962	.0142
(Constant)	2.840523	.263680		10.773	.0000

End Block Number 1 All requested variables entered.

REGRESSIONS: NPDES DATA

LANDUSE: 1 Urban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_LPAH

Block Number 1. Method: Enter TSS

Variable(s) Entered on Step Number
1.. TSS

Multiple R .68864
R Square .47422
Adjusted R Square .42164
Standard Error .50500

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	2.30017	2.30017
Residual	10	2.55027	.25503

F = 9.01933 Signif F = .0133

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
TSS	.014977	.004987	.688636	3.003	.0133
(Constant)	2.761790	.276905		9.974	.0000

End Block Number 1 All requested variables entered.

BIVARIATE CORRELATIONS: STORMWATER

LANDUSE: 1 Urban

- - Correlation Coefficients - -

	LOG_CPAH	LOG_HPAH	LOG_LPAH	LOG_TPAH	LOG_TOC	LOG_TSS
LOG_CPAH	1.0000 (19) P= .	.9981 (19) P= .000	.9105 (19) P= .000	.9643 (19) P= .000	-.0165 (19) P= .947	-.1085 (19) P= .658
LOG_HPAH	.9981 (19) P= .000	1.0000 (19) P= .	.9131 (19) P= .000	.9657 (19) P= .000	-.0167 (19) P= .946	-.0983 (19) P= .689
LOG_LPAH	.9105 (19) P= .000	.9131 (19) P= .000	1.0000 (19) P= .	.9865 (19) P= .000	.2003 (19) P= .411	-.1022 (19) P= .677
LOG_TPAH	.9643 (19) P= .000	.9657 (19) P= .000	.9865 (19) P= .000	1.0000 (19) P= .	.1274 (19) P= .603	-.1126 (19) P= .646
LOG_TOC	-.0165 (19) P= .947	-.0167 (19) P= .946	.2003 (19) P= .411	.1274 (19) P= .603	1.0000 (20) P= .	.2813 (20) P= .229
LOG_TSS	-.1085 (19) P= .658	-.0983 (19) P= .689	-.1022 (19) P= .677	-.1126 (19) P= .646	.2813 (20) P= .229	1.0000 (20) P= .
LOG_OG	-.0081 (9) P= .984	.0093 (9) P= .981	.0924 (9) P= .813	.0602 (9) P= .878	.6168 (10) P= .058	.1912 (10) P= .597
LOG_CPAH	-.0081 (9) P= .984					
LOG_HPAH	.0093 (9) P= .981					
LOG_LPAH	.0924 (9) P= .813					
LOG_TPAH	.0602 (9) P= .878					
LOG_TOC	.6168 (10) P= .058					
LOG_TSS	.1912 (10) P= .597					
LOG_OG	1.0000 (10) P= .					

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_TPAH

Block Number 1. Method: Enter LOG_TOC

Variable(s) Entered on Step Number
1.. LOG_TOC

Multiple R .77819
R Square .60559
Adjusted R Square .55628
Standard Error .30758

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	1.16209	1.16209
Residual	8	.75686	.09461

F = 12.28323 Signif F = .0080

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TOC	.611736	.174545	.778194	3.505	.0080
(Constant)	2.491364	.150189		16.588	.0000

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_LPAH

Block Number 1. Method: Enter LOG_TOC

Variable(s) Entered on Step Number

1.. LOG_TOC

Multiple R .80842
R Square .65354
Adjusted R Square .61023
Standard Error .23364

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.82376	.82376
Residual	8	.43671	.05459

F = 15.09048 Signif F = .0046

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TOC	.515045	.132585	.808416	3.885	.0046
(Constant)	2.339134	.114084		20.504	.0000

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

* * * * M U L T I P L E R E G R E S S I O N * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_HPAH

Block Number 1. Method: Enter LOG_TOC

Variable(s) Entered on Step Number
1.. LOG_TOC

Multiple R .71797
R Square .51549
Adjusted R Square .45492
Standard Error .44929

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	1.71808	1.71808
Residual	8	1.61486	.20186

F = 8.51137 Signif F = .0194

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TOC	.743818	.254957	.717973	2.917	.0194
(Constant)	1.944789	.219380		8.865	.0000

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_CPAH

Block Number 1. Method: Enter LOG_TOC

Variable(s) Entered on Step Number

1.. LOG_TOC

Multiple R .66956
R Square .44831
Adjusted R Square .37934
Standard Error .49516

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	1.59387	1.59387
Residual	8	1.96145	.24518

F = 6.50079 Signif F = .0342

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TOC	.716426	.280988	.669556	2.550	.0342
(Constant)	1.686537	.241778		6.976	.0001

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

* * * * * M U L T I P L E R E G R E S S I O N * * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_TPAH

Block Number 1. Method: Enter LOG_TSS

Variable(s) Entered on Step Number

1.. LOG_TSS

Multiple R .85595
R Square .73265
Adjusted R Square .69924
Standard Error .25323

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	1.40593	1.40593
Residual	8	.51302	.06413

F = 21.92378 Signif F = .0016

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TSS	1.226928	.262036	.855952	4.682	.0016
(Constant)	2.170273	.173783		12.488	.0000

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_LPAH

Block Number 1. Method: Enter LOG_TSS

Variable(s) Entered on Step Number

1.. LOG_TSS

Multiple R .77898
R Square .60680
Adjusted R Square .55765
Standard Error .24890

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.76485	.76485
Residual	8	.49561	.06195

F = 12.34600 Signif F = .0079

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TSS	.904955	.257551	.778975	3.514	.0079
(Constant)	2.144161	.170809		12.553	.0000

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_HPAH

Block Number 1. Method: Enter LOG_TSS

Variable(s) Entered on Step Number
1.. LOG_TSS

Multiple R .88638
R Square .78567
Adjusted R Square .75887
Standard Error .29882

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	2.61858	2.61858
Residual	8	.71436	.08930

F = 29.32488 Signif F = .0006

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TSS	1.674444	.309209	.886378	5.415	.0006
(Constant)	.1446889	.205069		7.056	.0001

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

* * * * MULTIPLE REGRESSION * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_CPAH

Block Number 1. Method: Enter LOG_TSS

Variable(s) Entered on Step Number

1.. LOG_TSS

Multiple R .88484
R Square .78295
Adjusted R Square .75581
Standard Error .31058

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	2.78362	2.78362
Residual	8	.77170	.09646

F = 28.85712 Signif F = .0007

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_TSS	1.726406	.321378	.884842	5.372	.0007
(Constant)	1.140093	.213139		5.349	.0007

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

* * * * M U L T I P L E R E G R E S S I O N * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_TPAH

Block Number 1. Method: Enter LOG_OG

Variable(s) Entered on Step Number
1.. LOG_OG

Multiple R .79945
R Square .63911
Adjusted R Square .57897
Standard Error .30890

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	1.01393	1.01393
Residual	6	.57253	.09542

F = 10.62578 Signif F = .0173

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_OG	.895688	.274775	.799446	3.260	.0173
(Constant)	2.614791	.156716		16.685	.0000

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_LPAH

Block Number 1. Method: Enter LOG_OG

Variable(s) Entered on Step Number
1.. LOG_OG

Multiple R .83955
R Square .70485
Adjusted R Square .65566
Standard Error .22477

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.72390	.72390
Residual	6	.30312	.05052

F = 14.32881 Signif F = .0091

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_OG	.756818	.199934	.839555	3.785	.0091
(Constant)	2.443576	.114031		21.429	.0000

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

* * * * MULTIPLE REGRESSION * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_HPAH

Block Number 1. Method: Enter LOG_OG

Variable(s) Entered on Step Number

1.. LOG_OG

Multiple R .74242
R Square .55119
Adjusted R Square .47639
Standard Error .44662

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	1.46982	1.46982
Residual	6	1.19682	.19947

F = 7.36865 Signif F = .0349

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_OG	1.078411	.397274	.742421	2.715	.0349
(Constant)	2.103694	.226584		9.284	.0001

End Block Number 1 All requested variables entered.

REGRESSIONS: STORMWATER DATA

LANDUSE: 2 Nonurban

* * * * M U L T I P L E R E G R E S S I O N * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOG_CPAH

Block Number 1. Method: Enter LOG_OG

Variable(s) Entered on Step Number

1.. LOG_OG

Multiple R .71510
R Square .51137
Adjusted R Square .42994
Standard Error .48585

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	1.48225	1.48225
Residual	6	1.41631	.23605

F = 6.27932 Signif F = .0462

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOG_OG	1.082961	.432172	.715104	2.506	.0462
(Constant)	1.814317	.246487		7.361	.0003

End Block Number 1 All requested variables entered.

BIVARIATE CORRELATIONS: CSO DATA

LANDUSE: 1 Urban

-- Correlation Coefficients --

	LOG_CPAH	LOG_HPAH	LOG_LPAH	LOG_TPAH	LOG_TOC	LOG_TSS
LOG_CPAH	1.0000 (9) P= .	.9996 (9) P= .000	.8237 (9) P= .006	.9405 (9) P= .000	-.3151 (9) P= .409	.4891 (9) P= .182
LOG_HPAH	.9996 (9) P= .000	1.0000 (9) P= .	.8318 (9) P= .005	.9451 (9) P= .000	-.3034 (9) P= .427	.5043 (9) P= .166
LOG_LPAH	.8237 (9) P= .006	.8318 (9) P= .005	1.0000 (9) P= .	.9661 (9) P= .000	-.1455 (9) P= .709	.6507 (9) P= .058
LOG_TPAH	.9405 (9) P= .000	.9451 (9) P= .000	.9661 (9) P= .000	1.0000 (9) P= .	-.2505 (9) P= .516	.5923 (9) P= .093
LOG_TOC	-.3151 (9) P= .409	-.3034 (9) P= .427	-.1455 (9) P= .709	-.2505 (9) P= .516	1.0000 (9) P= .	.5992 (9) P= .088
LOG_TSS	.4891 (9) P= .182	.5043 (9) P= .166	.6507 (9) P= .058	.5923 (9) P= .093	.5992 (9) P= .088	1.0000 (9) P= .
LOG_OG	.2425 (9) P= .530	.2543 (9) P= .509	.4427 (9) P= .233	.3509 (9) P= .354	.7625 (9) P= .017	.9403 (9) P= .000
LOG_OG						
LOG_CPAH	.2425 (9) P= .530					
LOG_HPAH	.2543 (9) P= .509					
LOG_LPAH	.4427 (9) P= .233					
LOG_TPAH	.3509 (9) P= .354					
LOG_TOC	.7625 (9) P= .017					
LOG_TSS	.9403 (9) P= .000					
LOG_OG	1.0000 (9) P= .					

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

BIVARIATE CORRELATIONS: RIVER DATA

LANDUSE: 1 Urban

-- Correlation Coefficients --

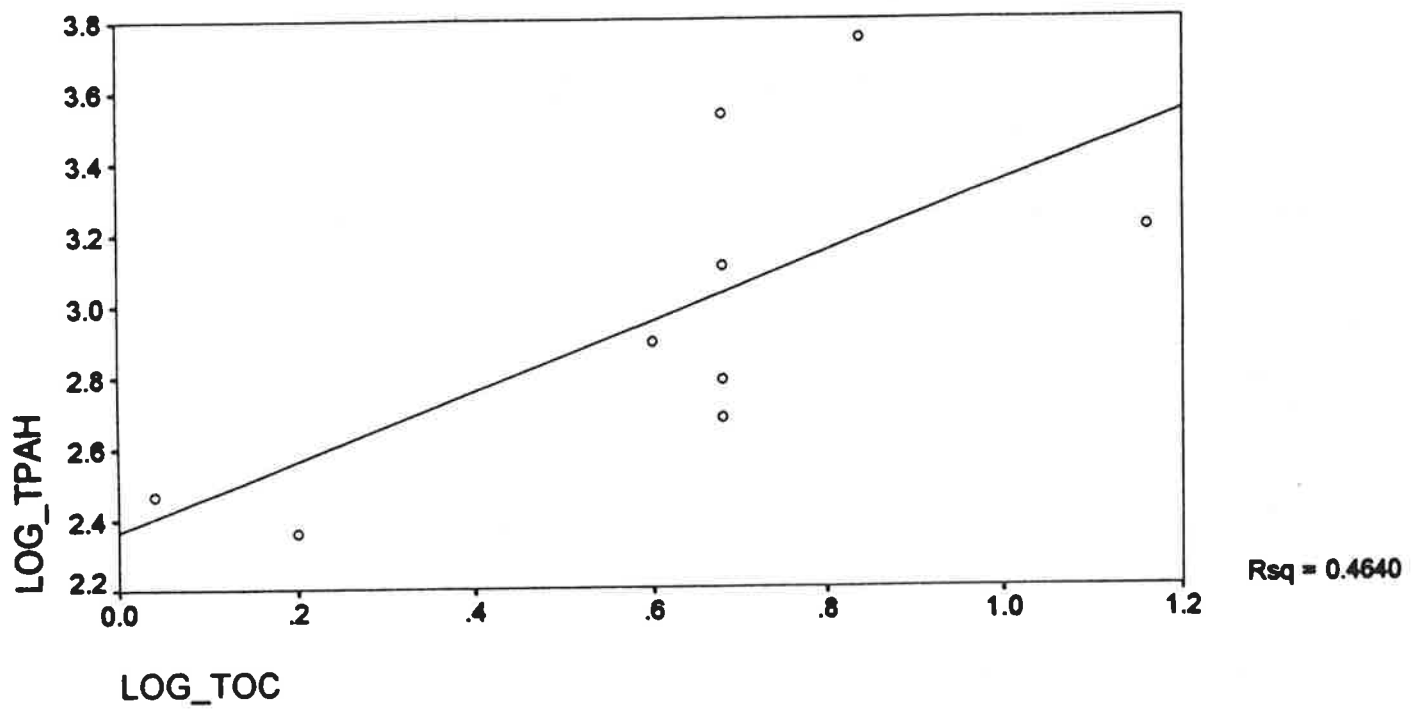
	LOG_OG	O_G
LOG_CPAH	.0476 (6) P= .929	-.0427 (6) P= .936
LOG_HPAH	.0045 (6) P= .993	-.0883 (6) P= .868
LOG_LPAH	-.1013 (6) P= .849	-.1679 (6) P= .751
LOG_TPAH	-.0930 (6) P= .861	-.1697 (6) P= .748
LOG_TOC	-.0443 (6) P= .934	-.0391 (6) P= .941
LOG_TSS	.4033 (6) P= .428	.4906 (6) P= .323
LOG_OG	1.0000 (6) P= .	.9871 (6) P= .000
O_G	.9871 (6) P= .000	1.0000 (6) P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

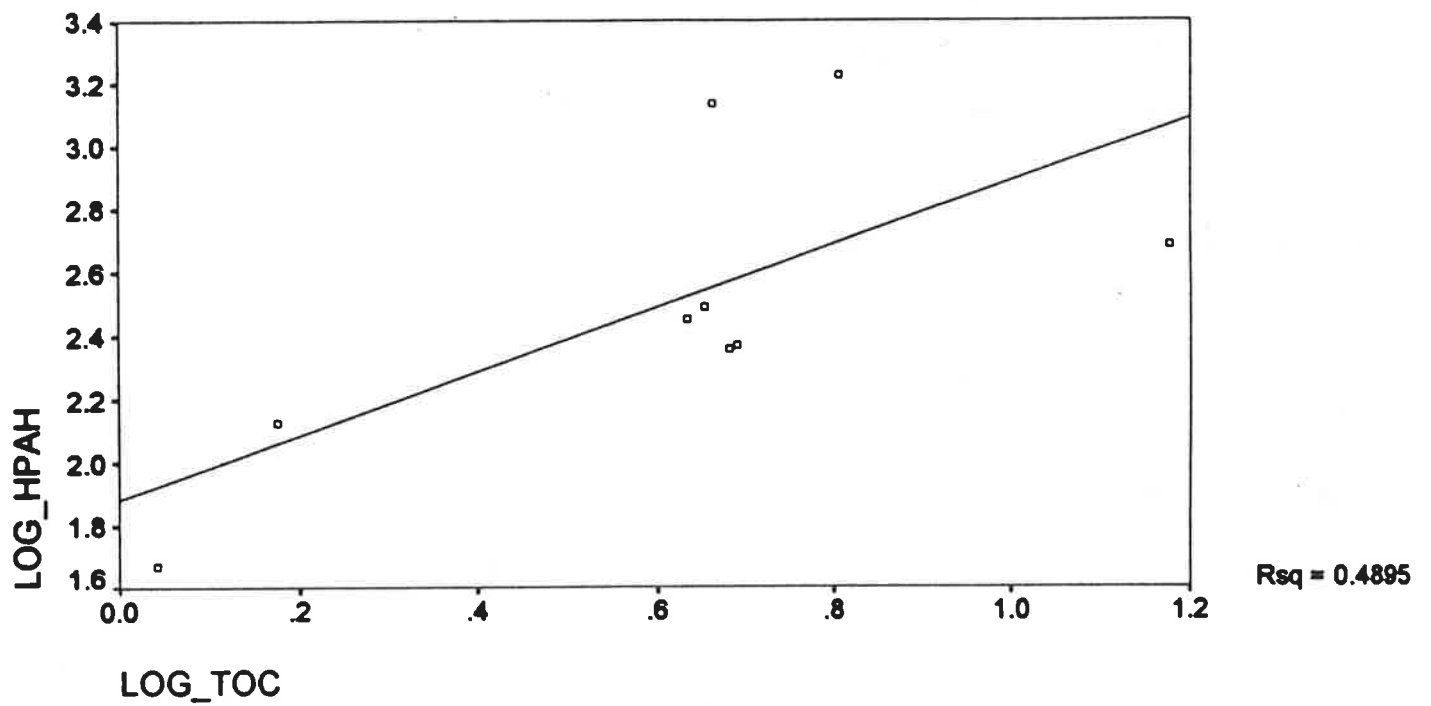
Scatterplot and Regression Line

River Source - Urban Category



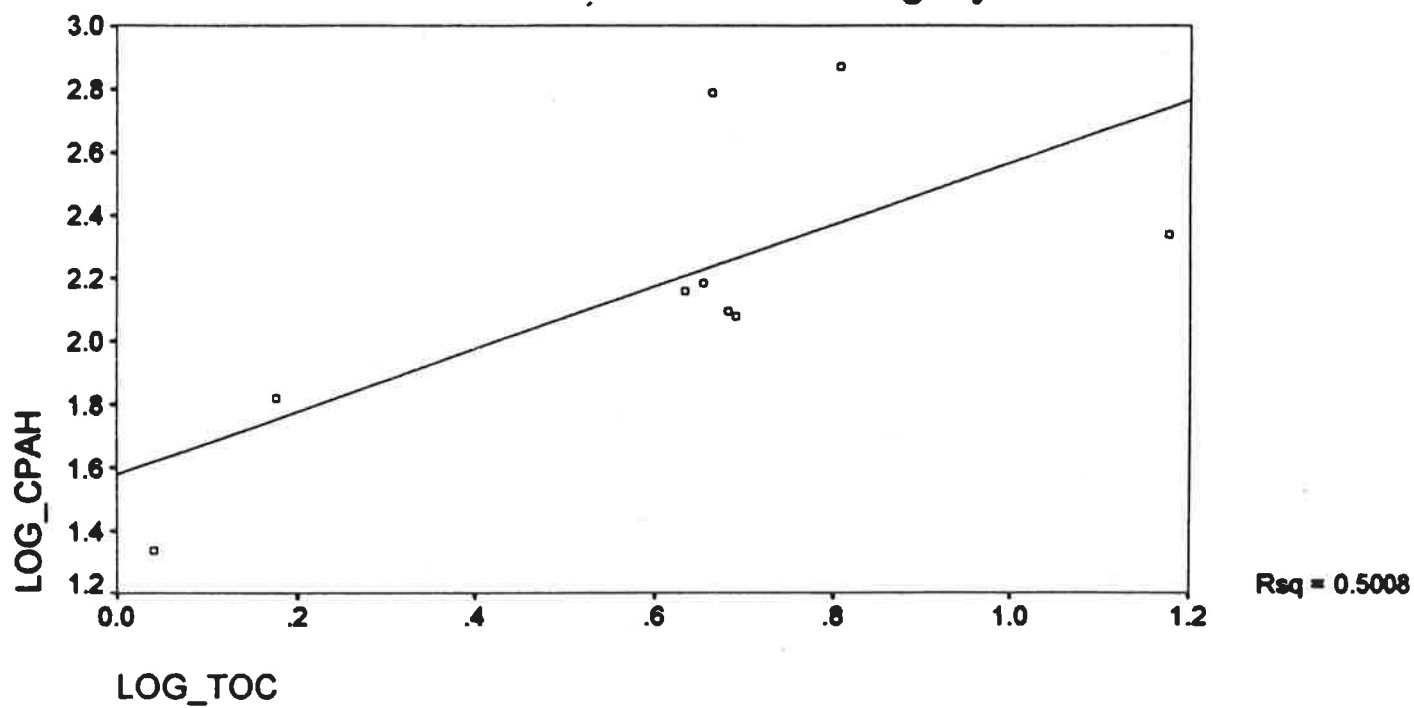
Scatterplot and Regression Line

River Source - Urban Category



Scatterplot and Regression Line

River Source - Urban Category



APPENDIX E
CALCULATION OF LOADINGS

CALCULATION OF LOADINGS

TOTAL PAH

DRAINAGE BASINS AND SOURCES	Watershed Category	Average Conc. (ng/l)	Standard Error of the Mean (ng/l)	Annual Flow Rate (m ³ /s)	Conversion Factor 0.031536	Estimated Loading (kg/yr)	Error on Loading (kg/yr)	Subtotal/ Total Loadings	Subtotal/ Total Error
COASTAL NPDES									
Merrimack Subtotal		6865	+/- 2652	2.59	0.031536	561	+/- 217	561	+/- 217
North Shore									
S. Essex		4717	Measured	1.19	0.031536	177	Measured		
Lynn		505	Measured	3.7	0.031536	58.9	Measured		
Remaining		6865	+/- 2652	0.51	0.031536	110	+/- 43		
Subtotal								346	+/- 43
Boston Harbor									
Deer Island		17533	Measured	11.6	0.031536	6414	Measured		
Nut Island		4705	Measured	5.7	0.031536	846	Measured		
Remaining		6865	+/- 2652	4	0.031536	866	+/- 335		
Subtotal								8126	+/- 335
South Shore									
Subtotal		6865	+/- 2652	0.44	0.031536	95.3	+/- 37	95.3	+/- 37
						Total NPDES Loading		9128	+/- 631
COASTAL CSO									
Boston Harbor South Shore		4780	+/- 1733	0.203	0.031536	30.6	+/- 11		
						Total CSO Loading		30.6	+/- 11
COASTAL RUNOFF									
Merrimack	Non-Urban	1314	+/- 459	0.13	0.031536	5.39	+/- 1.9		
North Shore	Urban	12190	+/- 2955	0.8	0.031536	308	+/- 75		
Boston Harbor	Urban	12190	+/- 2955	0.734	0.031536	282	+/- 68		
South Shore	Non-Urban	1314	+/- 459	0.51	0.031536	21.1	+/- 7.4		
Cape Cod	Non-Urban	1314	+/- 459	0.57	0.031536	23.6	+/- 8.3		
						Total Coastal Runoff Loading		640	+/- 160

CALCULATION OF LOADINGS

LMW PAHs

DRAINAGE BASINS AND SOURCES	Watershed Category	Average Conc. (ng/l)	Standard Error of the Mean (ng/l)	Annual Flow Rate (m³/s)	Conversion Factor 0.031536	Estimated Loading (kg/yr)	Error on Loading (kg/yr)	Subtotal/ Total Loadings	Subtotal/ Total Error
COASTAL NPDES									
Merrimack Subtotal		6572	+/- 2515	2.59	0.031536	537	+/- 205	537	+/- 205
North Shore									
S. Essex		4553	Measured	1.19	0.031536	171	Measured		
Lynn		427	Measured	3.7	0.031536	49.8	Measured		
Remaining		6572	+/- 2515	0.51	0.031536	106	+/- 40		
Subtotal								326	+/- 40.4
Boston Harbor									
Deer Island		16766	Measured	11.6	0.031536	6133	Measured		
Nut Island		4543	Measured	5.7	0.031536	817	Measured		
Remaining		6572	+/- 2515	4	0.031536	829	+/- 317		
Subtotal								7779	+/- 317
South Shore		6572	+/- 2515	0.44	0.031536	91.2	+/- 35	91.2	+/- 35
Subtotal								8733	+/- 598
COASTAL CSO									
Boston Harbor		2624	+/- 896	0.203	0.031536	16.8	+/- 5.7		
South Shore									
						Total CSO Loading		16.8	+/- 5.7
COASTAL RUNOFF									
Merrimack	Non-Urban	661	+/- 177	0.13	0.031536	2.71	+/- 0.7		
North Shore	Urban	7080	+/- 1503	0.8	0.031536	179	+/- 38		
Boston Harbor	Urban	7080	+/- 1503	0.734	0.031536	164	+/- 35		
South Shore	Non-Urban	661	+/- 177	0.51	0.031536	10.6	+/- 2.8		
Cape Cod	Non-Urban	661	+/- 177	0.57	0.031536	11.9	+/- 3.2		
						Total Coastal Runoff Loading		368	+/- 79

CALCULATION OF LOADINGS

HMW PAHs

DRAINAGE BASINS AND SOURCES	Watershed Category	Average Conc. (ng/l)	Standard Error of the Mean (ng/l)	Annual Flow Rate (m³/s)	Conversion Factor 0.031536	Estimated Loading (kg/yr)	Error on Loading (kg/yr)	Subtotal/ Total Loadings	Subtotal/ Total Error
COASTAL NPDES									
Merrimack		293	+/- 145	2.59	0.031536	23.9	+/- 12	23.9	+/- 12
Subtotal									
North Shore									
S. Essex		164	Measured	1.19	0.031536	6.15	Measured		
Lynn		78	Measured	3.7	0.031536	9.10	Measured		
Remaining		293	+/- 145	0.51	0.031536	4.71	+/- 2.3		
Subtotal								20.0	+/- 2.3
Boston Harbor									
Deer Island		767	Measured	11.6	0.031536	281	Measured		
Nut Island		162	Measured	5.7	0.031536	29.1	Measured		
Remaining		293	+/- 145	4	0.031536	37.0	+/- 18	347	+/- 18
Subtotal								4.07	+/- 2.0
South Shore		293	+/- 145	0.44	0.031536	4.07	+/- 2.0		
Subtotal								395	+/- 34
Total NPDES Loading									
COASTAL CSO									
Boston Harbor		2157	+/- 868	0.203	0.031536	13.8	+/- 5.6		
South Shore									
Total CSO Loading									
COASTAL RUNOFF									
Merrimack		653	+/- 288	0.13	0.031536	2.68	+/- 1.2		
North Shore		5109	+/- 1571	0.8	0.031536	129	+/- 40		
Boston Harbor		5109	+/- 1571	0.734	0.031536	118	+/- 36		
South Shore		653	+/- 288	0.51	0.031536	10.5	+/- 4.6		
Cape Cod		653	+/- 288	0.57	0.031536	11.7	+/- 5.2		
Total Coastal Runoff Loading									
								272	+/- 87
TOTAL LOADING								2242	+/- 517

CALCULATION OF LOADINGS

CARCINOGENIC PAHS

DRAINAGE BASINS AND SOURCES	Watershed Category	Average Conc. (ng/l)	Standard Error of the Mean (ng/l)	Annual Flow Rate (m ³ /s)	Conversion Factor 0.031536	Estimated Loading (kg/yr)	Error on Loading (kg/yr)	Subtotal/ Total Loadings	Subtotal/ Total Error
COASTAL NPDES									
Merrimack Subtotal		120	+/- 42	2.59	0.031536	9.80	+/- 3.4	9.80	+/- 3.4
North Shore									
S. Essex		84	Measured	1.19	0.031536	3.15	Measured		
Lynn		46	Measured	3.7	0.031536	5.37	Measured		
Remaining		120	+/- 42	0.51	0.031536	1.93	+/- 0.7		
Subtotal								10.4	+/- 0.7
Boston Harbor									
Deer Island		264	Measured	11.6	0.031536	96.6	Measured		
Nut Island		87	Measured	5.7	0.031536	15.6	Measured		
Remaining		120	+/- 42	4	0.031536	15.1	+/- 5.3		
Subtotal								127	+/- 5.3
South Shore									
Subtotal		120	+/- 42	0.44	0.031536	1.67	+/- 0.6	1.67	+/- 0.6
Total NPDES Loading								149	+/- 10
COASTAL CSO									
Boston Harbor		1265	+/- 525	0.203	0.031536	8.10	+/- 3.4		
South Shore									
Total CSO Loading								8.10	+/- 3.4
COASTAL RUNOFF									
Merrimack	Non-Urban	364	+/- 164	0.13	0.031536	1.49	+/- 0.7		
North Shore	Urban	2934	+/- 962	0.8	0.031536	74.0	+/- 24		
Boston Harbor	Urban	2934	+/- 962	0.734	0.031536	67.9	+/- 22		
South Shore	Non-Urban	364	+/- 164	0.51	0.031536	5.85	+/- 2.6		
Cape Cod	Non-Urban	364	+/- 164	0.57	0.031536	6.54	+/- 2.9		
Total Coastal Runoff Loading								156	+/- 53
TOTAL LOADING								1109	+/- 201