Technical Report

for the

Florida statewide airport stormwater study

Florida Department of Transportation

Clean Water – Safe Airports

June 30, 2005

Revised April 24, 2008

TECHNICAL REPORT
FLORIDA STATEWIDE AIRPORT STORMWATER STUDY

LIST OF REVISIONS

1. Revised cover to reflect revision date of April 24, 2008
2. Corrected Figures 12a through 12i to show Percentage Load
3. Added Units in Appendix D

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SECTION 1 - BACKGROUND SUMMARY

In 1998 the Florida Department of Transportation (FDOT) with assistance from the Florida Department of Environmental Protection (FDEP) and three Water Management Districts outlined a program to evaluate airport runway, taxiway and apron water quality. The project was jointly funded by the Federal Aviation Administration and FDOT, and was occasioned by FAA Advisory Circular (AC) 150/5200-33 *Hazardous Wildlife Attractants On or Near Airports*, first issued in 1997. Stormwater treatment ponds, and more specifically wet ponds, are identified in the AC as bird attractants and a safety hazard to aircraft. Other documents also identify standing water bodies as bird attractants and safety hazards around airports. This study was done to evaluate and quantify the chemical concentration and loading characteristics of airside runoff. It included testing some Best Management Practices (BMPs) available to airports to meet federal and state water management requirements without wet ponds.

In 1999, with Water Management and FDEP representation, FDOT selected a team of consultants lead by MEA Group, Inc., Lakewood Ranch, Florida, to develop and conduct the Florida Statewide Airport Stormwater Study. Team members included Ed Barber & Associates, Inc., Bradenton, Florida; URS Corporation, Tampa, Florida; Storm Water Resources of Florida, LC; and Advanced Environmental Laboratories, Inc., various Florida locations,.

During the course of the study a steering committee representing FDEP, St. John's River Water Management District (SJRWMD), South Florida Water Management District (SFWMD), Southwest Florida Water Management District (SWFWMD), FDOT and FAA refined the study, reviewed data, and commented on interim project findings. The purpose, in concert with the quality assurance program followed by the consultant team, was to identify unusual or controversial items during the conduct of the work. In this way, the findings were reviewed as they accumulated.

This document presents the technical findings of the project. It's companion document, the Florida Airports Stormwater Best Management Practices Manual, provides guidance on using the results and water management options available to airports. Pending regulatory adoption of the companion Best Management Practices Manual, the information within it is advisory, not regulatory. The results in this Technical Report for the Florida Statewide Airport Stormwater Study may be used as a data source in the same manner as other published studies of stormwater runoff.

SECTION 2 - STUDY DESIGN

Florida has long had a regulatory assumption that to limit non-point source pollution in receiving waters from land uses such as parking lots, streets, buildings and, in this case airports, it is necessary to detain or retain some fraction of stormwater runoff. This study does not generically test this particular hypothesis, and its results are directly applicable only to airside runoff. Two hypotheses are tested in the study. First, it was suggested based on available data that airside runoff was not likely to generate the typical constituent loading problems associated with other impervious surfaces. This is based on the operating conditions on the airport runways, taxiways and aprons; aircraft characteristics; and frequency of aircraft use. Second, it was suggested that those constituents that are present in the pavement runoff are effectively reduced by the grassed infield area to acceptable levels. Neither hypothesis had been tested to any great degree, and presumptive pollution control requirements have been applied to airside airport surfaces in precisely the same manner and to the same degree as they are to highways, parking lots and commercial development.

This phase of the study was technically designed to accomplish two things. First, it characterizes concentration and runoff of select airport types and airside usage areas within airports across Florida. Second, it provides data for a set of BMP sites, focusing on, but not limited to, overland flow. This establishes effectiveness for existing and potential BMPs compatible with airport sites.

2.A Basic Design Requirements

From a design perspective, the study must provide adequate data for representative areas and airports. To that end:

1. A constituent list had to be developed reflecting constituents that might reasonably be expected in airside pavement stormwater runoff.
2. Samples taken had to provide, by definition, an accurate portrayal of runoff concentrations for constituents of concern.
3. Acceptable sample collection and analytical protocols had to be developed.
4. Data quality assurance and management tools and procedures had to be selected and developed.
5. Definitions of events, seasons and recognition of site-specific physical and, in some cases, operational constraints had to be taken into account.
6. Equipment had to be selected for use in the study.
7. Methods had to be developed for data management and reduction in order to standardize and compare the results.
8. BMP test sites had to be designed.
9. Procedures to modify the program based on field experience as the study progressed had to be available.

All of these issues are linked in the design and ultimately in the evaluation components of the study. They were integrated into the work plan prior to taking the first sample, and subject to review and modification as the work progressed. The essential elements all comply with the limitations of scope, budget and site specific conditions.

Temporal and spatial variability is a major determinant of analytical and experimental design. A sample is a portion of something that represents a whole. The more varied the concentration of study constituents in runoff and the more divisions of airport type and area use differences, the greater the number of sites needed to properly apply meaningful statistical analysis. The potential effect of this variability on likely concentrations and loading characteristics of the runoff constituents of concern was a major factor in overall study design. Sampling decisions were made in the context of projected differences between airport types. Also, within each airport there are generally several distinctly different airside use sub-areas. Sampling design therefore reflected spatially varied, potential constituent exposure levels at differing airside areas on a given airport type.

Expected runoff constituent variations with season and during rainfall events themselves impact sampling design criteria. Sample design took into account temporal considerations and potential effects that these might have on constituent concentrations and, ultimately, loads. Also, the sampling program was planned in the context of distinct rainy and dry seasons. Some observational data were designed to evaluate the change in constituent concentration with time over a single event (i.e. a "first flush" or similar effect).

In order to properly quantify the amount of water falling at each site and the relationship of quantity to quality, the program design allowed for rainfall and runoff data collection more or less continuously at each monitoring station while it was operational. However, it was not practical, nor necessary to collect and analyze samples of *all* runoff for designated constituents. Statistical evaluations previously done and accepted, and those undertaken in this study, indicated that 10 samples per site were sufficient for valid inferences. This satisfied one design requirement of the study.

A primary design requirement was that the information *best reflect constituent loads* generated by Florida airport airside operations or attenuated by select BMPs. That is, the sampling reflects neither a worst nor best case condition. These two requirements, in concert with seasonal weather patterns, collection system physical characteristics, and sample volume constraints defined which events were sampled for laboratory analyses.

2.B Introduction to the Airport Environment

In its basic configuration an airport consists of *airside* and *landside* areas. *Airside* includes all areas commonly allocated for aircraft operations or servicing. They are often separated by a fence or other barrier from *landside* areas to limit access. Typically the *airside* includes significant open space/grass areas serving to separate runways and taxiways from each other. Ground vehicle traffic does occur on the *airside*. It is normally associated with servicing aircraft and routine inspections, and it is generally confined to aprons/ramps. Elements of the airport *airside* are:

- One or more runways for aircraft landing and takeoff operations. These are usually paved, but may be turf for facilities serving light airplanes.
- One or more taxiways allowing aircraft to move between the runway(s) and parking areas
- One or more aprons (also called "ramps") for aircraft to park.

Figure 1, excerpted from the Airport Facilities Directory, illustrates a Florida airport serving both light general aviation and commercial jet operations. The illustration is focused on *airside* facilities, but includes buildings that may be considered transitional. Terminal buildings, hangars, Fixed Base Operator (FBO) buildings, Airport Rescue and Fire Fighting (ARFF) stations, and U.S. Customs Service offices represent transitional structures. That is, they are located both *airside* and *landside*.

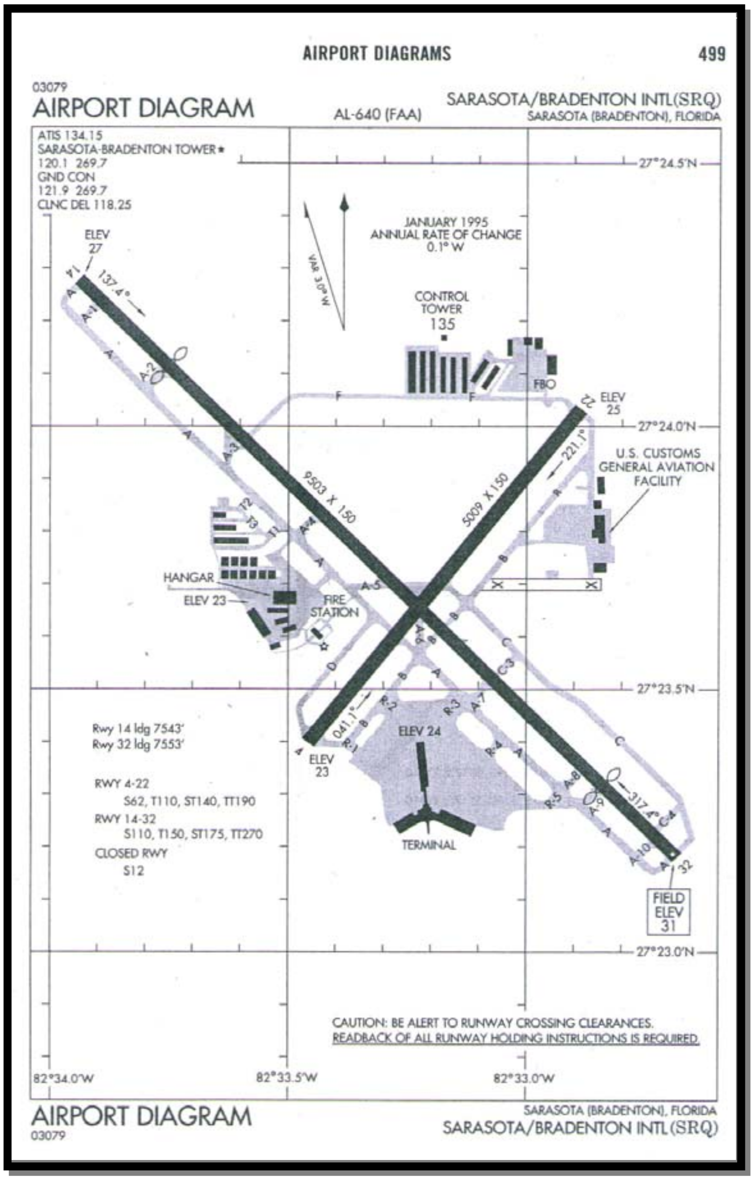


FIGURE 1 TYPICAL FLORIDA AIRPORT

This project tested runoff from runways, taxiways, aprons/ramps, and T-hangar areas for characterization purposes.

2.C Chemical Parameters Selection

Water quality monitoring programs and data from a variety of sources were collected and reviewed to generate a list of representative chemical parameters for storm event sampling at airports throughout Florida. Information from federal, state and local agencies was requested to determine appropriate water quality monitoring parameters for the project that are relevant to airports and of regulatory interest. Agencies initially contacted included those in Table 1 following. Only a listing of monitoring parameters was requested and not the monitoring data themselves.

Table 1 - Listing of Agencies Contacted for Airport Surface Water Monitoring Data and Information (Bold Text Denotes Agencies Providing Input**)**

Federal Agencies
U. S. Environmental Protection Agency, Region IV

State Agencies
Florida Department of Environmental Protection (FDEP)
Florida Department of Community Affairs (FDCA)

Regional Agencies
Northwest Florida Water Management District (NWFWMD)
St. Johns River Water Management District (SJRWMD)
South Florida Water Management District (SFWMD)
Southwest Florida Water Management District (SWFWMD)
Suwannee River Water Management District (SRWMD)
West Florida Regional Planning Council (WFRPC)
Apalachee Regional Planning Council (ARPC)
North Central Florida Regional Planning Council (NCFRPC)
East Central Florida Regional Planning Council (ECFRPC)
Tampa Bay Regional Planning Council (TBRPC)
Southwest Florida Regional Planning Council (SWFRPC)
Treasure Coast Regional Planning Council (TCRPC)

Local Agencies
Miami-Dade County Aviation Department
Dade Environmental Resource Management (DERM)

In addition to the specific requests of airport-related information and data, other references were used to select potential test parameters. Included were internet searches for information related to airport monitoring programs, monitoring parameter lists for pollution sources prepared by the Florida Department of Environmental Protection (FDEP), interviews with agency permitting staff and cross-references to surface water quality standards and criteria contained in Chapter 62-302, Florida Administrative Code. Monitoring parameters from internet searches generally focus upon glycol as a primary constituent of concern (e.g. SEA-TAC International Airport) for sites of de-icing. Glycol is stored for limited de-icing use at some airports in Florida. It was not found relevant to surface-water runoff monitoring programs in Florida due to very infrequent, low volume use.

Among the sources contacted for information regarding potential chemical constituents of concern resulting from runway maintenance were: the EPA Region 4 office, the EPA's Website, the FDEP Southwest District Office, Mac Dill Air Force Base-Tampa, U.S. Air Force Center for Environmental Excellence, several internet sites for Material Safety Data Sheets, and the FAA's Website. Several library literature databases were searched for keywords including aircraft tires, aircraft brakes, tires, runway maintenance, tire composition, and brake composition.

The limited information found regarding runway maintenance operations indicated that the common components of aircraft tires include natural rubber, polybutadiene, styrene-butadiene rubber which are compounded with carbon black, oils, and vulcanizing chemicals. Aircraft brakes typically are composed of copper, tin, iron, lead, graphite, carborundum, silica, alumina, emery, and asbestos substitutes. Typical petroleum constituents related to aviation fuel, lubricants, and hydraulic fluids were identified as potential contaminants. Also, metals such as chromium, lead, arsenic, cadmium, copper, mercury, nickel and zinc were among the most common potential storm water contaminants

The Charlotte County Airport pilot water-quality monitoring program served to both benefit and reinforce selection of the proposed monitoring parameters. Results from the pilot program were shared with the inter-agency steering committee. Two key conclusions from the pilot program were incorporated in the experiment design. First, small amounts of overland flow can vastly lower the concentrations for many constituents of interest. With their low initial concentrations this can result in substantial non-detects. It was deemed necessary to place the collection systems immediately adjacent to the pavement edge to appropriately characterize runoff from the pavement. Second, the typical USEPA-3-dry-days-between-event criteria can effectively eliminate many constituents from samples, particularly some fuel products. Therefore, wet season samples eliminated this criteria entirely to provide a more representative picture of constituent runoff.

The recommended parameters were reviewed by the Project QA Officer and the steering committee including FDEP and all Water Management Districts, except Northwest Florida . The agreed parameters selected as constituents of concern or relevant to the runoff and BMP characterization process for the Study are listed in Table 2.

Table 2 – Water Quality Monitoring Parameters

Statewide Airport Stormwater Study Parameters	Test Method
Arsenic As	6010
Cadmium Cd	6010
Chromium Cr	6010
Copper Cu	6010
Lead Pb	6010
Mercury Hg	7470
Nickel Ni	6010
Zinc Zn	6010
Hardness (mg/L of CaCO3)	SM2304B
Total Recoverable Petroleum Hydrocarbons TRPH	FL-PRO
Total Phosphorus Tot P	365.4
Total Nitrogen Tot N	Calculation
Nitrate + Nitrite Nox	SM4500NO3
Total Kjeldahl Nitrogen TKN	351.2
Total Suspended Solids TSS	160.2
pH	150.1
Conductivity	120.1

The study also included tests for polycyclic aromatic hydrocarbons (PAH) in soil. Soil samples were also analyzed for chlorinated pesticides. The Study included a single such sample of soil collected at each station. The objective was to evaluate presence and potential migration of these extremely non-soluble compounds in the overland flow alternative design.

2.D Site Selection

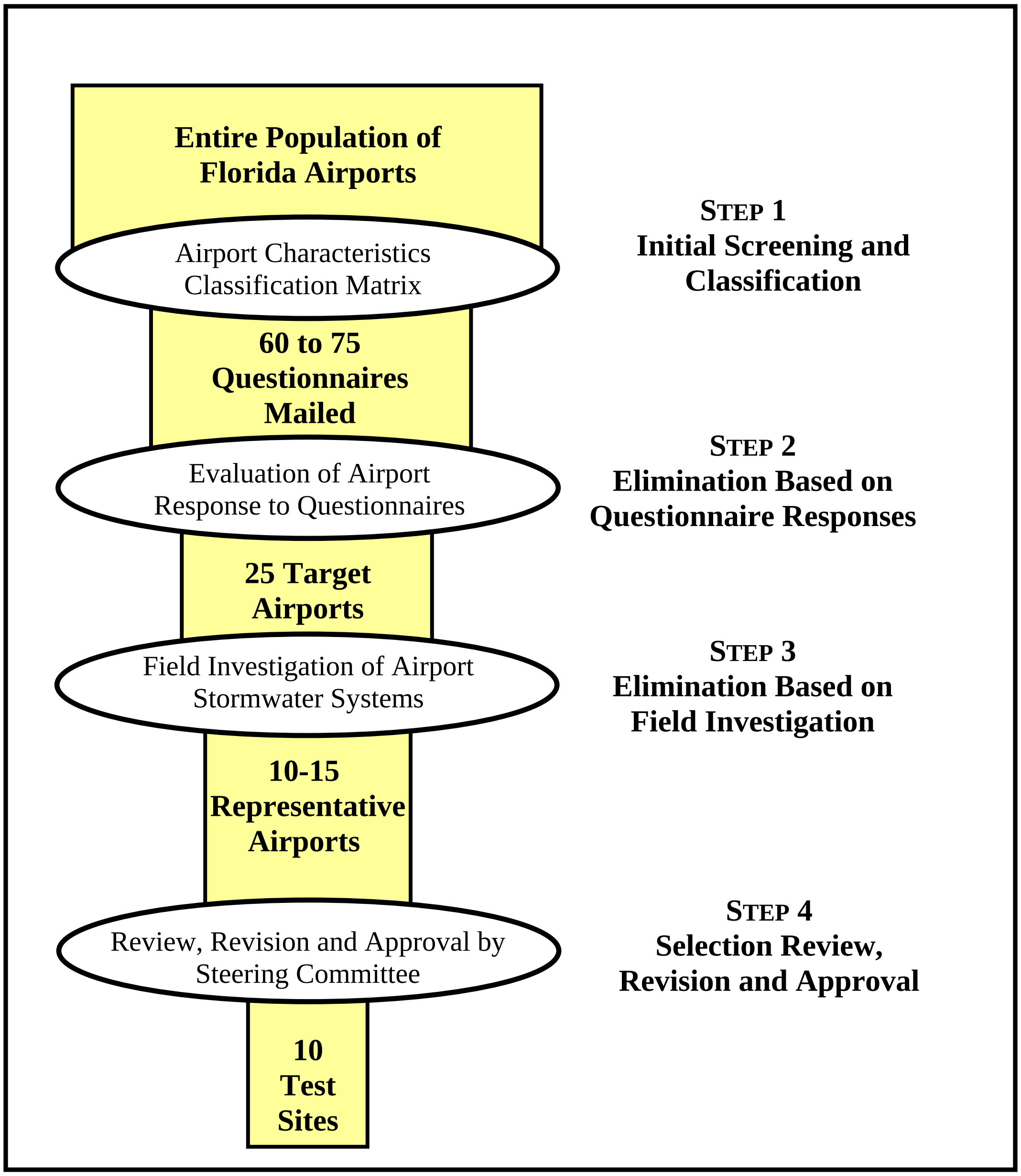
An absolute condition of the study was that the 10 selected airports and the various sites within them had to represent the 132 public use airports in the state. Generally speaking, there were four steps in the selection process as follows:

- STEP 1: Initial Screening and Classification
- STEP 2: Elimination Based on the Questionnaire Responses
- STEP 3: Elimination Based on the Field Investigation
- STEP 4: Selection Review and Approval by the Steering Committee

The four-step process used for selecting study airports is shown schematically in Figure 2.

Figure 2

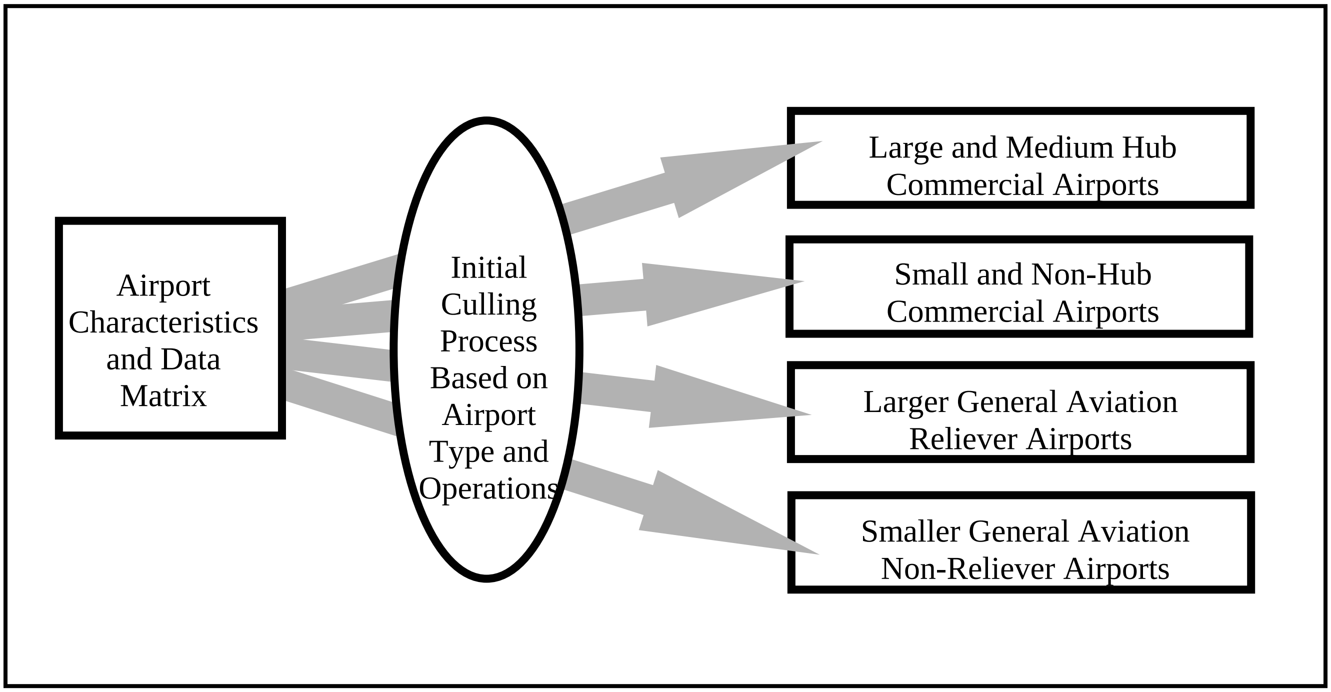
FOUR STEP AIRPORT SELECTION PROCESS



The initial screening process included two primary and two subsidiary airport classification classes based upon their relative sizes, types of aviation operations, and based aircraft. Operations were primarily classified as Commercial, providing scheduled air transportation and General Aviation representing private and charter aircraft usage. Secondary classification was based on the number of operations. This process is conceptually shown on Figure 3.

Figure 3

INITIAL CLASSIFICATION OF AIRPORTS



Factors used to initially reduce the population of candidate airports included eliminating those candidates with helicopter, seaplane and glider operations as the primary or sole operating activity. An additional factor - number of based aircraft - was used to further reduce the population of general aviation airports being considered. The rationale for this culling factor is that a general aviation operation with no based aircraft or exceedingly few based aircraft is atypical of conditions at most general aviation airports in Florida.

Preliminary testing left a surviving population of public use airports as 21 Commercial Carrier and 77 General Aviation Airports classified as follows:

Table 3 - Public Use Airports Classification

	Smaller Airports	Larger Airports
Commercial Carrier Aviation Airports	Group A Designated as Non- or Small Hub Airports (14 Candidates)	Group B Designated as Medium- or Large Hub Airports (7 Candidates)
General Aviation Airports	Group C Not Designated as General Aviation Reliever Airports (50 Candidates)	Group D Designated as General Aviation Reliever Airports (27 Candidates)

Candidate airports identified from Screening Step 1 were sent a questionnaire that provided substantial additional information on the stormwater management system, existing management plans, and ongoing regulatory issues. The following factors were causes for exclusion from the study:

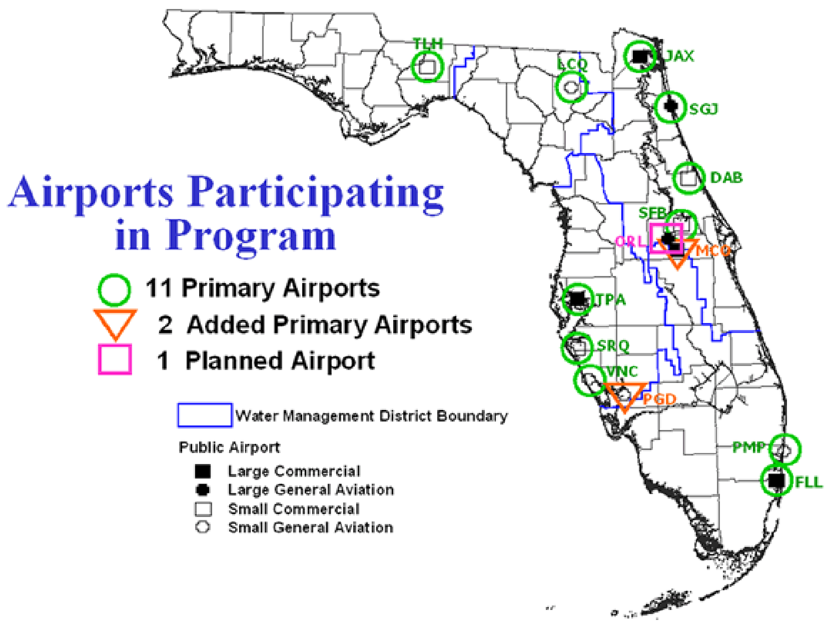
- Active Landfill or Waste Transfer Station
- Closed Landfill with a Current Leachate Problem
- Current Hazardous Waste Problems/Cleanup Project
- On-Site Agricultural Activities
- On-Site Septage Disposal Activities
- On-Site Sludge Disposal Activities
- Failure to Respond to the Questionnaire

Candidate airports remaining after Step 2 were field investigated to collect supplemental information on their stormwater management systems and to determine their suitability for instrumentation and field monitoring. Airports were eliminated if the field investigation revealed conditions or factors that would result in unsuccessful completion of field monitoring activities.

The final step in airport selection was the review of the recommended list by the steering committee, including representatives from FDEP, SJRWMD, SFWMD, SWFWMD and Suwannee River Water Management District (SRWMD). The review resulted in a program modification to include an 11th airport, Fort Lauderdale-Hollywood International, in the study. It also included a recommendation to use parallel data from Charlotte County and Orlando International Airports, which were doing similar testing separate from the Statewide Airport Stormwater Study. The same consulting team did both the Charlotte County and Orlando International studies, and data collection, verification and reduction processes were the same in all three studies.

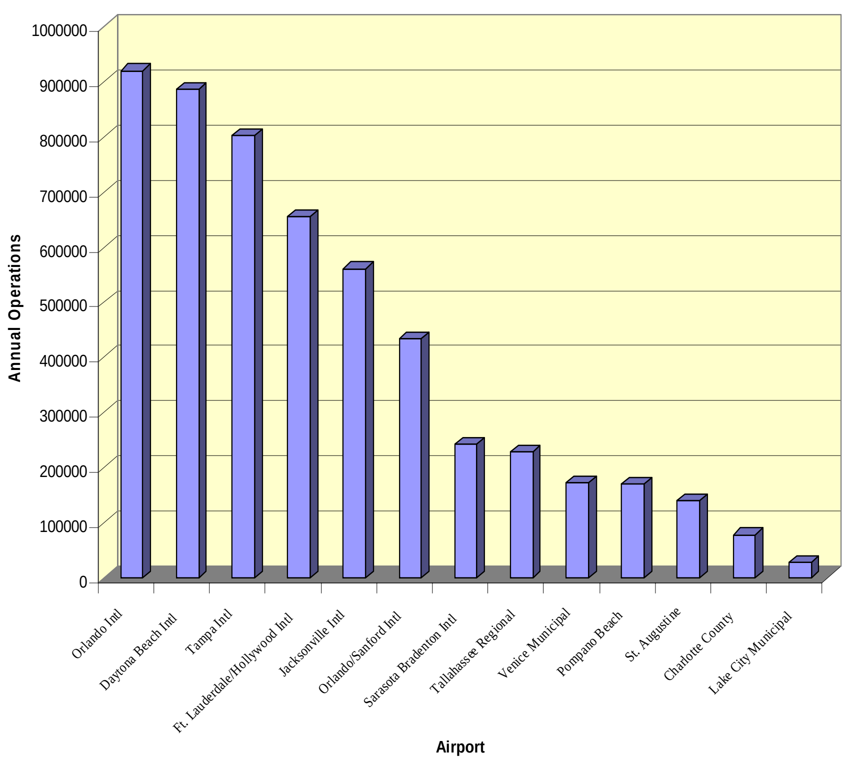
Figure 4 shows the 13 airports that participated in the study. The location designated as "Planned" is for a future "FAA Pond" monitoring project.

Figure 4



In addition to a wide geographic variability, the airports represent the full range of operation levels found in the state. The busiest airport, Orlando International, and an airport typical of minimal use, Lake City Municipal, represent the extremes of aircraft use. Figure 5 following shows the operations range the study captured.

Figure 5 – Aircraft Operations at Airports in Program



Within each airport the operations, airside use, and available BMPs were considered during the screening of candidate sites. Various uses are listed below

Airport Type	**Airside Use**	**BMP Use**
Large Commercial	Cargo Airport	Overland Flow
Large General Aviation	GA Apron	Oil / Water Separator
Small Commercial	Repair Apron	Dry Pond
Small General Aviation	Terminal Apron	"Bubbler" Stormwater Outlet
	Runway	Wet, Vegetated Swale
	Taxiway	
	T-Hangar	

Subsequent to the statewide screening of candidate airports, each candidate airport was visited to identify candidate sampling sites. A total of 82 candidate sampling sites were evaluated. Initially, 35 of these sites were selected, however the study expanded to ultimately address a total of 41 sites. The criteria for the selection of test sites were:

1. That there would be *no bias by geographic location,*
2. That there would be *no consideration of WMD affiliation,*
3. That there would be *no ranking by type of site only,*
4. That there would be *consideration of subjective ranking,*
5. That there would be *linkages between characterization and BMPs*.
6. That there would be *safe access to a secure sampling location*.

The sites selected and tested are described in Table 4, on page 13 following. Pictures of some of the sites are shown below in Figure 6.

Figure 6 – Some Example Installations

Table 4 - Sites Selected and Tested

Airport	Site Number	Study Element	Airport Type	Specific Sampler Collection Area	Feature
Venice	VNC-02	BMP	Small General Aviation	North Stormwater pond discharge	Dry Pond
Tallahassee	TLH-03	BMP	Small Commercial	Discharge Pipe from south oil/water separator	Oil/water Separator
Orlando Int'l.	MCO-02	BMP	Large Commercial	25 feet Overland Flow, Runway	Overland Flow
Orlando Int'l.	MCO-03	BMP	Large Commercial	50 feet Overland Flow, Runway	Overland Flow
Orlando Sanford	SFB-02	BMP	Small Commercial	25 feet Overland Flow,.Runway 9L-27R	Overland Flow
St. Augustine	SGJ-04	BMP	Large General Aviation	25 feet Overland Flow, Runway 13-31	Overland Flow
Sarasota Bradenton	SRQ-02	BMP	Small Commercial	25 feet Overland Flow, Runway 14-32	Overland Flow
Tampa	TPA-02	BMP	Large Commercial	25 feet Overland Flow Runway 36L-18R	Overland Flow
Charlotte County	PGD-02	BMP	Small General Aviation	Baffled outlet (Sediment Box) for North GA apron	Baffled Outlet
Charlotte County	PGD-03	BMP	Small General Aviation	500 feet of vegetated swale	Wet ditch
Venice	VNC-06	BMP	Small General Aviation	South row of T-Hangars with grassed entrance dividers	Hangar
Ft. Lauderdale Hollywood	FLL-02	Characterization	Large Commercial	FedEx Cargo Apron	Apron
Jacksonville	JAX-10	Characterization	Large Commercial	West side Cargo Apron, Ramp no. 1	Apron
Jacksonville	JAX-13	Characterization	Large Commercial	Southside of cargo ramp	Apron
Tampa	TPA-10	Characterization	Large Commercial	North Air Cargo Apron	Apron
Charlotte County	PGD-01	Characterization	Small General Aviation	North GA Apron	Apron
Pompano Beach	PMP-02	Characterization	Small General Aviation	Apron north of the Administrative Building	Apron

Airport	Site Number	Study Element	Airport Type	Specific Sampler Collection Area	Feature
Orlando Sanford	SFB-04	Characterization	Small Commercial	Northern edge of the GA flight training apron south of Runway 9Cwest of Taxiway K	Apron
Sarasota Bradenton	SRQ-06	Characterization	Small Commercial	GA apron west of Taxiway A	Apron
Venice	VNC-01	Characterization	Small General Aviation	Northwest GA Apron	Apron
Tampa	TPA-12	Characterization	Large Commercial	Southeast GA apron	Apron
Lake City	LCQ-05	Characterization	Small General Aviation	Repair Apron	Apron
Lake City	LCQ-01	Characterization	Small General Aviation	Northeast end of Runway 10-28	Runway
Orlando Int'l.	MCO-01	Characterization	Large Commercial	Runway	Runway
Pompano Beach	PMP-01	Characterization	Small General Aviation	Northwestern end of Runway 15-33	Runway
Orlando Sanford	SFB-01	Characterization	Small Commercial	South side of Runway 9L-27R	Runway
St. Augustine	SGJ-03	Characterization	Large General Aviation	Southeast end of Runway 13-31	Runway
Sarasota Bradenton	SRQ-01	Characterization	Small Commercial	Northwest side of the Runway 14-32	Runway
Tampa	TPA-01	Characterization	Large Commercial	Southeast side of Runway 36L-18R	Runway
Daytona Beach	DAB-06	Characterization	Small Commercial	North side of Taxiway Echo	Taxiway
Orlando Int'l.	MCO-04	Characterization	Large Commercial	Taxiway	Taxiway
Tampa	TPA-03	Characterization	Large Commercial	Southwest side of Taxiway	Taxiway
Sarasota Bradenton	SRQ-07	Characterization	Small Commercial	Taxiway	Taxiway
Sarasota Bradenton	SRQ-08	Characterization	Small Commercial	Taxiway	Taxiway

Airport	Site Number	Study Element	Airport Type	Specific Sampler Collection Area	Feature
Orlando Int'l.	MCO-05	Characterization	Large Commercial	Terminal apron	Apron
Daytona Beach	DAB-03	Characterization	Small Commercial	Terminal Apron area on the west side of the concourse	Apron
Jacksonville	Jax-03	Characterization	Large Commercial	Concourse B Apron	Apron
Sarasota Bradenton	SRQ-04	Characterization	Small Commercial	Westside of terminal apron	Apron
Tallahassee	TLH-02	Characterization	Small Commercial	South terminal area	Apron
St. Augustine	SGJ-02	Characterization	Large General Aviation	South Group of Hangars	Hangar
Venice	VNC-05	Characterization	Small General Aviation	North T-Hangars with paved entrance dividers	Hangar

2.E Rainfall and Sampling Event Definition

Recognizing that the sub-tropic nature of the Florida climate is quite variable, the study design included an evaluation of historic rainfall to facilitate developing sampling protocols. The purpose of the evaluation was to characterize the distribution of rainfall over time and space. The evaluation also provided a context within which the results of the Statewide Airport Stormwater Study could be viewed. Historic daily rainfall records for a 15-year period were compiled for climate stations located in the following nine Florida cities: Ft. Myers, Gainesville, Jacksonville, Miami, Orlando, Pensacola, Tallahassee, Tampa, and West Palm Beach. Table 5 summarizes National Climate Data Center information pertaining to station ID, name, location coordinates and period of record.

Table 5 – Summary Information for Climate Stations Used to Determine Storm Event Probabilities

[Source: National Climate Data Center, Southeast Regional Climate Center]

Station ID	Station name	Latitude (deg min)	Longitude (deg min)	Period of record (month / year)
83186	FORT_MYERS_FAA/AP	26° 34’	81° 52’	1/31 – 12/99
83326	GAINESVILLE_MUNI_ARPT	29° 40’	82° 16’	6/60 – 12/99
84358	JACKSONVILLE_WSO_AP	30° 30’	81° 41’	7/48 – 12/99
85663	MIAMI_WSCMO_AIRPORT	25° 47’	80° 18’	7/48 – 12/99
86628	ORLANDO_WSO_MCCOY	28° 27’	81° 19’	2/74 – 12/99
86997	PENSACOLA_FAA_ARPT	30° 28’	87° 11’	7/48 – 12/99
88758	TALLAHASSEE_WSO_AP	30° 22’	84° 22’	1/48 – 12/99
88788	TAMPA_WSCMO_ARPT	27° 58’	82° 31’	1/33 – 12/99
89525	WEST_PALM_BEACH_WSO_AP	26° 40’	80° 07’	7/48 – 12/99

Summary statistics for daily rainfall reported from 1985 through 1999 are presented in Table 6. No significant discrepancies are apparent in the record selected for analysis. Records compiled for the Ft. Myers station had the largest percentage of missing record. This did not appear to unduly influence the statistics calculated for this station when compared to the other 8 stations.

Table 6 – Summary Statistics for Daily Rainfall Reported From 1985 Through 1999.

Station ID	83186	83326	84358	85663	86628	86997	88758	88788	89525	All
Location	**Ft. Myers**	**Gainesville**	**Jacksonville**	**Miami**	**Orlando**	**Pensacola**	**Tallahassee**	**Tampa**	**WPalm Bch**	
Population Statistics										
Days in period analyzed	5478	5478	5478	5478	5478	5478	5478	5478	5478	49302
Days with missing record	855	0	0	0	0	155	31	0	61	1102
Relative amount missing	16%	0%	0%	0%	0%	3%	1%	0%	1%	2%

Station ID	**83186**	**83326**	**84358**	**85663**	**86628**	**86997**	**88758**	**88788**	**89525**	**All**
Location	**Ft. Myers**	**Gainesville**	**Jacksonville**	**Miami**	**Orlando**	**Pensacola**	**Tallahassee**	**Tampa**	**WPalm Bch**	
Minimum, inches	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum, inches	7.55	6.16	7.83	8.59	5.13	9.10	7.79	7.59	8.01	9.10
Average, inches	0.16	0.13	0.15	0.17	0.14	0.19	0.17	0.13	0.17	0.16

Exceedance frequency, %	**Daily Rainfall Volume, in inches**									
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.01	0.01	0.01	0.04	0.02	0.01	0.01	0.00	0.04	0.02
25	0.05	0.04	0.05	0.08	0.05	0.05	0.04	0.02	0.09	0.05
20	0.12	0.11	0.12	0.15	0.11	0.14	0.11	0.08	0.16	0.12
10	0.50	0.42	0.44	0.51	0.46	0.60	0.51	0.39	0.52	0.48
0	7.75	6.16	7.83	8.59	5.13	9.10	7.79	7.59	8.01	9.10

Annual Statistics Calendar Year	**Annual Rainfall Volume, in inches**									
1985	47.54	54.10	58.39	56.26	47.19	69.34	62.93	44.60	47.99	
1986	56.86	48.15	44.10	66.12	49.83	68.55	71.78	41.60	69.31	
1987	69.01	44.05	43.39	50.27	56.79	68.69	67.82	49.08	58.69	
1988	35.00	55.77	60.68	44.59	52.49	77.31	48.46	52.33	64.91	
1989	49.89	40.47	51.45	42.63	45.66	69.95	63.59	43.63	38.66	
1990	48.91	42.33	31.20	51.71	31.68	51.56	45.73	34.39	55.81	
1991	67.50	50.97	79.63	71.42	60.90	71.94	72.25	43.16	79.36	
1992	55.45	54.28	63.18	57.82	52.96	76.59	62.78	34.98	61.11	
1993	54.56	43.65	50.12	62.79	44.53	61.33	51.93	37.53	58.58	
1994	52.66	48.89	67.26	79.56	67.85	75.75	85.40	47.23	85.89	
1995	61.71	51.22	50.25	79.30	43.05	56.65	52.40	54.13	68.97	
1996		54.65	60.63	57.71	56.66	66.75	56.72	49.41	46.82	
1997		58.22	57.27	70.61	64.51	80.45	64.25	67.71	62.13	
1998	69.01	45.62	56.72	70.23	43.75	68.63	58.83	55.35	67.05	
1999	48.90	37.86	42.36	64.37	54.80	45.39	49.18	34.33	59.97	
Minimum annual, inches	35.00	37.86	31.20	42.63	31.68	45.39	45.73	34.33	38.66	
Average annual, inches	55.15	48.68	54.44	61.69	51.51	67.26	60.94	45.96	61.68	
Maximum annual, inches	69.01	58.22	79.63	79.56	67.85	80.45	85.40	67.71	85.89	
Range, inches	34.01	20.36	48.43	36.93	36.17	35.06	39.67	33.38	47.23	

Station ID	**83186**	**83326**	**84358**	**85663**	**86628**	**86997**	**88758**	**88788**	**89525**	**All**
Location	**Ft. Myers**	**Gainesville**	**Jacksonville**	**Miami**	**Orlando**	**Pensacola**	**Tallahassee**	**Tampa**	**WPalm Bch**	
Normal (1961-1990)[2]	53.44	50.65	51.31	56.10	47.24[2]	61.81	65.68	43.92	60.76	
Difference between normal and 15-year average, inches	1.71	-1.97	3.13	5.59	4.27	5.45	-4.74	2.04	0.92	
Relative difference, %	3.2	-3.9	6.1	10.0	9.0	8.8	-7.2	4.7	1.5	

[1]Source: http://water.dnr.state.sc.us/water/climate/sercc/norm_station.html
[2]Based on an incomplete period of record; daily records not available for about 43% of the 30-year period.

Results summarized in Table 6 indicate that daily rainfall in excess of a low volume such as 0.10 inch that might not induce runoff occurred at a frequency of about 72 days per year, or about 20% of the time. Greater volumes occurred at lesser frequencies. For example, daily rainfall exceeded on average 36 days per years, i.e. 10% of the time, ranged between 0.39 and 0.60 inches. The average daily rainfall during the 15-year period of evaluation ranges from 0.13 and 0.17 inches, although maximum daily volumes ranging from 5.13 to 9.10 inches were reported.

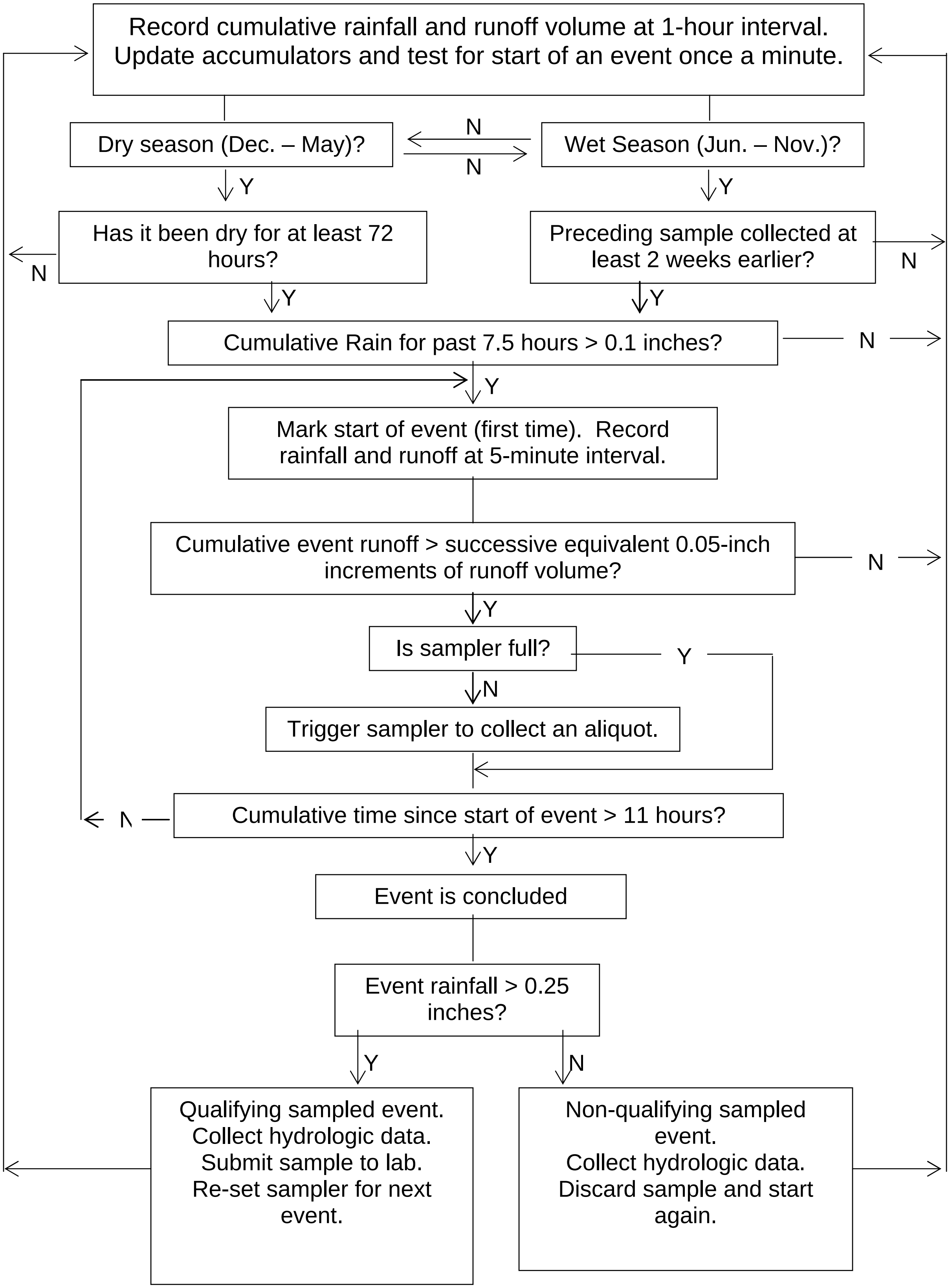
For purposes of the study, testing by season was originally specified. Seasons were divided into rainy and dry, with 5 events per site, per season originally required. However, analysis at the 70% data collection point indicated no statistical difference between seasonal data in the program. Data therefore were collected seasonally, but analyses were performed lumping both rainy and dry data.

Time limits were also found to be important to define events. This reflected the well-known start and stop nature of rain within any arbitrary period, sample preservation requirements and other factors. These factors were used in setting a maximum time limit of 11 hours for a sample event from beginning to end. The end of an event was defined as occurring when the lesser of two criteria where meets -- either 7.5 hours had elapsed with no rainfall, or 11 hours had elapsed since the event began. A minimum of 14 days was originally established between wet season events before a sample was collected. During the dry season, designated as December 1st to May 31st, a minimum of 3 dry days passed between events before a sample was collected

The following sampling event criteria were chosen based on the historic rainfall patterns and other practical considerations such as site access, laboratory analytical requirements related to preservation and volume, sampler capacity, and budgets. Sampling focused on rainfall events totaling 0.10 inches or more during an 11-hour period, which is equivalent to a daily rainfall of 0.22 inches. Automated samplers were programmed to collect sufficient sample volume when as little as 0.25 inches of runoff occurred and to shut down when full after 1.1 or more inches of runoff occurred.

Bulk samples of as much as 3.8 liters in volume were collected by compositing 220 mL aliquots of runoff collected successively as 0.05 inch increments of runoff were recorded at the site during an event. Discrete 1-liter samples for pollutagraph analysis were collected in a similar manner however each discrete sample was composed of two successive 500 mL aliquots collected at 0.05 inch increments.

The schematic on page 20 describes sampling protocols developed to accommodate Florida seasonal rainfall conditions. In all cases, sampling was initiated only after 0.1 inches of rainfall and sufficient volume of runoff had been measured. This allowed for an accounting of initial abstraction by infiltration and evaporation, and also provided sufficient flushing of remnant water retained in the water-collection system from prior storms.


Record cumulative rainfall and runoff volume at 1-hour interval. Update accumulators and test for start of an event once a minute.
Dry season (Dec. – May)?
N
N
Wet Season (Jun. – Nov.)?
Y
Y
Has it been dry for at least 72 hours?
N
Preceding sample collected at least 2 weeks earlier?
N
Y
Y
Cumulative Rain for past 7.5 hours > 0.1 inches?
N
Y
Mark start of event (first time). Record rainfall and runoff at 5-minute interval.
Cumulative event runoff > successive equivalent 0.05-inch increments of runoff volume?
N
Y
Is sampler full?
Y
N
Trigger sampler to collect an aliquot.
Cumulative time since start of event > 11 hours?
Y
Event is concluded
Event rainfall > 0.25 inches?
Y
N
Qualifying sampled event. Collect hydrologic data. Submit sample to lab. Re-set sampler for next event.
Non-qualifying sampled event. Collect hydrologic data. Discard sample and start again.

2.F Sampling Constraints and Instrumentation

A number of practical issues logistically affected the study, although none of these compromised the quality of the work, the results or conclusions. In addition to the usual technical problems encountered in this type of study, airport security and limitations based on airport site construction and sampling affected the study design. Additionally, the fact that September 11, 2001 happened before instrumentation and data collection increased the constraints placed on the project.

Stormwater sampling is challenging because rainfall by its very nature is intermittent and varies in frequency and intensity that is known only after a storm event has occurred. Feedback mechanisms such as telemetry systems or local observers are useful in assuring that sampling equipment is operating properly. In many typical applications, dataloggers and autosamplers when coupled with either telephone or radio telemetry systems provide a cost-effective means for sampling teams to remotely monitor the functional status of sampling systems and schedule site visits.

In the case of airports, particularly airside sampling, access is severely restricted. It typically requires an escort by properly trained and “badged” airport personnel who are available on a limited basis. In many cases, it was impractical, if not impossible, to arrange for a local observer to perform frequent inspections. The use of telecommunication devices is also regulated by FAA. Pre-clearance of cellular telephones and radios by the FAA to select areas at a regulated distance from the runways and taxiways targeted for sampling was required. This reflects possible communication and navigation interference and a resulting safety hazard to flight when not done. Generally, only one cellular phone or radio was permitted on each airport as a result.

Based on a consideration of these real constraints, a sampling system was designed to automatically measure and process hydrometric data in real time at the sampling location, and then to use the processed data to control sample collection.

Laboratory analytical requirements for sample preservation presented another constraint requiring further consideration. The initial QA plan provided that samples would be maintained at 40 degrees Fahrenheit from the time of sample collection until being processed by the laboratory. This turned out to be impractical to achieve. Airport security and site-access constraints and high temperatures made it impossible to continuously chill samplers using ice in anticipation of potential sampling event. Literature search indicated upwards of 700 pounds of ice per day per station would be needed to reliably maintain the temperatures. Placement of refrigeration equipment was also equally impossible, particularly at runway sites, because of height restrictions and lack of power supply. In order to assure the integrity of the samples a study within the study was conducted to assure that the results of non chilled samples did not statistically affect the results. This study is included in Appendix B.

Preservation for nutrients and TRPH was with sulfuric acid added to sampling containers prior to collection. Metals were preserved using nitric acid added subsequent to collection to avoid cross-contamination of the nutrient-sampling containers. Samples for conductivity, pH and TSS were not acidified. All samples were chilled immediately after collection and preservation with acid.

Minimum sample volumes required by the laboratory ranged from 200 milliliters (ml) for metals to 1 liter (L) for TSS and TRPH. As such, the autosamplers configured to collect composite samples were equipped with four 1-gallon (3.8 L) containers, one made of borosilicate glass for the TRPH sample and three made of polypropylene for the other 3 groups of preservation requirements. Autosamplers configured to collect discrete samples to define pollutographs were equipped with twelve, 1-L bottles made of either glass when TRPH was sampled, or polypropylene when the other constituent sets were sampled.

FAA safety requirements precluded installing above-ground structures and equipment immediately adjacent to runways, taxiways, and most aprons. Stormwater runoff from runways, taxiways and overland flow locations was collected using a trench drain capable of withstanding applied aircraft loads. A typical trench drain installation is shown in Figure 7. The selection of each site and length of drain was intended to provide a sample volume consistent with testing needs and rain event definitions. Visual reconnaissance by S. Brady, P.E. of MEA Group, D. Mades, P.E. of Ed Barber & Associates and Abdul Hatim, Ph.D. of FDOT was done at individual stations jointly and/or separately during rainfall events. The purpose was to verify that flows were not bypassing the system and to verify that observations of no flow during rainfall (100% infiltration) were, in fact, real. This was the case at all stations used for the program.

Figure 7 - Trench Drain Installation for an Overland Flow BMP Site

The "object free areas" associated with the runways and taxiways also limited location and height of the sampling equipment. This required that runoff collected by the trench drains be conveyed to remote measuring and sampling equipment locations within the infield. This was done using underground PVC pipe which terminated at a flow-measurement structure.

Several types of flow measurement structures were installed to accurately determine runoff. The first type was a rectangular weir box affixed beneath a grated drop inlet. A pressure transducer was attached within the weir box to monitor water levels in the weir box. The second type of flow / measuring device was a H-flume. H-flumes are equipped with shaft encoders to the depth of water at a defined location in the flume. The typical H-flume was 9 inches high. Another type of flow/measuring device was a V-Notch weir in open channel. The entrance channel to a V-Notch weir was equipped with shaft encoder to measure the depth of water at the notch.

Sampling equipment included Campbell CR10X and CR510 dataloggers, ISCO 3700 autosamplers, Enviro-Systems shaft encoders, KPSI pressure transducers, and Texas Electronics rain gauges. Shaft encoders and pressure transducers measured water level with a precision of 0.02 feet. The tipping bucket rain gauge registered rainfall in increments of 0.01 inches. The dataloggers were programmed as both a recorder and controller and in this case made determinations about beginning and end of rainfall events and triggered samplers, accordingly. Dataloggers were programmed to re-cycle through the complete program and to accumulate volumes and trigger samplers as needed at a 1-minute interval. Data were logged into "reports" within datalogger memory at frequencies of 5 minutes, 1 hour, and 24 hours.

The Study included installation of 41 portable samplers (data logger controlled) at the selected sites. At 31 of the stations, samples collected were flow weighted composites designed to generate mean concentrations and unit area loads on an event basis. Ten stations were solely dedicated to discrete samplers for generating pollutographs. These stations were used to analyze runoff characteristics over time on an event basis.

2.G Quality Assurance

Quality Assurance (QA) addresses not only sample collection, but data handling, data reduction, calculation method and arithmetic accuracy, and standards for using published data among others. Approach and procedures issues of this type were peer reviewed by the consultant team first, then presented to the steering committee representing the Florida Department of Transportation, the Florida Department of Environmental Protection, the Florida Water Management Districts and the Federal Aviation Administration. Data handling and arithmetic accuracy were the responsibilities of the individual consultant firms assigned these tasks. As a minimum, these items were done by one individual and checked by another. Random QA checks were performed by professionals from Storm Water Resources of Florida, LC for compliance with sampling procedures and for data handling.

Outlines of the data collection and handling for both the hydrology and chemistry elements follow. Field personnel responsible for sample and data collection were provided with field manuals with written descriptions of procedures and sampling apparatus. In-house training was provided to all field personnel prior to their involvement with sampling and data collection.

Hydrology

- Hydrology data were downloaded directly from the dataloggers onsite. Readings of key datalogger variables such as battery voltage, sampler status, water level, recent rainfall volume, and flow were recorded on field forms. The downloaded data and field forms were forwarded to a central data-management location.
- Data were combined into one master file.
- Event related data were extracted into spreadsheets for each station for further reduction and evaluation.
- Engineers/hydrologists reduced the data using three graphical procedures for each event. Graphs of stage-discharge, rainfall-runoff and hydrograph-hyetograph overlays were prepared and individually evaluated.
- Reduced and interpreted data were used for the volume portion of the load calculation.

Chemistry

- An initial field check was conducted for sample volume sufficiency, by the field technician.
- Chain-of-custody was established.
- Samples were removed from the samplers within 24 hours of event conclusion, immediately preserved, and then shipped to laboratory within 48 hours.
- The project laboratory processed the samples using Standard Methods and provided results in both electronic format and hard copy. The hard copy is the official record of results.
- Hard copies were screened for qualifying codes. Qualifier issues were resolved as needed.
- Electronic copies were combined into a Master EDR (Electronic Data Record) file.
- Master EDR data were compared with hard copy data and summarized using graphical, statistical frequency distributions. Differences between hard copy and EDR data were reconciled. Extreme or unexpected values were examined and evaluated as to cause. Extreme values related to improper sampling protocol, such as acidified samples submitted for analysis of pH, were eliminated from the Master EDR.
- Corrected Master EDR file data extracted into individual station and event worksheets for analysis to characterize frequency of occurrence and event loads.

Sampling and Equipment

- Approximately 5% of the total number of samples collected were dedicated to quality-assurance testing.
- New pre-cleaned sample containers and sections of newly constructed trench drains, H-flumes and sampler tubing were rinsed with de-ionized water. Drains are made of concrete with polymer add mix and painted metal grate. H-flumes are made of air-blown PVC panels. Sampler tubing is made of Teflon-lined plastic. Rinsate was collected and analyzed for the complete suite of study constituents. No interferences or residuals were detected.
- Equipment blanks were collected and analyzed. Sampling equipment that had been in place for at least 6 months was selected at random. Sampler intake was placed in a large

container of de-ionized water and the sampler was triggered manually six times to collect a composite sample similar to the routine sampling procedure.

- "Split" samples were collected by pouring half the contents of a sample container filled during stormwater runoff sampling into a second pre-cleaned sampling container.

SECTION 3 – DATA REDUCTION

3.A Site Hydrology and Hydraulics

Each test site was equipped to measure rainfall, runoff rates and volumes, and to use the information collected in real time to control the flow–weighted or discrete sampling of the runoff for various constituents. Initial designs of the collection and measuring systems were based on limited field survey work to establish the extent of site specific contributing area. These initial areas must be considered best estimates. Airport grades around the runways and taxiways are very flat, and uneven pavement edges and changes in wind speed and direction can alter the "contributing" drainage area from the estimate.

The rainfall and runoff data collected for each event were plotted as a cumulative runoff versus cumulative rainfall graph. The slope (m) of the best-fit line of these data is the product of runoff coefficient (C) and contributing area (A). Dividing the slope by the best estimate area (A), an effective runoff coefficient C is calculated for each storm.

Equation 1 $$C = m/A$$

An example of this type of plotting is reflected in this Sarasota Bradenton International Airport data reduction figure, the best fit line is constrained to pass through the origin as shown on Figure 8a. The actual best-fit line may have a non-zero y-intercept as shown in Figure 8b, which may be interpreted as an infiltration or initial abstraction. However, for consistency with load calculation procedures typically used, a C based on a best fit line through the origin is the preferred value.

Figure 8a - Example Rainfall-Runoff with "Best Fit" Through Origin

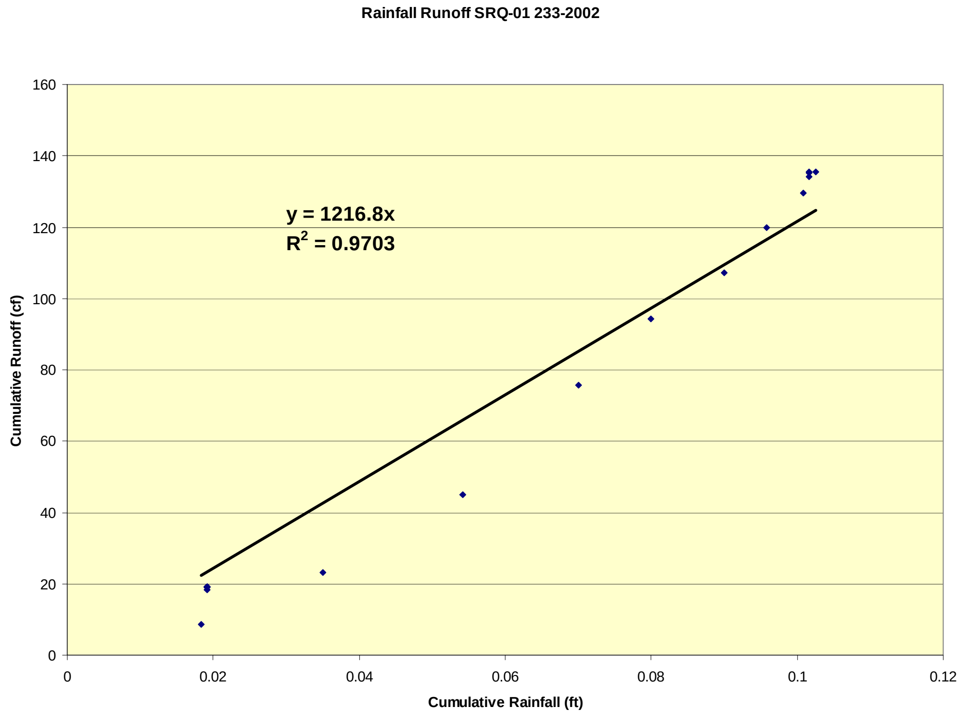
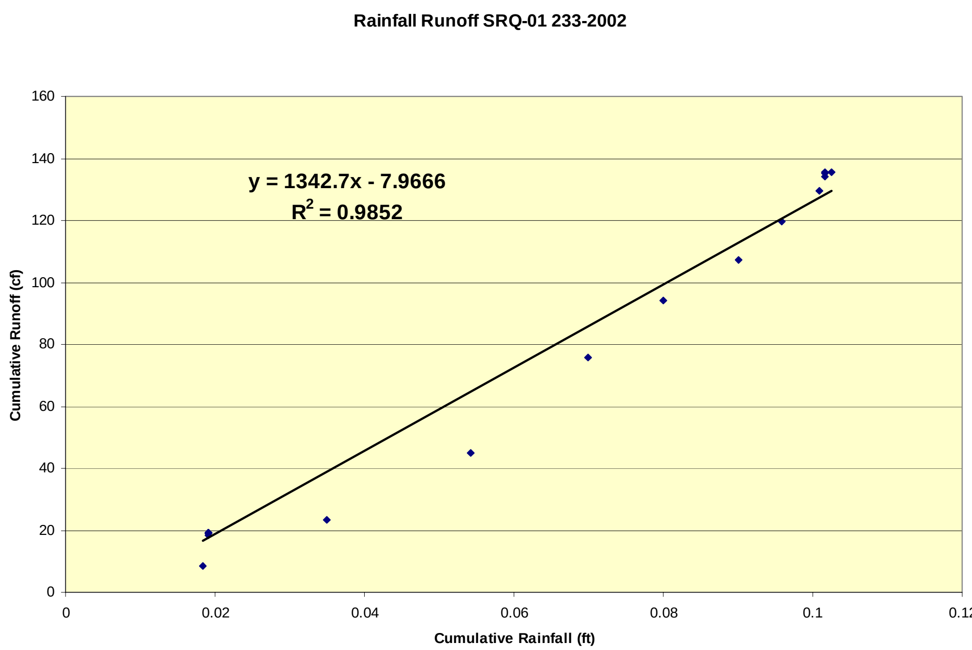


Figure 8b – Example Rainfall-Runoff with "Best Fit" with Y-Intercept



Time of Concentration (Tc) also affects data reduction for the Rainfall-Runoff Graphs whenever the actual Tc exceeds 5 minutes. Specifically, the flows must be offset from the rain by Tc in increments of 5 minutes when this condition exists. Figures 9a and 9b illustrate the impact of Tc on the Rainfall-Runoff graphs. Note that Tc is not a constant for a given site, but can and measurable does vary with rainfall intensity. This is consistent with the kinematic wave formulation of the parameter.

Figure 9a – Impact of Tc on Rainfall-Runoff (No Tc Correction)

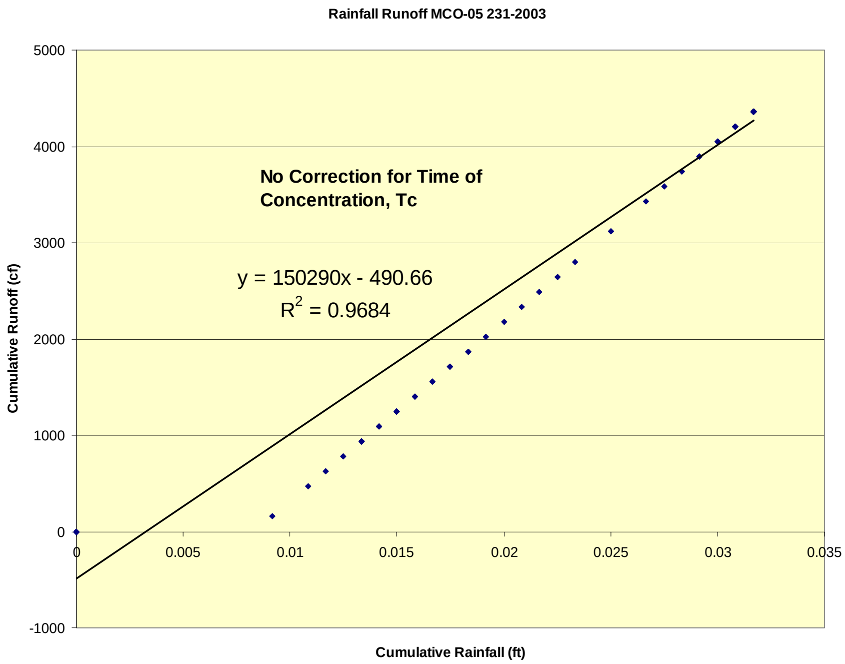
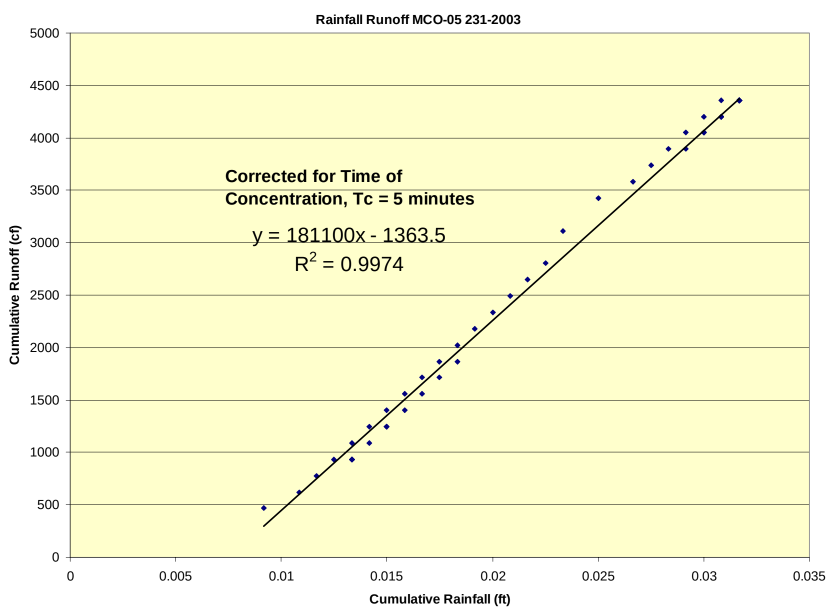
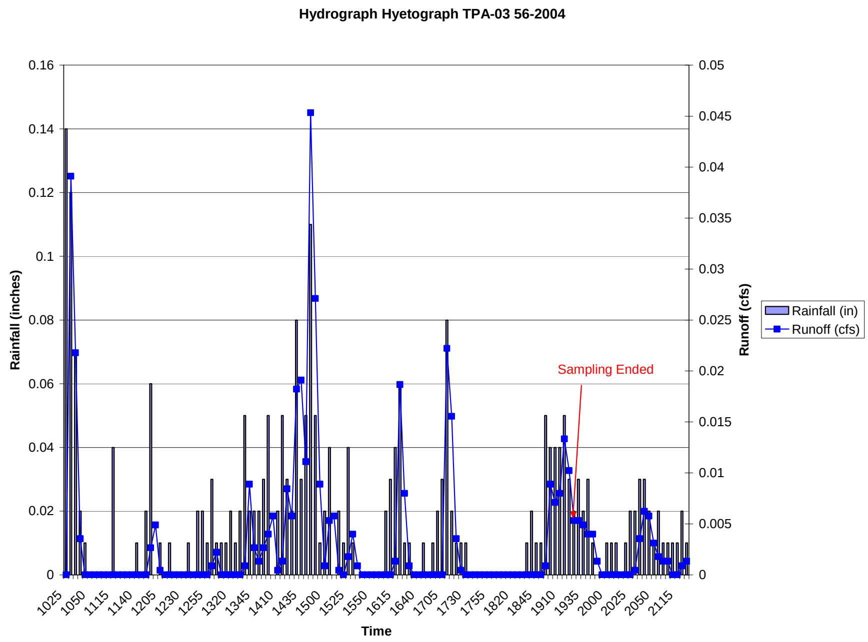


Figure 9b – Impact of Tc on Rainfall-Runoff (Tc Corrected)



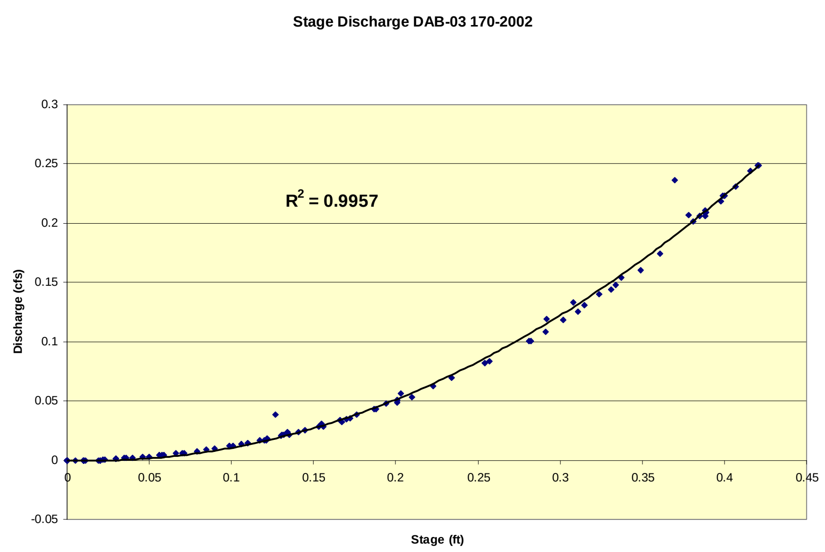
Additional to the rainfall-runoff graphs, plots include combined hyetographs and hydrographs to evaluate the runoff and the portion of the storm sampled. An example is included as Figure 10.

Figure 10 - Example 5-Minute Hyetograph-Hydrograph Plot



Also, to verify the function of the shaft encoder and flow measuring device, plots of stage versus discharge were done for each event. A typical plot is shown in Figure 11 following. The technique permits easy evaluation of non-zero start elevations, stuck floats and similar incidents that could affect an individual event record or sample.

Figure 11 – Example Stage Versus Discharge Plot



Each event was evaluated for the hydrology and hydraulics as described in this section. The full suite of these graphs is available on the data diskette for the project.

3.B Constituent Evaluations

Primary data reduction goals for the study include:

1. Identifying constituents of concern from airside pavement,
2. Establishing Event Mean Concentrations (EMCs) for those constituents associated with different airside pavement runoff,
3. Determining Concentration Reduction resulting from the various BMPs,
4. Determining Load Reduction from the various BMPs, and
5. Evaluating "first flush" effects (if any) for key constituents.

Comparison of the individual event EMC with FAC 62-302 Class III water quality standards is the primary method of identifying constituents of concern. Two such calculations are included. First is a comparison of the EMC with the standard based on a hardness of 100 mg/L as $CaCO_3$. The second is the EMC exceedance of the standard at a hardness of 130 mg/L as $CaCO_3$. These values bracket those representative of typical receiving waters, not the direct runoff hardness at the point of sampling. Compounds consistently above these values are defined as constituents of concern. Also, Total Phosphorus, Total Nitrogen, Total Suspended Solids and Total Recoverable Petroleum Hydrocarbons are analyzed as if they are constituents of concern, irrespective of their EMC values.

In many cases the constituent of interest is reported as below the Method Detection Limit (MDL) or between the MDL and the Practical Quantitation Limit (PQL). When reported below the MDL, statistical calculations are based on assuming ½ of the MDL as the EMC. Also, since MDL can and did vary for some analytes over the course of the study, the modal value is reported in this document. Individual reports include the MDL for each sample for each analyte and this is available on the data diskette for the project.

Statistical methods were used to establish the EMC for constituents of concern. Water-quality characteristics such as concentration and load typically exhibit skewed frequency distributions. For example, concentration is "bounded" by definition to be greater than or equal to zero, or more technically by the MDL associated with a specific laboratory method. Data transformation using logarithmic or power functions is commonly used to create frequency distributions of transformed data that are more symmetric in shape. Frequency distributions may be developed using either the un-transformed or transformed data. Frequency distributions of EMC's determined from this study were developed and evaluated for both the un-transformed data and base-10 logarithms of the data. The base-10 logarithms are more nearly a normal distribution, and the antilog of the mean of the transformed data is therefore reported as the Event Mean Concentration.

Frequency distributions can be presented in either tabulated or graphical forms. The histogram, box-whisker plot, and quantile plot are graphical forms implemented within the proprietary *Excel*® Add-In developed by Analyse-It®. The histogram is a bar chart that illustrates the number of observations found within prescribed sub-ranges of the full range of data. The box-whisker plot (Appendix D) is a graphic that shows the central location and scatter of observations along a number line. The quantile plot illustrates the frequency distribution of the data relative to a normal distribution. All three formats were used to prepare a descriptive summary of frequency distribution for each specific study constituent. Box-whisker plots were used to illustrate comparisons of data grouped into various categories such as airside use.

Concentration reduction from the BMPs tested is one measure of the constituent removal effectiveness of a structural control. It is essentially independent of flow and can occur even with no change in inflow or outflow across the BMP. The calculation for concentration reduction for any event is as follows:

Equation 2 Concentration Reduction (%) = ((Pavement Concentration – BMP Concentration)/Pavement Concentration) x 100%

Only those events that have runoff at both the pavement and the BMP are used in the concentration reduction calculations. That is, where 100% flow was infiltrated, a concentration reduction was not calculated for an event, although a load reduction (100%) was. The concentration reduction thus represents changes in concentration when flow occurs. The mean of the event reductions is reported as the concentration reduction efficiency.

Load reduction is a function of both concentration reduction and flow reduction. If all flow was infiltrated, the load reduction for an event was 100%. This occurred on a frequent basis for some of the BMP sites evaluated. Since sampling was on an event basis, calculations to annualize loads and load reductions were made. These use the effective runoff coefficient, C measured during the events and the mean of the event concentrations as follows:

Equation 3 Annual Load (kg/ha-yr) = .2535 (C) (Average Annual Rainfall (inches) x (Average EMC (mg/L))

Where EMC = event mean concentration and 0.2535 is a conversion factor

Equation 4 Load Reduction (%) = ((SRQ1 Load – SRQ2 Load)/SRQ1 Load) x 100%

"First flush" evaluations using the discrete samplers were done as follows:

1. Set all data at or below the MDL equal to zero.
2. Sum the non-zero EMCs for each event.
3. Divide each non-zero discrete result by the sum of the non-zero EMCs for the event to get a percentage for each discrete sample. Note that each discrete sample corresponds to a rainfall of 0.1 inches.
4. Take the arithmetic mean and the sample standard deviations of the percentages for each rainfall increment (0.1 inches).
5. Plot the mean, mean + 1 standard deviation and mean – 1 standard deviation with the qualifier that no values are less than 0% or more than 100% against the rainfall in 0.1 inch increments.
6. Use Excel curve fitting to attach either a power curve or logarithmic curve, whichever fits best, to the means so plotted.

SECTION 4 – RESULTS

4.A Event Characteristics

Samples were collected between September 7, 2001, and November 29, 2004. Rainfall during this period of time exhibited the typical variability, and was somewhat higher than the 1961-1990 normal rainfall reported by NOAA. Average annual rainfall during calendar years 2002, 2003 and 2004 ranged from to 9.6% below normal at Tallahassee (see Table 7) to 31.6% above normal at Tampa. The overall average rainfall associated with the 9 index statewide stations, considered in the sampling design phase, experienced 9.9% more rainfall than normal.

Table 7 - Annual Rainfall During Period of Study

Station ID	2002	2003	2004	Average	1961 - 1990 Normal	Departure From Normal	Relative Departure From Normal
83186 - Ft. Myers	52.05	70.64	61.83	61.51	53.44	8.07	15.1%
83326 - Gainesville	52.26	46.62	58.37	52.42	50.65	1.77	3.5%
84358 - Jacksonville	54.72	44.47	69.47	56.22	51.31	4.91	9.6%
85663 - Miami	63.29	72.13	54.44	63.29	56.10	7.19	12.8%
86628 - Orlando	66.39	52.68	59.24	59.44	47.24	12.20	25.8%
86997 - Pensacola	63.83	63.89	69.55	65.76	61.81	3.95	6.4%
88758 - Tallahassee	56.08	65.30	56.83	59.40	65.68	-6.28	-9.6%
88788 - Tampa	62.07	51.99	59.31	57.79	43.92	13.87	31.6%
89525 - West Palm Beach	60.17	65.75	65.12	63.68	60.76	2.92	4.8%
Total:	2532.86	2536.47	2558.16	539.4967	490.91	48.59	9.9%

Table 8 following presents the rainfall totals, durations and maximum intensities that were sampled during the course of the study. The table lists the total event rainfalls and durations, and the rainfalls and durations for the sampling portion of the events.

Table 8 - Event Rainfall Characteristics

	Event Total Rainfall (inches)	Event Rainfall Duration (hours)	5-Minute Maximum Intensity (inches/hour)	Sampled Total Rainfall (inches)	Sampled Rainfall Duration (hours)
Maximum	4.40	14.25	6.96	2.80	11.0
90th Percentile	1.62	10.16	3.72	1.19	7.4
Upper Quartile	1.17	7.55	2.58	.83	3.99
Median	.76	3.7	1.56	.5	1.62
Lower Quartile	.48	1.44	.84	.22	.43
Minimum	.11	.15	.12	.01	.03

The variety of storms includes events up to the 5-year recurrence interval in totals and intensities. Storms sampled include those associated with frontal systems and the more common convective activity. The range of events actually sampled compares nicely with the precipitation characteristics evaluated during the sampling design phase.

4.B Constituents of Concern

The table following illustrate which metal constituents exceed the Class III fresh water quality standards at the typical receiving water hardnesses of 100 mg/L to 130 mg/L $CaCO_3$. The table is presented in three ways, illustrating the combination of all sites, the pavement runoff sites only and the BMP sites only. BMP site data exclude those events that did not produce flows, since by definition they have 100% load reduction. Copper and lead are seen as the primary constituents to focus on, with cadmium and zinc possible but lesser likelihood of exceeding standards.

Total Phosphorus, Total Nitrogen and Total Suspended Solids do not have numerically defined standards. However, as evident in the EMC data in the following section, they are generally very low on the airside and would rarely, if ever, be a concern. Total Recoverable Petroleum Hydrocarbons also lack direct numerical standards, although the related Oils and Greases standard is defined as 0.5 mg/L. Inspection of the EMC data in the following section show these would likely be problematic only for terminal facilities.

Table 9 - Constituents Compared with Standards

Summary for All Monitoring Sites

Constituent	Number of Samples Analyzed	No. of Samples Exceeding Method Detection Limit	Exceedance Frequency in %	No. of Samples Exceeding Standard at 130 mg/L Hardness	Exceedance Frequency in %	No. of Samples Exceeding Standard at 100 mg/L Hardness	Exceedance Frequency in%
Lead	302	243	80	141	47	186	62
Copper	302	249	82	136	45	158	52
Cadmium	302	138	46	52	17	72	24
Zinc	302	280	93	31	10	35	12
Chromium, total	302	151	50	0	0	0	0
Arsenic	296	68	23	0	0	0	0
Nickel	302	54	18	0	0	0	0
Mercury *	302	50	17	302	100	302	100

*Note: Typical MDL for mercury is 0.000014 mg/L compared to a standard of 0.000012 mg/L.

Summary for Characterization Monitoring Sites Only

Constituent	Number of Samples Analyzed	No. of Samples Exceeding Method Detection Limit	Exceedance Frequency in %	No. of Samples Exceeding Standard at 130 mg/L Hardness	Exceedance Frequency in %	No. of Samples Exceeding Standard at 100 mg/L Hardness	Exceedance Frequency in%
Lead	219	181	83	115	53	148	68
Copper	219	190	87	106	48	123	56
Cadmium	219	105	48	42	19	58	26
Zinc	219	205	94	31	14	35	16
Chromium, total	219	122	56	0	0	0	0
Arsenic	217	49	23	0	0	0	0
Nickel	219	45	21	0	0	0	0
Mercury *	219	34	16	219	100	219	100

Summary for BMP Monitoring Sites Only

Constituent	Number of Samples Analyzed	No. of Samples Exceeding Method Detection Limit	Exceedance Frequency in %	No. of Samples Exceeding Standard at 130 mg/L Hardness	Exceedance Frequency in %	No. of Samples Exceeding Standard at 100 mg/L Hardness	Exceedance Frequency in%
Lead	83	62	75	26	31	38	46
Copper	83	59	71	30	36	35	42
Cadmium	83	33	40	10	12	14	17
Zinc	83	75	90	0	0	0	0
Chromium, total	83	29	35	0	0	0	0
Arsenic	79	19	24	0	0	0	0
Nickel	83	9	11	0	0	0	0
Mercury *	83	16	19	83	100	83	100

Table 10 - Event Mean Concentration Results

Constituent EMC Concentration [antilog(mean log10(C)], mg/L											
Airside Type	Copper	Lead	Zinc	Cadmium	Hardness	TRPH	Total Phosphorus	Total Nitrogen	TKN	NOX	TSS
Apron, GA	0.006	0.010	0.039	0.001	21	0.286	0.051	0.335	0.141	0.200	7.2
Apron, Terminal	0.020	0.004	0.055	0.001	13	0.566	0.057	0.398	0.184	0.206	5.2
Apron, T-Hangar	0.006	0.015	0.218	0.001	143	0.364	1.836	0.551	0.068	0.405	24.4
Apron, Air Cargo	0.008	0.004	0.048	0.001	14	0.421	0.053	0.259	0.150	0.118	4.4
Runway, GA	0.005	0.005	0.017	0.001	17	0.257	0.081	0.365	0.116	0.232	7.2
Runway, Air Carrier	0.024	0.003	0.065	0.001	23	0.269	0.049	0.401	0.165	0.191	9.7
Taxiway, Air Carrier	0.014	0.005	0.022	0.000	35	0.325	0.115	0.569	0.116	0.390	24.4
BMP, OF	0.009	0.002	0.021	0.000	19	0.287	0.089	0.436	0.110	0.310	6.7
Mode of Method Detection Limits	0.002	0.002	0.005	0.0004	1.0	0.200	0.050	0.050	0.050	0.050	2.0

4.C Event Mean Concentration

The Event Mean Concentrations (EMC) for either constituents of concern or those that will be needed for load matching calculations are presented in Table 10 on the preceding page. The summary statistics are included in Appendix C.

Results are consistent with expectations given the use characteristics on the airport airside. Lead is highest on the General Aviation and T-hangar Aprons where there is a ready source in the 100 octane, low-lead fuels used by the majority of the aircraft found on them. Taxiways and GA runways show slight lead elevations that probably reflect a combination of the overflow vent fuel losses in small aircraft, and an increase that may be due to the pavement material itself based on literature review. Copper is higher in the locations where heavier aircraft are braking more frequently.

TRPH is highest where fueling activities are greatest, although still low. Total Suspended Solids are generally low.

Nitrogen and Phosphorus are both low reflecting the lack of nutrient production and use on the airside. The T-hangar apron in is anomalous for both these materials, and may reflect some non-aviation related activity by tenants.

4.D Best Management Practice Effectiveness

4.D.1 Concentration Efficiency

Table 11 presents the concentration reduction efficiency for overland flow, oil-water separator and wet swale flow for constituents of concern. The table includes the number of samples available for analysis for each included BMP. Although other BMPs were tested in the study, the number of samples for these was insufficient for any inference. The data reduction summaries used for the table are included in Appendix D.

Table 11 – Concentration Efficiency

	Sample Number n	TSS	TRPH	TP	TN	Cd	Cu	Pb	Zn
Overland Flow	44-47	47%	8%	-4%	-50%	39%	36%	40%	67%
Oil / Water	9-10	-18%	12%	-1%	-148%	27%	34%	-4%	37%
Wet Swale	7-9	19%	10%	0%	8%	0%	53%	12%	56%

Negative values indicate a concentration increase

Several cautions are appropriate in interpreting the concentration data. Some samples were very small (one 220 ml aliquot) as a result of very low runoff after overland flow. Note that concentration reduction considers only those events that had measurable flow at the BMP as described in Section 3B. The load reductions in the following sections reflect 100% infiltration events; the concentration reductions do not. Also, in many cases, EMCs are near or below the detection limit, and the concentration reduction percentages reflect this. Review of data in Appendix D is advised.

Nutrient concentrations apparently increase as a result of overland flow. This result is consistent with that reported in the literature but may also have been influenced by the sampling method. Trench drains installed at grade within grassed infield areas at offsets from paved surfaces, such as the drain shown in Figure 7, accumulate sediment and organic detritus which drops directly into the drains and is subsequently flushed from the drain during a storm event. Higher concentrations of total phosphorus and total nitrogen are likely associated with organic forms of these elements as the concentrations of Total Kjeldahl Nitrogen (TKN) suggest. Load reduction for these is primarily from infiltration.

The data support a concentration reduction for total suspended solids, metals and petroleum hydrocarbons as a result of overland flow or wet swale flow. The oil-water separator reduced petroleum hydrocarbons and most metals, although suspended solids and lead both showed slight concentration increases when leaving the separator. This result in the oil-water separator may reflect a periodic flushing of accumulated sediments during rain events. The effectiveness of the oil-water separator is also influenced by maintenance programs. Results should be reviewed considering these factors.

Generally higher inflow concentrations show greater concentration reduction as a percentage based on inspection of the information in Appendix D. Also, with overland flow, "heavier" soils (Hydrologic Groups B and C) with higher silt or organic content appear to reduce concentrations more than sandy soils.

Speculatively, load reduction for metals in sandy soils may be primarily a function of infiltration based on this observation, although some filtration and biotic action from grasses, and minor isomorphous substitution of cations may occur. In the soils with higher organic, silt or clay content, metals may remove by particulate entrapment, adsorption, minor infiltration, pH change and similar. Mechanisms for hydrocarbon reductions are both abiotic and biotic.

4.D.2 Loads and Load Reduction

Florida Administrative Code 62-40 *Water Resource Implementation Rule* requires 80% to 95% load reduction for those pollutants that would cause or contribute to violations of state water quality. More importantly, issues of load matching and a projected change of Florida water policy to no net load increase from projects requires evaluation of load reduction efficiencies. Table 12 presents the load reduction efficiency for overland flow for constituents of concern. The oil-water separator and wet swale flow load reductions are essentially the concentration reductions only, since inflow and outflow volumes approach equality over time in these systems. The table includes the number of samples available for analysis. Events with 100% infiltration are included in the analysis as 100% load reduction, increasing the available samples in the study. The data reduction summaries used for the table are included in Appendix D. The same cautions as for concentration apply.

Table 12 - Overland Flow Load Reduction

Constituent	Reduction
Total Suspended Solids	65%
Total Recoverable Petroleum Hydrocarbons	52%
Total Phosphorus	21%
Total Nitrogen	41%
Total Kjeldahl Nitrogen	4%
Nitrate and Nitrite	63%
Cadmium	63%
Copper	68%
Lead	67%
Zinc	88%

Metal loads are reduced from 63% to 88% by overland flow on average, with a range of 45% to 94% for individual sites and parameters. Total Recoverable Petroleum Hydrocarbons are reduced 52% on average, within the same distance.

Consistent with the SWFWMD findings on the Low Impact Parking Lot Design project, nutrients show the least reduction in load. As discussed in Section 4.D.1 Concentration Efficiency, the load reduction calculated for certain constituents associated with particulate organic matter is influenced by the sampling method. Trench drains installed at offsets from paved surfaces accumulate sediment and organic detritus. The higher concentrations of total phosphorus and total nitrogen are likely associated with organic forms of these elements as the concentrations of total Kjeldahl nitrogen (TKN) suggest. The load reduction determined for nitrite + nitrate nitrogen, which is typically found in solution, is a better indicator of load reduction associated with readily transportable nutrients.

The primary components of load reduction are concentration reduction and runoff volume reduction. For overland flow both occur, with organic, clay and silts demonstrating higher concentration reduction and sand demonstrating higher infiltration. Infiltration was field verified by direct observation during rainfall events. That is, observation verified that flows were infiltrating and that runoff was not bypassing the collection systems. The actual, average overland flow distances before runway and taxiway runoffs are collected or channelized are generally much in excess of 25 to 50 feet used in the study due to FAA grading and safety concerns. Additional load reduction is likely in the extended distances. However, data from the Orlando International Airport sites suggest this is not a linear improvement. Rather, they imply the reduction, excepting that due solely to infiltration, occurs in the first 25 feet of overland flow.

4.D.3 First Flush Effects

Figures 12a through 12i depict the results of the first flush evaluation described in Section 3B. Three constituents, Total Suspended Solids, Lead and the Nitrogen series of nutrients, show a first flush effect with a power function describing the concentration as a function of rainfall. All of the other constituents of interest are best described by a logarithmic function, if any correlation exists. These are probably best characterized as an average concentration throughout the event.

Figure 12a

TSS Pollutagraph

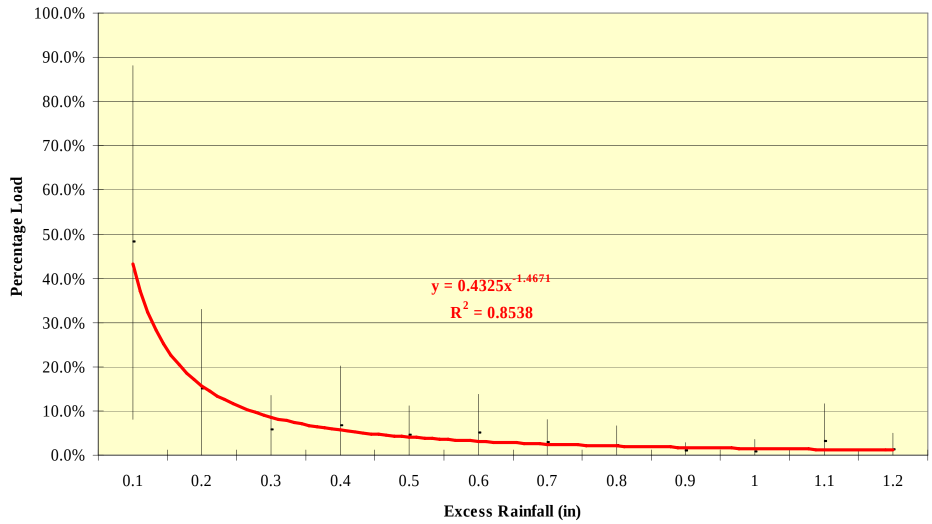


Figure 12b

TRPH Pollutagraph

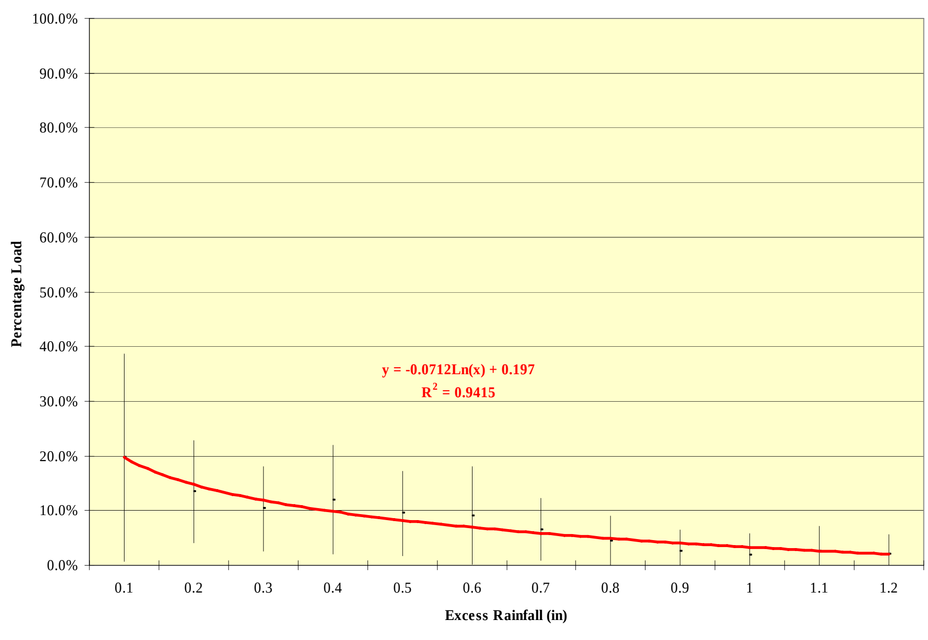


Figure 12c

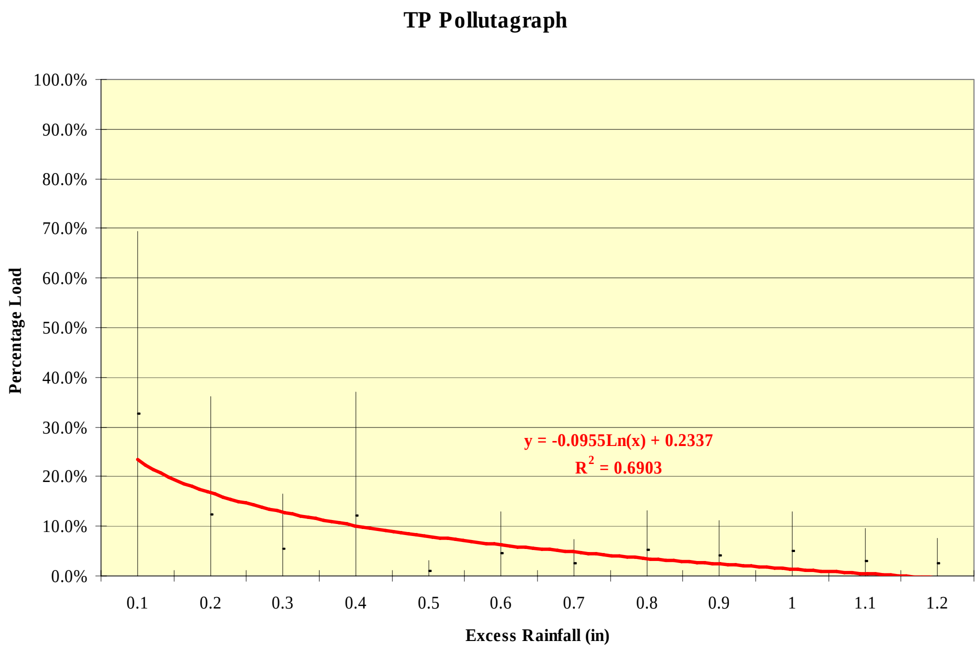


Figure 12d

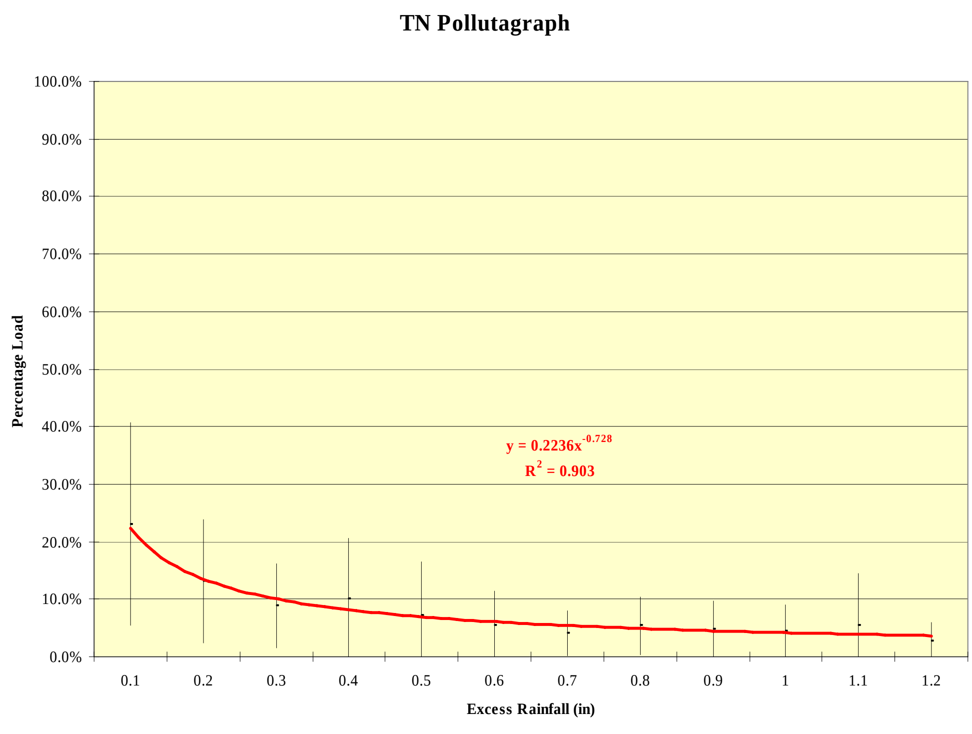


Figure 12e

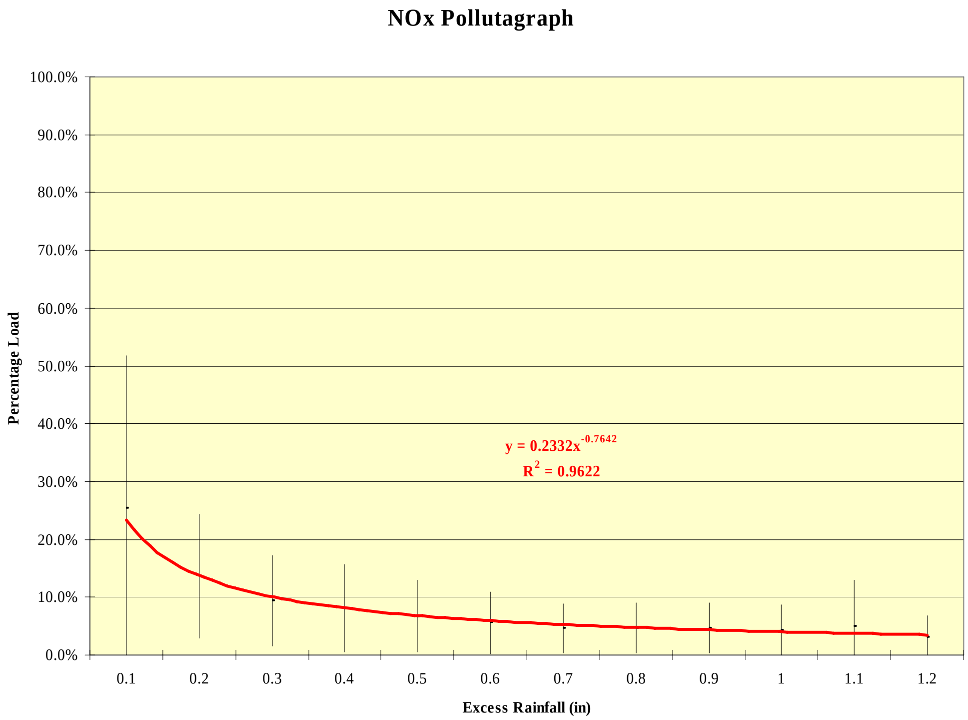


Figure 12f

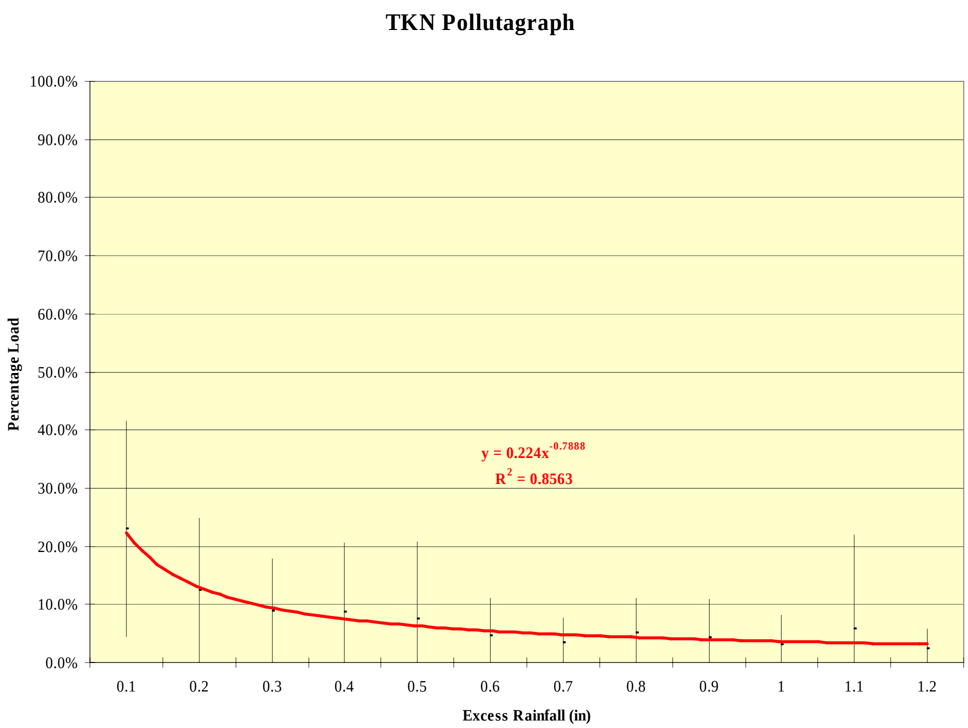


Figure 12g

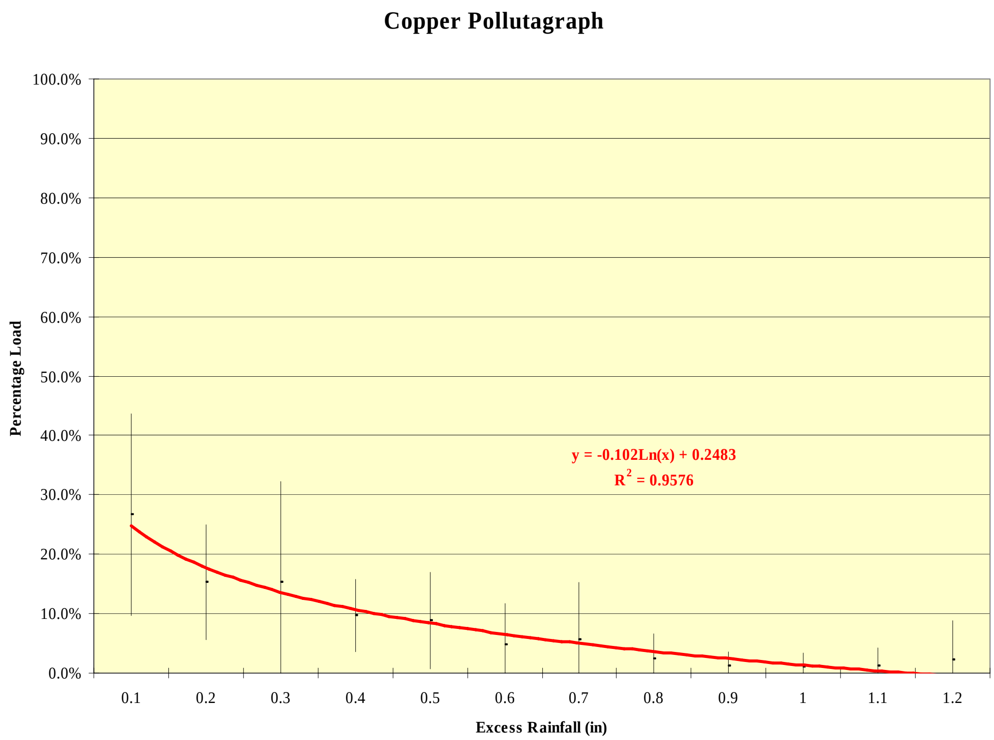


Figure 12h

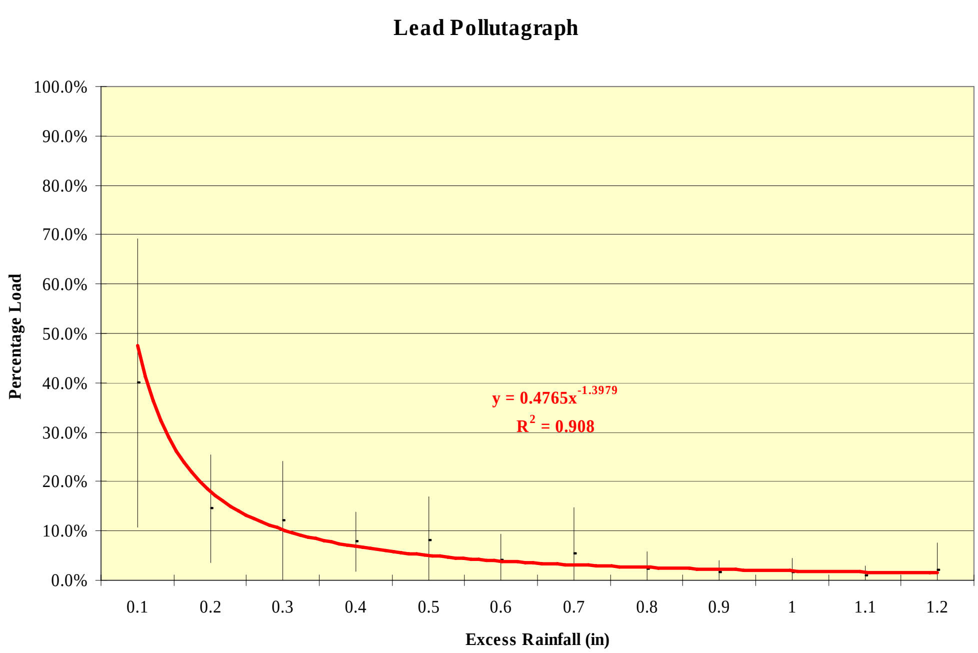
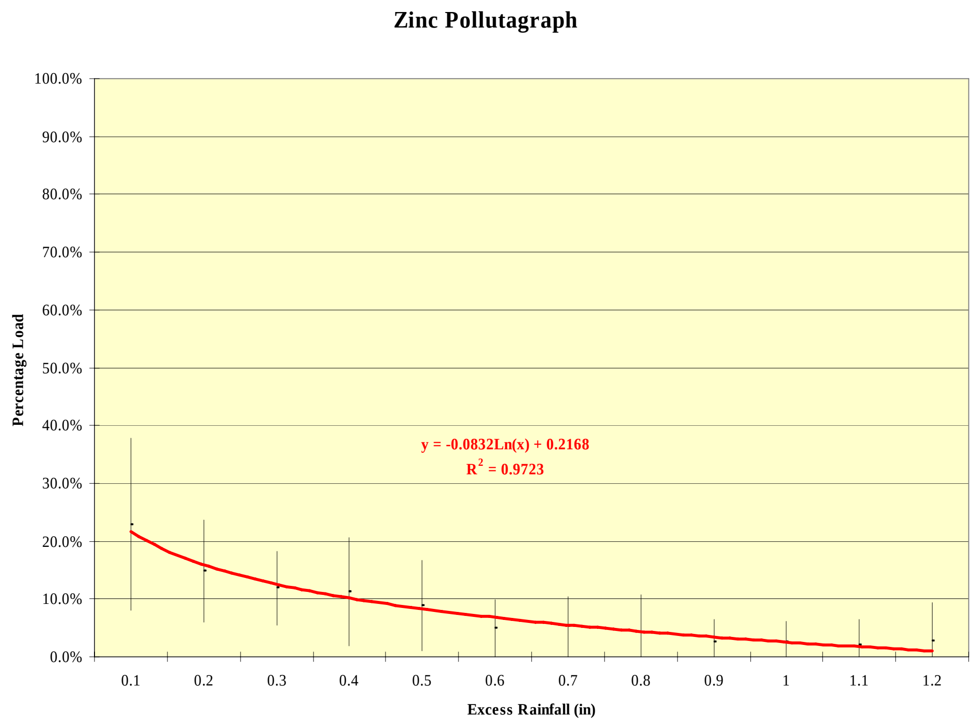


Figure 12i



4.D.4 Polycyclic Aromatic Hydrocarbons (PAH)

Samples of the upper 1-inch of soils were taken at the various sampling stations and tested for Chlorinated Pesticides and Polycyclic Aromatic Hydrocarbons (PAH). Except at Charlotte County Airport (PGD), and Sarasota Bradenton International Airport sites SRQ-7 and SRQ-8, the sample sites have had continuous usage for more than 10 years. In some cases the use has been continuous for over 50 years. Table 13 presents the results as a summary of the samples where specific compounds were detected.

Chlorinated Pesticides were detected only 9 times out of over 800 tests, none of which were collected at BMP sites.

Select PAHs were detected frequently adjacent to the pavements. This is an expected result given the compound sources described in Table 13. The detection frequency declines significantly with overland flow, as do concentration levels. Areas with higher water tables or less permeable soils are most likely to exhibit some migration of the material. Areas with higher infiltration rates exhibit minimal or no overland flow movement of the material over an extended period, 50 years in the case of Sarasota Bradenton International site SRQ-2.

The baffled outlet/sediment box serving as part of the treatment train at Charlotte County Airport had more PAH compounds detected than any other location. This was followed by the outlet area of the Oil-Water Separator at Tallahassee Regional Airport. Both receive direct runoff from the apron areas.

Table 13 – Soil Testing Results

	No. of Samples*	Analytical Method	Median of MDL for undiluted samples, ug/kg	No. of Samples Exceeding MDL	MDL Exceedance Frequency	No. of Samples from BMP sites Exceeding MDL	MDL Exceedance Frequency	BMP type (and sites) associated with exceedance
Chlorinated Pesticides:								
4,4`-DDE	42	SW8081A	3.4	2	4.8%	0	0.0%	
Endrin Aldehyde	42	SW8081A	8.5	2	4.8%	0	0.0%	
Methoxychlor	42	SW8081A	9.8	2	4.8%	0	0.0%	
4,4`-DDT	42	SW8081A	14	1	2.4%	0	0.0%	
Chlordane	42	SW8081A	170	1	2.4%	0	0.0%	
Endosulfan II	42	SW8081A	5.1	1	2.4%	0	0.0%	
4,4`-DDD	42	SW8081A	3.7	0	0.0%	0	0.0%	
Aldrin	42	SW8081A	5.3	0	0.0%	0	0.0%	
Alpha-BHC	42	SW8081A	9.4	0	0.0%	0	0.0%	
Beta-BHC	42	SW8081A	7.1	0	0.0%	0	0.0%	
Delta-BHC	42	SW8081A	7.5	0	0.0%	0	0.0%	
Dieldrin	42	SW8081A	4.7	0	0.0%	0	0.0%	
Endosulfan I	42	SW8081A	4.0	0	0.0%	0	0.0%	
Endosulfan Sulfate	42	SW8081A	7.8	0	0.0%	0	0.0%	

	No. of Samples*	Analytical Method	Median of MDL for undiluted samples, ug/kg	No. of Samples Exceeding MDL	MDL Exceedance Frequency	No. of Samples from BMP sites Exceeding MDL	MDL Exceedance Frequency	BMP type (and sites) associated with exceedance
Endrin	42	SW8081A	5.2	0	0.0%	0	0.0%	
Gamma-BHC (Lindane)	42	SW8081A	8.1	0	0.0%	0	0.0%	
Heptachlor	42	SW8081A	12	0	0.0%	0	0.0%	
Heptachlor Epoxide	42	SW8081A	4.3	0	0.0%	0	0.0%	
Toxaphene	42	SW8081A	190	0	0.0%	0	0.0%	
Polycyclic Aromatic Hydrocarbons (PAHs):								
Chrysene	42	SW8270C-SIM	25	28	66.7%	6	14.3%	Overland Flow (MCO2, MCO3, SGJ4, TPA2); Sediment Box (PGD2); Soil near OWS Outfall (TLH3)
Fluoranthene	42	SW8270C-SIM	135	26	61.9%	5	11.9%	Overland Flow (MCO2, MCO3, TPA2); Sediment Box (PGD2); Soil near OWS Outfall (TLH3)
Pyrene	42	SW8270C-SIM	125	26	61.9%	5	11.9%	Overland Flow (MCO2, MCO3, SGJ4); Sediment Box (PGD2); Soil near OWS outfall (TLH3)
Benzo(b)fluoranthene	42	SW8270C-SIM	84.5	25	59.5%	5	11.9%	Overland Flow (MCO2, MCO3, SGJ4); Sediment Box (PGD2); Soil near OWS outfall (TLH3)
Benzo(k)fluoranthene	42	SW8270C-SIM	98	22	52.4%	3	7.1%	Overland Flow (MCO3); Sediment Box (PGD2); Soil near OWS outfall (TLH3)
Benzo(a)anthracene	42	SW8270C-SIM	70.5	20	47.6%	3	7.1%	Overland Flow (MCO2); Sediment Box (PGD2); Soil near OWS outfall (TLH3)

	No. of Samples*	Analytical Method	Median of MDL for undiluted samples, ug/kg	No. of Samples Exceeding MDL	MDL Exceedance Frequency	No. of Samples from BMP sites Exceeding MDL	MDL Exceedance Frequency	BMP type (and sites) associated with exceedance
Benzo(g,h,i)perylene	42	SW8270C-SIM	91	20	47.6%	3	7.1%	Overland Flow (MCO3); Sediment Box (PGD2); Soil near OWS outfall (TLH3)
Indeno(1,2,3-cd)pyrene	42	SW8270C-SIM	65	19	45.2%	2	4.8%	Sediment Box (PD2); Soil near OWS outfall (TLH3)
Benzo(a)pyrene	42	SW8270C-SIM	79.5	18	42.9%	2	4.8%	Sediment Box (PD2); Soil near OWS outfall (TLH3)
Phenanthrene	42	SW8270C-SIM	135	18	42.9%	2	4.8%	Sediment Box (PD2); Soil near OWS outfall (TLH3)
Dibenz(a,h)anthracene	42	SW8270C-SIM	72	12	28.6%	1	2.4%	Sediment Box (PD2)
Anthracene	42	SW8270C-SIM	97	10	23.8%	1	2.4%	Sediment Box (PD2)
Fluorene	42	SW8270C-SIM	106	6	14.3%	0	0.0%	
Acenaphthene	42	SW8270C-SIM	104	5	11.9%	1	2.4%	Sediment Box (PD2)
Acenaphthylene	42	SW8270C-SIM	98	5	11.9%	0	0.0%	
Naphthalene	42	SW8270C-SIM	153	2	4.8%	0	0.0%	
1-Methylnaphthalene	42	SW8270C-SIM	112	1	2.4%	0	0.0%	
2-Methylnaphthalene	42	SW8270C-SIM	126	1	2.4%	0	0.0%	

Summary of sources associated with more frequently detected compounds.
The Risk Assessment Information System http://risk.lsd.ornl.gov/tox/profiles/chrysene_ragsa.shtml

Chrysene	Environmental manmade sources of chrysene include gasoline, diesel, and aircraft turbine exhausts; coal combustion and gasification; emissions from coke ovens, wood burning stoves, and waste incineration; and various industrial applications such as iron, aluminum, and steel production.
Flouranthene	Fluoranthene is a constituent of coal tar and petroleum-derived asphalt.
Benzo[b]fluoranthene	Benzo[b]fluoranthene is virtually insoluble in water and is slightly soluble in benzene and acetone. There is no commercial production or known use of this compound. Benzo[b]fluoranthene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion.
Pyrene	Pyrene is common in the environment as a product of incomplete combustion and has been identified in water, food, and in the air.
Benzo[a]anthracene	Benzo[a]anthracene is found in various kinds of smoke and flue gases, tobacco smoke, automobile exhaust, roasted coffee and in charcoal broiled, barbecued or smoked meats. It is an atmospheric contaminant near power plants and busy highways, and tends to bind to particulate matter in the atmosphere.
Benzo[k]fluoranthene	Benzo[k]fluoranthene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion.
Benzo(g,h,i)perylene	Benzo(g,h,i)perylene occurs naturally in crude oils and is present ubiquitously in products of incomplete combustion and in coal tar.
Benzo(a)pyrene	Benzo(a)pyrene occurs ubiquitously in products of incomplete combustion and in fossil fuels.
Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion.
Phenanthrene	Phenanthrene is present in products of incomplete combustion Some of the known sources of phenanthrene in the atmosphere are vehicular emissions, coal and oil burning, wood combustion, coke plants, aluminum plants, iron and steel works, foundries, municipal incinerators, synfuel plants, and oil shale plants.
Dibenz(a,h)anthracene	Dibenz(a,h)anthracene occurs as a component of coal tars, shale oils, and soot and has been detected in gasoline engine exhaust, coke oven emissions, cigarette smoke, charcoal broiled meats, vegetation near heavily traveled roads.
Anthracene	Anthracene is ubiquitous in the environment as a product of incomplete combustion of fossil fuels. It has been identified in surface and drinking water, ambient air, exhaust emissions from internal combustion engines, smoke of cigarettes and cigars, and in smoked foods and edible aquatic organisms.
Fluorene	Fluorene is a major component of fossil fuels and their derivatives and is also a byproduct of coal-conversion and energy-related industries. It is commonly found in vehicle exhaust emissions, crude oils, motor oils, coal and oil combustion products, waste incineration, and industrial effluents.
Acenaphthylene	Acenaphthene occurs in coal tar produced during the high temperature carbonization or coking of coal. It is used as a dye intermediate in the manufacture of some plastics and as an insecticide and fungicide. Acenaphthene is an environmental pollutant and has been detected in cigarette smoke, automobile exhausts, and urban air.

SECTION 5 – CONCLUSIONS

1. Data collected from airside monitoring during a period of 3 years and 4 months adequately addressed the sampling system design objectives developed for the FAA / FDOT joint funded Statewide Airport Stormwater Study with input from a guidance committee comprised of representatives from the Florida Department of Environmental Protection and Water Management Districts.
2. With the exception of a steep-sided wet-detention system designed per FAA guidelines, sufficient data were collected to characterize the effectiveness of other Best Management Practices, particularly overland flow and to a lesser extent, the effectiveness of an oil-water separator, dry detention system, sediment catch basin, and vegetated swale.
3. Airport airside pavement introduces only a minimal number of elements in concentrations that could be considered pollutants into surface water runoff. Chief among these are the metals copper, lead, cadmium and zinc in declining order of frequency detected.
4. Nutrients are generally very low in airside stormwater runoff, approaching values of natural systems. Load reduction is basically an exercise of runoff volume matching to the maximum extent practicable for these constituents.
5. Petroleum hydrocarbons are typically present at low concentrations in airside stormwater runoff, although discrete pollutagraph sampling characterized several events when runoff from aprons reflected small volumes of spilled petroleum products. The concentrations are slightly reduced by specialty structures and baffles. Source control, minimizing introduction of petroleum products, is likely the best means of control or improvement.
6. Total Suspended Solids, nitrogen compounds and lead exhibited the only pronounced "first flush" characteristics among other study constituents.
7. Overland flow is an effective method of concentration and load reduction for metals. Concentration reduction is more pronounced in soils with higher organic, silt or clay content, such as NRCS Hydrologic Group B and C soils. Load reduction by infiltration is the primary mechanism in sandier, well drained soils represented by NRCS Hydrologic Groups A and B.
8. Load and concentration reduction percentages are mostly higher when initial concentrations are elevated. This does not mean the reduction effectiveness is higher at high concentrations. Rather, when inflow and outflow values for many constituents are near or below the detection level for a significant number of events, the relative reduction in concentration cannot be adequately quantified. Probable reductions are greater than reported in this document. Of course, when concentrations are very low, the likelihood of the constituent exceeding a standard is reduced.
9. Overland flow is compatible with safe airport operations and with water quality management. This should become the primary water management technique for runways and taxiways. Aprons, because of the volume of runoff generated from their increased area and design geometry, will likely require other water management features. However, overland flow can be part of the treatment train even for aprons.
10. The Event Mean Concentrations determined by this project are usable for load reduction and load matching calculations for airside water management design. This is the recommended use of the data obtained from this study. Continuous simulation or annualized load calculations in a pre- and post-development condition are the recommended approach.

APPENDIX A

REFERENCES

REFERENCES

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APPENDIX B

SAMPLE PRESERVATION STUDY

Statewide Airport Stormwater Study
Evaluation of Preservation Timing
Performed by Ed Barber & Associates for MEA Group, Inc.

Purpose: Evaluate what influence the timing of sample preservation might have on analytical results.
Nutrients were not tested because protocol called for autosampler containers to be pre-preserved with sulfuric acid.
Continuous on-site chilling of autosamplers was not feasible.

Methodology: Collect a large-volume sample of runoff from a study site.
Split sample into 9 sub-samples.
Preserve 3 sub-samples immediately; store remaining unpreserved samples at room temperature.
After 12 hours, preserve another 3 sub-samples; store remaining un-preserved samples at room temperature.
After 24 hours, preserve the last 3 sub-samples.
Submit all sub-samples for analysis.

Approach: Three recently emptied 5-gallon, plastic jugs of commercial drinking water were rinsed with DI water, air dried, and capped with cellophane and aluminum foil.
On 4/3/02 EBA staff used a 1-liter glass sampling container to collect samples of runoff during rainfall from the H-flume at site SRQ6, the apron at Dolphin Aviation on Sarasota Airport.
Successive 1-liter collections of runoff were emptied into alternating jugs.
Sampling continued for about 15 minutes until each jug was filled with about 3 gallons of water.

Returned to office with bulk samples.
Bulk samples were further composited by pouring contents of one jug into the others.
Contents of jugs were poured into 9 set of samples containers. Each set consisted of two 0.5-liter, plastic containers for analysis of metals and physical parameters, and one 1-liter, glass bottle for TRPH.
Nine sample sets were divide into 3 groups labeled A, B, and C.

One set of samples was removed from each group and immediately preserved as follows:
Nitric acid was added to the samples designated for metals analysis.
Sulfuric acid was added to the bottles designated for TRPH analysis.
Nothing was added to the bottles designated for physical parameters (TSS, pH, conductivity) analysis.
All bottles in set were capped, labeled, and placed in cooler on ice.
Remaining sets of samples in groups A, B and C were kept in coolers at room temperature.

12-hours later a second set of samples was removed from groups A, B, and C; and preceding steps were repeated.

The preceding steps were repeated using the remaining sample sets 12 hours later (I.e. 24 hours subsequent to start).

Chain-of-Custody forms were completed and samples were submitted to laboratory for analysis with the following sample IDs.

	Group A	Group B	Group C
Immediate Preservation	SRQ6-IA	SRQ6-IB	SRQ6-IC
Preservation 12 hours after collection	SRQ6-12A	SRQ6-12B	SRQ6-12C
Preservation 24 hours after collection	SRQ6-24A	SRQ6-24B	SRQ6-24C

Findings: Of the study metals, only copper, lead, zinc were detected.
Friedman nonparametric test for statistical difference in median concentrations was calculated for select parameters.
In all cases, at a 5% significance level, the null hypothesis that the medians of the 3 treatment times are similar could not be rejected.

Worksheet to format data for analysis of Friedman's nonparametric test for statistical difference in the medians of multiple populations.

Ho: Null Hypothesis: There is no tendency for one population to have larger or smaller values than any other of the k populations.

Ha: Alternative Hypothesis: At least one population tends to have larger values than one or more of the other populations.

Test statistic is the Friedman test statistic F
Significance of results indicated by the p-value which is the probability of obtaining the test statistic, or one even less likely, when the null hypothesis is true. The p-value is the significance level attained by the data.
The lower the p-value, the stronger the case against the null hypothesis.

Application to preservation study:
Populations are the Immediate, 12-hour, and 24-hour preservations.
Repeated samples are groups A, B, and C

	Zinc Concentration (mg/L)		
Group	I	12	24
A	0.094	0.091	0.093
B	0.092	0.093	0.092
C	0.094	0.100	0.092

Friedman "F" 1.27 p-level 0.529

	TRPH Concentration (mg/L)		
Group	I	12	24
A	900	940	730
B	840	1100	800
C	930	1000	950

Friedman "F" 4.67 p-level 0.097

	Copper Concentration (mg/L)		
Group	I	12	24
A	0.012	0.012	0.012
B	0.011	0.011	0.011
C	0.012	0.011	0.011

Friedman "F" 2.00 p-level 0.368

	Lead Concentration (mg/L)		
Group	I	12	24
A	0.096	0.090	0.094
B	0.096	0.095	0.094
C	0.096	0.093	0.094

Friedman "F" 4.67 p-level 0.097

	TSS Concentration (mg/L)		
Group	I	12	24
A	11.0	11.0	13.0
B	10.0	11.0	11.0
C	10.0	9.5	12.0

Friedman "F" 3.80 p-level 0.150

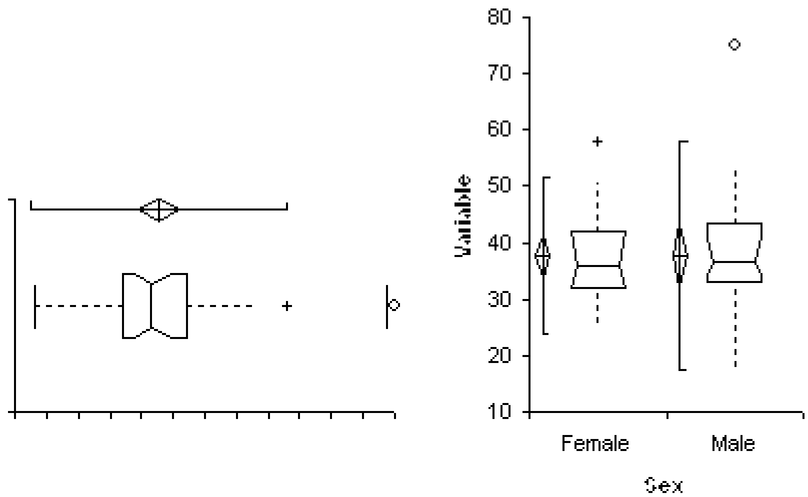
APPENDIX C

EMC SUMMARY STATISTICS

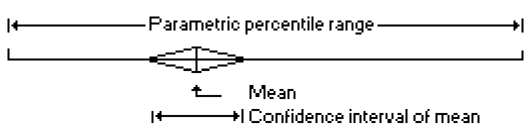
Box-Whisker plots

See also: Normality Test, Frequency histogram.

Box-plots graphically show the **central location** and **scatter/dispersion** of the observations of a sample(s). Single continuous descriptives shows a single horizontal box-plot for the sample. Comparative descriptives shows vertical box-plots for each sample, side-by-side for comparison.

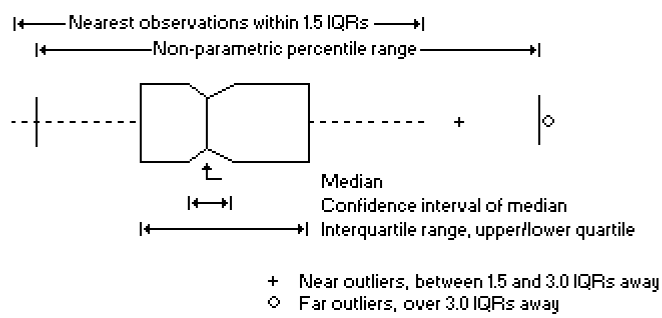


The blue line series shows **parametric statistics:**



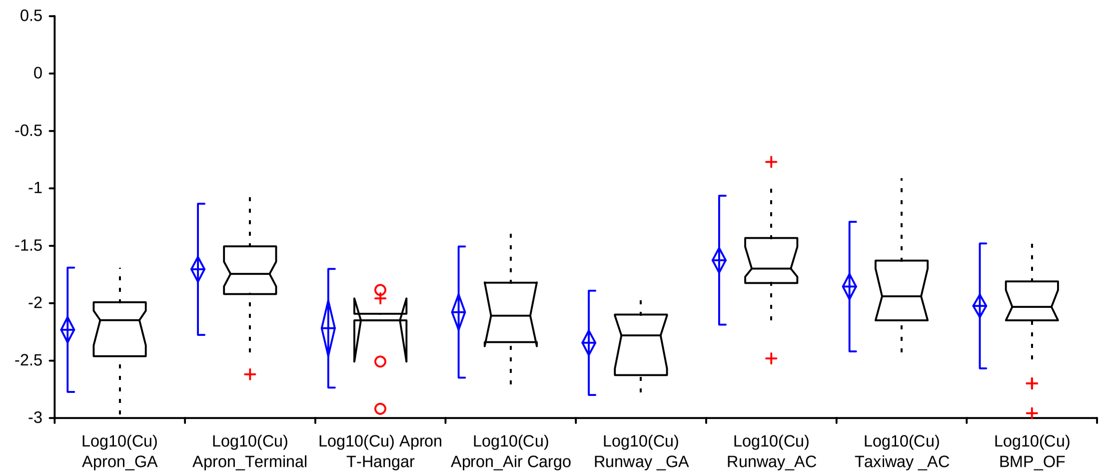
- the blue diamond shows the **mean** and the requested **confidence interval around the mean**.
- the blue notched lines show the requested **parametric percentile range**.

The notched box and whiskers show **non-parametric statistics**:



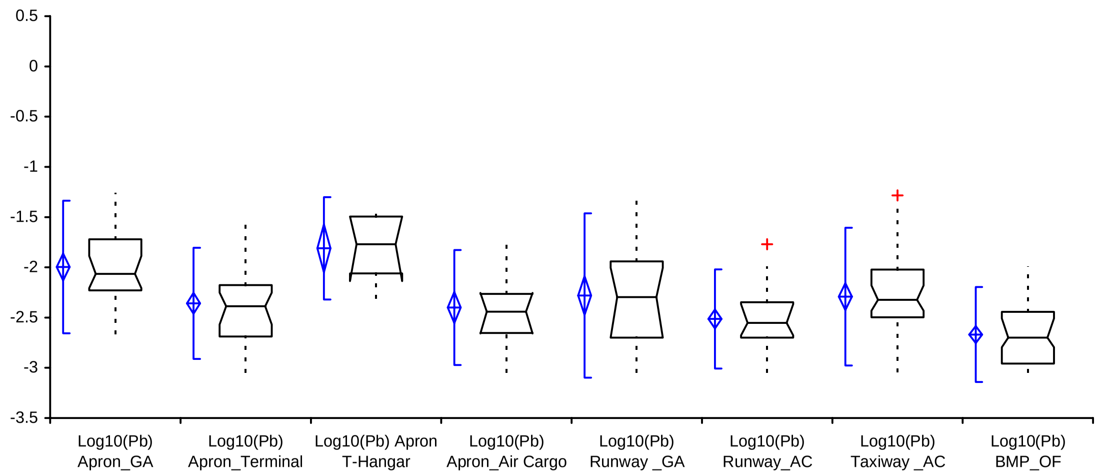
- the notched box shows the **median**, lower and upper **quartiles**, and **confidence interval around the median**.
- the dotted-line connects the **nearest observations within 1.5 IQRs** (inter-quartile ranges) of the lower and upper quartiles.
- red crosses (+) and circles (o) indicate **possible outliers** - observations more than 1.5 IQRs (**near outliers**) and 3.0 IQRs (**far outliers**) from the quartiles.
- the blue vertical lines show the requested **non-parametric percentile range**.

Test	**Comparative descriptives**
Variables	Log10(Cu) Apron_GA, Log10(Cu) Apron_Terminal, Log10(Cu) Apron T-Hangar, Log10(Cu) Apron_Air Cargo, Log10(Cu) Runway _GA, Log10(Cu) Runw
Performed by	rdoctora **Date** 3 June 2005



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(Cu) Apron_GA	37	-2.23148	0.329109	0.054105	-2.34121 to -2.12175	-2.14798	0.47007	-2.36653 to -2.06550
Log10(Cu) Apron_Terminal	42	-1.70429	0.347287	0.053588	-1.81251 to -1.59607	-1.74473	0.41563	-1.85387 to -1.63827
Log10(Cu) Apron T-Hangar	9	-2.21784	0.314460	0.104820	-2.45956 to -1.97613	-2.14874	0.05723	-2.50864 to -1.95861
Log10(Cu) Apron_Air Cargo	22	-2.07764	0.347325	0.074050	-2.23164 to -1.92365	-2.10805	0.51733	-2.37503 to -1.81816
Log10(Cu) Runway _GA	28	-2.34479	0.275859	0.052132	-2.45176 to -2.23782	-2.27986	0.52801	-2.56864 to -2.10791
Log10(Cu) Runway_AC	41	-1.62570	0.341220	0.053290	-1.73340 to -1.51800	-1.69897	0.39211	-1.76955 to -1.50864
Log10(Cu) Taxiway _AC	40	-1.85537	0.342752	0.054194	-1.96498 to -1.74575	-1.93971	0.51951	-2.14874 to -1.69897
Log10(Cu) BMP_OF	47	-2.02342	0.330975	0.048278	-2.12060 to -1.92625	-2.03152	0.33885	-2.14874 to -1.88606
Converted C, mg/L:								
Cu Apron_GA		0.006						
Cu Apron_Terminal		0.020						
Cu Apron T-Hangar		0.006						
Cu Apron_Air Cargo		0.008						
Cu Runway _GA		0.005						
Cu Runway_AC		0.024						
Cu Taxiway _AC		0.014						
Cu BMP_OF		0.009						

Test	**Comparative descriptives**
Variables	Log10(Pb) Apron_GA, Log10(Pb) Apron_Terminal, Log10(Pb) Apron T-Hangar, Log10(Pb) Apron_Air Cargo, Log10(Pb) Runway _GA, Log10(Pb) Runwa
Performed by	rdoctora **Date** 3 June 2005

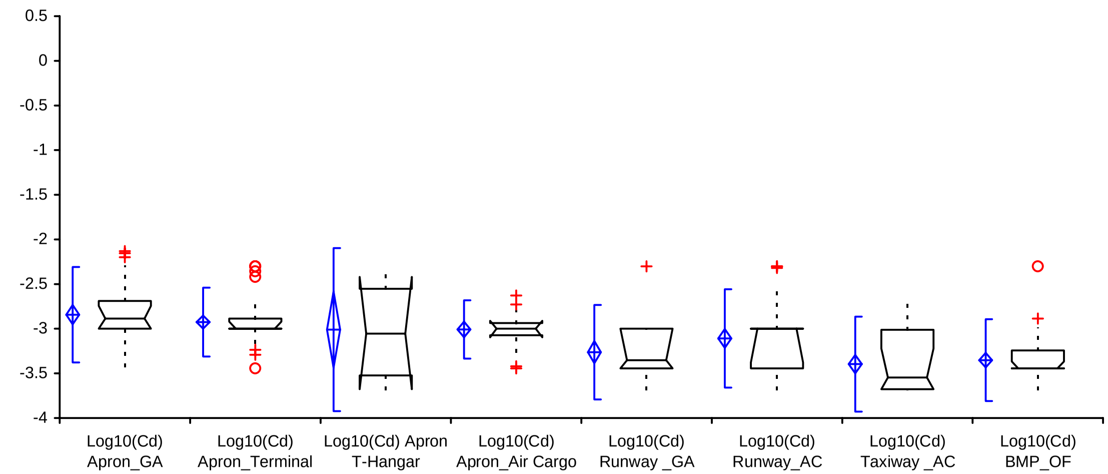


	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(Pb) Apron_GA	37	-1.99680	0.401628	0.066027	-2.13071 to -1.86289	-2.06550	0.50790	-2.20761 to -1.88606
Log10(Pb) Apron_Terminal	42	-2.35787	0.336250	0.051884	-2.46265 to -2.25309	-2.38773	0.51141	-2.56864 to -2.25181
Log10(Pb) Apron T-Hangar	9	-1.81073	0.309745	0.103248	-2.04882 to -1.57264	-1.76955	0.56563	-2.13668 to -1.49485
Log10(Pb) Apron_Air Cargo	22	-2.40023	0.347713	0.074133	-2.55440 to -2.24607	-2.44113	0.38826	-2.65758 to -2.25515
Log10(Pb) Runway _GA	28	-2.28026	0.497600	0.094037	-2.47321 to -2.08731	-2.29690	0.75836	-2.69897 to -2.00436
Log10(Pb) Runway_AC	41	-2.51348	0.299977	0.046849	-2.60817 to -2.41880	-2.55284	0.35218	-2.67778 to -2.36653
Log10(Pb) Taxiway _AC	40	-2.29177	0.416977	0.065930	-2.42512 to -2.15841	-2.32333	0.47507	-2.43180 to -2.18046
Log10(Pb) BMP_OF	47	-2.66915	0.287477	0.041933	-2.75356 to -2.58474	-2.69897	0.51491	-2.79588 to -2.50864

Converted C, mg/L:

Pb Apron_GA	0.010
Pb Apron_Terminal	0.004
Pb Apron T-Hangar	0.015
Pb Apron_Air Cargo	0.004
Pb Runway _GA	0.005
Pb Runway_AC	0.003
Pb Taxiway _AC	0.005
Pb BMP_OF	0.002

Test	**Comparative descriptives**
Variables	Log10(Cd) Apron_GA, Log10(Cd) Apron_Terminal, Log10(Cd) Apron T-Hangar, Log10(Cd) Apron_Air Cargo, Log10(Cd) Runway _GA, Log10(Cd) Runw
Performed by	rdoctora
Date	3 June 2005

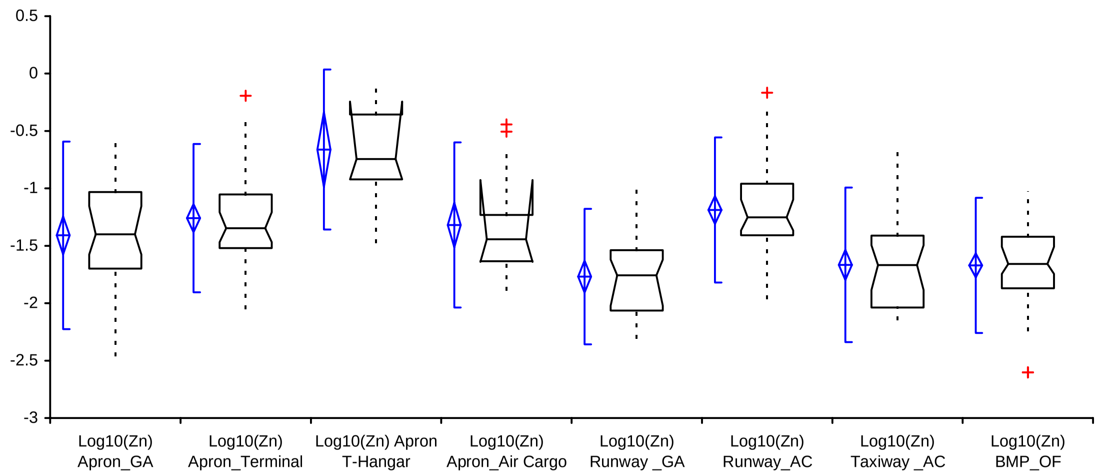


	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(Cd) Apron_GA	37	-2.84263	0.324927	0.053418	-2.95096 to -2.73429	-2.88606	0.31197	-3.00000 to -2.74473
Log10(Cd) Apron_Terminal	42	-2.92542	0.234491	0.036183	-2.99849 to -2.85235	-3.00000	0.11411	-3.00000 to -2.92082
Log10(Cd) Apron T-Hangar	9	-3.00965	0.555225	0.185075	-3.43643 to -2.58287	-3.05552	0.97004	-3.67778 to -2.42022
Log10(Cd) Apron_Air Cargo	22	-3.00851	0.198627	0.042347	-3.09658 to -2.92045	-3.00000	0.13749	-3.09691 to -2.91080
Log10(Cd) Runway _GA	28	-3.26263	0.321296	0.060719	-3.38721 to -3.13804	-3.35189	0.44370	-3.44370 to -3.00000
Log10(Cd) Runway_AC	41	-3.10796	0.334696	0.052271	-3.21360 to -3.00231	-3.00000	0.44370	-3.37675 to -3.00000
Log10(Cd) Taxiway _AC	40	-3.39605	0.323437	0.051140	-3.49949 to -3.29261	-3.54683	0.66513	-3.67778 to -3.22185
Log10(Cd) BMP_OF	47	-3.35171	0.278571	0.040634	-3.43351 to -3.26992	-3.44370	0.20057	-3.44370 to -3.36653

Converted C, mg/L:

Cd Apron_GA	0.001
Cd Apron_Terminal	0.001
Cd Apron T-Hangar	0.001
Cd Apron_Air Cargo	0.001
Cd Runway _GA	0.001
Cd Runway_AC	0.001
Cd Taxiway _AC	0.000
Cd BMP_OF	0.000

Test	**Comparative descriptives**
Variables	Log10(Zn) Apron_GA, Log10(Zn) Apron_Terminal, Log10(Zn) Apron T-Hangar, Log10(Zn) Apron_Air Cargo, Log10(Zn) Runway _GA, Log10(Zn) Runwa
Performed by	rdoctora — **Date** 3 June 2005

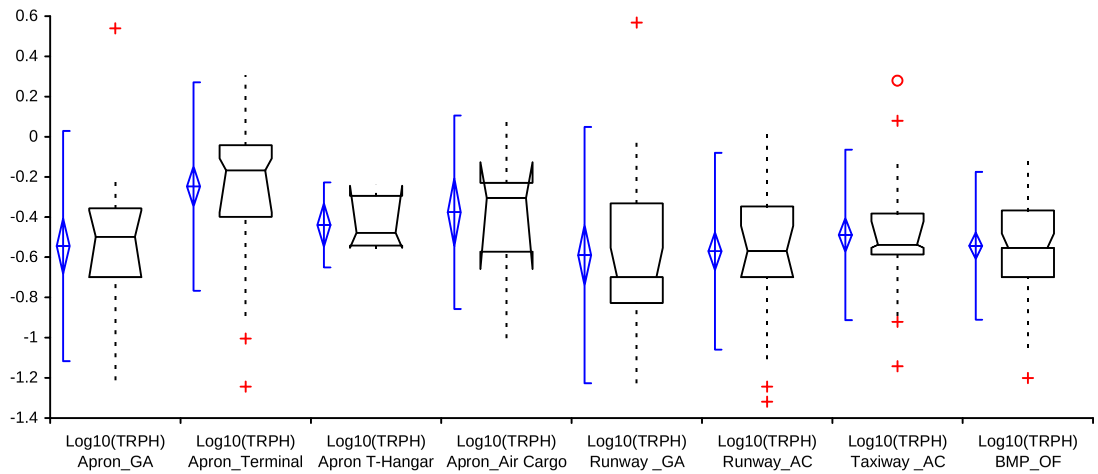


	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(Zn) Apron_GA	37	-1.40895	0.496568	0.081635	-1.57451 to -1.24339	-1.40012	0.66745	-1.57535 to -1.15490
Log10(Zn) Apron_Terminal	42	-1.25910	0.393056	0.060650	-1.38158 to -1.13661	-1.34689	0.46724	-1.46852 to -1.20761
Log10(Zn) Apron T-Hangar	9	-0.66167	0.423535	0.141178	-0.98722 to -0.33611	-0.74473	0.56427	-0.92082 to -0.24413
Log10(Zn) Apron_Air Cargo	22	-1.31889	0.437105	0.093191	-1.51269 to -1.12509	-1.44387	0.40314	-1.63930 to -0.92751
Log10(Zn) Runway _GA	28	-1.76811	0.358806	0.067808	-1.90724 to -1.62898	-1.75714	0.52610	-2.02228 to -1.61979
Log10(Zn) Runway_AC	41	-1.18828	0.384372	0.060029	-1.30960 to -1.06696	-1.25181	0.45033	-1.36653 to -1.09691
Log10(Zn) Taxiway _AC	40	-1.66604	0.409056	0.064678	-1.79686 to -1.53522	-1.66768	0.62577	-1.88606 to -1.49485
Log10(Zn) BMP_OF	47	-1.67047	0.358206	0.052250	-1.77564 to -1.56530	-1.65758	0.44960	-1.74473 to -1.50864

Converted C, mg/L:

Zn Apron_GA	0.039
Zn Apron_Terminal	0.055
Zn Apron T-Hangar	0.218
Zn Apron_Air Cargo	0.048
Zn Runway _GA	0.017
Zn Runway_AC	0.065
Zn Taxiway _AC	0.022
Zn BMP_OF	0.021

Test	**Comparative descriptives**
Variables	Log10(TRPH) Apron_GA, Log10(TRPH) Apron_Terminal, Log10(TRPH) Apron T-Hangar, Log10(TRPH) Apron_Air Cargo, Log10(TRPH) Runway _GA, L
Performed by	rdoctora
Date	3 June 2005

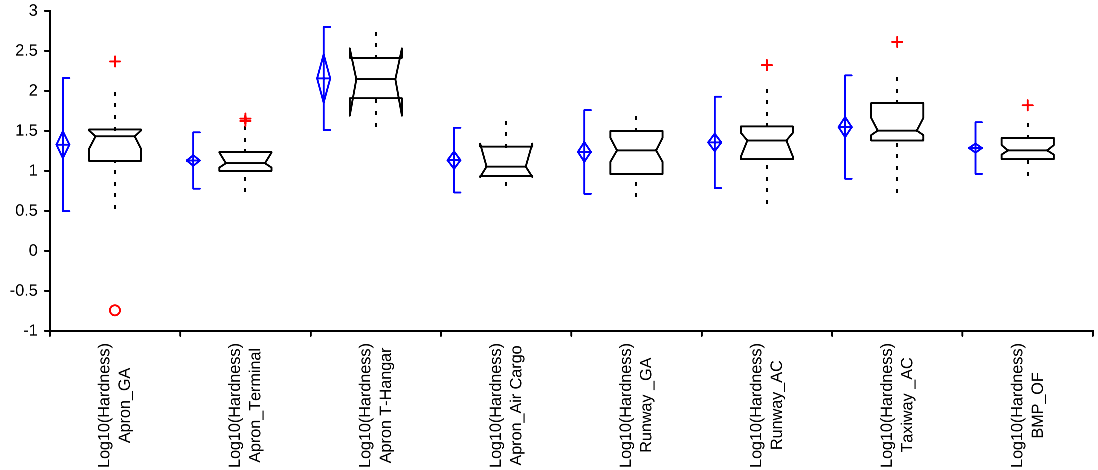


	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(TRPH) Apron_GA	27	-0.5442	0.34808	0.06699	-0.6819 to -0.4065	-0.4976	0.3427	-0.6990 to -0.3665
og10(TRPH) Apron_Terminal	41	-0.2475	0.31529	0.04924	-0.3470 to -0.1480	-0.1675	0.3558	-0.3768 to -0.1079
og10(TRPH) Apron T-Hangar	8	-0.4393	0.12878	0.04553	-0.5469 to -0.3316	-0.4773	0.2475	-0.5528 to -0.2441
g10(TRPH) Apron_Air Cargo	14	-0.3759	0.29280	0.07825	-0.5449 to -0.2068	-0.3054	0.3430	-0.6576 to -0.1266
Log10(TRPH) Runway _GA	28	-0.5894	0.38759	0.07325	-0.7397 to -0.4391	-0.6990	0.4953	-0.6990 to -0.5528
Log10(TRPH) Runway_AC	41	-0.5698	0.29765	0.04649	-0.6638 to -0.4759	-0.5686	0.3522	-0.6990 to -0.4437
Log10(TRPH) Taxiway _AC	39	-0.4886	0.25798	0.04131	-0.5722 to -0.4050	-0.5376	0.2041	-0.5528 to -0.4202
Log10(TRPH) BMP_OF	47	-0.5428	0.22367	0.03263	-0.6084 to -0.4771	-0.5528	0.3323	-0.5528 to -0.4815

Converted C, mg/L:

TRPH Apron_GA	0.286
TRPH Apron_Terminal	0.566
TRPH Apron T-Hangar	0.364
TRPH Apron_Air Cargo	0.421
TRPH Runway _GA	0.257
TRPH Runway_AC	0.269
TRPH Taxiway _AC	0.325
TRPH BMP_OF	0.287

Test	**Comparative descriptives**
Variables	Log10(Hardness) Apron_GA, Log10(Hardness) Apron_Terminal, Log10(Hardness) Apron T-Hangar, Log10(Hardness) Apron_Air Cargo, Log10(Hardnes
Performed by	rdoctora
Date	3 June 2005



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(Hardness) Apron_GA	37	1.3282	0.50564	0.08313	1.1596 to 1.4968	1.4314	0.3930	1.2730 to 1.5051
)(Hardness) Apron_Terminal	42	1.1298	0.21396	0.03301	1.0631 to 1.1965	1.0966	0.2367	1.0414 to 1.2304
0(Hardness) Apron T-Hangar	9	2.1550	0.39217	0.13072	1.8536 to 2.4564	2.1461	0.5065	1.6902 to 2.5315
(Hardness) Apron_Air Cargo	22	1.1350	0.24566	0.05238	1.0261 to 1.2439	1.0547	0.3713	0.9243 to 1.3424
g10(Hardness) Runway _GA	28	1.2371	0.31811	0.06012	1.1138 to 1.3605	1.2553	0.5410	1.1139 to 1.4150
og10(Hardness) Runway_AC	41	1.3556	0.34809	0.05436	1.2457 to 1.4655	1.3802	0.4102	1.1761 to 1.4771
g10(Hardness) Taxiway _AC	40	1.5482	0.39241	0.06205	1.4227 to 1.6737	1.5049	0.4680	1.4472 to 1.6628
Log10(Hardness) BMP_OF	47	1.2851	0.19607	0.02860	1.2275 to 1.3426	1.2553	0.2688	1.2041 to 1.3222

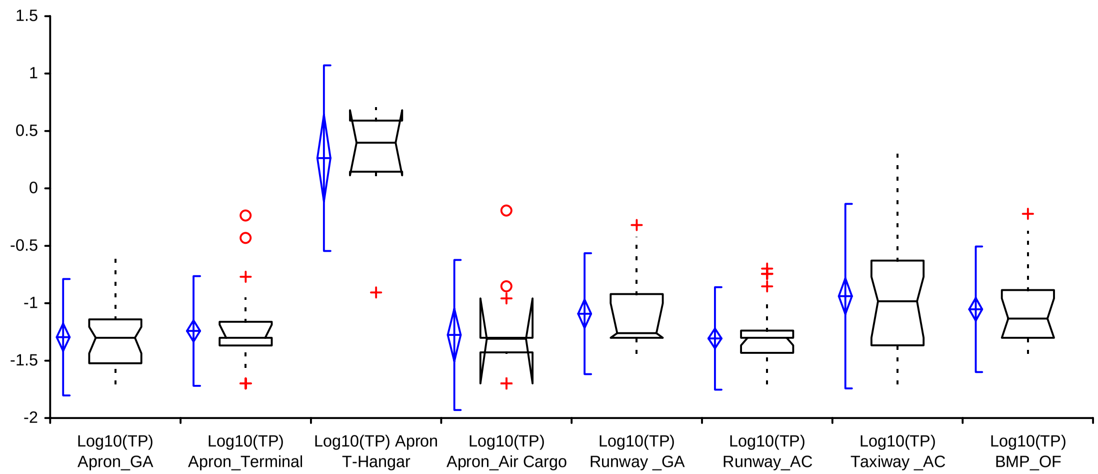
Converted C, mg/L:

Hardness Apron_GA	21
Hardness Apron_Terminal	13
Hardness Apron T-Hangar	143
Hardness Apron_Air Cargo	14
Hardness Runway _GA	17
Hardness Runway_AC	23
Hardness Taxiway _AC	35
Hardness BMP_OF	19

Test **Comparative descriptives**

Variables Log10(TP) Apron_GA, Log10(TP) Apron_Terminal, Log10(TP) Apron T-Hangar, Log10(TP) Apron_Air Cargo, Log10(TP) Runway _GA, Log10(TP) Runw

Performed by rdoctora **Date** 3 June 2005



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(TP) Apron_GA	28	-1.2961	0.30794	0.05820	-1.4155 to -1.1767	-1.3010	0.3827	-1.4367 to -1.2059
Log10(TP) Apron_Terminal	40	-1.2418	0.29074	0.04597	-1.3348 to -1.1488	-1.3010	0.2069	-1.3010 to -1.1871
Log10(TP) Apron T-Hangar	9	0.2638	0.49143	0.16381	-0.1140 to 0.6415	0.3979	0.4449	0.1139 to 0.6812
Log10(TP) Apron_Air Cargo	14	-1.2767	0.39719	0.10615	-1.5060 to -1.0473	-1.3099	0.1274	-1.6990 to -0.9579
Log10(TP) Runway _GA	28	-1.0916	0.32025	0.06052	-1.2158 to -0.9674	-1.2603	0.3802	-1.3010 to -1.0000
Log10(TP) Runway_AC	40	-1.3069	0.27155	0.04294	-1.3938 to -1.2201	-1.3010	0.1930	-1.3665 to -1.3010
Log10(TP) Taxiway _AC	40	-0.9386	0.48876	0.07728	-1.0949 to -0.7823	-0.9837	0.7373	-1.3010 to -0.7696
Log10(TP) BMP_OF	46	-1.0528	0.33246	0.04902	-1.1515 to -0.9541	-1.1340	0.4150	-1.3010 to -0.9586

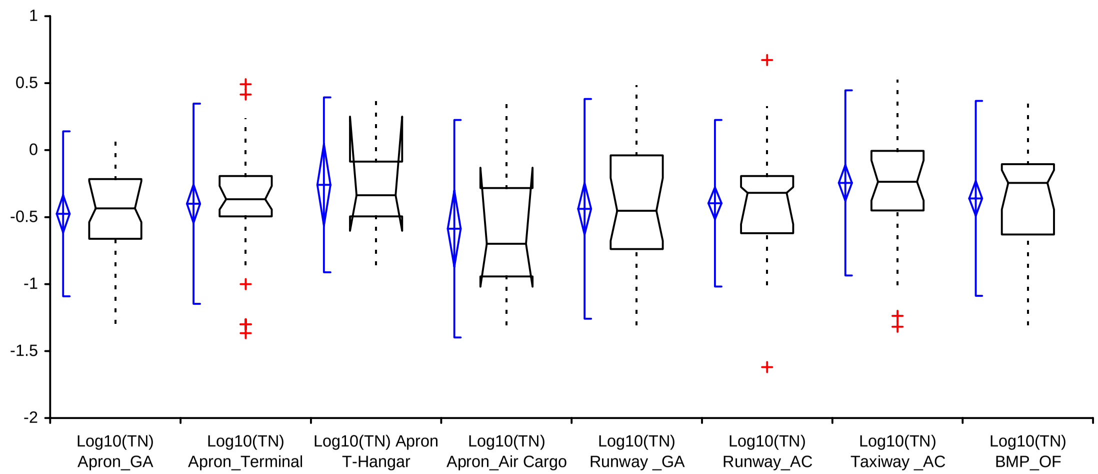
Converted C, mg/L:

TP Apron_GA	0.051
TP Apron_Terminal	0.057
TP Apron T-Hangar	1.836
TP Apron_Air Cargo	0.053
TP Runway _GA	0.081
TP Runway_AC	0.049
TP Taxiway _AC	0.115
TP BMP_OF	0.089

Test **Comparative descriptives**

Variables Log10(TN) Apron_GA, Log10(TN) Apron_Terminal, Log10(TN) Apron T-Hangar, Log10(TN) Apron_Air Cargo, Log10(TN) Runway _GA, Log10(TN) Runv

Performed by rdoctora **Date** 3 June 2005



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(TN) Apron_GA	30	-0.4753	0.37426	0.06833	-0.6151 to -0.3356	-0.4344	0.4449	-0.5376 to -0.2314
Log10(TN) Apron_Terminal	41	-0.4005	0.45443	0.07097	-0.5439 to -0.2570	-0.3665	0.3010	-0.4437 to -0.2676
Log10(TN) Apron T-Hangar	9	-0.2591	0.39717	0.13239	-0.5644 to 0.0462	-0.3372	0.4087	-0.6021 to 0.2504
Log10(TN) Apron_Air Cargo	14	-0.5863	0.49359	0.13192	-0.8713 to -0.3014	-0.6986	0.6608	-1.0190 to -0.1308
Log10(TN) Runway _GA	28	-0.4381	0.49850	0.09421	-0.6314 to -0.2448	-0.4533	0.6998	-0.6778 to -0.2076
Log10(TN) Runway_AC	41	-0.3966	0.37798	0.05903	-0.5159 to -0.2773	-0.3188	0.4260	-0.5528 to -0.2757
Log10(TN) Taxiway _AC	40	-0.2447	0.41988	0.06639	-0.3790 to -0.1104	-0.2368	0.4443	-0.3768 to -0.0757
Log10(TN) BMP_OF	47	-0.3603	0.44242	0.06453	-0.4902 to -0.2304	-0.2441	0.5246	-0.4437 to -0.1487

Converted C, mg/L:

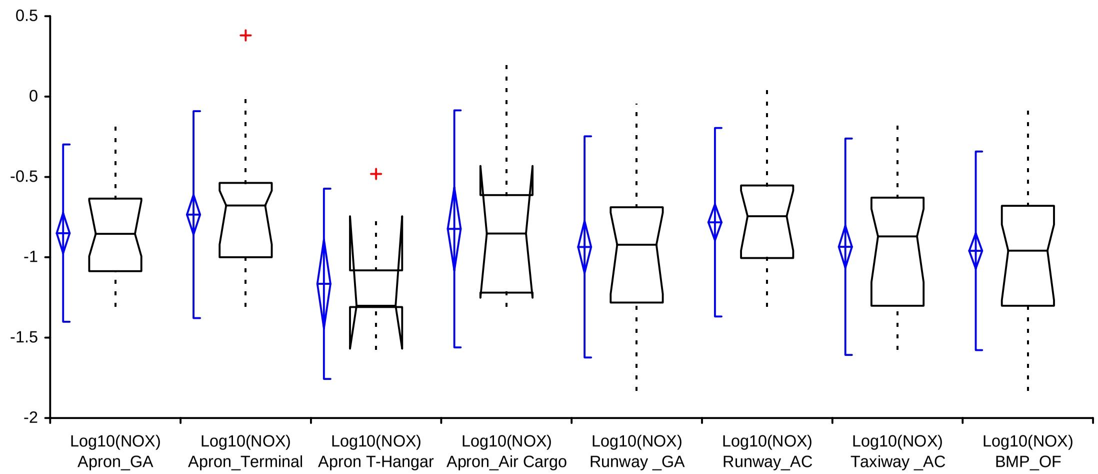
TN Apron_GA	0.335
TN Apron_Terminal	0.398
TN Apron T-Hangar	0.551
TN Apron_Air Cargo	0.259
TN Runway _GA	0.365
TN Runway_AC	0.401
TN Taxiway _AC	0.569
TN BMP_OF	0.436

analysed with: Analyse-it + General 1.71

Test Comparative descriptives

Variables Log10(NOX) Apron_GA, Log10(NOX) Apron_Terminal, Log10(NOX) Apron T-Hangar, Log10(NOX) Apron_Air Cargo, Log10(NOX) Runway _GA, Log10(

Performed by rdoctora **Date** 3 June 2005

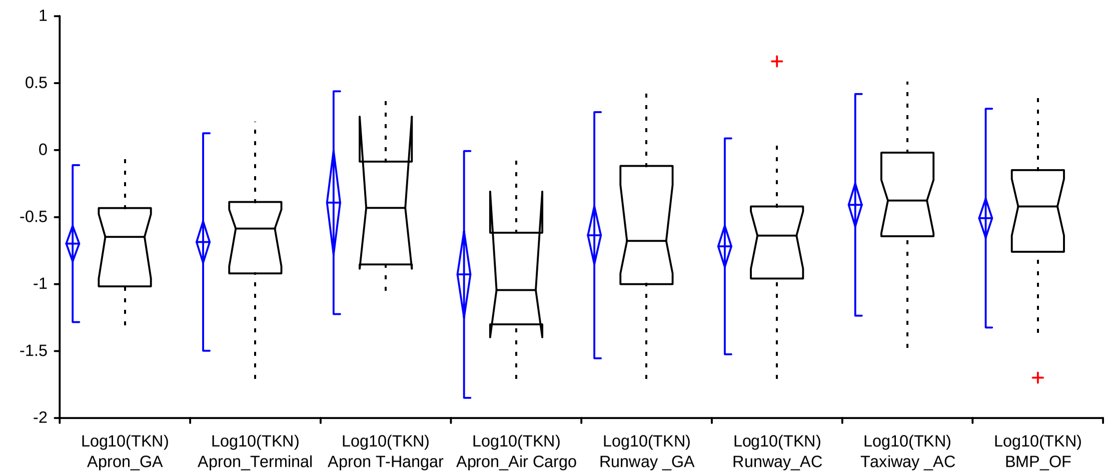


	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(NOX) Apron_GA	30	-0.8498	0.33547	0.06125	-0.9750 to -0.7245	-0.8539	0.4513	-0.9935 to -0.6478
Log10(NOX) Apron_Terminal	41	-0.7350	0.39133	0.06112	-0.8585 to -0.6115	-0.6778	0.4624	-0.9208 to -0.5850
Log10(NOX) Apron T-Hangar	9	-1.1652	0.35984	0.11995	-1.4418 to -0.8886	-1.3010	0.2289	-1.5686 to -0.7447
Log10(NOX) Apron_Air Cargo	14	-0.8237	0.44831	0.11982	-1.0825 to -0.5648	-0.8517	0.6062	-1.2518 to -0.4318
Log10(NOX) Runway _GA	28	-0.9355	0.41846	0.07908	-1.0978 to -0.7733	-0.9223	0.5934	-1.2291 to -0.7212
Log10(NOX) Runway_AC	41	-0.7820	0.35647	0.05567	-0.8946 to -0.6695	-0.7447	0.4515	-0.9586 to -0.5850
Log10(NOX) Taxiway _AC	40	-0.9344	0.40932	0.06472	-1.0653 to -0.8035	-0.8700	0.6718	-1.1549 to -0.6990
Log10(NOX) BMP_OF	47	-0.9599	0.37541	0.05476	-1.0702 to -0.8497	-0.9586	0.6213	-1.2676 to -0.7959

Converted C, mg/L:

NOX Apron_GA	0.141
NOX Apron_Terminal	0.184
NOX Apron T-Hangar	0.068
NOX Apron_Air Cargo	0.150
NOX Runway _GA	0.116
NOX Runway_AC	0.165
NOX Taxiway _AC	0.116
NOX BMP_OF	0.110

Test	**Comparative descriptives**
Variables	Log10(TKN) Apron_GA, Log10(TKN) Apron_Terminal, Log10(TKN) Apron T-Hangar, Log10(TKN) Apron_Air Cargo, Log10(TKN) Runway _GA, Log10(TI
Performed by	rdoctora — **Date** 3 June 2005



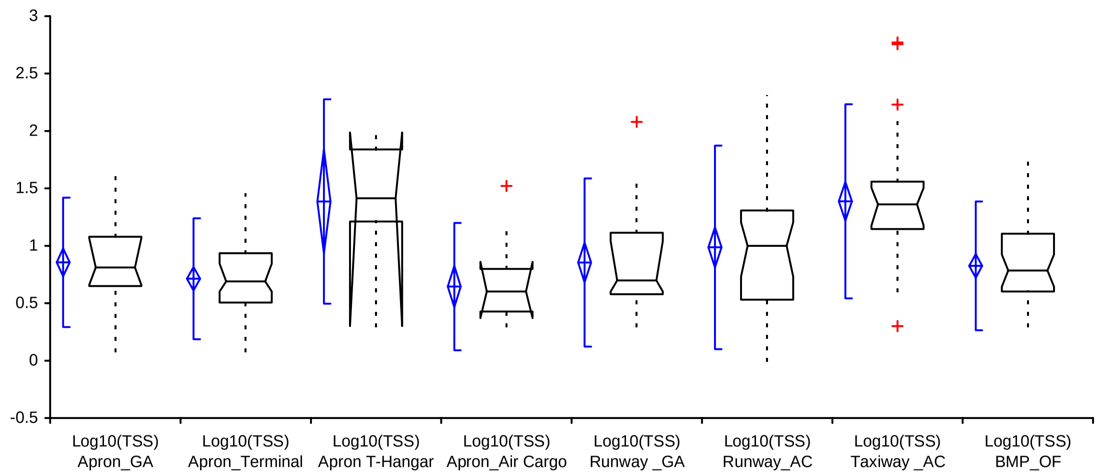
	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(TKN) Apron_GA	30	-0.6979	0.35593	0.06498	-0.8309 to -0.5650	-0.6477	0.5845	-0.9586 to -0.4783
Log10(TKN) Apron_Terminal	41	-0.6860	0.49342	0.07706	-0.8418 to -0.5303	-0.5850	0.5336	-0.8677 to -0.4437
Log10(TKN) Apron T-Hangar	9	-0.3922	0.50551	0.16850	-0.7808 to -0.0036	-0.4318	0.7677	-0.8861 to 0.2504
.og10(TKN) Apron_Air Cargo	14	-0.9277	0.55994	0.14965	-1.2510 to -0.6044	-1.0442	0.6850	-1.3979 to -0.3098
Log10(TKN) Runway _GA	28	-0.6352	0.55889	0.10562	-0.8519 to -0.4185	-0.6778	0.8822	-0.9208 to -0.2596
Log10(TKN) Runway_AC	41	-0.7182	0.49013	0.07654	-0.8729 to -0.5635	-0.6383	0.5384	-0.8861 to -0.4559
Log10(TKN) Taxiway _AC	40	-0.4089	0.50312	0.07955	-0.5698 to -0.2480	-0.3768	0.6242	-0.6198 to -0.2218
Log10(TKN) BMP_OF	47	-0.5079	0.49626	0.07239	-0.6537 to -0.3622	-0.4202	0.6098	-0.6383 to -0.2147

Converted C, mg/L:

TKN Apron_GA	0.200
TKN Apron_Terminal	0.206
TKN Apron T-Hangar	0.405
TKN Apron_Air Cargo	0.118
TKN Runway _GA	0.232
TKN Runway_AC	0.191
TKN Taxiway _AC	0.390
TKN BMP_OF	0.310

analysed with: Analyse-it + General 1.71

Test	**Comparative descriptives**
Variables	Log10(TSS) Apron_GA, Log10(TSS) Apron_Terminal, Log10(TSS) Apron T-Hangar, Log10(TSS) Apron_Air Cargo, Log10(TSS) Runway _GA, Log10(TS
Performed by	rdoctora
Date	3 June 2005



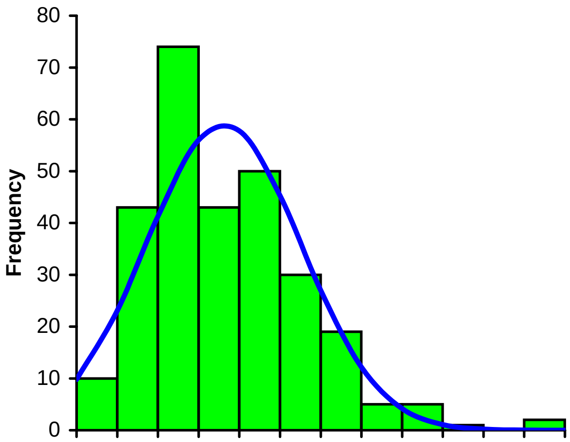
	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Log10(TSS) Apron_GA	33	0.8558	0.34285	0.05968	0.7343 to 0.9774	0.8118	0.4292	0.6593 to 1.0663
Log10(TSS) Apron_Terminal	40	0.7134	0.32012	0.05061	0.6111 to 0.8158	0.6901	0.4307	0.6021 to 0.8451
Log10(TSS) Apron T-Hangar	8	1.3865	0.54106	0.19129	0.9342 to 1.8389	1.4137	0.6281	0.3010 to 1.9868
.og10(TSS) Apron_Air Cargo	16	0.6449	0.33723	0.08431	0.4652 to 0.8246	0.6021	0.3701	0.3711 to 0.8608
Log10(TSS) Runway _GA	28	0.8546	0.44558	0.08421	0.6819 to 1.0274	0.6990	0.5361	0.6021 to 1.0414
Log10(TSS) Runway_AC	39	0.9867	0.53905	0.08632	0.8120 to 1.1614	1.0000	0.7778	0.7324 to 1.2041
Log10(TSS) Taxiway _AC	38	1.3869	0.51398	0.08338	1.2180 to 1.5559	1.3613	0.4131	1.1761 to 1.5051
Log10(TSS) BMP_OF	44	0.8253	0.34092	0.05140	0.7216 to 0.9289	0.7853	0.5032	0.6435 to 0.9243

Converted C, mg/L:

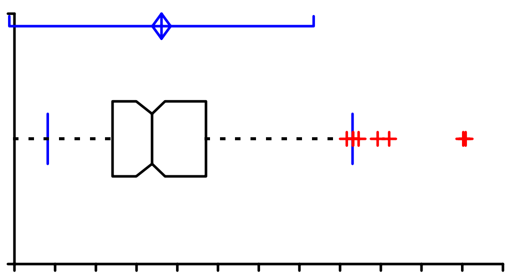
TSS Apron_GA		7.2
TSS Apron_Terminal		5.2
TSS Apron T-Hangar		24.4
TSS Apron_Air Cargo		4.4
TSS Runway _GA		7.2
TSS Runway_AC		9.7
TSS Taxiway _AC		24.4
TSS BMP_OF		6.7

analysed with: Analyse-it + General 1.71

Test	**Continuous summary descriptives**
Variable	Log10_TSS
Performed by	Dean Mades
Date	2 June 2005

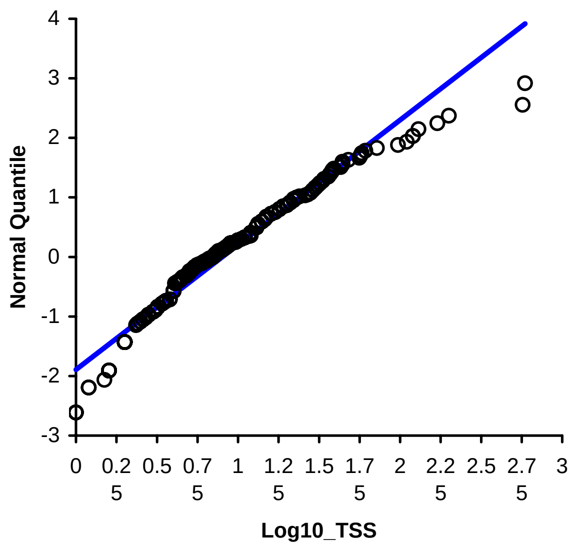


n	282	(cases excluded: 81 due to mi
Mean	0.903	
95% CI	0.847 to 0.959	
Variance	0.2274	
SD	0.4768	
SE	0.0284	
CV	53%	



Median	0.845
95.1% CI	0.748 to 0.924
Range	2.770852012
IQR	0.574031268

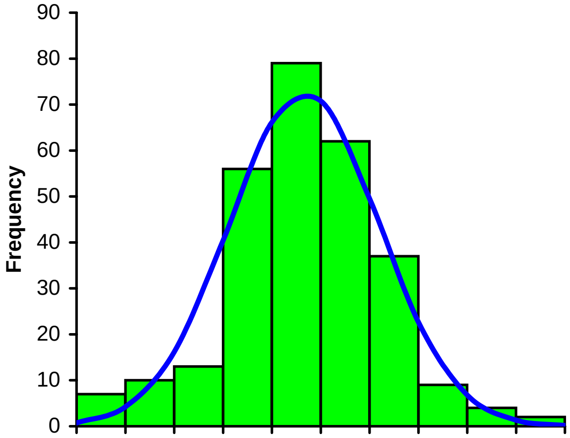
Percentile	
2.5th	0.204
25th	0.602
50th	0.845
75th	1.176
97.5th	2.076

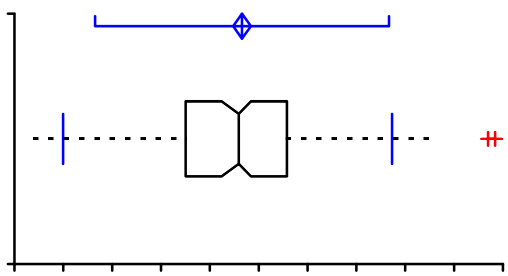


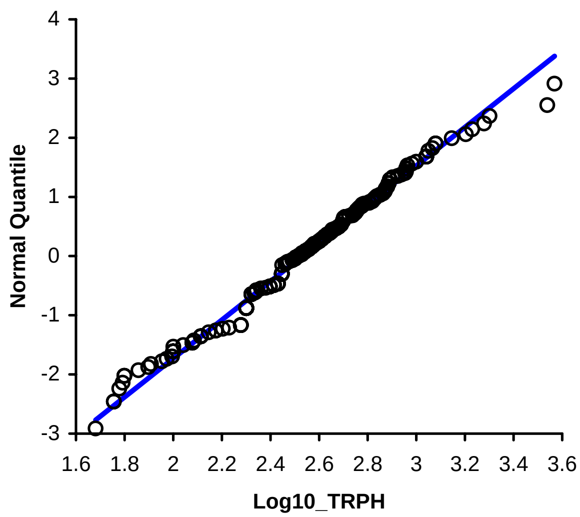
	Coefficient	p
Shapiro-Wilk	0.9598	<0.0001
Skewness	0.7991	<0.0001
Kurtosis	1.0070	0.0088

analysed with: Analyse-it + General 1.71

Test	**Continuous summary descriptives**
Variable	Log10_TRPH
Performed by	Dean Mades
Date	2 June 2005







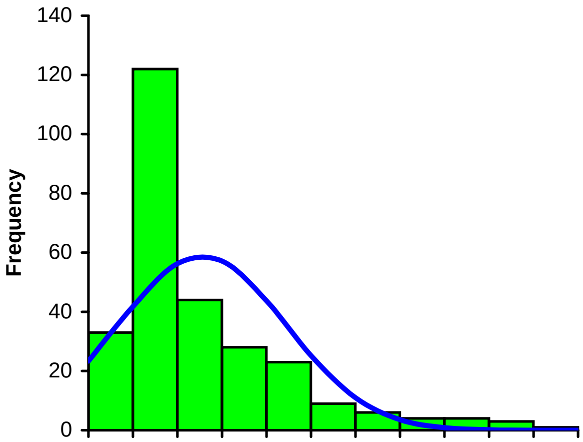
n	279	(cases excluded: 84 due to mi
Mean	2.532	
95% CI	2.496 to 2.568	
Variance	0.0942	
SD	0.3069	
SE	0.0184	
CV	12%	
Median	2.519	
95.8% CI	2.449 to 2.568	
Range	1.886960487	
IQR	0.414893027	

Percentile	
2.5th	1.799
25th	2.301
50th	2.519
75th	2.716
97.5th	3.146

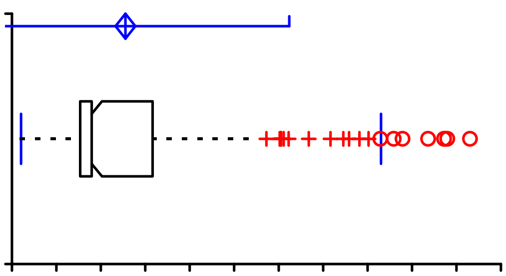
	Coefficient	**p**
Shapiro-Wilk	0.9852	0.0056
Skewness	0.0368	0.7982
Kurtosis	0.6807	0.0477

analysed with: Analyse-it + General 1.71

Test	**Continuous summary descriptives**
Variable	Log10_Total P
Performed by	Dean Mades
Date	2 June 2005

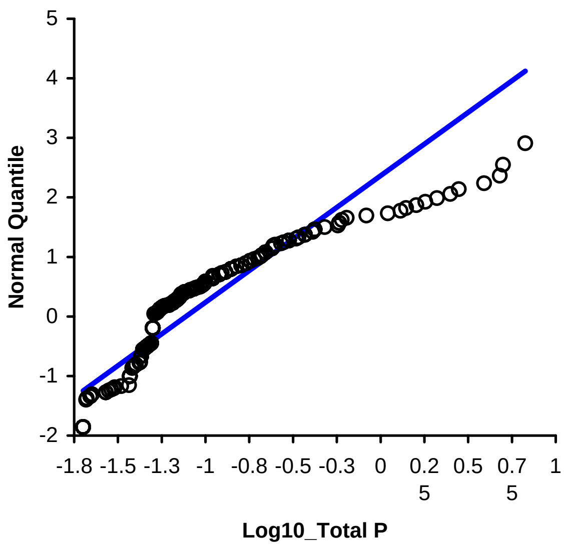


n	277	(cases excluded: 86 due to mi
Mean	-1.112	
95% CI	-1.167 to -1.056	
Variance	0.2212	
SD	0.4703	
SE	0.0283	
CV	-42%	



Median	-1.301
95.9% CI	-1.301 to -1.244
Range	2.525044807
IQR	0.40792423

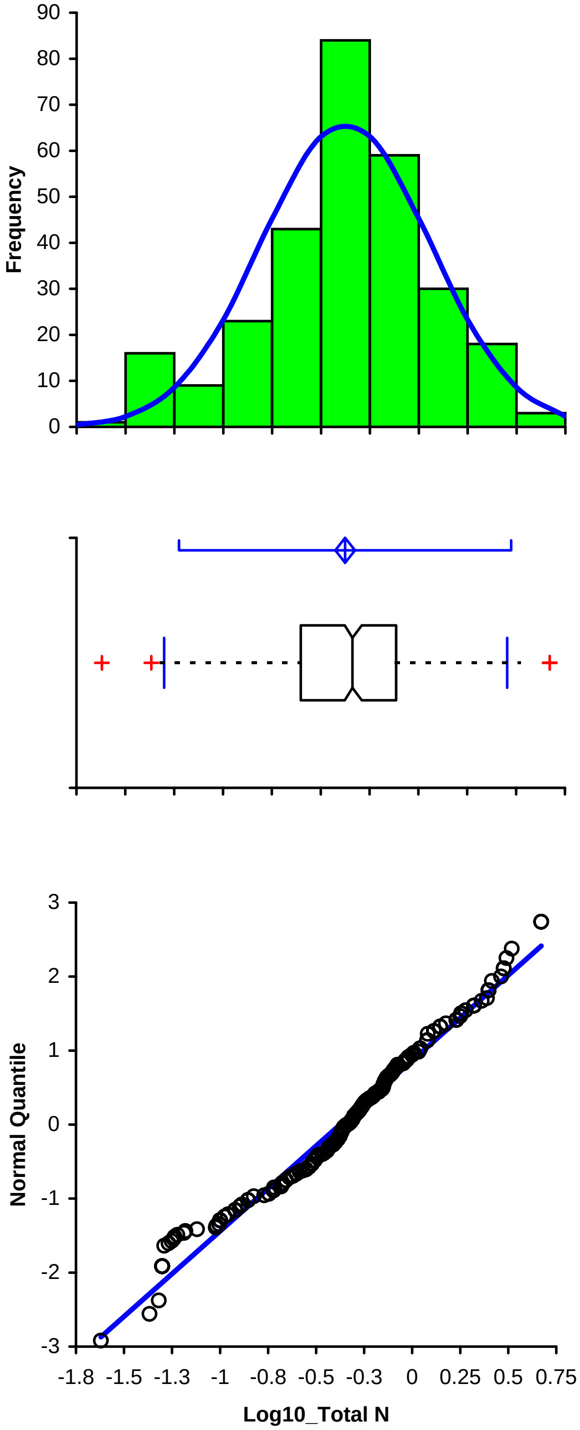
Percentile	
2.5th	-1.699
25th	-1.367
50th	-1.301
75th	-0.959
97.5th	0.326



	Coefficient	p
Shapiro-Wilk	0.8426	<0.0001
Skewness	1.6600	<0.0001
Kurtosis	3.2802	<0.0001

analysed with: Analyse-it + General 1.71

Test	**Continuous summary descriptives**
Variable	Log10_Total N
Performed by	Dean Mades
Date	2 June 2005



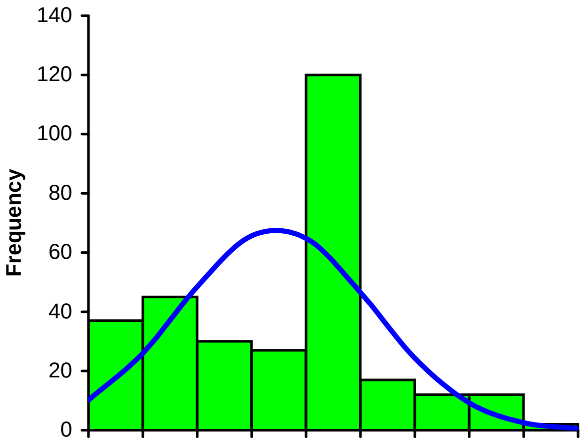
n	286	(cases excluded: 77 due to mi
Mean	-0.375	
95% CI	-0.425 to -0.325	
Variance	0.1881	
SD	0.4337	
SE	0.0256	
CV	-116%	
Median	-0.337	
96.2% CI	-0.377 to -0.290	
Range	2.291886616	
IQR	0.488550717	

Percentile	
2.5th	-1.301
25th	-0.602
50th	-0.337
75th	-0.114
97.5th	0.454

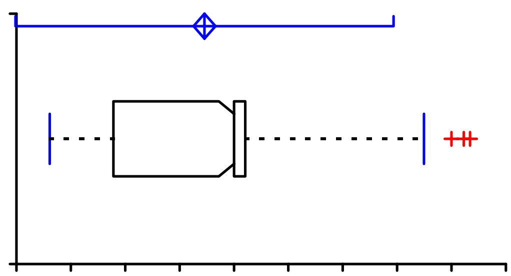
	Coefficient	**p**
Shapiro-Wilk	0.9771	0.0002
Skewness	-0.3607	0.0136
Kurtosis	0.0612	0.7321

analysed with: Analyse-it + General 1.71

Test	**Continuous summary descriptives**
Variable	Log10_Cadmium
Performed by	Dean Mades
Date	2 June 2005

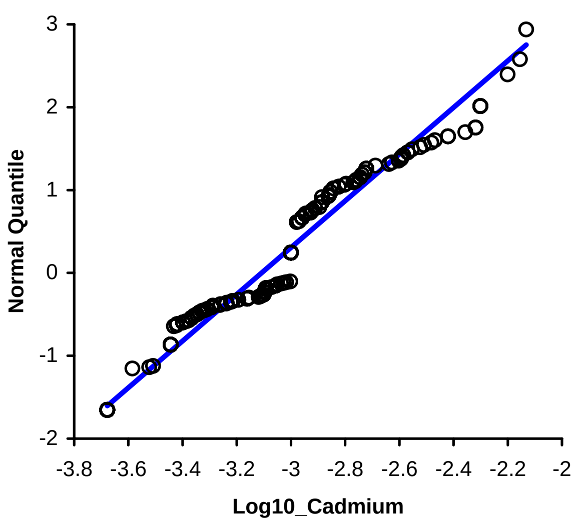


n	302 (cases excluded: 61 due to mi
Mean	-3.108
95% CI	-3.149 to -3.068
Variance	0.1259
SD	0.3548
SE	0.0204
CV	-11%



Median	-3.000
95.6% CI	-3.056 to -3.000
Range	1.545837067
IQR	0.485090184

Percentile	
2.5th	-3.678
25th	-3.444
50th	-3.000
75th	-2.959
97.5th	-2.301

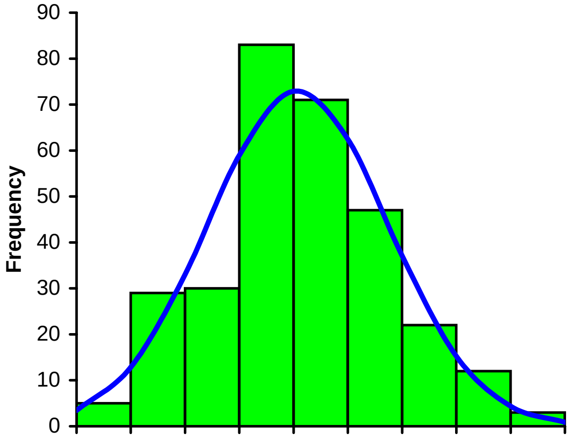


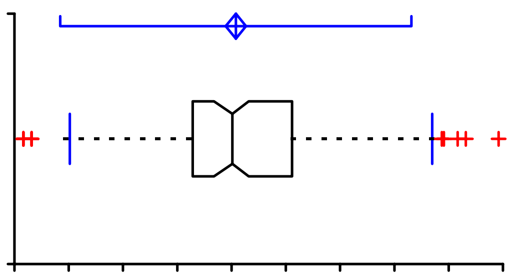
	Coefficient	p
Shapiro-Wilk	0.9388	<0.0001
Skewness	0.2431	0.0830
Kurtosis	-0.1334	0.6934

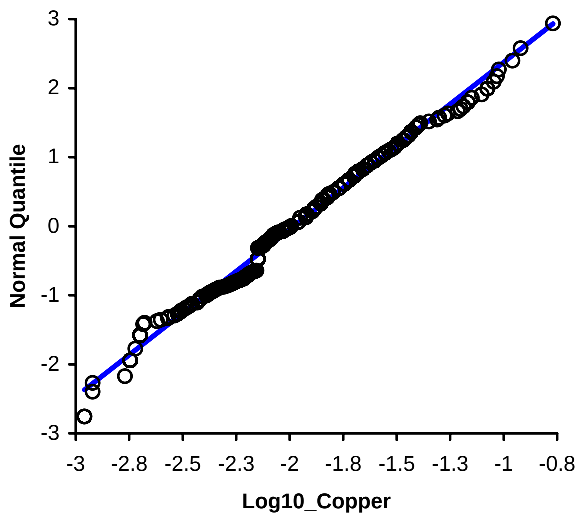
analysed with: Analyse-it + General 1.71

Test	**Continuous summary descriptives**
Variable	Log10_Copper
Performed by	Dean Mades

Date 2 June 2005







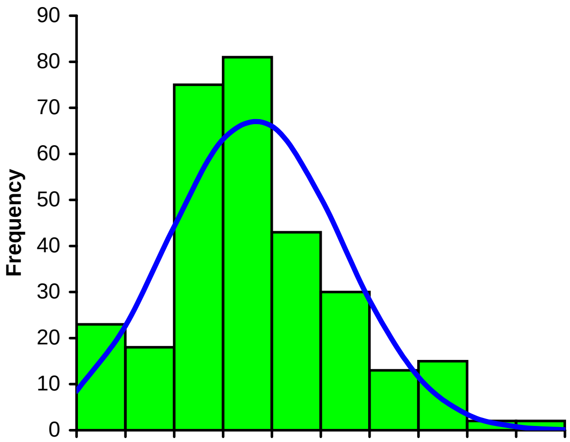
n	302 (cases excluded: 61 due to mi
Mean	-1.980
95% CI	-2.027 to -1.934
Variance	0.1703
SD	0.4127
SE	0.0237
CV	-21%
Median	-1.996
95.6% CI	-2.081 to -1.921
Range	2.189056236
IQR	0.457576949

Percentile	
2.5th	-2.745
25th	-2.179
50th	-1.996
75th	-1.721
97.5th	-1.076

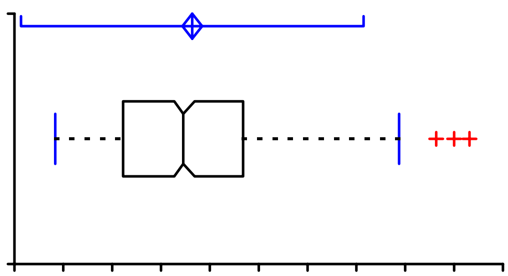
	Coefficient	**p**
Shapiro-Wilk	0.9888	0.0201
Skewness	0.1039	0.4540
Kurtosis	0.0181	0.8471

analysed with: Analyse-it + General 1.71

Test	**Continuous summary descriptives**
Variable	Log10_Lead
Performed by	Dean Mades
Date	2 June 2005

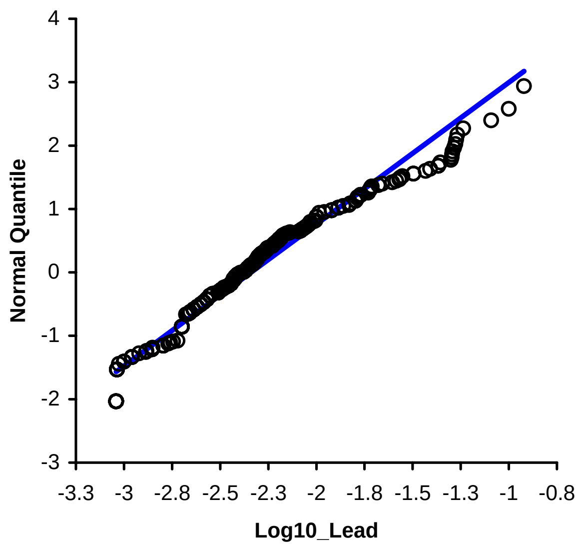


n	302 (cases excluded: 61 due to mi
Mean	-2.340
95% CI	-2.391 to -2.289
Variance	0.2000
SD	0.4472
SE	0.0257
CV	-19%



Median	-2.386
95.6% CI	-2.432 to -2.328
Range	2.120139854
IQR	0.613792254

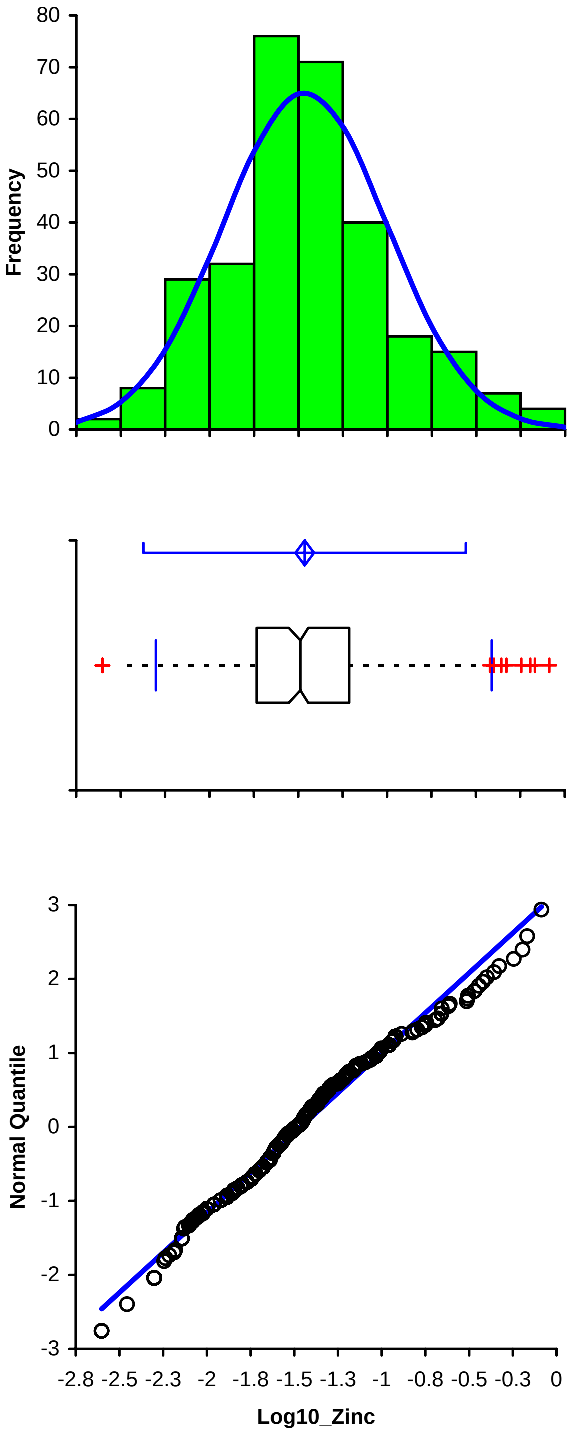
Percentile	
2.5th	-3.041
25th	-2.694
50th	-2.386
75th	-2.080
97.5th	-1.281



	Coefficient	p
Shapiro-Wilk	0.9577	<0.0001
Skewness	0.6692	<0.0001
Kurtosis	0.2726	0.3096

analysed with: Analyse-it + General 1.71

Test	**Continuous summary descriptives**
Variable	Log10_Zinc
Performed by	Dean Mades
Date	2 June 2005



n	302 (cases excluded: 61 due to mi
Mean	-1.464
95% CI	-1.516 to -1.412
Variance	0.2143
SD	0.4629
SE	0.0266
CV	-32%
Median	-1.488
95.6% CI	-1.553 to -1.444
Range	2.515873844
IQR	0.520822951

Percentile	
2.5th	-2.301
25th	-1.734
50th	-1.488
75th	-1.213
97.5th	-0.411

	Coefficient	**p**
Shapiro-Wilk	0.9842	0.0021
Skewness	0.3784	0.0080
Kurtosis	0.2411	0.3559

APPENDIX D

CONCENTRATION AND LOAD REDUCTION SUMMARIES BY PAIRED STATIONS

Test Sites	Concentration Reduction Efficiency for TOTAL SUSPENDED SOLIDS (TSS) NOTE: All concentrations in mg/L				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	32.9	6.3	81%	10	25% of data is BDL
SRQ 1-2	29	49.5	-71%	2	Six Events 100% infiltrated
SGJ 3-4	4.1	4.9	-20%	8	50% of data is BDL
TPA 1-2	8.9	5.1	43%	6	Four Events 100% infiltrated, 17% of data is BDL
Average			30%	26	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	37.3	9.0	76%	8	25% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	35.9	10.4	71%	10	
	Oil - Water Separator				
	Pavement	BMP	% Eff		Remarks
TLH 2-3	10	11.8	-18%	9	11% of data is BDL
	Sediment Box				
	Outlet	BMP	% Eff		Remarks
PGD 1-2	4.3	3.8	12%	3	7% of data is BDL
	Vegetated, Wet Swale 500 ft				
	Outlet	BMP	% Eff		Remarks
PGD 2-3	4.2	3.4	19%	7	11% of data is BDL

Test Sites	Load Reduction Efficiency for TOTAL SUSPENDED SOLIDS (TSS) NOTE: All loads in kg/ha-yr				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	120	53	56%	10	20% of data is BDL
SRQ 1-2	135	76	44%	8	Six Events 100% infiltrated, 9% of data is BDL
SGJ 3-4	28	14	50%	8	50% of data is BDL
TPA 1-2	77	16	79%	10	Four Events 100% infiltrated, 10% of data is BDL
Average			58%	36	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	120	32.4	73%	10	20% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	131.6	23.4	82%	10	60% of data is BDL

Test Sites	**Concentration Reduction Efficiency for TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (TRPH) NOTE: All concentrations in mg/L**				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	403	352	13%	10	
SRQ 1-2	200	247	-24%	3	Six Events 100% infiltrated, 100% of data is BDL
SGJ 3-4	305	287	6%	8	75% of data is BDL
TPA 1-2	186	198	-6%	6	Four Events 100% infiltrated
Average			2%	27	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	462	383	17%	9	
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	360	306	15%	10	
	Oil - Water Separator				
	Pavement	BMP	% Eff		Remarks
TLH 2-3	701	616	12%	9	
	Sediment Box				
	Pavement	BMP	% Eff		Remarks
PGD 1-2	413	425	-3%	4	52% of data is BDL
	Vegetated, Wet Swale 500 ft				
	Outlet	BMP	% Eff		Remarks
PGD 2-3	402	363	10%	7	44% of data is BDL
	GATS Jar				
	Used	Not Used	% Eff		Remarks
DAB7/SFB4	541	462	15%	2	DAB operations very much higher

Test Sites	Load Reduction Efficiency for TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (TRPH) NOTE: All loads in kg/ha-yr				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	2.90	2.93	-1%	10	9% of data is BDL
SRQ 1-2	1.68	0.43	74%	2	Six Events 100% infiltrated, 67% of data is BDL
SGJ 3-4	1.85	0.72	61%	8	75% of data is BDL
TPA 1-2	2.29	0.79	65%	10	Four Events 100% infiltrated, 20% of data is BDL
Average			43%	30	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	3	2	48%	10	11% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	3	0	84%	10	100% of data is BDL

Test Sites	Concentration Reduction Efficiency for TOTAL PHOSPHORUS (TP) NOTE: All concentrations in mg/L				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.0676	0.0558	17%	10	75% of data is BDL
SRQ 1-2	0.059	0.307	-420%	3	Six Events 100% infiltrated
SGJ 3-4	0.171	0.162	5%	8	38% of data is BDL
TPA 1-2	0.0921	0.0965	-5%	6	Four Events 100% infiltrated, 83% of data is BDL
Average			-40%	27	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.073	0.0763	-5%	9	75% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	2.396	0.178	93%	10	
	Oil - Water Separator				
	Pavement	BMP	% Eff		Remarks
TLH 2-3	0.1205	0.1217	-1%	8	22% of data is BDL
	Sediment Box				
	Pavement	BMP	% Eff		Remarks
PGD 1-2	0.0297	0.07	-136%	2	46% of data is BDL
	Vegetated, Wet Swale 500 ft				
	Outlet	BMP	% Eff		Remarks
PGD 2-3	0.044	0.044	0%	7	43% of data is BDL

Test Sites	**Load Reduction Efficiency for TOTAL PHOSPHORUS (TP)** **NOTE: All loads in kg/ha-yr**				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.4	0.32	20%	10	73% of data is BDL
SRQ 1-2	0.393	0.858	-118%	8	Six Events 100% infiltrated, 30% of data is BDL
SGJ 3-4	1.116	0.417	63%	8	38% of data is BDL
TPA 1-2	0.337	0.256	24%	10	Four events 100% infiltrated, 70% of data is BDL
Average			0%	36	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.4	0.309	23%	10	73% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	10.825	0.581	95%	10	33% of data is BDL

Test Sites	Concentration Reduction Efficiency for TOTAL NITROGEN (TN) NOTE: All concentrations in mg/L				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.587	0.512	13%	10	
SRQ 1-2	0.293	1.433	-389%	3	Six Events 100% infiltrated
SGJ 3-4	0.358	0.475	-33%	8	38% of data is BDL
TPA 1-2	0.333	0.84	-152%	6	Four Events 100% infiltrated
Average			-82%	27	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.57	0.618	-8%	9	
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	0.607	0.617	-2%	10	
	Oil - Water Separator				
	Pavement	BMP	% Eff		Remarks
TLH 2-3	0.442	1.098	-148%	9	
	Sediment Box				
	Pavement	BMP	% Eff		Remarks
PGD 1-2					
	Vegetated, Wet Swale 500 ft				
	Outlet	BMP	% Eff		Remarks
PGD 2-3	0.521	0.48	8%	7	

Test Sites	Load Reduction Efficiency for TOTAL NITROGEN (TN) NOTE: All loads in kg/ha-yr				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	5.762	3.975	31%	10	
SRQ 1-2	4.403	4.028	9%	8	Six Events 100% infiltrated
SGJ 3-4	2.564	0.521	80%	8	50% of data is BDL
TPA 1-2	2.744	2.447	11%	10	Four Events 100% infiltrated, 10% of data BDL
Average			31%	36	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	5.762	2.455	57%	10	
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	7.322	3.028	59%	10	20% of data is BDL

Test Sites	Load Reduction Efficiency for NITRATE + NITRITE (NOX) NOTE: All loads in kg/ha-yr				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	2.196	1.325	40%	10	9% of data is BDL
SRQ 1-2	1.849	0.717	61%	8	Six Events 100% infiltrated, 9% of data is BDL
SGJ 3-4	0.615	0.165	73%	8	88% of data is BDL
TPA 1-2	1.304	0.254	81%	10	Four Events 100% infiltrated, 33% of data is BDL
Average			63%	36	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	2.196	0.428	81%	10	33% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	1.128	0.619	45%	10	80% of data is BDL

Test Sites	Load Reduction Efficiency for TOTAL KJEDAHL NITROGEN (TKN) NOTE: All loads in kg/ha-yr				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	2.368	2.123	10%	10	18% of data is BDL
SRQ 1-2	1.553	3.145	-103%	8	Six Events 100% infiltrated, 18% of data is BDL
SGJ 3-4	1.278	0.55	57%	8	38% of data is BDL
TPA 1-2	2.524	2.167	14%	10	Four Events 100% infiltrated, 10% of data is BDL
Average			-3%	36	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	2.368	1.702	28%	10	18% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	2.801	2.7	4%	10	43% of data is BDL

Test Sites	Concentration Reduction Efficiency for CADMIUM (Cd) NOTE: All concentrations in mg/L				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.0009	0.0005	48%	10	
SRQ 1-2	0.0010	0.0011	-10%	3	Six Events 100% infiltrated, 67% of BMP data is BDL
SGJ 3-4	0.0012	0.0012	1%	8	90% of data is BDL
TPA 1-2	0.0005	0.0005	4%	6	Four Events 100% infiltrated, 94% of data is BDL
Average			18%	27	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.0010	0.0005	49%	9	50% of data is BDL
	Dry Retention Pond				
	Pavement	BMP	% Eff		Remarks
VNC 1-2	0.0039	0.002	49%	1	
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	0.0019	0.0002	87%	10	All BMP data is BDL
	Oil - Water Separator				
	Pavement	BMP	% Eff		Remarks
TLH 2-3	0.0015	0.0011	27%	10	44% of data is BDL
	Sediment Box				
	Pavement	BMP	% Eff		Remarks
PGD 1-2	0.0009	0.0011	-22%	4	88% of data is BDL
	Vegetated, Wet Swale 500 ft				
	Outlet	BMP	% Eff		Remarks
PGD 2-4	0.0010	0.0010	0%	9	88% of data is BDL

Test Sites	Load Reduction Efficiency for CADMIUM (Cd) NOTE: All loads in kg/ha-yr				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.0060	0.0030	50%	10	55% of data is BDL
SRQ 1-2	0.0070	0.002	71%	8	Six Events 100% infiltrated, 91% of data is BDL
SGJ 3-4	0.0040	0.0020	50%	8	90% of data is BDL
TPA 1-2	0.0004	0.0001	75%	10	Four events 100% infiltrated, 90% of data is BDL
Average			62%	36	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.0060	0.0020	67%	10	44% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	0.0090	0.0030	67%	10	100% of data is BDL

Test Sites	Concentration Reduction Efficiency for COPPER (Cu) NOTE: All concentrations in mg/L				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.0566	0.0147	74%	10	
SRQ 1-2	0.0280	0.0238	15%	3	Six Events 100% infiltrated
SGJ 3-4	0.0050	0.0050	0%	8	88% of data is BDL
TPA 1-2	0.0222	0.0202	9%	6	Four Events 100% infiltrated
Average			31%	27	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.0576	0.0129	78%	9	
	Dry Retention Pond				
	Pavement	BMP	% Eff		Remarks
VNC 1-2	0.0014	0.001	29%	1	BMP Data is at Detection Limit
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	0.0070	0.0060	14%	10	80% of BMP data BDL
	Oil - Water Separator				
	Pavement	BMP	% Eff		Remarks
TLH 2-3	0.0400	0.0266	34%	10	
	Sediment Box				
	Pavement	BMP	% Eff		Remarks
PGD 1-2	0.0032	0.0060	-88%	4	43% of data is BDL
	Vegetated, Wet Swale 500 ft				
	Outlet	BMP	% Eff		Remarks
PGD 2-3	0.0053	0.0025	53%	9	44% of data is BDL

Test Sites	Load Reduction Efficiency for COPPER (Cu) NOTE: All loads in kg/ha-yr				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.4470	0.1370	69%	10	
SRQ 1-2	0.3060	0.0580	81%	8	Six Events 100% infiltrated
SGJ 3-4	0.0320	0.0140	56%	8	50% of data is BDL
TPA 1-2	0.1790	0.0590	67%	6	Four Events 100% infiltrated
Average			69%	32	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.4470	0.0600	87%	10	0% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	0.0410	0.0220	46%	10	89% of data is BDL

Test Sites	Concentration Reduction Efficiency for LEAD (Pb) NOTE: All concentrations in mg/L				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.0039	0.0018	54%	10	Overland flow average EMC is BDL
SRQ 1-2	0.0048	0.0046	5%	3	Six Events 100% infiltrated
SGJ 3-4	0.0028	0.0025	11%	8	67% of data is BDL
TPA 1-2	0.0024	0.0030	-25%	6	Four Events 100% infiltrated, 27% of data is BDL
Average			18%	27	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.0043	0.0021	51%	9	25% of data is BDL
	Dry Retention Pond				
	Pavement	BMP	% Eff		Remarks
VNC 1-2	0.019	0.0045	76%	1	0% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	0.0196	0.0033	83%	10	
	Oil - Water Separator				
	Pavement	BMP	% Eff		Remarks
TLH 2-3	0.0048	0.0050	-4%	10	44% of data is BDL
	Sediment Box				
	Pavement	BMP	% Eff		Remarks
PGD 1-2	0.0048	0.0043	10%	4	11% of data is BDL
	Vegetated, Wet Swale 500 ft				
	Outlet	BMP	% Eff		Remarks
PGD 2-3	0.0041	0.0036	12%	9	22% of data is BDL

Test Sites	Load Reduction Efficiency for LEAD (Pb) NOTE: All loads in kg/ha-yr				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.0220	0.0120	45%	10	36% of data is BDL
SRQ 1-2	0.0470	0.0130	72%	8	18% of data is BDL
SGJ 3-4	0.0140	0.0050	64%	8	75% of data is BDL
TPA 1-2	0.0230	0.0080	65%	10	Four Events 100% infiltrated, 30% of data is BDL
Average			61%	36	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.0220	0.0070	68%	10	27% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	0.1640	0.0180	89%	10	43% of data is BDL

Test Sites	Concentration Reduction Efficiency for ZINC (Zn) NOTE: All concentrations in mg/L				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	0.1682	0.0210	88%	10	13% of data is BDL
SRQ 1-2	0.0540	0.0273	49%	3	Six Events 100% infiltrated
SGJ 3-4	0.0151	0.0160	-6%	8	25% of data is BDL
TPA 1-2	0.1025	0.0268	74%	6	Four Events 100% infiltrated
Average			53%	27	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	0.1808	0.0162	91%	9	13% of data is BDL
	Dry Retention Pond				
	Pavement	BMP	% Eff		Remarks
VNC 1-2	0.2208	0.021	90%	1	
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	0.3133	0.0581	81%	10	
	Oil - Water Separator				
	Pavement	BMP	% Eff		Remarks
TLH 2-3	0.0619	0.0391	37%	10	
	Sediment Box				
	Pavement	BMP	% Eff		Remarks
PGD 1-2	0.1065	0.0265	75%	4	22% of data is BDL
	Vegetated, Wet Swale 500 ft				
	Outlet	BMP	% Eff		Remarks
PGD 2-3	0.0281	0.0125	56%	9	22% of data is BDL

Test Sites	Load Reduction Efficiency for ZINC (Zn) NOTE: All loads in kg/ha-yr				
	Overland Flow 25 ft				
	Pavement	BMP	% Eff	Samples	Remarks
MCO 1-2	1.0990	0.1600	85%	10	9% of data is BDL
SRQ 1-2	0.6720	0.0740	89%	8	Six Events 100% infiltrated
SGJ 3-4	0.1900	0.0500	74%	8	25% of data is BDL
TPA 1-2	0.6890	0.0820	88%	10	Four Events 100% infiltrated
Average			84%	36	
	Overland Flow 50 ft				
	Pavement	BMP	% Eff		Remarks
MCO 1-3	1.0990	0.0620	94%	10	11% of data is BDL
	Grassed Dividers 5 to 10 ft				
	Pavement	BMP	% Eff		Remarks
VNC 5-6	2.2870	0.1510	93%	10	20% of data is BDL