BROADWAY OUTFALL STORMWATER RETROFIT PROJECT

Department of Environmental Protection
Contract Number WM793

In cooperation with:
Southwest Florida Water Management District
Project Number W241
and the
City of Temple Terrace

Phase II
Monitoring CDS Unit and Constructed Pond
Final Report

Submitted by
Betty Rushton, Ph.D.

Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34604

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Phase II
Monitoring CDS Unit and Constructed Marsh
Progress Report for Year One

Submitted by
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June 2006

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ABSTRACT

A major storm drain pipe was retrofitted with a CDS unit followed by a linear pond to help treat stormwater discharged from an urban drainage basin in Tampa, Florida. The CDS non-blocking screening, swirl concentrating technology design has a capacity to remove sediment and large sized particles such as litter, leaves, twigs, sand and paving residue from storm runoff. Results of this research suggest that it removes these gross solids very well, but it does not remove the dissolved and suspended particles present in the water column. The CDS unit did remove levels of polycyclic aromatic hydrocarbons (PAHs) at concentrations many times higher than levels considered toxic to benthic organisms. Since PAHs do not easily dissolve in water, they are rarely measured in storm water quality studies, but are considered a serious problem in sediments in portions of Tampa Bay. Much more material would have been collected by the CDS unit except street sweeping occurred on a regular schedule in the basin except when there was a problem with the street sweeper.

Wide variations were measured in the constituent concentrations of the material collected by the CDS unit, especially between samples that had been sieved, which showed much higher concentrations than whole samples. Also the same samples when analyzed by different laboratories showed significantly different concentrations. These results indicate standardized methods need to be established for quantifying gross solids.

The water quality data collected in the flow traveling through the CDS unit did not support the idea that the leaves collected by the unit leached nutrients and increased their concentrations in the water downstream, but this result may be influenced because leaching had already occurred while the leaves and water traveled through the storm drain together. If litter and large sized particles are the pollutants of concern in a drainage basin, a CDS unit is a good solution, but if dissolved or suspended particles, especially nutrients, are a problem, a CDS unit will not reduce those pollutants. A CDS unit is probably best suited as the first element in a series of stormwater treatment methods.

The small shallow pond constructed down stream from the CDS unit was monitored to determine if it might provide additional treatment. The pond could not be built according to specifications for a regulation stormwater pond because not enough land was available in this urban area, but it did improve some conditions. It reduced nitrate nitrogen 76 to 93 percent in base flow and about 20 to 60 percent in storm flow. Copper and zinc were reduced by 30 to 60 percent in storm flow. However, ammonia, total suspended solids, organic nitrogen and chlorophyll were greatly increased as water flowed through the pond. This was probably exacerbated by the uprooted plants caused by the storm surges. The pond was effective at reducing the amount of coliform bacteria from dangerously high concentrations measured before and after water passed through the CDS unit to acceptable levels before it left the site.

The pond served as an attractive wildlife amenity in this urban setting and was actively used by wading birds, hawks, and turtles.

INTRODUCTION

Urban development alters the quantity and quality of storm water runoff including changes in the rates, volumes, frequency, physical characteristics and pollutants in the discharge water. These changes have a serious impact on the health of receiving waters. In recognition of these problems governmental agencies in Florida began to regulate surface runoff in new developments in the early 1980s, but older neighborhoods continue to discharge stormwater untreated to our rivers, lakes and estuaries. This was the situation at the Broadway storm sewer, where the 132-acre watershed lacked any proven Best Management Practices such as ponds that would allow suspended contaminants an opportunity to settle out from the water column or for biological processes to take place prior to discharge into the Hillsborough River, the City of Tampa's drinking water reservoir and ultimately Tampa Bay.

The SWFWMD SWIM staff has identified Tampa Bay as the number one water body in need of protection in our area. The mission of the SWIM program is to protect, enhance, and restore water quality and related natural systems. Since 1990, the SWFWMD's SWIM Program has been implementing numerous projects to improve water quality in the Hillsborough River watershed and the Broadway Outfall retrofit is one of these projects

The project was designed to reduce the amount of pollution discharged to the Hillsborough River by installing a CDS unit and a constructed linear pond at a major storm sewer outfall. The CDS technology is designed to remove gross pollutants such as litter, leaves, twigs, sand and pavement residue from storm runoff. According to the company, the device is non-blocking and non-mechanical and is capable of capturing 95 to 100 percent of waterborne litter. In addition, tests have shown that the screen aperture size does not appear to be a critical factor to the performance of the CDS unit and solids, which are smaller than the aperture size of the separation screen, are also captured (Wong et al. 1996). Studies have also shown that the unit is effective for removing oil and greases by 63 to 96 percent when sorbents are added (Stenstrom and Lau 1998).

The Broadway Outfall retrofit project consists of two phases. Construction of the retrofit (Phase I) was completed in November 2001; and the evaluation effort (Phase II), was initiated in November 2002. Monitoring at the site is designed to determine how well the system removes pollutants before they are discharged to the Hillsborough River. Specifically, the project will measure: 1) how much and what kind of gross solids (>75microns) are collected by the CDS unit, 2) the concentration of constituents in the flow stream for the suspended and dissolved particles (< 75 microns), 3) the accumulation of pollutants in the sediments of the pond, 4) the characterization of the macroinvertebrates in the sediments of the pond, and 5) the hydrology of the system including storm flow, base flow and rainfall.

This report contains the results of the monitoring effort (Phase II).

METHODS

SITE DESCRIPTION

The drainage basin that discharges through the Broadway Outfall storm sewer is approximately 132.4 acres in size and includes a 30.6-acre high intensity commercial district immediately upstream from the site. The remainder of the watershed includes multi-family and residential land uses as well as a golf course and major urban thoroughfares. As part of the Broadway Outfall Stormwater Retrofit Project a Model PSW100_60 (32 cfs capacity) CDS unit was installed in series with an excavated sediment sump followed by a shallow linear marsh system, extending approximately 500 feet downstream from the unit. For the first year of the monitoring project, strong storm surges uprooted the marsh vegetation and created an open water area acting like a shallow pond. A later re-vegetation effort met with the same fate. It was recognized before construction that there was not enough land elevation in the drainage basin to install a CDS unit larger than 32 cfs capacity; and also not enough land area in this highly urbanized basin to build a pond to adequately treat the storm runoff. But it was expected that the installation would improve water quality being discharged to the river. A general location map of the project area and major highways is shown in Figure 1 and Appendix A. A diagram of the study site shows the location of the monitoring stations (Figure 2).

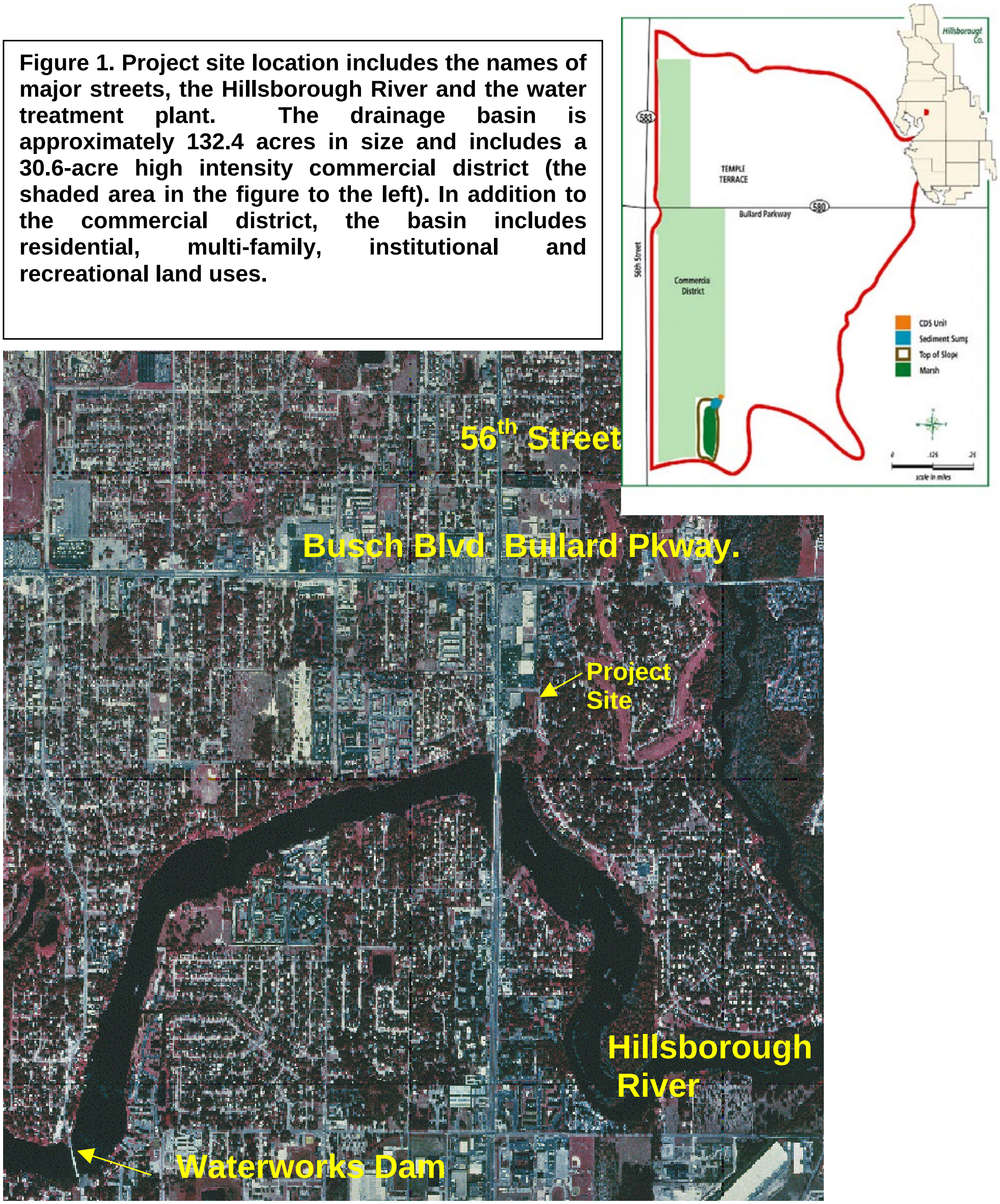
To collect litter, sediment and debris, a CDS unit was installed to reduce the gross solids transported through this urban basin and discharged into the Hillsborough River. Since these large particles degrade aquatic habitat, interfere with drinking-water treatment processes and affect recreational uses, the U.S. Environmental Protection Agency (USEPA 1998) has identified sediment as the most widespread pollutant in the Nation's rivers and streams. A CDS unit is designed to solve the problem of sediment transport by intercepting storm runoff in the conveyance pipe system. An added advantage for built out urban areas is the under ground installation that requires no land area. The mechanism by which the unit separates and retains gross solids is by deflecting the inflow and associated pollutants away from the main flow stream into a pollutant separation and containment chamber. A vertical section view (Figure 3) shows the dimensions of the CDS unit.

The CDS chamber is cleaned out one to two times a year with a vacuum truck and the gross pollutants are sent to a landfill or disposed of in some other appropriate manner. Gross solids have not usually been measured in storm water studies even though they degrade aquatic habitat, cause visual blight and smother productive sediments. This oversight is attributed to the type of water quality samplers commonly used. These samplers generally exclude solid material including trash, litter, debris and sediments larger than 64 microns. In the past, it has also been assumed that most of the pollutants were associated with the small sized particles that are collected with automatic samplers.

HYDROLOGY MEASUREMENTS

Hydrology was characterized using continuous sensors at three locations in the stormwater system. Flow was calculated from water level measurements, velocity meters and weir structures. Stations were located both in front of the CDS unit and the bypass diversion weir (location A, sta 934), and after the CDS unit (location B, sta 935) as shown in the plan view in Figure 3.

Figure 1. Project site location includes the names of major streets, the Hillsborough River and the water treatment plant. The drainage basin is approximately 132.4 acres in size and includes a 30.6-acre high intensity commercial district (the shaded area in the figure to the left). In addition to the commercial district, the basin includes residential, multi-family, institutional and recreational land uses.



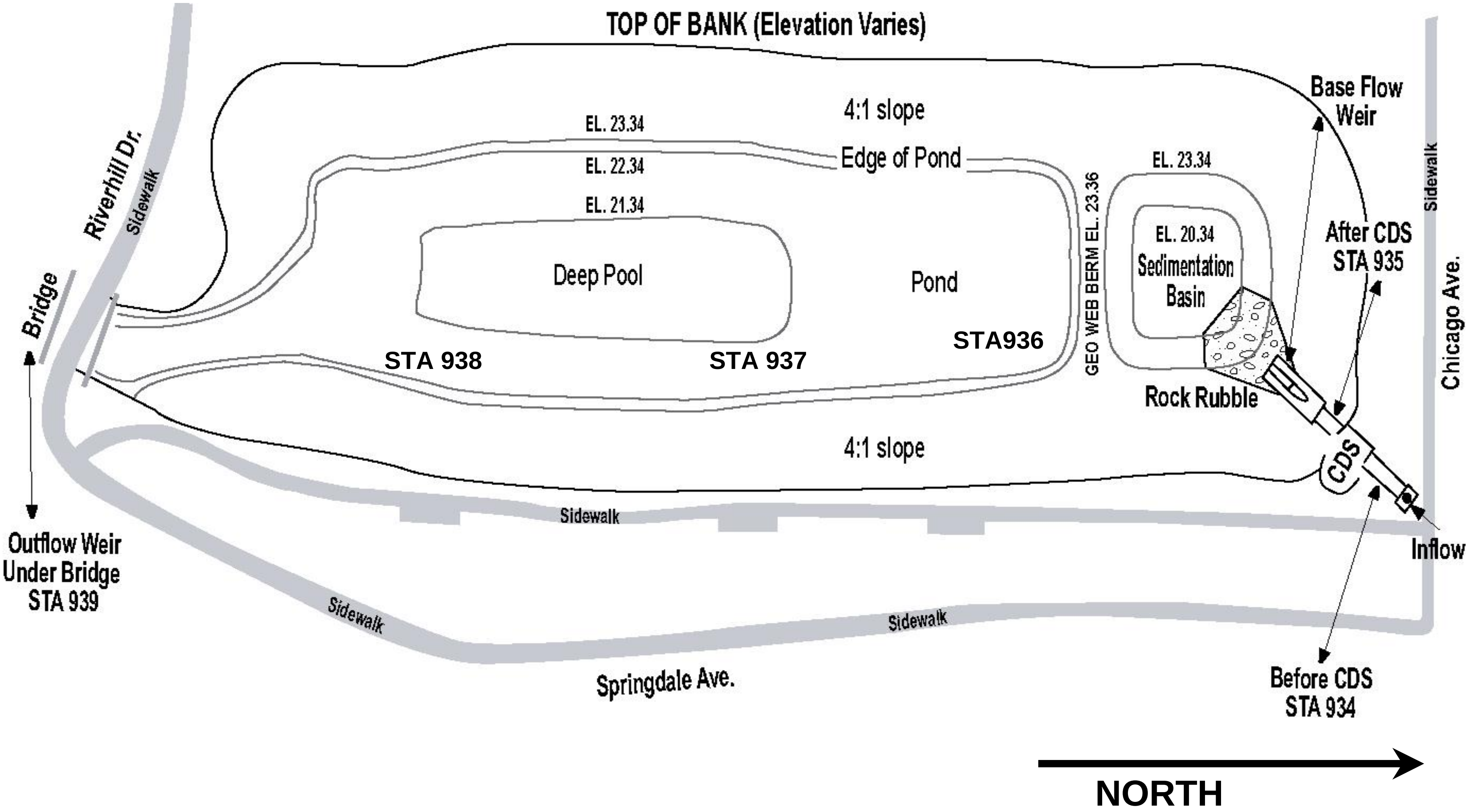
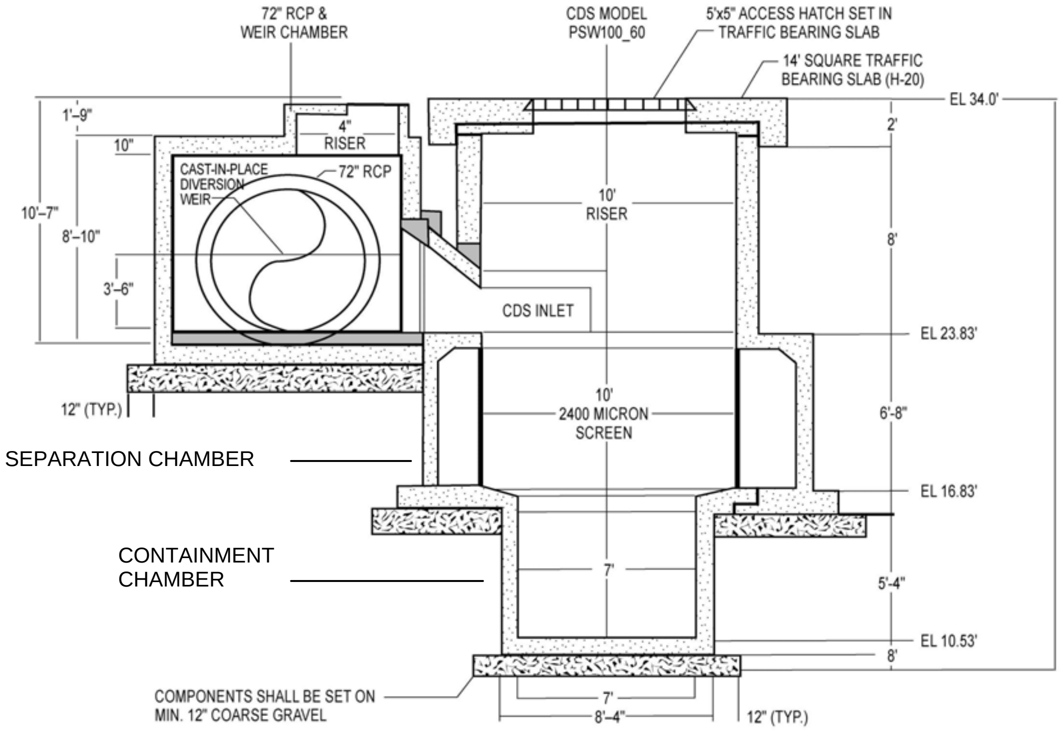
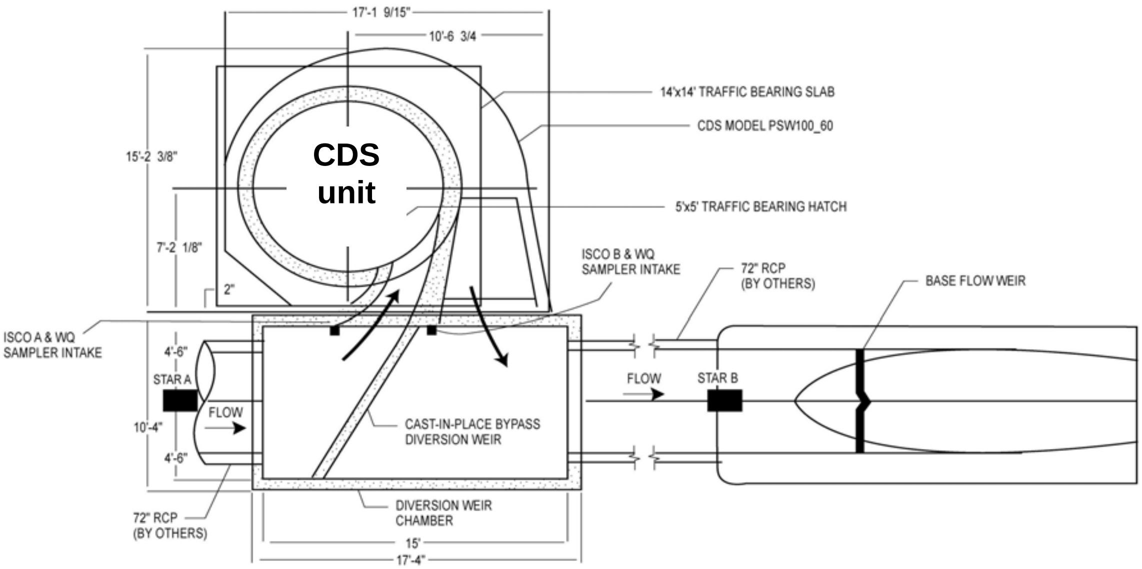


Figure 2. The site plan shows the location of sampling stations and sensors. Elevations are national geodetic vertical datum (NGVD) or essentially the elevation above mean sea level. Since sediment samples could not be collect in the pipe (sta 935) or under the bridge (sta 939) sediment and microinvertebrate samples were collected slightly down stream of sta 935 (beyond the rock rubble) and upstream of sta 934.



Vertical Section



Plan view

Figure 3. Diagrams of Continuous Deflective Separation (CDS) unit and the associated pipe with diversion by pass weir.

Flow and Level - It was assumed that flow both before and after the CDS unit would be the same since there was no way for water to leave the closed CDS system except over the bypass diversion weir or through the unit. The level at location A was used to measure the water that by-passed the CDS unit when water level was higher than 3.5 feet in the weir chamber. A sensor at location B measured velocity, which was multiplied by the area of the pipe to calculate flow for water levels greater than 0.6 feet. The base flow weir equation was used for levels less than 0.65 feet for both storm and base flow (See figure 3). Flow at the outfall of the pond (sta. 939) was calculated using a three-stage weir structure formula and a water level sensor. Flow and level data were monitored and recorded on a continual basis by electronic CR10™ data loggers. Diagrams with all the dimensions of the weirs and their formulas are shown in Appendix A.

Almost all methods for calculating flow, including those used in this project, require the most accurate measurement possible for water depth. Small differences in depth measurements create large errors in flow measurements since most of these equations use mathematical functions that increase errors exponentially. Another problem exists because many water level sensors drift over time, become covered in sediment or trash during storm events, or in the case of bubblers have algae growth inside the tubing. For the first 15 months, this project used two different sensors to measure water depth at the inflow: 1) An ISCO™ bubbler flowmeter (model 4230), and 2) A starflow™ ultrasonic Doppler velocity meter with SDI output which has a velocity range of 15 fps and level range of 6.6 feet. In order to try to keep errors to a minimum, the study site was visited three times a week during the rainy season and levels were compared to a stationary staff gauge during some site visits. Telephone contact with the site helped identify problems between visits.

After 16 months the original Starflow™ velocity meter quit working and efforts to repair it were unsuccessful, it was replaced with an old Marsh McBirney™ meter we had used in previous applications. (Institutional regulations made purchasing a new velocity meter nearly impossible). In addition to adapting the Marsh McBirney, two formulas were developed to estimate flow. A regression equation was used to estimate flow from water level using the good data collected during the first year of the study. This method is described in detail in Appendix A and is referred to in the hydrographs in Appendix D as "REGRESS". A different equation was developed by treating the base flow weir as a rectangular weir during storm flow and multiplying this by the area of the water in the pipe. This equation is also described in more detail in Appendix A and is referred to in the hydrographs as "BF FORMULA". The base flow formula under represented high flows because no adequate method was developed to resolve the area when the length of the weir decreased again after the pipe was more than half full. An equation was used for the area of the pipe when the regression (REGRESS) was used for flow. The Marsh McBirney could never be relied on to produce realistic data; therefore, the final 20 months mainly rely on the two formulas described above for flow measurements during storm events.

Another problem that made flow measurements difficult was caused by discrepancies in water level measured by the two sensors (Isco and Starflow). Although they read almost identical levels during low flow when we could check the results, they did not usually agree during maximum flow when water levels were changing rapidly. Often the ISCO level B meter cut off the top of the hydrograph at high flow. A regression equation from the first year of good data produced by the Starflow sensor was developed to account for this problem by relating level A before the bypass weir to level B after the bypass weir. Once again, see Appendix A for a more complete discussion.

Recognizing that we had problems with sensors, a monthly water budget was calculated that also included baseflow and the outflow from the pond. A 1 to 3 percent error was noted on a yearly basis for years one and three and a 9 percent error was noted during year two when broken pipes introduced unmeasured flow into or sometimes out of the pond and when several hurricanes passed through the region causing power outages. (Appendices C and D show these results).

Rainfall Measurements - were collected at the site with a tipping bucket rain gauge. The data from the rain gauge are transmitted to a data logger using a pulse counter where each tip of the bucket represents 0.01 inch of rainfall. Rainfall accuracy is affected by wind effects, rain splashing out of the gauge during high-intensity storms, tipping rate of tipping bucket not keeping up with high-intensity rains and calibration errors. To reduce calibration errors, we test the accuracy of the rain gauge by using a graduated cylinder from our laboratory to measure tips by the method listed in the operation manual. The gauge exposure and placement were selected to reduced measurement errors by keeping the gauge low, behind a fence and yet with 45^o open space in all direction. A telephone connection to the data logger allows the technician to access real time rainfall and determine the necessity for a site visit.

Rainfall amount, antecedent dry conditions, intensity and duration are calculated from this data using the following formulas:

Rain (in)	rainfall amounts for each event >0.05 inches (6 hours separates storms).
Inter-event dry (hr)	time period since previous rain event
Duration (hr)	period of active rainfall
Intensity (in/hr)	total event rainfall / duration
Max. intensity	a 15-minute period during the storm with the highest maximum intensity (in/15 min)
Runoff coefficient	inflow (ft^3) / rain amount (ft)*basin area (ft^2)

Data Loggers - (Campbell Scientific model CR10™) collected and stored information collected by the sensors. Sensor information is scanned every minute and reported at 15-minute intervals for later retrieval. The data were processed in EXCEL™ spreadsheets where they were organized into tables and figures for reports.

WATER QUALITY

Rainfall - water quality was sampled using An Aerochem Metric^{tm} model 301 precipitation collector. This equipment has a sensor that detects the occurrence of precipitation and activates a motor. The motor removes the lid from the wet collector and transfers it to the dry collector and when the rain stops the cycle is reversed. A small refrigerator mounted under the collector stores the sample until it is picked up, processed and transported to the laboratory. Dry fall is not measured. The rain bucket is washed and rinsed three times with DI water after each rain event and taken to the laboratory and acid washed on a schedule determined by rain events. The tubing from the rain bucket into the refrigerator is changed about every three months or more often if necessary.

Stormwater and Base Flow – water quality samples were collected on a flow-weighted basis at the inflow and outflow of the CDS unit and at the outflow of the pond using automated refrigerated (ISCO 3700) samplers. Since most velocity meters do not measure low flow less than 1 cfs, the flow-weighted samples were actually based on water level. For storm events, the actual number of samples collected depended on rainfall conditions. About once or twice a month base flow constituent concentrations were estimated by taking flow-weighted samples over several days between storm events. For the last 18 months of the three-year study, separate refrigerated samplers were installed to collect base flow. Before that time, they were collected by the same samplers and great care and some guess work had to be used to keep base flow out of storm samples. Even so, the cross-contamination should not be great because samples were collected on a flow-weighted basis so that much more sample was collected at high flows than during base flow. When the laboratory values were below the quantification limit, as often happens with metals, one-half the detection limit was substituted for summary statistics used in figures and tables.

The SWFWMD laboratory performed water quality analysis using methods published in their approved quality assurance plan. Grab samples were taken for some constituents that cannot be collected by automatic samplers. Filtered samples were collected and processed in the field at the same time as the rest of the samples for zinc, lead and copper. Once samples were processed with the appropriate reagents, they were transported to the laboratory on ice where laboratory personnel signed off on the chain of custody form. A summary table for the water quality sample protocol can be found in Table 1.

Table 1. Summary table explains water quality sample protocol.

Measurement	Vol ml	Glass Plastic	Preservation	Holding time	Sample Type	Sample Event
Nutrients	500	P	H_2SO_4 pH<2.0	28 days	C, G	S, B, O
Metals	250	P	HNO_3 pH<2.0	6 month	C, G	S, B, O
Suspended solid	1000	P	None	5 days	C, G	S, B, O
Hardness+	500	P	None	6 months	C, G	S, B, O
Chlorophyll	1000	P	None	6 hrs	G	O
Bacteria	300	P	None	6 hrs	G	O
Macro-invertebrates	na	Whirl packs	>10% formalin	8 hrs ice >8hrs for	G	O
Organic Carbon	40	G	HCL/H_2SO_4		G	O

Abbreviations: C=composite, G=grab, S=storm event, B=base flow, O=other.

A description of the laboratory methods and detection limits is in Table 2.

Table 2. Description of laboratory analysis for parameters measured in the water column. References refer to sections in Standard Methods (APHA 1992) or (EPA 1983), where more detailed descriptions can be found. When values were below the laboratory detection limit, one-half the detection limit was substituted.

Parameter	Method after May 2003	Det. Limit	Reference
Total Suspended Solids	Total filterable residue dried at 103-105^o C	0.5 mg/l	SM 2540 D
Total and dissolved lead	ICP-OES	0.010 mg/l	EPA 200.7
Total & dissolved copper	ICP-OES	0.003 mg/l	EPA 200.7
Total cadmium	ICP-OES	0.001 mg/l	EPA 200.7
Total and dissolved zinc	ICP-OES	0.002 mg/l	EPA 200.7
Total and dissolved iron	ICP-OES	0.0125 mg/l	EPA 200.7
Ammonia-N	Automated phenate	0.005 mg/l	SM4500 NH3-H
Total nitrogen	Potassium persulfate auto clave	0.03 mg/l	EPA 353.2 SM4500 MC
Nitrate-nitrite-N	Cadmium reduction	0.0025 mg/l	EPA 353.2
Total Phosphorus	Ammonium persulfate auto clave	0.01 mg/l	EPA 365.1
Ortho-phosphorus		0.01 mg/l	SM 4500-P-F
Calcium	ICP-OES	0.25 mg/l	EPA 200.7
Magnesium	ICP-OES	0.25 mg/l	EPA 200.7

QAPP Appendix_AR_TABELS

SEDIMENT SAMPLES

Sediment characteristics were monitored by evaluating samples collected at locations along the treatment path in the pond and in the ditch below the pond. Sediment Samples were collected before construction of the retrofit on May 2, 2001, again at the beginning of the monitoring study in August 2002, and near the end of the study in August 2004. The FDEP laboratory analyzed the sediment samples using methods in their approved QA/QP plan. Samples were collected at four to five sites located within the retrofit site.

Protocol - A sediment corer was used to collect the top five inches of sediment. About five aliquots are taken in close proximity to each other at each sampling location in order to collect enough sediment for sample analysis. The separate aliquots were well mixed using a modified four-corner method and placed in appropriately labeled containers, placed in ice in coolers and mailed over night to the laboratory in Tallahassee. Only stainless steel or glass equipment is used.

Sediment Quality - Samples were analyzed for particle size, total Kjeldahl nitrogen, total phosphorus, total lead, total zinc, total iron, total cadmium, polycyclic hydrocarbons, and pesticides.

Table 3. Numerical sediment quality assessment guidelines for Florida Inland waters (FDEP 2003). TEC=Threshold Effect Level, PEC=Probable Effect Level.

CONSTITUENT	**units**	**possible**	**probable**
Classification* ➔		**TEC**	**PEC**
METALS			
Cadmium	mg/kg	1.0	5.0
Chromium	mg/kg	43	110
Copper	mg/kg	32	150
Lead	mg/kg	36	130
Nickel	mg/kg	23	49
Zinc	mg/kg	120	460
POLYCYCLIC AROMATIC HYDROCARBONS			
Acenaphthene	ug/kg	6.7	89
Anthracene	ug/kg	57	850
Phenanthrene	ug/kg	200	1200
Benz[a]anthracene	ug/kg	110	1100
Benzo(a)pyrene	ug/kg	150	1500
Chrysene	ug/kg	170	1300
Dibenz[a,h]anthracene	ug/kg	33	140
Fluoranthene	ug/kg	420	2200
Pyrene	ug/kg	200	1500
Total PAHs	ug/kg	1600	23000
PESTICIDES			
Chlordane	ug/kg	3.2	18
DDD	ug/kg	4.9	28
DDE	ug/kg	3.2	31
DDT	ug/kg	4.2	63
Diazinon	ug/kg	0.38	NG

GROSS SOLIDS

The material collected by the CDS unit was analyzed each time the unit was vacuumed out. The unit was installed in December 2002 and the level in the unit is measured each month and cleanout performed when the material is about 5 to 6 feet deep.

Sampling Equipment - includes a vacuum truck for cleaning out the sump, a measuring device that includes a 6-inch disk rigidly fastened to a pole to estimate distance to the solids, and an Ekman dredge for collecting samples at different depths while the unit is being vacuumed out. It was noted that the Ekman dredge often was unable to close completely because leaves became attached to its jaws leaving a slit where some of the material was lost while it was being transferred into the collection bucket.

Gross Solid Quality - Gross solids are the litter, leaves, trash and sediment that are collected by the CDS unit. Based on accumulation and maintenance requirements, clean-out was required once or twice a year. During some sampling events the pollutants were analyzed by particle size and for some events only one to two representative samples were tested using the entire sample. Columbia Analytical Laboratory performed the analyses for: particle size, bulk density, total phosphorus, total Kjeldahl nitrogen, total copper, total lead, total zinc, total nitrogen, organic matter, total organic carbon and Polycyclic Aromatic Hydrocarbons. Considerable variation was noted between clean-out periods and also between analytical methods (whole vs. sieved samples). For the final clean-out, samples were sent to two different labs for comparison. In addition, since the Ekman dredge appeared to lose some sample through the slit while it was being transferred to an adjacent bucket, the final clean-out period included samples taken the next day from the disposal pile. The amount of leaves in the sample kept the Ekman from closing properly.

The Floating Litter - collected by the CDS unit was skimmed off the top about once a month and this is combined with the litter in the gross solids at time of clean-out to quantify the type and dry weight of the trash collected. The material is air dried under cover before being sorted and weighed. A misunderstanding caused some litter to be disposed of without being included for the third cleanout period and no litter was analyzed for the final cleanout period.

MACROINVERTEBRATES

Macroinvertebrates were evaluated by monitoring pre- and post-construction macroinvertebrate samples. The identification of macroinvertebrates is performed by Mote marine Laboratory. They provide a phylogenetic list of taxa with counts for each of the sediment stations and summarize the data with appropriate statistics such as the Shannon, Pielou, Margalef and Simpson metrics

Sampling Method - Macroinvertebrates were collected using the sampling procedure in the Mote Marine (MML) approved quality assurance plan. Samples were collected by SWFWMD technicians and sent to the Mote Marine laboratory for identification and analysis. Sampling kits are ordered from MML. Sampling sites correspond to the same locations as the sediment samples.

Invertebrate Sampling - Benthic macroinvertebrates were collected on four sampling dates and included four sites in the pond.. Samples were collected with a 6-inch by 6-inch Ekman dredge and sieved in the field using a #30 (250 *u*m) standard testing sieve. The organisms retained were placed into 4-liter Nalgene bottles, preserved with 10 percent formalin, and stained with rose Bengal. In the laboratory, organisms were sorted in white enamel pans and identified to genus and species using a variety of taxonomic keys. The Bengal solution is ordered from the SWFWMD lab. The lab prepares the solution using the following procedure: a calibrated syringe measures quantities of 100 percent buffered formalin-rose Bengal solution necessary to bring the contents of each sample jar to 10 percent formalin by volume.

Macroinvertebrate assemblages were evaluated using the Shannon-Weaver diversity Index and the equitability measurement. Diversity indices provide information on the effects of environmental stresses on biological communities, and values calculated for macroinvertebrate assemblages are often used to characterize water or sediment quality (USEPA 1973). The Sannon Weaver Diversity Index is based on information theory and takes into consideration the number of species (or taxa) present and the relative abundance of each species (or taxon). Species diversity can be calculated according to:

$$H= -\sum_{i=1}^{S}(p_i)(\log_2 p_i)$$

where H = the diversity index
s = the observed species
i = the species number
p_i = proportion of individuals of the total sample belonging to the *i*th species

The Shannon-Weaver Diversity Index has been used to determine diversity in polluted and unpolluted bodies of water. It has been estimated that unpolluted water typically has a diversity index between 3 and 4 and where in polluted water diversity measure is less than 2 in polluted water (Wilhm 1970).

The equitability measurement is used to describe the component of diversity which may be attributed to the "evenness" of the distribution of the total number of individuals among the species (or taxa) present. A measure of equitability, which is calculated as:

$$E' = H/H_M$$

where E’ = equitability
H =the observed species diversity.
H_M =the maximum species diversity based on the number of species in the sample.

The equitability measurement is more sensitive to pollution than the Shannon-Weaver Diversity measurement (EPA 1973) and usually ranges from 0 to 1. The equitability measurement ranges from 0.6 to 0.8 in unpolluted streams and 0.0 to 0.3 in polluted streams (Odum, 1983).

RESULTS AND DISCUSSION

An urban retrofit for treating stormwater runoff was constructed at the Broadway Outfall storm sewer during the autumn of 2001. It included the installation of a 32 cfs Continuous Deflective Separation (CDS) system in series with a shallow constructed pond, which is used for additional stormwater treatment. In November 2002, an evaluation study was initiated to document the ability of the system to remove pollutants. Below are the results of the three-year data collection effort.

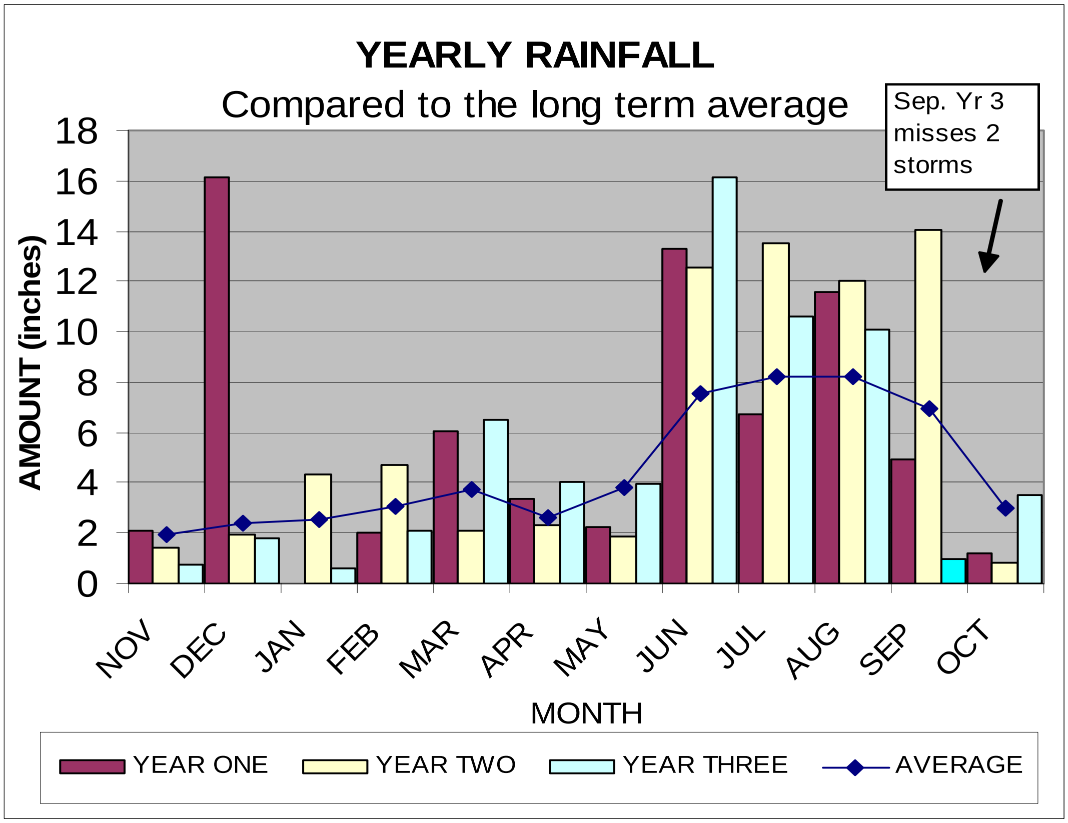
HYDROLOGY

Continuous monitoring sensors at the inflow and outflow of the stormwater retrofit stored rainfall data and water level information in data loggers to use for characterizing the hydrology of the system. Formulas were also developed to verify the data and to estimate hydrology values during periods of equipment failure.

Rainfall Amounts

Florida normally has wet and dry seasons with sixty percent of all rainfall occurring during the four summer months between June and October. The different storm patterns occurring in summer and winter are the result of atmospheric currents from both the tropics and temperate latitudes caused by changes in the global wind belts. Seasonal wind changes bring the Tampa Bay region within the westerlies in winter and the northern margin of the tropical easterlies in summer. The summer rainy season is the result of this changeover. In June the upper flow over the Florida peninsula changes from northwesterly to southerly as a trough moves westward and becomes established in the Gulf of Mexico (Barry and Chorley 1976). This deep moist southerly airflow provides appropriate conditions for convective storms. When this air passes over land, it is heated during the day, lifted aloft and as it rises the water vapor within it condenses, clouds form and convectional storms bring rainfall. These conditions help make Tampa an area of intense thunderstorm activity. Also in summer, some easterly waves from the tropics may intensify and organize into circular motion resulting in tropical storms and hurricanes bringing several days of rain. In the winter the weather is mostly controlled by frontal activity from the North. Since frontal storms rarely make it this far south in the spring and fall, these are usually dry months, especially in the fall (October – November) and spring (April – May). El Nino years can change this typical pattern.

Rainfall was above its normal amount of 52 inches per year during the three years of the study (Figure 4). During year one, no rain fell in January, but a record amount (16.16 inches) fell during December. El Nino conditions also helped increase rainfall for the year. In year two, four hurricanes came through Florida increasing rainfall amounts to levels far above the normal long-term average, while other months most often measured below average rainfall. Year three had the least amount of rainfall, but it was still above the long-term average.



D:\BROADWAY/RAIN

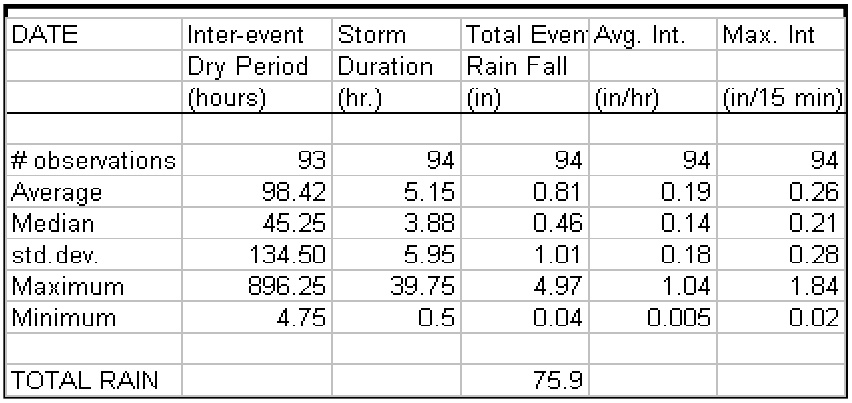
Figure 4. Rain amount (inches) for each month during the study period compared to the long-term average for the region.

Rainfall Characteristics

Accurate monitoring of precipitation intensity and total accumulated precipitation are necessary for planning, design, collection and interpretation of results for stormwater studies. These characteristics are not only relevant to water quantity issues where they affect flooding and peak discharge, but also to water quality impacts where they can affect constituent concentrations and pollutant removal efficiency. Antecedent conditions (inter-event dry period) and rainfall intensity may increase pollutant concentrations by providing time for accumulation on land surfaces as well as the rain energy to flush pollutants through the system.

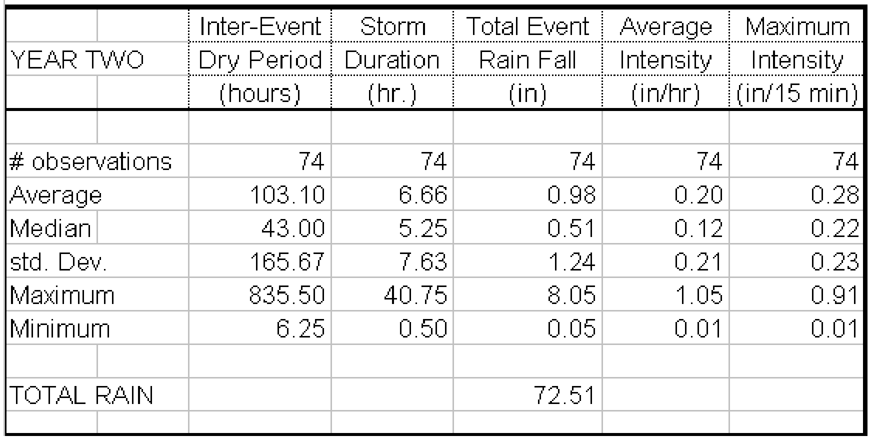
The summary statistics in Table 4 include data for the three years of data collection and represent most storms greater than 0.05 inches. All of the data for each storm event are in Appendix B. The data only include the active part of the storm and not the trailing 0.01 inch drips that are characteristics of some storms. Also electrical outages during thunderstorms sometimes interrupted data collection. Therefore the results may not reflect the rainfall amounts reported by weather stations that include all storms and all drips or even the amount reported in other parts of this report.

Table 4a. Summary of rainfall characteristics calculated for storms > 0.05 inches from October 2002 through October 2003. (See Appendix B for all of the data).



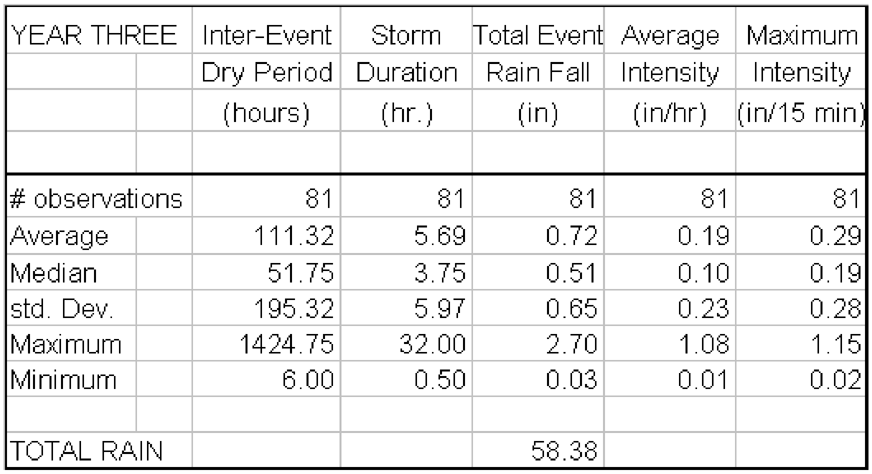
DATE	Inter-event	Storm	Total Even	Avg. Int.	Max. Int
	Dry Period	Duration	Rain Fall		
	(hours)	(hr.)	(in)	(in/hr)	(in/15 min)
# observations	93	94	94	94	94
Average	98.42	5.15	0.81	0.19	0.26
Median	45.25	3.88	0.46	0.14	0.21
std.dev.	134.50	5.95	1.01	0.18	0.28
Maximum	896.25	39.75	4.97	1.04	1.84
Minimum	4.75	0.5	0.04	0.005	0.02
TOTAL RAIN			75.9		

Table 4b. Summary of rainfall characteristics calculated for storms > 0.05 inches from October 2003 through October 2004. (See Appendix B for all of the data).



	Inter-Event	Storm	Total Event	Average	Maximum
YEAR TWO	Dry Period	Duration	Rain Fall	Intensity	Intensity
	(hours)	(hr.)	(in)	(in/hr)	(in/15 min)
# observations	74	74	74	74	74
Average	103.10	6.66	0.98	0.20	0.28
Median	43.00	5.25	0.51	0.12	0.22
std. Dev.	165.67	7.63	1.24	0.21	0.23
Maximum	835.50	40.75	8.05	1.05	0.91
Minimum	6.25	0.50	0.05	0.01	0.01
TOTAL RAIN			72.51		

Table 4c. Summary of rainfall characteristics calculated for storms > 0.05 inches from October 2004 through October 2005. (See Appendix B for all of the data).



YEAR THREE	Inter-Event	Storm	Total Event	Average	Maximum
	Dry Period	Duration	Rain Fall	Intensity	Intensity
	(hours)	(hr.)	(in)	(in/hr)	(in/15 min)
# observations	81	81	81	81	81
Average	111.32	5.69	0.72	0.19	0.29
Median	51.75	3.75	0.51	0.10	0.19
std. Dev.	195.32	5.97	0.65	0.23	0.28
Maximum	1424.75	32.00	2.70	1.08	1.15
Minimum	6.00	0.50	0.03	0.01	0.02
TOTAL RAIN			58.38		

Table 4 reveals that the rainfall characteristics for the three years show similar patterns. The large differences seen between the average and median values indicate the lognormal distribution of storm events with a few large storms skewing the average results. It should be noted that during the summer of year two, three hurricanes swept through the region increasing average rainfall amount and storm duration, but not median rainfall values. The differences seen in the amount of time between storm events appear to be the result of the amount of rainfall recorded. There was essentially no difference between average storm intensity between years.

Storm intensity, depth, duration and frequency may affect stormwater quality, but research results are mixed about their impact. Some researchers have found no correlation between the length of the dry antecedent period, but have found that the more intense storms carried a greater loading than less intense events of the same volume (Minton 2005). Flow velocities have been found to increase the amount and size of sediment removed from the pavement and this should have an affect on the material collected by the CDS unit in this study. The type of runoff collection system in the drainage basin also affects the type of runoff. Sheet flow exhibits lower velocities than gutter flow for the same flow amount and curbed roads produce even higher velocities (Minton 2005). Underground pipes probably have the same effect. In the large drainage basin served by the Broadway Outfall, all these factors are at work, but the fluctuations in pollutant concentrations during a storm are moderated by the large longitudinal dispersion in the drainage system.

The size of the storm also affects pollutant concentrations as described for an area in Milwaukee (Burton and Pitt 2002). Small rains (less than 0.5-in) represent the vast majority of rain events that occur and probably represent the majority of violations associated with wet-weather flows. Medium-sized storms (0.5-in to several inches) contribute the majority of runoff volume and mass pollutant discharges and probably the most adverse biological effects in receiving waters. The largest rains are the primary focus of drainage designs and must also be accounted for.

WATER LEVELS

To evaluate hydrology in stormwater studies accurately, one of the most crucial measurements is measuring the height of the water level correctly where the sensors are located. Since flow measurements are calculated from weir structures by using complicated formulas, which often include two and three part weir structures, errors are increased exponentially and can differ by orders of magnitude from level measurement that differ by as little as 0.04 feet. Accurate flow measurements are especially critical since the data are used in the calculation for constituent loads, which in turn estimate the efficiency of the stormwater system to remove pollution.

Water level data are also helpful in identifying activities in the watershed, comparing instruments, and determining the overall responses of the system. Since water level is such a crucial parameter for correctly analyzing how storm water systems work, considerable effort was spent inspecting this data. As an added precaution, two level sensors were used to evaluate water levels in front of the CDS unit, after the CDS unit and at the outflow of the pond. This was fortunate because problems were frequently encountered and some sensors failed entirely. Therefore, relationships had to be established using regression formulas and other equations to estimate flow for the final 16 months of this three-year study (Appendix A). Sensors were located in the storm sewer system near the inflow to the CDS unit and after the outflow in a six foot diameter pipe (see Figure 3b). A small 5-inch high V-notch weir was installed in the outflow 6-foot pipe to measure flows less than 1 cfs, which are not accurately measured with velocity meters. (Appendix A).

The water levels are compared for each month in Appendix C and an example is show in Figure 5.

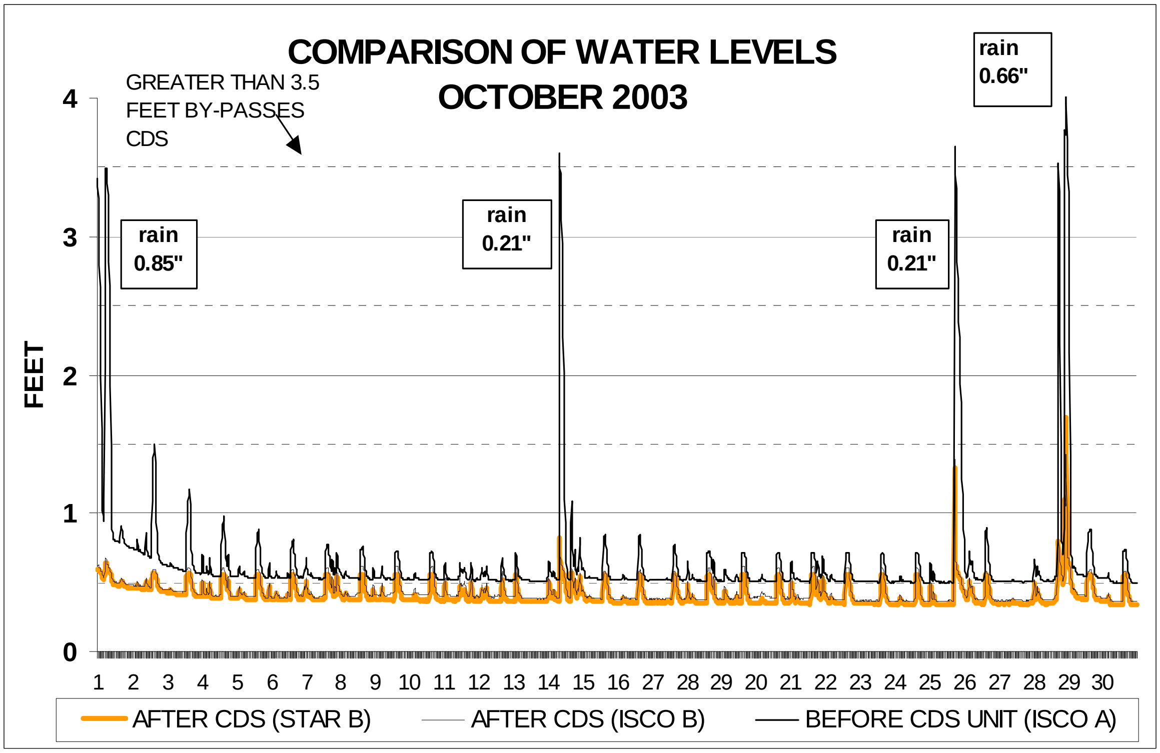


Figure 5. Water levels measured in front of the CDS unit (top line) and water levels after the CDS unit compared with two separate instruments. The amount of rainfall is also indicated.

Information gleaned from the water level graph (Figure 5) indicate that even for rain amounts as small as 0.21 inches, some of the storm flow bypasses the CDS unit. Also, for larger storms, water is held back to be treated later as shown for the higher levels measured in front of the CDS unit (ISCO A) at the end of large storm events. It also indicates that there is close agreement for the two level sensors located after the CDS unit. The ISCO measures levels about 0.025 feet higher, when compared to the STAR sensor. In addition, water levels are only moderately higher before the CDS unit than after the unit, indicating that even the base flow between storms is passing through the unit. When the CDS unit became clogged, one of the first indications was a much higher water level held back by the diversion weir. Of some interest is the increase in flow every afternoon when there is no rain. It was thought this might be caused by evapotranspiration, but an analysis of the data when compared to pond level showed this was not the case. Greater than 25 percent of all base flow is attributed to this daily pulse of water. Except when obscured by rain events, it occurs for about three to four hours between 14:00 and 17:30 each day. The graphs in Appendix C also indicate that after July 2004, differences occurred in the measured water levels compared to measurements before that time. Field comparisons located errors for both flows and these were corrected in calculations, but have not been corrected in the figures in Appendix C. Level A was recording on average 0. 24 ft too high and level B was 0.17 ft too low (see Appendix A). This indicates the importance of testing frequently for sensor drift and sensor problems.

STORM FLOWS

Water levels were used to calculate hydrographs for each storm and to construct water budgets for each year (Appendix D).

Hydrographs

Hydrographs were constructed for almost all flows for storms greater than 0.10 inches and include rain amounts, inflow from two different sensors, flow over the by-pass diversion weir, and outflow. The formulas used to convert water level to flow are shown in Appendix A. The hydrographs were useful for analyzing some characteristics of the system. In the Broadway Outfall drainage basin, flow occurs almost immediately after the first raindrop hits the ground indicating the efficiency of the underground pipe collection system to rapidly remove runoff from the drainage basin. Storm runoff is defined as the amount of precipitation that exceeds the infiltration capacity and depression storage in the drainage basin and the rapid rise and fall of the hydrographs again indicate the efficiency of the storm conveyance system and not much depression storage. In addition, storm events with as little as 0.06 inches of rain produced a measurable increase in flow of 2 to 3 cubic feet per second, and as little as 0.20 inches can produce peak flows of 10 to 12 cubic feet per second. The outflow usually starts discharging about thirty minutes to an hour after the peak flow at the inflow depending on how much storage capacity is available in the pond and the hydrographs demonstrate the capacity of even this small pond to moderate peak flows and slow the release rate to receiving waters.

Each flow meter often measured different peak flows and this resulted in somewhat different flow amounts. Peak flows for larger rain events are usually greater when measured by the STAR flow meter while smaller rain events often exhibit higher peaks when measured with the ISCO flow meter. The ISCO sensor under-estimated most storm flows after June 2003, and eventually a regression equation was developed to correct for this problem. Averages of the two flows were used in the summary calculations unless one was an obvious error. The results from both meters are shown on the hydrographs in Appendix D and an example is shown in Figure 6. Figure 6 also shows a comparison of flow meters with the various formulas and regression equations that had to be developed when equipment failed. During the summer of 2004, the STAR flow meter quit recording at all and an old Marsh McBirney meter was adapted to measure velocity at the site. It measured flow with mixed results and finally quit entirely. For the final 18 months of the study the two equations developed to measure flow from water level measurements estimated the flow. These formulas were compared in the hydrographs to flow measurements when the site was fully instrumented and gave comparable results. All of these adaptations are shown and explained in Appendix A.

Water Budget

To test the accuracy of flow measurements further, a water budget was developed for each month and these data are summarize by year in Table 5 and all the monthly data are located at the beginning of each year's hydrographs in Appendix D. Problems with debris and large snails plugging the weir structures caused problems with flow measurements. The debris was especially heavy at the outflow during September and October of 2003 when most of the marsh plants were uprooted causing water levels to be held artificially high. Since flow is calculated from level, the flow rates were also high as shown in the error column. A leak in the outflow weir during 2004 resulted in considerable unmeasured outflow. This problem probably affected base flow more than storm events because storm events have enough force to clean out weir structures and also overcome leaks and other constraints placed on accurate weir flow calculations. In general the numbers seem reasonable considering that not all parameters for the weir equations could be met and also the inherent variability displayed by measuring devices as described above (see Appendix A and D for more detail). Even though measurements were difficult, a realistic estimate of about ten to thirteen million cubic feet of flow was calculated for both the inflow and outflow during each year of study.

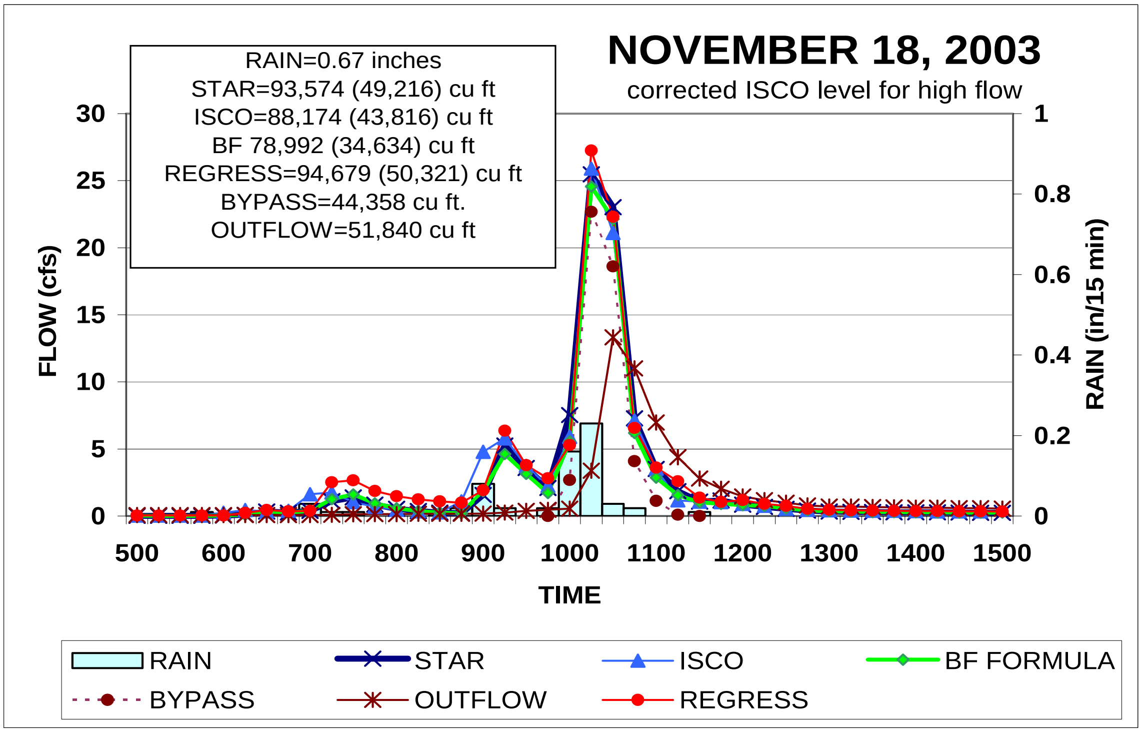


Figure 6. Comparison of flows measured by two different sensors (ISCO and STAR) as well as two equations that were developed to measure inflow from water levels (BF FORMULA and REGRESS)

The Water budget equation (flow in – flow out = change in storage) was used to calculate the water budgets. The terms for each of the elements include these parameters: 1) Rain is the amount of rain that fell directly on the pond, 2) base flow is the flow measured between rain events, 3) storm flow is the flow measured during rain events, 4) ET is the estimated amount of evapotranspiration lost from the pond, 5) storage is the amount of water stored or lost from the beginning of the month to the end of the month in the pond and 5) is the error term. The large error terms for September and October of 2003 were caused by grass, leaf litter and other debris caught in the weir at the outflow, holding water levels artificially high. Broken pipes allowing unmeasured flow into the pond caused the large error term in 2003-04. Most of the problems were fixed by year 2004-05. Even with these problems, the error term was small when compared to total inflows and outflows for each year: 2 percent in 2002-2003, 9 percent in 2003-2004, and less than 1 percent in 2004-2005.

Table 5. Water budget calculations for each of the three years of data collection

		INFLOW			storm*	OUTFLOW				
YEAR	RAIN	RAIN	BASE FLOW	STORM FLOW	BY-PASS FLOW	BASE FLOW	STORM FLOW	ET estimate	STORAGE loss or gain	ERROR
	inches	cu ft	cu ft	cu ft	cu ft	cu ft	cu ft	cu ft	cu ft	cu ft
2002-03	69.50	207,159	2,388,980	8,273,987	2,849,663	4,013,346	6,868,482	161,875	57,417	-230,994
2003-04	71.53	277,805	1,909,445	11,209,379	6,335,886	3,568,093	8,568,844	171,273	9,787	1,078,631
2004-05	61.11	237,336	2,234,714	9,102,286	4,168,377	4,268,626	7,036,884	171,273	44,228	53,324

* Bypass flow is already included in storm flow

A quick assessment of the data shown in the water budget in Table 5 calculated runoff coefficients for the 132-acre drainage basin for the three years of data collection as 0.25 for year one, 0.33 for year 2 and 0.31 for year three. The storm discharge estimated by the runoff coefficients at between 25 and 33 percent on a yearly basis is slightly low compared to the 30 percent runoff estimated for urban areas in Florida that range from 35 to 50 percent impervious (Livingston and McCarron 1990). The fact that more water was discharged as base flow at the outflow than at the inflow was caused by truncating the storm events so that the time period would coincide with the inflow hydrograph. This also accounts for the fact that more storm water flowed into the pond than flowed out and more base flow was measured leaving the pond than came into the pond. For most years almost half the stormwater bypassed the CDS unit on a yearly basis: 34 percent for year one, 57 percent for year two and 46 percent for year three. It should be noted that a larger unit was recommended for the area, but that the land was too flat to accommodate this recommendation without causing flooding upstream.

WATER QUALITY

The Broadway Outfall research site was instrumented to evaluate whether the CDS unit and small pond were successful in reducing suspended or dissolved pollutants in the water column. Water column concentrations are usually the only pollutants evaluated in most stormwater studies that use automatic samplers. Although the CDS unit sized for this monitoring site was not designed to remove these small size particles (<75 microns), these water column pollutants were evaluated for comparison purposes and also to understand some of the processes taking place in the system.

As was discussed in the hydrology section, the Broadway outfall responds almost immediately to even small rain events and the CDS unit does not retain water long enough to allow much time for treatment. This is a common problem experienced in treating storm water runoff in most established urban areas. Although water quality improvement in the system was often minimal, it did exhibit interesting trends for some constituents. The flow-weighted water quality samples collected using automated samplers are discussed in this section (see figures 2 and 3 for the exact location). For the analysis, median values were often used since water quality is seldom normally distributed and medians are often a better representation than averages since it reduces false impressions caused by outliers. All of the water quality data can be found in Appendix E along with summary tables and the data are summarized in this section (Figures 7-10).

Nitrogen

Most of the nitrogen species exhibit only small differences between the inflow and the outflow of the CDS unit, although there is often a large difference after water has traveled through the pond (Figure 7). A factor which might affect the nitrogen patterns is the material collected by the CDS unit which consists of 55 to 80 percent leaf material. Some studies have shown leaf litter exudes nutrients when left to rot in water. This does not seem to be a process in this system since there is usually even a slight reduction in nitrogen in both storm flow and base flow traveling through the CDS unit.

Total Nitrogen - usually shows a small though insignificant decrease in concentration as it travels through the CDS unit. The base flow measured both in front of and exiting the unit between storm events has somewhat higher concentrations than storm flow probably caused by the high nitrate levels in base flow. The averaged concentrations measured for total nitrogen for all years is: 1.14 mg/l in storm flow and 1.71 mg/l in base flow. These concentrations are somewhat lower than averaged total nitrogen levels published for central and south Florida land uses of: 2.00 mg/l for single-family residential, 2.32 mg/l for multi-family, 1.23 mg/l for low intensity commercial and 2.40 mg/l for high intensity commercial (Harper 2006). These are all land uses found in this 132-acre drainage basin. Even though total nitrogen concentrations were lower than measured in other Florida stormwater studies it was still higher than recommended for Florida by the Environmental Protection Agency. For both storm flow and base flow conditions, total nitrogen did not meet the recommendation for rivers and streams of 0.90 mg/L, but was only slightly higher at 1.1 mg/L (EPA 2000).

Nitrogen is transformed in a complex cycle, which includes oxidation-reduction reactions, assimilation by plants and organisms, diffusion into the atmosphere, precipitation into larger particles and other processes. These processes are strongly influenced by pH, dissolved oxygen, and temperature, which will be discussed in a later section. Since various nitrogen species exhibit quite different responses in the Broadway Outfall storm water system, these are discussed separately.

Ammonia Nitrogen - was the most variable of the nitrogen species tested and tended to increase in concentration as it traveled through the pond and appeared to double in concentration in each succeeding year. To try to better understand these patterns, the role of ammonia in the nitrogen cycle was investigated. Ammonia nitrogen is important in surface waters for three reasons (Kadlec and Knight 1996): 1) ammonia is the preferred nutrient form of nitrogen for most wetland plant species and for autotrophic bacteria species; 2) ammonia is chemically reduced and therefore can be readily oxidized in natural waters, resulting in significant oxygen consumption; and 3) un-ionized ammonia is toxic to many forms of aquatic life at low concentrations.

Since under the mostly aerobic conditions measured in the pond, ammonia should be rapidly oxidized to nitrate, it is surprising that ammonia is increased as water travels through the pond while nitrate is greatly reduced, especially during base flow between storm events. Ammonification proceeds more slowly under anaerobic than it does under aerobic conditions because of the reduced efficiency of heterotrophic decomposition in anaerobic environments. In addition, ammonia nitrogen is more likely to accumulate in anaerobic systems because of decreased nitrification rates. But in this pond ammonia increases and nitrate + nitrite greatly decreases and this pattern might be explained by the organic nitrogen.

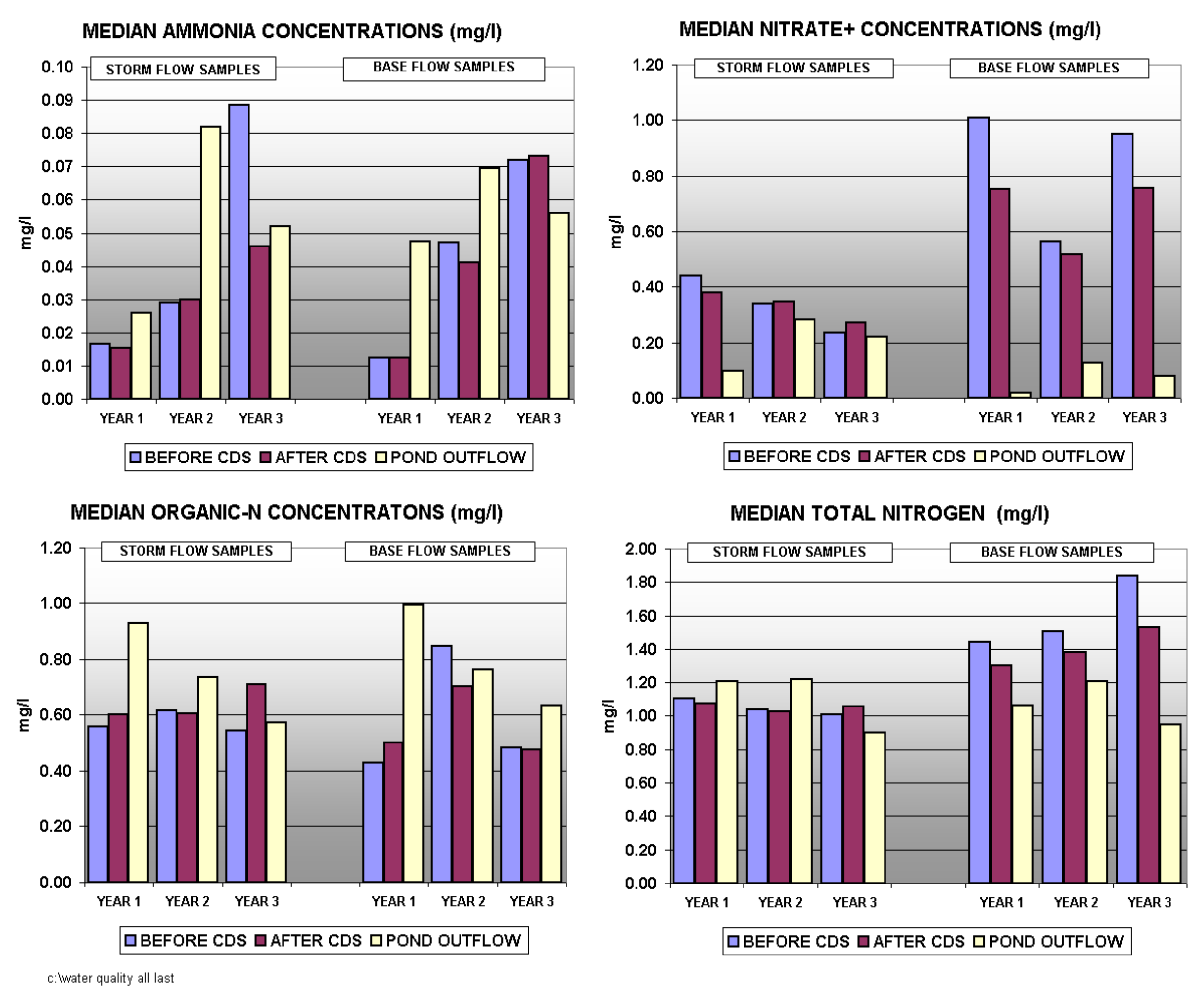


Figure 7. Median nitrogen water quality concentrations compared between years, between stations, and between storm flow and base flow samples

<u>Organic Nitrogen</u> - concentrations usually increased in the pond for both base flow and storm flow. One explanation for the increase of both organic nitrogen and ammonia may be the vegetation that was planted and subsequently uprooted by strong storm surges. In addition, grass clippings and other organic debris were introduced into the pond each time the side bank was mowed. Ammonification is the biological transformation of organic nitrogen to ammonia and is the first step in mineralization of organic nitrogen (Reddy and Patrick 1984). High loads of organic nitrogen can be readily converted to ammonia, emphasizing the importance of including enough

treatment capacity to oxidize all of this reduced nitrogen. It has been documented that organic nitrogen decreases as contact time in wetlands increases, although small concentrations of organic nitrogen still persist (Kadlec and Knight (1996). Kinetically, ammonification proceeds more rapidly than nitrification, thus creating the potential for increasing ammonia concentrations along the flow path of a wetland and requiring design for nitrogen removal to be based on the slower nitrification process (Kadlec and Knight 1996). Our other studies have also shown poor reduction of ammonia and organic nitrogen concentrations in stormwater ponds, usually about a 40 percent reduction (Rushton 2002, Rushton *et al*. 1997), but this is the first time an increase has been measured. The additional local input of organic matter caused by maintenance practices could explain these results. It also emphasizes the need for a well understood and followed pond maintenance plan. One explanation for the steady decline in organic nitrogen discharged from the pond over the years may be that most of the planted vegetation was uprooted during the first year of the study. It should be noted that a much larger pond was desired for this site, but there was not enough land available, and it was believed that even this small pond would provide a water quality benefit (which it does).

<u>Nitrate Plus Nitrite</u> - will be discussed primarily as nitrate since nitrite is chemically unstable and is generally found at very low concentrations. Nitrate showed a modest reduction in the CDS unit during storm events, and a much better reduction in the pond. These nitrate concentrations were much higher than we have usually measured in our other studies (Rushton 2002, Rushton *et al*. 1997) and may be the result of the golf course and upscale landscaping in the drainage basin. Although uptake of nitrate nitrogen by living plants is thought to be less important than ammonium nitrogen, it is still a transport route (Kadlec and Knight 1996). The Environmental Protection Agency (EPA) has identified nitrate as an essential nutrient for plant growth that can lead to eutrophic conditions and has set standards for our region. For rivers and streams, the ambient water quality criteria recommended for nitrate + nitrite is 0.02 mg/L (EPA 2000) and the median discharge water from the Broadway Outfall, although greatly reduced in the pond especially during base flow, failed to meet that criterion (0.20 mg/L for storms and 0.07 mg/l during base flow). Nitrate reduction is still a concern since, it is highly soluble and may be infiltrating into the groundwater thus still polluting the river even though it was greatly reduced in the pond.

Phosphorus

Phosphorus removal is difficult in any water treatment technology, but removal can be improved with pond design optimization. In built-up urban areas such as the Broadway Outfall, enough space to build effective systems is a major impediment. It is encouraging that the CDS unit was able to reduce phosphorus at all, and ortho-phosphorus, the most available chemical form was slightly reduced during most years (Figure 8 and Appendix E). Phosphorus was a significant constituent measured in the gross solids removed from the CDS unit as will be discussed later, especially concentrated in the leaf litter and this may account for the reduction of phosphorus in the water column.

Even though wetlands are often effective in removing phosphorus, there was most often a net increase in phosphorus concentrations after it flowed from the CDS unit through the pond. Wetlands provide an environment for the inter-conversion of all forms of phosphorus. Soluble reactive phosphorus is taken up by plants and converted to tissue phosphorous or may become sorbed to soils and sediments. The soil particles may be only weakly sorbed, however, and may subsequently desorb, especially under anaerobic conditions. In addition, the soil's capacity to sorb phosphorus is quickly exhausted as attachment sites become occupied. Also plant uptake is not a permanent storage and most of the stored phosphorus is returned to the water by decomposition processes. The trend for phosphorus concentrations to increase in each succeeding year may be the result of these processes, since newly constructed ponds with newly exposed soils often do exhibit better phosphate removal.

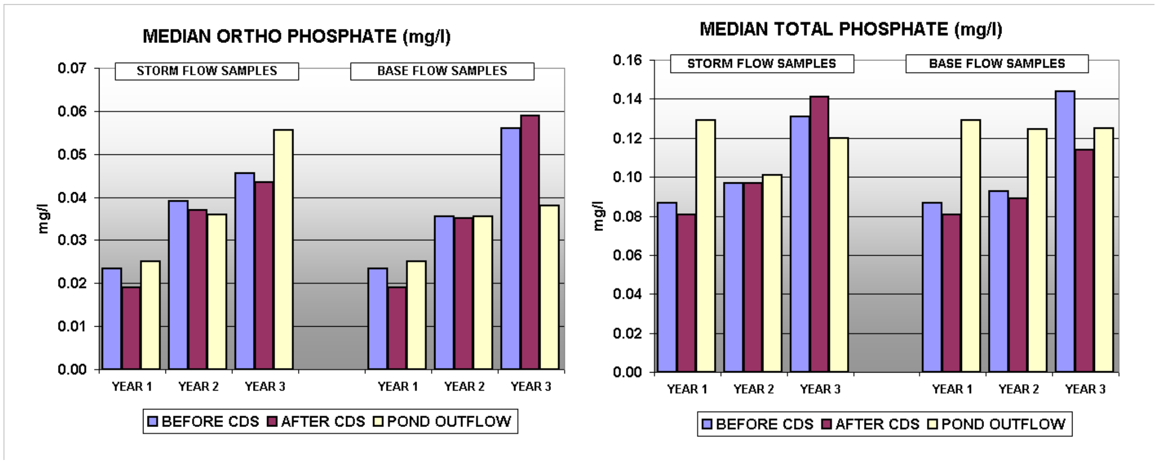


Figure 8. Phosphorus concentrations measured in front of the CDS unit at the discharge point of the CDS unit and at the outflow of the pond for both storm and base flow

Total Suspended Solids (TSS)

A CDS unit is designed to remove particles, but not the small sized particles sampled by automatic water quality samplers for TSS. As will be seen in the gross solids section, only a small amount of particle sizes less than 75 microns were collected in the CDS unit and only an insignificant change for this size particle was accomplished by the CDS unit. Although these results may be surprising to some, the TSS concentrations are not high in this drainage basin for an urban area (Figure 9); and low initial concentrations are extremely difficult to reduce further. In treatment wetlands for waste water, it has been found that the wetland removes about 75 percent of the incoming TSS, provided incoming TSS > 20 mg/L (Kadlec and Knight 1996). In this study, the much higher TSS measured during storms in the third year (average 35 mg/l) are effectively reduced by the pond., but the lower concentrations (14 mg/l) measured in earlier years were not reduced. It should also be noted that, although there are no water quality standards for stormwater, a well-run sewage treatment plant is allowed to discharge water with TSS of 20 mg/L (Randall *et al*. 1982). The 20 mg/l average storm TSS at the inflow and 14 mg/l average at the outflow suggest much lower values than measured for other Florida studies with the same land uses (Harper 1994). These concentrations (Harper 2006) were also averaged values measured in mg/l: single-family 33.0, multi-family 77.8, low- intensity commercial 59.2, and high-intensity commercial 69.7.

In analyzing the results, we expected the force of the water caused by high velocities during storm events to cause the physical re-suspension of particles in the CDS unit as well as in the pond, and this effect might be exacerbated because of the high length to width ratio of the pond, but an increase in TSS during storm events was not usually seen. The TSS increase in the pond during base flow can be attributed to invertebrate, plankton, macrophyte and periphyton litterfall A large number of wading birds also stirred up the sediments with their feeding habits. There appears to be a gradual decrease in TSS discharged from the pond in each succeeding year.

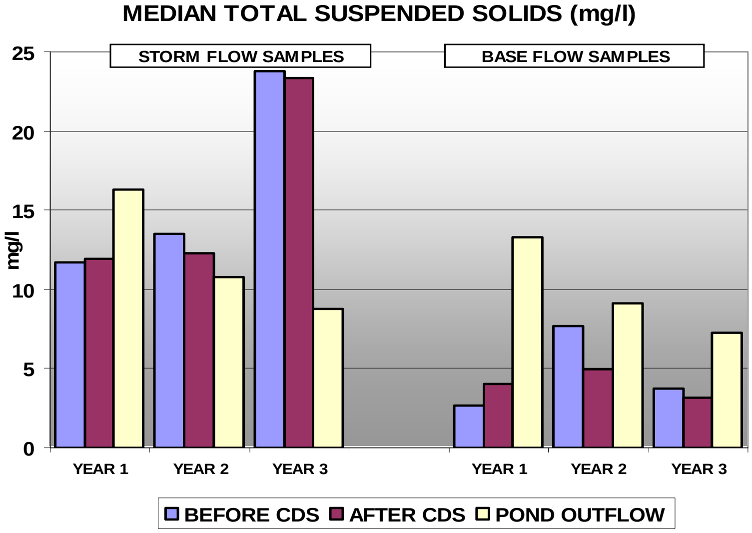


Figure 9. Water Column Total Suspended Solids (TSS) concentrations measured in front of the CDS, after discharge from the CDS unit and at the outflow of the pond for both storm flow and base flow.

Metals

In general, metal concentrations are much lower in base flow than in storm flow and concentrations are measured over twice as high during the third year in storm flow (Figure 10). The exception is copper. Lead is not discussed since almost all concentrations were below the laboratory limit of detection.

Aluminum - concentrations were much higher during storm flows than base flow and concentrations increased to over twice as much at the outflow of the pond. The primary source of total aluminum is often lake sediment (Sprenger and McIntosh 1989) and this is likely the explanation for this pattern. Unlike some of the other metals, aluminum is not involved in oxidation-reduction reactions, and concentrations in sediments are not directly affected by the presence of aerobic or anaerobic conditions (Kadlec and Knight 1996). There are no fresh water quality standards for aluminum, but all of the concentrations were well below the 1,500 ug/L standard for marine water.

Copper - The CDS unit did not increase or decrease copper concentrations, but copper exhibited significant reduction in the pond. Copper was also reduced during base flow until the final year when the samples at all stations were below the laboratory detection limit. It was reported in the hydrology section that there was a pulse of water every afternoon from about 2:00 to 5:00 o'clock that accounted for about 25 percent of the total base flow during the early years of the study. This pulse was much reduced by the final year and this may account for the much lower levels of copper during year three. It should be emphasized that the concentrations for copper were quite low during all years. Metals did not appear to be a problem at this site and only a few samples failed to meet water quality standards.

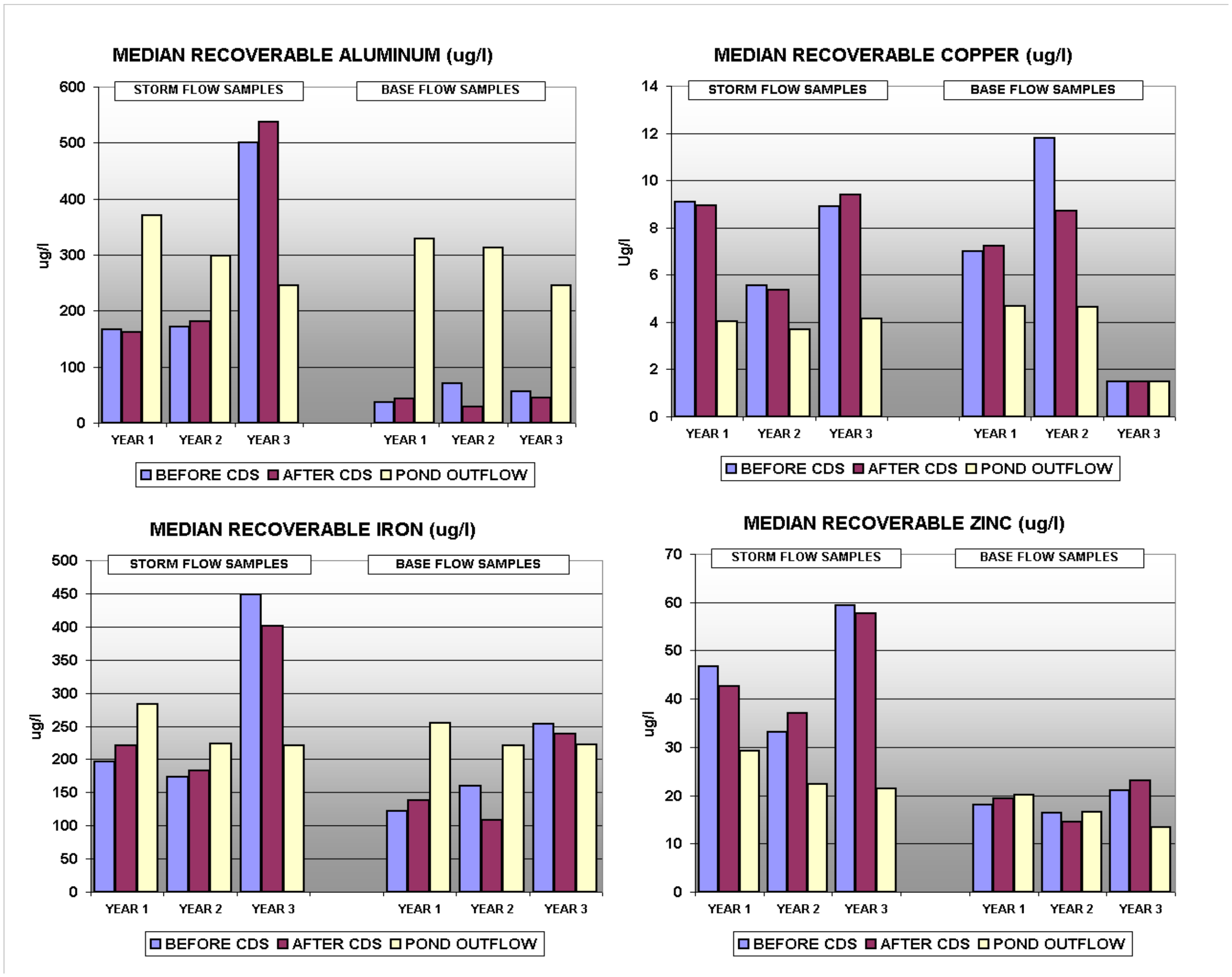


Figure 10. Median water Column metal concentrations measured in front of the CDS unit, after discharge from the CDS unit and at the outflow of the pond for both storm flow and base flow.

Zinc - Much higher concentrations of zinc are measured in storm flow than base flow and the pond is effective at removing these higher concentrations by more than half. There were no significant differences between concentrations of zinc as water passed through the CDS unit, the same pattern as seen for most of the other pollutants of concern. Even with the higher concentrations of zinc in storm flow, these levels are still far below what is considered harmful to wildlife. When the averaged concentrations for zinc at the Broadway Outfall (0.03 mg/l) are compared to average values for other site in Florida with comparable land uses (Harper 2006), they are less than single-family and multi-family land uses (0.057 to 0.086 mg/l) and considerable lower than other Florida sites for commercial land uses (0.083 to 0.160 mg/l).

The failure of the CDS unit to remove metal concentrations in the water column is a surprise, since conditions in the unit seemed to favor incorporation in the sediments. For example, Wilber and Hunter (1980) found that heavy metals precipitate out of solutions and adsorb onto clay particles or become bound into various oxides of iron, aluminum, and manganese with a neutral pH and some alkalinity. Other researchers

(Gambrell and Patrick 1977) have also found reduction of metal concentrations in conditions similar to those found in the CDS unit, which include reduced conditions and large amounts of organic matter. DePinto et al. (1980) reported that organics increase the capacity of stream sediments to sorb heavy metal ions and provide an efficient sink for heavy metals. These conditions were probably more effective in the pond, which may explain the reduction of copper and zinc as it flowed down-stream after leaving the CDS unit. The water that flows through the CDS unit probably does not mix with the water in the unit and instead is rapidly discharged downstream with no time for many transformations to take place, or else had already taken place upstream.

Iron - exhibits a pattern similar to that for aluminum (i.e. higher concentrations in storm flow and at the outfall of the pond). Iron is important in surface waters because it often control the concentration of other elements, including toxic heavy metals (Moore 1991). The relationship of metals with iron has frequently been demonstrated in our other stormwater studies with correlation coefficients greater than 0.50 (Rushton 2002, Rushton *et al*. 1997). In addition, iron is also strongly associated with suspended solids and phosphorus and probably explains some of the patterns of those constituents found in the water column data at the Broadway Outfall study site.

One of the processes that may affect iron concentrations is the oxidation-reduction cycle. When an oxidized layer forms on pond sediment surfaces, it provides an efficient trap for iron and manganese as well as for phosphate. Phosphorus is adsorbed on and complexed with ferric oxides and hydroxide, thereby greatly reducing transport of materials into the water column while scavenging materials such as phosphate from the water (Wetzel 1975). The dissolved oxygen levels to be discussed later provide some insight into processes in the pond. Other conditions that may explain iron concentrations are dissolved or colloidal organic matter (Wetzel 1975). Iron concentrations are not a water quality problem at this site and none of the concentrations were even close to the fresh water quality standard (1,000 ug/L), the upper level considered safe for recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

Percent Efficiency

Another method to evaluate the concentrations of pollutants in stormwater studies is to look at how much is removed (or increased). The percent efficiency (the ability of the CDS or the pond to remove pollutants) was calculated using both yearly average and median concentrations (Table 6 and Appendix E). A much better method to measure efficiency is to calculate individual loads for each storm event and then calculate a mass efficiency, but the problems with the flow measurements in year two would have skewed this data and for this flashy system with both storm flow and base flow almost equal, concentration efficiency seemed to give comparable results for understanding the system. Also the fact that the flow in the CDS was the same for both the inflow and outflow of the CDS unit and the outflow measured discharge similar to the inflow indicated that a reasonable estimate could be made using the yearly concentration data. The median efficiency is shown as well as the average efficiency because the water quality data are log normally distributed and contain outliers, therefore the median concentrations are often a better predictor of normal concentrations. Calculations using mass loading would have given greater weight to large storms and less weight to small storms, but since a large number of storm events were sampled, this should even out the results. Base flow efficiency is also given. It was recognized early on that the pond would not be large enough to provide much pollution removal, but it was hoped that it would be able to reduce more pollutants than the urban ditch. A larger pond could not be built because of land costs in this highly urbanized area.

Table 6. The efficiency of the CDS unit and the pond for removing pollutants. Negative percentages indicate an increase not a reduction in concentration.

Concentration Efficiency for Storm Events Using Averages

STORM	**AMMONIA**		**NITRATE +**		**ORGANIC-N**		**TOTAL N**		**ORTHO-P**	
	CDS	POND	CDS	POND	CDS	POND	CDS	POND	CDS	POND
YEAR ONE	22%	-170%	16%	65%	-27%	-51%	-7%	-16%	20%	-25%
YEAR TWO	-11%	-55%	0%	25%	-7%	-13%	-5%	-2%	-16%	46%
YEAR THREE	24%	12%	-12%	22%	-12%	16%	-9%	17%	32%	-12%
	TSS		**COPPER**		**ZINC**		**IRON**		**TOTAL P**	
	CDS	POND	CDS	POND	CDS	POND	CDS	POND	CDS	POND
YEAR ONE	7%	-29%	-16%	55%	-5%	43%	-7%	-17%	2%	-36%
YEAR TWO	-5%	3%	3%	32%	-5%	34%	-6%	-30%	-10%	21%
YEAR THREE	8%	63%	-13%	57%	-8%	63%	7%	47%	3%	20%
BASE	**AMMONIA**		**NITRATE +**		**ORGANIC-N**		**TOTAL N**		**ORTHO-P**	
	CDS	POND	CDS	POND	CDS	POND	CDS	POND	CDS	POND
YEAR ONE	-70%	-2%	22%	93%	-15%	-79%	8%	8%	27%	-72%
YEAR TWO	-8%	-55%	-33%	79%	59%	-83%	20%	27%	3%	-13%
YEAR THREE	19%	5%	4%	78%	19%	-16%	13%	41%	-7%	32%
	TSS		**COPPER**		**ZINC**		**IRON**		**TOTAL P**	
	CDS	POND	CDS	POND	CDS	POND	CDS	POND	CDS	POND
YEAR ONE	-27%	-168%	7%	48%	-11%	-4%	-21%	-73%	-5%	-107%
YEAR TWO	5%	-76%	11%	40%	-18%	26%	-2%	-53%	5%	-42%
YEAR THREE	50%	-135%	-1%	4%	2%	33%	23%	-4%	21%	-9%

Concentration Efficiency for Storm Events Using Medians

STORM	**AMMONIA**		**NITRATE +**		**ORGANIC-N**		**TOTAL N**		**ORTHO-P**	
	CDS	POND	CDS	POND	CDS	POND	CDS	POND	CDS	POND
YEAR ONE	6%	-65%	14%	74%	-8%	-54%	3%	-10%	19%	-32%
YEAR TWO	3%	-173%	-2%	19%	2%	-21%	1%	-18%	5%	3%
YEAR THREE	48%	-13%	-16%	19%	-31%	19%	-5%	15%	4%	-28%
	TSS		**COPPER**		**ZINC**		**IRON**		**TOTAL P**	
	CDS	POND	CDS	POND	CDS	POND	CDS	POND	CDS	POND
YEAR ONE	3%	-35%	2%	55%	5%	32%	-14%	-19%	7%	-47%
YEAR TWO	9%	12%	3%	31%	-11%	40%	-6%	-22%	0%	-4%
YEAR THREE	2%	62%	-6%	56%	3%	63%	11%	45%	-8%	15%
BASE	**AMMONIA**		**NITRATE +**		**ORGANIC-N**		**TOTAL N**		**ORTHO-P**	
	CDS	POND	CDS	POND	CDS	POND	CDS	POND	CDS	POND
YEAR ONE	0%	-280%	25%	98%	-17%	-94%	9%	18%	26%	-85%
YEAR TWO	13%	-70%	8%	76%	17%	-8%	8%	12%	1%	-1%
YEAR THREE	-1%	23%	21%	89%	2%	-34%	17%	38%	-5%	36%
	TSS		**COPPER**		**ZINC**		**IRON**		**TOTAL P**	
	CDS	POND	CDS	POND	CDS	POND	CDS	POND	CDS	POND
YEAR ONE	-46%	-245%	-3%	35%	-7%	-4%	-14%	-84%	-17%	-100%
YEAR TWO	35%	-83%	26%	47%	10%	-14%	33%	-105%	4%	-40%
YEAR THREE	15%	-130%	0%	0%	-10%	42%	6%	7%	16%	-6%

The efficiency of the system is characterized by the reduction (or increase) of pollutant concentrations from the inflow to the outflow of the CDS or Pond. A negative efficiency indicates a concentration increase. In general, the undersized CDS unit does not exhibit any consistent results for pollutant reductions in the water column. Almost all efficiencies are plus or minus about 20 percent and often removal or increase shift between years. It will be remembered that CDS units are not designed to remove the dissolved and suspended pollutants in the water column; they are designed to remove litter and bed loads and this reduction is not included in the water quality evaluation.

Although this small shallow pond did not usually remove pollutants, there were a few exceptions. Nitrates were usually reduced, and during base flow they were reduced by a considerable amount 76 to 98 percent. The more quiescent conditions during base flow conditions probably contributed to this result. Of some concern is the fact that nitrates are quite soluble and can migrate to the ground water where they frequently are a problem. The nitrates in this drainage basin were often measured at quite high concentrations of over 1.0 mg/l and high concentrations are more easily reduced. Base flow samples had averages over 1.0 mg/l. In contrast, ammonia concentrations always increased as water flowed through the pond.

Copper and zinc often showed fairly good removal efficiencies in the pond during storm flow (about 50 percent), but not quite as good results during base flow (30 to 60 percent). Organic nitrogen is usually increased in the pond probably a result of the uprooted aquatic vegetation and the large number of wading birds that used the site. Total suspended solids (TSS) were often reduced during storm flow, but increased by a large amount during base flow, probably caused by the same uprooted plant problems as organic nitrogen and also phytoplankton growth in this open water pond.

Dissolved Metals

Heavy metals are of great interest when discharged to receiving waters because they are possibly the most important toxic pollutants present (Burton and Pitt 2002), but the authors further explain, that stormwater metals are primarily associated with particulate fractions that are typically assumed to be “unavailable” to organisms. Many standards are based only on the dissolved portion, even though the particulate portion of heavy metals, which settle out in the sediments, may later be converted to more soluble forms through chemical or biological processes. Dissolved metals are defined as those particles that pass through a 0.45 micron laboratory filter and a comparison between the total recoverable and the dissolved portion of those metals found in measurable quantities at the Broadway Outfall are shown in Figure 11. As discussed above the concentrations of metals are usually measured much higher in storm flow than base flow except for copper where in the Broadway Outfall study base flow is sometimes higher and also variable between years. The copper results may be caused by some unmeasured activity discharging to the stormwater system between storms which also would explain the increased flow every afternoon during the early years of the study (see Appendix C). Most of the time the pond is able to reduce metal concentrations to low levels before discharge from the site for both storm flow and base flow.

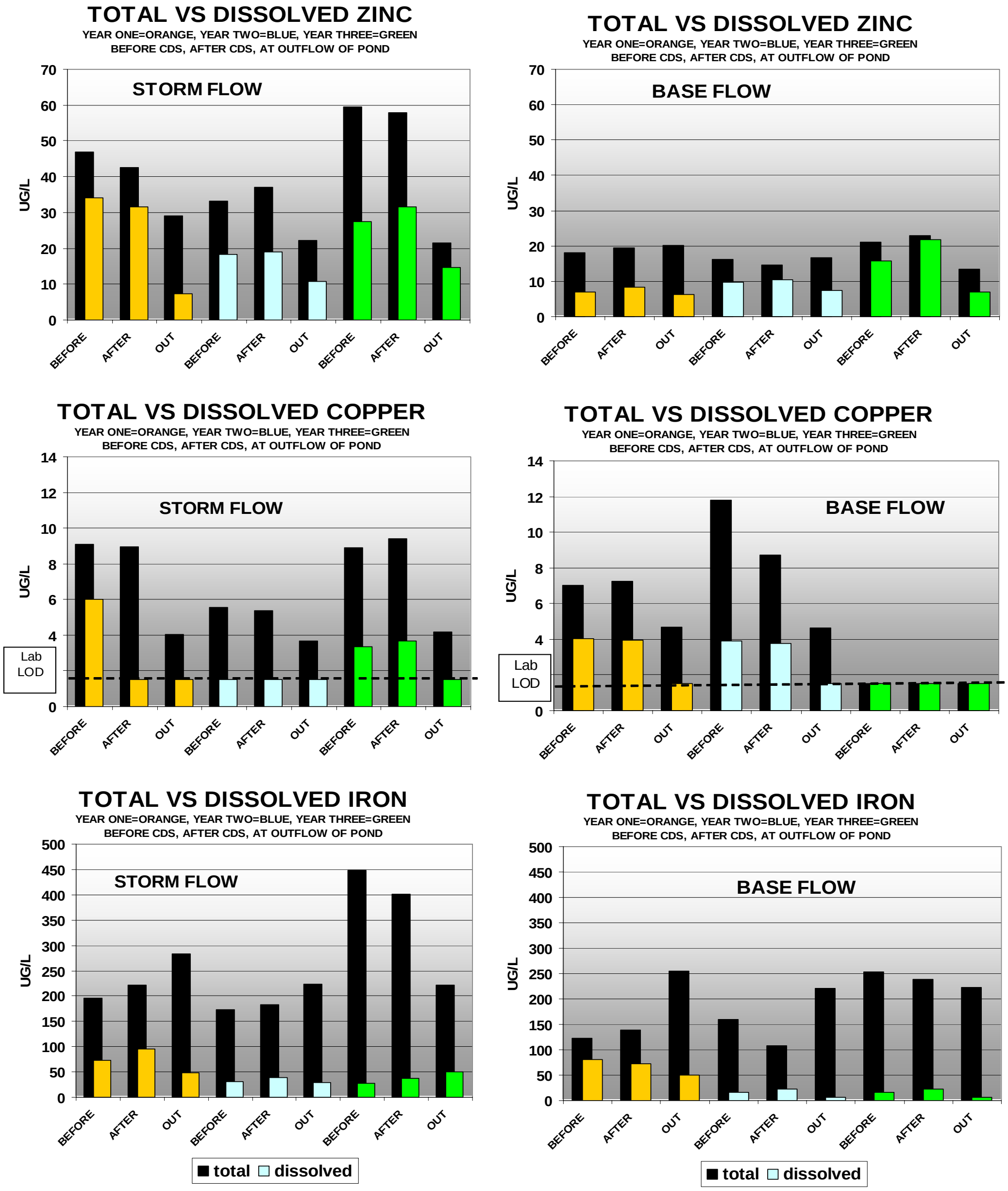


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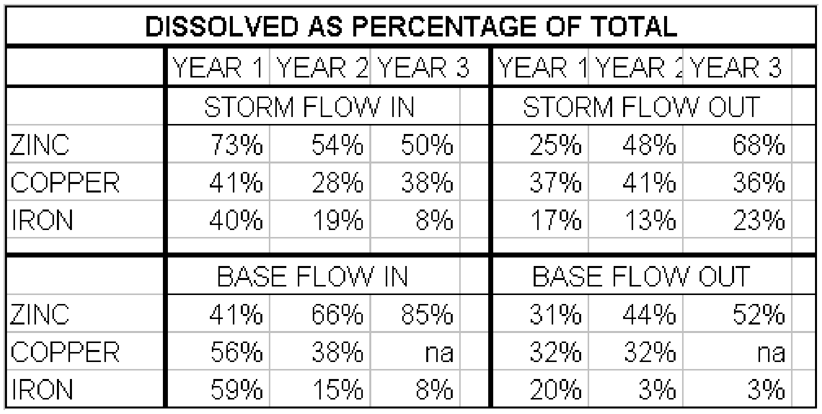
Figure 11. Median dissolved solid metal concentrations (in color) are compared to median total recoverable solids (black) for storm flow and base flow water quality samples. Key: Orange=year one, blue=year two and green=year three. BEFORE=entering the CDS unit, AFTER=discharging from the CDS unit, and OUT= flowing out of the pond.

The reason various studies report much different percentages for the dissolved portion can be explained by site conditions. The percentage of runoff measured in the dissolved form changes with environmental variables present in the water column such as pH, organic matter, humic material, dissolved oxygen, sulfide concentrations, ionic strength, water hardness and chlorides. At the Broadway Outfall, there is a slight reduction in the dissolved form from the inflow to the outflow during storm flow, but a more pronounced reduction during base flow when pond processes are better able to reduce pollution (Table 7). Other studies have reported somewhat different results.

The USGS (Ebbert *et al*. 1983 in Burton and Pitt 2002) found that when stormwater runoff discharge was high, the concentrations of the constituents in particulate forms tended to be high, and the concentrations of the constituents in dissolved forms tended to be low. During periods of low discharge, particulate concentrations were low and the dissolved concentrations were high. When the low flow associated with base flow at the Broadway outfall are compared to the high flow characteristic of storm flow, the total concentrations of zinc and iron are much lower, but there is not a correspondingly higher percentage in the dissolved fraction (Table 7). Copper is difficult to evaluate because so many of the samples were below the laboratory limit of detection (LOD).

Table 7. Percentage of heavy metals found in the dissolved fraction of total metals measured for each year at the inflow of the pond and at the outflow. (Inflow samples are an average between samples measured before the CDS unit and after the CDS unit).



DISSOLVED AS PERCENTAGE OF TOTAL

	YEAR 1	YEAR 2	YEAR 3	YEAR 1	YEAR	YEAR 3
	STORM FLOW IN			STORM FLOW OUT		
ZINC	73%	54%	50%	25%	48%	68%
COPPER	41%	28%	38%	37%	41%	36%
IRON	40%	19%	8%	17%	13%	23%
	BASE FLOW IN			BASE FLOW OUT		
ZINC	41%	66%	85%	31%	44%	52%
COPPER	56%	38%	na	32%	32%	na
IRON	59%	15%	8%	20%	3%	3%

Several studies reported in Minton (2005) also found much variability in the percentage of dissolved measured. For example, one study found 85 percent of iron, 29 percent of zinc and essentially none of the copper was measured as dissolved. In contrast, another study measured 100 percent of zinc and iron in the dissolved form and 50 percent for copper.

FIELD PARAMETERS

Physical water quality parameters are relevant to understanding the processes that influence constituent cycling in natural waters. For the third year of this study, dissolved oxygen (DO), pH, temperature and conductivity were measured in the pond about once a month using recording sensors. When both hydrolabs were working both the water at the inflow and water at the outflow of the pond were compared. All of the data are shown in Appendix F and an example is shown in Figure 12. The sensors were placed near the bottom of the pond where lower dissolved oxygen would be expected. Although the water was too nasty in the pipe and in the CDS unit to risk ruining the instruments, some inferences can be made about those conditions by comparing the inflow water quality in the pond to the outflow water quality and later when the chlorophyll concentrations are discussed.

Characteristics

Daily Fluctuations - Oxygen and pH are affected by photosynthesis, a process where green plants convert sunlight into chemical energy and give off oxygen during the day while both plants and animals consume oxygen through respiration at night. The pH fluctuates because photosynthesis during the day utilizes carbon dioxide and produces oxygen, thereby shifting the carbonate-bicarbonate-carbon dioxide equilibria to a higher pH. In aquatic environments, this is seen as the daytime increase and the nighttime disappearance of both dissolved oxygen and pH. In general, the greater the fluctuations are, the more productive (eutrophic) the system is. In winter these fluctuations are dampened because of reduced sunlight and the dormant state of the biota. These processes also explain the lower dissolved oxygen and pH measured at the inflow of the pond where water has recently been discharged through the underground pipes and CDS unit, a dark anaerobic environment. The concentrations are higher and the fluctuations greater at the outflow once plants and animals in the pond ameliorate conditions.

Rainfall Effects - Rainfall decreases the diurnal fluctuations, especially near the inflow of the pond. This effect is caused by rainfall and runoff flowing into the pond and diluting the pond water before reaching the outflow. Conductivity (specific conductance) usually decreased with rainfall input, because rainfall has low conductivity, and then slowly increases between storms as evapotranspiration and other processes increase ion concentrations. The effect is more obvious at the inflow where stormwater has had less time to mix with pond water.

Summary Data

The average and median values for the field parameters provide an indication of conditions in the pond at the Broadway Outfall (Table 8). Temperature followed a seasonal pattern (i.e. higher in summer and lower in winter) and was almost the same for the inflow and outflow. Dissolved oxygen (DO) showed only weak seasonal patterns, but the averaged values were much higher in February of 2005 caused by a cold front passing through the area. Normally DO is increased in winter because oxygen is more soluble in colder water. Dissolved oxygen and percent saturation are measured about 50 percent higher at the outflow of the pond than at the inflow caused by the anaerobic water discharged into the pond through the CDS unit. The higher concentration at the outflow is caused by algae photosynthesis that can raise DO during the day to high supersaturated conditions (> 12 mg/l) which then drop to low levels (< 4 mg/l) at night. Since low dissolved oxygen levels are detrimental to a healthy well-balanced ecosystem, state standards for all waters set the minimum level for any 24-hour period at 5.0 mg/l with 4.0 mg/l as the absolute minimum. The pond fails to meet these standards more than half the time at the inflow, but concentrations are usually raised to acceptable levels by the time water is discharged from the site.

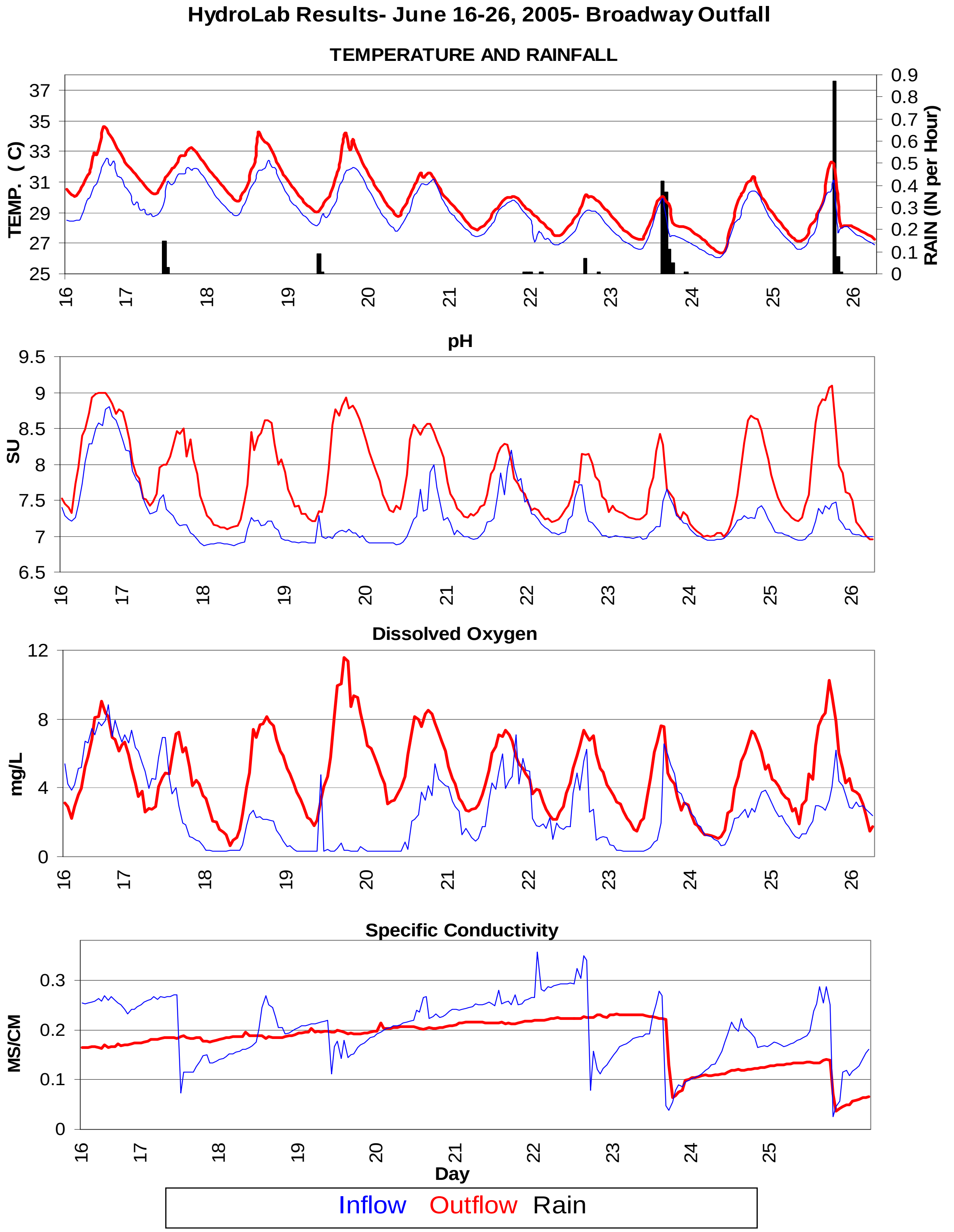


Figure 12. An example of the field parameters measured during one ten day period in summer. See Appendix F for graphs of all the data collected.

The pH showed the pond as an alkaline system with averaged pH values greater than 7.4 standard units. Because of its influence on other chemistry, pH is an important regulatory parameter therefore state standards require pH in a neutral range between 6.5 and 8.5 standard units for most waters. The pond almost always met these requirements except for a few hot days during the summer. One of the rationales behind the standard comes from the constraints of many treatment bacteria, which are not able to exist outside the range 4.0 < pH < 9.5 (Kadlec and Knight 1996).

Table 8. Field parameter summary data for the inflow and outflow of the pond at the Broadway Outfall.

RAIN inches	Date: start finish	Statistic	Temp degC	pH units	SpCond mS/cm	DO %Sat	DO mg/l	Batt volts	Station in pond at inflow or outflow
2.31	3-Apr-04	AVG	24.00	8.51	0.28	133.90	12.36	14.39	OUTFLOW
	13-Apr-04	MED	24.22	8.55	0.31	133.90	11.28	14.30	
0	13-Jan-05	AVG	16.87	7.43	0.30	36.08	3.50	12.99	INFLOW
	23-Jan-05	MED	16.62	7.44	0.31	35.50	3.55	12.90	
0	29-Jan-05	AVG	17.81	8.10	0.36	75.19	7.21	12.30	OUTFLOW
	8-Feb-05	MED	17.88	8.08	0.36	73.80	7.09	12.30	
2.13	27-Feb-05	AVG	19.02	7.10	0.18	38.58	3.63	10.68	INFLOW
	7-Mar-05	MED	19.38	6.95	0.18	34.55	3.28	10.50	
2.13	27-Feb-05	AVG	19.11	7.51	0.17	49.47	4.61	14.37	OUTFLOW
	7-Mar-05	MED	19.70	7.42	0.15	47.60	4.53	14.20	
0.70	4-Apr-05	AVG	24.94	7.57	0.30	48.41	3.98	13.74	INFLOW
	14-Apr-05	MED	24.52	7.51	0.32	51.50	4.12	13.70	
0.70	4-Apr-05	AVG	25.09	7.74	0.24	66.20	5.46	14.84	OUTFLOW
	14-Apr-05	MED	24.93	7.73	0.25	65.40	5.47	14.70	
2.62	19-Apr-05	AVG	23.35	7.68	0.17	59.45	5.04	13.94	OUTFLOW
	29-Apr-05	MED	23.26	7.63	0.13	54.70	4.85	13.90	
0.29	5-May-05	AVG	24.95	7.78	0.27	59.06	4.75	13.08	INFLOW
	15-May-05	MED	24.52	7.72	0.30	59.00	4.80	13.10	
0.29	5-May-05	AVG	26.68	8.18	0.18	76.20	6.10	13.19	OUTFLOW
	15-May-05	MED	26.60	8.26	0.18	71.00	5.79	13.20	
2.32	16-Jun-05	AVG	29.00	7.24	0.20	33.79	2.59	12.42	INFLOW
	26-Jun-05	MED	28.83	7.09	0.21	28.40	2.19	12.40	
2.32	16-Jun-05	AVG	29.92	7.80	0.18	63.74	4.78	12.30	OUTFLOW
	26-Jun-05	MED	29.84	7.60	0.19	58.00	4.50	12.20	
4.90	19-Aug-05	AVG	29.53	7.57	0.24	52.35	3.94	10.48	INFLOW
	29-Aug-05	MED	29.23	7.46	0.24	46.15	3.52	10.60	
INFLOW AVERAGE			**24.05**	**7.45**	**0.25**	**44.71**	**3.73**	**12.23**	**INFLOW**
INFLOW MEDIAN			**24.95**	**7.50**	**0.26**	**43.50**	**3.79**	**12.71**	
OUTFLOW AVERAGE			**23.71**	**7.93**	**0.23**	**74.88**	**6.51**	**13.62**	**OUTFLOW**
OUTFLOW MEDIAN			**23.86**	**7.87**	**0.20**	**70.54**	**5.78**	**13.78**	

Specific conductance is a measure of the total concentrations of ionized materials at the sampling site and was measured within the upper range for natural systems. The specific conductance of most natural inland surface waters is between 0.01 and 0.3 mS/cm (Kadlec and Knight 1996).

GROSS SOLIDS

Gross pollutants, collected in devices such as CDS units, are the solid material including trash, litter, debris and sediments larger than 75 um that are not effectively measured using automatic water quality samplers. Yet these pollutants degrade aquatic habitat, cause visual blight, smother productive sediments, leach harmful pollutants, and can cause unpleasant odors. Litter includes human derived trash, such as, paper, plastic, Styrofoam, metal and glass. Debris consists of organic material including leaves, branches, seeds, twigs, and grass clippings. Coarse sediments are inorganic breakdown products from soils, pavement or building material. All these pollutants are discharged as bed loads to rivers, lakes and streams. These are the sediments that build up in storm water ponds and will one day have to be removed or become a pollution source. They include the material that form deltas and cover productive bottom sediments, which create problems in natural water bodies and require multi-million-dollar stream and lake restoration efforts. The material collected by the CDS unit at the Broadway Outfall site was quantified on a yearly basis with representative samples collected each time the unit was vacuumed out. In addition, during most cleanouts, the samples were divided into particle size ranges and analyses were run on each particle size. Also the water quality data presented earlier was summarized to coincide with each cleanout period for comparison to the gross solids. All the data for this section can be found in Appendix G, an untested method for calculating efficiency of the system including both water quality and the gross solids is in Appendix H and a summary paper of the results is in Appendix I.

Volume Collected

The volume of material in the CDS unit is measured monthly and cleaned out when the depth is five to six feet. During these monthly inspections, the litter that is floating on the top of the mass is skimmed off and saved to be air dried and quantified later. The CDS unit has been vacuumed out five times since the unit was installed in November 2001. Since the monitoring study had not begun when the unit was first cleaned in June of 2002, no samples were taken. But samples were taken in April 2003, July 2003, March 2004 and April 2005. During all years the material collected by the CDS unit included an approximate volume of about 413 ft^3 (11.69 m^3) when the unit was about six feet deep. It appears that gross solids in this drainage basin are deposited primarily in a short time period of one to two months and volumes remain relatively unchanged during the rest of the year. Street sweeping activities in the basin likely explains some of the yearly variations. The data for the four cleanout events was roughly divided into a three year time period (Figure 13).

Although it appears from year one and year three data that February through April produce the most material in the unit, this was not true for year 2 when the unit also filled up during the summer rainy season. Of some interest is that during the summer of intense hurricanes, no material was collected. It should be remembered that during the rainy summer season of 2004, 57 percent of the storm flows bypassed the CDS unit while in 2003 only 38 percent did so, which could have affected the accumulation rates (see Table 5). Also in Figure 13, it appears that the unit collects more material during months with low rainfall amounts than it does when rainfall is high and intense storms are the norm. It should be noted that a much larger unit was recommended for this 132-acre drainage basin, but the terrain was too flat to accommodate the larger unit.

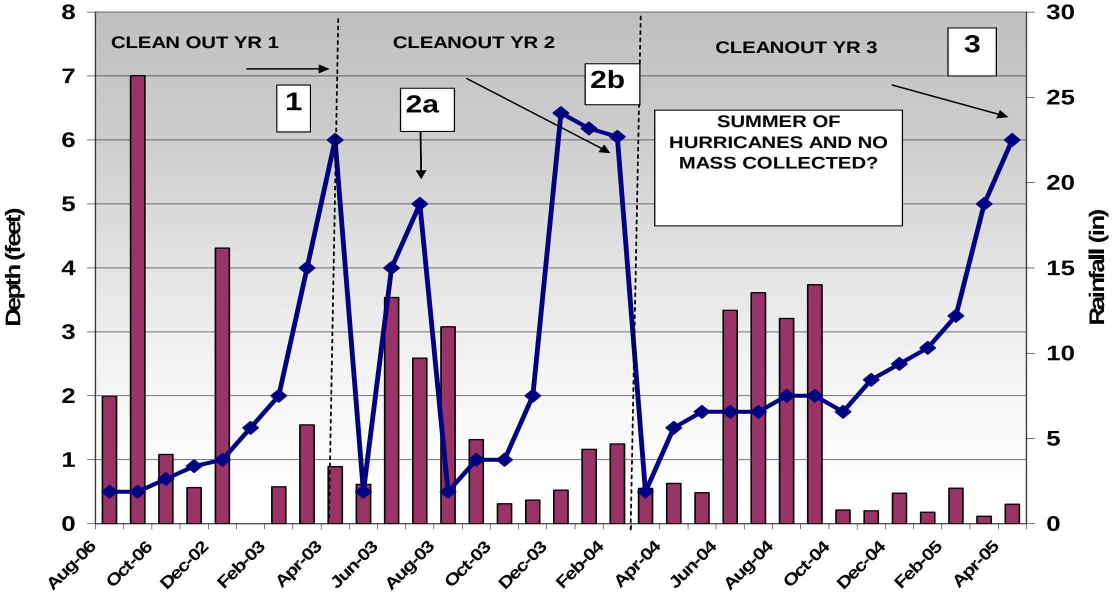


Figure 13. Measurements taken inside the CDS unit to determine how much material has been collected and to schedule clean-outs. The first cleanout is not shown in the figure and occurred on June 25, 2002. Street sweeping in the basin probably affected the accumulation of material in the CDS.

Chemical Analysis

The material collected in the CDS unit for each cleanout indicates considerable differences in concentrations between years as well as samples analyzed by different laboratory methods (Figure 14). The gross solid material that was analyzed from the CDS unit was compared to average water quality concentrations for both storm and base flows during the same cleanout intervals. Each solid bar in Figure 14 represents the average concentrations from two separate sample and the lines are the averaged water quality concentrations measured for storm and base flow during the cleanout intervals. The circles with an X are the results of duplicate samples sent to a different lab. These differences will be discussed in more detail later.

Water Quality - Flow weighted water quality samples were collected for most storm events and base flow samples were collected over several days about every two weeks to measure differences between the CDS inflow and outflow water quality concentrations (Figure 14). Only those constituents that were also measured in the sediments are discussed in this section and the water quality samples have been averaged to coincide with the cleanout periods. No water quality is shown for lead because most of the samples were below the laboratory limit of detection. Of some concern to researchers, is that water sitting in the CDS unit will increase nutrient concentrations because organic leaves and other debris are known to leach nutrients as they decompose (Strynchuk *et al.* 2000 and others). Although no statistical analysis has been performed, there is no consistent or obvious data in this study to support the idea that nutrients are being increased in concentration as water passes through the unit.

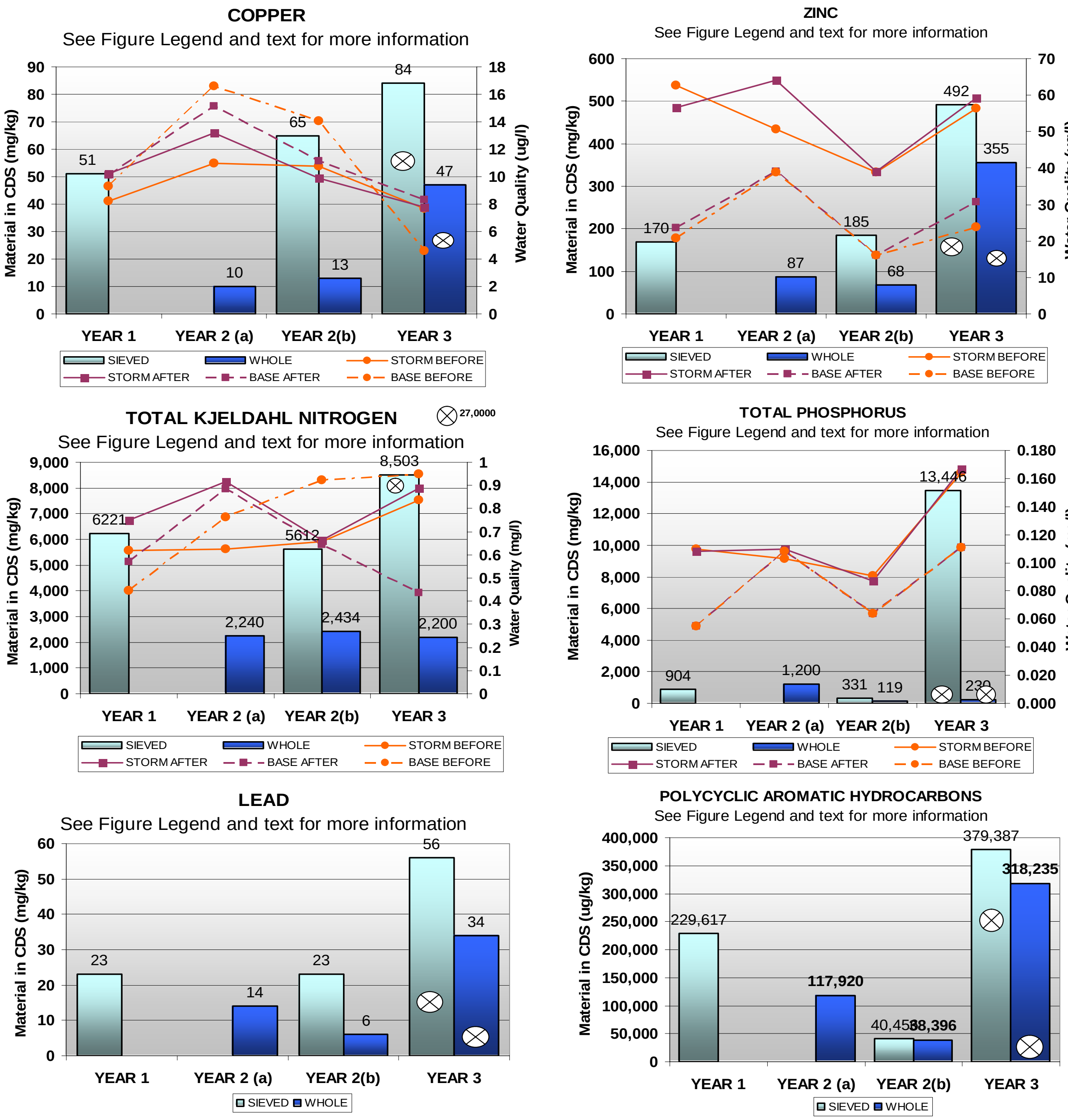


Figure 14 - Concentrations of pollutants in gross solids compared to the average water quality measured in storm flow and base flow during the sampling intervals. Key: BARS=constituent concentrations in the material collected by the CDS unit, LINES=average water quality concentrations measured during the same months as the material was collected in the CDS unit. SOLID LINES=storm flow samples. DASHED LINES=base flow samples. ORANGE CIRCLES=water quality before entering the CDS unit. MAROON SQUARES=water quality downstream of the CDS unit. Circles with an X represent concentrations measured by a different lab (#2) for the samples in year 3. Light blue bars=sieved samples; dark blue bars=whole samples. Holding times were greatly exceeded for lab #2.

One reason that there may be so little difference between the water quality before and after it enters the unit is that the water has been associated with the solids during the flow down the pipe and the residence time of the water in the CDS unit is too short to change the concentrations. A different sampling scheme with fresh leaves and a more controlled timing might have produced entirely different results than these concentrations averaged on a yearly basis. A summary of the water quality data divided into cleanout intervals is presented in a separate stand alone report in Appendix H.

Gross Solids - Representative samples of the material collected by the CDS unit were sent to a laboratory to be analyzed for Polycyclic Aromatic Hydrocarbons (PAH), metals, nutrients and percent organic matter using standard methods for soil analysis. The litter was quantified separately and was not included in the samples sent to the lab. For the gross solid chemical analyses, all the data are reported in Appendix G, and summarized in Figure 14. Each of the three samples collected contained five 2-liter aliquots taken at different depths in the CDS unit and then combined on a mass-weighted basis for the yearly results. A separate set of samples were collected on the opposite side of the CDS unit. There was considerable difference in the quantitative results between the different collection dates. To try to understand these difference better the year three material was divided and sent to two different labs for comparison.

When the gross solids (the solid bars in Figure 14) are compared for the four cleanout events, year 3 exhibits significantly greater concentrations of pollutants and in almost all cases the sieved samples have higher concentrations than the sample analyzed without sieving (a whole sample). For year one, the analysis was only conducted on sieved samples, which in this study mostly separated the leaves from the sediments. For year 2a, only a whole sample was analyzed. In years 2b and 3, both the sieved and whole samples were compared. For year 3 (lab #1), concentrations were significantly higher with the exception of the nutrients in the whole sample. Usually only two particle sizes had enough sample to be analyzed and 60 to 80 percent of the sample was for the largest particle size which included mostly leaves. We later learned that sieving is not recommended because it can substantially change the physiochemical characteristics of the sediment sample (US EPA 2006).

The PAHs were also measured at higher concentrations in the collected mass during year 3. In the early years, they were measured at almost the same concentrations as had been measured in the sediments at the end of the pipe before the project started to be discussed later, indicating that the CDS unit is removing these potentially carcinogenic particles from the storm water flow stream. A problem with interpreting the data is that absorbent bags designed to remove PAHs, were put in the CDS unit after each cleanout. There were some problems with the bags splitting open or sometimes floating back out into the storm sewer pipe and once one was even found in the pond. This could present a measurement problem especially if some of the spilled material was measured in samples raising concentrations. However, leaves and other particles are also effective for absorbing PAHs and this could possibly explain the extremely high concentrations measured in the mass.

Compared to Standards – The disposal of the material collected in CDS units is of some concern. When gross solids are compared to numerical sediment quality assessment guidelines for Florida inland waters (see Table 3); levels of copper and lead are often measured at concentrations that could be harmful to wildlife in the sieved samples, but rarely reach the level where they would probably cause a detrimental effect in the whole sample. Zinc was an exception in year 3. The lead measured for the first two years was well below the levels considered possibly toxic (> 46 mg/kg) and only in the third year, were concentrations measured above levels where they might cause problems to benthic organisms. The results for copper and zinc were similar, although the sieved samples reached levels where they might cause problems (>32 mg/kg for copper and > 120 mg/kg for zinc), but of greater concern the sieved samples were above the probable toxic level (> 460 mg/kg for zinc from lab #1). Results were different for lab #2 as will be discussed later.

The PAHs measured in the mass collected by the CDS unit present a more serious problem. Concentrations were always higher than the possible toxic level (> 1,600 ug/kg) and also greatly exceeded the probable toxic level (> 23,000 ug/kg). PAHs do not easily dissolve in water, which is one reason no water quality data are shown in Figure 14. PAHs tend to adhere to solid particles and settle to the bottom of rivers or lakes. PAHs have been identified as a serious problem in Hillsborough Bay (Grabe and Barron 2003) and collection units such as a CDS unit combined with proper disposal may help reduce this problem. These pollutants are a great concern since the plants and animals living on the land or in water can have bio-concentrations many times higher than the content PAHs in the soil or water (ATSDR 2001). Breakdown in soil and water generally takes weeks to months and is caused primarily by the action of microorganisms. More study is needed to determine the most cost effective method for treating and disposing of this material

Particle Size Analysis

The constituent concentrations measured in the material collected by the CDS unit during the four cleanout periods exhibited widely different results (see figure 14). To better understand these differences, samples were analyzed by particle size and for year three duplicate samples were sent to two different laboratories. Once the samples had been sorted into particle sizes using the dry sieve method, chemical analyses were performed on the different size ranges.

Sieve analysis was influenced by the large amount of leaves in the material collected by the CDS unit and most of the largest particle sizes were measured as leaves that do not go through sieves (Figure 15 and Appendix G-4). In addition, the sieve analysis was most often conducted on different sieve sizes each time the samples were analyzed. The two samples (A and B) taken from opposite sides of the CDS unit usually show comparable results, except for year one, when considerably more sediment was collected in sample B. During sample collection, it was noted that the leaves kept the Ekman dredge from closing completely and some of the sediment appeared to drain out of the samples before we could transfer it to the adjacent bucket. To test how much this might affect the results, we also collected a sample the next day from the disposal site (sample C) for year 3. Year three also includes samples from the two laboratories (COL=lab #1 and PPB=lab #2). As mentioned above US EPA does not recommend sieving for constituent concentrations. We learned the hard way.

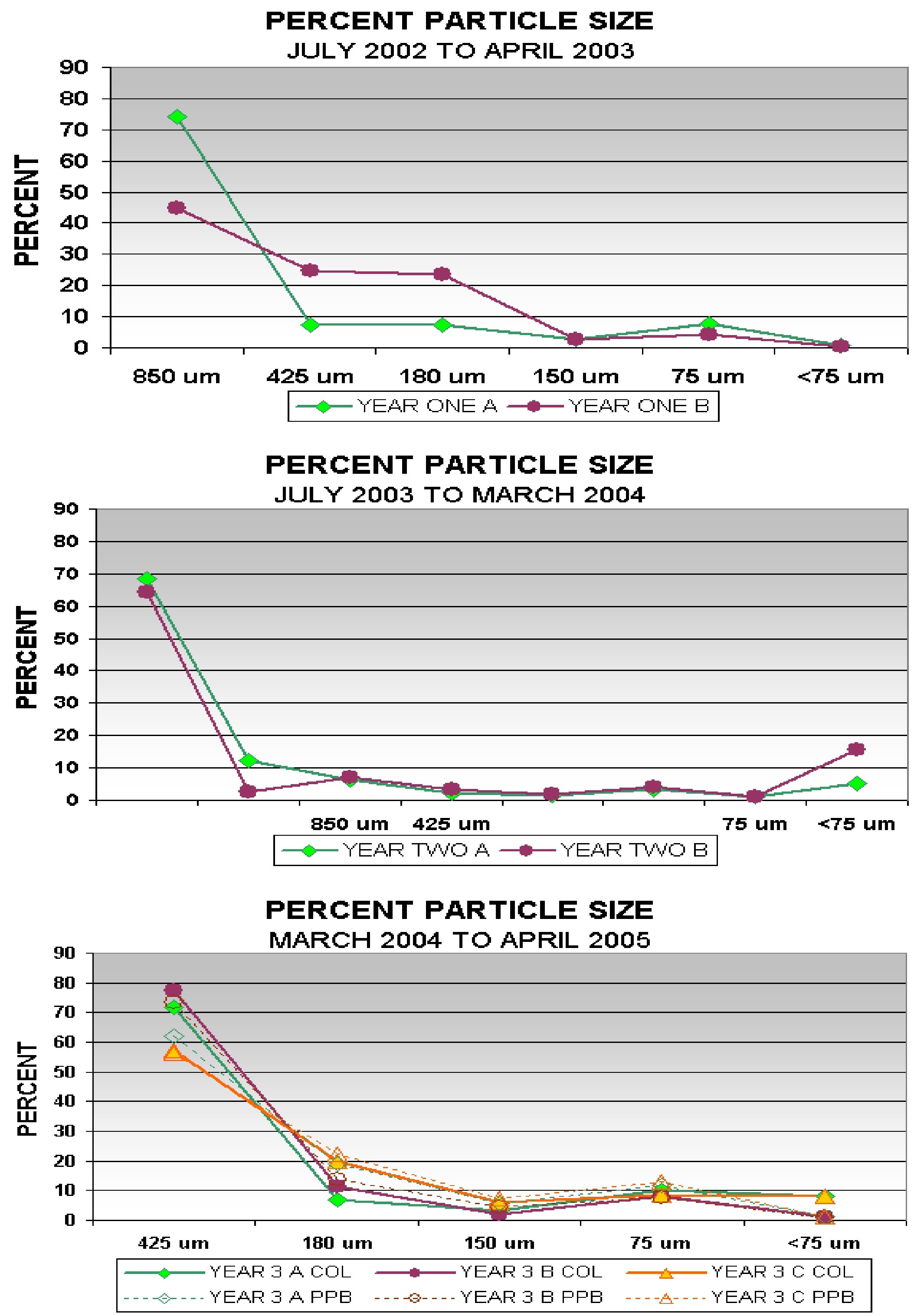


Figure 15. Particle size analysis for three cleanout periods. The largest particle size was mostly composed of leaf material.

Our concern about losing sediment from the samples collected by the Ekman dredge appears justified. Only about 55 percent of the sample was sorted out in the largest size fraction (leaves) at site C compared to 70 to 80 percent of the samples collected by the dredge. Another difference between the samples is that the dump site samples were collected the next day and the material sent to lab was in a much drier condition. Since most of the chemical analyses were conducted on only two or at most three particle sizes the results in the next section are shown as greater than 850 microns and less than 850 microns.

Comparison of Laboratory Results

The wide differences in the concentrations measured in the material for the different cleanout periods were of some concern. For year three, samples were sent to two different laboratories to compare results. Samples were sent to lab #1 that had performed our past analysis and duplicate samples from the same batch were sent to lab #2. It should be mentioned that lab #2 was sent a much larger amount of material than lab #1 because we were interested in having enough material to sort into more particle class sizes. As luck would have it, lab #2 did not have the time to analyze the samples and sent some of the samples to lab #1 to be analyzed. Although there is no difference between the samples sent to the laboratories, lab #2 samples had much longer holding times which exceeded recommendations by 25 to 40 days.

Sieved Samples - The chemical analysis performed on the sieved samples by the two labs show quite different results. Although more than two size fractions were sometimes analyzed, to make comparisons easier the data presented here combined these samples in the correct ratio to represent two size fractions (labeled leaves and sediments). Tables 9 shows the results of the two different labs in year three compared to samples collected in year one and year two where the same data is presented in both tables. The same data are shown in Figures in Appendix G.

Although the data trends are affected by the laboratory analysis in year three some obvious patterns are still noted. Metals are usually associated with the smaller particle size (the sediments) and much higher concentrations of metals are often measured in this sediment fraction until the third year for lab #1. Total Kjeldahl nitrogen (TKN) was expected to be elevated in the leaf fraction and this was often the case except for year two when TKN was measured in each fraction in about equal concentrations. But the biggest difference in concentrations was seen for year three in the data from lab #1 where concentrations in the sediments were the highest measured by any lab during the entire study. A different pattern was measured by lab #2 where the leaves had higher concentrations of TKN as expected. Total Phosphorus was often measured in about equal concentrations between the two size fractions except for lab #1 in the third year. Both leaves and sediment would be expected to contain phosphorus since it is an integral part of leaves but also readily attaches to soil particles, especially if iron is present and the environmental conditions are oxygenated. PAHs were measured by all labs at high levels during all years, but were greatly elevated in the results from lab #1 during year 3. The low concentrations of PAHs during year two may indicate that intervals that only include the winter dry season have much lower PAHs transported. The same argument may hold true for phosphorus. The data for organic carbon are a mystery.

Table 9. Comparison of results from two laboratories for year three

Laboratory # 1 (COL) for year three							Laboratory #2 (PPB) for year 3						
	Copper (mg/kg)		Zinc (mg/kg)		PAHs (ug/kg)			Copper (mg/kg)		Zinc (mg/kg)		PAHs (ug/kg)	
	leaves	sedimen	leaves	sediment	leaves	sediment		leaves	sediment	leaves	sediment	leaves	sediment
year 1 A	57	132	190	479	232,200	388,320	year 1 A	57	132	190	479	232,200	388,320
year 1 B	27	25	89	65	218,350	150,961	year 1 B	27	25	89	65	218,350	150,961
year 2 A	32	140	83	360	17,325	30,237	year 2 A	32	140	83	360	17,325	30,237
year 2 B	45	96	129	319	26,326	44,806	year 2 B	45	96	129	319	26,326	44,806
year 3 A	**91**	**69**	**620**	**250**	**273,310**	**634,895**	**year 3 A**	**30**	**36**	**124**	**282**	**213,045**	**263,427**
year 3 B	**80**	**96**	**530**	**260**	**344,285**	**513,575**	**year 3 B**	**44**	**87**	**191**	**776**	**239,655**	**407,690**
year 3 C	**52**	**40**	**320**	**201**	**396,585**	**371,163**	**year 3 C**	**23**	**57**	**177**	**156**	**254,270**	**268,085**
	TKN (mg/kg)		Tot. Phsophorus		TOC (mg/kg)			TKN (mg/kg)		Tot. Phsophorus		TOC (mg/kg)	
	leaves	sedimen	leaves	sediment	leaves	sediment		leaves	sediment	leaves	sediment	leaves	sediment
year 1 A	7,060	5,320	1,060	985	26	8	year 1 A	7,060	5,320	1,060	985	26	8
year 1 B	9,520	1,293	784	746	31	3	year 1 B	9,520	1,293	784	746	31	3
year 2 A	5,600	5,500	220	450	na	na	year 2 A	5,600	5,500	220	450	na	na
year 2 B	5,800	5,400	230	610	na	na	year 2 B	5,800	5,400	230	610	na	na
year 3 A	**3,500**	**20,000**	**5,400**	**33,000**	**148,000**	**27,000**	**year 3 A**	**7,904**	**2,472**	**488**	**404**	**220,000**	**25,949**
year 3 B	**6,000**	**17,000**	**6,500**	**38,000**	**57,000**	**22,000**	**year 3 B**	**12,416**	**4,799**	**559**	**446**	**220,000**	**25,516**
year 3 C	**2,100**	**15,730**	**3,000**	**26,040**	**64,000**	**26,380**	**year 3 C**	**12,063**	**2,564**	**338**	**508**	**220,000**	**26,580**

Whole Sample - The data for the whole sample (not sieved) are also puzzling. The concentrations for the individual PAHs show that the concentrations from lab #1 for samples A and B are considerably higher than for lab #2. While the samples from the two labs for the dump site (C) are almost identical (Figure 16). Longer holding times could possibly explain the reduction in A and B, but then why not in C?

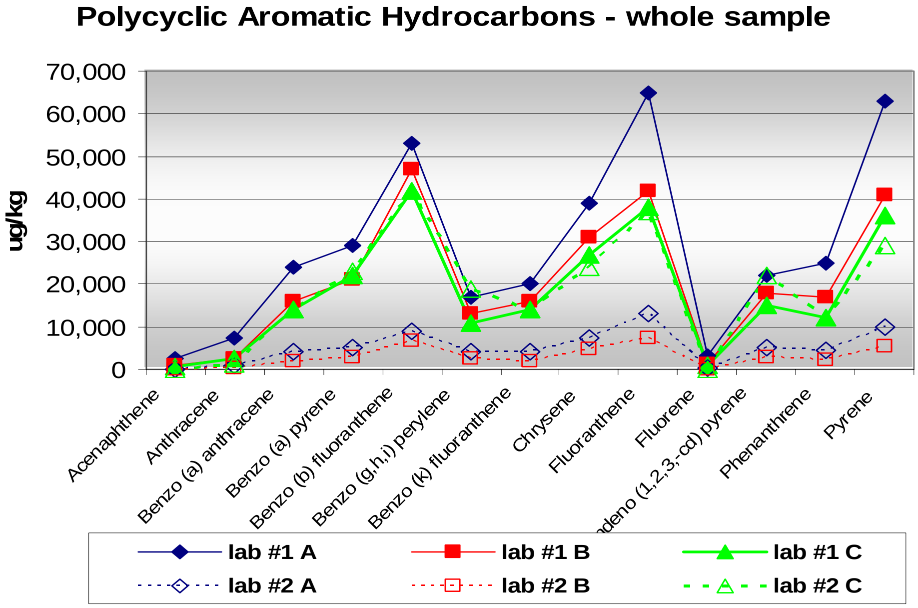


Figure 16. Comparison of individual PAHs analyzed by two different labs for year three.

There was also considerable difference in constituent concentrations for other parameters for samples A and B, but not necessarily for C (Figure 17). For metals the concentrations were usually twice as high for lab #1, while the opposite was true for the nutrients.

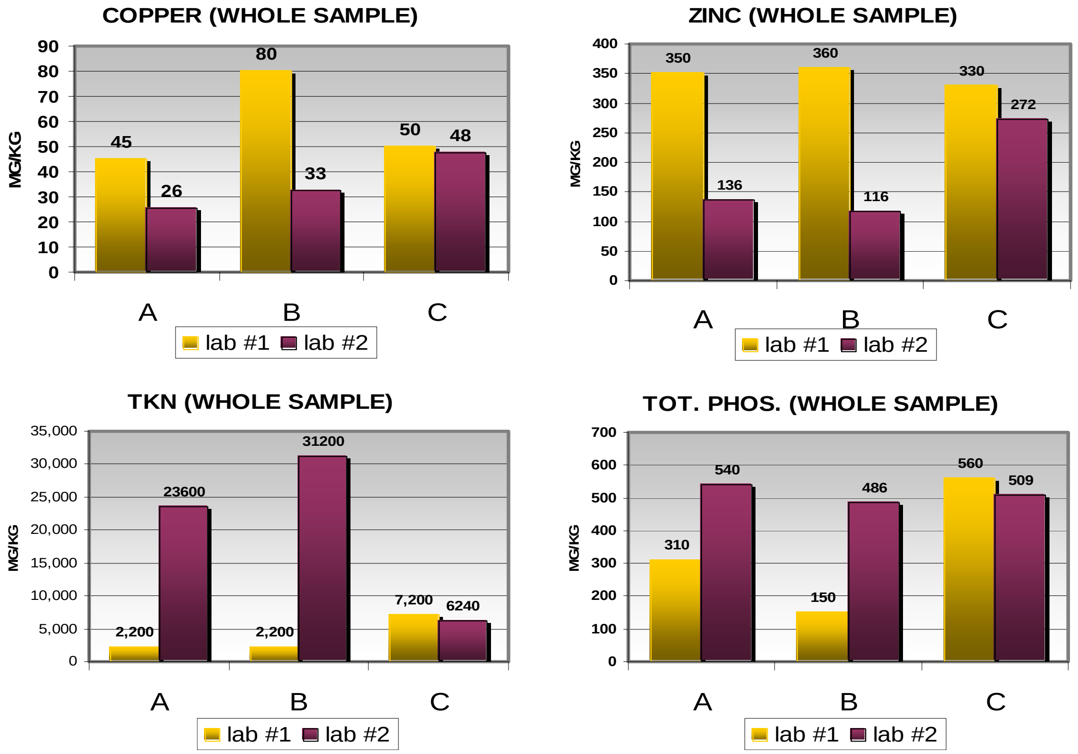


Figure 17. the concentrations of metals and nutrients measured in duplicate samples in year 3 as reported by two different laboratories.

To try to put this data in perspective, some of the physical parameters were investigated. It will be remembered from the particle size analysis that sample C contained more sediment than either A or B. This was verified when the percent solids measured in the samples are compared, the percentage in sample C contains almost twice as much solid as samples A and B (Figure 18).

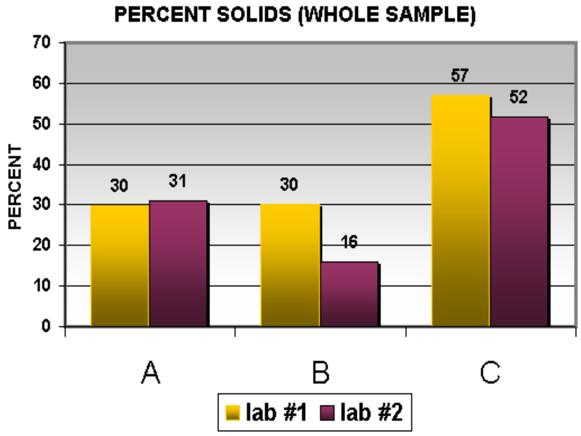


Figure 18. Percent solids measured in the samples analyzed by two labs. Percent organic matter was requested but not reported.

Much of the other physical data also supports the idea that sample C from the dump site was shipped to the laboratories in a much drier condition than samples A and

B (Figure 19). It should be remembered that these physical parameters were measured by the same sub-contractor for both lab #1 and lab #2, although the analysis for lab #2 were conducted on May 24th almost two weeks later than lab #1's samples which were analyzed on May 12th.

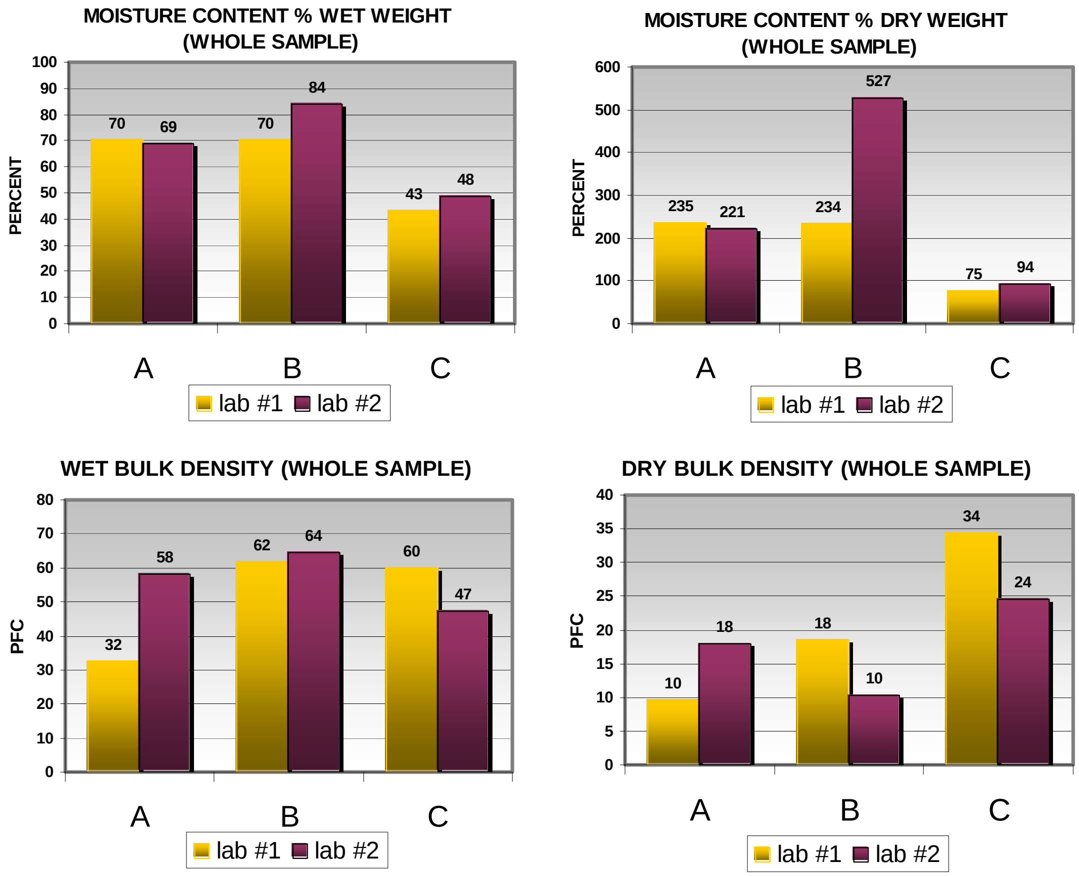


Figure 19. Physical parameters measured for the material in the CDS unit for year three as reported by two different laboratories.

Lessons Learned - Standardized methods need to be established for analyzing gross solids. Some of the results of the comparison of the different laboratory results in this study recommend these possible solutions. These guidelines are preliminary and a much more careful analysis conducted by more people involved with this type of analysis needs to be considered before these ideas are adopted. Also many of the following suggestions have been taken from an Environmental Protection Agency report intended for sediment sampling (US EPA 2006).

- All samples to be compared should be reported from the lab as dry weight. This makes comparison between researchers and sampling events more reasonable.
- If PAHs are to be analyzed UV shielding may be necessary to minimize ultraviolet light activated toxicity.
- Sample concentrations for volatile species can be affected by exposure to air (i.e. ammonia or volatile organics).

- Where metals are a concern, it may be necessary to sub-sample under oxygen-free conditions to minimize oxidative changes.
- When removing sub-samples avoid the material adjacent to the sides of the sampling device.
- Overlying water should be siphoned off, not decanted. Ideally the overlying water should be removed by slow siphoning using a clean tube near one side of the sampler. If water is turbid give it a chance to settle.
- Fill sample containers completely unless samples are to be frozen prior to analysis.
- Samples should be transported and stored at 1-4^{o} C with no headspace and no supernatant.
- Samples should use a #4 sieve (4.75 mm) to separate the leaves from the sediments. OR Some researchers have found good results for separating the leaf material by using 1 mm nylon screen with the material dried out and it was reported that this did a good job of separating the leaves from the sediments in bench scale tests (Daniel Smith, personal communication).
- Samples should be sent to the lab as soon as processed (within 2 days) to avoid holding time problems. The holding time (US EPA 2006) reported for extractable organics is 7 days (until extraction) and 30 days (after extraction) and the samples should be frozen.
- Sieved samples elevate concentrations and more study is needed to make these samples more comparable to a whole sample. The Environmental Protection Agency recommends that samples not be sieved because it can disrupt the natural chemical equilibrium by homogenizing or otherwise changing the biological activity with the sediment (US EPA 2006).
- If particle size analysis is conducted, send sufficient sample to the lab to make sure there is enough sample in different particle sizes to do chemical analysis (4 to 5 gallons is recommended).

Constituent Concentrations by Particle Size

For the final year, a 5 gallon container filled with sample was sent to lab #2 in order to analyze several particle sizes. Four particle sizes were separated by dry sieving that had enough sample for analysis (Figure 20). Most of the samples exhibit very little difference between different particle sizes. Samples A and B taken inside the CDS unit at time of cleanout sometimes show higher concentrations in Sample B, especially for zinc and copper. The only distinct pattern is for TKN in the largest particle size which mostly consists of leaves; while metals tend to be measured at their lowest concentrations in this largest size fraction.

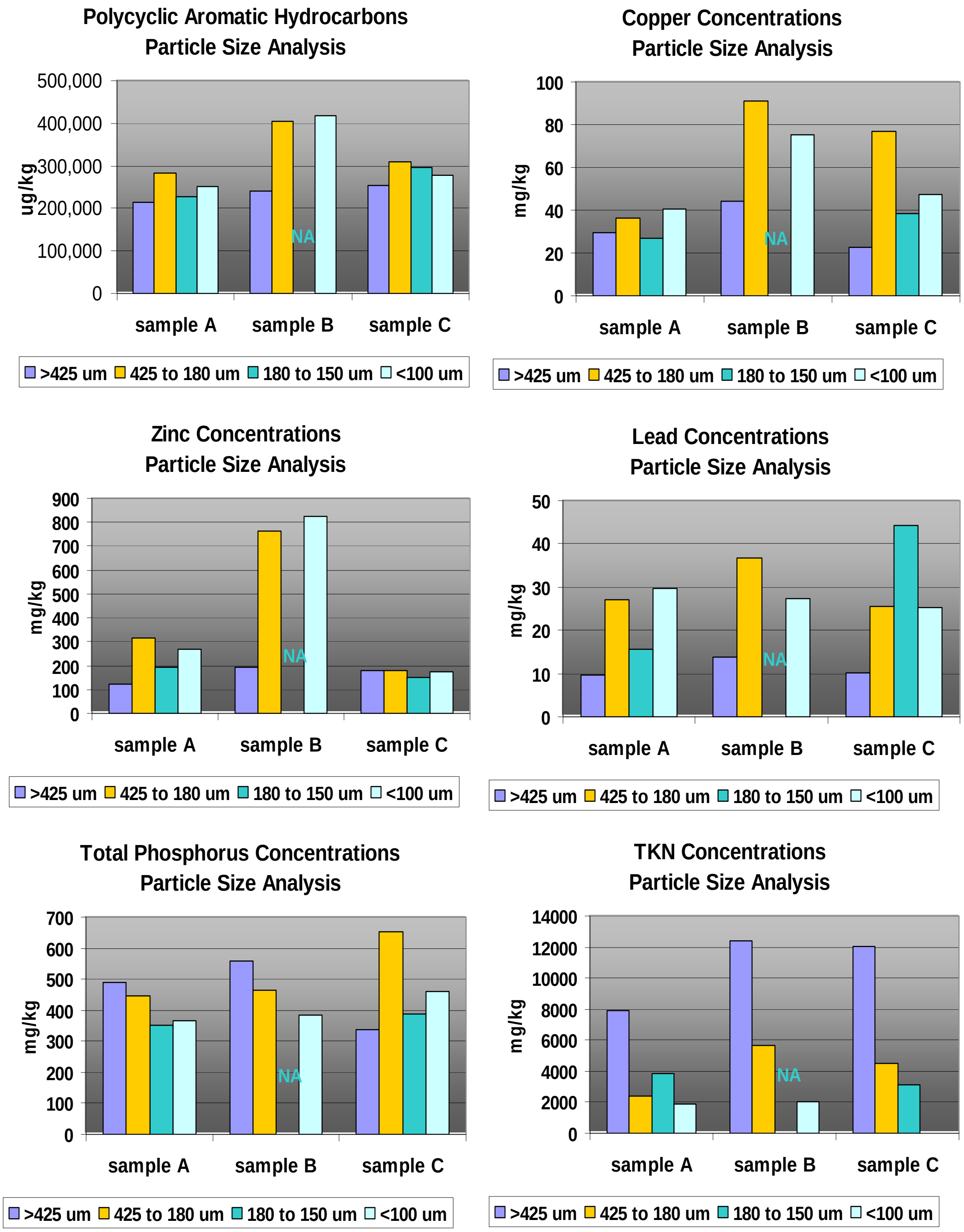


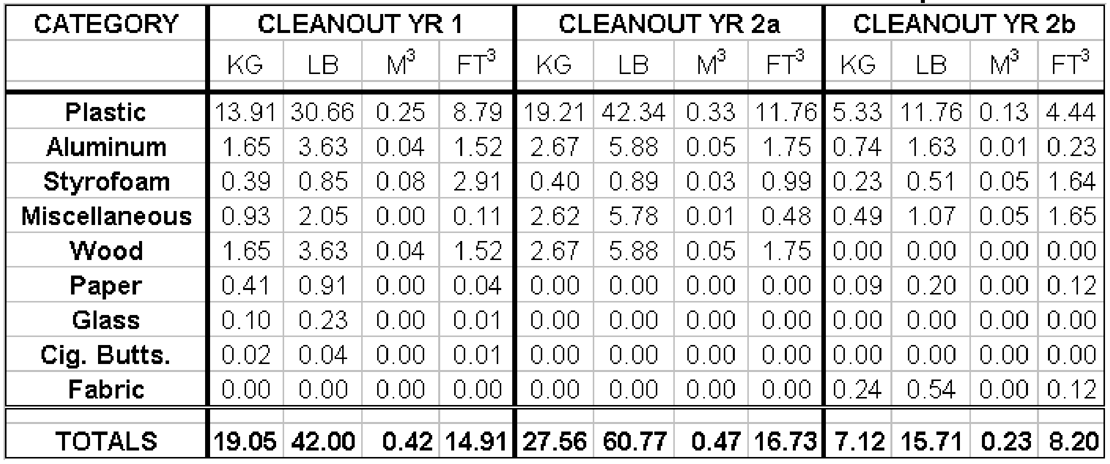
Figure 20. Constituents concentrations measured in each of four particle sizes (Sample B has only three). Analysis performed by lab #2.

Litter (Trash)

The litter was collected, air dried, weighed and sorted for each cleanout period (Table 10). The samples include the litter that had been skimmed off each month as well as the litter retrieved from the mass of material removed by the vacuum truck at the time of clean out. Although the amount of litter is small compared to the leaves and heavy sediments, it is an eye sore and has the potential to impact wildlife as well as leach pollutants. Plastics were measured more often than any other litter category, but Styrofoam was also found in large quantities.

During cleanout period 2b there is a question about whether the City of Temple Terrace personnel left us all the litter skimmed off the top each month or instead followed their normal procedure from the cleanout of their other CDS units and took it off to the landfill. At any rate much less litter was collected during this 10-month period than during the two previous collection intervals, which had covered much shorter time periods. Year 3 data are not available because of a communication problem with personnel. The amount of litter collected by the CDS unit during each cleanout reported was quite small (8 to 17 ft^3) compared to the amount of leaves and sediments removed from the CDS unit (182 ft^3 to 260 ft^3).

Table 10. Amount of litter collected in the CDS unit for 3 cleanout periods.



CATEGORY	CLEANOUT YR 1				CLEANOUT YR 2a				CLEANOUT YR 2b			
	KG	LB	M^3	FT^3	KG	LB	M^3	FT^3	KG	LB	M^3	FT^3
Plastic	13.91	30.66	0.25	8.79	19.21	42.34	0.33	11.76	5.33	11.76	0.13	4.44
Aluminum	1.65	3.63	0.04	1.52	2.67	5.88	0.05	1.75	0.74	1.63	0.01	0.23
Styrofoam	0.39	0.85	0.08	2.91	0.40	0.89	0.03	0.99	0.23	0.51	0.05	1.64
Miscellaneous	0.93	2.05	0.00	0.11	2.62	5.78	0.01	0.48	0.49	1.07	0.05	1.65
Wood	1.65	3.63	0.04	1.52	2.67	5.88	0.05	1.75	0.00	0.00	0.00	0.00
Paper	0.41	0.91	0.00	0.04	0.00	0.00	0.00	0.00	0.09	0.20	0.00	0.12
Glass	0.10	0.23	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cig. Butts.	0.02	0.04	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fabric	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.54	0.00	0.12
TOTALS	**19.05**	**42.00**	**0.42**	**14.91**	**27.56**	**60.77**	**0.47**	**16.73**	**7.12**	**15.71**	**0.23**	**8.20**

Decant Water

We had a concern about polluting the pond and downstream water quality when we saw the scum and turbid water being decanted during each cleanout (Figure 21). When we compared the concentrations of pollutants of concern in the decant water it usually does have higher concentrations, but not as high as expected.

The decanted samples are shown in the red bars and the yearly averaged water quality samples are in blue, two averaged concentrations are given for the decanted water because one of the samples had much higher concentrations than the rest of the samples. The decanted sample with the outlier removed is the second bar. Although the amount of water decanted is small compared to the stormwater passing through the system, the turbidity lasted for several days and was an eyesore. If the unit had been outfitted with a method to close off the inflow during cleanout, the water could have been decanted back into the storm sewer and stored in the pipe until the cleanout was complete and it would have been retreated.

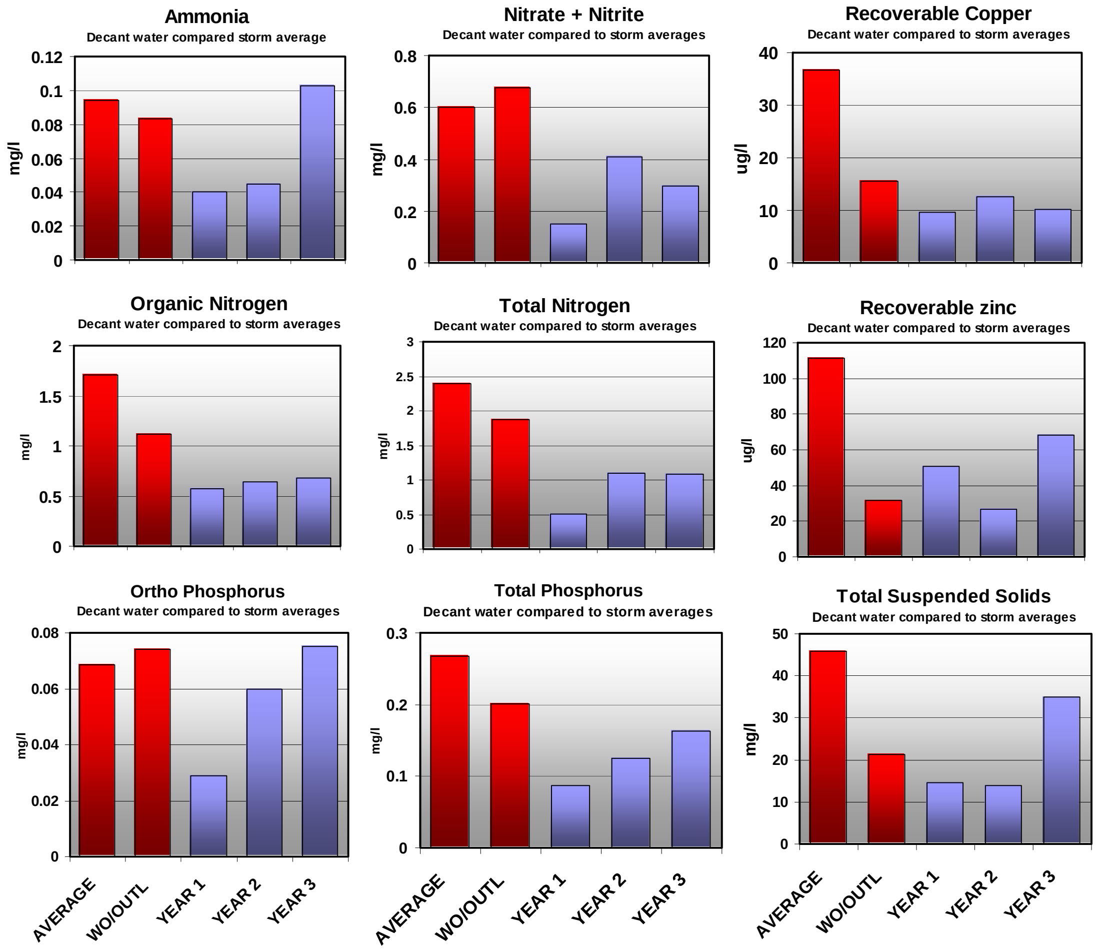


Figure 21. Average water quality concentrations decanted into the pond from the CDS unit during cleanout (1st two bars) compared to average water quality measured in storm flow on a yearly basis (last 3 bars). The red bars represent the decanted water both with and (the 1st bar) without an outlier (the 2nd bar), the blue bars are averaged storm flow for each of the three years.

SEDIMENT ANALYSIS

The effect of polluted sediments from gross solid deposition has not always been emphasized in stormwater studies that make their interpretation and pollution reduction based on water quality data for individual storm events. But sediments can accumulate pollutants through mechanisms of direct deposition of solids, or through various processes where soluble pollutants precipitate/sorb and contaminate the sediments. Scouring of storm conveyance systems and ultimately streams and rivers takes a long time and is difficult to relate to specific storm events. These polluted sediments may have a much greater toxic effect on the biota than the dissolved toxicants in the water column. Many studies have shown the severe detrimental effects of urban runoff on receiving water organisms (Pitt 1995). Other studies have documented that even tolerant species are eliminated when toxic levels of metals and PAHs are measured in the sediments (Rushton *et al*. 2004).

Sediment samples were collected before the retrofit was constructed to document existing conditions in the flow path from the point where water from the drainage basin was discharged into an existing ditch (STA 935). Samples were also collected in the ditch where the pond is now built and at the outfall of the pond under the bridge (See Figure 2 for sampling locations). All of the data are presented in Appendix J.

Polycyclic Aromatic Hydrocarbons (PAH)

PAHs were detected at toxic levels at this site in both the gross solids collected by the CDS unit and in the sediments before the retrofit. A summary graph of the total PAHs measured in the sediments is shown in Figure 22.

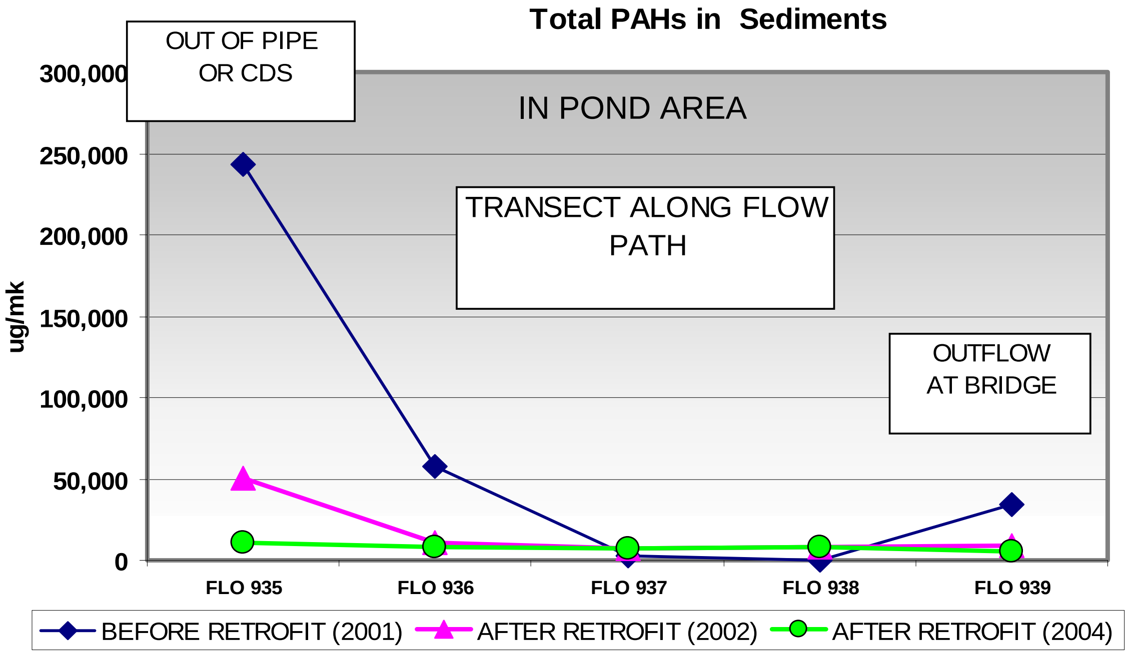


Figure 22. Total polycyclic aromatic hydrocarbons measured in the sediments in May 2001, before the retrofit was constructed in August 2002, almost a year after construction and again in August 2004. (See Figure 2 for station locations)

Not only were the PAH concentrations measured at much higher levels in the soils before the retrofit in 2001, but concentrations were also much higher near the storm sewer where it flowed into the open water ditch. Concentrations tapered off to non-detectible concentrations as water flowed down the ditch until it reached the bridge, where additional storm runoff entered the flow stream. Although PAH concentrations were much lower in 2002, they were detected at two stations where low or no concentrations had been detected in 2001. This was probably the result of moving the soil around when the pond was constructed and depositing some of the contaminated soils into the pond area

PAHs enter the environment mostly from volcanoes, forest fires, residential wood burning, pavement, and exhaust from automobiles and trucks (ATSDR 2001). PAHs do not easily dissolve in water, but stick to solid particles and settle to the bottoms of rivers or lakes. Breakdown of PAHs in soil and water generally takes weeks to months and is caused primarily by the actions of microorganisms. The data at the Broadway Outfall Retrofit site suggests that the CDS unit is reducing the amount of PAHs being transported to the Hillsborough River. The data also indicate that PAHs in the soils were confined close to where they entered the sunlit open aerobic ditch.

Metals

Metals were not measured during 2002, but in 2001 (before construction), levels were well below those concentrations considered toxic to organisms and were measured at even lower concentrations in 2004 (Figure 23). None of the metals even approached the level considered a possible toxicity problem in the sediments (see Table 3), although as will be remembered from the gross solid data, some of the gross solids did approach possibly toxic levels. The data from 2001 before the CDS unit was installed indicate that the ditch concentrated most metals near the outfall and the concentrations were greatly reduced downstream. Metals do not appear to be a problem at this site even though it drains a large asphalt parking lot and several major urban thoroughfares. Either the recently excavated pond or the CDS unit has resulted in even lower levels of metals in the sediments three years after construction. The data do show that ditches are a good mechanism for removing both PAHs and metals and perhaps better designs might solve some urban water pollution problems.

Nutrient concentrations present a different picture (Figure 24). Total Kjeldahl Nitrogen (TKN) was measured in high concentrations at the Broadway storm sewer outfall before the CDS unit was installed, but these concentrations were much lower in 2004. This may have resulted from the removal of leaves by the CDS unit. Total phosphorus presents a different picture. Concentrations of phosphorus were quite low in the sediments at the storm sewer outfall during both years and increased as water traveled through the heavily vegetated ditch/pond. The phosphorus levels in the ditch were quite high compared to some of our other studies (Rushton *et al.* 1997, Rushton 2002, and Rushton *et al.* 2004). Although the agricultural stormwater system studied in 2002, which had exceptionally high phosphorus concentrations in the water column (>2 mg/l), also had highly enriched sediments at some locations (> 2,000 mg/kg). The highest average concentrations of phosphorus measured in the water column entering the pond at the Broadway Outfall was only about 0.15 mg/l, so the elevated concentrations must have been caused by the dying vegetation planted in the pond and the grass clippings that were seen floating in the pond after mowing operations.

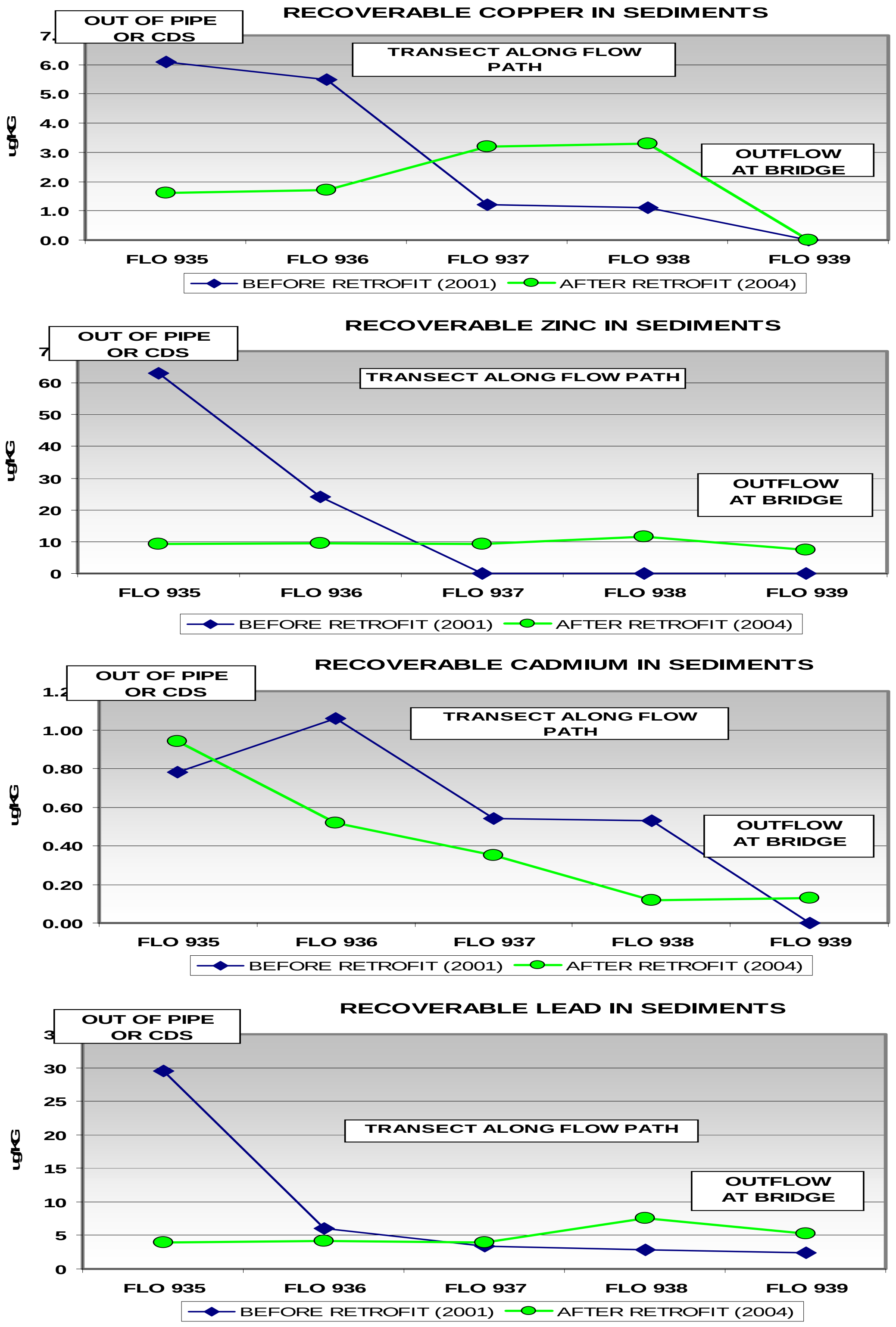
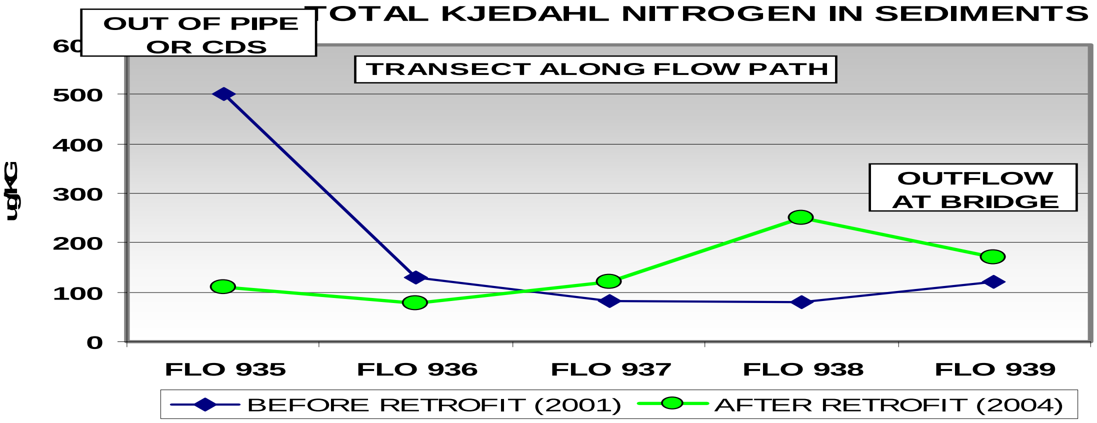


Figure 23. Metal concentrations are compared in the sediments at the Broadway Outfall before the CDS unit was installed and two years after installation.



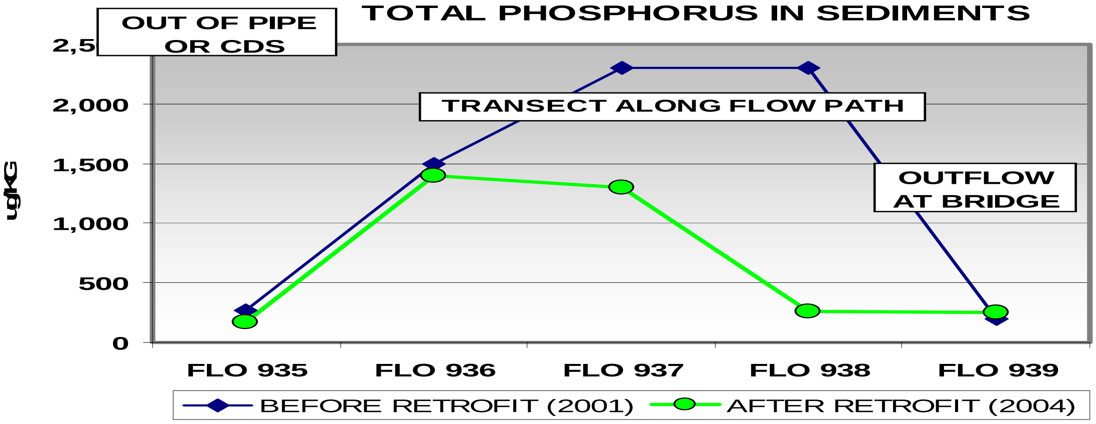


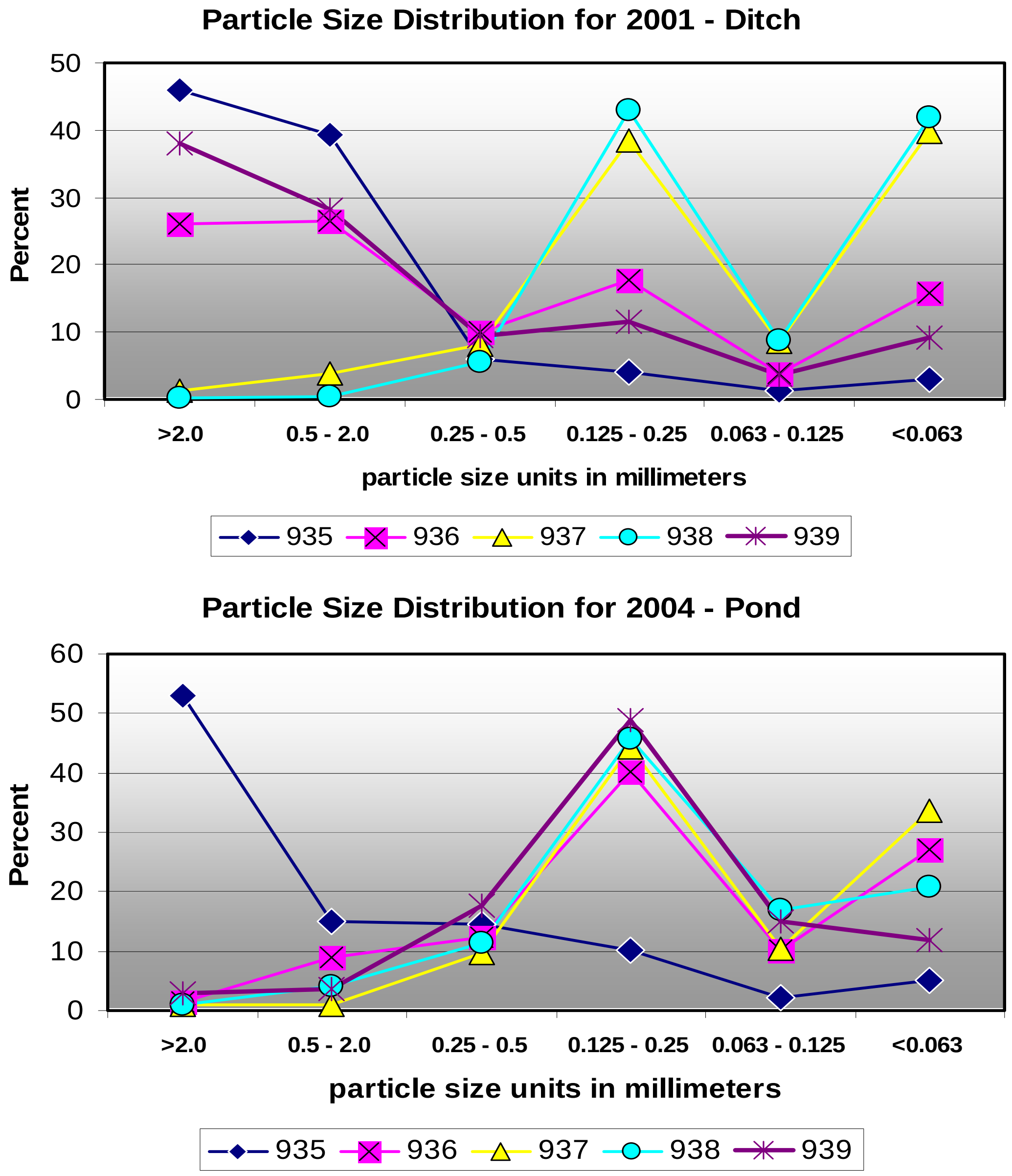
Figure 24. Nutrient concentrations measured along the flow path of the ditch (2001 or the pond (2004). See table 2 for site locations.

Pesticides

Tests were also run for pesticides and none were detected in 2001 and the few detected in 2002 were below the laboratory quantification limit. None were detected in 2004.

Particle Size Analysis

Particle size separation performed on the sediments in the pond (Figure 25) indicate that before the installation of the CDS unit, the large sized particles in the pipe were deposited near the inflow of the Broadway storm sewer (Stations 935 and 936) but soon tapered off to about the same particles size distribution as seen after the installation. Only Station 935 measured a large proportion of large particle sizes after construction and this may have been caused by the rubble that was placed near the entrance of the discharge pipe to armor the pond against the storm surges that pass through the system. The other anomaly between years was station 939, where two storm sewer pipes had entered the ditch before the pond was constructed but were rerouted in order to make only one inflow and one outflow into the pond for the monitoring study. The implication is that the CDS unit is removing particles larger than 500 mm that had been transported to the ditch before the CDS unit was installed. Another observation is that the large particles were not traveling very far down the ditch and there is a question about whether they would have reached the river or if it would have been necessary to remove them to keep from contaminating the environment as will be discussed in the next section.


Particle Size Distribution for 2001 - Ditch

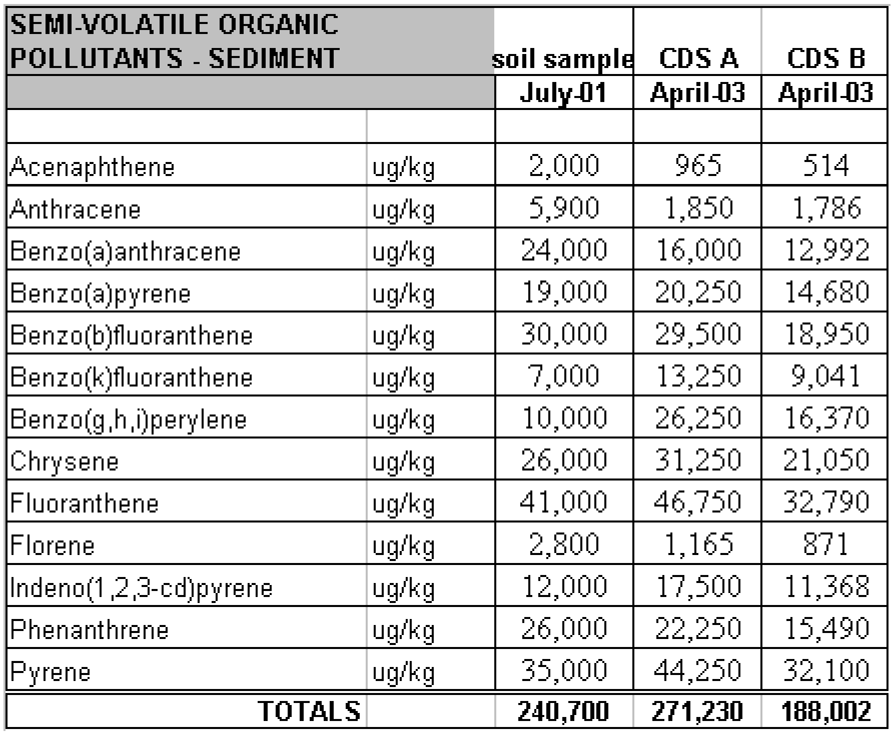
Particle Size Distribution for 2004 - Pond

Figure 25. Particle size distribution measured for the sediments in the ditch/pond before and after installation of the CDS unit. See Figure 2 for the location of the sampling sites. The sampling sites extend from where the Broadway Outfall storm sewer pipe discharged to the bridge location where the pond ended.

PAHs in Soil Compared to Gross Solids

When the pre-construction PAH soil samples collected in July 2001 near where the storm sewer pipe entered the ditch are compared to the samples collected in the CDS unit in April 2003, concentrations are similar (Table 11). This indicates that these toxic levels of hydrocarbons that were previously released to the environment are now removed from the flow stream and disposed of in a location where they can no longer contaminate a water body. The CDS unit has removed a serious long-term impact related to the re-suspension of previously deposited polluted material that has been reported as even more detrimental to the environment than the short-term "first flush" effect associated with urban runoff (Heaney 1978).

Table 11. Comparison of PAHs in the soil sample collected where the pipe enters the Broadway Outfall retrofit site (STA935) compared to concentrations measured in the CDS unit during cleanout.



SEMI-VOLATILE ORGANIC POLLUTANTS - SEDIMENT		soil sample	CDS A	CDS B
		July-01	April-03	April-03
Acenaphthene	ug/kg	2,000	965	514
Anthracene	ug/kg	5,900	1,850	1,786
Benzo(a)anthracene	ug/kg	24,000	16,000	12,992
Benzo(a)pyrene	ug/kg	19,000	20,250	14,680
Benzo(b)fluoranthene	ug/kg	30,000	29,500	18,950
Benzo(k)fluoranthene	ug/kg	7,000	13,250	9,041
Benzo(g,h,i)perylene	ug/kg	10,000	26,250	16,370
Chrysene	ug/kg	26,000	31,250	21,050
Fluoranthene	ug/kg	41,000	46,750	32,790
Florene	ug/kg	2,800	1,165	871
Indeno(1,2,3-cd)pyrene	ug/kg	12,000	17,500	11,368
Phenanthrene	ug/kg	26,000	22,250	15,490
Pyrene	ug/kg	35,000	44,250	32,100
TOTALS		**240,700**	**271,230**	**188,002**

The effect of polluted sediments from gross solid deposition has not always been emphasized in stormwater studies that usually base their interpretation and pollution reduction on water quality data for individual storm events. But sediments can accumulate pollutants through mechanisms of direct disposition of solids, or through various processes where soluble pollutants precipitate and contaminate the sediments. Scouring of storm conveyance systems and ultimately streams and rivers takes a long time and are difficult to relate to storm events. These polluted sediments probably have a greater toxic effect on runoff biota than the dissolved toxicants in the water column. Many studies have shown the severe detrimental effects of urban runoff on receiving water organisms (Pitt 1995) and our quantification of the sediments and macroinvertebrates to be discussed in the next section is an attempt to investigate this aspect of pollution at the Broadway Outfall storm sewer outfall.

MACROINVERTEBRATES

The assessment of macroinvertebrate abundance and diversity is useful for determining the ecological integrity of water bodies. Since they are generally sedentary and have a high reproductive rate, the number of macroinvertebrate species present in a water body is an excellent indicator of environmental conditions, They are an essential component of aquatic food webs and their abundance is closely tied to a system of productivity and consumer diversity.

Macroinvertebrate samples were taken in the ditch before the pond was constructed in May 2001, and samples were collected again in August 2002 one year after construction of the pond (Table 12). Although similar numbers of taxa and individuals were collected for both sampling dates, the samples taken at station 935 after the construction shows a much larger number of individual at the inflow to the pond immediately after discharging from the CDS unit. A large number of individuals of a few species are typical of polluted environments. All of the data for the benthic organisms can be found in Appendix K. Both sampling dates show a low number of taxa and species diversity.

Table 12. Results of the macroinvertebrate samples in 2001 and 2002 (See Figure 2 for sampling locations).

Summary statistics for benthic samples collected 2 May 2001. Broadway outfall.

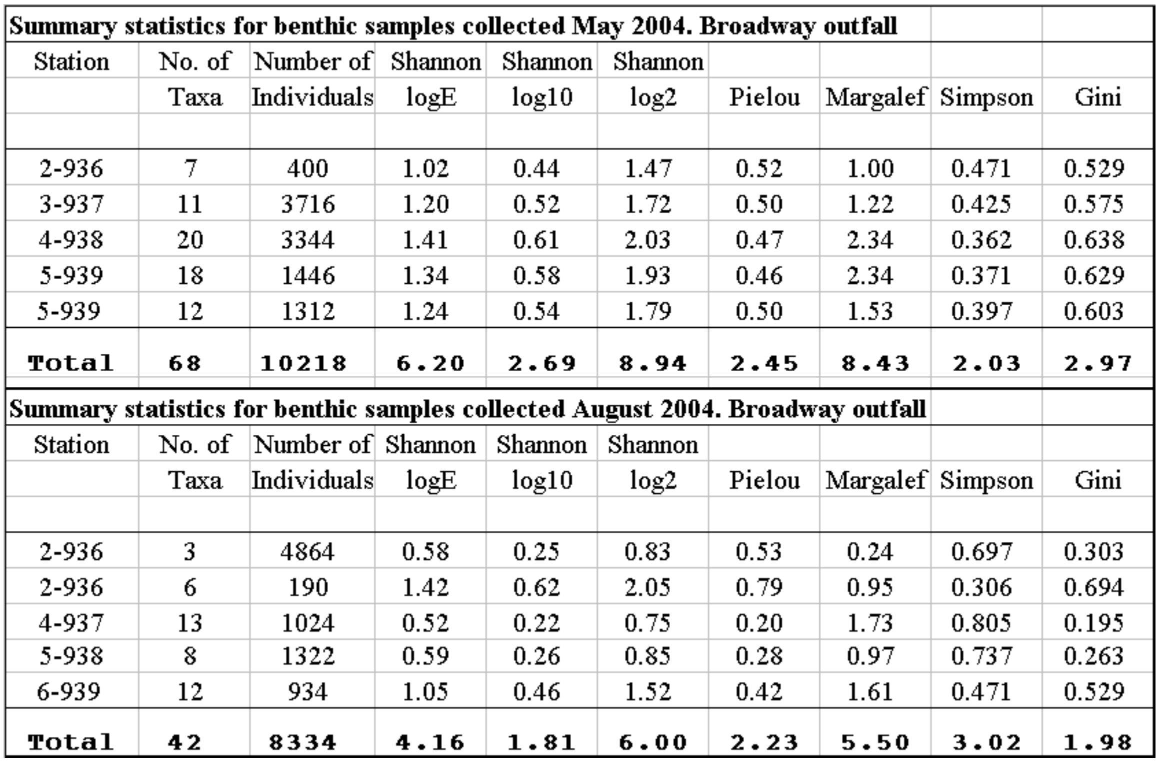
Station	No. of Taxa	Number of Individuals	Shannon logE	Shannon log10	Shannon 1082	Pielou	Margalef	Simpson	Gini
2-935	7	16	1.60	0.69	2.31	0.82	2.16	0.208	0.792
3-936	8	53	0.78	0.34	1.12	0.37	1.76	0.688	0.312
4-937	3	6	1.01	0.44	1.46	0.92	1.12	0.267	0.733
5-938	5	10	1.42	0.62	2.05	0.88	1.74	0.200	0.800
6-939	3	12	0.57	0.25	0.82	0.52	0.80	0.682	0.318
7-940	12	96	1.63	0.71	2.36	0.66	2.41	0.277	0.723
8-941	1	17	0.00	0.00	0.00	na	0.00	1.000	0.000
Total	**23**	**210**	**1.85**	**0.80**	**2.67**	**0.59**	**4.11**	**0.249**	**0.751**

Summary statistics for benthic samples collected 14 August 2002. Broadway outfall.

Station	No. of Taxa	Number of Individuals	Shannon logE	Shannon log10	Shannon 1082	Pielou	Margalef	Simpson	Gini
2-935	7	212	0.64	0.28	0.93	0.33	1.12	0.685	0.315
3-936	4	6	1.24	0.54	1.79	0.90	1.67	0.200	0.8
4-937	4	11	0.89	0.38	1.28	0.64	1.25	0.509	0.491
5-938	1	1	0.00	0.00	0.00	na	na	na	na
6-939	5	64	0.98	0.42	1.41	0.61	0.96	0.454	0.546
7-940	na	na	na	na	na	na	na	na	na
8-941	0	0	na	na	na	na	na	na	na
Total	**21**	**294**	**3.75**	**1.62**	**5.41**	**2.48**	**5.00**	**1.85**	**2.15**

Macroinvertebrates in the sediments were not sampled again until May 2004 and August 2004 to coincide with the same months as previous sampling events (Table 13). The results are quite different from the earlier sampling dates. In the two years since construction of the CDS unit and pond, a tremendous increase is measured in the number of taxa and the number of individuals as well as in the species diversity indices, even though two stations downstream from the pond have been eliminated making fewer sampling sites. Although variation between sampling dates is expected the lower number of taxa and individuals in August may be the result of the summer of intense hurricane activity. Also fewer taxa are found near the inflow of the pond.

Table 13. Results of the macroinvertebrate samples in 2004 (See Figure 2 for sampling locations).



Summary statistics for benthic samples collected May 2004. Broadway outfall

Station	No. of Taxa	Number of Individuals	Shannon logE	Shannon log10	Shannon log2	Pielou	Margalef	Simpson	Gini
2-936	7	400	1.02	0.44	1.47	0.52	1.00	0.471	0.529
3-937	11	3716	1.20	0.52	1.72	0.50	1.22	0.425	0.575
4-938	20	3344	1.41	0.61	2.03	0.47	2.34	0.362	0.638
5-939	18	1446	1.34	0.58	1.93	0.46	2.34	0.371	0.629
5-939	12	1312	1.24	0.54	1.79	0.50	1.53	0.397	0.603
Total	**68**	**10218**	**6.20**	**2.69**	**8.94**	**2.45**	**8.43**	**2.03**	**2.97**

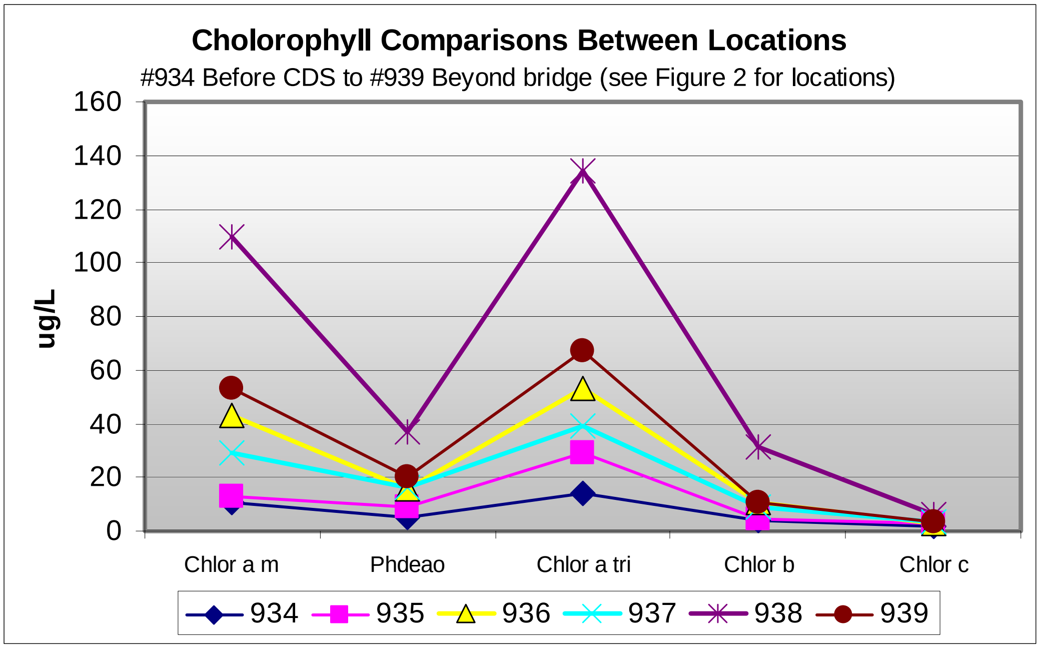
Summary statistics for benthic samples collected August 2004. Broadway outfall

Station	No. of Taxa	Number of Individuals	Shannon logE	Shannon log10	Shannon log2	Pielou	Margalef	Simpson	Gini
2-936	3	4864	0.58	0.25	0.83	0.53	0.24	0.697	0.303
2-936	6	190	1.42	0.62	2.05	0.79	0.95	0.306	0.694
4-937	13	1024	0.52	0.22	0.75	0.20	1.73	0.805	0.195
5-938	8	1322	0.59	0.26	0.85	0.28	0.97	0.737	0.263
6-939	12	934	1.05	0.46	1.52	0.42	1.61	0.471	0.529
Total	**42**	**8334**	**4.16**	**1.81**	**6.00**	**2.23**	**5.50**	**3.02**	**1.98**

CHLOROPHYLL

Chlorophyll is a photosynthetic pigment used extensively to estimate phytoplankton biomass. All green plants contain chlorophyll *a*. Other pigments that occur in phytoplankton include chlorophylls *b* and *c*. The degradation product, pheophytin, is a measure of algal remains (Kadlec and Kinght 1996). Chlorophyll *a* concentrations are strongly associated with other water quality parameters, such as, transparency, turbidity, total phosphorus and total suspended solids. This relationship is one of the most often used parameters to develop trophic state indices for water bodies. Chlorophyll measurements are useful indicators of the phytoplankton population and provide insight into the primary productivity and ecology of lakes, rivers and estuaries. Phytoplanktons are usually single-celled microscopic organisms and live suspended in the water column. They are essential to life and form the basis of the food chain. But too much phytoplankton creates eutrophic conditions and can cause loss of species diversity and turbid conditions.

Samples for chlorophyll analysis were collected at the site to characterize the water (Figure 26 and Appendix L). The various types of chlorophyll were measured in the order shown in the table beneath the figure. Samples were collected once before the monitoring began in 2002 and not again until 2004-05 when they were collected on a bi-monthly schedule. Not all locations were sampled each time, but the laboratory results give an indication of conditions in the system. Very low concentrations of chlorophyll were measured in the pipe before and after the CDS unit. This is not surprising since sunlight is necessary for phytoplankton growth. Once the water entered the pond, there is a gradual increase in concentrations until the water flows under the bridge limiting sunlight again and slightly reducing chlorophyll content in the water column. From the table in Appendix L, it is evident, that chlorophyll concentrations are higher in summer than winter and that most of the samples were collected during summer months, so this probably is not a fair comparison for assessing trophic state.



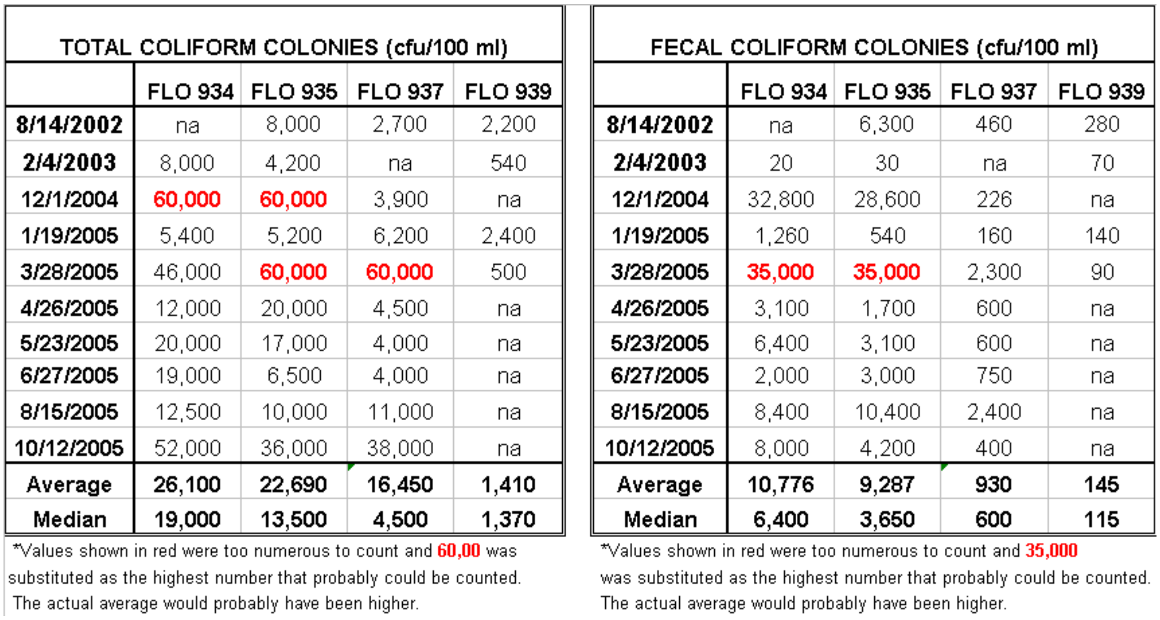
Chlorophyll	Chlorophyll *a*	Pheaophytin	Chlorophyll *a*	Chlorophyll *b*	Chlorophyll *c*
type	Monochro	Monochro	Tricho	Tricho	Tricho
units	ug/L	ug/L	ug/L	ug/L	ug/L

Figure 26. Averaged chlorophyll values for the eight sampling events conducted at different locations in the Broadway Outfall CDS/Pond system.

COLIFORM BACTERIA

Both fecal and total coliform bacteria was measured at high concentrations in the pipe before the CDS and after leaving the CDS, but the pond appears to reduce these high levels to acceptable concentrations (Table 14). The concentrations measured in the pipe greatly exceed the concentrations considered safe for fish and wildlife or human contact. If these few scattered results are any indication, the pond reduces these concentrations to acceptable levels. Even the CDS unit appears to reduce concentrations to some extent. The high concentrations in the pipe are possibly caused by septic tank infiltration, sewer cross connections, pet droppings or the stagnant conditions in the pipe. Stagnant conditions are conducive to bacterial growth. Fecal microorganisms accumulate in sediments where survival is extended from weeks to months (Burton and Pitt 2002).

Table 14. Coliform bacteria concentrations traveling from in front of the CDS (FLO 934) through the pond system to the outflow (FLO 939). See Figure 2 for sampling locations.



TOTAL COLIFORM COLONIES (cfu/100 ml)				
	FLO 934	FLO 935	FLO 937	FLO 939
8/14/2002	na	8,000	2,700	2,200
2/4/2003	8,000	4,200	na	540
12/1/2004	60,000	60,000	3,900	na
1/19/2005	5,400	5,200	6,200	2,400
3/28/2005	46,000	60,000	60,000	500
4/26/2005	12,000	20,000	4,500	na
5/23/2005	20,000	17,000	4,000	na
6/27/2005	19,000	6,500	4,000	na
8/15/2005	12,500	10,000	11,000	na
10/12/2005	52,000	36,000	38,000	na
Average	**26,100**	**22,690**	**16,450**	**1,410**
Median	**19,000**	**13,500**	**4,500**	**1,370**

*Values shown in red were too numerous to count and **60,00** was substituted as the highest number that probably could be counted. The actual average would probably have been higher.

FECAL COLIFORM COLONIES (cfu/100 ml)				
	FLO 934	FLO 935	FLO 937	FLO 939
8/14/2002	na	6,300	460	280
2/4/2003	20	30	na	70
12/1/2004	32,800	28,600	226	na
1/19/2005	1,260	540	160	140
3/28/2005	35,000	35,000	2,300	90
4/26/2005	3,100	1,700	600	na
5/23/2005	6,400	3,100	600	na
6/27/2005	2,000	3,000	750	na
8/15/2005	8,400	10,400	2,400	na
10/12/2005	8,000	4,200	400	na
Average	**10,776**	**9,287**	**930**	**145**
Median	**6,400**	**3,650**	**600**	**115**

*Values shown in red were too numerous to count and **35,000** was substituted as the highest number that probably could be counted. The actual average would probably have been higher.

Although there are wide fluctuations between sampling dates as indicated by the large difference between averaged and median values, standards are greatly exceeded in the pipe and the pond, but standards are usually met in the discharge water from the pond. According to the standards for class III waters using membrane filtration (MF) in units of cfu's/100 ml, fecal coliform counts shall not exceed an average value of 200 or must be less than 400 in 10 percent of monthly samples or less than 800 on any one day. The samples in the pipe greatly exceed these criteria, but the few samples taken at the outflow of the pond usually meets the standard for fecal coliform. The same pattern holds true for total coliform with samples in the pipe and the pond exceeding standards, but in this case standards are also slightly exceeded in the water discharged from the pond. For total coliform, concentrations must not exceed 1,000 as a monthly average, or less than 1,000 in 20 percent of samples or less than 24,000 on any day.

THE END OF THE NARRATIVE

SUMMARY OF RESULTS

HYDROLOGY (Appendices B and C)

- Rainfall was above its normal amount of 52 inches per year during the three years of the study (Figure 4). Year three had the least amount of rainfall (58 inches), but it was still above the long term average. Table 4 reveals that the rainfall characteristics for the three years show similar patterns. Also of note, during the summer of year two, three hurricanes swept through the region increasing average rainfall amount and storm duration, but not median rainfall values.
- Even for rain amounts as small as 0.21 inches, some of the storm flow bypasses the CDS unit (Figure 5). Greater than 25 percent of all base flow is attributed to a daily pulse of water. Except when obscured by rain events, it occurs for about three to four hours between 14:00 and 17:30 each day (Figure 5).

STORM FLOWS (Appendix D)

- The individual hydrographs were useful for analyzing characteristics of the system. In the Broadway Outfall drainage basin, flow occurs almost immediately after the first raindrop hits the ground indicating the efficiency of the underground pipe collection system to rapidly remove runoff from the drainage basin (Figure 6)
- Water budget calculations estimated that between ten and thirteen million cubic feet of flow passed through the system during each year of study (Table 5). The error term was small when compared to total inflows or outflows for each year: 2 percent in 2002-03, 9 percent in 2003-04 (broken pipe problems) and less than 1 percent in 2004-05. A quick assessment of the data shown in the water budget in Table 5 calculated runoff coefficients for the 132-acre drainage basin for the three years of data collection as 0.25 for year one, 0.33 for year 2 and 0.31 for year three.

WATER QUALITY (Appendix E)

- The CDS unit does not consistently change any of the constituents in the water column (Figures 7-10, Table 6). This should be no surprise since it is designed to remove gross pollutants not the suspended or dissolved pollutants in the water column.
- Most of the nitrogen species exhibit only small differences between the inflow and the outflow of the CDS unit, although there is often a large difference after water has traveled through the pond (Figure 7 and Table 6).
- Organic nitrogen concentrations usually increased in the pond for both base flow and storm flow (Figure 7 and Table 6). One explanation for the increase of both organic nitrogen and ammonia may be the vegetation that was planted and subsequently uprooted by strong storm surges. In addition, grass clippings and other organic debris were introduced into the pond each time the side bank was mowed.
- Nitrate showed a modest reduction in the CDS unit during storm events, and a much better reduction in the pond (Figure 7 and Table 6).
- Ortho-phosphorus, the most available chemical form, was slightly reduced in the CDS unit during most years (Figure 8 and Table 6).
- Even though wetlands are often effective in removing phosphorus, there was most often a net increase in phosphorus concentrations after it flowed from the CDS unit through the pond (Figure 8 and Table 6).

- An insignificant change in TSS occurred in the CDS unit. The TSS concentrations are not high at this site (average 12-30 percent-mg/l) (Figure 9 and Table 6) and the CDS unit is only designed to remover large size particles.
- In general, metal concentrations are much lower in base flow than in storm flow and concentrations are measured over twice as high during the third year in storm flow (Figure 10). The exception is copper. Lead is not discussed since almost all concentrations were below the laboratory limit of detection.
- Dissolved metals as a percentage of total concentrations in storm flow averaged about 50 percent for zinc, 37 percent for copper and 20 percent for iron (Figure 11 and Table 7).

FIELD PARAMETERS (Appendix F)

- Dissolved oxygen and pH are measured lower at the inflow of the pond because water has recently been discharged through the CDS unit, which is a dark anaerobic environment. The concentrations are higher and the fluctuations greater at the outflow once plants and animals in the pond ameliorate conditions (Figure 12) Rainfall decreases the diurnal fluctuations, especially near the inflow of the pond. This effect is caused by rainfall and runoff flowing into the pond and diluting the pond water before reaching the outflow (Figure 12)
- Conductivity (specific conductance) usually decreased with rainfall input, because rainfall has low conductivity, and then slowly increases between storms as evapotranspiration and other processes increase ion concentrations. The effect is more obvious at the inflow where stormwater has had less time to mix with pond water (Figure 12)
- Dissolved oxygen (DO) showed only weak seasonal patterns, but the averaged values were much higher in February of 2005 caused by a cold front passing through the area. Normally DO is increased in winter because oxygen is more soluble in colder water (Table 8).
- Dissolved oxygen and percent saturation are measured about 50 percent higher at the outflow of the pond than at the inflow caused by the anaerobic water discharged into the pond through the CDS unit. The higher concentration at the outflow is caused by algae photosynthesis that can raise DO during the day to high supersaturated conditions (> 12 mg/l) which then drop to low levels (< 4 mg/l) at night (Table 8).
- Specific conductance is a measure of the total concentrations of ionized materials at the sampling site and was measured within the upper range for natural systems. The specific conductance of most natural inland surface waters is between 0.01 and 0.3 mS/cm (Table 8).

GROSS SOLIDS (Appendices G, H and I)

- Year one and year three data indicate that February through April produce the most collected material in the CDS unit, this was not true for year 2 when the unit also filled up during the summer rainy season. Of some interest is that during the summer of intense hurricanes, no material was collected (Figure 13).
- When the gross solids (the solid bars in Figure 14) are compared for the four cleanout events, year 3 exhibits significantly greater concentrations of pollutants and in almost all cases the sieved samples have higher concentrations than the sample analyzed without sieving (a whole sample).
- Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) collected by the CDS unit were always measured higher than the possible toxic level (> 1,600

ug/kg) and also greatly exceeded the probable toxic level (> 23,000 ug/kg) (Figure 14).

- Our concern about losing sediment from the samples collected by the Ekman dredge appears justified. Only about 55 percent of the sample was sorted out in the largest size fraction (leaves) at site C compared to 70 to 80 percent of the samples collected by the dredge (Figure 15c).
- Significant differences in concentrations for the same sample of material collected by the CDS unit were measured by two different labs and some sample collection schemes are suggested to correct this problem (Table 9, Figures 16, 17, 18, 19, and page 46).
- Samples A and B taken inside the CDS unit at time of cleanout sometimes show higher concentrations in Sample B, especially for zinc and copper. The only distinct pattern is for TKN in the largest particle size which mostly consists of leaves; while metals tend to be measured at their lowest concentrations in this largest size fraction (Figure 20).
- The amount of litter collected by the CDS unit during each cleanouts reported was quite small (6 to 17 ft^3) compared to the amount of leaves and sediments removed from the CDS unit (182 ft^3 to 260 ft^3) Plastics were measured more often than any other litter category, but Styrofoam was also found in large quantities (Table 10)

SEDIMENT ANALYSIS (Appendix J)

- PAHs were detected at toxic levels at this site in both the gross solids collected by the CDS unit and in the sediments before the retrofit. A summary graph of the total PAHs measured in the sediments is shown in Figure 22.
- The data show that ditches are a good mechanism for removing both PAHs and metal concentrations in the sediments as water flows through the system and perhaps better designs might solve some urban water pollution problems (Figures 22 and 23).
- When the pre-construction PAH soil samples collected in July 2001 near where the storm sewer pipe entered the ditch are compared to the samples collected in the CDS unit in April 2003, concentrations are similar (Table 11). This indicates that these toxic levels of hydrocarbons that were previously released to the environment are now removed from the flow stream and disposed of in a location where they can no longer contaminate a water body.

MACROINVERTEBRATES (Appendix K)

- Macroinvertebrate samples were taken in the ditch before the pond was constructed in May 2001, and samples were collected again in August 2002 one year after construction of the pond (Table 12). Although similar numbers of taxa and individuals were collected for both sampling dates, the samples taken at station 935 after the construction shows a much larger number of individual at the inflow to the pond immediately after discharging from the CDS unit.
- In the two years since construction of the CDS unit and pond, a tremendous increase is measured in the number of taxa and the number of individuals as well as in the species diversity indices, even though two stations downstream from the pond have been eliminated making fewer sampling sites (Table 13).

CHLOROPHYLL (Appendix L)

- Very low concentrations of chlorophyll were measured in the pipe before and after the CDS unit. This is not surprising since sunlight is necessary for phytoplankton growth. Once the water entered the pond, there is a gradual increase in concentrations until the water flows under the bridge limiting sunlight again and slightly reducing chlorophyll content in the water column (Figure 27).

COLIFORM BACTERIA (Appendix M)

- Both fecal and total coliform bacteria was measured at high concentrations in the pipe before the CDS and after leaving the CDS, but the pond appears to reduce these high levels to acceptable concentrations (Table 14).

CONCLUSIONS

The monitored CDS unit, though undersized, is effective for removing gross solids from the storm water flow stream, but is less successful in removing the dissolved and suspended constituents typically measured with automatic samplers in most stormwater studies. The CDS unit removed toxic levels of PAHs. The CDS unit effectively removed polluted material that would have caused long-term detrimental effects by re-suspension of bottom sediments, leaching out of sequestered pollutants, smothering of benthic habitat and other problems associated with sediment transport.

CONCLUDING REMARKS

Although the CDS unit proved to be effective, a few modifications were noted that could make the units even better. We noticed that the floating litter was flushed back into the pipe (the A side of the diversion weir (sta. 934)) during base flow as the material circulated in the unit. A flapper valve of some sort that prevents back flow could solve this problem.

One of the biggest problems during cleanout was how to keep the base flow water out of the unit. Some method need to be devised for easily closing off the CDS unit entrance, and probably the exit as well, so that the polluted water in the CDS unit does not have to be continually decanted out of the unit creating a disposal problem.

Maintenance is a continuing responsibility for local governments. The units need to be visited at least once a month to determine if the screens are clogged, to make certain the unit is working properly and to skim off the collected floatables.

Landscape maintenance in the area around the pond killed much of the vegetation in the littoral zone and on the 4:1 slopes surrounding the pond that was planted to intercept runoff into the pond and provide wildlife habitat. Grass clippings found floating in the pond appeared to be a recurring problem.

Standardized methods need to be established for analyzing gross solids. Some recommendations to improve sampling techniques are suggested on page 44 of this document.

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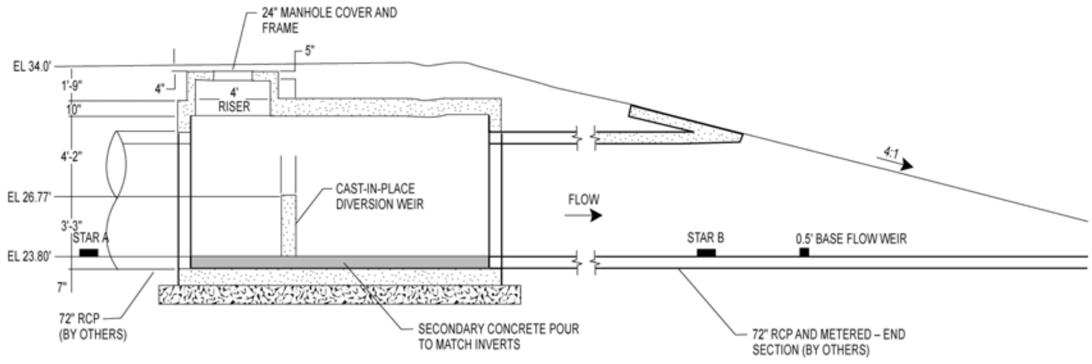
APPENDIX A

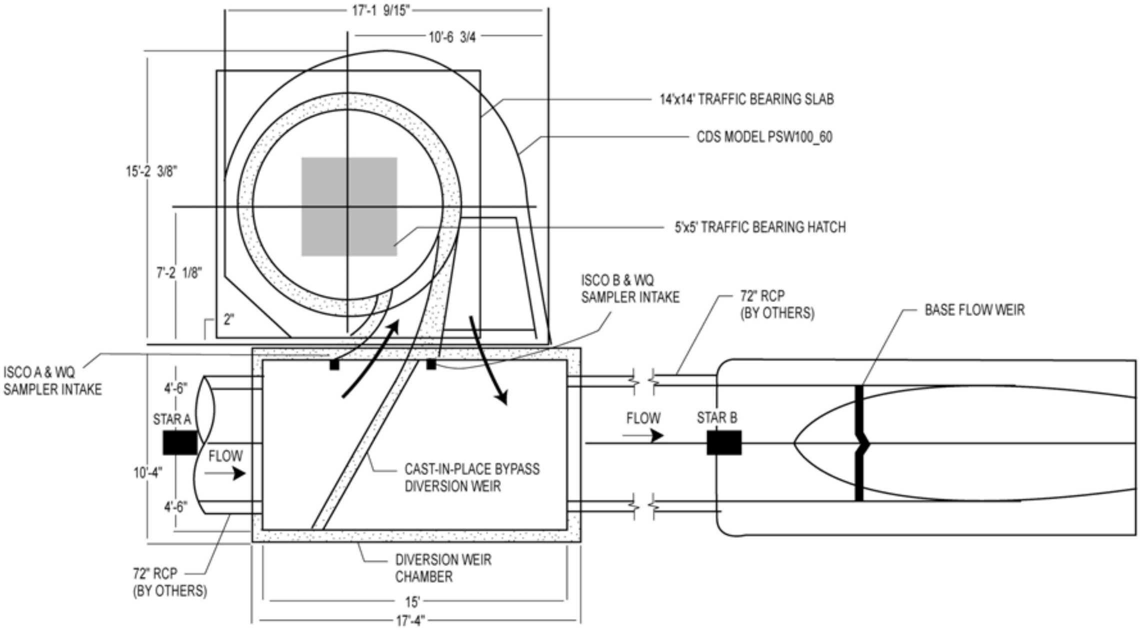
INFORMATION FOR METHOD SECTION

Weir dimensions and formulas and water quality assurance information

Figure A-1 Broadway Outfall Project Area (1995 Orthoquad Base)
Drainage basin outlined in blue and the project site is outlined in green.



Side view showing location of sensors before and after the CDS unit.



Plan view showing location of sensors, diversion weir, CDS unit, base flow weir and other features of the inflow pipe at Broadway Outfall.

Figure A-2. Dimensions of CDS unit design plan showing sensor locations.

Broadway *Flow Calculations*

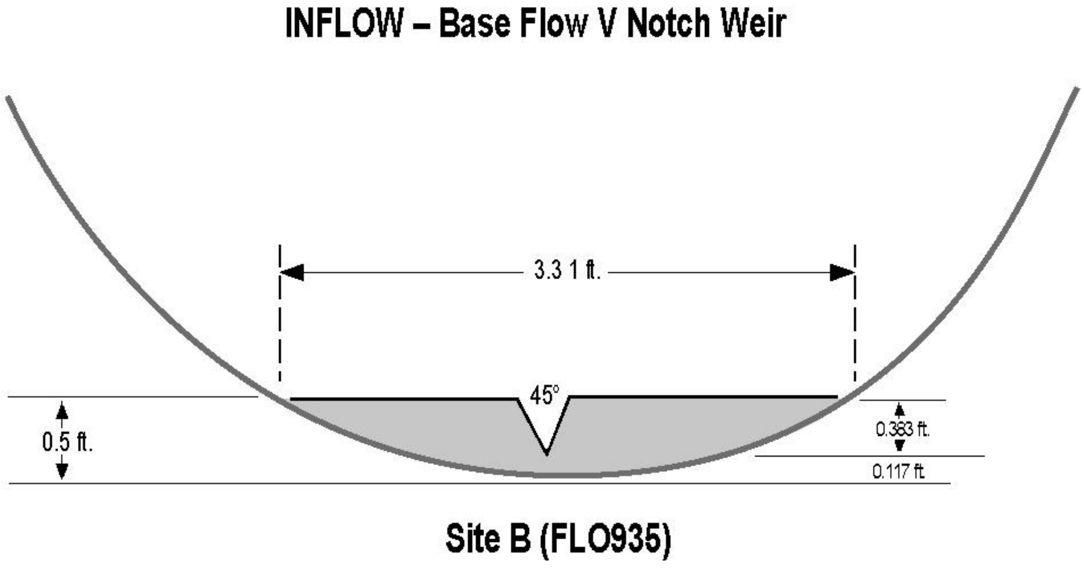


Figure A-3. Base flow weir installed in inflow pipe.
Low flows:

For levels less than 0.6 feet, the velocity sensor does not read correctly and the base flow formula is used to calculate flow using water level measured by the ISCO B and/or the STAR B level sensor with an aluminum weir and appropriate formulas (see Figure 2 for location of sensors).

The V-notch weir equation is used for free flowing water levels in the pipe that are less than 0.5 feet. It takes the form:

$$Q = K*H1^{2.5}$$

Where: Q (cfs) = flow rate
H1 (feet) = head on weir = water level-0.117 feet
K = a constant, dependent on the angle of notch (1.035 for 45^{o} cfs)

For heads greater than 0.383 feet and less than 0.6 feet, a rectangular weir without end contraction formula was used and added to the maximum flow for the V-notch (max flow for V-notch=0.10 cfs):

$$Q = K*L*H2^{1.5}$$

Where: Q (cfs) = flow rate
H2 (feet) = head above V-notch = H1-0.383
L (ft) = Crest of weir (3.31 feet)
K = constant =3.33 for cubic feet per second (cfs)

PIPE FORMULA:

Storm Flow:

For storm flows greater than 0.7 feet, the STAR velocity meter multiplied by the area of the pipe for that level (d) was used to calculate flow. Three different formulas were tried for calculating the area of the pipe for different levels and they all gave the same results, so we used the one below developed by Mike Beach:

$$A\ (\mathrm{ft}^2) = (D/2)^2 * \mathrm{arcos}(1-2d/D) - (D/2-d) * \mathrm{sqrt}(d(D-d))$$

Where: $A\ (\mathrm{ft}^2)$ = area of pipe at water depth d
D = diameter of pipe (ft)
d = depth of water (ft)

Storm Flows that bypass CDS unit:

Storm flows that bypassed the CDS unit were calculated using the water level measured at site A with the ISCO A level sensor (see Figure 2 and 3 for location of sensors).

A rectangular weir without end contractions was located between the inflow and outflow of the CDS unit (see Figure 3). A sharp crested aluminum plate was attached to the top of the cast-in-place bypass diversion weir to improve flow calculations.

The formula used for calculating the flow that bypassed the CDS unit is;

$$Q = K*L*H^{1.5}$$

Where: Q = flow (cfs)
L = length of weir = 10.33 ft
H = head (ft) = water level above weir crest
Weir crest = 3.5 feet above water level at station A

Problems associated with measurements:

- The height of V-notch was not greater than 2 times the head
- Heads were most often not 0.2 feet over weirs
- Base flow weir did not always spring free because of low heads
- Snails and other debris often clogged V-notch

Outflow:

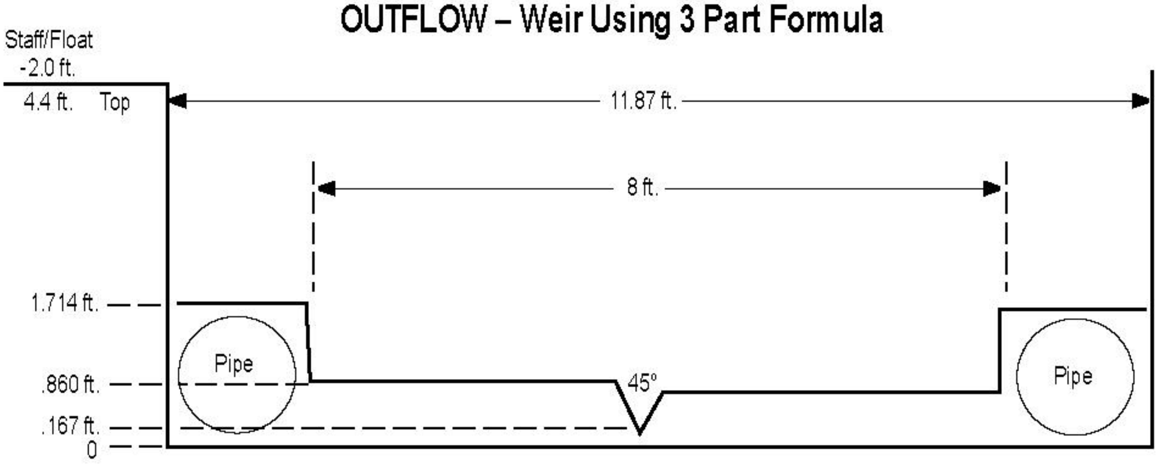


Figure A-4. Dimensions of outflow weir at Sta 939.

The outflow required a three-part formula to estimate flow out of the pond. The two pipes in the diagram above divert water that would have come into the pond immediately above the outflow weir but are now discharged below the weir.

For base flow, flow was measured through the 45^o V-notch using the following formula:

$$Q = K*H1^{2.5}$$

Where: Q (cfs) = flow rate
H1 (feet) = head on weir = water level-0.117 feet
K = a constant, dependent on the angle of notch (1.035 for 45^o cfs)

For heads greater than 0.860 feet, a rectangular weir with end contractions formula was used and added to the maximum flow (for the V-notch > 0.86 = 0.7 cfs and for flow > 1.714 max flow = 24 cfs):

$$Q = K*(L-0.2\ H2)*H2^{1.5}$$

Where:Q (cfs) = flow rate
H2 (feet) = head above V-notch = H1-0.860
L (ft) = Crest of weir (8 feet)
K = constant =3.33 for cubic feet per second (cfs)

Flow above 1.714 ft occurred rarely and used the formula above with:
H2 = H1-1.714
L = 11.87 feet

Regression Equation to estimate flow at Sta. 935:

The Star velocity meter became inoperable in February 2004. An old Marsh McBirney velocity meter was altered to measure the flow that left the CDS unit, but it failed to record correctly during most rain events. A regression equation was calculated using the data from the first year. This equation was used to estimate flow and to verify flow measurements when there was a question about their validity. Almost 800 data points were used to estimate the equation. Only values greater than 0.60 feet were used in the equation and lower flows were calculated using the base flow weir equation. The regression equation is shown below:

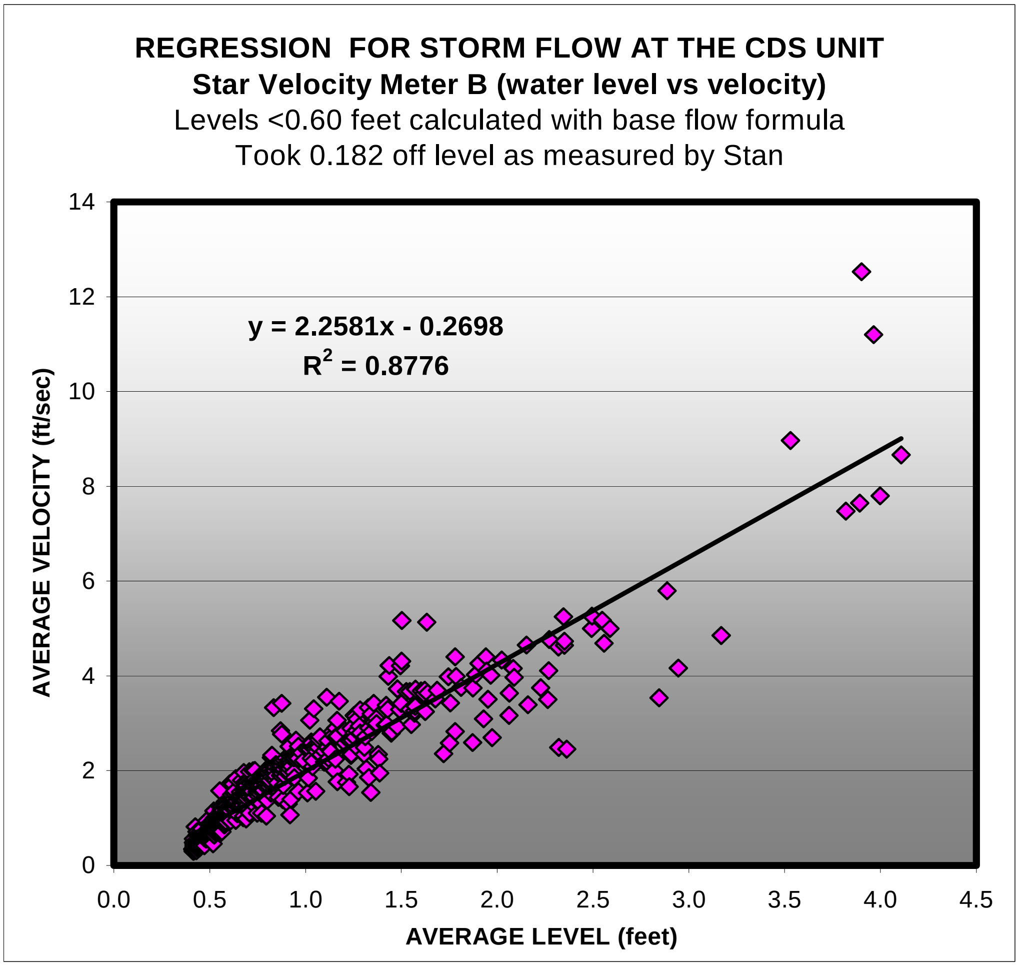


Figure A-5. Regression equation developed to estimate flow once velocity meter became inoperable. It also corrected for sensor drift experienced in final 18 months of study.

The STAR velocity meter stopped recording correctly during February 2004 and several methods were used to try to estimate flow including the regression equation shown above in Figure A-5. Comparisons for some of the results are shown in Appendix D and an example with the appropriate formulas is shown below.

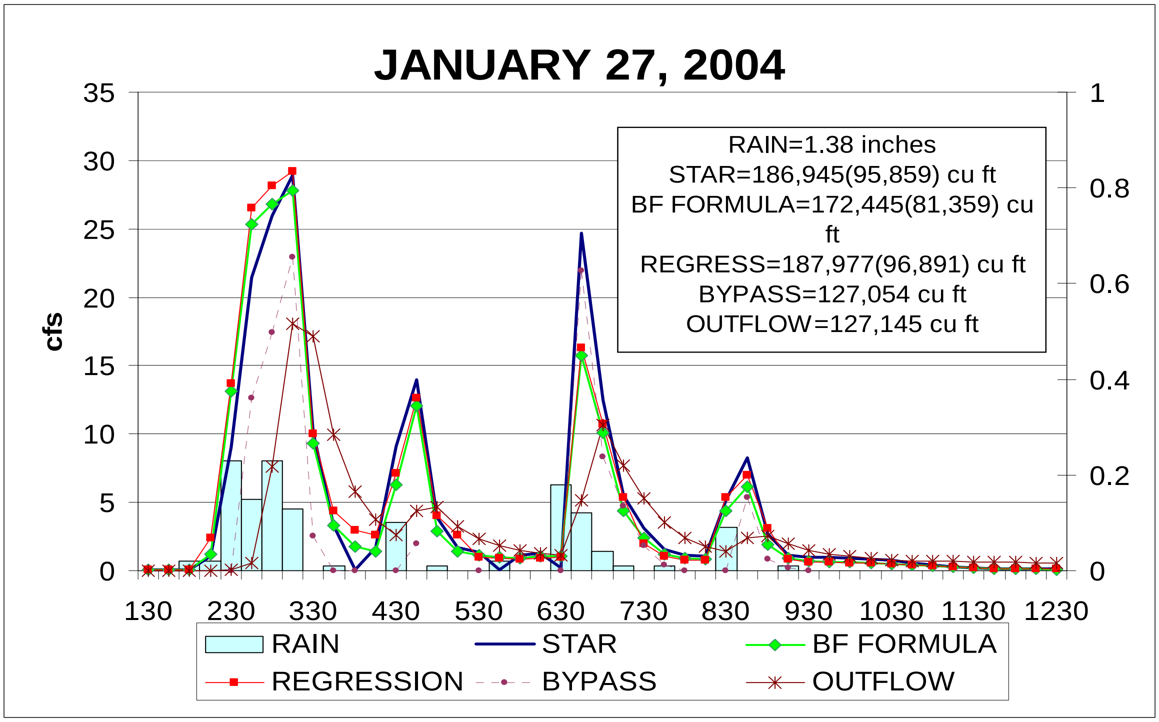


Figure A-6. An example of flows compared to sensors installed at the site. All calculations use the base flow weir formula for low flows because velocity meters are unable to read low flows.

Abbreviations used in formulas:

HT=Level from bottom of pipe (actual height of water in pipe)
h=head of water going through V-notch of base flow weir or over top of weir.

BF FORMULA: Derived from base flow weir formula using the top of weir as a rectangular weir without end contractions and adjusting for the changing length of weir as pipe diameter changes (Figure A-7). The 0.1 add on is for max flow thru v-notch. Formula under estimates flow when water level in pipe is over half full (3 ft)

Flow=(h^1.5)*3.33*(1.3095*ln(h)+4.5338)+0.1

REGRESS: A regression equation developed for velocity using water level during a year when the velocity meter was reading correctly. The velocity was then multiplied by pipe area (see previous pipe formula area).

Flow=(2.2581*HT)-0.2698

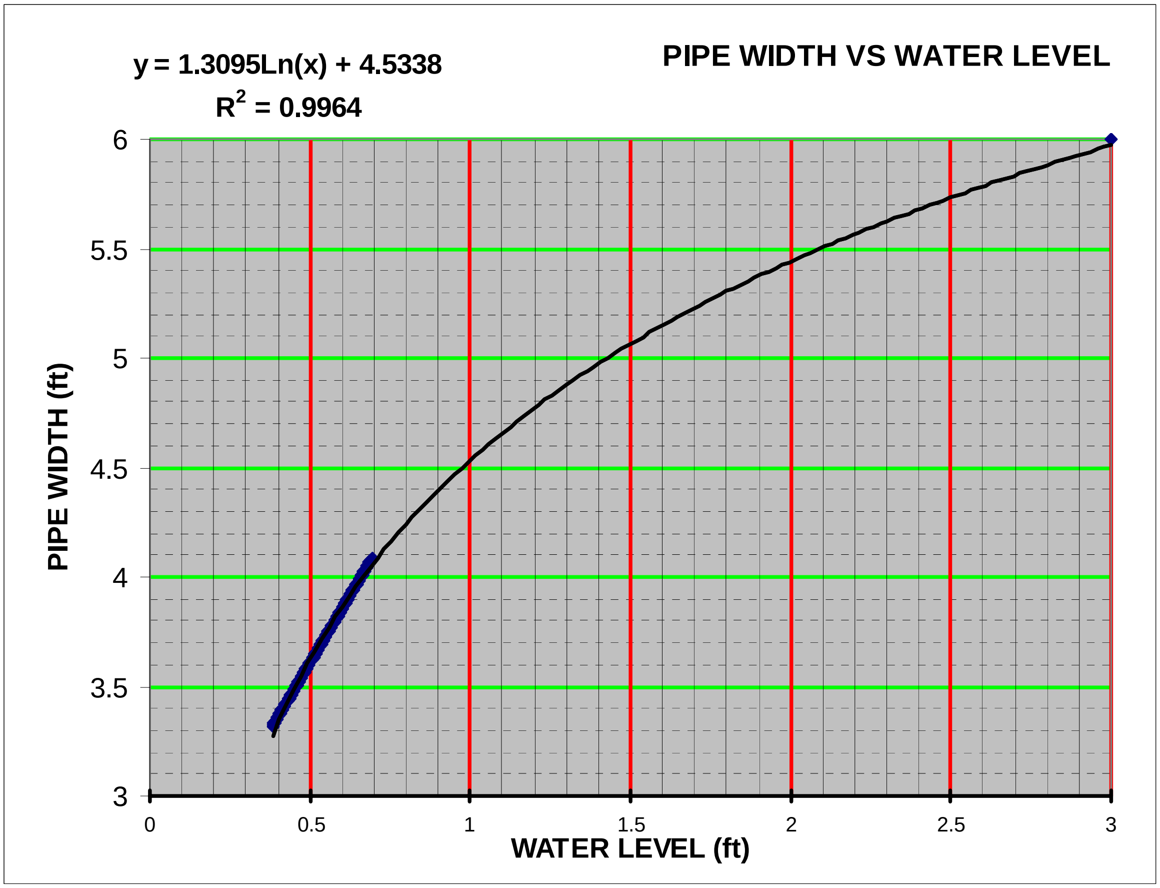
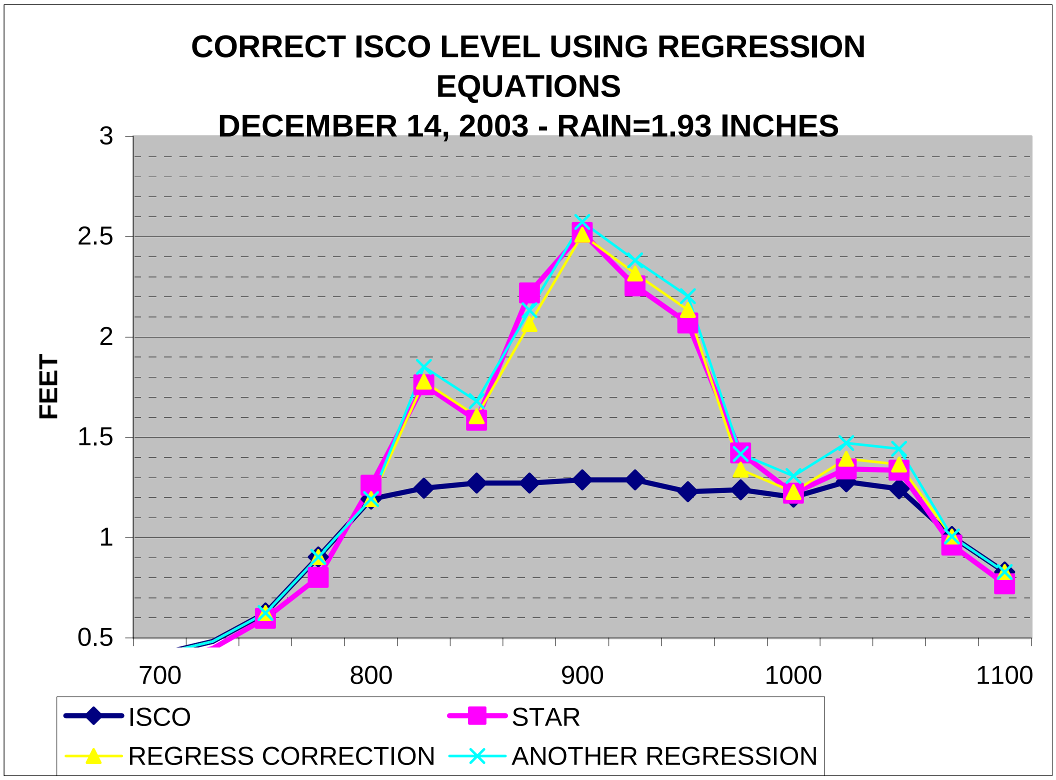


Figure A-7. A unique length of weir had to be calculated for each water level in the round 6 ft pipe and was used in the BF formula described above. On those rare occasions when the level in the pipe was greater than three feet, the cross sectional area was not correct and the REGRESS equation was more accurate.



Figures A-8. The ISCO level B meter often had difficulty measuring high flows as shown in this example. This always occurred when water was also discharging over the bypass weir. Several regression equations comparing Level A (before the CDS) with ISCO level B (after the CDS unit) were developed to correct for this problem once the Star sensors ceased to work. This is one example of making the level correction using the regression equations in Figure A-9.

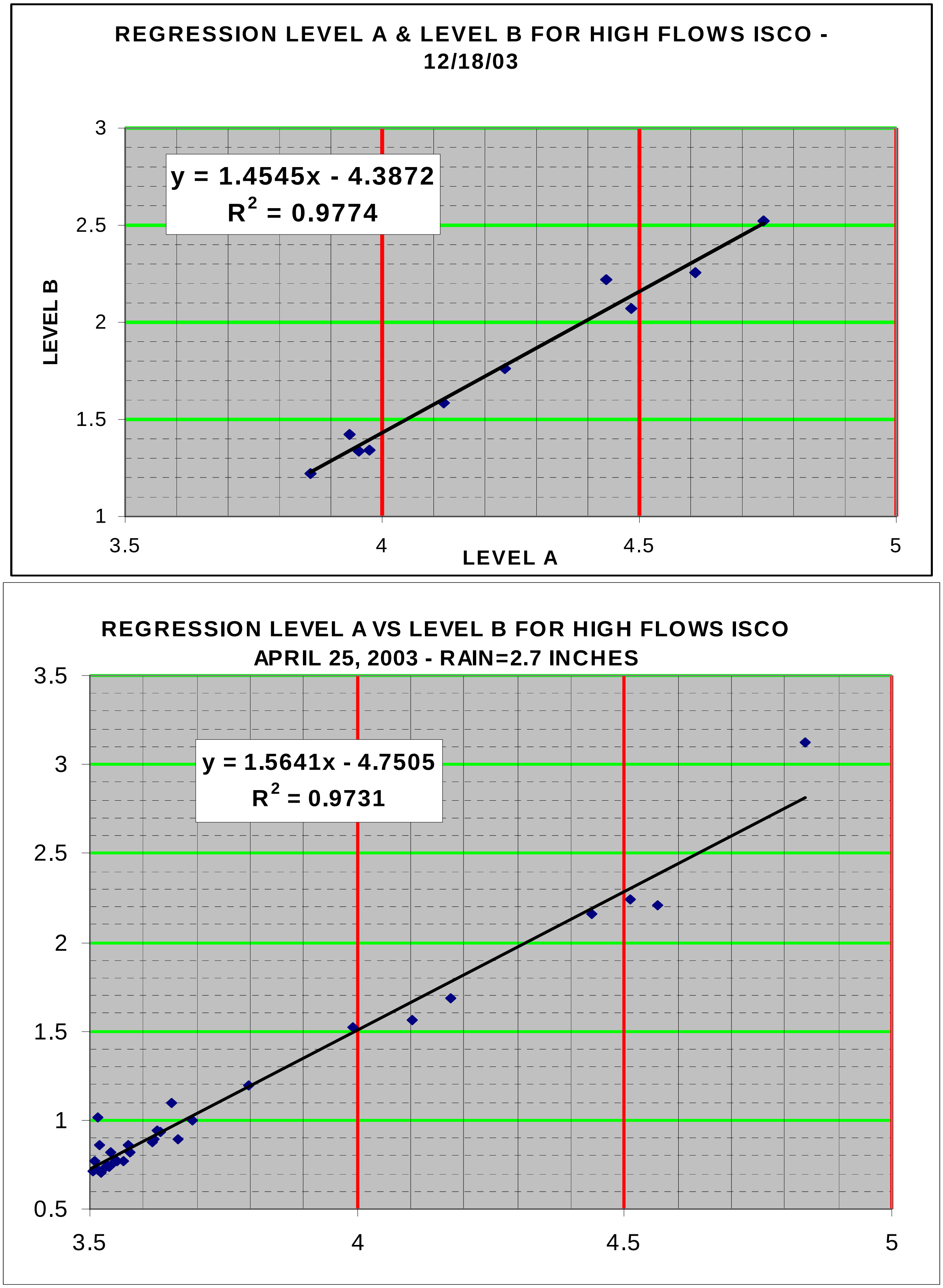
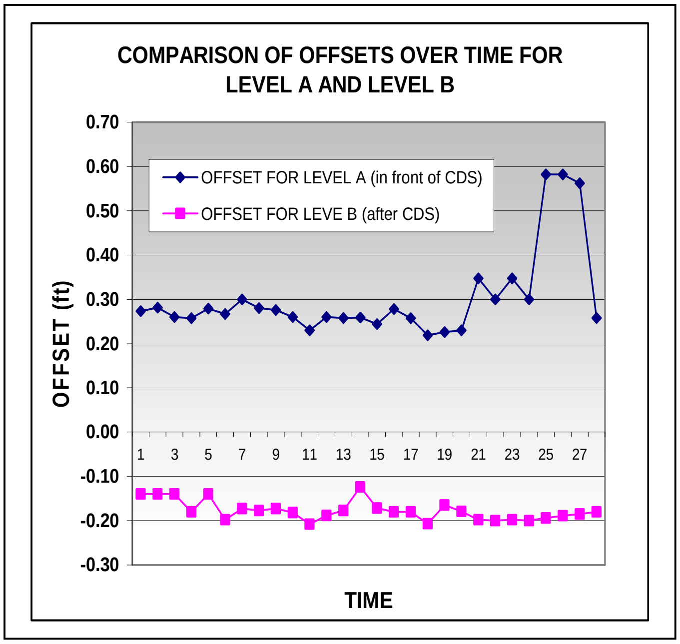


Figure A-9. Regression equations to correct for ISCO B (after CDS unit) levels when it was obviously not reading correctly.

Table A-1. Testing sensors for drift and developing offsets to make corrections for flow and level measurements. Errors in accurately reading staff gauges caused some of the minor variations.

DATE	LEVEL A	LEVEL B
14/18/2005	0.273	-0.140
4/15/2005	0.281	-0.140
4/19/2005	0.260	-0.140
4/25/2005	0.257	-0.180
4/26/2005	0.279	-0.140
4/29/2005	0.267	-0.198
5/2/2005	0.300	-0.173
5/4/2005	0.280	-0.177
5/12/2005	0.276	-0.173
5/23/2005	0.260	-0.182
5/25/2005	0.230	-0.208
6/5/2005	0.260	-0.188
6/7/2005	0.258	-0.177
6/13/2005	0.259	-0.124
6/15/2005	0.244	-0.172
6/24/2005	0.278	-0.180
6/27/2005	0.257	-0.180
7/11/2005	0.219	-0.207
7/13/2005	0.226	-0.165
7/14/2005	0.230	-0.179
8/1/2005	0.347	-0.198
8/11/2005	0.300	-0.200
8/1/2005	0.347	-0.198
8/11/2005	0.300	-0.200
8/15/2005	0.582	-0.194
8/17/2005	0.582	-0.189
8/19/2005	0.562	-0.185
9/16/2005	0.258	-0.180



EXAMPLE OF METHOD USED TO COLLECT SAMPLES IN SUMP FOR CDS UNIT.

Preparation to collect sample prior to sampling day

- Obtain sample bottles and chain of custody from laboratory
- Coordinate with sampling team and agree on date(s)
- Make copies of chain of custody forms
- Get supplies together such as extra pens, labels, log book etc
- Collect sampling equipment and store in one place
    - Gloves
    - Paper towels
    - Lab pads
    - Ethanol
    - DI water
    - Containers for mixing samples. Note restrictions on containers*.
    - Scoops and shovels
    - Leatherman
    - Measuring container (2 liter one worked for us)
    - Sampling equipment such as Ekman Dredge, soil corer, pool skimmer
- Locate coolers to store samples
- Obtain UPS shipping label for coolers
- Wash sampling equipment
    - Wash with liquinox and rinse 3X tap water & 3X DI water
    - Rinse with ethanol
    - Place on lab pads to air dry
- Obtain mesh bags for storing litter until it is sorted
- Make arrangement for vehicle & vacuum truck
- Do a dry run with equipment if method is not yet perfected
- Make table to convert measurement to volume measurements

Making measurements in the sump

- Seal off entrance and exit of unit from any base flow
- Appoint a recorder to take field notes and to make certain all tasks completed correctly
- Have field sample containers* (different from lab sample bottles)
- Remove floatables from the unit and set aside to air dry and measure later
- Measure to the top of material in sump and estimate volume from table
- Take water quality sample in sump
- Decant water from the sump
- Measure to the top of material in sump and estimate volume from table for calculations
- Take sample of material (about 2 liters) using ekman dredge or other suitable equipment
- Package, label and store on ice in appropriate containers until composited together later
- Make field notes
- Make visual estimate of how much material collected in each category – (percent sediment, percent foliage, and percent litter) and record in field journal
- Take duplicate sample on opposite side of unit and repeat previous four steps
- Have vacuum truck remove material in sump
- Take samples of material in sump at appropriate intervals by the above method (we did five levels about 1.25 feet apart)

Preparation of samples for lab analysis (later at office)

If samples represent different volumes of material, do calculations for
 ratio and determine correct percentage for each level
Mix samples together in one large container using appropriate ratio
Put mixture into lab bottles
Repeat previous three steps for the duplicate sample
Put samples in coolers
Fill out the appropriate paper work
Mail to the lab using their instructions

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*Depending on analysis only containers made out of certain materials can be used
 For example, stainless steel or glass for metals. Some plastics can't be used for PAHs.

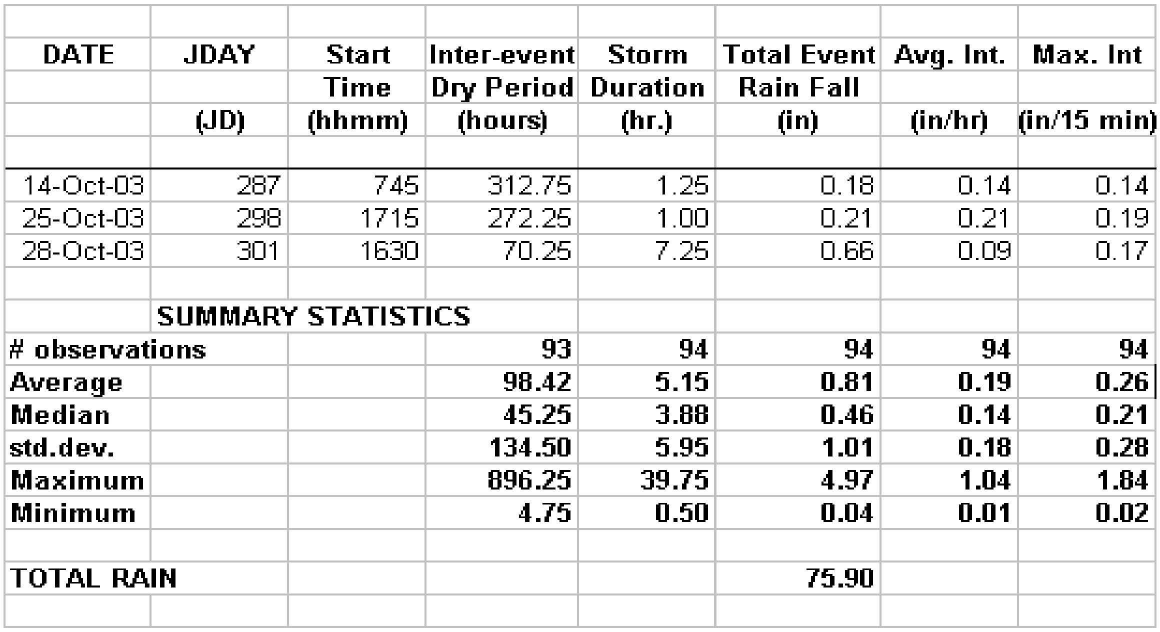
APPENDIX B

RAINFALL CHARACTERISTICS

Table B-1. Rainfall characteristics

DATE	JDAY	Start Time	Inter-Event Dry Period	Storm Duration	Total Event Rain Fall	Avg. Int.	Max. Int
	(JD)	(hhmm)	(hours)	(hr.)	(in)	(in/hr)	(in/15 min)
12-Oct-02	285	2200		3.25	2.06	0.63	0.84
13-Oct-02	286	1615	15.00	0.50	0.04	0.08	0.04
15-Oct-02	288	1400	45.25	3.75	0.86	0.23	0.38
16-Oct-02	289	200	8.25	1.75	0.13	0.07	0.09
23-Oct-02	296	1715	181.50	3.25	0.62	0.19	0.35
30-Oct-02	303	1200	159.50	1.75	0.33	0.19	0.11
01-Nov-02	305	1315	48.25	0.75	0.06	0.01	0.02
12-Nov-02	316	1730	267.50	13.00	0.72	0.06	1.84
16-Nov-02	320	915	74.75	22.75	1.26	0.06	0.08
05-Dec-02	339	1945	443.75	39.75	4.97	0.13	0.29
09-Dec-02	343	430	69.00	28.00	3.97	0.14	0.15
12-Dec-02	346	1515	54.75	20.25	4.82	0.24	0.39
20-Dec-02	354	615	162.75	2.25	0.50	0.22	0.29
24-Dec-02	358	1845	106.25	7.50	2.22	0.30	0.38
31-Dec-02	365	1815	160.00	6.00	3.63	0.61	0.44
07-Feb-03	38	900	896.25	0.75	0.04	0.05	0.08
09-Feb-03	40	330	41.75	11.50	0.28	0.02	0.06
10-Feb-03	41	1145	20.75	0.50	0.21	0.42	0.15
16-Feb-03	47	1630	148.25	6.50	0.53	0.08	0.11
22-Feb-03	53	1645	137.75	2.75	0.73	0.27	0.21
28-Feb-03	59	1430	139.00	5.25	0.32	0.06	0.24
07-Mar-03	66	2300	171.25	2.00	0.37	0.19	0.18
09-Mar-03	68	1900	46.00	0.50	0.04	0.08	0.02
17-Mar-03	76	30	173.00	2.75	0.68	0.25	0.25
17-Mar-03	76	1800	14.75	1.25	0.05	0.04	0.04
21-Mar-03	80	345	80.50	10.50	1.61	0.15	0.26
23-Mar-03	82	700	40.75	13.25	1.67	0.13	0.23
27-Mar-03	86	1400	89.75	4.00	0.95	0.24	0.42
09-Apr-03	99	215	296.25	4.50	0.19	0.04	0.05
09-Apr-03	99	1630	9.75	0.50	0.08	0.16	0.24
25-Apr-03	115	1830	385.50	11.25	2.70	0.24	0.47
29-Apr-03	119	1445	81.00	1.25	0.14	0.11	0.08
30-Apr-03	120	1230	20.50	4.00	0.18	0.05	0.07
01-May-03	121	315	10.75	7.50	0.26	0.03	0.03
17-May-03	137	1800	391.00	1.50	0.75	0.50	0.52
18-May-03	138	2030	25.00	1.25	0.35	0.28	0.15
22-May-03	142	1930	93.75	3.50	0.62	0.18	0.08
23-May-03	143	345	4.75	5.00	0.11	0.02	0.03
05-Jun-03	156	715	310.50	2.25	0.26	0.12	0.05
05-Jun-03	156	2100	11.50	0.75	0.10	0.13	0.05
08-Jun-03	159	1130	61.50	0.75	0.23	0.31	0.16
09-Jun-03	160	1100	22.50	2.75	0.35	0.13	0.15
10-Jun-03	161	1830	28.50	1.50	0.33	0.22	0.24
11-Jun-03	15	1545	19.75	1.75	1.01	0.58	0.69
16-Jun-03	15	1615	119.00	5.75	1.85	0.32	0.84

DATE	JDAY	Start	Inter-Event	Storm	Total Event	Avg. Int.	Max. Int
		Time	Dry Period	Duration	Rain Fall		
	(JD)	(hhmm)	(hours)	(hr.)	(in)	(in/hr)	(in/15 min)
18-Jun-03	15	1115	37.50	9.00	1.66	0.18	0.26
19-Jun-03	15	1215	16.25	5.00	1.89	0.38	0.48
20-Jun-03	15	1030	17.50	5.00	1.33	0.27	0.43
21-Jun-03	15	545	12.00	12.25	1.38	0.11	0.29
22-Jun-03	15	915	15.50	6.75	1.02	0.15	0.37
28-Jun-03	15	2215	150.50	4.25	1.35	0.32	0.29
30-Jun-03	15	1815	40.00	4.25	0.59	0.14	0.30
04-Jul-03	185	1800	552.50	0.50	0.52	1.04	0.35
07-Jul-03	188	2330	77.00	0.50	0.18	0.36	0.13
08-Jul-03	189	1800	18.00	0.75	0.18	0.24	0.12
11-Jul-03	192	1430	67.75	1.25	0.46	0.37	0.37
12-Jul-03	193	1830	26.75	4.50	0.38	0.08	0.08
13-Jul-03	194	1530	16.50	4.75	3.23	0.68	1.08
14-Jul-03	195	2015	24.00	1.50	0.15	0.10	0.03
17-Jul-03	198	1945	70.00	5.00	0.51	0.10	0.31
18-Jul-03	199	1900	18.25	1.00	0.15	0.15	0.08
20-Jul-03	201	900	37.00	3.25	0.32	0.10	0.23
25-Jul-03	206	1415	122.00	5.25	0.11	0.02	0.06
27-Jul-03	208	1515	43.75	1.00	0.24	0.24	0.22
01-Aug-03	213	1230	116.25	2.25	0.50	0.22	0.37
02-Aug-03	214	1545	25.00	6.50	1.35	0.21	0.50
04-Aug-03	216	1715	43.00	0.75	0.27	0.36	0.12
06-Aug-03	218	1200	42.00	1.75	0.46	0.26	0.45
07-Aug-03	219	1045	21.00	10.25	1.11	0.11	0.64
08-Aug-03	220	1345	16.75	4.00	0.21	0.05	0.03
09-Aug-03	221	915	15.50	7.50	1.00	0.13	0.42
10-Aug-03	222	515	12.50	6.00	0.72	0.12	0.26
11-Aug-03	223	1115	24.00	4.00	0.05	0.01	0.02
14-Aug-03	226	1115	68.00	2.00	0.15	0.08	0.03
16-Aug-03	228	1815	53.00	0.75	0.05	0.07	0.03
18-Aug-03	230	1245	41.75	4.00	2.99	0.75	1.28
19-Aug-03	231	1315	20.50	6.00	0.28	0.05	0.21
20-Aug-03	232	1515	20.00	3.50	0.33	0.09	0.07
21-Aug-03	233	1515	20.50	4.50	0.28	0.06	0.06
24-Aug-03	236	1945	72.00	6.25	0.10	0.02	0.05
25-Aug-03	237	1530	13.50	3.75	0.64	0.17	0.24
26-Aug-03	238	1815	23.00	3.25	0.78	0.24	0.61
03-Sep-03	246	1445	185.25	3.00	1.37	0.46	0.43
05-Sep-03	248	1245	43.00	5.00	0.45	0.09	0.07
13-Sep-03	256	1745	192.00	3.00	0.82	0.27	0.40
19-Sep-03	262	1800	141.25	5.50	0.49	0.09	0.26
20-Sep-03	263	1915	20.25	1.00	0.05	0.05	0.02
25-Sep-03	268	1200	111.75	12.50	0.50	0.04	0.05
28-Sep-03	271	1430	62.00	4.75	0.10	0.02	0.02
29-Sep-03	272	330	8.25	6.00	0.12	0.02	0.02
30-Sep-03	273	2115	35.75	9.75	0.85	0.09	0.29



DATE	JDAY	Start	Inter-event	Storm	Total Event	Avg. Int.	Max. Int
		Time	Dry Period	Duration	Rain Fall		
	(JD)	(hhmm)	(hours)	(hr.)	(in)	(in/hr)	(in/15 min)
14-Oct-03	287	745	312.75	1.25	0.18	0.14	0.14
25-Oct-03	298	1715	272.25	1.00	0.21	0.21	0.19
28-Oct-03	301	1630	70.25	7.25	0.66	0.09	0.17
	SUMMARY STATISTICS						
# observations			**93**	**94**	**94**	**94**	**94**
Average			**98.42**	**5.15**	**0.81**	**0.19**	**0.26**
Median			**45.25**	**3.88**	**0.46**	**0.14**	**0.21**
std.dev.			**134.50**	**5.95**	**1.01**	**0.18**	**0.28**
Maximum			**896.25**	**39.75**	**4.97**	**1.04**	**1.84**
Minimum			**4.75**	**0.50**	**0.04**	**0.01**	**0.02**
TOTAL RAIN					**75.90**		

Table B-2. Rainfall characteristics Year 2

DATE	JDAY	Start	Inter-Event	Storm	Total Event	Avg. Int.	Max. Int.
		Time	Dry Period	Duration	Rain Fall		
	(JD)	(hhmm)	(hours)	(hr.)	(in)	(in/hr)	(in/15 min)
4-Nov-03	309	1715	161.75	1.00	0.18	0.18	0.13
5-Nov-03	310	1600	21.75	1.25	0.5	0.40	0.41
18-Nov-03	323	545	300.50	6.00	0.67	0.11	0.23
14-Dec-03	348	630	618.75	5.00	1.93	0.39	0.39
18-Jan-04	18	700	835.50	8.75	1.87	0.21	0.36
19-Jan-04	19	1115	24.50	4.00	0.27	0.07	0.15
27-Jan-04	27	200	178.75	7.50	1.38	0.18	0.23
30-Jan-04	30	1815	80.75	10.00	0.31	0.03	0.04
31-Jan-04	31	1445	101.25	14.25	0.64	0.04	0.05
14-Feb-04	45	1400	321.00	8.50	0.35	0.04	0.05
24-Feb-04	55	1315	230.75	18.50	4.17	0.23	0.42
15-Mar-04	75	1530	463.75	8.75	0.09	0.01	0.03
16-Mar-04	76	715	7.00	39.00	1.98	0.05	0.80
11-Apr-04	102	1800	627.75	13.75	2.2	0.16	0.37
12-Apr-04	103	1530	7.75	7.75	0.11	0.01	0.02
30-Apr-04	121	1800	426.75	4.50	2.03	0.45	0.37
3-May-04	124	845	58.25	6.75	1.11	0.16	0.28
16-May-04	137	1600	382.00	4.00	0.24	0.06	0.14
17-May-04	138	1600	20.00	3.75	0.45	0.12	0.15
9-Jun-04	161	1830	550.75	3.25	1.12	0.34	0.42
10-Jun-04	162	1930	21.75	2.25	1.41	0.63	0.60
13-Jun-04	165	1730	67.75	7.50	1.13	0.15	0.40
14-Jun-04	166	1700	16.00	6.75	0.39	0.06	0.31
15-Jun-04	167	1445	15.00	4.50	0.06	0.01	0.04
19-Jun-04	171	1715	94.00	0.75	0.09	0.12	0.05
21-Jun-04	173	1300	43.00	1.25	0.06	0.05	0.03
24-Jun-04	176	1930	77.25	2.50	1.58	0.63	0.87
26-Jun-04	178	1645	45.25	7.00	4.20	0.60	0.91
27-Jun-04	179	1645	69.25	5.50	1.45	0.26	0.53
28-Jun-04	180	2000	27.25	1.00	0.35	0.35	0.12
29-Jun-04	181	1730	20.50	6.00	0.52	0.09	0.25
2-Jul-04	184	1445	69.25	3.00	0.50	0.17	0.40
5-Jul-04	187	1500	72.25	2.25	0.86	0.38	0.60
7-Jul-04	189	1200	42.75	0.50	0.10	0.20	0.08
12-Jul-04	194	1730	125.00	7.00	1.70	0.24	0.60
15-Jul-04	197	1215	66.00	2.00	0.12	0.06	0.11
16-Jul-04	198	145	11.50	3.00	0.21	0.07	0.09
16-Jul-04	198	1330	8.75	8.00	0.87	0.11	0.21
17-Jul-04	199	600	8.50	5.50	0.31	0.06	0.04
18-Jul-04	200	415	16.75	12.50	1.63	0.13	0.43
19-Jul-04	201	130	8.75	36.25	3.68	0.10	0.34
26-Jul-04	208	1345	144.00	2.50	2.63	1.05	0.83
28-Jul-04	210	1515	47.00	8.25	0.70	0.08	0.46

Table B-2. Rainfall characteristics Year 2

DATE	JDAY (JD)	Start Time (hhmm)	Inter-Event Dry Period (hours)	Storm Duration (hr.)	Total Event Rain Fall (in)	Avg. Int. (in/hr)	Max. Int. (in/15 min)
29-Jul-04	211	1530	16.00	5.50	0.21	0.04	0.07
31-Jul-04	213	1600	43.00	6.75	0.59	0.09	0.22
1-Aug-04	214	715	8.50	5.25	0.34	0.06	0.11
2-Aug-04	215	630	18.00	6.75	0.10	0.01	0.04
3-Aug-04	216	1830	29.25	1.00	0.32	0.32	0.15
4-Aug-04	217	830	13.00	6.25	0.33	0.05	0.09
5-Aug-04	218	845	18.00	2.00	0.11	0.06	0.05
7-Aug-04	220	200	39.25	7.25	2.00	0.28	0.83
7-Aug-04	220	1615	7.00	3.25	1.94	0.60	0.42
8-Aug-04	221	400	8.50	8.75	0.24	0.03	0.09
8-Aug-04	221	1900	6.25	1.50	0.15	0.10	0.08
9-Aug-04	222	1445	18.25	7.25	1.30	0.18	0.57
13-Aug-04	226	1330	87.50	6.50	0.44	0.07	0.06
14-Aug-04	227	430	6.50	17.75	0.86	0.05	0.16
16-Aug-04	229	1700	42.75	1.75	0.08	0.05	0.03
18-Aug-04	231	1645	46.00	0.50	0.49	0.98	0.48
21-Aug-04	234	1200	66.75	1.25	0.44	0.35	0.39
22-Aug-04	235	1445	25.50	2.00	0.76	0.38	0.40
23-Aug-04	236	1300	20.25	2.25	0.25	0.11	0.21
24-Aug-04	237	1130	20.25	5.25	0.60	0.11	0.14
25-Aug-04	238	1900	31.50	3.75	0.96	0.26	0.34
29-Aug-04	242	1030	83.75	3.50	0.23	0.07	0.20
31-Aug-04	244	2130	55.50	4.00	0.55	0.14	0.20
4-Sep-04	248	800	78.50	40.75	8.05	0.20	0.31
7-Sep-04	251	1745	46.25	0.50	0.09	0.18	0.08
8-Sep-04	252	1115	17.00	9.25	1.15	0.12	0.52
9-Sep-04	253	300	6.50	3.50	1.39	0.40	0.57
12-Sep-04	256	245	68.25	2.00	0.29	0.15	0.25
15-Sep-04	259	1645	84.00	1.25	0.23	0.18	0.21
20-Sep-04	264	2230	124.50	6.75	0.22	0.03	0.05
21-Sep-04	265	1200	6.75	1.50	0.05	0.03	0.01
26-Sep-04	270	445	111.25	6.50	1.78	0.27	0.15
	SUMMARY STATISTICS						
# observations			**74**	**74**	**74**	**74**	**74**
Average			**103.10**	**6.66**	**0.98**	**0.20**	**0.28**
Median			**43.00**	**5.25**	**0.51**	**0.12**	**0.22**
std. Dev.			**165.67**	**7.63**	**1.24**	**0.21**	**0.23**
Maximum			**835.50**	**40.75**	**8.05**	**1.05**	**0.91**
Minimum			**6.25**	**0.50**	**0.05**	**0.01**	**0.01**
TOTAL RAIN					**72.51**		

Table B-3. Rainfall characteristics Year 3

DATE	JDAY	Start	Inter-Event	Storm	Total Event	Avg. Int.	Max. Int.
		Time	Dry Period	Duration	Rain Fall		
	(JD)	(hhmm)	(hours)	(hr.)	(in)	(in/hr)	(in/15 min)
24-Nov-04	329	2000	1424.75	12.50	0.5	0.04	0.02
27-Nov-04	332	2000	59.50	2.25	0.16	0.07	0.06
10-Dec-04	345	1200	301.75	3.25	0.27	0.08	0.14
23-Dec-04	358	1400	310.75	0.75	0.07	0.09	0.03
25-Dec-04	360	445	38.00	13.00	1.43	0.11	0.11
14-Jan-05	14	645	469.00	9.25	0.57	0.06	0.20
22-Jan-05	22	2315	189.25	1.00	0.06	0.06	0.03
25-Feb-05	56	1400	805.75	4.75	0.36	0.08	0.07
27-Feb-05	58	30	29.75	13.00	1.68	0.13	0.17
3-Mar-05	62	1545	98.25	12.25	0.44	0.04	0.05
9-Mar-05	68	1100	237.50	9.75	0.52	0.05	0.06
14-Mar-05	73	1400	113.25	1.00	0.33	0.33	0.31
15-Mar-05	74	1745	26.75	5.75	0.33	0.06	0.20
16-Mar-05	75	1815	18.75	26.00	2.23	0.09	0.24
23-Mar-05	82	645	130.50	4.25	0.34	0.08	0.06
28-Mar-05	87	415	113.25	2.50	0.08	0.03	0.03
2-Apr-05	92	315	116.50	5.25	0.55	0.10	0.38
13-Apr-05	103	300	258.75	2.75	0.7	0.25	0.40
23-Apr-05	113	1730	251.75	4.00	1.16	0.29	0.44
26-Apr-05	116	1630	67.00	14.50	1.46	0.10	0.51
1-May-05	121	315	92.25	3.50	0.77	0.22	0.17
5-May-05	125	1300	102.25	5.25	0.31	0.06	0.22
16-May-05	136	1945	265.50	4.50	0.98	0.22	0.64
31-May-05	151	430	340.25	7.00	1.54	0.22	0.88
31-May-05	151	2330	12.00	12.25	1.66	0.14	0.93
2-Jun-05	153	145	12.75	9.75	0.58	0.06	0.12
3-Jun-05	154	530	18.00	6.25	0.09	0.01	0.02
4-Jun-05	155	545	18.00	3.50	0.18	0.05	0.10
4-Jun-05	155	1515	6.00	5.25	1.6	0.30	1.08
5-Jun-05	156	1400	51.75	1.50	1.34	0.89	0.88
8-Jun-05	159	2000	78.00	3.25	0.06	0.02	0.03
9-Jun-05	160	1345	14.50	5.50	1.17	0.21	0.66
10-Jun-05	161	530	10.25	30.75	0.7	0.02	0.07
12-Jun-05	163	1415	26.00	4.25	0.84	0.20	0.26
17-Jun-05	168	1145	113.25	0.50	0.18	0.36	0.15
19-Jun-05	170	945	45.50	1.00	0.1	0.10	0.09
22-Jun-05	173	1630	77.75	4.25	0.08	0.02	0.04
23-Jun-05	174	1530	18.75	7.25	0.96	0.13	0.31
25-Jun-05	176	1830	43.75	2.00	0.96	0.48	0.48
27-Jun-05	178	1330	41.00	9.50	0.77	0.08	0.45
28-Jun-05	179	1800	19.00	6.75	2.06	0.31	0.86
29-Jun-05	180	1430	13.75	0.50	0.33	0.66	0.30
29-Jun-05	180	2145	6.75	7.75	1.61	0.21	0.51

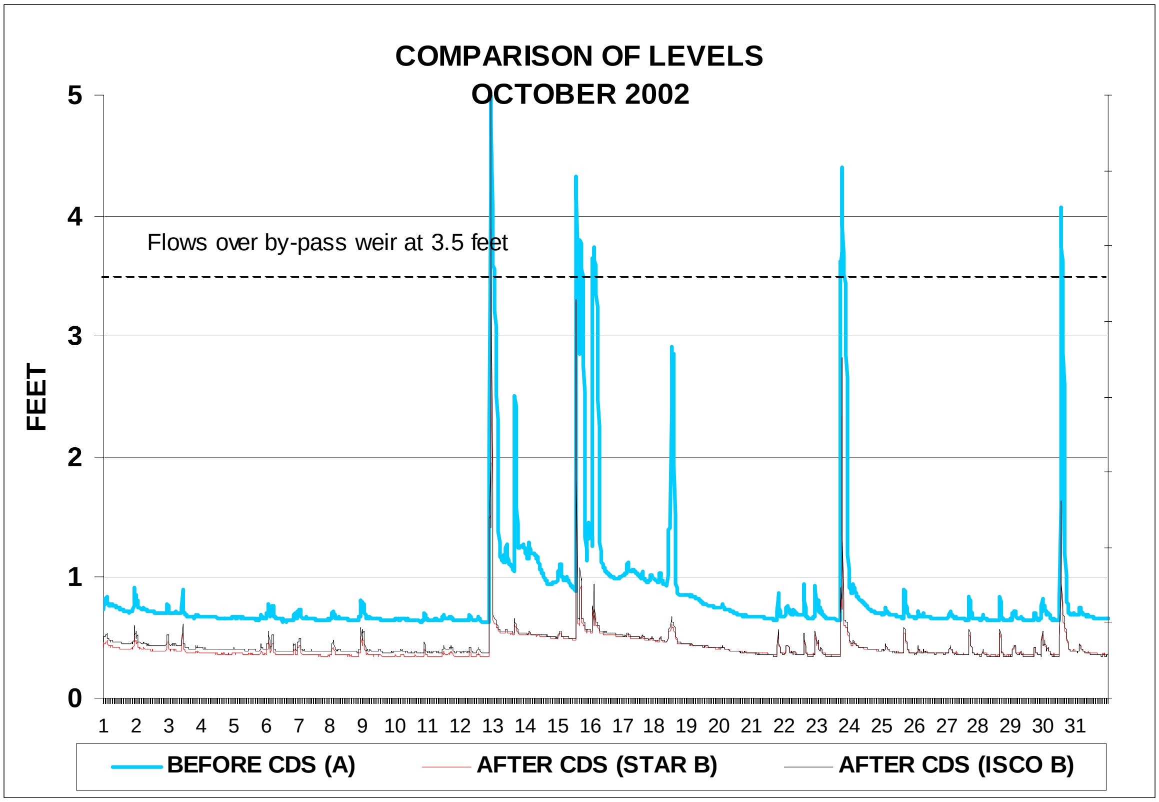
Table B-3. Rainfall characteristics Year 3 for storms > 0.05 inches

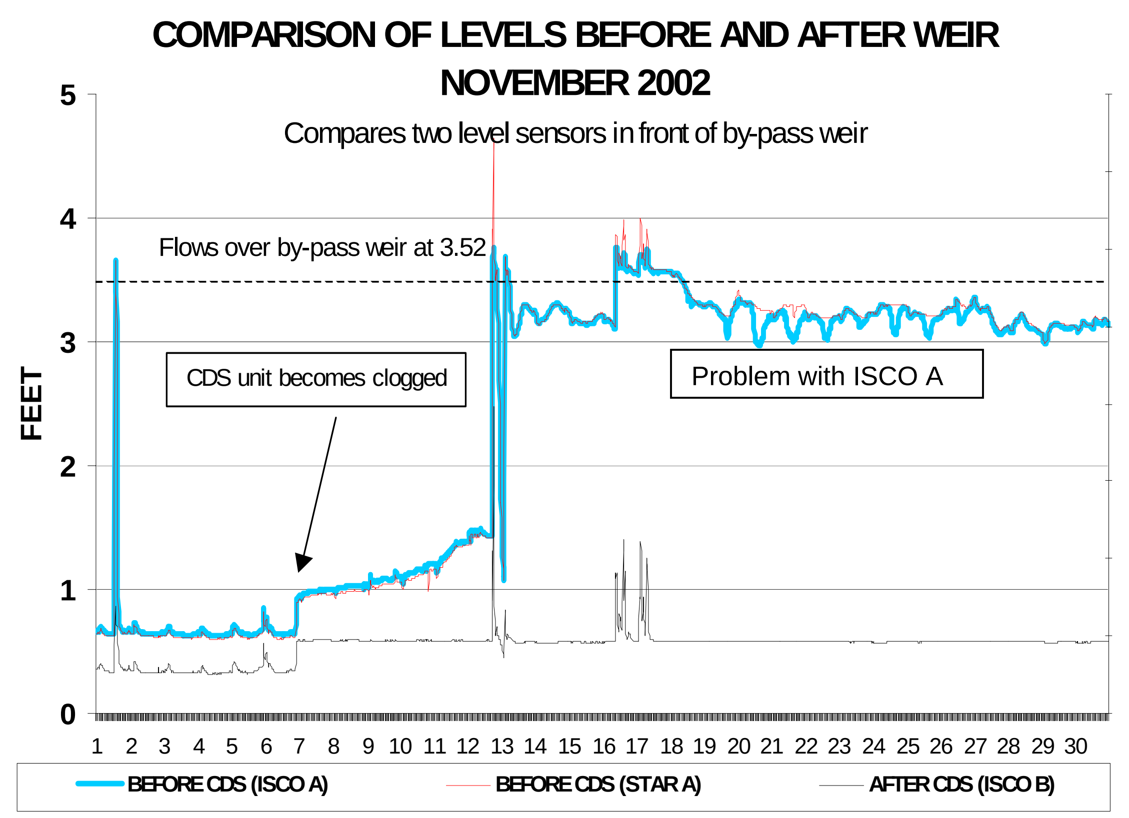
continued

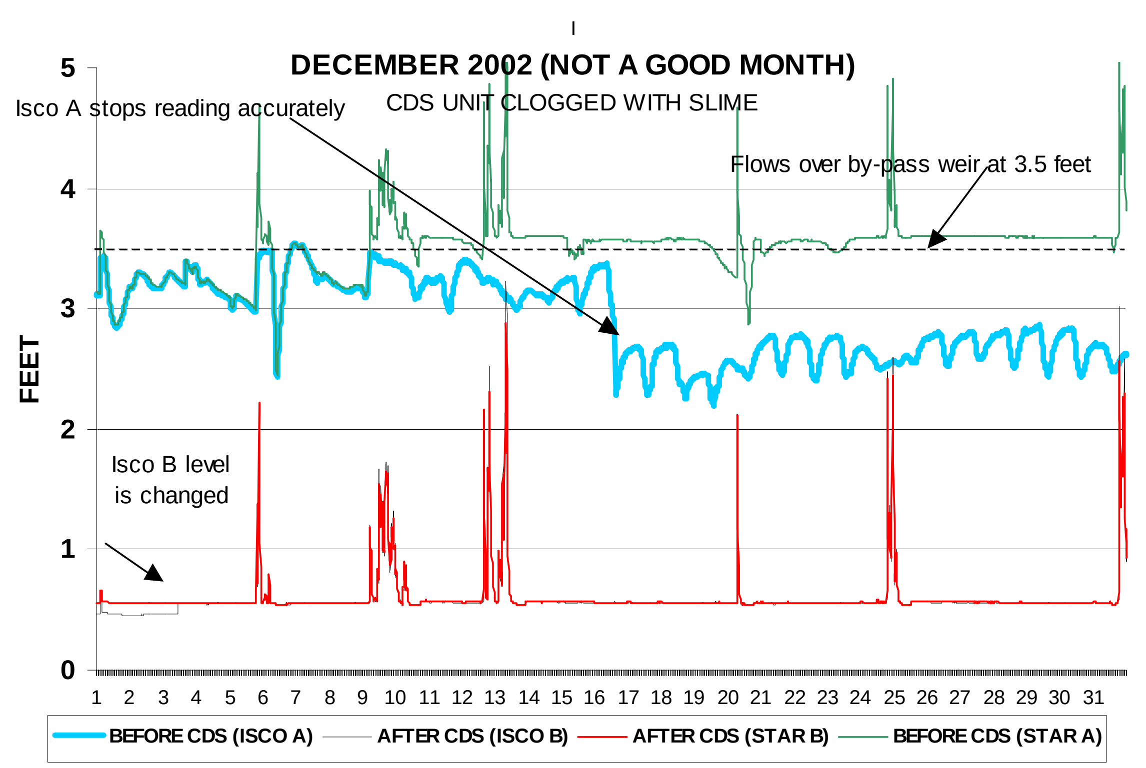
DATE	JDAY	Start Time	Inter-Event Dry Period	Storm Duration	Total Event Rain Fall	Avg. Int.	Max. Int.
	(JD)	(hhmm)	(hours)	(hr.)	(in)	(in/hr)	(in/15 min)
29-Jun-05	180	2145	6.75	7.75	1.61	0.21	0.51
30-Jun-05	181	1330	8.00	7.00	0.82	0.12	0.33
2-Jul-05	183	945	35.25	3.75	0.13	0.03	0.08
8-Jul-05	189	1830	149.00	2.00	0.14	0.07	0.07
9-Jul-05	190	230	6.00	32.00	1.91	0.06	0.38
12-Jul-05	193	1600	53.50	2.50	2.7	1.08	1.15
13-Jul-05	194	1500	20.50	2.75	2.01	0.73	0.77
14-Jul-05	195	1630	22.75	7.00	0.49	0.07	0.25
17-Jul-05	198	1815	66.75	1.75	0.08	0.05	0.03
21-Jul-05	202	2315	99.25	1.25	0.03	0.02	0.04
24-Jul-05	205	1500	62.50	6.00	1.16	0.19	0.34
28-Jul-05	209	1630	91.50	5.50	0.17	0.03	0.08
29-Jul-05	210	1330	15.50	8.75	1.15	0.13	0.49
30-Jul-05	211	1800	19.75	1.25	0.47	0.38	0.22
1-Aug-05	213	1630	45.25	2.25	1.18	0.52	0.80
5-Aug-05	217	1430	91.75	0.75	0.77	1.03	0.39
6-Aug-05	218	1330	22.25	7.00	0.89	0.13	0.41
7-Aug-05	219	1500	18.50	5.25	0.11	0.02	0.09
8-Aug-05	220	1500	24.00	1.75	0.16	0.09	0.06
9-Aug-05	221	1915	26.50	3.50	0.36	0.10	0.24
10-Aug-05	222	1345	15.00	3.50	0.25	0.07	0.16
13-Aug-05	225	1445	69.50	1.50	0.09	0.06	0.07
14-Aug-05	226	1445	22.50	2.00	0.22	0.11	0.17
17-Aug-05	229	15	55.50	3.75	0.13	0.03	0.06
21-Aug-05	233	1730	113.25	3.00	1.67	0.56	0.44
22-Aug-05	234	2015	23.75	3.25	0.56	0.17	0.27
23-Aug-05	235	1915	19.75	3.00	1.57	0.52	0.81
26-Aug-05	238	1715	67.00	1.50	0.18	0.12	0.16
27-Aug-05	239	1415	19.50	9.25	0.07	0.01	0.03
28-Aug-05	240	1530	16.00	8.75	1.99	0.23	0.03
31-Aug-05	243	1545	67.25	2.00	0.61	0.31	0.38
2-Sep-05	245	1415	44.50	4.00	0.34	0.09	0.09
5-Sep-05	248	1345	67.50	1.25	0.14	0.11	0.10
6-Sep-05	249	1545	24.75	0.75	0.22	0.29	0.14
22-Sep-05	265	1713	385.00	1.75	0.14	0.08	0.08
	Missed part of the 9/22 storm because of power failure.						
	Missed the 9/28-29 storm:also power failure; storm ended about 4:15 on Sept 29th.						
5-Oct-05	278	1945	212.75	1.00	0.94	0.94	0.53
6-Oct-05	279	1715	20.50	2.75	0.62	0.23	0.13
9-Oct-05	282	200	54.00	0.5	0.10	0.20	0.05
23-Oct-05	296	1930	353.00	15.25	1.70	0.11	0.18
	SUMMARY STATISTICS						
# observations			81	81	81	81	81
Average			111.32	5.69	0.72	0.19	0.29
Median			51.75	3.75	0.51	0.10	0.19
std. Dev.			195.32	5.97	0.65	0.23	0.28
Maximum			1424.75	32.00	2.70	1.08	1.15
Minimum			6.00	0.50	0.03	0.01	0.02
TOTAL RAIN					58.38		

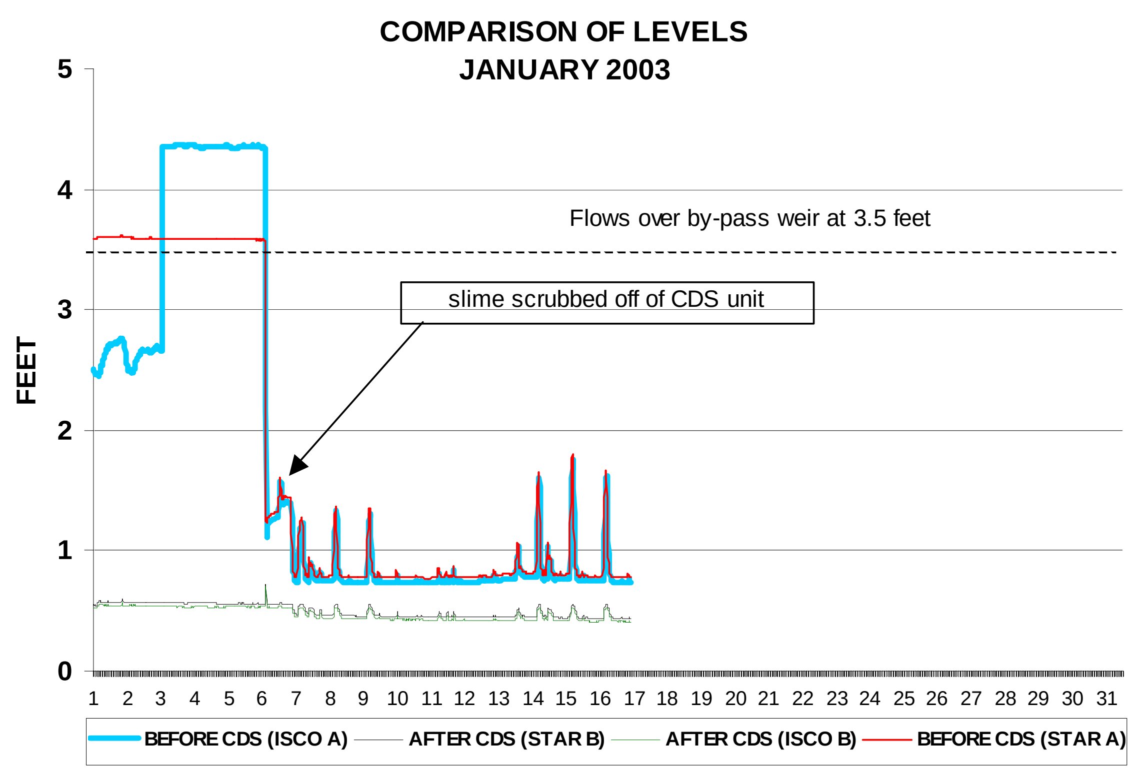
APPENDIX C

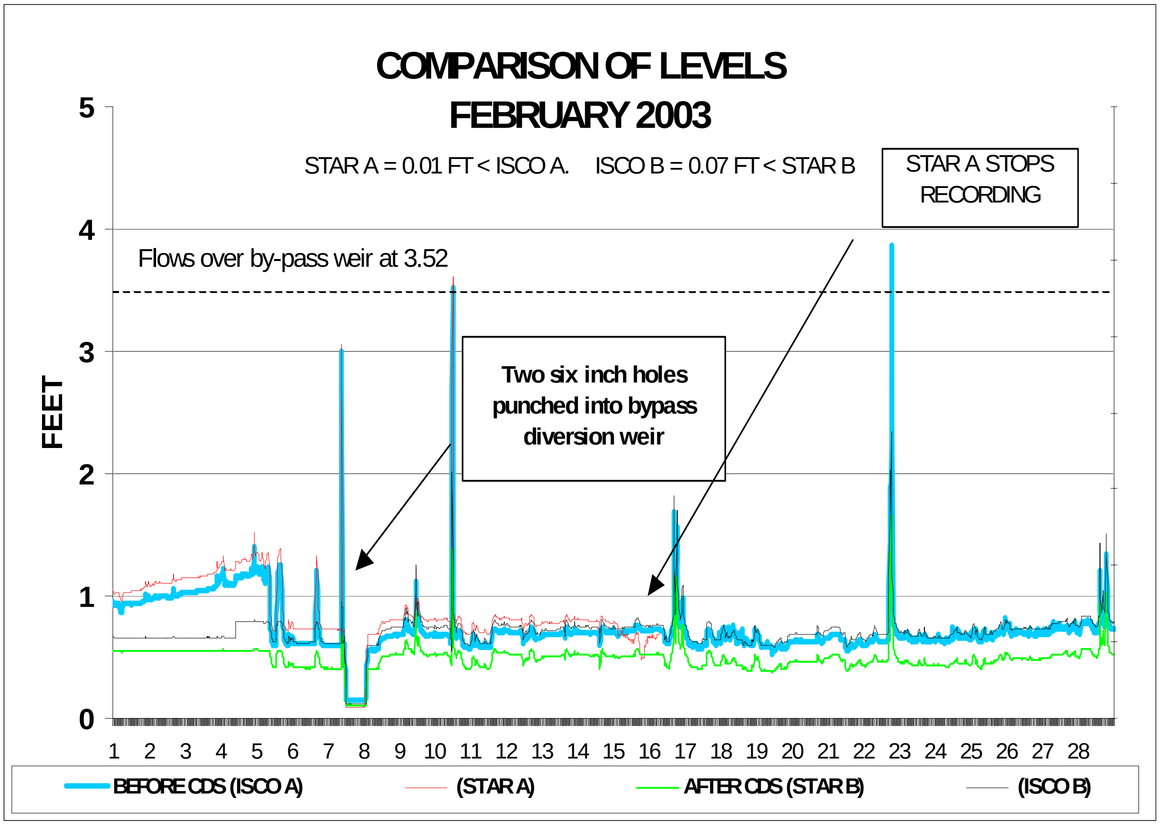
WATER LEVELS MEASURED IN FRONT OF THE CDS UNIT AND AFTER FLOW LEAVES CDS UNIT. FIGURES ALSO IDENTIFY PROBLEMS

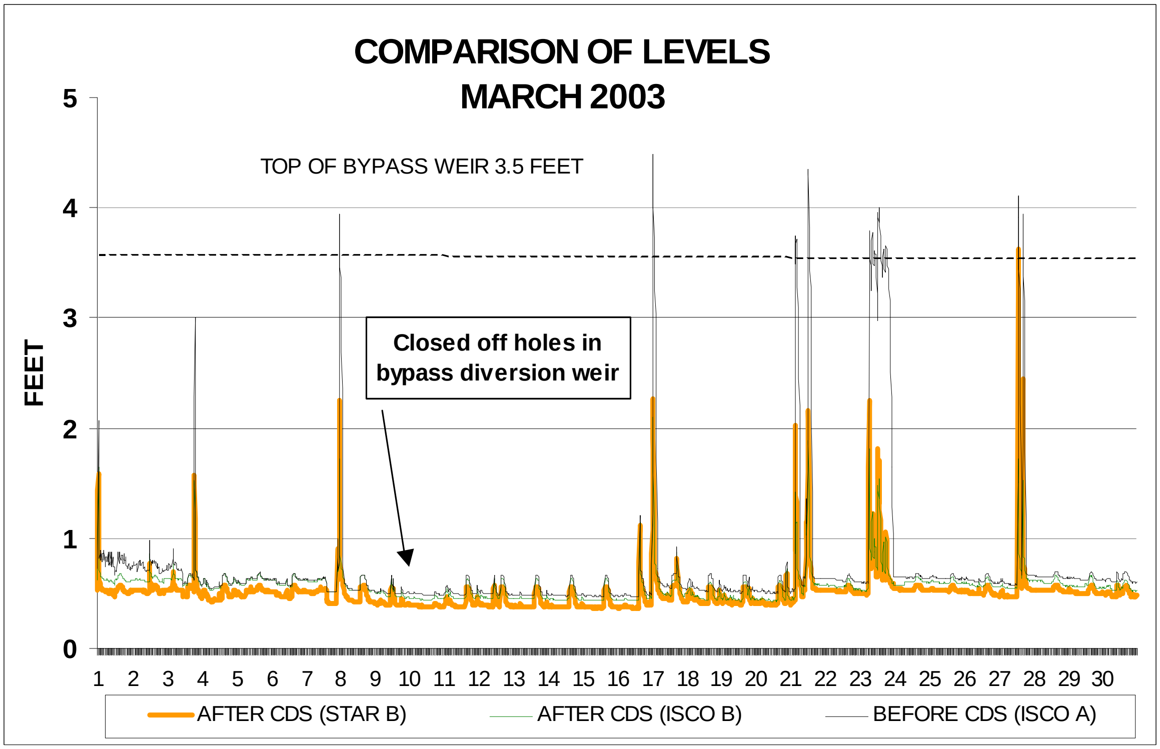

COMPARISON OF LEVELS
OCTOBER 2002
FEET
5
4
3
2
1
0
Flows over by-pass weir at 3.5 feet
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
BEFORE CDS (A)
AFTER CDS (STAR B)
AFTER CDS (ISCO B)

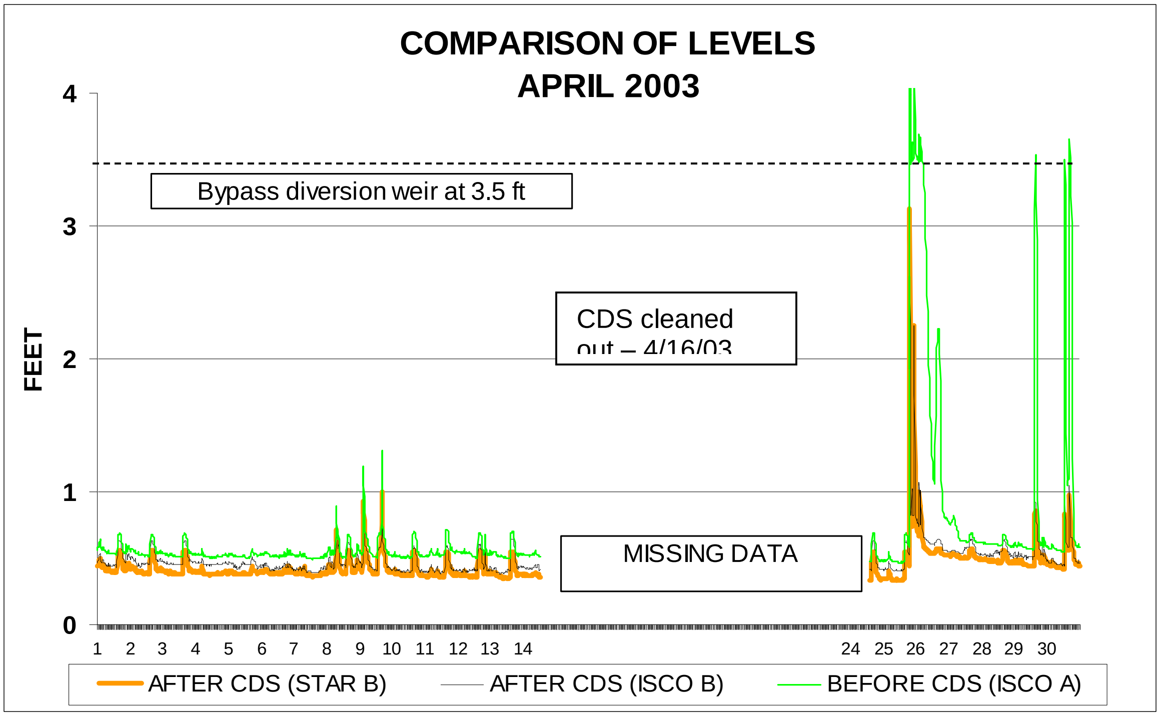

COMPARISON OF LEVELS BEFORE AND AFTER WEIR
NOVEMBER 2002
Compares two level sensors in front of by-pass weir
FEET
5
4
3
2
1
0
Flows over by-pass weir at 3.52
CDS unit becomes clogged
Problem with ISCO A
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
BEFORE CDS (ISCO A)
BEFORE CDS (STAR A)
AFTER CDS (ISCO B)

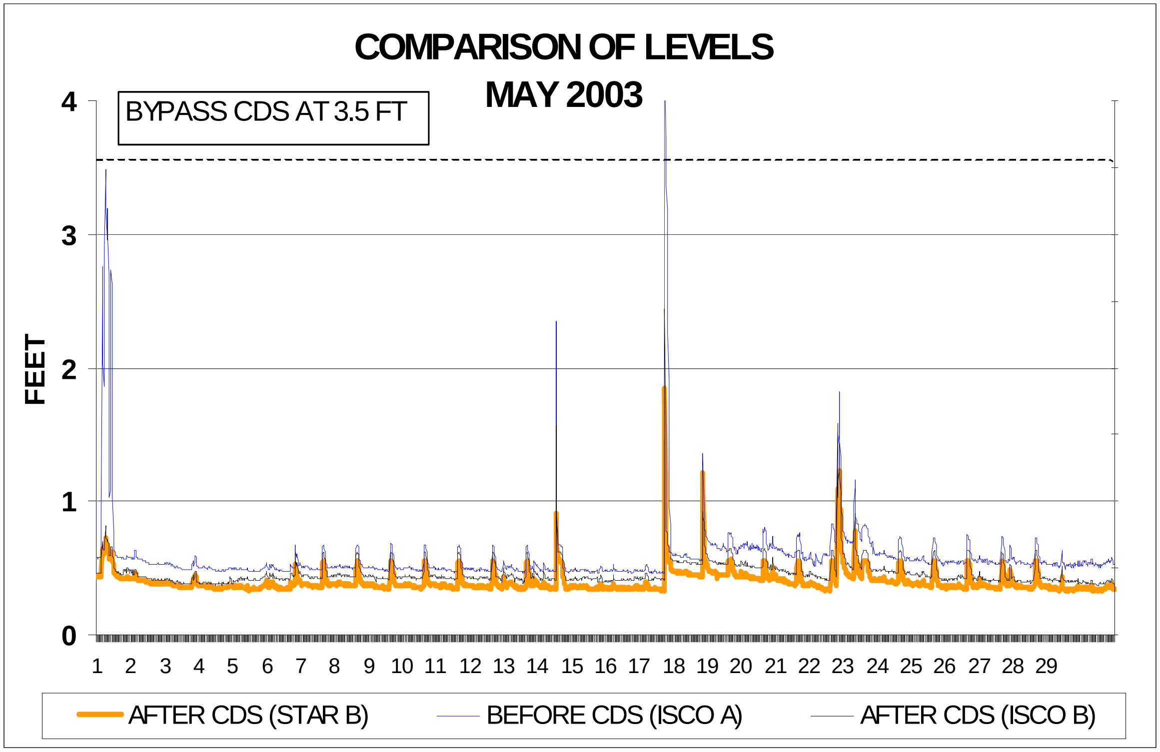

DECEMBER 2002 (NOT A GOOD MONTH)
Isco A stops reading accurately
CDS UNIT CLOGGED WITH SLIME
Flows over by-pass weir at 3.5 feet
Isco B level is changed
FEET
0
1
2
3
4
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
BEFORE CDS (ISCO A)
AFTER CDS (ISCO B)
AFTER CDS (STAR B)
BEFORE CDS (STAR A)

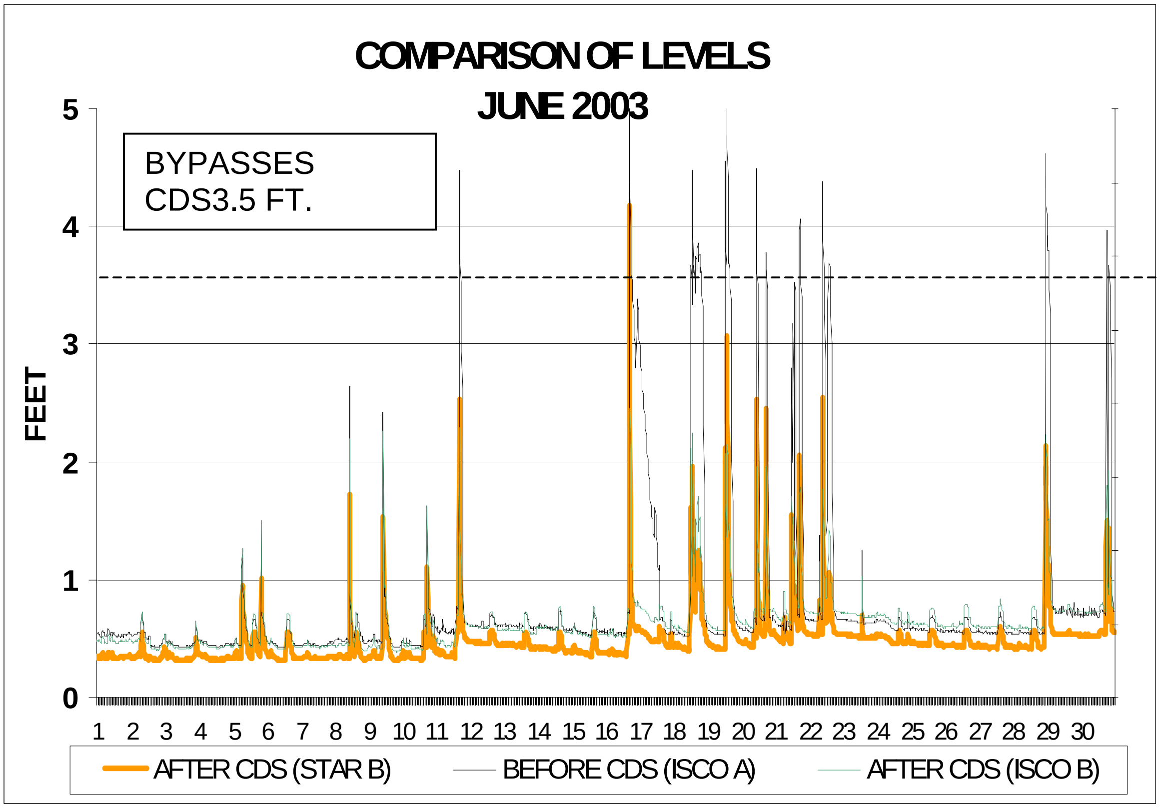

COMPARISON OF LEVELS
JANUARY 2003
Flows over by-pass weir at 3.5 feet
slime scrubbed off of CDS unit
FEET
0
1
2
3
4
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
BEFORE CDS (ISCO A)
AFTER CDS (STAR B)
AFTER CDS (ISCO B)
BEFORE CDS (STAR A)

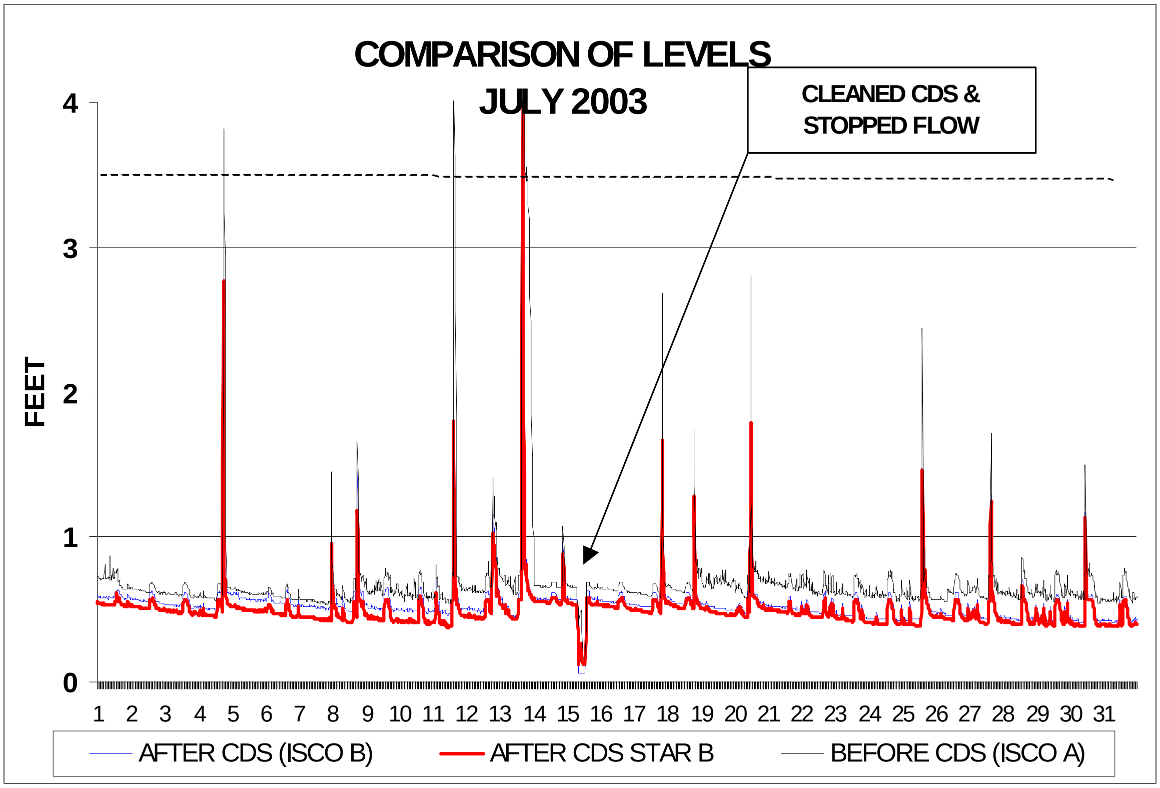

COMPARISON OF LEVELS
FEBRUARY 2003
STAR A = 0.01 FT < ISCO A. ISCO B = 0.07 FT < STAR B
STAR A STOPS RECORDING
Flows over by-pass weir at 3.52
Two six inch holes punched into bypass diversion weir
FEET
0
1
2
3
4
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
BEFORE CDS (ISCO A)
(STAR A)
AFTER CDS (STAR B)
(ISCO B)

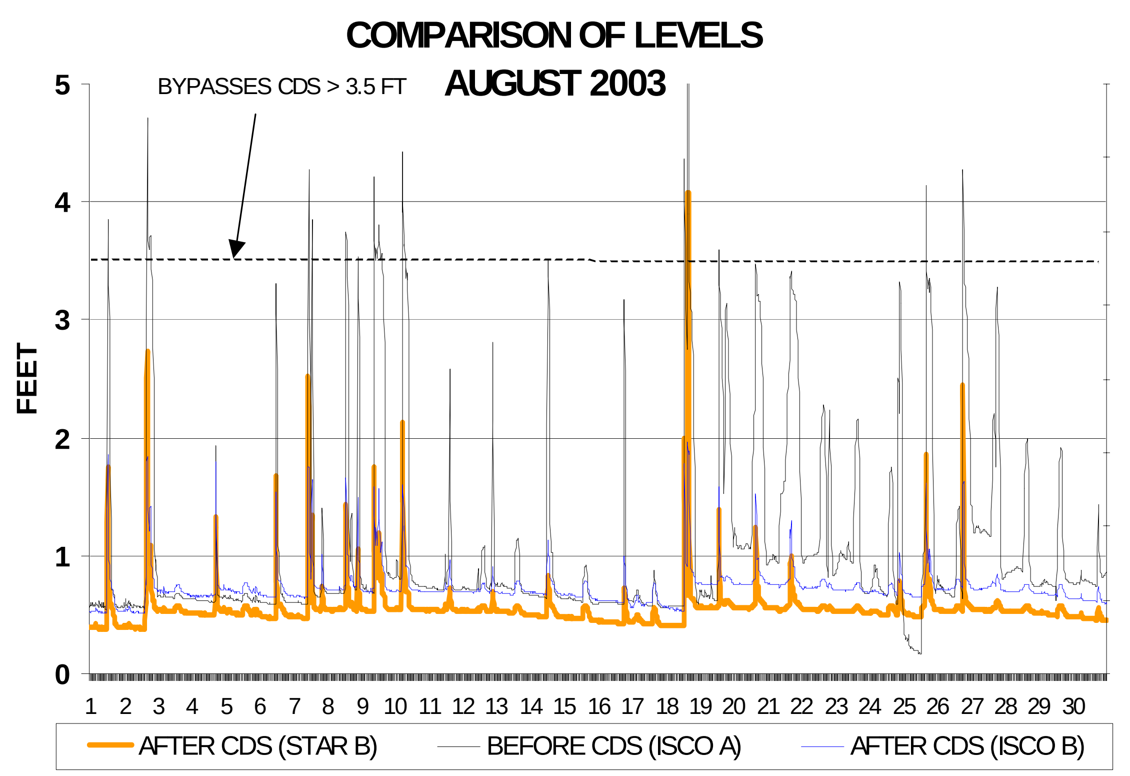

COMPARISON OF LEVELS
MARCH 2003
TOP OF BYPASS WEIR 3.5 FEET
Closed off holes in bypass diversion weir
FEET
0
1
2
3
4
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
AFTER CDS (STAR B)
AFTER CDS (ISCO B)
BEFORE CDS (ISCO A)

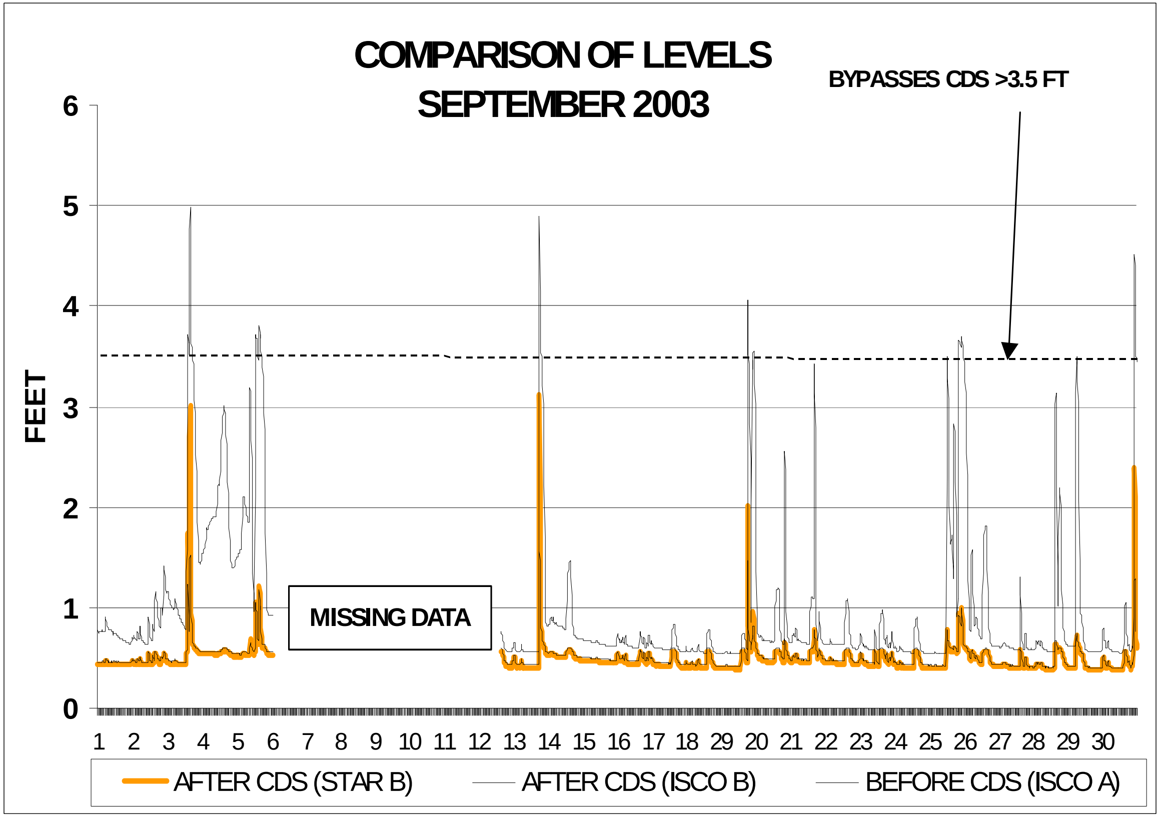

COMPARISON OF LEVELS
APRIL 2003
4
3
2
1
0
FEET
Bypass diversion weir at 3.5 ft
CDS cleaned out – 4/16/03
MISSING DATA
1 2 3 4 5 6 7 8 9 10 11 12 13 14
24 25 26 27 28 29 30
AFTER CDS (STAR B)
AFTER CDS (ISCO B)
BEFORE CDS (ISCO A)

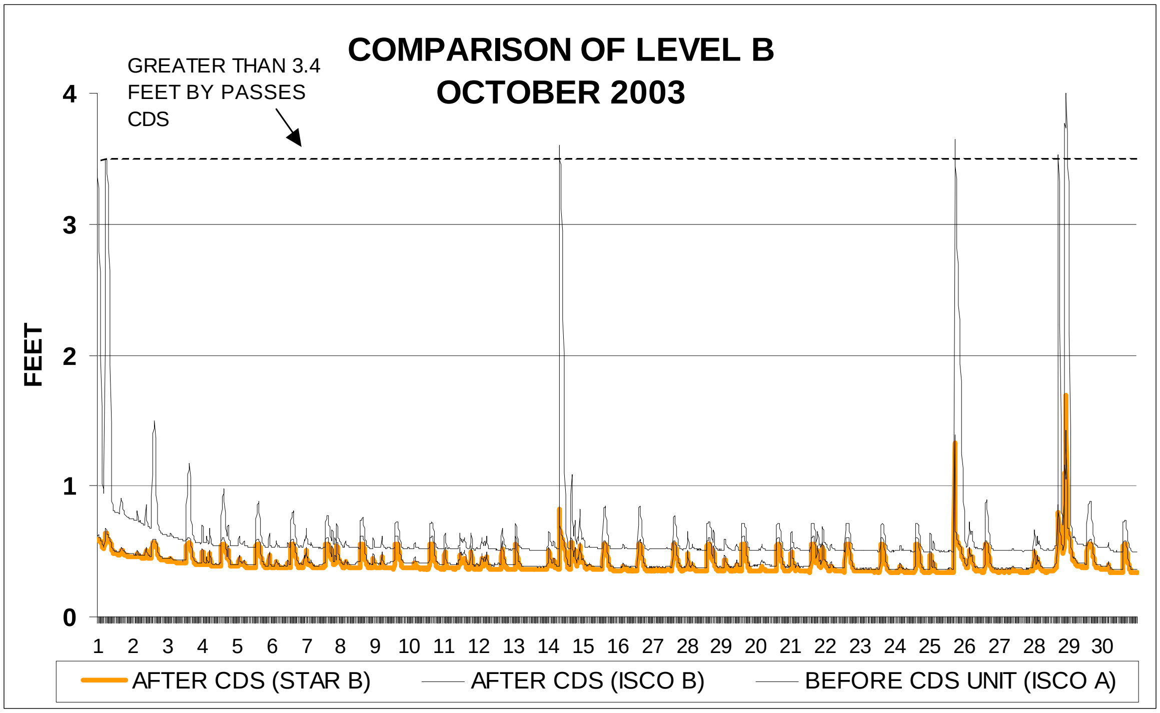

COMPARISON OF LEVELS
MAY 2003
BYPASS CDS AT 3.5 FT
4
3
2
1
0
FEET
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
AFTER CDS (STAR B)
BEFORE CDS (ISCO A)
AFTER CDS (ISCO B)

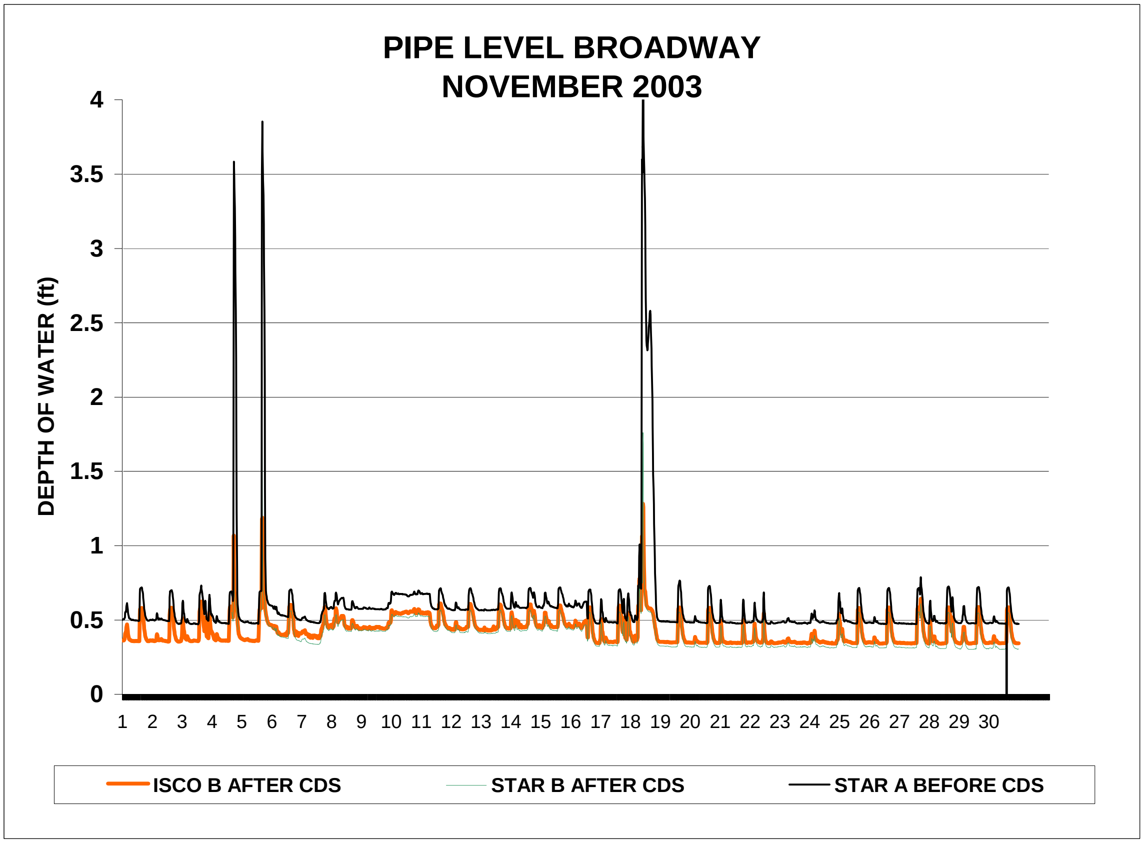

COMPARISON OF LEVELS
JUNE 2003
BYPASSES
CDS3.5 FT.
FEET
0
1
2
3
4
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
AFTER CDS (STAR B)
BEFORE CDS (ISCO A)
AFTER CDS (ISCO B)

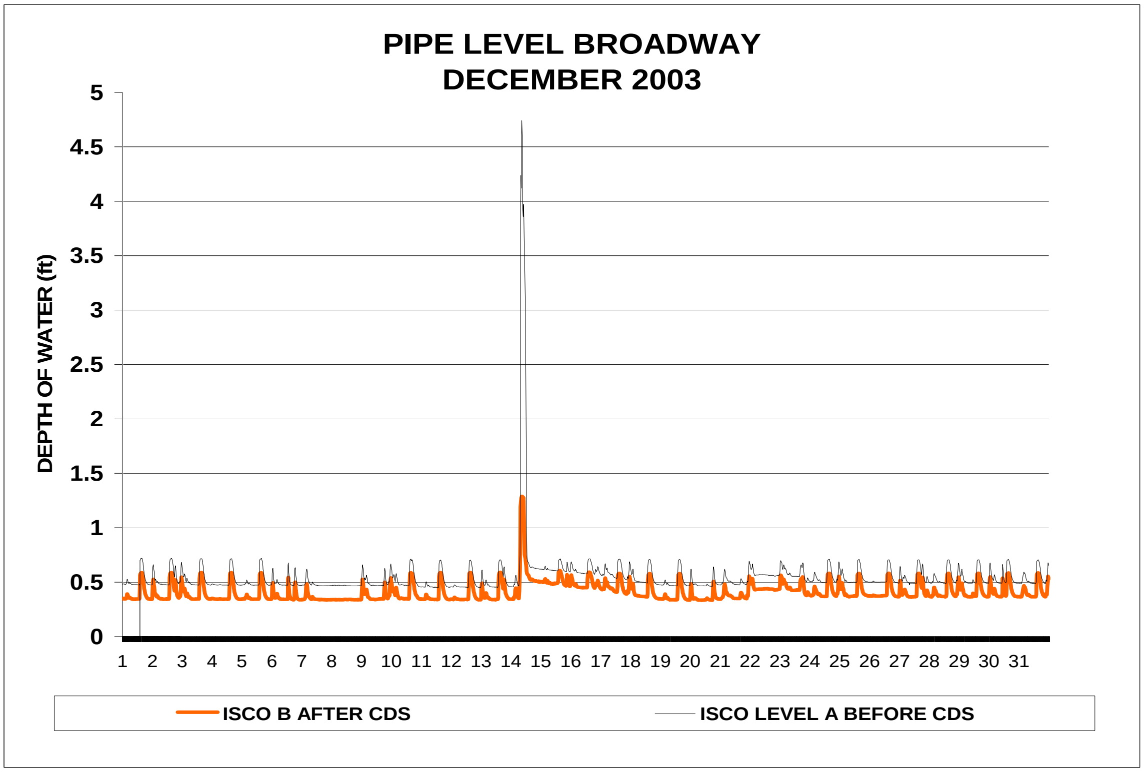

COMPARISON OF LEVELS
JULY 2003
CLEANED CDS &
STOPPED FLOW
FEET
0
1
2
3
4
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AFTER CDS (ISCO B)
AFTER CDS STAR B
BEFORE CDS (ISCO A)

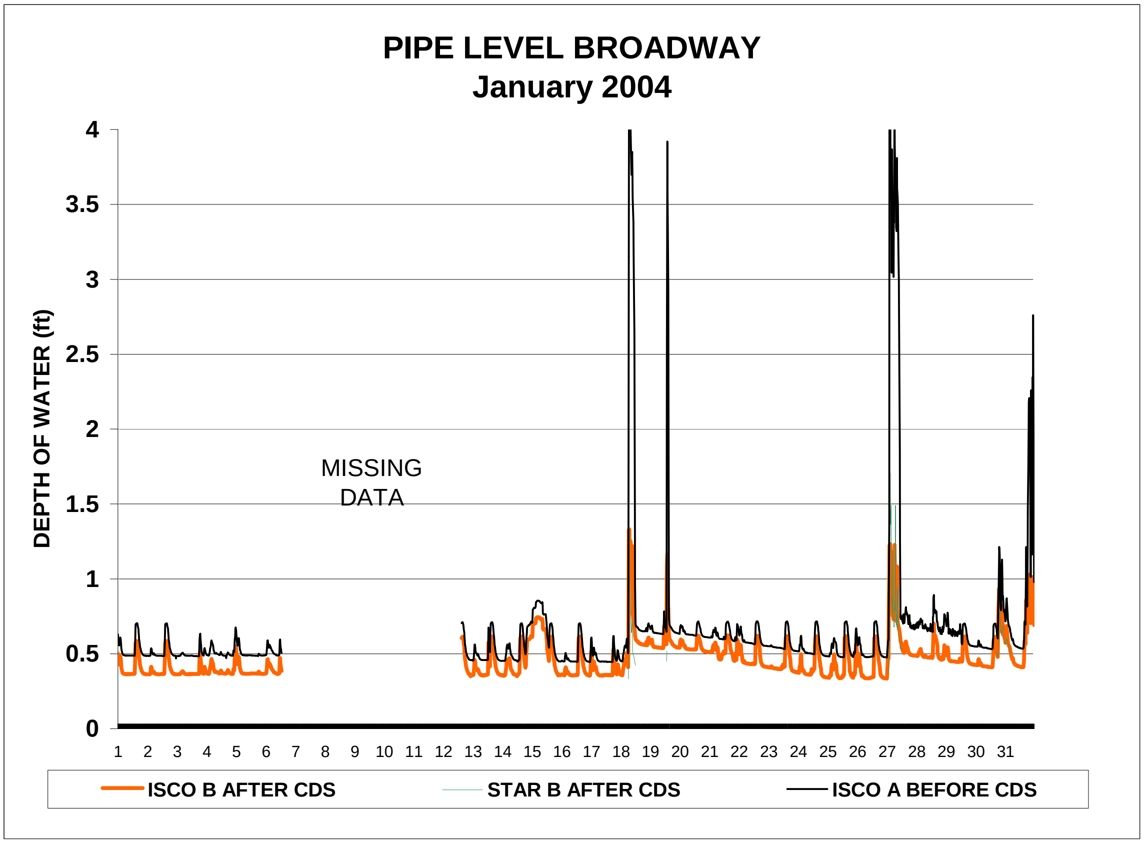

COMPARISON OF LEVELS
AUGUST 2003
BYPASSES CDS > 3.5 FT
FEET
0
1
2
3
4
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
AFTER CDS (STAR B)
BEFORE CDS (ISCO A)
AFTER CDS (ISCO B)

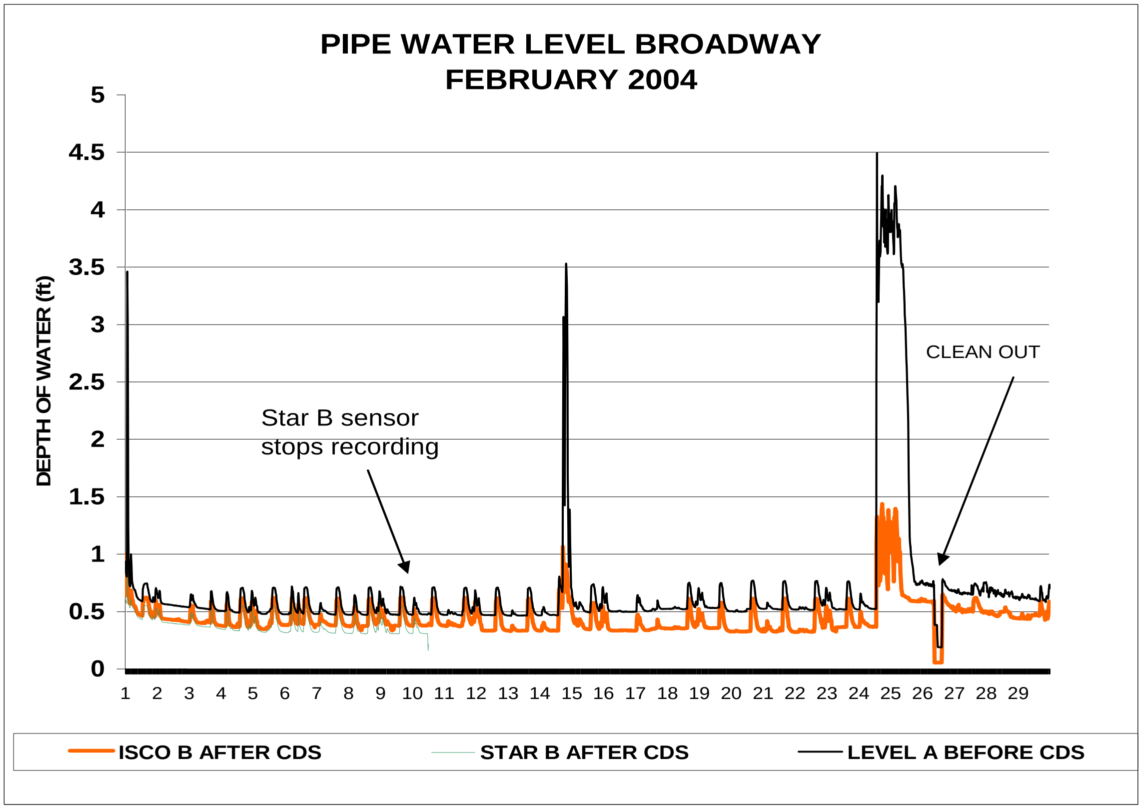

COMPARISON OF LEVELS
SEPTEMBER 2003
BYPASSES CDS >3.5 FT
MISSING DATA
FEET
0
1
2
3
4
5
6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 29 20 21 22 23 24 25 26 27 28 29 30
AFTER CDS (STAR B)
AFTER CDS (ISCO B)
BEFORE CDS (ISCO A)

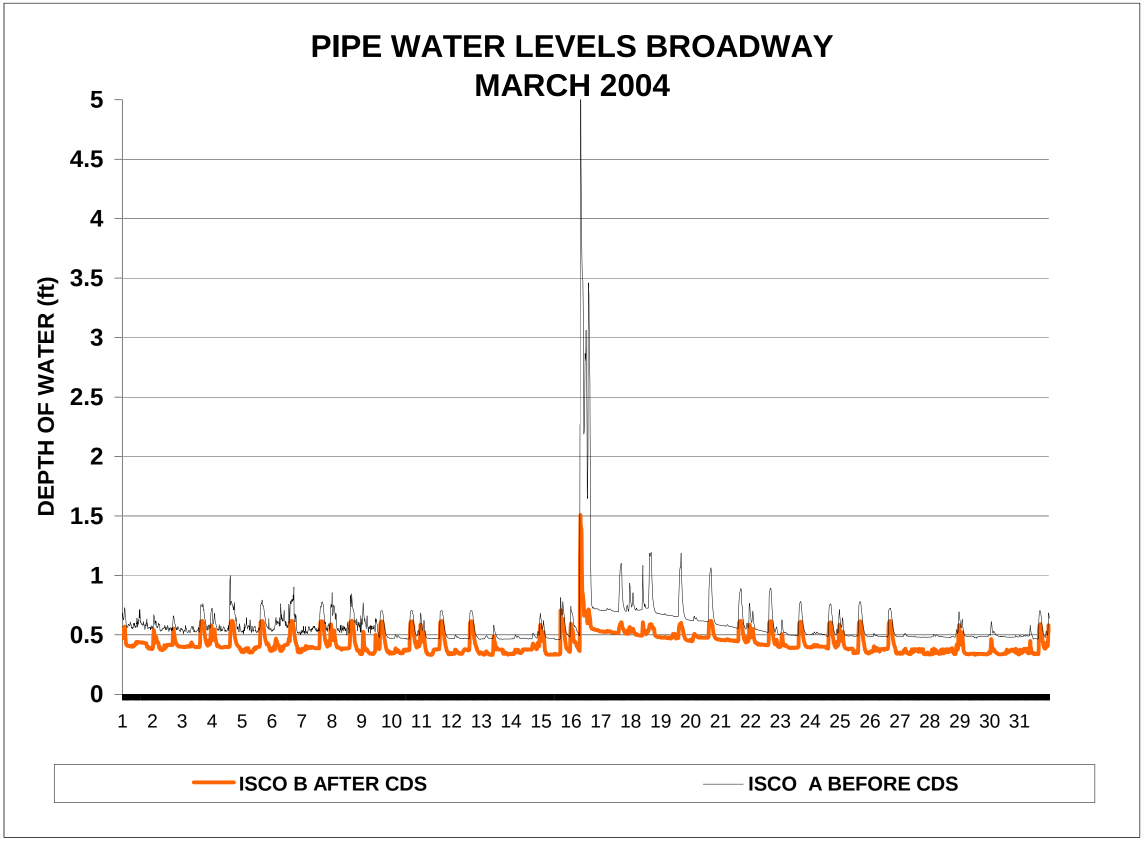

COMPARISON OF LEVEL B
OCTOBER 2003
GREATER THAN 3.4 FEET BY PASSES CDS
FEET
4
3
2
1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 27 28 29 20 21 22 23 24 25 26 27 28 29 30
AFTER CDS (STAR B)
AFTER CDS (ISCO B)
BEFORE CDS UNIT (ISCO A)

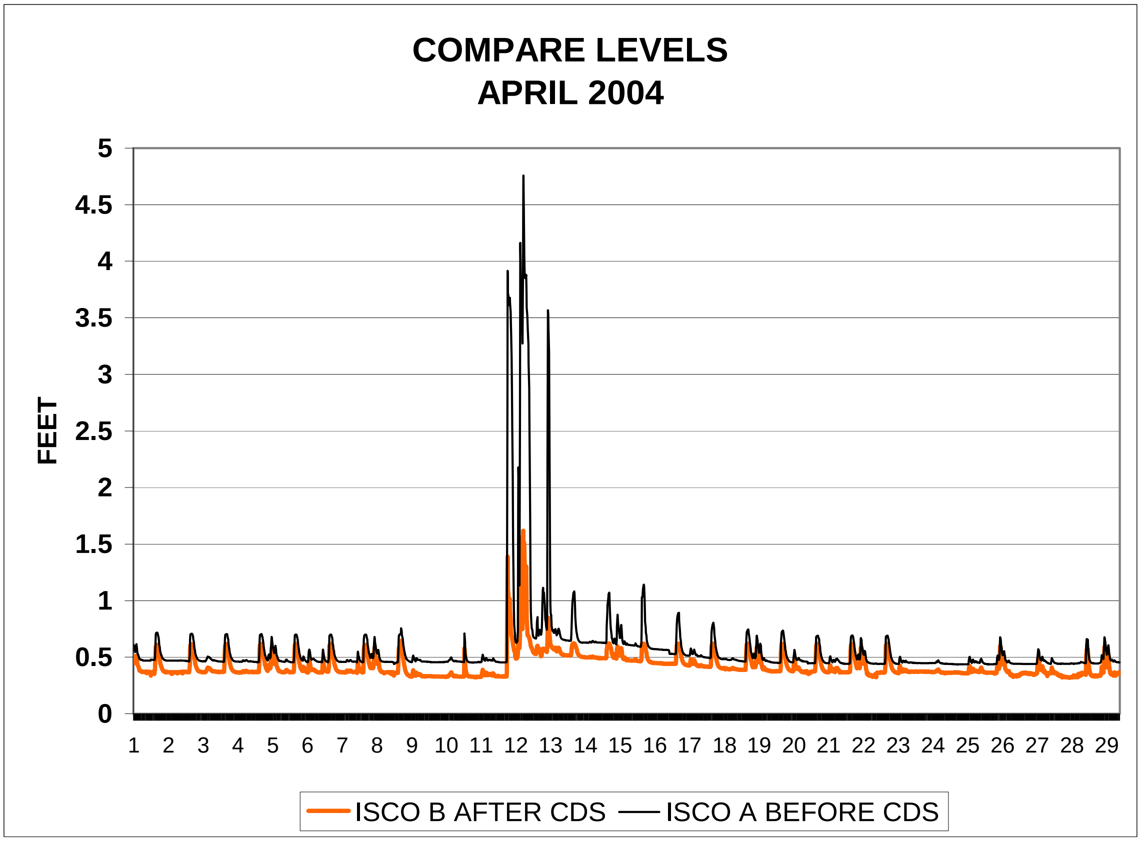

PIPE LEVEL BROADWAY
NOVEMBER 2003
DEPTH OF WATER (ft)
4
3.5
3
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
ISCO B AFTER CDS
STAR B AFTER CDS
STAR A BEFORE CDS

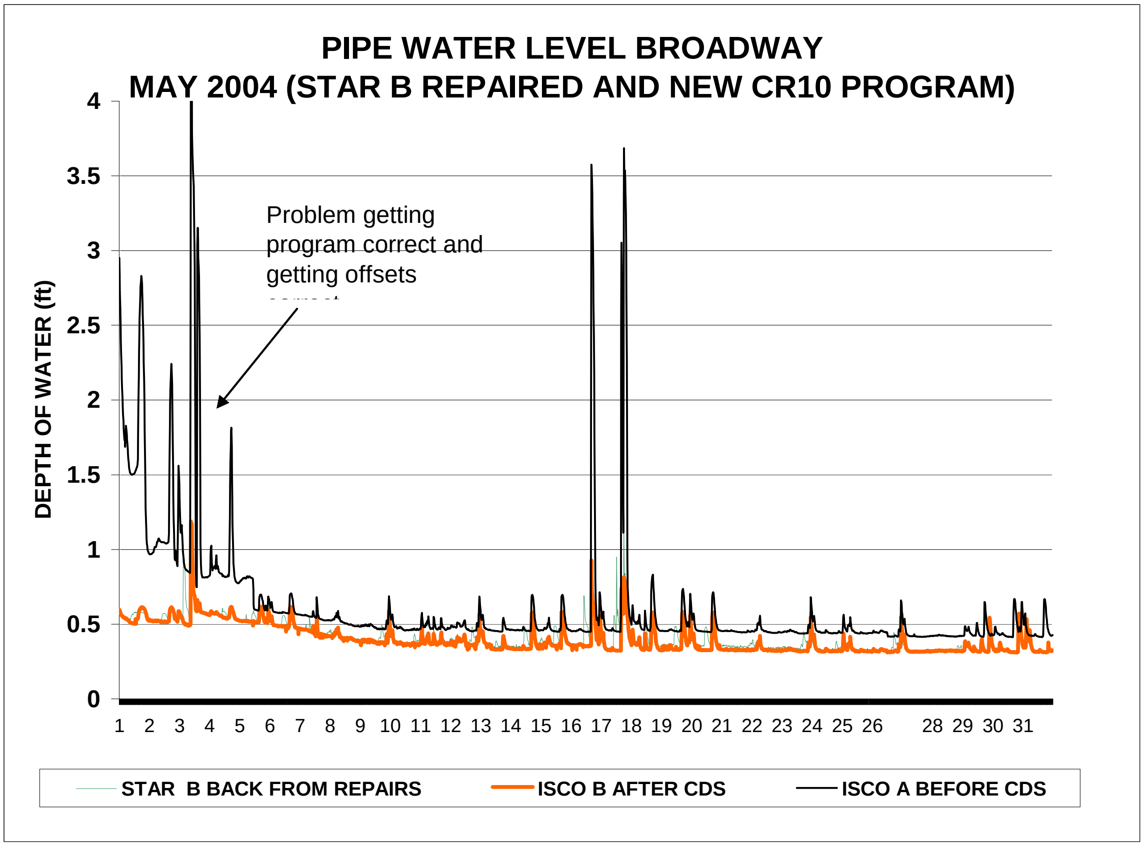

PIPE LEVEL BROADWAY
DECEMBER 2003
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
ISCO B AFTER CDS
ISCO LEVEL A BEFORE CDS


PIPE LEVEL BROADWAY
January 2004
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
MISSING
DATA
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
ISCO B AFTER CDS
STAR B AFTER CDS
ISCO A BEFORE CDS

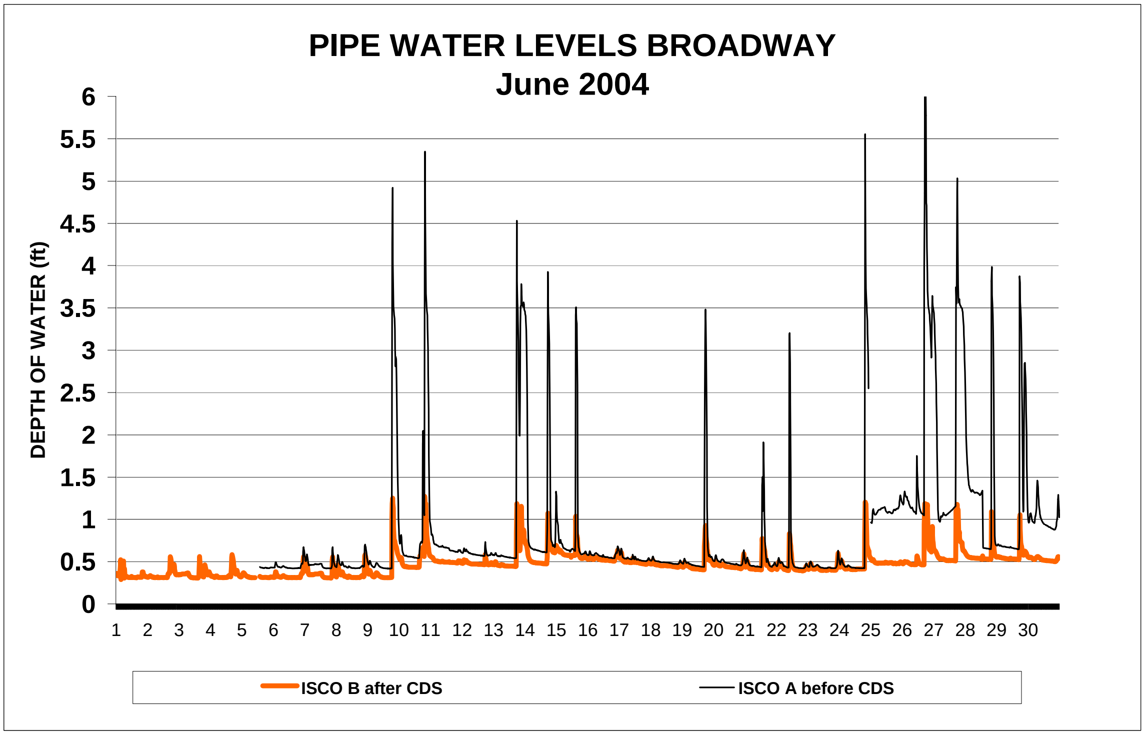

PIPE WATER LEVEL BROADWAY
FEBRUARY 2004
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Star B sensor stops recording
CLEAN OUT
ISCO B AFTER CDS
STAR B AFTER CDS
LEVEL A BEFORE CDS

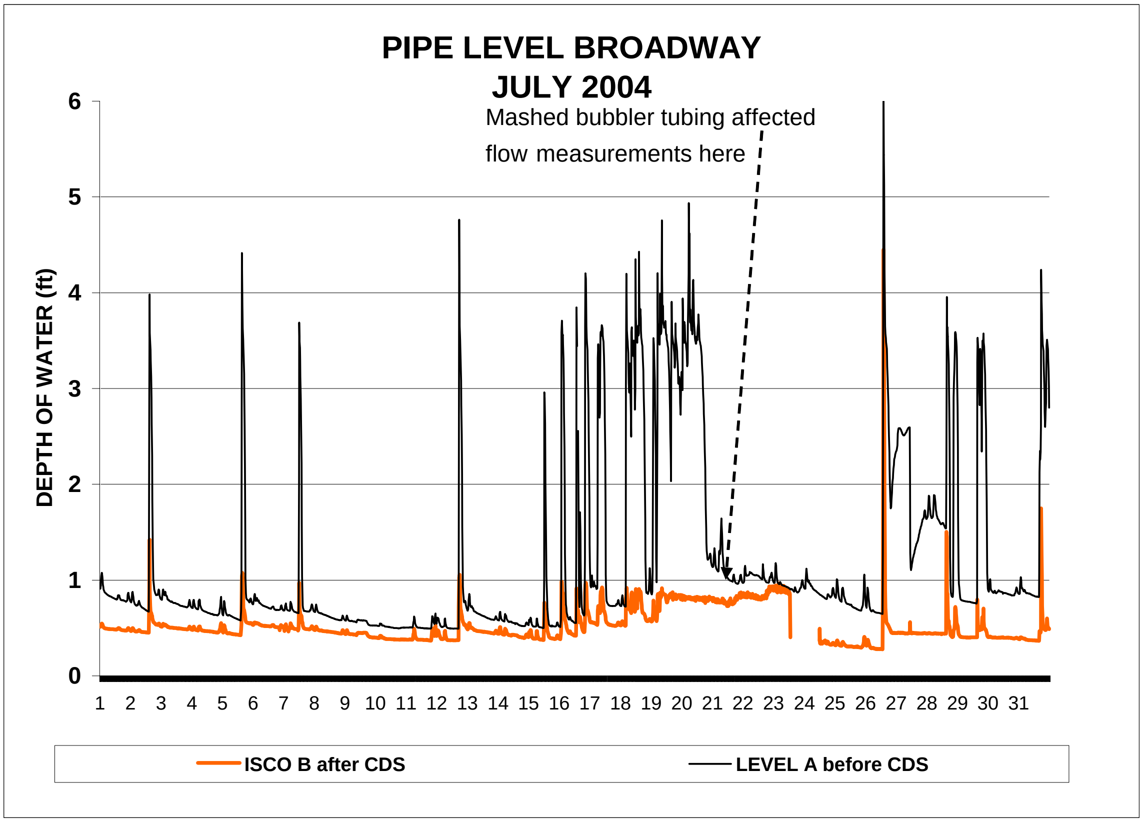

PIPE WATER LEVELS BROADWAY
MARCH 2004
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
ISCO B AFTER CDS
ISCO A BEFORE CDS

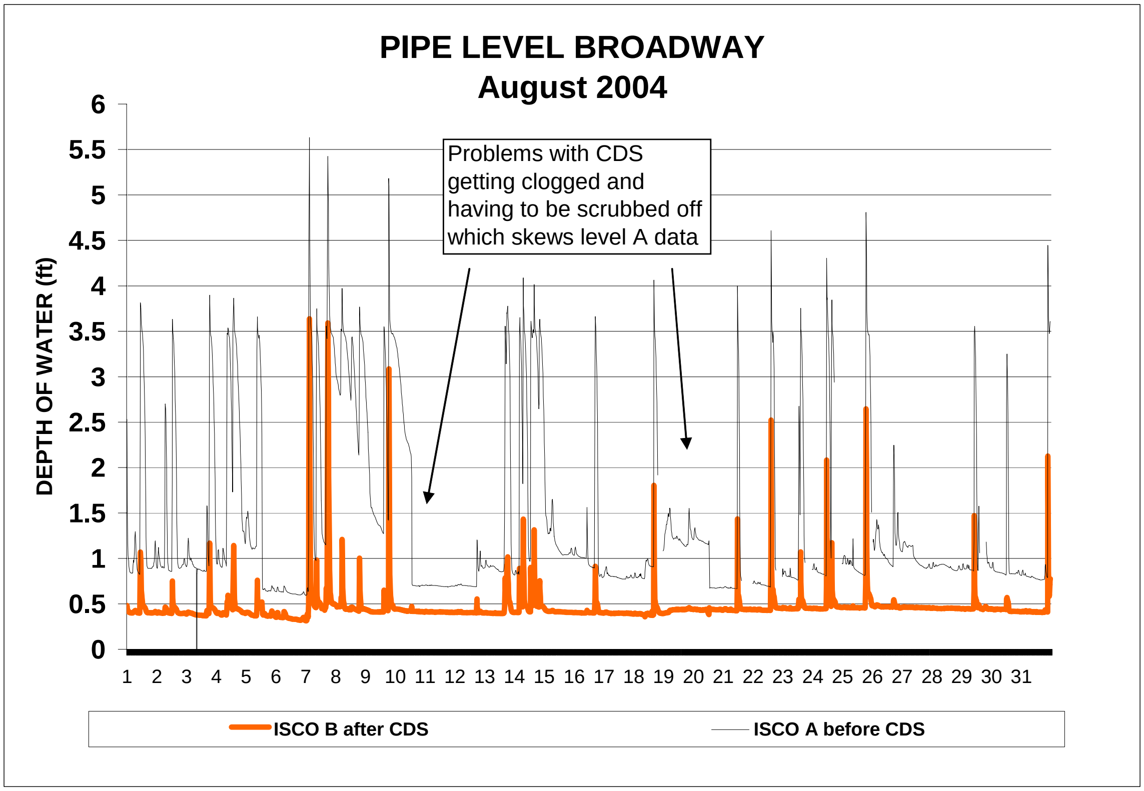


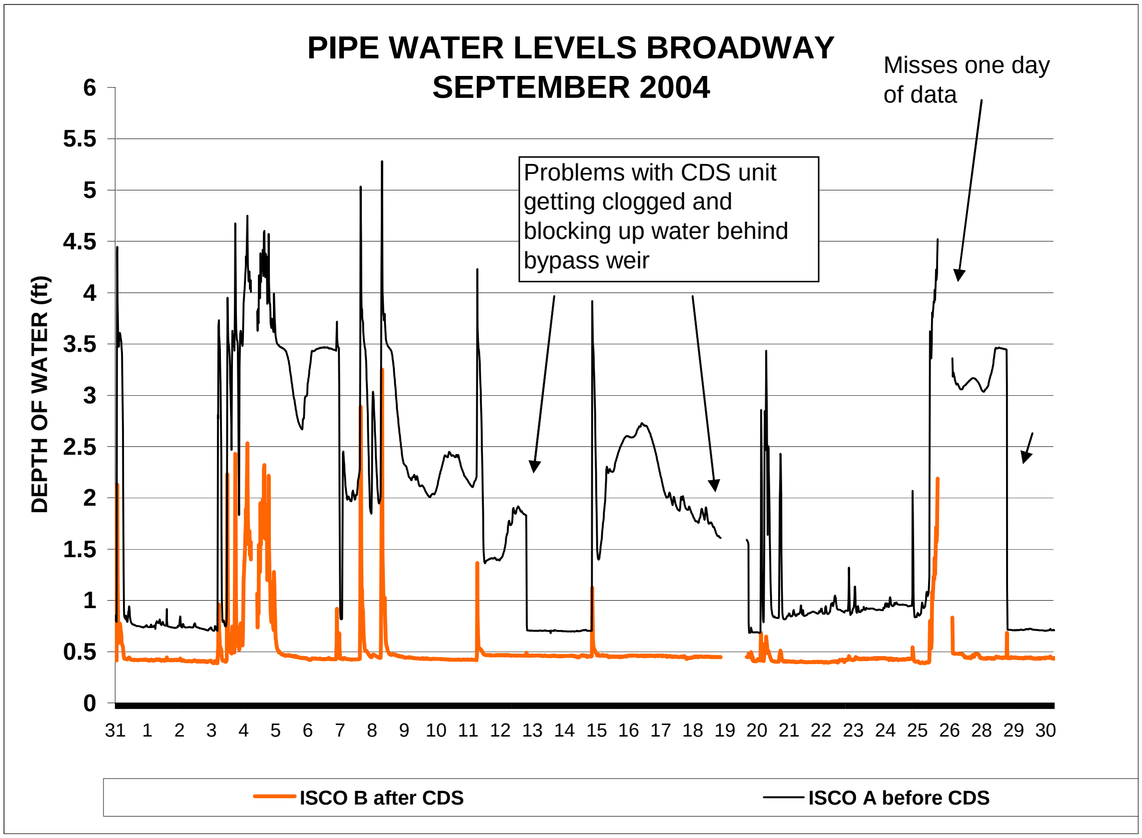


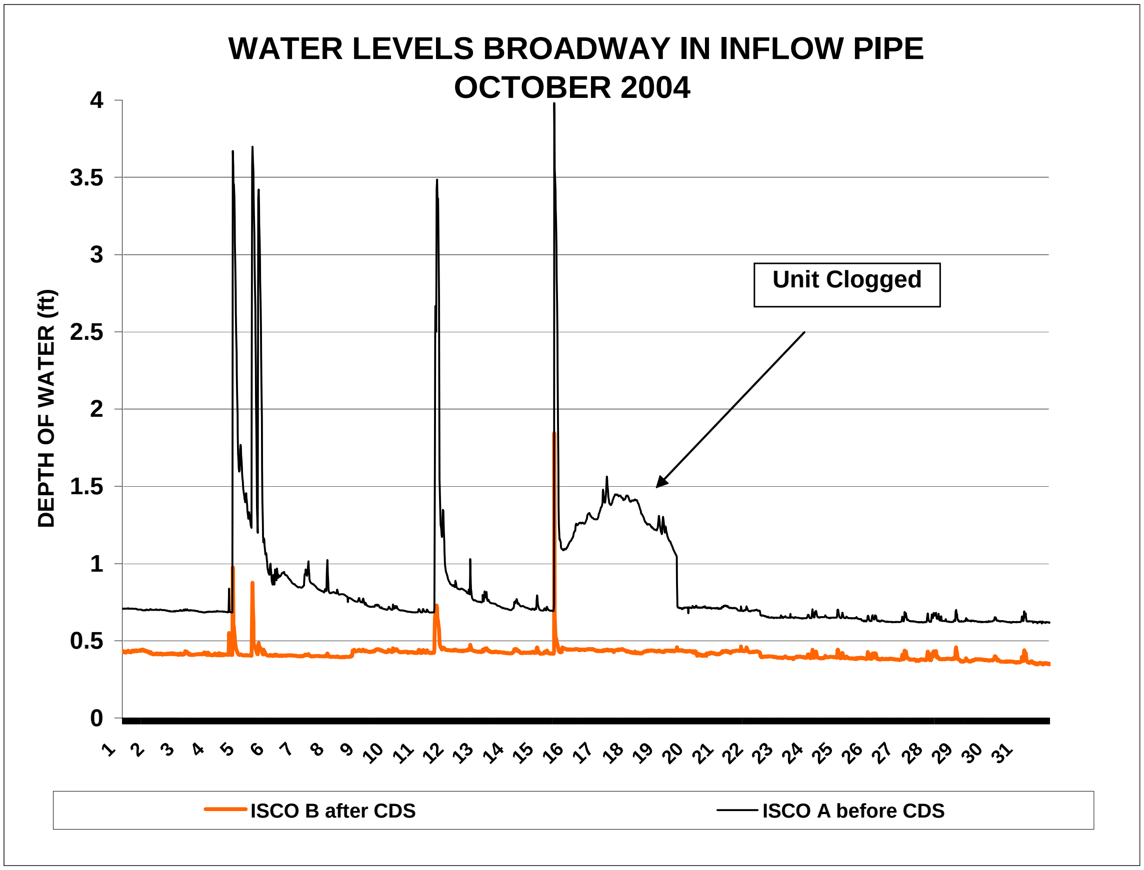
Problem getting program correct and getting offsets


PIPE WATER LEVELS BROADWAY
June 2004
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
ISCO B after CDS
ISCO A before CDS

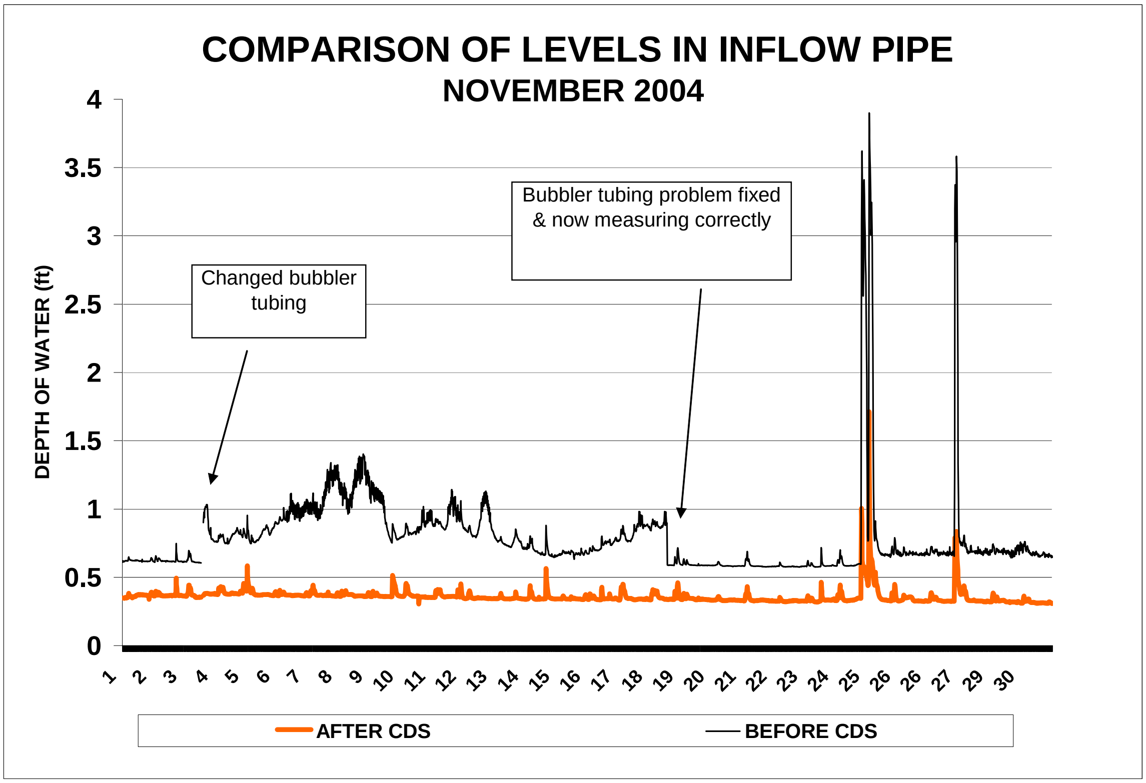

PIPE LEVEL BROADWAY
JULY 2004
Mashed bubbler tubing affected flow measurements here
DEPTH OF WATER (ft)
0
1
2
3
4
5
6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
ISCO B after CDS
LEVEL A before CDS


PIPE LEVEL BROADWAY
August 2004
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Problems with CDS getting clogged and having to be scrubbed off which skews level A data
ISCO B after CDS
ISCO A before CDS

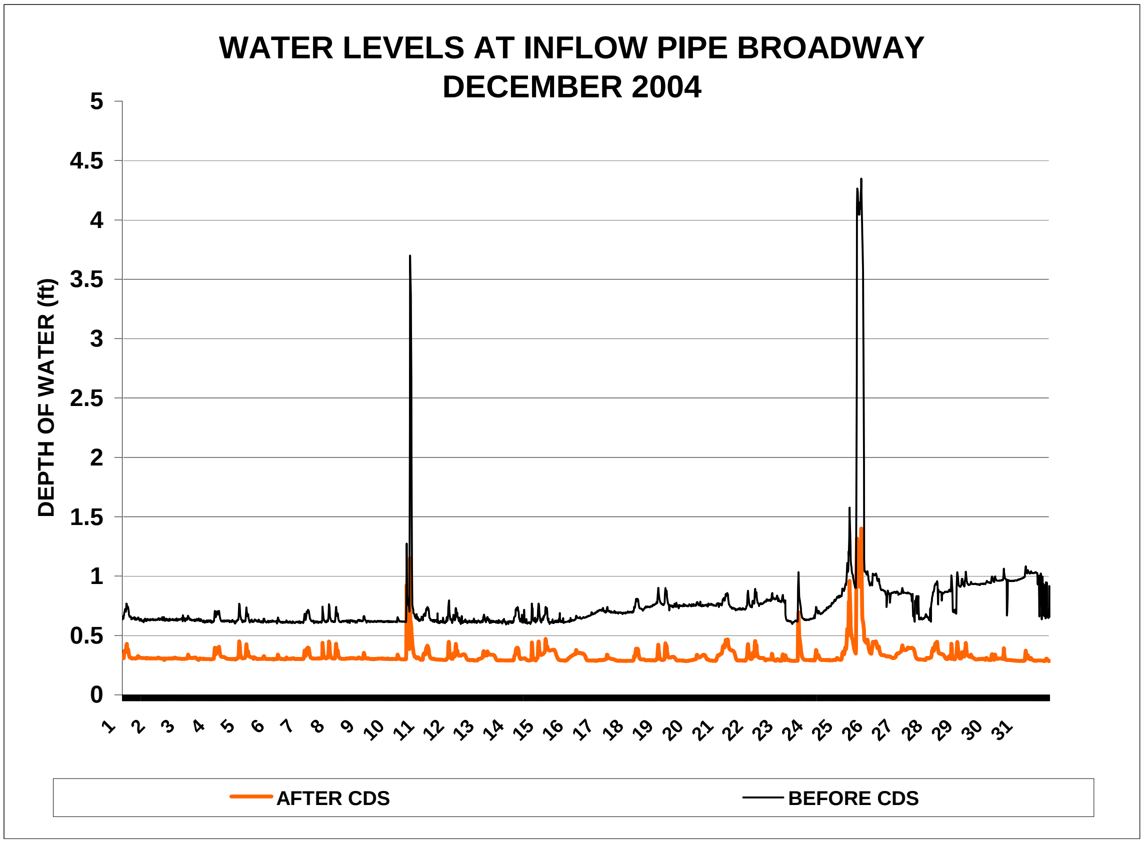

PIPE WATER LEVELS BROADWAY
SEPTEMBER 2004
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28 29 30
Misses one day of data
Problems with CDS unit getting clogged and blocking up water behind bypass weir
ISCO B after CDS
ISCO A before CDS

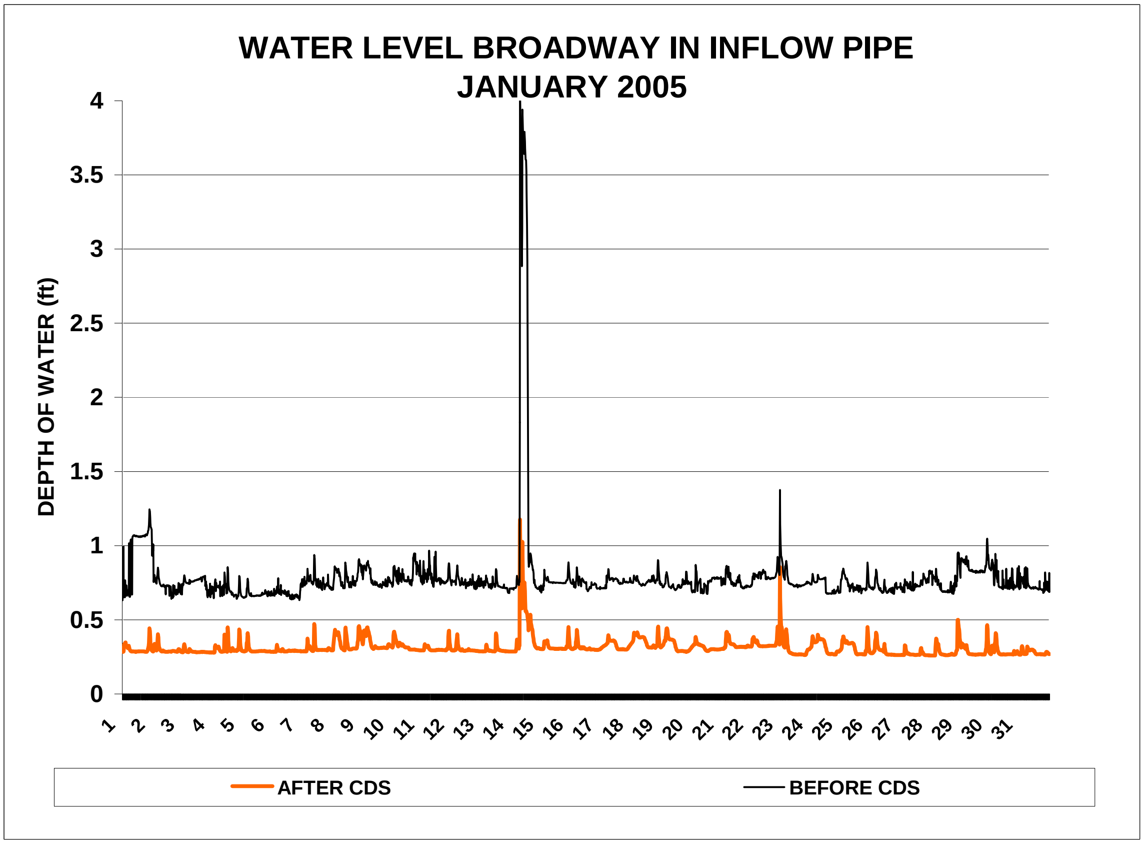


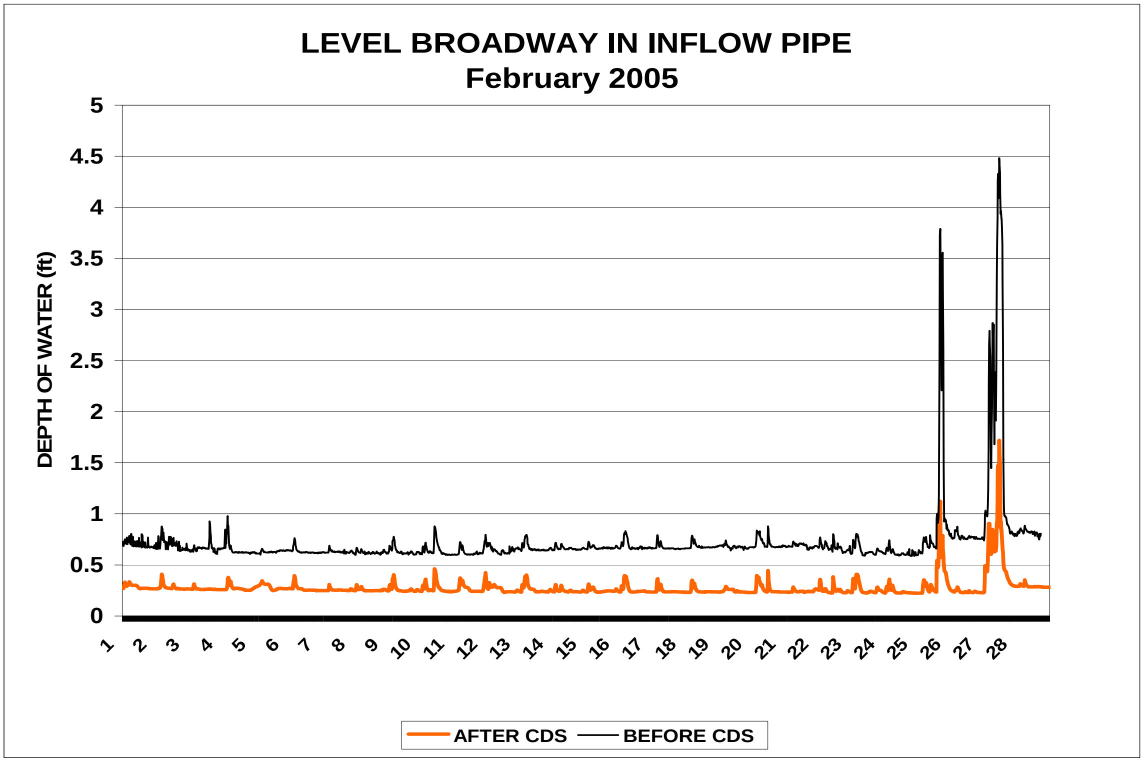
WATER LEVELS BROADWAY IN INFLOW PIPE
OCTOBER 2004

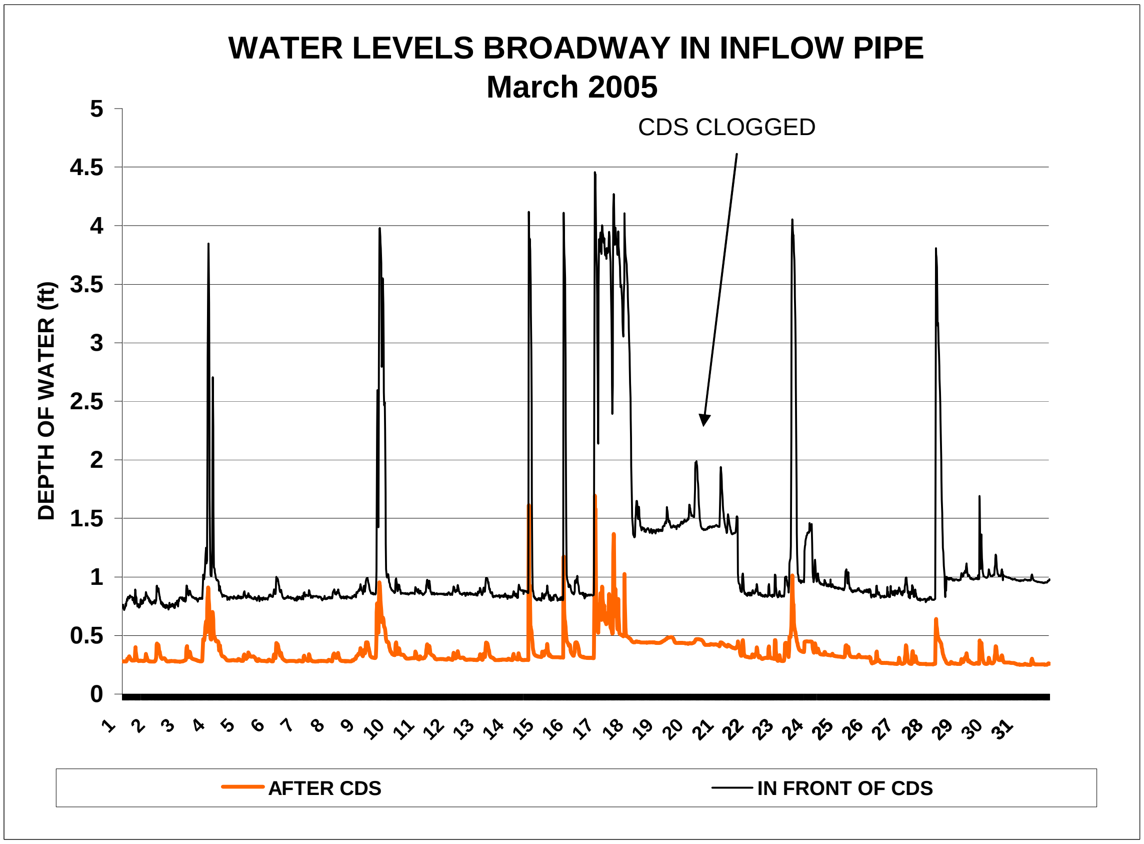


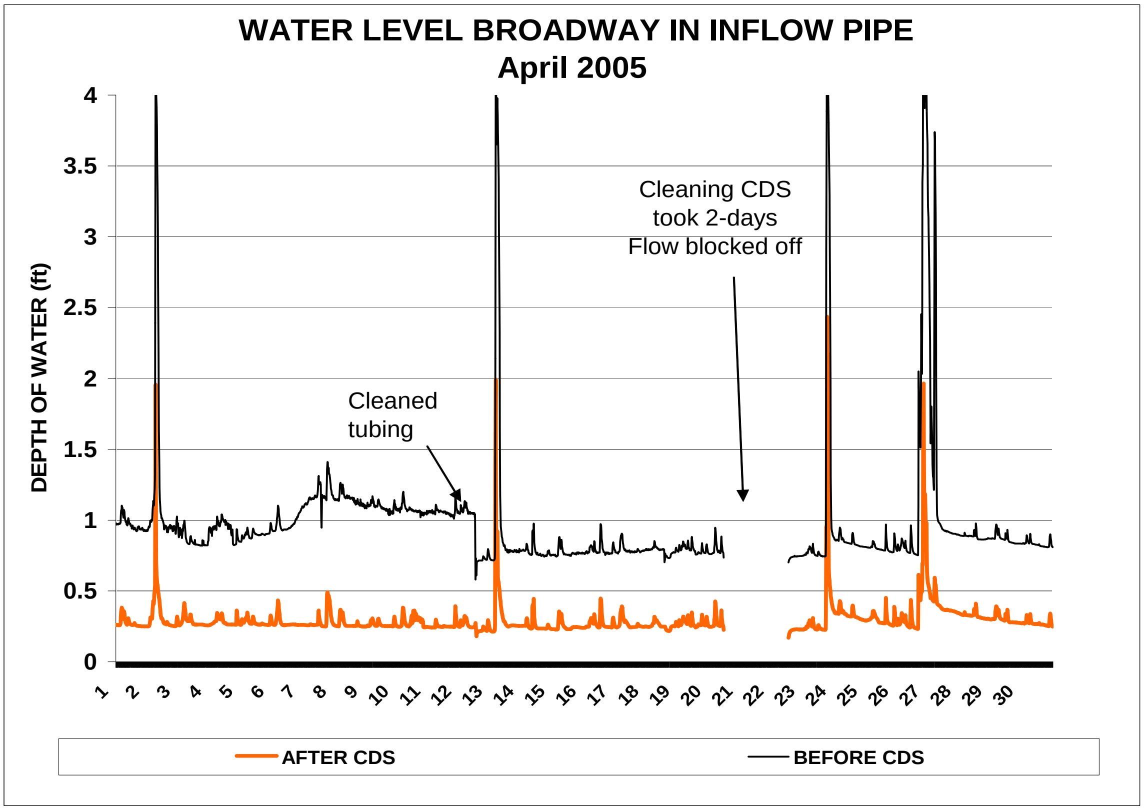
COMPARISON OF LEVELS IN INFLOW PIPE
NOVEMBER 2004

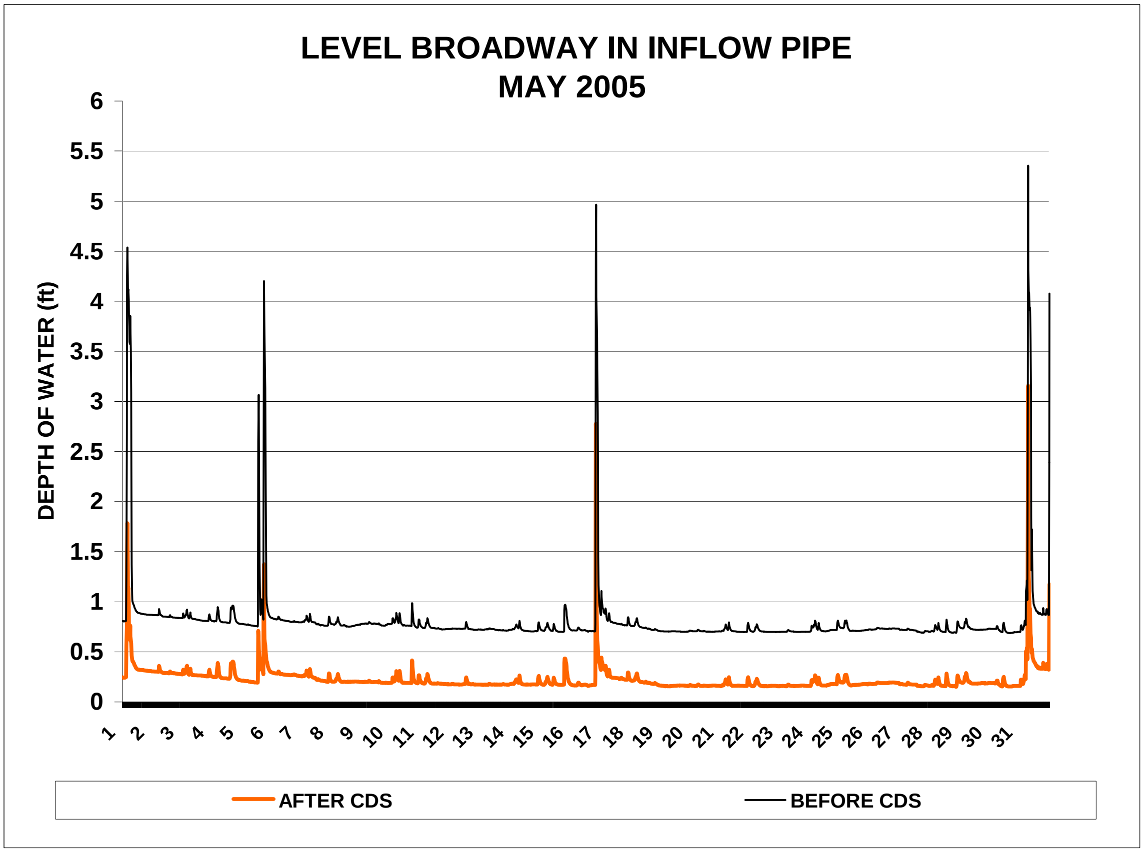

WATER LEVELS AT INFLOW PIPE BROADWAY
DECEMBER 2004
DEPTH OF WATER (ft)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AFTER CDS
BEFORE CDS

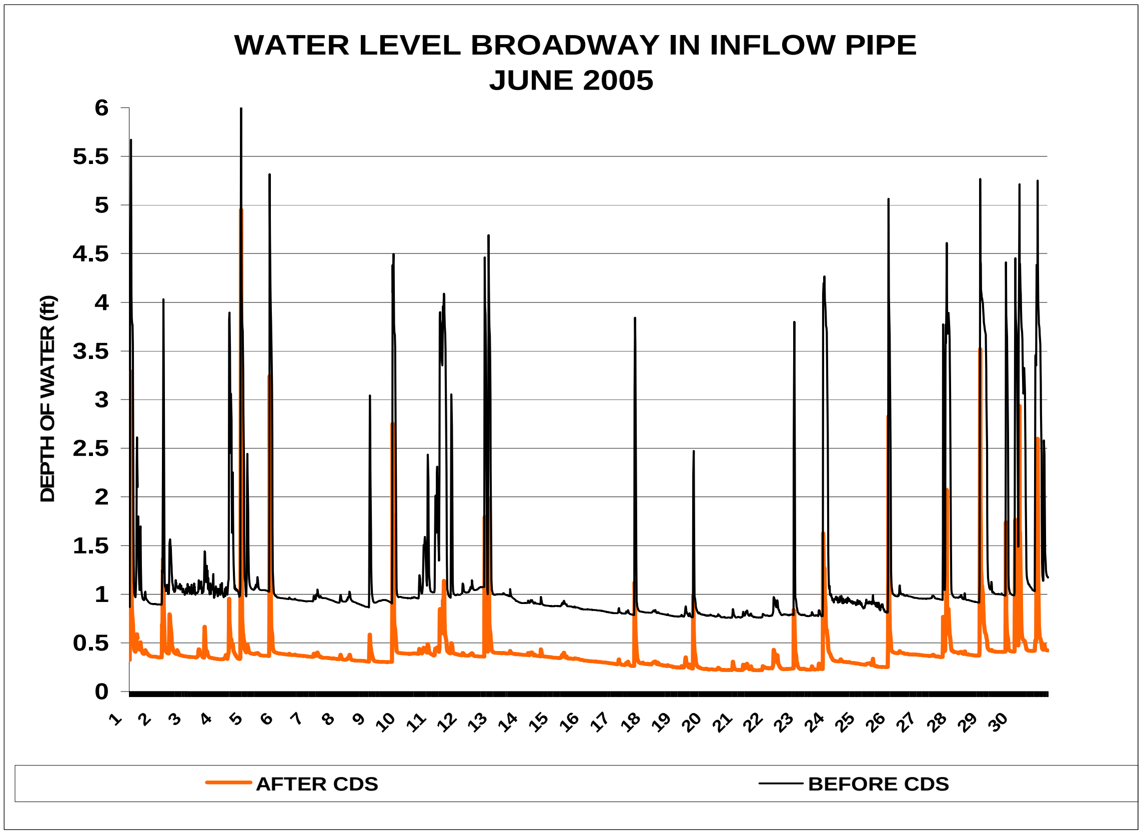

WATER LEVEL BROADWAY IN INFLOW PIPE
JANUARY 2005
DEPTH OF WATER (ft)
4
3.5
3
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AFTER CDS
BEFORE CDS

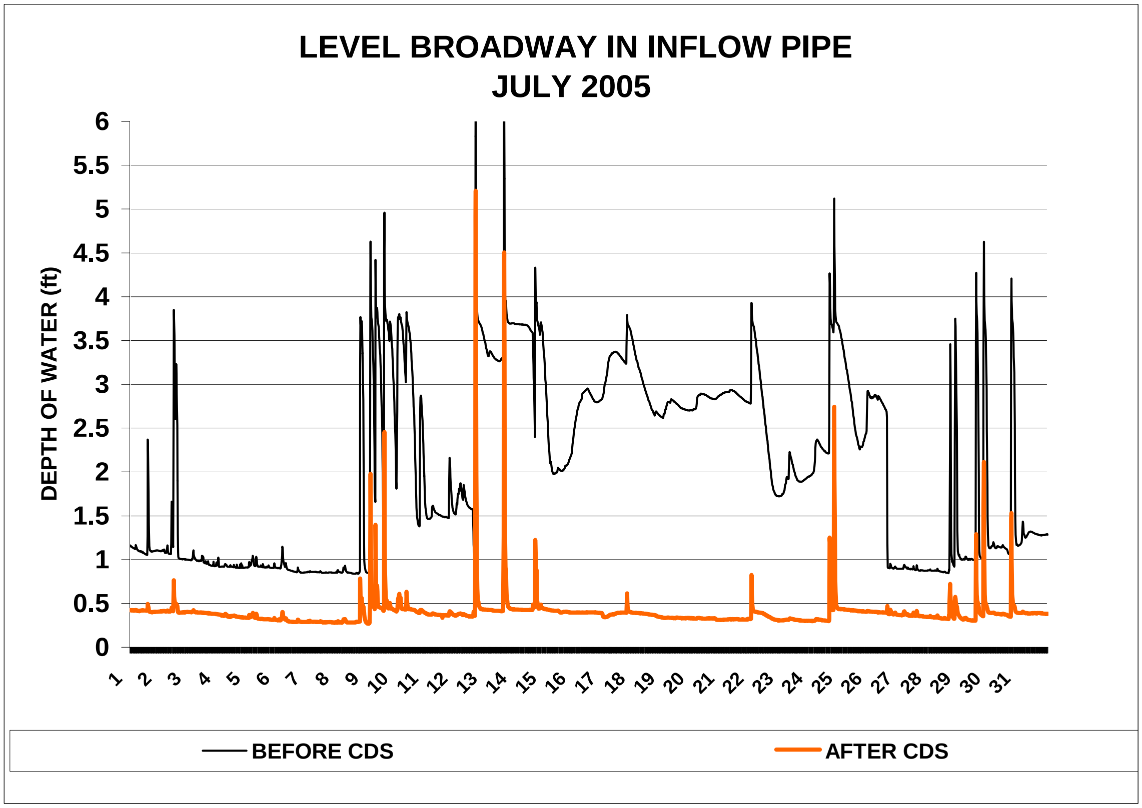

LEVEL BROADWAY IN INFLOW PIPE
February 2005
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
AFTER CDS
BEFORE CDS

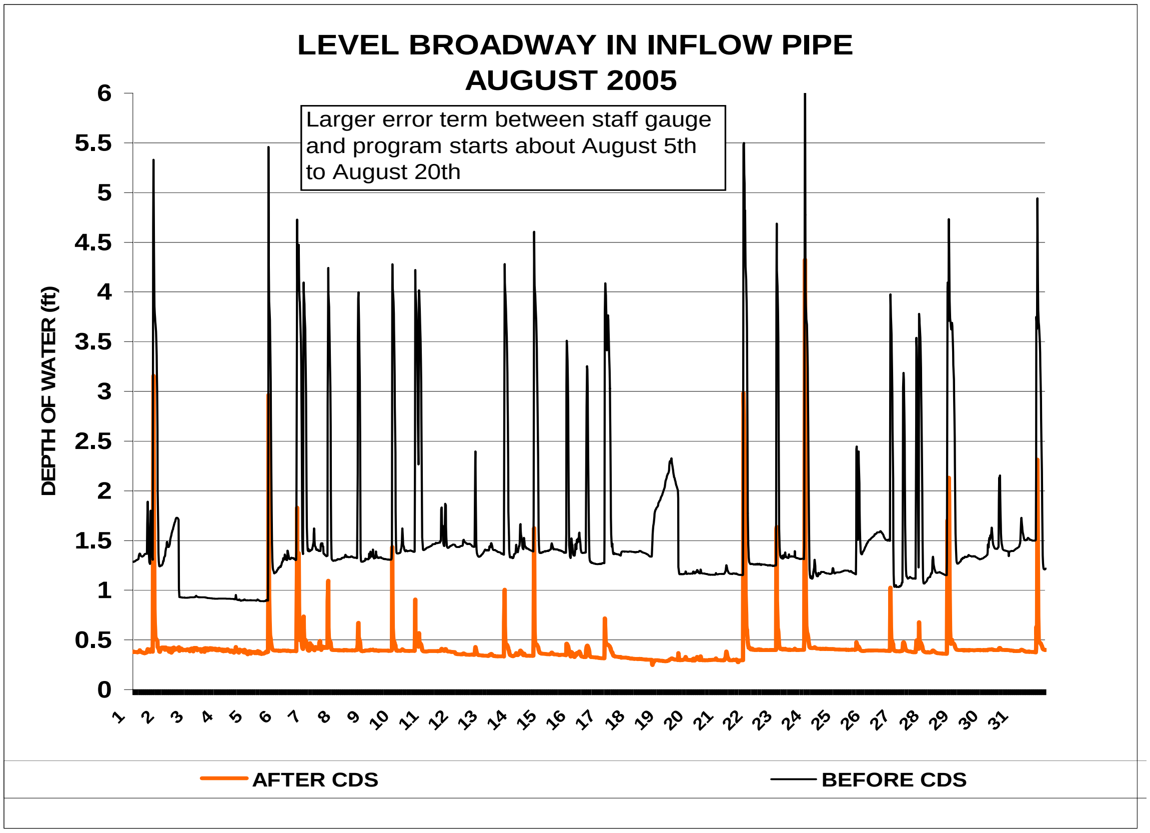

WATER LEVELS BROADWAY IN INFLOW PIPE
March 2005
CDS CLOGGED
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AFTER CDS
IN FRONT OF CDS

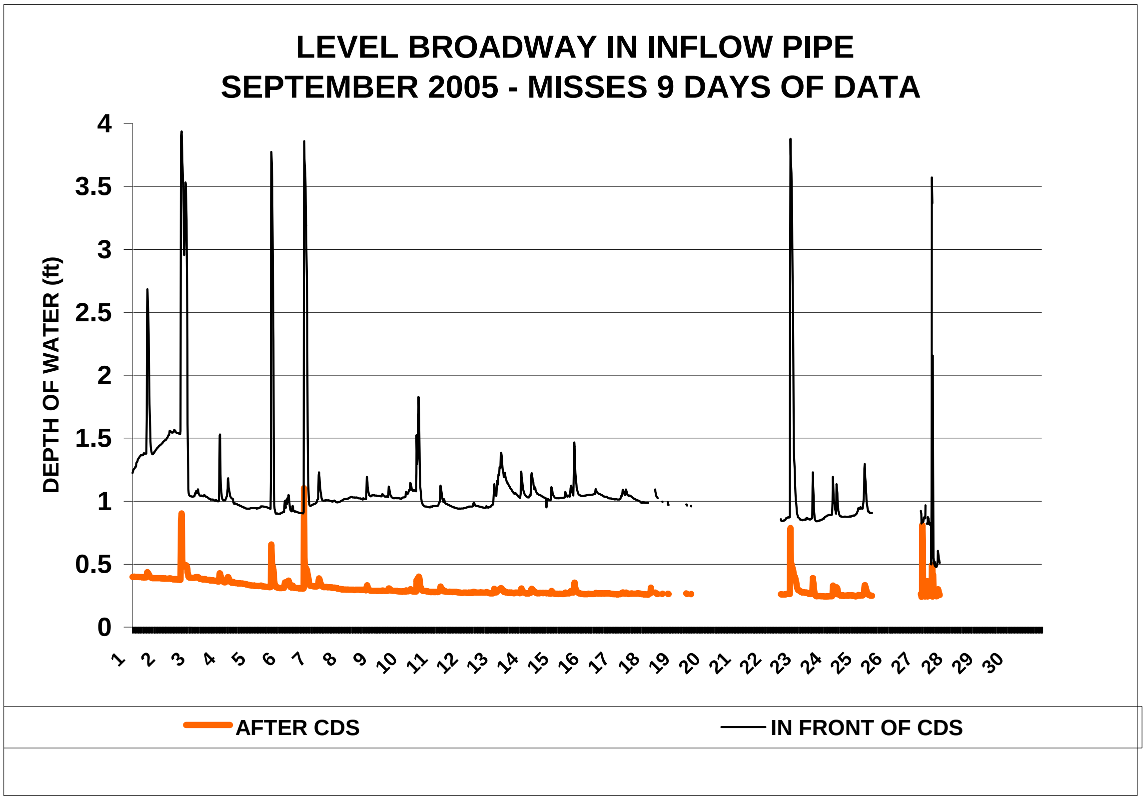

WATER LEVEL BROADWAY IN INFLOW PIPE
April 2005
DEPTH OF WATER (ft)
4
3.5
3
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Cleaned tubing
Cleaning CDS took 2-days Flow blocked off
AFTER CDS
BEFORE CDS

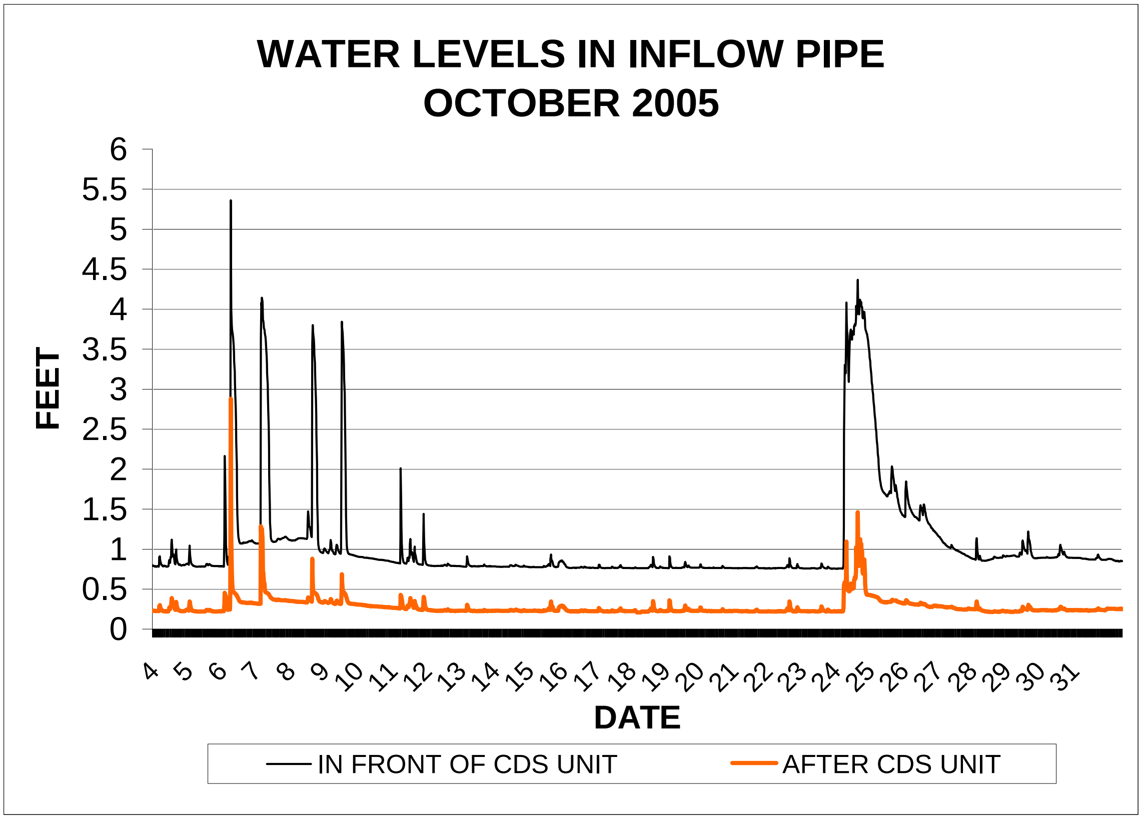

LEVEL BROADWAY IN INFLOW PIPE
MAY 2005
DEPTH OF WATER (ft)
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AFTER CDS
BEFORE CDS


WATER LEVEL BROADWAY IN INFLOW PIPE
JUNE 2005
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
AFTER CDS
BEFORE CDS


LEVEL BROADWAY IN INFLOW PIPE
JULY 2005
DEPTH OF WATER (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
BEFORE CDS
AFTER CDS


LEVEL BROADWAY IN INFLOW PIPE
AUGUST 2005
Larger error term between staff gauge and program starts about August 5th to August 20th
DEPTH OF WATER (ft)
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AFTER CDS
BEFORE CDS


LEVEL BROADWAY IN INFLOW PIPE
SEPTEMBER 2005 - MISSES 9 DAYS OF DATA
DEPTH OF WATER (ft)
4
3.5
3
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
AFTER CDS
IN FRONT OF CDS


WATER LEVELS IN INFLOW PIPE
OCTOBER 2005
FEET
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
DATE
IN FRONT OF CDS UNIT
AFTER CDS UNIT

APPENDIX D

FLOW DATA FOR INDIVIDUAL STORM EVENTS

Arrangement of Appendix D: A summary table with water budget calculations is shown first. The flow and rainfall data for most storms greater than 0.05 inches are shown for each month. (Explanatory notes to help understand results are still on some of the figures). Summary information in boxes on each graph shows the flow with bypass subtracted out in parentheses. For the first year, two sensors measured flow and the STAR meter measured velocity. In March of the second year the STAR sensor stopped recording and a Marsh McBirney velocity meter was installed to measure velocity with mixed results. For the final year, the Marsh McBirney stopped recording. Regression equations and a modified weir equation were developed and compared to the first year of data to estimate flow. See Appendix A for the description of these equations.

WATER BUDGET CALCULATION 2002-03

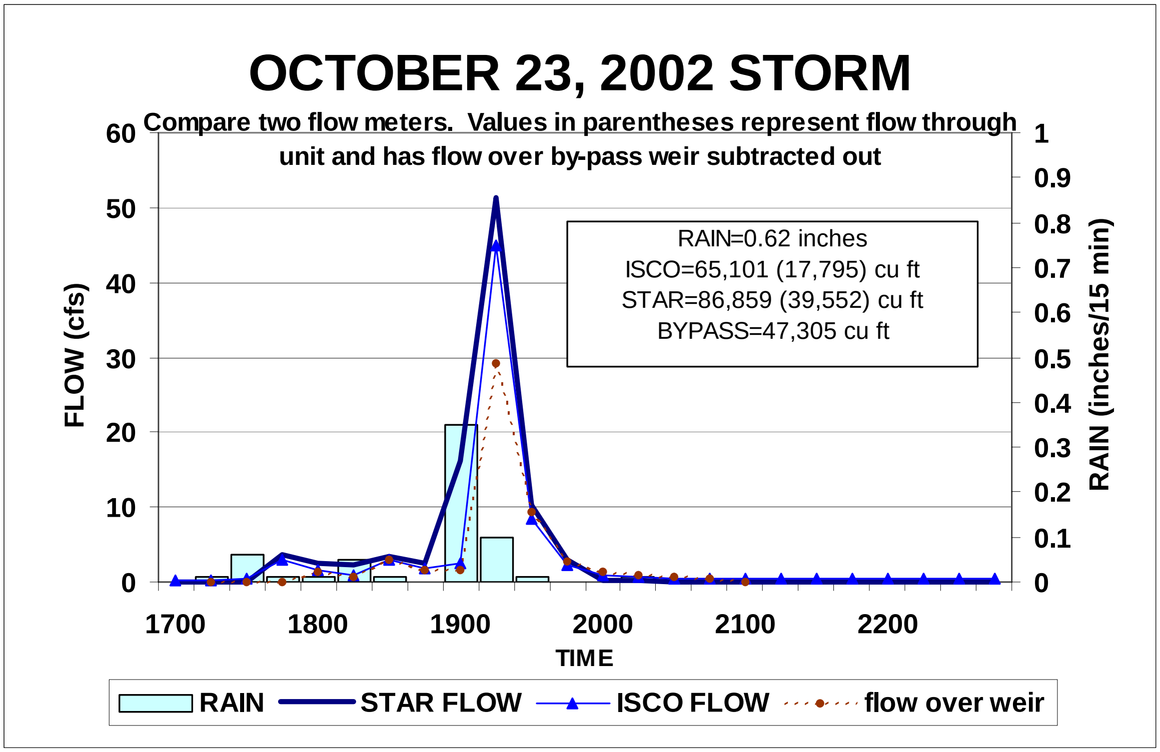
WATER BUDGET CALCULATIONS

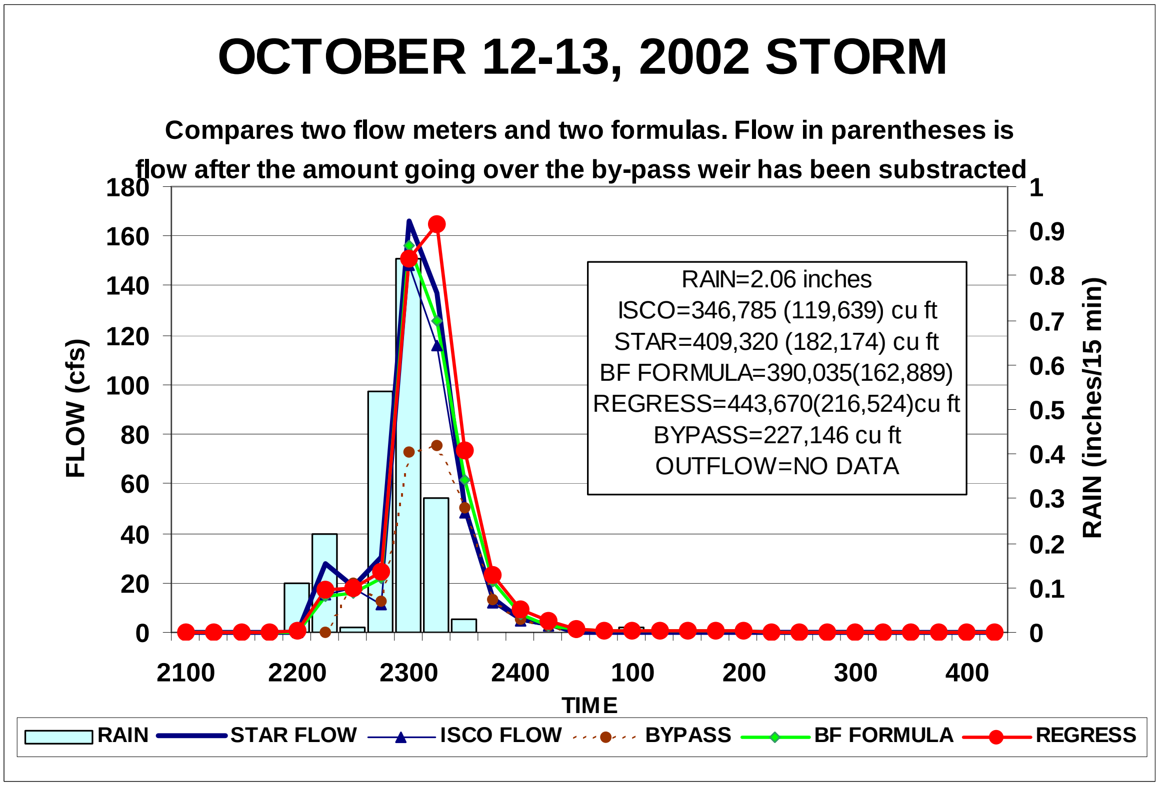
By-pass flow is the storm flow that goes over the overflow weir
Everything < 0.6 ft was calculated using the base flow weir
In graphs, total flow is shown first and the amount going into CDS unit is in Parentheses
The Isco gives more accurate level measurements according to Rebecca.
Later calculations showed the STAR was more accurate
When I did the November numbers, it looks as if the STAR water levels are better
Calculated the area of the pond as between 44,100 to 47,250 square feet
One calculation was 46,605 sq. feet and I will use that one until I can get a better number
RAIN OUT=rain measured with tipping bucket rain gauge at outflow until it stopped recording
RAIN IN=rain measured with tipping bucket rain gauge near the inflow
Estimated base flow at inflow from daily summary on ISCO strip charts for missing data

WATER BUDGET EQUATION:
FLOW IN – FLOW OUT = CHANGE IN STORAGE
Where: -Flow in = rain on pond, storm flow and base flow
-Flow out = flow out of pond (storm flow and base flow) and evapotranspiration (ET).
-Change in storage=difference between pond level at first of month compared to end of month times pond area
-The difference is caused by leaks, weir obstructions and other errors.

			INFLOW				OUTFLOW					REMARKS
	RAIN OUT inches	RAIN IN inches	RAIN cu ft	BASE FLOW cu ft	STORM FLOW cu ft	BY-PASS FLOW cu ft duplicates not in budget	BASE FLOW cu ft	STORM FLOW cu ft	ET (est) cu ft	STORAGE cu ft	SEEPAGE LEAK OR ERROR cu ft	
October	na	4.06	15,768	74,562	196,645	371,649						Testing instruments and formulas
November	na	2.12	8,234	197,666	230,541	141,742	124,716	199,122	12,816	11,185	88,601	CDS unit clogged & leak in outflow weir
December			no data collected									Instrument problems
January	0.00	0.00	no rainfall									No rainfall
February	2.01	2.17	8,428	216,815	200,066	6,717	237,166	160,501	6,991	11,185	9,466	Holes in by-pass weir
March	6.05	5.79	22,487	206,623	830,402	242,545	316,209	655,570	10,875	14,494	62,364	ISCO outflow gives better numbers for storms
April	3.34	3.35	13,011	268,202	490,437	89,936	267,792	475,424	16,855	13,236	-1,658	Base flow misses 10 days
May	2.23	2.30	8,933	210,761	309,695	0	301,252	278,524	19,263	-7,457	-62,194	ISCO @ out giving negative numbers; no good data; leve
June	na	13.26	51,499	169,169	2,204,091	840,147	374,441	1,918,438	20,972	26,658	84,249	Lost last version before I could check carefully. Used wro
July	na	6.70	26,021	247,311	1,214,978	475,892	687,955	801,546	22,875	-10,952	-13,114	CDS clean out
August	na	11.55	44,857	383,803	2,010,233	688,211	831,945	1,553,759	20,467	-7,923	40,645	Trouble with ISCO flows
September	na	4.93	19,147	274,866	660,365	316,565	559,618	716,376	16,312	10,253	-348,181	Pipe leaking into pond near outflow caused unmeasured
October	na	1.17	4,544	213,764	123,179	47,908	347,695	109,222	14,448	-3,262	-126,615	Vegetation blocking out weir causing flow errors

Used base flow weir formula for all flows <0.6 feet;Used velocity + pipe formula for storm flows





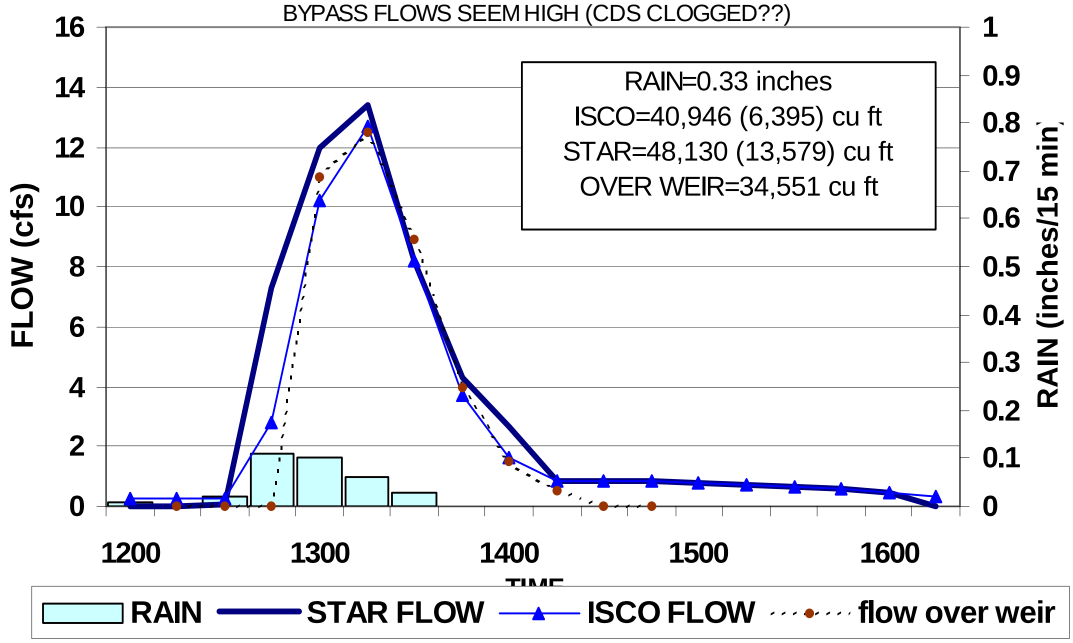
Formulas used the water level measured by the Star sensor, which reads slightly higher than the Isco water level sensor.

Storm #1

OCTOBER 30, 2002 STORM

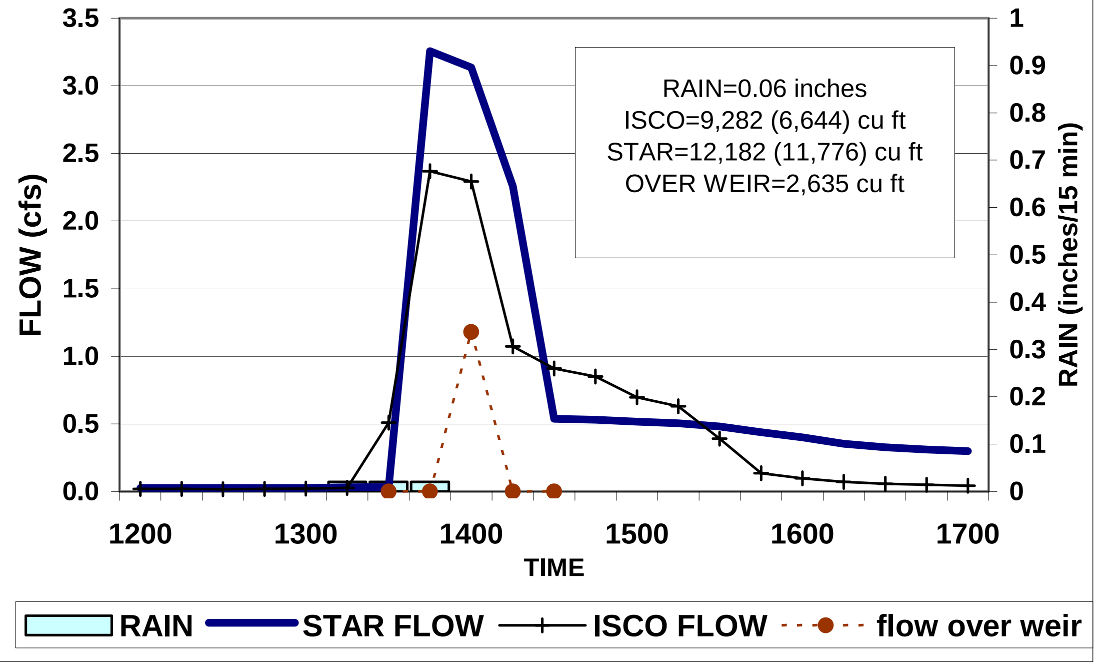
FLOW IN PARENTHESES REPRESENTS FLOW WITH BY-PASS FLOW REMOVED

BYPASS FLOWS SEEM HIGH (CDS CLOGGED??)

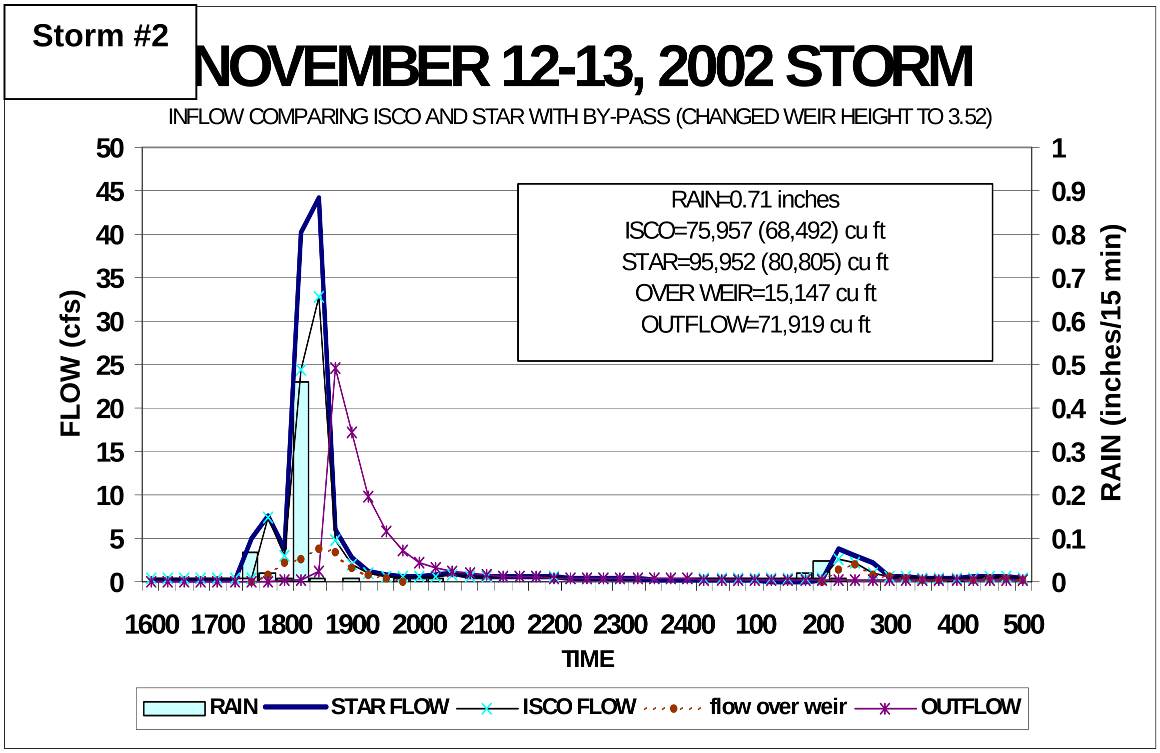


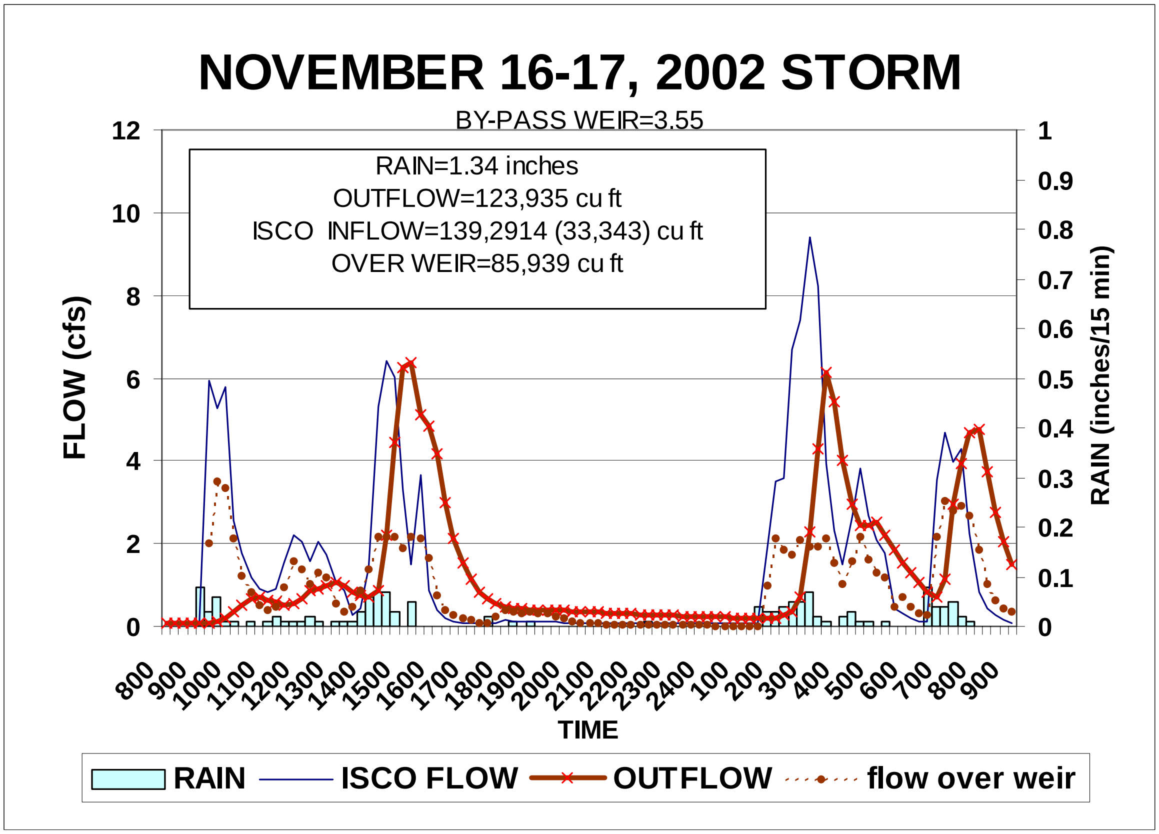
NOVEMBER 1, 2002 STORM

FLOW IN PIPE (CHANGED WEIR HEIGHT TO 3.6 FT)



Storm #2

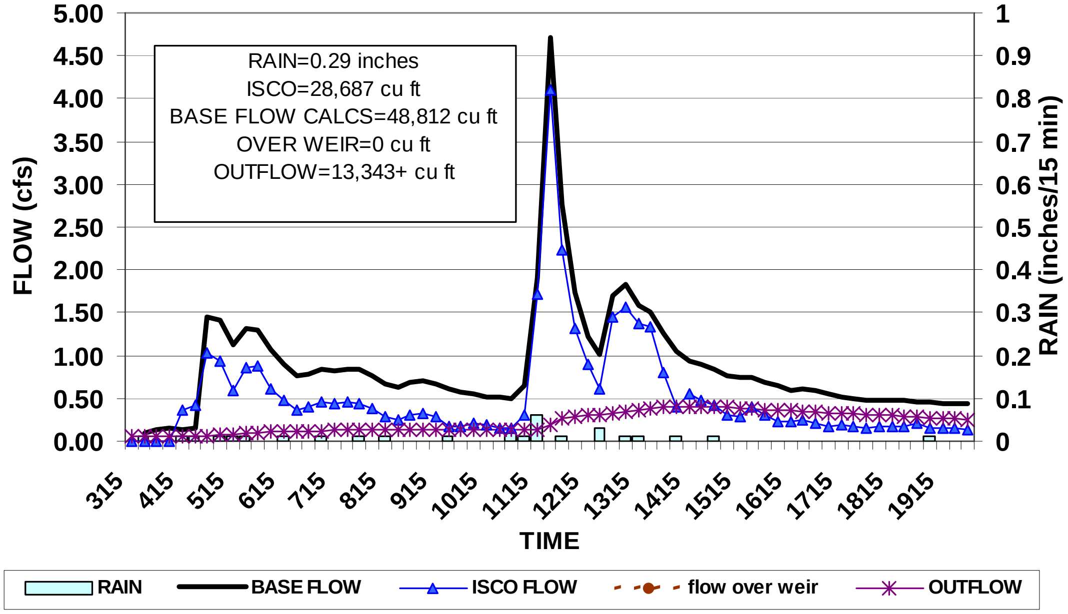

NOVEMBER 12-13, 2002 STORM
INFLOW COMPARING ISCO AND STAR WITH BY-PASS (CHANGED WEIR HEIGHT TO 3.52)
RAIN=0.71 inches
ISCO=75,957 (68,492) cu ft
STAR=95,952 (80,805) cu ft
OVER WEIR=15,147 cu ft
OUTFLOW=71,919 cu ft
FLOW (cfs)
50
45
40
35
30
25
20
15
10
5
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1600 1700 1800 1900 2000 2100 2200 2300 2400 100 200 300 400 500
TIME
RAIN
STAR FLOW
ISCO FLOW
flow over weir
OUTFLOW


NOVEMBER 16-17, 2002 STORM
BY-PASS WEIR=3.55
RAIN=1.34 inches
OUTFLOW=123,935 cu ft
ISCO INFLOW=139,2914 (33,343) cu ft
OVER WEIR=85,939 cu ft
FLOW (cfs)
12
10
8
6
4
2
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 100 200 300 400 500 600 700 800 900
TIME
RAIN
ISCO FLOW
OUTFLOW
flow over weir

Did not process December data because no water quality data and equipment failures.
Did not process January data because there was no rainfall.

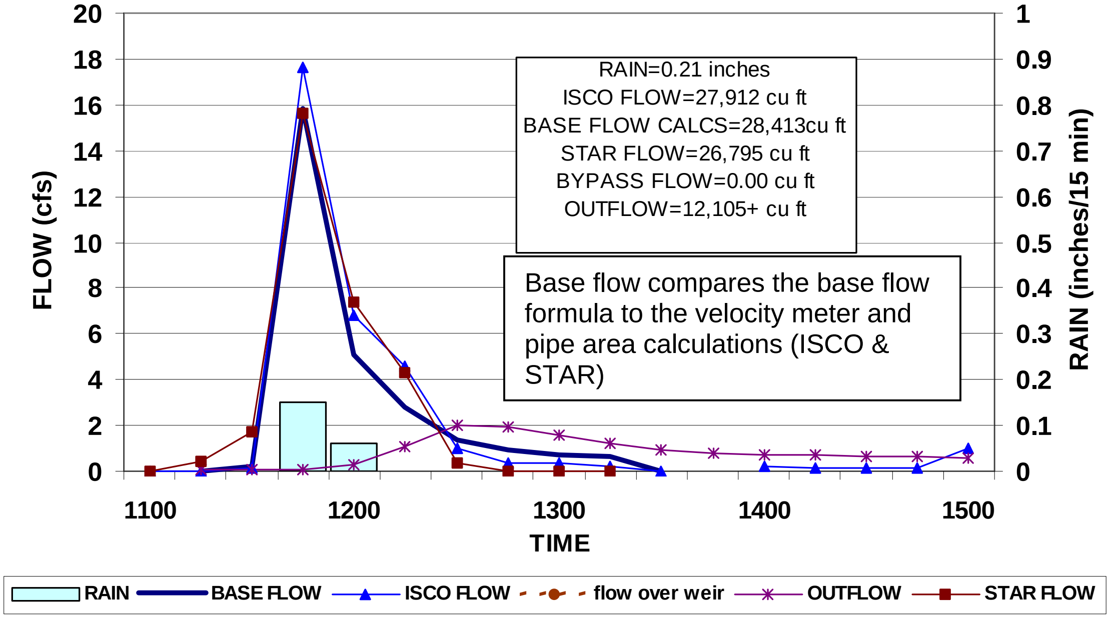
FEBRUARY 9, 2003 STORM

INFLOW COMPARING ISCO AND STAR WITH BY-PASS (CHANGED WEIR HEIGHT TO 3.52)

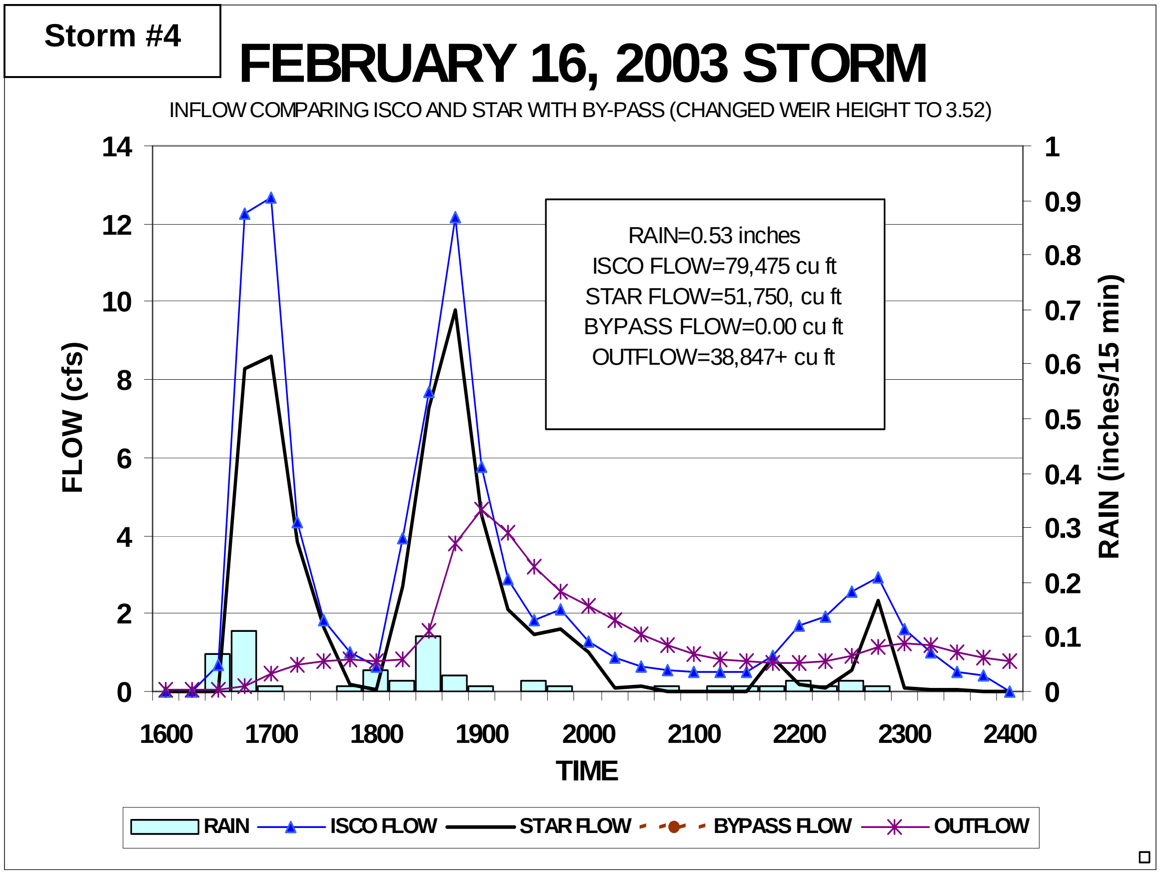


FEBRUARY 10, 2003 STORM

INFLOW COMPARING ISCO AND STAR WITH BY-PASS (CHANGED WEIR HEIGHT TO 3.52)



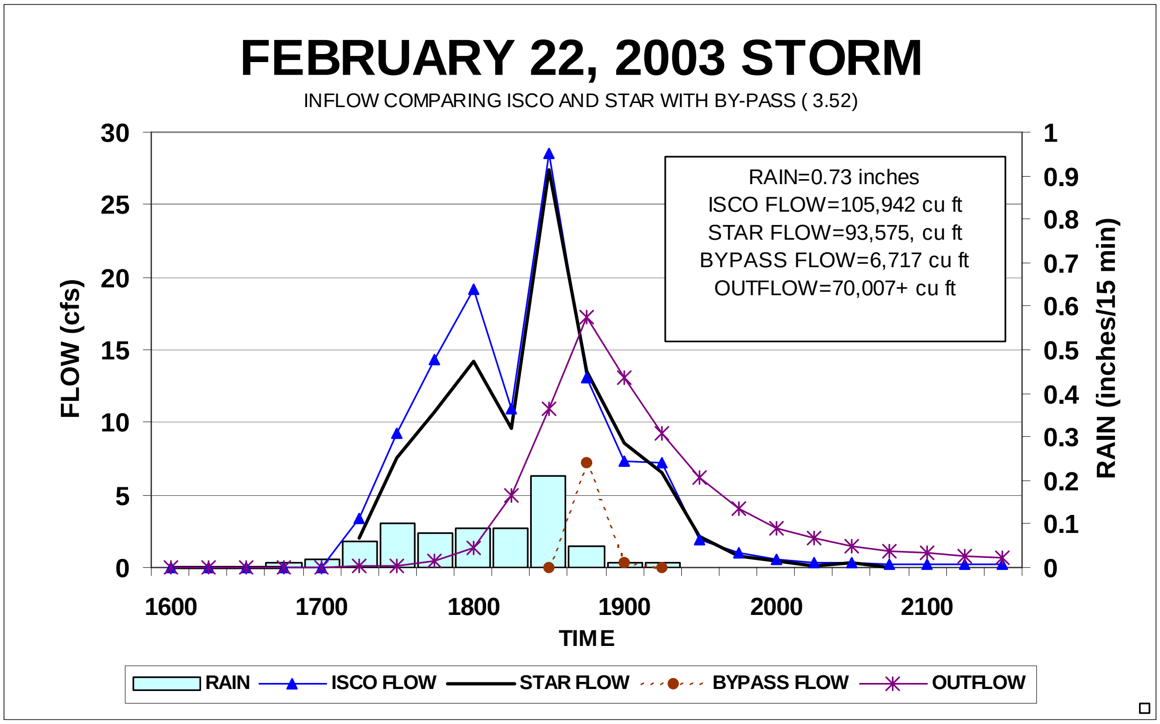
Storm #4



FEBRUARY 16, 2003 STORM

INFLOW COMPARING ISCO AND STAR WITH BY-PASS (CHANGED WEIR HEIGHT TO 3.52)

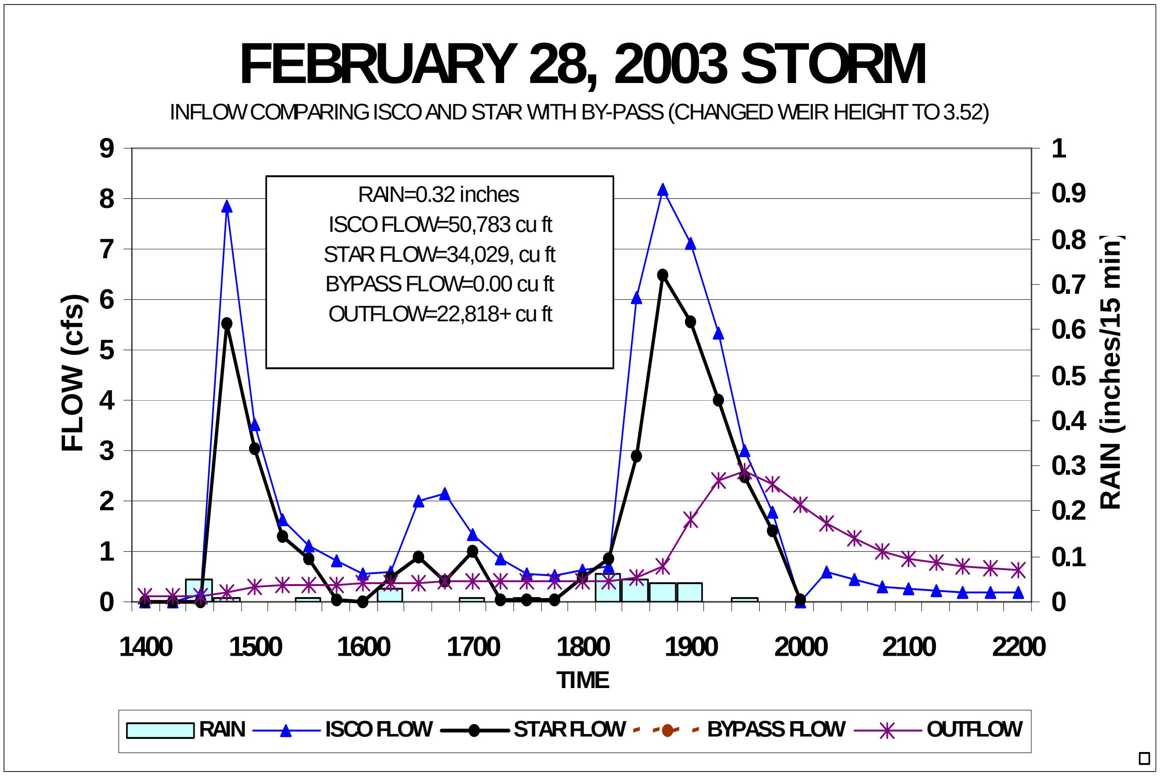
RAIN=0.53 inches
ISCO FLOW=79,475 cu ft
STAR FLOW=51,750, cu ft
BYPASS FLOW=0.00 cu ft
OUTFLOW=38,847+ cu ft



FEBRUARY 22, 2003 STORM

INFLOW COMPARING ISCO AND STAR WITH BY-PASS (3.52)

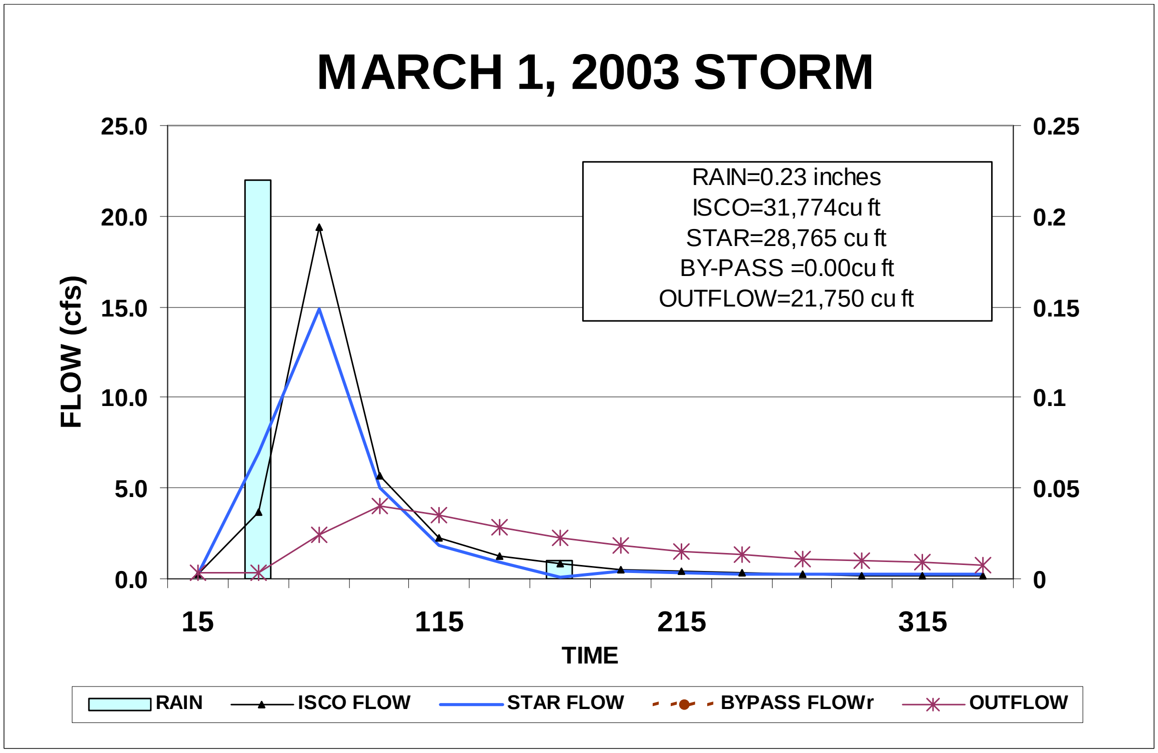
RAIN=0.73 inches
ISCO FLOW=105,942 cu ft
STAR FLOW=93,575, cu ft
BYPASS FLOW=6,717 cu ft
OUTFLOW=70,007+ cu ft



FEBRUARY 28, 2003 STORM

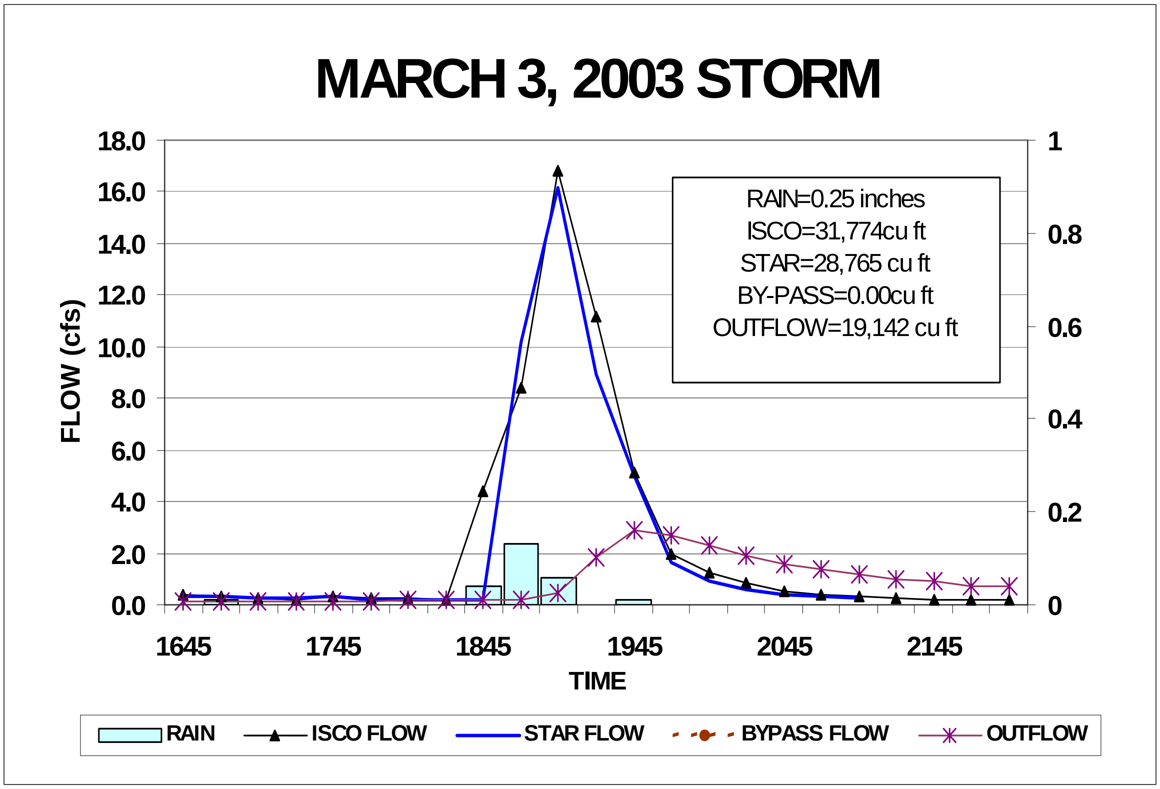
INFLOW COMPARING ISCO AND STAR WITH BY-PASS (CHANGED WEIR HEIGHT TO 3.52)

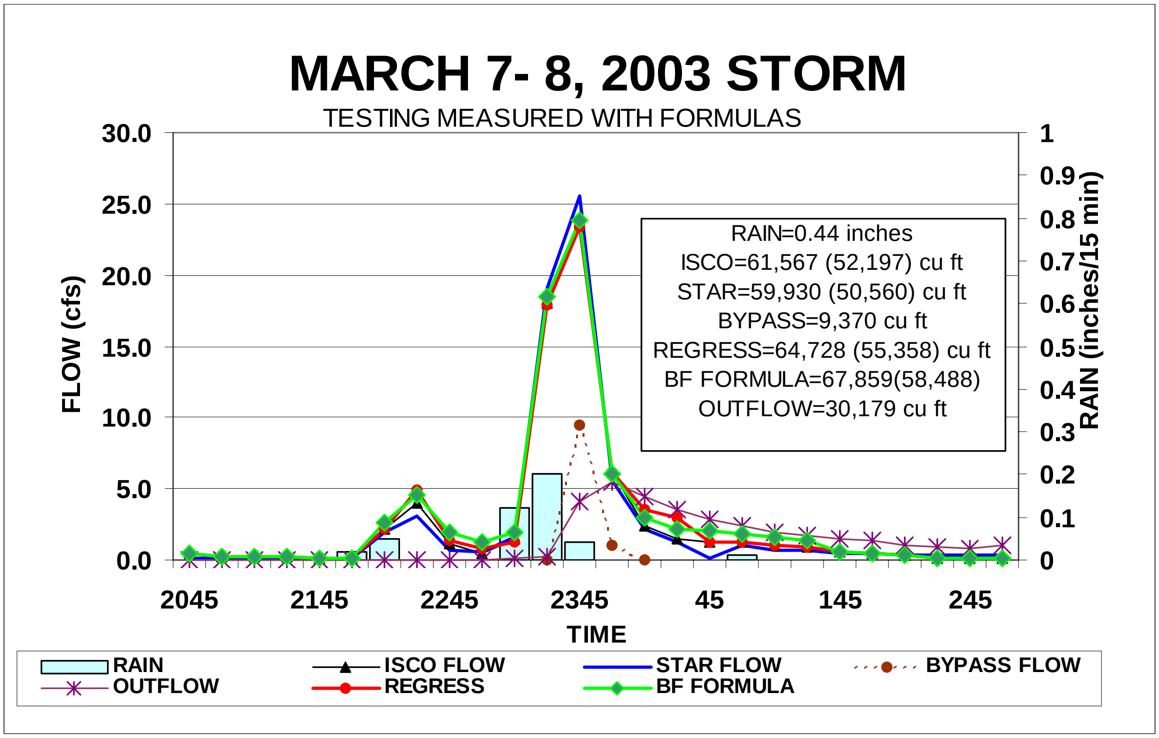
RAIN=0.32 inches
ISCO FLOW=50,783 cu ft
STAR FLOW=34,029, cu ft
BYPASS FLOW=0.00 cu ft
OUTFLOW=22,818+ cu ft



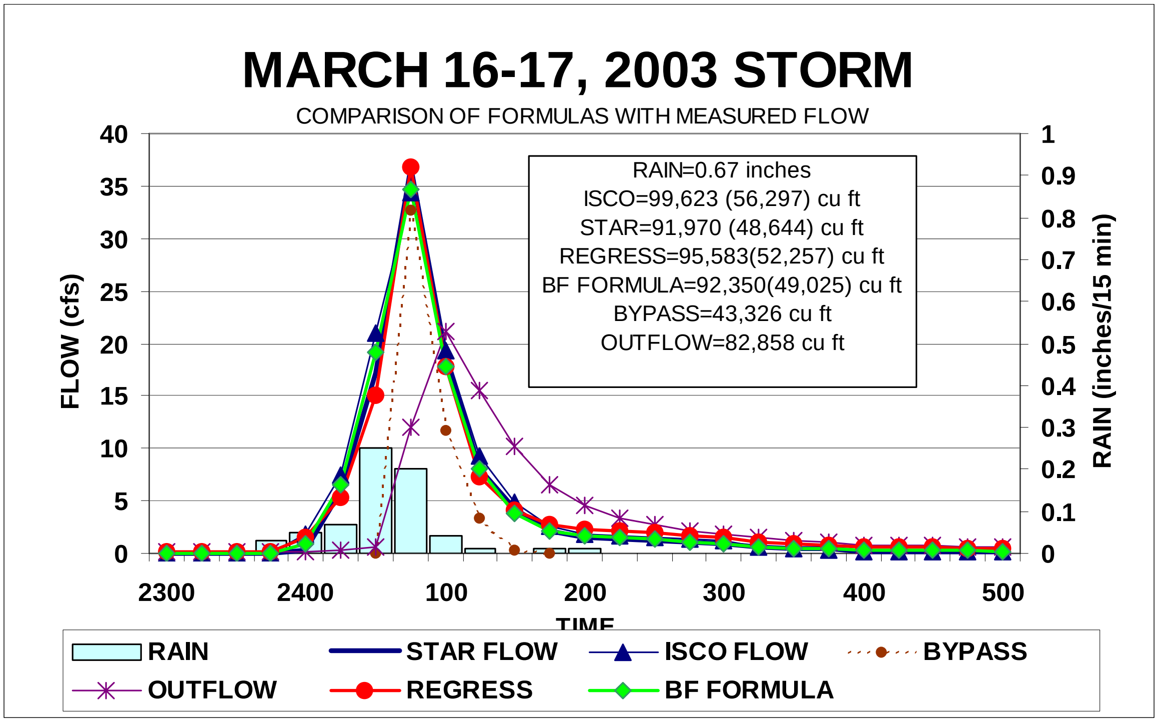
MARCH 1, 2003 STORM

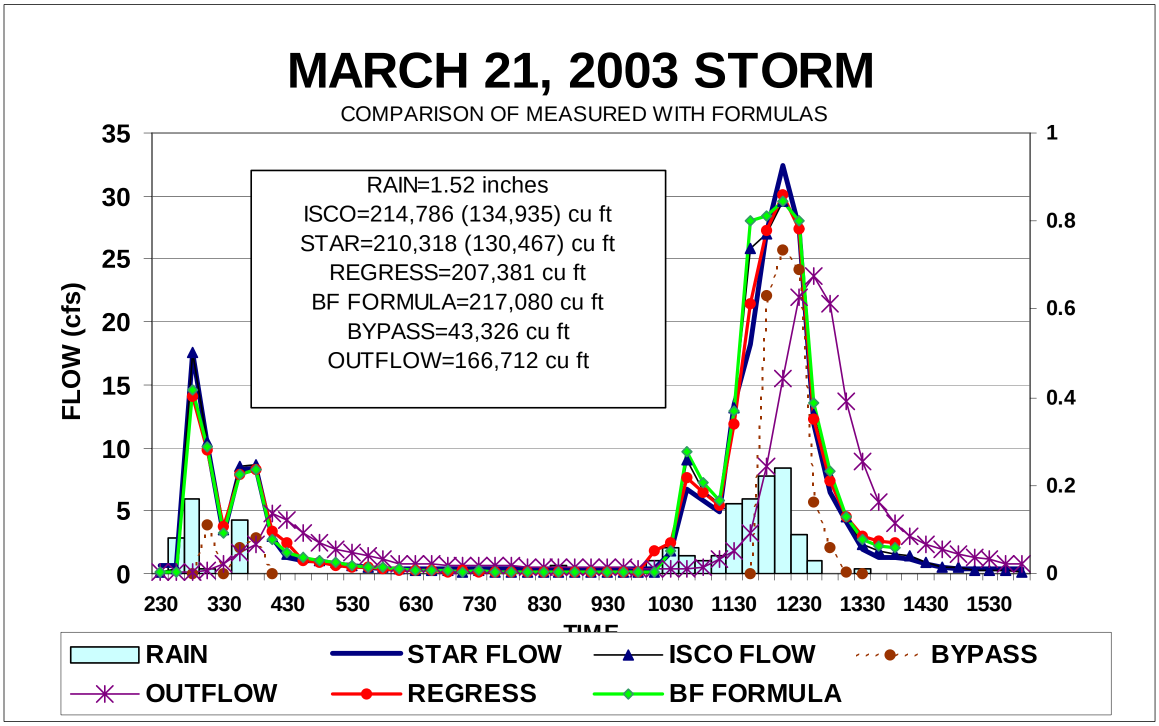
RAIN=0.23 inches
ISCO=31,774cu ft
STAR=28,765 cu ft
BY-PASS =0.00cu ft
OUTFLOW=21,750 cu ft

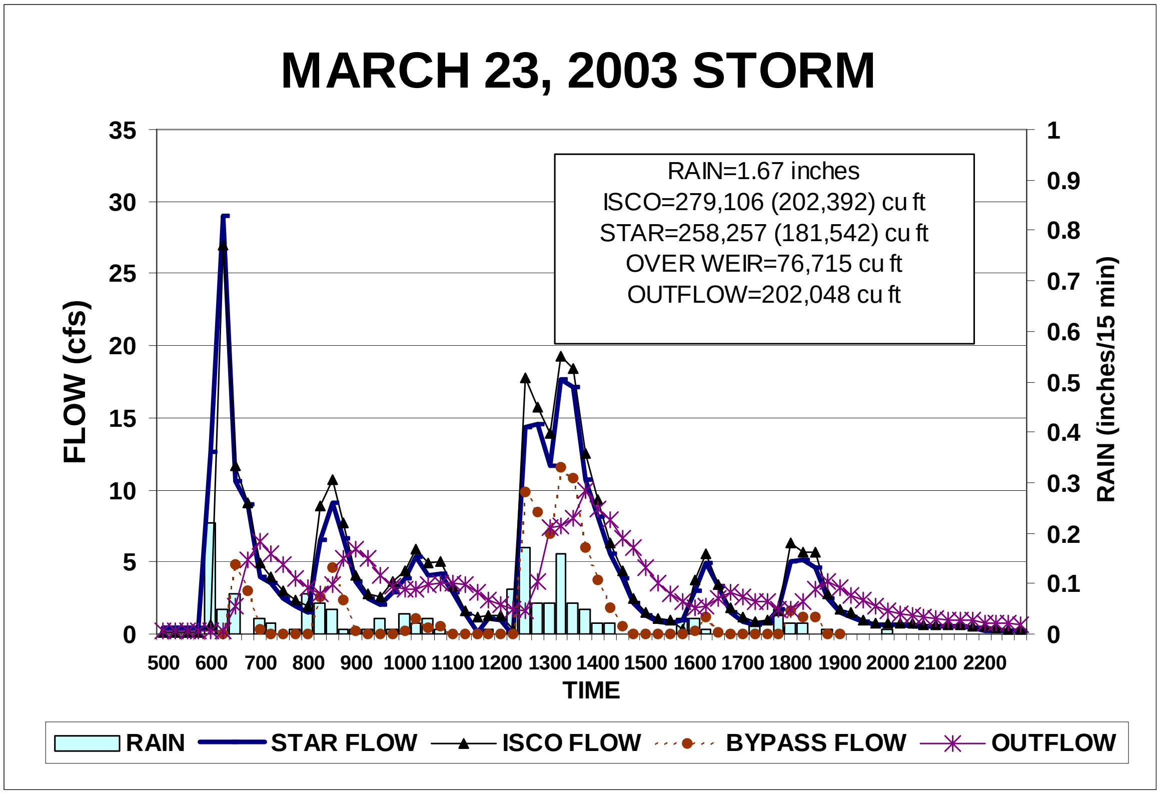

MARCH 3, 2003 STORM

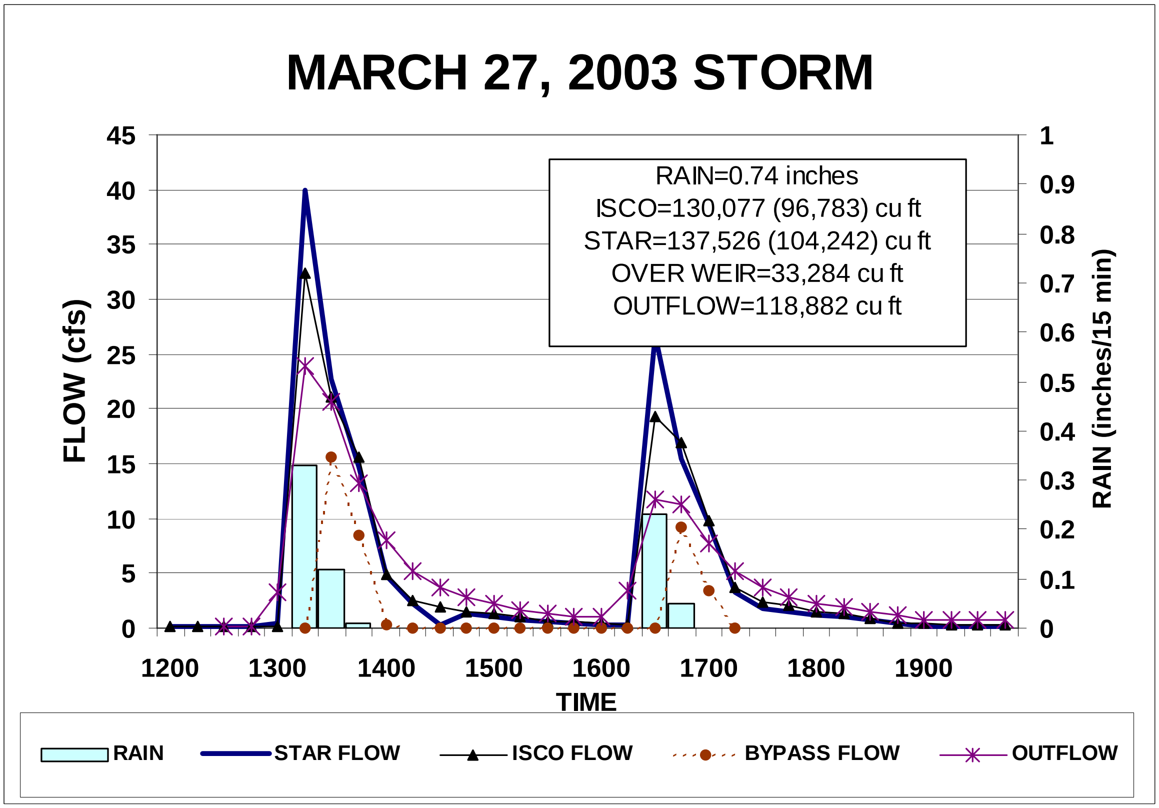

MARCH 7- 8, 2003 STORM

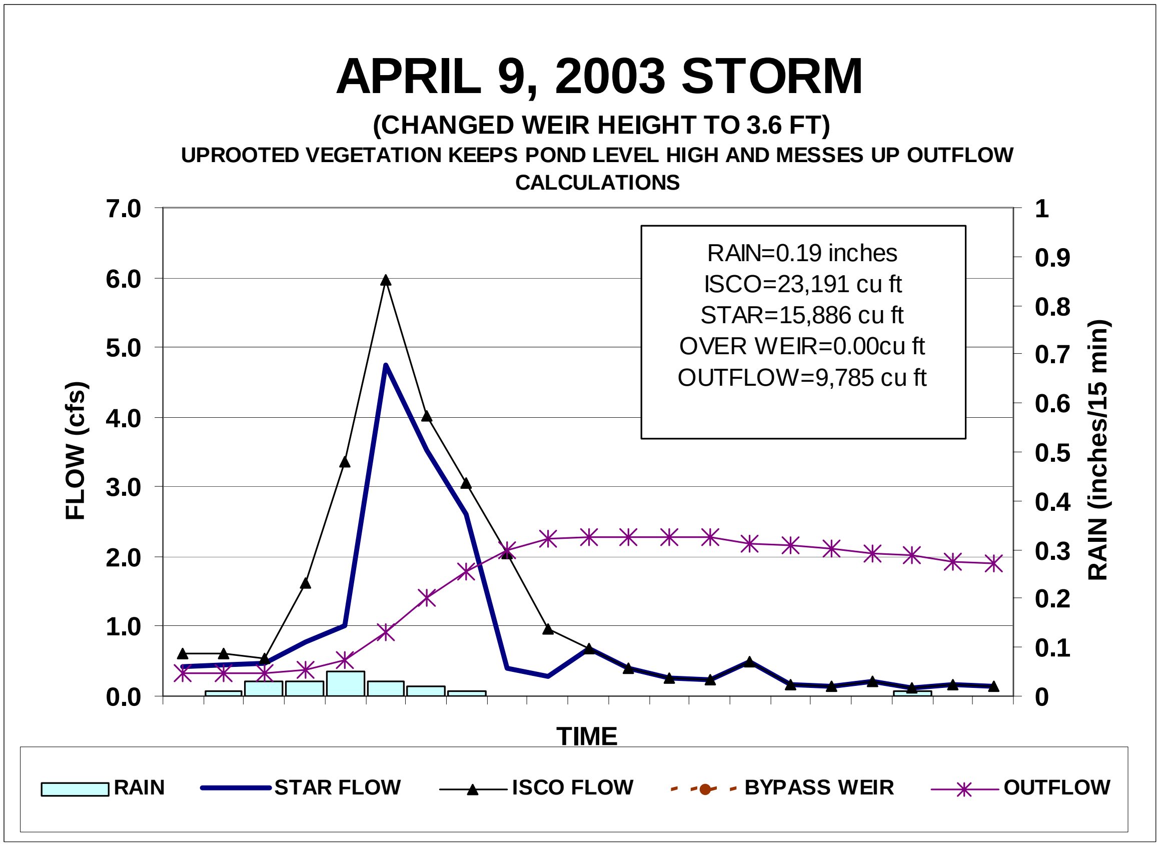
TESTING MEASURED WITH FORMULAS


MARCH 16-17, 2003 STORM
COMPARISON OF FORMULAS WITH MEASURED FLOW
RAIN=0.67 inches
ISCO=99,623 (56,297) cu ft
STAR=91,970 (48,644) cu ft
REGRESS=95,583(52,257) cu ft
BF FORMULA=92,350(49,025) cu ft
BYPASS=43,326 cu ft
OUTFLOW=82,858 cu ft
FLOW (cfs)
40
35
30
25
20
15
10
5
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2300
2400
100
200
300
400
500
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW
REGRESS
BF FORMULA


MARCH 21, 2003 STORM
COMPARISON OF MEASURED WITH FORMULAS
RAIN=1.52 inches
ISCO=214,786 (134,935) cu ft
STAR=210,318 (130,467) cu ft
REGRESS=207,381 cu ft
BF FORMULA=217,080 cu ft
BYPASS=43,326 cu ft
OUTFLOW=166,712 cu ft
FLOW (cfs)
35
30
25
20
15
10
5
0
1
0.8
0.6
0.4
0.2
0
230
330
430
530
630
730
830
930
1030
1130
1230
1330
1430
1530
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW
REGRESS
BF FORMULA


MARCH 23, 2003 STORM
RAIN=1.67 inches
ISCO=279,106 (202,392) cu ft
STAR=258,257 (181,542) cu ft
OVER WEIR=76,715 cu ft
OUTFLOW=202,048 cu ft
FLOW (cfs)
0
5
10
15
20
25
30
35
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
TIME
500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200
RAIN
STAR FLOW
ISCO FLOW
BYPASS FLOW
OUTFLOW

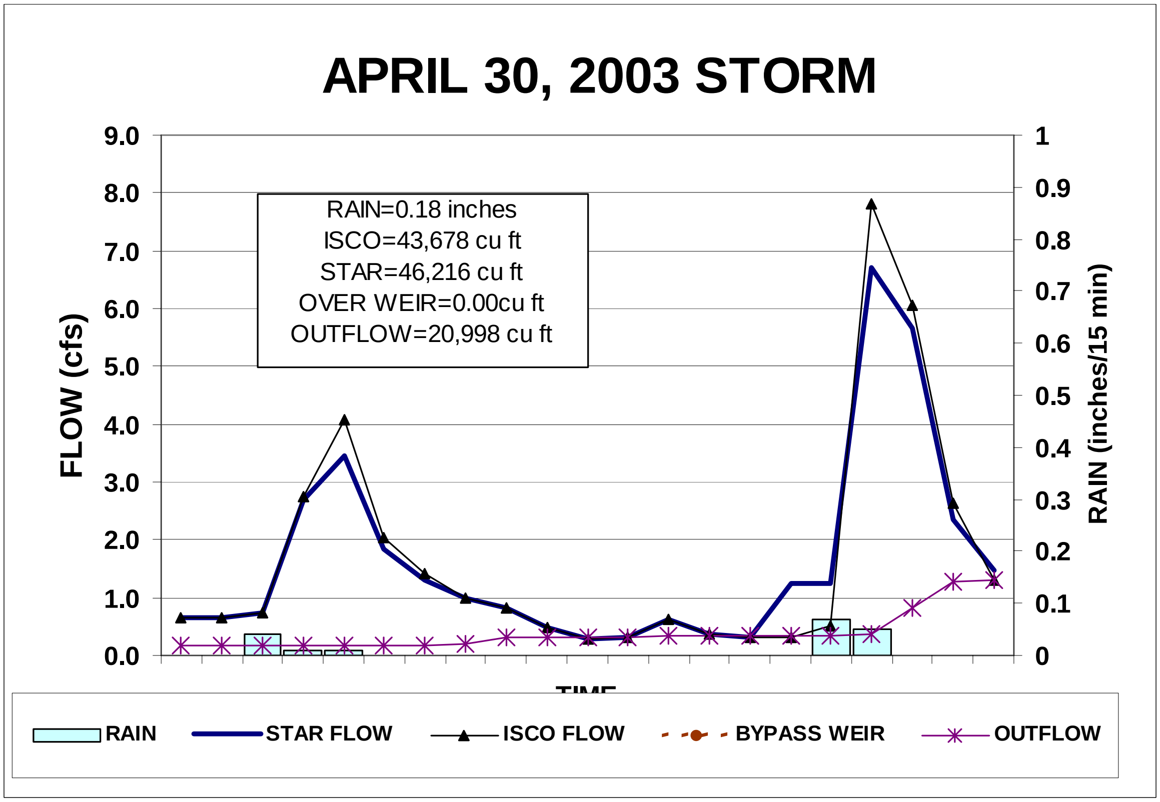

MARCH 27, 2003 STORM
RAIN=0.74 inches
ISCO=130,077 (96,783) cu ft
STAR=137,526 (104,242) cu ft
OVER WEIR=33,284 cu ft
OUTFLOW=118,882 cu ft
FLOW (cfs)
0
5
10
15
20
25
30
35
40
45
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
TIME
1200 1300 1400 1500 1600 1700 1800 1900
RAIN
STAR FLOW
ISCO FLOW
BYPASS FLOW
OUTFLOW



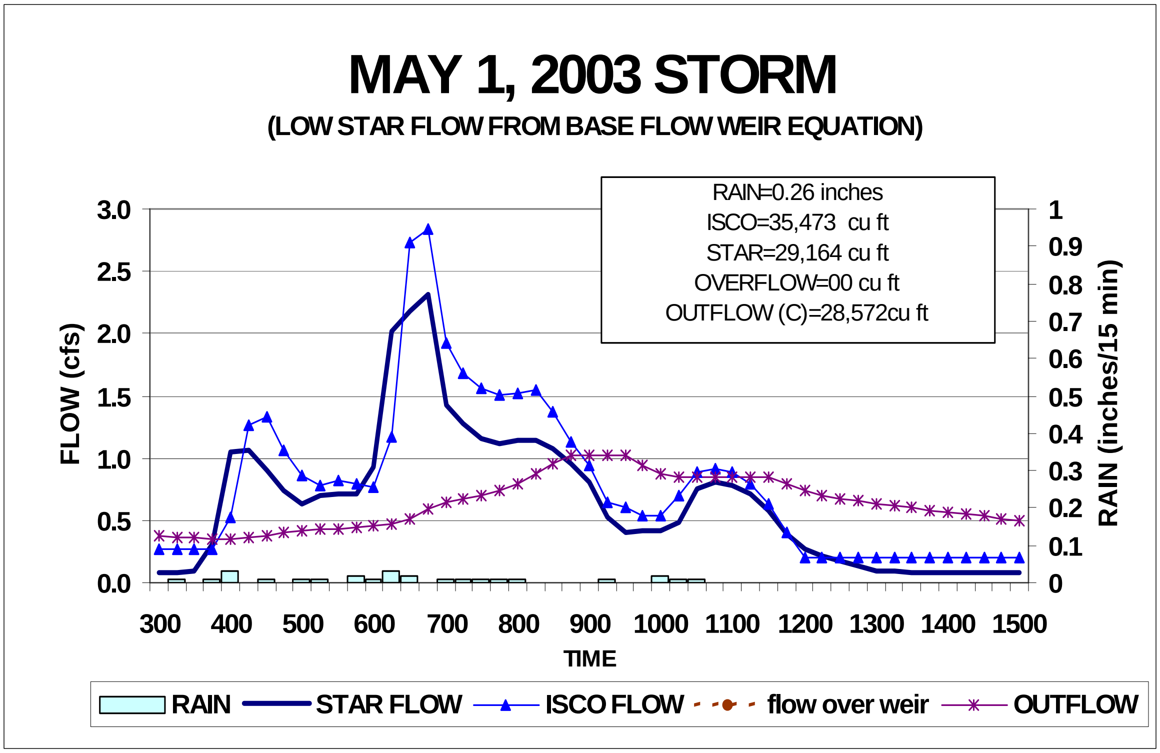
APRIL 9, 2003 STORM

(CHANGED WEIR HEIGHT TO 3.6 FT)

UPROOTED VEGETATION KEEPS POND LEVEL HIGH AND MESSES UP OUTFLOW CALCULATIONS



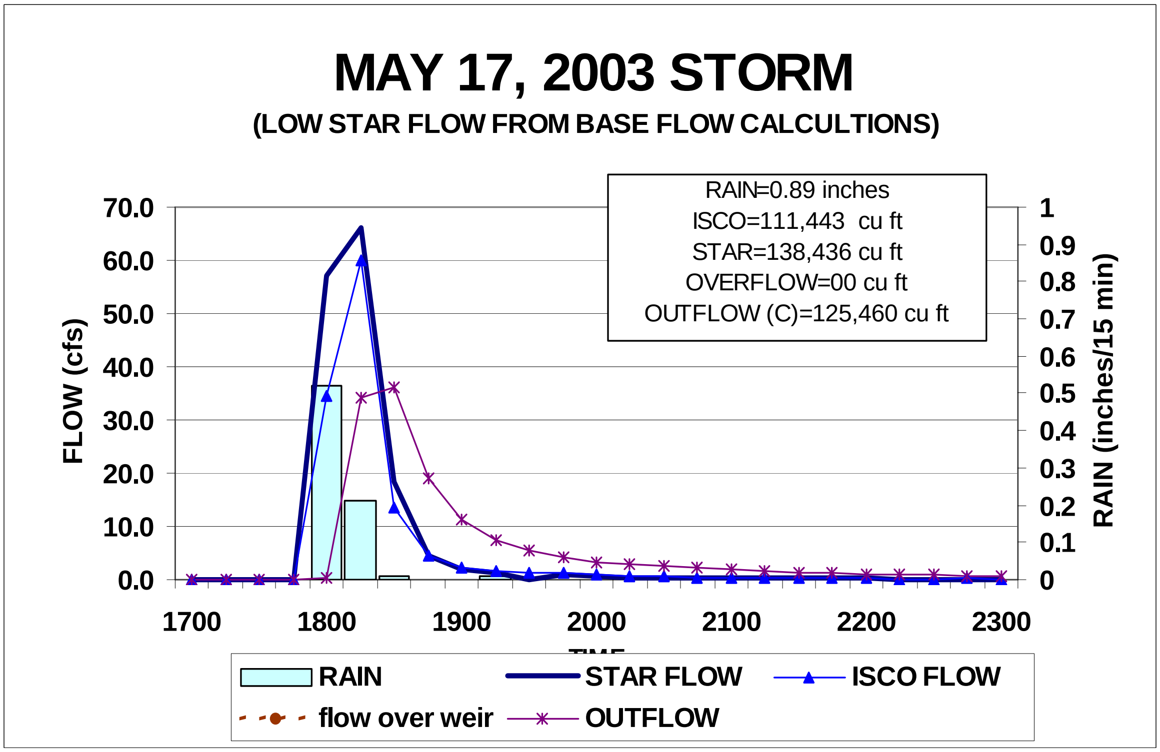
APRIL 30, 2003 STORM



MAY 1, 2003 STORM

(LOW STAR FLOW FROM BASE FLOW WEIR EQUATION)

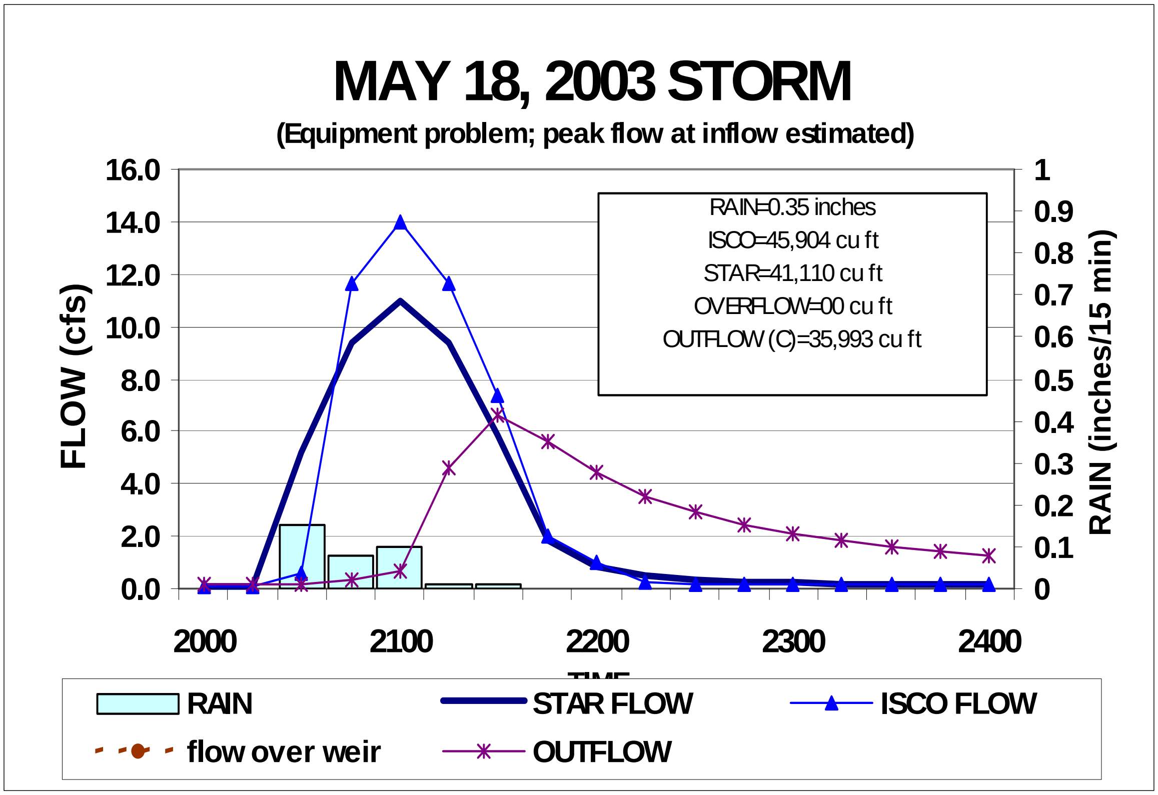
RAIN=0.26 inches
ISCO=35,473 cu ft
STAR=29,164 cu ft
OVERFLOW=00 cu ft
OUTFLOW (C)=28,572cu ft

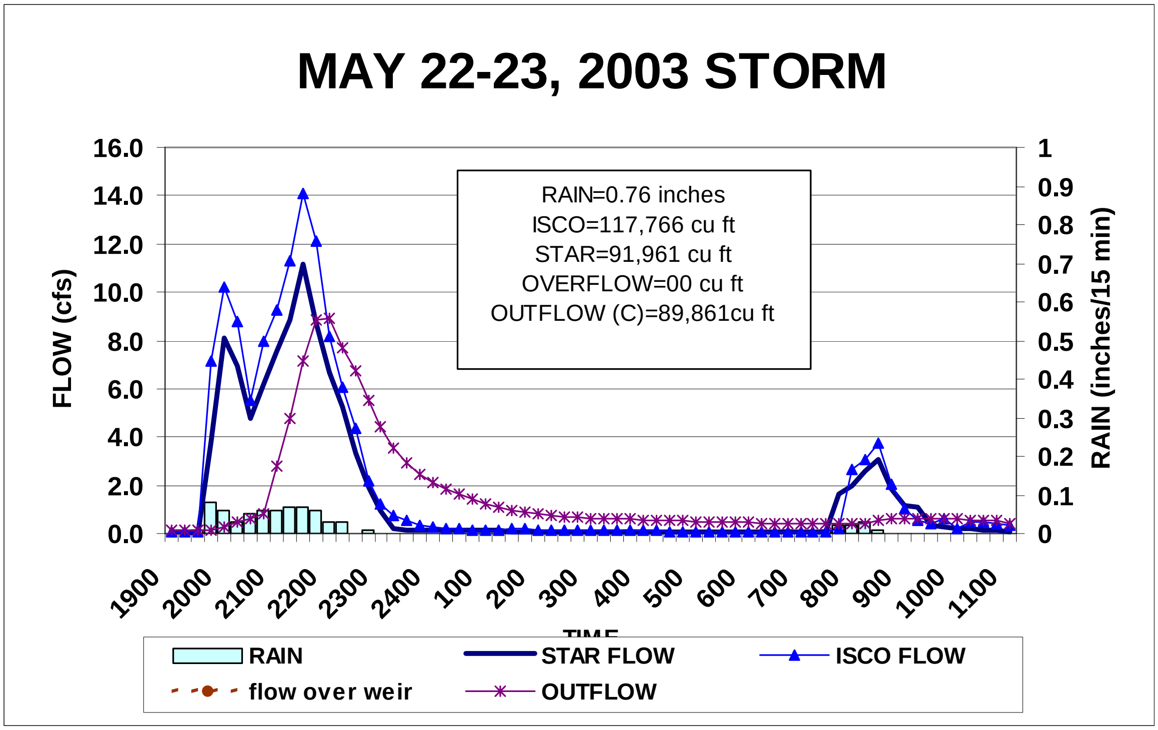


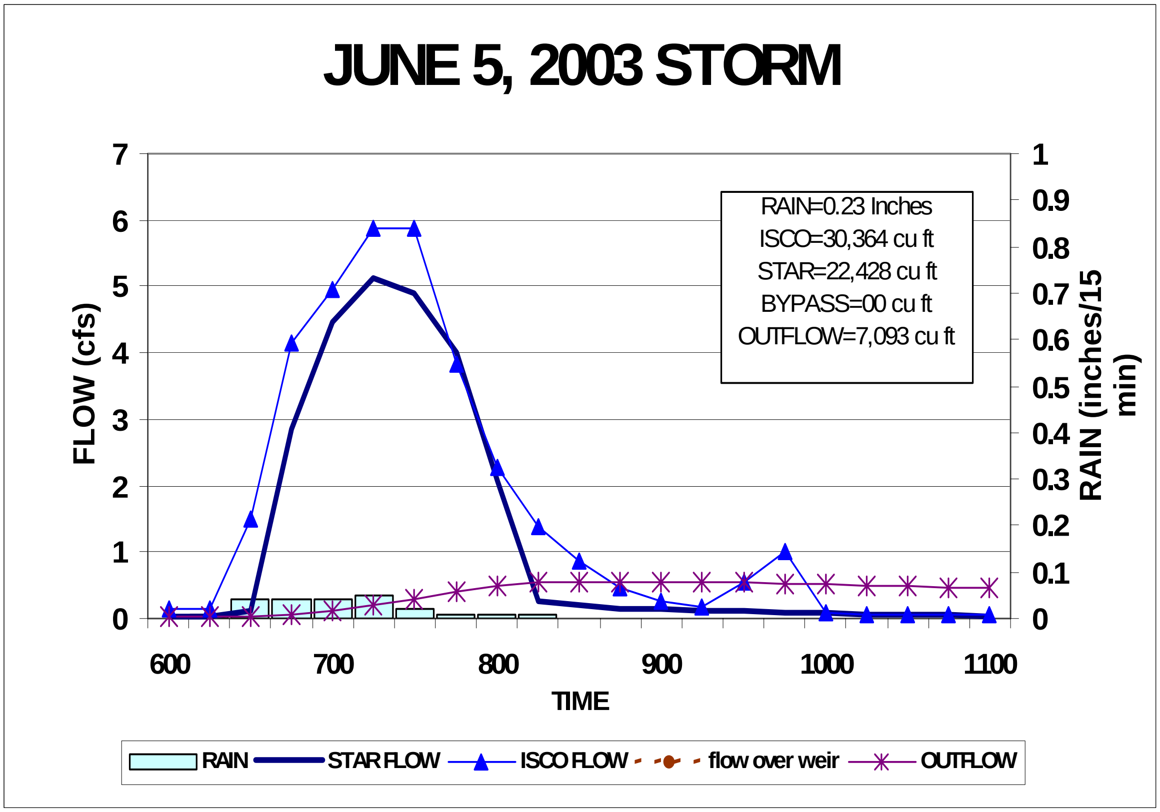
MAY 17, 2003 STORM

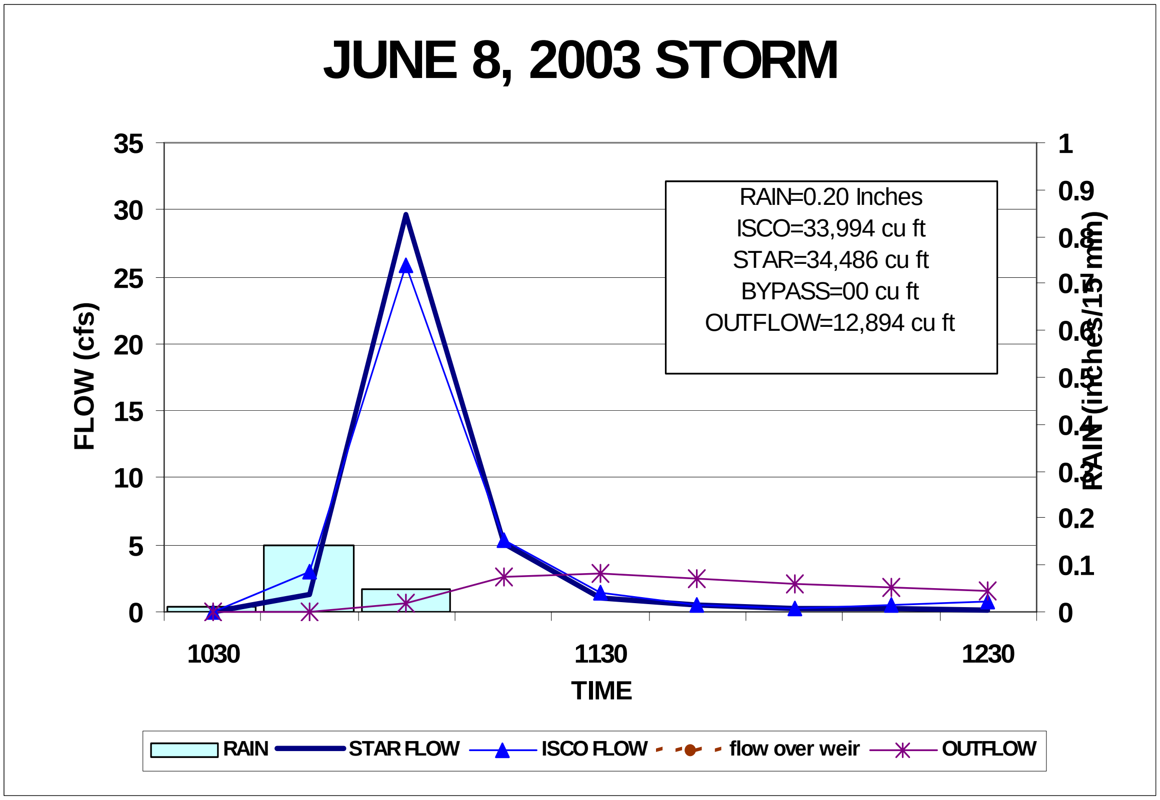
(LOW STAR FLOW FROM BASE FLOW CALCULTIONS)

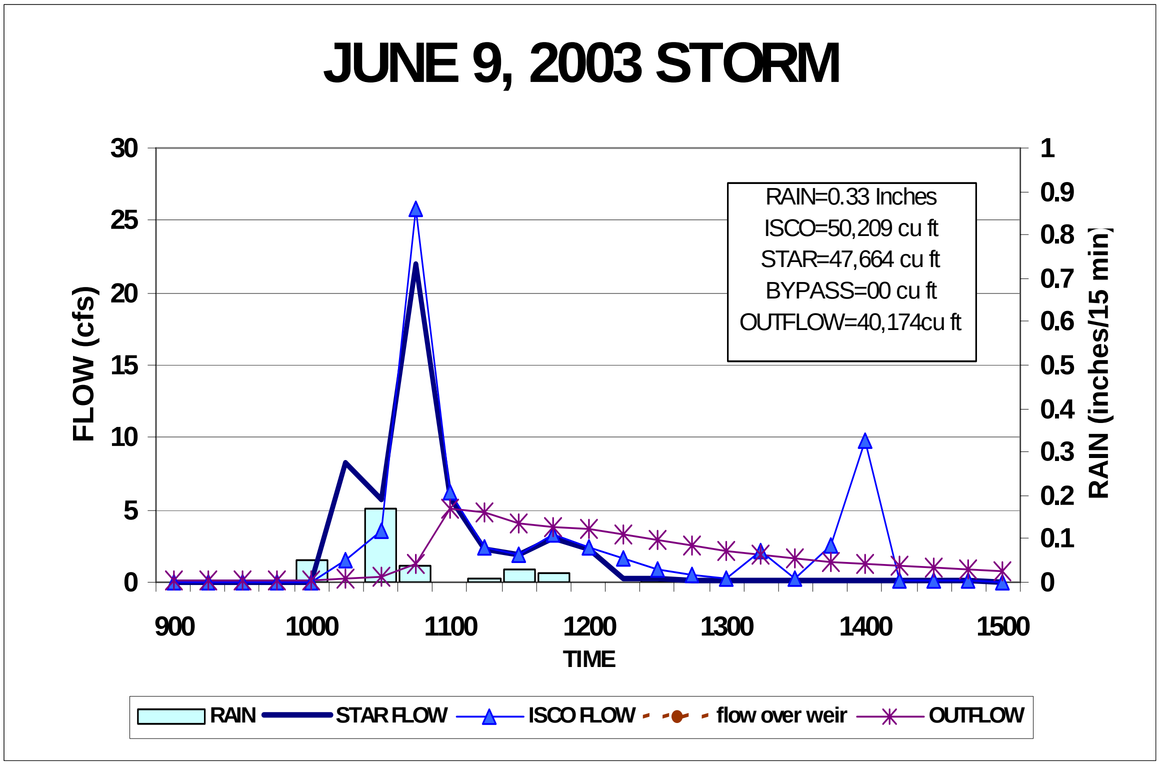
RAIN=0.89 inches
ISCO=111,443 cu ft
STAR=138,436 cu ft
OVERFLOW=00 cu ft
OUTFLOW (C)=125,460 cu ft

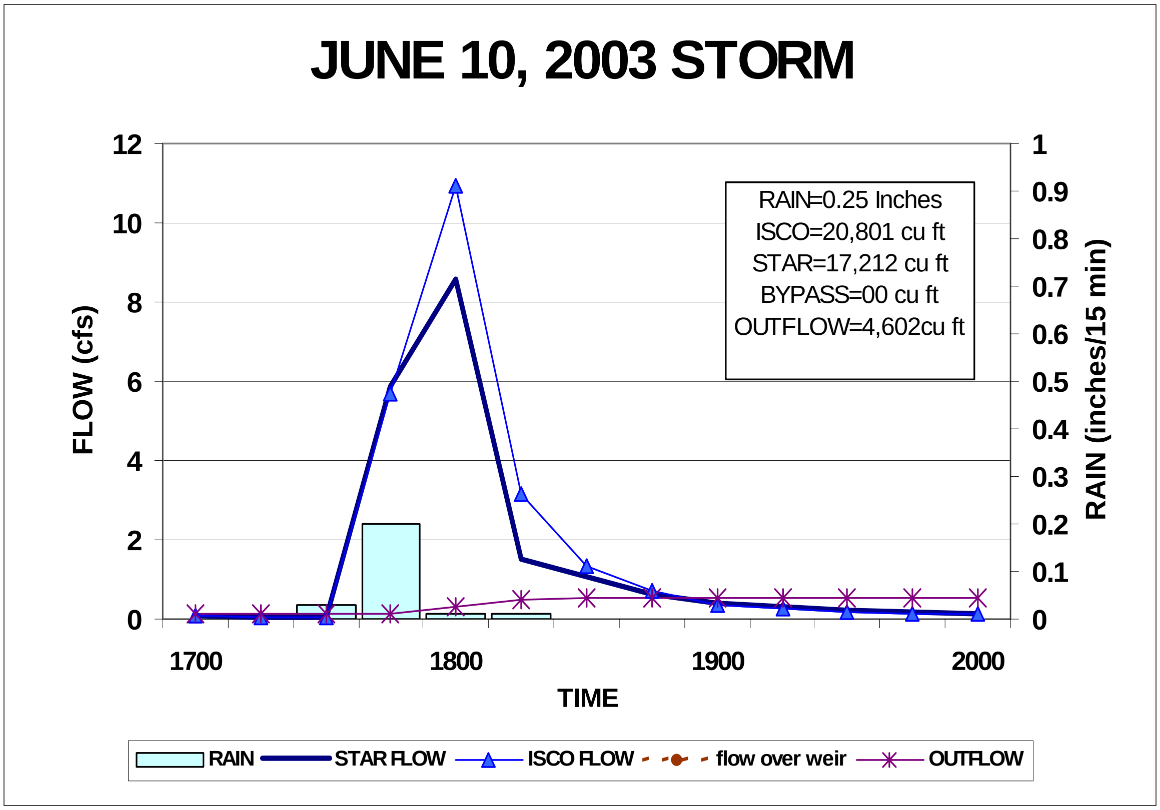

MAY 18, 2003 STORM
(Equipment problem; peak flow at inflow estimated)
RAIN=0.35 inches
ISCO=45,904 cu ft
STAR=41,110 cu ft
OVERFLOW=00 cu ft
OUTFLOW (C)=35,993 cu ft
FLOW (cfs)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2000
2100
2200
2300
2400
TIME
RAIN
STAR FLOW
ISCO FLOW
flow over weir
OUTFLOW

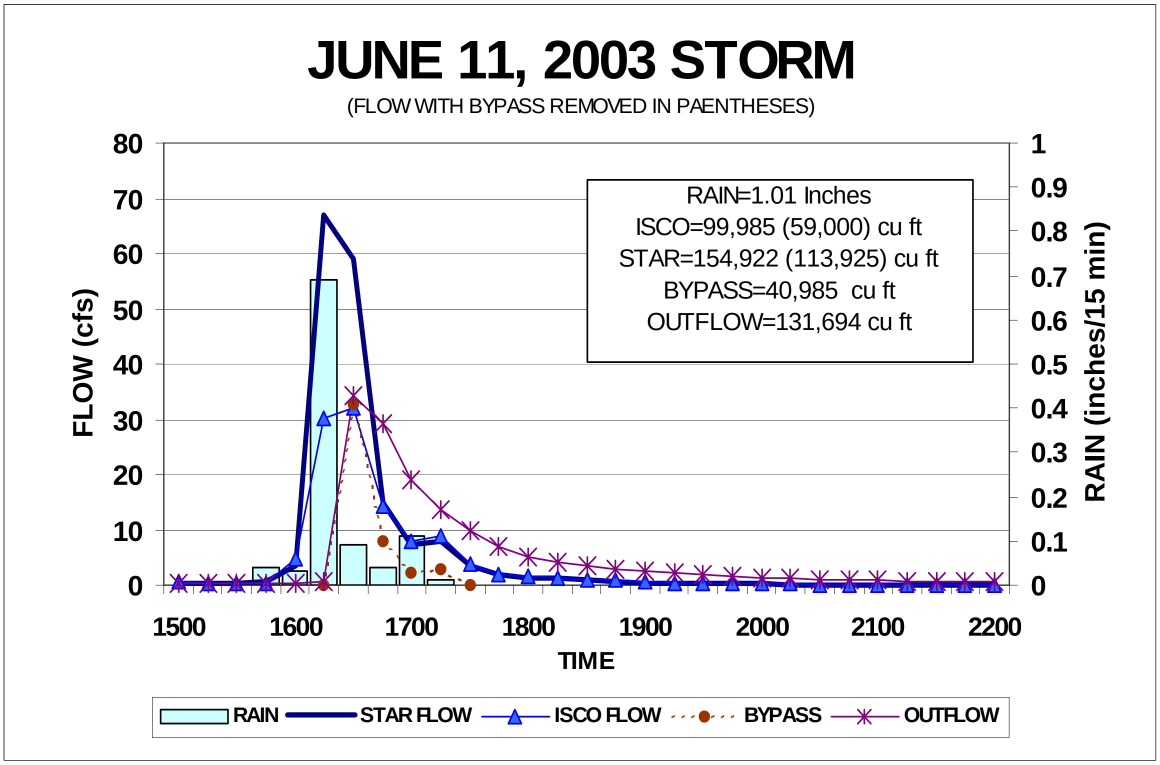

MAY 22-23, 2003 STORM
RAIN=0.76 inches
ISCO=117,766 cu ft
STAR=91,961 cu ft
OVERFLOW=00 cu ft
OUTFLOW (C)=89,861cu ft
FLOW (cfs)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1900
2000
2100
2200
2300
2400
100
200
300
400
500
600
700
800
900
1000
1100
TIME
RAIN
STAR FLOW
ISCO FLOW
flow over weir
OUTFLOW

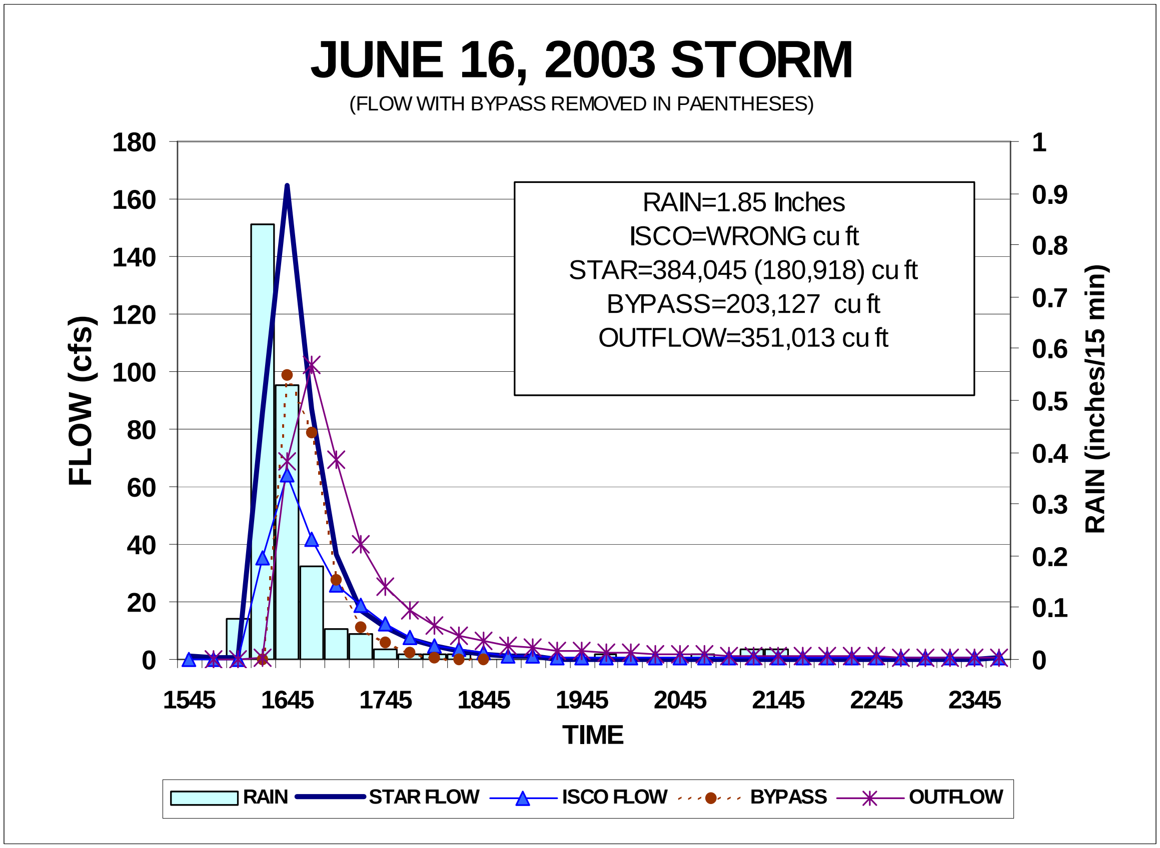

JUNE 5, 2003 STORM
FLOW (cfs)
0
1
2
3
4
5
6
7
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
TIME
600
700
800
900
1000
1100
RAIN=0.23 Inches
ISCO=30,364 cu ft
STAR=22,428 cu ft
BYPASS=00 cu ft
OUTFLOW=7,093 cu ft
RAIN
STAR FLOW
ISCO FLOW
flow over weir
OUTFLOW

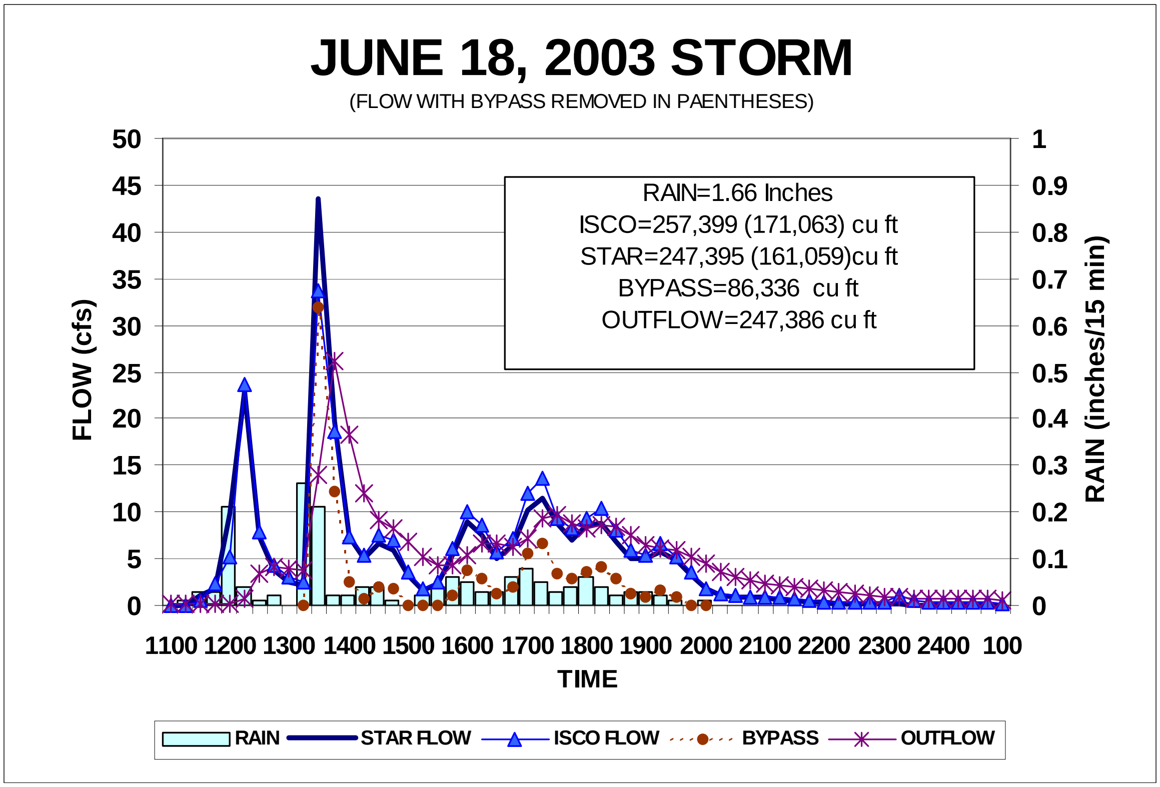

JUNE 8, 2003 STORM
FLOW (cfs)
0
5
10
15
20
25
30
35
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
TIME
1030
1130
1230
RAIN=0.20 Inches
ISCO=33,994 cu ft
STAR=34,486 cu ft
BYPASS=00 cu ft
OUTFLOW=12,894 cu ft
RAIN
STAR FLOW
ISCO FLOW
flow over weir
OUTFLOW

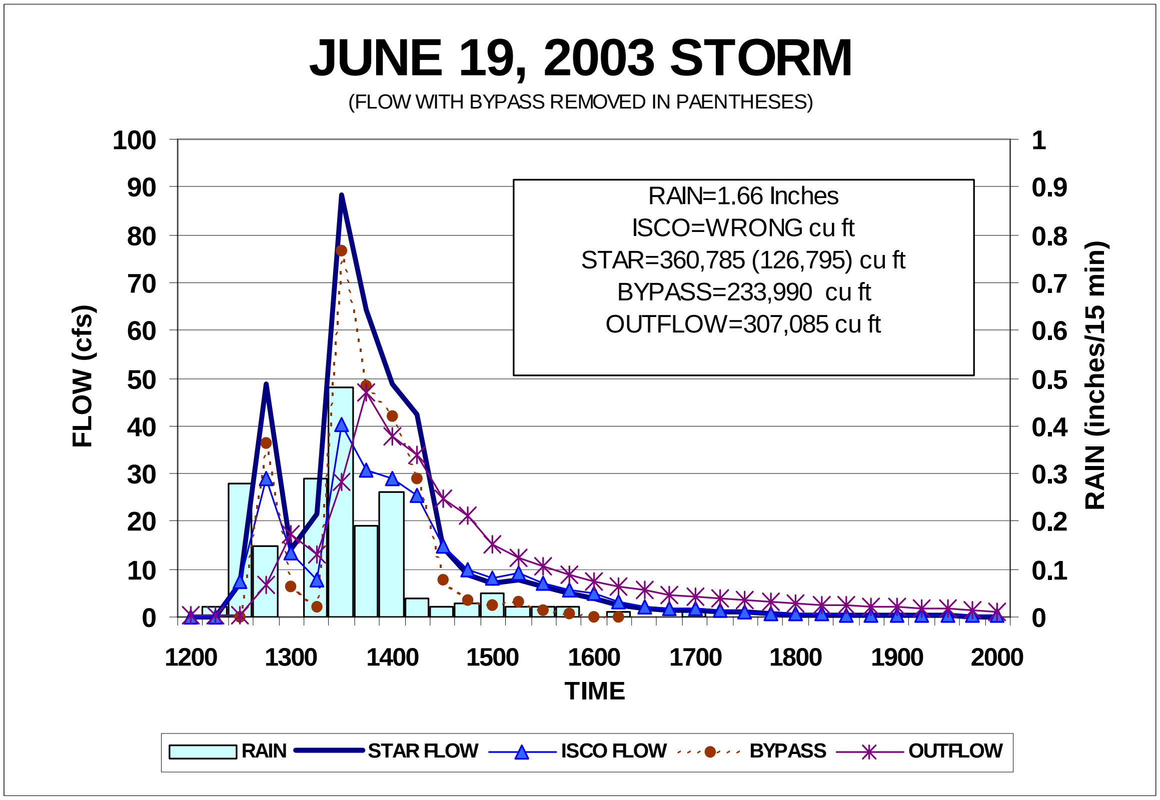

JUNE 9, 2003 STORM
RAIN=0.33 Inches
ISCO=50,209 cu ft
STAR=47,664 cu ft
BYPASS=00 cu ft
OUTFLOW=40,174cu ft
FLOW (cfs)
30
25
20
15
10
5
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
900
1000
1100
1200
1300
1400
1500
TIME
RAIN
STAR FLOW
ISCO FLOW
flow over weir
OUTFLOW

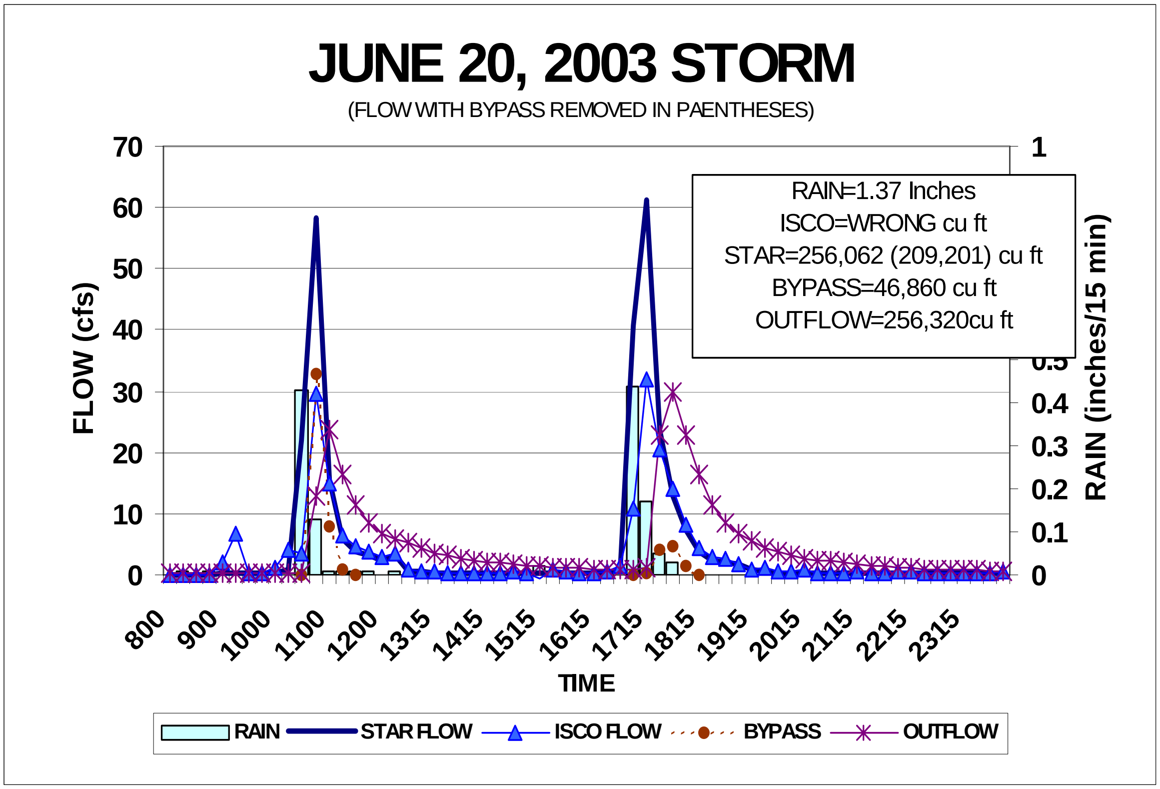

JUNE 10, 2003 STORM
RAIN=0.25 Inches
ISCO=20,801 cu ft
STAR=17,212 cu ft
BYPASS=00 cu ft
OUTFLOW=4,602cu ft
FLOW (cfs)
12
10
8
6
4
2
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1700
1800
1900
2000
TIME
RAIN
STAR FLOW
ISCO FLOW
flow over weir
OUTFLOW


JUNE 11, 2003 STORM
(FLOW WITH BYPASS REMOVED IN PAENTHESES)
RAIN=1.01 Inches
ISCO=99,985 (59,000) cu ft
STAR=154,922 (113,925) cu ft
BYPASS=40,985 cu ft
OUTFLOW=131,694 cu ft
FLOW (cfs)
0
10
20
30
40
50
60
70
80
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1500
1600
1700
1800
1900
2000
2100
2200
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW


JUNE 16, 2003 STORM
(FLOW WITH BYPASS REMOVED IN PAENTHESES)
RAIN=1.85 Inches
ISCO=WRONG cu ft
STAR=384,045 (180,918) cu ft
BYPASS=203,127 cu ft
OUTFLOW=351,013 cu ft
FLOW (cfs)
0
20
40
60
80
100
120
140
160
180
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1545
1645
1745
1845
1945
2045
2145
2245
2345
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW


JUNE 18, 2003 STORM
(FLOW WITH BYPASS REMOVED IN PAENTHESES)
RAIN=1.66 Inches
ISCO=257,399 (171,063) cu ft
STAR=247,395 (161,059)cu ft
BYPASS=86,336 cu ft
OUTFLOW=247,386 cu ft
FLOW (cfs)
50
45
40
35
30
25
20
15
10
5
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 100
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

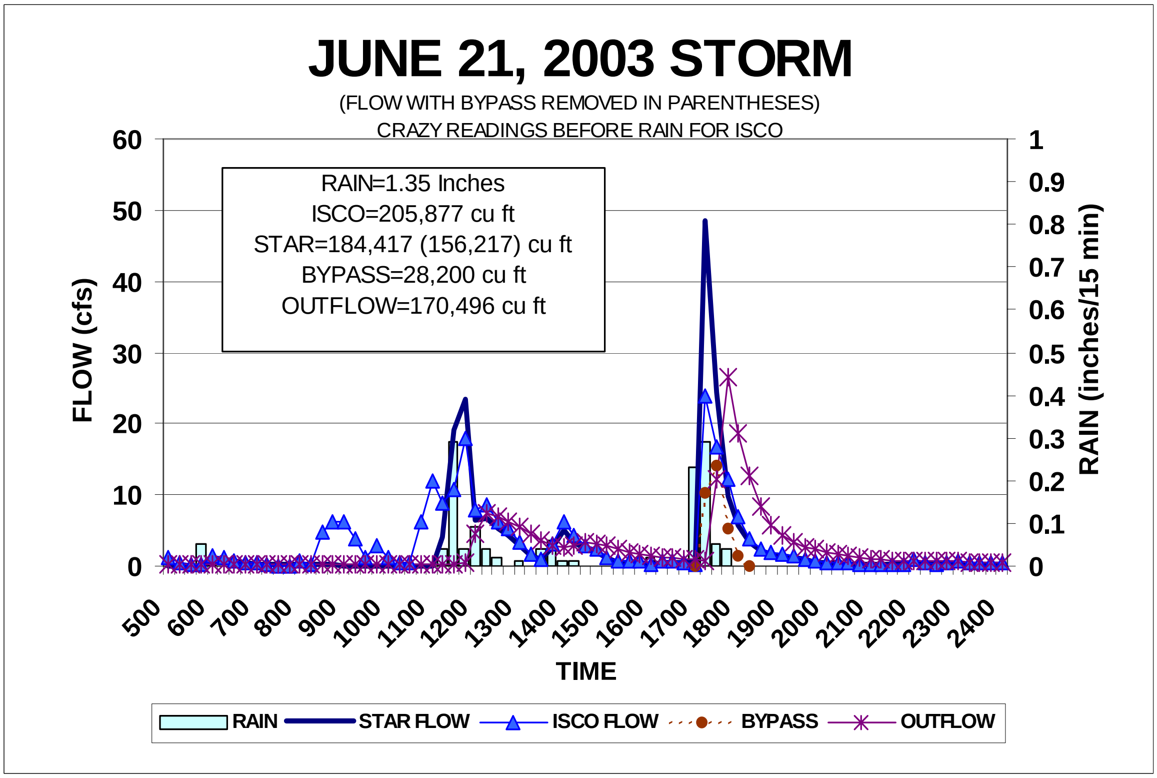

JUNE 19, 2003 STORM
(FLOW WITH BYPASS REMOVED IN PAENTHESES)
RAIN=1.66 Inches
ISCO=WRONG cu ft
STAR=360,785 (126,795) cu ft
BYPASS=233,990 cu ft
OUTFLOW=307,085 cu ft
FLOW (cfs)
100
90
80
70
60
50
40
30
20
10
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1200 1300 1400 1500 1600 1700 1800 1900 2000
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW



JUNE 20, 2003 STORM

(FLOW WITH BYPASS REMOVED IN PAENTHESES)

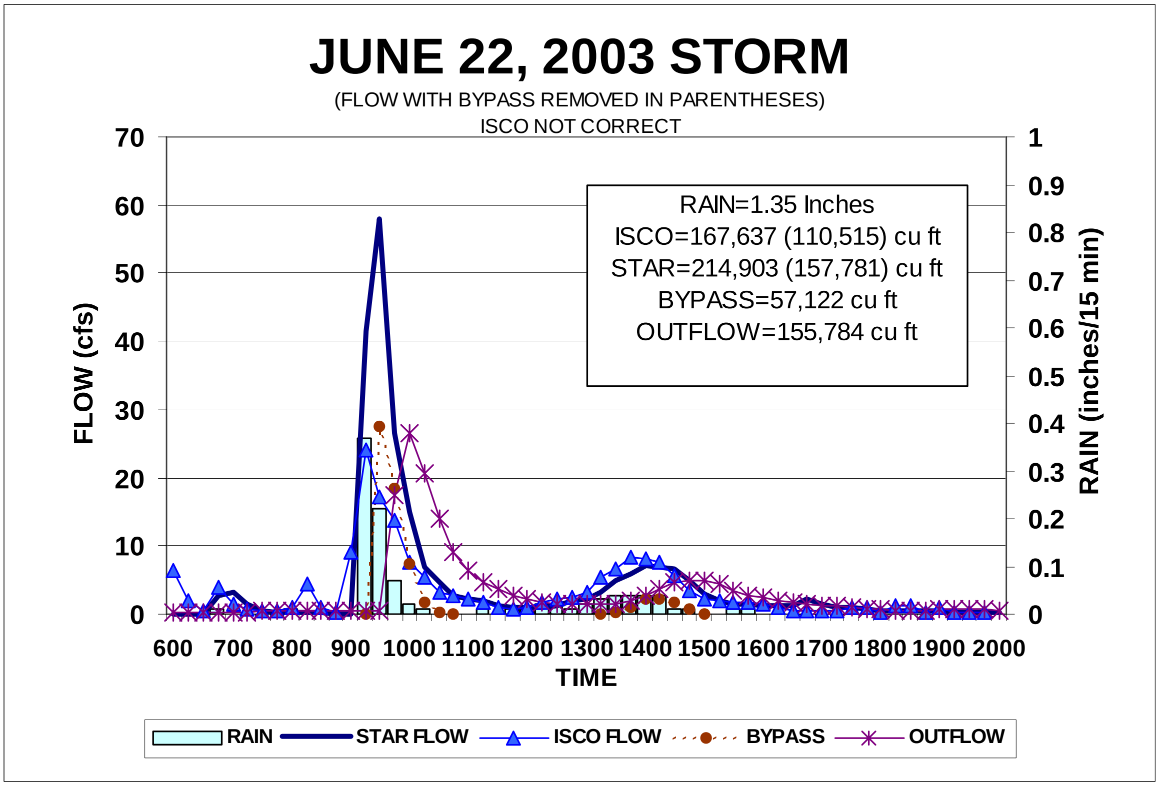
RAIN=1.37 Inches
ISCO=WRONG cu ft
STAR=256,062 (209,201) cu ft
BYPASS=46,860 cu ft
OUTFLOW=256,320cu ft



JUNE 21, 2003 STORM

(FLOW WITH BYPASS REMOVED IN PARENTHESES)
CRAZY READINGS BEFORE RAIN FOR ISCO

RAIN=1.35 Inches
ISCO=205,877 cu ft
STAR=184,417 (156,217) cu ft
BYPASS=28,200 cu ft
OUTFLOW=170,496 cu ft

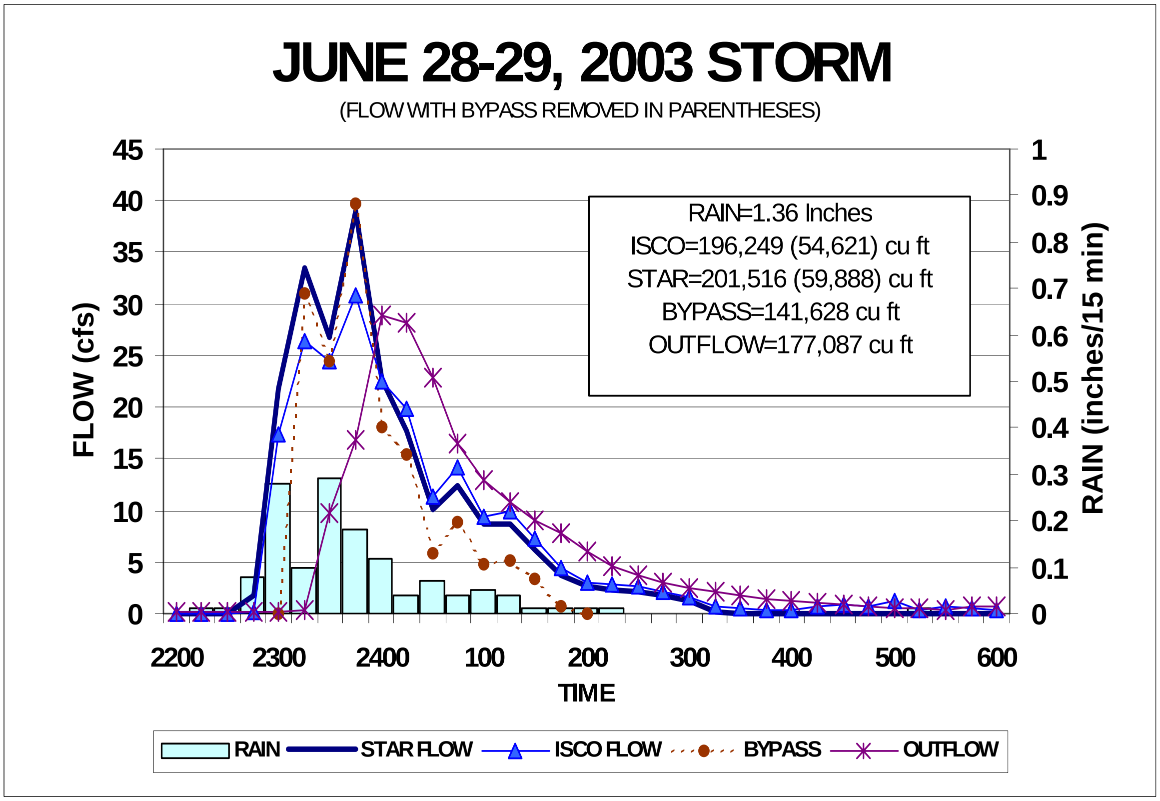


JUNE 22, 2003 STORM

(FLOW WITH BYPASS REMOVED IN PARENTHESES)

ISCO NOT CORRECT

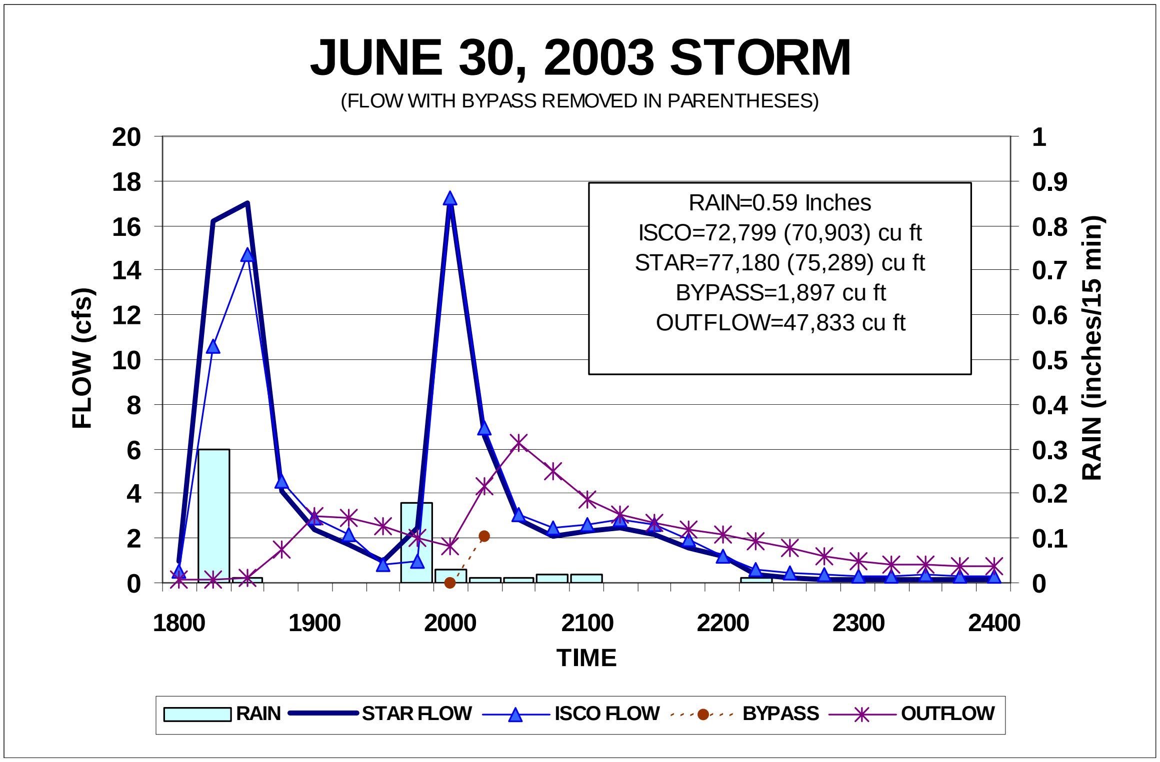
RAIN=1.35 Inches
ISCO=167,637 (110,515) cu ft
STAR=214,903 (157,781) cu ft
BYPASS=57,122 cu ft
OUTFLOW=155,784 cu ft

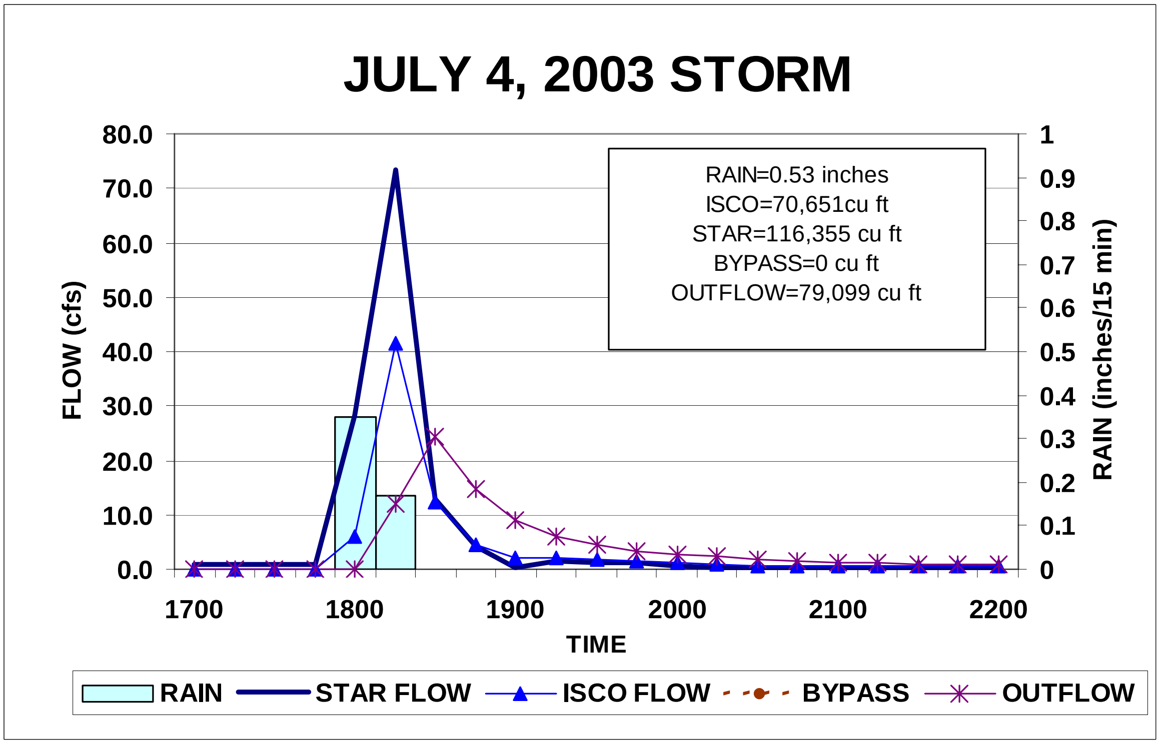


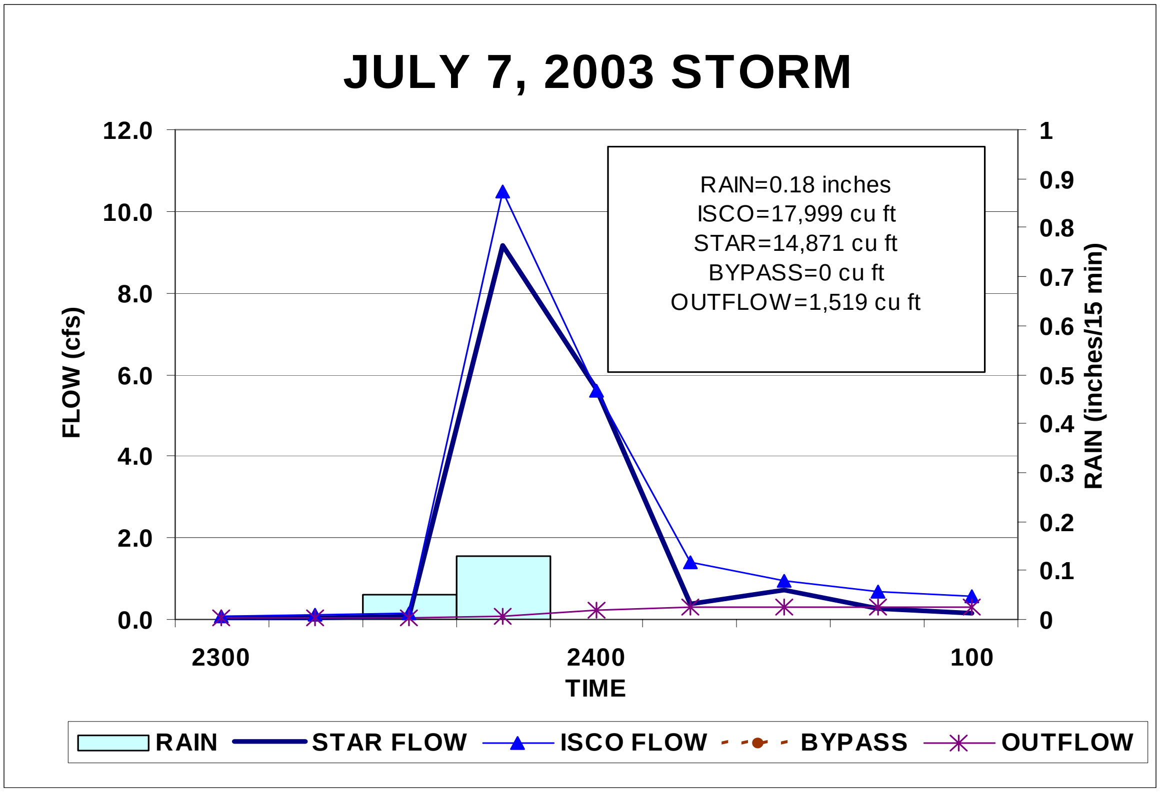
JUNE 28-29, 2003 STORM

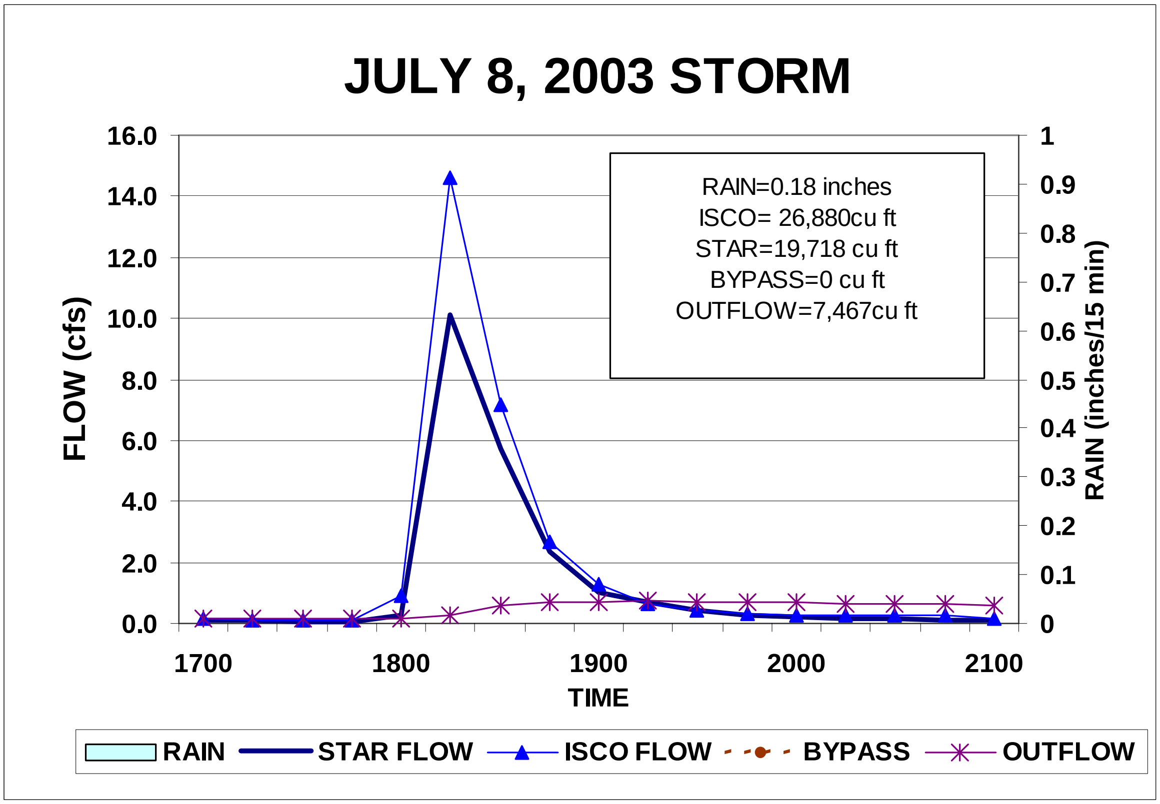
(FLOW WITH BYPASS REMOVED IN PARENTHESES)

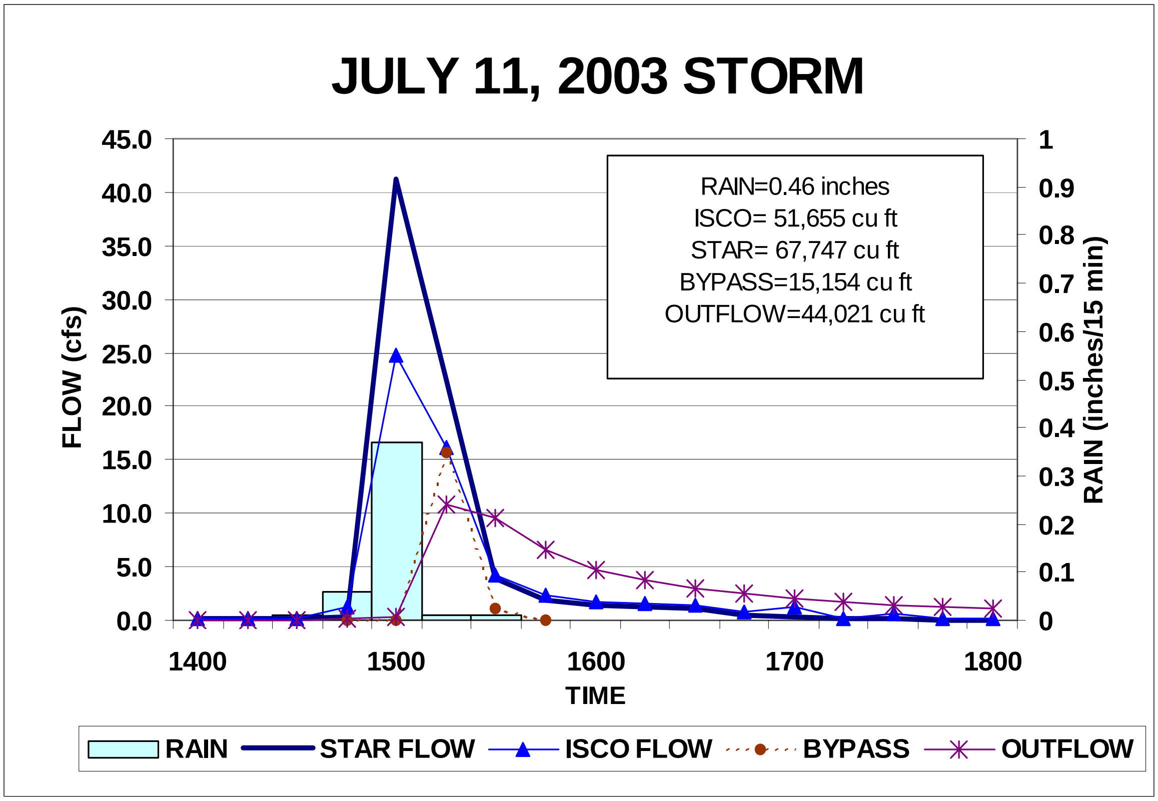
RAIN=1.36 Inches
ISCO=196,249 (54,621) cu ft
STAR=201,516 (59,888) cu ft
BYPASS=141,628 cu ft
OUTFLOW=177,087 cu ft


JUNE 30, 2003 STORM
(FLOW WITH BYPASS REMOVED IN PARENTHESES)
RAIN=0.59 Inches
ISCO=72,799 (70,903) cu ft
STAR=77,180 (75,289) cu ft
BYPASS=1,897 cu ft
OUTFLOW=47,833 cu ft
FLOW (cfs)
20
18
16
14
12
10
8
6
4
2
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1800
1900
2000
2100
2200
2300
2400
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW


JULY 4, 2003 STORM
RAIN=0.53 inches
ISCO=70,651cu ft
STAR=116,355 cu ft
BYPASS=0 cu ft
OUTFLOW=79,099 cu ft
FLOW (cfs)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1700
1800
1900
2000
2100
2200
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

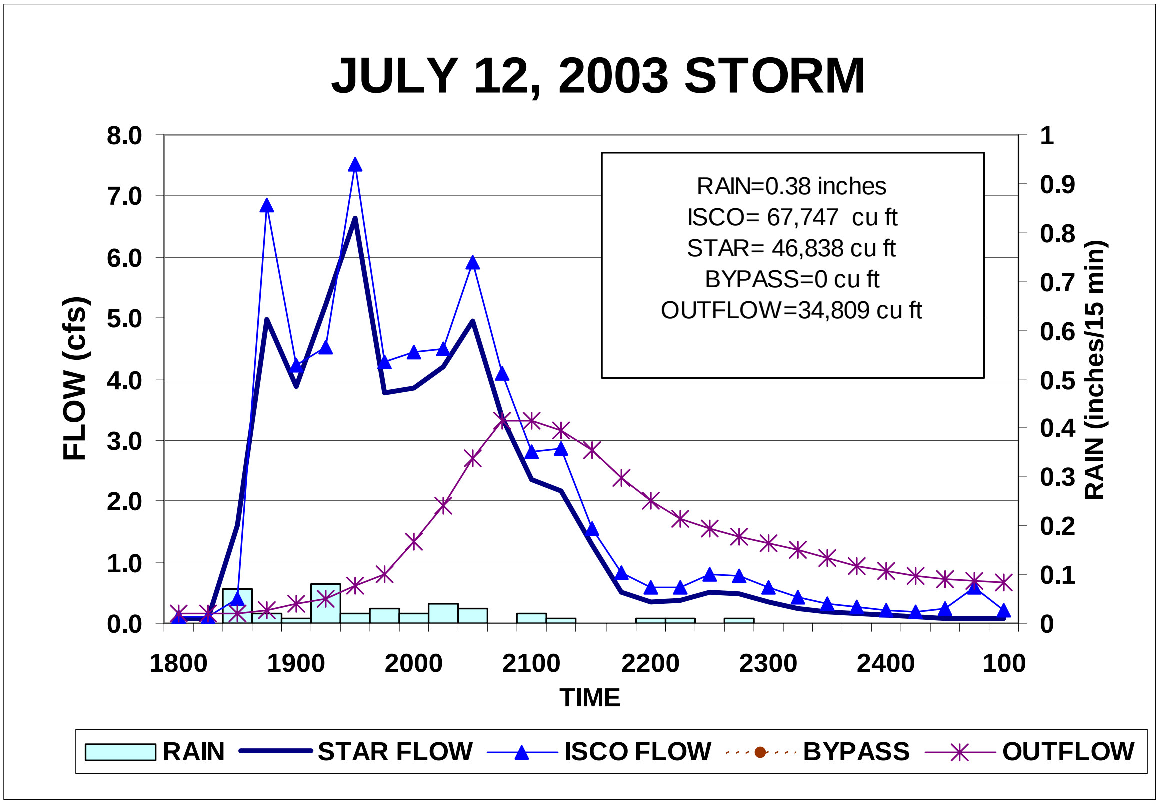

JULY 7, 2003 STORM
FLOW (cfs)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2300
2400
100
TIME
RAIN=0.18 inches
ISCO=17,999 cu ft
STAR=14,871 cu ft
BYPASS=0 cu ft
OUTFLOW=1,519 cu ft
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW


JULY 8, 2003 STORM
FLOW (cfs)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1700
1800
1900
2000
2100
TIME
RAIN=0.18 inches
ISCO= 26,880cu ft
STAR=19,718 cu ft
BYPASS=0 cu ft
OUTFLOW=7,467cu ft
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW



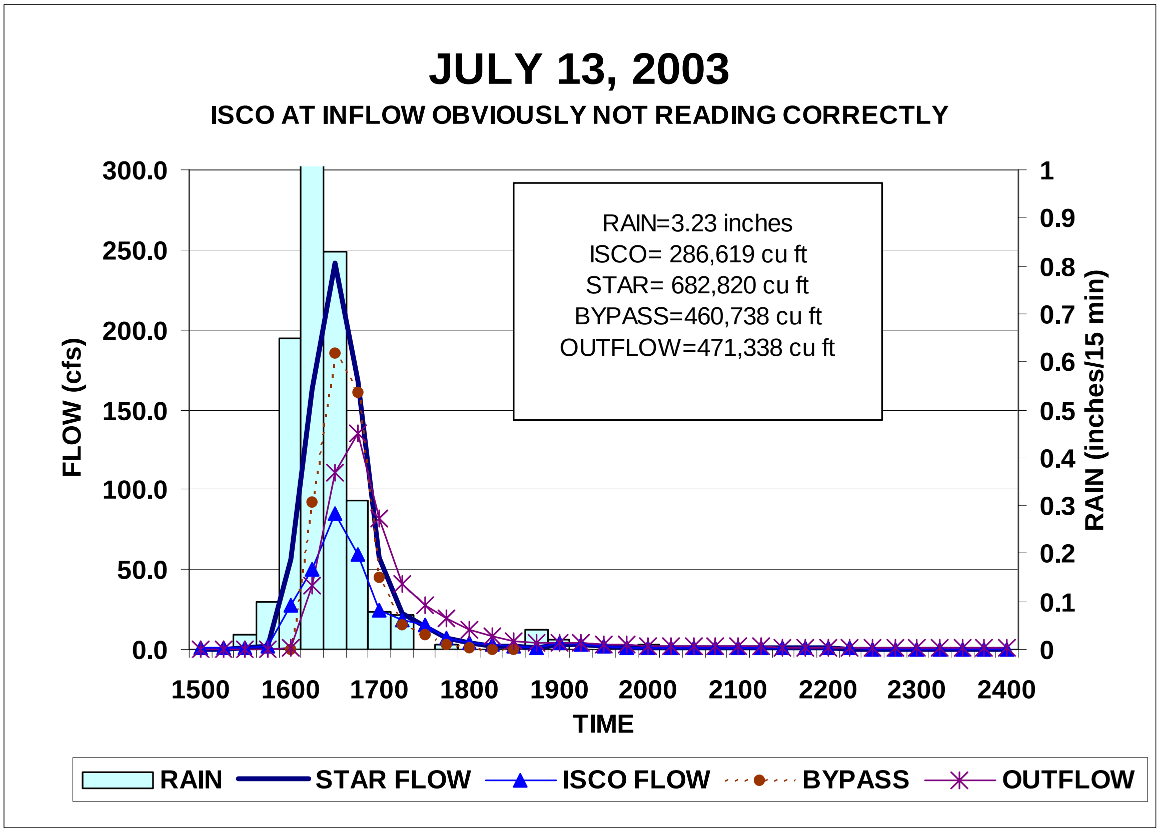
JULY 11, 2003 STORM

RAIN=0.46 inches
ISCO= 51,655 cu ft
STAR= 67,747 cu ft
BYPASS=15,154 cu ft
OUTFLOW=44,021 cu ft



JULY 12, 2003 STORM

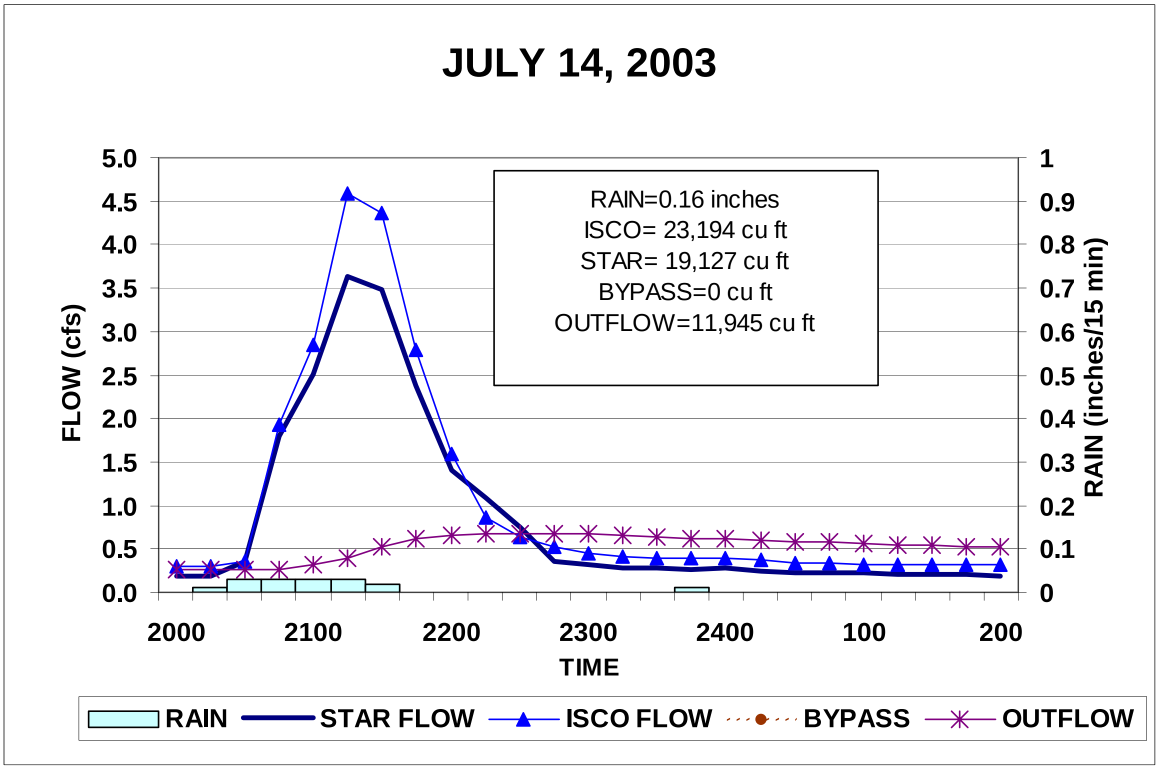
RAIN=0.38 inches
ISCO= 67,747 cu ft
STAR= 46,838 cu ft
BYPASS=0 cu ft
OUTFLOW=34,809 cu ft



JULY 13, 2003

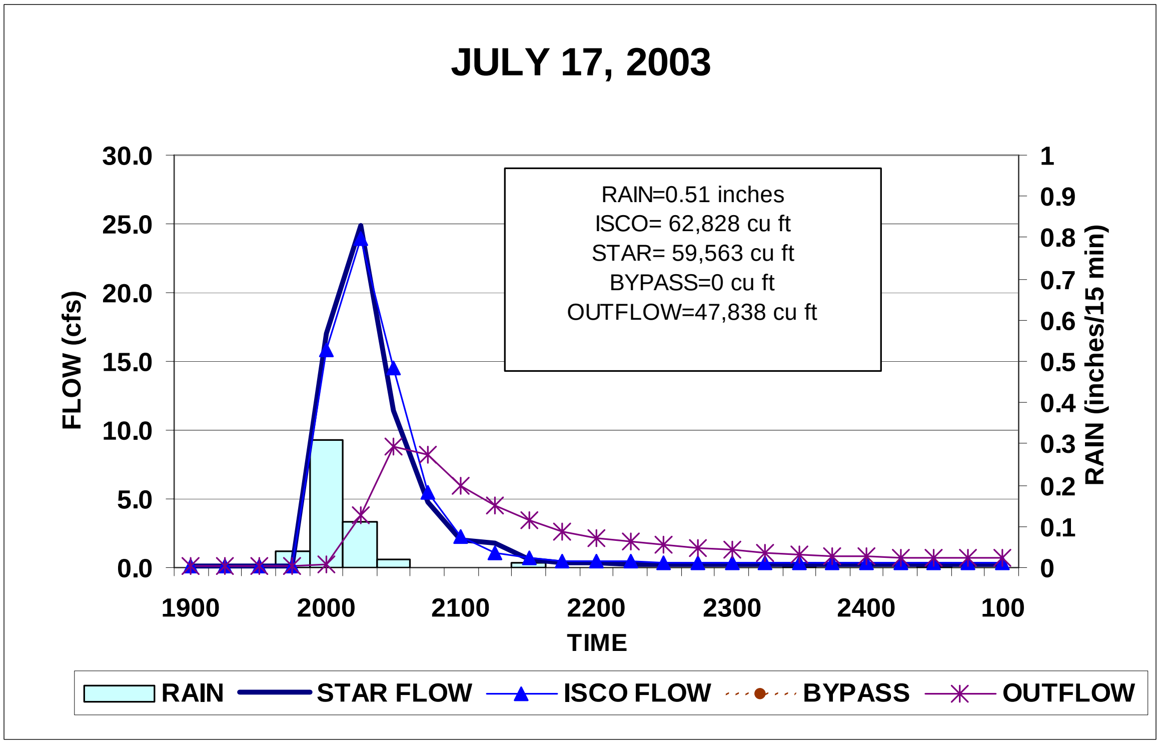
ISCO AT INFLOW OBVIOUSLY NOT READING CORRECTLY

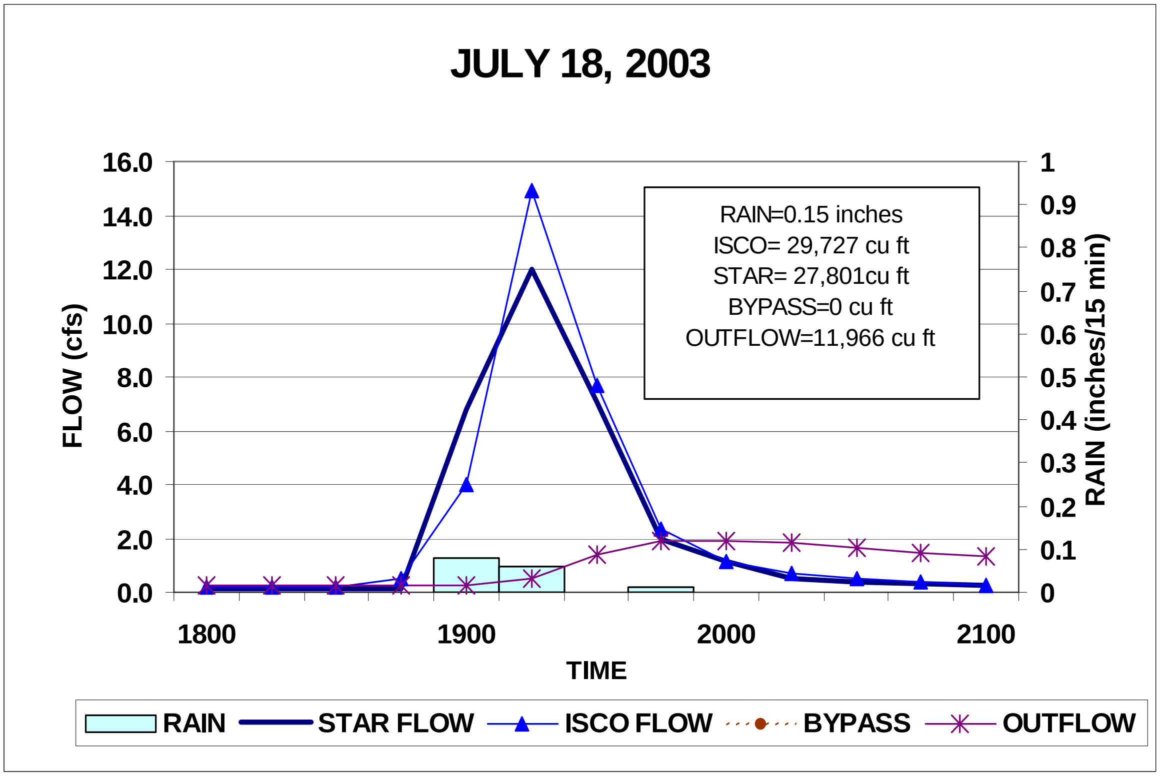
RAIN=3.23 inches
ISCO= 286,619 cu ft
STAR= 682,820 cu ft
BYPASS=460,738 cu ft
OUTFLOW=471,338 cu ft

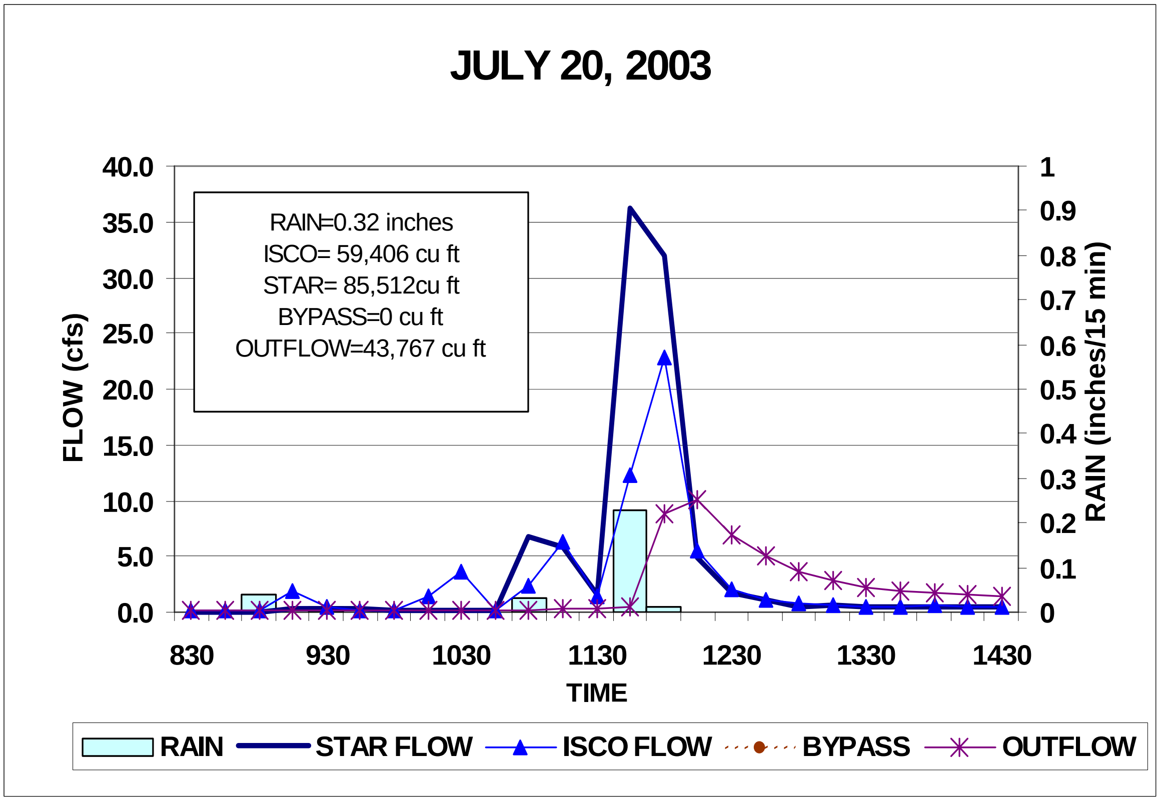


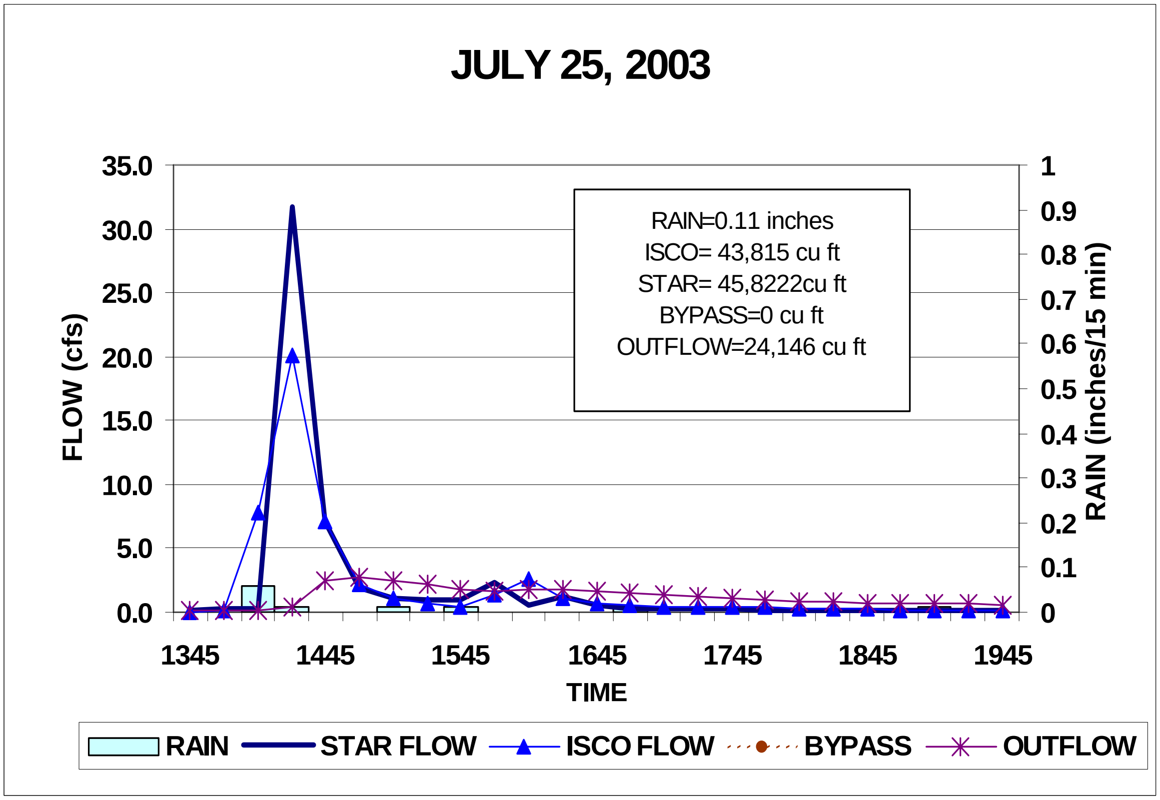
JULY 14, 2003

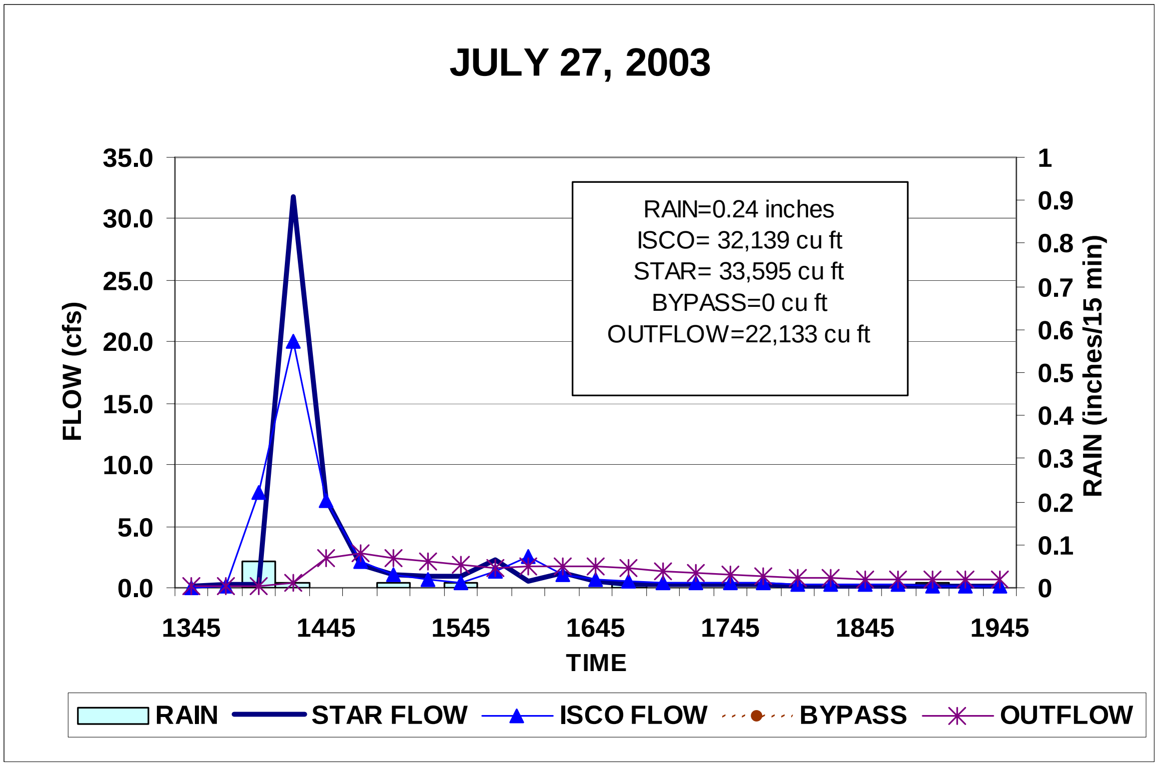
RAIN=0.16 inches
ISCO= 23,194 cu ft
STAR= 19,127 cu ft
BYPASS=0 cu ft
OUTFLOW=11,945 cu ft


JULY 17, 2003
RAIN=0.51 inches
ISCO= 62,828 cu ft
STAR= 59,563 cu ft
BYPASS=0 cu ft
OUTFLOW=47,838 cu ft
FLOW (cfs)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1900
2000
2100
2200
2300
2400
100
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

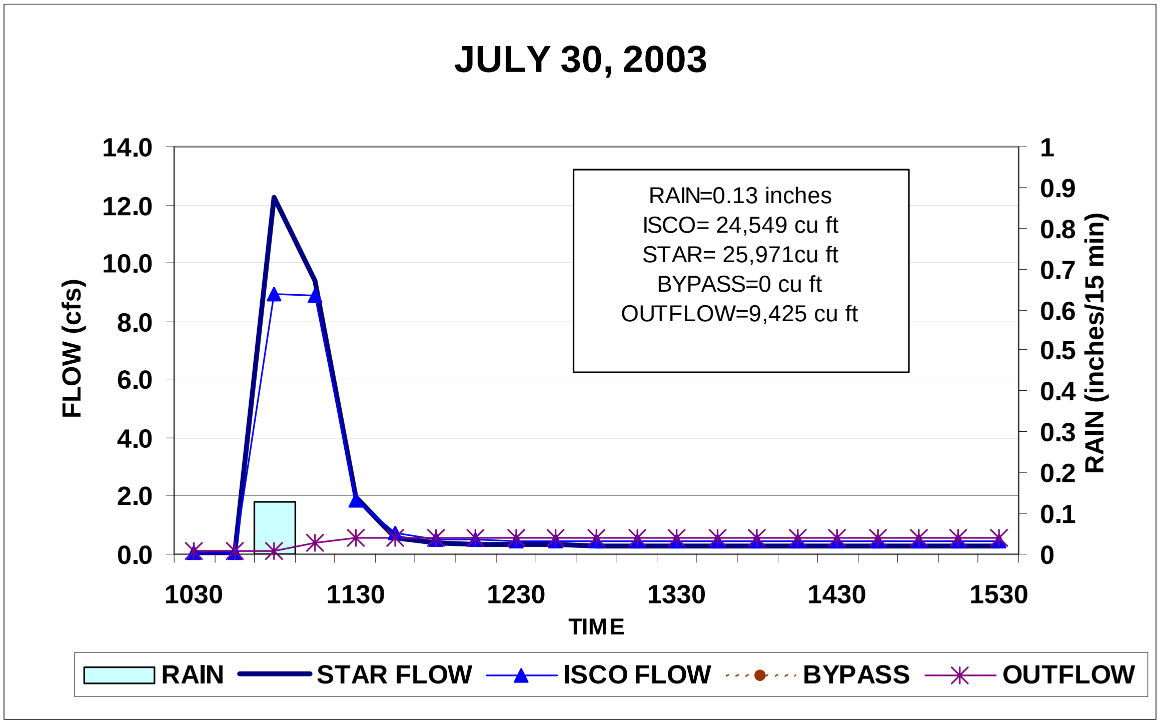

JULY 18, 2003
RAIN=0.15 inches
ISCO= 29,727 cu ft
STAR= 27,801cu ft
BYPASS=0 cu ft
OUTFLOW=11,966 cu ft
FLOW (cfs)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1800
1900
2000
2100
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW


JULY 20, 2003
RAIN=0.32 inches
ISCO= 59,406 cu ft
STAR= 85,512cu ft
BYPASS=0 cu ft
OUTFLOW=43,767 cu ft
FLOW (cfs)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
830
930
1030
1130
1230
1330
1430
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

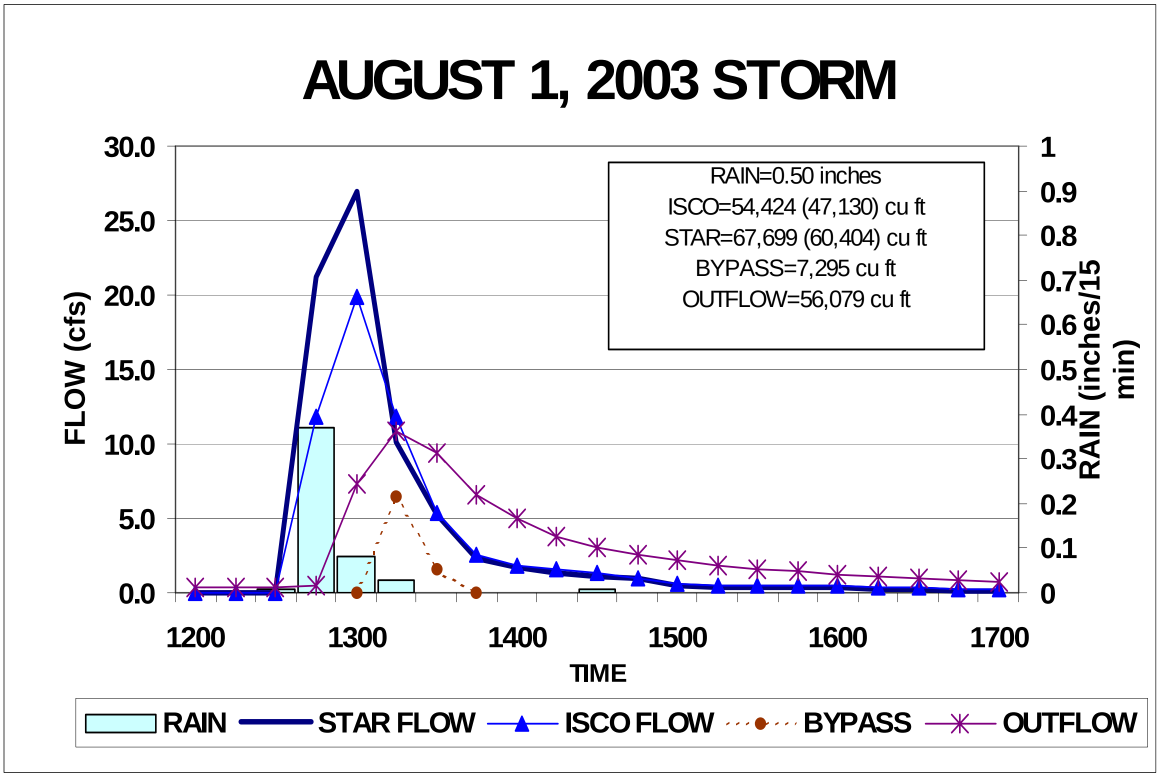

JULY 25, 2003
RAIN=0.11 inches
ISCO= 43,815 cu ft
STAR= 45,8222cu ft
BYPASS=0 cu ft
OUTFLOW=24,146 cu ft
FLOW (cfs)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1345
1445
1545
1645
1745
1845
1945
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

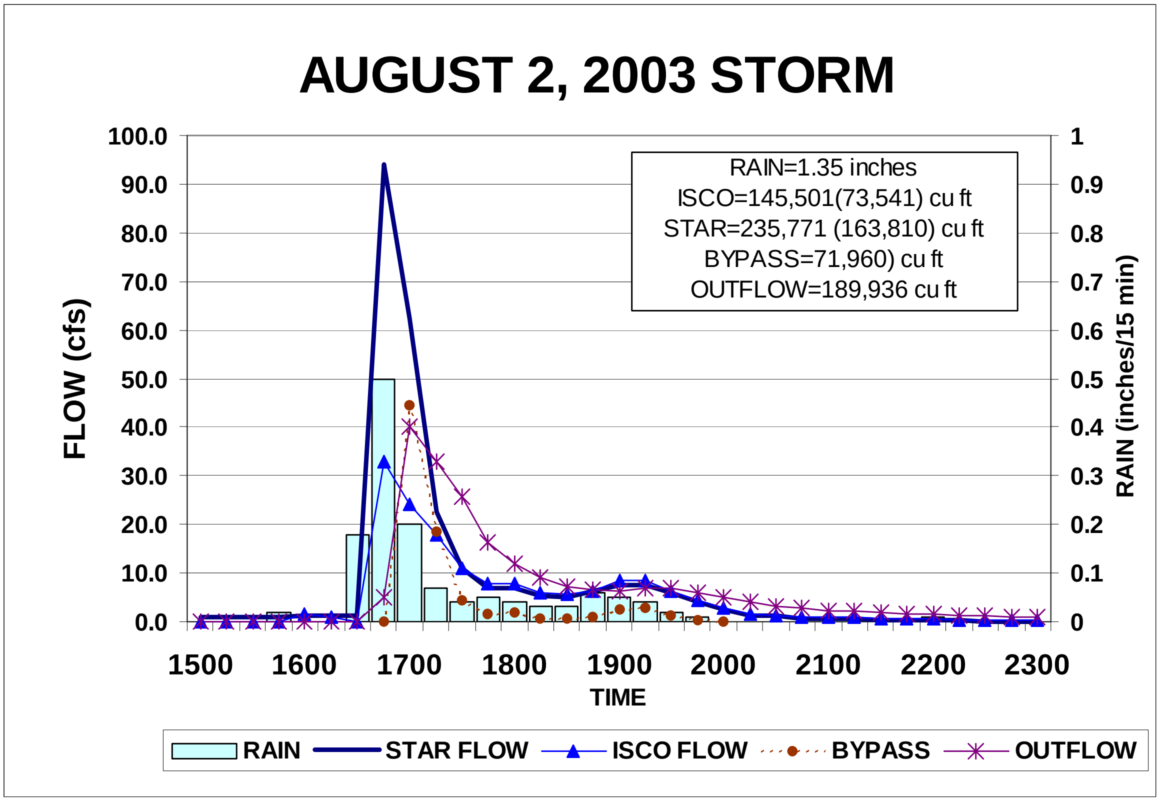


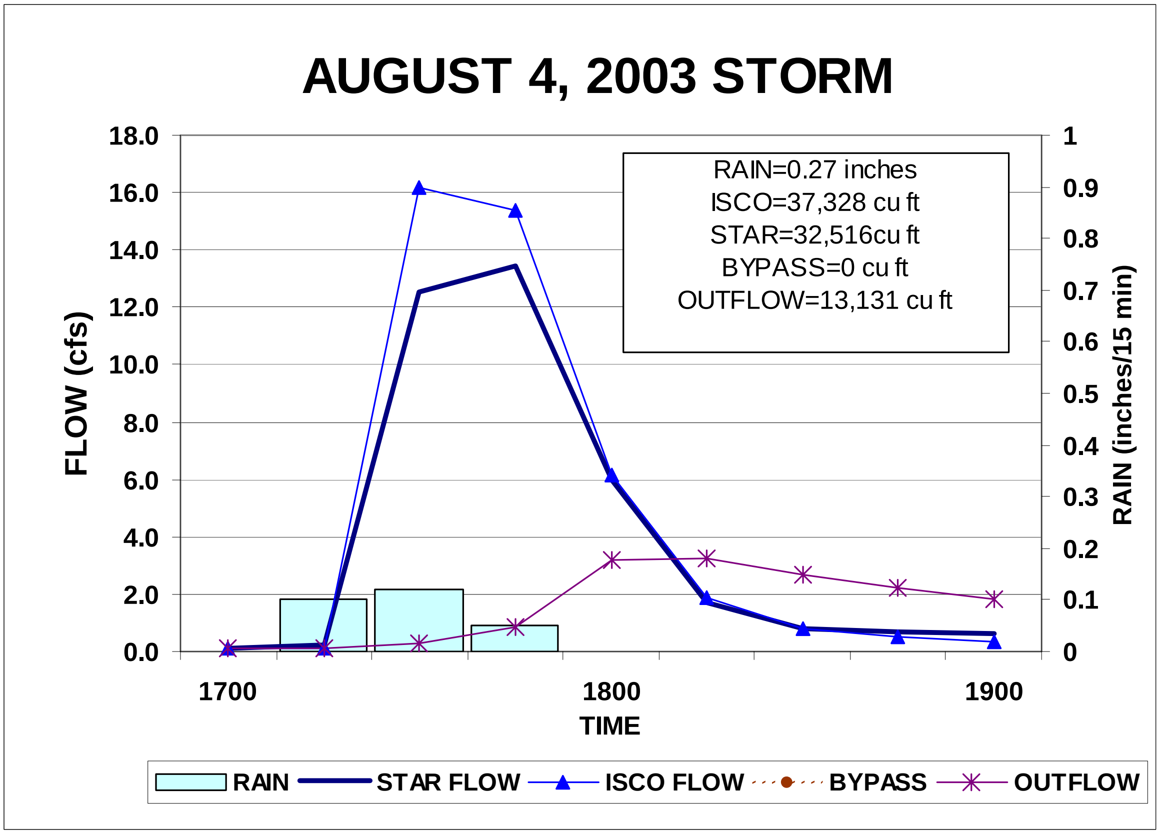
JULY 27, 2003

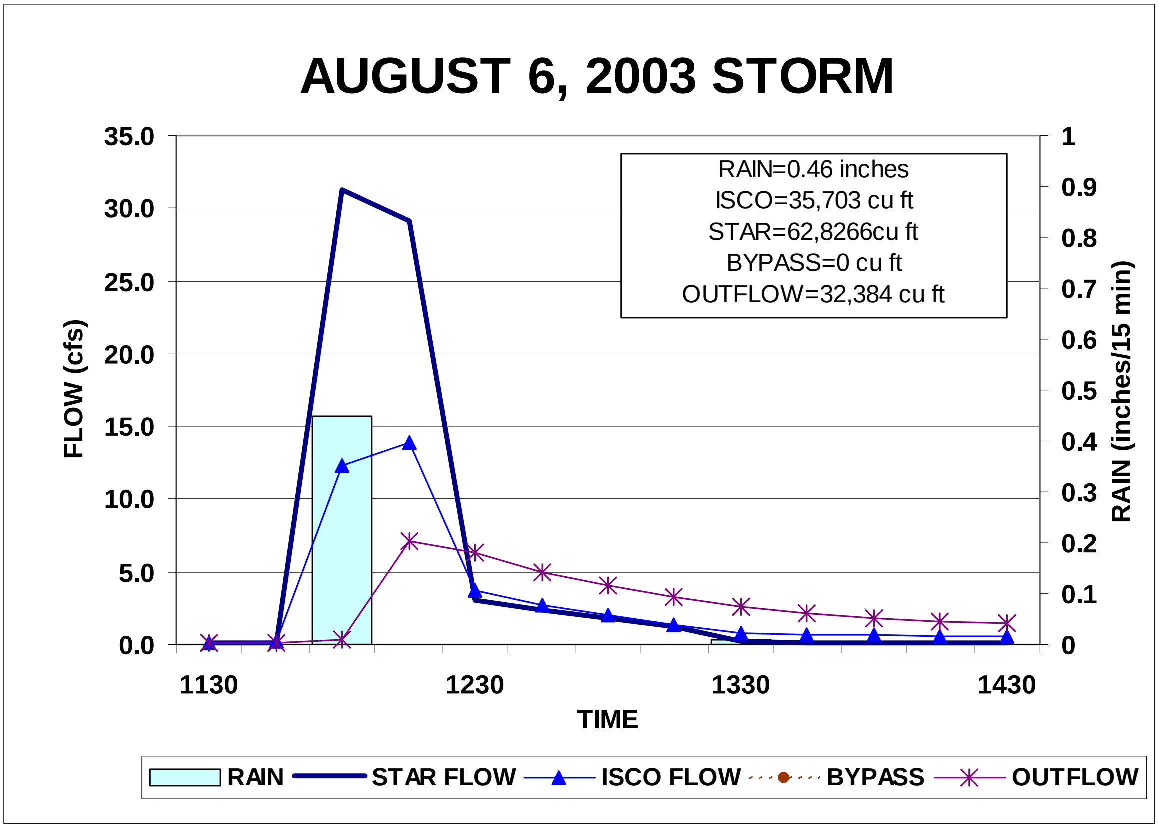


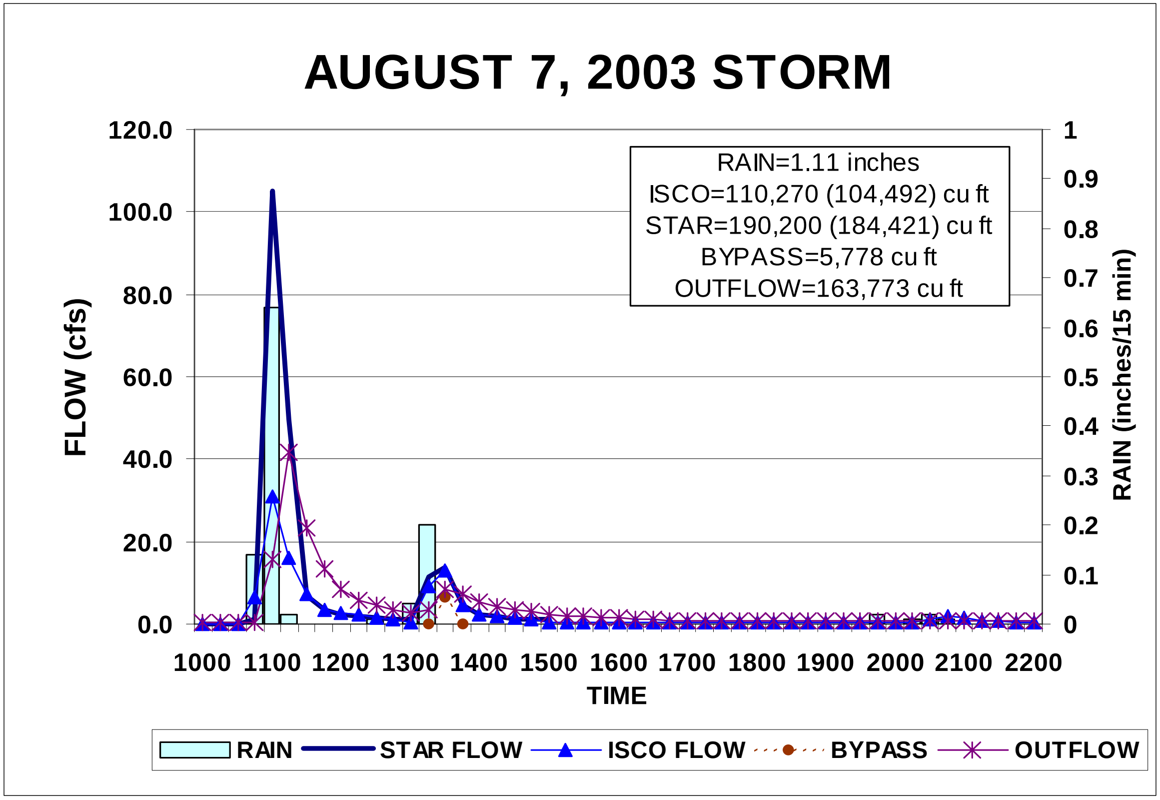
JULY 30, 2003

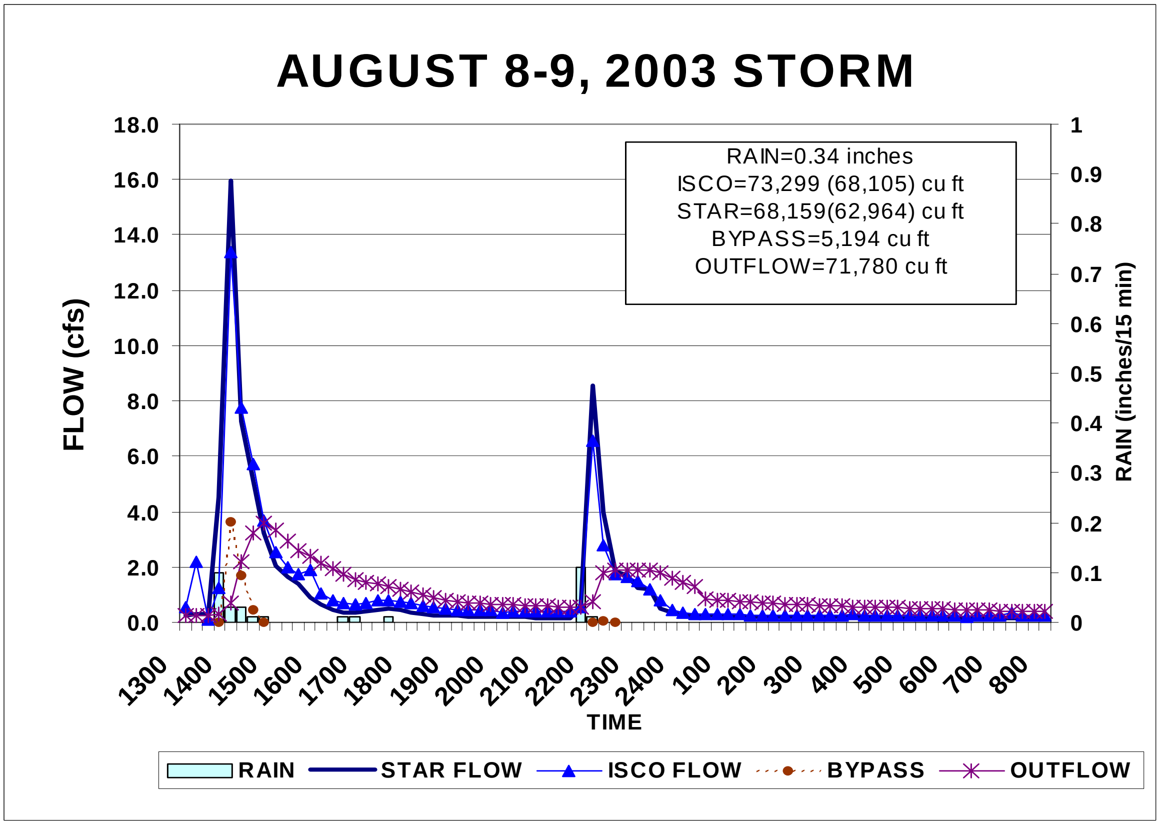

AUGUST 1, 2003 STORM
RAIN=0.50 inches
ISCO=54,424 (47,130) cu ft
STAR=67,699 (60,404) cu ft
BYPASS=7,295 cu ft
OUTFLOW=56,079 cu ft
FLOW (cfs)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1200
1300
1400
1500
1600
1700
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

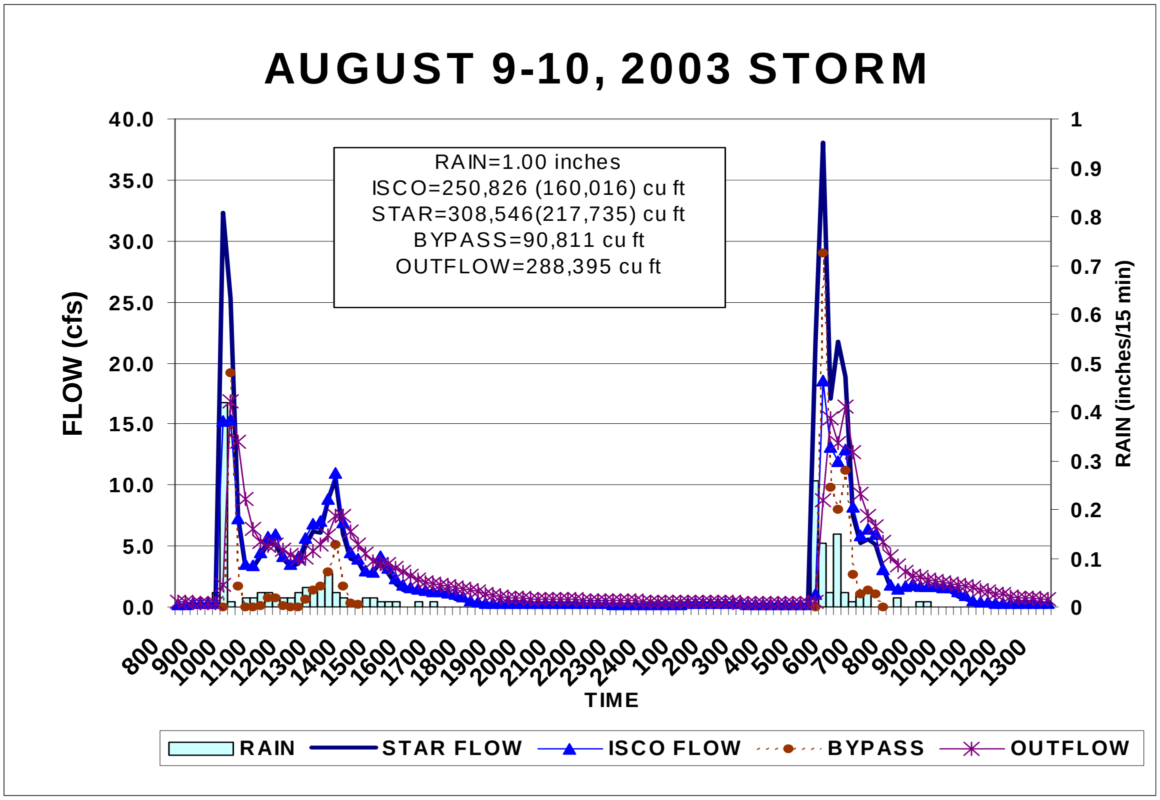

AUGUST 2, 2003 STORM
RAIN=1.35 inches
ISCO=145,501(73,541) cu ft
STAR=235,771 (163,810) cu ft
BYPASS=71,960) cu ft
OUTFLOW=189,936 cu ft
FLOW (cfs)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1500
1600
1700
1800
1900
2000
2100
2200
2300
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

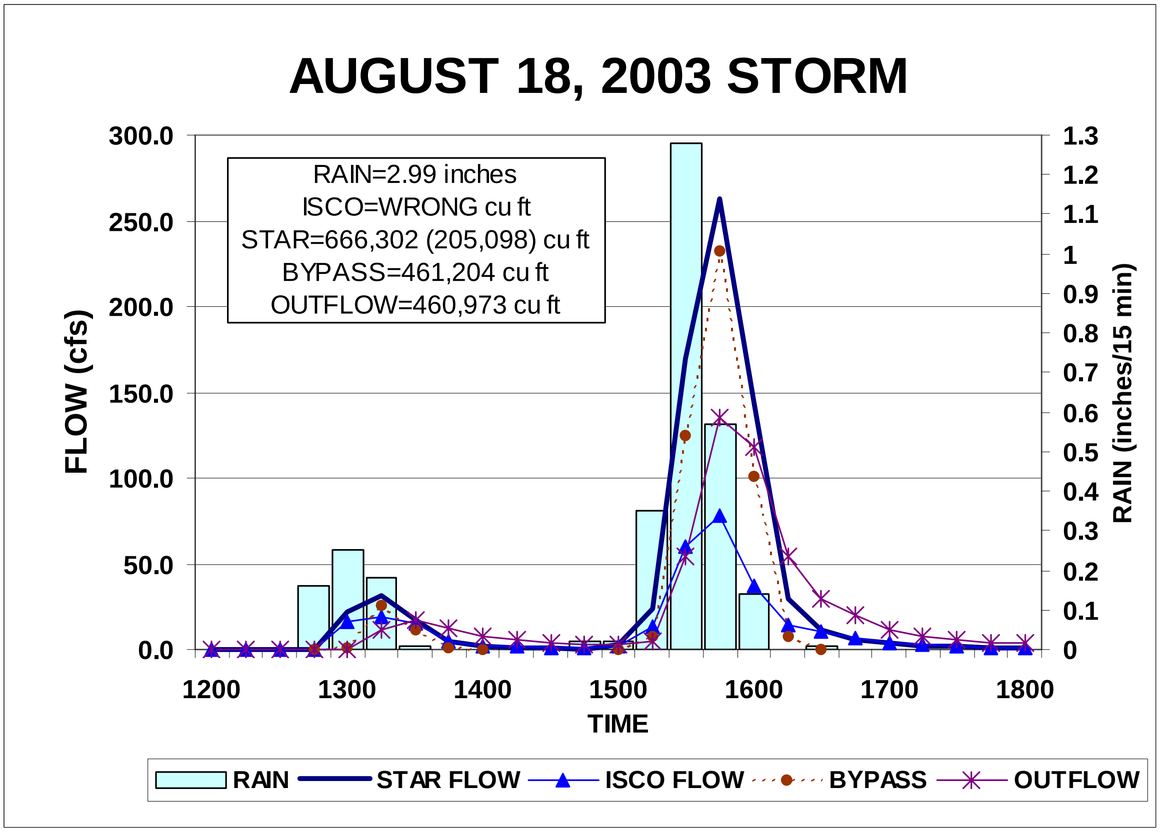

AUGUST 4, 2003 STORM
RAIN=0.27 inches
ISCO=37,328 cu ft
STAR=32,516cu ft
BYPASS=0 cu ft
OUTFLOW=13,131 cu ft
FLOW (cfs)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1700
1800
1900
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

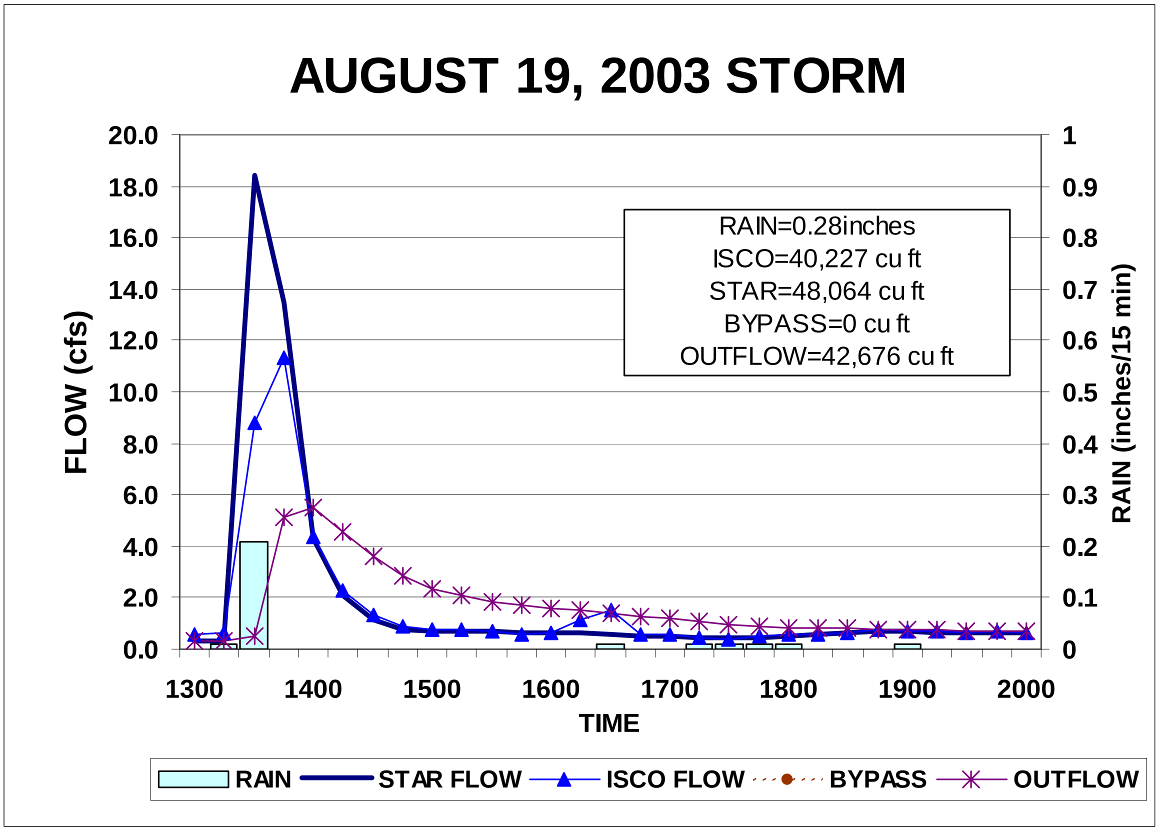

AUGUST 6, 2003 STORM
RAIN=0.46 inches
ISCO=35,703 cu ft
STAR=62,8266cu ft
BYPASS=0 cu ft
OUTFLOW=32,384 cu ft
FLOW (cfs)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1130
1230
1330
1430
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

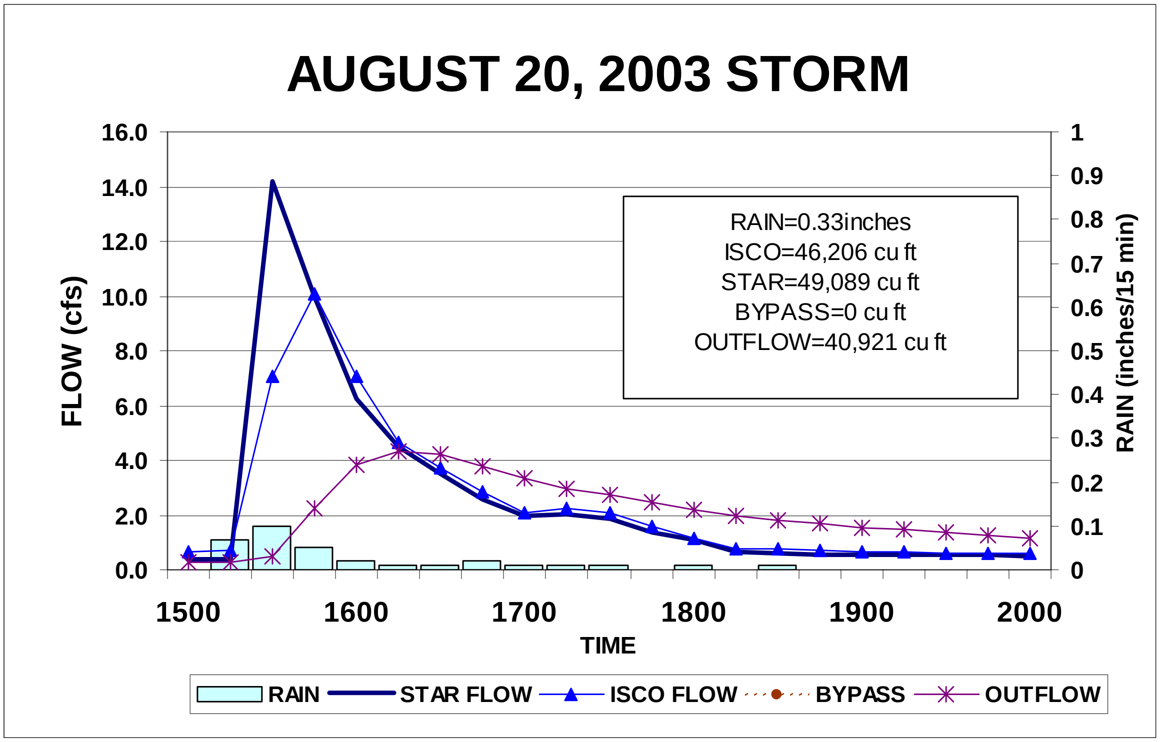

AUGUST 7, 2003 STORM

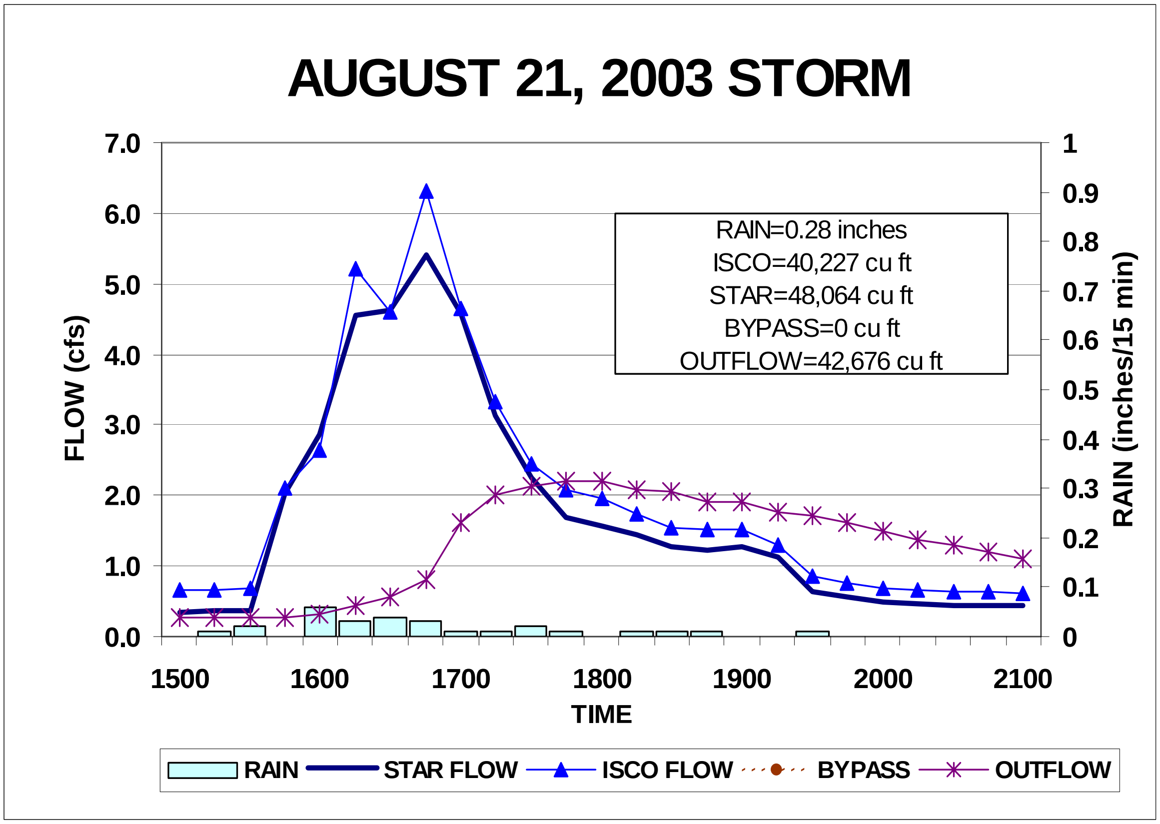

AUGUST 8-9, 2003 STORM

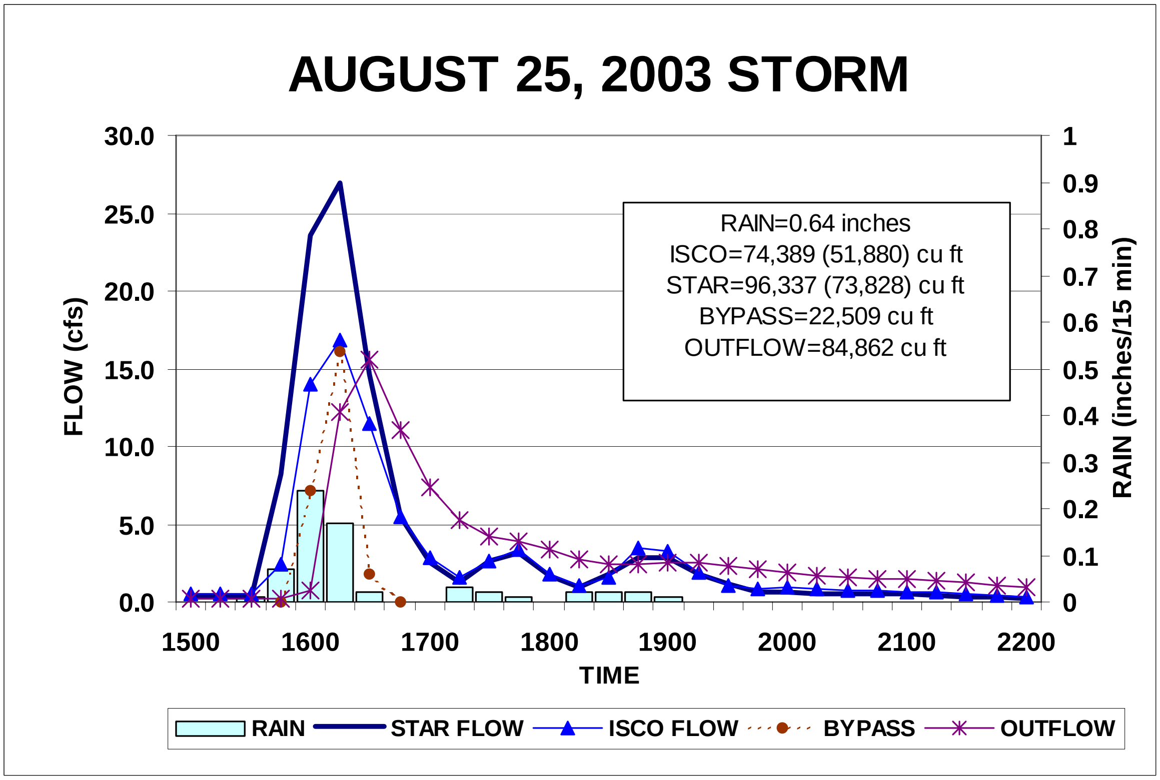

AUGUST 9-10, 2003 STORM
RAIN=1.00 inches
ISCO=250,826 (160,016) cu ft
STAR=308,546(217,735) cu ft
BYPASS=90,811 cu ft
OUTFLOW=288,395 cu ft
FLOW (cfs)
RAIN (inches/15 min)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

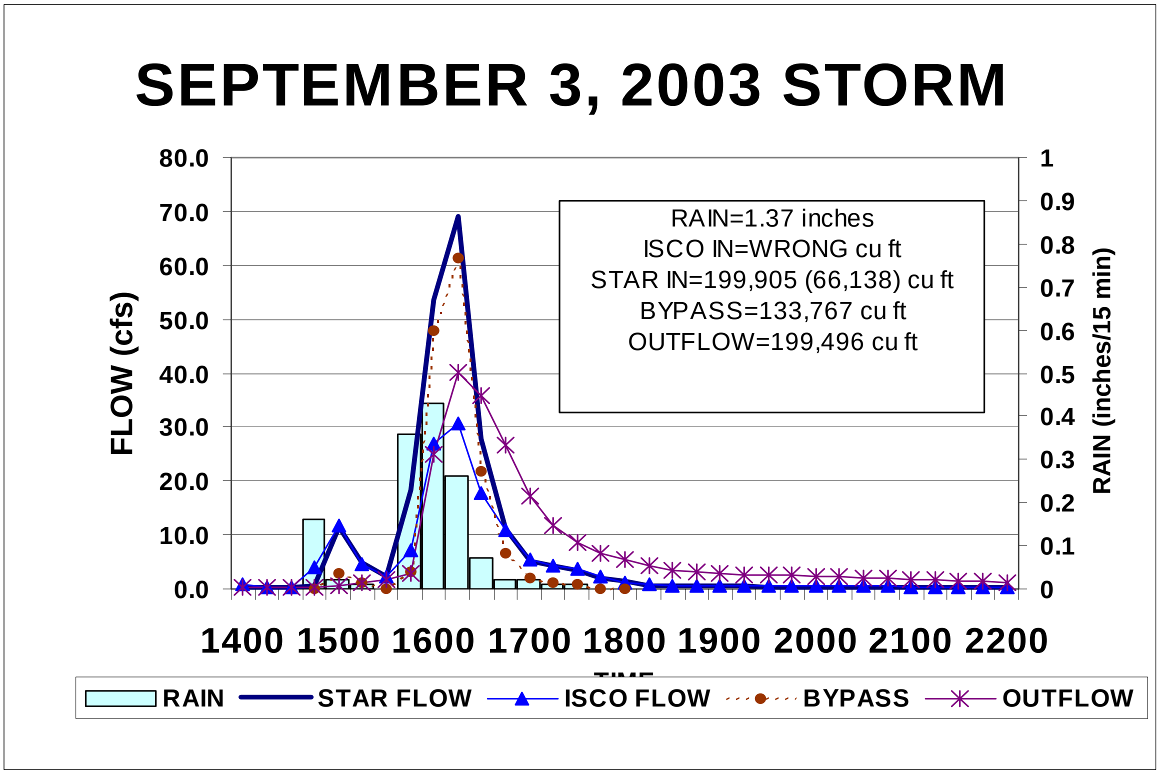

AUGUST 18, 2003 STORM
RAIN=2.99 inches
ISCO=WRONG cu ft
STAR=666,302 (205,098) cu ft
BYPASS=461,204 cu ft
OUTFLOW=460,973 cu ft
FLOW (cfs)
RAIN (inches/15 min)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1200
1300
1400
1500
1600
1700
1800
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

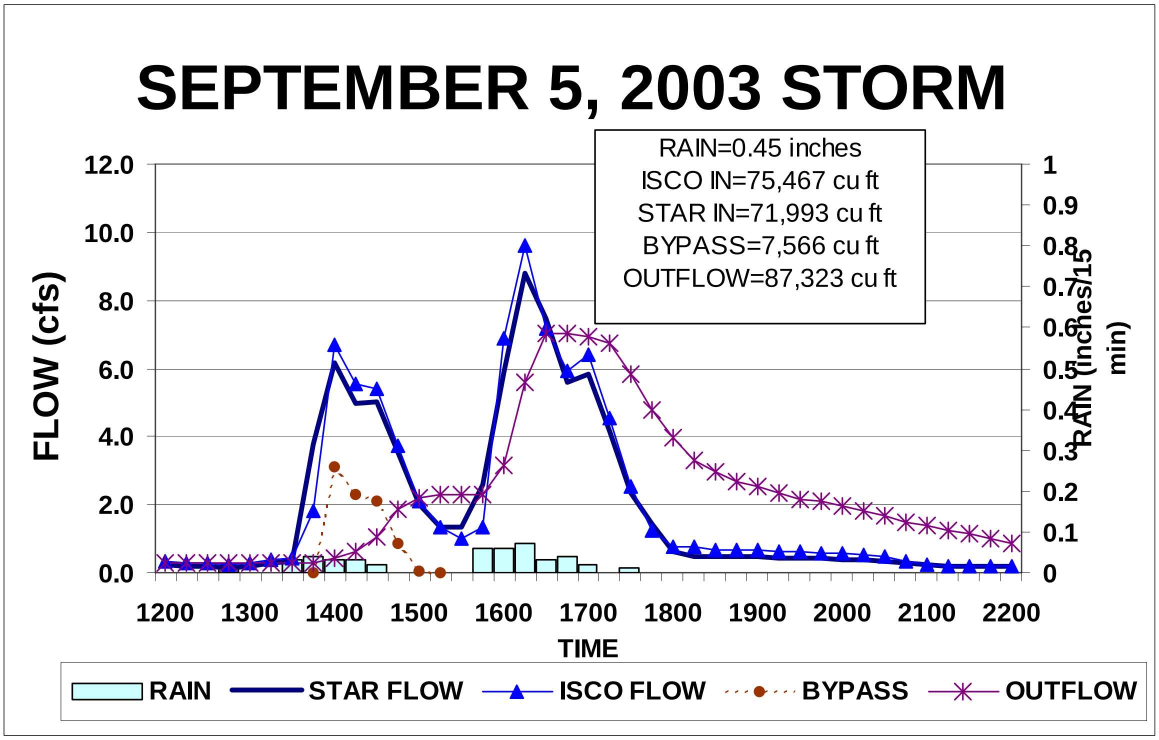

AUGUST 19, 2003 STORM
RAIN=0.28inches
ISCO=40,227 cu ft
STAR=48,064 cu ft
BYPASS=0 cu ft
OUTFLOW=42,676 cu ft
FLOW (cfs)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1300
1400
1500
1600
1700
1800
1900
2000
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

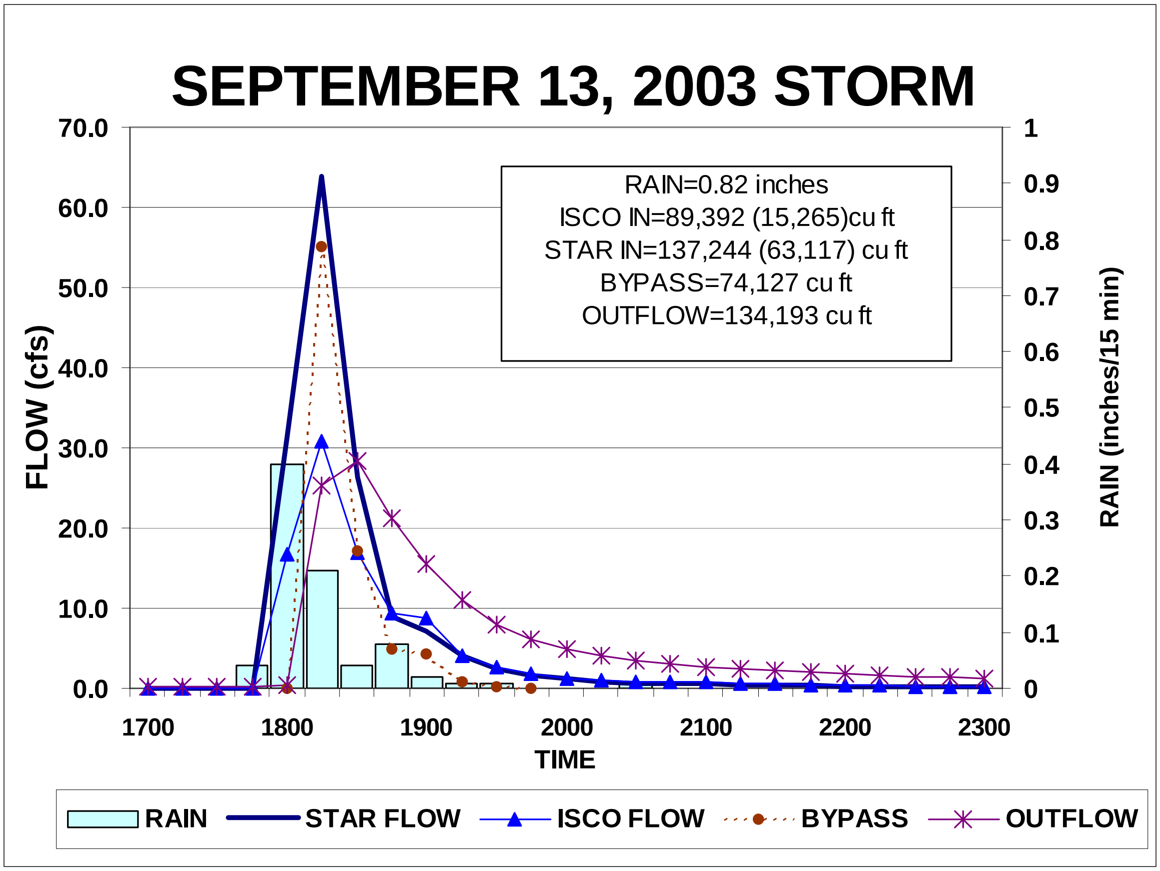

AUGUST 20, 2003 STORM
RAIN=0.33inches
ISCO=46,206 cu ft
STAR=49,089 cu ft
BYPASS=0 cu ft
OUTFLOW=40,921 cu ft
FLOW (cfs)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1500
1600
1700
1800
1900
2000
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

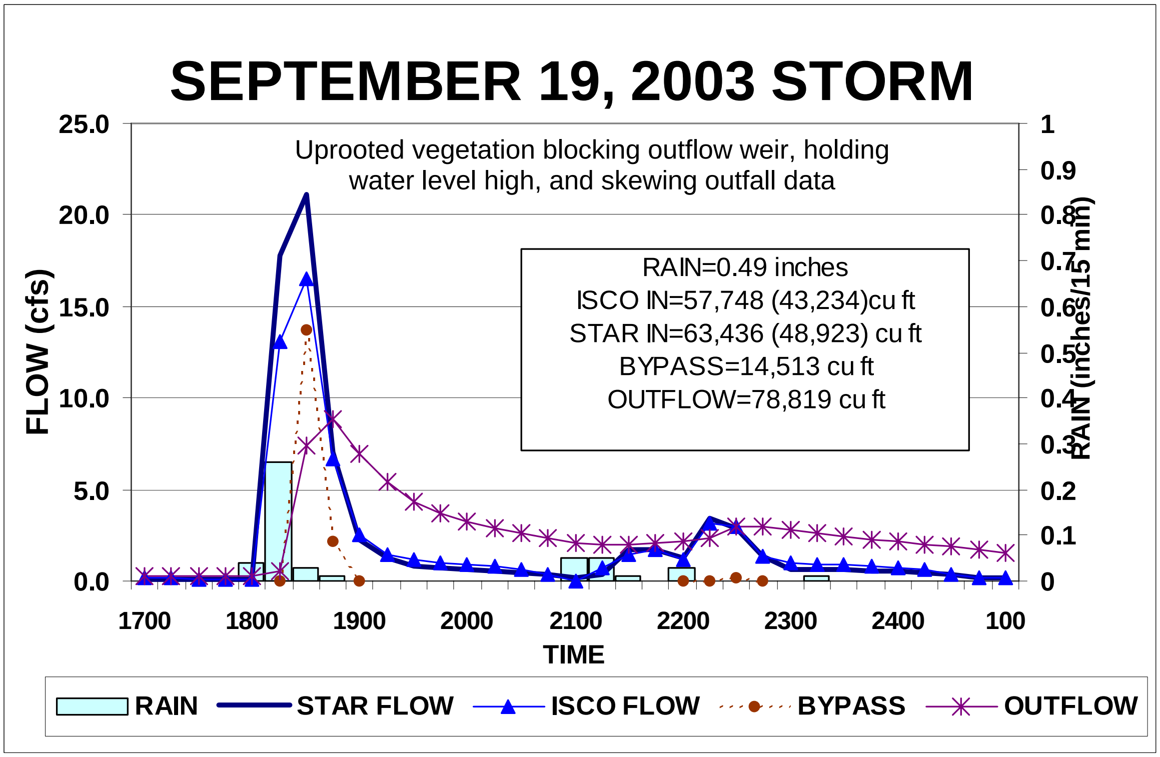

AUGUST 21, 2003 STORM
RAIN=0.28 inches
ISCO=40,227 cu ft
STAR=48,064 cu ft
BYPASS=0 cu ft
OUTFLOW=42,676 cu ft
FLOW (cfs)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1500
1600
1700
1800
1900
2000
2100
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

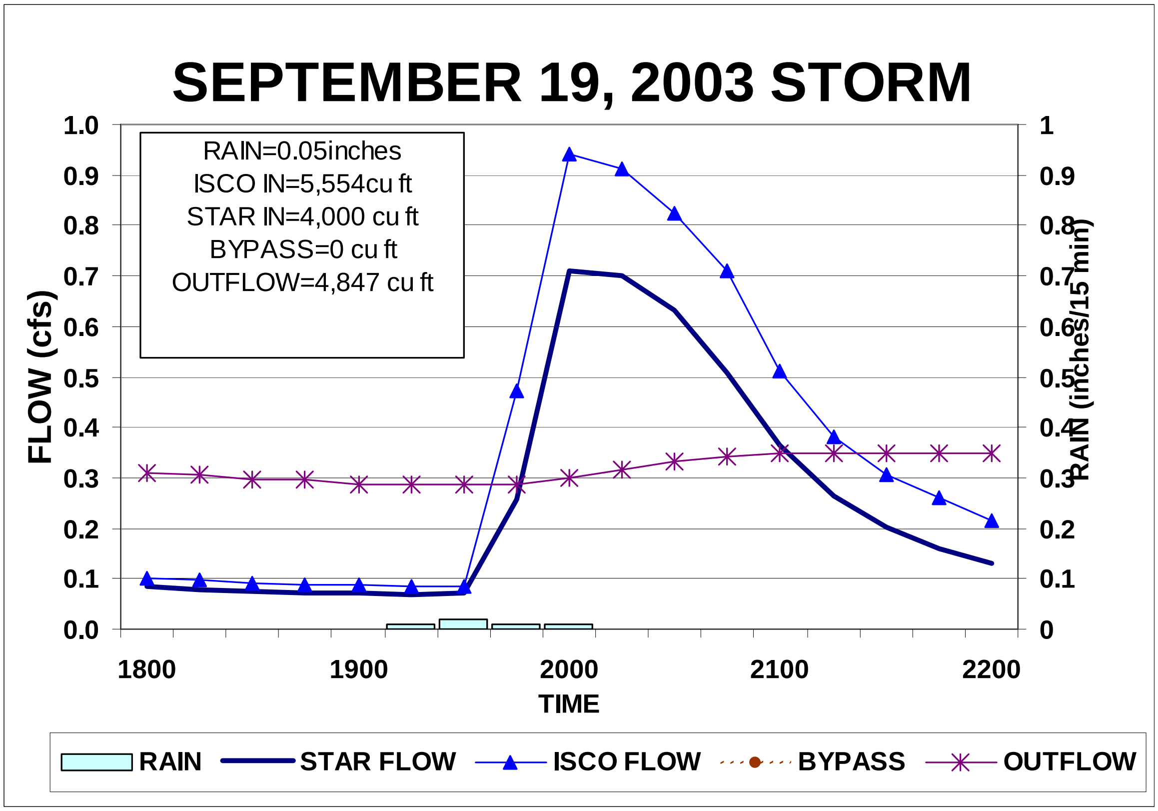

AUGUST 25, 2003 STORM
RAIN=0.64 inches
ISCO=74,389 (51,880) cu ft
STAR=96,337 (73,828) cu ft
BYPASS=22,509 cu ft
OUTFLOW=84,862 cu ft
FLOW (cfs)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1500
1600
1700
1800
1900
2000
2100
2200
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

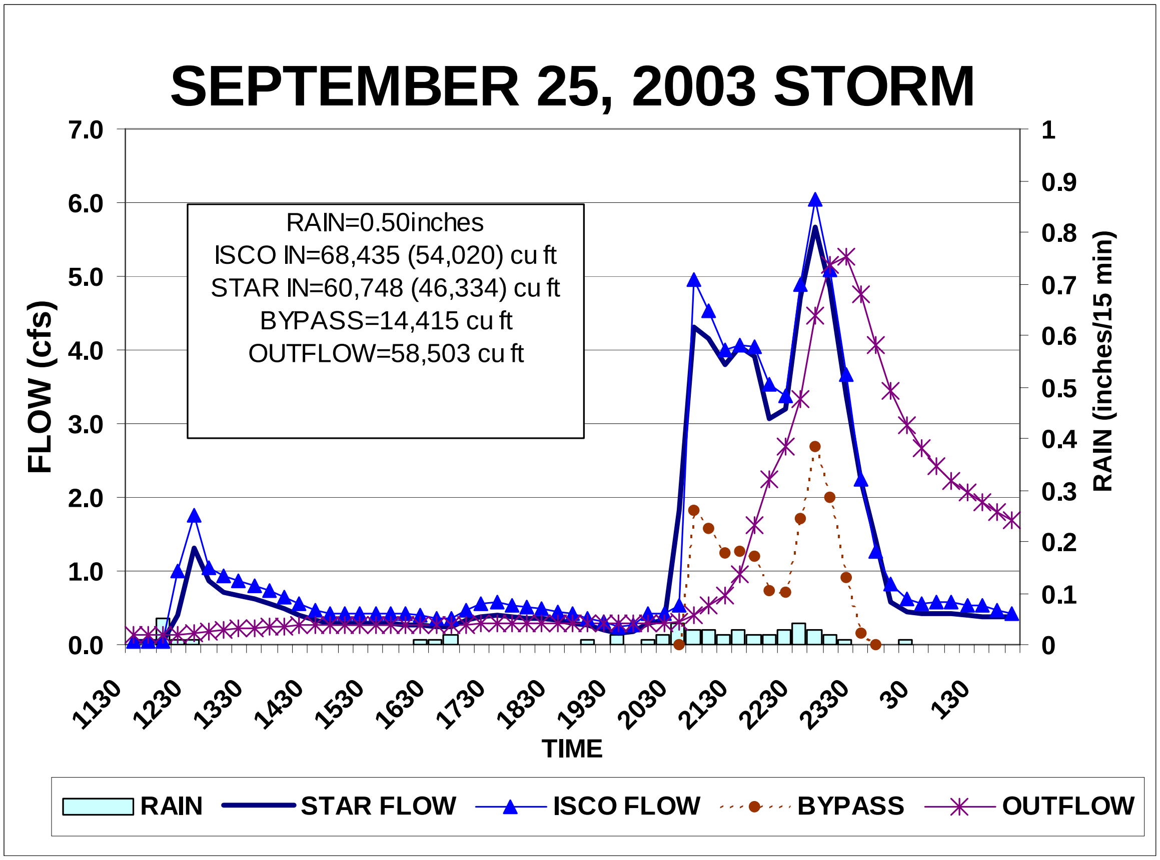

SEPTEMBER 3, 2003 STORM

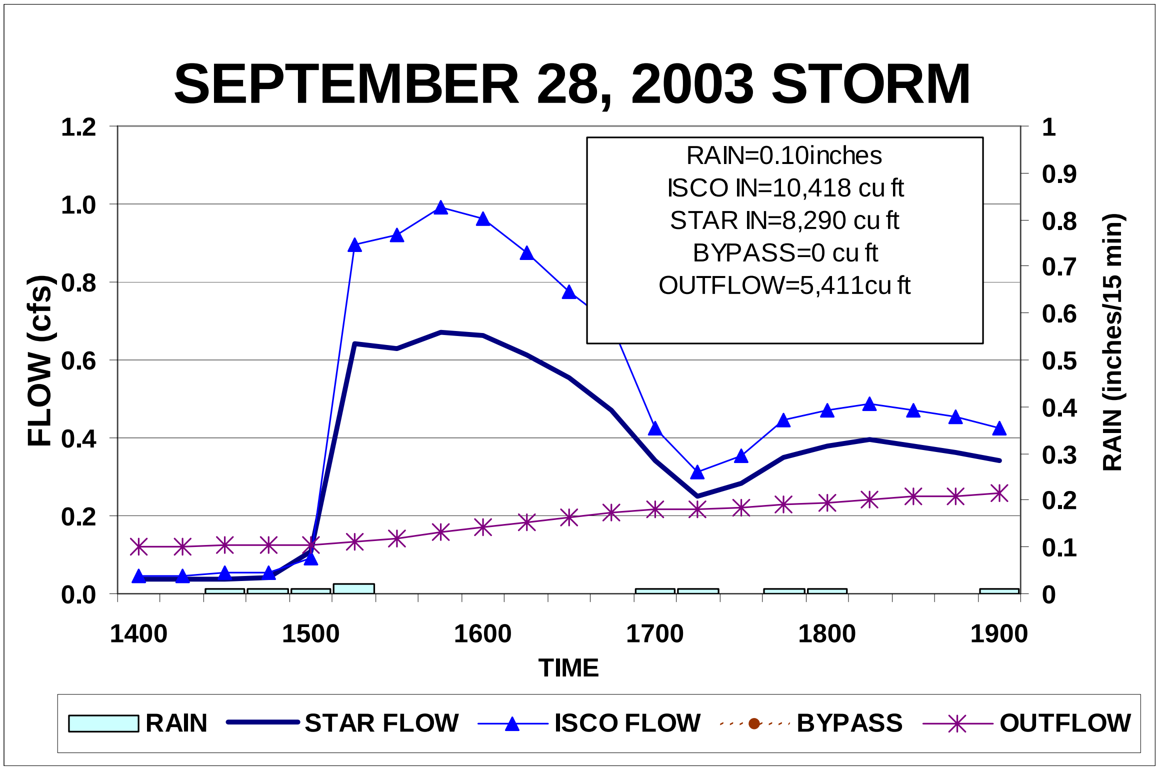

SEPTEMBER 5, 2003 STORM

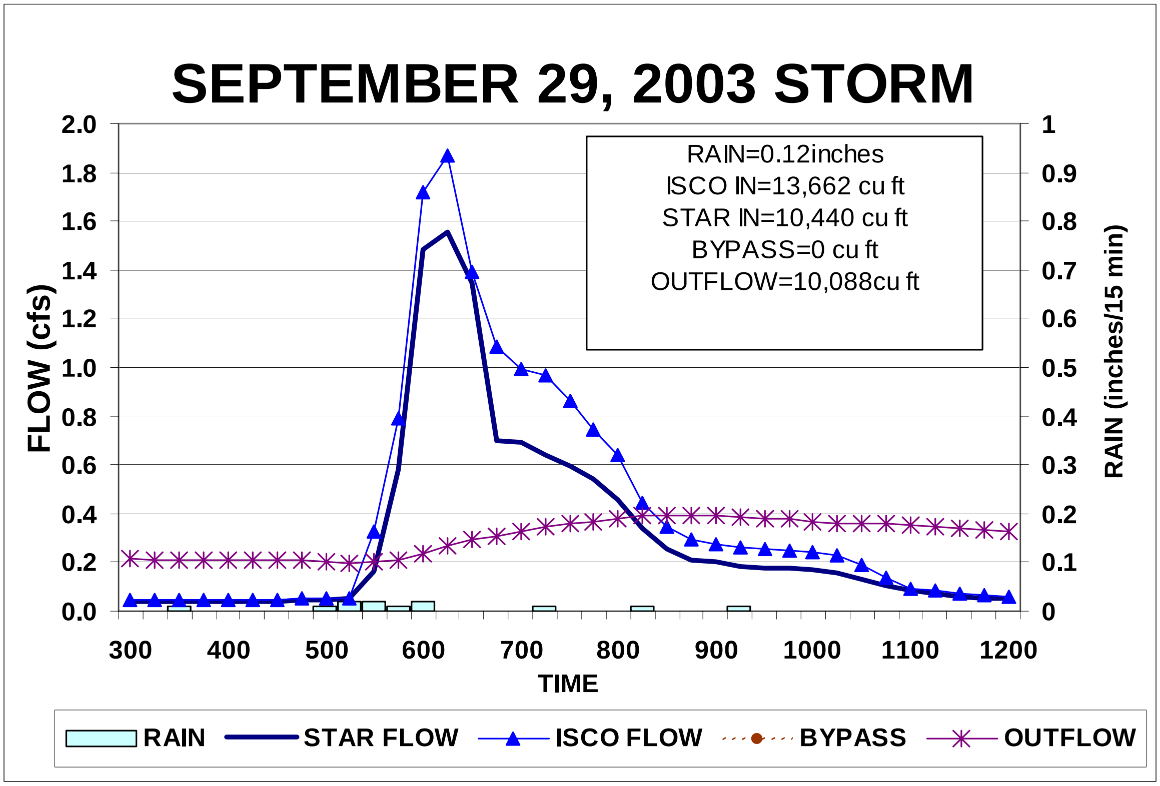

SEPTEMBER 13, 2003 STORM
RAIN=0.82 inches
ISCO IN=89,392 (15,265)cu ft
STAR IN=137,244 (63,117) cu ft
BYPASS=74,127 cu ft
OUTFLOW=134,193 cu ft
FLOW (cfs)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1700
1800
1900
2000
2100
2200
2300
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

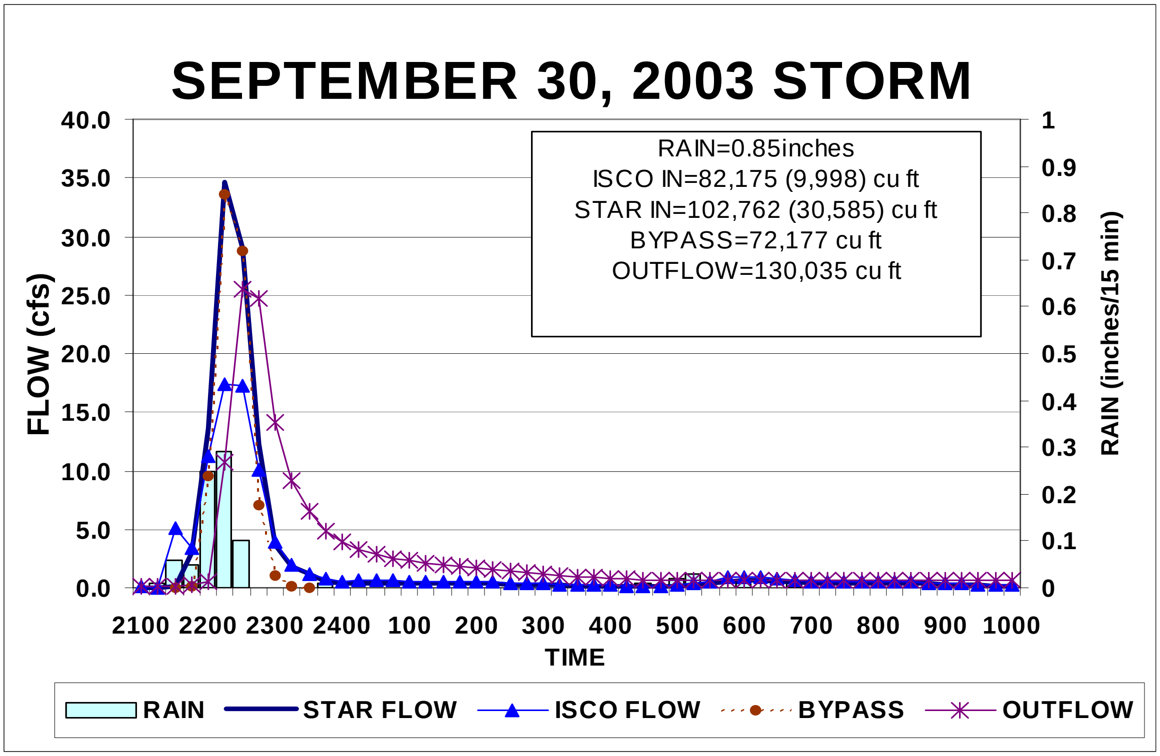

SEPTEMBER 19, 2003 STORM
Uprooted vegetation blocking outflow weir, holding water level high, and skewing outfall data
RAIN=0.49 inches
ISCO IN=57,748 (43,234)cu ft
STAR IN=63,436 (48,923) cu ft
BYPASS=14,513 cu ft
OUTFLOW=78,819 cu ft
FLOW (cfs)
25.0
20.0
15.0
10.0
5.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1700
1800
1900
2000
2100
2200
2300
2400
100
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW


SEPTEMBER 19, 2003 STORM
RAIN=0.05inches
ISCO IN=5,554cu ft
STAR IN=4,000 cu ft
BYPASS=0 cu ft
OUTFLOW=4,847 cu ft
FLOW (cfs)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1800
1900
2000
2100
2200
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

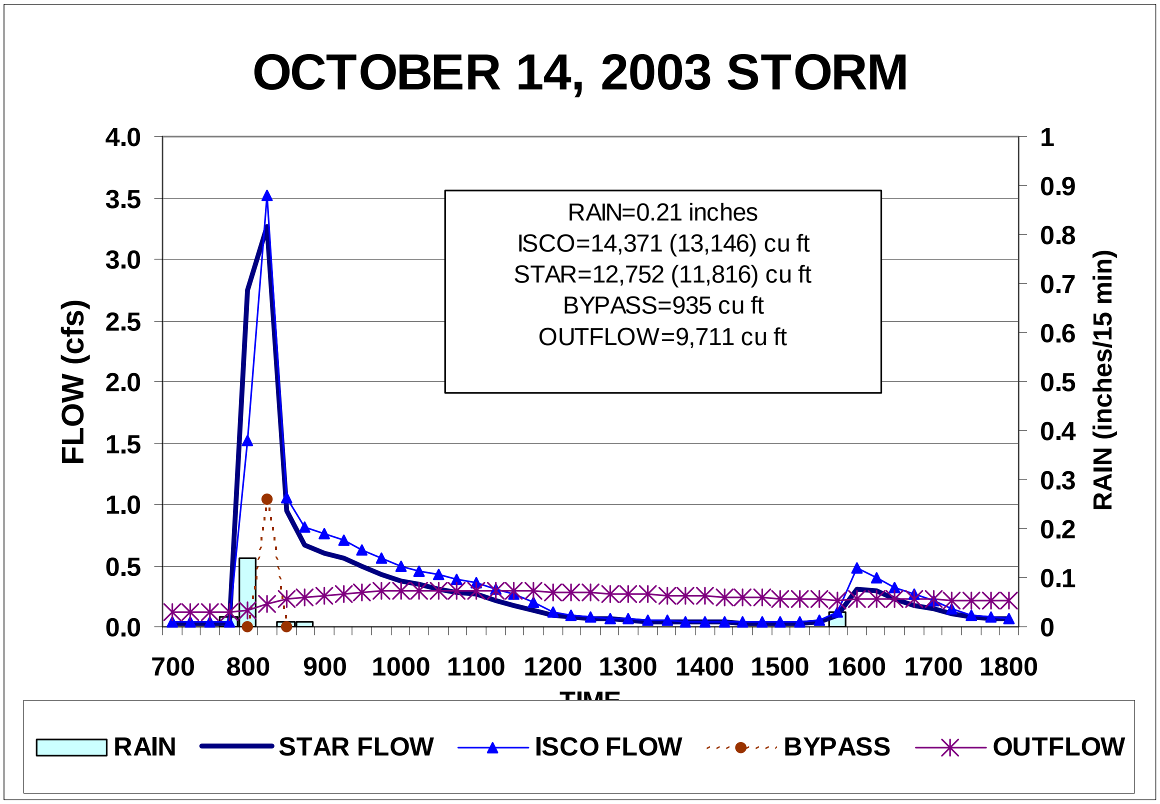

SEPTEMBER 25, 2003 STORM
RAIN=0.50inches
ISCO IN=68,435 (54,020) cu ft
STAR IN=60,748 (46,334) cu ft
BYPASS=14,415 cu ft
OUTFLOW=58,503 cu ft
FLOW (cfs)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1130
1230
1330
1430
1530
1630
1730
1830
1930
2030
2130
2230
2330
30
130
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

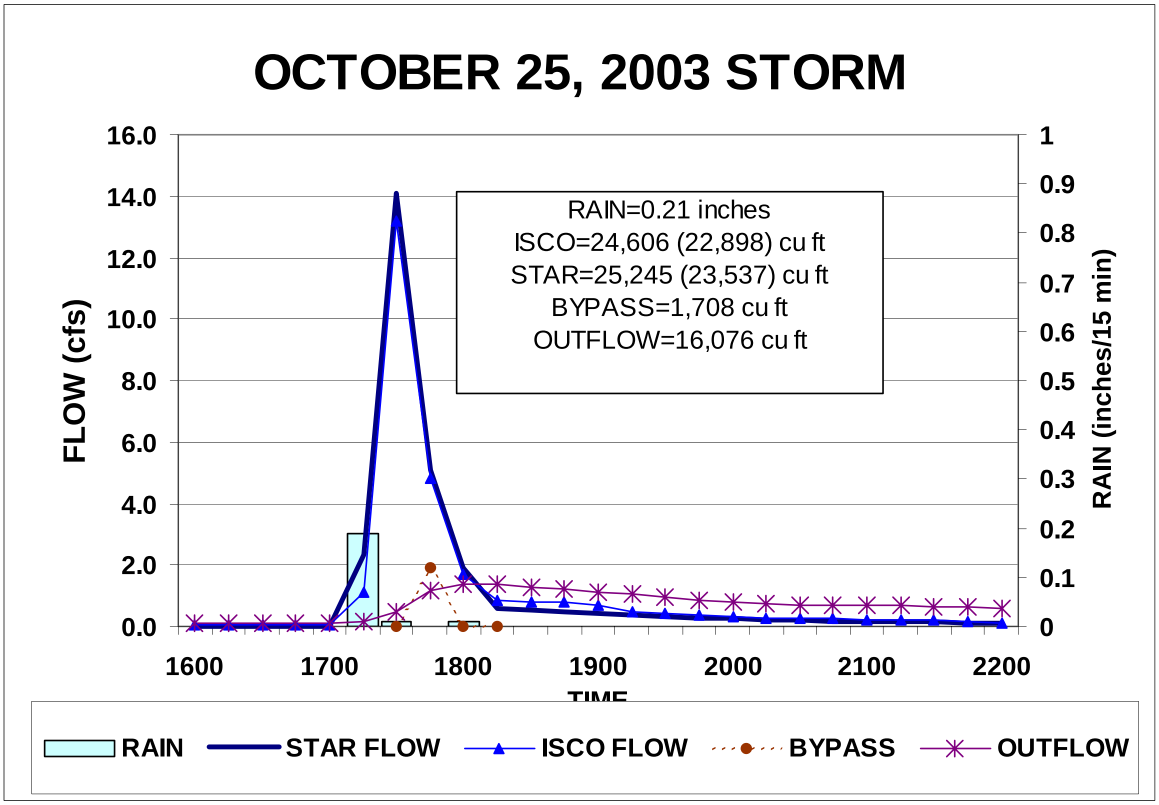

SEPTEMBER 28, 2003 STORM
RAIN=0.10inches
ISCO IN=10,418 cu ft
STAR IN=8,290 cu ft
BYPASS=0 cu ft
OUTFLOW=5,411cu ft
FLOW (cfs)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1400
1500
1600
1700
1800
1900
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

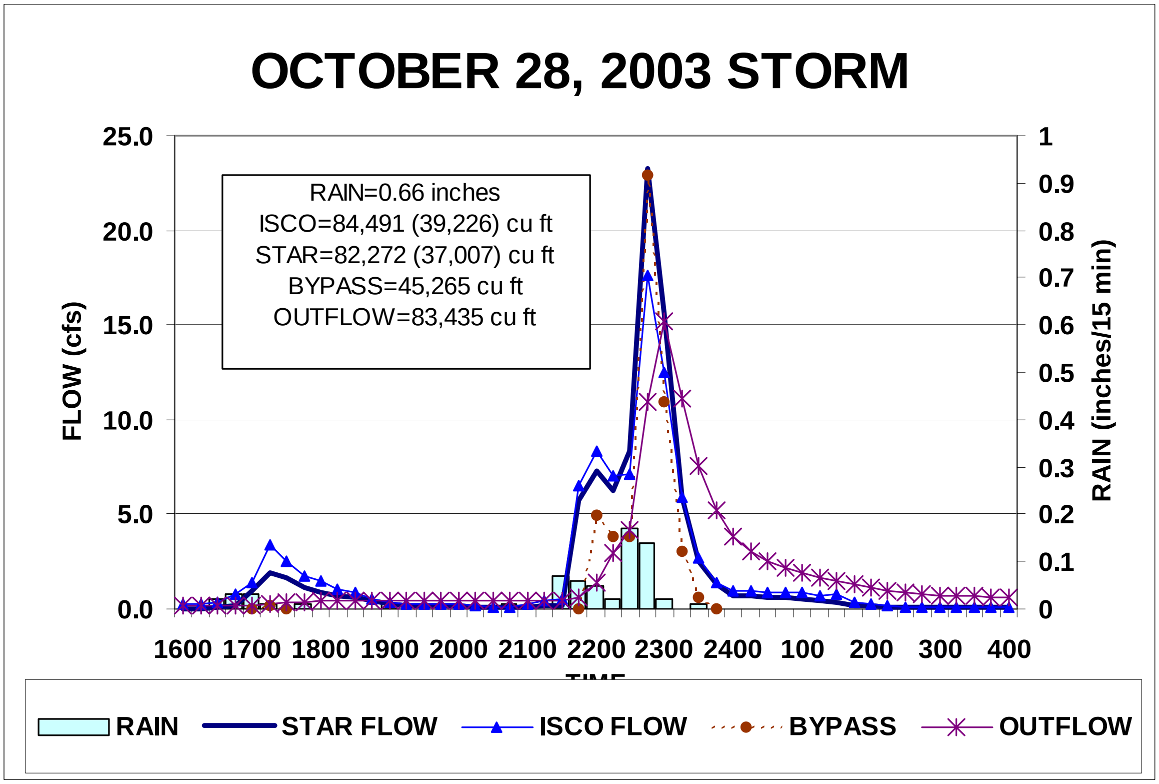

SEPTEMBER 29, 2003 STORM
RAIN=0.12inches
ISCO IN=13,662 cu ft
STAR IN=10,440 cu ft
BYPASS=0 cu ft
OUTFLOW=10,088cu ft
FLOW (cfs)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
300
400
500
600
700
800
900
1000
1100
1200
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW



Still problem with uprooted vegetation blocking outflow weir and skewing calculations.




OCTOBER 25, 2003 STORM
RAIN=0.21 inches
ISCO=24,606 (22,898) cu ft
STAR=25,245 (23,537) cu ft
BYPASS=1,708 cu ft
OUTFLOW=16,076 cu ft
FLOW (cfs)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1600
1700
1800
1900
2000
2100
2200
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW


OCTOBER 28, 2003 STORM
RAIN=0.66 inches
ISCO=84,491 (39,226) cu ft
STAR=82,272 (37,007) cu ft
BYPASS=45,265 cu ft
OUTFLOW=83,435 cu ft
FLOW (cfs)
25.0
20.0
15.0
10.0
5.0
0.0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1600
1700
1800
1900
2000
2100
2200
2300
2400
100
200
300
400
TIME
RAIN
STAR FLOW
ISCO FLOW
BYPASS
OUTFLOW

WATER BUDGET CALCULATIONS FOR 2003-04

Bypass flow is the storm flow that bypasses the CDS unit and discharges over weir
All flows less than 1 cfs were calculated using base flow weir (see appendix A).
In figures, total flow is shown first and the amount entering the CDS is in parentheses
Equipment failures after March necssitated developing formulas from water level (see Appendix A)
The area of the pond used in the calculations was 46,605 sq. ft.
Pipes used to divert flow around the pond kept breaking loose and diverting unmeasured flow into & out of pond
Some adjustment was made for this but it still caused errors, esp in June-Sept. Fixed Sept 15th.
The V-nothch weirs (in and out) used to calculate base flow were frequently clogged with debris.
Storm flow measurements were more accurate than base flow because of debris problems.
ISCO, STAR, McBIRNEY represent various sensors used to measure velocity and water levels.
BF FORMULA and REGRESS indicate formulas used to estimate flow (see Appendix A)
BF FORMULA not accurate when pipe is over half full and under estimates flow.

WATER BUDGET EQUATION:
FLOW IN - FLOW OUT = CHANGE IN STORAGE

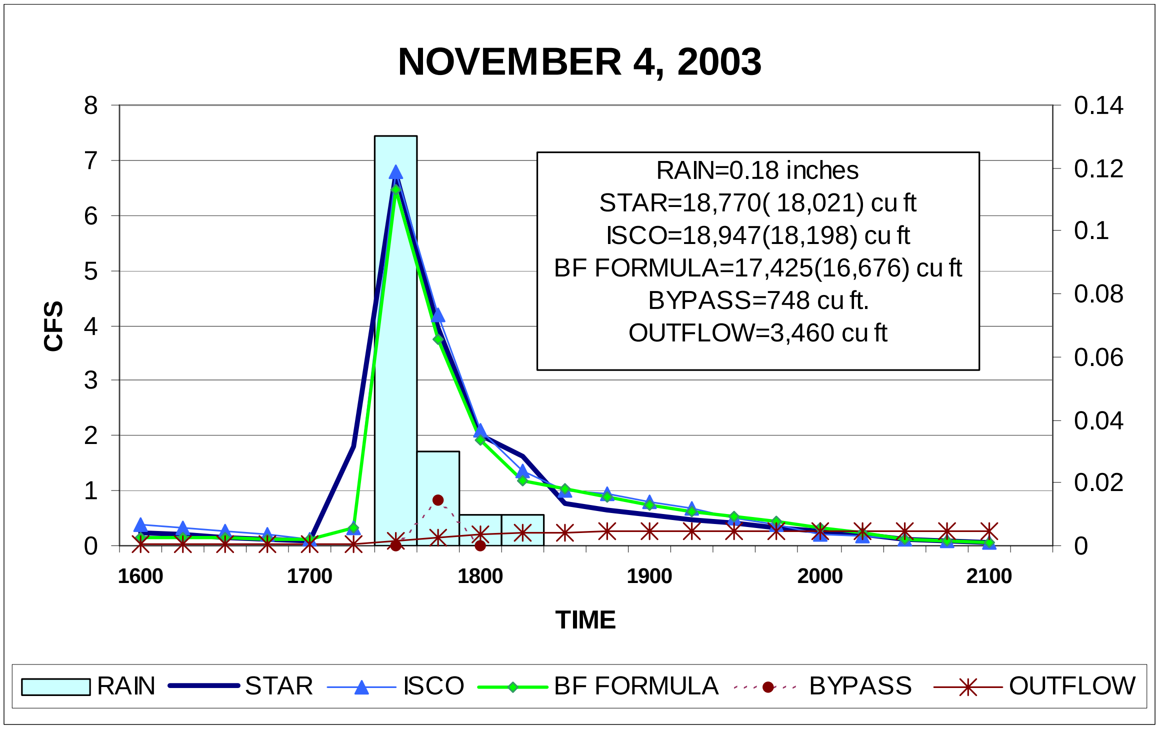
where: Flow in = rain on pond, storm flow and base flow
Flow out = flow out of pond (storm flow, base flow and ET)
Change in storage=difference between pond levels at from beginning to end of month
The error term is caused by leaks , weir obstructions, pipe leaks and other errors

Error term is about 8 to 9% of inflow or outflow on yearly basis, and 13 to 14% during months with broken pipes & unmeasured outflow

56% of storm flows bypass CDS unit

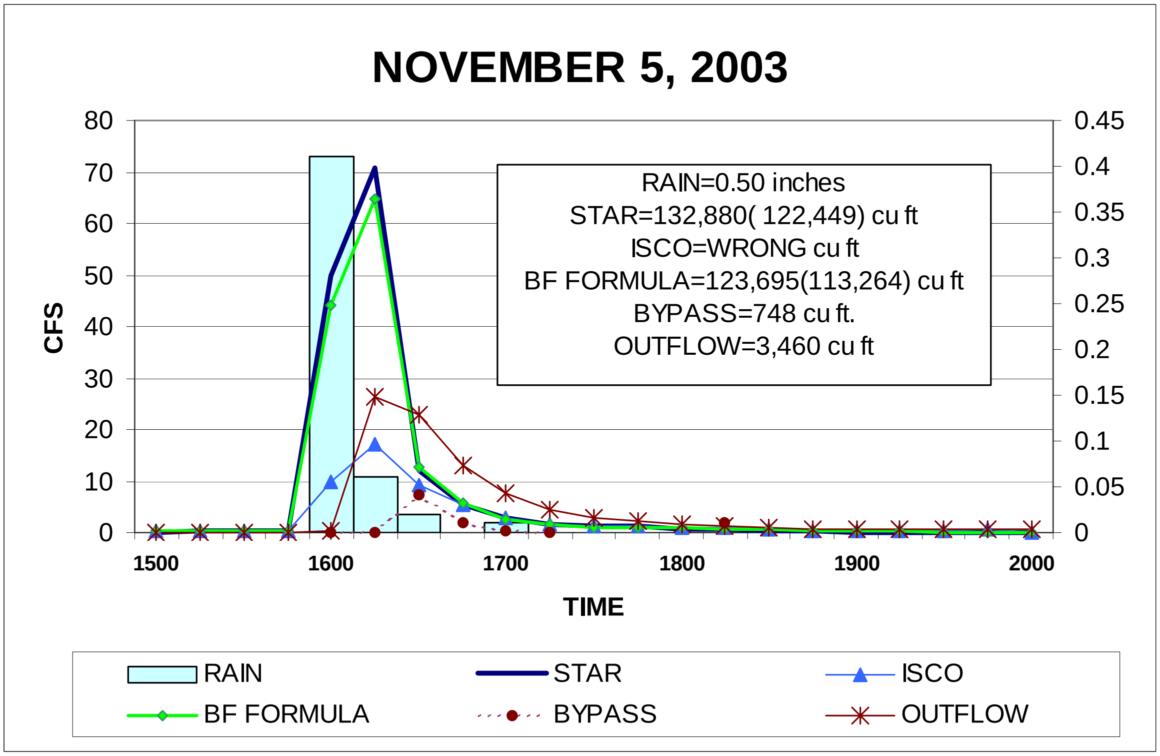
		INFLOW				OUTFLOW					REMARKS
POND AREA 46,605 sq. ft	RAIN inches	RAIN cu ft	BASE FLOW cu ft	STORM FLOW cu ft	BY-PASS FLOW cu ft duplicates not in budget	BASE FLOW cu ft	STORM FLOW cu ft	ET estimate cu ft	STORAGE loss or gain cu ft	ERROR cu ft	
November	1.39	5,398	121,751	227,224	55,538	276,627	133,970	12,816	-466	-68,574	Some problem with date and level measurement at outflow
December	1.96	7,612	135,174	270,392	211,086	149,832	185,787	6,991	-5,127	75,695	Developed regression equation to correct ISCO high flow
January	4.35	16,894	164,830	492,383	294,774	278,445	347,794	4,661	6,525	36,683	Removed 1.4 days when no inflow data
February	4.68	18,176	147,992	689,037	264,781	300,900	454,086	6,991	2,051	91,178	Cleaned out CDS which may affect base flow
March	2.07	8,039	163,650	394,038	200,406	194,818	260,007	11,651	932	98,319	Estimated for broken pipe & unmeasured outflow
April	2.35	9,127	137,776	297,860	179,842	159,490	201,977	16,312	3,728	63,256	Estimated for broken pipe & unmeasured outflow
May	1.82	7,068	134,322	180,292	86,718	203,177	111,381	18,642	32,530	-44,048	Writing new CR10 pgm, recalculating offsets, no velocity
June	12.52	48,625	61,217	1,986,186	1,127,403	309,789	1,501,580	20,972	-10,253	273,939	CDS unit clogged. Leaky pipes outflow. New program prol
July*	13.54	52,586	147,157	2,057,218	1,056,309	478,343	1,504,765	22,137	-20,133	271,849	Broken pipes and unmeasured outflow. CDS clogged ofte
August	12.04	46,760	130,287	1,614,266	993,362	453,830	1,075,927	19,807	-6,525	248,274	Part of August storm in Septmeber;CDS clogged
September	14.01	54,411	293,297	2,907,708	1,858,345	376,567	2,764,367	16,312	3,262	94,908	Pipe problem fixed on Sept. 15th.
October	0.80	3,107	271,992	92,775	7,322	386,275	27,203	13,982	3,262	-62,848	Outflow weir often clogged artificially increasing base flow
TOTAL	71.53	277,805	1,909,445	11,209,379	6,335,886	3,568,093	8,568,844	171,273	9,787	1,078,631	

Storage: negative = gain; positive = loss
July = bubbler line smashed during hurricane (July 19-20, 2004) complicated inflow measurements. Some adjustments made



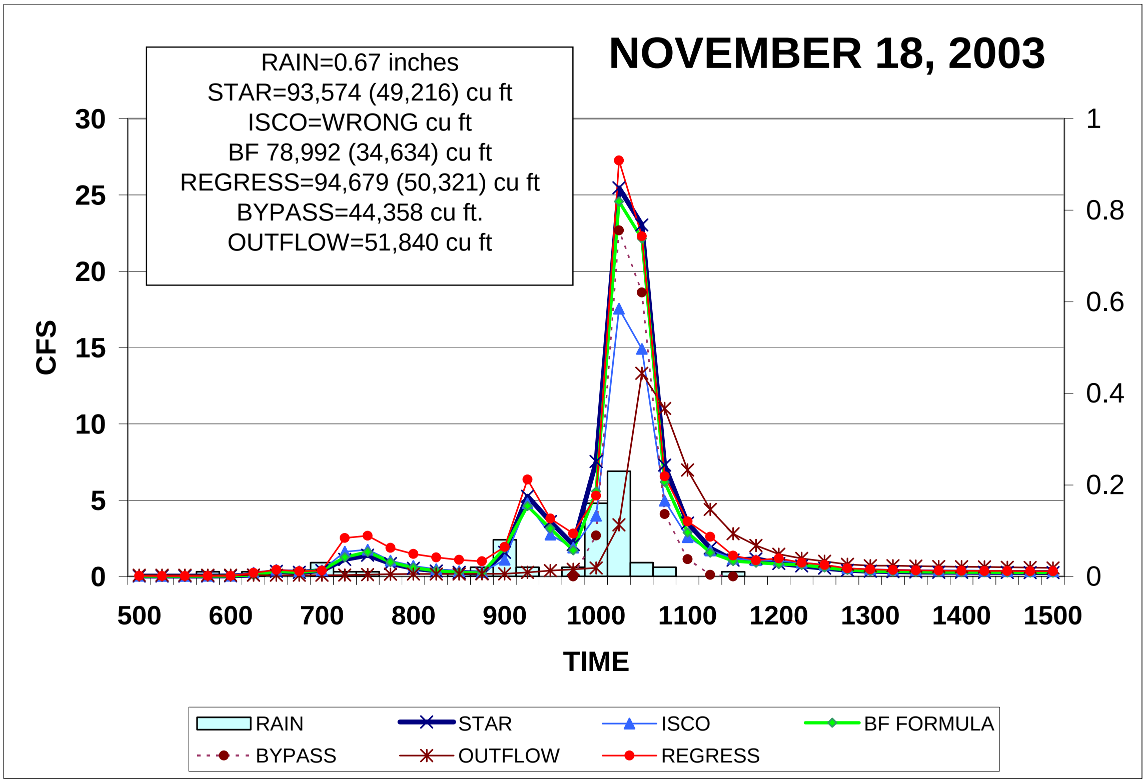
NOVEMBER 4, 2003

RAIN=0.18 inches
STAR=18,770(18,021) cu ft
ISCO=18,947(18,198) cu ft
BF FORMULA=17,425(16,676) cu ft
BYPASS=748 cu ft.
OUTFLOW=3,460 cu ft



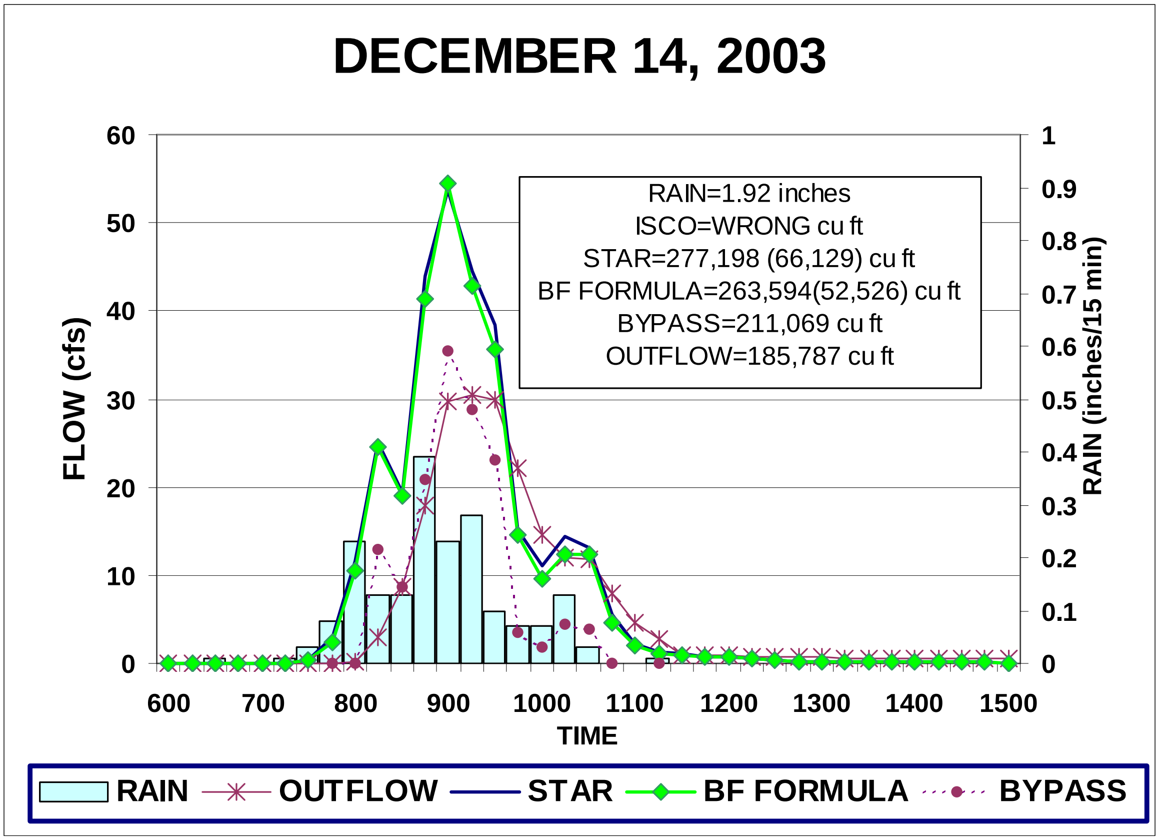
NOVEMBER 5, 2003

RAIN=0.50 inches
STAR=132,880(122,449) cu ft
ISCO=WRONG cu ft
BF FORMULA=123,695(113,264) cu ft
BYPASS=748 cu ft.
OUTFLOW=3,460 cu ft



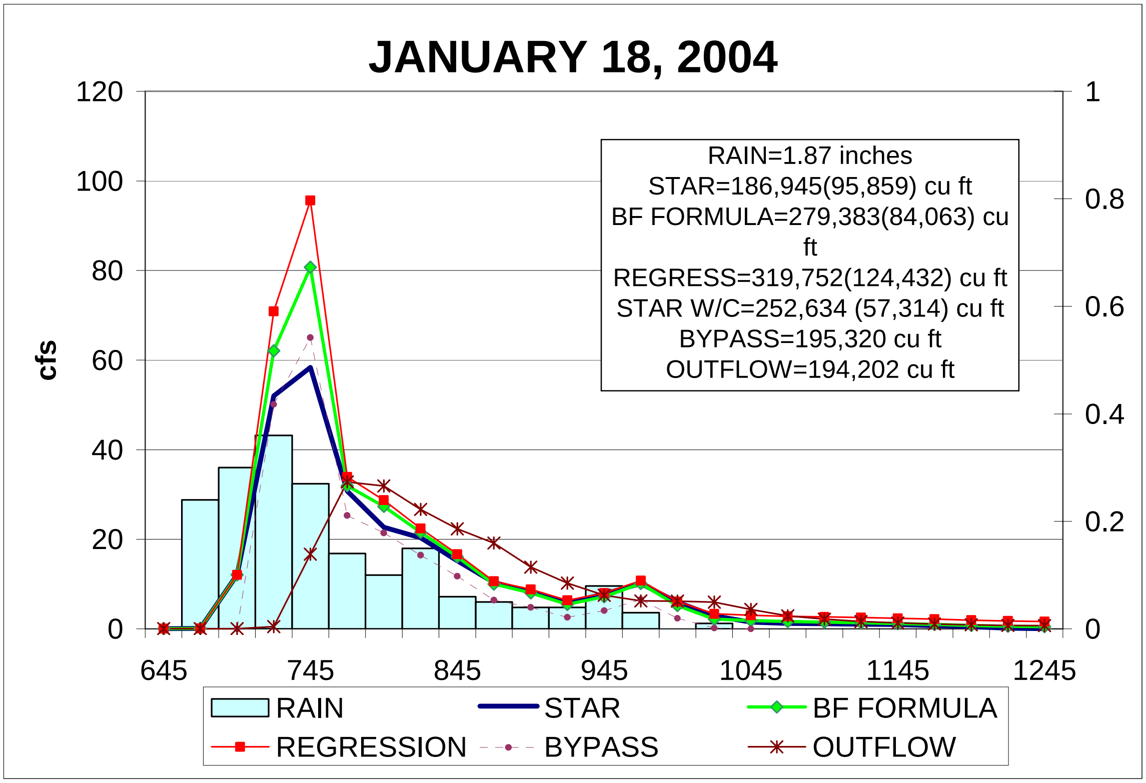
NOVEMBER 18, 2003

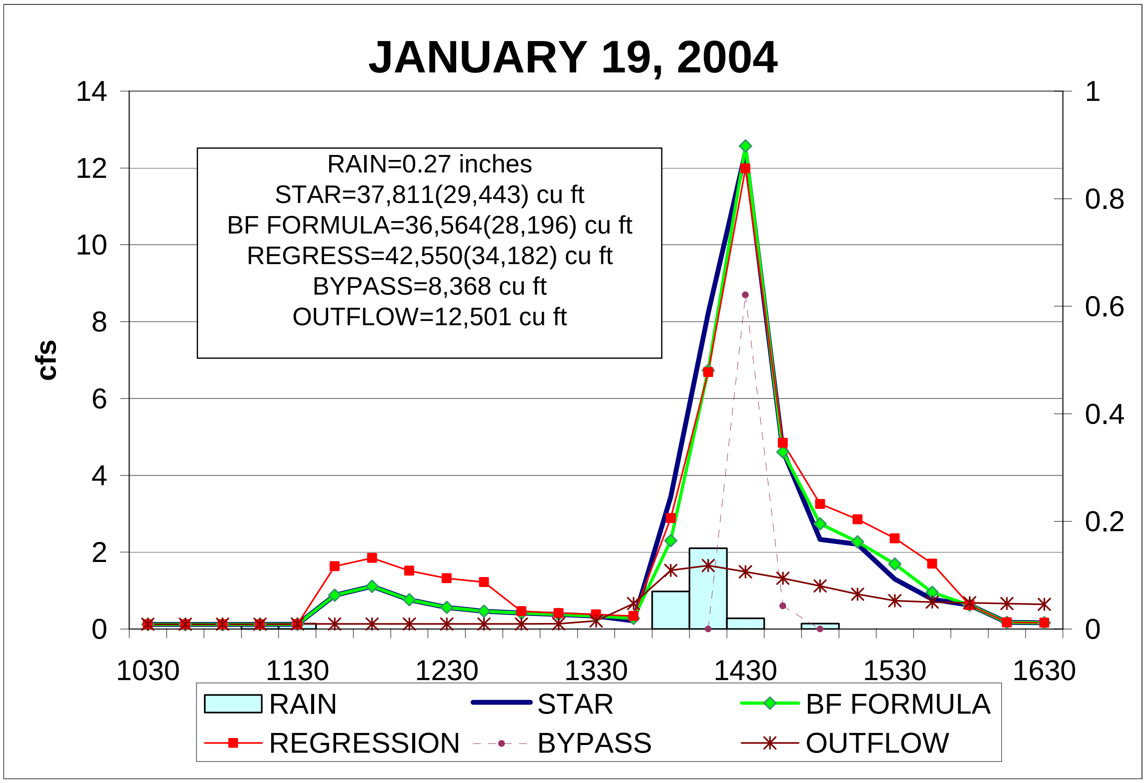
RAIN=0.67 inches
STAR=93,574 (49,216) cu ft
ISCO=WRONG cu ft
BF 78,992 (34,634) cu ft
REGRESS=94,679 (50,321) cu ft
BYPASS=44,358 cu ft.
OUTFLOW=51,840 cu ft

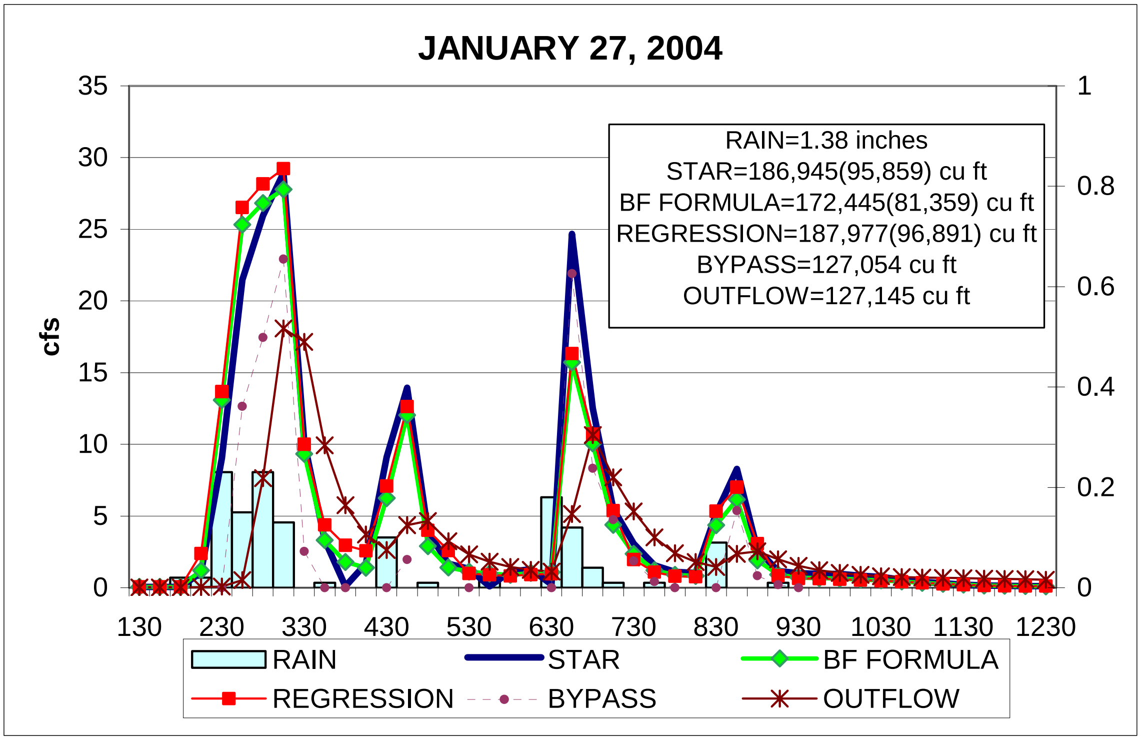


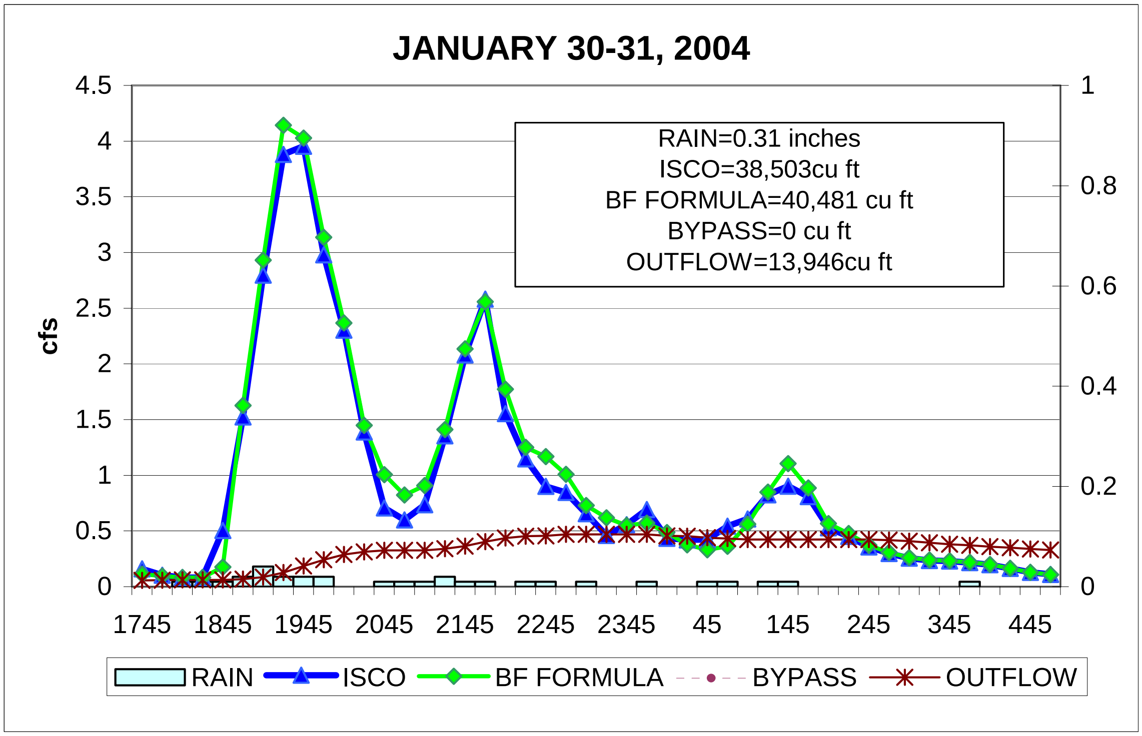
DECEMBER 14, 2003

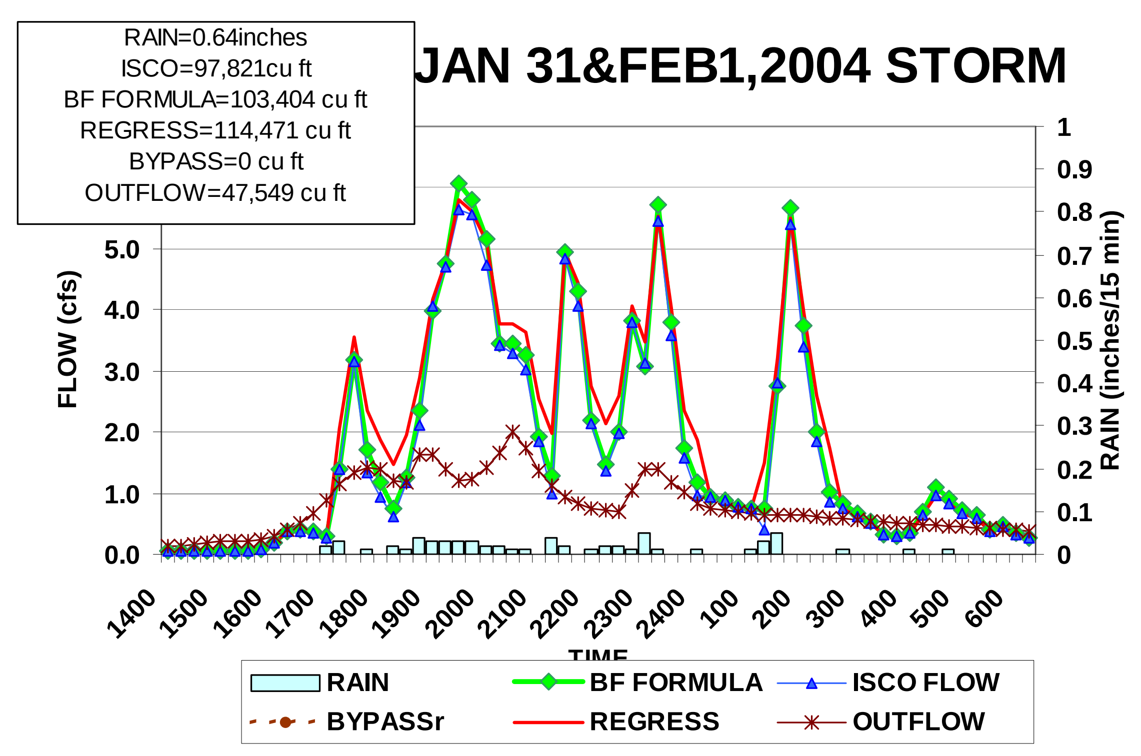
RAIN=1.92 inches
ISCO=WRONG cu ft
STAR=277,198 (66,129) cu ft
BF FORMULA=263,594(52,526) cu ft
BYPASS=211,069 cu ft
OUTFLOW=185,787 cu ft


JANUARY 18, 2004
cfs
120
100
80
60
40
20
0
1
0.8
0.6
0.4
0.2
0
645
745
845
945
1045
1145
1245
RAIN=1.87 inches
STAR=186,945(95,859) cu ft
BF FORMULA=279,383(84,063) cu ft
REGRESS=319,752(124,432) cu ft
STAR W/C=252,634 (57,314) cu ft
BYPASS=195,320 cu ft
OUTFLOW=194,202 cu ft
RAIN
STAR
BF FORMULA
REGRESSION
BYPASS
OUTFLOW


JANUARY 19, 2004
cfs
14
12
10
8
6
4
2
0
1
0.8
0.6
0.4
0.2
0
1030
1130
1230
1330
1430
1530
1630
RAIN=0.27 inches
STAR=37,811(29,443) cu ft
BF FORMULA=36,564(28,196) cu ft
REGRESS=42,550(34,182) cu ft
BYPASS=8,368 cu ft
OUTFLOW=12,501 cu ft
RAIN
STAR
BF FORMULA
REGRESSION
BYPASS
OUTFLOW

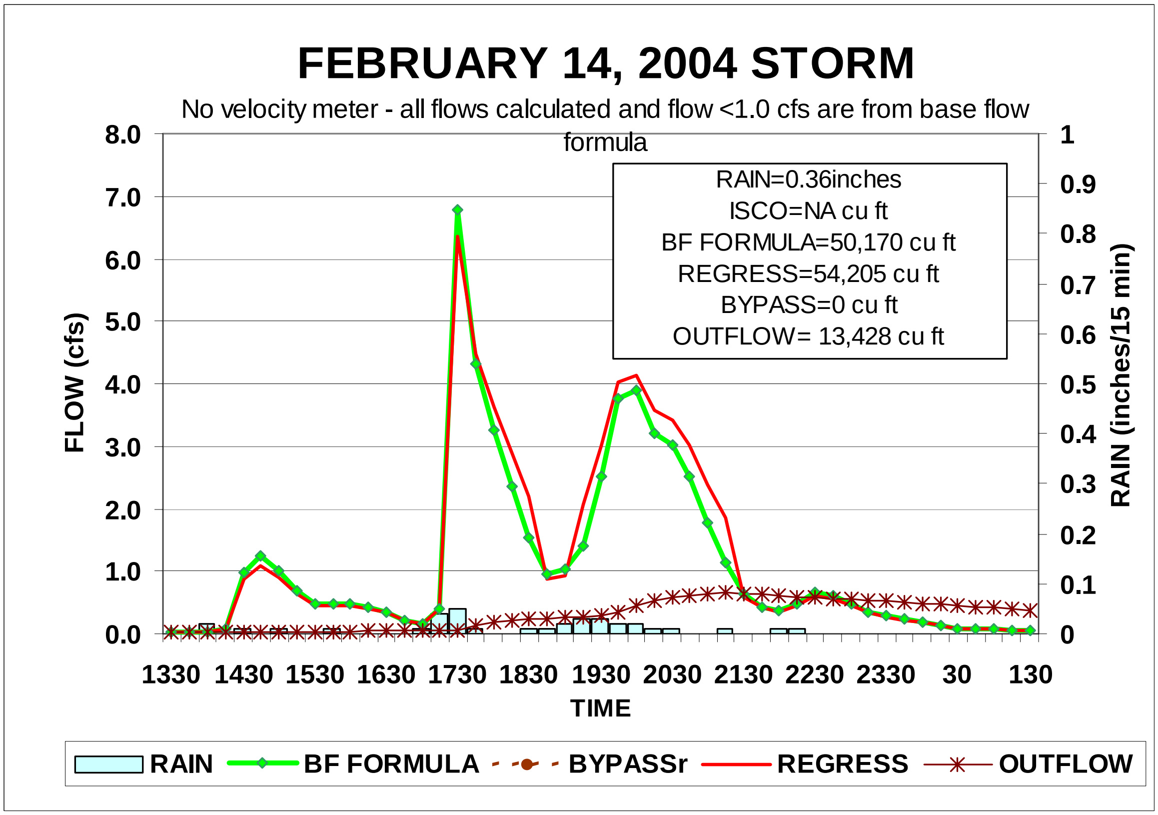

JANUARY 27, 2004
RAIN=1.38 inches
STAR=186,945(95,859) cu ft
BF FORMULA=172,445(81,359) cu ft
REGRESSION=187,977(96,891) cu ft
BYPASS=127,054 cu ft
OUTFLOW=127,145 cu ft
cfs
35
30
25
20
15
10
5
0
1
0.8
0.6
0.4
0.2
0
130
230
330
430
530
630
730
830
930
1030
1130
1230
RAIN
STAR
BF FORMULA
REGRESSION
BYPASS
OUTFLOW


JANUARY 30-31, 2004
RAIN=0.31 inches
ISCO=38,503cu ft
BF FORMULA=40,481 cu ft
BYPASS=0 cu ft
OUTFLOW=13,946cu ft
cfs
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
0.8
0.6
0.4
0.2
0
1745
1845
1945
2045
2145
2245
2345
45
145
245
345
445
RAIN
ISCO
BF FORMULA
BYPASS
OUTFLOW



JAN 31&FEB1,2004 STORM

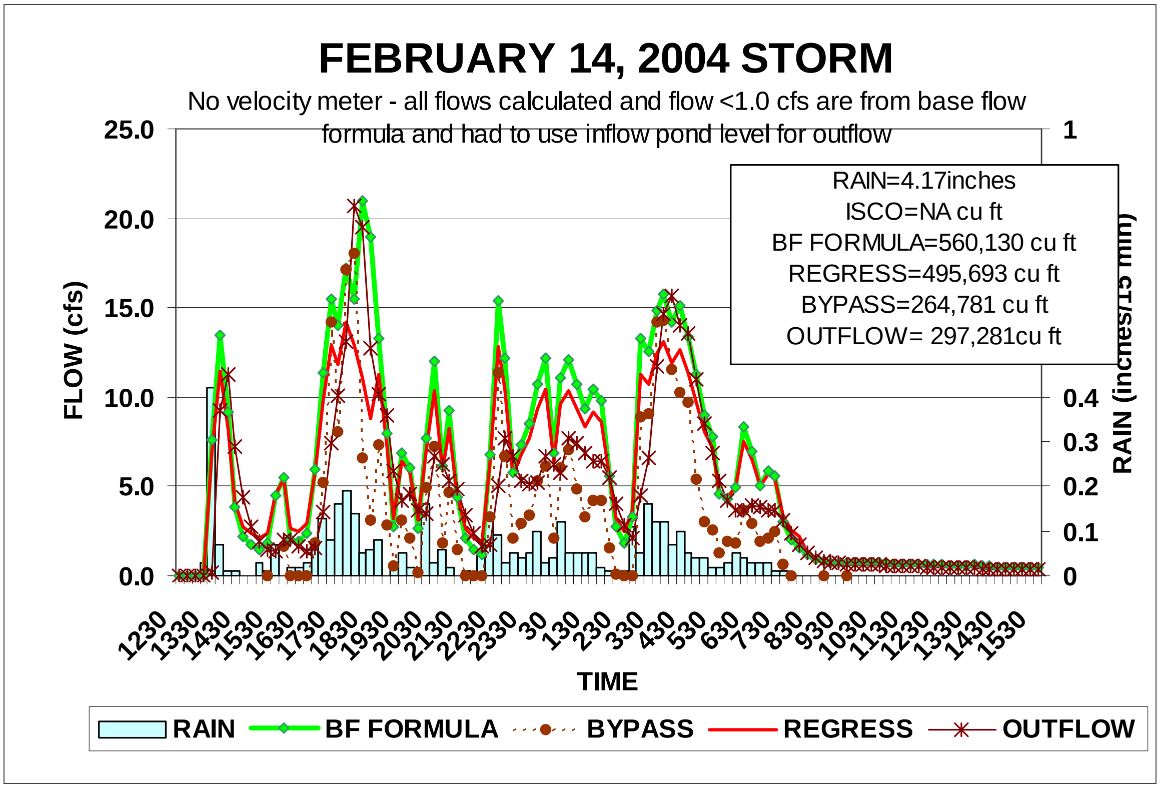
RAIN=0.64inches
ISCO=97,821cu ft
BF FORMULA=103,404 cu ft
REGRESS=114,471 cu ft
BYPASS=0 cu ft
OUTFLOW=47,549 cu ft

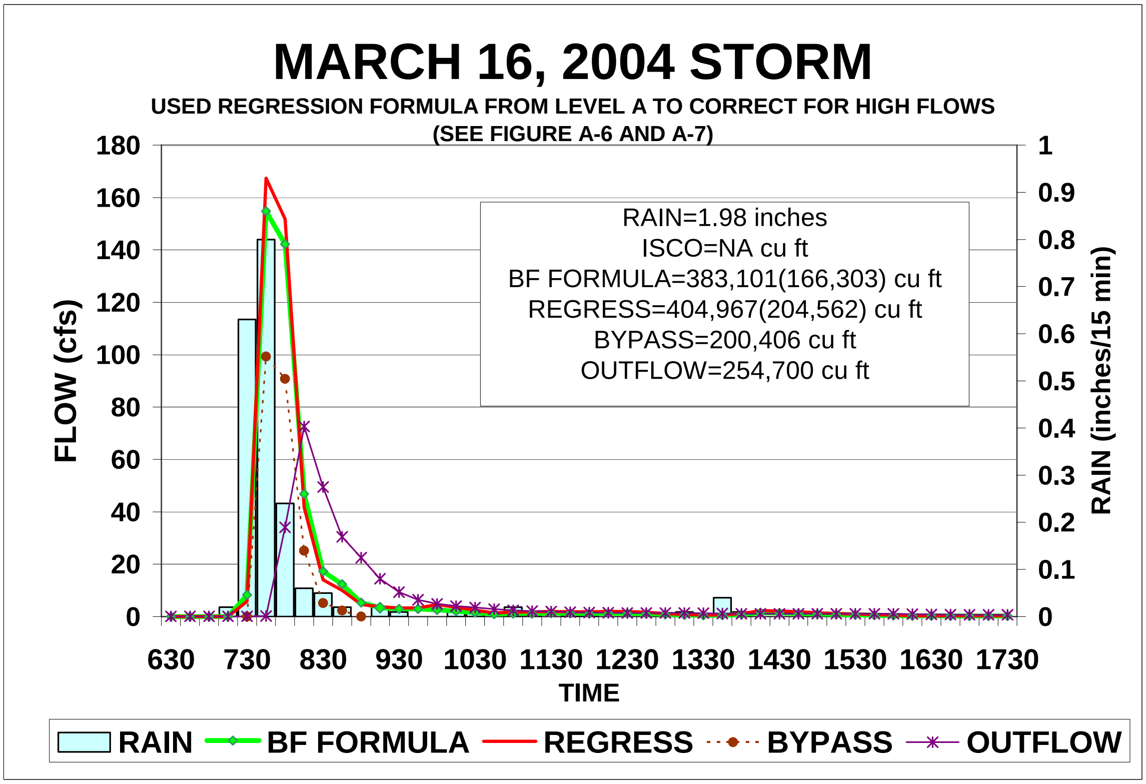


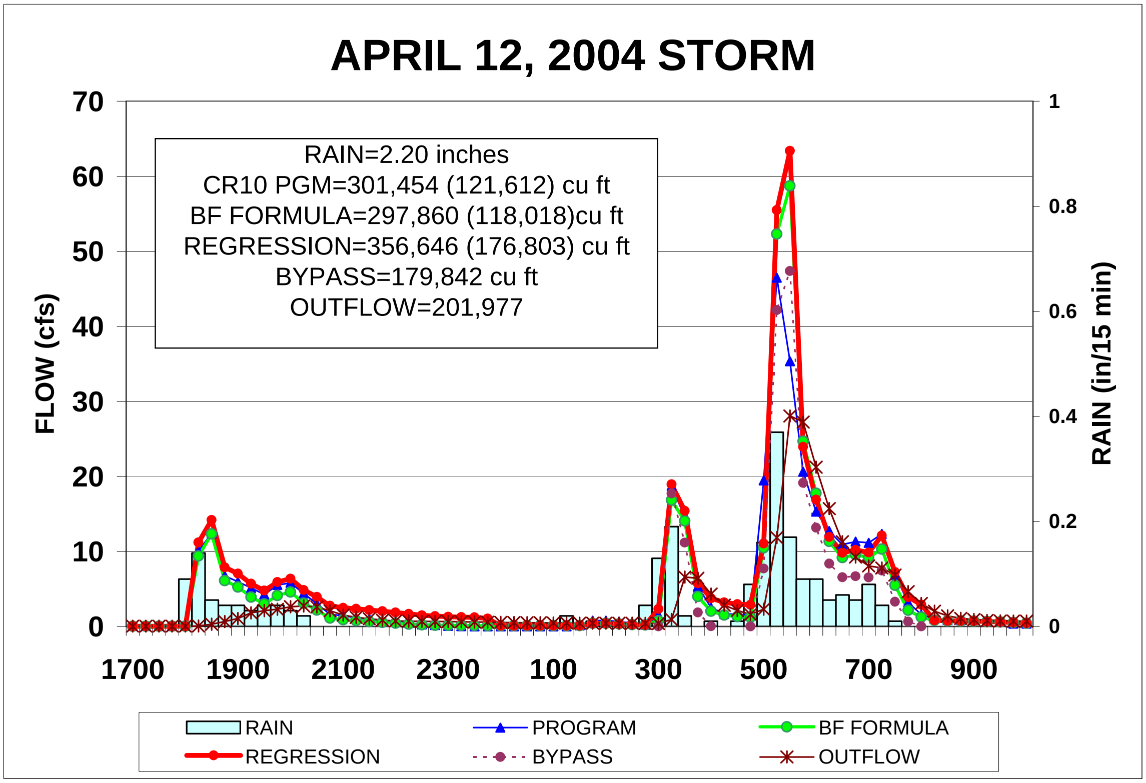
FEBRUARY 14, 2004 STORM

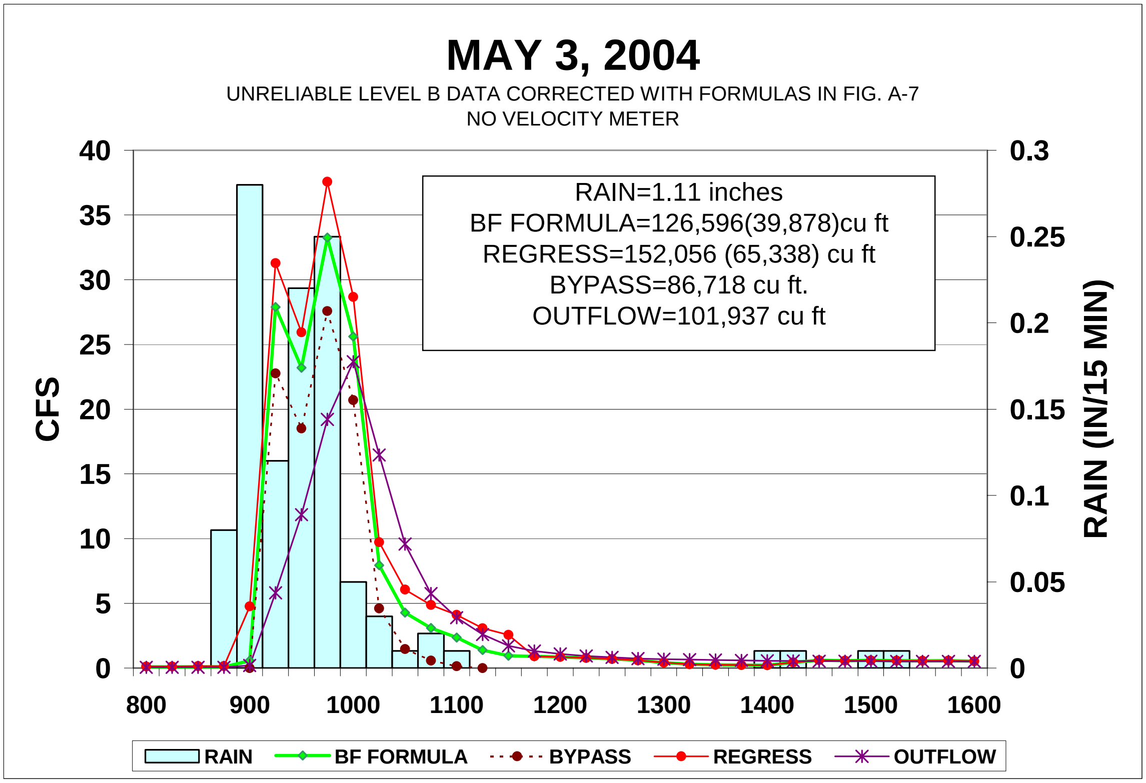
No velocity meter - all flows calculated and flow <1.0 cfs are from base flow formula

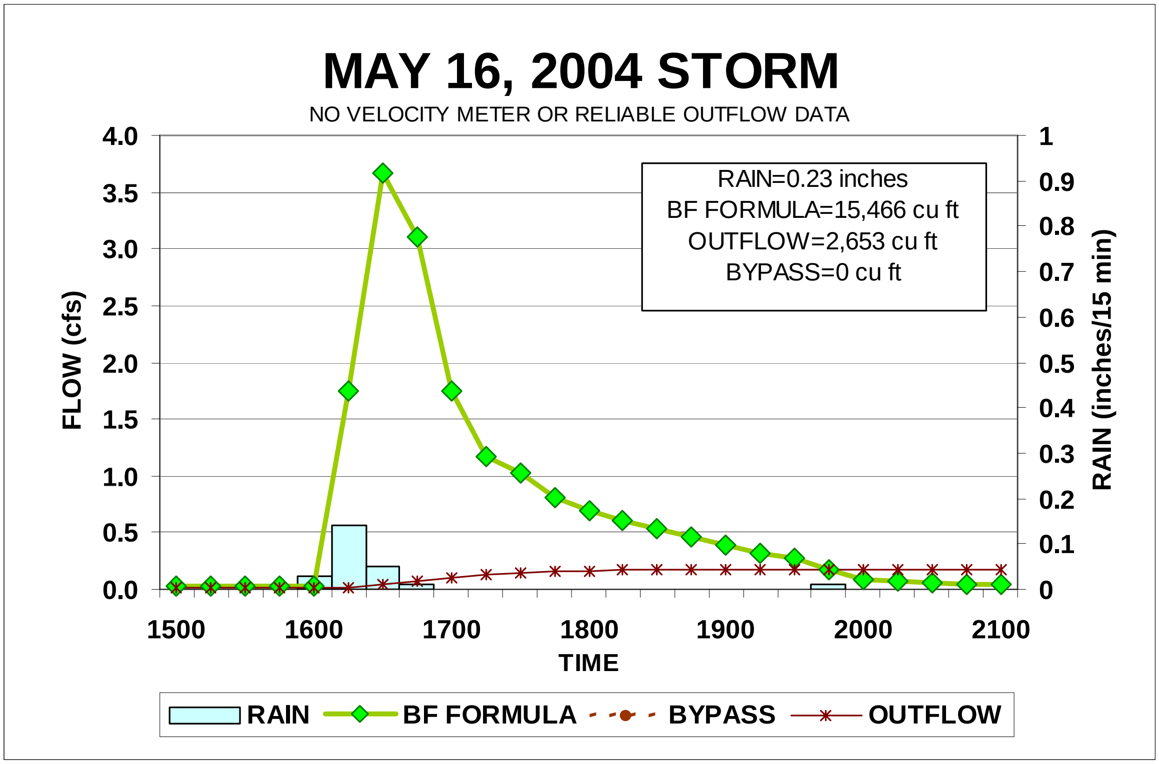
RAIN=0.36inches
ISCO=NA cu ft
BF FORMULA=50,170 cu ft
REGRESS=54,205 cu ft
BYPASS=0 cu ft
OUTFLOW= 13,428 cu ft


FEBRUARY 14, 2004 STORM
No velocity meter - all flows calculated and flow <1.0 cfs are from base flow formula and had to use inflow pond level for outflow
RAIN=4.17inches
ISCO=NA cu ft
BF FORMULA=560,130 cu ft
REGRESS=495,693 cu ft
BYPASS=264,781 cu ft
OUTFLOW= 297,281cu ft
FLOW (cfs)
25.0
20.0
15.0
10.0
5.0
0.0
RAIN (inches/15 min)
1
0.4
0.3
0.2
0.1
0
1230
1330
1430
1530
1630
1730
1830
1930
2030
2130
2230
2330
30
130
230
330
430
530
630
730
830
930
1030
1130
1230
1330
1430
1530
TIME
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

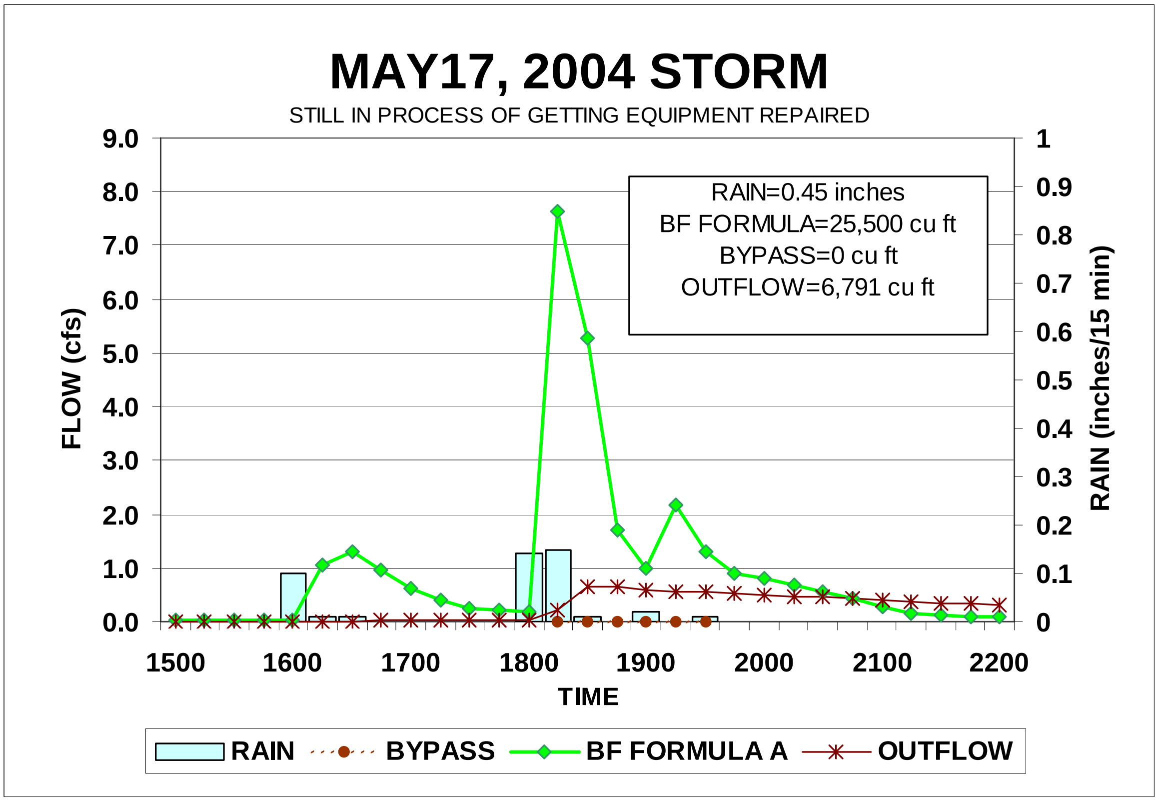

MARCH 16, 2004 STORM
USED REGRESSION FORMULA FROM LEVEL A TO CORRECT FOR HIGH FLOWS (SEE FIGURE A-6 AND A-7)
RAIN=1.98 inches
ISCO=NA cu ft
BF FORMULA=383,101(166,303) cu ft
REGRESS=404,967(204,562) cu ft
BYPASS=200,406 cu ft
OUTFLOW=254,700 cu ft
FLOW (cfs)
180
160
140
120
100
80
60
40
20
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
630
730
830
930
1030
1130
1230
1330
1430
1530
1630
1730
TIME
RAIN
BF FORMULA
REGRESS
BYPASS
OUTFLOW


APRIL 12, 2004 STORM
RAIN=2.20 inches
CR10 PGM=301,454 (121,612) cu ft
BF FORMULA=297,860 (118,018)cu ft
REGRESSION=356,646 (176,803) cu ft
BYPASS=179,842 cu ft
OUTFLOW=201,977
FLOW (cfs)
RAIN (in/15 min)
70
60
50
40
30
20
10
0
1
0.8
0.6
0.4
0.2
0
1700
1900
2100
2300
100
300
500
700
900
RAIN
PROGRAM
BF FORMULA
REGRESSION
BYPASS
OUTFLOW

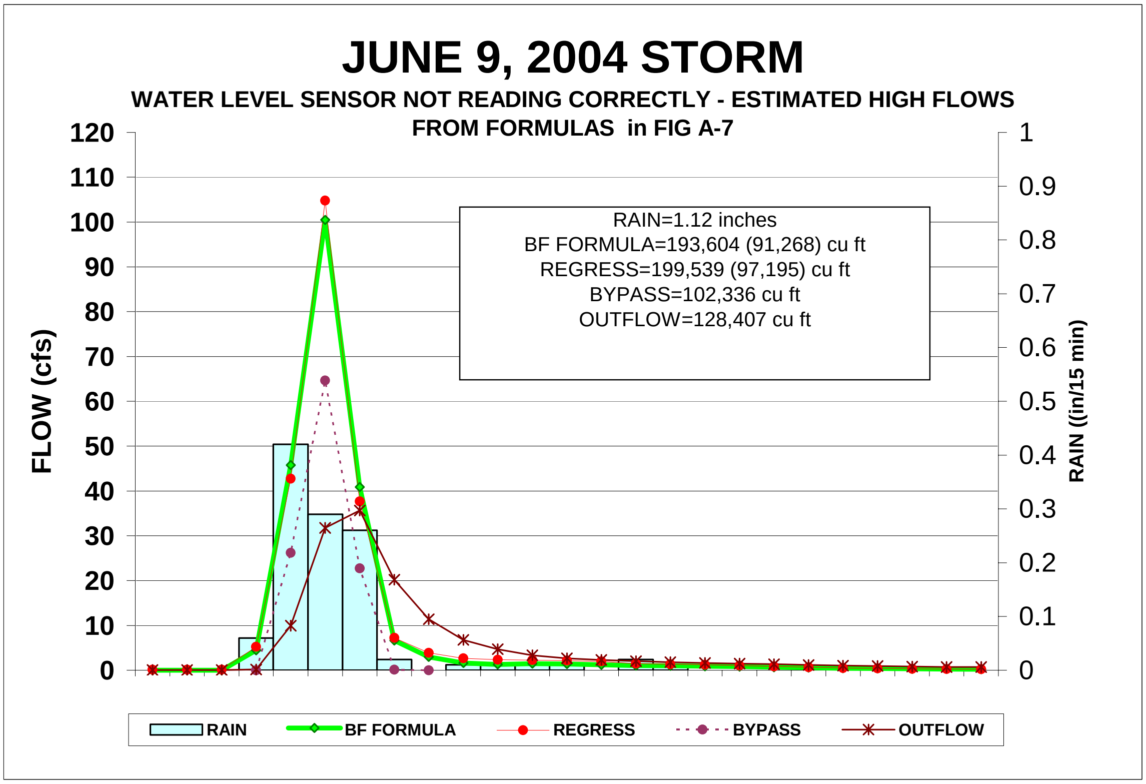

MAY 3, 2004
UNRELIABLE LEVEL B DATA CORRECTED WITH FORMULAS IN FIG. A-7
NO VELOCITY METER
RAIN=1.11 inches
BF FORMULA=126,596(39,878)cu ft
REGRESS=152,056 (65,338) cu ft
BYPASS=86,718 cu ft.
OUTFLOW=101,937 cu ft
CFS
RAIN (IN/15 MIN)
40
35
30
25
20
15
10
5
0
0.3
0.25
0.2
0.15
0.1
0.05
0
800
900
1000
1100
1200
1300
1400
1500
1600
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

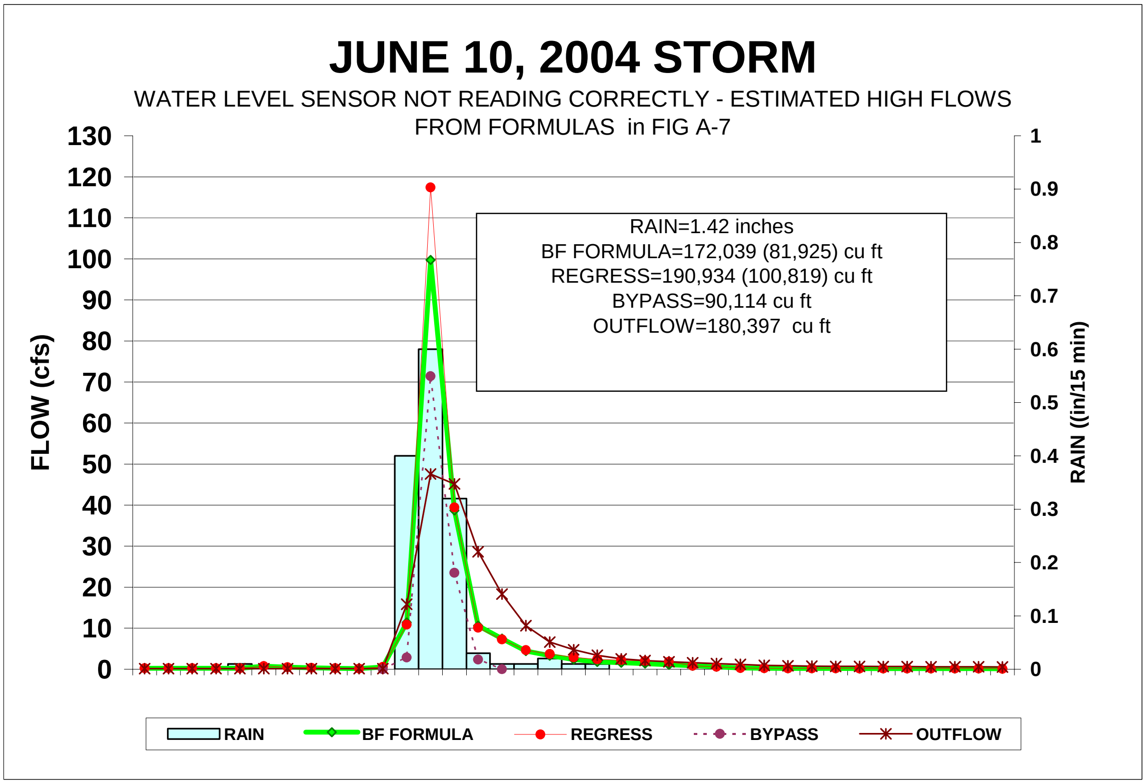

MAY 16, 2004 STORM

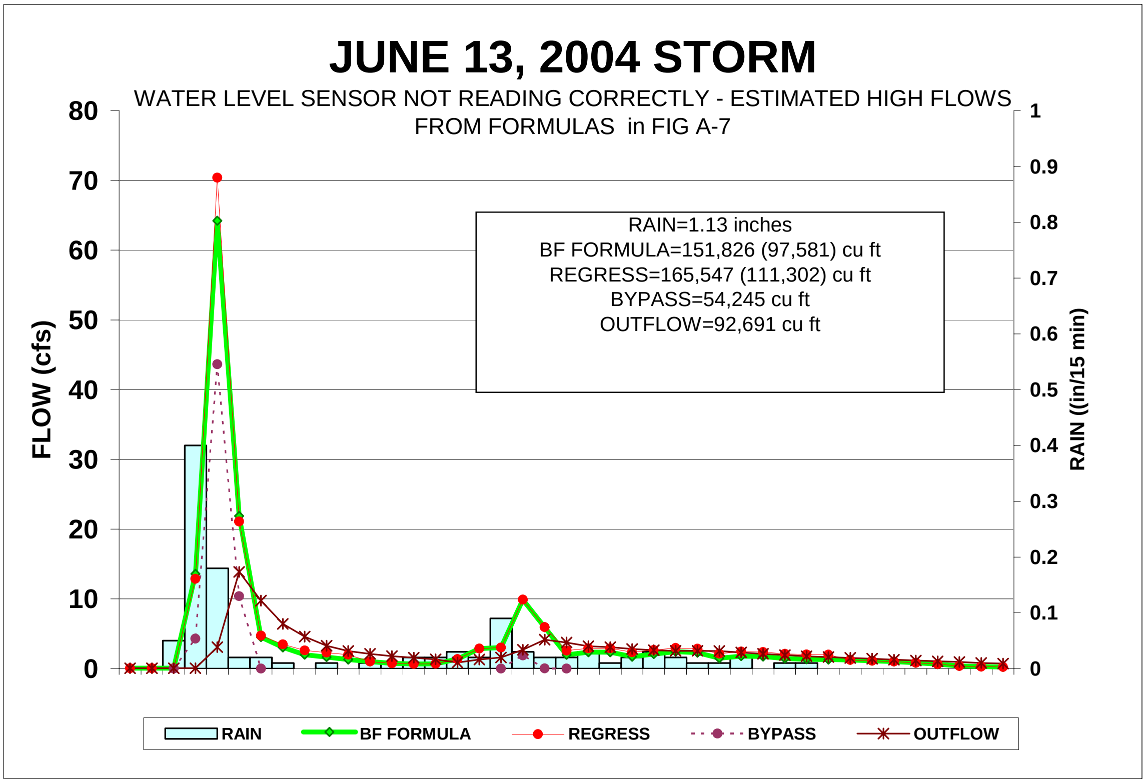
NO VELOCITY METER OR RELIABLE OUTFLOW DATA

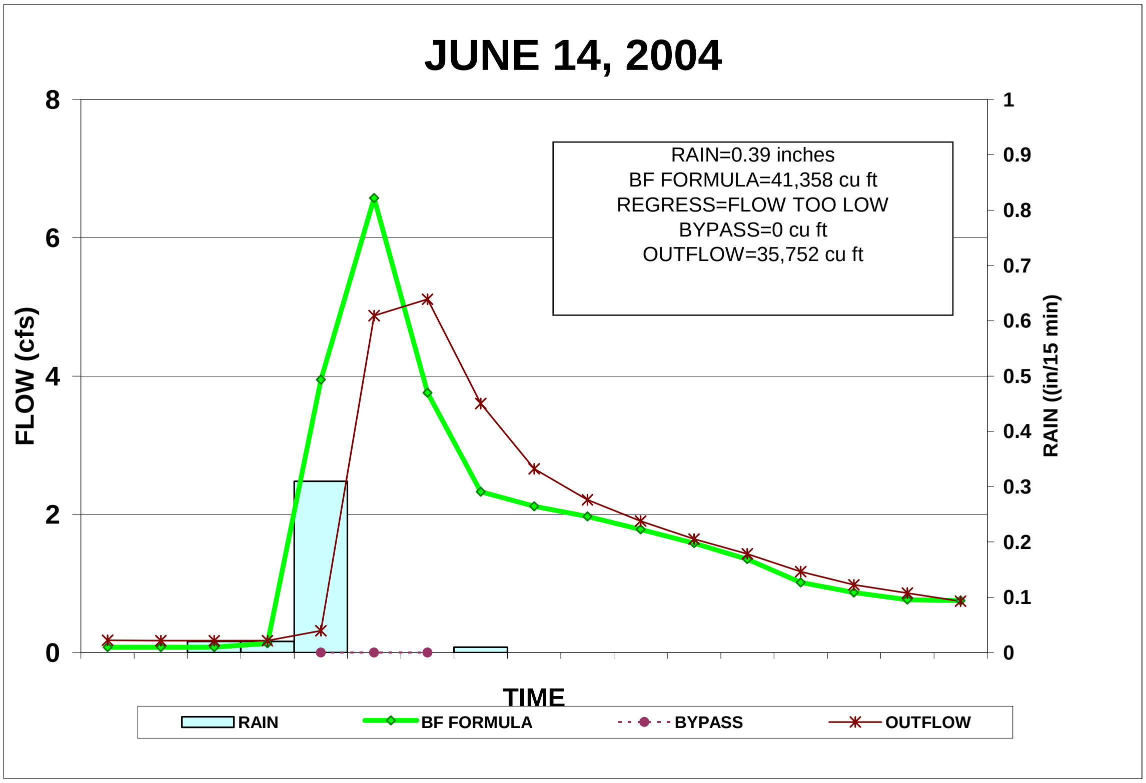

MAY17, 2004 STORM

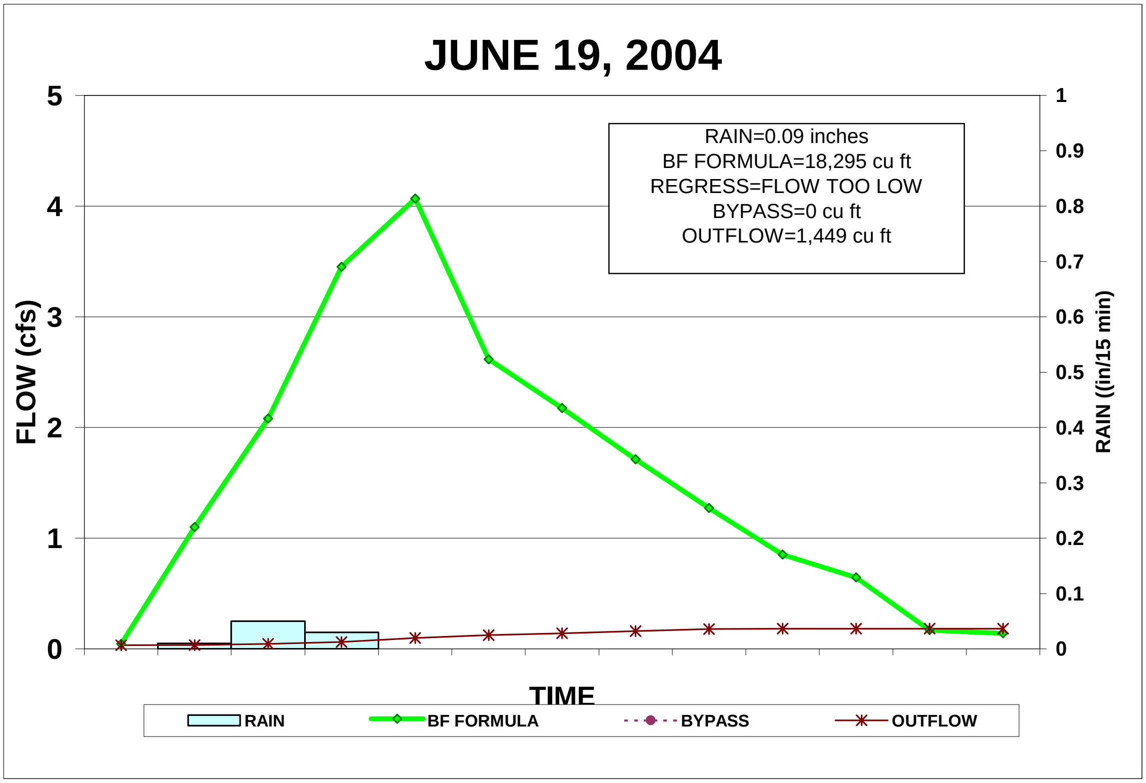
STILL IN PROCESS OF GETTING EQUIPMENT REPAIRED


JUNE 9, 2004 STORM
WATER LEVEL SENSOR NOT READING CORRECTLY - ESTIMATED HIGH FLOWS FROM FORMULAS in FIG A-7
RAIN=1.12 inches
BF FORMULA=193,604 (91,268) cu ft
REGRESS=199,539 (97,195) cu ft
BYPASS=102,336 cu ft
OUTFLOW=128,407 cu ft
FLOW (cfs)
0
10
20
30
40
50
60
70
80
90
100
110
120
RAIN ((in/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
RAIN
BF FORMULA
REGRESS
BYPASS
OUTFLOW

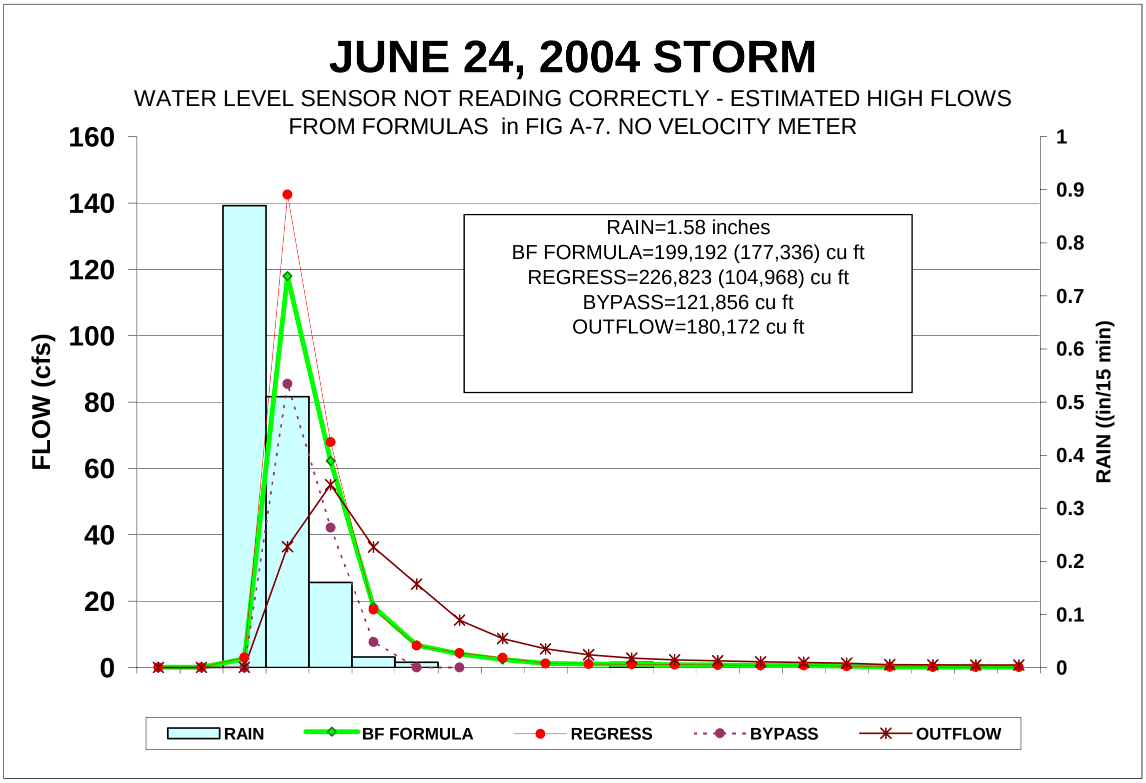

JUNE 10, 2004 STORM
WATER LEVEL SENSOR NOT READING CORRECTLY - ESTIMATED HIGH FLOWS FROM FORMULAS in FIG A-7
RAIN=1.42 inches
BF FORMULA=172,039 (81,925) cu ft
REGRESS=190,934 (100,819) cu ft
BYPASS=90,114 cu ft
OUTFLOW=180,397 cu ft
FLOW (cfs)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
RAIN ((in/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
RAIN
BF FORMULA
REGRESS
BYPASS
OUTFLOW


JUNE 13, 2004 STORM
WATER LEVEL SENSOR NOT READING CORRECTLY - ESTIMATED HIGH FLOWS FROM FORMULAS in FIG A-7
RAIN=1.13 inches
BF FORMULA=151,826 (97,581) cu ft
REGRESS=165,547 (111,302) cu ft
BYPASS=54,245 cu ft
OUTFLOW=92,691 cu ft
FLOW (cfs)
0
10
20
30
40
50
60
70
80
RAIN ((in/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
RAIN
BF FORMULA
REGRESS
BYPASS
OUTFLOW


JUNE 14, 2004
RAIN=0.39 inches
BF FORMULA=41,358 cu ft
REGRESS=FLOW TOO LOW
BYPASS=0 cu ft
OUTFLOW=35,752 cu ft
FLOW (cfs)
0
2
4
6
8
RAIN ((in/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
TIME
RAIN
BF FORMULA
BYPASS
OUTFLOW

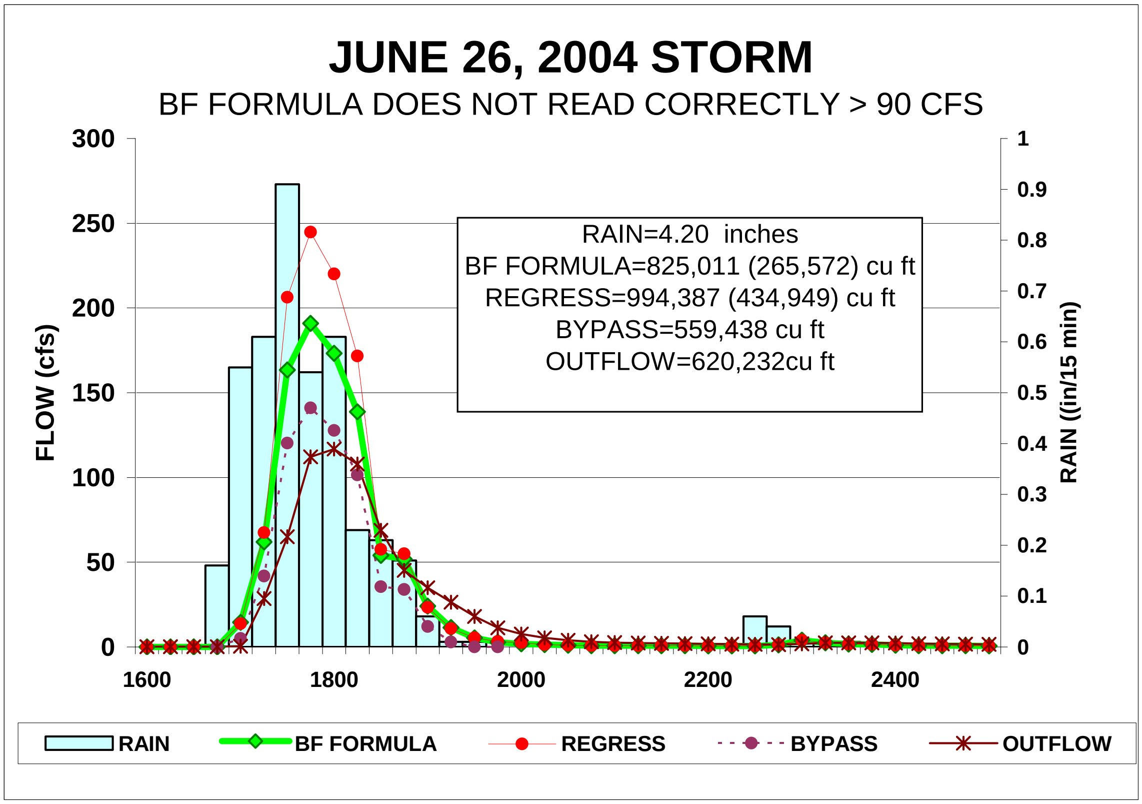

JUNE 19, 2004

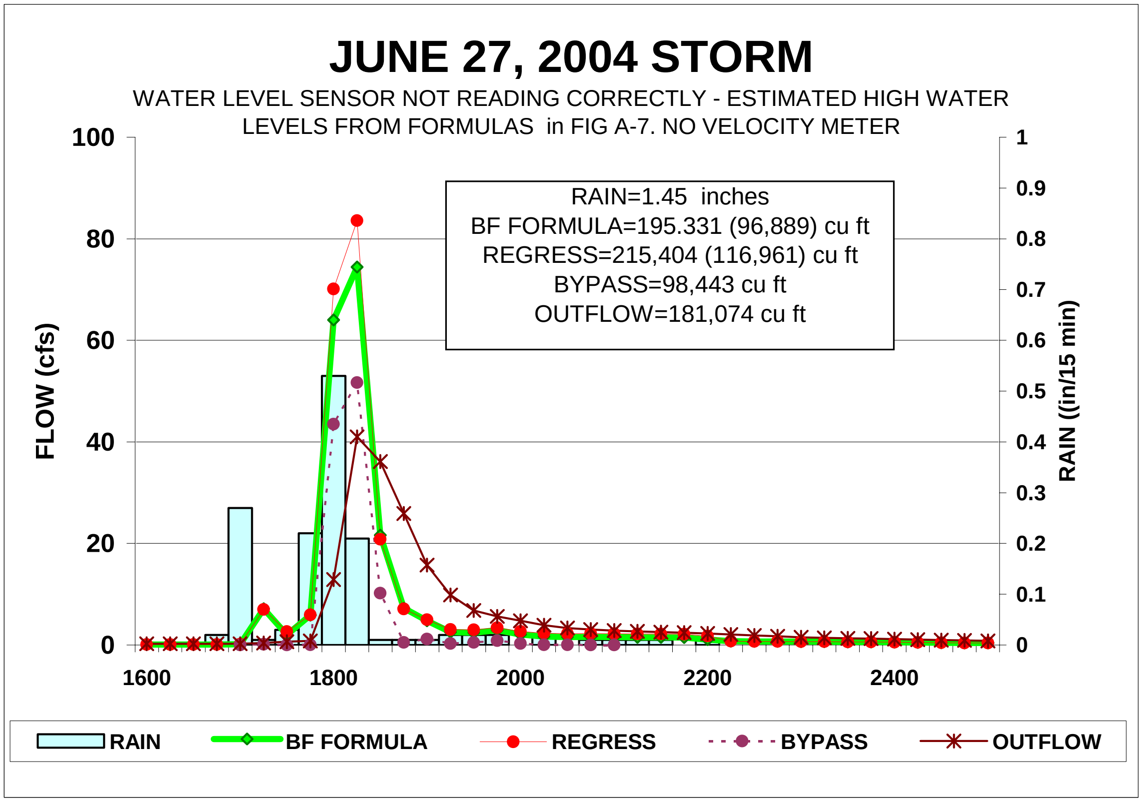
RAIN=0.09 inches
BF FORMULA=18,295 cu ft
REGRESS=FLOW TOO LOW
BYPASS=0 cu ft
OUTFLOW=1,449 cu ft

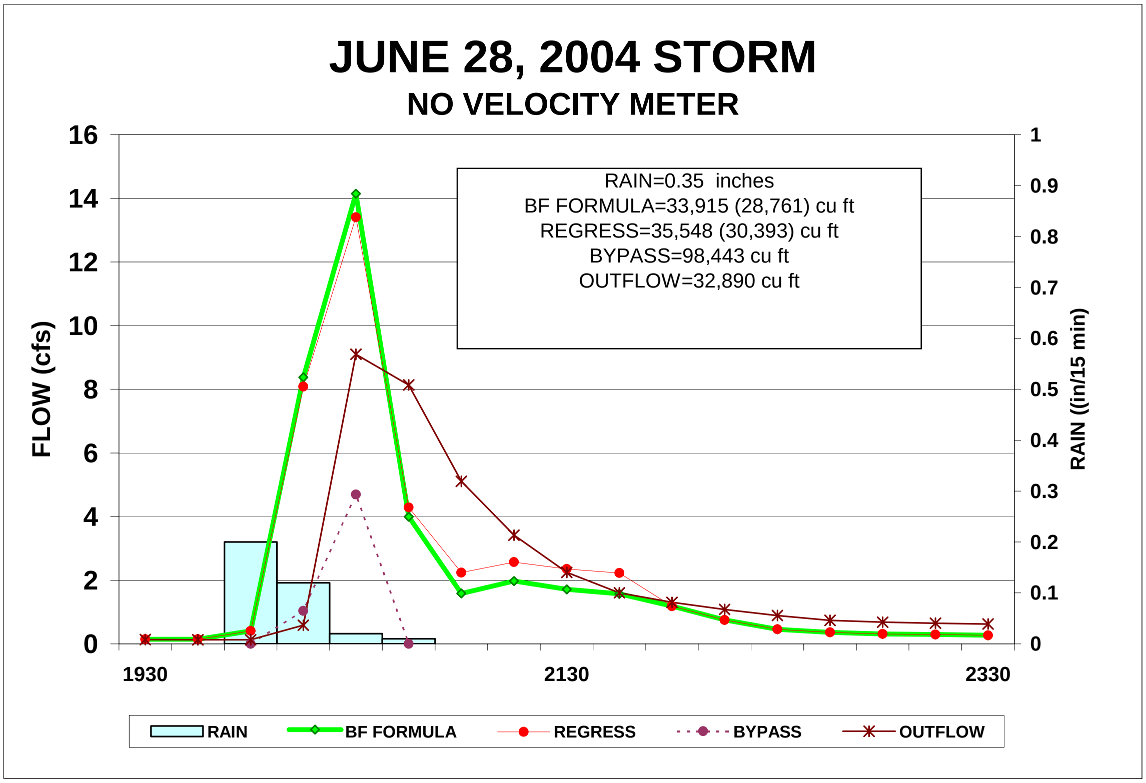

JUNE 24, 2004 STORM

WATER LEVEL SENSOR NOT READING CORRECTLY - ESTIMATED HIGH FLOWS FROM FORMULAS in FIG A-7. NO VELOCITY METER

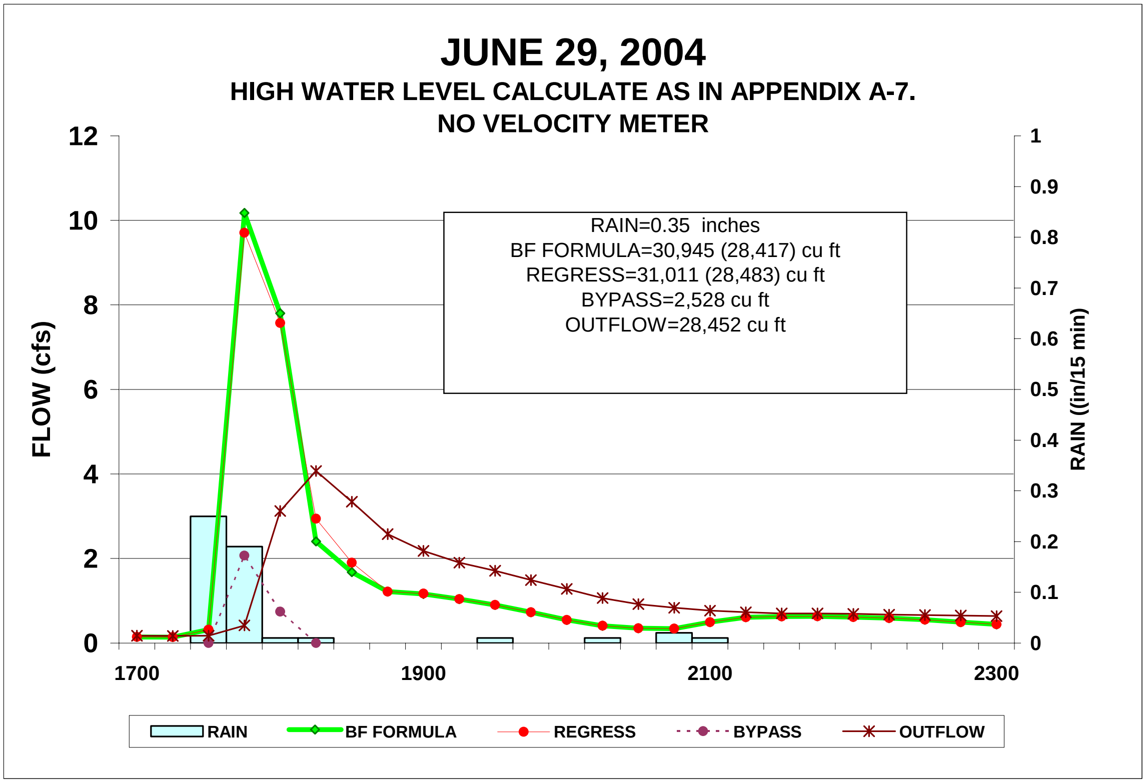
RAIN=1.58 inches
BF FORMULA=199,192 (177,336) cu ft
REGRESS=226,823 (104,968) cu ft
BYPASS=121,856 cu ft
OUTFLOW=180,172 cu ft


JUNE 26, 2004 STORM
BF FORMULA DOES NOT READ CORRECTLY > 90 CFS
RAIN=4.20 inches
BF FORMULA=825,011 (265,572) cu ft
REGRESS=994,387 (434,949) cu ft
BYPASS=559,438 cu ft
OUTFLOW=620,232cu ft
FLOW (cfs)
RAIN ((in/15 min)
300
250
200
150
100
50
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1600
1800
2000
2200
2400
RAIN
BF FORMULA
REGRESS
BYPASS
OUTFLOW

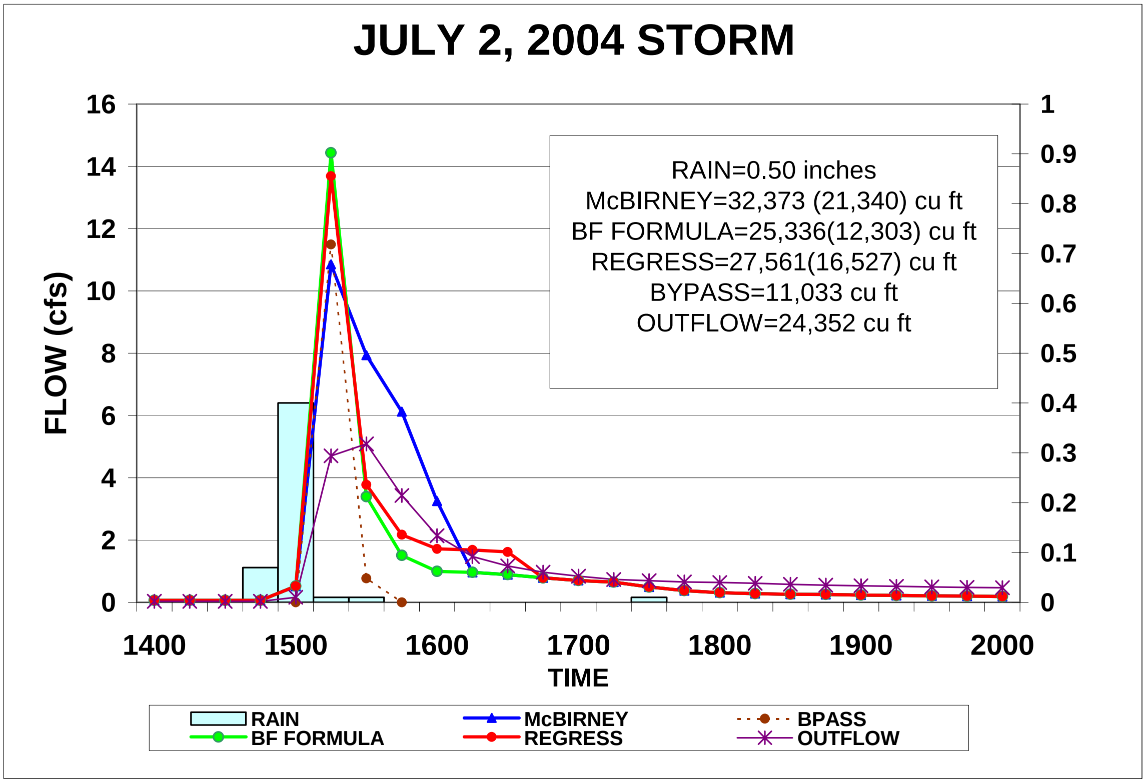

JUNE 27, 2004 STORM
WATER LEVEL SENSOR NOT READING CORRECTLY - ESTIMATED HIGH WATER LEVELS FROM FORMULAS in FIG A-7. NO VELOCITY METER
RAIN=1.45 inches
BF FORMULA=195.331 (96,889) cu ft
REGRESS=215,404 (116,961) cu ft
BYPASS=98,443 cu ft
OUTFLOW=181,074 cu ft
FLOW (cfs)
RAIN ((in/15 min)
100
80
60
40
20
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1600
1800
2000
2200
2400
RAIN
BF FORMULA
REGRESS
BYPASS
OUTFLOW



RAIN=0.35 inches
BF FORMULA=33,915 (28,761) cu ft
REGRESS=35,548 (30,393) cu ft
BYPASS=98,443 cu ft
OUTFLOW=32,890 cu ft

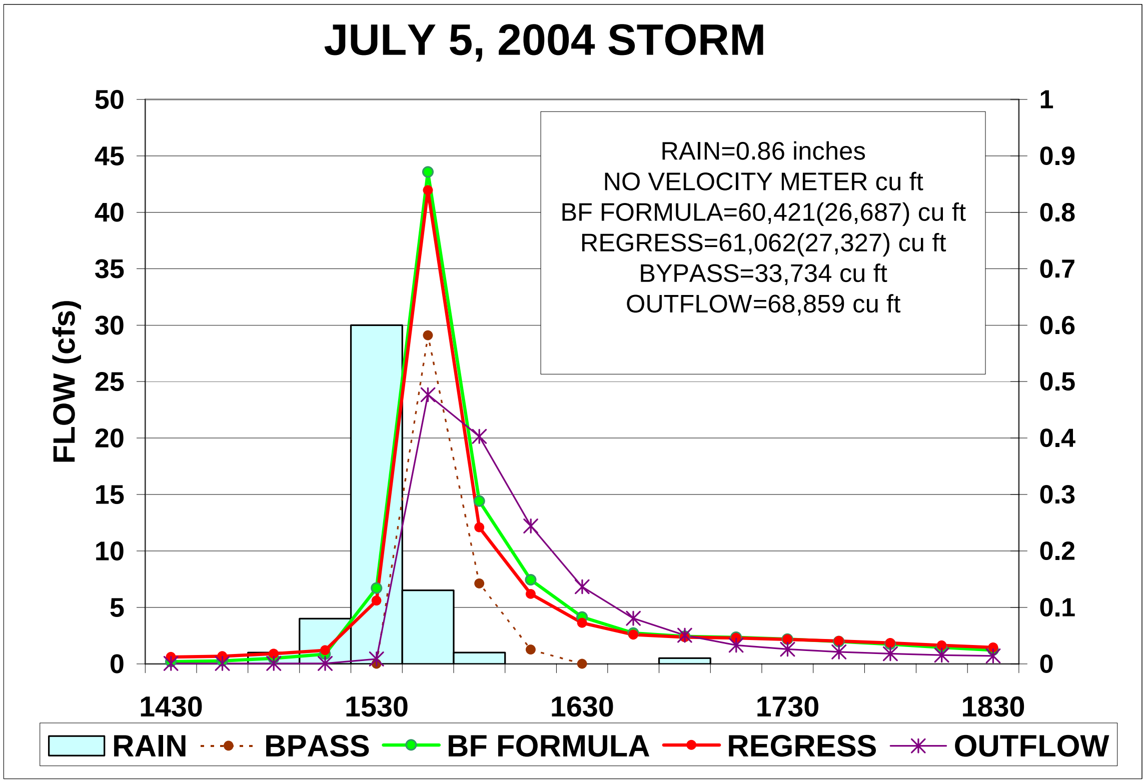


RAIN=0.35 inches
BF FORMULA=30,945 (28,417) cu ft
REGRESS=31,011 (28,483) cu ft
BYPASS=2,528 cu ft
OUTFLOW=28,452 cu ft



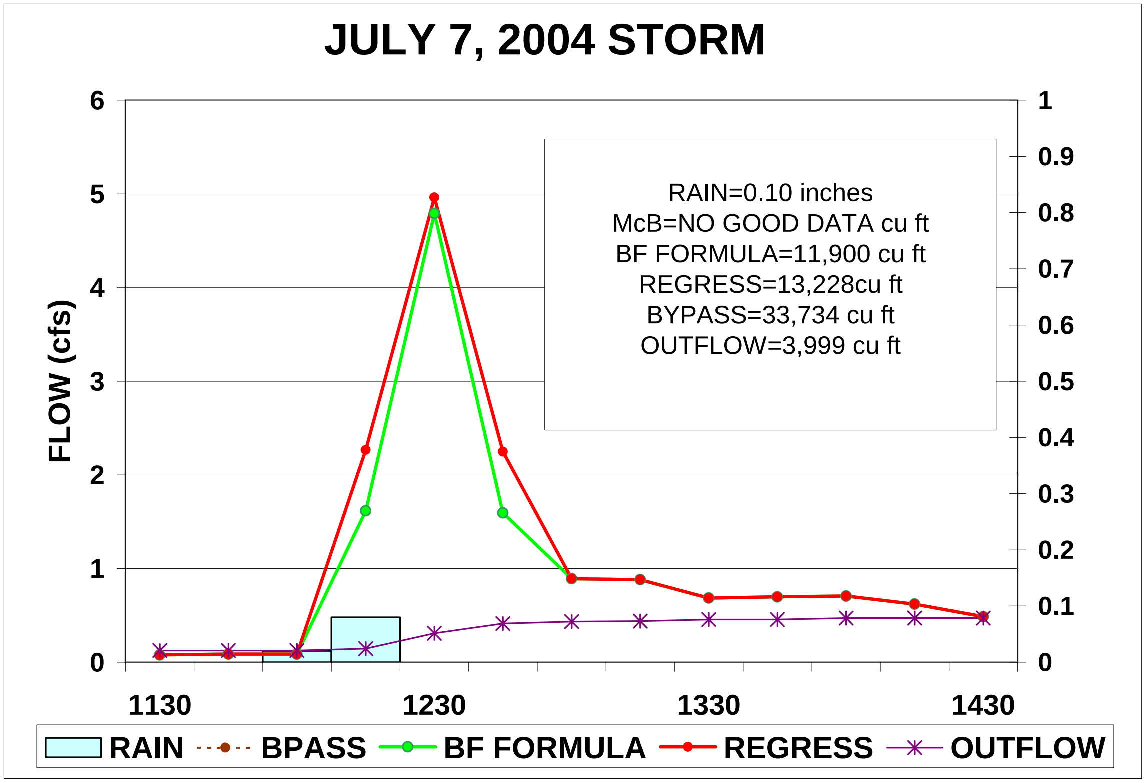
JULY 2, 2004 STORM

RAIN=0.50 inches
McBIRNEY=32,373 (21,340) cu ft
BF FORMULA=25,336(12,303) cu ft
REGRESS=27,561(16,527) cu ft
BYPASS=11,033 cu ft
OUTFLOW=24,352 cu ft



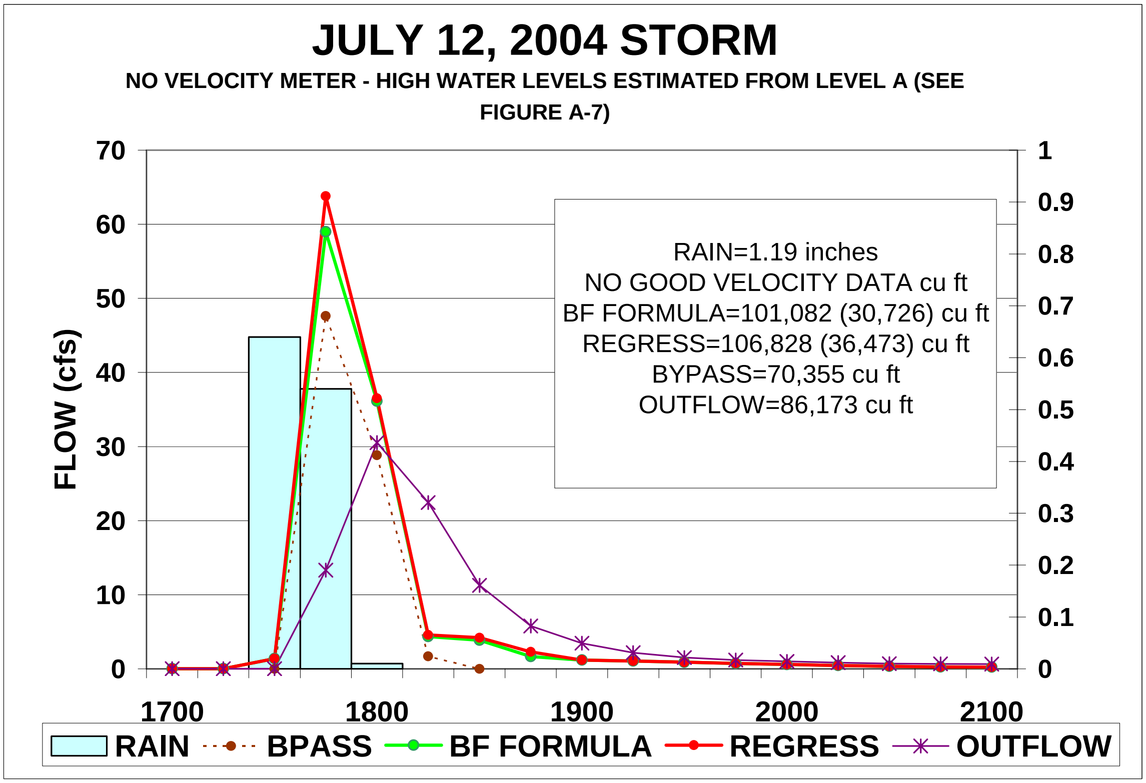
JULY 5, 2004 STORM

RAIN=0.86 inches
NO VELOCITY METER cu ft
BF FORMULA=60,421(26,687) cu ft
REGRESS=61,062(27,327) cu ft
BYPASS=33,734 cu ft
OUTFLOW=68,859 cu ft



JULY 7, 2004 STORM

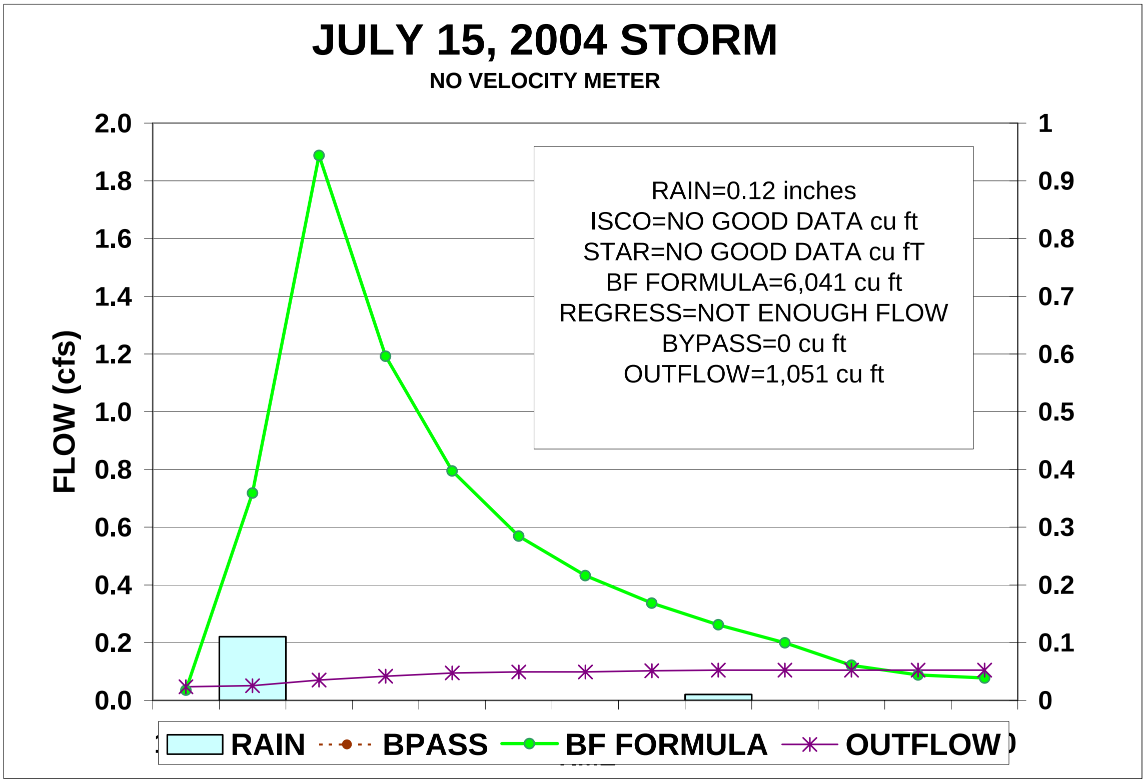
RAIN=0.10 inches
McB=NO GOOD DATA cu ft
BF FORMULA=11,900 cu ft
REGRESS=13,228cu ft
BYPASS=33,734 cu ft
OUTFLOW=3,999 cu ft

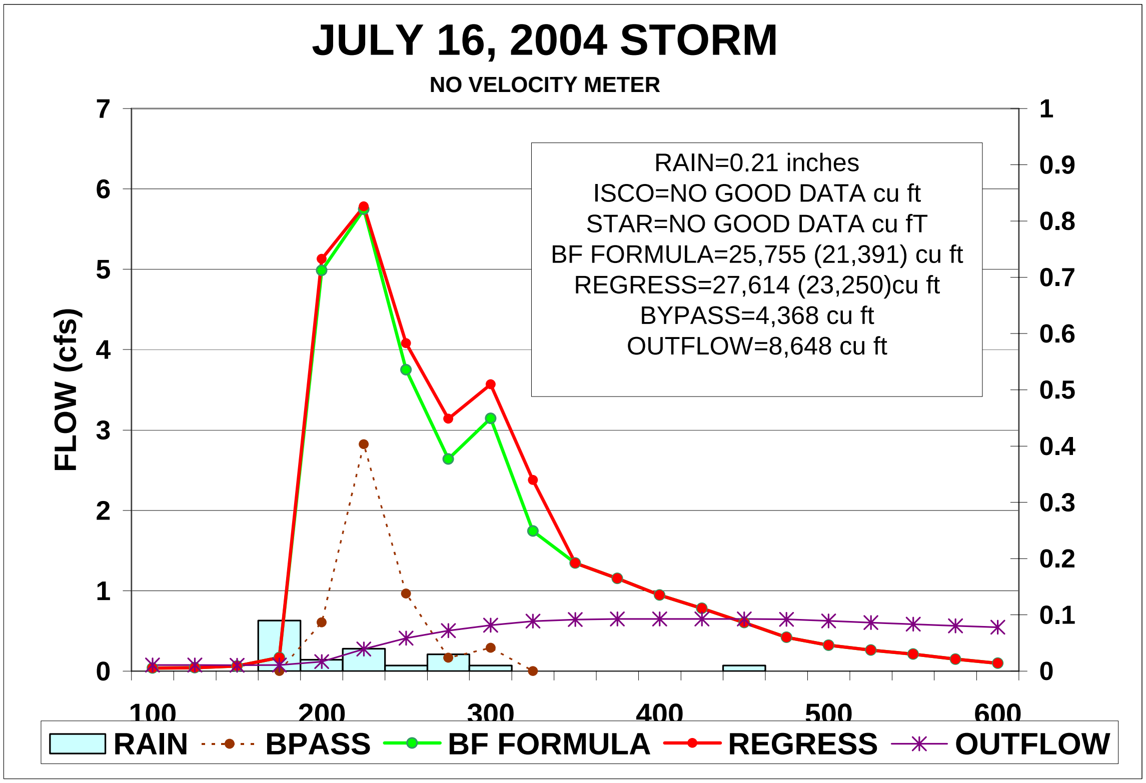


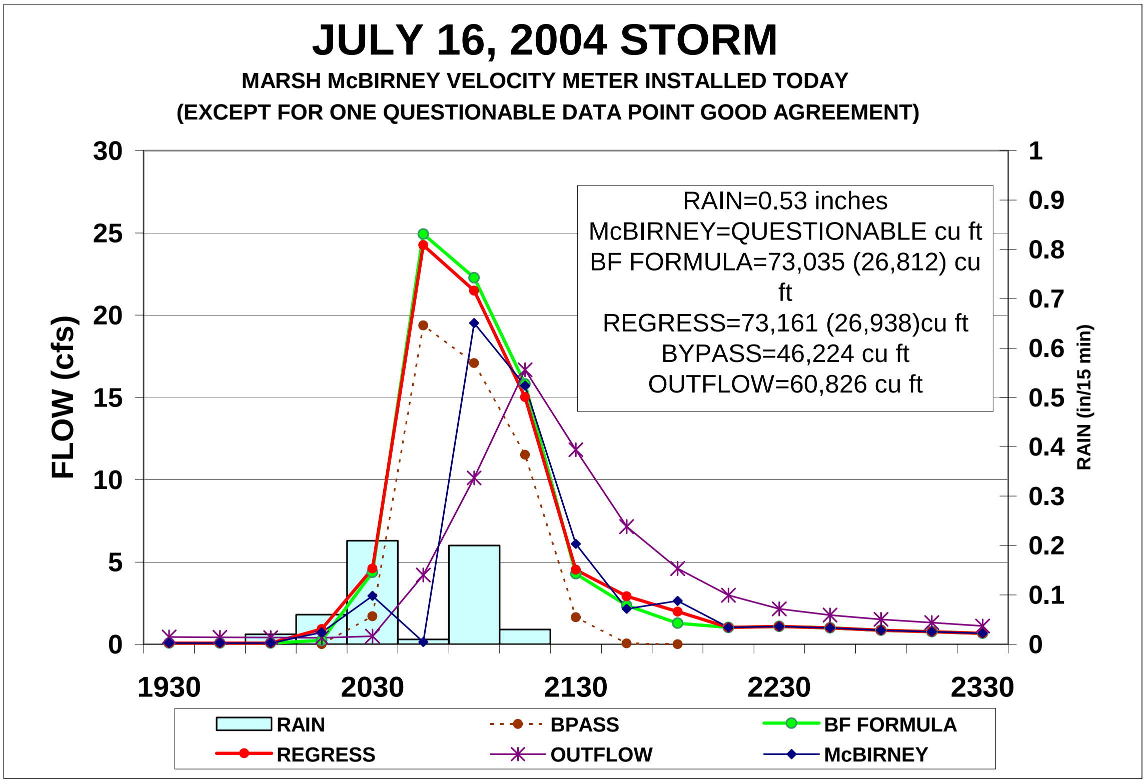
JULY 12, 2004 STORM

NO VELOCITY METER - HIGH WATER LEVELS ESTIMATED FROM LEVEL A (SEE FIGURE A-7)

RAIN=1.19 inches
NO GOOD VELOCITY DATA cu ft
BF FORMULA=101,082 (30,726) cu ft
REGRESS=106,828 (36,473) cu ft
BYPASS=70,355 cu ft
OUTFLOW=86,173 cu ft


JULY 15, 2004 STORM
NO VELOCITY METER
FLOW (cfs)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RAIN=0.12 inches
ISCO=NO GOOD DATA cu ft
STAR=NO GOOD DATA cu fT
BF FORMULA=6,041 cu ft
REGRESS=NOT ENOUGH FLOW
BYPASS=0 cu ft
OUTFLOW=1,051 cu ft
RAIN
BPASS
BF FORMULA
OUTFLOW


JULY 16, 2004 STORM
NO VELOCITY METER
FLOW (cfs)
7
6
5
4
3
2
1
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
100
200
300
400
500
600
RAIN=0.21 inches
ISCO=NO GOOD DATA cu ft
STAR=NO GOOD DATA cu fT
BF FORMULA=25,755 (21,391) cu ft
REGRESS=27,614 (23,250)cu ft
BYPASS=4,368 cu ft
OUTFLOW=8,648 cu ft
RAIN
BPASS
BF FORMULA
REGRESS
OUTFLOW

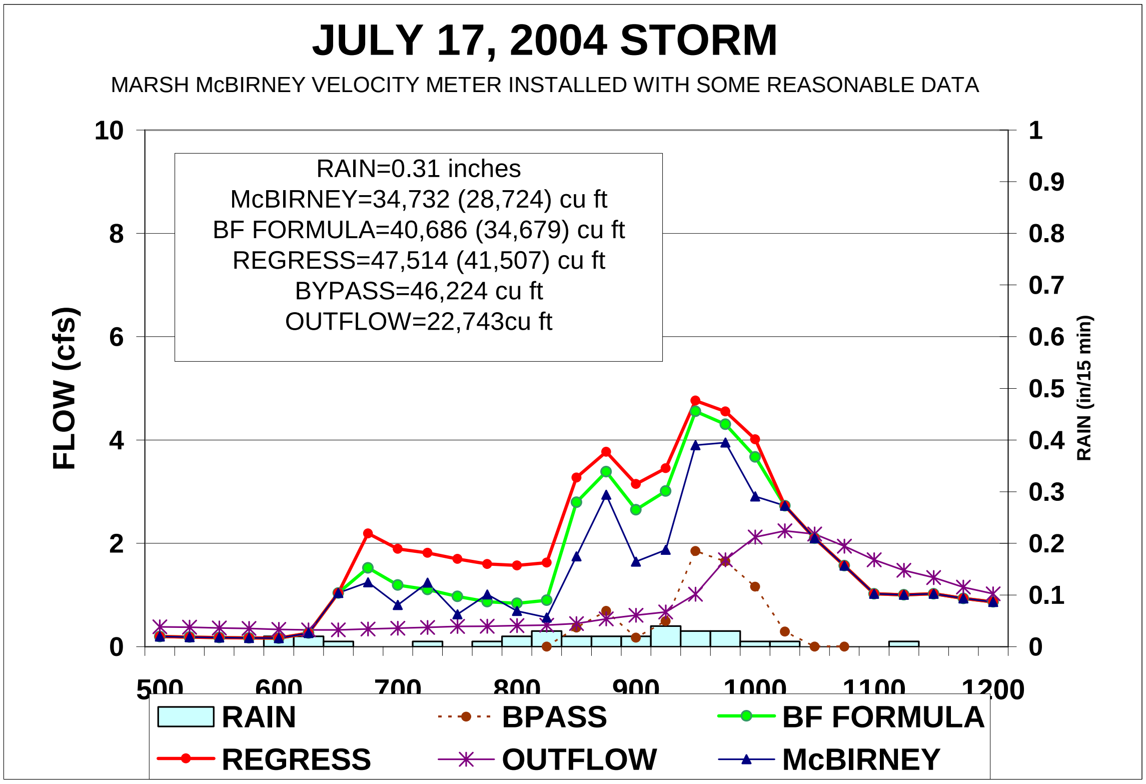


JULY 16, 2004 STORM

MARSH McBIRNEY VELOCITY METER INSTALLED TODAY

(EXCEPT FOR ONE QUESTIONABLE DATA POINT GOOD AGREEMENT)

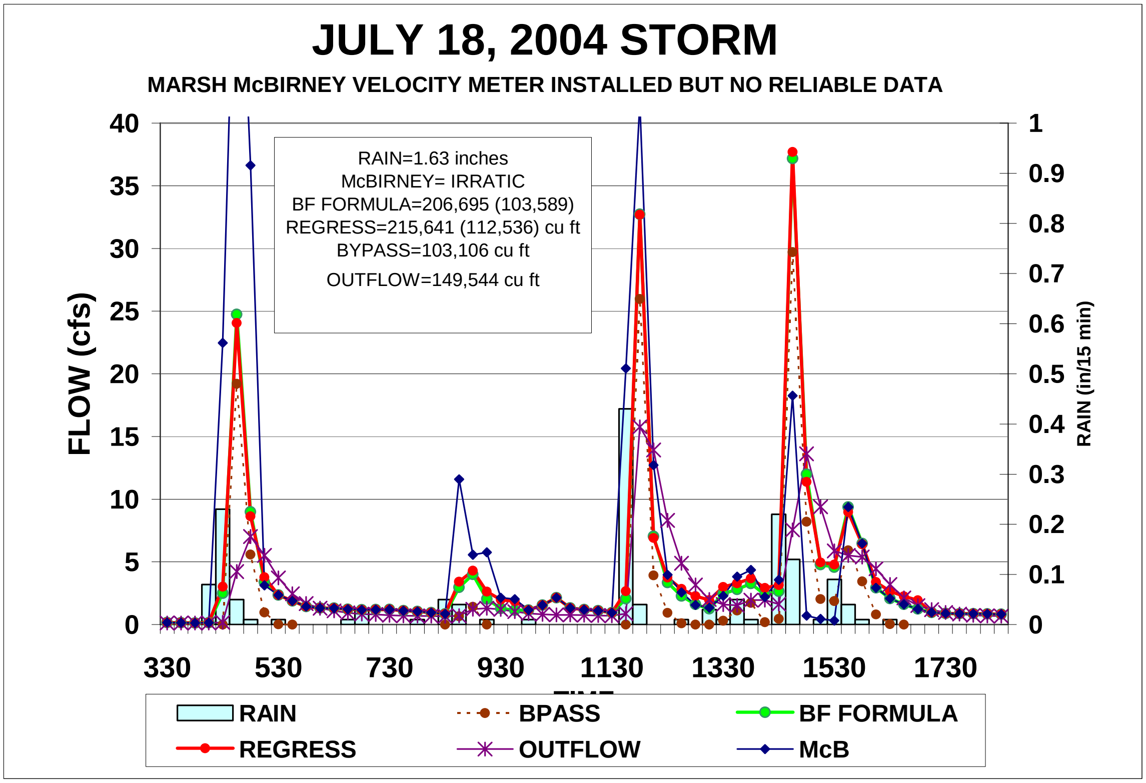
RAIN=0.53 inches
McBIRNEY=QUESTIONABLE cu ft
BF FORMULA=73,035 (26,812) cu ft
REGRESS=73,161 (26,938)cu ft
BYPASS=46,224 cu ft
OUTFLOW=60,826 cu ft

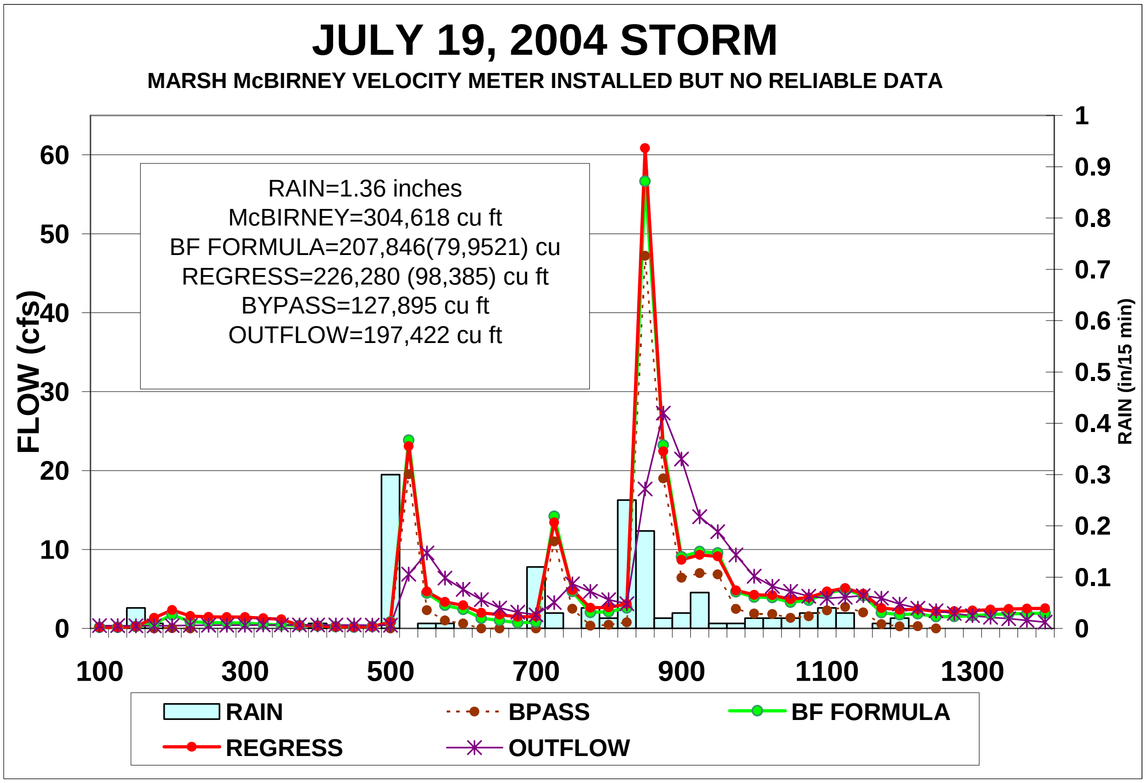


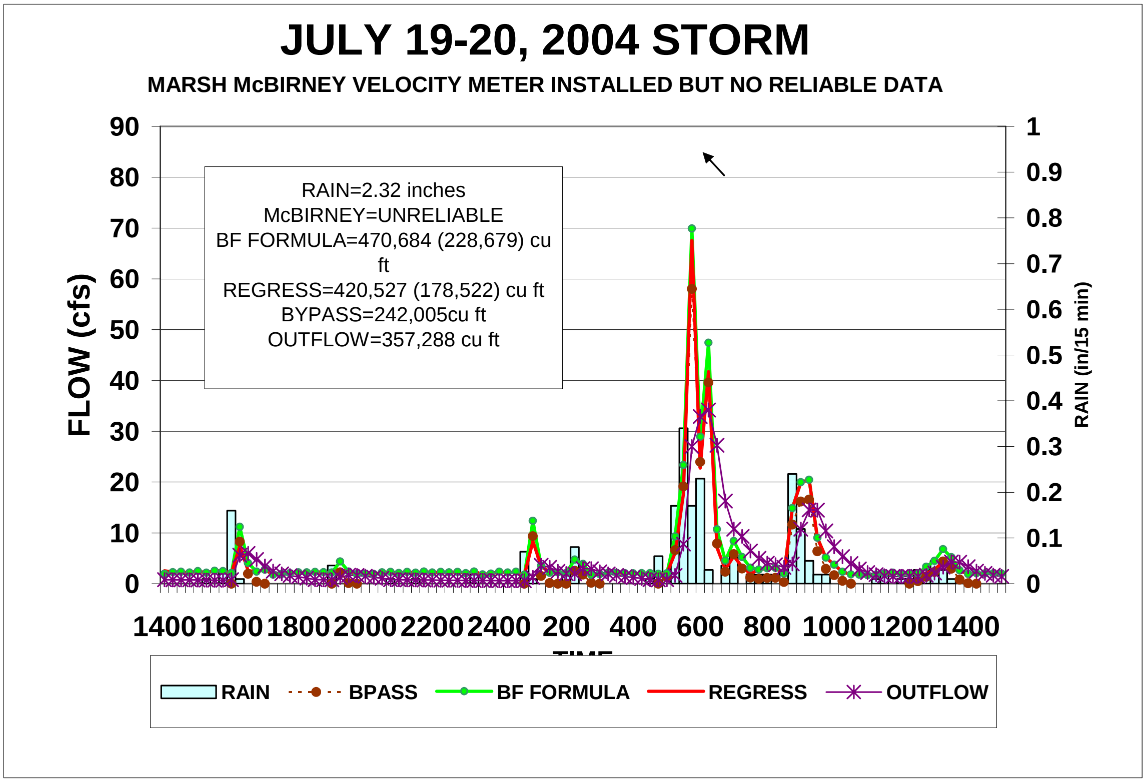
JULY 17, 2004 STORM

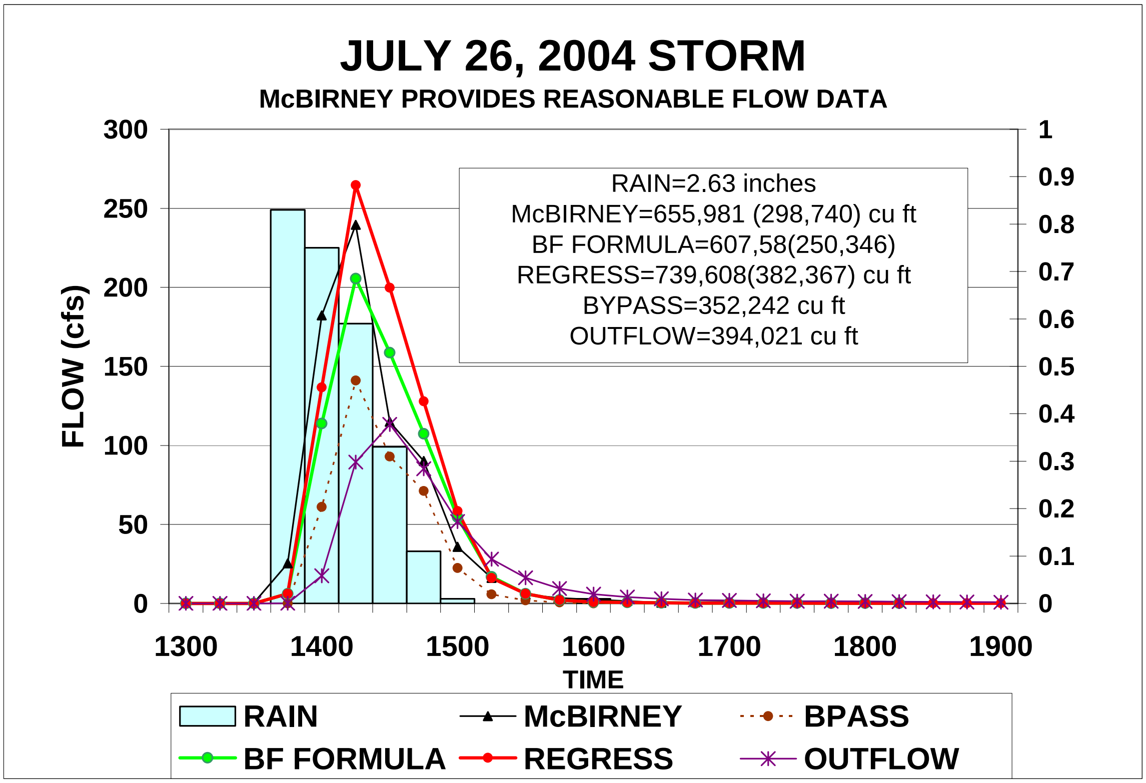
MARSH McBIRNEY VELOCITY METER INSTALLED WITH SOME REASONABLE DATA

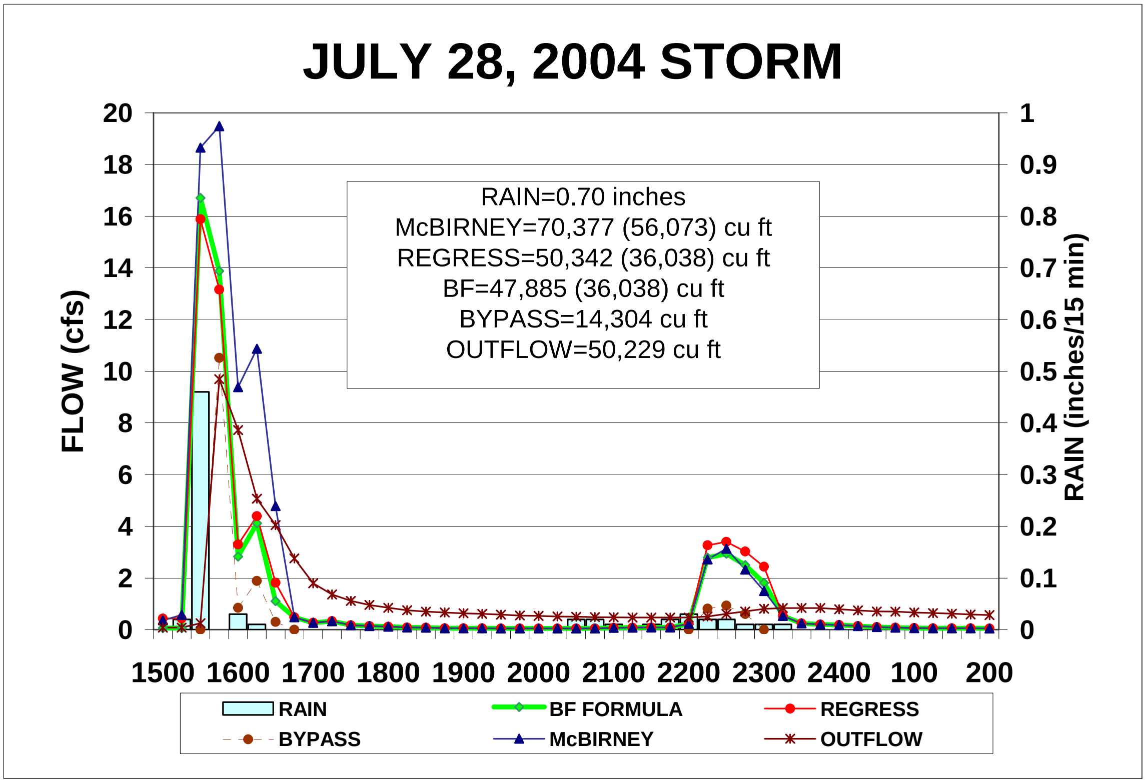
RAIN=0.31 inches
McBIRNEY=34,732 (28,724) cu ft
BF FORMULA=40,686 (34,679) cu ft
REGRESS=47,514 (41,507) cu ft
BYPASS=46,224 cu ft
OUTFLOW=22,743cu ft


JULY 18, 2004 STORM
MARSH McBIRNEY VELOCITY METER INSTALLED BUT NO RELIABLE DATA
RAIN=1.63 inches
McBIRNEY= IRRATIC
BF FORMULA=206,695 (103,589)
REGRESS=215,641 (112,536) cu ft
BYPASS=103,106 cu ft
OUTFLOW=149,544 cu ft
FLOW (cfs)
RAIN (in/15 min)
0
5
10
15
20
25
30
35
40
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
330
530
730
930
1130
1330
1530
1730
RAIN
BPASS
BF FORMULA
REGRESS
OUTFLOW
McB


JULY 19, 2004 STORM
MARSH McBIRNEY VELOCITY METER INSTALLED BUT NO RELIABLE DATA
RAIN=1.36 inches
McBIRNEY=304,618 cu ft
BF FORMULA=207,846(79,9521) cu
REGRESS=226,280 (98,385) cu ft
BYPASS=127,895 cu ft
OUTFLOW=197,422 cu ft
FLOW (cfs)
RAIN (in/15 min)
0
10
20
30
40
50
60
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
100
300
500
700
900
1100
1300
RAIN
BPASS
BF FORMULA
REGRESS
OUTFLOW

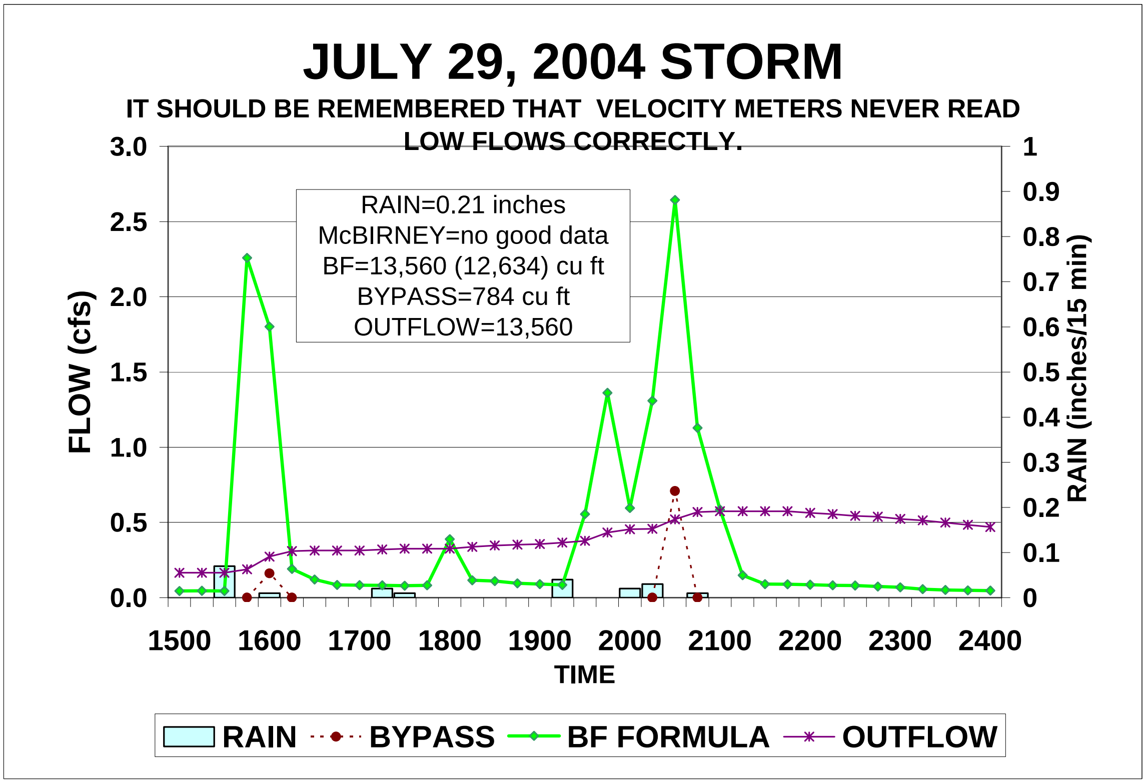

JULY 19-20, 2004 STORM
MARSH McBIRNEY VELOCITY METER INSTALLED BUT NO RELIABLE DATA
RAIN=2.32 inches
McBIRNEY=UNRELIABLE
BF FORMULA=470,684 (228,679) cu ft
REGRESS=420,527 (178,522) cu ft
BYPASS=242,005cu ft
OUTFLOW=357,288 cu ft
FLOW (cfs)
90
80
70
60
50
40
30
20
10
0
RAIN (in/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1400
1600
1800
2000
2200
2400
200
400
600
800
1000
1200
1400
TIME
RAIN
BPASS
BF FORMULA
REGRESS
OUTFLOW


JULY 26, 2004 STORM
McBIRNEY PROVIDES REASONABLE FLOW DATA
RAIN=2.63 inches
McBIRNEY=655,981 (298,740) cu ft
BF FORMULA=607,58(250,346)
REGRESS=739,608(382,367) cu ft
BYPASS=352,242 cu ft
OUTFLOW=394,021 cu ft
FLOW (cfs)
300
250
200
150
100
50
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1300
1400
1500
1600
1700
1800
1900
TIME
RAIN
McBIRNEY
BPASS
BF FORMULA
REGRESS
OUTFLOW



JULY 28, 2004 STORM

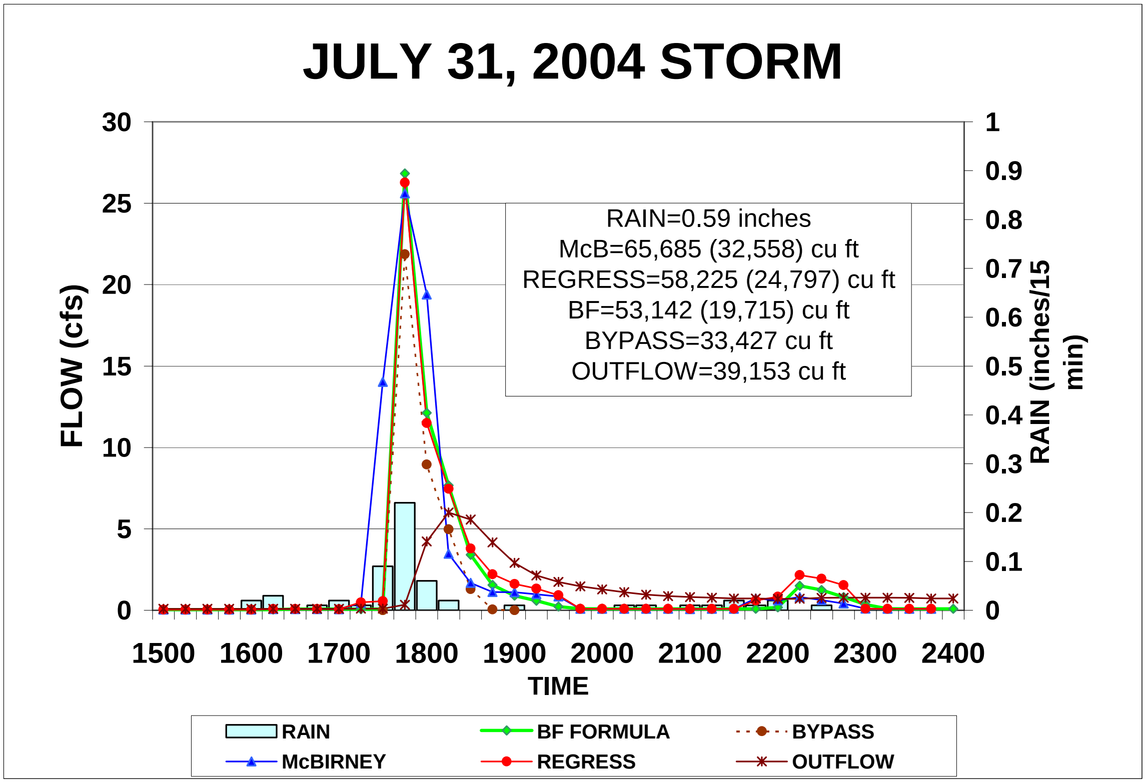
RAIN=0.70 inches
McBIRNEY=70,377 (56,073) cu ft
REGRESS=50,342 (36,038) cu ft
BF=47,885 (36,038) cu ft
BYPASS=14,304 cu ft
OUTFLOW=50,229 cu ft

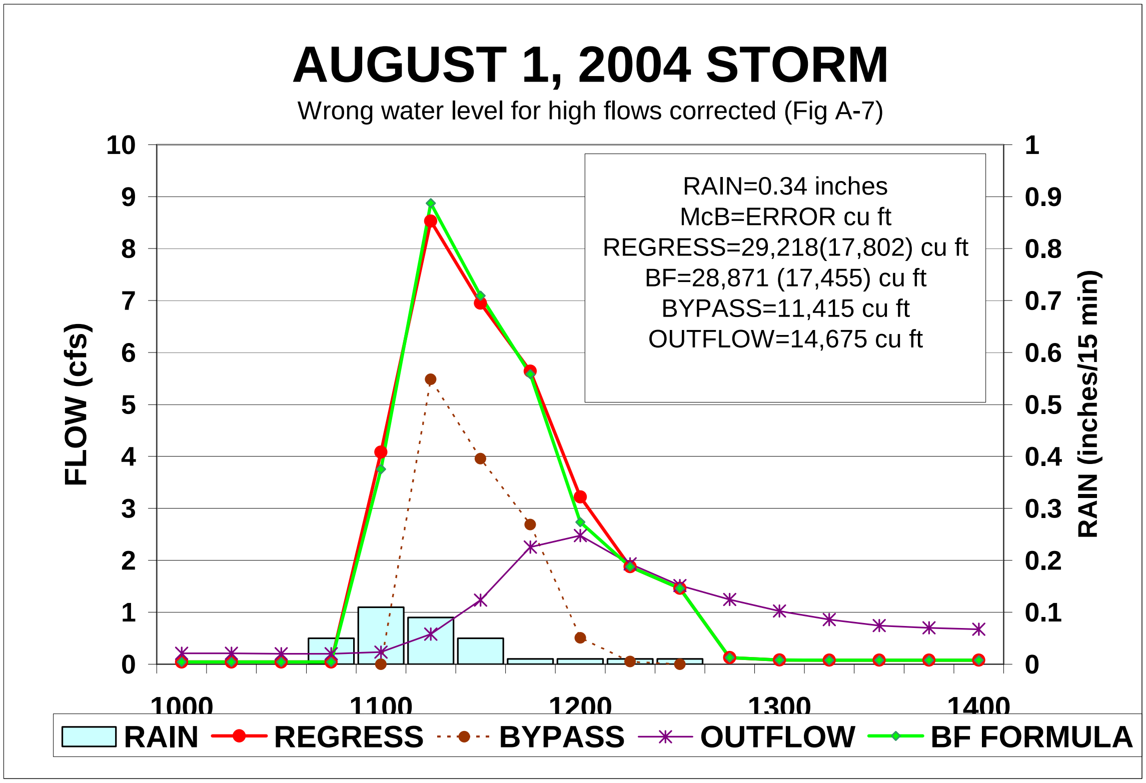


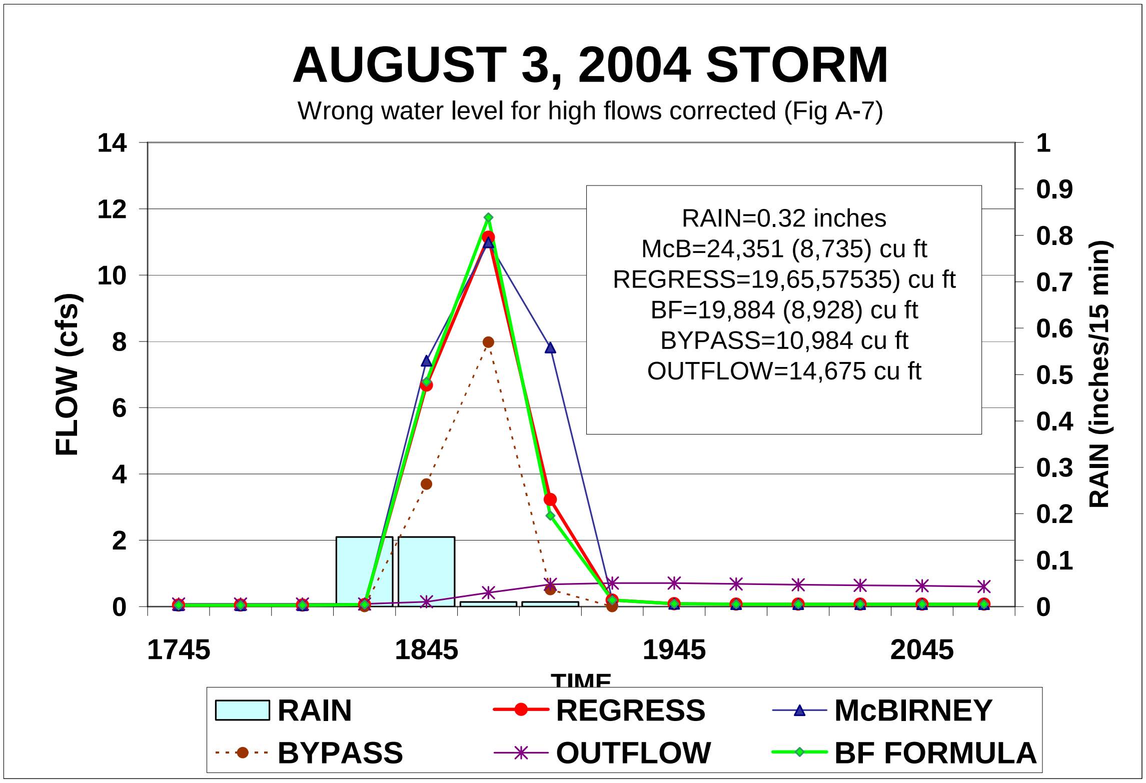
JULY 29, 2004 STORM

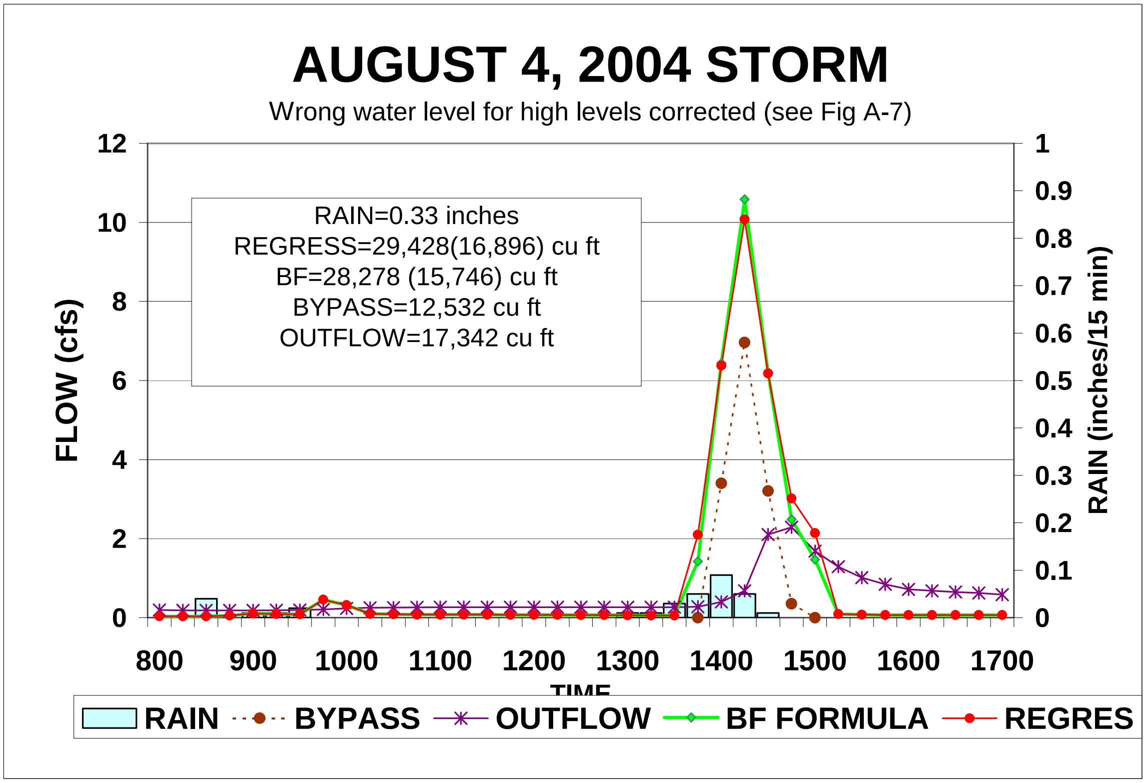
IT SHOULD BE REMEMBERED THAT VELOCITY METERS NEVER READ LOW FLOWS CORRECTLY.

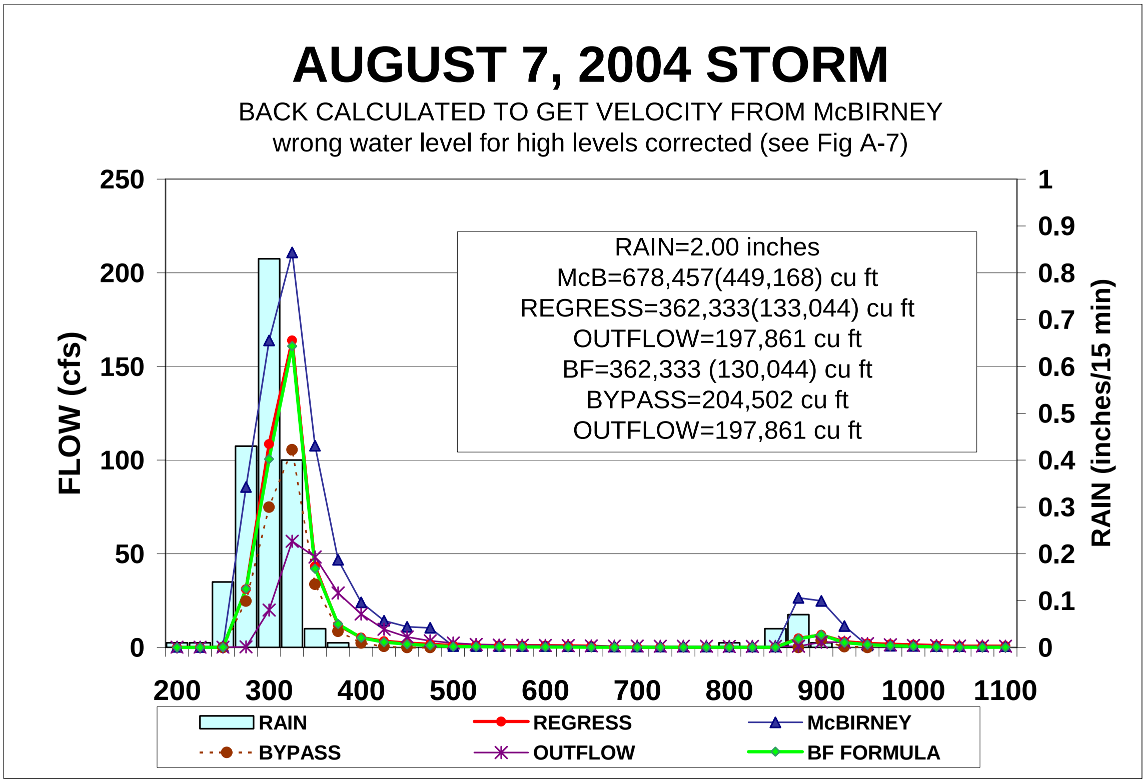
RAIN=0.21 inches
McBIRNEY=no good data
BF=13,560 (12,634) cu ft
BYPASS=784 cu ft
OUTFLOW=13,560

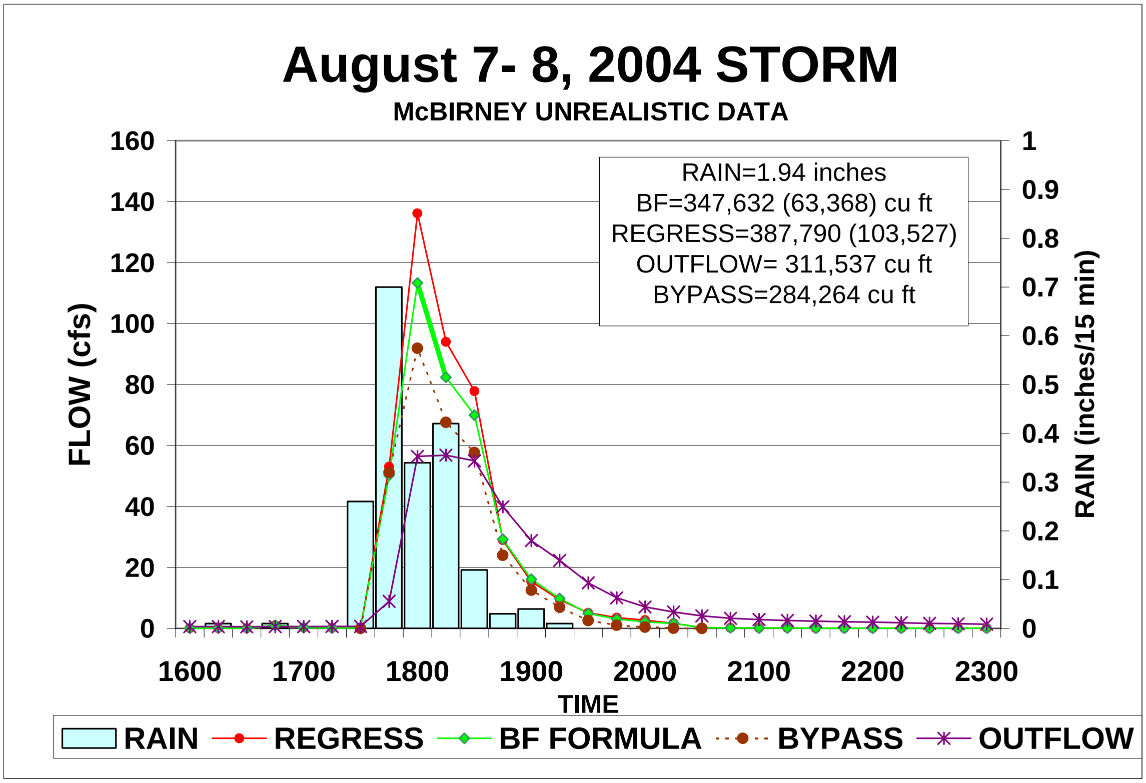

JULY 31, 2004 STORM
RAIN=0.59 inches
McB=65,685 (32,558) cu ft
REGRESS=58,225 (24,797) cu ft
BF=53,142 (19,715) cu ft
BYPASS=33,427 cu ft
OUTFLOW=39,153 cu ft
FLOW (cfs)
30
25
20
15
10
5
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
TIME
RAIN
McBIRNEY
BF FORMULA
REGRESS
BYPASS
OUTFLOW

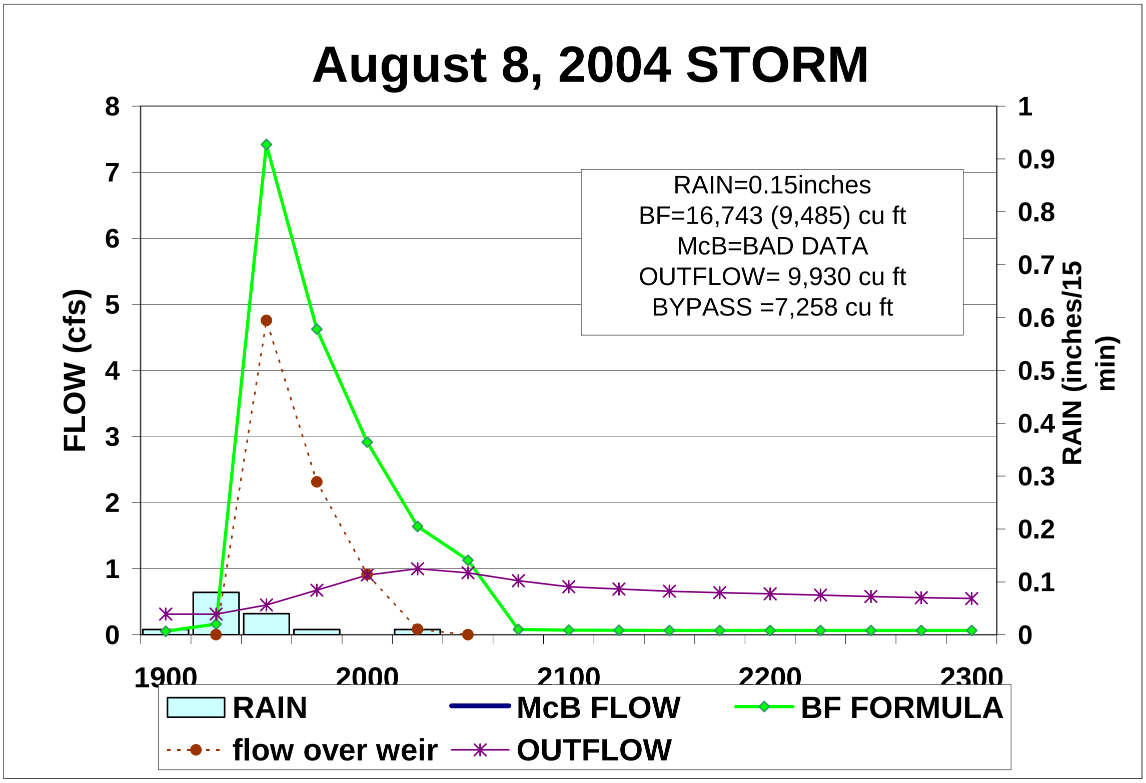

AUGUST 1, 2004 STORM
Wrong water level for high flows corrected (Fig A-7)
RAIN=0.34 inches
McB=ERROR cu ft
REGRESS=29,218(17,802) cu ft
BF=28,871 (17,455) cu ft
BYPASS=11,415 cu ft
OUTFLOW=14,675 cu ft
FLOW (cfs)
10
9
8
7
6
5
4
3
2
1
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1000
1100
1200
1300
1400
RAIN
REGRESS
BYPASS
OUTFLOW
BF FORMULA

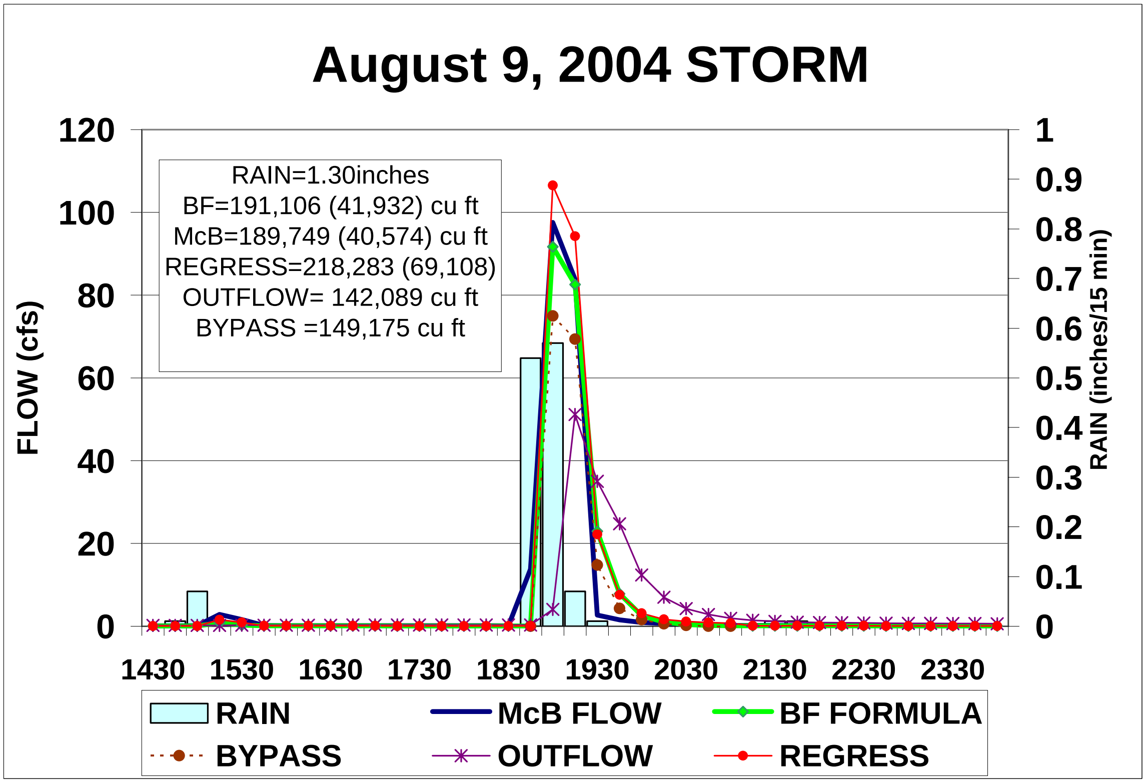

AUGUST 3, 2004 STORM
Wrong water level for high flows corrected (Fig A-7)
RAIN=0.32 inches
McB=24,351 (8,735) cu ft
REGRESS=19,65,57535) cu ft
BF=19,884 (8,928) cu ft
BYPASS=10,984 cu ft
OUTFLOW=14,675 cu ft
FLOW (cfs)
RAIN (inches/15 min)
14
12
10
8
6
4
2
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1745
1845
1945
2045
TIME
RAIN
REGRESS
McBIRNEY
BYPASS
OUTFLOW
BF FORMULA

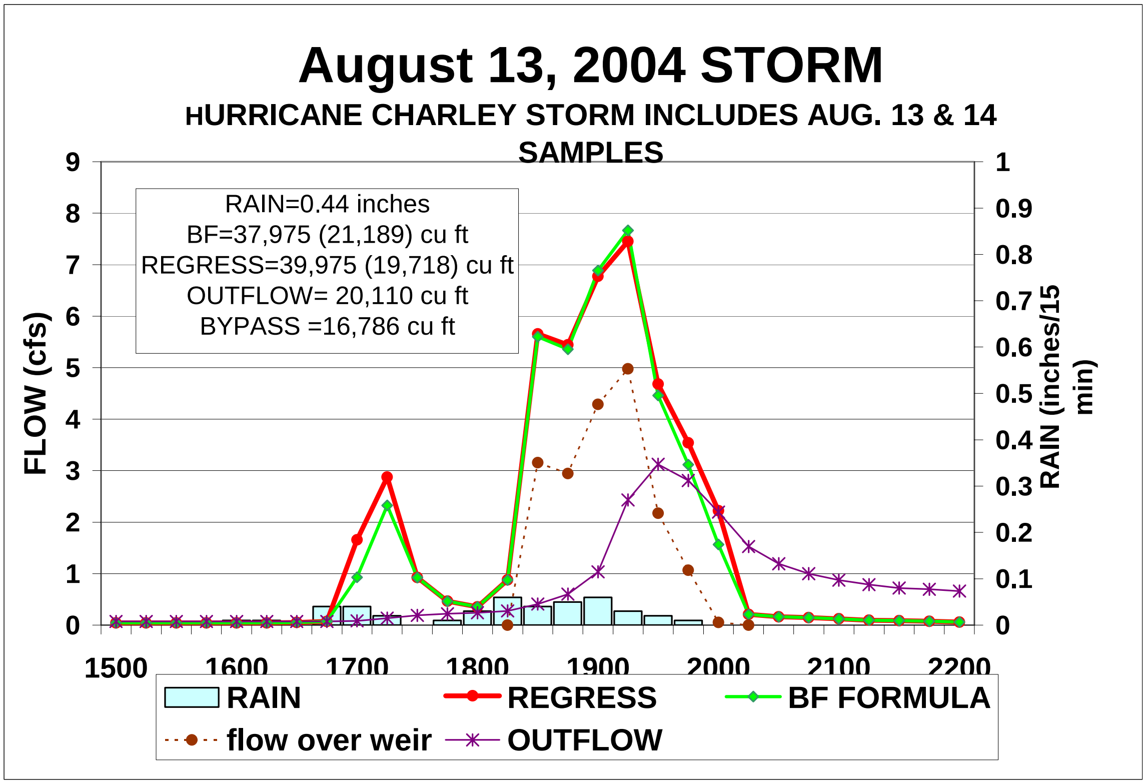

AUGUST 4, 2004 STORM
Wrong water level for high levels corrected (see Fig A-7)
RAIN=0.33 inches
REGRESS=29,428(16,896) cu ft
BF=28,278 (15,746) cu ft
BYPASS=12,532 cu ft
OUTFLOW=17,342 cu ft
FLOW (cfs)
RAIN (inches/15 min)
12
10
8
6
4
2
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
800
900
1000
1100
1200
1300
1400
1500
1600
1700
TIME
RAIN
BYPASS
OUTFLOW
BF FORMULA
REGRES

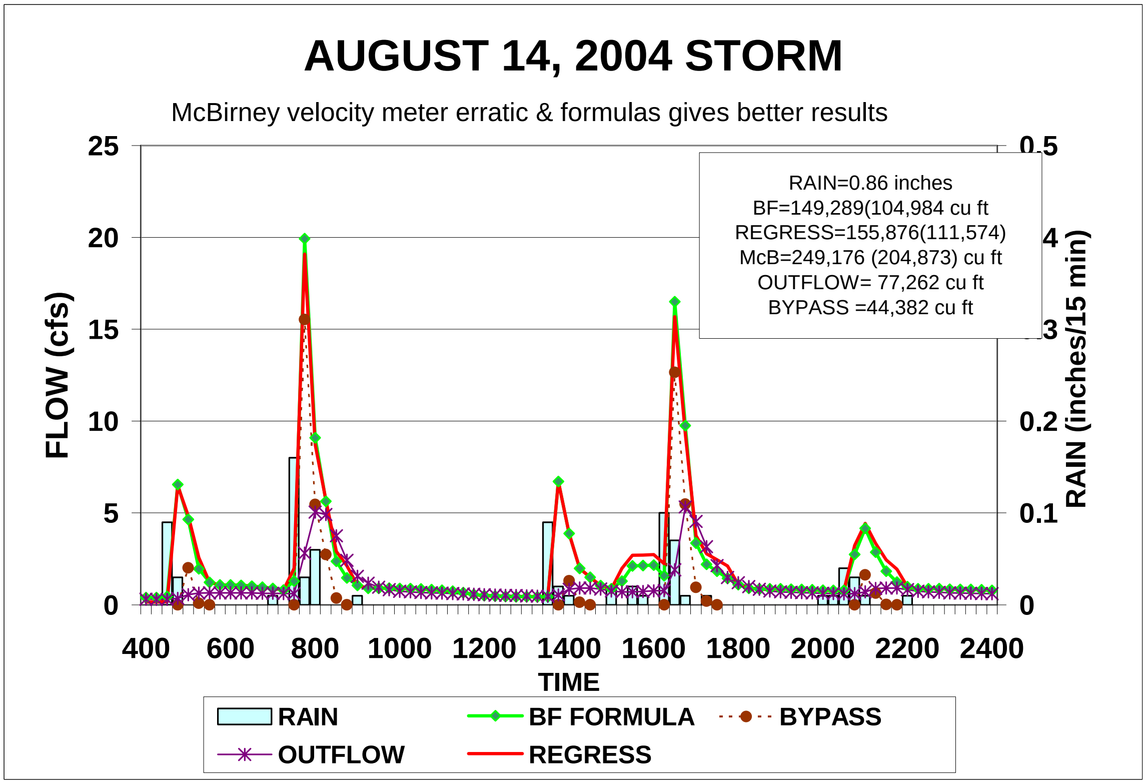

AUGUST 7, 2004 STORM
BACK CALCULATED TO GET VELOCITY FROM McBIRNEY
wrong water level for high levels corrected (see Fig A-7)
RAIN=2.00 inches
McB=678,457(449,168) cu ft
REGRESS=362,333(133,044) cu ft
OUTFLOW=197,861 cu ft
BF=362,333 (130,044) cu ft
BYPASS=204,502 cu ft
OUTFLOW=197,861 cu ft
FLOW (cfs)
250
200
150
100
50
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
200
300
400
500
600
700
800
900
1000
1100
RAIN
REGRESS
McBIRNEY
BYPASS
OUTFLOW
BF FORMULA

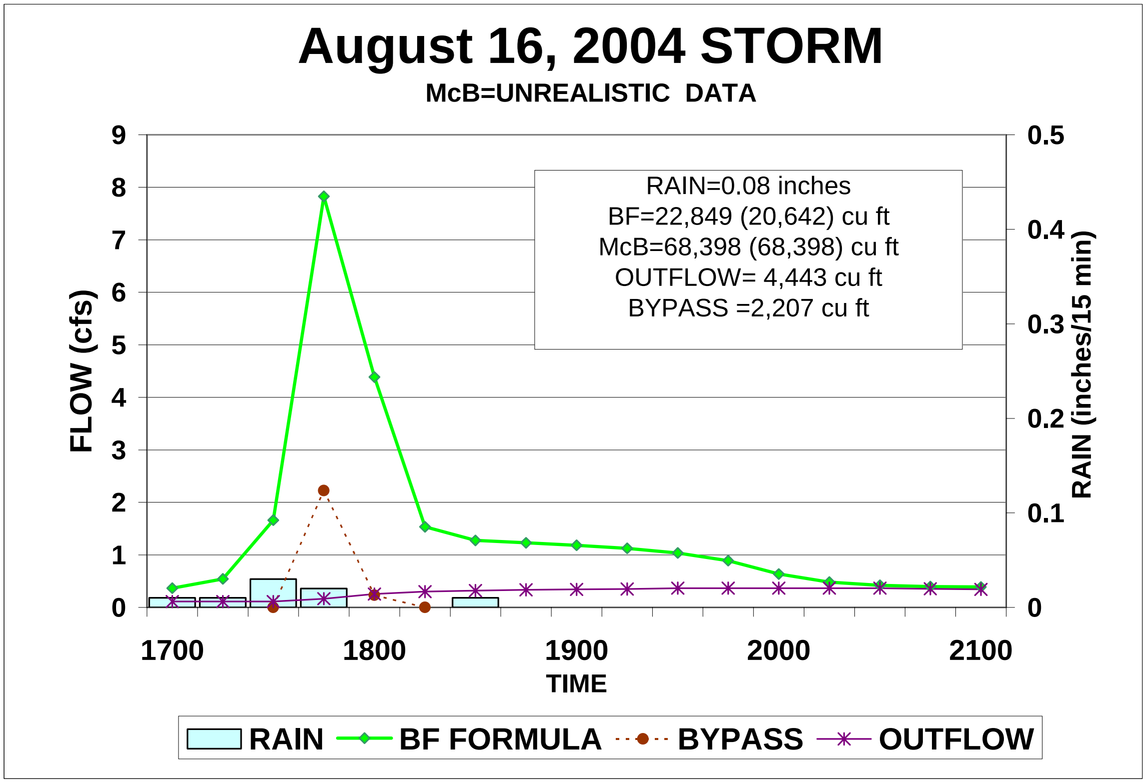

August 7- 8, 2004 STORM
McBIRNEY UNREALISTIC DATA
RAIN=1.94 inches
BF=347,632 (63,368) cu ft
REGRESS=387,790 (103,527)
OUTFLOW= 311,537 cu ft
BYPASS=284,264 cu ft
FLOW (cfs)
160
140
120
100
80
60
40
20
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1600
1700
1800
1900
2000
2100
2200
2300
TIME
RAIN
REGRESS
BF FORMULA
BYPASS
OUTFLOW

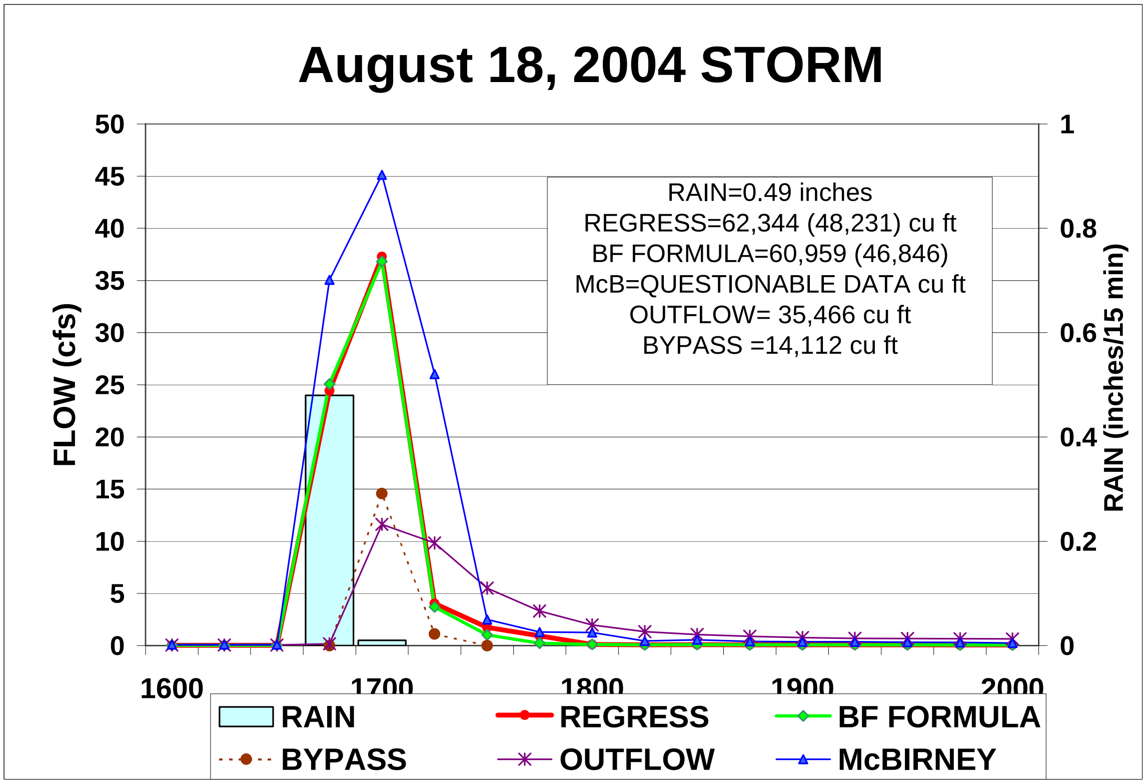

August 8, 2004 STORM
RAIN=0.15inches
BF=16,743 (9,485) cu ft
McB=BAD DATA
OUTFLOW= 9,930 cu ft
BYPASS =7,258 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
1
2
3
4
5
6
7
8
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1900
2000
2100
2200
2300
RAIN
McB FLOW
BF FORMULA
flow over weir
OUTFLOW

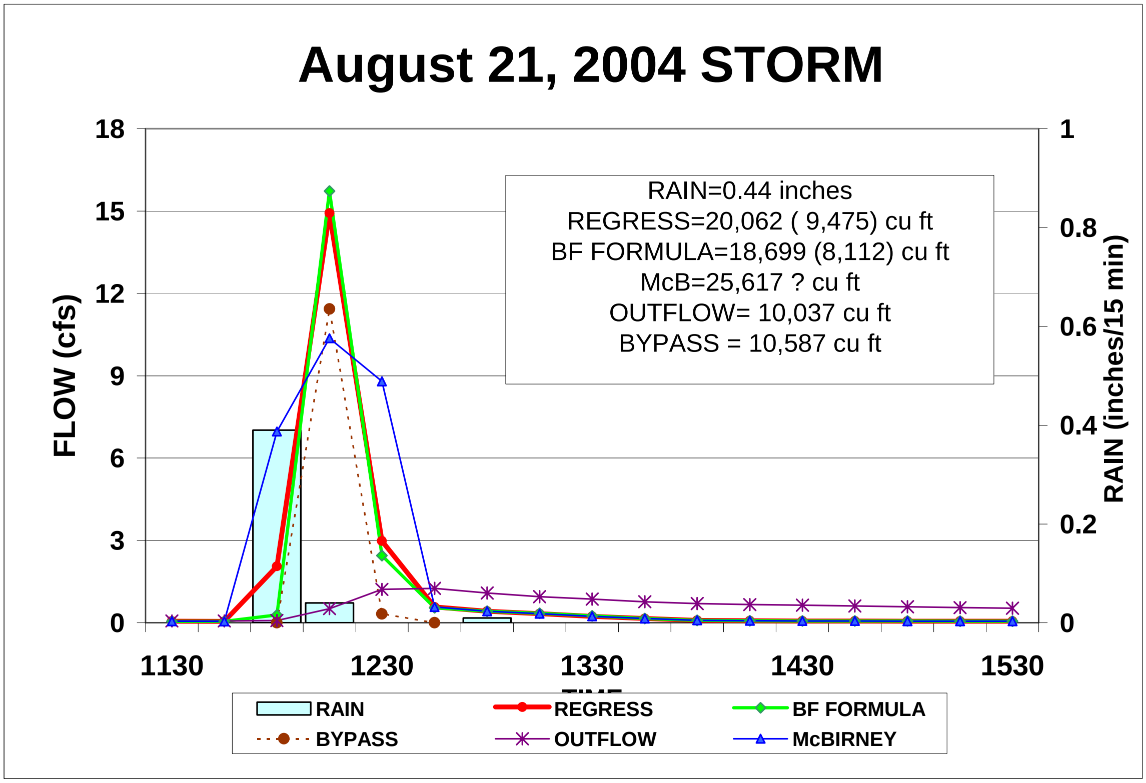

August 9, 2004 STORM
RAIN=1.30inches
BF=191,106 (41,932) cu ft
McB=189,749 (40,574) cu ft
REGRESS=218,283 (69,108)
OUTFLOW= 142,089 cu ft
BYPASS =149,175 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
20
40
60
80
100
120
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1430
1530
1630
1730
1830
1930
2030
2130
2230
2330
RAIN
McB FLOW
BF FORMULA
BYPASS
OUTFLOW
REGRESS

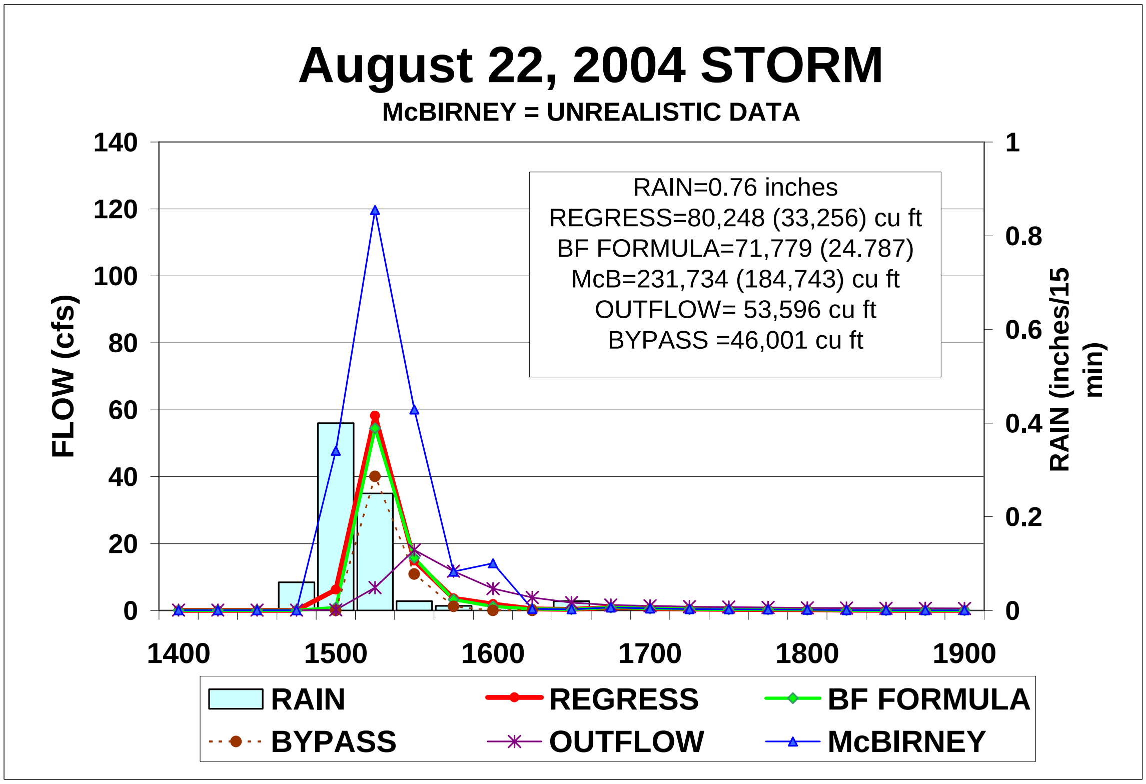

August 13, 2004 STORM
HURRICANE CHARLEY STORM INCLUDES AUG. 13 & 14 SAMPLES
RAIN=0.44 inches
BF=37,975 (21,189) cu ft
REGRESS=39,975 (19,718) cu ft
OUTFLOW= 20,110 cu ft
BYPASS =16,786 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
1
2
3
4
5
6
7
8
9
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1500
1600
1700
1800
1900
2000
2100
2200
RAIN
REGRESS
BF FORMULA
flow over weir
OUTFLOW

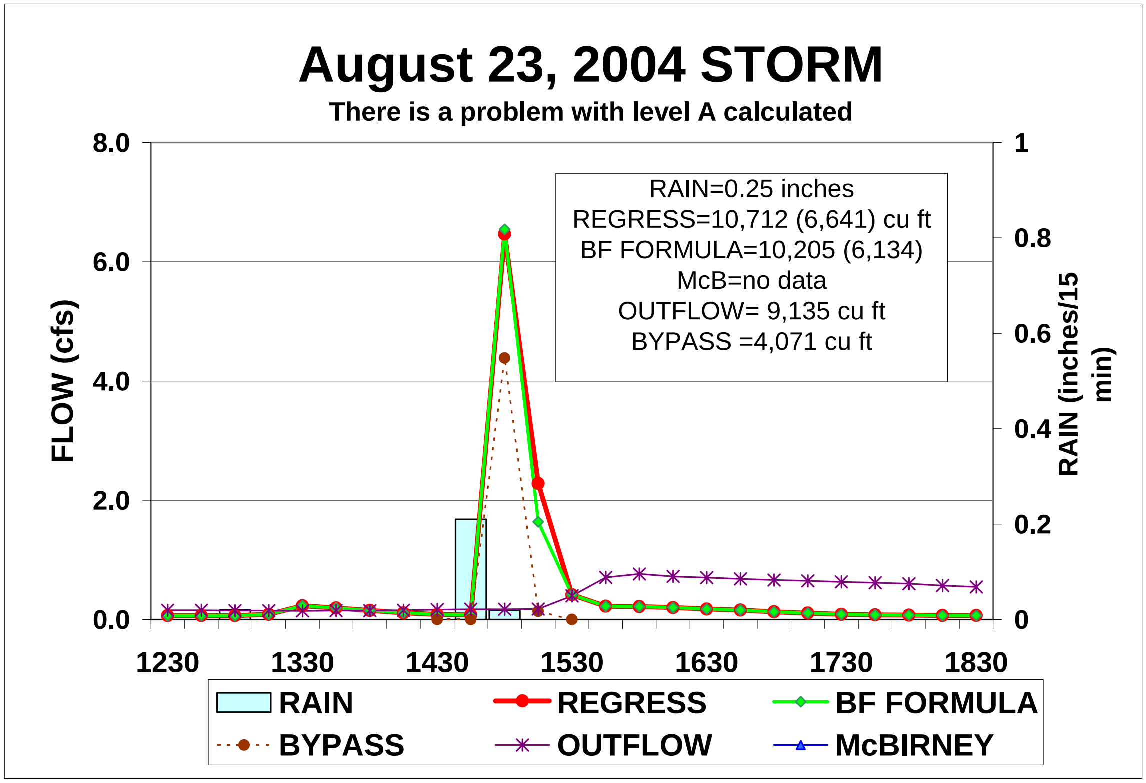

AUGUST 14, 2004 STORM
McBirney velocity meter erratic & formulas gives better results
RAIN=0.86 inches
BF=149,289(104,984 cu ft
REGRESS=155,876(111,574)
McB=249,176 (204,873) cu ft
OUTFLOW= 77,262 cu ft
BYPASS =44,382 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
5
10
15
20
25
0
0.1
0.2
0.3
0.4
0.5
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
TIME
RAIN
BF FORMULA
BYPASS
OUTFLOW
REGRESS

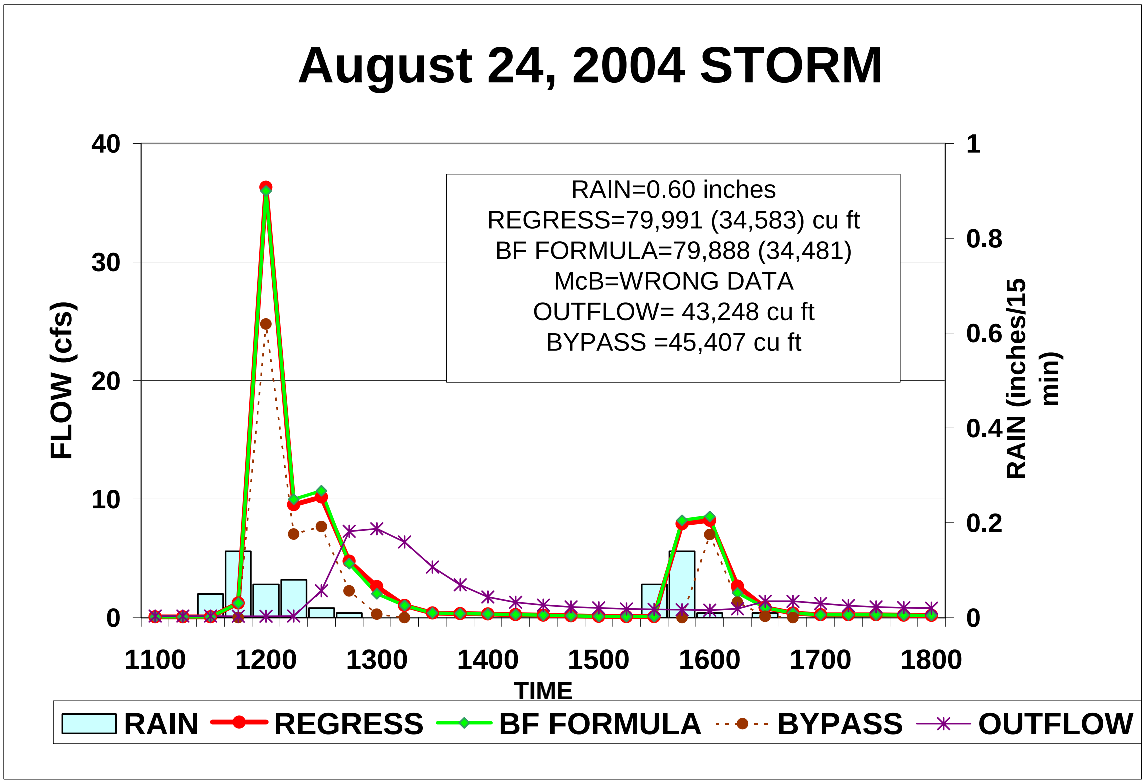

August 16, 2004 STORM
McB=UNREALISTIC DATA
RAIN=0.08 inches
BF=22,849 (20,642) cu ft
McB=68,398 (68,398) cu ft
OUTFLOW= 4,443 cu ft
BYPASS =2,207 cu ft
FLOW (cfs)
RAIN (inches/15 min)
TIME
0
1
2
3
4
5
6
7
8
9
0.1
0.2
0.3
0.4
0.5
1700
1800
1900
2000
2100
RAIN
BF FORMULA
BYPASS
OUTFLOW

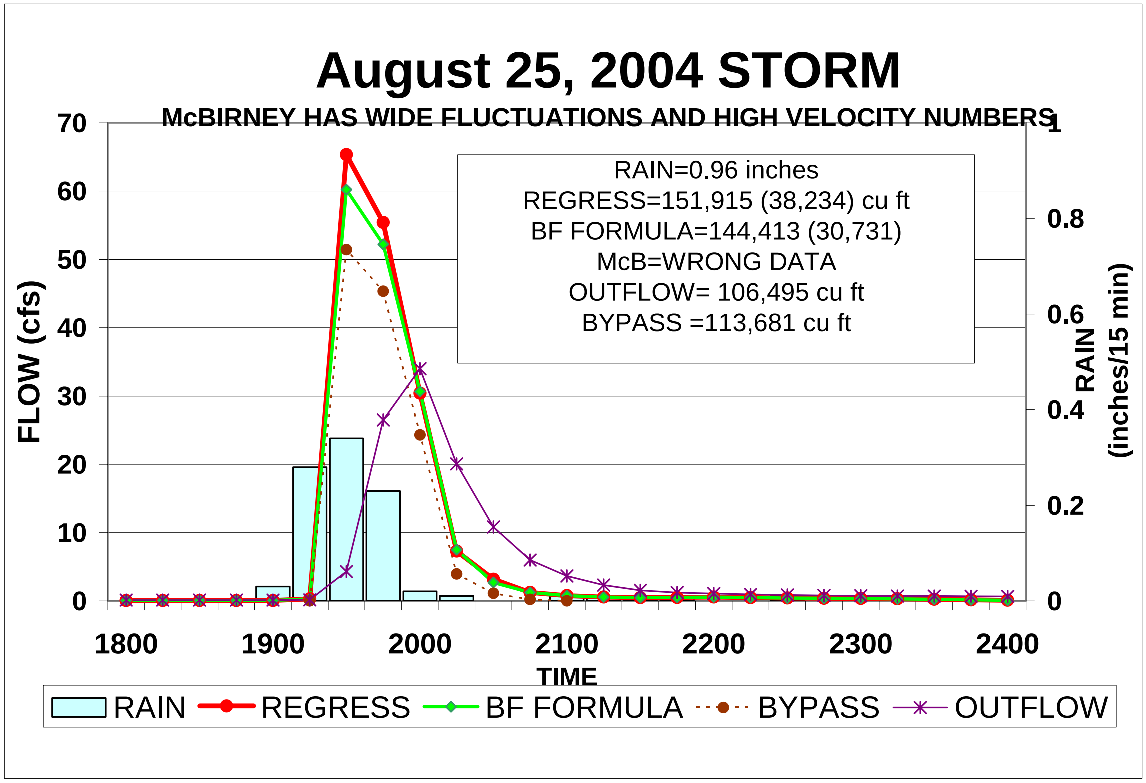

August 18, 2004 STORM
RAIN=0.49 inches
REGRESS=62,344 (48,231) cu ft
BF FORMULA=60,959 (46,846)
McB=QUESTIONABLE DATA cu ft
OUTFLOW= 35,466 cu ft
BYPASS =14,112 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
5
10
15
20
25
30
35
40
45
50
0.2
0.4
0.6
0.8
1
1600
1700
1800
1900
2000
RAIN
REGRESS
BF FORMULA
BYPASS
OUTFLOW
McBIRNEY


August 21, 2004 STORM
RAIN=0.44 inches
REGRESS=20,062 (9,475) cu ft
BF FORMULA=18,699 (8,112) cu ft
McB=25,617 ? cu ft
OUTFLOW= 10,037 cu ft
BYPASS = 10,587 cu ft
FLOW (cfs)
18
15
12
9
6
3
0
RAIN (inches/15 min)
1
0.8
0.6
0.4
0.2
0
1130
1230
1330
1430
1530
RAIN
REGRESS
BF FORMULA
BYPASS
OUTFLOW
McBIRNEY


August 22, 2004 STORM
McBIRNEY = UNREALISTIC DATA
RAIN=0.76 inches
REGRESS=80,248 (33,256) cu ft
BF FORMULA=71,779 (24.787)
McB=231,734 (184,743) cu ft
OUTFLOW= 53,596 cu ft
BYPASS =46,001 cu ft
FLOW (cfs)
140
120
100
80
60
40
20
0
RAIN (inches/15 min)
1
0.8
0.6
0.4
0.2
0
1400
1500
1600
1700
1800
1900
RAIN
REGRESS
BF FORMULA
BYPASS
OUTFLOW
McBIRNEY


August 23, 2004 STORM
There is a problem with level A calculated
RAIN=0.25 inches
REGRESS=10,712 (6,641) cu ft
BF FORMULA=10,205 (6,134)
McB=no data
OUTFLOW= 9,135 cu ft
BYPASS =4,071 cu ft
FLOW (cfs)
8.0
6.0
4.0
2.0
0.0
RAIN (inches/15 min)
1
0.8
0.6
0.4
0.2
0
1230
1330
1430
1530
1630
1730
1830
RAIN
REGRESS
BF FORMULA
BYPASS
OUTFLOW
McBIRNEY

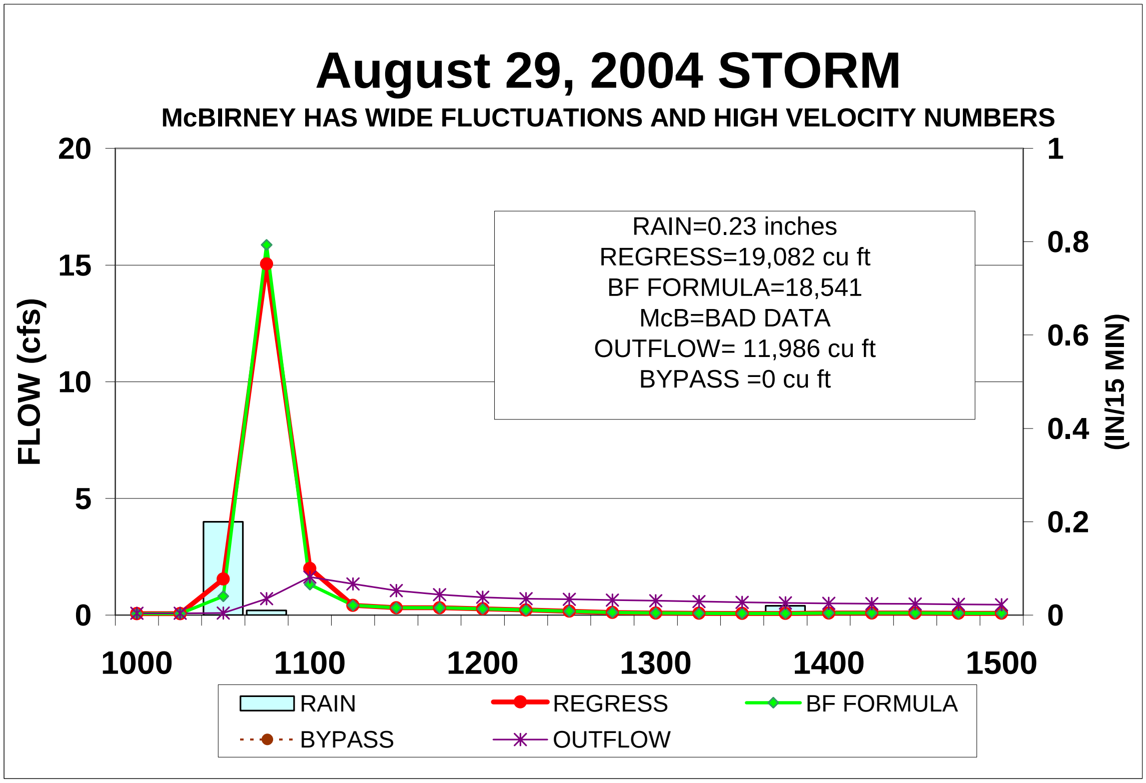

August 24, 2004 STORM
RAIN=0.60 inches
REGRESS=79,991 (34,583) cu ft
BF FORMULA=79,888 (34,481)
McB=WRONG DATA
OUTFLOW= 43,248 cu ft
BYPASS =45,407 cu ft
FLOW (cfs)
40
30
20
10
0
RAIN (inches/15 min)
1
0.8
0.6
0.4
0.2
0
1100
1200
1300
1400
1500
1600
1700
1800
TIME
RAIN
REGRESS
BF FORMULA
BYPASS
OUTFLOW



August 25, 2004 STORM

McBIRNEY HAS WIDE FLUCTUATIONS AND HIGH VELOCITY NUMBERS

RAIN=0.96 inches
REGRESS=151,915 (38,234) cu ft
BF FORMULA=144,413 (30,731)
McB=WRONG DATA
OUTFLOW= 106,495 cu ft
BYPASS =113,681 cu ft



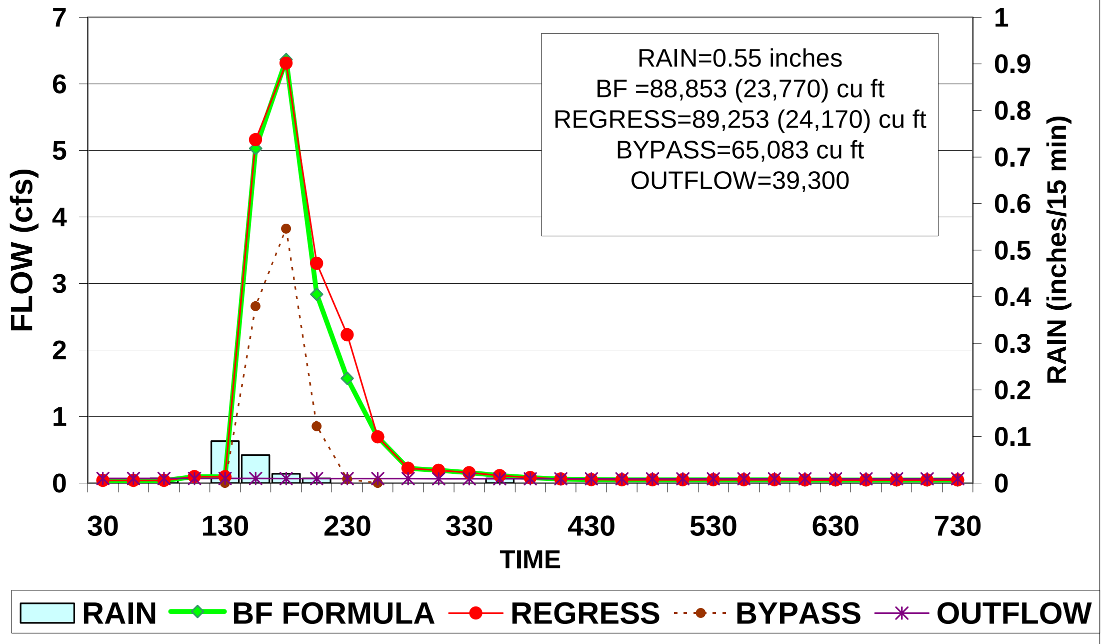
August 29, 2004 STORM

McBIRNEY HAS WIDE FLUCTUATIONS AND HIGH VELOCITY NUMBERS

RAIN=0.23 inches
REGRESS=19,082 cu ft
BF FORMULA=18,541
McB=BAD DATA
OUTFLOW= 11,986 cu ft
BYPASS =0 cu ft

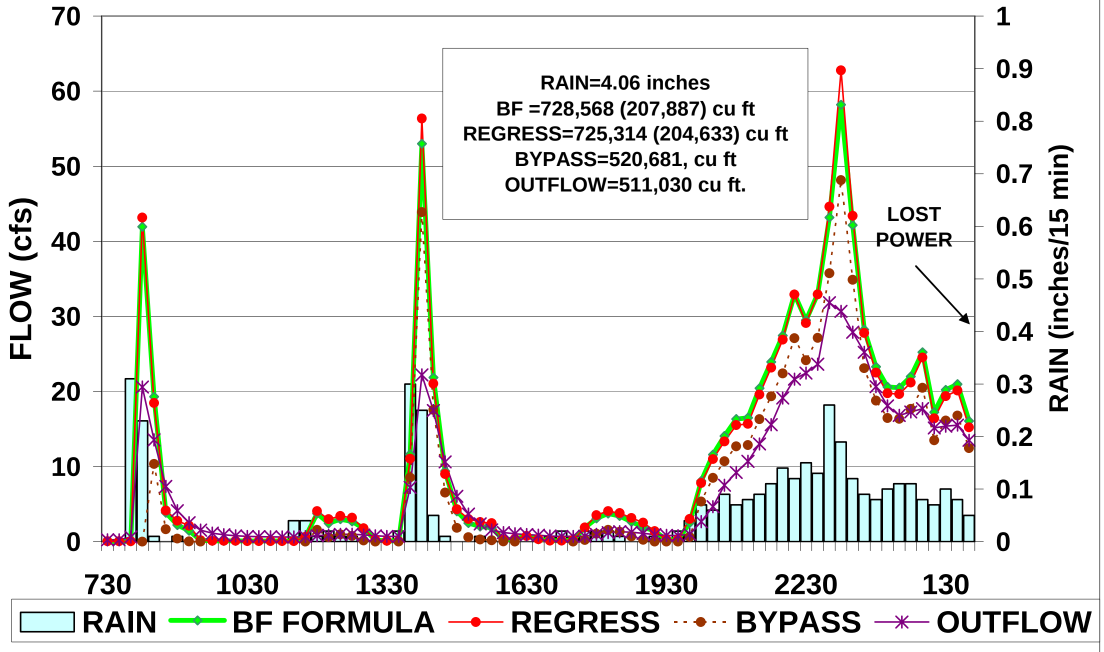
AUG 31 TO SEPT 1, 2004 STORM

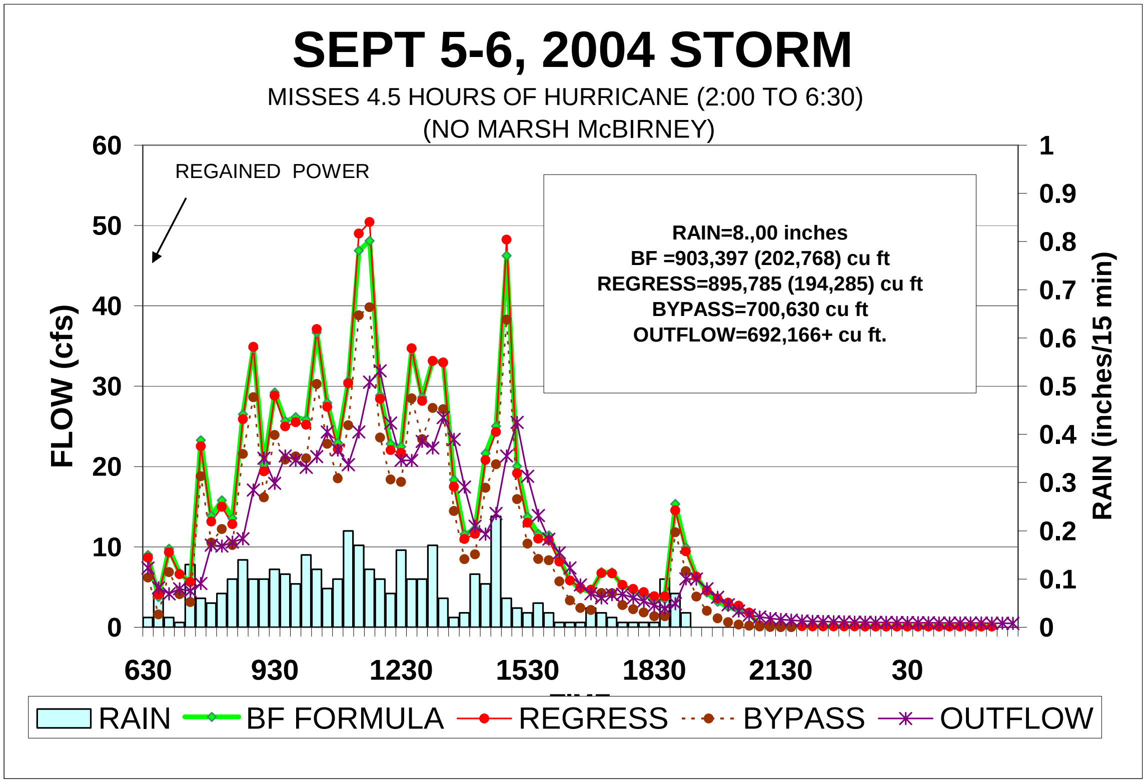
McBIRNEY FLOW METER ERRATIC



SEPT 4-5, 2004 STORM

McBIRNEY METER GIVES NO RESULTS

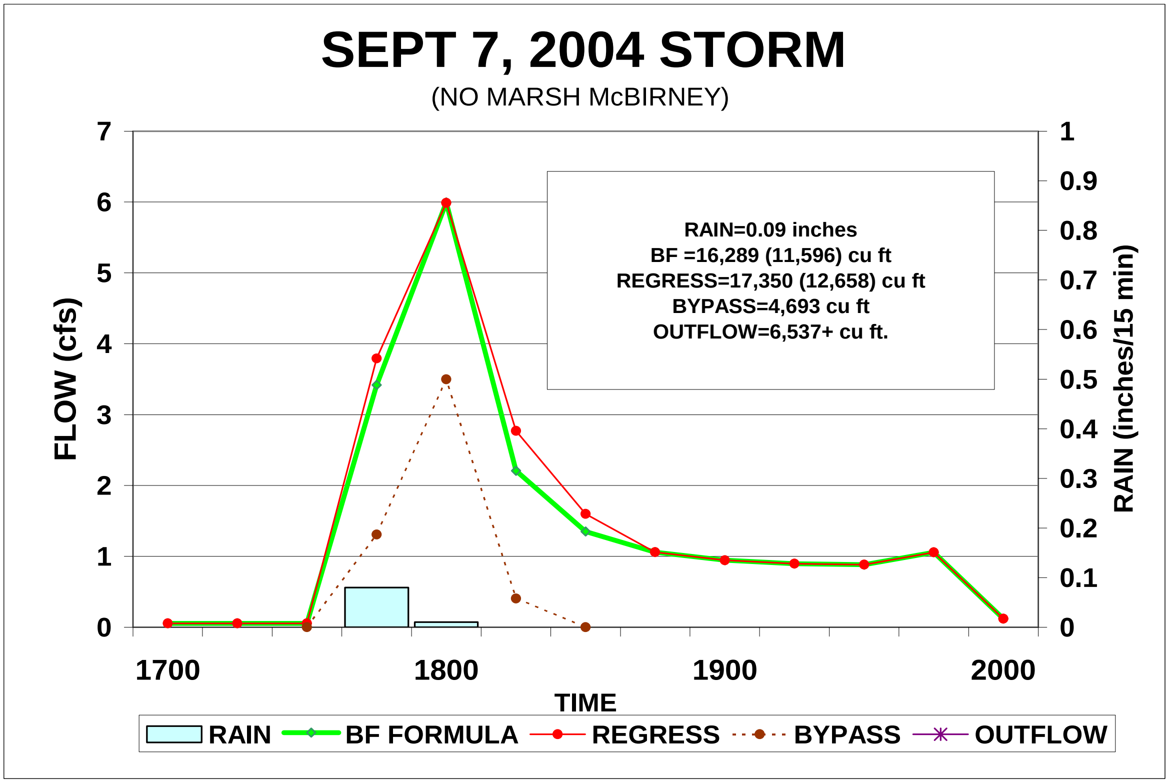




SEPT 5-6, 2004 STORM

MISSES 4.5 HOURS OF HURRICANE (2:00 TO 6:30)
(NO MARSH McBIRNEY)

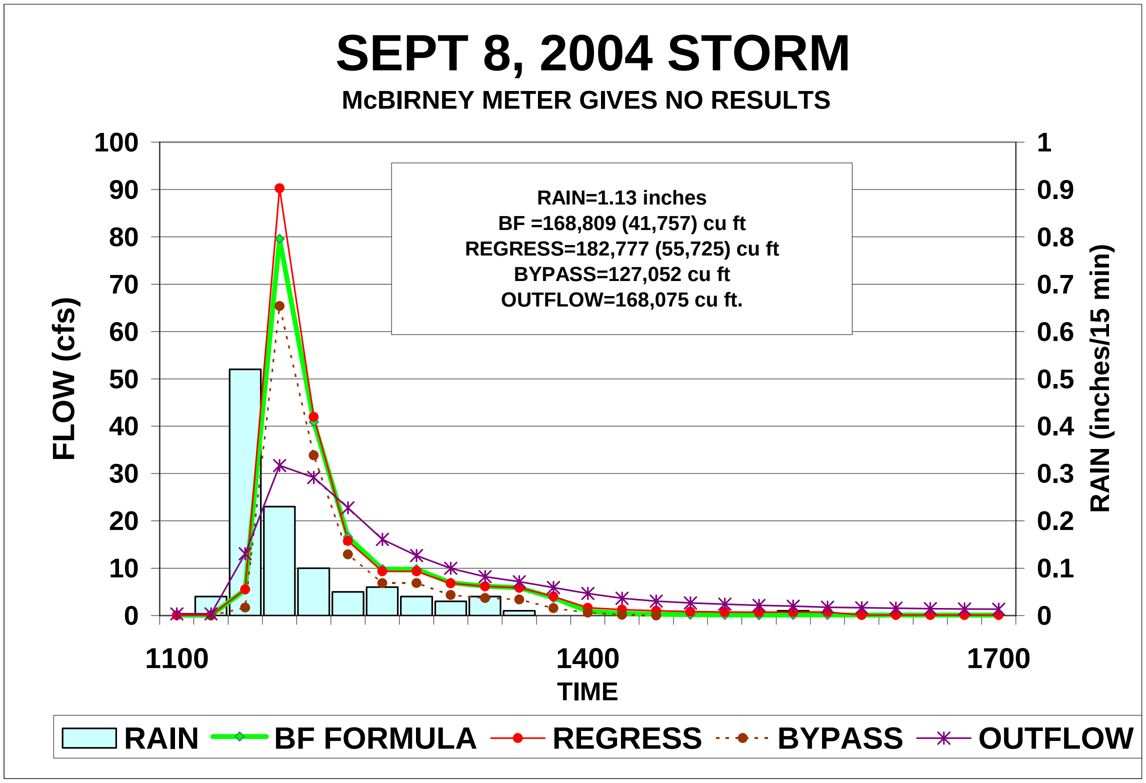
RAIN=8.,00 inches
BF =903,397 (202,768) cu ft
REGRESS=895,785 (194,285) cu ft
BYPASS=700,630 cu ft
OUTFLOW=692,166+ cu ft.



SEPT 7, 2004 STORM

(NO MARSH McBIRNEY)

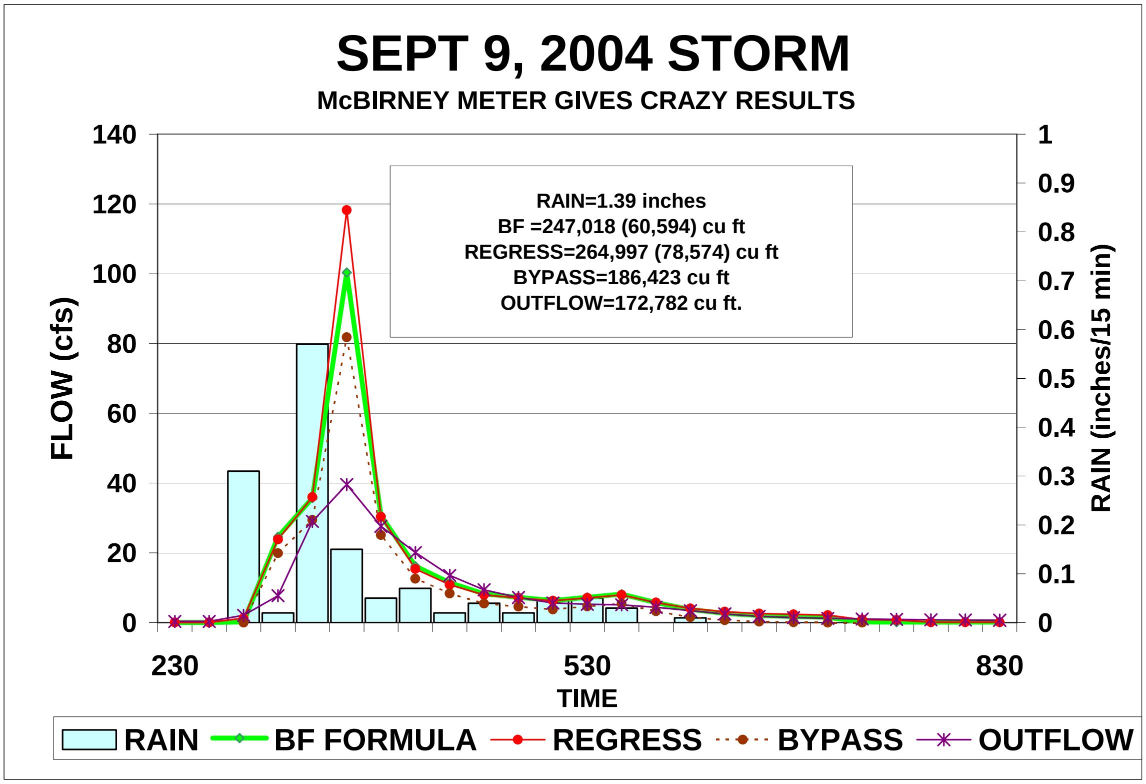
RAIN=0.09 inches
BF =16,289 (11,596) cu ft
REGRESS=17,350 (12,658) cu ft
BYPASS=4,693 cu ft
OUTFLOW=6,537+ cu ft.



SEPT 8, 2004 STORM

McBIRNEY METER GIVES NO RESULTS

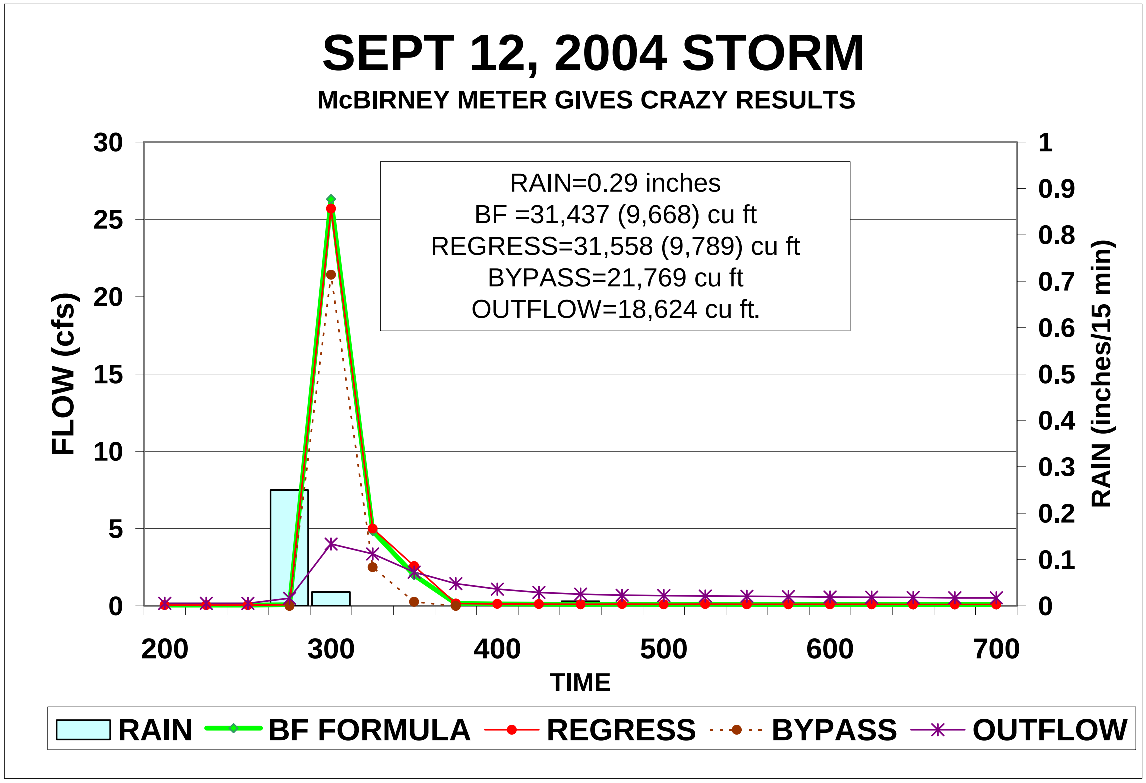
RAIN=1.13 inches
BF =168,809 (41,757) cu ft
REGRESS=182,777 (55,725) cu ft
BYPASS=127,052 cu ft
OUTFLOW=168,075 cu ft.

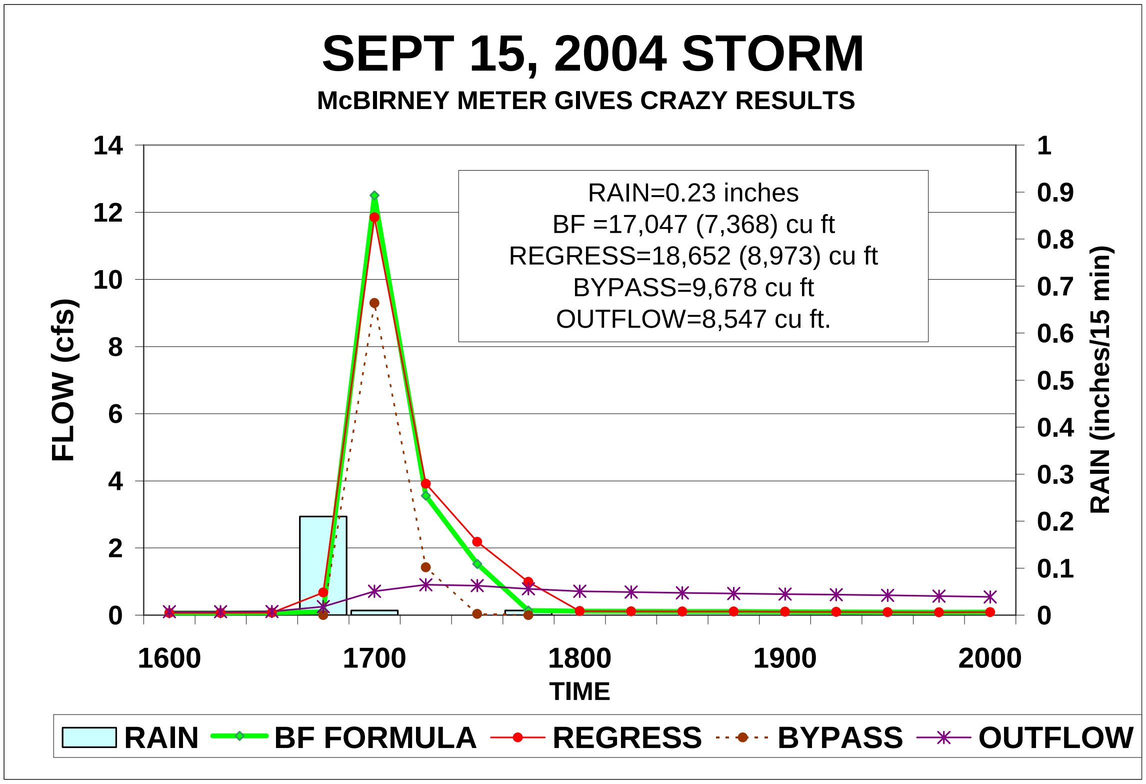


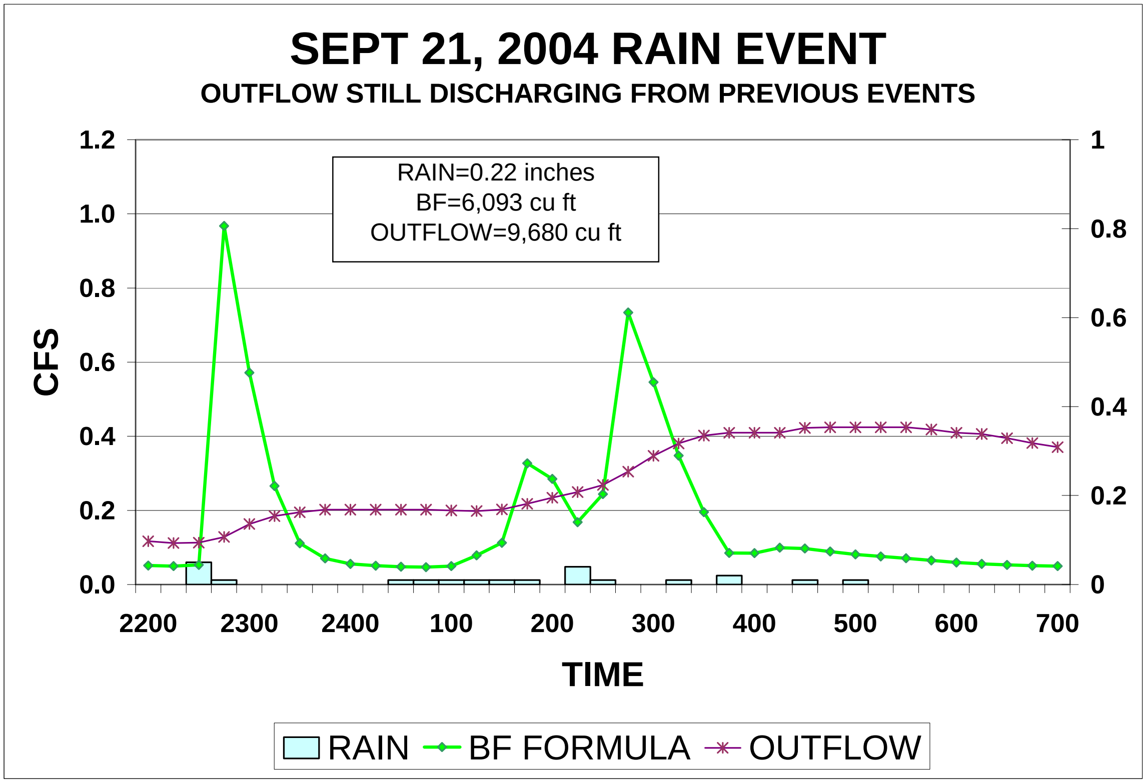
SEPT 9, 2004 STORM

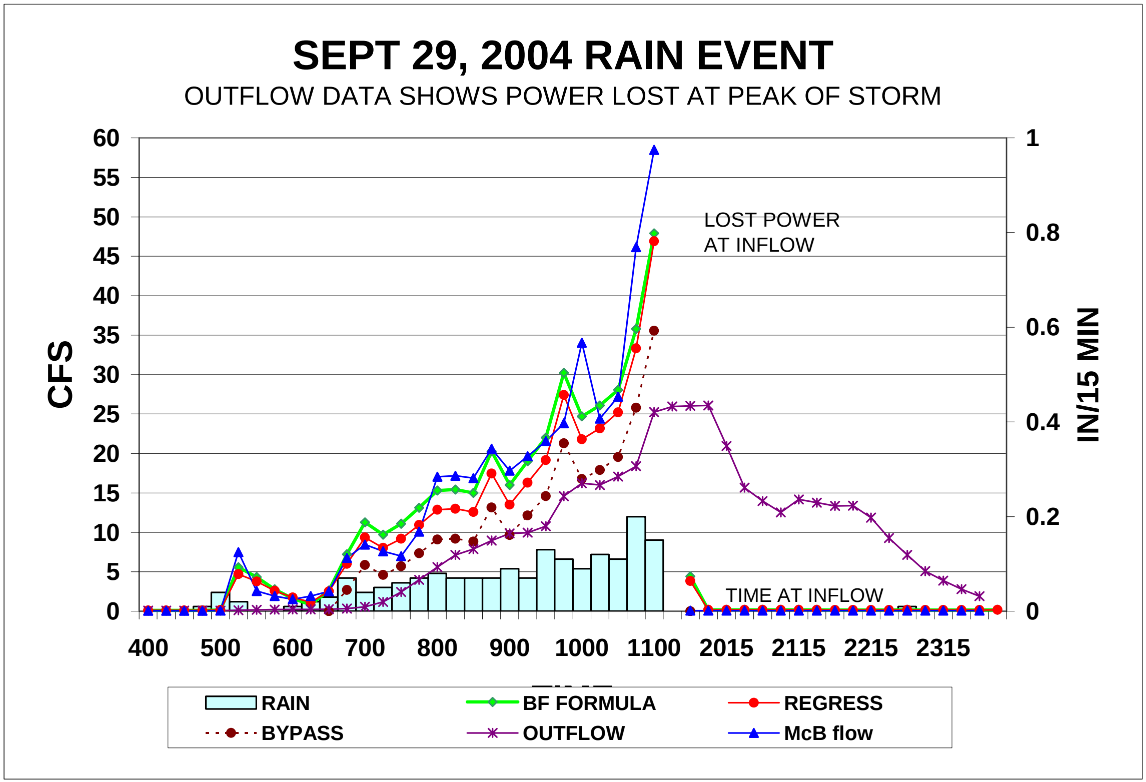
McBIRNEY METER GIVES CRAZY RESULTS

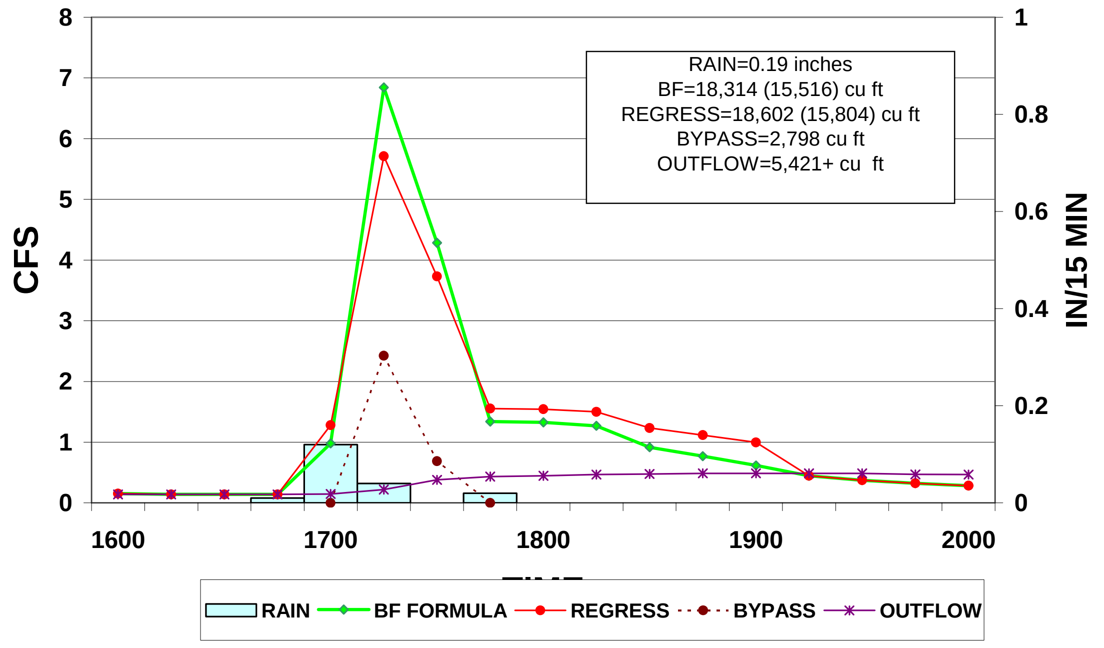
RAIN=1.39 inches
BF =247,018 (60,594) cu ft
REGRESS=264,997 (78,574) cu ft
BYPASS=186,423 cu ft
OUTFLOW=172,782 cu ft.


SEPT 12, 2004 STORM
McBIRNEY METER GIVES CRAZY RESULTS
RAIN=0.29 inches
BF =31,437 (9,668) cu ft
REGRESS=31,558 (9,789) cu ft
BYPASS=21,769 cu ft
OUTFLOW=18,624 cu ft.
FLOW (cfs)
0
5
10
15
20
25
30
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
200
300
400
500
600
700
TIME
RAIN
BF FORMULA
REGRESS
BYPASS
OUTFLOW


SEPT 15, 2004 STORM
McBIRNEY METER GIVES CRAZY RESULTS
RAIN=0.23 inches
BF =17,047 (7,368) cu ft
REGRESS=18,652 (8,973) cu ft
BYPASS=9,678 cu ft
OUTFLOW=8,547 cu ft.
FLOW (cfs)
0
2
4
6
8
10
12
14
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1600
1700
1800
1900
2000
TIME
RAIN
BF FORMULA
REGRESS
BYPASS
OUTFLOW

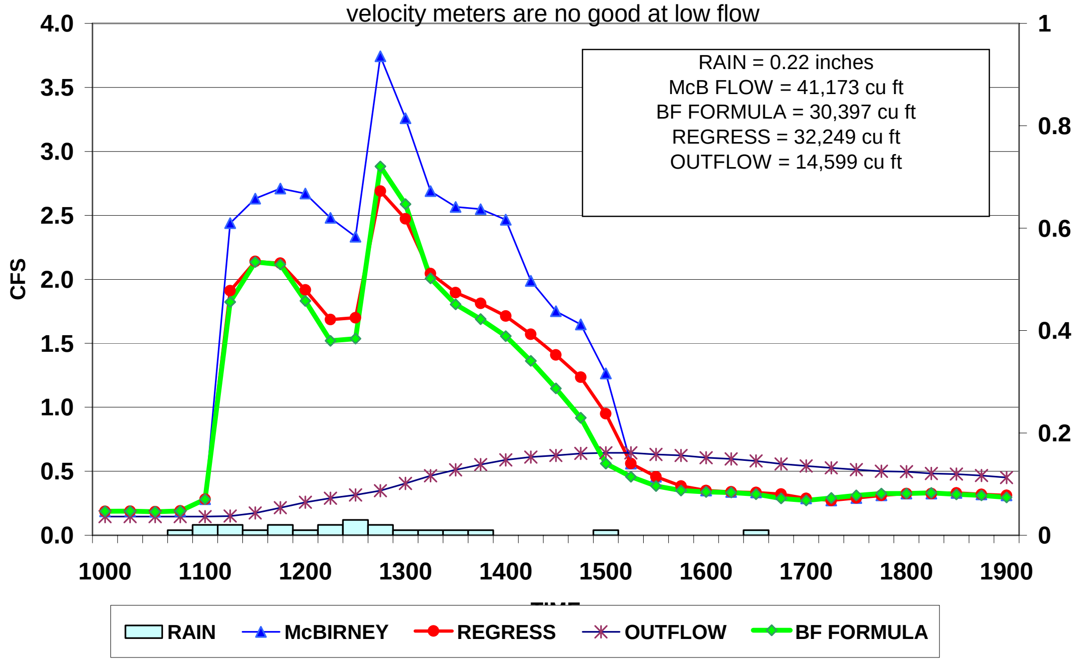

SEPT 21, 2004 RAIN EVENT
OUTFLOW STILL DISCHARGING FROM PREVIOUS EVENTS
RAIN=0.22 inches
BF=6,093 cu ft
OUTFLOW=9,680 cu ft
CFS
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1
0.8
0.6
0.4
0.2
0
2200
2300
2400
100
200
300
400
500
600
700
TIME
RAIN
BF FORMULA
OUTFLOW


SEPT 29, 2004 RAIN EVENT
OUTFLOW DATA SHOWS POWER LOST AT PEAK OF STORM
CFS
60
55
50
45
40
35
30
25
20
15
10
5
0
1
0.8
0.6
0.4
0.2
0
IN/15 MIN
LOST POWER
AT INFLOW
TIME AT INFLOW
400
500
600
700
800
900
1000
1100
2015
2115
2215
2315
RAIN
BF FORMULA
REGRESS
BYPASS
OUTFLOW
McB flow



OCTOBER 4, 2004 RAIN EVENT

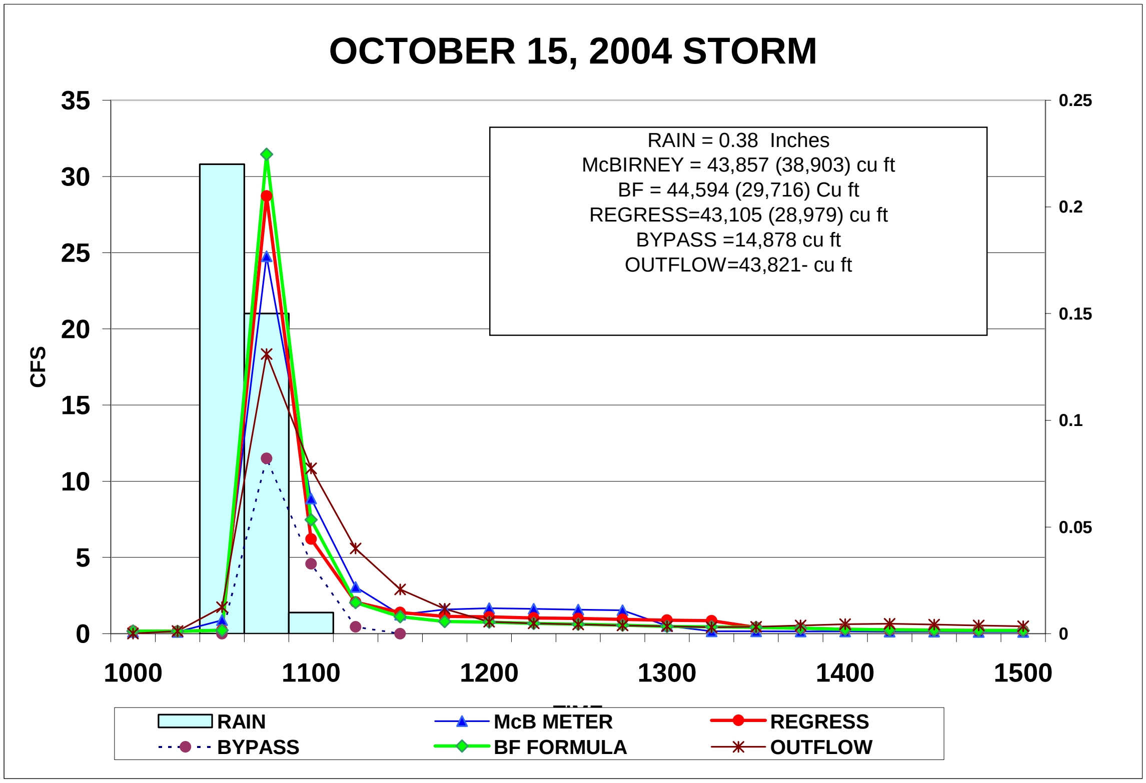
RAIN=0.19 inches
BF=18,314 (15,516) cu ft
REGRESS=18,602 (15,804) cu ft
BYPASS=2,798 cu ft
OUTFLOW=5,421+ cu ft



OCTOBER 11, 2004 STORM

Remember everything less than 1 cfs uses BF formula
velocity meters are no good at low flow

RAIN = 0.22 inches
McB FLOW = 41,173 cu ft
BF FORMULA = 30,397 cu ft
REGRESS = 32,249 cu ft
OUTFLOW = 14,599 cu ft


OCTOBER 15, 2004 STORM
RAIN = 0.38 Inches
McBIRNEY = 43,857 (38,903) cu ft
BF = 44,594 (29,716) Cu ft
REGRESS=43,105 (28,979) cu ft
BYPASS =14,878 cu ft
OUTFLOW=43,821- cu ft
CFS
35
30
25
20
15
10
5
0
0.25
0.2
0.15
0.1
0.05
0
1000
1100
1200
1300
1400
1500
TIME
RAIN
McB METER
REGRESS
BYPASS
BF FORMULA
OUTFLOW

WATER BUDGET CALCULATIONS FOR 2004-05

Bypass flow is the storm flow that bypasses the CDS unit and discharges over weir
All flows less than 1 cfs were calculated using base flow weir (see appendix A).
In figures, total flow is shown first and the amount entering the CDS is in parentheses
Equipment failures after March necssitated developing formulas from water level (see Appendix A)
The area of the pond used in the calculations was 46,605 sq. ft.
Installed separate refrigerated samplers to measure base flow
Leakey pipes discharging unmeasured outflow permanently fixed
The V-notch weirs (in and out) used to calculate base flow were frequently clogged with debris.
Storm flow measurements were more accurate than base flow because of debris problems.
ISCO, STAR, McBIRNEY represent various sensors used to measure velocity and water levels.
BF FORMULA and REGRESS indicate formulas used to estimate flow (see Appendix A)
BF FORMULA under estimates flow when pipe is more than half full (level > 3ft).

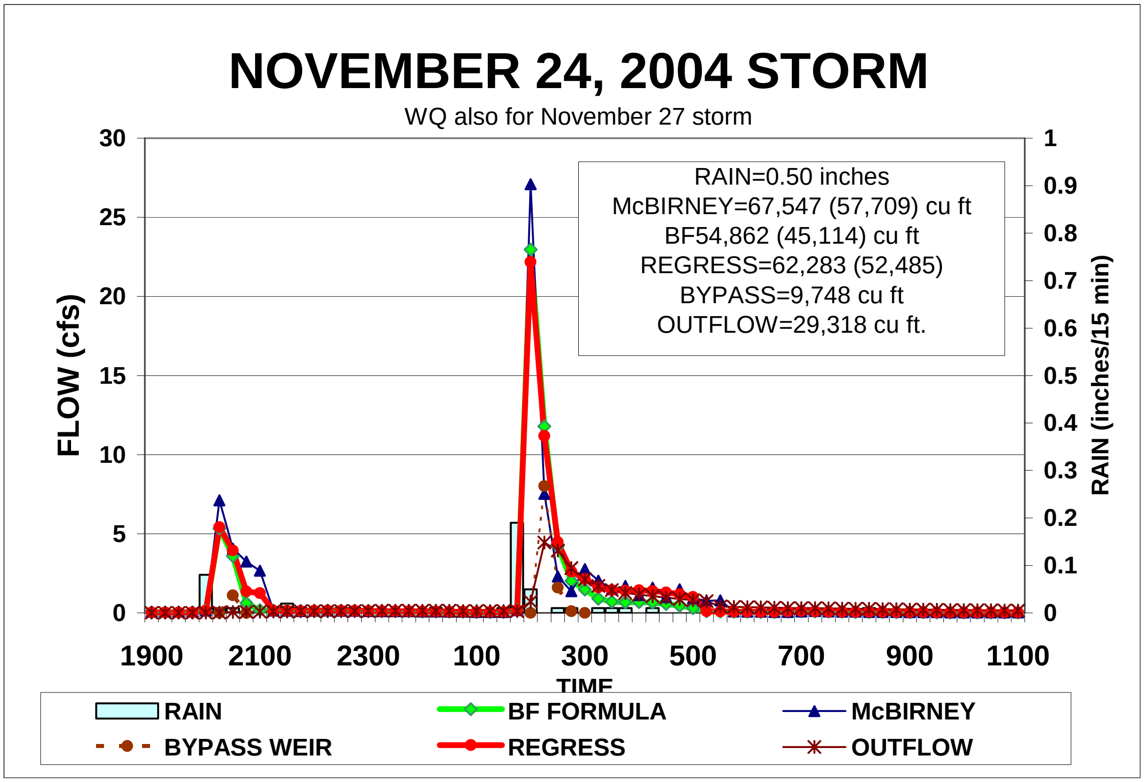
WATER BUDGET EQUATION:
FLOW IN - FLOW OUT = CHANGE IN STORAGE

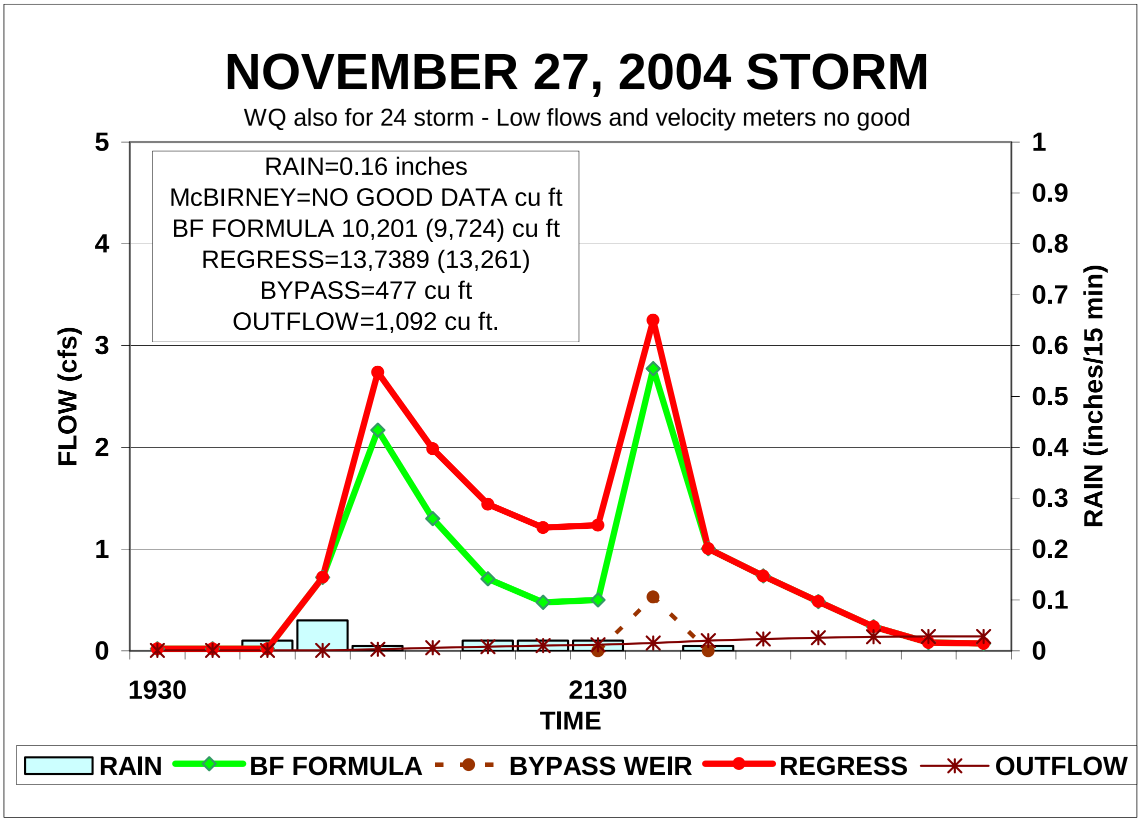
where: Flow in = rain on pond, storm flow and base flow
Flow out = flow out of pond (storm flow, base flow and ET)
Change in storage=difference between pond levels at from beginning to end of month
The error term is caused by weir obstructions, faulty sensors, offset errors and other problems

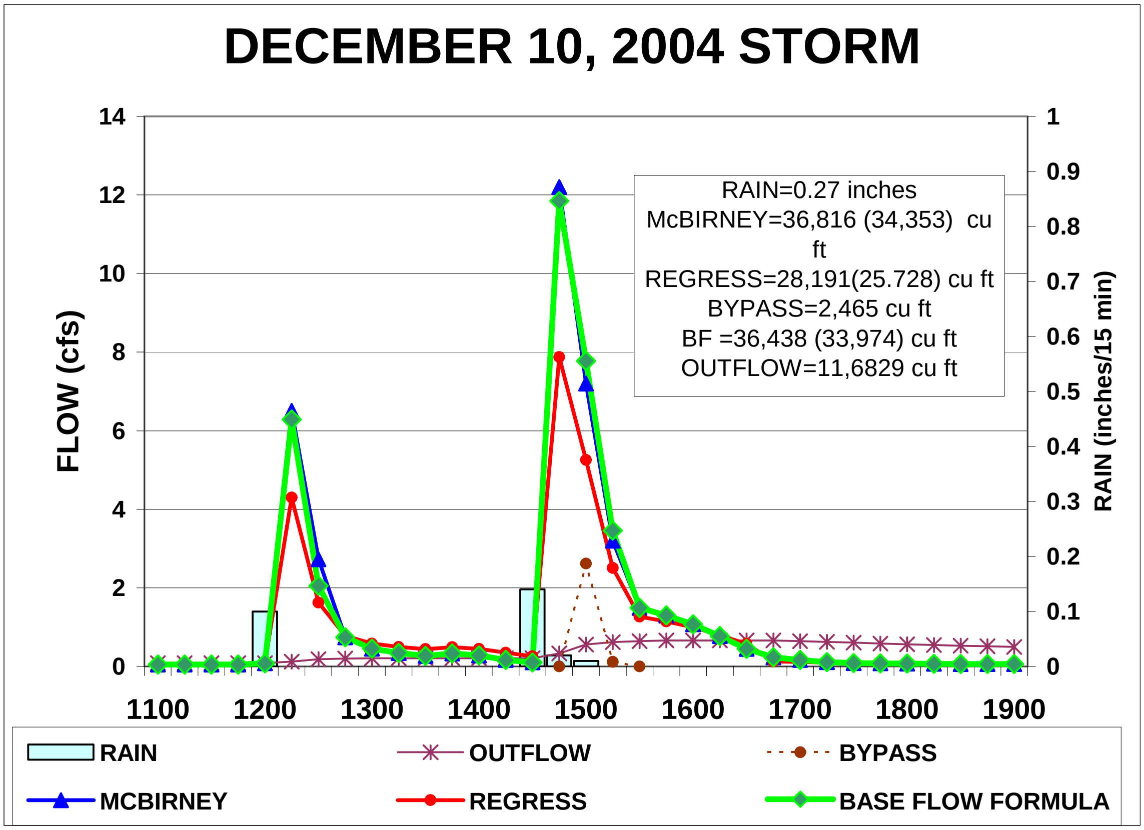
Error term is about 0.46% of inflow or outflow on yearly basis
46% of storm flows bypassed CDS unit on a yearly basis

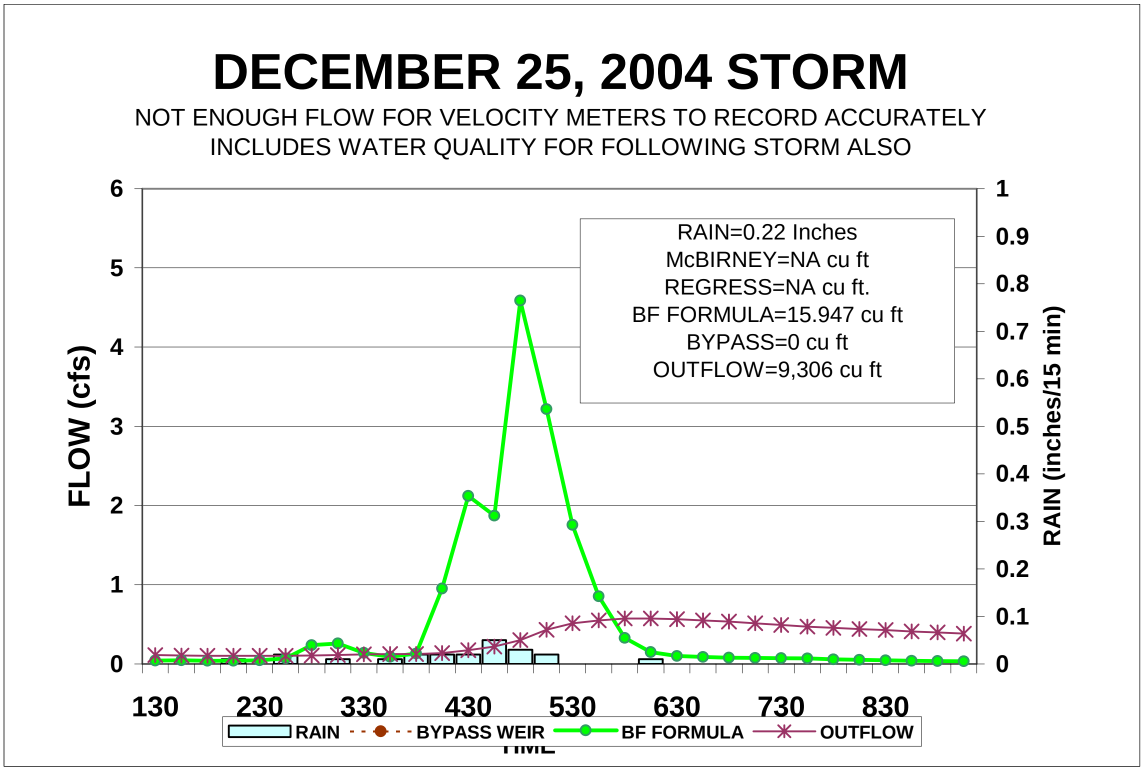
		INFLOW				OUTFLOW					REMARKS
POND ARE 46,605 sq. ft	RAIN inches	RAIN cu ft	BASE FLOW cu ft	STORM FLOW cu ft	BY-PASS FLOW cu ft duplicates not in budget	BASE FLOW cu ft	STORM FLOW cu ft	ET estimate cu ft	STORAGE loss or gain cu ft	ERROR cu ft	
November	0.75	2,913	72,835	70,517	10,225	105,177	30,489	12,816	9,787	-12,005	Making adjustments for field measurements
December	1.79	6,952	241,985	297,413	158,226	392,387	135,555	6,991	932	10,485	Used new offsets to reflect field measurements for base fl
January	0.67	2,602	49,308	104,327	60,567	107,625	38,745	4,661	5,127	80	No velocity meter (sent for repairs)
February	2.08	8,078	148,721	282,935	131,835	192,251	212,824	6,991	932	26,736	Cleaned CDS and lost two days of data
March	6.53	25,361	313,651	552,106	254,295	438,720	448,708	11,651	466	-8,427	Sensor drift problems (see Appendix A).
April	4.02	15,613	100,412	701,479	179,842	304,712	459,512	16,312	3,728	33,240	Change offsets to reflect all field measurements
May	3.95	15,341	104,623	548,190	230,347	205,280	435,798	18,642	27,870	-19,436	Used new offsets for all flows. No velocity meter
June	16.17	62,800	249,415	2,582,791	1,167,330	582,613	2,257,920	20,972	-10,253	43,754	Velocity meter gives up entirely Only used formulas
July	10.59	41,129	298,584	1,916,365	900,299	780,742	1,407,120	22,137	13,982	32,097	Problems with pond level which may affect outflow volume
August	10.05	39,032	335,558	1,514,062	835,117	677,218	1,196,622	19,807	13,795	-18,791	Some problems with level readings in front of CDS
September	0.98	3,806	165,055	71,867	7,962	220,191	21,895	16,312	-17,570	-100	Data logger problems, no data for nine days
October	3.53	13,710	154,567	460,234	232,332	261,710	391,696	13,982	-4,567	-34,310	Misses 2.5 days of data
TOTAL	61.11	237,336	2,234,714	9,102,286	4,168,377	4,268,626	7,036,884	171,273	44,228	53,324	

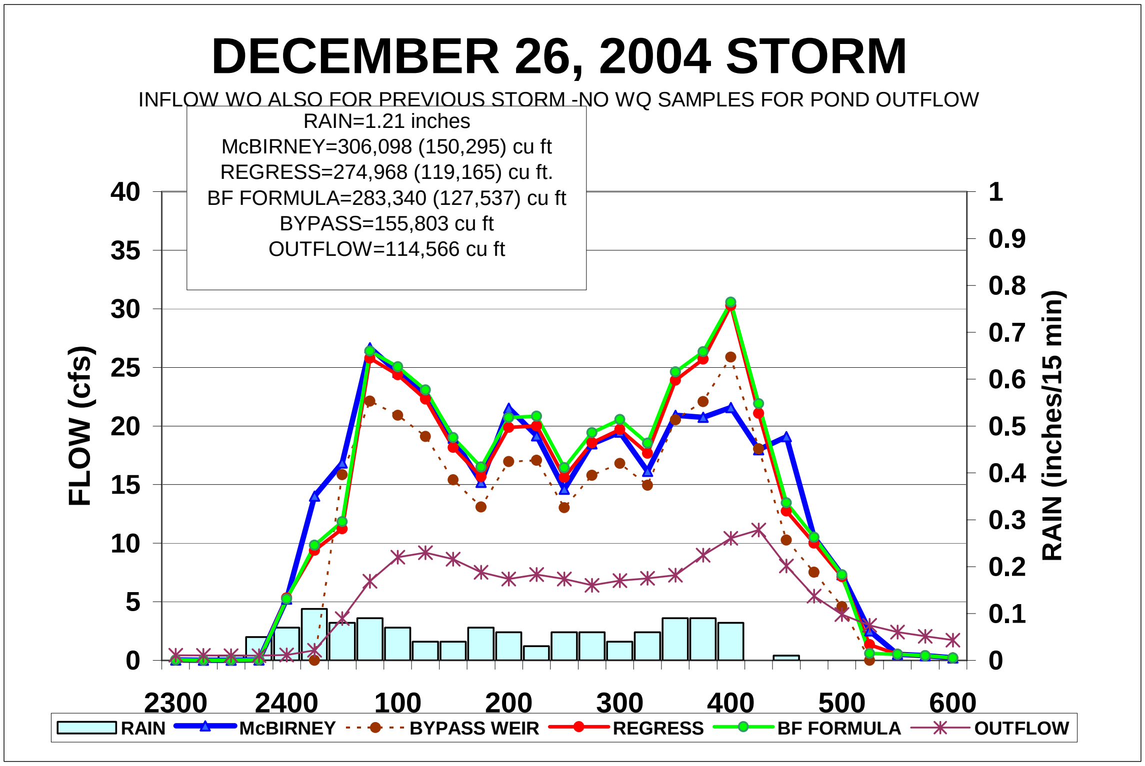
Storage: negative = gain; positive = loss


NOVEMBER 24, 2004 STORM
WQ also for November 27 storm
RAIN=0.50 inches
McBIRNEY=67,547 (57,709) cu ft
BF54,862 (45,114) cu ft
REGRESS=62,283 (52,485)
BYPASS=9,748 cu ft
OUTFLOW=29,318 cu ft.
FLOW (cfs)
30
25
20
15
10
5
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1900
2100
2300
100
300
500
700
900
1100
TIME
RAIN
BF FORMULA
McBIRNEY
BYPASS WEIR
REGRESS
OUTFLOW


NOVEMBER 27, 2004 STORM
WQ also for 24 storm - Low flows and velocity meters no good
RAIN=0.16 inches
McBIRNEY=NO GOOD DATA cu ft
BF FORMULA 10,201 (9,724) cu ft
REGRESS=13,7389 (13,261)
BYPASS=477 cu ft
OUTFLOW=1,092 cu ft.
FLOW (cfs)
5
4
3
2
1
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1930
2130
TIME
RAIN
BF FORMULA
BYPASS WEIR
REGRESS
OUTFLOW

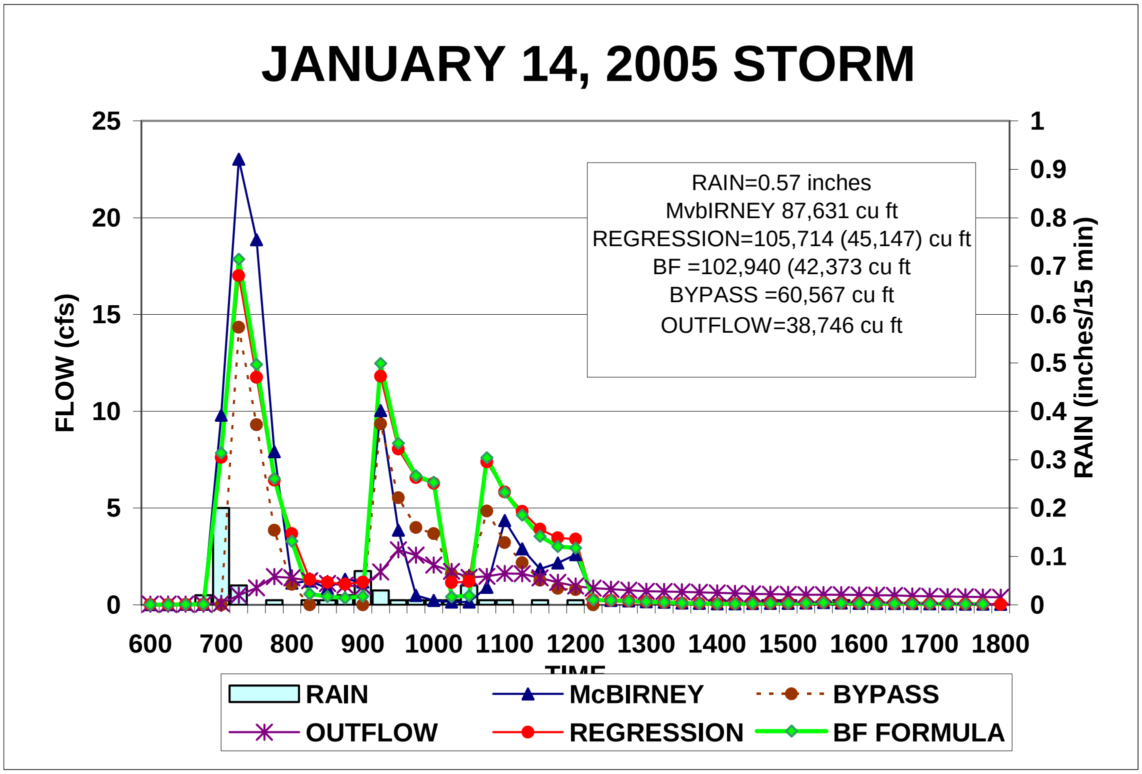

DECEMBER 10, 2004 STORM
RAIN=0.27 inches
McBIRNEY=36,816 (34,353) cu ft
REGRESS=28,191(25.728) cu ft
BYPASS=2,465 cu ft
BF =36,438 (33,974) cu ft
OUTFLOW=11,6829 cu ft
FLOW (cfs)
RAIN (inches/15 min)
14
12
10
8
6
4
2
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1100
1200
1300
1400
1500
1600
1700
1800
1900
RAIN
OUTFLOW
BYPASS
MCBIRNEY
REGRESS
BASE FLOW FORMULA


DECEMBER 25, 2004 STORM
NOT ENOUGH FLOW FOR VELOCITY METERS TO RECORD ACCURATELY
INCLUDES WATER QUALITY FOR FOLLOWING STORM ALSO
RAIN=0.22 Inches
McBIRNEY=NA cu ft
REGRESS=NA cu ft.
BF FORMULA=15.947 cu ft
BYPASS=0 cu ft
OUTFLOW=9,306 cu ft
FLOW (cfs)
RAIN (inches/15 min)
6
5
4
3
2
1
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
130
230
330
430
530
630
730
830
RAIN
BYPASS WEIR
BF FORMULA
OUTFLOW

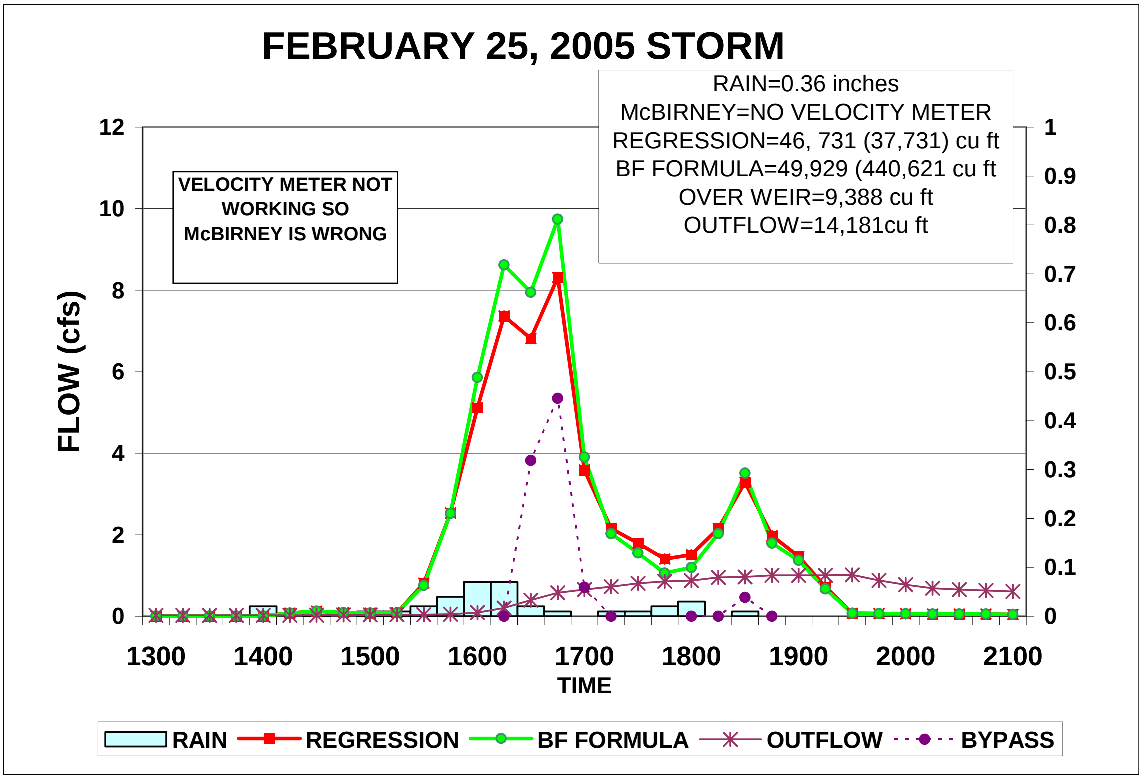

DECEMBER 26, 2004 STORM

INFLOW WO ALSO FOR PREVIOUS STORM -NO WQ SAMPLES FOR POND OUTFLOW

RAIN=1.21 inches
McBIRNEY=306,098 (150,295) cu ft
REGRESS=274,968 (119,165) cu ft.
BF FORMULA=283,340 (127,537) cu ft
BYPASS=155,803 cu ft
OUTFLOW=114,566 cu ft


JANUARY 14, 2005 STORM

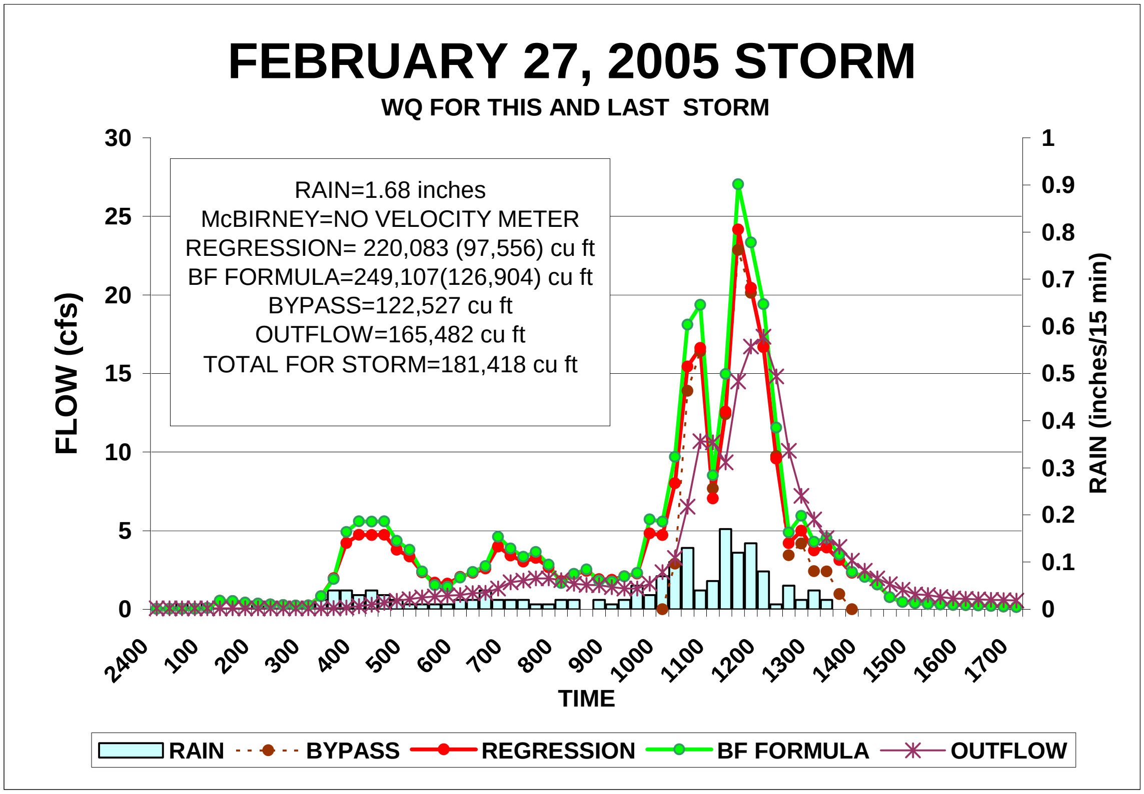
RAIN=0.57 inches
MvbIRNEY 87,631 cu ft
REGRESSION=105,714 (45,147) cu ft
BF =102,940 (42,373 cu ft
BYPASS =60,567 cu ft
OUTFLOW=38,746 cu ft



FEBRUARY 25, 2005 STORM

RAIN=0.36 inches
McBIRNEY=NO VELOCITY METER
REGRESSION=46, 731 (37,731) cu ft
BF FORMULA=49,929 (440,621 cu ft
OVER WEIR=9,388 cu ft
OUTFLOW=14,181cu ft

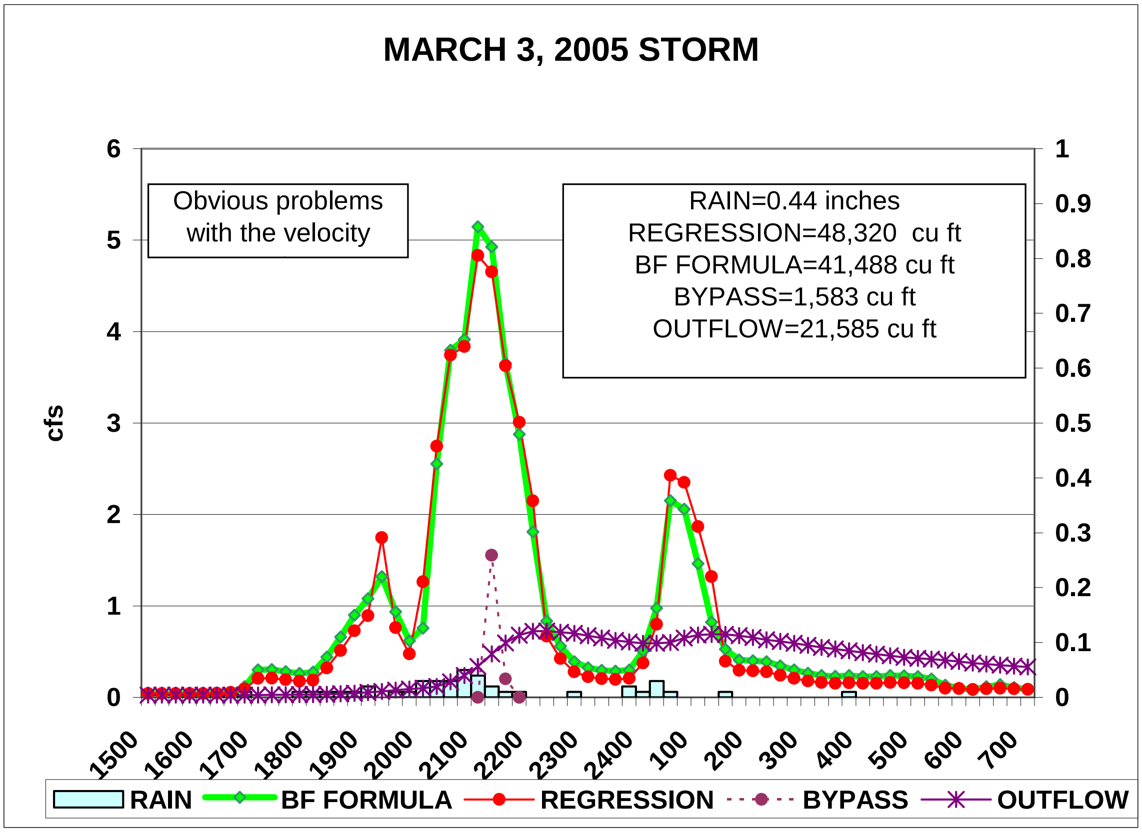
VELOCITY METER NOT WORKING SO McBIRNEY IS WRONG

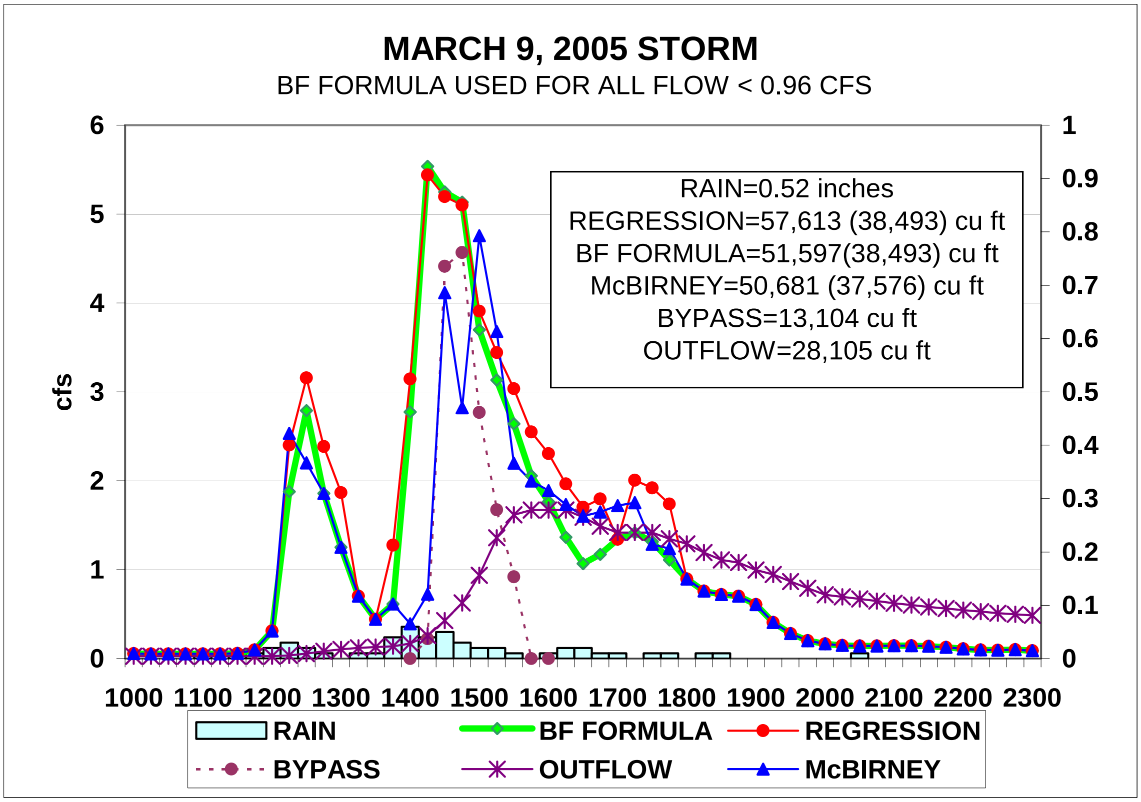


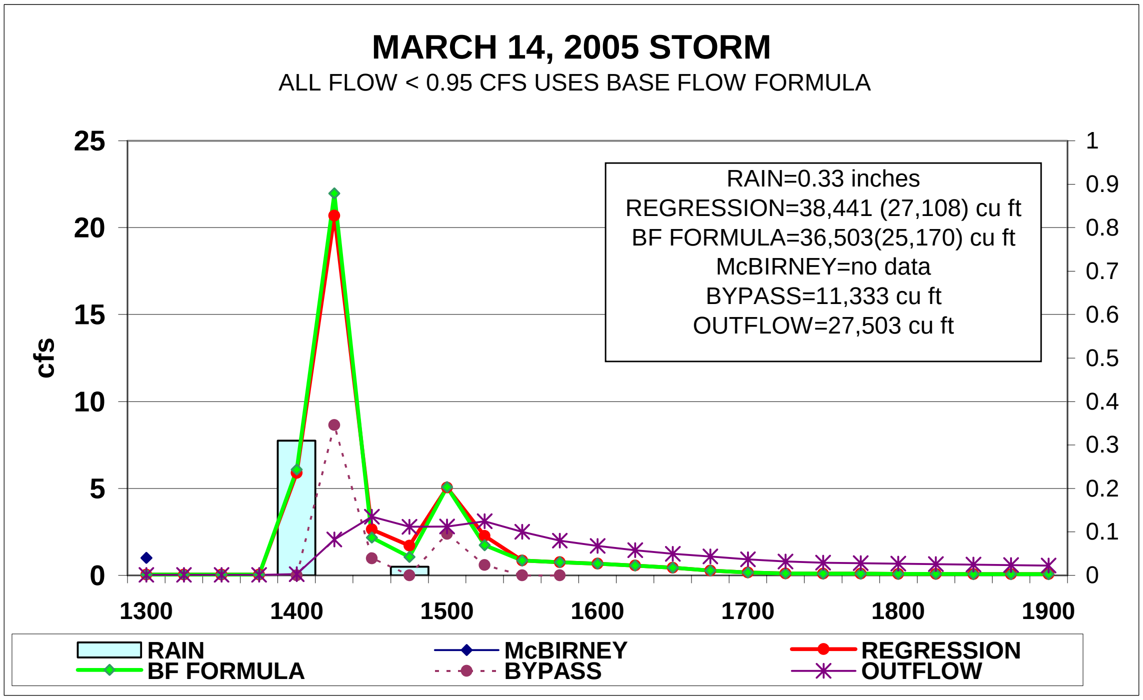
FEBRUARY 27, 2005 STORM

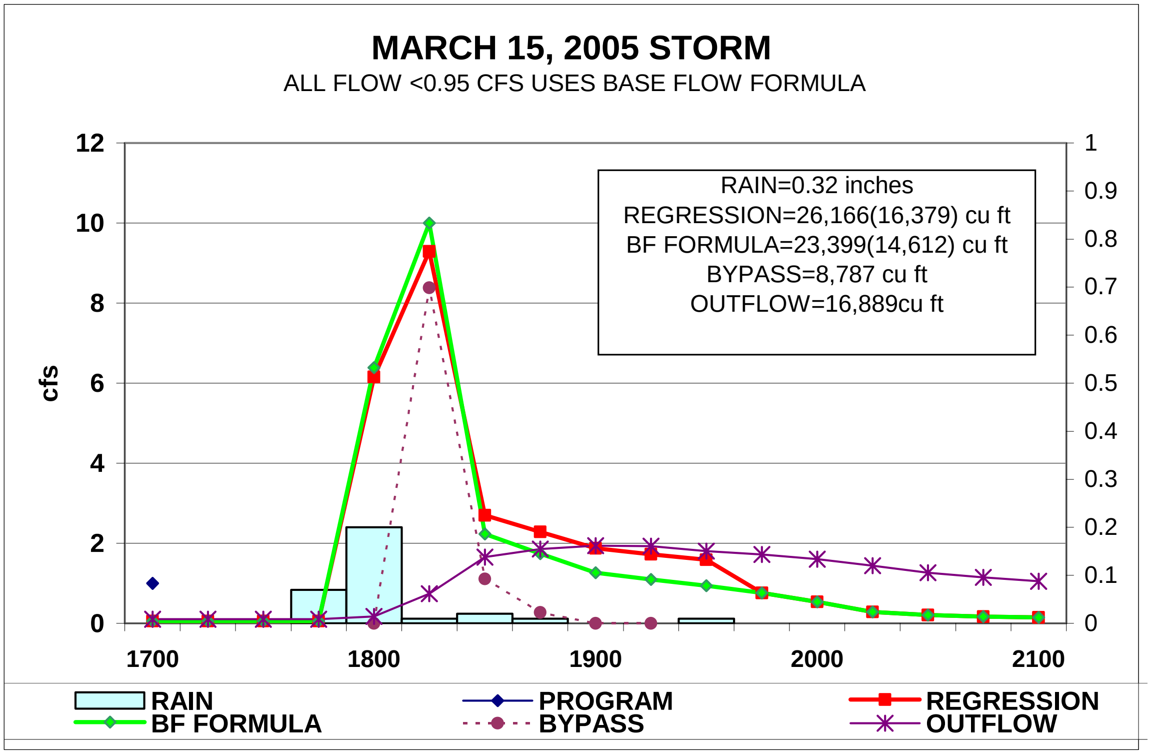
WQ FOR THIS AND LAST STORM

RAIN=1.68 inches
McBIRNEY=NO VELOCITY METER
REGRESSION= 220,083 (97,556) cu ft
BF FORMULA=249,107(126,904) cu ft
BYPASS=122,527 cu ft
OUTFLOW=165,482 cu ft
TOTAL FOR STORM=181,418 cu ft

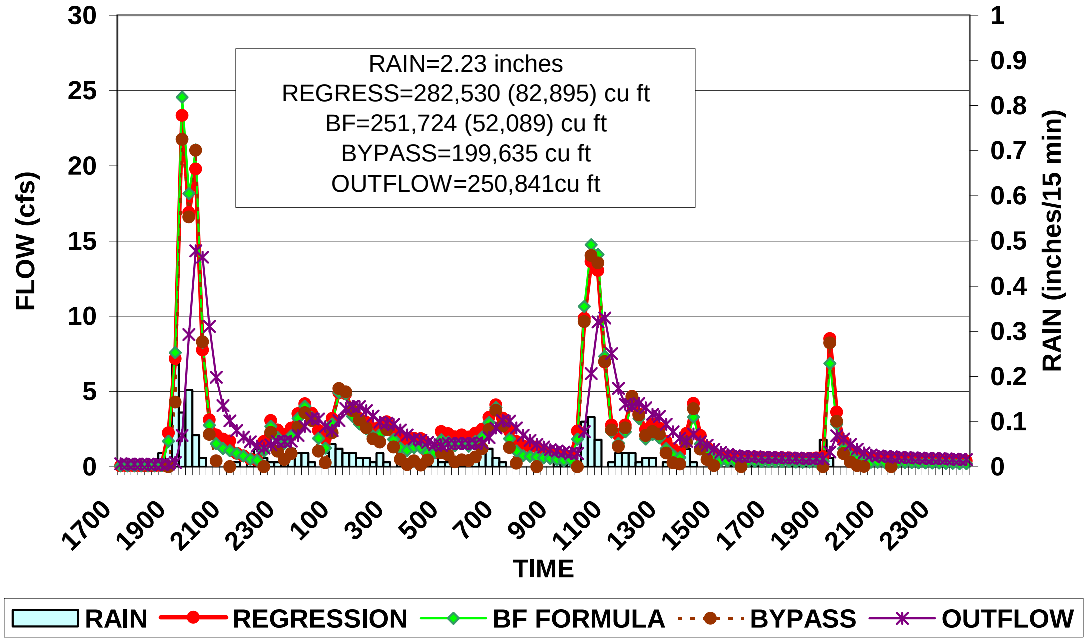

MARCH 3, 2005 STORM
Obvious problems with the velocity
RAIN=0.44 inches
REGRESSION=48,320 cu ft
BF FORMULA=41,488 cu ft
BYPASS=1,583 cu ft
OUTFLOW=21,585 cu ft
cfs
0
1
2
3
4
5
6
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
100
200
300
400
500
600
700
RAIN
BF FORMULA
REGRESSION
BYPASS
OUTFLOW


MARCH 9, 2005 STORM
BF FORMULA USED FOR ALL FLOW < 0.96 CFS
RAIN=0.52 inches
REGRESSION=57,613 (38,493) cu ft
BF FORMULA=51,597(38,493) cu ft
McBIRNEY=50,681 (37,576) cu ft
BYPASS=13,104 cu ft
OUTFLOW=28,105 cu ft
cfs
0
1
2
3
4
5
6
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
RAIN
BF FORMULA
REGRESSION
BYPASS
OUTFLOW
McBIRNEY

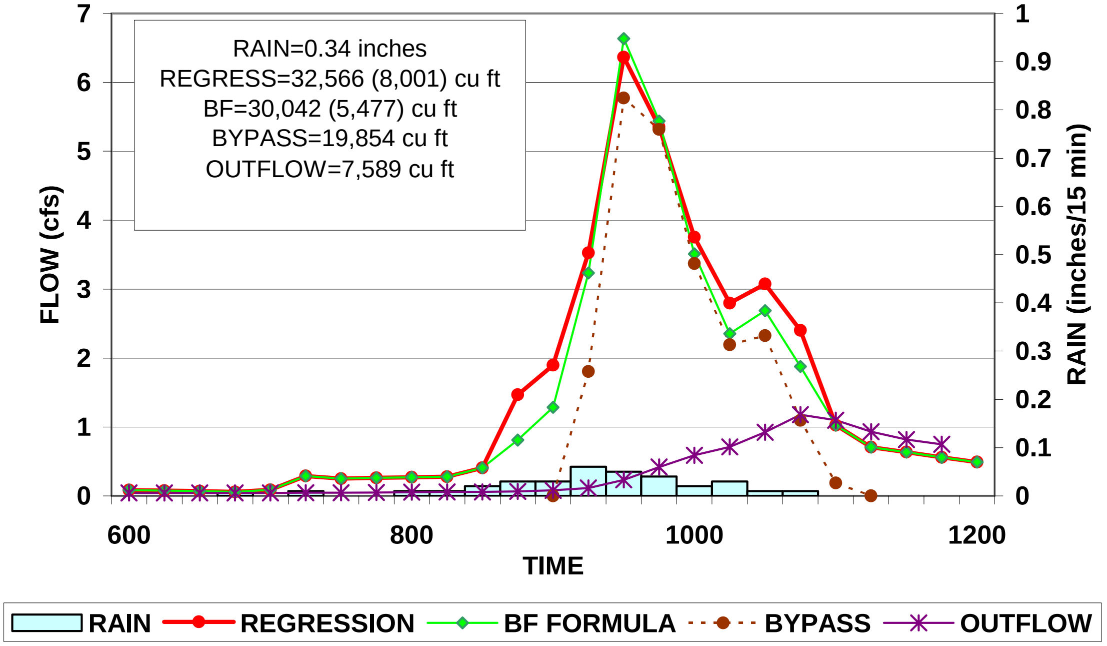

MARCH 14, 2005 STORM
ALL FLOW < 0.95 CFS USES BASE FLOW FORMULA
RAIN=0.33 inches
REGRESSION=38,441 (27,108) cu ft
BF FORMULA=36,503(25,170) cu ft
McBIRNEY=no data
BYPASS=11,333 cu ft
OUTFLOW=27,503 cu ft
cfs
25
20
15
10
5
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1300
1400
1500
1600
1700
1800
1900
RAIN
BF FORMULA
McBIRNEY
BYPASS
REGRESSION
OUTFLOW

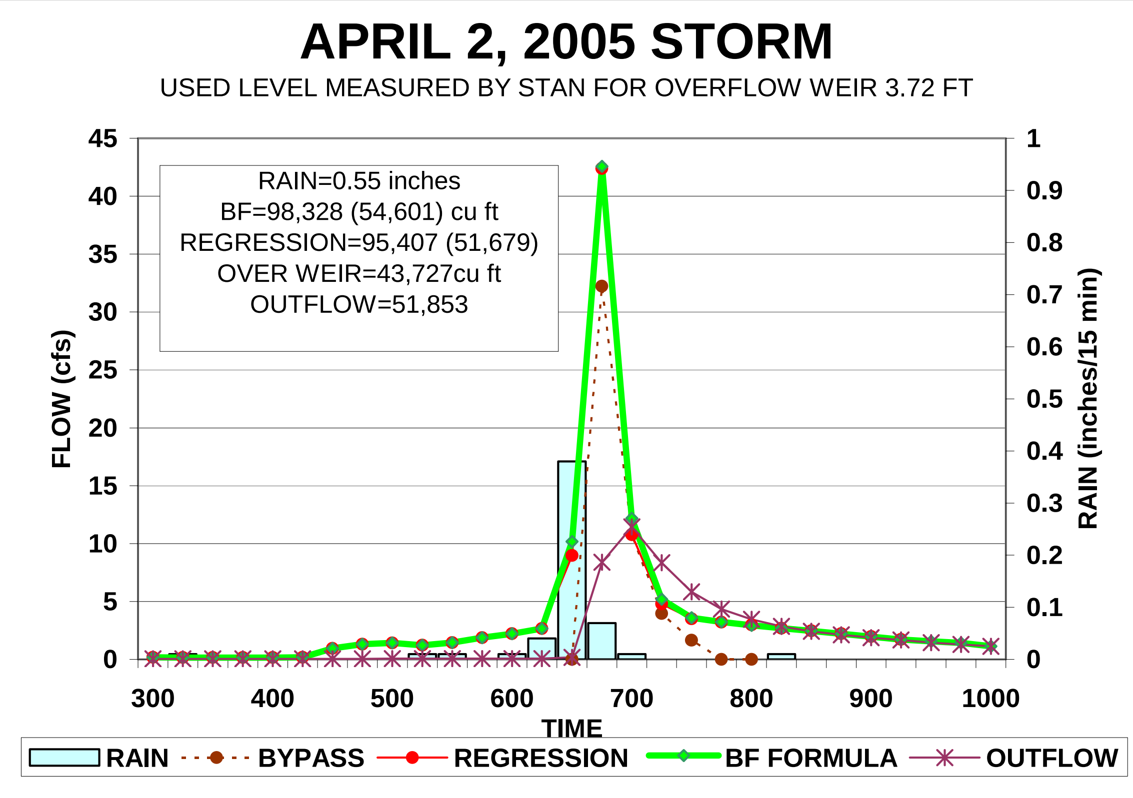

MARCH 15, 2005 STORM
ALL FLOW <0.95 CFS USES BASE FLOW FORMULA
RAIN=0.32 inches
REGRESSION=26,166(16,379) cu ft
BF FORMULA=23,399(14,612) cu ft
BYPASS=8,787 cu ft
OUTFLOW=16,889cu ft
cfs
12
10
8
6
4
2
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1700
1800
1900
2000
2100
RAIN
BF FORMULA
PROGRAM
BYPASS
REGRESSION
OUTFLOW

MARCH 16-17, 2005 STORM



MARCH 23, 2005 STORM

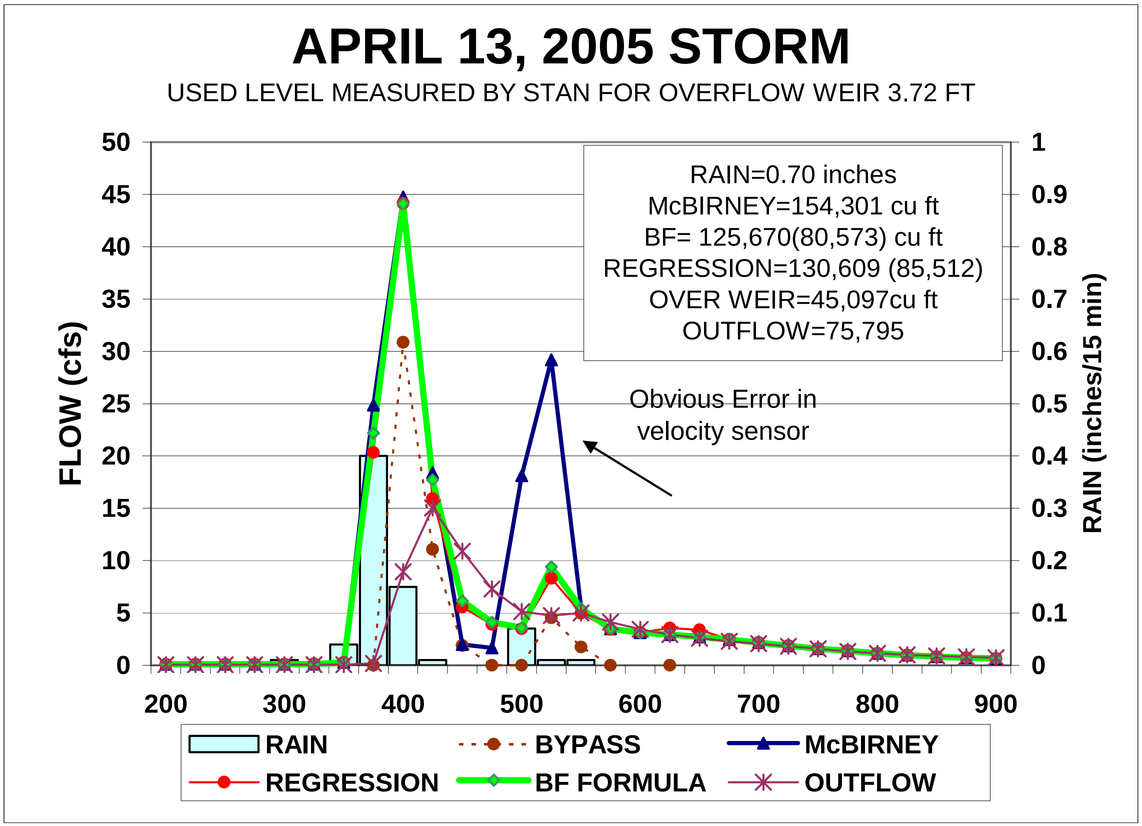




APRIL 2, 2005 STORM

USED LEVEL MEASURED BY STAN FOR OVERFLOW WEIR 3.72 FT

RAIN=0.55 inches
BF=98,328 (54,601) cu ft
REGRESSION=95,407 (51,679)
OVER WEIR=43,727cu ft
OUTFLOW=51,853

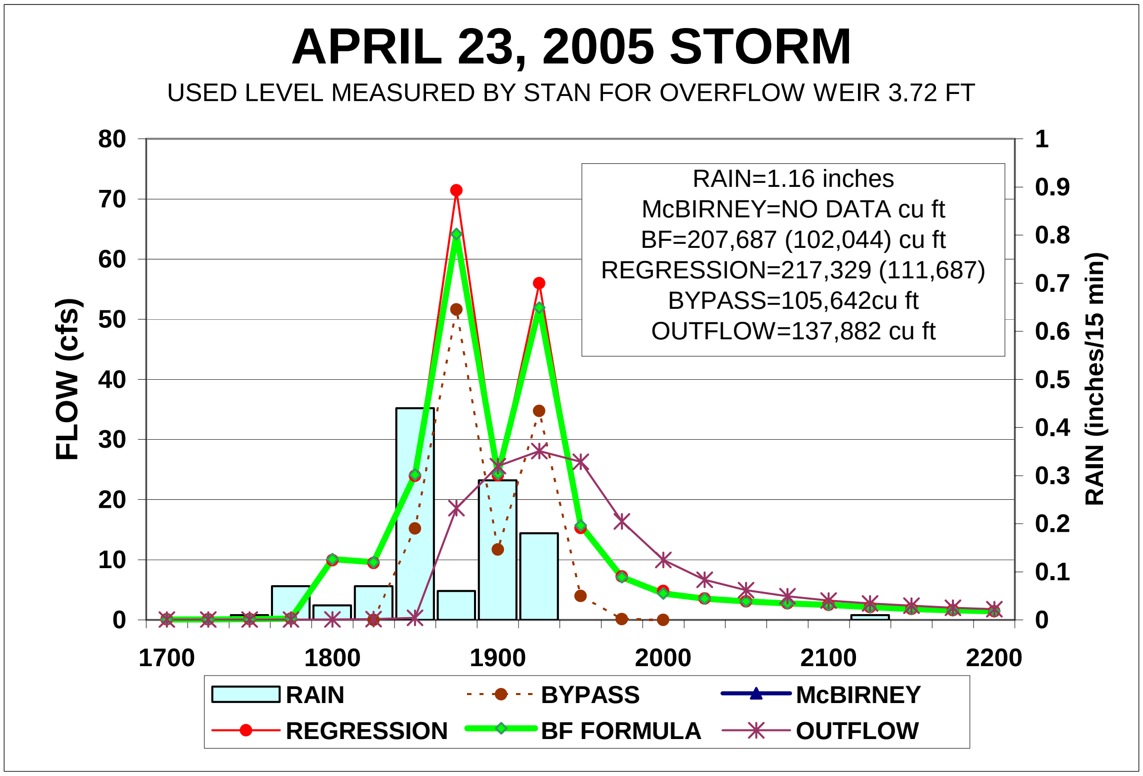


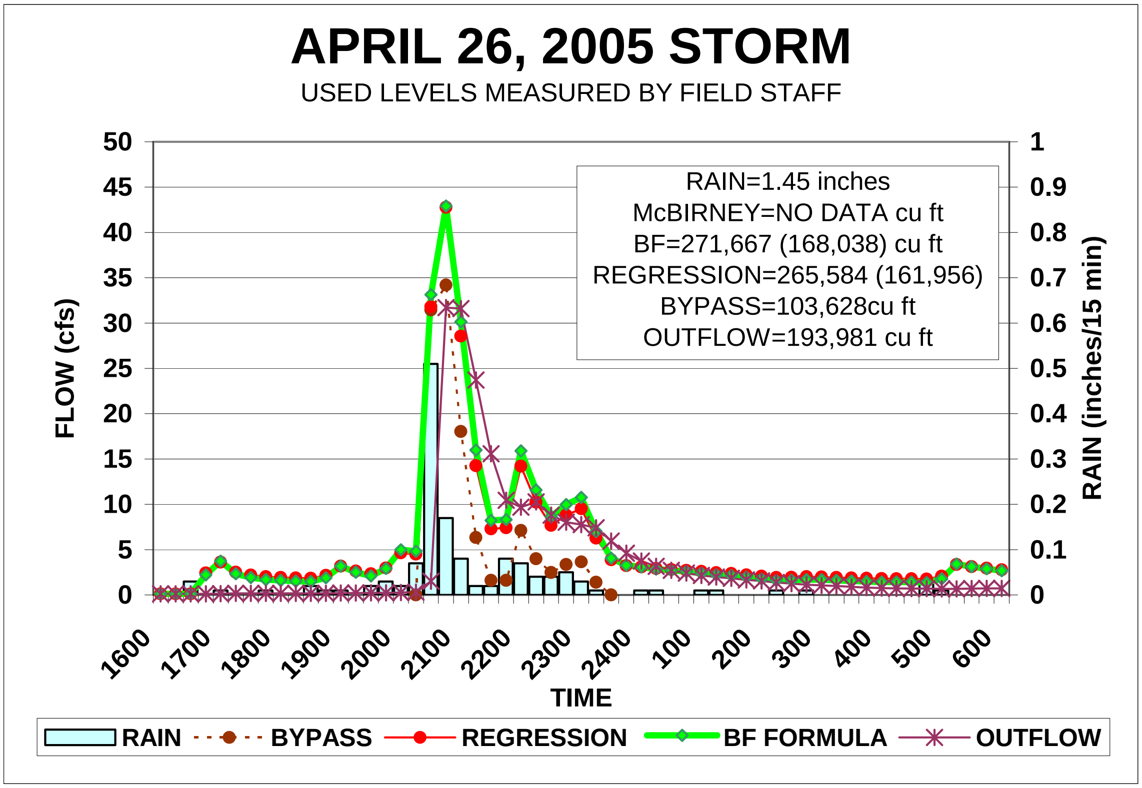
APRIL 13, 2005 STORM

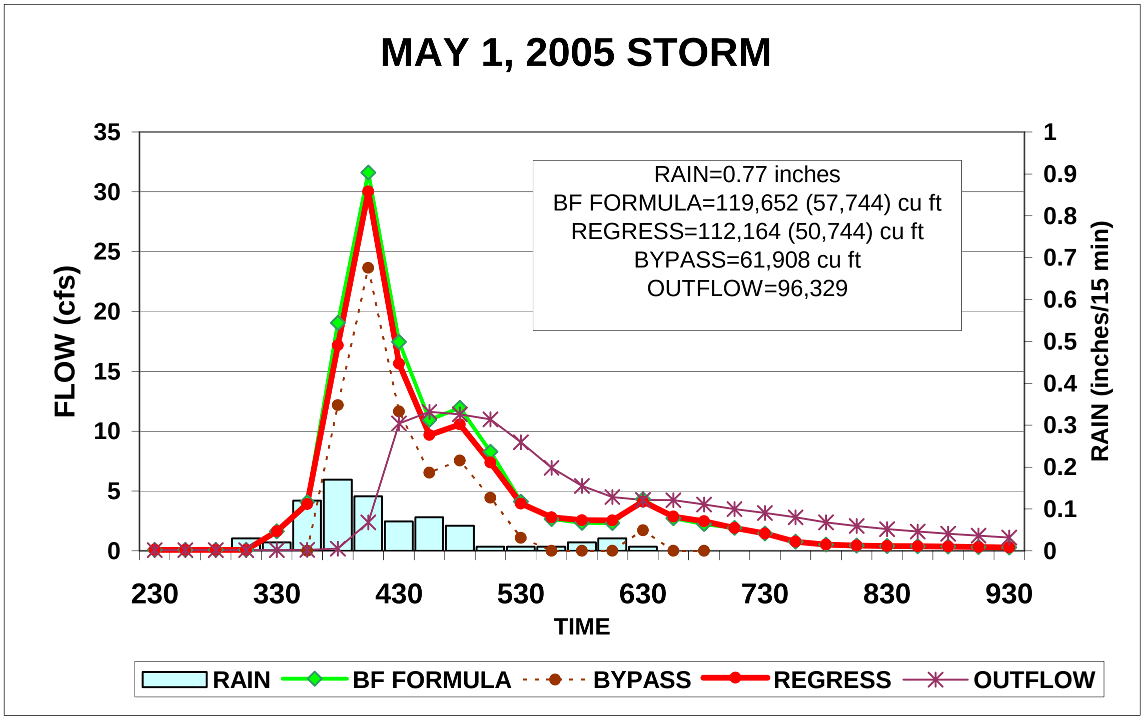
USED LEVEL MEASURED BY STAN FOR OVERFLOW WEIR 3.72 FT

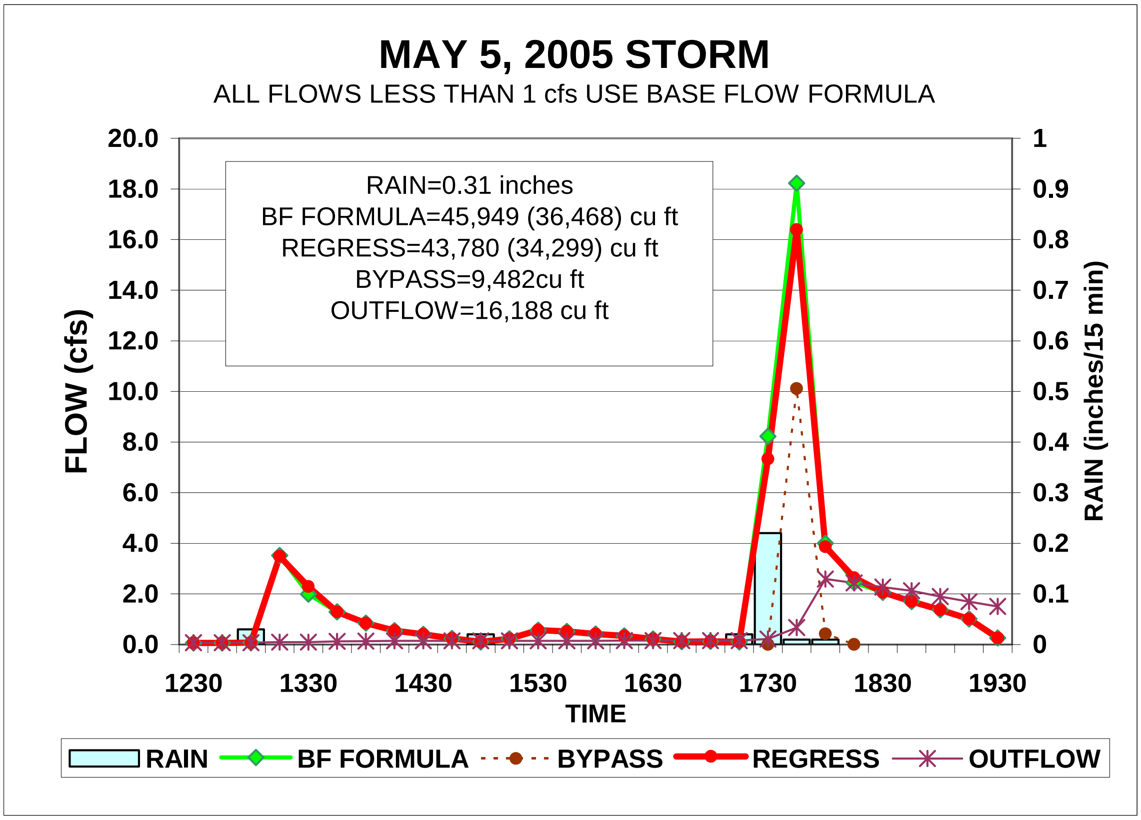
RAIN=0.70 inches
McBIRNEY=154,301 cu ft
BF= 125,670(80,573) cu ft
REGRESSION=130,609 (85,512)
OVER WEIR=45,097cu ft
OUTFLOW=75,795

Obvious Error in
velocity sensor

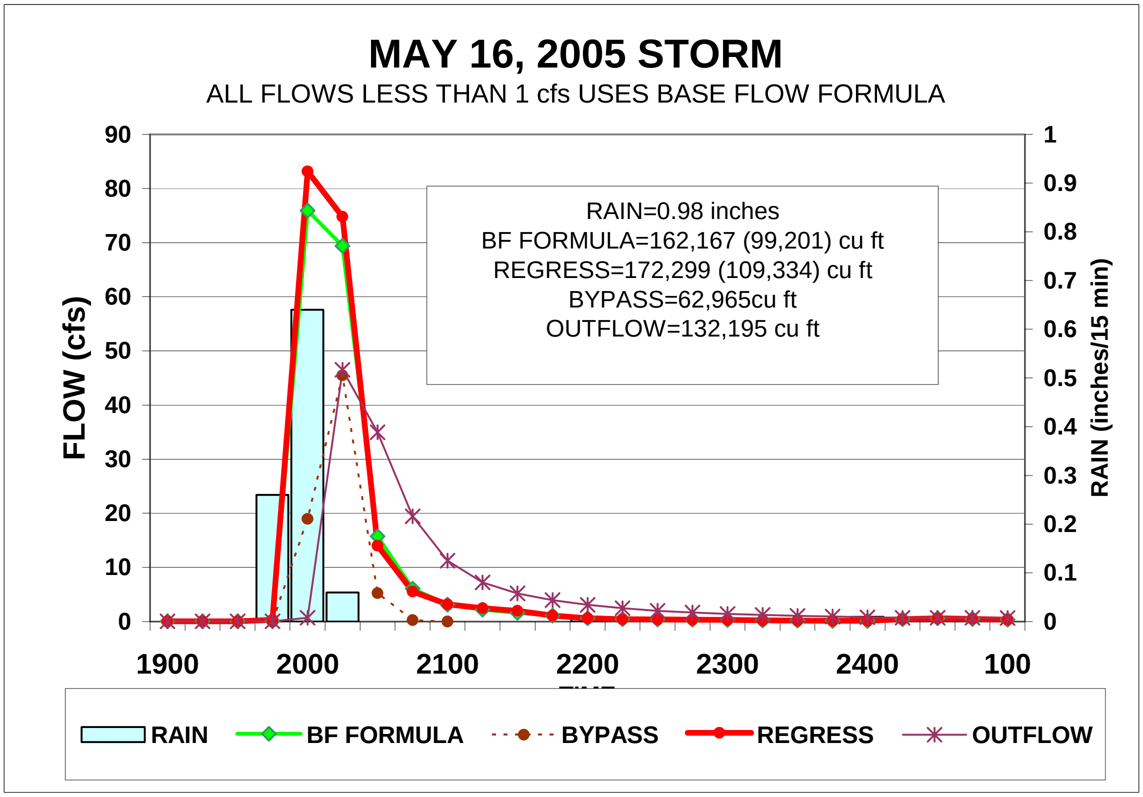

APRIL 23, 2005 STORM
USED LEVEL MEASURED BY STAN FOR OVERFLOW WEIR 3.72 FT
RAIN=1.16 inches
McBIRNEY=NO DATA cu ft
BF=207,687 (102,044) cu ft
REGRESSION=217,329 (111,687)
BYPASS=105,642cu ft
OUTFLOW=137,882 cu ft
FLOW (cfs)
0
10
20
30
40
50
60
70
80
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1700
1800
1900
2000
2100
2200
RAIN
BYPASS
McBIRNEY
REGRESSION
BF FORMULA
OUTFLOW


APRIL 26, 2005 STORM
USED LEVELS MEASURED BY FIELD STAFF
RAIN=1.45 inches
McBIRNEY=NO DATA cu ft
BF=271,667 (168,038) cu ft
REGRESSION=265,584 (161,956)
BYPASS=103,628cu ft
OUTFLOW=193,981 cu ft
FLOW (cfs)
0
5
10
15
20
25
30
35
40
45
50
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1600
1700
1800
1900
2000
2100
2200
2300
2400
100
200
300
400
500
600
TIME
RAIN
BYPASS
REGRESSION
BF FORMULA
OUTFLOW


MAY 1, 2005 STORM


MAY 5, 2005 STORM

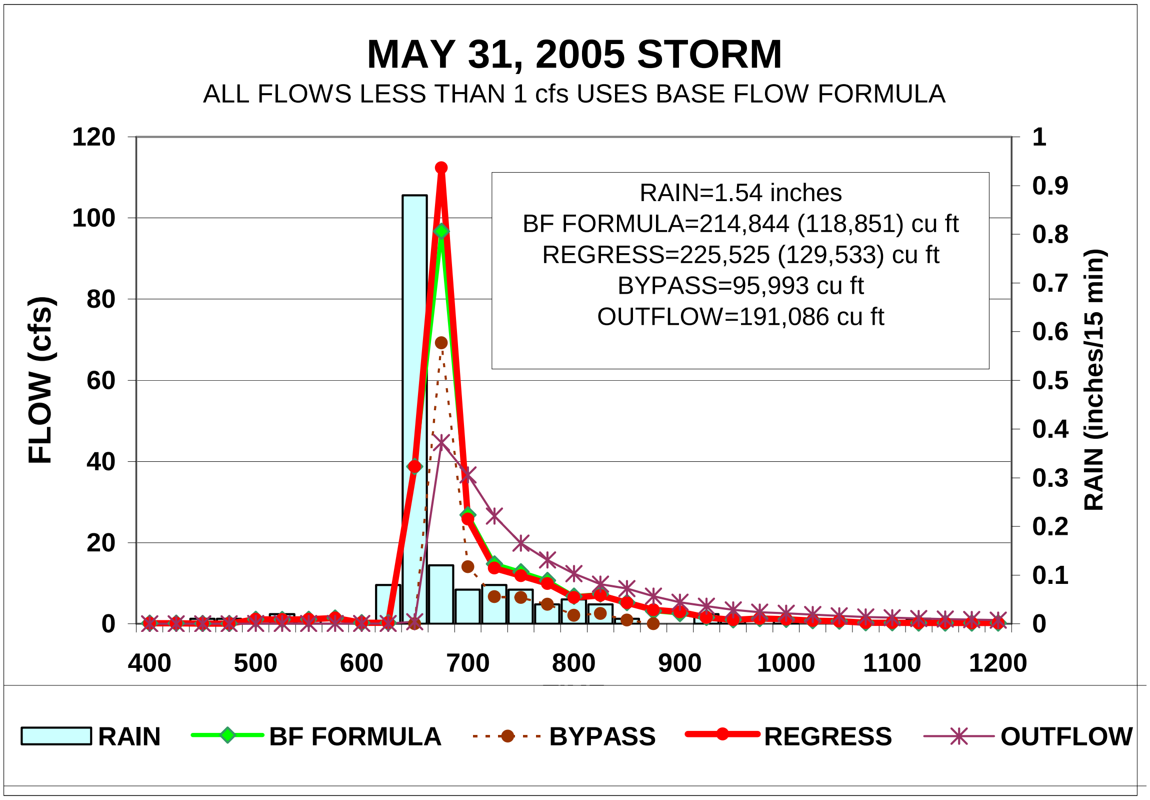
ALL FLOWS LESS THAN 1 cfs USE BASE FLOW FORMULA



MAY 16, 2005 STORM

ALL FLOWS LESS THAN 1 cfs USES BASE FLOW FORMULA

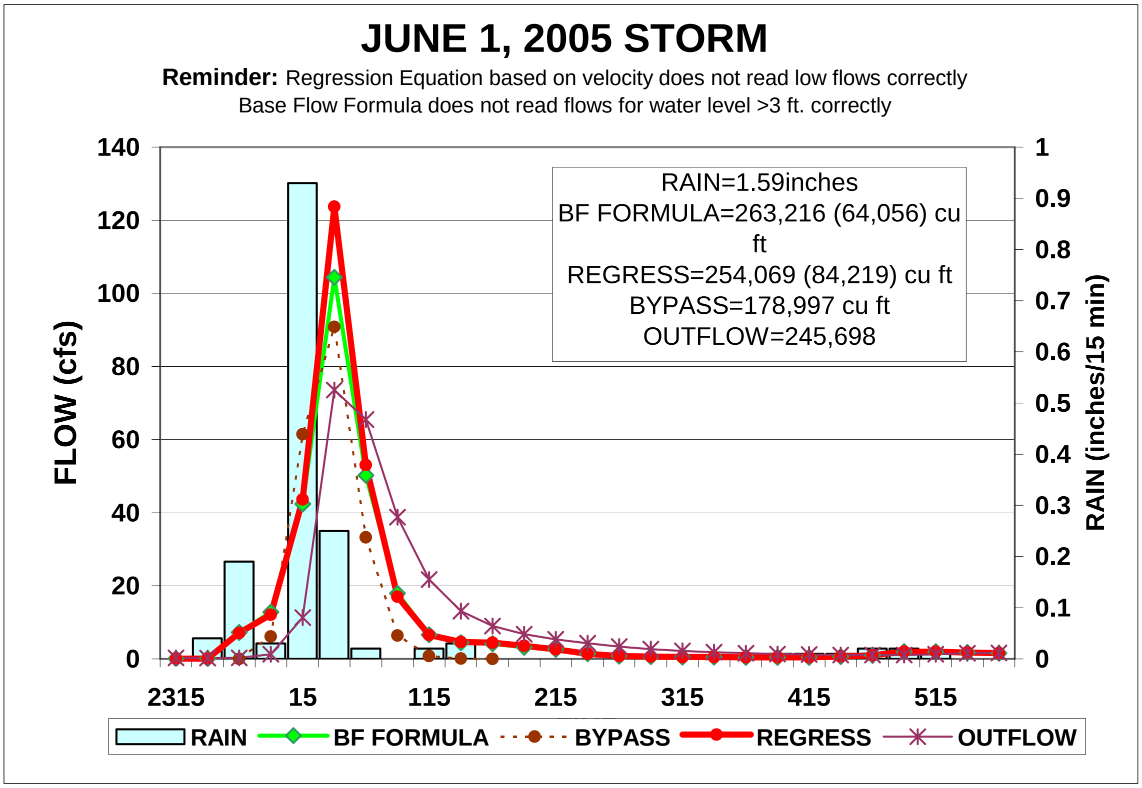
RAIN=0.98 inches
BF FORMULA=162,167 (99,201) cu ft
REGRESS=172,299 (109,334) cu ft
BYPASS=62,965cu ft
OUTFLOW=132,195 cu ft

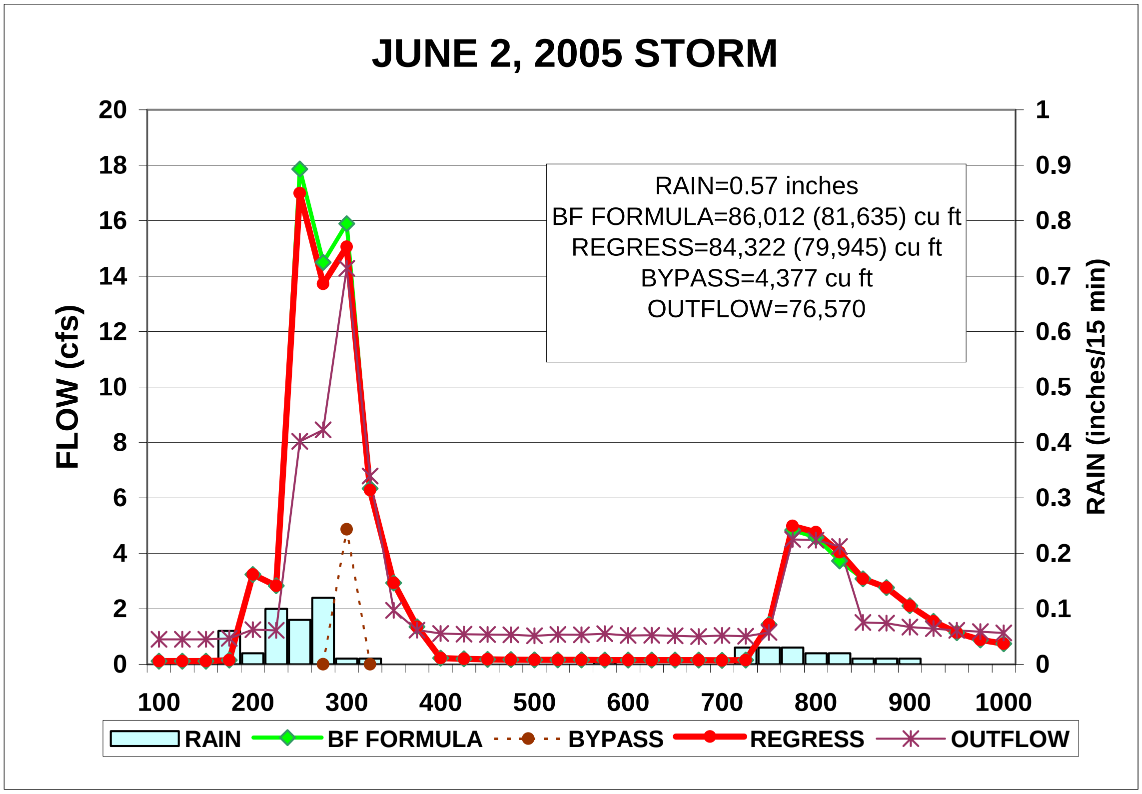


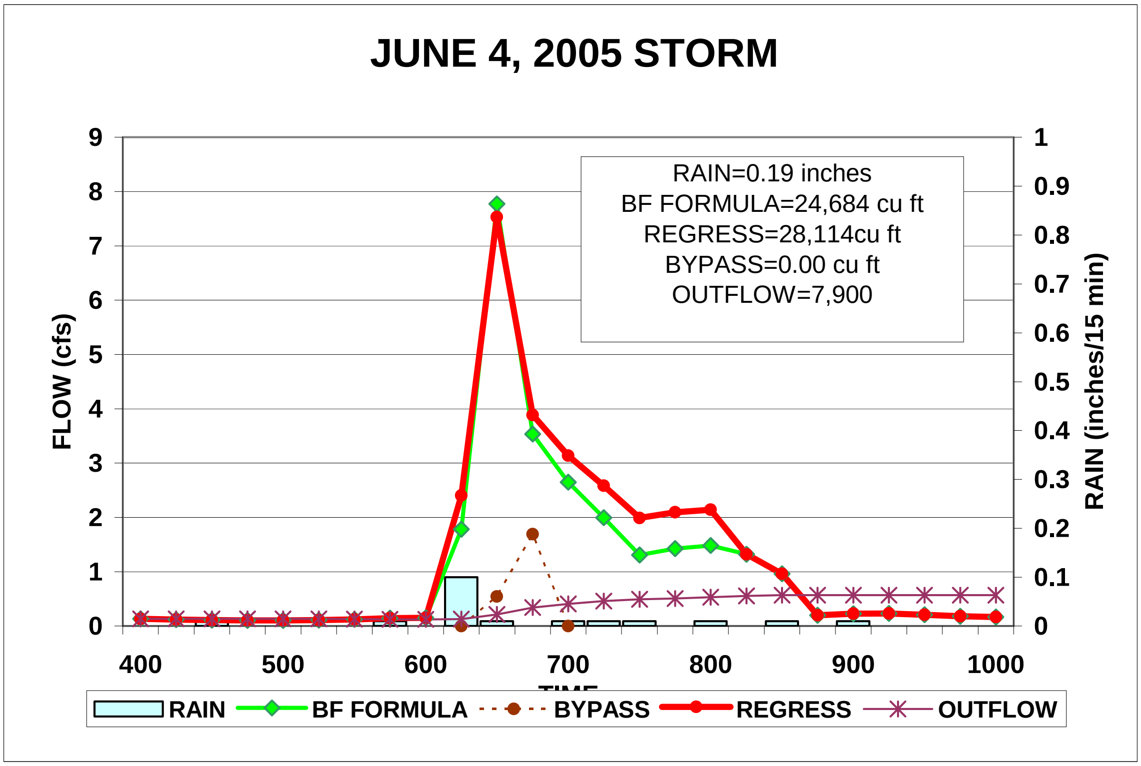
MAY 31, 2005 STORM

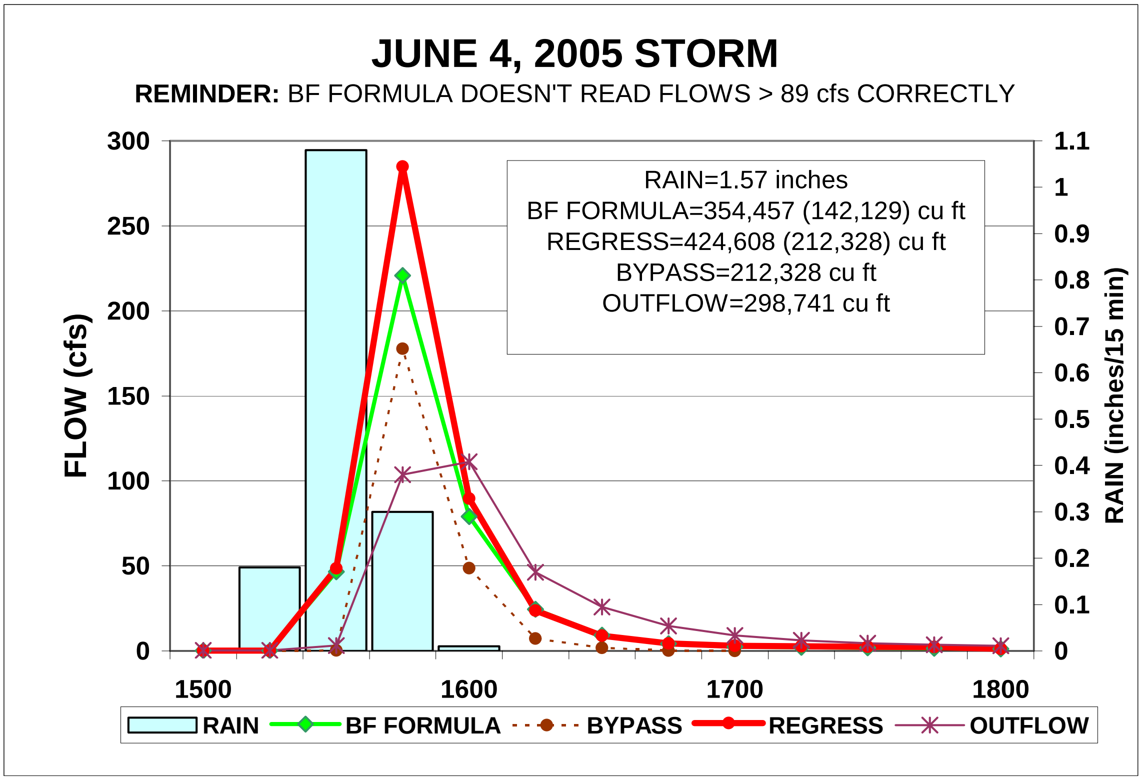
ALL FLOWS LESS THAN 1 cfs USES BASE FLOW FORMULA

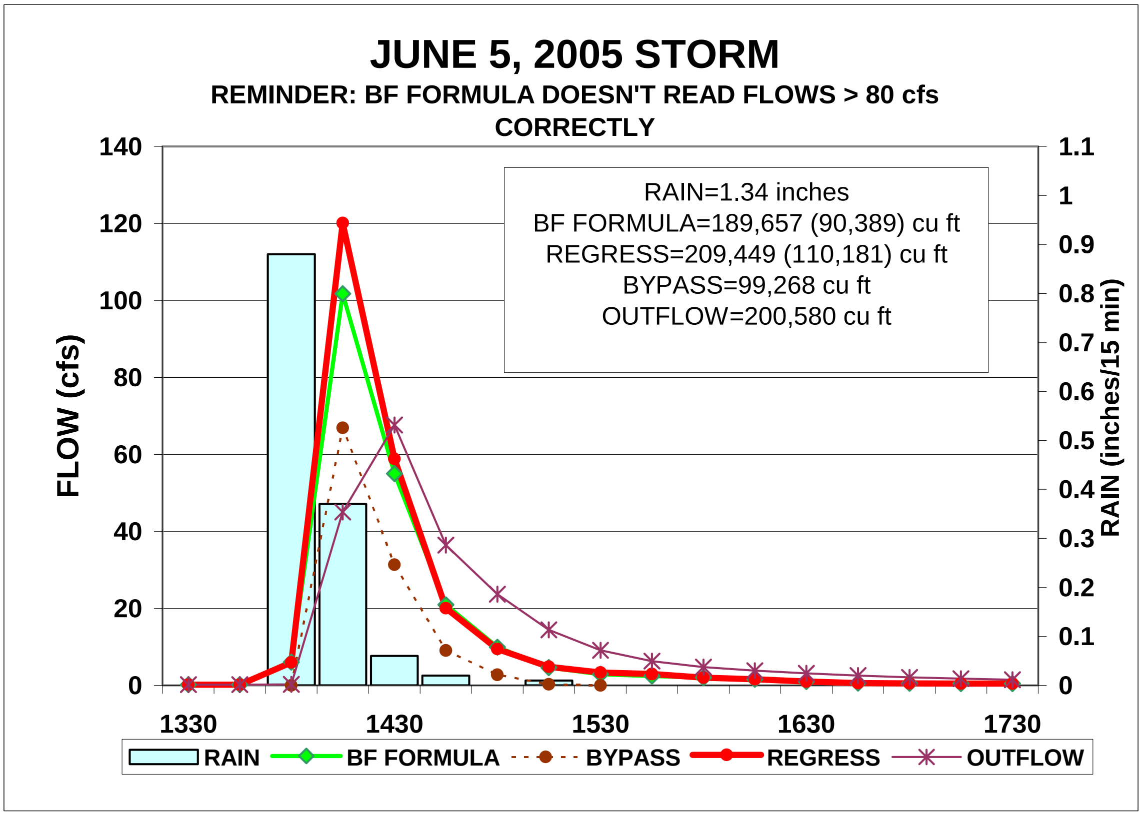
RAIN=1.54 inches
BF FORMULA=214,844 (118,851) cu ft
REGRESS=225,525 (129,533) cu ft
BYPASS=95,993 cu ft
OUTFLOW=191,086 cu ft

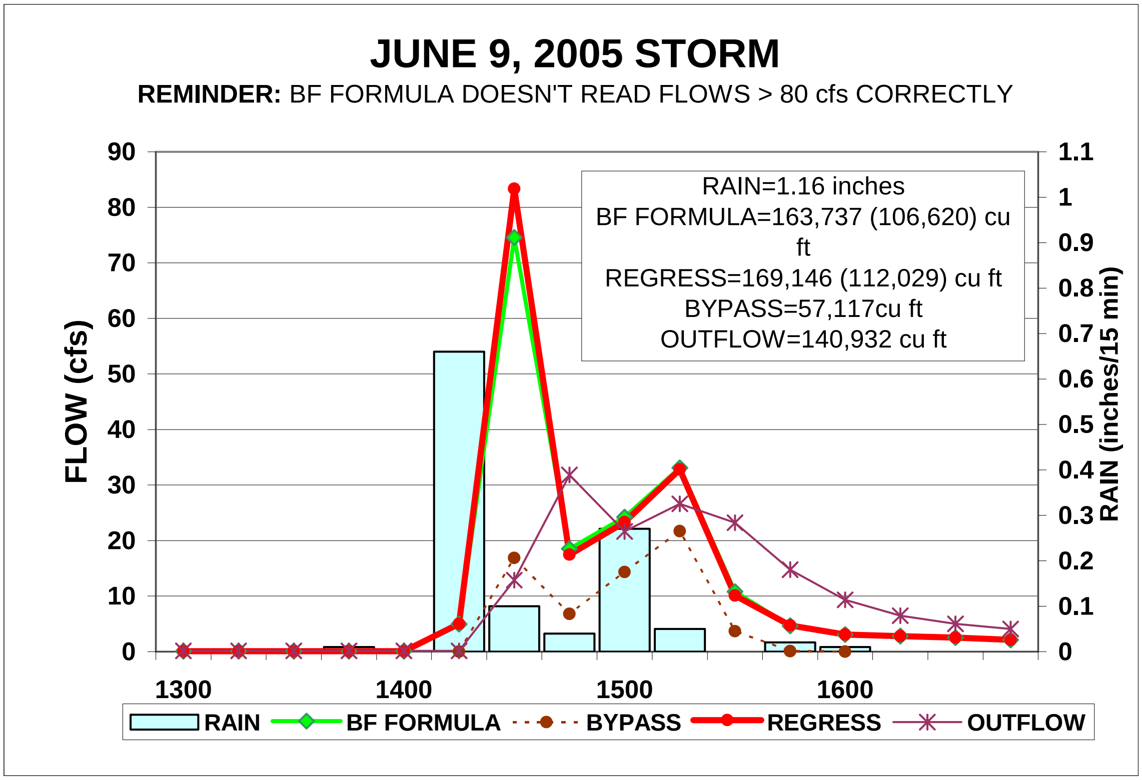

JUNE 1, 2005 STORM
Reminder: Regression Equation based on velocity does not read low flows correctly
Base Flow Formula does not read flows for water level >3 ft. correctly
RAIN=1.59inches
BF FORMULA=263,216 (64,056) cu ft
REGRESS=254,069 (84,219) cu ft
BYPASS=178,997 cu ft
OUTFLOW=245,698
FLOW (cfs)
RAIN (inches/15 min)
140
120
100
80
60
40
20
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2315
15
115
215
315
415
515
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

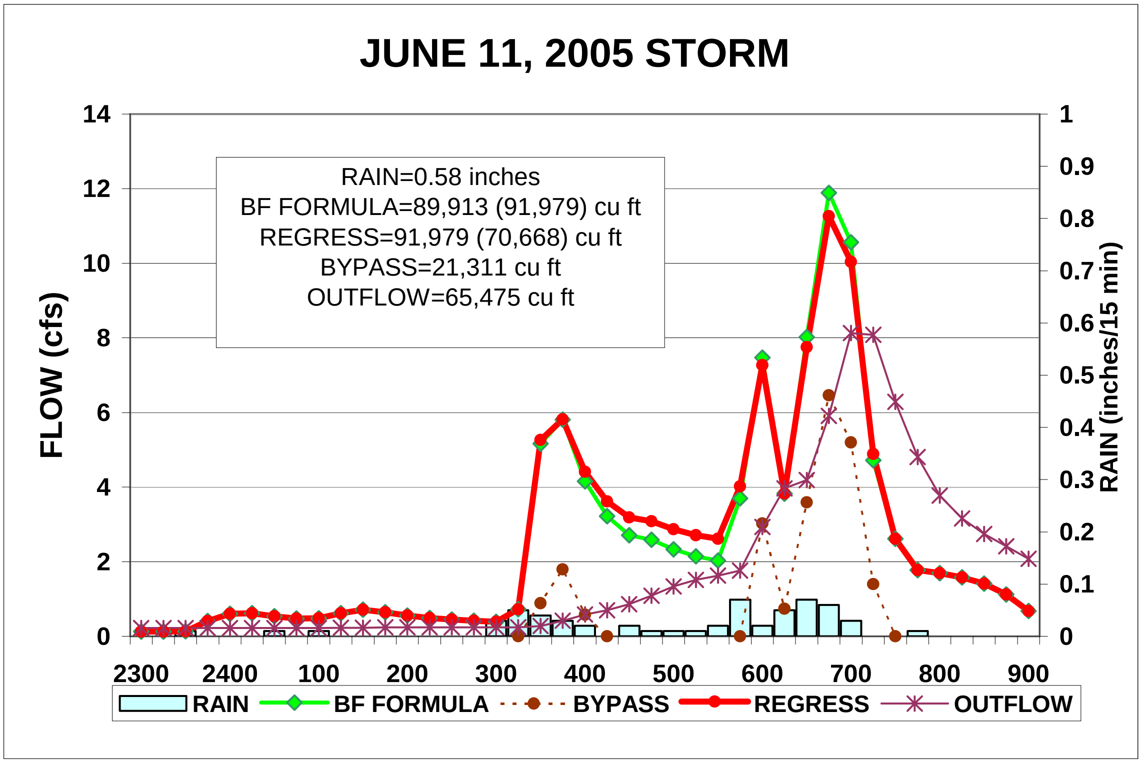

JUNE 2, 2005 STORM
RAIN=0.57 inches
BF FORMULA=86,012 (81,635) cu ft
REGRESS=84,322 (79,945) cu ft
BYPASS=4,377 cu ft
OUTFLOW=76,570
FLOW (cfs)
RAIN (inches/15 min)
20
18
16
14
12
10
8
6
4
2
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
100
200
300
400
500
600
700
800
900
1000
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

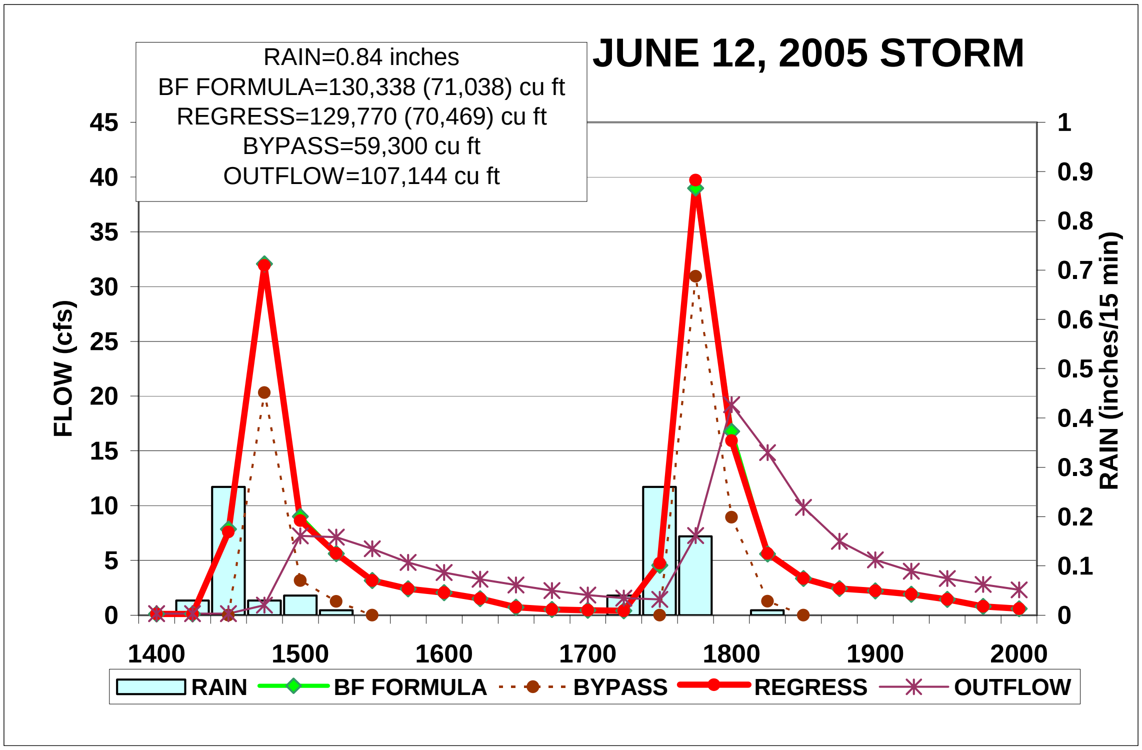

JUNE 4, 2005 STORM
RAIN=0.19 inches
BF FORMULA=24,684 cu ft
REGRESS=28,114cu ft
BYPASS=0.00 cu ft
OUTFLOW=7,900
FLOW (cfs)
RAIN (inches/15 min)
0
1
2
3
4
5
6
7
8
9
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
400
500
600
700
800
900
1000
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

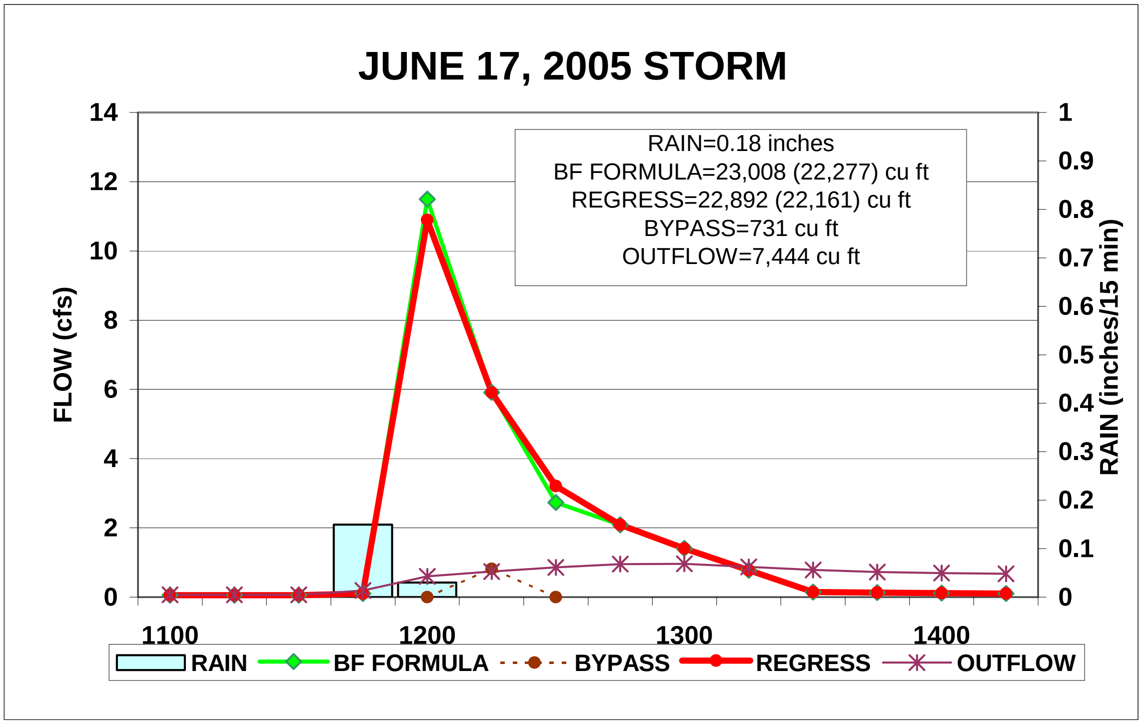

JUNE 4, 2005 STORM
REMINDER: BF FORMULA DOESN'T READ FLOWS > 89 cfs CORRECTLY
RAIN=1.57 inches
BF FORMULA=354,457 (142,129) cu ft
REGRESS=424,608 (212,328) cu ft
BYPASS=212,328 cu ft
OUTFLOW=298,741 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
50
100
150
200
250
300
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1500
1600
1700
1800
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

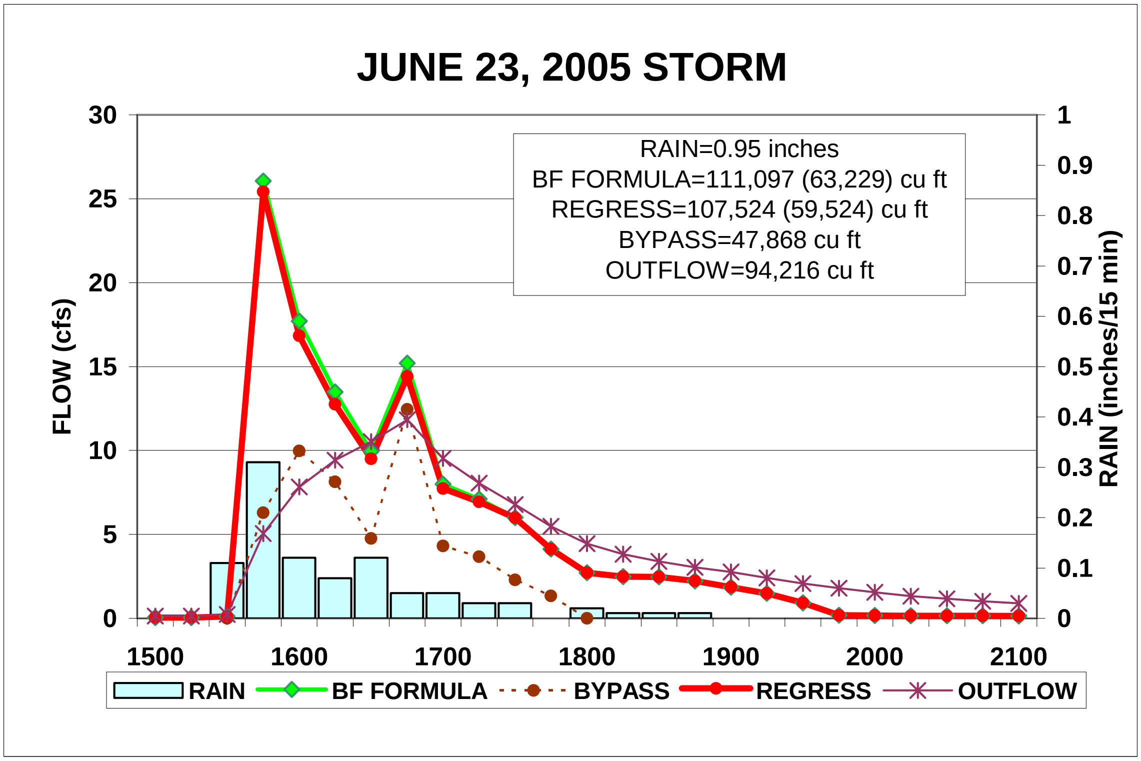

JUNE 5, 2005 STORM
REMINDER: BF FORMULA DOESN'T READ FLOWS > 80 cfs CORRECTLY
RAIN=1.34 inches
BF FORMULA=189,657 (90,389) cu ft
REGRESS=209,449 (110,181) cu ft
BYPASS=99,268 cu ft
OUTFLOW=200,580 cu ft
FLOW (cfs)
RAIN (inches/15 min)
140
120
100
80
60
40
20
0
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1330
1430
1530
1630
1730
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

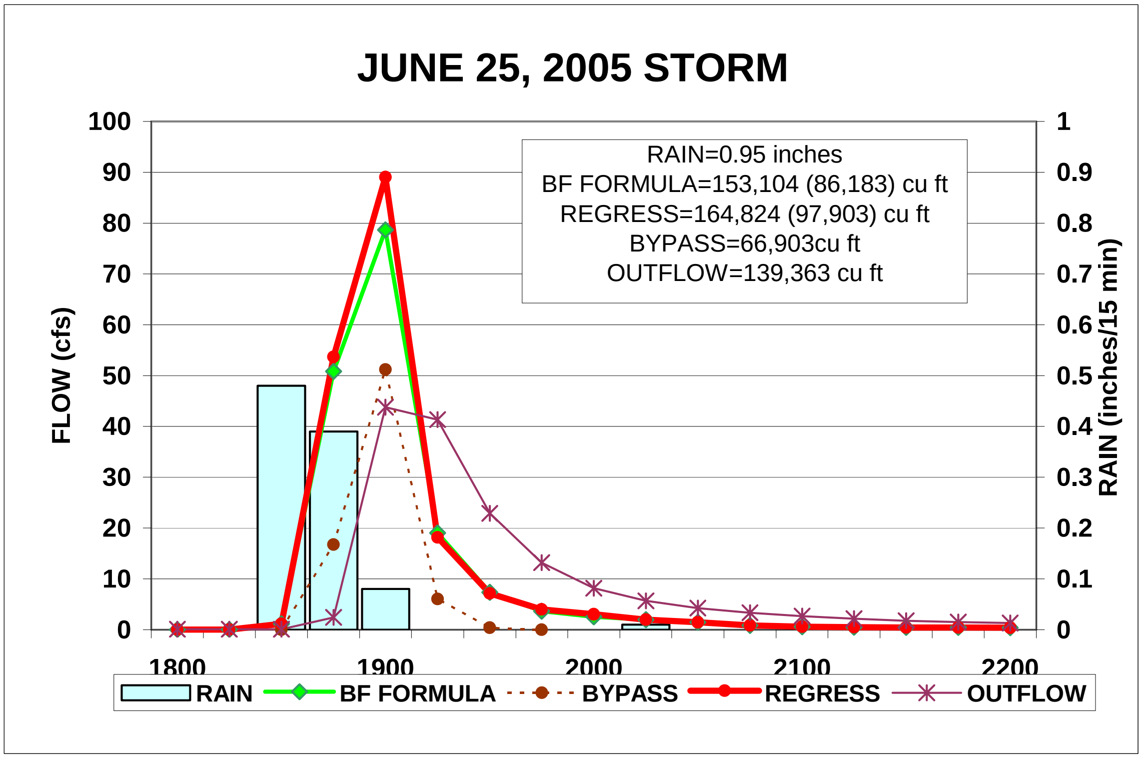

JUNE 9, 2005 STORM
REMINDER: BF FORMULA DOESN'T READ FLOWS > 80 cfs CORRECTLY
RAIN=1.16 inches
BF FORMULA=163,737 (106,620) cu ft
REGRESS=169,146 (112,029) cu ft
BYPASS=57,117cu ft
OUTFLOW=140,932 cu ft
FLOW (cfs)
RAIN (inches/15 min)
90
80
70
60
50
40
30
20
10
0
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1300
1400
1500
1600
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

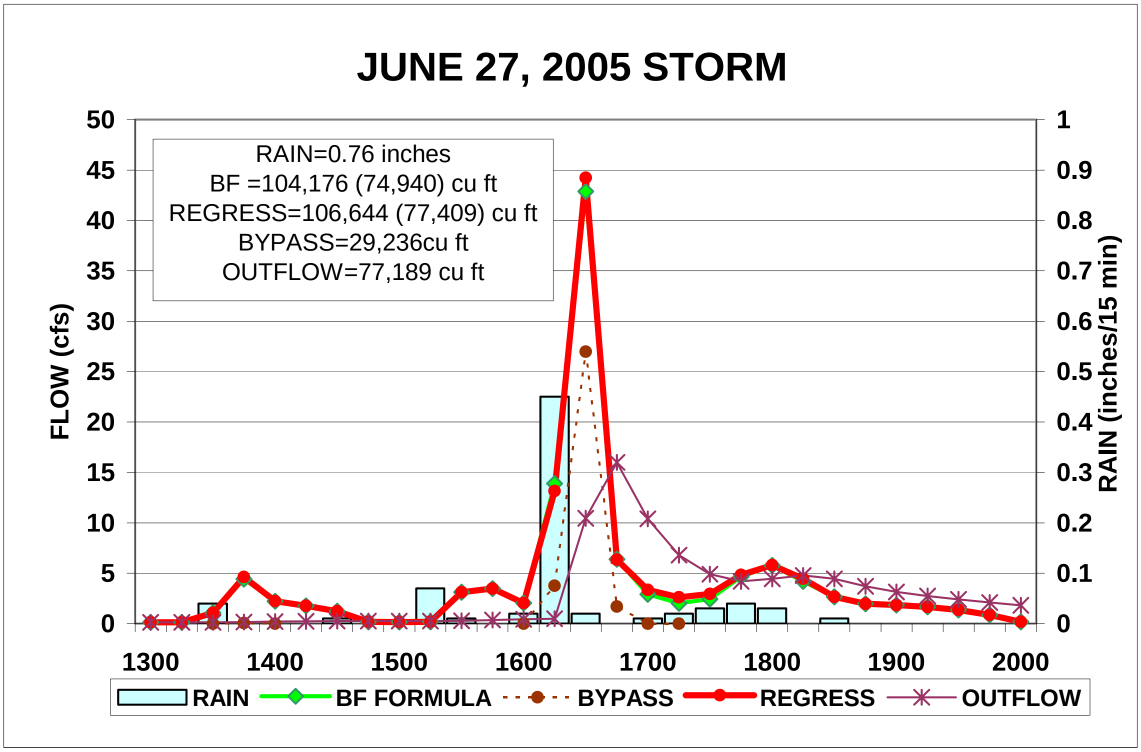

JUNE 11, 2005 STORM
RAIN=0.58 inches
BF FORMULA=89,913 (91,979) cu ft
REGRESS=91,979 (70,668) cu ft
BYPASS=21,311 cu ft
OUTFLOW=65,475 cu ft
FLOW (cfs)
14
12
10
8
6
4
2
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2300
2400
100
200
300
400
500
600
700
800
900
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

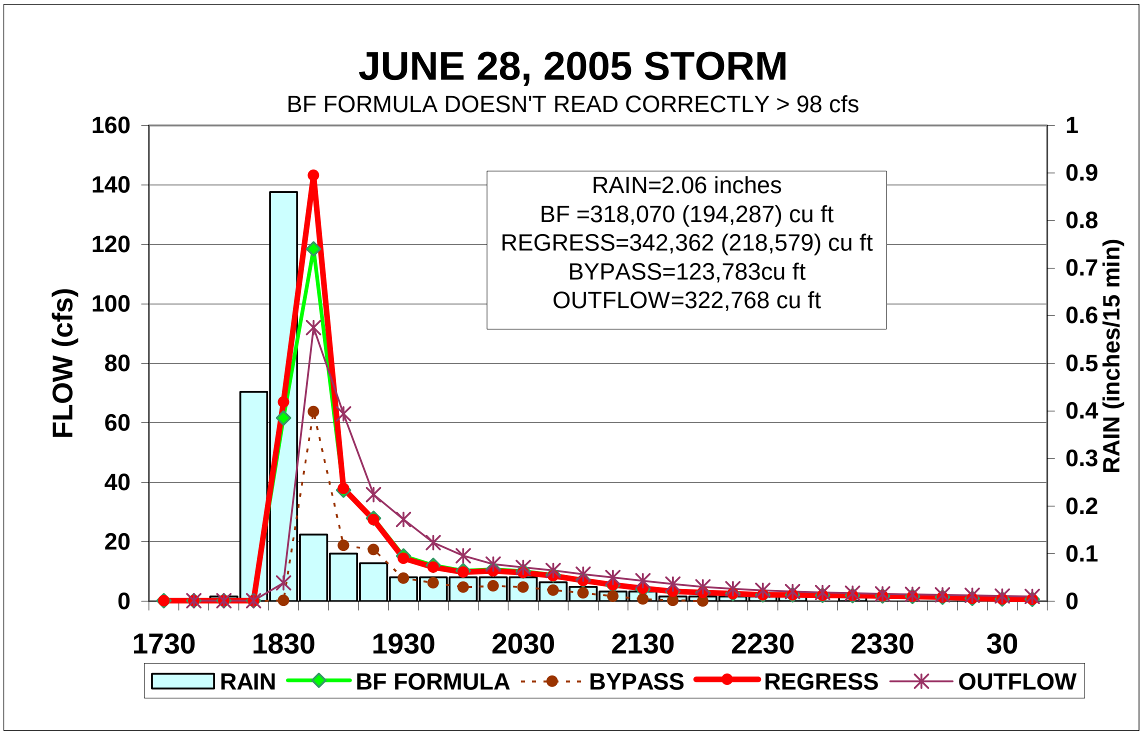

JUNE 12, 2005 STORM
RAIN=0.84 inches
BF FORMULA=130,338 (71,038) cu ft
REGRESS=129,770 (70,469) cu ft
BYPASS=59,300 cu ft
OUTFLOW=107,144 cu ft
FLOW (cfs)
45
40
35
30
25
20
15
10
5
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1400
1500
1600
1700
1800
1900
2000
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

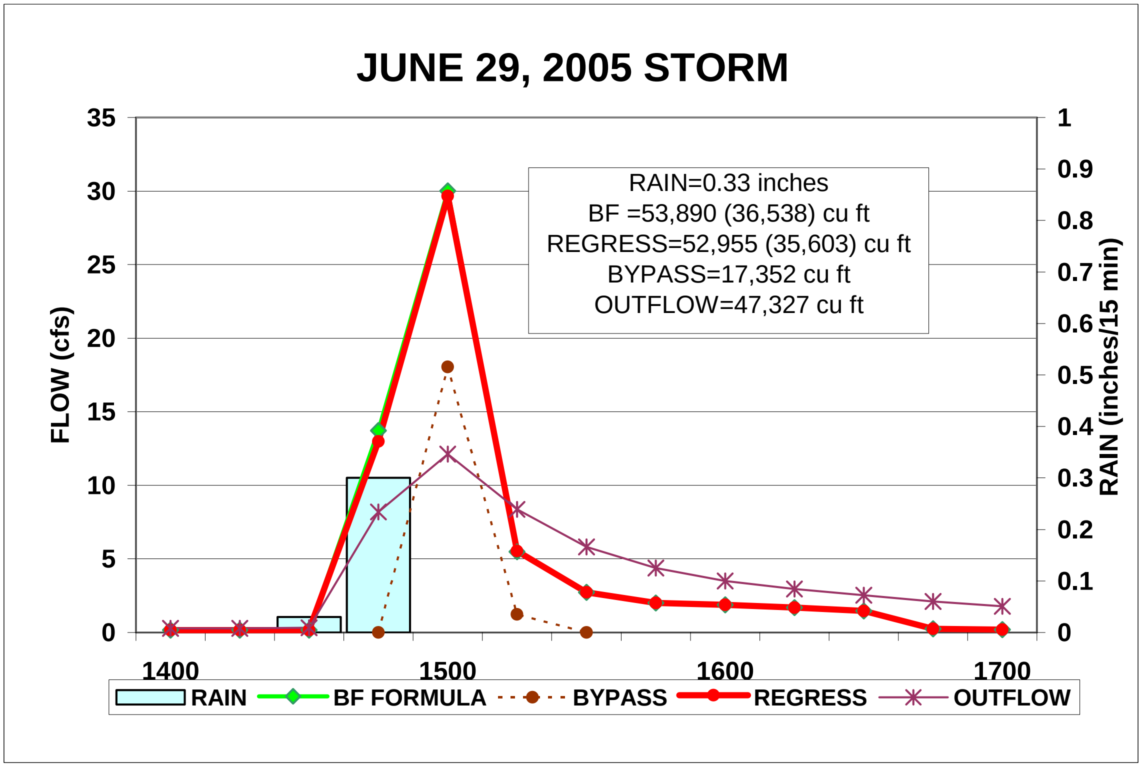

JUNE 17, 2005 STORM
RAIN=0.18 inches
BF FORMULA=23,008 (22,277) cu ft
REGRESS=22,892 (22,161) cu ft
BYPASS=731 cu ft
OUTFLOW=7,444 cu ft
FLOW (cfs)
RAIN (inches/15 min)
14
12
10
8
6
4
2
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1100
1200
1300
1400
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

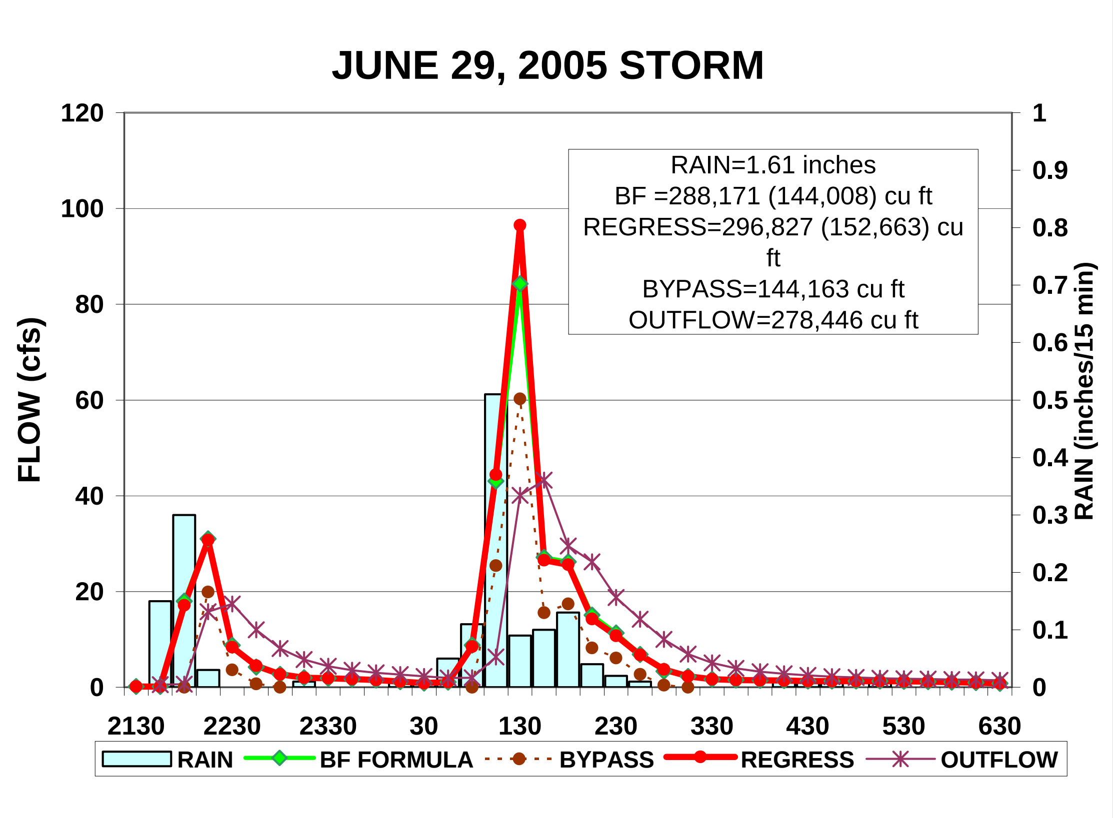

JUNE 23, 2005 STORM
RAIN=0.95 inches
BF FORMULA=111,097 (63,229) cu ft
REGRESS=107,524 (59,524) cu ft
BYPASS=47,868 cu ft
OUTFLOW=94,216 cu ft
FLOW (cfs)
RAIN (inches/15 min)
30
25
20
15
10
5
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1500
1600
1700
1800
1900
2000
2100
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

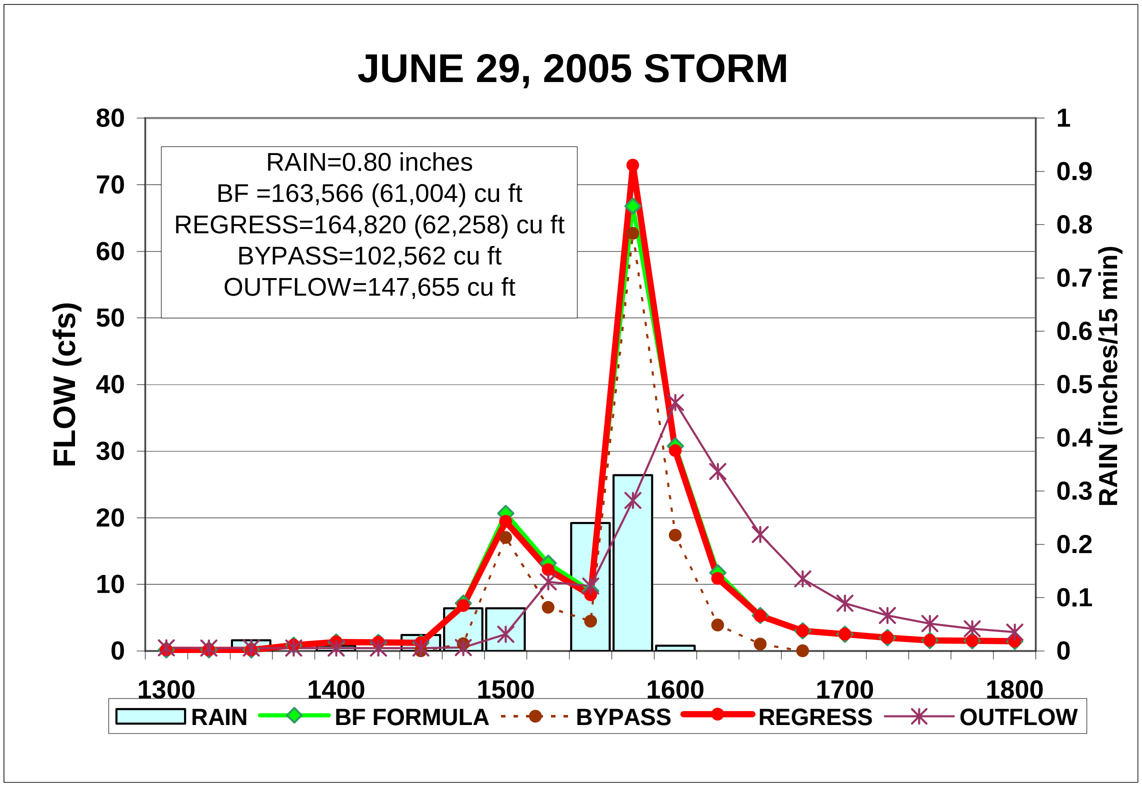

JUNE 25, 2005 STORM
RAIN=0.95 inches
BF FORMULA=153,104 (86,183) cu ft
REGRESS=164,824 (97,903) cu ft
BYPASS=66,903cu ft
OUTFLOW=139,363 cu ft
FLOW (cfs)
RAIN (inches/15 min)
100
90
80
70
60
50
40
30
20
10
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1800
1900
2000
2100
2200
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

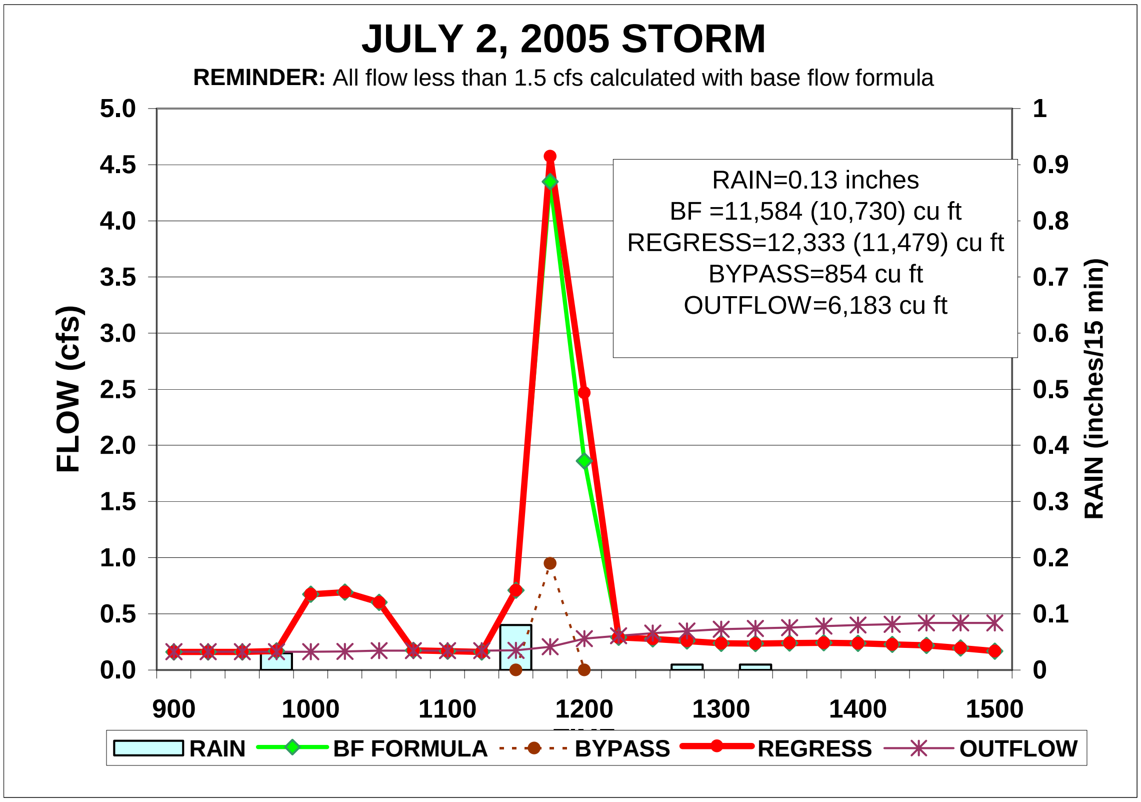

JUNE 27, 2005 STORM
RAIN=0.76 inches
BF =104,176 (74,940) cu ft
REGRESS=106,644 (77,409) cu ft
BYPASS=29,236cu ft
OUTFLOW=77,189 cu ft
FLOW (cfs)
RAIN (inches/15 min)
50
45
40
35
30
25
20
15
10
5
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1300
1400
1500
1600
1700
1800
1900
2000
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW


JUNE 28, 2005 STORM
BF FORMULA DOESN'T READ CORRECTLY > 98 cfs
RAIN=2.06 inches
BF =318,070 (194,287) cu ft
REGRESS=342,362 (218,579) cu ft
BYPASS=123,783cu ft
OUTFLOW=322,768 cu ft
FLOW (cfs)
0
20
40
60
80
100
120
140
160
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1730
1830
1930
2030
2130
2230
2330
30
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW


JUNE 29, 2005 STORM
RAIN=0.33 inches
BF =53,890 (36,538) cu ft
REGRESS=52,955 (35,603) cu ft
BYPASS=17,352 cu ft
OUTFLOW=47,327 cu ft
FLOW (cfs)
0
5
10
15
20
25
30
35
RAIN (inches/15 min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1400
1500
1600
1700
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW


JUNE 29, 2005 STORM
RAIN=1.61 inches
BF =288,171 (144,008) cu ft
REGRESS=296,827 (152,663) cu ft
BYPASS=144,163 cu ft
OUTFLOW=278,446 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
20
40
60
80
100
120
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
2130
2230
2330
30
130
230
330
430
530
630
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

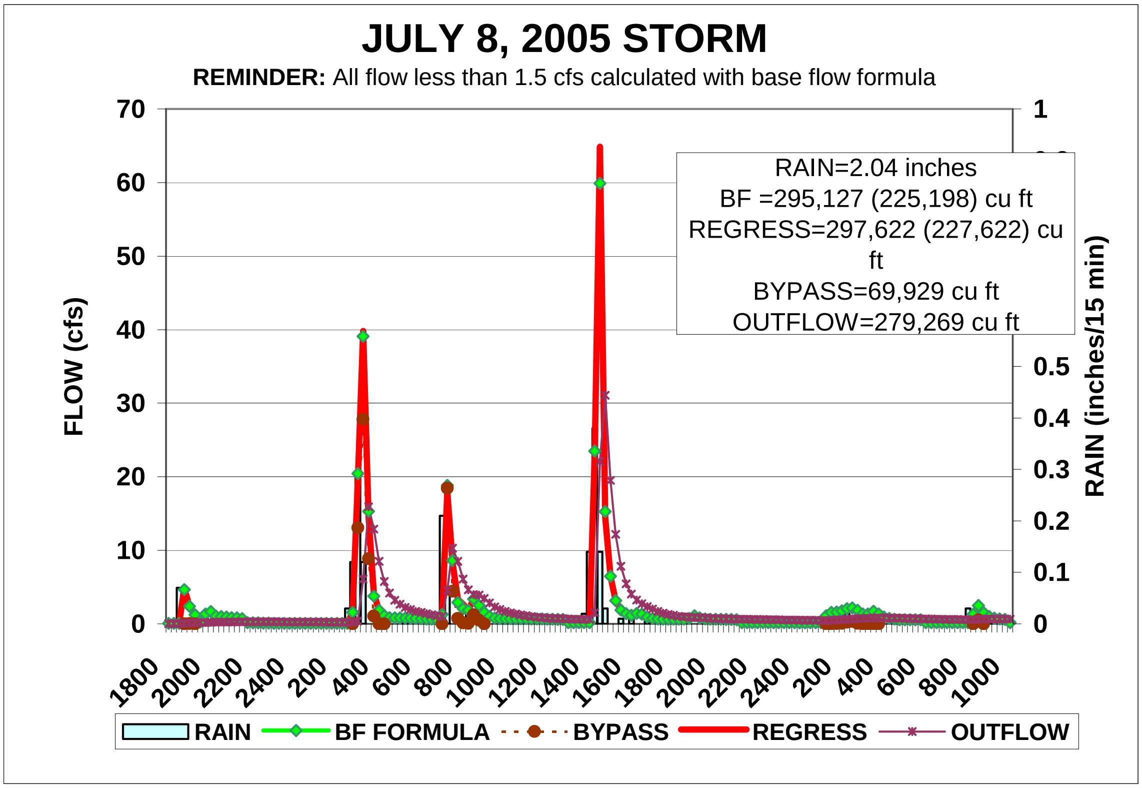

JUNE 29, 2005 STORM
RAIN=0.80 inches
BF =163,566 (61,004) cu ft
REGRESS=164,820 (62,258) cu ft
BYPASS=102,562 cu ft
OUTFLOW=147,655 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
10
20
30
40
50
60
70
80
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1300
1400
1500
1600
1700
1800
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW



JULY 2, 2005 STORM

REMINDER: All flow less than 1.5 cfs calculated with base flow formula

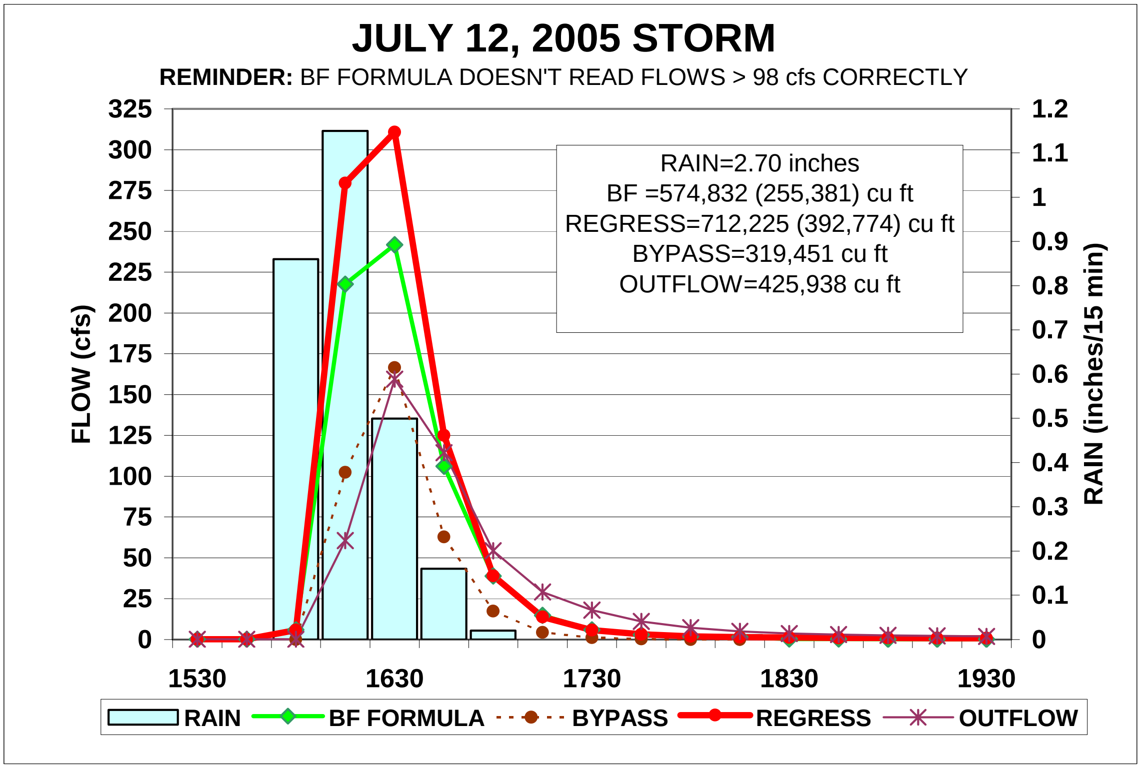
RAIN=0.13 inches
BF =11,584 (10,730) cu ft
REGRESS=12,333 (11,479) cu ft
BYPASS=854 cu ft
OUTFLOW=6,183 cu ft

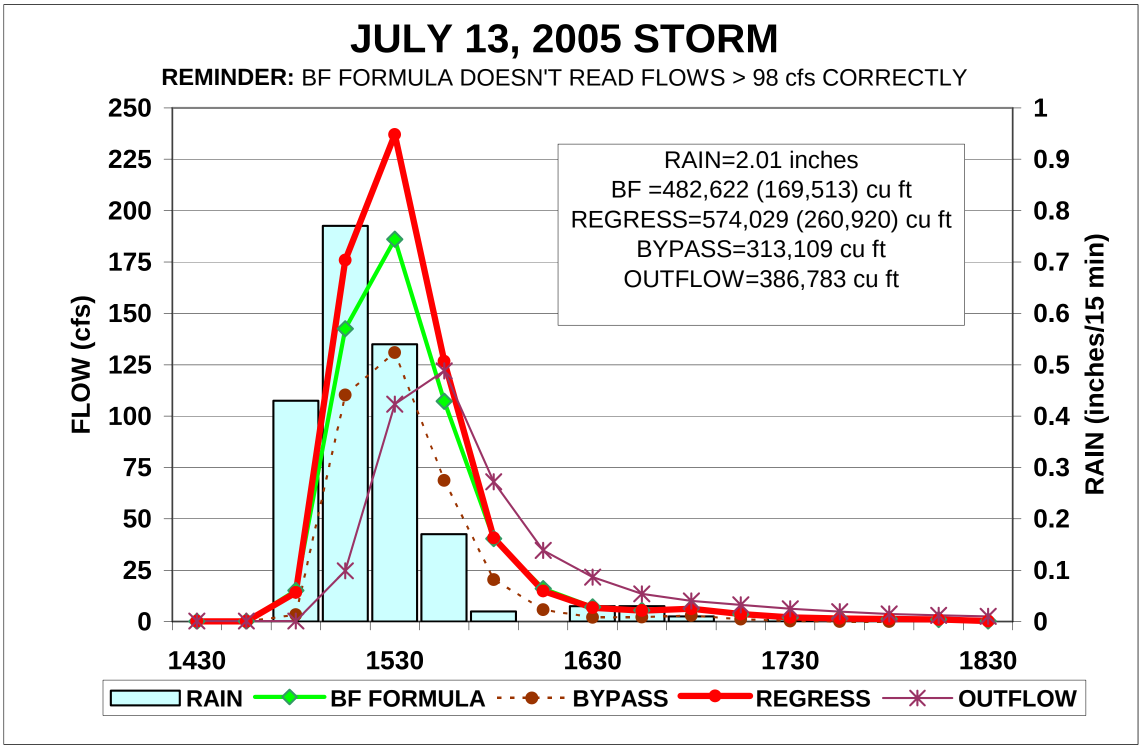


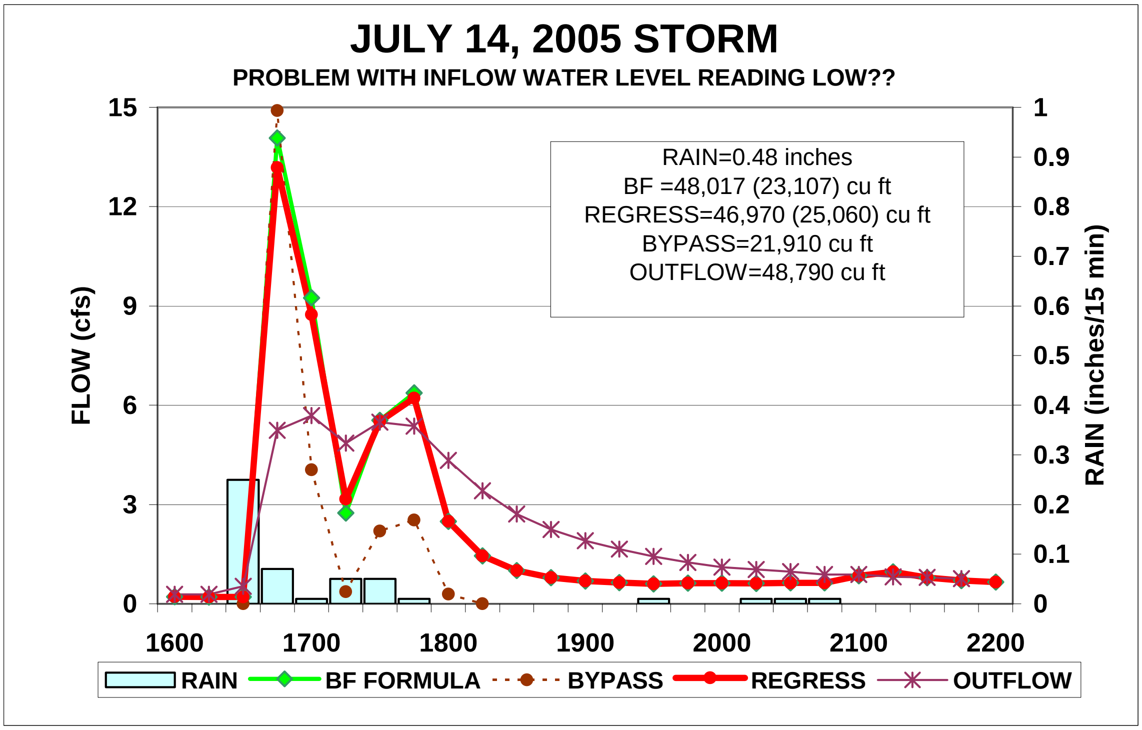
JULY 8, 2005 STORM

REMINDER: All flow less than 1.5 cfs calculated with base flow formula

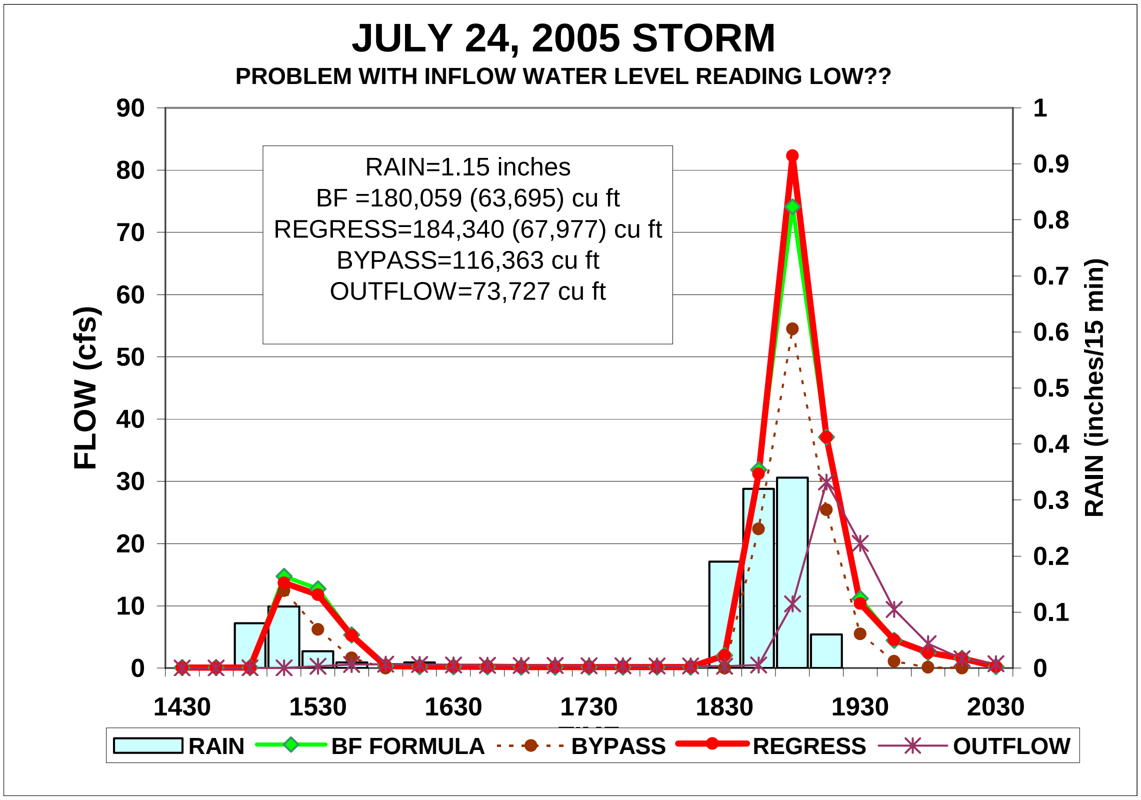
RAIN=2.04 inches
BF =295,127 (225,198) cu ft
REGRESS=297,622 (227,622) cu ft
BYPASS=69,929 cu ft
OUTFLOW=279,269 cu ft


JULY 12, 2005 STORM
REMINDER: BF FORMULA DOESN'T READ FLOWS > 98 cfs CORRECTLY
RAIN=2.70 inches
BF =574,832 (255,381) cu ft
REGRESS=712,225 (392,774) cu ft
BYPASS=319,451 cu ft
OUTFLOW=425,938 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1530
1630
1730
1830
1930
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

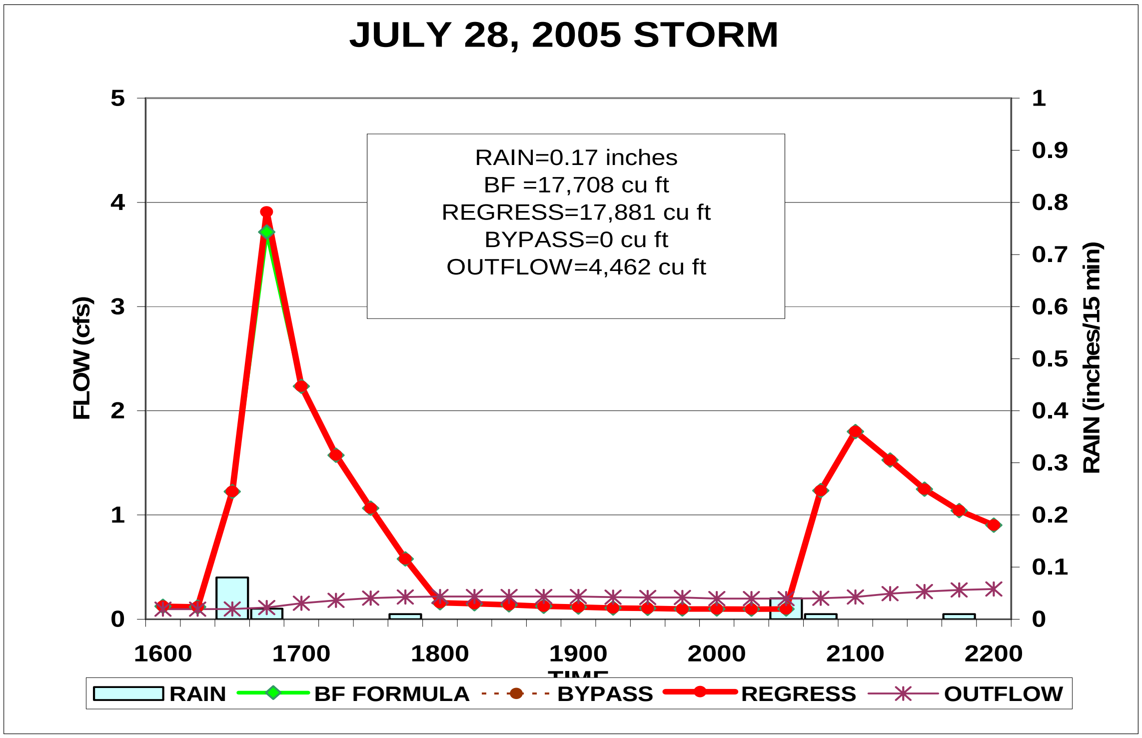

JULY 13, 2005 STORM
REMINDER: BF FORMULA DOESN'T READ FLOWS > 98 cfs CORRECTLY
RAIN=2.01 inches
BF =482,622 (169,513) cu ft
REGRESS=574,029 (260,920) cu ft
BYPASS=313,109 cu ft
OUTFLOW=386,783 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
25
50
75
100
125
150
175
200
225
250
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1430
1530
1630
1730
1830
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

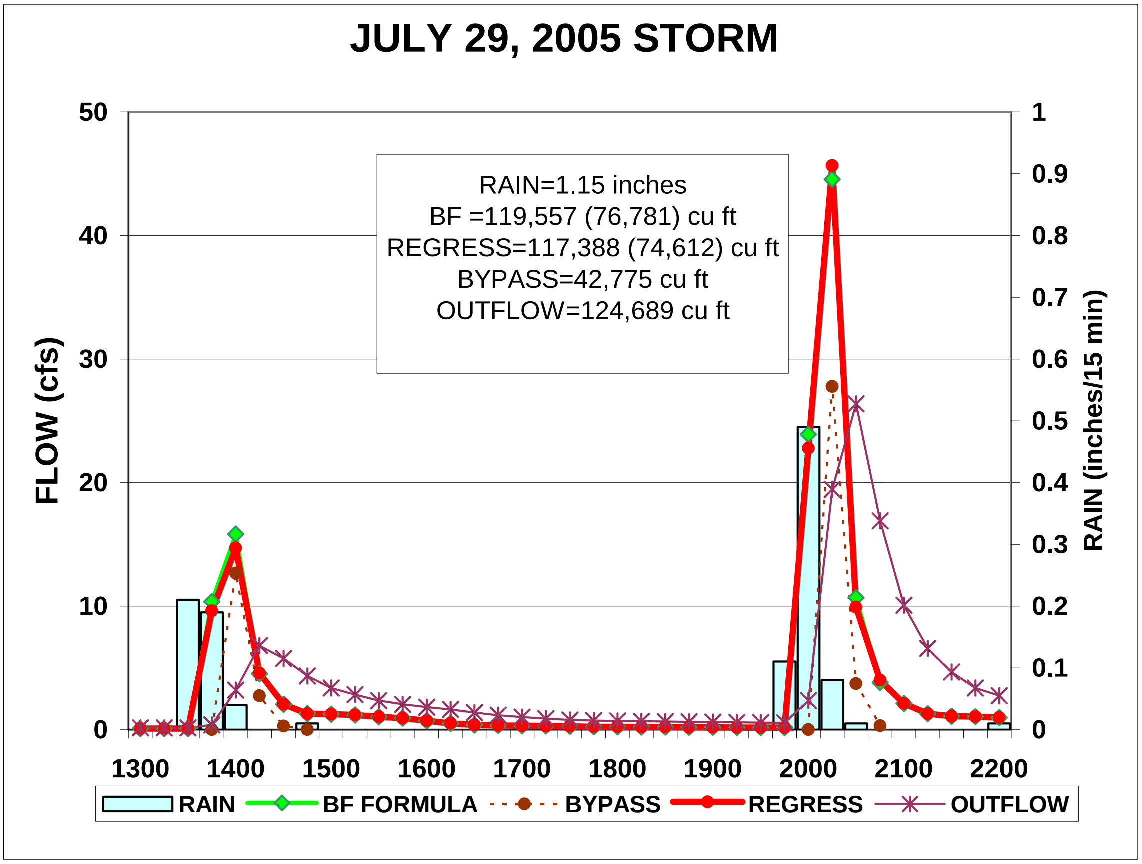

JULY 14, 2005 STORM

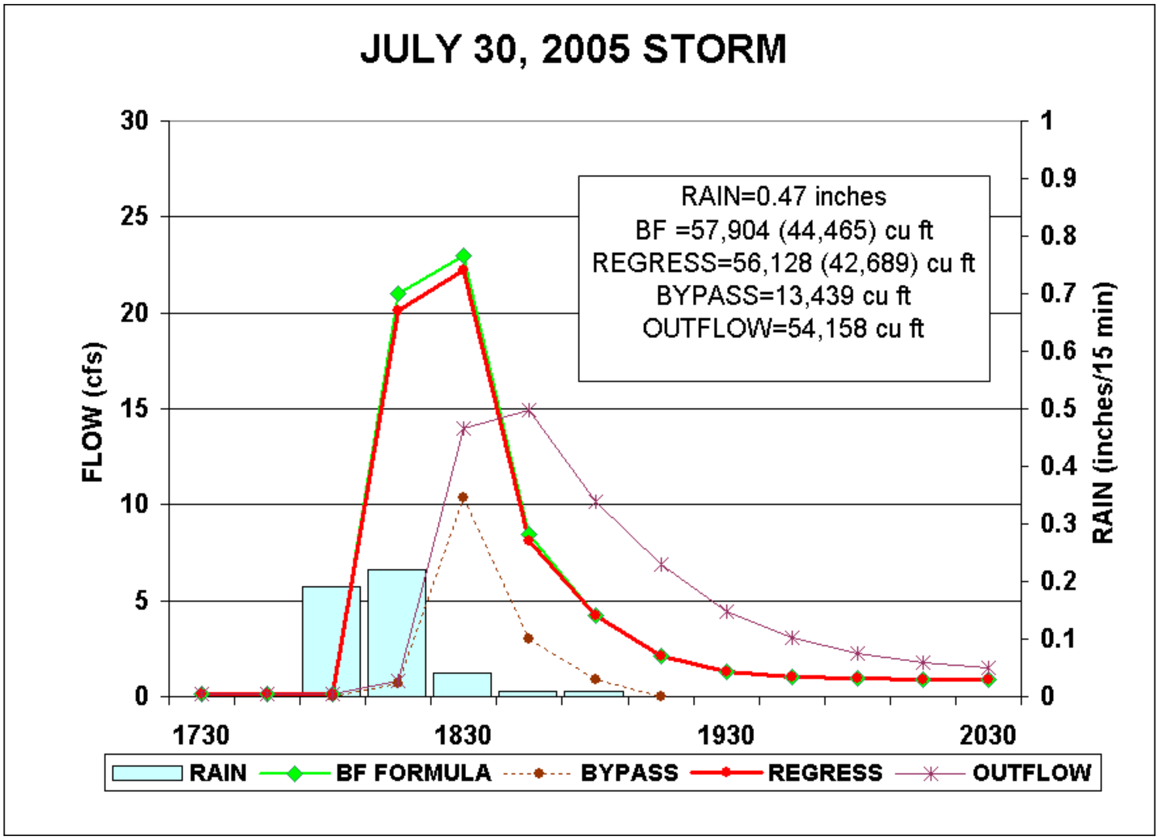
PROBLEM WITH INFLOW WATER LEVEL READING LOW??


JULY 24, 2005 STORM

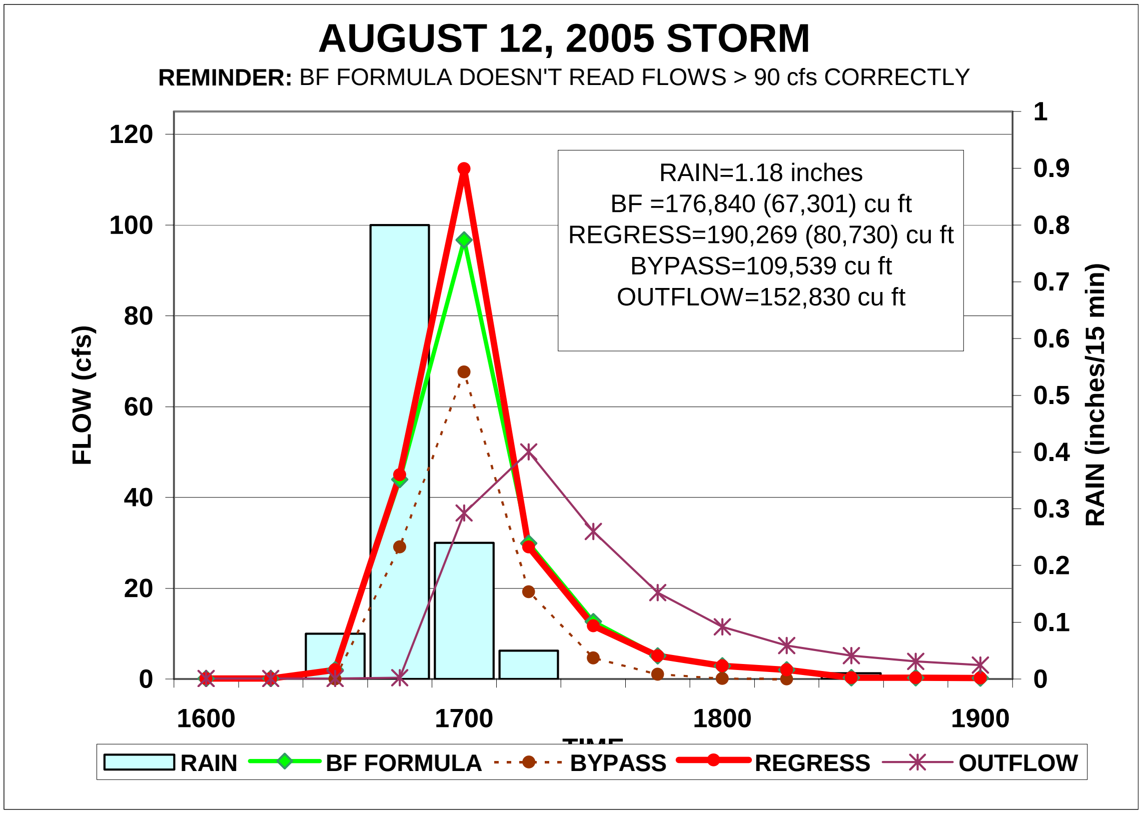
PROBLEM WITH INFLOW WATER LEVEL READING LOW??


JULY 28, 2005 STORM
RAIN=0.17 inches
BF =17,708 cu ft
REGRESS=17,881 cu ft
BYPASS=0 cu ft
OUTFLOW=4,462 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
1
2
3
4
5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1600
1700
1800
1900
2000
2100
2200
TIME
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW


JULY 29, 2005 STORM
RAIN=1.15 inches
BF =119,557 (76,781) cu ft
REGRESS=117,388 (74,612) cu ft
BYPASS=42,775 cu ft
OUTFLOW=124,689 cu ft
FLOW (cfs)
RAIN (inches/15 min)
0
10
20
30
40
50
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

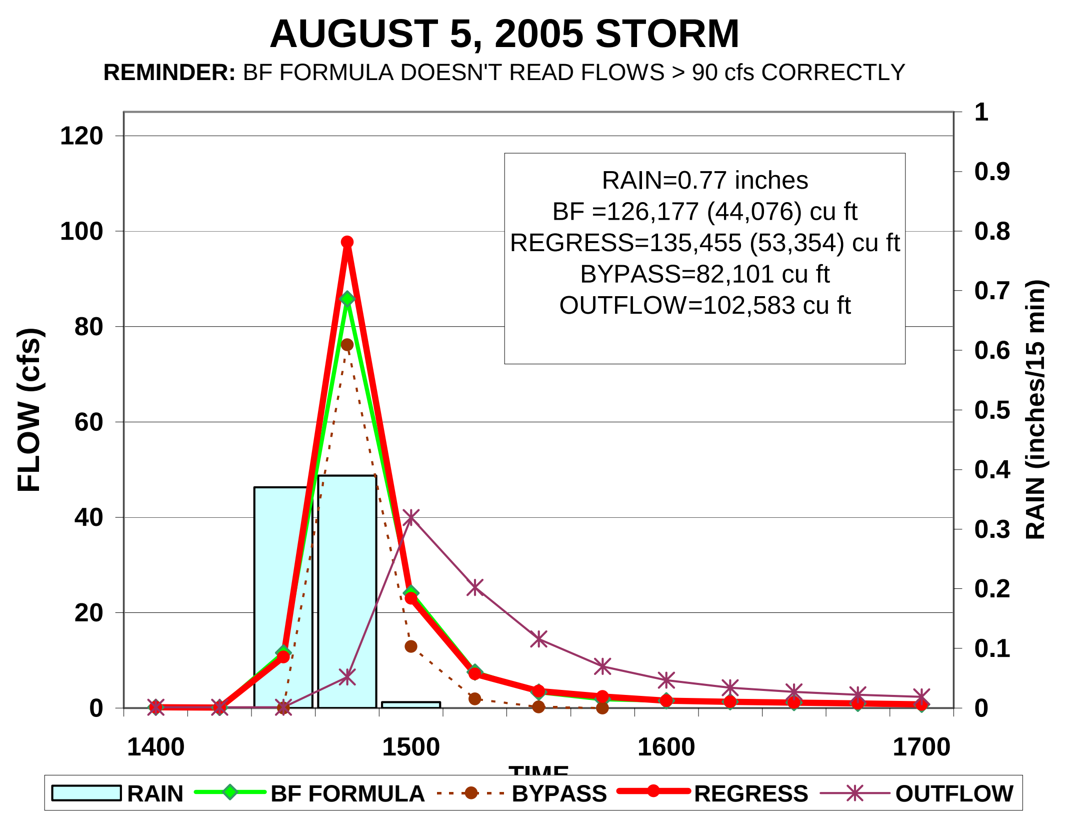


JULY 30, 2005 STORM

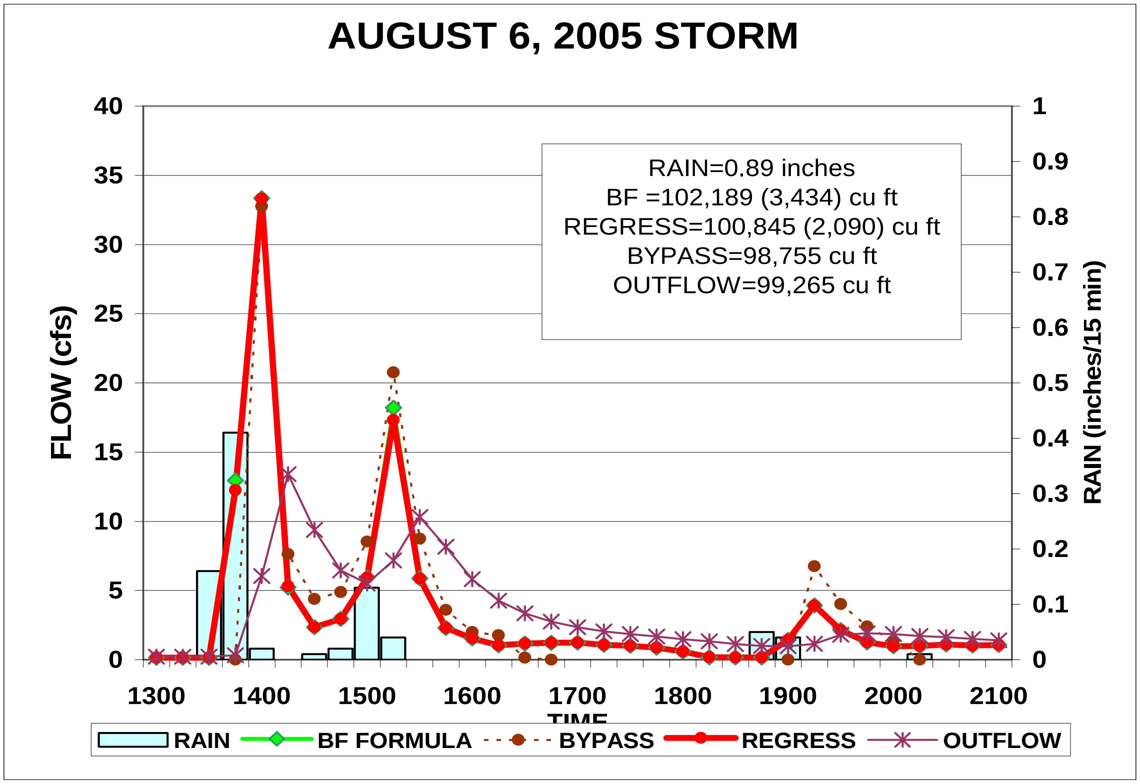


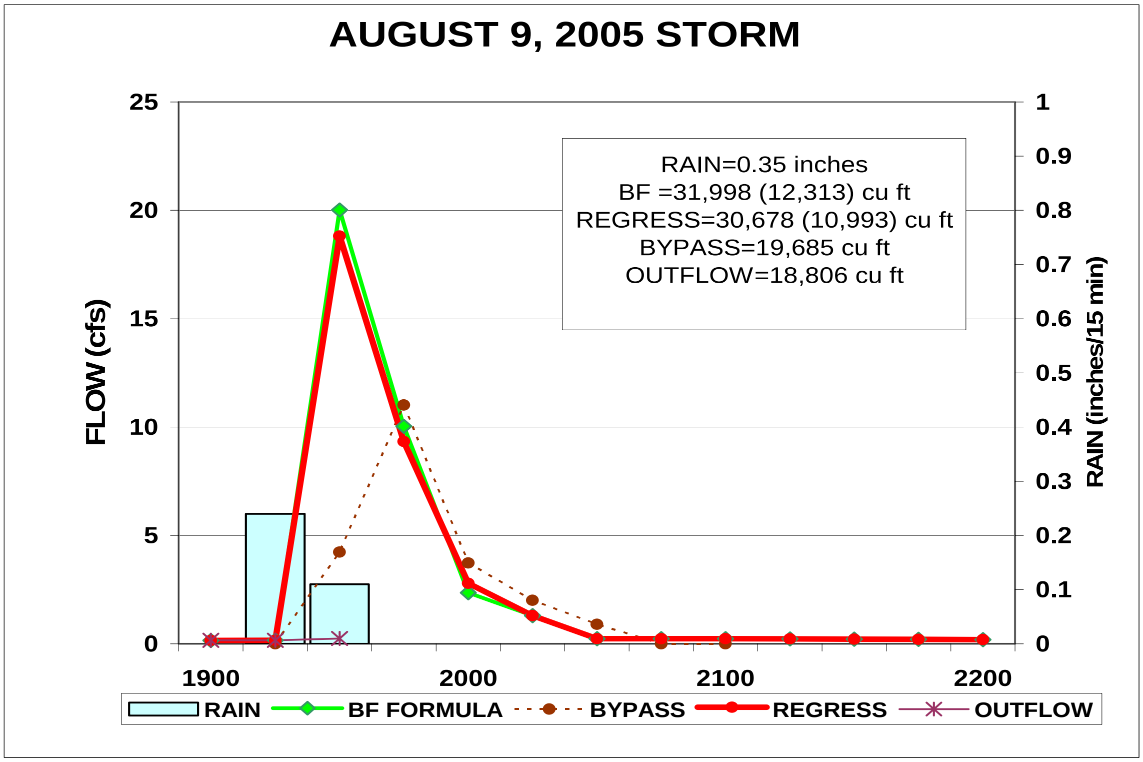
AUGUST 12, 2005 STORM

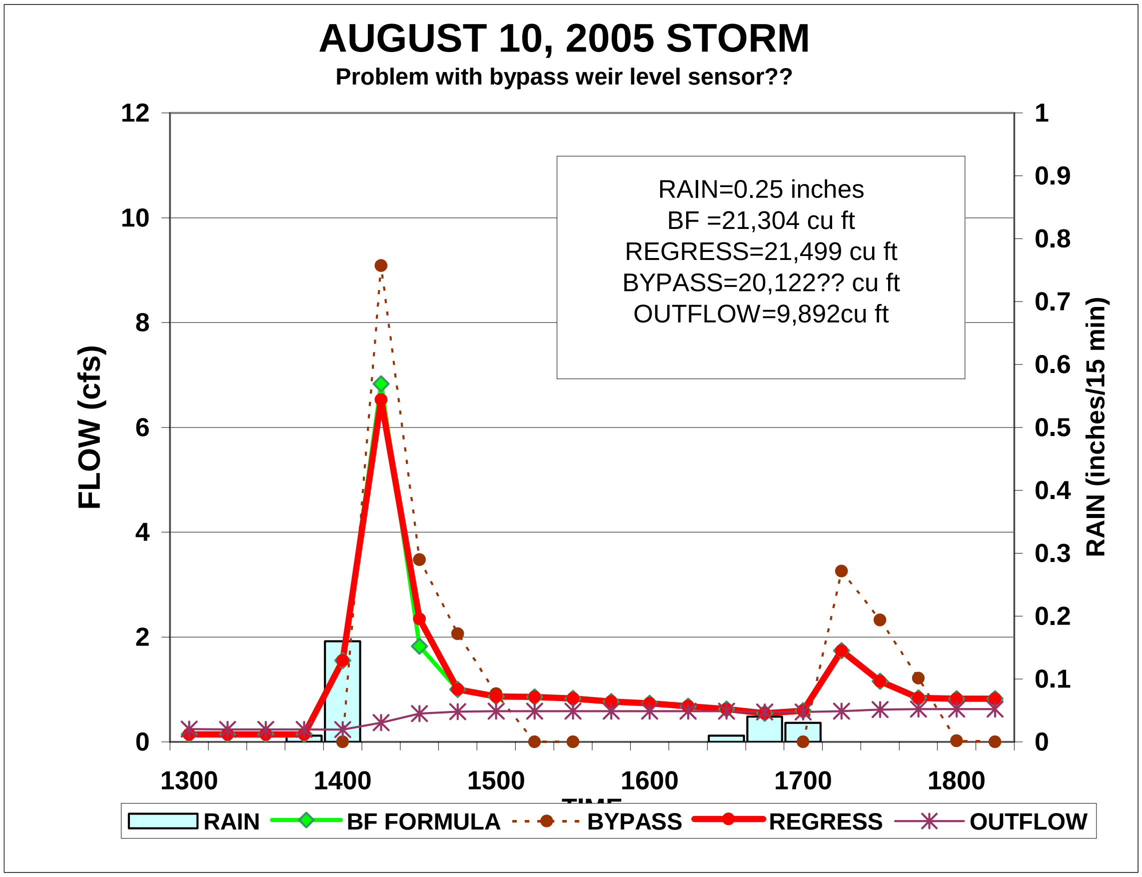
REMINDER: BF FORMULA DOESN'T READ FLOWS > 90 cfs CORRECTLY


AUGUST 5, 2005 STORM

REMINDER: BF FORMULA DOESN'T READ FLOWS > 90 cfs CORRECTLY

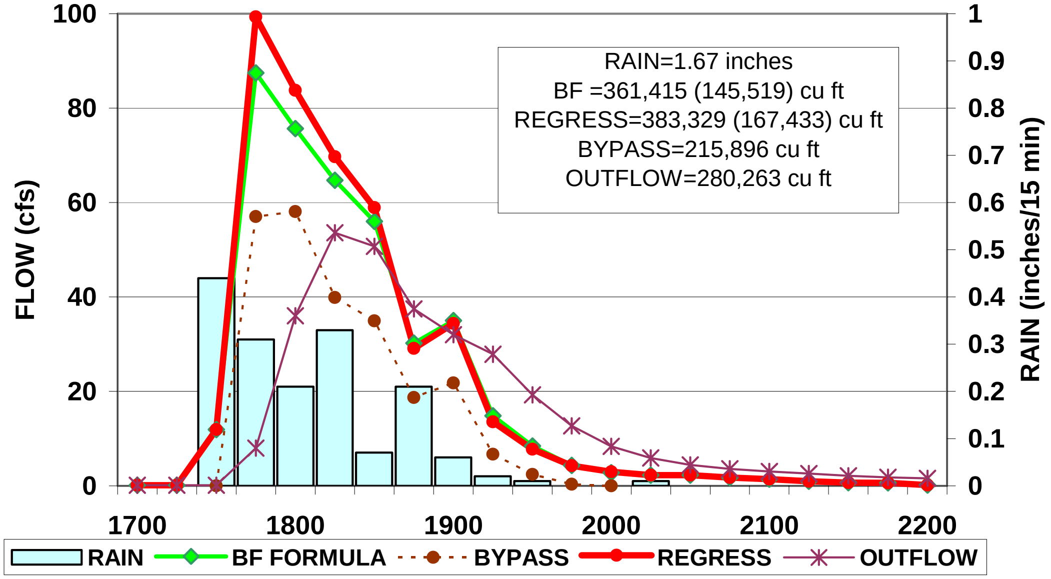

AUGUST 6, 2005 STORM


AUGUST 9, 2005 STORM
RAIN=0.35 inches
BF =31,998 (12,313) cu ft
REGRESS=30,678 (10,993) cu ft
BYPASS=19,685 cu ft
OUTFLOW=18,806 cu ft
FLOW (cfs)
RAIN (inches/15 min)
25
20
15
10
5
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1900
2000
2100
2200
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW


AUGUST 10, 2005 STORM
Problem with bypass weir level sensor??
RAIN=0.25 inches
BF =21,304 cu ft
REGRESS=21,499 cu ft
BYPASS=20,122?? cu ft
OUTFLOW=9,892cu ft
FLOW (cfs)
RAIN (inches/15 min)
12
10
8
6
4
2
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1300
1400
1500
1600
1700
1800
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

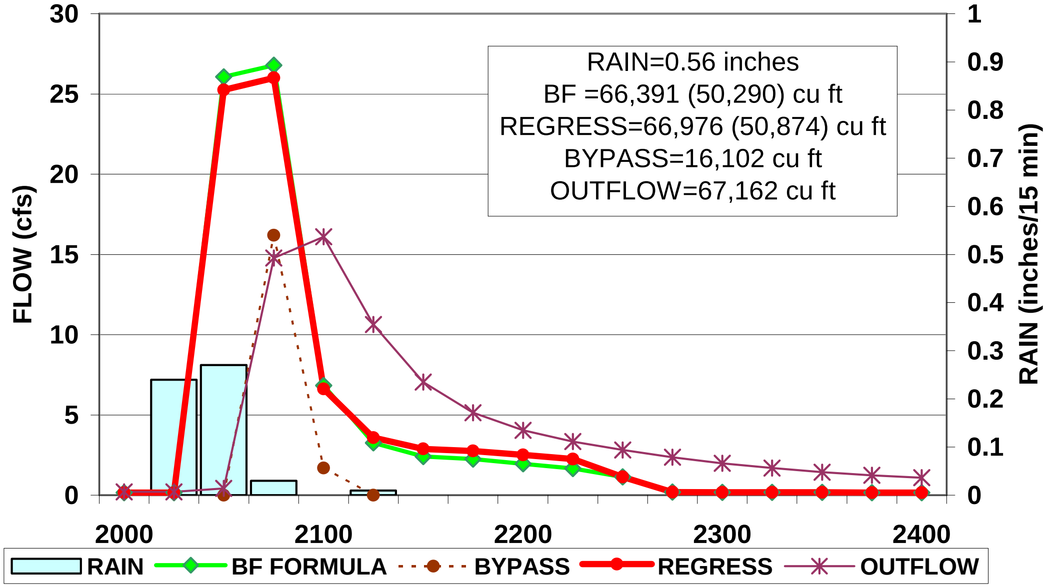
AUGUST 21, 2005 STORM

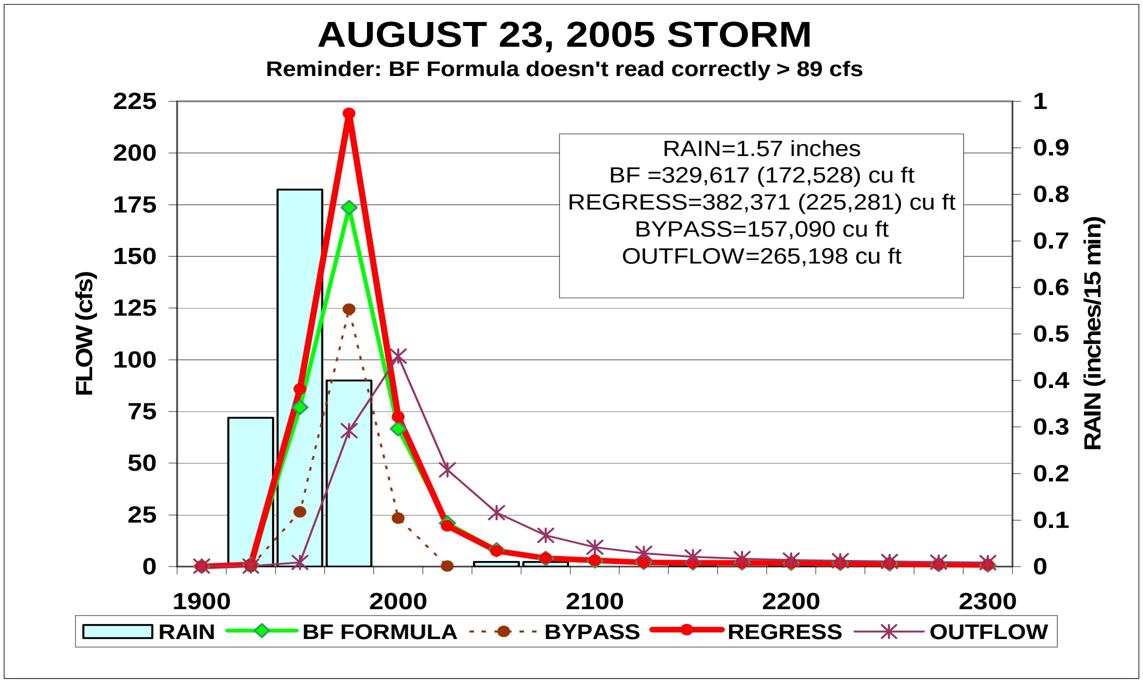
Reminder: BF Formula doesn't calculate flows > 90 cfs correctly



AUGUST 22, 2005 STORM

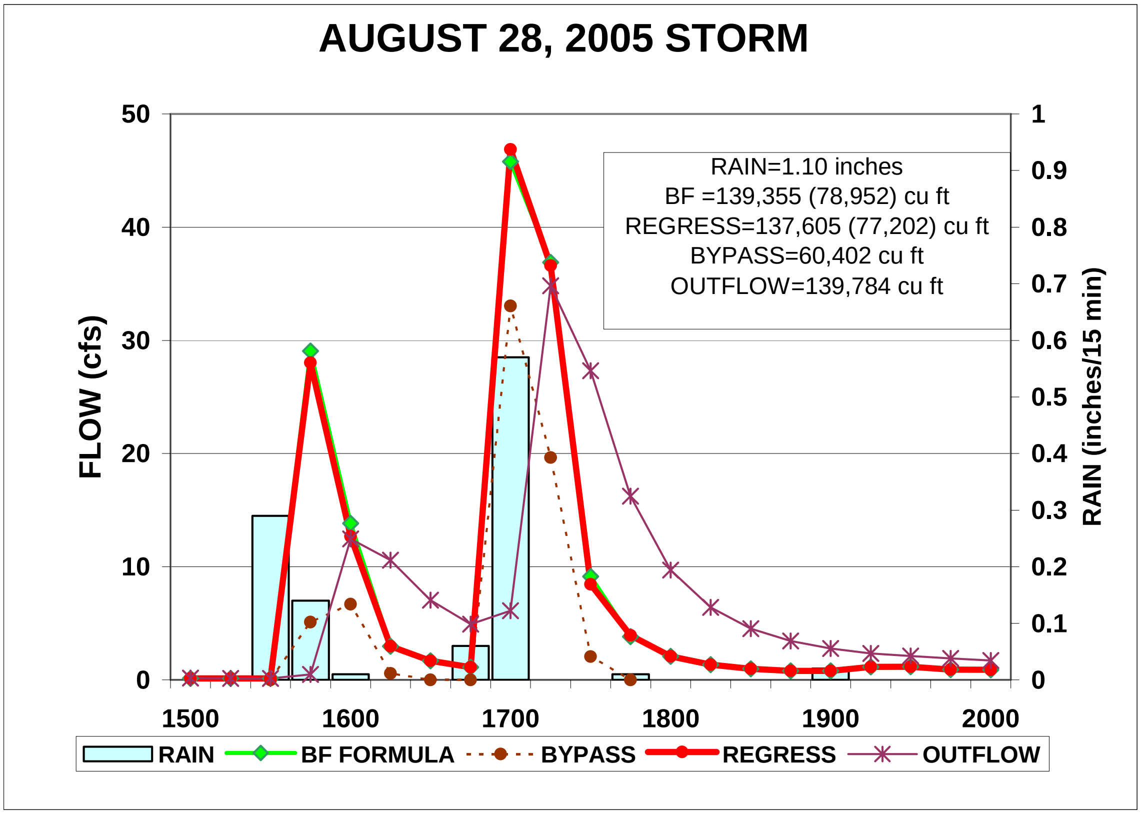
Sensor drift noted and some new offsets calculated



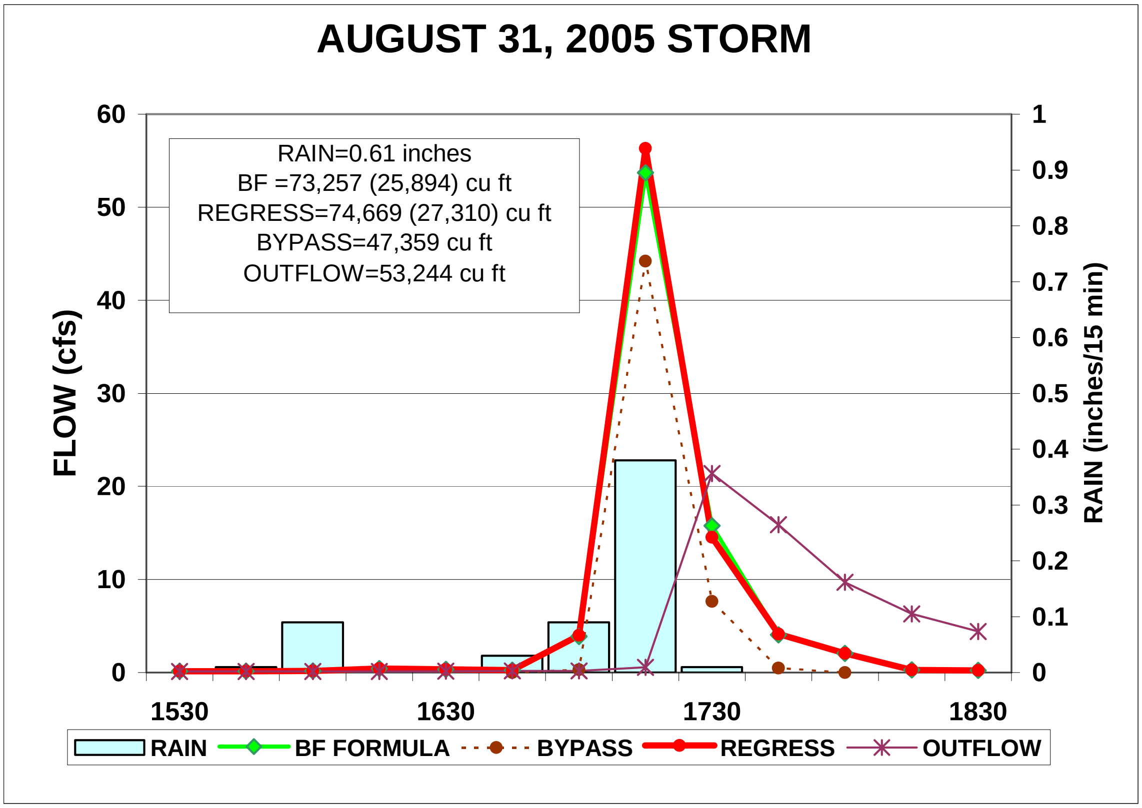


AUGUST 23, 2005 STORM

Reminder: BF Formula doesn't read correctly > 89 cfs



AUGUST 28, 2005 STORM


AUGUST 31, 2005 STORM
RAIN=0.61 inches
BF =73,257 (25,894) cu ft
REGRESS=74,669 (27,310) cu ft
BYPASS=47,359 cu ft
OUTFLOW=53,244 cu ft
FLOW (cfs)
60
50
40
30
20
10
0
RAIN (inches/15 min)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1530
1630
1730
1830
RAIN
BF FORMULA
BYPASS
REGRESS
OUTFLOW

APPENDIX E

WATER QUALITY CONCENTRATIONS

Table E-1. Summary statistics for storm events for year one. Efficiency shown as percentage and negative number indicated increase not removal.

	Ammonia				Nitrate + Nitrite				Organic Nitrogen				Total Nitrogen			
	mg/L as Nitrogen				mg/L as Nitrogen				mg/L as Nitrogen							
STORM	556	934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
FLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
Sample	30	32	32	30	30	32	32	30	31	32	32	30	30	32	32	30
Mean	0.213	0.040	0.032	0.085	0.226	0.450	0.379	0.133	0.066	0.571	0.725	1.096	0.507	1.061	1.136	1.314
Median	0.156	0.017	0.016	0.026	0.179	0.441	0.378	0.097	0.060	0.559	0.602	0.926	0.443	1.105	1.075	1.180
St. Dev.	0.182	0.057	0.043	0.176	0.166	0.232	0.204	0.140	0.117	0.297	0.336	0.720	0.366	0.287	0.317	0.830
Max	0.655	0.205	0.160	0.881	0.742	1.010	0.819	0.607	0.347	1.256	1.495	3.837	1.740	1.600	1.900	4.750
Min	0.032	0.003	0.003	0.006	0.056	0.007	0.006	0.005	-0.396	-0.427	0.264	0.314	0.042	0.235	0.600	0.480
C.V.	0.854	1.411	1.355	2.053	0.737	0.517	0.539	1.054	1.777	0.520	0.463	0.657	0.721	0.271	0.279	0.632
EFF% (MEAN)			22%	-170%			16%	65%			-27%	-51%			-7%	-16%
EFF% (MEDIAN)			6%	-65%			14%	74%			-8%	-54%			3%	-10%

	Ortho-Phosphorus				Total Phosphorus					Suspended Solids				Magnesium		
	mg/l				mg/l					mg/l				mg/l		
	Lab Detection Limit 0.01 mg/l				Lab Detection Limit 0.01 mg/l					Lab D. L. 0.05						
	556	934	935	939	556	934	935	939		934	935	939		934	935	939
	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW		BEFORE CDS	AFTER CDS	OUTFLOW		BEFORE CDS	AFTER CDS	OUTFLOW
storms																
Sample	30	32	32	30	30	32	32	29		30	30	28		31	31	29
Mean	0.007	0.029	0.023	0.029	0.011	0.100	0.098	0.133		14.47	13.45	17.39		3.15	3.01	2.92
Median	0.005	0.024	0.019	0.025	0.008	0.087	0.081	0.118		12.20	11.85	15.95		2.66	2.62	2.53
St. Dev.	0.006	0.022	0.018	0.022	0.009	0.048	0.048	0.054		10.25	8.70	6.93		1.93	1.71	1.75
Max	0.033	0.088	0.063	0.086	0.041	0.235	0.205	0.273		50.10	49.40	33.20		9.65	9.51	6.72
Min	0.005	0.005	0.005	0.005	0.004	0.036	0.028	0.059		1.59	3.29	7.36		0.74	0.71	0.53
C.V.	0.827	0.770	0.775	0.765	0.758	0.478	0.491	0.402		0.71	0.65	0.40		0.61	0.57	0.60
EFF% (MEAN)			20%	-25%			2%	-36%			7%	-29%			4%	3%
EFF% (MEDIAN)			19%	-32%			7%	-47%			3%	-35%			2%	3%

		Aluminum			Copper				Iron				Zinc			
		ug/L			ug/L				ug/L				ug/L			
					Lab Detection Limit 3.0				Lab Detection Limit 50.0				Lab Detection Limit 30			
		934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
		BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
Samples		32	32	30	30	32	32	30	30	32	32	30	25	32	32	30
Mean		200	185	392	1.58	9.63	11.16	4.98	50	223	239	279	16	51	54	31
Median		167	162	368	1.50	9.10	8.96	4.02	40	194	222	263	10	45	43	29
St. Dev.		146	118	196	0.52	8.33	10.53	3.17	37	117	123	119	18	25	30	11
Max		682	623	939	4.27	49.90	60.10	13.90	174	593	664	605	88	120	147	67
Min		42	43	81	1.00	1.50	1.50	1.50	6	43	85	4	2	10	12	16
C.V.		0.73	0.63	0.50	0.33	0.86	0.94	0.64	0.73	0.53	0.52	0.43	1.17	0.49	0.57	0.36
EFF% (MEAN)			7%	-112%			-16%	55%			-7%	-17%			-5%	43%
EFF% (MEDIAN)			3%	-127%			2%	55%			-14%	-19%			5%	32%

Table E-2. Summary statistics for base flow for year one. Efficiency is shown as percentage. Positive percentage = removal and negative percentage = increase.

BASE FLOW	Ammonia				Nitrate + Nitrite				Organic Nitrogen				Total Nitrogen			
	mg/L as Nitrogen				mg/L as Nitrogen				mg/L as Nitrogen							
	556	934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
Samples		42	42	38		42	42	38		42	42	40		42	42	38
Mean		0.018	0.030	0.087		0.960	0.746	0.050		0.515	0.590	1.058		1.493	1.366	1.252
Median		0.013	0.013	0.048		1.009	0.754	0.018		0.430	0.501	0.971		1.440	1.305	1.065
St. Dev.		0.018	0.039	0.131		0.335	0.286	0.059		0.268	0.324	0.645		0.307	0.265	0.680
Max		0.074	0.197	0.728		1.940	1.320	0.255		1.219	1.786	3.955		2.250	2.050	4.700
Min		0.000	0.000	0.006		0.269	0.177	0.005		0.101	0.085	0.000		0.760	0.800	0.560
C.V.		0.995	1.268	1.503		0.349	0.384	1.167		0.520	0.549	0.610		0.206	0.194	0.543
F% (MEAN)			-70%	-187%			22%	93%			-15%	-79%			8%	8%
% (MEDIAN)			0%	-280%			25%	98%			-17%	-94%			9%	18%

	Ortho-Phosphorus				Total Phosphorus					TSS				Magnesium		
	mg/l				mg/l					ug/L				mg/l		
	Lab Detection Limit 0.01 mg/l				Lab Detection Limit 0.01 mg/l					Lab D. L. 0.05						
	556	934	935	939	556	934	935	939		934	935	939		934	935	939
	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW		BEFORE CDS	AFTER CDS	OUTFLOW		BEFORE CDS	AFTER CDS	OUTFLOW
Samples		42	42	38		42	42	37		42	41	38		42	42	39
Mean		0.022	0.016	0.028		0.061	0.064	0.133		4.6	5.9	15.7		6.07	6.07	3.59
Median		0.018	0.013	0.024		0.051	0.059	0.118		2.6	3.9	13.3		6.07	6.06	2.67
St. Dev.		0.018	0.012	0.026		0.039	0.036	0.064		4.6	4.8	7.6		1.90	2.06	2.39
Max		0.091	0.046	0.116		0.169	0.185	0.305		21.5	23.8	29.9		9.89	10.20	10.70
Min		0.002	0.002	0.005		0.003	0.014	0.043		0.6	1.1	1.6		2.82	2.24	1.23
C.V.		0.838	0.752	0.933		0.643	0.560	0.478		1.0	0.8	0.5		0.31	0.34	0.67
F% (MEAN)			27%	-72%			-5%	-107%			-27%	-168%			0%	41%
% (MEDIAN)			26%	-85%			-17%	-100%			-46%	-245%			0%	56%

		Aluminum			Copper				Iron				Zinc			
					ug/L				ug/L				ug/L			
					Lab Detection Limit 3.0				Lab Detection Limit 50.0				Lab Detection Limit 30			
		934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
		BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
Samples		42	42	38		42	42	38		42	42	38	2	42	41	38
Mean		49.9	62.2	347.4		12.4	11.5	6.0		132.4	160.6	278.3	4.2	21.0	23.3	24.4
Median		37.5	43.8	329.5		7.0	7.2	4.7		122.0	138.5	254.5	4.2	18.0	19.2	20.0
St. Dev.		42.1	45.0	200.5		20.2	12.8	7.5		65.3	83.0	119.5	0.2	12.8	16.7	16.8
Max		205.0	222.0	890.0		116.0	61.2	38.1		413.0	412.0	616.0	4.4	50.0	67.6	100.0
Min		10.0	10.0	37.0		1.5	1.5	0.8		30.0	39.7	65.3	4.1	5.9	5.6	3.3
C.V.		0.8	0.7	0.6		1.6	1.1	1.2		0.5	0.5	0.4	0.0	0.6	0.7	0.7
			-25%	-459%			7%	48%			-21%	-73%			-11%	-4%
			-17%	-652%			-3%	35%			-14%	-84%			-7%	-4%

Table E-3. Nitrogen concentrations for storm events for year one

STORM EVENTS FOR YEAR ONE (2002-03)							CDS UNIT CLEANED OUT (6/25/02, 4/16/03, 7/15/03)											
Date			**Ammonia**				**Nitrate + Nitrite**				**Organic Nitrogen**				**Total Nitrogen**			
sample	**event**	**event**	mg/L as Nitrogen				mg/L as Nitrogen				mg/L as Nitrogen							
collected	**base**	**#**																
			556	934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
			RAIN	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**
10/30/2002	**E**	**1**	na	0.035	0.038	0.060	na	0.039	0.034	0.607	na	1.26	1.13	0.57	na	1.33	1.20	1.24
11/12/2002	**E**	**2**	0.173	0.060	0.146	0.078	0.147	0.569	0.560	0.328	-0.04	0.38	0.26	0.49	0.28	1.01	0.97	0.90
11/16/2002	**E**	**3**	0.066	0.033	0.012	0.017	0.057	0.379	0.410	0.097	0.06	0.20	0.45	0.70	0.18	0.61	0.87	0.81
02/16/2003	**E**	**4**	0.059	*0.006*	*0.006*	*0.006*	0.072	0.549	0.505	*0.005*	0.06	0.39	0.44	1.12	0.19	0.95	0.96	1.13
02/22/2003	**E**	**5**	0.131	*0.006*	0.017	*0.006*	0.128	0.571	0.445	0.126	0.13	0.62	0.66	0.93	0.39	1.20	1.12	1.06
03/03/2003	**E****	**6**	0.173	*0.006*	*0.006*	0.015	0.210	0.775	0.725	0.011	0.09	0.35	0.38	0.92	0.47	1.13	1.11	0.95
03/17/2003	**E**	**7**	0.175	0.061	0.044	*0.006*	0.103	0.615	0.431	0.031	0.24	0.77	0.96	1.28	0.52	1.45	1.43	1.32
03/21/2003	**E**	**8**	0.090	0.030	0.028	na	0.056	0.074	0.065	na	0.13	0.49	0.56	na	0.28	0.59	0.66	na
03/24/2003	**E**	**9**	0.626	0.200	0.148	0.083	0.199	0.309	0.263	0.059	0.22	0.54	0.63	0.56	1.04	1.05	1.04	0.70
03/27/2003	**E**	**10**	0.231	0.205	0.160	0.059	0.176	0.261	0.231	0.018	0.11	0.76	1.28	1.28	0.51	1.23	1.67	1.36
03/28/2003	**E**		0.214	0.012	*0.006*	0.065	0.135	1.010	0.819	0.200	0.07	0.17	0.31	0.70	0.42	1.19	1.13	0.96
04/25/2003	**E**	**12**	0.655	0.174	0.013	0.093	0.289	0.357	0.416	0.293	0.16	0.68	1.30	1.37	1.10	1.21	1.73	1.76
05/01/2003	**E**	**13**	na	0.029	0.063	*0.006*	na	0.490	0.409	*0.005*	na	0.90	0.97	1.26	na	1.42	1.44	1.27
05/18/2003	**E**	**15**	0.651	0.094	0.024	na	0.742	0.568	0.381	na	0.35	-0.43	1.50	na	1.74	0.24	1.90	na
05/22/2003	**E**	**16**	0.284	0.014	0.016	0.064	0.181	0.261	0.239	0.096	0.01	0.57	0.64	1.21	0.48	0.85	0.90	1.37
06/05/2003	**E**	**17**	0.311	0.016	0.018	0.881	0.212	0.297	0.288	0.032	0.12	0.86	1.17	3.84	0.64	1.17	1.48	4.75
06/09/2003	**E**	**18**	0.131	0.020	0.019	0.452	0.155	0.132	0.165	0.041	0.01	0.60	0.75	2.91	0.30	0.75	0.93	3.40
06/11/2003	**E**	**19**	0.385	0.130	0.067	0.276	0.537	0.402	0.295	0.369	0.11	1.07	1.17	0.91	1.03	1.60	1.53	1.55
06/22/2003	**E**	**20**	0.047	*0.006*	*0.006*	0.082	0.066	0.291	0.203	0.084	0.01	0.57	0.53	0.31	0.12	0.87	0.74	0.48
06/29/2003	**E**	**21**	0.080	*0.006*	*0.006*	0.013	0.088	0.479	0.460	0.054	0.09	0.55	0.60	1.31	0.26	1.03	1.07	1.38
07/11/2003	**E**	**22**	0.153	*0.006*	*0.006*	*0.006*	0.531	0.487	0.375	0.117	-0.01	0.63	0.69	0.92	0.68	1.12	1.07	1.04
08/07/2003	**E**	**23**	0.086	0.006	0.007	0.063	0.170	0.271	0.230	0.109	0.05	0.51	0.60	0.54	0.31	0.79	0.84	0.71
08/19/2003	**E**	**24**	0.077	0.005	0.007	0.051	0.361	0.512	0.241	0.245	-0.40	0.46	0.56	0.37	0.04	0.98	0.81	0.67
08/25/2003	**E**	**25**	0.112	0.022	0.011	0.012	0.390	0.793	0.659	0.218	0.03	0.35	0.44	0.53	0.53	1.16	1.11	0.76
08/26/2003	**E**	**26**	0.158	*0.003*	*0.003*	0.021	0.302	0.833	0.633	0.228	0.00	0.45	0.39	0.49	0.46	1.29	1.03	0.74
09/03/2003	**E**	**27**	0.053	0.006	*0.003*	0.010	0.146	0.450	0.462	0.129	0.03	0.54	0.54	0.85	0.23	0.99	1.00	0.99
09/19/2003	**E**	**28**	0.281	0.006	0.007	0.026	0.481	0.743	0.580	0.297	0.08	0.60	0.49	0.89	0.84	1.35	1.08	1.21
09/25/2003	**E**	**29**	0.032	0.011	0.011	0.050	0.121	0.424	0.303	0.109	0.05	0.51	0.52	1.17	0.199	0.949	0.835	1.33
09/30/2003	**E**	**30**	0.139	0.037	0.063	0.025	0.189	0.596	0.761	0.052	0.03	0.46	0.43	1.07	0.36	1.09	1.25	1.15
10/14/2003	**E**	**31**	0.516	0.016	0.018	0.011	0.251	0.424	0.312	0.005	0.10	0.85	1.13	1.44	0.869	1.29	1.46	1.46
10/25/2003	**E**	**32**	0.251	0.017	0.020	0.013	0.222	0.432	0.226	0.008	0.12	0.91	1.15	1.47	0.59	1.36	1.4	1.49
10/28/2003	**E**	**33**	0.059	0.018	0.015	0.015	0.056	0.007	0.006	0.007	0.06	0.69	0.58	1.46	0.173	0.711	0.6	1.485
# Samples			30	32	32	30	30	32	32	30	30	32	32	30	30	32	32	30
Mean			0.213	0.040	0.032	0.085	0.226	0.450	0.379	0.133	0.07	0.57	0.73	1.10	0.51	1.06	1.14	1.31
Median			0.156	0.017	0.016	0.026	0.179	0.441	0.378	0.097	0.07	0.56	0.60	0.93	0.44	1.11	1.08	1.18
St. Dev.			0.182	0.057	0.043	0.176	0.166	0.232	0.204	0.140	0.12	0.30	0.34	0.72	0.37	0.29	0.32	0.83
Max			0.655	0.205	0.160	0.881	0.742	1.010	0.819	0.607	0.35	1.26	1.50	3.84	1.74	1.60	1.90	4.75
Min			0.032	0.003	0.003	0.006	0.056	0.007	0.006	0.005	-0.40	-0.43	0.26	0.31	0.04	0.24	0.60	0.48
C.V.			0.85	1.41	1.35	2.05	0.74	0.52	0.54	1.05	1.74	0.52	0.46	0.66	0.72	0.27	0.28	0.63

Table E-4. Nitrogen concentrations for base flow samples for year one.

Date sample collected	base flow	event #	Ammonia				Nitrate + Nitrite				Organic Nitrogen				Total Nitrogen			
			mg/L as Nitrogen															
			556 RAIN	934 BEFORE CDS	935 AFTER CDS	939 OUTFLOW	556 RAIN	934 BEFORE CDS	935 AFTER CDS	939 OUTFLOW	556 RAIN	934 BEFORE CDS	935 AFTER CDS	939 OUTFLOW	556 RAIN	934 BEFORE CDS	935 AFTER CDS	939 OUTFLOW
10/30/2002	B	1		0.014	0.078	0.170		1.555	0.186	0.021		0.51	1.79	1.24		2.08	2.05	1.43
11/04/2002	B	2		0.021	0.012	na		1.252	0.925	na		0.35	0.36	na		1.62	1.3	na
11/12/2002	B	3		0.005	0.039	0.064		1.206	1.204	0.009		0.18	0.17	0.49		1.39	1.41	0.56
11/15/2002	B	4		0.017	0.047	0.059		0.922	0.878	0.102		0.10	0.09	0.59		1.04	1.01	0.75
11/21/2002	B	5		0.000	0.000	na		0.945	0.950	na		0.24	0.14	na		1.18	1.09	na
02/04/2003	B	6		0.023	0.037	*0.006*		0.929	0.970	*0.005*		0.33	0.30	0.96		1.28	1.31	0.973
02/06/2003	B**	7		*0.006*	*0.006*	*0.006*		1.160	0.988	0.062		0.24	0.28	1.10		1.41	1.27	1.17
02/12/2003	B	8		*0.006*	*0.006*	0.022		1.050	0.814	0.098		0.39	0.48	0.91		1.45	1.3	1.03
02/16/2003	B	9		*0.006*	*0.006*	na		0.770	0.714	na		1.10	0.89	na		1.88	1.61	na
02/21/2003	B	10		0.021	0.197	na		1.940	1.320	na		0.29	0.53	na		2.25	2.05	na
02/24/2003	B	11		0.018	*0.006*	0.017		0.984	0.434	0.042		0.36	0.71	0.71		1.36	1.15	0.766
02/26/2003	B	12		0.014	0.056	0.047		1.218	0.501	0.115		0.30	0.56	0.59		1.53	1.12	0.751
03/13/2003	B	13		0.023	0.122	0.021		1.056	1.223	*0.005*		0.41	0.60	1.31		1.49	1.94	1.34
03/21/2003	B	14		0.032	0.032	0.170		0.733	0.561	0.022		0.65	0.61	1.04		1.41	1.2	1.23
03/27/2003	B	15		0.023	*0.006*	0.271		0.850	0.699	0.122		0.55	0.59	0.58		1.42	1.29	0.974
03/31/2003		16		*0.006*	*0.006*	0.012		1.070	0.706	0.058		0.72	0.80	0.96		1.8	1.51	1.03
04/03/2003	B	17		0.044	0.015	*0.006*		1.040	0.699	*0.006*		0.40	0.47	0.98		1.48	1.18	0.991
04/07/2003	B	18		*0.006*	0.029	0.026		1.290	1.090	*0.005*		0.48	0.47	1.57		1.78	1.59	1.60
04/16/2003	B	19		*0.006*	*0.006*	*0.006*		1.190	0.887	*0.005*		0.29	0.46	1.38		1.49	1.35	1.39
04/18/2003	B	20		0.013	0.060	*0.006*		1.020	0.699	*0.005*		0.36	0.32	1.44		1.39	1.08	1.45
04/21/2003	B	21		*0.006*	0.051	*0.006*		1.280	1.100	*0.005*		0.34	0.35	1.61		1.63	1.5	1.62
04/24/2003	B	22		*0.006*	*0.006*	*0.006*		1.050	1.070	*0.005*		0.31	0.40	1.37		1.37	1.48	1.38
04/28/2003	B	23		0.067	0.041	0.218		0.427	0.353	0.255		0.94	0.86	0.63		1.43	1.25	1.1
05/12/2003	B	24		*0.006*	0.018	0.100		0.423	0.575	*0.005*		0.46	0.62	1.84		0.89	1.21	1.94
05/16/2003	B	25		0.059	0.073	0.028		0.498	0.547	0.101		1.07	1.22	1.81		1.63	1.84	1.94
05/22/2003	B	26		0.074	0.069	0.104		0.269	0.243	*0.005*		0.82	0.94	1.51		1.16	1.25	1.62
06/02/2003	B	27		0.022	0.035	0.728		1.140	0.373	0.017		1.00	1.02	3.96		2.16	1.43	4.7
06/11/2003	B	28		0.018	0.013	0.330		0.286	0.297	0.085		0.46	0.49	1.30		0.76	0.8	1.71
06/16/2003	B	29		0.035	0.093	0.067		0.281	0.177	0.017		1.09	1.35	1.52		1.41	1.62	1.6
07/07/2003	B	30		0.014	*0.006*	0.088		1.050	0.802	0.019		0.43	0.51	1.02		1.49	1.32	1.13
07/15/2003	B	31		0.013	0.012	0.057		0.795	0.492	0.175		0.54	0.62	0.48		1.35	1.12	0.708
07/18/2003	B	32		0.006	0.006	0.026		0.732	0.660	0.112		0.49	0.45	0.85		1.23	1.12	0.987
07/23/2003	B	33		*0.006*	*0.006*	0.081		0.838	0.669	0.016		0.48	0.44	0.92		1.32	1.11	1.02
07/30/2003	B	34		0.010	0.014	0.129		0.803	0.518	0.016		0.52	0.75	1.26		1.33	1.28	1.4
08/13/2003	B	35		0.008	0.011	0.139		0.998	0.796	0.130		0.60	0.75	0.61		1.61	1.56	0.875
08/29/2003	B	36		0.057	0.017	0.020		1.370	1.100	0.008		0.41	0.42	0.82		1.84	1.54	0.85
09/05/2003	B	37		0.006	*0.003*	0.069		1.025	0.865	0.071		0.55	0.48	0.53		1.58	1.35	0.667
09/10/2003	B	38		0.005	0.010	0.013		1.150	0.858	0.005		0.43	0.63	1.01		1.58	1.5	1.03
09/17/2003	B	39		0.011	0.010	0.048		1.160	0.957	0.037		0.37	0.39	0.75		1.54	1.36	0.834
09/19/2003	B	40		*0.003*	*0.003*	0.081		0.878	0.729	0.014		0.42	0.67	0.73		1.3	1.4	0.828
10/03/2003	B	41		0.012	0.008	0.044		0.855	0.778	0.125		0.43	0.44	0.54		1.3	1.23	0.707
10/06/2003	B	42		0.007	0.009	0.027		0.824	0.912	0.011		1.22	0.37	1.45		2.05	1.29	1.49
# Samples				42	42	38		42	42	38		42	42	38		42	42	38
Mean				0.018	0.030	0.087		0.960	0.746	0.050		0.515	0.590	1.114		1.493	1.366	1.252
Median				0.013	0.013	0.048		1.009	0.754	0.018		0.430	0.501	0.996		1.440	1.305	1.065
St. Dev.				0.018	0.039	0.131		0.335	0.286	0.059		0.268	0.324	0.613		0.307	0.265	0.680
Max				0.074	0.197	0.728		1.940	1.320	0.255		1.219	1.786	3.955		2.250	2.050	4.700
Min				0.000	0.000	0.006		0.269	0.177	0.005		0.101	0.085	0.476		0.760	0.800	0.560
C.V.				1.00	1.27	1.50		0.35	0.38	1.17		0.52	0.55	0.55		0.21	0.19	0.54

Table E-5. Water quality concentrations for storm events for year one

Date			Ortho-Phosphorus				Total Phosphorus				TSS			CALCIUM			MAGNESIUM		
sample	storm	event	MG/L				MG/L				ug/L			mg/l			mg/l		
collected	event	#	Lab Detection Limit 0.01				Lab Detection Limit 0.01				Lab D. L. 0.05								
			556	934	935	939	556	934	935	939	934	935	939	934	935	939	934	935	939
			RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	BEFORE CDS	AFTER CDS	OUTFLOW	BEFORE CDS	AFTER CDS	OUTFLOW	BEFORE CDS	AFTER CDS	OUTFLOW
10/30/2002	E	1	na	0.051	0.026	0.086	na	0.154	0.140	0.196	32.9	30.5	15.5	19.9	28.3	39.8	0.79	1.60	2.98
11/12/2002	E	2	*0.005*	0.070	0.056	0.047	*0.005*	0.195	0.162	0.179	26.9	16.0	16.3	66.0	66.8	51.7	9.65	9.51	4.29
11/16/2002	E	3	*0.005*	0.007	0.007	0.071	0.004	0.036	0.028	na	na	na	na	na	na	na	na	na	na
02/16/2003	E	4	*0.005*	*0.005*	0.010	0.013	0.025	0.052	0.056	0.101	6.3	8.6	13.5	47.0	44.6	50.8	4.03	3.82	6.65
02/22/2003	E	5	*0.005*	*0.005*	0.015	0.011	*0.005*	0.094	0.077	0.131	14.3	16.8	13.5	46.1	39.0	25.7	3.05	2.78	2.30
03/03/2003	E	6	*0.005*	0.010	0.013	0.042	*0.005*	0.039	0.046	0.145	11.7	11.8	11.1	61.7	60.6	44.1	5.14	5.22	4.01
03/17/2003	E	7	*0.005*	0.021	0.015	0.060	0.011	0.133	0.176	0.197	16.9	19.3	19.5	56.9	53.2	48.9	5.61	5.57	5.25
03/21/2003	E	8	*0.005*	0.038	0.033	na	*0.005*	0.117	0.114	na	15.5	15.7	na	12.8	12.1	na	0.74	0.71	na
03/24/2003	E	9	*0.005*	0.032	0.024	0.055	*0.005*	0.076	0.056	0.133	10.5	7.6	7.4	20.1	20.3	11.8	1.14	1.21	0.95
03/27/2003	E	10	*0.005*	0.081	0.063	0.048	0.014	0.190	0.169	0.186	34.4	49.4	26.6	18.4	22.0	29.7	0.76	1.25	2.22
03/28/2003	E	11	*0.005*	0.035	0.029	0.018	*0.005*	0.114	0.089	0.104	14.1	14.0	9.3	37.9	38.7	17.0	2.11	2.21	1.08
04/25/2003	E	12	0.019	0.029	*0.005*	0.045	0.017	0.124	0.181	0.263	10.1	12.8	33.2	21.6	32.4	26.3	2.18	2.32	2.97
05/01/2003	E	13	na	0.052	0.055	0.025	na	0.125	0.142	0.157	12.7	15.5	16.4	33.9	34.5	25.7	3.12	3.21	2.01
05/18/2003	E	14	0.033	0.054	0.021	na	0.041	0.235	0.205	na	50.1	18.3	na	34.4	36.8	na	2.60	2.98	na
05/22/2003	E	15	*0.005*	0.027	0.017	*0.005*	0.011	0.070	0.075	0.156	6.2	9.4	15.1	26.2	25.8	22.7	2.66	2.36	1.73
06/05/2003	E	16	*0.005*	0.013	0.019	0.010	0.014	0.082	0.124	0.177	14.3	15.4	20.0	42.6	38.2	37.9	4.99	3.12	4.24
06/09/2003	E	17	*0.005*	0.019	0.040	*0.005*	*0.005*	0.073	0.130	0.273	8.3	9.0	11.6	36.1	38.7	34.6	4.92	3.18	3.42
06/11/2003	E	18	*0.005*	*0.005*	*0.005*	0.041	0.025	0.102	0.095	0.098	na	na	na	29.4	28.1	16.4	2.15	2.62	1.21
06/22/2003	E	19	*0.005*	0.022	0.021	0.037	*0.005*	0.090	0.054	0.059	9.3	9.7	31.0	22.4	20.8	11.2	1.01	0.87	0.53
06/29/2003	E	20	*0.005*	0.025	0.019	0.011	*0.005*	0.067	0.082	0.143	1.6	3.3	20.5	35.8	36.6	32.2	2.86	2.83	2.53
07/11/2003	E	21	*0.005*	0.011	*0.005*	0.021	*0.005*	0.083	0.079	0.110	4.9	7.4	7.5	35.8	29.1	26.1	2.83	2.57	1.94
08/07/2003	E	22	*0.005*	0.015	0.023	0.025	*0.005*	0.060	0.053	0.076	6.6	10.9	11.1	31.4	31.5	18.9	1.77	1.77	1.10
08/19/2003	E	23	*0.005*	*0.005*	0.010	0.040	*0.005*	0.069	0.060	0.082	8.6	11.9	8.3	37.8	36.6	18.4	1.96	1.99	1.13
08/25/2003	E	24	*0.005*	0.024	*0.005*	*0.005*	0.010	0.055	0.059	0.087	13.9	6.4	12.9	41.2	40.5	25.2	2.37	2.50	1.78
08/26/2003	E	25	0.011	0.020	*0.005*	0.026	0.020	0.048	0.043	0.068	5.4	6.7	13.9	45.2	44.4	18.1	3.26	3.48	1.12
09/03/2003	E	26	*0.005*	0.043	0.011	0.040	0.013	0.103	0.070	0.129	15.4	16.6	20.6	29.5	31.0	22.5	2.03	2.16	1.88
09/19/2003	E	27	0.010	0.015	*0.005*	0.013	0.019	0.057	0.045	0.095	6.3	4.3	15.6	49.5	47.6	32.8	5.02	4.71	3.01
09/25/2003	E	28	*0.005*	0.025	0.026	*0.005*	*0.005*	0.073	0.069	0.073	9.7	8.0	21.1	30.5	28.7	37.6	1.83	1.84	3.59
09/30/2003	E	29	*0.005*	0.023	0.034	0.010	*0.005*	0.072	0.062	0.110	22.4	11.6	22.9	43.5	44.9	31.9	4.39	3.59	3.02
10/14/2003	E	30	*0.005*	0.088	0.062	0.030	0.016	0.160	0.150	0.118	17.8	12.3	24.9	45.9	48.4	45.8	4.32	4.07	5.51
10/25/2003	E	31	0.010	*0.005*	*0.005*	*0.005*	0.022	0.126	0.132	0.112	9.7	7.9	27.4	52.0	48.4	50.0	6.11	4.80	6.72
10/28/2003	E	32	*0.005*	0.039	0.048	*0.005*	0.012	0.126	0.118	0.113	17.6	16.1	20.3	26.9	28.0	43.4	2.23	2.40	5.62
# Samples			30	32	32	30	30	32	32	29	30	30	28	31	31	29	31	31	29
Mean			0.007	0.029	0.023	0.029	0.011	0.100	0.098	0.133	14.5	13.4	17.4	36.7	36.7	30.9	3.1	3.0	2.9
Median			0.005	0.024	0.019	0.025	0.008	0.087	0.081	0.118	12.2	11.9	15.9	35.8	36.6	29.7	2.7	2.6	2.5
St. Dev.			0.006	0.022	0.018	0.022	0.009	0.048	0.048	0.054	10.3	8.7	6.9	13.0	11.9	12.2	1.9	1.7	1.7
Max			0.033	0.088	0.063	0.086	0.041	0.235	0.205	0.273	50.1	49.4	33.2	66.0	66.8	51.7	9.7	9.5	6.7
Min			0.005	0.005	0.005	0.005	0.004	0.036	0.028	0.059	1.6	3.3	7.4	12.8	12.1	11.2	0.7	0.7	0.5
C.V.			0.83	0.77	0.77	0.76	0.76	0.48	0.49	0.40	0.71	0.65	0.40	0.35	0.32	0.39	0.61	0.57	0.60

Table E-6. Water quality concentrations for metals for storm events for year one.

Date sample collected	event		Aluminum			Copper				Iron				Zinc			
						ug/L				ug/L				ug/L			
						Lab Detection Limit 3.0				Lab Detection Limit 50.0				Lab Detection Limit 30			
			934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
			BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
10/30/2002	**E**	**1**	659	411	81	na	13.70	17.10	2.50	na	550	460	240	na	120.0	100.0	20.0
11/12/2002	**E**	**2**	371	189	408	1.50	9.80	8.10	4.00	70.0	400	220	320	na	90.0	70.0	60.0
11/16/2002	**E**	**3**	94	84	128	1.00	3.90	4.00	2.10	10.0	90	100	140	na	40.0	40.0	30.0
02/16/2003	**E**	**4**	64	77	163	*1.50*	8.33	9.19	13.90	28.2	132	163	184	14.0	45.6	53.2	37.3
02/22/2003	**E**	**5**	230	209	385	*1.50*	10.60	7.31	8.53	37.3	302	387	314	17.5	112.0	57.7	42.6
03/03/2003	**E****	**6**	71	87	170	*1.50*	4.24	9.13	6.78	70.4	164	229	243	88.1	35.2	41.5	25.0
03/17/2003	**E**	**7**	104	208	401	*1.50*	10.80	9.91	9.30	41.7	169	359	283	16.9	38.2	60.7	32.1
03/21/2003	**E**		343	325	na	*1.50*	3.89	3.89	na	37.1	256	261	na	7.2	60.1	55.5	na
03/24/2003	**E**	**8**	139	140	225	*1.50*	9.08	7.72	*1.50*	30.9	129	129	155	12.8	40.9	31.6	33.4
03/27/2003	**E**	**9**	682	623	603	*1.50*	9.58	18.80	8.21	55.7	593	664	419	26.8	86.1	99.5	27.1
03/28/2003	**E**	**10**	229	169	297	*1.50*	9.27	11.10	4.61	63.1	271	237	224	7.4	34.1	29.5	32.0
04/25/2003	**E**	**12**	196	154	939	*1.50*	6.18	16.20	13.00	78.1	204	323	605	19.3	50.0	38.7	66.7
05/01/2003	**E**	**13**	168	221	258	na	10.60	12.30	3.90	na	196	266	241	na	67.3	118.0	37.0
05/18/2003	**E**	**15**	253	181	na	4.27	13.20	17.30	na	122.0	286	223	na	44.7	74.9	62.0	na
05/22/2003	**E**	**16**	92	96	215	*1.50*	18.60	16.80	7.43	89.7	168	136	198	10.5	48.0	43.7	33.3
06/05/2003	**E**	**17**	128	186	273	*1.50*	11.50	11.70	4.82	42.2	42.6	305	410	13.9	60.2	147.0	25.8
06/09/2003	**E**	**18**	188	361	299	*1.50*	9.12	25.50	3.93	63.7	257	406	325	na	39.2	93.6	30.2
06/11/2003	**E**	**19**	290	148	641	*1.50*	11.00	9.75	5.88	73.9	311	160	382	33.2	65.8	45.1	40.9
06/22/2003	**E**	**20**	237	253	310	*1.50*	7.05	9.47	6.25	18.2	145	184	175	4.2	37.8	38.6	33.7
06/29/2003	**E**	**21**	185	198	713	*1.50*	9.66	8.78	6.10	174.0	155	183	459	na	10.4	11.6	23.8
07/11/2003	**E**	**22**	206	291	491	*1.50*	7.96	7.10	*1.50*	89.2	224	249	346	na	27.3	28.8	20.1
08/07/2003	**E**	**23**	154	155	370	*1.50*	6.29	6.33	3.41	20.4	189	179	225	6.4	35.2	41.0	25.2
08/19/2003	**E**	**24**	165	196	194	*1.50*	4.99	6.75	3.06	53.6	191	223	160	8.6	36.7	33.1	16.2
08/25/2003	**E**	**25**	140	112	359	*1.50*	*1.50*	3.13	*1.50*	71.1	181	155	206	6.1	26.1	26.7	24.0
08/26/2003	**E**	**26**	93	91	365	*1.50*	3.33	*1.50*	*1.50*	20.4	139	125	193	4.0	16.4	21.2	19.3
09/03/2003	**E**	**27**	208	106	619	*1.50*	3.34	*1.50*	*1.50*	20.8	218	143	334	5.6	35.3	27.5	27.6
09/19/2003	**E**	**28**	42	43	232	*1.50*	4.68	5.11	3.45	28.2	98.5	85	164	3.6	22.3	26.1	24.3
09/25/2003	**E**	**29**	120	108	550	*1.50*	3.72	4.58	4.04	*6.3*	154	124	3.9	2.0	44.5	39.7	28.6
09/30/2003	**E**	**30**	159	80	551	*1.50*	6.65	3.34	4.16	15.3	277	147	366	2.9	50.2	37.1	25.9
10/14/2003	**E**	**31**	142	206	535	*1.50*	49.90	60.10	3.33	21.2	222	390	335	10.1	60.6	77.9	19.9
10/25/2003	**E**	**32**	68	85	503	*1.50*	16.50	15.70	5.14	36.1	153	239	312	17.1	62.9	72.1	30.2
10/28/2003	**E**	**33**	178	129	495	*1.50*	9.30	7.86	3.97	18.0	266	183	405	5.7	70.3	52.9	29.2
# Samples			32	32	30	30	32	32	30	30	32	32	30	25	32	32	30
Mean			200	185	392	1.58	9.63	11.16	4.98	50	223	239	279	15.5	51.4	53.8	30.7
Median			167	162	368	1.50	9.10	8.96	4.02	40	194	222	263	10.1	45.1	42.6	28.9
St. Dev.			146	118	196	0.52	8.33	10.53	3.17	37	117	123	119	18.2	25.4	30.4	10.9
Max			682	623	939	4.27	49.90	60.10	13.90	174	593	664	605	88.1	120.0	147.0	66.7
Min			42	43	81	1.00	1.50	1.50	1.50	6	43	85	4	2.0	10.4	11.6	16.2
C.V.			0.73	0.63	0.50	0.33	0.86	0.94	0.64	0.73	0.53	0.52	0.43	1.17	0.49	0.57	0.36

DISSOLVED MEATALS YEAR ONE

Date		Dissolved Zinc						Dissolved Copper						Dissolved Iron						Dissolved Lead					
sample	event	ug/L						ug/L						ug/L						ug/L					
collected	base	Lab Detection Limit 15						Lab Detection Limit 3.0						Lab Detection Limit 50.0						Lab Detection Limit 2.0					
STORM FLOW		934	D Q	935	D Q	939	D Q	934	D Q	935	D Q	939	DQ	934	D Q	935	D Q	939	D Q	934	D Q	935	D Q	939	D Q
YEAR ONE		BEFORE CDS		AFTER CDS		OUTFLOW		BEFORE CDS		AFTER CDS		OUTFLOW		BEFORE CDS		AFTER CDS		OUTFLOW		BEFORE CDS		AFTER CDS		OUTFLOW	
11/13/2002	**E**	80.0		60.0		40.0	I	8.9	I	7.3	I	3.8	I	210.0		120.0		160.0		5.8		3.2		2.6	
11/18/2002	**E**	30.0	I	30.0	I	10.0	U	3.2	I	3.5	I	1.6	U	60.0	I	80.0	I	120.0		1.7		1.9		0.25	U
2/19/2003	**E**	19.7	J	22.9	J	4.9	IJ	3.6	I	4.9	I	7.3	I	60.1		65.7		52.6		*5*	U	*5*	U	*5*	U
2/23/2003	**E**	17.6	J	21.6	J	13.3		*1.5*	U	*1.5*	U	*1.5*	U	67.5		141.0		53.3		*5*	U	*5*	U	*5*	U
3/17/2003	**E**	17.6	J	20.2	J	5.8	IJ	6.0	I	5.2	I	*1.5*	U	70.4		69.7		41.2	I	*5*	U	*5*	U	*5*	U
3/21/2003	**E**	10.3		9.7		N/A		*1.5*	U	*1.5*	U	N/A		21.5	I	21.1	I	N/A		*5*	U	*5*	U	N/A	
3/24/2003	**E**	13.7		13.9		12.0		3.6	I	3.6	I	*1.5*	U	37.9	I	37.7	I	44.1	I	*5*	U	*5*	U	*5*	U
3/27/2003	**E**	13.2		12.1		4.3	I	*1.5*	U	*1.5*	U	*1.5*	U	27.3	I	33.3	I	48.8	I	*5*	U	*5*	U	5	U
3/28/2003	**E**	9.5		8.7		13.2		5.9	I	5.2	I	*1.5*	U	90.8		87.1		38.7	I	*5*	U	*5*	U	*5*	U
4/26/2003	**E**	23.8		21.5		18.9		*1.5*	U	10.1	I	*1.5*	I	32.8	I	196.0		44.8		*5*	U	*5*	U	*5*	U
5/1/2003	**E**	27.9		43.6		3.0	I	7.6	I	8.0	I	*1.5*	U	41.9	I	44.2	I	76.5		*5*	U	*5*	U	*5*	U
5/19/2003	**E**	30.0	J	22.2	J	77.2	J	7.9	I	8.8	I	*1.5*	U	51.3		57.4		47.0	I	*5*	U	*5*	U	*5*	U
5/23/2003	**E**	28.5		24.1		11.5		12.8		10.4	I	3.1	I	36.2	I	43.9	I	37.5	I	*5*	U	*5*	U	*5*	U
6/6/2003	**E**	40.2		49.7		9.2		5.7	I	4.7	I	*1.5*	U	56.2		76.2		48.8		*5*	U	*5*	U	*5*	U
6/9/2003	**E**	24.3		46.1		10.4		4.2	I	3.7	I	*1.5*	U	34.9	I	68.3		82.2		*5*	U	*5*	U	*5*	U
6/13/2003	**E**	23.5		21.9		15.6		3.2	I	*1.5*	U	*1.5*	U	22.9	I	21.4	I	50.4		*5*	U	*5*	U	*5*	U
6/23/2003	**E**	14.2		13.8		9.2		3.9	I	3.9	I	3.4	I	34.5	I	29.6	I	29.1	I	*5*	U	*5*	U	*5*	U
6/29/2003	**E**	18.9		19.6		7.3		4.8	I	5.0	I	*1.5*	U	31.4	I	33.7	I	30.8	I	*5*	U	*5*	U	*5*	U
7/12/2003	**E**	24.8		25.7		11.7		4.1	I	*1.5*	U	*1.5*	U	67.7		46.2		71.4		*5*	U	*5*	U	*5*	U
8/9/2003	**E**	19.6		23.8		9.4		3.8	I	4.0	I	*1.5*	U	87.0		80.1		43.4		*5*	U	*5*	U	*5*	U
8/20/2003	**E**	17.3		17.2		8.1		*1.5*	U	*1.5*	U	*1.5*	U	87.8		81.9		46.2		*5*	U	*5*	U	*5*	U
8/26/2003	**E**	15.1		17.7		12.2		*1.5*	U	*1.5*	U	*1.5*	U	83.9		82.3		31.6	I	*5*	U	*5*	U	*5*	U
8/27/2003	**E**	10.9		12.1		8.8		*1.5*	U	*1.5*	U	*1.5*	U	74.0		66.6		32.9	I	*5*	U	*5*	U	*5*	U
9/4/2003	**E**	13.9		12.8		10.4		*1.5*	U	*1.5*	U	*1.5*	U	50.9		45.0		37.1	I	*5*	U	*5*	U	*5*	U
9/21/2003	**E**	18.1		20.3		15.1		3.2	I	*1.5*	U	*1.5*	U	59.0		51.5		63.0		*5*	U	*5*	U	*5*	U
9/26/2003	**E**	30.1		27.1		10.5		*1.5*	U	*1.5*	U	*1.5*	U	57.4		42.2		93.2		*5*	U	*5*	U	*5*	U
10/1/2003	**E**	22.2		28.1		7.4		3.2	I	*1.5*	U	*1.5*	U	59.0		70.9		44.3		*5*	U	*5*	U	*5*	U
10/15/2003	**E**	42.3		47.1		5.5	I	49.9		60.1		3.3	U	73.3		95.6		36.6	I	*5*	U	*5*	U	*5*	U
10/27/2003	**E**	44.1		55.8		11.9		11.2		10.8		*1.5*	U	85.8		143.0		47.9		*5*	U	*5*	U	*5*	U
10/29/2003	**E**	34.1		31.5		12.3		*1.5*	I	7.9	I	4.0	U	68.6		61.4		71.4		*5*	U	*5*	U	*5*	U
3/3/2003	**E****	13.3	J	14.8	J	7.4	IJ	*1.5*	UJ	*1.5*	UJ	*1.5*	UJ	91.6		94.7		64.1		*5*	U	*5*	U	*5*	U
# Samples		31		31		30		31		30		30		31		31		30		31		31		30	
Mean		31.2		35.5		8.9		16.4		2.4		2.4		75.7		93.1		52.9		5.0		5.0		5.0	
Median		34.1		31.5		7.4		7.9		1.5		1.5		73.3		94.7		47.9		5.0		5.0		5.0	
St. Dev.		13.2		16.2		3.0		24.8		1.2		1.2		13.1		31.6		14.4		0.0		0.0		0.0	
Max		44.1		55.8		12.3		60.1		4.0		4.0		91.6		143.0		71.4		5.0		5.0		5.0	
Min		13.3		14.8		5.5		1.5		1.5		1.5		59.0		61.4		36.6		5.0		5.0		5.0	
C.V.		0.42		0.46		0.34		1.52		0.51		0.51		0.17		0.34		0.27		0.00		0.00		0.00	

DISSOLVED METALS BASE FLOW YEAR ONE																									
Date		**Dissolved Zinc**						**Dissolved Copper**						**Dissolved Iron**						**Dissolved Lead**					
sample	**event**	ug/L						ug/L						ug/L						ug/L					
collected	**base**	Lab Detection Limit 15						Lab Detection Limit 3.0						Lab Detection Limit 50.0						Lab Detection Limit 2.0					
BASE FLOW		934	**D Q**	935	**D Q**	939	**D Q**	934	**D Q**	935	**D Q**	939	**DQ**	934	**D Q**	935	**D Q**	939	**D Q**	934	**D Q**	935	**D Q**	939	**D Q**
YEAR ONE		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**	
11/12/2002	**B**	0.0	U	10.0	U	10.0	U	3.7	I	5.7	I	0.9	U	20.0	U	70.0	I	100.0	I	0.3	U	1.1	I	0.7	I
11/15/2002	**B**	10.0	U	20.0	I	10.0	U	2.6	I	4.0	I	2.1	U	40.0		50.0	I	100.0	I	0.6	I	0.9	I	1.1	I
11/21/2002	**B**	6.0	U	6.0	U	N/A		4.6	I	4.6	I	N/A		40.0	I	30.0	U	N/A		0.4	U	0.2	U	N/A	
2/4/2003	**B**	7.7	I	3.4	I	2.4	I	18.5		22.8		31.6		55.1		29.4	I	29.4	I	*0.2*	U	*0.2*	U	*0.2*	U
2/12/2003	**B**	20.3	J	17.2	J	16.6	J	9.3		10.1		11.1	I	91.8		86.3		38.7	I	0.5	I	0.5	I	0.5	I
2/16/2003	**B**	18.8	J	15.0	J	N/A		9.0	I	9.6	I	N/A		78.5		86.6		N/A		*5*	U	*5*	U	N/A	
2/21/2003	**B**	6.7	IJ	39.3	J	N/A		*1.5*	U	*1.5*	U	N/A		120.0		133.0		N/A		*5*	U	*5*	U	N/A	
2/24/2003	**B**	7.7	IJ	11.5	J	11.4	J	4.8	I	4.9	I	*1.5*	U	128.0		146.0		54.9		*5*	U	*5*	U	*5*	U
2/26/2003	**B**	4.8	IJ	6.4	IJ	7.3	IJ	4.3	I	*1.5*	U	*1.5*	U	129.0		239.0		68.6		*5*	U	*5*	U	*5*	U
3/13/2003	**B**	6.1	I	5.7	IJ	3.1	IJ	*1.5*	U	*1.5*	U	*1.5*	U	89.0		272.0		27.0	I	*5*	U	*5*	U	*5*	U
3/21/2003	**B**	19.8		22.3		16.4		6.0	I	4.7	I	*1.5*	U	98.7		85.2		95.9		*5*	U	*5*	U	*5*	U
3/27/2003	**B**	4.9	I	5.4	I	9.4		10.7	I	9.1	I	*1.5*	U	92.2		88.1		65.6		*5*	U	*5*	U	5	U
3/31/2003	**B**	4.8	I	8.3		7.5	I	6.9	I	6.7	I	*1.5*	U	99.4		101.0		68.8		*5*	U	*5*	U	*5*	U
4/3/2003	**B**	3.2	I	3.5	I	*1.0*	U	*1.5*	U	*1.5*	U	*1.5*	U	80.1		64.1		43.9	I	*5*	U	*5*	U	*5*	U
4/7/2003	**B**	2.7	I	4.4	I	2.7	I	*1.5*	U	*1.5*	U	*1.5*	U	65.9		74.2		29.6	I	*5*	U	*5*	U	*5*	U
4/16/2003	**B**	2.8	I	4.0	I	3.8	I	*1.5*	U	3.2	I	*1.5*	U	60.9		115.0		48.7	I	*5*	U	*5*	U	*5*	U
4/18/2003	**B**	*1.0*	*U*	*1.0*	*U*	2.4	I	*1.5*	U	*1.5*	U	*1.5*	U	53.9		69.1		49.6	I	*5*	U	*5*	U	*5*	U
4/21/2003	**B**	*1.0*	*U*	*1.0*	*U*	8.8		*1.5*	U	*1.5*	U	4.0	I	43.4	I	64.2		49.7	I	*5*	U	*5*	U	*5*	U
4/24/2003	**B**	2.5	I	2.5	I	*1.0*	U	*1.5*	U	*1.5*	U	*1.5*	U	48.8	I	55.9		40.6	I	*5*	U	*5*	U	*5*	U
4/28/2003	**B**	11.4		9.5		16.1		10.9	I	9.8	I	*1.5*	U	90.5		55.5		63.9		*5*	U	*5*	U	*5*	U
5/12/2003	**B**	3.0	I	2.7	IJ	4.0	IJ	3.8	I	*1.5*	U	*1.5*	U	34.8	I	63.9		44.7	I	*5*	U	*5*	U	*5*	U
5/16/2003	**B**	21.2	J	26.8	J	7.4	J	4.2	I	4.6	I	*1.5*	U	56.5		82.1		41.9	I	*5*	U	*5*	U	*5*	U
5/22/2003	**B**	7.7	I	7.2	I	9.6		57.0		43.9		*1.5*	U	46.1	I	45.8	I	45.2	I	*5*	U	*5*	U	*5*	U
6/2/2003	**B**	19.1		6.8	I	*1.0*	U	5.5	I	4.2	I	*1.5*	U	81.8		49.3	I	40.1	I	*5*	U	*5*	U	*5*	U
6/11/2003	**B**	22.9		30.9		13.2		3.2	I	*1.5*	U	*1.5*	U	33.5	I	68.1		85.7		*5*	U	*5*	U	*5*	U
6/16/2003	**B**	16.7	J	14.9	J	4.7	J	6.6	I	6.5	I	*1.5*	U	37.9	I	37.6	I	67.8		*5*	U	*5*	U	*5*	U
7/7/2003	**B**	4.6	I	5.9	I	3.5	I	5.3	I	5.3	I	*1.5*	U	81.3		69.1		63.7		*5*	U	*5*	U	*5*	U
7/15/2003	**B**	13.3		18.7		8.5		*1.5*	U	*1.5*	U	*1.5*	U	111.0		60.1		67.9		*5*	U	*5*	U	*5*	U
7/18/2003	**B**	7.4		8.4		6.2	I	*1.5*	U	3.4	I	*1.5*	U	82.7		80.1		52.7		*5*	U	*5*	U	*5*	U
7/23/2003	**B**	14.2		18.4		4.1	I	87.9		34.8		*1.5*	U	83.5		76.9		50.4		*5*	U	*5*	U	*5*	U
7/30/2003	**B**	9.7		10.4		7.1		19.5		36.8		9.2	I	85.2		83.5		161.0		*5*	U	*5*	U	*5*	U
8/13/2003	**B**	10.8		12.2		8.8		3.9	I	3.9	I	*1.5*	U	135.0		126.0		74.7		*5*	U	*5*	U	*5*	U
8/29/2003	**B**	3.6	I	3.9	I	*1.0*	U	*1.5*	U	*1.5*	U	*1.5*	U	98.0		81.4		45.5		*5*	U	*5*	U	*5*	U
9/5/2003	**B**	10.8		11.1		9.6		4.9	I	5.1	I	*1.5*	U	102.0		85.2		50.1		*5*	U	*5*	U	*5*	U
9/10/2003	**B**	5.8	I	7.3		3.1	I	*1.5*	U	3.1	I	*1.5*	U	77.0		57.1		30.0	I	*5*	U	*5*	U	*5*	U
9/17/2003	**B**	8.2		11.2		3.0	I	*1.5*	U	*1.5*	IJ	*1.5*	U	81.1		78.4		54.0		*5*	U	*5*	U	*5*	U
9/19/2003	**B**	4.8	I	5.0	I	4.1	I	*5.1*	IJ	*1.5*	U	*1.5*	U	57.9		50.7		60.8		*5*	U	*5*	U	*5*	U
10/3/2003	**B**	10.8		16.4		7.6		*1.5*	U	*1.5*	U	*1.5*	U	87.4		109.0		41.4		*5*	U	*5*	U	*5*	U
10/6/2003	**B**	5.8		9.9		5.8	I	*1.5*	U	*1.5*	U	*1.5*	U	42.0		51.3		32.6	I	*5*	U	*5*	U	*5*	U
2/6/2003	**B****	3.6	I	8.2		*1.0*	U	13.2		19.6		23.2		38.8	I	22.3	I	24.5	I	*0.2*	U	*0.2*	U	*0.2*	U
# Samples		40		40		37		40		40		37		40		40		37		40		40		37	
Mean		8.7		10.8		6.6		8.3		7.3		3.4		74.5		82.3		57.0		4.3		4.3		4.4	
Median		7.0		8.3		6.2		4.0		3.9		1.5		80.6		72.1		50.1		5.0		5.0		5.0	
St. Dev.		6.2		8.3		4.4		15.9		10.2		6.2		29.3		48.6		26.3		1.7		1.6		1.6	
Max		22.9		39.3		16.6		87.9		43.9		31.6		135.0		272.0		161.0		5.0		5.0		5.0	
Min		0.0		1.0		1.0		1.5		1.5		0.9		20.0		22.3		24.5		0.2		0.2		0.2	
C.V.		0.72		0.77		0.67		1.91		1.40		1.81		0.39		0.59		0.46		0.39		0.38		0.35	

Table E-7. Summary statistics for storm flow for year two. Efficiency is shown as percentages of concentrations. A positive number=percent removal; a negative number=percent increase.

YEAR TWO	Ammonia				Nitrate + Nitrite				Organic Nitrogen				Total Nitrogen			
STORM	mg/L as Nitrogen				mg/L as Nitrogen				mg/L as Nitrogen							
FLOW	556	934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
	RAIN	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**
# Samples	40	45	45	45	40	45	45	45	40	45	45	45	40	45	45	45
Mean	0.147	0.051	0.057	0.088	0.327	0.425	0.427	0.321	0.093	0.687	0.735	0.833	0.567	1.164	1.218	1.242
Median	0.134	0.029	0.030	0.082	0.316	0.340	0.348	0.282	0.047	0.616	0.606	0.736	0.540	1.040	1.030	1.220
St. Dev.	0.095	0.078	0.111	0.063	0.219	0.334	0.285	0.178	0.329	0.553	0.521	0.594	0.417	0.647	0.645	0.640
Max	0.344	0.415	0.738	0.309	0.985	1.440	1.310	0.790	2.040	2.809	3.137	3.862	2.258	4.300	4.320	4.530
Min	0.008	0.003	0.003	0.010	0.018	0.023	0.048	0.022	-0.364	-0.759	-0.069	-0.259	0.005	0.124	0.590	0.379
C.V.	0.647	1.527	1.946	0.713	0.670	0.786	0.668	0.554	3.552	0.805	0.709	0.713	0.737	0.556	0.529	0.515
EFF% (MEAN)			-11%	-55%			0%	25%			-7%	-13%			-5%	-2%
EFF% (MEDIAN)			-3%	-173%			-2%	19%			2%	-21%			1%	-18%

	Ortho-Phosphorus				Total Phosphorus				TSS				Magnesium			
	mg/l				mg/l				mg/l				mg/l			
	Lab Detection Limit 0.01 mg/l				Lab Detection Limit 0.01 mg/l				Lab D. L. 0.05							
	556	934	935	939	556	934	935	939		934	935	939		934	935	939
	RAIN	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**		**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**		**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**
storms																
# Samples	40	45	45	45	40	45	45	45		45	45	45		45	45	45
Mean	0.008	0.061	0.071	0.038	0.008	0.128	0.141	0.112		13.90	14.56	14.05		5.04	2.04	1.69
Median	0.005	0.039	0.037	0.036	0.005	0.097	0.097	0.101		13.50	12.30	10.80		4.83	1.63	1.32
St. Dev.	0.005	0.132	0.195	0.021	0.005	0.146	0.211	0.050		7.14	8.98	9.98		1.73	1.61	1.17
Max	0.021	0.914	1.340	0.107	0.020	1.040	1.480	0.255		28.60	34.30	41.30		7.75	7.30	5.17
Min	0.005	0.005	0.002	0.005	0.005	0.051	0.054	0.002		0.30	2.11	1.29		2.64	0.41	0.47
C.V.	0.568	2.157	2.752	0.562	0.642	1.144	1.500	0.449		0.51	0.62	0.71		0.34	0.79	0.69
EFF% (MEAN)			-16%	46%			-10%	21%			-5%	3%			60%	17%
EFF% (MEDIAN)			5%	3%			0%	-4%			9%	12%			66%	19%

	Aluminum				Copper				Iron				Zinc			
	ug/L				ug/L				ug/L				ug/L			
					Lab Detection Limit 3.0				Lab Detection Limit 50.0				Lab Detection Limit 30			
		934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
		BEFORE CDS	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**	**RAIN**	**BEFORE CDS**	**AFTER CDS**	**OUTFLOW**
# Samples		45	45	45	40	45	45	45	40	45	45	45	40	45	45	45
Mean		211	221	434	1.86	7.50	7.27	4.98	50	204	217	282	8	39	41	27
Median		171	181	299	1.50	5.54	5.37	3.68	39	173	183	224	8	33	37	22
St. Dev.		123	136	397	1.06	6.43	5.64	4.73	68	93	100	223	3	20	22	15
Max		481	610	2000	6.89	34.20	32.00	28.70	437	422	463	1250	16	128	141	83
Min		44	41	107	1.50	1.50	3.34	1.50	6	60	66	34	2	11	14	10
C.V.		0.58	0.62	0.92	0.57	0.86	0.78	0.95	1.36	0.46	0.46	0.79	0.41	0.51	0.53	0.54
EFF% (MEAN)			-5%	-96%			3%	32%			-6%	-30%			-5%	34%
EFF% (MEDIAN)			-6%	-65%			3%	31%			-6%	-22%			-11%	40%

Table E-8. Summary statistics for base flow for year two. Efficiency is shown as percentages of concentrations.

YEAR TWO	Ammonia				Nitrate + Nitrite				Organic Nitrogen				Total Nitrogen			
BASE	mg/L as Nitrogen				mg/L as Nitrogen				mg/L as Nitrogen							
FLOW	556	934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
# Samples		18	18	18		18	18	18		18	18	17		18	18	17
Mean		0.056	0.061	0.095		0.831	1.105	0.231		1.142	0.466	0.853		2.029	1.631	1.192
Median		0.047	0.041	0.070		0.563	0.519	0.127		0.846	0.705	0.764		1.505	1.380	1.210
St. Dev.		0.054	0.055	0.109		0.742	1.931	0.260		0.990	1.514	0.677		1.224	0.773	0.713
Max		0.203	0.217	0.459		2.510	8.550	0.993		4.667	1.942	2.230		5.380	3.300	2.740
Min		0.003	0.010	0.008		0.001	0.218	0.001		0.424	-5.368	-0.215		0.950	0.782	0.001
C.V.		0.964	0.905	1.151		0.892	1.748	1.129		0.867	3.251	0.794		0.603	0.474	0.598
EFF% (MEAN)			-8%	-55%			-33%	79%			59%	-83%			20%	27%
EFF% (MEDIAN)			13%	-70%			8%	76%			17%	-8%			8%	12%

	Ortho-Phosphorus				Total Phosphorus				TSS				Magnesium			
	mg/l				mg/l				mg/L				mg/L			
	Lab Detection Limit 0.01 mg/l				Lab Detection Limit 0.01 mg/l				Lab D. L. 0.05							
	556	934	935	939	556	934	935	939		934	935	939		934	935	939
	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW		BEFORE CDS	AFTER CDS	OUTFLOW		BEFORE CDS	AFTER CDS	OUTFLOW
# Samples		18	18	18		18	18	18		17	17	18		10	10	10
Mean		0.038	0.036	0.041		0.093	0.088	0.126		7.7	7.3	12.8		6.58	6.97	3.68
Median		0.036	0.035	0.036		0.093	0.089	0.125		7.7	5.0	9.1		7.51	7.63	2.82
St. Dev.		0.030	0.026	0.032		0.030	0.034	0.058		5.7	6.7	10.9		7.51	7.63	2.82
Max		0.088	0.080	0.107		0.138	0.177	0.236		22.4	29.7	53.2		9.43	9.81	7.12
Min		0.000	0.000	0.000		0.045	0.032	0.041		2.1	1.7	3.5		3.06	3.23	1.09
C.V.		0.812	0.714	0.775		0.318	0.383	0.461		0.7	0.9	0.9		1.14	1.09	0.76
EFF% (MEAN)			3%	-13%			5%	-42%			5%	-76%			-6%	47%
EFF% (MEDIAN)			1%	-1%			4%	-40%			35%	-83%			-2%	63%

	Aluminum				Copper				Iron				Zinc			
					ug/L				ug/L				ug/L			
					Lab Detection Limit 3.0				Lab Detection Limit 50.0				Lab Detection Limit 30			
		934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
		BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
# Samples		18	18	18		18	18	18		18	18	18		18	18	18
Mean		246.4	127.1	383.6		10.3	9.2	5.6		184.2	187.7	287.4		21.4	25.2	18.7
Median		70.3	28.6	313.0		11.8	8.7	4.6		160.0	108.0	221.0		16.3	14.6	16.6
St. Dev.		750.5	49.3	532.0		7.7	5.8	8.6		44.7	39.1	232.8		9.7	8.6	10.1
Max		2550.0	179.0	2020.0		25.4	23.5	31.9		221.0	186.0	981.0		45.4	40.9	43.3
Min		10.0	10.0	92.0		1.5	3.3	1.5		97.6	78.7	159.0		10.1	10.5	7.2
C.V.		3.0	0.4	1.4		0.7	0.6	1.6		0.2	0.2	0.8		0.5	0.3	0.5
			48%	-202%			11%	40%			-2%	-53%			-18%	26%
			59%	-994%			26%	47%			33%	-105%			10%	-14%

WATER QUALITY SAMPLES FOR STORM EVENTS FOR YEAR TWO

Date Sample Collected	Storm Event	#	Ammonia								Nitrate + Nitrite								Organic Nitrogen								Total Nitrogen							
			mg/L as Nitrogen																															
			556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
			RAIN		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**	
11/7/2003	E	**1**	0.157	D	0.1010	D	0.0950	D	0.0430	D	0.258		0.381		0.309		0.085		0.084		0.558		0.606		1.142		0.50	N	1.04	N	1.01	N	1.27	N
11/19/2003	E	**2**	0.063	D	0.0340	D	0.0490		0.0360		0.084		0.350		0.343		0.022		0.046		0.646		0.608		1.292		0.19	N	1.03	N	1		1.35	
12/15/2003	E	**3**	0.011	ID	0.0060	ID	0.0090	ID	0.0230	D	0.018		0.234		0.281		0.088		0.053		0.800		0.482		0.724		0.08	IN	1.04	N	0.772	N	0.835	N
1/12/2004	E	**4**	0.097	D	0.0060	ID	0.0060	ID	0.1250	D	0.219		0.606		0.658		0.133		-0.039		0.518		0.466		1.402		0.28	N	1.13	N	1.13	N	1.66	N
1/19/2004	E	**5**	0.130	D	0.0050	I,D	0.0250	D	0.1630	D	0.088		0.806		0.583		0.296		2.040		0.380		0.450		0.793		2.26	N	1.191	N	1.058	N	1.252	N
1/20/2004	E	**6**	0.188	D	0.0190	D	0.0170	D	0.0730	D	0.235		0.235		0.146		0.182		0.080		1.126		1.007		0.536		0.50	N	1.38	N	1.17	N	0.791	N
1/31/2004	E	**7**	0.018	D	0.0230	D	0.0170	D	0.0280	D	0.097		0.403		0.428		0.137		0.052		0.624		0.615		0.709		0.17	N	1.05	N	1.06	N	0.874	N
2/2/2004	E	**8**	0.077	D	0.0210	D	0.0150	ID	0.0210	D	0.120		0.238		0.248		0.161		0.029		0.455		0.461		0.571		0.23		0.714	N	0.724	N	0.753	N
4/13/2004	E	**9**	N/A		0.0214	D	0.0164	D	0.0100	ID	N/A		0.295		0.272		0.049		N/A		1.344		1.312		0.320		N/A		1.66	N	1.6	N	0.379	N
6/11/2004	E	**11**	0.234	D	0.0120	ID	0.0290	D	0.1540	D	0.404		0.061		0.121		0.422		-0.018		1.727		1.660		0.964		0.62	N	1.8	N	1.81	N	1.54	N
6/14/2004	E	**12**	0.177	D	0.0120	ID	0.0490	D	0.0760	D	0.271		0.023		0.048		0.248		0.012		1.885		1.843		0.646		0.46	N	1.92	N	1.94	N	0.97	N
6/15/2004	E	**13**	0.208	D	0.0710	D	0.0770	D	0.1200	D	0.333		0.334		0.259		0.259		-0.011		0.765		1.244		1.021		0.53	N	1.17	N	1.58	N	1.4	N
6/16/2004	E	**14**	N/A		0.0110	I,D	0.0130	I,D	0.1380	D	N/A		0.123		0.085		0.206		N/A		1.196		0.932		1.366		N/A		1.33	N	1.03	N	1.71	N
6/22/2004	E	**15**	N/A		0.4150	D	0.7380	D	0.0880	D	N/A		0.762		0.517		0.1		N/A		1.183		1.195		1.182		N/A		2.36	N	2.45	N	1.37	N
6/25/2004	E	**16**	0.211	D	0.0400	D	0.1240	D	0.1260	D	0.313		0.276		0.298		0.414		0.076		1.284		1.258		1.260		0.60	N	1.6	N	1.68	N	1.8	N
6/27/2004	E	**17**	0.124	D	0.0340	D	0.0670	D	0.0650	D	0.343		0.393		0.334		0.383		0.073		1.183		0.839		1.052		0.54	N	1.61	N	1.24	N	1.5	N
6/28/2004	E	**18**	0.266	D	0.0630	D	0.0640	D	0.1090	D	0.656		0.527		0.523		0.501		0.058		0.640		0.703		0.450		0.98	N	1.23	N	1.29	N	1.06	N
6/29/2004	E	**19**	0.173	D	0.0340	D	0.0360	D	0.0450	D	0.317		0.429		0.460		0.41		0.200		0.787		0.724		0.565		0.69	N	1.25	N	1.22	N	1.02	N
6/30/2004	E	**20**	0.195	D	0.0220	D	0.0080	I,D	0.0290	D	0.355		0.430		0.412		0.328		0.110		0.558		0.600		0.713		0.66	N	1.01	N	1.02	N	1.07	N
7/3/2004	E	**21**	0.222	D	0.0830	D	0.0690	D	0.0150	I,D	0.619		0.677		0.682		*0.369*		0.129		0.710		0.679		1.166		0.97	N	1.47	N	1.43	N	1.55	N
7/6/2004	E	**22**	0.170	D	0.0490	D	0.0860	D	0.0560	D	0.691		0.840		0.637		0.386		0.129		0.631		0.547		0.858		0.99	N	1.52	N	1.27	N	1.3	N
7/13/2004	E	**23**	0.342	D	0.0890	U	0.0860	D	0.1100	D	0.721		0.794		0.843		*0.79*		0.157		-0.759		-0.069		0.970		1.22		0.124		0.86	NJ	1.87	N
7/16/2004	E	**24**	0.128	D	0.0820	D	0.0360	D	0.0290	D	0.416		0.385		0.478		*0.219*		0.296		0.923		0.796		1.212		0.84		1.39	N	1.31	N	1.46	N
7/18/2004	E	**25**	0.111	D	0.0120	QID	0.0060	QID	0.1100	QD	0.258	U	0.280	Q	0.280	Q	*0.28*	Q	-0.364		0.638		0.714		0.430		0.01	U	0.93	N	1	N	0.82	N
7/19/2004	E	**26**	0.066	QD	0.0170	QD	0.0190	QD	0.1000	QD	0.120		0.160		0.150		*0.28*		0.034		0.433		0.471		0.170		0.22	N	0.61	N	0.64	QN	0.55	QN
7/20/2004	E	**27**	0.068	D	0.0190	D	0.0170	D	0.0930	D	0.130		0.180		0.180		*0.2*		0.022		0.401		0.413		0.117		0.22	QN	0.6	QN	0.61	QN	0.41	QN
7/21/2004	E	**28**	N/A		0.0590	D	0.0570	D	0.0850	D	N/A		1.090		1.110		*0.19*		N/A		0.461		0.413		0.325		N/A		1.61	QN	1.58	QN	0.6	QN
7/27/2004	E	**29**	0.344	D	0.1330	D	0.1300	D	0.0440	D	0.482		0.365		0.408		*0.379*		-0.006		0.422		0.352		1.277		0.82	J	0.92	N	0.89	N	1.7	N
8/2/2004	E	**30**	0.056	D	0.0025	D	0.0025	D	0.0820	D	0.556		0.340		0.466		0.321		-0.022		0.388		0.372		0.637		0.59	J	0.73	N	0.84	N	1.04	N
8/4/2004	E	**31**	0.095	D	0.0240	D	0.0150	ID	0.0900	D	0.327		0.231		0.354		0.188		0.038		0.685		0.571		0.672		0.46	N	0.94	N	0.94	N	0.95	N
8/7/2004	E	**32**	0.330	D	0.0940	D	0.1110	D	0.0720	D	0.314		0.322		0.348		0.282		0.056		0.584		0.661		1.426		0.70	N	1	N	1.12	N	1.78	N
8/8/2004	E	**33**	0.258	D	0.0290	D	0.0300	D	0.1720	D	0.180		0.179		0.254		0.231		0.092		0.682		0.846		0.467		0.53	N	0.89	N	1.13	N	0.87	N
8/10/2004	E	**34**	0.179	D	0.0440	D	0.0320	D	0.0590	D	0.379		0.250		0.275		0.434		0.072		0.616		0.583		0.467		0.63	N	0.91	N	0.89	N	0.96	N
8/16/2004	E	**35**	0.023	D	0.0025	UD	0.0060	ID	0.1580	D	0.139		0.123		0.311		0.275		0.048		0.445		0.543		0.757		0.21	N	0.57	N	0.86	N	1.19	N
8/19/2004	E	**36**	0.281	JD	0.0640	JD	0.0590	JD	0.0850	JD	0.985		1.357		1.030	J	0.764		0.024		0.039		1.031		-0.259		1.29	JQN	1.46	JN	2.12	JQN	0.59	JN
8/22/2004	E	**37**	0.119	JD	0.0490	JD	0.1460	JD	0.1100	JD	0.441	J	1.440	J	1.310	J	0.451	J	-0.020		-0.049		0.704		0.949		0.54	JQN	1.44	JN	2.16	JQN	1.51	JQN
8/23/2004	E	**38**	0.172	JD	0.0080	JID	0.0080	JID	0.0280	JD	0.630	J	0.565	J	0.674	J	0.663	J	-0.012		-0.013		-0.012		0.539		0.79	JQN	0.56	JN	0.67	JN	1.23	JQN
8/25/2004	E	**39**	0.077	JD	0.0070	JID	0.0080	JID	0.1210	JD	0.419	J	0.260	J	0.361	J	0.662	J	0.054		0.323		0.381		0.617		0.55	JN	0.59	JN	0.75	JN	1.4	JN
8/26/2004	E	**40**	0.250	D	0.0320	D	0.0300	D	0.1060	D	0.408		0.406		0.439		0.295		0.022		0.422		0.481		0.439		0.68	N	0.86	N	0.95	N	0.84	QN
9/1/2004	E	**41**	0.138	YQD	0.0300	YQD	0.0070	YQID	0.0700	YQD	0.452	YQ	0.360	YQ	0.455	YQ	0.268	YQ	0.010		0.390		0.418		0.742		0.60	YQN	0.78	YQN	0.88	YQN	1.08	YQN
9/8/2004	E	**42**	0.031	YD	0.0530	YD	0.0200	YD	0.0490	YD	0.037	YQ	0.077	YQ	0.091	Y	0.435	YQ	0.022		0.560		0.609		0.736		0.09	YIN	0.69	YN	0.72	YN	1.22	YN
9/9/2004	E	**43**	0.036	YD	0.0180	YD	0.0025	UYD	0.0370	YD	0.098	Y	0.152	Y	0.218	Y.	0.528	Y	0.036		0.450		0.370		0.745		0.17	YN	0.62	YN	0.59		1.31	YN
9/10/2004	E	**44**	0.029	YD	0.0025	UYD	0.0025	UYD	0.0220	YD	0.140	Y	0.174	Y	0.234	Y	0.24	Y	-0.019		0.414		0.544		0.388		0.15	YN	0.59	YN	0.78	YN	0.65	YN
9/28/2004	E	**45**	0.008	ID	0.0050	ID	0.0340	D	0.2840	D	0.040		0.076		0.201		0.511		0.062		0.669		0.495		1.065		0.11	N	0.75	N	0.73	N	1.86	N
# Samples			40		44		44		44		40		44		44		44		40		44		44		44		40		44		44		44	
Mean			0.147		0.0445		0.0562		0.0832		0.327		0.409		0.412		0.32		0.093		0.639		0.680		0.764		0.567		1.092		1.148		1.167	
Median			0.134		0.0265		0.0295		0.0790		0.316		0.337		0.346		0.281		0.047		0.600		0.603		0.730		0.540		1.035		1.025		1.205	
St. Dev.			0.095		0.0651		0.1118		0.0537		0.219		0.319		0.269		0.18		0.329		0.454		0.375		0.378		0.417		0.441		0.444		0.402	
Max			0.344		0.4150		0.7380		0.2840		0.985		1.440		1.310		0.79		2.040		1.885		1.843		1.426		2.258		2.360		2.450		1.870	
Min			0.008		0.0025		0.0025		0.0100		0.018		0.023		0.048		0.022		-0.364		-0.759		-0.069		-0.259		0.005		0.124		0.590		0.379	
C.V.			0.65		1.4619		1.9877		0.6453		0.67		0.78		0.65		0.562		3.552		0.711		0.551		0.494		0.737		0.404		0.387		0.344	

WATER QUALITY BASE FLOW YEAR TWO

Date Sample Collected	Base Flow	#	Ammonia								Nitrate + Nitrite							
			mg/L as Nitrogen															
			556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
			RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW	
11/10/2003	B	1			0.0080	ID	0.0340	D	0.1680	D			0.705		0.375		0.083	
12/3/2003	B	2			0.0650	D	0.1250	D	0.0720	D			0.531		0.576		*0.001*	U
12/11/2003	B	3			0.0550	D	0.0240	D	0.2000	D			0.868		0.703		*0.001*	U
12/18/2003	B	4			0.0120	ID	0.0170	D	0.0100	ID			0.486		0.358		0.019	
12/22/2003	B	5			*0.0025*	ID	0.0150	D	0.0250	UD			*0.0013*		0.688		0.628	U
1/22/2004	B	6			0.0230	D	0.0380	D	0.1430	D			0.125		0.295		0.154	
1/29/2004	B	7			0.0080	I,D	0.0170	D	0.0740	D			0.198		0.218		0.196	
3/19/2004	B	8			0.0050	I,D	0.0100	I,D	0.0600	D			0.276		0.279		*0.099*	
4/2/2004	B	9			0.0680	D	0.1550	D	0.0090	I,D			0.497		0.381		*0.053*	
4/27/2004	B	10			0.0410	D	0.0440	D	0.0080	I,D			0.947		0.882		*0.053*	
5/20/2004	B	11			0.0480	D	0.0640	D	0.0150	I,D			0.642		0.438		0.093	
6/5/2004	B	12			0.3410	D	0.0830	D	0.3090	D			1.150		1.100		0.359	
7/1/2004	B	13			0.0510	D	0.0620	D	0.0080	I,D			0.527		0.491		0.058	
7/7/2004	B	14			0.0390	D	0.2170	D	0.0690	D			0.595		0.834		*0.227*	
7/30/2004	B	15			0.1640	D	0.0850	D	0.0700	D			0.448		0.533		*0.476*	
9/23/2004	B	16			0.0680	YD	0.0380	YD	0.0480	YD			2.490	Y	8.550	N	*0.993*	Y
10/15/2004	B	17			0.1050	D	0.0470	D	0.1100	D			1.830		0.504		*0.4*	
# Samples					17		17		17				17		17		17	
Mean					0.0649		0.0632		0.0822				0.724		1.012		0.229	
Median					0.0480		0.0440		0.0690				0.531		0.504		0.099	
St. Dev.					0.0822		0.0562		0.0824				0.624		1.957		0.268	
Max					0.3410		0.2170		0.3090				2.490		8.550		0.993	
Min					0.0025		0.0100		0.0080				0.001		0.218		0.001	
C.V.					1.2657		0.8883		1.0022				0.86		1.93		1.172	

Date Sample Collected	Base Flow	#	Organic Nitrogen								Total Nitrogen							
			556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
			RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW	
11/10/2003	B	1			4.667		0.373		-0.215				5.38	N	0.782	N	0.036	N
12/3/2003	B	2			0.424		0.389		-0.072				1.02	N	1.09	N	*0.001*	N
12/11/2003	B	3			1.247		0.413		1.859				2.17	N	1.14	N	2.06	N
12/18/2003	B	4			0.702		1.025		0.730				1.2	N	1.4	N	0.759	N
12/22/2003	B	5			0.946		0.407		0.447				0.95	N	1.11	N	1.1	N
1/22/2004	B	6			1.432		0.837		0.675				1.58	N	1.17	N	0.972	N
1/29/2004	B	7			1.114		0.965		0.376				1.32	N	1.2	N	0.646	N
3/19/2004	B	8			1.229		1.071		0.367				1.51	N	1.36	N	0.526	N
4/2/2004	B	9			0.745		1.044		1.238				1.31	N	1.58	N	1.3	N
4/27/2004	B	10			0.512		0.604		0.919				1.5	N	1.53	N	0.98	N
5/20/2004	B	11			0.430		0.488		1.552				1.12	N	0.99	N	1.66	N
6/5/2004	B	12			2.809		3.137		3.862				4.3	N	4.32	N	4.53	N
7/1/2004	B	13			0.502		0.607		1.594				1.08	N	1.16	N	1.66	N
7/7/2004	B	14			0.726		0.829		0.914				1.36		1.88		1.21	N
7/30/2004	B	15			1.028		0.802		0.764				1.64	N	1.42	N	1.31	N
9/23/2004	B	16			0.642		-5.368		0.999				3.2	YN	3.22	YN	2.04	YN
10/15/2004	B	17			1.885		1.479		2.230				3.82	N	2.03	N	2.74	N
# Samples					17		17		17				17		17		17	
Mean					1.238		0.535		1.073				2.027		1.611		1.384	
Median					0.946		0.802		0.914				1.500		1.360		1.210	
St. Dev.					1.071		1.655		0.969				1.322		0.891		1.079	
Max					4.667		3.137		3.862				5.380		4.320		4.530	
Min					0.424		-5.368		-0.215				0.950		0.782		0.001	
C.V.					0.87		3.09		0.90				0.65		0.55		0.78	

STORM FLOW FOR YEAR TWO

			Ortho-Phosphorus								Total Phosphorus								TSS					
			MG/L Lab Detection Limit 0.01								MG/L Lab Detection Limit 0.01								ug/L Lab D. L. 0.05					
Date Sample Collected	Event	#	556 RAIN	D Q	934 BEFORE CDS	D Q	935 AFTER CDS	D Q	939 OUTFLOW	D Q	556 RAIN	D Q	934 BEFORE CDS	D Q	935 AFTER CDS	D Q	939 OUTFLOW	D Q	934 BEFORE CDS	D Q	935 AFTER CDS	D Q	939 OUTFLOW	D Q
11/7/2003	E	1	0.0110	I	0.046		0.041		0.020	I	*0.005*	U	0.119		0.127		0.002		25.7		19.3		27.5	
11/19/2003	E	2	*0.0050*	U	0.044		0.040		0.005		*0.005*	U	0.095		0.097		0.083		14.7		17.1		16.8	
12/15/2003	E	3	*0.0050*	U	*0.005*	U	*0.005*	I	0.015	I	*0.005*	U	0.075		0.067		0.154		15.8	J	7.5	J	25.7	J
1/12/2004	E	4	*0.0050*	U	0.018	I	0.025	I	0.029	I	*0.005*	U	0.075		0.088		0.108		10.7		10.8		27.6	
1/19/2004	E	5	*0.0050*	U	0.046		0.037		0.058		*0.005*	U	0.084		0.093		0.178		9.9		8.9		28.5	
1/20/2004	E	6	*0.0050*	U	*0.005*	U	*0.005*	U	0.050		*0.005*	U	0.156		0.145		0.107		12.4		11.8		11.1	
1/31/2004	E	7	*0.0050*	U	0.024	I	0.028	I	0.020	I	*0.005*	U	0.078		0.061		0.080		4.5		5.0		9.1	
2/2/2004	E	8	*0.0050*	U	*0.005*	U	0.021	I	0.025	I	*0.005*	U	0.076		0.064		0.089		5.4		7.2		7.7	
4/13/2004	E	9			*0.006*		0.002		0.052				0.121		0.150		0.085		18.7		18.4		4.7	
6/11/2004	E	11	*0.0160*	I	*0.072*		0.062		0.077		0.020	QI	0.230	Q	0.230	Q	0.200	Q	15.8		13.6		18.9	
6/14/2004	E	12	*0.0141*	I	*0.032*		0.037		0.046		*0.020*	QI	0.160	Q	0.220	Q	0.120	Q	19.3		12.9		6.4	
6/15/2004	E	13	*0.0120*	I	*0.052*		0.061		0.064		*0.005*	U	0.130		0.130		0.150		9.5		6.9		18.1	
6/16/2004	E	14			*0.026*	I	0.027	I	0.089				0.110		0.100		0.200		8.5		7.0		31.0	
6/22/2004	E	15			*0.914*		1.340		0.040				1.040		1.480		0.180		14.6		13.9		13.9	
6/25/2004	E	16	*0.0169*	I	*0.085*		0.105		0.107		*0.010*	I	0.210		0.190		0.200		11.8		11.1		41.3	
6/27/2004	E	17	*0.0120*	I	*0.056*		0.058		0.059		*0.017*	I	0.171	J	0.155	J	0.255	J	11.3	J	7.1	J	37.6	J
6/28/2004	E	18	*0.0140*	I	*0.053*		0.054		0.046		*0.012*	I	0.115	J	0.092	J	0.078	J	9.6	J	6.4	J	6.0	J
6/29/2004	E	19	*0.0210*	I	*0.045*		0.047		0.048		*0.017*	I	0.093	J	0.084	J	0.077	J	6.0	J	5.7	J	6.5	J
6/30/2004	E	20	*0.0170*	I	0.030	I	0.052		0.043		*0.016*	I	0.084	J	0.098	J	0.107	J	4.9	J	6.3	J	8.8	J
7/3/2004	E	21	*0.0050*	U	0.061		0.072		0.045		0.018	I	0.102		0.104		0.114		3.29		3.37		7.68	
7/6/2004	E	22	*0.0050*	U	0.050		0.068		0.031	I	*0.005*	U	0.101		0.100		0.130		8.6		2.1		11.4	
7/13/2004	E	23	0.0120	I	0.085		0.089		0.046		*0.005*	U	0.124		0.138		0.138		0.30		8.85		8.81	
7/16/2004	E	24	*0.0050*	U	0.053		0.045		0.011	I	*0.005*	U	0.142		0.136		0.131		19.90		23.20		12.00	
7/18/2004	E	25	0.0050	U	0.038		0.037		0.028	I	0.005	U	0.073		0.074		0.067		5.04		6.36		5.56	
7/19/2004	E	26	0.0050	U	0.033		0.033		0.033		0.005	U	0.069		0.067		0.058		8.41		8.28		5.14	
7/20/2004	E	27	0.0050	U	0.039		0.036		0.034		0.005	UQ	0.051	Q	0.054	Q	0.048	Q	6.64		9.62		4.29	
7/21/2004	E	28			0.063		0.066		0.050				0.081	Q	0.089	Q	0.071	Q	3.52		3.70		4.86	
7/27/2004	E	29	0.0120	I	0.070		0.066		0.023	I	0.012	I	0.141		0.102		0.117		13.10		5.62		36.20	
8/2/2004	E	30	*0.0050*	U	0.031	I	0.013	I	0.013	I	*0.005*	NJ	0.054	QJ	0.061	QJ	0.066	QJ	13.5	J	11.3	J	1.3	IJ
8/4/2004	E	31	*0.0050*	U	0.028	I	0.017	I	0.015	I	*0.005*	U	0.092		0.090		0.078		23.3		28.30		5.9	
8/7/2004	E	32	*0.0050*	U	0.024	I	0.018	I	0.023	I	*0.005*	U	0.082		0.098		0.081		28.6		30.6		16.4	
8/8/2004	E	33	*0.0050*	U	0.020	I	0.037		0.058		*0.005*	U	0.083		0.085		0.095		25.9		28.4		7.2	
8/10/2004	E	34	*0.0050*	U	0.037		0.029	I	0.027	I	*0.005*	U	0.097		0.086		0.087		25.3		33.6		16.3	
8/16/2004	E	35	*0.0050*	U	0.026	I	0.025	I	0.023	I	*0.005*	U	0.056		0.072		0.097		11.7		15.8		8.0	
8/19/2004	E	36	*0.0050*	U	0.042		0.024	I	0.046		*0.005*	UJ	0.129	J	0.124	J	0.173	J	19.7		31.5		17.7	
8/22/2004	E	37	*0.0050*	U	0.047		0.060		0.015	I	*0.005*	UJ	0.100	J	0.144	J	0.076	J	15.3		25.6		10.8	
8/23/2004	E	38	*0.0050*	U	0.036		0.032	I	0.018	I	*0.005*	UJ	0.086	J	0.084	J	0.078	J	20.7		22.1		9.7	
8/25/2004	E	39	*0.0050*	U	0.033		0.029	I	0.016	I	*0.005*	UJ	0.064	J	0.069	J	0.058	J	13.9	J	12.9		7.6	
8/26/2004	E	40	*0.0050*	U	0.039		0.033		0.036		*0.005*	U	0.085		0.097		0.110		20.3		34.3		11.8	
9/1/2004	E	41	0.0120	QI	0.038		0.028	I	0.048		0.011	YQ	0.058	YQ	0.055	YQ	0.101	YC	11.1	Y	12.3	Y	11.5	Y
9/8/2004	E	42	0.0120	YI	0.037	Y	0.038	Y	0.057	Y	*0.005*	JYC	0.085	Y	0.095	Y	0.092	YC	21.4		20.4	Y	4.1	Y
9/9/2004	E	43	0.0130	YI	0.053	Y	0.053	Y	0.046	Y	*0.005*	JYC	0.097	Y	0.082	Y	0.105	Y	18.4	Y	13.0	Y	10.6	Y
9/10/2004	E	44	*0.0050*	UY	0.068	Y	0.051	Y	0.047	Y	*0.0050*	JYC	0.105	Y	0.128	Y	0.102	Y	28.3	Y	25.9	Y	9.6	Y
9/28/2004	E	45	*0.0050*	U	0.024	I	0.030	I	0.032	I	*0.0050*	U	0.102		0.081		0.092		14.1		24.2		12.0	
# Samples			40		44		44		44		40		44		44		44		44		44		44	
Mean			0.0081		0.060		0.070		0.039		0.008		0.125		0.136		0.110		13.8		14.5		13.7	
Median			0.0050		0.039		0.037		0.038		0.005		0.096		0.096		0.099		13.3		12.1		10.7	
St. Dev.			0.0046		0.133		0.197		0.021		0.005		0.146		0.211		0.048		7.2		9.1		9.8	
Max			0.0210		0.914		1.340		0.107		0.020		1.040		1.480		0.255		28.6		34.3		41.3	
Min			0.0050		0.005		0.002		0.005		0.005		0.051		0.054		0.002		0.3		2.1		1.3	
C.V.			0.5677		2.22		2.82		0.54		0.64		1.17		1.55		0.44		0.52		0.63		0.72	

BASE FLOW FOR YEAR TWO

Date			Ortho-Phosphorus								Total Phosphorus								TSS					
sample	base	#	MG/L								MG/L								ug/L					
collected	flow		556 RAIN	DQ	934 BEFORE CDS	DQ	935 AFTER CDS	DQ	939 OUTFLOW	DQ	556 RAIN	DQ	934 BEFORE CDS	DQ	935 AFTER CDS	DQ	939 OUTFLOW	DQ	934 BEFORE CDS	DQ	935 AFTER CDS	DQ	939 OUTFLOW	DQ
11/10/2003	**B**	**1**			0.023	I	0.024	I	0.086				0.045		0.054		0.144		2.12		1.96		8.26	
12/3/2003	**B**	**2**			0.046		0.028	I	0.012	I			0.082		0.062		0.041		7.66	J	3.87	J	16.80	J
12/11/2003	**B**	**3**			0.019	I	0.032		0.005	U			0.119		0.032		0.236		13.10		1.72	I	53.20	
12/18/2003	**B**	**4**			*0.005*	U	*0.005*	U	0.016	I			0.060		0.103		0.070		8.33	J	9.17	J	10.60	J
12/22/2003	**B**	**5**			*0.005*	I	0.013	I	0.011	U			0.119		0.045		0.048		17.60	J	5.28	J	3.48	J
1/22/2004	**B**	**6**			*0.005*	U	*0.005*	U	0.030	I			0.138		0.064		0.107		10.00		7.50		13.20	
1/29/2004	**B**	**7**			*0.005*	U	0.010	I	0.040				0.133		0.119		0.053		9.24		8.83		7.37	
3/19/2004	**B**	**8**			*0.005*	U	*0.005*		0.107				0.109		0.121		0.197		2.60		11.70		8.36	
4/2/2004	**B**	**9**			0.000		0.000		0.000				0.067	Q	0.079	Q	0.190	Q	5.61		4.92		17.50	
4/27/2004	**B**	**10**			0.067		0.057		0.107				0.110		0.090		0.168		3.23		2.39		8.20	
5/20/2004	**B**	**11**			0.025		0.038		0.041				0.056		0.064		0.148		3.43		3.85		18.00	
6/5/2004	**B**	**12**			*0.114*		0.113		0.005	U			0.280	Q	0.350	Q	0.210	Q	15.9		16.9		28.9	
7/1/2004	**B**	**13**			0.058		0.057		0.049				0.084	J	0.085	J	0.184	J	2.83	J	2.59	J	15.90	J
7/7/2004	**B**	**14**			0.050		0.080		0.028	I			0.096		0.177		0.098		2.85		29.70		7.93	
7/30/2004	**B**	**15**			0.088		0.068		0.024	I			0.130		0.115		0.067						7.50	
9/23/2004	**B**	**16**			0.082	Y	0.059	Y	0.054	Y			0.107	Y	0.090	Y	0.124	Y	8.37	Y	10.40	Y	5.08	Y
10/15/2004	**B**	**17**			0.061		0.059		0.038				0.046		0.108		0.171		22.40		4.99		12.00	
# Samples					17		17		17				17		17		17		16		16		17	
Mean					0.039		0.038		0.038				0.105		0.103		0.133		8.45		7.86		14.25	
Median					0.025		0.032		0.030				0.107		0.090		0.144		8.00		5.14		10.60	
St. Dev.					0.035		0.032		0.034				0.055		0.072		0.062		6.09		7.16		11.79	
Max					0.114		0.113		0.107				0.280		0.350		0.236		22.40		29.70		53.20	
Min					0.000		0.000		0.000				0.045		0.032		0.041		2.12		1.72		3.48	
C.V.					0.91		0.83		0.88				0.52		0.70		0.47		0.72		0.91		0.83	

WATER QUALITY STORM EVENTS YEAR TWO

Date sample collected	event	#	Aluminum						Copper								Iron								Zinc							
									ug/L								ug/L								ug/L							
									Lab Detection Limit 3.0								Lab Detection Limit 50.0								Lab Detection Limit 30							
			934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
			BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW	
11/7/2003	E	1	337.0	N	210.0	N	737	N	1.50	U	13.70		9.39	I	5.00	I	15.9	I	422		279		448		8.8		56.5		51.1		30.1	
11/19/2003	E	2	183.0	N	204.0	N	286	D	1.50	U	10.50	I	8.81	I	1.50	U	6.3	U	273		274		209		4.9	I	54.5		55.8		16.5	
12/15/2003	E	3	167.0	N	132.0	N	654	N	1.50	U	33.00		19.60		6.47	I	6.3	U	186		153		397		2.4		33.2		28.9		37.6	
1/12/2004	E	4	105.0	N	111.0	N	415	N	1.50	U	10.40		9.31	I	6.48	I	6.3	U	162		183		329		5.5	I	31.8		41.5		57.1	
1/19/2004	E	5	77.6	N	103.0	N	1060	N	1.50	U	1.50	U	3.34	I	6.88	I	21.3	I	173		173		563		6.5		19.2		23.8		52.0	
1/20/2004	E	6	135.0	N	219.0	N	404	N	4.05	I	13.60		12.00		4.33	I	20.9	I	114		191		232		10.6		22.4		35.8		28.1	
1/31/2004	E	7	43.8	IN	49.3	IN	408	N	1.50	U	8.80	I	7.55	I	1.50	U	6.3	U	113		108		187		4.5	I	17.7		18.6		14.0	
2/2/2004	E	8	82.2	N	89.8	N	247	N	6.89	I	6.42	I	5.54	I	1.50	U	6.3	U	143		121		143		5.0	I	25.1		25.4		21.7	
4/13/2004	E	9	249.0	N	181.0	N	135	N			10.3	N	9.09	IN	4.59	IN			254	N	219	N	113	N			69.2	N	57.0	N	17.3	N
6/11/2004	E	11	51.7	I	46.6	I	469		1.50	U	5.84	I	5.75	I	9.42	I	78.8		70.2		77.5		307		14.7		11.4		14.5	J	34.3	
6/14/2004	E	12	46.3	IN	40.5	IN	107	N	1.50	UN	5.11	IN	5.39	IN	3.32	IN	44.2	N	60.2	N	66	N	78.5	N	7.3	N	11.4	N	13.9	N	9.9	N
6/15/2004	E	13	150.0	N	67.0	N	763	N	1.50	UN	3.97	IN	4.36	IN	6.64	IN	33.5	IN	147	N	106	N	33.5	IN	6.2	IN	37.0	N	26.6	N	30.1	N
6/16/2004	E	14	53.4	IN	60.0	IN	1610	N			3.41	IN	3.57	IN	3.78	IN			86.2	N	111	N	757	N			28.2	N	25.2	N	30.7	N
6/22/2004	E	15	179.0		163.0		299				10.20		10.00		4.20	I			225		219		236				62.9		65.9		18.2	
6/25/2004	E	16	164.0		178.0		1140		1.50	U	6.75	I	6.41	I	14.30		105		137		174		749		9.9		25.6		31.0		57.9	
6/27/2004	E	17	187.0		187.0		2000		4.10	I	5.71	I	4.42	I	28.70		437.0	J	173	J	158	J	1250	J	11.4		32.2		26.0		82.9	
6/28/2004	E	18	171.0		137.0		352		1.50	U	4.67	I	3.51	I	3.42	I	119.0	J	175		133		224		12.5		32.1		30.1		24.6	
6/29/2004	E	19	102.0		121.0		206		1.50	U	3.11	I	3.36	I	1.50	U	48.9		142		144		146		7.9		29.6		33.2		19.9	
6/30/2004	E	20	98.9		124.0		288		1.50	U	3.75	I	4.12	I	3.02	I	93.8		119		139		188		8.5		30.4		37.0		21.2	
7/3/2004	E	21	77.4		94.6		183		1.50	U	4.03	I	4.08	I	3.45	I	53.2		117		120		166		15.3		22.5		27.4		22.4	
7/6/2004	E	22	130.0		50.7	I	291		1.50	U	6.39	I	3.49	I	4.70	I	54.6		158		97.7		253		10.9		24.2		14.3		26.9	
7/13/2004	E	23	112.0		219.0		357		1.50	U	4.76		5.30	I	5.01	I	49.9		131		181		255		10.5		30.0		37.4		38.0	
7/16/2004	E	24	435.0		415.0		224		1.50	U	6.76	I	7.72	I	3.91	I	62.6		371		400		197		11.1		58.5		70.7		21.2	
7/18/2004	E	25	103.0		140.0		160		1.50	U	4.52	I	4.72	I	1.50	U	34.7	I	102		136		124		5.9	I	29.2		32.6		18.7	
7/19/2004	E	26	145.0		165.0		220		1.50	U	4.99	I	5.25	I	3.04	I	39.5	I	140		159		177		5.2	I	28.4		35.6		23.1	
7/20/2004	E	27	138.0		174.0		178		1.50	U	4.23	I	4.62	I	1.50	U	15.2	I	123		156		125		4.5	I	28.9		32.4		18.2	
7/21/2004	E	28	167.0		95.6		167				1.50	U	4.13	I	1.50	U			107		134		107				16.8		19.5		16.9	
7/27/2004	E	29	368.0		262.0		1220		1.50	U	5.88	I	4.49	I	13.60		25.0	I	294		216		737		8.8		39.9		31.2		54.4	
8/2/2004	E	30	193.0		164.0		166		1.50	U	3.36	I	3.86	I	3.27	I	14.5	I	167		166		130		7.2		43.0		41.6		21.4	
8/4/2004	E	31	347.0		302.0		120		1.50	U	5.54	I	5.67	I	1.50	U	60.4		302		309		117		10.1		71.3		65.6		13.3	
8/7/2004	E	32	423.0		401.0		492		1.50	U	5.68	I	4.99	I	3.69	I	43.8		384		342		295		7.7		63.1		53.4		26.1	
8/8/2004	E	33	481.0		610.0		306		1.50	U	4.93	I	25.40		1.50	U	13.1	I	318		411		228		5.8	I	33.8		39.2		16.3	
8/10/2004	E	34	399.0		426.0		440		1.50	U	4.09	I	4.36	I	3.29	I	54.7		278		302		289		5.0	I	29.3		32.7		21.5	
8/16/2004	E	35	158.0		218.0		202		1.50	U	3.36	IJ	4.01	I	3.17	I	19.2	I	130		198		191		4.0	I	33.3		41.9		13.2	
8/19/2004	E	36	303.0		482.0		519		3.24	I	10.50		8.01	I	5.96	I	45.7		286		463		370		15.9		54.1		86.1		30.7	
8/22/2004	E	37	245.0		360.0		197		1.50	U	7.48	I	8.46	I	3.87	I	56.6		260		409		230		10.1		48.6		66.5		16.4	
8/23/2004	E	38	303.0		346.0		195		3.49	I	5.27	I	5.38	I	3.46	I	39.0	I	251		295		180		10.4		48.8		51.1		23.3	
8/25/2004	E	39	228.0		243.0		205		1.50	U	5.42	I	5.37	I	3.55	I	53.4		202		223		178		7.7		43.4		43.8		20.2	
8/26/2004	E	40	339.0		415.0		278		1.50	U	6.38	I	6.97	I	3.00	IJ	44.4		286		349		164		5.8	I	45.8		50.1		16.7	
9/1/2004	E	41	141.0		173.0		199		1.50	U	5.42	I	5.56	I	3.57	I	25.7	I	136		171		211		7.7		41.3		42.6		22.3	
9/8/2004	E	42	269.0		306.0		139		1.50	U	4.64	I	5.20	I	1.50	U	65.2		214		261		131		6.4		40.6		46.2		13.6	
9/9/2004	E	43	410.0		331.0		461		1.50	U	4.32	I	4.18	I	3.68	I	34.7	I	279		248		365		3.4	I	53.2		38.3		38.3	
9/10/2004	E	44	412.0		428.0		325		1.50	U	9.98		5.20		3.81	I	12.5	I	288		314		232		5.1	I	33.2		35.6		23.8	
9/28/2004	E	45	352.0		332.0		375		1.50	U	13.10		13.30		8.16	I	37.6	I	411		309		252	J	9.1		54.6		49.3		22.0	
# Samples			44		44		44		40		44		44		44		40		44		44		44		40		44		44		44	
Mean			210.48		217.64		436.34		1.86		6.89		6.71		4.81		50		202		214		279		8.0		37.4		39.2		26.9	
Median			169		179.5		295		1.50		5.48		5.34		3.63		39		173		182		218		7.7		33.2		36.4		22.2	
St. Dev.			123.92		135.81		401.66		1.06		5.03		4.24		4.65		68		94		99		225		3.3		15.2		16.0		14.5	
Max			481		610		2000		6.89		33.00		25.40		28.70		437		422		463		1250		15.9		71.3		86.1		82.9	
Min			43.80		40.50		107		1.50		1.50		3.34		1.50		6		60		66		34		2.4		11.4		13.9		9.9	
C.V.			0.59		0.62		0.9205		0.57		0.73		0.63		0.97		1.36		0.46		0.46		0.80		0.41		0.41		0.41		0.54	

BASE FLOW YEAR TWO

Date sample collected	event	#	Aluminum						Copper								Iron								Zinc							
									ug/L								ug/L								ug/L							
									Lab Detection Limit 3.0								Lab Detection Limit 50.0								Lab Detection Limit 30							
			934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
			BEFORE CDS		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**	
11/10/2003	**B**	**1**	*10.00*	UN	*10.00*	UN	342	N			*1.50*	U	3.32	I	*1.50*	U			160		186		260				10.1		12.3		18.6	
12/3/2003	**B**	**2**	28.90	IN	28.60	IN	276	N			*5.55*	I	8.01	I	*1.50*	U			121		101		164				21.4		11.5		10.3	
12/11/2003	**B**	**3**	93.40	N	22.70	IN	2020	N			18.40		8.72	I	6.97	I			212		95		981				45.4		13.0		43.3	
12/18/2003	**B**	**4**	77.00	N	75.70	N	330	N			20.70		23.50		4.31	I			102		108		211				15.8		19.2		15.3	
12/22/2003	**B**	**5**	49.40	IN	26.60	IN	538	N			25.40		12.60		4.63	I			135		104		308				11.4		10.5		13.4	
1/22/2004	**B**	**6**	98.50	N	81.20	N	625	N			14	N	12.50	N	3.83	IN			98	N	79	N	300	N			11.7	N	12.6	N	22.8	N
1/29/2004	**B**	**7**	70.30	N	62.40	IN	313	N			14.3		12.80		*1.50*	U			123		93		159				15.5		19.4		23.0	
3/19/2004	**B**	**8**	233.00	N	68.00	N	233	N			5.61	IN	6.17	IN	5.61	IN			221	N	118	N	221	N			16.6	N	14.6	N	16.6	N
4/2/2004	**B**	**9**	25.60	IN	23.40	IN	195	N			11.8	N	12.20	N	31.90	N			178	N	174	N	192	N			22.9	N	40.9	N	10.7	N
4/27/2004	**B**	**10**	*10.00*	UN	*10.00*	UN	92	N			3.37	IN	3.73	IN	4.82	IN			179	N	185	N	189	N			16.3	N	15.0	N	7.2	N
5/20/2004	**B**	**11**	2550	N	179.00	N	305	N			6.82	IN	5.16	IN	*8.75*	IN			206	N	135	N	283	N			18.3	N	21.0	N	27.5	N
6/5/2004	**B**	**12**	245.0	N	372.0	N	324	N			34.2	N	32.00	N	12.30	N			273	N	366	N	387	N			128	N	141.0	N	47.4	N
7/1/2004	**B**	**13**	61.80	I	53.30		165				*1.50*	U	*1.50*	U	*1.50*	U			101		98.2		164				11.8		13.0		13.8	
7/7/2004	**B**	**14**	54.90		524.00		167				4.44	IJ	13.00		*1.50*	U			104		498		171				12.0		91.3		17.7	
7/30/2004	**B**	**15**	398.00		332.00		218				7.23	I	6.86	I	3.37	I			393		329		154				79.5		66.9		20.7	
9/23/2004	**B**	**16**	243.00		288.00		111				37		89.7		5.02	I			276		274		144				33.4		34.2		11.3	
10/15/2004	**B**	**17**	170.00	J	199.00	J	352	J			5.61	I	3.14	I	*10.20*				245	J	299	J	731	J			12.5		12.6		37.3	
11/15/2004	**B**	**18**	164.00		206.00		346				*1.50*	U	*1.50*	U	*1.50*	U			253		300		302				7.7		19.1		16.6	
11/24/2004	**B**	**19**	97.70		98.10		277				*1.50*	U	*1.50*	U	*1.50*	U			209		202		239				23.5		26.8		10.7	
# Samples			19		19		19				13		11		18				19		19		19				19		19		19	
Mean			246.34		140.00		380.47				12.55		9.88		6.15				189		197		293				27.0		31.3		20.2	
Median			70.30		28.60		313				11.80		8.72		4.63				160		108		221				16.3		14.6		16.6	
St. Dev.			750.49		49.28		532.02				7.73		5.79		8.62				45		39		233				9.7		8.6		10.1	
Max			2550		179		2020				25.40		23.50		31.90				221		186		981				45.4		40.9		43.3	
Min			10		10		92				1.50		3.32		1.50				98		79		159				10.1		10.5		7.2	
C.V.			3.05		0.35		1.3983				0.62		0.59		1.40				0.24		0.20		0.80				0.36		0.27		0.50	

DISSOLVED METALS FOR STORM FLOW - YEAR TWO

Date		**Dissolved Zinc**						**Dissolved Copper**								**Dissolved Iron**								**Dissolved Lead**							
sample	**event**	ug/L						ug/L								ug/L								ug/L							
collected	**base**	Lab Detection Limit 15						Lab Detection Limit 3.0								Lab Detection Limit 50.0								Lab Detection Limit 2.0							
		934	**DQ**	935	**DQ**	939	**DQ**	556	**DQ**	934	**DQ**	935	**DQ**	939	**DQ**	556	**DQ**	934	**DQ**	935	**DQ**	939	**DQ**	**556**	**DQ**	934	**DQ**	935	**DQ**	939	**DQ**
STORM		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**	
11/7/2003	**E**	23.4		24.2		13.8				*4.8*	I	4.5	I	3.6	I			68.0		71.3		66.3				*5*	U	*5*	U	*5*	U
11/19/2003	**E**	20.6		21.6		9.2				3.6	I	3.5	I	*1.5*	U			36.2	I	42.3		59.7				*5*	U	*5*	U	*5*	U
12/15/2003	**E**	12.0		13.0		8.7				6.5	I	4.6	I	*1.5*	U			31.1	I	30.3	I	27.8	I			*5*	U	*5*	U	*5*	U
1/12/2004	**E**	15.7		26.5		27.8				3.7	I	3.8	I	3.4	I			34.9	I	55.5		24.5	I			*5*	U	*5*	U	*5*	U
1/19/2004	**E**	10.2		11.2		11.2				*1.5*	U	*1.5*	U	*1.5*	U			57.5		59.3		35.8	I			*5*	U	*5*	U	*5*	U
1/20/2004	**E**	13.4		17.6		15.8				8.8	I	7.2	I	*1.5*	U			46.4		47.2		54.3				*5*	U	*5*	U	*5*	U
1/31/2004	**E**	12.7		13.2		7.0				5.9	I	4.4	I	*1.5*	U			52.5		45.6		41.0				*5*	U	*5*	U	*5*	U
2/2/2004	**E**	17.0		16.6		13.8				4.6	I	*1.5*	U	*1.5*	U			75.3		51.2		40.7				*5*	U	*5*	U	*5*	U
4/13/2004	**E**	49.2	N	40.7	N	10.2	N			7.0	IN	4.7	IN	*1.5*	UN			79.5	N	75.6	N	31.7	IN			*5*	UN	*5*	UN	*5*	UN
6/5/2004	**E**	109.0	N	112.0	N	29.3	N			34.2	N	22.3	N	7.2	IN			83.5	N	73.7	N	73.5	N			*5*	UN	*5*	UN	*5*	UN
6/11/2004	**E**	12.1		18.0	J	15.1				3.5	I	3.7	I	*1.5*	U			44.0		56.7		23.8	I			*5*	U	*5*	U	*5*	U
6/14/2004	**E**	5.2	IN	7.5	N	7.2	N			*1.5*	UN	3.1	IN	*1.5*	UN			16.6	IN	17.7	IN	13.8	IN			*5*	UN	*5*	UN	*5*	UN
6/15/2004	**E**	23.1	N	19.5	N	11.9	N			*1.5*	UN	*1.5*	UN	*1.5*	UN			28.3	IN	43.6	N	33.6	IN			*5*	UN	*5*	UN	*5*	UN
6/16/2004	**E**	21.4	N	22.4	N	5.0	IN			*1.5*	UN	3.8	UN	*1.5*	UN			31.1	IN	46.9	N	52.6	N			*5*	UN	*5*	UN	*5*	UN
6/22/2004	**E**	38.1		44.6		5.5	I			6.5	I	5.3	I	*1.5*	U			58.1		55.0		39.6	I			*5*	U	*5*	U	*5*	U
6/25/2004	**E**	14.7		18.4		10.7				*1.5*	U	3.5	I	3.5	I			43.0		34.5	IN	22.3	I			*5*	U	*5*	U	*5*	U
6/27/2004	**E**	17.6		18.3		8.2				*1.5*	U	*1.5*	U	*1.5*	U			27.7	I	31.0	IN	24.0	I			*5*	U	*5*	U	*5*	U
6/28/2004	**E**	19.8		30.1		15.3				*1.5*	U	*1.5*	U	3.4	I			43.1		38.2	I	14.0	I			*5*	U	*5*	U	*5*	U
6/29/2004	**E**	24.4		29.0		17.8				*1.5*	U	*1.5*	U	*1.5*	U			58.9		55.1		23.7	I			*5*	U	*5*	U	*5*	U
6/30/2004	**E**	24.5		27.7		11.9				*1.5*	U	*1.5*	U	*1.5*	U			56.7		52.4		21.8	I			*5*	U	*5*	U	*5*	U
7/3/2004	**E**	18.4		22.2		14.5				*1.5*	U	3.3	I	*1.5*	U			66.2		60.0		28.8	I			*5*	U	*5*	U	*5*	U
7/6/2004	**E**	14.3		10.5		13.4				3.8	I	*1.5*	U	*1.5*	U			51.3	I	58.4		23.3				*5*	U	*5*	U	*5*	U
7/13/2004	**E**	22.0		25.4		21.9				4.8	I	3.3	I	*1.5*	U			53.4		46.4		21.9	I			*5*	U	*5*	U	*5*	U
7/16/2004	**E**	24.8		27.7		9.3				3.9	I	3.4	I	*1.5*	U			37.8	I	49.7		26.9	I			*5*	U	*5*	U	*5*	U
7/18/2004	**E**	26.0		21.8		14.7				3.8	I	3.1	I	*1.5*	U			31.1	I	29.1	I	19.9	I			*5*	U	*5*	U	*5*	U
7/19/2004	**E**	17.0		16.0		13.5				*1.5*	U	*1.5*	U	*1.5*	U			26.6	I	20.5	I	14.3	I			*5*	U	*5*	U	*5*	U
7/20/2004	**E**	21.6		19.1		10.7				*1.5*	U	*1.5*	U	*1.5*	U			28.7	I	26.4	I	46.3	I			*5*	U	*5*	U	*5*	U
7/21/2004	**E**	16.7		16.4		12.3				*1.5*	U	*1.5*	U	*1.5*	U			78.5		76.1		21.4	I			*5*	U	*5*	U	*5*	U
7/27/2004	**E**	16.1		14.8		8.3				3.0	I	4.5	I	*1.5*	U			21.3	I	21.2	I	18.5	I			*5*	U	*5*	U	*5*	U
8/2/2004	**E**	22.4		26.4		11.1				*1.5*	U	*1.5*	U	*1.5*	U			17.9	I	36.0	I	15.9	I			*5*	U	*5*	U	*5*	U
8/4/2004	**E**	32.1		30.1		7.8				*1.5*	U	*1.5*	U	*1.5*	U			30.2	I	49.6		25.9	I			*5*	U	*5*	U	*5*	U
8/7/2004	**E**	19.2		18.3		8.8				*1.5*	U	*1.5*	U	*1.5*	U			20.7	I	20.2	I	20.4	I			*5*	U	*5*	U	*5*	U
8/8/2004	**E**	10.1		10.3		9.3				*1.5*	U	*1.5*	U	*1.5*	U			14.7	I	23.2	I	71.4				*5*	U	*5*	U	*5*	U
8/10/2004	**E**	11.1		9.9		8.1				*1.5*	U	4.4	I	*1.5*	U			12.8	I	14.2	I	34.4	I			*5*	U	*5*	U	*5*	U
8/16/2004	**E**	6.6		20.8		6.6				*1.5*	U	3.5	I	*1.5*	U			30.6	I	27.9	I	30.6	I			*5*	U	*5*	U	*5*	U
8/19/2004	**E**	26.9		30.5		8.7				6.9	I	*1.5*	U	*1.5*	U			57.9		22.8	I	36.0	I			*5*	U	*5*	U	*5*	U
8/22/2004	**E**	25.4		29.2		7.8				4.5	I	4.7	I	3.4	I			64.6		70.5		35.9	I			*5*	U	*5*	U	*5*	U
8/23/2004	**E**	22.5		20.5		13.8				*3.2*	I	*1.5*	U	*1.5*	U			20.3	I	21.7	I	32.4	I			*5*	U	*5*	U	*5*	U
8/25/2004	**E**	18.4		17.9		11.7				*1.5*	U	*1.5*	U	*1.5*	U			24.0	I	27.6	I	24.4	I			*5*	U	*5*	U	*5*	U
8/26/2004	**E**	17.5		16.5		7.4				6.4	I	*1.5*	U	4.5	IJ			21.9	I	21.9	I	31.0	I			*5*	U	*5*	U	*5*	U
9/1/2004	**E**	22.7		22.1		9.8				*1.5*	U	*1.5*	U	*1.5*	U			17.7	I	21.7	I	50.1				*5*	U	*5*	U	*5*	U
9/8/2004	**E**	14.9		14.8		9.4				*1.5*	U	*1.5*	U	*1.5*	U			*6.3*	U	18.0	I	*6.3*	U			*5*	U	*5*	U	*5*	U
9/9/2004	**E**	11.6		11.1		13.8				*1.5*	U	*1.5*	U	*1.5*	U			22.3	I	26.5	I	78.6				*5*	U	*5*	U	*5*	U
9/10/2004	**E**	10.7		9.0		8.9				*1.5*	U	*1.5*	U	*1.5*	U			26.5	I	29.3	I	33.5	I			*5*	U	*5*	U	*5*	U
9/28/2004	**E**	12.7		14.1		20.0	I			5.4	I	6.1	I	5.0	I			19.0	I	20.2	I	20.0				*5*	U	*5*	U	*5*	U
# Samples		45		45		45				45		45		45				45		45		45				45		45		45	
Mean		21.0		22.4		11.9				3.8		3.2		2.0				39.4		40.5		33.2				5		5		5	
Median		18.4		19.1		10.7				1.5		1.5		1.5				31.1		38.2		28.8				5		5		5	
St. Dev.		15.6		15.8		5.1				5.1		3.3		1.2				20.3		18.0		16.8				0		0		0	
Max		109.0		112.0		29.3				34.2		22.3		7.2				83.5		76.1		78.6				5		5		5	
Min		5.2		7.5		5.0				1.5		1.5		1.5				6.3		14.2		6.3				5		5		5	
C.V.		0.74		0.71		0.43				1.34		1.02		0.60				0.51		0.44		0.51				0.00		0.00		0.00	

DISSOLVED METALS IN BASE FLOW FOR YEAR TWO

Date		Dissolved Zinc						Dissolved Copper								Dissolved Iron								Dissolved Lead							
sample	event or	ug/L						ug/L								ug/L								ug/L							
collected	base flow	Lab Detection Limit 15						Lab Detection Limit 3.0								Lab Detection Limit 50.0								Lab Detection Limit 2.0							
		934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW	
11/10/2003	B	8.3		9.1		11.5				*1.5*	U	*1.5*	U	*1.5*	U			113.0		114.0		107.0				*5*	U	*5*	U	*5*	U
12/3/2003	B	7.9		5.2	I	5.2	I			*1.5*	U	*1.5*	U	*1.5*	U			47.4		33.6	I	31.8	I			*5*	U	*5*	U	*5*	U
12/11/2003	B	34.9		10.9		2.8	I			9.2	I	3.8	I	*1.5*	U			67.2		48.0		34.3	I			*5*	U	*5*	U	*5*	U
12/18/2003	B	9.3		10.0		5.2	I			*6.7*	I	*9.2*	I	*1.5*	U			43.0		51.5		50.2				*5*	U	*5*	U	*5*	U
12/22/2003	B	4.7	I	6.7		2.0	I			*1.5*	U	*1.5*	U	*1.5*	U			41.1		60.4		55.3				*5*	U	*5*	U	*5*	U
1/22/2004	B	5.8	IN	6.2	IN	13.3	IN			11.2	N	9.0	IN	3.7	IN			40.7	N	30.2	IN	62.9	N			*5*	U	*5*	UN	*5*	UN
1/29/2004	B	8.9		12.1		15.4				7.6	I	7.7	I	*1.5*	U			39.2	I	34.9	IN	40.1				*5*	U	*5*	U	*5*	U
3/19/2004	B	9.7	N	8.3	N	9.7	N			*1.5*	UN	3.8	IN	*1.5*	UN			79.8	N	66.6	N	79.8	N			*5*	UN	*5*	UN	*5*	UN
4/2/2004	B	18.6	N	26.8	N	42.9	N			9.8	N	8.9	IN	17.0	N			116.0	N	109.0	N	42.9	N			*5*	UN	*5*	UN	*5*	UN
4/27/2004	B	12.4	N	11.9	N	5.2	IN			*1.5*	UN	*1.5*	UN	3.5	IN			108.0	N	108.0	N	41.9	N			*5*	UN	*5*	UN	*5*	UN
5/20/2004	B	11.1	N	13.5	N	7.4	N			*1.5*	UN	*1.5*	UN	*1.5*	UN			73.4	N	78.0	N	27.1	IN			*5*	UN	*5*	UN	*5*	UN
7/1/2004	B	10.4		10.5		6.4				*1.5*	U	*1.5*	U	*1.5*	U			60.7		60.7		35.0	I			*5*	U	*5*	U	*5*	U
7/7/2004	B	11.6		26.5		10.1				5.0	J	5.0	I	*1.5*	U			60.8		39.5	I	48.9				*5*	U	*5*	U	*5*	U
9/23/2004	B	22.3		20.6		7.6				25.6		21.1		3.8				127.0		78.3		38.8	I			*5*	U	*5*	U	*5*	U
10/15/2004	B	7.2		5.5	I	6.0	I			3.9	I	*1.5*	U	*1.5*	U			70.5		27.5	I	167.0				*5*	U	*5*	U	*5*	U
# Samples		15		15		15				15		15		15				15		15		15				15		15		15	
Mean		12.2		12.3		10.0				6.0		5.3		3.0				72.5		62.7		57.5				5.0		5.0		5.0	
Median		9.7		10.5		7.4				3.9		3.8		1.5				67.2		60.4		42.9				5.0		5.0		5.0	
St. Dev.		7.8		7.0		9.8				6.5		5.4		4.0				30.2		29.4		36.7				0.0		0.0		0.0	
Max		34.9		26.8		42.9				25.6		21.1		17.0				127.0		114.0		167.0				5.0		5.0		5.0	
Min		4.7		5.2		2.0				1.5		1.5		1.5				39.2		27.5		27.1				5.0		5.0		5.0	
C.V.		0.64		0.57		0.98				1.08		1.02		1.34				0.42		0.47		0.64				0.00		0.00		0.00	

Table E-9. Summary statistics for storm flow for year three. Efficiency is shown as percentages of concentrations. Positive percentage=percent removal; negative percentage=percent increase.

YEAR THREE	Ammonia				Nitrate + Nitrite				Organic Nitrogen				Total Nitrogen			
	mg/L as Nitrogen				mg/L as Nitrogen				mg/L as Nitrogen							
STORM	556	934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
FLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
# Samples	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Mean	0.189	0.103	0.078	0.069	0.275	0.294	0.330	0.25709	0.14	0.68	0.77	0.64	0.59	1.08	1.17	0.97
Median	0.139	0.089	0.046	0.052	0.231	0.236	0.273	0.2215	0.07	0.54	0.71	0.57	0.52	1.01	1.06	0.90
St. Dev.	0.132	0.093	0.087	0.066	0.159	0.210	0.179	0.1797	0.00	0.40	0.37	0.36	0.30	0.53	0.45	0.42
Max	0.481	0.334	0.370	0.342	0.644	1.130	0.726	0.875	1.30	2.20	1.91	1.96	1.48	2.99	2.39	2.56
Min	0.018	0.003	0.003	0.008	0.084	0.011	0.161	0.04	0.00	0.25	0.21	0.07	0.14	0.39	0.43	0.43
C.V.	0.70	0.91	1.12	0.96	0.58	0.72	0.54	0.69899	0.00	0.58	0.48	0.56	0.51	0.49	0.39	0.44
EFF% (MEAN)			24%	12%			-12%	22%			-12%	16%			-9%	17%
EFF% (MEDIAN)			48%	-13%			-16%	19%			-31%	19%			-5%	15%

	Ortho-Phosphorus				Total Phosphorus					TSS						
	mg/l				mg/l					mg/l						
	Lab Detection Limit 0.01 mg/l				Lab Detection Limit 0.01 mg/l					Lab D. L. 0.05						
	556	934	935	939	556	934	935	939		934	935	939				
	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW		BEFORE CDS	AFTER CDS	OUTFLOW				
# Samples	34	34	34	34	34	34	34	34		34	34	34				
Mean	0.0059	0.075	0.051	0.057	0.017	0.163	0.159	0.126		35.0	32.2	11.9				
Median	0.0050	0.046	0.044	0.056	0.005	0.131	0.141	0.120		23.8	23.4	8.8				
St. Dev.	0.0037	0.111	0.039	0.035	0.025	0.085	0.088	0.060		41.7	29.2	10.1				
Max	0.0250	0.666	0.196	0.171	0.119	0.345	0.482	0.311		233.0	158.0	52.2				
Min	0.0050	0.020	0.005	0.005	0.005	0.054	0.055	0.005		3.4	4.6	2.4				
C.V.	0.62	1.48	0.76	0.61	1.49	0.52	0.55	0.48		1.19	0.91	0.85				
EFF% (MEAN)			32%	-12%			3%	20%			8%	63%				
EFF% (MEDIAN)			4%	-28%			-8%	15%			2%	62%				

		Aluminum			Copper				Iron				Zinc			
	ug/L				ug/L				ug/L				ug/L			
					Lab Detection Limit 3.0				Lab Detection Limit 50.0				Lab Detection Limit 30			
		934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
		BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
# Samples		34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Mean		662	643	365	1.97	10.13	11.40	4.94	68	548	509	271	10.4	68.4	74.0	27.7
Median		501	538	245	1.50	8.90	9.41	4.17	59	449	402	221	8.0	59.4	57.8	21.5
St. Dev.		605	533	331	1.00	5.41	6.25	3.70	47	414	362	195	10.1	40.8	49.9	23.4
Max		2960	2750	1550	5.17	22.70	29.10	18.80	231	2190	1990	1120	52.6	212.0	267.0	146.0
Min		104	102	88	1.50	1.50	3.97	1.50	6	74	104	76	2.5	15.4	13.3	6.7
C.V.		0.91	0.83	0.91	0.51	0.53	0.55	0.75	0.69	0.75	0.71	0.72	0.97	0.60	0.67	0.85
EFF% (MEAN)			3%	43%			-13%	57%			7%	47%			-8%	63%
EFF% (MEDIAN)			-7%	54%			-6%	56%			11%	45%			3%	63%

Table E-10. Summary statistics for base flow for year three. Efficiency is shown as percentages of concentrations.

YEAR THREE	Ammonia				Nitrate + Nitrite				Organic Nitrogen				Total Nitrogen			
BASE	mg/L as Nitrogen				mg/L as Nitrogen				mg/L as Nitrogen							
FLOW	556	934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
# Samples		13	13	13		13	13	13		13	13	13		13	13	13
Mean		0.123	0.100	0.095		1.149	1.109	0.240		0.725	0.589	0.686		2.00	1.74	1.02
Median		0.072	0.073	0.056		0.950	0.754	0.080		0.484	0.474	0.633		1.84	1.53	0.95
St. Dev.		0.167	0.098	0.125		0.723	0.672	0.316		0.624	0.447	0.354		0.66	0.86	0.48
Max		0.640	0.364	0.459		2.510	2.500	1.110		2.305	1.942	1.545		3.32	3.30	1.77
Min		0.003	0.003	0.007		0.034	0.287	0.008		0.314	0.000	0.084		1.24	0.21	0.15
C.V.		1.36	0.98	1.32		0.63	0.61	1.32		0.86	0.76	0.52		0.33	0.50	0.47
EFF% (MEAN)			19%	5%			4%	78%			19%	-16%			13%	41%
EFF% (MEDIAN)			-1%	23%			21%	89%			2%	-34%			17%	38%
	Ortho-Phosphorus				**Total Phosphorus**					**TSS**						
	mg/l				mg/l					ug/L						
	Lab Detection Limit 0.01 mg/l				Lab Detection Limit 0.01 mg/l					Lab D. L. 0.05						
	556	934	935	939	556	934	935	939		934	935	939				
	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW		BEFORE CDS	AFTER CDS	OUTFLOW				
# Samples		13	13	13		13	13	13		13	13	13				
Mean		0.067	0.072	0.049		0.144	0.114	0.125		7.1	3.6	8.4				
Median		0.056	0.059	0.038		0.124	0.104	0.110		3.7	3.1	7.2				
St. Dev.		0.036	0.039	0.028		0.101	0.046	0.054		8.4	2.8	6.6				
Max		0.136	0.173	0.096		0.403	0.211	0.280		32.7	12.2	28.4				
Min		0.029	0.034	0.015		0.059	0.067	0.065		1.0	1.1	2.7				
C.V.		0.53	0.54	0.57		0.70	0.40	0.44		1.18	0.79	0.79				
EFF% (MEAN)			-7%	32%			21%	-9%			50%	-135%				
EFF% (MEDIAN)			-5%	36%			16%	-6%			15%	-130%				
		Aluminum			**Copper**				**Iron**				**Zinc**			
					ug/L				ug/L				ug/L			
					Lab Detection Limit 3.0				Lab Detection Limit 50.0				Lab Detection Limit 30			
		934	935	939	556	934	935	939	556	934	935	939	556	934	935	939
		BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW	RAIN	BEFORE CDS	AFTER CDS	OUTFLOW
# Samples		13	13	13		13	13	13		13	13	13		13	13	13
Mean		77	59	234		2.41	2.44	2.33		309	238	248		24.8	24.3	16.3
Median		56	44	246		1.50	1.50	1.50		253	239	222		21.0	23.0	13.4
St. Dev.		74	50	131		1.70	1.62	1.60		205	73	130		15.9	8.9	8.0
Max		289	206	467		7.06	6.42	5.73		896	386	596		70.3	46.9	38.6
Min		25	10	50		1.50	1.50	1.50		100	109	117		7.7	13.0	9.9
C.V.		0.96	0.86	0.56		0.70	0.66	0.69		0.66	0.31	0.53		0.64	0.37	0.49
			24%	-300%			-1%	4%			23%	-4%			2%	33%
			21%	-455%			0%	0%			6%	7%			-10%	42%

STORM EVENTS FOR YEAR THREE

Date Sample Collected STORM FLOW YEAR THREE	Event	#	Ammonia								Nitrate + Nitrite								Organic Nitrogen								Total Nitrogen							
			mg/L as Nitrogen																															
			556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
			RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW	
11/29/2004	**E**	**1**	0.137	D	0.160	D	0.021	D	0.201	D	0.341		1.130		0.283		0.413		0.272		1.700		1.236		1.006		0.75	N	2.99	N	1.54	N	1.62	N
12/16/2004	**E**	**2**	0.086	D	0.024	D	0.022	D	0.040	D	0.271		0.258		0.226		0.354		0.513		2.198		1.912		0.606		0.87	N	2.48	N	2.16	N	1.00	N
12/27/2004	**E**	**3**	0.018	D	0.010	ID	0.007	ID	0.017	D	0.084		0.144		0.166		0.321		0.148		0.486		0.727		0.822		0.25	QN	0.64	N	0.90	QN	1.16	QN
1/14/2005	**E**	**4**	0.028	D	0.122	D	0.147	D	0.149	D	0.104		0.252		0.307		0.185		0.198		0.786		1.006		0.886		0.33	N	1.16	N	1.46	N	1.22	N
2/28/2005	**E**	**5**	0.113	D	0.016	D	0.013	ID	0.095	D	0.239		0.178		0.196		0.157		0.178		0.896		0.921		0.778		0.53	N	1.09	N	1.13	N	1.03	N
3/4/2005	**E**	**6**	0.229	D	0.237	D	0.178	D	0.046	D	0.220		0.232		0.278		0.087		0.051		0.551		0.584		0.437		0.50	N	1.02	N	1.04	N	0.57	N
3/10/2005	**E**	**7**	0.097	D	0.212	D	0.093	D	0.020	D	0.128		0.011		0.163		0.040		0.115		0.777		0.684		0.570		0.34	N	1.00	N	0.94	N	0.63	N
3/17/2005	**E**	**8**	0.196	D	0.038	D	0.055	D	0.043	D	0.150		0.219		0.196		0.113		0.244		1.153		0.789		0.594		0.59	N	1.41	N	1.04	N	0.75	N
4/4/2005	**E**	**9**	0.150	D	0.103	D	0.032	D	0.030	QD	0.086		0.349		0.267		0.055		0.454		0.938		1.341		1.085		0.69	N	1.39	N	1.64	N	1.17	N
4/13/2005	**E**	**10**	0.430	D	0.304	D	0.144	D	0.093	D	0.277		0.363		0.374		0.495		0.263		0.873		0.712		0.632		0.97	N	1.54	N	1.23	N	1.22	N
4/25/2005	**E**	**11**	0.217	D	0.334	D	0.300	D	0.064	D	0.282		0.488		0.583		0.246		0.000	J6	0.998		1.507		0.480		0.49	NJ	1.82	N	2.39	N	0.79	N
4/27/2005	**E**	**12**	0.481	D	0.327	D	0.370	D	0.113	D	0.323		0.366		0.440		0.360		0.000	J6	0.327		0.410		0.307		0.72	NJ	1.02	N	1.22	N	0.78	N
5/2/2005	**E**	**13**	0.296	D	0.088	D	0.139	D	0.072	D	0.297		0.216		0.328		0.169		0.000	J6	0.536		0.873		0.659		0.56	NJ	0.84	N	1.34	N	0.90	N
5/18/2005	**E**	**14**	0.382	D	0.207	D	0.198	D	0.140	D	0.644		0.548		0.710		0.516		0.064		0.775		1.292		1.204		1.09	N	1.53	N	2.20	N	1.86	N
5/31/2005	**E**	**15**	0.114	D	0.114	D	0.172	D	0.342	D	0.170		0.239		0.300		0.259		0.076		0.737		1.198		1.959		0.36	N	1.09	N	1.67	N	2.56	N
6/2/2005	**E**	**16**	0.075	D	0.014	ID	0.016	ID	0.050	D	0.122		0.144		0.201		0.240		0.003		0.712		0.213		0.310		0.20	N	0.87	N	0.43	N	0.60	N
6/4/2005	**E**	**17**	0.277	D	0.108	D	0.097	D	0.069	D	0.181		0.139		0.168		0.075		0.000	J6	0.533		0.815		0.576		0.42	NJ	0.78	N	1.08	N	0.72	N
6/5/2005	**E**	**18**	0.410	D	0.109	D	0.096	D	0.069	D	0.223		0.147		0.161		0.078		0.000	J6	0.524		0.733		0.523		0.43	NJ	0.78	N	0.99	N	0.67	N
6/6/2005	**E**	**19**	0.406	D	0.109	D	0.098	D	0.071	D	0.224		0.140		0.177		0.216		0.000	J6	0.521		0.725		0.333		0.40	NJ	0.77	N	1.00	N	0.62	N
6/10/2005	**E**	**20**	0.076	D	0.030	D	0.023	D	0.026	D	0.172		0.179		0.202		0.201		0.042		0.341		0.415		0.473		0.29	N	0.55	N	0.64	N	0.70	N
6/11/2005	**E**	**21**	0.084	D	0.039	D	0.076	D	0.058	D	0.121		0.101		0.226		0.058		0.085		0.250		0.308		0.314		0.29	N	0.39	N	0.61	N	0.43	N
6/13/2005	**E**	**22**	0.077	D	0.016	D	0.071	D	0.066	D	0.122		0.099		0.195		0.059		0.031		0.425		0.414		0.415		0.23	N	0.54	N	0.68	N	0.54	N
6/24/2005	**E**	**23**	0.403	QD	0.141	QD	0.091	QD	0.011	QID	0.596	Q	0.354	Q	0.433	Q	0.187	Q	0.131		0.755		0.936		1.302		1.13	N	1.25	N	1.46	N	1.50	N
7/11/2005	**E**	**24**	0.034	D	*0.003*	U	*0.003*	U	0.140	D	0.143		0.107		0.167		0.151		1.303		0.951		0.771		0.569		1.48	N1	1.06	N1	0.94	N1	0.86	N1
7/13/2005	**E**	**25**	0.108	D	0.050	D	0.022	D	0.032	DQ	0.216		0.214		0.221		0.109		0.066		0.656		0.697		0.589		0.39	N1	0.92	N1	0.94	N1	0.73	N1
7/14/2005	**E**	**26**	0.135	D	0.024	D	*0.003*	U	0.030	D	0.479		0.366		0.374		0.384		0.156		0.420		0.584		0.536		0.77	N1	0.81	N1	0.96	N1	0.95	N1
7/25/2005	**E**	**27**	0.325	D	0.063	D	0.016	ID	0.031	D	0.436		0.279		0.322		0.220		0.109		0.518		0.552		0.909		0.87	N1	0.86	N1	0.89	N1	1.16	N1
7/30/2005	**E**	**28**	0.229	D	0.083	D	0.016	D	0.071	D	0.487		0.573		0.674		0.223		0.084		0.644		0.710		0.746		0.80	QN	1.30	QN	1.40	QN	1.04	QN
8/2/2005	**E**	**29**	0.181	D	0.089	D	0.047	D	0.054	D	0.530		0.534		0.571		0.554		0.059		0.467		0.502		0.372		0.77	N1	1.09	N1	1.12	N1	0.98	N1
8/6/2005	**E**	**30**	0.124	D	0.061	D	0.045	D	0.014	ID	0.521		0.573		0.721		0.875		0.065		0.396		0.574		0.071		0.71	N1	1.03	N1	1.34	N1	0.96	N1
8/22/2005	**E**	**31**	0.130	D	0.138	D	0.012	ID	0.008	ID	0.332		0.320		0.441		0.358		0.000	J6	0.312		0.497		0.684		0.44	J6	0.77	N1	0.95	N1	1.05	N1
8/23/2005	**E**	**32**	0.218	D	0.109	D	0.021	D	0.036	D	0.480		0.427		0.726		0.473		0.062		0.294		0.423		0.391		0.76	N1	0.83	N1	1.17	N1	0.90	N1
8/24/2005	**E**	**33**	0.141	D	*0.003*	U	*0.003*	U	0.008	ID	0.237		0.189		0.188		0.263		0.022		0.479		0.660		0.459		0.40	N1	0.67	N1	0.85	N1	0.73	N1
8/29/2005	**E**	**34**	0.020	D	*0.003*	U	*0.003*	U	0.033	D	0.104		0.107		0.221		0.247		0.016		0.321		0.307		0.320		0.14	N1	0.43	N1	0.53	N1	0.60	N1
# Samples			34		34		34		34		34		34		34		34		34		34		34		34		34		34		34		34	
Mean			0.189		0.103		0.078		0.069		0.275		0.294		0.330		0.257		0.14		0.68		0.77		0.64		0.59		1.08		1.17		0.97	
Median			0.139		0.089		0.046		0.052		0.231		0.236		0.273		0.222		0.07		0.54		0.71		0.57		0.52		1.01		1.06		0.90	
St. Dev.			0.132		0.093		0.087		0.066		0.159		0.210		0.179		0.18		0.00		0.40		0.37		0.36		0.30		0.53		0.45		0.42	
Max			0.481		0.334		0.370		0.342		0.644		1.130		0.726		0.875		1.30		2.20		1.91		1.96		1.48		2.99		2.39		2.56	
Min			0.018		0.003		0.003		0.008		0.084		0.011		0.161		0.04		0.00		0.25		0.21		0.07		0.14		0.39		0.43		0.43	
C.V.			0.70		0.91		1.12		0.96		0.58		0.72		0.54		0.699		0.00		0.58		0.48		0.56		0.51		0.49		0.39		0.44	

BASE FLOW YEAR THREE

Date sample collected BASE FLOW YEAR THREE	base flow	event #	Ammonia								Nitrate + Nitrite								Organic Nitrogen								Total Nitrogen							
			mg/L as Nitrogen																															
			556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
			RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW		RAIN		BEFORE CDS		AFTER CDS		OUTFLOW	
11/15/2004	**B**	**1**			0.203	D	0.078	D	0.459	D			1.280		1.280		0.350				1.837		1.942		0.961	J			3.32	N	3.30	N	1.77	N
11/24/2004	**B**	**2**			0.046	D	0.026	D	0.156	D			2.510		2.500		0.266				0.484		0.474		0.838				3.04	N	3.00	N	1.26	N
12/9/2004	**B**	**3**			0.076	D	0.047	D	0.214	D			2.020		1.840		0.263				0.314		0.523		0.633				2.41	N	2.41	N	1.11	N
1/12/2005	**B**	**4**			0.070	D	0.049	D	0.056	D			1.330		1.270		0.056				0.330		0.401		0.738				1.73	N	1.72	N	0.85	N
2/14/2005	**B**	**5**			0.640	D	0.125	D	0.028	D			0.432		0.688		0.030				0.408		0.367		0.592				1.48	N	1.18	N	0.65	N
2/25/2005	**B**	**6**			0.072	D	0.082	D	0.067	D			0.652		0.705		0.072				0.636		0.733		0.731				1.36	N	1.52	N	0.87	N
3/3/2005	**B**	**7**			0.010	ID	0.011	ID	0.088	D			0.468		0.287		0.080				0.762		0.532		0.292				1.24	N	0.83	N	0.46	N
4/7/2005	**B**	**8**			0.150	D	0.189	D	0.022	D			0.860		0.754		0.025				0.460		0.467		0.903				1.47	N	1.41	N	0.95	N
4/18/2005	**B**	**9**			0.148	D	0.364	D	0.015	ID			0.950		0.595		0.047				0.742		0.000	J6	0.084				1.84	N	0.21	J6	0.15	N
5/16/2005	**B**	**10**			0.109	D	0.179	D	0.007	ID			0.831		0.407		0.008	I			0.510		0.584		1.545				1.45	N	1.17	N	1.56	N
6/22/2005	**B**	**11**			0.011	ID	0.069	D	0.082	D			0.034		0.697		1.110				2.305		0.764		0.568				2.35	N	1.53	N	1.76	N
8/5/2005	**B**	**12**			0.055	D	0.073	D	0.022	D			1.550		1.430		0.181				0.315		0.417		0.587				1.92	N	1.92	N	0.79	N
9/20/2005	**B**	**13**			0.003	U	0.003	U	0.015	ID			2.020		1.960		0.633				0.318		0.458		0.442				2.34	N	2.42	N	1.09	N
# Samples					13		13		13				13		13		13				13		13		13				13		13		13	
Mean					0.123		0.100		0.095				1.149		1.109		0.240				0.725		0.589		0.686				2.00		1.74		1.02	
Median					0.072		0.073		0.056				0.950		0.754		0.080				0.484		0.474		0.633				1.84		1.53		0.95	
St. Dev.					0.167		0.098		0.125				0.723		0.672		0.316				0.624		0.447		0.354				0.66		0.86		0.48	
Max					0.640		0.364		0.459				2.510		2.500		1.110				2.305		1.942		1.545				3.32		3.30		1.77	
Min					0.003		0.003		0.007				0.034		0.287		0.008				0.314		0.000		0.084				1.24		0.21		0.15	
C.V.					1.36		0.98		1.32				0.63		0.61		1.32				0.86		0.76		0.52				0.33		0.50		0.47	

STORM FLOW FOR YEAR THREE

Date Sample Collected	**Event**	**#**	**Ortho-Phosphate**								**Total Phosphate**								**TSS**					
			MG/L Lab Detection Limit 0.01								MG/L Lab Detection Limit 0.01								ug/L Lab D. L. 0.05					
			556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	934.0	DQ	935	DQ	939	DQ
			RAIN		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**	
11/29/2004	**E**	**1**	*0.005*	U	0.021	I	0.065		0.090		0.020	I	0.343		0.189		0.152		233.0		24.2		9.6	
12/16/2004	**E**	**2**	*0.005*	U	0.042		0.020	I	0.058		0.034		0.340		0.269		0.088		120.0		158.0		7.3	
12/27/2004	**E**	**3**	*0.005*	U	0.044		0.043		0.042		*0.005*	U	0.152		0.099		0.061		21.9		20.5		4.8	
1/14/2005	**E**	**4**	0.011	I	0.081		0.071		0.051		0.022	I	0.255		0.252		0.150		24.5		39.2		12.3	
2/28/2005	**E**	**5**	*0.005*	U	0.048		0.043		0.046		0.033		0.263	J	0.197	J	0.150	J	49.6	J	46.4	J	10.6	J
3/4/2005	**E**	**6**	*0.005*	U	0.040		0.043		0.053		0.011	I	0.197		0.149		0.110		22.8		23.0		5.8	
3/10/2005	**E**	**7**	*0.005*	U	0.089		0.063		0.027	I	*0.005*	U	0.219		0.150		0.107		15.0		20.1		6.6	
3/17/2005	**E**	**8**	*0.005*	U	0.666		0.005	U	0.005	U	*0.005*	U	0.181		0.135		0.082		33.3		32.7		9.1	
4/4/2005	**E**	**9**	*0.005*	U	0.077		0.064		0.058		0.010	QI	0.251	Q	0.328	Q	0.176	Q	25.5		42.1		11.2	
4/13/2005	**E**	**10**	*0.005*	U	0.160		0.109		0.117		0.019	I	0.304		0.167		0.229		17.3		4.7		8.0	
4/25/2005	**E**	**11**	*0.005*	U	0.188		0.196		0.171		0.011	I	0.345		0.482		0.245		40.2		52.0		5.4	
4/27/2005	**E**	**12**	*0.005*	U	0.053		0.050		0.137		*0.005*	U	0.121		0.140		0.202		28.9		25.1		8.5	
5/2/2005	**E**	**13**	*0.005*	U	0.041		0.034		0.063		*0.005*	UQ	0.088	Q	0.148	Q	0.128	Q	14.5		12.4		5.2	
5/18/2005	**E**	**14**	0.025	I	0.099		0.092		0.078		0.032		0.206		0.276		0.201		32.0		62.5		35.0	
5/31/2005	**E**	**15**	0.011	I	0.125		0.144		0.071		0.015	I	0.217		0.275		0.311		50.7		60.9		52.2	
6/2/2005	**E**	**16**	*0.005*	U	0.039		0.043		0.066		*0.005*	U	0.177		0.160		0.152		33.4		67.0		19.0	
6/4/2005	**E**	**17**	*0.005*	U	0.051		0.052		0.071		*0.005*	U	0.111		0.141		0.116		16.9		9.7		5.6	
6/5/2005	**E**	**18**	*0.005*	U	0.049		0.051		0.070		*0.005*	U	0.110		0.130		0.119		11.8		10.6		7.2	
6/6/2005	**E**	**19**	*0.005*	U	0.050		0.052		0.072		*0.005*	U	0.133		0.161		0.120		12.7		12.8		7.4	
6/10/2005	**E**	**20**	*0.005*	U	0.025	I	0.030	I	0.052		*0.098*		0.102		0.095		0.130		16.4		21.0		9.9	
6/11/2005	**E**	**21**	*0.005*	U	0.032	I	0.044		0.060		*0.005*	U	0.070		0.075		0.093		3.4		4.6		2.5	
6/13/2005	**E**	**22**	*0.005*	U	0.040		0.051		0.066		*0.005*	U	0.106		0.104		0.112		28.6		19.3		6.4	
6/24/2005	**E**	**23**	*0.005*	U	0.047		0.030		0.025		*0.005*	I	0.111		0.099		0.125		24.6		17.5		21.2	
7/11/2005	**E**	**24**	*0.005*	U	0.020	I	*0.005*	U	0.036		0.119		0.084		0.090		*0.005*	U	31.1		16.2		12.5	
7/13/2005	**E**	**25**	*0.005*	U	0.086		0.079		0.065		*0.005*	U	0.190		0.147		0.120		34.4		32.5		13.6	
7/14/2005	**E**	**26**	*0.005*	U	0.049		0.044		0.043		*0.005*	U	0.084		0.089		0.120		23.0		24.8		27.7	
7/25/2005	**E**	**27**	*0.005*	U	0.035		0.025		0.068		*0.005*	U	0.162		0.208		0.142		92.5		86.3		24.0	
7/30/2005	**E**	**28**	*0.005*	U	0.029		0.016		0.029	I	*0.005*	U	0.128		0.099		0.104		36.5		30.0		8.4	
8/2/2005	**E**	**29**	*0.005*	U	0.033		0.029	I	0.013	I	0.021	I	0.094		0.087		0.069		22.7		25.3		9.1	
8/6/2005	**E**	**30**	*0.005*	U	0.039		0.020	I	0.027	I	0.019	I	0.087		0.098		0.054		17.9		23.4		4.1	
8/22/2005	**E**	**31**	*0.005*	U	0.059		0.045		0.030	I	*0.005*	U	0.089		0.123		0.115		9.2		23.3		14.9	
8/23/2005	**E**	**32**	*0.005*	U	0.032	I	0.023	I	0.024	I	*0.005*	U	0.054		0.074		0.067		3.8		7.1		5.7	
8/24/2005	**E**	**33**	*0.005*	U	0.038		0.028	I	0.031	I	0.012	I	0.103		0.104		0.093		21.6		21.4		12.4	
8/29/2005	**E**	**34**	*0.005*	U	0.024	I	0.013	I	0.012	I	*0.005*	U	0.061		0.055		0.048		20.9		16.5		2.4	
# Samples			34		34		34		34		34		34		34		34		34		34		34	
Mean			0.0059		0.075		0.051		0.057		0.017		0.163		0.159		0.126		35.0		32.2		11.9	
Median			0.0050		0.046		0.044		0.056		0.005		0.131		0.141		0.120		23.8		23.4		8.8	
St. Dev.			0.0037		0.111		0.039		0.035		0.025		0.085		0.088		0.060		41.7		29.2		10.1	
Max			0.0250		0.666		0.196		0.171		0.119		0.345		0.482		0.311		233.0		158.0		52.2	
Min			0.0050		0.020		0.005		0.005		0.005		0.054		0.055		0.005		3.4		4.6		2.4	
C.V.			0.62		1.48		0.76		0.61		1.49		0.52		0.55		0.48		1.19		0.91		0.85	

BASE FLOW FOR YEAR THREE

Date			**Ortho-Phosphorus**								**Total Phosphorus**								**TSS**					
sample collected	**base flow**	**event #**	MG/L								MG/L								ug/L					
			Lab Detection Limit 0.01								Lab Detection Limit 0.01								Lab D. L. 0.05					
			556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	934.0	DQ	935	DQ		DQ
			RAIN		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**	
11/15/2004	**B**	**1**			0.075		0.062		0.062				0.089	J	0.088	J	0.125	J	7.8	J	12.2	J	9.9	J
11/24/2004	**B**	**2**			0.056		0.053		0.033				0.089	J	0.092	J	0.090	J	3.7	J	2.7	J	7.6	J
12/9/2004	**B**	**3**			0.053		0.056		0.096				0.059		0.070		0.122		4.0		4.0		6.2	
1/12/2005	**B**	**4**			0.029	I	0.034		0.029	I			0.060		0.067		0.105		3.3		2.3		9.3	
2/14/2005	**B**	**5**			0.060		0.048		0.015				0.204		0.104		0.065		7.2		1.1		3.2	
2/25/2004	**B**	**6**			0.040		0.059		0.035				0.124	J	0.146	J	0.102	J	3.6	J	4.8	J	9.7	J
3/3/2005	**B**	**7**			0.128		0.076		0.070				0.274		0.132		0.109		13.6		3.1		3.7	
4/7/2005	**B**	**8**			0.078		0.084		0.076				0.125		0.109		0.168		7.3		1.8		7.2	
4/18/2005	**B**	**9**			0.136		0.173		0.091				0.166		0.211		0.146		2.1		2.3		4.1	
5/16/2005	**B**	**10**			0.105		0.131		0.038				0.147		0.188		0.280		3.0		3.3		28.4	
6/22/2005	**B**	**11**			0.036		0.068		0.050				0.403		0.126		0.110		32.7		3.4		2.7	
8/5/2005	**B**	**12**			0.045		0.052		0.015	I			0.064		0.076		0.070		1.0		1.4		6.3	
9/20/2005	**B**	**13**			0.034		0.042		0.024	I			0.064		0.074		0.131		2.8		3.9		10.7	
# Samples					13		13		13				13		13		13		13		13		13	
Mean					0.067		0.072		0.049				0.144		0.114		0.125		7.1		3.6		8.4	
Median					0.056		0.059		0.038				0.124		0.104		0.110		3.7		3.1		7.2	
St. Dev.					0.036		0.039		0.028				0.101		0.046		0.054		8.4		2.8		6.6	
Max					0.136		0.173		0.096				0.403		0.211		0.280		32.7		12.2		28.4	
Min					0.029		0.034		0.015				0.059		0.067		0.065		1.0		1.1		2.7	
C.V.					0.53		0.54		0.57				0.70		0.40		0.44		1.18		0.79		0.79	

STORM EVENTS YEAR THREE CDS UNIT CLEANED OUT 4/20/05

Date			Aluminum						Copper								Iron								Zinc							
sample collected	event type	#							ug/L								ug/L								ug/L							
									Lab Detection Limit 3.0								Lab Detection Limit 50.0								Lab Detection Limit 30							
			934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
			BEFORE CDS		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**	
11/29/2004	**E**	**1**	2490		714		206		*1.50*	U	15.50		13.60		4.65	I	89.3		2190		839		184		9.0		130.0		164.0		35.1	
12/16/2004	**E**	**2**	1470		1960		257		*1.50*	U	20.60		23.90		*1.50*	U	154.0	J	1620	J	1990	J	262	J	9.3		212.0		267.0		16.2	
12/27/2004	**E**	**3**	419		253		166		*1.50*	U	6.54	I	3.97	I	*1.50*	U	59.1		647		292		180		3.7	I	86.5		54.5		11.2	
1/14/2005	**E**	**4**	416		542		291		*1.50*	U	9.61		10.30		3.22	I	67.8		433		558		261		5.5	I	92.9		110.0		21.2	
2/28/2005	**E**	**5**	599		594		240		3.16	I	12.10		11.80		4.37	I	68.2		845		678		273		7.8		144.0		119.0		35.6	
3/4/2005	**E**	**6**	335		331		198		*1.50*	U	6.67	I	6.61	I	*1.50*	U	24.0	I	617		343		160		4.1	I	94.6		80.8		16.2	
3/10/2005	**E**	**7**	224		303		165		*1.50*	U	4.74	I	7.21	I	3.11	I	32.6	I	697		331		194		3.2	I	58.7		79.5		24.6	
3/17/2005	**E**	**8**	642		410		237		*1.50*	U	15.70		13.00		9.27		54.0		622		418		205		5.4	I	101.0		68.4		29.9	
4/4/2005	**E**	**9**	538		660		172		5.17	I	10.00		12.80		3.45	I	*6.3*	U	654		749		203		52.6		95.3		121.0		24.2	
4/13/2005	**E**	**10**	471		102		183		*1.50*	U	19.70		5.17	I	5.82	I	81.3		465		199		223		34.6		82.0		41.3		30.6	
4/25/2005	**E**	**11**	696		961		147		*1.50*	U	9.69		15.30		3.13	I	65.4		623		205		205		30.3		97.4		142.0		18.5	J
4/27/2005	**E**	**12**	435		489		238		*1.50*	U	7.07	I	8.34	I	*1.50*	U	52.5		358		414		263		14.0		61.3		70.1		23.8	
5/2/2005	**E**	**13**	216		227		168		*1.50*	U	4.20	I	5.85	I	*1.50*	U	23.4	I	191		215		162		11.5		60.1		59.2		22.6	
5/18/2005	**E**	**14**	658		971		971		4.55	I	17.50		18.50		10.10		95.5		584		945		637		17.4		94.2		129.0		62.6	
5/31/2005	**E**	**15**	568		897		1550		*1.50*	U	11.80		17.90		18.80		49.3	J	527	J	867	J	1120		7.5		66.8		99.9		146.0	
6/2/2005	**E**	**16**	638		972		530		3.56	I	22.70		29.10		12.00		150.0		623		808		367		6.3	I	57.1		90.8		34.1	
6/4/2005	**E**	**17**	507		810		269		3.32	I	15.50		18.40		8.20	I	85.6		393		648		248		9.8		36.6		53.5		21.8	
6/5/2005	**E**	**18**	477		806		269		3.40	I	14.50		18.30		8.49	I	231.0		380		644		246		11.9		34.9		54.4		21.0	
6/6/2005	**E**	**19**	513		807		249		3.43	I	14.50		18.80		7.71	I	87.7		397		651		230		9.5		36.3		56.4		20.1	
6/10/2005	**E**	**20**	288		239		261		*1.50*	U	7.00	I	6.57	I	4.66	I	31.1	I	213		181		193		4.2	I	32.1		29.8		18.3	
6/11/2005	**E**	**21**	164		128		94.9		*1.50*	U	5.89	I	6.60	I	*1.50*	U	*6.3*	U	113		104		83.2		4.2	I	26.0		22.0		12.1	
6/13/2005	**E**	**22**	494		209		141		*1.50*	U	16.70		9.60		3.16	I	30.3	I	478		221		141		5.2	I	78.8		34.5		16.2	
6/24/2005	**E**	**23**	440		249		396		*1.50*	U	6.20	I	8.88	I	5.43	I	79.8		358		331		410		8.3		54.7		54.0		41.2	
7/11/2005	**E**	**24**	360		267		279		*1.50*	U	5.36	I	5.09	I	*1.50*	U	45.0		295		230		219		5.7		47.5		38.3		20.7	
7/13/2005	**E**	**25**	1260		1170		644		*1.50*	U	10.50		9.22		4.02	I	59.4		678		679		348		6.7		43.6		42.2		20.5	
7/14/2005	**E**	**26**	658		665		1270		*1.50*	U	4.39	I	4.76	I	6.72	I	94.2		363		364		636		5.8		32.5		32.5		41.7	
7/25/2005	**E**	**27**	2960		2750		788		*1.50*	U	9.86	I	8.29	I	*1.50*	U	55.6		1100		1010		326		11.1		103.0		94.9		21.8	
7/30/2005	**E**	**28**	1300		975		241		*1.50*	U	8.08	I	7.44		*1.50*	U	70.8		714		575		163		8.7		79.3		73.8		12.8	
8/2/2005	**E**	**29**	585		615		579		*1.50*	U	7.96	I	7.75	I	4.91	I	121.0		354		389		307		9.3		49.0		46.8		30.5	
8/6/2005	**E**	**30**	599		533		276		*1.50*	U	5.07	I	22.80		3.60	I	124.0		330		427		181		11.2		43.6		62.2		23.2	
8/22/2005	**E**	**31**	264		342		241		*1.50*	U	4.63	I	9.60		4.31	I	25.5		231		275		164		6.3		22.4		43.9		19.0	
8/23/2005	**E**	**32**	104		154		143		*1.50*	U	*1.50*	U	9.71		5.80	I	48.8		74		166		102		8.2		15.4		33.0		19.6	
8/24/2005	**E**	**33**	422		493		447		*1.50*	U	8.19	I	7.84	I	6.12	I	24.5	I	247		343		235		2.5	I	22.3		33.5		21.1	
8/29/2005	**E**	**34**	287		268		87.9		*1.50*	U	4.36	I	4.74	I	3.35	I	20.3	I	226		228		75.7		3.7	I	34.5		13.3		6.7	
# Samples			34		34		34		34		34		34		34		34		34		34		34		34		34		34		34	
Mean			662		643		365		1.97		10.13		11.40		4.94		68		548		509		271		10.4		68.4		74.0		27.7	
Median			501		538		245		1.50		8.90		9.41		4.17		59		449		402		221		8.0		59.4		57.8		21.5	
St. Dev.			605		533		331		1.00		5.41		6.25		3.70		47		414		362		195		10.1		40.8		49.9		23.4	
Max			2960		2750		1550		5.17		22.70		29.10		18.80		231		2190		1990		1120		52.6		212.0		267.0		146.0	
Min			104		102		88		1.50		1.50		3.97		1.50		6		74		104		76		2.5		15.4		13.3		6.7	
C.V.			0.91		0.83		0.91		0.51		0.53		0.55		0.75		0.69		0.75		0.71		0.72		0.97		0.60		0.67		0.85	

DISSOLVED METALS IN STORM FLOW FOR YEAR THREE

Date		Dissolved Zinc						Dissolved Copper						Dissolved Iron						Dissolved Lead					
sample	event or	ug/L						ug/L						ug/L						ug/L					
collected	base flow	Lab Detection Limit 15						Lab Detection Limit 3.0						Lab Detection Limit 50.0						Lab Detection Limit 2.0					
		934		935		939		934		935		939		934		935		939		934		935		939	
STORM FLOW YEAR THREE		BEFORE CDS	DQ	AFTER CDS	DQ	OUTFLOW	DQ	BEFORE CDS	DQ	AFTER CDS	DQ	OUTFLOW	DQ	BEFORE CDS	DQ	AFTER CDS	DQ	OUTFLOW	DQ	BEFORE CDS	DQ	AFTER CDS	DQ	OUTFLOW	DQ
11/29/2004	**E**	37.8		61		26.5		3.35	I	5.27	I	3.42	I	292		59.8		35	I	*5*	U	*5*	U	*5*	U
12/16/2004	**E**	49.8		49.2		8.87		6.38	I	4.3	I	*1.5*	U	66.7		72.1		71.8		*5*	U	*5*	U	*5*	U
12/27/2004	**E**	19.3		19.9		6.1	I	*1.5*	U	*1.5*	U	*1.5*	U	35.1	I	24.4	I	77.3		*5*	U	*5*	U	*5*	U
1/14/2005	**E**	45.2		43.4		12.9		4.41	I	4.14	I	*1.5*	U	44.2		56.9		81.8		*5*	U	*5*	U	*5*	U
2/28/2005	**E**	29.4		31.5		22.7		*1.5*	U	*1.5*	U	*1.5*	U	39.7	I	31.3	I	30.5	I	*5*	U	*5*	U	*5*	U
3/4/2005	**E**	36.6		36.8		10.9		*1.5*	U	*1.5*	U	*1.5*	U	196		42		50.1		*5*	U	*5*	U	*5*	U
3/10/2005	**E**	31.6		39.3		18.5		*1.5*	U	*1.5*	U	*1.5*	U	375		45.6		51.1		*5*	U	*5*	U	*5*	U
3/17/2005	**E**	25.8		23		37.5	I	5.23	I	6.14	I	5.66	I	31.4	I	37.4		37.5	I	*5*	U	*5*	U	*5*	U
4/4/2005	**E**	25.1		40.2		14.7		*1.5*	U	*1.5*	U	*1.5*	U	69.6		55.4		44.8		*5*	U	*5*	U	*5*	U
4/13/2005	**E**	35.8		37.4		23.6		*1.5*	U	3.83	I	3.59	I	21.1	I	122		66.2		*5*	U	*5*	U	*5*	U
4/25/2005	**E**	35.7		46.2		23.2	J	3.17	I	3.42	I	*1.5*	U	25.3	I	40.4		104		*5*	U	*5*	U	*5*	U
4/27/2005	**E**	27.4		31.6		17.5		3.25	I	*1.5*	U	*1.5*	U	30.2	I	36.2	I	92.2		*5*	U	*5*	U	*5*	U
5/2/2005	**E**	28.1		37.7		18		4.62	I	*1.5*	U	*1.5*	U	14.7	I	29.7	I	46.4		*5*	U	*5*	U	*5*	U
5/18/2005	**E**	28.5		33.2		18.4		4.11	I	3.68	I	*1.5*	U	25.4	I	43.9		52.7		*5*	U	*5*	U	*5*	U
5/31/2005	**E**	22		26.1		24.6		3.59	I	3.11	I	*1.5*	U	26.9	I	35.1	I	66.3		*5*	U	*5*	U	*5*	U
6/2/2005	**E**	14.5		14.4		13.2		9.68		8.42	I	4.84	I	28.8	I	22.7	I	32.8	I	*5*	U	*5*	U	*5*	U
6/4/2005	**E**	10.2		10.8		9.6		5.73	I	5.34	I	4.6	I	20.8	I	22.5	I	49.9		*5*	U	*5*	U	*5*	U
6/5/2005	**E**	10.1		10.6		10.1		5.04	I	5.02	I	4.52	I	21.8	I	23	I	48.1		*5*	U	*5*	U	*5*	U
6/6/2005	**E**	10.1		10.7		9.01		4.78	I	4.8	I	4.3	I	21	I	28.9	I	52		*5*	U	*5*	U	*5*	U
6/10/2005	**E**	13.8		14		9.71		3.46	I	3.68	I	*1.5*	U	15.3	I	24.2	I	27.2	I	*5*	U	*5*	U	*5*	U
6/11/2005	**E**	13.4		14.7		9.17		*1.5*	U	3.5	I	*1.5*	U	14	I	40.1		33.1	I	*5*	U	*5*	U	*5*	U
6/13/2005	**E**	135		14.9		9.13		*1.5*	U	3.3	I	*1.5*	U	14.4	I	37.8	I	34.6	I	*5*	U	*5*	U	*5*	U
6/24/2005	**E**	16.8		27.5		15.3		3.27	I	4.8	I	*1.5*	U	25.8	I	107		55.1		*5*	U	*5*	U	*5*	U
# Samples		23		23		23		23		23		23		23		23		23		23		23		23	
Mean		30.5		29.3		16.1		3.6		3.6		2.4		63.3		45.1		53.9		5.0		5.0		5.0	
Median		27.4		31.5		14.7		3.4		3.7		1.5		26.9		37.8		50.1		5.0		5.0		5.0	
St. Dev.		25.4		14.1		7.6		2.1		1.8		1.4		94.0		25.5		20.5		0.0		0.0		0.0	
Max		135.0		61.0		37.5		9.7		8.4		5.7		375.0		122.0		104.0		5.0		5.0		5.0	
Min		10.1		10.6		6.1		1.5		1.5		1.5		14.0		22.5		27.2		5.0		5.0		5.0	
C.V.		0.83		0.48		0.47		0.58		0.50		0.60		1.49		0.57		0.38		0.00		0.00		0.00	

BASE FLOW YEAR THREE

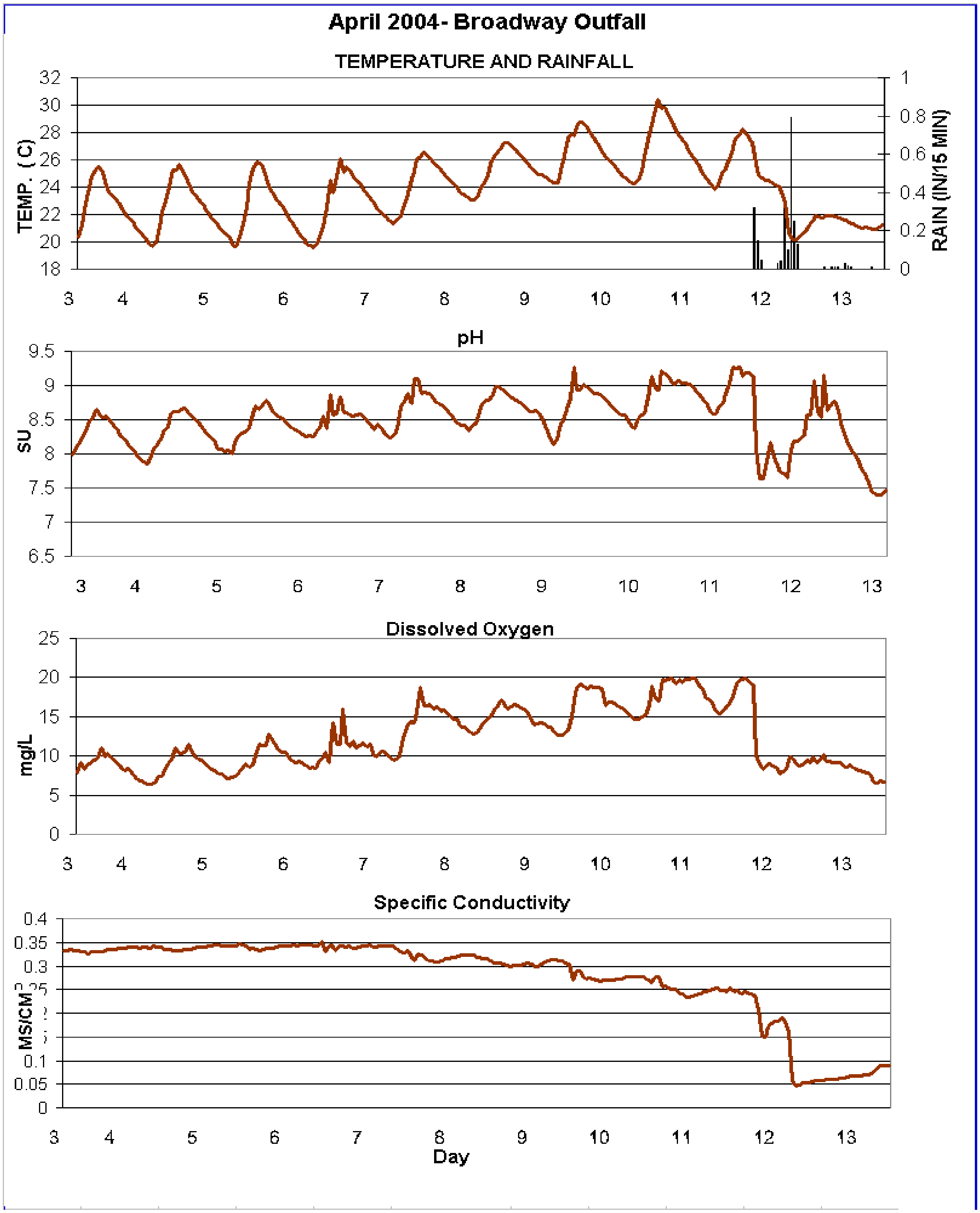
Date			Aluminum						Copper								Iron								Zinc							
sample									ug/L								ug/L								ug/L							
collected	base flow								Lab Detection Limit 3.0								Lab Detection Limit 50.0								Lab Detection Limit 30							
			934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ	556	DQ	934	DQ	935	DQ	939	DQ
			BEFORE CDS		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**		**RAIN**		**BEFORE CDS**		**AFTER CDS**		**OUTFLOW**	
11/15/2004	**B**	**1**	164.00		206.00		346				*1.50*	U	*1.50*	U	*1.50*	U			253		300		302				7.7		19.1		16.6	
11/24/2004	**B**	**2**	97.70		98.10		277				*1.50*	U	*1.50*	U	*1.50*	U			209		202		239				23.5		26.8		10.7	
12/9/2004	**B**	**3**	76.40		75.40		246				*1.50*	U	*1.50*	U	*1.50*	U			235		222		373				14.8		19.5		13.4	
1/12/2005	**B**	**4**	36.70	I	25.00	I	359				*1.50*	U	*1.50*	U	*1.50*	U			239		230		222				13.0		13.0		13.4	
2/14/2005	**B**	**5**	25.30	I	10.00	U	122				*1.50*	U	*1.50*	U	*1.50*	U			291		239		121				20.7		31.5		14.9	
2/25/2005	**B**	**6**	24.50	I	38.90	I	283				*1.50*	U	3.61	I	*1.50*	U			265		279		275				32.0		46.9		16.5	
3/3/2005	**B**	**7**	77.10		44.30	I	173				*1.5*	U	*1.5*	U	*1.5*	U			896		386		129				25		21.3		12	
4/7/2005	**B**	**8**	56.00		32.90	I	107				3.11	I	*1.5*	U	*1.5*	U			367		246		164				35.8		23		10.2	
4/18/2005	**B**	**9**	31.40	I	25.30	I	65.9				*1.5*	U	*1.5*	U	*1.5*	U			285		285		175				28.4		28.3		9.92	J
5/16/2005	**B**	**10**	29.10	I	29.80	I	467				1.5	U	1.5	U	5.73	I			217		241		596				21		17.5		38.6	
6/22/2005	**B**	**11**	289.00		54.80	I	50.2	I			4.55	I	4.7	I	5.01	I			530		235		220				70.3		26.3		25.6	
8/5/2005	**B**	**12**	56.30	I	66.50		171				7.06	I	6.42	I	*1.5*	U			100		114		117				18.3		28.7	J6	10.6	
9/20/2005	**B**	**13**	41.40	I	55.70	I	381				3.14	J	3.48		*4.58*				135		109		293				12.3		14.1		19.7	
# Samples			13		13		13				13		13		13				13		13		13				13		13		13	
Mean			77.30		58.67		234.47				2.41		2.44		2.33				309.38		237.54		248.15				24.83		24.31		16.32	
Median			56.00		44		246				2		2		2				253		239		222				21		23		13	
St. Dev.			74.44		50.28		131.30				1.70		1.62		1.60				205		72.66		130.31				15.86		8.88		8.03	
Max			289.00		206.00		467.00				7.06		6.42		5.73				896		386		596				70.3		46.90		38.60	
Min			24.50		10.00		50.20				1.50		1.50		1.50				100		109		117				7.72		13		9.92	
C.V.			0.96		0.86		0.56				0.70		0.66		0.69				0.66		0.31		0.53				0.64		0.37		0.49	

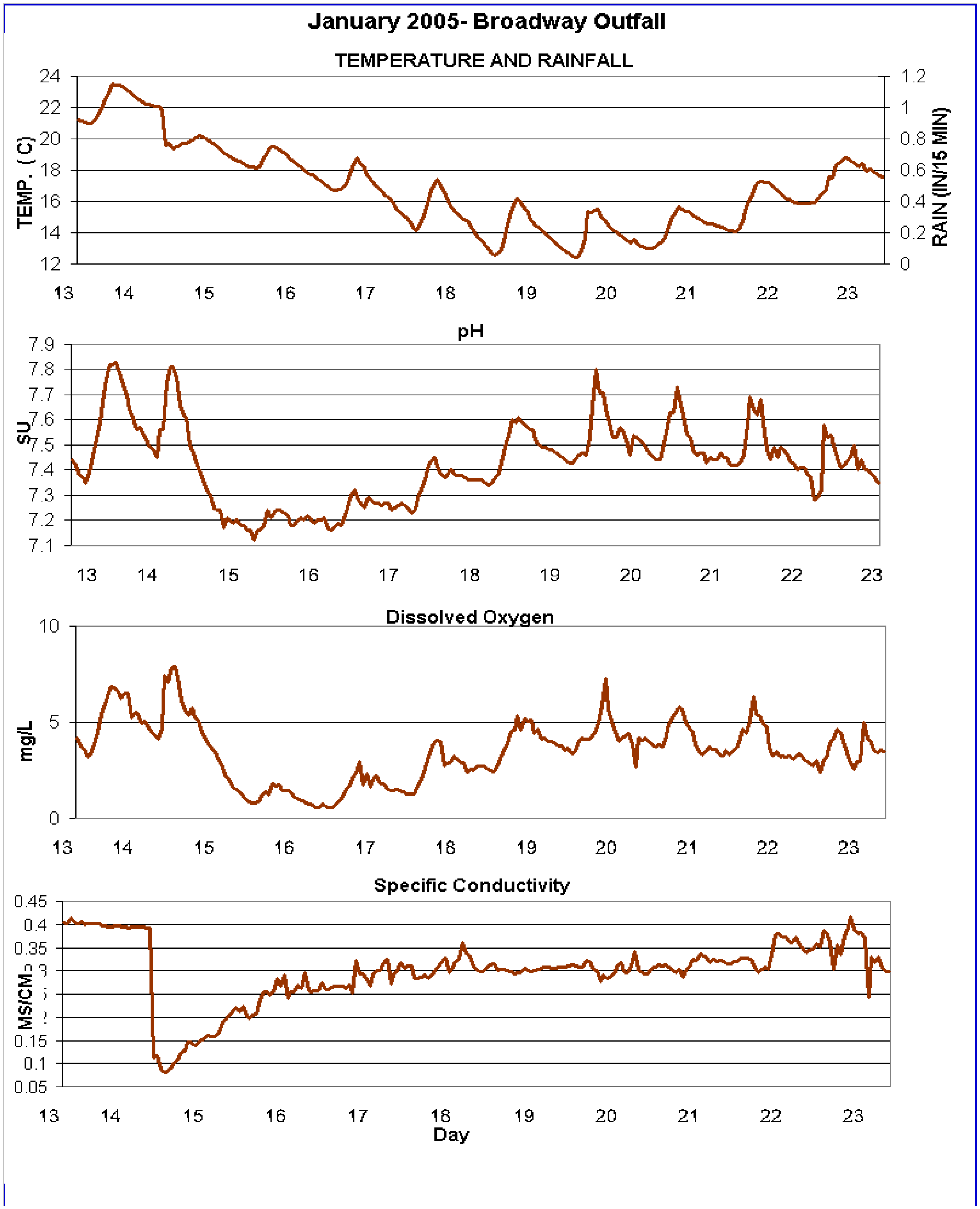
DISSOLVED METALS IN STORM FLOW FOR YEAR THREE

Date		Dissolved Zinc						Dissolved Copper						Dissolved Iron						Dissolved Lead					
sample	event or	ug/L						ug/L						ug/L						ug/L					
collected	base flow	Lab Detection Limit 15						Lab Detection Limit 3.0						Lab Detection Limit 50.0						Lab Detection Limit 2.0					
		934		935		939		934		935		939		934		935		939		934		935		939	
STORM FLOW YEAR THREE		**BEFORE CDS**	**DQ**	**AFTER CDS**	**DQ**	**OUTFLOW**	**DQ**	**BEFORE CDS**	**DQ**	**AFTER CDS**	**DQ**	**OUTFLOW**	**DQ**	**BEFORE CDS**	**DQ**	**AFTER CDS**	**DQ**	**OUTFLOW**	**DQ**	**BEFORE CDS**	**DQ**	**AFTER CDS**	**DQ**	**OUTFLOW**	**DQ**
11/15/2004	**B**	4.81	I	11.3		5.54	I	*1.5*	U	*1.5*	U	*1.5*	U	106		93.7		81.8		*5*	U	*5*	U	*5*	U
11/24/2004	**B**	18.9		21.8		3.57	I	*1.5*	U	*1.5*	U	*1.5*	U	88.5		69.1		64.4		*5*	U	*5*	U	*5*	U
12/9/2004	**B**	11.8		14.9		5.35		*1.5*	U	*1.5*	U	*1.5*	U	112		99.5		198		*5*	U	*5*	U	*5*	U
1/12/2005	**B**	9.1		11.2		3.96	I	*1.5*	U	*1.5*	U	*1.5*	U	130		122		23.5	I	*5*	U	*5*	U	*5*	U
2/14/2005	**B**	14		28.1		13.3		*1.5*	U	*1.5*	U	*1.5*	U	172		156		39.9		*5*	U	*5*	U	*5*	U
2/25/2005	**B**	27		40.8		6.41		*1.5*	U	*1.5*	U	*1.5*	U	171		168		18.3		*5*	U	*5*	U	*5*	U
3/3/2005	**B**	14.6		15.9		6.91		*1.5*	U	*1.5*	U	*1.5*	U	358		174		40.9		*5*	U	*5*	U	*5*	U
4/7/2005	**B**	15.7		22.3		9.64		*1.5*	U	*1.5*	U	*1.5*	U	171		161		54.8		*5*	U	*5*	U	*5*	U
4/18/2005	**B**	24.7		33.3		16.7	J	*1.5*	U	*1.5*	U	*1.5*	U	171		176		84.1		*5*	U	*5*	U	*5*	U
5/16/2005	**B**	18.3		15.3		13.5		*1.5*	U	*1.5*	U	*1.5*	U	108		105		74.6		*5*	U	*5*	U	*5*	U
6/22/2005	**B**	31.9		24.9		23.8		*1.5*	U	4.6	I	5.55	I	139		146		147		*5*	U	*5*	U	*5*	U
# Samples		11		11		11		11		11		11		11		11		11		11		11		11	
Mean		17.3		21.8		9.9		1.5		1.8		1.9		157.0		133.7		75.2		5.0		5.0		5.0	
Median		15.7		21.8		6.9		1.5		1.5		1.5		139.0		146.0		64.4		5.0		5.0		5.0	
St. Dev.		8.0		9.4		6.3		0.0		0.9		1.2		73.5		37.3		54.1		0.0		0.0		0.0	
Max		31.9		40.8		23.8		1.5		4.6		5.6		358.0		176.0		198.0		5.0		5.0		5.0	
Min		4.8		11.2		3.6		1.5		1.5		1.5		88.5		69.1		18.3		5.0		5.0		5.0	
C.V.		0.46		0.43		0.64		0.00		0.52		0.65		0.47		0.28		0.72		0.00		0.00		0.00	

APPENDIX F

FIELD PARAMETERS


April 2004- Broadway Outfall
TEMPERATURE AND RAINFALL
TEMP. (C)
32
30
28
26
24
22
20
18
RAIN (IN/15 MIN)
1
0.8
0.6
0.4
0.2
0
3
4
5
6
7
8
9
10
11
12
13
pH
SU
9.5
9
8.5
8
7.5
7
6.5
Dissolved Oxygen
mg/L
25
20
15
10
5
0
Specific Conductivity
MS/CM²
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Day



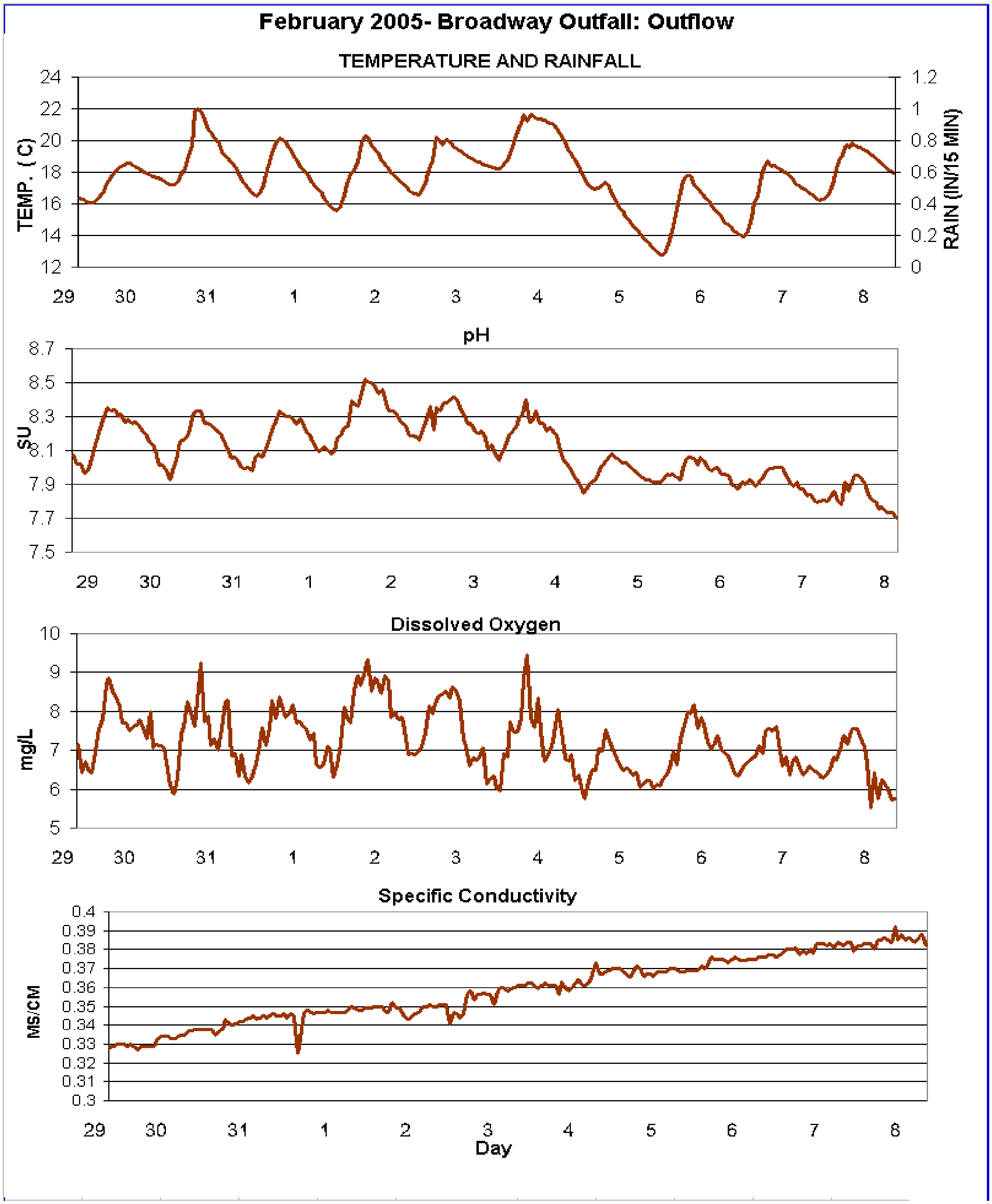
January 2005- Broadway Outfall

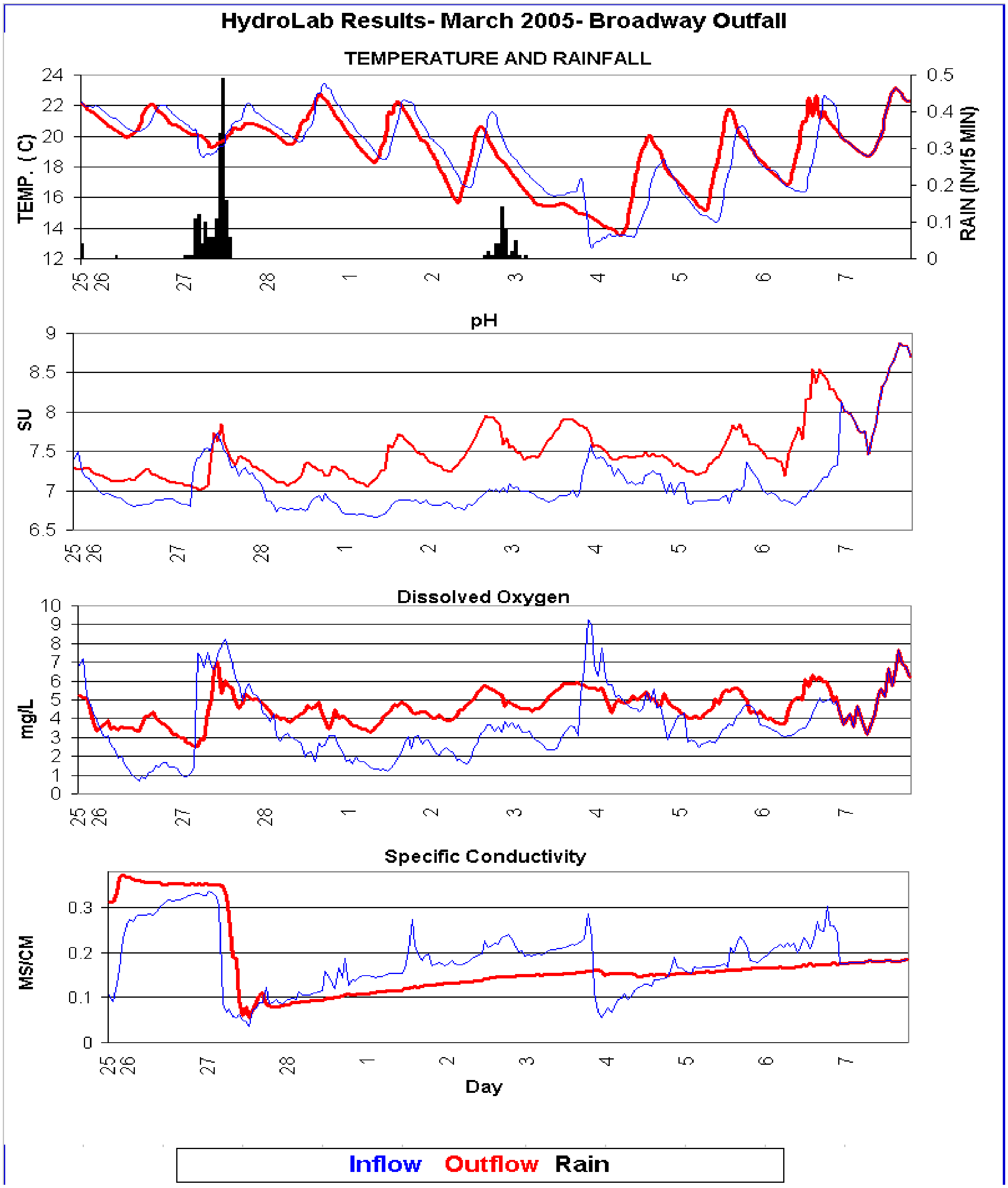
TEMPERATURE AND RAINFALL

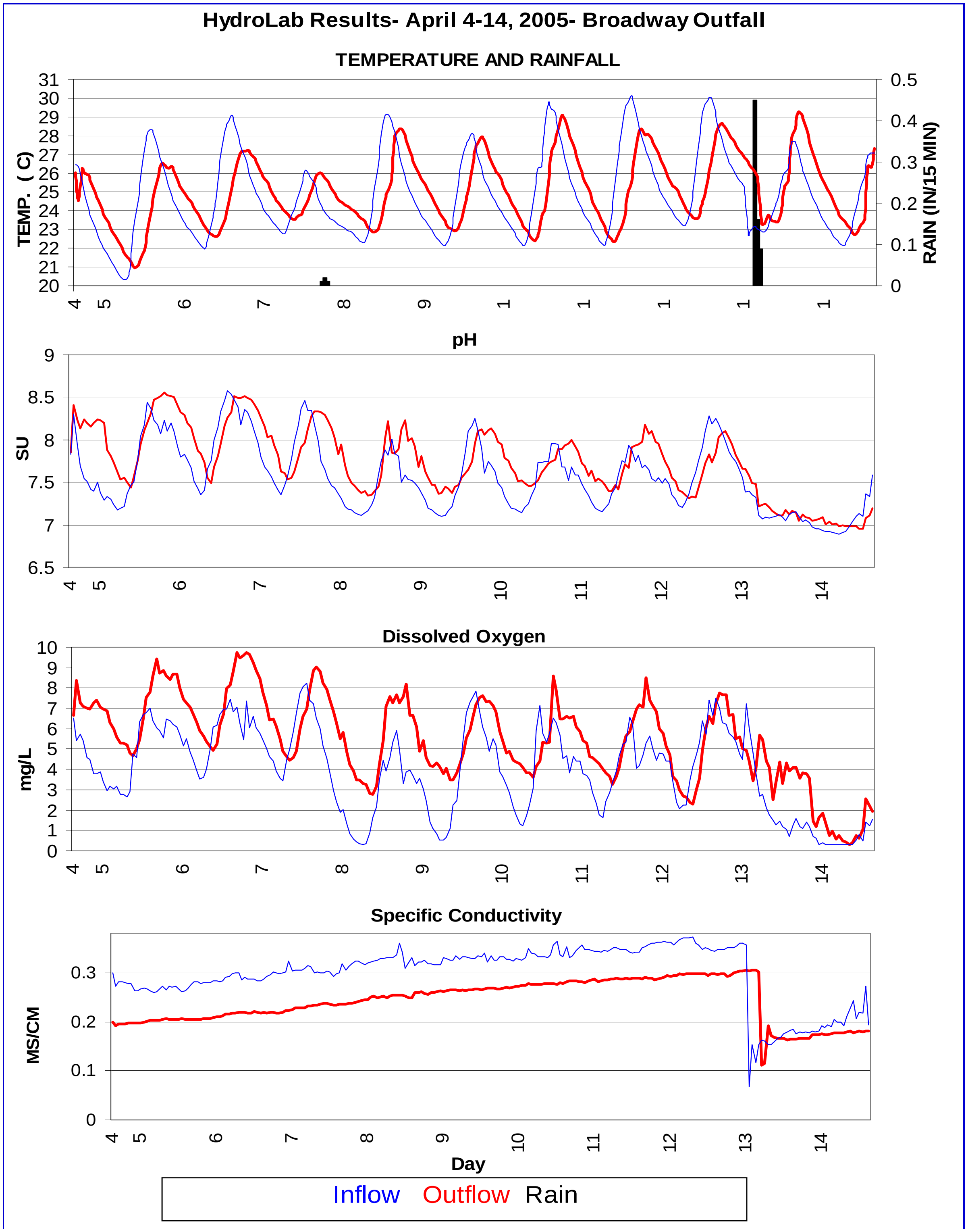
pH

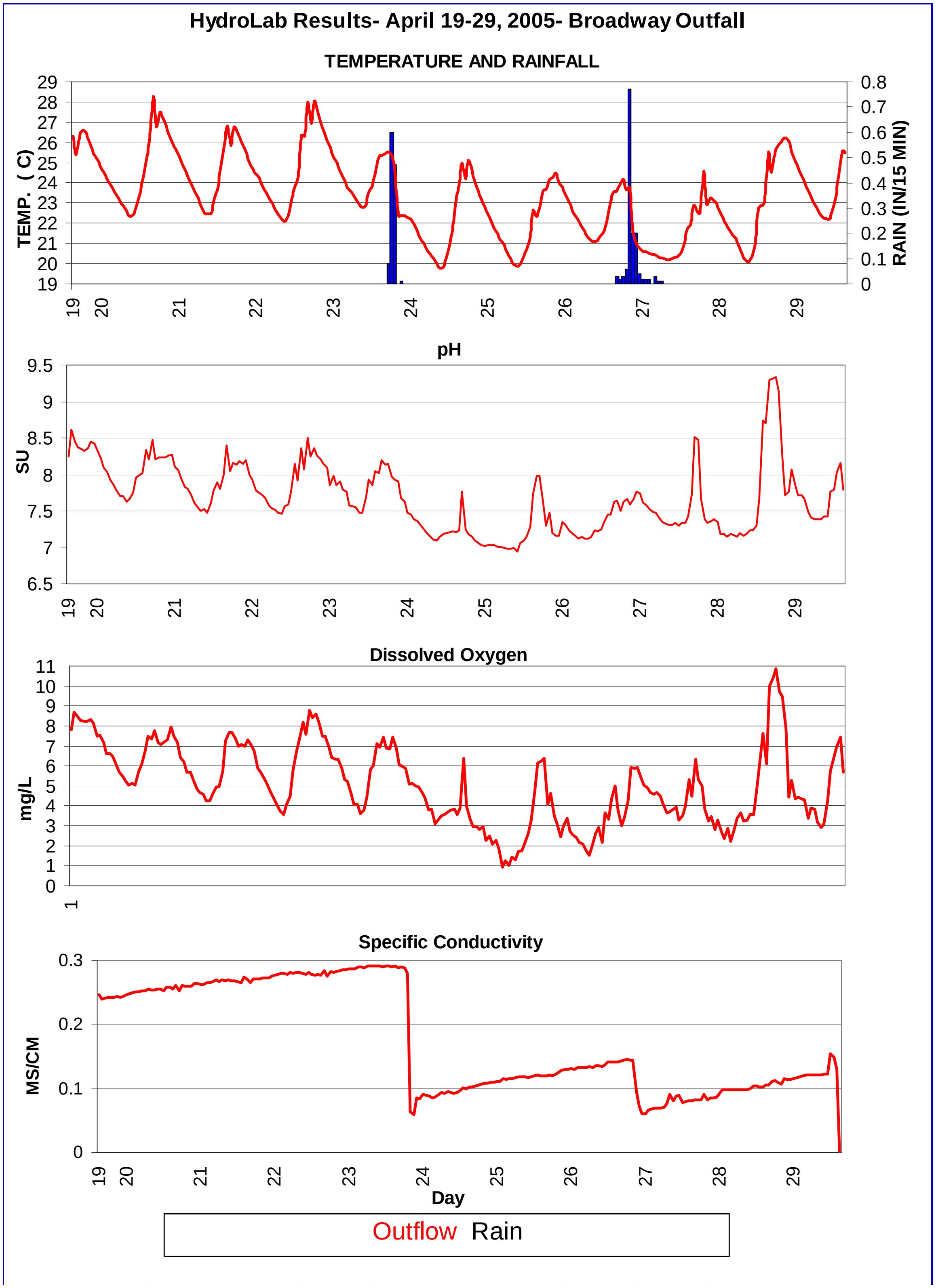
Dissolved Oxygen

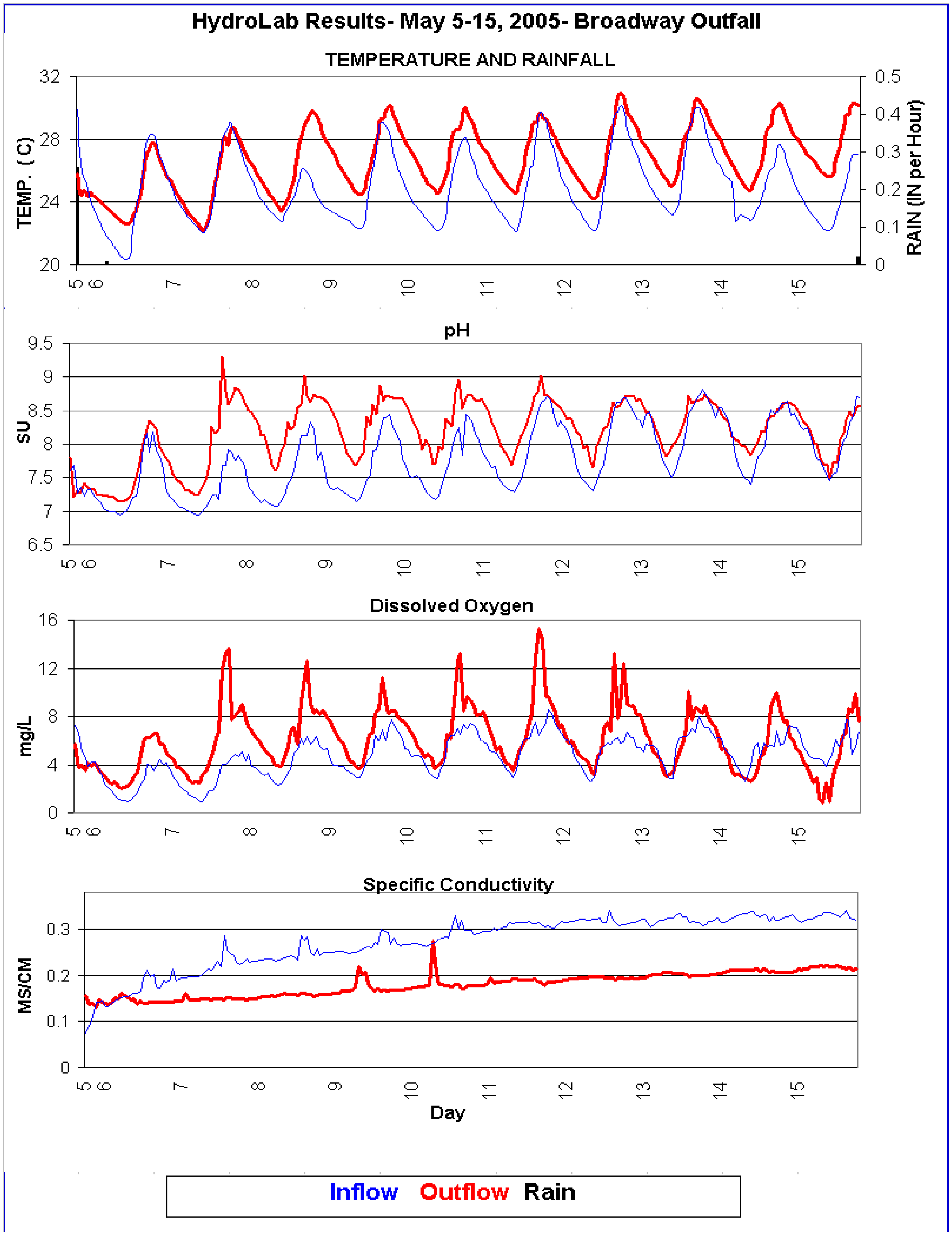
Specific Conductivity


February 2005- Broadway Outfall: Outflow
TEMPERATURE AND RAINFALL
TEMP. (C)
24
22
20
18
16
14
12
RAIN (IN/15 MIN)
1.2
1
0.8
0.6
0.4
0.2
0
29
30
31
1
2
3
4
5
6
7
8
pH
SU
8.7
8.5
8.3
8.1
7.9
7.7
7.5
Dissolved Oxygen
mg/L
10
9
8
7
6
5
Specific Conductivity
MS/CM
0.4
0.39
0.38
0.37
0.36
0.35
0.34
0.33
0.32
0.31
0.3
Day

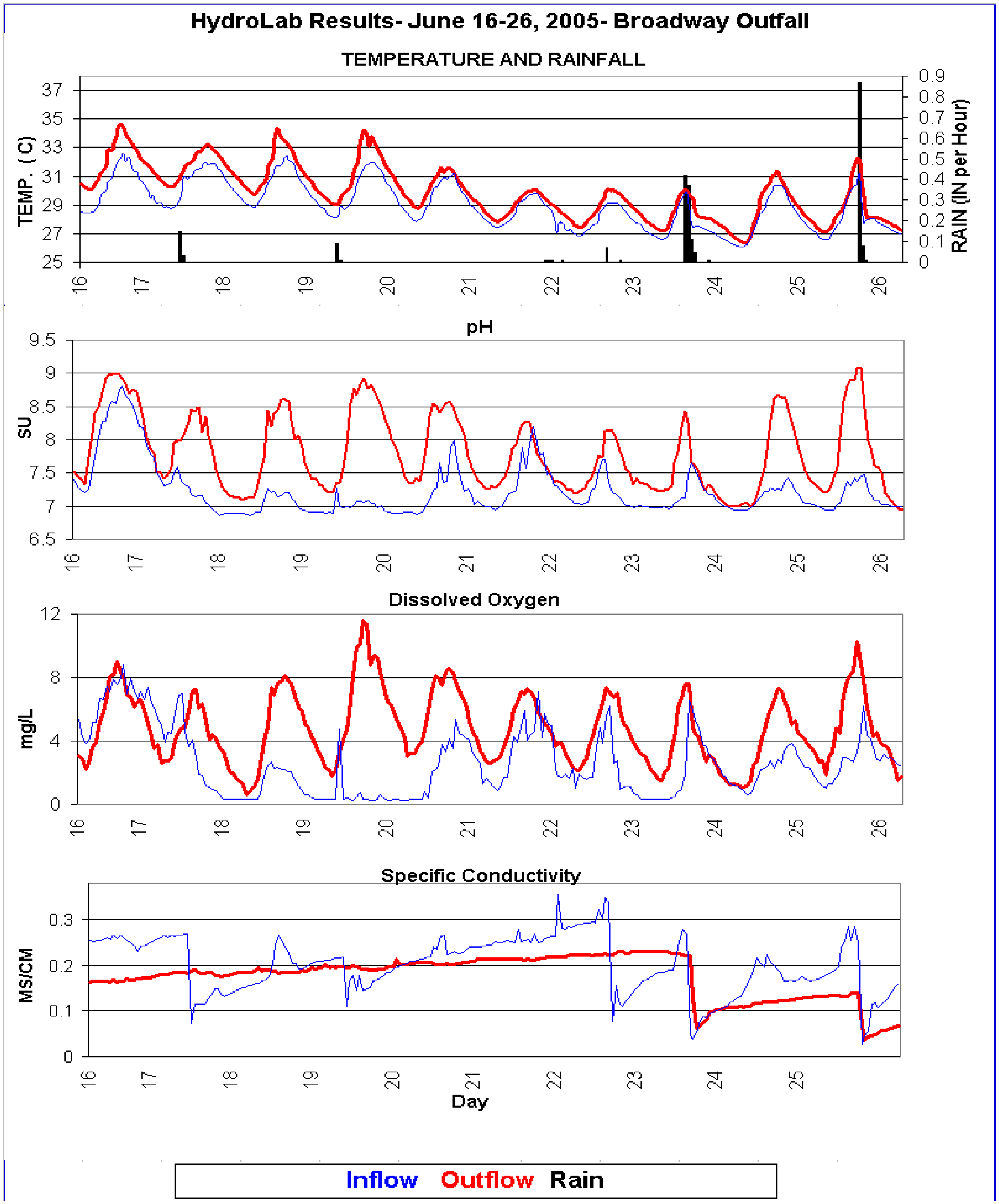

HydroLab Results- March 2005- Broadway Outfall
TEMPERATURE AND RAINFALL
TEMP. (C)
24
22
20
18
16
14
12
RAIN (IN/15 MIN)
0.5
0.4
0.3
0.2
0.1
0
25
26
27
28
1
2
3
4
5
6
7
pH
SU
9
8.5
8
7.5
7
6.5
Dissolved Oxygen
mg/L
10
9
8
7
6
5
4
3
2
1
0
Specific Conductivity
MS/CM
0.3
0.2
0.1
0
Day
Inflow
Outflow
Rain

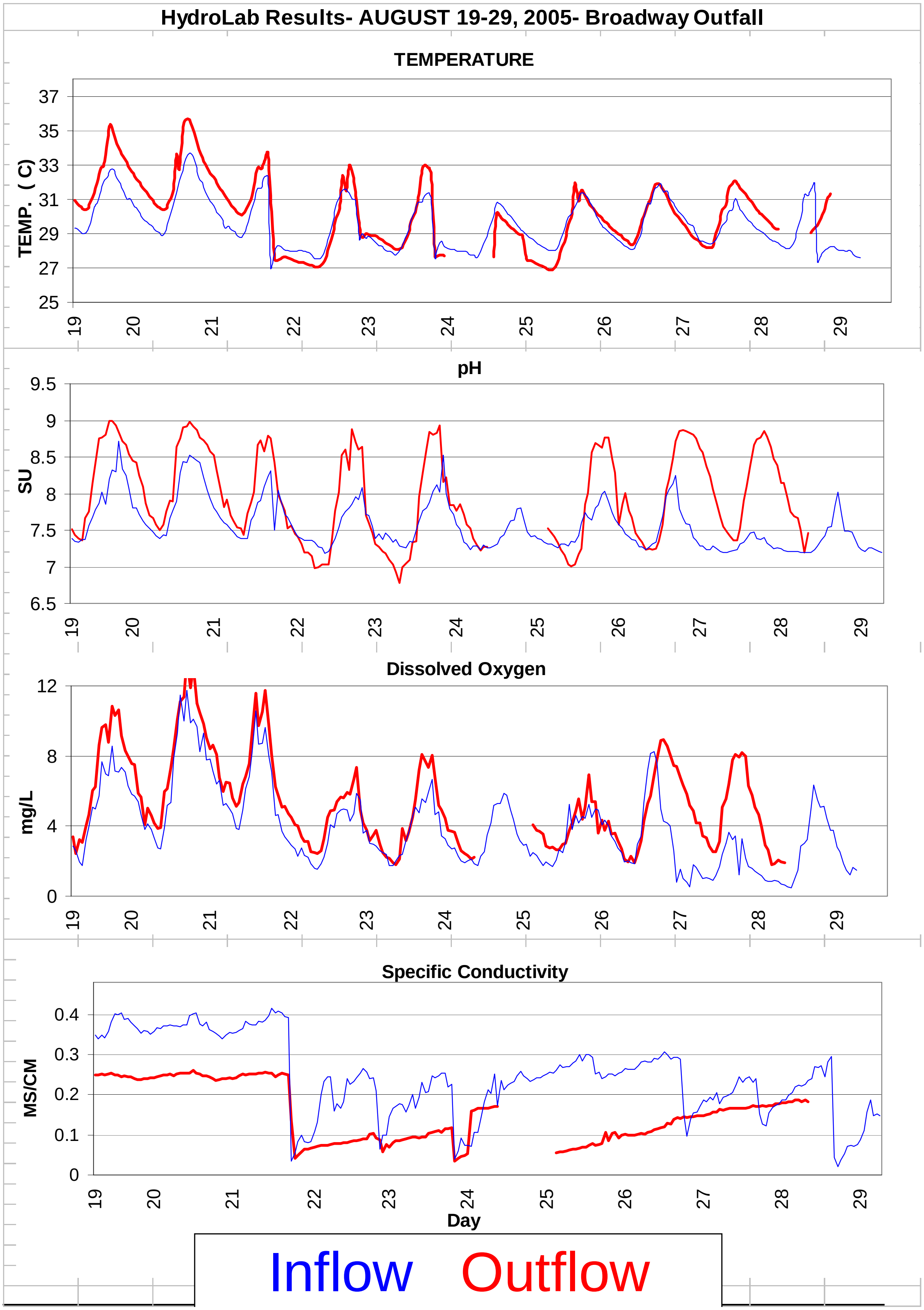

HydroLab Results- April 4-14, 2005- Broadway Outfall
TEMPERATURE AND RAINFALL
TEMP. (C)
31
30
29
28
27
26
25
24
23
22
21
20
RAIN (IN/15 MIN)
0.5
0.4
0.3
0.2
0.1
0
4
5
6
7
8
9
1
1
1
1
1
pH
SU
9
8.5
8
7.5
7
6.5
4
5
6
7
8
9
10
11
12
13
14
Dissolved Oxygen
mg/L
10
9
8
7
6
5
4
3
2
1
0
4
5
6
7
8
9
10
11
12
13
14
Specific Conductivity
MS/CM
0.3
0.2
0.1
0
4
5
6
7
8
9
10
11
12
13
14
Day
Inflow
Outflow
Rain


HydroLab Results- April 19-29, 2005- Broadway Outfall
TEMPERATURE AND RAINFALL
TEMP. (C)
29
28
27
26
25
24
23
22
21
20
19
RAIN (IN/15 MIN)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
19
20
21
22
23
24
25
26
27
28
29
pH
SU
9.5
9
8.5
8
7.5
7
6.5
19
20
21
22
23
24
25
26
27
28
29
Dissolved Oxygen
mg/L
11
10
9
8
7
6
5
4
3
2
1
0
1
Specific Conductivity
MS/CM
0.3
0.2
0.1
0
19
20
21
22
23
24
25
26
27
28
29
Day
Outflow
Rain



HydroLab Results- May 5-15, 2005- Broadway Outfall

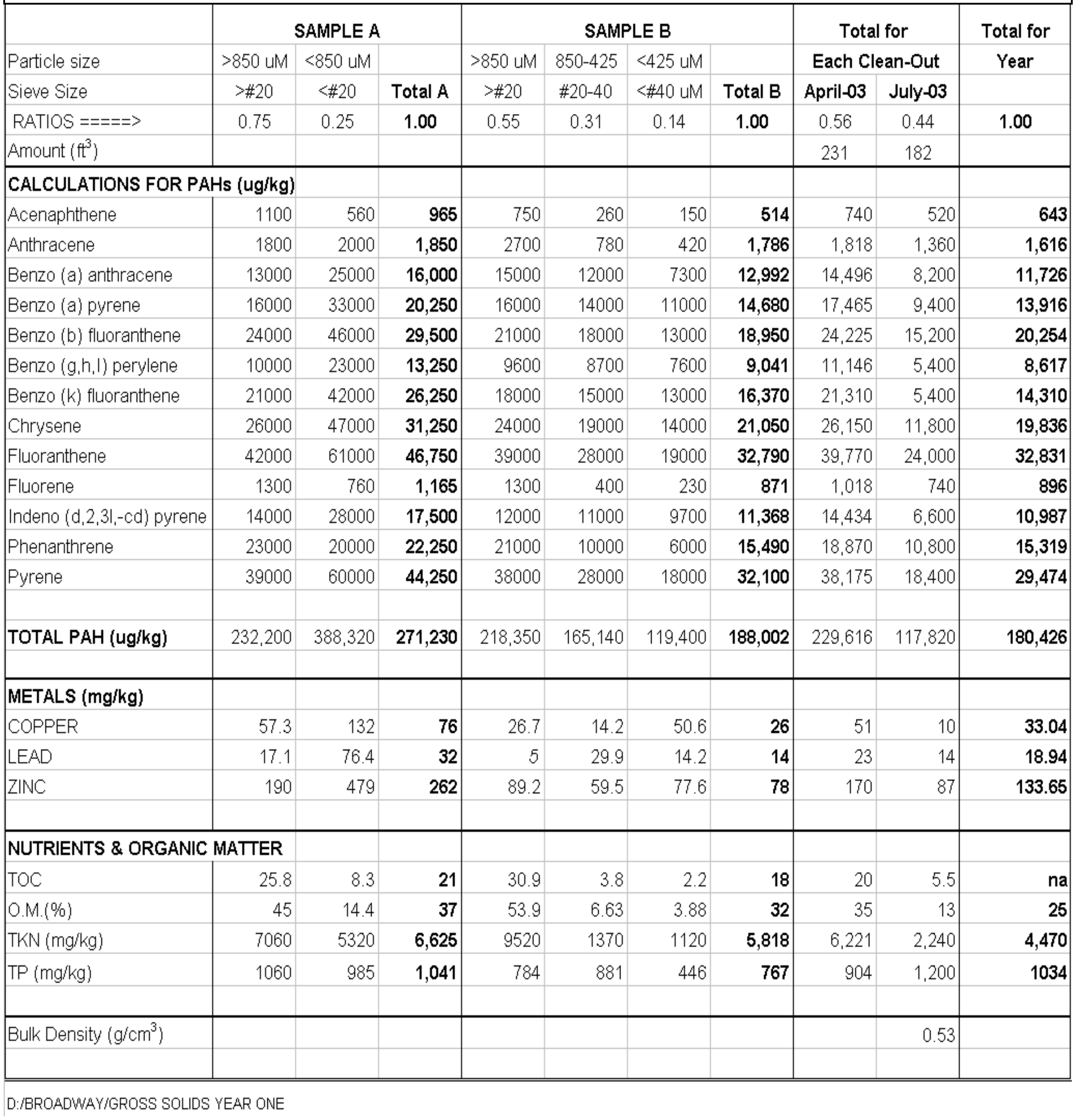

HydroLab Results- June 16-26, 2005- Broadway Outfall
TEMPERATURE AND RAINFALL
TEMP. (C)
37
35
33
31
29
27
25
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RAIN (IN per Hour)
16
17
18
19
20
21
22
23
24
25
26
pH
SU
9.5
9
8.5
8
7.5
7
6.5
Dissolved Oxygen
mg/L
12
8
4
0
Specific Conductivity
MS/CM
0.3
0.2
0.1
0
Day
Inflow
Outflow
Rain


HydroLab Results- AUGUST 19-29, 2005- Broadway Outfall
TEMPERATURE
TEMP. (C)
37
35
33
31
29
27
25
19
20
21
22
23
24
25
26
27
28
29
pH
SU
9.5
9
8.5
8
7.5
7
6.5
19
20
21
22
23
24
25
26
27
28
29
Dissolved Oxygen
mg/L
12
8
4
0
19
20
21
22
23
24
25
26
27
28
29
Specific Conductivity
MS/CM
0.4
0.3
0.2
0.1
0
19
20
21
22
23
24
25
26
27
28
29
Day
Inflow
Outflow

APPENDIX G

GROSS SOLIDS CONCENTRATIONS MEASURED IN CDS UNIT AT TIME OF CLEANOUT

Table G-1. Concentrations of constituents for clean out one (sieved sample) for April 2003 and clean out 2a (whole sample) for July 2003.



	SAMPLE A			**SAMPLE B**				**Total for**		**Total for**
Particle size	>850 uM	<850 uM		>850 uM	850-425	<425 uM		**Each Clean-Out**		**Year**
Sieve Size	>#20	<#20	**Total A**	>#20	#20-40	<#40 uM	**Total B**	**April-03**	**July-03**	
RATIOS =====>	0.75	0.25	**1.00**	0.55	0.31	0.14	**1.00**	0.56	0.44	**1.00**
Amount (ft^3)								231	182	
CALCULATIONS FOR PAHs (ug/kg)										
Acenaphthene	1100	560	**965**	750	260	150	**514**	740	520	**643**
Anthracene	1800	2000	**1,850**	2700	780	420	**1,786**	1,818	1,360	**1,616**
Benzo (a) anthracene	13000	25000	**16,000**	15000	12000	7300	**12,992**	14,496	8,200	**11,726**
Benzo (a) pyrene	16000	33000	**20,250**	16000	14000	11000	**14,680**	17,465	9,400	**13,916**
Benzo (b) fluoranthene	24000	46000	**29,500**	21000	18000	13000	**18,950**	24,225	15,200	**20,254**
Benzo (g,h,I) perylene	10000	23000	**13,250**	9600	8700	7600	**9,041**	11,146	5,400	**8,617**
Benzo (k) fluoranthene	21000	42000	**26,250**	18000	15000	13000	**16,370**	21,310	5,400	**14,310**
Chrysene	26000	47000	**31,250**	24000	19000	14000	**21,050**	26,150	11,800	**19,836**
Fluoranthene	42000	61000	**46,750**	39000	28000	19000	**32,790**	39,770	24,000	**32,831**
Fluorene	1300	760	**1,165**	1300	400	230	**871**	1,018	740	**896**
Indeno (d,2,3l,-cd) pyrene	14000	28000	**17,500**	12000	11000	9700	**11,368**	14,434	6,600	**10,987**
Phenanthrene	23000	20000	**22,250**	21000	10000	6000	**15,490**	18,870	10,800	**15,319**
Pyrene	39000	60000	**44,250**	38000	28000	18000	**32,100**	38,175	18,400	**29,474**
TOTAL PAH (ug/kg)	232,200	388,320	**271,230**	218,350	165,140	119,400	**188,002**	229,616	117,820	**180,426**
METALS (mg/kg)										
COPPER	57.3	132	**76**	26.7	14.2	50.6	**26**	51	10	**33.04**
LEAD	17.1	76.4	**32**	5	29.9	14.2	**14**	23	14	**18.94**
ZINC	190	479	**262**	89.2	59.5	77.6	**78**	170	87	**133.65**
NUTRIENTS & ORGANIC MATTER										
TOC	25.8	8.3	**21**	30.9	3.8	2.2	**18**	20	5.5	**na**
O.M.(%)	45	14.4	**37**	53.9	6.63	3.88	**32**	35	13	**25**
TKN (mg/kg)	7060	5320	**6,625**	9520	1370	1120	**5,818**	6,221	2,240	**4,470**
TP (mg/kg)	1060	985	**1,041**	784	881	446	**767**	904	1,200	**1034**
Bulk Density (g/cm^3)									0.53	

D:/BROADWAY/GROSS SOLIDS YEAR ONE

Table G-2. Constituent Concentrations of the gross solids for cleanout #2b on March 2004.

	SIEVED SAMPLE A			SIEVED SAMPLE B			WHOLE SAMPLE	
Particle size	>850 uM	<850 uM		>850 uM	<850 uM			
Sieve Size	>#4	<#10-#200	**Total A**	>#4	<#10-#200	**Total B**	**SAMPLE**	**SAMPLE**
RATIOS =====>	0.68	0.32	**1.00**	0.64	0.36	**1.00**	**A**	**B**
Amount (ft^3)								
CALCULATIONS FOR PAHs (ug/kg)								
Acenaphthene	48	120	**71**	68	240	**130**	51	75
Anthracene	66	170	**99**	100	210	**140**	158	237
Benzo (a) anthracene	740	1200	**887**	910	1300	**1,050**	1,263	1,842
Benzo (a) pyrene	1900	3300	**2,348**	2800	4800	**3,520**	1,924	2,895
Benzo (b) fluoranthene	6500	10000	**7,620**	8700	16000	**11,328**	5,526	7,632
Benzo (g,h,I) perylene	1400	2500	**1,752**	2100	5000	**3,144**	1,039	1,316
Benzo (k) fluoranthene	2000	3700	**2,544**	3200	4800	**3,776**	1,579	2,632
Chrysene	2000	2900	**2,288**	2400	3300	**2,724**	4,211	3,684
Fluoranthene	440	1200	**683**	1300	880	**1,149**	5,921	8,289
Fluorene	11	27	**16**	28	46	**34**	112	158
Indeno (d,2,3I,-cd) pyrene	1700	3200	**2,180**	2700	5800	**3,816**	1,316	1,711
Phenanthrene	60	170	**95**	290	210	**261**	1,197	1,974
Pyrene	460	1100	**665**	1100	920	**1,035**	4,605	6,447
Dibenz(a,h) anthracene	bd	650	**208**	630	1300	**871**	329	421
TOTAL PAH (ug/kg)	17,325	30,237	**21,457**	26,326	44,806	**32,979**	29,231	39,313
METALS (mg/kg)								
COPPER	32	140	**67**	45	96	**63**	13	13
LEAD	5.1	78	**28**	*8.4*	31	**17**	5	6
ZINC	83	360	**172**	129	319	**197**	62	74
NUTRIENTS & ORGANIC MATTER								
TOC								
O.M.(%)							101	100
TN (mg/kg)	5600	5500	**5,568**	5800	5400	**5,656**	2,240	2,368
TP (mg/kg)	220	450	**294**	230	610	**367**	1,200	111
Bulk Density (g/cm^3)							0.10	

DATA for whole sample as it was reported by lab and converted to dry weight by dividing by 0.76.

Conversion changes wet weight to dry weight according to the laboratory director.

Even though sieved samples reported as wet weight lab director and I decided they couldn't have been sieved wet.

Particle sizes are adjusted to make more comparable to other data

D:/BROADWAY/GROSS SOLIDS YEAR TWO

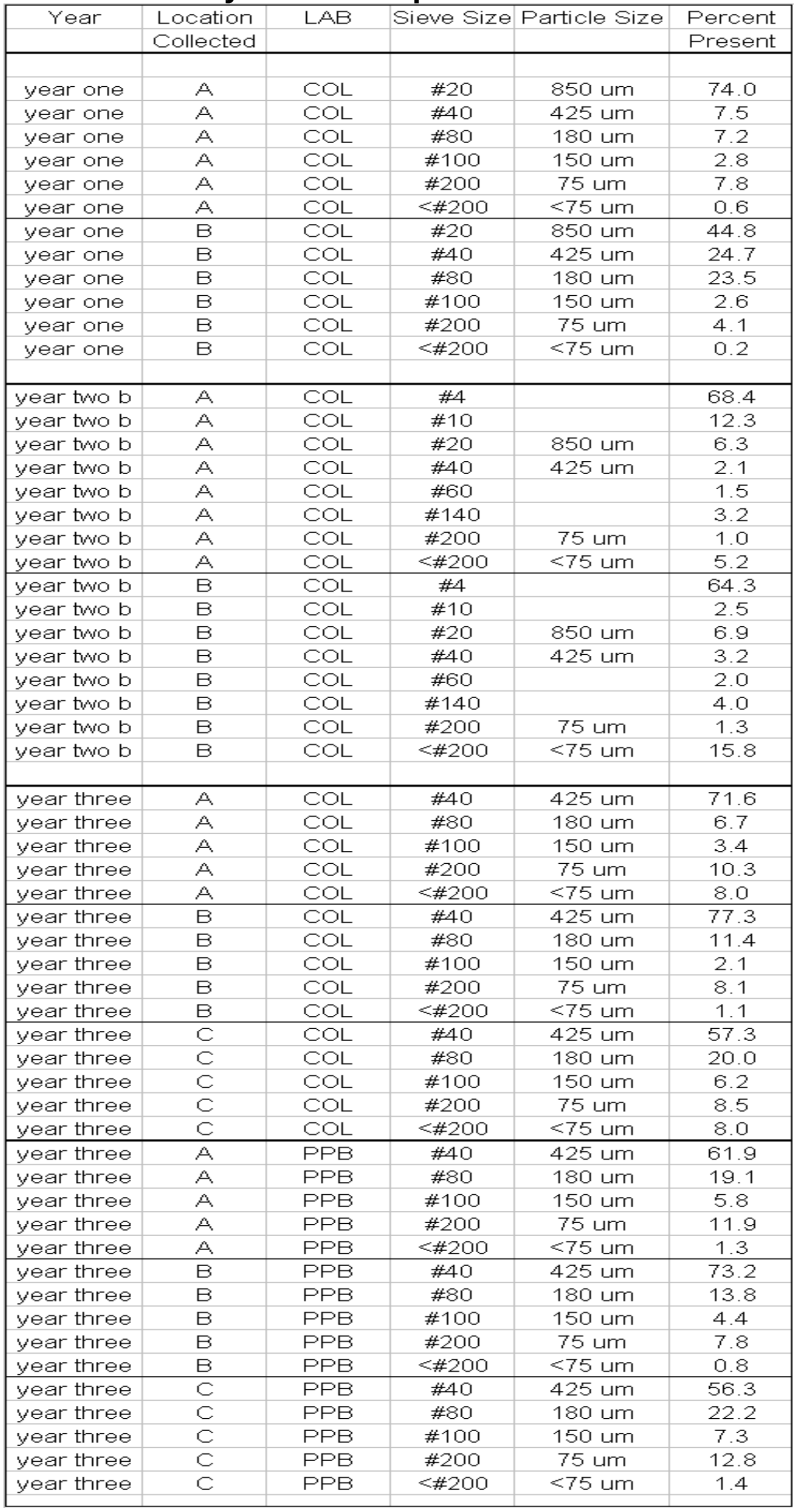
Table G-3. Chemical analysis Table F-3. Analysis of the material in the CDS unit for year three.

Separated by Partical Size	NE Corner (A)			SW Corner (B)			Dump Site (C)				Avg. for
Particle size*	>425 um	< 425 um		>425 um	< 425 um		>425 um	425-75 um	< 75 um		A & B
Sieve Size	> 40	40-200	**Total A**	> 40	40-200	**Total B**	> 40	40-200	<200	**Total C**	
RATIOS =====>	0.72	0.284	**1.00**	0.77	0.227	**1.00**	0.57	0.35	0.08	**1.00**	**1.00**
CALCULATIONS FOR PAHs (ug/kg)											
Acenaphthene	*320*	810	***460***	*200*	*200*	***199***	*250*	450	580	***346***	***330***
Anthracene	1700	2900	**2,048**	1800	2200	**1,885**	2100	2400	2200	**2,213**	**1,967**
Benzo (a) anthracene	15000	38000	**21,592**	16000	30000	**19,130**	21000	23000	25000	**22,020**	**20,361**
Benzo (a) pyrene	24000	62000	**34,888**	27000	49000	**31,913**	33000	34000	41000	**33,990**	**33,401**
Benzo (b) fluoranthene	20000	100000	**42,800**	53000	86000	**60,332**	65000	56000	73000	**62,490**	**51,566**
Benzo (g,h,i) perylene	23000	56000	**32,464**	23000	30000	**24,520**	23000	24000	28000	**23,750**	**28,492**
Benzo (k) fluoranthene	20000	39000	**25,476**	28000	45000	**31,775**	31000	29000	37000	**30,780**	**28,626**
Chrysene	35000	65000	**43,660**	39000	52000	**41,834**	43000	37000	45000	**41,060**	**42,747**
Fluoranthene	53000	98000	**65,992**	62000	81000	**66,127**	68000	53000	60000	**62,110**	**66,060**
Fluorene	*290*	*185*	***261***	*285*	*175*	***259***	*235*	820	640	***472***	***993***
Indeno (1,2,3,-cd) pyrene	27000	68000	**38,752**	33000	53000	**37,441**	38000	38000	47000	**38,720**	**38,097**
Phenanthrene	13000	27000	**17,028**	15000	22000	**16,544**	19000	18000	16000	**18,410**	**16,786**
Pyrene	41000	78000	**51,672**	46000	63000	**49,721**	53000	43000	49000	**49,180**	**50,697**
TOTAL PAH (ug/kg)	273,310	634,895	**377,093**	344,285	513,575	**381,681**	396,585	358,670	424,420	**385,542**	**379,387**
METALS (mg/kg)											
COPPER	91	69	**85**	80	96	**83**	52	34	63	**47**	**84**
LEAD	45	30	**41**	*79*	43	**71**	*46*	23	30	**37**	**56**
ZINC	620	250	**517**	530	260	**467**	320	190	250	**269**	**492**
NUTRIENTS & ORGANIC MATTER											
TOC	148000	27000	**114,228**	57000	22000	**48,884**	64000	26000	28000	**47,820**	**81,556**
Moisture(%)	7.7	0.8	**5.8**	6.3	0.7	**5.0**	14.7	1.7	1.0	**9.1**	**5.4**
TKN (mg/kg)	3500	200000	**59,320**	6000	170000	**43,210**	2100	3000	70000	**7,847**	**51,265**
TP (mg/kg)	5400	33000	**13,260**	6500	38000	**13,631**	3000	23000	39000	**12,880**	**13,446**
SOILS TESTING											
Percent Solids (%)			**29.9**			**30.0**				**57.1**	**30.0**
Moisture Content (% wet wt.)			**70.1**			**70.0**				**42.9**	**70.1**
Moisture Content (% dry wt.)			**234.6**			**233.5**				**75.2**	**234.1**
Loss on Ignition (%)			**72.7**			**72.8**				**29.3**	**72.8**
Wet Bulk Density (pfc)			**32.3**			**61.6**				**59.9**	**47.0**
Wet Bulk Density (g/cm^3)			**0.52**			**1.00**				**0.97**	**0.76**
Dry Bulk Density (pfc)			**9.65**			**18.47**				**34.24**	**14.06**
Dry Bulk Density (g/cm^3)			**0.156**			**0.30**				**0.55**	**0.23**

*The largest particle size is mostly leaves

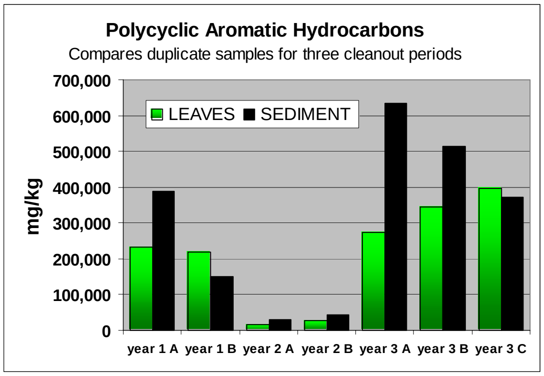
Numbers in italics (Acenaphthene and Fluorene) were below the laboratory detection limit and one-half the detection limit was used

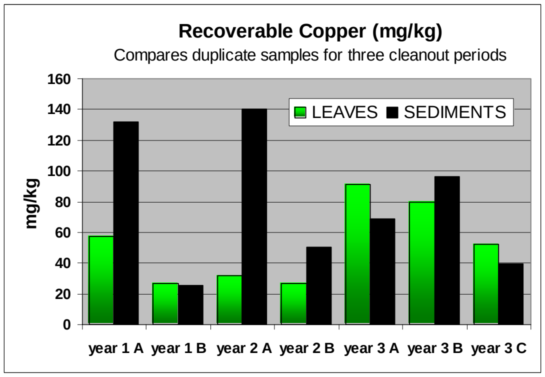
Table G-4. Particle size analysis for the three cleanouts where sieve analyses were performed. COL=lab #1 and PPB=lab #2. Samples A and B were collected in the CDS unit with an Ekman dredge. Sample C was collected the next day at the dump site.

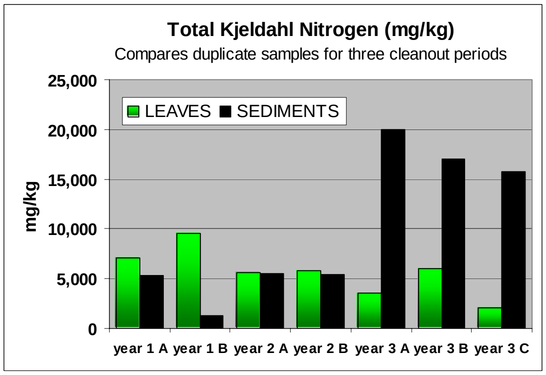


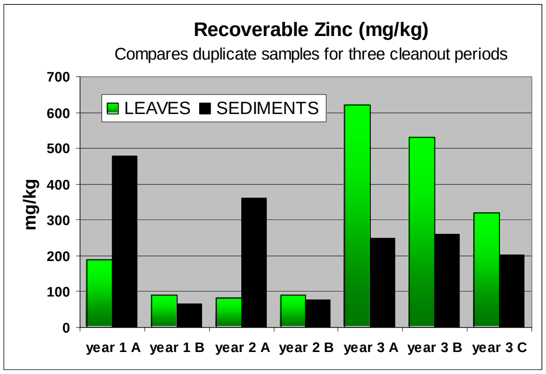
Year	Location Collected	LAB	Sieve Size	Particle Size	Percent Present
year one	A	COL	#20	850 um	74.0
year one	A	COL	#40	425 um	7.5
year one	A	COL	#80	180 um	7.2
year one	A	COL	#100	150 um	2.8
year one	A	COL	#200	75 um	7.8
year one	A	COL	<#200	<75 um	0.6
year one	B	COL	#20	850 um	44.8
year one	B	COL	#40	425 um	24.7
year one	B	COL	#80	180 um	23.5
year one	B	COL	#100	150 um	2.6
year one	B	COL	#200	75 um	4.1
year one	B	COL	<#200	<75 um	0.2
year two b	A	COL	#4		68.4
year two b	A	COL	#10		12.3
year two b	A	COL	#20	850 um	6.3
year two b	A	COL	#40	425 um	2.1
year two b	A	COL	#60		1.5
year two b	A	COL	#140		3.2
year two b	A	COL	#200	75 um	1.0
year two b	A	COL	<#200	<75 um	5.2
year two b	B	COL	#4		64.3
year two b	B	COL	#10		2.5
year two b	B	COL	#20	850 um	6.9
year two b	B	COL	#40	425 um	3.2
year two b	B	COL	#60		2.0
year two b	B	COL	#140		4.0
year two b	B	COL	#200	75 um	1.3
year two b	B	COL	<#200	<75 um	15.8
year three	A	COL	#40	425 um	71.6
year three	A	COL	#80	180 um	6.7
year three	A	COL	#100	150 um	3.4
year three	A	COL	#200	75 um	10.3
year three	A	COL	<#200	<75 um	8.0
year three	B	COL	#40	425 um	77.3
year three	B	COL	#80	180 um	11.4
year three	B	COL	#100	150 um	2.1
year three	B	COL	#200	75 um	8.1
year three	B	COL	<#200	<75 um	1.1
year three	C	COL	#40	425 um	57.3
year three	C	COL	#80	180 um	20.0
year three	C	COL	#100	150 um	6.2
year three	C	COL	#200	75 um	8.5
year three	C	COL	<#200	<75 um	8.0
year three	A	PPB	#40	425 um	61.9
year three	A	PPB	#80	180 um	19.1
year three	A	PPB	#100	150 um	5.8
year three	A	PPB	#200	75 um	11.9
year three	A	PPB	<#200	<75 um	1.3
year three	B	PPB	#40	425 um	73.2
year three	B	PPB	#80	180 um	13.8
year three	B	PPB	#100	150 um	4.4
year three	B	PPB	#200	75 um	7.8
year three	B	PPB	<#200	<75 um	0.8
year three	C	PPB	#40	425 um	56.3
year three	C	PPB	#80	180 um	22.2
year three	C	PPB	#100	150 um	7.3
year three	C	PPB	#200	75 um	12.8
year three	C	PPB	<#200	<75 um	1.4

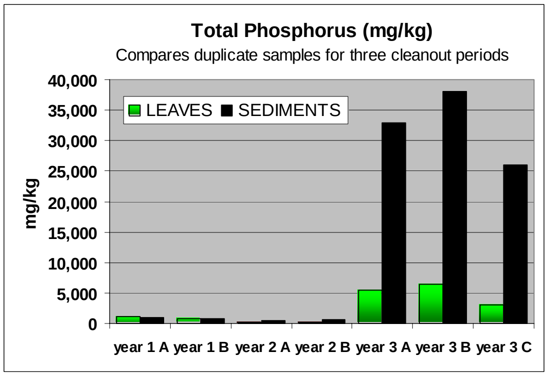
Figure G-1 and Table G-5. Constituent concentrations for a year compared to results from lab #1 for year 3.











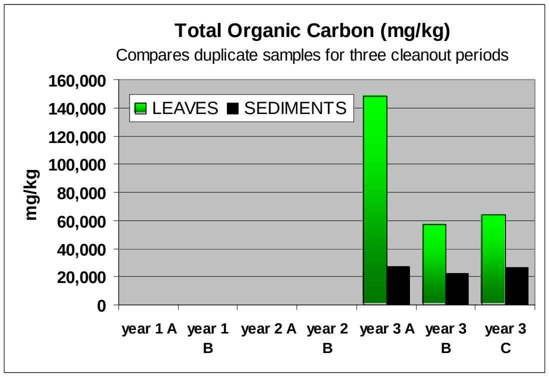


Table. Concentration of constituents in material collected from CDS unit.

	Copper (mg/kg)		Zinc (mg/kg)		PAHs (ug/kg)	
	leaves	sediment	leaves	sediment	leaves	sediment
year 1 A	57	132	190	479	232,200	388,320
year 1 B	27	25	89	65	218,350	150,961
year 2 A	32	140	83	360	17,325	30,237
year 2 B	26.7	50.6	89	78	26,326	44,806
year 3 A	91	69	620	250	273,310	634,895
year 3 B	80	96	530	260	344,285	513,575
year 3 C	52	40	320	201	396,585	371,163
	TKN (mg/kg)		Total Phsophorus		TOC (mg/kg)	
	leaves	sediment	leaves	sediment	leaves	sediment
year 1 A	7,060	5,320	1,060	985	26	8
year 1 B	9,520	1,293	784	746	31	3
year 2 A	5,600	5,500	220	450	na	na
year 2 B	5,800	5,400	230	610	na	na
year 3 A	3,500	20,000	5,400	33,000	148,000	27,000
year 3 B	6,000	17,000	6,500	38,000	57,000	22,000
year 3 C	2,100	15,730	3,000	26,040	64,000	26,380

Red numbers represent weighted combination of two reported sieve sizes

Figure G-2 and Table G-6. Constituent concentrations for all years compared to results from lab #2 for year 3.

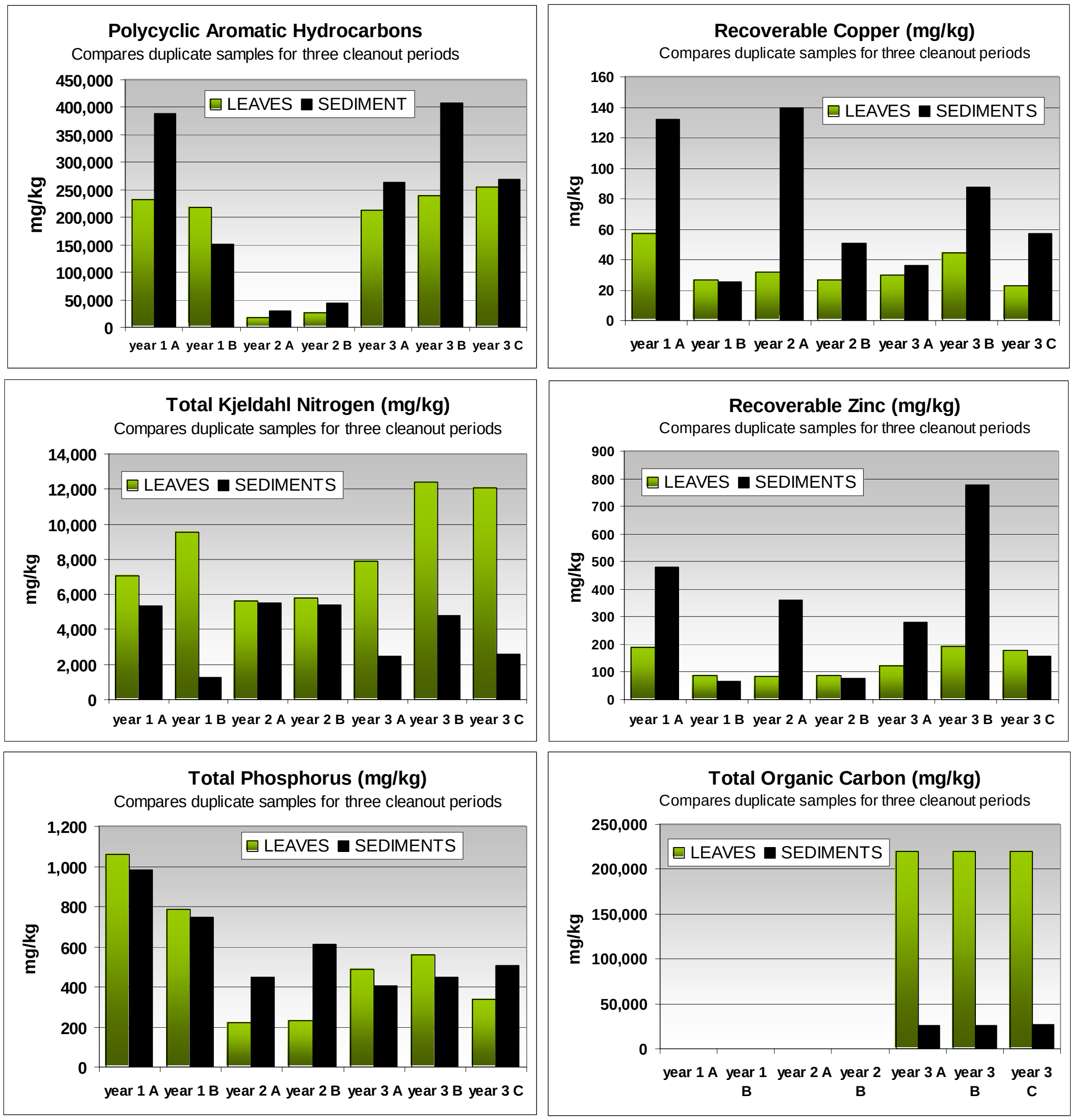


Table. Concentration of constituents in material collected from CDS unit.

	Copper (mg/kg)		Zinc (mg/kg)		PAHs (ug/kg)	
	leaves	sediment	leaves	sediment	leaves	sediment
year 1 A	57	132	190	479	232,200	388,320
year 1 B	27	25	89	65	218,350	150,961
year 2 A	32	140	83	360	17,325	30,237
year 2 B	27	51	89	78	26,326	44,806
year 3 A	30	36	124	282	213,045	263,427
year 3 B	44	87	191	776	239,655	407,690
year 3 C	23	57	177	156	254,270	268,085
	TKN (mg/kg)		Total Phsophorus		TOC (mg/kg)	
	leaves	sediment	leaves	sediment	leaves	sediment
year 1 A	7,060	5,320	1,060	985	26	8
year 1 B	9,520	1,293	784	746	31	3
year 2 A	5,600	5,500	220	450	na	na
year 2 B	5,800	5,400	230	610	na	na
year 3 A	7,904	2,472	488	404	220,000	25,949
year 3 B	12,416	4,799	559	446	220,000	25,516
year 3 C	12,063	2,564	338	508	220,000	26,580

Red numbers represent weighted combination of two reported sieve sizes

APPENDIX H

GROSS SOLIDS: AN UNTESTED METHOD FOR EFFICIENCY CALCULATION

GROSS SOLIDS: AN UNTESTED METHOD FOR EFFICIENCY CALCULATIONS

Betty Rushton, Ph.D.

Many monitoring programs designed to determine the effectiveness of Best Management Practices (BMPs) for stormwater management have narrowly defined the size, concentration and mass of solids in the runoff. Since most monitoring and BMP evaluation studies have continued the same methods that were developed to sample wastewater treatment systems, these studies typically use paired influent/effluent samples collected with automatic water quality samplers to determine the efficiency of a BMP to remove pollutants.

Automatic samplers generally exclude solid material including trash, litter, debris and sediments larger than 100 microns. Yet these pollutants degrade aquatic habitat, cause visual blight, smother productive sediments, leach harmful pollutants, and can cause unpleasant odors. This solid material is referred to in this paper as gross solids and is divided into three categories: 1) Litter includes human derived trash, such as paper, plastic, Styrofoam, metal and glass; 2) Debris consists of organic material including leaves, branches, seeds, twigs and grass clippings; and 3) Coarse sediments are inorganic breakdown products from soils, pavement or building materials. New methods for characterization and analysis of all pollutants of concern are needed if better data is to be obtained and used in decisions on compliance with TMDLs and NPDES permits and the selection of BMPs that will achieve pollution reduction goals.

The growing interest in mitigating the aesthetics and environmental impacts of trash and debris in the nations' waters and regulation of these pollutants through TMDLs has resulted in the development of a number of proprietary products designed to trap and separate these gross solids from the runoff path before discharge.

The Broadway Outfall project is trying to test the efficiency of a CDS unit and emphasizes some of the problems associated with adequately measuring pollution reduction. A CDS unit is an underground stormwater treatment method used to capture gross solids in urban areas by intercepting storm runoff in the conveyance pipe system. The mechanism by which the unit separates and retains gross solids is by deflecting the inflow and associated pollutants away from the main flow stream into a pollutant separation and containment chamber.

This retrofit project was designed to reduce the amount of pollution discharged to the Hillsborough River and ultimately Tampa Bay by installing a MODEL PSW100_60 (32 CFS capacity) CDS unit and a constructed linear marsh. The drainage basin is approximately 132.4 acres in size and includes a 30.6-acre high intensity strip commercial district immediately upstream. The remainder of the watershed includes multi-family and residential land uses as well as a golf course and major urban thoroughfares. The drainage basin receives no sewage overflow and the streets are periodically cleaned with a street sweeper. The purpose of this paper is to calculate the ability of the CDS unit to remove pollutant loads (percent efficiency) by also incorporating the material collected in the CDS sump. The proposed calculations for including gross solids in efficiency calculations described in this paper are intended to elicit discussion from other researchers and it is not a proven or recommended method.

Methods

The method to collect the data is presented in this section and the method to calculate efficiency is discussed later.

Hydrology - Hydrology measurements were calculated using velocity meters, water level sensors, and tipping bucket rain gauges. Levels were converted to flow using appropriate weir and pipe formulas. This information was stored in data loggers until retrieved and downloaded into spreadsheets to be processed into tables and figures. Bypass flow over a diversion weir was also measured. The flow was measured continuously and this flow was divided into storm flow, base flow and bypass flow. The flow calculations were checked against an estimated water budget for the pond (Rushton 2004).

Water Quality - Flow weighted samples were collected to measure water quality for both storm flow and base flow using automated samplers. Samples were taken in front of and after the CDS unit. It was not possible to sample the overflow concentrations because these became almost immediately mixed with the CDS outflow downstream of the diversion weir. For bypassed flow, it was assumed that the same concentrations would be present as were measured at the inflow of the CDS unit. The system discharged continuously, and the base flow samples were collected several times during the month with each sample representing about a two-day period.

Gross Solids - Representative samples of the material in the CDS unit were analyzed each time the unit was vacuumed out. The trash was removed from the mass of material and was quantified separately. Standard methods for soil analysis were used to quantify the gross solids. The amount collected in the CDS unit was estimated by using the volume of the sump basin and the depth of the material in the sump.

Results And Discussion

During the first year of the study the CDS unit collected almost all of its gross solids during a six-month period in the spring and summer (Figure 1). The data in this report represent this six-month period, which extended from February 1st to July 14th, 2003. During this time period, 18 storm samples and 26 base flow samples were analyzed for water quality. This included 57 percent of all the storm event rainfall and many of the smaller events that were not sampled were included in the base flow samples. All of the flow was measured and included in the calculations for mass loading. Both average and median values for water quality were used in the calculations to estimate load reductions. The CDS unit collected 336 cubic feet of material and most of the collected mass was leaves (55 to 75 percent).

Calculating pollution removal

One of the purposes of the study was to calculate load reductions that could be compared to other stormwater studies and that are appropriate for determining TMDLs. The automatic water quality samplers usually used to evaluate pollution reduction do not adequately sample the gross solids collected by CDS units and other proprietary devices. The following section explains the method used to include gross solids in the calculation for load reductions.

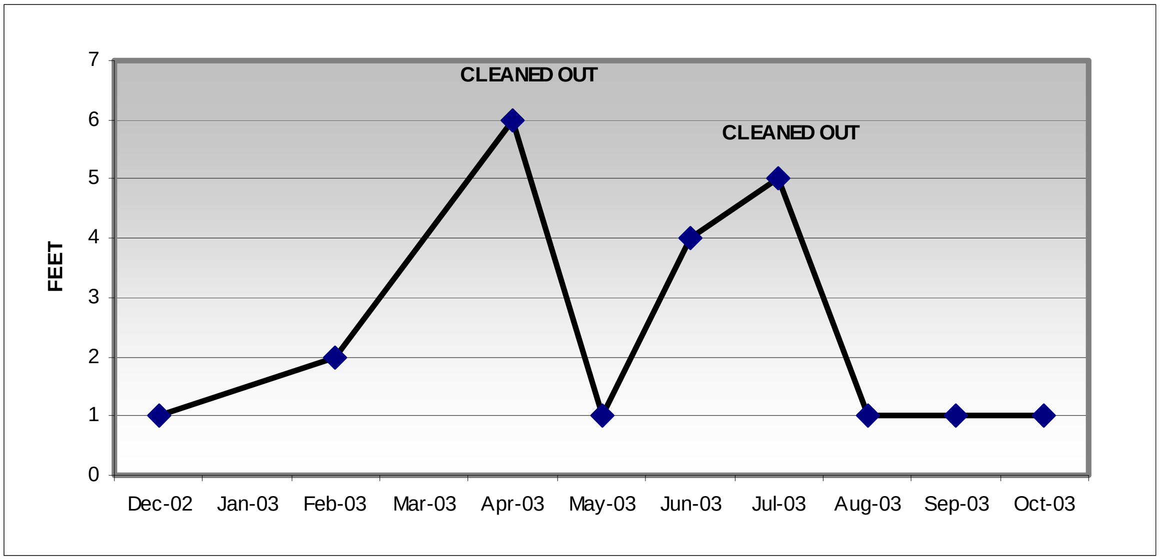


Figure 1. Measurements taken inside the CDS unit to determine how much material had been collected and to schedule clean-outs. The period from February 1 to July 14, 2003 includes the data analyzed for this report.

A summary of all the flow, water quality and gross solids data collected during the six-month period used to calculate pollution load reductions is shown in Table 1. Several assumptions had to be made and these include:

- The same amount of water left the CDS unit as entered at the inflow, except for the flow that was discharged over the bypass weir.
- The water that discharged over the bypass weir had the same water quality as the water that entered the CDS unit.
- The average and median values for water quality analyzed for the sampled storms (57 percent) are representative of all storms.
- The average and median values for water quality analyzed for the base flow sampled (about 30 percent) are representative of all base flow.
- The gross solids that were collected in the CDS unit represent all the gross solids that entered the system (This is not entirely true because floating litter and leaves did bypass the CDS unit during high flow and considerable pavement material was noted in the sediments in the pond).
- The calculations for solids use total suspended solids for the water quality data and total solids collected by the CDS unit for the gross solids.

The standard method for measuring BMP system efficiency (the amount of pollution reduced or increased) is calculated with the following formula:

$$\text{percent efficiency} = \frac{(\text{load in}) - (\text{load out})}{(\text{load in})}$$

To use the formula all the loads must be in comparable units. For our analysis we used grams and kilograms.

Step 1.
To convert the gross solids loads, the volume had to be converted from cubic feet to kilograms. The bulk density measurement was used for this calculation. .

(Mass of gross solids)*(bulk density)*(conversion factors)

Where:
Mass of gross solids = 336 cubic feet
Bulk Density = 0.54 g/cm^3

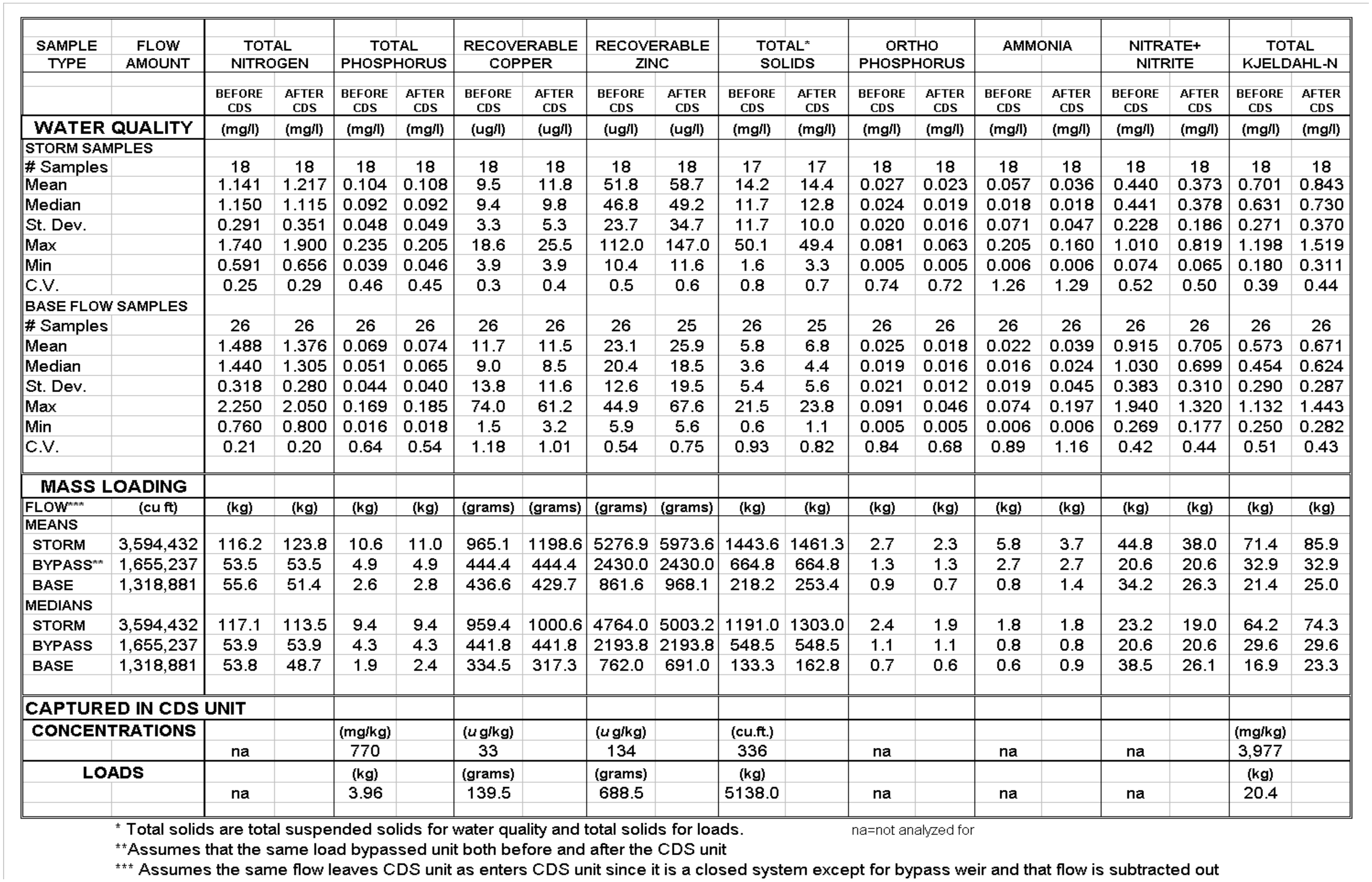
Using these calculations our site had 5137 kilograms of gross solids measured during the two cleanout periods.

Step 2.
To convert the individual constituents measured by the laboratory for the gross solids material. The constituents were reported in mg/kg. The calculation took the form:

(Constituent mg/kg)*(5137 kg of gross solids)*(conversion factors)

The results from these calculations are shown as the loads captured in CDS unit in Table 1.

Table 1. Summary data for water quality and gross solid concentrations and loads for the period Feb. 1 to July 12, 2004.



SAMPLE TYPE	FLOW AMOUNT	TOTAL NITROGEN		TOTAL PHOSPHORUS		RECOVERABLE COPPER		RECOVERABLE ZINC		TOTAL* SOLIDS		ORTHO PHOSPHORUS		AMMONIA		NITRATE+ NITRITE		TOTAL KJELDAHL-N	
		BEFORE CDS	AFTER CDS	BEFORE CDS	AFTER CDS	BEFORE CDS	AFTER CDS	BEFORE CDS	AFTER CDS	BEFORE CDS	AFTER CDS	BEFORE CDS	AFTER CDS	BEFORE CDS	AFTER CDS	BEFORE CDS	AFTER CDS	BEFORE CDS	AFTER CDS
WATER QUALITY		(mg/l)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
STORM SAMPLES																			
# Samples		18	18	18	18	18	18	18	18	17	17	18	18	18	18	18	18	18	18
Mean		1.141	1.217	0.104	0.108	9.5	11.8	51.8	58.7	14.2	14.4	0.027	0.023	0.057	0.036	0.440	0.373	0.701	0.843
Median		1.150	1.115	0.092	0.092	9.4	9.8	46.8	49.2	11.7	12.8	0.024	0.019	0.018	0.018	0.441	0.378	0.631	0.730
St. Dev.		0.291	0.351	0.048	0.049	3.3	5.3	23.7	34.7	11.7	10.0	0.020	0.016	0.071	0.047	0.228	0.186	0.271	0.370
Max		1.740	1.900	0.235	0.205	18.6	25.5	112.0	147.0	50.1	49.4	0.081	0.063	0.205	0.160	1.010	0.819	1.198	1.519
Min		0.591	0.656	0.039	0.046	3.9	3.9	10.4	11.6	1.6	3.3	0.005	0.005	0.006	0.006	0.074	0.065	0.180	0.311
C.V.		0.25	0.29	0.46	0.45	0.3	0.4	0.5	0.6	0.8	0.7	0.74	0.72	1.26	1.29	0.52	0.50	0.39	0.44
BASE FLOW SAMPLES																			
# Samples		26	26	26	26	26	26	26	25	26	25	26	26	26	26	26	26	26	26
Mean		1.488	1.376	0.069	0.074	11.7	11.5	23.1	25.9	5.8	6.8	0.025	0.018	0.022	0.039	0.915	0.705	0.573	0.671
Median		1.440	1.305	0.051	0.065	9.0	8.5	20.4	18.5	3.6	4.4	0.019	0.016	0.016	0.024	1.030	0.699	0.454	0.624
St. Dev.		0.318	0.280	0.044	0.040	13.8	11.6	12.6	19.5	5.4	5.6	0.021	0.012	0.019	0.045	0.383	0.310	0.290	0.287
Max		2.250	2.050	0.169	0.185	74.0	61.2	44.9	67.6	21.5	23.8	0.091	0.046	0.074	0.197	1.940	1.320	1.132	1.443
Min		0.760	0.800	0.016	0.018	1.5	3.2	5.9	5.6	0.6	1.1	0.005	0.005	0.006	0.006	0.269	0.177	0.250	0.282
C.V.		0.21	0.20	0.64	0.54	1.18	1.01	0.54	0.75	0.93	0.82	0.84	0.68	0.89	1.16	0.42	0.44	0.51	0.43
MASS LOADING																			
FLOW***	(cu ft)	(kg)	(kg)	(kg)	(kg)	(grams)	(grams)	(grams)	(grams)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
MEANS																			
STORM	3,594,432	116.2	123.8	10.6	11.0	965.1	1198.6	5276.9	5973.6	1443.6	1461.3	2.7	2.3	5.8	3.7	44.8	38.0	71.4	85.9
BYPASS**	1,655,237	53.5	53.5	4.9	4.9	444.4	444.4	2430.0	2430.0	664.8	664.8	1.3	1.3	2.7	2.7	20.6	20.6	32.9	32.9
BASE	1,318,881	55.6	51.4	2.6	2.8	436.6	429.7	861.6	968.1	218.2	253.4	0.9	0.7	0.8	1.4	34.2	26.3	21.4	25.0
MEDIANS																			
STORM	3,594,432	117.1	113.5	9.4	9.4	959.4	1000.6	4764.0	5003.2	1191.0	1303.0	2.4	1.9	1.8	1.8	23.2	19.0	64.2	74.3
BYPASS	1,655,237	53.9	53.9	4.3	4.3	441.8	441.8	2193.8	2193.8	548.5	548.5	1.1	1.1	0.8	0.8	20.6	20.6	29.6	29.6
BASE	1,318,881	53.8	48.7	1.9	2.4	334.5	317.3	762.0	691.0	133.3	162.8	0.7	0.6	0.6	0.9	38.5	26.1	16.9	23.3
CAPTURED IN CDS UNIT																			
CONCENTRATIONS				(mg/kg)		(u g/kg)		(u g/kg)		(cu.ft.)								(mg/kg)	
		na		770		33		134		336		na		na		na		3,977	
LOADS				(kg)		(grams)		(grams)		(kg)								(kg)	
		na		3.96		139.5		688.5		5138.0		na		na		na		20.4	

* Total solids are total suspended solids for water quality and total solids for loads. na=not analyzed for

**Assumes that the same load bypassed unit both before and after the CDS unit

*** Assumes the same flow leaves CDS unit as enters CDS unit since it is a closed system except for bypass weir and that flow is subtracted out

Step 3.
To convert water quality data to loads (average and median values were calculated separately but they both use the same method).

(constituent mg/l)*(flow for time period ft^3)*(conversion factors)

Where:
Storm flow for period = 3,594,432 cubic feet
Bypass flow for period=1,655,237 cubic feet
Base flow for period=1,318,881 cubic feet
Constituent concentrations from Table 1
The results are shown as mass loading in Table 1.Step 4.
The efficiency of the CDS unit to remove pollutants is calculated by the standard formula and uses either the average or median loads as calculated above.

Percent efficiency = <u>(storm in+bypass in+base in+sump) – (storm out + bypass in +base out)</u>
(storm in + bypass in + base in + sump)

Where:
Storm in = storm loads in front of CDS unit calculated by Step 3 above
Bypass in=bypass loads in front of CDS unit calculated by step 3 above.
Base in=base flow loads in front of CDS unit calculated by step 3 above
Sump=loads calculated in step 2 above.
Storm out =storm loads after CDS unit calculated by step 3 above
Base out=base flow loads after CDS unit calculated by step 3 above

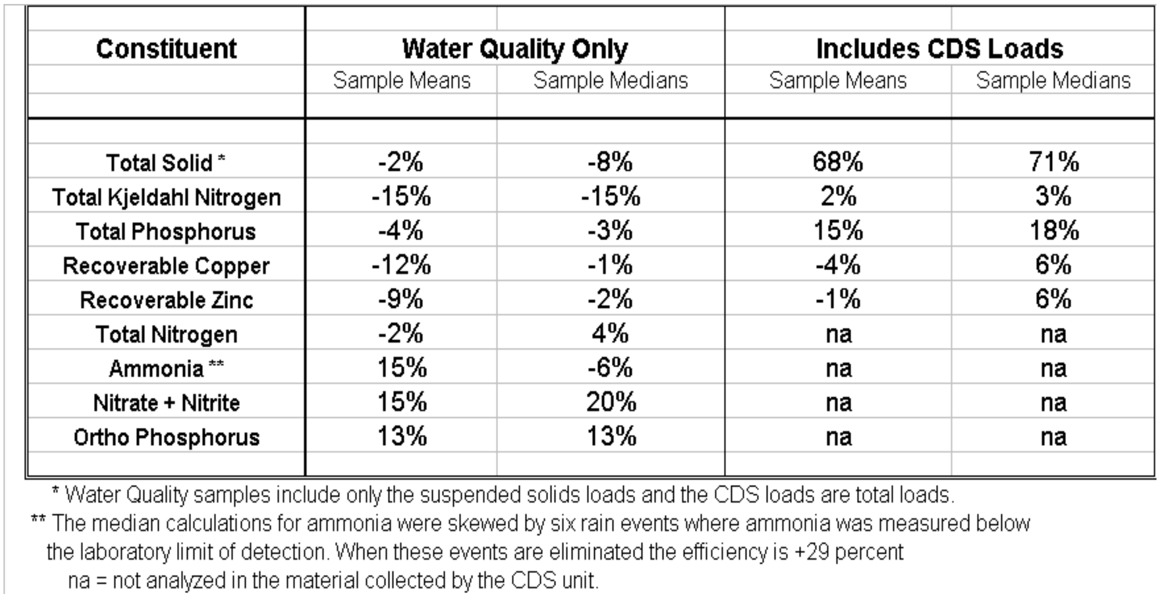
Pollution Removal Efficiency

Including the sump material in the efficiency calculations improves the efficiency of the CDS unit to remove pollutants by a large amount and also shows that the CDS unit is quite good at reducing some pollutants and is not effective for removing others. The percent efficiency calculated for loads both with and without the sump material is shown in Table 2.

Total Solids – The unit is quite effective at removing the larger solid material (>75 microns) found in bed loads such as street dirt, leaves and other large size particles. Total solids were removed by 68 to 71 percent. This is not surprising since the units were designed to capture this type of material. If the 32 percent of the flow that bypassed the CDS unit is considered by assuming that the bypassed flow contained the same proportion of material as was collected by the CDS unit then the percent reduction is between 56 and 58 percent. The increase in suspended loads in the water column indicates that particles are being broken down into smaller particles as they moves around in the CDS unit.

Total Phosphorus – The efficiency measured for total phosphorus (15 percent to 18 percent) probably reflects the fact that phosphorus easily attaches to soil particles and organic material and it is expected it would be reduced by attaching to solids. Ortho phosphorus, the inorganic portion of total phosphorus is reduced by 13 percent in the water samples indicating it is being transformed to organic nitrogen or attaching to particles. Better efficiency would probably have been measured except that leaf litter releases phosphorus when soaked in water (Strynchuk et al. 1999). In bench studies, concentrations of phosphorus increased by 89 percent in water after it was soaked with grass clippings and tree leaves for only one day. There was a corresponding decrease in the phosphorus measured in the solids of 54 percent.

Table 2. Load Efficiencies including loads for water quality samples only and loads that also include the amount retained in the CDS unit. Negative percentages indicate higher loads were discharged from the CDS unit than entered.



Constituent	Water Quality Only		Includes CDS Loads	
	Sample Means	Sample Medians	Sample Means	Sample Medians
Total Solid *	-2%	-8%	68%	71%
Total Kjeldahl Nitrogen	-15%	-15%	2%	3%
Total Phosphorus	-4%	-3%	15%	18%
Recoverable Copper	-12%	-1%	-4%	6%
Recoverable Zinc	-9%	-2%	-1%	6%
Total Nitrogen	-2%	4%	na	na
Ammonia **	15%	-6%	na	na
Nitrate + Nitrite	15%	20%	na	na
Ortho Phosphorus	13%	13%	na	na

* Water Quality samples include only the suspended solids loads and the CDS loads are total loads.

** The median calculations for ammonia were skewed by six rain events where ammonia was measured below the laboratory limit of detection. When these events are eliminated the efficiency is +29 percent

na = not analyzed in the material collected by the CDS unit.

Total Kjeldahl Nitrogen (TKN) – When the sump material is included in the calculations, TKN improves from an increase of 15 percent to a small amount of removal (2 percent to 3 percent). Some of this can be explained by nitrogen transformations. TKN is the combination of organic nitrogen and ammonia. Much of the ammonia and nitrate is converted to organic nitrogen and these soluble nutrients are reduced in the CDS unit as shown for the water quality sample means. The negative efficiency for water quality samples for ammonia was caused by six rain events where concentrations for both the inflow and outflow were below the laboratory detection limit. When these values were removed the ammonia in the CDS was reduced by 29 percent instead of the 6 percent increase calculated in the table. It might be expected that nitrogen would increase in the water column as it passed through the CDS unit. TKN was increased by 31 percent in water that was used to soak grass clippings and tree leaves in bench experiments when measured after one day (Strynchuk et al. 1999). There was a corresponding decrease in concentrations in the litter of 11 percent.

Recoverable Metals – Copper, lead and zinc were measured at low concentrations at the site and probably exhibited no reduction by the CDS unit. Besides the low concentrations, the low pollution removal can possibly be explained by the tendency of metals to attach to the smaller sized particles such as clay, which were not collected by the CDS unit. Particle size analysis measured no particles retained less than 75 microns. Although organic material has been found to be an effective sink for metals and most of the material collected by the CDS unit was tree leaves, the zinc, lead and copper concentrations retained were quite low and averaged values were below levels considered toxic to sensitive organisms. (Lead was not evaluated for this paper because most concentrations were below the laboratory detection limit).

Conclusions

Including the gross solids in the efficiency calculations improves the performance of these systems. Other methods are still needed to remove most constituents to acceptable levels.

Reference

Syrynchuk, J., J. Royal and G. England. 1999. Grass and Leaf Decomposition and Nutrient Release Study under Wet Conditions. In Sixth Biennial Stormwater Research & Watershed Management Conference. Southwest Florida Water Management District, 2379 Broad Street, Brooksville, Florida 34604.

APPENDIX I

GROSS SOLIDS: A SUMMARY PAPER OF RESULTS

Removal of Pollutants by a CDS Unit at a Major Storm Outfall in Florida

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Abstract

A major storm drain pipe was retrofitted with a CDS unit and a linear pond to help treat stormwater discharged from an urban drainage basin in Tampa, Florida. The CDS technology is designed to remove large sized particles such as litter, leaves, twigs, sand and paving residue from storm runoff. Results of this research suggest that it removes these gross solids very well, but it does not remove the dissolved and suspended particles present in the water column. The CDS unit did remove levels of PAHs at concentrations many times higher than levels considered toxic to benthic organisms. Since PAHs do not easily dissolve in water, they are rarely measured in water quality studies, but are considered a serious problem in sediments in portions of Tampa Bay. The data did not support the idea that the leaves collected by the CDS unit leached nutrients and increased their concentrations in the water that left the CDS unit, but this result may be influenced because leaching had already occurred while the leaves and discharge water traveled through the storm drain together. If litter and large sized particles are the pollutants of concern in a drainage basin, a CDS unit is a good solution, but if dissolved or suspended particles, especially nutrients, are a problem, a CDS unit will not reduce those pollutants. A CDS unit is probably best suited as the first element in a series of stormwater treatment methods.

Introduction

This stormwater retrofit project was designed to reduce the amount of pollution discharged to the Hillsborough River and ultimately Tampa Bay by constructing a CDS unit and small pond at a major urban storm sewer outfall. The project consisted of two phases. Construction of the retrofit (phase 1) was completed in November 2001; and the performance evaluation effort (phase II) was initiated in November 2002 and was completed in November 2005. The monitoring project was designed to measure: 1) how much and what kind of gross solids (> 64 microns) are collected by the CDS unit, 2) the concentration of constituents in the runoff for the suspended and dissolved particles for storm flow and base flow 3) the accumulation of pollutants in the sediments of the pond, 4) the species and diversity of the macro-invertebrates in the sediments, and 5) the hydrology of the system including storm flow, base flow and rainfall. This paper only includes results from the CDS unit for four cleanout periods covering a three-year time span and also reports some of the hydrology and water quality data for the cleanout intervals. A complete report should be available on the internet after December 2006.
http://www.swfwmd.state.fl.us/documents/

Site Description

The drainage basin that discharges through the Broadway Outfall storm sewer is approximately 53.58 hectares (132.4 acres) in size and includes a 12.3 hectare (30.6-acres) high intensity commercial district immediately upstream from the site.

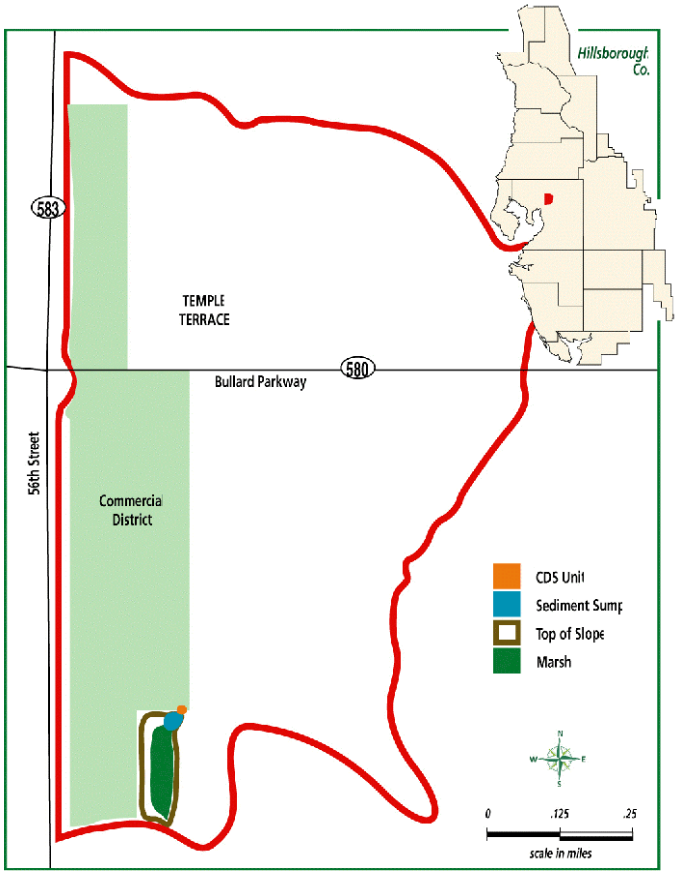


Figure 1 - Site plan showing the drainage basin (red outline) and other features

The remainder of the watershed includes multifamily and residential land uses as well as a golf course and major urban thoroughfares (Figure 1). As part of the Broadway Outfall Storm water Retrofit Project a Model PSW100_60 (0.906 cms (32 cfs) capacity) Continuous Deflective Separation (CDS) unit was installed in front of an excavated sediment sump followed by a shallow linear marsh, extending approximately 152.4 meters (500 feet) downstream from the unit. For the first year of the monitoring project, strong storm surges uprooted the marsh vegetation and created an open water area acting like a shallow pond. Planting was repeated several times, but the plants could never withstand the storm water pulses and were always uprooted in a short period of time. The vegetation planted on the 4:1 side slopes to the marsh was compromised by landscaping practices and were either mowed over or severely pruned.

A CDS unit is an underground stormwater treatment device used to capture gross pollutants in urban areas by intercepting storm runoff in the conveyance pipe system. The mechanism by which the unit separates and retains gross solids is by deflecting the inflow and associated pollutants away from the main flow stream into a pollutant separation and containment chamber. A vertical cross section view (Figure 2) shows the dimensions of the CDS unit installed at the Broadway Outfall.

When the unit reached its full storage capacity (about 1.83 m (6 ft) deep) the containment chamber was cleaned out with a vactor truck and the gross solids were sent to a landfill or disposed of in some other appropriate manner. Gross solids have not usually been measured in storm water studies since they are not included in the water collected using automated water quality samplers. These samplers generally exclude solids including trash, litter, debris, leaves and sediments larger than 64 microns, which are the kinds of pollutants that CDS units are designed to capture. This makes comparison with traditional stormwater inflow-outflow studies difficult.

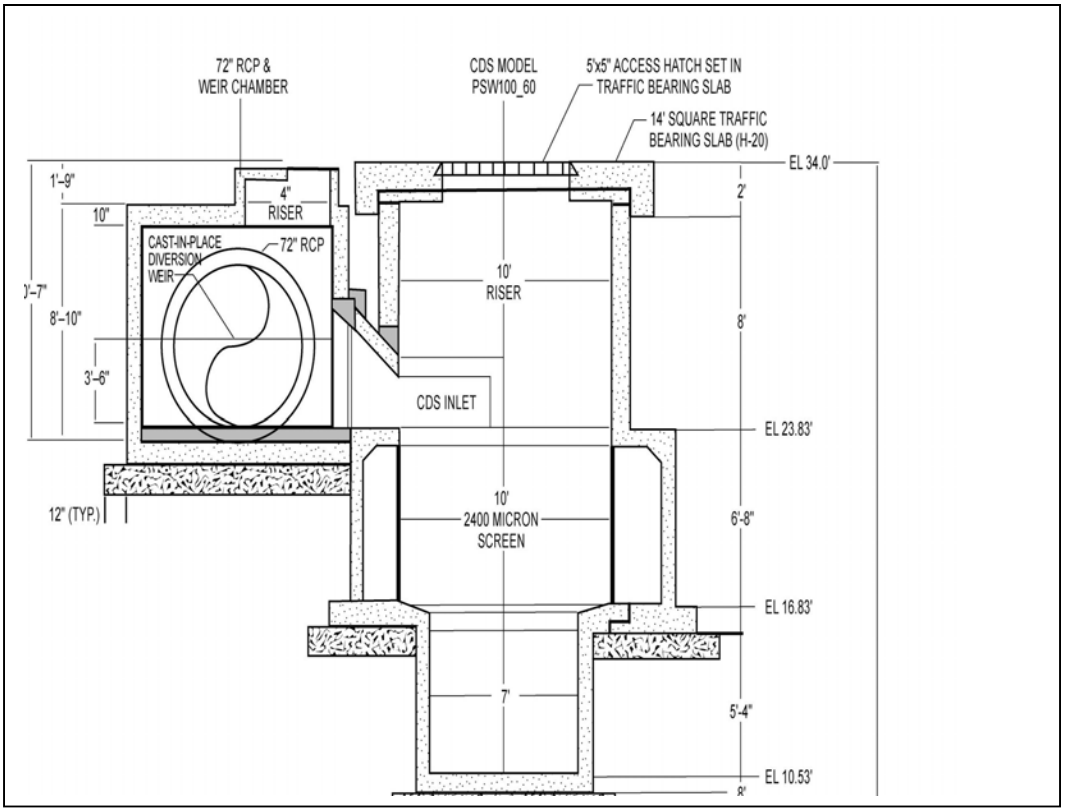


Figure 2 - A vertical cross section view of the CDS unit

Methods

Hydrology Measurements were calculated using velocity meters, water level sensors, tipping bucket rain gauges and appropriate weirs and formulas. This information was stored in data loggers until retrieved and downloaded into spreadsheets to be processed into tables and figures. Bypass flow over a diversion weir was also measured.

Water quality was measured by taking flow-weighted samples (based on water level) for both storm flow and base flow using automated refrigerated samplers. Measurements were made in front of and after the CDS unit.

Gross solids were analyzed each time the unit was vacuumed out. The material in the unit, excluding the litter, was measured monthly and cleaned out when the material was about 5 to 6 feet deep. The floatable litter was skimmed off the top each month and air dried in meshed bags to be combined with the litter extracted from the mass (sediment and debris) at the time of cleanout when all the litter was sorted and weighted by category. The rest of the mass was analyzed using methods developed for soil samples. Representative samples taken at each 0.30 meter (1 ft) depth were collected during cleanout (one 2-liter aliquot taken from each side of the containment chamber at each depth). Each side was composited separately into one sample for the two samples sent to the laboratory for analysis. These two sample results were averaged for this report.

Results and Discussion

Gross Solids Compared to Rainfall

Gross solids, collected in devices such as CDS units, are the solid material including trash, litter, debris and sediments larger than 64 um that are not effectively measured using automatic water quality samplers. Yet these pollutants degrade aquatic habitat, cause visual blight, smother productive sediments, leach harmful pollutants, and can cause unpleasant odors. Litter includes human derived trash, such as, paper, plastic, Styrofoam, metal and glass. Debris consists of organic material including leaves, branches, seeds, twigs, and grass clippings. Coarse sediments are inorganic breakdown products from soils, pavement or building material. All these pollutants are often discharged as bed loads to rivers, lakes and streams. These are the sediments that build up in storm water ponds and will one day have to be dredged or become a pollution source. They include the material that forms deltas and covers productive bottom sediments creating problems in natural water bodies that require multi-million-dollar restoration efforts, especially in streams and lakes.

The material collected by the CDS unit for the Broadway Outfall monitoring effort was quantified on a yearly basis with representative samples collected each time the unit was vacuumed out. The CDS unit collected the majority of the sediment and debris during a two-month period and for the rest of the time period (typically 8 to 13 months) only a minimal change was measured inside the unit (Figure 3). The data presented here cover four cleanout events occurring within a three-year period. One of the difficulties in monitoring the site was that the material had to be removed from the CDS unit when it reached its capacity of 1.83 m (6ft) and this did not occur at regular intervals. In order to make comparisons to other parameters, especially water quality, the time periods were roughly divided into yearly segments (from March to March of each year) as follows:

First Cleanout - Installation of the CDS unit was completed in November of 2001 and the first cleanout was performed on June 25, 2002 when the mass of material reached the capacity of the unit. This was eight months after installation and four months before the monitoring project was initiated. The equipment to monitor water quality and hydrology was installed and these measurements were begun in November 2002.

Second Cleanout – On April 16, 2003, ten months after the first cleanout, the unit once again reached capacity. In this cleanout the volume of material removed was 6.54 m^3 (231 ft^3). This was the first time the material was analyzed for the constituents in the mass collected by the CDS unit and compared to the available six months of water quality data collected for both storm and base flow to be discussed later. This is referred to as Cleanout Year 1 in the tables and figures.

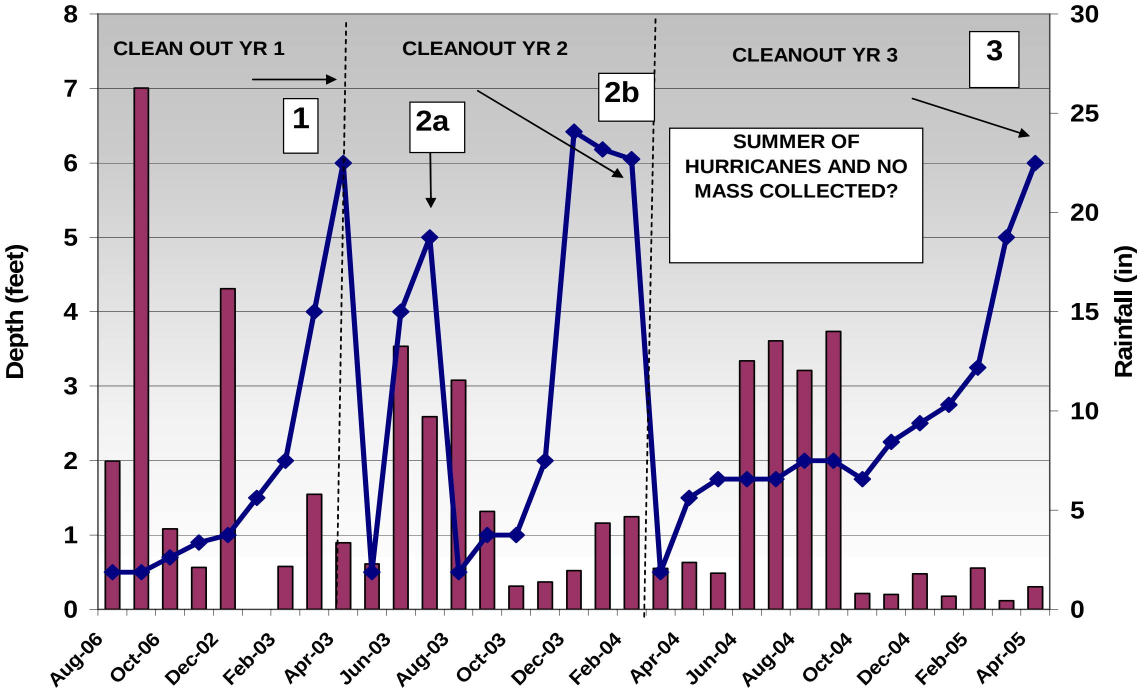


Figure 3 - Accumulation of sediment and debris collected in CDS unit compared to monthly rainfall

Third Cleanout –Three months later on, July15, 2003, the unit was once again almost full and the material removed. In this cleanout 7.36 m^3 (260 ft^3) was vacuumed out of the unit. Since there were two cleanout events during this year, this is referred to in the tables and figures as cleanout year 2a.

Fourth Cleanout – Although the CDS unit had reached capacity again by December 2003 (a five month interval), the unit was not cleaned out until February 26, 2004. It is obvious from Figure 3 that some of the material was scoured out and passed downstream indicating the importance of performing maintenance in a timely manner. This is referred to as Cleanout year 2b and the volume of material removed was 7.36 m^3 (260 ft^3).

Fifth Cleanout – It took over one year before the unit needed to be cleaned out again on March 20, 2005. It should be noted that during the summer of 2004, this part of Florida experienced three large hurricanes and the unit collected no material during these severe storms, unlike the above average rainfall the previous summer which had completely filled the CDS unit with sediment and debris in only three months. This final interval is referred to as Cleanout Year 3 and the volume of material removed was 6.82 m^3 (242 ft^3).

Summary - Although it appears from year one and year three data that February through April produce the most material in the unit, this was not true for year 2. Of some interest is that during the summer of intense hurricanes, no material was collected. Although the water budget calculated for this project is not discussed in this paper, it should be mentioned that during the rainy summer season of 2004, 58 percent of the storm flows bypassed the CDS unit while in 2003 only 38 percent did so, which could have affected the accumulation rates. Also in Figure 3, it appears that the unit collects more material during months with low rainfall amounts than it does when rainfall is high and intense storms are the norm. It should be noted that a much larger unit was recommended for this 53 hectare drainage basin, but the terrain was too flat to accommodate the larger unit.

Gross Solids Compared to Water Quality

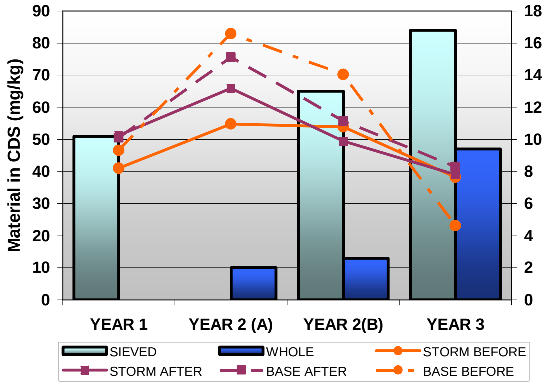
The material collected in the CDS unit for each cleanout indicates considerable differences in concentrations between years as well as samples analyzed by different laboratory methods (Figure 4). The samples were also compared to average water quality for both storm and base flows during the interval and these results are discussed later.

Gross Solids - When the gross solids (the solid bars in Figure 4) are compared for the four cleanout events, year 3 exhibits significantly greater concentrations of pollutants and in almost all cases the sieved samples for all events have higher concentrations than the sample analyzed without sieving (a whole sample). For year one, the analysis was only conducted on sieved samples, which in this study mostly separated the leaves from the sediments. For year 2a, only a whole sample was analyzed. In years 2b and 3, both the sieved and whole samples were compared.

Considering the heterogeneities associated with large particles which increase variability, concentrations for each cleanout showed fairly consistent results for all gross solid samples of the same type until the final cleanout period. For year 3, concentrations were significantly higher with the exception of the nutrients in the whole sample. Usually two particle sizes were analyzed and 60 to 80 percent of the sample was for the largest particle size which included mostly leaves (Rushton 2006), (Space constraints for this paper preclude a discussion of the particle size analysis). Also these analyses are preliminary and a more complete evaluation of the data for year three with a comparison of results from two different laboratories on the same samples may provide more insight and change some of the results.

COPPER

See Figure Legend and text for more information



ZINC

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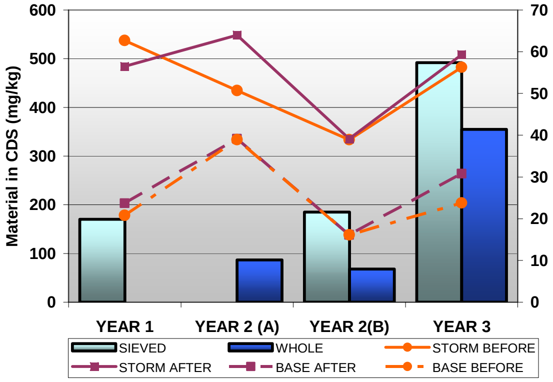

TOTAL KJELDAHL NITROGEN

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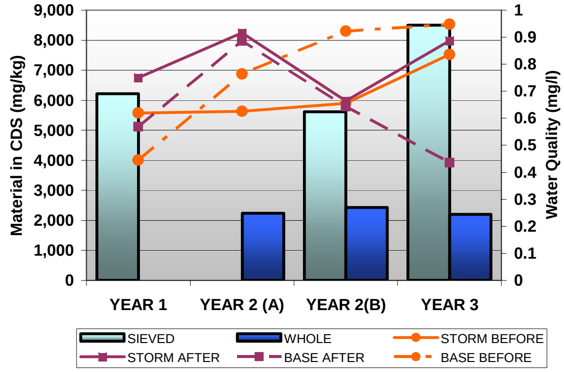

TOTAL PHOSPHORUS

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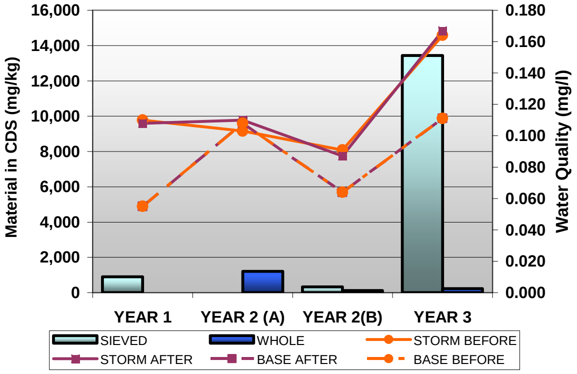

LEAD

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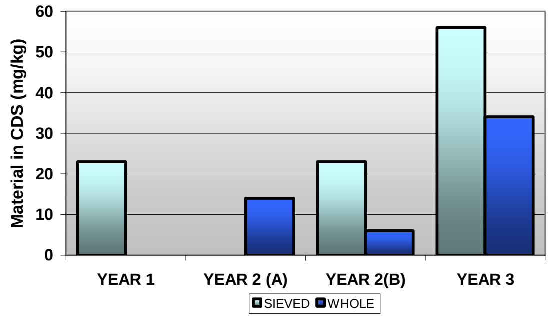

POLYCYCLIC AROMATIC HYDROCARBONS

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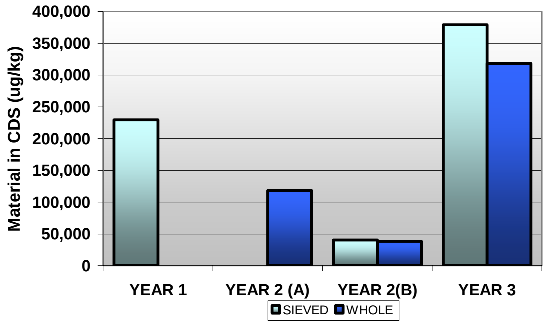

Figure 4 - Concentrations of pollutants in gross solids compared to the average water quality measured in storm flow and base flow during the sampling intervals. Key: BARS=constituent concentrations in the material collected by the CDS unit, LINES= average water quality concentrations measured during the same months as the material was collected in the CDS unit. SOLID LINES=storm flow samples. DASHED LINES=base flow samples. ORANGE CIRCLES=water quality before entering the CDS unit. MAROON SQUARES=water quality downstream of the CDS unit.

The PAHs were also measured at higher concentrations in the collected mass during year 3. In the early years, they were measured at almost the same concentrations as had been measured in the sediments at the end of the pipe before the project started (Rushton 2004), indicating that the CDS unit is removing these potentially carcinogenic particles from the storm water flow stream. Absorbent bags designed to remove PAHs were put in the CDS unit after each cleanout. There were some problems with the bags splitting open or sometimes floating back out into the storm sewer pipe and once one was even found in the pond. This could present a measurement problem especially if some of the spilled material was measured in samples raising concentrations. However, leaves and other organic particles are also effective for absorbing PAHs and this could possibly explain the extremely high concentrations measured in the mass.

The disposal of the material collected in CDS units is of some concern. The copper and lead measured for the first two years were well below the levels considered possibly toxic (> 34 mg/kg for copper and > 46 mg/kg for lead) and only in the third year, were concentrations measured above levels where they might cause problems to benthic organisms. The results for zinc were similar, although the sieved samples reached levels where they might cause problems (> 150 mg/kg), but of greater concern the sieved samples were above the probable toxic level (> 410 mg/kg). The sediment quality guidelines are taken from NOAA (1999).

The PAHs measured in the mass collected by the CDS unit present a more serious disposal problem. Concentrations were always higher than the possible toxic level (> 4,022 ug/kg) and also greatly exceeded the probable toxic level (> 44,792 ug/kg). PAHs do not easily dissolve in water, which is one reason no water quality data are shown in Figure 4. PAHs tend to adhere to solid particles and settle to the bottom of rivers or lakes. PAHs have been identified as a serious problem in Hillsborough Bay (Grabe and Barron 2003) and collection units such as a CDS combined with proper disposal may help reduce this problem. These pollutants are a great concern since the plants and animals living on the land or in water can have bioconcentrations many times higher than the content PAHs in the soil or water (ATSDR 2001). Breakdown in soil and water generally takes weeks to months and is caused primarily by the action of microorganisms. More study is needed to determine the most cost effective method for treating and disposing of this material.

Water Quality – Flow weighted water quality samples were collected for most storm events and base flow samples were collected over several days about every two weeks to measure differences between the inflow and outflow water quality concentrations (Figure 4). Only those constituents that were also measured in the sediments are discussed in this paper. No water quality is shown for lead because most of the samples were below the laboratory limit of detection. Of some concern, was that water sitting in the CDS unit would increase nutrient concentrations because organic leaves and other debris are known to leach nutrients as they decompose (Strynchuk *et al.* 2000 and others).

Although no statistical analysis has been performed, there is no consistent or obvious data in this study to support the hypothesis that nutrients are being increased in concentration as water passes through the unit. One reason that there may be so little difference between the water quality before and after it enters the unit is that the water has been associated with the solids during the flow down the pipe and the residence time of the water in the CDS unit is too short to change the concentrations. A different sampling scheme with fresh leaves and a more controlled timing might have produced entirely different results than these concentrations averaged on a yearly basis.

Litter (Trash)

The litter was collected, air dried, weighed and sorted for each cleanout period (Table 1). The samples include the litter that had been skimmed off each month as well as the litter retrieved from the mass of material removed by the vacuum truck at the time of clean out. Although the amount of litter is small compared to the leaves and heavy sediments, it is an eye sore and has the potential to impact wildlife as well as leach pollutants. Plastics were measured more often than any other litter category, but Styrofoam was also found in large quantities.

During cleanout period 2b there is a question about whether the City of Temple Terrace personnel left us all the litter skimmed off the top each month or followed their normal procedure from the cleanout of their other CDS units and took it off to the landfill. At any rate much less litter was collected during this 10 month period than during the two previous collection intervals, which had covered much shorter time periods. Year 3 data are not available at this time. The amount of litter collected by the CDS unit during each cleanout was quite small (6 to 17 ft^3) compared to the amount of leaves and sediments removed from the CDS unit (182 ft3 to 260 ft^3).

Table 1. Amount of litter collected in the CDS unit.

CATEGORY	CLEANOUT YR 1				CLEANOUT YR 2a				CLEANOUT YR 2b			
	KG	LB	M^3	FT^3	KG	LB	M^3	FT^3	KG	LB	M^3	FT^3
Plastic	13.91	30.66	0.25	8.79	19.21	42.34	0.33	11.76	5.33	11.76	0.13	4.44
Aluminum	1.65	3.63	0.04	1.52	2.67	5.88	0.05	1.75	0.74	1.63	0.01	0.23
Styrofoam	0.39	0.85	0.08	2.91	0.40	0.89	0.03	0.99	0.23	0.51	0.05	1.64
Miscellaneous	0.93	2.05	0.00	0.11	2.62	5.78	0.01	0.48	0.49	1.07	0.05	1.65
Wood	1.65	3.63	0.04	1.52	2.67	5.88	0.05	1.75	0.00	0.00	0.00	0.00
Paper	0.41	0.91	0.00	0.04	0.00	0.00	0.00	0.00	0.09	0.20	0.00	0.12
Glass	0.10	0.23	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cig. Butts.	0.02	0.04	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fabric	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.54	0.00	0.12
TOTALS	**19.05**	**42.00**	**0.42**	**14.91**	**27.56**	**60.77**	**0.47**	**16.73**	**7.12**	**15.71**	**0.23**	**8.20**

Conclusions

- A CDS unit was effective for removing leaves, large size sediment and litter from stormwater runoff.
- Highly toxic levels of PAHs were also removed from the stormwater flow stream, which would probably travel as bedloads to the river.
- No apparent differences were measured for nutrients before or after water flowed through the CDS unit, which suggests the decomposing leaves in the unit were not increasing nutrient concentrations in the water column. (Statistical analysis and a better experimental design are needed to verify this conclusion drawn from this data averaged over a long time period).
- Sieving samples into particle size cause large increases in concentrations.
- A device is needed at the entrance of the CDS unit that can close off the base flow during cleanout and that will keep the material from floating back out of the unit into the pipe during base flow.

Acknowledgements

This project including the preparation of this report was funded in part by a Section 319(h) Nonpoint Source Management Program grant from the U.S. Environmental Protection Agency through a contract with the Florida Department of Environmental Protection. The SWFWMD laboratory staff was indispensable in carefully analyzing water quality samples that could never be collected on a pre-determined schedule. Rebecca Hastings and Stan Kane as well as numerous interns collected data, repaired equipment, entered data into tables and figures, visited the site at least once a week and kept everything in working order. Their help was greatly appreciated.

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Appendix Table I.1a. Storm samples taken for four cleanout periods before and after runoff entered a CDS unit installed at the Broadway outfall in Tampa, Florida.

STORM SAMPLES

	AMMONIA		NITRATE +		ORGANIC N		TOTAL N		ORTHO P		TOTAL P		TSS		COPPER		ZINC	
	mg/l		mg/l		mg/l		mg/l		mg/l		mg/l		mg/l		ug/l		ug/l	
	934 BEFORE CDS	935 AFTER CDS	934 BEFORE CDS	935 AFTER CDS	934 BEFORE CDS	935 AFTER CDS	934 BEFORE CDS	935 AFTER CDS	934 BEFORE CDS	935 AFTER CDS	934 BEFORE CDS	935 AFTER CDS	935 BEFORE CDS	935 AFTER CDS	934 BEFORE CDS	935 AFTER CDS	934 BEFORE CDS	935 AFTER CDS
FOR CLEANOUT YEAR 1 (WQ samples from 10-31-02 to 4-28-03) Misses water quality data from July to November.Takes from November 2002 until April 2003 to fill CDS unit																		
# Samples	12	12	12	12	12	12	12	12	12	12	12	12	11	11	12	12	12	12
Mean	0.0690	0.0520	0.457	0.407	0.55	0.70	1.08	1.16	0.032	0.025	0.110	0.108	17.6	18.4	8.28	10.20	62.7	56.5
Median	0.0340	0.0225	0.464	0.424	0.51	0.60	1.16	1.12	0.031	0.020	0.116	0.102	14.3	15.7	9.18	9.16	47.8	54.4
St. Dev.	0.0774	0.0612	0.283	0.239	0.30	0.38	0.26	0.32	0.025	0.019	0.054	0.056	9.5	12.0	3.10	4.84	31.1	23.6
Max	0.2050	0.1600	1.010	0.819	1.28	1.30	1.45	1.73	0.081	0.063	0.195	0.181	34.4	49.4	13.70	18.80	120.0	100.0
Min	0.0060	0.0060	0.017	0.015	0.17	0.26	0.59	0.66	0.005	0.005	0.036	0.028	6.3	7.6	3.89	3.89	34.1	29.5
C.V.	1.1222	1.1776	0.62	0.59	0.55	0.54	0.24	0.27	0.79	0.75	0.49	0.52	0.54	0.65	0.37	0.47	0.50	0.42
FOR CLEANOUT YEAR 2A (5-1-03 to 7-12-03). CDS unit filled in short time from April 2003 to July 2003.																		
# Samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Mean	0.036	0.025	0.379	0.313	0.591	0.891	1.005	1.228	0.025	0.022	0.103	0.110	12.9	11.8	10.97	13.19	50.7	64.0
Median	0.016	0.018	0.402	0.295	0.598	0.746	1.030	1.070	0.022	0.019	0.083	0.095	9.1	9.7	10.60	11.70	60.2	45.1
St. Dev.	0.045	0.024	0.141	0.100	0.423	0.329	0.398	0.377	0.017	0.016	0.053	0.046	14.5	5.2	3.41	5.77	21.6	44.0
Max	0.130	0.067	0.568	0.460	1.068	1.495	1.600	1.900	0.054	0.055	0.235	0.205	50.1	18.3	18.60	25.50	74.9	147.0
Min	0.006	0.006	0.132	0.165	0.000	0.531	0.235	0.740	0.005	0.005	0.067	0.054	1.590	3.290	7.05	7.10	10.4	11.6
C.V.	1.257	0.944	0.373	0.319	0.717	0.369	0.396	0.307	0.678	0.710	0.511	0.420	1.122	0.443	0.31	0.44	0.4	0.7
FOR CLEANOUT YEAR 2B (8-9-03 to 4-13-04). CDS unit fills in almost a year August 2003 to March 2004.																		
# Samples	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Mean	0.019	0.020	0.453	0.384	0.639	0.644	1.110	1.048	0.024	0.021	0.091	0.087	12.2	10.8	10.78	9.89	38.9	39.1
Median	0.016	0.015	0.424	0.312	0.558	0.562	1.090	1.058	0.020	0.021	0.078	0.070	10.7	10.8	7.96	7.10	35.2	35.8
St. Dev.	0.021	0.023	0.216	0.196	0.248	0.267	0.231	0.245	0.021	0.017	0.032	0.036	6.0	4.5	11.29	12.32	17.5	16.5
Max	0.101	0.095	0.833	0.761	1.344	1.312	1.660	1.600	0.088	0.062	0.160	0.150	25.7	19.3	49.90	60.10	70.3	77.9
Min	0.003	0.003	0.007	0.006	0.345	0.395	0.711	0.600	0.005	0.002	0.048	0.043	4.5	4.3	1.50	1.50	16.4	18.6
C.V.	1.149	1.132	0.477	0.512	0.388	0.414	0.208	0.234	0.849	0.825	0.354	0.408	0.494	0.417	1.05	1.25	0.451	0.421
FOR CLEANOUT YEAR 3 (6-5-04 to 4-27-05) Takes over a full year to fill CDS unit from March 2004 to April 2005.																		
# Samples	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
Mean	0.082	0.077	0.408	0.405	0.753	0.810	1.244	1.291	0.085	0.078	0.164	0.167	23.7	21.6	7.65	7.80	56.3	59.3
Median	0.039	0.035	0.328	0.323	0.639	0.694	1.055	1.125	0.046	0.046	0.113	0.103	15.9	16.4	5.70	5.38	43.2	42.3
St. Dev.	0.104	0.091	0.344	0.257	0.591	0.396	0.709	0.494	0.154	0.036	0.153	0.092	35.6	27.1	5.70	5.58	39.0	50.6
Max	0.415	0.738	1.440	1.310	2.809	3.137	4.300	4.320	0.914	1.340	1.040	1.480	233.0	158.0	34.20	32.00	212.0	267.0
Min	0.003	0.003	0.011	0.048	0.000	0.000	0.124	0.590	0.020	0.005	0.051	0.054	0.3	2.1	1.50	3.36	11.4	13.9
C.V.	1.269	1.185	0.843	0.636	0.784	0.489	0.570	0.382	1.823	0.461	0.937	0.554	1.499	1.256	0.74	0.72	0.693	0.853

Appendix Table I.2a. Base flow samples taken for four cleanout periods before and after runoff entered a CDS unit installed at the Broadway outfall in Tampa, Florida.

BASE FLOW SAMPLES

	AMMONIA		NITRATE +		ORGANIC N		TOTAL N		ORTHO P		TOTAL P		TSS		COPPER		ZINC	
	mg/l		mg/l		mg/l		mg/l		mg/l		mg/l		mg/l		ug/l		ug/l	
	934	935	934	935	934	935	934	935	934	935	934	935	935	935	934	935	934	935
	BEFORE CDS	**AFTER CDS**	**BEFORE CDS**	**AFTER CDS**	**BEFORE CDS**	**AFTER CDS**	**BEFORE CDS**	**AFTER CDS**	**BEFORE CDS**	**AFTER CDS**	**BEFORE CDS**	**AFTER CDS**	**BEFORE CDS**	**AFTER CDS**	**BEFORE CDS**	**AFTER CDS**	**BEFORE CDS**	**AFTER CDS**
FOR CLEANOUT YEAR 1 (WQ samples from 10-31-02 TO 4-28-03) Misses water quality data from July to November.Takes from November 2002 until April 2003 to fill CDS unit																		
# Samples	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
Mean	0.0170	0.0378	1.084	0.824	0.428	0.531	1.529	1.393	0.023	0.018	0.053	0.055	3.7	5.1	9.34	10.10	20.8	23.7
Median	0.0140	0.0290	1.050	0.878	0.358	0.471	1.450	1.300	0.018	0.016	0.040	0.052	2.0	3.7	8.48	7.30	18.1	17.5
St. Dev.	0.0148	0.0455	0.294	0.291	0.235	0.348	0.276	0.294	0.018	0.013	0.041	0.029	4.7	3.9	6.34	6.74	13.1	18.0
Max	0.0670	0.1970	1.940	1.320	1.104	1.786	2.250	2.050	0.068	0.046	0.160	0.118	21.5	13.3	26.60	29.70	50.0	58.6
Min	0.0060	0.0060	0.427	0.186	0.101	0.085	1.040	1.010	0.002	0.002	0.005	0.014	0.6	1.1	1.50	3.18	5.9	5.6
C.V.	0.8746	1.2028	0.27	0.35	0.55	0.66	0.18	0.21	0.77	0.76	0.77	0.53	1.29	0.76	0.68	0.67	0.6	0.8
FOR CLEANOUT YEAR 2A (5-1-03 to 7-12-03). CDS unit filled in short time from April 2003 to July 2003.																		
# Samples	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mean	0.030	0.040	0.593	0.438	0.733	0.846	1.356	1.324	0.027	0.018	0.091	0.108	8.9	11.6	16.60	15.13	32.0	41.2
Median	0.020	0.027	0.461	0.433	0.680	0.778	1.380	1.285	0.019	0.015	0.088	0.103	7.9	10.1	9.22	8.65	32.5	30.6
St. Dev.	0.024	0.034	0.355	0.206	0.294	0.333	0.440	0.316	0.029	0.012	0.042	0.044	4.3	5.5	23.31	18.77	10.8	27.3
Max	0.074	0.093	1.140	0.802	1.094	1.350	2.160	1.840	0.091	0.035	0.169	0.185	15.3	23.8	74.00	61.20	44.9	93.6
Min	0.006	0.006	0.269	0.177	0.426	0.490	0.760	0.800	0.005	0.005	0.046	0.052	4.3	7.3	4.21	4.58	16.4	18.5
C.V.	0.806	0.843	0.599	0.469	0.401	0.394	0.324	0.239	1.071	0.651	0.465	0.413	0.478	0.473	1.404	1.241	0.337	0.663
FOR CLEANOUT YEAR 2B (8-9-03 to 4-13-04). CDS unit fills in almost a year August 2003 to March 2004.																		
# Samples	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Mean	0.020	0.027	0.727	0.647	0.902	0.616	1.649	1.291	0.017	0.015	0.077	0.064	5.4	4.5	14.03	11.15	16.1	16.1
Median	0.008	0.014	0.824	0.688	0.549	0.483	1.500	1.290	0.013	0.010	0.063	0.062	3.2	3.9	5.55	7.17	12.9	14.6
St. Dev.	0.022	0.039	0.361	0.251	0.927	0.247	0.905	0.200	0.016	0.014	0.035	0.027	4.3	2.9	24.65	13.06	9.3	7.5
Max	0.068	0.155	1.370	1.100	4.667	1.071	5.380	1.580	0.067	0.057	0.138	0.121	17.6	11.7	116.00	50.80	45.4	40.9
Min	0.003	0.003	0.001	0.218	0.369	0.369	0.950	0.782	0.000	0.000	0.035	0.029	1.4	1.7	1.50	1.50	5.9	7.1
C.V.	1.120	1.437	0.496	0.388	1.028	0.401	0.549	0.155	0.932	0.947	0.451	0.415	0.789	0.653	1.757	1.172	0.578	0.467
FOR CLEANOUT YEAR 3 (6-5-04 to 4-27-05) Takes over a full year to fill CDS unit from March 2004 to April 2005.																		
# Samples	16	16	16	16	16	16	16	16	16	16	16	16	15	15	16	16	16	16
Mean	0.131	0.095	1.261	1.538	0.817	0.341	2.209	1.974	0.070	0.068	0.114	0.111	6.7	6.5	4.62	8.30	23.8	30.8
Median	0.074	0.078	1.115	0.834	0.639	0.532	1.785	1.880	0.061	0.059	0.093	0.104	4.0	3.6	1.50	1.50	22.1	26.8
St. Dev.	0.148	0.091	0.780	1.991	0.545	1.653	0.927	0.965	0.029	0.031	0.058	0.039	5.3	7.4	8.82	21.92	17.4	21.3
Max	0.640	0.364	2.510	8.550	1.885	1.942	3.820	3.300	0.136	0.173	0.274	0.211	22.4	29.7	37.00	89.70	79.5	91.3
Min	0.010	0.011	0.432	0.287	0.314	-5.368	1.080	0.211	0.029	0.034	0.046	0.067	2.1	1.1	1.50	1.50	7.7	12.6
C.V.	1.135	0.960	0.618	1.294	0.667	4.848	0.420	0.489	0.407	0.453	0.511	0.350	0.794	1.149	1.91	2.64	0.732	0.690

APPENDIX J

SEDIMENT ANALYSIS

BROADWAY OUTFALL - PRECONSTRUCTION

SEDIMENT SAMPLING

MAY 2, 2001

CONSTITUENT	SITE	FLO 935		FLO 936		FLO 937		FLO 937 DUP		FLO 938		FLO 939		FLO 940		FLO 941		FLO 941d	
SEMI-VOLATILE ORGANIC POLLUTANTS - SEDIMENT																			
Acenaphthene	ug/kg	2,000	I	—	U	—	U	—	U	—	U	—	U	—	U	—	U	370	I
Anthracene	ug/kg	5,900		600	I	—	U	—	U	—	U	—	U	—	U	760	I	710	I
Benzo(a)anthracene	ug/kg	24,000		4,600		—	U	—	U	—	U	2,500	I	180	I	3,700		3,300	
Benzo(a)pyrene	ug/kg	19,000		4,500		—	U	—	U	—	U	2,700	I	230	I	3,700		3,300	
Benzo(b)fluoranthene	ug/kg	30,000		7,500		150	I	—	U	—	U	4,100		360	I	5,300		4,700	
Benzo(k)fluoranthene	ug/kg	7,000		2,300		—	U	—	U	—	U	1,600	I	130	I	1,900	I	1,700	
Benzo(g,h,i)perylene	ug/kg	10,000		2,700		—	U	—	U	—	U	2,300	I	180	I	2,500	I	1,900	
Bis(2-ethylhexyl)phthalate	ug/kg	—	U	2,500		—	U	—	U	—	U	—	U	—	U	—	U	–	U
Butyl benzyl phthalate	ug/kg	2,100	I	410		—	U	—	U	—	U	—	U	—	U	—	U	3,700	
Chrysene	ug/kg	26,000		6,300		130	I	—	U	—	U	3,900		330	I	5,200		4,500	
Di-n-octyl phthalate	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U		
Fluoranthene	ug/kg	41,000		11,000		2,000	I	130	I	—	U	6,800		510		9,900		8,100	
Florene	ug/kg	2,800	I	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
Indeno(1,2,3-cd)pyrene	ug/kg	12,000		3,200		—	U	—	U	—	U	2,600	I	210	I	3,000		2,400	
Phenanthrene	ug/kg	26,000		3,800		—	U	—	U	—	U	2,200	I	200	I	3,700		3,200	
Pyrene	ug/kg	35,000		7,800		140	I	95	I	—	U	5,200		390		7,600		6,300	
METALS, TOTAL RECOVERABLE - SEDIMENT																			
Aluminum_308	ug/kg	1,170.00		1,250.00		2,920.00		1,720.00		3,570.00	A	1,280.00		7,730.00		720.00		3,550.00	
Cadmium	ug/kg	0.78	I	1.06		0.54	I	0.53	I	—	U	0.78	I	0.69		0.50	I	0.77	I
Chromium	ug/kg	7.29	J	11.10	J	13.60	J	8.41	J	7.99	AJ	8.50	J	32.60	J	5.64	J	11.90	J
Copper	ug/kg	6.10		5.50		1.20	I	1.10	I	—	U	5.00		1.10	I	2.00		5.10	I
Iron_271	ug/kg	2,290.00	J	3,550.00	J	1,270.00	J	659.00	J	813.00	AJ	5,790.00	J	2,930.00	J	1,110.00	J	3,860.00	J
Lead	ug/kg	29.50		6.00		3.40		2.80	I	2.40	I	21.20		5.40	I	10.90		15.10	
Manganese	ug/kg	38.20		17.80		4.70		4.00		3.20	A	27.60		26.50		41.50		174.00	
Nickel	ug/kg	—	U	3.60		3.00	I	—	U	—	U	—	U	8.60		—	U	–	U
Zinc	ug/kg	63.00		24.00		—	U	—	U	—	U	37.00		6.90	I	39.00		54.00	
TOTAL KJELDAHL NITROGEN - SOIL																			
TKN	mg/kg	500.00	J	130.0	J	82.0		80	A	120		290.0	J	180.00		150	J	270	
TOTAL PHOSPHOROUS - SOIL																			
Total - P	mg/kg	270.00		1500.0		2300.0		2300	A	200		260.0	JA	1200.00		330	JA	180	
ORGANONITROGEN AND PHOSPHORUS PESTICIDES - SEDIMENT																			
Chlorpyrifos Ethyl	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
Diazanon	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
Parathion Methyl	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
ORGANOCHLORINE PESTICIDES-SOIL																			
Aldrin	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
Chlordane	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
DDD-p,p'	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
DDE-p,p'	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
DDT-p,p'	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
Dieldrin	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
Endosulfan Sulfate	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
PCB-1248	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U
PCB-1260	ug/kg	—	U	—	U	—	U	—	U	—	U	—	U	—	U	—	U	–	U

KEY:

A - Value reported is the mean of two or more determinations

I - Value reported is less than the minimum quantitation limit, and greater than or equal to the minimum detection limit.

J - Estimated Value

N - Presumptive evidence of presence of material.

U - Material was analyzed but not detected; value reported is the minimum detection limit.

BROADWAY OUTFALL - AFTER CONSTRUCTION

SEDIMENT SAMPLING FOR BASELINE

AUGUST 14, 2002

CONSTITUENT	site>	FLO 935	FLO 936	FLO 937	FLO 938	FLO 939	FLO 940	FLO 941
SEMI-VOLATILE ORGANIC POLLUTANTS								
Acenaphthene	ug/kg	83 I	— U	— U	— U	— U	na	— U
Anthracene	ug/kg	320 I	— U	— U	— U	— U	na	— U
Benzo(a)anthracene	ug/kg	3,000	640	490	520	530	na	— U
Benzo(a)pyrene	ug/kg	3,800	960	560	810	770	na	— U
Benzo(b)fluoranthene	ug/kg	7,700	1,800	1,000	1,500	1,400	na	— U
Benzo(k)fluoranthene	ug/kg	2,100	580	320 I	480	550	na	— U
Benzo(g,h,i)perylene	ug/kg	2,100	590	360	600	560	na	— U
Bis(2-ethylhexyl)phthalate	ug/kg	3,000	— U	— U	— U	— U	na	— U
Butyl benzyl phthalate	ug/kg	— U	— U	— U	— U	530 I	na	— U
Chrysene	ug/kg	5,900	4	760	980	920	na	— U
Di-n-octyl phthalate	ug/kg	250 I	1,300 U	— U	— U	— U	na	— U
Dibenzo(a,h)anthracene	ug/kg	580	— U	100 I	150 I	130 I	na	— U
Fluoranthene	ug/kg	8,900	1,700	1,300	1,300 U	1,200	na	— U
Florene	ug/kg	140 I	— U	370	— U	— U	na	— U
Indeno(1,2,3-cd)pyrene	ug/kg	2,300	620	— U	610	500	na	— U
Phenanthrene	ug/kg	2,500	570	680	380	410	na	— U
Pyrene	ug/kg	7,500	1,600	1,200	1,200	1,200	na	— U
METALS, TOTAL RECOVERABLE								
Aluminum_308	ug/kg	na	na	na	na	na	na	na
Cadmium	ug/kg	na	na	na	na	na	na	na
Chromium	ug/kg	na	na	na	na	na	na	na
Copper	ug/kg	na	na	na	na	na	na	na
Iron_271	ug/kg	na	na	na	na	na	na	na
Lead	ug/kg	na	na	na	na	na	na	na
Manganese	ug/kg	na	na	na	na	na	na	na
Nickel	ug/kg	na	na	na	na	na	na	na
Zinc	ug/kg	na	na	na	na	na	na	na
TOTAL KJELDAHL NITROGEN - SOIL								
TKN	mg/kg	na	na	na	na	na	na	na
TOTAL PHOSPHOROUS - SOIL								
Total - P	mg/kg	na	na	na	na	na	na	na
ORGANONITROGEN AND PHOSPHORUS PESTICIDES								
Chlorpyrifos Ethyl	ug/kg	11.00 J	— U	— U	— U	— U	na	— U
Diazanon	ug/kg	— U	— U	— U	— U	— U	na	— U
Parathion Methyl	ug/kg	— U	— U	— U	— U	— U	na	— U
ORGANOCHLORINE PESTICIDES-SOIL								
Aldrin	ug/kg	— U	— U	— U	— U	— U	na	— U
Chlordane	ug/kg	— U	— U	— U	9.2 I	— U	na	— U
DDD-p,p'	ug/kg	— U	— U	— U	— U	— U	na	— U
DDE-p,p'	ug/kg	— U	— U	— U	— U	— U	na	— U
DDT-p,p'	ug/kg	— U	— U	— U	— U	— U	na	— U
Dieldrin	ug/kg	— U	— U	— U	— U	— U	na	— U
Endosulfan Sulfate	ug/kg	— U	— U	— U	— U	— U	na	— U
Methoxychlor	ug/kg	13.00 N	6.7 N	— U	— U	— U	na	— U
PCB-1248	ug/kg	— U	— U	— U	— U	— U	na	— U
PCB-1260	ug/kg	— U	— U	— U	— U	— U	na	— U

KEY:

A - Value reported is the mean of two or more determinations

I - Value reported is less than the minimum quantitation limit, and greater than or equal to the minimum detection limit.

J - Estimated Value

N - Presumptive evidence of presence of material.

U - Material was analyzed but not detected; value reported is the minimum detection limit.

BROADWAY OUTFALL

SEDIMENT SAMPLING

August 26, 2004

CONSTITUENT	site>	FLO 936		FLO 936 DUP		FLO 937		FLO 938		FLO 939		FLO 940	FLO 941
SEMI-VOLATILE ORGANIC POLLUTANTS		1PM		1:20 PM		11:35AM		11:15AM		10:30AM			
Acenaphthene	ug/kg	83	U	83	U	79	U	77	U	76	U	na	na
Anthracene	ug/kg	83	U	150	I	79	U	77	U	76	U	na	na
Benzo(a)anthracene	ug/kg	540		910		320		520		400		na	na
Benzo(a)pyrene	ug/kg	710		1100		460		800		510		na	na
Benzo(b)fluoranthene	ug/kg	970		1500		650		1200		630		na	na
Benzo(k)fluoranthene	ug/kg	760		1100		540		870		510		na	na
Benzo(g,h,i)perylene	ug/kg	460		690		310	I	550		320		na	na
Bis(2-ethylhexyl)phthalate	ug/kg	500	U	500	U	2500		460	U	450	U	na	na
Butyl benzyl phthalate	ug/kg	83	U	83	U	79	U	77	U	76	U	na	na
Chrysene	ug/kg	930		1500		650		1100		600		na	na
Di-n-octyl phthalate	ug/kg	83	U	83	U	79	U	77	U	76	U	na	na
Dibenzo(a,h)anthracene	ug/kg	83	U	83	U	79	U	77	U	76	U	na	na
Fluoranthene	ug/kg	1500		2500		860		1400		1000		na	na
Florene	ug/kg	83		83	U	79	U	77	U	76	U	na	na
Indeno(1,2,3-cd)pyrene	ug/kg	420		640		290	I	510		300	I	na	na
Phenanthrene	ug/kg	420		920		200	I	330		280	I	na	na
Pyrene	ug/kg	1200		2100	*1	700	*1	1200	*1	810	J	na	na
METALS, TOTAL RECOVERABLE													
Aluminum_308	ug/kg	7970		7230	A	6940		5210		4400		na	na
Cadmium	ug/kg	0.94		0.52	A	0.35		0.12	I	0.13		na	na
Chromium	ug/kg	29.9		27	A	26.2		14		16.5		na	na
Copper	ug/kg	1.6	I	1.7	I	3.2		3.3		0.79	U	na	na
Iron_271	ug/kg	2880		2750	A	3000		2430		1770		na	na
Lead	ug/kg	4		4.2	A	4		7.6		5.3		na	na
Manganese	ug/kg	23		17.9	A	6.4		8.5		7.5		na	na
Nickel	ug/kg	4.7	I	4.7	I	5.71	J	3.7	I	2.8	I	na	na
Zinc	ug/kg	9.3	J	9.4	AJ	9.2	J	11.5		7.5	I	na	na
TOTAL KJELDAHL NITROGEN - SOIL													
TKN	mg/kg	110	*1	78	*1	120	*1	250	*1	170	*3	na	na
TOTAL PHOSPHOROUS - SOIL													
Total - P	mg/kg	170		1400		1300		260		250	A	na	na
ORGANONITROGEN AND PHOSPHORUS PESTICIDES													
Chlorpyrifos Ethyl	ug/kg	4.5	U	2.3	U	2.2	U	2.1	U	2.1	U	na	na
Diazanon	ug/kg	4.5	UJ	4.5	*2	4.3	*2	4.3	*2	4.2	*2	na	na
Parathion Methyl	ug/kg	6.8	U	6.8	U	6.5	U	6.4	U	6.2	U	na	na
ORGANOCHLORINE PESTICIDES-SOIL													
Aldrin	ug/kg	1.4	U	0.45	U	0.43	U	0.43	U	0.42	U	na	na
Chlordane	ug/kg	6.8	U	6.8	U	6.5	U	11	I	9.3	I	na	na
DDD-p,p'	ug/kg	0.91	U	0.91	U	0.87	U	0.85	U	0.83	U	na	na
DDE-p,p'	ug/kg	0.91	U	0.91	U	0.87	U	0.85	U	0.83	U	na	na
DDT-p,p'	ug/kg	1.4	UJ	1.4	*2	1.3	*2	1.3	*2	0.83	U	na	na
Dieldrin	ug/kg	0.45	U	0.45	U	0.43	U	0.43	U	1.2	*2	na	na
Endosulfan Sulfate	ug/kg	0.91	*2	0.91	*2	0.87	*2	0.85	*2	0.83	*2	na	na
Methoxychlor	ug/kg	11	U	15	U	11	U	11	U	10	U	na	na
PCB-1248	ug/kg	9.1	U	9.1	U	8.7	U	8.5	U	8.3	U	na	na
PCB-1260	ug/kg	14	U	14	U	13	U	13	U	12	U	na	na

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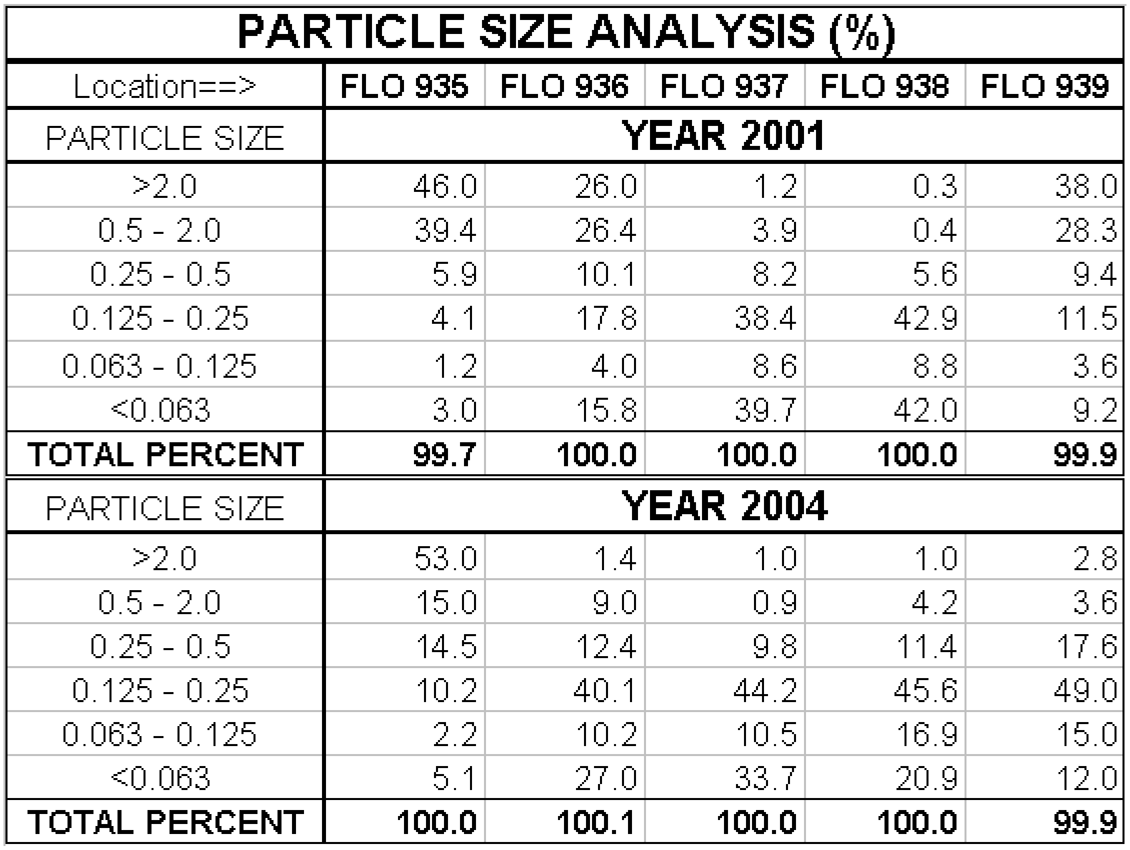
greater than or equal to the minimum detection limit.
J - Estimated Value
N - Presumptive evidence of presence of material.
U - Material was analyzed but not detected; value reported is the minimum detection limit.
*1 - MS,RPD (Batch failure)
*2 - UJ,CCV (Batch recovery Failure)
*3 - AJ,MS,RPD (Batch failure)

Table J-1. Particle size analysis for the ditch sediments in year 2001 before the pond was constructed and in year 2004 in the pond three years after construction. Particle size in millimeters.



PARTICLE SIZE ANALYSIS (%)					
Location==>	**FLO 935**	**FLO 936**	**FLO 937**	**FLO 938**	**FLO 939**
PARTICLE SIZE	**YEAR 2001**				
>2.0	46.0	26.0	1.2	0.3	38.0
0.5 - 2.0	39.4	26.4	3.9	0.4	28.3
0.25 - 0.5	5.9	10.1	8.2	5.6	9.4
0.125 - 0.25	4.1	17.8	38.4	42.9	11.5
0.063 - 0.125	1.2	4.0	8.6	8.8	3.6
<0.063	3.0	15.8	39.7	42.0	9.2
TOTAL PERCENT	**99.7**	**100.0**	**100.0**	**100.0**	**99.9**
PARTICLE SIZE	**YEAR 2004**				
>2.0	53.0	1.4	1.0	1.0	2.8
0.5 - 2.0	15.0	9.0	0.9	4.2	3.6
0.25 - 0.5	14.5	12.4	9.8	11.4	17.6
0.125 - 0.25	10.2	40.1	44.2	45.6	49.0
0.063 - 0.125	2.2	10.2	10.5	16.9	15.0
<0.063	5.1	27.0	33.7	20.9	12.0
TOTAL PERCENT	**100.0**	**100.1**	**100.0**	**100.0**	**99.9**

APPENDIX K

MACROINVERTEBRATES

Table K-1. Phylogenetic list of taxa with counts for each station. Broadway outfall 02-May-01

	Taxa	2 (935)	3 (936)	4 (937)	5 (938)	6 (939)	7 (940)	8 (941)
PHYLUM MOLLUSCA								
CLASS GASTROPODA								
ORDER BASOMMATOPHORA								
FAMILY ANCYLIDAE								
	Hebetancylus excentricus	0	0	0	0	0	1	0
FAMILY PLANORBIDAE								
	Micromenetus floridensis	1	0	0	0	0	0	0
FAMILY PHYSIDAE								
	Physella	1	0	0	0	0	0	0
PHYLUM ANNELIDA								
CLASS OLIGOCHAETA								
FAMILY ENCHYTRAEIDAE								
	cf. Enchytraeidae	0	2	0	0	0	0	0
FAMILY TUBIFICIDAE								
	Tubificidae	6	44	0	4	10	5	17
FAMILY NAIDIDAE								
	cf Pristina synclites	0	1	0	0	0	0	0
	Dero							
	Dero cff nivea	0	0	0	0	0	5	0
	Dero cf flabelliger							
	Dero cff digitata	1	0	0	0	0	4	0
	cf. Haemonais waldvogeli	0	0	1	1	0	33	0
	cf. Pristinella	0	1	0	0	0	0	0
PHYLUM UNIRAMIA								
SUBPHYLUM HEXAPODA								
CLASS PTERYGOTA								
ORDER DIPTERA								
	Diptera (larvae)	0	0	0	0	0	1	0
FAMILY CHIRONOMIDAE								
	Tanypus	1	0	0	0	0	1	0
	Orthocladiinae	0	0	0	0	1	0	0
	Chironominae (pupae)	0	1	0	0	0	0	0
	Chironomus	5	0	3	3	0	38	0
	Goeldichironomus	0	0	0	1	0	0	0
	Goeldichironomus holoprasinus	0	1	0	0	0	1	0
	Goeldichironomus cff holoprasinus	0	0	0	0	0	2	0
	Keifferulus dux/pungens	0	0	0	1	0	2	0
	Polypedilum illinoense gp.	0	2	2	0	1	0	0
	Polypedilum tritum	0	1	0	0	0	0	0
	Chironomini (pupae)	1	0	0	0	0	0	0
	Tanytarsus	0	0	0	0	0	3	0
	TOTALS	**16**	**53**	**6**	**10**	**12**	**93**	**17**

Table K-2. Phylogenetic list of taxa with counts for each station. Broadway outfall 14-Aug-02

Taxa	2 (935)	3 (936)	4 (937)	5 (938)	6 (939)	7 (940)	8 (941)
PHYLUM MOLLUSCA							
CLASS GASTROPODA							
ORDER BASOMMATOPHORA							
FAMILY PLANORBIDAE							
Biomphalaria glabrate	*1*	*1*	*1*	*0*	*0*	*na*	*0*
FAMILY AMPULLARIIDAE							
Pomacea paludosa	*0*	*0*	*0*	*1*	*1*	*na*	*0*
PHYLUM ANNELIDA							
CLASS OLIGOCHAETA							
FAMILY TUBIFICIDAE							
Tubificidae	*30*	*0*	*0*	*0*	*0*	*na*	*0*
FAMILY NAIDIDAE							
cf Pristina	*0*	*1*	*0*	*0*	*0*	*na*	*0*
Dero	*2*	*0*	*0*	*0*	*0*	*na*	*0*
Dero flabelliger	*0*	*0*	*1*	*0*	*2*	*na*	*0*
Dero cf flabelliger	*0*	*1*	*0*	*0*	*0*	*na*	*0*
Dero digitata complex	*173*	*3*	*8*	*0*	*39*	*na*	*0*
Dero cf. furcata	*3*	*0*	*0*	*0*	*0*	*na*	*0*
cf. Pristinella	*0*	*0*	*0*	*0*	*3*	*na*	*0*
PHYLUM CRUSTACEA							
CLASS BRANCHIOPODA							
ORDER CLADOCERA							
FAMILY MACROTHRICIDAE							
Ilyocryptus	0	0	1	0	0	*na*	0
PHYLUM UNIRAMIA							
SUBPHYLUM HEXAPODA							
ORDER DIPTERA							
FAMILY CHIRONOMIDAE							
Tanypus	*1*	*0*	*0*	*0*	*0*	*na*	*0*
Chironomus	*2*	*0*	*0*	*0*	*0*	*na*	*0*
TOTALS	**212**	**6**	**11**	**1**	**45**	**0**	**0**

Table K-3. Phylogenetic list of taxa with counts for each station. Broadway outfall 04-May-04 – See Figure 2 for station locations.

4-May-04		**3**	**4**	**5**	**6**	**6**
Taxonomic Group/Identified Taxa		**FLO936**	**FLO937**	**FLO938**	**FLO939**	**FLO939 dup**
PHYLUM ANNELIDA						
CLASS OLIGOCHAETA						
FAMILY LUMBRICULIDAE						
	Lumbriculidae	0	0	0	0	0
FAMILY ENCHYTRAEIDAE						
	cf. Enchytraeidae	4	0	0	0	0
FAMILY TUBIFICIDAE						
	Tubificidae	252	2228	1033	257	380
FAMILY NAIDIDAE						
	Pristina	0	0	89	0	0
	cf. Pristina	0	0	0	34	12
	Dero cf. flabelliger	4	0	0	0	0
	Dero digitata complex	108	911	1712	794	726
	cf. Haemonais waldvogeli	0	34	0	0	12
	cf. Pristinella	16	0	59	11	0
CLASS HIRUDINEA						
FAMILY GLOSSIPHONIIDAE						
	Glossiphoniidae	12	169	30	11	12
FAMILY HIRUDINIDAE						
	Hirudinidae	0	34	0	11	12
PHYLUM MOLLUSCA						
CLASS GASTROPODA						
	Gastropoda	0	5	3	0	0
ORDER MESOGASTROPODA						
FAMILY VIVIPARIDAE						
	Viviparus georgianus	0	0	0	0	0
FAMILY THIARIDAE						
	Melanoides	0	0	108	0	0
	Melanoides tuberculata	0	75	163	280	100
ORDER BASOMMATOPHORA						
FAMILY ANCYLIDAE						
	Ancylidae	0	0	3	0	0
FAMILY PLANORBIDAE						
	cf. Planorbidae	0	0	8	0	0
FAMILY PHYSIDAE						
	Physella	0	0	0	2	8
	Physella hendersoni	0	0	35	0	0
CLASS BIVALVIA						
ORDER VENEROIDA						
FAMILY SPHAERIIDAE						
	Sphaeriidae	0	215	43	8	38
				Continued next page-------		

Table K-3 (continued). Phylogenetic list of taxa with counts for each station. Broadway outfall 04-May-04 – See Figure 2 for station locations.

4-May-04		3	4	5	6	6
Taxonomic Group/Identified Taxa		FLO936	FLO937	FLO938	FLO939	FLO939 dup
PHYLUM CRUSTACEA						
CLASS MALACOSTRACA						
ORDER CUMACEA						
FAMILY BODOTRIIDAE						
	Cyclaspis pustulata	0	0	3	0	0
ORDER TANAIDACEA						
FAMILY PSEUDOZEUXIDAE						
	Hargeria rapax	0	0	0	2	0
ORDER AMPHIPODA						
FAMILY COROPHIIDAE						
	Monocorophium	4	0	3	0	0
	Grandidierella bonnieroides	0	0	3	2	0
PHYLUM UNIRAMIA						
SUBPHYLUM HEXAPODA						
ORDER COLLEMBOLA						
FAMILY ENTOMOBRYIDAE						
	Entomobryidae	0	0	0	0	0
ORDER ODONATA						
FAMILY GOMPHIDAE						
	Aphylla	0	0	0	0	0
FAMILY LIBELLULIDAE						
	Libellulidae	0	0	3	0	0
HETEROPTERA-HEMIPTERA						
FAMILY CORIXIDAE						
	Corixidae	0	0	0	4	0
FAMILY BELOSTOMATIDAE						
	Belostomatidae	0	0	0	0	0
ORDER DIPTERA						
FAMILY CERATOPOGONIDAE						
	Ceratopogonidae	0	0	5	2	2
FAMILY CHIRONOMIDAE						
	Chironomidae	0	0	0	2	0
	Tanypus	0	15	10	4	4
	Chironomidae (pupae)	0	0	0	0	0
	Chironomus	0	25	23	14	6
	Cryptochironomus	0	5	0	0	0
	Goeldichironomus	0	0	0	4	0
	Polypedilum	0	0	8	0	0
	Polypedilum illinoense gp.	0	0	0	4	0
	TOTALS	**400**	**3716**	**3344**	**1446**	**1312**

Table K-4. Phylogenetic list of taxa with counts for each station. Broadway outfall 04-August-04 – See Figure 2 for station locations.

4-Aug-04		**3**	**3**	**4**	**5**	**6**
Taxonomic Group/Identified Taxa		**FLO936**	**FLO936**	**FLO937**	**FLO938**	**FLO939**
			dup			
PHYLUM ANNELIDA						
CLASS OLIGOCHAETA						
FAMILY LUMBRICULIDAE						
	Lumbriculidae	0	0	0	0	10
FAMILY ENCHYTRAEIDAE						
	cf. Enchytraeidae	0	0	0	0	0
FAMILY TUBIFICIDAE						
	Tubificidae	4013	93	917	1128	267
FAMILY NAIDIDAE						
	Pristina	0	0	0	0	0
	cf. Pristina	0	0	0	0	0
	Dero cf. flabelliger	0	0	0	0	0
	Dero digitata complex	547	37	49	113	29
	cf. Haemonais waldvogeli	0	0	0	13	0
	cf. Pristinella	0	0	0	0	3
CLASS HIRUDINEA						
FAMILY GLOSSIPHONIIDAE						
	Glossiphoniidae	0	9	20	0	10
FAMILY HIRUDINIDAE						
	Hirudinidae	0	5	0	0	3
PHYLUM MOLLUSCA						
CLASS GASTROPODA						
	Gastropoda	0	0	0	7	2
ORDER MESOGASTROPODA						
FAMILY VIVIPARIDAE						
	Viviparus georgianus	0	0	2	7	8
FAMILY THIARIDAE						
	Melanoides	0	0	0	0	0
	Melanoides tuberculata	304	23	14	50	582
ORDER BASOMMATOPHORA						
FAMILY ANCYLIDAE						
	Ancylidae	0	0	2	0	0
FAMILY PLANORBIDAE						
	cf. Planorbidae	0	0	0	0	12
FAMILY PHYSIDAE						
	Physella	0	0	2	0	0
	Physella hendersoni	0	0	0	2	4
CLASS BIVALVIA						
ORDER VENEROIDA						
FAMILY SPHAERIIDAE						
	Sphaeriidae	0	23	0	2	0
				Continued next page-------		

Table K-4 (continued). Phylogenetic list of taxa with counts for each station. Broadway outfall 04-August-04 – See Figure 2 for station locations.

4-Aug-04		**3**	**3**	**4**	**5**	**6**
Taxonomic Group/Identified Taxa		**FLO936**	**FLO936**	**FLO937**	**FLO938**	**FLO939**
			dup			
PHYLUM CRUSTACEA						
CLASS MALACOSTRACA						
ORDER CUMACEA						
FAMILY BODOTRIIDAE						
	Cyclaspis pustulata	0	0	0	0	0
ORDER TANAIDACEA						
FAMILY PSEUDOZEUXIDAE						
	Hargeria rapax	0	0	0	0	0
ORDER AMPHIPODA						
FAMILY COROPHIIDAE						
	Monocorophium	0	0	0	0	0
	Grandidierella bonnieroide	0	0	0	0	0
PHYLUM UNIRAMIA						
SUBPHYLUM HEXAPODA						
ORDER COLLEMBOLA						
FAMILY ENTOMOBRYIDAE						
	Entomobryidae	0	0	4	0	0
ORDER ODONATA						
FAMILY GOMPHIDAE						
	Aphylla	0	0	2	0	0
FAMILY LIBELLULIDAE						
	Libellulidae	0	0	4	0	4
HETEROPTERA-HEMIPTERA						
FAMILY CORIXIDAE						
	Corixidae	0	0	0	0	0
FAMILY BELOSTOMATIDAE						
	Belostomatidae	0	0	2	0	0
ORDER DIPTERA						
FAMILY CERATOPOGONIDAE						
	Ceratopogonidae	0	0	0	0	0
FAMILY CHIRONOMIDAE						
	Chironomidae	0	0	0	0	0
	Tanypus	0	0	0	0	0
	Chironomidae (pupae)	0	0	2	0	0
	Chironomus	0	0	4	0	0
	Cryptochironomus	0	0	0	0	0
	Goeldichironomus	0	0	0	0	0
	Polypedilum	0	0	0	0	0
	Polypedilum illinoense gp.	0	0	0	0	0
	TOTALS	**4867**	**193**	**1028**	**1327**	**940**

APPENDIX L

CHLOROPHYLL

Appendix L-1. Chlorophyll concentrations measured at different locations starting in front of the CDS unit (#934) going through the pond and ending below the bridge (939). See Figure 2 for site locations.

Date and Site Location (see Figure 2)	site	Chlorophyll a Monochro ug/L	Pheaophytin Monochro ug/L	Chlorophyll a Tricho ug/L	Chlorophyll b Tricho ug/L	Chlorophyll c Tricho ug/L
8/14/2002						
FLO0000934	**934**	N/A	N/A	N/A	N/A	N/A
FLO0000935	**935**	16.1	14.6	56.3	5.3	5.4
FLO0000936	**936**	37.8	22.0	52.0	8.7	6.4
FLO0000937	**937**	42.9	32.9	63.5	11.6	5.3
FLO0000938	**938**	276.0	89.6	335.0	80.3	9.3
FLO0000939	**939**	7.9	4.5	10.7	2.6	1.2
5/12/2004						
FLO0000934	**934**	3.1	4.8	5.9	2.0	2.6
FLO0000935	**935**	2.9	4.7	5.7	1.6	1.6
FLO0000936	**936**	52.8	21.6	66.7	16.2	3.4
FLO0000937	**937**	41.1	26.3	57.5	15.2	9.3
FLO0000938	**938**	48.4	30.8	67.5	18.6	9.3
FLO0000939	**939**	41.1	24.6	56.6	13.2	5.1
8/24/2004						
FLO0000934	**934**	9.9	4.2	12.5	3.6	1.4
FLO0000935	**935**	N/A	N/A	N/A	N/A	N/A
FLO0000936	**936**	10.0	3.6	12.2	4.1	2.1
FLO0000937	**937**	N/A	N/A	N/A	N/A	N/A
FLO0000938	**938**	39.3	11.7	46.8	15.0	2.2
FLO0000940	**939**	N/A	N/A	N/A	N/A	N/A
2/7/2005						
FLO0000935	**934**	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*
FLO0000935	**935**	N/A	N/A	N/A	N/A	N/A
FLO0000936	**936**	N/A	N/A	N/A	N/A	N/A
FLO0000937	**937**	4.2	3.4	6.3	1.3	*0.5*
FLO0000938	**938**	N/A	N/A	N/A	N/A	N/A
FLO0000939	**939**	3.3	2.4	4.8	*0.5*	*0.5*
3/21/2005						
FLO0000934	**934**	29.6	11.4	37.0	9.0	1.2
FLO0000935	**935**	19.5	8.4	24.9	6.2	1.6
FLO0000936	**936**	N/A	N/A	N/A	N/A	N/A
FLO0000937	**937**	15.3	5.1	18.6	5.4	1.1
FLO0000938	**938**	N/A	N/A	N/A	N/A	N/A
FLO0000939	**939**	N/A	N/A	N/A	N/A	N/A
5/23/2005						
FLO0000934	**934**	N/A	N/A	N/A	N/A	N/A
FLO0000935	**935**	N/A	N/A	N/A	N/A	N/A
FLO0000936	**936**	95.3	26.8	114.0	18.7	2.6
FLO0000937	**937**	N/A	N/A	N/A	N/A	N/A
FLO0000938	**938**	75.5	16.4	87.5	10.8	3.0
FLO0000939	**939**	138.0	35.5	164.0	13.0	5.2

continued next page

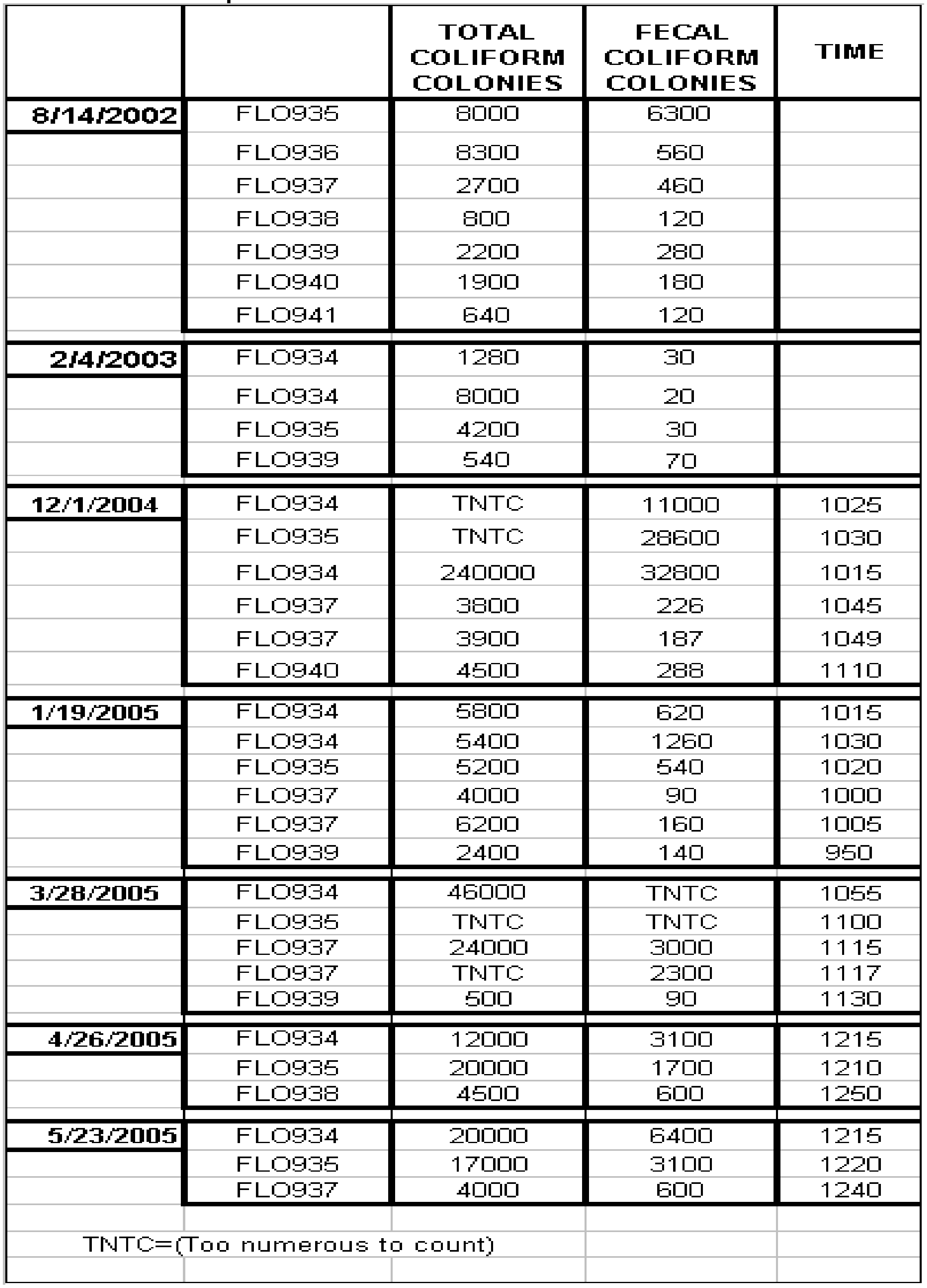
Appendix L-1 (continued). Chlorophyll concentrations measured at different locations.

Date and		Chlorophyll a	Pheaophytin	Chlorophyll a	Chlorophyll b	Chlorophyll c
Site Location	site	Monochro	Monochro	Tricho	Tricho	Tricho
(see Figure 2)		ug/L	ug/L	ug/L	ug/L	ug/L
4/26/2005						
FLO0000934	934	N/A	N/A	N/A	N/A	N/A
FLO0000935	935	N/A	N/A	N/A	N/A	N/A
FLO0000936	936	14.5	7.3	19.2	3.7	1.1
FLO0000937	937	N/A	N/A	N/A	N/A	N/A
FLO0000938	938	14.7	9.4	10.7	3.8	1.0
FLO0000939	939	N/A	N/A	N/A	N/A	N/A
6/26/2005		20.7				
FLO0000934	934	N/A	N/A	N/A	N/A	N/A
FLO0000935	935	N/A	N/A	N/A	N/A	N/A
FLO0000936	936	39.5	13.1	48.2	9.4	1.9
FLO0000937	937	39.6	12.2	48.0	10.6	1.8
FLO0000938	938	N/A	N/A	N/A	N/A	N/A
FLO0000939	939	52.1	23.6	67.3	15.3	2.2
8/15/2005						
FLO0000934	934	N/A	N/A	N/A	N/A	N/A
FLO0000935	935	N/A	N/A	N/A	N/A	N/A
FLO0000936	936	21.4	7.1	26.2	5.2	1.3
FLO0000937	937	32.3	15.9	42.5	9.7	2.1
FLO0000938	938	N/A	N/A	N/A	N/A	N/A
FLO0000939	939	78.0	30.8	98.2	19.0	6.8
10/12/2005						
FLO0000934	934	N/A	N/A	N/A	N/A	N/A
FLO0000935	935	54.7	21.6	68.8	14.6	2.1
FLO0000936	936	N/A	N/A	N/A	N/A	N/A
FLO0000937	937	51.4	22.4	65.7	13.3	2.6
FLO0000938	938	N/A	N/A	N/A	N/A	N/A
FLO0000939	939	36.1	14.8	45.7	9.8	3.6

APPENDIX M

BACTERIA

Table M-1. Bacteria measured at Broadway Outfall. See Figure 2 for station locations. Stations are generally ordered from inside the pipe before the CDS unit to the outfall of the pond.



		TOTAL COLIFORM COLONIES	FECAL COLIFORM COLONIES	TIME
8/14/2002	FLO935	8000	6300	
	FLO936	8300	560	
	FLO937	2700	460	
	FLO938	800	120	
	FLO939	2200	280	
	FLO940	1900	180	
	FLO941	640	120	
2/4/2003	FLO934	1280	30	
	FLO934	8000	20	
	FLO935	4200	30	
	FLO939	540	70	
12/1/2004	FLO934	TNTC	11000	1025
	FLO935	TNTC	28600	1030
	FLO934	240000	32800	1015
	FLO937	3800	226	1045
	FLO937	3900	187	1049
	FLO940	4500	288	1110
1/19/2005	FLO934	5800	620	1015
	FLO934	5400	1260	1030
	FLO935	5200	540	1020
	FLO937	4000	90	1000
	FLO937	6200	160	1005
	FLO939	2400	140	950
3/28/2005	FLO934	46000	TNTC	1055
	FLO935	TNTC	TNTC	1100
	FLO937	24000	3000	1115
	FLO937	TNTC	2300	1117
	FLO939	500	90	1130
4/26/2005	FLO934	12000	3100	1215
	FLO935	20000	1700	1210
	FLO938	4500	600	1250
5/23/2005	FLO934	20000	6400	1215
	FLO935	17000	3100	1220
	FLO937	4000	600	1240

TNTC=(Too numerous to count)

APPENDIX N

PICTURES

June 2002 Inflow to pond

March 2003 Inflow to pond

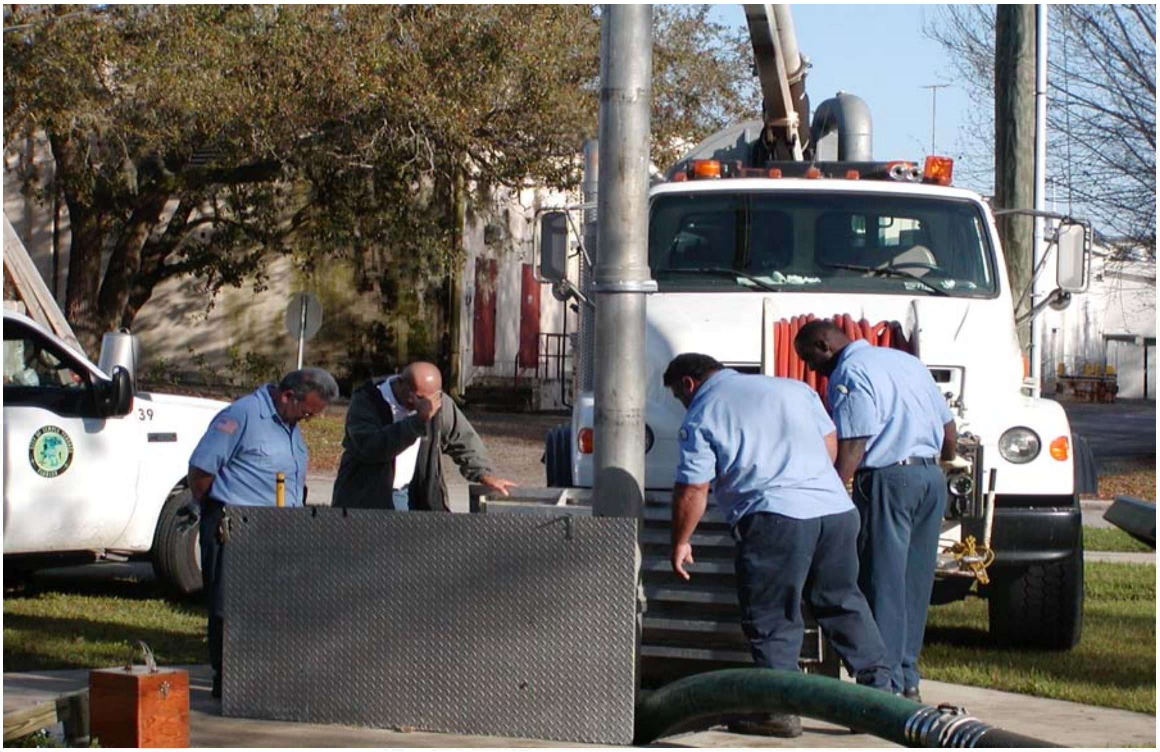
November 2003 Outflow of pond

January 2005 Inflow to pond.

Installation showing CDS to left, diversion weir in collection chamber of pipe

Collecting water quality samples at the outflow station

Sorting through dumped material of CDS unit to retrieve litter.



Cleaning out CDS unit

View of instrument trailer showing four refrigerated samplers for collecting storm flow and base flow samples. The CR10 and ISCO water level sensor is shown on the back wall.

Inside the pipe looking out toward the pond. The base flow weir is shown.

Entrance to CDS unit showing staff gauge and trash during base flow conditions. The diversion weir is off to the right.

Looking down into the CDS unit from the top.

Looking upstream of the CDS unit where three pipes join together.

Looking down at base flow weir showing debris backing up water & creating measurement problems.