2011
City of Fort Collins

Lower Cache la Poudre River
&
Urban Creek

Water Quality Report

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2011 Lower Poudre River & Urban Creek Water Quality Report

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Introduction:

This 2011 Lower Poudre and Urban Creek Water Quality Report provides a water quality-focused summary of the scope, status and trends of the City's monitoring efforts on the Cache la Poudre River through Fort Collins and three urban creeks in our community. The presentation includes discussion of current and future regulatory changes and initiatives that affect the Poudre. In addition, key stormwater quality enforcement and improvement efforts, regulatory requirements, activities and associated compliance and non-compliance issues are also highlighted. Details on river and creek monitoring site locations, test parameters, key results and trends are presented. It must be noted, however, that aspects of this report are limited in scope: flow and water quality are just two of many key factors that influence and reflect the health of a river or creek. Other factors include man-made changes and activities as well as stream geomorphology and the abundance and diversity of its biological community. The ability of the biological community in a stream to survive and thrive is dependent, in part, on the quantity, quality and physical characteristics of the water flow as well as stream habitat. Future monitoring reporting efforts and programs will strive to identify, assess and explain the interdependencies that tie together the many factors affecting the health of the Poudre and urban creeks in our community.

Purpose of the Report:

In order to fulfill City Council's goal of protecting and enhancing the Poudre River as outlined in Council Resolution 92-14 "Framework for Environmental Action" and Resolution 95-14 "Approving the Watershed Approach to Stormwater Quality Management", City staff has prepared the following status report on water quality conditions in key urban creeks and the Cache la Poudre River through Fort Collins. This report also includes summaries on the 2011 status of several stormwater quality monitoring and improvement programs in the City.

Executive Summary:

In 2011 several significant regulatory changes occurred that reveal both positive and negative trends in current water quality conditions in the Poudre through Fort Collins as well as our urban creeks.

1. **Nutrient Criteria**: There is one new water quality control program under development in Colorado that will also have significant cost impacts on the design, capital improvements and long-term operation of the City's two water reclamation facilities. This regulatory program is called "Nutrient Criteria". The proposed changes focus on limiting the discharge of the key the nutrients nitrogen and phosphorus into state waterways. These nutrients can promote the growth of nuisance algae that can adversely affect water quality and disrupt the food web in lakes, reservoirs, rivers, and streams. In addition, algae blooms can create aesthetic problems (visual, taste and odor) for drinking water supplies and adversely impact

recreational activities like swimming. Additional details on this issue and its potential impacts are presented on page 14.

2. **Selenium levels in the Poudre**: Water quality conditions in the Cache la Poudre River from Shields Street downstream to just above Boxelder Creek are currently better than all WQCD-defined aquatic life stream standards except for the levels of selenium. Selenium is associated with shale and is naturally present in the soils, river- and creek-banks in our area. Over the years, higher selenium levels in the Poudre have not been observed. However, the WQCD-defined stream standard is now more restrictive and reported selenium levels exceed that new stricter standard. The selenium levels were sufficient for the WQCD to list the Poudre through the City as 303(d)-impaired for chronic exposure aquatic life standards. The WQCD gave this listing a low 303(d) priority for corrective action. Further details regarding this issue are presented on pages 10 and 12.

3. **Both Fossil Creek and Boxelder Creek are listed as "303(d)-impaired" (low priority) for high selenium levels.** Like the Poudre, exceedances of regulated selenium levels in Fossil and Boxelder Creeks were the result of new, stricter selenium standards and not reduced water quality in the creeks. City data show that high selenium levels in our urban creeks are observed during and after major storm events. In addition, any activities that erode creek banks or otherwise contribute to soil erosion can contribute to higher selenium levels in the water. Further details on this issue are presented on page 54.

4. **Both Fossil Creek and Spring Creek 303(d) listed as impaired, *high priority*, for seasonal *E. coli* contamination**: *E. coli* is an indicator of fecal contamination. Although these bacteria can be pathogens, their presence in water indicates that other water-borne disease-causing enteric bacteria (Salmonella, Shigella) may also be present. In our urban creeks, high *E. coli* levels show strong seasonal trends with the highest levels appearing during the late spring and summer months and the lowest levels during the late fall and winter. These urban creeks are listed as a "high priority" because of the corresponding high probability of human and animal contact during recreational activities in nearby parks. The State is expecting proactive corrective actions be taken on this issue. In response, additional creek water quality monitoring and field survey efforts are underway to ensure that possible illicit discharges, leakage from sewer pipes or septic systems are not contributing to the problem. Additional details on this issue are presented starting on page 59.

5. **Stormwater Monitoring Programs Underway**: The City in cooperation with Colorado State University (CSU) is conducting a wet-weather monitoring program to assess the effectiveness of existing structural stormwater Best Management Practices (BMPs) and new Low Impact Development (LID) BMPs. Data collection activities started in the winter months of 2009 and continued through 2011. Details on the stormwater quality programs begin on page 20.

Regulatory changes and corresponding impacts at the local level point to the continued need for long-term, proactive monitoring and testing programs for the Poudre and our urban creeks. Successful water quality monitoring programs will help keep our community at the forefront of environmental protection efforts and provide the data necessary for careful stewardship of our limited resources.

- ## History of the City's River, Creek and Stormwater Quality Monitoring Programs:

In the mid-1970s, the Colorado Water Quality Control Commission held its first stream classification hearings for the Cache la Poudre River. At that time, both Federal and State Clean Water Act mandates were being implemented across the state and the nation. Unfortunately, little or no water quality data were available for the Poudre as it flowed past the City's two wastewater treatment plants. At the Commission's hearings it quickly became apparent that because of this lack of data, the City was at both a tactical and strategic disadvantage: proof was needed that treated discharges from its wastewater treatment plants were not harming the river. As a result, the City initiated several long-term monitoring efforts to gather flow and water quality data to protect both the Poudre and the City's interests.

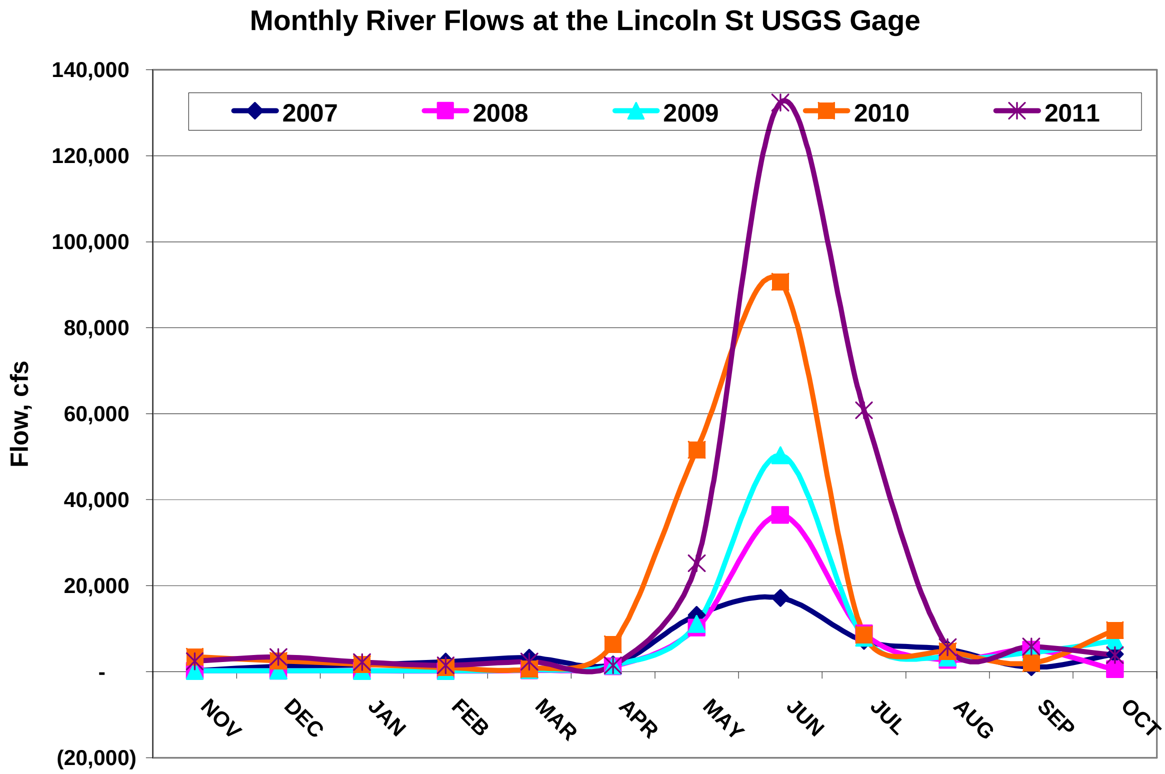
Since the late 1970s and in cooperation with the US Geological Survey (USGS), the City has been monitoring both flow and water quality in the Cache la Poudre River above and through Fort Collins. Beginning in the early 1980s, and in cooperation with Colorado State University and Kodak Colorado Division (KCD), the USGS program was expanded to include assessments of the fish and benthic macro-invertebrate communities in the Poudre. At that same time, City staff from the Pollution Control Lab began weekly water quality monitoring both up- and down-stream of the City's two wastewater treatment plants. The City-CSU-KCD cooperative program expanded in 2007 to form the Poudre Monitoring Alliance.

The Poudre Monitoring Alliance is part of EPA's award winning *Performance Track* program. It brings together under one roof the monitoring efforts of the City, Boxelder and South Fort Collins Sanitation Districts, the Town of Windsor, KCD and the City of Greeley. The alliance monitors over 42 miles of the Poudre at ten separate sites from Lincoln Street to its confluence with the Platte. In May 2007, the Utility received a letter of appreciation from Dave Akers, manager of the Clean Water Facilities program of the Colorado Water Quality Control Division commending the City's thirty year commitment to on-going water quality monitoring on the Cache la Poudre River. In the late fall of 2007, the City received a letter of recognition from then Senator Ken Salazar lauding the example of the Poudre Monitoring Alliance for on-going regional cooperation.

Since 1984, the City has monitored water quality in Parkwood Lake. Beginning in 2000, the City's water quality monitoring program was expanded to include routine testing at three urban creeks: Boxelder Creek, Spring Creek and Fossil Creek. In 2003, the stormwater quality monitoring program initiated a water quality assessment of the effectiveness of the Udall treatment site below Lincoln Street.

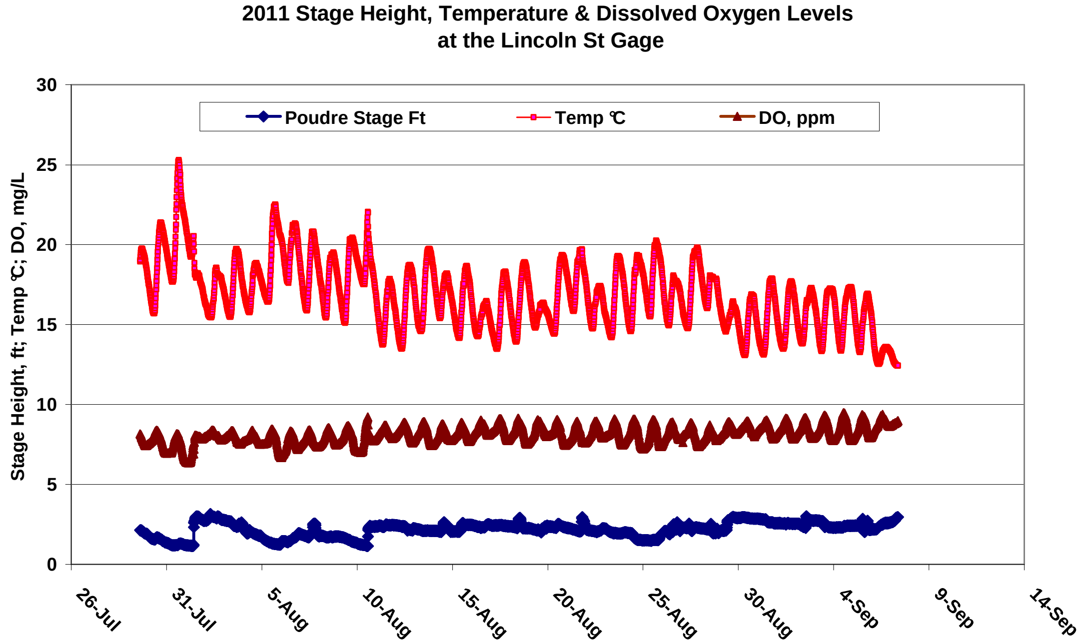
- **Agencies with Monitoring Activities on the Poudre & Urban Creeks in Fort Collins:**

Natural water bodies in the Fort Collins area are actively monitored at numerous locations to evaluate the impacts of human and natural activities on water quality. Water quality datasets for some sites in the City begin in the mid-1970s. The Cache la Poudre River, as it flows through town from Shields Street to Boxelder Creek (Segment 11), is currently sampled and tested by several agencies, including: the City of Fort Collins, Colorado State University (CSU), the Colorado Water Quality Control Division (WQCD), the Colorado Department of Health & Environment (CDPHE), the U.S. Geological Survey (USGS), In-Situ, Inc., Boxelder Sanitation District, and RiverWatch.

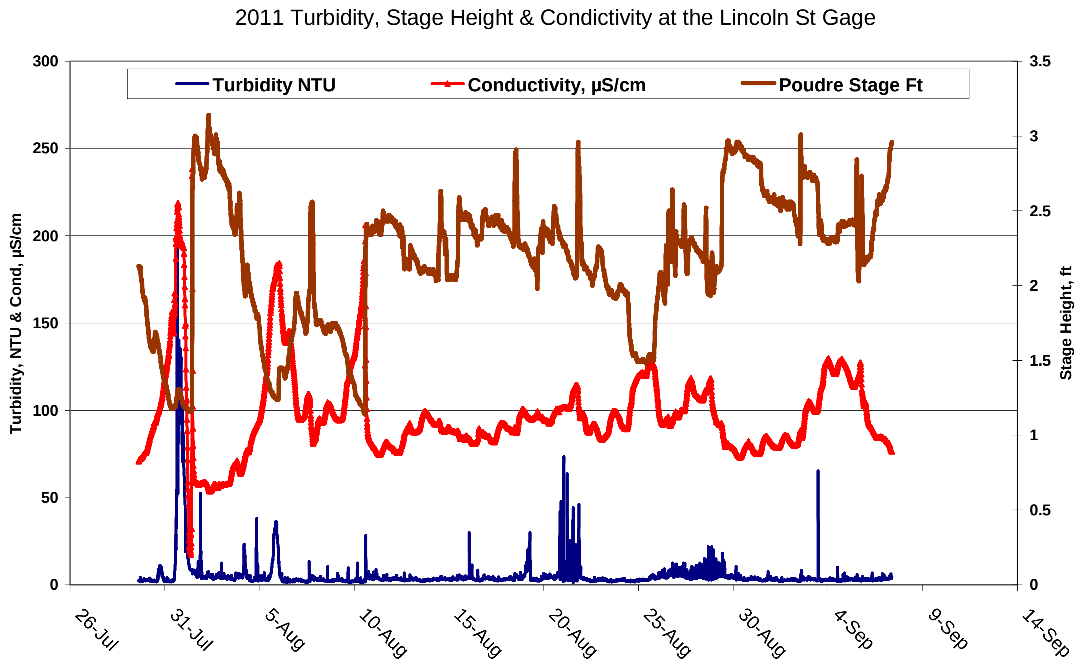


2011 spring runoff flows in the Poudre were substantially above the levels observed in several previous years. The presence of large numbers and biomass of brown trout observed during the November 2011 CSU fish surveys may have been in part a results of these higher than normal flows.

Stage Height, Temperature and Dissolved Oxygen Levels in the Cache la Poudre River at the Lincoln St Gage. The following data was collected in cooperation with In-Situ®, Inc. as part of an on-going program to monitor water quality in the Poudre in “real time”. The data show the daily cycles observed in water temperature and dissolved oxygen levels in the water.



Telemetry captured a significant storm event during the first week in July. Data showed an inverse relationship between flow and conductivity (salinity) and a parallel surge in turbidity was observed with increased flow.



This and other real-time water quality data from this site are collected and relayed to an on-line database using instrumentation provided by In-Situ®, Inc. Data can be viewed and downloaded in near real time via the internet.

Water Quality Monitoring Locations, Test Parameters and Test Frequencies:

Location details for the City's water quality monitoring sample sites on the Cache la Poudre River are presented in **Appendix A**. The table includes sites routinely checked by the staff from the Utility's Pollution Control Lab plus river sites that are part of the Poudre Monitoring Alliance. **Appendix B** provides details on the 2011 monitoring locations and test frequencies for the Cache la Poudre River and six urban creek sites, respectively. In addition, maps of the Boxelder Creek, Spring Creek and Fossil Creek watersheds are presented

Currently there are four key monitoring sites on the Poudre in Fort Collins that are checked each week by staff from the Pollution Control Lab:

1. the Lincoln Street USGS Gage (06752260),
2. a site upstream of Prospect Street,
3. at the Nature Center above the Drake Water Reclamation Facility (DWRF), and
4. at the USGS Boxelder Gage (06752280) located upstream of the confluence of the Poudre with Boxelder Creek above I-25.

Moving downstream from the Boxelder Gage to the confluence of the Poudre with the South Platte, there are six additional river sites that combine to form the ten water quality test locations for the Poudre Monitoring Alliance.

To evaluate the potential impacts of the City's two wastewater treatment plants on the Cache la Poudre River, the Utilities sponsors a biosurvey program of fish and bottom-dwelling invertebrates in the river both upstream and downstream of the City's water reclamation facilities. CSU provides the field experience and technical expertise for these studies. The City, Carestream Health, Inc (formerly Kodak Colorado Division) and CSU have participated for 30 years, and Boxelder Sanitation District joined the program eight years ago. At a location on the Poudre downstream of Martinez Park, the City and Carestream share the costs of the biosurvey program.

Beginning in 2007, the biosurvey program became an integral part of the Poudre Monitoring Alliance. For the City of Fort Collins and as part of the regional Poudre Monitoring Alliance, this biosurvey program includes: 1) testing four sites eight times each year for bacteriological, physical, and chemical parameters, 2) testing three sites four times each year for benthic macro-invertebrate population abundance and diversity, and 3) testing two sites once each year for fish abundance and diversity. Overall the data show strong seasonal trends with generally the highest species diversity and population numbers in early summer months. Similarly, the data show that the Poudre below Shields Street to the confluence with the Platte is primarily flow and habitat-limited rather than water quality-limited.

Poudre & Municipal Separate Stormwater System (MS4) Water Quality Monitoring Programs and Associated Cost:

2011 Monitoring Program Description	Cost	Comment
USGS: 2011 U.S. Geologic Survey cooperative monitoring program for six flow and two water quality sites on the Cache la Poudre from the Michigan River near Cameron Pass to the gage station upstream of Boxelder Cr.	$133,700	City's share: $91,920. Federal funds cover the remaining portion of the cooperative program.
Poudre River: City's Pollution Control and Water Quality Lab monitoring on Cache la Poudre River at both up- and down-stream sites from water reclamation facilities with both a weekly schedule and 8 special data collections for the Poudre Monitoring Alliance including the CSU fish and benthic macroinvertebrate surveys.	$92,152	Cost value of field sampling, field measurements and lab work; includes City's portion of Lower Poudre Monitoring Alliance Program.
Urban Creeks: City's Pollution Control and Water Quality Lab quarterly monitoring at two sites on three urban creeks plus Parkwood Lake at three locations twice each year.	$6,939	Cost value of field sampling, field measurements and lab work.
2011 **CSU** Fish and Macro-invertebrate Biosurveys on the Poudre through the City as part of the Lower Poudre Monitoring Alliance Program	$22,250	Part of the Lower Poudre Monitoring Alliance Program
Municipal Separate Stormwater System (**MS4**) Permit Compliance Program	$210,000	Managed by the Division of Government and Regulatory Affairs

In 2011, the City committed over $538,000 to collect both flow and water quality data on the lower Cache la Poudre River as well as water quality data on key urban creeks, Parkwood Lake, stormwater and for MS4 permit compliance. USGS data is used to help manage operations at the City's two water reclamation facilities and to manage its extensive water rights portfolio. The data is also used to assess regulatory compliance and stormwater impacts on key urban creeks in the City as well as the river.

Is the Cache la Poudre River through Fort Collins Meeting All Stream Standards? *No*, Selenium levels exceed the aquatic life stream standards.

Water quality conditions for the Cache la Poudre are reviewed approximately every five years by the Water Quality Control Division (WQCD) of the Colorado Department of Public Health and Environment (CDPHE). This review is used to develop new stream classifications and standards, to identify exceedences in water quality standards and then to subsequently develop discharge permit limits for industries, communities and sanitation districts. Permitted discharge limits are designed to protect public health as well as aquatic life in the receiving stream. The WQCD completed a review of the Poudre through Fort Collins in 2010. A summary of their findings is presented in the following table:

Poudre Water Quality: Standards vs. Actual Test Results. 2010 report from the Colorado Water Quality Control Division for Segment 11 of the Cache la Poudre from Shields Street to Boxelder Creek just upstream of I-25.

Parameter	**TVS†**	**Results‡**	**# of Tests**	**Meeting Std?**
pH, std units	6.5 – 9.0	7.6 – 8.51	438	Yes
Dissolved Oxygen, mg/L	5	8.4	384	Yes
Hardness, mg/L as CaCO3	NA	284	448	Yes
E. coli # / 100ml	126	24	185	Yes
Arsenic, dissolved, µg/L	7.6	0	112	Yes
Cadmium, dissolved, µg/L	0.93	0	148	Yes
Copper, dissolved, µg/L	21.81	2.77	330	Yes
Iron, dissolved, µg/L	NA	69	286	Yes
Iron, total recoverable	1000	180	264	Yes
Lead, dissolved, µg/L	7.67	0	145	Yes
Manganese, dissolved, µg/L	2335	53.4	119	Yes
Selenium, dissolved, µg/L	**4.60**	**5.4**	**205**	**No**
Silver, dissolved, µg/L	1.93	0	208	Yes
Zinc, dissolved, µg/L	302.5	23.2	147	Yes
Uranium, dissolved, µg/L	4738	9.4	5	Yes
Ammonia-N, mg/L	TVS	0.3	381	Yes
Nitrate-N, mg/L	100	1.18	252	Yes
Sulfate, mg/L	NA	282.4	75	Yes

Derived from "Colorado Department of Public Health & Environment. Water Quality Control Commission, Regulation No. 38, WQCD Exhibit 38-11, June 2009..

† = TVS: Table Value Standard µg/L = part per billion mg/L = part per millions

‡ Results from the Water Quality Control Division, US Geological Survey, RiverWatch, Boxelder Sanitation District and the City of Fort Collins. Selenium exceedences on the Cache la Poudre were reported by RiverWatch. TVS stream standard for Selenium was reduced by the EPA to a lower level in 2001. Selenium exceedences were the result of stricter standards, more reported data and not a change resulting in deterioration of water quality.

The chronic dissolved selenium standard was exceeded in the Cache La Poudre River at the USGS gage above Boxelder Creek (BSD #Station 4), at Lee Martinez Park (Riverwatch, RW #599), at Prospect Rd. (RW #602), and above Boxelder Creek (USGS #6752280). The acute dissolved copper standard was exceeded in the Cache La Poudre River at Lee Martinez Park (RW #599).

303(d) Listing of *Impaired* Waters on the Cache la Poudre River

In accordance with Section 303 of the Clean Water Act (PL 92-500), the Colorado Water Quality Control Division (WQCD) evaluates waters every two years to determine if they are impaired from meeting their water quality criteria. Waters that are determined to be impaired are added to the State's 303(d) list and become eligible for grant funds to determine the cause of impairment. Based on data collected in part by the City, the Cache la Poudre River, below the confluence with Boxelder Creek and then east to the South Platte River was put on the State's 303(d) list for high *E. coli* levels in 2004. The presence of *E. coli* is an indicator of fecal contamination in the water. This has been a long-term issue on the lower reaches of the Cache La Poudre and is attributed primarily non-point source, stormwater runoff and irrigation return waters from agricultural operations.

Table 3 presents a summary of the 303(d) listing status for the Cache la Poudre River from the Monroe diversion through the various classification segments to its confluence with the Platte River east of Greeley.

However, both Fossil and Boxelder Creeks as well as Segments 11 and 12 of the Poudre below Shields Street are listed as 303(d) impaired for selenium values that exceed the aquatic life chronic table value stream standard of 4.6 µg/L (part per billion). The following paragraph provides details on the toxicity, nature and fate of selenium in waters and the environment:

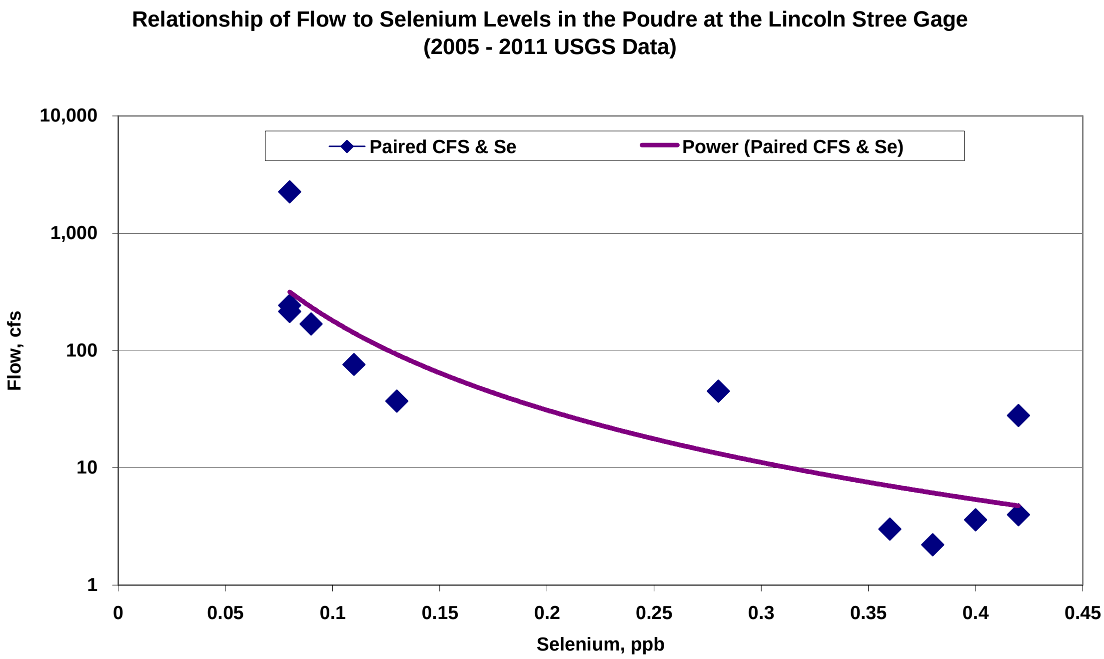
> *"Selenium is an essential nutrient for humans and animals. There is a narrow margin between too little and too much selenium. Selenium can be harmful to humans at 5 to 10 times recommended daily dose (55 micrograms per day for adults). Selenium is more toxic to vertebrates than to invertebrates and plants. Selenium is more toxic to fish and wildlife than to humans. Selenium "bioaccumulates" in the food chain, when selenium is ingested in amounts greater than the body needs, the excess selenium is not excreted, but instead is retained within the body. As organisms are preyed upon by other animals higher on the food chain, the predator takes on the entire body burden of selenium carried by the prey. High concentrations of selenium can result in adverse impacts to birds and fish, including selenium poisoning and reproductive toxicity. Extremely high concentrations of selenium can result in adverse impacts to livestock."* (Source: Fountain Creek Watershed Group, Pikes Peak and Pueblo Areas Council of Governments)

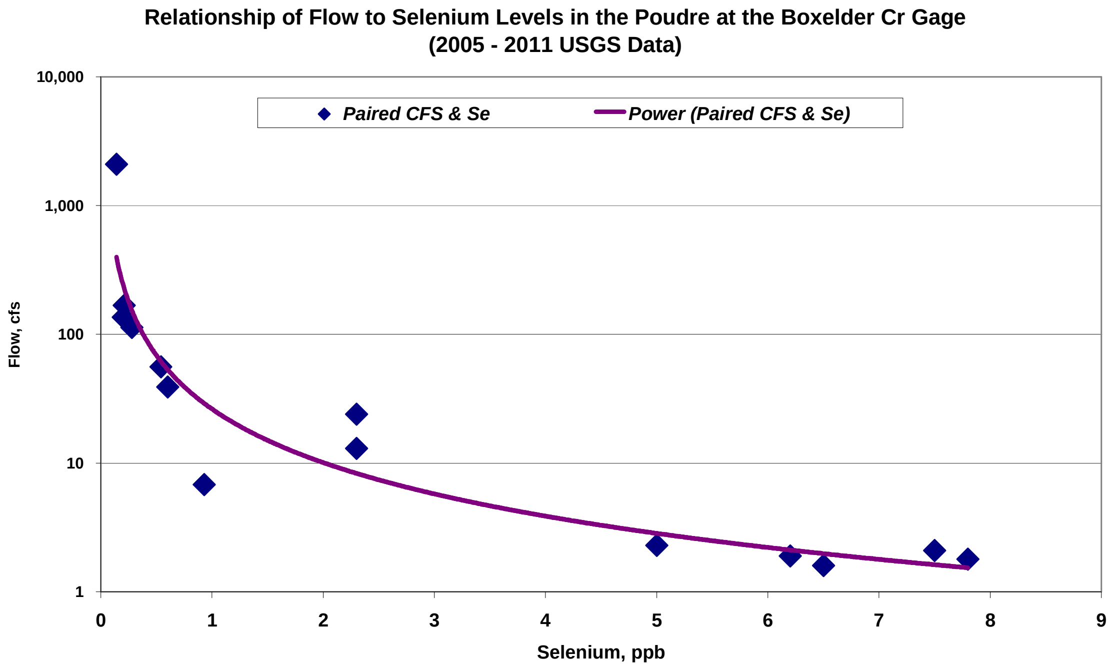
It should be noted that the selenium-impaired listings given in the following table are a result of a lower EPA and CDPHE aquatic life stream standard and <u>not</u> changing water quality. For comparison, the safe drinking water standard for selenium is 50 µg/L (microgram per liter or part per billion, ppb) and Fort Collins drinking water contains less than 1 µg/L or less than 1 ppb.

2010 Colorado 303(d) Listing of Impaired Waters on the Cache la Poudre River:

River Segment COSPCP ID#	Segment Description	Designation	Use Classifications	Portion	Impairment	State's Priority	Easy Fix?
10	**Cache la Poudre River, Monroe Canal to Shields Street**	Anti-Degradation Review (ADR) in 2009†	Aquatic Life Cold 2 Recreation E Water Supply Agriculture	Below confluence with North Fork	**pH, Copper**	Medium	No
11	**Cache la Poudre River, Shields St to Boxelder Cr**	ADR in 2009†	Aquatic Life Warm 2 Recreation E Agriculture	All	**Selenium**	Low	No
12	**Cache la Poudre River, Boxelder Cr to S. Platte River**	ADR in 2009†	Aquatic Life Warm 2 Recreation E Agriculture	All	**Selenium / *E. coli***	Low / High	No
13a	All tributaries to the Cache la Poudre River, including all lakes reservoirs and wetlands, from the North Fork of the Cache la Poudre River to the confluence with the South Platte River; **Spring and Fossil Creeks**	--	Aquatic Life Warm 2 Recreation E Water Supply Agriculture	Spring Cr & Fossil Cr	**Selenium for Fossil Cr / Seasonal *E. coli* both Fossil and Spring Creeks**	Low / High	No
13b	**Boxelder Creek** from source to the Cache la Poudre River	--	Aquatic Life Warm 2 5/15-9/15 Recreation P 9/16-5/14 Recreation N Agriculture	All	**Selenium / Seasonal *E. coli***	Low / High	No
22	**Fossil Cr Reservoir**	Use Protected Status Renewed in 2009	Aquatic Life Warm 2 Recreation E Water Supply Agriculture	Fossil Creek Reservoir	Selenium	Low	No

Derived from: Colorado Department of Public Health and Environment; Water Quality Control Commission; 5 CCR 1002-93 April 2008; Regulation #93; Section 303(d) list water-quality-limited segments requiring TMDLs. † Moved to "Reviewable" Anti-Degradation Status by the Water Quality Control Commission on 09 June of 2009.





At both of the USGS gaging stations in Fort Collins, ambient selenium concentrations increased as the flow decreased. This may reflect the effect of selenium-laden groundwater recharge to the river under low flow conditions and conversely, dilution during periods of high flow.

Colorado Nutrient Criteria for Lakes, Reservoirs, Rivers & Streams

Background:

Nutrient criteria were adopted in the March 2012 Regulation 31 Basic Standards Hearing. In preparation for that hearing, the Colorado Department of Health and Environment (CDPHE) - Water Quality Control Division (WQCD) has developed preliminary criteria for total phosphorus and total nitrogen.

The nutrient criteria will consist of both a "**Control Regulation** 85" for permitted dischargers and a set of "**Stream Standards**" spelled out in the Water Quality Control Division's Regulation 31:

- The **Control Regulation** will define technology-based requirements for dischargers to "control" the release of nutrients and will be based on best available technology (BAT):

Control Parameter	Annual Median Effluent Concentration	95 Percentile Effluent Concentration
Total Phosphorus	1.0 mg/L	2.5 mg/L
Total Inorganic Nitrogen (TIN)	15 mg/L	20 mg/L

Other requirements of the proposed control regulation include:

- o Municipal Separate Stormwater System (MS4) control measures:

  Public education and outreach targeting potential nutrient sources and
  Identification and control of nutrient sources from municipal operations

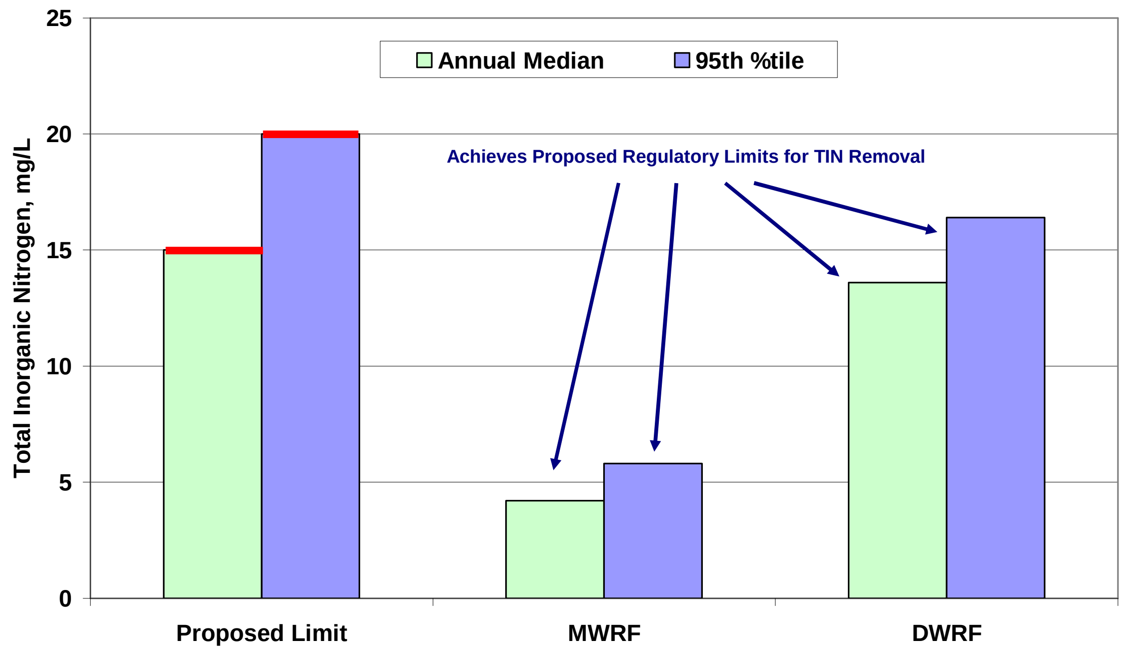
- o Proposed Monitoring requirements for Publicly Owned Treatment Works (POTWs):

  Monthly effluent monitoring for total inorganic nitrogen (TIN) and phosphorus and
  Monthly in-stream monitoring above and below the POTW discharge

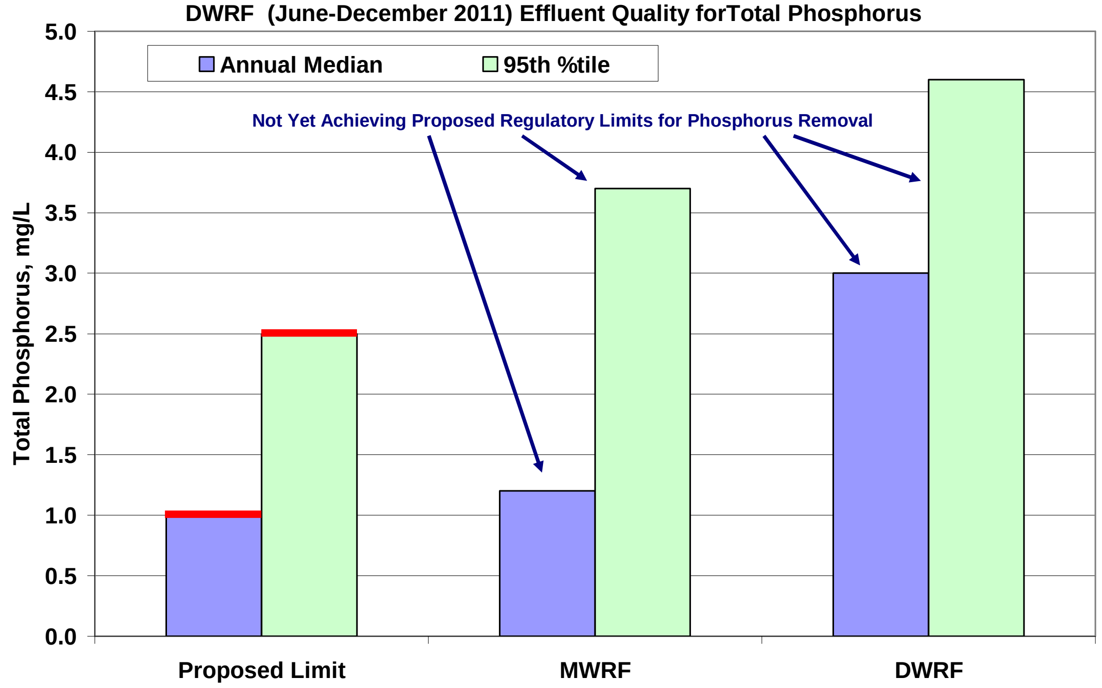
- o Proposed Monitoring Requirements for MS4s:

  Both wet and dry weather monitoring at representative outfalls throughout the MS4

Comparison of Proposed Reg85 Limits to MWRF (July - December 2011) & DWRF (June - December 2011) Effluent Quality for Total Inorganic Nitrogen (TIN)



Comparison of Proposed Reg85 Limits with MWRF (July-December 2011) & DWRF (June-December 2011) Effluent Quality forTotal Phosphorus



- **Stream Standards:** Regulation 31 will set water quality standards based on protection of designated uses and these standards will be based on best available science.

  The WQCD has developed the following preliminary stream standards for total phosphorus and total inorganic nitrogen levels for rivers and streams:

Proposed Nutrient Criteria Regulated Standards for Rivers and Streams (*From Shields Street to the Platte, the Poudre is classified as "warm water"*).
:

Designation	Total Phosphorus†	Total Nitrogen (TN) ‡	Chlorophyll-a[a]
Cold Water	0.11 mg/L	1.25 mg/L	150 mg/m^2
Warm Water	0.17 mg/L	2.01 mg/L	150 mg/m^2

† Running annual median of Total Phosphorus (µg/L), allowable exceedence frequency of 1-in-5 years.
‡ Running Annual median Total Nitrogen (TN). TN is the sum of the levels of Total Kjeldahl Nitrogen, Nitrate-Nitrogen and Nitrite-Nitrogen.
[a] Summer (July 1 – September 30) maximum attached algae, not to exceed.

Proposed Nutrient Criteria Regulated Standards for Lakes and Reservoirs *(Fossil Creek Reservoir, the receiving water for treated DWRF effluent, is classified "warm water" but is **not** a drinking water supply)*:

Designation	Total Phosphorus†	Total Nitrogen (TN) ‡	Chlorophyll-a[a]
Cold Water	0.025 mg/L	0.426 mg/L	8 µg/L
Warm Water	0.083 mg/L	0.91 mg/L	20 µg/L

1. Summer (July 1 – September 30) average Total Phosphorus (µg/L) in the mixed layer of lakes (median of multiple depths), allowable exceedence frequency of 1-in-5 years.
† Total Nitrogen (TN) is the sum of the levels of Total Kjeldahl Nitrogen, Nitrate-Nitrogen and Nitrite-Nitrogen. Summer (July 1 – September 30) average Total Nitrogen (µg/L) in the mixed layer of lakes (median of multiple depths), allowable exceedence frequency of 1-in-5 years.
[a] Summer (July 1 – September 30) average Chlorophyll-a (µg/L) in the mixed layer of lakes (median of multiple depths), allowable exceedence frequency of 1-in-5 years. For lakes and reservoirs greater than 25 acres.

- **Cost Implications for the City to Implement Wastewater Treatment Nutrient Controls**:

  - Biological Nutrient Removal (BNR) was recently completed at MWRF for phosphorus and TIN removal. If future regulations require Enhanced Nutrient Removal of phosphorus and nitrogen, an additional 8 million dollars in capital improvements will be needed.

Comparison of Proposed Colorado Nutrient Criteria to Various Wastewater Treatment Technologies:

Treated Effluent Test Parameter	Typical Municipal Raw Sewage, mg/L	Treated Effluent (No Nutrient Removal), mg/L	Typical Biological Nutrient Removal (BNR), mg/L	Enhanced Nutrient Removal (ENR), mg/L	Limits of Current Treatment Technology, mg/L	Colorado In-Stream Nutrient Criteria, mg/L Cold Water (Warm Water)
Total Phosphorous	4 - 8	4 - 6	1 – 3	0.3 or less	0.05 - 0.07	0.11 (0.17)
Total Nitrogen	25 - 35	20 - 30	8 - 10	3 - 6	3 -4	1.25 (2.01)

Sources: **Municipal Wastewater Treatment Considerations: Dave Clark (HDR) – presentation to Colorado Nutrient Workgroup, April 13, 2010:**
http://projects.ch2m.com/cwqf/Workgroups/Content/nutrient_criteria/Meetings/04%202010%20April/Colorado%20Nutrient%20LOT%20and%20Permitting.pdf
and http://www.waterworld.com/index/display/article-display/286210/articles/waterworld/volume-23/issue-3/editorial-feature/wastewater-industry-moving-toward-enhanced-nutrient-removal-standards.html

- Both capital improvements and operational changes will be needed to bring the DWRF into compliance with the proposed tighter limits on discharges of phosphorus and total inorganic nitrogen (TIN). TIN is the sum of the ammonia, nitrate and nitrite concentrations as nitrogen.

Fort Collins Water Reclamation Facility Biological Nutrient Removal (BNR) Construction Timeline and Costs.

The Mulberry WRF re-started operations on July 5th, 2011. Treatment processes are being fine-tuned to achieve effluent levels of nutrients below the newly established control limits. Changes and improvements to the Drake WRF are under construction as described in the following table:

Reclamation Facility	Current Status	Cost
Mulberry WRF	Upgrades Complete	$25.2 Million
Drake WRF: North Treatment Trains	Design: Complete Construction to be Completed in October 2012	$7.5 Million
Drake WRF: South Treatment Train	Design: 2014 Construction: 2015	$3.2 Million

Note: if Enhanced Nutrient Removal (ENR) becomes required, and additional $50 to $60 million dollars in capital improvements will be required.

Implementation Timeline for Nutrient Control Regulation "85" for the Mulberry and Drake Water Reclamation Facilities:

Water Quality Control Commission Nutrient Control Rulemaking Hearing	March 12 & 13, 2012
Final Action on Rulemaking	June 11, 2012
Control Limits Effective Date	September 30, 2012
City must comply with nutrient control effluent limitations (or receive a compliance schedule)	After November 30, 2013 or upon discharge permit renewal anticipated in 2015(?)

- **Nutrient Control Stream Standards (Regulation 31)**:

Water Quality Control Commission Nutrient Control Rulemaking Hearing	March 12 & 13, 2012
Final Action on Rulemaking	June 11, 2012
Initiate monitoring on wastewater discharges	March 1, 2013
Municipal Separate Stormwater Systems (MS4s) prepare and submit discharge assessment data reports to the Colorado Water Quality Control Division (WQCD)	October 31, 2014
Interim values for Total Nitrogen can be adopted as standards	After May 31, 2017 and prior to May 31, 2022
Interim values for total phosphorus, total nitrogen and chlorophyll-a can be adopted as water quality standards in all segments during regularly scheduled basin hearings	After May 31, 2022.

• Colorado Nutrient Control Regulations and Drinking Water Treatment:

Lakes and reservoirs that are directly used as drinking water supplies can be significantly impacted by the effects of excess nutrient loading. Primary concerns include the growth of nuisance algae. In turn, decaying algae can contribute to the production of high levels of disinfection by-products as well as taste and odor compounds like geosmin. At the 2012 hearings, a new sub-designation for drinking water reservoirs was created for those reservoirs where water is taken out and then treated for drinking water. The new Protected Water Supply Reservoir (PWSR) subset is referred to as *direct use* lakes and reservoirs. The PWSR chlorophyll-a standard will not automatically apply to all direct-use water supply reservoirs, but will be applied to individual reservoirs through the normal basin regulation rulemaking hearing process.

In the March hearings, the Colorado Water Quality Control Commission developed a chlorophyll-a limit for direct use water supply lakes and reservoirs. The limit is an average of 5 µg/L chlorophyll-a in the mixed layer (median of multiple depths) during the July 1st to September 30th time period. The limit applies to both cold and warm-water lakes and reservoirs and can only be exceeded once every five years.

This sub-designation affects Horsetooth Reservoir, one of the City's two drinking water supplies. In 2011, the average total phosphorus concentrations in the raw water intakes from Horsetooth Reservoir and the Cache la Poudre River were 0.01 and 0.03 mg/L (ppm), respectively. These levels are well below the proposed limits for a direct use drinking water supply.

Should either Glade or Halligan-Seaman Reservoirs be used as direct sources for drinking water production rather than water exchanges, nutrient criteria may become important issues in relation to both water production and non-pointsource pollution control.

"*Anti-Degradation Review Status*" for the Cache la Poudre River through Fort Collins:

The Colorado Water Quality Control Commission (WQCC) approved the change to "anti-degradation review (ADR)" status for Segments 10, 11, and 12 of the Poudre in 2009. The basic purpose of ADR status is to maintain and protect existing water quality. These three river segments extend from the Monroe Canal diversion upstream of Gateway Park to the confluence of the Poudre with the Platte east of Greeley. Overall, it will mean stricter discharge limits in the future for both of the City's water reclamation facilities

> ***"Evidence shows that the water quality in this* [i.e. the Poudre] *segment is better than TVS* [*sic*: table value standards] *for the key parameters, and supports the removal of the Use-Protected designation …. Of the 12 key parameters, only the dissolved selenium standard was exceeded."***

2010 - 2011 Colorado Water Quality Control Division Stream Classification Segments of the Lower Cache la Poudre River. Segments 10, 11, 12, 13b and 14 are all now classified with anti-degradation review (ADR) status:

Poudre River Classification Segment ID#	Segment Description
10	Cache la Poudre River, Monroe Canal to Shields Street
11	Cache la Poudre River, Shields St to Boxelder Cr
12	Cache la Poudre River, Boxelder Creek to S. Platte River
13a	All tributaries to the Cache la Poudre River, including all lakes reservoirs and wetlands, from the North Fork of the Cache la Poudre River to the confluence with the South Platte River (Spring Creek, Fossil Creek, Parkwood Lake)
13b	Boxelder Creek from source to the Cache la Poudre River
14	Horsetooth Reservoir
22	Fossil Creek Reservoir (Use-Protected Classification)

Stormwater Quality Study Programs Underway in 2010 and 2011:

Since October of 2009, the City of Fort Collins (City) has partnered with Colorado State University (CSU) to conduct a stormwater sampling program of numerous stormwater Best Management Practices (BMPs). The Udall Natural Area (Udall WP) and the Howes St. BMP were two of the volume-based BMPs studied and each treated large portions of Old Town Fort Collins before allowing stormwater runoff to be discharged to the Cache la Poudre River (Poudre River). Volume-based stormwater BMPs are designed to improve the water quality (WQ) of stormwater runoff by attenuating the peak flow of runoff to reduce erosion in receiving waters. In addition, the stored volume of water is kept in the BMP while pollutants and sediment settles out of the water column. Other City stormwater sampling sites can be characterized as low impact development (LID) facilities and are not discussed in this report.

There were two major differences between the Udall WP and the Howes St. BMP. Primarily, the Udall WP drained over a much longer time because of its pond configuration and WQ outlet structures. Secondly, the amount of stored baseflow between runoff events and the amount of runoff detained during runoff events was much greater at the Udall WP. The WQ performance of each BMP is related to the hydraulic retention time (HRT) that the BMP provided. The HRT was defined as the average amount of time that stormwater runoff was detained in a BMP during a runoff event (total storm volume/average discharge rate). The HRT is approximately equal to the drawdown time of a BMP because runoff will typically enter a BMP over a short period and exit a BMP over a longer period. BMPs providing longer HRTs would be expected to provide greater WQ enhancement because there would be more opportunity for physiochemical and biological interaction including adsorption of pollutants to settleable particles, sedimentation, plant uptake, and biological uptake. Increasing the HRT that a BMP provides requires more storage volume, costs more to construct, and takes away land that could be developed for other uses. In sum, there is a tradeoff between the size of a BMP, the cost to build a BMP, and the capacity for pollutant removal.

The relationship between the HRT and BMP WQ enhancement was investigated using results from the City stormwater sampling project and using other stormwater studies from the International BMP Database (BMP Database). Messamer (2011) produced a Thesis entitled “An Evaluation of Hydraulic Retention Time on BMP Water Quality Performance” and a copy was submitted to the City. Methods of the investigation and detailed WQ analysis appear in the Thesis.

The purpose of this report is to highlight the key findings from City stormwater sampling program and the HRT investigation from the Thesis. Moreover, this report synthesizes the findings and applies them to City WQ objectives. The findings could be used to justify and/or change current design standards for the City stormwater program. Furthermore, recommendations are made for WQ improvements at the Udall WP and Howes St. BMP.

Sampling Sites

The Oak Street Outfall discharges stormwater runoff to the Udall WP where the runoff is treated by two wet extended detention ponds before being discharged to the Poudre River. The facility was constructed with extra storage capacity for the drainage area it serves and provides longer drawdown times than is customary for wet ponds (Rocky Mountain Consultants 2001, UDFCD 2010). Two ponds were constructed in series and each pond's outlet structure was built with WQ orifices to control the release of stored water. Sampling equipment was placed at the BMP inlet (the Oak St. Outfall), at the outlet of Pond 1, and at the outlet of Pond 2 in order to characterize the change in WQ through each pond. Figure 1 shows the sampling locations at the facility.

The Howes St. BMP treats stormwater runoff that is discharged by the Howes St. Outfall before it reaches the Poudre River. Water flows through a constructed wetland channel (CWC) and some ponding occurs at a small concrete wing-walled structure. Then, runoff flows through more of the CWC and enters an old oxbow pond/wetland area before discharging to the Poudre River. The outlet of the facility is comprised of two culverts and does not have any WQ regulator to control effluent flow. Overall, the BMP is undersized for the contributing area that it serves. Sampling equipment was placed at the BMP inlet (Howes St. Outfall) and at the outlet of the wetland pond to characterize the overall change in WQ as it moved through the facility. Figure 1 shows the sampling locations of the facility.

BMP characteristics are shown in Table 1 for the Howes St. BMP and the Udall WP. Note that each BMP has a contributing area of around 520 acres, but the Udall WP has a longer design drawdown time and provides more storage. The water quality control volume (WQCV) is the recommended design storage for each facility according to the Urban Drainage Flood Control District (UDFCD) design manual (UDFCD 2010). The Udall WP was constructed with 160% of the required storage according to UDFCD guidelines. Most of the extra storage volume was built in order to allow future projects to re-route stormwater flow into the facility. However, the WQCV depends on the design drawdown time, and the ponds at Udall were designed to detain water for 40 hours. UDFCD recommends a 12-hour drawdown period of the WQCV for wet ponds (WPs) and a 40-hour drawdown period for dry extended detention basins (EDBs). The available storage volume at the Howes St. BMP was estimated using flow records from the sampling program and it is approximately 35% to 60% undersized for a typical wetland pond according to UDFCD guidelines.

Table 1. BMP Characteristics for the Howes St. BMP and Udall WP

BMP Charactersistics	Howes St. BMP	Udall WP		
		Pond 1	Pond 2	Total
Total Contributing Area (acres)	524	-	-	517
Percent Impervous of Contributing Area (%)	52	-	-	64
Current BMP Storage Size (acre-ft)	3 to 5*	7.4	9.8	17.2
Calculated WQCV (acre-ft)**	8.3			10.8
Design Drawdown Time (hrs)	10 to 30*	40	40	80+

* Observed BMP storage utilized and drawdown time from calculated from flow records

** Howes St. BMP WQCV for a wetland pond, Udall WP WQCV for an extended detention basin

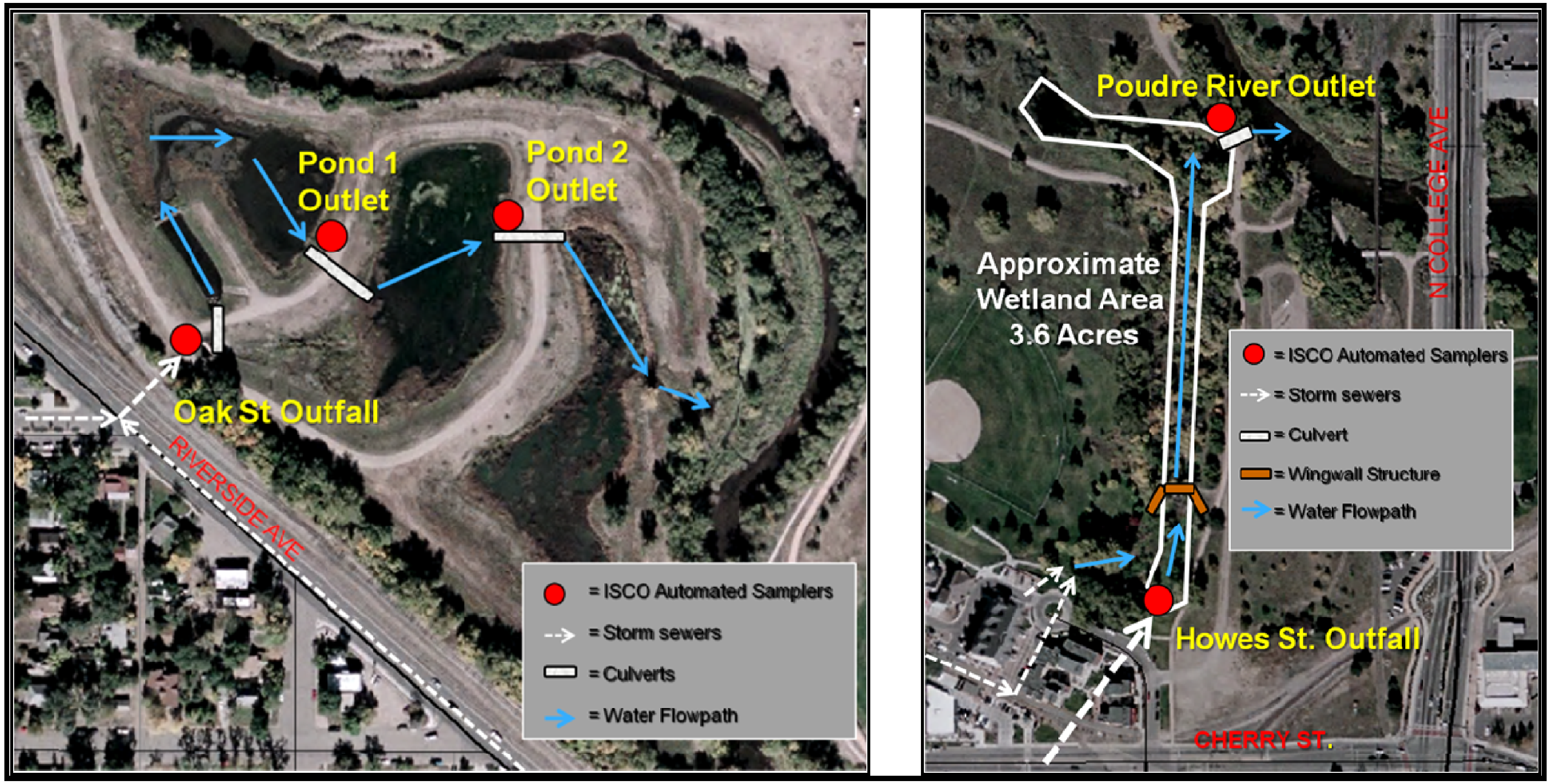


Figure 1. Udall WP (left) and Howes St. BMP (right) Sampling Locations

Water Quality Results

Numerous WQ constituents were analyzed for multiple events from 2009 to 2011. At each sampling site, a representative event mean concentration (EMC) was calculated for a runoff event. Numerous aliquot samples were collected using automated equipment and then combined to form a representative EMC at each site during a runoff event. From the fall of 2009 to the spring of 2011, 13 events were sampled at the Udall WP and Howes St. BMP. Table 2 shows the events that were successfully collected at each sampling location.

Table 2. Summary of Storms Sampled from 2009 to Spring 2011

	Howes St. BMP		Udall WP		
Storm Date	**Howes Inlet**	**Howes Outlet**	**Udall Inlet**	**Udall Pond 1**	**Udall Pond 2**
10/27/2009		X	X	X	X
3/20/2010		X			
4/21/2010	X	X	X	X	X
4/28/2010	X	X	X	X	X
5/11/2010	X	X	X		
5/26/2010	X		X		
6/11/2010	L		L		
7/4/2010	X	X	X	X	X
8/8/2010	L	L	L	L	L
10/22/2010				X	X
11/9/2010	X	X	X		X
4/13/2011	X	X	X	X	X
4/24/2011	X	X	X	X	X

X = Full Sampling Suite from PCL Lab

L = Limited Sampling from CSU Lab

[red] EMC Not used in Analysis-Did not meet screening criteria (red cells: 10/27/2009 Udall Pond 2; 4/21/2010 Howes Inlet and Howes Outlet; 5/11/2010 Howes Outlet; 4/13/2011 Udall Pond 2)

[yellow] Equipment problems but believed to be representative EMC (yellow cells: 4/13/2011 Howes Outlet; 4/24/2011 Howes Outlet)

Note that paired influent to effluent events were not always collected. During summer months, the Poudre River level rose high enough to prevent sampling from the BMP outlets. Other complications like intense rainfall, insufficient rainfall, uneven rainfall, maintenance activities at the sites coinciding with sampling events, or equipment malfunction prevented successful sampling at certain locations for specific events. Table 2 shows some data that was removed from analysis (highlighted in red) because a representative EMC was not collected (i.e. less than 60% of the runoff hydrograph was collected in aliquot samples). Despite having to remove some of the data points, there was a good variety of storm events collected over multiple seasons.

The methods of analysis used to describe the WQ removal at each site utilized all available data points and adhered to strict statistical requirements. Enough data was collected to draw some strong conclusions about the performance of each BMP, especially when the facilities were compared to one another. Messamer (2011) used numerous analytical methods to describe the WQ improvements from each BMP in his Thesis. The "Effluent Probability Method" emerged as the single most useful method because all of the available data points were displayed via probability plots. All of the collected EMCs at a specific site were ranked from smallest to largest for a particular WQ constituent. Then, once each EMC was ranked, it was assigned a plotting position (using the Cunnane formula) and plotted. The resulting lines gave an overall estimate of whether treatment occurred at a BMP from inlet to outlet over the course of sampling. Furthermore, flatter effluent lines indicated more consistent treatment from a BMP because similar EMCs were observed. The value corresponding to the 50% exceedence point was the median of the observed values because half of the EMCs were higher and half of the EMCs were lower than this point.

Caution should be taken when interpreting the probability plots. Since the influent and effluent values were independently ranked at each site, the implied pollutant removal between adjacent points on two lines can be misleading. The removal rate may have never actually occurred during a single event. For example, in Figure 2 it appears that TSS was reduced by about 20 mg/L from Pond 1 to Pond 2 for each storm. Some storms had corresponding EMC's that were reduced more than 20 mg/L; others had EMC's that were reduced less than 20 mg/L. The points on the lines cannot be used to predict the BMP's performance for individual events. The plots should be used as a tool to determine whether treatment occurred at a BMP over the course of numerous events.

Formal statistical testing was also conducted to determine whether a perceivable change in water quality occurred at each BMP. The Ranksum Test compares the median value between two groups of observations and determines the degree of confidence that each distribution is statistically different. The total number of observations in each group is taken into account, and the method works well with small datasets. For this application, influent water quality results were compared to effluent water quality results at each BMP.

Table 3 shows the results of the Ranksum Test for each constituent. The table was organized to show the confidence level for the difference between effluent values and influent values. For example, according to Table 3, it can be said with 96.9% confidence that effluent TSS values at the Howes St. BMP were less than influent TSS values. Red values indicate that an increase in concentration occurred from inlet to outlet. Values in bold show with 90% or greater confidence that effluent concentrations were less than influent concentrations.

When viewing the probability plots, it is good to reference Table 3 for the statistical results. The probability plots generally agree with the statistical results and efficiently show the median value and all of the observed values at each sampling location. The quantity of the difference is shown best by the plots while the strength of that difference is summed in Table 3.

Table 3. Confidence Level (%) Between Median Differences Using Ranksum Test

Pollutant	Howes Inlet to Howes Outlet	Udall Inlet to Pond 2 Outlet	Udall Inlet to Pond 1 Outlet	Pond 1 Outlet to Pond 2 Outlet
TSS (mg/L)	**96.9**	**100.0**	**99.8**	**99.7**
COD (mg/L)	-6.9	71.7	70.1	23.8
TOC (mg/L)	0.0	27.6	3.2	4.5
TR Cu (ug/L)	-31.4	**90.5**	82.9	60.0
D Cu (ug/L)	26.2	**96.9**	**94.1**	41.8
TR Zn (ug/L)	-9.5	**90.5**	87.5	85.7
D Zn (ug/L)	61.9	**94.1**	77.2	86.8
TP (mg/L)	80.0	**97.3**	72.8	71.9
TN (mg/L)*	88.6	65.0	-40.4	37.2
TKN (mg/L)	87.2	**91.2**	82.6	46.6
NH_3 (mg/L)	**98.4**	**98.3**	**93.0**	79.3
NO_2+NO_3 (mg/L)	5.5	-69.3	-45.3	-16.0
Organic N (mg/L)**	83.5	67.2	53.0	-5.5
E. coli (#/100 mL)***	-94.8	-25.3	-40.2	0.0

Negative values (in red) show increase in median from inlet to outlet
* TN was measured directly by CSU for two events, otherwise it was calculated by adding TKN + NO_2 + NO_3
** Organic N was estimated for each storm by subtracting TKN - NH_3
*** E. coli grab samples were analyzed, no EMCs were collected for E. coli

Total Suspended Solids (TSS)

TSS was arguably the most important WQ constituent to monitor because other pollutants will adsorb to suspended particles and settle out of the water column. Volume-based BMPs primarily target TSS for removal through sedimentation by storing and attenuating runoff and discharging it over a longer period. Figure 2 shows the probability plots generated for the two BMPs.

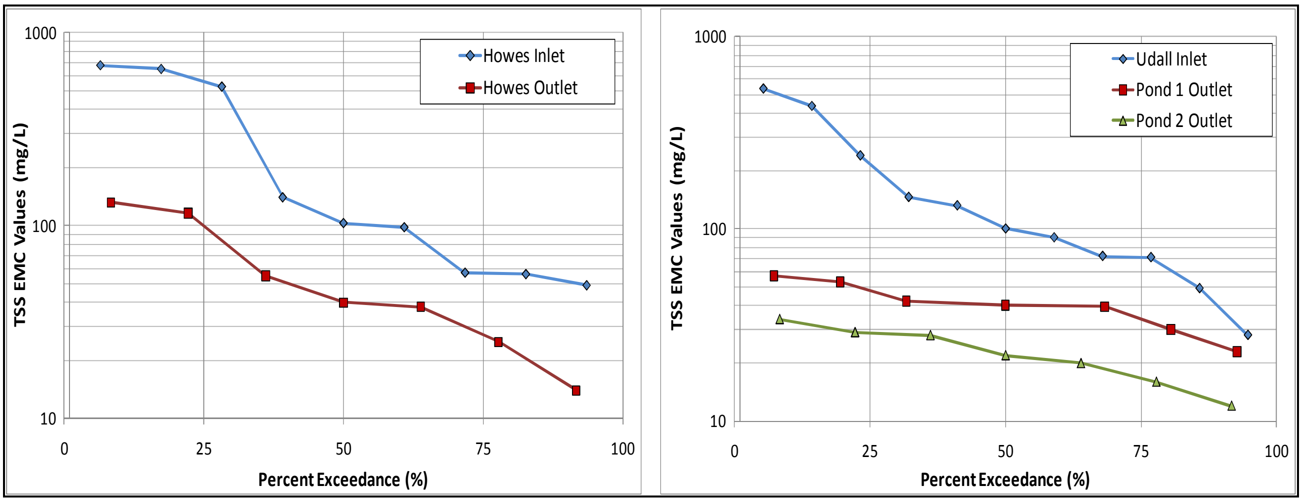


Figure 2. TSS Removal at the Howes St. BMP and Udall WP

According to Figure 2, the median influent of TSS at each BMP's inlet was around 100 mg/L. At the outlet of the Howes St. BMP, the median was reduced to 40 mg/L. The two lines do not cross which indicates that significant removal occurred at the Howes St. BMP. According to Table 3, the difference is statistically strong (96.9% confidence). At the Udall WP, the median value for TSS was reduced to 40 mg/L at the Pond 1 outlet. At the Pond 2 outlet, TSS was reduced to 22 mg/L. None of the lines cross which implies that significant reductions occurred from the inlet to the Pond 1 outlet, and then again from the Pond 1 outlet to the Pond 2 outlet. Additionally, results shown in Table 3 verify that statistically significant reductions in TSS occurred, and overall it can be said with 100% certainty that the effluent at Udall entering the Poudre River had lower TSS concentrations than influent stormwater.

Some important information was gained from the TSS analysis. First, the Howes St. BMP had a median EMC equal to the Pond 1 outlet. This suggests that the Howes St. BMP has the potential to remove TSS as effectively as Pond 1. However, once plotted, the slope of the Howes St. BMP outlet EMCs was much steeper than the Pond 1 outlet EMCs signifying a wider variance in observed values. Essentially, the Howes St. BMP did not perform as consistently as Pond 1 at Udall. This can likely be attributed to the outlet configuration at the Howes St. BMP because it did not contain a WQ mechanism to release stored water slowly.

Secondly, there was additional removal of TSS from Pond 2 at Udall, but the magnitude of the reduction was much less. Pond 1 reduced the median of the TSS EMCs from 100 mg/L to 40 mg/L but Pond 2 only reduced the median from 40 to 22 mg/L. Approximately 77% of the WQ enhancement can be attributed to Pond 1. This finding substantiates that the construction of Pond 2 was beneficial for TSS removal, but Pond 1 functions more efficiently.

Oxygen Demand

Two parameters were measured to determine the oxygen demand of runoff entering and exiting the facilities. Chemical oxygen demand (COD) is a measure of the potential oxygen depletion from biological and chemical substances in runoff and total organic carbon (TOC) is a measure of the organic content in runoff. High COD or TOC values signify that substances exist in the water that will remove large amounts of dissolved oxygen from runoff. Low dissolved oxygen in the water can be harmful for fish and other aquatic species.

Figure 3 displays the probability plots for both COD and TOC at the sampling locations. COD was not significantly removed at the Howes St. BMP. The figure indicates that COD may have been reduced at the Udall WP, but the results were not statistically significant (71.7% confidence that COD was lower at the BMP outlet compared to the inlet). TOC was not significantly reduced at either facility.

Overall, neither BMP significantly improved the oxygen demand from stormwater. However, the results show that neither BMP consistently increased the oxygen demand from inlet to outlet, which is also possible. Organic matter stored at the bottom of ponds can promote anaerobic conditions that have a negative impact on the dissolved oxygen in stormwater. Currently, neither has a negative effect on the dissolved oxygen from stormwater runoff and the Udall WP might be removing some of the COD in stormwater runoff (but not at statistically significant levels).

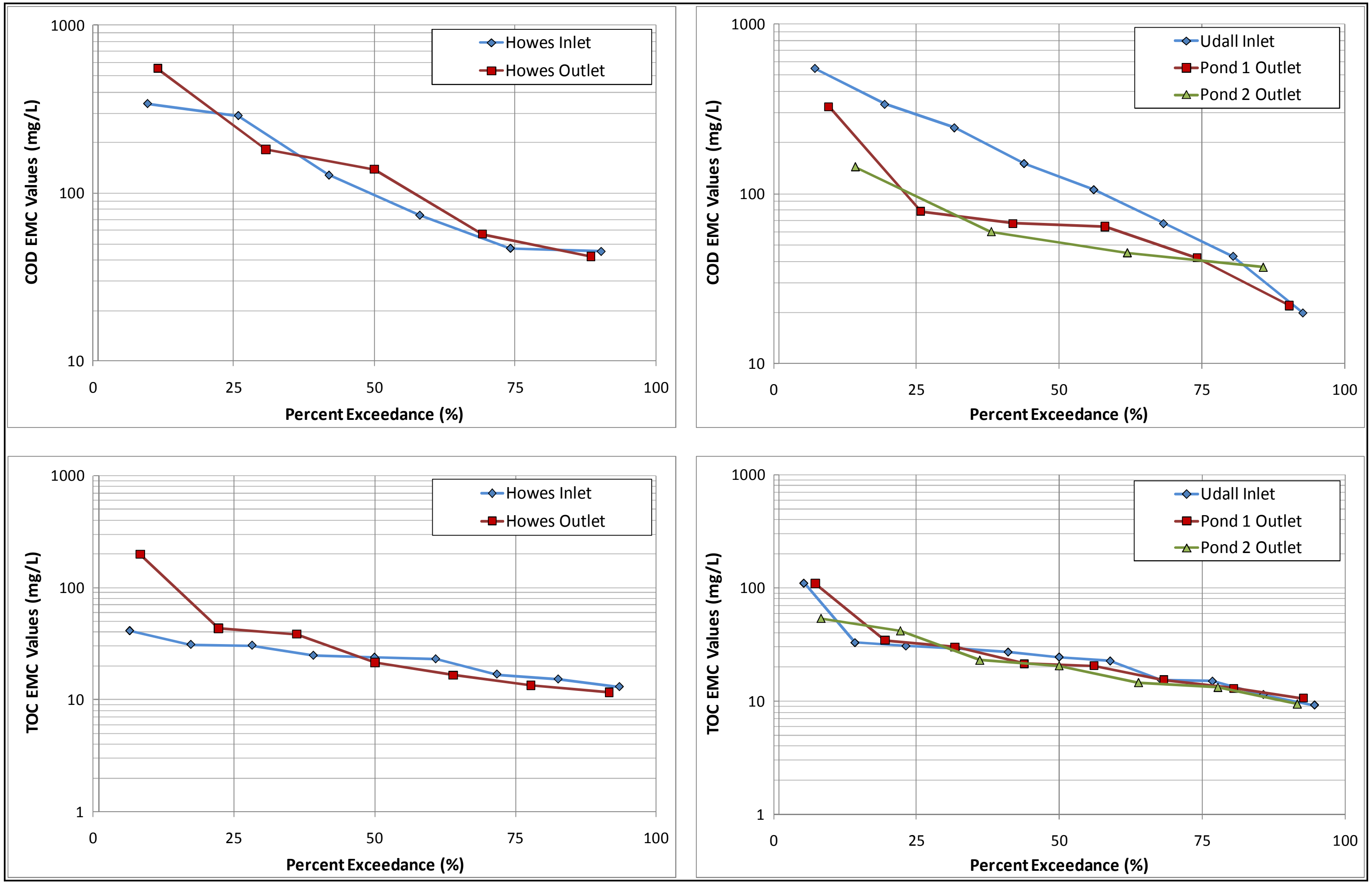


Figure 3. COD and TOC Removal at the Howes St. BMP and Udall WP

Heavy Metals

Total recoverable zinc (TR Zn), dissolved zinc (D Zn), total recoverable copper (TR Cu), and dissolved copper (D Cu) were analyzed to determine how effective the BMPs were at removing heavy metals from stormwater runoff. Other heavy metals are more difficult to quantify because they exist in lower concentrations than zinc and copper. The dissolved portion of a constituent represents the amount of a particular pollutant that passes through a small filter and is more difficult to remove through sedimentation.

There were several instances where the lab failed to perform metals analysis that was requested. There were two or three storms depending on the sampling location where metals analysis was not performed in time to meet holding requirements. Formal statistical analysis often resulted in inconclusive results, most likely because of the smaller sample sizes. Despite the limited points, some clear trends emerged when the Howes St. BMP was compared to the Udall WP.

Figure 4 shows the TR Cu and D Cu removal at both BMPs. There was evidence of both TR Cu removal and D Cu removal at the Udall WP, especially from the inlet to the Pond 2 outlet. There was no overlapping of lines implying that there were significant reductions in copper concentrations. Formal statistical testing in Table 3 also shows significant reductions in copper concentrations from inlet to outlet. At the Howes St. BMP, there was no indication of TR Cu removal or D Cu removal. Another interesting thing to note is that inlet copper concentrations were higher at Udall than at Howes St. This means that copper removal may not be as big of a concern at the Howes St. BMP, which treats a contributing area that contains fewer busy roads and commercial areas. The effluent TR Cu at Pond 1 was nearly identical to the Howes St. BMP effluent. In sum, the larger Pond 1 at Udall consistently removed copper from influent runoff, but the concentrations of TR Cu leaving the pond were similar to the Howes St. BMP (where no observable WQ enhancement took place). As with TSS, there was significant removal of copper from Pond 2, but Pond 1 removed most of the pollutant load.

Figure 5 shows the TR Zn and D Zn removal at both BMPs. There was evidence of TR Zn removal at the Udall WP, but not at the Howes St. BMP. Formal statistical testing also showed significant zinc removal at Udall, but not at Howes St. The inlet at Udall had higher concentrations of zinc than the inlet at the Howes St. BMP. Unlike the results for TSS and copper, Pond 2 at Udall removed substantial loads of zinc that were approximately equal to the zinc removed by Pond 1. There was an indication that D Zn was reduced at the Howes St. BMP and at the Udall WP.

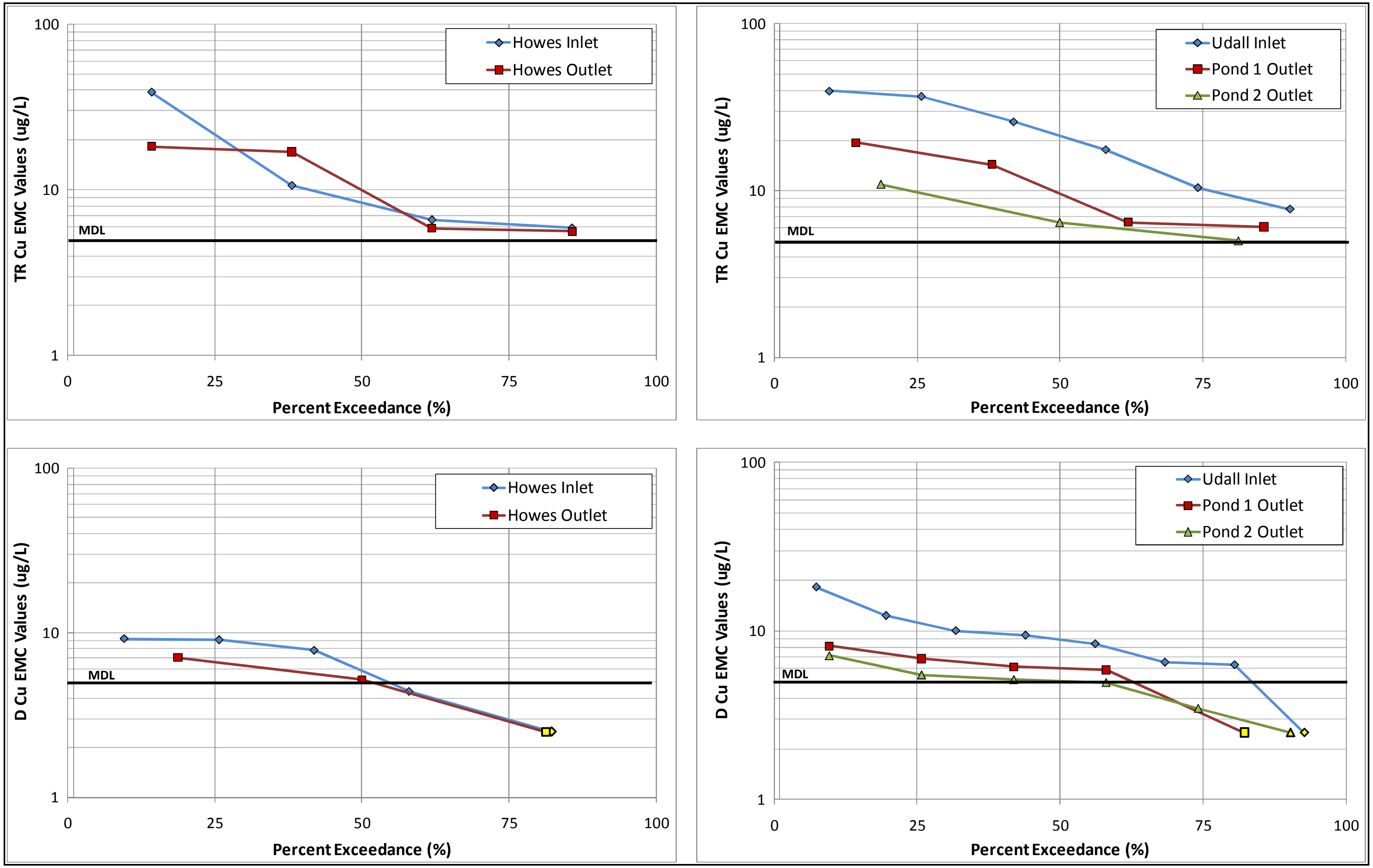


Figure 4. Total Recoverable (TR) and Dissolved (D) Copper Removal at the Howes St. BMP and Udall WP

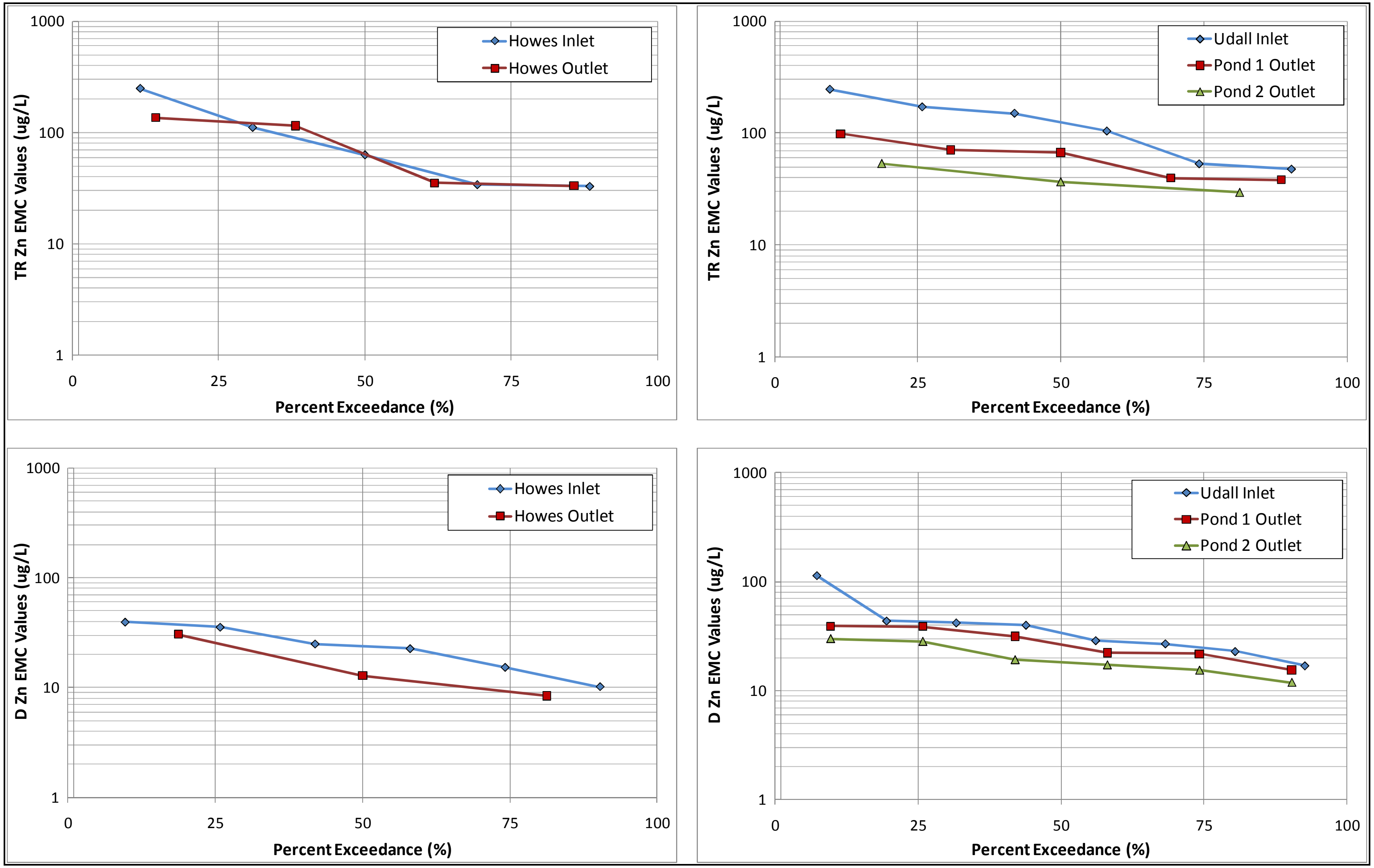


Figure 5. Total Recoverable and Dissolved Zinc Removal at the Howes St. BMP and Udall WP

Nutrients

Measured nutrient parameters included total phosphorous (TP), nitrate (NO_3), ammonia (NH_3), and Total Kjeldahl Nitrogen (TKN). From the measured nitrogen species, an estimate of the organic nitrogen (ON) and total nitrogen (TN) was calculated for each storm. CSU labs analyzed two events where only TN and TP were measured.

Figure 7 shows the TP removal and TN removal at each sampling location. According to the plot, significant TP reduction was achieved at both sites and there was a significant reduction in TP between the Pond 1 outlet and the Pond 2 outlet. Formal statistical testing only resulted in a significant TP reduction at Udall from inlet to Pond 2 outlet. Effluent TP EMCs from the Howes St. BMP was very similar to the effluent TP EMCs from Pond 1 at Udall. TN was reduced at the Howes St. BMP but not reduced at the Udall WP. There was removal of other nitrogen species (shown in subsequent plots) but overall there was no significant reduction in TN at the Udall WP.

Figure 8 shows the nitrate ($NO_2 + NO_3$) results and the ammonia results for both sites. There was no significant reduction in nitrate at either facility. Nitrate is very difficult to remove from stormwater runoff and it was not surprising that the BMPs did not remove nitrate consistently. Ammonia was reduced significantly at each pond at Udall and at the Howes St. BMP. The effluent values at the Pond 1 outlet were nearly identical to the effluent of the Howes St. BMP, especially if the lowest point on the curve is ignored. Figure 9 shows the TKN and ON removal at both sampling sites. The Howes St. BMP removed significant amounts of TKN and ON. The Udall WP removed some TKN and ON but not at statistically significant levels, and there was no perceivable benefit of having the second pond at Udall.

Overall, the Udall WP did not significantly reduce the nitrogen content of stormwater runoff. However, it was successful in removing some of the more toxic forms of nitrogen. One possible explanation could be that ammonia and TKN (measure of ammonia + ON) were converted into ON through natural processes. Large algae blooms were observed at the site, which may have reduced ammonia through photosynthesis and increased ON from algal die-off. Figure 6 shows an example of the extensive algae growth at the Udall WP. The Howes St. BMP reduced all forms of nitrogen except nitrate. The influence of plant life in the CWC and pond area could be responsible for the reduction of nitrogen because biological uptake is a major removal pathway. Both BMPs removed TP.

Figure 6. Algal Bloom at the Udall WP (August 2011)

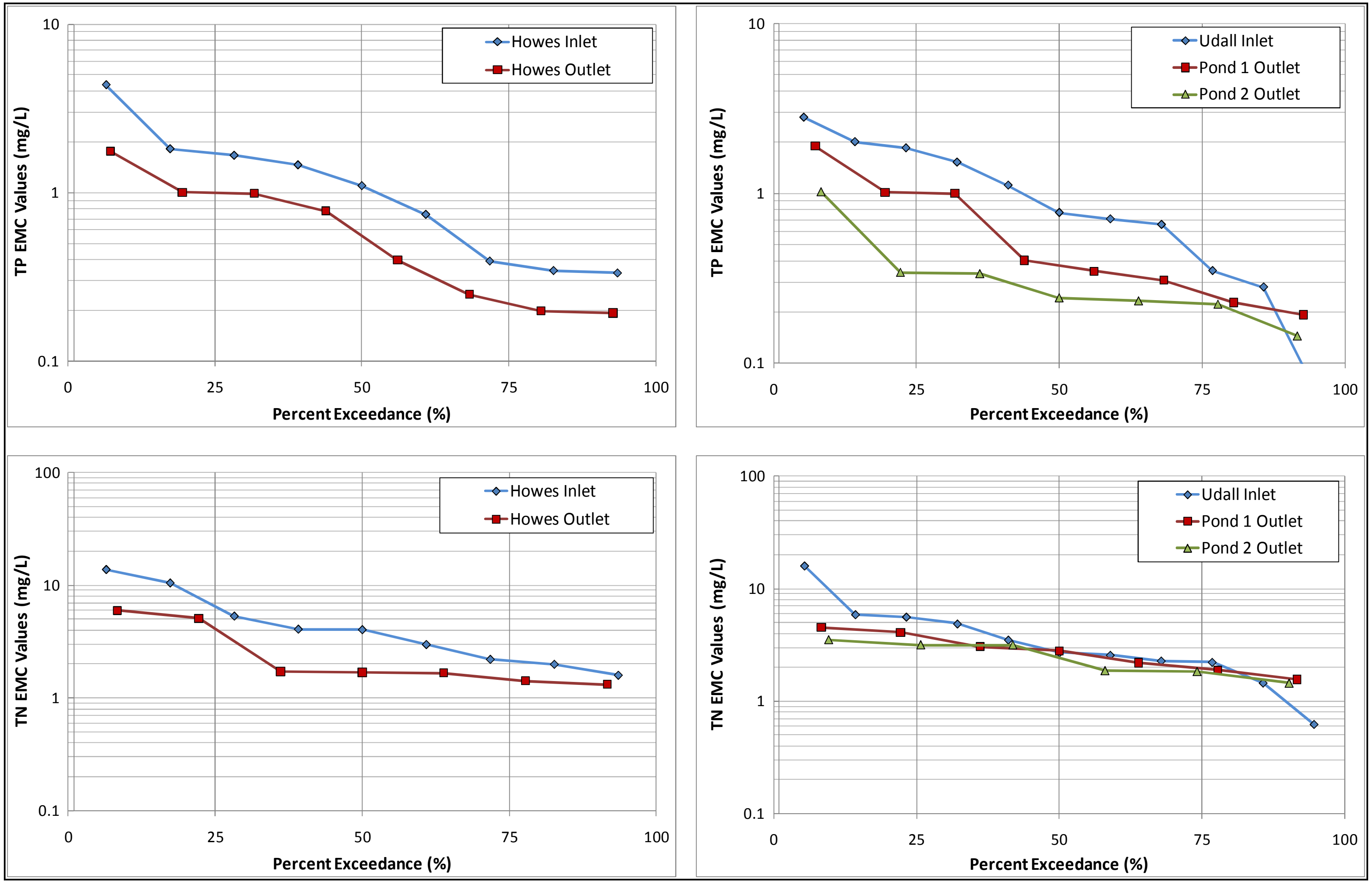


Figure 7. Total Phosphate and Total Nitrogen Removal at the Howes St. BMP and the Udall WP

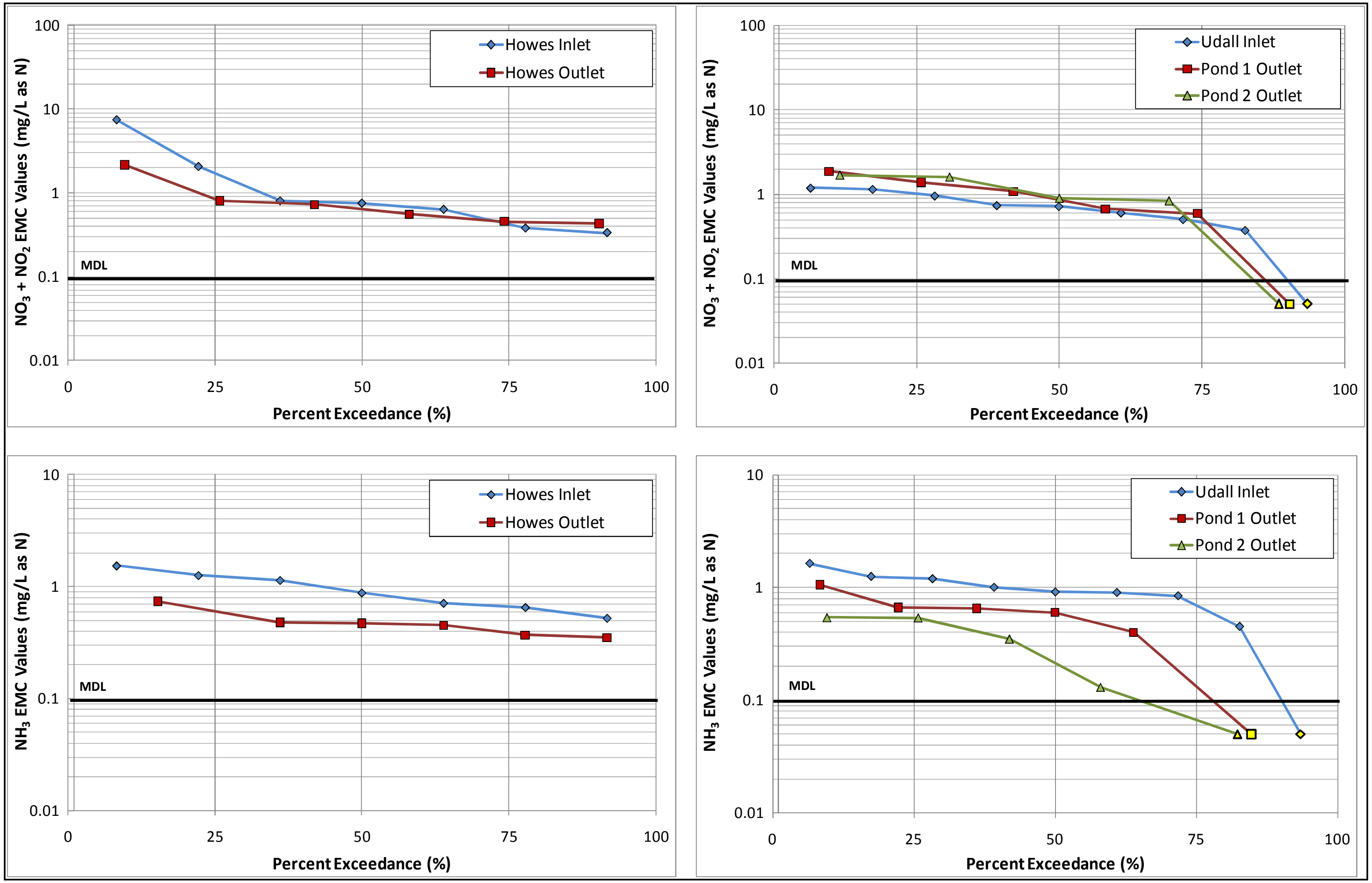


Figure 8. Nitrate-Nitrogen and Ammonia-Nitrogen Removal at the Howes St. BMP and the Udall WP

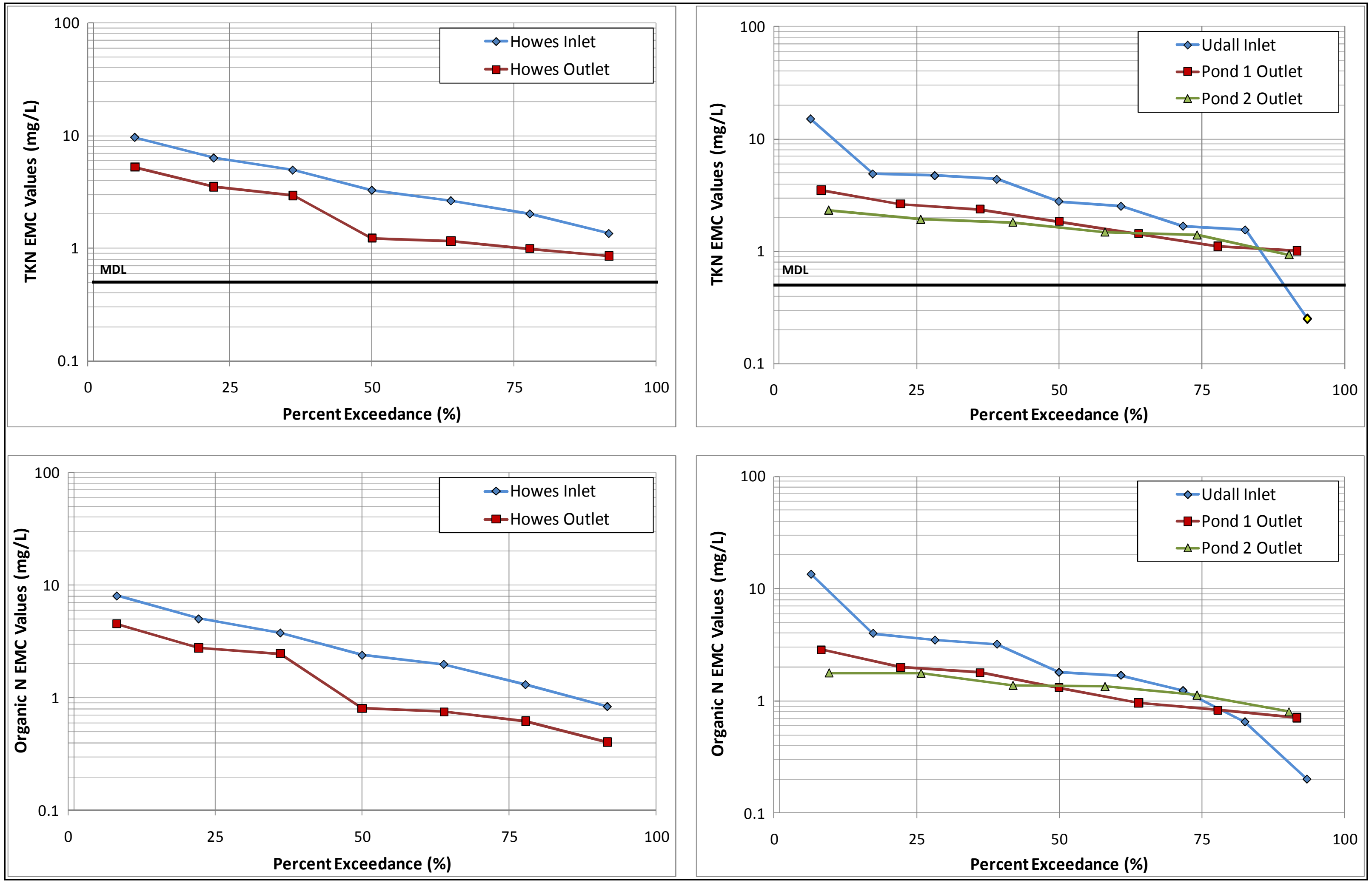


Figure 9. TKN and Organic Nitrogen Removal at the Howes St. BMP and the Udall WP

E. coli

Escherichia coli (*E. coli*) grab samples were collected at each sampling location during runoff events. Unlike the collected EMCs for other pollutants, the *E. coli* values represented the concentration of *E. coli* at a specific time during an event. Nevertheless, enough samples were collected and analyzed to determine how each BMP affected E. coli levels. Figure 10 shows the probability plots generated for the *E. coli* grab samples at each BMP.

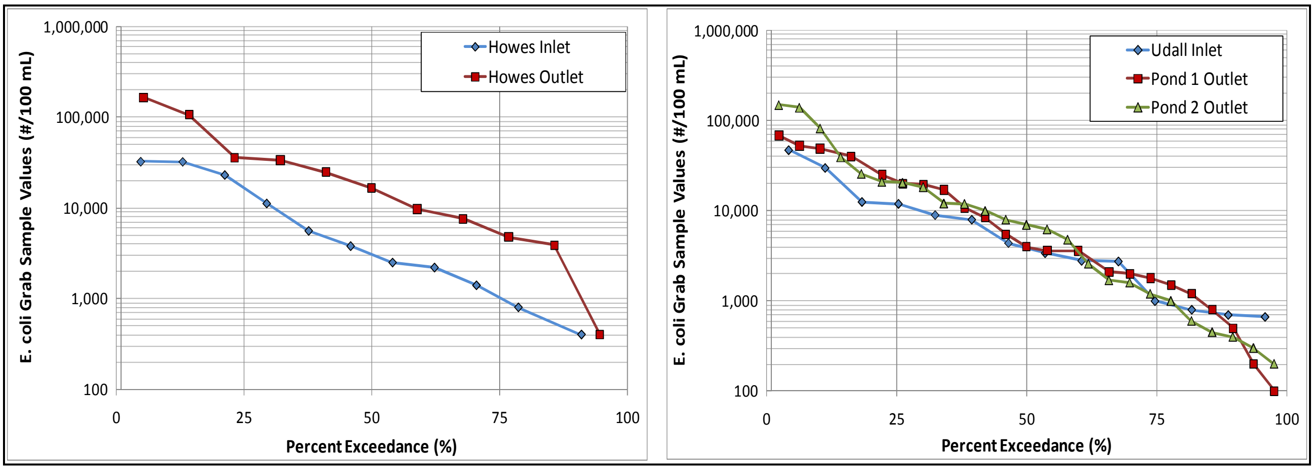


Figure 10. *E. coli* levels at the Howes St. BMP and Udall WP

E. coli concentrations were extremely variable at each location and ranged from 100/100 mL to over 100,000/100 mL. These values were consistent with other stormwater sampling studies (Clary et al 2008). The Environmental Protection Agency (EPA) set the fresh recreation waters criteria at 126/100 mL. Neither site discharged *E. coli* at concentrations of the same order of magnitude as the EPA criteria. The designated use of the Poudre River through town does not include recreation so stormwater discharge is not required to meet the numeric criteria. In addition, the concentration of *E. coli* in the Poudre River was not measured, and the additional volume of flowing water would be expected to dilute the concentration of *E. coli* from stormwater runoff.

Figure 10 shows that there was a significant increase in *E. coli* at the Howes St. BMP from the inlet to the outlet. Table 3 also shows a statistically significant increase in E. coli form inlet to outlet at the Howes St. BMP. One possible explanation for the increase is that an additional source added *E. coli* to the pond downstream of the inlet sampling location. Possible sources included the nearby Lee Martinez Park, a horse farm adjacent to Lee Martinez Park, and a horse trail along the perimeter of the BMP where sampling personnel frequently encountered horse droppings. Numerous citizens were observed taking dogs for walks near the pond, and pet waste could introduce *E. coli* to the facility. Another possible explanation is that wildlife from within the pond contributed to the *E. coli* increase. There is not much that can be done to remove *E. coli* from stormwater runoff using BMPs that do not utilize filtration as the primary removal mechanism (Clary et al 2008).

Figure 10 shows no significant increase or reduction in *E. coli* levels at the Udall WP. Inlet and outlet lines overlap, which implies that no significant changes in *E. coli* levels occurred at the site. Formal statistical testing also showed insignificant changes in *E. coli* from inlet to outlet and from pond to pond. There was concern that the Udall WP was increasing *E. coli* because it attracts wildlife and has a long HRT. Knuth (2004) reported an increase in *E. coli* concentration of two orders of magnitude from the inlet to the Pond 2 outlet. No E. coli grab sample from this study was as high as reported values from the study done in 2004.

Figure 11 shows the geometric mean of the *E. coli* samples from this study (labeled as 2010) compared to the values reported by Knuth (2004). The current study collected 12 grab samples at the inlet and 25 samples at each pond outlet; Knuth only collected three samples at each location.

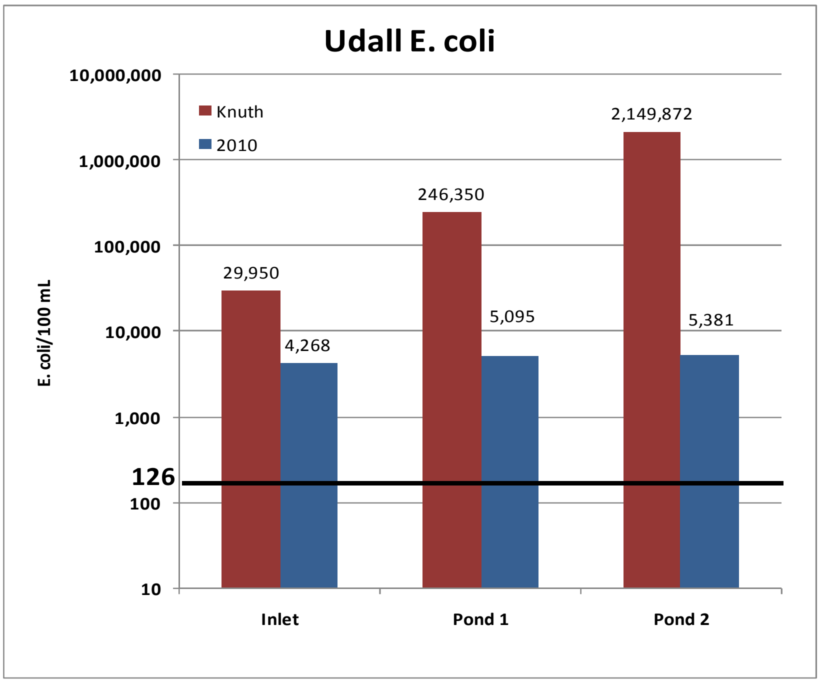


Figure 11. Geometric Mean of *E. coli* Samples at the Udall WP for the Two Studies

Low Impact Development Pilot Projects

In an effort to implement innovative stormwater management strategies in Colorado, the City of Fort Collins initiated a demonstration project to construct a retrofit bioretention basin at the City's Utility Service Center parking lot. The goal of the Fort Collins project was multi-faceted and involves a significant monitoring effort. The drainage basins contributing to these bioretention areas are highly impervious, fully developed, lack room for idealized construction conditions or standard designs, and contain a significant amount of public right-of-way or paved areas typical of urbanized environments. The City of Fort Collins has partnered with Colorado State University to collect and analyze data from a variety of LID-type BMPs, including this project.


Utilities Service Center Bioretention Construction, June 2011


Utilities Service Center Bioretention pre-Treatment Forebay, June 2012

Utilities Service Center Bioretention Monitoring and educational Signage, June 2012


Utilities Service Center Landscaping and Seeding, April 2012

Utilities Service Center Landscaping and Seeding, June 2012

Key points of the project include the following:

1. Existing grades and available land necessitated the use of dual, cascading bioretention cells instead of a single large basin as is typically installed.
2. Due to limited available room, the bioretention area was knowingly undersized. Eight sizing methodologies were investigated during the design.
3. Clay soils with low permeability dominate the area. Nevertheless, the bioretention cells have open bottoms to allow as much infiltration as possible. The project includes sub-surface storage and also uses an underdrain system controlled by a gate valve.
4. The stormwater quality benefits of bioretention are now widely known and tested, proving them to be excellent treatment measures. However, little data exists to evaluate the potential runoff volume reduction of bioretention in a semi-arid climate. Therefore, this project will be monitored for volume reduction. The monitoring approach consists of flumes, weirs, pressure transducers, and soil moisture sensors to assess the amount of evaporated moisture in each cell.
5. There are numerous recommendations across the country regarding the optimum bioretention soil media mixture. Some of these recommendations contradict each other or may lead towards either premature media clogging or a questionable ability to sustain healthy, attractive vegetation. This project will evaluate both the media mixture recommended by the updated UDFCD Volume 3 and a hybrid mixture of sand, compost, and loam with input from a notable CSU soil scientist. Each cell will contain a different soil media mixture.
6. A common failure mechanism of bioretention is clogging at the media surface. This project evaluates the use of forebay boxes and pea gravel filtration to reduce gross sediment load to the bioretention cells and improve their longevity. The project also replaces standard geotextile fabrics, which also often clog, with an aggregate diaphragm layer.

7. Vegetation was carefully chosen to be native plantings that can typically handle adverse environments. They consist of a number of grasses and flowers to meet a project goal that the area be aesthetically pleasing as well as functional. The health of the plantings will be monitored in order to improve future plant selection options.
8. This project was a team effort with collaboration between the City of Fort Collins, the City of Loveland and Colorado State University.
9. Design and construction considerations for retrofitting bioretention into fully developed basins will also be discussed.
   In conclusion, the use of bioretention as a stormwater management strategy will become more prevalent in the future as retrofit solutions are used in previously urbanized environments. This represents another step in improving the knowledge-base and the construction and maintenance practices that can be used to meet evolving local, state and federal stormwater management regulations.

Stormwater Criteria Update

On December 20th, 2011, Council adopted upon second reading the new "Stormwater Criteria Manual" replacing the Storm Drainage Design Criteria and Construction Standards that was originally adopted in 1984 and update in 1998.
The "Stormwater Criteria Manual" is the newly revised governing document that now sets stormwater policies in Fort Collins and provides the drainage criteria for all new stormwater design and construction activities.
The latest version of the manual was adopted in December 2011 by the City Council with Ordinance 174, 2011
This version incorporates most of the 2011 version of the Urban Drainage and Flood Control District (UDFCD) Manual with amendments that are unique to the City of Fort Collins.
A complete listing of the adopted amendments adopted can be found at:

http://www.fcgov.com/utilities/business/builders-and-developers/development-forms-guidelines-regulations/stormwater-criteria

Additionally the City had separately adopted in 2010 a Detention Pond Landscaping Standards that regulate landscaping and construction standards in stormwater detention pond facilities. Together these two documents represent a shift in stormwater quality and quantity management that encourages the use of filtration and infiltration methods to treat and reduce the volume and quantity of runoff and pollutants in City streams and waterways. These will be complemented in the future with a Low Impact Development (LID) policy and regulations that will further encourage and provide additional incentives towards the use of green infrastructure techniques in stormwater management.

The following code revisions will be introduced as part of Spring 2012 update of the Land Use Code that will further clarify and reinforce existing stormwater policies and regulations for all new development.

Land Use Code Section 3.4.3 - Water Quality Update

The development must comply with all applicable local, state and federal water quality standards, including, but not limited to, those regulating erosion and sedimentation, storm drainage and runoff control and treatment, solid waste, and hazardous substances. Projects must be designed such that all runoff draining from development sites is treated in accordance with the criteria set forth in the "Stormwater Criteria Manual". Stormwater control and treatment measures may include, but are not be limited to:

Grass Buffers

Grass Swales

Bioretention (Rain Garden or Porous Landscape Detention)

Extended Detention Basins (EDB)

Sand Filters

Retention Ponds

Constructed Wetland Ponds

Constructed Wetland Channels and

Permeable Pavements

2011 Stormwater Quality Monitoring Program Costs:

Monitoring Program Description	Cost	Comment
City-CSU event-based Best Management Practices (BMP) Stormwater Quality Monitoring Program	$ 44,000	Approximately $22,000 in direct water quality testing costs with the balance for salaries and program expenses. Project funded through the City-CSU stormwater contract.
Low Impact Development (LID) Pilot Project Monitoring Equipment Costs (new Equipment, Replacement and Repair)	$7,000	Project funded through the LID Monitoring Pilot Program
Winter Runoff Monitoring Study	$10,000	$3,000 in lab costs and $7,000 in salary costs. Salary costs funded by Regulatory and Government Affairs with the remaining funded by City-CSU contract
Sheldon and Sherwood Lake Water Quality Monitoring and Analysis	$12,000	Equipment, lab analysis and salary costs; funded by City-CSU contract

2011 Municipal Separate Stormwater Sewer System (MS4) Water Quality Study Programs:

MS4 Report Background & Highlights:

The City of Fort Collins is required by the Colorado Water Quality Control Division (WQCD) to have a Municipal Separate Storm Sewer System (MS4) permit in order to discharge stormwater from its MS4 into State waters. The City must implement a Colorado Discharge Permit System (CDPS) Stormwater Management Program in accordance with the MS4 permit. The City's Stormwater Management Program is a comprehensive program comprised of six minimum control measures designed to reduce the discharge of pollutants from its MS4. Each measure requires several detailed elements that must be implemented annually or on an ongoing basis.

In addition to maintaining permit compliance, the elements facilitate protection of water quality and habitat of the Cache la Poudre River and our urban streams. City staff takes pride in implementation of these pollution prevention measures and the resulting urban watershed quality. Many of the elements identified below were originally developed as a part of the "*Watershed Approach to Stormwater Quality*". Listed below are the minimum control measures, abbreviated requirements, and 2011 accomplishments.

1. **Public Education and Outreach -** *The permittee must implement a public education program in an effort to promote behavior change by the public to reduce water quality impacts associated with pollutants in stormwater runoff and illicit discharges*

Highlights of the 2011 stormwater education program:

- The City's WaterSHED (Stormwater Habitat Education Development) program educated 3,912 students and 464 adults, for a total of 6,530 student and 1204 adult contact hours.
- Staff provided a guest lecture on stream ecology to a CSU class.
- Staff educated 350 students and 150 adults on the land-water connection at the Birding Fair.
- Six City employees from various departments participated in a stream study.
- Larimer County Youth Corps participated in stream education and stenciling.
- Staff, in cooperation with Art in Public Places, initiated a program to place specially designed cast metal storm drain markers and manhole covers at various locations throughout the city. To help educate the public regarding the land/water connection and to help maintain water quality in local streams, Fort Collins residents are invited to participate in a design contest for the markers and manhole covers. Designs chosen will include depictions of aquatic insects from a local watershed.
- Storm drain stenciling program participants stenciled 203 storm drains and applied 71 storm drain decals.
- Eighteen adults were trained though the Master Naturalist program.
- The Children's Water Festival had 1700 student participants.
- The Stormwater Business Outreach Program distributed stormwater education packets to 57 gas stations. Packets included the following materials:

- Removable sticker to place on the window washing fluid reservoirs to demonstrate business' commitment to a healthy environment.
- Spill cleanup and power washing flyers to place on the work bulletin board or in the employee reference book to help guide employees with best practices.
- Storm drain marker to adhere to the curb near a storm drain to educate the community on the importance of keeping storm drains clear of pollutants.

Students gather macroinvertebrates to study the stream health

City staff participate in Poudre Life class

Students at Red Fox Meadows

2. **Public Participation and Involvement -** *The permittee must provide a mechanism and process to allow the public to review and provide input on the CDPS Stormwater Management Program.*

- An annual update of the permit Stormwater Management Program is presented to the Natural Resources Advisory Board and the Water Board. The 2011 MS4 Permit update included a summary of the 2010 MS4 Permit annual report, minimum control measure internal assessment and tracking, and program challenges and successes.
- The City's MS4 Permit Stormwater Management Program description and 2008-2011 annual reports are posted on the City's website at:

http://www.fcgov.com/utilities/what-we-do/stormwater/stormwater-quality/management-program

3. **Illicit Discharge Detection and Elimination -** *The permittee must develop, implement and enforce a program to detect and eliminate illicit discharges into the permittee's MS4.*

- Staff responded to 45 spill complaint calls in 2011. Responses included site visits, incident investigations, on-site and phone education, delivery of educational door hangers and follow-up letters. Staff reported 7 verbal and 3 written notices of violation, and one charge to recover City clean-up costs.
- Staff collaborated with the Colorado Division of Fire Safety regarding Best Management Practices for fire suppression system discharges.
- Staff implemented the RGA spill response on-call program including purchasing spill equipment and providing training to employees.

Staff oversaw cleanup of a mineral oil spill to a stormwater channel

Staff advised on cleanup and reporting requirements for diesel spill

4. **Construction Site Runoff Control –** *The permittee must develop and implement a program to assure adequate design, implementation, and maintenance of BMPs at construction sites within the MS4 to reduce pollutant discharges and protect water quality.*

- Staff performed 1,167 inspections on 78 construction sites for sediment and erosion control in 2011. Enforcement measures for inadequate sediment and erosion control included: 86 verbal warnings, three written notices of violation, two stop-work orders, 22 building permits held, and holds issued on 185 initial building permits until installation of erosion control measures was complete.
- Staff assisted City engineering staff with the development of erosion control and wetlands plans for 10 City projects.
- Staff advised private developers and their contractors on-site with erosion control requirements and plan implementation.
- Staff responded to over 350 phone calls addressing customer questions regarding soil erosion control, stormwater pond inspections and permit compliance.
- Staff advised City departments and contractors on Construction Stormwater Permit and Stormwater Management Plan requirements for 10 City projects.
- Staff attended 8 development construction permitting meetings to review plans for new building projects within the City.
- Staff implemented PermiTrack Erosion and Sediment Control web-based construction site inspection tracking database program

Erosion control best management practices help keep construction site sediment out of the Poudre

Vehicle tracking pad help prevent construction vehicles from tracking mud onto the street

Construction site watering operations help reduce wind erosion

5. **Post-Construction Stormwater Management in New Development/Redevelopment -** *The permittee must develop, implement, and enforce a program to address stormwater runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the MS4. The program must ensure that controls are in place that would prevent or minimize water quality impacts.*

- Staff inspected 107 permanent water quality control features, or best management practices. Enforcement actions included 53 written notices of violation and one verbal notice of violation.
- Staff participated in the Stormwater Quality Team to review stormwater Best Management Practices in Fort Collins.

Water quality weir helps remove pollutants from stormwater

Water quality swale not functioning properly due to needed maintenance

Properly functioning water quality swale after maintenance was performed

6. **Pollution Prevention/Good Housekeeping for Municipal Operations -** *The permittee must develop and implement an operation and maintenance program that includes an employee training component and has the ultimate goal of preventing or reducing pollutants in runoff from municipal operations.*

- Staff conducted Stormwater Pollution Prevention / Good Housekeeping / Hazardous Waste Training for 253 City employees.
- Staff conducted stormwater inspections at nine City facilities.

Staff are trained to follow Best Management Practices to prevent stormwater pollution

Well-trained City employees responded quickly to clean up a hydraulic fluid spill

The following activities supplement the programs that support MS4 Permit requirements:

- Staff collaborated with Stormwater Engineering on the City of Fort Collins Storm Drainage Criteria Exceptions Manual.
- Staff participated in the Colorado Stormwater Council (CSC) and the Permit Compliance Committee.
- Staff hosted CDPHE Industrial Stormwater Permit Outreach workshops for customers and staff.
- Staff provided a training session to Poudre Fire Authority on storm water regulations and firefighting operations.

2011 Fort Collins Urban Creek Water Quality Monitoring Program:

The Colorado Department of Health and Environment (CDPHE) has established public use classifications and water quality standards for Spring Creek and Fossil Creek designed to protect aquatic life and support public uses, recreation and agriculture. Available water quality data from November 2000 through August 2007 show that Fossil Creek and Spring Creek consistently meet water quality standards for pH, dissolved oxygen, and nitrite designed to support aquatic life.

The water quality standard for the indicator bacteria, *E. coli*, is designed to protect recreational use. Spring Creek and Fossil Creek are both designated as “Recreation Class 1a” waterbodies. This classification indicates waters where primary contact occurs including swimming and frequent water play by children. Water quality data for *E .coli* show strong seasonal trends with individual values above the water quality standard primarily during summer months. Sources of *E. coli* contamination include human and animal waste. Controlling or minimizing contamination from improper connections to the City’s river and creeks is the focus of the Utility’s Illicit Discharge Program, a component of the City’s stormwater quality program.

In 2006, Fossil Creek was included on CDPHE’s list of impaired waterbodies for non-attainment of the selenium water quality standard. Available monitoring data shows selenium values consistently above the water quality standard. High concentrations of selenium are found in local shale deposits.

The EPA has published more stringent Selenium standard of 4.6 ppb in a revision of water quality criteria. Consequently in 2006, Colorado adopted this as a water quality standard and is now placing numerous river and stream segments on the 303(d) list for Selenium. The following local stream segments were put on the 303(d) list in 2006 due to exceeding the new selenium standard:

- the Poudre River from Boxelder Creek to where it meets the South Platte River,
- all of Fossil Creek, and
- Boxelder Creek, from its origin in northern Colorado to where it meets the Poudre River.

Selenium is naturally occurring in the underlying shale. The listings given above were a result of a new lower standard and not changing water quality. Selenium can be mobilized by precipitation runoff and infiltration to surface water and groundwater, resulting in elevated stream concentrations.

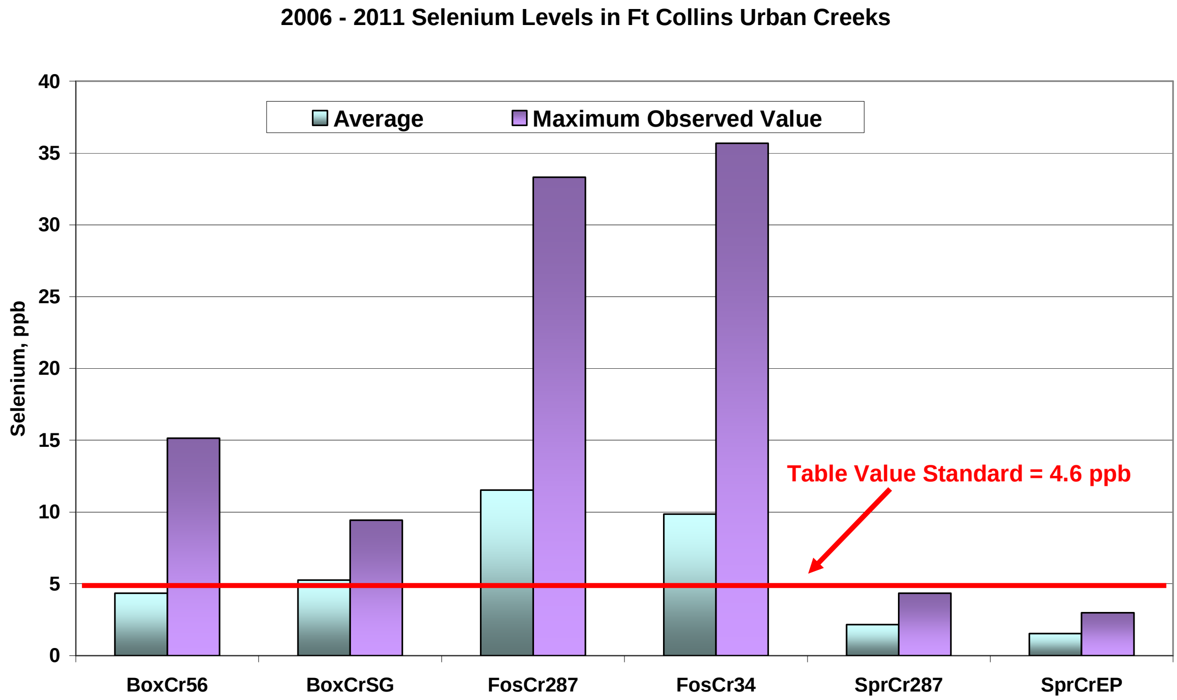
As directed in City Council Resolution 2000-128, “Recognizing the Need to Protect Water Quality”, the City monitors Boxelder Creek, Spring Creek, and Fossil Creek at two sites every calendar quarter for inorganic chemicals, dissolved oxygen and bacteria. Parkwood Lake is sampled twice per year for bacteriological, physical, and chemical parameters.

2011 Monitoring Sites and Test Parameter Matrix for Urban Creek Sites through Fort Collins.

City of Fort Collins / Utilities Pollution Control Lab	Surface Water Quality Test Matrix						
	CREEK MONITORING SITES						PARKWOOD LAKE
Test Parameters	**FOSC287**	**FOSC34**	**SPRC287**	**SPRCEP**	**BXC56**	**BSCXG**	**PKL**
Alkalinity, mg/L as CaCO3							
Ammonia-N, mg/L	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	2/year
Arsenic, µg/L							
Biochemical Oxygen Demand, mg/L							2/year
Cadmium, µg/L							
Chromium, µg/L							
Conductivity, µmhos/cm	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	
Copper, µg/L							2/year
Dissolved Organic Carbon, mg/L							
Dissolved Oxygen, mg/L	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	
E. coli / 100ml	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	
Flow, cfs							
Hardness, mg/L as CaCO3	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	2/year
Iron, µg/L							
Lead µg/L							2/year
Manganese, µg/L							
Mercury, µg/L							
Nickel, µg/L							
Nitrate-N, mg/L	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	2/year
Nitrite-N, mg/L	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	2/year
pH	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	2/year
Selenium, µg/L	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	
Silver, µg/L							2/year
Sulfate							
Temperature, ℃	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	2/year
TKN-N, mg/L							
Total Organic Carbon, mg/L							
Total Phosphorus, mg/L	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	1/Qtr	2/year
Zinc, µg/L							2/year

Site Code	Description
FOSC34	Fossil Creek at County Rd 34
FOSC287	Fossil Creek at College Avenue
SPRC_EP	Spring Creek at Edora Park
SPRC287	Spring Creek at College Avenue
BXCG	Boxelder Creek Gage
BXC56	Boxelder Creek at County Road 56
PKL	Parkwood Lake

2006 – 2011 Maximum, Average and Aquatic Life Table Value Standard for Selenium Levels in Fort Collins Urban Creeks.



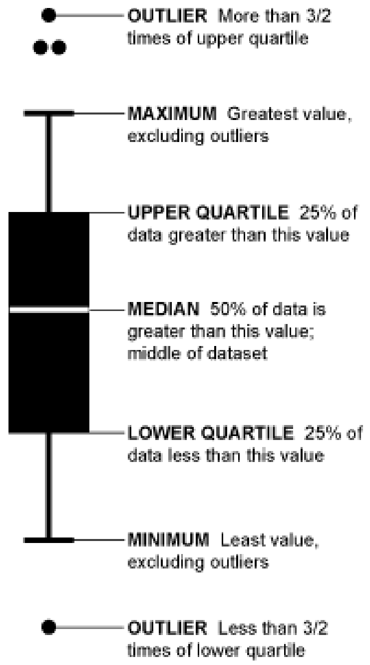
Legend:

BoxCr56 = Boxelder Creek at County Road 56
BoxCrSG = Boxelder Creek at Staff Gage located south of Prospect St.
FosCr287 = Fossil Creek at Hwy 287
FosCr34 = Fossil Creek at County Road 34
SprCr287 = Spring Creek at Hwy 287
SprCrEP = Spring Creek at Edora Park

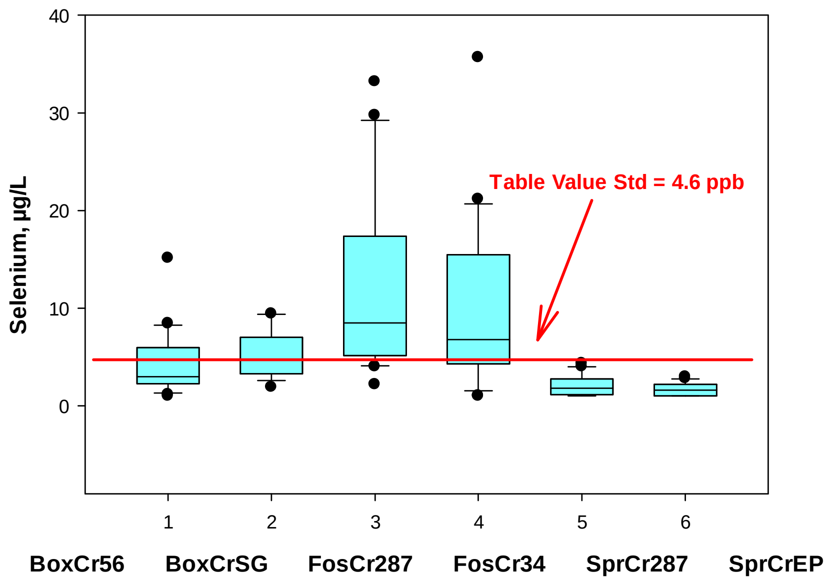
The Colorado Department of Health, Water Quality Control Division has listed both Boxelder Creek and Fossil Creek as 303(d)-impaired for the naturally elevated selenium levels. The Table Value Standard (TVS) for selenium in these creeks is set at 4.6 micrograms per liter (parts per billion, ppb). Selenium is associated with the shale common to soils in our geographic region. The City's Pollution Control Lab monitors the selenium levels in each of these three urban creeks at two locations every calendar quarter.

How to Read a Boxplot or a Box & Whisker Plot?

1. First note the location of the median (white line) in the box. If the median is in the middle the box, the data is not skewed to a predominance of high or low values. The overall height of the box indicates the overall range or distribution of the data. A tall box indicates a wide range in values.
2. The top and bottom of the box define the upper and lower quartiles at 25% and 75%.
3. The maximum and minimum values (excluding outliers) are represented by the horizontal lines at the end of the whiskers.
4. Outlier data points are represented by dots.



Boxplots of 2006 - 2011 Selenium Levels in Ft. Collins Urban Creeks



- The plots show substantially higher and a broader range of selenium concentrations in Fossil Creek than in either Boxelder or Spring Creeks. Selenium levels in both Boxelder Creek and Fossil Creek exceed the table value standard for aquatic life.

- **Parkwood Lake Water Quality:**

Since 1983, the City has shared in an agreement with the Parkwood Property Owner's Association (POA) for water quality monitoring on Parkwood Lake. The lake receives water from Arthur Ditch and stormwater from City streets. In return for giving permission for the City to use the lake as a receiving waterbody for stormwater, the City committed to an ongoing water quality monitoring program.

Twice each year, field measurements are taken and water samples are collected for testing at three defined locations near the shoreline of the lake. A summary of the data since 2006 is presented in the table below. Water quality is currently meeting applicable standards. However, should the Colorado Water Quality Control Division (WQCD) adopt strict "nutrient criteria" standards there may be issues with total phosphorus levels in the lake. Phosphorus is a common constituent of lawn and garden fertilizers as well as animal and bird feces.

2006 - 2011 Parkwood Lake Water Quality Summary

Parameter	Average	Maximum	Minimum	Standard	Good?
Ammonia-N (Nitrogen), mg/L	<0.1	0.1	<0.1	TVS †	**Yes**
Biochemical Oxygen Demand-5 Day, mg/L	4.21	8	<2	none	**Yes**
Conductivity, µmhos/cm	380	712	234	none	**Yes**
Dissolved Oxygen, mg/L	8.4	13	6	5	**Yes**
E. coli per 100 ml	13.4 (geomean)	143	<1	126 ‡	**Yes**
Hardness, mg/L as CaCO3	155	263	111	none	**Yes**
Lead, µg/L	<5.0	<5.0	<5.0	10.55	**Yes**
Nitrate-N, mg/L	<0.05	0.09	<0.05	10	**Yes**
Nitrite-N, mg/L	<0.05	<0.05	<0.05	0.5	**Yes**
pH	8.4	8.7	7.7	6.5 - 9.0	**Yes**
Silver, µg/L	<0.2	<0.2	<0.2	3.27	**Yes**
Temperature, ℃	16.9	24.6	10.0	*I.D.*	**Yes**
Total Phosphate, mg/L	0.09	0.13	<0.1	0.083 [a]	**???[a]**
Zinc, µg/L	<5.0	<5.0	<5.0	393.2	**Yes**

Legend:

† TVS: Table Value Standard based on pH and temperature calculation

‡ Standard is based on geometric mean calculation of available stream or lake data

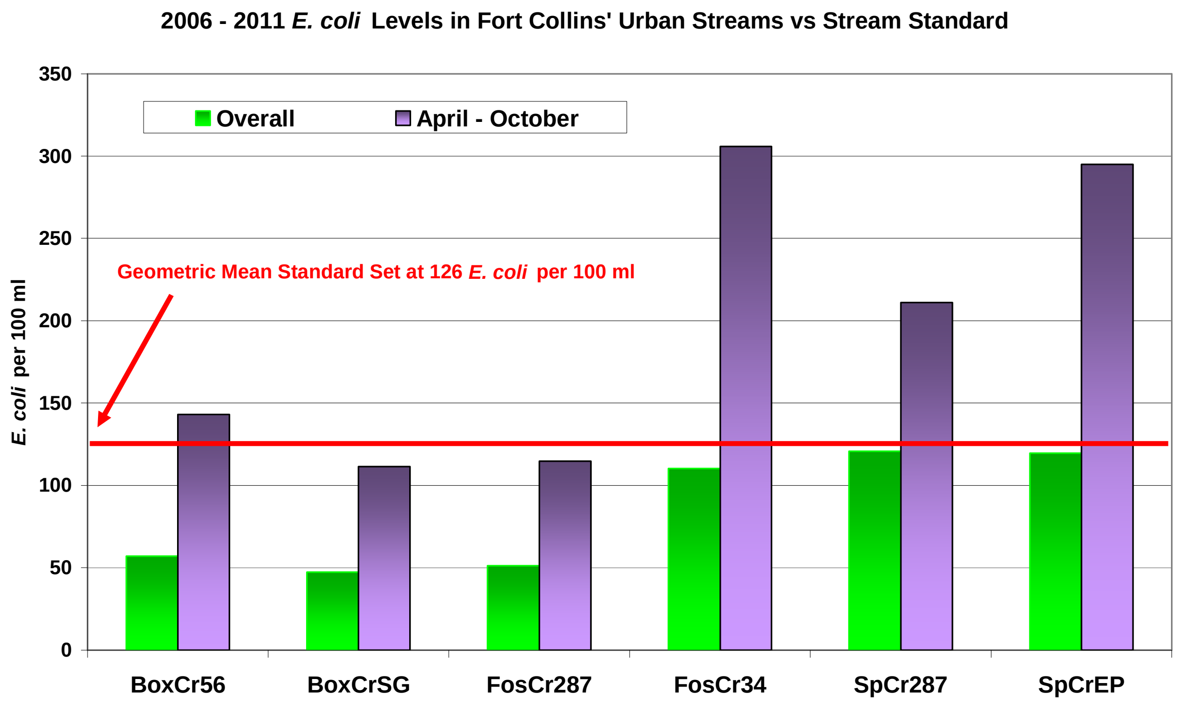
I.D. = Insufficient Data

a: Possible problem with very strict future "Nutrient Criteria" Standards for Lakes and Reservoirs. **Exceedence of standard only allowed once every five years**.

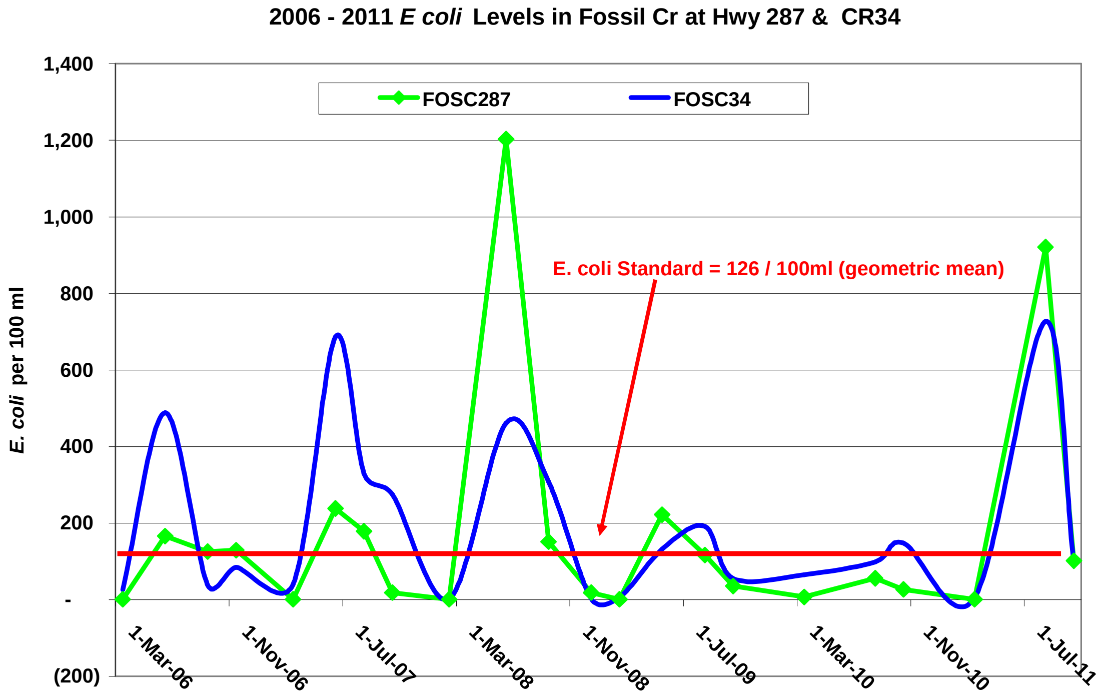
E. coli contamination in Fossil Creek and Spring Creek:

Using several years of City and USGS data and focusing on the months of April through October, the Colorado WQCD has determined that both Fossil Creek and Spring Creek are now 303(d)-listed as "impaired" for *E. coli* contamination. Both creeks were also given a "high priority" designation for developing corrective actions. Potential sources of *E. coli* contamination include failing septic systems, leaking sewer lines, domestic animals (pets, cattle, horses, etc.) and wildlife. Additional monitoring to identify potential point sources of contamination within the creeks will need to be completed.

The diagram presented below depicts the overall and seasonal geometric mean values of *E. coli* levels found in key Fort Collins urban creeks for the 2006 – 2009 timeframe compared to the stream standard of 126 *E. coli* per 100 ml. *E. coli* levels were monitored once each calendar quarter for this time period and the overall and seasonal (April through October) geometric means were calculated per Colorado Water Quality Control Division (WQCD) procedures. The overall geometric mean values (n=20) for each site were all below the 126 *E. coli* / 100 ml limit set by the WQCD. However, data for the April through October showed the creeks to be in violation of the water quality standard.

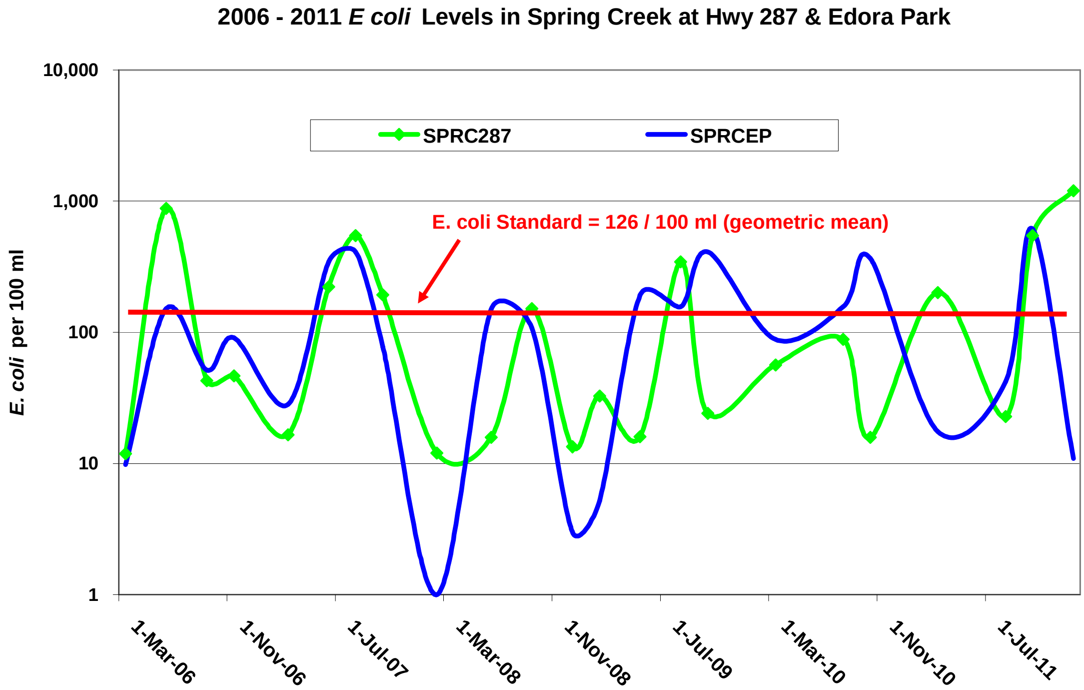


2006 – 2011 Overall and April through October *E. coli* levels in Fort Collins key urban creeks versus the stream standard of 126 *E. coli* per 100 milliliters (ml). All three sites are listed as 303(d) – seasonally impaired for high *E. coli* levels during the spring and summer months.



2006 – 2011 Overall and seasonal *E. coli* levels in Fossil Creek at County Road 34 versus the stream standard of 126 *E. coli* per 100 milliliters (ml) and the overall geometric mean of the data. Note the strong seasonal trends with the highest *E. coli* levels observed in the spring and summer months. Fossil Creek is listed as 303(d)-impaired for seasonal high levels of *E. coli* contamination.

The water quality standard for the indicator bacteria, E. coli, is designed to protect recreational use. Spring Creek and Fossil Creek are both designated as "Recreation Class 1a" waterbodies. This classification indicates waters where primary contact occurs including swimming and frequent water play by children. Water quality data for E .coli show strong seasonal trends with individual values above the water quality standard primarily during summer months. Controlling or minimizing contamination from improper connections to the City's river and creeks is the focus of the Utility's Illicit Discharge Program, a component of the City's stormwater quality program.



2006 – 2011 Overall and seasonal *E. coli* levels in Spring Creek at Edora Park versus the stream standard (straight red line) of 126 *E. coli* per 100 milliliters (ml) and the overall geometric mean of the data. Note the strong seasonal trends with the highest *E. coli* levels observed in the spring and summer months. Spring Creek is listed as 303(d)-impaired for seasonal high levels of *E. coli* contamination.

APPENDIX A

2011 City of Fort Collins Water Quality Monitoring Site Location Details:

Sample Site Name	Site Description	River Mile
City of Fort Collins Cache la Poudre River Monitoring Sites:		
Poudre @ Shields St	USGS Sample Site 06752258	45.00
PMRT	Poudre River at Martinez Park	44.50
Lincoln Street Gage	USGS Gage 06752260	43.44
432PLNC	Poudre River @ Lincoln Ave.	43.20
1EFF	001A - Mulberry effluent weir	-
1EFF	001A - Mulberry (MWRF) outfall to Poudre	42.49
PBRY	Poudre River @ Mulberry Street	41.60
390PPROS at Prospect St	USGS Sample Site 06752270	40.30
387PNAT	Poudre River @ Nature Center	38.70
2EFF	002B - Fossil Creek weir @ Drake	-
2EFF	002B - Fossil Creek outfall @ Drake	-
2EFF	002D - Poudre outfall @ Drake (DWRF)	38.39
2EFF	005B - PRPA @ Drake	-
370PBOX	Poudre River above Boxelder Creek	37.59
Boxelder Gage	USGS Gage 06752280 above Boxelder Cr	37.59
City of Fort Collins Urban Creek Monitoring Sites:		
FOSC287	Fossil Creek Ditch at Hwy 287	
FOSC34	Fossil Creek Ditch at CR34	
SPRC287	Spring Creek at Hwy 287	
SPRC-EP	Spring Creek at Edora Park	
BXC56	Boxelder Creek at CR56	
BXCG	Boxelder Creek Gage	
Lower Poudre Monitoring Alliance Sample Sites:		
432PLNC	Poudre at Lincoln St Gage above Mulberry WRF	43.2
390PPROS	Poudre at Prospect St Bridge below Mulberry WRF	39
370PBOX	Poudre at USGS Gage above Boxelder Cr	37
350LCR5	Poudre at Larimer County Rd 5	35
325PFOS	Poudre downstream of Fossil Cr Reservoir outlet	32.5
225SGAGE	Poudre at Staff Gage above Kodak Colorado Division	22.5
200STTH	Poudre at Shark's Tooth	20
145FSPUR	Poudre at Farmer's Spur below KCD	14.5
055WPCF	Poudre at Greeley WPCF gage	5.5
022FERN	Poudre at Fern Avenue below Greeley	2.2
City of Fort Collins Parkwood Lake Stormwater Impact Monitoring Sites:		
PKLa	Parkwood Lake Site A	Northeast Corner
PKLb	Parkwood Lake Site B	Southwest Corner
PKLc	Parkwood Lake Site C	Southeast Corner

APPENDIX B

2011 Monitoring Sites and Test Parameter Matrix for Cache la Poudre River Sites through Ft. Collins.

City of Fort Collins / Utilities Pollution Control Lab	Surface Water Quality Test Matrix			
	POUDRE RIVER MONITORING SITES			
Test Parameters	**432PLNC**	**390PPROS**	**380PNAT**	**370PBOX**
Alkalinity, mg/L as CaCO3	8/year	8/year	8/year	8/year
Ammonia-N, mg/L	1/week	1/week	1/week	1/week
Arsenic, µg/L	8/year	8/year	8/year	8/year
Biochemical Oxygen Demand, mg/L				
Cadmium, µg/L	8/year	8/year	8/year	8/year
Chromium, µg/L	8/year	8/year	8/year	8/yar
Conductivity, µmhos/cm	1/week	1/week	1/week	1/week
Copper, µg/L	8/year	8/year	8/year	8/year
Dissolved Organic Carbon, mg/L	8/year	8/year	8/year	8/year
Dissolved Oxygen, mg/L	1/week	1/week	1/week	1/week
E. coli / 100ml	1/week	1/week	1/week	1/week
Flow, cfs	1/week	8/year	8/year	1/week
Hardness, mg/L as CaCO3	1/week	1/week	1/week	1/week
Iron, µg/L	8/year	8/year	8/year	8/year
Lead µg/L	8/year	8/year	8/year	8/year
Manganese, µg/L	8/year	8/year	8/year	8/year
Mercury, µg/L	8/year	8/year	8/year	8/year
Nickel, µg/L	8/year	8/year	8/year	8/year
Nitrate-N, mg/L	1/week	1/week	1/week	1/week
Nitrite-N, mg/L	1/week	1/week	1/week	1/week
pH	1/week	1/week	1/week	1/week
Selenium, µg/L	8/year	8/year	8/year	8/year
Silver, µg/L	8/year	8/year	8/year	8/year
Sulfate	8/year	8/year	8/year	8/year
Temperature, ℃	1/week	1/week	1/week	1/week
TKN-N, mg/L	8/year	8/year	8/year	8/year
Total Organic Carbon, mg/L	1/week	1/week	1/week	1/week
Total Phosphorus, mg/L	1/week	1/week	1/week	1/week
Zinc, µg/L	8/year	8/year	8/year	8/year

Legend:

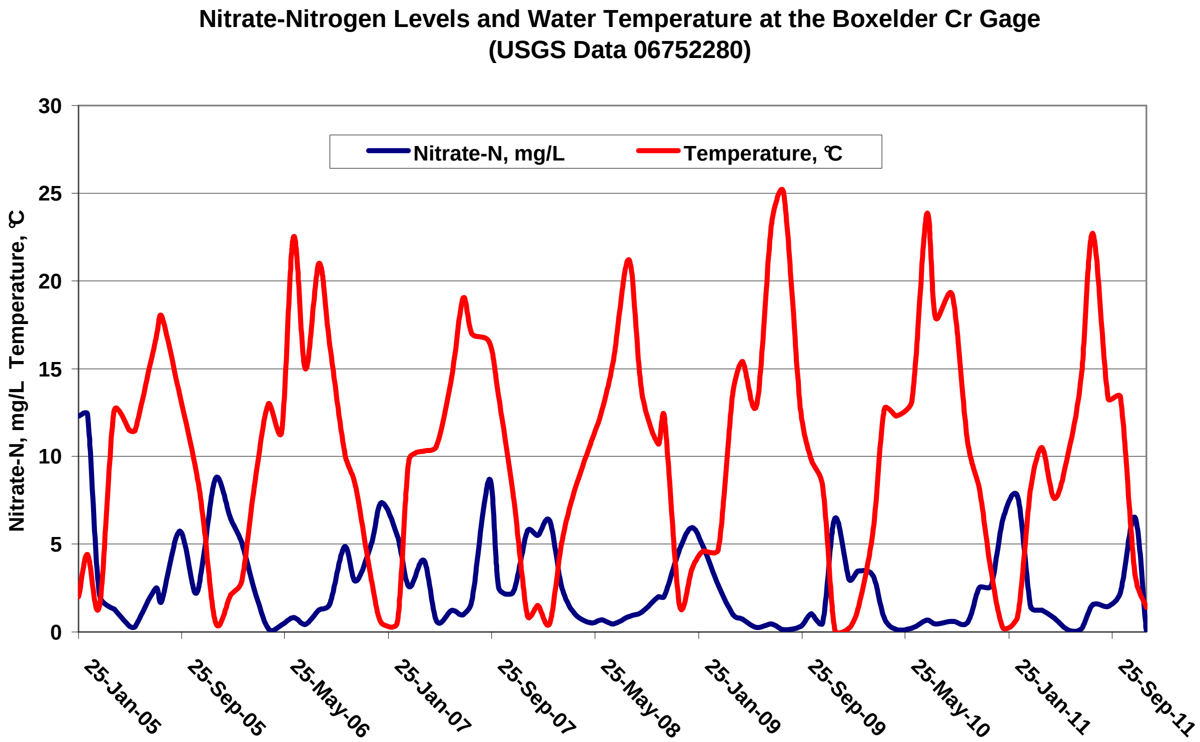
Site Code	Description
432PLNC	Poudre River @ Lincoln Ave.
390PPROS	Poudre River at Prospect Street
380PNAT	Poudre River @ Nature Center
370PBOX	Poudre River above Boxelder Creek

APPENDIX C

Cooperative United States Geological Survey (USGS) Flow and Water Quality Monitoring on the Cache la Poudre in Segment 11 through Fort Collins:

The City has participated in the USGS cooperative flow and water quality monitoring program on the Cache la Poudre River for over thirty years. This program plays mission critical roles in both managing the City's $700 million dollar water resources portfolio and providing independent documentation of ambient water quality conditions in the Poudre. Having accurate flow and water quality data is also essential for the Water Quality Control Division (WQCD) to develop accurate stream standards and discharge permit limits for the City's two water reclamation facilities.

The City pays the USGS a majority of the costs to record stream flow and water quality at several gage stations on the Poudre. At the USGS water quality sites, samples are collected and tested each month for a lengthy list of water quality parameters. Both the Lincoln Street and the river site above Boxelder Creek are equipped with continuous recording water flow gages. Real-time flow data for these two sites are posted at the USGS web site and available to the public. The entire historical record of flow and water quality data for the City-sponsored sites on the Cache la Poudre is available at the USGS web site.



The combined USGS-City cost total for the October 2010 through September 2011 USGS flow and water quality monitoring on the Poudre was $133,700. The City's share of that amount was $91,920 with the remaining amount obtained from Federal matching funds. Details for the

2011 USGS flow and water quality sites on the Cache la Poudre River are presented in the following table:

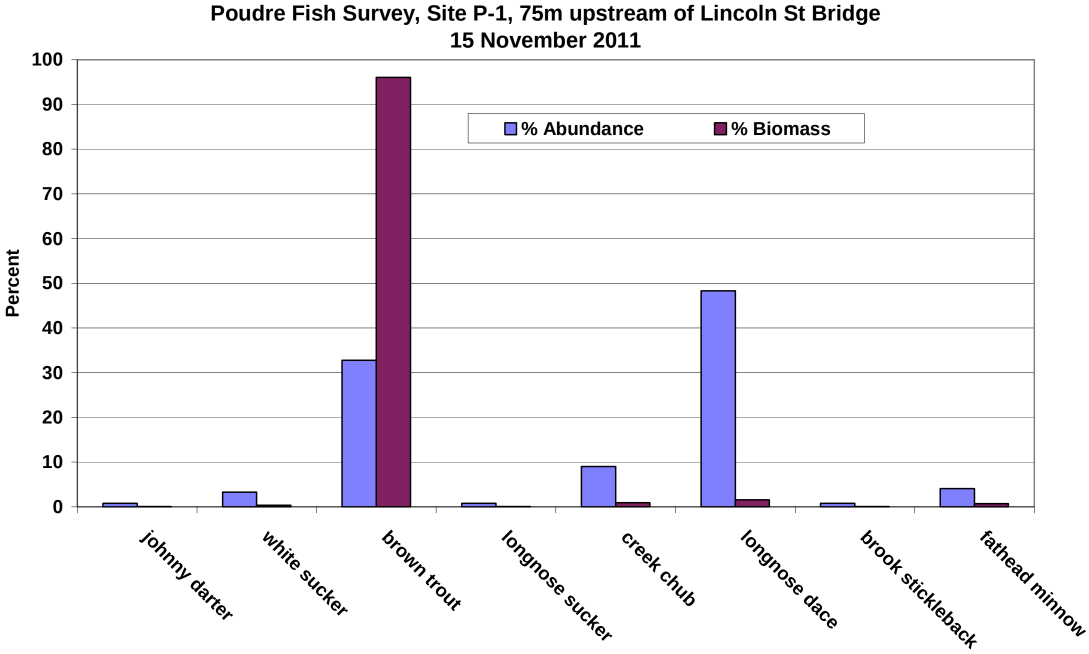
City of Fort Collins & USGS Water Flow & Quality Cooperative Monitoring Sites, Period of Record and Cost-Sharing Importance to the USGS:

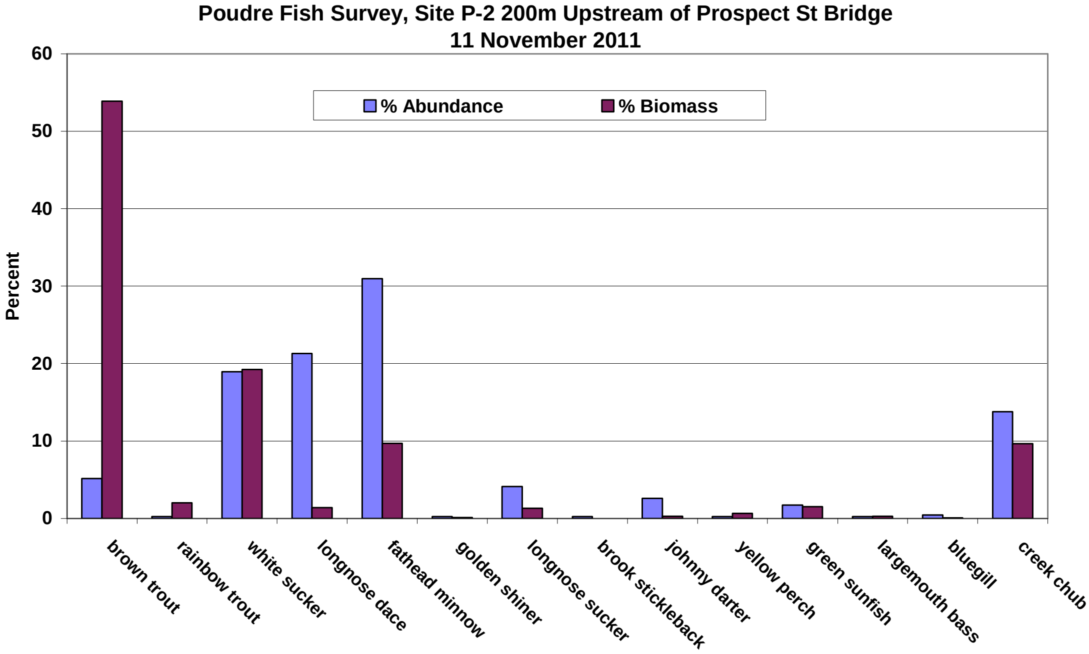
Site Number	Location	Period of Record	Flow and/or Water Quality	Importance to USGS †
6614800	Michigan River near Cameron Pass	1973 - Present	Flow	High
6746095	Joe Wright Cr above Reservoir	1978 – Present	Flow	Low
6746100	Joe Wright Cr blw Reservoir	1978 – Present	Flow	Low
06751150	North Fork Cache la Poudre blw Halligan Res.	1998 – Present	Flow	Low
06752258	Cache la Poudre at Shields St	1975 – 2005	Quality & Instantaneous Flow	Low
06752260	Cache la Poudre at Lincoln St	1975 – Present	Flow & Quality	High
06572270	Cache la Poudre at Prospect St	1975 – 2005	Quality & Instantaneous Flow	Low
06752280	Cache la Poudre above Boxelder Cr	1979 – Present	Flow & Quality	Medium
06737500	Horsetooth Res in conjunction with NCWCD & USBR	1969 - 2008	Quality	Low

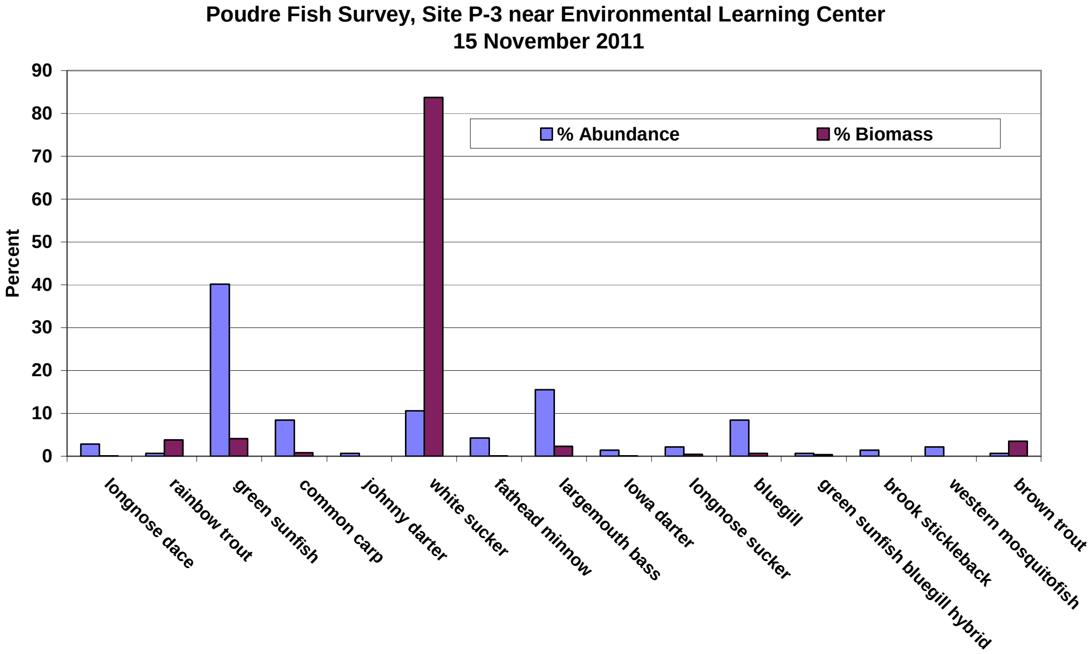
† Ranking priorities influence the cost-sharing percentages. A higher USGS importance ranking increases proportion of available Federal matching funds for flow and water quality monitoring.

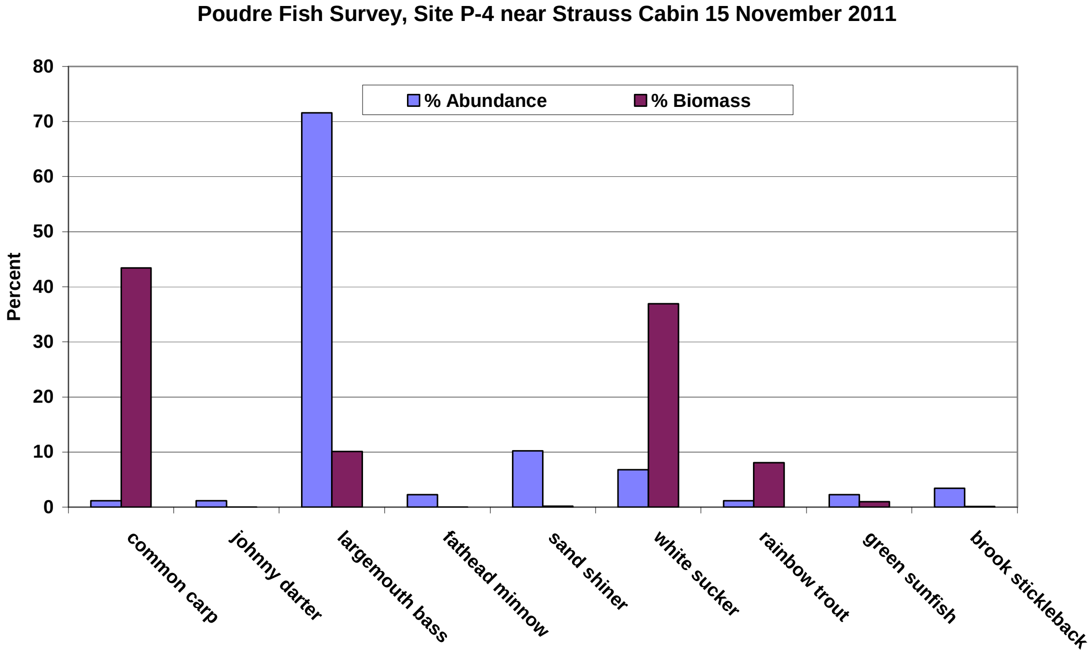
APPENDIX D: 2011 Fall Season Fish Survey Results on the Cache la Poudre from Dr Kevin Bestgen, CSU

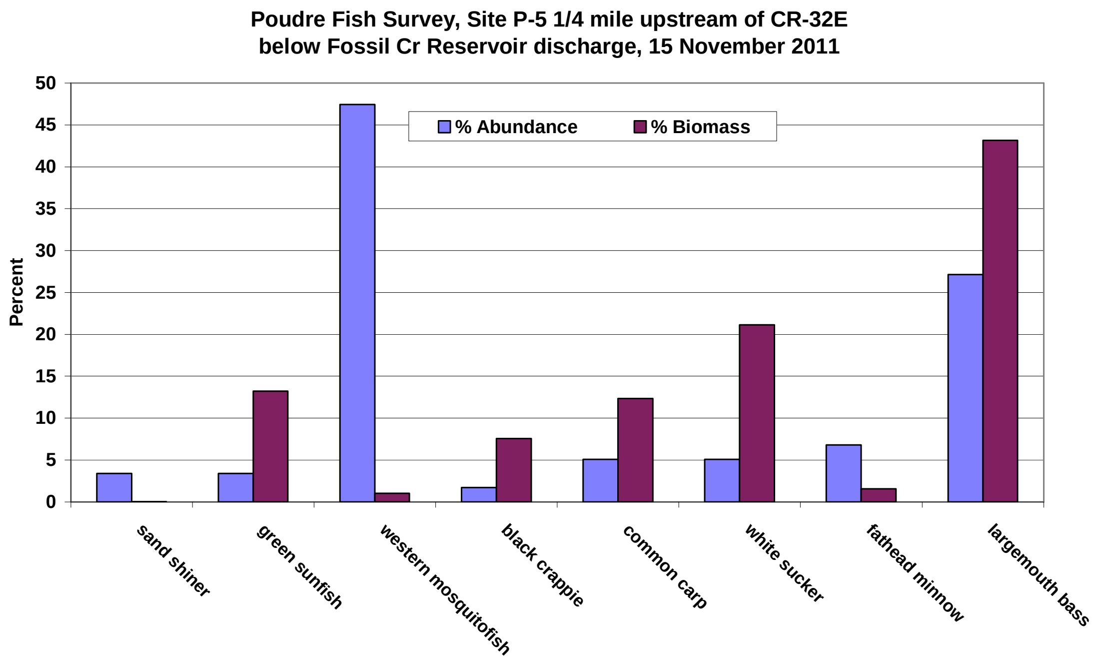
Percent abundance and biomass results by species are presented for four sites on the Poudre starting upstream of Lincoln Street in Old Town to the Strauss Cabin located upstream of I-25. The complete 2011 Poudre water quality, fish and macroinvertebrate survey report from CSU is available from the Utility's Environmental Services Division.

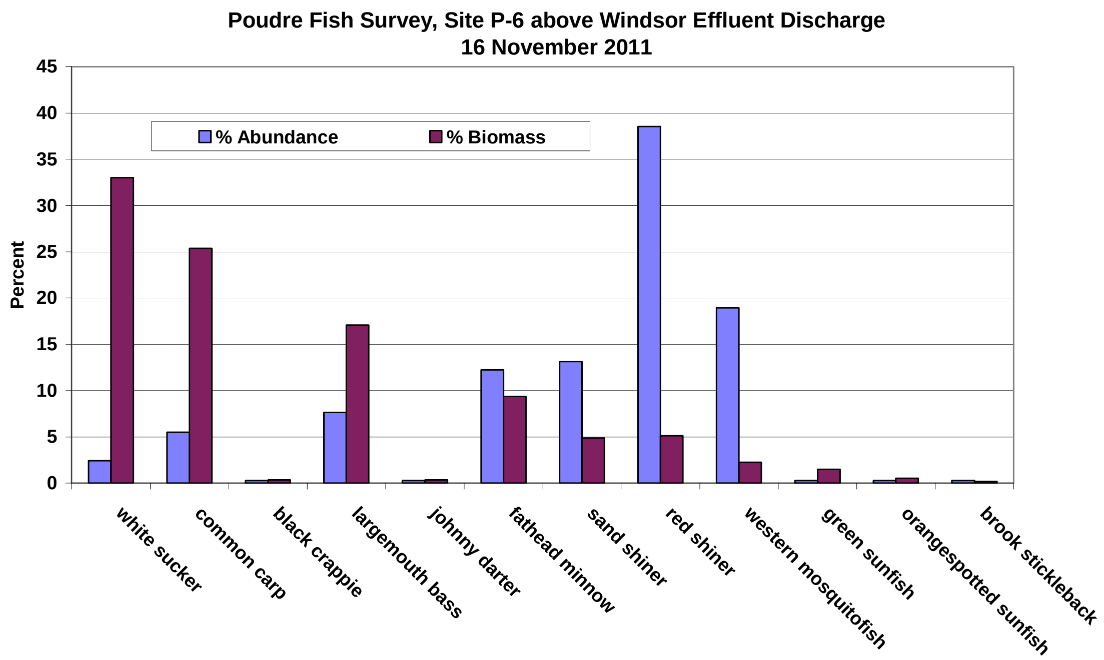


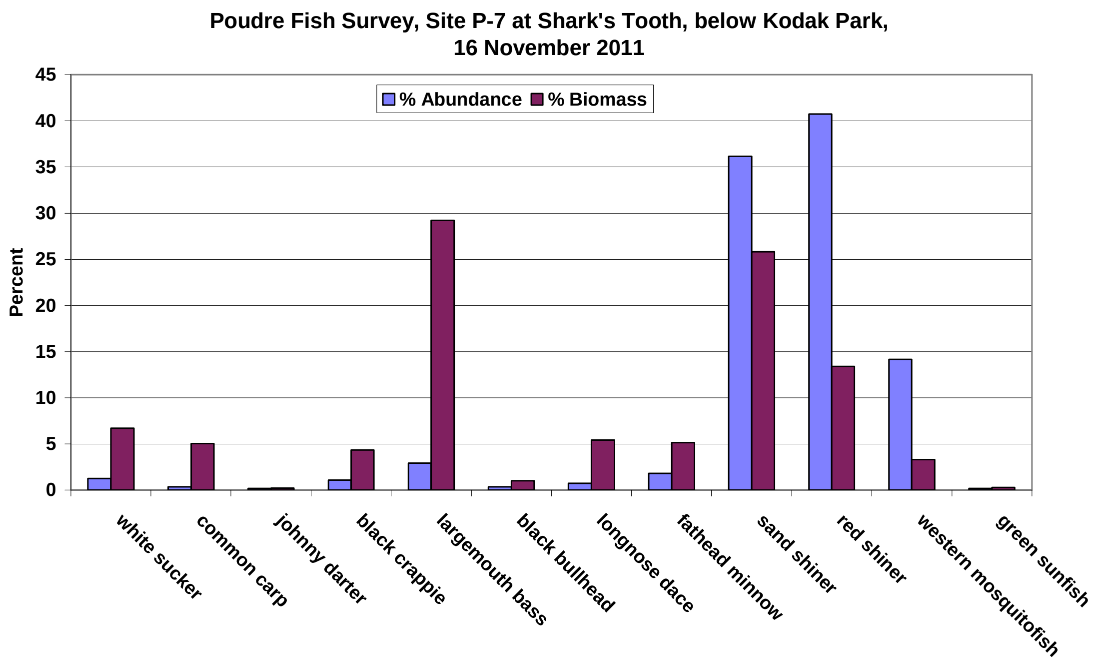


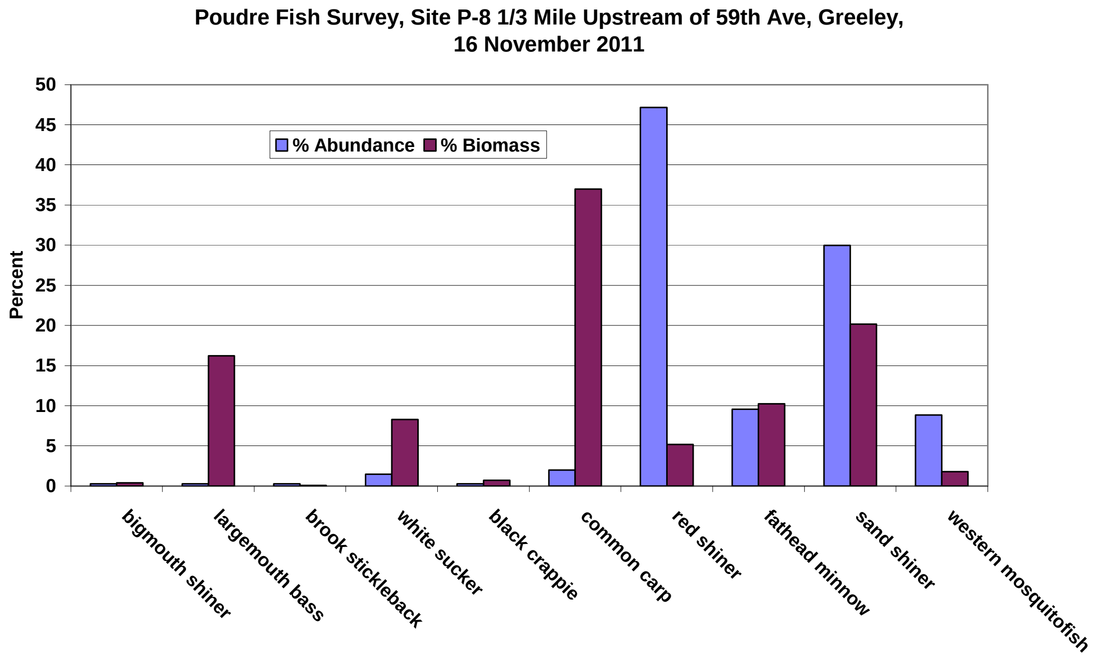

Poudre Fish Survey, Site P-3 near Environmental Learning Center
15 November 2011
% Abundance
% Biomass
Percent
90
80
70
60
50
40
30
20
10
0
longnose dace
rainbow trout
green sunfish
common carp
johnny darter
white sucker
fathead minnow
largemouth bass
Iowa darter
longnose sucker
bluegill
green sunfish bluegill hybrid
brook stickleback
western mosquitofish
brown trout


Poudre Fish Survey, Site P-4 near Strauss Cabin 15 November 2011
% Abundance
% Biomass
Percent
80
70
60
50
40
30
20
10
0
common carp
johnny darter
largemouth bass
fathead minnow
sand shiner
white sucker
rainbow trout
green sunfish
brook stickleback

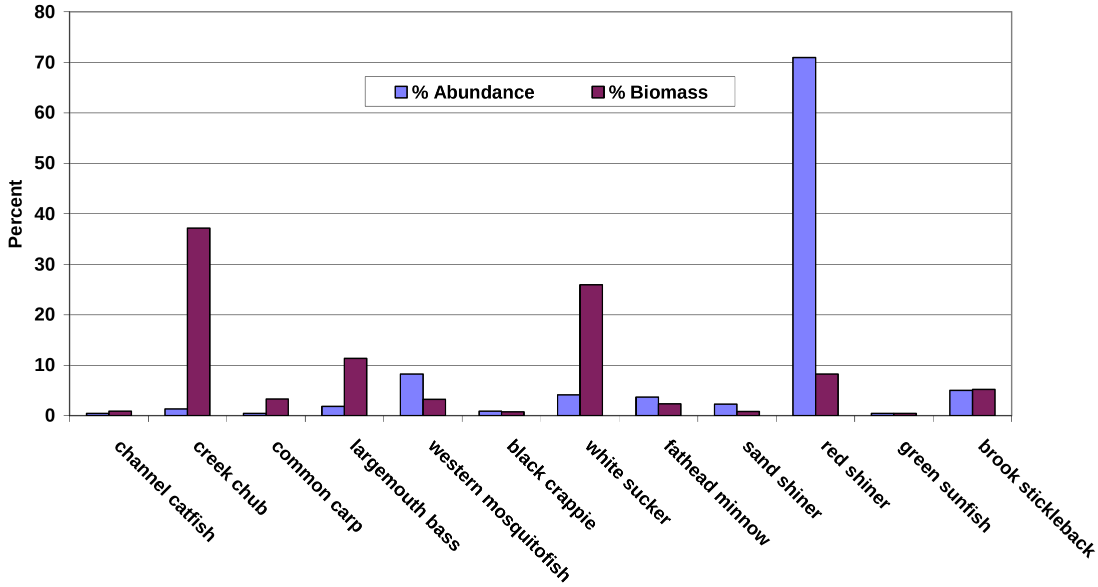

Poudre Fish Survey, Site P-5 1/4 mile upstream of CR-32E
below Fossil Cr Reservoir discharge, 15 November 2011
Percent
50
45
40
35
30
25
20
15
10
5
0
% Abundance
% Biomass
sand shiner
green sunfish
western mosquitofish
black crappie
common carp
white sucker
fathead minnow
largemouth bass


Poudre Fish Survey, Site P-6 above Windsor Effluent Discharge
16 November 2011
Percent
45
40
35
30
25
20
15
10
5
0
% Abundance
% Biomass
white sucker
common carp
black crappie
largemouth bass
johnny darter
fathead minnow
sand shiner
red shiner
western mosquitofish
green sunfish
orangespotted sunfish
brook stickleback


Poudre Fish Survey, Site P-7 at Shark's Tooth, below Kodak Park,
16 November 2011
% Abundance
% Biomass
Percent
45
40
35
30
25
20
15
10
5
0
white sucker
common carp
johnny darter
black crappie
largemouth bass
black bullhead
longnose dace
fathead minnow
sand shiner
red shiner
western mosquitofish
green sunfish


Poudre Fish Survey, Site P-8 1/3 Mile Upstream of 59th Ave, Greeley,
16 November 2011
% Abundance
% Biomass
Percent
50
45
40
35
30
25
20
15
10
5
0
bigmouth shiner
largemouth bass
brook stickleback
white sucker
black crappie
common carp
red shiner
fathead minnow
sand shiner
western mosquitofish

Poudre Fish Survey, Site P-9, just Upstream of Hwy 85, Greeley, 16 November 2011



Poudre Fish Survey, Site P-10, above confluence with South Platte, 16 November 2011