# APPENDIX H

# Los Angeles County
# BMP Effectiveness Study

# LOS ANGELES COUNTY BMP EFFECTIVENESS STUDY

**County of Los Angeles**
**Department of Public Works**

**August 2005**

# 1.0 EXECUTIVE SUMMARY

As part of the current National Pollution Discharge Elimination System (NPDES, 2001) permit and Special Studies, County of Los Angeles Public Works also conducted a Best Management Practices effectiveness study to evaluate how well structural and treatment control Best Management Practices (BMPs) affect the quality of storm water run off. The study included monitoring, collection of stormwater runoff samples, and evaluation of six BMPs during 2004-05 storm season. The data obtained from water samples were analyzed by utilizing statistical methods to determine the removal effectiveness of several pollutants of concern.

The selected BMPs were evaluated for their removal effectiveness of trash, bacteria, TSS, oil and grease, nutrients, metals, and organics. Water samples from one BMP site were tested for toxicity by Brown (2005) as part of a collaborative effort to evaluate the removal effectiveness of toxicity. These BMPs included five catch basin inserts connected in series with a hydrodynamic separator downstream of these inserts in the City of South Pasadena, an enhanced manhole in one of County Public Works maintenance yards in the City of Los Angeles, a bioswale located in the City of Los Angeles inside a small public park, and a treatment train that consisted of a wet vault for oil and sediments separation followed by an infiltration trench inside a recycling metal recycling facility in the City of Los Angeles.

Sampling at the catch basin inserts was conducted manually during the first 3 hours of a storm event. At the remaining sites a minimum of 15 storms was sampled. Water samples were collected from the inflow and the outflow of the device. For the hydrodynamic separator, autosamplers were used to collect flow-weighted composites throughout the storm event. The data obtained from the recycling metal yard was part of another study program to evaluate groundwater augmentation and reuse. Discrete samples of stormwater runoff were manually collected upstream and downstream of the wet vault during the first 2 hours of the storm.

Catch basin inserts used in this study are made of fabrics and designed to remove coarse sediments, oil and grease, and debris. The field observations show that the inserts capture some debris and larger trash. The results from mean inflow and mean outflow have shown poor to low removal for many constituents tested. The statistical analyses indicated that there is no difference between median inflow and median outflow of bacteria, TSS, nutrients, metals, and pesticides. There was a net reduction of oil and grease in the effluent in two out of the three samples that detected. The catch basin inserts captured bulk and solid material that were carried along with surface water runoff from the adjacent streets. The removal capacity of trash and solid material decreased with increasing flow. The inserts were cleaned prior to sampling two storm events and the results did not show any apparent improvement in the removal effectiveness of inserts.

A hydrodynamic separator at the City of South Pasadena that was installed down stream of the catch basin inserts was tested for its removal effectiveness of contaminants from stormwater runoff. The separator was designed to remove bulky materials and fine sediments depending on the screen sizes used. The findings of the statistical analyses on data have indicated that there is no difference between the medians of contaminant concentration in the inflow and the outflow for bacteria, TSS, nutrients, and metals.

An enhanced manhole currently in use at one of County Public Works maintenance yards was selected to investigate its removal effectiveness of contaminants. This BMP was designed to remove hydrocarbons and TSS from the runoff generated at this yard. The results showed that the enhanced manhole removed relatively more metals as compared with the hydrodynamic separator in the City of South Pasadena. The statistical analyses indicated that there is no difference between the medians of contaminant concentration in the inflow and the outflow for bacteria, TSS, nutrients, and metals.

Brown (2005) performed toxicity tests to determine fresh water species *C. dubia* (water flea) reproduction and survival and marine species Strongylocentrotus purpuratus (sea urchins) fertilization as they become exposed to stormwater runoff samples. A study initiated by the California Regional Water Quality Control Board, San Diego region (CRWQCB, 2002) showed that organophosphate pesticides such as diazinon caused the toxicity to the water fleas and toxicity to the sea urchins was caused by zinc, two constituents commonly found in the stormwater runoff. The toxicity tests were conducted on stormwater samples collected from 5 storms upstream and downstream of the hydrodynamic separator. The results from sea urchins showed that the hydrodynamic separator did not reduce toxicity. None of the samples were toxic to *C. dubia* survival or reproduction.

The BMP evaluation also compared the effluent concentration of selected dissolved metals and organophosphate pesticides with their chronic water quality criteria. Most of the influent and the effluent concentrations were above the chronic criteria. the net reduction in concentrations were small and also above the chronic criteria.

The bioswale is a BMP that was built as part of a small neighborhood park. The data on this BMP is limited to three sampled storms. The comparison of contaminant concentrations bar graphs for inflow and outflow indicates that the bioswale appears to be effective in removing metals and TSS from stormwater. Samples from more storms should be collected and analyzed to better evaluate the removal effectiveness of this bioswale.

The wet vault consists of a screen and baffle to remove sediments and oil from the runoff. The analyses for removal effectiveness of this BMP and the infiltration trench used in the metal recycling yard are based on a limited number of storms. For the wet vault, there was a net negative removal for COD, hardness, and nutrients. Nonparametric tests showed no difference between the median inflow and the outflow concentrations for the constituents tested.

Brown (2005) also performed toxicity tests on stormwater runoff upstream and downstream of the wet vault to determine whether this BMP reduced toxicity of the stormwater. Toxicity from two of the storms sampled was too high to detect any differences between the inflow and the outflow. Samples from other storms tested did not show reduction in toxicity as a result of this BMP.

The infiltration trench was used as part of an infiltration and water augmentation project to study the effect of infiltrating stormwater on groundwater recharge. Almost all the contaminants tested were not detected in the groundwater samples. Copper detected in the groundwater by a factor of 150 times less than what was detected in the stormwater. Hardness in the groundwater was relatively higher than in the stormwater, which may have been contributed by the underlying soil strata as a natural source for hardness.

In this study, the effectiveness removal of BMPs was found to be variable depending on the size of the storm and inflow pollutant concentrations. Generally, the BMPs tested showed higher removal rate at higher inflow concentrations except for bacteria and nutrients. The removal efficiencies calculated for the $10^{th}$ and the $90^{th}$ percentiles on the lognormal transformed data for the inflow and the outflow concentrations for metals, bacteria, and nutrients were negative or relatively low. The statistical analyses showed an overlap of confidence intervals about the mean inflow and the mean outflow concentrations for all the constituents tested. The removal effectiveness of BMPs may also depend on the peak flow and the residence time to allow sufficient time to remove contaminant by processes such as settling or surface attachment.

The maintenance issues observed in this study were related to sedimentation, vegetative growth, and trash accumulation. The cost of maintenance may vary based on the location, land use, the BMP type, and the frequency of trash and sediment cleaning. For example, County Public Works has been maintaining the hydrodynamic separator, the catch basin inserts, and the enhanced manhole. The cleaning at these sites is twice a year before and after the storm season. In the trash study program, County Public Works has cleaned catch basin inserts and the hydrodynamic separator recently after each storm. There is not enough data to show that frequent cleaning increased the removal effectiveness of catch basin inserts and the hydrodynamic separator. The maintenance at Bimini Slough Ecology Park is routine and consists of periodic trimming of the plants and vegetation and trash removal from the bioswale and the surrounding park. The maintenance at the recycling metal yard in downtown, Los Angeles involves routine yard cleaning and inspection of the wet vault and the infiltration gallery during storm season. Infiltration trench can become less effective or clogged if sediments accumulate and as a result the maintenance costs will increase.

## 2.0 INTRODUCTION

Increase in pollutant loads and runoff due to urbanization can significantly impact receiving waters. Best Management Practices (BMPs) can be used to reduce the impact. However, a more thorough understanding of the characteristics of urban runoff is needed to select BMPs to meet long-term water-quality objectives. As shown in this study, BMPs cannot completely mitigate the impacts by the urbanization. Some have low removal effectiveness and others may only reduce load for certain pollutants only. There is also variability in the influent characteristics and sample collection. It is possible that a BMP reduces pollutant loading effectively, but that the treated levels may still be above regulatory limits. There are different approaches to analyzing data and evaluating removal effectiveness. Some statistical methods estimate mean and the median of the data and other methods test the significance of a hypothesis to determine whether the differences in the mean inflow and the mean outflow of contaminant concentrations are significant. In this study, the removal effectiveness was assessed by parametric and nonparametric statistical methods. Depending on the method used, the calculations can be very different.

The current 2001 NPDES municipal stormwater permit requires the County of Los Angeles to conduct an evaluation of structural and treatment control BMPs. The goal of this study was to investigate a minimum of five BMPs and to determine their effectiveness in removing various pollutants of concern in storm water. In 2004-05, County Public Works evaluated six different BMPs. The results of this study and conclusions are discussed in this report.

Previous studies have evaluated effectiveness of various BMPs. A study by Caltrans (2004) was conducted to evaluate sand infiltration BMPs and found them to be very effective in reducing metals, nutrients, and TSS. Other municipalities and manufacturers of BMPs have also evaluated BMPs both structural and non-structural. County Public Works is currently testing catch basin inserts and hydrodynamic separators as part of LA County's trash reduction and implementation plan for trash Total Maximum Daily Load (TMDL). County Public Works has also supported water augmentation study (LASGRWC, 2002 and 2004) to assess potential effects of infiltrating urban stormwater runoff on groundwater quality. The results of the study are presented here and have shown no evidence of groundwater degradation as a result of infiltration. The data from many other studies are also available in the International Stormwater BMP Database. According to Strecker (2004), the BMP database provides a useful tool to develop more accurate design requirements for stormwater BMPs as well as better targeted implementation plans for TMDLs. Additionally, the data from this study were used to compare removal effectiveness of the hydrodynamic separator and the Enhanced Manhole with the data from other BMPs in the same category within the database.

## 3.0 STUDY DESIGN

The study design consisted of selecting six BMPs in various locations. The criteria used for a BMP selection included: single inflow and outflow, ability to retrofit the BMP for stormwater sampling and flow measurements, hydrology and historical rainfall data, and safety and proper access. All sites were built on private or public properties requiring permission to access entry, install samplers, and collect stormwater runoff samples.

Samples were collected during a storm event at each site at the inlet and the outlet of the BMP to measure its removal effectiveness. The samples at most sites were flow-weighted composites and collected by auto samplers over the entire storm period. Samples at the catch basin inserts were manually collected every 20 minutes for the first three hours of each storm. Samples collected at the wet vault were also collected manually every 30 minutes for the first two hours of each storm.

The stormwater runoff samples from four BMP sites were analyzed at the County of Los Angeles Agricultural Laboratory and samples from the metal yard were analyzed at an independent laboratory as part of another study program. The constituents tested for all sites at a minimum included: bacteria, suspended solids, metals, oil and grease, nutrients, and organics. Trash was not weighed and trash quantity was not studied at these sites. However, each BMP was observed for its ability to capture and retain trash and bulk solids and their migration pattern through the BMP. Southern California Coastal Water Research Project (Brown, 2005) completed an independent study by conducting toxicity testing at two of the sites to determine whether a reduction in toxicity is achieved using BMPs.

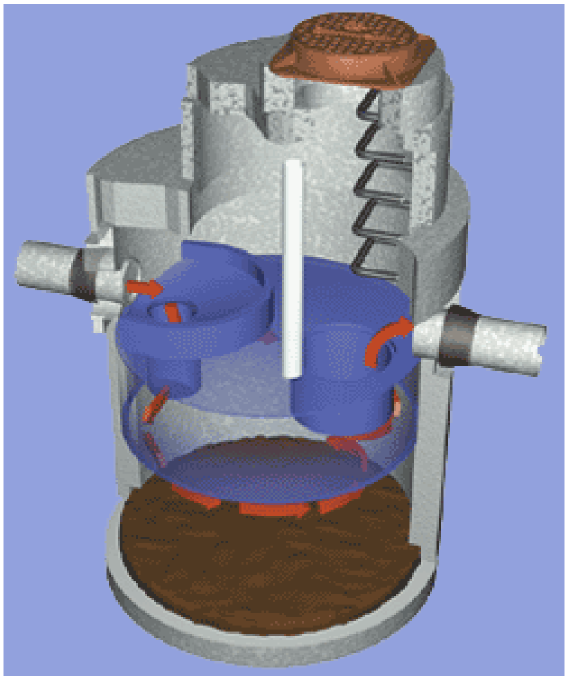
### 3.1 Enhanced Manhole, Road Maintenance District 3 Yard, Westchester

This BMP is located at one of County Public Works maintenance yards within the City of Los Angeles. It is designed to remove suspended solids and hydrocarbons from stormwater runoff (Figure 1.a). During a storm event, most of the runoff in the yard flows through concrete swales inside the yard to a 2-foot concrete ditch built along the southern boundary of the yard (Figures 1(c) and 2). The runoff inside the ditch flows to the western boundary of the yard where a 6-inch berm diverts the flow into the BMP's 1-foot diameter inlet pipe (Figures 1(d) and 3). As stormwater runoff flows into the inlet of the unit, pollutants such as oil and other liquids are trapped and sediments settle by gravity to the bottom of a chamber that is always full of water. This treated runoff flows into the concrete ditch downstream of the inlet pipe by another 1-foot diameter pipe where it is discharged into the storm drain system.

The total capacity of the enhanced manhole is 3,715 gallons. This BMP is designed to treat up to 1 CFS, or runoff from a 10-year storm. The hydraulic residence time is 8 minutes and increases with flows below the designed flow rate. This BMP is cleaned out twice a year before and after the storm season to remove debris and sediments deposited inside the manhole.

The maintenance yard is 4.1 acres (Figure 21, section 11). It consists of an auto repair shop, a weld shop, fueling station, car wash, concrete pad construction, material storage and solid waste disposal bins, street sweeping and loader trucks, and heavy equipment storage. The ground at this yard is paved and is considered to be 99% impervious. The yard also maintains and uses other BMPs such as absorbent socks to prevent sediments and spills from entering storm drain. The yard is also swept once a week.

The sampling equipment at this site consisted of two Sigma 900 MAX refrigerated samplers (Figure 1(d)). Connected to each sampler was flexible tubing attached to a ring and secured at the pipe invert in order to properly collect samples from runoff (Figure 1(b)). Each sampler could collect up to 10 gallons of runoff. They were programmed to take samples by a flow-weighted method where a user-defined flow volume passes through the device and then the machine takes a sample of runoff with pre-selected volume. Given the capacity of sampling volume and the size of containers, flow volume was generally held constant for each storm. However, the storm season of 2004-05 was an unusually wet season, rated as the second highest in the history of record keeping. As a result of continuous rain for several days, the machines were also adjusted several times to collect samples for higher flow volumes passing through the system. Generally, the machines were programmed to sample runoff when every 100 to 500 cubic feet of runoff that passed through the inlet pipe. A pressure sensor at the outlet pipe measured water depth inside the pipe. These depths were then converted into flow rate using the sampler's internal program, which is based on Manning's equation for flow of water through a pipe.



(a)

(b)

(c)

(d)

Figure 1. (a) Enhanced manhole showing flow direction and collection of sediments at the bottom. (b) Typical intake tubing and flexible ring for sample collection (c) samplers, concrete swale and ditch, and absorbent socks, (d) refrigerated samplers and glass containers.

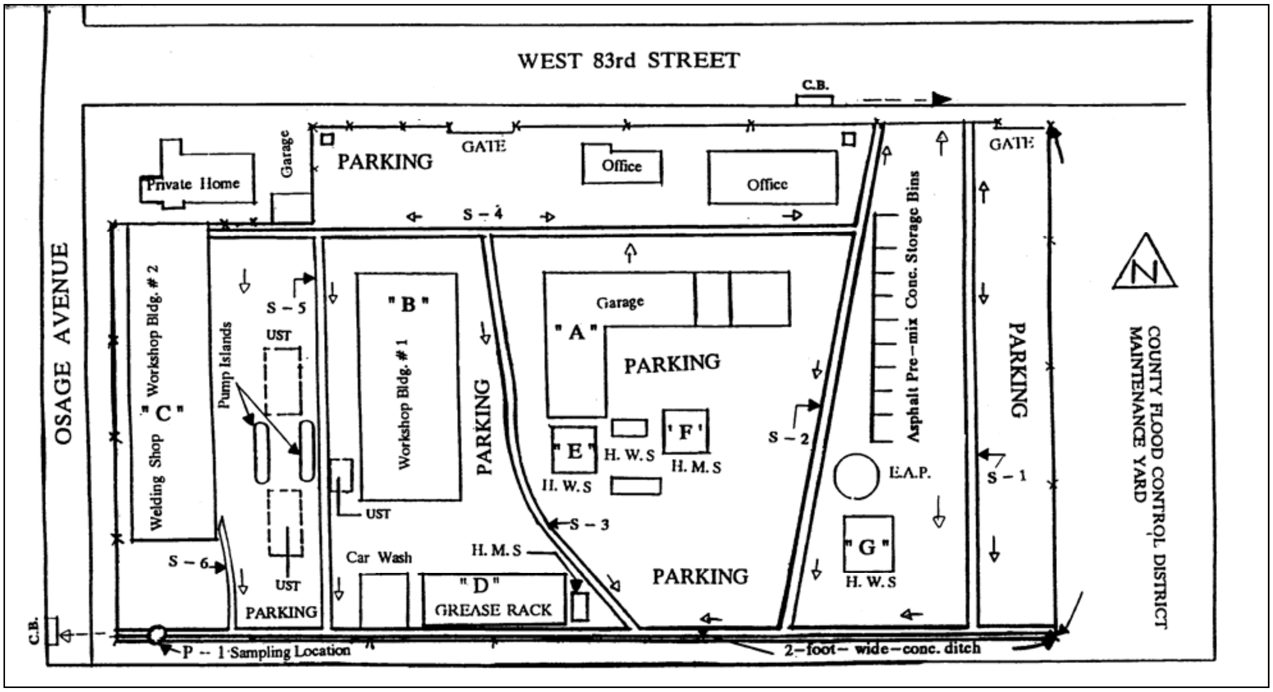



Figure 2. Road Maintenance Yard - showing sampling location, drainage map, and the yard facilities.

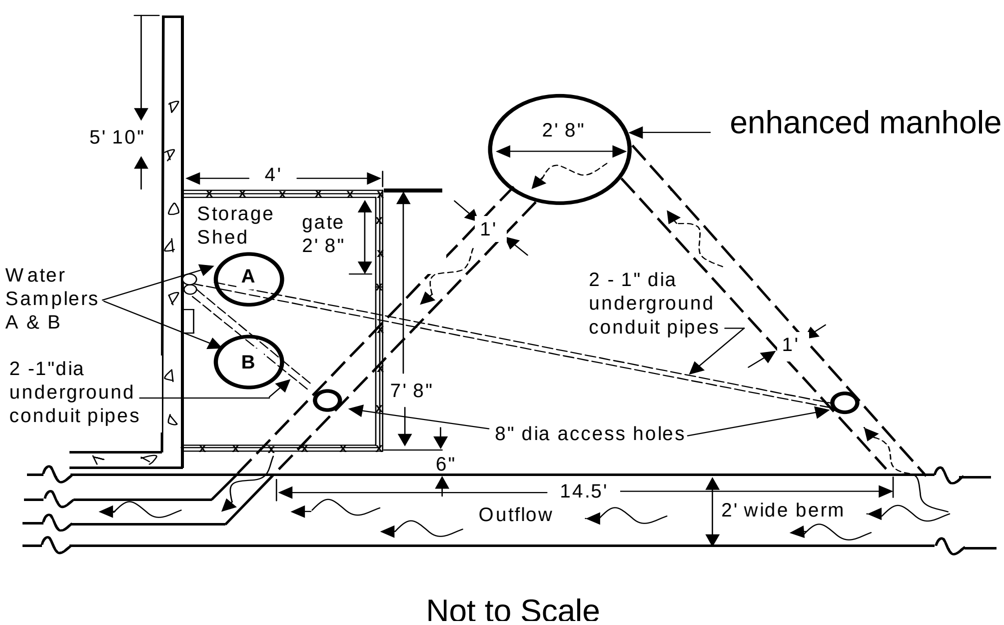



Figure 3. Showing the enhanced manhole in the center, monitoring stations, and sampling locations.

## 3.2 Catch Basin Inserts and Hydrodynamic Separator, South Pasadena

Two BMP types installed within the City of South Pasadena were selected to study their removal effectiveness of various pollutants (Figure 4). This location has a drainage area of 11.2 acres and is equally divided among residential, manufacturing, and recreational (Figure 22, section 11). The runoff from this area drains into five catch basins. The inserts installed inside catch basins are in direct path of flow and can trap bulky material such as trash, leafs, and settling solids. During heavier runoffs, the inserts become submerged with water causing floatable and finer debris to flow over the inserts reducing removal effectiveness of this BMP. Some portion of other lighter or bulky materials such as dust and tree leaves may bypass these insert by frequent wind action.

The runoff from catch basins enter a single storm drain where they mix together and flow downstream to the inlet of an offline hydrodynamic separator it is further treated. The effluent from the hydrodynamic returns to the storm drain and discharges into Arroyo Seco Channel along side freeway 110 where it ultimately discharges into Los Angeles River.

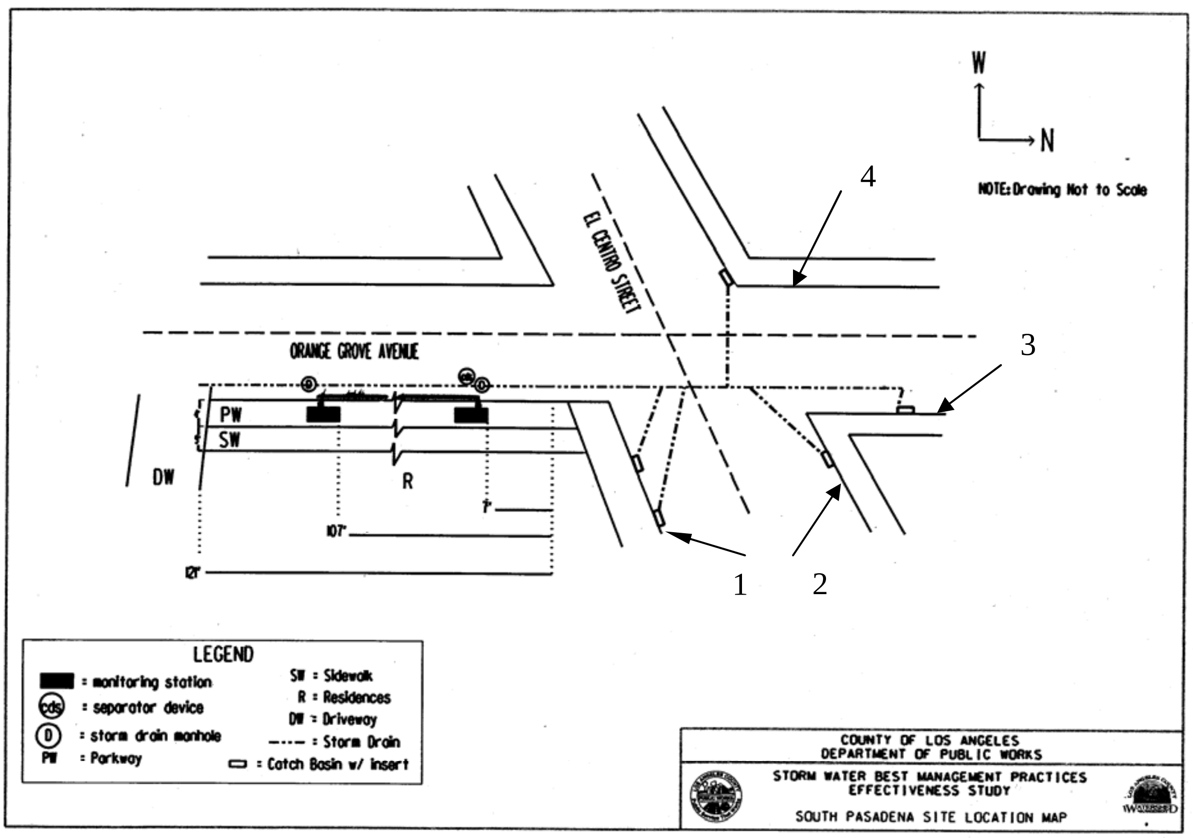



Figure 4. Location map for two BMPs: catch basin inserts and a hydrodynamic separator. Also shown in the map are monitoring locations and underground storm drains.

County Public Works began retrofitting this site for monitoring the hydrodynamic separator in 2004-05 after permission from neighborhood residences and the City of South Pasadena were obtained. Two sampler housings were built on concrete pads in the parkway. Conduits for intake tubes to sample runoff inside the underground storm drains were also installed. Prior to the work done on preparing the site, the catch basins were retrofitted with inserts as part of a trash study program. The catch basins were retrofitted with filter fabrics held in place by metal frames. The frames are bolted on the surface of the concrete wall inside the curb inlet (Figure 5). The filters are made of a non-woven polypropylene cloth designed to capture coarse sediments, oil, grease, litter, and debris from stormwater runoff. These filters have a relatively small volume compared to the volume of the catch basin sump, and may require frequent sediment removal. County Public Works has been cleaning the inserts as part of the trash study program and implementation plan for trash TMDL, more frequently after each storm during the later part of the 2004-05 storm season.

(a)

(b)

Figure 5. (a) Curb inlet and catch basin insert located at the corner of El Centro and Orange Grove in City of South Pasadena. (b) Filter fabric and the frame assembly installed inside the curb inlet.

The hydrodynamic separator at this location was installed in 2002-03 and has been in operation since then. This offline unit is non-mechanical unit and gravity driven without external power source. It is designed to use the energy of water to concentrate, screen and trap storm water pollutants using a separation screen (Figure 6). The pretreated stormwater runoff downstream of the catch basins is diverted into this offline unit to further treat and remove pollutants. The device has a design flow rate of 6 CFS sufficient to treat the runoff from a 1-2 year storm. The unit has a maximum storage capacity of 1,111 gallons. Hydraulic residence time for this device is 24 seconds and increases for flows below the design flow rate. This device is designed to remove suspended and fine solids with finer screen openings. The removal efficiency is a function of particle size related to screen opening. For example, removal efficiency of solid particles is as high as 100% for particle sizes greater than the screen with openings 2,400 µm and reduces for smaller particle sizes. In this offline unit, a standard screen with 4,700 µm opening was installed to capture solids larger than the standard screen opening. The device is cleaned out by decanting the existing water inside the unit, vacuuming the sediments from the bottom of the sump, and removing the trash from the decanted water. The trash is also weighed as part of the trash study program and categorized as man made or natural to quantify the amount of trash generated. The cleaning is typically done twice a year and more frequently after each storm as part of the trash study program.

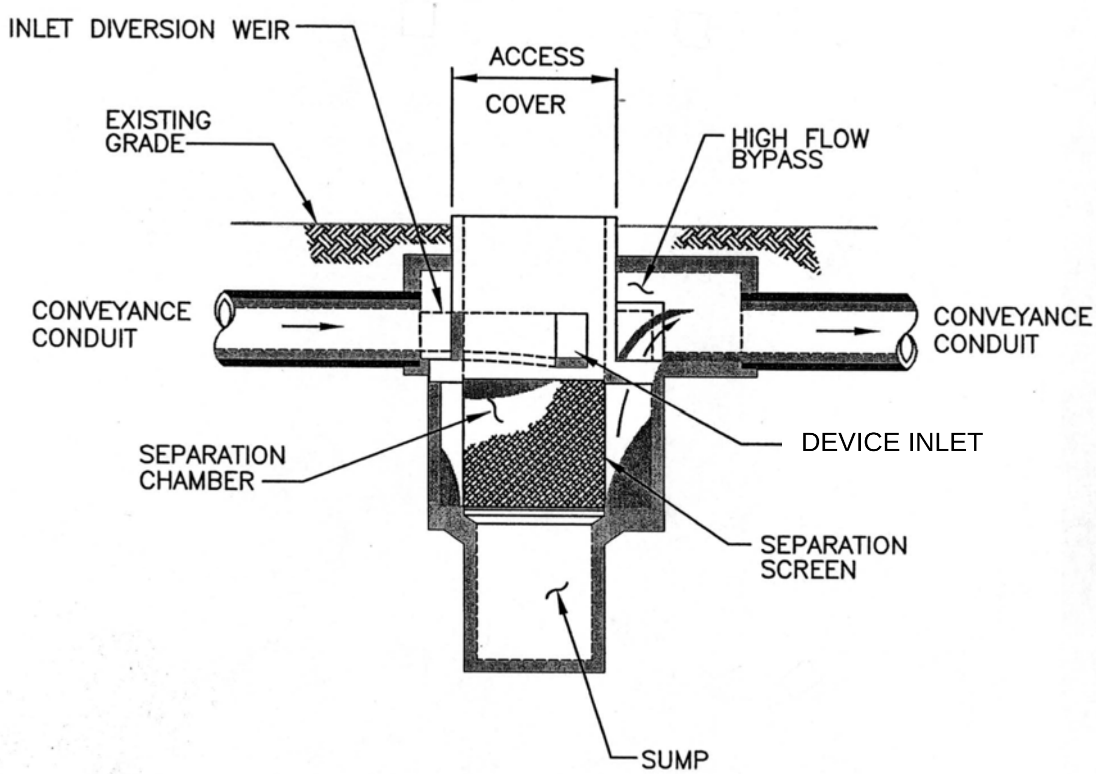



Figure 6. A hydrodynamic separator showing general description of the unit and elevation view.

The catch basins are located upstream of the hydrodynamic separator (Figure 4). Sampling at this location was conducted in three stages. First, at the beginning of each storm, manually discrete samples were collected from the gutters at the locations 1-4 and were mixed to represent the bacteria population sample upstream of the catch basins. At the downstream, a sample was collected with the aid of an autosampler from the runoff mixture inside the storm drain representing bacteria population downstream of the catch basins. This sample also represented bacteria population in the runoff upstream of the hydrodynamic separator. A sample of runoff was also collected down stream of the separator. The samples were delivered to the lab within the 6 hours, the maximum holding time for bacteria. Second, discrete samples were manually collected in 20-minute intervals at the locations 1-4 and were mixed to represent event mean concentrations (EMCs) for the first 3 hours of the storm upstream of catch basins. Discrete samples were also collected downstream of catch basins with the aid of an autosampler and mixed to represent EMCs for catch basins treated runoff. These manually composited discrete samples were also taken to the lab for analysis of metals, nutrients, TSS, oil and grease, and pesticides. Third, the autosamplers upstream and downstream of the hydrodynamic device continued to collect flow-weighted discrete samples for the duration of storm. The samples from this stage represented EMCs for contaminants upstream and downstream of the hydrodynamic separator for the duration of storm.

The data from the 3-hour grab composite were used to determine the removal effectiveness of catch basin inserts while data from the flow-weighted composites were used to determine the removal effectiveness of the hydrodynamic separator.

(a) (b) (c) (d)

Figure 7. (a) Cover of hydrodynamic separator in the foreground and housing containing autosampler. (b) Autosampler, battery, and containers. (c) Storm drain invert upstream of the hydrodynamic separator, flexible intake tubing and ring attachment for sample collection. (d) Inside the main chamber of a typical hydrodynamic separator showing trapped debris and trash.

## 3.3 Bioswale, Koreatown, City of Los Angeles

Another BMP selected was a bioswale recently built together with a small neighborhood park in a vacated street in the City of Los Angeles. The park is managed by a nonprofit organization. The watershed drainage area for this bioswale is approximately 6.5 acres (Figure 23, section 11). Runoff from mainly urban activities and adjacent strip mall flows into a culvert on the southeast corner of Bimini Place and 2nd street. The stormwater runoff from this culvert is directed into the bioswale inlet on the west side of the park (Figure 8). The swale is approximately 200 feet long. It was designed with a capacity to handle the runoff from a 50-year storm. The swale is 4 feet wide by 2 feet deep. The channel bottom is paved with porous cinder blocks 4 inches deep inside the topsoil. Each block is a placeholder for an individual brush plant to grow inside the bioswale channel (Figure 9). Additionally, large boulders were placed along the length of the swale to support the channel edges, to provide erosion control, and a natural appearance.

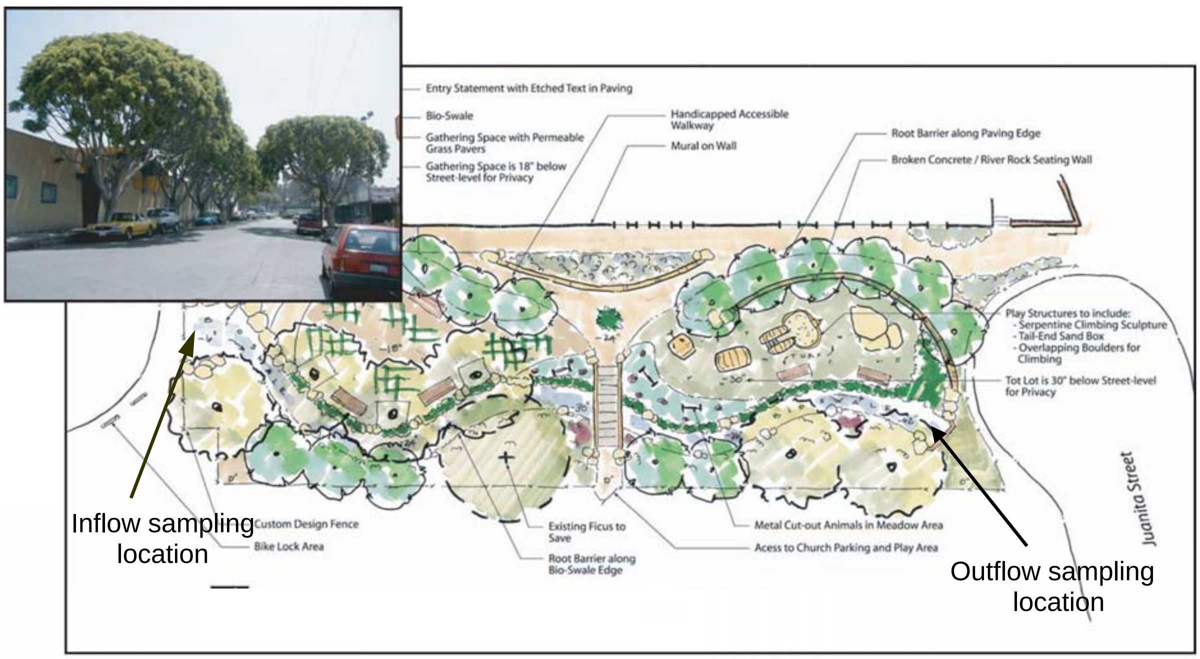



Figure 8. Bimini Slough Ecology Park – Before (left): city street in Koreatown with underground storm drain. After (right) storm drain brought to the surface and integrated into a neighborhood park.

(a)

(b)

Figure 9. (a) Bioswale as it was originally built. (b) One year later - Bioswale showing plant growth inside the channel.

The bioswale was retrofitted with flow measuring devices to measure flow and to sample near the inlet and the outlet (Figure 8). A 1-foot high H-flume was installed at each location (Figure 10). This flume size was chosen to measure runoff flows maximum of 862 gallons per minute (gpm) or up to a 2-year storm to provide good resolution at low flows and runoff that vary over a wide range.

(a)

(b)

Figure 10. (a) Installed are: An H-flume, stilling well, conduits for pressure sensor, and intake tubing for sampling at the inlet of bioswale. (b) H-flume installed at the outlet of bioswale.

## 3.4 Wet Vault and Infiltration Trench, Downtown Los Angeles

These BMPs are part of a study program funded in part by County Public Works (LASGRWC, 2002, 2004) to investigate potential effects of stormwater infiltration on groundwater supply using infiltration BMPs. These BMPs were installed at a privately owned metal recycling yard to monitor stormwater runoff. The yard is 0.85 acre and located in the City of Los Angeles downtown area. The runoff from the yard drains to a pretreatment BMP (Figure 11). This BMP is designed to attenuate peak stormwater flow to promote settlement of suspended sediments, capture floating trash or debris, and to prevent release of floatable oil and grease with baffles. The runoff from the wet vault enters an underground pipe that flows downstream into an infiltration trench BMP (Figure 12).

Storms predicted to be of sufficient size and duration to generate runoff were sampled at this site. Grab samples were collected every half hour for the first 2 hours of storm upstream and downstream of the wet vault (Figure 12, M-SW-01 and M-SW-02). M-SW-01 is on the surface of pavement inside the chain link area upstream of the wet vault. M-SW-02 is an access port to the effluent from the wet vault where the effluent is gravity fed to an 8-inch diameter pipe below the ground.

The effluent from the wet vault flows downstream inside the 8-inch diameter pipe a distance of 95 feet before it reaches an infiltration gallery of two 48-inch perforated pipes where more monitoring stations are set up to monitor groundwater and subsurface soil-water zone (Figure 12). Stormwater samples were also collected from lysimeters and a groundwater monitoring well installed along the infiltration trench to determine how well the infiltration worked in removing pollutants from stormwater as it percolated inside the soil matrix.


Figure 11. Metal recycling facility - showing wet vault inside the sump.

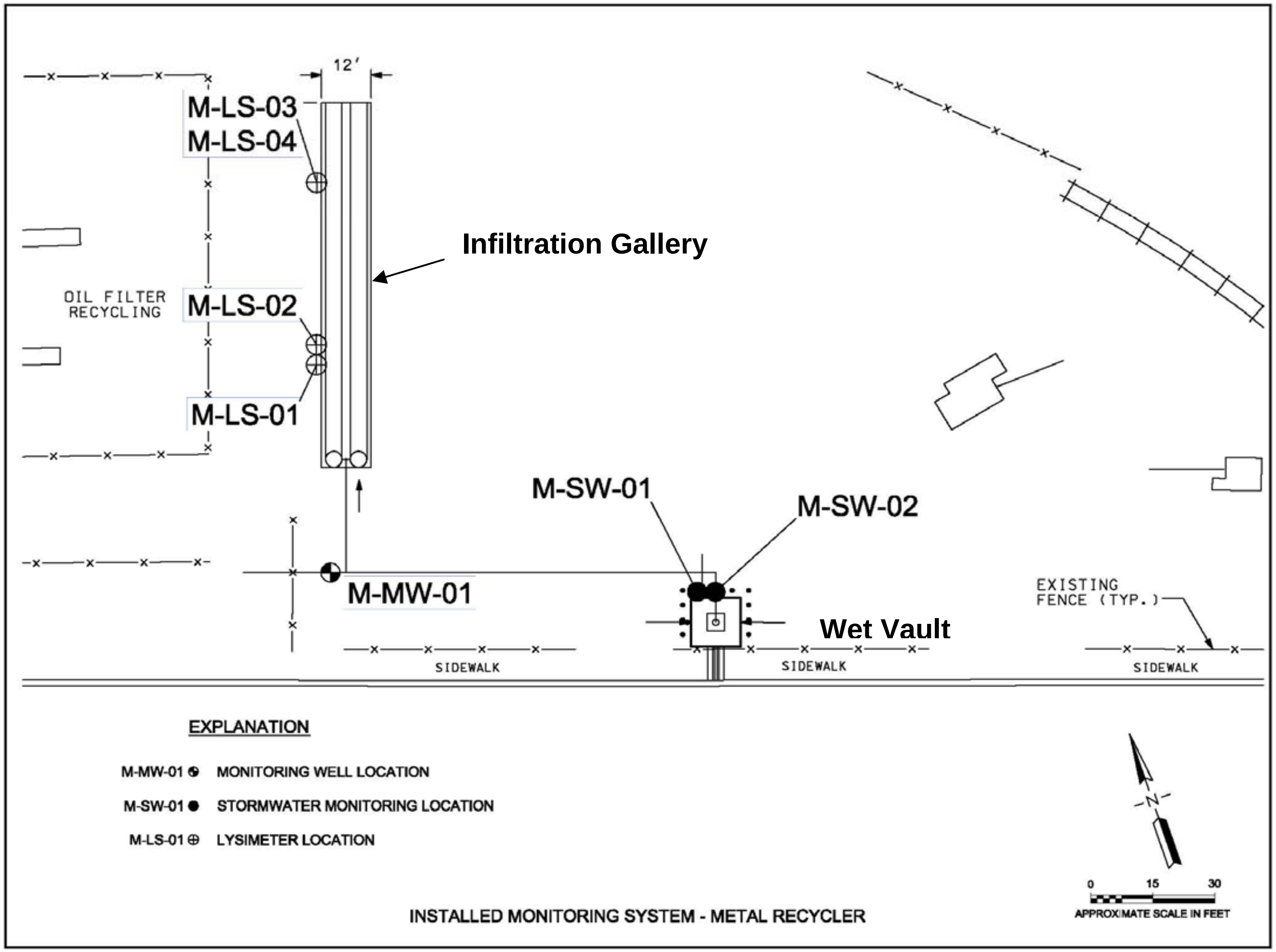



Figure 12. Metal recycling yard showing sampling locations, wet vault, and infiltration trench BMP.

# 4.0 RAINFALL DATA

2004-05 was an unusually wet season with rain that sometimes lasted a week. The rainfall data from local area gauges were used to obtain rainfall data and rainfall intensities. Generally, most storms had recorded a 2-year frequency by the rain gauges in the vicinity of the site locations (Table 1). In particular, the highest rainfall intensity recorded was at LA City College rain gauge station and was a 100-year storm. The bar graphs of rainfall data for all storms are presented in section 12 (Figures 24-26).

Table 1. Location of rain gauges used and highest rainfall intensities recorded for this study during 2004-05 storm season.

| BMPs | Rain Gauge Location | Station No. | Highest rain fall intensity (year, date) |
|---|---|---|---|
| Catch basin insert, hydrodynamic separator | Fremont-headquarters | 1277 | 25, 1/7/05 |
| Bioswale | LA City College | 355B | 100, 12/27/04 |
| Enhanced manhole | Ballona Creek | AL370 | 25, 1/7/05 |
| Wet vault | LA City College | 355B | 25, 1/7/05 |

# 5.0 SAMPLING METHODS

The Technology Acceptance Reciprocity Partnership protocol (TARP, 2003) developed guidelines to perform an independent validation of data supporting specific technology performance claims. An example of performance claim could be:

*"The Model X system can capture and treat the first half-inch, 24-hour storm for a 10-acre runoff area. Under these conditions, a total suspended solid (TSS) removal rate of 85% +/- 5% (at 95% confidence level) can be achieved with inflow TSS concentrations greater than 100 mg/l."*

The protocol provides a uniform method for demonstrating stormwater technologies and developing test assurance (QA) plans for certification or verification of performance claims. One of the key advantages to using this protocol is to demonstrate effectiveness. As a result of establishing this protocol, a nationwide stormwater BMP database on the performance capabilities of structural and non-structural BMPs has been developed by the American Society of Civil Engineers (ASCE) and the U.S. Environmental Protection Agency (EPA). The database includes BMP removal effectiveness for specific contaminants as well as site-specific data, area hydrologic data, and BMP specifications for locations throughout the U.S. In this study, the following criteria were used based on the guidelines developed by TARP to collect field data and to investigate removal effectiveness of selected BMPs:

- Collected samples from storms of at least 0.1 inch of total rainfall.
- Collected flow-weighted composite samples where it was possible.
- Collected a minimum of 10 water quality samples per storm event using autosamplers. At the catch basins, collected 9 samples per event for a total of three hours.
- Used an inter-event period of 24 hours. Acceptable range: 6 to 72 hours.
- Sampled a minimum of 15 storms in 2004-05. Acceptable range: 15 to 20 storms. The bioswale was sampled during three consecutive storms once it was retrofitted for sampling and permission obtained from property owners. The metal yard recycling facility has been sampled 5 times as part of another study program and sampling is ongoing.
- Performed sample data quality assurance and control.
- Selected a number of parameters and pollutants to test. These included: total suspended solids, nutrients, bacteria, metals, chemical oxygen demand (COD), oil and grease, and pesticides (Table 2).
- Calculated BMPs effectiveness choosing from the recommended methods: Efficiency ratio, summation of loads, regression of loads, mean concentration, and efficiency of individual storms.
- Performed statistical tests to ensure that the data are reliable, significant, and within confidence limits. If the data set was not normally distributed, it was evaluated using nonparametric analysis.

Table 2. List of constituents tested, reporting limits, and analytical methods used.

| Constituent | Reporting Limit | Unit | Analytical Method |
|---|---|---|---|
| Oil and Grease | 1.00 | mg/L | EPA 413.1 |
| **Bacteria** | | | |
| Total Coliform | 20.00 | mpn/100mL | SM 9230B |
| Fecal Coliform | 20.00 | mpn/100mL | SM 9230B |
| Enterococcus | 20.00 | mpn/100mL | SM 9230B |
| Streptococcus | 20.00 | mpn/100mL | SM 9230B |
| | | | |
| COD | 10.00 | mg/L | EPA 410.4 |
| TSS | 2.00 | mg/L | EPA 160.2 |
| Total Phosphorus | 0.05 | mg/L | EPA 365.3 |
| Dissolved Phosphorus | 0.05 | mg/L | EPA 365.3 |
| Ammonia-N | 0.10 | mg/L | EPA 350.3 |
| Nitrate-N | 0.50 | mg/L | SM 4110B |
| Nitrite-N | 0.03 | mg/L | SM 4110B |
| Kjeldahl-N | 0.10 | mg/L | EPA 351.4 |
| **Metals (Total and dissolved)** | | | |
| Aluminum | 100.00 | ug/L | EPA 200.8 |
| Antimony | 0.50 | ug/L | EPA 200.8 |
| Arsenic | 1.00 | ug/L | EPA 200.8 |
| Barium | 10.00 | ug/L | EPA 200.8 |
| Beryllium | 0.50 | ug/L | EPA 200.8 |
| Cadmium | 0.25 | ug/L | EPA 200.8 |
| Chromium | 0.50 | ug/L | EPA 200.8 |
| Chromium 6 | 0.50 | ug/L | EPA 200.8 |
| Copper | 0.50 | ug/L | EPA 200.8 |
| Iron | 100.00 | ug/L | EPA 236.1 |
| Lead | 0.50 | ug/L | EPA 200.8 |
| Manganese | 30.00 | ug/L | EPA 200.8 |
| Mercury | 0.20 | ug/L | EPA 245.1 |
| Nickel | 1.00 | ug/L | EPA 200.8 |
| Selenium | 1.00 | ug/L | EPA 200.8 |
| Silver | 0.25 | ug/L | EPA 200.8 |
| Thallium | 1.00 | ug/L | EPA 200.8 |
| Zinc | 1.00 | ug/L | EPA 200.8 |
| Organophosphate Pesticides | .01 - 2.0 | ug/L | EPA 507 |

# 6.0 DATA ANALYSES

It has been shown that stormwater runoff EMCs for many constituents fit well by a lognormal distribution (NURP, 1983). A most commonly method used to transform data to lognormal distribution is when the natural log of the raw data is computed and the results are then plotted on a normal probability plot. An effect of the transformation is to reduce skewness at the tail end. Furthermore, by transforming the data, assumptions such as normality that are not satisfied in the original data can be satisfied by the transformed data.

In the data analyses, methods described in task 3.1 (URS, 1999) and task 3.4 (GeoSyntec, 2000) were used to calculate efficiency of each BMP for constituents of interest. Among several methods to evaluate pollutant removal effectiveness, Lognormal Statistical Efficiency method (LSE) was used to describe the statistical distribution of water quality upstream and downstream of BMPs.

Using the LSE method, the log EMC can be calculated for each EMC. The normalization is as follows:

$$\text{Mean of the Log EMCs} = \frac{\sum_{j=1}^{m} Log_e\left(EMC_j\right)}{\text{m}}$$

Where, m is the number of events measured. Computing the mean and standard deviation of log transforms of the sample EMCs and then converting them into arithmetic estimate often obtains a better estimate of the mean of the population due to the more typical distributional characteristics of water quality data. The conversion from lognormal to arithmetic mean are given in the Table 3 below:

Table 3. Transformation between logarithmic transformed population statistics and estimates of arithmetic population statistics (URS, 1999).

| | |
|---|---|
| T=EXP(U) | S=M*CV |
| M=EXP(U+0.5*W$^2$) | W=SQRT (LN (1+CV$^2$)) |
| M=T*SQRT (1+CV$^2$) | U=LN (M/EXP (0.5*W)) |
| CV=SQRT (EXP (W$^2$)-1) | U=LN (M/SQRT (1+CV$^2$)) |

Where mean and standard deviation for logarithmic statistics are U and W and the mean, standard deviation, coefficient of variation and median for arithmetic statistics are M, S, CV, and T respectively. Both methods provide an estimate of the population mean, but the approach utilizing the log-transformed data tends to provide a better estimator when contaminant and constituent levels have a lognormal distribution (NURP, 1983). As the sample size increases, the two values converge.

In this study, several statistical tests were performed based on the outcome of each test and selection of appropriate responses as illustrated in Figure 13. Distribution plots of raw data for many parameters were skewed requiring lognormal transformation of the raw data. A normal probability plot was generated and Anderson-Darling test statistic was performed to examine whether or not transformed data followed an approximately normal distribution. For the normality test, the hypotheses were, H0: data follow a normal distribution vs. Ha: data do not follow a normal distribution. If the P-Value obtained from the test was less than a significance level of 0.05, then the data did not follow a normal distribution or that the lognormal transformation did not have an effect in transforming the data into a normal distribution. In this study, most of the P-Values obtained were greater than 0.05 suggesting that the hypothesis that the distribution is normal could not be rejected. A few tests that rejected the null hypothesis suggested the log transformation did not have an effect in normalizing the data and were retested by removing extreme values. The results suggested that the null hypothesis could not be rejected after removing the extreme values, consistent with the majority of data that were originally tested for normality. Thus the extreme values played an important part in reducing the ability to normalize with lognormal transformation of the raw data. However, accepting a distribution as a normal distribution when in fact it is not a normal distribution causes type II error to occur. There are methods to calculate the probability of type II occurrence; however, the calculation would be based on a normal distribution and a hypothesis test other than testing for normality.

Assuming that the distribution of a data set was normal (possibility of type II error), one-way ANOVA was used to test whether the mean inflow is equal to mean outflow of the BMP device for various constituents. The effect of the BMP will be considered significant if the probability (P-Value) that the resulting F-ratio from the ANOVA test could have been generated by chance is less than a chosen significance level. In this study, a significance level of 0.05 was used in all the tests. As an alternative to ANOVA test, the results were then compared with two non-parametric methods such as Mann-Whitney and Kruskal-Wallis tests that are used for any distribution with the hypothesis that the median inflow is equal to median outflow (see results section).

ANOVA test assumes that the data come from a normal distribution. A nonparametric test implies that there is no assumption of a specific distribution for the population that the data comes from. An advantage of a parametric test is that if the assumptions hold, the power, or the probability of rejecting H0 when it is false, is higher than the power of a corresponding nonparametric test with equal sample sizes. An advantage of nonparametric tests is that the test results are more robust against violation of the assumptions. Therefore, if assumptions are violated for a test based upon a parametric model, the conclusions based on parametric test p-values may be more misleading than conclusions based upon nonparametric test p-values.

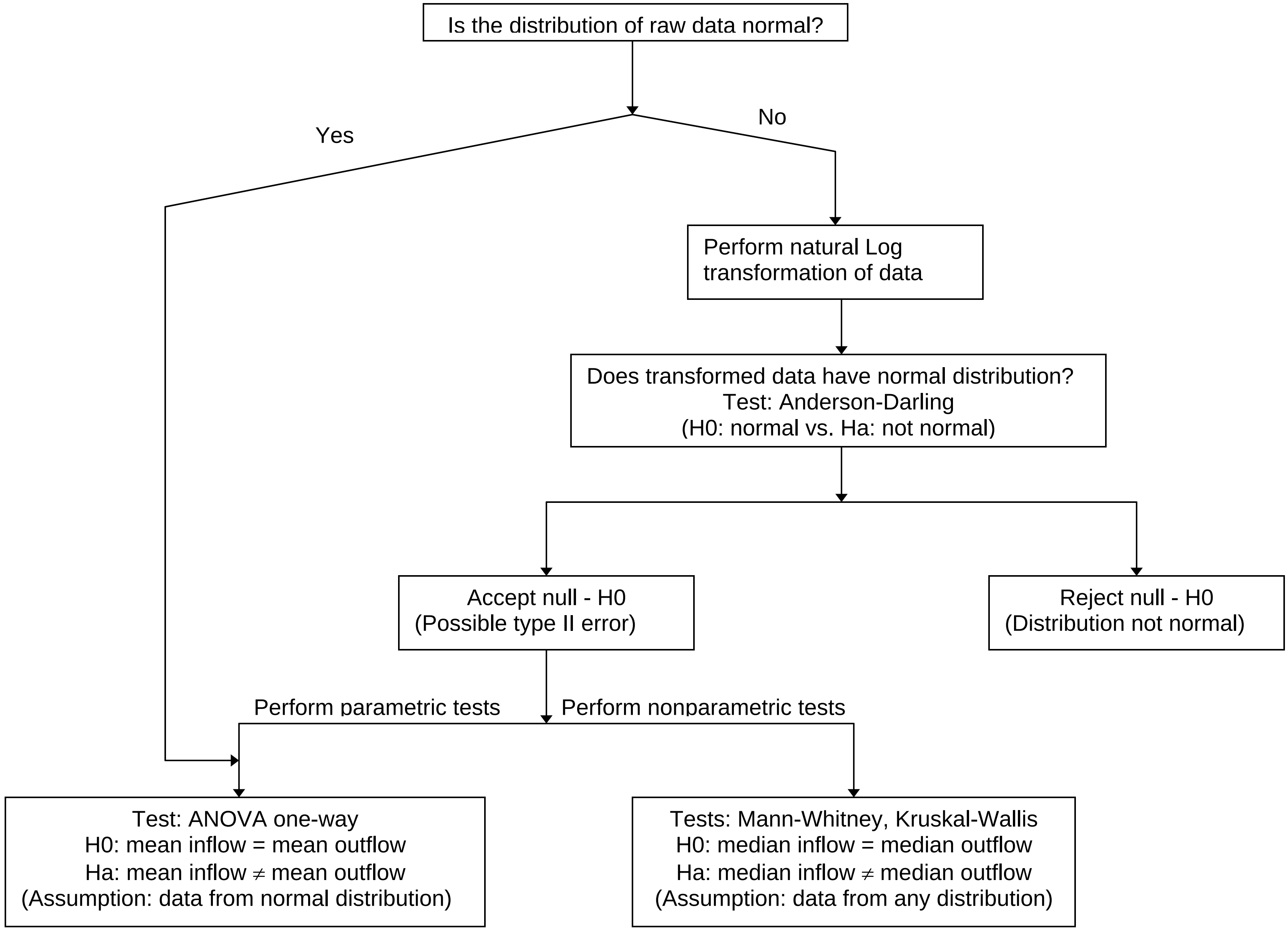



Figure 13. process diagram for selecting statistical tests.

In addition to statistical analyses of data and hypothesis testing, graphical methods were used to provide additional insight to determine whether the differences in the inflow and the outflow water quality measures were statistically significant (GeoSyntec, 2000). The plots were generated for each constituent based on the results obtained from the statistical analyses. These plots included in the analyses were: linear influent/effluent plots, box and whisker plots, and normal probability plots. Examples of these plots and their interpretation are described below.

## 6.1 Interpretation of Linear Influent/Effluent Plots

Similar to Figure 14, plots were prepared based on data collected for each storm. Water quality sample concentration for each storm was plotted on a linear scale with influent and effluent being identified using different symbols (Figure 14). In this study, the graphs were generated to provide the number of samples collected during 2004-05 storm season, which events had paired samples, and the relative difference between influent and effluent concentrations. Data from all samples were shown in chronological order similar to Figure 14.

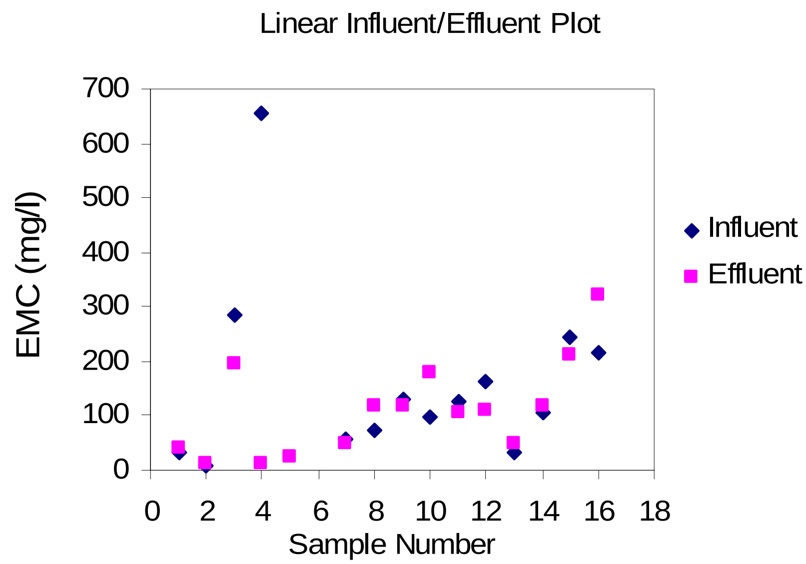



Figure 14. Example of a linear influent and effluent plot used to show relative differences between influent and effluent concentrations.

## 6.2 Interpretation of Probability Plots

These plots were used to provide the following information:

- How well the data or the lognormal transformed data, at each station were represented by the normal distribution.
- Mean and standard deviation of the normal distribution and the value of any specific quantile. Slope of the normal approximation indicated the magnitude of the standard deviation (straight line), the x-intercept showed the log mean concentration.
- Relationship between two distributions across the range of quantiles.

- Presence of any significant outliers.
- Width of 95% confidence interval of the normal approximation.

Two examples of probability plots are shown below to explain the range of behaviors that were encountered during the analyses of water quality data. The first example (Figure 15) demonstrates the behavior of two transformed data sets (one from the inflow and one from the outflow of a BMP) that have very similar standard deviations (parallel lines in the normal probability plot) and a uniform difference (in the log-scale) across the range of quantiles. This indicates that there is a difference not only in the log mean EMC, but a difference across any given quantile. However, these differences were statistically insignificant.

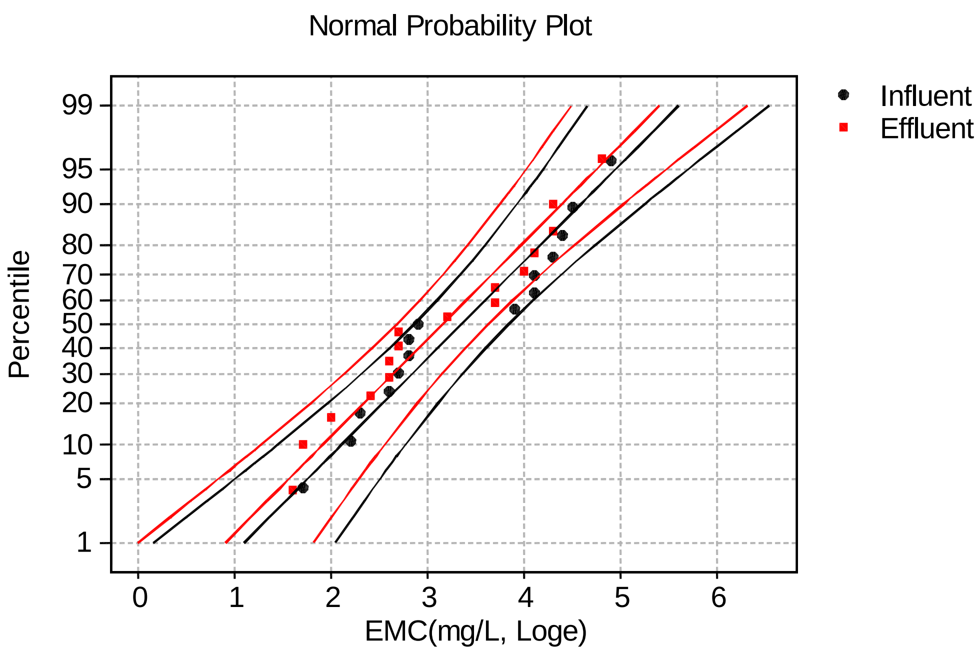



Figure 15. Example of a normal probability plot for a BMP showing similar standard deviations and consistent positive difference in the log transformed values across the range of quantiles.

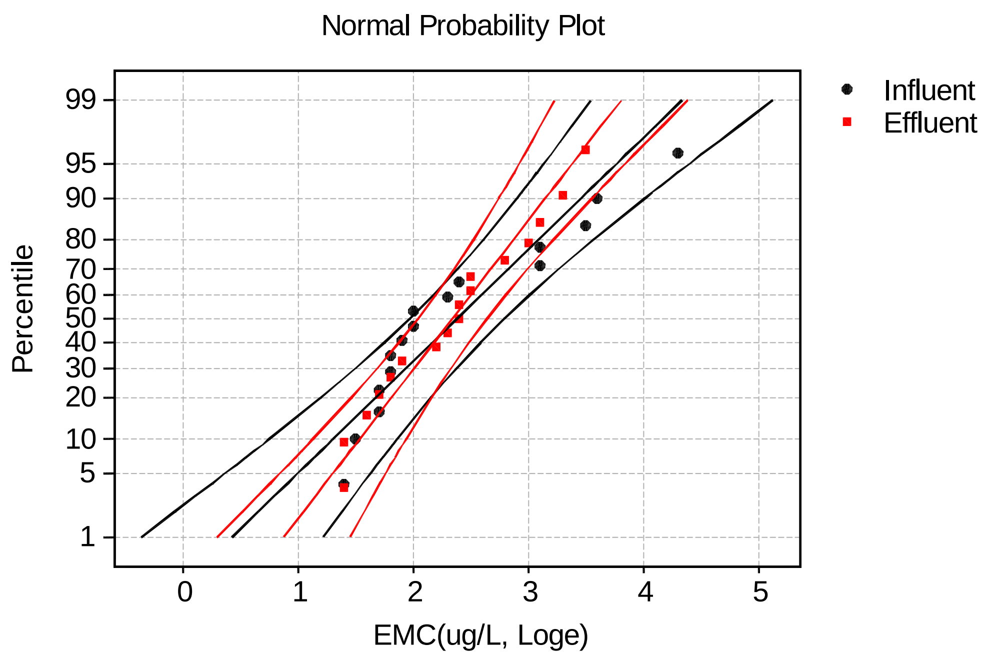



Figure 16. Example of a normal probability plot for a BMP showing higher standard deviation at the outflow than at the inflow and a positive difference between the inflow and outflow at high quantiles and negative difference between the inflow and outflow at low quantiles.

## 6.3 Interpretation of Box and Whisker Plots

Box and whisker plots used in this study graphically show the central location and scatter/dispersion of the sampled data (Figure 17). The plots also provide information about the distribution of inflow and outflow concentrations, confidence intervals, extreme values, and positive or negative efficiencies. The box and whisker plots used in this report have the following structure:

- The center of the blue diamond shows the mean and the height shows the confidence interval.
- The blue lines above and below the diamond show percentile range.
- The notched box shows the median, lower and upper quartiles, and confidence interval around the median.
- The dotted line connects the nearest observations within 1.5 inter-quartile ranges (IQRs) of the lower and upper quartiles.
- Possible outliers: red crosses (+) are near outliers (between 1.5 and 3.0 IQRs away) and circles (o) are far outliers (over 3.0 IQRs away).

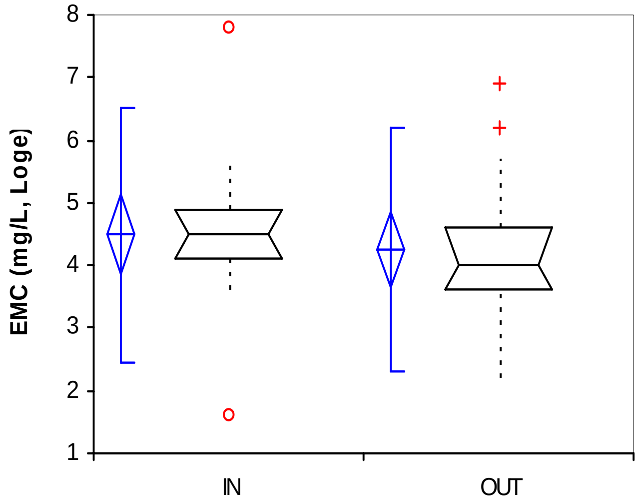



Figure 17. Annotation of box and whisker plots.

The median value gives an estimate of the central location of the distribution that is less sensitive than mean to a single or small number of high or low observations (Figure 17). In addition, the median is a distribution-free statistic and therefore often gives a better estimate of the central location of the distribution when the data depart significantly from the normality. Therefore, the box and whisker plots provide an additional tool, (i.e., in addition to comparison of the log mean) which is helpful for assessing differences in influent and effluent quality particularly where normality may be a poor assumption.

The extent to which the confidence intervals for the distributions of event concentrations at the inflow and outflow overlap give a good indication if the median can be considered statistically different (i.e., reject the null hypothesis that the inflow median and outflow medians are the same). In most cases, the parametric analyses of variance (ANOVA) and the non-parametric Kruskal-Wallis test supported the results of box plot. In this study, three primary behaviors were observed when comparing distributions of inflow and outflow event median concentrations using box and whisker plots:

- Positive or negative differences where the confidence intervals do not overlap (Figure 18).
- Positive or negative differences where the confidence intervals marginally overlap (Figure 19(a)).
- Differences where the confidence intervals appreciably overlap (Figure 19(b)).
- In some cases, the 95% confidence limit is either in excess of the third quartile or less than the first quartile or both. These cases correspond to a distribution of values that is strongly skewed and/or has a low number of samples (Figures 18-19).

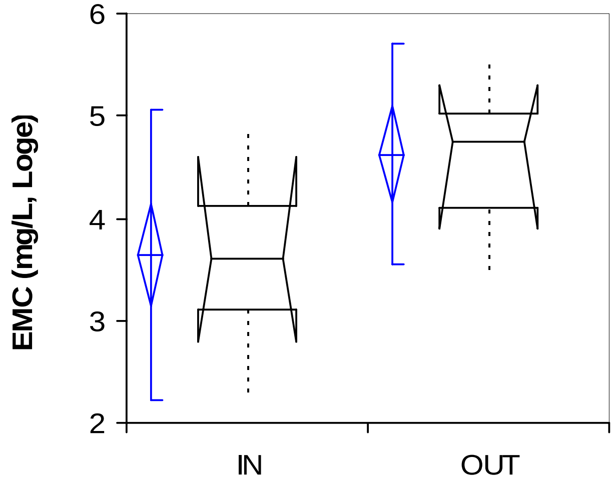



Figure 18. Example of statistically significant negative removal efficiency was observed in TSS for catch basin inserts. Confidence interval about the mean inflow did not overlap with confidence interval about the mean outflow in the box plots.

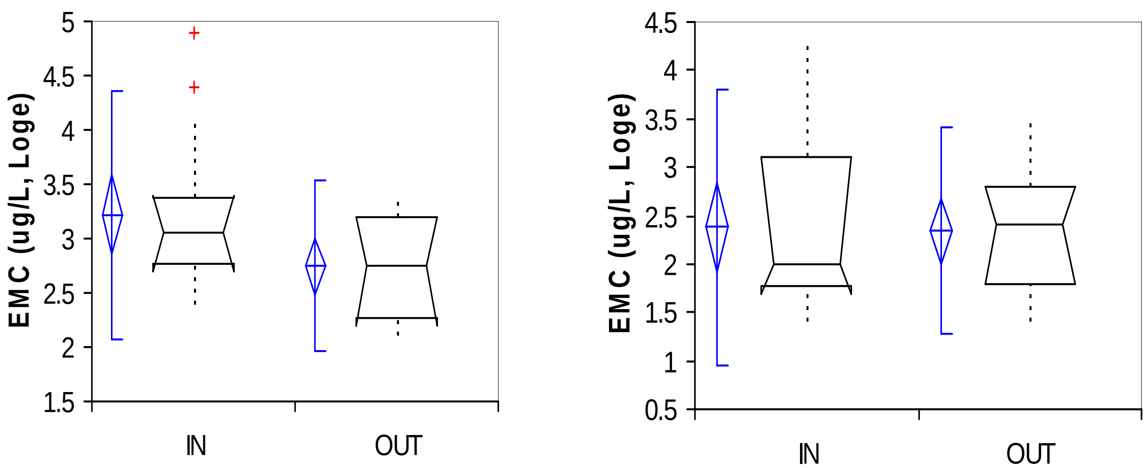



Figure 19. (a) Example of positive removal efficiency where marginal overlap of the confidence intervals about the mean was observed in dissolved copper for wet vault. (b) Example of statistically ambiguous difference in median event concentration i.e., confidence interval for inflow overlapping with confidence interval in the outflow box plots.

## 6.4 Calculation of Removal Efficiencies

The overall efficiency is summarized by reporting: the P-Value, the percent difference between the arithmetic estimate of the mean log transformed EMCs in the inflow and the outflow along with the confidence limit of the means. A P-Value greater than 0.05 implies that there is no difference in the mean of log transformed concentrations in the inflow and outflow. The percent difference with arithmetic estimate of mean indicates percent removal. When these differences are negative, the net removal effectiveness is negative.

Water quality data did not generally follow a straight line on normal probability plot, but did at least from about the $10^{th}$ to the $90^{th}$ percentile on lognormal probability plots where extreme values are not present in the data. The percent difference in removal for specific percentiles ($10^{th}$ and $90^{th}$) was also reported in this study similar to percent difference in arithmetic estimate of the mean. Some of these estimates based on the normal probability plots turned out negative at both percentiles. For example, percent difference for TSS in the catch basin inserts was negative both at the $10^{th}$ and the $90^{th}$ percentiles implying that catch basin inserts may not be suited for reducing TSS in stormwater. Conversely, a greater positive difference at the $90^{th}$ percentile as compared with a positive or negative difference at the $10^{th}$ percentile may suggest that the BMP is more effective in reducing a given contaminant entering the BMP at a relatively higher concentration.

## 7.0 Results

The results presented here are based on the analyses of the following constituents of concern:

**Bacteria**: Total coliform, fecal coliform, enterococcus, streptococcus
**Metals**: Total and dissolved: copper, lead, and zinc
**Others**: COD, nutrients, TSS, hardness, pesticides, oil and grease

### 7.1 Bioswale (Koreatown, City of Los Angeles)

There was not enough data to perform statistical analyses of removal effectiveness of the bioswale; the results presented here are based on the data collected from three storms. Preliminary results indicate that the bioswale appears to be effective in removing metals, TSS, COD, oil and grease, Kjeldahl, and nitrite from the stormwater (Figures section 13). Additional tests and collection of stormwater samples are recommended to investigate the removal effectiveness of bioswale.

### 7.2 Wet Vault and Infiltration Trench (Downtown, City of Los Angeles)

A limited number of statistical analyses were performed on the data from these BMPs. The median of lognormal transformed concentrations for effluent was higher than median influent concentrations for COD, hardness, nitrate, nitrite, Kjeldahl, and ammonia. The confidence interval about the median for outflow overlapped the confidence interval about the median for inflow. Therefore, the observed differences in the median were not statistically significant at the 95% confidence level. Additionally, the nonparametric tests showed that there was no difference between the median of inflow and outflow. Figures 31-33 in section 14 are bar graphs showing the relative differences in the inflow and outflow for several parameters analyzed.

The infiltration trench was monitored at 4 locations at 31 and 57 feet below the ground with lysimeters to obtain samples of soil moisture from percolation of stormwater runoff. There was also a groundwater well with groundwater at 225 feet below the ground surface. The data from groundwater did not show increase in any of the constituents tested. Almost all of the constituents were not detected in the samples from the groundwater. Groundwater appeared to have higher hardness content (593 mg/l) than the stormwater (400-472 mg/l). This could be due to underlying soils and higher hardness content. Total copper was at concentrations of a factor 150 times less than in the stormwater. Because of the low groundwater at this site, it is not clear whether the groundwater will become affected by pollution carried in the stormwater. Additional and long-term sampling will be necessary to study stormwater infiltration at this site.

Brown (2005) performed toxicity tests on stormwater runoff at this site. Samples from the inflow and the outflow of the wet vault device were tested on sea urchin fertilization. Toxicity of samples from two storm events was too high to detect any differences between the inflow and outflow toxicity. Samples from other storm events could not show reduction in toxicity as a result of this pretreatment. The toxicity results from *C. dubia* survival or reproduction were also inconsistent among the sampling events. Some samples showed higher toxicity in the outflow samples than the inflow.

As a pretreatment BMP, the wet vault at this site blocks debris and bulky materials from the inflow. For fine solids, the preliminary results showed some removal of TSS from the inflow.

## 7.3 Enhanced Manhole (Westchester, City of Los Angeles)

The box plots showed that the lognormal transformed EMCs in the outflow is generally less than EMCs in the inflow for most constituents except for nitrite and ammonia (section 15, Figures). These differences were comparable to the differences obtained from the 90$^{th}$ percentile method. The 90$^{th}$ percentile removal differences for the contaminants tested were: metals 14 to 52% (dissolved) and 31 to 52% (total), COD 42%, hardness 18%, Kjeldahl 56%, ammonia 22%, nitrite –64%, nitrate 22%, TSS 26%. The ANOVA tests showed that confidence interval about the mean for the outflow overlapped the confidence interval about the mean for the inflow. Therefore the observed differences in the means were not statistically significant at the 95% confidence level. Additionally, the nonparametric tests showed that there was no difference between the median of the inflow and the outflow for the constituents of concern.

## 7.4 Catch Basin Inserts (South Pasadena)

The box plots showed that the lognormal transformed EMCs in the outflow was lower for the effluent than EMCs in the inflow for: hardness, nitrate, metals, and was higher for: COD, Kjeldahl, ammonia, nitrite, and TSS (section 16, Figures). The positive differences were comparable to the differences obtained from the 90$^{th}$ percentile method. The 90$^{th}$ percentile removal differences for the contaminants tested were: metals 2 to 35% (dissolved) and –0.4 to 52% (total) lowest removal were for lead, COD –13%, hardness 53%, nitrate 8%, nitrite –10%, Kjeldahl –83%, ammonia –35%, and TSS –93%. The ANOVA tests showed that confidence interval about the mean for the outflow overlapped the confidence interval about the mean for the inflow. Therefore the observed differences in the means were not statistically significant at the 95% confidence level. Additionally, the nonparametric tests showed that there was no difference between the median of the inflow and the outflow for the constituents of concern.

Catch basin inserts generally exhibited poor to low trash removal capture. During episodes of high runoff flows, the floatable debris appeared to pass over the filter because of high water level inside the inserts.

## 7.5 Hydrodynamic Separator (South Pasadena)

The box plots showed that the lognormal transformed EMCs in the outflow is generally less than EMCs in the inflow for most constituents except for total lead (section 17, Figures). These differences were comparable to the differences obtained from the 90$^{th}$ percentile method. The 90$^{th}$ percentile removal differences for the contaminants tested were: metals 13 to 27% (dissolved) and -3 to 11% (total), COD 18%, hardness 22%, Kjeldahl 6%, ammonia 29%, nitrite 2%, nitrate 36%, TSS 46%. The ANOVA tests showed that confidence interval about the mean for outflow overlapped the confidence interval about the mean for the inflow. Therefore the observed differences in the mean were not statistically significant at the 95% confidence level. Additionally, the nonparametric tests showed that there was no difference between the median of inflow and outflow for the constituents of concern.

Brown (2005) performed toxicity tests on stormwater runoff at this site. Samples from the inflow and the outflow of the hydrodynamic separator from 5 storm events were shown to be highly toxic to sea urchin fertilization; the device did not reduce the toxicity. None of the samples were toxic to *C. dubia* survival or reproduction.

This BMP is designed to capture trash, bulky materials, and sediments as low as 4,700 microns in size. The device is an offline unit designed for runoff flow rates as high as 6 CFS. Any runoff flows in access of 6 CFS will bypass the device thus reducing the overall removal effectiveness of trash. In this study, one storm may have exceeded 6 CFS level at one point as the flow data indicated.

## 7.6 Comparison to Freshwater Chronic Criteria

The effluent mean concentrations for dissolved metals and organophosphate pesticides were also compared with water quality criteria shown in Table 4. These water quality criteria were obtained from various sources.

Table 4. Freshwater criteria

| Constituents | Freshwater Chronic Criteria ($\mu$g/l) |
|---|---|
| **Organophosphate Pesticides** | |
| Chlorpyrifos[1] | 0.041 |
| Diazinon[2] | 0.05 |
| **Dissolved Metals** | |
| Copper[3] | $0.96\exp[0.8545\ln(hardness) - 1.702]$ |
| Lead[3] | $[1.46203 - 0.145712\ln(hardness)]\exp[1.273\ln(hardness) - 4.705]$ |
| Zinc[3] | $0.96\exp[0.8473\ln(hardness) + 0.884]$ |

1 – National Water Quality Criteria (EPA, 2002), 2- Cal Fish and Game (Spieman), 3- Cal Toxics Rule (EPA, 2000). For hardness greater than 400 mg/l, use hardness = 400 mg/l in the formula to calculate the chronic criterion.

### 7.6.1 Bimini Slough Ecology Park

The results for three storm are shown in Figure 20. The mean effluent concentrations for selected dissolved metals were not reduced below the chronic criteria.

Organophosphate pesticides were not detected in the inflow or the outflow of the bioswale. Therefore, no comparison could be made to the chronic criteria.

### 7.6.2 Wet Vault and Infiltration Trench

These BMPs were in series. The results for five storm are shown in Figure 21. The mean influent concentration for selected dissolved metals were not reduced below the chronic criteria in the wet vault. For two storms (12/28/04 and 2/11/05), dissolved zinc concentrations for both influent and effluent were below the chronic criteria. The results for infiltration trench show that dissolved metals event mean concentrations were far below the chronic criteria.

Water quality samples were not tested for organophosphates. Therefore, no comparison could be made to the chronic criteria.

### 7.6.3 Enhanced Manhole

The results for 2004-05 storm season are plotted in Figure 22. The mean influent and effluent concentrations for selected dissolved metals were not reduced below the chronic criteria. For some data points, the chronic criteria were above the mean effluent concentrations for dissolved lead, however, the data points plotted on the x-axis are indicative of concentrations not detected in the inflow and the outflow.

The water quality samples tested from a number of storms showed chlorpyrifos in one storm with influent concentration of 0.1 $\mu$g/l and not detected in the effluent. There was also diazinon detected in two of the storms with influent concentrations above chronic criteria. Diazinon was not detected in the effluent water samples.

### 7.6.4 Catch Basin Inserts and Hydrodynamic Separator

The catch basin inserts were upstream of the hydrodynamic separator. The results for 2004-05 storm season are plotted in Figure 23. The data for catch basin inserts were from the first three hours of each storm. The mean influent and effluent concentrations for selected dissolved metals were not reduced below the chronic criteria. For some data points, the chronic criteria were above the mean effluent concentrations for dissolved lead; however, the data points plotted on the x-axis are indicative of concentrations not detected in the inflow and the outflow. Similar results were obtained for the hydrodynamic separator.

The water quality samples tested from a number of storms showed chlorpyrifos in four storms and diazinon in three storms. For catch basin inserts, there was a reduction in chlorpyrifos below the chronic criterion and in another storm the influent and effluent mean concentrations were both above the chronic criteria. Diazinon detected in one storm had concentrations above the chronic criteria for both influent and the effluent water samples. Another storm detected below the chronic criterion in the influent and was not detected in the effluent water sample. Similar results were obtained from the water samples upstream and downstream of the hydrodynamic separator with effluent concentration in two samples were larger than influent concentrations and indication that they were reduced.

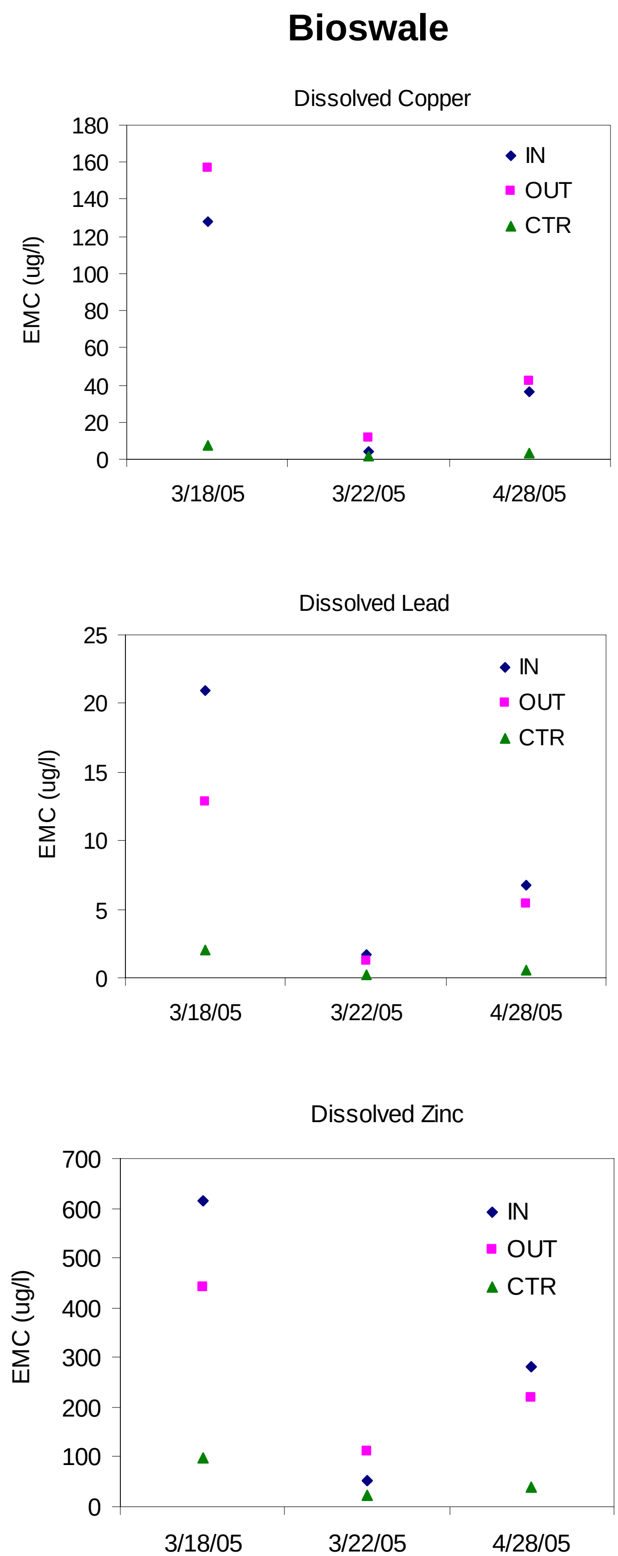



Figure 20. Event mean concentrations for dissolved metals at Bimini Slough Ecology Park. Also shown are the chronic criteria for dissolved metals in the outflow.

## Wet Vault and Infiltration Trench

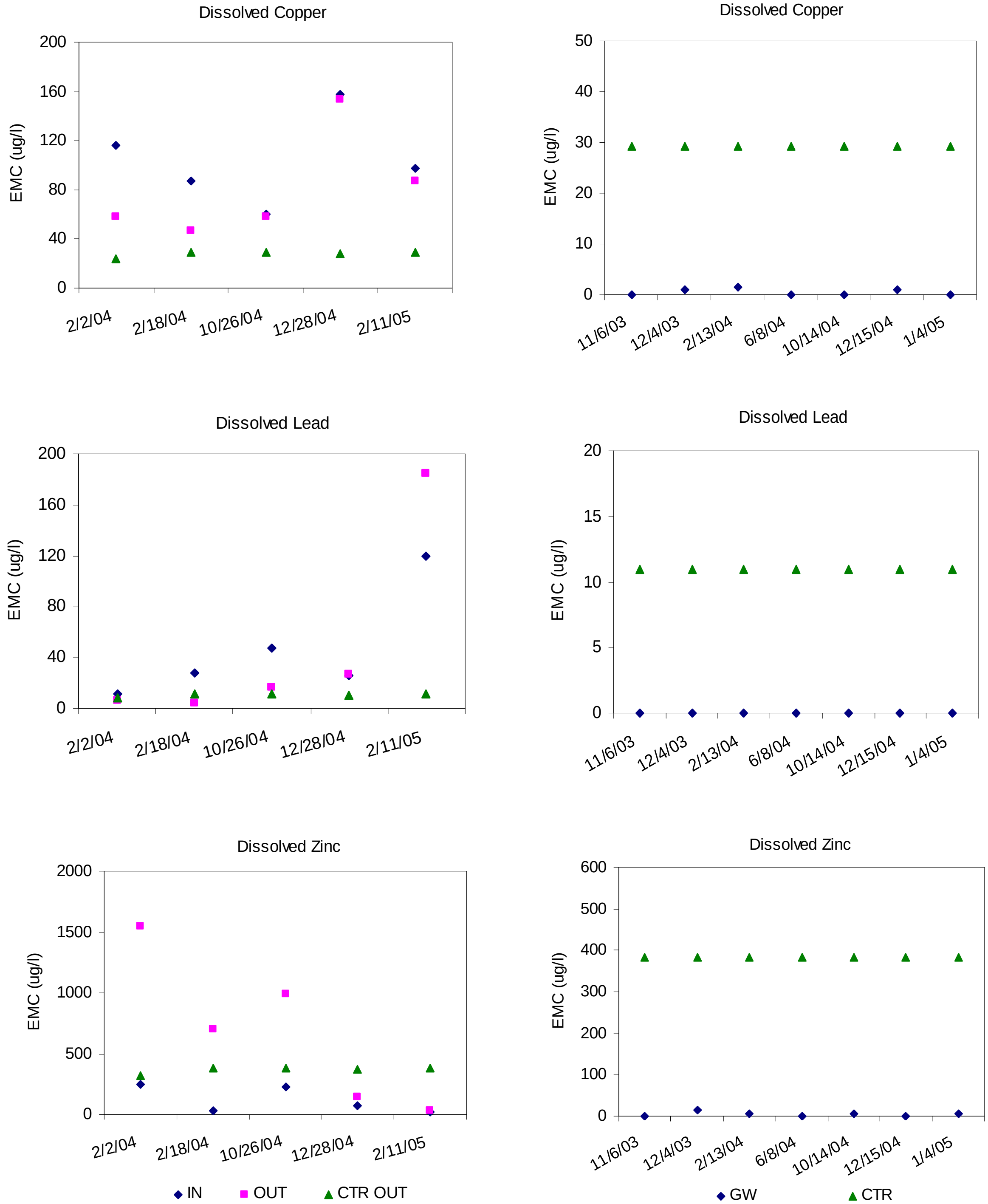
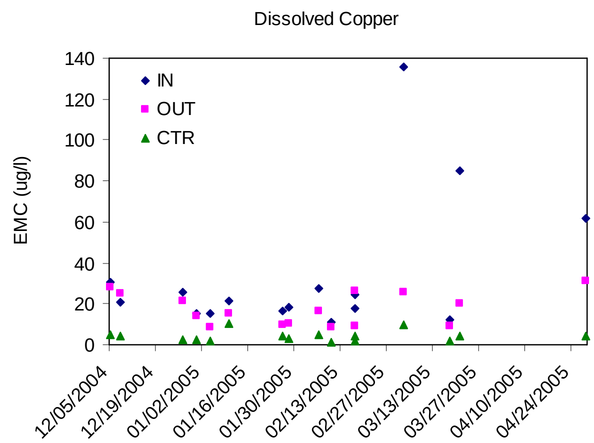
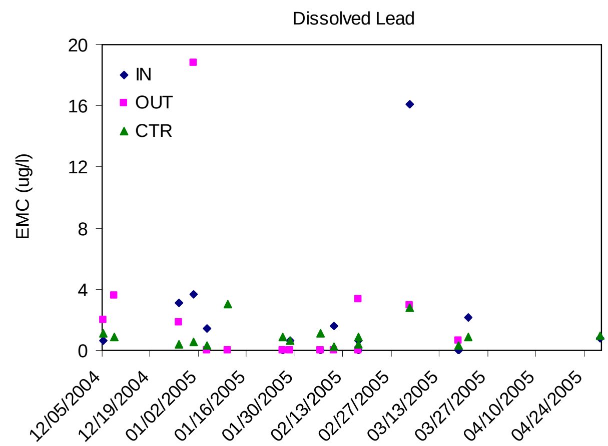



Figure 21. Event mean concentrations for dissolved metals in downtown, City of Los Angeles. Also shown are the chronic criteria for dissolved metals in the outflow. On the left are concentrations in the inflow and the outflow of wet vault. On the right are concentrations in groundwater. Data shown on the x-axis are below detection limit.

## Enhanced Manhole



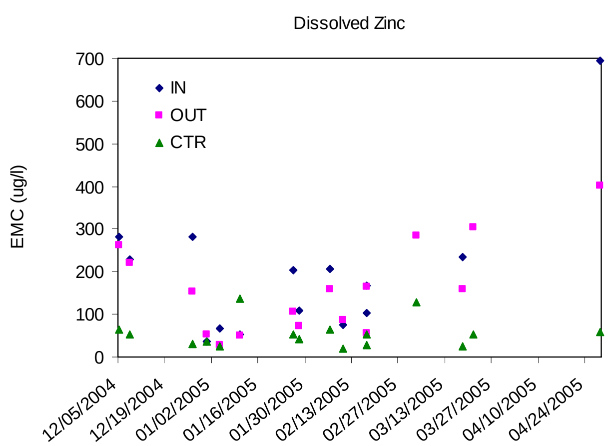




Figure 22. Event mean concentrations for dissolved metals at Westchester. Also shown are the chronic criteria for dissolved metals in the outflow.

## Catch Basin Inserts and Hydrodynamic Separator

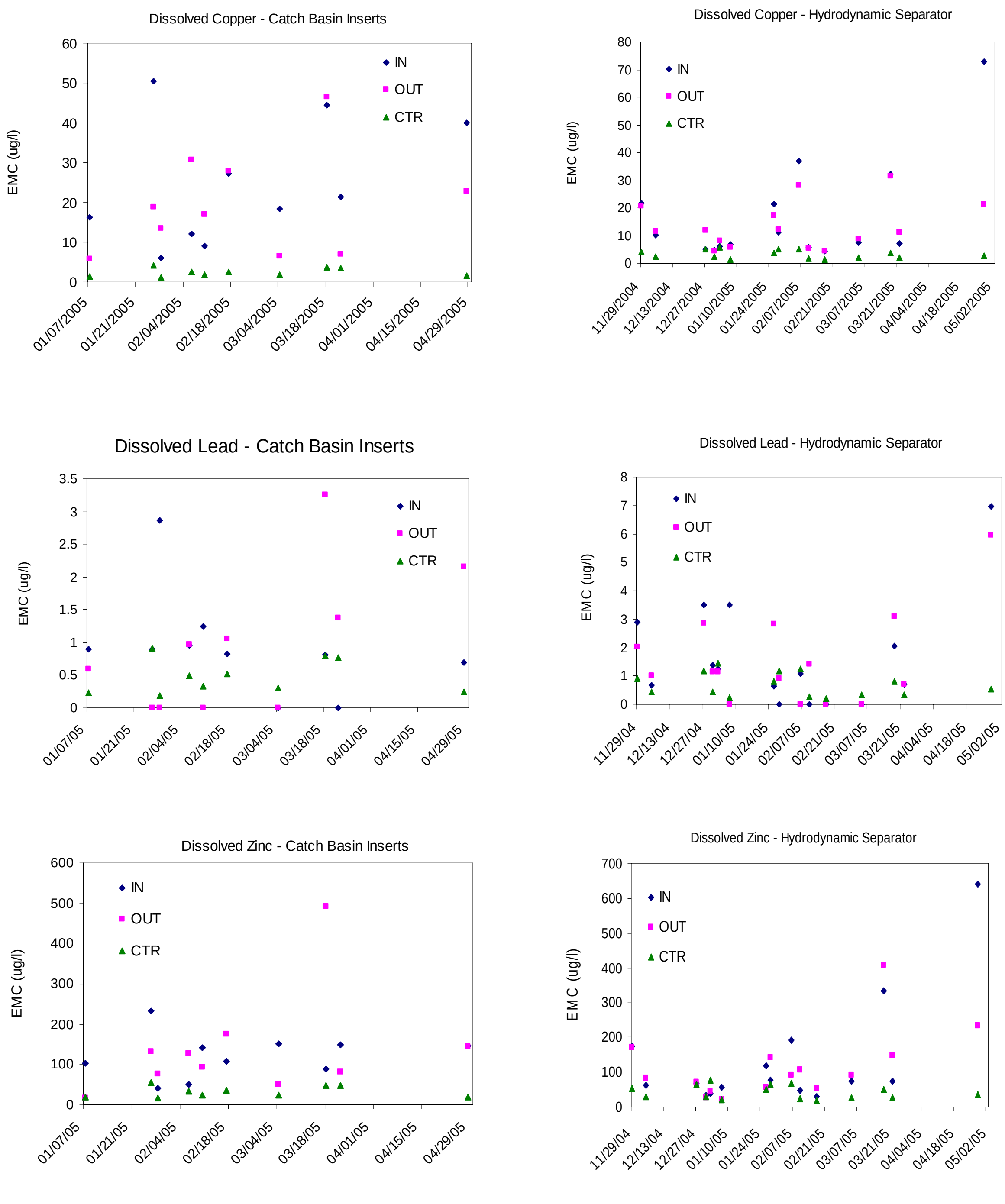



Figure 23. Event mean concentrations for dissolved metals in South Pasadena. Also shown are the chronic criteria for dissolved metals in the outflow. On the left are concentrations in the inflow and the outflow of catch basin inserts. On the right are concentrations in the inflow and the outflow of hydrodynamic separator. Data shown on the x-axis are below detection limit.

# 8.0 DISCUSSION

This study investigated removal effectiveness of BMPs for various pollutants of concern from stormwater runoffs. These BMPs were also monitored as part of other studies. For example, a hydrodynamic separator in the City of South Pasadena was also studied for trash removal. The wet vault and infiltration BMPs were also studied for water reuse and augmentation programs.

Based on the preliminary results obtained from the storm season of 2004-05, the following table is a summary of how the selected BMPs performed in removing pollutants of concern. These results were based on the comparison of 90$^{th}$ percentiles of EMCs to the arithmetic mean for the inflow and the outflow of collected stormwater runoff data, discrete bacteria samples, and bar graphs of the limited data set from two BMPs. Most BMPs were tested for oil and grease and pesticides, however, they showed up only in a few storms and therefore were not able to run statistical analysis because of small sample size. The results from bacteria were based on the grab samples. For bacteria, analysis based on EMCs is recommended and discrete samples composited over a period of time may show results more indicative of bacteria levels during a storm and removal effectiveness. This approach is limited to a sampling time less than 6 hours for storm longer than 6 hours.

A comparison of the removal effectiveness from different BMPS shows that infiltration trench is relatively high followed possibly by the bioswale or the wet vault (Table 5). The hydrodynamic separator and enhanced manhole exhibited low removal.

Table 5**.** Relative removal effectiveness of various BMPs.

| **Removal Effectiveness for Removing Targeted Pollutants of Concern** | | | **Trash** | **Bacteria** | **TSS** | **Oil & Grease** | **Nutrients** | **Metals** | **Pesticides** | **Organics** |
|---|---|---|---|---|---|---|---|---|---|---|
| Public Domain | Infiltration | Infiltration Trench | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Biofiltration | Bioswale | 1 | N-1 | 3 | 2 | 1 | 2 | U | U |
| Proprietary | Flow Through Separation | Catch Basin Inserts | 2 | N | N | 2 | N-1 | N-2 | U | U |
| | | Enhanced Manhole | U | N-2 | 1 | U | N-2 | 2 | U | U |
| | | Hydrodynamic Separator | 3 | N-1 | 2 | U | 1 | N-1 | U | U |
| | | Wet Vault | 3 | 2 | 1 | 3 | 1 | 1 | U | U |

<u>Removal Effectiveness</u>
U = Unkown:limited data, not tested, or not detected
N = Negative Removal
1 = Relatively Low
2 = Relatively Moderate
3 = Relatively High

In a study by Brown (2005) two toxicity tests were conducted to determine the removal effectiveness of toxicity for several BMPs. Included in the study were the hydrodynamic separator in the City of South Pasadena and the wet vault in the City of Los Angeles. Brown used freshwater organisms (water fleas) and a marine species (sea urchins) to determine the removal effectiveness of toxicity. The study did not identify the cause of toxicity.

The hydrodynamic separator did not have any effect in reducing toxicity for either of the two species tested. From the study by Brown and previous studies by CRWQCB, it can be inferred from the results that the toxicity associated with dissolved metals such as zinc did not change because of low removal. The $90^{th}$ percentile removal difference for a selected number of dissolved metals was in range of 13 to 27% with dissolved zinc equal to 13%. Pesticides such as diazinon and chlorpyrifos showed up in a limited number of storm samples and generally at a higher concentration in the outflow than in the inflow.

Toxicity tests for some storms in the City of Los Angeles metal recycling yard showed a reduction downstream of the wet vault for both species tested. However, the toxicity in the inflow and the outflow were often too high for other storms to determine if a consistent reduction had occurred. The EMCs obtained from the five storms showed negative removal for dissolved zinc and lead and small positive removal for dissolved copper. The stormwater samples were not tested for organophosphate pesticides.

The study compared the effluent concentration of selected dissolved metals and organophosphate pesticides with the freshwater chronic criteria to evaluate the ability of the BMPs in reducing the concentration below the chronic criteria. In all the samples that were compared, the concentration for the influent and the effluent were above the chronic criteria. The results from the hydrodynamic separator are consistent with Brown's (2005) toxicity tests in that the reductions in the effluent concentrations were too small to show any apparent changes in the water flea reproduction or the sea urchin fertilizations tests.

The International Stormwater BMP Database provides a spreadsheet with flow and water quality data for each storm event for various BMPs tested over the past decade. The database was developed under a cooperative agreement between the American Society of Civil Engineers (ASCE) and the U.S. Environmental Agency (USEPA) and has now several sponsoring partners. Wright Water Engineers, Inc. and GeoSyntec Consultants maintain the database. The water quality data obtained from this study was used to compare with the existing water quality data from this database for similar BMPs. The BMP categories listed are: Biofilter, Detention Basin, Hydrodynamic Device, Media Filter, Percolation Trench/Well, Porous Pavement, Wetland Basin, and Wetland Channel.

The database can be used to make relative comparisons between different types of BMPs. There may be concern on how these BMPs perform based on the geographical location or the size of storms. These issues should also be addressed. The hydrodynamic separator and the enhanced manhole in this study are both listed as hydrodynamic devices in the BMP database. Therefore, the data in this study were used to compare removal effectiveness with the data from other hydrodynamic devices documented in the BMP database. The data for TSS, dissolved copper and dissolved zinc were plotted together with the existing data from the BMP database and were also compared with a 45-degree line, which represented no removal. In Figure 20, the plots on the left represented data from the enhanced manhole at the County maintenance yard in Westchester and the plots on the right were from the hydrodynamic separator in the City of South Pasadena. The data points are clustered near the 45-degree line in both plots. The data points for the enhanced manhole in Westchester were below the 45-degree line indicating net reduction in TSS, dissolved copper, and dissolved lead. Also the plots show that dissolved zinc concentrations are higher in this region than those reported in the BMP database.

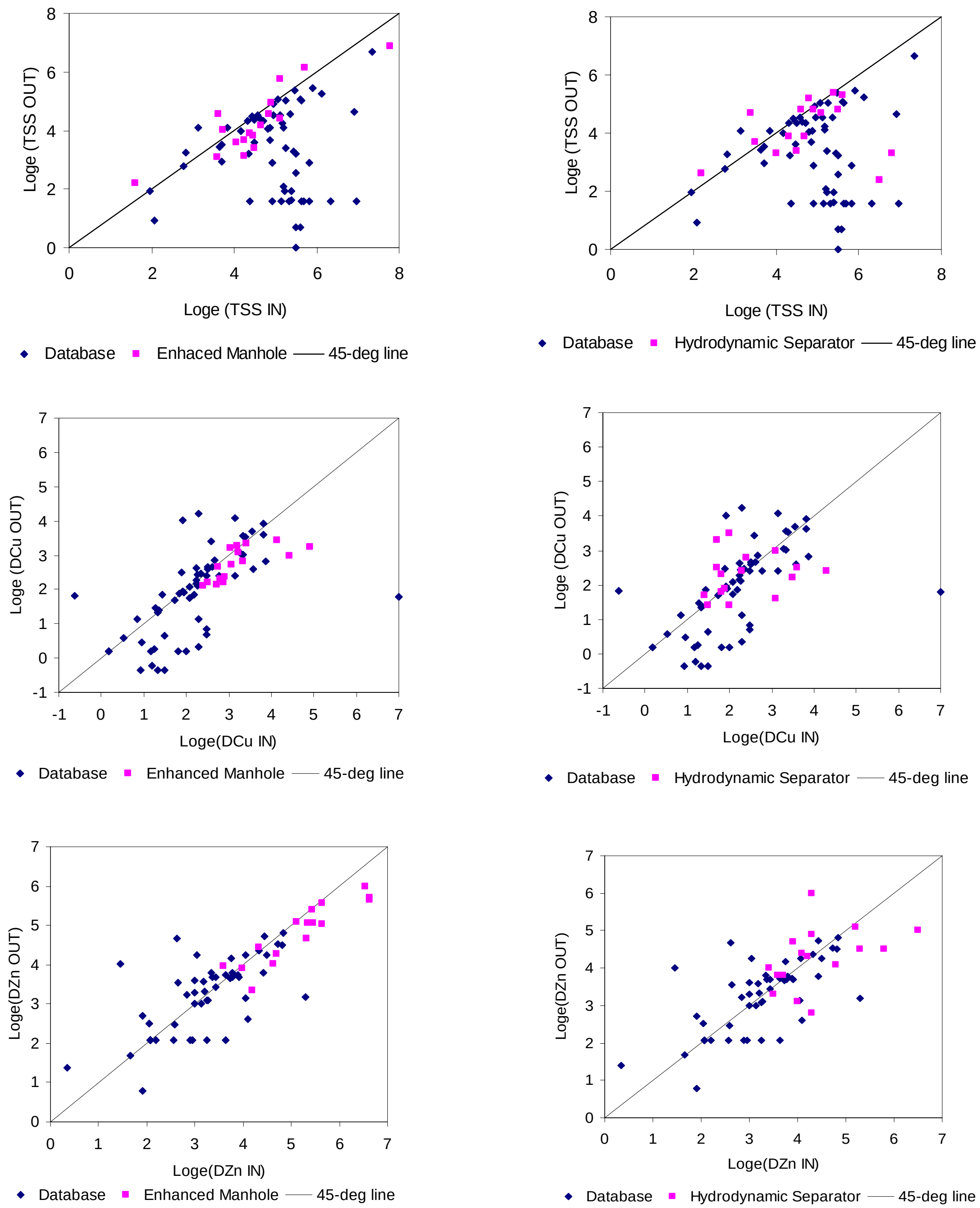



Figure 24. Comparison of data from BMP database with the data from enhanced manhole on the left and data from a hydrodynamic separator on the right.

# 9.0 FUTURE WORK

This study investigated the removal effectiveness of 6 selected BMPs. The results can be used to compare with data and or claims from the manufacturers of some of these BMPs. The water quality data for two BMPs were from a limited number of storm events and these analyses were limited to making qualitative comparisons between the inflow and outflow for various pollutants. In order to obtain additional information and to confirm these preliminary results, more data from future storms is necessary.

The most common performance measure used today is “percent removal” of pollutants (Strecker, et. al., 2001). As statistical methods have shown in this study percent removals can be statistically insignificant and depending on the BMP type, size of flow, and concentration of contaminants the results can also be variable. The confidence intervals about the mean inflow and the mean outflow overlapped in all of the data analyzed indicating that the percent removals were statistically insignificant. The $90^{th}$ percentile percent removal from the normal probability plots and lognormal transformed arithmetic mean of percent removal were comparable and were therefore used to explain relative removal effectiveness of BMPs. A percent removal based on the simple arithmetic mean was not used because of the presence of outliers.

It appears that the bioswale in this study is showing removal of a wide mixture of pollutants of concern based on three storms sampled. Therefore, it is recommended that the bioswale be further investigated during 2005-06 storm season. To make relative comparisons, it is recommended to also study another BMP during the same storm season. In this case, the enhanced manhole showed higher percent removals relative to the hydrodynamic separator. It is therefore recommended to continue the study with the bioswale and the enhanced manhole.

The results of this study and many others will contribute to the expansion of the BMP database which will provide useful tools to develop more accurate design requirements for stormwater BMPs as well as implementation plans for TMDLs. BMPs can then be targeted based upon their expected performance and with regard to pollutants of concern. It can be more effective to utilize multiple BMPs wherever possible to account for variability in the concentration of pollutants and uncertainties that are associated with BMPs.

# 10.0 REFERENCES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# 11.0 SITE LOCATION MAP

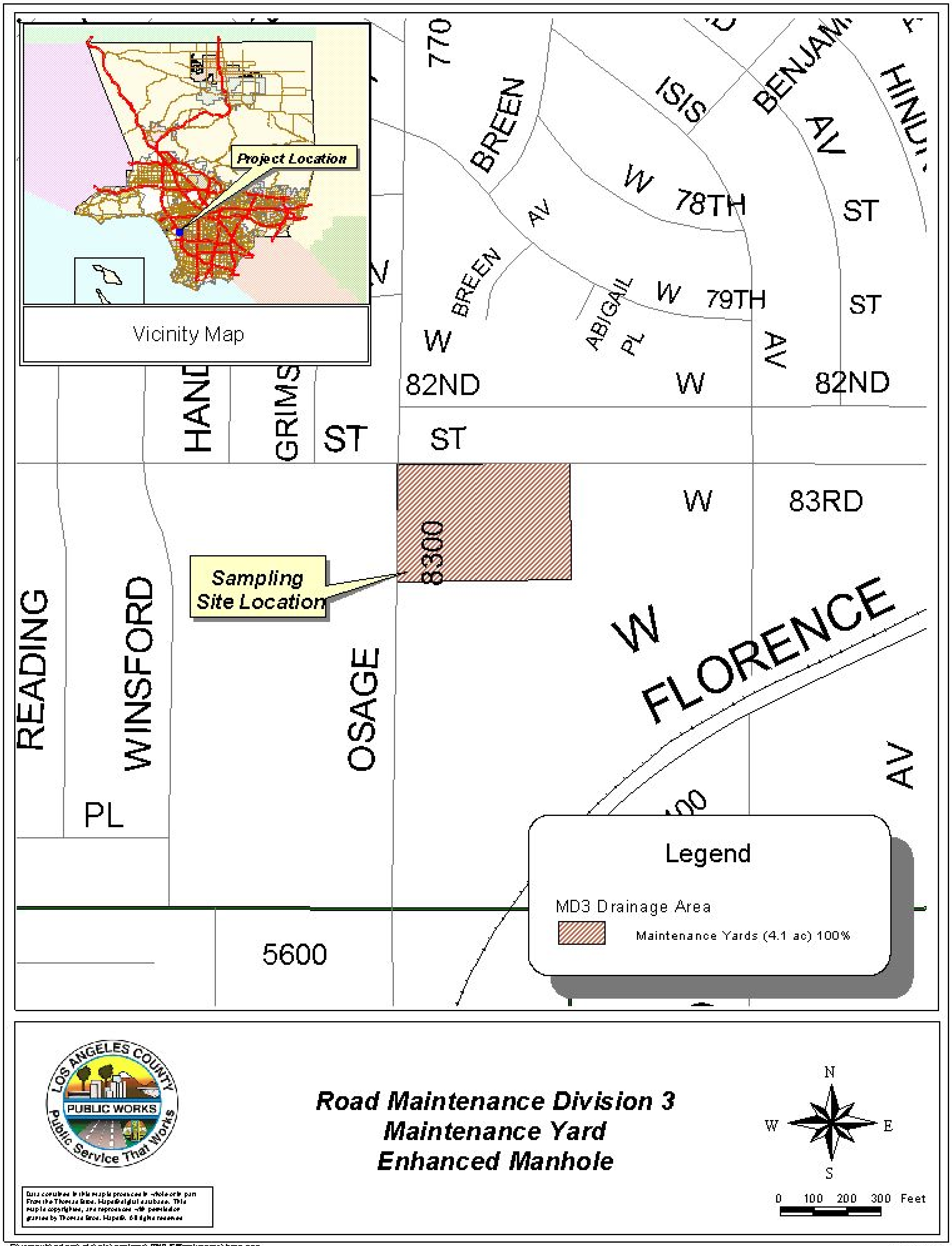



Figure 25. Drainage area and land use in the maintenance yard.

## Site Location Map

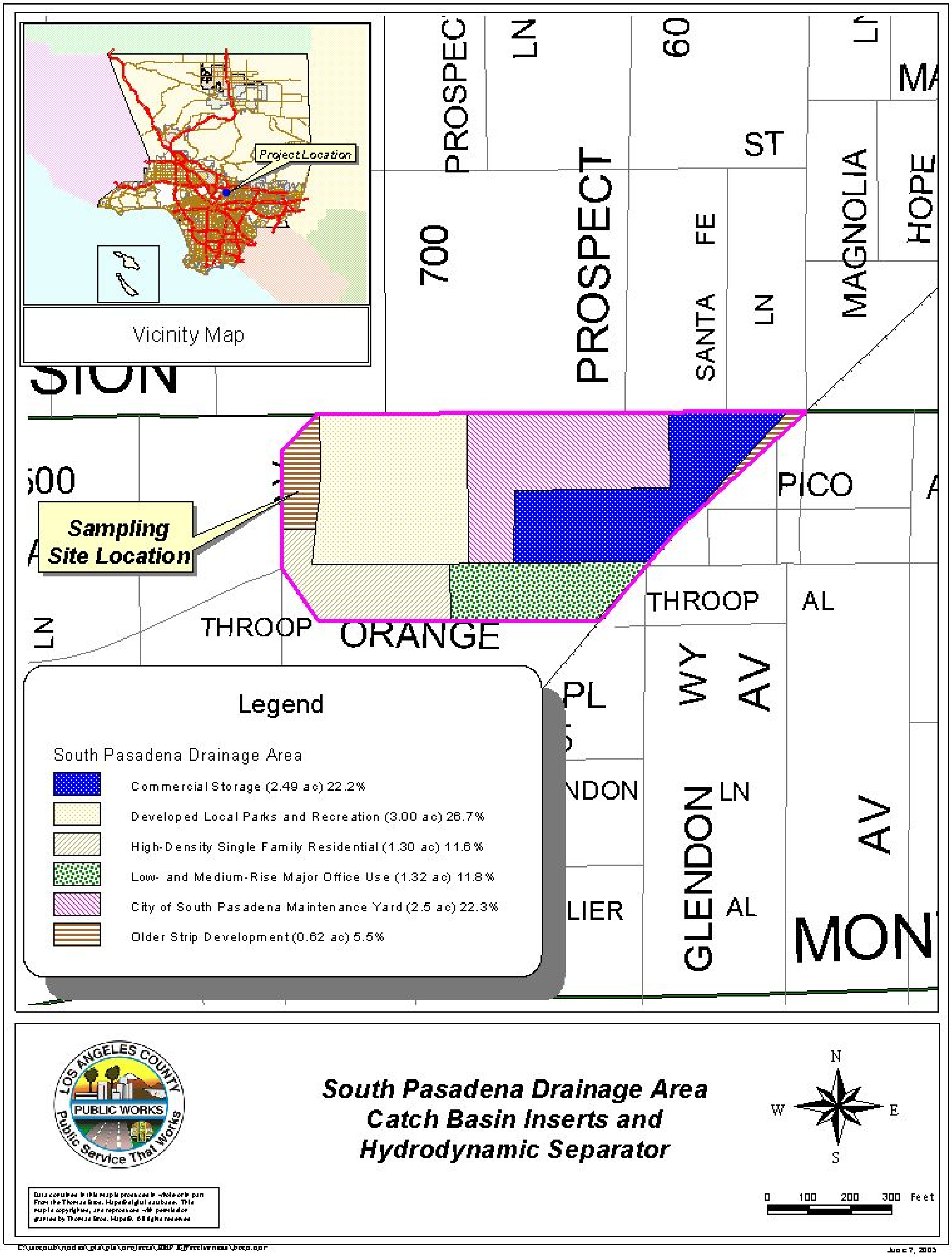



Figure 26. Drainage area and land use in South Pasadena.

## Site Location Map

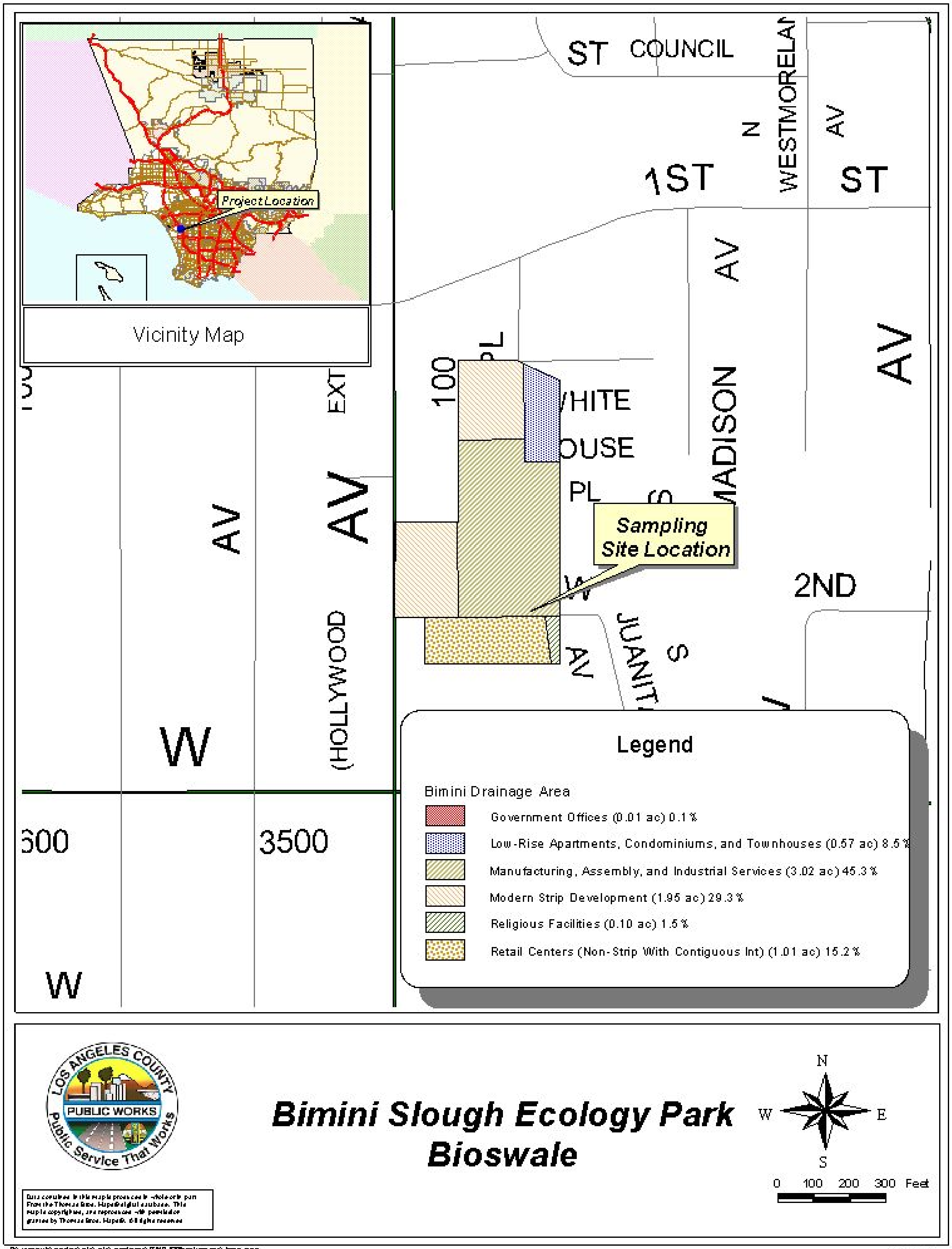



Figure 27. Drainage area and land use in Bimini Slough Ecology Park.

# 12.0 RAINFALL DATA AND RAINFALL FREQUENCY

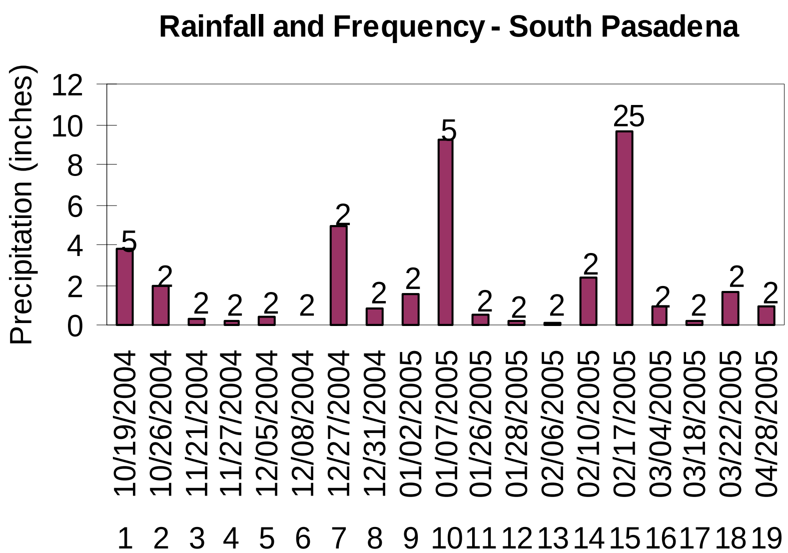



Figure 28. Rainfall data and rainfall frequency for 2004-05 storm season.

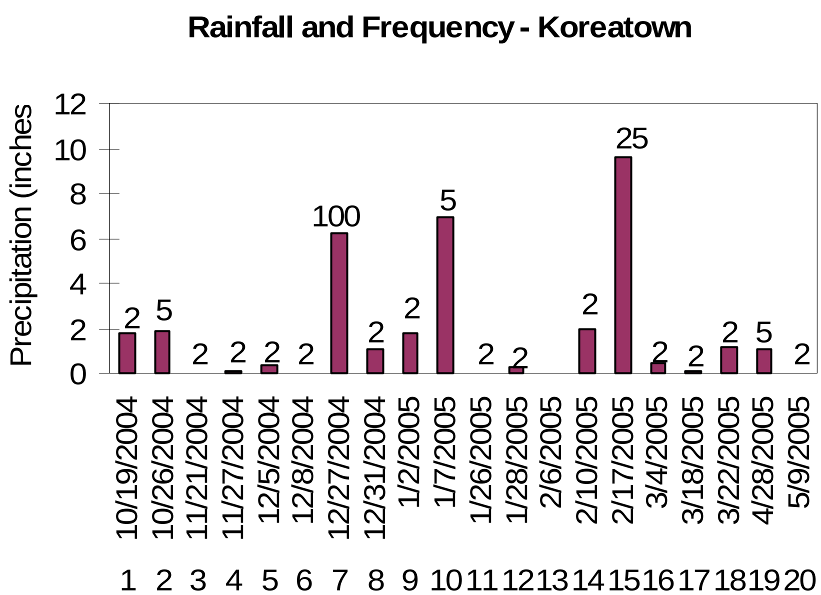



Figure 29. Rainfall data and rainfall for 2004-05 storm season.

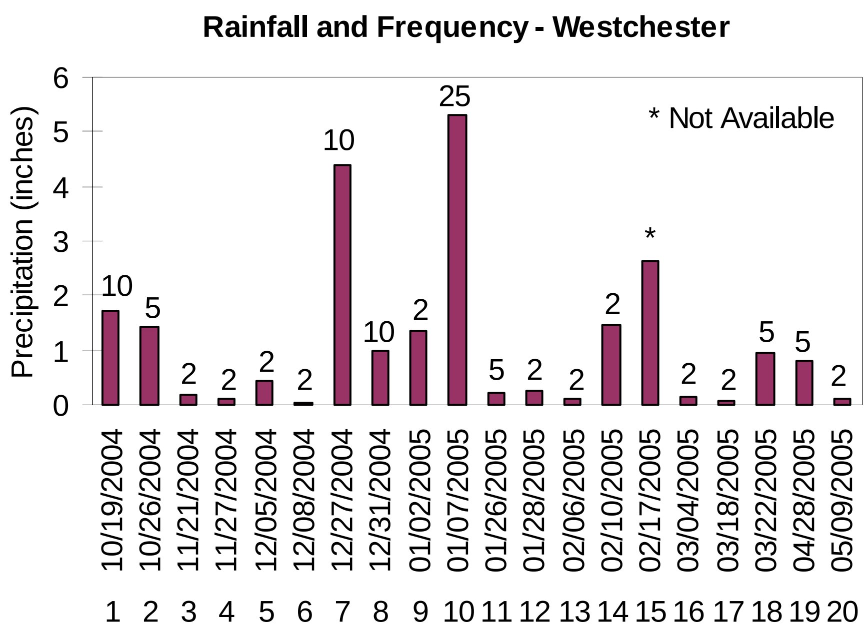



Figure 30. Rainfall data and rainfall frequency for 2004-05 storm season.

# 13.0 BiOSWALE

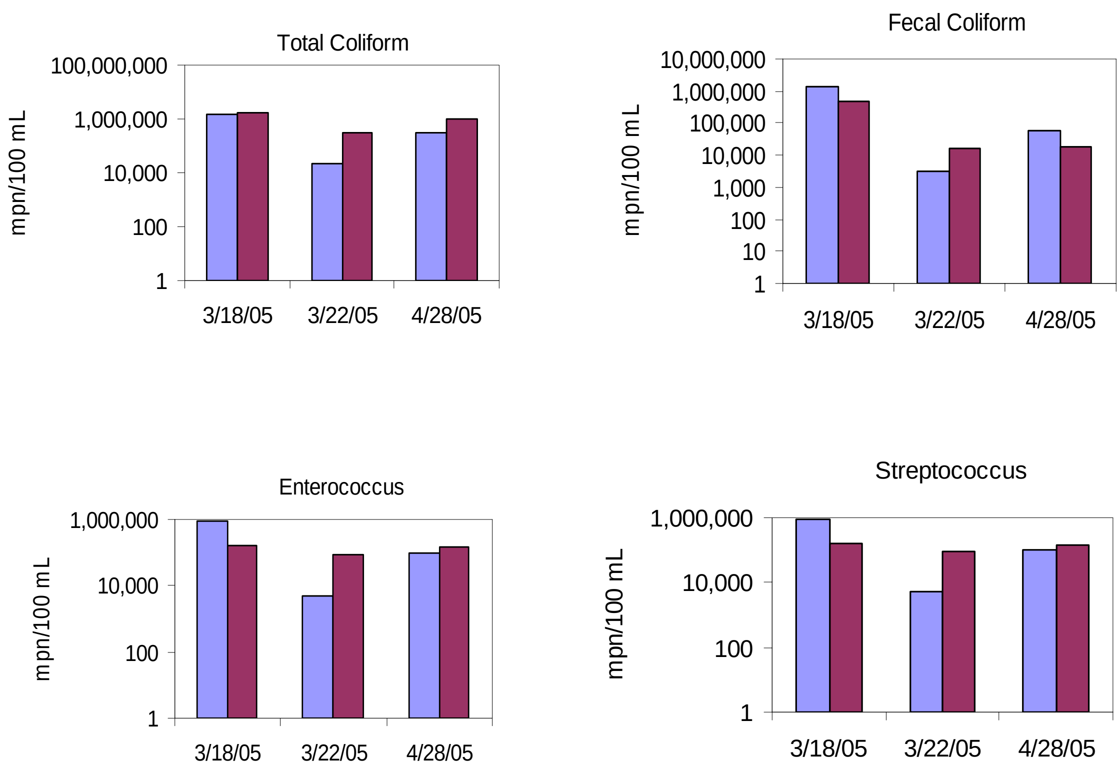



Figure 31. Bacteria removal from the bioswale ( inflow, outflow).

## Bioswale

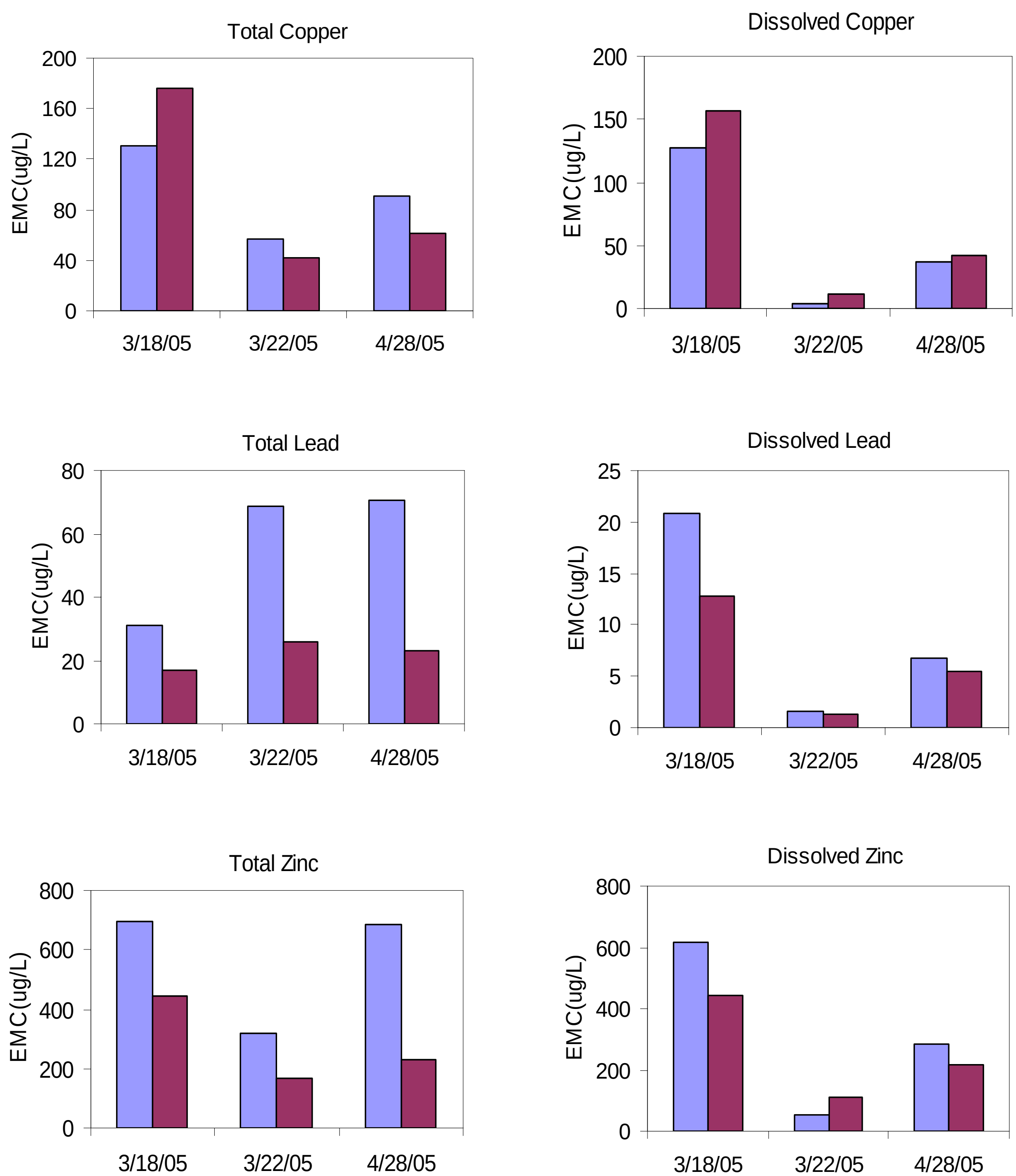



Figure 32. Metal removal from the bioswale ( inflow, outflow).

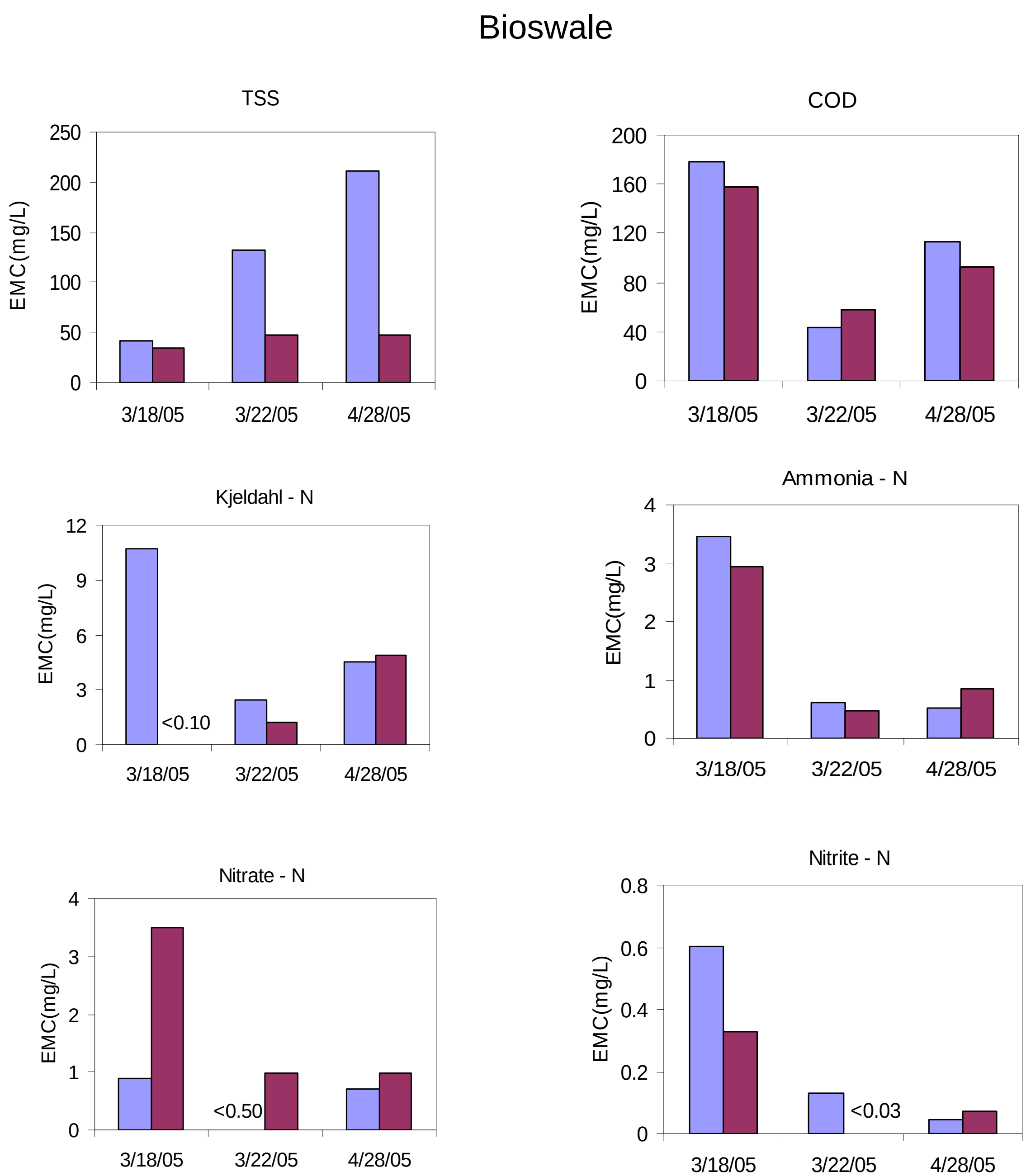



Figure 33. TSS, COD, and nutrients removal from the bioswale.

(symbol "<" means below detection limit and not detected. inflow outflow)

## Bioswale

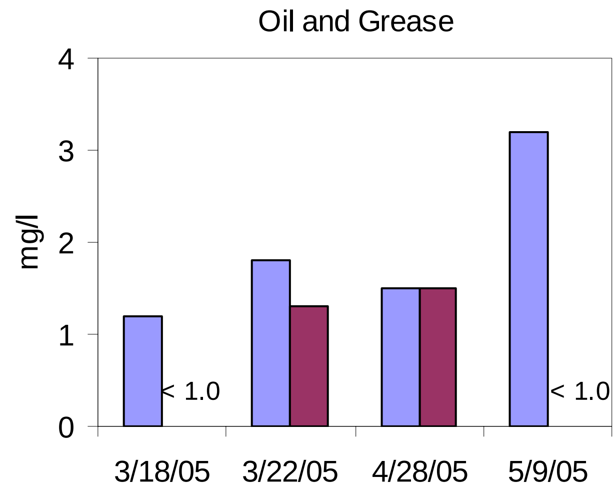



Figure 34. Oil and grease removal from the bioswale.

(symbol "<" means below the detection limit and not detected. inflow, outflow ).

# 14.0 WET VAULT

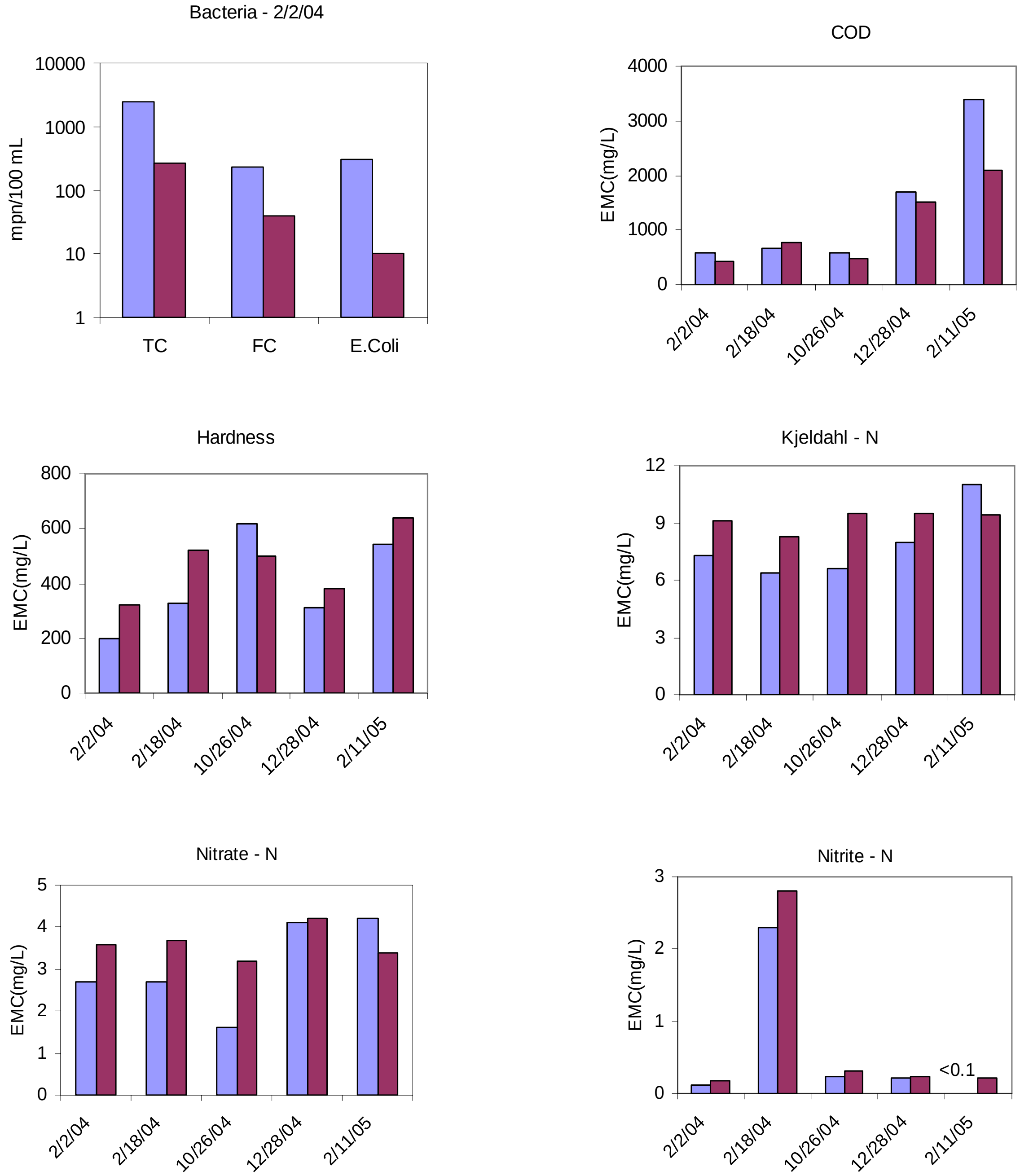



Figure 35. Bacteria, COD, hardness, nutrients removal from the wet vault.
(symbol "<" means below detection limit and not detected. inflow outflow)

## Wet Vault

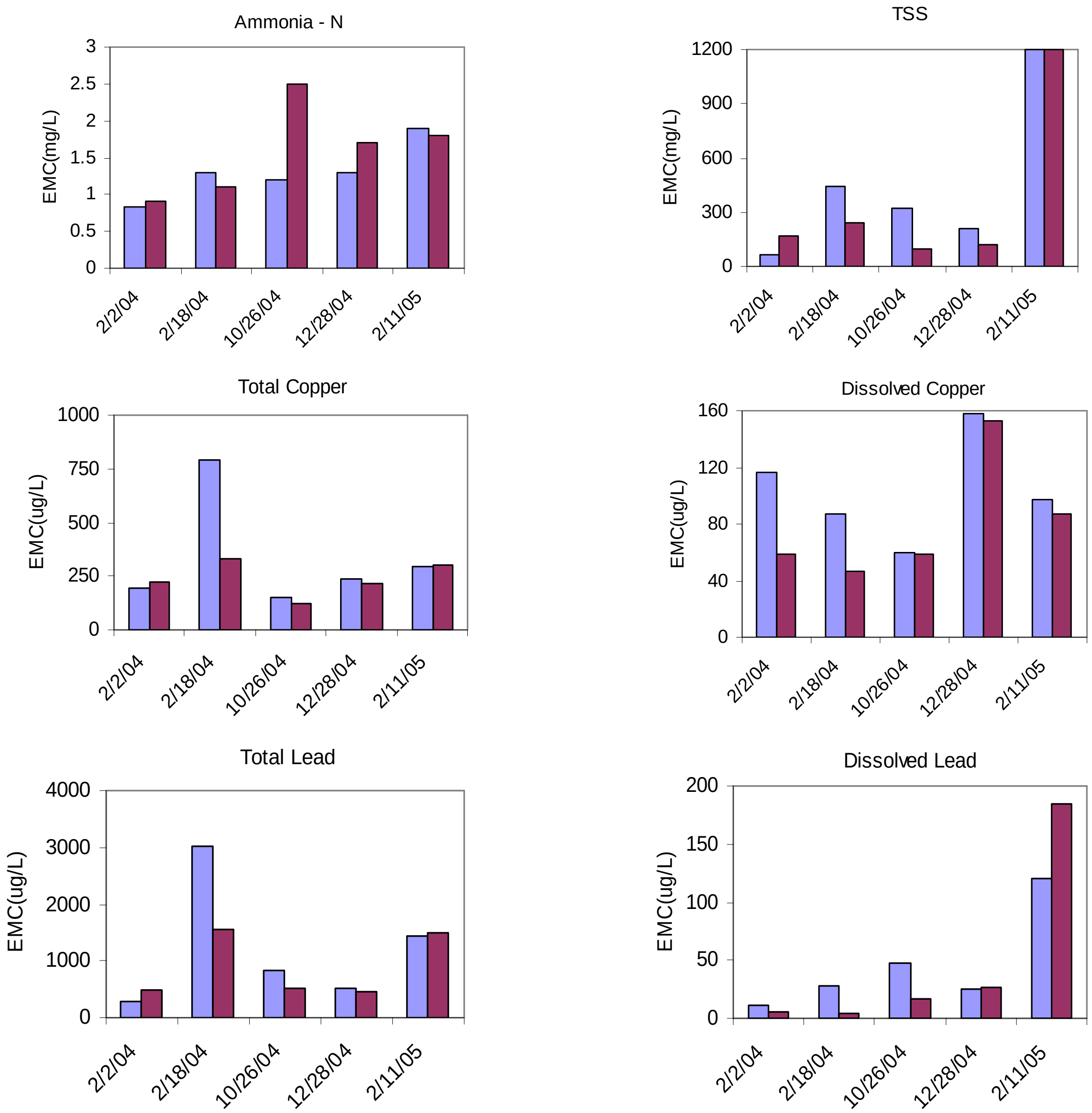



Figure 36. Ammonia, TSS, and metals removal from the wet vault – metal recycling yard.

( inflow outflow)

## Wet Vault

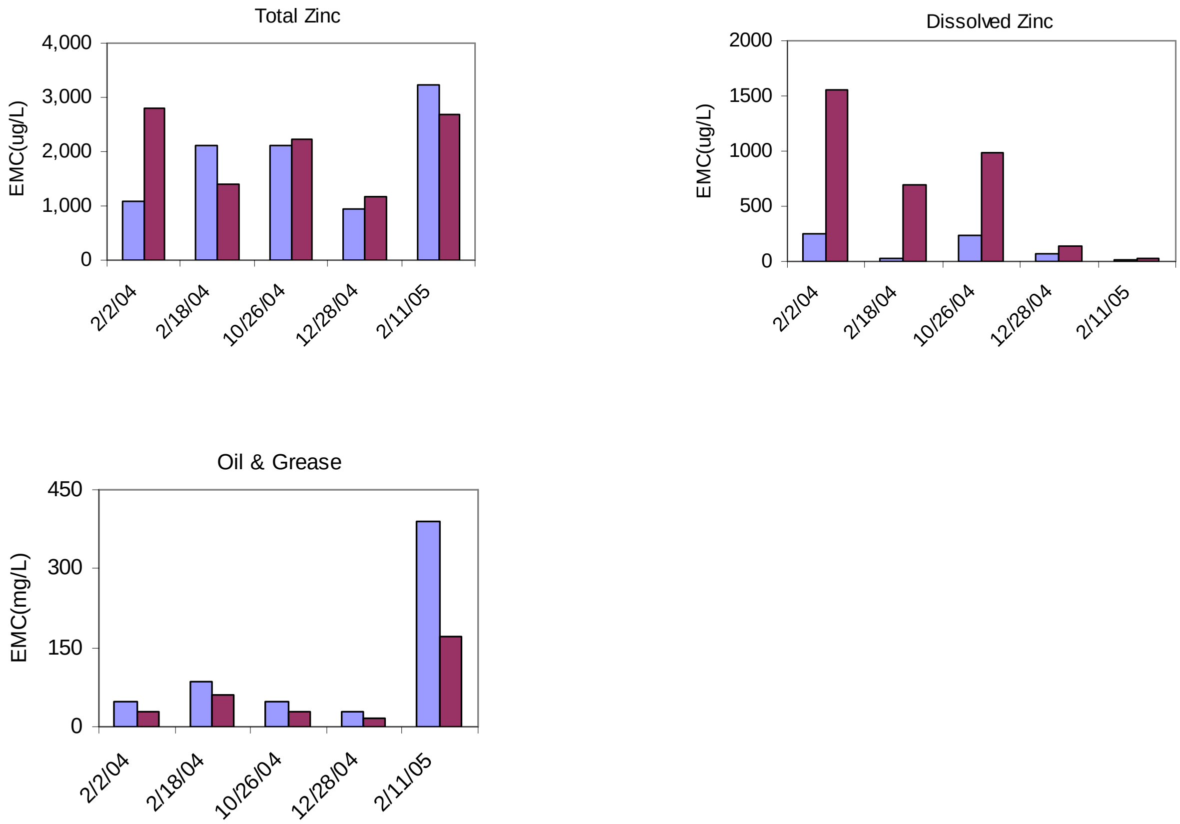



Figure 37. Metals, oil and grease removal from the wet vault – metal recycling yard.

inflow outflow

# 15.0 ENHANCED MANHOLE

Enhanced Manhole

City Westchester

Total Coliform (mpn/100 mL)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 15 | 12.65 | 1.83 | 13.67 | 11.64 |
| Outlet | 14 | 12.61 | 1.46 | 13.65 | 11.96 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 1678209.64 | 312804.39 | 5.27 | 6577384.96 | -3220965.67 |
| Outlet | 1060682.45 | 364813.98 | 2.73 | 2732351.45 | -610986.55 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 617527.20 | 37% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 224.5 | 1 | 0.925, 0.068 |

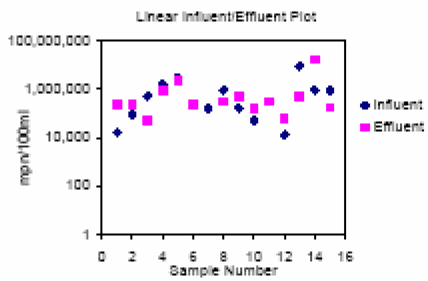
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 74.96 | 0.06 | 0.805 |

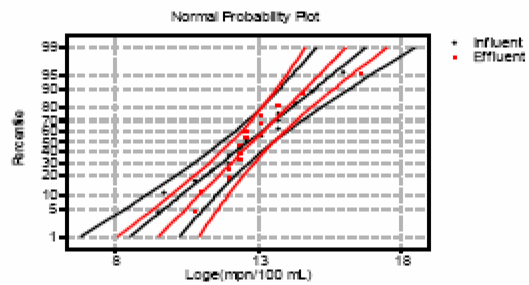
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0 | 0.983 |

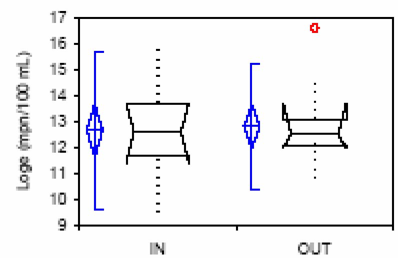
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 32334.82 | 60048.03 |
| 25th Percentile | 94740.80 | 141153.04 |
| 75th Percentile | 1032713.13 | 942885.37 |
| 90th Percentile | 3025842.13 | 2216411.49 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow 10th Percentile | -27713.21 | -85.71% |
| Inflow 90th Percentile-Outflow 90th Percentile | 809430.64 | 26.75% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 109.3% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 184.8% |



Enhanced Manhole

City Westchester

Fecal Coliform (mpn/100 mL)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 15 | 9.19 | 2.83 | 10.75 | 7.62 |
| Outlet | 14 | 9.33 | 2.95 | 11.03 | 7.62 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 535064.65 | 9766.04 | 54.78 | 16768229.21 | -15698099.91 |
| Outlet | 875672.33 | 11255.04 | 77.80 | 40202600.09 | -38451255.42 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -340607.69 | -64% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 226.5 | 0.9649 | 0.040, 0.085 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 225.45 | 0.02 | 0.896 |

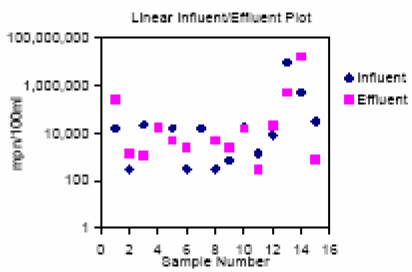
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0 | 0.948 |

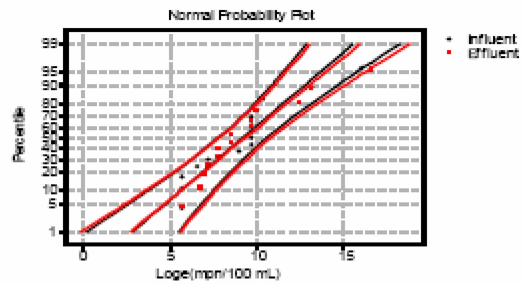
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 293.92 | 294.21 |
| 25th Percentile | 1545.03 | 1653.42 |
| 75th Percentile | 61728.44 | 76618.97 |
| 90th Percentile | 324519.21 | 430584.99 |

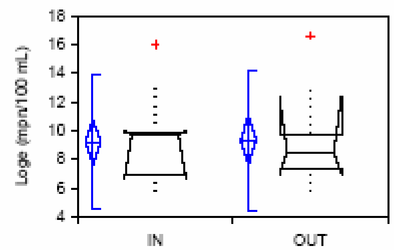
| Inflow 10th Percentile-Outflow 10th | Difference | % Difference |
|---|---|---|
| | -0.29 | -0.10% |

| Inflow 90th Percentile-Outflow 90th | Difference | % Difference |
|---|---|---|
| | -106065.78 | -32.68% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 329.3% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 356.1% |



Enhanced Manhole

City Westchester

Enterococcus (mpn/100 mL)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 15 | 10.61 | 2.92 | 12.22 | 8.99 |
| Outlet | 14 | 10.04 | 2.10 | 11.25 | 8.82 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 2839512 | 40403.30 | 70.27 | 113351245.63 | -107672221.10 |
| Outlet | 207385.6 | 22827.34 | 9.03 | 1288432.72 | -873661.51 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 2632126.66 | 93% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 236 | 0.6446 | 0.315, 0.647 |

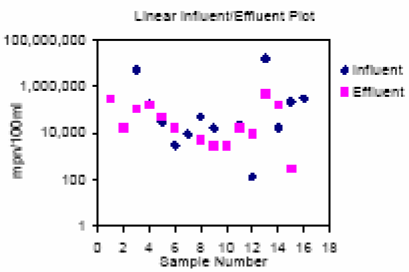
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 178.8 | 0.36 | 0.553 |

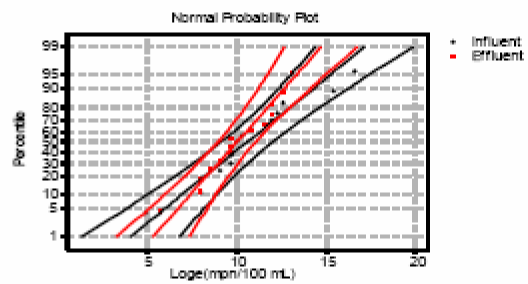
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.23 | 0.631 |

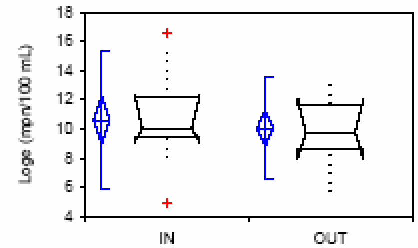
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 1092.26 | 1705.14 |
| 25th Percentile | 6040.85 | 5827.25 |
| 75th Percentile | 270222.24 | 89420.03 |
| 90th Percentile | 1494646.08 | 305590.12 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | -612.88 | -56.11% |
| Inflow 90th Percentile-Outflow | 1189055.96 | 79.55% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 100.8% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 101.2% |



Enhanced Manhole

City Westchester

**Streptococcus (mpn/100 mL)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 15 | 11.36 | 2.27 | 12.62 | 10.10 |
| Outlet | 14 | 10.26 | 2.14 | 11.50 | 9.03 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 1135648 | 85819.37 | 13.20 | 9434930.10 | -7163633.38 |
| Outlet | 283439.2 | 28689.48 | 9.83 | 1891678.00 | -1324799.69 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 852209.21 | 75% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 247 | 0.3329 | 0.114, 0.377 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 140.56 | 1.78 | 0.193 |

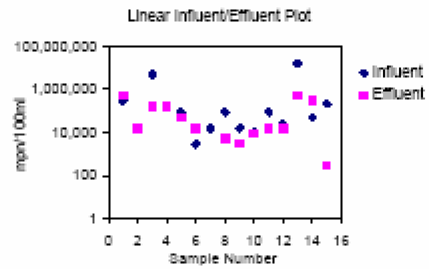
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.96 | 0.326 |

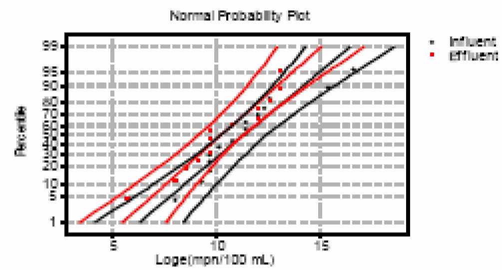
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 5146.64 | 2040.81 |
| 25th Percentile | 19516.20 | 7138.09 |
| 75th Percentile | 377377.01 | 115312.37 |
| 90th Percentile | 1431022.812 | 403285.4892 |

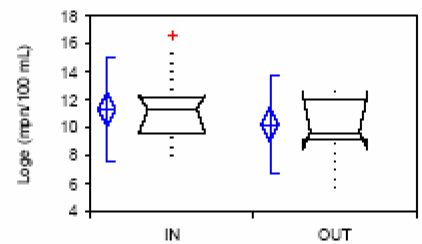
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 3105.84 | 60.35% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 262064.64 | 69.44% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 114.0% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 126.4% |



**Enhanced Manhole**

**City** Westchester

**Total Copper (ug/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 3.73 | 0.63 | 4.06 | 3.39 |
| Outlet | 16 | 3.48 | 0.53 | 3.76 | 3.19 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 50.47 | 41.47 | 0.69 | 69.11 | 31.82 |
| Outlet | 37.16 | 32.30 | 0.57 | 48.43 | 25.89 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 13.30 | 26% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 292 | 0.2988 | 0.439, 0.841 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 10.6 | 1.49 | 0.232 |

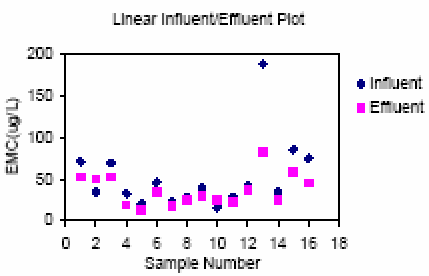
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 1.12 | 0.291 |

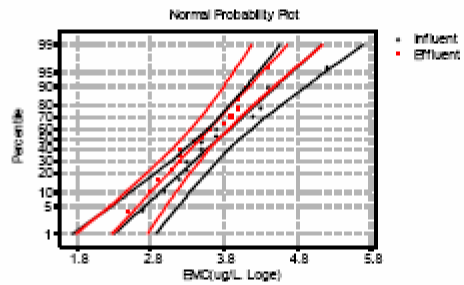
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 19.06 | 16.74 |
| 25th Percentile | 27.54 | 22.85 |
| 75th Percentile | 62.44 | 45.65 |
| 90th Percentile | 90.24 | 62.32 |

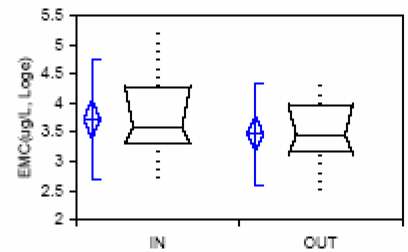
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 2.32 | 12.17% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 27.92 | 30.94% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 62.5% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -52.2% |



Enhanced Manhole

City Westchester

Dissolved Copper (ug/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 3.22 | 0.69 | 3.59 | 2.85 |
| Outlet | 16 | 2.74 | 0.48 | 3.00 | 2.49 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 31.78 | 25.00 | 0.79 | 45.08 | 18.49 |
| Outlet | 17.42 | 15.55 | 0.51 | 22.12 | 12.73 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 14.36 | 45% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 310.5 | 0.0822 | 0.021, 0.105 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 12.2129 | 5.1 | 0.031 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 3.07 | 0.08 |

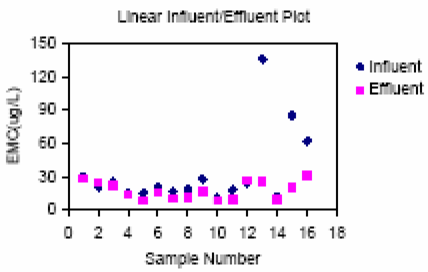
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 10.58 | 8.60 |
| 25th Percentile | 15.90 | 11.38 |
| 75th Percentile | 39.30 | 21.23 |
| 90th Percentile | 59.07 | 28.11 |

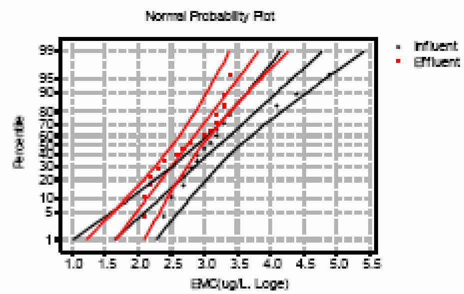
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 1.98 | 18.74% |

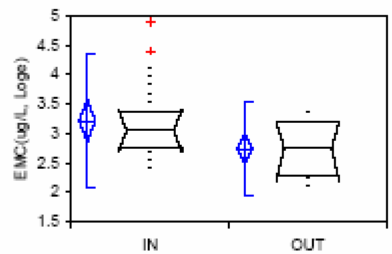
| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 30.96 | 52.41% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 71.8% |

| | |
|---|---|
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -19.6% |



Enhanced Manhole

City Westchester

Total Lead (ug/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 2.33 | 1.23 | 2.99 | 1.67 |
| Outlet | 16 | 2.21 | 0.74 | 2.60 | 1.81 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 21.99 | 10.29 | 1.89 | 44.10 | -0.13 |
| Outlet | 11.96 | 9.08 | 0.86 | 17.43 | 6.50 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 10.02 | 46% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 275 | 0.6915 | 0.506, 0.132 |

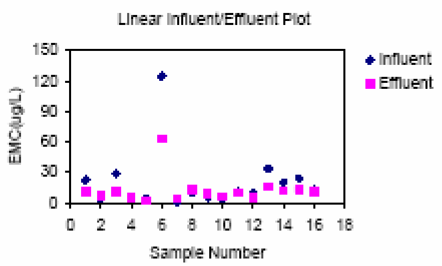
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 31.17 | 0.12 | 0.731 |

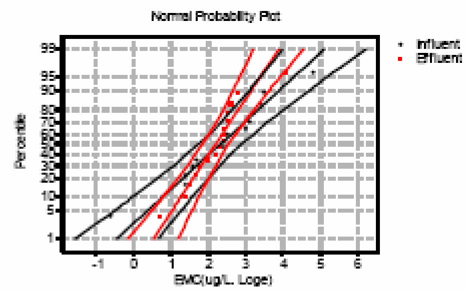
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.17 | 0.678 |

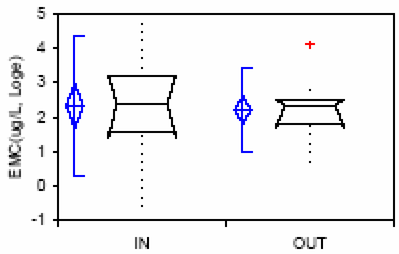
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 2.23 | 3.61 |
| 25th Percentile | 4.60 | 5.59 |
| 75th Percentile | 23.01 | 14.75 |
| 90th Percentile | 47.47 | 22.82 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | -1.38 | -62.04% |
| Inflow 90th Percentile-Outflow | 24.66 | 51.94% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 85.3% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 13734.4% |



**Enhanced Manhole**

**City** Westchester

**Dissolved Lead (ug/L)**

| | Count | Log Data Mean | SD | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 5 | 1.16 | 1.42 | 2.92 | -0.60 |
| Outlet | 4 | 1.38 | 1.06 | 3.07 | -0.32 |

| | Arithmetic Data Mean | Median | COV | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 8.73 | 3.19 | 2.55 | 36.32 | -18.87 |
| Outlet | 6.96 | 3.96 | 1.45 | 22.97 | -9.05 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 1.77 | 20% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 95 | 0.4136 | 0.123, 0.277 |

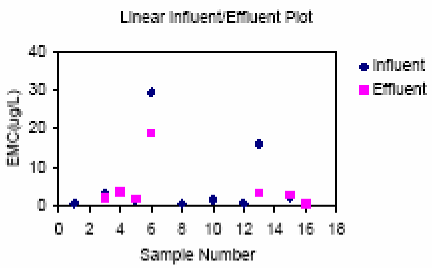
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 23.14 | 0.2 | 0.662 |

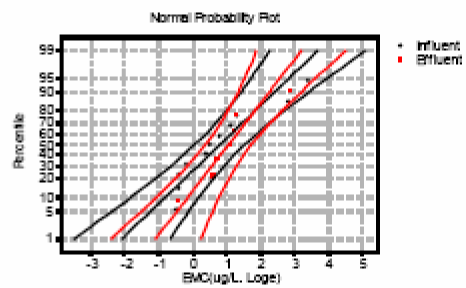
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.74 | 0.39 |

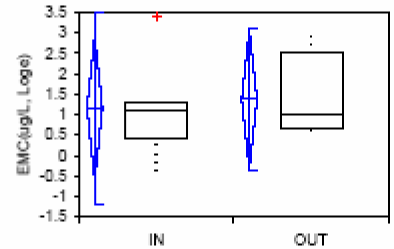
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.45 | 0.88 |
| 25th Percentile | 0.96 | 1.55 |
| 75th Percentile | 5.14 | 5.36 |
| 90th Percentile | 10.91 | 9.37 |

| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -0.43 | -94.70% |
| **Inflow 90th Percentile-Outflow** | **Difference** | **% Difference** |
| | 1.54 | 14.10% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 124.9% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 221.7% |



**Enhanced Manhole**

**City** Westchester

**Total Zinc (ug/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 5.49 | 0.79 | 5.92 | 5.07 |
| Outlet | 16 | 5.20 | 0.59 | 5.51 | 4.89 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 332.97 | 243.17 | 0.94 | 498.91 | 167.04 |
| Outlet | 215.87 | 181.27 | 0.65 | 290.23 | 141.50 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 117.11 | 35% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 290.5 | 0.3262 | 0.452, 0.262 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 15.36 | 1.41 | 0.244 |

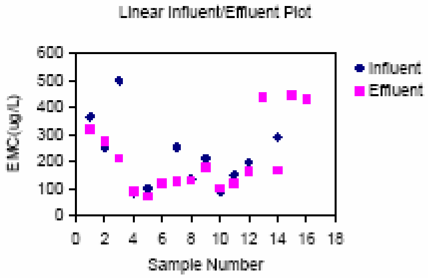
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 1 | 0.318 |

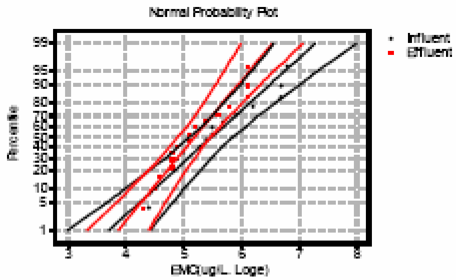
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 90.91 | 87.06 |
| 25th Percentile | 144.88 | 123.22 |
| 75th Percentile | 408.10 | 266.64 |
| 90th Percentile | 650.34 | 377.44 |

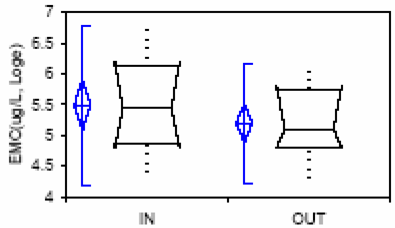
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 3.85 | 4.24% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 272.91 | 41.96% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 71.6% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -73.8% |



Enhanced Manhole

City Westchester

Dissolved Zinc (ug/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 5.18 | 0.91 | 5.67 | 4.69 |
| Outlet | 16 | 4.84 | 0.77 | 5.25 | 4.43 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 269.90 | 177.91 | 1.14 | 433.95 | 105.85 |
| Outlet | 169.26 | 126.15 | 0.89 | 249.91 | 88.60 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 100.65 | 37% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 289 | 0.3547 | 0.531, 0.505 |

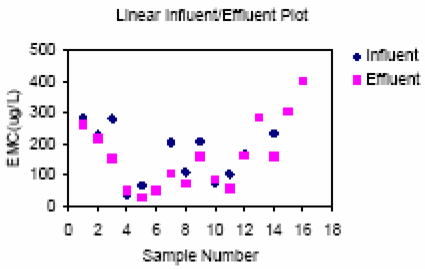
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 22.267 | 1.33 | 0.258 |

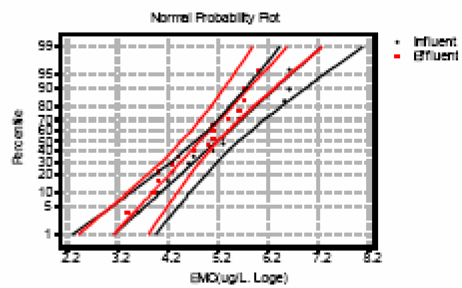
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.89 | 0.346 |

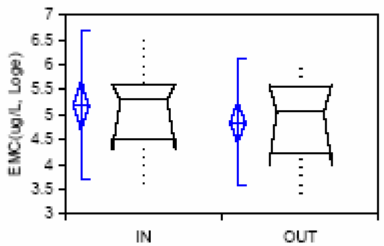
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 57.30 | 48.72 |
| 25th Percentile | 97.99 | 76.45 |
| 75th Percentile | 322.95 | 208.14 |
| 90th Percentile | 552.30 | 326.62 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | 8.58 | 14.97% |
| Inflow 90th Percentile-Outflow | 225.68 | 40.86% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 79.6% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -136.1% |



**Enhanced Manhole**

City Westchester

COD (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 17 | 4.31 | 0.90 | 4.78 | 3.85 |
| Outlet | 17 | 3.88 | 0.78 | 4.28 | 3.48 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 112.29 | 74.57 | 1.13 | 177.28 | 47.29 |
| Outlet | 65.65 | 48.54 | 0.91 | 96.40 | 34.91 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 46.64 | 42% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 335 | 0.2021 | 0.536, 0.460 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 24.33 | 2.2 | 0.147 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 1.67 | 0.196 |

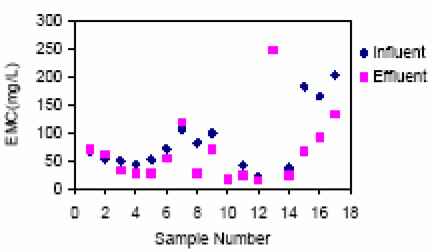
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 24.21 | 18.47 |
| 25th Percentile | 41.25 | 29.19 |
| 75th Percentile | 134.80 | 80.71 |
| 90th Percentile | 229.66 | 133.38 |

| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 5.74 | 23.72% |

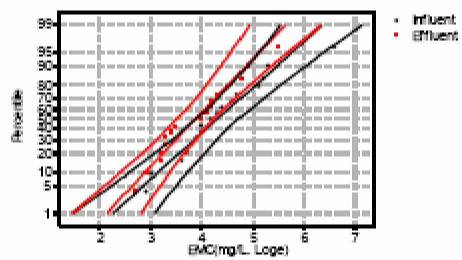
| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 96.28 | 41.92% |

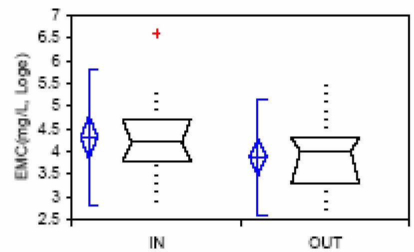
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 80.3% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -103.8% |

Linear Influent/Effluent Plot




Normal Probability Plot



Enhanced Manhole

City Westchester

Hardness (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 17 | 3.75 | 0.66 | 4.09 | 3.41 |
| Outlet | 17 | 3.55 | 0.63 | 3.87 | 3.22 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 53.14 | 42.65 | 0.74 | 73.46 | 32.83 |
| Outlet | 42.45 | 34.71 | 0.70 | 57.82 | 27.08 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 10.69 | 20% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 321.5 | 0.4168 | 0.843, 0.164 |

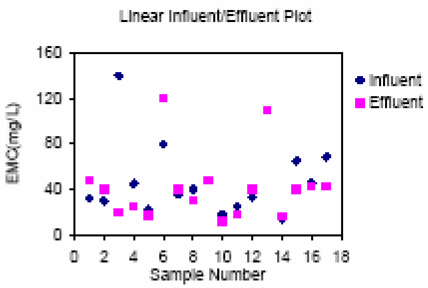
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 13.845 | 0.85 | 0.362 |

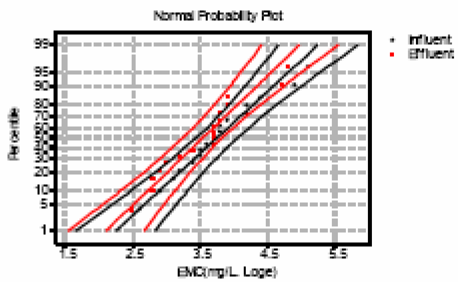
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.69 | 0.407 |

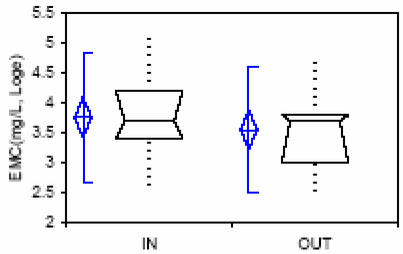
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 18.69 | 15.77 |
| 25th Percentile | 27.63 | 22.92 |
| 75th Percentile | 65.83 | 52.57 |
| 90th Percentile | 97.29 | 79.23 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | 2.92 | 15.63% |
| Inflow 90th Percentile-Outflow | 18.06 | 18.56% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 63.1% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -76.2% |



**Enhanced Manhole**

City Westchester

Kjeldahl - N (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 17 | 1.01 | 0.98 | 1.51 | 0.50 |
| Outlet | 16 | 0.41 | 0.80 | 0.84 | -0.01 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 4.40 | 2.73 | 1.26 | 7.25 | 1.55 |
| Outlet | 2.07 | 1.51 | 0.94 | 3.11 | 1.03 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 2.33 | 53% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 337 | 0.0864 | 0.243, 0.209 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 27.649 | 3.64 | 0.066 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 2.99 | 0.084 |

| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.81 | 0.56 |
| 25th Percentile | 1.44 | 0.90 |
| 75th Percentile | 5.18 | 2.54 |
| 90th Percentile | 9.20 | 4.06 |

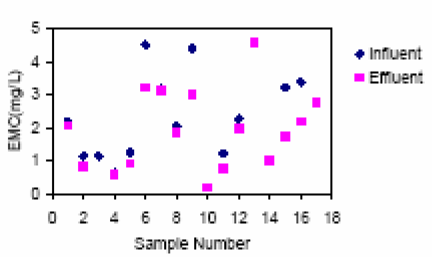
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.25 | 30.84% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 5.14 | 55.86% |

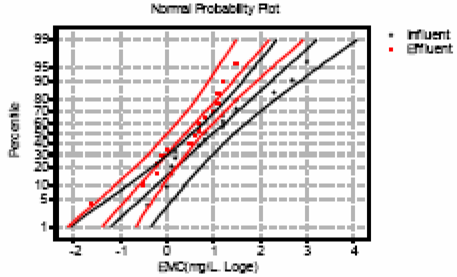
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 85.7% |
|---|---|

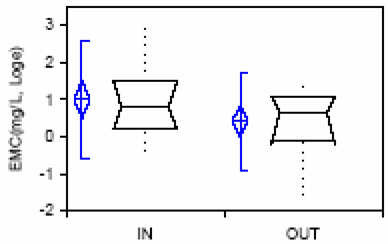
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -101.3% |
|---|---|

Linear Influent/Effluent Plot




Normal Probability Plot



**Enhanced Manhole**

City Westchester

**Ammonia - N (mg/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | -0.83 | 0.89 | -0.36 | -1.30 |
| Outlet | 16 | -0.94 | 0.78 | -0.53 | -1.36 |

| | | Arithmetic Data | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 0.64 | 0.44 | 1.09 | 1.02 | 0.27 |
| Outlet | 0.53 | 0.39 | 0.91 | 0.78 | 0.27 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 0.12 | 18% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 270 | 0.8356 | 0.904, 0.240 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 20.995 | 0.15 | 0.706 |

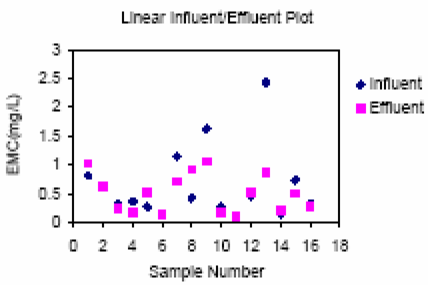
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.05 | 0.821 |

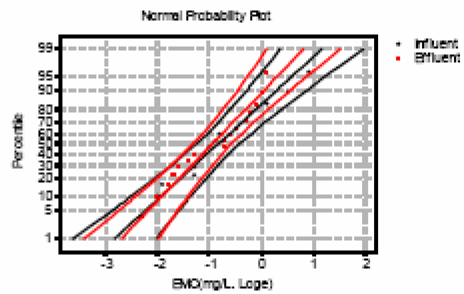
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.15 | 0.15 |
| 25th Percentile | 0.24 | 0.23 |
| 75th Percentile | 0.76 | 0.65 |
| 90th Percentile | 1.31 | 1.02 |

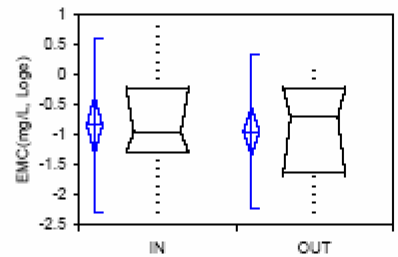
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.00 | -1.96% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.28 | 21.68% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 73.5% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -190.8% |



Enhanced Manhole

City Westchester

Nitrite - N (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 4 | -2.75 | 0.54 | -1.88 | -3.62 |
| Outlet | 4 | -1.88 | 1.24 | 0.11 | -3.86 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 0.07 | 0.06 | 0.59 | 0.14 | 0.00 |
| Outlet | 0.33 | 0.15 | 1.93 | 1.35 | -0.69 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -0.26 | -349% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 165.5 | 0.5755 | 0.078, 0.018 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 12.257 | 0.07 | 0.8 |

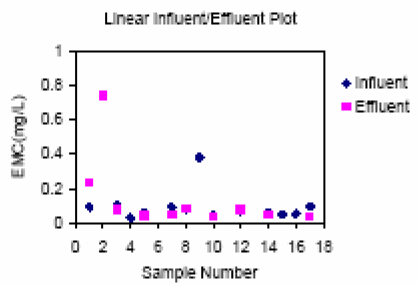
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.35 | 0.556 |

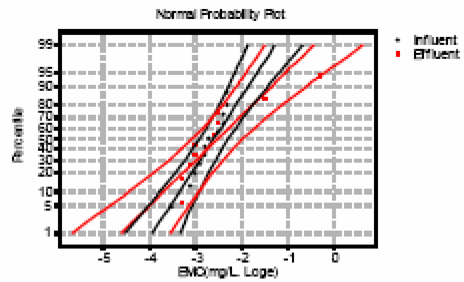
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.04 | 0.03 |
| 25th Percentile | 0.05 | 0.04 |
| 75th Percentile | 0.11 | 0.15 |
| 90th Percentile | 0.16 | 0.26 |

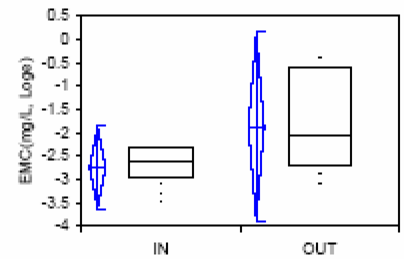
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.01 | 26.27% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -0.10 | -64.35% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 578.5% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -27951.2% |



**Enhanced Manhole**

City Westchester

**Nitrate - N (mg/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 5 | -0.54 | 0.63 | 0.24 | -1.32 |
| Outlet | 4 | -0.58 | 0.87 | 0.80 | -1.95 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 0.71 | 0.58 | 0.69 | 1.32 | 0.10 |
| Outlet | 0.82 | 0.56 | 1.06 | 2.19 | -0.56 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -0.11 | -15% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 127 | 0.4023 | 0.162, 0.540 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 15.148 | 0.51 | 0.483 |

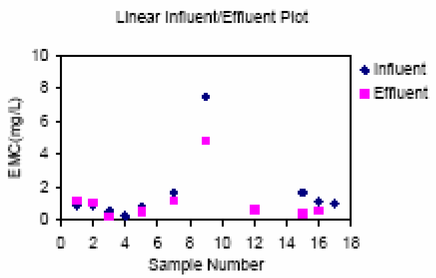
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.76 | 0.382 |

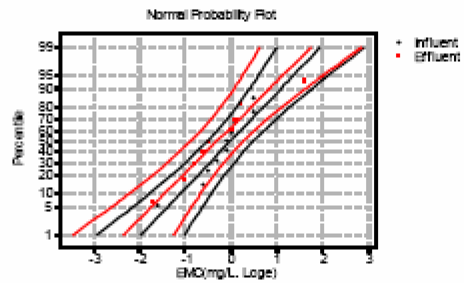
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.34 | 0.24 |
| 25th Percentile | 0.56 | 0.41 |
| 75th Percentile | 1.75 | 1.34 |
| 90th Percentile | 2.91 | 2.28 |

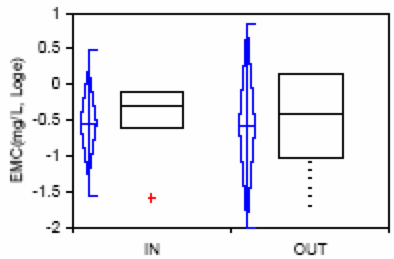
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.10 | 28.67% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.63 | 21.65% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 142.2% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -2130.9% |



Enhanced Manhole

City Westchester

TSS (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 17 | 4.49 | 1.23 | 5.13 | 3.86 |
| Outlet | 17 | 4.25 | 1.18 | 4.86 | 3.65 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 191.41 | 89.49 | 1.89 | 377.49 | 5.33 |
| Outlet | 141.16 | 70.31 | 1.74 | 267.51 | 14.81 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 50.25 | 26% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 326 | 0.3348 | 0.028, 0.368 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 47.13 | 0.34 | 0.564 |

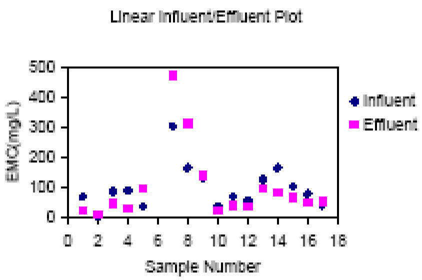
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.96 | 0.326 |

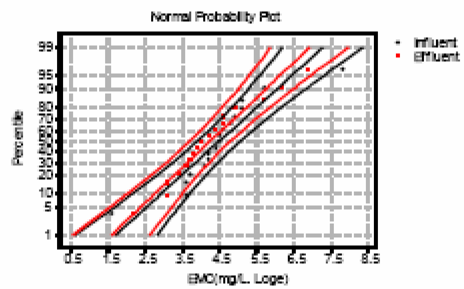
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 19.32 | 16.20 |
| 25th Percentile | 39.93 | 32.47 |
| 75th Percentile | 200.54 | 152.23 |
| 90th Percentile | 414.55 | 305.15 |

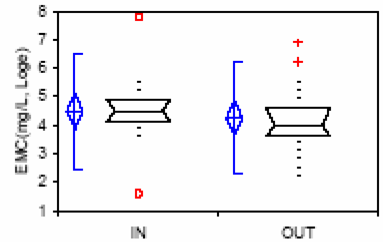
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 3.12 | 16.13% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 109.40 | 26.39% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 96.1% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -4922.7% |



# 16.0 CATCH BASIN INSERTS

Catch Basin Inserts

City South Pasadena

**Total Coliform (mpn/100 mL)**

| | Count | Log Data Mean | SD | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 15 | 11.36 | 1.27 | 12.06 | 10.65 |
| Outlet | 17 | 12.30 | 1.17 | 12.90 | 11.70 |

| | Arithmetic Data Mean | Median | COV | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 192452.29 | 85496.38 | 2.02 | 407398.13 | -22493.55 |
| Outlet | 435283.23 | 220367.12 | 1.70 | 816530.86 | 54035.59 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -242830.94 | -126% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 168 | 0.9381 | .003, .270 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 51.64 | 4.82 | 0.0361 |

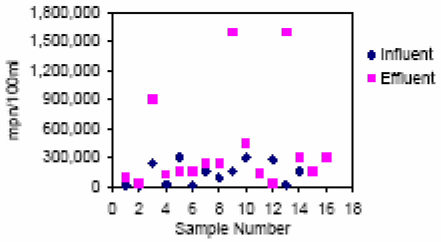
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 2.37 | 0.1239 |

| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 17500.77 | 51534.15 |
| 25th Percentile | 36315.50 | 98715.77 |
| 75th Percentile | 196769.15 | 479260.71 |
| 90th Percentile | 412503.51 | 890911.17 |

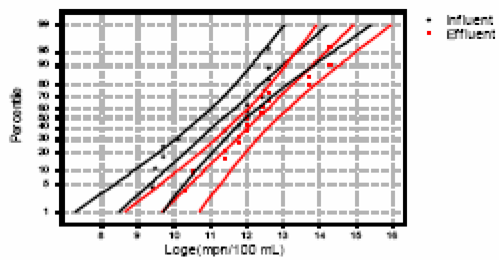
| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow 10th | -34033.38 | -194.47% |
| Inflow 90th Percentile-Outflow 90th | -478407.65 | -115.98% |

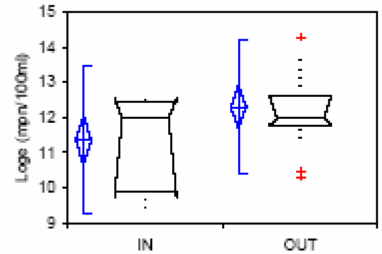
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 86.7% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 3730.1% |

Linear Influent/Effluent Plot




Normal Probability Plot



Catch Basin Inserts

City South Pasadena

**Fecal Coliform (mpn/100 mL)**

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 15 | 8.54 | 1.59 | 9.42 | 7.66 |
| Outlet | 17 | 8.44 | 2.57 | 9.76 | 7.11 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 17943.31 | 5104.44 | 3.37 | 51433.21 | -15546.59 |
| Outlet | 125503.70 | 4610.07 | 27.21 | 1881094.97 | -1630087.58 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -107560.39 | -599% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 129 | 0.5226 | .146, .612 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 141.01 | 0.02 | 0.8953 |

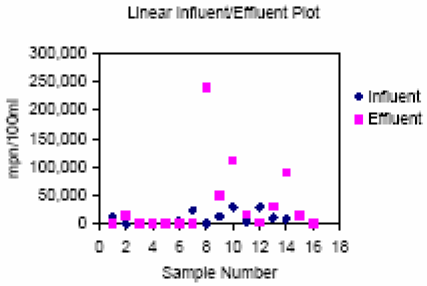
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0 | 0.9548 |

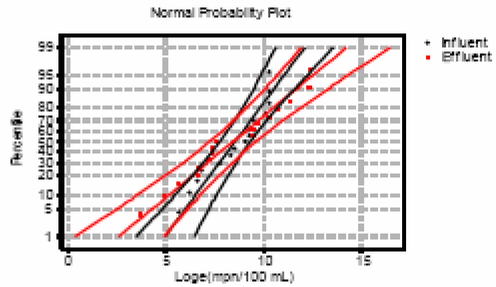
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 720.54 | 186.79 |
| 25th Percentile | 1808.04 | 1719.86 |
| 75th Percentile | 14044.69 | 29732.62 |
| 90th Percentile | 35954.16 | 110194.25 |

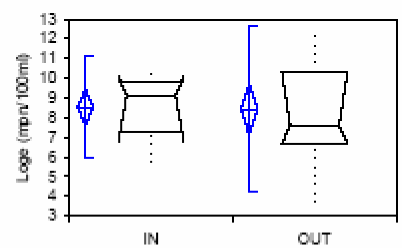
| Inflow 10th Percentile-Outflow 10th | Difference | % Difference |
|---|---|---|
| | 533.75 | 74.08% |

| Inflow 90th Percentile-Outflow 90th | Difference | % Difference |
|---|---|---|
| | -74240.09 | -206.49% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 3269.3% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 12199.7% |



Catch Basin Inserts

City South Pasadena

Enterococcus (mpn/100 mL)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 15 | 9.32 | 1.14 | 9.95 | 8.69 |
| Outlet | 17 | 9.31 | 1.27 | 9.96 | 8.65 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 21246.48 | 11155.68 | 1.62 | 40319.63 | 2173.33 |
| Outlet | 24651.83 | 11013.84 | 2.00 | 50033.64 | -729.98 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -3405.35 | -16% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 127.5 | 0.5 | .016, .680 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 43.82 | 0 | 0.9764 |

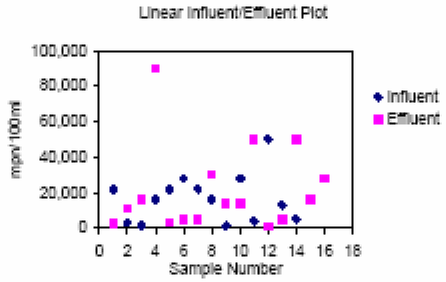
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0 | 1 |

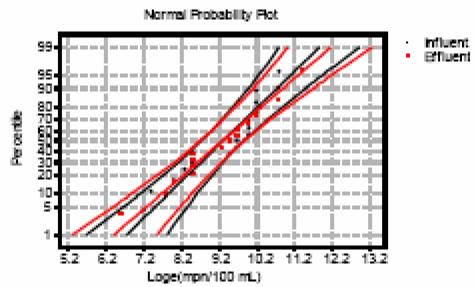
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 2738.05 | 2275.60 |
| 25th Percentile | 5166.75 | 4675.07 |
| 75th Percentile | 22026.47 | 24343.01 |
| 90th Percentile | 44801.64 | 52052.08 |

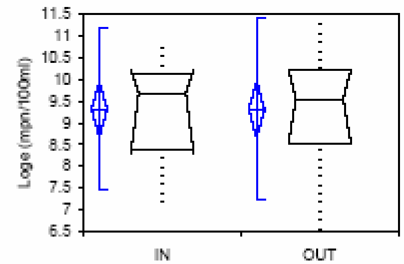
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 462.44 | 16.89% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -7250.44 | -16.18% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 101.8% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -2202.2% |



Catch Basin Inserts

City South Pasadena

**Streptococcus (mpn/100 mL)**

| | Count | Log Data Mean | SD | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 15 | 9.76 | 1.48 | 10.58 | 8.95 |
| Outlet | 17 | 9.89 | 1.44 | 10.63 | 9.15 |

| | Arithmetic Data Mean | Median | COV | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 51774.79 | 17382.74 | 2.81 | 132225.60 | -28676.02 |
| Outlet | 55538.31 | 19741.87 | 2.63 | 130627.25 | -19550.64 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -3763.52 | -7% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 135 | 0.6121 | .352, .558 |

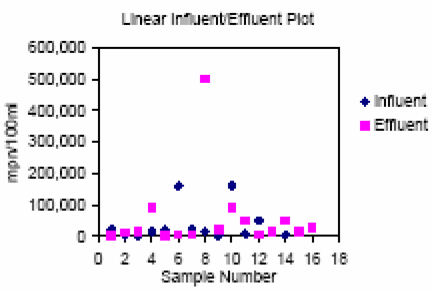
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 63.79 | 0.06 | 0.8069 |

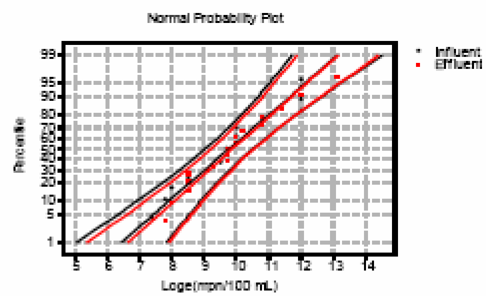
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.08 | 0.7759 |

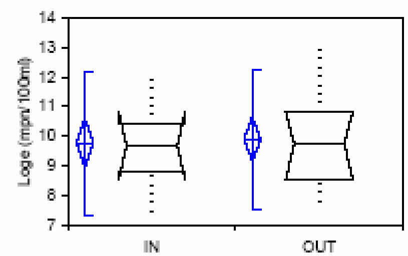
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 2751.77 | 3261.69 |
| 75th Percentile | 29732.62 | 49020.80 |
| 90th Percentile | 109097.80 | 115844.03 |

| | | |
|---|---|---|
| Inflow 10th | Difference | % Difference |
| Percentile-Outflow | -509.92 | -18.53% |
| Inflow 90th | Difference | % Difference |
| Percentile-Outflow | -6746.23 | -6.18% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 114.8% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 555.5% |



Catch Basin Inserts

City South Pasadena

Total Copper (ug/L)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 14 | 3.64 | 0.70 | 4.04 | 3.23 |
| Outlet | 10 | 3.49 | 0.58 | 3.91 | 3.07 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 48.50 | 37.93 | 0.80 | 70.81 | 26.19 |
| Outlet | 38.84 | 32.79 | 0.64 | 56.48 | 21.20 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 9.66 | 20% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 187.5 | 0.4823 | 0.312, 0.005 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 9.565 | 0.29 | 0.597 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.54 | 0.464 |

| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 15.95 | 16.16 |
| 25th Percentile | 24.04 | 22.59 |
| 75th Percentile | 59.82 | 47.58 |
| 90th Percentile | 90.16 | 66.53 |

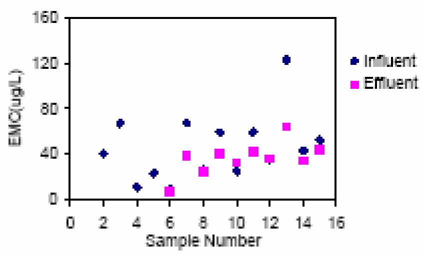
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -0.20 | -1.27% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 23.63 | 26.21% |

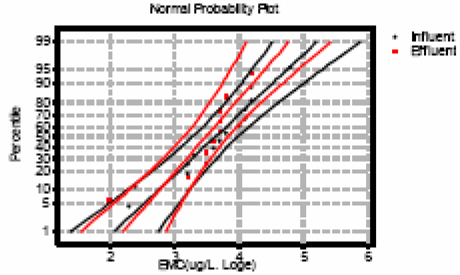
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 70.1% |
|---|---|

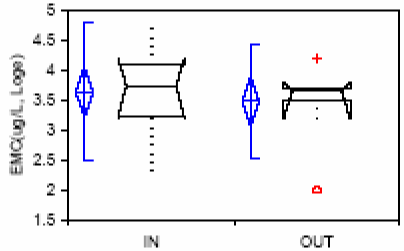
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -115.7% |
|---|---|

Linear Influent/Effluent Plot




Normal Probability Plot



Catch Basin Inserts

**City** South Pasadena

**Dissolved Copper (ug/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 14 | 3.10 | 0.75 | 3.53 | 2.67 |
| Outlet | 10 | 2.75 | 0.69 | 3.25 | 2.25 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 29.46 | 22.20 | 0.87 | 44.30 | 14.62 |
| Outlet | 19.91 | 15.64 | 0.79 | 31.13 | 8.69 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 9.55 | 32% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 190 | 0.3949 | 0.860, 0.434 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 12.42 | 1.34 | 0.259 |

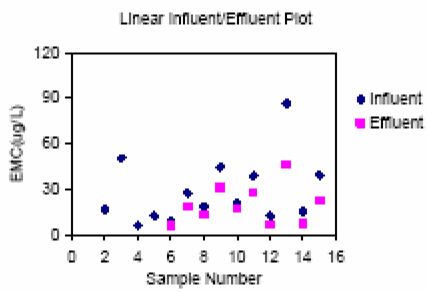
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.77 | 0.38 |

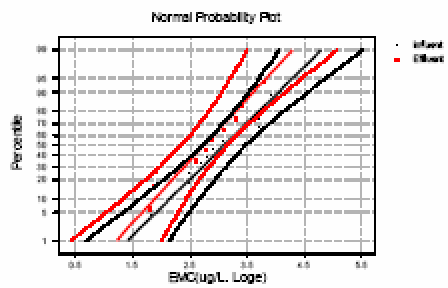
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 8.77 | 6.72 |
| 25th Percentile | 13.61 | 10.03 |
| 75th Percentile | 36.20 | 24.40 |
| 90th Percentile | 56.22 | 36.40 |

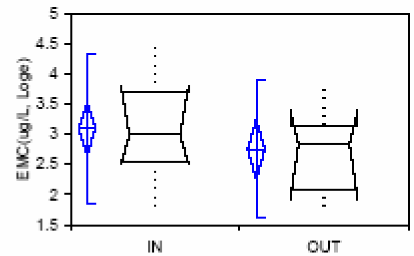
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 2.04 | 23.33% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 19.81 | 35.24% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 80.4% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -113.0% |



Catch Basin Inserts

City South Pasadena

Total Lead (ug/L)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 14 | 2.33 | 0.95 | 2.88 | 1.78 |
| Outlet | 10 | 2.65 | 0.71 | 3.16 | 2.14 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 16.18 | 10.26 | 1.22 | 27.55 | 4.80 |
| Outlet | 18.18 | 14.15 | 0.81 | 28.66 | 7.70 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -2.00 | -12% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 165 | 0.5775 | 0.392, 0.527 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 16.936 | 0.81 | 0.377 |

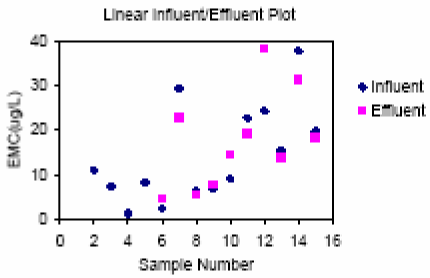
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.34 | 0.558 |

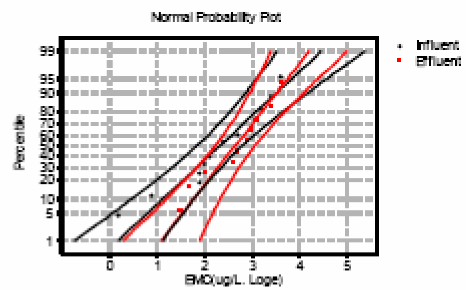
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 3.16 | 5.99 |
| 25th Percentile | 5.52 | 9.00 |
| 75th Percentile | 19.08 | 22.26 |
| 90th Percentile | 33.33 | 33.45 |

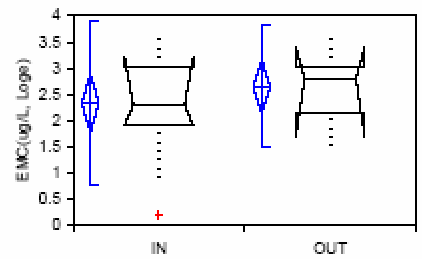
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -2.83 | -89.52% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -0.12 | -0.36% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 72.1% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -497.1% |



Catch Basin Inserts

City South Pasadena

Dissolved Lead (ug/L)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 11 | 0.33 | 0.80 | 0.86 | -0.21 |
| Outlet | 6 | 0.30 | 0.61 | 0.94 | -0.34 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 1.91 | 1.39 | 0.95 | 3.13 | 0.70 |
| Outlet | 1.63 | 1.35 | 0.68 | 2.78 | 0.47 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 0.28 | 15% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 96 | 0.8016 | 0.094, 0.695 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 8.285 | 0.01 | 0.943 |

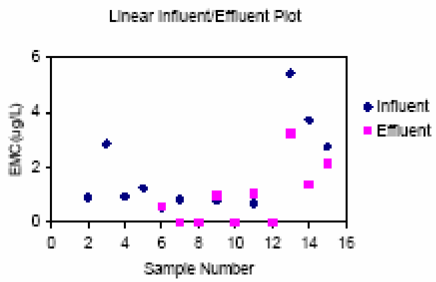
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.09 | 0.763 |

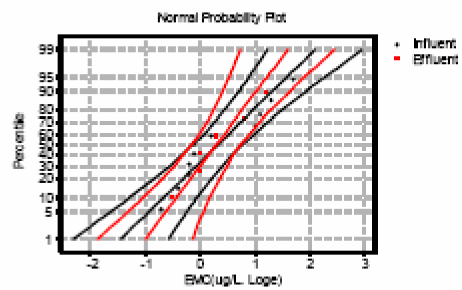
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.52 | 0.66 |
| 25th Percentile | 0.83 | 0.93 |
| 75th Percentile | 2.32 | 1.97 |
| 90th Percentile | 3.69 | 2.86 |

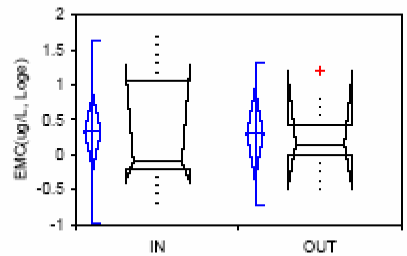
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -0.14 | -26.25% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.83 | 22.46% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 84.8% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -300.6% |



Catch Basin Inserts

City South Pasadena

Total Zinc (ug/L)

| | | Log Data | | | | |
|---|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL | |
| Inlet | 14 | 5.00 | 0.68 | 5.39 | 4.61 | |
| Outlet | 10 | 5.08 | 0.51 | 5.45 | 4.71 | |

| | Arithmetic Data | | | | | |
|---|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL | |
| Inlet | 186.79 | 148.41 | 0.76 | 269.20 | 104.38 | |
| Outlet | 183.46 | 160.77 | 0.55 | 255.59 | 111.33 | |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 3.33 | 2% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 172 | 0.8836 | 0.763, 0.188 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 8.393 | 0.1 | 0.757 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.03 | 0.861 |

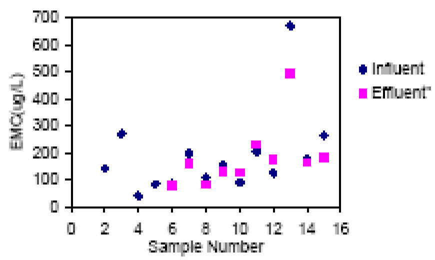
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 64.23 | 86.08 |
| 25th Percentile | 95.50 | 115.72 |
| 75th Percentile | 230.63 | 223.34 |
| 90th Percentile | 342.92 | 300.25 |

| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -21.86 | -34.03% |

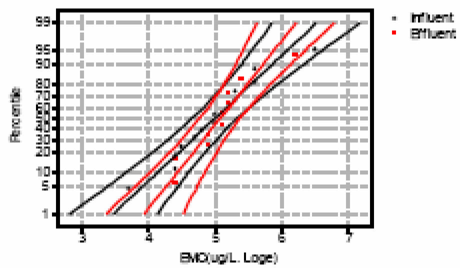
| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 42.68 | 12.44% |

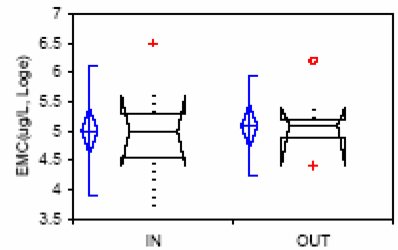
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 58.6% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -144.9% |

Linear Influent/Effluent Plot




Normal Probability Plot



Catch Basin Inserts

City South Pasadena

Dissolved Zinc (ug/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 14 | 4.69 | 0.62 | 5.16 | 4.21 |
| Outlet | 10 | 4.62 | 0.87 | 5.24 | 4.00 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 151.79 | 108.39 | 0.98 | 237.71 | 65.86 |
| Outlet | 147.89 | 101.49 | 1.06 | 259.99 | 35.78 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 3.91 | 3% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 181 | 0.7474 | 0.523, 0.505 |

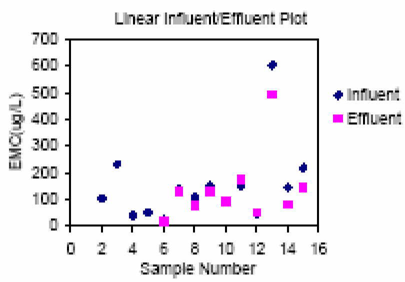
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 15.558 | 0.04 | 0.852 |

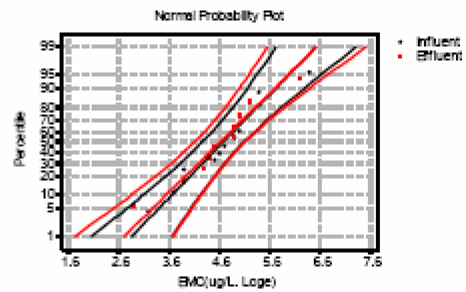
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.12 | 0.725 |

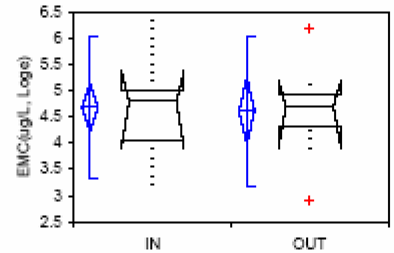
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 39.33 | 35.34 |
| 25th Percentile | 63.57 | 58.25 |
| 75th Percentile | 184.77 | 176.83 |
| 90th Percentile | 298.63 | 291.46 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | 3.99 | 10.16% |
| Inflow 90th Percentile-Outflow | 7.17 | 2.40% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 84.9% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -294.7% |



Catch Basin Inserts

City South Pasadena

COD (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 13 | 3.48 | 0.81 | 3.97 | 3.00 |
| Outlet | 9 | 3.68 | 0.76 | 4.27 | 3.09 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 45.13 | 32.61 | 0.96 | 71.22 | 19.04 |
| Outlet | 52.98 | 39.56 | 0.89 | 89.28 | 16.69 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -7.86 | -17% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 141.5 | 0.6165 | 0.378, 0.265 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 12.671 | 0.32 | 0.579 |

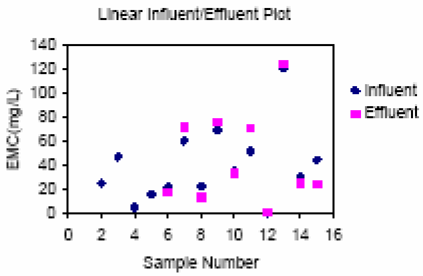
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.29 | 0.593 |

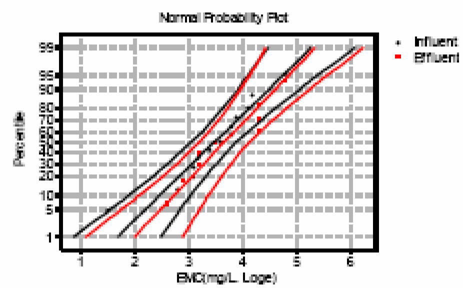
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 12.09 | 15.71 |
| 25th Percentile | 19.34 | 24.33 |
| 75th Percentile | 54.98 | 64.32 |
| 90th Percentile | 87.98 | 99.62 |

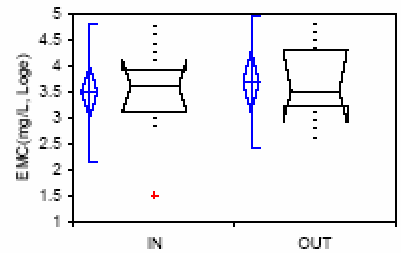
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -3.62 | -29.94% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -11.64 | -13.24% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 76.6% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -368.9% |



Catch Basin Inserts

City South Pasadena

Hardness (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 14 | 3.31 | 0.85 | 3.80 | 2.82 |
| Outlet | 10 | 2.99 | 0.50 | 3.35 | 2.63 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 39.12 | 27.31 | 1.03 | 62.30 | 15.95 |
| Outlet | 22.56 | 19.89 | 0.54 | 31.20 | 13.92 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 16.57 | 42% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 190 | 0.3959 | 0.017, 0.519 |

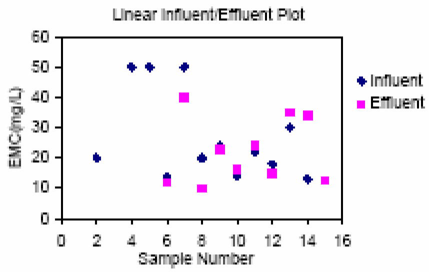
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 12.205 | 1.11 | 0.303 |

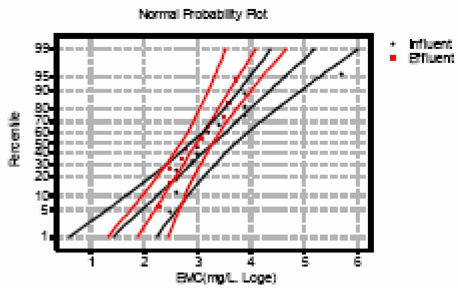
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.77 | 0.38 |

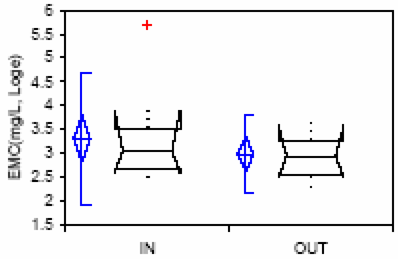
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 9.58 | 10.80 |
| 25th Percentile | 15.74 | 14.42 |
| 75th Percentile | 47.38 | 27.42 |
| 90th Percentile | 77.82 | 36.61 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | -1.22 | -12.72% |
| Inflow 90th Percentile-Outflow | 41.21 | 52.95% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 77.7% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -95.6% |



**Catch Basin Inserts**

**City** South Pasadena

**Kjeldahl - N (mg/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 14 | 0.46 | 0.95 | 1.01 | -0.09 |
| Outlet | 10 | 0.99 | 1.03 | 1.73 | 0.25 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 2.50 | 1.59 | 1.21 | 4.26 | 0.75 |
| Outlet | 4.58 | 2.69 | 1.38 | 9.09 | 0.07 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -2.08 | -83% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 150 | 0.1514 | 0.064, 0.566 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 22.953 | 1.66 | 0.211 |

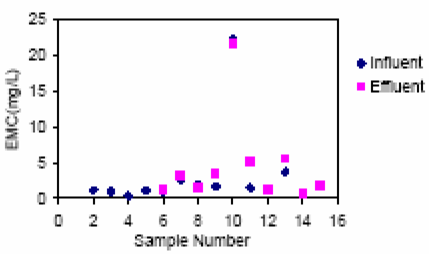
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 2.14 | 0.143 |

| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.49 | 0.77 |
| 25th Percentile | 0.85 | 1.39 |
| 75th Percentile | 2.95 | 5.21 |
| 90th Percentile | 5.15 | 9.43 |

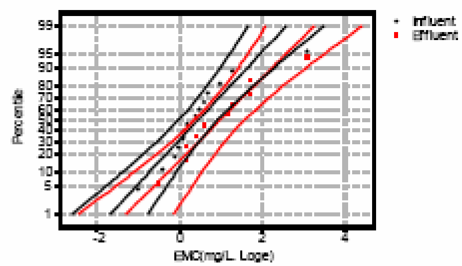
| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | -0.28 | -56.39% |
| Inflow 90th Percentile-Outflow | -4.28 | -82.96% |

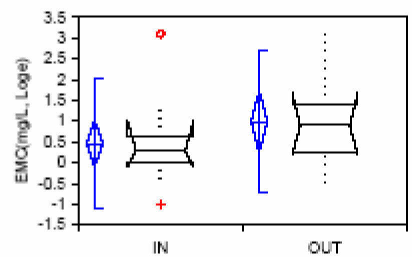
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 96.4% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -1113.9% |

Linear Influent/Effluent Plot




Normal Probability Plot



Catch Basin Inserts

City South Pasadena

Ammonia - N (mg/L)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 14 | -0.62 | 0.70 | -0.22 | -1.02 |
| Outlet | 10 | -0.62 | 0.95 | 0.06 | -1.30 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 0.68 | 0.54 | 0.79 | 1.00 | 0.37 |
| Outlet | 0.85 | 0.54 | 1.22 | 1.59 | 0.11 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -0.16 | -24% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 180 | 0.7922 | 0.796, 0.402 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 14.5 | 0 | 0.997 |

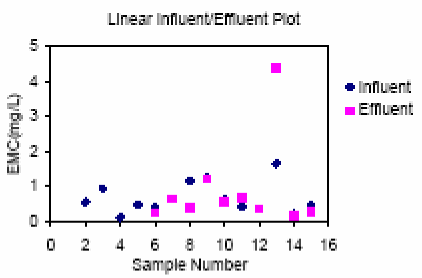
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.09 | 0.77 |

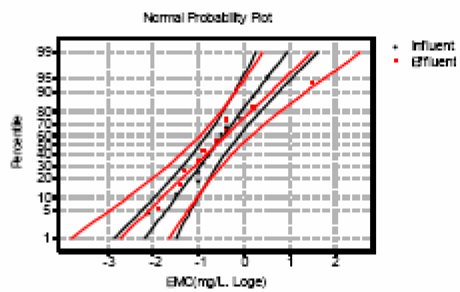
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.23 | 0.17 |
| 25th Percentile | 0.34 | 0.29 |
| 75th Percentile | 0.84 | 0.99 |
| 90th Percentile | 1.27 | 1.72 |

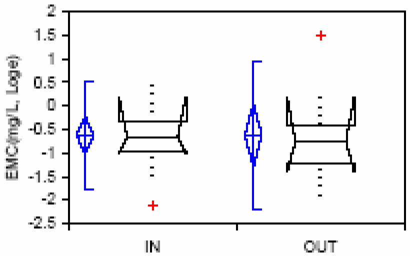
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.06 | 25.84% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -0.45 | -35.22% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 89.1% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -326.4% |



**Catch Basin Inserts**

City South Pasadena

**Nitrite - N (mg/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 8 | -2.49 | 0.75 | -1.86 | -3.11 |
| Outlet | 6 | -2.43 | 0.77 | -1.62 | -3.24 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 0.11 | 0.08 | 0.86 | 0.19 | 0.03 |
| Outlet | 0.12 | 0.09 | 0.90 | 0.23 | 0.01 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -0.01 | -7% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 58.5 | 0.8973 | 0.16, 0.601 |

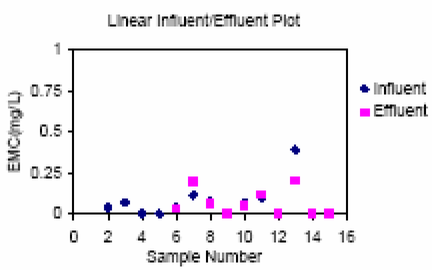
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 7.64 | 0 | 0.947 |

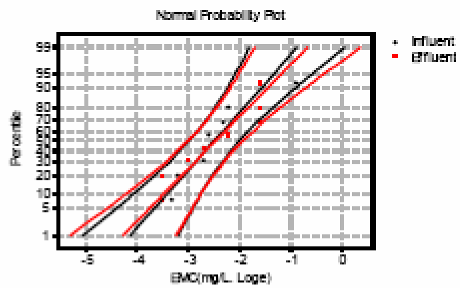
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.04 | 0.8454 |

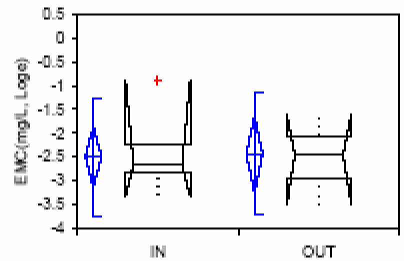
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.03 | 0.04 |
| 25th Percentile | 0.05 | 0.05 |
| 75th Percentile | 0.13 | 0.14 |
| 90th Percentile | 0.20 | 0.22 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | -0.01 | -33.33% |
| Inflow 90th Percentile-Outflow | -0.02 | -10.00% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 96.6% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -655.5% |



Catch Basin Inserts

City South Pasadena

Nitrate - N (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 12 | 0.11 | 0.76 | 0.59 | -0.38 |
| Outlet | 9 | -0.09 | 0.87 | 0.58 | -0.76 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 1.49 | 1.11 | 0.89 | 2.33 | 0.65 |
| Outlet | 1.34 | 0.91 | 1.06 | 2.43 | 0.24 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 0.15 | 10% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 146.5 | 0.3198 | 0.083, 0.063 |

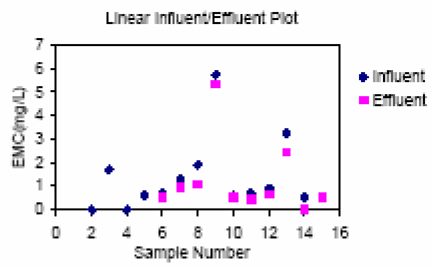
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 12.63 | 0.31 | 0.587 |

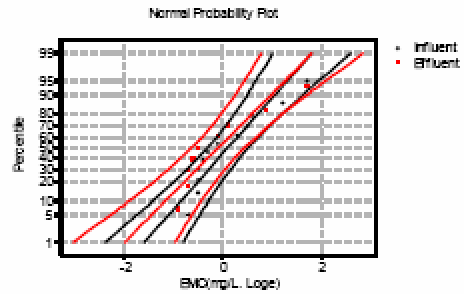
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 1.06 | 0.303 |

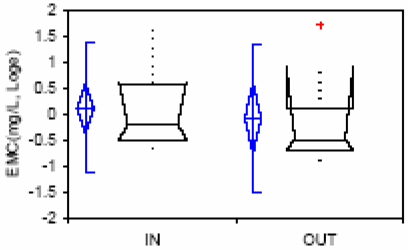
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.44 | 0.32 |
| 25th Percentile | 0.68 | 0.53 |
| 75th Percentile | 1.82 | 1.59 |
| 90th Percentile | 2.84 | 2.62 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | 0.12 | 26.86% |
| Inflow 90th Percentile-Outflow | 0.22 | 7.85% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 89.5% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -273.4% |



Catch Basin Inserts

City South Pasadena

TSS (mg/L)

| | Count | Log Data Mean | SD | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 14 | 3.64 | 0.86 | 4.14 | 3.14 |
| Outlet | 10 | 4.62 | 0.65 | 5.09 | 4.15 |

| | Arithmetic Data Mean | Median | COV | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 55.46 | 38.20 | 1.05 | 89.16 | 21.76 |
| Outlet | 125.74 | 101.49 | 0.73 | 191.52 | 59.96 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -70.28 | -127% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 130 | 0.0092 | 0.633, 0.774 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 19.12 | 9.04 | 0.0065 |

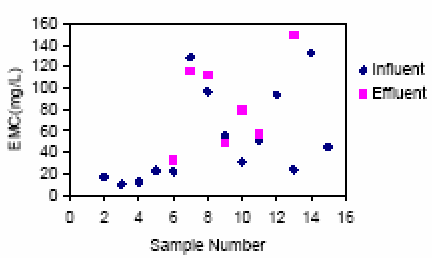
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 6.94 | 0.008 |

| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 13.15 | 45.80 |
| 25th Percentile | 21.79 | 66.76 |
| 75th Percentile | 66.96 | 154.28 |
| 90th Percentile | 116.57 | 224.93 |

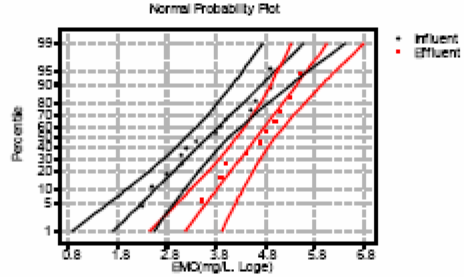
| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | -32.65 | -248.27% |
| Inflow 90th Percentile-Outflow | -108.36 | -92.96% |

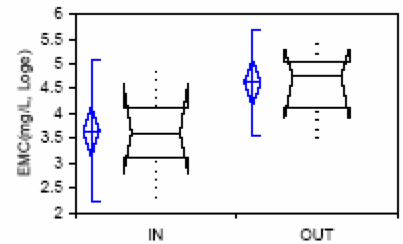
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 32.8% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -780.1% |

Linear Influent/Effluent Plot




Normal Probability Plot



Catch Basin Inserts

City South Pasadena

TSS (mg/L)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 14 | 3.64 | 0.86 | 4.14 | 3.14 |
| Outlet | 10 | 4.62 | 0.65 | 5.09 | 4.15 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 55.46 | 38.20 | 1.05 | 89.16 | 21.76 |
| Outlet | 125.74 | 101.49 | 0.73 | 191.52 | 59.96 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -70.28 | -127% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 130 | 0.0092 | 0.633, 0.774 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 19.12 | 9.04 | 0.0065 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 6.94 | 0.008 |

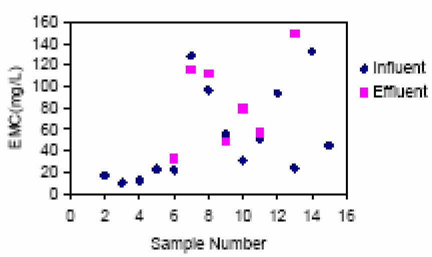
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 13.15 | 45.80 |
| 25th Percentile | 21.79 | 66.76 |
| 75th Percentile | 66.96 | 154.28 |
| 90th Percentile | 116.57 | 224.93 |

| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -32.65 | -248.27% |

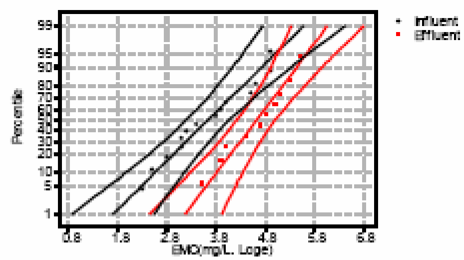
| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -108.36 | -92.96% |

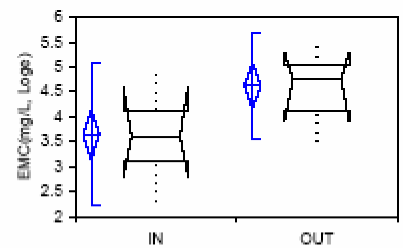
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 32.8% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -780.1% |

Linear Influent/Effluent Plot




Normal Probability Plot



# 17.0 HYDRODYNAMIC SEPARATOR

Hydrodynamic Separator

City South Pasadena

**Total Coliform (mpn/100 mL)**

| | | Log Data | | | | |
|---|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 17 | 12.30 | 1.17 | 12.90 | 11.70 |
| Outlet | 16 | 12.63 | 1.10 | 13.22 | 12.05 |

| | | Arithmetic Data | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 435283.23 | 220367.12 | 1.70 | 816530.86 | 54035.59 |
| Outlet | 561024.26 | 306827.66 | 1.53 | 1018552.90 | 103495.62 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -125741.03 | -29% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 167.5 | 0.8733 | .270, .028 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 40.79 | 0.7 | 0.4086 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 1.3 | 0.2534 |

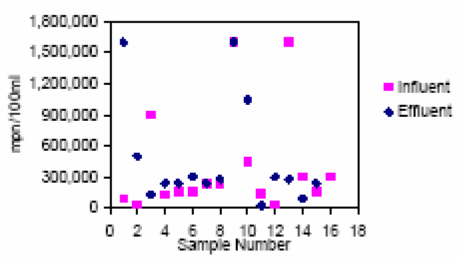
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 51534.15 | 77652.58 |
| 25th Percentile | 98715.77 | 147266.63 |
| 75th Percentile | 479260.71 | 627614.49 |
| 90th Percentile | 890911.17 | 1190638.17 |

| Inflow 10th Percentile-Outflow 10th | Difference | % Difference |
|---|---|---|
| | -26118.42 | -50.68% |

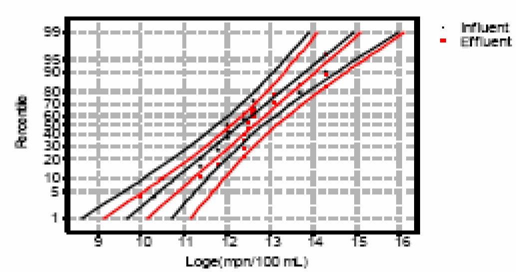
| Inflow 90th Percentile-Outflow 90th | Difference | % Difference |
|---|---|---|
| | -299727.01 | -33.64% |

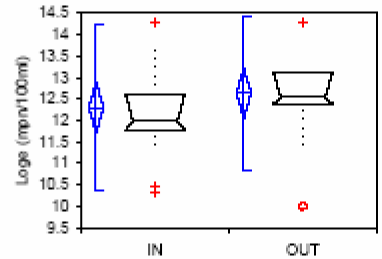
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 87.3% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | -1785.0% |

Linear Influent/Effluent Plot




Normal Probability Plot



Hydrodynamic Separator

City South Pasadena

Fecal Coliform (mpn/100 mL)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 17 | 8.44 | 2.57 | 9.76 | 7.11 |
| Outlet | 17 | 8.29 | 2.22 | 9.44 | 7.15 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 125503.70 | 4610.07 | 27.21 | 1881094.97 | -1630087.58 |
| Outlet | 46913.70 | 4000.42 | 11.68 | 328765.49 | -234938.08 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 78589.99 | 63% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 144 | 0.4931 | .612, .737 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 184.51 | 0.03 | 0.8643 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0 | 0.9862 |

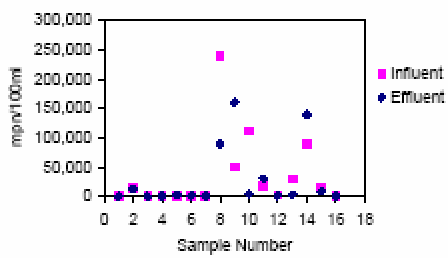
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 186.79 | 244.69 |
| 25th Percentile | 1719.86 | 897.85 |
| 75th Percentile | 29732.62 | 18958.35 |
| 90th Percentile | 110194.25 | 70262.96 |

| Inflow 10th Percentile-Outflow 10th | Difference | % Difference |
|---|---|---|
| | -57.90 | -31.00% |

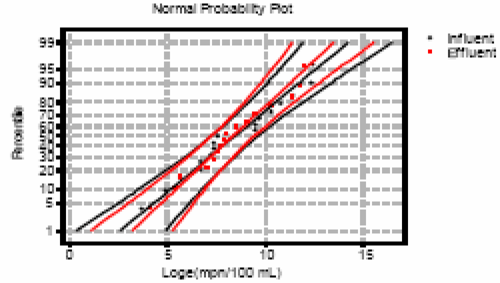
| Inflow 90th Percentile-Outflow 90th | Difference | % Difference |
|---|---|---|
| | 39931.29 | 36.24% |

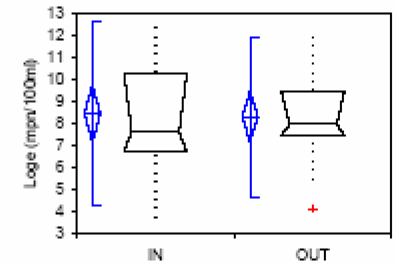
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 112.5% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 120.2% |

Linear Influent/Effluent Plot




Normal Probability Plot



Hydrodynamic Separator

City South Pasadena

Enterococcus (mpn/100 mL)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 17 | 9.31 | 1.27 | 9.96 | 8.65 |
| Outlet | 17 | 9.08 | 1.50 | 9.85 | 8.32 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 24651.83 | 11013.84 | 2.00 | 50033.64 | -729.98 |
| Outlet | 26965.23 | 6819.04 | 2.89 | 67027.29 | -13096.83 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -2313.40 | -9% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 142.5 | 0.4722 | .680, .007 |

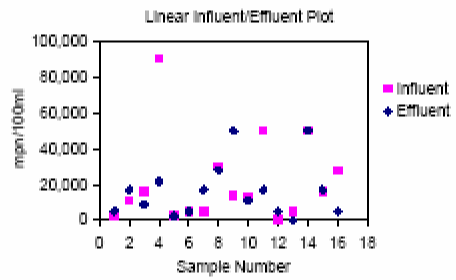
| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 61.97 | 0.22 | 0.6435 |

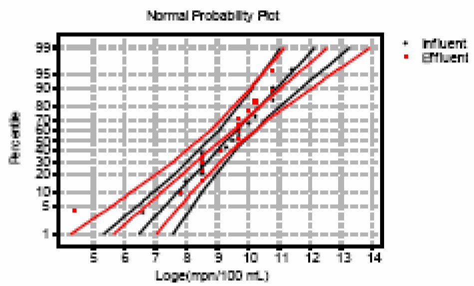
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0 | 0.9444 |

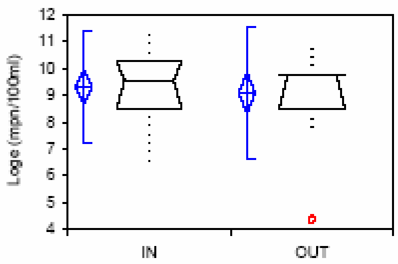
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 2275.60 | 1465.57 |
| 25th Percentile | 4675.07 | 3133.79 |
| 75th Percentile | 24343.01 | 23623.56 |
| 90th Percentile | 52052.06 | 59278.38 |

| | Difference | % Difference |
|---|---|---|
| Inflow 10th Percentile-Outflow | 810.03 | 35.60% |
| Inflow 90th Percentile-Outflow | -7226.31 | -13.88% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 126.2% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 9282.1% |



Hydrodynamic Separator

City South Pasadena

Streptococcus (mpn/100 mL)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 17 | 9.89 | 1.44 | 10.63 | 9.15 |
| Outlet | 17 | 9.42 | 2.02 | 10.46 | 8.39 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 55538.31 | 19741.87 | 2.63 | 130627.25 | -19550.64 |
| Outlet | 94473.54 | 12390.83 | 7.56 | 461640.58 | -272693.49 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -38935.24 | -70% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 121.5 | 0.2125 | .558, .003 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 99.45 | 0.6 | 0.4437 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.64 | 0.425 |

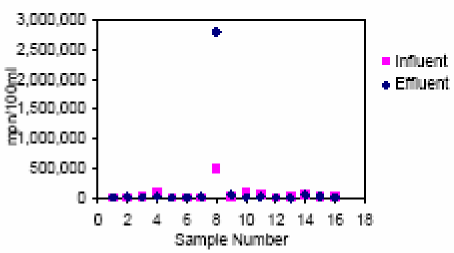
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 3261.69 | 1002.25 |
| 25th Percentile | 7707.89 | 3229.23 |
| 75th Percentile | 49020.80 | 49020.80 |
| 90th Percentile | 115844.03 | 164390.50 |

| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 2259.44 | 69.27% |

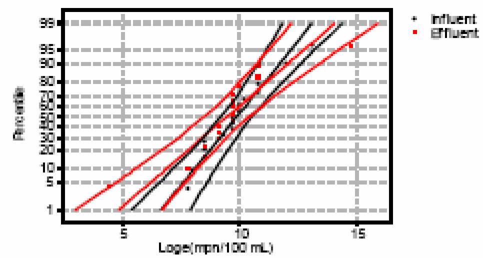
| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -48546.47 | -41.91% |

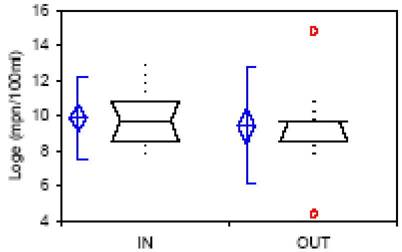
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow CL) | 308.8% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow CL) | 2461.3% |

Linear Influent/Effluent Plot




Normal Probability Plot



Hydrodynamic Separator

City South Pasadena

Total Copper (ug/L)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 3.46 | 0.51 | 3.73 | 3.19 |
| Outlet | 17 | 3.26 | 0.65 | 3.60 | 2.93 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 36.07 | 31.70 | 0.54 | 46.51 | 25.63 |
| Outlet | 32.29 | 26.17 | 0.72 | 44.28 | 20.29 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 3.79 | 10% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 286 | 0.6268 | 0.593, 0.153 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 10.901 | 0.88 | 0.354 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.26 | 0.614 |

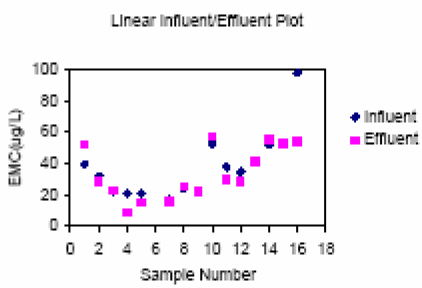
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 16.86 | 11.69 |
| 25th Percentile | 22.74 | 17.13 |
| 75th Percentile | 44.18 | 39.99 |
| 90th Percentile | 59.57 | 58.57 |

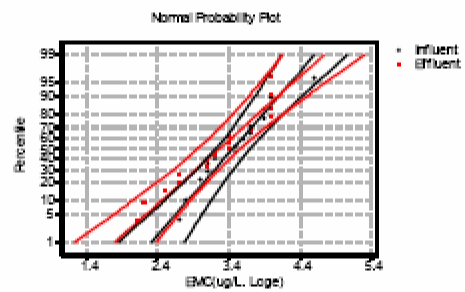
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 5.17 | 30.66% |

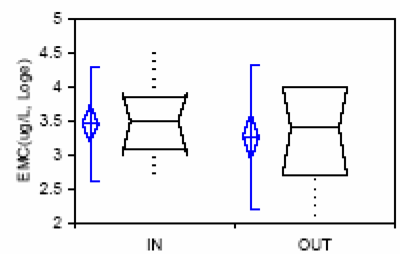
| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 1.00 | 1.68% |

| Max Percent Removal (Upper Inflow CL to Lower Outflow | 56.4% |
|---|---|

| Min Percent Removal (Lower Inflow CL to Upper Outflow | -72.7% |
|---|---|



**Hydrodynamic Separator**

City South Pasadena

**Dissolved Copper (ug/L)**

| | Log Data | | | | | 
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 2.38 | 0.87 | 2.84 | 1.92 |
| Outlet | 17 | 2.34 | 0.65 | 2.68 | 2.01 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 15.78 | 10.82 | 1.06 | 24.71 | 6.85 |
| Outlet | 12.85 | 10.39 | 0.73 | 17.65 | 8.05 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 2.93 | 19% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 268.5 | 0.9139 | 0.025, 0.754 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 18.119 | 0.02 | 0.881 |

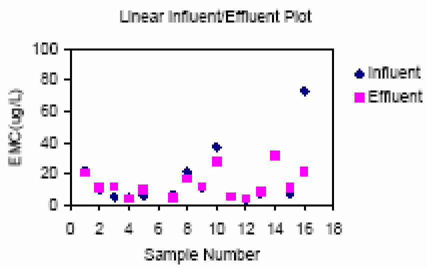
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.02 | 0.9 |

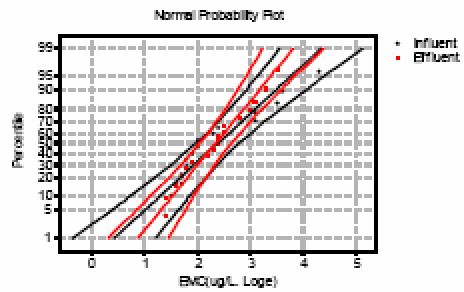
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 3.68 | 4.63 |
| 25th Percentile | 6.13 | 6.79 |
| 75th Percentile | 19.08 | 15.91 |
| 90th Percentile | 31.80 | 23.35 |

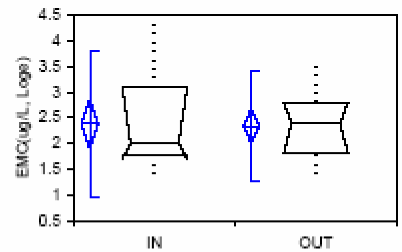
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -0.95 | -25.70% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 8.45 | 26.57% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 67.4% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -157.5% |



Hydrodynamic Separator

City South Pasadena

Total Lead (ug/L)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 2.44 | 0.96 | 2.96 | 1.93 |
| Outlet | 17 | 2.32 | 1.09 | 2.88 | 1.76 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 18.25 | 11.52 | 1.23 | 30.21 | 6.29 |
| Outlet | 18.32 | 10.15 | 1.50 | 32.46 | 4.17 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| -0.06 | 0% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 281.5 | 0.7458 | 0.441, 0.198 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 32.84 | 0.12 | 0.727 |

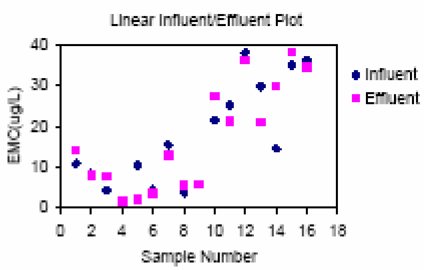
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.12 | 0.732 |

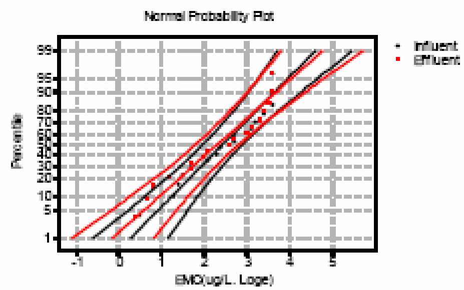
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 3.50 | 2.63 |
| 25th Percentile | 6.15 | 4.99 |
| 75th Percentile | 21.56 | 20.67 |
| 90th Percentile | 37.89 | 39.19 |

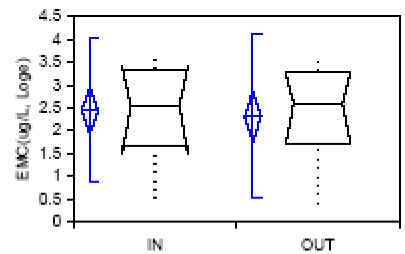
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.87 | 24.86% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -1.29 | -3.42% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 86.2% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -415.7% |



Hydrodynamic Separator

City South Pasadena

Dissolved Lead (ug/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 12 | 0.52 | 0.75 | 0.99 | 0.04 |
| Outlet | 13 | 0.45 | 0.67 | 0.86 | 0.05 |

| | | Arithmetic Data | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 2.22 | 1.68 | 0.87 | 3.46 | 0.99 |
| Outlet | 1.97 | 1.57 | 0.75 | 2.87 | 1.07 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 0.25 | 11% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 161.5 | 0.7856 | 0.575, 0.748 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 11.634 | 0.05 | 0.827 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.09 | 0.765 |

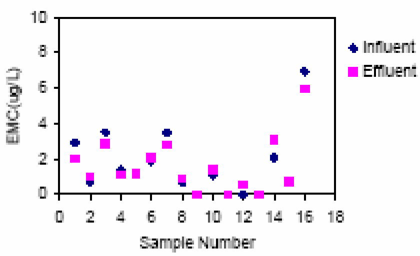
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.67 | 0.69 |
| 25th Percentile | 1.03 | 1.02 |
| 75th Percentile | 2.72 | 2.43 |
| 90th Percentile | 4.22 | 3.59 |

| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -0.02 | -3.48% |

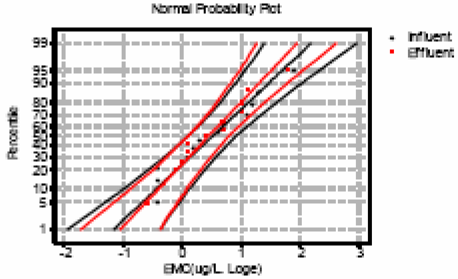
| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.62 | 14.77% |

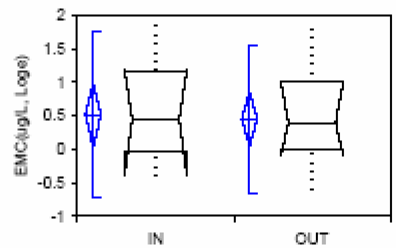
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 68.9% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -189.0% |

Linear Influent/Effluent Plot




Normal Probability Plot



Hydrodynamic Separator

City South Pasadena

Total Zinc (ug/L)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 4.94 | 0.76 | 5.35 | 4.54 |
| Outlet | 17 | 4.88 | 0.71 | 5.25 | 4.52 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 187.62 | 140.30 | 0.89 | 276.36 | 98.87 |
| Outlet | 170.18 | 131.94 | 0.61 | 241.47 | 98.90 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 17.43 | 9% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 274.5 | 0.9426 | 0.727, 0.516 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 16.895 | 0.06 | 0.813 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.01 | 0.928 |

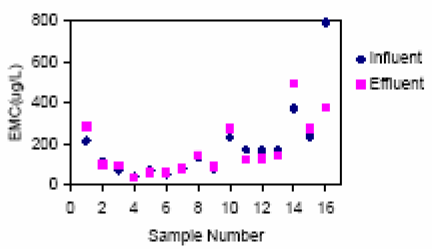
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 54.47 | 54.34 |
| 25th Percentile | 85.27 | 82.71 |
| 75th Percentile | 230.81 | 210.44 |
| 90th Percentile | 361.33 | 320.35 |

| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.13 | 0.23% |

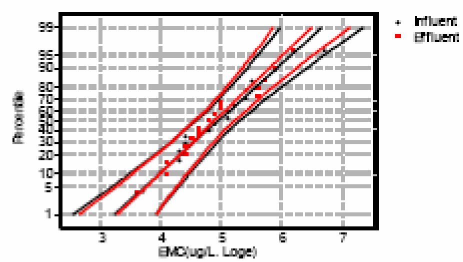
| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 40.99 | 11.34% |

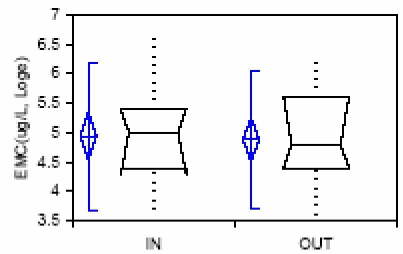
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 64.2% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -144.2% |

Linear Influent/Effluent Plot




Normal Probability Plot



**Hydrodynamic Separator**

City South Pasadena

**Dissolved Zinc (ug/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 4.43 | 0.87 | 4.90 | 3.97 |
| Outlet | 17 | 4.34 | 0.84 | 4.77 | 3.91 |

| | | Arithmetic Data | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 123.19 | 84.04 | 1.07 | 193.54 | 52.84 |
| Outlet | 109.53 | 76.80 | 1.02 | 166.80 | 52.26 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 13.66 | 11% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-values |
| 269.5 | 0.9426 | 0.094, 0.967 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 22.902 | 0.09 | 0.765 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.01 | 0.928 |

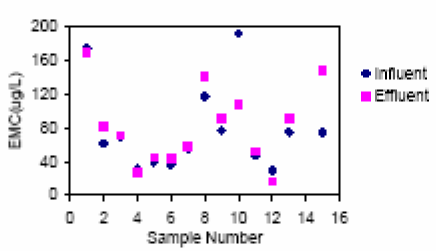
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 28.39 | 26.94 |
| 25th Percentile | 47.47 | 44.24 |
| 75th Percentile | 148.77 | 133.29 |
| 90th Percentile | 251.26 | 218.94 |

| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 1.45 | 5.11% |

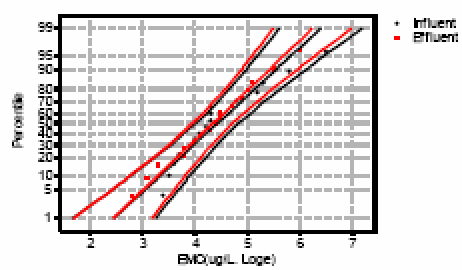
| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 32.32 | 12.86% |

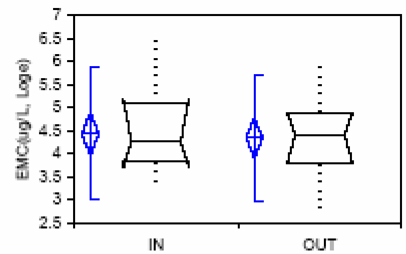
| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 73.0% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -215.7% |

Linear Influent/Effluent Plot




Normal Probability Plot



Hydrodynamic Separator

City South Pasadena

COD (mg/L)

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 15 | 3.35 | 1.00 | 3.90 | 2.79 |
| Outlet | 16 | 3.15 | 1.00 | 3.68 | 2.62 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 47.00 | 28.41 | 1.32 | 81.31 | 12.69 |
| Outlet | 38.47 | 23.34 | 1.31 | 65.34 | 11.61 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 8.53 | 18% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 259.5 | 0.4526 | 0.103, 0.384 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 29.4 | 0.3 | 0.589 |

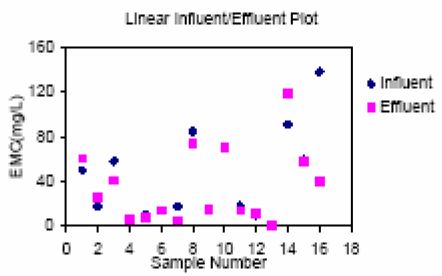
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.59 | 0.441 |

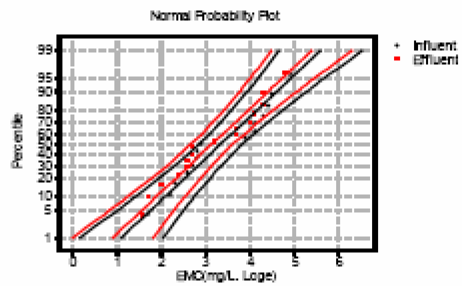
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 8.20 | 6.75 |
| 25th Percentile | 8.11 | 12.14 |
| 75th Percentile | 54.63 | 44.84 |
| 90th Percentile | 98.40 | 80.70 |

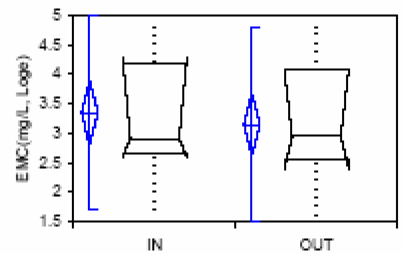
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 1.45 | 17.72% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 17.69 | 17.98% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 85.7% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -414.9% |



**Hydrodynamic Separator**

City South Pasadena

**Hardness (mg/L)**

| | Count | Log Data Mean | SD | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 16 | 3.34 | 0.68 | 3.70 | 2.97 |
| Outlet | 17 | 3.21 | 0.59 | 3.51 | 2.90 |

| | Mean | Arithmetic Data Median | COV | UCL | LCL |
|---|---|---|---|---|---|
| Inlet | 35.54 | 28.15 | 0.77 | 50.14 | 20.94 |
| Outlet | 29.39 | 24.68 | 0.65 | 39.16 | 19.62 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 6.16 | 17% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 281 | 0.7595 | 0.207, 0.198 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 12.73 | 0.35 | 0.557 |

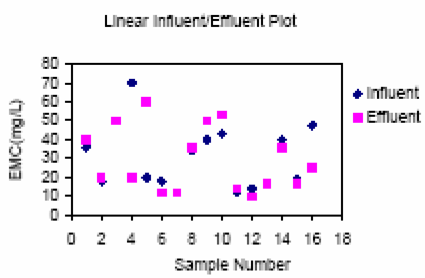
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.11 | 0.746 |

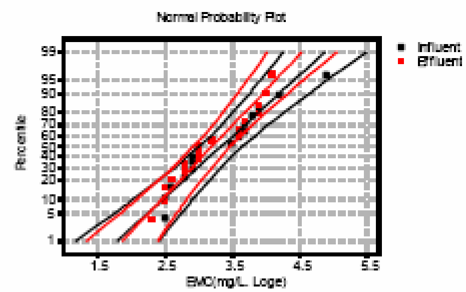
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 12.06 | 11.83 |
| 25th Percentile | 18.02 | 16.76 |
| 75th Percentile | 43.97 | 36.33 |
| 90th Percentile | 65.69 | 51.45 |

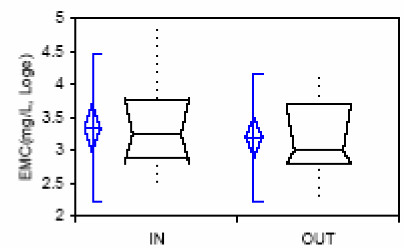
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.23 | 1.87% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 14.24 | 21.67% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 60.9% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -87.0% |



**Hydrodynamic Separator**

City South Pasadena

**Kjeldahl - N (mg/L)**

| | Log Data | | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 0.91 | 0.93 | 1.40 | 0.41 |
| Outlet | 17 | 0.61 | 1.11 | 1.18 | 0.04 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 3.82 | 2.48 | 1.17 | 6.20 | 1.43 |
| Outlet | 3.43 | 1.84 | 1.57 | 6.20 | 0.66 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 0.38 | 10% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 306.5 | 0.2207 | 0.405, 0.04 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 33.58 | 0.67 | 0.418 |

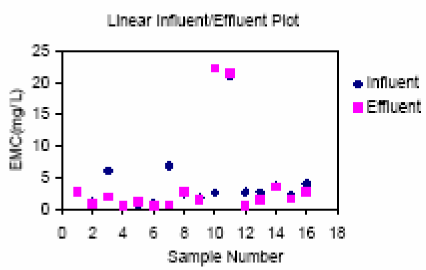
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 1.54 | 0.214 |

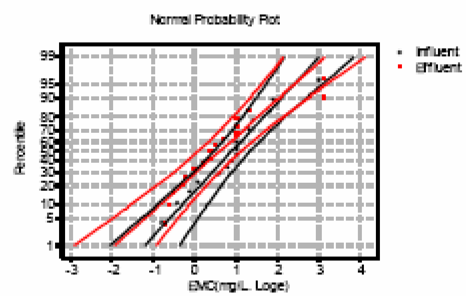
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.78 | 0.46 |
| 25th Percentile | 1.35 | 0.89 |
| 75th Percentile | 4.54 | 3.82 |
| 90th Percentile | 7.85 | 7.37 |

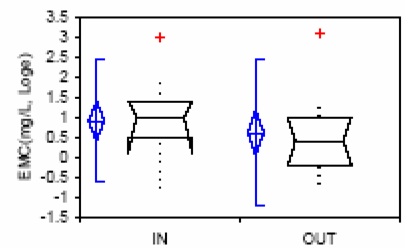
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.32 | 40.88% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.48 | 6.14% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 89.3% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -333.6% |



**Hydrodynamic Separator**

City South Pasadena

**Ammonia - N (mg/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 15 | -0.75 | 0.97 | -0.21 | -1.28 |
| Outlet | 15 | -0.83 | 0.76 | -0.41 | -1.25 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 0.76 | 0.47 | 1.24 | 1.28 | 0.24 |
| Outlet | 0.58 | 0.43 | 0.88 | 0.86 | 0.30 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 0.18 | 23% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 235.5 | 0.9174 | 0.867, 0.838 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 21.127 | 0.07 | 0.786 |

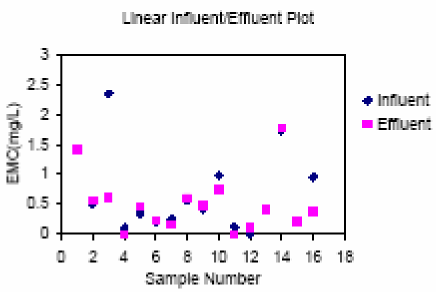
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.02 | 0.901 |

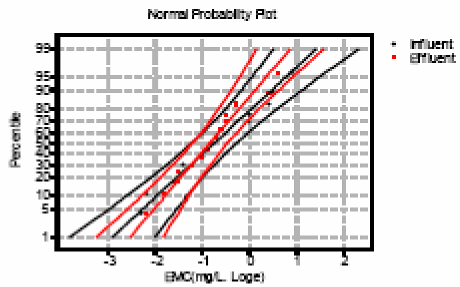
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.14 | 0.17 |
| 25th Percentile | 0.25 | 0.27 |
| 75th Percentile | 0.89 | 0.71 |
| 90th Percentile | 1.57 | 1.11 |

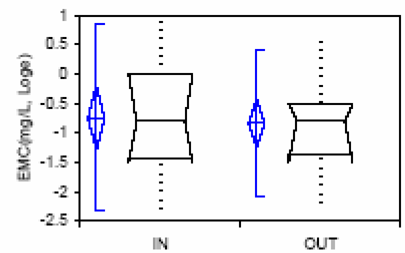
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | -0.03 | -18.80% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.46 | 29.23% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 76.7% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -264.4% |



Hydrodynamic Separator

City South Pasadena

Nitrite - N (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 14 | -2.79 | 0.59 | -2.44 | -3.13 |
| Outlet | 12 | -2.89 | 0.67 | -2.47 | -3.32 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 0.07 | 0.06 | 0.65 | 0.10 | 0.05 |
| Outlet | 0.07 | 0.06 | 0.75 | 0.10 | 0.04 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 0.00 | 6% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 203.5 | 0.4715 | 0.215, 0.083 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 9.579 | 0.18 | 0.673 |

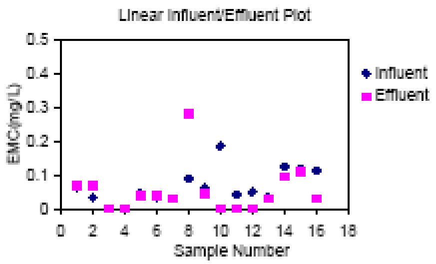
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 0.56 | 0.456 |

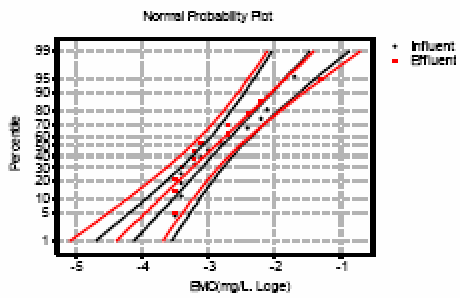
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.03 | 0.02 |
| 25th Percentile | 0.04 | 0.04 |
| 75th Percentile | 0.09 | 0.09 |
| 90th Percentile | 0.13 | 0.13 |

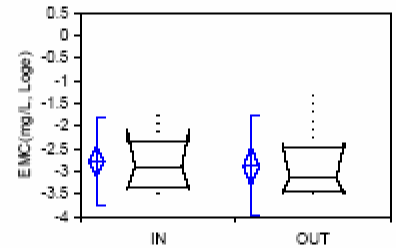
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.01 | 17.68% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.00 | 1.72% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 64.2% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -123.1% |



Hydrodynamic Separator

City South Pasadena

Nitrate - N (mg/L)

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 10 | -0.19 | 0.69 | 0.30 | -0.68 |
| Outlet | 11 | -0.56 | 0.62 | -0.14 | -0.98 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 1.05 | 0.83 | 0.78 | 1.63 | 0.47 |
| Outlet | 0.69 | 0.57 | 0.69 | 1.01 | 0.37 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 0.36 | 34% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 131.5 | 0.1392 | 0.458, 0.186 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 8.886 | 1.7 | 0.207 |

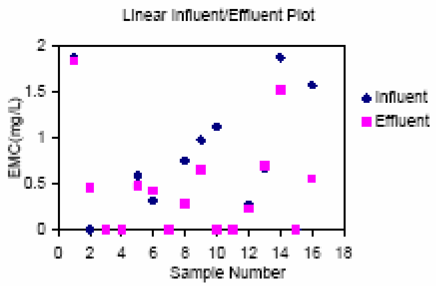
| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 2.29 | 0.13 |

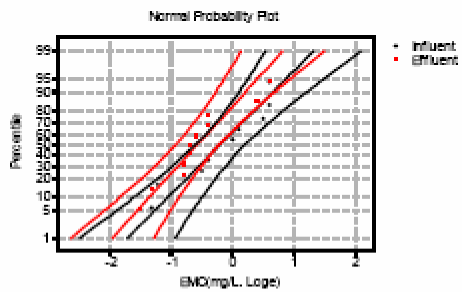
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 0.36 | 0.27 |
| 25th Percentile | 0.53 | 0.38 |
| 75th Percentile | 1.28 | 0.85 |
| 90th Percentile | 1.91 | 1.22 |

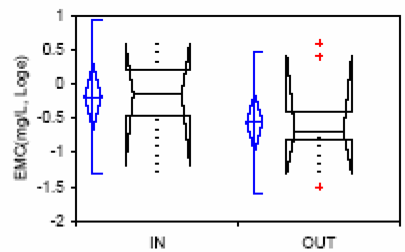
| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.09 | 26.06% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 0.69 | 35.94% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 77.2% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -117.7% |



**Hydrodynamic Separator**

City South Pasadena

**TSS (mg/L)**

| | | Log Data | | | |
|---|---|---|---|---|---|
| | Count | Mean | SD | UCL | LCL |
| Inlet | 16 | 4.74 | 1.15 | 5.35 | 4.12 |
| Outlet | 17 | 4.24 | 1.01 | 4.75 | 3.72 |

| | Arithmetic Data | | | | |
|---|---|---|---|---|---|
| | Mean | Median | COV | UCL | LCL |
| Inlet | 221.28 | 114.15 | 1.66 | 417.05 | 25.51 |
| Outlet | 114.82 | 69.08 | 1.33 | 193.20 | 36.44 |

| Pollutants Removal | |
|---|---|
| Mean Inflow - Mean Outflow | Percent Difference |
| 106.46 | 48% |

| Mann-Whitney U Test, Anderson-Darling Normality Test | | |
|---|---|---|
| U-Statistics | Probability | AD, P-Values |
| 305.5 | 0.2345 | 0.835, 0.268 |

| Analysis of Variance (ANOVA) | | |
|---|---|---|
| Sum of Sqaures | F-ratio | P-Value |
| 36.2 | 1.78 | 0.191 |

| Kruskal-Wallis Test | |
|---|---|
| KW Statistic | Probability |
| 1.46 | 0.228 |

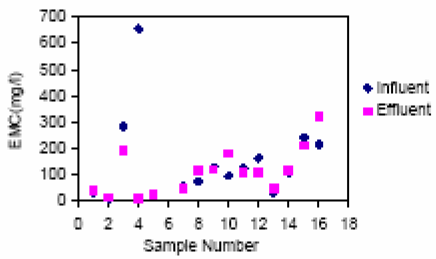
| | Inlet | Outlet |
|---|---|---|
| 10th Percentile | 27.38 | 19.73 |
| 25th Percentile | 53.84 | 35.72 |
| 75th Percentile | 241.99 | 133.61 |
| 90th Percentile | 475.90 | 256.34 |

| Inflow 10th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 7.65 | 27.96% |

| Inflow 90th Percentile-Outflow | Difference | % Difference |
|---|---|---|
| | 219.56 | 46.14% |

| | |
|---|---|
| Max Percent Removal (Upper Inflow CL to Lower Outflow | 91.3% |
| Min Percent Removal (Lower Inflow CL to Upper Outflow | -657.4% |

Linear Influent/Effluent Plot




Normal Probability Plot