Thea Foss and Wheeler-Osgood Waterways

2012 Source Control and Water Year 2012 Stormwater Monitoring Report

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Prepared for
Washington State Department of Ecology and
U.S. Environmental Protection Agency

Prepared by
City of Tacoma

PROJECT OVERVIEW

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also referred to as Superfund, contaminated bottom sediments were remediated in the Thea Foss and Wheeler-Osgood Waterways in Tacoma, Washington under the oversight of the Environmental Protection Agency (EPA) at a cost of $105M. Sources of Contaminants of Concern (COCs) continue to exist in the drainage basins and are conveyed to the waterways via stormwater (municipal and private), aerial deposition, marinas, and groundwater discharges. The contaminants identified as having the greatest potential to affect sediment quality following the cleanup action include polycyclic aromatic hydrocarbons (PAH) and phthalates.

When the waterway sediment remediation projects were completed, the majority of the sediment surface had no, or very low concentrations of contaminants present since the surface was either dredged to clean sediments or covered with new, clean capping materials. It was anticipated that ongoing source contributions to the waterway would cause concentrations of contaminants to increase gradually. Over time, the goal is to have the contaminant concentrations equilibrate at a level below the sediment cleanup standards set by the EPA. The City developed a predictive model so that actual sediment monitoring results can be compared to model predictions to determine areas where additional source controls may be needed to remain in compliance.

Since stormwater is one of the potential sources, the City has been implementing a comprehensive monitoring and source control strategy in the Foss Waterway Watershed since 2001. This includes monitoring of water and sediments in municipal outfalls and using this monitoring information to guide control of contaminant sources in the drainage basins. The intent of this program is to help provide long-term protection of sediment quality in the waterways. The strategy's elements are integrated with the City's National Pollutant Discharge Elimination System (NPDES) requirements; however, many of the elements exceed these requirements.

Over an 11 year period (August 2001-September 2012), stormwater and stormwater sediments have been sampled at the 7 major outfalls that discharge into the Thea Foss and Wheeler-Osgood Waterways. This depth of data provides the basis for meaningful statistical evaluation of the trends over the program period. Based on this statistical analysis, the City determined that forty-one statistically significant time trends (41 out of 49 tests, or approximately 84% of the tests) were shown in Year 11, with all trends in the direction of decreasing concentrations. This is a larger number of significant reductions than has been observed previously, however the statistical approach used in 2012 was somewhat modified from that used in previous years. The City is confident that these changes in the statistical approach have improved the City's ability to discern trends.

The time trends were modeled with best-fit regression equations to estimate percent reductions over the 11 year monitoring period for these constituents and outfalls:

- **Total Suspended Solids (TSS)**: Approximately 52 to 63% reduction in OF230, OF235, OF237B and OF245;
- **Lead**: Approximately 51 to 56% reduction in OF230, OF235, OF237B and OF245;
- **Zinc**: Approximately 32 to 50% reduction in OF235, OF237A, OF237B, OF245 and OF254;

- **Polycyclic Aromatic Hydrocarbons (PAH):** Approximately 87 to 97% reduction in phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene in all 7 outfalls; and

  Bis(2-ethylhexyl)phthalate (DEHP): Approximately 58 to 91% reduction in all 7 outfalls.

As shown by these significant reductions in various constituents of concern, the improvement in stormwater quality since the mid-1990s indicates that source control efforts by the City and others in the Foss Waterway Watershed have been effective in reducing chemical concentrations in stormwater. These efforts have resulted in fewer sites in the watershed with comparatively higher contaminant concentrations relative to other locations. Because the program has been so effective, the concentrations of contaminants of concern in stormwater in the Foss Waterway Watershed are reaching a level where the opportunities for large reductions are more limited. This may lead to the few, if any, additional decreasing trends in contaminant concentrations, lower percentages of reduction per year, and potentially even a few minor increasing trends, particularly if looking only at results from more recent years.

The sediments in the waterway are the true barometer, however, of whether additional source controls are needed for compliance with regulatory requirements. When the sediments were last evaluated in 2011 for the head of the waterway, the data were generally consistent with model predictions with the exception of one contaminant. This contaminant will be closely watched as additional results become available to see whether it is indicative of a new or changed source to the waterway. Additional sediment sampling in the waterway is scheduled for 2013 and 2014. The sediment data will be closely evaluated and compared to the stormwater and storm sediment monitoring results to determine if additional source control actions are needed.

Ongoing control of sources which are outside the City's jurisdiction must also continue to be coordinated by other federal, state, and local authorities. The City will continue to move forward with ongoing source tracing investigations, treatability studies, and other special investigations for evaluating and identifying cost-effective controls for remaining contaminants in municipal stormwater where such control is determined necessary to protect the waterway.

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LIST OF ABBREVIATIONS

AKART	All Known and Reasonable Technologies
ANOVA	Analysis of Variance
BMP	Best Management Practices
BNSF	Burlington Northern Santa Fe
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHB	Citizen's for a Healthy Bay
City	City of Tacoma
CIPP	Cured-In-Place Pipe
COCs	Contaminants of Concern
CRM	Certified Reference Manual
DEHP	Bis(2-ethylhexyl) phthalate
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
FWDA	Foss Waterway Development Authority
HPAHs	High Molecular Weight PAHs
HSPF	Hydrological Simulation Program - Fortran
IDDE	Illicit Discharge Detection and Elimination
ISWGP	Industrial General Stormwater Permit issued by Ecology
LCS	Laboratory Control Sample
LID	Low Impact Development
LPAHs	Low Molecular Weight PAHs
LUST	Leaking Underground Storage Tank
MLLW	Mean Lower Low Water
MS4	Municipal Separated Storm Sewer System
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPDES Phase I Permit	NPDES Phase I Municipal Stormwater Permit dated January 17, 2007
NWDC	Northwest Detention Center
OF	Outfall
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated biphenyls
PIC	Pierce County Code Enforcement Officers Group
PSD	Particulate Size Distribution
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
SSPM	Stormwater Suspended Particulate Matter
SAP	Sampling and Analysis Plan

SQO	Sediment Quality Objectives
SR	State Route
STRAP	Stormwater Rapid Assessment Program
SWMP	Stormwater Management Program
SWPPP	Stormwater Pollution Prevention Plan
TPCHD	Tacoma Pierce County Health Department
TSS	Total Suspended Solids
USGS	United States Geological Survey
UST	Underground Storage Tank
WCC	Washington Conservation Corps
WRDA	Water Resources Development Act
WSDOT	Washington State Department of Transportation
WY	Water Year

EXECUTIVE SUMMARY

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also referred to as Superfund, contaminated bottom sediments were remediated in the Thea Foss and Wheeler-Osgood Waterways in Tacoma, Washington under the oversight of the Environmental Protection Agency (EPA) at a cost of $105M. The waterways are located in a highly urbanized basin with residential, commercial and industrial land uses and transportation corridors. Sources of Contaminants of Concern (COC) continue to exist in the drainage basins and are conveyed to the waterway via stormwater (municipal and private), aerial deposition, marinas, and groundwater discharges. The contaminants identified as having the greatest potential to affect sediment quality following the cleanup action include polycyclic aromatic hydrocarbons (PAH) and phthalates.

Under a Consent Decree with the EPA dated May 9, 2003, along with prior regulatory agreements, the City of Tacoma (City) is implementing a stormwater monitoring and source control strategy for the municipal storm drains entering the Thea Foss and Wheeler-Osgood Waterways to help provide long-term protection of sediment quality in the waterways. The Thea Foss Post-Remediation Source Control Strategy uses a multifaceted approach consisting of aggressive source control efforts, continuation of a comprehensive monitoring program, a computer model to predict impacts and a decision matrix to identify the need for additional source controls. The strategy's elements are integrated with the City's National Pollutant Discharge Elimination System (NPDES) Phase I requirements, however, many of the elements exceed NPDES requirements.

Under the comprehensive monitoring program, annual baseflow[1], stormwater and stormwater suspended particulate matter (SSPM) monitoring of the stormwater discharges to the Thea Foss Waterway are used to evaluate effectiveness of these source control efforts, and to provide early warning of any new problems which arise in the drainages. The requirements of the monitoring program and the approach to the evaluation of results were outlined in the 2001 Sampling and Analysis Plan (SAP) for the Thea Foss and Wheeler-Osgood Waterways dated September 2001 (City of Tacoma 2001) and approved by EPA on September 13, 2001.

This annual report outlines the City's existing programs and studies which were completed in Water Year 2012 (WY2012), and includes a discussion of the need for additional source controls. Annual source control evaluations are completed for the 7 major outfalls discharging to the waterways; outfalls (OF) OF230, OF235, OF237A, OF237B, OF243, OF245, and OF254. The evaluations include a drain by drain assessment and incorporate the review of ongoing studies, source control investigations, water quality data and SSPM data for that outfall/basin.

As part of the WY2012 evaluation, this report reviews results from the first 11 years of outfall monitoring conducted under the Foss Monitoring Program and source control actions completed in the Thea Foss drainage basins. Since there are no new waterway sediment results available this year, evaluation of results relative to computer model predictions is not included in this report. Each year, the history and trends emerging over the program are examined and presented in terms of the following questions:

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[1] After 10 years of baseflow monitoring were completed at the end of WY2011, baseflow monitoring was discontinued (approval granted by EPA and Ecology on 2/7/12 and 2/9/12 respectively). Baseflow quantity and quality were determined to be well characterized by the 10 year monitoring record.

- Is stormwater quality improving over time?
- What efforts have affected change?
- Is Thea Foss sediment quality in compliance with Superfund Sediment Quality Objectives (SQO)?
- Is Thea Foss sediment quality better or worse than computer model predictions?
- Are additional source controls required?

IS STORMWATER QUALITY IMPROVING OVER TIME?

Over an 11 year period (August 2001-September 2012), stormwater and SSPM have been sampled at the 7 major outfalls that discharge into the Thea Foss and Wheeler-Osgood Waterways. In addition, baseflow was sampled at the same 7 outfalls for the first 10 years of the program. Over the last 11 years, 1,400 samples have been collected with 322 baseflow and 793 stormwater samples collected at the outfalls and 68 outfall and 217 upline SSPM samples collected in pipeline sediment traps deployed throughout the watershed. This depth of data provides the basis for meaningful statistical evaluation of the trends over the program period.

Stormwater Time Trend Analysis. Forty-one statistically significant time trends (41 out of 49 tests, or approximately 84% of the tests) were shown in Year 11 using simple linear regression. All trends were in the direction of decreasing concentrations. This is a larger number of significant reductions than has been observed previously. In Year 10, 37 significant trends were detected;, in Year 9, 26 significant trends were observed; in Year 8, 10 significant trends were observed; and in Year 7, only 4 significant trends were observed. It should be noted that some new statistical approaches were implemented in WY2012 and for this reason, this year's results are not fully comparable to previous year's results. However these changes have improved the statistical approach to the trend analysis, and the City's ability to discern trends.

The time trends were modeled with best-fit regression equations to estimate percent reductions over the 11 year monitoring period for these constituents and outfalls:

- **Total Suspended Solids (TSS)**: Approximately 52 to 63% reduction in OF230, OF235, OF237B and OF245;
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- **Bis(2-ethylhexyl)phthalate (DEHP)**: Approximately 58 to 91% reduction in all 7 outfalls.

WHAT EFFORTS HAVE AFFECTED CHANGE?

The cumulative effect of municipal, state, and federal source control efforts has likely caused the observed improvements in stormwater quality. The City has directed numerous source control efforts in this watershed focused on these COCs. Refer to Sections 2 and 5 for more detail regarding specific efforts.

The City implements aggressive source control activities that comply with or exceed the requirements of the NPDES permit requirements. Many of these activities have been developed specifically to respond to sources of contaminants found during various investigations.

Stormwater Management Program. The NPDES Phase I Municipal Stormwater Permit dated January 17, 2007 (NDPES Phase I Permit) requires a Stormwater Management Program which is divided into 10 components including stormwater outfall sampling, source control, maintenance, inspections, capital projects, and program development and implementation for our municipal separated storm sewer system (MS4). The City integrates these NPDES program elements with the current Thea Foss Program.

The City's stormwater ordinance, through the 2012 Stormwater Management Manual, requires stormwater treatment and control systems on new and redeveloped sites and provides a mechanism for enforcement of the stormwater management regulations. Through new development and redevelopment, stormwater runoff from industrial and commercial sites throughout Thea Foss Basin is being converted from untreated to treated runoff (i.e., removal of solids from stormwater runoff).

In 2012, City staff performed numerous field activities within the Thea Foss Watershed including the following:

- Responded to 322 spills/complaints including conducting investigations;
- Provided technical assistance on source control and best management practices;
- Conducted 199 business inspections;
- Assessed an additional 100,000 feet of pipe under the STRAP program.

All of our business inspections, complaints and spills, and various source control field activities are documented and tracked using a web-based database. The web-based database is an effective tool for retrieving historical information and examining trends.

Special Studies. The City has conducted a number of special studies to better understand the distribution of DEHP and PAHs in the urban environment and how those and other COCs might best be controlled.

Stormwater treatment studies. Stormwater treatment studies are being conducted to evaluate the ability of proprietary and public domain stormwater treatment systems to remove DEHP and PAHs from stormwater runoff. Systems tested to date include StormFilter, AquaFilter, pervious pavements, bioswales and rain gardens. The City will evaluate each technology's effectiveness, applicability and reasonableness for use within the Thea Foss Waterway Watershed.

Basin-wide sewer line cleaning. Basin-wide sewer line cleaning was conducted in 4 entire drainage basins (OF254 in 2006; OF230 and OF235 in 2007; and OF237B in 2011) and part of a 5th basin (OF237A in 2008). The objective of the sewer line cleaning program is to remove residual sediments in the storm drains and sediment-bound contaminants. Contaminants in sediments present in the system may not solely be from new sources, but may in part be from legacy contamination in the pipe that could be continuing to impact stormwater or baseflow quality through re-suspension and/or dissolution.

A statistical comparison of pre-cleaning versus post-cleaning data ("before" and "after" conditions) shows there are statistically significant reductions in the mean concentrations of all 7 Thea Foss index chemicals in OF235, in 6 of the 7 index chemicals in OF230 and OF237B, and in 5 of the 7 index chemicals in OF237A and OF254. While this is representative of the results of combined source control efforts, sewer line cleaning appears to have been effective at accelerating removal of PAHs from stormwater, with 60 to 90% reductions in all 5 drains, including both light and heavy PAH fractions. DEHP shows a significant reduction of approximately 63 to 82% in OF235, OF237A, and OF237B. DEHP is also showing a significant reduction ranging from 7 to 37% in the other 2 drains.

Zinc shows a significant reduction of 22 to 34% in response to line cleaning in 4 of the 5 basins (OF235, OF237A, OF237B, and OF254). In 2010, reductions in TSS and lead concentrations were only discernible in 1 basin (OF235). In 2012, reductions of 24 to 45% in TSS are statistically significant in 3 of the 5 basins (OF230, OF235, and OF237B), and 20 to 38% in lead are statistically significant in 2 of the 5 basins (including OF230 and OF235). These statistical comparisons will continue to be updated as more post-cleaning data are collected. The statistical power of this test should increase over time, and quite possibly statistical differences that can't be resolved today may be distinguishable in the future.

GIS-based pollutant loading model. The City is completing development of a GIS-based pollutant loading model to evaluate other stormwater BMPs that may be effective on a basin-wide scale (i.e., affecting tens, hundreds, or thousands of acres). The BMPs under consideration are street sweeping, low-impact development (LID), and engineered treatment devices such as filtration vaults. The goals of this study are: to evaluate the feasibility and cost-effectiveness of stormwater BMPs implemented on a basin-wide scale; to identify areas of concentrated pollutant runoff where source control efforts are best focused; and to assess the degree to which stormwater BMPs will cause a reduction of pollutant loadings, and thereby improvements in Thea Foss sediment quality. The model is being calibrated to the City's stormwater monitoring record. Following calibration, basin-wide BMP implementation scenarios will be run to determine their cost effectiveness at reducing end-of-pipe pollutant loads. The report will be submitted for discussion upon finalization.

Other State Regulations. In July 2012, the Washington State Department of Ecology (Ecology) reissued the final modified Industrial Stormwater General Permit (ISWGP) which includes new requirements. It is anticipated that under Ecology's ISWGP and the existing Construction Stormwater Permit, contaminants in stormwater will be reduced over time from industrial facilities and construction sites. It is also anticipated that reductions of air pollution will occur through Ecology's Air Program. As reductions in air pollution are realized, the pollutant loads washed off upland surfaces and entrained in stormwater runoff will decrease.

IS THEA FOSS SEDIMENT QUALITY IN COMPLIANCE WITH SQOS? IS IT BETTER OR WORSE THAN COMPUTER MODEL PREDICTIONS?

When the waterway sediment remediation projects were completed, the majority of the sediment surface had no, or very low concentrations of contaminants present since the surface was either dredged to clean sediments or covered with new, clean capping materials. It was anticipated that ongoing source contributions to the waterway would cause concentrations of contaminants to increase gradually. Over time, the goal is to have the contaminant concentrations equilibrate at a level below the sediment cleanup standards set by the EPA. The City developed a predictive model so that actual sediment monitoring results can be compared to model predictions to determine areas where additional source controls may be needed to remain in compliance.

The sediments in the waterway are the true barometer of whether additional source controls are needed for compliance with regulatory requirements. When the sediments were last evaluated in 2011 for the head of the waterway, the data were generally consistent with model predictions with the exception of one contaminant, dibenzo(a,h)anthracene. This contaminant will be closely watched as additional results become available to see whether it is indicative of a new or changed source to the waterway. Additional sediment sampling in the waterway is scheduled for 2013 in the City's work area and in 2014 in the Utilities' work area. The sediment data will be closely evaluated and compared to the stormwater and storm sediment monitoring results to determine if additional source control actions are needed.

ARE ADDITIONAL SOURCE CONTROLS REQUIRED?

While overall trends are decreasing, analytical data indicates that there are some areas where higher concentrations of certain contaminants are present and where additional source control efforts can be implemented. Source control efforts are focused on the COCs for each basin and whether it is found in baseflow, stormwater or SSPM as follows:

Constituents of Interest in Each Basin:

		230	235	237A	237B	243	245	254
TSS	Baseflow	--	--	--	--	--	--	--
	Stormwater	--	--	--	--	--	--	✓
Mercury	Baseflow	--	--	--	--	--	--	--
	Stormwater	--	--	--	--	--	--	--
	Stormwater SPM	✓	--	--	--	✓	--	n/a
Zinc	Baseflow	✓					✓	
	Stormwater		✓				✓	✓
	Stormwater SPM							n/a
Lead	Baseflow		✓			✓		
	Stormwater		✓			✓		
	Stormwater SPM					✓		n/a
LPAHs[1]	Baseflow	--	--	--	--	--	--	--
	Stormwater	--	--	--	--	--	--	--
	Stormwater SPM	--	--	--	--	--	--	n/a
HPAHs[2]	Baseflow	--	--	--	--	--	--	--
	Stormwater	--	--	--	--	--	--	✓
	Stormwater SPM	--	--	--	--	--	--	n/a
Phthalates	Baseflow	--	✓	--	--	--	--	--
	Stormwater	✓	✓	--	--	--	--	--
	Stormwater SPM	--	--	--	--	--	✓	n/a
PCBs	Stormwater SPM	--	--	--	--	--	--	-n/a-

✓ chemical of concern.
[1] As represented by indicator COC phenanthrene
[2] As represented by indicator COCs indeno(1,2,3-cd)pyrene and pyrene
(grey box) shows statistically significant improvement.
(hatched box) shows potential improvement based on qualitative evaluation.
n/a – not applicable

The City believes further improvements in stormwater quality may be realized in the future with ongoing NPDES Phase I Permit programs and continuing improvements in source control implementation. Sediment trap results are valuable in that they provide an early warning of potential stormwater sources to the waterway sediments that can be investigated and addressed before SQO exceedances requiring action are identified in the waterways. The City is moving forward with ongoing source tracing investigations, treatability studies, and other special investigations to evaluate and identify cost-effective controls for DEHP and PAHs that are consistent with the recommendations of the Sediment Phthalate Work Group. Add

2013 Source Control Work Plan. The source control work plan for 2013 identifies specific activities for the watershed and for each basin. Each activity was prioritized in order from highest to lowest with higher priorities given to eliminating/reducing point sources and activities that are based on best professional judgment to provide a measurable benefit in reducing chemical loadings to the waterway. A full list of activities is found in Section 6 of this report. Some highlights planned for 2013 are:

- **OF230**: Continue source tracing for mercury and PCBs, along with PAHs and phthalates in the area draining to FD3a and FD18.
- **OF235**: Complete design and begin construction of the Hood Street Treatment Retrofit project.
- **OF237A**: Continue to monitor Tacoma Pierce County Health Department (TPCHD) activities at the site of the underground storage tank (UST) removal at the neighborhood fueling station (EZ Mart) and reinspect the FD31 branch as needed upon completion of their work. Investigate potential sources of phthalates in the area draining to FD10c.
- **OF237B**: Complete source tracing investigation for PCBs in the vicinity of FD34/35.
- **OF243**: Investigate source of mercury at Burlington Northern Santa Fe(BNSF) and elsewhere in drainage area for FD23.
- **OF245**: Conduct a joint inspection at Truck Rail Handling/Quality Transport with TPCHD and Ecology to identify any potential source(s) of phthalates.
- **OF254**: Continue follow-up inspections at Northwest Detention Center for proper operation and maintenance of their onsite treatment facilities.

CONCLUSION

Reduction of contaminant loads to the Thea Foss and Wheeler-Osgood Waterways over the years, through the City's implementation of its stormwater source control program, as well as through the control of other sources, has been substantial. The improvement in stormwater quality since the mid-1990s indicates that source control efforts by the City and others in the Foss Waterway Watershed have been effective in reducing chemical concentrations in stormwater. The City believes some minor additional improvements in stormwater quality may be realized in the future with ongoing NPDES Phase I Permit programs and continuing improvements in source control implementation. Ongoing control of sources which are outside the City's jurisdiction must also continue to be coordinated by other federal, state, and local authorities. The City is moving forward with ongoing source tracing investigations, treatability studies, and other special investigations for evaluating and identifying cost-effective controls for metals, DEHP and PAHs in municipal stormwater.

The improvements in stormwater quality since the mid-1990s indicate that source control efforts in the Foss Waterway Watershed have been effective in the reduction of chemical concentrations in stormwater. Tests performed show 84% statistically significant time trends, all in the direction of decreasing concentrations. This result is significant and a testament to the City's ongoing comprehensive source control program. Source control activities currently being implemented by the City include business inspections, response to spills and illicit discharges, mapping/maintenance/cleaning of the stormwater system, pollutant source tracing, and implementation of the City's Surface Water Management Manual through our stormwater ordinance.

It should be noted that while considerable improvements to stormwater quality have been made, the largest changes were realized in the earlier years of the program when major sources were identified and eliminated. Because the source control program has been so effective through the years, fewer major sources or maintenance actions are needed and the program is beginning to approach an equilibrium or maintenance mode. In other words, the concentrations of contaminants of concern in the stormwater in the Foss Waterway Watershed are reaching a level where the opportunities for large reductions are more limited. This may over time lead to the appearance of fewer additional decreasing trends in contaminant concentrations, lower percentages of reduction, and potentially even a few minor increasing trends, particularly if looking only at results from more recent years. However, our data shows that the City's stormwater source control and monitoring program have been very effective in reducing contaminant levels in stormwater and SSPM.

1.0 INTRODUCTION

1.1 OBJECTIVES

Under a Consent Decree with the EPA dated May 9, 2003, the City completed remediation of marine sediments in the majority of the Thea Foss and Wheeler-Osgood Waterways in Tacoma, Washington in March 2006. Remediation of the southernmost 1,000 feet of the Thea Foss Waterway was completed in 2004 by a group of private utilities under a separate Consent Decree with EPA. The waterways are narrow estuarine water bodies on the southeastern margin of Commencement Bay, with 13 municipal outfalls that discharge stormwater to the waterways as well as numerous private outfalls.

With the completion of the cleanup action in the Thea Foss and Wheeler-Osgood Waterways, it is necessary to continue monitoring source control activities to ensure sediment quality is protected in dredged and capped areas and to ensure that natural recovery is attained in areas where active remediation was not required. Included as part of the Consent Decree Statement of Work, a letter addendum dated November 1, 2001 (identified as Attachment 1 to the Consent Decree), provides a detailed schedule and work plan for the City's stormwater source control efforts for the Thea Foss and Wheeler-Osgood Waterways. This addendum, herein referred to as the Stormwater Work Plan Addendum, includes a description of stormwater monitoring efforts, studies, source control efforts and BMP assessments for municipal stormwater sources. Based upon these various efforts and evaluations, an approach to future stormwater source control decision-making identified as the Thea Foss Post-Remediation Source Control Strategy (herein referred to as the Source Control Strategy), was developed and included in the work plan. The approach and decision-making strategy are shown in Figure 1-1.

This report summarizes the City's existing programs, sampling results and studies completed in 2012, and the City's decision matrix for identifying additional source controls, if and when such controls are needed, to ensure protection of sediment quality in Thea Foss and Wheeler-Osgood Waterways. This report is specifically concerned with control of municipal stormwater sources. There are other sources which could also potentially affect sediment quality in the waterways, including groundwater seeps, marinas, atmospheric fallout, NPDES-permitted industrial discharges, and other private stormwater discharges. These sources are outside the scope of the City's Source Control Strategy for municipal stormwater, and largely outside the City's jurisdiction.

1.2 BACKGROUND

1.2.1 Remedial Action Description

In 2006, the City completed remediation of marine sediments in the Thea Foss and Wheeler-Osgood Waterways. The remedy for the waterway included a combination of natural recovery, dredging, and capping. The dredged material was disposed of in a nearshore confined disposal facility (CDF) in the nearby St. Paul Waterway.

In general, the remedy included the following elements:

- No action at the mouth of the waterway, an area of clean sediments;
- Natural recovery north of East 11th Street, an area where low-level contamination is expected to recover to below the SQOs within 10 years (2016), and which is currently below required navigational depths;

- Some combination of dredging (complete or partial) followed by capping over any residual contaminated sediment in the area from the East 11th Street Bridge to just north of the State Route (SR) 509 Bridge. Note that the authorized channel depth requirements are maintained in this area; and
- Capping (by others, referred to herein as the Utilities) from just north of the SR509 Bridge to the head of the waterway to maintain a depth of 10 feet Mean Low Low Water (MLLW). Deauthorization of the federal navigation channel in this area was required, and was approved as part of the Water Resources Development Act (WRDA) Bill of 2007.

Other remedy features included:

- Construction of intertidal habitat as mitigation for construction impacts;
- Dredging to maintain authorized depths in the active navigation channel;
- Capping of about 20 acres of sediments in channel and harbor areas; and
- New slopes and erosion protection on about 10,000 feet of shoreline.

1.2.2 Drainage Basin Description

The Thea Foss and Wheeler-Osgood Waterways are estuarine waterways on the southeastern margin of Commencement Bay. In Commencement Bay and the waterways, average tidal fluctuations vary from 0 feet MLLW to 11 feet MLLW. Extreme tides, which generally occur in June and December, range from approximately –4.0 feet MLLW to 14.5 feet MLLW. The Thea Foss Waterway lies north-south along the City's downtown corridor. The Wheeler-Osgood Waterway lies west-east and connects to east side of the Thea Foss Waterway just south of the 11th Street Bridge. The Thea Foss and Wheeler-Osgood Waterways are commonly referred to as the Thea Foss or Foss Waterway and are referred to herein as the Foss Waterway. The drainage area tributary to the Foss Waterway is referred to herein as the Foss Waterway Watershed.

The Foss Waterway Watershed is 1 of 9 watersheds in the City (see Figure 1-2). This watershed covers approximately 5,864 acres and is comprised of drainage basins located in the south-central portion of Tacoma. The area borders the North Tacoma Watershed on the north, Lawrence Street on the west, and East F to East K Streets on the east. The area extends as far south as 86th Street and also includes portions of the tideflats on the east side of the Foss Waterway (see Figure 1-2).

The primary municipal outfalls to the Foss Waterway are OF237A and OF237B (the twin 96ers), OF230, OF235, OF243, OF245, and OF254. These 7 outfalls cover 5,744 acres (98%) of the watershed. There are also several other smaller outfalls that discharge to the waterway. Primary land uses within the basins draining to each of the major outfall are as follows:

Outfall	Area (Ac)	Land Use
230	557	Commercial and Residential
235	156	Residential and Commercial
237A	2,823	Residential, Commercial and Industrial
237B	1,991	Residential and Commercial
243	59	Industrial and Commercial
245	39	Industrial and Commercial
254	119	Industrial and Commercial

Overall, land use in the watershed is predominately residential, although most of the City's commercial businesses are also located in this watershed (see Figure 1-3). There are some industrial uses, which are concentrated mainly in the eastern tideflat areas and Nalley Valley portions of the watershed.

Several of the outfalls discharging to Foss Waterway are tidally-influenced and portions of the pipe are inundated with marine water twice a day depending on the pipe elevations and the tide height. Continuous or tidal baseflow is also present in some of the outfalls. Baseflow in OF230, OF 235, OF237A and OF237B is continuous. In OF237A and OF237B, this baseflow is derived from old creeks and seeps that were piped and/or infiltrating groundwater. In OF230 and OF235, this baseflow consists of groundwater and/or noncontact cooling water. Baseflow in OF243, OF245 and OF254 is seasonal (i.e., higher in the winter and lower in the summer) and is believed to be due to groundwater infiltration due to the high water tables in the tideflat area.

The City has performed a significant amount of sampling and analysis in recent years of the storm drains entering the Foss Waterway. Over the last 11 years, 1,400 samples have been collected [baseflow (322), stormwater (793) and SSPM samples (68 outfall and 217 upline)]. The purpose of the sampling efforts is to evaluate the quality of stormwater discharges to the Foss Waterway and the effect of those discharges on sediment quality. Early in the program, the results of these efforts were used in an overall evaluation of source loadings to the waterway to predict whether municipal stormwater discharges would be protective of sediment quality following remediation. Prior to beginning remedial action projects, EPA determined that sufficient source control was in place to complete the work. Now the results of stormwater monitoring are used to evaluate the effectiveness of source control efforts, and to provide early warning of any new problems which arise in the drainages. In addition, the results are used to track changes in stormwater quality and to document the improvements that have been realized over time due to source control and other efforts.

1.2.3 Contaminants of Concern

COCs are those contaminants which have been identified through sediment monitoring and model predictions to have the greatest potential to compromise sediment quality in the waterways following remediation. They are, therefore, the primary target for source control activities for the municipal storm drains as well as other potential sources which are largely not in the City's control. DEHP and various PAHs are the primary COCs for the Foss Waterway and have, therefore, been the primary focus of source control activities to date. In addition, residual concentrations of other legacy COCs for which sources have largely been controlled through regulatory bans or restrictions are continuing to be monitored. These legacy COCs include mercury, PCBs, and pesticides. Source control activities have also been conducted for these COCs.

1.3 THEA FOSS POST-REMEDIATION SOURCE CONTROL STRATEGY

For ongoing evaluation of the municipal stormwater discharges and their relation to future sediment conditions in the waterway, the City has established a source control strategy. This strategy is set forth in Figure 1-1.

The City is continuing to implement a comprehensive stormwater monitoring program and is also conducting several more specialized studies for the Foss Waterway Watershed. The results of these projects will be used to continue to focus source control efforts and to assess the source control program's effectiveness. The various components of the post-remediation source control strategy are described in more detail below.

The City is committed to an ongoing program of stormwater source control to maintain and enhance stormwater quality in the Foss Waterway Watershed. The City will implement all "reasonable and practicable" controls necessary to improve stormwater quality and comply with regulatory standards. "Reasonable and practicable" shall take into consideration maintenance requirements, flood control and cost in comparison to the effectiveness achieved or expected in reducing contaminant loads to the Foss Waterway.

The remainder of this report is as follows:

- Section 2 provides a summary of the source control activities performed during 2012 in the Foss Waterway Watershed including an update on special studies.
- Section 3 presents the results of the Water Year 2001-2012 stormwater and storm sediment monitoring.
- Section 4 is reserved for the results of the Foss Waterway sediment monitoring program and an update of the recontamination evaluation. No new sediment data was obtained during WY2012 so no update is provided in this report. The section is retained, however, to provide consistent placement of information from year to year.
- Section 5 provides an update on the evaluation of program effectiveness for the Thea Foss Source Control Strategy.
- Section 6 presents a summary of the conclusions and recommendations.

2.0 SUMMARY OF SOURCE CONTROL ACTIVITIES

This section provides a summary of source control activities including an update on special studies performed in 2012 in the Foss Waterway Watershed. These activities and special studies are further detailed in Appendix A, where relevant, in the specific outfall work plan sections.

The source control activities performed in 2012 are summarized in Sections 2.1 and 2.2 including those associated with the 2012 Work Plan and those associated with the City's NDPES Phase 1 Permit as part of the City's Stormwater Management Program. Section 2.3 presents a summary of the special studies conducted under the Thea Foss Program relevant to source control within the Foss Waterway Watershed.

2.1 MASTER SPREADSHEET (DRAIN, ACTION, DATE, POTENTIAL COCS, STATUS)

A comprehensive listing of source control investigations and other actions for each outfall drainage area is provided in Table 2-1. The activities for each outfall are grouped by the following types of actions:

- Construction – major site construction or development;
- Inspection – major or notable business inspections;
- Onsite Facilities or Public Facilities – onsite facility or public facility constructed;
- Maintenance – key storm system maintenance activities performed;
- Point Sources – point source to storm system identified and/or controlled;
- UST – underground storage tank or leaking underground storage tank (UST/LUST) located, removed or closed in place;
- Cleanup Actions – site cleanup action underway or completed;
- Spill – spill reported and cleaned;
- Fines/violations – fine or violation issued by a regulatory agency; and
- Education – public education activities.

Each action is defined by drainage basin, date/year of occurrence, potential COCs, status (ongoing, completed, 1 time) and a short description. Once completed or identified, these activities by themselves may result in a very small impact in the total pollutant load. Over time, however, these very small pollutant load impacts are additive and an overall real reduction in the total pollutant load may be observed. This will be further evaluated in Section 5, Thea Foss Program Effectiveness: Water Years 2001 to 2012.

From August 2001 through 2012, approximately 445 actions have occurred within the Foss Waterway Watershed. The actions specific to the primary outfalls as shown in Table 2-1 are summarized as follows:

Action	Thea Foss	230	235	237A	237B	243	245	254
Construction	76	29	17	18	4	2	--	6
Inspection[1]	92	14	15	24	9	7	7	16
Facilities	52	8	8	14	9	4	3	6
Maintenance	45	11	8	4	3	5	7	7
Point Sources	40	4	3	15	10	--	2	6
UST	30	10	4	7	4	2	3	--
Cleanup Actions	18	2	2	4	--	6	2	2
Spill[1]	21	2	--	7	1	3	5	3
Fines[1]	11	1	1	4	--	--	2	3
Education	5	4	1	--	--	--	--	--
Total	**390**	**85**	**59**	**97**	**40**	**29**	**31**	**49**

[1]The number reported includes notable actions only. The total numbers of inspections and spills are provided in Section 2.2.2.

2.1.1 Stormwater Suspended Particulate Matter (SSPM) Monitoring

SSPM monitoring is used in identifying potential problem areas in sub-drainage systems. Multi-year sampling is used to confirm an ongoing problem area or to confirm control/resolution of an ongoing problem. Between WY2002 and WY2012, upstream monitoring was completed in some of the Foss drainage basins. Table 2-2 lists the upstream monitoring locations for each of these years. The data for each of these monitoring stations are provided in Appendix D, Tables D-15 and D-16.

The drainage basins and SSPM data are shown graphically in Figures 2-1a through 2-1d for 4 of the key COCs (i.e., mercury, total PAHs, total phthalates and total PCBs). These figures show each outfall and upline sediment trap location and the “level” of concentration for that location for that year. The “levels” of concentrations are color-coded as low, medium and high concentration ranges with each additional year stacked on the previous year.

Low concentration ranges (green) represent concentrations that are similar to other locations with no need for additional source control efforts at this time. Medium concentration ranges (yellow) represent concentration levels that are slightly above other locations. For locations with medium levels, additional source control may be needed, but are at a lower priority in comparison to other locations with higher levels that are determined to be of greater impact. High concentration ranges (red) represent concentration levels above and beyond other locations in the Foss Waterway Watershed, and the need for additional source control is higher in comparison to other locations.

In WY2012, SSPM data for the most part remained the same. However, a few locations increased and a few decreased in concentration.

- **Mercury**: FD3-New (OF230) and FD18b (OF230) both increased to the high range of measurements for WY2012 after being low in WY2011. FD18 (OF230), FD23 (OF243), and FD34 (OF238B) were all in the moderate range for WY2012 (see Figure 2-1a). For FD18 and FD34, this represented an increase when compared to WY2011 results; however, both sites have had intermittent mercury exceedences during the 11 year monitoring period. FD23 SSPM concentrations have been in the medium range consistently since 2007 (with the exception of 2009 when a sample was not available). FD3a decreased from the medium to the low range in WY2012.

- **PAHs**: FD13b (OF237A) decreased to low range measurements in WY2012. PAHs increased to the medium range of measurements at FD31 (OF237B) (see Figure 2-1b). For FD31, SSPM concentrations were in the low range in WY2011, but had been in the high and medium ranges between WY2008 and WY2010.
- **Total Phthalates**: FD10c (OF237A) remained in the medium range of measurements (see Figure 2-1c) and FD18 (OF230) increased to the medium range in WY2012. Total phthalates decreased to low range measurements at MH390 (OF245) and at FD22 (OF245/248).
- **Total PCBs**: FD16B (OF230) and FD34 (OF237B) measured in the high range in WY2012 (see Figure 2-1d). FD34 has been intermittently high in the past, but this was the first time FD16b had SSPM concentrations in the high range. In addition, total PCBs decreased to the low range at FD18 (OF230) and FD3a (OF230).

Over the 11 year monitoring period, the number of sites with concentrations in the medium and high levels has decreased. This is a good indicator of the effectiveness of the source control program. However, as indicated above, a few sites remain at medium and high levels or fluctuate to the medium and high levels as compared to the other sites in the Foss Waterway Watershed and are therefore the focus of additional source control work.

The data results by basin are discussed in Section 5 of this report. The City will continue to conduct SSPM monitoring using sediment traps at the outfalls and at upstream locations in several drainage basins. Future plans and decisions related to upstream monitoring studies are discussed cooperatively with EPA, Ecology and others, as applicable.

2.1.2 Foss Stormwater Work Group

The Stormwater Work Plan Addendum required that the City prepare and submit quarterly Stormwater Source Control Reports. In a letter dated June 10, 2008, EPA and Ecology agreed that quarterly Stormwater Source Control Reports would no longer be required and that 1 annual submission providing the status of source control activities would be sufficient. This source control status report is submitted annually and is appended to the City's NPDES Annual Report which is due March 31 of each year.

A Foss Stormwater Work Group, consisting of representatives from the City, Ecology, EPA, Port of Tacoma, Citizens for a Healthy Bay (CHB), Foss Waterway Development Authority (FWDA) and the Utilities, has met on a periodic basis through the years to discuss the status of source control activities. In years past, this meeting was held at least annually, but a meeting was not required in 2011 or 2012. The last annual Foss Stormwater Work Group meeting was held on June 17, 2010. Copies of the Annual Stormwater Monitoring Report including the Annual Work Plan are provided to CHB and the Utilities at the same time that they are provided to EPA and Ecology.

Tacoma submitted the 2011 Stormwater Source Control Report and Water Year 2011 Stormwater Monitoring Report on March 31, 2012. In the 2011 Source Control Report, the City recommended several source control activities referred to herein as the 2012 Work Plan (City of Tacoma 2012). A summary of the status or outcomes of source control activities identified in the 2012 Work Plan is provided below.

2.1.3 2012 Source Control Work Plan

The majority of the recommended tasks from the 2012 Work Plan were completed or are ongoing at this time. Activities from the 2012 Work Plan and their current status are as follows:

Priority 1 tasks:

- **OF254**: Re-evaluate the post-cleaning stormwater and baseflow data to determine the ongoing effectiveness of storm line cleaning and the onsite BMP performance.

  Status: Baseflow sampling was discontinued in WY2011, so new data was not available for comparison. WY2012 stormwater data were reviewed and appear to show a slight increase from previous years. Since only 4 samples were collected from OF254 in WY2012, these results may be skewed due to small sample size.

- **OF235**: Continue support of Ecology-led investigations.

  Status: Coordination with Ecology on projects throughout the watershed is ongoing.

- **OF237A**: PAHs and mercury in the area draining to FD13 and FD13b. Review of the 2011-2012 SSPM data to monitor improvement from the stormwater treatment retrofit.

  Status: WY2012 SSPM data for FD13 and FD13b were reviewed and PAH results were in the low range at both locations. Mercury results at both locations also remained in the low range as they have since 1 medium range detection in FD13b in WY2005.

- **OF237B**: Monitor TPCHD activities at the site of the neighborhood fueling station and reinspect the FD31 branch, if needed, for other possible sources of PAHs and TPHs.

  Status: The TPCHD work is ongoing at the site at this time, and the City is continuing to monitor their work. In OF237B, PAHs are only present intermittently at FD31 and they increased from low to medium range concentrations in WY2012. The City is continuing to monitor the ongoing TPCHD work at the EZ Mart and will evaluate the need for additional source control work when that investigation is complete.

- **OF230**: Continue mercury and PCB source tracing in the area draining to FD3a.

  Status: This source control investigation is continuing at this time. A copy of the status report and a more detailed summary are included in Appendix A. Composite segment samples and subsequent subsamples have been analyzed to target the areas of concern. Additional sampling and source control investigations will be completed in 2013.

- **OF235**: Design and construct the Hood Street Treatment Retrofit project in 2012 and 2013.

  Status: Design work is ongoing at this time. Work is tied to construction of a larger project, the Prairie Line Trail, so coordination with other agencies is necessary. It is currently anticipated that the work will be completed in 2013 or 2014.

Other Priority 1 tasks are:

- Review of the 2011-2012 SSPM data to confirm existing conditions in the basin.

  Status: Completed. An evaluation of these results is included in Sections 3 and 5 and is summarized above.

- Monitor the major construction activities in the OF230 and OF235 drainage basins.

  Status: Ongoing. The Pacific Avenue street improvements project is ongoing. Additional projects are planned for 2013 including the Hood Street Treatment retrofit project, the ‘A’ Street Pipe Replacement and Treatment System project, sanitary sewer replacements, and a CIPP project.

- Monitor and conduct inspections at new developments as completed to review appropriate BMPs for each site.

  Status: Inspections at new developments were completed, including the inspection/approval of 117 new devices.

- Continue Foss Stormwater Monitoring Water Year 2012.

  Status: WY2012 stormwater monitoring was completed and WY2013 stormwater monitoring is currently underway.

- Implement the City’s Stormwater Management Manual, 2012 Edition.

  Status: The 2012 Stormwater Management Manual is currently being implemented.

- Continue NPDES business inspections program and document the inspections using the business inspections database. Respond and track all complaints/spills in the complaints database.

  Status: Business inspections and spill/complaint response is continuing and activities are tracked in the database.

- Participate with UWT and WSU Extension in Ecology Grant to develop a continuing TRC and TAPE program for Stormwater Treatment Technologies.

  Status: Participation in this program is ongoing.

- Monitor the major construction activities related to the WSDOT, Nalley Valley Viaduct/SR-16 rebuild and construction of the Sounder corridor (Freighthouse to South 56th Street).

  Status: The Sounder project was monitored until its completion this year, and the WSDOT project is continuing at this time and is being monitored by the City.

- Monitor the SuperValu site and its compliance with the Ecology lead order.

  Status: No new developments were noted.

Priority 2 tasks:

- **OF245**: Investigate Quality Transport with TPCHD to locate source(s) of phthalates.

  Status: This is a TPCHD lead site. TPCHD completed a Site Hazard Assessment in 2012 giving the site an overall ranking of 4. The City performed sanitary system mapping and inspections in 2012 and is continuing to work cooperatively with TPCHD and Ecology to monitor ongoing operations and practices at the site.

- **OF230**: Mercury and PCBs source tracing in the area draining to FD18.

  Status: This is being completed in conjunction with the FD3a investigation discussed in the Priority 1 section above.

- **OF237A**: Investigate potential sources of phthalates in the area draining to FD10c.

  Status: No new information is available at this time.

- **OF243**: Continue mercury source tracing investigations. Continue working with businesses in the BNSF Yard.

  Status: No new information is available at this time.

Priority 3 tasks are:

- Evaluate the source(s) of acenaphthene in baseflow in Basin 243 and 245.

  Status: No new information is available at this time.

- **OF230**: PAHs and phthalates source tracing in the area draining to FD3a and FD18.

  Status: This is being completed in conjunction with the FD3a investigation discussed in the Priority 1 section above.

- **OF235**: Phthalate source tracing in the area draining to FD6a.

  Status: No new information is available at this time.

- **OF237A**: PAHs and mercury in the area draining to FD2a and FD10. Review of the 2011-2012 SSPM data to confirm improvement in SSPM.

  Status: No new information is available at this time.

- **OF237B**: Review 2012 SSPM PAH and PCB data in areas of concern and additional source tracing techniques, if needed.

  Status: An investigation for sources of PCBs in the area draining to FD34 and FD35 is currently underway. A report on the status of that investigation is included in Appendix A.

- **OF254**: DEHP - Conduct follow-up inspections at Northwest Detention Center (NWDC) if needed.

  Status: A follow-up inspection and annual stormwater device inspection was conducted in June and the results of that inspection are included in Appendix A. Continued and potentially more frequent follow up is needed in 2013 to ensure that the treatment device is properly maintained.

2.2 CITY OF TACOMA PHASE I MUNICIPAL STORMWATER PERMIT

On August 1, 2012, Ecology issued a new 1 year NPDES Stormwater Permit for Phase I Municipalities including the Cities of Tacoma and Seattle, and Pierce, King, Thurston, Snohomish and Clark Counties. The 2012 permit replaces the existing NPDES Phase I Permit issued in 2007. The conditions of the new 2012 permit are identical to the 2007 permit[2]. It regulates the discharge of stormwater to surface waters and groundwaters of the state from the City's MS4. The permit is designed to protect and improve the water quality of receiving waters by implementing stormwater management activities. The City's program is described in the Tacoma's Stormwater Management Program (SWMP) which guides the operation of Tacoma's Surface Water Management Utility during the 2007 and current 2012 permit term (City of Tacoma 2010).

The City's program and its progress in 2012 are summarized in an annual report. The NPDES Annual Report is used as a tool to assess the City's progress and to determine whether any changes to the SWMP procedures or priorities are needed to fulfill the permit obligations. The SWMP is evaluated annually, and updated when necessary, based on the annual report and program assessment. Table 2-1 identifies program related activities as required under the NPDES Phase 1 Permit as part of the City's SWMP.

On August 1, 2013, a new 5 year NPDES Permit will go into effect. The City will be revising our program to meet the conditions and requirements of the new permit.

2.2.1 City of Tacoma Stormwater Management Program

Tacoma's SWMP is divided into 10 components as outlined in the 2007 and 2012 NPDES Municipal Stormwater Permits Section S5 (City of Tacoma 2010). The SWMP components are summarized here:

- **Legal**: The City has the legal authority to control discharges to and from the municipal storm sewers owned by the City, Chapter 12.08 of the Tacoma Municipal Code.
- **Mapping**: The City's stormwater system is updated with new information as it becomes available.
- **Coordination**: Internal and external coordination agreements/mechanisms are established to facilitate cooperation between City departments and surrounding municipalities.
- **Public Involvement and Participation**: Opportunities are provided for in the SWMP.
- **New Development and Redevelopment**: The City of Tacoma Stormwater Management Manual 2012 Edition (previously the Surface Water Management Manual Tacoma 2008 Edition, 2009 Revision) provides a commonly accepted set of technical standards and guidance on stormwater management measures that control quantity and quality of stormwater produced by new development and redevelopment of property. The minimum requirements in Ordinance 12.08 require flow control and water quality treatment of new and redeveloped sites, private and public development, including right-of-way improvements in Tacoma. The minimum requirements for commercial and high traffic areas include treatment to remove at least 80% of the solids on an annual basis.

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[2] Both the 2007 and the 2012 NPDES permit were in effect during WY2012. Since the conditions of both permits are essentially identical, no changes were made to the City's SWMP.

Through implementation of this manual, more sediment should be removed in the future, thus helping to remove sediment-associated contaminants which may become entrained in municipal stormwater. This program should reduce the sediment and associated particulate-bound COCs discharging into the municipal stormwater system and its receiving waters.

- **Structural Stormwater Controls**: A program to prevent or reduce impacts to waters of the state caused by stormwater discharges must be developed and must consist of structural stormwater controls. Projects must be selected and an implementation schedule is required.
- **Source Control**: Inspections of pollutant-generating sources are required for commercial, industrial and multi-family properties including City-owned sites.
- **Illicit Connections**: Continue the ongoing program to detect, remove and prevent illicit connections and discharges, including spill response, for discharges into the City's MS4.
- **Operation and Maintenance**: Maintenance standards and inspection programs are required for public and private stormwater facilities. BMPs are also required for the maintenance and operation of public streets and roads to reduce stormwater impacts.
- **Education and Outreach**: Educational programs need to provide information to elected officials, policymakers, residents, businesses including home-based and mobile businesses, landscapers and property managers, industries, engineers, contractors, land developers, municipal permitting and planning staff, and others. The educational program will be designed to achieve improvements in the understanding of each target audience.

Stormwater Management Goals and Challenges. The City considers itself a leader in responding to the issues of water quality related to urban runoff. Our activities have included pioneering efforts in water quality testing to identify pollutants in stormwater runoff as early as 1980. Current efforts include investigating source control and treatment of stormwater pollutants like phthalates. The Tacoma City Council and Tacoma's Surface Water Utility ratepayers have supported substantial rate increases in recognition of the importance of protecting and enhancing the water quality in Commencement Bay and our fresh water lakes, wetlands and streams in the face of increasing stormwater runoff and pollutant loads from urban development, increased traffic and population pressure.

The City's goals established for the original Stormwater Management Program in 1999 under the first NPDES Municipal Stormwater Permit further emphasize the City's commitment to meeting the water quality goals under this permit. The goals of the City's SWMP include the following:

- Manage stormwater to minimize flooding and erosion;
- Manage stormwater to minimize contact with contaminants;
- Mitigate the impacts of increased runoff due to urbanization;
- Manage runoff from developed properties and those being developed;
- Protect the health, safety and welfare of the public;
- Correct or mitigate existing water quality problems; and

- Restore and maintain the chemical, physical, and biological integrity of the receiving waters in the City for protection of beneficial uses.

Tacoma's SWMP is administered by the Surface Water Section of the Science and Engineering Division of the Environmental Services Department (City of Tacoma 2010). Note that this is a change from previous years and is the result of a change in the organizational structure at the City. Staffing and budget are designed to meet the program goals and challenges described above. Our current work includes:

- Inspecting business activities and permitting and inspecting new construction projects.
- Collection and analysis of stormwater quality monitoring data.
- Implementing a source control and monitoring program focused in the Foss Waterway Watershed to protect the completed Superfund cleanup action, and enhancing habitat areas to restore beneficial uses.
- Mapping, maintaining and cleaning a stormwater system that includes over 440 miles of storm pipe, 10,000 manholes, 18,300 catch basins, and 21 stormwater ponds.
- Rehabilitating and replacing aging infrastructure and improving the storm system with capital projects to address identified water quantity and quality issues. With an Ecology Grant, Tacoma launched a new program, Stormwater Rapid Assessment Program (STRAP) in 2011. Under this program, a specialized camera is deployed in every pipe assessing not only its condition, but also the need for sediment removal. This information is stored in GIS and used to prioritize maintenance and capital improvement projects.
- Providing public education about stormwater and surface water management and sharing information with staff from federal, state and neighboring municipal governments, environmental groups, businesses and interested citizens.
- Participating in regional watershed councils and committees.

The current City Stormwater Management Manual (Stormwater Manual) includes the BMP selection and design criteria that are equivalent to Ecology's 2005 Stormwater Management Manual for Western Washington (2005 Ecology Manual). The Stormwater Manual assists in meeting this permit's requirements to protect water quality, reduce the discharge of pollutants to the maximum extent practicable, and satisfy the state All Known and Reasonable Technologies (AKART) requirements as required by the SWMP. The City issued the 2012 edition of the Stormwater Manual to clarify language in the existing manual and correct errors. Previous editions were called the Surface Water Management Manual.

STRAP is designed to visually inspect and rank the entire City storm conveyance system. Each of the asset management sub-basins for the Foss drainage is shown on Figure 2-2. The goal is to have the 429 mile system evaluated within a 4 year time period. The ranking and video will be added to the map-based database which is publically available on the City's GovMe website: www.govme.org/map. This map-based database will help to guide the City's Capital Improvement Program.

The video inspections completed to date have revealed eroded pipe segments, root intrusion and poorly constructed tap in connections. A number of relining or replacement projects have been added the City's list of Capital Improvement Projects as a result of STRAP. One of these projects is in the headwaters of FS01 and is slated to begin construction in 2013. The STRAP results on the Thea Foss basins to date are shown on Table 2-3.

2.2.2 2012 Business Inspections/Spills/Complaints

The City began conducting stormwater business inspections prior to 1984 as part of its delegated responsibility to implement Ecology's NPDES sanitary sewer pretreatment program. Subsequently, the inspection program was intensified in the Foss Waterway Watershed in response to EPA's identification of municipal outfalls as a potential source of contaminants to the Foss Waterway, which had been identified as a problem area within the Commencement Bay Superfund Site. In 2002, under the Consent Decree with the EPA for the Foss Waterway Superfund Cleanup, the City further expanded its comprehensive source control program in the Foss Waterway Watershed. The City's Source Control Program was later expanded City-wide to fulfill the 2007 NPDES permit requirements.

The current program is managed by the Environmental Compliance Section and includes the following:

- Inspecting multi-family units (including 4 or more residential units) in addition to businesses and industries. Inspections address both stormwater and sanitary compliance.
- Providing information on BMPs and program literature directly to businesses during site visits (which are available in the City's Stormwater Management Manual).
- Educating the general public and businesses on BMPs and City environmental programs.
- Inspecting and signing off on commercial drainage facilities. This inspection also provides an educational opportunity for Environmental Compliance inspectors to review operation and maintenance requirements with the builder or owner.
- Continuing to implement the City's IDDE Program which includes investigation and termination of illicit connections. The IDDE Program uses the City's database to track the complete process of screening, investigation, referral to responsible agencies (if other than the City), and enforcement.
- Use of a SQL/Access database, the Environmental Services Spills and Complaints Database, to track spills, complaints, business inspections and flooding claims since 2003. Regular updates and refinements have been made to facilitate advanced data management for tracking inspections.
- Investigating potential illicit discharges based on complaints, business inspection reports and stormwater monitoring information and responding to potential and confirmed illicit discharges using the same procedures applied to potential illicit connections.

Out of all the 2012 business inspections/spill and complaints responses (1,045 business inspections, 932 spill/complaint responses and 938 treatment device inspections), only 7 formal warning letters were sent City-wide. Six of those were in the Foss Waterway Watershed. Four Notice of Violation letters were sent in 2012 with 2 in the Foss Waterway Watershed. City-wide, only 0.38% of all inspections led to formal warnings or enforcement which shows that the City's education-based source control program is very successful and that the business community and City's residents are very supportive and engaged in protecting stormwater quality.

Thus far, for the stormwater permit cycle (2007 to present), Tacoma has canvassed/inspected more than 95% of the City, inspecting both sanitary and stormwater compliance. The vast majority of the inspections find catch basins that have never been cleaned. Our inspection efforts have resulted in tons of catch basin sediment removal, drainage repair, sewer protection, and customer education.

The City conducts a bi-weekly inspector's meeting for training and coordination with both internal and external staff including periodic guest representatives from the Port of Tacoma, Ecology, TPCHD and other neighboring jurisdictions. In addition, Tacoma participates in the monthly Pierce County Code Enforcement Officers Group (PIC).

Documentation for these activities is available upon request, however, is not presented herein.

2.2.3 City-wide Program Activities

The following is a summary of City-wide activities. Those activities that are specific to the Foss Waterway Watershed are further discussed in Appendix A. City-wide program activities for business inspections and spills and complaints response are discussed in Section 2.2.2.

Several special investigations were completed in 2012 including but not limited to:

- Documented and issued 4 Notice of Violations (see Appendix A);
- Documented and issued 11 formal warning letters (see Appendix A);
- Provided technical assistance, education and training to City-owned facilities that are potential pollutant generating sites with specific business practices that may significantly impact surface water and wastewater quality;
- Conducted environmental inspection of City-owned facilities to evaluate site compliance with Tacoma Municipal Code, Stormwater Management Program and NPDES Permit requirements. Inspected fire stations, Police Headquarters, 6 police substations, Fleet Maintenance, 7 parking garages, Dock Street sewer line cleaning and sweeper dump site, Street Operations, Solid Waste, Cheney Stadium, Convention Center, Museum of Glass, 7 communications facilities, Central Wastewater Treatment Plant, Asphalt Plant, Tacoma Public Utilities (Water, Rail, Power, Pole Yard), Traffic Signal Shop, Center for Urban Waters, and a Eductor Decant Facility;
- Inspected and serviced stormwater treatment devices serving City facilities including oil water separators, cartridge filter vaults, swales, ponds, rain gardens and catch basins;
- Fleet Maintenance facility - cleaned 2 stormwater oil water separators, 3 sanitary oil water separators, and 2 cartridge filter vaults (19 media filter cartridges replaced);
- Fleet Maintenance facility - changed out a leaking garbage dumpster for a new dumpster;
- For the 10 existing SWPPPs for City facilities, the Fire Garage, Street Operations Upper Yard, Traffic Signal and Streetlight Shop, Asphalt Plant, Fleet Maintenance, Dock Street sewer line cleaning and sweeper dump site, Tacoma Water, Tacoma Rail, Tacoma Power, and TPU Pole Yard, the City:
    - Inspected sites
    - Reviewed SWPPPs and updated as needed
    - Issued a new SWPPP – Dock Street

- Provided site specific SWPPP training

- Two additional new SWPPPs for City facilities are pending in 2013;
- Stormwater BMP training was performed at City facilities;
- The Tacoma Dome was washed under an SAD permit;
- EPA Stormwater Audit – Conducted a joint inspection with EPA, Ecology, and their contractors at the Street Operations Upper Yard (SWPPP), TPU Water (SWPPP), and Street Operations Wash Pad;
- Mapped City facilities:
  - Fire Garage, Traffic Signal and Streetlight Shop, Street Operations Upper Yard, Dock Street Sewer Line Cleaning and Sweeper Dump Site, and TPU Pole Storage Yard;
- Conducted an assessment of the Catchall Environmental Catch Basin Insert as part of the Urban Clean Water Technology Innovation Partnership;
- Provided a presentation to University of Washington Professor McDonald and the freshman science class regarding various aspects of the City Stormwater Program and local stormwater;
- IDDE: Smoked tested 8,207 addresses. Located 7 cross-connections (3 have been corrected and 4 are in design. Of the 4 in design, 3 will be repaired during a planned sanitary sewer replacement and for the other, a side sewer will be constructed by the City in Spring 2013 and it will then be available for connection by the property owner
- WSDOT SR-16 Nalley Valley and I-5 Project Coordination – Continued to monitor ongoing construction (OF237A).

Other Major Program elements that are ongoing in 2012 include:

- The Public Works Environmental Services Emergency Flood Response Plan, including:
  - Attended Management Sewer Emergency Operations Center (SEOC) Meetings
  - Response and radio training, PowerPoint update
  - Phone list update
  - PPE ordering and distribution
  - Vehicle readiness and stocking
  - Refinement of the SEOC database;
- Provided daytime, evening and weekend pager coverage;
- Maintained field and spill supplies;
- Car Wash Kit Program and Drain Marking Program implemented by EnviroChallenger team;
- Utilized the Washington Conservation Corps (WCC) for projects and provided program education regarding source control work;
- CHB coordination;
- Provided ongoing oversight and certification of mobile washers.

Training and coordination activities included:

- Participated in the Water Works Here, Economic Development Board for Tacoma-Pierce County. This is a campaign to help develop an international center for clean water technology in Tacoma: http://waterworkshere.com/;
- Coordinated claim response with the City's Legal Department and provided annual refresher training;
- Bi-weekly inspectors meeting with training, spill debriefs, safety and guests;
- Attended quarterly Puget Sound Regional inspectors group meetings and made a formal presentation;
- Central Treatment Plant SWPPP presentation;
- Ongoing database training;
- Participated in updating business inspections and BMP databases;
- Thea Foss Superfund Work Plan and activity support/development. Coordinated source control activities and watershed monitoring;
- Trained inspectors in CESCL (Certified Erosion & Control Lead), 2 day program;
- Coordinated with CHB on Commencement Bay Cleanup issues;
- Interacted regularly with CHB – Bay Patrol and spill hotline;
- Participated in a variety of community events;
- Launched the Private Treatment and Flow Control Device Annual Inspection program; and
- Developed and implemented a 4-part training series to train staff how to inspect stormwater treatment and flow devices.

All of these activities are expected to benefit the quantity and quality of stormwater discharges to the Foss Waterway. Documentation for each of these activities is available upon request, however, is not presented herein.

2.3 BMP Effectiveness Studies

The primary COCs in waterway sediments are DEHP and PAHs. Since their presence is fairly ubiquitous in urban runoff, many of the City's source control efforts over the years have been aimed at these constituents. Phthalates in particular are widespread in the urban environment. Because of challenges faced by the City and others in addressing phthalate contamination, a Phthalate Work Group comprised of the City, EPA, Ecology, King County/Metro, and Seattle Public Utilities was formed in 2006 to research the sources, pathways and treatment options for phthalates and other ubiquitous compounds in stormwater. The group developed a Summary of Findings and Recommendations document[3] which is currently in the process of being implemented by the regulatory agencies. In addition, the City is continuing to research the

[3] Document is available on the Washington State Department of Ecology's website. To view the document copy and paste this link into your web browser: http://www.ecy.wa.gov/programs/tcp/smu/phthalates/Summary%20of%20Findings%20and%20Recommendations%20FINAL%20092807.pdf

sources and treatment options for phthalates and PAHs in stormwater as described further below.

2.3.1 NPDES S8.F BMP Monitoring

Section S8F of the NPDES Phase I Permit requires Tacoma to conduct detailed performance monitoring on 2 stormwater treatment types that are standard technologies in our manual, bioinfiltration and biofiltration. Bioinfiltration facilities provide enhanced treatment and biofiltration facilities provide basic treatment. The City selected the following BMPs for evaluation monitoring:

- Two bioinfiltration facilities at the Salishan Hope VI Redevelopment (Salishan) – East 46th and R Street Swale and East 44th Street Pond; and
- Two biofiltration facilities – East 32nd Street and Trolley Court.

The Salishan project is a residential redevelopment project consisting of over 1,200 housing units, including both single and multi-family. During redevelopment, the existing stormwater conveyance system was replaced with new infrastructure including a system of biofiltration and bioinfiltration facilities. East 46th and R Street Swale and East 44th Street pond facilities were designed to meet the requirements for basic and enhanced treatment as specified in the Tacoma Surface Water Management Manual (and 2005 Ecology Manual).

The East 32nd Street improvement required treatment of the improved street runoff. The land use in the area is residential on 1 side of the street and an office building with a parking lot on the opposite side of the street. The East 32nd Street improvement bioswale consists of 2 parallel bioswales that receive street runoff from catch basins along East 32nd Street through a pair of 12-inch pipes, 1 for each bioswale. The Trolley Court development required treatment of the street, new residences, and 1 commercial building. The land use in the area is residential and commercial. The Trolley Court bioswale is located at 1712 State St. It receives runoff from surrounding streets and residences through a 12-inch pipe. These facilities were designed to meet the requirements for basic treatment as specified in the Tacoma Surface Water Management Manual (and 2005 Ecology Manual).

The water analytes identified as parameters of concern by Ecology are those that will provide information regarding the effectiveness of basic and enhanced treatment BMPs. These parameters are:

- Conventionals: Hardness, pH, Particle Size Distribution (PSD), and TSS;
- Metals (dissolved & total): Copper and zinc; and
- Nutrients: Orthophosphate and total phosphorus.

In addition, the City added chemicals of concern for the Foss Waterway recontamination evaluation including metals (dissolved and total), lead and mercury, and organic compounds, PAHs and phthalates.

In August 2012, the City submitted a request to Ecology to eliminate the East 32nd Street Swale and Trolley Court Swale sites and replace them with 2 new wet vault sites. In summer 2012, the City also identified issues with flow measurements at the East 46th and R Street Swale and the East 44th Street Pond. New equipment was selected for the sites and installed prior to the start of WY2013 sampling. The site changes are described in the revised Quality Assurance

Project Plan (QAPP) submitted on October 26, 2012 and approved by Ecology on January 8, 2013.

Sampling at the East 46th and R Street Swale and the East 44th Street Pond and 2 new wet vault sites is continuing at this time. It is anticipated that monitoring will be completed in 2013. A final report will be prepared following completion of the monitoring and will be submitted with the WY2013 deliverable.

2.3.2 GIS-Based Stormwater Pollutant Loading Model

The City is completing a GIS-based pollutant loading model to evaluate the effectiveness of other stormwater BMPs that may be implemented on a basin-wide scale. This study will include an evaluation of street sweeping, low-impact development (LID), and engineered treatment devices (e.g., *StormFilter* vaults by ConTech Construction Products, Inc.; Milesi et al. 2006).

The goals of this study are as follows:

- Evaluate the feasibility and cost-effectiveness of stormwater BMPs implemented on a basin-wide scale;
- Identify areas of concentrated pollutant runoff where source control efforts are best focused;
- Assess the degree to which stormwater BMPs will cause a reduction of pollutant loadings to the Foss Waterway, and in response, improvements in Foss Waterway sediment quality; and
- Develop recommendations for cost-effective source control investments.

A pollutant loading model has been developed for the same 3 basins that were selected for NPDES monitoring. These basins are largely dominated by a particular land use – OF237B (residential), OF235 (commercial), and OF245 (industrial) – thus providing a cross section of land use intensity in the Foss Waterway Watershed. The modeling is being performed using Hydrologic Simulation Program Fortran (HSPF), a Untied States Geological Survey (USGS) supported stormwater runoff program widely applied to urban stormwater projects in the Pacific Northwest.

Sediment and pollutant loading functions are being developed based on the land use and hydrologic characteristics in the drainages. The basin characteristics that affect the wash-off rates of sediments and pollutants include the following:

- Pervious and impervious surface coverage;
- Land use classification (residential, commercial, industrial);
- Street classification (residential, arterial, highway);
- Street use intensity (e.g., traffic count);
- Slope, soil type, vegetative cover; and
- Projected property development and redevelopment rates.

The model-generated flows, sediment and pollutant loads are being calibrated to the City's end-of-pipe stormwater monitoring records to ensure that the modeled loads are in agreement with the observed loads. The focus of the model calibration is not to match each individual storm event, but to match the statistical distribution of suspended sediment and pollutant concentrations on an annual and multi-year basis. The model calibration period coincides with Year 1 through Year 9 of the City's stormwater monitoring program.

Model calibration for the 3 focus basins (OF237B, OF235, and OF243) has been completed and currently basin-wide stormwater BMPs are being applied to the model using BMP load reductions estimated based on typical field performance data.

Conceptual cost estimates will be developed for implementing the various BMPs on a basin-wide scale, and the net reduction in end-of-pipe pollutant loadings will be modeled. The cost-effectiveness of the different BMPs (i.e., pounds of pollutant removed per dollar spent) will be evaluated and compared, leading to recommendations for future source control investments if they are found to be required.

2.3.3 Storm Line Cleaning

To fulfill an NPDES permit requirement, the City evaluated the effectiveness of a thorough and systematic maintenance practice for aging pipe systems. Between 2006 and 2008, the City completed basin-wide sewer line cleaning of 3 entire drainage basins (OF254, OF235, and OF230) and part of a 4th basin (OF237A). In 2010 to 2011, a 5 basin (OF237B) was cleaned. The objective of the sewer line cleaning program was to remove residual sediments in the storm drains, some of which may contain legacy contamination from past years that may continue to contaminate stormwater or baseflow through resuspension and/or dissolution.

An overall analysis of this effectiveness evaluation was included in the WY2011 report and results are updated here with the WY2012 data. In summary, sewer line cleaning appears to have been effective at removing all 7 of the contaminants tested in the majority of drains, including TSS (24 to 45% reductions in 3 out of 5 drains), lead (20 to 38% reductions in 2 out of 5 drains), zinc (22 to 34% reductions in 4 out of 5 drains), PAHs (60 to 90% reduction in all 5 drains, including both light and heavy PAH fractions), and DEHP (7 to 82% reductions in all 5 drains). This effectiveness evaluation will continue to be updated as more post-cleaning data become available.

2.3.4 Enhanced Street Sweeping

In January 2007, the City's street sweeping program was transferred from the Streets and Grounds division to the Sewer Transmission Maintenance section for continued implementation. The program was enhanced at that time in an attempt to reduce sediment buildup in the storm sewer system. The schedule was set to sweep all areas of the City twice per year, with more frequent sweeping in the business districts and on major arterials. The 12 primary business districts in the City are swept at night 2 to 3 times per week and major arterials are swept on a 3-week rotation. The City also increased communications with residents, which helped raise awareness of the importance of the street sweeping program.

In 2007, when the work was transferred over, sweeping was done with a combination of mechanical and vacuum sweepers. In 2008, the City started the transition from mechanical sweepers to regenerative air machines. The City currently uses 4 regenerative air sweepers. GPS is used to track the number of miles swept and the amount of material removed is recorded. Similar to line cleaning, the effectiveness of the program was evaluated and results are presented in Table 2-5. The results are discussed in more detail in Section 5.

2.3.5 CIPP Lining

In 2010, 13,500 feet of existing storm sewer was rehabilitated in OF230 using Cured-In-Place Pipe (CIPP) construction technologies. This approach fixes pipe defects (e.g. cracks, holes) that could have allowed potentially contaminated groundwater and soil from historic “hot spots” to enter the storm sewer system. Similar to line cleaning and street sweeping, the effectiveness of this approach was evaluated and results are presented in Table 2-6. The results are discussed in more detail in Section 5.

3.0 STORMWATER AND STORM SEDIMENT MONITORING RESULTS

One component of the Thea Foss Post-Remediation Source Control Strategy is a stormwater monitoring program. This program is being completed as part of the Stormwater Work Plan Addendum of the Consent Decree and under Ecology Administrative Water Quality Orders (No. DE01WQHQ-3241, Ecology 2001 and No. DE01WQHQ-3241A-01, Ecology 2004). The objectives of the stormwater monitoring program are:

- To measure the effectiveness of stormwater source control actions and whether statistically significant reductions in concentrations of target COCs have been realized. This will be achieved by gathering data to identify spatial and temporal trends in the quality of municipal stormwater;
- To provide an early indication of any new water or sediment quality problems which may be associated with the storm drains; and
- To trace sources of contamination in outfalls using sediment traps.

Over an 11 year period (August 2001–September 2012), stormwater and SSPM were sampled at the 7 major outfalls that discharge into the Thea Foss and Wheeler-Osgood Waterways. In addition, baseflow was sampled at the same 7 outfalls for the first 10 years of the program[4]. Over the last 11 years, 1,400 samples have been collected with 322 baseflow and 793 stormwater samples collected at the outfalls and 68 outfall and 217 upline SSPM samples collected in pipeline sediment traps deployed throughout the watershed. The whole-water and SSPM concentrations discharged to the waterway are dependent upon a number of factors. Some of these factors include:

- Weather conditions and rainfall amounts and distributions which cannot be controlled by the City;
- Inherent variability of chemical concentrations in stormwater runoff which are addressed using statistically based sampling designs;
- Source activities and land use within the basin; and
- Illicit discharges.

Section 3.1, Sample Representativeness, is a summary of the Data Validation Report which is presented in Appendix B. WY2012 analytical data for stormwater and SSPM, along with other data generated during the 11 year monitoring program are presented in Appendix D.

3.1 SAMPLE REPRESENTATIVENESS

Representativeness evaluates field sampling approximation of actual (true) stormwater and SSPM water quality and quantity of the Foss Waterway Watershed. Representative sampling results are used to identify trends in stormwater quality, provide an early indication of new contaminant sources and trace sources of contamination within the municipal outfalls (SAP goals, City of Tacoma 2001).

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[4] After 10 years of baseflow monitoring were completed at the end of WY2011, baseflow monitoring was discontinued (approval granted by EPA and Ecology on 2/7/12 and 2/9/12 respectively). Baseflow quantity and quality were determined to be well characterized by the 10 year monitoring record.

3.1.1 Monitoring Design

Stormwater comprises the majority of freshwater discharge from municipal outfalls and is a direct result of precipitation which produces stormwater runoff and is not a direct result of tidal fluctuations. Baseflow represents the continuous daily discharge from the municipal outfalls that is not a direct result of precipitation and is not a direct result of tidal fluctuations. Sources of baseflow may originate from seeps, creeks, groundwater infiltration, and illicit connections (see Appendix B).

Baseflow monitoring was discontinued after WY2011 because after 10 years of monitoring it was determined that the baseflow component was well characterized. Annual sampling goals for WY2012 include (from each monitoring outfall):

- Ten stormwater samples; and
- One SSPM sample from each outfall, except for OF254. Five of these locations are collected using in-line sediment traps placed to collect SSPM from stormwater only. The other SSPM location, Manhole-390 (OF245), is a sump manhole and the sediment it collects represents a combination of stormwater and baseflow.

Stormwater monitoring is conducted at 7 of the 13 primary City outfalls to the Foss Waterway. These 7 outfalls comprise approximately 5,744 acres, or 98%, of the total Foss Waterway Watershed drainage (5,864 acres, see Section 1.2.2). Monitored outfalls include OF230, OF235, OF237A, OF237B, OF243, OF245 and OF254. Primary land uses within the Foss Waterway Watershed include residential, commercial and industrial.

In January 2006, the City began sampling at a new monitoring location (described as 237A New) for OF237A. This new manhole structure was constructed downstream of the original 237A monitoring location during the BNSF realignment project. This location represents the entire drainage with inclusion of the FD2a branch (23rd Street Lateral). Both locations, 237A and 237A New, were sampled between January 2006 and October 2011 in order to build a large enough data set so that the 2 sampling locations could be compared. Sampling at 237A was discontinued in October 2011 because the sites were deemed equivalent. The statistical analysis is presented in Section 3.2.4.

Contaminant source tracing is further executed through sampling of SSPM (see Section 2.1.1). One station is located within the stormwater distribution system, near each outfall that represents the entire basin. It was not possible to locate an SSPM station within OF254 because of tidal influence. Additional upstream stations have been established throughout the Foss Waterway Watershed to evaluate and isolate contaminant sources. Up to 33 SSPM stations are sampled annually strictly for source tracing purposes.

3.1.2 Rainfall Summary for WY2012

For each Water Year, 2002 through 2012, monthly and annual rainfall totals are presented in Table 3-1. The total rainfall for Year 11 was 42.63 inches, 3.7 inches greater than the recent historic average of 38.95 inches (Tacoma No. 1 National Oceanic and Atmospheric Administration (NOAA) site). Rainfall during the wet season was 4.6 inches greater than normal rainfall conditions, accounting for the above average rainfall seen in Year 11. In contrast, rainfall during the dry season was slightly lower, but near normal conditions (within 1 inch). The WY2012 weather patterns consisted of a wide range of events including dry spells, extreme cold spells, windstorms, heavy rains and snow.

With 11 years of monitoring, the average monthly and annual average rainfall depths for the monitoring period are approaching the historical record and believed to be representative of the average historical record. Table 3-1 also shows that the average monthly rainfall for each month during the monitoring period is consistent with historic averages except for January, which is approximately 1.6 inches more than the historical average and February which is approximately 1.6 inches lower than the historical average.

3.1.3 Baseflow

In OF230, OF235, OF237A, and OF237B, baseflow is continuous, derived from old creeks that were piped, seeps or groundwater infiltration, and tides have a minimal effect. Baseflow in all of these systems also includes some amount of non-contact cooling water. A summary of baseflow sources to these outfalls is provided in Appendix B.

OF243, OF245 and OF254 do not have any creeks or other sources that provide constant baseflow. These drains do have tidal backflushing year round and during the wet season there is evidence of groundwater infiltration due to the high water table in the tideflat area. The groundwater table is comprised of a bottom layer, which is influenced by tides and an upper fresher water lens. In the wet season, the upper lens is freshened by rain recharge and salinity effects (e.g., conductivity) are less.

As indicated above, baseflow sampling was conducted during the first 10 years of the monitoring program but was discontinued after WY2011 when it was determined that the baseflow had been well characterized.

3.1.4 Stormwater

The intent of stormwater sampling is to identify trends in stormwater quality, to measure the effectiveness of source control actions, and to provide early warning of any new problems that arise in the watershed. Stormwater representativeness is a function of seasonal and individual storm characteristics.

Individual storms, historic averages and seasonal effects. Storm events are variable in nature by runoff volume, flow rate, antecedent rainfall, and season. Each year, this variability is evaluated by comparing the magnitude and intensity of the runoff hydrographs (see Figure 3-2), where samples were collected on the hydrographs, time between storm events, and time of year the samples were collected, to determine whether a representative range of storm types were included in the monitoring program.

Storm sampling during WY2012 closely approximated historic storm magnitudes (see Figure 3-3): 65% of 1982-2009 storms deposited approximately 0.15-0.49 inches of rainfall compared to 69% from WY2002-WY2012 and 64% for WY2012. In WY2012, a slight bias towards larger storms is apparent, with 12% of storms sampled having greater than 0.9 inches total depth as compared to 9% of the 1982-2009 storms and 9% of the WY2002-WY2012 storms. The growing recent monitoring record completed under this program is a closer approximation of the historical record.

Based on the historical record (1982-2009), 84% of annual precipitation occurs during the wet season and 16% during the dry season (see Figure 3-4). Stormwater sampling under the monitoring program is slightly biased toward the dry season, with 24% (WY2002-WY2012) and 20% (WY2012) of sampled storms occurring during the dry season. This is due to the fact that antecedent periods are easier to meet in the dry season as compared to the wet season, which provides more opportunities for sampling.

Individually, the sampled storm volume is proportional to the total storm volume (see Figures 3-5a through 3-5g). As illustrated in the figures, during early program storm sampling in OF230, OF237A and OF237B there were a limited number of events where the proportion between total storm volume and the volume of the event sampled has a higher differential than the proportion achieved in subsequent years. This is due to event characteristics and building expertise of the City's stormwater monitoring crew.

Numeric goals. Stormwater sampling representativeness criteria is summarized as follows (SAP 2001 and revisions in annual reports):

- Ten samples collected annually at 7 sites;
- Precipitation:
  - Proportional to storm seasonality;
  - During storm flow conditions, defined as:
    1. Total precipitation of at least 0.2 inches and,
    2. Less than 0.02 inches of precipitation in the previous 24 hours (antecedent period).
- Storm, sampling and tidal influence including,
  - Flow composites representing 75% of the total storm volume (OF237A[5] and OF237B) or,
  - Conductivity (tidal influence) of ≤ 2,000 μS/cm (≤ 5,000 μS/cm at OF243 and OF254), and
  - A minimum of 10 aliquots composited at all sites.

A dry period of 6 hours provides delineation between individual storms.

In WY2012, samplers were deployed 34 times at the various outfalls, resulting in 186 individual sample deployments (see Appendix B, Table B4-1). Sixty samples were submitted for analysis during WY2012. OF235, OF237B and OF245 each had at least 10 events sampled. OF230 and OF237A each had 9 events sampled4 and at OF243 and OF254 4 events were successfully sampled. All events except 4 had less than 0.02 inches of precipitation in the previous 24 hours (an antecedent period of 24 hours). While the antecedent period was somewhat less than 24 hours required for these 4 events, minimal to no runoff occurred, and all sites were at baseflow conditions prior to the start of the rain event. These exceptions are described in detail in Appendix B.

All sites achieved a minimum of 10 aliquots to be composited. For most of the samples, all aliquots are believed to be representative of stormwater and the event sampled. However, several samples did include aliquot(s) that were collected before or after the storm but the composites are believed to be representative of the stormwater event sampled. These exceptions are described in detail in Appendix B.

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[5] OF237A which is now monitored at the 237A New manhole has some tidal influence so criteria does not strictly apply.

All of the events except 3 met the criteria of a minimum of 0.2 inches of rainfall. These events occurred on November 11, 2011 (0.17 inches), November 21, 2011 (0.18 inches), and April 3, 2012 (0.15 inches). While the precipitation criteria were not met, the samplers enabled successfully during the tidal window and adequate volume was collected for analysis. Therefore, the samples are representative of 0.15, 0.17, and 0.18 inch events.

Site-specific conductivity criteria were achieved in OF230, OF235, OF237A, OF237B, and all but 1 sample for OF245. Conductivity measurements of the aliquots composited for OF243 (criteria goal of ≤ 5,000 μS/cm) were less than 6,500 μS/cm, with 2 of the 4 samples measuring less than 5,000 μS/cm (see Appendix C, Table C-5). Conductivity measurements of all but 1 (max aliquot conductivity of 5,333 μS/cm) sample composited for OF254 (criteria goal of ≤ 5,000 μS/cm) measured less than 5,000 μS/cm (see Appendix C, Table C-7). All WY2012 storm samples at all sites are representative of individual storm events that are not impacted by tidal influences.

As indicated above, the 10 sample per year requirement for each outfall was met for OF235, OF237B and OF245. OF230 and OF237A each had 9 samples and OF243 and OF254 each had 4 samples. Every attempt has been made each year to collect representative samples from 10 storms at each outfall. At OF230 and OF237A, the unusually dry summer led to the inability to collect the 10th sample. OF243 and OF254 have been historically challenging for the City to achieve the goal of 10 samples. This, coupled with some equipment issues, led to the lower number of successful sampling events in WY2012. While 10 storm events have not been sampled every year at every outfall, the City believes that the overall sampling program is successful in sampling precipitation events that meet storm criteria.

Stormwater Representativeness. Over the course of the City's 11 year monitoring record, a representative range of storm events has been characterized considering the following hydrological variables (see Figure 3-2):

- Total rainfall;
- Runoff hydrograph;
- Intensity;
- Antecedent period; and
- Season.

3.1.5 Stormwater Suspended Particulate Matter Monitoring - Sediment Traps and MH390 Sump

SSPM monitoring is considered successful provided that samples obtained from each monitoring outfall have laboratory results are that are verifiable. Sample volumes available at each site vary with weather and insufficient volumes may be available to perform all analyses. In 2012, 7 samples from the 6 outfall[6] locations (FD1, FD2, FD2a, FD3-New, FD6, FD23 and MH-390) were submitted to the City laboratory for analysis. Additional upline sediment traps were also placed for source tracing purposes. In all, a total of 27 SSPM samples were collected which includes the outfall and upline locations.

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[6] OF254 does not have a sediment trap because of tidal influences.

3.1.6 Representativeness of WY2012 Laboratory Analyses

The 2012 laboratory quality assurance/quality control (QA/QC) review included 60 stormwater samples, 27 SSPM samples, certified reference materials (CRM), duplicates, method blanks, spikes, surrogates, laboratory control samples (LCS), and equipment rinsate blanks collected as specified in the Thea Foss and Wheeler-Osgood Waterways Stormwater Monitoring SAP (City of Tacoma 2001) (September 2001 and subsequent revisions).

Numeric effectiveness criteria were generated from the full review as presented in Appendix B. Reviewed data include classification as:

- Tier I – results that were rejected or could be interpreted as a loss of data, and
- Tier II – results which are classified by the laboratory as estimates, and are within 50% of the laboratory defined rejection range.

This type of analysis is helpful in identifying issues to be addressed when the majority of data quality is acceptable, yet may still be improved. In 2012, 98% of stormwater and 97% of SSPM data met method quality objectives. Only 0.4% of the data were classified as censored or rejected. Stormwater and SSPM samples are therefore considered representative. This review is discussed in detail in Appendix B.

3.2 MONITORING RESULTS: WY2002-WY2012 (YEARS 1 THROUGH 11)

This section presents a qualitative and quantitative description of spatial and temporal patterns in stormwater, and storm sediment quality in Monitoring Years 1 through 11 which occurred in WY2002 through WY2012. The qualitative analysis is derived from visual inspection of summary tables and box plots appended to this report (see Appendices E through H). The quantitative analysis includes statistical test procedures described in Section 9.3 of the Thea Foss Stormwater SAP (City of Tacoma 2001) as subsequently revised in the City's annual monitoring reports.

The objective of the statistical evaluation is to test the magnitude and significance of spatial and temporal trends in the monitoring data. Spatial trend analysis includes identification of particular municipal storm drains that may be significantly higher or lower in concentration compared to other storm drains in the Foss Waterway Watershed. Temporal trend analysis includes identification of increases or decreases in stormwater concentrations over time that may be caused by source control actions, construction activities, changes in source strength, land use, or other characteristics of the drainage basins over time.

Temporal trend analysis also includes an evaluation of seasonality, and whether significantly higher stormwater concentrations are observed during certain parts of the year. Conventional wisdom suggests higher concentrations might be expected during dry season conditions because there is more time for contaminants to accumulate on drainage basin surfaces between runoff events. There are 2 seasons in a water year, as defined in the NPDES Phase I Permit; the wet season runs from October 1 through April 30 and the dry season runs from May 1 through September 30.

3.2.1 Summary Statistics

For each detected chemical at each outfall, the following summary statistics are calculated for both stormwater and baseflow data (see Appendix E):

- Number of samples analyzed
- Number of samples with detected chemical concentrations
- Arithmetic mean concentration
- Median concentration
- Minimum and maximum concentrations
- 10^{th} and 90^{th} percentile concentrations
- 95% upper confidence limit on the arithmetic mean concentration
- Standard deviation of the arithmetic mean concentration
- Percent coefficient of variation
- Standard error of the arithmetic mean concentration

Global summary statistics averaged over all municipal outfalls in the Thea Foss drainage basin and all available monitoring years (WY2002-WY2012: Years 1 through 11) are provided in Table 3-2 and Table 3-3 for baseflow[7] and stormwater data, respectively. The global summary statistics include:

- Total number of samples
- Percentage of samples with detected concentrations
- Minimum and maximum detected concentrations for each outfall
- Mean and median concentrations for each outfall
- Global weighted-mean concentrations for the entire Thea Foss basin (weighted by number of samples per outfall)
- Overall maximum concentration for all outfalls, and sampling date of maximum concentration

Summary statistics were generated using Microsoft® Office Excel 2007. For non-detected concentrations, 1/2 reporting limit values were used as specified in the Foss SAP (City of Tacoma 2001.)

3.2.2 Constituents of Interest

Summary charts for stormwater, baseflow, and SSPM were prepared and statistical tests were performed on the following indicator parameters:

- Total Suspended Solids (TSS)

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[7] Baseflow results are presented for WY2002 to WY2011 since baseflow monitoring was discontinued after WY2011.

- Metals (total lead and total zinc)
- Polycyclic Aromatic Hydrocarbons (PAHs, including phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene)
- Bis(2-ethylhexyl)phthalate (DEHP) [plus butylbenzylphthalate and total phthalates]

These represent the primary COCs for protection of sediment quality in the Thea Foss Waterway.

In addition, several hydrophobic constituents were evaluated statistically in SSPM only, because of their relatively poor solubility in stormwater and tendency to adhere to suspended sediments, including the following:

- Mercury
- Polychlorinated Biphenyls (PCB)
- 4,4'-DDT
- Total Petroleum Hydrocarbons

3.2.3 Statistical Test Methods

The stormwater monitoring data were subjected to the following statistical tests:

- Qualitative Assessment of Spatial and Temporal Trends
- Analysis of Variance (ANOVA) and Post-Hoc Comparison Tests:
    - Parametric ANOVA and Tukey Test (Stormwater Data)
    - Nonparametric ANOVA (Kruskal-Wallis Test) and Dunn Test (Baseflow and SSPM Data)[8]
- Time Trend Analysis (Seasonal Kendall and Lognormal Linear Regression)

The ANOVA, Kruskal-Wallis, and Tukey tests were performed using SYSTAT® Version 13. The lognormal regressions and nonparametric post-hoc test (Dunn Test) were performed in Microsoft Excel using the equations in Zar (1999). Time trend analysis (Seasonal Kendall test) was performed using the freeware Kendall.exe (a DOS executable program that runs under current versions of the Windows operating system) available from the USGS (http://pubs.usgs.gov/sir/2005/5275/downloads/).

3.2.4 Comparison Between OF237A and OF237A New Data

As discussed in Section 3.1.1, sampling at OF237A New began in January 2006 following installation of a new manhole downstream of the original 237A monitoring location. This new monitoring location included runoff from the FD2a branch (23rd Street Lateral) that was not previously captured in the OF237A location. Samples were collected from both monitoring locations from January 2006 to the end of WY2011.

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[8] Storm sediment has historically been tested using a parametric ANOVA and Tukey post-hoc test. The data was re-evaluated in 2012 and determined to be best subjected to nonparametric statistical tests. This analysis is described in more detail in Section 3.3.3.

With over 5 years of data from both locations, a t-test was performed to see if the 2 datasets were generally equivalent (see Table 3-4). No statistically significant ($p < 0.05$) differences were observed. This suggests that the monitoring locations are generally equivalent and the data sets can be combined. For all WY2012 analyses, the data set used for OF237A includes data from the original OF237A monitoring location through February 26, 2006 (date first sample was successfully collected from OF237A New monitoring location) and from the OF237A New monitoring location thereafter.

Although the t-test showed no statistically significant differences, minor differences between the data sets likely exist. As a result, results from statistical tests for WY2012 at OF237A New should not be directly compared to previous results.

3.3 SPATIAL ANALYSIS

This section presents a qualitative and quantitative spatial analysis of differences in baseflow[9], stormwater and SSPM quality between municipal storm drains. It should be noted that there are similarities as well as differences in the spatial patterns of exceedences observed in baseflow, stormwater, and SSPM, as discussed in the following sections and as shown on Tables 3-6, 3-7, and 3-9.

Qualitative analysis includes inspection of drain-by-drain summary statistics and box plots. Quantitative analysis includes nonparametric ANOVA (Kruskal-Wallis test) and post-hoc comparison (Dunn Test) for SSPM data, and lognormal parametric ANOVA and post-hoc comparison (Tukey Test) for stormwater data. Note that this information is used to guide stormwater source control activities that are discussed further in Section 5.

3.3.1 Baseflow Quality

Qualitative Outfall Comparisons. Inspection of summary tables and box plots of baseflow quality among the various Foss outfalls suggests the following generalized conclusions (see Table 3-2 and Appendices D, E, F and G):

- In general, the following drains exhibited elevated baseflow concentrations relative to their neighboring drains in the Foss Waterway Watershed: lead in OF235; zinc in OF245; DEHP in OF235.
- OF237A and OF237B, by far the largest of the baseflow discharges, exhibit the lowest concentrations of TSS, metals and PAHs compared to the smaller drains OF230, OF235, OF243, OF245 and OF254. This may be caused by significant contributions from inflowing surface water (creeks) and groundwater (springs) to the baseflow in these 2 drainages.
- The mean concentrations and interquartile ranges of organic constituents (i.e., DEHP and PAHs) in OF237A and OF237B are lower than all other drains, and these drains are generally characterized by fewer extreme values.
- The highest overall concentration of TSS in baseflow was reported in OF230 in Year 8 (319 mg/L in March 2009). This TSS anomaly may have been caused by a major construction project in the basin.

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[9]The baseflow analysis presented in Section 3.3.1 is from the WY2011 report and is included for reference purposes. No baseflow sampling was performed in WY2012.

- Unusually high concentrations of LPAHs were reported in OF237A in Year 1 (Feb 2002), including the highest measured baseflow concentrations of naphthalene, 2-methylnaphthalene, fluorene, and total LPAHs. This appears to have been an anomaly because such extreme concentrations have not been reproduced in the remaining 9 baseflow monitoring years.
- The highest mean or maximum concentrations of several High Molecular Weight PAHs (HPAH) were reported in OF235 (including benzo(a)pyrene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene), mainly in Year 5 (January and August 2006). This appears to have been an anomaly because such extreme concentrations have not been reproduced in the remaining 5 monitoring years.
- The highest mean and/or maximum concentrations of several Low Molecular Weight PAHs (LPAH) and HPAHs have been reported in OF254 including acenaphthylene, anthracene, phenanthrene, benzo(a)anthracene, benzofluoranthenes, chrysene, fluoranthene, pyrene and total HPAHs, mainly in Year 4 (February and July 2005).
- The highest mean, median, and maximum concentrations of DEHP in baseflow occurred in OF230 and OF235. The highest mean and maximum butylbenzylphthalate concentrations occurred in OF245, the highest mean and maximum diethylphthalate concentrations occurred in OF237A, and the highest mean and maximum di-n-octyl phthalate concentrations occurred in OF235. As a result, it appears that the phthalate compositions are quite variable around the basins. Most of the peak phthalate concentrations occurred earlier in the monitoring program (WY2002 through WY2005). However, the highest baseflow di-n-butylphthalate concentration on the east side of the waterway was measured in OF243 during Year 9.
- For the majority of outfalls, Year 10 (the last year of baseflow monitoring) shows similar or lower average concentrations in the index chemicals than observed over the previous 9 monitoring years.

Nonparametric ANOVA (Kruskal-Wallis Test). ANOVA was performed to determine whether or not there are statistically significant differences in baseflow quality between outfalls. The ANOVA test helps to determine whether baseflow quality in the Foss Waterway Watershed is relatively uniform across drainages (i.e., all outfalls are drawn from a single statistical population), or whether there is reason to believe that certain drainages are unique (i.e., characterized by unusually high or low concentrations).

Because many of the constituents in the baseflow data sets (in particular, phthalates and most PAHs, among others) contain a high percentage of undetected values (i.e., greater than 50%, in some cases much higher), nonparametric statistical procedures were applied. The Kruskal-Wallis test is a variant of ANOVA performed with ranks. The Kruskal-Wallis test statistic is approximated by the Chi-squared distribution with 6 (n-1) degrees of freedom (n = 7 outfalls in the monitoring program). Because it is a nonparametric test, it requires no assumptions about the underlying statistical distribution of the data.

Nonparametric ANOVA tests (Kruskal-Wallis tests) were performed using: (1) all 10 years of baseflow monitoring data, and (2) only the last 2 years of baseflow monitoring data. Kruskal-Wallis tests performed using the entire 10 year monitoring record have significantly more power to discriminate between drains due to a much larger sample size. Kruskal-Wallis tests performed using only the last 2 years of monitoring data have lower statistical power, but provide information about the most current conditions in the storm drains. This more recent analysis is important because a number of source control actions have been implemented during the 10 year baseflow monitoring period.

Following are the results of the Kruskal-Wallis test using all 10 years of baseflow monitoring data:

Parameter	X^2 Statistic	Probability	Significant?
TSS	92.5	<0.001	Yes
Total Lead	122.0	<0.001	Yes
Total Zinc	188.6	<0.001	Yes
Phenanthrene	32.0	<0.001	Yes
Pyrene	85.2	<0.001	Yes
Indeno(1,2,3-cd)pyrene	3.3	0.772	No
DEHP	31.0	<0.001	Yes

The Kruskal-Wallis test results for all 10 years indicate it is possible to differentiate baseflow quality between outfalls in the Foss Waterway Watershed for nearly all constituents. There is greater than 99.9% probability ($p < 0.001$) that 1 or more outfalls are different from the norm, either higher or lower, with 1 exception. Differences in indeno(1,2,3-cd)pyrene concentrations are not statistically significant, and outfalls cannot be differentiated on the basis of this chemical. Indeno(1,2,3-cd)pyrene was only detected 11% of the time in baseflow samples, which helps to explain why it has such low statistical power.

Following are the results of the Kruskal-Wallis test using only the last 2 years of monitoring data:

Parameter	X^2 Statistic	Probability	Significant?
TSS	26.6	<0.001	Yes
Total Lead	31.9	<0.001	Yes
Total Zinc	43.3	<0.001	Yes
Phenanthrene	10.2	0.115	No
Pyrene	23.7	<0.001	Yes
Indeno(1,2,3-cd)pyrene	1.8	0.936	No
DEHP	4.3	0.639	No

The Kruskal-Wallis test results for the last 2 years of monitoring indicate it is possible to differentiate baseflow quality between outfalls in the Foss Waterway Watershed for inorganic constituents (TSS, lead, zinc) and the most frequently detected PAH – pyrene. However, differences in phenanthrene, DEHP and indeno(1,2,3-cd)pyrene concentrations are not statistically significant, and baseflow in the watershed cannot be differentiated on the basis of these chemicals. These are also the 3 index chemicals with the lowest detection frequencies.

Nonparametric Post-Hoc Comparison (Dunn Test). Because the Kruskal-Wallis test showed statistically significant differences in baseflow quality between the municipal storm drains for most constituents, follow-on tests were performed to determine which specific drains are higher or lower than normal. These follow-on tests are called pair-comparison tests, or post-hoc tests. The Dunn Test is an appropriate post-hoc test for nonparametric data.

The results of the nonparametric pair-comparison tests for the 10 year monitoring period and for the last 2 years are summarized in Table 3-6. The numbers in the table indicate the number and direction of statistically significant pair comparisons for every indicator constituent and every outfall. For example, "+3" indicates a particular chemical in a particular outfall is significantly higher than 3 other outfalls; whereas "-3" indicates a particular constituent in a particular outfall is significantly lower than 3 other outfalls.

Each outfall is compared to a maximum of 6 other outfalls (there are 7 total outfalls in the monitoring program). Outfalls and constituents that exhibit a higher number of significant pair comparisons help to identify drainages that are increasingly unique (either higher or lower in concentration) compared to the other outfalls being monitored in the Foss Waterway Watershed.

Drainages and constituents exhibiting significant differences in baseflow quality, based on the entire 10 year baseflow monitoring record, include the following (see Table 3-6A):

- **TSS**. OF237A (-5) and OF237B (-5) exhibited consistently lower TSS concentrations in baseflow compared to the other outfalls.
- **Total Lead**. OF237A (-4) and OF237B (-5) exhibited consistently lower lead concentrations in baseflow compared to the other outfalls. Baseflow quality in OF235 (+4) is most elevated in lead, followed by OF243 (+3).
- **Total Zinc**. OF237A (-5) and OF237B (-5) exhibited consistently lower zinc concentrations in baseflow compared to the other outfalls. Baseflow quality in OF230 (+4) and OF245 (+5) are most elevated in zinc.
- **DEHP**. OF235 (+4) contains significantly elevated DEHP concentrations in baseflow, higher than almost all other outfalls. This same pattern is observed in stormwater data, as described later in this section. No other outfalls appear to be very anomalous.
- **PAHs**. Baseflow in OF237A and OF237B exhibited consistently lower concentrations of pyrene (-4 and -5, respectively) compared to the other outfalls, and OF237B also had relatively low phenanthrene concentrations (-2). All other outfalls showed similar levels of phenanthrene and pyrene concentrations in baseflow. As discussed in the preceding section, no outfalls can be differentiated on the basis of indeno(1,2,3-cd)pyrene.

In summary, these results indicate OF237A and OF237B have the highest number of negative pair comparisons; therefore, the baseflow quality in these outfalls is consistently better than the other drainages. This may be due to significant contributions to baseflow from inflowing creeks and groundwater springs in these 2 drainages. Certain other drainages have isolated enrichments of lead (OF235 and OF243), DEHP (OF235), and zinc (OF230 and OF245).

The number of statistically significant differences is considerably lower when only the last 2 years of monitoring data are evaluated (see Table 3-6B). Using this more limited data set, OF237A and OF237B still exhibit lower than average concentrations of most constituents. The locally elevated levels of zinc and lead are still evident, although the number of significant differences is reduced. However, the unusually high concentration of DEHP in OF235 identified in the analysis of the 10 year data set is not evident in recent years. It is therefore possible that the City's phthalate-focused source control efforts are helping to control DEHP in OF235.

3.3.2 Stormwater Quality

Qualitative Outfall Comparisons. Inspection of summary tables and box plots of stormwater quality among the various Foss Waterway storm drains suggests the following generalized conclusions (see Table 3-3 and Appendices D, E, F and G):

- **TSS**. Comparatively higher TSS concentrations were observed in OF235 and OF254. OF235 and OF254 had elevated maximum (441 and 354 mg/L), mean (77 and 104 mg/L), and median (59 and 85 mg/L) concentrations, respectively. OF237A and OF230 had the lowest mean and median TSS concentrations.
- **Metals**. Comparatively higher mean, median and maximum lead concentrations were observed in OF235; OF243 also showed evidence of elevated lead concentrations, including the highest overall lead concentration (379 µg/L) in September 2009. The highest mean (0.041 µg/L) and maximum (0.87 µg/L) mercury concentrations were observed in OF254 and OF245, respectively. The highest mean (171 µg/L) and maximum (1,170 µg/L) zinc concentrations were observed in eastside outfalls OF245 and OF243, respectively.
- **Phthalates**. DEHP is the phthalate compound with most frequent detections (78% detection) and the highest mean and median concentrations. The highest median, mean, and maximum concentrations of DEHP were observed in OF235 (3.7, 6.0, and 97 µg/L, respectively), and the second highest concentrations were observed in OF230 (3.4, 4.6, and 44 µg/L, respectively). Unusually elevated DEHP concentrations were also found in OF245 in Year 2 (October 2002 through April 2003) and in Year 7 in OF230 and OF243, but these appear to be isolated occurrences. Certain other phthalates, though less frequently detected, peaked at higher concentrations. In particular, elevated diethylphthalate concentrations were measured in OF237A (230 µg/L), OF235 (590 µg/L), OF245 (430 µg/L), and OF254 (120 µg/L). The peak butylbenzylphthalate concentration was measured in OF245 (290 µg/L). However, diethylphthalate and butylbenzylphthalate were detected in less than half the samples (32% and 39% detection, respectively). The fact that the peak concentrations of various phthalates occur in different outfalls indicates that the phthalate composition is somewhat variable across the Thea Foss drainage basins.
- **PAHs**. OF235 contained the highest maximum concentrations of the lighter weight PAH compounds naphthalene, 2-methylnaphthalene, and total LPAHs. Comparatively higher mean and median concentrations of other LPAHs and the maximum concentration of anthracene were observed in OF254. The highest maximum concentrations for several other LPAH compounds, including acenaphthene, acenaphthylene, fluorene, and phenanthrene were observed in OF245. Comparatively higher mean, median, and maximum concentrations of HPAHs were observed in OF237A and OF254. In general, PAH concentrations over the last 4 years (Years 8 through 11) were relatively low compared to previous monitoring years.

Parametric ANOVA Results. ANOVA was performed to determine whether or not there are statistically significant differences between outfalls. The ANOVA test helps to determine whether stormwater quality in the Foss Waterway Watershed is relatively uniform across drainages (i.e., all outfalls are drawn from a single statistical population), or whether there is reason to believe that certain drainages are unique (i.e., characterized by unusually high or low concentrations).

Goodness-of-fit tests show that practically all stormwater analytes in all outfalls may be characterized by lognormal or nearly lognormal statistical distributions (City of Tacoma 2009a). These goodness-of-fit tests were verified again in 2012 using the entire 11 year monitoring record; results are presented in Table 3-5. Therefore, lognormal parametric ANOVA tests were conducted. The ANOVA test statistic is the F statistic with 6 (n-1) degrees of freedom (n = 7 outfalls in the monitoring program).

ANOVA and post-hoc comparison tests were performed using: (1) all 11 years of monitoring data, and (2) only the last year of monitoring data. ANOVA tests using the entire 11 year monitoring record have significantly more power to discriminate between drains due to a much larger sample size. ANOVA tests using only the last year of monitoring data have lower statistical power, but provide information on the most current conditions in the storm drains, to better determine whether the City's source control actions have resulted in recent improvements in stormwater quality and to guide future source control activity prioritization.

Following are the results of the parametric ANOVA test using all 11 years of stormwater monitoring data:

Parameter	F Statistic	Probability	Significant?
TSS	9.43	<0.001	Yes
Total Lead	96.7	<0.001	Yes
Total Zinc	28.7	<0.001	Yes
Phenanthrene	4.2	0.001	Yes
Pyrene	8.0	<0.001	Yes
Indeno(1,2,3-cd)pyrene	7.1	<0.001	Yes
DEHP	10.4	<0.001	Yes

The parametric ANOVA test results indicate there is greater than or equal to 99.9% probability ($p \leq 0.001$) that 1 or more outfalls are significantly different from the norm, either higher or lower, for every 1 of the index constituents. As a result, post-hoc tests were performed to identify which specific outfalls contain unusually high or low stormwater concentrations.

Following are the results of the parametric ANOVA test using only the last year of monitoring data:

Parameter	F Statistic	Probability	Significant?
TSS	5.2	<0.001	Yes
Total Lead	32.4	<0.001	Yes
Total Zinc	9.2	<0.001	Yes
Phenanthrene	2.9	0.017	Yes
Pyrene	7.8	<0.001	Yes
Indeno(1,2,3-cd)pyrene	5.3	<0.001	Yes
DEHP	4.6	0.001	Yes

The ANOVA test results indicate it is possible to differentiate stormwater quality between outfalls in the Foss Waterway Watershed for every 1 of the index constituents using only the last year of data.

Parametric Post-Hoc Comparison (Tukey Test). Because the ANOVA test showed statistically significant differences ($p < 0.05$) between stormwater quality in the various municipal drainages, post-hoc tests were performed to determine which specific drains are higher or lower than normal. The Tukey Test is an appropriate post-hoc test for parametric ANOVA. The results of the parametric post-hoc tests are summarized in Table 3-7.

Drainages and constituents exhibiting significant differences in stormwater quality, based on the entire 11 year monitoring record, include the following (see Table 3-7A):

- **TSS**. TSS concentrations are moderately lower in OF230 (-3). TSS concentrations are significantly higher in OF254 (+6).
- **Total Lead**. OF237A (-3), OF237B (-4), and OF245 (-4) contain lead concentrations that are moderately to significantly below average. OF235 (+6) and OF243 (+4) are significantly elevated compared to other outfalls.
- **Total Zinc**. Zinc concentrations in OF237B (-6) are significantly lower than all other outfalls. OF235 (+3) and OF254 (+3) are moderately elevated in zinc and OF245 (+4) is significantly elevated in zinc.
- **DEHP**. OF230 (+5) and OF235 (+5) contain significantly elevated DEHP concentrations, higher than most other outfalls. DEHP concentrations in the remaining outfalls are relatively low and largely indistinguishable from 1 another.
- **PAHs**. OF237B has moderately lower concentrations of phenanthrene (-3) and pyrene (-3). OF245 has significantly lower concentrations of pyrene (-4) and indeno(1,2,3-c,d)pyrene (-5). OF254 has moderately higher concentrations of pyrene (+3).

In summary, these results indicate that OF235 and OF254, and to a lesser degree OF230, have the highest number of positive pair comparisons; therefore, source control activities are best focused on these drainages. OF237B and OF245 have the highest number of negative pair comparisons, being either neutral or moderately to strongly lower in concentration for all index constituents (except total zinc in OF245) relative to other drains, and therefore exhibit the best overall stormwater quality. OF243 and OF237A have generally good stormwater quality for a majority of constituents, with OF243 showing evidence of being enriched with lead. With 11 years of monitoring data, very good statistical power has been achieved, and the spatial patterns in Foss stormwater are relatively stable and consistent from 1 monitoring year to the next.

When looking at only the last year of monitoring data (see Table 3-7B), some differences in the trends are observed. Lead remains significantly elevated in OF235 (+5) and OF243 (+5) and DEHP remains moderately elevated in OF235 (+3). In summary, the 1 year results indicate that OF235 and OF254 have the highest number of positive pair combinations, which is consistent with the results for the 11 year monitoring record.

3.3.3 Baseflow Versus Stormwater Quality

Summary statistics for baseflow[10] and stormwater quality for WY2002-WY2012 are provided in Table 3-2 and Table 3-3, respectively. These tables include weighted mean concentrations

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[10] Baseflow results are presented for WY2002 to WY2011 since baseflow monitoring was discontinued after WY2011.

averaged across all 7 outfalls in the Foss Waterway Watershed (weighted by sample size for each outfall). The weighted mean concentrations in baseflow and stormwater are summarized below for the Thea Foss index chemicals.

Constituent	Units	Mean Baseflow	Mean Stormwater	Ratio
TSS	mg/L	12	70	17%
Lead	µg/L	5.5	30	18%
Zinc	µg/L	47	128	37%
Phenanthrene	µg/L	0.013	0.098	13%
Pyrene	µg/L	0.026	0.206	13%
Indeno(1,2,3-c,d)pyrene	µg/L	0.006	0.050	12%
DEHP	µg/L	1.1	3.5	31%

Inspection of these summary statistics indicates the following:

- Baseflow concentrations are consistently lower than stormwater concentrations. Average baseflow concentrations range from approximately 1/10 to 1/3 (12 to 37%) of stormwater concentrations.
- In addition to lower mean concentrations, baseflow samples are typically characterized by less extreme values and less frequent detections.
- Because the TSS content is almost 6 times higher in stormwater, the increased chemical concentrations that are observed during storm events may be caused in part by suspended sediments entrained in the runoff.

3.3.4 Storm Sediment Quality

SSPM samples were collected in pipeline sediment traps and in the MH390 sump (representing OF245). These samples include suspended particulate matter in transport through the storm drains. OF254 does not have a sediment trap because of tidal influences. SSPM data help to provide information on hydrophobic constituents such as mercury, HPAHs, DDTs and PCBs, which have a strong affinity for sediments, but are poorly soluble and often undetected in whole-water samples. In conjunction with baseflow and stormwater data, SSPM data are used to help the City, EPA, and Ecology identify and trace unusually elevated sources of contaminants in the municipal drainages.

Due to the limited dataset available for review (only 1 sample per year), the assumption was made in previous reports that the SSPM data would follow a lognormal distribution similar to the stormwater data. With 11 years of sediment data now available for review, the statistical distribution of the data was tested using *MTCA Stat*. The goodness-of-fit results are presented in Table 3-8. Based on this analysis and the fact that at least 1 sediment trap location for each analyte was not well described by a lognormal distribution, nonparametric statistical tests were used.

ANOVA was performed to identify storm drains with significantly higher or lower sediment concentrations compared to other drains in the Foss Waterway Watershed. A nonparametric ANOVA (Kruskal-Wallis Test) was performed, with 5 (n-1) degrees of freedom (n = 6 outfalls in the sediment trap monitoring program).

Following are the results of the nonparametric ANOVA test using all 1 years of storm sediment data:

Parameter	F Statistic	Probability	Significant?
Total Lead	47.821	<0.001	Yes
Total Zinc	37.272	<0.001	Yes
Total Mercury	36.334	<0.001	Yes
TPH-Heavy Oil	25.673	<0.001	Yes
DDT	5.677	0.339	No
Phenanthrene	37.769	<0.001	Yes
Pyrene	28.721	<0.001	Yes
Indeno(1,2,3-cd)pyrene	40.066	<0.001	Yes
Total PCBs	5.606	0.346	No
DEHP	20.509	<0.001	Yes
BBP	47.743	<0.001	Yes
Total Phthalates	31.629	<0.001	Yes

The nonparametric ANOVA test results indicate there is a high probability (equal or greater than 99% confidence; $p \leq 0.01$) that storm sediment concentrations in 1 or more outfalls are significantly different from the norm, either higher or lower, for most analytes. However, differences in DDT and total PCB concentrations between outfalls cannot be discerned in this data set. This is not surprising for DDT, considering the high percentage of undetected DDT concentrations, and the fact that no DDT isomers were detected in any drains during the last 4 monitoring years. Similar to DDT, PCBs have not been detected in the outfall sediment traps during the last 5 years of monitoring.

Following are the results of the nonparametric ANOVA test using only the last 5 years of monitoring data:

Parameter	F Statistic	Probability	Significant?
Total Lead	23.749	<0.001	Yes
Total Zinc	22.124	<0.001	Yes
Total Mercury	20.090	0.001	Yes
TPH-Heavy Oil	13.119	0.022	Yes
DDT	0.293	0.998	No
Phenanthrene	20.504	0.001	Yes
Pyrene	18.930	0.002	Yes
Indeno(1,2,3-cd)pyrene	20.992	0.001	Yes
Total PCBs	0.000	1.000	No
DEHP	11.648	0.040	Yes
BBP	22.666	<0.001	Yes
Total Phthalates	15.063	0.010	Yes

The nonparametric ANOVA test results indicate it is possible to differentiate SSPM quality between outfalls in the Foss Waterway Watershed for the same number of index constituents (all except for DDT and Total PCBs) using only the last 5 years of data.

Pair-comparison tests were performed using the Dunn method, as summarized in Table 3-9A and Table 3-9B. Each outfall is compared to a maximum of 5 other outfalls in the storm sediment monitoring program (6 outfalls total). Outfalls and constituents that exhibit a higher number of significant pair comparisons help to identify drainages that are increasingly unique (either higher or lower concentrations) compared to the other drains in the Foss Waterway Watershed.

Following is a summary of observations regarding spatial patterns in SSPM quality based on the 11 year monitoring record. The spatial patterns observed in the SSPM data are sometimes but not always consistent with the patterns observed in stormwater data (compare Table 3-9 and Table 3-7). Discrepancies between these 2 data sets are included below and may be caused by differential transport of pollutants in dissolved and particulate phases.

- **Metals**. SSPM in OF230 and OF243 are somewhat elevated in lead (+2 and +3, respectively), mercury (both +3), and zinc (+1 and +2, respectively); OF235 is relatively neutral (+2 to 0); and OF237A, OF237B and OF245 have relatively lower concentrations of the index metals (-1 to -3) except for zinc in OF245 (+1). Some of these patterns are contrary to those observed in stormwater. For example, zinc concentrations in OF235 are elevated in stormwater (+3), but not in SSPM (0) and zinc concentrations in OF243 are slightly elevated in SSPM (+2) but not in stormwater (-2).
- **Total Petroleum Hydrocarbons (TPH-Oil)**. SSPM in OF237B is much lower in TPH-Oil (-3) relative to the other outfalls.
- **DDT**. No significant differences in DDT concentrations were observed among the 6 outfalls.
- **PAHs**. Storm sediment in OF245 contains somewhat lower concentrations of PAHs (-2 to -3) relative to all other outfalls. OF230 and OF237A are slightly enriched in PAHs (+1 to +2). These patterns are generally consistent with those observed in stormwater except for OF237B where SSPM is neutral (0 to +1) and stormwater somewhat lower than other locations (-3 to +1).
- **Total PCBs**. No significant differences in total PCB concentrations were observed among the 6 outfalls.
- **Phthalates**. DEHP is fairly ubiquitous and consistent in storm sediment throughout the various drainages; only OF237B (-2) shows a slightly lower concentration in DEHP. These patterns are not altogether consistent with those observed in stormwater. For example, DEHP in OF230 and OF235 was significantly elevated in stormwater (both +5), but not in storm sediment (+1 and 0, respectively). OF243 and OF245 exhibit notably different phthalate compositions that are dominated by butylbenzylphthalate (+2 and +4). In particular, OF245 has 6 of the 7 highest butylbenzylphthalate concentrations in the monitoring program.

When looking at only the last 5 years of monitoring data (see Table 3-9B), fewer spatial patterns are observed, but the patterns are generally consistent with the 11 year monitoring record results (Table 3-9A). This suggests that there has not been a significant change in spatial distribution over the 11 year monitoring record.

3.4 Seasonal Analysis

This section presents a qualitative evaluation of seasonality in baseflow and stormwater quality by inspection of seasonal box plots (see Appendix H). As per the City's NPDES Phase I Permit, the wet season is defined as October 1 through April 30, and the dry season is defined as May 1 through September 30.

It might be expected that dry season conditions would generate higher contaminant concentrations in both baseflow and stormwater. This might be caused by more isolated storms and longer antecedent dry periods between storms, resulting in longer periods of contaminant accumulation on the surfaces of the drainage basin. The seasonal effect on runoff quality found through the City's monitoring program is evaluated below.

3.4.1 Seasonal Analysis of Stormwater Quality

Inspection of box plots comparing stormwater quality between the wet and dry seasons suggests the following:

- In general, seasonal effects in stormwater appear to be weaker than those observed under baseflow conditions.
- Metals (lead and zinc) in stormwater showed occasional evidence of seasonality, i.e., higher median, mean, and/or peak concentrations during dry season months.
- Evidence of seasonal effects in TSS concentrations is weak in all outfalls.
- Evidence of seasonal effects was rarely observed in organics data. OF230 showed weak evidence of seasonality for DEHP and PAHs while other outfalls generally did not.
- Similar patterns were observed in baseflow data, i.e., inorganic constituents exhibit stronger evidence of seasonality, whereas evidence of seasonality for organic constituents is weak or absent.

Although seasonal effects on stormwater quality are not pronounced, and sometimes weak or absent, seasonality was nevertheless considered during long-term time-trend analysis (i.e., through use of the Seasonal Kendall test), as presented in the next section.

3.5 TIME TREND ANALYSIS

This section presents a qualitative and quantitative analysis of time trends in stormwater quality. The objective of time trend analysis is to identify specific drains and constituents that show evidence of significant improvement or degradation in stormwater quality over time. The changes can be a result of source control actions in the drainage basins that help to curtail pollutant concentrations, or alternatively, changes or disturbances in the watersheds that may cause concentrations to increase, for example, temporary construction activities, or increased urban density and traffic.

3.5.1 Stormwater Time Trends

Qualitative Analysis of Time Trends. Inspection of box plots comparing stormwater quality from 1 monitoring year to the next suggests the following (see Appendix G):

- Time trends are difficult to discern by visual inspection of the year-to-year box plots due to the generally high degree of variability in stormwater data. Time trends are evaluated using more quantitative statistical tests later in this section.
- In spite of the inherent variability of the data, there nevertheless appear to be across-the-board reductions in most PAH compounds and DEHP in most drains over the last 3 years. Having stabilized at low levels for several consecutive years, these trends may be indicative of the effectiveness of the City's source control program.

- WY2010 (Year 9) was problematic for OF243, which was characterized by unusually high concentrations of TSS, lead, and zinc in stormwater. In WY2011 (Year 10), the concentrations of these constituents declined with slight upticks in WY2012 (Year 11).
- Unusually dry (Year 2 and Year 4) and unusually wet (Year 6) monitoring years are summarized in Table 3-1. The last 3 monitoring years (Years 9 to 11) were the 2nd, 3rd, and 4th wettest years of the 11 year monitoring record. However, there is no discernible relationship between these unusual water years and stormwater quality. Reliable correlations between stormwater quality and other hydrologic parameters (i.e., rain depth, rainfall intensity, and antecedent period; see Figure 3-2) are not discernible either.

Seasonal Kendall Test. Stormwater time trends were evaluated using the nonparametric Seasonal Kendall test. The use of the Seasonal Kendall test requires that the data be stratified by season. The monitoring year was divided into 2 seasons (i.e., wet season from October 1 through April 30 and dry season from May 1 through September 30), as specified in the NPDES Phase I Permit.

The results of the Seasonal Kendall test are summarized in Table 3-10, including the calculated Z statistic, the corresponding probability (p value), and if appropriate, the Seasonal Kendall slope estimator. The p-value should be less than 0.05 to provide evidence of a significant time trend with 95% confidence.

As shown in Table 3-10, 37 trends were shown to be significant using this method (37 out of 49 tests, or approximately 75% of the tests). All trends were in the direction of decreasing concentrations. This is a same number of significant reductions than were detected in Year 10. In comparison to Year 10, new trends were detected for TSS in OF245 and lead and zinc in OF230. Trends were observed in Year 10, but not in Year 11, for zinc in OF254 and TSS and lead in OF237A.

Due to the combination of 237A and 237A New data this year (see Section 3.2.4), the 237A New data set is slightly different than the historic dataset – this change in the data set likely explains why trends were detected at 237A in Year 10 for TSS and lead, but not in Year 11.

The following trends were significant according to the Seasonal Kendall test:

- **TSS**. Decreasing TSS concentrations in OF230, OF235, OF237B and OF245.
- **Lead**. Decreasing lead concentrations in OF230, OF235, OF237B and OF245.
- **Zinc**. Decreasing zinc concentrations in OF230 and OF237B.
- **PAHs**. Decreasing phenanthrene, pyrene and indeno(1,2,3-cd)pyrene concentrations in every outfall.
- **DEHP**. Decreasing DEHP concentrations in nearly every outfall (all except OF254).

Overall, these results provide further and ongoing evidence of the effectiveness of the City's source control program.

Regression Analysis. Historically, the time trends that were determined to be statistically significant according to the Seasonal Kendall test were analyzed further using least-squares regression analysis. Given the confirmation that the data are well defined by a lognormal distribution (Table 3-5) and the weak seasonality of the dataset (see Section 3.4.1), a simple linear regression was performed on all the analytes (7 analytes per outfall; 49 possible trends) rather than on just the analytes that were statistically significant with the Seasonal Kendall test.

The simple linear regression is performed using the logarithms (base 10) of the stormwater concentrations. This is equivalent to an exponential decay model, which is a typical decay profile for environmental data. No seasonal effects were modeled with the regression given that such effects are not consistently observed, and are especially weak for organic compounds (see Sections 3.4.1 and 3.4.2).

The relevant regression statistics are summarized in Table 3-11. The linear regression results were also compared to the estimated percent reduction results that are generated from the Seasonal Kendall test[11]. As shown in Table 3-12, the simple linear regression and Seasonal Kendall percent reductions are generally similar for most analytes/outfalls. The simple linear regression results will be the only results presented in future years as the data is well defined by lognormal distributions (Table 3-5) and the data has little or no seasonality.

Scatterplots of the time-series data and best-fit lognormal regression models are presented on Figures 3-6a (TSS), 3-6b (lead), 3-6c and 3-6d (zinc), 3-6e and 3-6f (phenanthrene), 3-6g and 3-6h (pyrene), 3-6i and 3-6j (indeno(1,2,3-cd)pyrene), and 3-6k and 3-6l (DEHP). These plots show all significant cases of the simple linear regression test.

The regression analysis confirms that reducing trends are statistically significant in 41 cases at greater than 96% confidence. Trends for TSS and lead in OF237A were not detected this year, while they were detected in Year 10. This is likely due to the fact that the dataset for OF237A includes data from OF237A and OF237A New this year (see Section 3.2.4), so the data is slightly different than the historical data.

The best-fit regression equations are used to estimate percent reductions over the 11 year monitoring period for these constituents and outfalls:

- **TSS**: Approximately 52 to 63% reduction in OF230, OF235, OF237B and OF245.
- **Lead**: Approximately 51 to 56% reduction in OF230, OF235, OF237B and OF245.
- **Zinc**: Approximately 32 to 50% reduction in OF235, OF237A, OF237B, OF245 and OF254.
- **PAHs**: Approximately 87 to 97% reduction in phenanthrene, pyrene and indeno(1,2,3-cd)pyrene in all 7 outfalls.
- **DEHP**: Approximately 58 to 91% reduction in all 7 outfalls.

3.6 CONCLUSIONS

The City has been performing outfall monitoring in the Thea Foss Basin for 11 years. Most of the COCs have undergone significant reductions in concentrations and loads compared to past

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[11] These have not been historically shown in the annual reports, but they are generated by the Seasonal Kendall calculator. Since the City is planning to only perform the simple linear regression in the future (i.e., no prescreen the data for a trend using Seasonal Kendall) because the data is well defined by lognormal distributions, the estimated reductions from Seasonal Kendall are shown for comparison purposes.

monitoring efforts in the late 1980s through mid-1990s. The cumulative effect of federal, state and municipal source control efforts has likely caused the observed improvements in stormwater quality. The City has directed numerous source control efforts in this watershed, including control of potential TSS, metals, PAH and DEHP sources. In particular, PAH and DEHP concentrations in the last 4 years appear to be generally below the average concentrations in the majority of outfalls. Having stabilized now for several consecutive monitoring years, the observed concentration reductions are likely an indication of source control effectiveness. The City will continue to evaluate the source(s) of the COCs in the Foss Waterway Watershed. The COCs for each basin and source control priorities are discussed in Section 5.

A large number of significant reductions have been observed in the City's 11 year monitoring record. Forty-one time trends were shown in Year 11 to be statistically significant (41 out of 49 tests, or approximately 84% of the tests) using simple linear regression. All trends were in the direction of decreasing concentrations. In Year 10, 37 significant trends were detected, in Year 9, 26 significant trends were observed; in Year 8, 10 significant trends were observed; and in Year 7, only 4 significant trends were observed. As noted in Section 3.5.1 some new statistical approaches were implemented in WY2012 and for this reason, this year's results are not fully comparable to previous year's results. However these changes have improved the statistical approach to the trend analysis, and the City's ability to discern trends.

With a comprehensive 11 year monitoring record – including substantial sampling of storm events and baseflow events in 7 drains every year for at least 11 years[12] – the drainages in the Foss Waterway Watershed have been well characterized. Significant reducing trends have been observed in a majority of cases, including statistically significant reductions in PAHs, TSS, lead, zinc, and DEHP concentrations in all or a majority of the drains, attesting to the effectiveness of the City's source control program. In 2012, the City submitted a request to reduce the frequency of stormwater sampling. EPA and Ecology subsequently authorized the City to reduce the frequency of sampling to 8 times per year for the west side outfalls (OF230, OF235, OF237A New, and OF237B) and to 3 times per year for the east side outfalls (OF243, OF245 and OF254) starting with WY2013 sampling.

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[12] Baseflow sampling was discontinued at the end of WY2011, so there is a 10 year record for baseflow. Stormwater sampling has continued and currently has 11 years of monitoring data.

4.0 THEA FOSS WATERWAY SEDIMENT MONITORING

The purpose of this section is to evaluate time trends in sediment quality in post-remediation monitoring in the Thea Foss Waterway. When new sediment analytical results are available, they are compared to SQOs to determine if sediment quality in the waterway is being protected from ongoing sources. In addition, post-remediation sediment data are compared with computer model predictions to assess rates of change in waterway sediment concentrations and to extrapolate trends into the future.

The Utilities are responsible for collecting post-construction sediment quality data in the head of Thea Foss Waterway. The City is responsible for collecting post-construction sediment quality data in all other areas, including the middle and outer portions of the Thea Foss Waterway and in the Wheeler-Osgood Waterway. During this stormwater monitoring year, WY2012, no monitoring was required under either the Utilities' or the City's sediment monitoring programs and, therefore, no new results are available to present. Note that the Utilities' and the City's sediment monitoring programs are on different schedules because the remedial actions were completed at different times in different parts of the waterway. The City is scheduled to perform Year 7 monitoring under the sediment monitoring program in 2013, and the Utilities will be performing their Year 10 waterway sediment monitoring in 2014. Therefore, the next updated evaluation of time trends in sediment quality will be presented in the WY2013 report submitted in March 2014.

5.0 THEA FOSS PROGRAM EFFECTIVENESS: WATER YEARS 2001 TO 2012

In this section, program effectiveness of the Thea Foss Source Control Strategy is evaluated by linking source control activities, long-term outfall monitoring, post-construction sediment monitoring and WASP modeling (see Figure 1-1). Note that no new post-construction sediment monitoring was done during WY2012 so no additional evaluation of waterway impacts was performed during this monitoring period. The next round of in waterway sediment monitoring will be performed in WY2013, so an evaluation of stormwater results in the context of sediment impacts will be provided in next year's WY2013 report.

Long-term outfall monitoring is used to measure the effectiveness of Tacoma's SWMP and on-the-ground source control activities. Monitoring also provides information for setting priorities for future source control activities. Monitoring tools used to achieve this are temporal trend analysis and spatial trend analysis. Temporal trend analysis provides a measure of changes in the characteristics of the drainage basins over time by identifying increases or decreases of contaminant concentrations. These changes can be the result of source control activities, construction activities or other impacts in the basin that alter land use. Spatial trend analysis identifies particular municipal storm drains that may be significantly higher or lower in contaminant concentrations compared to other storm drains in the Foss Waterway Watershed and guides source control prioritization.

Each subsection includes a presentation of baseflow, stormwater and SSPM data. SSPM data help to provide information on extremely hydrophobic constituents such as mercury, HPAHs, DDTs, and PCBs, which have a strong affinity for sediments, but are poorly soluble and often not detectable in whole-water samples. In conjunction with baseflow and stormwater data, SSPM data are used to help the City, EPA, and Ecology identify areas of unusually elevated contaminants in the municipal drainages and to determine the need for focused source control work.

It should be noted that the spatial patterns observed in baseflow are not always consistent with those observed in stormwater and SSPM. Discrepancies between these data sets may be caused by differential transport of pollutants in dissolved and particulate phases or how the source is introduced into the system (e.g., below ground leak, illicit connection, contact with stormwater).

Post-construction surface sediment data from the waterway is used as another tool to evaluate the effectiveness of existing source controls in the Foss Waterway Watershed, whether additional source controls and BMPs for municipal stormwater discharges or other sources are necessary and appropriate, and if so, where and how they might best be implemented. As indicated above, since there is no new waterway sediment data available this year, this analysis was not performed this year.

Although the recommendations presented in this section are intended specifically for municipal outfalls and activities within their respective drainage basins, stormwater discharges must also be evaluated in the context of other source loads to the waterway. It is anticipated that chemical loads from other sources will be appropriately monitored and managed under other federal, state, and local regulatory programs.

5.1 OUTFALL 230

Many activities have occurred in the OF230 drainage basin, some of which may have contributed to improvements in the quality of baseflow, stormwater and SSPM. TSS, PAHs and DEHP show a marked improvement along with other contaminants that have source(s) linked to water quality concentrations. Figure 5-1a shows the annual average concentration for stormwater, baseflow and SSPM.

This section provides a summary of water/sediment quality results within the OF230 drainage basin and compares the water/sediment data results with the major source control and other activities that have occurred within the basin. A more detailed description of source control activities is provided in Appendix A.

5.1.1 Water and SSPM Quality

Annual and seasonal data for baseflow, stormwater and SSPM for the COCs and other parameters is used to identify ongoing areas of concern. The following paragraphs summarize the WY2001-WY2012 monitoring results for OF230, where COCs in this outfall are different from other Foss drainage basins, and where subsequent source control activities may be focused.

5.1.1.a TSS and Metals

Baseflow. TSS concentrations in OF230 baseflow (+2) are slightly above average (see Table 3-6a). TSS concentrations over the 10 year baseflow monitoring record were fairly consistent with the exception of Year 8 (WY2011) (see Figures G-11a, G-21a and 5-1a). During Year 8, the Broadway LID (street improvements in downtown Tacoma) was under construction. It is suspected that the Broadway LID construction is the source of the anomaly; however, no direct linkage to this source could be confirmed.

Baseflow quality in OF230 (+4) is elevated in zinc as compared to the other outfalls except for OF245 (see Table 3-6a and Figures F-13 and F-33). These baseflow concentrations remained fairly consistent during the 10 year baseflow monitoring period (see Figures G-13a and G-33a). Since this chemical is not a COC in Thea Foss Waterway, source control will not be a high priority for this chemical.

Stormwater. TSS concentrations in OF230 stormwater were some of the lowest mean and median observed in all the drainages (see Table 3-3 and Figures F-1 and F-21). Stormwater TSS concentrations in OF230 (-3) are well below average (see Table 3-7A). As shown in Figure 3-6a and Table 3-11, TSS has shown a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 63% reduction in TSS concentrations in OF230 in an 11 year period (see Table 3-11).

As shown in Figure G-2a, G-3a, G-22a, and G-23a, lead and zinc concentrations in stormwater have remained fairly consistent over the last 11 years. Stormwater quality in OF230 for the 11 year data set is slightly elevated in lead (+1) and neutral (0) for zinc as compared to the other outfalls (see Table 3-7A). When only the last year of monitoring data are evaluated (see Table 3-7B), zinc is slightly higher than other outfalls (+1) and lead is below average (-2) (see Table 3-7B).

SSPM. Storm sediment in OF230 is generally elevated in lead, mercury, and zinc (+2, +3 and +1, respectively) as compared to the other outfalls (see Table 3-9 and boxplots in Appendix F) when looking at the 11 year monitoring record. When looking at only the last 5 years of data (Table 3-9B), SSPM quality in OF230 is equivalent to the other basins (all 0).

The highest WY2012 SSPM concentrations for mercury in the watershed were found in the OF230 drainage basin (see Figure 2-1a). Mercury concentrations were highest at upline sediment trap locations FD18b, FD18, FD3a, and FD3-New (0.186 - 0.827 µg/kg) (see Figures 2-1a and 5-2a).

In WY2012, mercury concentrations at FD3a decreased from medium levels to low levels, but increased from low to high levels in FD3-New. Mercury at FD18 and FD18b increased from low in both locations in WY2011 to medium and high levels, respectively, in WY2012.

As shown in Figures 2-1a and 5-2a, mercury concentrations at all these locations generally decreased from WY2004 to WY2009 which is believed to be a result of the storm line cleaning project and removal of a point source (see Section 5.1.2 below). Due to increasing contamination levels in recent years (after point source removal and storm line cleaning), a source of mercury is likely still present.

5.1.1.b PAHs

Baseflow. Baseflow results over the 10 year baseflow monitoring record indicate that phenanthrene and pyrene levels are slightly worse (+1) in OF230 in comparison to other outfalls. No statistically significant results were observed for indeno(1,2,3-c,d)pyrene (Table 3-6a).

Stormwater. OF230 had similar levels of phenanthrene, pyrene, and indeno(1,2,3-c,d)pyrene in stormwater as compared to other outfalls (all at +1) when looking at the 11 year monitoring record (see Table 3-7A and boxplots in Appendix F). When looking at the most recent 1 year monitoring record, pyrene is better quality (-2) than other outfalls and phenanthrene and indeno(1,2,3-c,d)pyrene are of similar quality (0).

Most PAH concentrations in stormwater appear to have decreased in the last 6 years (see Figure 5-1a and figures in Appendix G). OF230 stormwater showed weak evidence of seasonality (see boxplots in Appendix H). As shown in Table 3-11 and Figures 3-6e, 3-6g, and 3-6i, PAHs (phenanthrene, pyrene and indeno(1,2,3-cd)pyrene) show a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 92 to 96% reduction in PAHs in OF230 in an 11 year period (see Table 3-11). In particular, there is a consistent decrease from WY2007 (Year 6) to WY2012 (Year 11) (see Figure 5-1a and boxplots in Appendix G) that occurred following cleaning of the storm lines (see Section 5.1.2).

SSPM. SSPM quality in OF230 is slightly enriched in indeno(1,2,3-cd)pyrene (+2), in phenanthrene (+1) and in pyrene (+1) (see Table 3-9 and boxplots in Appendix F). As shown in Figure 5-1a, SSPM PAH concentrations increased from WY2005 to WY2007. Since WY2007, PAH concentrations have remained fairly consistent. The data indicates there is a possible ongoing source(s) of PAHs in Basin 230 that is present in the stormwater sediments, but isn't seen in stormwater concentrations.

As shown in Figure 5-2a, FD3b and FD16b PAH concentrations have generally slowly decreased over the last 11 years with an increase in FD3b seen in WY2012. This increase will need to be watched in future year's SSPM results. All other OF230 sub-basins appear to have remained consistent over the last 11 years. The higher concentrations for total HPAHs and LPAHs in SSPM were found in FD3a with total PAHs ranging from 86,280 to 249,170 µg/kg in the past 11 years (see Figure 5-2a). However, these concentrations are considered to be relatively low level (see Figure 2-1b) and are therefore a lower priority for source control.

5.1.1.c Phthalates

Baseflow. The highest mean and maximum concentrations of DEHP in baseflow occurred in OF230 (see Table 3-2 and Figures F-20 and F-40). DEHP, however, is fairly ubiquitous and consistent in baseflow throughout all drainages except OF235 (see Table 3-6a). Over the 11 years, the peak phthalate concentrations occurred earlier in the monitoring program (WY2002 through WY2005) and baseflow phthalates gradually decreased through WY2011 (see Figures G-20a and G-40a).

OF230 showed weak evidence of seasonality in baseflow for DEHP (see boxplots in Appendix H). DEHP show qualitative evidence of higher dry season concentrations.

Stormwater. The second highest mean, median, and maximum concentrations of DEHP in stormwater were observed in OF230 (4.58, 3.39, and 44.1 µg/L, respectively) (see Table 3-3 and Figures F-8 and F-28). Unusually high peak concentrations of DEHP were observed in Year 7 (WY2008) in OF230, but these appear to be isolated occurrences (see Figures G-8a and G-28a). OF230 contains significantly elevated DEHP concentrations (+5) in stormwater when reviewing the 11 year monitoring record (see Table 3-7A). Elevated concentrations of DEHP in OF230 are not evident (0) when only the last year of monitoring data is evaluated (see Table 3-7B).

As shown in Table 3-11 and Figure 3-6k, DEHP shows a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 77% reduction in DEHP in OF230 in the 11 year period. In particular, there is a consistent decrease in phthalate concentrations from WY2008 to WY2012 (see Figures 5-1a, G-8a and G-28a) that occurred following cleaning of the storm lines (see Section 5.1.2).

OF230 also showed weak evidence of seasonality in stormwater for DEHP (see boxplots in Appendix H). DEHP show qualitative evidence of higher dry season concentrations.

SSPM. OF230 SSPM quality is slightly enriched (+1) in DEHP and total phthalates when looking at the entire 11 year monitoring record (see Table 3-9A and Figures F-49 and F-61). Within OF230, some of the highest concentrations of total phthalates were found in FD3a (max of 161,500 µg/kg in WY2004), in FD3b (max of 130,590 µg/kg in WY2005), FD16 (max of 161,860 µg/kg in WY2010), and in FD18 (max of 100,520 µg/kg in WY2004) (see Figures 2-1c and 5-2a). There may be a source(s) of phthalates at these locations within OF230.

5.1.1.d Pesticides

Baseflow and Stormwater. Pesticides are not a COC tested for under the 2001 SAP.

SSPM. The highest concentrations of DDT were found in OF230 (see boxplots in Appendix F) in SSPM samples. However, no statistically significant differences in DDT concentrations were observed among outfalls for the 11 year record (see Table 3-9A). DDT was found at 220 and 260 µg/kg at FD3a (WY2002 and WY2003, OF 230), which was at least 5 times greater than the other SSPM samples at this location (see Appendix D, Tables D-15 and D-16). DDT was not detected from WY2007 to WY2012 with the exception of 1 detection in FD10c in WY2010 at 50 µg/kg. DDT concentrations appear to be decreasing.

5.1.1.e PCBs

Baseflow and Stormwater. PCBs are not a COC tested for under the 2001 SAP.

SSPM. The highest concentrations in SSPM PCBs were found in OF230 (see boxplots in Appendix F). When detected, total PCBs range from 11 to 713 µg/kg and consist mainly of Aroclor 1254 and 1260. The concentrations observed at the outfall sediment trap (FD3-New) are up to 5 times greater than those observed in the other outfall sediment traps (see Figures F-51 and F-63). No statistically significant differences in quality were observed in SSPM between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

As shown on Figure 2-1d, PCBs concentrations at FD3a, FD3-New, FD18, and FD16 were at a high level before the 2007 cleaning project and were at low levels immediately following the cleaning (also see Figure 5-2a and Section 5.1.2). However, PCBs concentrations at FD3a were once again at high levels in WY2010 and WY2011, but returned to low levels in WY2012. PCB concentrations increased from low to high levels in FD16b in WY2012. PCBs concentrations at FD18 are also fluctuating between low, medium, and high levels after pipe cleaning. This suggests that there may be an ongoing source of PCBs in OF230.

5.1.2 Source Control Program Activities

Mercury Source Tracing Investigation. In 2006, during initial source investigation activities, a source of mercury was found near S. 11th Street and Yakima Avenue in a private parking area by Bates Technical College. Mercury laden sediment was removed from this private catch basin and post cleaning samples confirmed that the mercury source was removed. Also as a result of this investigation, a 75-100 year old deteriorated pipe from 15th to 13th Streets along Court A was abandoned and filled with CDF in the summer of 2007, and the stormwater was redirected to a new pipe on A Street.

As indicated above, intermittent mercury exceedences in SSPM in FD18b, FD18, FD3a and FD3 New indicate the likely presence of a remaining source. Therefore, a source tracing investigation was launched in 2012 to further investigate potential sources of mercury in this drainage basin. A copy of the source tracing report is included in Appendix A. Initial data obtained from the investigation have narrowed the areas from which the source of mercury appears to emanate. Additional investigation is currently underway to further target the source. It is expected that this investigation will be completed in 2013.

PCBs Source Tracing Investigation. Since the inception of the sediment trap monitoring program, intermittently high levels of PCBs have been identified in some of the OF230 sediment traps (see Figure 2-1d), but source control investigations to date have been unable to identify a source. Because of the likely presence of a remaining intermittent source, a source tracing investigation was launched in 2012 in conjunction with the mercury source tracing work described above, to further investigate potential sources of PCBs in this drainage basin. A copy of the source tracing report is included in Appendix A. Initial data obtained from the investigation have narrowed the areas from which a source of PCBs appears to emanate. Additional investigation is currently underway to further target the source. It is expected that this investigation will be completed in 2013.

Storm System Cleaning. In 2007, the municipal storm system in OF230 was cleaned and video inspected. The objective of this project was to remove residual sediments in the storm drains that may contain legacy contaminants. As discussed in detail in the WY2011 report (City of Tacoma 2012), storm system cleaning contributed to significant reductions in stormwater concentrations. Sewer line cleaning is an important component of the City's source control program. In combination with other source control activities, it appears to have been effective at removing 6 of the 7 compounds tested. Over time as sediments re-accumulate in the pipes, the systems will need to be cleaned again. The City is currently monitoring the results as shown in Figures 5-1a to 5-1g to determine the appropriate maintenance schedule for pipe cleaning projects.

Enhanced Street Sweeping Program. In January 2007, the City's street sweeping program was enhanced in an attempt to reduce sediment buildup in the storm sewer system. Under the enhanced program, the sweeping frequency was increased, air regenerative sweepers replaced mechanical sweepers, and the City also increased communications with residents, which helped raise awareness of the importance of the street sweeping program.

Statistically significant reductions were evident for TSS, lead, PAHs and DEHP (see Table 2-5). Street sweeping, along with other source control activities, resulted in reductions of TSS at 28%, lead at 23%, DEHP at 35% and PAH (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene) at 69 to 75%. PAHs in Figure 5-1a shows a consistent decrease from WY2007 to WY2012 that occurred following the start of street sweeping and the cleaning of the storm lines.

2010 Stormwater Pipe Retrofit Project. In 2010, 13,500 linear feet of existing storm sewer main was structurally rehabilitated in the OF230 drainage basin. The rehabilitation was accomplished by means of Cured-In-Place Pipe (CIPP) construction technologies using resin impregnated liners which fixed defects (cracks, holes, etc.) in the pipe that could have allowed potentially contaminated groundwater and soil from historic "hot spots" to enter the storm sewer system

The pre-construction and post-construction monitoring data were reviewed and statistically significant reductions in OF230 were evident for TSS, lead, zinc, PAHs and DEHP (see Table 2-6). CIPP lining, along with other source control activities, resulted in reductions of TSS at 53%, lead at 52%, zinc at 14%, DEHP at 77% and PAH (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene) at 85 to 89%.

General Source Control Activities. In addition to the ongoing investigation and maintenance activities described above, the City has, and is continuing to implement other source control program elements in the OF230 drainage basin which are described in more detail in Appendix A. Several other source control actions are currently underway in this basin, including the

Sauro's Cleanerama Site Remediation and the removal of USTs at the Former Heidelberg Brewery. In addition, the City responded to a report of a soapy discharge, which led to the issuance of a warning letter to a window washing company. Source control staff is also monitoring the Pacific Avenue streetscape project which began in late 2012 and is expected to continue through 2013. In addition, an extensive storm line CIPP retrofit project is planned for construction in 2013.

5.1.3 Outfall 230 2013 Work Plan

As shown in Table 3-11 and Figures 3-6a, 3-6b, 3-6e, 3-6g, 3-6i and 3-6k, TSS, lead, PAHs (phenanthrene, pyrene, and ideno(1,2,3-c,d)pyrene) and DEHP show a statistically significant improvement in OF230 stormwater quality from 2001 to present with an estimated 63% reduction for TSS, 56% for total lead, 92 to 96% reduction for each of the 3 index PAHs (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene), and 77% for DEHP in the 11 year period (see Table 3-11).

As described in detail above, OF230 monitoring results generally show:

- Baseflow – Significantly higher zinc (+4) than all other outfalls, except for OF245 (see Table 3-6a).
- Stormwater – Moderately lower TSS (-3), but significantly higher DEHP (+5) concentrations compared to other outfalls when evaluating the 11 year monitoring record (see Table 3-7a).
- SSPM - Outfall results show moderately higher mercury (+3) compared to other sediment trap locations (see Table 3-9A) when evaluating the entire 11 year monitoring record. Upline sediment traps show possible areas of concern for mercury, phthalates and PCBs.

Therefore, the following recommendations are included in the 2013 Work Plan for OF230:

- Continue source tracing for mercury and PCBs, in the area draining to FD18, FD18b, FD3a and FD3-New. Also analyze phthalates in conjunction with this investigation
- Perform initial screening investigation of source of PCBs in FD16b.
- Monitor the major construction activities in OF230 drainage basin including Pacific Avenue streetscape, A Street line replacement and treatment system, sanitary line replacements, and the CIPP pipe project.

5.2 OUTFALL 235

Many activities occurred in the OF235 drainage basin, some of which are contributing to improvements in baseflow, stormwater and SSPM quality. Statistically significant improvements in all index COCs (TSS, lead, zinc, PAHs, and DEHP) have been observed in stormwater in OF235 (Table 3-11). It is, therefore, likely that the City's source control efforts have helped to reduce these constituents in OF235. Figure 5-1b shows the annual average concentrations for stormwater, baseflow and SSPM.

This section provides a summary of water/sediment quality results within the OF235 drainage basin and compares the water/sediment data results with the major source control and other activities that have occurred within the basin. A more detailed description of source control activities is provided in Appendix A.

5.2.1 Water and SSPM Quality

Annual and seasonal data for baseflow, stormwater and SSPM for the COCs and other parameters is used to identify ongoing areas of concern. The following paragraphs summarize the WY2001-WY2012 monitoring results for OF235, where COCs in this outfall are different from other Foss drainage basins, and where subsequent source control activities may be focused.

5.2.1.a TSS and Metals

Baseflow. Some of the highest TSS concentrations (258 mg/L) were observed in OF235 (see Table 3-2 and Figures F-11 and F-31) in WY2006. TSS in OF235 baseflow is above average (+2) compared to other outfalls in the Thea Foss Watershed (see Table 3-6a). Over the 10 years of baseflow monitoring, TSS concentrations in baseflow decreased (see Figure 5-1b) with the exception of WY2006. The lowest average zinc concentration in baseflow was detected in WY2010.

OF235 also had the highest average, median and maximum baseflow concentrations of lead (14, 6.5 and 112 µg/L, respectively) (see Table 3-2 and Figures F-12 and F-32) and is most elevated in lead (+4) in comparison to other outfalls (see Table 3-6a).

For inorganic constituents (TSS, total lead, and total zinc), baseflow concentrations during dry season conditions appear to be higher than baseflow concentrations during wet season conditions (see boxplots in Appendix H).

Stormwater. Comparatively higher TSS concentrations were observed in stormwater with maximum (441 mg/L), mean (77 mg/L), and median (59 mg/L) TSS concentrations (Table 3-3). The highest maximum TSS concentration (441 mg/L) was observed in OF235 in WY2001 (see Table 3-3 and Figures F-1 and F-21).

TSS in OF235 is somewhat above average (+1) compared to other outfalls when looking at the entire 11 year monitoring record in the Thea Foss Watershed (see Table 3-7A). As shown in Table 3-11 and Figure 3-6a, TSS shows a statistically significant improvement in stormwater quality from 2001 to present with an estimated 62% reduction of TSS in 11 years. The trend is gradual over time and does not lend itself to be a direct result of any 1 action. Figures 5-1b, G-1a and G-21a also show the gradual downward trend of TSS over the last 11 years.

Comparatively higher mean, median and maximum lead concentrations were observed in OF235 stormwater in comparison to baseflow. OF235 is significantly elevated in lead (+6) and zinc (+3) compared to all other outfalls when looking at the 11 year monitoring record (see Table 3-7A). When only the last year of monitoring data is evaluated, lead is still significantly elevated (+5) in OF235, but zinc is only slightly elevated (+1) (see Table 3-7B).

Total lead and zinc in OF235 showed occasional evidence of seasonality (i.e., higher median, mean, and/or peak concentrations during dry season months) (see boxplots in Appendix H). This may be caused by more isolated storms and longer antecedent dry periods between storms.

As shown in Table 3-11 and Figure 3-6b and 3-6c, lead and zinc show a statistically significant improvement in stormwater quality from 2001 to present with an estimated

52% and 35% reduction respectively in 11 years. The trend is gradual over time and does not lend itself to be a direct result of any 1 action. Figure 5-1b and the boxplots in Appendix G also show the gradual trends of lead and zinc over the last 11 years. It is, therefore, possible that the City's source control efforts have helped to reduce lead and zinc in OF235. However, these stormwater concentrations indicate that there may be a source(s) of lead in OF235 since levels are above and beyond those found throughout the Thea Foss Watershed. Lead and zinc are not COCs in Thea Foss Waterway and as a result source control will not be a high priority for these chemicals.

SSPM. Consistent with stormwater results (+6), total lead in SSPM is elevated in OF235 (+2) (see Table 3-7A and Table 3-9A). Results for all other constituents are the same or slightly better than other outfalls (see Table 3-9A).

5.2.1.b PAHs

Baseflow. OF235 had similar levels of phenanthrene and pyrene concentrations in baseflow as compared to all the smaller drainages (see Figure F-4 and F-6). Phenanthrene is at average levels (0) and pyrene is at slightly elevated (+2) levels compared to other outfalls (see Table 3-6a) when reviewing the 10 year baseflow monitoring record. No statistically significant differences were observed for indeno(1,2,3-c,d)pyrene.

Similar to TSS, the highest mean or maximum concentrations of several HPAHs were reported in OF235 (including benzo(a)pyrene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene), mainly in WY2006 (see Table 3-2). This appears to have been an anomaly because such extreme concentrations have not been reproduced in the remaining 4 monitoring years. As shown in Figure 5-1b, LPAH and HPAH concentrations in baseflow have generally decreased from WY2007 to the end of baseflow monitoring (WY2011) with only a slight uptick for LPAHs in WY2011.

Stormwater. OF235 stormwater contained the highest mean, median, and/or maximum concentrations of the very light end compounds naphthalene and 2-methylnaphthalene and total LPAHs (see Table 3-3). ANOVA results show that OF235 is slightly above average for PAHs (phenanthrene at +1, pyrene at +2, and indeno(1,2,3-cd)pyrene at +1) when looking at the entire 11 year monitoring record (see Table 3-7A and boxplots in Appendix F). As shown in Figure 5-1b in the boxplots in Appendix G, LPAH and HPAH concentrations in stormwater have generally decreased from 2007 to present with very minor increases over the last couple of years. These decreases are believed to be due to the storm line cleaning project (see Section 5.2.2). When only the last year of monitoring data is evaluated, concentrations of PAHs are the same as the 11 year record with the exception of pyrene which is even more elevated (+3) compared to other outfalls (see Table 3-7B).

As shown in Table 3-11 and Figures 3-6e, 3-6g, and 3-6i, PAHs (phenanthrene, pyrene and indeno(1,2,3-cd)pyrene) show a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 92 to 95% reduction in PAHs in OF235 in an 11 year period (see Table 3-11).

SSPM. Average concentrations are relatively neutral (-1 to 0) for SSPM compared to the other outfalls. As shown in Figure 2-1b, PAH concentrations in storm sediment are considered low level and are similar to other outfall and upland locations. In fact, LPAH and HPAH concentrations in storm sediment have remained fairly consistent over the last 11 years (see Figure 5-1b).

5.2.1.c Phthalates

Baseflow. Baseflow concentrations during dry season conditions appear to be higher than baseflow concentrations during wet season conditions for DEHP (see Figures H-20a and H-40a). The highest median and second highest mean and maximum concentrations of DEHP in baseflow occurred in OF235 (see Table 3-2 and boxplots in Appendix F). Similar to TSS, the highest concentration occurred in August 2006 (21.3 µg/L). The highest mean and maximum di-n-octylphthalate concentrations also occurred in OF235 (see Table 3-2). This appears to have been an anomaly because such extreme concentrations were not reproduced in the remaining 4 baseflow monitoring years.

OF235 (+4) contains significantly elevated DEHP concentrations in baseflow, higher than all other outfalls (see Table 3-6a).

Stormwater. Consistent with the pattern observed with baseflow, the highest median, mean, and maximum stormwater concentrations of DEHP were also observed in OF235 (3.7, 6.0, and 97 µg/L, respectively). Unusually high peak concentrations of DEHP were observed in WY2003 (Year 2) in OF235, but these appear to be isolated occurrences (October 2002 and December 2002) and are not evident in recent years (see Table 3-3, Figure 5-1b and boxplots in Appendices F and G). The cause of the outliers during WY2003 is unknown.

DEHP is usually the phthalate compound with most frequent detections and the highest median concentrations. However, a higher maximum concentration of diethylphthalate was detected in OF235 stormwater (590 µg/L). OF235 (+5) contains significantly elevated DEHP concentrations, higher than all other outfalls except OF230 which is also +5 (see Table 3-7A). When only the last year of monitoring data are evaluated, DEHP concentrations in OF235 remains elevated (+3) and is higher than all other outfalls (see Table 3-7).

As shown in Table 3-11 and Figure 3-6k, DEHP shows a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 86% reduction in DEHP in OF235 in an 11 year period. In particular, there is a consistent decrease in phthalate concentrations from 2005 (Year 4) to 2012 (Year 11) (see Figures 5-1b, G-8a and G-28a) which is believed to be due to the storm line cleaning project and other source control activities (see Section 5.2.2).

SSPM. Even though DEHP in OF235 was significantly elevated in stormwater (+5), in storm sediment, the average concentration is neutral (0) compared to the other outfalls (see Table 3-9 and Figures F-49 and F-61). As shown in Figure 2-1c, phthalate concentrations are at low levels in OF235 and are similar to other outfall and upland locations. In fact, phthalate concentrations in storm sediment have remained fairly consistent over the last 11 years (see Figure 5-1b). Discrepancies between the stormwater and storm sediment data sets may be caused by differential transport of pollutants in dissolved and particulate phases. Source control investigations will look at sources that lend themselves to transport in dissolved phases.

Within OF235, total phthalate concentrations at location FD6a remain greater than phthalate concentrations at FD6b (see Figure 5-2b). In 2010, the highest levels to date were detected at FD6a. This indicated a possible source of phthalates in the area draining to FD6a. However, OF235 SPMM total phthalate concentration is consistent in storm sediment throughout the various drainages and as a result source control will be given a lower priority for phthalates (see Table 3-9A).

5.2.1.d Pesticides

Baseflow and Stormwater. Pesticides are not a COC tested for under the 2001 SAP.

SSPM. No statistically significant differences in quality were observed in SSPM in DDT between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

5.2.1.e PCBs

Baseflow and Stormwater. PCBs are not a COC tested for under the 2001 SAP.

SSPM. No statistically significant differences in quality were observed in SSPM between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

5.2.2 Source Control Program Activities

Enhanced Street Sweeping Program. In January 2007, the City's street sweeping program was enhanced in an attempt to reduce sediment buildup in the storm sewer system. Under the enhanced program, the sweeping frequency was increased, air regenerative sweepers replaced mechanical sweepers, and the City also increased communications with residents, which helped raise awareness of the importance of the street sweeping program.

Statistically significant reductions were evident for TSS, lead, zinc, PAHs and DEHP (see Table 2-5). Street sweeping, along with other source control activities, resulted in reductions of TSS at 46%, lead at 40%, zinc at 30%, DEHP at 70% and PAH (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene) at 63 to 66%.

Storm System Cleaning. In 2007, the municipal storm system in OF235 was cleaned and video inspected. The objective of this project was to remove residual sediments in the storm drains that may contain legacy contaminants. As discussed in detail in the WY2011 report (City of Tacoma 2012) storm system cleaning contributed to significant reductions in stormwater concentrations. Sewer line cleaning is an important component of the City's source control program. In combination with other source control activities, it appears to have been effective at removing all 7 of the compounds tested. Over time as sediments re-accumulate in the pipes, the systems will need to be cleaned again. The City is currently monitoring the results as shown in Figures 5-1a to 5-1g to determine the appropriate maintenance schedule for pipe cleaning projects.

General Source Control Activities. In addition to the ongoing maintenance activities described above, the City is continuing to implement other source control program elements in the OF235 drainage basin which are summarized here and described in more detail in Appendix A. Several other source control actions are currently underway in this basin, including UST removal at the former Heidelberg Brewery site and the UW Joy Building under TPCHD oversight. A warning letter was issued to a contractor for failure to implement BMPs during construction activities. In addition, a planned storm line retrofit project in the Hood Street corridor which will include a regional stormwater treatment facility, and an extensive storm line CIPP retrofit project are expected to begin construction in 2013.

5.2.3 Outfall 235 2013 Work Plan

TSS, lead, zinc, DEHP, and PAHs have all shown a statistically significant improvement in stormwater quality from 2001 to present (see Table 3-11 and Figures 3-6a, 3-6b, 3-6c, 3-6e, 3-6g, 3-6i and 3-6k). As shown in Table 3-11, TSS shows an estimated 62% reduction over 11 years, lead at 52%, zinc at 35%, DEHP at 86% and PAHS (both light and heavy PAH fractions) at 92 to 95% reductions.

As described in detail above, OF235 results generally show:

- Baseflow – Significantly higher lead (+4) and DEHP (+4) than all other outfalls (see Table 3-6a).
- Stormwater – Moderately higher zinc (+3) and significantly higher lead (+6) and DEHP (+5) as compared to other outfalls when evaluating the 11 year monitoring record (see Table 3-7A).
- SSPM – Slightly higher lead (+2) compared to other sediment trap locations (see Table 3-9A) when evaluating the entire 11 year monitoring record.

Therefore, the following recommendations are included in the 2013 Work Plan for the OF235 drainage basin:

- Complete design and begin construction of the Hood Street Treatment Retrofit Project in 2013 and 2014.
- Monitor the major construction activities in the drainage basin including the CIPP pipe project.
- Area draining to FD6A is somewhat higher than other branches of OF235 in PAH concentrations in stormwater, and stormwater concentrations at the outfall rank highest overall. Evaluate need for additional source control following installation of the Hood Street treatment device.

5.3 OUTFALL 237A

Many source control efforts have been targeted in the OF237A drainage basin and have resulted in improvements in baseflow, stormwater and SSPM quality. Zinc, PAHs and DEHP concentrations have shown a statistically significant improvement in stormwater quality from 2001 to present with an estimated 32% reduction in zinc concentrations, and 77 to 97% reduction in DEHP and PAHs concentrations in 11 years. Statistically significant trends for TSS and lead were observed in Year 10, but not in Year 11 (WY2012); this is likely due to the updated data set used for statistical analysis that combines historical OF237A data with recent OF237A New data (see Section 3.2.4).

This section provides a summary of water/sediment quality results within the OF237A drainage basin and compares the water/sediment data results with the major source control and other activities that have occurred within the basin. A more detailed description of source control activities is provided in Appendix A.

5.3.1 Water and SSPM Quality

Annual and seasonal data for baseflow, stormwater and SSPM for the COCs and other parameters is used to identify ongoing areas of concern. The following paragraphs summarize the WY2001-WY2012 monitoring results for OF237A, where COCs in this outfall are different from other Foss drainage basins, and where subsequent source control activities may be focused. As described in Section 3.2.4, the OF237A (for data prior to February 26, 2006) and OF237A New data sets (for data after February 26, 2006) were merged this year. While the data sets are generally the same, the box plots in Appendix G appear to show a change in the data in between WY2006 (Year 5) and WY2007 (Year 6). This suggests that there are small differences in the 2 sampling locations.

5.3.1.a TSS and Metals

Baseflow. OF237A, along with OF237B, by far the largest of the baseflow discharges, exhibit the lowest concentrations of TSS and metals compared to the smaller drains OF230, OF235, OF243, OF245 and OF254 (see box plots in Appendix F). This may be due to significant contributions from inflowing surface water (creeks) and groundwater (springs) to the baseflow in these 2 drainages (see Appendix B, Figure B-2). In fact, OF237A (-4 to -5) exhibited consistently lower TSS, lead and zinc concentrations in baseflow compared to the other outfalls (see Table 3-6a).

Stormwater. Stormwater TSS, lead and zinc concentrations at OF237A (-2, -3 and -2, respectively) are also well below average (see Table 3-7A). In stormwater, OF237A generally had the lowest mean and median TSS concentrations. As shown in Figure 3-6c and Table 3-11, zinc shows a statistically significant improvement (32% reduction) in stormwater quality from 2001 to present.

SSPM. OF237A also exhibits lower concentrations of indicator metals in SSPM, compared to the smaller drains OF230, OF243, and OF245 (see boxplots in Appendix F). ANOVA statistical tests on SSPM showed that OF237A is relatively neutral (-1 to -2) in metals (lead, mercury, and zinc) (see Table 3-9A) compared to other outfalls for the 11 year monitoring record. When looking at only the last 5 years of monitoring data, no statistically significant differences were observed in comparison to other outfalls (see Table 3-9B).

5.3.1.b PAHs

Baseflow. The mean concentrations and interquartile ranges of PAHs in baseflow in OF237A and OF237B are lower than all other drains, and are characterized by fewer extreme values. ANOVA tests show that OF237A baseflow concentrations were well below average for pyrene (-4) and neutral for phenanthrene (0) (see Table 3-6a). No outfalls can be differentiated on the basis of indeno(1,2,3-cd)pyrene. Two major source control actions, the DA-1 Line and UST removal at Key Bank, along with storm line cleaning and other source control activities appear to have contributed to the significant reduction in PAH concentrations in the baseflow.

Stormwater. The average concentrations of several of the lighter PAH compounds were relatively similar in baseflow and stormwater samples. OF237A stormwater quality also shows some evidence of being enriched in HPAHs. Higher mean, median and/or maximum concentrations of several HPAHs were observed in OF237A (see Table 3-3 and boxplots in Appendix F) compared to other drains. However, PAH concentrations over the last 4 years (Years 8 through 11) were relatively low compared to the previous monitoring years.

ANOVA results showed that OF237A is above average for the HPAHs pyrene (+2) and indeno(1,2,3-c,d)pyrene (+1) relative to other drainages (see Table 3-7A) over the 11 year monitoring record. When looking at the most recent 1 year monitoring record (see Table 3-7B), OF237A is generally neutral (-1 to 0) for the HPAHs pyrene and indeno(1,2,3-c,d)pyrene.

As shown in Table 3-11 and Figures 3-6e, 3-6g, and 3-6i, PAHs (phenanthrene, pyrene, and indeno[1,2,3-cd]pyrene) show a statistically significant improvement in stormwater quality from 2001 to present. There is an estimated 95 to 97% reduction in 11 years. This is likely due to a combination of actions including the point source removals and sewer line cleaning projects. Boxplots in Appendix G also show the gradual trends of PAHs in stormwater.

SSPM. As shown in Table 3-9, storm sediment in OF237A is slightly enriched in PAHs with phenanthrene, indeno(1,2,3-c,d)pyrene and pyrene all at +1. PAHs in SSPM have remained fairly stable over the last eleven years (see Figure 5-1c) with the exception of WY2009 which had slightly lower concentrations. Figure 2-1b shows that PAH concentrations at FD13b remained elevated at medium levels in WY2011, but dropped to low levels in WY2012. In WY2012, all sediment traps in OF237A were at low levels (see Figure 2-1b).

5.3.1.c Phthalates

Baseflow. OF237A baseflow exhibits slightly lower DEHP levels (-1) compared to other outfalls (see Table 3-6a). Baseflow concentrations also have the highest maximum diethylphthalate concentrations of all outfalls.

Stormwater. As shown in Table 3-11 and Figure 3-6k, DEHP show a statistically significant improvement in stormwater quality from 2001 to present. There is an estimated 77% reduction in 11 years (see Table 3-11). The trend is gradual over time and does not lend itself to be a direct result of any 1 action (see boxplots in Appendix G and Figure 5-1c).

In comparison to other outfalls, DEHP in OF237A is slightly better quality (-2 and -1 respectively) over the entire 11 year monitoring record and the only the last 5 year data set (see Table 3-7A).

SSPM. DEHP concentrations in OF237A are of similar quality (0) as other outfalls (see Table 3-9A) when looking at the 11 year monitoring record.

Total phthalate concentrations in SSPM at all but 2 sediment traps were detected at similar concentrations as those found throughout the Thea Foss Waterway (see Figure 2-1c). At location FD10c, total phthalate concentrations are the highest observed in the OF237A drainage basin (52,570 to 93,560 µg/kg) (see Figure 2-1c and 5-2c). The concentrations have remained fairly consistent for the last 10 years indicating that there is an ongoing source(s) in this sub-basin. Therefore, additional source control for FD10c is needed.

5.3.1.d Pesticides

Baseflow and Stormwater. Pesticides were not detected at the reporting limits in whole-water samples and are therefore not a COC.

SSPM. No statistically significant differences in quality were observed in SSPM in DDT between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

5.3.1.e PCBs

Baseflow and Stormwater. PCBs were not detected at the reporting limits in whole-water samples and are therefore not a COC.

SSPM. No statistically significant differences in quality were observed in SSPM between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

In WY2006, PCBs concentrations at all locations were the highest measured in the OF237A drainage basin, ranging from 177 to 390 µg/kg (see Figure 5-2c). Since WY2006 and after the pipe cleaning in 2007, PCB concentrations in SSPM have decreased in concentration. From WY2007 to present, PCB concentrations in the OF237A drainage basin are similar to those found throughout the Foss Waterway Watershed (see Figure 2-1d).

5.3.2 Source Control Program Activities

Point Source Removal. In 2002, Washington State Department of Transportation (WSDOT) removed and sealed the DA-1 Line French drain system that was believed to be a source of PAHs from historical coal tar deposits on the Standard Chemical Site (S. 23rd and “A” Streets) (OF237A FD2a branch). In response to this action, PAH concentrations in baseflow decreased in WY2003 and WY2004 (see Figure 5-1c).

In 2007, Key Bank completed a cleanup of a diesel tank that had leaked into surrounding soils and the storm sewer system from a back-up generator’s return fuel line. This is in the sub-basin draining to FD13b. As shown in Figure 5-1c, PAHs concentrations in baseflow decreased in WY2008 and have remained fairly consistent since (also see boxplots in Appendix G).

Enhanced Street Sweeping Program. In January 2007, the City’s street sweeping program was enhanced in an attempt to reduce sediment buildup in the storm sewer system. Under the enhanced program, the sweeping frequency was increased, air regenerative sweepers replaced mechanical sweepers, and the City also increased communications with residents, which helped raise awareness of the importance of the street sweeping program.

Statistically significant reductions were evident for zinc, PAHs and DEHP (see Table 2-5). Street sweeping, along with other source control activities, resulted in reductions of zinc at 16%, DEHP at 49% and PAH (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene) at 58 to 64%.

Storm System Cleaning. Targeted areas in the northern portion of the 237A system were cleaned in 2008. The objective of this project was to remove residual sediments in the storm drains that may contain legacy contaminants. As discussed in detail in the WY2011 report (City of Tacoma 2012), storm system cleaning contributed to significant reductions in stormwater concentrations. Sewer line cleaning is an important component of the City’s source control program. In combination with other source control activities, it appears to have been effective at removing 5 of the 7 compounds tested. Over time as sediments re-accumulate in the pipes, the systems will need to be cleaned again. The City is currently monitoring the results as shown in Figures 5-1a to 5-1g to determine the appropriate maintenance schedule for pipe cleaning projects.

Media Filtration System Installation. In 2010, the City installed a media filtration system that treats stormwater from the FD13 sub-basin, approximately 50 acres in size. After 1 year, FD13, which is immediately downstream of the media filtration system, had minimal sediment and no sample was submitted for analysis. In WY2012, the concentration of PAHs had decreased to the low range.

General Source Control Activities. In addition to the ongoing investigation and maintenance activities described above, the City is continuing to implement other source control program elements in the OF237A drainage basin which are summarized here and described in more detail in Appendix A. Several other source control actions are currently underway in this basin, including UST removal actions at several sites under TPCHD oversight. In addition, a warning letter and Notice of Violation was issued for discharge of turbid water during construction of the Sound Transit D to M Streets Track and Signal Project near South Tacoma Way (see Appendix A).

5.3.3 Outfall 237A 2013 Work Plan

In Basin 237A, zinc, PAHs and DEHP concentrations have shown a statistically significant improvement in stormwater quality from 2001 to present with an estimated 32% reduction of zinc concentration, and a 77 to 97% reduction of DEHP and PAHs concentrations over the 11 years of monitoring (Table 3-11 and Figure 3-6). The decrease in these concentrations appears to have resulted not only from removal/control of point sources, but also from the combination of many other activities.

As described in detail above, OF237A results generally show:

- Baseflow – Significantly lower TSS (-5), lead (-4), zinc (-5), and pyrene (-4) compared to other outfalls (see Table 3-6A).
- Stormwater – Moderately lower TSS (-2), lead (-3), and zinc (-2) compared to other outfalls, and slightly higher pyrene and indeno(1,2,3-cd)pyrene (+2 and +1 respectively) when evaluating the 11 year monitoring record (see Table 3-7A).
- SSPM – Slightly lower mercury (-2) and butylbenzylphthlate (-2) compared to other sediment trap locations (see Table 3-9A) when evaluating the entire 11 year monitoring record.

Therefore, the following recommendations are included in the 2013 Work Plan for OF237A:

- Review the WY2013 SSPM data for FD13 to monitor improvement from the stormwater treatment retrofit along with an evaluation of the information to advise the establishment of a maintenance schedule.
- Investigate potential sources of phthalates in the area draining to FD10c.
- Continue to monitor the TPCHD-lead UST removal at the EZ Mart site near FD31.
- Continue to monitor the major construction activities including the WSDOT Nalley Valley Viaduct/SR-16 rebuild.

5.4 OUTFALL 237B

OF237B exhibits the best overall baseflow and stormwater quality with some of the lowest median concentrations for the COCs in baseflow, stormwater and stormwater SSPM. Figure 5-1d shows the annual average concentration for stormwater, baseflow and SSPM. All 7 indicator parameters (TSS, metals, PAHs and DEHP) have shown a statistically significant improvement in stormwater concentrations from WY2002 through WY2012.

This section provides a summary of water/sediment quality results within the OF237B drainage basin and compares the water/sediment data results with the major source control and other activities that have occurred within the basin. A more detailed description of source control activities is provided in Appendix A.

5.4.1 Water and SSPM Quality

Annual and seasonal data for baseflow, stormwater and SSPM for the COCs and other parameters is used to identify ongoing areas of concern. The following paragraphs summarize the WY2001-WY2012 monitoring results for OF237B, where COCs in this outfall are different from other Foss drainage basins, and where subsequent source control activities may be focused.

5.4.1.a TSS and Metals

Baseflow. OF237B along with OF237A, by far the largest of the baseflow discharges, exhibit the lowest concentrations of TSS and metals, compared to the smaller drains OF230, OF235, OF243, OF245 and OF254 (see boxplots in Appendix F). This may be caused by significant contributions from inflowing surface water (creeks) and groundwater (springs) to the baseflow in these 2 drainages. As shown in Table 3-6a, OF237B exhibited consistently lower TSS, total lead and total zinc concentrations (-5) in baseflow compared to the other outfalls (except OF237A which is of similar quality).

Stormwater. As shown in Table 3-11 and Figures 3-6a to 3-6c, TSS, lead and zinc concentrations show a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 49 to 53% reductions, in TSS, lead and zinc in OF237B in the 11 year period.

In comparison to other outfalls, TSS (-1) concentrations are slightly better while lead (-4) and zinc (-6) concentrations are significantly better when looking at the 11 year monitoring record (see Table 3-7A). When only the last year of monitoring data is evaluated, OF237B results are similar (e.g., TSS at -2, lead at -3, and zinc at -6), but slightly less pronounced due to the smaller dataset.

SSPM. As shown in Table 3-9, SSPM in OF237B contains relatively lower concentrations (-2 to -3) of metals (also see boxplots in Appendix F).

Within the OF237B drainage basin, mercury was detected at higher concentrations in recent years at FD34 which has periodic medium level concentrations (see Figure 2-1a).

5.4.1.b PAHs

Baseflow. The mean concentrations and interquartile ranges of PAHs in baseflow in OF237B are lower than all other drains, and baseflow quality in this drain is generally characterized by fewer extreme values (see boxplots in Appendix F). Baseflow in

OF237B exhibited consistently lower concentrations of phenanthrene (-2) and pyrene (-5) compared to the other outfalls (see Table 3-6a).

HPAHs were found in baseflow in WY2004 (see boxplots in Appendix G). HPAH concentrations in baseflow for the remaining years were largely undetected. This indicates that a source of the HPAH in WY2004 has since been controlled.

Stormwater. As shown in Table 3-7A, stormwater in OF237B contains somewhat lower concentrations of phenanthrene (-3) and pyrene (-3) and slightly elevated in indeno(1,2,3-c,d)pyrene (+1) when looking at the 11 year monitoring record. When looking only at the last year of monitoring data, the basin is neutral (0 to -2) to slightly better than other outfalls (Table 3-7B).

PAHs concentrations in stormwater have shown a statistically significant improvement from WY2002 through WY2012 with an 91 to 95% reduction in pyrene, phenanthrene, and indeno(1,2,3-c,d)pyrene in 11 years (see Table 3-11).

SSPM. As shown in Table 3-9, SSPM in OF237B is neutral to slightly enriched in PAHs, phenanthrene (0), pyrene (+1), and indeno[1,2,3-cd]pyrene (0).

As shown in Figure 2-1b, PAHs in SSPM at FD31 have ranged from low to high levels in recent years with medium levels present in WY2012 suggesting an ongoing or new source is present. One point source removal has been completed near this location, a UST at Willard School, and another UST removal at the EZ Mart is currently being performed under TPCHD oversight (see Appendix A).

5.4.1.c Phthalates

Baseflow. OF237B baseflow exhibits slightly lower DEHP levels (-1) compared to other outfalls (see Table 3-6a). DEHP concentrations have been relatively constant over the 10 year baseflow monitoring record (see boxplots in Appendix G).

Stormwater. As shown in Table 3-11 and Figure 3-6k, DEHP concentrations show a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 85% reduction in an 11 year period (see Table 3-11).

In comparison to other outfalls, DEHP in OF237B is slightly better quality over the entire 11 year monitoring record (-2) and in only the last year of monitoring data (-1) (see Table 3-7B).

SSPM. DEHP (-2), butylbenzylphthalate (-2) and total phthalate (-3) concentrations in SSPM are somewhat lower than observed in other locations (see Table 3-9A and boxplots in Appendix F). No areas of concern were noted in the upline sediment traps.

5.4.1.d Pesticides

Baseflow and Stormwater. Pesticides are not a COC tested for under the 2001 SAP.

SSPM. No statistically significant differences in quality were observed in SSPM in DDT between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

5.4.1.e PCBs

Baseflow and Stormwater. PCBs were not detected at the reporting limits in whole-water samples and are therefore not a COC.

SSPM. No statistically significant differences in quality were observed in SSPM between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

In the upline traps, FD34 and FD35 have had intermittent concentrations of concern for total PCBs (see Figure 2-1d). In WY2012, FD34 levels were again in the high range. Investigations to date have not located a possible source of PCBs. Due to the high levels seen in WY2012, a source control investigation is currently underway.

5.4.2 Source Control Program Activities

FD31 PAH Investigation. TPH and PAH concentrations in SSPM decreased at FD31 in WY2011 as a result of the removal of leakage from an UST at Willard Staff School and from a neighborhood fueling station which closed (see Figure 2-1b). In addition, the City cleaned and video inspected the FD31 branch as part of the PAH source tracing investigation. However, PAH concentrations since WY2008 at FD31 have intermittently been at concentrations of concern (see Figure 2-1b). In 2011, TPCHD began the process of initiating a Phase I/II assessment of 3402 Pacific Avenue, EZ Food Mart. This action is continuing at this time. Once the UST removal is complete and more SSPM data are available, the need for additional source tracing efforts for PAHs in this sub-basin will be evaluated.

PCB and Mercury Source Tracing in FD34 and FD35. PCBs have been found intermittently over time in the sub-basins draining to FD34 and FD35 (see Figure 2-1d). A source tracing investigation to try to narrow the source of PCBs in this area was initiated in 2012. Initial results narrowed the source to 1 leg of the drainage system leading to FD34 and additional source tracing is currently underway. A report on the current status of this investigation is included in Appendix A.

Enhanced Street Sweeping Program. In January 2007, the City's street sweeping program was enhanced in an attempt to reduce sediment buildup in the storm sewer system. Under the enhanced program, the sweeping frequency was increased, air regenerative sweepers replaced mechanical sweepers, and the City also increased communications with residents, which helped raise awareness of the importance of the street sweeping program.

Statistically significant reductions were evident for TSS, lead, zinc, PAHs and DEHP (see Table 2-5). Street sweeping, along with other source control activities, resulted in reductions of TSS at 22%, lead at 30%, zinc at 28%, DEHP at 55% and PAH (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene) at 56 to 64%.

Storm System Cleaning. In 2010-2011, targeted areas in the northern portion of the OF237B system were cleaned and video inspected. The objective of this project was to remove residual sediments in the storm drains that may contain legacy contaminants. As discussed in detail in the WY2011 report (City of Tacoma 2012), storm system cleaning contributed to significant reductions in stormwater concentrations. Sewer line cleaning is an important component of the City's source control program. In combination with other source control activities, it appears to have been effective at removing 6 of the 7 compounds tested. Over time as sediments re-accumulate in the pipes, the systems will need to be cleaned again. The City is currently monitoring the results as shown in Figures 5-1a to 5-1g to determine the appropriate maintenance schedule for pipe cleaning projects.

General Source Control Activities. In addition to the ongoing investigation and maintenance activities described above, the City is continuing to implement other source control program elements in the OF237B drainage basin which are summarized here and described in more detail in Appendix A.

5.4.3 Outfall 237B 2013 Work Plan

TSS, metals (lead and zinc), PAHs and DEHP concentrations in stormwater have shown a statistically significant improvement from WY2002 through WY2012 (see Figures 3-6a to 3-6c, 3-6e, 3-6g, 3-6i, and 3-6k). There has been an estimated 49 to 53% reduction of TSS and metals concentrations in 11 years and an 85% reduction of concentration for DEHP in 11 years (see Table 3-11). PAHs showed an 91 to 95% reduction in 11 years for the index PAHs (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene). This improvement is believed to be the result of the combination of all source control activities within the basin, including business and multi-family inspections, maintenance activities and public education.

OF237B exhibits the best overall baseflow and stormwater quality with some of the lowest median concentrations for the COCs (see Table 3-6 and Table 3-7). SSPM quality in OF237B is also of better quality than other Foss basins (see Table 3-9).

As described in detail above, OF237B results generally show:

- Baseflow – Significantly lower TSS (-5), lead (-5), zinc (-5), and pyrene (-5) compared to other outfalls (see Table 3-6a).
- Stormwater – Moderately lower phenanthrene (-3) and pyrene (-3) and significantly lower lead (-4) and zinc (-6) compared to other outfalls when evaluating the 11 year monitoring record (see Table 3-7).
- SSPM – Moderately lower lead (-3), zinc (-3), TPH-Heavy Oil (-3), and total phthalates (-3) compared to other sediment trap locations (see Table 3-9A) when evaluating the entire 11 year monitoring record.

Therefore, the following recommendations are included in the 2013 Work Plan for the OF237B drainage basin:

- Continue source tracing investigation for PCBs near FD34 and FD35.
- Monitor TPCHD activities at the site of the neighborhood fueling station (EZ Mart) and re-inspect the FD31 branch, if needed, for other possible sources of PAHs and TPHs.

5.5 OUTFALL 243

Many activities have occurred in Basin 243 in recent years. Some of these activities have resulted in improvements in stormwater and SSPM quality. Figure 5-1e shows the annual average contaminant concentrations for stormwater, baseflow and SSPM. PAHs and DEHP concentrations show a statistically significant improvement in stormwater quality.

This section provides a summary of water/sediment quality results within the OF243 drainage basin and compares the water/sediment data results with the major source control and other activities that have occurred within the basin. A more detailed description of source control activities is provided in Appendix A.

5.5.1 Water and SSPM Quality

Annual and seasonal data for baseflow, stormwater and SSPM for the COCs and other parameters is used to identify ongoing areas of concern. The following paragraphs summarize the WY2001-WY2012 monitoring results for OF243, where COCs in this outfall are different from other Foss drainage basins, and where subsequent source control activities may be focused.

5.5.1.a TSS and Metals

Baseflow. WY2003 (Year 2) TSS and total metals (lead and zinc) data in OF243 baseflow exhibit higher than average variability (i.e., >80%) (see boxplots in Appendix G). This is believed to be due to major land disturbance activities (e.g., bank construction disturbances at the beginning of the Thea Foss Waterway remediation project, Pick's Cove redevelopment, and American Plating remediation) that occurred in 2002 and 2003.

In WY2007 (Year 6), TSS and total lead data in OF243 baseflow exhibit slightly higher means (see boxplots in Appendix G) which are believed to be due to land disturbances associated with construction of the D Street Overpass.

Baseflow concentrations appear to be relatively consistent among outfalls (+2 for TSS), although mean values are somewhat elevated in OF243 (see Table 3-6a and boxplots in Appendix F). Total lead is moderately elevated in baseflow (+3) as compared to all other outfalls. Lead and zinc concentrations also appear to be higher in the dry season compared to the wet season (see boxplots in Appendix H).

Stormwater. TSS (-1) and zinc (-2) are of slightly better quality than other basins, while total lead is moderately elevated in stormwater at OF243 (+4) as compared to all other basins (see Table 3-7 and boxplots in Appendix F). The highest overall lead concentration (379 µg/L) and zinc concentration (1,170 µg/L) were detected in OF243 (Table 3-3). These outliers appear to be relatively isolated occurrences (see boxplots in Appendix G).

As shown in Figure 5-1e, TSS and zinc concentrations in stormwater have remained fairly consistent over the last 11 years. No significant trends were detected for TSS, lead or zinc over the 11 year monitoring record.

Similar to baseflow, lead and zinc stormwater concentrations during dry season conditions appear to be higher than concentrations during wet season conditions (see boxplots in Appendix H). This may be caused by more isolated storms and longer antecedent dry periods between storms. If metals continue to be of concern, increasing source control activities, such as sweeping in the dry season may be warranted.

SSPM. Storm sediment in OF243 is elevated in lead (+3), mercury (+3) and zinc (+2) (see Table 3-9A) when looking at the 11 year monitoring record. When only looking at the most recent 5 year data set, results are similar (lead at +2, mercury at +1, and zinc at +1) but less pronounced due to the smaller data set.

Some of the highest SSPM concentrations of lead, mercury, and zinc were detected consistently at FD23 (see boxplots in Appendix F). Lead and zinc concentrations at these outfalls were still generally 2 to 10 times higher than the other SSPM samples (see Tables D-15 and D-16). As shown in Figure 5-1e, zinc concentrations in SSPM samples have remained fairly consistent over the last 11 years with slight increases seen over the last several years. Lead and zinc are not currently a major concern in the Thea Foss Waterway sediments, but additional source control work may be considered when additional results are available.

As shown in Figure 2-1a, medium to high levels of mercury are present at FD23. This indicates that there may be a source(s) of mercury within the OF243 drainage basin and additional investigation is warranted.

5.5.1.b PAHs

Baseflow. OF243 had similar levels of phenanthrene (0) (see Table 3-6a). Pyrene concentrations in baseflow were slightly elevated (+2) as compared to other drainages. No statistically significant differences were observed for indeno(1,2,3-c,d)pyrene.

Over the 10 years of baseflow monitoring, the PAH concentrations were dominated by the LPAH acenaphthene (see LPAHs and HPAHs in Figure 5-1e). The average concentrations of acenaphthene in OF243 were 0.030 μg/L in baseflow (Table 3-2) and at 0.018 μg/L in stormwater. Acenaphthene was detected in 95% of the baseflow samples (Table E-5). The median concentration for the baseflow samples was higher than the median concentration for the outfalls' stormwater samples (0.028 and 0.017 μg/L, respectively). These results indicate that there may be a source(s) of acenaphthene which is diluted by stormwater. The source of these acenaphthene during baseflow conditions is unknown in this basin. Figure 5-1e shows that PAH concentrations in baseflow have remained generally the same over the 10 years of baseflow monitoring with slight decreases in HPAHs in WY2011.

Stormwater. OF243 is neutral to slightly lower (0 to -1) for PAHs in comparison to other outfalls (see Table 3-7 and boxplots in Appendix F).

As shown in Table 3-11 and Figures 3-6f, 3-6h and 3-6i, PAHs (phenanthrene, pyrene, and indeno[1,2,3-cd]pyrene) are showing a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 89 to 93% reductions in OF243 in an 11 year period. As shown in Figure 5-1e, PAH concentrations in stormwater were fairly stable from WY2002 until WY2007. From WY2007 to WY2009 the concentrations decreased, and they have remained fairly stable from WY2009 to present.

SSPM. In SSPM, LPAHs and HPAHs concentrations at OF243 were not substantially different from other outfalls (all 3 indicator COCs at 0) (see Table 3-9 and Figure 2-1b).

5.5.1.c Phthalates

Baseflow. DEHP is to be relatively consistent in baseflow among outfalls (except OF235) with OF243 at slightly below average (-1) (see Table 3-6a).

The highest baseflow DEHP concentration (16 µg/L) on the eastside of the waterway was measured in OF243 during WY2010. This wasn't repeated in WY2011 indicating that this may have been a 1 time occurrence.

Stormwater. DEHP appears to be relatively consistent among outfalls (except OF230 and OF235) (see Table 3-7). Figure 5-1e shows total phthalate concentrations in stormwater were fairly stable from WY2002 to WY2008 and from WY2008 to WY2012 the concentrations have generally decreased.

One unusually high peak concentration of DEHP (41 µg/L) was also observed in 2008 stormwater in OF243 (see Table 3-3 and boxplots in Appendix G), but this appears to be isolated occurrence. The source is unknown.

As shown in Table 3-11 and Figure 3-6, DEHP is showing a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 90% reduction in an 11 year period.

SSPM. OF243 is slightly enriched in DEHP, butylbenzylphthalate, and total phthalates (+1 to +2) (see Table 3-9A). OF243 exhibits notably different phthalate compositions that are dominated by butylbenzylphthalate. Figures F-50 and F-62 show OF243 butylbenzylphthalate average, median and maximum concentrations in SSPM well above all outfalls except OF245.

In Figure 2-1c, total phthalate concentrations levels at FD23 were medium in WY2002 and WY2003. Since WY2004, total phthalate concentrations levels at FD23 have been low.

5.5.1.d Pesticides

Baseflow and Stormwater. Pesticides are not a COC tested for under the 2001 SAP.

SSPM. No statistically significant differences in quality were observed in SSPM in DDT between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

5.5.1.e PCBs

Baseflow and Stormwater. PCBs are not a COC tested for under the 2001 SAP.

SSPM. No statistically significant differences in quality were observed in SSPM between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

As shown in Figure 5-1e, the WY2009 to WY2011 total PCB concentrations were the lowest concentration measured to date at this location.

5.5.2 Source Control Program Activities

Redevelopment of the Area. Redevelopment in the OF243 basin has resulted in some improvements in stormwater and SSPM quality. As shown in Table 3-11 and Figure 3-6l, DEHP concentrations show a statistically significant improvement in stormwater quality with an 90% reduction since 2001. Total phthalate concentrations also show an improvement in stormwater since 2008 (see Figure 5-1e). As shown in Figure 2-1c, phthalate concentrations levels at FD23 were at medium levels in 2002 and 2003 but have been at low levels since 2004. These decreases may reflect the redevelopment and improvements at the former Picks Cove Marina site and portions of the American Plating site, along with better BMPs at the new Foss Landing Marina. Development activities do not, however, appear to have improved the concentrations of mercury in SSPM in FD23.

Point Source Removal. In 2002 and again in 2009, the SR509 WSDOT stormwater treatment pond was rebuilt to remove black oil/tar emanating from the old Northern Pacific Rail yard oil pipeline along East D Street and East 19th Street. Removal of this point source is believed to have contributed to reductions in PAHs that have been observed.

Enhanced Street Sweeping Program. In January 2007, the City's street sweeping program was enhanced in an attempt to reduce sediment buildup in the storm sewer system. Under the enhanced program, the sweeping frequency was increased, air regenerative sweepers replaced mechanical sweepers, and the City also increased communications with residents, which helped raise awareness of the importance of the street sweeping program.

Statistically significant reductions were evident for zinc, PAHs and DEHP (see Table 2-5). Street sweeping, along with other source control activities, resulted in reductions of zinc at 34%, DEHP at 38% and PAH (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene) at 51 to 70%.

Outfall 243 Mercury Source Tracing. Mercury has been found in the medium to high range of concentrations in all samples analyzed from FD23 since WY2002 (see Figure 2-1a). Some source tracing work was completed in 2008 and 2009, but no likely point-source of mercury was identified. After working with BNSF in 2009-2010 to gain access to the BNSF yard, the City completed focused business inspections for most of the yard. An updated drainage map was also completed in September 2011. A follow up inspection, including the inspection of onsite ditches and swales, was conducted in 2012. Mercury concentrations in WY2011 and WY2012 remain in the mid-range of concentrations as represented in Figure 2-1a and source control investigations will continue in 2013 to evaluate this area for mercury.

Acenaphthene in Baseflow. In OF243, acenaphthene was detected in 95% of the baseflow samples and at concentrations higher than those found in stormwater. The average and median concentrations of acenaphthene were 0.030 and 0.028 µg/L in baseflow and both at 0.007 µg/L at in stormwater. These results indicate that there may be a source(s) of acenaphthene which is diluted by stormwater. The source of these acenaphthene during baseflow conditions is unknown in this basin.

General Source Control Activities. In addition to the ongoing investigation and maintenance activities described above, the City is continuing to implement other source control program elements in the OF243 drainage basin which are summarized here and described in more detail in Appendix A.

5.5.3 Outfall 243 2013 Work Plan

PAHs and DEHP concentrations in stormwater have shown a statistically significant improvement from WY2002 through WY2012 (see Figures 3-6f , 3-6h, 3-6j, and 3-6l). There has been an estimated 90% reduction on concentration for DEHP in 11 years (see Table 3-11). PAHs showed an 89 to 93% reduction in 11 years for the index PAHs (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene.

As described in detail above, OF243 results generally show:

- Baseflow – Moderately higher lead (+3) compared to other outfalls (see Table 3-6a).
- Stormwater – Significantly higher lead (+4) compared to other outfalls when evaluating the 11 year monitoring record (see Table 3-7).
- SSPM – Moderately higher lead (+3) and mercury (+3) compared to other sediment trap locations (see Table 3-9A) when evaluating the entire 11 year monitoring record.

Therefore, the following recommendations are included in the 2013 Work Plan for OF243:

- Continue mercury source tracing investigations. Continue working with businesses in the BNSF yard to evaluate other potential sources.
- Evaluate the source(s) of acenaphthene in baseflow.
- Evaluate enhancement to street sweeping program as a pilot BMP effectiveness study for source control for lead and zinc in industrial areas.

5.6 OUTFALL 245

Many source control activities have occurred in the OF245 drainage basin since the beginning of the monitoring program. Some of these activities have resulted in statistically significant improvements in stormwater quality. Figure 5-1f shows the annual average contaminant concentrations for stormwater, baseflow and SSPM. Several of the businesses in the area not only discharge stormwater to OF245 but discharge stormwater to the adjacent outfalls, OF248 and OF249.

This section provides a summary of water/sediment quality results within the OF245 drainage basin and compares the water/sediment data results with the major source control and other activities that have occurred within the basin. A more detailed description of source control activities is provided in Appendix A.

5.6.1 Water and SSPM Quality

Annual and seasonal data for baseflow, stormwater and SSPM for the COCs and other parameters is used to identify ongoing areas of concern. The following paragraphs summarize the WY2001-WY2012 monitoring results for OF245, where COCs in this outfall are different from other Foss drainage basins, and where subsequent source control activities may be focused.

5.6.1.a TSS and Metals

Baseflow. For inorganic constituents (TSS, total lead, and total zinc), baseflow concentrations during dry season conditions appear to be higher than baseflow concentrations during wet season conditions (see boxplots in Appendix H).

Baseflow TSS concentrations are slightly elevated in OF245 (+2) (see Table 3-6a). In baseflow, TSS is relatively consistent year-to-year, although summer concentrations are somewhat elevated in WY2004 (Year 3) (see Figures 5-1f and boxplots in Appendix G). In July and August 2004, the stormwater line and laterals were replaced during this same period. These elevated concentrations appear to be associated with the storm pipe construction project.

Lead appears to be relatively consistent among outfalls, although mean values are somewhat lower (-1) in OF245 (see Table 3-6a and boxplots in Appendix F).

Zinc appears to be relatively consistent among outfalls, except for OF245 which is elevated in zinc (+5) (see Table 3-6a and boxplots in Appendix F). The highest baseflow zinc concentrations are found in OF245 with maximum, mean and median concentrations at 1,950, 174 and 52 µg/L, respectively (see Table 3-2). As shown in Figure 5-1f, the zinc concentrations, WY2007 and WY2008, were the highest zinc concentrations found in baseflow in OF245 (see boxplots in Appendix G). None of the actions listed in Table 2-1 occurred during this period, thus, the source for the zinc concentrations is unknown.

Stormwater. Stormwater TSS concentrations are neutral (0) to slightly better than average (-1) in OF245 when looking at the entire 11 year monitoring record and the most recent 5 year data set respectively (see Table 3-7A and 3-5B).

Lead concentrations are better than average in OF245 when looking at the entire 11 year monitoring record (-4) and the most recent 1 year data set (-3) (see Table 3-7A and 3-5B).

Zinc, on the other hand, is elevated in OF245 (see boxplots in Appendix F). The highest stormwater zinc concentrations are found in OF245 with mean and median concentrations at 171 and 144 µg/L, respectively (see Table 3-3). The 11 year record shows that the basin is significantly elevated (+4), but the 5 year record shows that the outfall is only slightly elevated (+1) (see Table 3-7).

As shown in Table 3-11 and Figures 3-6a, 3-6b, and 3-6c, TSS, lead, and zinc are showing a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 59% reduction in TSS, 51% reduction in lead, and a 33% reduction in zinc in an 11 year period.

In stormwater, zinc boxplots showed occasional evidence of seasonality (i.e., higher median, mean, and/or peak concentrations) during dry season months (see Figures H-3b and H-23b). This may be caused by more isolated storms and longer antecedent dry periods between storms. Increasing source control activities, such as sweeping, in the dry season may be warranted.

SSPM. Zinc is slightly elevated (+1) compared to the other outfalls, while lead (-3) and mercury (-2) are slightly lower than the other outfalls (see Table 3-9 and boxplots in Appendix F).

Within Basins 245/248, mercury was detected at medium concentrations periodically at FD22 until WY2010 (see Figure 2-1a). All other sediment trap/sump locations have had low levels. Since WY2009, mercury concentrations at FD21 are similar to those measured at FD22 (see Figure 5-2e).

5.6.1.b PAHs

Baseflow. OF245 had similar levels of phenanthrene (+1) and pyrene (+2) concentrations in baseflow as compared to all the smaller drainages (see Table 3-6a). No significant differences were observed between any basins for indeno(1,2,3-c,d)pyrene.

Average concentrations of acenaphthene were elevated by unusually high baseflow concentrations in OF245. Acenaphthene average baseflow concentrations were slightly (1.5 times) higher than stormwater concentrations in OF245. Acenaphthene was detected in 86% (37 out of 43) of the baseflow samples. The median concentration for the baseflow samples was twice the median concentration for the outfalls' stormwater samples (0.026 and 0.010 μg/L, respectively). The source of acenaphthene during baseflow conditions is unknown in this basin.

Stormwater. OF245 is neutral (phenanthrene at 0) to significantly lower (pyrene at -4 and indeno(1,2,3-c,d)pyrene at -5) for PAHs in comparison to other outfalls (see Table 3-7 and boxplots in Appendix F) when looking at the entire 11 year monitoring record. When looking at only the last year of data, the results are similar (phenanthrene at 0, pyrene at -2 and indeno(1,2,3-c,d)pyrene at -2), but not as pronounced due to the small data set.

In stormwater, the highest maximum concentrations for several LPAHs including acenaphthene, acenaphthylene, fluorene, and phenanthrene were observed in OF245 (see Table 3-3). The high concentrations have not been observed since the Northern Pacific Rail yard oil pipeline area has been remediated (see Section 5.6.2).

As shown in Table 3-8 and Figures 3-6f, 3-6h and 3-6i, PAHs (phenanthrene, pyrene, and indeno[1,2,3-cd]pyrene) are showing a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 87 to 92% reductions in PAHs in an 11 year period. As shown in Figure 5-1f, PAH concentrations in stormwater were fairly stable from WY2002 until WY2007 and from WY2007 to WY2009 the concentrations decreased and remain fairly stable from WY2009 to present.

SSPM. OF245 SSPM has significantly lower concentrations of phenanthrene (-2), pyrene (-2) and indeno(1,2,3-cd)pyrene (-3) relative to all other outfalls (see Table 3-9 and boxplots in Appendix F). All sediment traps/sumps are considered to have low levels (see Figure 2-1b).

5.6.1.c Phthalates

Baseflow. DEHP is to be relatively consistent in baseflow among outfalls (except OF235) with OF245 at neutral (0) (see Table 3-6a). Baseflow concentrations appear to have remained fairly stable over the 10 year baseflow monitoring period (see boxplots in Appendix G).

Stormwater. DEHP appears to be relatively consistent among outfalls (except OF235), although mean concentrations are somewhat lower (-2) in OF245 (see Table 3-7A) when looking at the entire 11 year monitoring record. When looking at only the last year of data, the basin is considered neutral (0) (see Table 3-7B).

Unusually elevated DEHP concentrations were found in OF245 stormwater in WY2003 (Year 2) (see total phthalates in Figure 5-1f and box plots in Appendix G). Possible sources of phthalates in this drain is believed to be the former bulk liquid phthalate transloading facility and not from residues from the in-place lining of the storm line that was completed in March 2003 (see Section 5.6.2). These sources are believed to be historic since the water quality is improving. Most of the peak phthalate concentrations occurred earlier in the monitoring program (2002 through 2005) (see Figure 5-1f and boxplots in Appendix G).

OF245 exhibits a notably different phthalate composition that is dominated by butylbenzylphthalate in stormwater and SSPM. Butylbenzylphthalate concentrations in OF245 were among the highest of any reported phthalates in the monitoring program (see Table 3-3, and Table D-15). In stormwater, OF245 butylbenzylphthalate average concentration is 16 µg/L as compared to 2.8-9.2 µg/L in the other drains. Elevated peak concentrations of diethylphthalate were also detected in OF245 at 430 µg/L in stormwater.

As shown in Table 3-11 and Figure 3-6l, DEHP is showing a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 91% reduction in DEHP in OF245 in a 11 year period (see Table 3-11).

SSPM. OF245 is neutral (0) for DEHP, significantly enriched in butylbenzylphthalate (+4), and slightly enriched in total phthalates (+2) (see Table 3-9A). As with stormwater, SSPM composition is dominated by butylbenzylphthalate. Figures F-50 and F-62 show OF245 butylbenzylphthalate average, median and maximum concentrations in SSPM well above all other outfalls.

Within OF245 and the adjacent OF248, additional sediment traps were located around a suspected source of phthalates, the former MPS site (see Section 5.6.2). FD21 (OF245) and FD22 (OF248) phthalate concentrations are high in WY2003 and WY2004 at 911,400 (max at FD22) and 187,400 µg/kg (max at FD21). Since WY2006, phthalates at FD22 stabilized at or slightly below 100,000 µg/kg with the exception of WY2012 which was below 50,000 µg/kg. As shown in Figures 2-1c and 5-2f, DEHP and total phthalates in WY2012 were all at low levels and appear to be decreasing over the last 1 or 2 years. This indicates that source control actions may be effectively reducing concentrations.

5.6.1.d Pesticides

Baseflow and Stormwater. Pesticides were not detected at the reporting limits in whole-water samples and are therefore not a COC.

SSPM. No statistically significant differences in quality were observed in SSPM in DDT between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

5.6.1.e PCBs

Baseflow and Stormwater. PCBs are not a COC tested for under the 2001 SAP.

SSPM. No statistically significant differences in quality were observed in SSPM between outfall samples when reviewing both the entire 11 year monitoring record and only the last 5 years of data (see Table 3-9).

5.6.2 Source Control Program Activities

MH390/Outfall 245 Black Oil/Tar Releases. Black oil and tar blobs were observed seeping into the storm drains through joints and cracks. Before the extent of the contamination was understood, the City completed 3 maintenance projects (2 line replacements and 1 relining) to alleviate this issue. After these projects were complete, seeps continued to leak into the storm drain system. Further investigations found contamination along the entire length of the old Northern Pacific Rail yard oil pipeline area along East D Street and East 19th Street. Ecology ordered remediation of the pipeline in 2008 and 2009. During this period, 5 UST/LUSTs were also removed or filled.

After completion of all of these activities, oil absorbent snares placed in the storm lines remained clean. Use of the oil snares in this basin was discontinued in 2010. These actions contributed to the reductions in PAH concentrations at this location.

Enhanced Street Sweeping Program. In January 2007, the City's street sweeping program was enhanced in an attempt to reduce sediment buildup in the storm sewer system. Under the enhanced program, the sweeping frequency was increased, air regenerative sweepers replaced mechanical sweepers, and the City also increased communications with residents, which helped raise awareness of the importance of the street sweeping program.

Statistically significant reductions were evident for TSS, lead, PAHs and DEHP (see Table 2-5). Street sweeping, along with other source control activities, resulted in reductions of TSS at 29%, lead at 20%, DEHP at 73% and PAH (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene) at 61 to 67%.

Former MPS Site Investigation. Investigation at this site has been ongoing through the years of this program. The site is now operating under the name of Quality Transport, Inc. Quality Transport, Inc. cleaned a majority of their system in 1997 and in 2000 with no effect on the sediment trap phthalate concentrations downstream of their facility (City of Tacoma 2009b). Average total phthalate concentrations show a peak in WY2003 with a decline in stormwater and baseflow chemistry in WY2004 and WY2005 (see Figure 5-1f). Baseflow concentrations appear to have remained stable since WY2005; however, stormwater concentrations have decreased.

Because of the intermittent medium to high SSPM concentrations, this site was referred to Ecology and TPCHD for follow-up. Additional follow-up from all involved agencies is needed to fully assess the operations and site conditions at this property to assure that proper controls are in place.

Truck Traffic Effects on Water and SSPM Quality. Truck traffic is believed to be 1 of the major sources of zinc and TPH in the OF245 drainage basin. As shown in Figure 5-1f, average COC concentrations in SSPM decreased in WY2005 and increased in WY2006. In particular, average TPH and zinc concentrations were lowest in WY2005, then increased and stabilized between WY2006 to WY2012. In 2005, truck traffic was diminished in the basin with the closure of a warehouse and East D Street during the overpass construction. In 2006, truck traffic resumed when the warehouse and the overpass reopened.

In 2008, Ecology reported that the major sources of zinc contributing to stormwater runoff on industrial sites are:

- Galvanized metals;
- Motor oils/hydraulic fluids exposed on the ground, or absorbed by solid particles such as dust and dirt roads, parking lots, and loading docks, and other surfaces; and
- Tire dust from forklifts, trucks, and other vehicles. Where trucks and truck trailers make tight turns, a considerable amount of zinc is released.

Ecology recommends 2 methods that can be used to reduce zinc contributions: replacing or coating galvanized metals and sweeping with industrial vacuum sweepers to clean paved areas. It is anticipated that under Ecology's Industrial Stormwater General Permit (ISWGP), zinc concentrations and other chemicals in stormwater will be reduced over time at industrial facilities. As new information is available on sources and control of such pollutants, the City will update its Stormwater Management Manual as necessary.

Acenaphthene in Baseflow. In OF245, acenaphthene was detected in 86% of the baseflow samples and at concentrations about 4 times higher than those found in stormwater. It appears that a source is ongoing since acenaphthene was detected at the same levels in the WY2004-WY2011 baseflow events. The source of acenaphthene during baseflow conditions is unknown in this basin.

General Source Control Activities. In addition to the ongoing investigation and maintenance activities described above, the City is continuing to implement other source control program elements in the OF245 drainage basin which are summarized here and described in more detail in Appendix A.

5.6.3 Outfall 245 2013 Work Plan

TSS, metals (lead and zinc), PAHs and DEHP concentrations in stormwater have shown a statistically significant improvement from WY2002 through WY2012 (see Figures 3-6a to 3-6c, 3-6f, 3-6g, 3-6h, and 3-6l). There has been an estimated 33 to 59% reduction for TSS and metals concentrations in 11 years and a 91% reduction on concentration for DEHP in 11 years (see Table 3-11). PAHs showed an 87 to 92% reduction in 11 years for the index PAHs (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene.

As described in detail above, OF245 results generally show:

- Baseflow – Significantly higher zinc (+5) compared to other outfalls (see Table 3-6a).
- Stormwater – Significantly higher zinc (+4) and significantly lower lead (-4), pyrene (-4), and indeno(1,2,3-c,d)pyrene (-5) compared to other outfalls when evaluating the 11 year monitoring record (see Table 3-7).
- SSPM – Significatly higher butylbenzylphthalate (+4) and moderately lower lead (-3) and indeno(1,2,3-c,d)pyrene (-3) compared to other sediment trap locations (see Table 3-9A) when evaluating the entire 11 year monitoring record.

Therefore, the following recommendations are included in the 2013 Work Plan for OF245:

- Conduct joint inspection at Quality Transport for evaluation of phthalate source.
- Evaluate the source(s) of acenaphthene in baseflow.
- Evaluate enhancement to street sweeping program as a pilot BMP effectiveness study for source control for lead and zinc in industrial areas.

5.7 OUTFALL 254

Many source control activities have occurred in the OF254 drainage basin since the beginning of the monitoring program. Some of these activities have resulted in statistically significant improvements in stormwater quality. Figure 5-1g shows the annual average contaminant concentrations for stormwater, baseflow and SSPM.

This section provides a summary of water/sediment quality results within the OF254 drainage basin and compares the water/sediment data results with the major source control and other activities that have occurred within the basin. A more detailed description of source control activities is provided in Appendix A.

5.7.1 Water Quality

Annual and seasonal data for baseflow and stormwater for the COCs and other parameters is used to identify ongoing areas of concern. The following paragraphs summarize the WY2001-WY2012 monitoring results for OF254, where COCs in this outfall are different from other Foss drainage basins, and where subsequent source control activities may be focused. Note that there are not sediment traps in the OF254 drainage basin due to tidal influence.

5.7.1.a TSS and Metals

Baseflow. For inorganic constituents (TSS, total lead, and total zinc), baseflow concentrations during dry season conditions appear to be higher than baseflow concentrations during wet season conditions (see boxplots in Appendix H).

In WY2008 (Year 7), TSS was detected at higher concentrations well above all the other years (see Figures G-11b and G-31b). In WY2007 (Year 6), lead was detected at higher concentrations well above all the other years (see boxplots in Appendix G). These concentrations were not repeated in the following years.

TSS (+2), lead (+1), and zinc (+1) concentrations are slightly elevated in OF254, but are generally similar in quality to the other smaller drainages (see Table 3-6a).

Stormwater. TSS concentrations in OF254 stormwater are above average when looking at the entire 11 year monitoring record (+6) and only the last year of data (+3) (see Table 3-7). OF254 has the highest mean (104 mg/L) and median (85 mg/L) of all the basins (see boxplots in Appendix F). In 11 years of monitoring, average TSS concentrations appear to be highest in Years 6, 7 and 11 (see boxplots in Appendix G). In addition, highest average concentrations of mercury were observed in OF254 stormwater (0.041 µg/L) but it does not appear to be significantly greater than most of the other outfalls (see Table 3-3). The source(s) of TSS and mercury are unknown.

Lead concentrations are better than neutral (0) in OF254 when looking at the entire 11 year monitoring record and the most recent 5 year data set (see Table 3-7).

Zinc, on the other hand, is elevated in OF254 (see boxplots in Appendix F). The 11 year record shows that the basin is significantly elevated (+3), but the 1 year record shows that the outfall is only slightly elevated (+1) (see Table 3-7). Since OF245 is also similarly elevated in zinc, this indicates that there may be a source(s) of zinc present in the industrialized basins. As discussed in Section 5.6.2, truck traffic is a source of zinc but may not be the only source. Since the 1 year ANOVA (see Table 3-7B) did not show zinc as significantly elevated in OF245 or OF254, source control efforts may have reduced zinc concentrations.

As shown in Table 3-11 and Figure 3-6c, zinc is showing a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 50% reductions in an 11 year period.

SSPM. No sediment traps are installed in OF254, so there are no results to discuss.

5.7.1.b PAHs

Baseflow. OF254 had similar levels of phenanthrene (0) and pyrene (+2) concentrations in baseflow as compared to all the smaller drainages (see Table 3-6a). No significant differences were observed between any basins for indeno(1,2,3-c,d)pyrene.

The highest baseflow mean and/or maximum concentrations of several LPAHs and HPAHs have been reported in OF254 including acenaphthylene, anthracene, phenanthrene, benzo(a)anthracene, benzofluoranthenes, chrysene, fluoranthene, pyrene and HPAHs. These results occurred mainly in WY2005 (Year 4, February and July 2005) and WY2009 (see Table 3-2).

PAH concentrations in baseflow appear to be decreasing over time in OF254 (see Figure 5-1g and boxplots in Appendix G). There is also qualitative evidence that there are slightly higher dry season concentrations for various PAHs in OF254 baseflow (see boxplots in Appendix H).

Stormwater. OF254 is slightly elevated (phenanthrene and indeno(1,2,3-c,d)pyrene at +1) to significantly elevated (pyrene at +3) for PAHs in comparison to other outfalls (see Table 3-7 and boxplots in Appendix F) when looking at the entire 11 year monitoring record. When looking at only the last year of data, the results for phenathrene are similar (+1), but pyrene (+5) and indeno(1,2,3-c,d)pyrene (+3) are more pronounced.

OF254 has some of the highest concentrations of PAHs in water quality in the Thea Foss Basin, but these concentrations are improving. In the stormwater, comparatively higher concentrations of LPAHs and HPAHs were observed in OF254 (see Table 3-3). The highest mean or maximum concentrations of several LPAHs and HPAHs in stormwater have been reported in OF254 including acenaphthene, acenaphthylene, anthracene, total LPAHs, chrysene, benzo(a)anthracene, fluoranthene, and pyrene (see Table 3-3).

PAHs concentrations have decreased in OF254 stormwater from 2001 to present (see boxplots in Appendix G). As shown in Table 3-11 and Figures 3-6f, 3-6h and 3-6j, PAHs (phenanthrene, pyrene and indeno(1,2,3-cd)pyrene) show a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 89, 97 and 96% reduction, respectively, in PAHs in a 11 year period. In particular is the consistent decrease from WY2007 to WY2011 (see Figures 5-1g) that occurred following cleaning of the storm lines. WY2012 results are slightly higher than the last couple of years. This could be due to a very limited data set (only 4 samples). PAH results for future years should be watched to see if this is an ongoing issue.

SSPM. No sediment traps are installed in OF254, so there are no results to discuss.

5.7.1.c Phthalates

Baseflow. DEHP is to be relatively consistent in baseflow among outfalls (except OF235) with OF254 at slightly below average (-1) (see Table 3-6a).

However, in WY2008 (Year 7), DEHP was detected at higher concentrations in the baseflow dry weather events well above all the other years (see boxplots in Appendix G). Those dry weather baseflow DEHP concentrations were at the same levels as the average stormwater concentrations for Basin 254. These concentrations were not repeated in the following years, WY2009 through WY2011. Source tracing identified 1 source of the DEHP to be laundry lint that accumulated on the open ground and eventually washed into the private storm drain system. Since installations of the stormwater treatment system in 2009, the DEHP concentrations were not repeated (see Figure 5-1g).

Stormwater. DEHP appears to be relatively consistent among outfalls (except OF235), although mean concentrations are somewhat lower (-2) in OF254 (see Table 3-7). Figure 5-1g shows total phthalate concentrations in stormwater were fairly stable from WY2002 to WY2009 where they then decreased.

As shown in Table 3-11 and Figure 3-6l, DEHP shows a statistically significant improvement in stormwater quality from 2001 to present. The best-fit regression equations result in an estimated 58% reduction in a 11 year period.

SSPM. No sediment traps are installed in OF254, so there are no results to discuss.

5.7.1.d Pesticides

Baseflow and Stormwater. Pesticides are not a COC tested for under the 2001 SAP.

SSPM. No sediment traps are installed in OF254, so there are no results to discuss.

5.7.1.e PCBs

Baseflow and Stormwater. PCBs are not a COC tested for under the 2001 SAP.

SSPM. No sediment traps are installed in OF254, so there are no results to discuss.

5.7.2 Source Control Program Activities

Storm System Cleaning. In 2006, the municipal storm system in OF254 was cleaned and video inspected. The objective of this project was to remove residual sediments in the storm drains that may contain legacy contaminants. As discussed in detail in the WY2011 report (City of Tacoma 2012) storm system cleaning contributed to significant reductions in stormwater concentrations. Sewer line cleaning is an important component of the City's source control program. In combination with other source control activities, it appears to have been effective at removing all 7 of the compounds tested. Over time as sediments re-accumulate in the pipes, the systems will need to be cleaned again. The City is currently monitoring the results as shown in Figures 5-1a to 5-1g to determine the appropriate maintenance schedule for pipe cleaning projects.

Enhanced Street Sweeping Program. In January 2007, the City's street sweeping program was enhanced in an attempt to reduce sediment buildup in the storm sewer system. Under the enhanced program, the sweeping frequency was increased, air regenerative sweepers replaced mechanical sweepers, and the City also increased communications with residents, which helped raise awareness of the importance of the street sweeping program.

Statistically significant reductions were evident for zinc, PAHs and DEHP (see Table 2-5). Street sweeping, along with other source control activities, resulted in reductions of zinc at 28%, DEHP at 8% and PAH (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene) at 62 to 77%.

Northern Pacific Rail Yard Oil Pipeline and Standard Oil Site Cleanup. Another source of PAHs in the basin may have been associated with the Northern Pacific Rail yard oil pipeline area along East D Street to the old Standard Oil site. In 2009, the Northern Pacific Rail yard oil pipeline area along East D Street and East 19th Street was remediated as directed by Ecology. In 2010, the final phase of this cleanup within the OF254 basin was completed. Ecology has oversight of the remediation project.

Northwest Detention Center DEHP Investigation. The NWDC (formerly known as INS), a private immigration-related prison, was previously identified as a point source of DEHP (City of Tacoma 2009b). In 2009, NWDC was remodeled and media filtration stormwater treatment devices were installed. Further sampling and source tracing identified 1 source of the DEHP to be laundry lint, so the City required that filters be placed in the catch basins, and that the property owner provide regular maintenance of these devices. This site will require continued inspection and monitoring to ensure that proper maintenance of the treatment devices is being performed.

General Source Control Activities. In addition to the ongoing investigation and maintenance activities described above, the City is continuing to implement other source control program elements in the OF254 drainage basin which are summarized here and described in more detail in Appendix A.

5.7.3 Outfall 254 2013 Work Plan.

Zinc, PAHs and DEHP concentrations in stormwater have shown a statistically significant improvement from WY2002 through WY2012 (see Figures 3-6c, 3-6f, 3-6g, 3-6h, and 3-6l). There has been an estimated 50% reduction for zinc concentrations in 11 years and a 58% reduction on concentration for DEHP in 11 years (see Table 3-11). PAHs showed an 89 to 97% reduction in 11 years for the index PAHs (phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene.

As described in detail above, OF254 results generally show:

- Baseflow – Slightly elevated TSS (+2) and pyrene (+2) compared to other outfalls (see Table 3-6a).
- Stormwater – Significantly higher TSS (+6), moderately elevated zinc (+3) and pyrene (+3) compared to other outfalls when evaluating the 11 year monitoring record (see Table 3-7).

Therefore, the following recommendations are included in the 2013 Work Plan for the OF254 drainage basin:

- Increase frequency of follow up monitoring at NWDC to ensure treatment device is functioning properly. Consider placement of sediment trap downstream.

6.0 RECOMMENDATIONS AND 2013 WORK PLAN

The improvements in stormwater quality since the mid-1990s indicate that source control efforts in the Foss Waterway Watershed have been effective in the reduction of chemical concentrations in stormwater. With the City's comprehensive 11 year monitoring data set, updated statistical analyses have been completed. Forty-one statistically significant time trends (41 out of 49 tests, or approximately 84% of the tests) were observed in Tacoma's stormwater monitoring record. All trends were in the direction of decreasing concentrations. This is a larger number of significant reductions than has ever been observed previously, but the results are not directly comparable due to a change in the statistics approach.

This result is significant and a testament to the City's ongoing comprehensive source control program. Source control activities currently being implemented by the City include business inspections, response to spills and illicit discharges, mapping/maintenance/cleaning of the stormwater system, pollutant source tracing, and implementation of the City's Surface Water Management Manual through our stormwater ordinance. With continued monitoring and source control actions, coupled with implementation of Phase 1 NPDES Permit programs, further improvements in stormwater quality may be realized.

It should be noted however, that while considerable improvements to stormwater quality have been made, the largest changes were realized in the earlier years of the program when major sources were identified and eliminated. Because the source control program has been so effective through the years, fewer major sources or maintenance actions are needed and the program is beginning to approach an equilibrium or maintenance mode. In other words, the concentrations of contaminants of concern in the stormwater in the Foss Waterway Watershed are reaching a level where the opportunities for large reductions are more limited. While this may over time lead to the appearance of fewer decreasing trends in contaminant concentrations if looking only at results from more recent years, the fact remains that the City's stormwater source control and monitoring program have been very effective in reducing contaminant levels in stormwater and SPPM.

Reduction of overall contaminant loads to the Foss Waterway has been achieved through the City's implementation of these stormwater source controls. Control of other sources, many of which are outside the City's jurisdiction and must be coordinated by other federal, state, and local authorities, have also lead to reduction in contaminant loads. Reductions of air and marina pollution are achieved through Ecology's Air Program and through the Marina Source Control Program which was developed specifically for the Foss Waterway. Reductions in air pollution will decrease not only the direct loads from atmospheric fallout to the surface of the waterway, but will also decrease the pollutant loads washed off upland surfaces and entrained in stormwater runoff. The marina improvements implemented by the Foss Waterway Marina, Foss Landing Marina, Johnny's Dock Marina, and Delin Docks, including installation of facility improvements, have undoubtedly translated into reduced source loads for marinas. Finally, upland and in-water remedial actions implemented by Ecology and the Utilities in 2003 and 2004 were directed at controlling tar seeps in the head of the waterway. The effectiveness of these combined actions will continue to be verified through long-term monitoring of stormwater, storm sediment, and marine sediment, and supplemented by source monitoring programs conducted by other parties.

6.1 THEA FOSS WATERWAY SEDIMENT MONITORING PROGRAM

During this stormwater monitoring year, WY2012, no monitoring was required under either the Utilities' or the City's sediment monitoring programs and therefore no new results are available to present. The City is scheduled to perform Year 7 post-construction monitoring of the waterway sediments in 2013, and the Utilities will be performing their Year 10 post-construction monitoring in 2014. Therefore, the next updated evaluation of time trends in sediment quality will be presented in the WY2013 report submitted in March 2014.

6.2 2013 WORK PLAN

Priorities for 2013 source control work are set in order of highest to lowest as 1, 2, and 3. Higher priorities were given to eliminating/reducing point sources and activities that are based on best professional judgment to provide a measurable benefit in reducing chemical loadings to the waterway for those COCs of most concern in waterway sediments.

Priorities will also be based on overall outfall contributions to the waterways. That is, the outfalls with the largest chemical loading contributions to the waterway will generally receive the higher priority. Table 6-1 shows the discharge volume and chemical loadings for each of the municipal outfalls. It should be noted that there are other sources which could also potentially affect sediment quality in the waterways, including groundwater seeps, marinas, atmospheric fallout, NPDES-permitted industrial discharges, and other private stormwater discharges. These sources are outside the scope of the City's Source Control Strategy for municipal stormwater, and largely outside the City's jurisdiction.

For the municipal outfalls, 72% of the freshwater volume discharging to the waterways is from baseflow, mainly from OF237A, OF237B, OF235 and OF230. However, baseflow conveys relatively low concentrations of COCs, typically characterized by reduced maximum values and less frequent detections than in stormwater. The proportion of the contaminant load attributed to baseflow is:

- 16% of the load for phenanthrene,
- 10% of the load for pyrene,
- 16% for dibenz(a,h)anthracene, and
- 28% of the total load for DEHP.

The largest proportion of chemicals discharging into the waterways from municipal outfalls is from stormwater (see Table 6-1). The chemical loading from stormwater is:

- 84% of the total load for phenanthrene,
- 90% of the total load for pyrene,
- 84% for dibenz(a,h)anthracene, and
- 72% of the total load for DEHP.

Priority 1 tasks are ongoing or will be initiated in spring 2013, followed by Priority 2 and then Priority 3. Updates, schedules and tasks will be reported in the 2013 Annual Source Control Report.

Priority 1 tasks are:

- **230:** Continue source tracing investigation in area draining to FD3a and FD18 for mercury and PCBs, with PAHs and phthalates analyzed as well.
- **235:** Complete design and begin construction of Hood St. Retrofit.
- **237A**: Investigate potential sources of phthalates in the area draining to FD10c.
- **237A:** Continue to monitor TPCHD activities at the site of the UST removal at the neighborhood fueling station (EZ Mart) and reinspect the FD31 branch as needed upon completion of their work.
- **237B:** Complete source tracing investigation for PCBs at FD34/35.
- **243**: Investigate source of mercury at BNSF and elsewhere in drainage area for FD23.
- **245**: Conduct joint inspection with TPCHD and Ecology at Truck Rail Handling/Quality Transport to identify any potential source(s) of phthalates.
- **254**: Continue follow-up inspections at NWDC for proper operation and maintenance of their onsite treatment facilities. Consider placement of sediment trap downstream.

Priority 2 tasks are:

- **230:** Perform initial screening investigation for potential sources of PCBs at FD16B.
- **235:** Area draining to FD6A higher than other branches of OF235 in PAH concentrations in stormwater, and stormwater concentrations at the outfall rank highest overall. Evaluate need for additional source control following installation of Hood St treatment device.
- **243/245:** Evaluate enhancement to street sweeping program in this area as a pilot BMP effectiveness study for source control for lead and zinc in industrial areas.

Priority 3 tasks are:

- **243/245:** Investigate source of acenapthene in baseflow.

In addition, the City will perform a number of tasks as part of the source control program:

- Continue Foss Stormwater Monitoring WY2013.
- Review of the WY2013 SSPM data to confirm existing conditions in the basin and to set maintenance schedules for treatment units within the basin (where appropriate).
- Monitor the major construction activities throughout the watershed.
- Monitor and conduct inspections at new developments as completed to review appropriate BMPs for each site.
- Implement the City's Stormwater Management Manual, 2012 Edition.
- Continue NPDES business inspections program and document the inspections using the business inspections database. Respond and track all complaints/spills in the complaints database.

- Participate with UWT and WSU Extension in Ecology Grant to develop a continuing TRC and TAPE program for Stormwater Treatment Technologies.

- Monitor TPCHD and Ecology UST/LUST removal projects along with any other remediation projects in the watershed.

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TABLES

Table 2-1
Master Spreadsheet for Source Control Actions

Action Number	Action Number by Basin	Sub basin	Action	Date	Potential COCs	Status	Description
All and NPDES Basin							
1	1		Drought	7/1/2007	Unknown	One Event	One of the driest summers on record
2	2		Drought	5/2009-7/2009	Unknown	One Event	One of the driest summers on record
3	3		Drought	Aug-Sept	Unknown	One Event	One of the longest dry streaks on record
4	4		Earthquake	2/28/2001	Unknown	One Event	6.8 Earthquake
5	5		Flood	11/14/2001	Unknown	One Event	Flooding
6	6		Flood	1/5/2006	Unknown	One Event	Flooding
7	7		Flood	11/6/2007	Unknown	One Event	Flooding
8	8		Flood	12/3/2007	Unknown	One Event	Flooding
9	9		Flood	1/7/2009	Unknown	One Event	Flooding
10	10		Snow	1/1/2007	Unknown	One Event	Record Snow event
11	11		Wet	9/1/2010	Unknown	One Event	3rd all time wettest September
12	12		Cleanup	2011-2012	All	Ongoing	Broad EIS and South Tacoma's Downtown Subarea plan for Brownsfields and site cleanups
13	13		Edu	7/2/2005	All	Completed	PC Dental Education Outreach
14	14		Edu	7/2/2005	All	Completed	PC Dental Education Outreach
15	15		Const Permit	2002	All	Ongoing	Construction Stormwater Permit
16	16		Ind Permit	2008	All	Ongoing	Industrial General Stormwater Permit
17	17		Inspect	2002	All	Completed	106 City Wide Inspections
18	18		Inspect	2003	All	Completed	350 Thea Foss Inspections, 31 City Wide Inspections
19	19		Inspect	2003	All	Completed	263 Thea Foss Inspections, 154 City Wide Inspections
20	20		Inspect	2004	All	Completed	167 Thea Foss Inspections,142 City Wide Inspections
21	21		Inspect	2004	All	Completed	47 Thea Foss Inspections,180 City Wide Inspections
22	22		Inspect	2005	All	Completed	482 Thea Foss Inspections, 1,299 City Wide Inspections
23	23		Inspect	2005	All	Ongoing	City-wide Business inspections
24	24		Inspect	2006	All	Completed	485 Thea Foss Inspections, 1,790 City Wide Inspections
25	25		Inspect	2006	All	Completed	Inspections: 805 Thea Foss Basin , 303 follow ups; 2,209 City Wide, 407 follow ups
26	26		Inspect	2007	All	Completed	City Facilities and Tacoma Public Schools Inspected
27	27		Inspect	2010	All	Completed	City Facilities Inspected: Fire, Maintenance, Parking, Theaters, Solid Waste, Cheney Stadium
28	28		Inspect	2011	All	Completed	City Facilities: Fire Station retrofitting for wash pad/foam test areas
29	29		Inspect	2011	All	Completed	City Facilities Inspections: 45 sanitary and 4 stormwater pump stations and 7 communications facilities
30	30		Inspect	2011	All	Completed	Business Inspections: 452 in Thea Foss and 1,408 City Wide.
31	31		Inspect	2011	All	Completed	BMP Inspections: 119 in Thea Foss and 351 City Wide.
32	32		Inspect	2012	All	Completed	City Facilities inspections - Inspected/serviced treatment devices, inspected City facilities including fire stations, parking garages, street operations, equipment and material storage yards, facilities, asphalt plant, etc.
33	33		Inspect	2012	All	Ongoing	Fire Station Retrofit for wash pad/foam test. One station completed
34	34		Inspect	2012	All	Completed	Conducted 938 device inspections City wide, including 117 new devices signed off or inspected
35	35		Inspect	2012	All	Completed	199 business inspections and follow up visits in the Foss Waterway Watershed and 1045 business inspections and follow up visits City wide
36	36		Inspect	2012	All	Completed	Ten SWPPs were reviewed and updated for City Facilities and 3 new SWPPs are pending for 2013
37	37		Manual	2007	All	Completed	Surface Water Manual 2008 ed
38	38		Manual	2/27/2007	All	Completed	Surface Water Manual 2009 revision
39	39		Manual	1/1/2012	All	Ongoing	Surface Water Manual 2012 revision
40	40		Permit	2/27/2007	All	Ongoing	City-wide NPDES Phase 1 Permit 2007-2012
41	41		Permit	8/1/2012	All	Ongoing	City-wide NPDES Phase 1 Permit 2012 & 2013-2018
42	42		SD Maint	2/27/2007	All	Ongoing	Catch Basin and Stormwater Facilities Maintenance Programs
43	43		Spills	2000-2012	All	Ongoing	City-wide Spills/Complaints Response
44	44		Spills	2002	All	Completed	152 spills/complaints
45	45		Spills	2003	All	Completed	197 spills/complaints
46	46		Spills	2004	All	Completed	182 spills/complaints
47	47		Spills	2005	All	Completed	176 spills/complaints
48	48		Spills	2006	All	Completed	219 spills/complaints
49	49		Spills	2007	All	Completed	158 spills/complaints
50	50		Spills	2008	All	Completed	144 spills/complaints
51	51		Spills	2009	All	Completed	147 spills/complaints
52	52		Spills	2010	All	Completed	spills/complaints: Thea Foss 262; City Wide 977
53	53		Spills	2011	All	Completed	spills/complaints: Thea Foss Basin 262; City Wide 864
54	54		Spills	2012	All	Completed	322 spills/complaints
55	55		Sweeping	2010 - 2012	All	Ongoing	Street Sweeping Circuit

Table 2-1
Master Spreadsheet for Source Control Actions

Action Number	Action Number by Basin	Sub basin	Action	Date	Potential COCs	Status	Description
OF230 Basin							
56	1		Cleanup 1	2006	Metals, PAH	Completed	Parcel 5 site cleanup Ecology lead
57	2		Cleanup 2	2009-2010	Solvents	Ongoing	Sauro's Cleanerama, 14th & Pacific future cleanup and development
58	3		Const 1	2001	TSS	Completed	Art Museum Construction
59	4		Const 2	11/1/2001	TSS	Completed	Pierce County Jail Construction
60	5		Const 3	2002	TSS	Completed	LINK Construction
61	6		Const 4	2002	TSS	Completed	Museum of Glass and Thea's Landing Construction Dock Street
62	7		Const 5	2003	TSS	Completed	Albers Mill Construction
63	8		Const 6	11/2003-10/2004	TSS	Completed	Courtyard Marriot Construction
64	9		Const 7	2004	TSS	Completed	U of W Tacoma Campus Construction – 2 buildings
65	10		Const 8	2004	TSS	Completed	St. Joseph Hospital Construction
66	11		Const 9	2004	TSS	Completed	Esplanade Construction on Thea Foss Waterway
67	12		Const 10	8/1/2004	TSS	Completed	Marcourt Building 744 Market Street Construction
68	13		Const 11	11/1/2004	TSS	Completed	Convention Center Construction completed
69	14		Const 12	7/2004-2/2005	TSS	Completed	Pacific Ave. was rebuilt for several blocks
70	15		Const 13	10/1/2006	TSS	Completed	708 Market St Construction
71	16		Const 14	10/1/2006	TSS	Completed	1501 Tacoma Ave Condos Construction
72	17		Const 15	11/1/2006	TSS	Completed	Market Street:13th-15th Street Apartments
73	18		Const 16	2007	TSS	Completed	Dock Street Condos Construction
74	19		Const 17	2007	TSS	Completed	St. Helen & 4th-6th Street Construction. Media Filter added
75	20		Const 18	10/1/2007	TSS	Completed	505 Broadway Condos Construction
76	21		Const 19	2008	TSS	Completed	Fawcett Ave & 13th Construction
77	22		Const 20	1/2008-3/2008	TSS	Completed	Dock Street Pump Station Construction
78	23		Const 21	2009	TSS	Completed	S 13th and Pacific Ave Luzon building demo
79	24		Const 22	2009-2010	TSS	Completed	Broadway/St. Helens LID construction
80	25		Const 23	2010	TSS	Completed	S 13th and Pacific Ave Luzon building construction
81	26		Const 24	2011	TSS	Ongoing	1142 S Fawcett Ave Condos: Jan-Sept 2011
82	27		Const 25	2011	TSS	Ongoing	2120 South C Street old Heidelberg demo
83	28		Const 26	2012	TSS	Completed	Foss Waterway Seaport Renovation
84	29		Const 27	2012	TSS	Ongoing	Building removal and site redevelopment at old Colonial Fruit Warehouse
85	30		Const 28	2012	TSS	Completed	Construction site washout - South 9th and Broadway
86	31		Const 29	2012	TSS	Ongoing	Pacific Avenue Streetscape Project
87	32		Edu 1	7/2005	All	Completed	"A" St Restaurants Grease education program
88	33		Edu 2	2006	All	Completed	SW/auto care public education program Pie grant study
89	34		Edu 3	3/2007	All	Completed	Cigarette Butt public education program
90	35		Edu 4	7/2/2005	All	Completed	Public Market Flyer and education
91	36		Inspect 1	2006	TSS	Completed	1 BMP inspected
92	37		Inspect 2	10/2006-11/2006	Unknown	Completed	700 E D Street, Process Water Discharge (fish parts)
93	38		Inspect 3	2007	TSS	Completed	2 BMP inspected
94	39		Inspect 4	2007-2011	All	Completed	100% of area inspected
95	40		Inspect 5	2008	TSS	Completed	1 BMP inspected
96	41		Inspect 6	2009	All	Completed	226 concentrated business inspections in the 230 Basin.
97	42		Inspect 7	2010	All	Completed	260 concentrated business inspections in the 230 Basin.
98	43		Inspect 8	2011	All	Completed	62 business inspections in the 230 Basin.
99	44		Inspect 9	10/2009	All	Completed	Multicare Hospital Complex inspected
100	45		Inspect 10	10/2009	All	Completed	PC Jail, buildings and WA National Guard Armory inspected and mapped.
101	46		Inspect 11	2010	All	Completed	St. Joseph Hospital Complex inspected
102	47		Inspect 12	2010	All	Completed	Bates Community College inspected.
103	48		Inspect 13	2010	All	Completed	Republic Parking Facilities inspected.
104	49		Inspect 14	2012	All	Completed	29 business inspections in the OF 230 basin
105	50		Maint 1	12/2000	All	Completed	Pipe cleaned in upper reaches of 230 near St. Joseph Hospital
106	51		Maint 2	2000-2011	All	Ongoing	BIA sweeping and trash collection
107	52	FD3B	Maint 3	2/1/2002	TSS	N/A	FD3B sediment trap filled with gravel
108	53		Maint 4	11/1/2002	TSS	Completed	Hood Street pipe rebuilt after earthquake damage
109	54		Maint 5	2006	All	Completed	Curb marking
110	55	FD3A	Maint 6	1/1/2006	All	Completed	cleaned/TVed FD3A.
111	56		Maint 7	2007	Unknown	Ongoing	eroded pipe segments and other pipe drilled through the storm lines.
112	57		Maint 8	3/12-5/14/2007	All	Completed	cleaned/TVed entire municipal storm drainages.

Table 2-1
Master Spreadsheet for Source Control Actions

Action Number	Action Number by Basin	Sub basin	Action	Date	Potential COCs	Status	Description
113	58		Maint 9	3/2007-5/2007	All	Completed	abandoned and filled pipe on Court A from 15th to 13th Sts. Redirected to new pipe on A St.
114	59		Maint 10	6/2010-11/2010	All	Completed	CIPP Stormwater pipe retrofit - 13,500 feet relined.
115	60		Maint 11	2012	All	Completed	Enhanced street sweeping, general system cleaning and maintenance
116	61		Onsite Fac 1	2003-2004	TSS	Completed	11 media filters,1 bioswales, 3 vortex separators, 2 o/w separators/wet vaults
117	62		Onsite Fac 2	2005	TSS	Completed	2 o/w separators/wet vaults, 1 bioswales
118	63		Onsite Fac 3	2006	TSS	Completed	4 media filter, 2 bioswale
119	64		Onsite Fac 4	2007	TSS	Completed	1 media filter
120	65		Onsite Fac 5	2008	TSS	Completed	8 media filters, 8 bioswale
121	66		Onsite Fac 6	2009	TSS	Completed	2 media filters
122	67		Onsite Fac 7	2011	TSS	Completed	3 media filters
123	68		Onsite Fac 8	2012	TSS	Completed	2 media filters
124	69		Fine/Violation 1	2012	soapy water	Completed	Sheer Vision Company - warning letter for discharge of sudsy water
125	70		Point Source 1	2005-2006	Solvent	low risk	Found oil/solvent groundwater to CB at South 17th & Court "C". TPCHD/Ecology.
126	71		Point Source 2	1/2006-4/2006	Hg	Completed	Hg removed from CB, S. 11th and Yakima parking area, Bates Technical College. CB and private system cleaned
127	72		Point Source 3	2008	Unknown	Completed	C Ct. restaurants leaking dumpster/compactor re-routed to sanitary.
128	73		Point Source 4	8/1/2010	Unknown	Completed	Russell Investments 900 employees moved to Seattle
129	74		Spill 1	2009	Unknown	Completed	PAM spill response and containment
130	75		Spill 2	3/16/2011	Unknown	Completed	Sanitary sewer collapse. SSO to Outfall 230
131	76		UST 1	2003-2004	Unknown	Ongoing	TPCHD Act program which finds and removes old USTs.
132	77		UST 2	3/1/2007	PAH	Completed	USTs removed Dock Street Project
133	78		UST 3	5/1/2007	PAH	Completed	USTs removed South 17th & Tacoma Ave
134	79		UST 4	8/1/2007	PAH	Completed	2 USTs removed near 15th Street overpass
135	80		UST 5	2008	PAH, TPH	Completed	Plaza Parking Garage expansion, removed 3 USTs and contamination.
136	81		UST 6	3/1/2008	PAH, TPH	Completed	2 USTs removed along Dock Street, BNSF track relocation
137	82		UST 7	2009	PAH, TPH	Completed	UST removed Broadway LID construction.
138	83		UST 8	10/2011-1/2012	PAH, TPH	Completed	1 UST @ 902 S. Market St, Urban Grace/First Baptist Church.
139	84		UST 9	8/1/2012	PAH, TPH	Ongoing	3 UST @ 1701xx Court C
140	85		UST 10	8/1/2012	PAH, TPH	Ongoing	1 UST @ 732 Commerce Street
OF235 Basin							
141	1		Cleanup 1	2001	TCE	Ongoing	U of W Tacoma groundwater investigation for Solvents Ecology and TPCHD oversight
142	2		Cleanup 2	2001	PAH	Completed	Standard Chemical Site, Ecology – coal tar.
143	3		Const 1	2001	TSS	Completed	U of W Tacoma Science Building Construction
144	4		Const 2	2002	TSS	Completed	Art Museum Construction
145	5		Const 3	2003	TSS	Completed	LINK Construction
146	6		Const 4	2004	TSS	Completed	Albers Mill Construction
147	7		Const 5	2004	TSS	Completed	U of W Tacoma Campus Construction – 2 buildings
148	8		Const 6	2005	TSS	Completed	St. Joseph Hospital Construction
149	9		Const 7	2006	TSS	Completed	Commerce & 19th Construction
150	10		Const 8	2006	TSS	Completed	6th & Fawcett Construction
151	11		Const 9	2006	TSS	Completed	1717 Market Street Construction
152	12		Const 10	2006	TSS	Completed	UWT Construction
153	13		Const 11	2007	TSS	Completed	Pacific Ave. was rebuilt for several blocks
154	14		Const 12	2007	TSS	Completed	Goodwill Construction
155	15		Const 13	2007-2011	TSS	Completed	UWT Construction - Joy Building
156	16		Const 14	2010	TSS	Completed	UWT Construction - Jet Building
157	17		Const 15	2011	TSS	Ongoing	UWT Construction - 4 Story building and sky bridge to Tioga building
158	18		Const 16	2011	TSS	Ongoing	St. Joseph Hospital Parking Garage Construction
159	19		Const 17	8/2011 - 2012	TSS	Ongoing	Holiday Inn Express Construction 21st & C St
160	20		Edu	2007	All	Completed	SW/auto care public education program Pie grant study
161	21		Inspect 1	2007-2011	All	Completed	100 % area inspected
162	22		Inspect 2	2007	TSS	Completed	1 BMP inspected
163	23		Inspect 3	2008	TSS	Completed	4 BMP inspected
164	24		Inspect 4	2008	TSS	Completed	3 BMP inspected
165	25		Inspect 5	2008	Metals	Completed	Bronze Works wastewater – pretreatment program
166	26		Inspect 6	2009	All	Completed	51 concentrated business inspections in the 235 Basin.
167	27		Inspect 7	2010	All	Completed	56 concentrated business inspections in the 235 Basin.
168	28		Inspect 8	2011	All	Completed	8 business inspections in the 235 Basin.

Table 2-1
Master Spreadsheet for Source Control Actions

Action Number	Action Number by Basin	Sub basin	Action	Date	Potential COCs	Status	Description
169	29		Inspect 9	2009	All	Completed	UWT Campus and SW Trmt Facilities Inspected/cleaning needed
170	30		Inspect 10	2010	All	Completed	Multicare Hospital Complex inspected
171	31		Inspect 11	2010	All	Completed	St. Joseph Hospital Complex inspected
172	32		Inspect 12	2010	All	Completed	WSDOT Pond 21st & Pacific
173	33		Inspect 13	2010	All	Completed	City Shops - paint/carpentry BMPs/inspections completed
174	34		Inspect 14	2010-2011	All	Completed	Esplanade cleaning of sidewalks needed BMPs
175	35		Inspect 15	2012	All	Completed	30 business inspections completed in the OF235 drainage basin
176	36		Maint. 1	2000-2009	Unknown	Completed	emergency repair of collapsed storm/sanitary sewers at 21st and Jefferson.
177	37		Maint. 2	2002-2008	None	Completed	mapped Court House and Washington State Museum storm drains.
178	38		Maint. 3	2003-2004	None	Completed	Located missing manhole on SR-705
179	39		Maint. 4	10/1/2005	All	Completed	Curb marking
180	40		Maint. 5	9/1/2006	Unknown	Ongoing	eroded pipe segments and other pipe drilled through the storm lines.
181	41		Maint. 6	2000-2011	All	Ongoing	BIA sweeping and trash collection
182	42		Maint. 7	8/1/2007	All	Completed	cleaned/TVed entire municipal storm drainages.
183	43		Maint 8	2012	All	Completed	Enhanced street sweeping, general system cleaning and maintenance
184	44		Onsite Fac 1	12/2002-3/2003	All	Completed	L Street Rain Gardens constructed
185	45		Onsite Fac 2	2003-2004	TSS	Completed	1 media filters
186	46		Onsite Fac 3	2003-2004	TSS	Completed	1 media filter, 1 bioswale
187	47		Onsite Fac 4	2003-2004	TSS	Completed	1 vortex separator
188	48		Onsite Fac 5	2007-2009	TSS	Completed	5 media filters, 1 bioswale
189	49		Onsite Fac 6	2009-2010	TSS	Completed	5 media filters,1 bioswales, 2 vortex separators, 4 o/w seperators/wet vaults
190	50		Onsite Fac 7	2010	TSS	Completed	10 media filters - 4 sites
191	51		Onsite Fac 8	2012	TSS	Completed	3 media filters - 3 sites
192	52		Fine/Violation 1	2/1/2012	TSS	Ongoing	Holiday Inn Express Construction 21st & C St - Second Warning Letter
193	53		Point Source 1	7/2004-2/2005	All	Completed	City Shop III moved to Basin 237A.
194	54		Point Source 2	5/15- 6/25/2007	BTEX	Completed	Pugnetti Park gasoline (BTEX) in ground, Ecology oversight.
195	55	FD6A	Point Source 3	Jul 2007 DEHP	Completed		dumpster draining to storm at local hospital was removed
196	56		UST 1	10/2002-2006	PAH, TPH	Completed	USTs removed at old Chevron on Pacific Ave
197	57		UST 2	10/2007-12/2007	PAH, TPH	Completed	3 USTs removed at 23rd St & K, L, and M Streets.
198	58		UST 3	2011-2012	PAH, TPH	Ongoing	5 USTs @ 2120 S. C St, Former Heildelberg Brewery.
199	59		UST 4	2/1/2012	PAH, TPH	Completed	1 UST removed at UW Joy Building including removal of contaminated soils
OF237A Basin							
200	1		Cleanup 1	Dec 02-Mar 03	PAH	Completed	Standard Chemical Site, Ecology – coal tar.
201	2		Cleanup 2	8/1/2003	Pb	Completed	site soil cleanup for lead, Police headquarters and Fleet Maintenance
202	3		Cleanup 3	2003-2004	TSS	Completed	Construction and Waste removed - Tacoma Rescue Mission.
203	4	FD13/FD13B	Cleanup 4	2007	PAH, TPH	Completed	Key Bank soil/CB cleanup completed.
204	5		Const 1	2004-2005	TSS	Completed	Police headquarters and Fleet Maintenance
205	6		Const 2	7/2004-2/2005	TSS	Completed	Pacific Ave. was rebuilt for several blocks
206	7		Const 3	2005	TSS	Completed	BNRR realignment project: 60' outfall extension, new manhole structures, 23rd Street lateral (FD2A) included.
207	8		Const 4	12/1/2006	TSS	Completed	sink holes at I5 Yakima/Delin Construction
208	9		Const 5	2007	TSS	Completed	25th & Yakima Ave
209	10		Const 6	2007	TSS	Completed	WSDOT Freeway right-of-way HOV Lanes on SR-16
210	11		Const 7	1/1/2007	TSS	Completed	I5 Yakima/Delin/G St Construction
211	12		Const 8	1/1/2007	TSS	Completed	I5 Yakima/Delin/G St Construction
212	13		Const 9	12/1/2007	TSS	Completed	WSDOT M St. grading/stockpile runoff treated
213	14		Const 10	2008	TSS	Completed	WSDOT Freeway right-of-way HOV Lanes on I-5,
214	15		Const 11	2008-2009	TSS	Completed	Goodwill Construction 27th St & Tacoma Ave
215	16		Const 12	2009-2011	TSS	Ongoing	WSDOT Construction Freeway right-of-way entire SR-16 interchange
216	17		Const 13	2011-2012	TSS	Ongoing	SAD: WSDOT SR-16 interchange; 12,829,299 gals discharged
217	18		Const 14	2010-2012	TSS	Ongoing	Sound Transit, D to M Street Cooridor
218	19		Const 15	2011	TSS	Ongoing	SAD: Sound Transit, D to M Street Cooridor; 45,236,634 gals discharged
219	20		Const 16	2/1/2011	TSS	Completed	Tacoma Street & Grounds Shop III Building Collapse cleanup
220	21		Const 17	7/4/2005	TSS	Ongoing	Walmart
221	22		Const 18		TSS	Ongoing	Water Ditch Trail
222	23		Fac 1	2006	TSS	Completed	I5 - Yakima and M St Ponds constructed
223	24		Fac 2	2009	TSS	Completed	I5 – 3 MG Pond constructed
224	25	FD13/FD13B	Fac 3	2010	TSS	Completed	StormFilter Retrofit on-line

Table 2-1
Master Spreadsheet for Source Control Actions

Action Number	Action Number by Basin	Sub basin	Action	Date	Potential COCs	Status	Description
225	26		Fac 4	2011	TSS	Future	I5 – 22 MG Pond
226	27		Fine 1	6/1/2010	TSS	Completed	Notice of Violation Bill's Towing
227	28		Fine 2	10/13/2011	PAH, TPH	Completed	Notice of Violation Heating oil tank drained onto lawn
228	29		Fine/Violation 3	2012	TSS	Completed	Warning Letter - Sound Transit D to M Streets Track and Signal Project. Untreated water bypassing the treatment facility
229	30		Fine/Violation 4	2012	Unknown	Completed	Notice of Violation - Sound Transit D to M Streets Track and Signal Project. Untreated water bypassing the treatment facility
230	31		Inspect 1	2002	Unknown	Completed	Operations greatly reduced at Birds Eye (formerly Nalley's Fine Foods).
231	32		Inspect 2	2002	Unknown	Completed	Atlas Foundry zero discharge for stormwater runoff.
232	33		Inspect 3	11/1/2003	TSS	Completed	Cleaning/maintenance of the Coca-Cola Truck Yard SW treatment system.
233	34		Inspect 4	2003-2004	TSS	Completed	CB filters installed at Tacoma Mall
234	35		Inspect 5	2003-2004	All	Completed	Joint inspections with Ecology/TPCHD in the South Tacoma Groundwater Protection District.
235	36	FD10/FD13	Inspect 6	2003-2004	All	Completed	targeted business inspections
236	37		Inspect 7	2005	All	Completed	Business Inspections - South Tacoma Trunkline.
237	38		Inspect 8	7/1/2005	All	Completed	TNT inspection – Oil Tank and UST found
238	39		Inspect 9	2006	TSS	Completed	6 BMP inspected
239	40		Inspect 10	2007	TSS	Completed	6 BMP inspected
240	41		Inspect 11	12/1/2007	All	Completed	TNT inspection – no petroleum leak
241	42		Inspect 12	2009	All	Completed	252 Concentrated business inspections.
242	43		Inspect 13	2011	All	Completed	251 business inspections.
243	44		Inspect 14	2007-2011	All	Completed	Concentrated business inspections - 100% area completed
244	45		Inspect 15	2008	TSS	Completed	7 BMP inspected
245	46		Inspect 16	2008	All	Completed	Business Inspections - South Tacoma Trunkline.
246	47		Inspect 17	2009	All	Completed	Business Inspections with TPCHD in S. Tacoma Channel Groundwater Protection District.
247	48		Inspect 18	2009	Unknown	Completed	Tacoma Dome grease traps connections confirmed
248	49		Inspect 19	2010	Unknown	Completed	261 targetted business inspections
249	50	FD13/FD13B	Inspect 20	2010	PAH	Completed	concentrated business inspections in subbasin
250	51		Inspect 21	2010	PAH, Metals	Completed	WSDOT Stormwater Ponds inspections
251	52	FD13/FD13B	Inspect 22	3/1/2011	PAH, Metals	Completed	Tacoma News Tribune inspections: cooling tower to sanitary/fuel island
252	53	FD13/FD13B	Inspect 23	2011	Metals	Completed	DSHS inspections: cooling tower from storm to sanitary
253	54		Inspect 24	2012	All	Completed	76 business inspections completed in the OF237A drainage basin
254	55		Maint 1	8/2006-3/2007	Unknown	Completed	3,000' SW pipe upgrade on Center St for trunk line at Cedar and Center Streets, and the Leach Creek Force main.
255	56		Maint 2	2008	TSS	Completed	large void at intersection of So. 26th and Jefferson repaired.
256	57		Maint 3	4/28-8/8/2008	All	Completed	targeted areas of Basin 237A were cleaned/TVed, north of Center Street, all sediment trap monitored drainage areas
257	58		Maint 4	2012	All	Completed	Enhanced street sweeping, general system cleaning and maintenance
258	59		Onsite Fac 1	2003-2004	TSS	Completed	7 media filters, 3 bioswales, 9 vortex separators, 6 o/w separators/wet vaults
259	60		Onsite Fac 2	2005	TSS	Completed	5 media filters, 6 bioswales
260	61		Onsite Fac 3	2006	TSS	Completed	15 media filter, 1 bioswale, 1 vortex separators 4 o/w separators/wet vaults
261	62		Onsite Fac 4	2008	TSS	Completed	3 bioswale
262	63		Onsite Fac 5	2009	TSS	Completed	3 media filters, 1 bioswale
263	64		Onsite Fac 6	2009	All	Completed	Classy Chassy Carwash ows for carwash to sanitary
264	65		Onsite Fac 7	2010	TSS	Completed	8 sites with media filters
265	66		Onsite Fac 8	2009-2011	PAH, TPH	Completed	Petro-Card ows to sanitary
266	67		Onsite Fac 9	2011	TSS	Completed	5 sites w/media filters; 4 sites w/ infiltration
267	68		Onsite Fac 10	2012	TSS	Completed	2 media filters, one porous asphalt, three bioswales - 6 sites
268	69		Point Source 1	3/1/2003	PAH	Completed	WSDOT sealed the DA-1 Line.
269	70		Point Source 2	9/1/2003	PAH, unknown	Completed	Alpine Cold Storage fire, 25th & Holgate.
270	71	FD-2A	Point Source 3	2004	Hg	Completed	neon sign businesses relocated or shut down.
271	72	FD10	Point Source 4	2004	Hg	Completed	circuit boards manufacturer on Lawrence Street shut down
272	73	FD10c	Point Source 5	2005-2011	PAH, unknown	Completed	Petro Card OWS to sanitary, S. 35th & Lawrence done Jul 2011
273	74		Point Source 6	10/1/2007	Unknown	Completed	Tacoma Mall misconnections removed.
274	75		Point Source 7	10/6/2007	PAH, unknown	Completed	Atlas Foundry major explosion and fire.
275	76		Point Source 8	2008	Unknown	Completed	Top Foods waste compactor to storm removed.
276	77		Point Source 9	2008	Unknown	Completed	City/County EOC, South 25th, a sewer misconnection fixed.
277	78	FD-2	Point Source 10	4/1/2009	Unknown	Completed	Elephant Car Wash misconnected to storm was corrected.
278	79	FD-2	Point Source 11	6/1/2009	Unknown	Completed	Business misconnected to storm was corrected.
279	80	FD-2	Point Source 12	4/22/2010	Unknown	Completed	Verticle World misconnected to storm was corrected.
280	81		Point Source 13	5/1/2009	PAH, unknown	Completed	Vehicle washing at TFD #9, South 18th & Cedar St.
281	82	FD-2A	Point Source 14	8/1/2010	Metals	Completed	Notice of Violation, The Bronze Works.
282	83		Point Source 15	6/1/2011	Unknown	Completed	Bird's Eye (Formerly Nalley's) closed, NPDES discharges ceased.

Table 2-1
Master Spreadsheet for Source Control Actions

Action Number	Action Number by Basin	Sub basin	Action	Date	Potential COCs	Status	Description
283	84	FD13/FD13B	Spill 1	1/4/2007	PAH, TPH	Completed	Key Bank diesel generator leak to soil/CB located.
284	85		Spill 2	2008	TPH	Completed	Feral Transport trucks leaking on side street (WSP, Ecology and local agencies).
285	86		Spill 3	2009	TPH	Completed	EPA Criminal Dumping at Classy Chassy Carwash site
286	87		Spill 4	5/18/2010	PAH, TPH	Completed	Northbound I5 semi-truck fire - no release
287	88		Spill 5	6/16/2010	PAH, TPH	Completed	Home Biodeisel Fire - sheen on waterway
288	89		Spill 6	4/1/2011	PAH, TPH	Completed	Tacoma Streets & Grounds petroleum spill @ S 37th & G Street
289	90		Spill 7	11/16/2011	PAH, TPH	Completed	75 gal diesel spill from truck accident to WSDOT Pond @ Center St
290	91		UST 1	2004	PAH, TPH	Completed	48th St & Park Ave UST removed
291	92		UST 2	4/1/2004	PAH, TPH	Completed	3919 S Center St UST removed
292	93	FD-2	UST 3	2010-2011	PAH, TPH	Completed	Foremost 2413 Pacific Ave, 3 USTs removed/soil contamination remediated
293	94		UST 4	2012	PAH TPH	Ongoing	2340 S. Holgate - two large out-of-service gasoline fuel tanks identified
294	95		UST 5	2012	PAH TPH	Ongoing	1 UST @ the Elks Club 1965 S. Union St
295	96		UST 6	2012	PAH TPH	Completed	1 UST @ Apartment Complex at 3831 S. Yakima
296	97		UST 7	2012	PAH TPH	Ongoing	2 UST @ Cook's Concrete 1521 S. Grant Ave. LUST - independent action
OF237B Basin							
297	1		Const 1	2005	None	Completed	60' OFs extended, new manhole structure
298	2		Const 2	2009-2010	TSS	Ongoing	Freeway right-of-way HOV Lanes on I-5,
299	3		Const 3	2010-2012	TSS	Completed	LeMay Museum - Warning letter for TSS in 2010
300	4		Const 4	2012	None	Completed	Tacoma Dome Roof Cleaning
301	5		Fac.	2001	All	Ongoing	drainage pond- 5708 McKinley Avenue.
302	6		Inspect 1	2003-2004	All	Completed	Equipment washing stopped at S. 38th & Pacific Ave., A-Berg Equipment Rentals.
303	7		Inspect 2	2006	TSS	Completed	1 BMP inspected
304	8		Inspect 3	2007	TSS	Completed	5 BMP inspected
305	9		Inspect 4	2007-2011	All	Completed	100% of businesses/multi-family inspected.
306	10		Inspect 5	2008	TSS	Completed	9 BMP inspected
307	11		Inspect 6	2009	TSS	Completed	118 inspections
308	12		Inspect 7	2010	TSS	Completed	45 inspections
309	13		Inspect 8	2011	TSS	Completed	51 inspections
310	14		Inspect 9	2012	All	completed	20 inspections completed in the OF237B drainage basin
311	15	FD31	Maint 1	2005	PAH, TPH	Completed	FD31 branch pipe cleaned/TVed.
312	16		Maint 2	2011	All	Completed	Entire system cleaned/TVed.
313	17		Maint 3	2012	All	Completed	Enhanced street sweeping, general system cleaning and maintenance
314	18		Onsite Fac 1	2003-2004	TSS	Completed	4 media filters,4 bioswales, 2 vortex separators/wet vaults
315	19		Onsite Fac 2	2005	TSS	Completed	6 media filters
316	20		Onsite Fac 3	2006	TSS	Completed	3 media filters, 2 bioswales,1 wetpond/detention pond
317	21		Onsite Fac 4	2008	TSS	Completed	7 media filters
318	22		Onsite Fac 5	2009	TSS	Completed	1 media filter
319	23		Onsite Fac 6	2010	TSS	Completed	1 media filter and 4 biofiltration swales
320	24		Onsite Fac 7	2011	TSS	Completed	2 sites w/ media filters
321	25		Onsite Fac 8	2012	TSS	Completed	1 media filter
322	26		Point Source 1	2002	All	Completed	WSDOT Vactor Dump Site (South 38th) closed.
323	27		Point Source 2	2003	All	Completed	WSDOT Vactor Dump Site (South 38th) stormwater routed to pretreatment system then sanitary sewer.
324	28		Point Source 3	3/1/2003	All	Completed	WSDOT Vactor Dump Site (South 38th) permitted
325	29		Point Source 4	10/1/2004	Unknown	Completed	Cross-connection removed- Persian rug cleaning business
326	30	FD31	Point Source 5	2005	PAH, TPH	Completed	1950s UST (heating fuels) at Tacoma Public Schools Willard Staff
327	31	FD31	Point Source 6	2005	PAH, TPH	Completed	neighborhood fueling station closed
328	32		Point Source 7	2005	Unknown	Ongoing	old closed demolition landfill, S. 35th and Pacific Ave listed by TPCHD.
329	33		Point Source 8	2006	Unknown	Completed	Tacoma Dome equipment wash pad rerouted to sanitary.
330	34		Point Source 9	2008	Unknown	Completed	Ketebo Apartments, failing side sewer repaired.
331	35		Point Source 10	2008	Unknown	Completed	Lighthouse.cross- connection repaired
332	36		Spill 1	12/4/2010	PAH, TPH	Completed	1,000 gallon release cleanup completed.
333	37		UST 1	2003-2004	PAH, TPH	Completed	Several USTs/LUSTs removed.
334	38	FD31	UST 2	1/1/2006	PAH, TPH	Completed	Inspected 1950s UST (heating fuels) at Tacoma Public Schools Willard Staff
335	39	FD31	UST 3	11/1/2011	PAH, TPH	Completed	UST removed at Tacoma Public Schools Willard Staff
336	40	FD31	UST 4	7/3/2005	PAH, TPH	Ongoing	3402 Pacific Ave, EZ Mart, Phase I/II assesment, Possible UST

Table 2-1
Master Spreadsheet for Source Control Actions

Action Number	Action Number by Basin	Sub basin	Action	Date	Potential COCs	Status	Description
OF243 Basin							
337	1		Cleanup 1	2002	Hg, DEHP	Completed	Pick's Cove sold & remediated. Now Foss Landing Marina.
338	2		Cleanup 2	5/1/2002	PAH	Completed	SR509 WSDOT Stormwater Ponds cleanup.
339	3		Cleanup 3	6/1/2003	Metals	Completed	American Plating Cleanup, Ecology
340	4		Cleanup 4	8/2008-9/2008	PAH	Completed	N.Pacific Rail yard oil pipeline Phase 1 cleanup D Street, SR509, WSDOT Stormwater Ponds rebuilt.
341	5		Cleanup 5	6/1/2009	PAH	Completed	N.Pacific Rail yard oil pipeline cleanup cleanup D Street & E 19th St.
342	6		Cleanup 6	2012	Metals	Completed	American Plating Cleanup and Site Development
343	7		Const 1	4/2006-6/2008	TSS	Completed	D Street Grade separation construction
344	8		Const 2	2010	TSS	Ongoing	Sound Transit, D to M Street Cooridor, utilities relocated near Frieghthouse
345	9		Inspect 1	6/4/2007	Unknown	Completed	LRI inspection/BMPs required.
346	10		Inspect 2	2008	Hg	Completed	source traing using SSPM samples in laterals
347	11		Inspect 3	2009	Hg	Completed	source traing using SSPM samples in laterals
348	12		Inspect 4	2011	All	Completed	5 business inspections
349	13		Inspect 5	2010	All	Completed	2 business inspections
350	14		Inspect 6	2011	All	Ongoing	BNSF Rail yard inspections - 11 subleases
351	15		Inspect 7	2012	All	Completed	5 business inspections completed in the OF243 drainage basin
352	16		Maint 1	9/1/2001	None	Completed	Tide Flex valve replaced
353	17		Maint 2	1/1/2002	PAH	Completed	WSDOT leg cleaned
354	18		Maint 3	2004	None	Completed	railroad yards remodeled/stormwater system mapped
355	19		Maint 4	2005	None	Completed	SR509 storm system mapped.
356	20		Maint 5	2012	All	Completed	Enhanced street sweeping, general system cleaning and maintenance
357	21		Onsite Fac 1	2001	TSS	Completed	media filter
358	22		Onsite Fac 2	2003	TSS	Completed	bioswale
359	23		Onsite Fac 3	6/1/2008	TSS	Completed	media filter D Street Grade separation
360	24		Onsite Fac 4	2012	TSS	Completed	2 media filters
361	25		Spill 1	2007	Unknown	Completed	starch spill on a rail spur cleaned.
362	26		Spill 2	6/4/2007	Unknown	Completed	LRI spill cleaned
363	27		Spill 3	2008	Unknown	Completed	starch spill on a rail spur, Glacier Transport (now called Tanawax Trucking).
364	28		UST	6/1/2006	PAH, TPH	Completed	UST removed during D Street Grade separation
365	29		UST	8/1/2006	PAH, TPH	Completed	UST removed during D Street Grade separation
OF245 Basin							
366	1	MH390	Cleanup 1	1997	PAH	Completed	N.Pacific Rail yard oil pipeline cleanup cleanup D Street & E 19th St.
367	2	MH390	Cleanup 2	2008-2011	PAH	Completed	N.Pacific Rail yard oil pipeline cleanup D Street.
368	3	MH390	Fine 1	2000	PAH, TPH	Completed	Ecology fined SuperValu for spills
369	4	MH390	Fine 2	2000	PAH, TPH	Completed	Tacoma Fixture's spill, Ecology fine.
370	5	FD21/22	Inspect 1	2005	Phthalates	Completed	MPS Joint inspections and sampling with Ecology.
371	6	MH390	Inspect 2	2007	All	Closed	SQG hazardous Waste Facility closed.
372	7	MH390	Inspect 3	2008	All	Ongoing	Phoenix new waste treatment & transporter permitted. Trans-loading of hazardous waste shipments occur in the near by BNSF rail yard.
373	8	MH390	Inspect 4	2008	Unknown	Completed	LRI inspection/BMPs required.
374	9	MH390	Inspect 5	2010	All	Completed	7 business inspections
375	10	MH390	Inspect 6	2011	All	Completed	7 business inspections
376	11		Inspect 7	2012	All	Completed	4 business inspections in the OF245 drainage basin
377	12	MH390	Maint 1	10/1/2001	PAH	Completed	604' pipe slip-lined
378	13	MH390	Maint 2	9/1/2002	PAH	Completed	300' stormwater line & laterals replaced on E. 19th St.
379	14	MH390	Maint 3	3/1/2003	PAH	Completed	24' outfall pipe replaced with HPDE.
380	15	FD21/22	Maint 4	2/1/2004	All	Completed	cleaned city lines from Quality Transport (MPS).
381	16	FD21/22	Maint 5	2008	All	Completed	Cleaned Quality Transport (MPS) pipes.
382	17	FD21/22	Maint 6	2009	All	Completed	Cleaned Quality Transport (MPS) pipes.
383	18		Maint 7	2012	All	Completed	Enhanced street sweeping, general system cleaning and maintenance
384	19	MH390	Onsite Fac. 1	5/1/2004	TSS	Completed	media filter installed (basic treatment)
385	20	MH390	Onsite Fac. 2	8/1/2004	PAH, TPH	Completed	SuperValu 5 oil/water separators onsite.
386	21	MH390	Onsite Fac. 3	2010	PAH, TPH	Completed	SuperValu 3 oil/water separators onsite.
387	22	MH390	Point Source 1	9/1/2004	PAH	Completed	TVed petroleum/tar blobs in pipe E. 19th St.
388	23	MH390	Point Source 2	7/1/2005	PAH	Completed	TVed petroleum/tar blobs in pipe E. 19th St., see cleanup 2008
389	24	MH390	Spill 1	12/1/2006	Unknown	Completed	starch spill on a rail spur cleaned.
390	25	MH390	Spill 2	6/4/2007	TPH	Completed	Matrix Trucking petroleum spill
391	26	MH390	Spill 3	6/4/2007	Unknown	Completed	LRI spill cleaned

Table 2-1
Master Spreadsheet for Source Control Actions

Action Number	Action Number by Basin	Sub basin	Action	Date	Potential COCs	Status	Description
392	27	MH390	Spill 4	9/1/2007	PAH, TPH	Completed	4 petroleum spills SuperValu's OF249
393	28	MH390	Spill 5	12/2/2010	PAH, TPH	Completed	Diesel Truck Fire, contained
394	29	MH390	UST 1	10/1/2007	PAH	Completed	3 USTs removed at Nichols Trucking
395	30	MH390	UST 2	2007-2008	PAH	Completed	Diesel UST removed at Tacoma Fixtures
396	31	MH390	UST 3	7/1/2009	PAH	Completed	Diesel UST removed at Tacoma Fixtures
OF254 Basin							
397	1		Cleanup 1	12/1/2006	Metals, PAHs, PCBs	Completed	Site cleanup. Port of Tacoma ownership
398	2		Cleanup 2	2010	PAH	Completed	N.Pacific Rail yard oil pipeline cleanup D Street.
399	3		Const 1	2003	TSS	Completed	INS Detention Facility Construction
400	4		Const 2	2003-2004	TSS	Completed	Panattoni site construction
401	5		Const 3	1/2006-12/2006	TSS	Completed	Portside Warehouse Facility
402	6		Const 4	2007	TSS	Completed	INS Detention Facility Expansion Construction
403	7		Const 5	10/2008-2009	TSS	Completed	Ecology fined First Student Facility, permit required/turbid discharge; 2008 now is Durham.
404	8		Const 6	6/17/2011	TSS	Completed	TPU Hydrant Repair discharges muddy water
405	9		Fine 1	2007	All	Completed	Feed Commodities inspection/BMPs
406	10		Fine/Violation 2	2012	Diesel	Ongoing	First Student - Second Warning Letter
407	11		Fine/Violation 3	2012	Diesel	Ongoing	First Student - Notice of Violation
408	12		Inspect 1	2002	All	Completed	Ecology business inspections
409	13		Inspect 2	2003	All	Completed	drive-by observations and complaint investigations
410	14		Inspect 3	2003	All	Completed	16 industries were inspected
411	15		Inspect 4	2003-2004		Completed	Storm sediment sampling/TV inspection of storm pipe
412	16		Inspect 5	12/1/2005	All	Completed	7 BMP inspections
413	17		Inspect 6	2006	All	Completed	Basin 254 Public Outreach Meeting
414	18		Inspect 7	5/1/2006	All	Completed	Initial business inspections of all facilities
415	19		Inspect 8	6/1/2006	All	Completed	collected pipe sediment data from businesses
416	20		Inspect 9	8/1/2006	TSS, PAH, TPH	Completed	First Student Facility inspected by Ecology.
417	21		Inspect 10	11/1/2006	All	Completed	5 BMP inspections
418	22		Inspect 11	2007	All	Completed	5 BMP inspections
419	23		Inspect 12	2008	All	Completed	Focused inspections: TriPak, Urban Logistics, NW Detention Center, Portside Complex, First Student, Pacific Machine, Johnson Postman, Urban Accessories
420	24		Inspect 13	2008	All	Completed	Jan 26-28, March 23-25, Apr 27-28, Jun 12-14, 2006 cleaned/TV inspected entire municipal storm drainages
421	25		Inspect 14	2010	All	Completed	20 business inspections
422	26		Inspect 15	2011	All	Completed	9 business inspections
423	27		Inspect 16	2012	All	Completed	9 business inspections in the OF254 drainage basin
424	28		Maint 1	2006	TSS	Completed	First Student Facility media filter
425	29		Maint 2	4/1/2006	Unknown	Completed	update GIS map of public/private systems
426	30		Maint 3	6/1/2006	All	Ongoing	regular street vacuum sweeping of the area
427	31		Maint 4	2007	All	Ongoing	Increased street sweeping frequency.
428	32		Maint 5	2/1/2008	TSS	Completed	1-wet/detention pond, 1-bioswale, 1-vortex sep
429	33		Maint 6	2010	TSS	Completed	Nichols Trucking Yard 2 update tide gate valve
430	34		Maint 7	2012	All	Completed	Enhanced street sweeping, general system cleaning and maintenance
431	35		Onsite Fac. 1	2005	TSS	Completed	1-media filter, 1-bioswale, 2-detention/wet vault, 2-wet pond
432	36		Onsite Fac. 2	2006	TSS	Completed	2-wet pond
433	37		Onsite Fac. 3	2007-2010	TSS	Completed	2 Contech Stormfilter vaults connected, NW Detention Center/INS Detention Facility
434	38		Onsite Fac. 4	2009	TSS	Completed	First Student Facility turbid discharge
435	39		Onsite Fac. 5	2010	TSS	Ongoing	First Student Facility turbid discharge
436	40		Onsite Fac 6	2012	TSS	Completed	Above ground settling tank
437	41		Point Source 1	2003-2006	TPH, PAHs	Completed	petroleum discharge removed. BMPs required.
438	42		Point Source 2	12/15/2005	Hg	complete	Reinhold Petroleum Hg @ 4.75 mg/kg in CB
439	43		Point Source 3	8/1/2006	DEHP	Ongoing	NW Detention Center DEHP@ 610,000 ug/kg in stormwater pond inlet.
440	44		Point Source 4	8/1/2006	DEHP	Ongoing	NW Detention Center DEHP@ 790,000 ug/kg
441	45		Point Source 5	2008-2011	DEHP	Completed	NW Detention Center onsite DEHP@ 270,000-880,000 ug/kg; after media filter offsite DEHP was low. Source was laundry lint from dryer vent.
442	46		Point Source 6	2009	Unknown	Completed	LRI spill. BMPs required.
443	47		Spill 1	6/4/2007	PAH, TPH	Completed	Urban Logistics oil spill to SW pond
444	48		Spill 2	12/12/2008	PAH, TPH	Completed	CB on street by Codel Inc diesel spill.
445	49		Spill 3	6/2010-2011	PAH, TPH	Completed	4 spills in 12 months at First Student - LOOK AT DATA!!! June 2010-2011

Table 2-2
Sediment Trap Monitoring Locations for 2002-2012

		WY2002	WY2003	WY2004	WY2005	WY2006	WY2007	WY2008	WY2009	WY2010	WY2011	WY2012
Dates Deployed		8/31/01 3/25-26/02	8/27-29/02 4/28/03	8/27/03 4/8/04	8/24-26/04 4/05	8/26-30/05 4/06/06	8/21-23/06 3/1*:4/20/07	8/21-24/07 4/3-4/08	8/28/2008 5/4-8/09	8/27/2009 8/23-24/10	8/23-24/10 8/25-26/11	8/24-25/11 8/14-23/12
OF237A	FD2	X	X	X	X	X 9/26/05	X	X	X	X	X	X
	FD2A	X	Pulled 3/10/03	Site gone	X	X 1/9/06	X	X	X	X	X	X
	FD5	X	X	X	X	X	X	X	X	X	X	X
	FD10		X	X	X	X	X	X	X	X	X	X
	FD10B		X	X	X	X	X	X	X	X	X	X
	FD10C		X	X	X	X	X	X	X	X	X	X
	FD13		X	X	X	X	X	X	X	X	X	X
	FD13B		X	X	X	X	X	X	X	X	X	X
OF237B	FD1	X	X	X	X	X 9/26/05	X	X	X	X	X	X
	FD30		X		X			X	X			
	FD31		X		X			X	X	X	X	X
	FD32		X		X			X	X			
	FD33		X		X			X	X			
	FD34		X		X			X	X	X	X	X
	FD35		X		X			X	X	X	X	X
	FD36		X		X			X	X			
	FD37		X		X			X	X			
	FD38		X		X			X	X			
OF230	FD3NEW	X	X	X	X	X	X *	X	X	X	X	X
	FD3	X	X	X	X	X	X *	X	X	X	X	X
	FD3A	X	X	X	X	X	X *	X	X	X	X	X
	FD3B	X	Pulled	X	X	X	X *	X	X	X	X	X
	FD16		Lost	X	X	X	X *	X	X	X	X	X
	FD16B		X	X	X	X	X *	X	X	X	X	X
	FD18		X	X	X	X	X *	X	X	X	X	X
	FD18B		X	X	X	X	X *	X	X	X	X 1/24/11	X
OF235	FD6	X	X	X	X	X	X *	X	X	X	X	X
	FD6-A					X 10/7/05	X *	X	X	X	X	X
	FD6-B					X 10/6/05	X *	X	X	X	X	X
OF243	FD23	X	X	X	X	X	X	X	X	X	X	X
OF245	MH390	X	X	X	X	X	X	X	X	X	X	X
	FD21	X	X	X	X	X	X	X	X	X	X	X
OF248	FD22	X	X	X	X	X	X	X	X	X	X	X

In 2006, FD2, FD2A and FD1 weren't installed until construction was complete on the outfall extensions for Outfalls 237A and 237B. In 2011, FD18B wasn't installed until pipe relining construction was complete in Basin 230.

Table 2-3
STRAP Assessment for the Thea Foss Basin

Basin	Basin Total (ft)	Assessment (ft)			Total Assessed (ft)	Capacity (ft)		Maintenance Needed (ft)	Percentage			Total Percentage
		Green	Yellow	Red		No Issue	Issues		Green	Yellow	Red	
FS_01	42,147	10,200	18,455	6,616	35,271			2,750	24.20%	43.80%	15.70%	83.70%
FS_02	45,510	22,866	5,988	681	29,535		2,431	8,900	50.20%	13.20%	1.50%	64.90%
FS_03	40,111	17,362	5,879	1,495	24,736			3,879	43.30%	14.70%	3.70%	61.70%
FS_04	32,980	6,271	7,680	5,320	19,271			3,561	19.00%	23.30%	16.10%	58.40%
FS_05	88,374	44,448	17,137	9,192	70,777		2,616	223	50.30%	19.40%	10.40%	80.10%
FS_06	21,998	7,843	3,559	2,876	14,278		1,452	683	35.70%	16.20%	13.10%	64.90%
FS_07	24,509	9,640	7,092	2,828	19,560			2,316	39.30%	28.90%	11.50%	79.80%
FS_08	34,743	6,223	5,569	636	12,428			3,987	17.90%	16.00%	1.80%	35.80%
FS_09	56,053	3,445	4,398	4,251	12,094			4,989	6.10%	7.80%	7.60%	21.60%
FS_10	60,936	13,023	7,135	2,416	22,574			8,081	21.40%	11.70%	4.00%	37.00%
FS_11	102,176	34,595	2,571	3,404	40,570		1,982	6,403	33.90%	2.50%	3.30%	39.70%
FS_12	16,262	2,879	2,266		5,145			348	17.70%	13.90%		31.60%
FS_13	8,989	3,940			3,940				43.80%			43.80%
FS_14	6,324	1,348	154	783	2,285				21.30%	2.40%	12.40%	36.10%
FS_15	4,128	753			753			158	18.20%			18.20%
Total	**585,240**	**184,836**	**87,883**	**40,498**	**313,217**	**0**	**8,481**	**46,278**	**31.6%**	**15.0%**	**6.9%**	**53.5%**
Whole City Total		858,844	370,979	121,671	1,351,494	803	20,497	311,419	34.10%	14.70%	4.80%	53.70%

Key:

Green *is used when the pipe is in excellent condition.*

Yellow *is used when the pipe needs to be repaired in the future. The pipe will most likely be able to be lined. This ranking will cover a wide range of root intrusion, minor holes, and*

Red *is used when the pipe is in need of immediate attention. The pipes will most likely need to be replaced or spot repaired. This ranking typically includes pipes in which the*

Capacity *is also being tracked in the STRAP database. This information is being obtained through separate modeling efforts.*

Table 2-4
Stormwater Summary Statistics, Before and After Line Cleaning

OF230*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning
Count	49	45	50	49	50	49	50	49	50	49	50	49	49	49
Minimum	13.9	4.8	7.8	5.7	53.6	36.6	0.011	0.008	0.035	0.010	0.005	0.002	0.50	0.20
Median	49.5	30.8	22.6	14.2	120.0	114.0	0.143	0.022	0.307	0.032	0.102	0.008	4.90	1.68
Arithmetic Mean	61.3	46.6	28.9	23.1	136.7	120.7	0.181	0.045	0.368	0.077	0.110	0.027	5.59	3.53
Maximum	232.0	304.0	125.0	229.0	721.0	485.0	0.653	0.235	1.200	0.467	0.346	0.161	24.90	44.10
Standard Deviation	43.3	54.5	20.0	32.9	98.3	71.5	0.150	0.053	0.276	0.108	0.083	0.043	4.24	6.44
Standard Error	6.2	8.1	2.8	4.7	13.9	10.2	0.021	0.008	0.039	0.015	0.012	0.006	0.61	0.92
t-statistic	2.943		3.231		1.163		8.645		9.730		8.309		4.138	
p-value	0.002		0.001		0.124		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	**Yes**		**Yes**		No		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	**24%**		**20%**		--		**75%**		**79%**		**76%**		**37%**	

OF235*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning
Count	54	59	54	64	54	64	54	64	54	64	54	64	53	64
Minimum	10.4	7.8	23.2	9.5	37.3	40.7	0.009	0.002	0.034	0.002	0.005	0.002	0.50	0.32
Median	78.0	40.8	80.0	54.6	137.5	102.5	0.138	0.024	0.328	0.041	0.073	0.007	6.10	1.61
Arithmetic Mean	101.0	55.6	95.8	59.5	165.1	118.1	0.170	0.053	0.339	0.104	0.080	0.022	9.55	2.95
Maximum	441.0	176.0	368.0	204.0	475.0	406.0	0.479	0.689	1.010	0.854	0.280	0.145	97.00	16.70
Standard Deviation	77.8	38.4	57.0	29.5	95.3	58.3	0.108	0.093	0.215	0.139	0.055	0.032	13.46	3.08
Standard Error	10.6	5.0	7.8	3.7	13.0	7.3	0.015	0.012	0.029	0.017	0.008	0.004	1.85	0.39
t-statistic	4.268		5.196		3.338		8.636		9.164		8.637		7.163	
p-value	<0.001		<0.001		0.001		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	**Yes**		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	**45%**		**38%**		**28%**		**69%**		**69%**		**73%**		**69%**	

OF237A*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning
Count	60	40	60	40	60	40	60	39	60	39	60	39	59	39
Minimum	3.5	7.7	1.7	2.9	41.8	37.2	0.005	0.002	0.035	0.014	0.005	0.002	0.50	0.20
Median	49.0	38.7	12.7	10.6	105.5	76.7	0.125	0.018	0.326	0.030	0.096	0.006	3.30	0.97
Arithmetic Mean	56.5	55.5	15.0	14.7	117.1	91.5	0.162	0.028	0.423	0.066	0.126	0.019	3.41	1.25
Maximum	281.0	400.0	43.2	67.8	361.0	238.0	0.893	0.309	2.930	0.770	0.680	0.269	13.70	5.48
Standard Deviation	41.0	69.3	8.4	13.3	52.7	45.3	0.159	0.049	0.446	0.125	0.130	0.044	2.50	1.19
Standard Error	5.3	11.0	1.1	2.1	6.8	7.2	0.021	0.008	0.058	0.020	0.017	0.007	0.32	0.19
t-statistic	1.605		1.207		3.191		9.580		11.272		10.129		5.763	
p-value	0.056		0.115		0.001		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	No		No		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	--		--		**22%**		**83%**		**84%**		**85%**		**63%**	

OF237B*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning
Count	92	14	92	16	92	17	92	17	92	17	92	17	91	17
Minimum	3.6	7.8	1.5	2.6	15.0	26.6	0.002	0.006	0.010	0.008	0.003	0.002	0.35	0.20
Median	53.3	30.6	11.9	7.7	63.5	41.2	0.052	0.012	0.127	0.018	0.039	0.003	2.50	0.56
Arithmetic Mean	68.6	43.7	15.4	10.7	81.9	53.9	0.080	0.016	0.180	0.020	0.054	0.005	3.10	0.54
Maximum	278.0	97.6	64.2	23.8	243.0	136.0	0.838	0.053	1.493	0.051	0.546	0.019	12.00	1.02
Standard Deviation	51.2	30.9	11.6	6.6	50.0	28.8	0.104	0.012	0.210	0.010	0.071	0.005	2.61	0.24
Standard Error	5.3	8.3	1.2	1.7	5.2	7.0	0.011	0.003	0.022	0.003	0.007	0.001	0.27	0.06
t-statistic	1.964		1.470		2.566		4.435		6.181		5.964		6.773	
p-value	0.026		0.072		0.006		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	**Yes**		No		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	**36%**		--		**34%**		**80%**		**89%**		**90%**		**82%**	

Table 2-4
Stormwater Summary Statistics, Before and After Line Cleaning

OF254*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning	Pre-Cleaning	Post-Cleaning
Count	37	49	37	50	37	50	37	50	37	50	37	50	37	50
Minimum	5.2	14.3	4.2	3.1	73.7	43.1	0.018	0.002	0.086	0.002	0.012	0.002	0.50	0.23
Median	77.0	86.8	16.7	13.8	157.0	124.5	0.133	0.042	0.402	0.068	0.060	0.013	2.20	1.24
Arithmetic Mean	83.4	117.6	20.4	19.9	181.9	138.1	0.159	0.063	0.572	0.138	0.071	0.023	2.61	2.43
Maximum	240.0	354.0	49.5	68.0	427.0	334.0	0.657	0.283	4.120	0.773	0.239	0.110	6.60	10.20
Standard Deviation	48.2	82.2	10.7	15.7	83.1	72.7	0.116	0.060	0.654	0.178	0.042	0.027	1.73	2.53
Standard Error	7.9	11.7	1.8	2.2	13.7	10.3	0.019	0.008	0.108	0.025	0.007	0.004	0.28	0.36
t-statistic	-1.936		1.254		3.001		5.978		8.151		7.870		1.702	
p-value	0.972		0.107		0.002		<0.001		<0.001		<0.001		0.046	
Significant? (p < 0.05)	No		No		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	--		--		**24%**		**60%**		**76%**		**68%**		**7%**	

Notes:

**Following are the dates of the City's sewer-line cleaning activities:*

OF230: March 12 through May 14, 2007

OF235: May 15 through June 25, 2007

OF237A: April 28 through August 8, 2008 (only the northern half of this drainage basin was cleaned)

OF237B: November 7, 2010 to February 24, 2011

OF254: January 26 through June 14, 2006

**Any monitoring events within the window of cleaning activities were excluded from the analysis.*

OF237A location includes data from OF237A New sampling location for all data collected after to 2/26/06.

Table 2-5
Stormwater Summary Statistics, Before and After Street Sweeping

Outfall 230*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping
Count	41	47	41	52	41	52	41	52	41	52	41	52	40	52
Minimum	13.9	4.8	7.8	5.7	53.6	36.6	0.011	0.008	0.005	0.002	0.035	0.010	0.50	0.20
Median	49.5	32.2	24.4	14.3	122.0	113.0	0.157	0.024	0.102	0.009	0.316	0.033	4.55	1.79
Arithmetic Mean	64.9	46.8	30.4	23.4	141.1	120.5	0.192	0.052	0.112	0.034	0.383	0.094	5.65	3.65
Maximum	232.0	304.0	125.0	229.0	721.0	485.0	0.653	0.235	0.346	0.228	1.200	0.553	24.90	44.10
Standard Deviation	45.6	53.4	21.4	32.0	106.0	70.2	0.161	0.060	0.089	0.054	0.296	0.132	4.66	6.28
Standard Error	7.1	7.8	3.3	4.4	16.6	9.7	0.025	0.008	0.014	0.007	0.046	0.018	0.74	0.87
t-statistic	2.987		3.145		1.295		7.410		7.942		6.561		3.280	
p-value	0.002		0.001		0.099		<0.001		<0.001		<0.001		0.001	
Significant? (p < 0.05)	**Yes**		**Yes**		No		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	**28%**		**23%**		--		**73%**		**69%**		**75%**		**35%**	

Outfall 235*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping
Count	44	62	44	67	44	67	44	67	44	67	44	67	43	67
Minimum	10.4	7.8	23.2	9.5	37.3	40.7	0.009	0.002	0.005	0.002	0.034	0.002	0.50	0.32
Median	81.8	45.0	81.5	54.8	135.0	104.0	0.147	0.024	0.078	0.008	0.355	0.041	6.20	1.70
Arithmetic Mean	107.6	58.3	99.4	59.9	169.5	119.4	0.178	0.066	0.083	0.029	0.359	0.126	10.09	3.04
Maximum	441.0	176.0	368.0	204.0	475.0	406.0	0.479	0.776	0.280	0.338	1.010	1.164	97.00	16.70
Standard Deviation	82.6	40.4	61.1	29.2	102.7	58.0	0.115	0.127	0.058	0.053	0.224	0.194	14.76	3.06
Standard Error	12.5	5.1	9.2	3.6	15.5	7.1	0.017	0.016	0.009	0.006	0.034	0.024	2.25	0.37
t-statistic	4.112		5.098		3.125		7.228		7.369		7.569		6.481	
p-value	<0.001		<0.001		0.001		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	**Yes**		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	**46%**		**40%**		**30%**		**63%**		**66%**		**65%**		**70%**	

Outfall 237A*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping
Count	44	52	44	52	44	52	44	51	44	51	44	51	43	51
Minimum	13.1	3.5	5.0	1.7	41.8	37.2	0.005	0.002	0.005	0.002	0.041	0.014	0.50	0.20
Median	51.7	39.4	13.4	10.6	105.5	84.7	0.126	0.021	0.100	0.007	0.341	0.040	2.60	1.03
Arithmetic Mean	53.1	60.9	14.5	15.9	118.6	99.4	0.163	0.059	0.118	0.049	0.405	0.165	3.37	1.73
Maximum	120.0	400.0	31.5	67.8	361.0	238.0	0.893	0.828	0.669	0.680	1.770	2.930	13.70	7.90
Standard Deviation	23.4	71.4	6.8	13.6	55.7	47.9	0.146	0.129	0.115	0.114	0.324	0.434	2.70	1.71
Standard Error	3.5	9.9	1.0	1.9	8.4	6.6	0.022	0.018	0.017	0.016	0.049	0.061	0.41	0.24
t-statistic	1.267		0.778		2.261		7.153		7.739		6.708		3.794	
p-value	0.104		0.219		0.013		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	No		No		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	--		--		**16%**		**64%**		**58%**		**59%**		**49%**	

Outfall 237B*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping
Count	45	60	45	62	45	63	45	63	45	63	45	63	44	63
Minimum	7.5	3.6	3.8	1.5	31.3	15.0	0.005	0.002	0.005	0.002	0.028	0.002	0.50	0.20
Median	60.3	41.1	14.3	8.6	70.5	59.1	0.091	0.017	0.061	0.008	0.242	0.027	3.00	0.90
Arithmetic Mean	76.4	59.3	18.0	12.7	93.3	67.5	0.102	0.043	0.066	0.029	0.238	0.085	3.87	1.74
Maximum	278.0	211.0	64.2	54.8	232.0	243.0	0.423	0.838	0.277	0.546	0.972	1.493	12.00	8.70
Standard Deviation	55.1	48.2	12.5	10.1	54.0	43.4	0.071	0.109	0.051	0.074	0.174	0.200	3.02	1.83
Standard Error	8.2	6.2	1.9	1.3	8.0	5.5	0.011	0.014	0.008	0.009	0.026	0.025	0.46	0.23
t-statistic	2.239		2.823		3.170		7.332		8.100		6.588		5.181	
p-value	0.014		0.003		0.001		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	**Yes**		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	**22%**		**30%**		**28%**		**58%**		**56%**		**64%**		**55%**	

Table 2-5
Stormwater Summary Statistics, Before and After Street Sweeping

Outfall 243*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping
Count	32	35	32	35	32	35	32	35	32	35	32	35	31	35
Minimum	10.7	4.4	9.7	1.4	51.1	19.6	0.023	0.005	0.005	0.002	0.033	0.012	0.50	0.20
Median	58.4	55.7	27.1	32.1	99.9	68.4	0.098	0.019	0.033	0.005	0.163	0.040	3.10	0.56
Arithmetic Mean	69.4	82.1	46.5	54.6	147.2	97.0	0.100	0.030	0.041	0.020	0.180	0.074	3.33	2.07
Maximum	220.0	300.0	353.0	379.0	1170.0	392.0	0.221	0.116	0.121	0.113	0.620	0.452	8.40	41.00
Standard Deviation	50.2	73.0	61.5	72.1	193.8	78.3	0.055	0.029	0.029	0.032	0.124	0.099	2.11	6.84
Standard Error	8.9	12.3	10.9	12.2	34.3	13.2	0.010	0.005	0.005	0.005	0.022	0.017	0.38	1.16
t-statistic	-0.090		0.126		2.448		7.515		5.612		5.229		5.513	
p-value	0.536		0.450		0.009		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	No		No		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	--		--		**34%**		**70%**		**51%**		**59%**		**38%**	

Outfall 245*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping
Count	41	54	41	58	41	57	41	57	41	57	41	57	40	56
Minimum	17.6	6.2	2.7	1.7	54.8	27.7	0.019	0.002	0.005	0.002	0.026	0.002	0.75	0.20
Median	72.4	51.2	12.2	9.5	146.0	136.0	0.083	0.025	0.025	0.004	0.123	0.027	3.40	0.94
Arithmetic Mean	83.8	59.7	14.8	11.9	186.9	164.2	0.136	0.045	0.026	0.010	0.162	0.058	5.58	1.50
Maximum	243.0	186.0	38.8	60.0	585.0	498.0	1.650	0.477	0.057	0.051	1.310	0.295	31.00	6.90
Standard Deviation	52.9	39.6	8.5	10.2	122.8	108.5	0.256	0.067	0.014	0.013	0.200	0.071	6.54	1.47
Standard Error	8.3	5.4	1.3	1.3	19.2	14.4	0.040	0.009	0.002	0.002	0.031	0.009	1.03	0.20
t-statistic	2.591		2.357		1.323		6.626		6.416		7.060		7.375	
p-value	0.006		0.010		0.095		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	**Yes**		**Yes**		No		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	**29%**		**20%**		--		**67%**		**61%**		**64%**		**73%**	

Outfall 254*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping
Count	35	47	35	48	35	48	35	48	35	48	35	48	35	48
Minimum	5.2	14.3	8.6	3.1	73.7	43.1	0.018	0.002	0.012	0.002	0.086	0.002	0.50	0.23
Median	78.8	86.8	17.3	13.8	179.0	115.0	0.133	0.041	0.060	0.013	0.402	0.063	2.20	1.15
Arithmetic Mean	86.0	117.4	21.0	20.0	186.6	134.6	0.161	0.061	0.073	0.022	0.584	0.133	2.62	2.41
Maximum	240.0	354.0	49.5	68.0	427.0	334.0	0.657	0.283	0.239	0.110	4.120	0.773	6.60	10.20
Standard Deviation	48.0	83.4	10.6	16.0	83.0	71.6	0.118	0.060	0.042	0.027	0.670	0.179	1.78	2.58
Standard Error	8.1	12.2	1.8	2.3	14.0	10.3	0.020	0.009	0.007	0.004	0.113	0.026	0.30	0.37
t-statistic	-1.564		1.546		3.475		6.073		8.258		8.113		1.733	
p-value	0.939		0.063		<0.001		<0.001		<0.001		<0.001		0.043	
Significant? (p < 0.05)	No		No		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	--		--		**28%**		**62%**		**70%**		**77%**		**8%**	

Notes:
**Street sweeping program started in January 2006 and was in full swing by January 2007. Any monitoring events within the startup window (1/1/06 to 1/1/07) were excluded from the analysis.*
237A location includes data from 237A New sampling location for all data collected after to 2/26/06.

Table 2-6
Stormwater Summary Statistics, Before and After CIPP Lining

Outfall 230*	TSS (mg/l)		Lead (ug/l)		Zinc (ug/l)		Phenanthrene (ug/l)		Pyrene (ug/l)		Indenopyrene (ug/l)		Bis(2EH)phthalate (ug/l)	
	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping	Pre-Sweeping	Post-Sweeping
Count	80	13	82	16	82	16	82	16	82	16	82	16	81	16
Minimum	9.7	4.8	5.7	5.8	53.6	36.6	0.010	0.008	0.013	0.010	0.003	0.002	0.45	0.20
Median	43.1	26.9	21.6	11.4	122.0	85.3	0.098	0.018	0.226	0.019	0.064	0.004	4.50	1.11
Arithmetic Mean	56.4	26.3	28.7	13.8	132.9	114.0	0.137	0.021	0.273	0.029	0.085	0.010	5.38	1.22
Maximum	232.0	62.2	229.0	35.4	721.0	485.0	0.653	0.055	1.200	0.109	0.346	0.042	44.10	3.11
Standard Deviation	43.2	17.9	28.8	8.7	82.4	106.0	0.136	0.013	0.262	0.028	0.081	0.012	5.80	0.86
Standard Error	4.8	5.0	3.2	2.2	9.1	26.5	0.015	0.003	0.029	0.007	0.009	0.003	0.64	0.22
t-statistic	3.605		3.559		2.095		5.917		5.158		6.271		5.646	
p-value	<0.001		<0.001		0.019		<0.001		<0.001		<0.001		<0.001	
Significant? (p < 0.05)	**Yes**		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	
Percent Reduction in Mean	**53%**		**52%**		**14%**		**85%**		**89%**		**88%**		**77%**	

Notes:
**CIPP lining is OF230 occurred between June 2010 and November 2010. Any monitoring events within the lining window (6/10 to 11/10) were excluded from the analysis.*

Table 3-1
Total Rain Depth (Inches) during Past and Present Monitoring Years

		WY2002	WY2003	WY2004	WY2005	WY2006	WY2007	WY2008	WY2009	WY2010	WY2011	WY2012	WY2002 -WY2012 Average	Historical Monthly	
														Mean NCDC 1971-2000	Average Mar 1982 - Aug 2009
WET	October	3.32	0.41	8.88	3.61	3.00	1.28	3.64	2.36	4.18	4.64	3.39	3.52	3.39	3.49
WET	November	10.13	2.96	6.15	2.81	6.25	15.81	2.64	7.61	7.74	5.37	5.98	6.68	6.10	6.73
WET	December	6.82	6.58	4.65	4.03	6.28	8.05	8.36	4.03	2.67	6.83	6.44	5.89	5.89	5.65
WET	January	6.68	8.5	6.79	4.71	11.93	6.92	4.63	7.15	7.40	5.17	7.02	6.99	5.38	6.01
WET	February	3.56	1.71	2.55	0.79	2.59	4.09	2.84	1.61	3.95	3.54	3.19	2.77	4.44	3.63
WET	March	4.16	5.08	2.18	3.14	1.91	6.09	4.16	4.68	4.91	6.57	7.11	4.54	4.18	4.09
WET	April	3.64	3.3	0.91	4.74	2.46	1.34	1.76	3.31	2.90	5.13	3.74	3.02	2.87	2.96
DRY	May	1.14	0.55	2.56	3.34	1.56	1.31	1.01	3.03	4.15	3.77	2.33	2.25	2.01	1.93
DRY	June	1.36	0.36	0.64	1.26	2.25	1.44	1.26	0.33	3.05	1.40	2.54	1.44	1.58	1.56
DRY	July	0.42	0.13	0.00	1.16	0.11	1.30	0.26	0.00	0.78	0.74	0.87	0.52	0.86	0.73
DRY	August	0.06	0.29	2.75	0.04	0.00	0.90	2.32	1.04	0.24	0.27	0.00	0.72	0.83	0.88
DRY	September	0.36	0.69	3.26	0.92	0.74	2.22	0.39	2.82	3.93	0.96	0.02	1.48	1.42	1.14
	Wet Season	38.31	28.54	32.11	23.83	34.42	43.58	28.03	30.75	33.75	37.25	36.87	33.40	32.25	32.56
	Dry Season	3.34	2.02	9.21	6.72	4.66	7.17	5.24	7.22	12.15	7.14	5.76	6.42	6.70	6.24
	Total	41.65	30.56	41.32	30.55	39.08	50.75	33.27	37.97	45.90	44.39	42.63	39.82	38.95	38.80

Key:

Color	*Months*	*Seasons/Years*
(dark green)	*> 2" above historical monthly average*	*> 8" above historical seasonal/yearly average*
(light green)	*> 1" above historical monthly average*	*> 4" above historical seasonal/yearly average*
(white)	*≤ 1" above/below historical monthly average*	*≤ 4" above/below historical seasonal/yearly average*
(yellow)	*> 1" below historical monthly average*	*> 4" below historical seasonal/yearly average*
(orange)	*> 2" below historical monthly average*	*> 8" below historical seasonal/yearly average*

Table 3-2
Summary Statistics for Baseflow

	Overall Data: Overall Detections	Overall Data: % Detections	Overall Data: Arithmetic Mean	Overall Data: Weighted Mean	Overall Data: Max	Overall Data: Date of Max	OF230 Min	OF230 Max	OF230 Arithmetic Mean	OF230 Median	OF235 Min	OF235 Max	OF235 Arithmetic Mean	OF235 Median
Conventionals														
Hardness (mg/L as CaCO3)	281/281	100		N/A	N/A	N/A	27.9	249	144	142	123	199	155	149
pH (pH units)	296/296	100		N/A	N/A	N/A	6.8	9.0	7.7	7.7	7.1	8.0	7.7	7.7
TSS (mg/L)	273/295	93	12.29	12.2	319	3/12/09	0.26	319	15.8	5.90	0.31	258	25.4	6.85
Metals in ug/L														
Lead	209/289	72	5.52	5.53	112	8/7/06	0.97	29.8	5.56	4.0	1.64	112	14.29	6.5
Mercury	18/293	6	0.03	0.03	0.38	7/26/04	*0.025*	0.250	0.036	*0.025*	*0.025*	0.38	0.041	*0.025*
Zinc	283/286	99	46.55	47.5	1,950	8/28/07	19.3	108	46.6	34.0	6.6	355	41.9	17.20
Dissolved Lead	169/288	59	2.88	2.86	47.2	8/28/07	*0.140*	5.5	1.52	1.25	*0.210*	6.0	1.56	1.10
Dissolved Mercury	9/289	3	0.028	0.03	0.193	7/27/04	*0.025*	0.059	0.031	*0.025*	*0.025*	*0.025*	*0.025*	*0.025*
Dissolved Zinc	274/286	96	25.3	25.9	1,220	8/28/07	6.42	95.0	29.15	24.4	3.80	29.9	10.78	9.24
PAHs in ug/L														
2-Methylnaphthalene	55/297	19	0.015	0.015	2.100	2/12/02	*0.002*	0.122	0.013	0.005	*0.002*	0.023	0.006	*0.005*
Acenaphthene	124/297	42	0.014	0.014	0.103	11/21/02	*0.002*	0.013	0.005	*0.005*	*0.002*	0.032	0.011	0.012
Acenaphthylene	7/297	2	0.004	0.004	0.019	7/17/08	*0.002*	*0.005*	*0.004*	*0.005*	*0.002*	*0.005*	*0.004*	*0.005*
Anthracene	36/297	12	0.006	0.006	0.077	7/17/05	*0.002*	0.012	0.004	*0.005*	*0.002*	0.031	0.006	*0.005*
Fluorene	56/291	19	0.006	0.006	0.086	2/12/02	0.002	0.012	0.005	*0.005*	*0.002*	0.060	0.009	*0.005*
Naphthalene	139/297	47	0.023	0.023	3.000	2/12/02	*0.005*	0.228	0.026	0.014	*0.003*	0.054	0.011	0.009
Phenanthrene	134/297	45	0.013	0.013	0.684	7/17/05	*0.002*	0.060	0.012	0.011	*0.002*	0.115	0.014	0.005
Total LPAHs[1,2]	496/1776	28	0.066	0.011	3.276	N/A	0.016	0.270	0.056	0.043	*0.013*	0.206	0.056	0.045
Benzo(a)anthracene	72/297	24	0.012	0.012	1.110	1/13/09	*0.001*	0.066	0.007	*0.005*	*0.001*	0.114	0.013	*0.005*
Benzo(a)pyrene	42/297	14	0.007	0.007	0.142	1/24/06	*0.002*	0.057	0.006	*0.005*	*0.002*	0.142	0.013	*0.005*
Benzo(g,h,i)perylene	52/297	18	0.007	0.007	0.166	8/7/06	*0.002*	0.023	0.007	*0.005*	*0.002*	0.166	0.012	*0.005*
Benzo(b,k)fluoranthenes	115/297	39	0.015	0.015	0.376	7/17/05	*0.002*	0.113	0.013	0.007	*0.002*	0.344	0.026	0.006
Chrysene	76/297	26	0.011	0.011	0.362	3/12/09	*0.002*	0.087	0.010	*0.005*	*0.002*	0.199	0.018	*0.005*
Dibenz(a,h)anthracene	14/297	5	0.005	0.005	0.028	8/7/06	*0.002*	0.011	0.005	*0.005*	*0.002*	0.028	0.005	*0.005*
Fluoranthene	177/297	60	0.021	0.021	1.140	3/12/09	*0.003*	0.133	0.017	0.011	*0.003*	0.295	0.029	0.012
Indeno(1,2,3-c,d)pyrene	32/297	11	0.006	0.006	0.115	8/7/06	*0.002*	0.019	0.005	*0.005*	*0.002*	0.115	0.009	*0.005*
Pyrene	234/297	79	0.026	0.026	0.879	7/17/05	*0.004*	0.173	0.021	0.015	*0.003*	0.253	0.034	0.018
Total HPAHs[1]	814/2673	30	0.112	0.012	3.287	N/A	0.025	0.671	0.091	0.060	*0.025*	1.639	0.162	0.068
Total PAHs[1]	1310/4449	29	0.178	0.012	4.185	N/A	0.041	0.840	0.147	0.121	*0.038*	1.845	0.217	0.116
Phthalates in ug/L														
Bis(2-ethylhexyl)phthalate	85/290	29	1.07	1.06	33.0	3/23/10	*0.26*	33.00	2.00	*0.50*	*0.20*	21.30	1.84	0.72
Butylbenzylphthalate	29/297	10	0.56	0.56	16.0	7/28/04	*0.09*	*0.70*	*0.39*	*0.50*	0.09	1.60	*0.44*	*0.50*
Diethylphthalate	65/297	22	0.92	0.92	32.0	2/5/03	*0.07*	8.40	0.69	*0.50*	*0.04*	15.00	0.91	*0.50*
Dimethylphthalate	2/297	1	0.36	0.36	*0.5*	N/A	*0.02*	*0.50*	*0.36*	*0.50*	*0.02*	*0.50*	*0.36*	*0.50*
Di-n-butylphthalate	59/297	20	0.43	0.43	4.3	3/23/10	*0.10*	*0.50*	*0.40*	*0.50*	0.05	*0.50*	*0.40*	*0.50*
Di-n-octyl phthalate	5/297	2	0.38	0.38	3.9	7/26/04	*0.04*	*2.00*	*0.40*	*0.50*	*0.04*	3.90	0.44	*0.50*
Total Phthalates[3]	245/1782	14			33.4	N/A	*0.23*	33.40	4.44	0.94	0.12	22.90	4.06	1.60

	OF237A Min	OF237A Max	OF237A Arithmetic Mean	OF237A Median	OF237B Min	OF237B Max	OF237B Arithmetic Mean	OF237B Median
Conventionals								
Hardness (mg/L as CaCO3)	85.4	134	105	105	61	129	111	113
pH (pH units)	6.8	7.8	7.4	7.4	5.9	8.0	7.2	7.3
TSS (mg/L)	0.26	16.3	3.08	2.1	0.26	16.9	2.54	1.3
Metals in ug/L								
Lead	*0.06*	6.11	1.21	0.70	*0.07*	6.6	0.99	0.60
Mercury	*0.025*	0.196	0.031	*0.025*	*0.025*	*0.025*	*0.025*	*0.025*
Zinc	1.65	27.0	9.5	9.3	1.05	14.2	4.43	3.7
Dissolved Lead	*0.051*	*4.5*	*0.81*	*0.60*	*0.016*	4.0	0.83	*0.65*
Dissolved Mercury	*0.025*	0.135	0.031	*0.025*	*0.025*	*0.025*	*0.025*	*0.025*
Dissolved Zinc	2.30	12.6	7.7	7.4	*0.60*	14.3	4.6	3.7
PAHs in ug/L								
2-Methylnaphthalene	*0.002*	2.100	0.063	*0.005*	*0.002*	0.019	0.005	*0.005*
Acenaphthene	*0.002*	0.031	0.005	*0.005*	*0.002*	*0.005*	*0.004*	*0.005*
Acenaphthylene	*0.002*	0.016	0.004	*0.005*	*0.002*	*0.005*	*0.004*	*0.005*
Anthracene	*0.002*	*0.005*	*0.004*	*0.005*	*0.002*	*0.005*	*0.004*	*0.005*
Fluorene	*0.002*	0.086	0.007	*0.005*	*0.002*	*0.005*	*0.004*	*0.005*
Naphthalene	*0.002*	3.000	0.088	0.010	*0.002*	0.025	0.007	*0.005*
Phenanthrene	*0.002*	0.149	0.011	*0.005*	*0.002*	*0.008*	*0.004*	*0.005*
Total LPAHs[1,2]	*0.010*	3.276	0.119	0.031	*0.011*	0.050	0.028	*0.030*
Benzo(a)anthracene	*0.001*	0.022	0.006	*0.005*	*0.001*	0.045	0.005	*0.005*
Benzo(a)pyrene	*0.002*	0.020	0.006	*0.005*	*0.002*	0.041	0.005	*0.005*
Benzo(g,h,i)perylene	*0.002*	0.022	0.006	*0.005*	*0.002*	0.044	0.006	*0.005*
Benzo(b,k)fluoranthenes	*0.002*	0.047	0.011	*0.005*	*0.002*	0.107	0.008	*0.005*
Chrysene	*0.002*	0.026	0.006	*0.005*	*0.002*	0.060	0.005	*0.005*
Dibenz(a,h)anthracene	*0.002*	0.010	*0.005*	*0.005*	*0.002*	0.011	*0.005*	*0.005*
Fluoranthene	*0.002*	0.046	0.010	0.005	*0.003*	0.088	0.007	*0.005*
Indeno(1,2,3-c,d)pyrene	*0.002*	0.018	0.005	*0.005*	*0.002*	0.039	0.005	*0.005*
Pyrene	*0.002*	0.056	0.013	0.005	*0.002*	0.078	0.007	*0.005*
Total HPAHs[1]	*0.022*	0.249	0.067	0.045	*0.022*	0.513	0.052	*0.045*
Total PAHs[1]	*0.034*	3.464	0.186	0.087	*0.033*	0.543	0.081	0.075
Phthalates in ug/L								
Bis(2-ethylhexyl)phthalate	*0.20*	1.60	0.56	*0.50*	*0.20*	*0.80*	*0.50*	*0.50*
Butylbenzylphthalate	0.09	*0.50*	*0.37*	*0.50*	*0.05*	*0.50*	*0.36*	*0.50*
Diethylphthalate	0.04	32.00	1.99	*0.50*	*0.04*	17.00	0.99	*0.50*
Dimethylphthalate	*0.02*	*0.50*	*0.35*	*0.50*	*0.02*	*0.50*	*0.35*	*0.50*
Di-n-butylphthalate	0.05	*0.50*	*0.41*	*0.50*	0.05	*0.50*	*0.39*	*0.50*
Di-n-octyl phthalate	*0.04*	*0.50*	*0.35*	*0.50*	*0.04*	*0.50*	*0.35*	*0.50*
Total Phthalates[3]	0.20	32.00	4.60	1.00	0.20	32.10	5.28	1.21

	OF243 Min	OF243 Max	OF243 Arithmetic Mean	OF243 Median	OF245 Min	OF245 Max	OF245 Arithmetic Mean	OF245 Median	OF254 Min	OF254 Max	OF254 Arithmetic Mean	OF254 Median
Conventionals												
Hardness (mg/L as CaCO3)	463	2,310	1418	1,345	136	2,880	874	808	386	4,410	2799	3,030
pH (pH units)	6.6	7.8	7.1	7.1	7.1	8.0	7.4	7.4	6.7	7.6	7.1	7.2
TSS (mg/L)	1.5	42.7	13.6	10.7	0.3	78.9	9.6	6.40	1.8	140	16.1	7.7
Metals in ug/L												
Lead	*0.385*	43.9	7.56	3.99	*0.13*	18.2	3.30	1.65	*0.24*	39.0	5.75	2.9
Mercury	*0.025*	0.075	0.029	*0.025*	*0.025*	*0.125*	*0.029*	*0.025*	*0.025*	*0.055*	*0.026*	*0.025*
Zinc	5.3	73.6	21.60	15.4	11.8	1,950	174.1	52.3	7.24	95.2	27.7	23.6
Dissolved Lead	0.013	35.6	5.38	2.13	*0.007*	18.9	2.80	0.80	*0.013*	47.2	7.26	2.10
Dissolved Mercury	*0.025*	0.193	0.030	*0.025*	*0.025*	*0.125*	*0.029*	*0.025*	*0.025*	0.114	0.028	*0.025*
Dissolved Zinc	*0.130*	45.8	12.3	8.9	0.600	1,220	91.4	20.9	*0.325*	54.7	21.3	16.3
PAHs in ug/L												
2-Methylnaphthalene	*0.002*	*0.006*	*0.004*	*0.005*	*0.002*	0.018	0.005	*0.005*	0.002	0.022	0.006	*0.005*
Acenaphthene	*0.005*	0.069	0.030	0.028	*0.002*	0.103	0.031	0.026	*0.002*	0.096	0.012	*0.005*
Acenaphthylene	*0.002*	*0.005*	*0.004*	*0.005*	*0.002*	*0.008*	*0.004*	*0.005*	*0.002*	0.019	0.005	*0.005*
Anthracene	*0.002*	0.022	0.007	*0.005*	*0.002*	0.014	0.006	*0.005*	*0.002*	0.077	0.008	*0.005*
Fluorene	*0.002*	0.013	0.005	*0.005*	*0.002*	0.017	0.006	*0.005*	*0.002*	0.060	0.008	*0.005*
Naphthalene	*0.001*	0.017	0.007	*0.006*	*0.003*	0.057	0.011	0.009	*0.002*	0.034	0.008	*0.005*
Phenanthrene	0.002	0.057	0.011	*0.005*	*0.002*	0.028	0.011	0.008	*0.002*	0.684	0.028	0.005
Total LPAHs[1,2]	*0.025*	0.151	0.065	0.061	0.013	0.181	0.068	0.064	0.010	0.898	0.068	0.030
Benzo(a)anthracene	*0.001*	0.055	0.008	*0.005*	*0.001*	0.021	0.006	*0.005*	*0.001*	1.110	0.043	0.005
Benzo(a)pyrene	*0.002*	0.042	0.007	*0.005*	*0.002*	0.048	0.006	*0.005*	*0.002*	0.131	0.010	*0.005*
Benzo(g,h,i)perylene	*0.002*	0.046	0.008	*0.005*	*0.002*	0.033	0.006	*0.005*	*0.002*	0.055	0.008	*0.005*
Benzo(b,k)fluoranthenes	0.002	0.105	0.013	*0.005*	*0.002*	0.062	0.009	*0.005*	*0.002*	0.376	0.027	0.013
Chrysene	*0.002*	0.098	0.011	*0.005*	*0.002*	0.063	0.008	*0.005*	*0.002*	0.362	0.020	0.005
Dibenz(a,h)anthracene	*0.002*	0.012	*0.005*	*0.005*	*0.002*	0.013	*0.005*	*0.005*	*0.002*	0.017	0.005	*0.005*
Fluoranthene	*0.003*	0.133	0.022	0.015	*0.003*	0.046	0.013	0.011	*0.003*	1.140	0.051	0.013
Indeno(1,2,3-c,d)pyrene	*0.002*	0.034	0.006	*0.005*	*0.002*	0.018	0.005	*0.005*	*0.002*	0.053	0.007	*0.005*
Pyrene	*0.005*	0.116	0.030	0.021	0.004	0.081	0.024	0.023	0.002	0.879	0.051	0.022
Total HPAHs[1]	0.031	0.606	0.109	0.072	0.029	0.368	0.081	0.073	0.024	3.287	0.222	0.078
Total PAHs[1]	0.055	0.757	0.174	0.133	0.042	0.436	0.149	0.141	0.034	4.185	0.290	0.116
Phthalates in ug/L												
Bis(2-ethylhexyl)phthalate	*0.20*	16.00	1.03	*0.50*	*0.20*	3.30	0.72	*0.50*	*0.08*	10.00	0.82	*0.50*
Butylbenzylphthalate	*0.09*	*1.80*	*0.43*	*0.50*	*0.09*	16.00	1.49	*0.50*	0.09	1.40	*0.41*	*0.50*
Diethylphthalate	*0.05*	10.00	0.71	*0.50*	0.04	4.40	0.65	*0.50*	0.04	3.80	0.48	*0.50*
Dimethylphthalate	*0.02*	*0.50*	*0.38*	*0.50*	*0.02*	*0.50*	*0.35*	*0.50*	*0.02*	*0.50*	*0.36*	*0.50*
Di-n-butylphthalate	0.05	4.30	*0.55*	*0.50*	0.15	1.30	*0.46*	*0.50*	0.05	*0.50*	*0.40*	*0.50*
Di-n-octyl phthalate	*0.04*	*0.50*	*0.37*	*0.50*	*0.04*	*0.50*	*0.36*	*0.50*	*0.04*	*0.50*	*0.36*	*0.50*
Total Phthalates[3]	0.10	22.87	3.14	1.10	0.21	18.70	3.91	1.30	0.22	13.80	2.21	1.27

Notes:
1 = PAH summations based on 1/2 detection limit for nondetects.
2 = Calculation of Total LPAHs does not include 2-Methylnaphthalene.
3 = Phthalate summations exclude nondetect values.
OF237Anew isn't included in the count of samples.

Highest average or highest median concentration detected in Years 1-10 monitoring.
Highest maximum concentration detected in Years 1-10 monitoring.
Results in italics indicate nondetected values.

Table 3-3
Summary Statistics for Stormwater

	Overall Data						OF230				OF235				OF237A New				OF237B				OF243				OF245				OF254			
	Overall Detections	% Detections	Arithmetic Mean[4]	Weighted Mean[5]	Max	Date of Max	Min	Max	Arithmetic Mean	Median	Min	Max	Arithmetic Mean	Median	Min	Max	Arithmetic Mean	Median	Min	Max	Arithmetic Mean	Median	Min	Max	Arithmetic Mean	Median	Min	Max	Arithmetic Mean	Median	Min	Max	Arithmetic Mean	Median
Conventionals																																		
Hardness (mg/L as CaCO3)	705/705	100	N/A	N/A	N/A	N/A	9.1	179	21.7	18.5	16.6	61.3	32.9	31.9	12.4	66.6	32.1	29.7	20.7	1,220.0	56.8	45.9	59.3	3,150	505.3	392.0	14.0	285	60.5	48.0	49.5	1,720	494.6	427
pH (pH units)	705/705	100	N/A	N/A	N/A	N/A	5.0	10.6	6.8	6.8	5.4	8.6	6.9	6.9	5.7	7.9	6.7	6.6	5.7	7.8	6.8	6.8	6.1	7.4	6.9	7.0	5.6	7.6	6.8	6.8	6.2	8.1	7.1	7.0
TSS (mg/L)	687/687	100	70.8	70.2	441	10/10/01	4.8	304	54.2	39.1	7.8	441	77.3	59.3	6.1	187	47.9	41.7	3.6	278	65.7	49.1	4.4	300	75.6	56.8	6.2	243	70.4	54.9	5.2	354	104.4	84.7
Metals in ug/L																																		
Lead	697/704	99	30.3	30.4	379	9/5/09	5.7	229	26.2	20.8	9.5	368	75.8	63.3	0.6	45	13.2	11.7	1.5	64	14.6	11.3	1.4	379	48.9	26.6	1.7	60	13.2	10.8	3.1	68	20.3	16.2
Mercury	102/705	14	0.036	0.036	0.870	5/20/08	0.025	0.130	0.037	0.025	0.025	0.190	0.041	0.025	0.025	0.125	0.029	0.025	0.025	0.216	0.033	0.025	0.025	0.188	0.038	0.025	0.025	0.870	0.036	0.025	0.025	0.307	0.041	0.025
Zinc	704/704	100	128.4	128.1	1,170	8/6/04	36.6	721	128.9	118.0	37.3	475	139.3	125.0	34.8	361	105.8	99.0	15.0	243	77.4	63.1	19.6	1,170	119.3	92.2	27.7	585	171.3	144.0	43.1	427	156.7	136.0
Dissolved Lead	412/704	59	2.54	2.54	145	8/6/04	0.20	9.05	1.28	0.77	0.18	28.0	7.61	5.66	0.18	4.11	0.79	0.55	0.14	11.40	0.77	0.55	0.01	145.0	4.90	1.37	0.08	6.27	0.78	0.55	0.01	12.20	1.65	0.75
Dissolved Mercury	11/704	2	0.027	0.027	0.552	5/20/08	0.025	0.100	0.026	0.025	0.025	0.100	0.026	0.025	0.025	0.100	0.026	0.025	0.025	0.100	0.026	0.025	0.025	0.552	0.032	0.025	0.025	0.108	0.026	0.025	0.025	0.211	0.029	0.025
Dissolved Zinc	701/703	100	54.4	54.3	910	8/6/04	11.5	445	65.1	55.1	13.0	262	49.6	43.1	14.1	282	62.0	47.4	6.3	161	29.0	23.3	8.4	910	46.2	29.7	18.3	335	72.9	54.4	7.7	239	56.2	43.2
PAHs in ug/L																																		
LPAHs in ug/L																																		
2-Methylnaphthalene	532/703	76	0.029	0.030	4.130	3/16/02	0.002	0.330	0.030	0.016	0.001	4.130	0.055	0.015	0.001	2.310	0.039	0.013	0.002	0.250	0.015	0.010	0.002	0.136	0.015	0.009	0.001	1.143	0.032	0.012	0.001	0.141	0.019	0.014
Acenaphthene	356/703	51	0.015	0.015	0.855	8/6/04	0.002	0.080	0.009	0.005	0.002	0.086	0.012	0.005	0.002	0.532	0.016	0.005	0.002	0.063	0.006	0.005	0.002	0.045	0.018	0.017	0.002	0.855	0.021	0.010	0.002	0.352	0.023	0.013
Acenaphthylene	220/703	31	0.008	0.008	0.095	8/6/04	0.002	0.060	0.007	0.005	0.001	0.060	0.007	0.005	0.001	0.056	0.006	0.005	0.002	0.064	0.005	0.005	0.002	0.064	0.009	0.005	0.001	0.095	0.010	0.005	0.001	0.070	0.012	0.006
Anthracene	394/703	56	0.020	0.020	0.389	2/21/02	0.002	0.122	0.014	0.005	0.002	0.138	0.018	0.010	0.002	0.238	0.015	0.009	0.002	0.097	0.010	0.005	0.002	0.079	0.023	0.019	0.002	0.289	0.015	0.005	0.002	0.389	0.048	0.024
Fluorene	492/703	70	0.020	0.020	0.928	8/6/04	0.002	0.246	0.017	0.010	0.001	0.083	0.017	0.012	0.001	0.655	0.020	0.010	0.002	0.078	0.010	0.005	0.002	0.098	0.017	0.013	0.001	0.928	0.033	0.012	0.001	0.159	0.028	0.018
Naphthalene	548/700	78	0.034	0.036	4.430	3/16/02	0.003	0.362	0.035	0.024	0.002	4.430	0.066	0.020	0.002	0.606	0.033	0.021	0.003	0.130	0.018	0.015	0.003	0.135	0.024	0.017	0.002	0.795	0.040	0.021	0.002	0.111	0.025	0.022
Phenanthrene	686/703	98	0.097	0.098	1.650	8/6/04	0.008	0.653	0.115	0.060	0.002	0.776	0.112	0.074	0.002	1.310	0.121	0.063	0.002	0.838	0.068	0.041	0.005	0.221	0.066	0.044	0.002	1.650	0.087	0.049	0.002	0.657	0.110	0.076
Total LPAHs[1,2]	2696/4215	64	0.188	0.031	4.930	N/A	0.008	0.923	0.186	0.128	0.000	4.930	0.223	0.132	0.009	3.062	0.212	0.115	0.000	1.134	0.105	0.071	0.000	0.473	0.150	0.111	0.000	4.612	0.197	0.104	0.000	1.244	0.239	0.173
HPAHs in ug/L																																		
Benzo(a)anthracene	557/703	79	0.062	0.062	0.915	2/21/02	0.001	0.439	0.072	0.038	0.001	0.555	0.066	0.036	0.001	0.737	0.083	0.036	0.001	0.685	0.047	0.023	0.001	0.335	0.043	0.022	0.001	0.247	0.026	0.018	0.001	0.915	0.095	0.055
Benzo(a)pyrene	514/703	73	0.063	0.063	0.865	2/18/07	0.002	0.563	0.084	0.045	0.001	0.498	0.068	0.034	0.001	0.865	0.094	0.035	0.002	0.690	0.053	0.022	0.002	0.182	0.041	0.022	0.001	0.133	0.025	0.013	0.002	0.428	0.076	0.048
Benzo(g,h,i)perylene	605/703	86	0.068	0.069	0.764	9/4/07	0.003	0.457	0.093	0.060	0.002	0.410	0.076	0.056	0.002	0.764	0.104	0.055	0.002	0.614	0.064	0.032	0.003	0.189	0.045	0.029	0.002	0.112	0.032	0.022	0.003	0.253	0.063	0.051
Benzo(b,k)fluoranthenes	602/703	86	0.175	0.175	2.150	9/4/07	0.002	1.396	0.237	0.136	0.002	1.199	0.170	0.101	0.005	2.150	0.284	0.134	0.002	1.763	0.149	0.064	0.005	0.554	0.113	0.058	0.002	0.414	0.064	0.036	0.005	1.662	0.207	0.131
Chrysene	642/703	91	0.131	0.131	1.906	2/21/02	0.002	0.860	0.160	0.085	0.002	0.678	0.132	0.086	0.004	1.340	0.189	0.106	0.002	0.965	0.100	0.049	0.002	0.516	0.087	0.050	0.002	0.420	0.061	0.030	0.002	1.906	0.189	0.114
Dibenz(a,h)anthracene	319/703	45	0.015	0.015	0.177	9/4/07	0.002	0.088	0.020	0.012	0.002	0.154	0.015	0.005	0.002	0.177	0.023	0.007	0.002	0.143	0.013	0.005	0.002	0.044	0.010	0.005	0.002	0.027	0.007	0.005	0.002	0.071	0.014	0.011
Fluoranthene	695/703	99	0.212	0.212	3.964	2/21/02	0.003	1.687	0.251	0.128	0.003	1.550	0.225	0.156	0.013	2.500	0.308	0.157	0.003	1.835	0.150	0.071	0.014	0.444	0.124	0.080	0.002	1.720	0.092	0.052	0.003	3.964	0.335	0.196
Indeno(1,2,3-c,d)pyrene	526/703	75	0.049	0.050	0.669	9/4/07	0.002	0.346	0.071	0.042	0.002	0.338	0.051	0.033	0.002	0.669	0.085	0.039	0.002	0.546	0.045	0.021	0.002	0.137	0.032	0.019	0.002	0.058	0.018	0.014	0.002	0.239	0.044	0.032
Pyrene	698/703	99	0.206	0.206	4.120	2/21/02	0.010	1.200	0.227	0.130	0.002	1.164	0.220	0.151	0.012	2.190	0.280	0.153	0.002	1.493	0.150	0.076	0.012	0.620	0.129	0.079	0.002	1.310	0.111	0.065	0.002	4.120	0.329	0.188
Total HPAHs[1]	5158/6327	82	0.978	0.109	13.558	N/A	0.025	6.680	1.210	0.667	0.000	6.497	1.017	0.685	0.054	10.888	1.464	0.746	0.019	8.734	0.771	0.393	0.031	2.880	0.612	0.351	0.000	4.393	0.426	0.268	0.000	13.558	1.349	0.798
Total PAHs[1]	7854/10542	75	1.166	0.078	14.681	N/A	0.037	7.494	1.396	0.755	0.000	7.552	1.240	0.824	0.073	11.869	1.676	0.878	0.025	9.868	0.876	0.455	0.065	3.353	0.763	0.454	0.000	9.005	0.623	0.350	0.000	14.681	1.588	0.950
Phenols in ug/L																																		
4-Methylphenol	221/257	86	0.047	0.048	0.568	1/21/03	0.005	0.280	0.068	0.025	0.005	0.568	0.072	0.040	0.005	0.149	0.031	0.022	0.005	0.160	0.027	0.021	0.005	0.481	0.054	0.029	0.005	0.320	0.045	0.030	0.005	0.252	0.034	0.023
Phthalates in ug/L																																		
Bis(2-ethylhexyl)phthalate	544/696	78	3.44	3.54	97	10/3/02	0.204	44.1	4.58	3.39	0.321	97.0	5.95	3.68	0.204	13.70	2.53	1.49	0.204	12.00	2.63	1.78	0.204	41.00	2.66	1.60	0.204	31.0	3.19	1.80	0.225	10.20	2.54	1.90
Butylbenzylphthalate	271/703	39	3.05	3.18	290	2/15/03	0.085	8.40	0.69	0.50	0.085	6.60	1.07	0.50	0.085	1.90	0.49	0.50	0.085	2.80	0.42	0.50	0.085	9.20	1.34	0.50	0.085	290	16.72	1.10	0.085	6.10	0.59	0.50
Diethylphthalate	223/703	32	2.63	2.80	590	12/10/02	0.077	9.30	0.65	0.50	0.077	590	5.58	0.50	0.085	230.00	3.53	0.50	0.050	52.00	1.52	0.50	0.070	7.60	0.58	0.50	0.077	430	4.51	0.50	0.070	120	2.04	0.50
Dimethylphthalate	76/697	11	0.37	0.37	4.70	9/29/05	0.016	4.70	0.45	0.50	0.016	2.40	0.36	0.50	0.016	0.50	0.33	0.50	0.016	0.55	0.33	0.50	0.016	1.00	0.35	0.50	0.016	1.10	0.34	0.50	0.016	3.20	0.45	0.50
Di-n-butylphthalate	193/703	27	0.44	0.44	4.80	6/12/04	0.050	1.60	0.46	0.50	0.050	1.60	0.42	0.50	0.095	4.80	0.48	0.50	0.095	0.84	0.40	0.50	0.050	1.10	0.41	0.50	0.148	1.60	0.46	0.50	0.100	1.30	0.44	0.50
Di-n-octyl phthalate	138/693	20	0.46	0.47	4.50	8/6/04	0.042	3.20	0.61	0.50	0.042	3.20	0.56	0.50	0.042	2.50	0.42	0.50	0.042	2.30	0.40	0.50	0.042	1.00	0.36	0.50	0.042	4.10	0.39	0.50	0.042	4.50	0.49	0.50
Total Phthalates[3]	1445/4195	34	8.72	1.53	596.4	N/A	0.00	44.1	5.77	4.10	0.000	596.4	12.4	4.81	0.00	230	5.97	2.12	0.00	66.2	4.03	2.30	0.000	41.0	3.97	2.33	0.000	593.1	24.09	3.60	0.000	123.2	4.77	2.20

Notes:
1 = PAH summations based on 1/2 detection limit for nondetects.
2 = Calculation of Total LPAHs does not include 2-Methylnaphthalene.
3 = Phthalate summations exclude nondetect values.
4 = Overall data arithmetic mean is average of individual outfall means.

Highest average or highest median concentration detected in Years 1-11 monitoring.
Highest maximum concentration detected in Years 1-11 monitoring.

Table 3-4
t-test Results - OF237A vs. OF237A New

Conventionals	p-value
Conductivity (µS)	0.221
Hardness (mg/L as CaCO3)	0.069
pH (pH units)	0.695
TSS (mg/L)	0.271
Metals in ug/L	
Lead	0.095
Mercury	0.971
Zinc	0.617
Dissolved Lead	0.782
Dissolved Mercury	N/A[a]
Dissolved Zinc	0.077
PAHs in ug/L	
LPAHs	
2-Methylnaphthalene	0.745
Acenaphthene	0.192
Acenaphthylene	0.928
Anthracene	0.912
Fluorene	0.888
Naphthalene	0.794
Phenanthrene	0.482
HPAHs	
Benzo(a)anthracene	0.711
Benzo(a)pyrene	0.958
Benzo(g,h,i)perylene	0.566
Benzo(b,k)fluoranthenes	0.641
Chrysene	0.777
Dibenz(a,h)anthracene	0.801
Fluoranthene	0.795
Indeno(1,2,3-cd)pyrene	0.882
Pyrene	0.773
Phthalates in ug/L	
Di(2-ethylhexyl)phthalate	0.724
Butylbenzylphthalate	0.687
Diethylphthalate	0.304
Dimethylphthalate	0.221
Di-n-butylphthalate	0.877
Di-n-octyl phthalate	0.507

a - Not applicable due to nondetects.

Table 3-5
Goodness of Fit - Stormwater

Lognormal Goodness of Fit Test using *MTCA Stat* - 11 Year Data Set							
Analyte	**OF230**	**OF235**	**OF237A**	**OF237B**	**OF243**	**OF245**	**OF254**
TSS	LOGNORM 1.00	LOGNORM 1.00	LOGNORM 0.98	LOGNORM 0.97	LOGNORM 0.98	LOGNORM 0.96	LOGNORM 0.96
Lead	LOGNORM 0.98	LOGNORM 0.97	LOGNORM 0.98	LOGNORM 0.99	LOGNORM 0.97	LOGNORM 0.99	LOGNORM 0.99
Zinc	LOGNORM 0.96	LOGNORM 0.98	LOGNORM 0.99	LOGNORM 0.99	LOGNORM 0.94	LOGNORM 0.99	LOGNORM 0.99
Phenanthrene	LOGNORM 0.97	LOGNORM 0.97	LOGNORM 0.95	LOGNORM 0.97	LOGNORM 0.97	LOGNORM 0.98	LOGNORM 0.99
Pyrene	LOGNORM 0.94	LOGNORM 0.94	(LOGNORM) 0.90	LOGNORM 0.96	LOGNORM 0.97	LOGNORM 0.98	LOGNORM 0.97
Indenopyrene	(LOGNORM) 0.88	(LOGNORM) 0.90	LOGNORM 0.95	LOGNORM 0.98	LOGNORM 0.93	(LOGNORM) 0.86	LOGNORM 0.93
BEP	LOGNORM 0.97	LOGNORM 0.99	LOGNORM 0.94	LOGNORM 0.97	LOGNORM 0.96	LOGNORM 0.98	LOGNORM 0.97

Notes:
R^2 value provided below each distribution determination.
LOGNORM - R^2 value greater than 0.9
(LOGNORM) = R^2 value greater than 0.8, but less than 0.9

Table 3-6
Spatial Analysis of Baseflow Quality (ANOVA Results)

A. Nonparametric Outfall Pair Comparisons, Years 1-10							
Analyte	**OF230**	**OF235**	**OF237A**	**OF237B**	**OF243**	**OF245**	**OF254**
TSS	2	2	-5	-5	2	2	2
Total Lead	2	4	-4	-5	3	-1	1
Total Zinc	4	0	-5	-5	0	5	1
Bis(2-ethylhexyl)phthalate	0	4	-1	-1	-1	0	-1
Phenanthrene	1	0	0	-2	0	1	0
Pyrene	1	2	-4	-5	2	2	2
Indeno(1,2,3-c,d)pyrene	No Significant Differences						

B. Nonparametric Outfall Pair Comparisons, Years 9-10							
Analyte	**OF230**	**OF235**	**OF237A**	**OF237B**	**OF243**	**OF245**	**OF254**
TSS	0	0	-2	-1	2	1	0
Total Lead	1	2	-2	-3	2	0	0
Total Zinc	2	0	-2	-3	0	2	1
Bis(2-ethylhexyl)phthalate	No Significant Differences						
Phenanthrene	No Significant Differences						
Pyrene	0	0	-2	-1	2	1	0
Indeno(1,2,3-c,d)pyrene	No Significant Differences						

Key:

- *Well Below Average (-6 to -3)*
- *Below Average (-2 to -1)*
- *Neutral (0)*
- *Above Average (1 to 2)*
- *Well Above Average (3 to 6)*

Table 3-7
Spatial Analysis of Stormwater Quality (ANOVA Results)

A. Parametric Outfall Pair Comparisons, Years 1-11							
Analyte	**OF230**	**OF235**	**OF237A**	**OF237B**	**OF243**	**OF245**	**OF254**
TSS	-3	1	-2	-1	-1	0	6
Total Lead	1	6	-3	-4	4	-4	0
Total Zinc	0	3	-2	-6	-2	4	3
DEHP	5	5	-2	-2	-2	-2	-2
Phenanthrene	1	1	0	-3	0	0	1
Pyrene	1	2	2	-3	-1	-4	3
Indeno(1,2,3-c,d)pyrene	1	1	1	1	0	-5	1

B. Parametric Outfall Pair Comparisons, Year 11							
Analyte	**OF230**	**OF235**	**OF237A**	**OF237B**	**OF243**	**OF245**	**OF254**
TSS	-2	0	0	-2	2	-1	3
Total Lead	-2	5	-2	-3	5	-3	0
Total Zinc	1	1	1	-6	1	1	1
DEHP	0	3	-1	-1	-2	0	1
Phenanthrene	0	1	-2	0	0	0	1
Pyrene	-2	3	-1	-2	-1	-2	5
Indeno(1,2,3-c,d)pyrene	0	1	0	-1	-1	-2	3

Key:

- *Well Below Average (-6 to -3)*
- *Below Average (-2 to -1)*
- *Neutral (0)*
- *Above Average (1 to 2)*
- *Well Above Average (3 to 6)*

Table 3-8
Goodness of Fit - Sediment

Lognormal Goodnes of Fit Test using *MTCA Stat* - 11 Year Data Set						
Analyte	**OF230 FD3New**	**OF235 FD6**	**OF237A FD2**	**OF237B FD1**	**OF243 FD23**	**OF245 MH390**
Lead	Not Normal	LOGNORM	LOGNORM	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.77	0.93	0.92	0.96	0.95	0.93
Normal R^2	0.45	0.91	0.96	0.85	0.94	0.98
Copper	N/A	N/A	N/A	N/A	N/A	N/A
Lognormal R^2	N/A - 1 pt	N/A - 2 pt	N/A - 1 pt	N/A - 2 pt	N/A - 1 pt	N/A - 3 pt
Normal R^2	N/A - 1 pt	N/A - 2 pt	N/A - 1 pt	N/A - 2 pt	N/A - 1 pt	N/A - 3 pt
Mercury	LOGNORM	Not Normal	LOGNORM	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.92	0.56	0.99	0.95	0.93	0.96
Normal R^2	0.73	--	0.95	0.81	0.86	0.85
Zinc	Not Normal	(LOGNORM)	LOGNORM	LOGNORM	(LOGNORM)	(LOGNORM)
Lognormal R^2	0.71	0.88	0.92	0.96	0.87	0.88
Normal R^2	0.45	0.93	0.95	0.96	0.93	0.95
TPH - Heavy Oil	Not Normal	LOGNORM	LOGNORM	LOGNORM	(LOGNORM)	(LOGNORM)
Lognormal R^2	0.54	0.97	0.97	0.97	0.81	0.81
Normal R^2	0.95	0.94	0.97	0.91	0.95	0.90
DDT	N/A	N/A	N/A	N/A	N/A	N/A
Lognormal R^2	--	--	--	--	--	No Detects
Normal R^2	0.97	--	--	--	--	No Detects
Phenanthrene	(LOGNORM)	LOGNORM	Not Normal	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.85	0.92	0.70	0.96	0.92	0.94
Normal R^2	0.78	0.87	0.90	0.92	0.89	0.75
Indeno(1,2,3-cd)pyrene	(LOGNORM)	LOGNORM	Not Normal	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.88	0.98	0.72	0.98	0.98	0.97
Normal R^2	0.95	0.92	0.92	0.90	0.96	--
Pyrene	LOGNORM	LOGNORM	Not Normal	LOGNORM	LOGNORM	(LOGNORM)
Lognormal R^2	0.96	0.93	0.72	0.91	0.97	0.84
Normal R^2	0.99	0.96	0.90	0.79	0.96	0.43
Total PCBs	N/A	N/A	N/A	N/A	N/A	N/A
Lognormal R^2	--	--	--	--	--	--
Normal R^2	0.83	0.69	0.79	0.57	0.73	0.46
DEHP	LOGNORM	Not Normal	LOGNORM	LOGNORM	(LOGNORM)	(LOGNORM)
Lognormal R^2	0.95	0.71	0.93	0.95	0.88	0.86
Normal R^2	0.96	0.97	0.96	0.75	0.97	0.86
Butylbenzylphthalate	(LOGNORM)	LOGNORM	LOGNORM	LOGNORM	(LOGNORM)	LOGNORM
Lognormal R^2	0.87	0.94	0.96	0.98	0.90	0.92
Normal R^2	0.60	0.80	0.87	0.81	0.78	0.73
Total Phthalates	LOGNORM	Not Normal	LOGNORM	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.94	0.79	0.93	0.96	0.92	0.95
Normal R^2	0.98	0.95	0.96	0.78	0.89	0.79

Notes:
R^2 value provided below each distribution determination.
LOGNORM - R^2 value greater than 0.9
(LOGNORM) = R^2 value greater than 0.8, but less than 0.9

Table 3-9
Spatial Analysis of Storm Sediment Quality (ANOVA Results)

A. Nonparametric Outfall Pair Comparisons, Years 1-11						
Analyte	**OF230**	**OF235**	**OF237A**	**OF237B**	**OF243**	**OF245**
Lead	2	2	-1	-3	3	-3
Mercury	3	0	-2	-2	3	-2
Zinc	1	0	-1	-3	2	1
TPH-OIL	1	0	0	-3	1	1
DDT	No significant differences					
Phenanthrene	1	0	1	0	0	-2
Indeno(1,2,3-cd)pyrene	2	-1	1	1	0	-3
Pyrene	1	0	1	0	0	-2
Total PCBs	No significant differences					
DEHP	1	0	0	-2	1	0
Butylbenzylphthalate	-1	-1	-2	-2	2	4
Total Phthalates	1	0	-1	-3	1	2

B. Nonparametric Outfall Pair Comparisons, Years 7-11						
Analyte	**OF230**	**OF235**	**OF237A**	**OF237B**	**OF243**	**OF245**
Lead	0	0	0	-1	2	-1
Mercury	0	0	0	-1	1	0
Zinc	0	0	0	-2	1	1
TPH-OIL	0	0	0	-1	1	0
DDT	No significant differences					
Phenanthrene	1	0	1	0	0	-2
Indeno(1,2,3-cd)pyrene	1	0	1	0	0	-2
Pyrene	1	0	1	0	0	-2
Total PCBs	No significant differences					
DEHP	No significant differences					
Butylbenzylphthalate	0	0	0	-2	1	1
Total Phthalates	No significant differences					

Key:

Well Below Average (-6 to -3)
Below Average (-2 to -1)
Neutral (0)
Above Average (1 to 2)
Well Above Average (3 to 6)

Table 3-9 - NonParametric ANOVA Sediment Trap.xlsx

Table 3-10
Time Trend Analysis of Stormwater Quality (Seasonal Kendall Test)

	OF230	OF235	OF237A	OF237B	OF243	OF245	OF254
Total Suspended Solids							
Z-Stat	**-2.620**	**-3.062**	-1.765	**-2.807**	-0.250	**-2.760**	1.318
p Value	**0.009**	**0.002**	0.078	**0.005**	0.803	**0.006**	0.188
Slope	**-2.833**	**-5.567**	N/A	**-4.046**	N/A	**-5.177**	N/A
Total Lead							
Z-Stat	**-2.642**	**-2.995**	-1.703	**-3.749**	0.125	**-2.525**	-0.395
p Value	**0.008**	**0.003**	0.089	**<0.001**	0.901	**0.012**	0.693
Slope	**-1.775**	**-4.562**	N/A	**-1.288**	N/A	**-0.876**	N/A
Total Zinc							
Z-Stat	**-2.000**	-1.703	-0.528	**-3.198**	-1.372	-1.585	-1.713
p Value	**0.046**	0.089	0.597	**0.001**	0.170	0.113	0.087
Slope	**-4.975**	N/A	N/A	**-3.800**	N/A	N/A	N/A
Phenanthrene							
Z-Stat	**-4.066**	**-3.230**	**-3.817**	**-3.699**	**-3.312**	**-2.995**	**-3.426**
p Value	**<0.001**	**0.001**	**<0.001**	**<0.001**	**0.001**	**0.003**	**0.001**
Slope	**-0.019**	**-0.014**	**-0.017**	**-0.009**	**-0.009**	**-0.008**	**-0.015**
Pyrene							
Z-Stat	**-3.817**	**-3.765**	**-2.941**	**-3.908**	**-2.938**	**-3.176**	**-4.085**
p Value	**<0.001**	**<0.001**	**0.003**	**<0.001**	**0.003**	**0.002**	**<0.001**
Slope	**-0.042**	**-0.035**	**-0.033**	**-0.023**	**-0.014**	**-0.013**	**-0.058**
Indeno(1,2,3-cd)pyrene							
Z-Stat	**-3.465**	**-2.877**	**-2.173**	**-3.539**	**-3.188**	**-3.424**	**-3.163**
p Value	**0.001**	**0.004**	**0.030**	**<0.001**	**0.001**	**0.001**	**0.002**
Slope	**-0.014**	**-0.008**	**-0.008**	**-0.006**	**-0.004**	**-0.003**	**-0.007**
Bis(2-ethylhexyl)phthalate							
Z-Stat	**-2.877**	**-2.877**	**-2.760**	**-2.807**	**-3.992**	**-4.169**	-0.922
p Value	**0.004**	**0.004**	**0.006**	**0.005**	**<0.001**	**<0.001**	0.356
Slope	**-0.542**	**-0.580**	**-0.338**	**-0.279**	**-0.371**	**-0.543**	N/A

Notes:

Seasonal Kendall test performed using USGS freeware program "Kendall.exe"

237A location includes data from 237A New sampling location for all data collected after 2/26/06.

Bold *= Statistically significant time trend ($p < 0.05$).*

N/A = Not applicable due to insignificant time trend.

Table 3-11
Regression Statistics of Stormwater Time Trends

Analyte	Outfall Number	Sample Count	S_x	S_y^2	slope	y-intercept	R^2	t - statistic	Significance Level	Est % Reduction in 11 years
Total Suspended Solids	OF230	96	1169	0.117	-0.00011	5.79	0.135	-3.83	>99.9%	63%
	OF235	114	1180	0.105	-0.00011	5.92	0.148	-4.42	>99.9%	62%
	OF237B	110	1171	0.122	-0.00008	4.80	0.071	-2.87	99.5%	52%
	OF245	104	1190	0.099	-0.00010	5.53	0.133	-3.96	>99.9%	59%
Lead	OF230	101	1192	0.093	-0.00009	4.79	0.122	-3.70	>99.9%	56%
	OF235	119	1193	0.051	-0.00008	4.91	0.174	-4.97	>99.9%	52%
	OF237B	112	1186	0.107	-0.00008	4.29	0.090	-3.29	99.9%	53%
	OF245	108	1203	0.089	-0.00008	4.07	0.098	-3.40	>99.9%	51%
Zinc	OF235	119	1193	0.046	-0.00005	3.91	0.066	-2.87	99.5%	35%
	OF237A*	101	1197	0.035	-0.00004	3.64	0.073	-2.80	99.4%	32%
	OF237B	113	1194	0.063	-0.00007	4.64	0.117	-3.84	>99.9%	49%
	OF245	107	1195	0.064	-0.00004	3.89	0.043	-2.18	96.9%	33%
	OF254	91	1097	0.046	-0.00008	5.12	0.151	-3.97	>99.9%	50%
Phenanthrene	OF230	101	1192	0.245	-0.00028	9.66	0.448	-8.97	>99.9%	92%
	OF235	119	1193	0.295	-0.00028	9.67	0.373	-8.33	>99.9%	92%
	OF237A*	100	1193	0.341	-0.00032	11.06	0.417	-8.37	>99.9%	95%
	OF237B	113	1194	0.259	-0.00026	8.94	0.385	-8.34	>99.9%	91%
	OF243	72	1160	0.183	-0.00025	8.46	0.465	-7.79	>99.9%	90%
	OF245	107	1200	0.203	-0.00022	7.18	0.334	-7.26	>99.9%	87%
	OF254	91	1097	0.187	-0.00024	8.36	0.379	-7.37	>99.9%	89%
Pyrene	OF230	101	1192	0.343	-0.00034	12.40	0.484	-9.64	>99.9%	96%
	OF235	119	1193	0.280	-0.00029	10.43	0.426	-9.32	>99.9%	93%
	OF237A*	100	1193	0.328	-0.00034	12.22	0.488	-9.66	>99.9%	96%
	OF237B	113	1194	0.313	-0.00033	11.83	0.498	-10.49	>99.9%	95%
	OF243	72	1160	0.196	-0.00023	8.04	0.375	-6.49	>99.9%	89%
	OF245	107	1200	0.253	-0.00026	8.85	0.376	-7.95	>99.9%	91%
	OF254	91	1097	0.319	-0.00039	14.34	0.565	-10.75	>99.9%	97%
Indeno(1,2,3-c,d)pyrene	OF230	101	1192	0.460	-0.00036	12.55	0.401	-8.14	>99.9%	96%
	OF235	119	1193	0.386	-0.00033	11.47	0.411	-9.04	>99.9%	95%
	OF237A*	100	1193	0.483	-0.00036	12.66	0.387	-7.87	>99.9%	97%
	OF237B	113	1194	0.378	-0.00033	11.15	0.405	-8.70	>99.9%	95%
	OF243	72	1160	0.291	-0.00029	9.60	0.393	-6.73	>99.9%	93%
	OF245	107	1200	0.234	-0.00028	8.91	0.476	-9.76	>99.9%	92%
	OF254	91	1097	0.281	-0.00034	11.69	0.495	-9.34	>99.9%	96%
Bis(2-ethylhexyl)phthalate	OF230	100	1190	0.203	-0.00016	6.59	0.172	-4.52	>99.9%	77%
	OF235	118	1190	0.205	-0.00022	9.01	0.323	-7.43	>99.9%	86%
	OF237A *	99	1190	0.175	-0.00016	6.38	0.201	-4.93	>99.9%	77%
	OF237B	112	1191	0.199	-0.00020	8.25	0.299	-6.85	>99.9%	85%
	OF243	71	1157	0.234	-0.00025	10.00	0.365	-6.30	>99.9%	90%
	OF245	105	1199	0.215	-0.00026	10.29	0.439	-8.97	>99.9%	91%
	OF254	91	1097	0.161	-0.00009	3.86	0.064	-2.47	98.5%	58%

237A - Includes data from 237A New site for all samples collected after 2/26/06.*

Shaded cells indicate newly significant trend detected in Water Year 2012

Table 3-12
Simple Linear Regression vs. Seasonal Kendall Percent Reductions

Analyte	Outfall Number	Sample Count	Linear Regression				Seasonal Kendall			
			slope	y-intercept	Significance Level	Est % Reduction in 11 years	slope	y-intercept	Significance Level	Est % Reduction in 11 years
Total Suspended Solids	230	96	-0.00011	5.79	>99.9%	63%	-2.83	54.03	99.1%	53%
	235	114	-0.00011	5.92	>99.9%	62%	-5.57	89.54	99.8%	63%
	237A New*	101	-0.00005	3.55	93.7%	36%	-1.51	51.48	92.2%	30%
	237B	110	-0.00008	4.80	99.5%	52%	-4.05	75.38	99.5%	54%
	243	72	0.00000	1.74	0.7%	0%	-1.00	67.50	19.7%	15%
	245	104	-0.00010	5.53	>99.9%	59%	-5.18	89.16	99.4%	59%
	254	90	0.00005	0.03	88.3%	-56%	3.84	63.11	81.2%	-60%
Lead	230	101	-0.00009	4.79	>99.9%	56%	-1.78	31.95	99.2%	56%
	235	119	-0.00008	4.91	>99.9%	52%	-4.56	96.18	99.7%	48%
	237A New*	101	-0.00003	2.32	82.5%	25%	-0.43	15.01	91.1%	29%
	237B	112	-0.00008	4.29	99.9%	53%	-1.29	19.48	>99.9%	67%
	243	72	0.00001	0.91	25.7%	-14%	0.27	29.22	9.9%	-9%
	245	108	-0.00008	4.07	>99.9%	51%	-0.88	18.26	98.8%	49%
	254	91	-0.00006	3.42	94.6%	41%	-0.30	18.58	30.7%	16%
Zinc	230	101	-0.00002	2.99	82.2%	20%	-4.98	153.90	95.5%	33%
	235	119	-0.00005	3.91	99.5%	35%	-4.50	162.50	91.1%	28%
	237A New*	101	-0.00004	3.64	99.4%	32%	-1.99	116.00	40.3%	17%
	237B	113	-0.00007	4.64	>99.9%	49%	-3.80	86.33	99.9%	45%
	243	72	-0.00005	3.98	93.4%	38%	-2.59	112.70	83.0%	23%
	245	107	-0.00004	3.89	96.9%	33%	-6.19	193.10	88.7%	32%
	254	91	-0.00008	5.12	>99.9%	50%	-7.88	195.20	91.3%	41%
Phenanthrene	230	101	-0.00028	9.66	>99.9%	92%	-0.02	0.21	>99.9%	92%
	235	119	-0.00028	9.67	>99.9%	92%	-0.01	0.18	99.9%	80%
	237A New*	100	-0.00032	11.06	>99.9%	95%	-0.02	0.21	>99.9%	82%
	237B	113	-0.00026	8.94	>99.9%	91%	-0.01	0.10	>99.9%	87%
	243	72	-0.00025	8.46	>99.9%	90%	-0.01	0.13	99.9%	73%
	245	107	-0.00022	7.18	>99.9%	87%	-0.01	0.11	99.7%	76%
	254	91	-0.00024	8.36	>99.9%	89%	-0.02	0.17	99.9%	93%
Pyrene	230	101	-0.00034	12.40	>99.9%	96%	-0.01	0.46	>99.9%	33%
	235	119	-0.00029	10.43	>99.9%	93%	-0.04	0.42	>99.9%	87%
	237A New*	100	-0.00034	12.22	>99.9%	96%	-0.03	0.42	99.7%	80%
	237B	113	-0.00033	11.83	>99.9%	95%	-0.02	0.24	>99.9%	98%
	243	72	-0.00023	8.04	>99.9%	89%	-0.01	0.20	99.7%	72%
	245	107	-0.00026	8.85	>99.9%	91%	-0.01	0.16	99.9%	81%
	254	91	-0.00039	14.34	>99.9%	97%	-0.06	0.51	>99.9%	115%
Indeno(1,2,3-c,d)pyrene	230	101	-0.00036	12.55	>99.9%	96%	-0.01	0.15	100.0%	95%
	235	119	-0.00033	11.47	>99.9%	95%	-0.01	0.09	99.6%	95%
	237A New*	100	-0.00036	12.66	>99.9%	97%	-0.01	0.12	97.0%	65%
	237B	113	-0.00033	11.15	>99.9%	95%	-0.01	0.06	>99.9%	104%
	243	72	-0.00029	9.60	>99.9%	93%	0.00	0.05	99.9%	86%
	245	107	-0.00028	8.91	>99.9%	92%	0.00	0.03	99.9%	75%
	254	91	-0.00034	11.69	>99.9%	96%	-0.01	0.07	99.8%	99%
Bis(2-ethylhexyl)phthalate	230	100	-0.00016	6.59	>99.9%	77%	-0.54	6.65	99.6%	83%
	235	118	-0.00022	9.01	>99.9%	86%	-0.58	8.38	99.6%	70%
	237A New*	99	-0.00016	6.38	>99.9%	77%	-0.34	3.98	99.4%	87%
	237B	112	-0.00020	8.25	>99.9%	85%	-0.28	3.63	99.5%	79%
	243	71	-0.00025	10.00	>99.9%	90%	-0.37	4.00	>99.9%	95%
	245	105	-0.00026	10.29	>99.9%	91%	-0.54	5.76	>99.9%	97%
	254	91	-0.00009	3.86	98.5%	58%	-0.08	2.76	64.4%	30%

237A New - Includes data from 237A site collected prior to 2/26/06.*

Shaded cells indicate significance levels greater than 95%

Table 6-1
Percent of Annual Loading Rates by Outfall

Stormwater Outfalls		Phenanthrene			Pyrene			Dibenz(ah)anthracene			Bis(2-ethylhexyl)phthalate			Volume, ac-ft/yr	% of Total Volume
		Contaminant Load in Kg/Year	% of Total SW Load	% of Total Load	Contaminant Load in Kg/Year	% of Total SW Load	% of Total Load	Contaminant Load in Kg/Year	% of Total SW Load	% of Total Load	Contaminant Load in Kg/Year	% of Total SW Load	% of Total Load		
OF237A	SW	0.155	36.4%	7.1%	0.389	41.3%	10.7%	0.042	41.1%	15.4%	3.70	22.7%	15.5%	789	10.5%
	BF	0.043	10.1%	2.0%	0.045	4.8%	1.2%	0.009	8.8%	3.3%	1.75	10.7%	7.3%	2,027	27.1%
OF237B	SW	0.088	20.7%	4.0%	0.208	22.1%	5.7%	0.015	14.7%	5.5%	3.70	22.7%	15.5%	731	9.8%
	BF	0.019	4.5%	0.9%	0.038	4.0%	1.0%	0.003	2.9%	1.1%	1.92	11.8%	8.0%	3,113	41.6%
OF230	SW	0.055	12.9%	2.5%	0.111	11.8%	3.1%	0.016	15.6%	5.9%	1.75	10.7%	7.3%	244	3.3%
	BF	0.002	0.4%	0.1%	0.003	0.3%	0.1%	0.001	1.0%	0.4%	0.26	1.6%	1.1%	87	1.2%
OF235	SW	0.027	6.3%	1.2%	0.055	5.8%	1.5%	0.005	4.9%	1.8%	1.59	9.8%	6.7%	126	1.7%
	BF	0.005	1.2%	0.2%	0.011	1.2%	0.3%	0.003	2.9%	1.1%	0.64	3.9%	2.7%	166	2.2%
OF245		0.006	1.4%	0.3%	0.007	0.7%	0.2%	0.001	0.7%	0.3%	0.22	1.4%	0.9%	33	0.4%
OF243		0.006	1.4%	0.3%	0.010	1.1%	0.3%	0.002	2.0%	0.7%	0.19	1.2%	0.8%	45	0.6%
OF254		0.010	2.3%	0.5%	0.035	3.7%	1.0%	0.003	2.9%	1.1%	0.18	1.1%	0.8%	50	0.7%
All Other SW Outfalls		0.010	2.4%	0.5%	0.029	3.1%	0.8%	0.003	2.5%	1.0%	0.38	2.3%	1.6%	72	1.0%
BF Total		**0.07**	**16.2%**	**3.1%**	**0.10**	**10.3%**	**2.7%**	**0.016**	**15.6%**	**5.9%**	**4.57**	**28.1%**	**19.2%**	**5,393**	**72.1%**
SW Total		**0.36**	**84%**	**16.3%**	**0.84**	**90%**	**23.3%**	**0.086**	**84%**	**31.6%**	**11.71**	**72%**	**49.1%**	**2,090**	**27.9%**
Total Outfall Loadings		**0.43**		**19.4%**	**0.94**		**26.0%**	**0.102**		**37.4%**	**16.28**		**68.2%**	**7,483**	
Total Loadings		**2.19**		**100.0%**	**3.62**		**100.0%**	**0.273**		**100.0%**	**23.86**		**100.0%**		

Loadings as developed for the 2006 WASP Model Update.
SW - Stormwater
BF- Baseflow

FIGURES

Figure 1-1
Thea Foss Post-Remediation Source Control Strategy

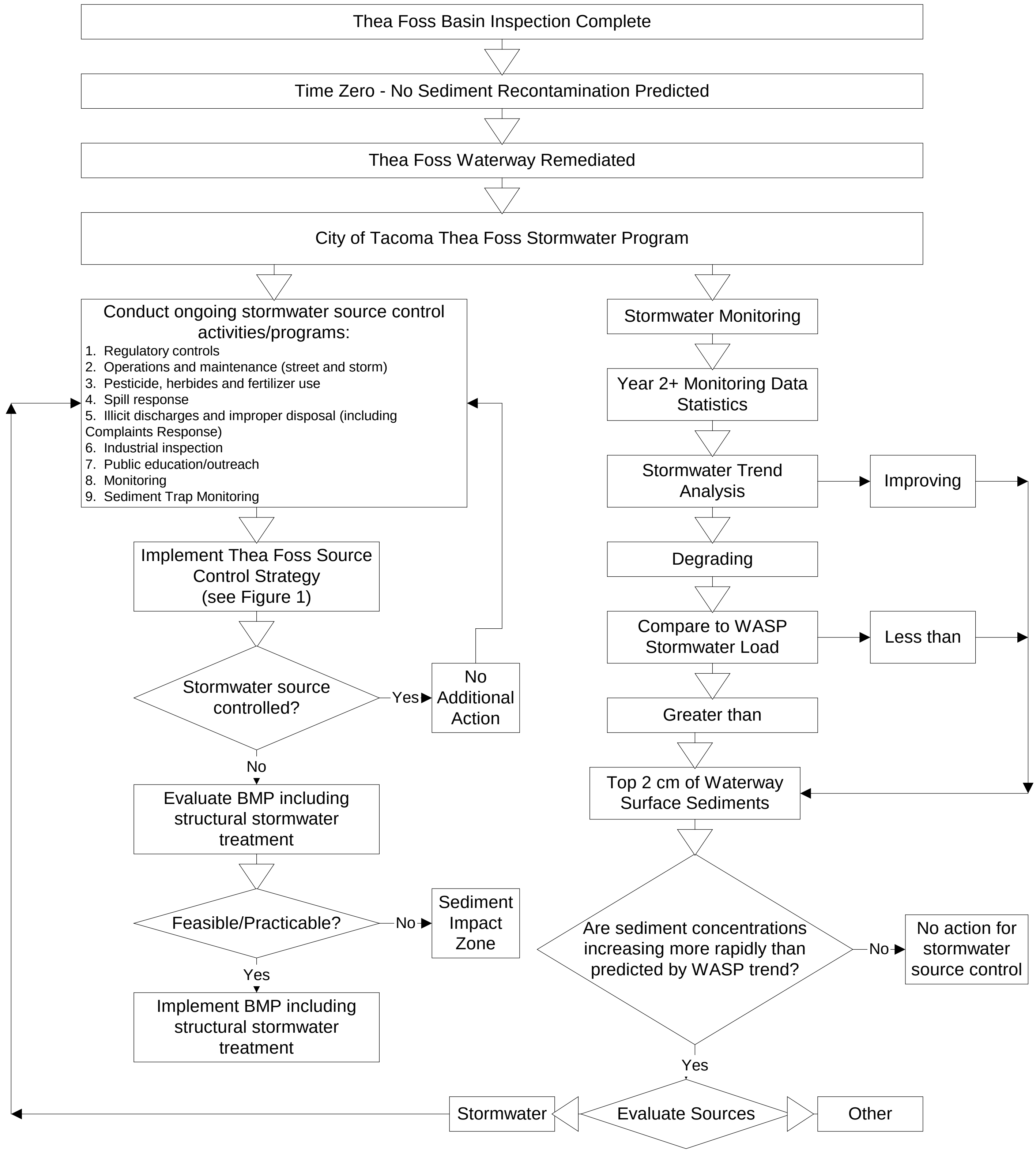
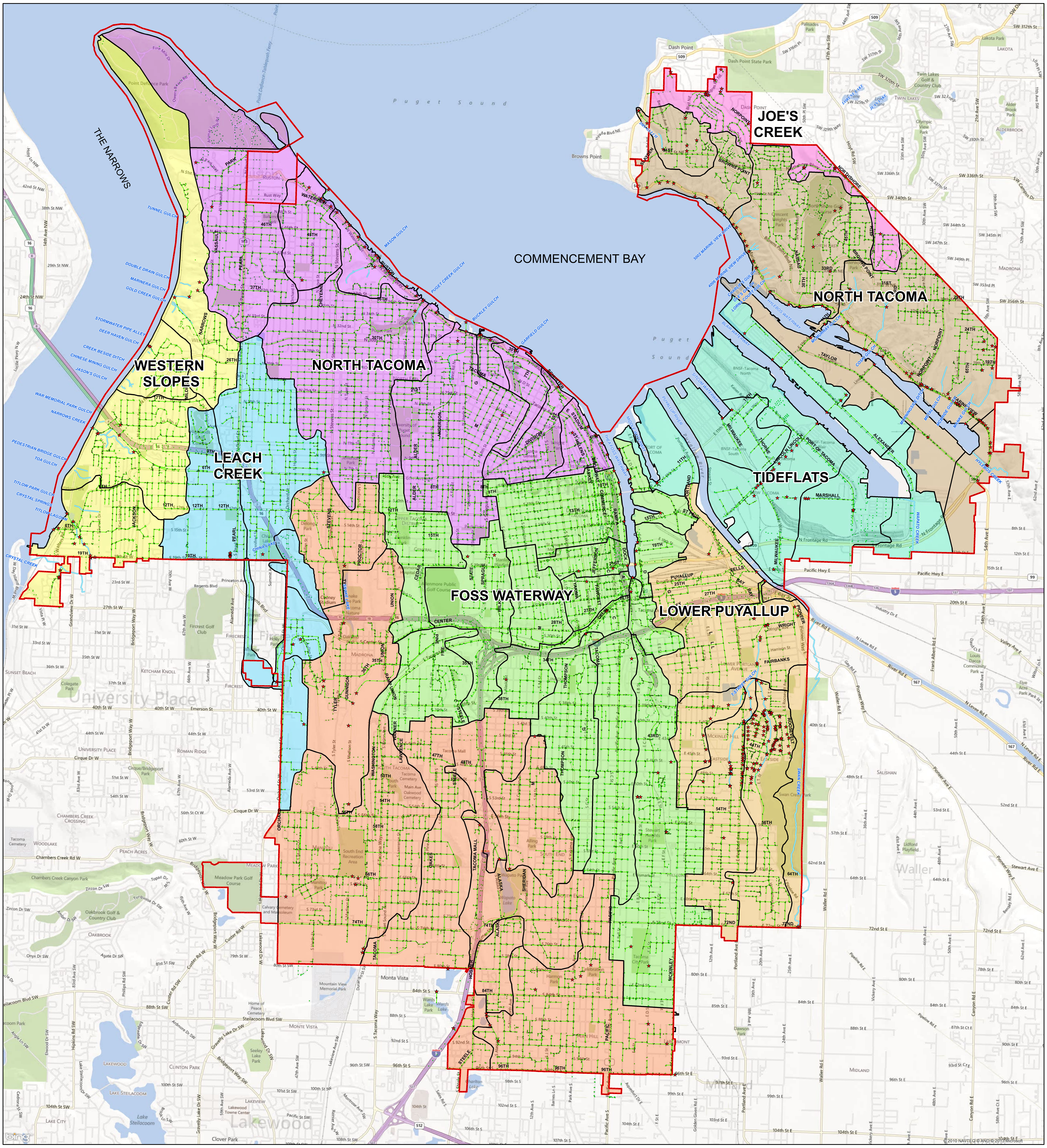


Figure 1-1 Source Control Strategy

Figure 1-2
City of Tacoma Watersheds



WATERSHEDS

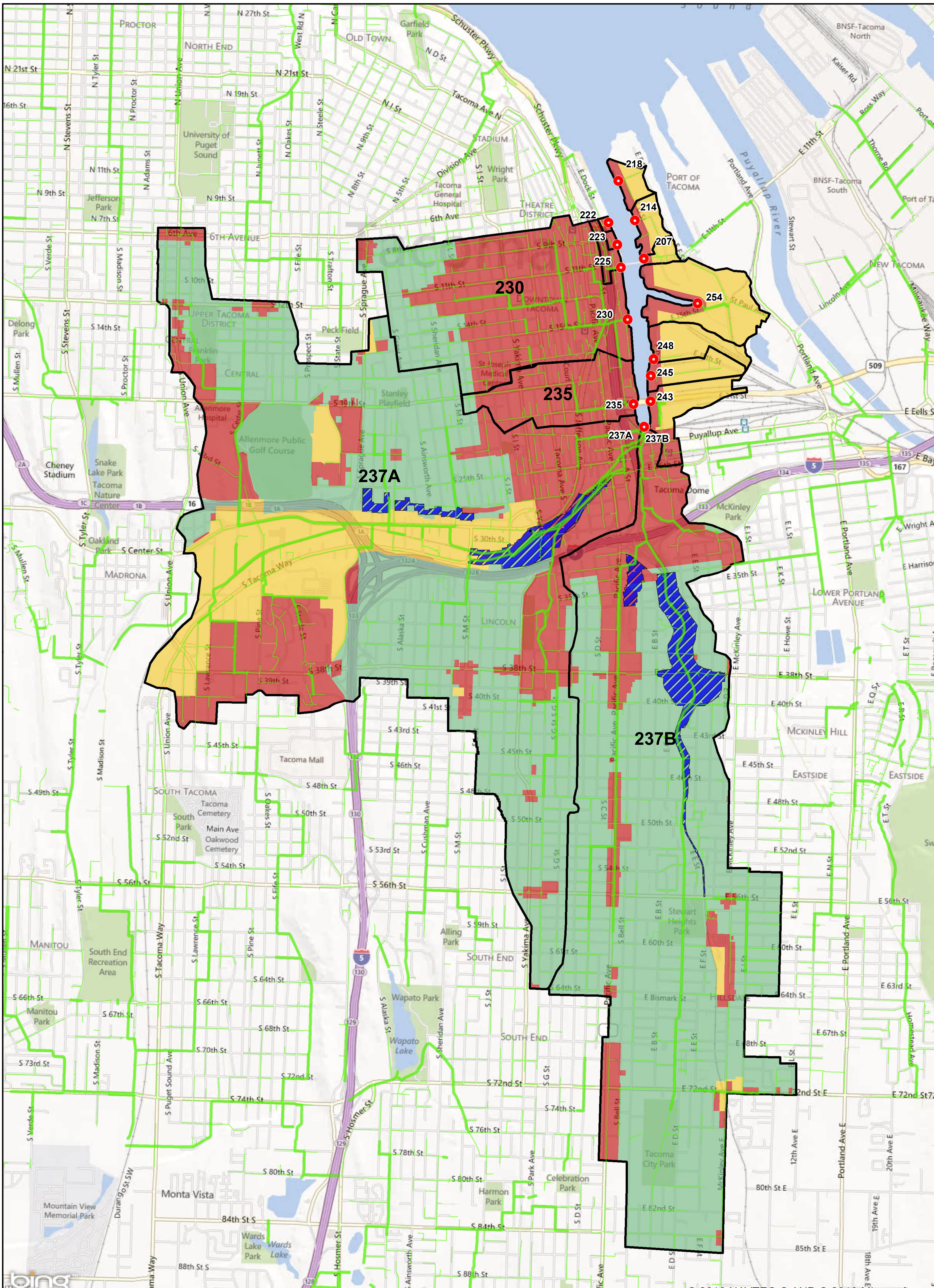
- WESTERN SLOPES
- TIDEFLATS
- NORTH TACOMA
- NE TACOMA
- LOWER PUYALLUP
- LEACH CREEK
- JOE'S CREEK
- FOSS WATERWAY
- FLETT CREEK
- TACOMA CITY LIMITS
- OUTFALLS
- SUB-BASINS

Created in ArcGIS 9 using ArcMap

Source: Environmental Services Division,
Public Works Department City of Tacoma
Date: June 2009

Tacoma

Figure 1-3
Thea Foss Basins Land Use



Legend

- STORM LINES
- TRUNKLINES 24" AND LARGER
- OUTFALLS

Map Date: February 22, 2013
Source: Environmental Services Division, Public Works Department City of Tacoma

Center for Urban Waters
326 East D Street, Tacoma WA 98421
(253) 591-5588

N

0 1,000 2,000 4,000 Feet

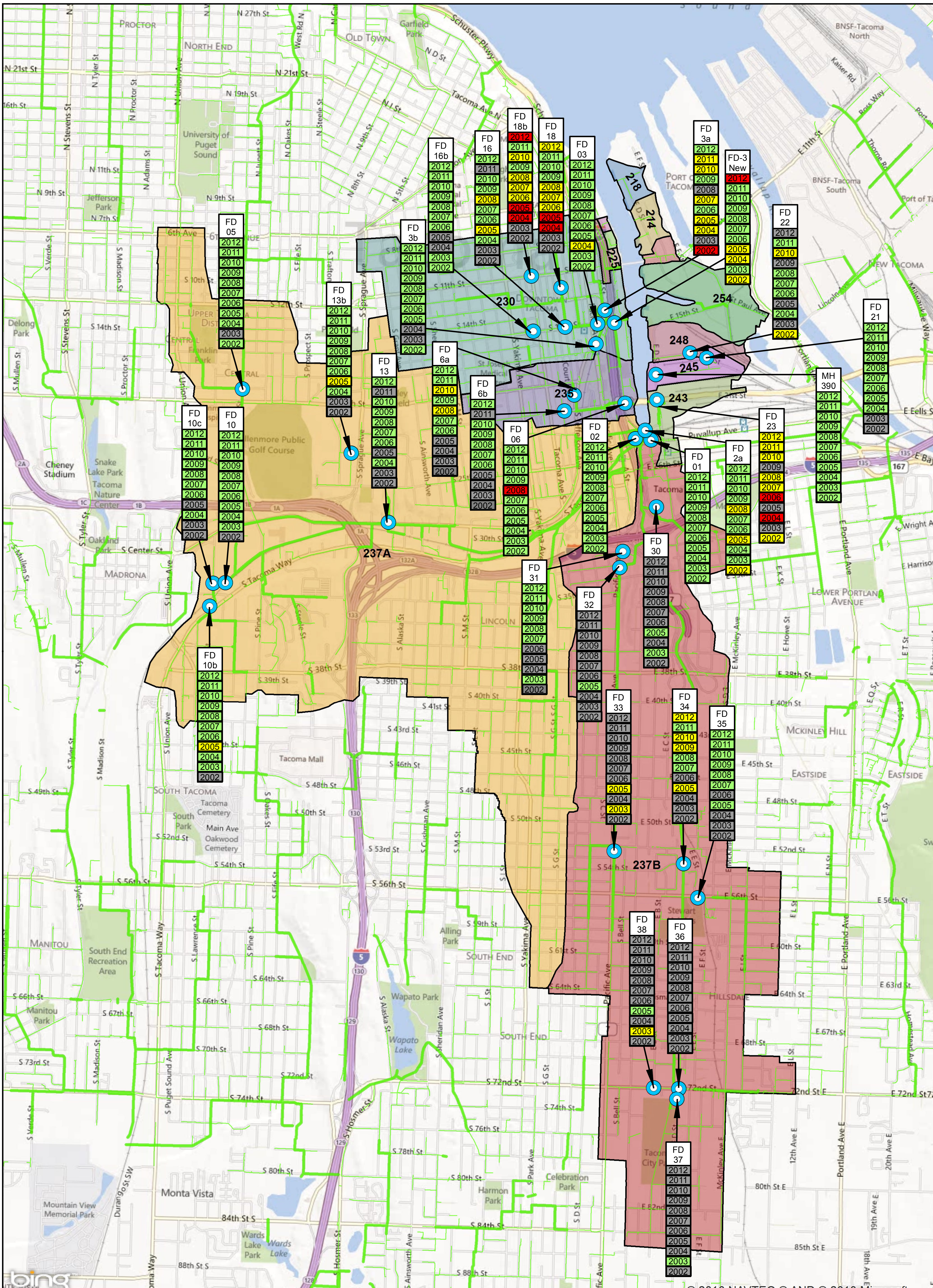
Land Use

- OPEN SPACE
- COMMERCIAL
- INDUSTRIAL
- RESIDENTIAL

Tacoma

Datarequest/MHenley/Thea Foss Monitoring Program Figure 2-1c - Van Pelt

Figure 2-1a
Sediment Trap Results - Mercury



Legend

- SAMPLE SITE LOCATIONS
- STORM LINES
- TRUNKLINES 24" AND LARGER

Map Date: February 19, 2013
Source: Environmental Services Division, Public Works Department City of Tacoma

Center for Urban Waters
326 East D Street, Tacoma WA 98421
(253) 591-5588

N

0 1,000 2,000 4,000 Feet

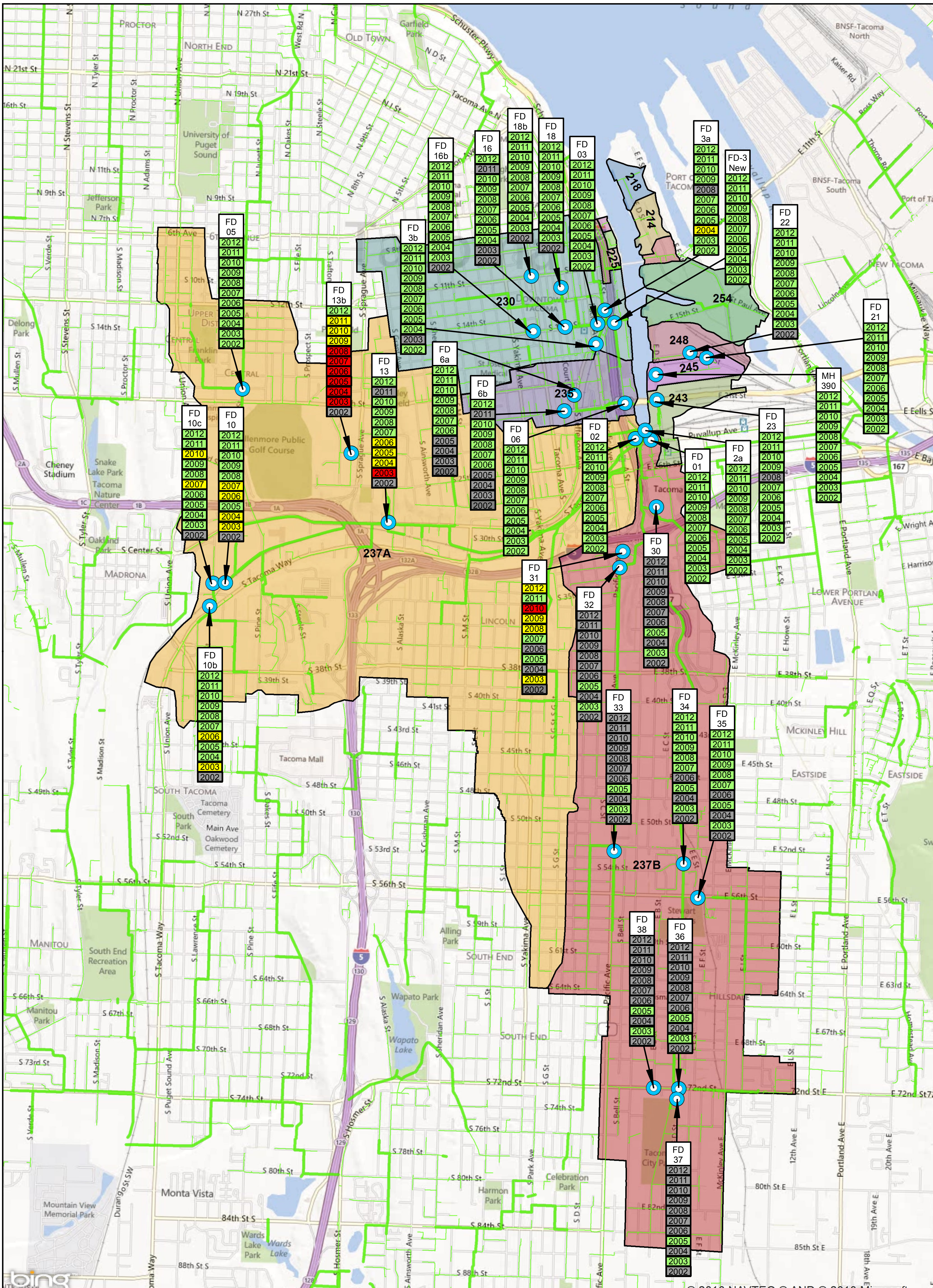
Symbol Level Key

- NO ANALYSIS
- SMALL LEVELS - <.20 ug/Kg
- MEDIUM LEVELS - .20 - .70 ug/Kg
- LARGE LEVELS - >.70 ug/Kg

Tacoma

Datarequest/MHenley/Thea Foss Monitoring Program Figure 2-1a - Van Pelt

Figure 2-1b
Sediment Trap Results - PAHs



Legend

SAMPLE SITE LOCATIONS
STORM LINES
TRUNKLINES 24" AND LARGER

Map Date: February 19, 2013
Source: Environmental Services Division, Public Works Department City of Tacoma

Center for Urban Waters
326 East D Street, Tacoma WA 98422
(253) 591-5588

N

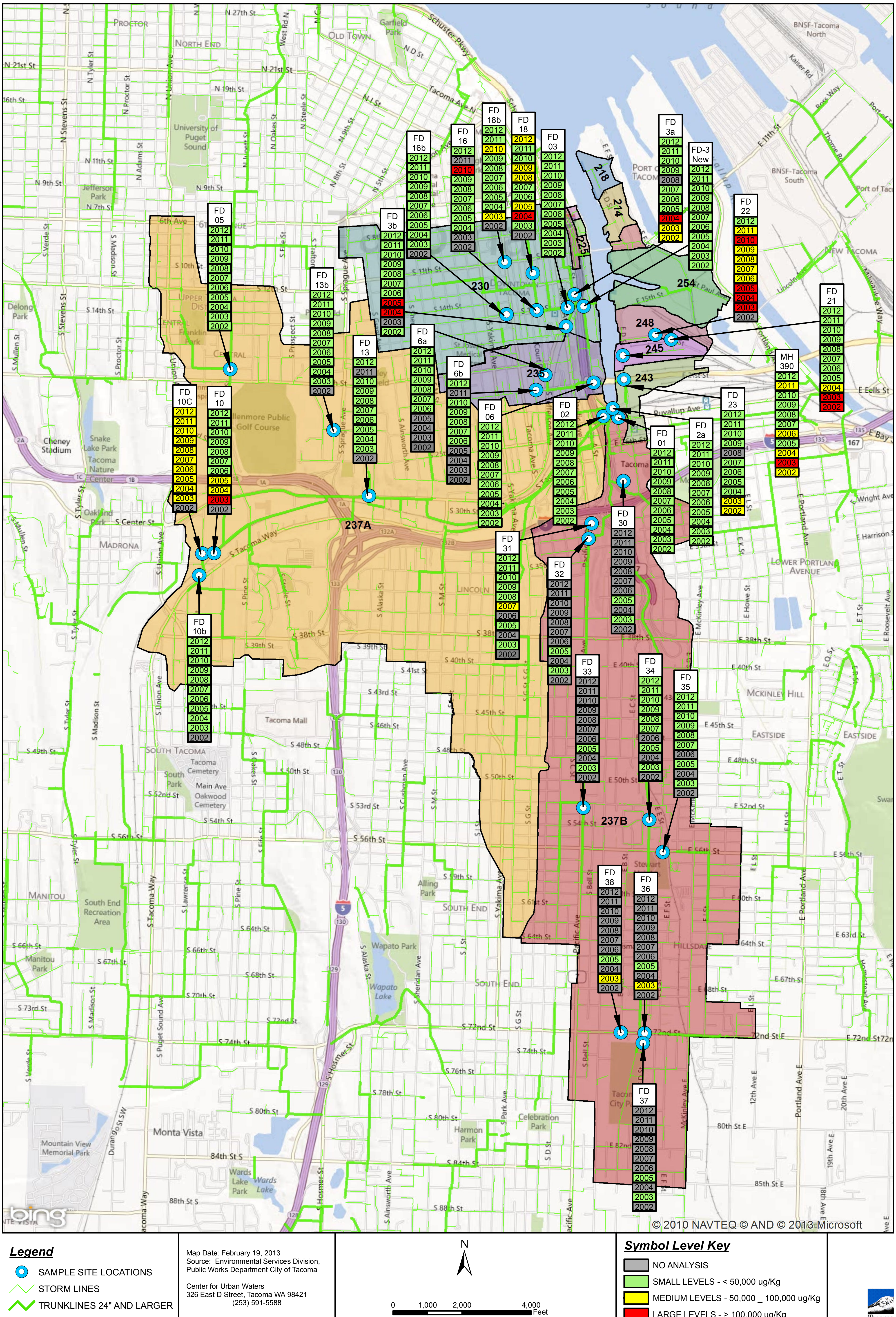
0 1,000 2,000 4,000 Feet

Symbol Level Key

NO ANALYSIS
SMALL LEVELS - < 164,000 ug/Kg
MEDIUM LEVELS - 164,000 _ 300,000 ug/Kg
LARGE LEVELS - > 300,000 ug/Kg

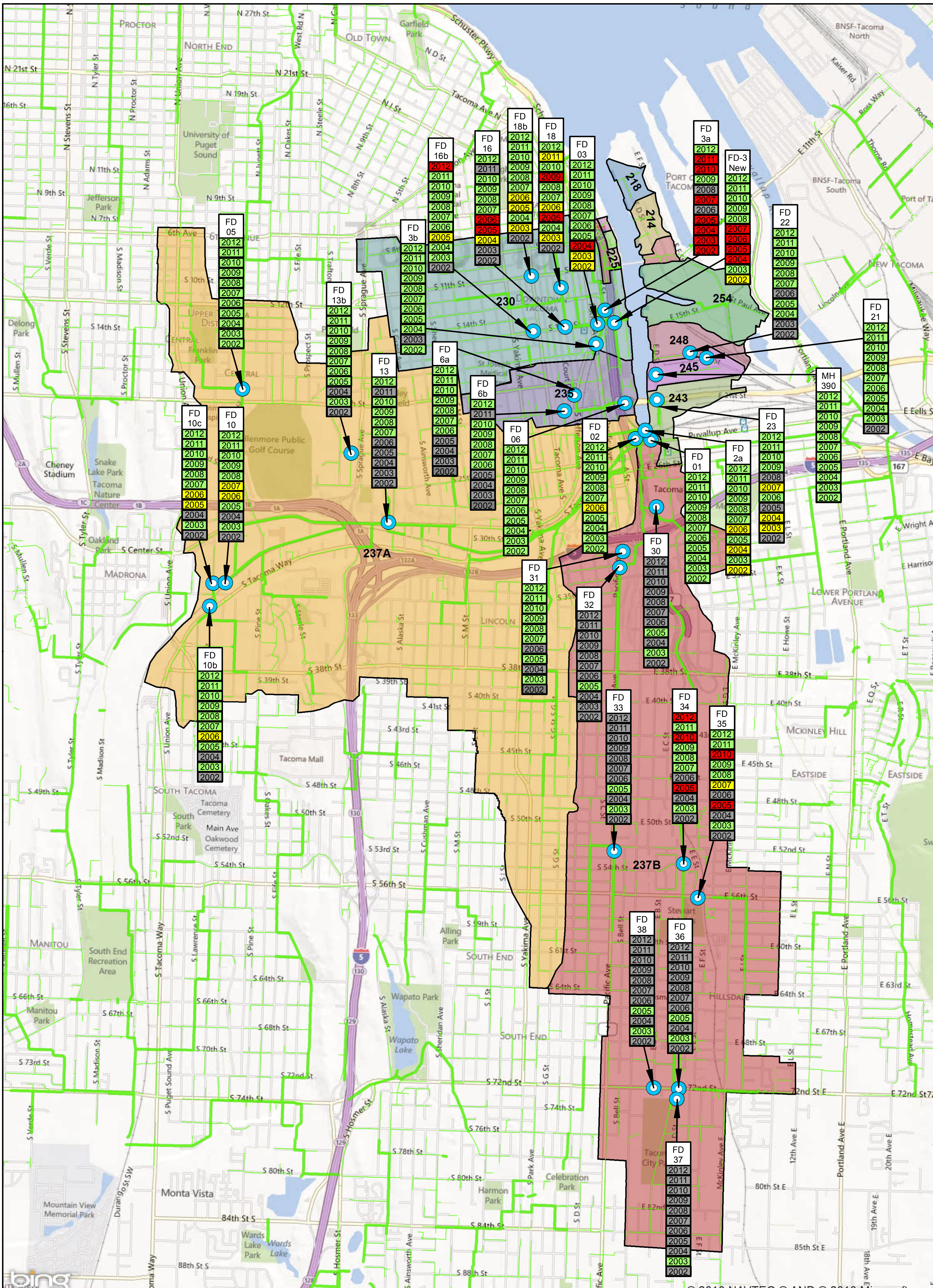
Datarequest/MHenley/Thea Foss Monitoring Program Figure 2-1b - Van Pelt

Figure 2-1c
Sediment Trap Results - Phthalates



Datarequest/MHenley/Thea Foss Monitoring Program Figure 2-1c - Van Pelt

Figure 2-1d
Sediment Trap Results - PCBs



Legend

SAMPLE SITE LOCATIONS
STORM LINES
TRUNKLINES 24" AND LARGER

Map Date: February 19, 2013
Source: Environmental Services Division, Public Works Department City of Tacoma

Center for Urban Waters
326 East D Street, Tacoma WA 98421
(253) 591-5588

N

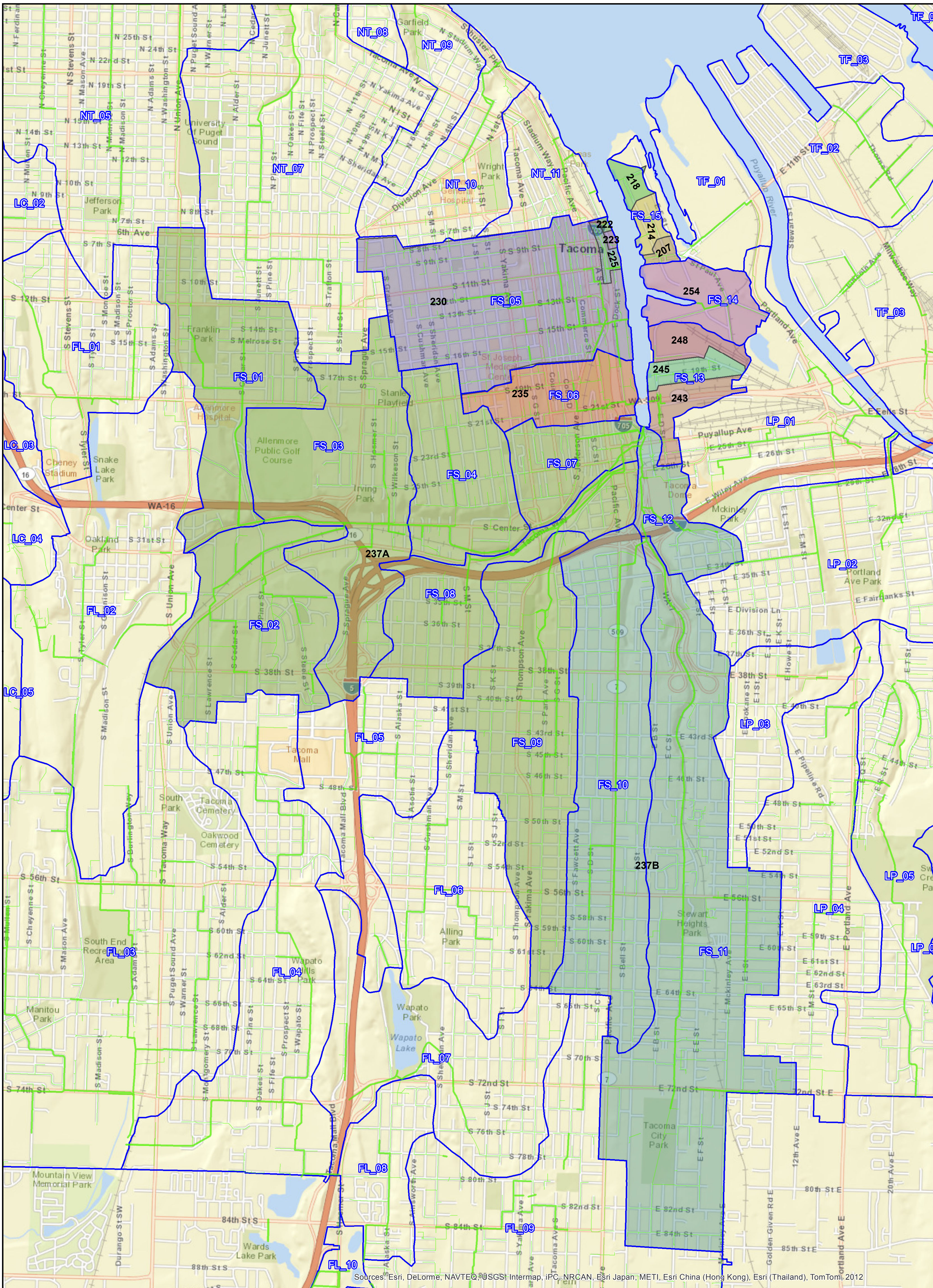
0 1,000 2,000 4,000 Feet

Symbol Level Key

NO ANALYSIS
SMALL LEVELS - < 120 ug/Kg
MEDIUM LEVELS - 120 _ 400 ug/Kg
LARGE LEVELS - > 400 ug/Kg

Datarequest/MHenley/Thea Foss Monitoring Program Figure 2-1d - Van Pelt

Figure 2-2
Stormwater Sub-Basins In the Thea Foss Basin (2012)



Legend

STORM LINES

TRUNKLINES 24" AND LARGER

Map Date: February 22, 2013
Source: Environmental Services Division, Public Works Department City of Tacoma

Center for Urban Waters
326 East D Street, Tacoma WA 98421
(253) 591-5588

N

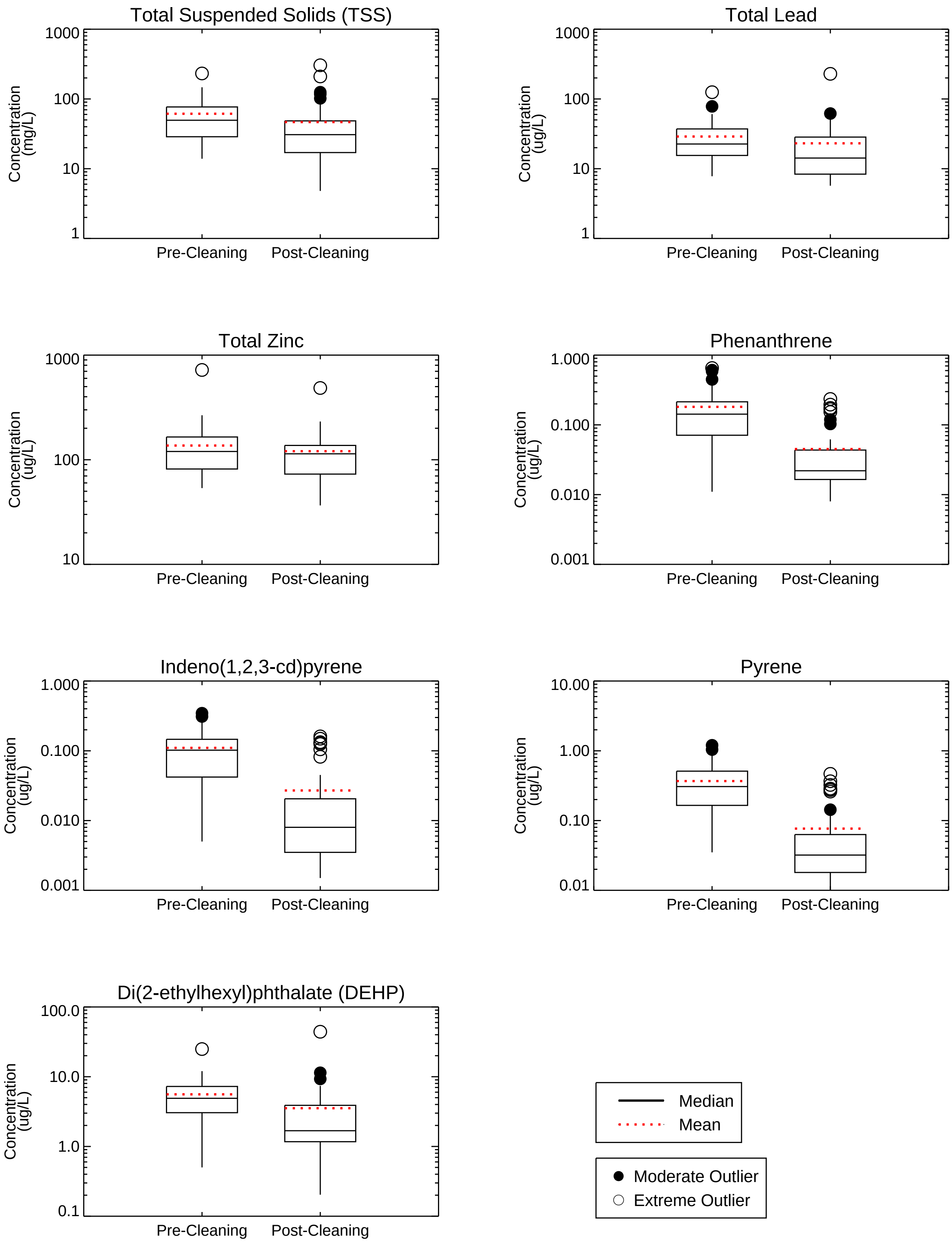
0 1,000 2,000 4,000 Feet

STORM SUB-BASINS

Tacoma

Datarequest/MHenley/Thea Foss Monitoring Program Figure 2-1c - Van Pelt

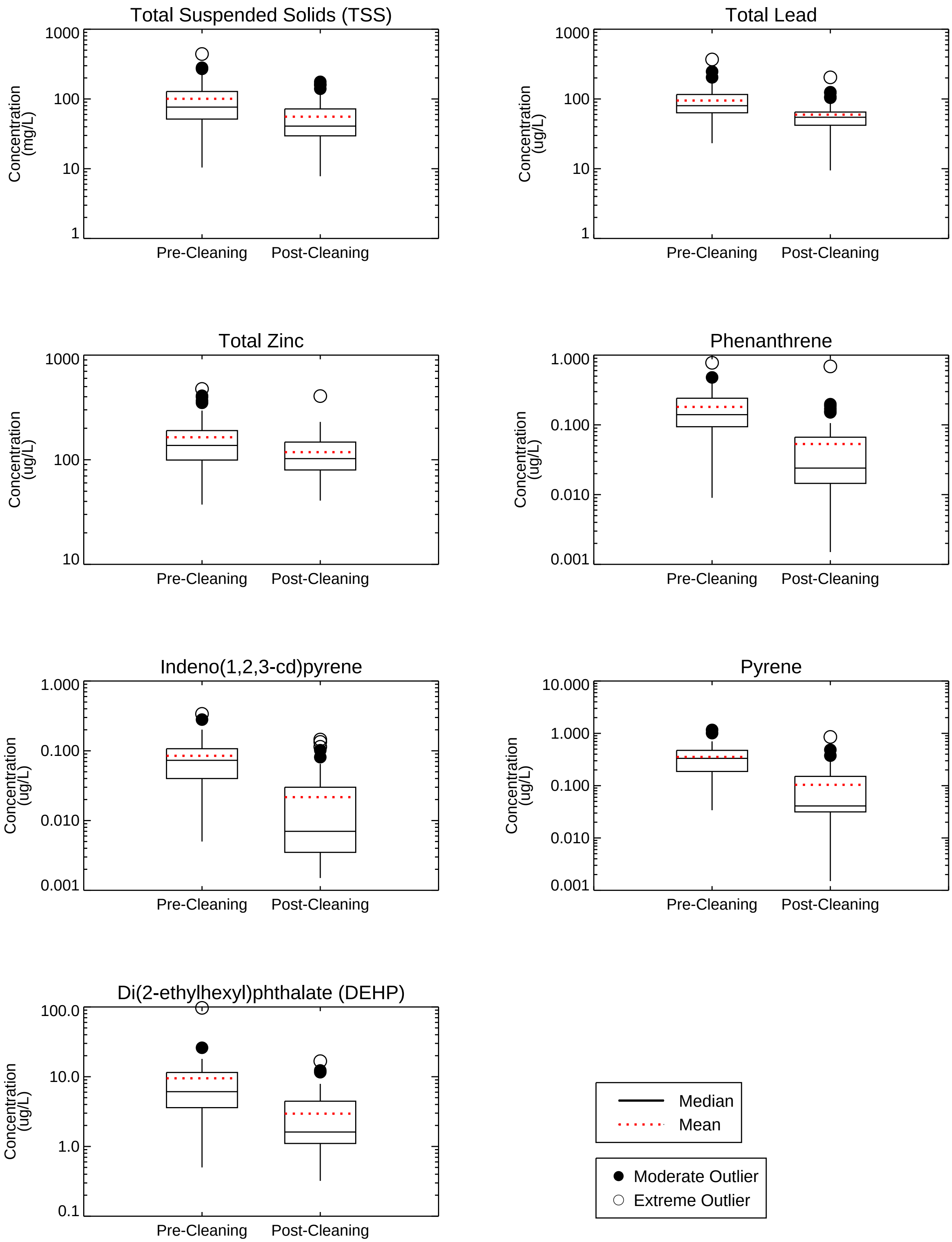
Figure 2-3a
Outfall 230 Storm Line Cleaning Comparison [Log Scale]



Notes:

Tukey Box boundaries display the interquartile range (IQR) of the distribution ranging from the first quartile to the third. The central 50% of data is within the box boundaries.The whiskers represent the remaining data minus the outliers. The moderate outlier value is greater than the third quartile plus 1.5*IQR or less than the first quartile minus 1.5*IQR. The extreme outlier value is greater than the third quartile plus 3.0*IQR or less than the first quartile minus 3.0*IQR.

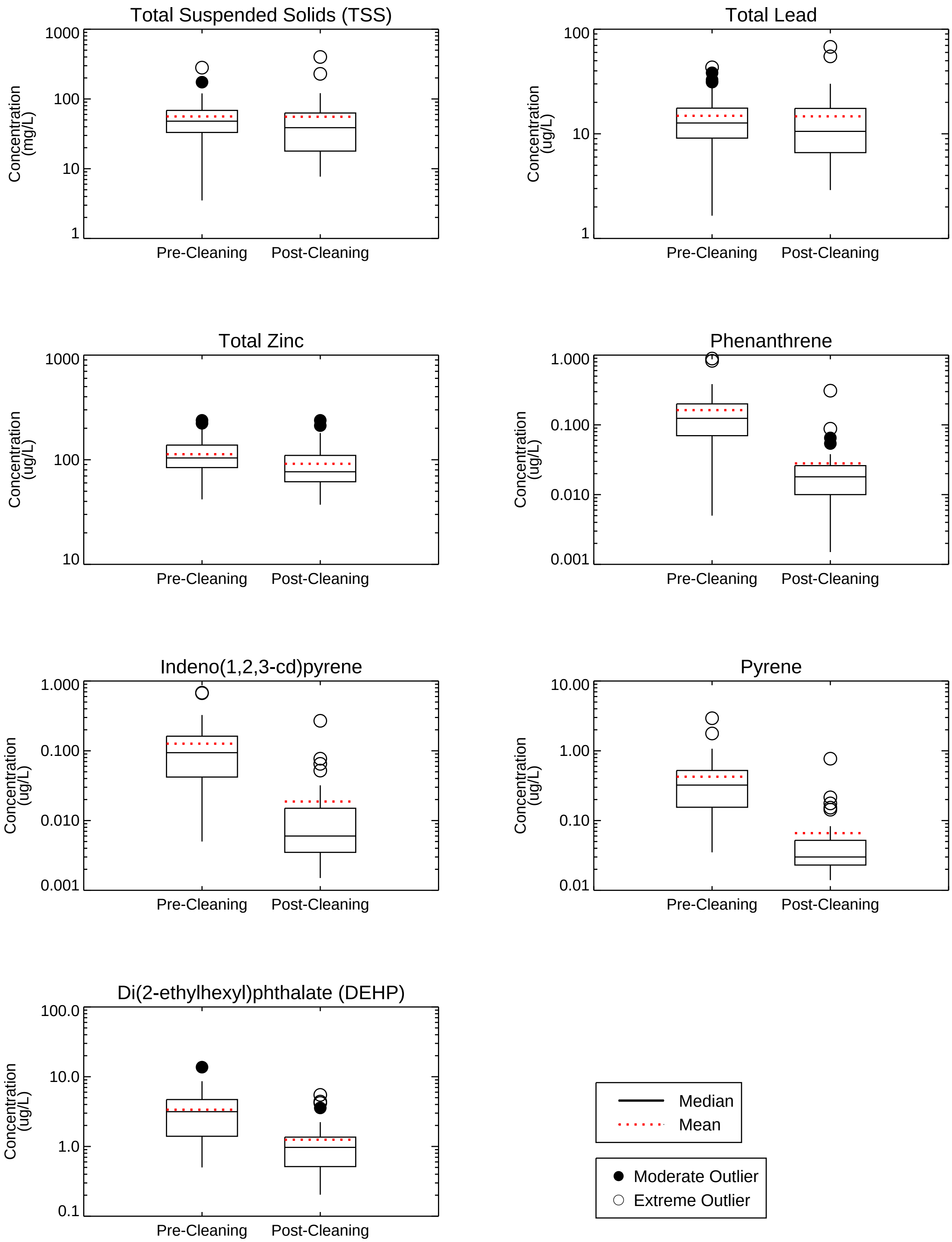
Figure 2-3b
Outfall 235 Storm Line Cleaning Comparison [Log Scale]



Notes:

Tukey Box boundaries display the interquartile range (IQR) of the distribution ranging from the first quartile to the third. The central 50% of data is within the box boundaries.The whiskers represent the remaining data minus the outliers.
The moderate outlier value is greater than the third quartile plus 1.5*IQR or less than the first quartile minus 1.5*IQR.
The extreme outlier value is greater than the third quartile plus 3.0*IQR or less than the first quartile minus 3.0*IQR.

Figure 2-3c
Outfall 237A Storm Line Cleaning Comparison [Log Scale]

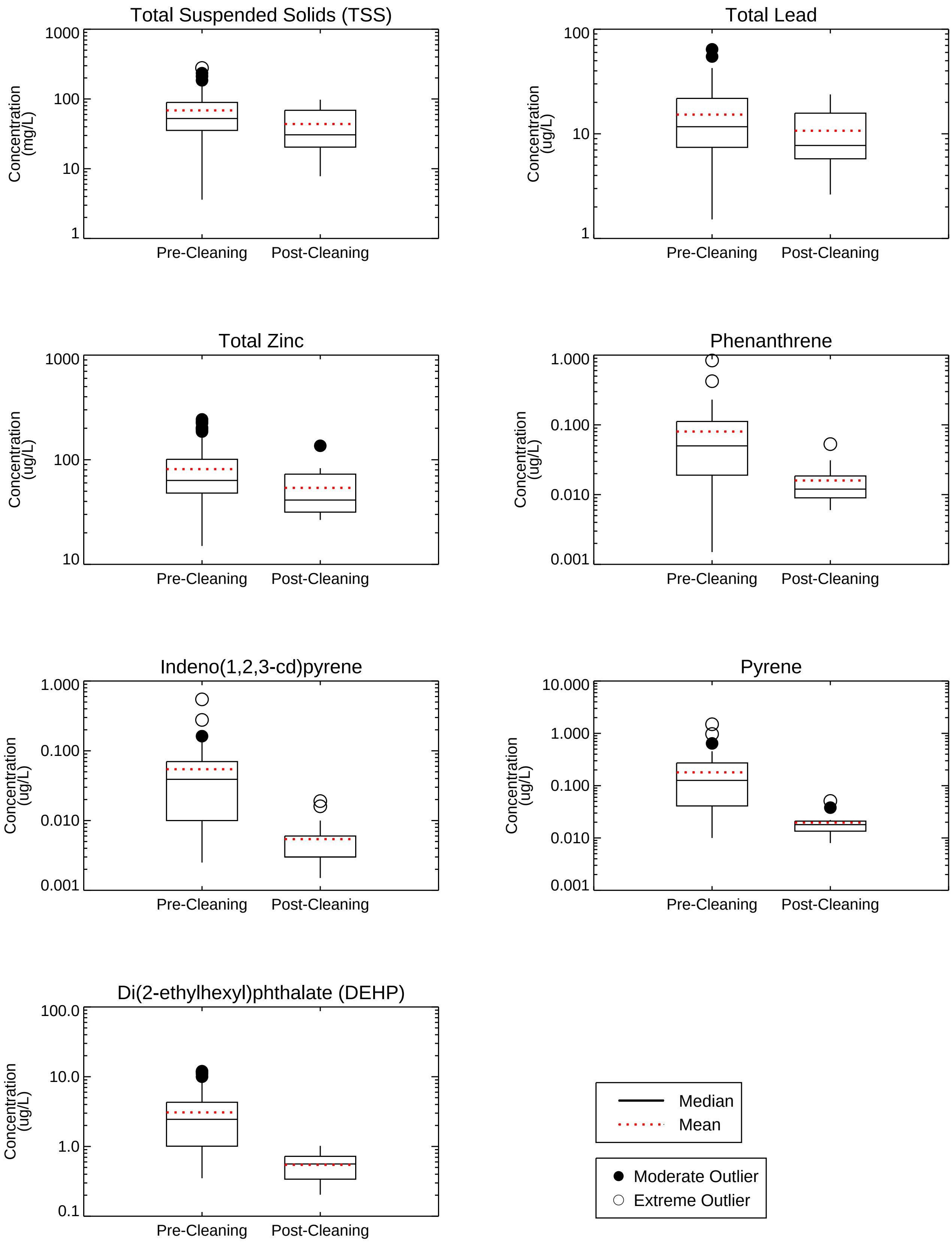


Notes:

Tukey Box boundaries display the interquartile range (IQR) of the distribution ranging from the first quartile to the third. The central 50% of data is within the box boundaries.The whiskers represent the remaining data minus the outliers.
The moderate outlier value is greater than the third quartile plus 1.5*IQR or less than the first quartile minus 1.5*IQR.
The extreme outlier value is greater than the third quartile plus 3.0*IQR or less than the first quartile minus 3.0*IQR.

BOX_WHISKER_STORM_LINE_COMPARISON_2012.pro

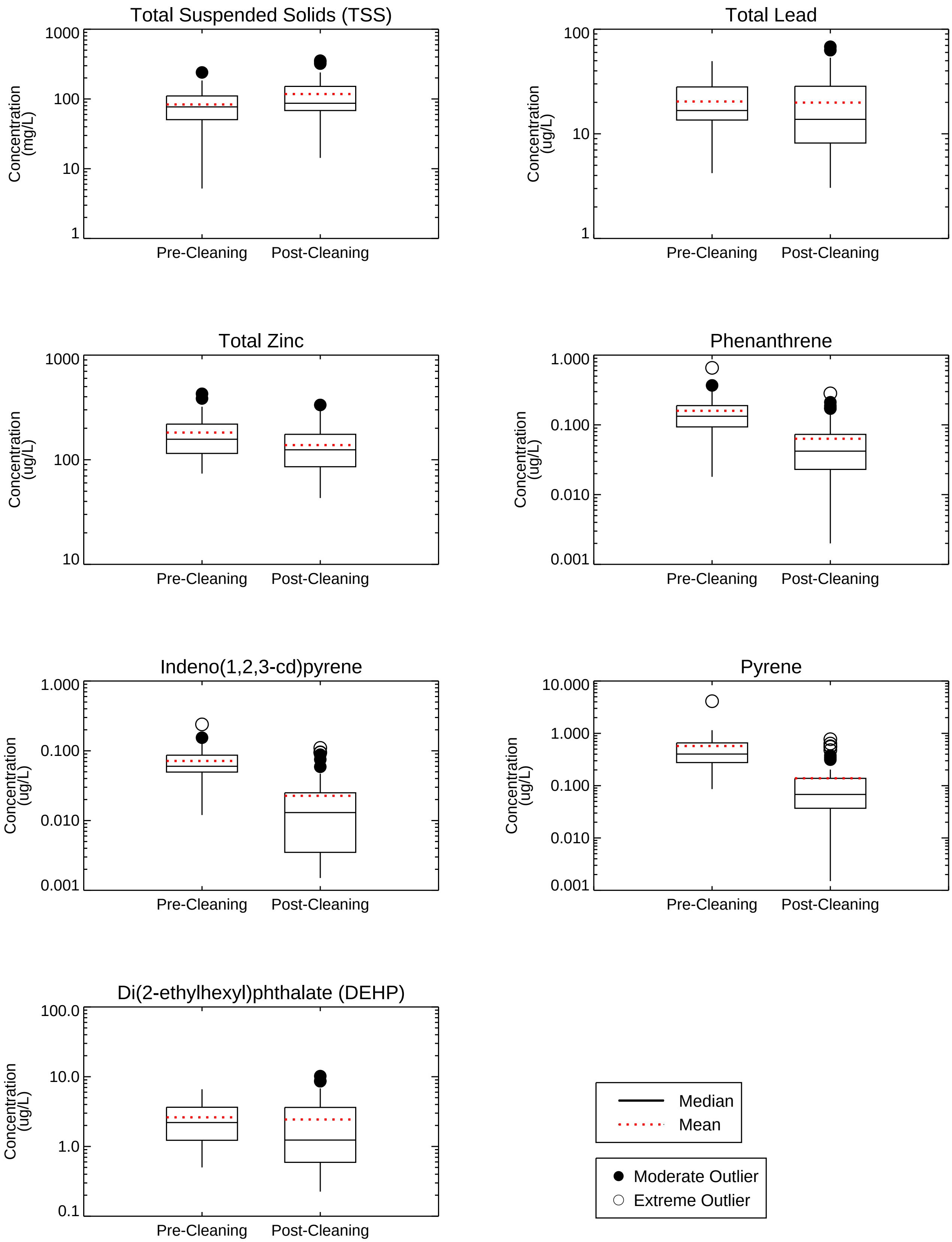
Figure 2-3d
Outfall 237B Storm Line Cleaning Comparison [Log Scale]



Notes:

Tukey Box boundaries display the interquartile range (IQR) of the distribution ranging from the first quartile to the third. The central 50% of data is within the box boundaries.The whiskers represent the remaining data minus the outliers. The moderate outlier value is greater than the third quartile plus 1.5*IQR or less than the first quartile minus 1.5*IQR. The extreme outlier value is greater than the third quartile plus 3.0*IQR or less than the first quartile minus 3.0*IQR.

Figure 2-3e
Outfall 254 Storm Line Cleaning Comparison [Log Scale]



Notes:

Tukey Box boundaries display the interquartile range (IQR) of the distribution ranging from the first quartile to the third. The central 50% of data is within the box boundaries.The whiskers represent the remaining data minus the outliers. The moderate outlier value is greater than the third quartile plus 1.5*IQR or less than the first quartile minus 1.5*IQR. The extreme outlier value is greater than the third quartile plus 3.0*IQR or less than the first quartile minus 3.0*IQR.

Figure 3-1
Daily Rainfall - Monthly Averages WY2002-WY2012

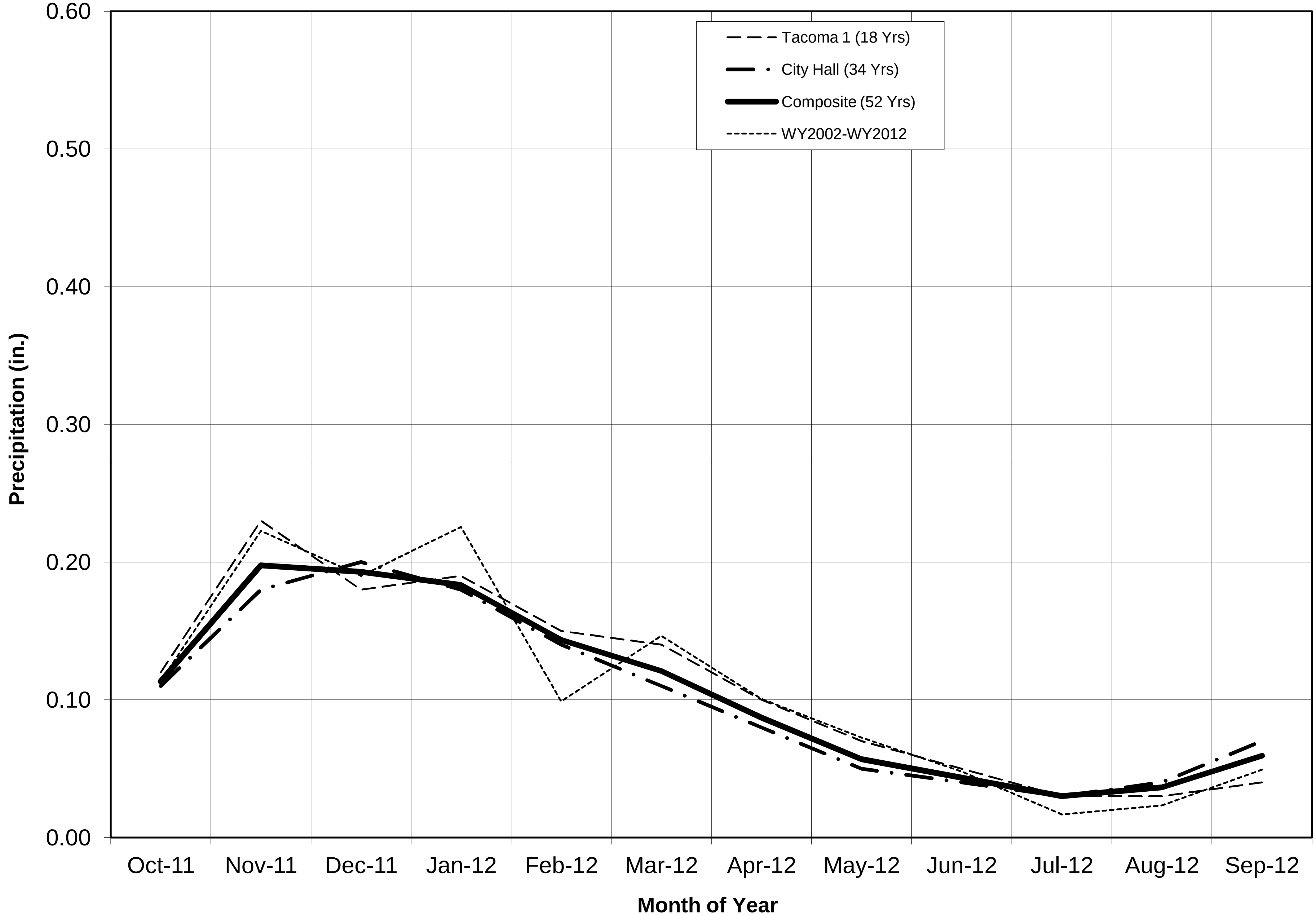
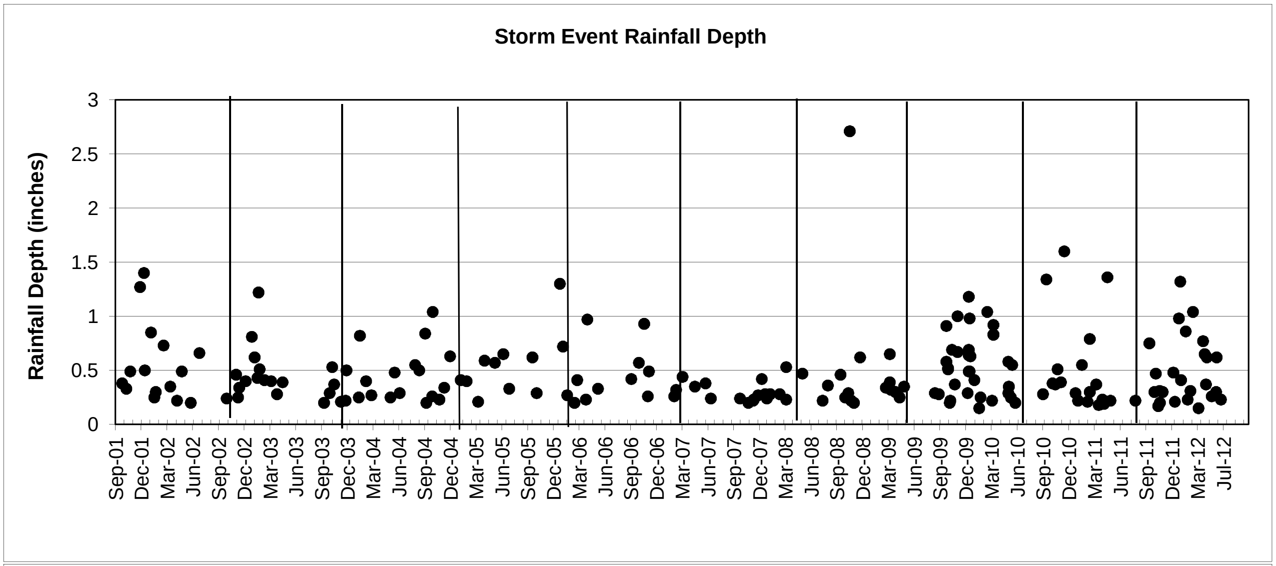
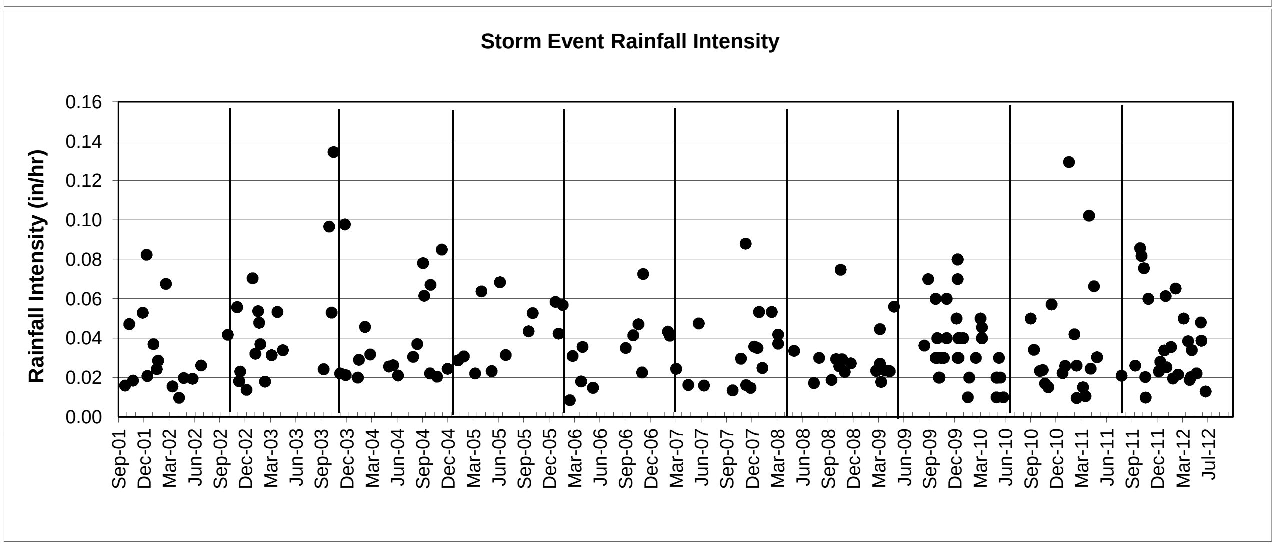


Figure 3-1.xlsFigure 3-1

Figure 3-2
Storm Event Hydrologic Parameters
October 2001 - September 2012





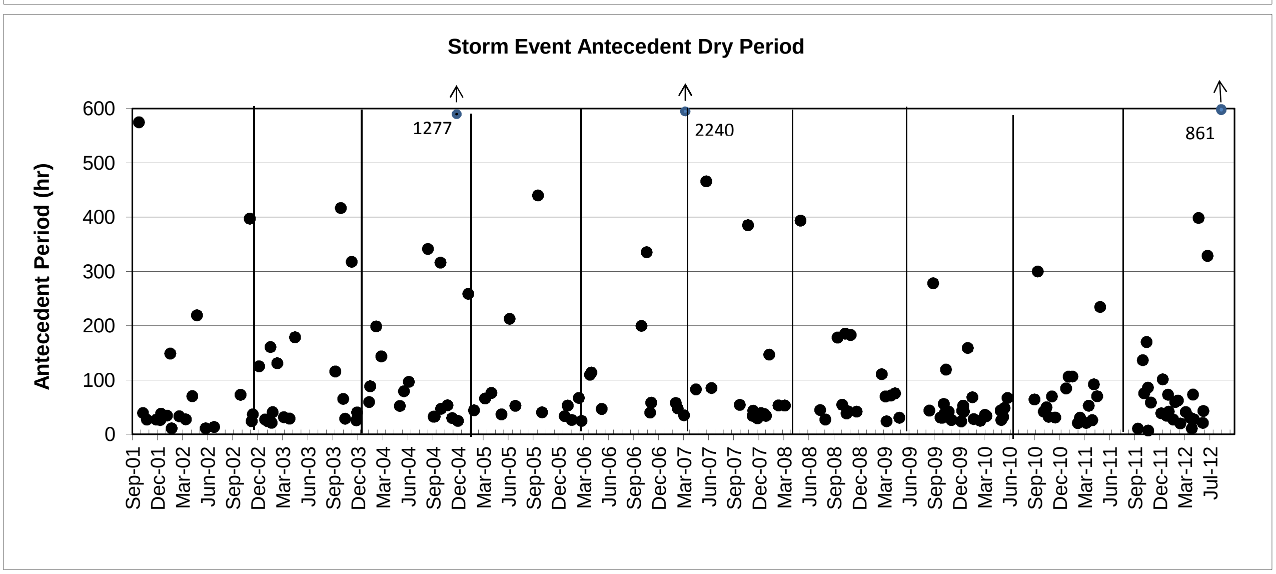


Figure 3-3
Representativeness of Sampled Storm Sizes

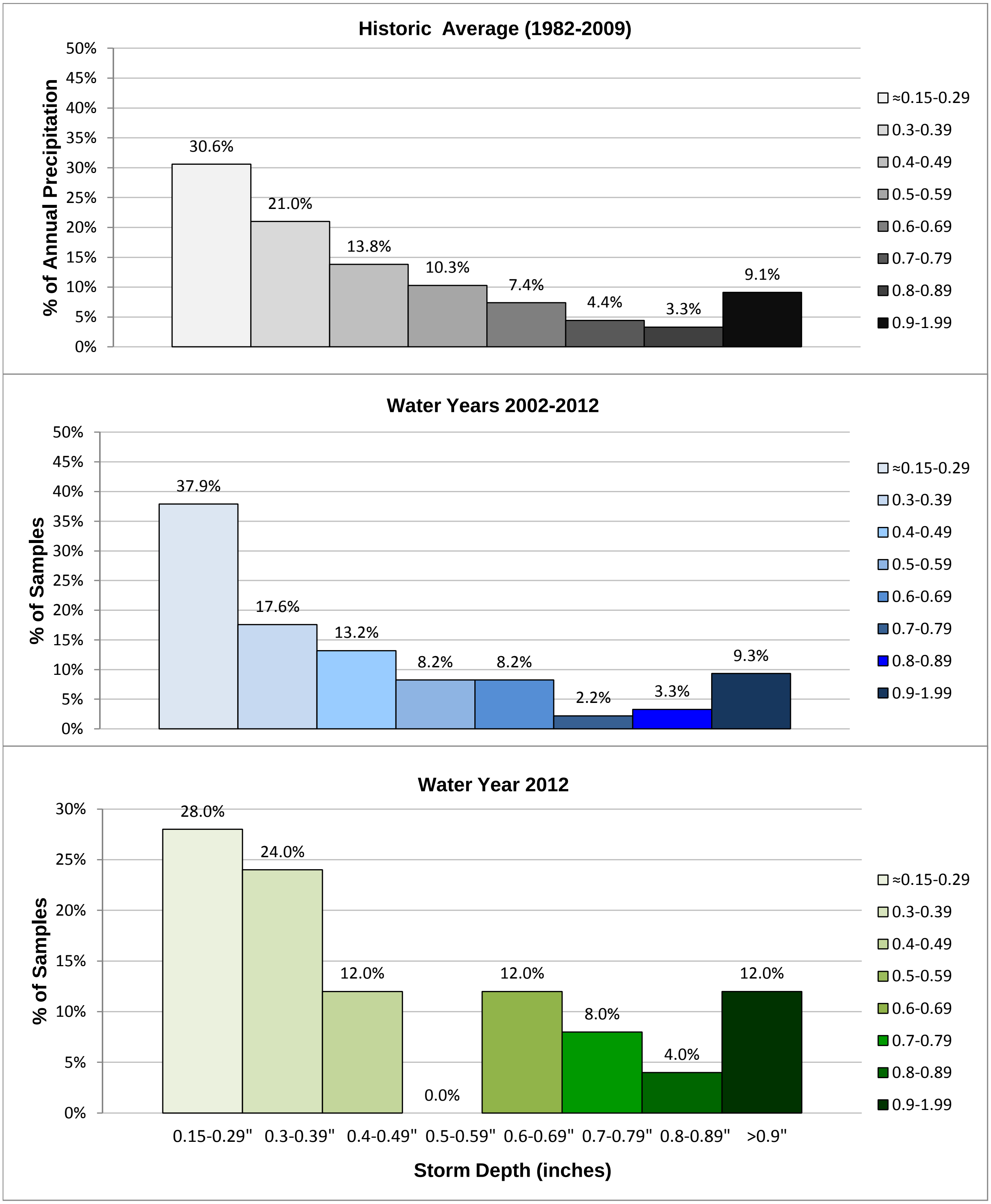


Figure 3-4
Representativeness of Seasonal Sampling Distribution

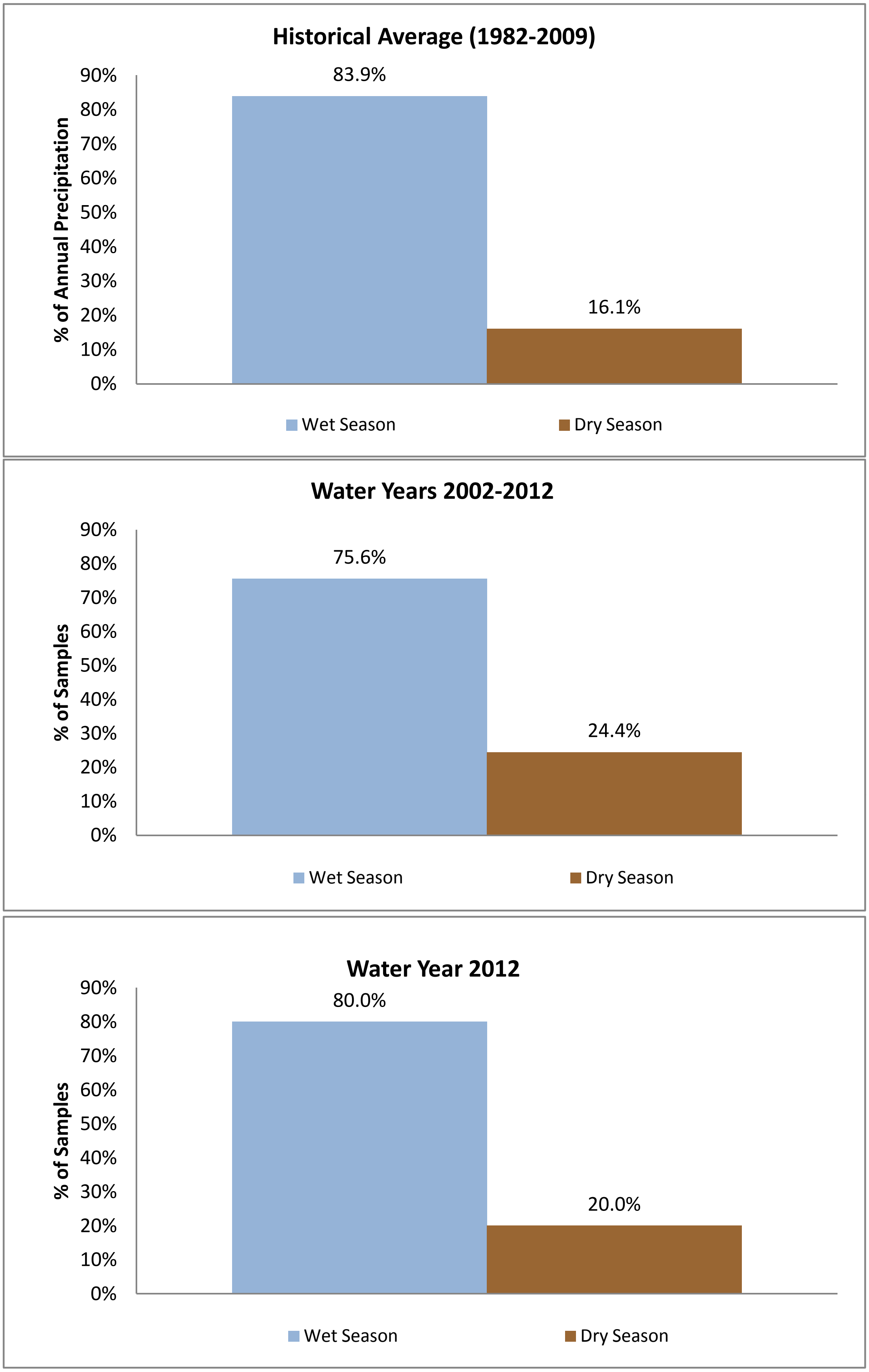
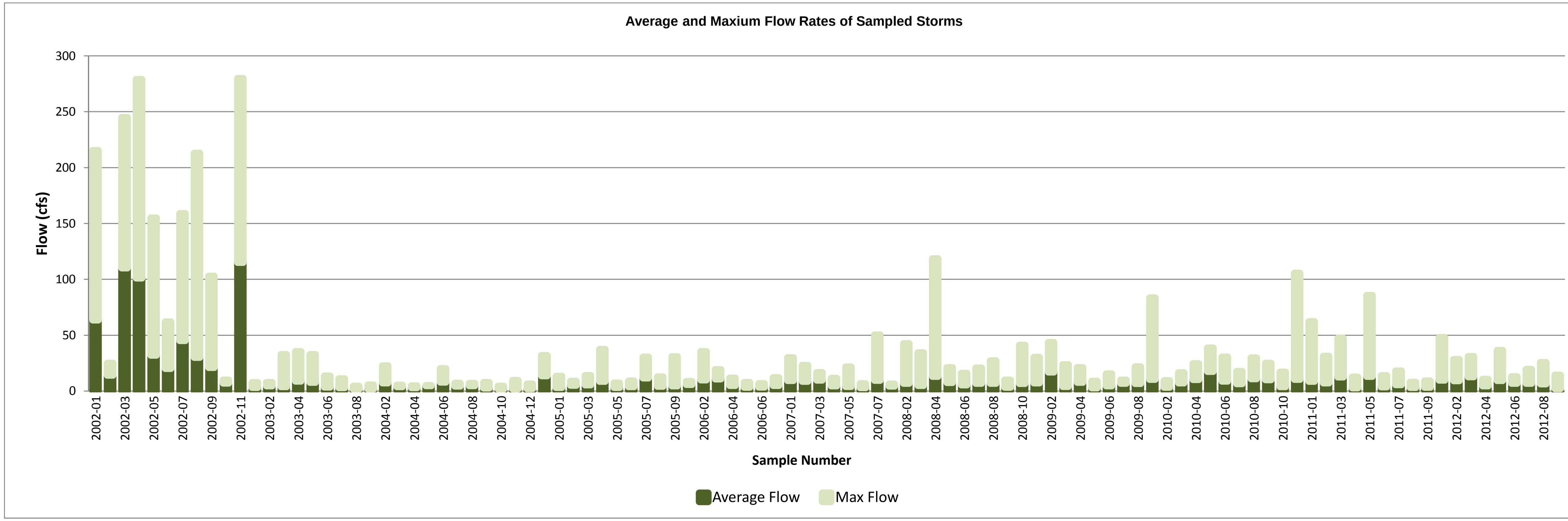


Figure 3-4 Seasonal Representativeness 2012.xls

Figure 3-5a
Sampled Storm Flows and Volumes - OF230



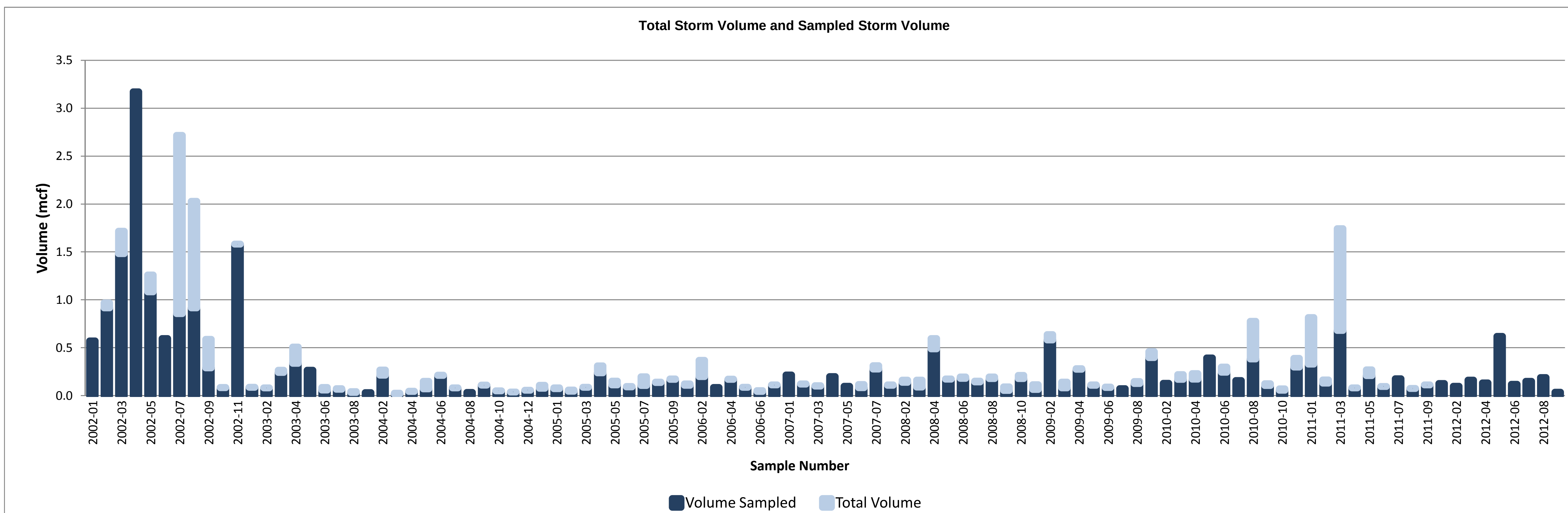
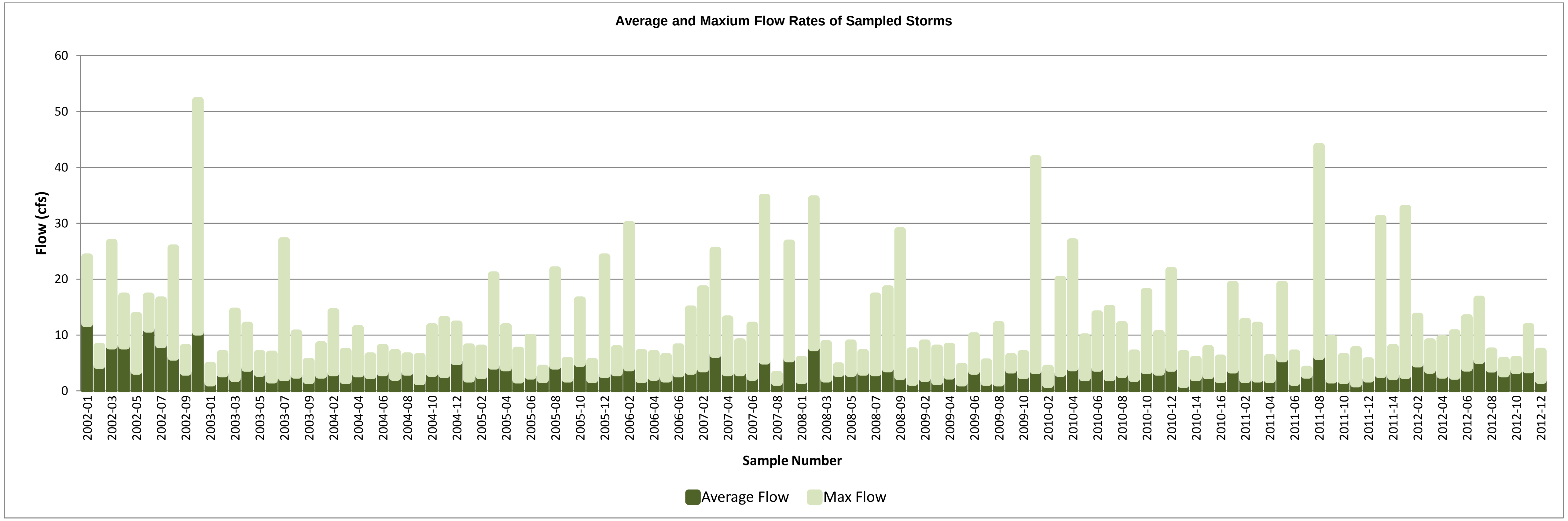


Figure 3-5a - Flow Data 230.xls

Figure 3-5b
Sampled Storm Flows and Volumes - OF235



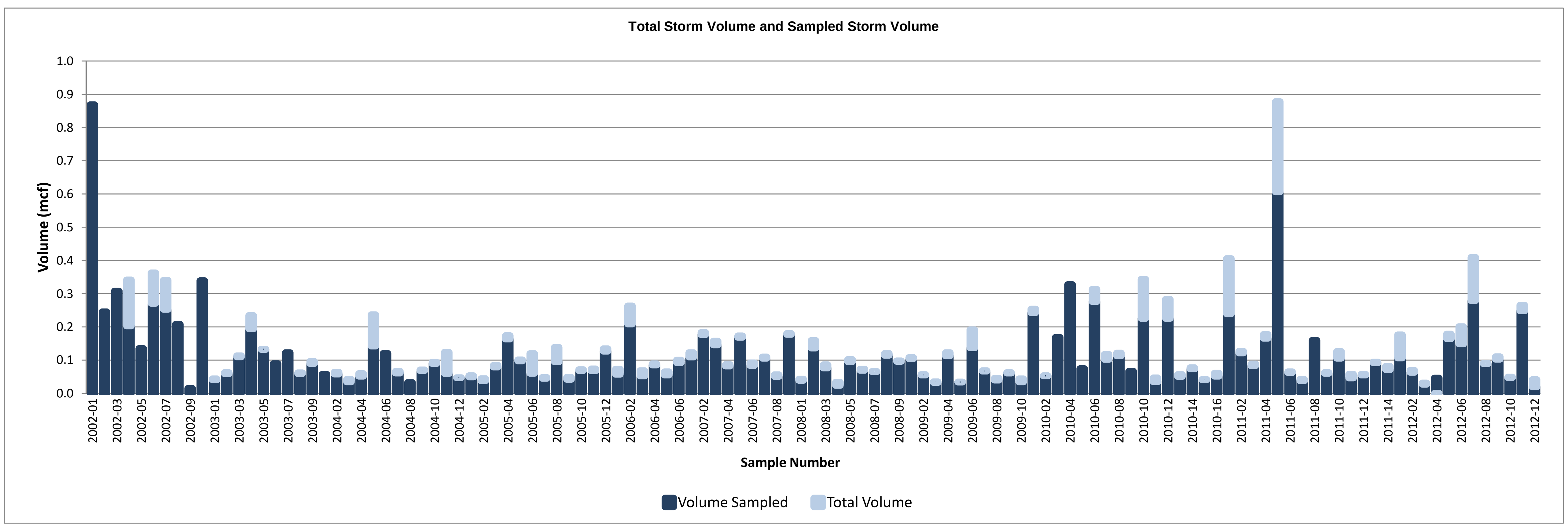
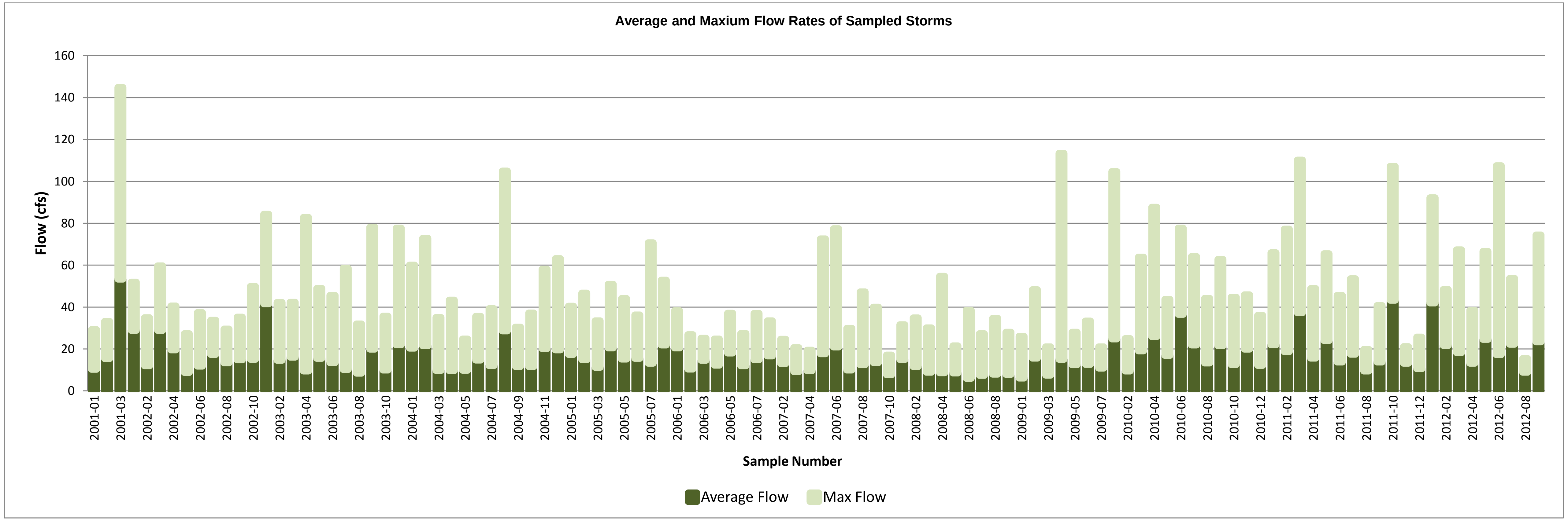


Figure 3-5b - Flow Data 235.xls

Figure 3-5c
Sampled Storm Flows and Volumes - OF237A



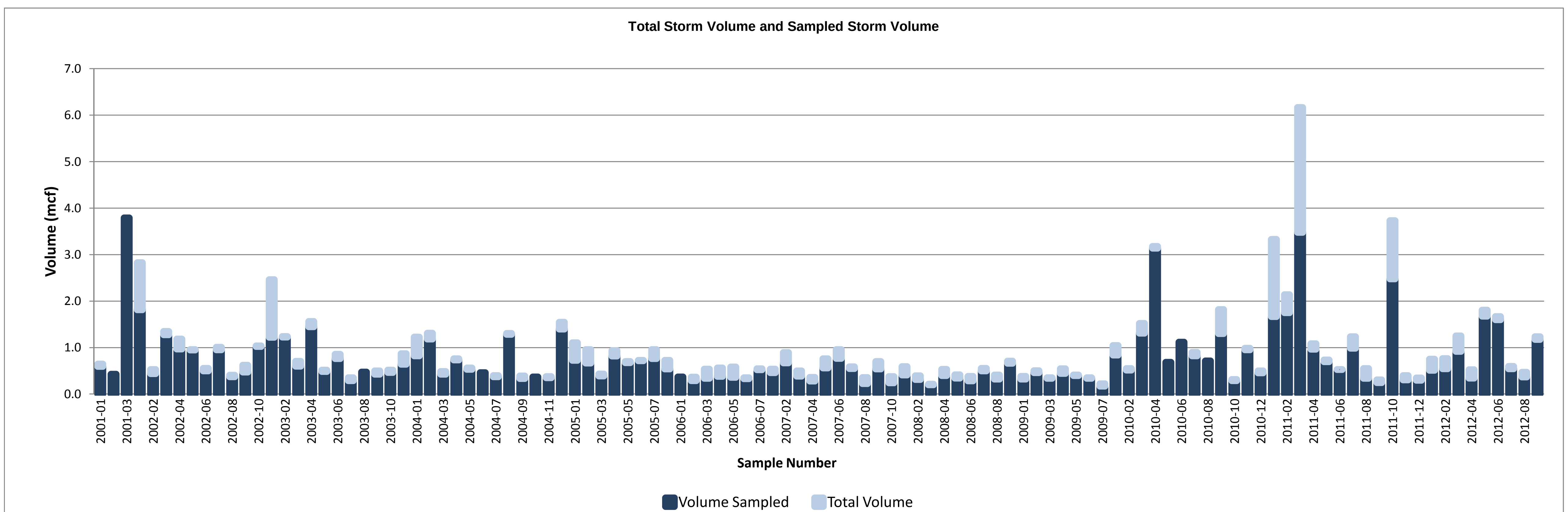
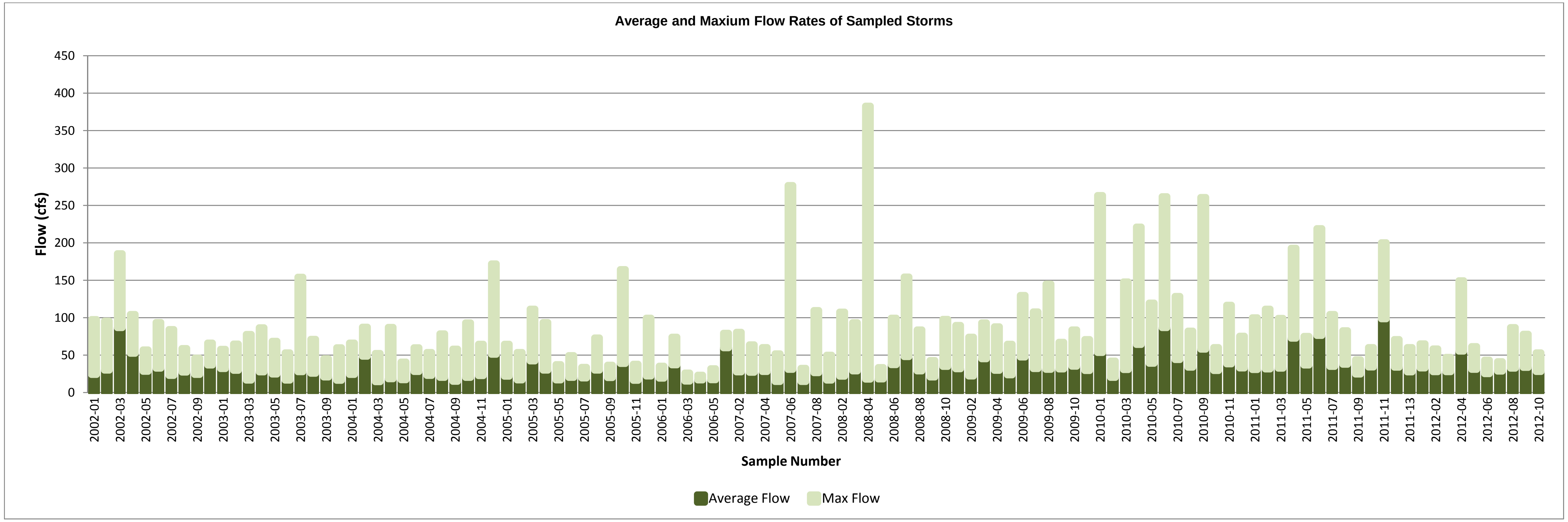


Figure 3-5c - Flow Data 237A.xls

Note: Data is from the old sampling site 237A through end of WY2011. Data from WY2012 onward is from 237A New site.

Figure 3-5d
Sampled Storm Flows and Volumes - OF237B



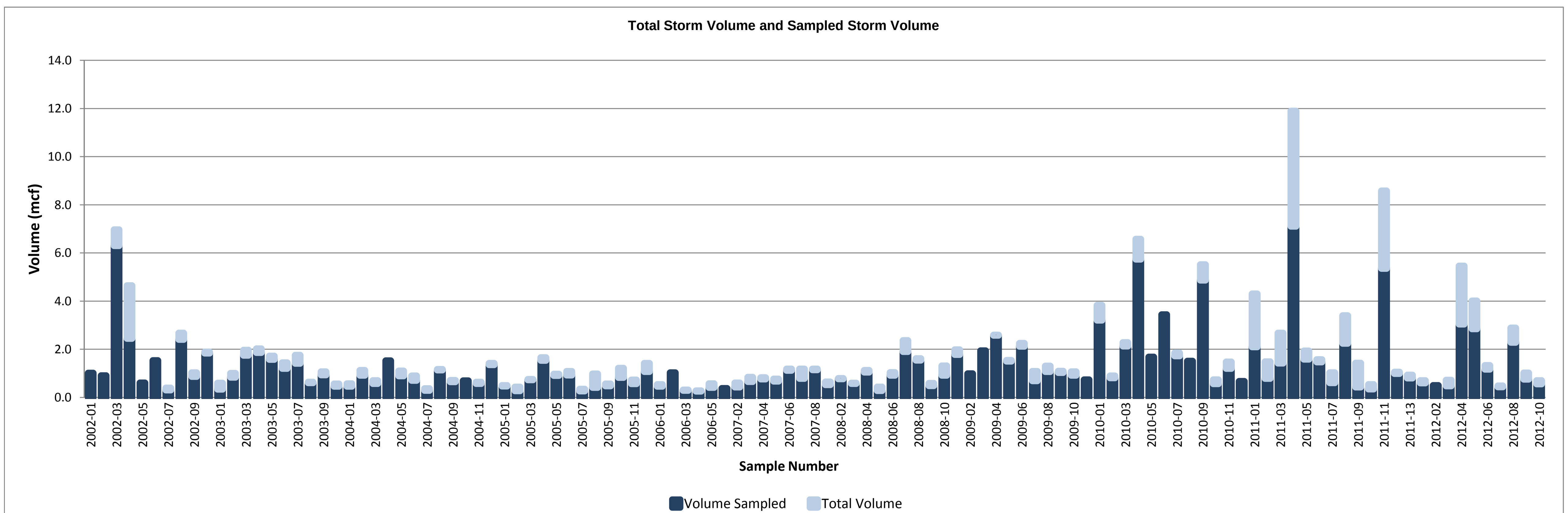
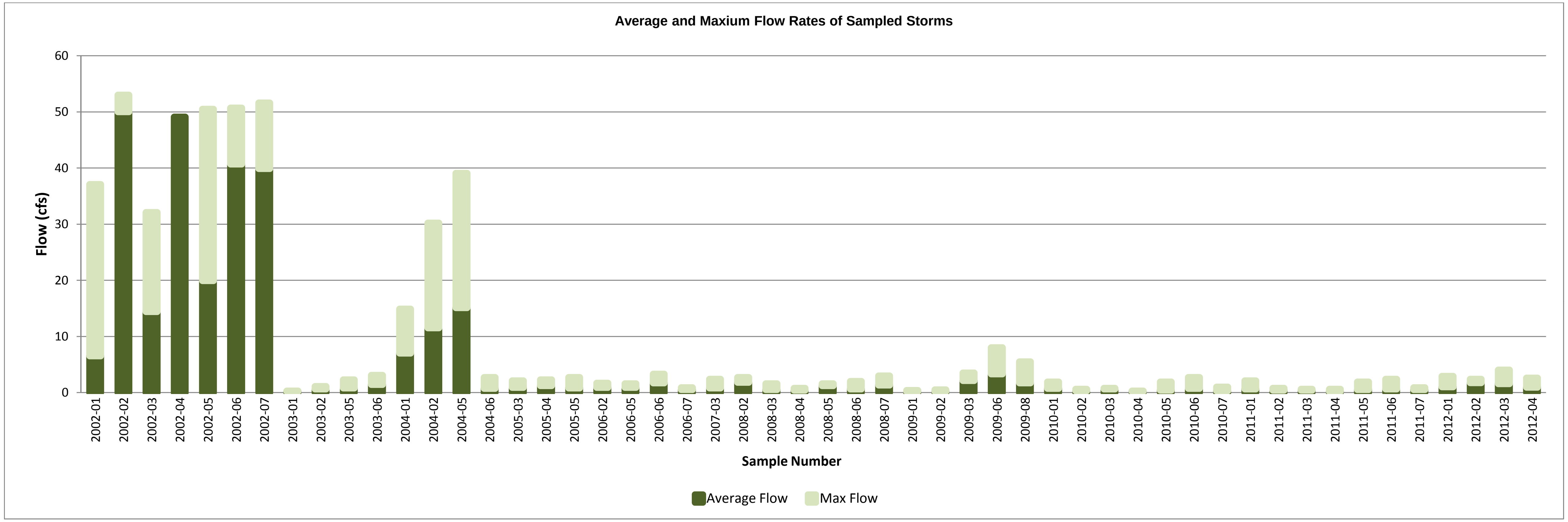


Figure 3-5d - Flow Data 237B.xls

Figure 3-5e
Sampled Storm Flows and Volumes - OF243



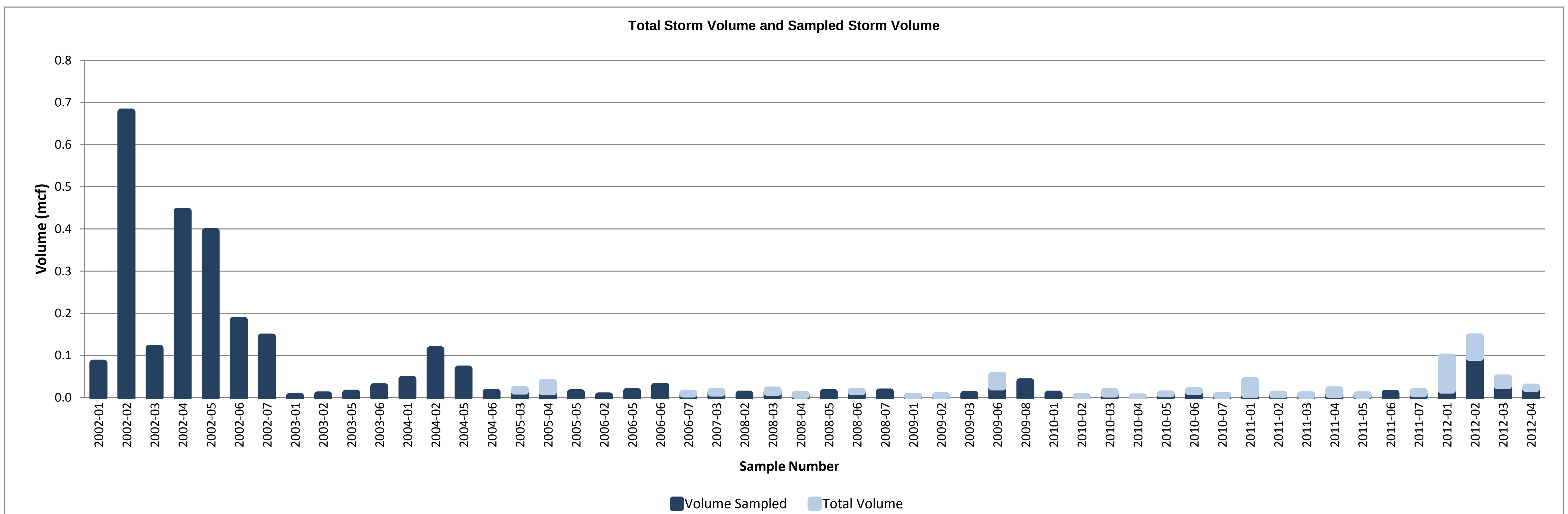
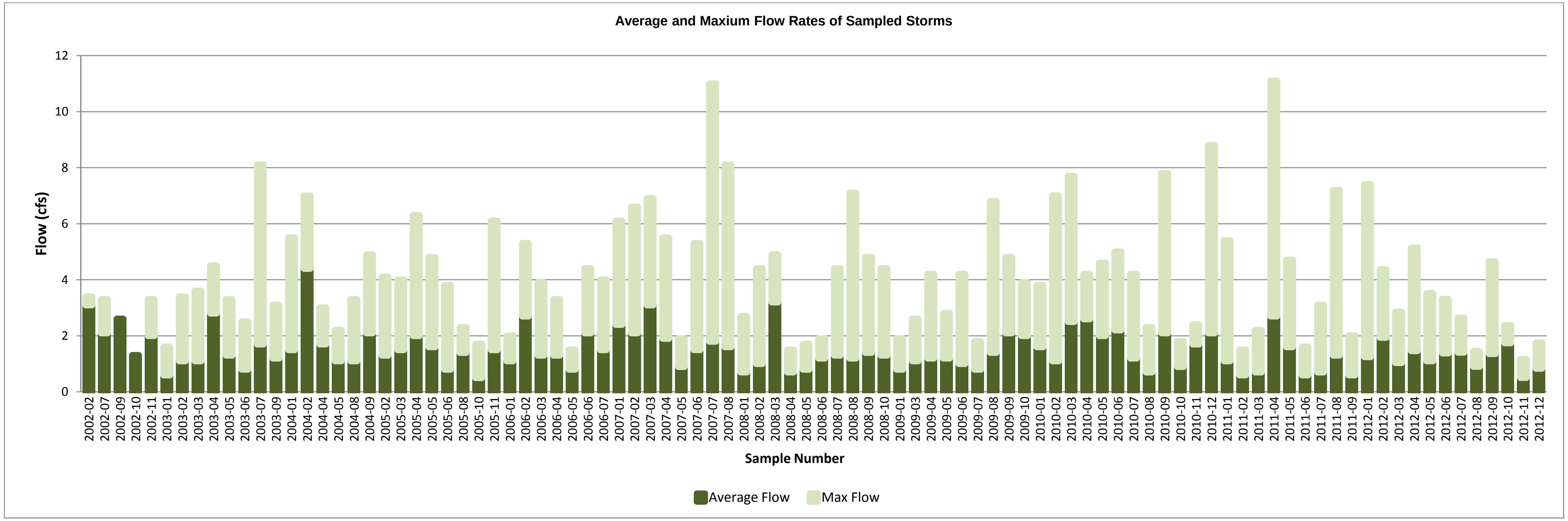


Figure 3-5f
Sampled Storm Flows and Volumes - OF245



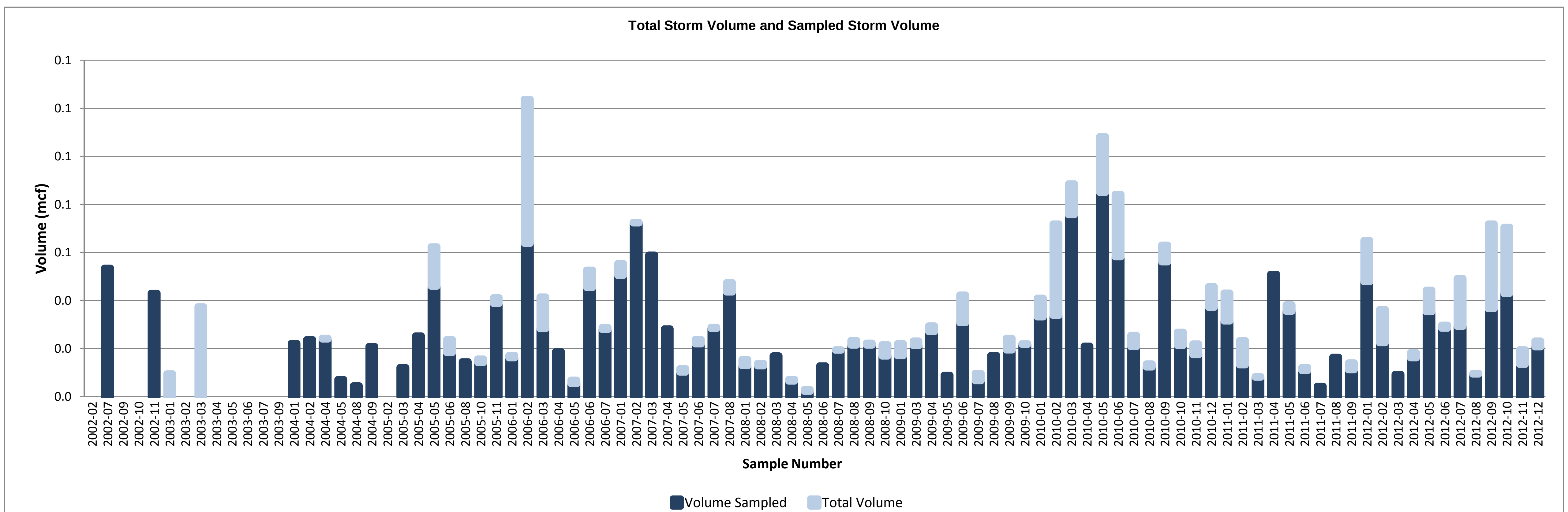
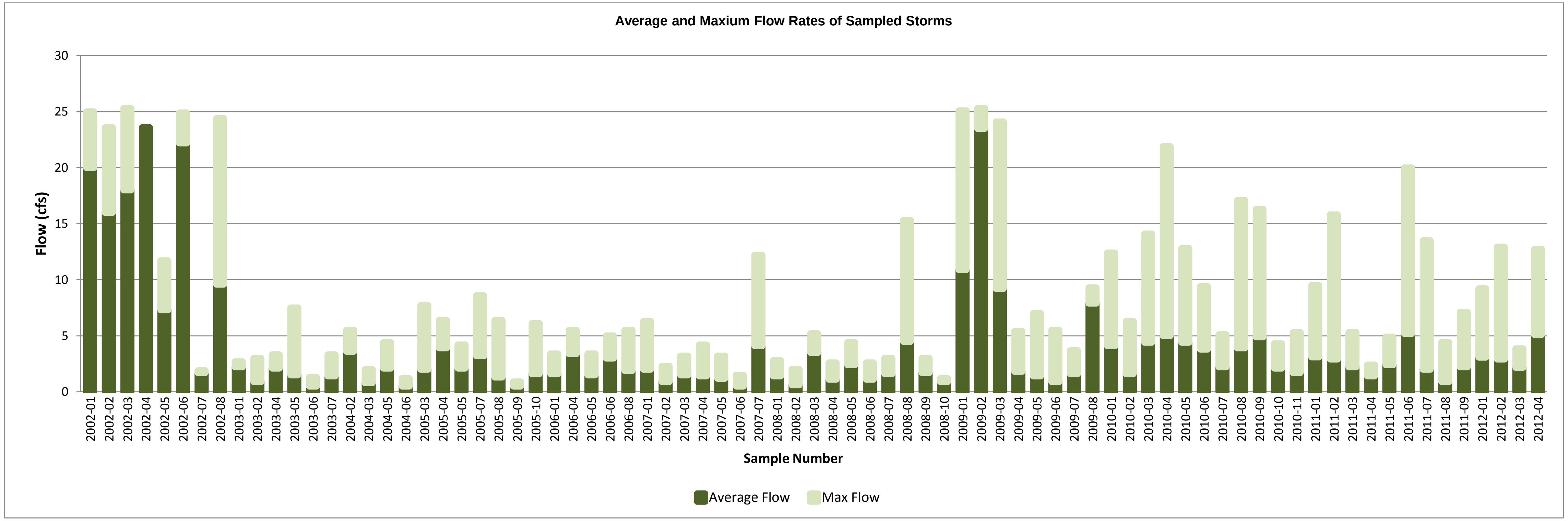


Figure 3-5f - Flow Data 245.xls

Figure 3-5g
Sampled Storm Flows and Volumes - OF254



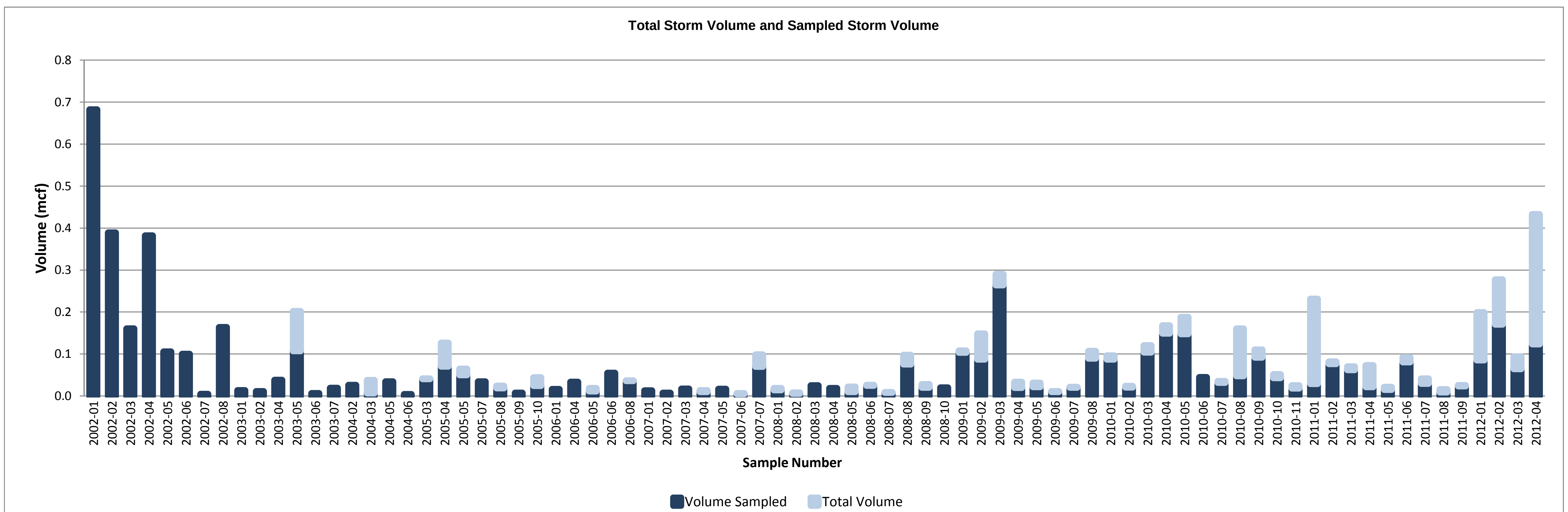
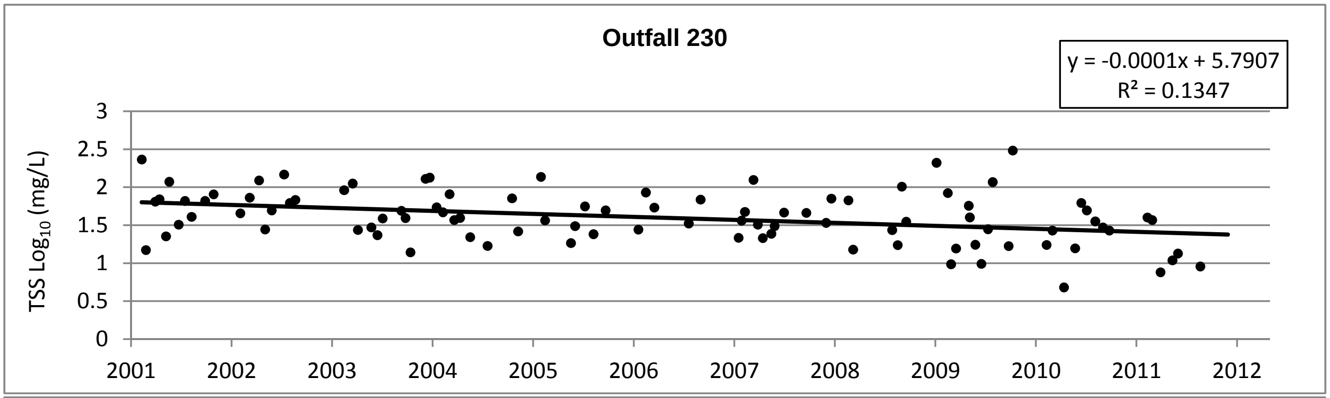
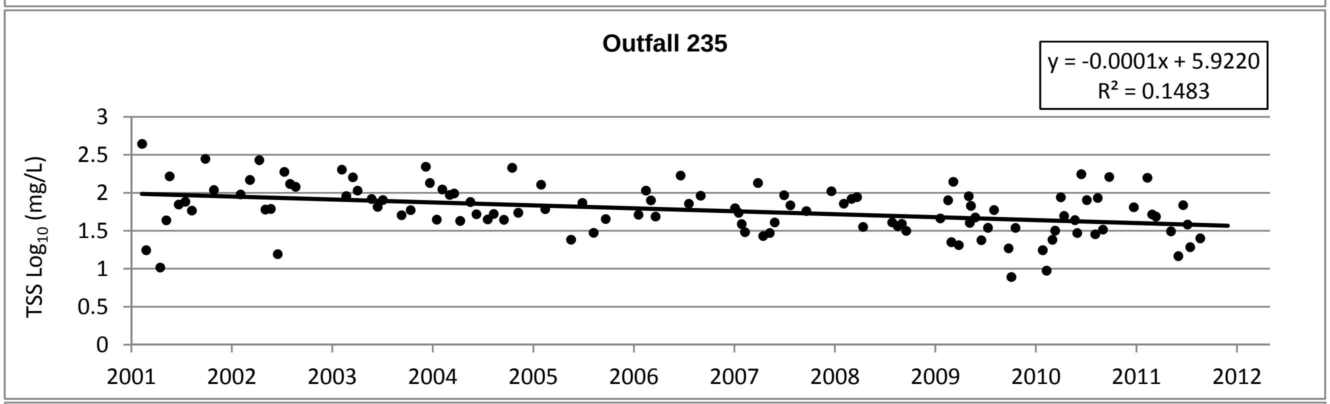
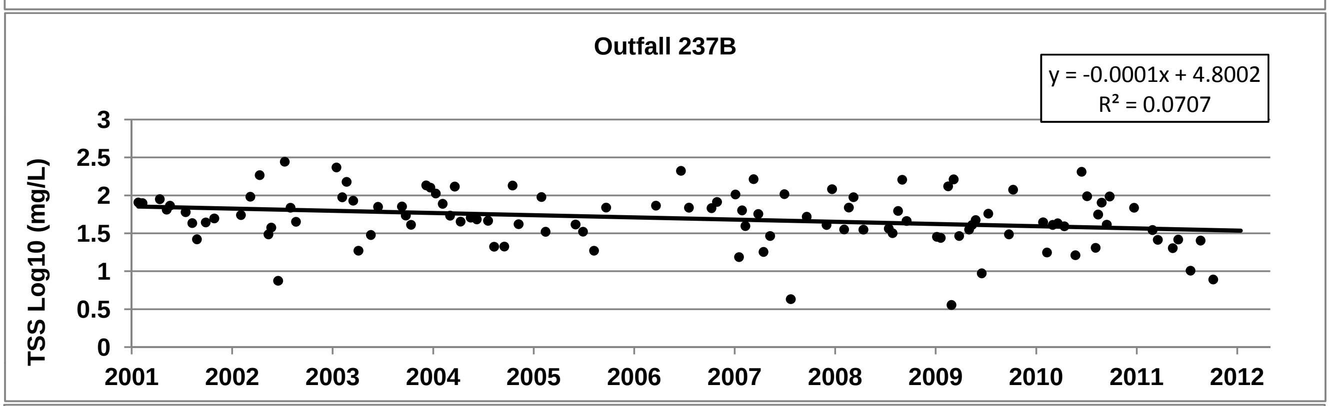


Figure 3-6a
Linear Regression Analysis of Stormwater Time Trends
Time Series for Total Suspended Solids (TSS)
September 2001 - September 2012







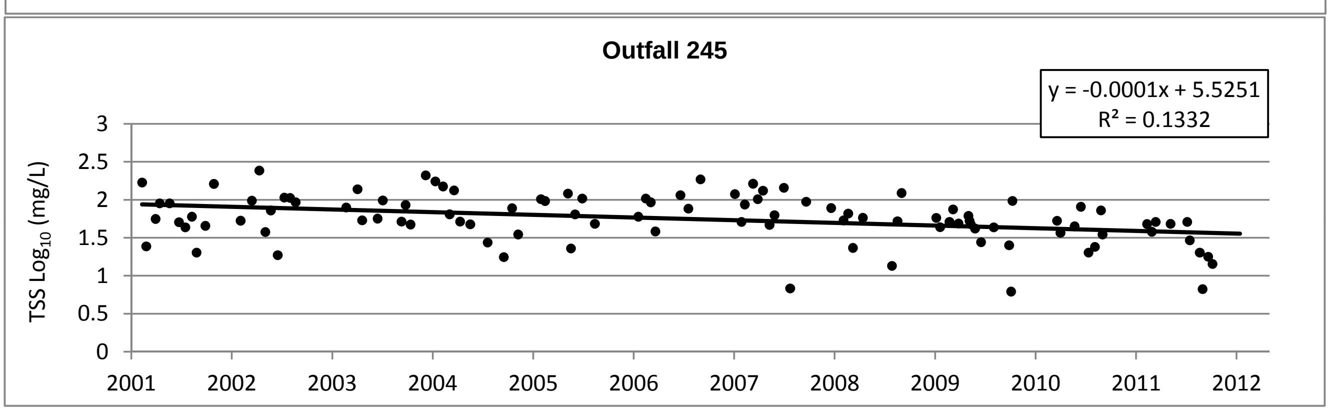
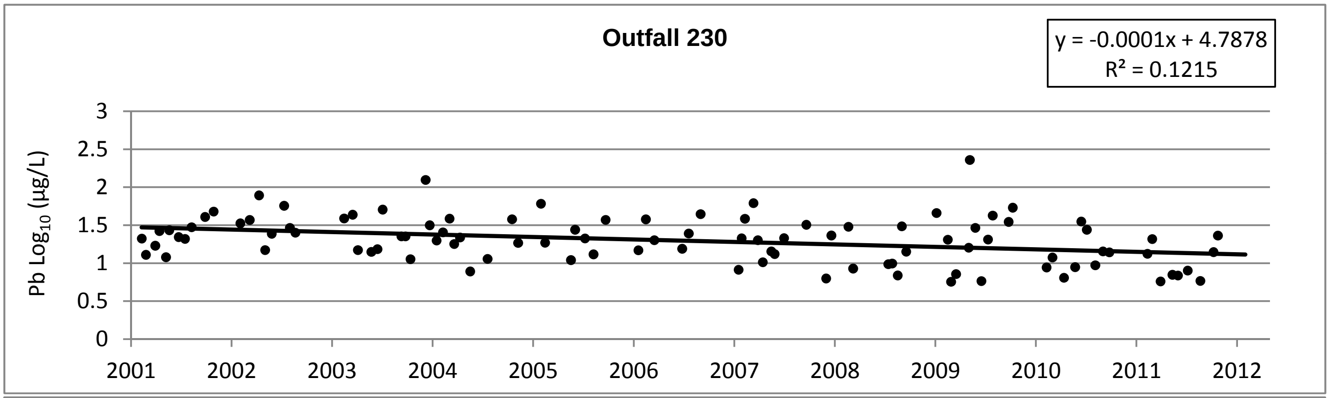
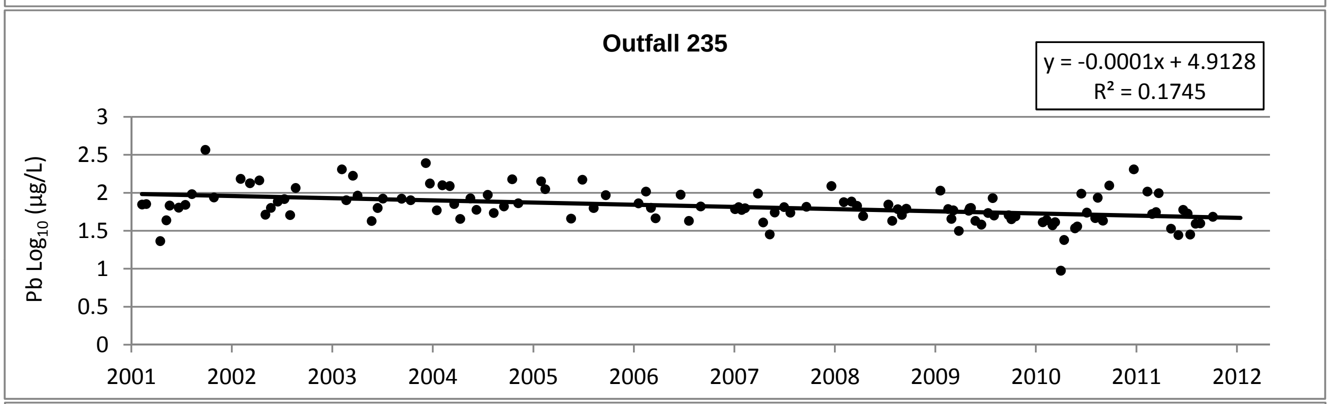
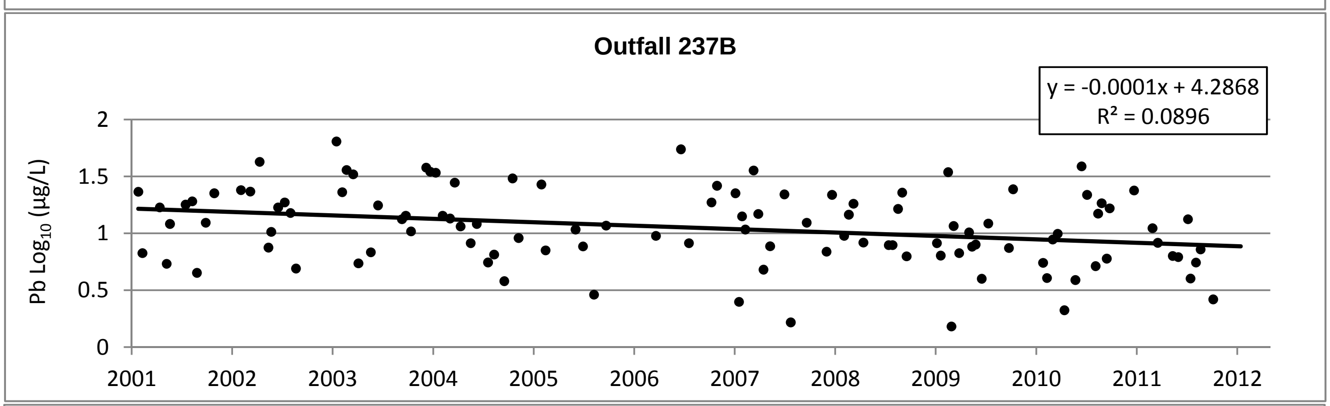


Figure 3-6b
Linear Regression Analysis of Stormwater Time Trends
Time Series for Total Lead
September 2001 - September 2012







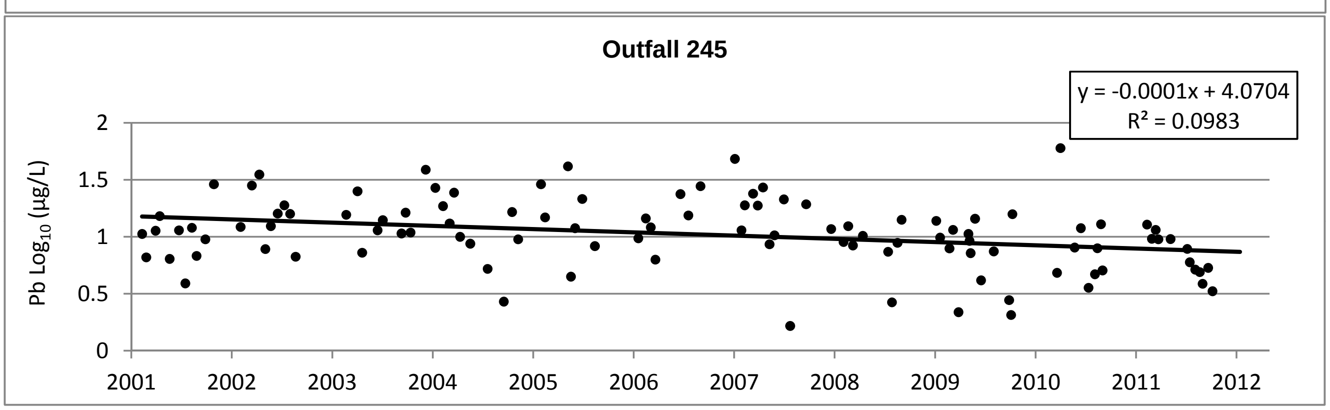
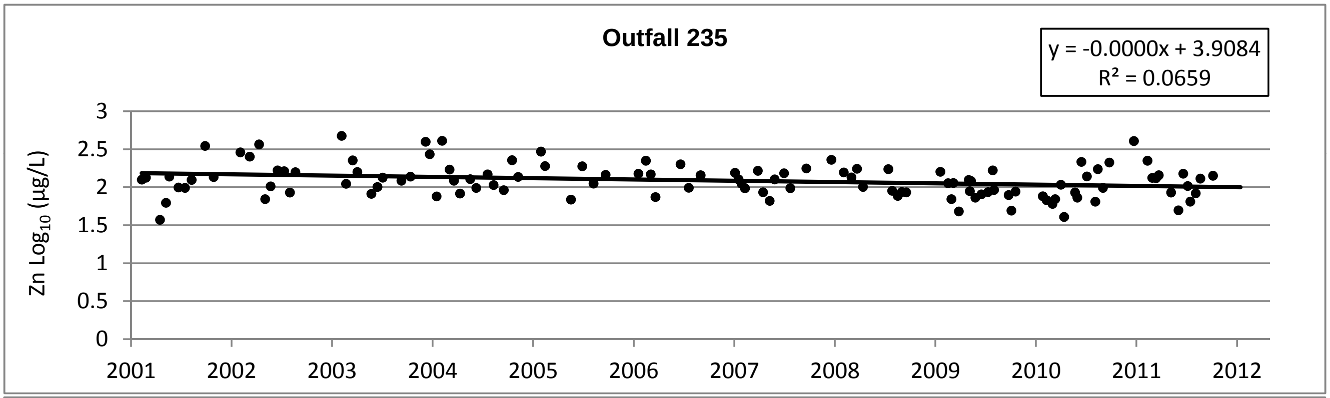
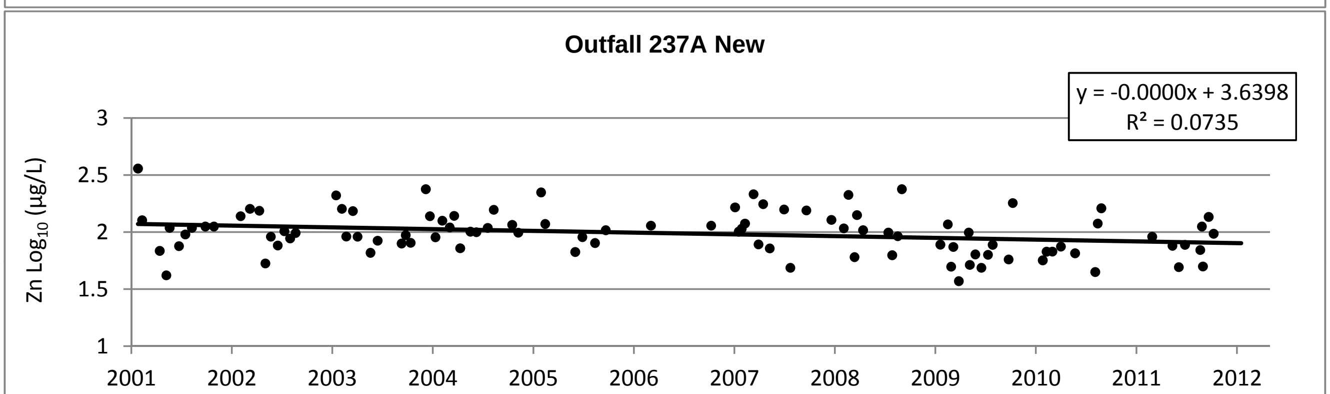
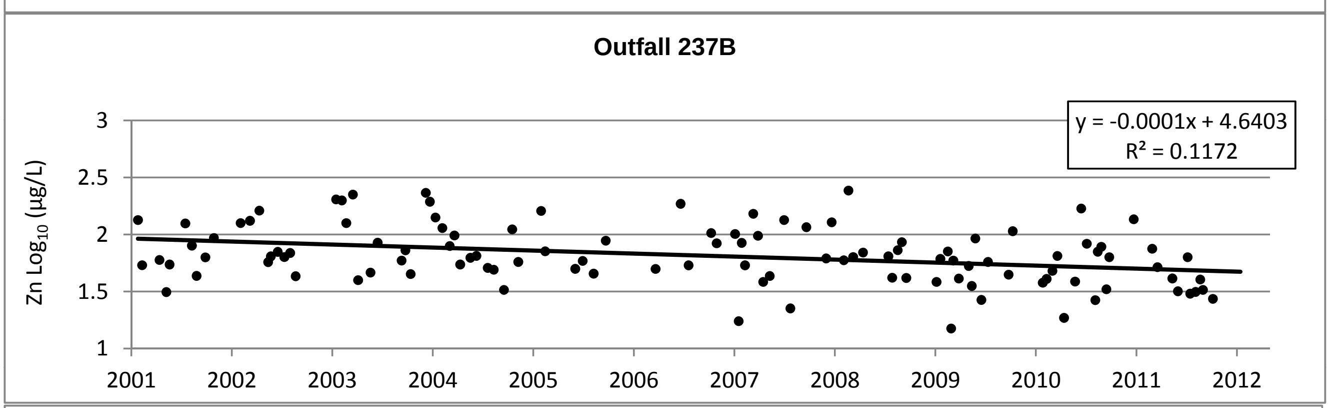


Figure 3-6c
Linear Regression Analysis of Stormwater Time Trends
Time Series for Total Zinc
September 2001 - September 2012







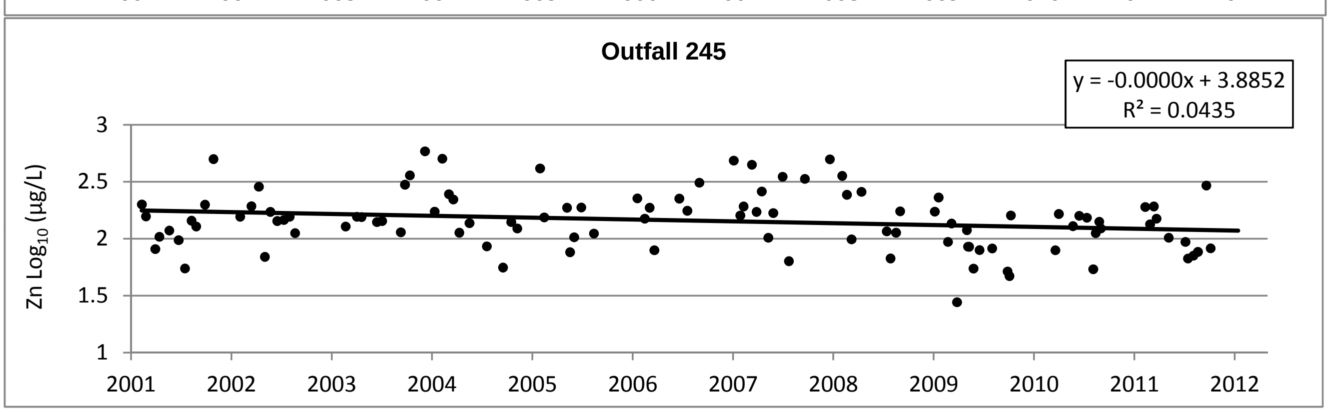


Figure 3-6d
Linear Regression Analysis of Stormwater Time Trends
Time Series for Total Zinc
September 2001 - September 2012

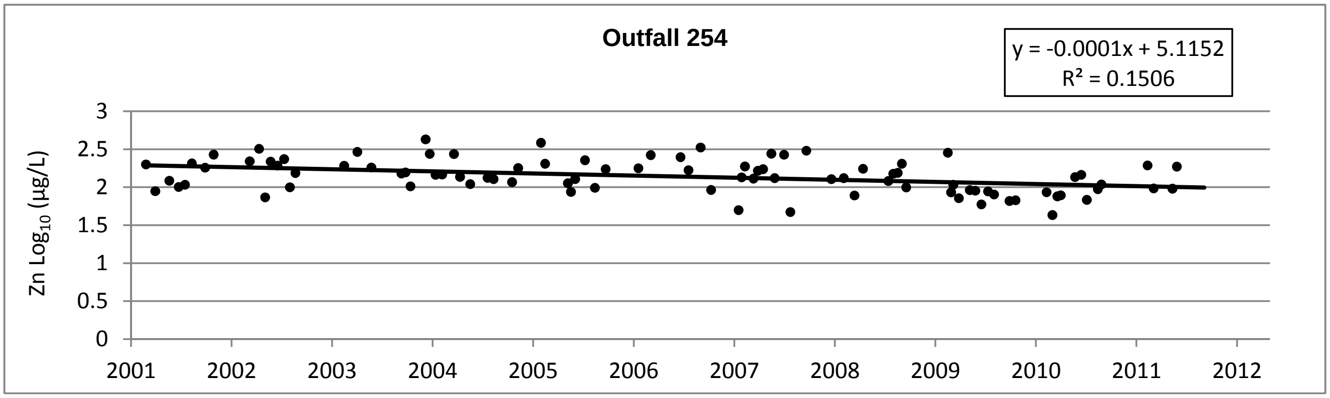


Figure 3-6e
Linear Regression Analysis of Stormwater Time Trends
Time Series for Phenanthrene
September 2001 - September 2012

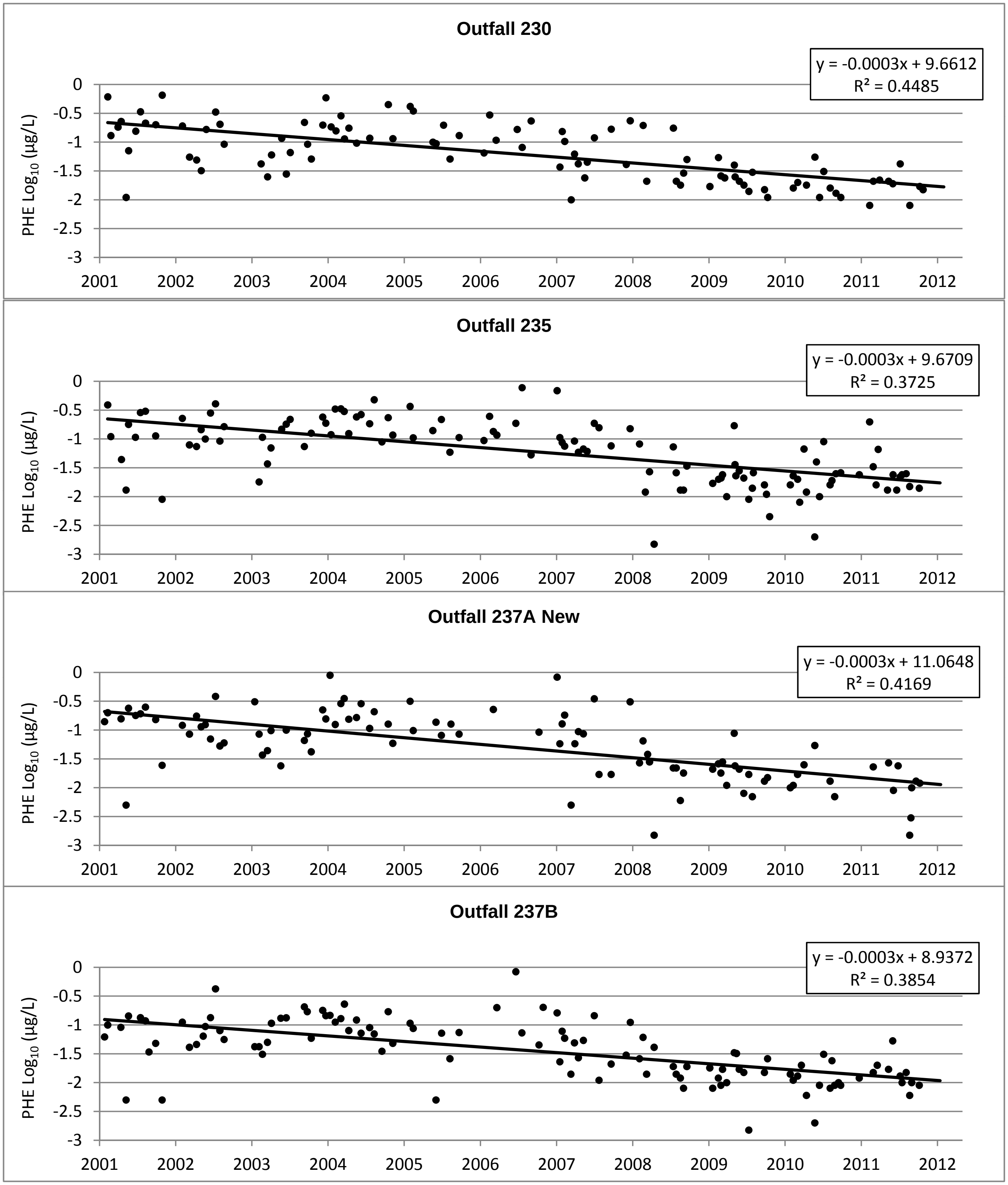


Figure 3-6f
Linear Regression Analysis of Stormwater Time Trends
Time Series for Phenanthrene
September 2001 - September 2012

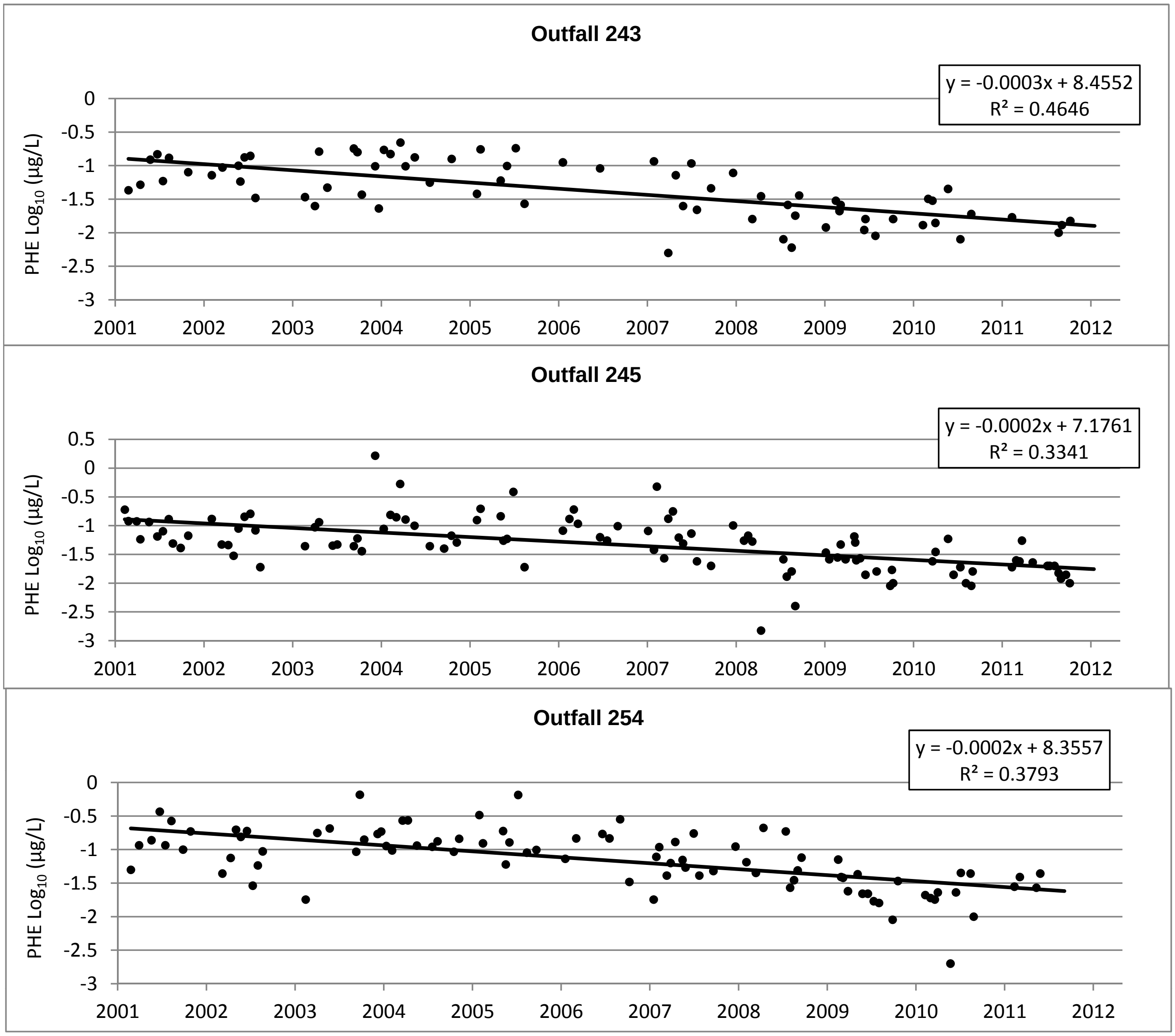


Figure 3-6g
Linear Regression Analysis of Stormwater Time Trends
Time Series for Pyrene
September 2001 - September 2012

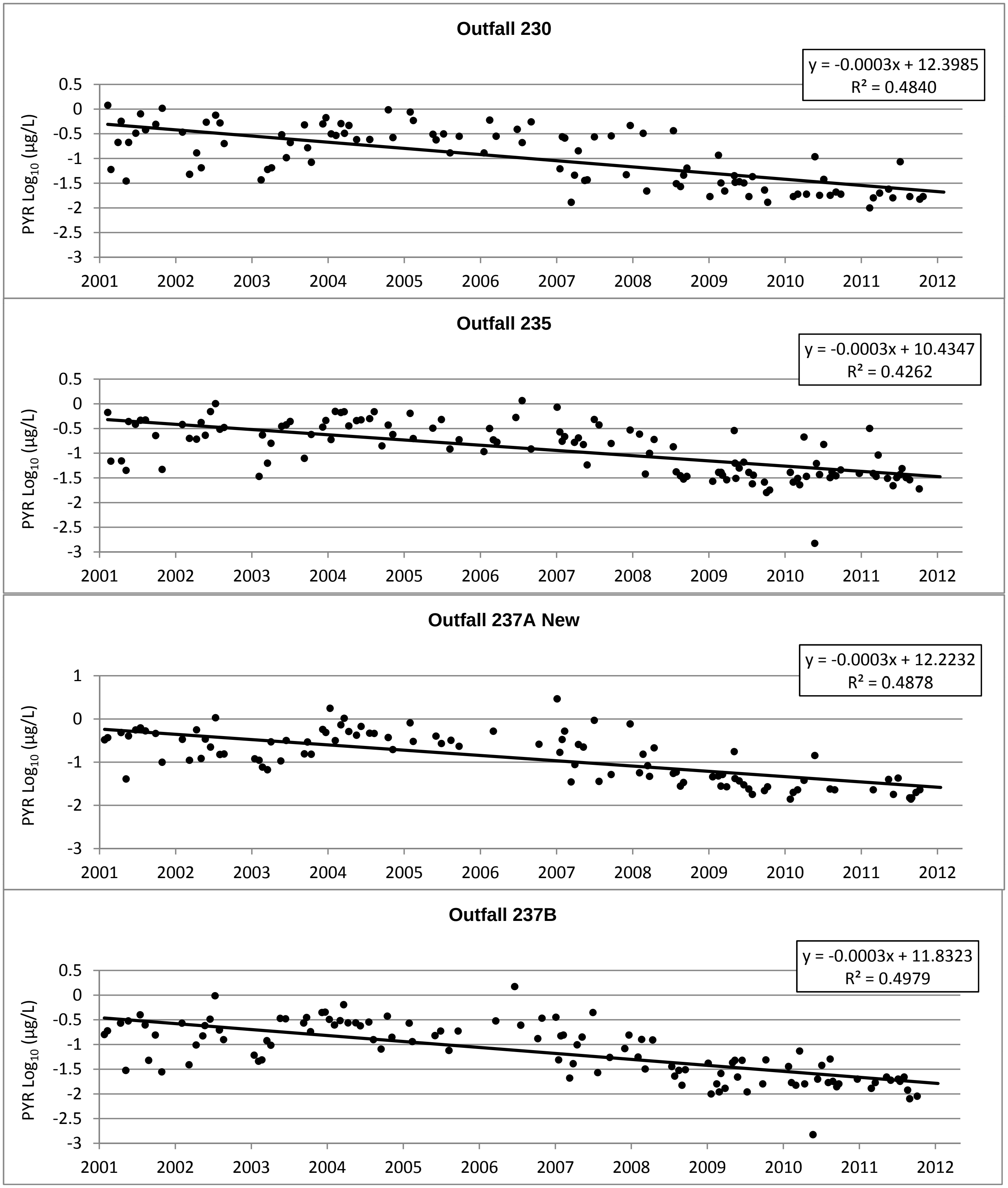


Fig_3-6a_to_3-6l_Linear_Regression_Plots_2012.xlsx

Figure 3-6h
Linear Regression Analysis of Stormwater Time Trends
Time Series for Pyrene
September 2001 - September 2012

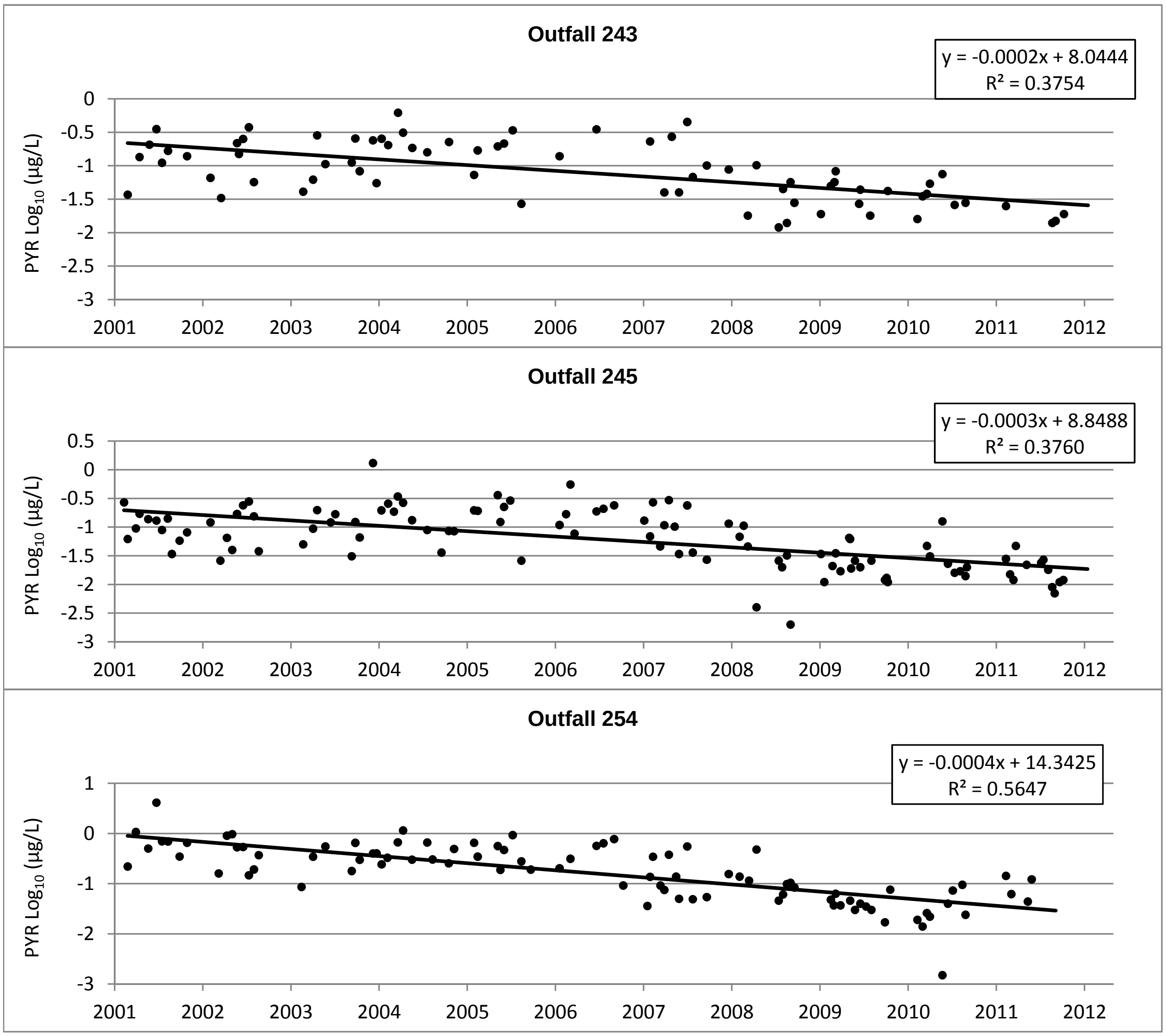


Figure 3-6i
Linear Regression Analysis of Stormwater Time Trends
Time Series for Indeno(1,2,3-c,d)pyrene
September 2001 - September 2012

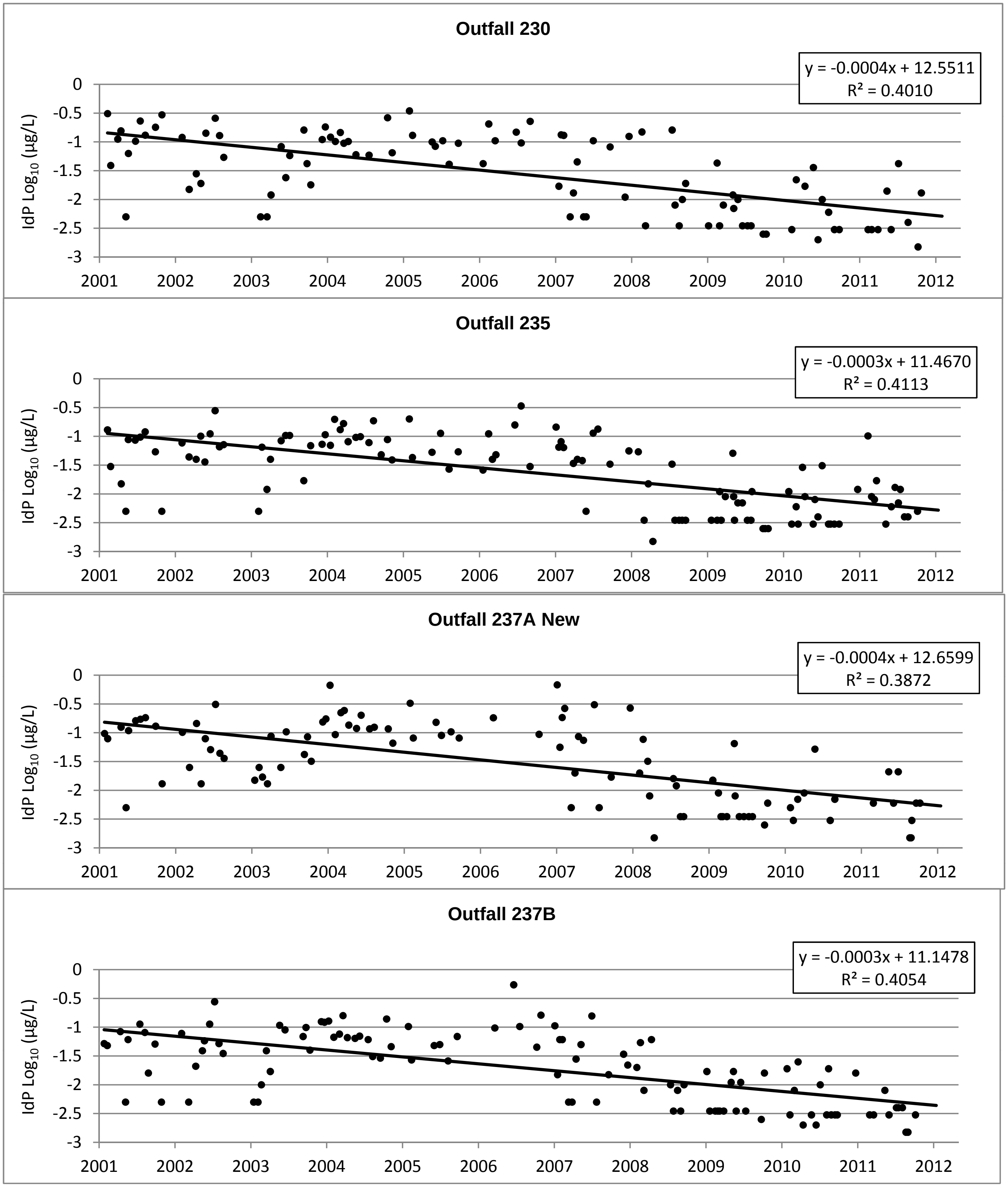
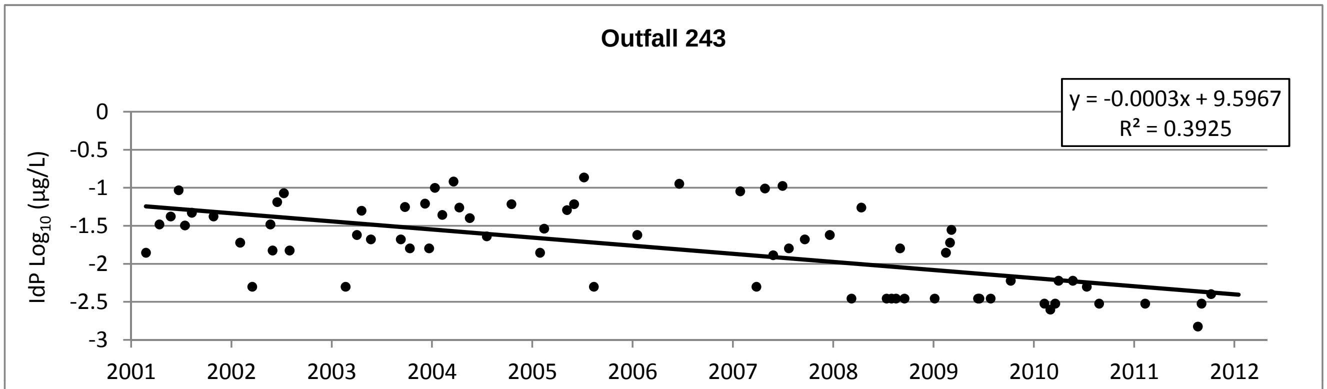
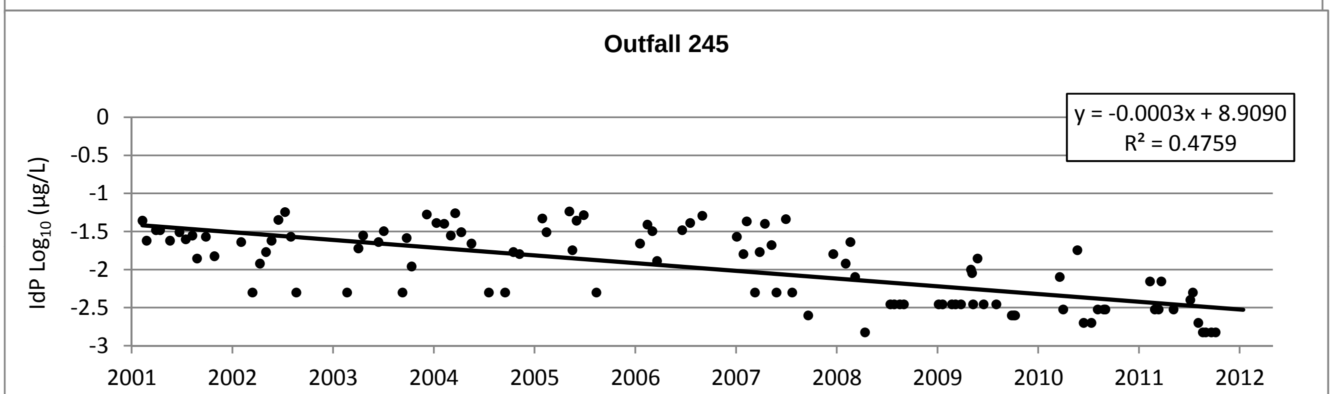


Fig_3-6a_to_3-6l_Linear_Regression_Plots_2012.xlsx

Figure 3-6j
Linear Regression Analysis of Stormwater Time Trends
Time Series for Indeno(1,2,3-c,d)pyrene
September 2001 - September 2012





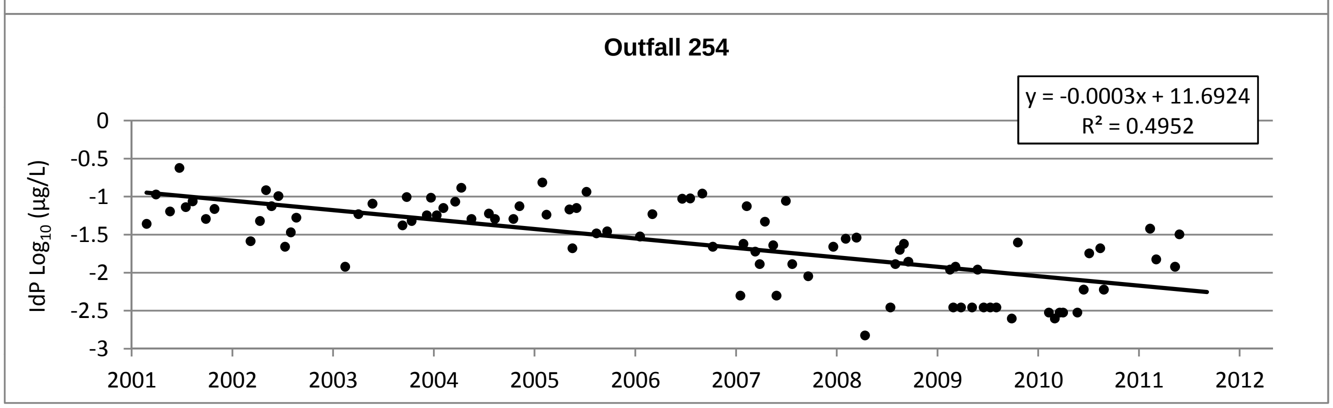
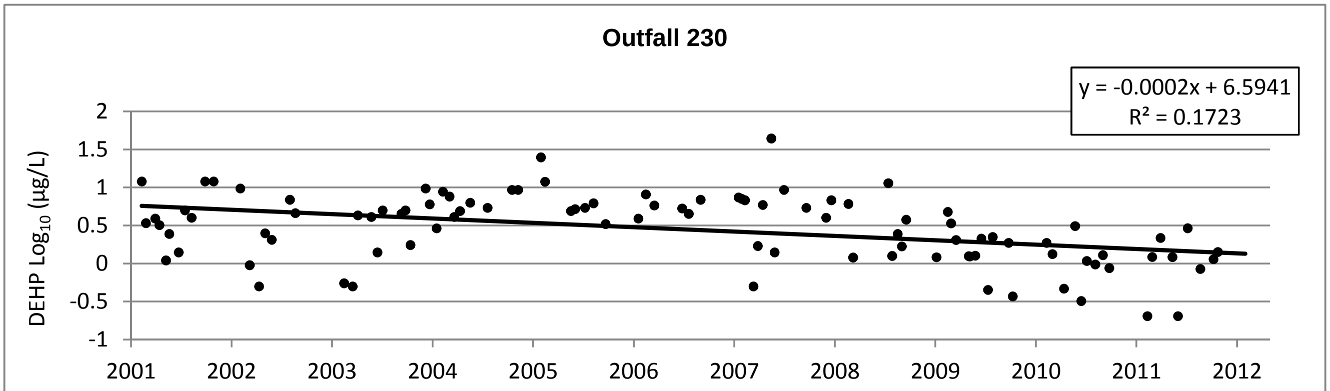
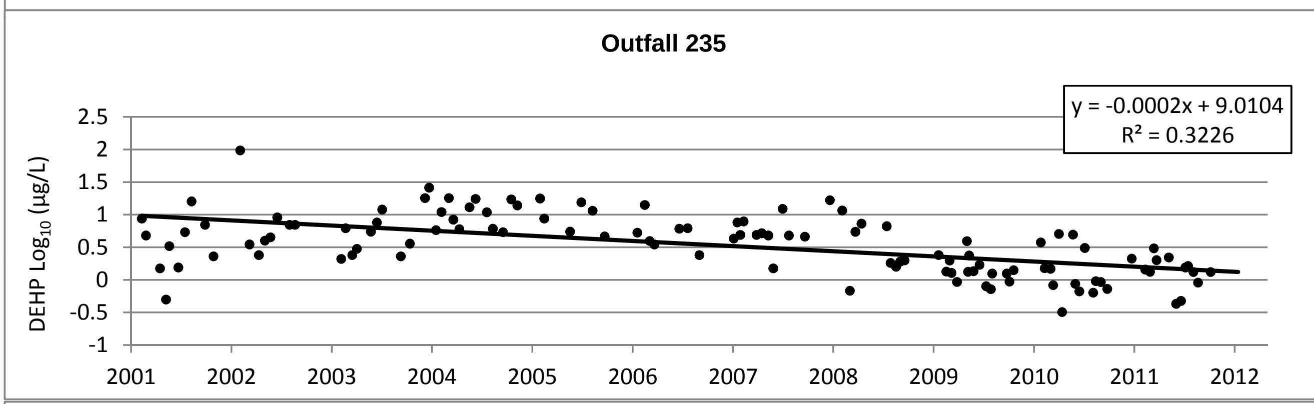
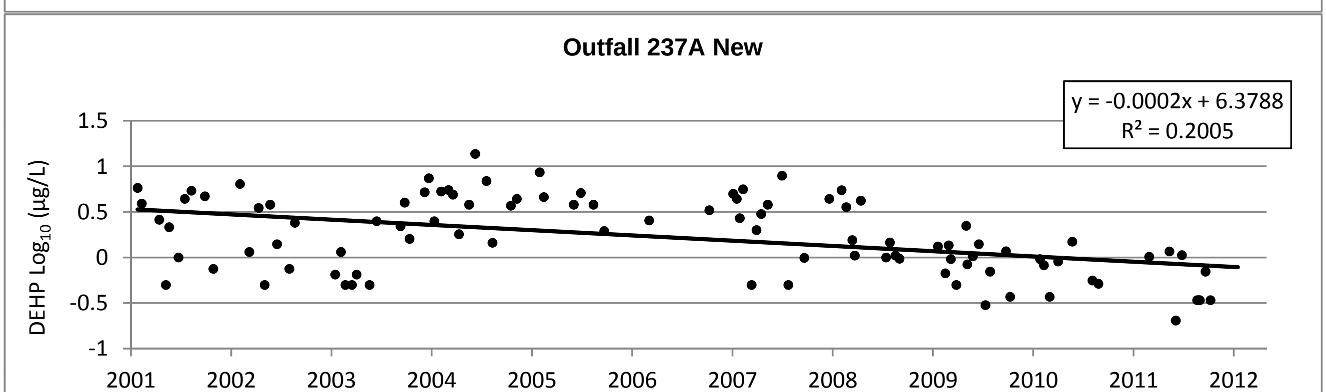


Figure 3-6k
Linear Regression Analysis of Stormwater Time Trends
Time Series for Bis(2-ethylhexyl)phthalate (DEHP)
September 2001 - September 2012







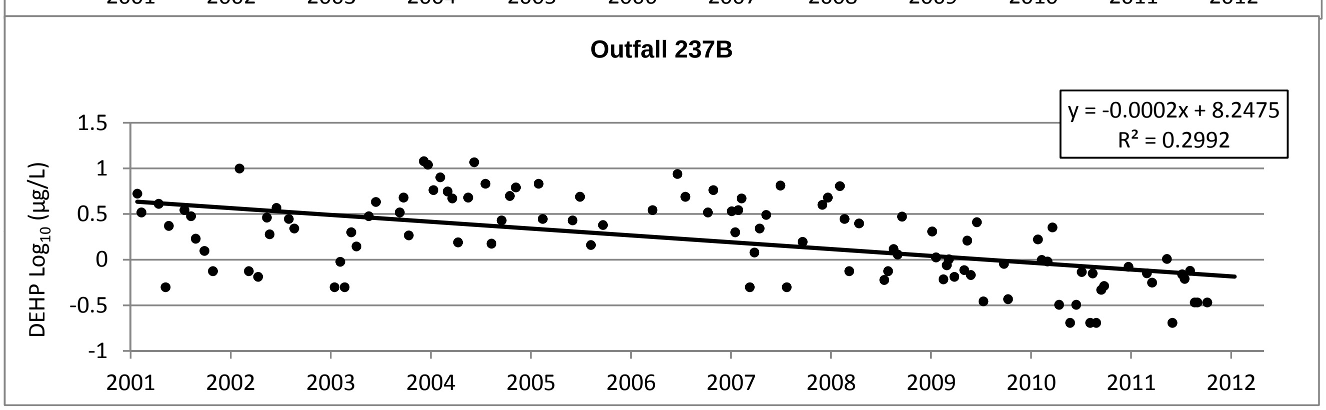
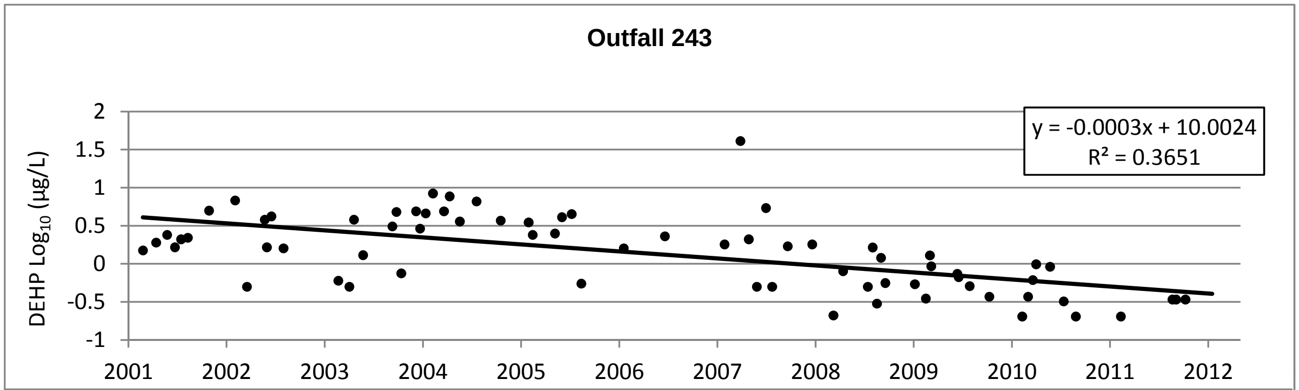
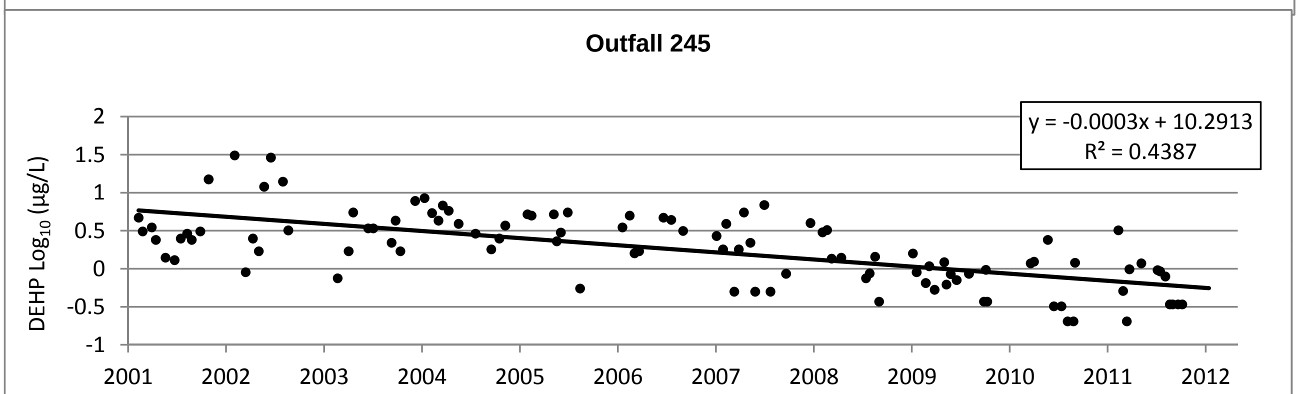


Figure 3-6l
Linear Regression Analysis of Stormwater Time Trends
Time Series for Bis(2-ethylhexyl)phthalate (DEHP)
September 2001 - September 2012





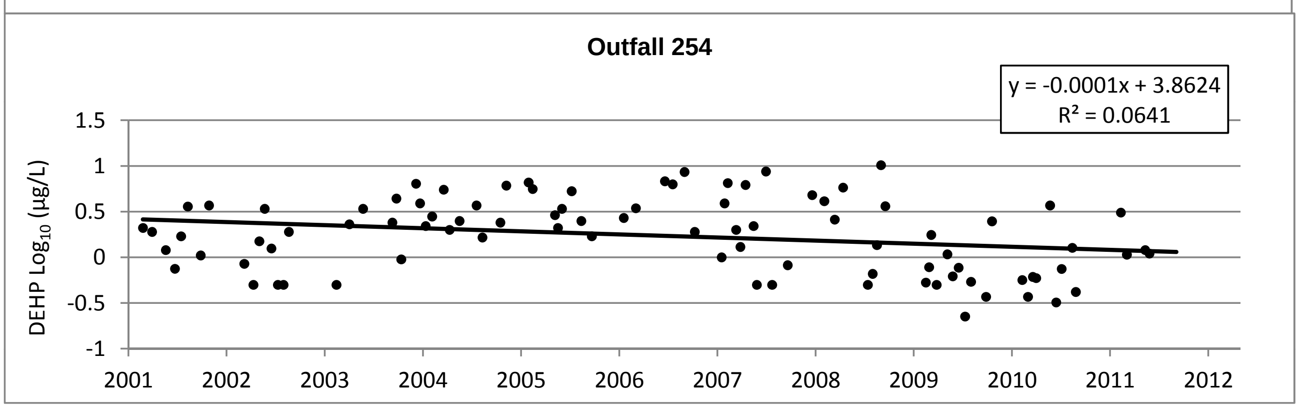
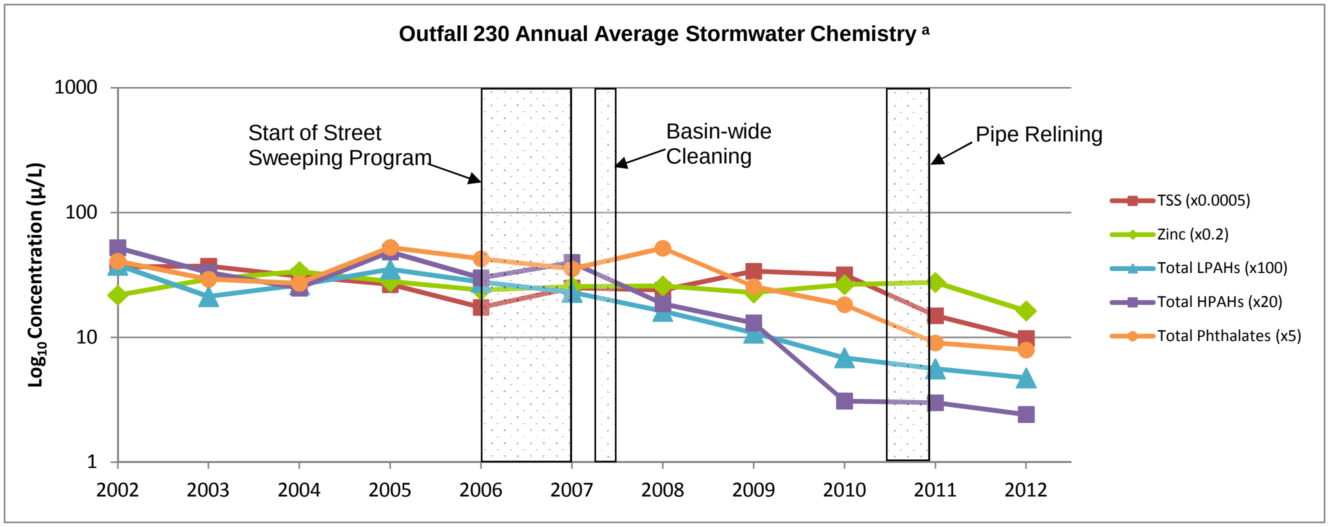
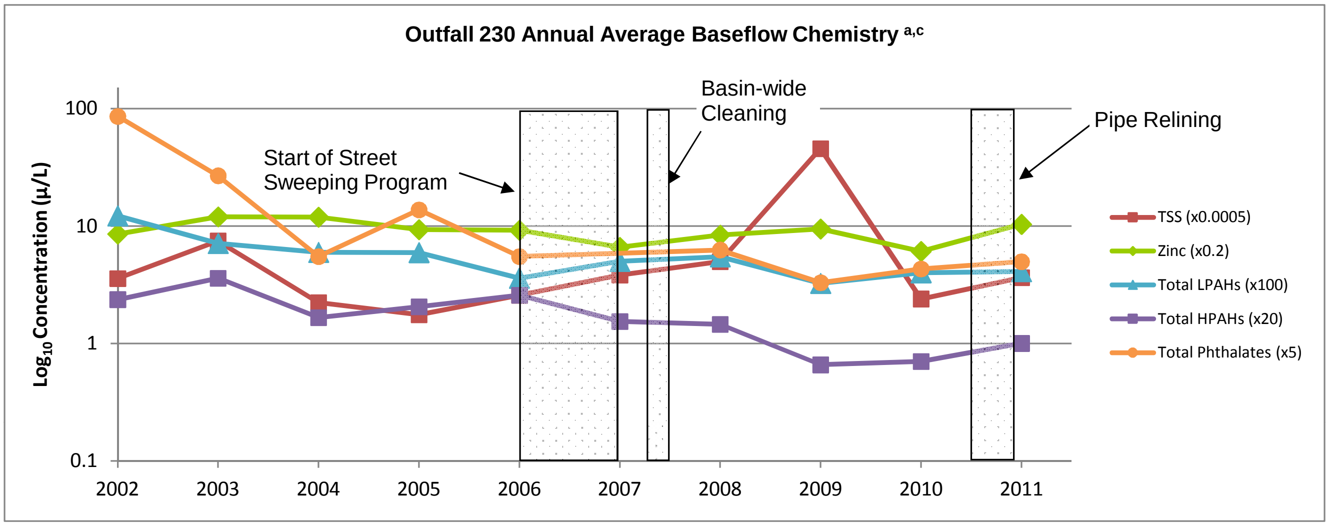
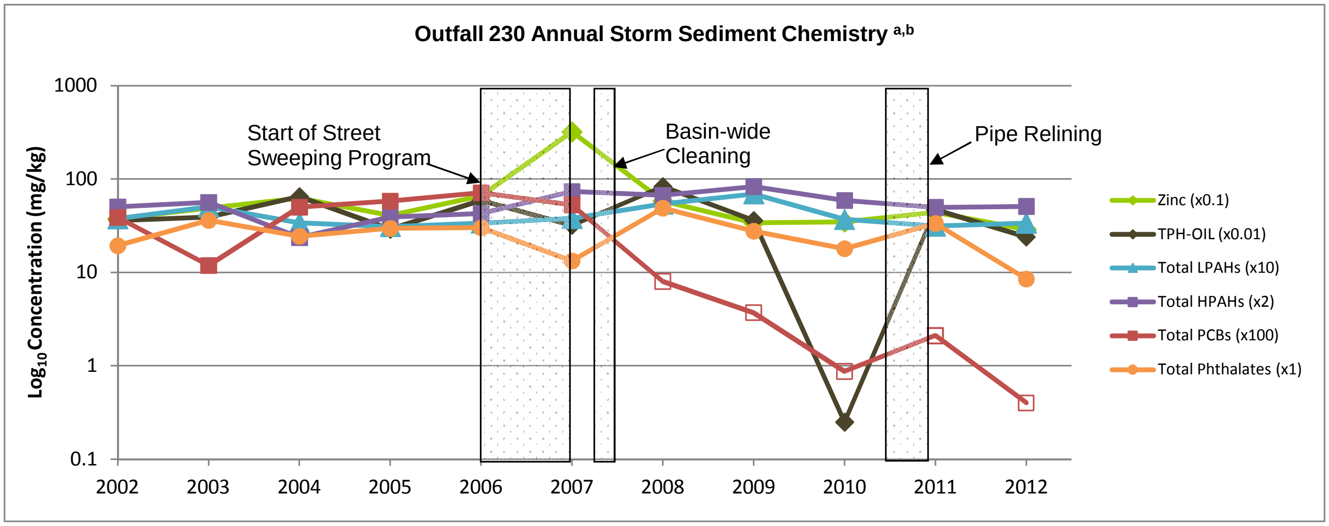


Figure 5-1a
Analysis of Monitoring Trends in Stormwater, Baseflow, and Storm Sediment
OF230







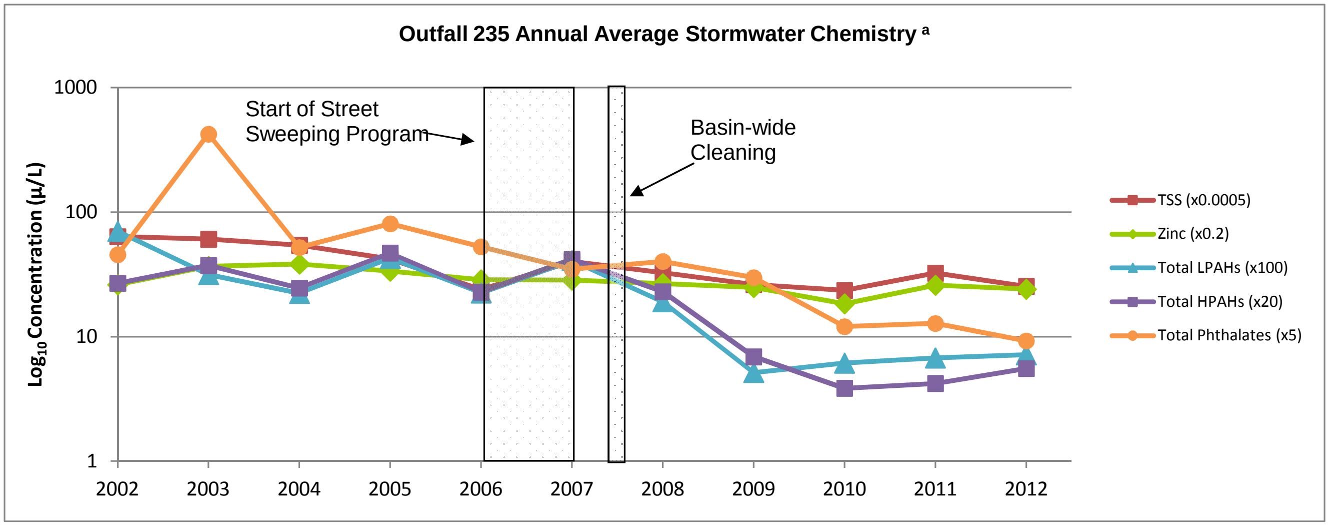
Notes:

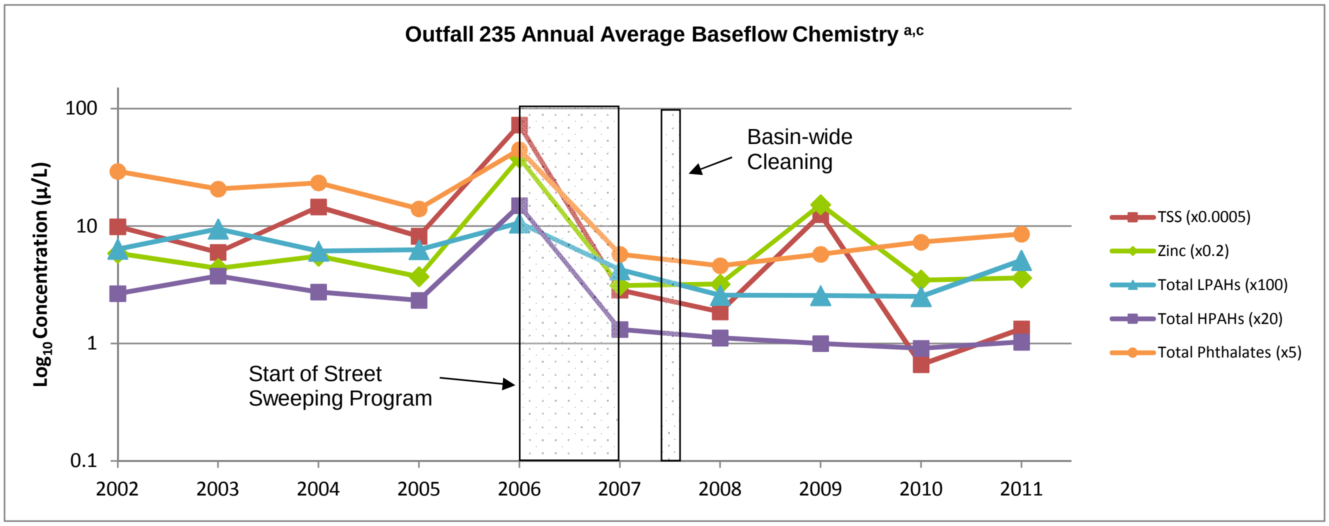
[a] Results shown are a product of chemistry data and an analyte-specific multiplier in order to display results on a common scale

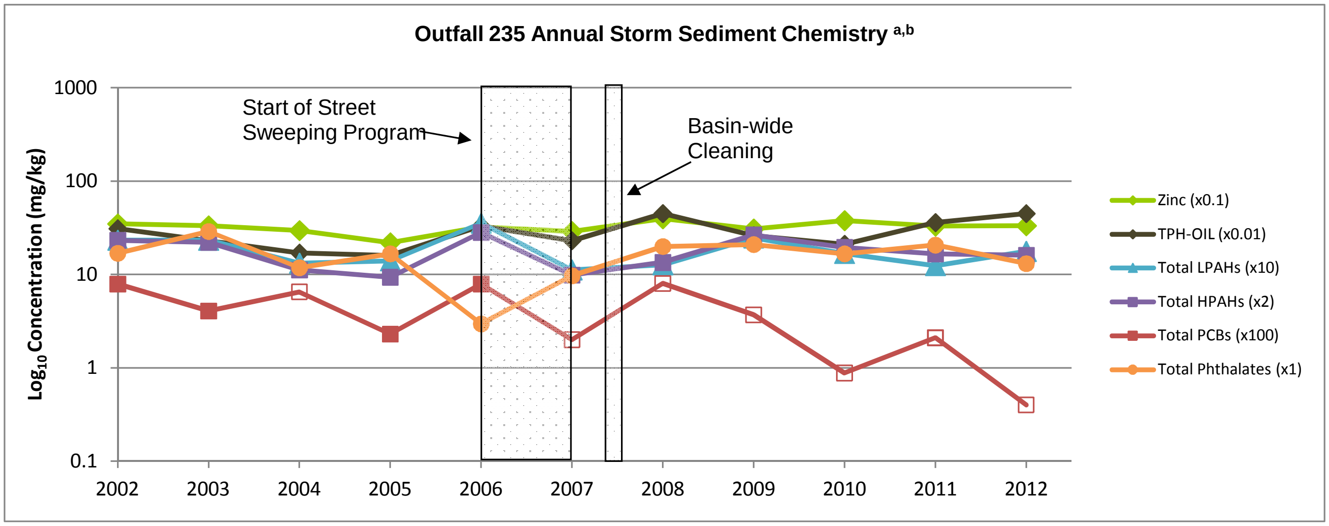
[b] Open symbols denote censored data; highest detection limit posted as value

[c] Baseflow sampling was discontinued after WY2011.

Figure 5-1b
Analysis of Monitoring Trends in Stormwater, Baseflow, and Storm Sediment
OF235







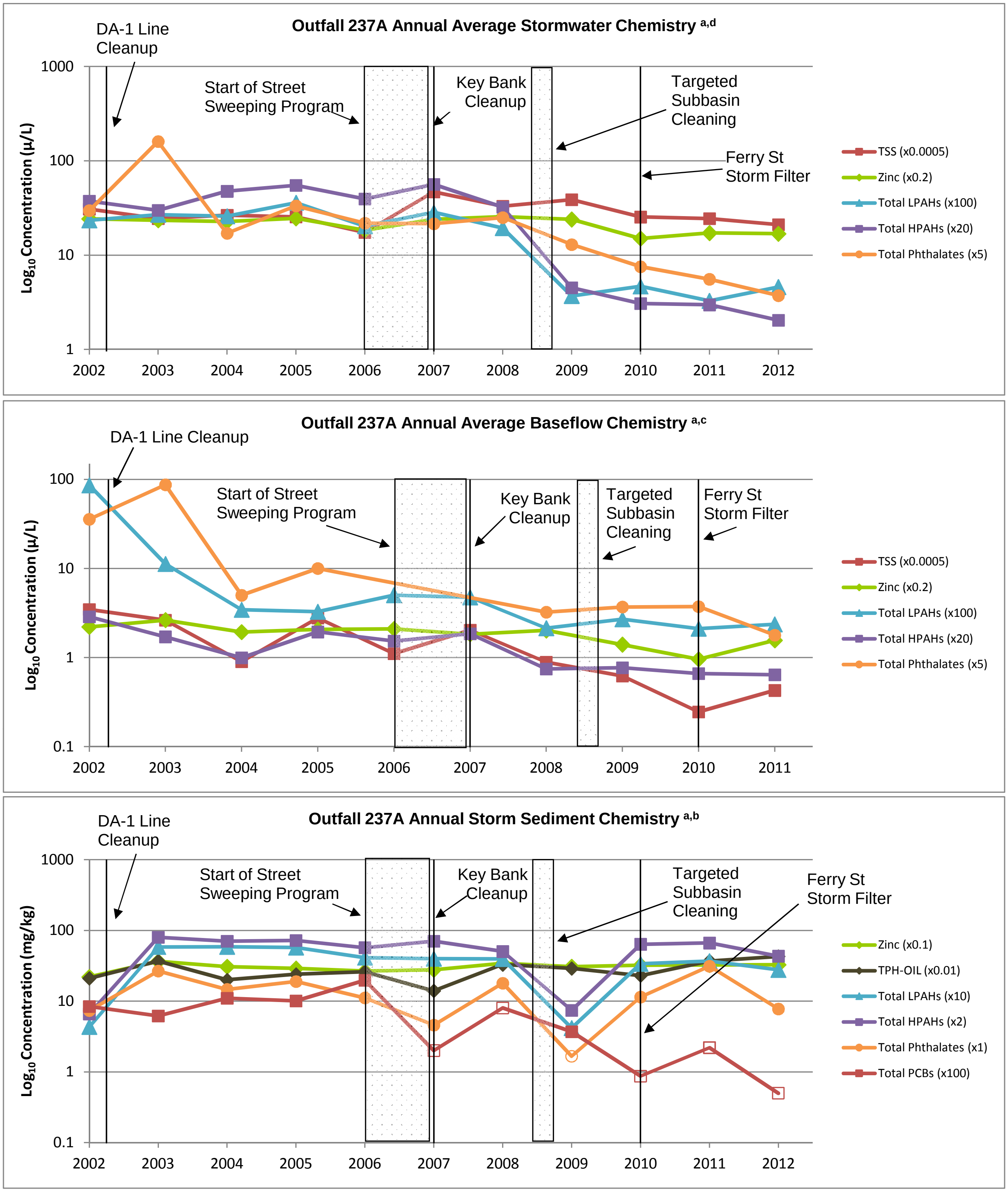
Notes:

[a] Results shown are a product of chemistry data and an analyte-specific multiplier in order to display results on a common scale

[b] Open symbols denote censored data; highest detection limit posted as value

[c] Baseflow sampling was discontinued after WY2011.

Figure 5-1c
Analysis of Monitoring Trends in Stormwater, Baseflow, and Storm Sediment
OF237A



Notes:

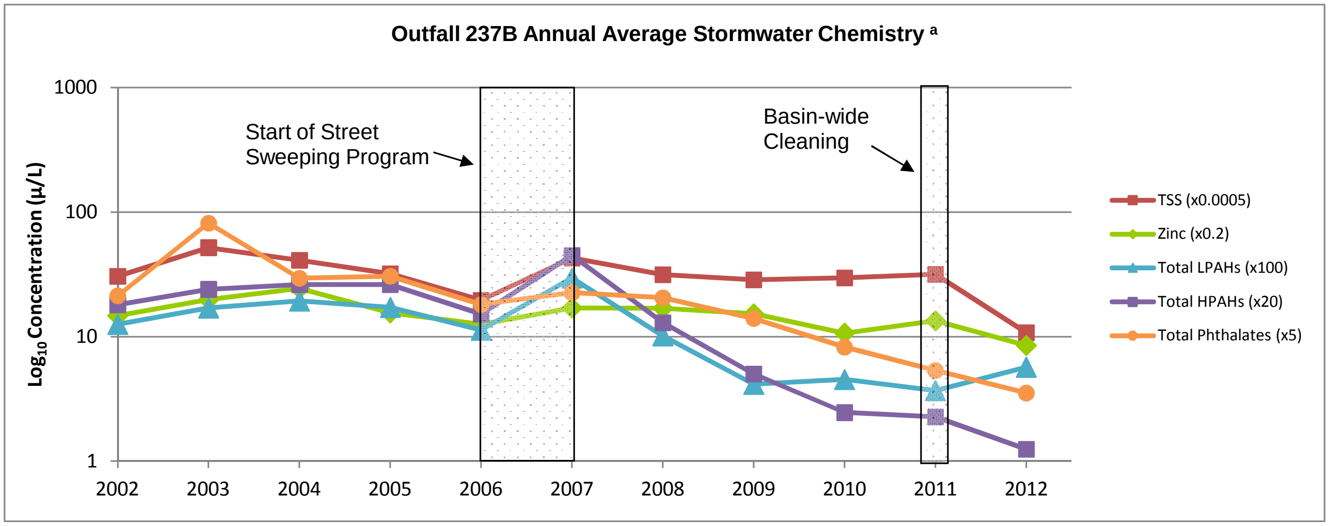
[a] Results shown are a product of chemistry data and an analyte-specific multiplier in order to display results on a common scale

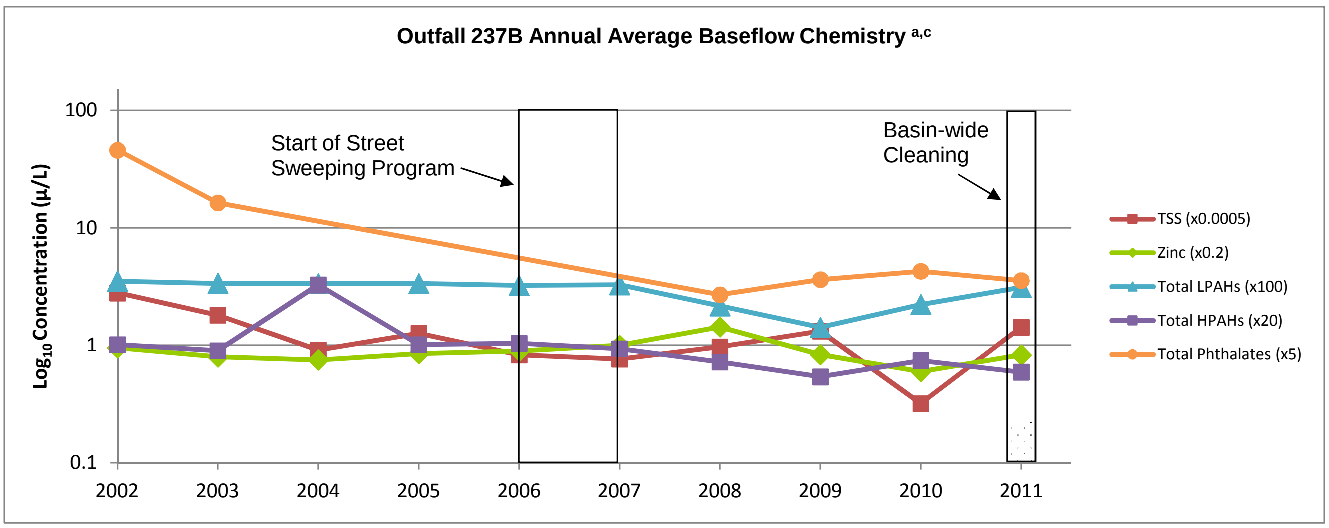
[b] Open symbols denote censored data; highest detection limit posted as value

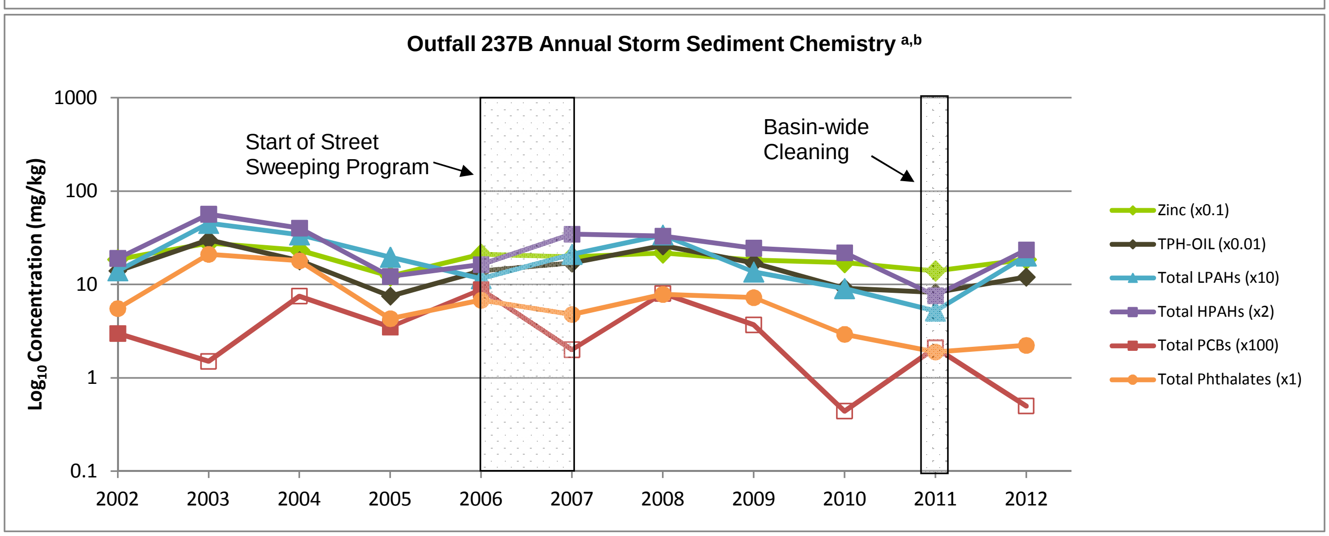
[c] Baseflow sampling was discontinued after WY2011.

[d] 237A data Includes data from the old 237A site for events prior collected prior to 2/26/06. Events after 2/26/06 were from the 237A New site.

Figure 5-1d
Analysis of Monitoring Trends in Stormwater, Baseflow, and Storm Sediment
OF237B

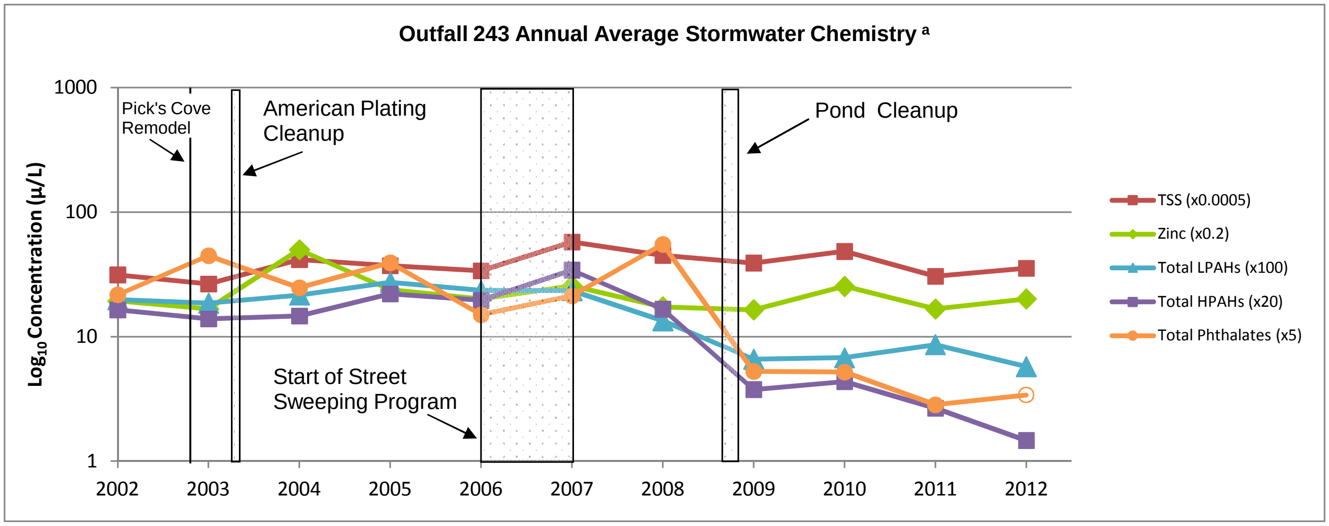


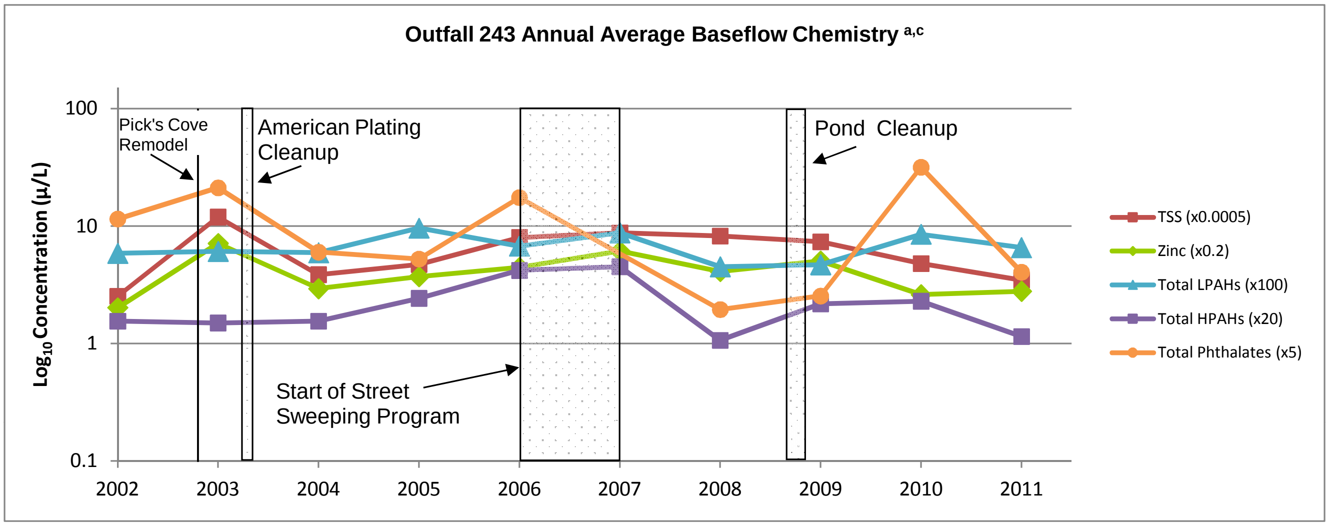


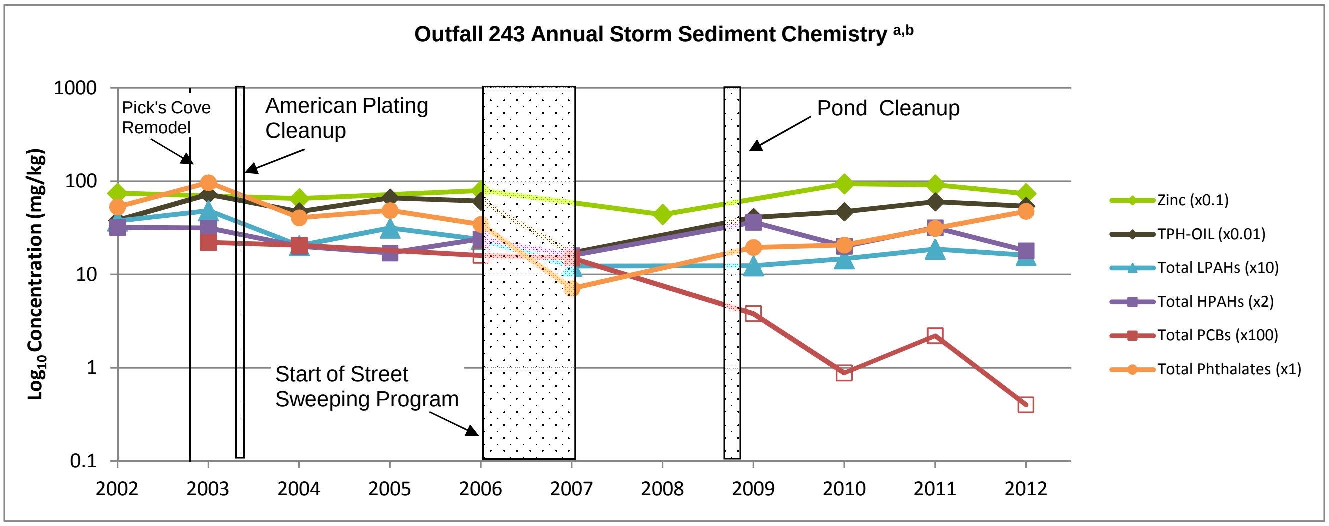


Notes:
[a] Results shown are a product of chemistry data and an analyte-specific multiplier in order to display results on a common scale
[b] Open symbols denote censored data; highest detection limit posted as value
[c] Baseflow sampling was discontinued after WY2011.

Figure 5-1e
Analysis of Monitoring Trends in Stormwater, Baseflow, and Storm Sediment
OF243







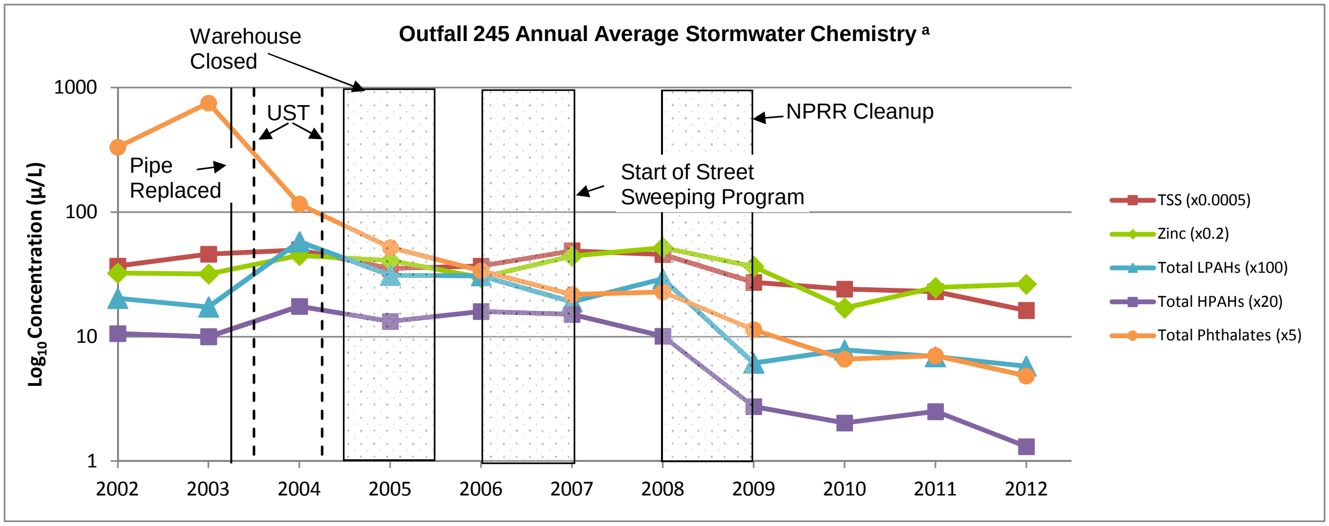
Notes:

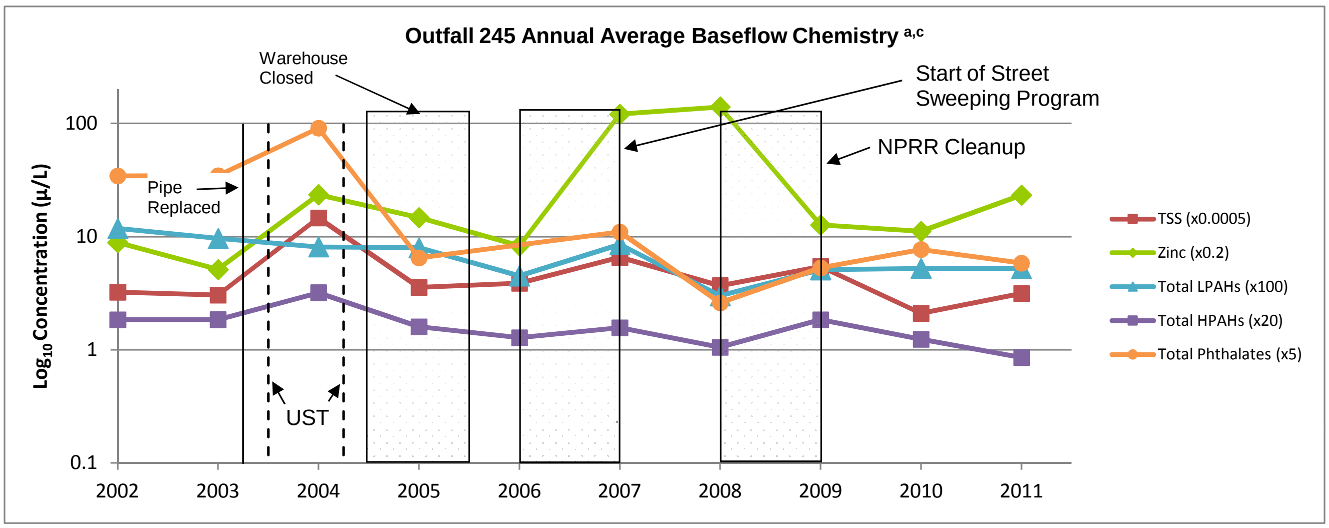
[a] Results shown are a product of chemistry data and an analyte-specific multiplier in order to display results on a common scale

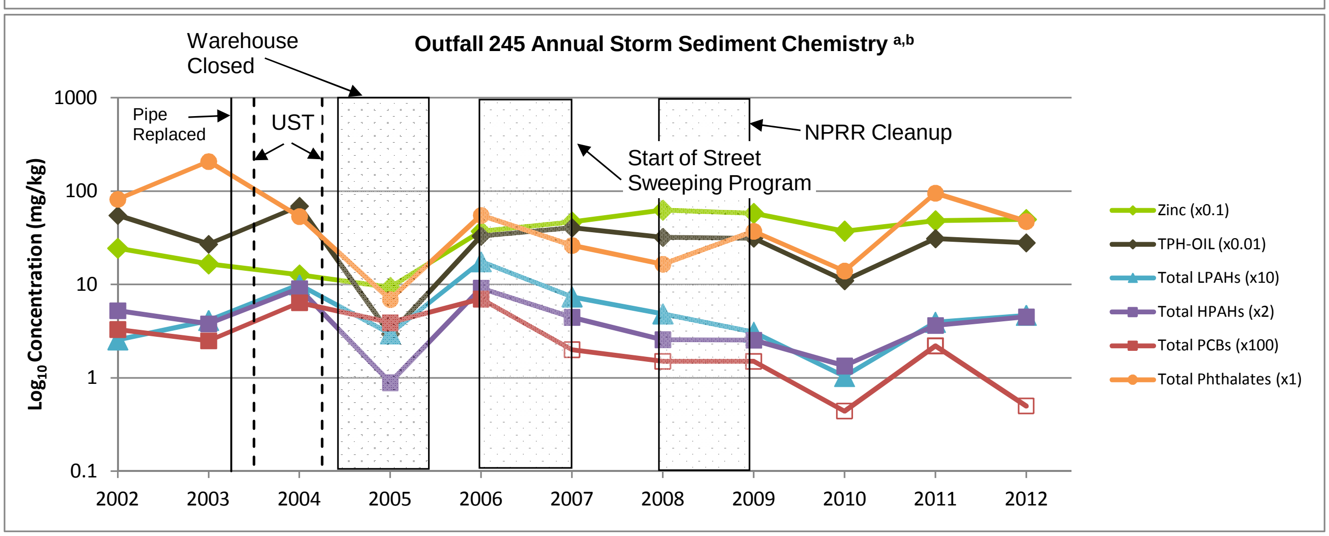
[b] Open symbols denote censored data; highest detection limit posted as value

[c] Baseflow sampling was discontinued after WY2011.

Figure 5-1f
Analysis of Monitoring Trends in Stormwater, Baseflow, and Storm Sediment
OF245







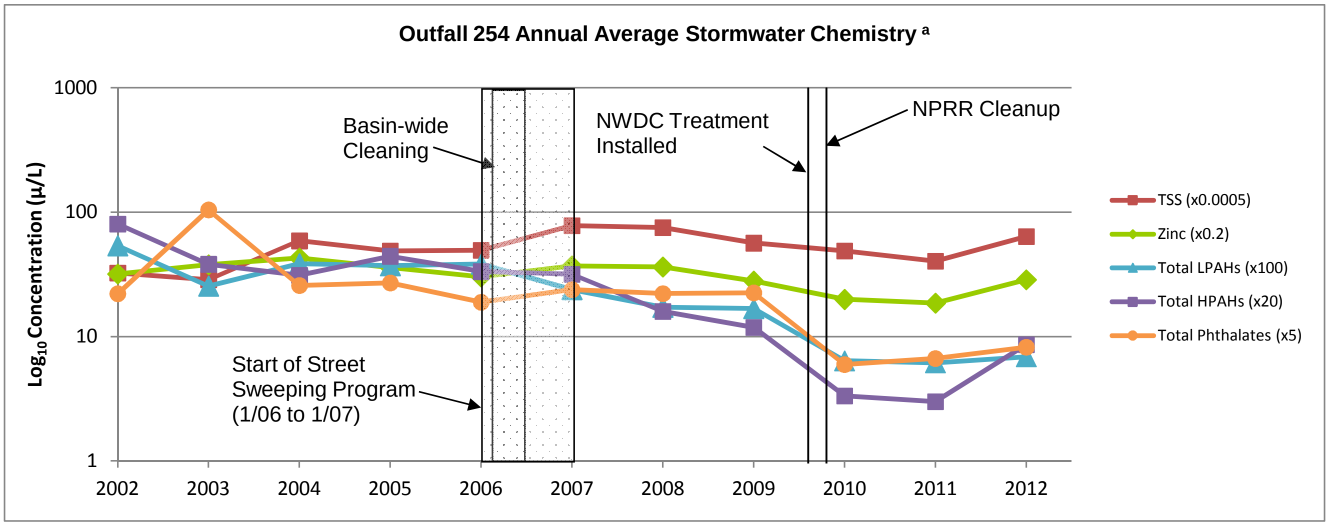
Notes:

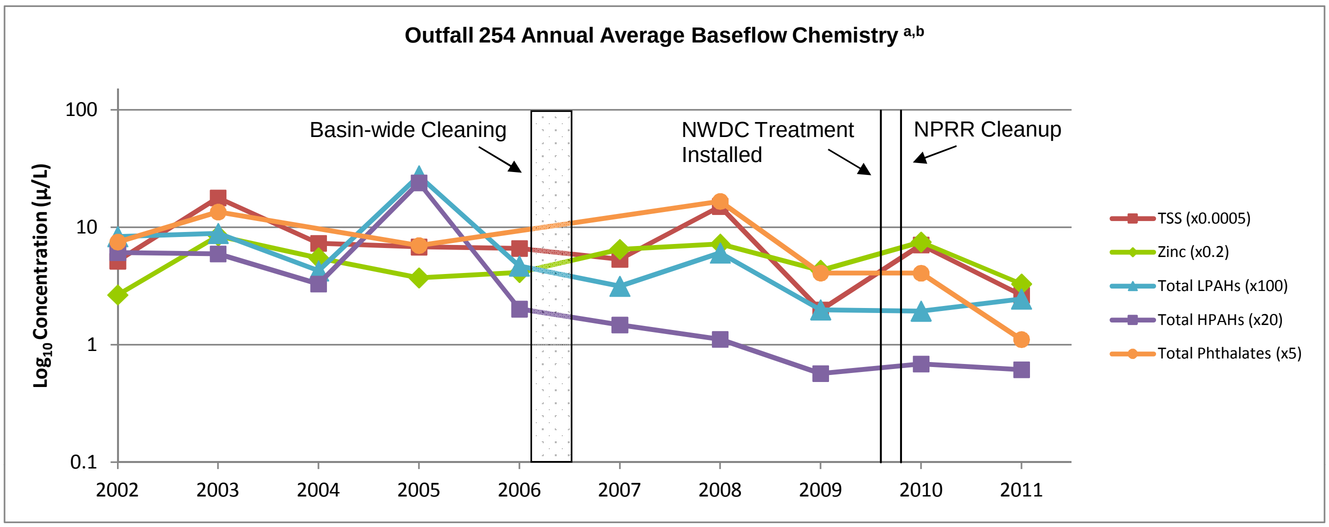
[a] Results shown are a product of chemistry data and an analyte-specific multiplier in order to display results on a common scale

[b] Open symbols denote censored data; highest detection limit posted as value

[c] Baseflow sampling was discontinued after WY2011.

Figure 5-1g
Analysis of Monitoring Trends in Stormwater and Baseflow, and Storm Sediment
OF254



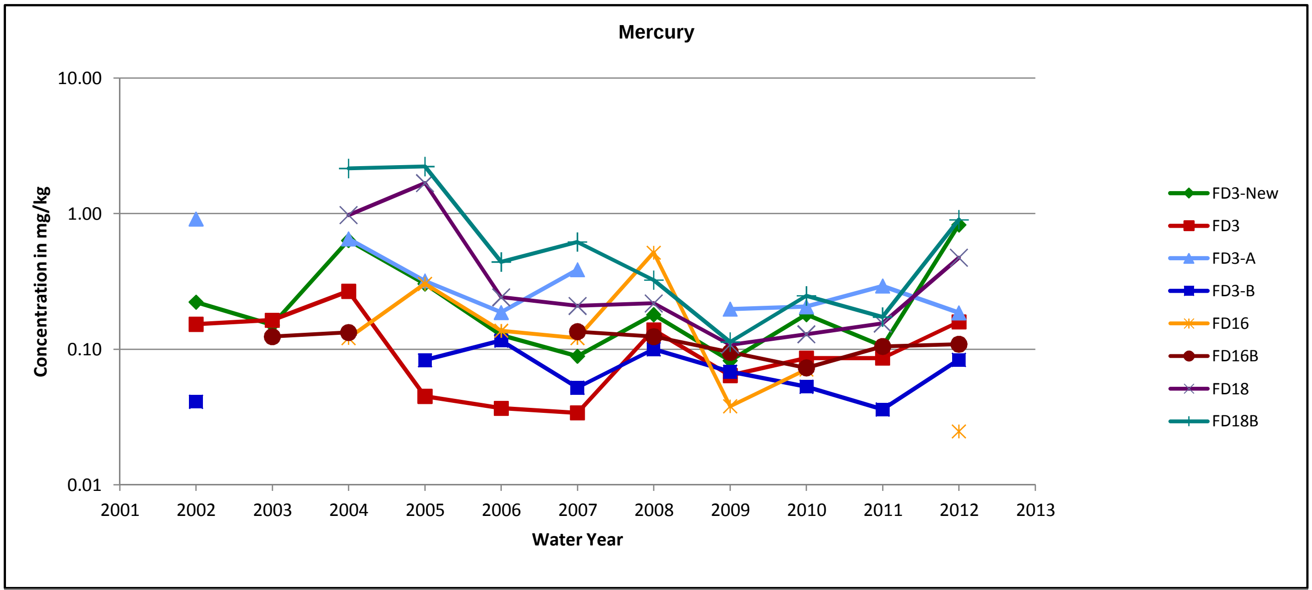


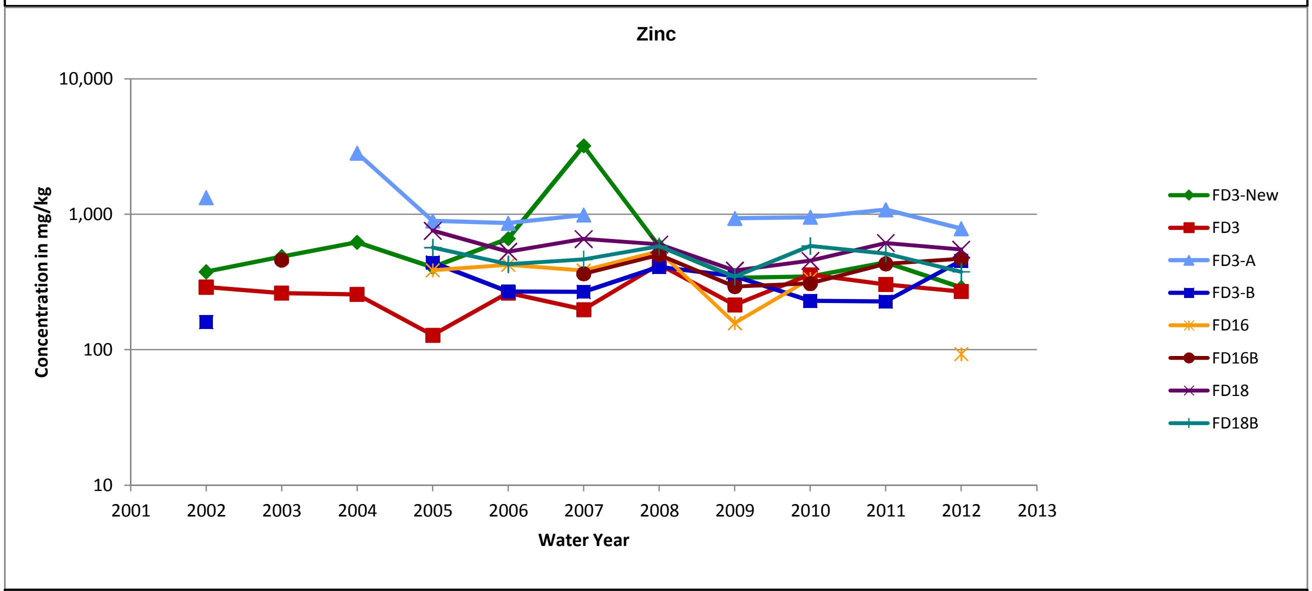
Notes:

[a] Results shown are a product of chemistry data and an analyte-specific multiplier in order to display results on a common scale

[b] Baseflow sampling was discontinued after WY2011.

Figure 5-2a
Analysis of Monitoring Trends in Storm Sediment
OF230





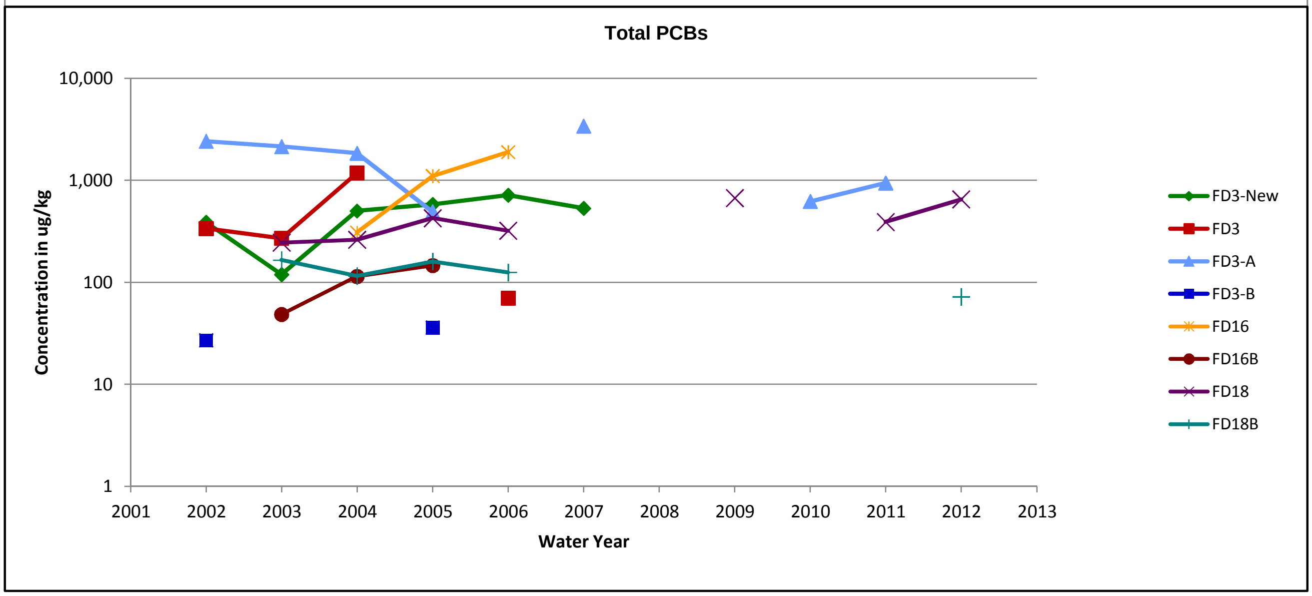
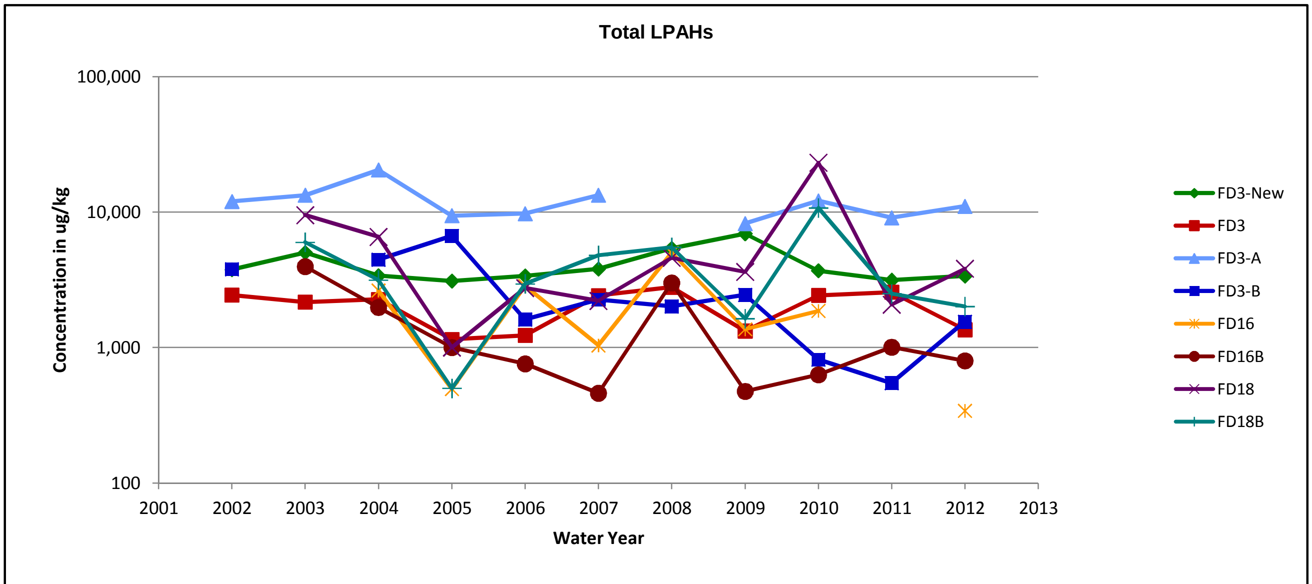
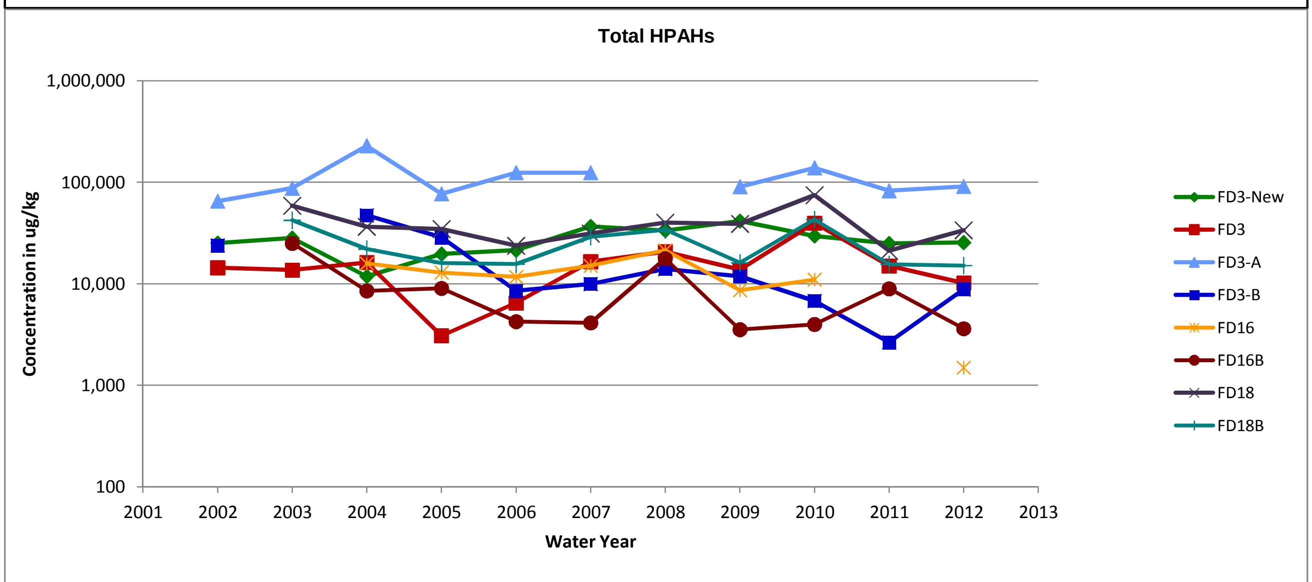


Figure 5-2a 230 SedT Trend Charts_LOG.xls

Figure 5-2a (continued)
Analysis of Monitoring Trends in Storm Sediment
OF230





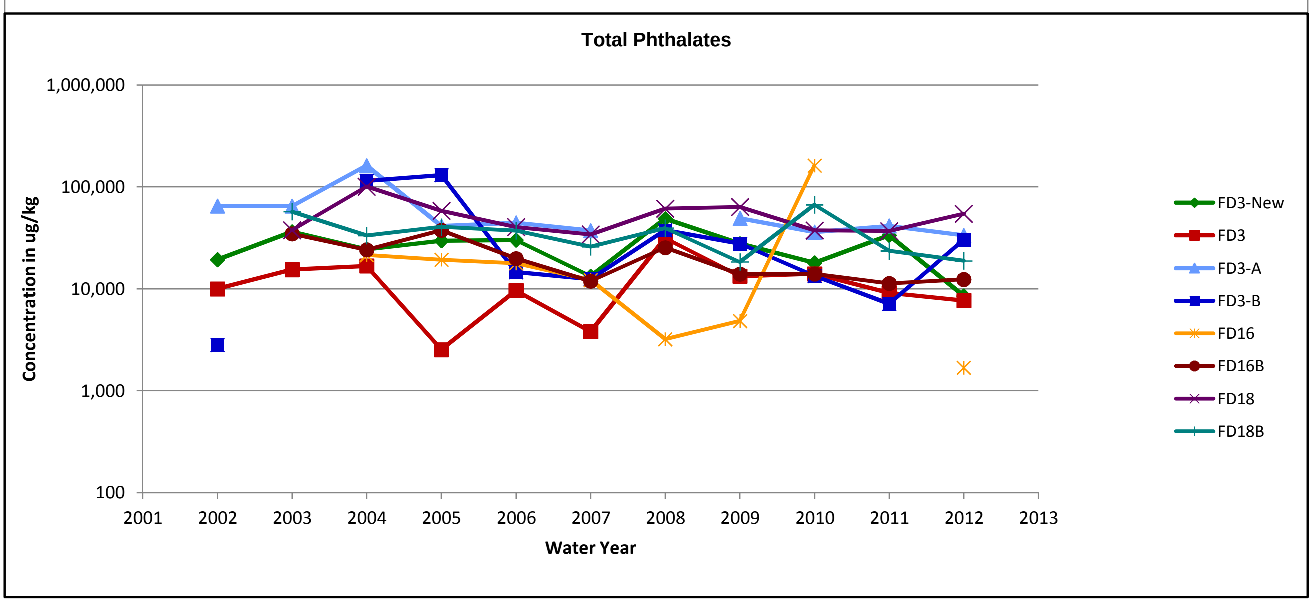
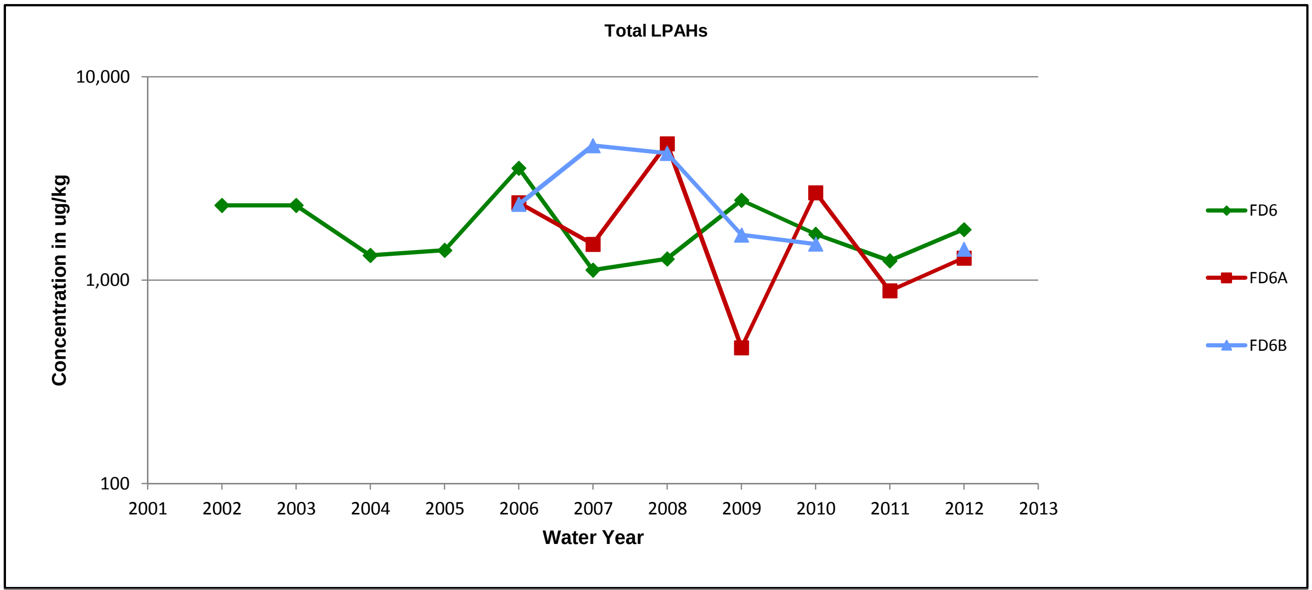
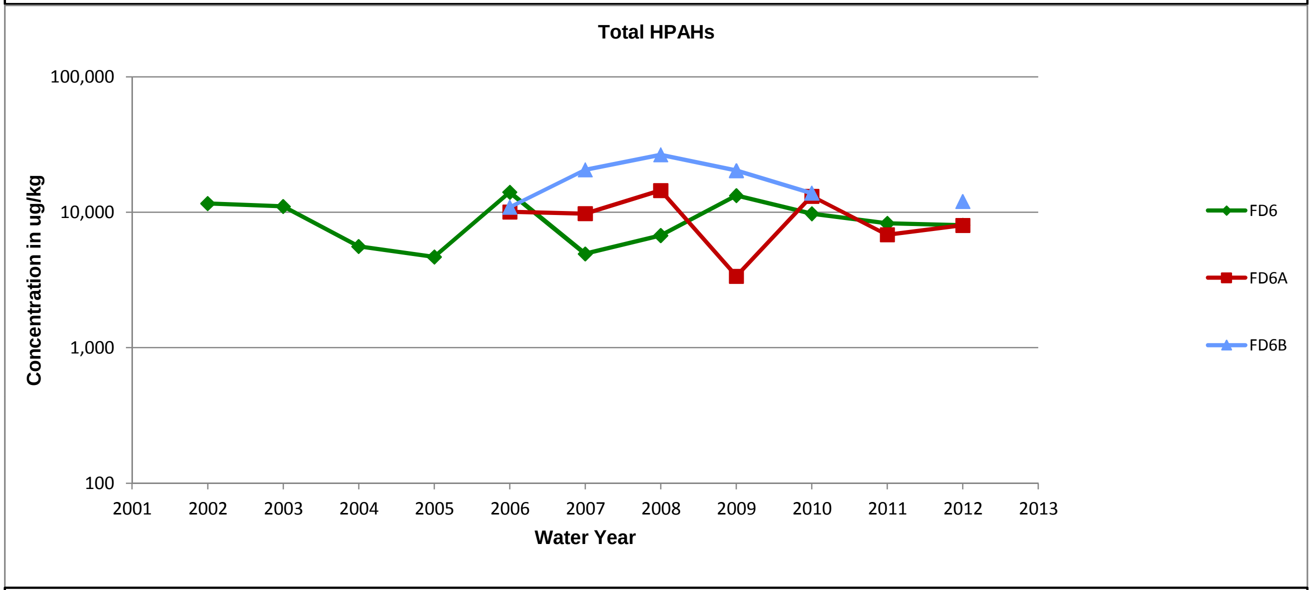


Figure 5-2b
Analysis of Monitoring Trends in Storm Sediment
OF235





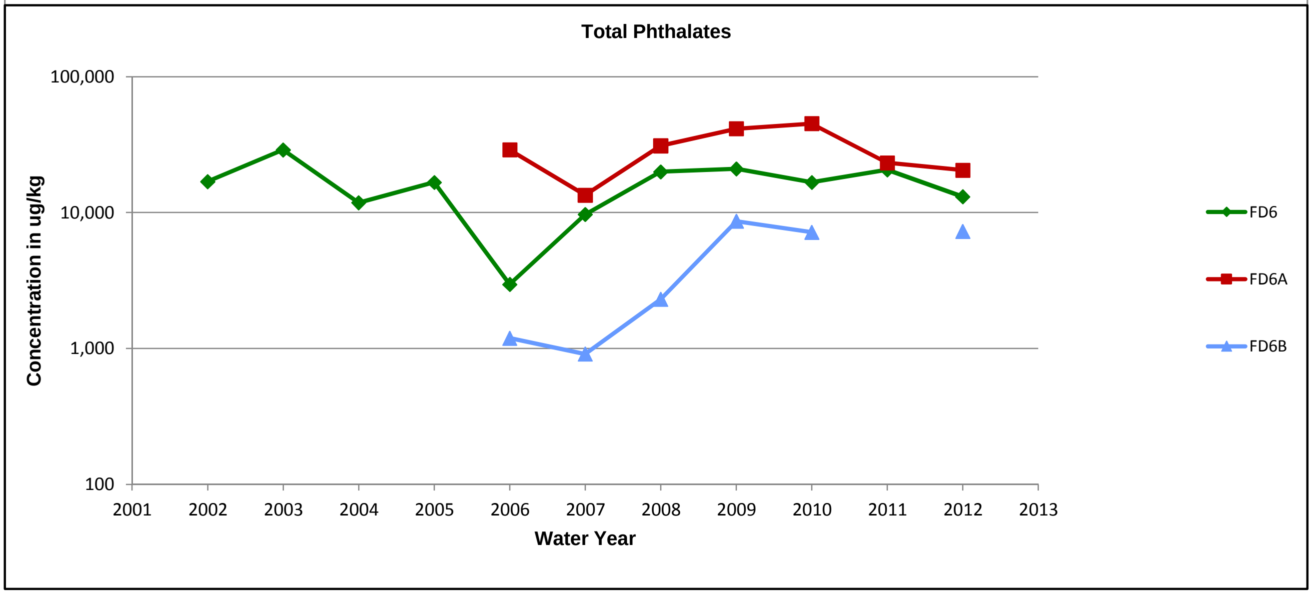
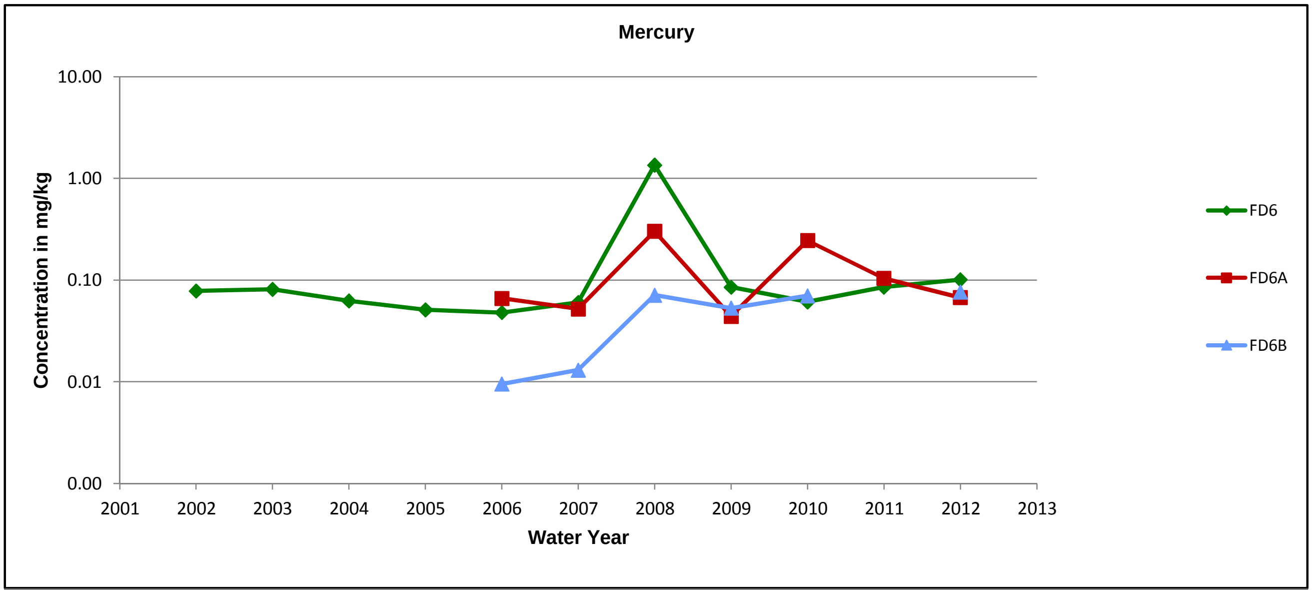
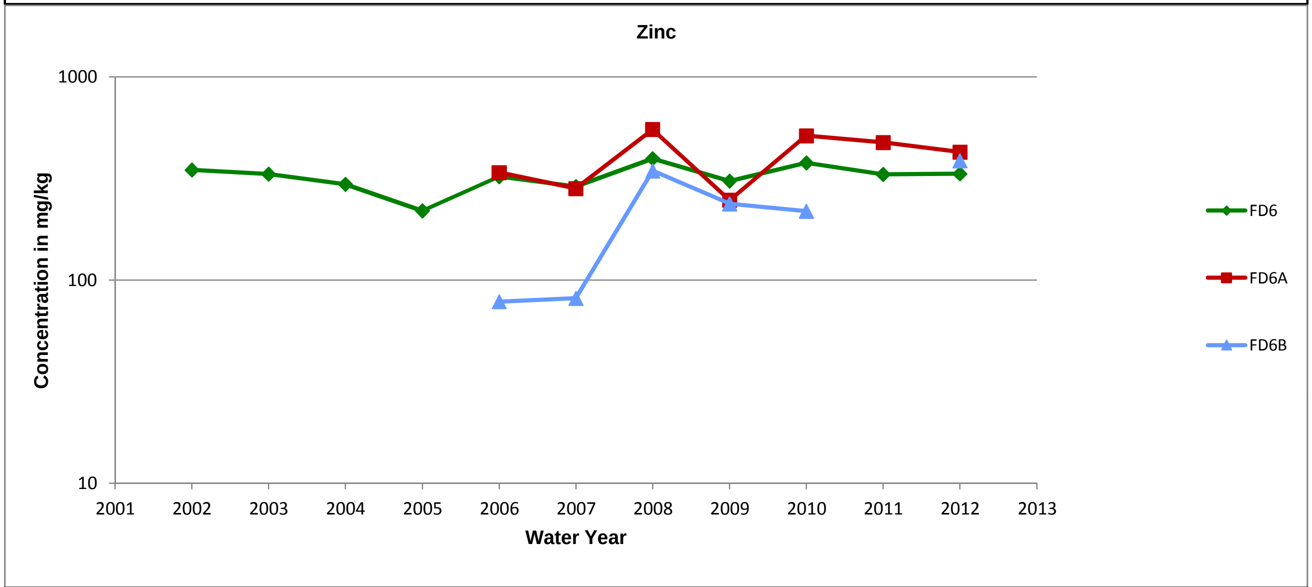


Figure 5-2b (continued)
Analysis of Monitoring Trends in Storm Sediment
OF235





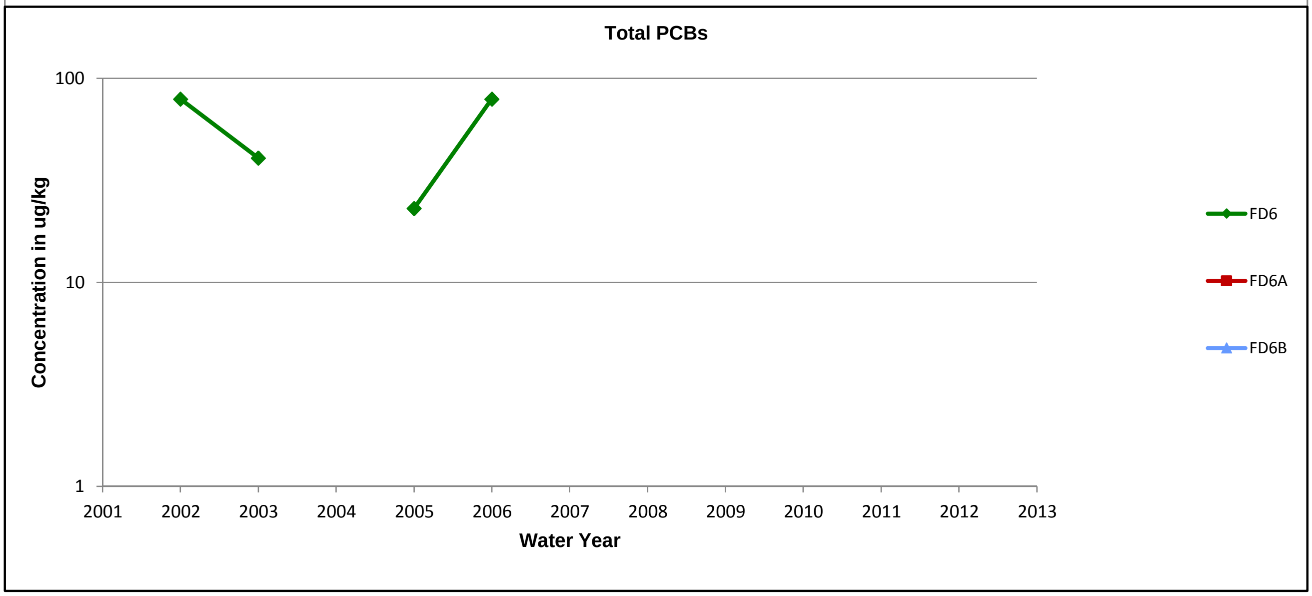
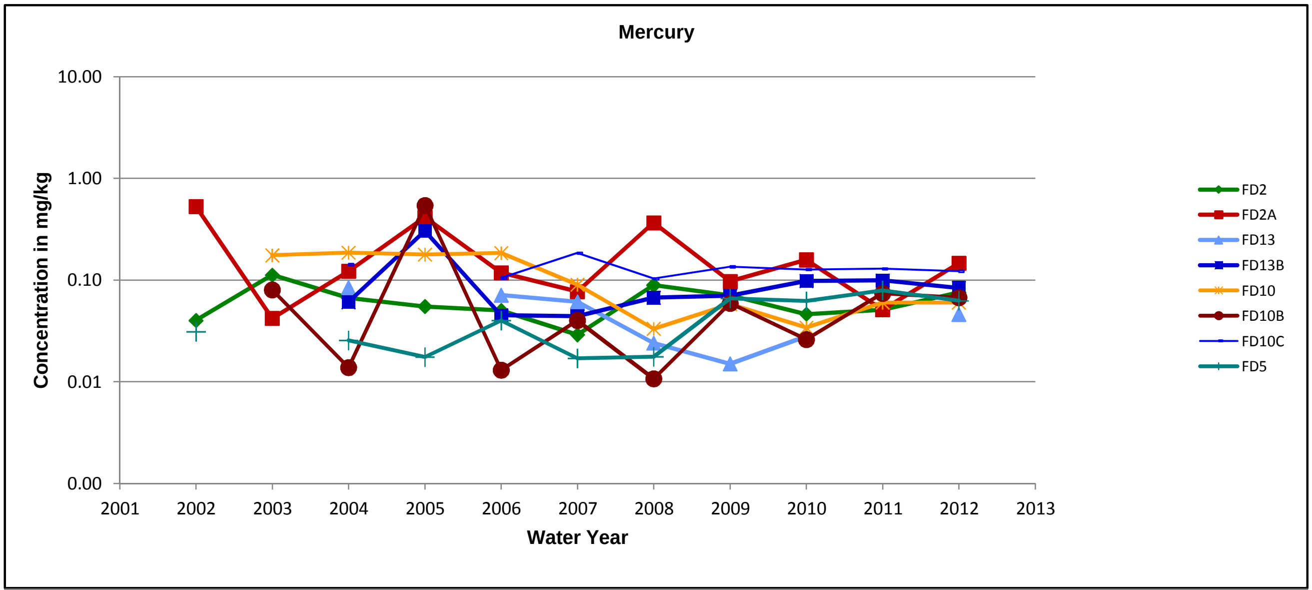
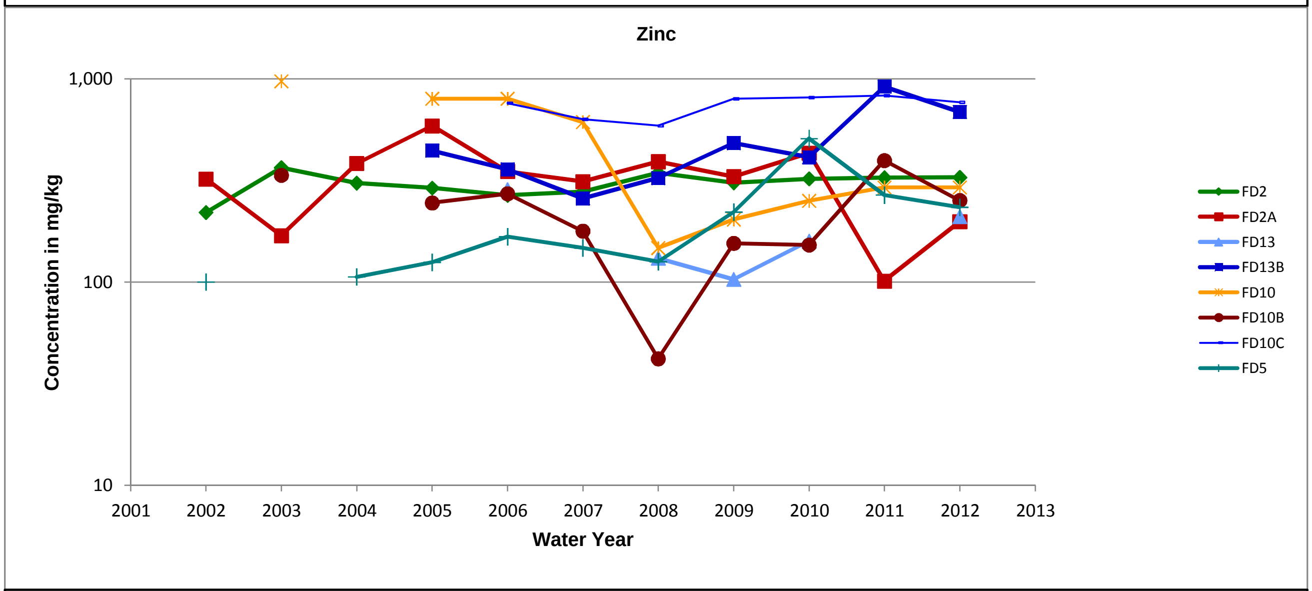


Figure 5-2b 235 SedT Trend Charts_LOG.xls

Figure 5-2c
Analysis of Monitoring Trends in Storm Sediment
OF237A





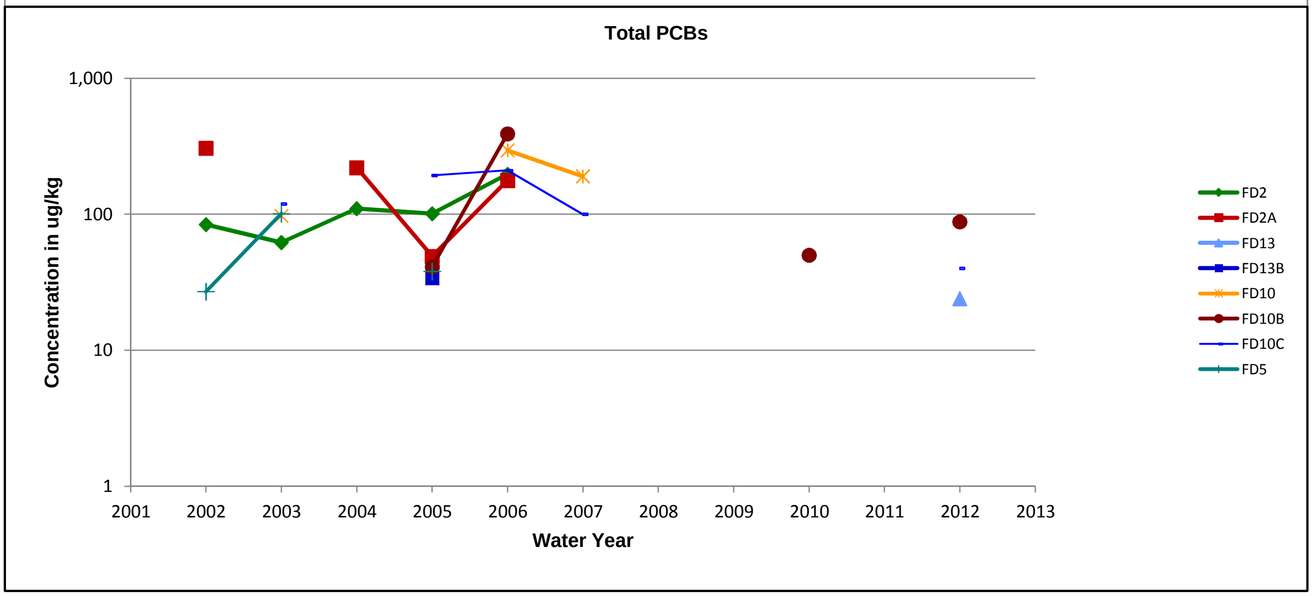
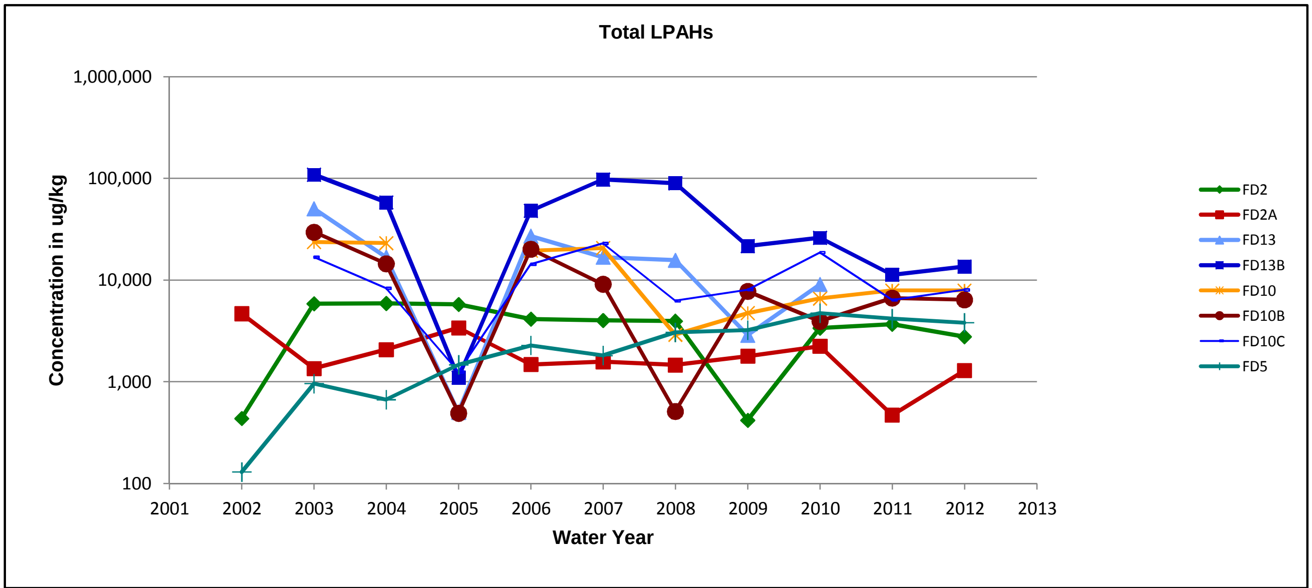
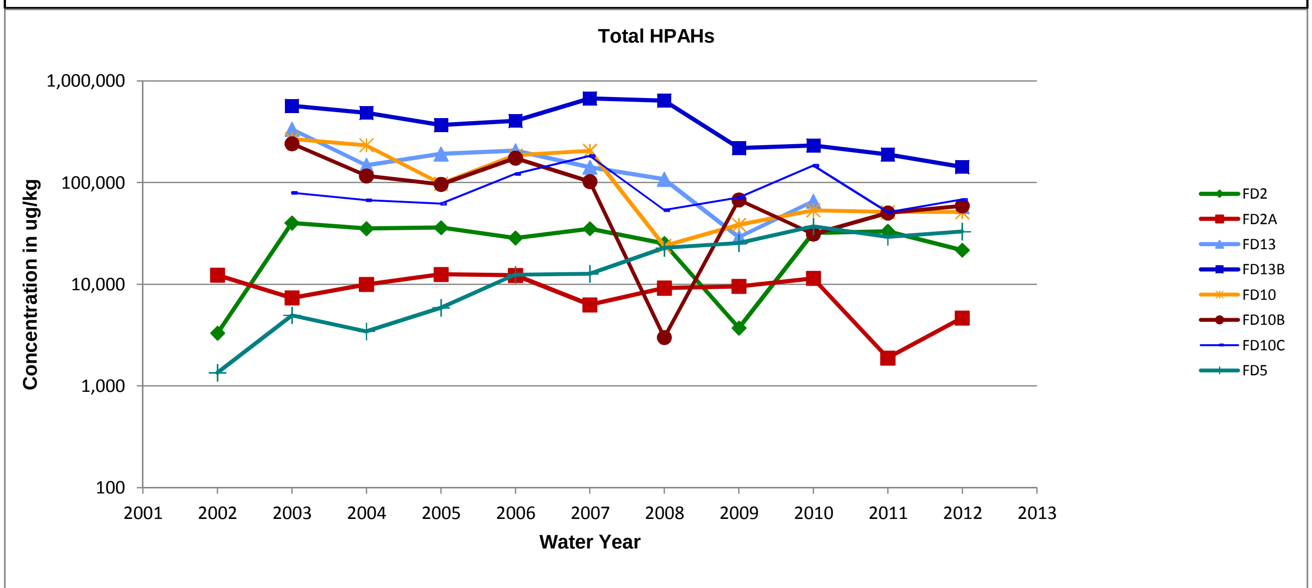


Figure 5-2c (continued)
Analysis of Monitoring Trends in Storm Sediment
OF237A





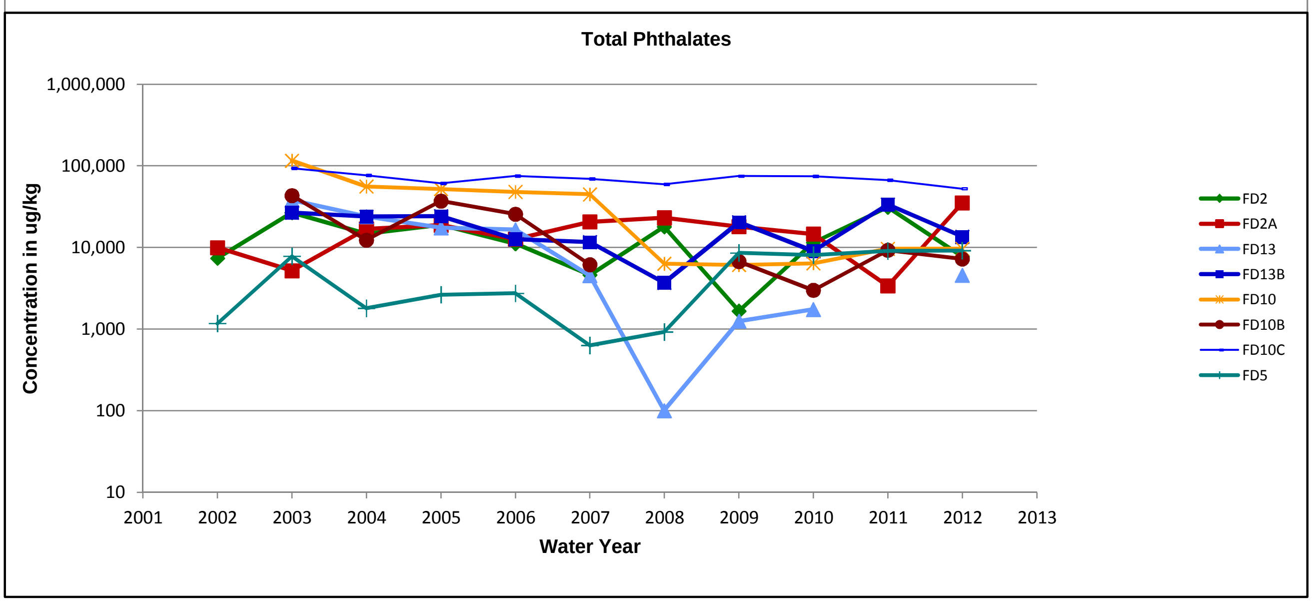
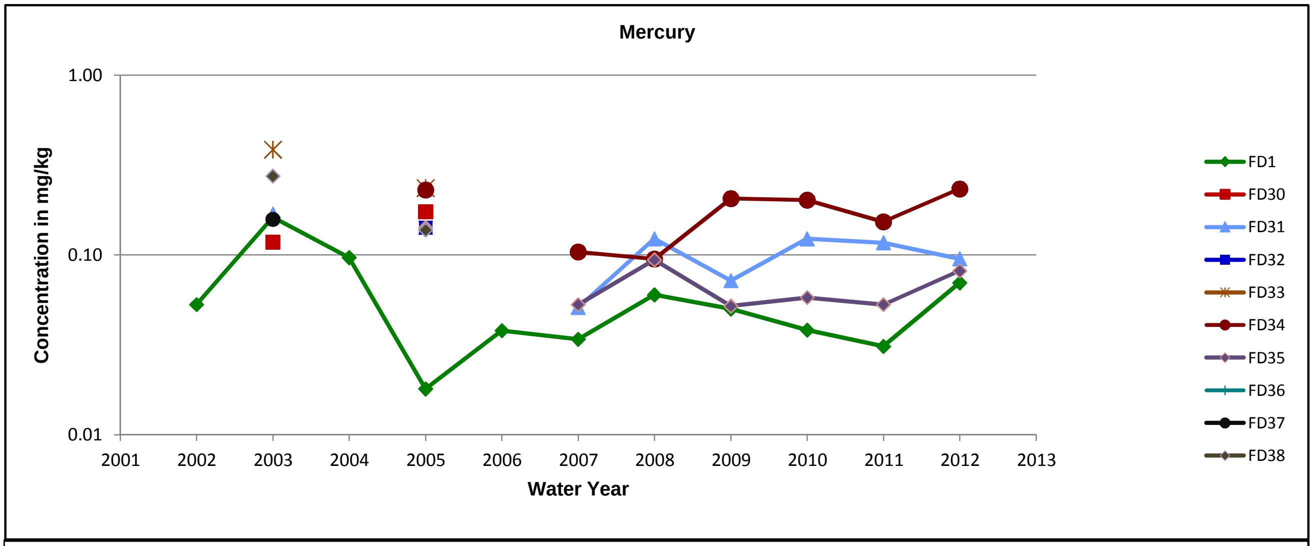
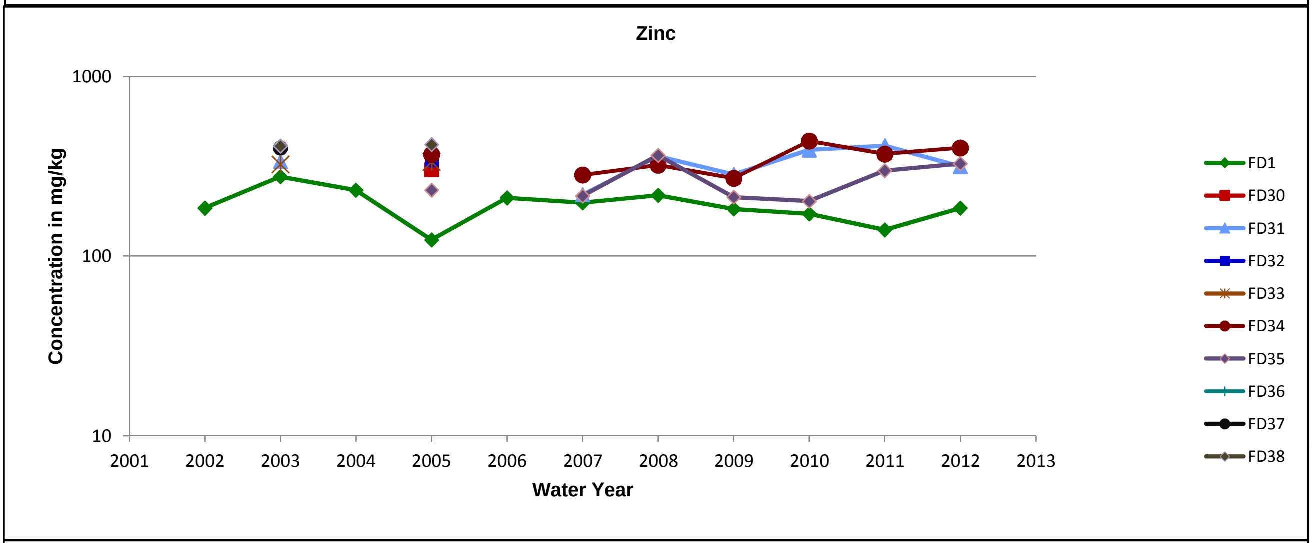


Figure 5-2c 237A SedT Trend Charts_LOG.xls

Figure 5-2d
Analysis of Monitoring Trends in Storm Sediment
OF237B





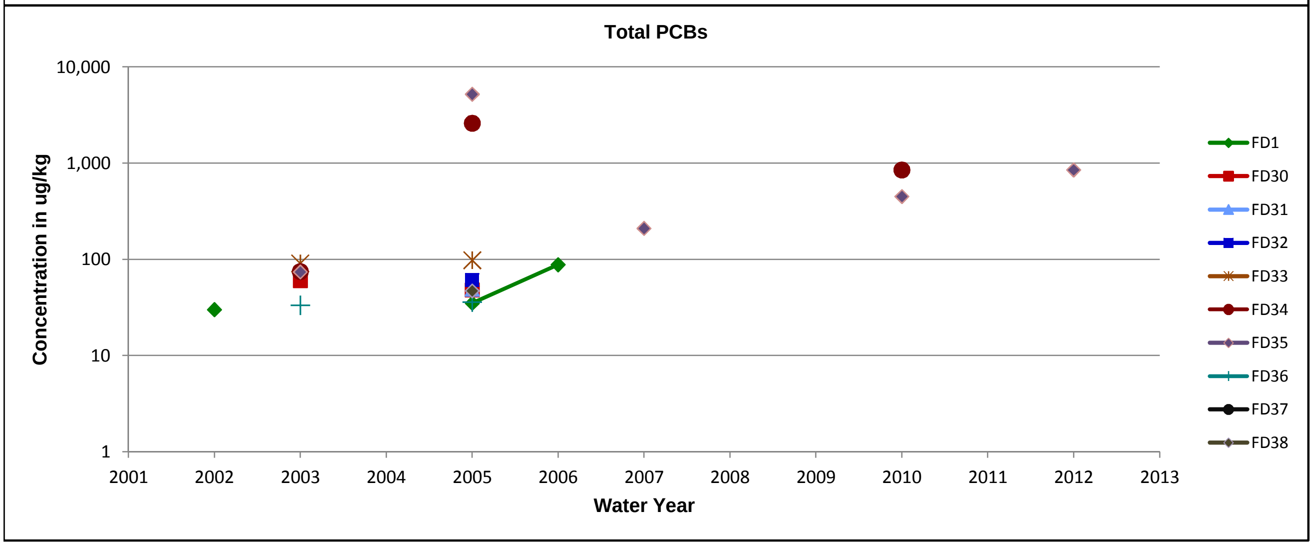
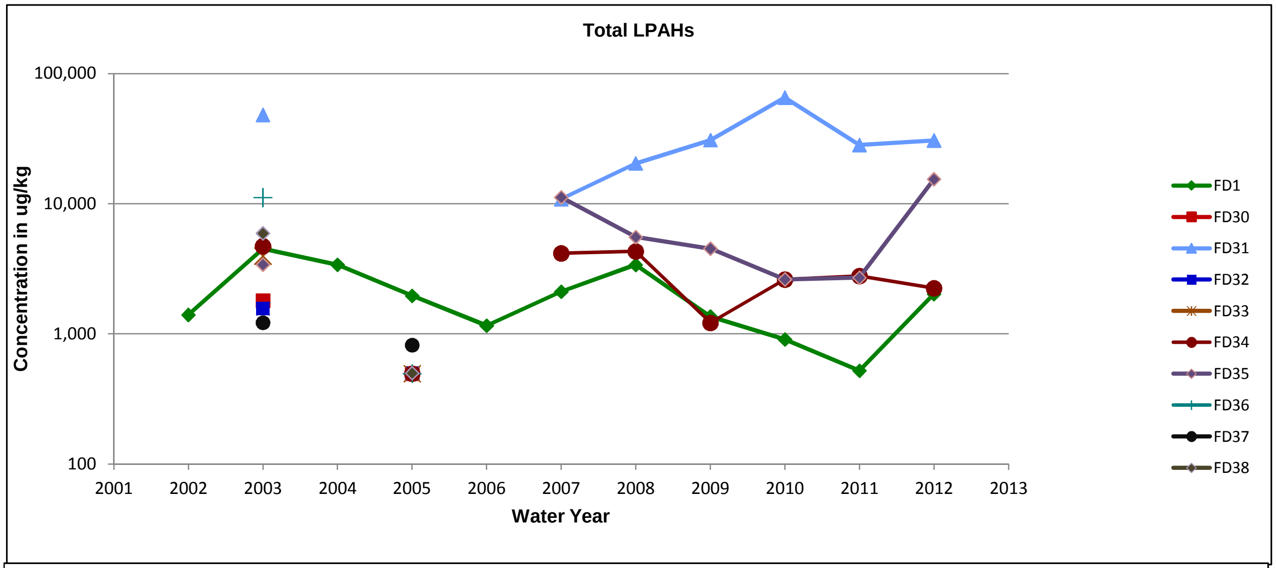
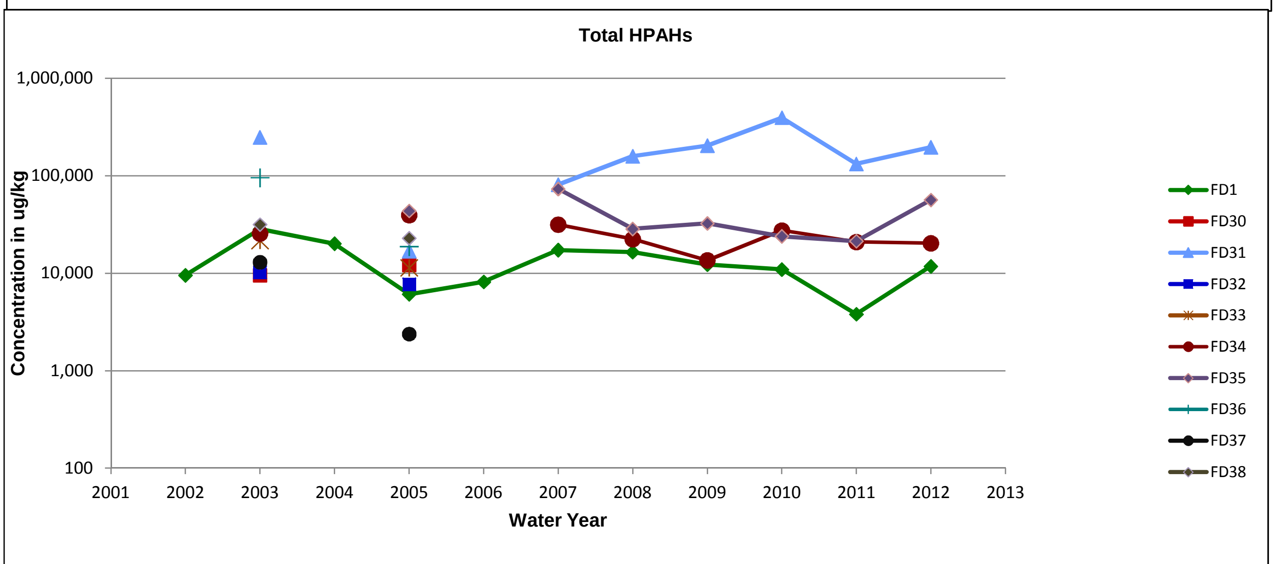


Figure 5-2d (continued)
Analysis of Monitoring Trends in Storm Sediment
OF237B





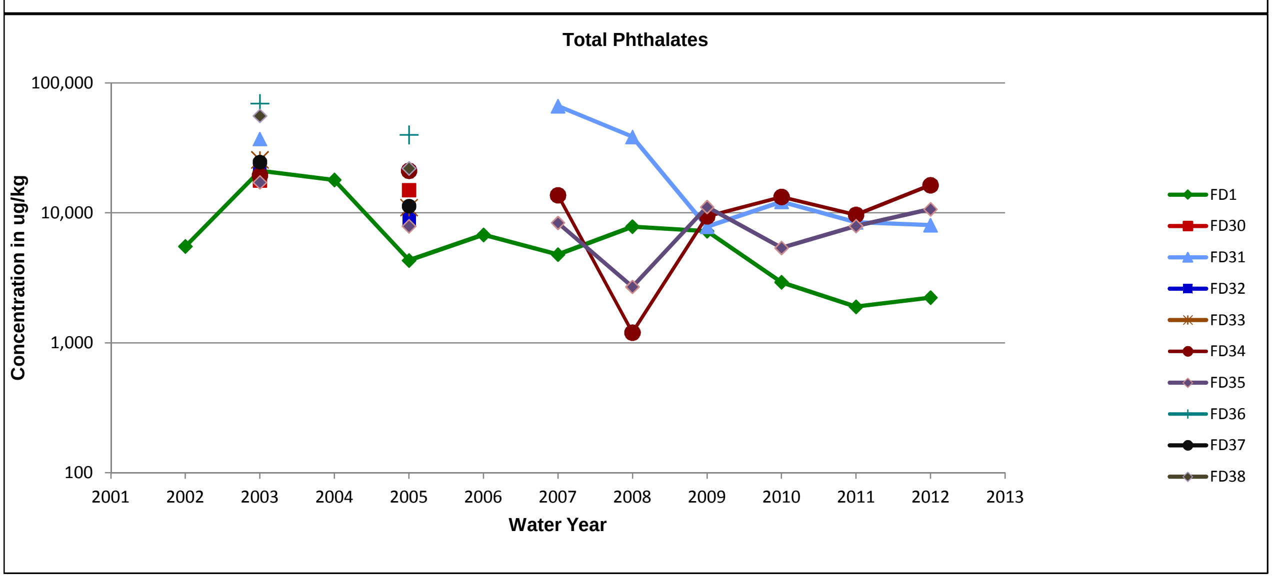
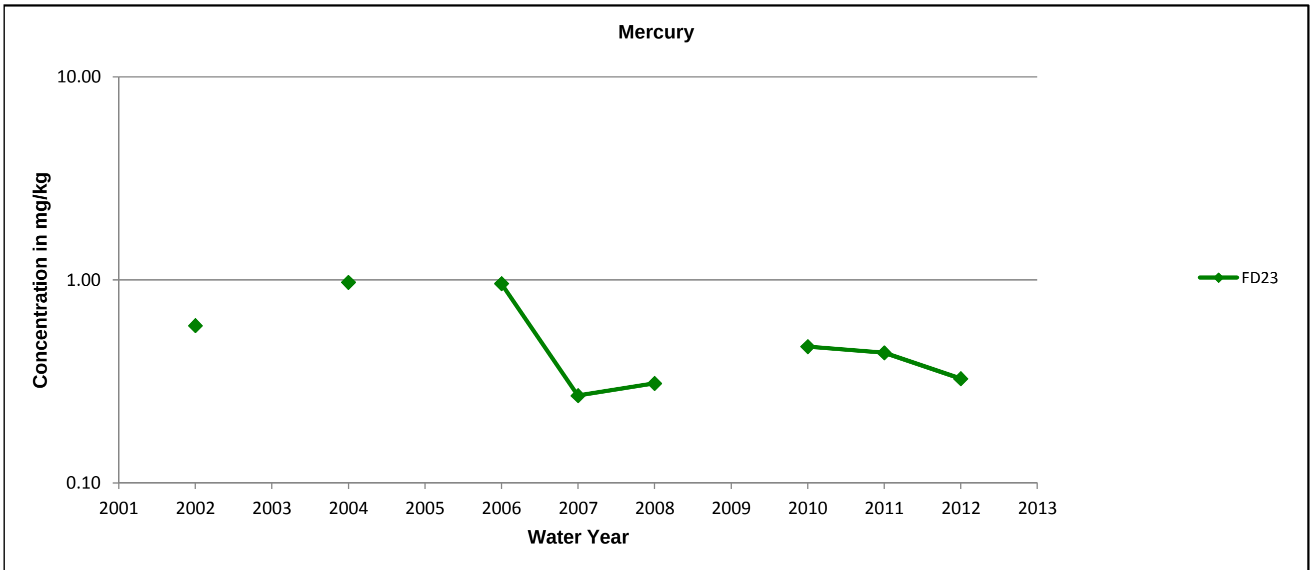
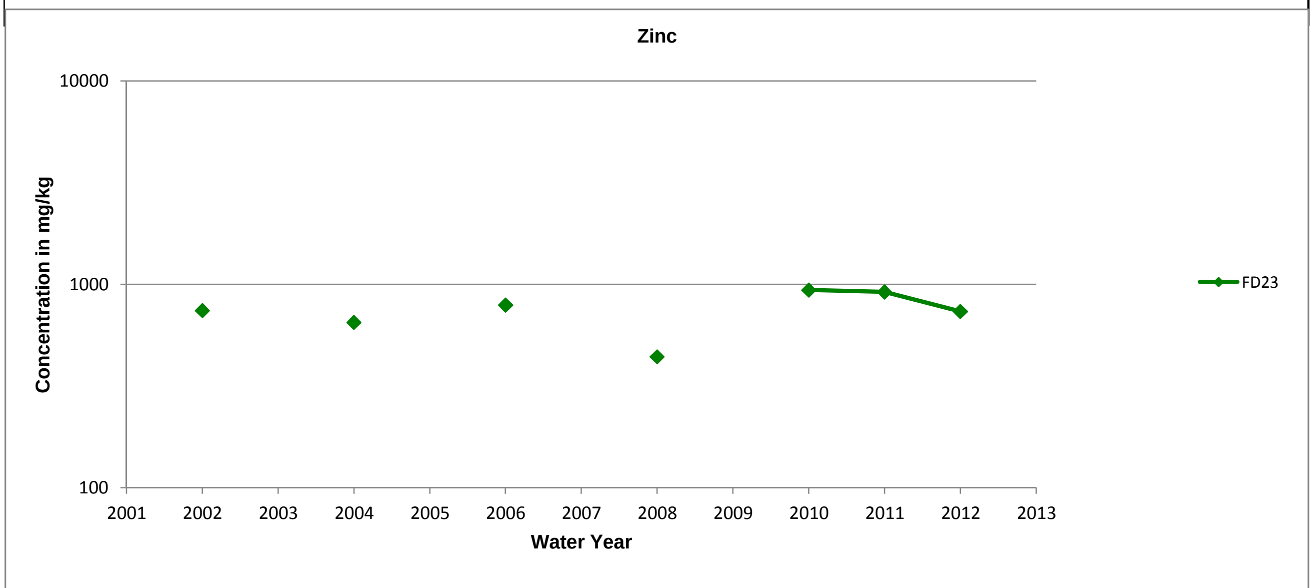


Figure 5-2e
Analysis of Monitoring Trends in Storm Sediment
OF243





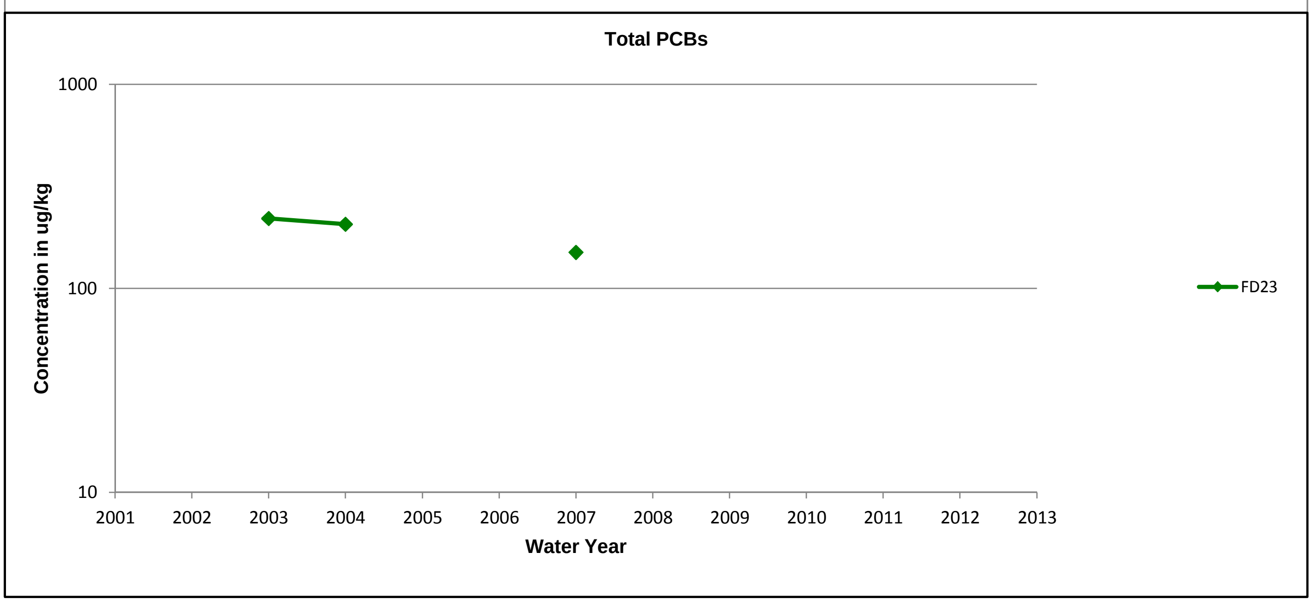
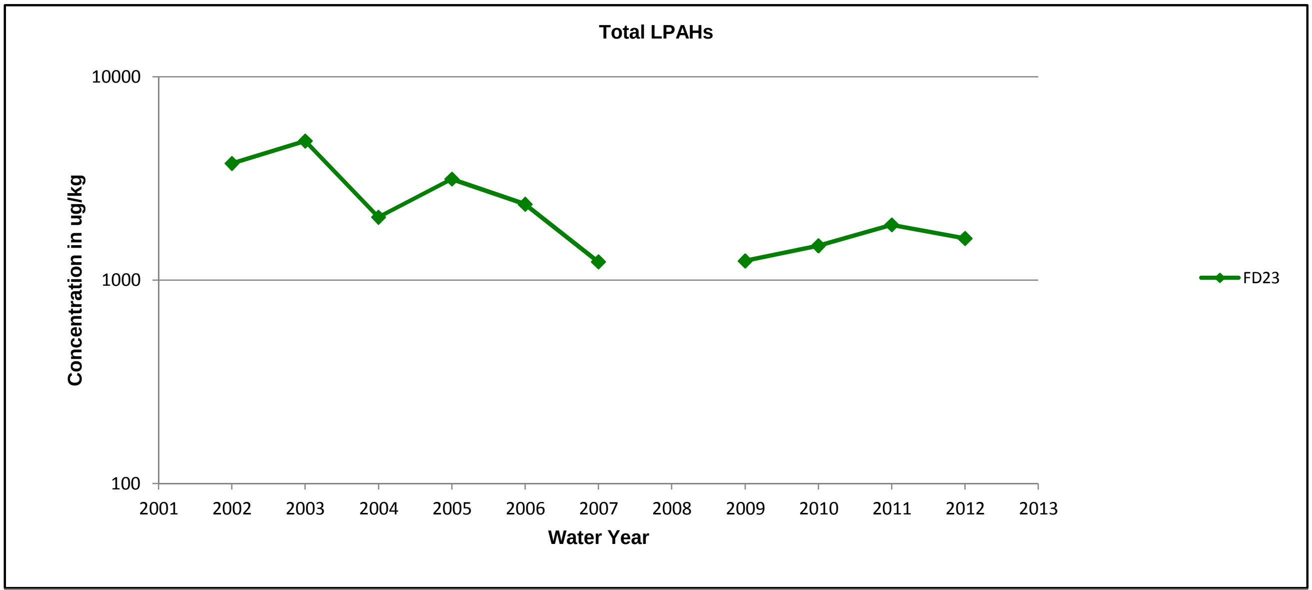
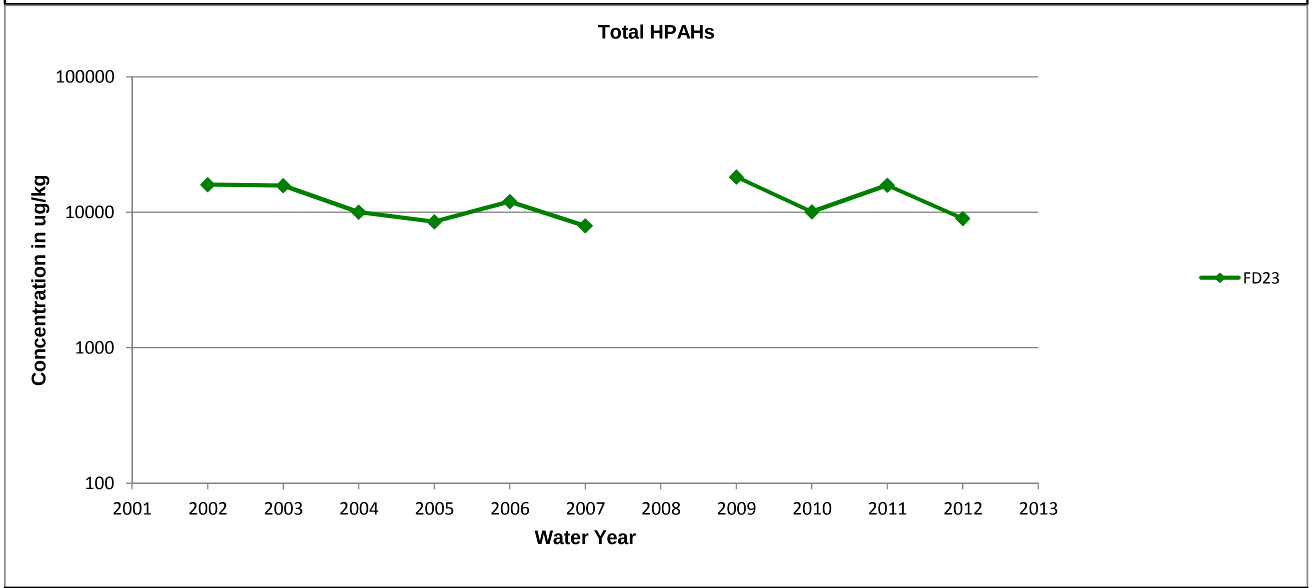


Figure 5-2e (continued)
Analysis of Monitoring Trends in Storm Sediment
OF243





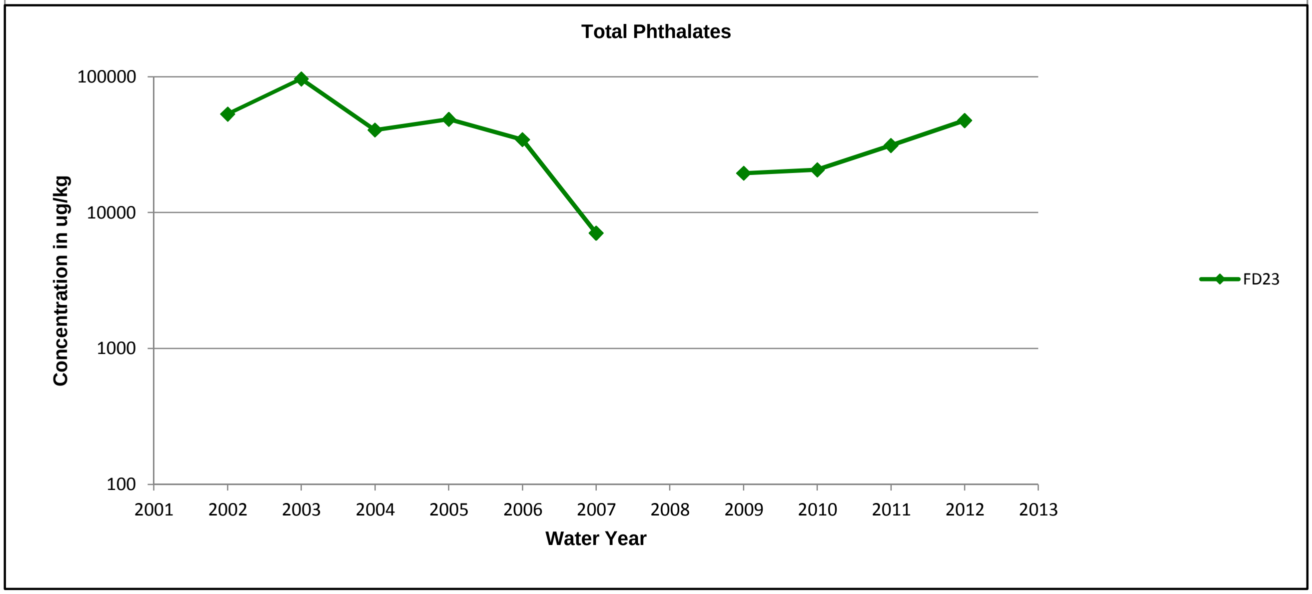
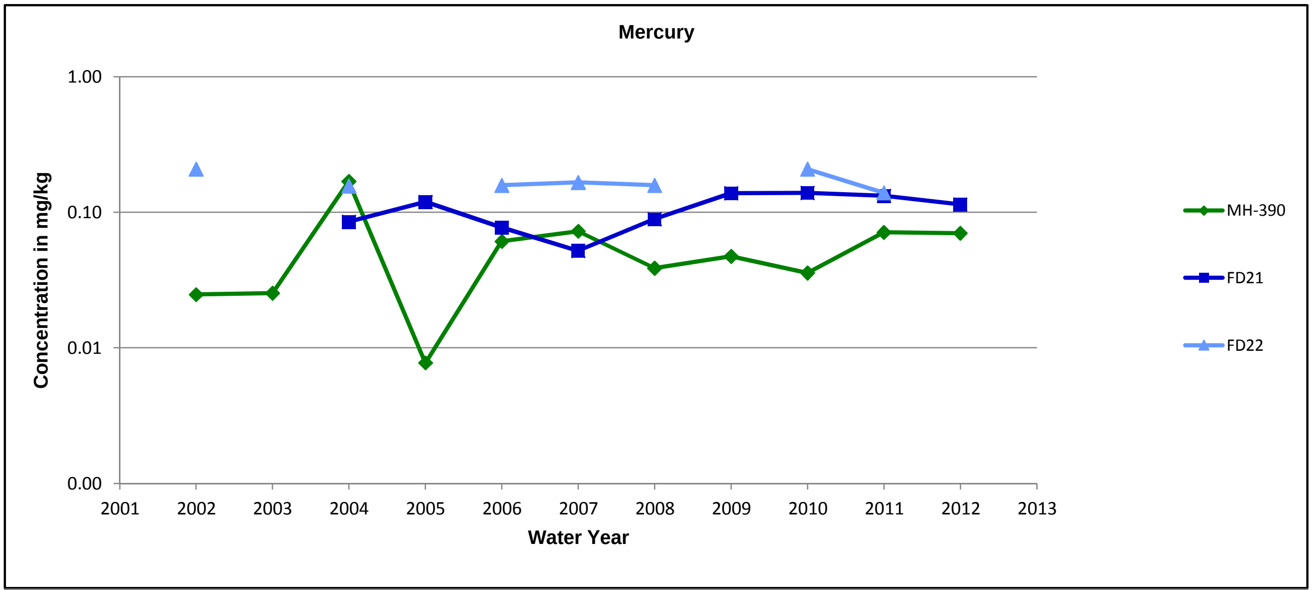
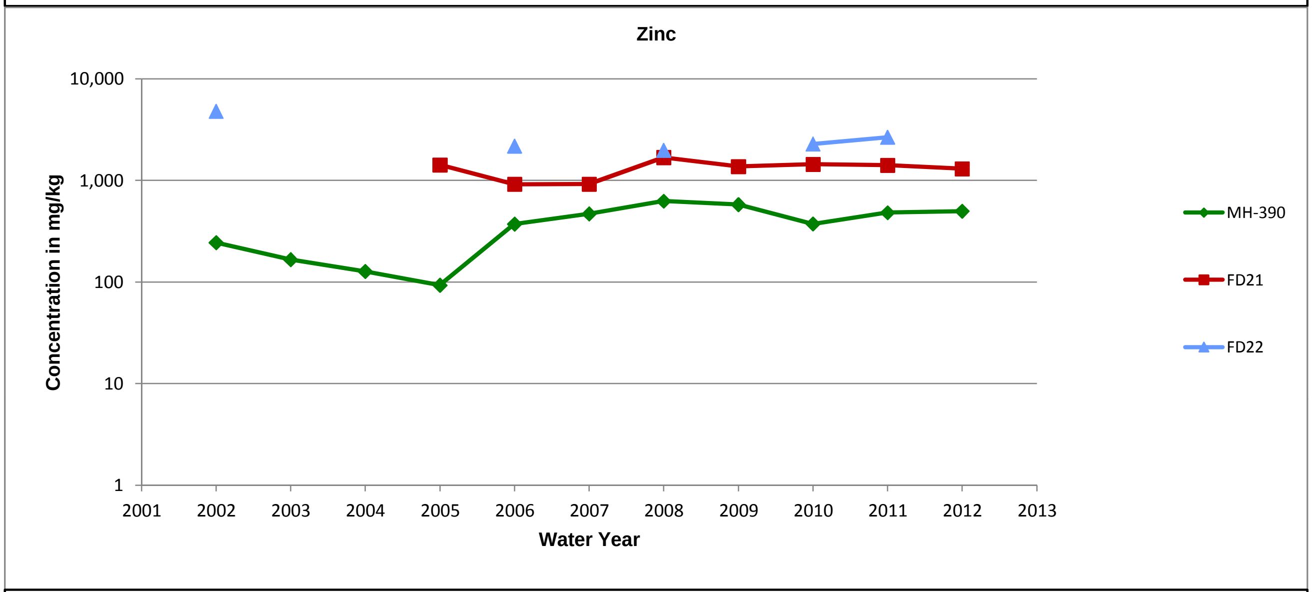


Figure 5-2f
Analysis of Monitoring Trends in Storm Sediment
OF245





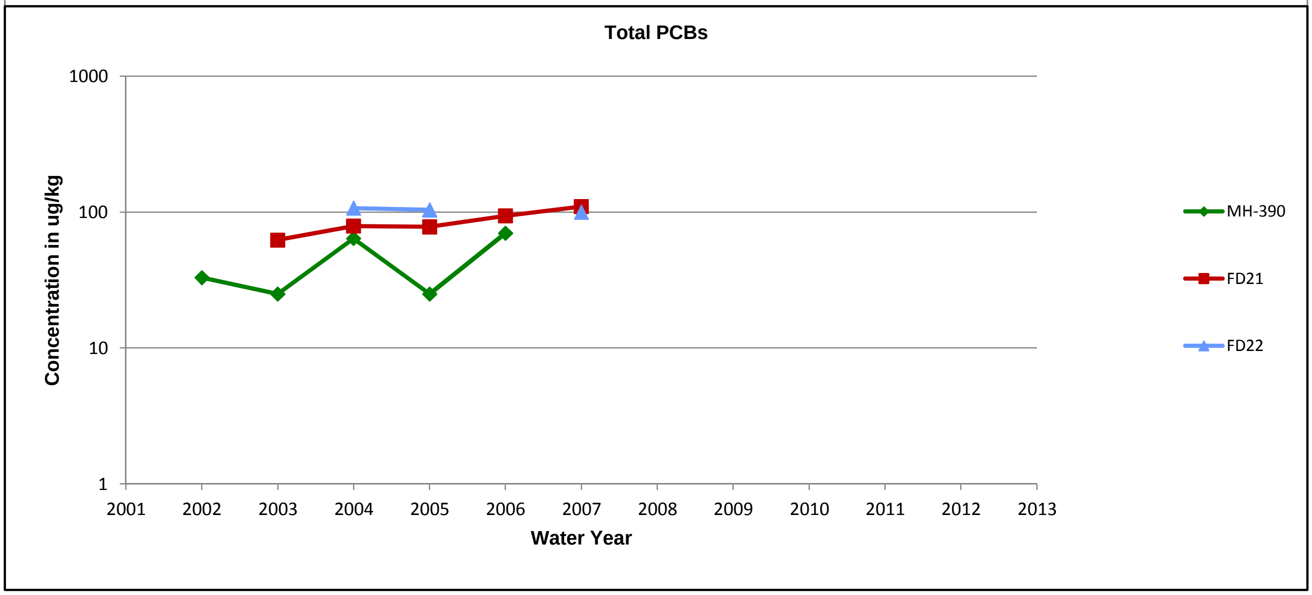


Figure 5-2f 245 SC - SedT Trend Charts_LOG.xls

Figure 5-2f (continued)
Analysis of Monitoring Trends in Storm Sediment
OF245