USE OF AUTOMATED SAMPLER TO CHARACTERIZE URBAN STORMWATER RUNOFF IN PECAN CREEK

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The purpose of this study was to use the Global Water Stormwater Sampler SS201 to characterize the urban runoff in Pecan Creek. Location of the samplers was influenced by land use and ease of installation. Determination of the constituents for analysis was modeled after those used in the NPDES permit for seven cities within the Dallas/Ft.Worth metroplex. Some metals, notably cadmium and arsenic, exceeded the U.S. EPA's MCL's. Statistical analysis revealed first flush samples to be significantly more concentrated than composite samples. Minimum discharge loadings were found to be significantly lower than maximum discharge loadings. Additionally there were significant differences of specific constituents between station locations and storm events.

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CHAPTER 1

INTRODUCTION

Protecting urban streams water quality has increasingly become a major challenge for many municipalities. One aspect considered vital to watershed protection is the water quality effect that storm water has on receiving waters. Urban storm water runoff has been recognized as a major contributor of pollution to receiving waters (Heaney and Huber, 1984). In the City of Denton, TX this will be a major challenge considering the urban sprawl taking place. With growth spawns the serious concern of non-point source pollution impacts to area streams and reservoirs. In addition, land-use activities can release toxic chemicals that could hinder the survival of the floral and faunal communities. During storm events these chemicals are flushed from impervious surfaces to our rivers and potentially into our drinking water sources. Urban runoff was reported as the second most frequent cause of pollution of surface waters in the United States (Marsalek, 1991).

Little data exists regarding the quality of urban runoff in the City of Denton's Pecan Creek. However, Phase II has been added to the National Pollution Discharge Elimination System (NPDES) that requires small municipal separate storm sewer systems serving less than 100,000 people to address their storm water discharge if those discharges adversely impact water quality (Federal Register, 1999). Under this ruling Denton may be required to monitor their storm water discharges. A sampling program must be initiated in order to investigate and uncover any potentially degrading water quality concerns Pecan Creek runoff may have upon receiving water bodies.

Collection of storm water samples may pose potential difficulties such as safety considerations and the intermittent nature of storm water events (Federal Register, 1992). Aid from an automated sampler can help reduce those difficulties. In addition to using an automated sampler to retrieve samples, identification of parameters to analyze in the water samples and the location of samplers is equally important. The purpose of this study is evaluate the following hypotheses:

1) Ho = Pecan Creek first flush and composite storm water samples will not differ in concentrations and loadings.

   Ha = Pecan Creek first flush and composite storm water samples will differ in concentrations and loadings.

2) Ho = Pecan Creek contaminant concentrations of both first flush and composite storm water samples will not be different between storm events.

   Ha = Pecan Creek contaminant concentrations of both first flush and composite storm water samples will be different between storm events.

3) Ho = Pecan Creek storm water contaminant concentrations of both first flush and composite samples will not differ between storm water stations.

   Ha = Pecan Creek storm water contaminant concentrations of both first flush and composite samples will differ between storm water stations.

A secondary purpose of this study was to determine the efficacy and dependability of the Global Water Stormwater Sampler SS201 to collect urban storm water. Additionally a graphical comparison will be made between background and storm water samples.

CHAPTER 2

BACKGROUND

Automated Samplers

An issue to consider when choosing an automated sampler is whether they capture the first flush and composite samples. Chang et al. (1990) defined the first flush as the first tenth of an inch of rainfall and suggests the first flush tends to be more concentrated in contaminants than the duration of the storm. Additionally, a sampler should be able to collect sequential grabs, mix sequential grabs for a composite sample, or provide a flow-weighted single or multiple composites. Flow-weighted composite sampling, also referred to as time-weighted composite sampling, is considered essential for contaminant loading determinations (Roesner et al., 1998).

The ISCO 3700 sampler has been used extensively to capture urban runoff. Typically these samplers are combined with flow meters for flow proportional sampling (McElheney, 1999). Although ISCO samplers meet EPA storm water monitoring runoff monitoring requirements they are very costly. The United States Geological Survey (USGS) deploys ISCO samplers all over the country. According to Dan McElheney with the USGS Fort Worth office, the typical cost to install a storm water runoff capture site using an ISCO sampler as well as an ISCO flow meter is about $18,000-20,000. Problems can also arise from using these samplers. Most commonly, the flow meters, which are responsible for triggering the sampler as well as recording the flow, get clogged with debris that prevents sampling (Andrews, 1999). An alternative to the ISCO automated sampler is the Global Water SS201 automated storm water sampler.

The Global Water Stormwater Sampler SS201 is designed to follow the sampling guidelines of the Stormwater Program and costs $985 per sampler (40 CFR, 1992). Global Water samplers are also equipped with a first flush sample bottle and a composite sample bottle. Global Water Stormwater Sampler SS201 has been used by many organizations.

In 1999 Global Water reported a sale of over 100 storm water samplers (Hitson, 2000). A variety of organizations have used these samplers, including naval shipyards, universities, consulting firms, and government municipalities. For example, the University of Wisconsin Department of Biological Sciences deploys Global Water samplers to measure biological parameters in storm water (Ehlinger, 1999). Richard Riley of the City of Fort Lauderdale has used these automated samplers the past three years to analyze for metals in an industrial pretreatment program. Portmouth Naval Shipyard uses the samplers to analyze and report metal loads in catch basins and storm pipes to comply with their NPDES permit (Flagg, 2000). Upon implementing a sampling program it is essential to identify the land use relative to sampling locations to understand potential sources of pollution.

Land Use

The Nationwide Urban Runoff Program study (NURP) found no statistical difference between residential, mixed, and commercial land uses in regard to their storm water characteristics (Athayde et al., 1983). However, Kennedy (1995) found statistically different concentrations among residential, commercial, highway, and industrial land uses in North Central Texas. Moreover, statistical significance was found in 11 of the 13 parameters analyzed in the region, suggesting land use affected storm water composition. The USGS has been monitoring the nation's waters since 1992 through their National Water Quality Assessment (NAWQA) program, having found that water quality patterns are repeating themselves over space and time in relation to land use (U.S. Geological Survey, 1996). For example, concentrations of nutrients and pesticides were moderate in major rivers draining mixed land uses because of dilution by water from undeveloped areas. Regardless of land use, urbanization can affect stream conditions such as temperature, nutrient loading, macro invertebrate diversity, fish diversity, instream habitat, changes in stream flow peaks and frequency, spawning success, and bacterial contamination, due to a large amount of impervious cover (Heaney et al., 1998). Land use can also affect the types of storm water constituents present.

Common Storm Water Constituents

Due to the large array of constituents found in storm water this study attempts to focus on the contaminants that are known to present the greatest risk to humans and aquatic life. Moreover, due to regional similarities, parameters analyzed were those analyzed for NPDES permitting in North Central Texas including Dallas, Fort Worth, Garland, Mesquite, Arlington, and Plano (North Texas Council of Governments, 1999).

Table 1 shows constituents found in storm water with their respective ranges and level of concern with regards to and aquatic life impacts.

Table 1- Contaminant summary.

Storm water contaminant	Range (mg/L)	Storm water problem	
		Human	Aquatic
Chromium (Total and Dissolved)	0.01 - 2.30	Major	Major
Arsenic (Total and Dissolved)	0.001 - 0.21	Minor	Minor
Cadmium (Total and Dissolved)	0.00005 - 13.73	Minor	Major
Copper (Total and Dissolved)	0.00006 - 1.41	No	Major
Lead (Total and Dissolved)	0.00057 - 26.0	Major	Major
Zinc (Total and Dissolved)	0.0007 - 22.0	Minor	Major
Calcium	0.04 - 2113.8	No	No
Magnesium	0.02 - 304.2	No	No
Sodium	0.18 - 660	Minor	No
Potassium	0.01 - 34	Minor	No
Sulfate	0.06 - 1252	Minor	Minor
Oil and Grease	0.001 - 110	Minor	Minor
Hardness	12 - 1100	No	No
Ammonia	0.07 - 16.0	Minor	Major
Total Kjedahl Nitrogen (TKN)	0.07 - 16.0	Minor	Major
BOD-biological oxygen demand(5-day)	1.0 - 7700	Minor	Minor
COD-chemical oxygen demand	7.0 - 2200	Minor	Minor
TSS-total suspended solids	1 - 36,200	Major	Major
TS-total solids	76 - 36,200	No	Major
pH	4.5 - 8.7	Minor	Minor
Conductance-uS/cm	*?	**?	**?
Alkalinity	8 - 1273	No	No
DO-dissolved oxygen	0 - 14.0	No	Major
Chloride	0.30 - 25,000	Major	Major
Diazinon	*?	Major	Major
Atrazine	*?	Major	Major
Total Phosphorus as P	0.01 - 7.3	No	Minor
Dissolved Phosphorus as P	0.0381 - 3.52	No	Minor
Fecal Coliform (per/100 ml)	0.2 - 1.9E6	Major	No

(Makepeace et al. 1995 and U.S. Geological Survey, 1996)
*Ranges of values have not been established for storm water runoff.
**Conductance is a physical parameter that is dependant upon the presence of ions in solution, therefore the cause of high conductance (inorganic acids, bases, and salts) could be the source of aquatic or human problems.

In 1983 the USGS conducted the Nationwide Urban Runoff Program (NURP) to examine the quality characteristics of urban runoff. Findings show that the metals, copper, zinc, and lead were 3 of the 13 metals on the EPA's priority pollutant list detected above water quality criteria and drinking water standards in 91% of the samples (Athayde et al., 1983). In addition, freshwater chronic exceedences were common for these three trace metals along with cadmium.

Copper is a major aquatic toxic metal in storm water. Its sources include wear of tires and brakes and weed control in detention ponds. Additional sources include parking areas, storage areas, loading docks, vehicle service areas, landscape areas, and metal finishing industries (Pitt et al., 1995). Copper exceeded freshwater chronic criteria in 82% of the samples collected in the NURP study and is considered the major toxic metal in urban runoff (Athayde et al., 1983).

Zinc, which exceeded freshwater chronic criteria in 77% of the NURP study samples, was found to be most commonly associated with suspended solids. However, Pitt et al. (1995) found zinc to be associated with dissolved sample portions with sources coming from roof runoff from galvanized roof drainage components. Moreover, Lopes and Fossum (1995) found dissolved zinc to be positively correlated with a high percentage of commercial land use (60%), undeveloped land use (52%), and impervious area (75%). Other sources of zinc include wear from tires and brake pads (Ward, 1990).

Sources of lead include emissions from gas-powered vehicles and tire wear, roof areas, parking areas, street runoff, and vehicle service areas (Pitt et al., 1995). Lead was found to exceed freshwater chronic criteria in 94% of the samples and acute criteria in 23% of the samples.

Cadmium in storm water is a concern for both drinking water and aquatic life. According to Morrison et al., (1984) cadmium tends to be elevated when higher levels of dissolved solids exist. Sources of cadmium include batteries, combustion, wear of tires and brakes, fertilizers and pesticides, metal finishing industrial discharges, and deterioration of galvanized pipes in streams (Makepeace et al., 1995, Pitt et al., 1995, and Clesceri et al., 1989). Mean storm water concentrations range from 0.0003 to 0.011 mg/L (Makepeace et al., 1995).

In addition to heavy metals, phosphorus and nitrogen found in storm water can contribute to water quality degradation in receiving waters. Nitrogen in storm water can be present as inorganic nitrogen, organic nitrogen, nitrate, nitrite, ammonia, and total kjeldahl nitrogen. Eutrophication and aquatic life are major nitrogen related concerns. Sources of nitrogen in storm water include fertilizers, industrial cleaning operations, animal feedlots, animal excrement, clogged septic systems, plowed native vegetation, and combustion of fossil fuels (Makepeace et al., 1995).

Phosphorus can be found in both absorbed and dissolved forms. Total phosphorus in storm water ranges between 0.01 to 7.30 mg/L (Makepeace et al., 1995). Soluble phosphorus in storm water has been found at concentrations ranging between 0.0381 to 3.52 mg/L. Sources of phosphorus include tree leaves, fertilizers, industrial wastes, detergents, and lubricants (Makepeace et al., 1995). Waschbusch et al., (1996) conducted a study in two urban residential basins in Madison, Wisconsin and found lawns and streets to be the largest sources of total and dissolved phosphorus contributing approximately 80% of the phosphorus loading. High phosphorus concentrations can result in water quality degradation and lake eutrophication.

Bacterial contaminants can also come from storm water. Total coliforms, fecal coliforms and fecal streptococci are indicator organisms that may be problematic in storm water. Total coliforms are not good indicators of human health risk if there are no sewage connections to the storm water collection system (Athayde et al. 1983). However, fecal coliforms also impact on storm sewer systems. Sources of fecal material on soil and pavement include dogs, cats, rodents, and birds. Additionally, Marino and Gannon (1991) found fecal coliforms have the ability to multiply in storm drains during warm, dry weather periods. Values of fecal coliforms in storm water can range from 0.2 to 1,900,000 CFU/100 ml. Fecal streptococci can also be found in storm water at ranges of 3.0 to 1,400,000 CFU/100 ml. Human fecal material in the storm water system is considered to be present if the fecal coliform/fecal streptococci ratio is greater than 4.0 (Makepeace et al., 1995).

Physical contaminants of storm water are another constituent of concern commonly found in storm water. By volume sediment is the world's largest water pollutant. Both dissolved and suspended solids can impact the quality of storm water. Total solids in storm water have mean concentration values between 481 and 1,440 mg/L (Makepeace et al., 1995). Total suspended solids in storm water have mean concentration that range between 4 and 1223 mg/L (Makepeace et al., 1995). According to the NURP final report, urban runoff control should be implemented when total suspended solids are high. Contaminants considered to be associated with suspended solids include organic chemicals and metals. Even without sorbed chemicals, sediment can harm waterways by filling them in, destroying habitat, and increasing turbidity.

Polychlorinated biphenyls, polycyclic aromatic hydrocarbons, halogenated aliphatics, halogenated ethers, phenol and cresols, phthalate esters, nitrosamines, and pesticides are organic contaminates that have been identified in storm water. Due to the large abundance of organics, the high cost of analyzing them, and the fact that many of these contaminants need to be samples through grab methods due to their incompatibility with the plastic tubing, this study focuses on two organic pesticides (Clesceri et al., 1989).

Atrazine, a triazine herbicide, has been found frequently in surface waters fed by storm water runoff, in both agricultural and urban environments. According to the Environmental Protection Agency (1999b) between 75-85 billion tons of atrazine are sold annually making it one of the most widely used pesticides. Additionally the NAWQA program reports that atrazine has been detected in about 75% of urban streams throughout the U.S. (Hamilton, 2000). Solomon et al. (1996) suggest exposure of atrazine to biota in pulses greater than 20 ug/L is possible in low order streams. Drinking water standards for atrazine are 3 ug/L and aquatic life criteria are set at 1.8 ug/L (USEPA, 1999a).

Diazinon is an orgranophosphate insecticide that can also enter waterways through storm water runoff. Amato (1992) found that diazinon was the major effluent toxicant in a 1992 analysis of a municipal wastewater treatment plant which triggered a survey of diazinon concentrations in municipal wastewaters showing that diazinon is a common contaminant. About eight million pounds of diazinon are used in the United

States annually. Drinking water standards are 0.6 ug/L and the aquatic life criterion is 0.06 ug/L (USEPA, 1999a).

CHAPTER 3

METHODS

Study Area

Denton, TX is located 30 miles north of Dallas, TX and has a population of 75,390. (Figure 1). Pecan Creek Watershed occupies 24.75 square miles located within Denton, TX (Figure 2). Average annual rainfall is approximately 34.7 inches.

Figure 1: Denton, TX.

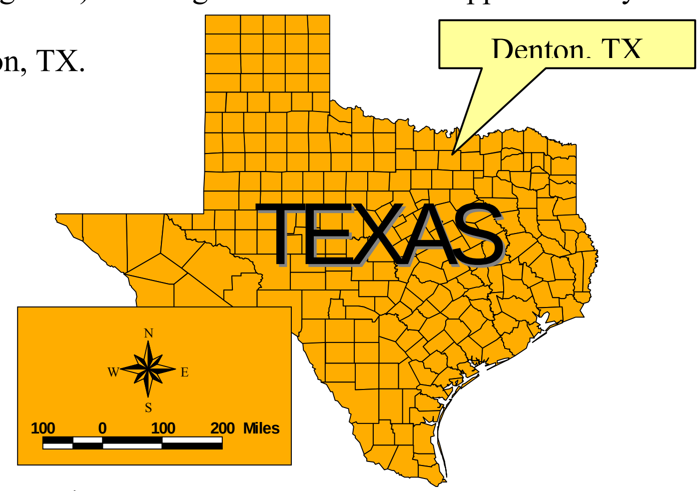
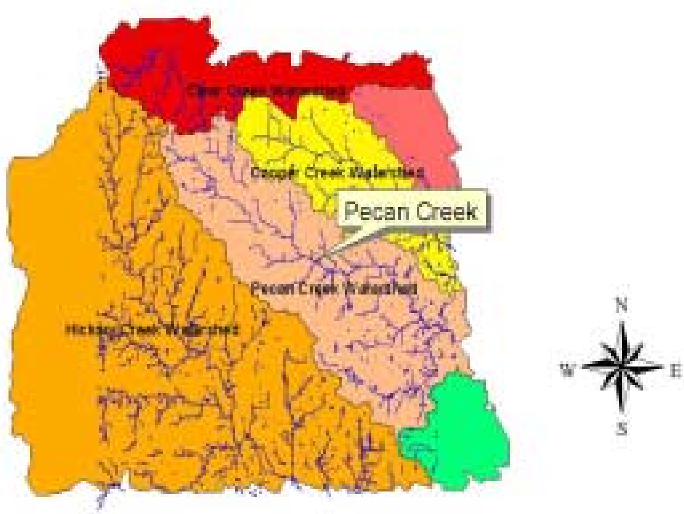


Figure 2: Pecan Creek.



Denton is a rapidly growing city with large development projects taking place. Poor construction practices as a result of the development are a potential pollution source to Pecan Creek. An additional by product of development is increased impervious surfaces. Large periods of drought could cause a buildup of pollutants on the impervious surfaces that get washed off in the spring.

Pecan Creek drainage through the city is largely concrete lined. However, a recent drainage project implemented a gunnite channel following the segment of concrete lined channel to improve water quality. After stretching through a portion of natural conditions Pecan Creek eventually discharges into Lake Lewisville that provides drinking water to many communities.

Many land uses have a probable influence on the water quality of the Pecan Creek watershed including agricultural, commercial, industrial, single-family residential, vacated/underused, multi-family, office, recreational, institutional, mobile home, transportation, and extra territorial jurisdiction (APPENDIX A). Upstream from the City of Denton land uses tend to be largely agricultural posing a potential source of contamination coming from pesticides and fertilizers. Single-family residential land uses however, have the largest potential to degrade water quality within the city. Additional contamination sources within the city could come from automobiles in high traffic areas.

Pecan Creek Storm Water Stations (PCSWS)

Pecan Creek Storm Water Stations were selected based on ease of installation, safety of automated sampler deployment and collection, and land use. To visualize the PCSWS's locations refer to APPENDIX A.

Pecan Creek Storm Water Station 1 (PCSWS1)

PCSW1 is located at the Pecan Creek Bridge at Gay Street (Figure 3). Drainage feeding this station is approximately 576 acres with the following land use composition: 80% vacated land, 9% agricultural land, 6% recreational land, and the remaining 5% is composed of commercial and single family residential buildings.

Figure 3: PCSWS1.

Pecan Creek Storm Water Station 2 (PCSWS2)

PCSWS2 is located at the Boliver St. Bridge between Panhandle St. and Ferguson St. (Figure 4). Drainage feeding this station is approximately 751 acres and is highly mixed in land use consisting of 67% vacated, 12% agricultural, 7% single-family residential, 9% recreational, and the final 5% comprising commercial, industrial, and institutional land uses.

Figure 4: PCSWS2.

Pecan Creek Storm Water Station 3 (PCSWS3)

PCSWS3 is located at the Frame St. Bridge near McKinney St. (Figure 5). Drainage feeding this station is approximately 867 acres with the following land use composition: 58% vacated, 14 % single family residential, 11% agricultural, 10.5% recreational, and the final 6.5% is composed of industrial, multi-family, institutional, and commercial land use.

Figure 5: PCSWS3.

Pecan Creek Storm Water Station 4 (PCSWS4)

PCSWS4 is located at the Mayhill Rd. Bridge between Morse St. and McKinney St. (Figure 6). Drainage feeding this station is approximately 1504 acres with the following land use composition: 50% vacated, 17% single family residential, 6% commercial, 7.5% recreational, 6.5% agricultural, and the final 13% composed of office, industrial, institutional, transportation, and multi-family land use.

Figure 6: PCSWS4.

Stormwater Samplers

Stormwater samplers were purchased from Global Water Inc., Sacramento, CA. Global Water samplers meet the requirements of the U.S. EPA Stormwater sampling program (40 CFR, 1992). A one-gallon glass first flush sample bottle along with a one-gallon glass time weighted second sample bottle assure that the guidelines were met. To ensure that proper chemical constituent testing was performed, all samples were transferred to glass bottles. Cross-contamination was eliminated because there was a separate intake tube for each bottle. Float switches prevented bottle overflow situations by automatically turning off the sample pump when the bottles reached full capacity (Global Water, 1997).

The Global Stormwater Sampler is enclosed in a rainproof expanded UV protected PVC case. Sample pumps are of peristaltic nature with a flow rate of 1000 ml per minute when the sampler pump elevation is four feet higher than the intake strainer elevation. A CMOS solid-state logic timer/controller is contained in epoxy. A solid-state water level sensor is included to engage the sampling pump. The two sampling pump hoses are nylon and 15 feet in length reinforced with ¼ inch polyethylene flexible tubing sections with an intake strainer to prevent clogging. Global Stormwater Samplers are powered via AH gel cell rechargeable batteries (Global Water, 1997).

Storm Event Sampling Procedure

To characterize the storm water in Pecan Creek four storm events were sampled using the Global Water Stormwater Sampler SS201 and analyzed for water chemistry constituents displayed in Table 1. Samplers were tested before the first rain event to ensure safety and sampling of the first flush. Composite sampling was set to pull 200 ml every 10-minutes to obtain a 3-hour and 20-minute storm event.

In addition to the storm water sampling one base flow background data collection through grab method was conducted. Base flow collection sites are located at PCSWS1, PCSWS4, and Sycamore St. Bridge. No flow conditions at base flow make it inadequate to sample at both PCSWS2 and PCSWS3 for background data (APPENDIX B).

Parameters

Storm event samples were analyzed for the water chemistry parameters listed in Table 2. All samples were analyzed through the following laboratories:

Denton Municipal Laboratory	Certes Environmental Laboratories
1100 Mayhill Rd.	2209 Wisconsin Street, Suite 200
Denton, TX 76208	Dallas, TX 75229
TRAC Environmental/Biomedical	University of North Texas
Chemistry and Toxicology	Environmental Sciences Aquatic
113 Cedar Street	Toxicology Lab
Denton, TX 76201	Denton, Texas 76203

Table 2: Water chemistry parameters to be analyzed and the method of analysis.

Parameter	Method Of Analysis
Chromium (Total and *Dissolved mg/L)	Standard Methods 3500-Cr-Atomic Absorption Method
Arsenic (Total and *Dissolved mg/L)	Standard Methods 3500-As Atomic Absorption Method
Cadmium (Total and *Dissolved mg/L)	Standard Methods 3500-Cd Atomic Absorption Method
Copper (Total and *Dissolved mg/L)	Standard Methods 3500-Cu Atomic Absorption Method
Lead (Total and *Dissolved mg/L)	Standard Methods 3500-Pb Atomic Absorption Method
Zinc (Total and *Dissolved mg/L)	Standard Methods 3500-Zn Atomic Absorption Method
Calcium (mg/L)	Standard Methods 3500-Ca Atomic Absorption Method
Magnesium (mg/L)	Standard Methods 3500-Mg Atomic Absorption Method
Sodium (mg/L)	EPA Method 200.7

Potassium (mg/L)	EPA Method 200.7
Sulfate (mg/L)	EPA Method 375.4
Fecal Coliform (colonies/100 ml)	City Of Denton Municipal Laboratory Water Bacteriology Quality Assurance Plan Fecal Coliform/Membrane Filter Procedure
Oil and Grease (mg/L)	EPA Method 413.1
Total Hardness (mg/L CaCO3)	Standard Methods 2340 Hardness by Calculation
Total Kjedahl Nitrogen (TKN) (mg/L)	EPA Method 351.3
BOD-biological oxygen demand (5-day) (mg/L)	EPA Method 405.1
COD-chemical oxygen demand (mg/L)	EPA/Hach #8000 Direct Measurement
TSS-total suspended solids (mg/L)	Total Non-Filterable Residue EPA Method 160.2
TS-total solids (mg/L)	Total Residue EPA Method 160.3
pH	Field Hydrolab DataSonde
Conductance-uS/cm	Field Hydrolab DataSonde
Alkalinity (mg/L CaCO3)	EPA Method 310.1 Titrametric (pH 4.5)
DO-dissolved oxygen (mg/L)	Field Hydrolab DataSonde
Chloride (mg/L)	Ion Selective Electrode Analysis w/Orion 901 Microprocessor
Ammonia (mg/L)	EPA Method 350.3
Diazinon (mg/L)	EPA Method 614
Atrazine (ppb)	RaPID Assay 96 well EnviroGard Plate kits (Method 4670)
Total Phosphorus as P (mg/L)	EPA Method 365.2
Dissolved Phosphorus as P (mg/L)	EPA Method 365.2

* Filtered using 0.045 micron filter.

Materials List

- 4 Global Water Stormwater Samplers (SS201) each consisting of the following:

Peristaltic pump with a flow rate of 1000 mL per minute at 4 ft head with a maximum lift of 22 ft, 9” L X 17” W X 22” H expanded UV protected PVC enclosure, ¼” polyethylene sample tubing with intake strainer, logic timer/controller: (CMOS solid state fully potted in epoxy, solid state water level sensor with a 15’ cable), rechargeable AH gel cell battery

- 8-1 gallon glass sample bottles (two for each sampler)
- 3/8”x 3” concrete anchor bolts
- ¼” concrete anchor bolts
- ¼” wing nuts
- 83/45 Abus padlocks
- ½” clear tubing
- Duct tape
- Sampler inside plate
- Sampler bracket
- Wall plate
- Equipment list
- Rotary hammer
- Gas powered generator
- Drill bits (1/4”-3/8”)
- Three pound sledge hammer
- Appropriate wrenches

Attaching the Bracket to the Sampler

Hoop's Machine Welding located at 600 Fort Worth Drive Denton, TX fabricated the sampler brackets. Sampler brackets consisted of a backing plate (Figure 7), inside plate (Figure 8), and wall plate (Figure 9). Backing plates are 14" length X 10" height with two 22.5" lengths of 1" steel square tubing welded at the top and bottom of the backing plate. Tubing was required for two reasons: first, there are two 3/8" holes drilled into each end to provide a location for a lock; second, it provides a mechanism to attach to the wall plate. Four bolt holes were drilled into the back of the sampler to provide a mechanism to attach to the inside plate which is cut 12" in length and 10" in height to the backing plate. By placing the inside plate inside the sampler in line with the bolt holes and the backing plate, bolts consisting of 4-1 ½" galvanized bolts with their respective washers and nuts were inserted into the holes to link the backing plate, sampler, and inside plate. To prevent water from seeping into the sampler, weather stripping was cut to fit the perimeter of the inside of the backing plate and attached (Figure 10).

Attaching the Wall Plate

Wall plates were attached using a rotary hammer with a 3/8" concrete bit powered by a gas generator. Wall plates were placed on the downstream side of concrete bridges to lessen the chance of debris hitting the sampler. The wall bracket was held into place while the concrete was bored out. 3/8" anchor bolts were hammered in to the four locations that are drilled. Lock tite was applied to the bolts before tightening them.

Figure 7: Backing plate.

Figure 8: Inside plate.

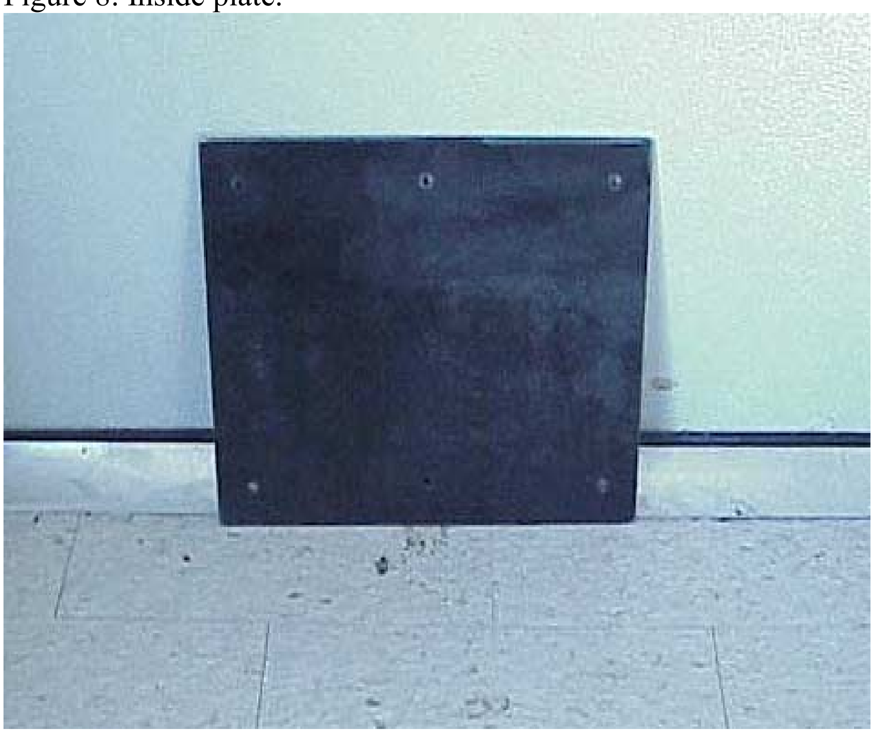


Figure 9: Wall plate.

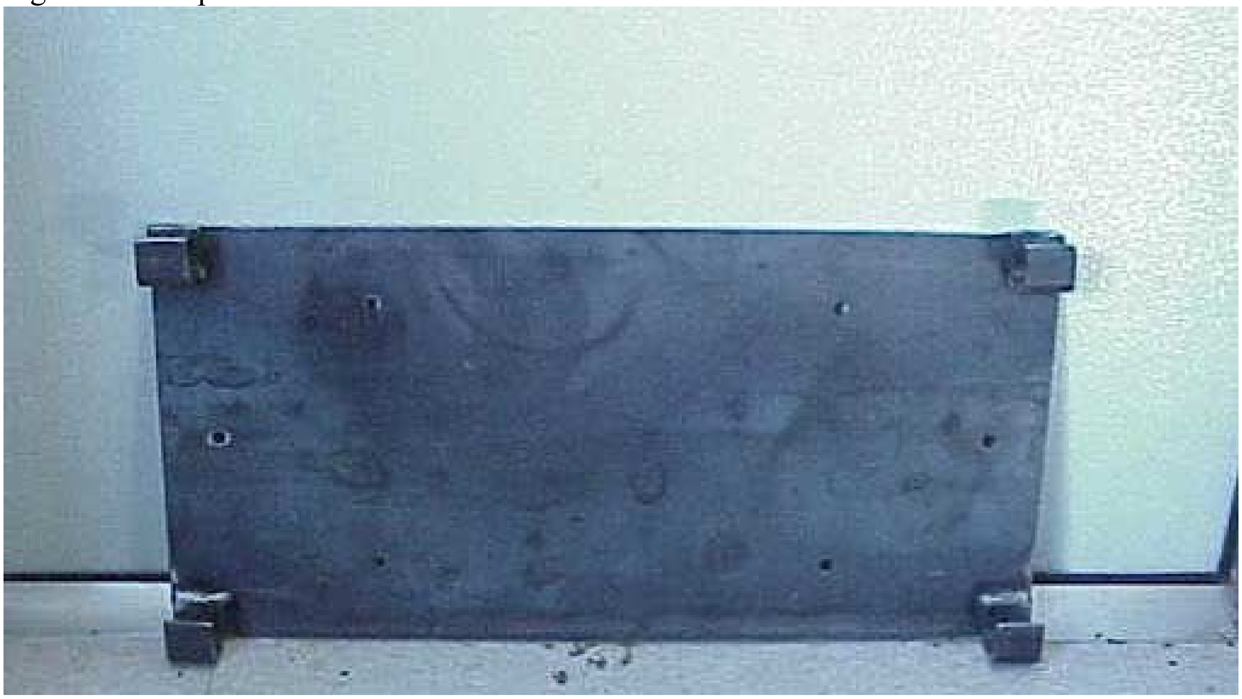


Figure 10: Sampler bracket attached to Global Water Sampler SS201.

Global Water Sampler Installation

The Global Water Samplers were installed upright to the wall plate to ensure that the samples were pumped properly. Each sampler was locked into place before a storm event using two padlocks. ¼" holes were drilled into the concrete, and ¼" anchor bolts were used to attach and guide the polyethylene tubing through plastic connectors. Connectors were used to attach over the anchor bolt which was tightened down with a ¼" wing nut. Intake structures were located just above the current stream height to catch the first flush. It must be noted that the stream height was lower than the natural stream height due to the relative drought conditions. Therefore, the height of the strainer needed to be manipulated with regard to the stream conditions before each storm event. Tubing was cut and reconnected using couplers to accommodate such a situation. Triggers were duct taped to the top of the strainer to ensure the sampler would not sample until the strainers were completely inundated. Ensuring that the trigger does not get activated by actual rainfall hitting the sensors, a ½" clear tubing was cut to the length of the trigger (approximately 2") then placed over the trigger and duct taped to the body of the sensor above the trigger. 3/32" holes were drilled into the tubing to ensure creek flow would enter the tubing to activate the trigger.

Precipitation Data

The City of Denton Water Plant supplied rainfall data. Both the duration and the total amount of rainfall were reported (APPENDIX P).

Flow Measurements

To determine instream loadings, flow measurements were calculated using Manning's roughness coefficient and stream channel slopes. Values were applied to the U.S. Army Corps of Engineers HEC1 hydraulic model to determine flow. A minimum flow calculation was made to estimate the first flush loading and a maximum flow was estimated from maximum stream gage height (APPENDIX Q). These calculations were applied to water chemistry parameter concentrations to estimate loadings.

Statistical Analysis

Visual comparisons were made between background sample analyses and storm water sample analyses. Histograms were generated to check normality of both first flush data and composite data. To compare first flush and composite sample concentrations, a Wilcoxon Signed Rank test was used to evaluate the null hypothesis that they are equal. To compare minimum loadings and maximum loadings a Wilcoxon Signed Rank test was used to evaluate the null hypothesis that they are equal. Spearman rank analysis was applied to explore associations between variables. Median comparisons were made to compare chemical concentration between storm events and station locations using Kruskal Wallis nonparametric analyses. The statistical procedures used in this study followed standard procedures for storm water analysis outlined in the North Texas Council of Government's (1999) Texas Nonpoint SourceBook.

CHAPTER 4

RESULTS AND DISCUSSION

Background Summary Statistics

Background data for each parameter were compiled from sampling stations PCSWS1, Sycamore St. bridge, and PCSW4 (APPENDIX B) to produce summary statistics computed through the SPLUS (October 1999) statistical software package: minimum, maximum, standard deviation, mean, median, 1st and 3rd quartile, total Number, and NA's (not analyzed). Statistical analyses from background data show the mean and median of each parameter to be unequal suggesting the data to be of non-normal distribution.

```
      ***  Summary Statistics for data in:  background.dataset ***

      $$$"Factor Summaries":
 Ammonia..mg.L.        Diazinon
 Length:        3   Length:        3
   Mode:character     Mode:character
 Atrazine..ppb.
 Length:        3
   Mode:character

      $$$"Numeric Summaries":
          Chromium..Total.mg.L. Arsenic..Total.mg.L.
     Min:           0.003000000          0.006000000
 1st Qu.:           0.005500000          0.007250000
    Mean:           0.007666667          0.008133333
  Median:           0.008000000          0.008500000
 3rd Qu.:           0.010000000          0.009200000
     Max:           0.012000000          0.009900000
 Total N:           3.000000000          3.000000000
   NA's :           0.000000000          0.000000000
Std Dev.:           0.004509250          0.001975686
          Cadmium..Total.mg.L. Copper..Total.mg.L.
     Min:          0.005000000               0.005
 1st Qu.:          0.005500000               0.008
    Mean:          0.007000000               0.011
  Median:          0.006000000               0.011
 3rd Qu.:          0.008000000               0.014
```

```
     Max:          0.010000000               0.017
 Total N:          3.000000000               3.000
   NA's :          0.000000000               0.000
Std Dev.:          0.002645751               0.006
          Lead..Total.mg.L. Zinc..Total.mg.L

     Min:        0.01000000        0.02000000
 1st Qu.:        0.01000000        0.03000000
    Mean:        0.01666667        0.03333333
  Median:        0.01000000        0.04000000
 3rd Qu.:        0.02000000        0.04000000
     Max:        0.03000000        0.04000000
 Total N:        3.00000000        3.00000000
   NA's :        0.00000000        0.00000000
Std Dev.:        0.01154701        0.01154701
          Chromium..Dissolved.mg.L.
     Min:               0.004000000
 1st Qu.:               0.005500000
    Mean:               0.007666667
  Median:               0.007000000
 3rd Qu.:               0.009500000
     Max:               0.012000000
 Total N:               3.000000000
   NA's :               0.000000000
Std Dev.:               0.004041452
          Arsenic..Dissolved.mg.L.
     Min:             0.0076000000
 1st Qu.:             0.0080000000
    Mean:             0.0082666667
  Median:             0.0084000000
 3rd Qu.:             0.0086000000
     Max:             0.0088000000
 Total N:             3.0000000000
   NA's :             0.0000000000
Std Dev.:             0.0006110101
          Cadmium..Dissolved.mg.L.
     Min:              0.004000000
 1st Qu.:              0.005000000
    Mean:              0.005333333
  Median:              0.006000000
 3rd Qu.:              0.006000000
     Max:              0.006000000
 Total N:              3.000000000
   NA's :              0.000000000
Std Dev.:              0.001154701
          Copper..Dissolved.mg.L.
     Min:             0.009000000
 1st Qu.:             0.012000000
    Mean:             0.015333333
  Median:             0.015000000
 3rd Qu.:             0.018500000
     Max:             0.022000000
 Total N:             3.000000000
   NA's :             0.000000000
Std Dev.:             0.006506407
          Lead..Dissolved.mg.L. Zinc..Dissolved.mg.L.
     Min:                  0.01            0.02100000
 1st Qu.:                  0.01            0.02900000
    Mean:                  0.01            0.06566667
  Median:                  0.01            0.03700000
```

```
 3rd Qu.:                 0.01            0.08800000
     Max:                 0.01            0.13900000
 Total N:                 3.00            3.00000000
   NA's :                 0.00            0.00000000
Std Dev.:                 0.00            0.06401042
         Calcium..mg.L. Magnesium..mg.L.
     Min:       48.67000         5.721000
 1st Qu.:       57.37000         7.598000
    Mean:       75.98000         8.398667
  Median:       66.07000         9.475000
 3rd Qu.:       89.63500         9.737500
     Max:      113.20000        10.000000
 Total N:        3.00000         3.000000
   NA's :        0.00000         0.000000
Std Dev.:       33.38692         2.333737
         Sodium..mg.L. Potassium..mg.L.
     Min:     45.100000         0.738000
 1st Qu.:     46.200000         2.743000
    Mean:     47.033333         4.199667
  Median:     47.300000         4.748000
 3rd Qu.:     48.000000         5.930500
     Max:     48.700000         7.113000
 Total N:      3.000000         3.000000
   NA's :      0.000000         0.000000
Std Dev.:      1.814754         3.222679
         Sulfate..mg.L.
     Min:       86.17000
 1st Qu.:      113.64000
    Mean:      131.69333
  Median:      141.11000
 3rd Qu.:      154.45500
     Max:      167.80000
 Total N:        3.00000
   NA's :        0.00000
Std Dev.:       41.62174
         Fecal.Coliform..coln..100.ml..
     Min:                       10.0000
 1st Qu.:                       40.0000
    Mean:                      697.7767
  Median:                       70.0000
 3rd Qu.:                     1041.6650
     Max:                     2013.3300
 Total N:                        3.0000
   NA's :                        0.0000
Std Dev.:                     1139.6975
         Oil.and.Grease..mg.L.
     Min:              0.500000
 1st Qu.:              0.950000
    Mean:              1.900000
  Median:              1.400000
 3rd Qu.:              2.600000
     Max:              3.800000
 Total N:              3.000000
   NA's :              0.000000
Std Dev.:              1.705872
         Total.Hardness..mg.L.CaCO3.
     Min:                  147.00000
 1st Qu.:                  178.50000
    Mean:                  228.66667
  Median:                  210.00000
```

```
 3rd Qu.:                   269.50000
     Max:                   329.00000
 Total N:                     3.00000
   NA's :                     0.00000
Std Dev.:                    92.42474
         Tota.Kjedahl.Nitrogen..mg.L.
     Min:                   0.2950000
 1st Qu.:                   0.4300000
    Mean:                   0.5013333
  Median:                   0.5650000
 3rd Qu.:                   0.6045000
     Max:                   0.6440000
 Total N:                   3.0000000
   NA's :                   0.0000000
Std Dev.:                   0.1830036
         BOD.5.day..mg.L. COD..mg.L. TSS..mg.L.
     Min:        2.7000000    8.00000   2.000000
 1st Qu.:        2.8250000   15.00000   3.000000
    Mean:        2.9500000   53.00000   4.666667
  Median:        2.9500000   22.00000   4.000000
 3rd Qu.:        3.0750000   75.50000   6.000000
     Max:        3.2000000  129.00000   8.000000
 Total N:        3.0000000    3.00000   3.000000
   NA's :        1.0000000    0.00000   0.000000
Std Dev.:        0.3535534   66.18912   3.055050
         TS..mg.L.          pH Temperature.C.
     Min: 445.00000 7.33000000     14.7600000
 1st Qu.: 501.50000 7.40500000     14.9650000
    Mean: 524.33333 7.43000000     15.0333333
  Median: 558.00000 7.48000000     15.1700000
 3rd Qu.: 564.00000 7.48000000     15.1700000
     Max: 570.00000 7.48000000     15.1700000
 Total N:   3.00000 3.00000000      3.0000000
   NA's :   0.00000 0.00000000      0.0000000
Std Dev.:  68.96618 0.08660254      0.2367136
         Conductance..us.cm. Alkalinity.mg.L.CaCO3.
     Min:            616.9000              143.28000
 1st Qu.:            616.9000              148.35500
    Mean:            692.4333              188.78667
  Median:            616.9000              153.43000
 3rd Qu.:            730.2000              211.54000
     Max:            843.5000              269.65000
 Total N:              3.0000                3.00000
   NA's :              0.0000                0.00000
Std Dev.:            130.8276               70.21335
          DO.mg.L. Chloride..mg.L.
     Min:  4.640000        58.20000
 1st Qu.: 10.480000        58.50000
    Mean: 12.426667        64.93333
  Median: 16.320000        58.80000
 3rd Qu.: 16.320000        68.30000
     Max: 16.320000        77.80000
 Total N:  3.000000         3.00000
   NA's :  0.000000         0.00000
Std Dev.:  6.743451        11.14690
         Total.Phosphorus..mg.L.
     Min:               0.0910000
 1st Qu.:               0.1380000
    Mean:               0.2070000
  Median:               0.1850000
```

```
 3rd Qu.:              0.2650000
     Max:              0.3450000
 Total N:              3.0000000
   NA's :              0.0000000
Std Dev.:              0.1284212
          Dissolved.Phosphorus..mg.L.
     Min:                  0.0850000
 1st Qu.:                  0.1285000
    Mean:                  0.1686667
  Median:                  0.1720000
 3rd Qu.:                  0.2105000
     Max:                  0.2490000
 Total N:                  3.0000000
   NA's :                  0.0000000
                    Std Dev.:                  0.0820508
```

Collection of the background samples took place during a period of more than 20 days without significant rainfall. Fortunately, this posed an opportunity to uncover stream effects upon constituents during dry conditions. Background median concentrations show that many of the constituent's exist in the channel during pre-storm conditions at concentrations below U.S. EPA Drinking Water Standards with the exception of arsenic (total) and cadmium (total).

Background samples show cadmium and arsenic concentrations exceeded the U.S. EPA Drinking Water Standards Maximum Contaminant Level (MCL). Median background concentrations for cadmium (total) were .006 mg/L compared to the MCL of .005 mg/L. Arsenic (total) background concentrations were .0085 mg/L, which is higher than the MCL of .005 mg/L. Detected metal concentrations may be representative of concentrations found in area soils.

Calcium, magnesium, sodium, potassium, and sulfate were all at notably high levels. Calcium with a median concentration of 66.07 mg/L and magnesium with a median concentration of 9.475 mg/L are both prominent occurring elements in nature as well as the North Texas region suggesting these high concentrations may be indigenous to the area. Sodium (median concentration of 47.3 mg/L), potassium (median concentration of 4.74 mg/L), sulfate (median concentration of 141.11 mg/L) and chloride (median concentration of 58.8 mg/L) are abundant as well in natural waters and may be at typical concentrations for the Denton area.

Total solids (median concentration of 558 mg/L) could be elevated from discharged loadings of solids during prior storm events. Total suspended solids are low (median concentration of 4.0 mg/L) probably due to the lack of mixing stemming from the dry period causing the suspended sediments to settle.

First Flush Summary Statistics

First flush data were gathered for every parameter from each storm location and each storm event to produce following summary statistics computed through the SPLUS statistical software package: minimum, maximum, standard deviation, mean, median, 1st and 3rd quartile, total Number, and NA's (not analyzed). Statistical analysis from first flush data shows the mean and median of each parameter to be unequal. Graphical exploratory data analysis through histogram plots (APPENDIX C) generated from the first flush data set show a non-Gaussian distribution for each parameter, with the majority of the plots being skewed to the right.

```
    ***  Summary Statistics for data in:  ffdataset ***

          Chromium..Total.mg.L. Arsenic..Total.mg.L.
     Min:           0.001000000           0.00220000
 1st Qu.:           0.006000000           0.00475000
    Mean:           0.011785714           0.01100000
  Median:           0.009000000           0.00860000
 3rd Qu.:           0.016250000           0.01675000
     Max:           0.028000000           0.02600000
 Total N:          96.000000000          96.00000000
```

```
   NA's :          82.000000000          82.00000000
Std Dev.:           0.008377429           0.00791979
         Cadmium..Total.mg.L. Copper..Total.mg.L.
     Min:           0.002000000          0.01100000
 1st Qu.:           0.004000000          0.02325000
    Mean:           0.005000000          0.02900000
  Median:           0.005500000          0.03000000
 3rd Qu.:           0.006000000          0.03675000
     Max:           0.006000000          0.04900000
 Total N:          96.000000000         96.00000000
   NA's :          82.000000000         82.00000000
Std Dev.:           0.001240347          0.01065544
         Lead..Total.mg.L. Zinc..Total.mg.L.
     Min:        0.01000000         0.0500000
 1st Qu.:        0.03000000         0.0760000
    Mean:        0.05214286         0.1692143
  Median:        0.04500000         0.1325000
 3rd Qu.:        0.06750000         0.2575000
     Max:        0.13000000         0.3450000
 Total N:       96.00000000        96.0000000
   NA's :       82.00000000        82.0000000
Std Dev.:        0.03285834         0.1056294
         Chromium..Dissolved.mg.L.
     Min:               0.006000000
 1st Qu.:               0.008000000
    Mean:               0.010642857
  Median:               0.010500000
 3rd Qu.:               0.012000000
     Max:               0.018000000
 Total N:              96.000000000
   NA's :              82.000000000
Std Dev.:               0.003499608
         Arsenic..Dissolved.mg.L.
     Min:               0.00070000
 1st Qu.:               0.00300000
    Mean:               0.01125714
  Median:               0.00695000
 3rd Qu.:               0.01765000
     Max:               0.03860000
 Total N:              96.00000000
   NA's :              82.00000000
Std Dev.:               0.01115063
         Cadmium..Dissolved.mg.L.
     Min:              0.002000000
 1st Qu.:              0.003000000
    Mean:              0.004571429
  Median:              0.004000000
 3rd Qu.:              0.005750000
     Max:              0.008000000
 Total N:             96.000000000
   NA's :             82.000000000
Std Dev.:              0.001827747
         Copper..Dissolved.mg.L.
     Min:             0.009000000
 1st Qu.:             0.011250000
    Mean:             0.015500000
  Median:             0.013500000
 3rd Qu.:             0.019250000
     Max:             0.029000000
 Total N:            96.000000000
```

```
   NA's :            82.000000000
Std Dev.:             0.005814438
          Lead..Dissolved.mg.L. Zinc..Dissolved.mg.L.
    Min:            0.00000000            0.01400000
 1st Qu.:            0.01000000            0.04225000
    Mean:            0.04642857            0.06314286
  Median:            0.02500000            0.06500000
 3rd Qu.:            0.05750000            0.07325000
    Max:            0.16000000            0.14400000
 Total N:           96.00000000           96.00000000
   NA's :           82.00000000           82.00000000
Std Dev.:            0.05300321            0.03245792
          Calcium..mg.L. Magnesium..mg.L.
    Min:       41.62000         2.424000
 1st Qu.:       50.81000         3.364000
    Mean:       67.52143         6.063357
  Median:       65.20500         4.851500
 3rd Qu.:       79.68250         8.085500
    Max:      111.60000        12.070000
 Total N:       96.00000        96.000000
   NA's :       82.00000        82.000000
Std Dev.:       20.45028         3.283688
          Sodium..mg.L. Potassium..mg.L.
    Min:      3.70000         1.404000
 1st Qu.:     19.20000         3.499750
    Mean:     30.43571         5.302571
  Median:     29.20000         5.302000
 3rd Qu.:     42.02500         7.307000
    Max:      67.00000         9.713000
 Total N:     96.00000        96.000000
   NA's :     82.00000        82.000000
Std Dev.:     17.59561         2.553178
          Sulfate..mg.L. Fecal.Coliform..coln..100.ml.
    Min:       11.00000                      1810.000
 1st Qu.:       29.68750                      7275.003
    Mean:       63.27786                     16853.587
  Median:       44.00000                     17280.435
 3rd Qu.:       74.00000                     24648.750
    Max:      182.80000                     35215.000
 Total N:       96.00000                        96.000
   NA's :       82.00000                        86.000
Std Dev.:       52.00992                     10989.430
          Total.Hardness..mg.L.CaCO3. Ammonia..mg.L.
    Min:                    45.01100       0.180000
 1st Qu.:                    55.72350       0.200000
    Mean:                    73.58479       1.020000
  Median:                    69.53750       0.300000
 3rd Qu.:                    89.75950       0.512500
    Max:                   123.67000       7.050000
 Total N:                    96.00000      96.000000
   NA's :                    82.00000      86.000000
Std Dev.:                    22.55864       2.127659
          Total.Kjedahl.Nitrogen..mg.L.
    Min:                       0.71600
 1st Qu.:                       1.06400
    Mean:                       1.74150
  Median:                       1.35500
 3rd Qu.:                       2.03250
    Max:                       3.54000
 Total N:                      96.00000
```

```
   NA's :                      92.00000
Std Dev.:                       1.24449
          BOD.5.day..mg.L. COD..mg.L. TSS..mg.L.
     Min:          3.80000    16.0000    52.0000
 1st Qu.:         19.70000   114.0000   100.5000
    Mean:         44.68182   239.7143   490.2143
  Median:         30.00000   165.0000   291.0000
 3rd Qu.:         73.90000   303.2500   525.5000
     Max:        107.60000   720.0000  2300.0000
 Total N:         96.00000    96.0000    96.0000
   NA's :         85.00000    82.0000    82.0000
Std Dev.:         34.46966   214.7085   614.2378
          TS..mg.L. Alkalinity..mg.L.CaCO3.
     Min:   923.000                20.89000
 1st Qu.:  1445.750               111.93750
    Mean:  2319.000               136.76300
  Median:  2425.000               131.34000
 3rd Qu.:  3298.250               188.06000
     Max:  3503.000               222.88000
 Total N:    96.000                96.00000
   NA's :    92.000                86.00000
Std Dev.:  1247.557                65.55824
          Chloride..mg.L. Diazinon..mg.L.
     Min:         0.00000       0.0000000
 1st Qu.:        16.95000       0.0000000
    Mean:        37.42857       0.1571429
  Median:        26.00000       0.0000000
 3rd Qu.:        58.00000       0.0000000
     Max:        95.00000       0.9000000
 Total N:        96.00000      96.0000000
   NA's :        82.00000      82.0000000
Std Dev.:        27.67305       0.3321591
          Total.Phosphorus..mg.L.
     Min:                0.140000
 1st Qu.:                0.563750
    Mean:                1.490571
  Median:                0.948500
 3rd Qu.:                1.465000
     Max:                5.380000
 Total N:               96.000000
   NA's :               82.000000
Std Dev.:                1.607968
          Dissolved.Phosphorus..mg.L. Atrazine..ppb.
     Min:                   0.1050000       0.560000
 1st Qu.:                   0.2290000       2.871000
    Mean:                   0.5997857       4.284857
  Median:                   0.6485000       5.313000
 3rd Qu.:                   0.9175000       5.594000
     Max:                   1.2000000       7.191000
 Total N:                  96.0000000      96.000000
   NA's :                  82.0000000      89.000000
Std Dev.:                   0.3922651       2.595409
```

All of the parameters analyzed were detected in the first flush samples. Metals summary statistics, both total and dissolved, showed median concentrations were at or below U.S. EPA MCL's except for cadmium (total) (>.005 mg/L) and arsenic (total) (>.005 mg/L). However, concentrations of the first flush samples do show that all metals are being washed off into the creek during storm events.

Fecal coliform and total suspended solids were washed into the creek at high levels during the first flush of the sampled storm events. Fecal coliform (median level of 17280.435 colonies/100 mL), a human health concern, was very high suggesting possible illicit wastewater discharges and large amounts of animal and bird feces entering the creek. Total suspended solids had a median concentration of 291 mg/L however the maximum median concentration was 2300 mg/L suggesting large amounts of debris buildup on the streets as well as possible cultivated native vegetation entering the waterways.

The pesticides diazinon and atrazine were found at exceeded water quality criteria levels during the first flush as well. Although the median concentration for diazinon is 0.00 mg/L the pesticide was detected at a maximum concentration of .9 mg/L, which is above the U.S. EPA aquatic life criteria of .06 ug/L. Aquatic life is also endangered for atrazine exposure (median concentration of 5.31 ppb) which exceeds aquatic life criteria of 1.8 ug/L). High levels of these pesticides found in the first flush may be due to the overuse and misuse.

Total phosphorus (median concentration of .9485 mg/L and maximum concentration of 5.38 mg/L) and dissolved phosphorus (median concentration of .6485 mg/L and maximum concentration of 1.2 mg/L) were other notable constituents. Sources such as tree leaves, branches, detergents, and fertilizers that buildup on paved and vegetative surfaces all could contribute to the elevated levels of nutrients resulting in possible water quality degradation and eutrophication.

Composite Summary Statistics

Composite data were gathered for every parameter from each storm location and each storm event to produce the following summary statistics computed through the SPLUS statistical software package: minimum, maximum, standard deviation, mean, median, 1st and 3rd quartile, total Number, and NA's (not analyzed). Statistical analysis from composite data shows the mean and median of each parameter to be unequal. Graphical exploratory data analysis through histogram plots (APPENDIX D) generated from the composite data set show a non-Gaussian distribution for each parameter with the majority of distributions being skewed to the right.

```
       ***  Summary Statistics for data in:  compdataset ***

          Chromium..Total.mg.L. Arsenic..Total.mg.L.
     Min:           0.002000000          0.002500000
 1st Qu.:           0.005250000          0.003900000
    Mean:           0.009785714          0.009064286
  Median:           0.008500000          0.008100000
 3rd Qu.:           0.012500000          0.011550000
     Max:           0.031000000          0.020400000
 Total N:          96.000000000         96.000000000
   NA's :          82.000000000         82.000000000
Std Dev.:           0.007180942          0.006126563
          Cadmium..Total.mg.L. Copper..Total.mg.L.
     Min:          0.001000000          0.01300000
 1st Qu.:          0.003000000          0.01725000
    Mean:          0.003642857          0.02742857
  Median:          0.003500000          0.02350000
 3rd Qu.:          0.005000000          0.03075000
     Max:          0.005000000          0.08300000
 Total N:         96.000000000         96.00000000
   NA's :         82.000000000         82.00000000
Std Dev.:          0.001277446          0.01802867
          Lead..Total.mg.L. Zinc..Total.mg.L.
     Min:        0.00000000        0.06400000
 1st Qu.:        0.02000000        0.07275000
    Mean:        0.04214286        0.14185714
```

```
  Median:        0.03000000        0.12800000
 3rd Qu.:        0.04750000        0.17450000
     Max:        0.13000000        0.30600000
 Total N:       96.00000000       96.00000000
   NA's :       82.00000000       82.00000000
Std Dev.:        0.03866594        0.07922981
         Chromium..Dissolved.mg.L.
     Min:               0.002000000
 1st Qu.:               0.005250000
    Mean:               0.008571429
  Median:               0.007000000
 3rd Qu.:               0.011750000
     Max:               0.016000000
 Total N:              96.000000000
   NA's :              82.000000000
Std Dev.:               0.004362679
         Arsenic..Dissolved.mg.L.
     Min:              0.002200000
 1st Qu.:              0.003200000
    Mean:              0.008292857
  Median:              0.005050000
 3rd Qu.:              0.010200000
     Max:              0.029200000
 Total N:             96.000000000
   NA's :             82.000000000
Std Dev.:              0.007918767
         Cadmium..Dissolved.mg.L.
     Min:              0.002000000
 1st Qu.:              0.002250000
    Mean:              0.003714286
  Median:              0.003500000
 3rd Qu.:              0.004000000
     Max:              0.008000000
 Total N:             96.000000000
   NA's :             82.000000000
Std Dev.:              0.001728876
         Copper..Dissolved.mg.L.
     Min:             0.001000000
 1st Qu.:             0.008250000
    Mean:             0.012857143
  Median:             0.010500000
 3rd Qu.:             0.017000000
     Max:             0.029000000
 Total N:            96.000000000
   NA's :            82.000000000
Std Dev.:             0.008282114
         Lead..Dissolved.mg.L. Zinc..Dissolved.mg.L.
     Min:            0.00000000            0.00200000
 1st Qu.:            0.01000000            0.03325000
    Mean:            0.03792857            0.07221429
  Median:            0.02000000            0.06050000
 3rd Qu.:            0.03825000            0.08575000
     Max:            0.14000000            0.24100000
 Total N:           96.00000000           96.00000000
   NA's :           82.00000000           82.00000000
Std Dev.:            0.04594389            0.06098824
         Calcium..mg.L. Magnesium..mg.L.
     Min:       20.32000          1.60000
 1st Qu.:       31.65000          2.13425
    Mean:       37.91643          2.97250
```

```
  Median:       36.72000          2.73150
 3rd Qu.:       44.08000          3.40400
     Max:       57.76000          6.05300
 Total N:       96.00000         96.00000
   NA's :       82.00000         82.00000
Std Dev.:       10.92208          1.27178
          Sodium..mg.L. Potassium..mg.L.
     Min:       4.50000         2.164000
 1st Qu.:      14.12500         2.819000
    Mean:      24.71429         4.236143
  Median:      18.65000         4.056500
 3rd Qu.:      40.12500         5.404750
     Max:      48.10000         7.745000
 Total N:      96.00000        96.000000
   NA's :      82.00000        82.000000
Std Dev.:      15.49183         1.678556
          Sulfate..mg.L. Fecal.Coliform..coln..100.ml.
     Min:        9.39000                       3046.60
 1st Qu.:       12.67250                       3440.00
    Mean:       39.51500                       9838.99
  Median:       26.50000                       3850.00
 3rd Qu.:       49.80750                       5580.00
     Max:      126.00000                      46560.00
 Total N:       96.00000                         96.00
   NA's :       82.00000                         86.00
Std Dev.:       35.36578                      13936.95
          Total.Hardness..mg.L.CaCO3. Ammonia..mg.L.
     Min:                    21.93200       0.150000
 1st Qu.:                    33.81800       0.232500
    Mean:                    40.88893       0.659000
  Median:                    39.26500       0.425000
 3rd Qu.:                    49.38350       0.640000
     Max:                    62.74200       2.190000
 Total N:                    96.00000      96.000000
   NA's :                    82.00000      86.000000
Std Dev.:                    11.73798       0.659856
          Total.Kjedahl.Nitrogen..mg.L.
     Min:                      1.080000
 1st Qu.:                      1.132500
    Mean:                      1.717500
  Median:                      1.240000
 3rd Qu.:                      1.825000
     Max:                      3.310000
 Total N:                     96.000000
   NA's :                     92.000000
Std Dev.:                      1.066876
          BOD.5.day..mg.L. COD..mg.L. TSS..mg.L.
     Min:         15.40000    72.0000    83.0000
 1st Qu.:         22.30000   107.0000   178.0000
    Mean:         29.65538   169.4286   319.2143
  Median:         24.00000   130.0000   226.0000
 3rd Qu.:         29.30000   151.5000   456.2500
     Max:         59.80000   676.0000   764.0000
 Total N:         96.00000    96.0000    96.0000
   NA's :         83.00000    82.0000    82.0000
Std Dev.:         13.60524   150.7641   197.3654
          TS..mg.L. Alkalinity..mg.L.CaCO3.
     Min:  292.0000                 34.8200
 1st Qu.:  337.7500                 62.6900
    Mean:  541.7500                117.2633
```

```
  Median:  496.0000                 86.5600
 3rd Qu.:  700.0000                121.5800
     Max:  883.0000                379.0900
 Total N:   96.0000                 96.0000
   NA's :   92.0000                 87.0000
Std Dev.:  273.1976                104.1428
         Chloride..mg.L. Diazinon..mg.L.
     Min:        0.00000       0.0000000
 1st Qu.:        7.38250       0.0000000
    Mean:       23.03000       0.3357143
  Median:       12.15000       0.0000000
 3rd Qu.:       24.25000       0.2250000
     Max:       89.00000       3.4000000
 Total N:       96.00000      96.0000000
   NA's :       82.00000      82.0000000
Std Dev.:       25.50083       0.9017992
         Total.Phosphorus..mg.L.
     Min:               0.204000
 1st Qu.:               0.894750
    Mean:               1.982643
  Median:               1.320000
 3rd Qu.:               2.337500
     Max:               5.750000
 Total N:              96.000000
   NA's :              82.000000
Std Dev.:               1.706406
         Dissolved.Phosphorus..mg.L. Atrazine..ppb.
     Min:                  0.1040000       0.270000
 1st Qu.:                  0.2935000       1.560000
    Mean:                  0.6686429       2.640500
  Median:                  0.6850000       1.929500
 3rd Qu.:                  0.9200000       4.297750
     Max:                  1.6200000       5.190000
 Total N:                 96.0000000      96.000000
   NA's :                 82.0000000      90.000000
Std Dev.:                  0.4467132       2.001246
```

All of the constituents were detected in the composite samples suggesting a possible continual discharge of the pollutants throughout the sampling. However, most of the constituents were at or below U.S. EPA drinking water standards. Arsenic (total) was the only toxic metal to exceed the U.S. EPA MCL of .005 mg/L.

Notable concern for contamination comes from fecal coliform, total suspended solids, diazinon, atrazine, total phosphorus, and dissolved phosphorus. Fecal coliform (median concentration of 3850.00 colonies/100 mL and maximum concentration of 46560.00 colonies/100 mL) shows a continual contribution of animal and bird feces with possible additional runoff contributions from illicit wastewater discharges throughout the sampling event. Total suspended solids (median concentration of 226 mg/L and maximum concentration of 764 mg/L) indicate a continual loading of sediments to the creek. Potential eutrophication problems and water quality degradation come from total phosphorus (median concentration of 1.32 mg/L) and dissolved phosphorus (median concentration of 1.32 mg/L). Aquatic life and human health concern come from elevated levels that were above U.S. EPA drinking water standards for diazinon (maximum concentration of 3.40 mg/L) and atrazine (median concentration of 1.92 ppb and maximum concentration of 5.19 ppb). Detected levels of phosphorus and pesticides may indicate the lack of filtering of these constituents in the stream channel particularly the concrete lined portion.

Field and Grab Sample Summary Statistics

Field and grab sample data were gathered for every parameter from each storm location and each storm event to produce the following summary statistics computed through the SPLUS statistical software package: minimum, maximum, standard deviation, mean, median, 1st and 3rd quartile, total Number, and NA's (not analyzed). Statistical analysis from field and grab sample data shows the mean and median of each parameter to be closer to equal than the composite and first flush samples. Graphical exploratory data analysis through histogram plots (APPENDIX E) generated from the field and grab sample data set show a non-Gaussian relationship of each parameter however, the plots are only slightly skewed to the right.

```
***  Summary Statistics for data in:  swphysicaldataset ***

          Oil.and.Grease..mg.L.         pH
     Min:                     0  7.3000000
 1st Qu.:                     0  7.7550000
    Mean:                     0  7.9293333
  Median:                     0  7.8500000
 3rd Qu.:                     0  7.9750000
     Max:                     0  8.7600000
 Total N:                    96 96.0000000
   NA's :                    92 81.0000000
Std Dev.:                     0  0.4137713
          Temperature.© Conductance..us.cm. DO..mg.L.
     Min:      15.06000            164.0000  5.480000
 1st Qu.:      16.45500            235.8500  6.665000
    Mean:      18.27400            292.0933  7.777333
  Median:      18.23000            286.0000  7.870000
 3rd Qu.:      19.65000            334.3000  8.645000
     Max:      21.70000            556.0000 11.030000
 Total N:      96.00000             96.0000 96.000000
   NA's :      81.00000             81.0000 81.000000
Std Dev.:       2.21706             92.6850  1.455656
```

All of the physical parameters did not seem to have a negative influence from storm water. However, the data may be erroneous due to the method of analysis and sampling that was conducted through a grab and field measurement protocol. Most of the sampling and analysis was not conducted at peak flow due to the dynamics and time of occurrence of storm events.

Comparison Between Background, First flush, and Composite Medians

Figure 11 shows that the first flush median concentrations were higher than the composite and background levels for Copper (total), Lead (total), Zinc (total), Chromium (dissolved), Lead (dissolved), and Zinc (dissolved). Arsenic (dissolved), Cadmium (dissolved), and Copper (dissolved) background median concentrations were higher than both first flush and composite median concentrations. Chromium (total) and Arsenic (total) had similar median concentrations for all samples. Cadmium (total) had a lower composite median concentration than either first flush or background sample medians.

These findings suggest storm water as a potential source of metals contamination to the creek. Copper, lead, chromium, and zinc buildup on paved surfaces and is washed off during the first flush and throughout the storm event. Potential sources of metals are; galvanized pipes, wear of tires and brakes, fertilizers, pesticides, and metal finishing industries.

Figure 11: First flush, composite, and background median comparison concentrations from all storms and all stations for metals.

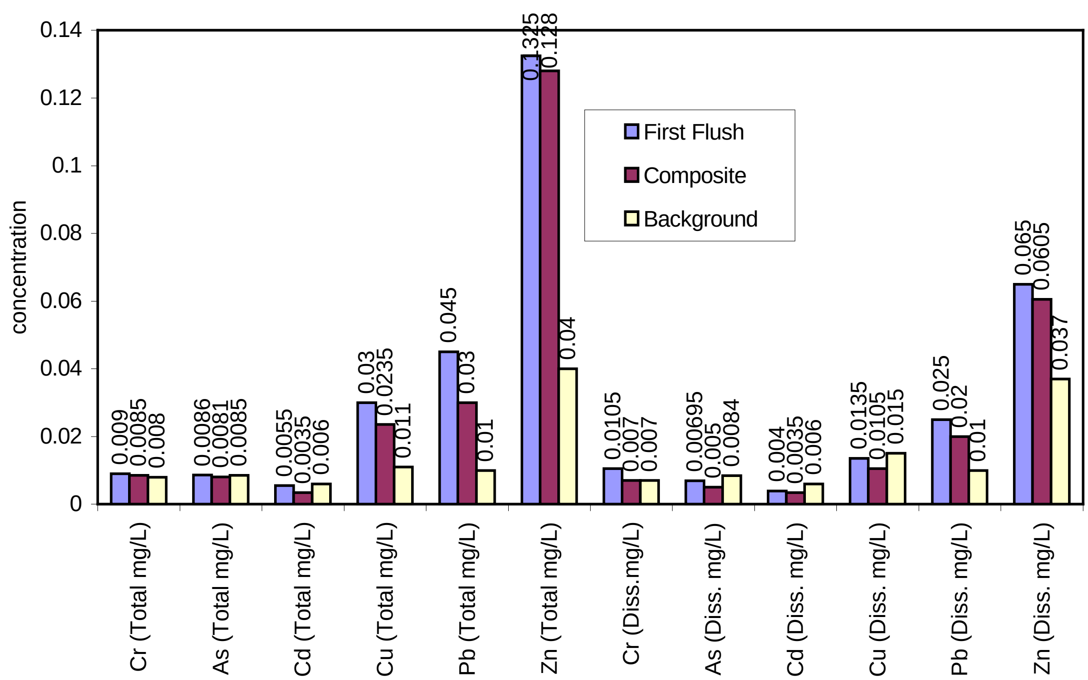


Figure 12 shows the first flush median concentrations to be consistently higher than the composite median concentrations for all of the constituents. Interestingly, background median concentrations were higher than first flush median concentrations and for composite concentrations for all of the constituents. Collection of grab samples was performed under no flow conditions following a drought period of more than 20 days. Upon grab sampling for background data there was a strong hydrogen sulfide odor emitting from each sampling location indicating decomposition of organic matter was taking place under reducing conditions so bacteria were reducing sulfate while consuming organic matter. High background levels of the elements calcium, magnesium, sodium, potassium, and chloride could be a result of natural occurrences indigenous to the area and a lack of mixing from wet weather.

Figure 12: First flush, composite, and background median concentrations from all storms and all stations for calcium, magnesium, sodium, chloride, potassium, sulfate, total hardness, and alkalinity.

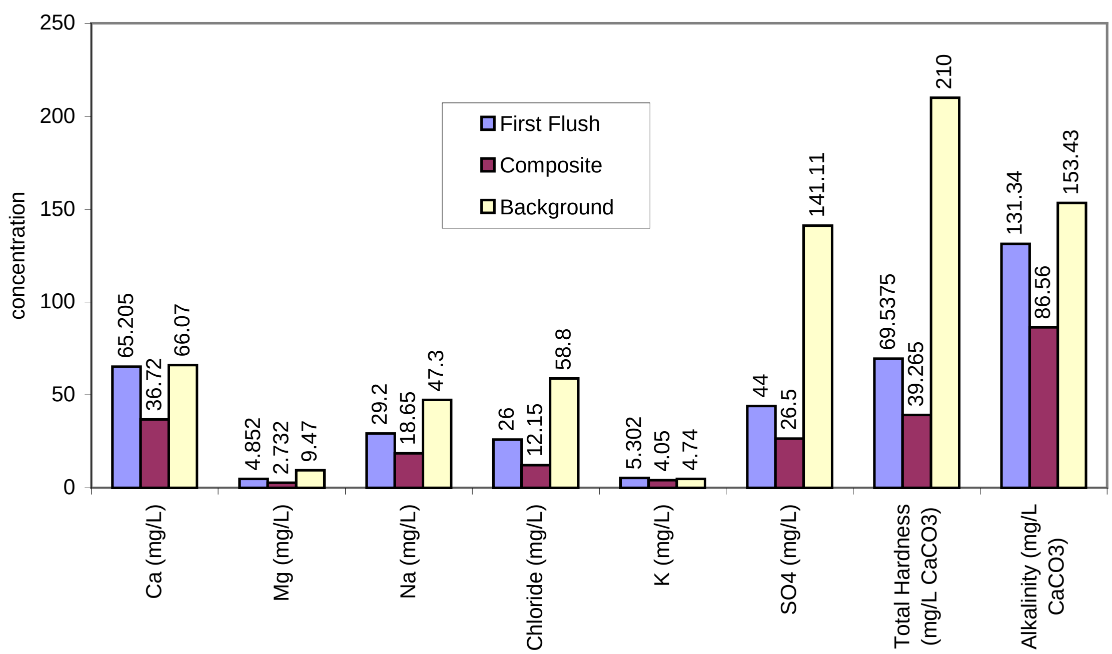
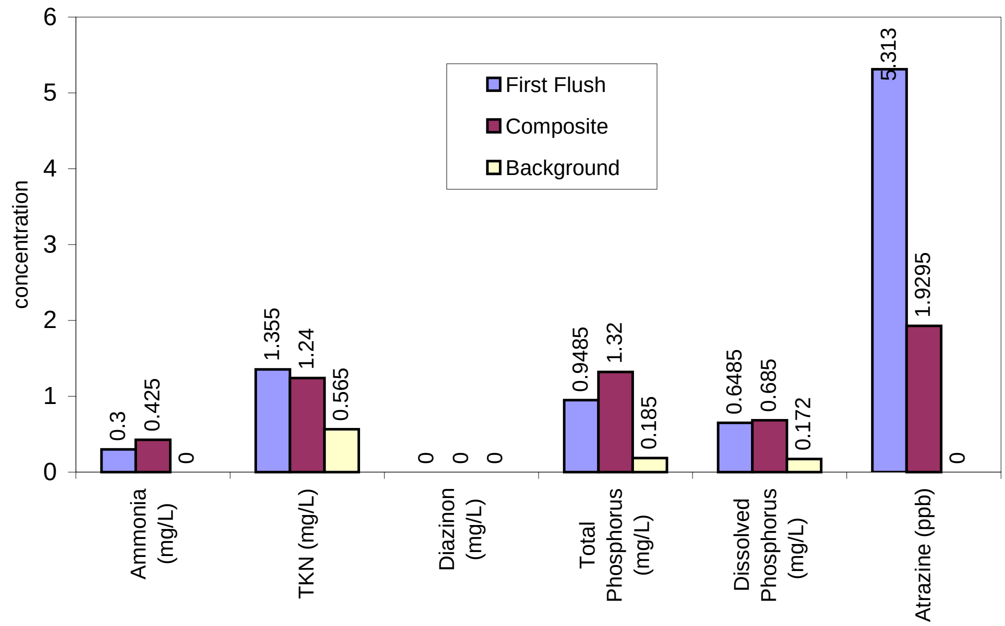


Figure 13 shows higher first flush median concentrations for total kjeldhal nitrogen and for atrazine than for composite samples. Atrazine values were higher than the drinking water standards of 3 ug/L, which have an impact on the receiving water bodies that supply drinking water. In addition, aquatic life criteria standards for atrazine of 1.8 ug/L were exceeded which may adversely impact aquatic life if subject to these pulses of atrazine on a regular basis. Values for ammonia, dissolved phosphorus, total phosphorus was slightly higher for composite samples than for first flush values and background samples suggesting a continual flush of nutrient from sources such as tree leaves, organic matter, and fertilizers. Such high levels of nutrients could potentially cause eutrophication and water quality degradation at the receiving water body.

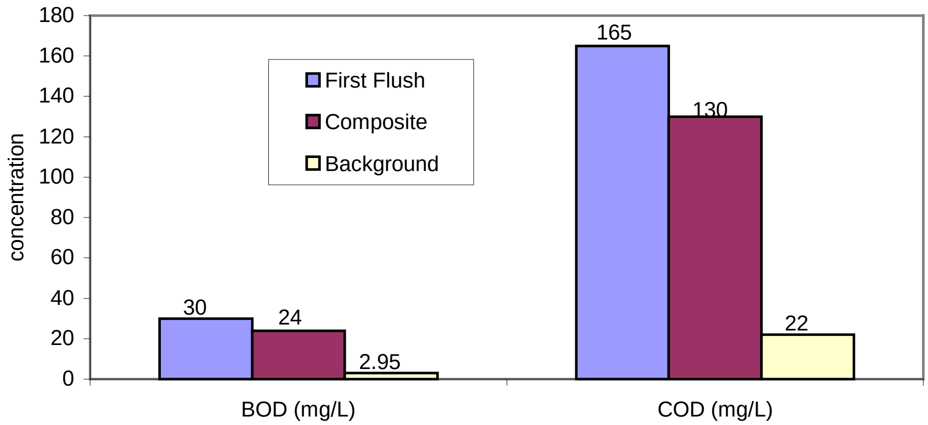
Figure 13: First flush, composite, and background median concentrations from all storms and all stations for ammonia, total kjeldhal nitrogen, diazinon, total phosphorus, dissolved phosphorus, and atrazine.



NOTE: Diazinon samples were below detection limits for a majority of the samples thus the medians are represented as zero. Atrazine and ammonia were not analyzed in background samples.

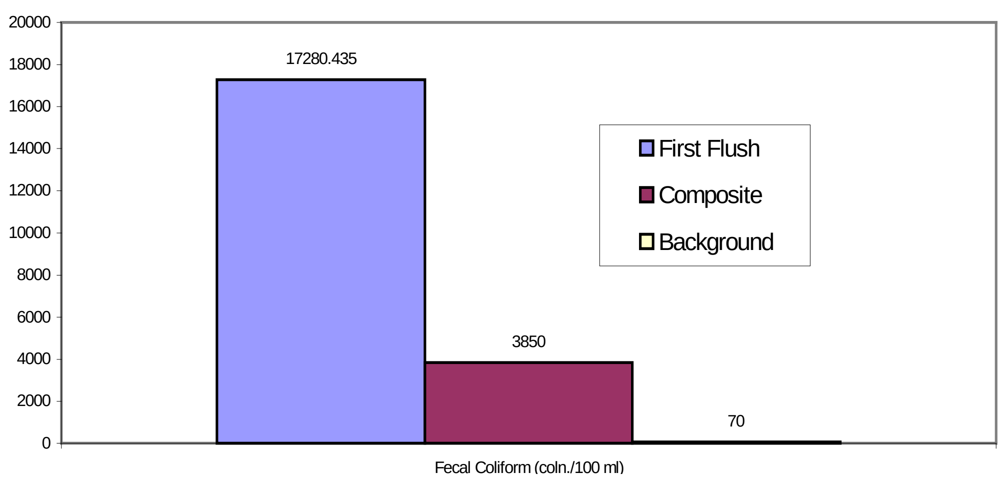
Figure 14 shows median concentrations of BOD and COD to be highest for first flush samples and lowest for background samples. BOD concentrations in the storm water samples could be related to high organic wastes or over enrichment of nutrients. COD concentrations in storm water could be associated with higher carbon dioxide levels produced from decaying organic matter found in the sediments and nutrients captured by the sampler.

Figure 14: First flush, composite, and background median concentrations from all storms and all stations for biological oxygen demand and chemical oxygen demand.



Fecal Coliform (Figure 15) was much higher in the first flush compared to either the composite or the background sample median concentrations. High fecal coliform concentrations in storm water are typically the result of animal feces or possible illicit wastewater discharges. Higher first flush values could be a result of buildup of fecal matter on pavement over a period of time.

Figure 15: First flush, composite, and background median concentrations from all storms and all stations for fecal coliform.



For total solids and total suspended solids (Figure 16), first flush samples had higher median concentrations than composite samples or background samples. Higher levels of total solids and total suspended solids in storm water compared to background samples are result of dirt and debris washed off of the roads during the rain event. Background samples analyzed for total suspended solids were found to have a median of 4 mg/L. However, the total solids show a higher median concentration for background than for composite samples potentially due to higher water levels or a pooling affect could have caused a settling of the suspended sediments and dissolving of the sediments throughout the composite sampling. In addition, much of the sediment may have been washed off in the initial runoff leaving the composite sample with lower amounts of solids captured.

Figure 16: First flush, composite, and background median concentrations from all storms and all stations for total suspended solids and total solids.

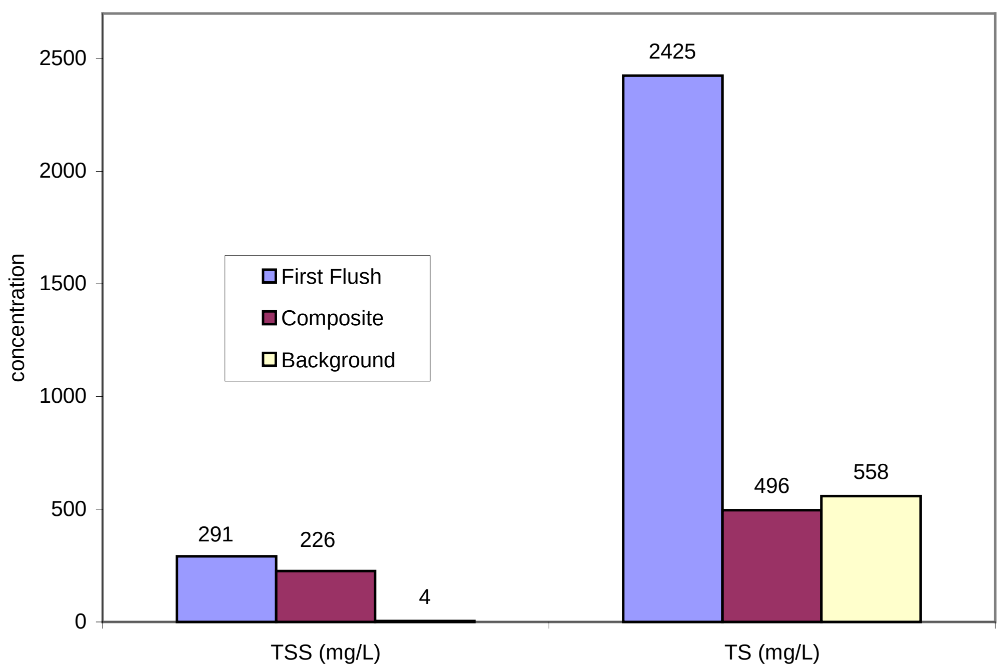
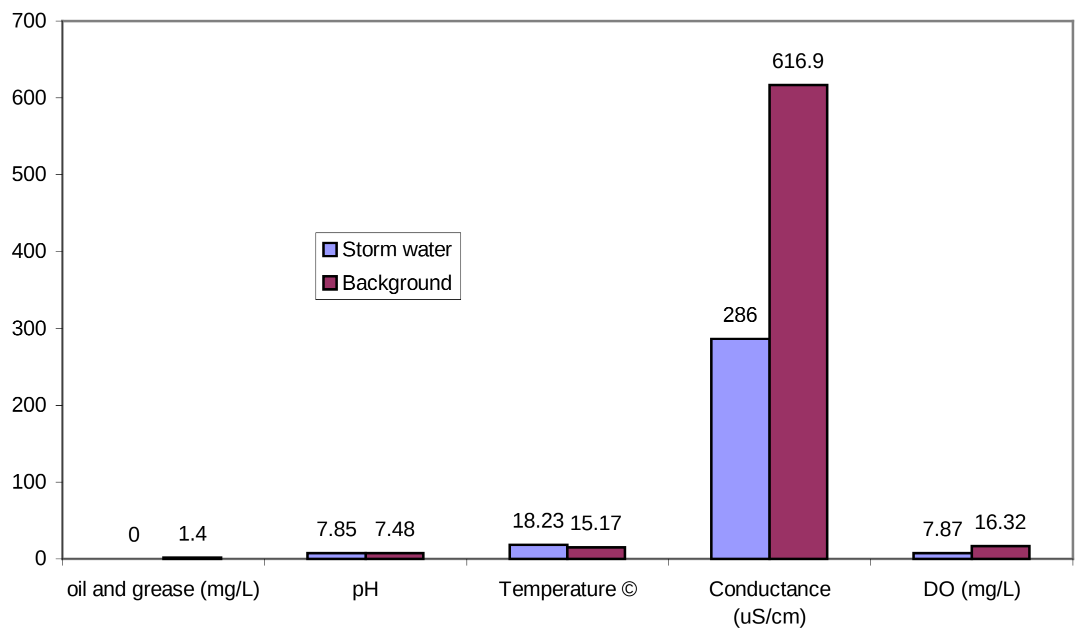


Figure 17 shows conductivity and dissolved oxygen to be higher in background samples than storm water samples. Higher levels of good conductors such as sodium and chloride in found background samples compared to storm water samples could explain the higher conductivity values in the background samples. The higher dissolved oxygen levels in background could be a result of lower suspended solids and organic matter that would promote the consumption of dissolved oxygen. Temperature and pH were slightly higher in storm water samples. Oil and grease was found to be 0 mg/L in storm water samples however, lab reporting limits for storm water were >5 mg/L therefore any value found below the 5 mg/L will not be reported as having any oil and grease.

Figure 17: Median concentrations from all storms and all stations of constituents calculated in the field including pH, conductivity, dissolved oxygen and temperature. Oil and grease samples were taken through the grab method then analyzed at the lab.



First Flush Versus Composite Samples

Analysis of first flush concentrations versus composite concentrations was performed by applying a Wilcoxon signed rank test using the SPLUS statistical software package (APPENDIX F). The number of pairs = 16. Results revealed significant differences (p-value ≤ .05) at 95% confidence for cadmium (total), calcium, magnesium, hardness, and chloride. Table 3 shows the first flush medians to be more concentrated than the composite medians for these constituents, suggesting the initial runoff (first flush) to be of higher concentration than runoff that contributed to the composite sample concentration. This is primarily due to the buildup of the constituents on paved surfaces that is released during the initial runoff during the storm event.

Table 3: Median concentrations of first flush and composite samples for cadmium (total), calcium, magnesium, total hardness, and chloride.

	Median First Flush Concentration (mg/L)	Median Composite Concentration (mg/L)
Cd (T)	0.006	0.004
Ca	65.205	36.720
Mg	4.852	2.732
TH	69.538	39.265
Cl	26.000	12.150

Minimum Loading Versus Maximum Loading

Analysis of minimum loading versus maximum loading was performed by application of Wilcoxon signed rank test using SPLUS statistical software package (APPENDIX G). Minimum loading is the minimum discharge based loading using the first flush concentrations. Maximum loading is the maximum discharge based loading using composite concentrations. Tests revealed all of the samples to be significant (p-value ≤ .05) at 95% confidence except for diazinon, total solids, and total kjeldhal nitrogen. Table 4 shows the medians of the minimum loadings to be much lower than the maximum loadings. Potential error exists however, because the composite sample includes 200ml of first flush sample and the Global Water sampler is not equipped to grab a separate flow-weighted sample during maximum discharge rate. The higher loadings in column two are primarily due to the much larger discharge rate because the concentrations in column 2 are lower than concentrations in column 1.

Table 4: Median minimum loadings and median maximum loadings for each constituent.

	Median Min. Loadings (lbs/day)	Median Max. Loadings (lbs/day)
Cr (T)	0.670487141	3.463
As (T)	0.880083488	3.260
Cd (T)	0.380461467	1.631
Cu (T)	2.290968172	13.243
Pb (T)	4.883478893	12.811
Zn (T)	10.37732522	67.990
Cr (D)	1.133185034	3.347
As (D)	0.823038542	2.832
Cd (D)	0.647534305	1.523
Cu (D)	1.513646501	3.929
Pb (D)	3.008682594	5.232
Zn (D)	5.502207523	30.121
Ca	8500.845891	17394.959
Mg	777.8548993	1402.688
Na	4087.886656	9784.759
K	664.1434196	2040.757
SO4	6797.57282	12269.922
FC	5.99661E+12	8.02216E+12
TH	9589.524269	19406.372
NH4	45.24540767	170.46054
TKN	127.8292271	1395.9424
BOD	3618.510594	11684.099
COD	17412.86851	58541.8697
TSS	19004.19324	116414.843
TS	188651.0067	384250.977
ALK	10153.95178	34970.7363
Cl	4275.29616	8738.80018
Diaz	0	0

Total P	81.84560662	440.028
Diss P	45.3166127	222.030
Atraz	286.4196782	1608.888

Correlation Between Storm Water Constituents

A Spearman rank correlation matrix was computed for the first flush data (APPENDIX H) and the composite data (APPENDIX I), using Minitab software package (Ryan et al, 1992) to identify if any of the storm water constituents were correlated at 95% confidence. First flush correlations revealed copper (total) to be positively associated with each of zinc (total), arsenic (dissolved), and negatively correlated with sodium and sulfate. Chromium (total) was associated with total suspended solids, and BOD with each of COD and total suspended solids. In addition, calcium was correlated with each of magnesium and hardness. Other correlations included, magnesium with each of total hardness, chemical oxygen demand, and total suspended solids, and ammonia with each of alkalinity, chloride, and atrazine.

Positive associations of the metals could be a result of influence from the wear of automobile parts. An increase in total suspended solids could promote the decaying of organic matter, which may explain its positive association with BOD and COD. Ammonia is negatively correlated with chloride and alkalinity but positively correlated with atrazine. Applications of fertilizers and pesticides at the same time may be responsible for the positive correlation.

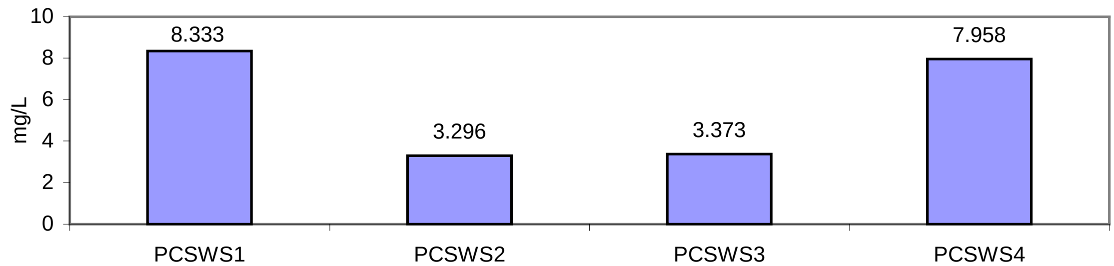
Composite correlations revealed associations of copper (total) with each of copper (dissolved), calcium, and alkalinity. Magnesium was correlated with each of potassium, sulfate, and hardness. Zinc was associated with calcium, total hardness, alkalinity, total phosphorus, and dissolved phosphorus. Chromium (dissolved) was associated with each of ammonia and total phosphorus.

Magnesium can be found with sulfate in the form of magnesium sulfate. Other correlations found in the composite samples may be suggestive of the dynamics of storm water. Throughout a storm event many of these constituents are continually running off into the creek due to a number of sources that may be located near one another and contain the correlated composite sample constituents.

Analysis of Storm Water Locations and Events

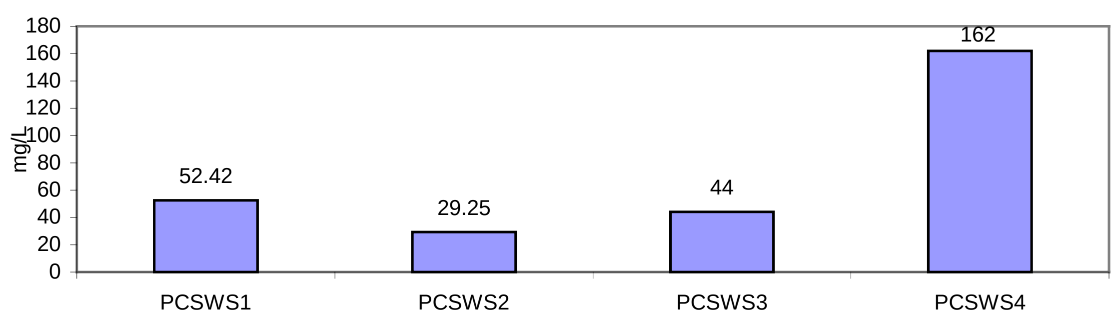
Analysis of significant differences between locations and between events was conducted by applying the Kruskal-Wallis statistical test using the SPLUS statistical software package. First flush concentrations of magnesium, potassium, sulfate, and zinc (total) were significantly different between stations (p-value $\leq .05$) at 95% confidence (APPENDIX J). (Figure 18) shows PCSWS1 and PCSWS4 had the highest median magnesium concentrations. Both locations are within natural drainage conditions compared to PCSWS2 and PCSWS3, which are encompassed by concrete lined drainage. Thus, the natural magnesium content in the soils could have contributed to the higher levels at these stations. During the concrete lined portion of the creek the storm water is not in contact with soils that contain magnesium. Additional contributions to the magnesium concentrations at PCSWS1 And PCSWS4 may come from a pooling effect or slowing down of the storm water that occurs in naturally lined creeks compared to the imperviousness of a concrete lined creek causing the storm water to flash through the channel.

Figure 18. First flush median concentrations of magnesium between station locations.



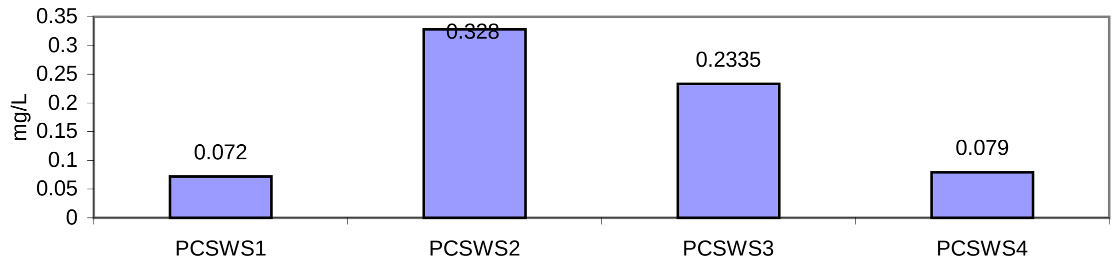
Median first flush concentrations for sulfate highest in PCSWS4 (Figure 19). Drainage area for PCSWS4 is 1504 acres of which 17% comes from single-family residents causing a potential source to be fertilizers that contain sulfur. PCSWS4 is a larger naturally vegetated portion of the creek located furthest downstream. During the first flush the sulfate concentrations may have rushed through the concrete portion of the creek and settled out in the larger drainage area of PCSWS4 when the sampling occurred. Moreover, background concentrations for sulfate were higher at PCSWS4 compared to PCSWS1 before sampling occurred which ultimately contributing to higher concentrations during the first flush at PCSWS4.

Figure 19: First flush median concentrations of sulfate between station locations.



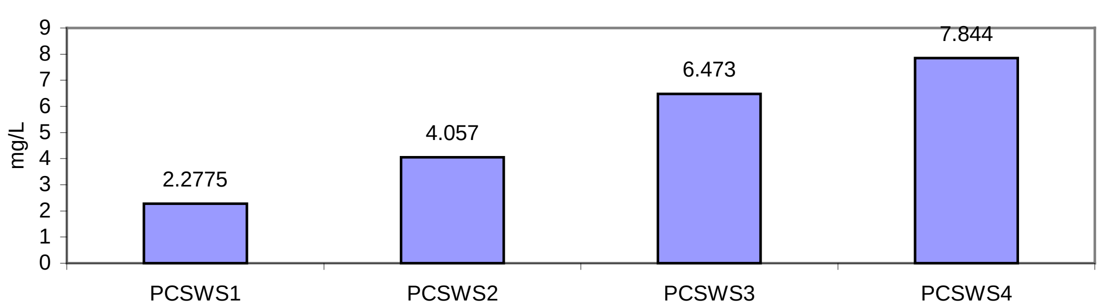
Median first flush concentrations for zinc (total) (Figure 20) were highest in PCSWS2 and PCSWS3. Both locations are concrete lined and are located in the highest traffic areas suggesting the most probable source to be wear from tires and brakes. When the runoff reaches PCSWS4 the zinc levels drop suggesting a possible settling of zinc mineral by adsorbing to sediment that settles out in the surrounding natural drainage area.

Figure 20. First flush median concentrations of zinc (total) between station locations.



Median first flush concentrations for potassium (Figure 21) show an increasing trend downstream. Probable cause could be from the accumulation of contributions of potassium from each location. The percentage of single-family residential land uses increase proportionally to the first flush concentrations of potassium suggesting the main source of the constituent could be from fertilizers. However, additional contributions of insecticides and soaps from each location in the creek could also be potential sources of potassium.

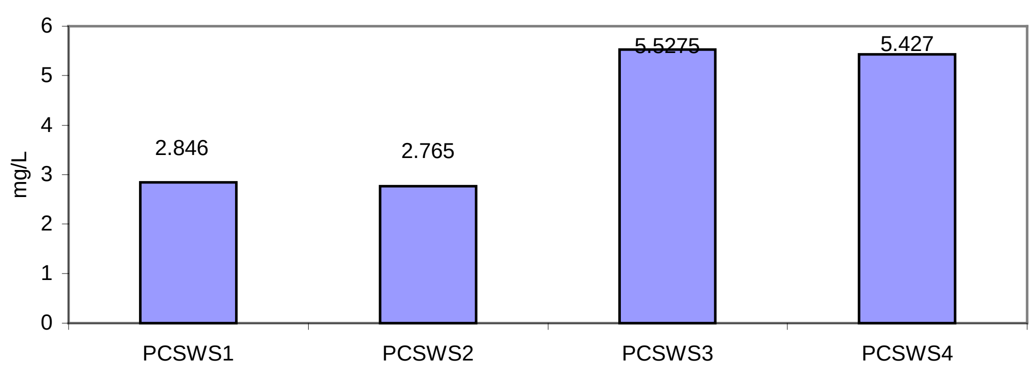
Figure 21: First flush median concentrations of potassium between station locations.



First flush concentrations between storm events were not significantly different for any constituent (p-value ≤ .05) at 95% confidence (APPENDIX K). This indicates a lack of seasonal variation and suggests all of the constituents could be detected at similar levels in the first flush samples during the months sampling took place. Additional cause may be attributed to large variances in first flush concentrations among stations causing insignificant differences in median concentrations between storms.

Composite potassium concentrations differed between station locations (p-value ≤ .05) at 95% confidence (APPENDIX L). Potassium concentrations were highest at PCSWS3 and PCSWS4 (Figure 22). Single-family residential units make up a combined 198.8 acres that feed these two locations compared to 54.2 acres for PCSWS1 and PCSWS3. As a result, fertilizers applied by these residents could be the main source of higher potassium levels at these locations. No other constituents differed significantly between station locations

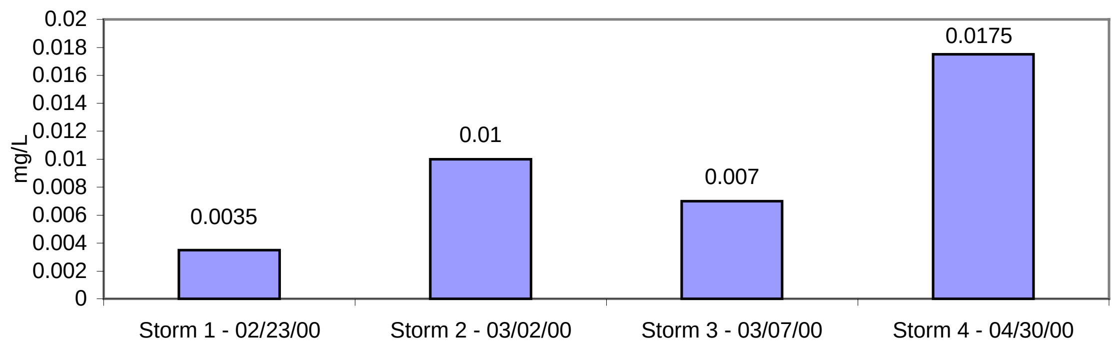
Figure 22. Composite median concentrations of potassium between station locations.



Arsenic (total), cadmium (total), chromium (dissolved), copper (dissolved), sodium, and ammonia differed between storm events (p-value ≤ .05) at 95% confidence

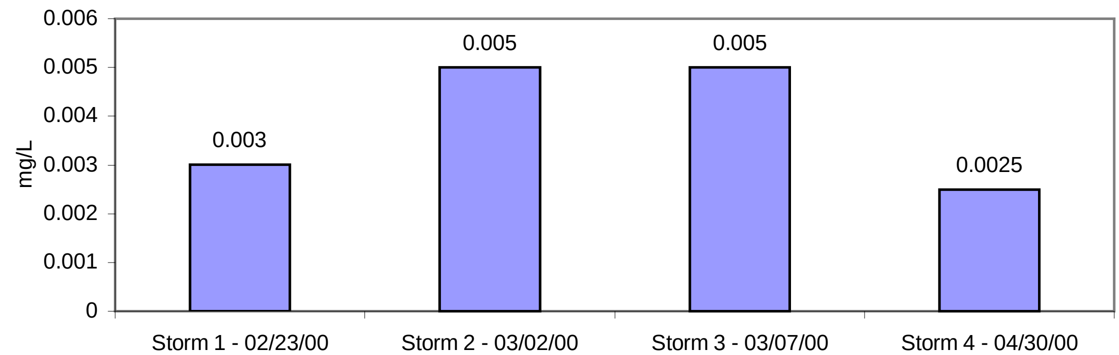
(APPENDIX M). Median composite concentrations for arsenic (total) (Figure 23) show the storm occurring on 04/30/00 to have the highest concentrations. Pesticides are a potential source given the event took place near the beginning of spring when applications are more prevalent. Storm 4 also had the largest rainfall total compared to the other storms, which caused a higher discharge and may have promoted more arsenic the wash off into the creek. Improper industrial discharges containing arsenic may have contributed to the higher levels as well.

Figure 23. Composite median concentrations of arsenic (total) between storms.



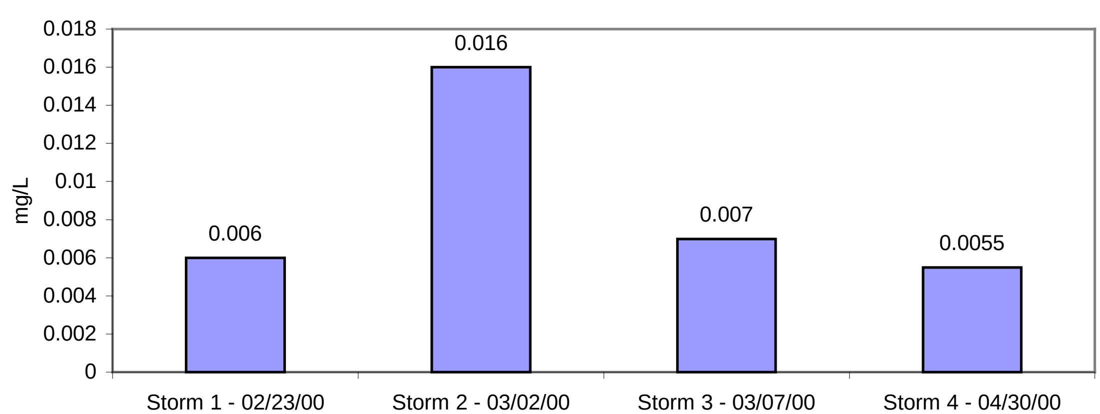
Median composite concentrations for cadmium (total) (Figure 24) show storms occurring on 03/03/00 and 03/07/00 to be highest. Both storm events had lower rainfall totals producing lower discharge levels. As a result the composite samples were more concentrated but produced lower loadings. Average cadmium (total) loadings from storms 2 and 3 were 1.442 compared to 2.667 for storms 1 and 4. Possible contributions from increased automobile usage during these storms promoting the wear of tires and brake pads may have added to the cadmium concentrations as well. In addition, pesticides containing cadmium could have been applied before storms 2 and 3 contributing to higher concentrations.

Figure 24. Composite median concentrations of cadmium (total) between storms.



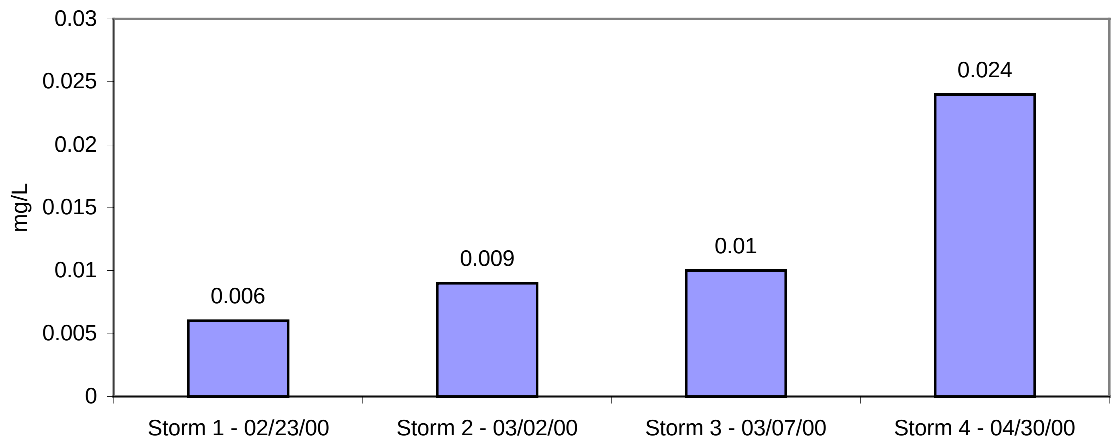
Median composite concentrations for chromium (dissolved) (Figure 25) are highest for the storm event occurring on 03/02/00. Lower discharge levels during this storm may have promoted a higher concentration of dissolved chromium due to lack of mixing in the creek. Chromium captured by storm 2 may have been a result of carry over from the chromium contributions that were washed from storm 1 that occurred 7 days prior. A source of chromium is the wear of bushings and bearings on automobiles suggesting that storm 2 may have had increase automobile usage. Other possible sources include increased applications of chromium containing fertilizers or pesticides could have contributed to higher levels during storm 2.

Figure 25. Composite median concentrations of chromium (dissolved) between storms.



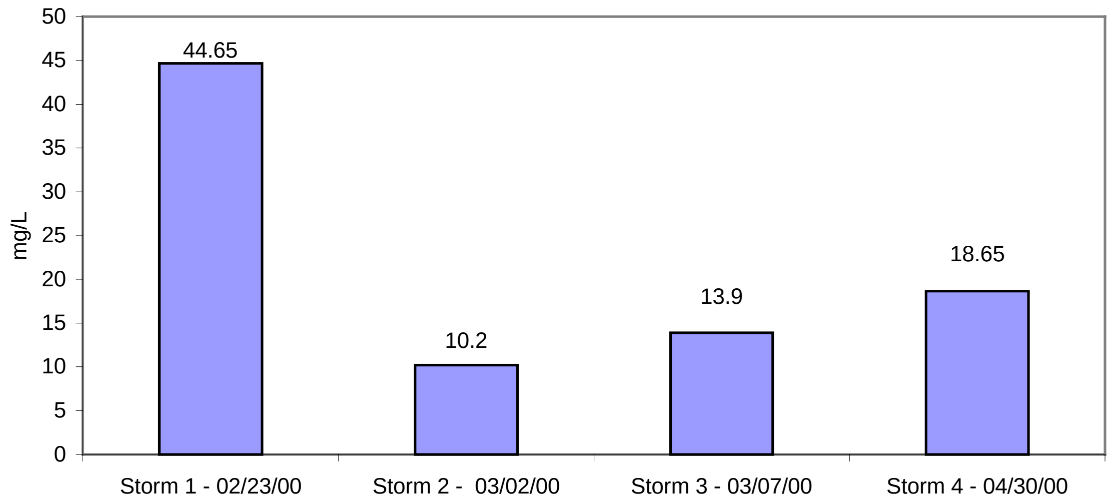
Median composite concentrations for copper (dissolved) (Figure 26) are highest for the storm event occurring on 04/30/00. Rainfall was the highest for storm 4 that may have allowed for more copper to be washed off into the creek. Inputs from of spring applications of copper containing pesticides or fungicides or brake wear from increased vehicular traffic during this period may have contributed to higher levels of dissolved copper.

Figure 26. Composite median concentrations of copper (dissolved) between storms.



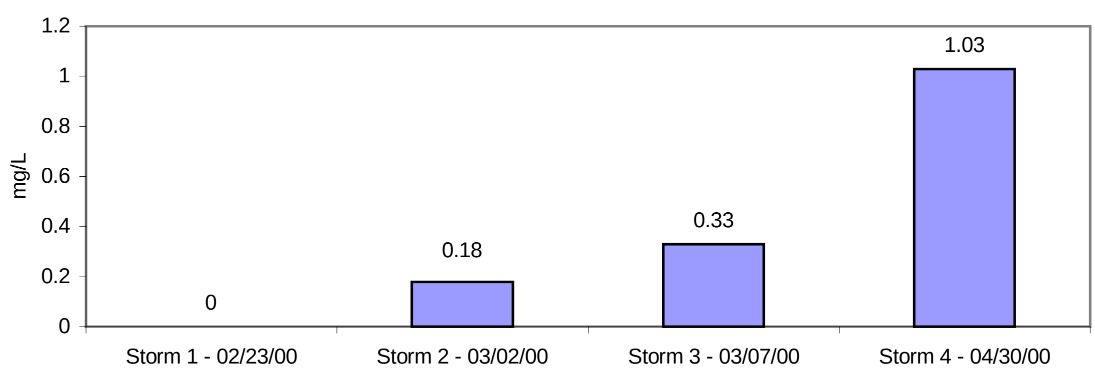
Median composite concentrations for sodium (Figure 27) are highest for the storm event occurring on 02/23/00. Storm 1 occurred after a drought period of more than 25 days. Background levels before the storm were already to be higher than the first flush and composite samples thus, storm 1 one was probably largely influenced by these existing levels of sodium. Additional concentrations of sodium could have been influenced by the buildup of salts on the pavement during the dry period that were washed of during storm 1.

Figure 27. Composite median concentrations of sodium between storms.



Median composite concentrations for ammonia (Figure 28) are highest for the storm event occurring on 04/30/00. Storm 4 had the highest rainfall amount allowing more ammonia to be washed off into the creek. Additionally, higher discharge levels as a result of more rainfall could allow for other nitrogen forms such as organic nitrogen, to convert to ammonia during the storm. Spring fertilizer applications may have contributed to the higher levels of ammonia as well.

Figure 28. Composite median concentrations of ammonia between storms.



NOTE: ammonia was not analyzed in storm 1 samples.

Effectiveness of the Global Water Stormwater Sampler SS201

The Global Water Stormwater Sampler SS201 functioned properly 14 out of 16 times for an 87.5% effectiveness rate. Error was primarily due to battery failure. Battery malfunctions can be alleviated by charging after each storm event and before a storm in which the sampler has been unused for and extended period of time.

Deployment of the samplers was very easy and safe. Being able to deploy the samplers at bridges and overpasses made the samplers very hard to be vandalized. Additionally, with the possibility of before storm creek levels changing during rainy seasons and drought periods the samplers are easy to retrofit the intake hoses accordingly allowing for the sensors to trigger the sampler to begin capturing storm water.

A problem associated with the sampler is the inability to effectively calculate flow-weighted loadings without the use of a flow meter. Moreover, the sampler does not provide an internal clock to record the start time of the sampling, which would be useful for analysis of time-weighted composite samples.

Difficulty in using the Global Water sampler can also occur in selecting the constituents to analyze for. Since there is limited volume the samplers can pull there is a limit to the number of constituents one can test for. During this study more parameters could not have been selected due to this lack of volume in the sampling containers. Consideration of the numbers of constituents and the volume needed for analysis of the chosen constituents should be calculated before sampling occurs.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Summary

The Global Water Stormwater Sampler SS201 was used to characterize the urban runoff in Pecan Creek. Location of the samplers was influenced by land use and ease of installation. Determination of the constituents for analysis was modeled after those used in the NPDES permit for seven cities within the Dallas\Ft.Worth metroplex. Metals, the class of chemicals that are the greatest concern, were found to exceed U.S. EPA MCL's. Arsenic (total) and cadmium (total) exceeded the U.S. EPA MCL in both background and first flush samples. In the composite sample arsenic (total) was found to exceed its MCL.

Additional elevated concentrations come from atrazine and diazinon that were found to exceed aquatic life and drinking water standards in both the first flush and composite samples. Total and dissolved phosphorus, total suspended solids, and fecal coliforms were also found at elevated levels as a result of storm water runoff in both first flush and composite samples.

Statistical analysis revealed first flush samples to be significantly more concentrated than composite samples. Minimum discharge loadings were found to be significantly lower than maximum discharge loadings as a result of higher loadings. Additionally there were significant differences of specific constituents between station locations and storm events. Statistical analysis of first flush samples showed significant difference between station locations for magnesium, sulfate, zinc, and potassium.

Statistical analysis of composite samples showed significant difference between stations for potassium. Statistical analysis of composite samples also showed significant differences between storms for arsenic (total), cadmium (total), chromium (dissolved), copper (dissolved), sodium, and ammonia.

Conclusions

Storm water continues to be a major challenge in this country. Many municipalities are required under NPDES to monitor their storm water discharges. Many municipalities however are not required under current law to permit their discharges but may have a potential problem with storm water runoff and its adverse impacts on receiving water bodies. A goal of this was to identify sampling locations, install samplers, and collect and analyze the urban storm water runoff in Pecan Creek.

The first hypothesis that Pecan Creek first flush and composite storm water samples were the same in concentrations and loadings was rejected. Cadmium (total), calcium, magnesium, hardness, and chloride were found to be more concentrated in the first flush compared to the composite samples. All of the constituents were found to have significantly different loadings with composite based maximum discharge loadings being higher than the first flush based minimum discharge loadings.

The second hypothesis that Pecan Creek contaminant concentrations of both first flush and composite samples will not be different between storms was rejected for some composite sample constituents. Composite median concentrations for arsenic (total), cadmium (total), chromium (dissolved), copper (dissolve), sodium, and, ammonia were all found to be different between storm events. Conversely, first flush concentrations were not found to be different between storm events, which accepts the null hypothesis.

First flush contaminant concentrations and composite contaminant concentrations between station locations were found to reject the third null hypotheses that they were not different for several constituents. First flush analysis showed differences between stations for magnesium, sulfate, zinc, and potassium. Composite analysis showed potassium to be different between stations.

A secondary purpose of the study was to evaluate the storm water sampling ability of Global Water Stormwater Sampler SS201, which was ideal to initiate a storm water-monitoring program. The Global Water sampler was easy to install at 4 bridges located within Pecan Creek. The samplers were easy to program and very reliable. Malfunctions were most likely due to operator error.

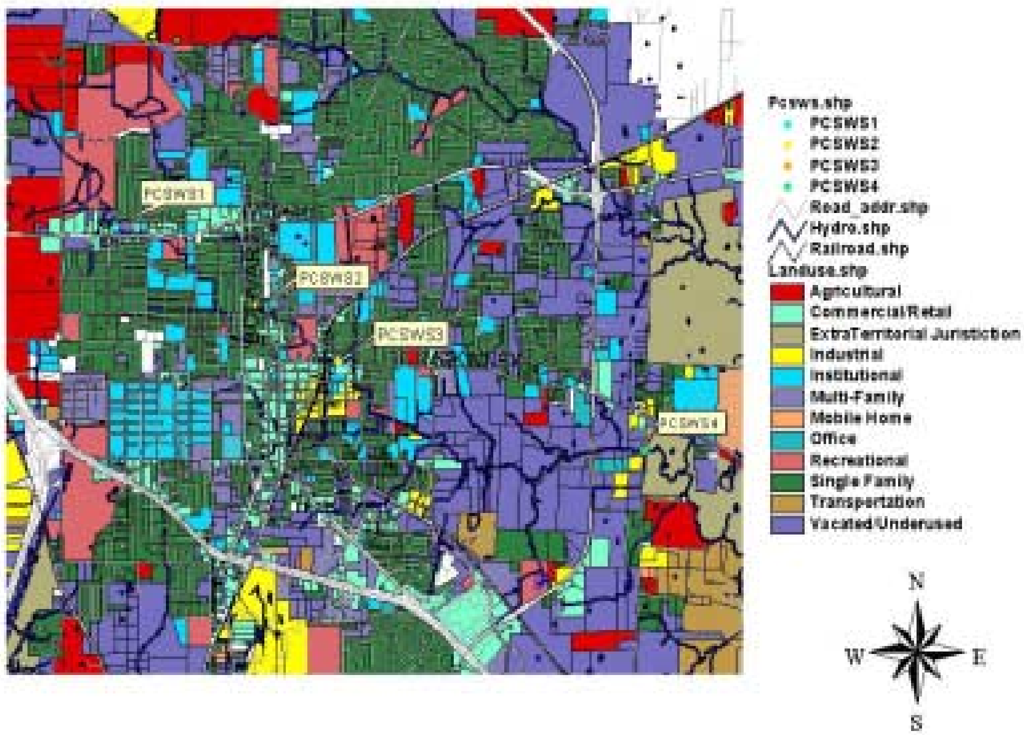
It is important to understand what pollutants are in a watershed and at what concentrations. This study provided a baseline to characterizing the storm water that feeds Pecan Creek. This study showed that there is potential for human and aquatic life hazards from toxic and dangerous pollutants found in the storm water runoff discharging into Pecan Creek. Locations with a higher percentage of single-family residential land uses showed to have higher levels of constituents found in fertilizers and pesticides suggesting anthropogenic influence. In addition, this study shows that storm water concentrations can vary with time. By understanding that spring storm events can have higher concentrations of many constituents, maybe public officials can implement more education programs on fertilizer and pesticide applications and promote ride sharing and car pooling during times of expected higher traffic days.

This study provided baseline information for developing a future storm water-monitoring program. Future research can build upon this data and provide the City of Denton with useful information to act on implementing mitigation activities regarding their storm water. More research should be conducted to evaluate other parameters that have the potential to degrade water quality as well as the constituents analyzed with in this study.

APPENDIX A

LAND USE MAP IN RELATION TO PCSWS'S

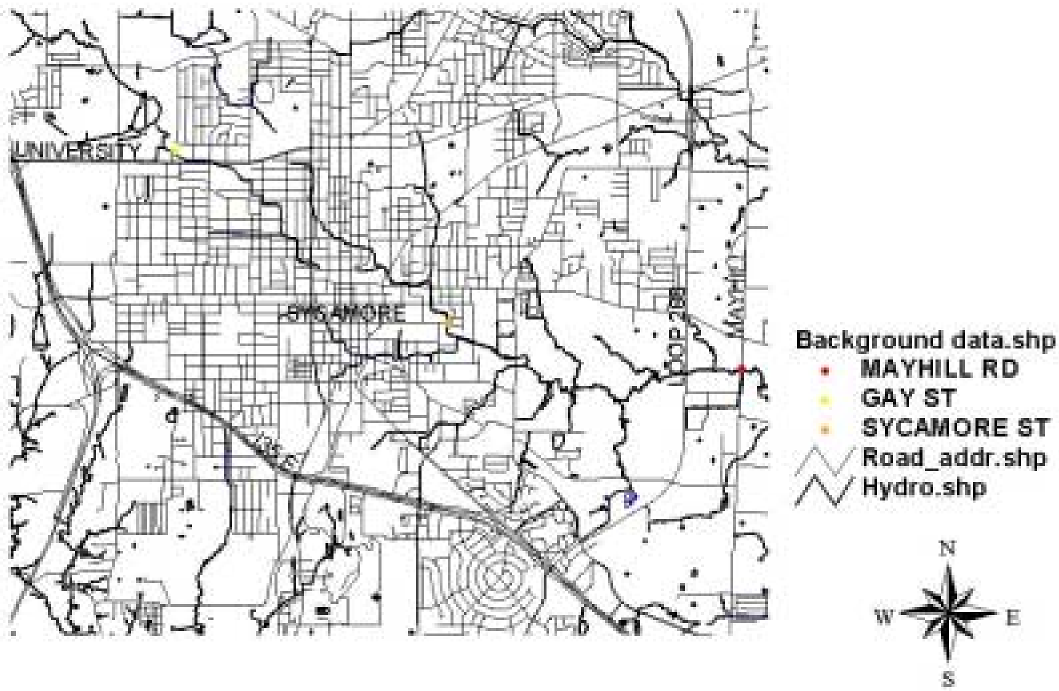
Figure 29: City of Denton PCSWS's in relation to its land use



APPENDIX B

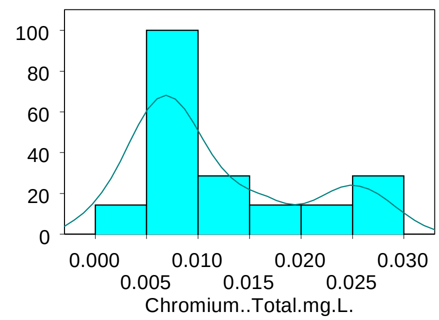
BASE FLOW SAMPLING LOCATIONS

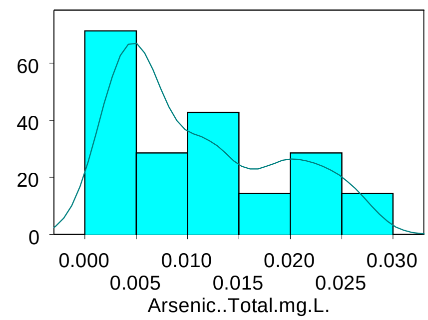
Figure 30: City of Denton's Pecan Creek base flow sampling locations

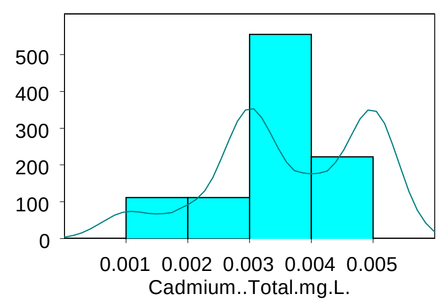


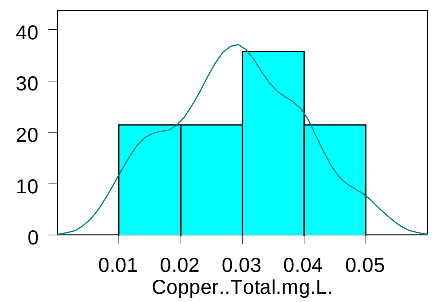
APPENDIX C

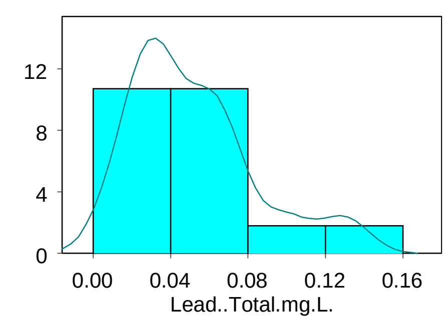
FIRST FLUSH SAMPLE HISTOGRAMS

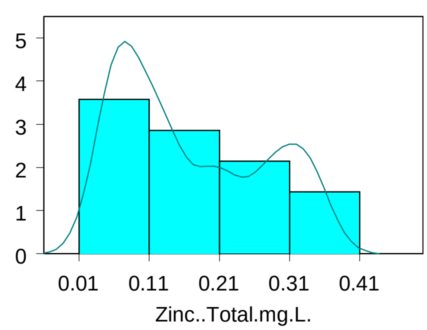

100
80
60
40
20
0
0.000
0.005
0.010
0.015
0.020
0.025
0.030
Chromium..Total.mg.L.

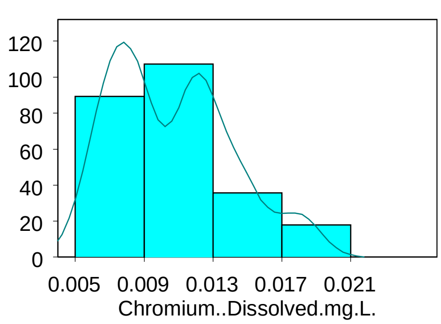

60
40
20
0
0.000
0.005
0.010
0.015
0.020
0.025
0.030
Arsenic..Total.mg.L.

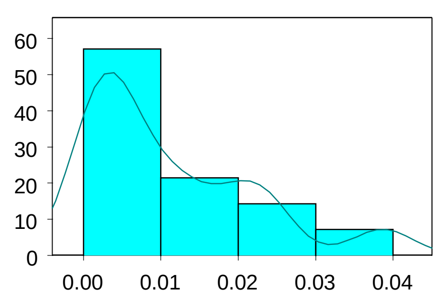

500
400
300
200
100
0
0.001 0.002 0.003 0.004 0.005
Cadmium..Total.mg.L.

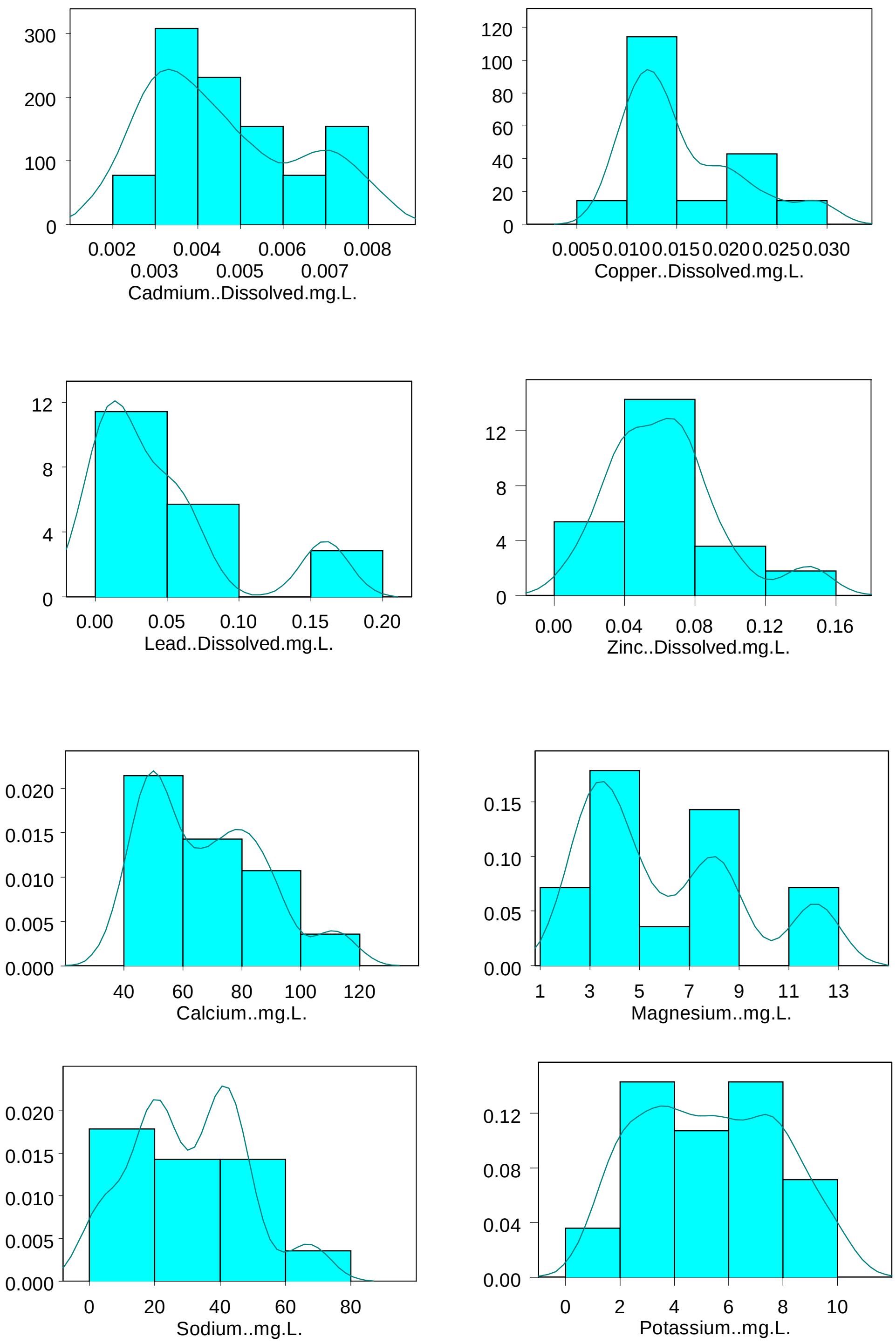

40
30
20
10
0
0.01 0.02 0.03 0.04 0.05
Copper..Total.mg.L.

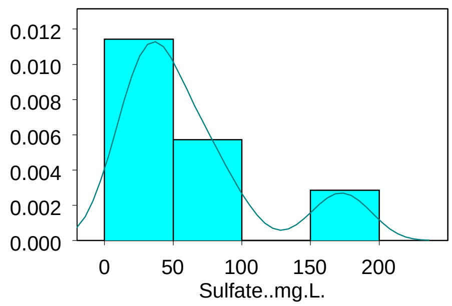

12
8
4
0
0.00 0.04 0.08 0.12 0.16
Lead..Total.mg.L.

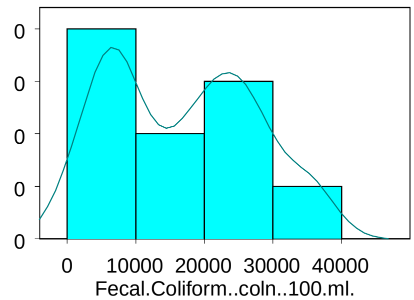

5
4
3
2
1
0
0.01 0.11 0.21 0.31 0.41
Zinc..Total.mg.L.

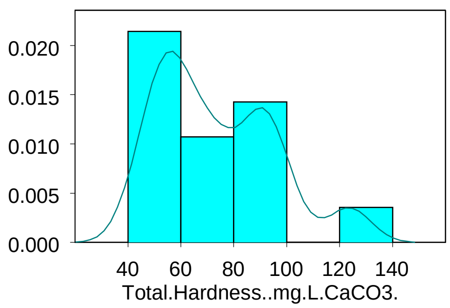

120
100
80
60
40
20
0
0.005 0.009 0.013 0.017 0.021
Chromium..Dissolved.mg.L.

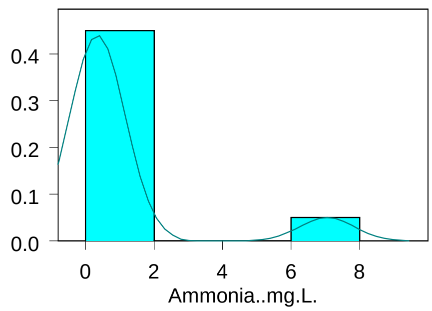

60
50
40
30
20
10
0
0.00 0.01 0.02 0.03 0.04

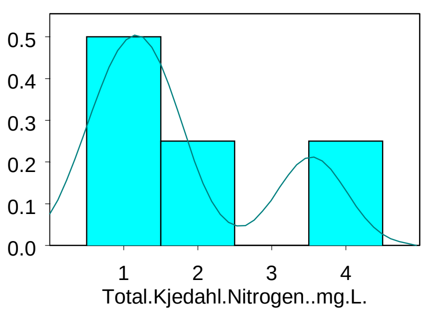

300
200
100
0
0.002
0.004
0.006
0.008
0.003
0.005
0.007
Cadmium..Dissolved.mg.L.
120
100
80
60
40
20
0
0.005
0.010
0.015
0.020
0.025
0.030
Copper..Dissolved.mg.L.
12
8
4
0
0.00
0.05
0.10
0.15
0.20
Lead..Dissolved.mg.L.
12
8
4
0
0.00
0.04
0.08
0.12
0.16
Zinc..Dissolved.mg.L.
0.020
0.015
0.010
0.005
0.000
40
60
80
100
120
Calcium..mg.L.
0.15
0.10
0.05
0.00
1
3
5
7
9
11
13
Magnesium..mg.L.
0.020
0.015
0.010
0.005
0.000
0
20
40
60
80
Sodium..mg.L.
0.12
0.08
0.04
0.00
0
2
4
6
8
10
Potassium..mg.L.

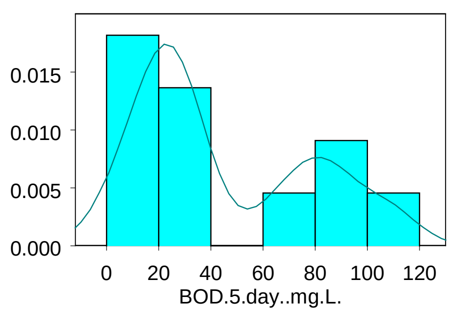

0.012
0.010
0.008
0.006
0.004
0.002
0.000
0 50 100 150 200
Sulfate..mg.L.

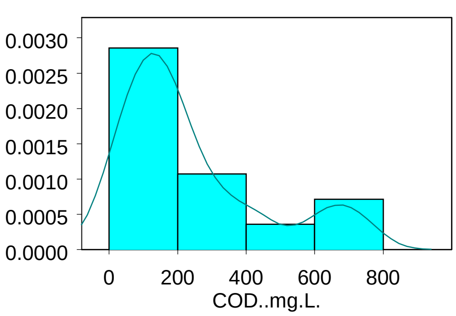

0
0
0
0
0
0 10000 20000 30000 40000
Fecal.Coliform..coln..100.ml.

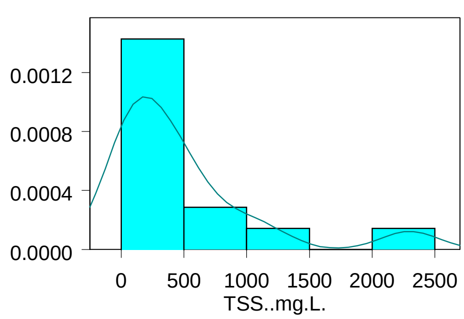

0.020
0.015
0.010
0.005
0.000
40 60 80 100 120 140
Total.Hardness..mg.L.CaCO3.

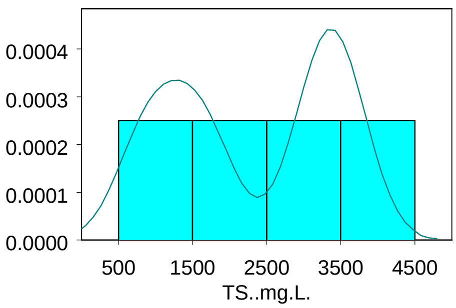

0.4
0.3
0.2
0.1
0.0
0 2 4 6 8
Ammonia..mg.L.

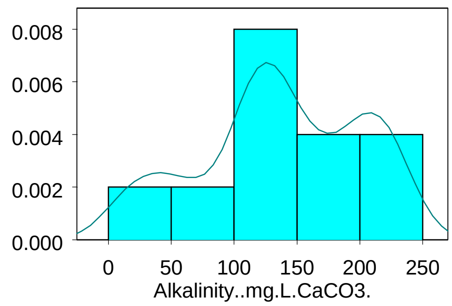

0.5
0.4
0.3
0.2
0.1
0.0
1 2 3 4
Total.Kjedahl.Nitrogen..mg.L.

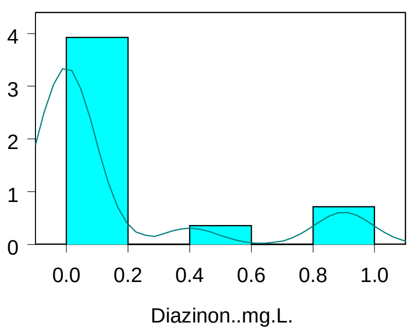

0.015
0.010
0.005
0.000
0 20 40 60 80 100 120
BOD.5.day..mg.L.

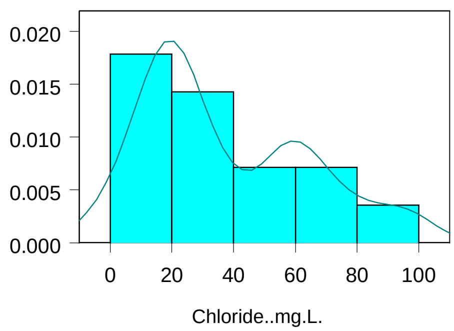

0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0 200 400 600 800
COD..mg.L.

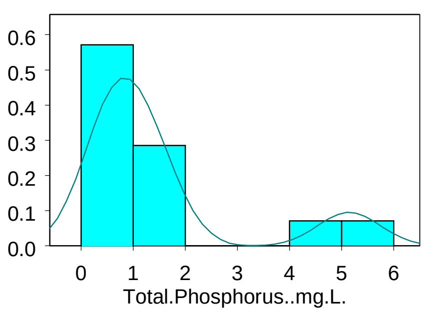

0.0012
0.0008
0.0004
0.0000
0 500 1000 1500 2000 2500
TSS..mg.L.

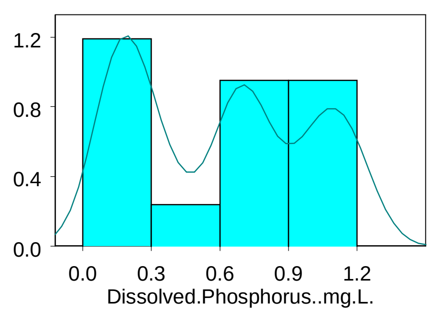

0.0004
0.0003
0.0002
0.0001
0.0000
500
1500
2500
3500
4500
TS..mg.L.

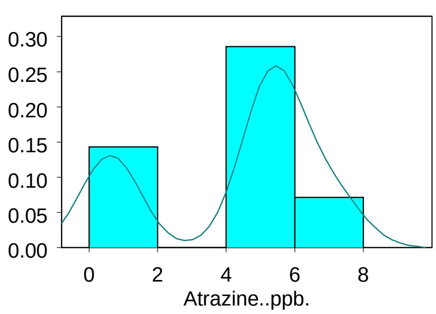

0.008
0.006
0.004
0.002
0.000
0
50
100
150
200
250
Alkalinity..mg.L.CaCO3.


4
3
2
1
0
0.0
0.2
0.4
0.6
0.8
1.0
Diazinon..mg.L.


0.020
0.015
0.010
0.005
0.000
0
20
40
60
80
100
Chloride..mg.L.

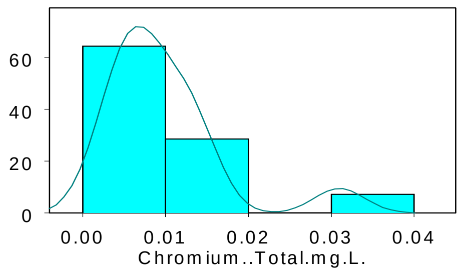

0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1
2
3
4
5
6
Total.Phosphorus..mg.L.

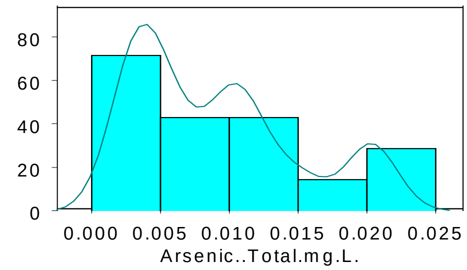

1.2
0.8
0.4
0.0
0.0
0.3
0.6
0.9
1.2
Dissolved.Phosphorus..mg.L.

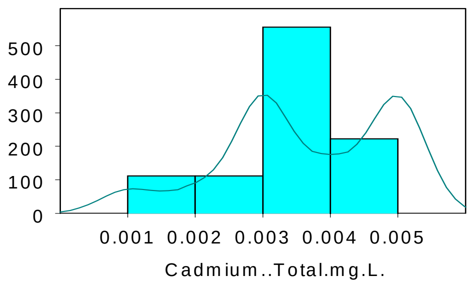

0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
2
4
6
8
Atrazine..ppb.

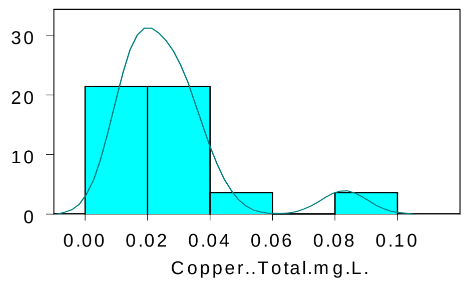
APPENDIX D

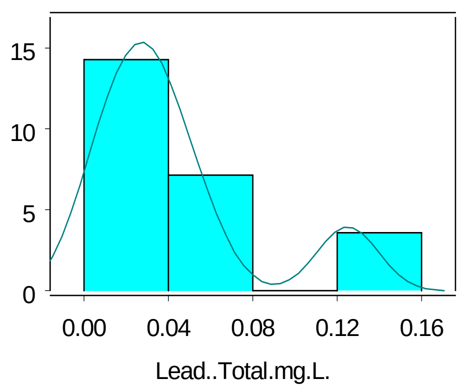
COMPOSITE SAMPLE HISTOGRAMS

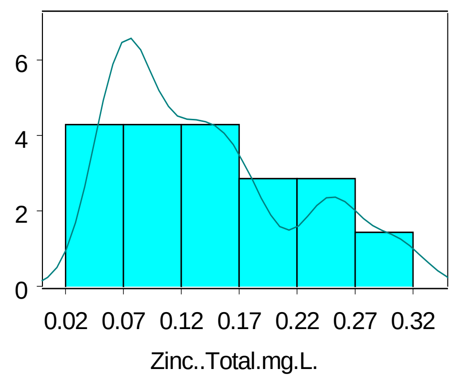

0 20 40 60
0.00 0.01 0.02 0.03 0.04
Chromium..Total.mg.L.

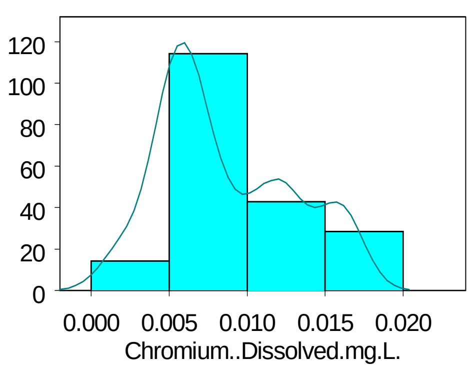

0 20 40 60 80
0.000 0.005 0.010 0.015 0.020 0.025
Arsenic..Total.mg.L.

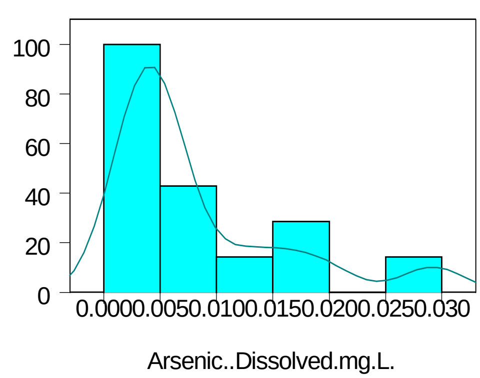

0 100 200 300 400 500
0.001 0.002 0.003 0.004 0.005
Cadmium..Total.mg.L.

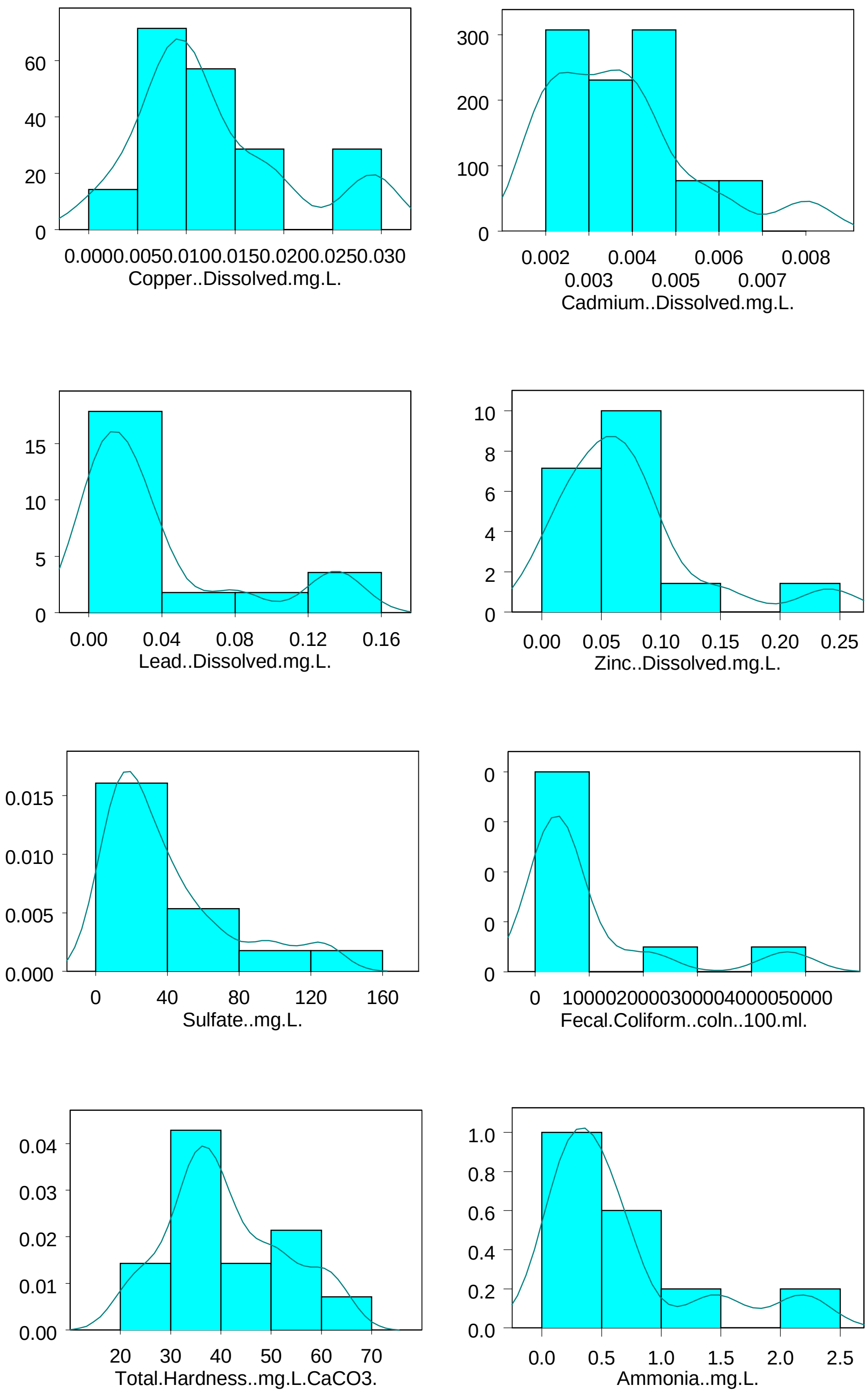

0 10 20 30
0.00 0.02 0.04 0.06 0.08 0.10
Copper..Total.mg.L.

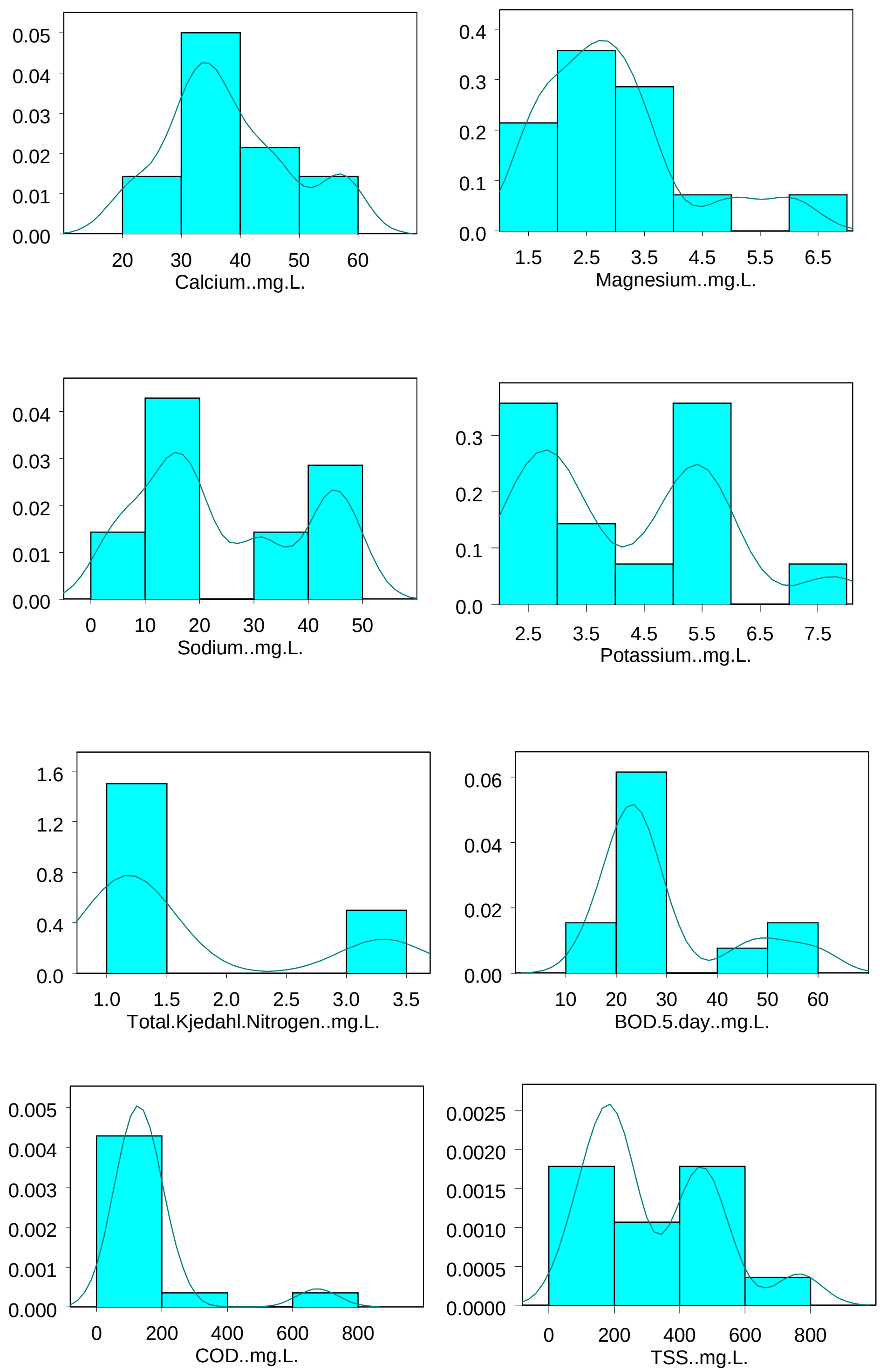

0 5 10 15
0.00 0.04 0.08 0.12 0.16
Lead..Total.mg.L.

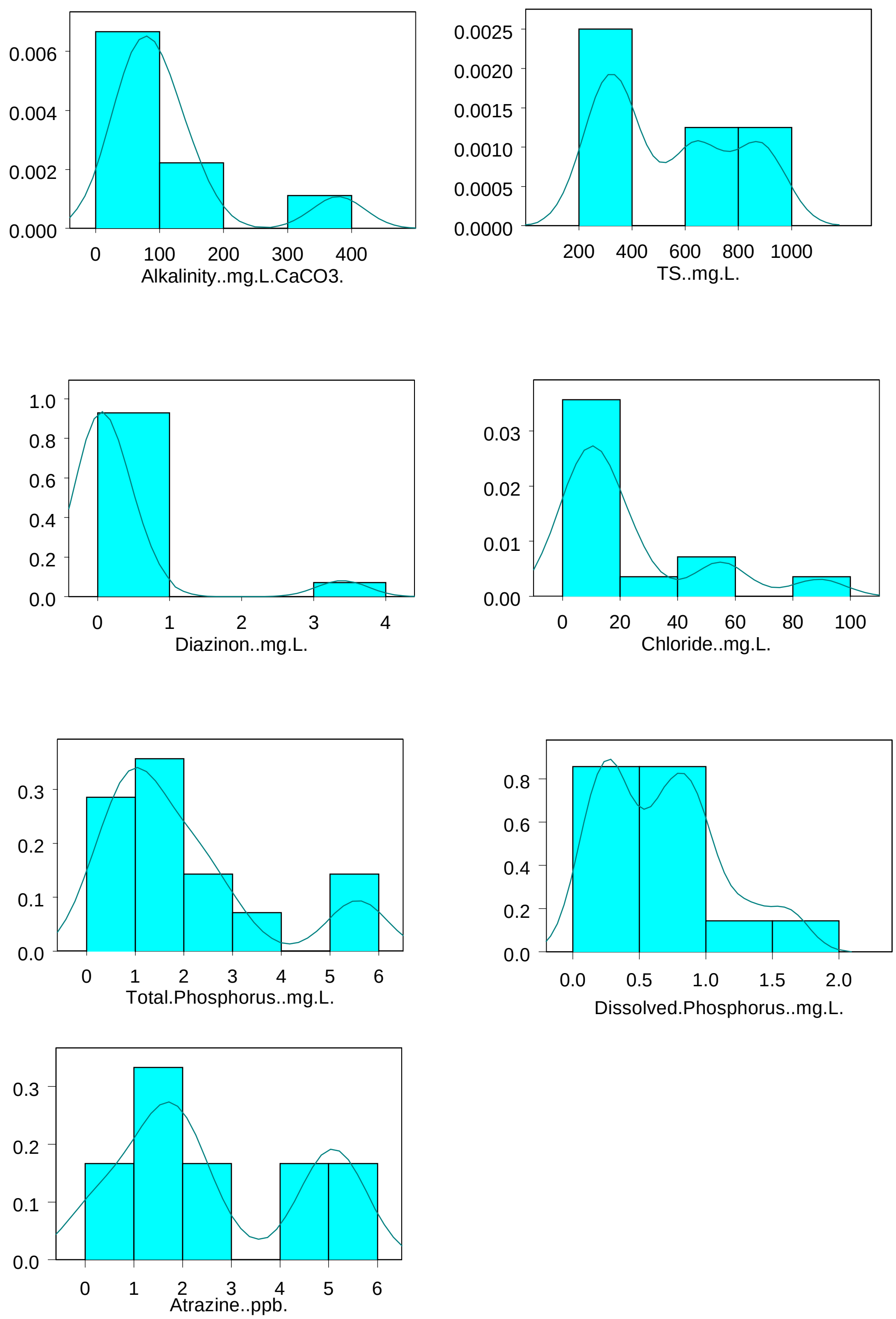

0 2 4 6
0.02 0.07 0.12 0.17 0.22 0.27 0.32
Zinc..Total.mg.L.


0 20 40 60 80 100 120
0.000 0.005 0.010 0.015 0.020
Chromium..Dissolved.mg.L.


0 20 40 60 80 100
0.0000.0050.0100.0150.0200.0250.030
Arsenic..Dissolved.mg.L.

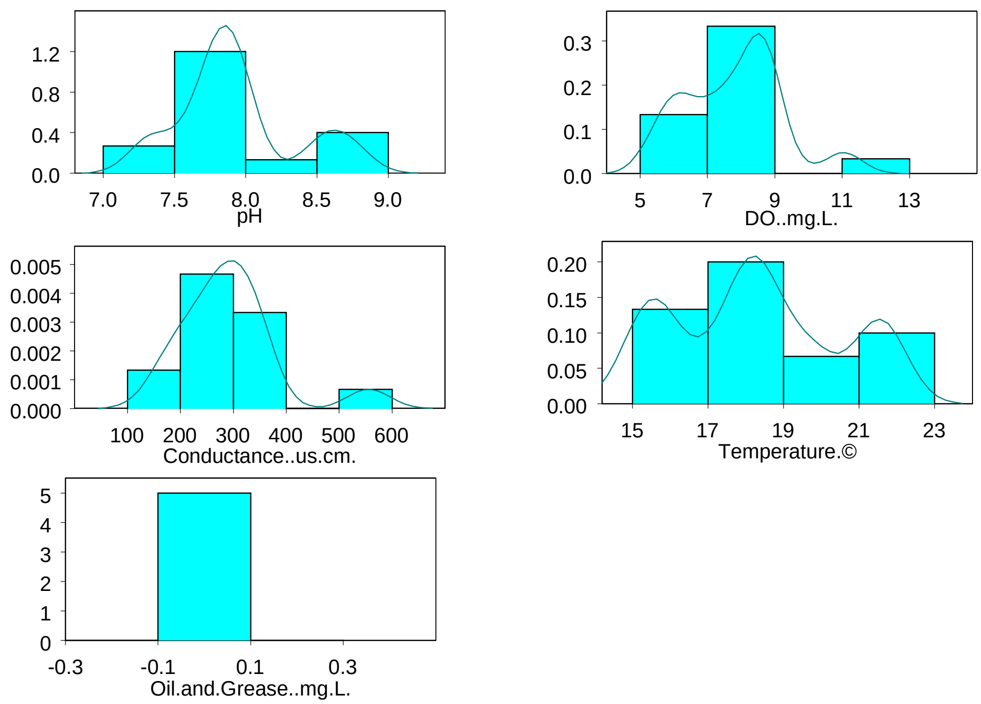

0 20 40 60
0.0000.0050.0100.0150.0200.0250.030
Copper..Dissolved.mg.L.
0 100 200 300
0.002 0.004 0.006 0.008
0.003 0.005 0.007
Cadmium..Dissolved.mg.L.
0 5 10 15
0.00 0.04 0.08 0.12 0.16
Lead..Dissolved.mg.L.
0 2 4 6 8 10
0.00 0.05 0.10 0.15 0.20 0.25
Zinc..Dissolved.mg.L.
0.000 0.005 0.010 0.015
0 40 80 120 160
Sulfate..mg.L.
0 0 0 0 0
0 1000020000300004000050000
Fecal.Coliform..coln..100.ml.
0.00 0.01 0.02 0.03 0.04
20 30 40 50 60 70
Total.Hardness..mg.L.CaCO3.
0.0 0.2 0.4 0.6 0.8 1.0
0.0 0.5 1.0 1.5 2.0 2.5
Ammonia..mg.L.


0.05
0.04
0.03
0.02
0.01
0.00
20 30 40 50 60
Calcium..mg.L.
0.4
0.3
0.2
0.1
0.0
1.5 2.5 3.5 4.5 5.5 6.5
Magnesium..mg.L.
0.04
0.03
0.02
0.01
0.00
0 10 20 30 40 50
Sodium..mg.L.
0.3
0.2
0.1
0.0
2.5 3.5 4.5 5.5 6.5 7.5
Potassium..mg.L.
1.6
1.2
0.8
0.4
0.0
1.0 1.5 2.0 2.5 3.0 3.5
Total.Kjedahl.Nitrogen..mg.L.
0.06
0.04
0.02
0.00
10 20 30 40 50 60
BOD.5.day..mg.L.
0.005
0.004
0.003
0.002
0.001
0.000
0 200 400 600 800
COD..mg.L.
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0 200 400 600 800
TSS..mg.L.


Alkalinity..mg.L.CaCO3.
TS..mg.L.
Diazinon..mg.L.
Chloride..mg.L.
Total.Phosphorus..mg.L.
Dissolved.Phosphorus..mg.L.
Atrazine..ppb.

APPENDIX E

FIELD AND GRAB SAMPLE HISTOGRAMS


pH
DO..mg.L.
Conductance..us.cm.
Temperature.©
Oil.and.Grease..mg.L.

APPENDIX F

FIRST FLUSH VERSUS COMPOSITE CONCENTRATIONS USING WILCOXON SIGNED RANK TEST

```
        Wilcoxon signed-rank test

data:  x: Chromium.Totalff. in wilcoxon2 , and y: Cr.Tcomp. in wilcoxon2
signed-rank normal statistic with correction Z = 0.9487, p-value = 0.3428
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Arsenic.Totalff. in wilcoxon2 , and y: As.Tcomp. in wilcoxon2
signed-rank statistic V = 58, n = 14, p-value = 0.7609
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Cadmium.Totalff. in wilcoxon2 , and y: Cd.Tcomp. in wilcoxon2
signed-rank normal statistic with correction Z = 3.3365, p-value = 0.0008
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Copper.Totalff. in wilcoxon2 , and y: Cu.Tcomp. in wilcoxon2
signed-rank normal statistic with correction Z = 0.7853, p-value = 0.4323
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Lead.Totalff. in wilcoxon2 , and y: Pb.Tcomp. in wilcoxon2
signed-rank normal statistic with correction Z = 1.1963, p-value = 0.2316
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Zinc.Totalff. in wilcoxon2 , and y: Zn.Tcomp. in wilcoxon2
signed-rank statistic V = 62, n = 14, p-value = 0.583
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Chromium.Dissolvedff. in wilcoxon2 , and y: Cr.Dcomp. in wilcoxon2
signed-rank normal statistic with correction Z = 1.606, p-value = 0.1083
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Arsenic.Dissolvedff. in wilcoxon2 , and y: As.Dcomp. in wilcoxon2
signed-rank statistic V = 67, n = 14, p-value = 0.391
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Cadmium.Dissolvedff. in wilcoxon2 , and y: Cd.Dcomp. in wilcoxon2
signed-rank normal statistic with correction Z = 1.5757, p-value = 0.1151
```

```
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Copper.Dissolvedff. in wilcoxon2 , and y: Cu.Dcomp. in wilcoxon2
signed-rank normal statistic with correction Z = 1.6024, p-value = 0.1091
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Lead..Dissolved.mg.L. in wilcoxon2 , and y: Pb..D. in wilcoxon2
signed-rank normal statistic with correction Z = 0.7013, p-value = 0.4831
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Zinc.Dissolvedff. in wilcoxon2 , and y: Zn.Dcomp. in wilcoxon2
signed-rank statistic V = 51, n = 14, p-value = 0.9515
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Calciumff. in wilcoxon2 , and y: Cacomp in wilcoxon2
signed-rank statistic V = 105, n = 14, p-value = 0.0001
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Magnesiumff. in wilcoxon2 , and y: Mgcomp in wilcoxon2
signed-rank statistic V = 105, n = 14, p-value = 0.0001
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Sodiumff. in wilcoxon2 , and y: Nacomp in wilcoxon2
signed-rank normal statistic with correction Z = 0.8477, p-value = 0.3966
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Potassiumff. in wilcoxon2 , and y: Kcomp in wilcoxon2
signed-rank statistic V = 83, n = 14, p-value = 0.058
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Sulfateff. in wilcoxon2 , and y: SO4comp in wilcoxon2
signed-rank normal statistic with correction Z = 1.7586, p-value = 0.0786
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test
```

```
data:  x: Fecal.Coliformff. in wilcoxon2 , and y: FCcomp in wilcoxon2
signed-rank statistic V = 40, n = 10, p-value = 0.2324
alternative hypothesis: true mu is not equal to 0


       Exact Wilcoxon signed-rank test

data:  x: Total.Hardnessff. in wilcoxon2 , and y: THcomp in wilcoxon2
signed-rank statistic V = 105, n = 14, p-value = 0.0001
alternative hypothesis: true mu is not equal to 0


       Exact Wilcoxon signed-rank test

data:  x: Total.Kjedahl.Nitrogenff. in wilcoxon2 , and y: TKNcomp in wilcoxon2
signed-rank statistic V = 5, n = 4, p-value = 1
alternative hypothesis: true mu is not equal to 0


       Exact Wilcoxon signed-rank test

data:  x: BODff in wilcoxon2 , and y: BODcomp in wilcoxon2
signed-rank statistic V = 47, n = 11, p-value = 0.2402
alternative hypothesis: true mu is not equal to 0


       Wilcoxon signed-rank test

data:  x: CODff. in wilcoxon2 , and y: CODcomp in wilcoxon2
signed-rank normal statistic with correction Z = 1.2561, p-value = 0.2091
alternative hypothesis: true mu is not equal to 0


       Wilcoxon signed-rank test

data:  x: TSSff in wilcoxon2 , and y: TSScomp in wilcoxon2
signed-rank normal statistic with correction Z = 0.6595, p-value = 0.5096
alternative hypothesis: true mu is not equal to 0


       Exact Wilcoxon signed-rank test

data:  x: TSff. in wilcoxon2 , and y: TSScomp in wilcoxon2
signed-rank statistic V = 10, n = 4, p-value = 0.125
alternative hypothesis: true mu is not equal to 0


       Wilcoxon signed-rank test

data:  x: Chlorideff. in wilcoxon2 , and y: Clcomp in wilcoxon2
signed-rank normal statistic with correction Z = 1.9784, p-value = 0.0479
alternative hypothesis: true mu is not equal to 0


       Wilcoxon signed-rank test

data:  x: Diazinonff. in wilcoxon2 , and y: Diazcomp in wilcoxon2
signed-rank normal statistic with correction Z = -0.3331, p-value = 0.7391
alternative hypothesis: true mu is not equal to 0
```

```
        Wilcoxon signed-rank test

data:  x: Total.Phosphorusff. in wilcoxon2 , and y: Total.Pcomp in wilcoxon2
signed-rank normal statistic with correction Z = -0.7849, p-value = 0.4325
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Dissolved.Phosphorusff. in wilcoxon2 , and y: Diss.Pcomp in wilcoxon2
signed-rank statistic V = 56, n = 14, p-value = 0.8552
alternative hypothesis: true mu is not equal to 0



        Exact Wilcoxon signed-rank test

data:  x: Atrazine.ff in wilcoxon2 , and y: Atrazine.comp in wilcoxon2
signed-rank statistic V = 17, n = 6, p-value = 0.2188
alternative hypothesis: true mu is not equal to 0
```

APPENDIX G

MINIMUM LOADING VERSUS MAXIMUM LOADING USING WILCOXON SIGNED RANK TEST

```
        Exact Wilcoxon signed-rank test

data:  x: Min.Chromium..Total.. in loadings , and y: Max.Chromium..Total. in
loadings
signed-rank statistic V = 0, n = 14, p-value = 0.0001
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Arsenic..Total.. in loadings , and y: Max.Arsenic..Total. in
loadings
signed-rank statistic V = 0, n = 14, p-value = 0.0001
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Cadmium.Total.. in loadings , and y: Max.Cadmium..Total. in
loadings
signed-rank statistic V = 2, n = 14, p-value = 0.0004
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Copper.Total.. in loadings , and y: Max.Copper.Total. in loadings
signed-rank statistic V = 4, n = 14, p-value = 0.0009
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Lead.Total.. in loadings , and y: Max.Lead..Total. in loadings
signed-rank statistic V = 12, n = 14, p-value = 0.0085
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Zinc..Total.. in loadings , and y: Max.Zinc..Total.mg.L. in
loadings
signed-rank statistic V = 2, n = 14, p-value = 0.0004
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Chromium..Dissolved. in loadings , and y:
Max.Chromium..Dissolved. in loadings
signed-rank statistic V = 6, n = 14, p-value = 0.0017
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Arsenic.Dissolved. in loadings , and y: Max.Arsenic..Dissolved.
in loadings
signed-rank statistic V = 19, n = 14, p-value = 0.0353
alternative hypothesis: true mu is not equal to 0
```

```
        Exact Wilcoxon signed-rank test

data:  x: Min.Cadmium.Dissolved. in loadings , and y: Max.Cadmium..Dissolved.
in loadings
signed-rank statistic V = 5, n = 14, p-value = 0.0012
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Copper..Dissolved. in loadings , and y: Max.Copper..Dissolved. in
loadings
signed-rank statistic V = 5, n = 14, p-value = 0.0012
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Min.Lead..Dissolved. in loadings , and y: Max.Lead..Dissolved. in
loadings
signed-rank normal statistic with correction Z = -2.8577, p-value = 0.0043
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Zinc..Dissolved. in loadings , and y: Max.Zinc..Dissolved. in
loadings
signed-rank statistic V = 3, n = 14, p-value = 0.0006
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Calcium in loadings , and y: Max.Calcium in loadings
signed-rank statistic V = 5, n = 14, p-value = 0.0012
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Magnesium in loadings , and y: Max.Magnesium in loadings
signed-rank statistic V = 7, n = 14, p-value = 0.0023
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Sodium in loadings , and y: Max.Sodium in loadings
signed-rank statistic V = 6, n = 14, p-value = 0.0017
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Potassium in loadings , and y: Max.Potassium in loadings
signed-rank statistic V = 2, n = 14, p-value = 0.0004
alternative hypothesis: true mu is not equal to 0
```

```
        Exact Wilcoxon signed-rank test

data:  x: Min.Sulfate in loadings , and y: Max.Sulfate in loadings
signed-rank statistic V = 14, n = 14, p-value = 0.0134
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Fecal.Coliform in loadings , and y: Max.Fecal.Coliform in
loadings
signed-rank statistic V = 13, n = 10, p-value = 0.1602
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Total.Hardness in loadings , and y: Max.Total.Hardness in
loadings
signed-rank statistic V = 5, n = 14, p-value = 0.0012
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Total.Kjedahl.Nitrogen in loadings , and y:
Max.Total.Kjedahl.Nitrogen in loadings
signed-rank statistic V = 0, n = 4, p-value = 0.125
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.BOD in loadings , and y: Max.BOD in loadings
signed-rank statistic V = 0, n = 11, p-value = 0.001
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.COD in loadings , and y: Max.COD in loadings
signed-rank statistic V = 4, n = 14, p-value = 0.0009
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.TSS in loadings , and y: Max.TSS in loadings
signed-rank statistic V = 4, n = 14, p-value = 0.0009
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.TS in loadings , and y: Max.TS in loadings
signed-rank statistic V = 3, n = 4, p-value = 0.625
alternative hypothesis: true mu is not equal to 0
```

```
        Exact Wilcoxon signed-rank test

data:  x: Min.Chloride in loadings , and y: Max.Chloride in loadings
signed-rank statistic V = 21, n = 14, p-value = 0.0494
alternative hypothesis: true mu is not equal to 0


        Wilcoxon signed-rank test

data:  x: Min.Diazinon in loadings , and y: Max.Diazinon in loadings
signed-rank normal statistic with correction Z = -0.5552, p-value = 0.5788
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Total.Phosphorus in loadings , and y: Max.Total.Phosphorus in
loadings
signed-rank statistic V = 0, n = 14, p-value = 0.0001
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.Dissolved.Phosphorus in loadings , and y:
Max.Dissolved.Phosphorus in loadings
signed-rank statistic V = 3, n = 14, p-value = 0.0006
alternative hypothesis: true mu is not equal to 0


        Exact Wilcoxon signed-rank test

data:  x: Min.atraz in loadings , and y: Max.Atraz in loadings
signed-rank statistic V = 0, n = 6, p-value = 0.0312
alternative hypothesis: true mu is not equal to 0
```

APPENDIX H

SPEARMAN CORRELATION MATRIX CALCULATED FROM FIRST FLUSH SAMPLE CONCENTRATIONS

MTB > correlation c32-c62

	C32	C33	C34	C35	C36	C37	C38	C39
C33	0.426							
C34	-0.337	-0.571						
C35	0.451	0.632	0.090					
C36	0.416	0.013	-0.151	-0.058				
C37	0.335	0.481	0.050	0.665	0.076			
C38	-0.011	-0.323	0.444	0.217	0.082	0.165		
C39	0.040	0.585	-0.206	0.577	-0.134	0.341	-0.032	
C40	-0.459	-0.770	0.598	-0.573	0.253	-0.499	0.057	-0.463
C41	0.249	0.296	-0.278	0.251	0.529	0.004	-0.030	0.508
C42	-0.393	-0.226	-0.040	-0.328	0.433	-0.177	0.087	0.099
C43	-0.139	-0.130	0.497	0.301	0.138	0.358	0.506	0.288
C44	0.302	-0.315	0.529	0.137	0.119	-0.068	0.011	-0.225
C45	-0.104	-0.310	0.124	-0.358	0.058	-0.613	-0.408	-0.220
C46	-0.103	0.048	-0.442	-0.618	0.371	-0.372	-0.484	-0.308
C47	0.401	0.424	-0.428	0.168	0.448	0.376	0.009	0.169
C48	-0.152	-0.112	-0.390	-0.696	0.214	-0.349	-0.508	-0.383
C49	0.393	0.204	0.237	0.603	0.255	0.466	0.736	-0.066
C50	0.384	-0.275	0.371	0.071	0.314	-0.160	-0.078	-0.277
C51	0.413	0.563	-0.438	0.584	0.015	0.182	0.064	0.766
C52	0.199	0.791	0.492	0.775	0.133	0.564	0.949	0.959
C53	0.145	0.407	-0.037	0.290	-0.293	0.321	0.326	0.126
C54	0.390	0.349	-0.079	0.404	-0.080	0.569	0.515	0.018
C55	0.642	0.393	-0.367	0.250	0.009	0.402	0.076	-0.161
C56	0.199	0.791	0.492	0.775	0.133	0.564	0.949	0.959
C57	0.505	-0.019	0.034	-0.124	0.439	0.037	-0.534	-0.709
C58	-0.187	-0.434	0.079	-0.489	0.241	-0.081	0.059	-0.413
C59	-0.410	-0.331	0.114	-0.259	-0.368	-0.267	0.518	-0.202
C60	-0.300	0.138	0.026	0.044	-0.383	0.160	-0.152	0.407
C61	-0.351	-0.319	0.288	-0.285	0.238	0.112	0.174	0.165
C62	-0.325	0.000	-0.352	-0.078	-0.349	-0.155	0.450	0.266

	C40	C41	C42	C43	C44	C45	C46	C47
C41	0.042							
C42	0.453	0.490						
C43	0.181	0.252	0.370					
C44	0.361	-0.023	-0.214	-0.013				
C45	0.470	0.009	0.184	-0.305	0.537			
C46	0.185	-0.081	0.336	-0.442	-0.156	0.374		
C47	-0.423	0.079	0.115	0.090	-0.396	-0.125	0.249	
C48	0.121	-0.331	0.126	-0.473	-0.152	0.393	0.876	0.305
C49	-0.185	0.399	-0.088	0.268	0.207	-0.476	-0.528	-0.121

C50	0.396	0.126	-0.118	-0.143	0.955	0.626	-0.020	-0.288
C51	-0.526	0.569	0.160	0.093	-0.364	-0.073	-0.308	0.568
C52	0.000	0.997	0.316	0.832	0.235	-0.398	-0.640	-0.368
C53	-0.518	-0.177	-0.244	0.174	-0.134	-0.547	-0.046	-0.148
C54	-0.559	-0.196	-0.266	0.266	-0.207	-0.653	-0.242	0.305
C55	-0.586	-0.110	-0.486	-0.068	-0.070	-0.538	-0.092	0.156
C56	0.000	0.997	0.316	0.832	0.235	-0.398	-0.640	-0.368
C57	0.311	-0.074	-0.068	-0.294	0.628	0.485	0.446	0.010
C58	0.197	-0.357	0.077	0.073	0.076	0.130	0.355	0.174
C59	0.094	-0.240	0.121	-0.165	-0.235	-0.055	-0.110	-0.211
C60	-0.179	-0.318	0.100	0.222	-0.240	-0.112	0.117	0.086
C61	0.461	0.108	0.628	0.503	-0.084	-0.099	0.194	0.024
C62	-0.239	0.459	0.349	0.268	-0.639	-0.726	-0.443	-0.682

	C48	C49	C50	C51	C52	C53	C54	C55
C49	-0.786							
C50	-0.055	0.197						
C51	-0.441	-0.012	-0.274					
C52	-0.980	0.996	0.129	*				
C53	-0.264	0.549	-0.311	-0.167	0.819			
C54	-0.314	0.751	-0.319	0.138	0.885	0.892		
C55	-0.112	0.495	-0.112	-0.119	0.638	0.709	0.771	
C56	-0.980	0.996	0.129	*	1.000	0.819	0.885	0.638
C57	0.295	-0.006	0.698	-0.648	-0.049	-0.074	-0.114	0.250
C58	0.641	-0.339	0.051	-0.684	-0.822	-0.202	-0.079	-0.015
C59	-0.147	0.339	-0.257	0.029	0.258	0.224	0.221	-0.129
C60	0.130	-0.638	-0.402	0.146	-0.367	0.246	0.037	-0.182
C61	0.077	-0.300	-0.152	-0.144	0.263	0.104	-0.081	-0.358
C62	-0.563	0.375	-0.636	0.756	0.234	0.502	0.449	0.532

	C56	C57	C58	C59	C60	C61
C57	-0.049					
C58	-0.822	-0.042				
C59	0.258	-0.453	-0.111			
C60	-0.367	-0.207	-0.051	-0.193		
C61	0.263	-0.062	0.126	-0.046	0.525	
C62	0.234	-0.602	-0.281	0.383	-0.077	0.000

*** Minitab Release 8.3 *** Minitab, Inc. ***

NOTE:					
	Cr (T) = C32	As (T) = C33	Cd (T) = C34	Cu (T) = C35	Pb (T) = C36
	Zn (T) = C37	Cr (D) = C38	As (D) = C39	Cd (D) = C40	Cu (D) = C41
	Pb (D) = C42	Zn (D) = C43	Ca = C44	Mg = C45	Na = C46
	K = C47	SO4 = C48	Fecal Coliform = C49		Total Hardness = C50
	NH4 = C51	TKN = C52	BOD = C53	COD = C54	TSS = C55
	TS = C56	ALK = C57	Cl = C58	Diazinon = C59	Total Phosphorus = C60
	Dissolved Phosphorus = C61		Atrazine = C62		

APPENDIX I

SPEARMAN CORRELATION MATRIX CALCULATED FROM COMPOSITE SAMPLE CONCENTRATIONS

MTB > correlation c32-c62

	C32	C33	C34	C35	C36	C37	C38	C39
C33	-0.216							
C34	-0.154	-0.366						
C35	0.051	0.385	-0.367					
C36	0.098	0.521	-0.490	0.251				
C37	0.147	0.180	0.215	0.467	-0.159			
C38	-0.139	0.033	0.661	-0.058	-0.210	0.265		
C39	0.269	0.284	-0.366	0.282	0.257	-0.200	-0.286	
C40	0.052	-0.242	0.679	-0.300	-0.140	0.037	0.610	-0.334
C41	-0.342	0.873	-0.354	0.570	0.279	0.216	-0.080	0.344
C42	-0.143	0.002	0.428	-0.392	-0.111	0.081	0.042	-0.065
C43	-0.104	0.336	0.263	0.211	0.142	0.246	0.412	0.138
C44	0.320	0.011	0.062	0.566	0.097	0.660	-0.024	-0.116
C45	-0.210	0.213	0.244	0.379	0.286	0.266	0.066	0.125
C46	-0.033	-0.284	-0.366	-0.304	0.352	-0.524	-0.529	0.204
C47	-0.280	0.125	0.051	0.313	0.162	0.407	-0.102	0.169
C48	-0.272	0.336	0.081	0.465	0.401	0.251	-0.042	0.262
C49	0.241	0.037	0.090	0.575	0.190	0.590	0.016	-0.099
C50	-0.052	0.506	-0.503	0.234	0.368	-0.258	-0.695	0.460
C51	-0.127	0.434	0.258	0.035	-0.407	0.190	0.864	-0.049
C52	-0.069	0.482	0.057	-0.308	0.426	0.069	0.212	-0.124
C53	0.223	-0.319	0.000	-0.071	0.178	0.278	0.023	-0.326
C54	0.525	-0.393	-0.336	-0.214	0.204	-0.174	-0.374	-0.204
C55	0.929	-0.976	0.775	0.868	0.497	0.797	-0.173	0.442
C56	-0.075	-0.091	-0.369	-0.757	0.078	-0.833	-0.305	0.559
C57	-0.181	0.246	0.264	0.454	0.263	0.493	0.391	-0.271
C58	-0.627	0.074	0.385	-0.007	-0.153	-0.196	0.231	-0.041
C59	0.055	0.178	0.210	0.079	0.047	0.638	0.554	-0.253
C60	-0.305	0.502	0.300	0.074	0.140	0.557	0.400	-0.143
C61	-0.289	0.764	0.717	0.347	0.359	0.739	0.803	-0.486
C62	-0.449	0.204	0.719	-0.102	-0.733	0.174	0.370	-0.105

	C40	C41	C42	C43	C44	C45	C46	C47
C41	-0.495							
C42	0.062	0.018						
C43	0.199	0.353	-0.069					
C44	-0.235	0.172	0.129	-0.024				
C45	-0.129	0.375	0.424	0.143	0.626			
C46	-0.266	-0.313	0.111	-0.367	-0.222	0.059		
C47	-0.239	0.273	0.562	0.055	0.411	0.688	0.248	
C48	-0.275	0.505	0.413	0.248	0.543	0.899	0.033	0.771
C49	-0.203	0.194	0.156	0.037	0.982	0.705	-0.169	0.455

C50	-0.383	0.618	0.419	-0.322	0.011	0.234	0.491	0.492
C51	0.000	0.435	0.738	-0.573	0.151	0.283	0.400	0.236
C52	0.446	0.092	0.086	0.356	-0.344	-0.109	0.026	-0.086
C53	0.367	-0.543	-0.281	0.121	-0.022	-0.343	0.187	-0.004
C54	0.027	-0.529	-0.022	-0.327	0.029	-0.288	0.512	-0.103
C55	0.447	-0.836	0.316	0.115	0.801	0.707	-0.600	0.708
C56	-0.552	-0.118	0.105	-0.199	-0.581	-0.296	0.426	-0.201
C57	0.016	0.350	0.092	0.598	0.618	0.642	-0.260	0.383
C58	0.069	0.216	0.290	-0.052	-0.072	0.331	-0.240	0.168
C59	0.016	0.093	0.134	0.371	0.367	0.182	-0.182	0.279
C60	-0.024	0.475	0.444	0.528	0.279	0.517	-0.244	0.517
C61	0.697	0.667	-0.234	0.302	0.399	0.567	-0.699	-0.027
C62	0.097	0.518	0.904	-0.012	0.075	0.422	-0.408	0.438

	C48	C49	C50	C51	C52	C53	C54	C55
C49	0.640							
C50	0.503	0.080						
C51	-0.086	0.151	*					
C52	-0.152	-0.324	-0.072	-0.076				
C53	-0.286	-0.031	-0.355	-0.981	0.360			
C54	-0.380	-0.015	0.092	-0.141	0.111	0.469		
C55	0.947	0.801	*	-0.400	-0.680	0.564	0.707	
C56	-0.158	-0.581	-0.073	-0.419	-0.248	-0.360	-0.067	-0.577
C57	0.607	0.697	-0.254	0.147	0.077	0.065	-0.189	0.834
C58	0.441	0.022	0.214	*	-0.352	-0.494	-0.720	*
C59	0.121	0.358	-0.479	0.822	0.272	0.282	-0.029	-0.176
C60	0.491	0.297	-0.186	0.757	0.445	-0.062	-0.315	-0.058
C61	0.460	0.399	-0.500	0.655	0.711	-0.110	-0.783	0.327
C62	0.440	0.075	0.891	0.868	-0.203	-0.767	-0.525	-0.108

	C56	C57	C58	C59	C60	C61
C57	-0.684					
C58	0.174	0.069				
C59	-0.339	0.592	-0.312			
C60	-0.240	0.654	0.004	0.730		
C61	-0.374	0.633	0.393	0.716	0.921	
C62	-0.033	0.114	0.710	0.036	0.500	0.200

*** Minitab Release 8.3 *** Minitab, Inc. ***

NOTE:	Cr (T) = C32	As (T) = C33	Cd (T) = C34	Cu (T) = C35	Pb (T) = C36
	Zn (T) = C37	Cr (D) = C38	As (D) = C39	Cd (D) = C40	Cu (D) = C41
	Pb (D) = C42	Zn (D) = C43	Ca = C44	Mg = C45	Na = C46
	K = C47	SO4 = C48	Total Hardness = C49		NH4 = C50
	TKN = C51,	BOD = C52	COD = C53	TSS = C54	TS = C55
	ALK = C56	Cl = C57	Diazinon = C58	Total Phosphorus = C59	
	Dissolved Phosphorus = C60		Atrazine = C61	Fecal Coliform = C62	

APPENDIX J

KRUSKAL WALLIS STATISTICAL ANALYSIS OF FIRST FLUSH DATA BETWEEN STATION LOCATIONS

Kruskal-Wallis rank sum test

data: CrTff and stations
Kruskal-Wallis chi-square = 4.2075, df = 3, p-value = 0.2399
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: AsTff and stations
Kruskal-Wallis chi-square = 2.8288, df = 3, p-value = 0.4188
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CdTff and stations
Kruskal-Wallis chi-square = 2.5394, df = 3, p-value = 0.4682
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CuTff and stations
Kruskal-Wallis chi-square = 6.8406, df = 3, p-value = 0.
0772
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: PbTff and stations
Kruskal-Wallis chi-square = 4.3957, df = 3, p-value = 0.2218
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ZnTff and stations
Kruskal-Wallis chi-square = 10.3333, df = 3, p-value = 0.0159
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CrDff and stations
Kruskal-Wallis chi-square = 3.69, df = 3, p-value = 0.2969
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: AsDff and stations
Kruskal-Wallis chi-square = 2.5558, df = 3, p-value = 0.4653
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CuDff and stations
Kruskal-Wallis chi-square = 1.0365, df = 3, p-value = 0.7924
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CdDff and stations
Kruskal-Wallis chi-square = 3.3746, df = 3, p-value = 0.3374
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: PbDff and stations
Kruskal-Wallis chi-square = 2.1861, df = 3, p-value = 0.5347
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ZnDff and stations
Kruskal-Wallis chi-square = 4.0667, df = 3, p-value = 0.2544
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Caff and stations
Kruskal-Wallis chi-square = 5.7114, df = 3, p-value = 0.1265
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Naff and stations
Kruskal-Wallis chi-square = 5.5634, df = 3, p-value = 0.1349
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Kff and stations
Kruskal-Wallis chi-square = 9.1667, df = 3, p-value = 0.0272

alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: FCff and stations
Kruskal-Wallis chi-square = 7.4364, df = 3, p-value = 0.0592
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: BODff and stations
Kruskal-Wallis chi-square = 4.5, df = 3, p-value = 0.2123
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Clff and stations
Kruskal-Wallis chi-square = 2.132, df = 3, p-value = 0.5455
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Ammoniaff and stations
Kruskal-Wallis chi-square = 2.4525, df = 3, p-value = 0.4839
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Mgff and stations
Kruskal-Wallis chi-square = 8.381, df = 3, p-value = 0.0388
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: SO4ff and stations
Kruskal-Wallis chi-square = 7.8905, df = 3, p-value = 0.0483
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: TSSff and stations
Kruskal-Wallis chi-square = 3.1333, df = 3, p-value = 0.3715
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ALKff and stations
Kruskal-Wallis chi-square = 2.3091, df = 3, p-value = 0.5108
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CODff and stations
Kruskal-Wallis chi-square = 6.2905, df = 3, p-value = 0.0983
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: THff and stations
Kruskal-Wallis chi-square = 5.9667, df = 3, p-value = 0.1132
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Diazff and stations
Kruskal-Wallis chi-square = 3.125, df = 3, p-value = 0.3728
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: TPhosff and stations
Kruskal-Wallis chi-square = 6.9619, df = 3, p-value = 0.0731
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: DPff and stations
Kruskal-Wallis chi-square = 1.6762, df = 3, p-value = 0.6422
alternative hypothesis: two.sided

APPENDIX K

KRUSKAL WALLIS STATISTICAL ANALYSIS OF FIRST FLUSH DATA BETWEEN STORM EVENTS

Kruskal-Wallis rank sum test

data: CrTff2 and storms
Kruskal-Wallis chi-square = 7.6672, df = 3, p-value = 0.0534
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: AsTff2 and storms
Kruskal-Wallis chi-square = 6.6754, df = 3, p-value = 0.083
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CdTff2 and storms
Kruskal-Wallis chi-square = 5.8006, df = 3, p-value = 0.1217
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CuTff2 and storms
Kruskal-Wallis chi-square = 4.3141, df = 3, p-value = 0.2295
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: PbTff2 and storms
Kruskal-Wallis chi-square = 0.7801, df = 3, p-value = 0.8542
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ZnTff2 and storms
Kruskal-Wallis chi-square = 0.9524, df = 3, p-value = 0.8128
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CrDff2 and storms
Kruskal-Wallis chi-square = 4.8186, df = 3, p-value = 0.1856
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: AsDff2 and storms
Kruskal-Wallis chi-square = 5.5824, df = 3, p-value = 0.1338

alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CuDff2 and storms
Kruskal-Wallis chi-square = 6.494, df = 3, p-value = 0.0899
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CdDff2 and storms
Kruskal-Wallis chi-square = 6.3964, df = 3, p-value = 0.0938
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: PbDff2 and storms
Kruskal-Wallis chi-square = 5.1719, df = 3, p-value = 0.1596
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ZnDff2 and storms
Kruskal-Wallis chi-square = 2.6, df = 3, p-value = 0.4575
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Caff2 and storms
Kruskal-Wallis chi-square = 7.1095, df = 3, p-value = 0.0685
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Naff2 and storms
Kruskal-Wallis chi-square = 0.8722, df = 3, p-value = 0.8321
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Kff2 and storms
Kruskal-Wallis chi-square = 1.8667, df = 3, p-value = 0.6005
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: FCff2 and storm
Kruskal-Wallis chi-square = 1.4727, df = 2, p-value = 0.4789
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: BODff2 and storms
Kruskal-Wallis chi-square = 2.3409, df = 3, p-value = 0.5047
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Clff2 and storms
Kruskal-Wallis chi-square = 5.1416, df = 3, p-value = 0.1617
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Ammoniaff2.storms and storms
Kruskal-Wallis chi-square = 6.7914, df = 3, p-value = 0.0789
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Mgff2 and storms
Kruskal-Wallis chi-square = 1.4524, df = 3, p-value = 0.6933
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: SO4ff2 and storms
Kruskal-Wallis chi-square = 0.519, df = 3, p-value = 0.9147
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: TSSff2 and storms
Kruskal-Wallis chi-square = 7.3381, df = 3, p-value = 0.0619
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ALKff2 and storms

Kruskal-Wallis chi-square = 1.8182, df = 3, p-value = 0.611
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: THff2 and storms
Kruskal-Wallis chi-square = 1.2952, df = 3, p-value = 0.7303
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CODff2 and storms
Kruskal-Wallis chi-square = 5.2095, df = 3, p-value = 0.1571
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Diazff2 and storms
Kruskal-Wallis chi-square = 1.4792, df = 3, p-value = 0.6871
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: TPhosff2 and storms
Kruskal-Wallis chi-square = 1.4857, df = 3, p-value = 0.6856
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: DPhosff2 and storms
Kruskal-Wallis chi-square = 6.1333, df = 3, p-value = 0.1053
alternative hypothesis: two.sided

APPENDIX L

KRUSKAL WALLIS STATISTICAL ANALYSIS OF COMPOSITE SAMPLES BETWEEN STATION LOCATIONS

Kruskal-Wallis rank sum test

data: CrTcomp2 and stations
Kruskal-Wallis chi-square = 3.5262, df = 3, p-value = 0.3174
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: AsTcomp2 and stations
Kruskal-Wallis chi-square = 2.7507, df = 3, p-value = 0.4317
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: PbTcomp2 and stations
Kruskal-Wallis chi-square = 2.4363, df = 3, p-value = 0.4869
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CrDcomp2 and stations
Kruskal-Wallis chi-square = 0.7243, df = 3, p-value = 0.8675
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: AsDcomp2 and stations
Kruskal-Wallis chi-square = 0.8681, df = 3, p-value = 0.8331
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CdDcomp2 and stations
Kruskal-Wallis chi-square = 2.604, df = 3, p-value = 0.4568
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CuDcomp2 and stations
Kruskal-Wallis chi-square = 0.6879, df = 3, p-value = 0.8761
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: PbDcomp2 and stations
Kruskal-Wallis chi-square = 4.185, df = 3, p-value = 0.2422
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ZnDcomp2 and stations
Kruskal-Wallis chi-square = 0.8381, df = 3, p-value = 0.8403
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Nacomp2 and stations
Kruskal-Wallis chi-square = 2.081, df = 3, p-value = 0.5558
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Kcomp2 and stations
Kruskal-Wallis chi-square = 8.3143, df = 3, p-value = 0.0399
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Ammoniacomp2 and stations
Kruskal-Wallis chi-square = 0.7273, df = 3, p-value = 0.8668
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: BODcomp2 and stations
Kruskal-Wallis chi-square = 5.2253, df = 3, p-value = 0.156
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CODcomp2 and stations
Kruskal-Wallis chi-square = 2.805, df = 3, p-value = 0.4227
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: TSScomp2 and stations
Kruskal-Wallis chi-square = 2.1762, df = 3, p-value = 0.5367

alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ALKcomp2 and stations
Kruskal-Wallis chi-square = 1.5333, df = 3, p-value = 0.6746
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Diazcomp2 and stations
Kruskal-Wallis chi-square = 2.3747, df = 3, p-value = 0.4984
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CdTcomp2 and stations
Kruskal-Wallis chi-square = 0.5325, df = 3, p-value = 0.9117
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CuTcomp2 and stations
Kruskal-Wallis chi-square = 1.7888, df = 3, p-value = 0.6174
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ZnTcomp2 and stations
Kruskal-Wallis chi-square = 4.8189, df = 3, p-value = 0.1855
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Mgcomp2 and stations
Kruskal-Wallis chi-square = 6.9429, df = 3, p-value = 0.0737
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Clcomp2 and stations
Kruskal-Wallis chi-square = 2.2991, df = 3, p-value = 0.5127
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: THcomp2 and stations
Kruskal-Wallis chi-square = 4.2667, df = 3, p-value = 0.2341
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Cacomp2 and stations
Kruskal-Wallis chi-square = 4.8762, df = 3, p-value = 0.1811
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: SO4comp2 and stations
Kruskal-Wallis chi-square = 4.2286, df = 3, p-value = 0.2378
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: FCcomp2 and stations
Kruskal-Wallis chi-square = 2.0909, df = 3, p-value = 0.5538
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: DPhoscomp2 and stations
Kruskal-Wallis chi-square = 4.704, df = 3, p-value = 0.1948
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: TPhoscomp2 and stations
Kruskal-Wallis chi-square = 4.3524, df = 3, p-value = 0.2258
alternative hypothesis: two.sided

APPENDIX M

KRUSKAL WALLIS STATISTICAL ANALYSIS OF COMPOSITE SAMPLES BETWEEN STORM EVENTS

Kruskal-Wallis rank sum test

data: CrTcomp and storms
Kruskal-Wallis chi-square = 2.4381, df = 3, p-value = 0.4866
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: AsTcomp and storms
Kruskal-Wallis chi-square = 8.2096, df = 3, p-value = 0.0419
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CdTcomp and storms
Kruskal-Wallis chi-square = 11.1094, df = 3, p-value = 0.0111
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: PbTcomp and storms
Kruskal-Wallis chi-square = 4.8061, df = 3, p-value = 0.1866
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CrDcomp and storms
Kruskal-Wallis chi-square = 7.9254, df = 3, p-value = 0.0476
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: AsDcomp and storms
Kruskal-Wallis chi-square = 3.7022, df = 3, p-value = 0.2955
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CdDcomp and storms
Kruskal-Wallis chi-square = 6.5591, df = 3, p-value = 0.0874
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: PbDcomp and storms
Kruskal-Wallis chi-square = 4.8615, df = 3, p-value = 0.1822
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CuDcomp and storms
Kruskal-Wallis chi-square = 10.8897, df = 3, p-value = 0.0123
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ZnDcomp and storms
Kruskal-Wallis chi-square = 3.6667, df = 3, p-value = 0.2998
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Nacomp and storms
Kruskal-Wallis chi-square = 9.2048, df = 3, p-value = 0.0267
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Kcomp and storms
Kruskal-Wallis chi-square = 1.7381, df = 3, p-value = 0.6285
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: BODcomp and storms
Kruskal-Wallis chi-square = 0.7637, df = 3, p-value = 0.8581
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CODcomp and storms
Kruskal-Wallis chi-square = 5.9249, df = 3, p-value = 0.1153
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: TSScomp and storms
Kruskal-Wallis chi-square = 6.8095, df = 3, p-value = 0.0782

alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ALKcomp and storm
Kruskal-Wallis chi-square = 1.0667, df = 2, p-value = 0.5866
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Ammoniacomp and storm
Kruskal-Wallis chi-square = 6.7455, df = 2, p-value = 0.0343
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: CuTcomp and storms
Kruskal-Wallis chi-square = 6.2896, df = 3, p-value = 0.0983
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: ZnTcomp and storms
Kruskal-Wallis chi-square = 7.3578, df = 3, p-value = 0.0613
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Mgcomp and storms
Kruskal-Wallis chi-square = 2.6333, df = 3, p-value = 0.4517
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Clcomp and storms
Kruskal-Wallis chi-square = 4.0983, df = 3, p-value = 0.251
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: THcomp and storms
Kruskal-Wallis chi-square = 2.4238, df = 3, p-value = 0.4892
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Cacomp and storms
Kruskal-Wallis chi-square = 2.9628, df = 3, p-value = 0.3974
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: SO4comp and storms
Kruskal-Wallis chi-square = 3.5095, df = 3, p-value = 0.3195
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: FCcomp and storms
Kruskal-Wallis chi-square = 5.5455, df = 3, p-value = 0.1359
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: DPhoscomp and storms
Kruskal-Wallis chi-square = 5.1273, df = 3, p-value = 0.1627
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: TPhoscomp and storms
Kruskal-Wallis chi-square = 4.5333, df = 3, p-value = 0.2093
alternative hypothesis: two.sided

Kruskal-Wallis rank sum test

data: Diazcomp and storms
Kruskal-Wallis chi-square = 2.7421, df = 3, p-value = 0.4331
alternative hypothesis: two.sided

APPENDIX N

RAW BACKGROUND DATA

Table 5: Pecan Creek background data collected at Gay St. Bridge on Feb-16-2000.

Pecan Creek Background Data For Stormwater Analysis
Collected Feb-16-2000 at Gay Street Bridge

Time of Collection	Parameter	Value	Method of Collection
12:00PM	Chromium (Total mg/L)	0.008	Grab
12:00PM	Arsenic (Total mg/L)	0.010	Grab
12:00PM	Cadmium (Total mg/L)	0.005	Grab
12:00PM	Copper (Total mg/L)	0.017	Grab
12:00PM	Lead (Total mg/L)	0.030	Grab
12:00PM	Zinc (Total mg/L)	0.040	Grab
12:00PM	Chromium (Dissolved mg/L)	0.007	Grab
12:00PM	Arsenic (Dissolved mg/L)	0.008	Grab
12:00PM	Cadmium (Dissolved mg/L)	0.006	Grab
12:00PM	Copper (Dissolved mg/L)	0.022	Grab
12:00PM	Lead (Dissolved mg/L)	0.010	Grab
12:00PM	Zinc (Dissolved mg/L)	0.021	Grab
12:00PM	Calcium (mg/L)	113.200	Grab
12:00PM	Magnesium (mg/L)	9.475	Grab
12:00PM	Sodium (mg/L)	47.300	Grab
12:00PM	Potassium (mg/L)	0.738	Grab
12:00PM	Sulfate (mg/L)	86.170	Grab
12:00PM	Fecal Coliform (coln./100 ml)	2013.330	Grab
12:00PM	Oil and Grease (mg/L)	3.800	Grab
12:00PM	Total Hardness (mg/L CaCO3)	329.000	Grab
12:00PM	Ammonia (mg/L)	NA	
12:00PM	Tota Kjedahl Nitrogen (mg/L)	0.295	Grab
12:00PM	BOD 5-day (mg/L)	invalid	Grab
12:00PM	COD (mg/L)	8.000	Grab
12:00PM	TSS (mg/L)	2.000	Grab
12:00PM	TS (mg/L)	570.000	Grab
12:00PM	pH	7.330	Field
12:00PM	Temperature(C)	14.760	Field
12:00PM	Conductance (us/cm)	843.500	Field
12:00PM	Alkalinity (mg/L CaCO3)	269.650	Grab
12:00PM	DO (mg/L)	4.640	Field
12:00PM	Chloride (mg/L)	58.800	Grab
12:00PM	Diazinon (mg/L)	<0.2	Grab
12:00PM	Total Phosphorus (mg/L)	0.345	Grab
12:00PM	Dissolved Phosphorus (mg/L)	0.249	Grab
12:00PM	Atrazine (ppb)	NA	

Table 6: Pecan Creek background data collected at Sycamore St. Bridge on Feb-16-2000.

Pecan Creek Background Data For Stormwater Analysis
Collected Feb-16-2000 at Sycamore Street Bridge

Time of Collection	Parameter	Value	Method of Collection
12:30PM	Chromium (Total mg/L)	0.012	Grab
12:30PM	Arsenic (Total mg/L)	0.009	Grab
12:30PM	Cadmium (Total mg/L)	0.010	Grab
12:30PM	Copper (Total mg/L)	0.005	Grab
12:30PM	Lead (Total mg/L)	0.010	Grab
12:30PM	Zinc (Total mg/L)	0.020	Grab
12:30PM	Chromium (Dissolved mg/L)	0.012	Grab
12:30PM	Arsenic (Dissolved mg/L)	0.008	Grab
12:30PM	Cadmium (Dissolved mg/L)	0.004	Grab
12:30PM	Copper (Dissolved mg/L)	0.015	Grab
12:30PM	Lead (Dissolved mg/L)	0.010	Grab
12:30PM	Zinc (Dissolved mg/L)	0.037	Grab
12:30PM	Calcium (mg/L)	48.670	Grab
12:30PM	Magnesium (mg/L)	5.721	Grab
12:30PM	Sodium (mg/L)	48.700	Grab
12:30PM	Potassium (mg/L)	4.748	Grab
12:30PM	Sulfate (mg/L)	141.110	Grab
12:30PM	Fecal Coliform (coln./100 ml)	70.000	Grab
12:30PM	Oil and Grease (mg/L)	0.500	Grab
12:30PM	Total Hardness (mg/L CaCO3)	147.000	Grab
12:30PM	Ammonia (mg/L)	NA	
12:30PM	Tota Kjedahl Nitrogen (mg/L)	0.565	Grab
12:30PM	BOD 5-day (mg/L)	3.200	Grab
12:30PM	COD (mg/L)	22.000	Grab
12:30PM	TSS (mg/L)	8.000	Grab
12:30PM	TS (mg/L)	445.000	Grab
12:30PM	pH	7.480	Field
12:30PM	Temperature(C)	15.170	Field
12:30PM	Conductance (us/cm)	616.900	Field
12:30PM	Alkalinity(mg/L CaCO3)	143.280	Grab
12:30PM	DO (mg/L)	16.320	Field
12:30PM	Chloride (mg/L)	58.200	Grab
12:30PM	Diazinon (mg/L)	<0.2	Grab
12:30PM	Total Phosphorus (mg/L)	0.091	Grab
12:30PM	Dissolved Phosphorus (mg/L)	0.085	Grab
12:30PM	Atrazine (ppb)	NA	

Table 7: Pecan Creek background data collected at Mayhill Rd. Bridge on Feb-16-2000.

Pecan Creek Background Data For Stormwater Analysis
Collected Feb-16-2000 at Mayhill Road Bridge

Time of Collection	Parameter	Value	Method of Collection
1:15PM	Chromium (Total mg/L)	0.003	Grab
1:15PM	Arsenic (Total mg/L)	0.006	Grab
1:15PM	Cadmium (Total mg/L)	0.006	Grab
1:15PM	Copper (Total mg/L)	0.011	Grab
1:15PM	Lead (Total mg/L)	0.010	Grab
1:15PM	Zinc (Total mg/L)	0.040	Grab
1:15PM	Chromium (Dissolved mg/L)	0.004	Grab
1:15PM	Arsenic (Dissolved mg/L)	0.009	Grab
1:15PM	Cadmium (Dissolved mg/L)	0.006	Grab
1:15PM	Copper (Dissolved mg/L)	0.009	Grab
1:15PM	Lead (Dissolved mg/L)	0.010	Grab
1:15PM	Zinc (Dissolved mg/L)	0.139	Grab
1:15PM	Calcium (mg/L)	66.070	Grab
1:15PM	Magnesium (mg/L)	10.000	Grab
1:15PM	Sodium (mg/L)	45.100	Grab
1:15PM	Potassium (mg/L)	7.113	Grab
1:15PM	Sulfate (mg/L)	167.800	Grab
1:15PM	Fecal Coliform (coln./100 ml)	10.000	Grab
1:15PM	Oil and Grease (mg/L)	1.400	Grab
1:15PM	Total Hardness (mg/L CaCO3)	210.000	Grab
1:15PM	Ammonia (mg/L)	NA	
1:15PM	Tota Kjedahl Nitrogen (mg/L)	0.644	Grab
1:15PM	BOD 5-day (mg/L)	2.700	Grab
1:15PM	COD (mg/L)	129.000	Grab
1:15PM	TSS (mg/L)	4.000	Grab
1:15PM	TS (mg/L)	558.000	Grab
1:15PM	pH	7.480	Field
1:15PM	Temperature(C)	15.170	Field
1:15PM	Conductance (us/cm)	616.900	Field
1:15PM	Alkalinity(mg/L CaCO3)	153.430	Grab
1:15PM	DO(mg/L)	16.320	Field
1:15PM	Chloride (mg/L)	77.800	Grab
1:15PM	Diazinon (mg/L)	<0.2	Grab
1:15PM	Total Phosphorus (mg/L)	0.185	Grab
1:15PM	Dissolved Phosphorus (mg/L)	0.172	Grab
1:15PM	Atrazine (ppb)	NA	

APPENDIX O

RAW STORM WATER DATA

Table 8: Storm water data collected from station PCSWS1 on 02/23/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max.Loading (lbs/Day)
02/23/2000 @ 9:15AM	Chromium (Total mg/L)	0.009	0.009			0.510248833	1.844857816
02/23/2000 @ 9:15AM	Arsenic (Total mg/L)	0.010	0.004			0.583951442	0.860933648
02/23/2000 @ 9:15AM	Cadmium (Total mg/L)	0.004	0.003			0.226777259	0.614952605
02/23/2000 @ 9:15AM	Copper (Total mg/L)	0.024	0.013			1.360663554	2.664794624
02/23/2000 @ 9:15AM	Lead (Total mg/L)	0.010	0.050			0.566943148	10.24921009
02/23/2000 @ 9:15AM	Zinc (Total mg/L)	0.069	0.064			3.911907719	13.11898892
02/23/2000 @ 9:15AM	Chromium (Dissolved mg/L)	0.012	0.002			0.680331777	0.409968404
02/23/2000 @ 9:15AM	Arsenic (Dissolved mg/L)	0.005	0.003			0.260793848	0.635451026
02/23/2000 @ 9:15AM	Cadmium (Dissolved mg/L)	0.003	0.004			0.170082944	0.819936807
02/23/2000 @ 9:15AM	Copper (Dissolved mg/L)	0.013	0.005			0.737026092	1.024921009
02/23/2000 @ 9:15AM	Lead (Dissolved mg/L)	0.010	0.010			0.566943148	2.049842018
02/23/2000 @ 9:15AM	Zinc (Dissolved mg/L)	0.042	0.002			2.38116122	0.409968404
02/23/2000 @ 9:15AM	Calcium (mg/L)	50.810	31.550			2880.638133	6467.251568
02/23/2000 @ 9:15AM	Magnesium (mg/L)	4.209	2.044			238.6263709	418.9877085
02/23/2000 @ 9:15AM	Sodium (mg/L)	22.600	48.100			1281.291514	9859.740108
02/23/2000 @ 9:15AM	Potassium (mg/L)	3.410	2.164			193.3276134	443.5858128
02/23/2000 @ 9:15AM	Sulfate (mg/L)	39.840	10.720			2258.7015	2197.430644
02/23/2000 @ 9:15AM	Fecal Coliform (coln./100 ml)	25465.000	3046.600			6.54867E+12	2.83274E+12
02/23/2000 @ 9:15AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
02/23/2000 @ 9:15AM	Total Hardness (mg/L CaCO3)	55.02	33.59			3119.264504	6886.239276
02/23/2000 @ 9:15AM	Ammonia (mg/L)	NA	NA			NA	NA
02/23/2000 @ 9:15AM	Total Kjedahl Nitrogen (mg/L)	1.530	1.150			86.7423016	235.7318321
02/23/2000 @ 9:15AM	BOD, 5-day (mg/L)	107.600	45.120			6100.308269	9248.887187
02/23/2000 @ 9:15AM	COD (mg/L)	626.000	152.000			35490.64105	31157.59868
02/23/2000 @ 9:15AM	TSS (mg/L)	2300.000	511.000			130396.924	104746.9271
02/23/2000 @ 9:15AM	TS (mg/L)	3230.000	353.000			183122.6367	72359.42325
02/23/2000 @ 9:15AM	pH	7.500	8.100	8.000		NA	NA
02/23/2000 @ 9:15AM	Temperature ©	NA	NA	15.060		NA	NA
02/23/2000 @ 9:15AM	Conductance (us/cm)	NA	NA	273.600		NA	NA
02/23/2000 @ 9:15AM	Alkalinity (mg/L CaCO3)	109.450	N/A			6205.192752	NA
02/23/2000 @ 9:15AM	DO (mg/L)	NA	NA	6.160		NA	NA
02/23/2000 @ 9:15AM	Chloride (mg/L)	20.400	5.010			1156.564021	1026.970851
02/23/2000 @ 9:15AM	Diazinon (mg/L)	0.900	<0.200			51.02488329	0
02/23/2000 @ 9:15AM	Total Phosphorus (mg/L)	0.512	0.204			29.02748916	41.81677717
02/23/2000 @ 9:15AM	Dissolved Phosphorus (mg/L)	0.105	0.104			5.952903051	21.31835699
02/23/2000 @ 9:15AM	Atrazine (ppb)	7.191	NA			407.6888175	NA

NA = not analyzed Fecal Coliform loadings are represented as colonies/day

Table 9: Storm water collected from station PCSWS2 on 02/23/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
02/23/2000 @ 9:45AM	Chromium (Total mg/L)	0.028	0.009			0.83072545	4.612144541
02/23/2000 @ 9:45AM	Arsenic (Total mg/L)	0.023	0.003			0.676447866	1.434889413
02/23/2000 @ 9:45AM	Cadmium (Total mg/L)	0.006	0.003			0.178012596	1.537381514
02/23/2000 @ 9:45AM	Copper (Total mg/L)	0.049	0.018			1.453769537	9.224289082
02/23/2000 @ 9:45AM	Lead (Total mg/L)	0.070	0.030			2.076813624	15.37381514
02/23/2000 @ 9:45AM	Zinc (Total mg/L)	0.328	0.071			9.731355266	36.38469582
02/23/2000 @ 9:45AM	Chromium (Dissolved mg/L)	0.012	0.005			0.356025193	2.562302523
02/23/2000 @ 9:45AM	Arsenic (Dissolved mg/L)	0.005	0.006			0.14834383	3.074763027
02/23/2000 @ 9:45AM	Cadmium (Dissolved mg/L)	0.004	0.003			0.118675064	1.537381514
02/23/2000 @ 9:45AM	Copper (Dissolved mg/L)	0.014	0.007			0.415362725	3.587223532
02/23/2000 @ 9:45AM	Lead (Dissolved mg/L)	0.010	0.010			0.296687661	5.124605046
02/23/2000 @ 9:45AM	Zinc (Dissolved mg/L)	0.071	0.086			2.10648239	44.07160339
02/23/2000 @ 9:45AM	Calcium (mg/L)	87.950	24.620			2609.367974	12616.77762
02/23/2000 @ 9:45AM	Magnesium (mg/L)	4.334	1.600			128.5844321	819.9368073
02/23/2000 @ 9:45AM	Sodium (mg/L)	23.600	43.100			700.1828789	22087.04775
02/23/2000 @ 9:45AM	Potassium (mg/L)	7.444	3.456			220.8542945	1771.063504
02/23/2000 @ 9:45AM	Sulfate (mg/L)	29.250	14.690			867.8114071	7528.044812
02/23/2000 @ 9:45AM	Fecal Coliform (coln./100 ml)	35215.000	3323.300			4.73912E+12	7.72503E+12
02/23/2000 @ 9:45AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
02/23/2000 @ 9:45AM	Total Hardness (mg/L CaCO3)	92.28	26.22			2737.952407	13436.71443
02/23/2000 @ 9:45AM	Ammonia (mg/L)	NA	NA			NA	NA
02/23/2000 @ 9:45AM	Total Kjedahl Nitrogen (mg/L)	3.54	1.08			105.0274318	553.4573449
02/23/2000 @ 9:45AM	BOD, 5-day (mg/L)	86.60	22.80			2569.31514	11684.0995
02/23/2000 @ 9:45AM	COD (mg/L)	720	676			21361.51156	346423.3011
02/23/2000 @ 9:45AM	TSS (mg/L)	852.00	465.00			25277.78868	238294.1346
02/23/2000 @ 9:45AM	TS (mg/L)	3503.00	639.00			103929.6875	327462.2624
02/23/2000 @ 9:45AM	pH	7.70	8.10	8.62		NA	NA
02/23/2000 @ 9:45AM	Temperature ©	NA	NA	17.78		NA	NA
02/23/2000 @ 9:45AM	Conductance (us/cm)	NA	NA	215.50		NA	NA
02/23/2000 @ 9:45AM	Alkalinity (mg/L CaCO3)	214.92	149.25			6376.4112	76484.73031
02/23/2000 @ 9:45AM	DO (mg/L)	NA	NA	8.53		NA	NA
02/23/2000 @ 9:45AM	Chloride (mg/L)	16.50	6.51			489.5346399	3336.117885
02/23/2000 @ 9:45AM	Diazinon (mg/L)	<0.20	<0.20			0	0
02/23/2000 @ 9:45AM	Total Phosphorus (mg/L)	0.55	0.82			16.43649639	421.7549953
02/23/2000 @ 9:45AM	Dissolved Phosphorus (mg/L)	0.37	0.25			10.97744344	126.0652841
02/23/2000 @ 9:45AM	Atrazine (ppb)	0.69	0.27			20.56045488	137.3394152

NA = not analyzed   Fecal Coliform loadings are represented as colonies/day

Table 10: Storm water collected from station PCSWS3 on 02/23/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
02/23/2000 @ 10:00AM	Chromium (Total mg/L)	0.010	0.006			3.182649449	9.062459449
02/23/2000 @ 10:00AM	Arsenic (Total mg/L)	0.018	0.005			5.66511602	8.156213504
02/23/2000 @ 10:00AM	Cadmium (Total mg/L)	0.004	0.003			1.27305978	4.531229725
02/23/2000 @ 10:00AM	Copper (Total mg/L)	0.030	0.014			9.547948348	21.14573872
02/23/2000 @ 10:00AM	Lead (Total mg/L)	0.040	0.020			12.7305978	30.20819816
02/23/2000 @ 10:00AM	Zinc (Total mg/L)	0.144	0.066			45.83015207	99.68705394
02/23/2000 @ 10:00AM	Chromium (Dissolved mg/L)	0.009	0.011			2.864384505	16.61450899
02/23/2000 @ 10:00AM	Arsenic (Dissolved mg/L)	0.003	0.005			0.954794835	8.005172514
02/23/2000 @ 10:00AM	Cadmium (Dissolved mg/L)	0.003	0.003			0.954794835	4.531229725
02/23/2000 @ 10:00AM	Copper (Dissolved mg/L)	0.011	0.009			3.500914394	13.59368917
02/23/2000 @ 10:00AM	Lead (Dissolved mg/L)	0.020	0.020			6.365298899	30.20819816
02/23/2000 @ 10:00AM	Zinc (Dissolved mg/L)	0.044	0.028			14.00365758	42.29147743
02/23/2000 @ 10:00AM	Calcium (mg/L)	46.510	20.320			14802.50259	30691.52934
02/23/2000 @ 10:00AM	Magnesium (mg/L)	2.738	1.612			871.4094193	2434.780772
02/23/2000 @ 10:00AM	Sodium (mg/L)	42.100	45.000			13398.95418	67968.44587
02/23/2000 @ 10:00AM	Potassium (mg/L)	6.050	3.130			1925.502917	4727.583013
02/23/2000 @ 10:00AM	Sulfate (mg/L)	63.000	9.390			20050.69153	14182.74904
02/23/2000 @ 10:00AM	Fecal Coliform (coln./100 ml)	14760.870	4040.000			2.13094E+13	2.76787E+13
02/23/2000 @ 10:00AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
02/23/2000 @ 10:00AM	Total Hardness (mg/L CaCO3)	49.25	21.93			15673.91201	33126.31011
02/23/2000 @ 10:00AM	Ammonia (mg/L)	NA	NA			NA	NA
02/23/2000 @ 10:00AM	Total Kjedahl Nitrogen (mg/L)	1.18	3.31			375.552635	4999.456796
02/23/2000 @ 10:00AM	BOD, 5-day (mg/L)	80.90	24.00			25747.63405	36249.8378
02/23/2000 @ 10:00AM	COD (mg/L)	430.00	126.00			136853.9263	190311.6484
02/23/2000 @ 10:00AM	TSS (mg/L)	1138.00	430.00			362185.5073	649476.2605
02/23/2000 @ 10:00AM	TS (mg/L)	1620.00	292.00			515589.2108	441039.6932
02/23/2000 @ 10:00AM	pH	7.90	8.10	8.50		NA	NA
02/23/2000 @ 10:00AM	Temperature ©	NA	NA	18.23		NA	NA
02/23/2000 @ 10:00AM	Conductance (us/cm)	NA	NA	328.60		NA	NA
02/23/2000 @ 10:00AM	Alkalinity (mg/L CaCO3)	164.18	121.58			52252.73866	183635.6366
02/23/2000 @ 10:00AM	DO (mg/L)	NA	NA	11.03		NA	NA
02/23/2000 @ 10:00AM	Chloride (mg/L)	18.30	5.60			5824.248493	8458.295486
02/23/2000 @ 10:00AM	Diazinon (mg/L)	<0.20	<0.20			0	0
02/23/2000 @ 10:00AM	Total Phosphorus (mg/L)	4.91	2.38			1562.68088	3594.775582
02/23/2000 @ 10:00AM	Dissolved Phosphorus (mg/L)	0.63	0.39			199.5521205	589.0598642
02/23/2000 @ 10:00AM	Atrazine (ppb)	5.37	1.54			1708.12796	2330.562488

NA = not analyzed   Fecal Coliform loadings are represented as colonies/day

Table 11: Storm water collected from station PCSWS4 on 02/23/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
02/23/2000 @ 10:15AM	Chromium (Total mg/L)	0.023	0.031			4.838706027	52.17387369
02/23/2000 @ 10:15AM	Arsenic (Total mg/L)	0.005	0.003			0.988779058	4.207570459
02/23/2000 @ 10:15AM	Cadmium (Total mg/L)	0.005	0.004			1.051892615	6.732112734
02/23/2000 @ 10:15AM	Copper (Total mg/L)	0.023	0.030			4.838706027	50.4908455
02/23/2000 @ 10:15AM	Lead (Total mg/L)	0.050	0.040			10.51892615	67.32112734
02/23/2000 @ 10:15AM	Zinc (Total mg/L)	0.079	0.144			16.61990331	242.3560584
02/23/2000 @ 10:15AM	Chromium (Dissolved mg/L)	0.008	0.007			1.683028183	11.78119728
02/23/2000 @ 10:15AM	Arsenic (Dissolved mg/L)	0.001	0.006			0.147264966	9.761563464
02/23/2000 @ 10:15AM	Cadmium (Dissolved mg/L)	0.004	0.004			0.841514092	6.732112734
02/23/2000 @ 10:15AM	Copper (Dissolved mg/L)	0.009	0.001			1.893406706	1.683028183
02/23/2000 @ 10:15AM	Lead (Dissolved mg/L)	0.000	0.030			0	50.4908455
02/23/2000 @ 10:15AM	Zinc (Dissolved mg/L)	0.032	0.020			6.732112734	33.66056367
02/23/2000 @ 10:15AM	Calcium (mg/L)	78.040	57.760			16417.93993	97211.70788
02/23/2000 @ 10:15AM	Magnesium (mg/L)	12.050	4.982			2535.061201	8384.84641
02/23/2000 @ 10:15AM	Sodium (mg/L)	39.900	44.300			8394.103065	74558.14853
02/23/2000 @ 10:15AM	Potassium (mg/L)	8.490	5.768			1786.11366	9707.706562
02/23/2000 @ 10:15AM	Sulfate (mg/L)	182.800	52.410			38457.19399	88207.50709
02/23/2000 @ 10:15AM	Fecal Coliform (coln./100 ml)	6585.330	3660.000			6.28419E+12	2.7941E+13
02/23/2000 @ 10:15AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
02/23/2000 @ 10:15AM	Total Hardness (mg/L CaCO3)	90.09	62.74			18953.00113	105596.5543
02/23/2000 @ 10:15AM	Ammonia (mg/L)	NA	NA			NA	NA
02/23/2000 @ 10:15AM	Total Kjedahl Nitrogen (mg/L)	0.72	1.33			150.6310224	2238.427484
02/23/2000 @ 10:15AM	BOD, 5-day (mg/L)	3.80	20.70			799.4383871	34838.6834
02/23/2000 @ 10:15AM	COD (mg/L)	120.00	150.00			25245.42275	252454.2275
02/23/2000 @ 10:15AM	TSS (mg/L)	362.00	764.00			76157.0253	1285833.532
02/23/2000 @ 10:15AM	TS (mg/L)	923.00	883.00			194179.3767	1486113.886
02/23/2000 @ 10:15AM	pH	7.80	8.10	8.76		NA	NA
02/23/2000 @ 10:15AM	Temperature ©	NA	NA	15.81		NA	NA
02/23/2000 @ 10:15AM	Conductance(us/cm)	NA	NA	243.70		NA	NA
02/23/2000 @ 10:15AM	Alkalinity (mg/L CaCo3)	196.02	79.60			41238.39806	133969.0434
02/23/2000 @ 10:15AM	DO (mg/L)	NA	NA	8.55		NA	NA
02/23/2000 @ 10:15AM	Chloride (mg/L)	75.80	12.30			15946.69204	20701.24666
02/23/2000 @ 10:15AM	Diazinon (mg/L)	<0.20	<0.20			0	0
02/23/2000 @ 10:15AM	Total Phosphorus (mg/L)	0.59	1.46			124.7544641	2457.221148
02/23/2000 @ 10:15AM	Dissolved Phosphorus (mg/L)	0.16	0.39			32.60867105	647.9658506
02/23/2000 @ 10:15AM	Atrazine (ppb)	0.56	1.62			118.0223514	2726.505657

NA = not analyzed   Fecal Coliform loadings are represented as colonies/day

Table 12: Storm water collected from station PCSWS1 on 03/03/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
03/02/2000 @ 15:28	Chromium (Total mg/L)	0.006	0.008			0.340165889	1.424100771
03/02/2000 @ 15:28	Arsenic (Total mg/L)	0.002	0.010			0.124727492	1.691119665
03/02/2000 @ 15:28	Cadmium (Total mg/L)	0.006	0.005			0.340165889	0.890062982
03/02/2000 @ 15:28	Copper (Total mg/L)	0.017	0.013			0.963803351	2.314163752
03/02/2000 @ 15:28	Lead (Total mg/L)	0.060	0.030			3.401658886	5.34037789
03/02/2000 @ 15:28	Zinc (Total mg/L)	0.075	0.092			4.252073608	16.37715886
03/02/2000 @ 15:28	Chromium (Dissolved mg/L)	0.014	0.016			0.793720407	2.848201541
03/02/2000 @ 15:28	Arsenic (Dissolved mg/L)	0.001	0.005			0.062363746	0.818857943
03/02/2000 @ 15:28	Cadmium (Dissolved mg/L)	0.007	0.004			0.396860203	0.712050385
03/02/2000 @ 15:28	Copper (Dissolved mg/L)	0.011	0.009			0.623637462	1.602113367
03/02/2000 @ 15:28	Lead (Dissolved mg/L)	0.050	0.030			2.834715738	5.34037789
03/02/2000 @ 15:28	Zinc (Dissolved mg/L)	0.039	0.053			2.211078276	9.434667605
03/02/2000 @ 15:28	Calcium (mg/L)	90.420	31.950			5126.299941	5687.502453
03/02/2000 @ 15:28	Magnesium (mg/L)	8.128	2.540			460.8113904	452.1519947
03/02/2000 @ 15:28	Sodium (mg/L)	42.600	10.200			2415.177809	1815.728483
03/02/2000 @ 15:28	Potassium (mg/L)	2.294	2.792			130.0567581	497.0111689
03/02/2000 @ 15:28	Sulfate (mg/L)	77.000	23.000			4365.462237	4094.289716
03/02/2000 @ 15:28	Fecal Coliform (coln./100 ml)	22200.000	4320.000			5.70903E+12	3.48823E+12
03/02/2000 @ 15:28	Oil and Grease (mg/L)	NA	NA		<5	NA	NA
03/02/2000 @ 15:28	Total Hardness (mg/L CaCO3)	98.548	34.490			5587.111332	6139.654447
03/02/2000 @ 15:28	Ammonia (mg/L)	0.180	0.210			10.20497666	37.38264523
03/02/2000 @ 15:28	Total Kjedahl Nitrogen (mg/L)	NA	NA			NA	NA
03/02/2000 @ 15:28	BOD, 5-day (mg/L)	invalid	invalid			NA	NA
03/02/2000 @ 15:28	COD (mg/L)	126.000	119.000			7143.483661	21183.49896
03/02/2000 @ 15:28	TSS (mg/L)	100.000	100.000			5669.431477	17801.25963
03/02/2000 @ 15:28	TS (mg/L)	NA	NA			NA	NA
03/02/2000 @ 15:28	pH	NA	NA	7.30		NA	NA
03/02/2000 @ 15:28	Temperature ©	NA	NA	15.66		NA	NA
03/02/2000 @ 15:28	Conductance (us/cm)	NA	NA	286.00		NA	NA
03/02/2000 @ 15:28	Alkalinity (mg/L CaCO3)	135.320	379.090			7671.874675	67482.79514
03/02/2000 @ 15:28	DO (mg/L)	NA	NA	7.87		NA	NA
03/02/2000 @ 15:28	Chloride (mg/L)	61.000	10.000			3458.353201	1780.125963
03/02/2000 @ 15:28	Diazinon (mg/L)	0.400	0.500			22.67772591	89.00629816
03/02/2000 @ 15:28	Total Phosphorus (mg/L)	0.810	1.960			45.92239496	348.9046888
03/02/2000 @ 15:28	Dissolved Phosphorus (mg/L)	0.760	0.730			43.08767922	129.9491953
03/02/2000 @ 15:28	Atrazine (ppb)	5.052	4.984			286.4196782	887.2147801

NA = not analyzed Fecal Coliform loadings are represented as colonies/day

Table 13: Storm water collected from station PCSWS2 on 03/03/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
03/03/2000 @ 15:34	Chromium (Total mg/L)	0.014	0.014			0.415362725	4.229147743
03/03/2000 @ 15:34	Arsenic (Total mg/L)	0.003	0.004			0.074171915	1.14791153
03/03/2000 @ 15:34	Cadmium (Total mg/L)	0.006	0.005			0.178012596	1.510409908
03/03/2000 @ 15:34	Copper (Total mg/L)	0.030	0.028			0.890062982	8.458295486
03/03/2000 @ 15:34	Lead (Total mg/L)	0.100	0.020			2.966876605	6.041639633
03/03/2000 @ 15:34	Zinc (Total mg/L)	0.217	0.249			6.438122234	75.21841343
03/03/2000 @ 15:34	Chromium (Dissolved mg/L)	0.018	0.016			0.534037789	4.833311706
03/03/2000 @ 15:34	Arsenic (Dissolved mg/L)	0.003	0.002			0.089006298	0.66458036
03/03/2000 @ 15:34	Cadmium (Dissolved mg/L)	0.006	0.005			0.178012596	1.510409908
03/03/2000 @ 15:34	Copper (Dissolved mg/L)	0.020	0.008			0.593375321	2.416655853
03/03/2000 @ 15:34	Lead (Dissolved mg/L)	0.030	0.010			0.890062982	3.020819816
03/03/2000 @ 15:34	Zinc (Dissolved mg/L)	0.144	0.088			4.272302312	26.58321438
03/03/2000 @ 15:34	Calcium (mg/L)	74.850	56.660			2220.707139	17115.96508
03/03/2000 @ 15:34	Magnesium (mg/L)	2.424	2.405			71.91708892	726.5071659
03/03/2000 @ 15:34	Sodium (mg/L)	3.700	4.500			109.7744344	1359.368917
03/03/2000 @ 15:34	Potassium (mg/L)	3.769	2.268			111.8215793	685.1219344
03/03/2000 @ 15:34	Sulfate (mg/L)	13.000	12.000			385.6939587	3624.98378
03/03/2000 @ 15:34	Fecal Coliform (coln./100 ml)	27933.000	3560.000			3.75913E+12	4.87804E+12
03/03/2000 @ 15:34	Oil and Grease (mg/L)	NA	NA		<5	NA	NA
03/03/2000 @ 15:34	Total Hardness (mg/L CaCO3)	77.274	59.065			2292.624228	17842.47225
03/03/2000 @ 15:34	Ammonia (mg/L)	0.200	0.180			5.933753211	54.3747567
03/03/2000 @ 15:34	Total Kjedahl Nitrogen (mg/L)	NA	NA			NA	NA
03/03/2000 @ 15:34	BOD, 5-day (mg/L)	27.100	23.800			804.0235601	7189.551163
03/03/2000 @ 15:34	COD (mg/L)	207.000	180.000			6141.434573	54374.7567
03/03/2000 @ 15:34	TSS (mg/L)	540.000	424.000			16021.13367	128082.7602
03/03/2000 @ 15:34	TS (mg/L)	NA	NA			NA	NA
03/03/2000 @ 15:34	pH	NA	NA	7.82		NA	NA
03/03/2000 @ 15:34	Temperature ©	NA	NA	17.10		NA	NA
03/03/2000 @ 15:34	Conductance (us/cm)	NA	NA	164.00		NA	NA
03/03/2000 @ 15:34	Alkalinity (mg/L CaCO3)	127.360	34.820			3778.614045	10518.4946
03/03/2000 @ 15:34	DO (mg/L)	NA	NA	8.62		NA	NA
03/03/2000 @ 15:34	Chloride (mg/L)	58.000	89.000			1720.788431	26885.29637
03/03/2000 @ 15:34	Diazinon (mg/L)	< 0.2	< 0.2			0	0
03/03/2000 @ 15:34	Total Phosphorus (mg/L)	0.140	5.380			4.153627248	1625.201061
03/03/2000 @ 15:34	Dissolved Phosphorus (mg/L)	0.730	0.670			21.65819922	202.3949277
03/03/2000 @ 15:34	Atrazine (ppb)	5.818	2.239			172.6128809	676.3615569

NA = not analyzed   Fecal Coliform loadings are represented as colonies/day

Table 14: Storm water collected from station PCSWS3 on 03/03/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
03/03/2000 @ 15:47	Chromium (Total mg/L)	0.005	0.005			1.591324725	2.69716055
03/03/2000 @ 15:47	Arsenic (Total mg/L)	0.012	0.012			3.787352845	6.365298899
03/03/2000 @ 15:47	Cadmium (Total mg/L)	0.006	0.004			1.90958967	2.15772844
03/03/2000 @ 15:47	Copper (Total mg/L)	0.038	0.032			12.09406791	17.26182752
03/03/2000 @ 15:47	Lead (Total mg/L)	0.020	0.040			6.365298899	21.5772844
03/03/2000 @ 15:47	Zinc (Total mg/L)	0.297	0.306			94.52468865	165.0662257
03/03/2000 @ 15:47	Chromium (Dissolved mg/L)	0.012	0.013			3.819179339	7.012617431
03/03/2000 @ 15:47	Arsenic (Dissolved mg/L)	0.023	0.005			7.320093734	2.589274128
03/03/2000 @ 15:47	Cadmium (Dissolved mg/L)	0.003	0.004			0.954794835	2.15772844
03/03/2000 @ 15:47	Copper (Dissolved mg/L)	0.010	0.014			3.182649449	7.552049541
03/03/2000 @ 15:47	Lead (Dissolved mg/L)	0.010	0.000			3.182649449	0
03/03/2000 @ 15:47	Zinc (Dissolved mg/L)	0.100	0.149			31.82649449	80.3753844
03/03/2000 @ 15:47	Calcium (mg/L)	51.310	36.790			16330.17433	19845.70733
03/03/2000 @ 15:47	Magnesium (mg/L)	3.355	3.179			1067.77889	1714.854678
03/03/2000 @ 15:47	Sodium (mg/L)	19.200	18.000			6110.686943	9709.777981
03/03/2000 @ 15:47	Potassium (mg/L)	5.340	5.338			1699.534806	2879.488604
03/03/2000 @ 15:47	Sulfate (mg/L)	46.000	36.000			14640.18747	19419.55596
03/03/2000 @ 15:47	Fecal Coliform (coln./100 ml)	7600.000	3400.000			1.09717E+13	8.31928E+12
03/03/2000 @ 15:47	Oil and Grease (mg/L)	NA	NA		<5	NA	NA
03/03/2000 @ 15:47	Total Hardness (mg/L CaCO3)	54.665	39.969			17397.95322	21560.56201
03/03/2000 @ 15:47	Ammonia (mg/L)	0.200	0.150			63.65298899	80.91481651
03/03/2000 @ 15:47	Total Kjedahl Nitrogen (mg/L)	NA	NA			NA	NA
03/03/2000 @ 15:47	BOD, 5-day (mg/L)	66.900	51.600			21291.92482	27834.69688
03/03/2000 @ 15:47	COD (mg/L)	238.000	214.000			75747.0569	115438.4716
03/03/2000 @ 15:47	TSS (mg/L)	220.000	168.000			70018.28789	90624.59449
03/03/2000 @ 15:47	TS (mg/L)	NA	NA			NA	NA
03/03/2000 @ 15:47	pH	NA	NA	7.95		NA	NA
03/03/2000 @ 15:47	Temperature ©	NA	NA	18.23		NA	NA
03/03/2000 @ 15:47	Conductance (us/cm)	NA	NA	183.00		NA	NA
03/03/2000 @ 15:47	Alkalinity (mg/L CaCO3)	20.890	62.690			6648.5547	33816.99898
03/03/2000 @ 15:47	DO (mg/L)	NA	NA	8.67		NA	NA
03/03/2000 @ 15:47	Chloride (mg/L)	95.000	55.000			30235.16977	29668.76605
03/03/2000 @ 15:47	Diazinon (mg/L)	< 0.2	< 0.2			0	0
03/03/2000 @ 15:47	Total Phosphorus (mg/L)	5.380	5.750			1712.265404	3101.734633
03/03/2000 @ 15:47	Dissolved Phosphorus (mg/L)	0.670	1.620			213.2375131	873.8800183
03/03/2000 @ 15:47	Atrazine (ppb)	5.313	5.190			1690.941653	2799.652651

NA = not analyzed   Fecal Coliform loadings are represented as colonies/day

Table 15: Storm water collected from station PCSWS4 on 03/03/2000.
This site experienced an equipment problem resulting in a failure to obtain sample from automated sampler.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
03/03/2000 @ 16:04	Chromium (Total mg/L)						
03/03/2000 @ 16:04	Arsenic (Total mg/L)						
03/03/2000 @ 16:04	Cadmium (Total mg/L)						
03/03/2000 @ 16:04	Copper (Total mg/L)						
03/03/2000 @ 16:04	Lead (mg/L)						
03/03/2000 @ 16:04	Zinc (mg/L)						
03/03/2000 @ 16:04	Chromium (Dissolved mg/L)						
03/03/2000 @ 16:04	Arsenic (Dissolved mg/L)						
03/03/2000 @ 16:04	Cadmium (Dissolved mg/L)						
03/03/2000 @ 16:04	Copper (Dissolved mg/L)						
03/03/2000 @ 16:04	Lead (Dissolved mg/L)						
03/03/2000 @ 16:04	Zinc (Dissolved mg/L)						
03/03/2000 @ 16:04	Calcium (mg/L)						
03/03/2000 @ 16:04	Magnesium (mg/L)						
03/03/2000 @ 16:04	Sodium (mg/L)						
03/03/2000 @ 16:04	Potassium (mg/L)						
03/03/2000 @ 16:04	Sulfate (mg/L)						
03/03/2000 @ 16:04	Fecal Coliform (coln./100 ml)						
03/03/2000 @ 16:04	Oil and Grease (mg/L)				<5		
03/03/2000 @ 16:04	Total Hardness (mg/L CaCO3)						
03/03/2000 @ 16:04	Ammonia (mg/L)						
03/03/2000 @ 16:04	Tota Kjedahl Nitrogen						
03/03/2000 @ 16:04	BOD, 5-day (mg/L)						
03/03/2000 @ 16:04	COD (mg/L)						
03/03/2000 @ 16:04	TSS (mg/L)						
03/03/2000 @ 16:04	TS (mg/L)						
03/03/2000 @ 16:04	pH			7.91			
03/03/2000 @ 16:04	Temperature ©			15.54			
03/03/2000 @ 16:04	Conductance (us/cm)			556.00			
03/03/2000 @ 16:04	Alkalinity (mg/L CaCO3)						
03/03/2000 @ 16:04	DO (mg/L)			8.86			
03/03/2000 @ 16:04	Chloride (mg/L)						
03/03/2000 @ 16:04	Diazinon (mg/L)						
03/03/2000 @ 16:04	Total Phosphorus (mg/L)						
03/03/2000 @ 16:04	Dissolved Phosphorus (mg/L)						
03/03/2000 @ 16:04	Atrazine (ppb)						

NA = not analyzed

Table 16: Storm water collected from station PCSWS1 on 03/08/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
03/08/2000 @ 10:00 AM	Chromium (Total mg/L)	0.005	0.011			0.283471574	1.12741311
03/08/2000 @ 10:00 AM	Arsenic (Total mg/L)	0.004	0.011			0.232446691	1.10691469
03/08/2000 @ 10:00 AM	Cadmium (Total mg/L)	0.006	0.005			0.340165889	0.512460505
03/08/2000 @ 10:00 AM	Copper (Total mg/L)	0.015	0.017			0.850414722	1.742365716
03/08/2000 @ 10:00 AM	Lead (Total mg/L)	0.030	0.030			1.700829443	3.074763027
03/08/2000 @ 10:00 AM	Zinc (Total mg/L)	0.121	0.078			6.860012087	7.994383871
03/08/2000 @ 10:00 AM	Chromium (Dissolved mg/L)	0.006	0.012			0.340165889	1.229905211
03/08/2000 @ 10:00 AM	Arsenic (Dissolved mg/L)	0.002	0.012			0.130396924	1.188908371
03/08/2000 @ 10:00 AM	Cadmium (Dissolved mg/L)	0.008	0.008			0.453554518	0.819936807
03/08/2000 @ 10:00 AM	Copper (Dissolved mg/L)	0.012	0.011			0.680331777	1.12741311
03/08/2000 @ 10:00 AM	Lead (Dissolved mg/L)	0.060	0.041			3.401658886	4.202176138
03/08/2000 @ 10:00 AM	Zinc (Dissolved mg/L)	0.068	0.241			3.855213404	24.70059632
03/08/2000 @ 10:00 AM	Calcium (mg/L)	80.230	30.280			4548.584874	3103.460816
03/08/2000 @ 10:00 AM	Magnesium (mg/L)	8.538	2.753			484.0560595	282.1607538
03/08/2000 @ 10:00 AM	Sodium (mg/L)	41.800	14.800			2369.822357	1516.883094
03/08/2000 @ 10:00 AM	Potassium (mg/L)	2.261	2.900			128.1858457	297.2270927
03/08/2000 @ 10:00 AM	Sulfate (mg/L)	65.000	22.000			3685.13046	2254.82622
03/08/2000 @ 10:00 AM	Fecal Coliform (coln./100 ml)	7166.670	6000.000			1.84301E+12	2.78941E+12
03/08/2000 @ 10:00 AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
03/08/2000 @ 10:00 AM	Total Hardness (mg/L CaCO3)	88.768	33.033			5032.640933	3385.62157
03/08/2000 @ 10:00 AM	Ammonia (mg/L)	0.180	0.330			10.20497666	33.8223933
03/08/2000 @ 10:00 AM	Tota Kjedahl Nitrogen (mg/L)	NA	NA			NA	NA
03/08/2000 @ 10:00 AM	BOD, 5-day (mg/L)	invalid	59.800			NA	6129.027635
03/08/2000 @ 10:00 AM	COD (mg/L)	112.000	103.000			6349.763254	10556.68639
03/08/2000 @ 10:00 AM	TSS (mg/L)	136.000	236.000			7710.426809	24188.13582
03/08/2000 @ 10:00 AM	TS (mg/L)	NA	NA			NA	NA
03/08/2000 @ 10:00 AM	pH	NA	NA	7.850		NA	NA
03/08/2000 @ 10:00 AM	Temperature ©	NA	NA	21.700		NA	NA
03/08/2000 @ 10:00 AM	Conductance (us/cm)	NA	NA	276.000		NA	NA
03/08/2000 @ 10:00 AM	Alkalinity (mg/L CaCO3)	222.880	86.560			12636.02888	8871.716255
03/08/2000 @ 10:00 AM	DO (mg/L)	NA	NA	7.050		NA	NA
03/08/2000 @ 10:00 AM	Chloride (mg/L)	39.000	12.000			2211.078276	1229.905211
03/08/2000 @ 10:00 AM	Diazinon (mg/L)	< 0.2	< 0.2			0	0
03/08/2000 @ 10:00 AM	Total Phosphorus (mg/L)	1.210	1.170			68.60012087	119.9157581
03/08/2000 @ 10:00 AM	Dissolved Phosphorus (mg/L)	1.070	0.920			60.6629168	94.29273284
03/08/2000 @ 10:00 AM	Atrazine (ppb)	NA	NA			NA	NA

NA = not analyzed Fecal Coliform loadings are represented as colonies/day

Table 17: Storm water collected from station PCSWS2 on 03/08/2000.
This site experienced an equipment problem resulting in a failure to obtain sample from automated sampler.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
03/08/2000 @ 10:10 AM	Chromium (Total mg/L)						
03/08/2000 @ 10:10 AM	Arsenic (Total mg/L)						
03/08/2000 @ 10:10 AM	Cadmium (Total mg/L)						
03/08/2000 @ 10:10 AM	Copper (Total mg/L)						
03/08/2000 @ 10:10 AM	Lead (Total mg/L)						
03/08/2000 @ 10:10 AM	Zinc (Total mg/L)						
03/08/2000 @ 10:10 AM	Chromium (Dissolved mg/L)						
03/08/2000 @ 10:10 AM	Arsenic (Dissolved mg/L)						
03/08/2000 @ 10:10 AM	Cadmium (Dissolved mg/L)						
03/08/2000 @ 10:10 AM	Copper (Dissolved mg/L)						
03/08/2000 @ 10:10 AM	Lead (Dissolved mg/L)						
03/08/2000 @ 10:10 AM	Zinc (Dissolved mg/L)						
03/08/2000 @ 10:10 AM	Calcium (mg/L)						
03/08/2000 @ 10:10 AM	Magnesium (mg/L)						
03/08/2000 @ 10:10 AM	Sodium (mg/L)						
03/08/2000 @ 10:10 AM	Potassium (mg/L)						
03/08/2000 @ 10:10 AM	Sulfate (mg/L)						
03/08/2000 @ 10:10 AM	Fecal Coliform (coln./100 ml)						
03/08/2000 @ 10:10 AM	Oil and Grease (mg/L)						
03/08/2000 @ 10:10 AM	Total Hardness (mg/L CaCO3)						
03/08/2000 @ 10:10 AM	Ammonia (mg/L)						
03/08/2000 @ 10:10 AM	Tota Kjedahl Nitrogen						
03/08/2000 @ 10:10 AM	BOD, 5-day (mg/L)						
03/08/2000 @ 10:10 AM	COD (mg/L)						
03/08/2000 @ 10:10 AM	TSS (mg/L)						
03/08/2000 @ 10:10 AM	TS (mg/L)						
03/08/2000 @ 10:10 AM	pH						
03/08/2000 @ 10:10 AM	Temperature ©						
03/08/2000 @ 10:10 AM	Conductance (us/cm)						
03/08/2000 @ 10:10 AM	Alkalinity (mg/L CaCO3)						
03/08/2000 @ 10:10 AM	DO (mg/L)						
03/08/2000 @ 10:10 AM	Chloride (mg/L)						
03/08/2000 @ 10:10 AM	Diazinon (mg/L)						
03/08/2000 @ 10:10 AM	Total Phosphorus (mg/L)						
03/08/2000 @ 10:10 AM	Dissolved Phosphorus (mg/L)						
03/08/2000 @ 10:10 AM	Atrazine (ppb)						

NA = not analyzed

Table 18: Storm water collected from station PCSWS3 on 03/08/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
03/08/2000 @ 10:40 AM	Chromium (Total mg/L)	0.001	0.002			0.318264945	0.690473101
03/08/2000 @ 10:40 AM	Arsenic (Total mg/L)	0.005	0.007			1.55949823	2.313084888
03/08/2000 @ 10:40 AM	Cadmium (Total mg/L)	0.006	0.005			1.90958967	1.726182752
03/08/2000 @ 10:40 AM	Copper (Total mg/L)	0.030	0.020			9.547948348	6.904731009
03/08/2000 @ 10:40 AM	Lead (Total mg/L)	0.030	0.010			9.547948348	3.452365505
03/08/2000 @ 10:40 AM	Zinc (Total mg/L)	0.196	0.176			62.37992921	60.76163288
03/08/2000 @ 10:40 AM	Chromium (Dissolved mg/L)	0.015	0.009			4.773974174	3.107128954
03/08/2000 @ 10:40 AM	Arsenic (Dissolved mg/L)	0.011	0.002			3.532740889	0.828567721
03/08/2000 @ 10:40 AM	Cadmium (Dissolved mg/L)	0.005	0.006			1.591324725	2.071419303
03/08/2000 @ 10:40 AM	Copper (Dissolved mg/L)	0.013	0.010			4.137444284	3.452365505
03/08/2000 @ 10:40 AM	Lead (Dissolved mg/L)	0.070	0.130			22.27854615	44.88075156
03/08/2000 @ 10:40 AM	Zinc (Dissolved mg/L)	0.074	0.049			23.55160593	16.91659097
03/08/2000 @ 10:40 AM	Calcium (mg/L)	41.620	33.030			13246.18701	11403.16326
03/08/2000 @ 10:40 AM	Magnesium (mg/L)	3.391	2.710			1079.236428	935.5910517
03/08/2000 @ 10:40 AM	Sodium (mg/L)	18.100	13.900			5760.595504	4798.788051
03/08/2000 @ 10:40 AM	Potassium (mg/L)	6.896	5.717			2194.75506	1973.717359
03/08/2000 @ 10:40 AM	Sulfate (mg/L)	29.000	30.000			9229.683403	10357.09651
03/08/2000 @ 10:40 AM	Fecal Coliform (coln./100 ml)	19800.000	46560.000			2.85841E+13	7.29122E+13
03/08/2000 @ 10:40 AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
03/08/2000 @ 10:40 AM	Total Hardness (mg/L CaCO3)	45.011	35.740			14325.42344	12338.75431
03/08/2000 @ 10:40 AM	Ammonia (mg/L)	0.780	0.650			248.2466571	224.4037578
03/08/2000 @ 10:40 AM	Tota Kjedahl Nitrogen (mg/L)	NA	NA			NA	NA
03/08/2000 @ 10:40 AM	BOD, 5-day (mg/L)	19.900	24.300			6333.472404	8389.248176
03/08/2000 @ 10:40 AM	COD (mg/L)	172.000	149.000			54741.57053	51440.24602
03/08/2000 @ 10:40 AM	TSS (mg/L)	52.000	184.000			16549.77714	63523.52528
03/08/2000 @ 10:40 AM	TS (mg/L)	NA	NA			NA	NA
03/08/2000 @ 10:40 AM	pH	NA	NA	7.900		NA	NA
03/08/2000 @ 10:40 AM	Temperature ©	NA	NA	21.500		NA	NA
03/08/2000 @ 10:40 AM	Conductance (us/cm)	NA	NA	343.000		NA	NA
03/08/2000 @ 10:40 AM	Alkalinity (mg/L CaCO3)	57.210	51.740			18207.9375	17862.53912
03/08/2000 @ 10:40 AM	DO (mg/L)	NA	NA	5.480		NA	NA
03/08/2000 @ 10:40 AM	Chloride (mg/L)	16.000	11.000			5092.239119	3797.602055
03/08/2000 @ 10:40 AM	Diazinon (mg/L)	0.900	0.500			286.4384505	172.6182752
03/08/2000 @ 10:40 AM	Total Phosphorus (mg/L)	1.200	1.110			381.9179339	383.212571
03/08/2000 @ 10:40 AM	Dissolved Phosphorus (mg/L)	0.970	0.700			308.7169966	241.6655853
03/08/2000 @ 10:40 AM	Atrazine (ppb)	NA	NA			NA	NA

NA = not analyzed

Fecal Coliform loadings are represented as colonies/day

Table 19: Storm water collected from station PCSWS4 on 03/08/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
03/08/2000 @ 10:47 AM	Chromium (Total mg/L)	0.006	0.004			1.262271138	1.553564477
03/08/2000 @ 10:47 AM	Arsenic (Total mg/L)	0.006	0.003			1.304346842	1.320529805
03/08/2000 @ 10:47 AM	Cadmium (Total mg/L)	0.005	0.005			1.051892615	1.941955596
03/08/2000 @ 10:47 AM	Copper (Total mg/L)	0.011	0.018			2.314163752	6.991040147
03/08/2000 @ 10:47 AM	Lead (Total mg/L)	0.060	0.000			12.62271138	0
03/08/2000 @ 10:47 AM	Zinc (Total mg/L)	0.050	0.123			10.51892615	47.77210767
03/08/2000 @ 10:47 AM	Chromium (Dissolved mg/L)	0.008	0.006			1.683028183	2.330346716
03/08/2000 @ 10:47 AM	Arsenic (Dissolved mg/L)	0.014	0.004			2.987375026	1.359368917
03/08/2000 @ 10:47 AM	Cadmium (Dissolved mg/L)	0.007	0.002			1.472649661	0.776782239
03/08/2000 @ 10:47 AM	Copper (Dissolved mg/L)	0.017	0.011			3.57643489	4.272302312
03/08/2000 @ 10:47 AM	Lead (Dissolved mg/L)	0.050	0.080			10.51892615	31.07128954
03/08/2000 @ 10:47 AM	Zinc (Dissolved mg/L)	0.063	0.057			13.25384694	22.1382938
03/08/2000 @ 10:47 AM	Calcium (mg/L)	50.810	44.780			10689.33275	17392.15432
03/08/2000 @ 10:47 AM	Magnesium (mg/L)	7.027	6.053			1478.329881	2350.931445
03/08/2000 @ 10:47 AM	Sodium (mg/L)	46.900	31.000			9866.752725	12040.1247
03/08/2000 @ 10:47 AM	Potassium (mg/L)	5.264	5.427			1107.432545	2107.798604
03/08/2000 @ 10:47 AM	Sulfate (mg/L)	95.000	68.000			19985.95968	26410.59611
03/08/2000 @ 10:47 AM	Fecal Coliform (coln./100 ml)	1810.000	20480.000			1.72723E+12	3.60802E+13
03/08/2000 @ 10:47 AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
03/08/2000 @ 10:47 AM	Total Hardness (mg/L CaCO3)	57.837	50.833			12167.66263	19743.08577
03/08/2000 @ 10:47 AM	Ammonia (mg/L)	0.290	0.300			61.00977165	116.5173358
03/08/2000 @ 10:47 AM	Tota Kjedahl Nitrogen (mg/L)	NA	NA			NA	NA
03/08/2000 @ 10:47 AM	BOD, 5-day (mg/L)	invalid	15.400			NA	5981.223237
03/08/2000 @ 10:47 AM	COD (mg/L)	42.000	72.000			8835.897963	27964.16059
03/08/2000 @ 10:47 AM	TSS (mg/L)	66.000	176.000			13884.98251	68356.83699
03/08/2000 @ 10:47 AM	TS (mg/L)	not analyzed	not analyzed			NA	NA
03/08/2000 @ 10:47 AM	pH	NA	NA	7.620		NA	NA
03/08/2000 @ 10:47 AM	Temperature ©	NA	NA	21.500		NA	NA
03/08/2000 @ 10:47 AM	Conductance (us/cm)	NA	NA	228.00		NA	NA
03/08/2000 @ 10:47 AM	Alkalinity (mg/L CaCO3)	119.400	90.040			25119.19564	34970.73638
03/08/2000 @ 10:47 AM	DO (mg/L)	NA	NA	5.930		NA	NA
03/08/2000 @ 10:47 AM	Chloride (mg/L)	26.000	26.000			5469.841596	10098.1691
03/08/2000 @ 10:47 AM	Diazinon (mg/L)	< 0.2	0.300			0	116.5173358
03/08/2000 @ 10:47 AM	Total Phosphorus (mg/L)	1.550	1.180			326.0867105	458.3015207
03/08/2000 @ 10:47 AM	Dissolved Phosphorus (mg/L)	1.200	0.920			252.4542275	357.3198297
03/08/2000 @ 10:47 AM	Atrazine (ppb)	NA	NA			NA	NA

NA = not analyzed   Fecal Coliform loadings are represented as colonies/day

Table 19: Storm water collected from station PCSWS1 on 05/01/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
05/01/2000 @ 10:45AM	Chromium (Total mg/L)	0.009	0.005			0.510248833	2.373501284
05/01/2000 @ 10:45AM	Arsenic (Total mg/L)	0.007	0.015			0.391190772	7.167973879
05/01/2000 @ 10:45AM	Cadmium (Total mg/L)	0.006	0.003			0.340165889	1.424100771
05/01/2000 @ 10:45AM	Copper (Total mg/L)	0.040	0.083			2.267772591	39.40012132
05/01/2000 @ 10:45AM	Lead (Total mg/L)	0.030	0.120			1.700829443	56.96403082
05/01/2000 @ 10:45AM	Zinc (Total mg/L)	0.057	0.065			3.231575942	30.8555167
05/01/2000 @ 10:45AM	Chromium (Dissolved mg/L)	0.009	0.007			0.510248833	3.322901798
05/01/2000 @ 10:45AM	Arsenic (Dissolved mg/L)	0.019	0.029			1.065853118	13.8612475
05/01/2000 @ 10:45AM	Cadmium (Dissolved mg/L)	0.005	0.003			0.283471574	1.424100771
05/01/2000 @ 10:45AM	Copper (Dissolved mg/L)	0.020	0.029			1.133886295	13.76630745
05/01/2000 @ 10:45AM	Lead (Dissolved mg/L)	0.020	0.010			1.133886295	4.747002569
05/01/2000 @ 10:45AM	Zinc (Dissolved mg/L)	0.067	0.085			3.79851909	40.34952183
05/01/2000 @ 10:45AM	Calcium (mg/L)	111.600	36.650			6327.085528	17397.76441
05/01/2000 @ 10:45AM	Magnesium (mg/L)	12.070	3.522			684.3003793	1671.894305
05/01/2000 @ 10:45AM	Sodium (mg/L)	4.600	19.200			260.7938479	9114.244932
05/01/2000 @ 10:45AM	Potassium (mg/L)	1.404	4.657			79.59881794	2210.679096
05/01/2000 @ 10:45AM	Sulfate (mg/L)	11.000	126.000			623.6374625	59812.23237
05/01/2000 @ 10:45AM	Fecal Coliform (coln./100 ml)	NA	NA			NA	NA
05/01/2000 @ 10:45AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
05/01/2000 @ 10:45AM	Total Hardness (mg/L CaCO3)	123.670	40.172			7011.385908	19069.65872
05/01/2000 @ 10:45AM	Ammonia (mg/L)	0.520	1.450			29.48104368	688.3153725
05/01/2000 @ 10:45AM	Total Kjedahl Nitrogen (mg/L)	NA	NA				
05/01/2000 @ 10:45AM	BOD, 5-day (mg/L)	19.500	22.300			1105.539138	10585.81573
05/01/2000 @ 10:45AM	COD (mg/L)	16.000	78.000			907.1090363	37026.62004
05/01/2000 @ 10:45AM	TSS (mg/L)	60.000	83.000			3401.658886	39400.12132
05/01/2000 @ 10:45AM	TS (mg/L)	NA	NA			NA	NA
05/01/2000 @ 10:45AM	pH	NA	NA	7.830		NA	NA
05/01/2000 @ 10:45AM	Temperature ©	NA	NA	19.900		NA	NA
05/01/2000 @ 10:45AM	Conductance (us/cm)	NA	NA	340.000		NA	NA
05/01/2000 @ 10:45AM	Alkalinity (mg/L CaCO3)	NA	NA			NA	NA
05/01/2000 @ 10:45AM	DO (mg/L)	NA	NA	6.280		NA	NA
05/01/2000 @ 10:45AM	Chloride (mg/L)	<5.0	19.000			0	9019.304881
05/01/2000 @ 10:45AM	Diazinon (mg/L)	0.200	3.400			11.33886295	1613.980873
05/01/2000 @ 10:45AM	Total Phosphorus (mg/L)	0.911	0.508			51.64852075	241.1477305
05/01/2000 @ 10:45AM	Dissolved Phosphorus (mg/L)	0.156	0.263			8.844313104	124.8461676
05/01/2000 @ 10:45AM	Atrazine (ppb)	NA	NA			NA	NA

NA = not analyzed

Table 21: Storm water collected from station PCSWS2 on 05/01/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
05/01/2000 @ 10:30AM	Chromium (Total mg/L)	0.017	0.014			0.504369023	9.440061926
05/01/2000 @ 10:30AM	Arsenic (Total mg/L)	0.026	0.010			0.771387917	6.877759404
05/01/2000 @ 10:30AM	Cadmium (Total mg/L)	0.004	0.002			0.118675064	1.348580275
05/01/2000 @ 10:30AM	Copper (Total mg/L)	0.040	0.040			1.186750642	26.9716055
05/01/2000 @ 10:30AM	Lead (Total mg/L)	0.030	0.010			0.890062982	6.742901376
05/01/2000 @ 10:30AM	Zinc (Total mg/L)	0.345	0.170			10.23572429	114.6293234
05/01/2000 @ 10:30AM	Chromium (Dissolved mg/L)	0.007	0.005			0.207681362	3.371450688
05/01/2000 @ 10:30AM	Arsenic (Dissolved mg/L)	0.023	0.015			0.691282249	10.24921009
05/01/2000 @ 10:30AM	Cadmium (Dissolved mg/L)	0.002	0.002			0.059337532	1.348580275
05/01/2000 @ 10:30AM	Copper (Dissolved mg/L)	0.014	0.018			0.415362725	12.13722248
05/01/2000 @ 10:30AM	Lead (Dissolved mg/L)	0.000	0.000			0	0
05/01/2000 @ 10:30AM	Zinc (Dissolved mg/L)	0.014	0.022			0.415362725	14.83438303
05/01/2000 @ 10:30AM	Calcium (mg/L)	64.840	36.880			1923.722791	24867.82027
05/01/2000 @ 10:30AM	Magnesium (mg/L)	3.296	1.681			97.78825292	1133.481721
05/01/2000 @ 10:30AM	Sodium (mg/L)	19.200	4.600			569.6403082	3101.734633
05/01/2000 @ 10:30AM	Potassium (mg/L)	4.057	2.756			120.3661839	1858.343619
05/01/2000 @ 10:30AM	Sulfate (mg/L)	31.000	11.000			919.7317477	7417.191514
05/01/2000 @ 10:30AM	Fecal Coliform (coln./100 ml)	NA	NA			NA	NA
05/01/2000 @ 10:30AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
05/01/2000 @ 10:30AM	Total Hardness (mg/L CaCO3)	68.136	38.561			2021.511044	26001.302
05/01/2000 @ 10:30AM	Ammonia (mg/L)	0.490	0.520			14.53769537	350.6308716
05/01/2000 @ 10:30AM	Total Kjedahl Nitrogen (mg/L)	NA	NA			NA	NA
05/01/2000 @ 10:30AM	BOD, 5-day (mg/L)	30.000	19.400			890.0629816	13081.22867
05/01/2000 @ 10:30AM	COD (mg/L)	158.000	93.000			4687.665037	62708.9828
05/01/2000 @ 10:30AM	TSS (mg/L)	482.000	212.000			14300.34524	142949.5092
05/01/2000 @ 10:30AM	TS (mg/L)	NA	NA			NA	NA
05/01/2000 @ 10:30AM	pH	NA	NA	7.800		NA	NA
05/01/2000 @ 10:30AM	Temperature ©	NA	NA	18.300		NA	NA
05/01/2000 @ 10:30AM	Conductance (us/cm)	NA	NA	294.000		NA	NA
05/01/2000 @ 10:30AM	Alkalinity (mg/L CaCO3)	NA	NA			NA	NA
05/01/2000 @ 10:30AM	DO (mg/L)	NA	NA	8.700		NA	NA
05/01/2000 @ 10:30AM	Chloride (mg/L)	14.000	<5.0			415.3627248	0
05/01/2000 @ 10:30AM	Diazinon (mg/L)	< 0.1	< 0.1			0	0
05/01/2000 @ 10:30AM	Total Phosphorus (mg/L)	0.986	0.622			29.25340333	419.4084656
05/01/2000 @ 10:30AM	Dissolved Phosphorus (mg/L)	0.238	0.156			7.061166321	105.1892615
05/01/2000 @ 10:30AM	Atrazine (ppb)	NA	NA			NA	NA

NA = not analyzed

Table 22: Storm water collected from station PCSWS3 on 05/01/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
05/01/2000 @ 10:15AM	Chromium (Total mg/L)	0.025	0.013			7.956623624	12.13182816
05/01/2000 @ 10:15AM	Arsenic (Total mg/L)	0.014	0.020			4.328403251	18.94431627
05/01/2000 @ 10:15AM	Cadmium (Total mg/L)	0.004	0.003			1.27305978	2.799652651
05/01/2000 @ 10:15AM	Copper (Total mg/L)	0.033	0.027			10.50274318	25.19687386
05/01/2000 @ 10:15AM	Lead (Total mg/L)	0.070	0.060			22.27854615	55.99305303
05/01/2000 @ 10:15AM	Zinc (Total mg/L)	0.271	0.249			86.24980008	232.3711701
05/01/2000 @ 10:15AM	Chromium (Dissolved mg/L)	0.012	0.005			3.819179339	4.666087752
05/01/2000 @ 10:15AM	Arsenic (Dissolved mg/L)	0.039	0.019			12.28502687	18.10442048
05/01/2000 @ 10:15AM	Cadmium (Dissolved mg/L)	0.003	0.002			0.954794835	1.866435101
05/01/2000 @ 10:15AM	Copper (Dissolved mg/L)	0.024	0.019			7.638358679	17.73113346
05/01/2000 @ 10:15AM	Lead (Dissolved mg/L)	0.160	0.140			50.92239119	130.6504571
05/01/2000 @ 10:15AM	Zinc (Dissolved mg/L)	0.083	0.067			26.41599043	62.52557588
05/01/2000 @ 10:15AM	Calcium (mg/L)	65.570	47.580			20868.63244	44402.49105
05/01/2000 @ 10:15AM	Magnesium (mg/L)	5.369	3.479			1708.764489	3246.663858
05/01/2000 @ 10:15AM	Sodium (mg/L)	34.800	31.200			11075.62008	29116.38757
05/01/2000 @ 10:15AM	Potassium (mg/L)	9.713	7.745			3091.30741	7227.769928
05/01/2000 @ 10:15AM	Sulfate (mg/L)	42.000	96.000			13367.12769	89588.88484
05/01/2000 @ 10:15AM	Fecal Coliform (coln./100 ml)	NA	NA			NA	NA
05/01/2000 @ 10:15AM	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
05/01/2000 @ 10:15AM	Total Hardness (mg/L CaCO3)	70.939	51.059			22577.39693	47649.15491
05/01/2000 @ 10:15AM	Ammonia (mg/L)	7.050	2.190			2243.767862	2043.746435
05/01/2000 @ 10:15AM	Total Kjedahl Nitrogen (mg/L)	NA	NA			NA	NA
05/01/2000 @ 10:15AM	BOD, 5-day (mg/L)	32.000	29.300			10184.47824	27343.27423
05/01/2000 @ 10:15AM	COD (mg/L)	325.000	134.000			103436.1071	125051.1518
05/01/2000 @ 10:15AM	TSS (mg/L)	453.000	216.000			144174.0201	201574.9909
05/01/2000 @ 10:15AM	TS (mg/L)	NA	NA			NA	NA
05/01/2000 @ 10:15AM	pH	NA	NA	7.710		NA	NA
05/01/2000 @ 10:15AM	Temperature ©	NA	NA	19.400		NA	NA
05/01/2000 @ 10:15AM	Conductance (us/cm)	NA	NA	347.000		NA	NA
05/01/2000 @ 10:15AM	Alkalinity (mg/L CaCO3)	NA	NA			NA	NA
05/01/2000 @ 10:15AM	DO (mg/L)	NA	NA	7.700		NA	NA
05/01/2000 @ 10:15AM	Chloride (mg/L)	26.000	16.000			8274.888569	14931.48081
05/01/2000 @ 10:15AM	Diazinon (mg/L)	< 0.1	< 0.1			0	0
05/01/2000 @ 10:15AM	Total Phosphorus (mg/L)	1.660	3.000			528.3198086	2799.652651
05/01/2000 @ 10:15AM	Dissolved Phosphorus (mg/L)	1.120	1.290			356.4567383	1203.85064
05/01/2000 @ 10:15AM	Atrazine (ppb)	NA	NA			NA	NA

NA = not analyzed

Table 23: Storm water collected from station PCSWS4 on 05/01/2000.

Date and Time	Parameter	First Flush	Composite	Field	Grab	Min. Loading (lbs/Day)	Max. Loading (lbs/Day)
05/01/2000 @ 9:45M	Chromium (Total mg/L)	0.007	0.006			1.472649661	23.30346716
05/01/2000 @ 9:45M	Arsenic (Total mg/L)	0.020	0.020			4.228608311	79.23178833
05/01/2000 @ 9:45M	Cadmium (Total mg/L)	0.002	0.001			0.420757046	3.883911193
05/01/2000 @ 9:45M	Copper (Total mg/L)	0.026	0.031			5.469841596	120.401247
05/01/2000 @ 9:45M	Lead (Total mg/L)	0.130	0.130			27.34920798	504.908455
05/01/2000 @ 9:45M	Zinc (Total mg/L)	0.120	0.133			25.24542275	516.5601886
05/01/2000 @ 9:45M	Chromium (Dissolved mg/L)	0.007	0.006			1.472649661	23.30346716
05/01/2000 @ 9:45M	Arsenic (Dissolved mg/L)	0.009	0.003			1.872368854	11.65173358
05/01/2000 @ 9:45M	Cadmium (Dissolved mg/L)	0.004	0.002			0.841514092	7.767822385
05/01/2000 @ 9:45M	Copper (Dissolved mg/L)	0.029	0.029			6.100977165	112.6334246
05/01/2000 @ 9:45M	Lead (Dissolved mg/L)	0.160	0.020			33.66056367	77.67822385
05/01/2000 @ 9:45M	Zinc (Dissolved mg/L)	0.043	0.064			9.046276486	248.5703163
05/01/2000 @ 9:45M	Calcium (mg/L)	50.740	41.980			10674.60625	163046.5919
05/01/2000 @ 9:45M	Magnesium (mg/L)	7.958	3.055			1674.192285	11865.34869
05/01/2000 @ 9:45M	Sodium (mg/L)	67.000	18.100			14095.36104	70298.79259
05/01/2000 @ 9:45M	Potassium (mg/L)	7.844	5.188			1650.209134	20149.73127
05/01/2000 @ 9:45M	Sulfate (mg/L)	162.000	42.000			34081.32071	163124.2701
05/01/2000 @ 9:45M	Fecal Coliform (coln./100 ml)	NA	NA			NA	NA
05/01/2000 @ 9:45M	Oil and Grease (mg/L)	NA	NA		NA	NA	NA
05/01/2000 @ 9:45M	Total Hardness (mg/L CaCO3)	58.698	45.035			12348.79854	174911.9406
05/01/2000 @ 9:45M	Ammonia (mg/L)	0.310	0.610			65.21734211	2369.185827
05/01/2000 @ 9:45M	Total Kjedahl Nitrogen (mg/L)	NA	NA			NA	NA
05/01/2000 @ 9:45M	BOD, 5-day (mg/L)	17.200	27.000			3618.510594	104865.6022
05/01/2000 @ 9:45M	COD (mg/L)	64.000	126.000			13464.22547	489372.8103
05/01/2000 @ 9:45M	TSS (mg/L)	102.000	500.000			21458.60934	1941955.596
05/01/2000 @ 9:45M	TS (mg/L)	NA	NA			NA	NA
05/01/2000 @ 9:45M	pH	NA	NA	7.370		NA	NA
05/01/2000 @ 9:45M	Temperature ©	NA	NA	18.400		NA	NA
05/01/2000 @ 9:45M	Conductance (us/cm)	NA	NA	303.000		NA	NA
05/01/2000 @ 9:45M	Alkalinity (mg/L CaCO3)	NA	NA			NA	NA
05/01/2000 @ 9:45M	DO (mg/L)	NA	NA	7.230		NA	NA
05/01/2000 @ 9:45M	Chloride (mg/L)	58.000	55.000			12201.95433	213615.1156
05/01/2000 @ 9:45M	Diazinon (mg/L)	< 0.1	< 0.1			0	0
05/01/2000 @ 9:45M	Total Phosphorus (mg/L)	0.452	2.210			95.09109236	8583.443736
05/01/2000 @ 9:45M	Dissolved Phosphorus (mg/L)	0.226	0.967			47.54554618	3755.742123
05/01/2000 @ 9:45M	Atrazine (ppb)	NA	NA			NA	NA

NA = not analyzed

APPENDIX P

RAINFALL DATA

Table 24: February 2000 rainfall data.

Date	Rainfall (inches)	Duration (hours)
2/1	0	
2/2	0	
2/3	0	
2/4	0	
2/5	0	
2/6	0	
2/7	0	
2/8	0	
2/9	0	
2/10	0	
2/11	0	
2/12	0	
2/13	0	
2/14	0	
2/15	0	
2/16	0	
2/17	0	
2/18	0	
2/19	0	
2/20	0	
2/21	0	
2/22	1.54	4.5
2/23	0.01	0.5
2/24	0.01	0.5
2/25	0.04	1
2/26	0	
2/27	0	
2/28	0	
2/29	0	

Figure 31: February 2000 rainfall

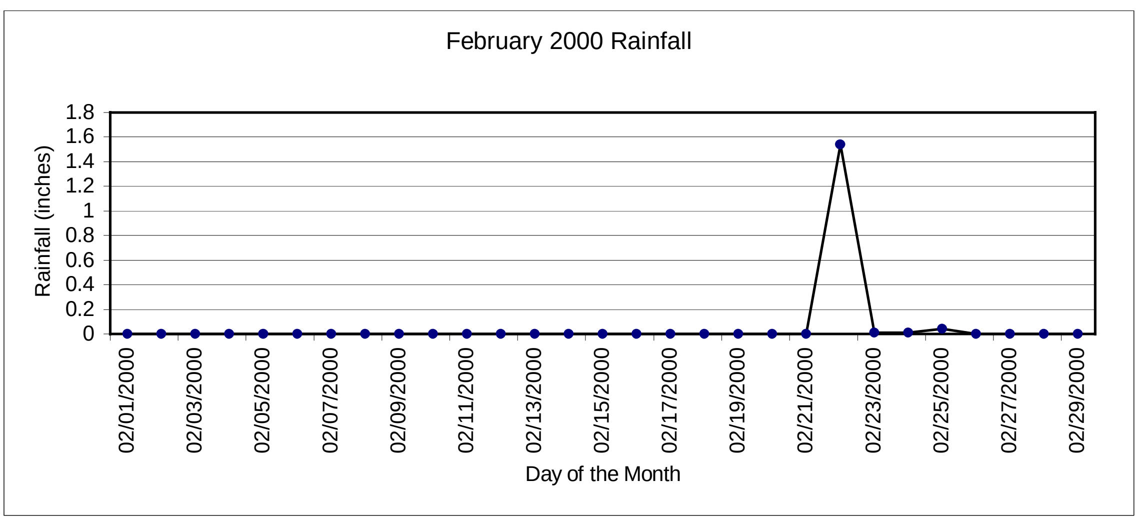


Table 25: March 2000 rainfall data.

Date	Rainfall (inches)	Duration (hours)
3/1/00	0	
3/2/00	1.1	16
3/3/00	0	
3/4/00	0	
3/5/00	0	
3/6/00	0	
3/7/00	0.25	3
3/8/00	0	
3/9/00	0	
3/10/00	0.55	5
3/11/00	0	
3/12/00	0	
3/13/00	0	
3/14/00	0	
3/15/00	0	
3/16/00	0.12	3
3/17/00	0	
3/18/00	0	
3/19/00	0	
3/20/00	0	
3/21/00	0.66	5
3/22/00	0	
3/23/00	0	
3/24/00	0	
3/25/00	0	
3/26/00	0.19	2
3/27/00	0	
3/28/00	0.02	2
3/29/00	0.01	0.5
3/30/00	0	
3/31/00	0	

Figure 32: March 2000 rainfall.

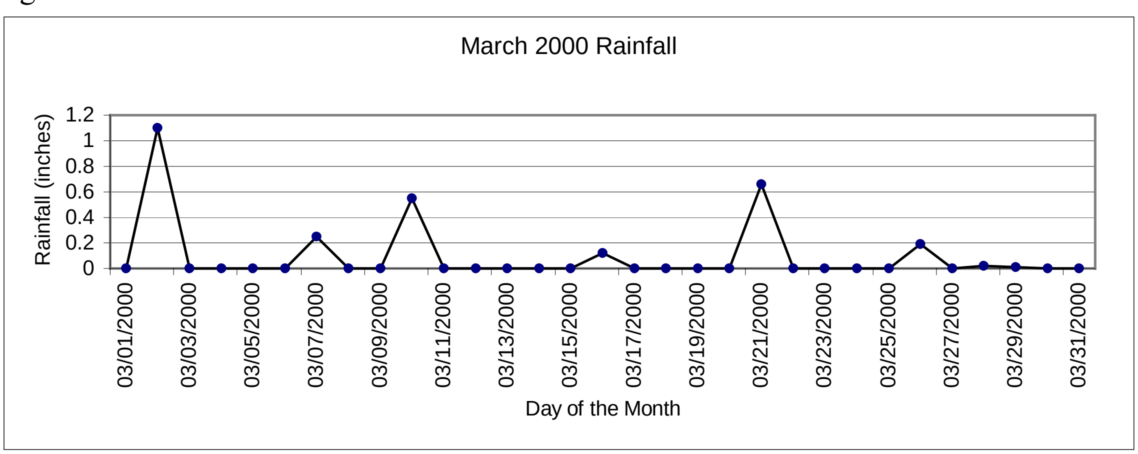
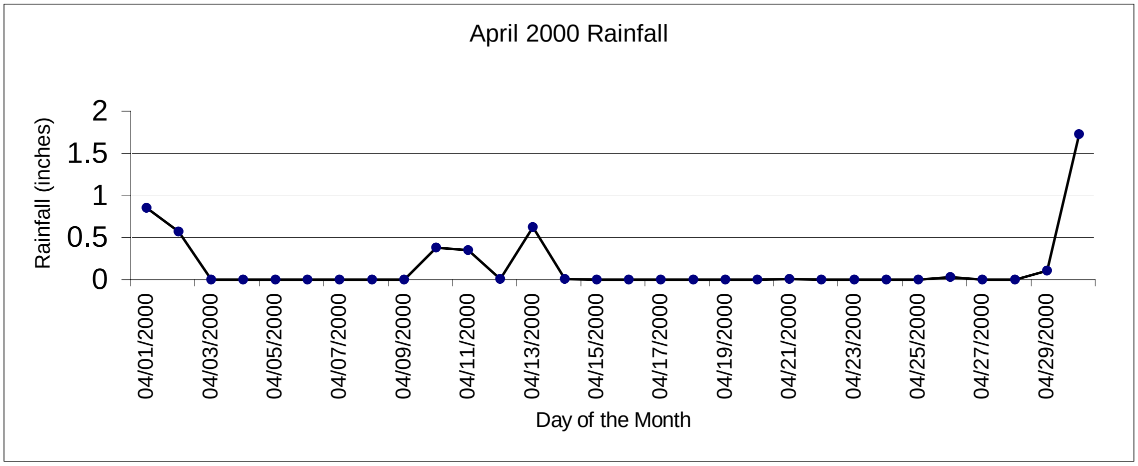


Table 26: April 2000 rainfall data.

Date	Rainfall (inches)	Duration (hours)
4/1	0.85	4
4/2	0.57	2
4/3	0	
4/4	0	
4/5	0	
4/6	0	
4/7	0	
4/8	0	
4/9	0	
4/10	0.38	11.5
4/11	0.35	18.5
4/12	0.01	
4/13	0.62	
4/14	0.01	
4/15	0	1
4/16	0	1
4/17	0	
4/18	0	
4/19	0	
4/20	0	
4/21	0.01	
4/22	0	1.5
4/23	0	
4/24	0	
4/25	0	
4/26	0.03	
4/27	0	
4/28	0.11	1.5
4/29	0	
4/30	1.73	4.5

Figure 33: April 2000 Rainfall.



APPENDIX Q

HYDROLOGIC DATA

Table 27: Hydrology data for each station location and sampling rain event.

PSWS1

Rain Event	Minimum Gauge Height (ft.)	Maximum Gauge Height (ft.)	Minimum Flow (cfs)	Maximum Flow (cfs)	Rainfall (in.)
02/22/2000	0.7	1.68	10.51	38	1.54
03/02/2000	0.7	1.5	10.51	33	1.1
03/07/2000	0.7	1	10.51	19	0.25
04/30/2000	0.7	2.4	10.51	88	1.73

PSWS2

Rain Event	Minimum Gauge Height (ft.)	Maximum Gauge Height (ft.)	Minimum Flow (cfs)	Maximum Flow (cfs)	Rainfall (in.)
02/22/2000	0.2	1.1	5.5	95	1.54
03/02/2000	0.2	0.8	5.5	56	1.1
03/07/2000	0.2	0.4	5.5	18	0.25
04/30/2000	0.2	1.5	5.5	125	1.73

PSWS3

Rain Event	Minimum Gauge Height (ft.)	Maximum Gauge Height (ft.)	Minimum Flow (cfs)	Maximum Flow (cfs)	Rainfall (in.)
02/22/2000	0.6	1.6	59	280	1.54
03/02/2000	0.6	0.85	59	100	1.1
03/07/2000	0.6	0.6	59	64	0.25
04/30/2000	0.6	1.2	59	173	1.73

PSWS4

Rain Event	Minimum Gauge Height (ft.)	Maximum Gauge Height (ft.)	Minimum Flow (cfs)	Maximum Flow (cfs)	Rainfall (in.)
02/22/2000	0.25	1.2	39	312	1.54
03/02/2000	0.25	0.9	39	193	1.1
03/07/2000	0.25	0.5	39	72	0.25
04/30/2000	0.25	1.9	39	720	1.73

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