Nose Creek Watershed

2011 Water Quality Monitoring Report

For the Nose Creek Watershed Partnership

Palliser Environmental Services Ltd.
March 2012

Nose Creek Watershed Partnership

Palliser Environmental Services Ltd.

Acknowledgements

The Nose Creek Watershed Partnership would like to thank the City of Airdrie, Alberta Conservation Association Grant Eligible Fund, Bow River Basin Council, City of Calgary, Calgary Airport Authority, Town of Crossfield, Encana, Land Steward Centre, Rocky View County and the Royal Bank of Canada (RBC Blue Water Project) for their contributions to the 2011 Nose Creek Water Monitoring Program.

Executive Summary

In 2011, the Nose Creek Watershed Partnership (NCWP) completed the third year of a surface water quality monitoring program for the Nose Creek watershed as recommended in the Nose Creek Watershed Water Management Plan. Six sites in the watershed were sampled twice monthly during April, May and June and once per month from July to October. In addition, the City of Calgary collected water samples monthly at four sites from January to December. Water monitoring results were compared to the Bow River Basin Council Water Quality Objectives established for the Nose Creek watershed (BRBC 2008). Poorer water quality results were expected in 2011, as streamflows were substantially higher compared to 2009 or 2010. Higher precipitation and increased surface runoff volume transports nutrients, sediment and other contaminants to the creeks.

In 2011, and similar to previous years, water temperature in Nose and West Nose creeks were below the acute water temperature objective of 29^{o}C and the chronic water temperature objective of 24^{o}C (see table below). The pH compliance rate was also high at Nose Creek (99%) and West Nose Creek (100%) and was the same as or comparable to pH in previous years. Temperature and pH do not appear to be a concern at Nose or West Nose creeks based on established objectives. However, the temperature objectives do not consider cooler temperatures required for trout species which are known to inhabit the lower reach (within the Calgary City Limits) of Nose Creek. A lower temperature objective may be more suitable to meet the requirements of coldwater fish species. Cooler water temperatures can be obtained by establishing and maintaining riparian vegetation, particularly trees and shrubs to provide shade.

At Nose Creek, seven samples did not meet the acute dissolved oxygen guideline of 5 mg/L and the chronic seven day guideline of 6.5 mg/L. The compliance rate for acute dissolved oxygen was lower compared to 2010 but similar to 2009 and higher compared to 1999-2001. At West Nose Creek, no samples were below the acute 5 mg/L guideline and one sample was below the 6.5 mg/L chronic guideline for dissolved oxygen. Compliance with the acute and chronic dissolved oxygen guidelines has always been greater at West Nose Creek compared to Nose Creek. The diurnal fluctuation of dissolved oxygen at Nose Creek and West Nose Creek is not well understood. However, it is likely that low dissolved oxygen concentrations prevail during the night and on days with heavy cloud cover due to the large amount of instream vegetation (i.e., algae and rooted aquatic macrophytes) that consume oxygen.

Electrical conductivity at Nose Creek ranged from 264 to 4397 uS/cm and 63% of samples met the water quality objective of less than 1000 uS/cm. Compliance rates were higher at West Nose Creek compared to Nose Creek in 2011 and in previous years. High electrical conductivity within the City of Calgary, particularly during the winter months is a concern. Sources contributing to high conductivity probably include road salt. In 2011, total dissolved solids concentrations were lower at Nose Creek and West Nose Creek compared to previous years. Thirty-six percent (36%) and 80% of samples met the water quality objectives of less than 500 mg/L at Nose Creek and West Nose Creek, respectively, which was a higher compliance rate than previous years. Total dissolved solids followed a trend similar to electrical conductivity.

Total phosphorus ranged from 0.033 to 0.973 mg/L at Nose Creek and 4% of samples complied with the water quality objective of less than 0.05 mg/L. At West Nose Creek concentrations were somewhat better (0.021 to 0.555 mg/L) as in previous years and 25% of samples complied with the water quality objective. Much of the phosphorus in the creeks is in the dissolved form and is readily available to plants. Phosphorus concentrations are a concern at both creeks since it enriches freshwater (a process known as eutrophication), contributing to the growth of aquatic plants. Although aquatic plants produce oxygen

through photosynthesis during the day; however, on cloudy days or during the night, the plants consume oxygen for respiration and can deteriorate fish habitat conditions. In addition, oxygen is used during the decomposition of plant material, again decreasing oxygen resources for fish and other aquatic life. Sources of phosphorus include organic and inorganic fertilizers that are used for agricultural crop production and urban lawn maintenance, livestock manure, pet feces, poorly designed or failing septic systems, and treated municipal effluent. Application of phosphorus at the appropriate rates will limit the amount of excess phosphorus that can be transported to Nose or West Nose creeks.

For nitrate-nitrite nitrogen, 93% and 82% of samples met the water quality objective of less than 1.5 mg/L at Nose Creek and West Nose Creek, respectively. Nitrate-nitrite nitrogen concentrations are not a concern at Nose and West Nose creeks as compliance was high in 2011 and in previous years. Ammonia-nitrogen concentrations were less than the detection limit of the analytical equipment (0.9 mg/L) 100% of the time at Nose and West Nose creeks; however, the detection limit was often greater than the guideline (which varies based on pH and temperature). It may be that actual ammonia-nitrogen concentrations were greater than water quality objectives. Monitoring ammonia-nitrogen concentration in 2012 using a lower detection limit (e.g., 0.05 mg/L) is recommended.

Sixty-seven percent (67%) and 64% of samples analysed for fecal and *E. coli* bacteria counts at Nose Creek and West Nose Creek, respectively, met the water quality objective of less than 100 CFU/100 mL. Bacteria counts ranged from < 1 to greater than 2420 CFU/100 mL at both creeks. Elevated fecal coliform counts are a concern at Nose Creek and West Nose Creek. In rural areas, bacteria sources are generally linked to wildlife (e.g., beaver, deer), waterfowl (e.g., ducks and geese) and livestock (e.g., horses and cattle). In addition to waterfowl, large number of dogs and dog parks concentrated in urban centres can contribute bacteria to Nose Creek either directly or via stormwater runoff.

Water quality improvements for Nose Creek and West Nose Creek may be obtained by implementing best management practices in rural and urban areas, including off-stream watering for livestock, stormwater management in urban areas (reductions in volumes generated, treatment of water in storm ponds), stoop and scoop at dog parks and private yards, reductions in lawn fertilizer and effective street cleaning prior to spring runoff and rainfall. In addition, maintaining and improving riparian area condition will reduce water temperatures via shade from trees and shrubs and aid in the filtration of runoff water prior to flowing into the creeks.

Parameter	Nose Creek				West Nose Creek				BRBC WQOs
	1999-2001	2009	2010	2011	1999-2001	2009	2010	2011	
Temperature	100	100	100	100	100	100	100	100	WQO: Should not exceed 29°C at any time or 7-day mean of 24°C.
pH	95	97	79	99	100	100	100	100	6.5 – 9.0[b]
Dissolved Oxygen	84	91	97	90	86	100	100	100	≥5.0 mg/L (1-day acute)
	69	79	92	79	76	95	100	96	≥6.5 mg/L (mean 7-day chronic)
Electrical Conductivity	38	29	27	63	91	90	76	86	<1000 µS/cm[c]
Total Dissolved Solids	15	0	9	36	6	0	0	80	<500 mg/L[d]
Total Phosphorus	2	0	12	4	15	52	33	25	<0.05 mg/L
Nitrate-Nitrite Nitrogen	89	83	94	93	85	88	93	82	<1.5 mg/L
Total Ammonia	91	83	88	100	97	100	100	100	Guideline depends on pH and temperature: CCME table
Fecal Coliform Bacteria	42	38	56	67	45	38	53	64	<100 CFU/100 mL

Table of Contents

1.0 INTRODUCTION

The Nose Creek Watershed Partnership completed the Nose Creek Watershed Water Management Plan (Plan) in 2007. On completion, the City of Airdrie, City of Calgary, Rocky View County and Alberta Environment agreed to implement the recommendations within the Plan to the best of their ability. One of the recommendations in the plan was to integrate the current water quality monitoring that is conducted by various agencies, municipalities and organizations into a comprehensive program that avoids duplication of effort and promotes sharing of information. Palliser Environmental Services Ltd. was retained to develop a comprehensive long-term water monitoring strategy for the Nose Creek watershed that is consistent with the recommendations and implementation actions of the Nose Creek Watershed Water Management Plan (2007) and the water quality objectives set for Nose Creek by the Bow River Basin Council (2008).

Effective watershed management includes monitoring the state of air, land and water resources. Monitoring water resources in terms of its physical, chemical and biological character allows managers to determine if the water quality meets requirements for various uses, including human, livestock and ecological (aquatic) needs. Water monitoring can also provide insight into land management practices as runoff quality is reflected in surface water bodies (e.g., stormwater from urban and rural landscapes). Flow volumes may increase or decrease according to changes in land cover. Water monitoring is a critical decision-support system for any water management program. With appropriate water quality data, land managers can make decisions that will help protect the integrity of water bodies for future generations.

The Bow River Basin Council has identified reach-specific desired outcomes for the Bow River watershed (BRBC). For the Nose Creek watershed the desired outcomes are:

- Surface water quality that is appropriate for irrigation of crops.
- Surface water quality that is appropriate for livestock watering.
- Surface water quality where water withdrawal systems are protected from high levels of algae and/or macrophytes.
- Surface water quality that maintains the existing cool-water aquatic ecosystem fauna structure and abundance (e.g., healthy pike populations and benthic invertebrates) (BRBC 2008).

Short- to long-term performance monitoring and management recommendations for the Nose Creek as identified by the BRBC (2008) are summarized in Appendix A.

Palliser Environmental Services Ltd. (PESL) was contracted in 2011 to monitor six sites identified in the Long-Term Water Monitoring Strategy. The City of Calgary monitored four sites in the watershed as part of their monitoring program.

2.0 BACKGROUND

2.1 Water Quality Parameters

The Nose Creek watershed water monitoring program monitors 11 parameters that describe the physical and chemical state of stream quality: temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, total phosphorus, dissolved phosphorus, nitrate+nitrite nitrogen, fecal coliform bacteria, and total suspended solids. A short description (sources, concerns) of each water quality variable is presented below. In addition, the water monitoring program measures discharge (water volume) at water quality sites.

Temperature

Water temperature has direct and indirect effects on nearly all aspects of aquatic ecology. The amount of oxygen that can be dissolved in water is partly governed by temperature. Cold water can hold more oxygen than warm water. Temperature also influences the rate of photosynthesis by algae and aquatic plants (BRBC 2008) and is an important determinant of total ammonia (NH_3) concentrations. Fish species also have specific preference and tolerances for water temperatures. Cold water species (trout and whitefish) select summer water temperatures from 10 to 18^{o}C whereas cool water species (e.g., pike, fathead minnow, brook stickleback) select summer water temperatures from 18 to 26^{o}C (Nelson and Paetz 1992).

pH

This is a logarithmic scale based on the Hydrogen Ion concentration by which water and other substances are measured to determine if they are acidic, neutral or alkaline. The midpoint of the scale is pH 7.0 and is neutral. Readings from 0 to <7.0 are acidic and the lower the number the more strongly acid the solution. Battery acid has a pH value of approximately 0. Readings from >7.0 to 14 are alkaline, with the higher numbers indicating a strongly basic or alkaline solution. Chlorine bleach has a pH of approximately 13. pH is an important determinant of total ammonia (NH_3) concentration as increasing the acidity of a solution by one pH unit can cause the total ammonia to increase tenfold. The provincial pH guideline for the protection of freshwater aquatic life is 6.5 to 8.5. The federal pH guideline for the protection of freshwater aquatic life is 6.5 to 9.0 (Alberta Environment 1999).

Dissolved Oxygen

Oxygen is vital to freshwater organisms. Oxygen is soluble in water and the solubility increases with decreasing water temperature (i.e., cold water holds more oxygen). Oxygen enters the water directly from the atmosphere or by aquatic plant/algae photosynthesis. Oxygen is removed by the respiration of animals and plants and by organic decomposition. The provincial oxygen guideline for the protection of freshwater aquatic life is 5 mg/L (acute: 1 day minimum) and 6.5 mg/L (chronic: 7 day mean). The federal cold water biota oxygen guideline for the protection of freshwater aquatic life is 6.5 mg/L (other life stages) to 9.5 mg/L (early life stages) (Alberta Environment 1999).

Electrical Conductivity

Electrical Conductivity (EC) is the measure of minerals (e.g., sodium, chloride, magnesium, potassium) dissolved in the water (total dissolved solids), or the salinity. EC is measured as the resistance of a solution to electrical flow; therefore, the purer the water is (i.e., the lower its salinity) the greater its resistance to electrical flow will be. EC, when applied to water, refers to the electrical charge of a given water sample and is expressed as micro Seimens per centimeter (µS/cm) (USEPA 1978; Cole 1994). Sources can include soil and mineral weathering, surface runoff from saline soils, groundwater discharge, municipal and industrial effluents, agricultural runoff and aerosol fallout. Excessive salts applied to soils may interfere with extraction of water by plants. High total dissolved solids may also affect taste and palatability of drinking water and at high concentrations may have a laxative effect. High conductivity water is also undesirable in most industrial process waters. The irrigation guideline for electrical conductivity is 1000 µS /cm (Alberta Agriculture 1983); however, this does not provide adequate protection for crops sensitive to salinity such as strawberries, raspberries, beans and carrots. To protect these crops a guideline limit of 700 µS/cm is recommended (CCREM 1987).

Total Dissolved Solids

Total dissolved solids (TDS) comprise inorganic salts and small amounts of organic matter that are dissolved in water. TDS refers to the total amount of substances in the water other than the pure water. The principal constituents are usually the cations calcium, magnesium, sodium and potassium and the anions carbonate, bicarbonate, chloride, sulphate and, particularly in groundwater, nitrate (from agricultural use). Conductivity measurements are converted to TDS values by a factor that varies with the type of water, typically 0.55 to 0.75. For irrigation water, the TDS should not exceed 500 to 3500 mg/L, depending on the crop. For livestock water, the TDS should not exceed 3000 mg/L (AENV 1999).

Total and Dissolved Phosphorus

Phosphorus is an essential nutrient required for plant growth. Sources of phosphorus can include animal manures (e.g., cattle, waterfowl), commercial inorganic fertilizers, sewage treatment plants, phosphate-containing detergents, food processing plants, urban runoff, atmospheric deposition, and natural levels found in soils and bottom sediments. Total phosphorus (TP) measures the nutrient in all forms whether particulate or dissolved, organic or inorganic. Dissolved phosphorus (DP) indicates the phosphorus not associated with sediment particles. Dissolved phosphorus is a closer measure of the nutrient more readily available for plant growth, though the phosphorus in particulate form is potentially available for plant growth through time. The particulate phosphorus concentration gives an indication of the sediments suspended in the water column.

Excessive nutrients in water can cause eutrophic conditions with increased algae and weed growth. In some circumstances, increased plant abundance can change the chemistry of the water, affect oxygen concentrations (through photosynthesis /respiration and decay of organic matter), affect aesthetics and affect the physical movement of water. Dense growths of filamentous algae and aquatic plants can physically block culverts and clog water intakes. Certain strains of algae can impart an off-taste to drinking water and in some instances blue-green algae produce a toxin that can cause health issues for humans and is toxic to livestock and waterfowl. Phosphorus concentrations are expressed as milligrams per litre (mg/L) of water (USEPA 1978; Cole 1994). Total phosphorus concentration guidelines for rivers (Environment Canada 2004) range from 0.025 to 0.050 mg/L, with Alberta and Manitoba guidelines at 0.050 mg/L, Ontario and Quebec at 0.030 mg/L and Australia and New Zealand at 0.035 to 0.037mg/L. These are typically for the protection of aquatic life.

Nitrate+Nitrite Nitrogen

Nitrate is the principal and most stable form of inorganic nitrogen in aquatic environments. Nitrite is an intermediate form in the nitrification/denitrification pathway and can be toxic; however, it is usually found in low concentrations because of its instability in the presence of oxygen. Nitrate and nitrite are typically reported as a combined concentration due to the instability of nitrite. Natural sources of nitrogen to surface water bodies can include atmospheric deposition. Human sources of nitrogen include municipal and industrial wastewater, septic tanks and runoff from agricultural practices. Nitrate is necessary for plant growth; however, elevated concentrations can also result in the excessive growth of algae and aquatic plants. High concentrations of nitrate can pose a toxic risk for infants and livestock watering. The nitrate-nitrite water quality objective for Nose Creek is <1.5 mg/L chosen from the City of Calgary Total Loading Management Target that corresponds to 5 mg/L oxygen for the period April 1 to

September 30 (BRBC 2008). The nitrate+nitrite guideline for the protection of livestock water is <100 mg/L and the nitrite guideline for the protection of livestock water is <10 mg/L (AENV 1999).

Total Ammonia

Total ammonia is the most reduced form of inorganic nitrogen in water and includes both the ionized (NH_4) and un-ionized forms (NH_3). Un-ionized ammonia (NH3) is the toxic form and its concentration depends on a combination of pH and water temperature. In most well-oxygenated waters, ammonia is quickly converted to nitrate. Ammonia is produced by the decomposition of organic matter. Ammonia can be found in municipal and industrial wastewater effluent and in runoff downstream of fields with intensive manure or fertilizer applications (BRBC 2008). Measurements of total ammonia in the aquatic environment are often expressed as `total ammonia-nitrogen` and is the sum of ammonia (NH_3) and ammonium (NH_4). The total ammonia target for Nose Creek is the CCME guideline which varies depending on water temperature and pH.

Fecal Coliform Bacteria

Fecal coliform bacteria (FCB) are specific to the intestinal tracts of warm-blooded animals (cattle, birds, pets etc.) and humans and are thus a more specific test for animal waste or sewage contamination. FCB can enter surface waters through fecal contamination by wildlife, domestic animals and through wastewater discharges or surface water runoff. Fecal coliform bacteria are not necessarily harmful to human health, but they indicate fecal contamination and the possible presence of other pathogenic organisms including *Escherichia coli* (*E. coli*), *Salmonella*, *Giardia* and *Cryptosporidium* which can have serious health implications affecting drinking water, irrigation, livestock watering and recreation (BRBC 2008). FCB can be a concern for fresh garden produce particularly leafy crops such as lettuce. Fecal coliform bacteria levels are expressed as the number of bacteria colonies per 100 mL of water. The irrigation guideline for fecal coliform bacteria is 100 colonies per 100 mL (Alberta Environment 1999).

Total Suspended Solids

Total suspended solids (TSS) are a measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms which are held in suspension in water. Total suspended solids concentrations are expressed as milligrams per litre (mg/L) of water (USEPA 1978). Suspended solids can transport nutrients and contaminants downstream and may be aesthetically undesirable. Excessively high TSS in irrigation water can cause the formation of crusts on top of the soil which can inhibit water infiltration, and plant emergence and impedes soil aeration. The formation of films on plant leaves can reduce sunlight and impede photosynthesis. TSS residues can reduce the marketability of some leafy crops such as lettuce. High TSS can interfere with the treatment of drinking and industrial process water. High concentrations of suspended and deposited sediment can reduce benthic invertebrate abundance and species richness. Deposited sediment can fill in deep pools and bury spawning gravels leading to reduced survival of fry fish. Sub-lethal effects on fish can include avoidance/re-distribution, reduced feeding/growth, respiratory impairment, reduced tolerance to disease and increased physiological stress. In very high concentrations, suspended sediment can result in direct mortality of fish (Waters 1995). For the protection of aquatic life, the AENV (1999) chronic guideline indicates TSS should not be increased by more than 10 mg/L above background.

2.2 Bow River Basin Water Quality Objectives for Nose Creek

Table 1 summarizes the water quality objectives or targets identified for the Nose Creek watershed by the Bow River Basin Council (BRBC).

Table 1 - Summary of indicators identified in the BRBC Watershed Management Plan.

Indicator	WQO/Target
Water Temperature	WQO: should not exceed 29°C at any time or a 7 day mean of 24°C.[a]
Dissolved Oxygen	Target: ≥5.0 mg/L (acute daily minimum); ≥6.5 mg/L (7-day average)[b]
Total Phosphorus	WQO: to be developed. Target: reduction in number of exceedances of the provincial guideline (0.05 mg/L) (AENV 1999).
Total Dissolved Phosphorus	WQO: to be developed.
Nitrate + Nitrite Nitrogen	WQO: <1.5 mg/L. Target: eliminate levels that cause nuisance aquatic plant growth.
Total Ammonia	WQO: US EPA during the growing season for growth of aquatic vegetation. To apply outside of the mixing zone (AENV 1995). Target: Should not exceed CCME guidelines for aquatic life. Guideline is variable depending on temperature and pH (table available in CCME fact sheet).
Pathogens as indicated by Fecal Coliforms	Target: less than 100 fecal coliforms per 100 mL (no single value to exceed objective at the point of withdrawal)
Total Suspended Solids	WQO: to be developed. Target: maintain and then reduce TSS loadings from current levels.
Attached Algae (Periphyton biomass defined as chlorophyll *a*)	WQO: No periphytic algal biomass that adversely affects users. Target: 150 mg/m^2 maximum value during open water season.
Pesticides and degradation products	WQO: not recommended at this time. Target: should not exceed CCME guidelines for aquatic life in the river.
Riparian Condition	Target for Nose Creek: a 'Healthy with Problems' rating. Target for West Nose Creek: a 'Healthy' rating
Runoff, soil erosion and impervious areas	Target: impervious and runoff recommendations as detailed in the Nose Creek Watershed Water Management Plan.

[a]This is likely too warm if trout are to survive in Nose Creek.

3.0 METHODS

Ten sites within the Nose Creek watershed were sampled twice monthly during April, May and June and once per month from June to October 2011 (Figure 1). More frequent sampling during April to June was completed to account for the spring runoff and the higher rainfall during these months. The number of samples collected at each site in 2011 ranged from 7 (some sites were dry in late summer) to 10. Five sites were located on Nose Creek and one site was on West Nose Creek (Table 2). On October 13th, an additional grab sample was collected from a small intermittent channel than drains the Town of Crossfield effluent holding ponds to obtain additional water quality data when the Town of Crossfield was releasing effluent from September 27th to October 18th. Grab samples were collected at each site with bottles supplied by ALS Laboratories (Calgary) and using standard protocols (e.g., triple rinsing and preservation, where required). Water samples were kept on ice in coolers and transported to ALS Laboratories. ALS Laboratories is a CALA[1] accredited lab for criteria and standards

[1] CALA – Canadian Association for Laboratory Accreditation Inc.

Insert Figure 1

established by the Association under their Certificate of Laboratory Proficiency. Samples were analysed using APHA[2] approved methods for nitrate+nitrite nitrogen (NO_3+NO_2-N), total phosphorus (TP), dissolved phosphorus (DP), total suspended solids (TSS) and fecal coliform bacteria (FCB). At each site *in situ* water quality was completed by measuring dissolved oxygen, percent oxygen saturation, water temperature, pH, total dissolved solids and electrical conductivity using a Hanna (Model HI 9828) multi-parameter water quality meter. Water samples from Nose Creek were collected between 10:50 am and 12:10 pm (**NC u/s Crossfield**), 11:20 am and 12:45 pm (**NC d/s Crossfield**), 12:00 pm and 1:30 pm (**NC u/s Airdrie**), 2:10 pm and 3:30 pm (**NC d/s Airdrie**), 9:20 am and 10:40 am (**NC u/s WNC**), 9:20 am and 11:39 am (**NC at 15 St**) and 8:51 am and 10:23 am (**NC at Mouth**). Water samples from West Nose Creek were collected between 1:00 pm and 2:30 pm (**WNC at Bighill Springs Rd**), 10:02 am and 12:03 pm (**WNC at Mountain View Rd**) and 9:36 am and 10:51 am (**WNC at Mouth**).

Discharge at the sites monitored by PESL was calculated using a Swoffer water velocity meter (Model 2100). The discharge was calculated as a function of width, depth and water velocity (i.e., the velocity-area method). The mean number of panels (width x depth x velocity) completed at each discharge transect was 18 (range: 11 to 28) for Nose Creek and 18 (range 13 to 22) for West Nose Creek. Staff gauges were installed at five locations: **NC u/s Crossfield**, **NC d/s Crossfield**, **NC u/s Airdrie**, **NC d/s Airdrie** and **NC u/s WNC**. The water level on the staff gauge was recorded each time a discharge measurement was calculated. At the end of 2012, a stage-discharge graph will be constructed for each site using data from the years 2009 to 2012.

The City of Calgary Water Quality Services (WQS) collected water samples at three sites (**Nose Creek at Mouth**, **Nose Creek at 15 St**, and **West Nose Creek at Mountain View Rd**) from January to December and one site (**West Nose Creek at Mouth**) from April to October (Table 2). The samples were analysed for total phosphorus, total dissolved phosphorus, total suspended solids, nitrate+nitrite nitrogen (NO_3+NO_2 –N), total ammonia and E*. coli* at the City's WQS Laboratory using APHA approved methods. The City of Calgary is a CALA accredited laboratory. The City of Calgary staff used a YSI 556 MPS (Multi-Probe System) meter to measure *in situ* pH, conductivity, water temperature and dissolved oxygen at the four sites.

All water chemistry data was summarized into tables by site and sampling date and values exceeding the guideline were shown as a bold font. Sample data for total phosphorus, dissolved phosphorus, fecal coliform and total suspended solids were divided into three groups according to season and expected water quality/quantity conditions:

Winter: November to March (low flow, low biological activity, ice-covered conditions),
Spring: April to June (higher flow, spring runoff),
Summer: July to October (moderate flow, high biological activity).

These data were summarized by median values on an annual basis (2011) and by season and presented in graph format (annual data). The data for each site were compared to water quality objectives established by the Bow River Basin Council (BRBC WQOs) to determine compliance. Overall, the data were summarized in a percent compliance format.

[2] APHA – American Public Health Association

Table 2 – Site descriptions, location and parameters analysed for the Nose Creek Watershed Partnership water quality monitoring program. Sites marked with an * (asterisk) were sampled by the City of Calgary.

Site Name	UTM Coordinates		Staff Gauge Location
Nose Creek (NC)			
NC u/s Crossfield	11U703543	5701784	Installed along right downstream bank, mounted on T-post, snug to bank. Fence needs brush cleaned out to prevent pooling.
NC d/s Crossfield	11U705270	5698762	Staff gauge installed on south side of post in the east side of the culvert (upstream end). Installed in 2010.
NC u/s Airdrie	11U707182	5690627	Installed on wood piling, along right downstream bank, underneath bridge. Installed in 2010.
NC d/s Airdrie	11U709175	5682704	Installed along right downstream bank and mounted on T-post, snug to bank. May move with ice. Staff gauge was washed away during high flows in 2011 and site back flooded by a beaver dam.
NC at 15 St*	11U708027	5673032	No staff gauge or discharge monitoring at this site.
NC u/s WNC	11U706614	5668605	Installed along left downstream bank on T-post, snug to bank. May move with ice.
NC at Mouth*	11U708859	5659391	No staff gauge or discharge monitoring at this site.
West Nose Creek (WNC)			
WNC at Bighill Springs Rd	11U690928	5683285	No staff gauge at this site.
WNC at Mountain View Rd*	11U699702	5674845	No staff gauge or discharge monitoring at this site.
WNC at Mouth*	11U706601	5668415	No staff gauge or discharge monitoring at this site.

4.0 RESULTS

4.1 Compliance with Water Quality Objectives

Table 3 summarizes the 2011 water quality percent compliance with the recommended water quality guidelines and compares historical compliance rates from 2010, 2009 and 1999-2001.

Table 3 – Summary of historical (1999-2001, 2009, 2010) water quality compliance rates (%) in comparison with 2011 for Nose Creek (NC) and West Nose Creek (WNC).

Parameter	Nose Creek				West Nose Creek				BRBC WQOs
	1999-2001	2009	2010	2011	1999-2001	2009	2010	2011	
Temperature	100	100	100	100	100	100	100	100	WQO: Should not exceed 29°C at any time or 7-day mean of 24°C.
pH	95	97	79	99	100	100	100	100	6.5 – 9.0[b]
Dissolved Oxygen	84	91	97	90	86	100	100	100	≥5.0 mg/L (1-day acute)
	69	79	92	79	76	95	100	96	≥6.5 mg/L (mean 7-day chronic)
Electrical Conductivity	38	29	27	63	91	90	76	86	<1000 µS/cm[c]
Total Dissolved Solids	15	0	9	36	6	0	0	80	<500 mg/L[d]
Total Phosphorus	2	0	12	4	15	52	33	25	<0.05 mg/L
Nitrate-Nitrite Nitrogen	89	83	94	93	85	88	93	82	<1.5 mg/L
Total Ammonia	91	83	88	100	97	100	100	100	Guideline depends on pH and temperature: CCME table
Fecal Coliform Bacteria	42	38	56	67	45	38	53	64	<100 CFU/100 mL

PRECIPITATION DATA					
Time Period	**1999-2001**	**2009**	**2010**	**2011**	**Comments**
Total Precipitation (mm):Jan-Dec	318 - 459 mean: 397	328	455	519	Majority of precipitation during winter falls as snow. Converted to water equivalent for 'total precipitation'.
Total Precipitation (mm):spring	156 - 221 mean: 183	68	180	223	
Total Precipitation (mm):summer	104 - 206 mean: 165	166	226	216	
Total Precipitation (mm):winter	32 - 71 mean: 49	94	49	80	

[a] Madawaska Consulting 2002
[b] pH guideline is from CCREM (1987)
[c] conductivity guideline is for irrigation (Alberta Agriculture 1983)
[d] AENV (1999) guideline for irrigation
[e] Precipitation data is from Calgary International Airport (www.climate.weatheroffice.gc.ca: National Climate Data and Information Archive). Total Precipitation: the sum of the total rainfall and the water equivalent of the total snowfall.

Table 3 also provides the total precipitation data for the study years. The year 2011 was the wettest year (519 mm) with the wettest spring (223 mm). The driest year was 2009 (328 mm) with the driest spring (68 mm) and summer (166 mm). The year 2010 was also a wet year (455 mm), particularly the summer (226 mm). The combined years 1999-2001 had average precipitation; although, the year 2000 was the driest (318 mm) and had the driest summer (104 mm). The year 1999 had the driest winter (32 mm).

Some trends with water quality compliance and total precipitation are apparent. Fecal coliform bacteria and total dissolved solids (TDS) generally had higher compliance rates in wet years (2010 and 2011) compared to drier years (1999-2001 and 2009). No other trends were apparent with compliance rates and total precipitation. Analysis of median parameter concentrations by season/year with total precipitation may reveal stronger trends; however, such analysis is beyond the scope of this baseline water quality monitoring report.

Higher fecal coliform compliance during wet years may seem counterintuitive as runoff from rural agricultural pastures and impervious surfaces in urban areas typically carries high bacteria numbers (Young and Thackston 1999); however, a large amount of runoff could serve to dilute (lower) bacteria numbers; whereas, in dry years discharge from point sources of runoff (outfalls, sediment ponds) can contribute high numbers of bacteria to the base flow of streams (Gregory and Frick 2000). Lower TDS compliance rates during drier years is not an unexpected result as hot, dry weather during low rainfall years will increase the evaporation rate of streams and ponds resulting in higher concentrations of salts.

4.2 Water Quantity (Discharge)

The five discharge sites at Nose Creek had varied stream widths due to a range of flows in 2011: **NC u/s Crossfield** (1.05 to 1.9 m: mean 1.44 m), **NC d/s Crossfield** (1.05 to 2.20 m: mean 1.61 m), **NC u/s Airdrie** (4.8 to 12.90 m: mean 9.47 m), **NC d/s Airdrie** (3.45 to 10.00 m: mean 5.26 m) and **NC u/s WNC** (4.15 to 6.50 m: mean 4.96 m). In 2011, the discharge within Nose Creek varied substantially by location and date ranging from 0.0 to 2.216 m^3/s (Table 4). The highest flows occurred in April when water levels were too high to safely obtain a discharge at four sites. There was a high discharge at **NC u/s Crossfield** and **NC d/s Crossfield** during April but flows decreased substantially during May and early June, increased slightly in late June with minor to no flow from mid-July to mid-October. **Nose Creek u/s Airdrie** had higher flows from April to early May, lower flows from late May to early June, and higher flow again in late June with minor to low flow from mid-July to mid-October. **Nose Creek d/s Airdrie** and **NC u/s WNC** showed similar discharge patterns with higher flow from April to late June (1.029 to 2.216 m^3/s), and lower flow from late July to mid-October (0.039 to 0.498 m^3/s). Although the two sites **Nose Creek u/s Airdrie** and **Nose Creek d/s Airdrie** are relatively close to each other, discharge at **Nose Creek d/s Airdrie** ranged from 1.3 to 49 times higher than the corresponding flow at **NC u/s Airdrie**. This indicates that precipitation runoff and discharge from stormwater ponds and outfalls in Airdrie can contribute a substantial amount of flow to Nose Creek. The highest measured discharge in Nose Creek was 2.216 m^3/s on June 23rd at **NC d/s Airdrie** (Table 4); although, higher flows would have occurred in April when measurements could not be obtained.

The discharge at Nose Creek in 2011 was substantially higher than the flows in 2010 and 2009. The mean site discharge in 2011 was 4 to 12 times more compared to 2010 and 3 to 6 times more compared to 2009.

Table 4 - Water discharge at sites within Nose Creek and West Nose Creek, from April to October 2011. Shaded cell indicates maximum discharge for site.

Date	Nose Creek					West Nose Creek
	NC u/s Crossfield	NC d/s Crossfield	NC u/s Airdrie	NC d/s Airdrie	NC u/s WNC	WNC at Big Hill Springs Rd
Apr-13	0.916	1.308	flood	flood	flood	0.722
Apr-27	0.746	flood	1.633	2.136	2.113	0.493
May-10	0.057	0.122	0.661	1.133	1.685	0.312
May-24	0.007	0.113	0.310	1.029	1.640	0.300
Jun-09	0.048	0.167	0.573	1.145	1.697	0.423
Jun-23	0.126	0.287	0.936	2.216	2.140	0.497
Jul-19	minor flow	0.007	0.007	0.344	0.431	0.109
Aug-18	no flow	0.006	minor flow	0.242	0.498	0.064
Sep-15	no flow	no flow	no flow	0.039	0.176	0.045
Oct-13	dry	no flow	0.106	0.085	0.199	0.059

flood: water levels very high and unsafe
minor flow: water movement visible but too slow to register on velocity meter, discharge probably <0.001 m^3/s
no flow: no visible water movement, but standing water may be present
dry: no moving or standing water, substrate is exposed and dry

The discharge site at West Nose Creek ranged in width from 1.7 to 2.5 m with a mean width of 2.12 m. The discharge at the West Nose Creek site ranged between 0.045 and 0.722 m^3/s with the highest flow in early April (during spring runoff) and the lowest flow in mid-September, a month which had low rainfall (Table 4). The flow increased in late June to 0.497 concurrent with a period of heavy rainfall. The discharge in 2011 at the West Nose Creek site was higher compared to 2010 and 2009. The consistent discharge from July to September 2009 during a low-precipitation summer suggested the majority of the flow at **WNC at Big Hill Springs Rd** in 2009 was from groundwater sources.

4.3 Water Quality Parameters

Temperature

Water temperature in 2011 at Nose Creek ranged from -0.1 to 24.3^{o}C (N=67) at the seven sites (Table 5). The lowest temperature (-0.1^{o}C) occurred in February, March and December and the warmest water temperature (24.3^{o}C) occurred July 19th at **NC d/s Airdrie** (Table 5). All of the water sample temperatures at Nose Creek were below the water quality objective of 29°C (acute) and 24^{o}C (7-day chronic). The July 19th temperature of 24.3^{o}C at **NC d/s Airdrie** on July 19th was slightly above 24^{o}C (7-day chronic); however, this sample was collected at 2:45 pm which would represent the daily maximum. Daily nighttime temperatures would likely decrease well below 24^{o}C. The water temperature compliance rate at Nose Creek in 2011 (100%) was identical when compared to historical compliance data in 2010, 2009 and 1999-2001 (Table 3).

Water temperature in 2011 at West Nose Creek ranged from 0.0 to 19.7^{o}C (N=28) (January through December (Table 5) at the three sites (Table 5). The lowest temperature (0^{o}C) occurred in November and December during the ice-covered period and the warmest water temperature (19.7^{o}C) occurred July 19th at **WNC at Big Hill Springs Rd** (Table 5). All of the water temperatures at West Nose Creek were below the water quality objective of 29°C (acute) and 24^{o}C (7-day chronic). The water temperature compliance rate in 2011 (100%) at West Nose Creek was identical when compared to historical compliance data in 2010, 2009 and 1999-2001 (Table 3).

Water temperatures in streams and rivers undergo a diurnal[3] cycle with the maxima usually occurring in the afternoon and the minima occurring during the latter half of the night. In small streams in the summer the diurnal fluctuations in temperature are not usually greater than 6^{o}C (Hynes 1970; Hauer and Hill 1996). The water temperatures collected from June to August during this study would represent maximum or near maximum temperature for those collected in the afternoon (i.e., **NC u/s Airdrie**, **NC d/s Airdrie** and **WNC at Big Hill Springs Rd**) while those collected in the morning would represent temperatures somewhere between the minimum and maximum. In all likelihood, the compliance rate would remain the same (100%) if the maximum temperature had been collected at each site. In 2009, Morris (2009) continuously monitored water temperature every 30 minutes at **NC u/s Airdrie** and **NC at Mouth** from June 23 to September 4, a low-flow, low-precipitation year. The maximum (acute) temperature of 29^{o}C was never exceeded at either site and the chronic 7-day temperature of 24^{o}C was not reached at **NC at Mouth** and water temperatures only briefly exceeded 24^{o}C for 1 and 2 days in July (Morris 2009).

pH

The pH of water samples from Nose Creek ranged from 6.86 to 9.34 (N=67). At Nose Creek, 99% of the samples were within the pH target compliance objective (6.5 to 9.0), with the single non-compliant pH occurring August 18th at **NC d/s Crossfield**. No samples at Nose Creek were below the lower limit of the target compliance objective (i.e., <6.5) (Table 6). The pH compliance rate in 2011 at Nose Creek (99%) was higher when compared to 2010 (79%), and slightly higher when compared to 2009 (97%) and 1999-2001 (95%) (Table 3).

The pH of water samples from West Nose Creek ranged from 7.50 to 8.62 (N=28). At West Nose Creek, 100% of the samples met the target compliance objective for pH. No samples at West Nose Creek were below the lower limit of the target compliance objective (i.e., <6.5)

[3] Diurnal: Having a daily cycle or pattern that re-occurs every 24 hours, synonymous with the term ‘diel.’

(Table 6). The pH compliance rate in 2011 at West Nose Creek (100%) was identical when compared to 2010, 2009 and historical compliance data from 1999-2001 (Table 3).

pH tends to undergo a diurnal fluctuation during the active growing season that is mediated by plant photosynthesis. The highest pH values occur during peak photosynthesis (afternoon) and the lowest pH values occur during plant respiration (late evening/early morning). During photosynthesis plants absorb carbon dioxide (CO_2), eliminate bicarbonates, precipitate carbonates and form hydroxyl ions which lead to an increase in pH. Conversely, at night plants undergo a process of respiration which releases CO_2 and lowers the pH. In 2009, Morris (2009) continuously monitored pH every 30 minutes at **NC u/s Airdrie** and **NC at Mouth** from June 23 to September 4, a low-flow, low-precipitation year. The pH never fell below 6.5 at either site, and the pH never exceeded 9.0 at the **NC at Mouth** site. At **NC u/s Airdrie**, the pH was generally above 9.0 from late-June to late-July and was below 9.0 from late-July to early-September (Morris 2009). The continuously high pH in 2009 at **NC u/s Airdrie** may have been due to the fact that the site had no flow (i.e., site was stagnant) and was subject to intensified photosynthesis for much of the study whereas in 2010 and 2011 the site was continuously flowing. In this study, **NC u/s Airdrie**, **NC d/s Airdrie** and **WNC at Big Hill Springs Rd** samples were collected between 12:00 pm to 3:30 pm and probably represent the maximum or near maximum pH. At the other sites in this study the maximum pH may not have been reached at the time of sampling and the compliance rate may be overestimated if the late-day pH maximum was greater than 9.0.

Table 5 - Water temperature (^{o}C) data from Nose Creek and West Nose Creek, January to December 2011. A yellow value indicates the may have exceeded the chronic 7-day water temperature objective for that site and date. Blank cells indicate no sample was taken (nf: indicates 'no flow', standing water may have been present).

Temperature (°C)	24-Jan	23-Feb	28-Mar	13-Apr	20-Apr	27-Apr	10-May	16-May	24-May	09-Jun	20-Jun	23-Jun	18-Jul	19-Jul	18-Aug	22-Aug	15-Sep	19-Sep	13-Oct	17-Oct	21-Nov	19-Dec
NOSE CREEK																						
NC u/s Crossfield				0.5		8.1	9.3		9.3	13.3		17.7		16.8	nf		nf		dry			
NC d/s Crossfield				0.7		8.7	12.0		11.9	15.5		20.9		19.8	15.2		nf		nf			
NC u/s Airdrie				3.6		9.2	11.9		9.0	15.8		21.1		20.8	15.3		nf		5.9			
NC d/s Airdrie				4.1		9.4	13.3		11.5	16.1		19.7		24.3	17.9		15.0		8.8			
NC at 15 St		-0.1	0.0		3.5			11.4			14.2		20.3			17.5		10.5		1.5	0.0	-0.0
NC u/s WNC				2.4		8.7	10.9		11.5	14.1		18.8		20.7	15.9		11.1		5.6			
NC at Mouth	0.0	0.0	-0.1		4.0			10.7			13.5		19.8			16.8		11.0		3.1	0.0	-0.1
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				2.9		7.5	10.5		8.4	15.1		17.9		19.7	13.6		11.2		5.6			
WNC at Mountain View Rd	0.1	0.2			2.3			9.6			13.1		18.3			15.5		8.9		0.7	0	0
WNC at Mouth					2.8			10.2			12.8		17.1			14.5		10.0		2.1		

Table 6 - pH data from Nose Creek and West Nose Creek, January to December 2011. A red value indicates the pH exceeded the pH water quality objective for that site and date. Blank cells indicate no sample was taken (nf: indicates 'no flow', standing water may have been present).

pH	24-Jan	23-Feb	28-Mar	13-Apr	20-Apr	27-Apr	10-May	16-May	24-May	09-Jun	20-Jun	23-Jun	18-Jul	19-Jul	18-Aug	22-Aug	15-Sep	19-Sep	13-Oct	17-Oct	21-Nov	19-Dec
NOSE CREEK																						
NC u/s Crossfield				7.36		7.20	7.01		7.80	7.64		7.99		7.70	nf		nf		dry			
NC d/s Crossfield				7.87		7.46	7.37		8.44	8.54		8.37		8.83	**9.34**		nf		nf			
NC u/s Airdrie				7.42		7.59	7.66		8.06	8.28		7.90		7.54	7.85		nf		8.35			
NC d/s Airdrie				7.92		7.92	8.38		8.40	8.76		8.17		8.50	8.49		8.72	8.65	8.90			
NC at 15 St		7.89	7.86		8.19			8.65			8.24		8.82			8.69				8.53	8.07	7.94
NC u/s WNC				6.86		7.13	7.10		7.70	8.40		8.48		8.73	8.57		8.81		8.67			
NC at Mouth	8.08	8.19	8.04		8.21			8.63			8.23		8.53			8.51		8.38		8.44	8.17	8.19
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				7.50		7.72	8.08		8.38	8.44		8.14		8.31	8.57		8.57		8.50			
WNC at Mountain View Rd	7.81		8.15		8.29			8.47			8.22		8.41			8.45		8.40		8.41	8.04	8.30
WNC at Mouth					8.30			8.62			8.27		8.48			8.38		8.18		8.33		

Dissolved Oxygen

Dissolved oxygen in Nose Creek ranged from 0.34 to 13.99 mg/L (N=67) in 2011 (Table 7). At Nose Creek, seven samples were less than the 1-day 5.0 mg/L acute dissolved oxygen objective, resulting in a 90% compliance rate. Seven samples were less than the 7-day 6.5 mg/L chronic dissolved oxygen objective[4], resulting in a 79% compliance rate. The lowest dissolved oxygen concentration (0.34 mg/L) at Nose Creek occurred at **NC at 15 St** on February 23 and the maximum concentration (13.99 mg/L) was recorded at **NC at Mouth** on November 21. At Nose Creek, the acute oxygen compliance rate in 2011 (90%) was lower than 2010 (97%), and 2009 (91%) and higher than 1999-2001 (84%) (Table 3). The chronic oxygen compliance rate in 2011 (79%) was lower than 2010 (100%), the same as 2009 (79%) and higher than 1999-2001 (69%) (Table 3).

Dissolved oxygen in West Nose Creek ranged from 5.44 to 15.22 mg/L (N=28) in 2011 (Table 7). At West Nose Creek, no samples were less than the 1-day 5.0 mg/L acute dissolved oxygen objective. A sample from January 24th at **WNC at Mountain View Rd** had an oxygen concentration of 5.44 mg/L which was less than the 6.5 mg/L chronic dissolved oxygen objective; however, it is not known if the sample was less than 6.5 mg/L for more than 7 days. The maximum dissolved oxygen concentration at West Nose Creek occurred on May 10th at **WNC at Big Hill Springs Rd**. At West Nose Creek, the acute oxygen compliance rate in 2011 (100%) was the same as 2010 and 2009 (100%) and higher than 1999-2001 (86%) (Table 3). The chronic oxygen compliance rate in 2011 (96%) was similar to 2010 (100%) and 2009 (95%) and higher than 1999-2001 (76%) (Table 3).

In 2009, Morris (2009) recorded fluctuations in oxygen concentration at **NC u/s Airdrie** from June 23 to September 4 and observed that oxygen concentrations often fell below 5 mg/L during the night. At **NC at Mouth**, oxygen concentrations were always above 5 mg/L from June 23 to July 3 (no data collected after July 3) (Morris 2009). A highly variable dissolved oxygen regime at sites within Nose Creek is probably due to aquatic macrophytes and filamentous algae. In aquatic systems, algae and aquatic plants are the primary sources and consumers of oxygen. Extensive diurnal variation in oxygen concentrations is often observed in creeks and rivers with dense growths of aquatic plants. Sunlight promotes intense photosynthesis (oxygen production) during daylight hours, particularly in late afternoon, with lower oxygen concentrations often observed at night, just before dawn, as a result of plant respiration (oxygen consumption) (Hynes 1970). The large diurnal fluctuations in dissolved oxygen in 2009 at **NC u/s Airdrie** may have been exacerbated due to the fact that the site had no flow (i.e., site was stagnant) and may have been subject to intensified photosynthesis for much of the study whereas in 2010 and 2011 the site was flowing when oxygen samples were taken. Nonetheless, it is likely that most of the sites within this study undergo diurnal oxygen fluctuations during the active growing season (June to September) with oxygen concentrations often falling below 5 mg/L during late evening/early morning.

Electrical Conductivity

In 2011, electrical conductivity (EC) ranged from 264 to 4397 µS/cm (N=67) in Nose Creek (Table 8). The maximum EC in Nose Creek 4397 µS/cm) occurred at **NC at Mouth** on March 28th, while the lowest EC (264 µS/cm) occurred at **NC u/s Crossfield** on April 13th. In 2011, 63% of the samples from Nose Creek met the compliance target of less 1000 µS/cm. All of the

[4] The 6.5 mg/L chronic dissolved oxygen objective is a 7-day running average. Samples in this study were taken approximately from one to three times monthly; therefore, it was assumed oxygen values less than 6.5 mg/L did not meet the chronic guideline for one week but in most cases the mean 7-day oxygen concentration was likely greater than 6.5 mg/L. Therefore, chronic compliance rates in this report are likely underestimated.

sampling sites from **NC d/s Airdrie** upstream to **NC u/s Crossfield** met the electrical conductivity guideline from April to October with the exception of **NC u/s Airdrie** (1071 µS/cm) on October 13th which was concurrent with the release of treated effluent from the Town of Crossfield from September 27th to October 18th. A water sample was obtained on October 13th from the channel draining the Town of Crossfield holding ponds and electrical conductivity was 1220 µS/cm and above the guideline of 1000 µS/cm.

The sites within the City of Calgary (**NC at 15 St**, **NC u/s WNC** and **NC at Mouth)** had a low compliance rate of 27% (N=33) compared to the compliance rate of 97% for the sites upstream of Calgary. The electrical conductivity compliance rate in 2011 (63%) at Nose Creek was higher than 2010 (27%), 2009 (29%) and 1999-2001(38%) (Table 3).

Electrical conductivity at West Nose Creek ranged from 411 to 3419 µS/cm (N=28), with the lowest electrical conductivity at **WNC at Big Hill Springs Rd** on April 13th and the highest on January 24th at **WNC at Mountain View Rd**. A total of 86% of the samples from West Nose Creek were in compliance with the water quality objective of less than 1000 µS/cm. The site **WNC at Mouth** had the lowest compliance rate at 57% while the site **WNC at Big Hill Springs Rd** had the highest compliance rate at 100%. The electrical conductivity compliance rate in 2011 (86%) at West Nose Creek was higher when compared to 2010 (76%) but lower when compared to 2009 (90%) and 1999-2001 (91%) (Table 3).

Table 7 - Dissolved oxygen from Nose Creek and West Nose Creek, January to December 2011. A red value indicates the oxygen did not meet the applicable acute oxygen water quality objective. A yellow value indicates the oxygen did not meet the chronic 7-day oxygen water quality objective. Blank cells indicate no sample was taken (nf: indicates 'no flow', standing water may have been present).

Dissolved Oxygen (mg/L)	24-Jan	23-Feb	28-Mar	13-Apr	20-Apr	27-Apr	10-May	16-May	24-May	09-Jun	20-Jun	23-Jun	18-Jul	19-Jul	18-Aug	22-Aug	15-Sep	19-Sep	13-Oct	17-Oct	21-Nov	19-Dec
NOSE CREEK																						
NC u/s Crossfield				7.80		8.17	9.27		**4.85**	9.13		5.79		**2.56**	nf		nf		dry			
NC d/s Crossfield				6.34		6.43	11.74		**4.93**	10.86		8.53		7.57	7.59		nf		nf			
NC u/s Airdrie				7.70		8.08	8.37		**4.35**	7.10		**3.71**		**1.05**	7.86		nf		10.70			
NC d/s Airdrie				7.56		9.16	12.12		5.10	10.31		6.05		12.06	11.03		11.86		11.34			
NC at 15 St		**0.34**	8.45		10.87			10.76			11.80		7.47			8.52		9.40		13.54	9.37	10.76
NC u/s WNC				8.57		8.77	10.35		5.56	7.15		6.21		7.91	8.56		7.07		8.46			
NC at Mouth	10.59	11.27	10.93		11.32			10.37			12.91		6.82			9.04		9.57		13.21	13.99	13.22
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				7.06		9.49	15.22		7.66	9.20		6.95		12.54	13.39		13.30		15.19			
WNC at Mountain View Rd	5.44		10.08		11.51			11.79			12.10		9.68			10.85		11.08		13.98	10.43	12.83
WNC at Mouth					12.27			14.47			14.01		8.98			10.59		8.99		13.12		

Table 8 - Electrical conductivity data from Nose Creek and West Nose Creek, January to December 2011. A red value indicates the electrical conductivity exceeds the applicable electrical conductivity water quality objective. Blank cells indicate no sample was taken (nf: indicates 'no flow', standing water may have been present).

Electrical Conductivity (µS/cm)	24-Jan	23-Feb	28-Mar	13-Apr	20-Apr	27-Apr	10-May	16-May	24-May	09-Jun	20-Jun	23-Jun	18-Jul	19-Jul	18-Aug	22-Aug	15-Sep	19-Sep	13-Oct	17-Oct	21-Nov	19-Dec
NOSE CREEK																						
NC u/s Crossfield				264		341	603		794	677		747		785	nf		nf		dry			
NC d/s Crossfield				341		379	742		914	770		831		842	677		nf		nf			
NC u/s Airdrie				499		582	754		914	781		980		850	885		nf		**1071**			
NC d/s Airdrie				542		620	772		798	794		904		923	835		785		973			
NC at 15 St		**2688**	**1422**		681			**1014**			**1012**		**1038**			962		**1146**		**1241**	**1473**	**1467**
NC u/s WNC				597		767	992		**1266**	995		**1041**		**1111**	**1046**		**1057**		**1169**			
NC at Mouth	**2708**	**1669**	**4397**		965			757			996		**1147**			**1137**		**1109**		**1243**	**1489**	**3352**
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				411		519	687		825	647		764		649	723		736		880			
WNC at Mountain View Rd	**3419**		873		795			893			837		806			864		863		869	991	927
WNC at Mouth					**1029**			984			904		949			**1034**		790		**1045**		

Total Dissolved Solids

Total dissolved solids (TDS) ranged from 172 to 823 mg/L (N=44) in Nose Creek (Table 9). The maximum TDS concentration in Nose Creek (823 mg/L) at **NC u/s WNC** occurred on May 24 while the lowest TDS concentration (172 mg/L) occurred on April 13th at **NC u/s Crossfield**. Nose Creek had on average higher TDS concentrations in comparison to West Nose Creek. At Nose Creek, the TDS compliance rate in 2011 (36%) was higher than 2010 (9%), 2009 (0%) and 1999-2001 (15%) (Table 3).

Total dissolved solids (TDS) at West Nose Creek (**WNC at Big Hill Springs Rd**) ranged from 269 to 573 mg/L (N=10) (Table 9). At West Nose Creek, the TDS compliance rate in 2011 (80%) was considerably higher than 2010 and 2009 (0%) and 1999-2001 (6%) (Table 3).

Grasby et al. (1997) determined that Nose Creek has a TDS load, particularly sulphate, which is significantly higher than the Bow River or its other tributaries. Using chemical and stable isotope analysis to determine sources of TDS in Nose Creek they determined that substantial amounts of water are added to Nose Creek by leaking municipal pipes via groundwater from Airdrie and Calgary. They identified three clusters of sulphate in Nose Creek in the fall that suggested different sources. Upstream of Airdrie, the source of sulphate was identified as being consistent with SO_2 emissions during processing of sour gas near Crossfield. The oxidation of organic matter in soils was identified as the primary source of increased sulphate concentrations between Airdrie and Calgary. The third source of sulphates within the City of Calgary was identified as a large flux of water added by the City of Calgary (via leaking pipes) that is oxidizing reduced forms of sulphur in the till, which is then mobilized as SO_4 and transported into Nose Creek via groundwater flow (Grasby *et al.* 1997).

Table 9 - Total dissolved solids (TDS) data from Nose Creek and West Nose Creek, April to October 2011. A red value indicates the TDS exceeds the water quality objective.

Total Dissolved Solids (mg/L)	13-Apr	27-Apr	10-May	24-May	09-Jun	23-Jun	19-Jul	18-Aug	15-Sep	13-Oct
Nose Creek										
NC u/s Crossfield	172	223	399	**516**	440	485	**515**	nf	nf	dry
NC d/s Crossfield	244	251	486	**594**	**500**	**540**	**551**	442	nf	nf
NC u/s Airdrie	328	381	498	**594**	**507**	**637**	**558**	**580**	nf	**708**
NC d/s Airdrie	380	406	**507**	**519**	**516**	**588**	**600**	**544**	**510**	**642**
NC u/s WNC	383	498	**653**	**823**	**646**	**676**	**723**	**681**	**686**	**767**
West Nose Creek										
WNC at Big Hill Springs Rd	269	339	439	**536**	420	496	425	475	478	**573**

Total Phosphorus

Total phosphorus, ranging from 0.033 to 0.973 mg/L (N=67), often exceeded the target compliance objective (0.05 mg/L) at Nose Creek throughout the year and had a compliance rate of 4% (Table 10). At Nose creek, the total phosphorus compliance rate in 2011 (4%) was lower than 2010 (12%) but higher when compared to 2009 (0%) and 1999-2001 (2%) (Table 3). The highest TP concentration (0.973 mg/L) which occurred on October 13th at **NC u/s Airdrie** coincided with the release of effluent from the Town of Crossfield sewage lagoons, which occurred from September 27th to October 18th (Table 10). A water sample was obtained on October 13th from the channel draining the Town of Crossfield sewage lagoons and total phosphorus was elevated at 2.34 mg/L. The seasonal median TP concentration was above 0.05 mg/L for winter, spring and summer at the Nose Creek sites (Figure 2); although, the median total phosphorus at **NC at Mouth** was at the guideline for the winter (0.051 mg/L). The highest median TP concentrations generally occurred in the spring with the exception of **NC u/s Airdrie** which had a high median TP during the summer due to the treated effluent from Crossfield.

Twenty-five percent of the West Nose Creek samples had TP concentrations below the target compliance objective of 0.05 mg/L, and ranged from 0.021 to 0.555 mg/L (N=28) (Table 10). At West Nose Creek, the total phosphorus compliance rate in 2011 (25%) was lower than 2010 (33%) and 2009 (52%) but higher than 1999-2001 (15%) (Table 3). The lowest TP concentration was 0.021 mg/L on August 18th at **WNC at Big Hill Springs Rd** and the highest was 0.555 mg/L on October 13th at **WNC at Mountain View Rd**. By site, the highest compliance rate was at **WNC at Mountain View Rd** (36%) and the lowest compliance rate was at **WNC at Big Hill Springs Rd** (10%). The seasonal median TP concentration was above the 0.05 mg/L guideline for the winter (0.162 mg/L), spring (0.162 to 0.200 mg/L) and summer (0.034 to 0.86 mg/L) at all sites with the exception of **WNC at Mountain View Rd** during the summer (0.034 mg/L).

Phosphorus concentrations are a concern at both creeks since it enriches freshwater (a process known as eutrophication), contributing to the growth of aquatic plants. Aquatic plants produce oxygen through photosynthesis during the day; however, on cloudy days or during the night, the plants consume oxygen for respiration and can deteriorate fish habitat conditions. In addition, oxygen is used during the decomposition of plant material, again decreasing oxygen resources for fish and other aquatic life.

Sources of phosphorus include organic and inorganic fertilizers that are used for agricultural crop production and urban lawn maintenance, livestock manure, pet feces, poorly designed or failing septic systems, and treated municipal effluent. In urban areas, Waschbusch *et al.* (1999) found lawns and streets were the largest sources of phosphorus in urban stormwater. Rast and Lee (1983) examined nearly 100 watersheds in the United States and found urban area phosphorus nutrient export coefficients were about two times higher than the export coefficients from agricultural (row crops) areas. This difference was due in part to the greater amount of runoff in urban areas than in agricultural areas due to the greater amount of impervious surfaces. Urban areas contributed about 10 times more phosphorus per unit area than forested areas. Similarly, both urban and agricultural areas contributed much greater amounts of phosphorus per unit area than forested areas (Rast and Lee 1983).

Table 10 - Total phosphorus data from Nose Creek and West Nose Creek, January to December 2011. A red value indicates total phosphorus exceeds the water quality objective for site and date. Blank cells indicate no sample was taken.

Phosphorus, Total (mg/L)	24-Jan	23-Feb	28-Mar	13-Apr	20-Apr	27-Apr	10-May	16-May	24-May	09-Jun	20-Jun	23-Jun	18-Jul	19-Jul	18-Aug	22-Aug	15-Sep	19-Sep	13-Oct	17-Oct	21-Nov	19-Dec
Nose Creek																						
NC u/s Crossfield				0.807		0.290	0.225		0.424	0.461		0.515		0.392	nf		nf		dry			
NC d/s Crossfield				0.623		0.305	0.188		0.137	0.237		0.337		0.305	0.302		nf		nf			
NC u/s Airdrie				0.560		0.309	0.301		0.551	0.306		0.342		0.662	0.480		nf		0.973			
NC d/s Airdrie				0.483		0.291	0.250		0.284	0.227		0.328		0.327	0.192		0.157		0.239			
NC at 15 St		0.105	0.497		0.277			0.212			0.253		0.239			0.151		0.103		0.122	0.048	0.086
NC u/s WNC				0.503		0.285	0.175		0.239	0.228		0.253		0.185	0.112		0.100		0.095			
NC at Mouth	0.049	0.054	0.262		0.248			0.117			0.236		0.116			0.063		0.144		0.055	0.033	0.051
West Nose Creek																						
WNC at Big Hill Springs Rd				0.510		0.213	0.134		0.146	0.167		0.229		0.111	0.021		0.060		0.126			
WNC at Mountain View Rd	0.555		0.236		0.200			0.093			0.333		0.065			0.037		0.030		0.031	0.046	0.087
WNC at Mouth					0.162			0.051			0.191		0.092			0.031		0.210		0.046		

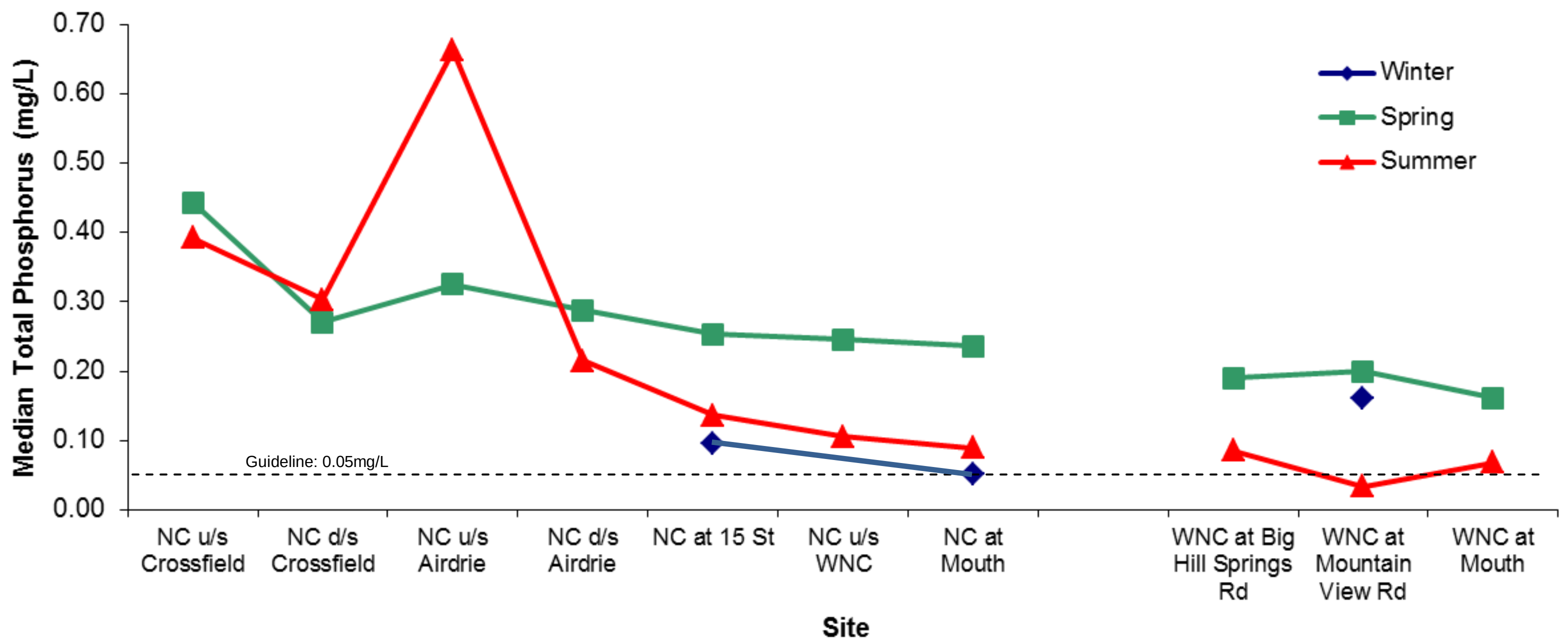

Figure 2 - Seasonal median total phosphorus in Nose Creek and West Nose Creek (upstream to downstream) in 2011.

Total Dissolved Phosphorus

Total dissolved phosphorus (TDP) in Nose Creek ranged from <0.010 to 0.755 mg/L (N=67) (Table 11). The highest TDP concentrations occurred on April 13th when the median was 0.468 mg/L whereas the lowest TDP concentrations occurred on August 18th when the median was 0.115 mg/L (Table 11). The highest TDP concentration (0.755 mg/L) occurred on October 13th at **NC u/s Airdrie** which coincided with the release of effluent from the Town of Crossfield sewage lagoons, which occurred from September 27th to October 18th. A water sample was obtained on October 13th from the channel draining the Town of Crossfield sewage lagoons and dissolved phosphorus was elevated at 1.79 mg/L. The highest seasonal median concentrations of dissolved phosphorus at Nose Creek occurred during the spring and the lowest during the summer (Figure 3). The higher summer median concentration of dissolved phosphorus at **NC u/s Airdrie** was due to the Town of Crossfield effluent release. Generally, the seasonal median concentration of dissolved phosphorus was higher in spring and summer at the upper watershed sites compared to the lower watershed sites (Figure 3). The higher concentration of TDP at the upper sites was probably due to agricultural runoff and the lower TDP concentration at the lower sites was probably a result of dissolved phosphorus uptake by filamentous algae and aquatic plants at the lower sites which was observed to be dense.

Total dissolved phosphorus (TDP) in West Nose Creek ranged from 0.010 to 0.502 mg/L (N=28) (Table 11). The lowest dissolved phosphorus occurred on October 17th (0.010 mg/L) at **WNC at Mouth** and the highest on January 24th (0.502 mg/L) also at **WNC at Mountain View Rd**. Similar to Nose Creek, the highest spring median concentrations of dissolved phosphorus occurred at the most upstream site (**WNC at Big Hill Springs Rd**), but this trend was not apparent for the summer period which had a similar median concentration at the three sites (Figure 3).

Table 11 - Dissolved phosphorus data from Nose Creek and West Nose Creek, January to December 2011. Blank cells indicate no sample was taken.

Phosphorus, Dissolved (mg/L)	24-Jan	23-Feb	28-Mar	13-Apr	20-Apr	27-Apr	10-May	16-May	24-May	09-Jun	20-Jun	23-Jun	18-Jul	19-Jul	18-Aug	22-Aug	15-Sep	19-Sep	13-Oct	17-Oct	21-Nov	19-Dec
Nose Creek																						
NC u/s Crossfield				0.679		0.250	0.207		0.369	0.433		0.494		0.392	nf		nf		dry			
NC d/s Crossfield				0.526		0.252	0.116		0.067	0.198		0.291		0.296	0.121		nf		nf			
NC u/s Airdrie				0.468		0.289	0.271		0.524	0.288		0.327		0.660	0.447		nf		0.755			
NC d/s Airdrie				0.439		0.249	0.183		0.169	0.152		0.204		0.294	0.108		0.075		0.095			
NC at 15 St		0.068	0.378		0.194			0.154			0.188		0.211			0.104		0.064		0.060	0.029	0.066
NC u/s WNC				0.345		0.190	0.128		0.113	0.123		0.181		0.135	0.038		0.041		0.016			
NC at Mouth	0.024	0.026	0.166		0.141			0.042			0.140		0.057			0.024		0.051		0.014	<0.010	0.019
West Nose Creek																						
WNC at Big Hill Springs Rd				0.330		0.157	0.087		0.097	0.127		0.173		0.090	<0.020		0.028		0.014			
WNC at Mountain View Rd	0.502		0.180		0.120			0.046			0.251		0.035			0.025		0.022		0.016	0.019	0.024
WNC at Mouth					0.092			0.012			0.128		0.064			0.022		0.037		0.010		

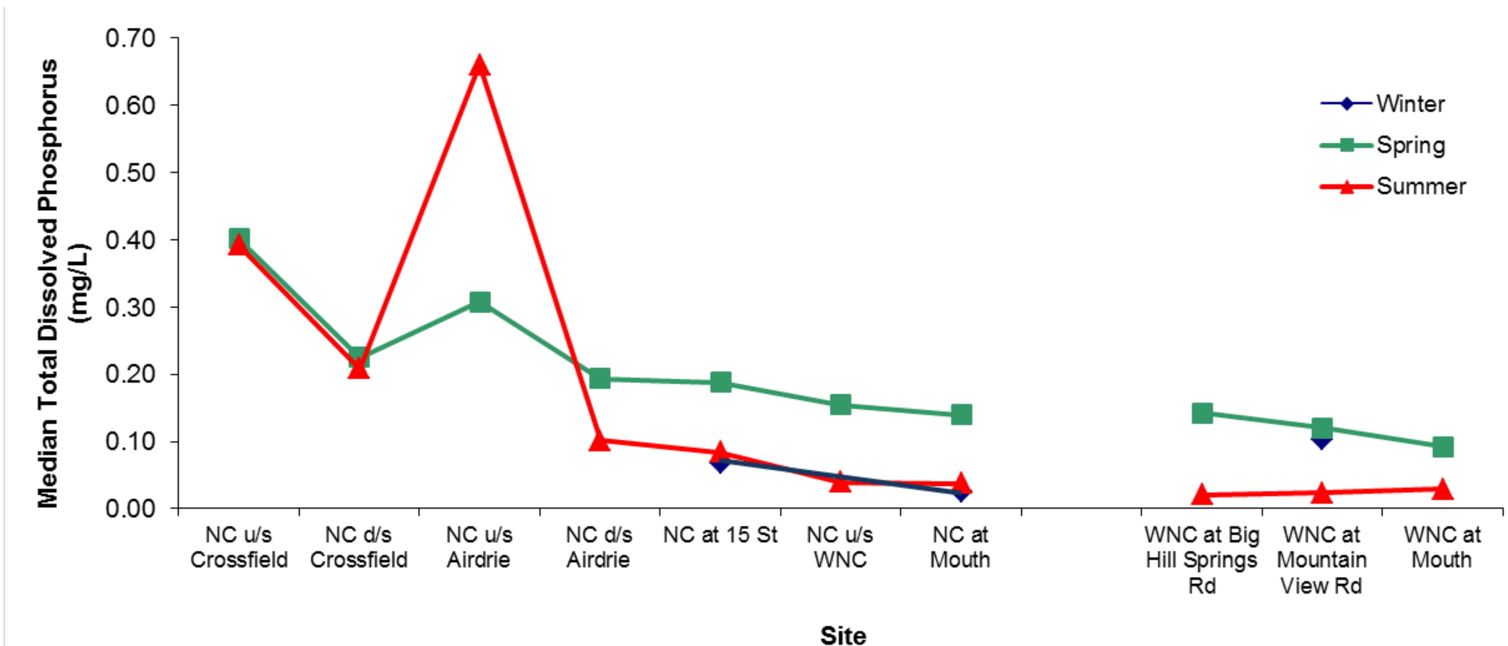

Figure 3 - Seasonal median total dissolved phosphorus in Nose Creek and West Nose Creek in 2011 (upstream to downstream).

Nitrate-Nitrite

At Nose Creek, nitrate-nitrite (<0.071 to 2.63 mg/L) was usually below the guideline of 1.5 mg/L with an overall compliance rate of 93% in 2011 (N=67) (Table 12). The five samples exceeding the guideline all occurred at **NC at Mouth** from October to February. Thirty-nine percent of the samples were below the detection limit for nitrate-nitrite. The higher concentrations of nitrate-nitrite during the colder months are probably due to reduced utilization by plants/algae and increased inputs from groundwater. A water sample was obtained on October 13th from the channel draining the Town of Crossfield sewage lagoons and nitrate-nitrite was elevated at 0.956 mg/L but within the maximum range occurring at other sites. At Nose Creek, the nitrate-nitrite compliance rate in 2011 (93%) was similar to 2010 (94%) and higher than 2009 (83%) and 1999-2001 (89%) (Table 3).

At West Nose Creek, nitrate-nitrite was also usually below the guideline of 1.5 mg/L with an overall compliance rate of 82% in 2011 (N=28) (Table 12). Of the five samples exceeding the guideline, three occurred from October to January and three of the exceedances occurred at **WNC at Mouth**. Thirty-six percent of the samples were below the detection limit for nitrate-nitrite. At West Nose Creek, the nitrate-nitrite compliance rate in 2011 (82%) was lower than 2010 (93%), 2009 (88%) and 1999-2001 (85%) (Table 3).

Total Ammonia-N

At Nose Creek, total ammonia-N concentrations were always below the detection limit (0.9 mg/L) and was considered to have an overall compliance rate of 100% in 2011 (N=23) (Table 13). Although 100% of the samples were below the detection limit for total ammonia-N; 52% of the sample detection limits were greater than the total ammonia-N guideline[5]; thus, there is some uncertainty as to whether these samples met the guideline. At Nose Creek, the total ammonia-N compliance rate in 2011 (100%) was higher than 2010 (88%), 2009 (83%) and 1999-2001 (91%) (Table 3).

At West Nose Creek, total ammonia-N were always below the detection limit (0.9 mg/L) and was considered to have an overall compliance rate of 100% in 2011 (N=18) (Table 13). Although 100% of the samples were below the detection limit for total ammonia-N; 83% of the sample detection limits were greater than the total ammonia-N guideline; thus, there is some uncertainty as to whether these samples met the guideline. At West Nose Creek, the total ammonia-N compliance rate in 2011 (100%) was the same as 2010 (100%), 2009 (100%) and slightly higher than 1999-2001 (97%) (Table 3).

[5] Total ammonia guidelines vary and are dependent on pH and water temperature.

Table 12 - Nitrate-nitrite nitrogen data for Nose Creek and West Nose Creek, January to December 2011. A red value indicates the nitrate-nitrite nitrogen exceeds the water quality objective for that site and date. Blank cells indicate no sample was taken.

Nitrate-nitrite nitrogen (mg/L)	24-Jan	23-Feb	28-Mar	13-Apr	20-Apr	27-Apr	10-May	16-May	24-May	09-Jun	20-Jun	23-Jun	18-Jul	19-Jul	18-Aug	22-Aug	15-Sep	19-Sep	13-Oct	17-Oct	21-Nov	19-Dec
NOSE CREEK																						
NC u/s Crossfield				0.921		0.130	<0.071		0.072	0.125		<0.071		<0.071	nf		nf		dry			
NC d/s Crossfield				0.490		<0.071	0.193		<0.071	0.227		<0.071		<0.071	<0.071		nf		nf			
NC u/s Airdrie				0.207		<0.071	<0.071		<0.071	<0.071		0.095		<0.071	<0.071		nf		0.125			
NC d/s Airdrie				0.172		<0.071	<0.071		0.214	0.196		0.300		0.213	0.262		0.856		0.323			
NC at 15 St		<0.60	<0.60		<0.60			<0.60			<0.60		<0.60			<0.60		<0.60		<0.60	0.79	0.74
NC u/s WNC				0.230		0.072	0.105		0.120	0.362		0.315		0.311	0.490		0.369		0.385			
NC at Mouth	**2.63**	**2.42**	0.84		0.68			<0.60			0.63		0.92			1.11		1.47		**1.56**	**2.60**	**1.97**
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				0.425		0.119	<0.071		<0.071	0.103		0.123		0.359	0.359		0.422		0.961			
WNC at Mountain View Rd	**4.85**		0.76		<0.60			<0.60			<0.60		1.30			<0.60		<0.60		1.13	**1.64**	1.43
WNC at Mouth					<0.60			<0.60			0.65		<0.60			**1.58**		**1.61**		**1.99**		

Table 13 - Total ammonia-N data for Nose Creek and West Nose Creek, January to December 2011. A yellow value indicates the detection limit of the total ammonia-N analysis was greater than the total ammonia-N guideline for that site and date; therefore, it is uncertain if the sample meets the guideline. Blank cells indicate no sample was taken.

Total Ammonia-N (mg/L)	24-Jan	23-Feb	28-Mar	20-Apr	16-May	20-Jun	18-Jul	22-Aug	19-Sep	17-Oct	21-Nov	19-Dec
NOSE CREEK												
NC at 15 St		<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
NC at Mouth	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
WEST NOSE CREEK												
WNC at Mountain View Rd	<0.9		<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
WNC at Mouth				<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9		

Fecal Coliform

Bacteria concentrations ranged from <1 to >2420 CFU/100 mL in Nose Creek (N=67) (Table 14) in 2011. The highest concentration of fecal coliform (>2420 CFU/100 mL) occurred on December 19th at **NC at Mouth**. A water sample was obtained on October 13th from the channel draining the Town of Crossfield sewage lagoons and fecal coliform bacteria were low at 4 CFU/100 mL. Overall, 67% of the Nose Creek samples had bacteria concentrations below the target compliance objective of 100 CFU/100 mL. The sites **NC u/s Airdrie** and **NC u/s Crossfield** had the highest compliance rate at 100% and 86%, respectively, whereas the site **NC at Mouth** had the lowest compliance rate at 25%. The sites upstream of Calgary had higher compliance rates ranging from 75 to 100% compared to the sites within the City of Calgary which ranged from 25 to 64%. At Nose Creek, the overall bacteria compliance rate in 2011 (67%) was higher than 2010 (56%), 2009 (38%) and 1999-2001 (42%) (Table 3). Seasonally, the highest median concentration of bacteria in winter, spring and summer occurred at **NC at Mouth** (Figure 4). Generally, the median concentration of bacteria in the spring was below the guideline with the exception of **NC at Mouth**. The median concentration of bacteria in the summer was generally below the guideline with the exception of **NC d/s Crossfield** and **NC at 15 St** and **NC at Mouth** (Figure 4). It is not known why the spring bacteria concentrations are so much higher at **NC at Mouth** compared to upstream sites as the spring concentrations are on average 10 times higher than the upstream sites. The data suggests there is a significant contributor of fecal bacteria to Nose Creek downstream of the confluence of West Nose Creek. Stormwater outfalls could be a potential contributor of fecal bacteria. Exceedance of fecal coliform guidelines at **NC d/s Crossfield** (summer) may be due to runoff from the Town of Crossfield. Exceedance of fecal coliform guidelines at **NC at 15 St** (summer) may be due to direct livestock access and runoff from grazing areas from upstream areas. It is not known why the bacteria concentrations were high at **NC at Mouth** during the winter (median: 687 CFU/100 mL) but the count is similar to the 2010 results at the same site (Palliser Environmental 2011).

Bacteria concentrations ranged from <1 to >2420 CFU/100 mL in West Nose Creek (N=28) in 2011 (Table 14). The highest bacteria count was at **WNC at Mountain View Rd** on June 20th with the second highest count (1733 CFU/100 mL) occurring at **WNC at Mouth** on September 19th. Sixty-four percent of the West Nose Creek samples had fecal coliform concentrations below the target compliance objective of 100 CFU/100 mL. The sites **WNC at Big Hill Springs Rd** had the highest compliance rate at 70%, whereas, the site **WNC at Mouth** had the lowest compliance rate at 57%. At West Nose Creek, the fecal coliform compliance rate in 2011 (64%) was higher than 2010 (53%), 2009 (38%) and 1999-2001 (45%) (Table 3). Seasonally, the spring and winter median concentration of bacteria at West Nose Creek was below the guideline. The summer median concentration of bacteria at **WNC at Big Hill Springs Rd** was also below the guideline; however, median summer concentrations at **WNC at Mountain View Rd** and **WNC at Mouth** were above the guideline (Figure 4). The high bacteria concentrations at **WNC at Mountain View Rd** may have been due to agricultural sources whereas at **WNC at Mouth** higher bacteria concentrations were probably due to City of Calgary stormwater outfalls.

Elevated fecal coliform counts are a concern at Nose Creek and West Nose Creek. In rural areas, bacteria sources are generally linked to wildlife (e.g., beaver, deer, muskrat), waterfowl (e.g., ducks and geese), livestock (e.g., cattle, horses and poultry) and humans (Hagedorn *et al.* 1999; Hyer and Moyer 2003). In urban areas, dogs (including dog parks), cats, waterfowl (particularly geese), birds and humans are sources of fecal coliform (Whitlock *et al.* 2002; Sercu *et al.* 2009). Runoff from nonpoint sources such as parking lots, lawns and pastures are a major source of bacteria particularly after storm events in areas with high watershed development and large areas of impervious surfaces (Gregory and Frick 2000).

Table 14 - Bacteria data (fecal and *E. coli*) for Nose Creek and West Nose Creek, January to December 2011. A red value indicates the fecal bacteria count exceeds the water quality objective. Blank cells indicate no sample was taken.

Bacteria (CFU/100mL)	24-Jan	23-Feb	28-Mar	13-Apr	20-Apr	27-Apr	10-May	16-May	24-May	09-Jun	20-Jun	23-Jun	18-Jul	19-Jul	18-Aug	22-Aug	15-Sep	19-Sep	13-Oct	17-Oct	21-Nov	19-Dec
NOSE CREEK																						
NC u/s Crossfield				14		36	2		**292**	20		30		12	nf		nf		dry			
NC d/s Crossfield				22		48	36		18	78		94		**384**	**372**		nf		nf			
NC u/s Airdrie				6		<1	2		88	32		28		6	48		nf		36			
NC d/s Airdrie				2		4	6		**188**	56		66		**112**	46		40		26			
NC at 15 St		2	5		9			5			**124**		**326**			**205**		**115**		23	1	17
NC u/s WNC				6		46	12		**152**	**166**		62		**186**	68		**100**		22			
NC at Mouth	**687**	**770**	**687**		**105**			**921**			**299**		**770**			86		**649**		44	96	**>2420**
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				**104**		<1	2		68	14		**156**		58	42		**110**		10			
WNC at Mountain View Rd	3		8		7			61			**>2420**		62			**285**		**276**		**194**	86	32
WNC at Mouth					10			25			81		**435**			**153**		**1733**		50		

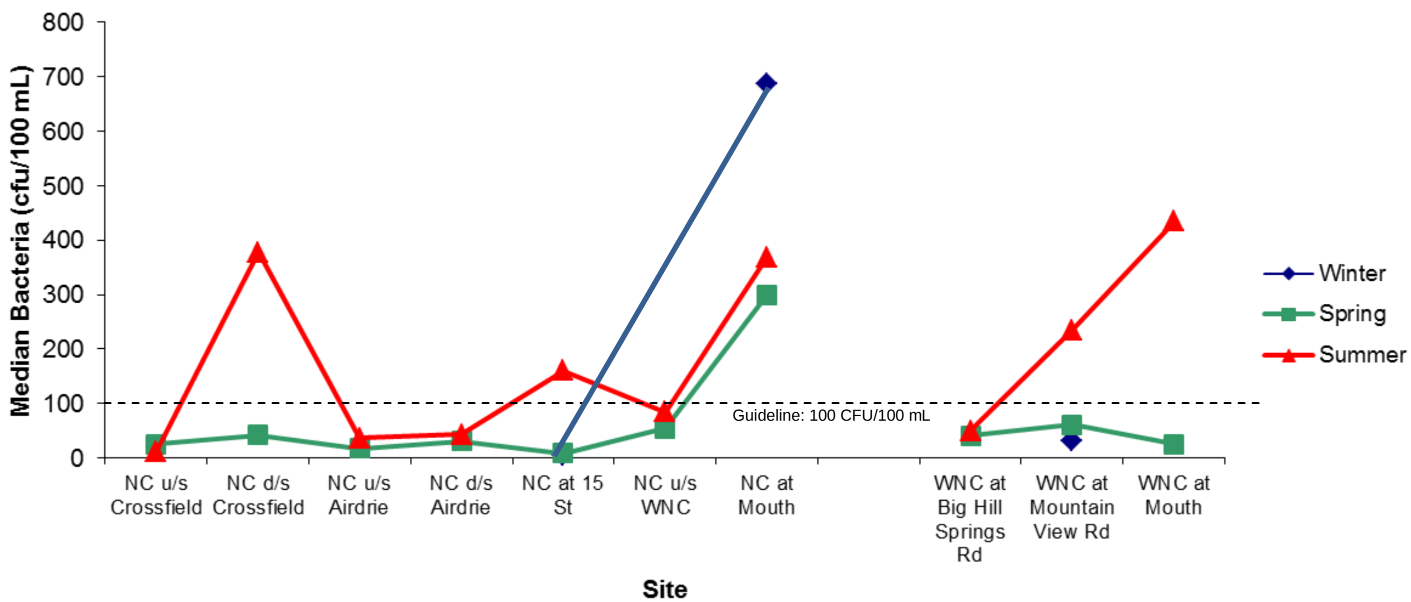

Figure 4 - Seasonal median bacteria concentration in Nose Creek and West Nose Creek in 2011. Data points for **NC d/s Airdrie**, **NC u/s WNC** and **WNC at Big Hill Springs Rd** represent fecal coliform bacteria. Other data points represent *E. coli.*

Total Suspended Solids

In 2011, total suspended solids (TSS) ranged from <3 to 86 mg/L in Nose Creek (N=67) (Table 15). The range of TSS concentrations in 2011 (<3 to 86) was lower than 2010 (<3 to 138 mg/L), 2009 (4 to 221 mg/L) and 2000-2001 (0.6 to 1620 mg/L) at Nose Creek. The lowest concentrations of suspended sediment (<3 mg/L) at Nose Creek occurred in nine samples, with four at **NC u/s Crossfield** (from May 10th to July 19th) and five at **NC d/s of Crossfield** (from April 27th to July 19th). The highest concentration of suspended solids occurred at **NC u/s WNC** (86.0 mg/L) on April 13th during the spring runoff period. A water sample was obtained on October 13th from the channel draining the Town of Crossfield sewage lagoons and total suspended solids was low at 8.0 mg/L. Seasonally, the spring, summer and winter median TSS concentration increased from upstream to downstream (although the trend was not as evident for summer) which is probably the result of the increase in watershed area at each downstream site in conjunction with TSS contributions from stormwater outfalls in Airdrie and Calgary (Figure 5).

In 2011, total suspended solids (TSS) ranged from <3 to 108.7 mg/L in West Nose Creek (N=28) (Table 15). The 2011 range of TSS (<3 to 108.7 mg/L) is lower than 2010 (3 to 249 mg/L), 2009 (4 to 262 mg/L), but higher than 2000-2001 (1.6 to 72.3 mg/L). The lowest concentrations of suspended sediment (<3 mg/L) at West Nose Creek occurred at **WNC at Big Hill Springs Rd** (August 18th) and the highest concentration of suspended solids occurred at **WNC at Mouth** (108.7 mg/L) on September 18th. The spring median TSS concentrations at West Nose Creek were higher than winter or summer concentrations. The highest spring and summer median concentration of TSS occurred at **WNC at Mouth** (Figure 5); although, the median summer TSS concentration was similar at the three sites. There was a TSS trend evident during the spring with higher median TSS concentrations from upstream to downstream, probably as a result of the influence of a larger watershed area.

Table 15 - Total suspended solids data from Nose Creek and West Nose Creek, January to December 2011. Blank cells indicate no sample was taken.

Total Suspended Solids (mg/L)	24-Jan	23-Feb	28-Mar	13-Apr	20-Apr	27-Apr	10-May	16-May	24-May	09-Jun	20-Jun	23-Jun	18-Jul	19-Jul	18-Aug	22-Aug	15-Sep	19-Sep	13-Oct	17-Oct	21-Nov	19-Dec
NOSE CREEK																						
NC u/s Crossfield				17.0		8.0	<3.0		<3.0	<3.0		3.0		<3.0	nf		nf		dry			
NC d/s Crossfield				18.0		7.0	13.0		9.0	8.0		10.0		5.0	19.0		nf		nf			
NC u/s Airdrie				8.0		<3.0	<3.0		<3.0	3.0		<3.0		<3.0	4.0		nf		40.0			
NC d/s Airdrie				30.0		13.0	5.0		30.0	18.0		68.0		6.0	14.0		11.4		17.0			
NC at 15 St		3.9	24.0		54.3			10.3			35.3		18.6			13.9		12.0		16.0	5.3	6.0
NC u/s WNC				86.0		20.0	18.0		27.0	40.0		28.0		11.0	21.0		12.9		19.0			
NC at Mouth	12.5	13.6	30.8		57.3			15.7			67.1		17.8			16.7		59.3		12.9	11.0	18.9
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				32.0		7.0	13.0		8.0	11.0		15.0		9.0	<3.0		8.0		7.0			
WNC at Mountain View Rd	4.2		5.5		56.0			21.5			30.6		20.1			3.0		3.9		12.7	32.1	59.7
WNC at Mouth					38.0			5.3			58.8		9.6			6.0		108.7		10.7		

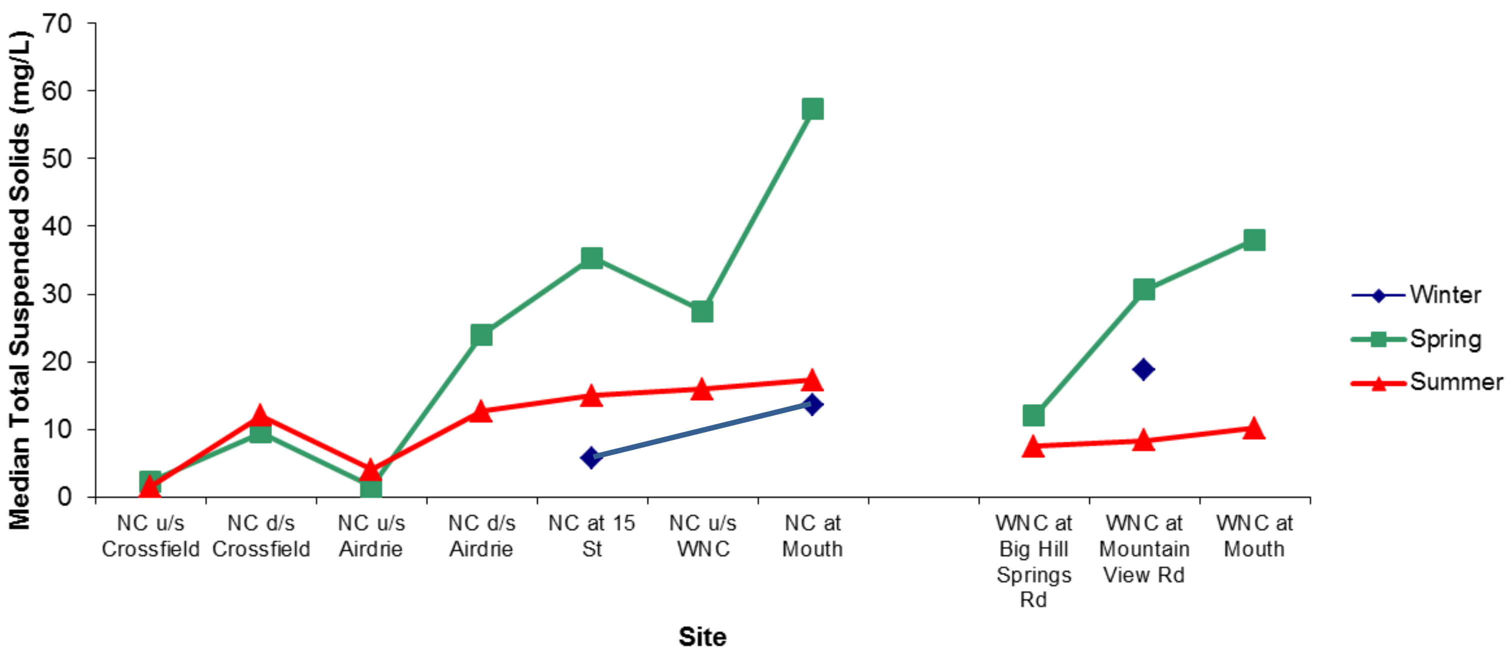

Figure 5 - Seasonal median total suspended solids in Nose Creek and West Nose Creek (upstream to downstream) in 2011.

5.0 SUMMARY AND RECOMMENDATIONS

The following summarizes the results of the water quality parameters monitored at Nose Creek and West Nose Creek in 2011:

- All temperatures in Nose Creek and West Nose Creek in 2011 were below the acute water temperature objective of 29°C and the chronic water temperature objective of 24°C, which was the same compliance rate as 2010, 2009 and 1999 to 2001.
- The pH compliance rate at Nose Creek in 2011 (99%) was higher than 2010 and similar to 2009 and 1999-2001. The pH at West Nose Creek in 2011 was always within the compliance range of 6.5 to 9.0 which is the same as 2010, 2009 and 1999-2001.
- At Nose Creek in 2011, seven oxygen samples were less than the acute guideline of 5 mg/L and at West Nose Creek no samples were less than 5 mg/L. The compliance rate for acute oxygen in 2011 was lower at Nose Creek compared to 2010, similar to 2009 and higher than 1999-2001. The acute compliance rate at West Nose Creek was 100% from 2009-2011 which is higher than 1999-2001(86%).
- At Nose Creek in 2011, seven samples were less than the chronic seven day oxygen guideline of 6.5 mg/L and at West Nose Creek one sample was less than the chronic guideline. The compliance rate for chronic oxygen in 2011 at Nose Creek and West Nose Creek was lower or similar to 2009 and 2010 but higher than 1999-2001.
- Electrical conductivity at Nose Creek in 2011 ranged from 264 to 4397 µS/cm and 63% of samples met the water quality objective of less than 1000 µS/cm compared to 27% in 2010, 29% in 2009 and 38% from 1999-2001. Electrical conductivity at West Nose Creek in 2011 ranged from 411 to 3419 µS/cm and 86% of samples met the water quality objective of less than 1000 µS/cm compared to 76% in 2010, 90% in 2009 and 91% from 1999-2001.
- Total dissolved solids at Nose Creek in 2011 ranged from 172 to 823 mg/L and 36% of samples met the water quality objective of less than 500 mg/L compared to 9% in 2010, 0% in 2009 and 15% from 1999-2001. Total dissolved solids at West Nose Creek in 2011 ranged from 269 to 573 mg/L and 80% of samples met the water quality objective of less than 500 mg/L compared to 0% in 2010, 0% in 2009 and 15% from 1999-2001.
- Total phosphorus at Nose Creek in 2011 ranged from 0.033 to 0.973 mg/L and 4% of the samples met the water quality objective of less than 0.05 mg/L compared to 12% in 2010, 0% in 2009 and 2% from 1999-2001. Total phosphorus at West Nose Creek in 2011 ranged from 0.021 to 0.555 mg/L and 25% of samples met the water quality objective of less than 0.05 mg/L compared to 33% in 2010, 52% in 2009 and 15% from 1999-2001.
- Nitrate-nitrite at Nose Creek in 2011 ranged from <0.071 to 2.63 mg/L and 93% of the samples met the water quality objective of less than 1.5 mg/L compared to 94% in 2010, 83% in 2009 and 89% from 1999-2001. Nitrate-nitrite at West Nose Creek in 2011 ranged from <0.071 to 4.85 mg/L and 82% of samples met the water quality objective of less than 1.5 mg/L compared to 93% in 2010, 88% in 2009 and 85% from 1999-2001.
- Total ammonia at Nose Creek in 2011 was always <0.9 mg/L and 100% of the samples met the water quality objective compared to 88% in 2010, 83% in 2009 and 91% from 1999-2001. Total ammonia at West Nose Creek in 2011 was always less than 0.9 mg/L and 100% of samples met the water quality objective compared to 100% in 2010, 100% in 2009 and 97% from 1999-2001.
- Bacteria (fecal and *E. coli*) at Nose Creek in 2011 ranged from <1 to >2420 CFU/100 mL and 67% of samples met the water quality objective of less than 100 CFU/100 mL compared to 56% in 2010, 38% in 2009 and 42% from 1999-2001. Bacteria at West

Nose Creek in 2011 ranged from <1 to >2420 CFU/100 mL and 64% of samples met the water quality objective of less than 100 CFU/100 mL compared to 53% in 2010, 38% in 2009 and 45% from 1999- 2001.

- Total suspended solids (TSS) at Nose Creek in 2011 ranged from <3 to 86 mg/L which was a lower range when compared to 2010 (1.5 to 138 mg/L), 2009 (4 to 221 mg/L) and 2000-2001 (0.6 to 1620 mg/L). Total suspended solids at West Nose Creek in 2011 ranged from <3 to 108.7 mg/L which was a lower range when compared to 2010 (3 to 249 mg/L), 2009 (4 to 262 mg/L) but a higher range when compared to 2000-2001 (1.6 to 72.3 mg/L).

The following recommendations are provided for the Nose Creek watershed monitoring program:

- The results of the water monitoring program in 2011 should be disseminated to the Nose Creek Watershed Partnership membership. The report could be posted on the NCWP website, or the results could be summarized in a simple 4-page factsheet. Monitoring results could also be communicated to all stakeholders at an annual meeting or other community meeting.
- Reasonably detailed (spatially and temporally) water quality data exists for the Nose Creek watershed for the years 1980 and 1999-2001. It is recommended that the current monitoring program continue for at least 5 years (with review at this time) to account for years with varying precipitation (2009 was a low precipitation year and 2011 was a higher precipitation year) but to also allow for a historical comparison.
- In order to obtain a more comprehensive water quality dataset for the watershed, it is recommended monitoring begin in April and extend to October. During the months of April, May and June sampling should occur twice monthly to better characterize the influence of spring runoff and rainfall. Samplng should occur once monthly from July to October.
- The NCWP may want to consider installing continuous water quality monitoring sondes (e.g., YSI or HydroLab) to better understand diurnal fluctuations in dissolved oxygen, temperature and pH. It should be noted that water quality sondes would substantially increase the budget of the water quality monitoring program due to rental/purchase costs and the requirement for frequent maintenance and data downloading.
- From 2009 to 2011, the City of Calgary reported their bacteria data as *E. coli* and Palliser Environmental reported their data as fecal coliform. Much of the historical data has been reported as fecal coliform and the BRBC has set their water quality target as 100 CFU/100 mL as indicated by fecal coliform. The province has also used fecal coliform to set irrigation guidelines (AENV 1999). Therefore, it is recommended that the City also analyse their samples for fecal coliform bacteria to facilitate data analysis and comparison to historical data and regulatory guidelines. Palliser Environmental will continue to have their samples analysed for fecal coliform bacteria only, in order to keep costs as low as possible for the Nose Creek Watershed Partnership.
- Due to the low detection limits of the City of Calgary total ammonia analysis it is recommended that the NCWP include total ammonia to the parameters analysed for 2012. Due to budget constraints, it is also recommended that NCWP drop nitrate-nitrite nitrogen from the parameters analysed due to high compliance in 2011 and previous years. These recommendations are only intended for the samples collected by Palliser Environment and the City of Calgary should continue with its parameter list.

6.0 CLOSURE

We trust the information provided is sufficient to describe the water quality of the Nose Creek watershed in 2011. If you have any questions, please do not hesitate to contact Palliser Environmental Services Ltd. at 403-684-3117.

Yours truly,

Palliser Environmental Services Ltd.

Scott Stoklosar, M.Sc., P.Biol.
Senior Fisheries Biologist

Sandi Riemersma, M.Sc.
Environmental Biologist

7.0 REFERENCES

Alberta Agriculture. 1983. Guidelines for irrigation water quality. Agdex 562-1.

Alberta Environment. 1999. Surface water quality guidelines for use in Alberta. Publication No.: T/483. Environmental Service and Natural Resource Service. 20 pp.

Bow River Basin Council (BRBC). 2008. Bow Basin watershed management plan. Phase one: water quality. Prepared by the Bow Basin Watershed Management Plan Steering Committee. 84 pp.

CCREM (Canadian Council of Resource and Environment Ministers). 1987 (and updates). Canadian water quality guidelines. Environmental Quality Guidelines Division, Water Quality Branch, Ottawa, Ontario.

Cole, G.A. 1994. Textbook of limnology, 4th edition. Waveland Press, Inc. 412 pp.

Environment Canada. 2004. Canadian guidance framework for the management of phosphorus in freshwater systems. Report No. 1-8. Ecosystem Health Science-Based Solutions. National Guidelines and Standards Office Water Policy Coordination Directorate. Environment Canada. 114 pp.

Grasby, S.E., I. Hutcheon and H.R. Krouse. 1997. Application of the stable isotope composition of SO4 to tracing anomalous TDS in Nose Creek, southern Alberta, Canada. Applied Geochemistry 12: 567-575.

Gregory, M.B. and E.A. Frick. 2000. Fecal-coliform bacteria concentrations in streams of the Chattahoochee River National Recreation Area, Metropolitan Atlanta, Georgia, May–October 1994 and 1995. U.S. Geological Survey Water-Resources Investigations Report 00-4139. 8 pp.

Hagedorn, C., S.L. Robinson, J.R. Filtz, S.M. Grubbs, T.A. Angier and R.B. Reneau. 1999. Determining sources of fecal pollution in a rural Virginia watershed with antibiotic resistance patterns in Fecal Streptococci. Applied and Environmental Microbiology 5522-5531.

Hyer, K.E. and D.L. Moyer. 2003. Patterns and sources of fecal coliform bacteria in three streams in Virginia, 1999-2000. United States Geological Survey. Water-Resources Investigations Report 03-4115

Hynes, H.B.N. 1970. The Ecology of Running Waters. The University of Toronto Press. 555 pp.

Madawaska Consulting. 2002. Nose Creek surface water quality data, final report 2001. Prepared by P.M. Cross. Prepared for City of Calgary, City of Airdrie and MD of Rocky View. 87 pp.

Nelson, J.S., and M.J. Paetz. 1992. The fishes of Alberta, second edition. University of Alberta Press. 437 pp.

Nose Creek Watershed Partnership (NCWP). 2007. Nose Creek Watershed Water Management Plan. Prepared by Palliser Environmental Services Ltd. 52 pp.

Palliser Environmental Services Ltd. (PESL). 2010. Nose Creek Watershed 2009 Water Quality Monitoring Report. Prepared for the Nose Creek Watershed Partnership. 22 pp.

Palliser Environmental Services Ltd. (PESL). 2011. Nose Creek Watershed 2010 Water Quality Monitoring Report. Prepared for the Nose Creek Watershed Partnership. 28 pp.

Rast, W., and G. F. Lee. 1983. Nutrient loading estimates for lakes. Journal of Environmental Engineering 109(2): 502-518.

Sercu, B., L. Van de Werfhorst, J. Murray and P. Holden. 2009. Storm drains are sources of human fecal pollution during dry weather in three urban southern California watersheds. Environmental Science and Technology 43(2): 293-298.

USEPA (United States Environmental Protection Agency). 1978. Quality criteria for water. U.S. Government Printing Office. 256 pp.

R.J. Waschbusch, W.R. Selbig, and R.T. Bannerman. 1999. Sources of phosphorus in stormwater and street dirt from two urban residential basins in Madison, Wisconsin, 1994–95. U.S. Geological Survey Water-Resources Investigations Report 99-4021. 47 pp.

Waters, T.F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph. 251 pp.

Whitlock, J.E., D.T. Jones and V.J. Harwood. 2002. Identification of the sources of fecal coliforms in an urban watershed using antibiotic resistance analysis. Water Research 36(17): 4273-4282.

Young, K. D. and E. L. Thackston. 1999. Housing density and bacterial loading in urban streams. Journal of Environmental Engineering. December: 1177-1180.

APPENDIX A

Bow River Basin Council: Summary of Monitoring and Management Requirements for Nose Creek

Total Suspended Solids WQO and research: A total suspended solids WQO should be developed for Nose Creek. Research is required to identify the anthropogenic causes of total suspended solids in Nose Creek and how it compares in quantity to natural causes (NCWP; Long-Term: 2013-2014).

Dissolved Oxygen Monitoring: Enhanced monitoring of DO is required to better characterize and understand low nocturnal DO concentrations (AENV/City of Calgary; Short-Term Goal: 2008-10).

Periphyton Biomass: Future water quality monitoring should include the collection of periphyton biomass (as chlorophyll *a*). (AENV; Short-Term: 2008-10)

Peak and Base Flows: Further research is needed to compare the frequency and magnitude of base and peak flows. Storm events should remain within the range of pre-development conditions (pre-1970s) (NCWP; Short-Term: 2008-10).

Total Phosphorus Reductions: Responsible for working to reduce total phosphorus and total dissolved phosphorus. Conduct research into the primary productivity of Nose Creek (NCWP; Medium-Term: 2011-2012).

Enhanced stream and stormwater flow monitoring at various points throughout the system is needed to assist in the identification of the impervious and runoff targets (City of Calgary; Short-Term Goal: 2008-10)