

Implementation of a stormwater pollution prevention plan
at North Carolina State University and its effects on
water quality

By

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Abstract

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Stormwater Runoff has become one of the greatest challenges in water pollution control, as this source of contamination is a major contributor to water quality impairment of waterbodies nationwide. Stormwater runoff picks up pollutants as it travels across land and creates negative effects on water quality, aquatic biota, and stream temperature. In an effort to protect water quality, the Division of Water Quality and the federal Clean Water Act implemented the National Pollutant Discharge Elimination System (NPDES) program in 1972 making it illegal to discharge pollutants into surface waters without a permit. NC State's Environmental Health and Safety Office (EHSO) are currently working on updating the University's Stormwater Pollution Prevention Plan to maintain compliance with their Stormwater Permit. The Environmental Health and Safety Office Stormwater data from the years 2007-2011 were analyzed and used to create multiple graphs. Findings from the data analysis suggest that there are pollutants found in Stormwater on campus that are both above and below regulatory limits. Certain pollutants were above regulatory limits in the same location from 2007-2011. Total Suspended Solids, Lead, Copper, and Fecal Coliform showed results that were 100% above the regulatory limit. In order to help improve the water quality of Rocky Branch Creek and other waterways on campus, there will need to be a strict enforcement of the Stormwater Pollution Prevention Plans by the EHSO and the Chancellor of the University. By implementing consequences it will help reduce the amount of pollutants that will flow into the waterways on campus and can begin to improve the water quality. In addition, the EHSO will need to spread more public awareness about what stormwater pollution is and how to prevent it in order to keep NC State's waterways free of pollutants.

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Chapter 1: Introduction

1.1 Stormwater runoff

According to the Natural Research Council (NRC) stormwater runoff is now listed as one of the greatest challenges in managing nationwide water pollution, because it is a major factor in water quality impairment¹. In urban and suburban areas, rain and snowmelt are not able to soak into the ground because much of the land surface is covered by buildings and pavement. Consequently, urban areas rely on storm drains to carry large amounts of runoff from paved areas and roofs to nearby waterways². The Environmental Protection Agency's (EPA) report on *Urban Stormwater Management in the United States* asserts that the stormwater runoff can include pollutants such as metals, sediments, pathogens, hydrocarbons, and fertilizers/nutrients¹. In addition, the EPA report affirms that the increase in velocity and volume of runoff often causes sediment deposition, stream bank erosion, and channel incision in stream channels¹.

1.2 Water Quality

Common sources of urban pollution include pet wastes, improperly sited, designed and maintained onsite wastewater treatment (septic) systems, automobile fluids, lawn and garden fertilizers and pesticides, vehicle emissions, household chemicals that are improperly disposed of, and road deicing/anti-icing chemicals³. These sources of urban pollution can negatively affect stream temperature, water quality and aquatic biota. Stormwater picks up pollutants such as nutrients, soil particles, toxic chemicals and oil and grease as it travels across land. These pollutants are then carried to nearby lakes and streams and can cause many water quality problems. Sediments often carry chemicals such as nitrogen, phosphorus, and toxins which further pollute the water. Increased sediments can clog the gills of fish and other aquatic life, as

well as, alter the ecology of the water body. In addition, stormwater runoff from developed areas increases the stream temperature which can stress or kill temperature-sensitive aquatic life.

Excessive stormwater runoff increases the amount of water in streams, resulting in flooding and streambank erosion.

1.3 Regulations

In an effort to protect water quality, the Division of Water Quality and the federal Clean Water Act implemented the National Pollutant Discharge Elimination System (NPDES) program in 1972 making it illegal to discharge pollutants into surface waters without a permit. Phase I of the NPDES program was established in 1990 and focused on site and operations planning to reduce pollutant sources. Furthermore, Phase I covers construction activities that disturb five or more acres, industrial activities, and municipalities with populations of 100,000 or more that are owned or operated by a municipal separate storm sewer system (MS4)³. Permit requirements were expanded in Phase II of the program to communities that contain less than 100,000 in population and public entities that own or operate a municipal separate storm sewer system and to construction disturbing an acre or more of land⁴.

Specific permit requirements include:

- developing a stormwater management program
- identifying Best Management Practices (BMPs) and measuring goals for each control measure
- identifying control measures for public education and outreach
- public participation/involvement
- illicit discharge detection and elimination
- construction site runoff control
- post-construction runoff control
- pollution prevention/good housekeeping³.

1.4 Best Management Practices

Stormwater BMPs are methods that help control pollutants and prevent other damaging effects to stormwater runoff. There are two categories of BMPs: structural and nonstructural. The preferred method of reducing pollution from developing urban and suburban areas in North Carolina is the use of non-structural BMPs⁵.

The most appropriate BMP for a basin or given site is based on whether there is development in place or development has yet to occur⁶. Nonstructural BMPs are the most cost-effective in areas with existing development because retrofitting structural controls in a developed area can be expensive⁶. When there is new development or significant redevelopment, structural controls are more appropriate because they have been integrated into the planning of the infrastructure⁶.

Non-structural BMPs diminish pollution in runoff by reducing the opportunity for the stormwater runoff to be exposed to the pollutants⁴. In addition, non-structural BMPs have smaller costs and are usually easier to design and implement. To ensure the non-structural BMPs are being implemented, annual inspections are required; however, there is no need for labor maintenance. Non-structural BMPs do not require labor maintenance because they do not have technical or engineering designs associated with them. Other advantages of non-structural BMPs include: reduced land clearing costs, reduced costs for total infrastructure, and reduced total stormwater management costs.

Even though the benefits of nonstructural BMPs appear promising, they still have their disadvantages. One of the most significant disadvantages is the uncertainty over the performance of many practices, specifically in terms of improving stormwater quality, improving the health of

receiving waters and changing people's behavior¹. Examples of non-structural BMPs are: public education and participation, spill prevention and cleanup, street and storm drain maintenance and material exposure controls.

Structural BMPs are physical structures that are designed to reduce downstream erosion, promote groundwater recharge, provide flood control, and remove pollutants from stormwater runoff⁴. Engineered construction and design are typically needed for structural BMPs.

The several types of structural BMPs vary greatly in their design and they each have advantages and disadvantages relative to each other. Some structural BMP advantages include: using infiltration and/or detention/retention facilities (e.g. wet detention basins, infiltration devices, and stormwater wetlands) to provide considerable stormwater quantity handling capability; provides numerous types of pollutant removal mechanisms such as microbial action, sedimentation, filtration, and plant uptake (e.g. bioretention, stormwater wetlands); and can provide high levels of pollutant removal ability and stormwater quantity handling⁴. Common disadvantages of structural BMPs include high costs, labor maintenance, location, and the need for planning. Examples of structural BMPs include: bioretention ponds, sand filters, stormwater wetlands, wet detention basins, and infiltration devices. NC State has implemented numerous structural BMP's such as wet detention basins (see Image 1), permeable pavements (see Image 2), and rain gardens (see Image 2).



Image 1: Wet Detention Basin



Image 2: Permeable Pavement/ Rain Garden

Chapter 2: NC State's Stormwater Issues

NC State University is located in Wake County, NC (see Image 3). The University occupies approximately 2,200 acres across 5 major sections of campus: Centennial, South, Central, North, and West. There are approximately 200 buildings on campus, 55 roads, and 15 parking lots for fuels and hazardous chemicals which can impact stormwater quality. In addition the University is involved in approximately 20 construction projects annually which can also have a negative impact on stormwater quality. Some of the main areas of concern for stormwater are buildings that are close to the outfall at Rocky Branch Creek, such as Talley Student Center, the Student Health Center, Miller Fields etc. On Centennial Campus, the main area of concern is the outfall at North Creek. These areas have consistently shown high sampling results for numerous pollutants over the past five years.



Image 3: Map of Wake County, NC



Image 4: Map of Central Campus

As part of the Clean Water Act and NPDES program, any municipal operation that discharges storm water runoff into waterways must obtain a Municipal Separate Storm Sewer System (MS4) permit. NC State University is considered a municipal operation because it is a public entity that discharges into waters of the United States. NC State University has been in compliance with the Clean Water Act and NPDES program and has obtained MS4 permits since April 2005. The University's MS4 permit recently expired in 2010 and they are currently in the process of applying for a new permit. To become eligible for a permit, NC State must first submit a Notice of Intent, install stormwater control measures to minimize pollutants in stormwater runoff, and develop a stormwater pollution prevention plan. The University has already completed the first two steps of the permitting process.

As NC State University continues to grow in size each year, it is taking strides to prevent pollutants from entering stormwater runoff on campus. Throughout the Universities' campus, stormwater runoff flows into stormwater drains that are connected to Rocky Branch Creek and other local waterways. Multiple buildings on campus do not follow the proper procedures for preventing pollution runoff. Specific buildings including Case Dining Hall, Weaver Labs, and Sullivan Zone Shops were found to be in violation of proper stormwater prevention methods. Case Dining Hall performs cleaning activities directly over the storm drain (see Image 5) which is very harmful to Rocky Branch Creek. The Weaver Labs store equipment outside that is not covered (see Image 6). Over time these pieces of equipment have rusted and the metals have flowed into our storm drains. In addition, the Sullivan Zone Shops have stockpiles of sand in their parking lot that is not covered (see Image 7). Their stockpiles erode directly into the storm drains located in their parking lots resulting in high sediment accumulations in Rocky Branch Creek. Ellen Buckner, Stormwater Specialist with the Environmental Health and Safety Office (EHSO) on Campus, said that the University is hoping that by implementing Stormwater Pollution Prevention Plans, the water quality of Rocky Branch Creek will improve between 5-10% by reducing stormwater runoff pollutants.



Image 5: Case Dining Hall



Image 6: Weaver Labs



Image 7: Sullivan Zone Shops

Chapter 3: Stormwater Pollution Prevention Plan

In 1994, the University began implementation of the stormwater management programs to mitigate stormwater pollution impacts on local water quality. Then in April 2005, North Carolina State University obtained their first MS4 permit as well as developed a stormwater pollution prevention plan as part of the NPDES stormwater pollution prevention process. The stormwater pollution prevention plan and MS4 permit have been in effect since April 2005 and

expired in January 2010. A copy of the MS4 permit and stormwater pollution prevention plan can be found at the Environmental Health and Safety Office on NC State's campus.

According to the NPDES guidelines, entities are required to rewrite their stormwater pollution prevention plan when their permit expires every five years. Renewal of an existing NPDES permit must be requested and accompanied by a complete application 180 days prior to expiration of the existing permit.

NC State's EHSO (Environmental Health and Safety Office) is currently working on applying for a new stormwater permit as well as updating the University's Stormwater Pollution Prevention Plan. The stormwater permit application is scheduled to be submitted to the Division of Water Quality by June 2012. In addition it is the University's goal is to have every facility on campus follow the pollution prevention plan and improve water quality in Rocky Branch Creek by 5-10%.

The updating process began in September 2011 with the EHSO creating a new draft stormwater pollution prevention plan. As part of the drafting process, the EHSO reviewed the pollution prevention plans of other Universities in North Carolina as well as, how they incorporated EPA stormwater regulations into the plan. The review process helped to create NC State's process for updating its stormwater pollution prevention plan which is discussed below.

The process for updating the plan includes:

- Presentation to NC State's Stormwater Committee for approval.
- The committee will look over the draft and make suggestions, if any changes are required.
- The draft will then return to the EHSO for changes and finalization.

- Once the plan is finalized the EHSO will distribute the plans to facilities on campus for implementation.
- The EHSO will make a yearly inspection of the facilities to make sure that they are following the pollution prevention plan.
- The EHSO will use an environmental consulting firm to collect annual water quality data (ex. Total Suspended Solids, Biological Oxygen Demand etc) from Rocky Branch Creek, to analyze how water quality changes over time.

Chapter 4: Data Collection and Methods

The data that is used in this analysis is obtained from the NC State Stormwater Program Annual Reports from 2007-2011. The EHSO currently uses Terraine Environmental Consulting Inc. to collect annual stormwater data from multiple locations across campus including Centennial Campus, and Main Campus. Centennial Campus sample locations, as displayed in Image 8, are: a stream located under Campus Shore Drive, an outfall to a constructed wetland, an outfall to a stormwater management pond, and an outfall to the beginning of North Creek. The Main Campus data, as displayed in Image 9, are collected from a culvert at Pullen Road, an outfall directly flowing to Rocky Branch Creek, an outfall at Morrill Drive, and an outfall at Dan Allen Drive.

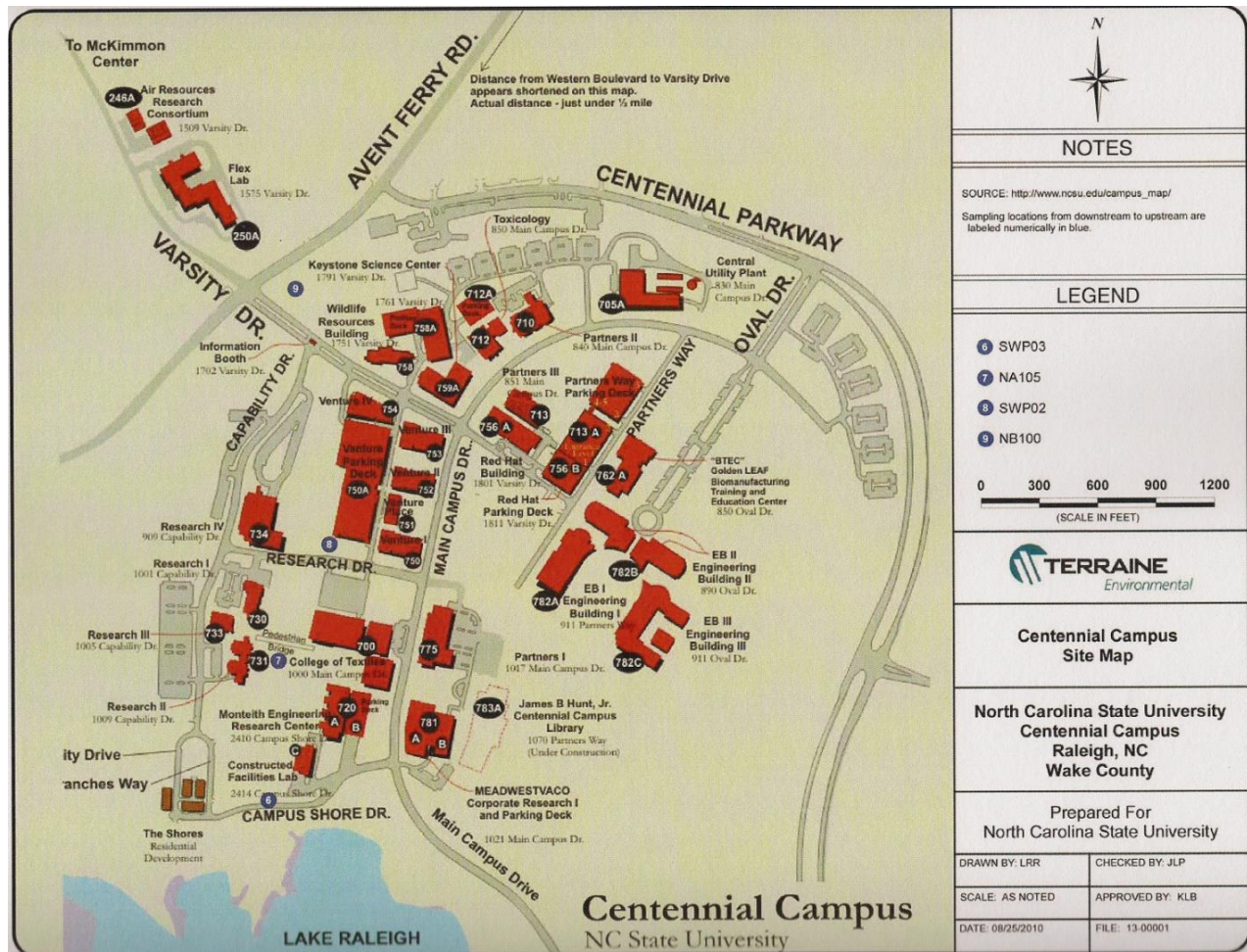


Image 8: Sampling Locations on Centennial Campus

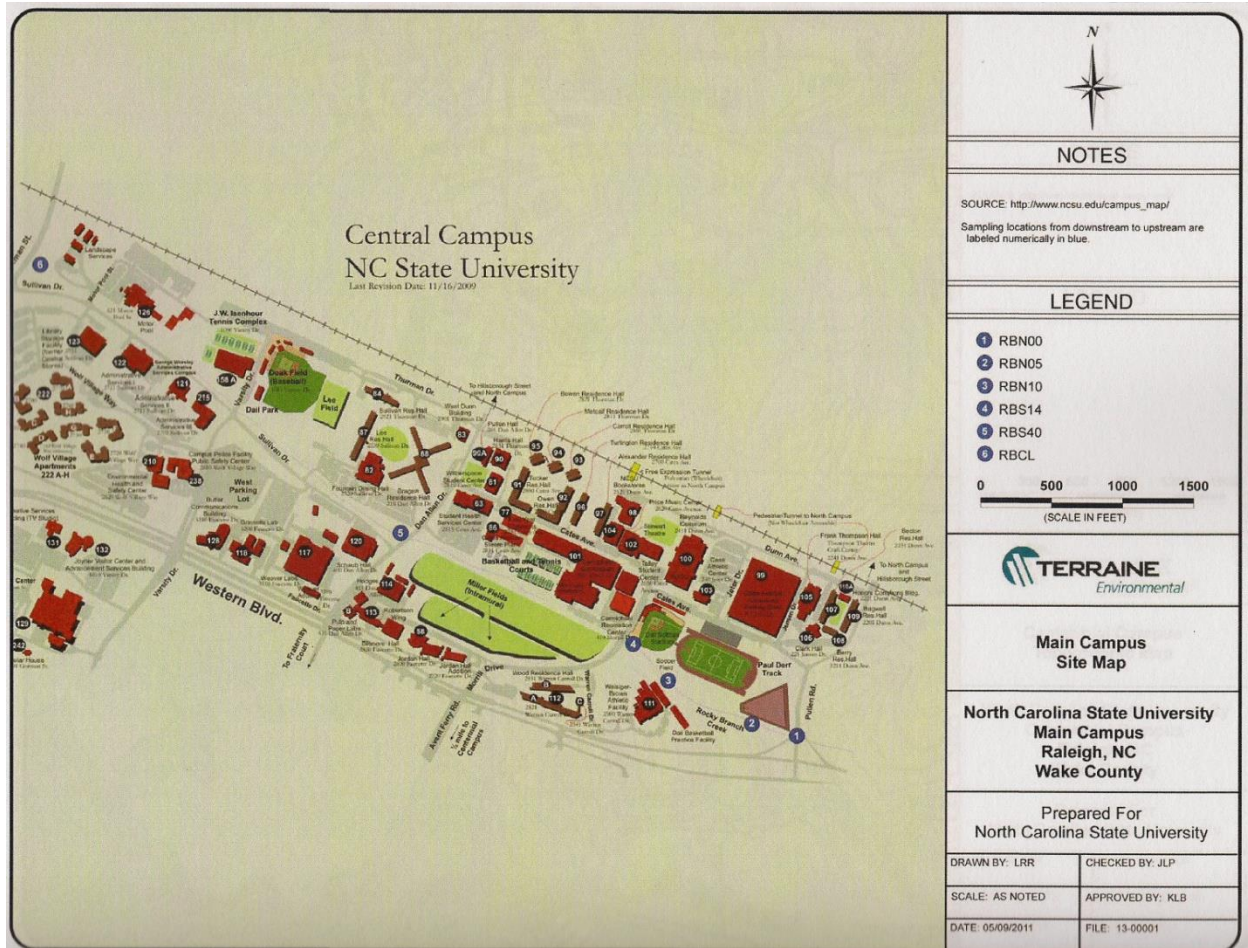


Image 9: Sampling Locations on Main Campus

Terraine Inc. performs samples on a quarterly basis, after a measurable rainfall event. Terraine Inc. collects grab samples at each of the locations listed above using accepted standards and practices in accordance with 40 CFR 122.21 (g) (7). Following grab outfall and in-stream sample collection; samples are placed in ice-chilled coolers and transported under proper chain of custody controls from the site to the ESC laboratory in Mt. Juliet, Tennessee for analysis by: Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total and Dissolved Phosphorus, Total Kjeldahl

Nitrogen (TKN), Nitrates, Nitrite, Ammonia, and multiple metals such as Lead, Mercury, Arsenic etc. and sends all sampling data records to EHSO.

Methods

The graphs used in this project were created by using data from the 2007-2011 NC State Stormwater Program Annual Reports. The data was analyzed by looking at each year of the reports and comparing the sampling results to the regulatory limits. The sampling locations of the contaminants were also examined to determine if any contaminants above regulatory limits occurred in the same sampling location during the past five years.

After analyzing the data, multiple bar graphs were created to display the contaminants that are above and below regulatory limits, contaminants that are above regulatory limits at the same sampling location, specific contaminants that trended above and below regulatory limits for the past five years, and specific parameters that are above 100% of the regulatory limit.

Chapter 5: Results/Discussion

The correlations between parameters and regulatory limits from 2007-2008 were examined and are displayed in Figures 1-4. Figures 5-14 display the correlations between parameters and regulatory limits from 2009-2011 and are found in the Appendix.

Figures 1-4 display the measured results for parameters that are above and below regulatory limits versus the required regulatory limits. In 2007, Cyanide, Total Antimony, Total Arsenic, Total Beryllium, Total Cadmium, Total Chromium, Total Lead, Total Mercury, Total Selenium, Total Silver, Total Thallium and Phenols had measured values that were lower than the regulatory limits.

Figure 2 shows parameters that were above regulatory limits in 2007. These parameters are Fecal Coliform, COD, TKN, Organic Nitrogen, and TDS. Fecal Coliform, COD, and TDS had measured values that were a lot higher than the required regulatory limits compared to TKN and Organic Nitrogen.

In 2008 (Figure 3), Arsenic, Beryllium, Cadmium, Nickel, Selenium, Silver, Thallium, Mercury, Cyanide, and Total Phenols were below regulatory limits. Furthermore, the parameters above regulatory limits were Fecal Coliform, Ammonia, TDS, TSS, and TKN (Figure 4). Fecal Coliform and TSS had the highest measured values above regulatory limits (Figure 4).

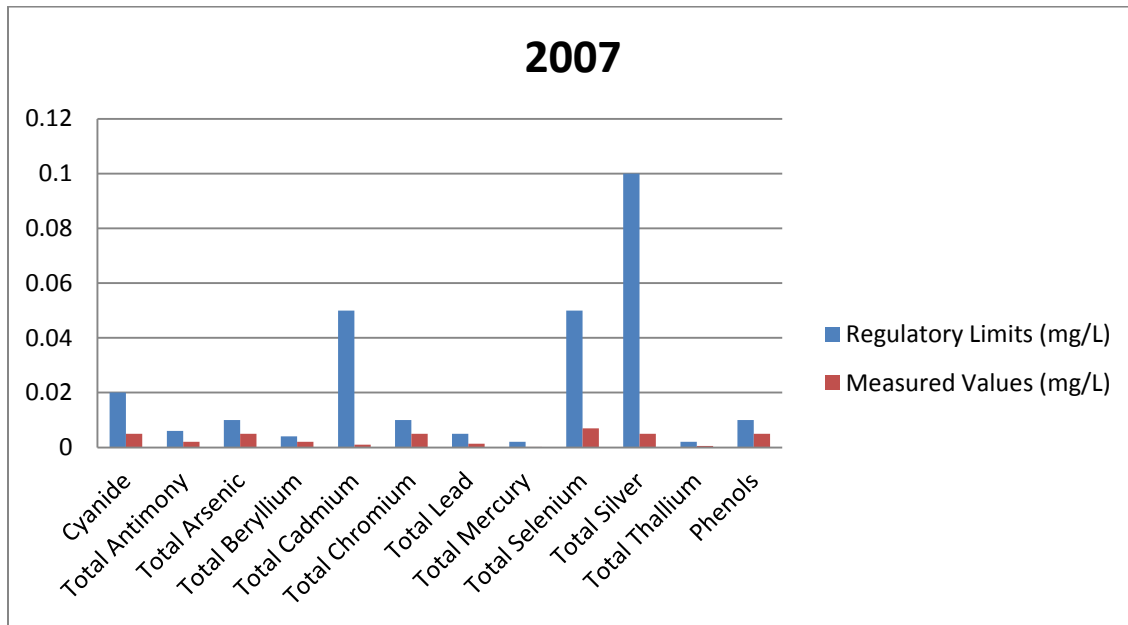


Figure 1: Parameters below regulatory limits for all sample locations in 2007

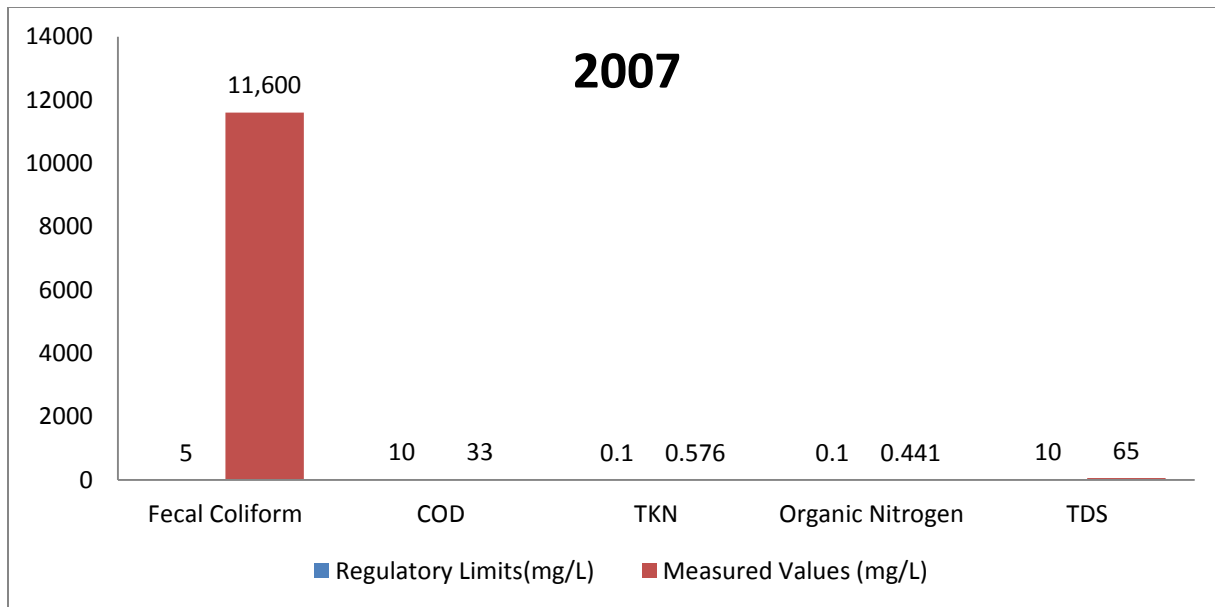


Figure 2: Parameters above regulatory limits (mg/L) for all sample locations in 2007

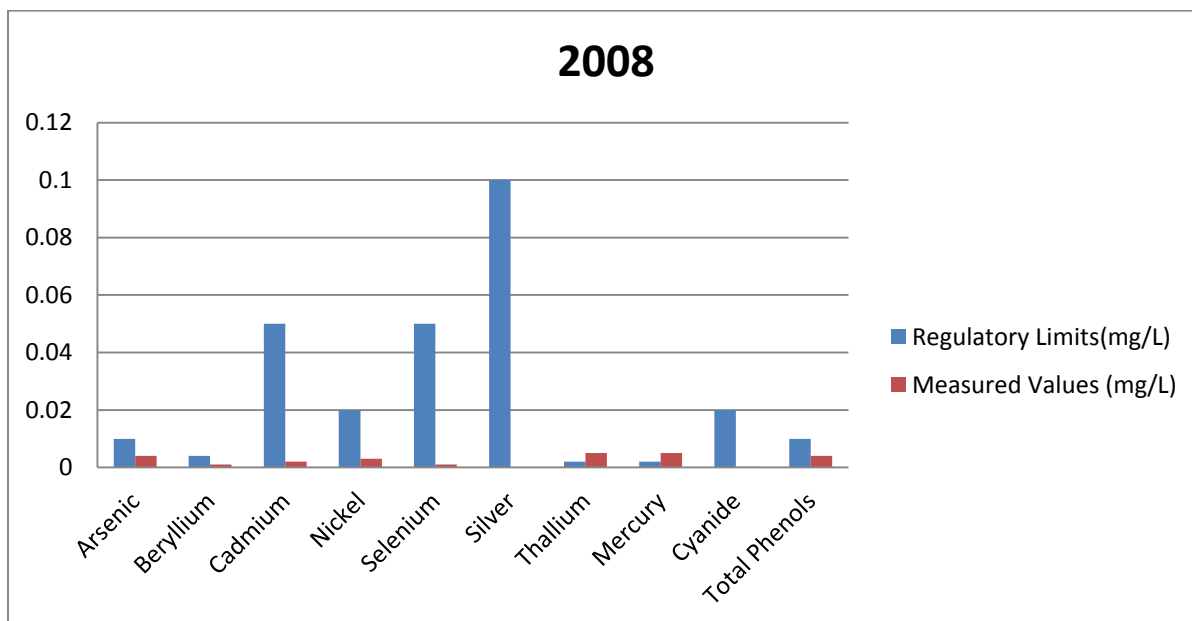


Figure 3: Parameters below regulatory limits for all sample locations in 2008

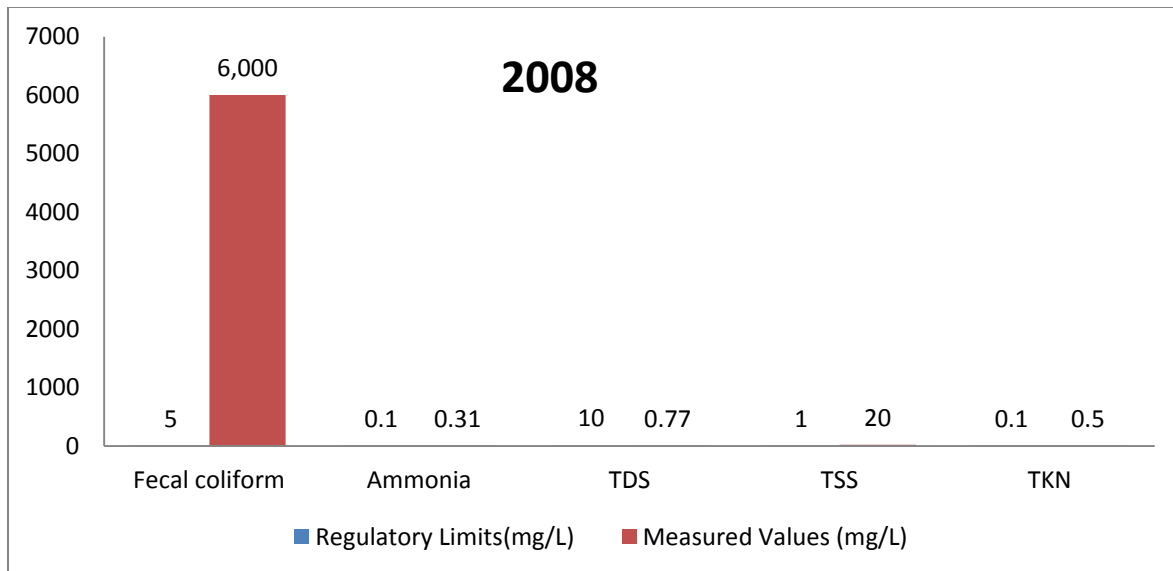


Figure 4: Parameters above regulatory limits (mg/L) for all sample locations in 2008

Figures 15-21 display the specific sampling locations where parameters were above regulatory limits from 2007-2011.

NB 100, SWPO2, and SWPO3 had only two parameters that were above regulatory limits (Figures 18, 19, and 21). RBS 14 had six parameters that were above regulatory limits which was the highest of all the sampling locations (Figure 16). RBNOO and RBS-40 both had five parameters that were above regulatory limits which was the second highest amount of parameters for all sampling locations (Figures 20 and 15).

At RBS-40 (Figure 15), RBN10 (Figure 17) and SWPO3 (Figure 21), there were two parameters, TSS and Fecal Coliform, that had extremely high measured values above the regulatory limits.

RBS-14 (Figure 16) and SWP02 (Figure 19) shows that Fecal Coliform and COD had the highest measured values versus regulatory limits. Furthermore, Fecal Coliform had measured values that were above regulatory limits for all sampling locations.

NB 100 (Figure 18) shows that both Fecal Coliform and Nitrate/Nitrite had measured values that were above regulatory limits. In addition RBN00 (Figure 20) had two parameters, TSS and Fecal Coliform, that had measured values that were extremely high above the regulatory limits.

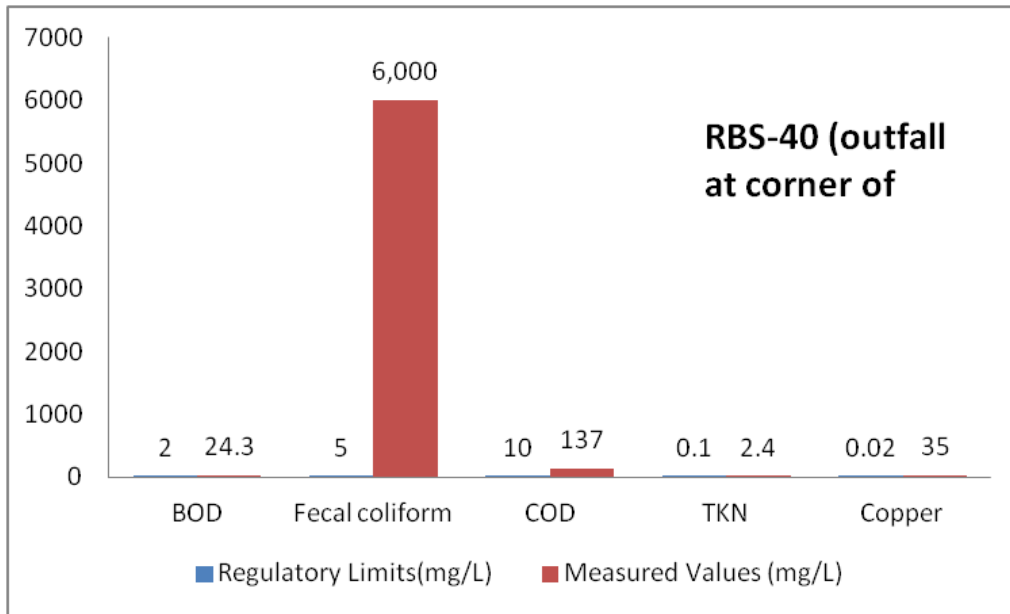


Figure 15: Parameters that exceeded regulatory limits (mg/L) at RBS-40 from 2007-2011

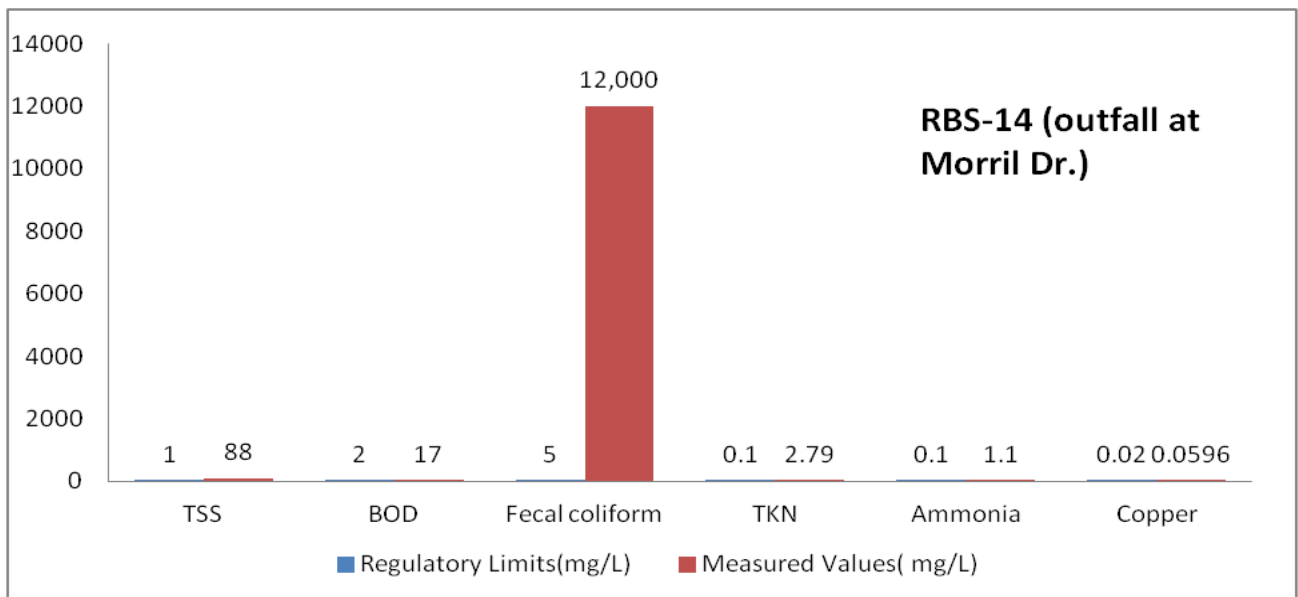


Figure 16: Parameters that exceeded regulatory limits at RBS-14 from 2007-2011

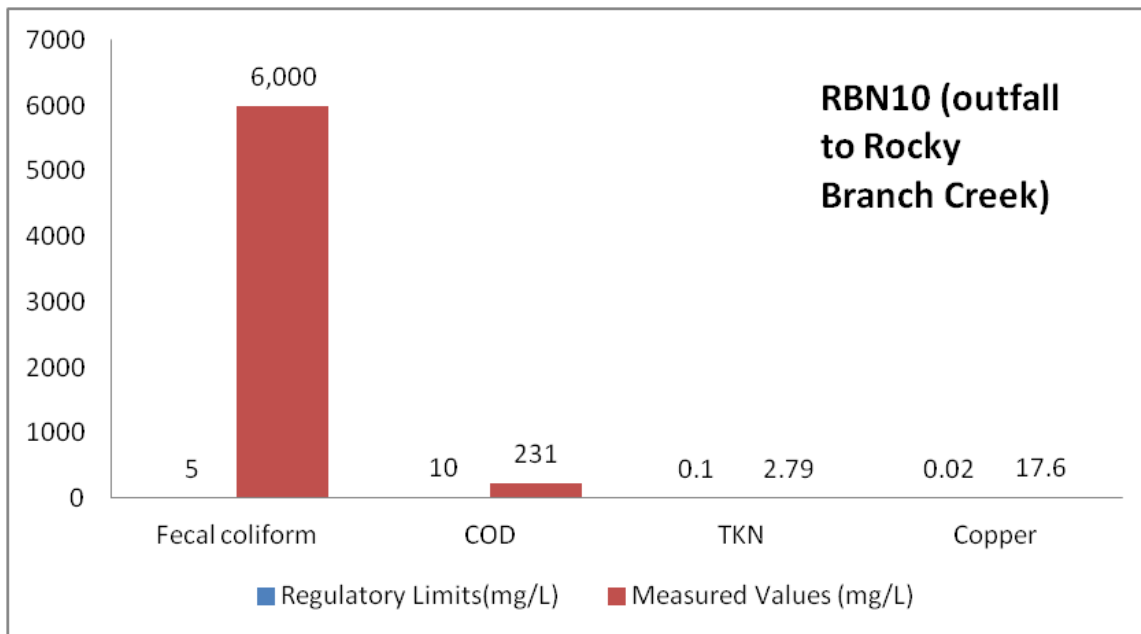


Figure 17: Parameters that exceeded regulatory limits (mg/L) at RBN-10 from 2007-2011

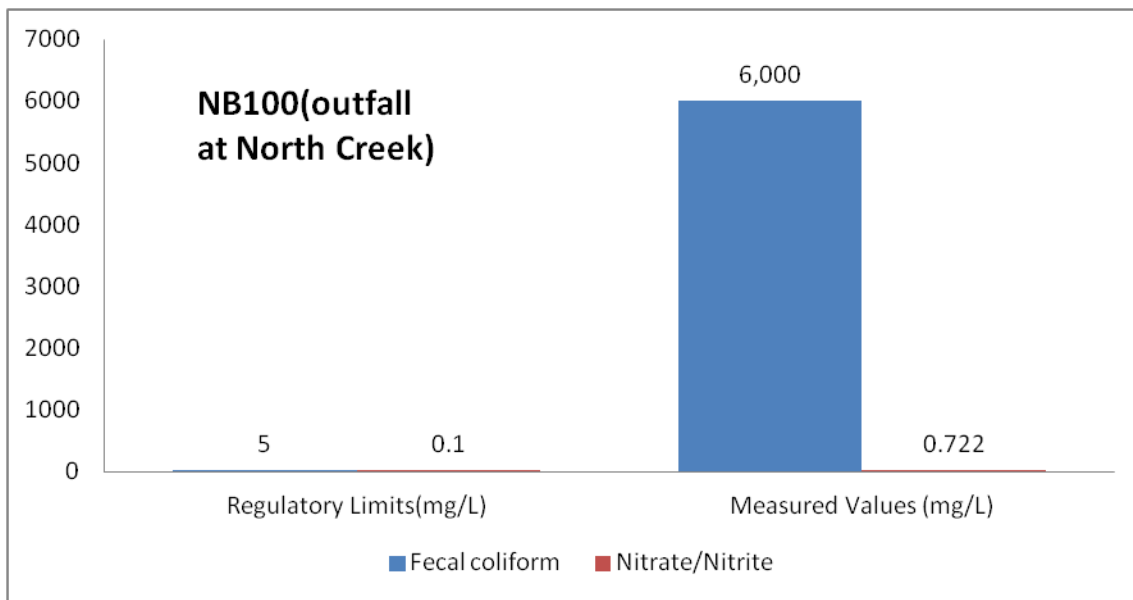


Figure 18: Parameters that exceeded regulatory limits (mg/L) at NB100 from 2007-2011

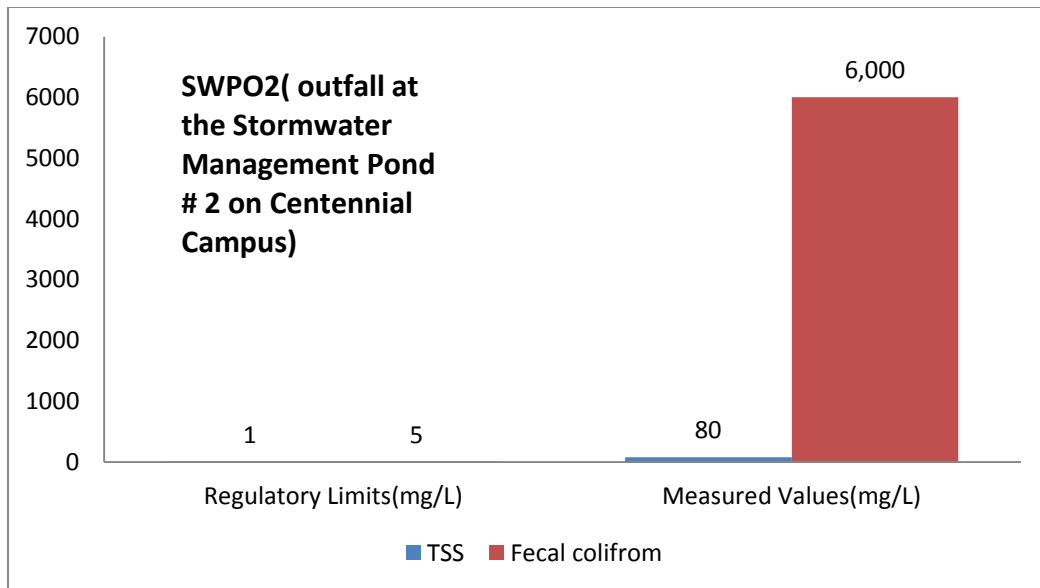


Figure 19: Parameters that exceeded regulatory limits (mg/L) at SWPO2 from 2007-2011

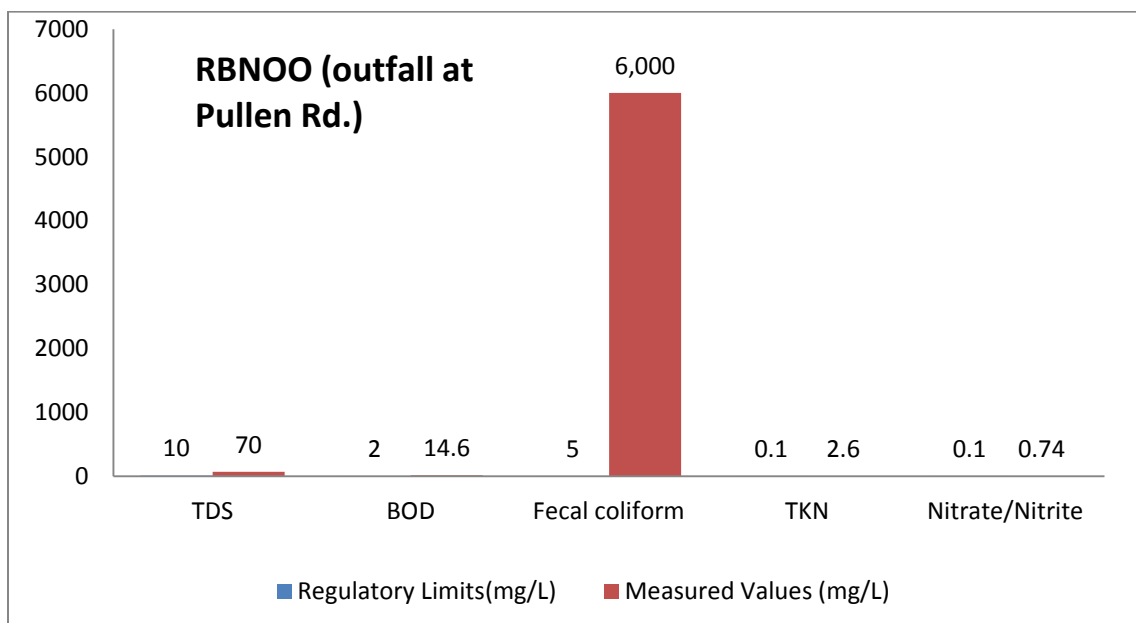


Figure 20: Parameters that exceeded regulatory limits at RBN00 from 2007-2011

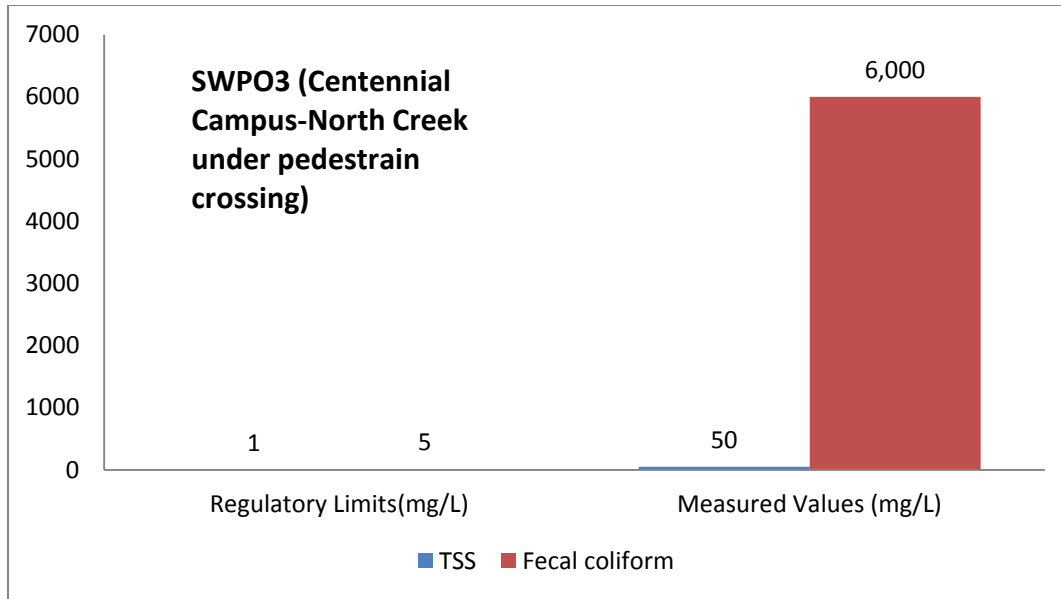


Figure 21: Parameters that exceeded regulatory limits (mg/L) at SWPO3 from 2007-2011

The correlations between trends above and below regulatory limits were analyzed and are shown in Figures 22 and 23. Nitrogen, Zinc, Ammonia, TSS, TDS, Organic Nitrogen, TKN, COD, and Fecal Coliform were the only parameters that continuously rose above regulatory limits from 2007-2011. Consequently, Arsenic, Beryllium, Cadmium, Nickel, Selenium, Silver, Thallium, Mercury, Cyanide and Total Phenols shown in Figure 23 were the only parameters that were continuously below the regulatory limits from 2007-2011. In Figure 24, the sampling results for Total Suspended Solids, Lead, Copper, and Fecal Coliform were the only parameters whose sampling results were 100% above the regulatory limit.

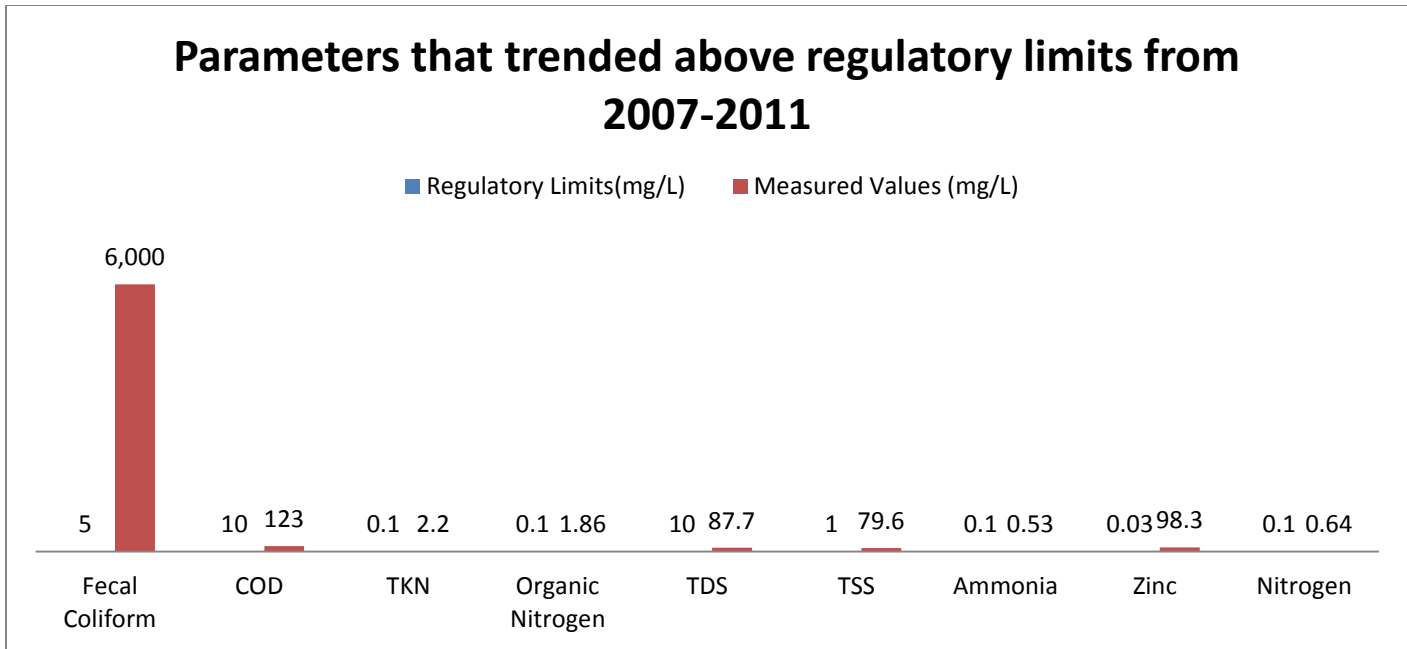


Figure 22: Parameters that trended above regulatory limits from 2007-2011

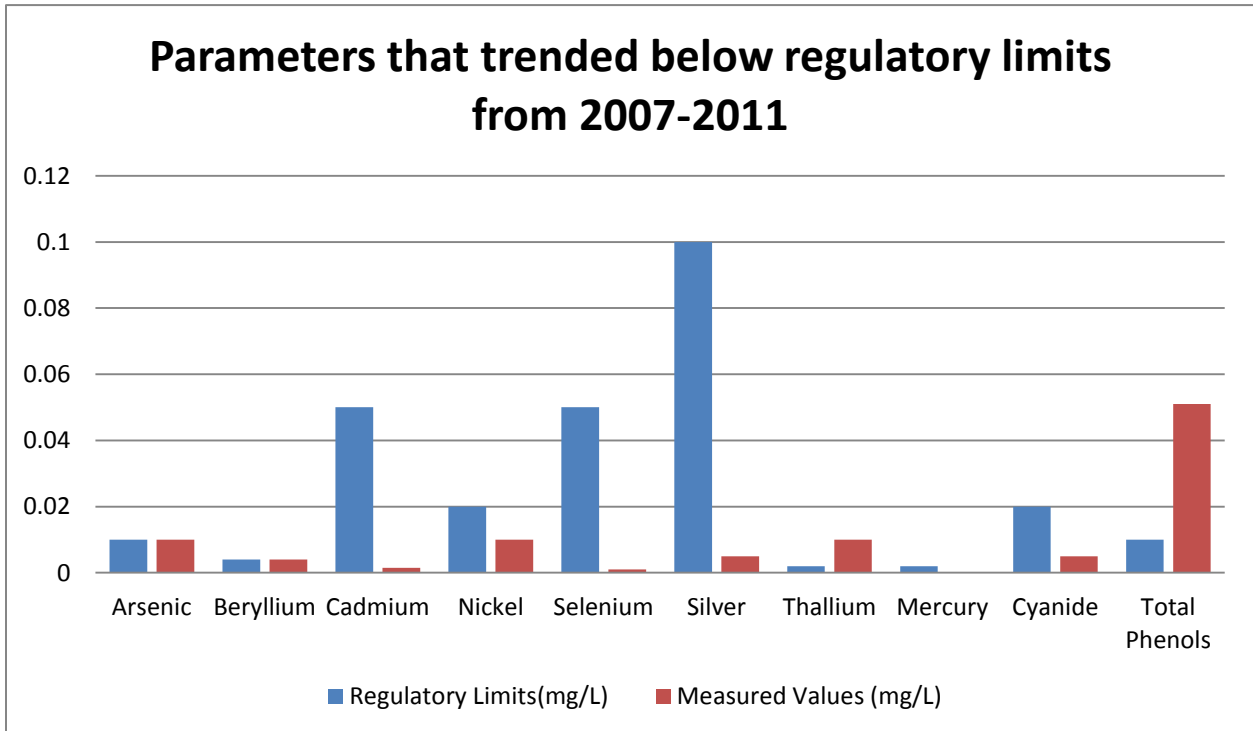


Figure 23: Parameters that trended below regulatory limits from 2007-2011

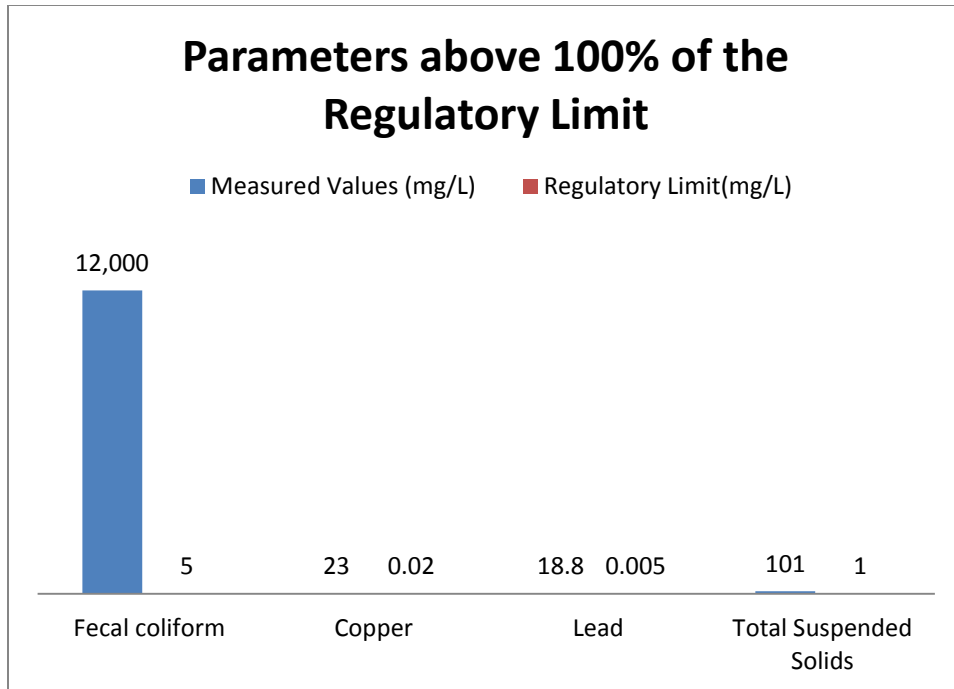


Figure 24: Parameters above 100% of the Regulatory Limit

5.1 Illicit discharges

In August 2006 there was an illicit discharge to Rocky Branch Creek as a result of an off-campus contribution (Table 1). This discharge to Rocky Branch Creek may be the reason that Fecal Coliform, TSS, TDS, COD, and BOD were extremely elevated beyond the regulatory limit. It is also possible that in March 2011 the overflow of grease, a radiator leak, and a leaking gas tank could be the cause of elevated levels of Chromium, Copper, Zinc and other pollutants to Rocky Branch Creek (Table 1). However it is certain that the pollutants which should be carefully examined are Nitrogen, Zinc, Ammonia, TSS, TDS, Organic Nitrogen, TKN, COD and Fecal coliform because they have continually risen above regulatory limits for the past five years.

Table 1: Illicit discharge reports on campus that were close to water sampling dates

Date	Description
8-8-06	Dirty water discharge to Rocky Branch-off-campus contribution
8-31-06	Root blocking a section of the sanitary sewer
7-10-08	Dead fish
8-11-08	Cloudy from Meredith college construction
9-11-09	Hydraulic oil-Gardner lot
10-1-09	Radiator leak-Wolf Village
3-1-11	Overflow of grease-Clark dining hall
3-16-11	Radiator leak-Dan Allen deck
3-18-11	Leaking gas tank-Avent Ferry complex
3-23-11	Leak in cooling tower-CVM Chiller plant

Chapter 6: Conclusion

6.1 Determining data trends

After examining the Stormwater data from the past five years, it can be concluded that there are numerous pollutants coming from outfalls throughout campus that do not meet regulatory requirements. However, it is uncertain how and when these pollutants have contaminated the waterways that run through campus.

It is difficult to determine if a certain building or area on campus is causing pollutants to flow into the waterways because none of the pollutants had the same results during any of the sampling dates. In some months there were pollutants that were above regulatory limits in the same locations, yet during the following sampling dates those same pollutants were below regulatory limits. Thus, it is difficult to determine if there are patterns to the data.

6.2 Stormwater Pollution Prevention Plans

The goal of the new stormwater pollution prevention plan will be to improve water quality on campus by 5-10 percent. However, the development of the plan alone will not improve water quality. In order to help improve the water quality of Rocky Branch Creek and other waterways on campus, there will need to be a strict enforcement of the Stormwater Pollution Prevention Plans by the EHSO and the Chancellor of the University. It is unlikely that the development of the plan alone will be effective. The development of a multi pronged approach including employee training and penalties for non-compliance will create greater probability of success. For example, when the EHSO makes yearly inspections at each facility to determine if they are following the SWPPP, then the EHSO should inform the Chancellor which facilities are not following the plan so that the Chancellor can administer some sort of consequence. By implementing consequences it will help reduce the amount of pollutants that will flow into the waterways on campus and can begin to improve the water quality.

6.3 Necessary actions

In addition to enforcing the SWPPP's, it is necessary for the EHSO to find an environmental consulting firm that will take water samples more than once or twice a year. In order to determine the health of the waterways, more samples will need to be conducted. Samples taken at least four or more times a year will allow the EHSO to determine if there are elevated levels of pollutants in the waterways and will allow them to determine if there are any trends in the data from year to year. It will also allow the EHSO to perform any immediate remediation activities to the waterways every couple of months instead of only finding out about a problem during a sampling event taken only once or twice a year.

Lastly, it is important for the EHSO to bring public awareness about Stormwater Pollution Prevention to students and staff throughout the campus. The EHSO currently informs students and staff about Stormwater Pollution at the NC State Earth Day in April of every year. Nevertheless, the EHSO needs to work on more public awareness activities. Such activities could include distributing flyers throughout campus, setting up an informational booth in the Brickyard, and even conducting informational meetings in residence halls across campus. It is important to spread awareness about what stormwater pollution is and how to prevent it in order to keep NC State's waterways free of pollutants.

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Appendix

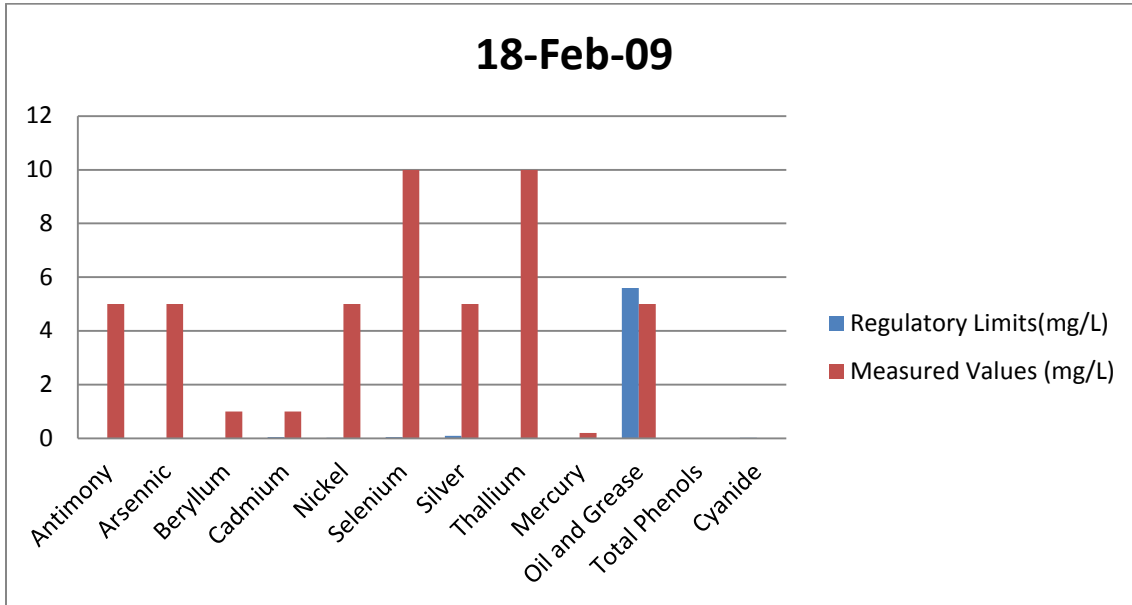


Figure 5: Parameters below regulatory limits for all sample locations on February 18, 2009

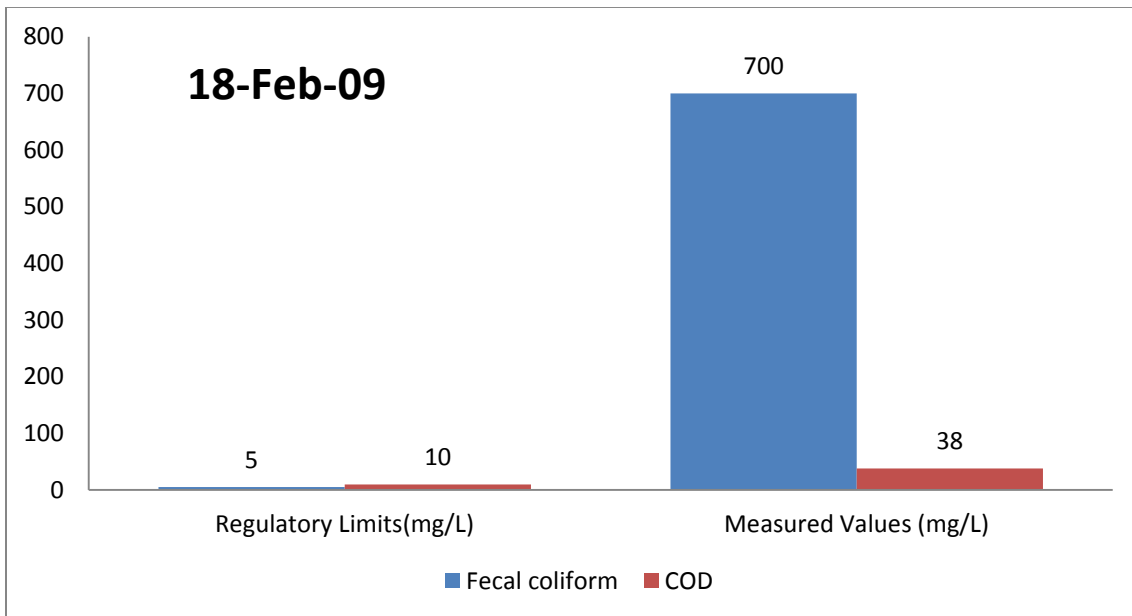


Figure 6: Parameters above regulatory limits (mg/L) for all sample locations on February 18, 2009

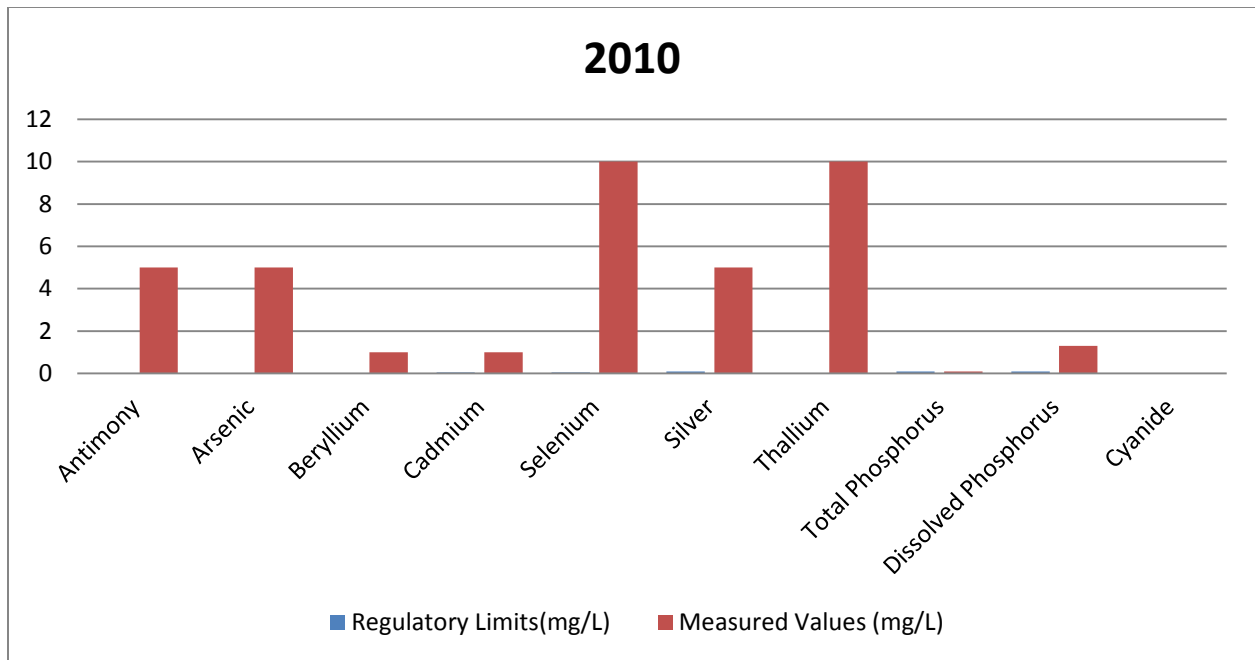


Figure 7: Parameters below regulatory limits for all sample locations in 2010

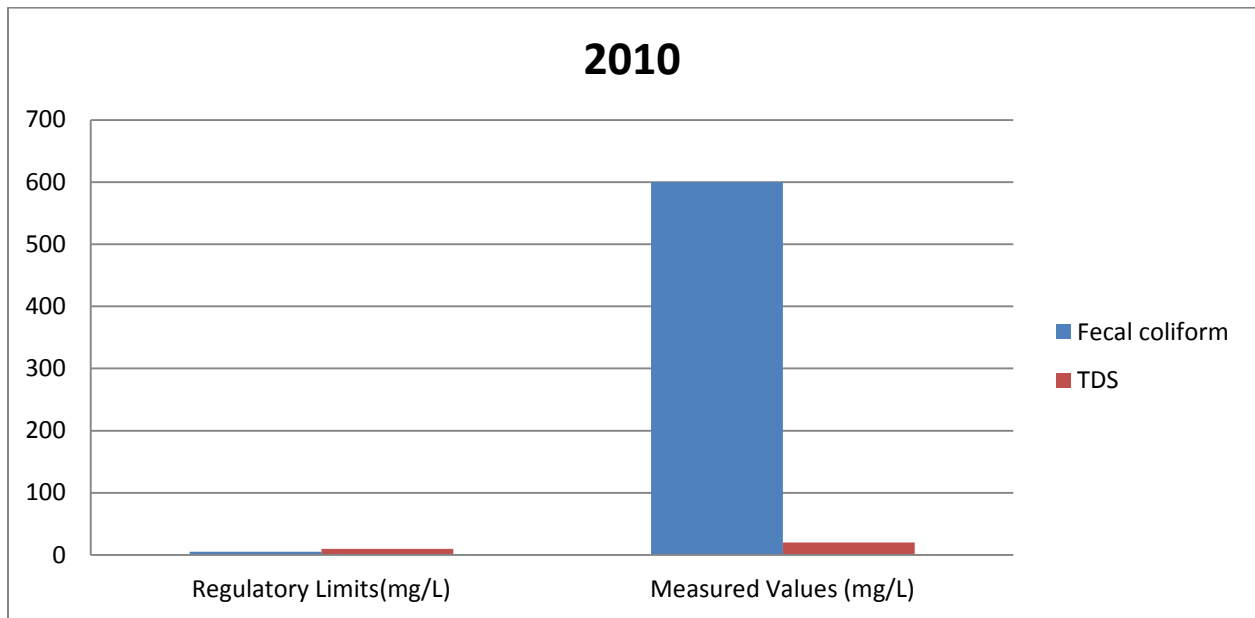


Figure 8: Parameters above regulatory limits (mg/L) for all sample locations in 2010

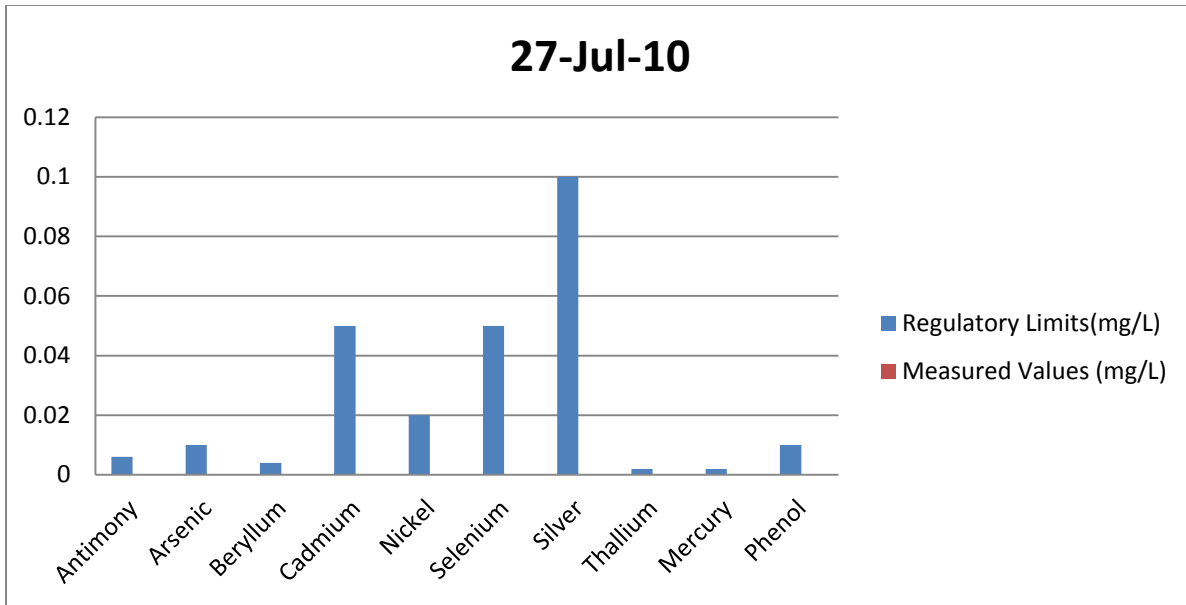


Figure 9: Parameters below regulatory limits for all sample locations on July 27, 2010

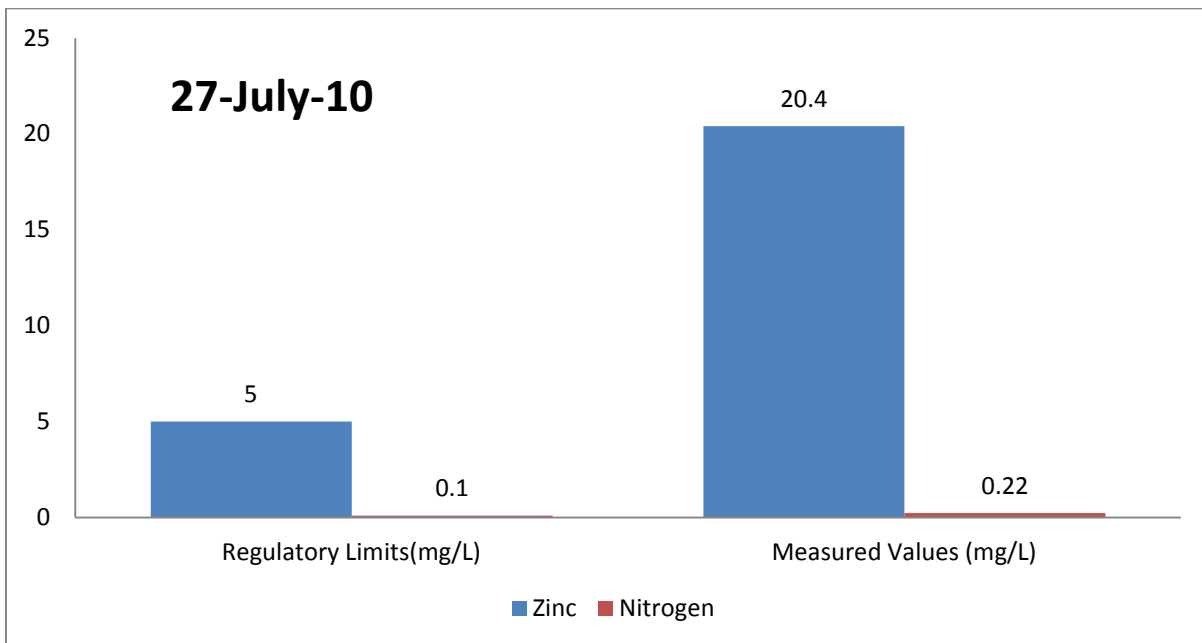


Figure 10: Parameters above regulatory limits (mg/L) for all sample locations on July 27, 2010

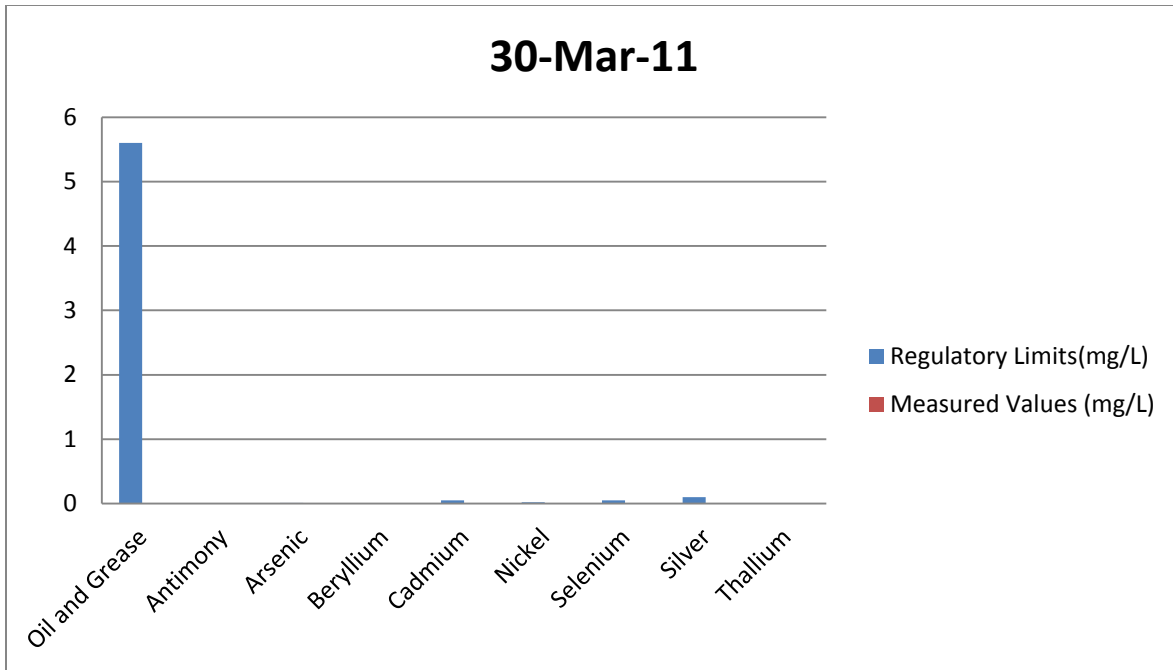


Figure 11: Parameters below regulatory limits for all sample locations on March 30, 2011

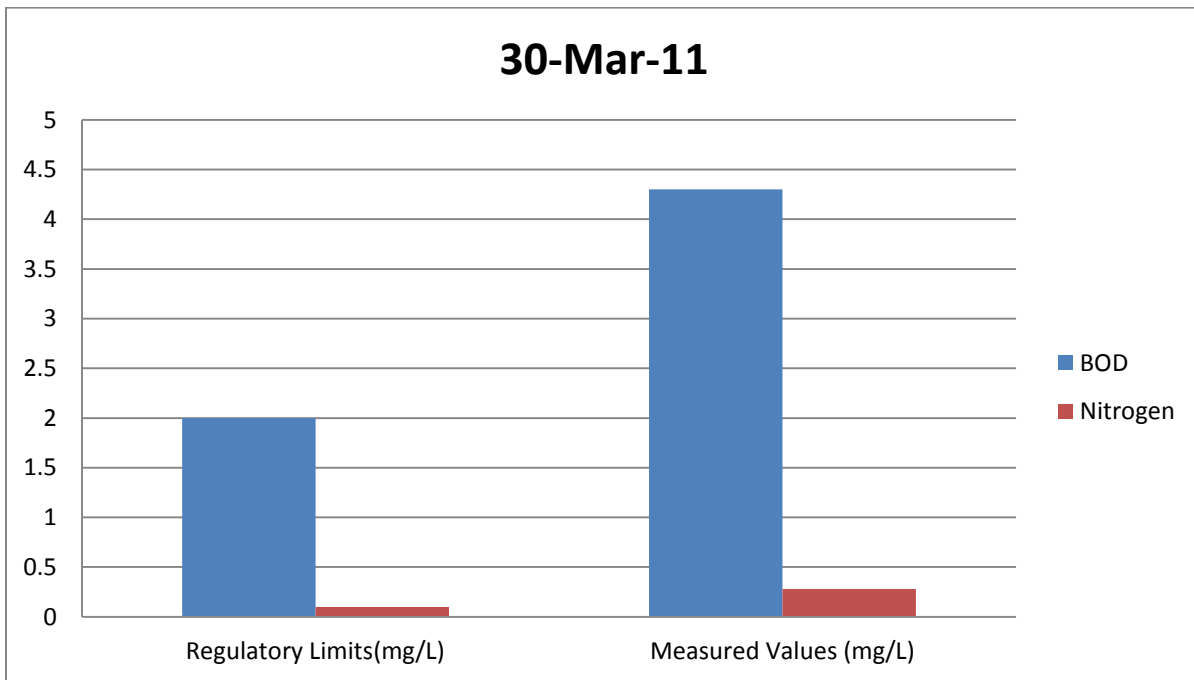


Figure 12: Parameters above regulatory limits (mg/L) for all sample locations on March 30, 2011

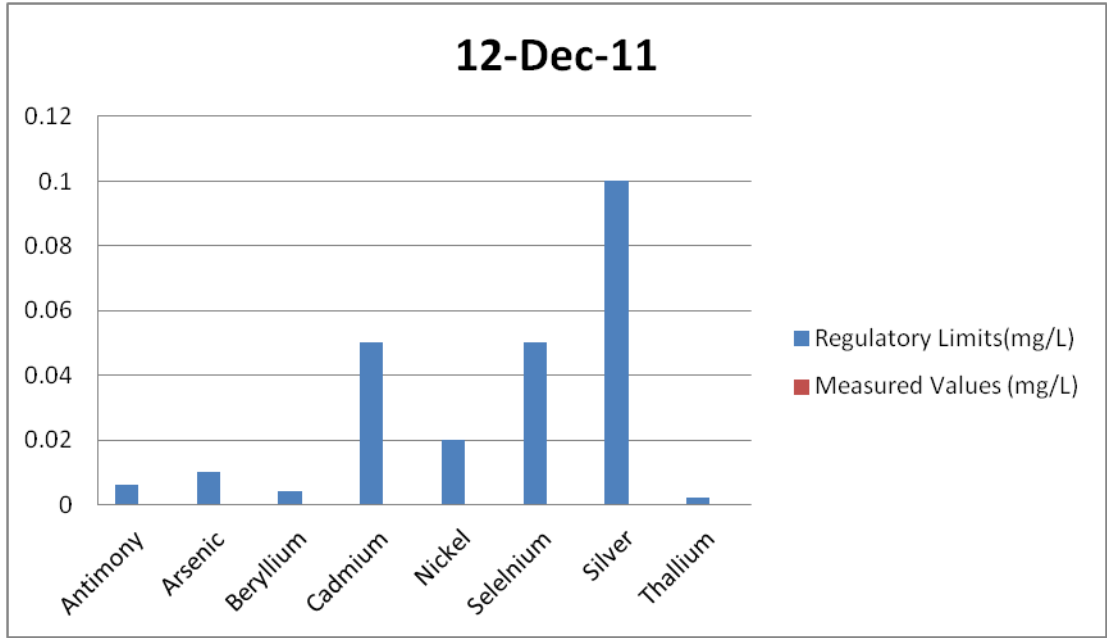


Figure 13: Parameters below regulatory limits for all sample locations on December 21, 2011

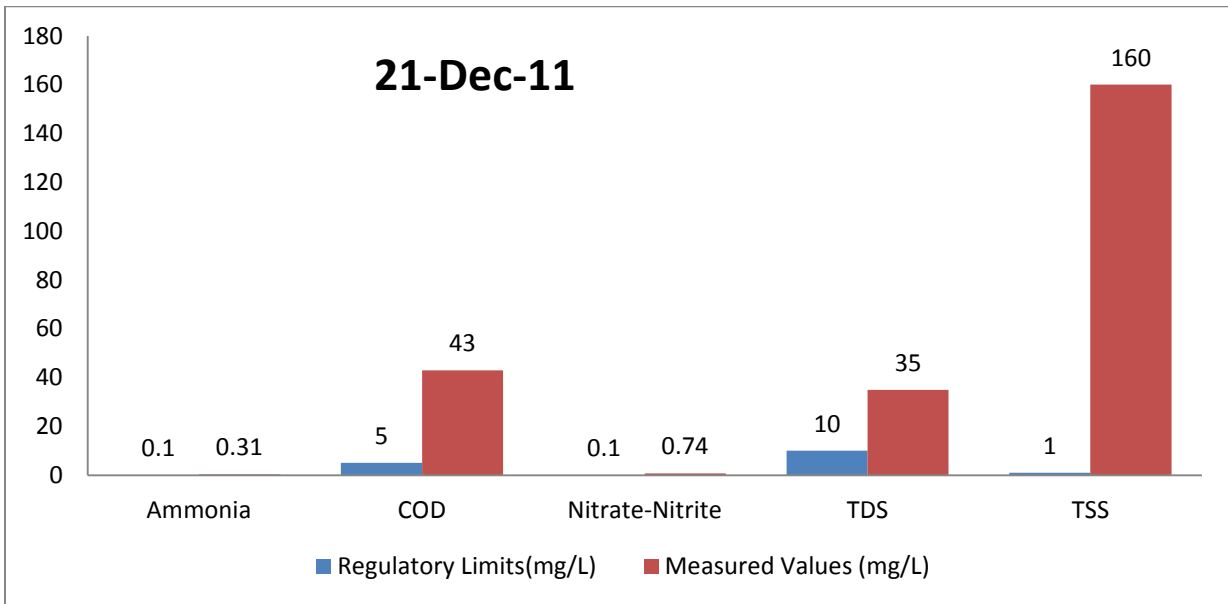


Figure 14: Parameters above regulatory limits (mg/L) for all sample locations on December 21, 2011