Alberta CreekWatch
A Report Card on Urban Creek Water Quality
2016

Calgary's Fish Creek was ranked first for best water quality

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Table of Contents

Executive Summary

The second annual CreekWatch Report Card examines the state of urban creeks in Alberta based on the water quality data collected through the use of citizen science, water quality technicians and lab analysis. We are sharing our findings with the public, governments, and water quality professionals to collaboratively work towards the consistent monitoring and improvement of our urban creeks in Alberta.

Urban creeks function as conduits for stormwater runoff, and top rankings denote greater overall water quality, while lower rankings signify lesser overall water quality. See Table 1.

Table 1 Overall urban creek rankings

A Report Card on Urban Creek Water Quality, 2016				
Rank 2016	**Creek**	**Score**	**Location**	**Rank 2015**
1	Fish Creek	85%	Calgary	1
2	Wedgewood Creek	76%	Edmonton	
3	Pine Creek	74%	Calgary	2
4	Oldman Creek	73%	Strathcona County	
5	Blackmud Creek	72%	Edmonton	3
6	Waskasoo Creek	70%	Red Deer	
7	Whitemud Creek	69%	Edmonton	4
8	West Nose Creek	58%	Calgary	5
9	Nose Creek	56%	Calgary	7
10	Mill Creek	54%	Edmonton	6

In 2016, between the months of March and October, there were 68 trained volunteers and two science technicians in Edmonton, Red Deer and Calgary whose work combined for 338 site visits, over 3,100 collected data points, and an estimated 350 hours total time spent monitoring ten urban creeks.

The CreekWatch monitoring program suggests that Edmonton, Red Deer and Calgary have a range of water quality exemplified in their stormwater creeks. It would be important to investigate the best management practices employed in the top ranked creeks for potential emulation into the management practices of the lower ranked creeks.

Of special note, the top ranked creek, Calgary's Fish Creek, contains multiple constructed wetlands that collect stormwater runoff from the streets of the surrounding communities. These networks of engineered wetlands function to allow sediment to settle and pollutants to be removed before water moves downstream. On the opposite end of the rankings, the two lowest ranked creeks, Edmonton's Mill Creek and Calgary's Nose Creek, drain significant land areas without sufficient wetlands to settle out the runoff. A significant portion of Mill Creek is also currently buried, preventing ecosystem functions as the water travels underground. Red Deer's Waskasoo Creek, while not ranking high or low, has nearly 100 stormwater outfalls whose impacts are mitigated with headwater wetlands.

To achieve improved urban creek water quality in the future, it is recommended to:

- increase public and industry education, making people aware that a.) stormwater runoff from our streets, homes, businesses, and parking lots travels through storm drains largely untreated into our waterways, and b.) their stewardship actions can make a positive difference;
- consider stormwater impacts in any new snow removal planning involving calcium chloride, to-the-pavement scarping or localized snow dumps;
- uncover (daylight) and remove pipes and culverts from buried creeks, reinstating open-air ecosystem functions
- increase constructed/engineered wetlands as a means for stormwater treatment

Acknowledgements

CreekWatch was made possible through HSBC Water Programme funding and HSBC volunteers in a collaborative effort with the RiverWatch Institute of Alberta.

The enthusiasm and time donated by citizen science volunteers was amazing. Sixty-eight trained volunteers used a loan-pool of monitoring equipment to collect data from their local creeks in Edmonton, Red Deer and Calgary. Volunteers were recruited from the following organizations:

HSBC Bank Canada
Keepers of Mill Creek
GE Water
Trace Associates
Ann and Sandy Cross Conservation Area
EPCOR
Waskasoo Neighborhood Community

Advice and support was received from organizations and professionals across Alberta to help plan, develop, manage and analyze CreekWatch data collection, and include the following:

Alberta Environment & Parks
City of Calgary Water Resources
City of Edmonton Drainage Services
City of Red Deer Environmental Services
Bow River Basin Council
North Saskatchewan Watershed Alliance
EPCOR Water Canada
Web3 Marketing
Exova
Salmo Consulting
Victoria Hansen & Miranda Lisowski

Thank you everyone.

Introduction

CreekWatch comprises of a citizen science network for the collection of useable, cost-effective and publicly available data on urban creek stormwater quality. The primary goal of CreekWatch is to collect baseline water quality data on urban stormwater creeks in Alberta. Urban stormwater tributaries face unique stressors that already make them some of the most highly impacted local waterways, and consequently, they are of interest and importance to communities and watershed managers.

With increasing residential and industrial development, many urban surfaces are now impermeable, allowing snowmelt and rainwater to move much more quickly over these areas rather than soaking into the soil. Along this surface run-off journey, stormwater collects various contaminants from vehicles, roadway maintenance, industries, pet waste and neighborhood yards that ultimately discharges into creeks that impact river ecology and urban sustainability. See Table 2 for total stormwater outfalls per monitored creek.

Table 2 Total number of urban stormwater outfalls per monitored creek

Urban Stormwater Outfalls per Creek										
	Calgary				Edmonton					Red Deer
	Fish Creek	Nose Creek	West Nose Creek	Pine Creek	Whitemud Creek	Blackmud Creek	Mill Creek	Wedgewood Creek	Oldman Creek	Waskasoo Creek
Total Outfalls	14	53	14	2	16	11	46	1	0	99*

Source: City of Calgary Water Resources, 2016; City of Edmonton Drainage Services, 2016, City of Red Deer Environmental Services, 2017. *Waskasoo Creek has 73 stormwater outfalls and is joined by Piper Creek that has an additional 26 stormwater outfalls.

Justification

The first two years of CreekWatch aimed to establish a framework and tools for incorporating public participation in science research (citizen science) to address existing issues and research gaps in stormwater monitoring. Contributions were made to address issues and research gaps including:

- the number and frequency of stormwater creeks being monitored
- baseline data for stormwater quality
- reliability of volunteer citizen science data
- the cost-efficiency of monitoring programs
- the public availability of online data
- and the engagement of a public able to understand and contribute to the management of rivers and streams.

Site Information

Sampling sites were identified on urban tributaries of the North Saskatchewan River in Edmonton, the Red Deer River in Red Deer, and the Bow River in Calgary. Sites were selected based on the consideration of accessibility, perceived value of tributary importance, the extent of our resources to collect data, and the advice and suggestions from other water quality professionals. Samples were collected at the mouth of each selected tributary. See Appendices 7 - 16 for individual creek descriptions.

Study Design

Three levels of data collection were undertaken in 2016 as means to involve citizen science volunteers, increase the number of sampling events, and to provide quality assurance.

Level One data was obtained through trained citizen science volunteers using manual equipment, as seen in Photo 1. This involved the use of Hach testing kits housed in wheeled coolers for ease of transport and access (See Photo 2). Expectations were that each volunteer would collect data on their own free time at least 2-4 times through the open-water season. We had 25 volunteers in Edmonton, 7 in Red Deer, and 36 volunteers in Calgary. Water sampling occurred between the months of March and October 2016.

Photo 1 - Volunteers streamside performing water quality tests.

Photo 2 - Level One Hach Monitoring Kit.

Level Two data was collected by CreekWatch Technicians on a weekly basis between March-October (See Photo 3). This involved the use of a YSI Professional Plus instrument capable of measuring a wide range of parameters. Also included in the equipment were two separate LaMotte 1200 Colorimeters, one for nitrate-nitrogen and one for phosphorus. See Photo 4.

Photo 3 - CreekWatch Technician using Level Two Equipment.

Photo 4 - Level Two Electronic Monitoring Equipment.

The collection of **Level Three** data happened once in 2016, and this involved the submission of water samples to Exova for laboratory-based testing. All three levels of data were collected at the same time, allowing for a unique comparison between the three different data levels to verify accuracy and consistency. See Appendix 3 for detailed explanations on equipment and levels of monitoring, and see Appendix 4 for a comparison of data across three levels of data.

Table 3 Total sampling events in 2016

Sampling Events per Creek											
	Calgary				Edmonton					Red Deer	
	Fish Creek	Nose Creek	West Nose Creek	Pine Creek	Whitemud Creek	Blackmud Creek	Mill Creek	Wedgewood Creek	Oldman Creek	Waskasoo Creek	Total Events
Level One	5	13	9	28	7	3	8	1	1	18	**93**
Level Two	26	39	25	23	41	22	22	18	18	2	**235**
Level Three	1	1	1	1	1	1	1	1	1	0	**9**
Total Events	**30**	**53**	**35**	**52**	**49**	**26**	**31**	**20**	**20**	**20**	**338**

All volunteers and technicians were provided a unique PIN to access the data entry portion of the CreekWatch website. This information could be entered on a computer or mobile device, and once submitted, it was available for public viewing in real-time. Please see Appendix 5 for a description of the data viewing and entry platform.

General Observations

All ten monitored creeks contained flowing water throughout the open-water season in 2016.

- A very dry drought-like spring turned into a very wet summer across much of the province.
- Severe weather was particularly common across much of Alberta, with many events of large hail, strong winds, and heavy rain.
- Two counties declared states of agricultural disaster due to extreme precipitation.
- Total precipitation across Alberta was above average, with the Calgary region experiencing the wettest July in 89 years.

The comparability of our three levels of data was shown to be an effective way to determine the accuracy of each method of data collection. By means of these comparisons, we can speak to the accuracy of the data we are collecting. With the data collected in Level One and Two being relatively close, there is definitely a trade-off for the cost effectiveness of using volunteer water quality monitoring equipment as a valuable means to collect data.

Graphing the individual water quality parameters showed that there is a general pattern in the life of creeks and there are many direct correlations between the parameters that we are monitoring. See the box-and-whisker plots in Appendix 6. For instance, temperature had a direct correlation with dissolved oxygen levels. As temperature increased, dissolved oxygen levels decreased. Another interesting pattern was the pH levels that were noticeably similar within each city's creeks, although widely different between Edmonton and Calgary.

In creating a report card summary of stormwater creek water quality, it became apparent that there is a range of creek water quality in Edmonton, Red Deer and Calgary. This report functions as baseline water quality data for the 2016 open-water season and will be used going forward to compare differences in water quality over the years.

Stewardship Action

In June 2016, a stewardship project was coordinated along a section of Nose Creek in Calgary. This was coordinated with the help of the City of Calgary and volunteers spent an afternoon removing invasive plants from selected areas. The target plant for the day was Common tansy (*Tanacetum vulgare*), which has taken up residence along much of the Bow River and its tributaries in Calgary. Listed as a noxious weed in Alberta, this plant grows in dense 1.5m tall stands with yellow button-like flowers. As seen in the photos below, our volunteers had a great time removing this plant and look forward to more events in 2017. In addition to this event, volunteers in Edmonton planted over 150 native trees along Gold Bar Creek.

Photo 5 - Common Tansy (Tanacetum vulgare) at the confluence of Nose Creek

Photo 6 – Volunteers were well equipped by the City of Calgary to properly remove the entire plant

Analysis

While each study creek had a different source area, the data might be best compared for changes along the length of a particular creek. Ranking creeks with each other was the chosen comparison method in this first year of establishing a volunteer network. Other comparison methods such as the Canadian Council for Ministers of the Environment (CCME) Water Quality Index were considered and will be considered again. It is of interest to note that the highest ranked creek (Fish Creek, Calgary) is known for its constructed stormwater treatment wetlands while the lowest ranked creek (Mill Creek, Edmonton) receives discharges from the Town of Crossfield and City of Airdrie before even entering the City of Calgary.

In 2016, between the months of March and October:

- there were 68 trained volunteers and two science technicians in Edmonton, Red Deer and Calgary
- a combined 338 total sampling events
- over 3,100 collected water sample data points
- an estimated 350 hours total time spent on ten urban creeks
- fourteen portable water monitoring kits were distributed
- 18 sampling locations were monitored across urban creeks in Edmonton, Red Deer and Calgary.

Conclusion

The key CreekWatch objective is to provide valuable, low-cost community stormwater data to support informed decisions on urban watershed management, and to make this data readily available in a timely manner to watershed managers and the public. An annual report card on the water quality of urban stormwater creeks is one method to accomplish this objective. See Table 1 for the 2016 CreekWatch Report Card. The second year of CreekWatch March - October 2017 further established a framework and tools for incorporating and communicating public participation in science research (citizen science).

Three key success strategies were again applied during CreekWatch Year Two:

1. Monitoring equipment required constant kit maintenance, upkeep, and the replacing of consumables throughout the season for both Level One and Level Two equipment.
2. Data accuracy was checked again this year by collecting three levels of data on the same day to compare our equipment results against lab results.
3. The engagement of volunteers was ongoing throughout the season with frequent program updates, friendly reminders, and technical support for equipment and online data entry.

Next Steps

Looking ahead to the 2017 season, CreekWatch is taking steps to expand the project scope to allow:

- The inclusion of additional urban creeks and additional sampling sites on currently monitored creeks.
- The addition of more volunteers to complement the current volunteer base established in 2015-2016 through collaboration with other corporate and community groups.
- A protocol for replicate sampling in the case of outlier data points.
- Earlier monitoring of the spring freshet with experienced volunteers.
- Data analysis for the total area of all combined outfalls for each creek.
- The purchasing of additional equipment for additional groups of volunteers.

Recommendations

Of special note, the top ranked creek, Calgary’s Fish Creek, contains multiple constructed wetlands that collect stormwater runoff from the streets of the surrounding communities. These networks of engineered wetlands function to allow sediment to settle and pollutants to be removed before water moves downstream. On the opposite end of the rankings, the two lowest ranked creeks, Edmonton’s Mill Creek and Calgary’s Nose Creek, drain significant land areas without sufficient wetlands to settle out the runoff. A significant portion of Mill Creek is also currently buried, preventing ecosystem functions as the water travels underground. Red Deer’s Waskasoo Creek, while not ranking high or low, has nearly 100 stormwater outfalls whose impacts are mitigated with headwater wetlands.

To achieve improved urban creek water quality in the future, it is recommended to:

- increase public and industry education, making people aware that a.) stormwater runoff from our streets, homes, businesses, and parking lots travels through storm drains largely untreated into our waterways, and b.) their stewardship actions can make a positive difference;
- consider stormwater impacts in any new snow removal planning involving calcium chloride, to-the-pavement scarping or localized snow dumps;
- uncover (daylight) and remove culverts and pipes from buried creeks, reinstating open-air ecosystem functions
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APPENDICES

Appendix 1. Stream Ranking Calculations Based on Median Values for Eleven Parameters

Recent approaches to river health assessment recognize the importance of examining physical, chemical and biological interactions. The comparison ranking of study creeks was based on a point system for eleven parameters using median values for dissolved oxygen, ammonia nitrogen, nitrate-nitrogen, phosphorus, temperature, conductivity, turbidity, chloride, E.coli, and total coliforms. A benthic macroinvertebrate index was also used as a metric, explained in Appendix 2.

Ranking the 10 study creeks meant that there were 1-10 points available for each parameter. The highest point (ten) was awarded for the lowest value in each parameter except for dissolved oxygen and benthic macroinvertebrates, Percentages were assigned based on the total possible points for each creek to account for missing data.

Points were totaled for each individual creek to achieve the rankings (1-10). Rankings were interpreted as an indication of overall water quality compared between the ten monitored creeks. Top rankings denoted greater overall water quality, while lower rankings signified lesser overall water quality.

Table 4 Stream ranking calculations based on median values of 11 collected parameters

Stream Ranking Calculations based on Median Values for Eleven Parameters										
City	**Calgary**				**Edmonton**					**Red Deer**
Parameters	**Fish Creek**	**Nose Creek**	**West Nose Creek**	**Pine Creek**	**Whitemud Creek**	**Blackmud Creek**	**Mill Creek**	**Wedgewood Creek**	**Oldman Creek**	**Waskasoo Creek**
Dissolved Oxygen (mg/L)	9.42	8.95	8.39	9.22	9	9.22	9.78	7.71	9.59	8.72
Points	8	5	3	7	6	7	10	2	9	4
Ammonia Nitrogen (mg/L)	0.25	0.25	0.25	0.25	0.13	0.25	0.25	0.13	0.25	0.25
Points	9	9	9	9	10	9	9	10	9	9
Nitrate-nitrogen (mg/L)	0.15	0.4	0.64	0.18	0.05	0.05	0.34	0.05	0.06	0.09
Points	7	4	3	6	10	10	5	10	9	8
Phosphorus (mg/L)	0.15	0.06	0.12	0.14	0.05	0.13	0.19	0.05	0.33	0.04
Points	4	8	7	5	9	6	3	9	2	10
Water Temperature (°C)	11.3	13.1	11.7	12.1	17.5	16.1	15.7	13.6	15.5	13.3
Points	10	7	9	8	1	2	3	5	4	6
Turbidity (NTU)	10	29	25	10	14	12	10	14.5	10	19
Points	10	4	5	10	8	9	10	7	10	6
Conductivity (mS/cm)	0.47	0.93	0.79	0.73	0.67	0.64	1.08	0.61	0.6	0.66
Points	10	2	3	4	5	7	1	8	9	6
Chloride (mg/L)	47	97	65	60	70	72.5	135	65	77	70
Points	10	4	8	9	7	6	3	8	5	7
E.coli (per 100mL)	0	500	200	100	0	0	950	0	0	-
Points	10	7	8	9	10	10	6	10	10	-
Total Coliforms (per 100mL)	950	2800	2900	1900	900	450	2350	100	200	-
Points	6	3	2	5	7	8	4	10	9	-
Benthic Macroinvertebrate Index	17.2	14.5	12	15.2	3.4	6.4	10.9	5.3		-
Points	10	8	7	9	3	5	6	4	-	-
Total Points	94	61	64	81	76	79	60	83	76	56
Percentage	85%	56%	58%	74%	69%	72%	54%	76%	73%	70%
RANK	**1**	**9**	**8**	**3**	**7**	**5**	**10**	**2**	**4**	**6**

*** Percentages were assigned based on the total possible points for each creek to account for missing data on Wedgewood Creek and Waskasoo Creek.**

Appendix 2. Benthic Macroinvertebrate Index

Aquatic macroinvertebrate sampling was conducted once on eight of the monitored creeks in 2016. Table 5 displays total macroinvertebrate counts from each creek. Macroinvertebrates are organisms without backbones, which are visible to the eye without the aid of a microscope. They live on, under, and around rocks and sediment on the bottoms of lakes, rivers, and streams. Aquatic biomonitoring can indicate preceding river conditions for weeks or months prior to collection.

Metrics can be used to analyze and interpret biological data by condensing lists of organisms and turning them into relevant biological information. The procedures and scoring index described here are based in part on guidelines for Volunteer Stream Monitoring developed by the US Environmental Protection Agency.

1. Select sample location in moving water
2. Thoroughly kick substrate while holding a 1m x 1m seine net downstream to collect organisms
3. Rinse sample from the net into a bucket and ensure all organisms are free of the net
4. Filter the bucket through a strainer to collect invertebrates while removing debris
5. Empty strainer into a shallow tub and carefully remove organisms with a dropper and isolate using an ice cube tray
6. Identify, count, and record organisms according to an invertebrate key
7. Safely release all organisms back into the stream

Table 5 Total macroinvertebrate counts 2016

Invertebrate	Fish Creek	Nose Creek	West Nose Creek	Pine Creek	Whitemud Creek	Blackmud Creek	Mill Creek	Wedgewood Creek
mayfly nymph (PS)	27	7	16	25	-	3	-	-
stonefly nymph (PS)	19	-	-	-	-	-	4	-
caddisfly larva (MPT)	11	10	7	40	-	-		-
midge larva (PT)	-	22	12	10	-	-	40	-
leeches (PT)	-	-	-	-	-	-	-	1
snails (PT)	-	-	-	-	-	-	-	10
water beetles (MPT)	-	-	-	-	10	-	-	80
bristleworms (PT)	-	17	6	1	-	1	-	-
flatworms (MPT)	-	95	-	-	-	-	-	-
cranefly larva (MPT)	2	-	-	7	-	-	1	-
blackfly larva (PT)	-	13	8	-	-	-		-
amphipod (MPT)	-	-	-	1	-	-	5	-
TOTAL COUNT	**59**	**164**	**49**	**84**	**10**	**4**	**50**	**91**

*No sampling was done on Waskasoo Creek or Oldman Creek

Three categories of invertebrates were identified being pollution sensitive (PS), moderately pollution tolerant (MPT), and pollution tolerant (PT). Relative abundance was also established as rare, common, or dominant. Scores were calculated based on the scoring index below.

Table 6 Benthic macroinvertebrate scoring index

	Pollution Sensitive	Moderately Pollution Sensitive	Pollution Tolerant
Rare	5.0	3.2	1.2
Common	5.6	3.4	1.1
Dominant	5.3	3.0	1.0

*Source: US Environmental Protection Agency (1997). Volunteer Stream Monitoring: A methods manual, Ch. 4 Macroinvertebrates and habitat: www.epa.gov/owow/monitoring/volunteer/stream/ums40.html

Appendix 3. Equipment and Parameters for Three Levels of Monitoring

Three levels of data collection were undertaken by CreekWatch as means to provide quality assurance. The following table summarizes the equipment and the physical, chemical, and biological parameters for each monitoring level in 2016.

Table 7 Summary of CreekWatch monitoring levels

Summary of CreekWatch Monitoring Levels			
Monitoring Level	**Level One**	**Level Two**	**Level Three**
Equipment	**Manual Hach kits used several times a year per volunteer**	**YSI Probes used once per week by technicians**	**Lab analysis used once per year**
PHYSICAL	**Parameters Measured**		
Water Temperature (°C)	X	X	-
Turbidity (NTU)	X	X	X
Conductivity (mS/cm)	-	X	X
TDS (mg/L)	-	X	X
Salinity (ppt)	-	X	X
CHEMICAL	**Parameters Measured**		
Dissolved Oxygen (mg/L)	X	X	X
Ammonia Nitrogen (mg/L)	X	-	X
Nitrate-Nitrogen (mg/L)	-	X	X
Orthophosphorous (mg/L)	X	X	X
pH	X	X	X
Chloride (mg/L)	X	-	X
BIOLOGICAL	**Parameters Measured**		
E.coli (per 100ML)	-	X	-
Total Coliforms (per 100ML)	-	X	-

Level One Monitoring

Level One monitoring equipment was purchased through Hach Canada and testing kits were housed in wheeled coolers for ease of transport and storage. Each portable lab cost approximately $700. Expectations were that each volunteer would collect data on their own free time at least 2-4 times through the open-water season. We had 25 volunteers in Edmonton, 7 in Red Deer, and 36 volunteers in Calgary.

Level Two Monitoring

YSI equipment was purchased from Hoskin Scientific Ltd. Each kit cost approximately $4,400. *Level Two* data was collected on a weekly basis between March-October by CreekWatch technicians using YSI Professional Plus instruments capable of measuring a range of parameters. Also included in the portable lab were two separate LaMotte 1200 Colorimeters – one for nitrate-nitrogen and one for phosphorus.

Level Three Monitoring

The collection of **Level Three** data happened once in 2016, and this involved the submission of water samples to Exova for laboratory testing. Each laboratory analysis of a creek sample cost $214.

Cost Comparisons for Three Levels of Monitoring

Three different levels of monitoring allowed CreekWatch to make a unique comparison for accuracy and costs. There were advantages and disadvantages associated with each type of monitoring that included: instrument complexity, cost, calibration and maintenance, technique accuracy and precision, replacement costs for damaged equipment, and transportability. Lab analysis was the benchmark for all comparisons and while defined as the most accurate, it was the most expensive. The chart below depicts the cost of each monitoring level.

Table 8 Cost comparison for three levels of monitoring

Cost Comparison for Three Levels of Monitoring			
Level	**Cost/Sample**	**% Cost**	**Notes**
Level Three Lab	**$214**	**100%**	**Per one site**
Level Two YSI Probes	**$52**	**24%**	**Per 100 Sites sampled**
Level One Hach Kits	**$5**	**2%**	**Per 100 Sites sampled**

Table 9 Cost breakdown of Level One equipment purchases. We currently have 12 sets of these tests.

Parameter	Method	Cost
Dissolved Oxygen	Drop count titration	$100.00
pH	Colour-disc	$123.37
Phosphate	Colour-disc	$144.35
Ammonia-Nitrogen	Test strips	$32.87
Turbidity	Secchi tube	$57.77
Temperature	Thermometer	$18.30
Chloride	Drop count titration	$100
TOTAL		$576.66

Table 10 Cost breakdown of Level Two equipment purchases. We currently have two sets of these tests.

Unit	Parameters	Cost
YSI Pro Plus with Quattro Cable	pH, DO, temperature, TDS, conductivity	$3,519.00
LaMotte Colorimeter	Nitrate-Nitrogen	$658.00
LaMotte Colorimeter	Orthophosphate	$605.00
Coliscan Easygel	E.coli, Total coliforms	$450.00
TOTAL		$5,232.00

Level One and Level Two monitoring were more cost effective than lab analysis, and provided reliably sound data as explained in Appendix 4.

Appendix 4. Accuracy Comparisons for Three Levels of Monitoring

The CreekWatch use of three different monitoring levels allowed a unique comparison for accuracy. The following two tables for dissolved oxygen and pH show the percent accuracy difference as referenced to lab results. All three monitoring levels were conducted at the same location, date and time. The "% difference" for Level Two Monitoring was calculated using the formula (Level Two reading – Level Three reading) / Level Three reading * 100). Here, a lower percentage difference is better because it is closer to the standard of lab analysis i.e. the results do not differ by much.
Dissolved oxygen and pH were the only parameters measured and comparable across all three levels of monitoring.

Table 11 Comparing instrument accuracy across three levels of monitoring for pH - October 2016

Comparing Accuracy Across Three Levels of Monitoring for pH				
Location	Level Three Lab Results	Level Two YSI Probe Comparison	Level One Hach Kit Comparison	Mean % Difference for both YSI and Hach Kits
Nose Creek	8.18	3%	0%	1%
W. Nose Creek	8.24	3%	-1%	1%
Fish Creek	8.29	2%	1%	1%
Pine Creek	8.37	3%	1%	2%
Whitemud Creek	8.17	5%	0%	2%
Blackmud Creek	8.05	3%	-1%	1%
Mill Creek	8.08	5%	0%	3%
Oldman Creek	8.27	7%	3%	5%
Wedgewood Creek	7.94	-3%	-2%	-2%

Table 12 Comparing instrument accuracy across three levels of monitoring for dissolved oxygen - October 2016

Comparing Accuracy Across Three Levels of Monitoring for Dissolved Oxygen (mg/L)				
Location	Level Three Lab Results	Level Two YSI Probe Comparison	Level One Hach Kit Comparison	Mean % Difference for both YSI and Hach Kits
Whitemud Creek	12.3	1%	6%	4%
Wedgewood Creek	11.2	2%	7%	5%
Blackmud Creek	12.3	4%	-2%	1%
Mill Creek	12.1	18%	-17%	0%
Oldman Creek	10.4	5%	-23%	-9%

***Lab results were not available for DO in Calgary due to timing of sample drop off.**

Comparing the accuracy of three levels of monitoring is a way to examine the accuracy of each level of data that is reported. By means of these comparisons, we can speak to the accuracy of the data we are collecting. With the data collected in Level One and Two being relatively close, there is definitely a trade-off for the cost effectiveness of using volunteer water quality monitoring equipment as a valuable means to collect data.

The network of volunteers contributed credible useable data while monitoring urban creeks in Alberta. Both Level One and Level Two data collection revealed comparable results to lab analysis across all parameters.

Appendix 5. CreekWatch Website and Data Entry Platform

The CreekWatch website (www.creekwatch.ca) has been developed to support a data input and graphing platform. The creation of a database, by Web3 Marketing in Edmonton, allows for the uploading of water quality data and is an essential part of virtually preserving the data collected through CreekWatch. This allows for ease of data collection, input, and synthesis amongst online viewers. Our volunteers are trained on how to input data to the website. This information is then available for immediate public viewing, allowing for trend analysis, graphing, and comparison amongst the creeks.

Data entry

Each volunteer is assigned a unique user ID with a secure PIN in order to access the data entry portion of the website. This ensures accuracy of data inputted. Users are prompted to fill in each page completely before moving forward to mitigate input error. Drop-down menu allows differing levels of equipment to be compared against other levels. Having a user ID allows CreekWatch to track who is collecting information, determine the frequency and duration of each sample collected, and monitor the number of samples collected at each selected site.

Data viewing

Once data has been submitted, it becomes publicly available on the site. Anyone who visits www.creekwatch.ca will be able to view the data. Simply select a site, an indicator, and timespan as seen in the photo below. The second photo displays the graphing capabilities.

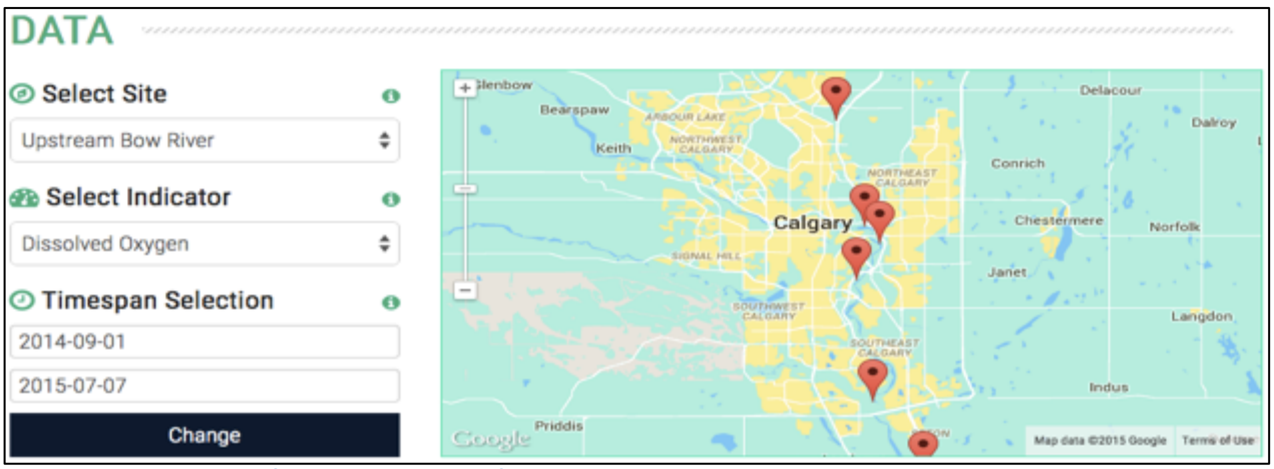

Photo 7 - Screen capture of the data-viewing platform

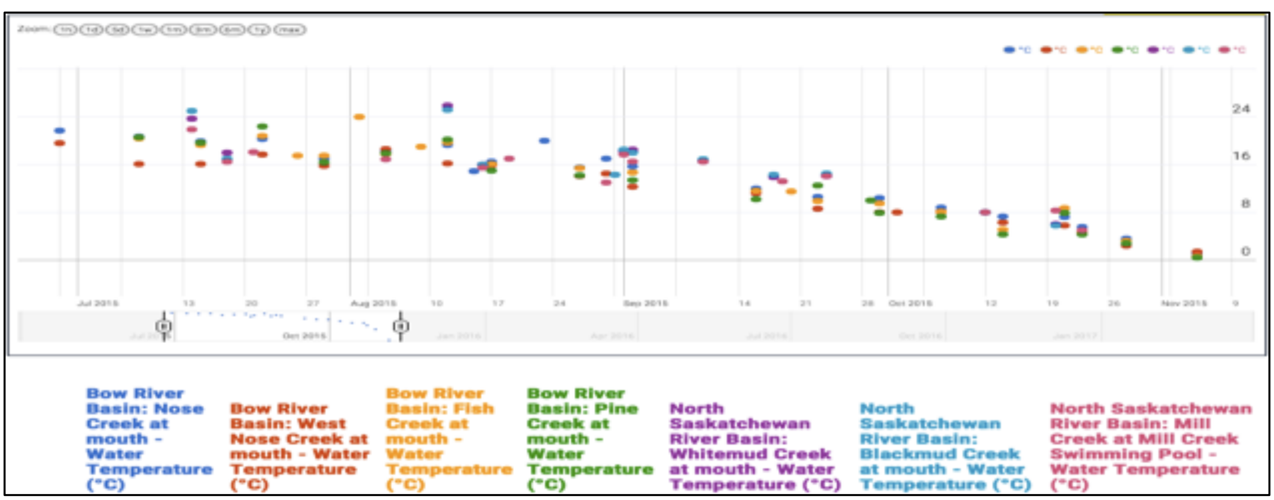

Photo 8 - Screen capture of the data-graphing platform, temperature measurements across seven creeks

Appendix 6. Box-and-Whisker Plots for all monitored Physical and Chemical Parameters

Box plots enable us to study the distributional characteristics of a group of scores and they provide a useful way to visualize a range of responses for a large group of data. The graph presents information from a 5 number summary of the lower extreme, lower quartile, median, upper quartile, and upper extreme. The "box" represents the middle half of all the data points, with the vertical line representing the median value. Long boxes indicate a larger interquartile range, which mean the data is really spread out around the median value. Short boxes represent the opposite, indicating a smaller interquartile range with data more concentrated around the median value. The "whiskers" represent the upper and lower extremes of the data. The longer the whisker, the greater the variance among the values.

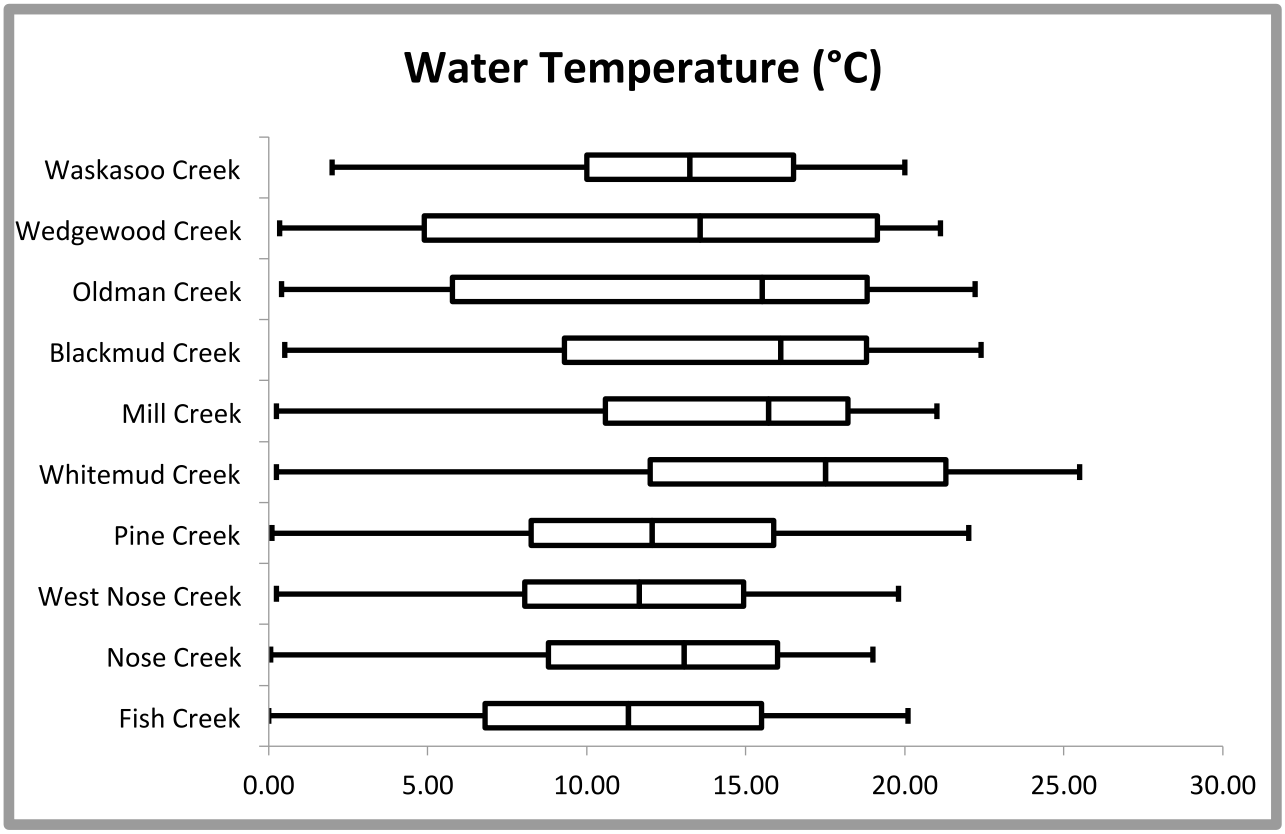

Figure 1 Distribution of data shown in a box-and-whisker plot for temperature

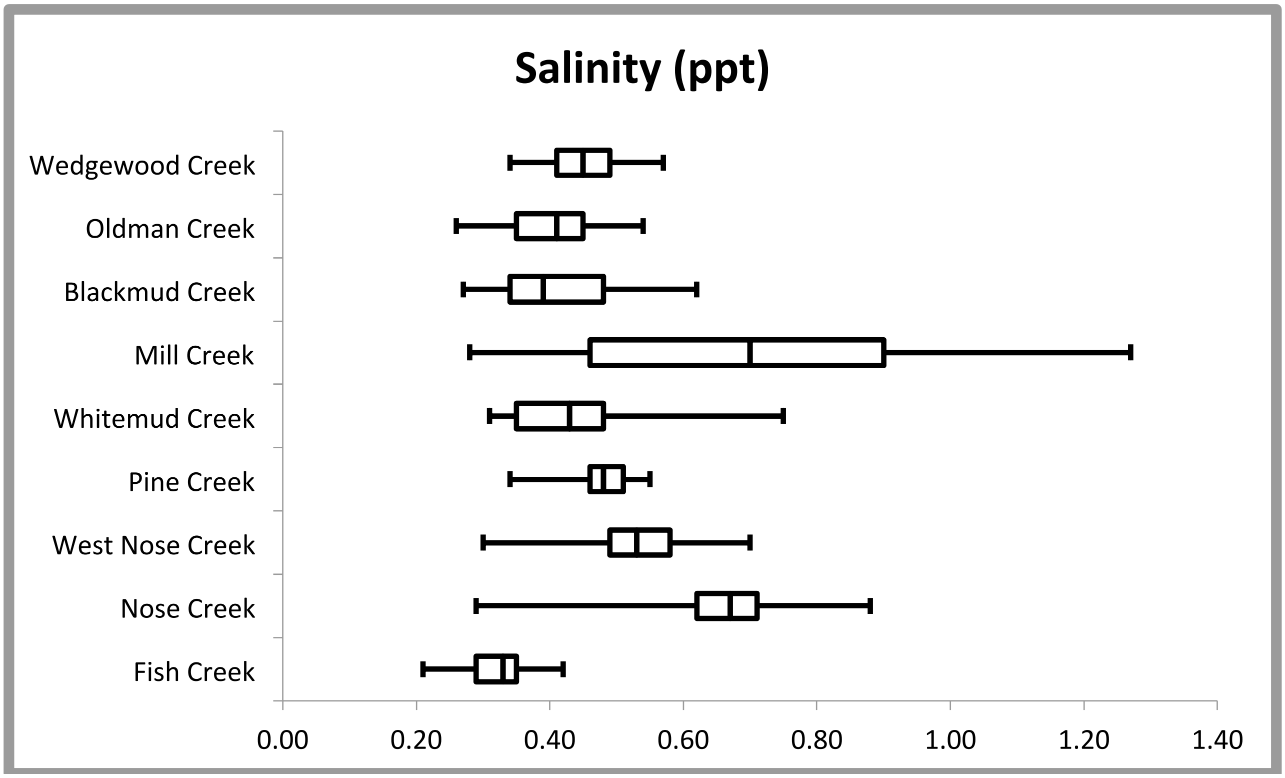

Figure 2 Distribution of data shown in a box-and-whisker plot for salinity

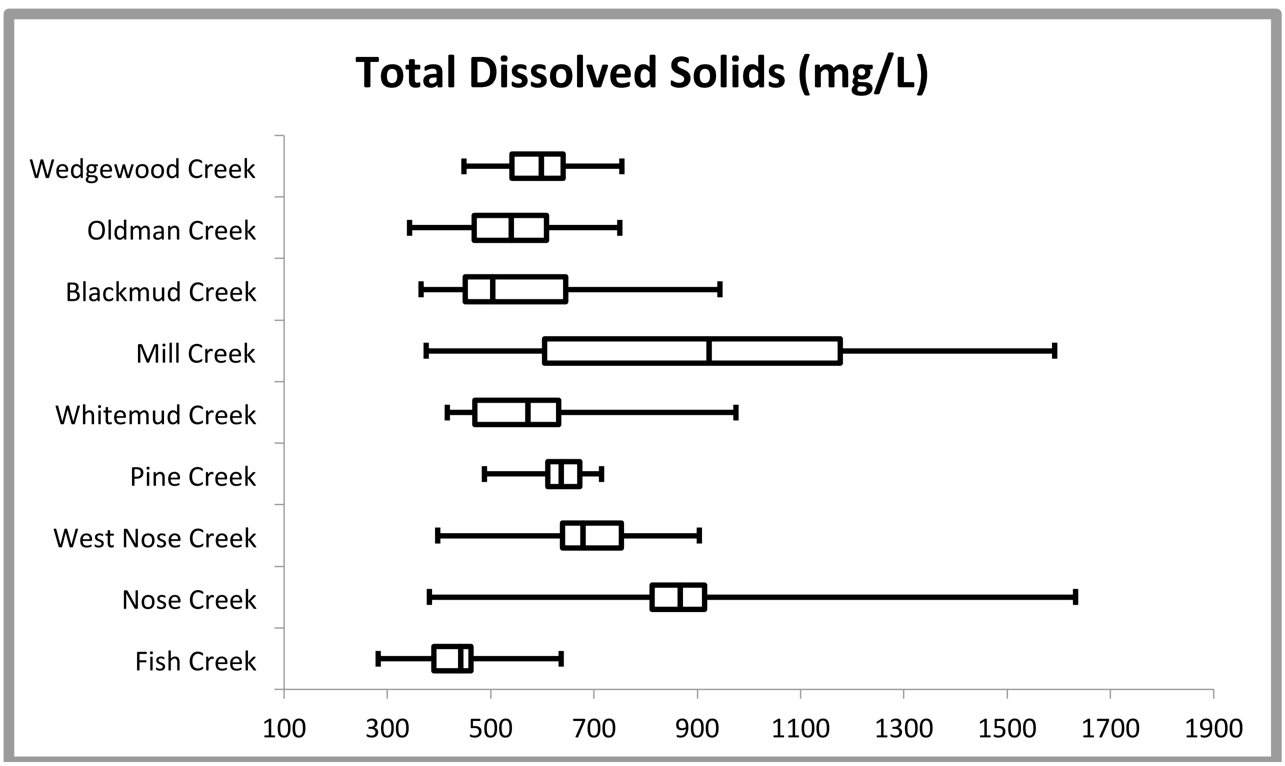

Figure 3 Distribution of data shown in a box-and-whisker plot for total dissolved solids

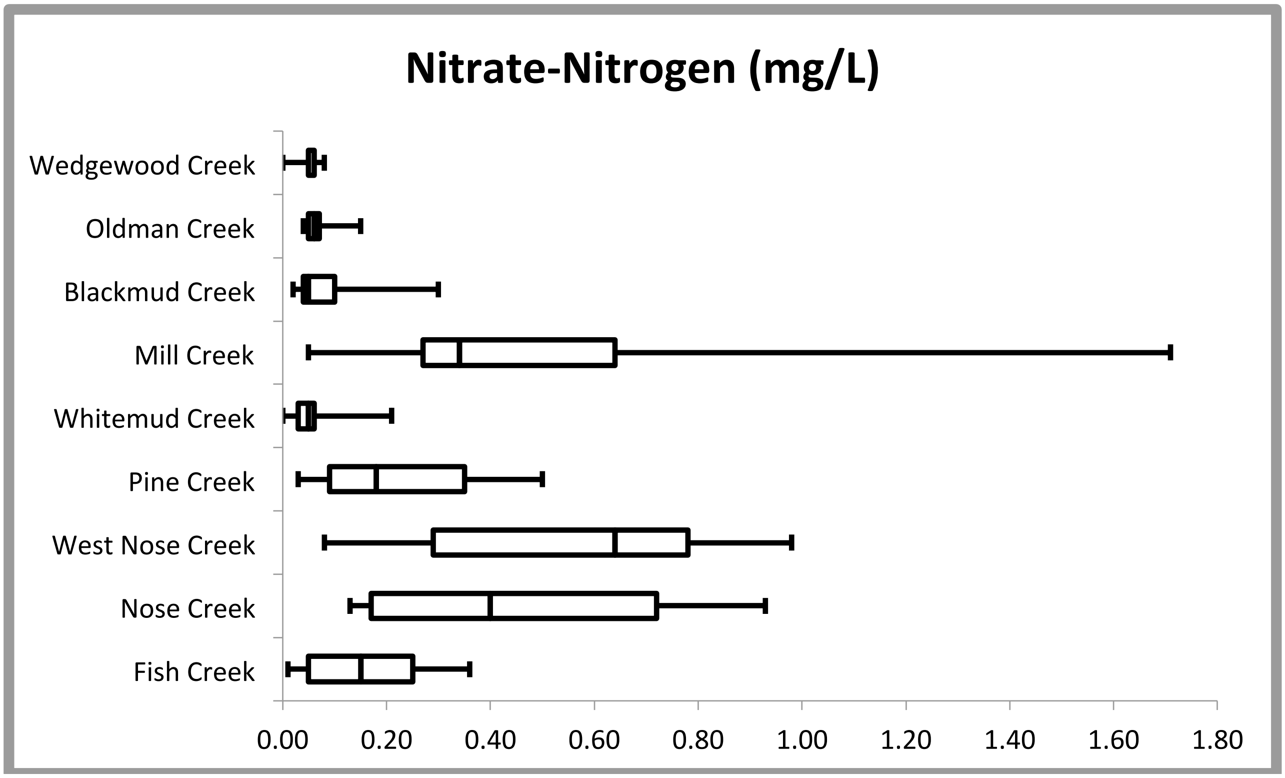

Figure 4 Distribution of data shown in a box-and-whisker plot for nitrate-nitrogen

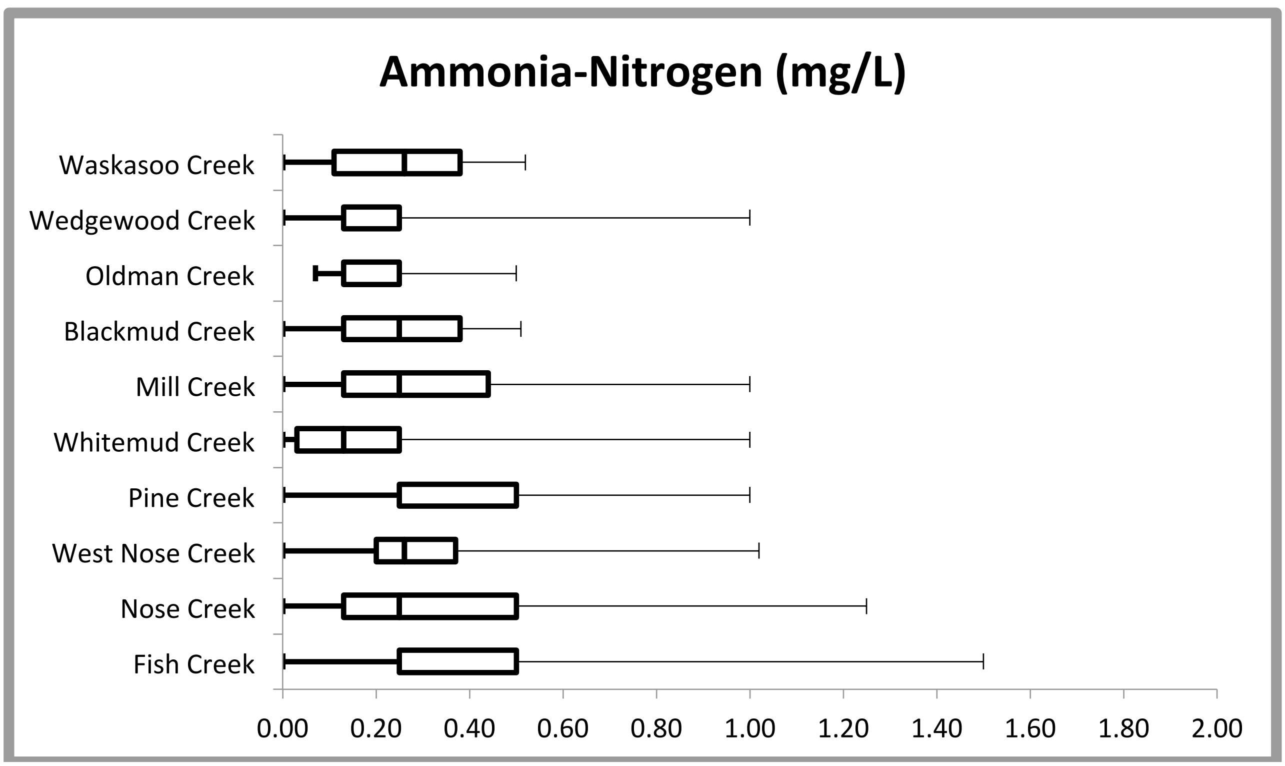

Figure 5 Distribution of data shown in a box-and-whisker plot for ammonia-nitrogen

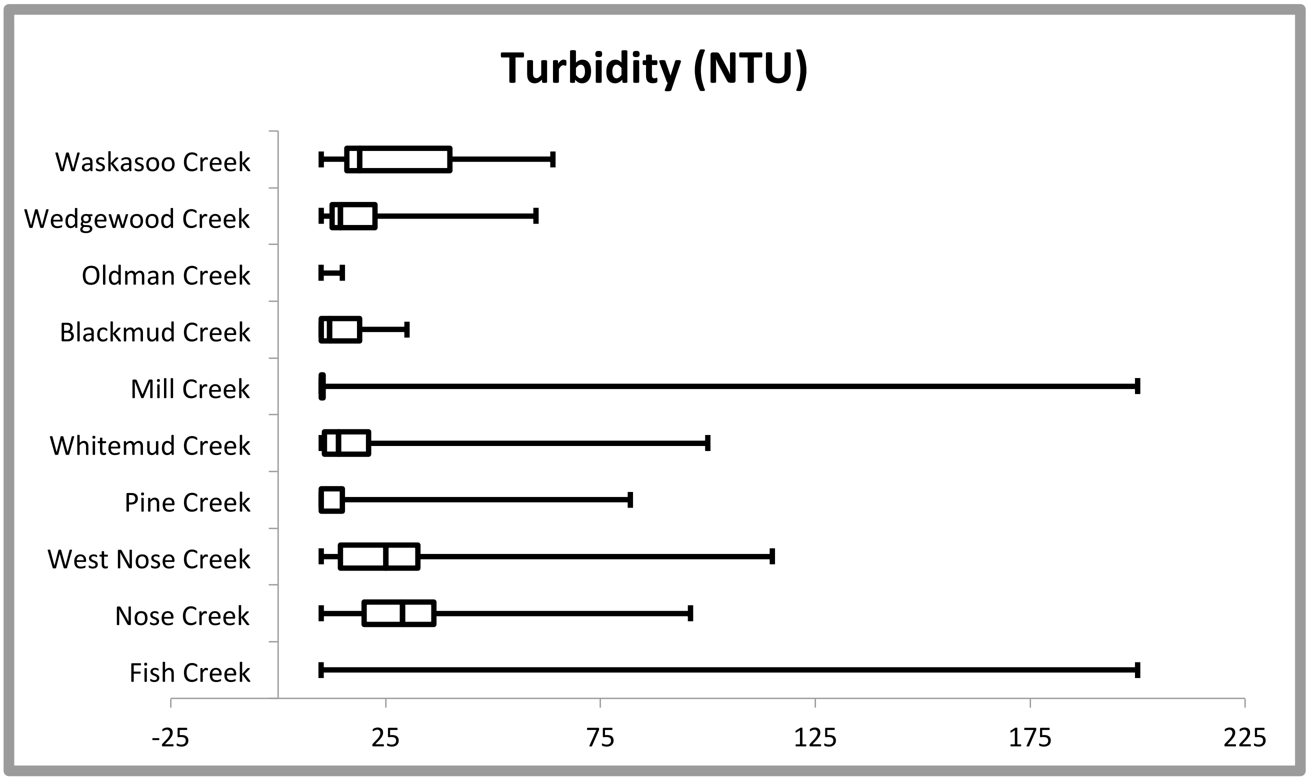

Figure 6 Distribution of data shown in a box-and-whisker plot for turbidity

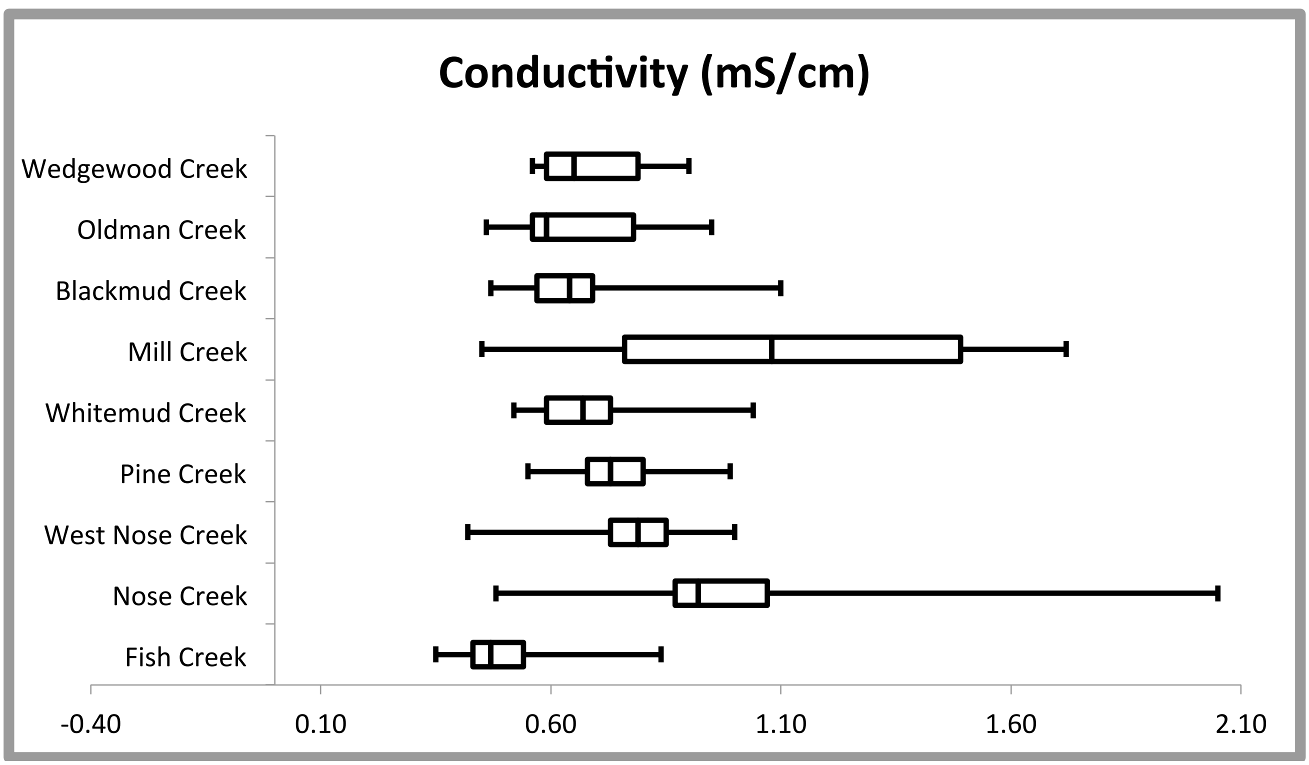

Figure 7 Distribution of data shown in a box-and-whisker plot for conductivity

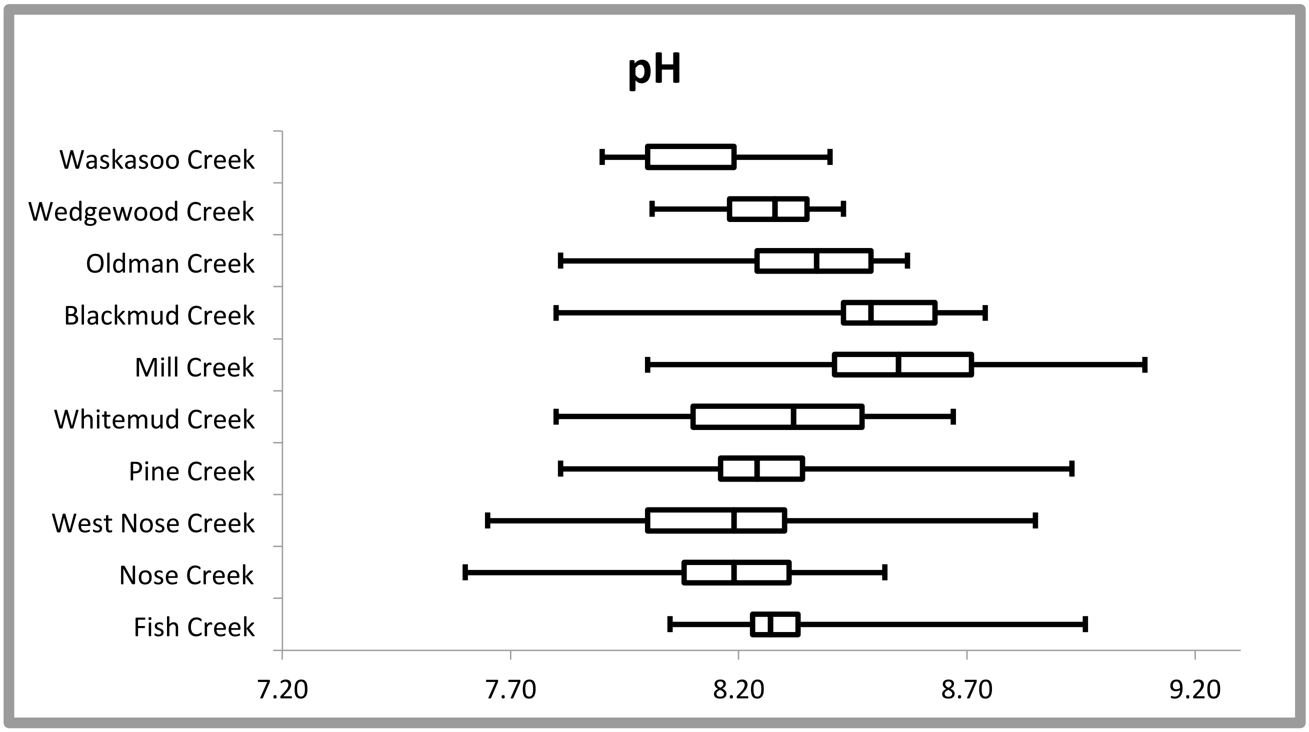

Figure 8 Distribution of data shown in a box-and-whisker plot for pH

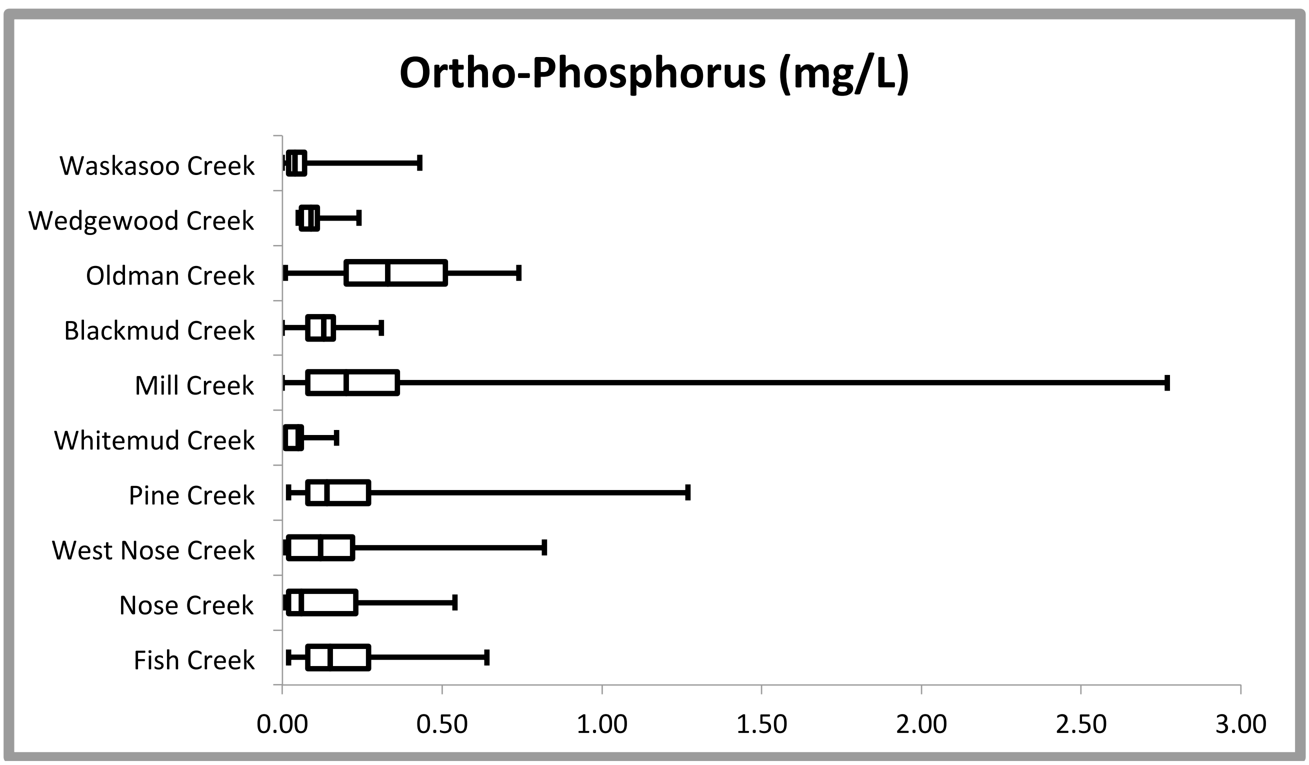

Figure 9 Distribution of data shown in a box-and-whisker plot for orthophosphorus

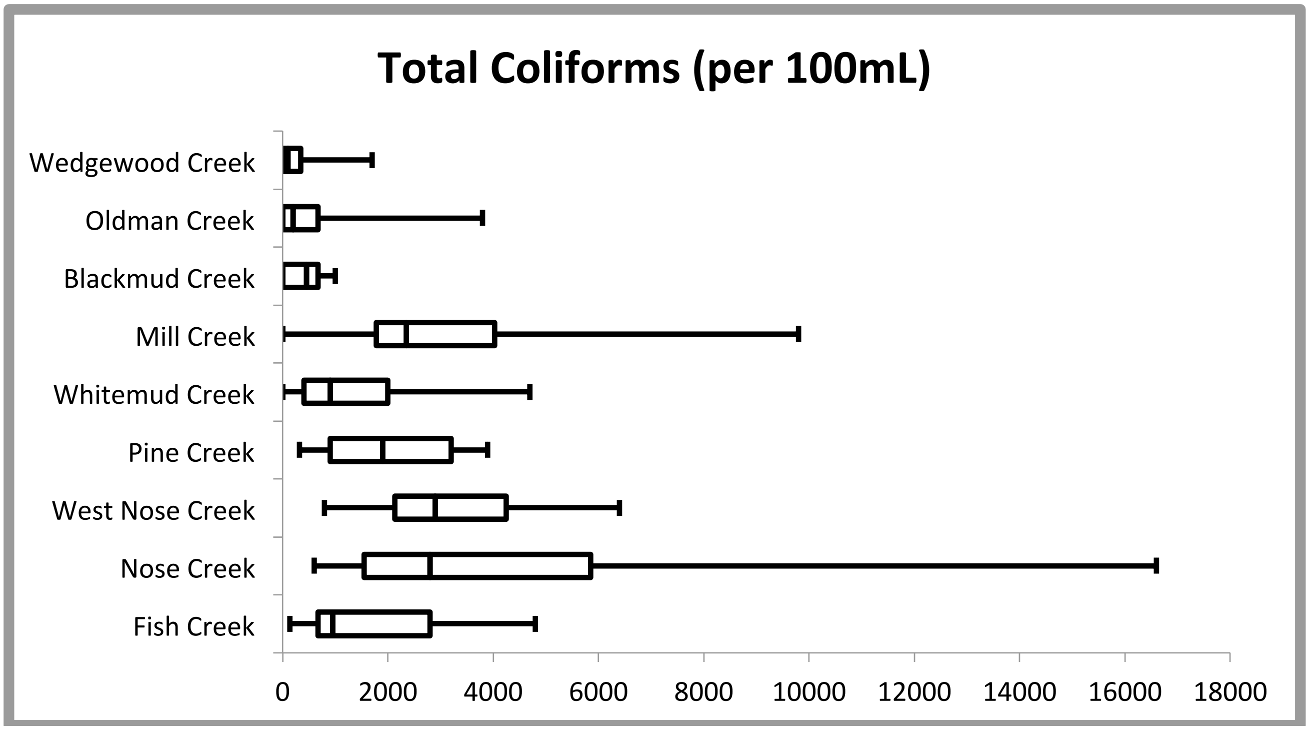

Figure 10 Distribution of data shown in a box-and-whisker plot for total coliforms

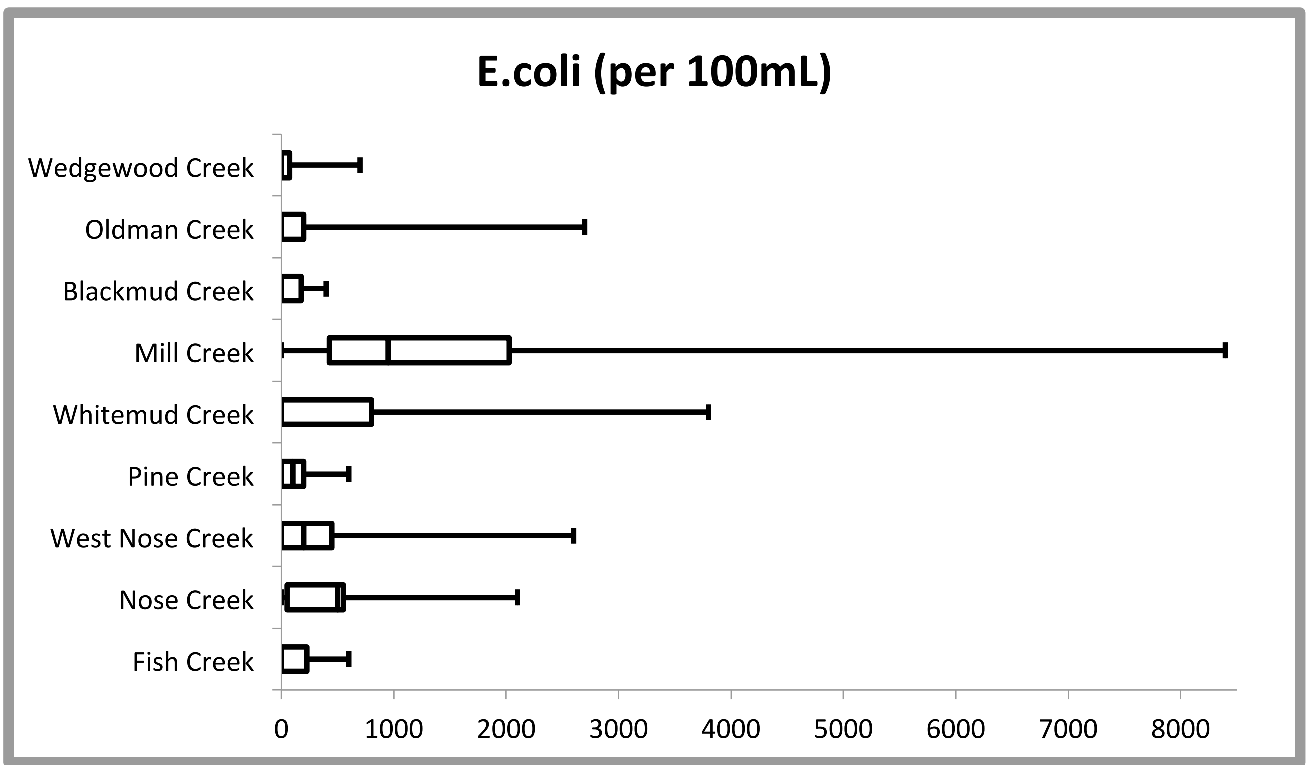

Figure 11 Distribution of data shown in a box-and-whisker plot for E.coli

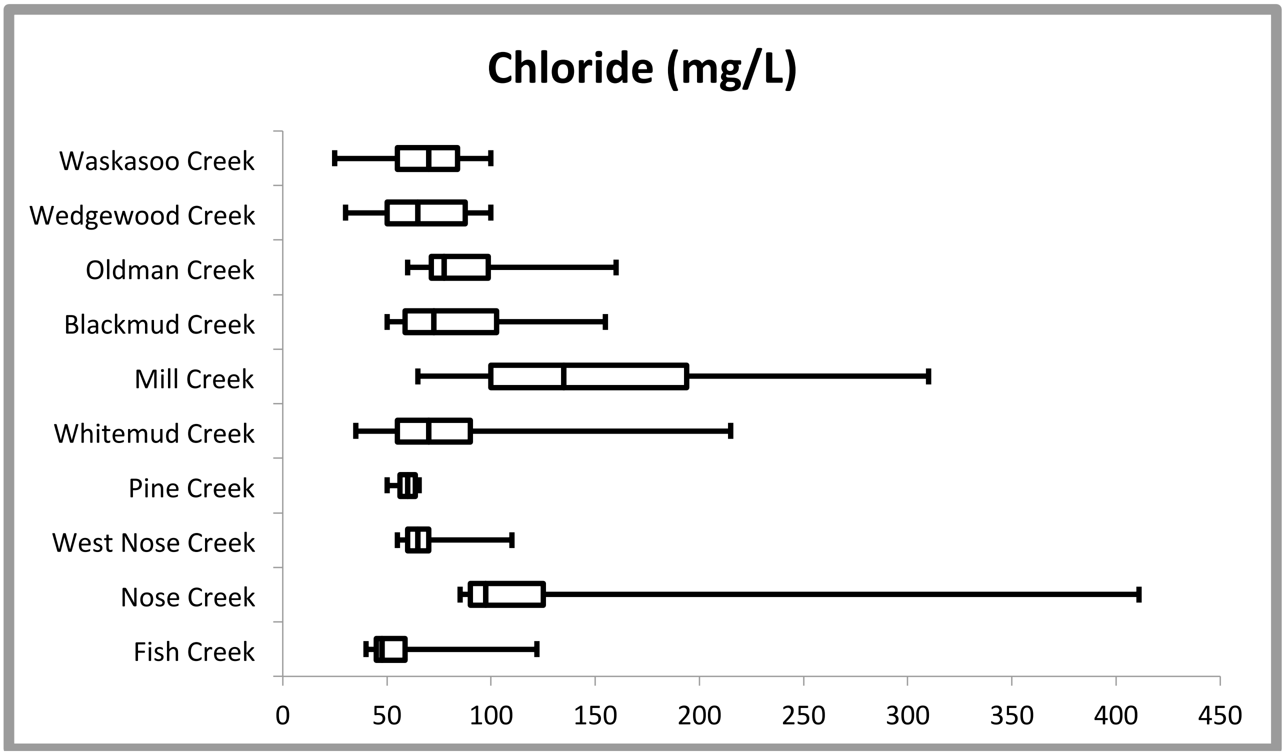

Figure 12 Distribution of data shown in a box-and-whisker plot for chloride

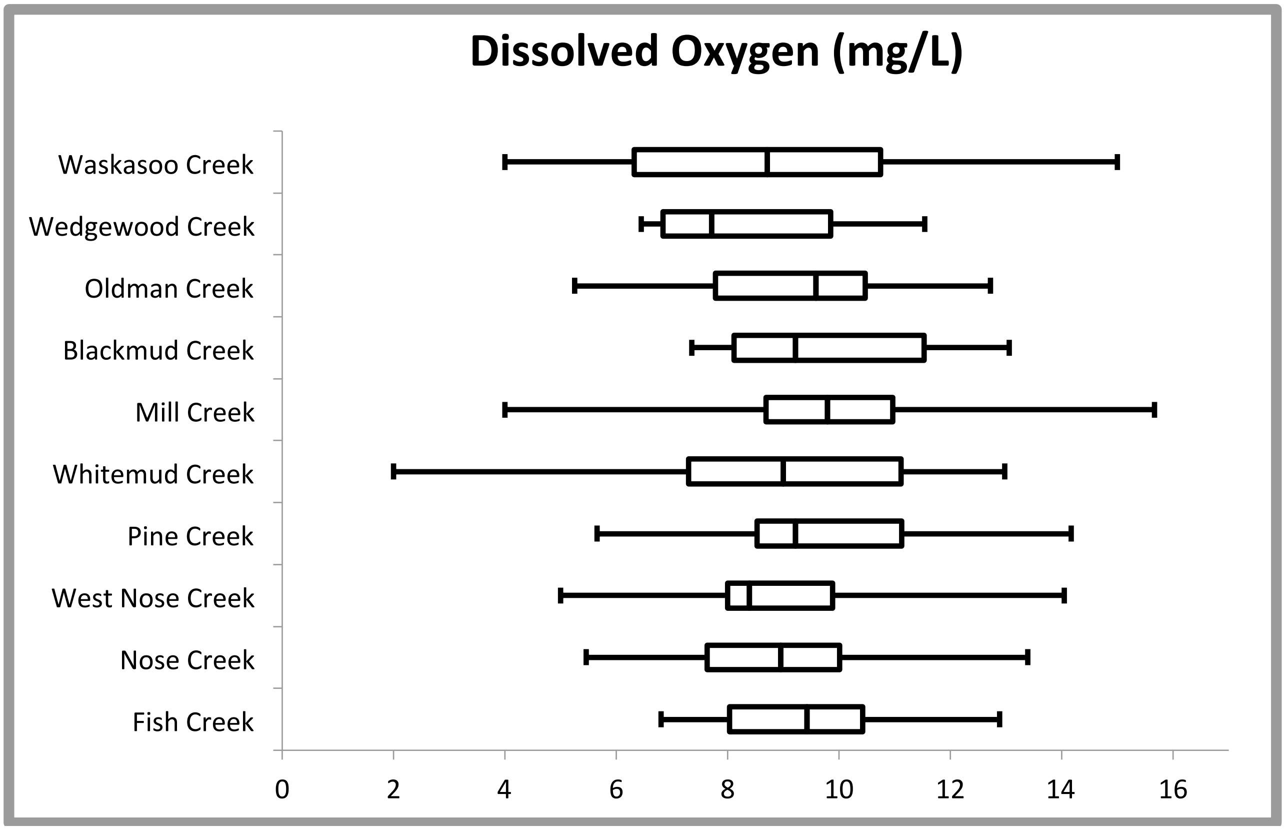

Figure 13 Distribution of data shown in a box-and-whisker plot for dissolved oxygen

Appendix 7. Creek Water Quality Summary – Fish Creek (Calgary, Alberta)

Primary Site Name: Fish Creek at mouth
Site Location Data – GPS: 50.904326, -114.010253
Watershed: South Saskatchewan River Basin

Stream Profile: Fish Creek originates in Kananaskis Country before traveling east through Tsuu T'ina First Nation and then ultimately reaching Calgary before entering the Bow River. The upper sections of Fish Creek are primarily forested, while the middle section is more agricultural and grassland coverage, and urban land use is more prominent near the creek mouth. The lower portion also receives stormwater discharge from the City of Calgary's encompassing residential neighborhoods. Within Calgary's city limits, Fish Creek is popularly known as the largest urban park in Canada, stretching 19 kilometers from east to west. Offering a variety of trail networks for walking, biking, or hiking, the park offers an easily accessible urban resource.

Site Photo:

Photo 9 - A view upstream, facing west near its confluence with the Bow River in Fish Creek Provincial Park

Table 13 Fish Creek Data Summary 2016

Water Quality Parameter	Fish Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	9.43	9.42	12.89	6.80	29
Ammonia Nitrogen	0.52	0.25	3.00	0.00	25
Nitrate-nitrogen	0.16	0.15	0.36	0.01	17
Phosphorus	0.21	0.15	0.64	0.02	29
PH	8.33	8.27	8.96	8.05	29
Water Temperature	11.18	11.30	20.10	0.00	29
Turbidity	22.03	10.00	200.00	10.00	29
Conductivity	0.49	0.47	0.84	0.35	29
TDS	429.75	442.00	636.50	282.00	29
Salinity	0.32	0.33	0.42	0.21	28
Chloride	58.20	47.50	122.00	40.00	10
E.coli	118.75	0.00	600.00	0.00	19
Total Coliforms	1635.00	950.00	4800.00	140.00	16

Appendix 8. Creek Water Quality Summary – Nose Creek (Calgary, Alberta)

Primary Site Name: Nose Creek at mouth
Site Location Data – GPS: 51.044963, -114.019647
Watershed: South Saskatchewan River Basin

Stream Profile: Nose Creek's headwaters extend all the way through the northern reaches of Rocky View County and into Mountain View County. Covering such a large geographical area at roughly 75 kilometers in length, there are many different land uses that have the potential to impact the creek. The land coverage is primarily agricultural, with urban influences as it travels through the town of Crossfield, and the cities of Airdrie and Calgary. It final stretch travels past the Calgary Zoo before reaching the Bow River.

Site Photo:

Photo 10 - A view downstream looking south 100m from its confluence at the Bow River

Table 14 Nose Creek Data Summary 2016

Water Quality Parameter	Nose Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	9.05	8.95	13.38	5.46	32
Ammonia Nitrogen	0.33	0.25	1.25	0	29
Nitrate-nitrogen	0.44	0.4	0.92	0.13	15
Phosphorus	0.14	0.06	0.54	0.01	32
PH	8.16	8.18	8.51	7.6	32
Water Temperature	11.94	13.05	19	0.5	32
Turbidity	32.17	29	96	10	32
Conductivity	0.99	0.93	2.05	0.48	22
TDS	864.43	867.5	1632.5	381	22
Salinity	0.64	0.67	0.88	0.29	21
Chloride	145.13	97.5	411	85	8
E.coli	545.45	500	2100	0	11
Total Coliforms	5045.45	2800	16600	600	11

Appendix 9. Creek Water Quality Summary – West Nose Creek (Calgary, Alberta)

Primary Site Name: West Nose Creek at mouth
Site Location Data – GPS: 51.130073, -114.047870
Watershed: South Saskatchewan River Basin

Stream Profile: West Nose Creek is a significant and permanent tributary to Nose Creek that drains a third of the entire Nose Creek Watershed. Originating in the northwestern portion of the watershed, it travels 65 kilometers before joining Nose Creek near the Calgary International Airport.

Site Photo:

Photo 11 – The confluence of West Nose Creek with Nose Creek, Deerfoot Trail in the background

Table 15 West Nose Creek Data Summary 2016

Water Quality Parameter	West Nose Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	8.87	8.39	14.04	5.00	32
Ammonia Nitrogen	0.33	0.25	1.00	0.00	31
Nitrate-nitrogen	0.57	0.64	0.97	0.08	16
Phosphorus	0.17	0.12	0.81	0.01	32
PH	8.15	8.19	8.85	7.65	32
Water Temperature	11.26	11.65	19.80	0.25	32
Turbidity	27.59	25.00	115.00	10.00	32
Conductivity	0.78	0.79	0.99	0.42	24
TDS	685.04	679	904.00	397.00	24
Salinity	0.52	0.52	0.69	0.30	23
Chloride	71.26	65.00	110.00	55.00	9
E.coli	369.33	200.00	2600.00	0.00	15
Total Coliforms	3086.67	2900.00	6400.00	800.00	15

Appendix 10. Creek Water Quality Summary – Pine Creek (Calgary, Alberta)

Primary Site Name: Pine Creek at mouth
Site Location Data – GPS: 50.844988, -113.961947
Watershed: South Saskatchewan River Basin

Stream Profile: Pine Creek enters the Bow River at Policeman's Flats just south of Calgary. The headwaters are found 20km west on the Ann and Sandy Cross Conservation Area near Priddis, Alberta. It travels through agricultural and ranchland before its confluence, along with two golf courses on the edge of Calgary.

Site Photo:

Photo 12 – The mouth of Pine Creek as it joins the Bow River

Table 16 Pine Creek Data Summary 2016

Water Quality Parameter	Pine Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	9.57	9.22	14.17	5.65	28
Ammonia Nitrogen	0.35	0.25	1	0	26
Nitrate-nitrogen	0.22	0.18	0.49	0.03	16
Phosphorus	0.21	0.14	1.27	0.02	28
PH	8.28	8.24	8.93	7.81	28
Water Temperature	12	12.05	22	0.1	28
Turbidity	14.79	10	82	10	28
Conductivity	0.74	0.73	0.99	0.55	27
TDS	633.96	637	715	488	27
Salinity	0.48	0.48	0.55	0.34	26
Chloride	59.55	60	65.5	50	10
E.coli	129.41	100	600	0	17
Total Coliforms	1984.71	1900	3900	320	17

Appendix 11. Creek Water Quality Summary – Whitemud Creek (Edmonton, Alberta)

Primary Site Name: Whitemud Creek at mouth
Site Location Data – GPS: 53.505454, -113.561679
Watershed: North Saskatchewan River Basin

Stream Profile: Whitemud Creek is a major tributary of the North Saskatchewan River and provides many vital terrestrial and aquatic ecological functions in the southwest portion of Edmonton. Whitemud Creek was named during the Palliser Expedition for the white-coloured mud along the creek's banks. The ravine provides ample opportunity for hiking and interactions with nature through old growth coniferous forests, deciduous and mixed-wood forests, meadows, and riparian communities.

Site Photo:

Photo 13 - A view near its confluence with the North Saskatchewan River

Table 17 Whitemud Creek Data Summary 2016

Water Quality Parameter	Whitemud Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	9.05	9.00	12.98	2.00	25
Ammonia Nitrogen	0.38	0.13	4.00	0.00	18
Nitrate-nitrogen	0.06	0.05	0.21	0.00	14
Phosphorus	0.05	0.05	0.17	0.00	25
PH	8.28	8.32	8.67	7.80	25
Water Temperature	15.32	17.50	25.50	0.25	25
Turbidity	19.88	14.00	100.00	10.00	24
Conductivity	0.70	0.67	1.04	0.52	18
TDS	576.78	572.00	975.00	416.00	18
Salinity	0.44	0.43	0.75	0.31	17
Chloride	76.56	70.00	215.00	35.00	25
E.coli	692.31	0.00	3800.00	0.00	13
Total Coliforms	1453.85	900.00	4700.00	0.00	13

Appendix 12. Creek Water Quality Summary – Blackmud Creek (Edmonton, Alberta)

Primary Site Name: Blackmud Creek at mouth
Site Location Data – GPS: 53.454896, -113.546976
Watershed: North Saskatchewan River Basin

Stream Profile: The headwaters of Blackmud Creek are located near the town of Nisku. It meanders north, crossing Highway 2 before entering the Edmonton city limits. Within the City limits, Blackmud Creek offers ample opportunities to enjoy nature through interactions made available at numerous urban parks. The eventual confluence is located in Mactaggart Sanctuary where it joins Whitemud Creek before traveling the final distance to the North Saskatchewan River.

Site Photo:

Photo 14 - A view upstream facing east at its confluence with Whitemud Creek in Mactaggart Sanctuary

Table 18 Blackmud Creek Data Summary 2016

Water Quality Parameter	Blackmud Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	9.89	9.22	13.06	7.36	21
Ammonia Nitrogen	0.26	0.25	0.50	0.00	15
Nitrate-nitrogen	0.09	0.05	0.30	0.02	14
Phosphorus	0.13	0.13	0.31	0.00	21
PH	8.49	8.49	8.74	7.80	21
Water Temperature	13.50	16.10	22.40	0.50	21
Turbidity	15.50	12.00	30.00	10.00	20
Conductivity	0.66	0.64	1.09	0.47	20
TDS	559.11	503.75	944.00	364.60	20
Salinity	0.41	0.38	0.61	0.27	19
Chloride	82.10	72.50	155.00	50.00	20
E.coli	100.00	0.00	400.00	0.00	14
Total Coliforms	400.00	450.00	1000.00	0.00	14

Appendix 13. Creek Water Quality Summary – Mill Creek (Edmonton, Alberta)

Primary Site Name: Mill Creek at Mill Creek Swimming Pool
Site Location Data – GPS: 53.520047, -113.473965
Watershed: North Saskatchewan River Basin

Stream Profile: Mill Creek flows through south central Edmonton before entering the North Saskatchewan River. Named after a flourmill established in 1878 near the creek's mouth, it enters Edmonton's City limits through passing beneath Anthony Henday Drive. It eventually opens up into Mill Creek Ravine that offers scenic views and hiking opportunities within the bustling city of Edmonton. Sections of the creek are engineered underground to accommodate City infrastructure, and this includes the final section of the creek that enters the North Saskatchewan River through a raised culvert. The City of Edmonton is currently exploring the potential of resurfacing the north portion of the creek.

Site Photo:

Photo 15 - A view upstream facing southeast in the Mill Creek Ravine

Table 19 Mill Creek Data Summary 2016

Water Quality Parameter	Mill Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	9.88	9.78	15.65	4.00	28
Ammonia Nitrogen	0.30	0.25	1.00	0.00	22
Nitrate-nitrogen	0.52	0.34	1.70	0.05	16
Phosphorus	0.33	0.19	2.76	0.00	28
PH	8.56	8.55	9.08	8.00	28
Water Temperature	13.94	15.70	21.00	0.25	28
Turbidity	20.32	10.00	200.00	0.00	28
Conductivity	1.11	1.08	1.72	0.45	21
TDS	925.94	923.00	1592.50	375.70	21
Salinity	0.70	0.70	1.26	0.28	20
Chloride	151.11	135.00	310.00	65.00	22
E.coli	1764.29	950.00	8400.00	0.00	14
Total Coliforms	3114.29	2350.00	9800.00	0.00	14

Appendix 14. Creek Water Quality Summary – Wedgewood Creek (Edmonton, Alberta)

Primary Site Name: Wedgewood Creek
Site Location Data – GPS: 53.480750, -113.628739
Watershed: North Saskatchewan River Basin

Stream Profile: Wedgewood Creek enters the City limits in the southwest corner and travels 5 kilometers to the North Saskatchewan River. The steep ravine near the mouth offers great nature viewing opportunities with towering spruce trees, plenty of bird life, and a great view of the North Saskatchewan River once at the confluence.

Site Photo:

Photo 16 - A view upstream facing west before the confluence with the North Saskatchewan River

Table 20 Wedgewood Creek Data Summary 2016

Water Quality Parameter	Wedgewood Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	8.34	7.71	11.54	6.45	18
Ammonia Nitrogen	0.24	0.13	1.00	0.00	14
Nitrate-nitrogen	0.05	0.05	0.08	0.00	11
Phosphorus	0.05	0.05	0.08	0.00	18
PH	8.26	8.29	8.44	8.01	18
Water Temperature	12.11	13.55	21.10	0.35	18
Turbidity	19.39	14.50	60.00	10.00	18
Conductivity	0.69	0.61	0.90	0.56	18
TDS	595.67	598.00	754.00	448.50	18
Salinity	0.45	0.45	0.57	0.34	17
Chloride	65.54	65.00	100.00	30.00	18
E.coli	114.29	0.00	700.00	0.00	14
Total Coliforms	400.00	100.00	1700.00	0.00	14

Appendix 15. Creek Water Quality Summary - Oldman Creek (Strathcona County, Alberta)

Primary Site Name: Oldman Creek
Site Location Data – GPS: 53.570936, -113.250509
Watershed: North Saskatchewan River Basin

Stream Profile: Oldman Creek exists just outside of the City limits, flowing out of Boag Lake just west of Sherwood Park. It meanders roughly 14km beginning in multiple subdivisions before opening up to farmland, and finally the community of Akenside as it heads north. There is limited access to Oldman Creek, as much of it is on private property and it is characterized with steep ravines as it nears its confluence with the North Saskatchewan River.

Site Photo:

Photo 17 - A view facing downstream near the Yellowhead Highway

Table 21 Oldman Creek Data Summary 2016

Water Quality Parameter	Oldman Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	9.23	9.59	12.71	5.25	18
Ammonia Nitrogen	0.24	0.25	0.5	0.07	14
Nitrate-nitrogen	0.07	0.06	0.15	0.04	13
Phosphorus	0.35	0.33	0.74	0.01	18
PH	8.33	8.37	8.56	7.81	18
Water Temperature	13.17	15.5	22.2	0.4	18
Turbidity	10.39	10	15	10	18
Conductivity	0.65	0.6	0.95	0.46	18
TDS	541.62	539.5	750	342.5	18
Salinity	0.4	0.41	0.54	0.26	17
Chloride	88.02	77.5	160	60	18
E.coli	350	0	2700	0	14
Total Coliforms	650	200	3800	0	14

Appendix 16. Creek Water Quality Summary – Waskasoo Creek (Red Deer, Alberta)

Primary Site Name: Waskasoo Creek
Site Location Data – GPS: 52.277396, -113.805605
Watershed: Red Deer River Basin

Stream Profile: Waskasoo Creek's headwaters extend from the parklands of central Alberta as the creek parallels the Red Deer River before its confluence in the City of Red Deer. The creek travels through significant areas of farmland with limited natural land cover, and where the natural flow at times has been diverted or channelized. Piper Creek joins Waskasoo Creek within the City limits, and there are many green spaces along the creek's riparian areas that provide great walking trails that lead up to the creek's confluence with the Red Deer River.

Site Photo:

Photo 18 – Waskasoo Creek as it enters the Red Deer River

Table 22 Waskasoo Creek Data Summary 2016

Water Quality Parameter	Waskasoo Creek Summary 2016				
	Mean	Median	Max	Min	Number
Dissolved Oxygen	8.72	8.72	15	4	18
Ammonia Nitrogen	0.25	0.25	0.5	0	15
Nitrate-nitrogen	0.09	0.09	0.09	0.09	1
Phosphorus	0.08	0.04	0.43	0	18
PH	8.07	8	8.4	7.9	18
Water Temperature	12.31	13.25	20	2	17
Turbidity	29.08	19	64	10	13
Conductivity	0.66	0.66	0.91	0.40	2
TDS	533.25	533.25	760.50	306.00	2
Salinity	0.41	0.41	0.58	0.23	2
Chloride	67.5	70	100	25	14
E.coli	-	-	-	-	0
Total Coliforms	-	-	-	-	0