Flood Recovery – Detailed Ambient Water Quality Report - July 19, 2013

Sampling results from July 2-5, 2013

Alberta Government

Table of Contents

EXECUTIVE SUMMARY

In response to the recent flood events in Southern Alberta, Environment and Sustainable Resource Development (ESRD) has implemented enhanced water quality monitoring programs for both ambient (raw) water in rivers, streams and reservoirs, and treated drinking water. This summary describes the results from monitoring between June 17 and July 5, 2013 for the ambient water quality monitoring, including some results collected prior to the flood. Results from monitoring of treated drinking water will be reported separately.

Enhanced water quality monitoring was implemented beginning July 2, 2013 at sites on the Bow River, Elbow River, Highwood River, Little Bow River, Sheep River, Mosquito Creek and Twin Valley Reservoir.

Flooding can bring contaminants to the water system, including increased levels of sedimentation. Sampling of untreated river, stream and reservoir water found concentrations of monitored variables (physical, chemical and microbiological) that have been observed in the past under similar high flow conditions. However, exceedances of Canadian Council of Ministers of Environment for Irrigation Water Use, and Canadian Recreational Water Use Guidelines for contact recreation, were recorded for the Bow River downstream of Calgary, the Oldman River, the South Saskatchewan River and Mosquito Creek.

The recorded guideline exceedances supported recommendations that Albertans should not use the rivers and streams for irrigation of gardens and should avoid them for recreational use given the existing conditions at the time. For recreation, these conditions included high river flows with eroded and unstable river banks, in addition to water quality considerations.

A few exceedances of Protection of Aquatic Life guidelines were also recorded. However, those guidelines are based on longer term, chronic exposure conditions, and the observed levels will not cause acute fish mortality.

Untreated water from rivers, streams, lakes and reservoirs should never be used for drinking water at any time.

Ambient water quality monitoring is continuing and all collected data results are being shared with Alberta Agriculture and Rural Development, Alberta Health, Alberta Health Services and Health Canada. Updates of the monitoring results will be provided to the public as they become available.

1.0 INTRODUCTION

From June 20 to 24, 2013, major flooding occurred in Southern Alberta due to heavy, intense rainfall in the upper and mid watersheds. Key watersheds impacted were the Bow, Elbow, South Saskatchewan, Sheep, Highwood and Little Bow rivers as well as Mosquito Creek. The Oldman River basin also experienced impacts but to a lesser extent.

Significant overland flooding occurred in a number of urbanized communities, including Black Diamond, Bragg Creek, Canmore, Calgary, High River, Medicine Hat and Okotoks; First Nations communities, including Stoney and Siksika First Nations; and rural properties and landowners living adjacent to the flooding watercourses. Recreational areas in parts of Banff National Park and Kananaskis Country were also heavily affected. Key impacts were: impaired and lost homes, agricultural operations and businesses; transportation infrastructure (roads, bridges); tourism facilities; and loss of wastewater treatment plant (WWTP) and water treatment plant (WTP) operations.

Post-flood ambient water quality monitoring was initiated in the more populated downstream portions of the watersheds in order to inform river users of potential risks from the ambient waters. Water quality was a concern to downstream water treatment plant operators and their water users; irrigators withdrawing water from our rivers; those dependant on waterways for livestock watering, the sport fishing industry and tourism; and users of the waterbodies for recreation, rafting, canoeing and contact recreation such as swimming, water skiing, etc. The basic questions being addressed are: is the water safe for human use, and secondly, are conditions sufficient to maintain healthy and diverse communities of instream plants and animals.

2.0 MONITORING PROGRAM

Sampling Locations*:* Post-flood, enhanced water quality monitoring conducted the week of July 2 to 5, 2013 focused on the following water bodies (Figures 1 to 3):

Bow River (five sites): Bow River at Cochrane, at Carseland (below the Carseland weir), Cluny, and Ronalane (near the Ronalane Bridge); and the Elbow River at the 9th Avenue SE bridge in Calgary. These are part of ESRD's Long Term River Network (LTRN) monitoring sites that are routinely monitored on a monthly basis *(Figure 1).*

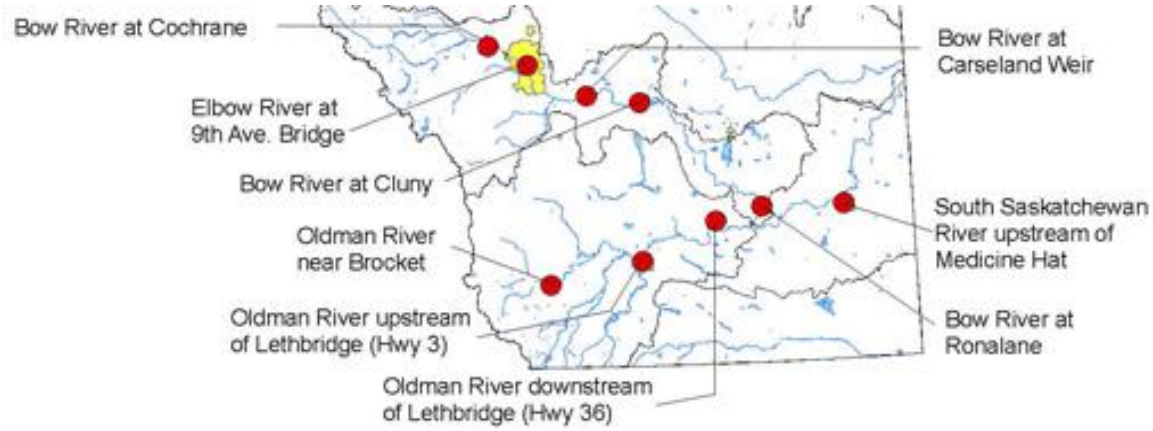

Figure 1. Location of Long Term River Network sampling sites on the Bow, Oldman and South Saskatchewan rivers.

South Saskatchewan River (SSR) (one site): SSR above Medicine Hat also part of ESRD's Long Term River Network (LTRN) monitoring sites *(Figure 1).*

Highwood River (three sites): Highwood River at the diversion canal above High River; below High River at Highway 547, and near the mouth at the confluence with the Bow River *(Figure 2).*

Mosquito Creek (two sites): Mosquito Creek at Highway 2, and at Highway 529 east of Parkland *(Figure 3).*

Twin Valley Reservoir: Near the North and South Intakes for Twin Valley Water Co-op (referred to in the graphs as North Basin, South Basin) (Figure 3). Note, a composite sample was also taken from the Central basin as part of ESRD's normal monitoring program.

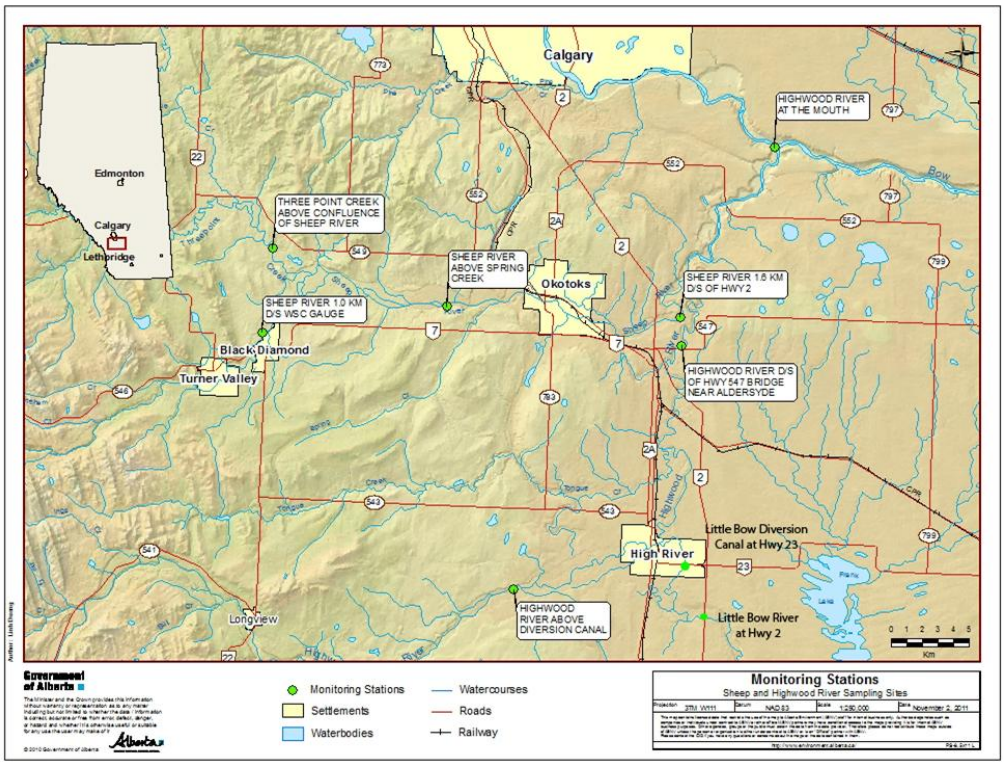

Figure 2. Location of sampling sites on the Highwood and Sheep rivers.

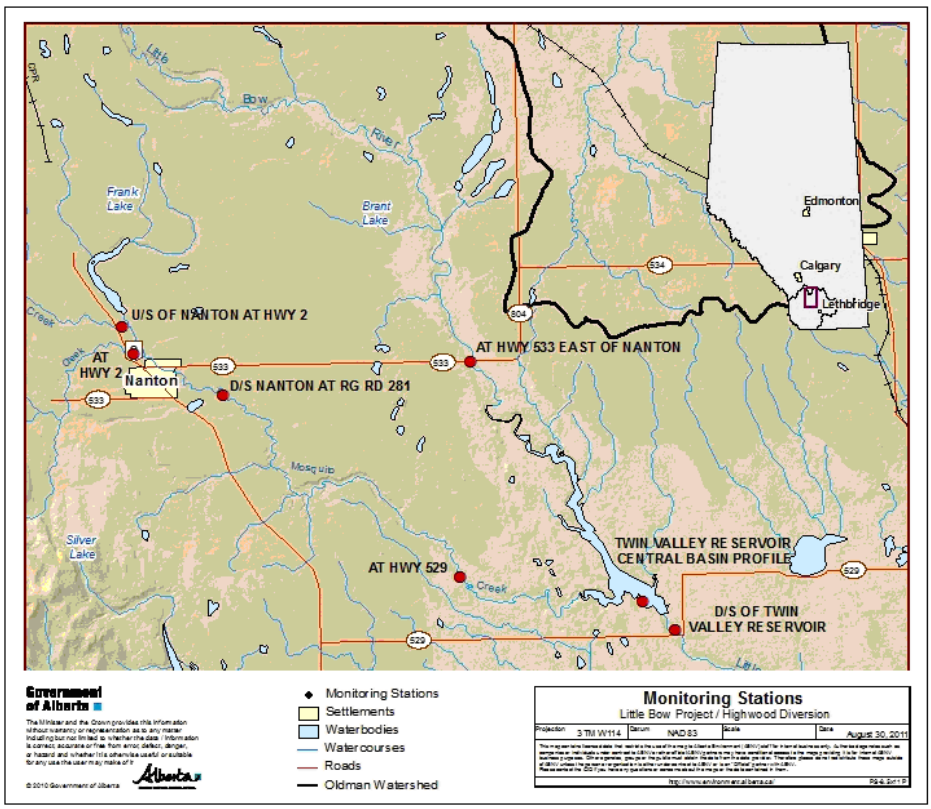

Figure 3. Location of sampling sites on the Little Bow River, Mosquito Creek and Twin Valley Reservoir.

All of the above listed sites are being sampled weekly during July 2013.
Additional sites on the Oldman River (three sites), and Threepoint Creek (one site, near the mouth at the confluence with the Sheep River) were sampled during the week of June 24 as part of ESRD's regular 2013/2014 water quality monitoring program. The Little Bow River (two sites), Mosquito Creek (three sites) and Nanton Creek (one site) were sampled on June 17, pre-flood as part of the regular monitoring program. These additional sites are reported here for the variables that overlap with the enhanced flood-impact monitoring project.

List of Variables:

A wide variety of biological, chemical and physical variables (approximately 230) were analyzed from grab samples collected at each site. These include:

- routine chemistry and physical measurements: major ions (salts), Total Dissolved Solids (TDS), electrical conductivity, nutrients (nitrogen and phosphorus species), total suspended sediments (TSS), pH, water temperature, dissolved oxygen, total organic carbon (TOC) and others.
- metals, both dissolved and total metals
- microbial (fecal coliform bacteria, E. Coli, Bacteroides and Cryptosporidium and Giardia; these are all indicators of fecal material in water)
- pesticides (a scan of 69 pesticides)
- polyaromatic hydrocarbons (PAH's – a scan of 27 compounds)
- BTEX (benzene, toluene, ethylbenzene and xylene) and F1-4 hydrocarbons

For a complete list of all variables being analyzed, please refer to the spreadsheet of raw data results posted on July 12, 2013 at: http://environment.alberta.ca/04221.html

Contaminants of concern include human sewage, livestock manure, fuel from flooded vehicles, and leakage from facilities storing fuel, pesticides, fertilizers, and industrial chemicals. The above variables provide a good indication of potential water quality impacts from the flood.

ESRD's regular 2013/2014 ambient monitoring program continues and covers many of the same sites but with a smaller suite of variables.

Methods of Assessment:

All water quality data are being compared to Canadian Council of Ministers of the Environment (CCME) water use guidelines. These guidelines include use of the water for irrigation, livestock watering and recreation. The data are also compared to the CCME protection of aquatic life guidelines. These guidelines were developed to ensure safe use of ambient waters for a given activity. The most recent CCME guideline values are available at: http://www.ccme.ca/publications/cegg_rcge.html

Data will also be compared, where possible, to historic conditions, to identify the relative change in water quality due to flood conditions. Historic conditions for the Long Term River Network sites on the Bow, Oldman and South Saskatchewan river mainstem are

provided in the appendices. These conditions are based on median values (50 percentile) and peak and low values (90, 75 and 25 percentiles) during the open water period, 2004-2009. Historic values for the Little Bow River, Mosquito Creek, the Sheep and Highwood rivers will be included in the next reporting.

3.0 RESULTS AND DISCUSSION

3.1 Mainstem Sites; Bow, Oldman and South Saskatchewan rivers:

Data was collected during the enhanced monitoring, July 2 to 5 but also the preceding week during routine scheduled monitoring (June 24-28) at three Oldman River sites. Both sets of data are provided here for microbiological and routine variables. Pesticide and metals data for the Oldman River sites are pending, waiting for completed analyses and reporting from the laboratory.

Microbiological:

The three Bow River sites below Calgary, two of the Oldman River sites, and the South Saskatchewan River site all had levels of fecal coliform bacteria and E. coli that exceeded Canadian Council of Ministers of the Environment guidelines for irrigation water use (100 cfu/100 mL of water sample; cfu = bacteria colony-forming-units) and contact recreation (400 cfu/100 mL in a single water sample) (Figures 4 and 5).

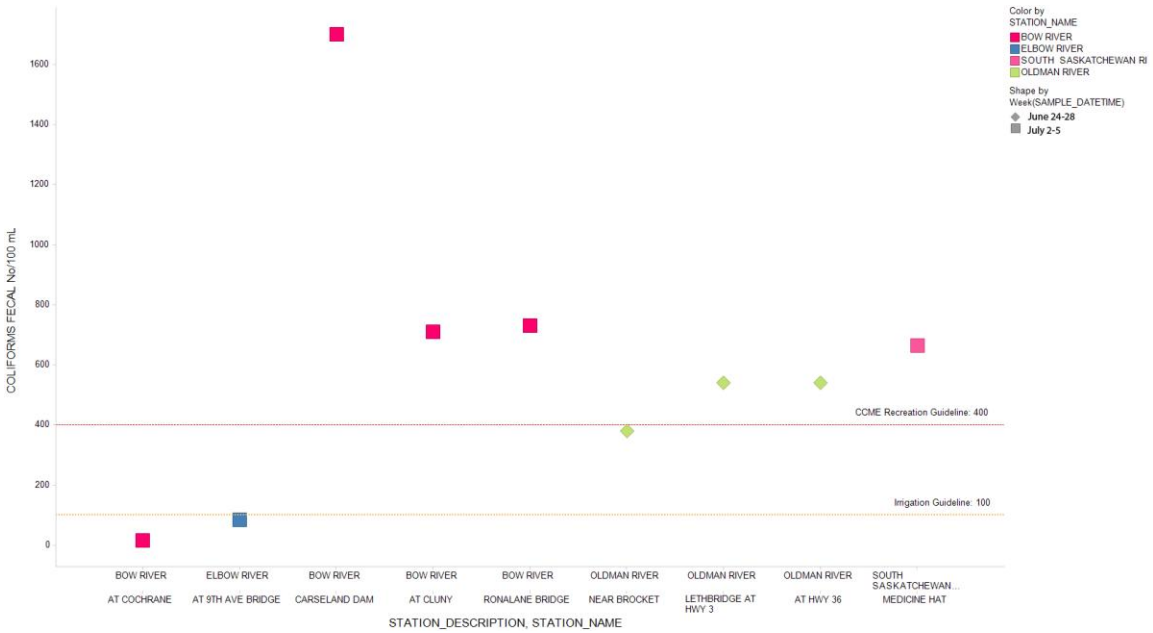

Figure 4. Fecal coliform bacteria numbers at Bow, Oldman and South Saskatchewan River sites.

Figure 5. E.coli bacteria numbers at Bow, Oldman and South Saskatchewan sample sites.

E.coli and fecal coliforms were highest on the Bow River below Carseland and decline in a downstream direction to the South Saskatchewan River site at Medicine Hat. The Bonnybrook WWTP in Calgary was not fully functioning at the time and would be one source of the high levels of fecal bacteria. The Bow River at Cochrane had the lowest values. The Elbow River also had low values. These are probably low due to settling out of bacteria in the Glenmore Reservoir upstream of the sample site. Nonetheless, the values are low considering the very turbid and wide-spread flood waters in the Elbow River below the dam as it travelled through both residential areas and the Stampede grounds.

No Giardia or *Cryptosporidium* were detected at the Bow and South Saskatchewan River sites that were sampled (Table 1). However, fecal material of human origin was detected, based on the Bacteroides data, at all sites other than the Bow River at Cochrane. No fecal material of cow origin was detected based on the Bacteroides data.

Table 1. Microbial data, *Cryptosporidium*, Giardia and Bacteroides, July 2-5, 2013, Bow and South Saskatchewan River sites.

Date of Collection	Collection Site	*Crypto-sporidium* oocysts Reportable #'s per 100 L	*Giardia* cysts Reportable #'s per 100L	Human Bacteroides	Cow Bacteroides
02-Jul-13	Bow River near Ronalane Bridge	0	0	D	ND
02-Jul-13	Bow River below Carseland Dam	0	0	D	ND
02-Jul-13	Bow River at Cochrane	0	0	ND	ND
02-Jul-13	South Saskatchew an River above Med Hat	0	0	D	ND
02-Jul-13	Bow River at Cluny	0	0	D	ND
ND - not detected; D, detected					

Routine Chemistry:

Nutrients, including various nitrogen and phosphorus species, and ions such as calcium, chloride, sodium, sulphate and Total Dissolved Solids, were within Alberta Surface Water Quality and Canadian Council of Ministers of the Environment guidelines for aquatic life, contact recreation, livestock watering and irrigation. Total Dissolved Solids (TDS) (Figure 6) and Electrical conductivity (also called in this report, Specific Conductance) (Figure 7) are both measures of the concentration of salts in a water body.

Figure 6. Total Dissolved Solid concentrations measured at the Bow, Oldman and South Saskatchewan river sites.

Figure 7. Electrical conductivity (specific conductance) measured at Bow, Oldman and South Saskatchewan river sites.

Both TDS and electrical conductivity were within irrigation use guidelines at all mainstem river sites.

Levels of turbidity (measured as NTU) (Figure 8), and Total Suspended Solids (mg/L) (Figure 9) are both a measure of particulates suspended in the water column. Turbidity is a common measurement for source water coming into wastewater treatment plants. Total Suspended Solid measurements are used to determine loads of sediment, including the number of kilograms of sediment per unit of time being transported at a given location in a river.

Figure 8. Turbidity measurements at the Bow, Oldman and South Saskatchewan river sites.

Figure 9.
Total Suspended Solid measurements at the Bow, Oldman and South Saskatchewan river sites.

Monitoring shows that particulate numbers are high, especially at the Bow and South Saskatchewan River sites, reflecting that the continued high flows were still contributing to on-going bank erosion and suspension of bottom sediments, and still contained sediment loading from overland runoff.

Of interest to water treatment plant operators are the levels of organic carbon in source water for potable use. More disinfectant is required to treat waters with high Total Organic Carbon (TOC) levels. TOC levels of less than 3-5 mg/L are preferred for water treatment plant operations. The mainstem sites are generally within this range (Figure 10).

Figure 10. Total organic carbon (TOC) measured at the Bow, Oldman and South Saskatchewan river sites.

Metals:

For metals, there are exceedances of Protection of Aquatic Life (PAL) chronic guideline values, notably aluminum (Figure 11) and iron at most sites, with some new historic maximum values recorded. These are variables known to be high during high runoff periods, and are associated with high Total Suspended Solids. Both dissolved and total metals were analyzed. In most cases the metals are mainly in particulate form and are therefore less available for exposure to organisms. The CCME PAL guidelines are based on chronic exposure, not acute. Exceedance of chronic values is of lesser concern if subsequent sampling identifies either lower concentrations or non-detections of the specific metals of concern. Most metals in the mainstem sites were below guideline values, as per arsenic, mercury and selenium (Figures 12-14). The one exception was mercury at the Bow River at Cluny site (Figure 13), which was slightly over the CCME Protection of Aquatic Life guideline.

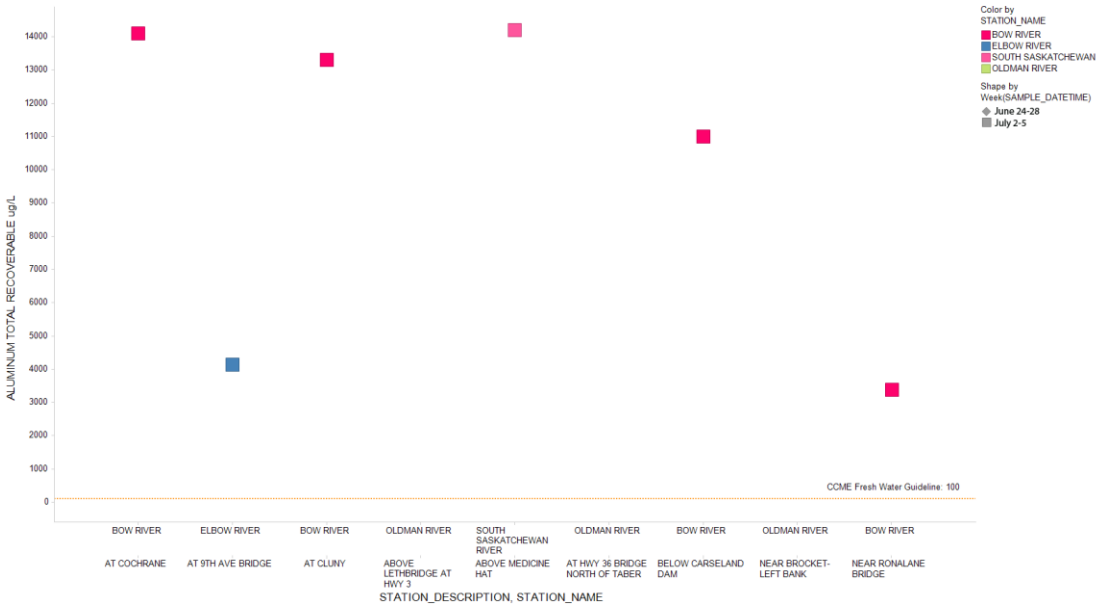

Figure 11. Total Recoverable Aluminum measured at the Bow and South Saskatchewan river sites.

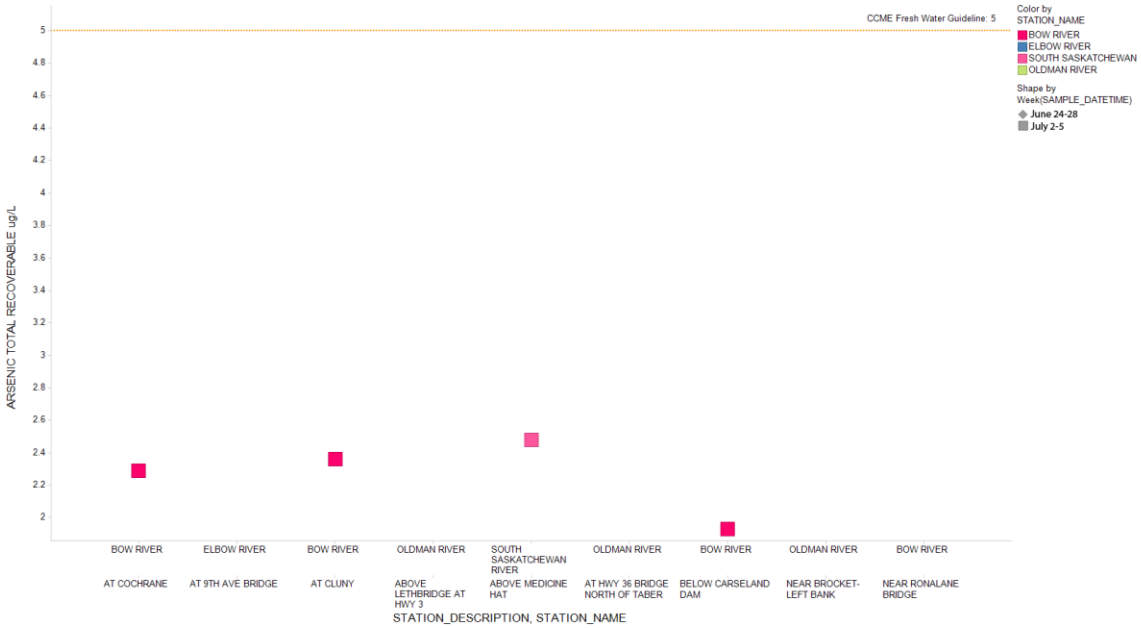

Figure 12. Total Arsenic measured at the Bow and South Saskatchewan river sites.

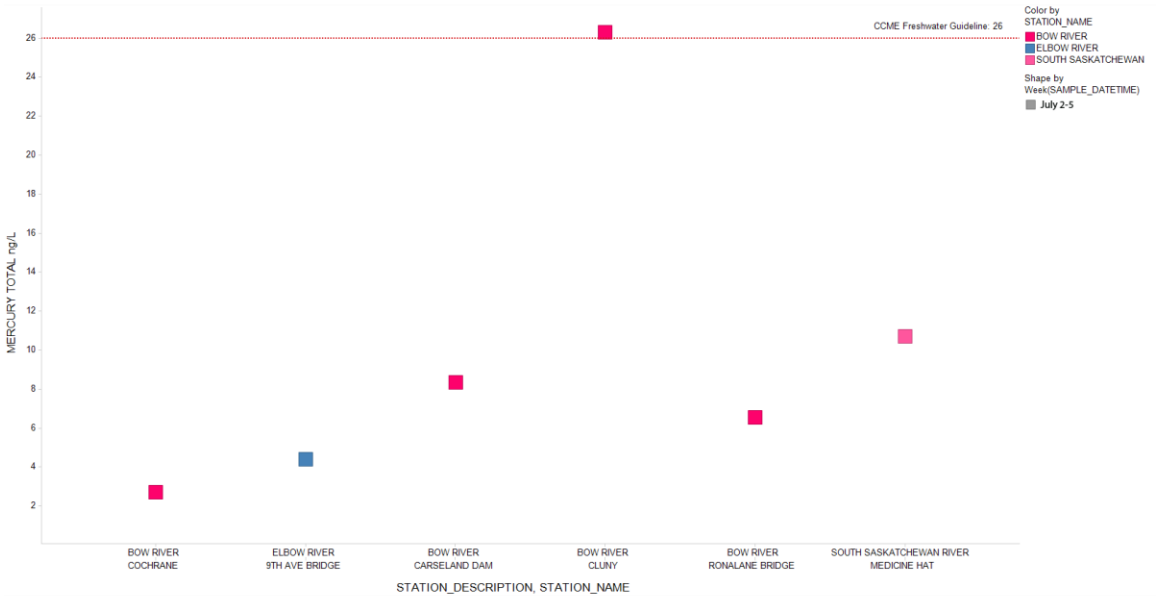

Figure 13. Total Mercury measured at the Bow and South Saskatchewan river sites.

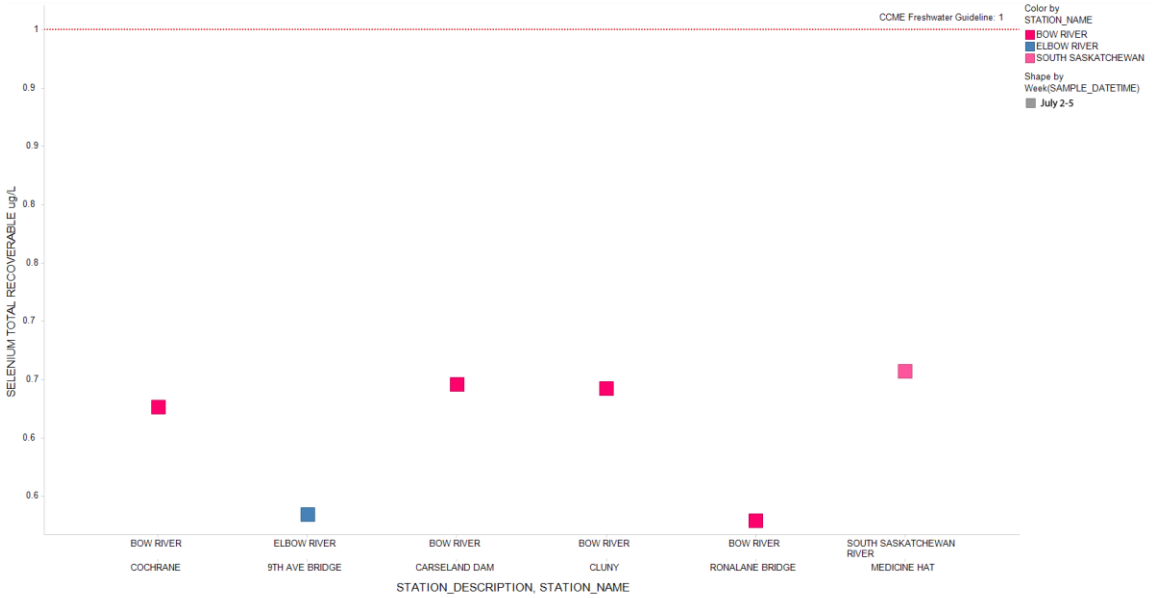

Figure 14. Total Selenium measured at the Bow and South Saskatchewan river sites.

Pesticides:

Based on a scan of 69 pesticides, the Bow and South Saskatchewan river sites had from zero to two pesticide detections (Table 2), and none were above published guidelines. Based on historical pesticide data, the results are within the normal range. The Oldman River data is still pending.

Table 2. Pesticides detected in the Bow and South Saskatchewan rivers.

STATION_NAME	STATION_DESCRIPTION	SAMPLE	Number of Pesticides Detected	2,4-D (DICHLOROPHENOXYACETIC ACID) ug/L	MCPP (MECOPROP) ug/L
BOW RIVER	AT COCHRANE	7/2/2013	0	L0.005	L0.005
ELBOW RIVER	AT 9TH AVE BRIDGE	7/2/2013	0	L0.005	L0.005
BOW RIVER	BELOW CARSELAND DAM	7/2/2013	2	0.005	0.005
BOW RIVER	AT CLUNY	7/2/2013	0	L0.005	L0.005
BOW RIVER	NEAR RONALANE BRIDGE	7/2/2013	1	0.008	L0.005
SOUTH SASKATCHEWAN RIVER	ABOVE MEDICINE HAT	7/2/2013	1	0.004	L0.005
	Number of Dectections			3	1

Note: other variables tested for with no "hits" can be found at the end of this report

Organics (PAH's, BTEX and Hydrocarbons):

Polycyclic aromatic hydrocarbons (PAH's) were detected at all mainstem river sites on the Bow and South Saskatchewan rivers (Table 3); the Oldman sites are pending. The most detections were found in the South Saskatchewan River above Medicine Hat, the least detections (3) at the Bow River at Cochrane. The number of detections increased in a downstream direction. Most values are below the CCME guidelines for the protection of aquatic life; these are chronic, not acute level guidelines. Sampling in subsequent weeks will determine whether levels remain as measured on July 3, or are reduced as flows and sediment levels are reduced.

BTEX and straight chain hydrocarbons (C6-C50) were also part of the organics analysis. To date these have not been detected at any of the sites.

Table 3. Polycyclic aromatic hydrocarbons at Bow and South Saskatchewan river sites, July 2, 2013.

STATION_NAME	STATION_DESCRIPTION	Number of Detections	PHENANTHRENE ug/L	2-METHYLNAPHTHALENE ug/L	1-METHYLNAPHTHALENE ug/L	PYRENE ug/L	NAPHTHALENE ug/L	ACENAPHTHENE ug/L	CHRYSENE ug/L	FLUORANTHENE ug/L	FLUORENE ug/L	BENZO(G,H,I)PERYLENE ug/L	RETENE (7-ISOPROPYL-1-METHYLPHENANTHRENE) ug/L	BENZO(A)ANTHRACENE ug/L	BENZO(A)PYRENE ug/L	BENZO(B,J,K)FLUORANTHENE ug/L	BENZO(E)PYRENE ug/L	INDENO(1,2,3-C,D)PYRENE ug/L	PERYLENE ug/L
BOW RIVER	AT COCHRANE	3	0.012	0.012	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10	0.012	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10
BOW RIVER	BELOW CARSELAND DAM	9	0.034	0.025	0.017	0.014	0.016	L0.10	0.008	0.012	0.008	L0.10	L0.10	0.006	L0.10	L0.10	L0.10	L0.10	L0.10
BOW RIVER	AT CLUNY	10	0.027	0.026	0.017	0.01	0.011	0.005	0.006	0.009	0.007	0.005	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10
BOW RIVER	NEAR RONALANE BRIDGE	10	0.031	0.027	0.018	0.01	0.007	0.005	0.007	0.009	0.007	L0.10	L0.10	0.005	L0.10	L0.10	L0.10	L0.10	L0.10
SOUTH SASKATCHEWAN R	ABOVE MEDICINE HAT	14	0.028	0.022	0.014	0.014	L0.10	L0.10	0.011	0.012	L0.10	0.007	0.012	0.009	0.006	0.016	0.01	0.006	0.009
	Number of Detections		5	5	4	4	3	2	4	4	3	2	2	3	1	1	1	1	1

Note: other variables tested for with no "hits" can be found at the end of this report

3.2 Highwood and Sheep rivers

Data was collected during the enhanced monitoring, July 2 to 5 but also the preceding week during routine scheduled monitoring that included an additional site on the Sheep River at Black Diamond and a tributary, Threepoint Creek. Both sets of data are provided here for microbiological and routine chemistry variables.

Microbiological:

The Highwood and Sheep river sites had fecal bacteria levels that meet all use guidelines during the week of July 2 to 5. These include guidelines for irrigation use and contact recreation. Exceptions occurred in samples from June 24 to 28 immediately

after the flood when at three sites, values were above the irrigation guideline. At the time, however, it was unlikely that irrigators were using the water due to the very wet conditions on the land. These figures show a decrease after the main storm event (Figure 15 and 16).

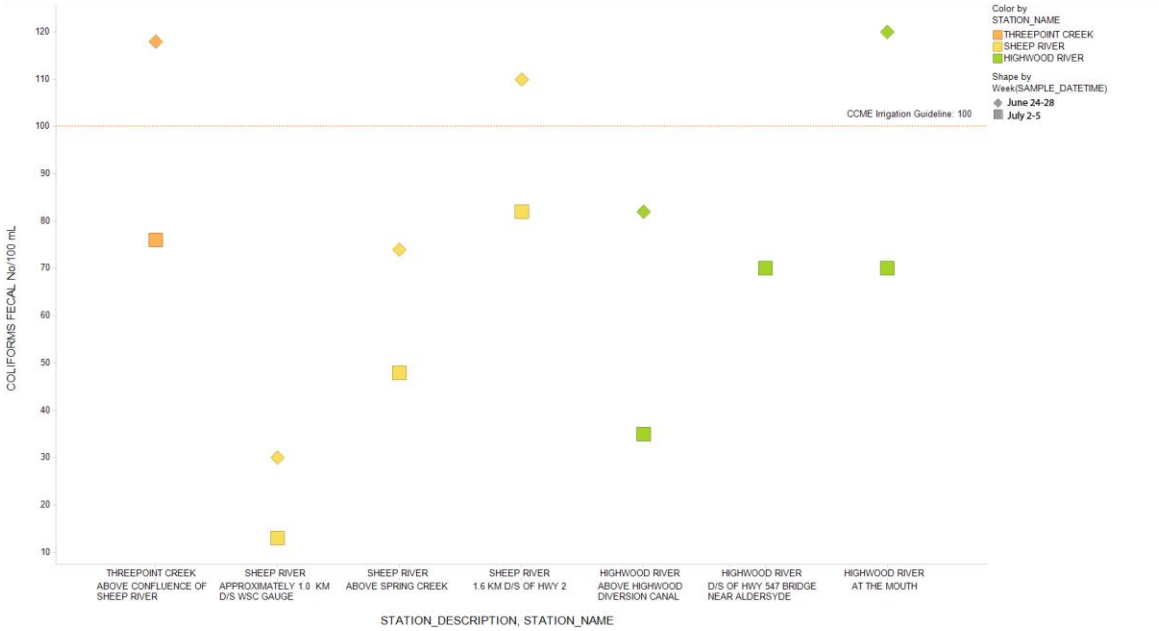

Figure 15. Fecal coliform bacteria numbers measured at Highwood River, Sheep River and Threepoint Creek sites.

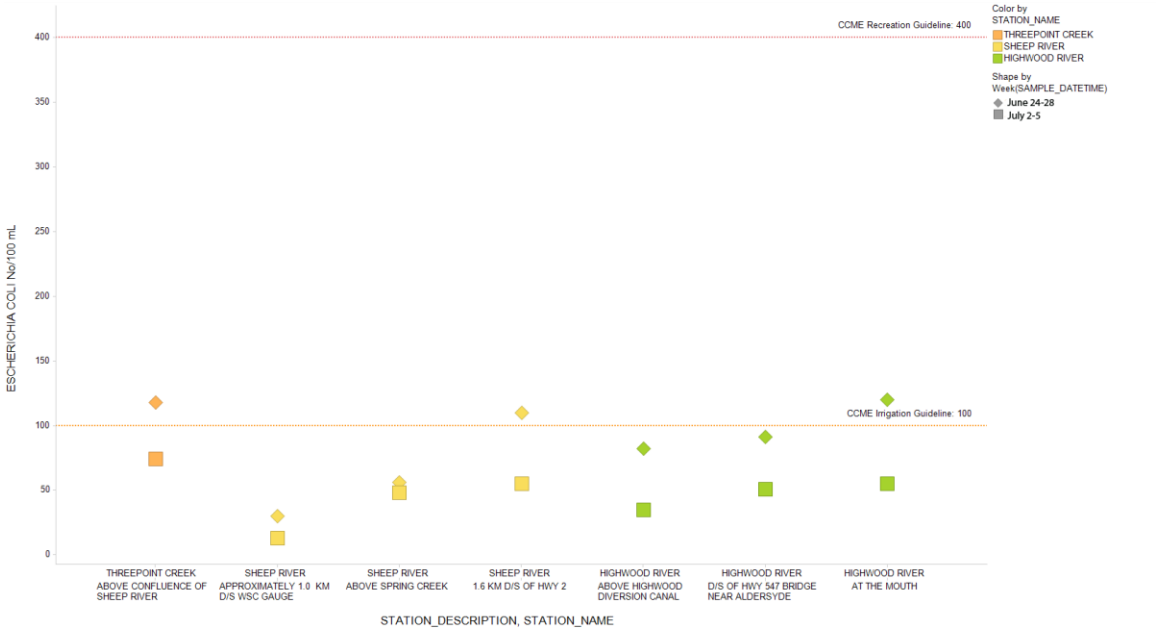

Figure 16. E. coli numbers measured at Highwood River, Sheep River and Threepoint Creek sites.

Considering the extent of high flood waters, the results, compared to other high water events, are quite reasonable, and it is expected that as the high waters recede, the bacteria levels will go down more.

Cryptosporidium was not detected in these rivers (Table 4); however, Giardia cysts were reported for two sites on the Highwood River and the Sheep River at Highway 2 below Okotoks. Based on the Bacteroides test, human fecal material was not present in any of the samples, and fecal material from cattle was detected at only one site, namely the Highwood River above the Diversion canal (upstream of the town of High River).

Table 4. Microbial data, *Cryptosporidium*, Giardia and Bacteroides, July 2-5, Highwood and Sheep rivers.

Date of Collection	Collection Site	*Crypto-sporidium* oocysts Reportable #'s per 100 L	*Giardia* cysts Reportable #'s per 100L	Human Bacteroides	Cow Bacteroides
02-Jul-13	Highwood River below Hwy 547 Bridge	0	50	ND	ND
02-Jul-13	Highwood River near the Mouth	0	0	ND	ND
02-Jul-13	Highwood River above Highwood Diversion Canal	0	150	ND	D
02-Jul-13	Sheep River @ Hwy 2	0	167	ND	ND
02-Jul-13	Sheep River above Spring Creek	0	0	ND	ND
ND - not detected; D, detected					

Routine Chemistry:

All salts are at levels within guidelines. Based on Total Dissolved Solids (Figure 15) and electrical conductivity (Figure 16), all water is within guidelines for irrigation use. There are no livestock watering issues.

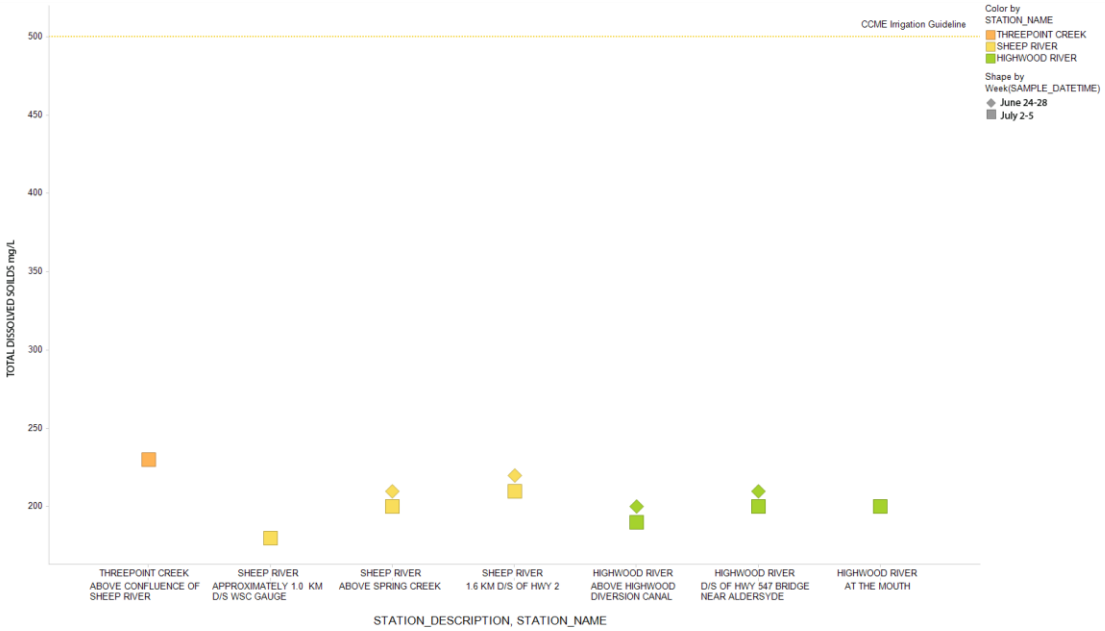

Figure 17. Total Dissolved Solids measured at Highwood River, Sheep River and Threepoint Creek sites.

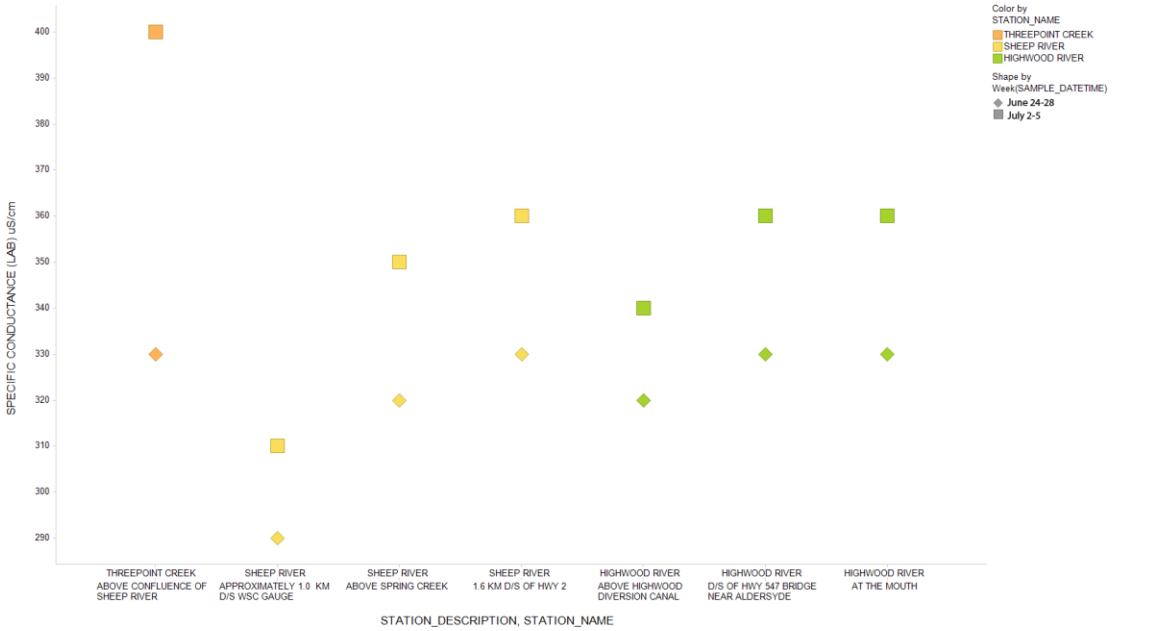

Figure 18. Electrical conductivity (specific conductance) measured at Highwood River, Sheep River and Threepoint Creek sites.

Sediment levels as expressed by turbidity (Figure 19) and Total Suspended Solids (Figure 20) are elevated due to the impact of overland runoff and instream erosion. The highest values were recorded in the week following the flood event, and values decreased in the subsequent week.

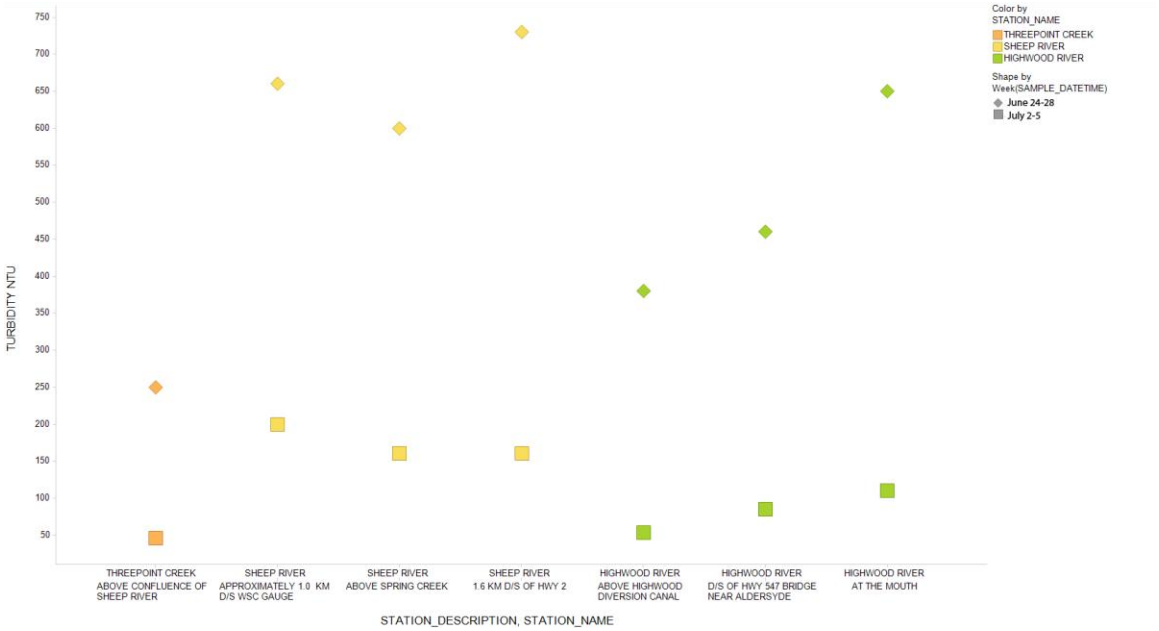

Figure 19. Turbidity measured at Highwood River, Sheep River and Threepoint Creek sites.

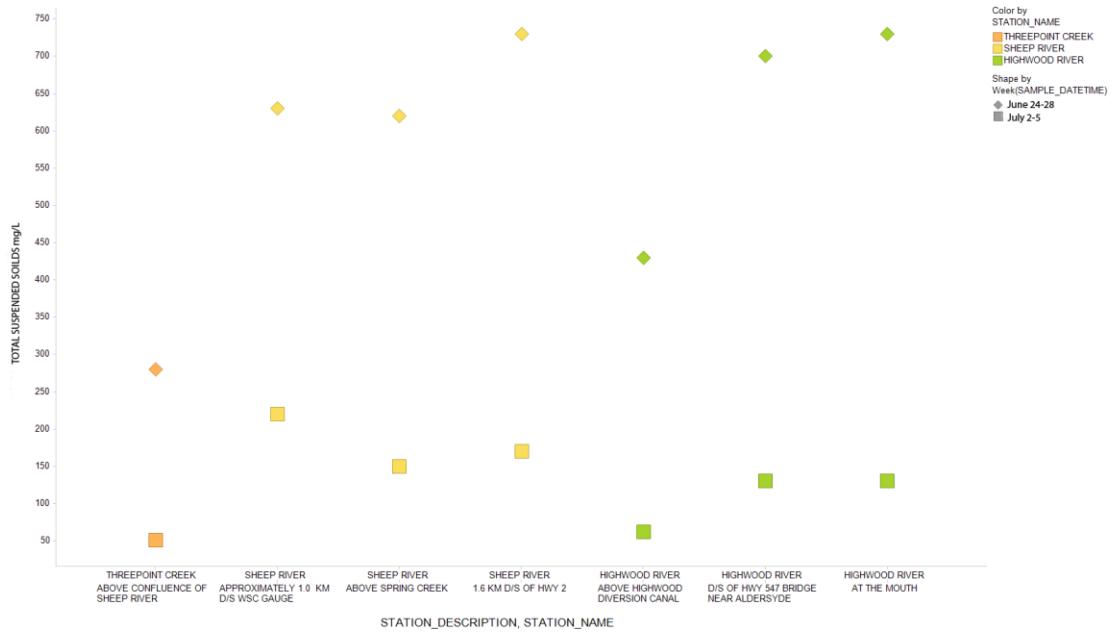

Figure 20. Total Suspended Solids measured at Highwood River, Sheep River and Threepoint Creek sites.

Total organic carbon (TOC) (Figure 21) levels are high in the first week post flood but then recede to acceptable levels of 3-5 mg/L in the week of July 2.

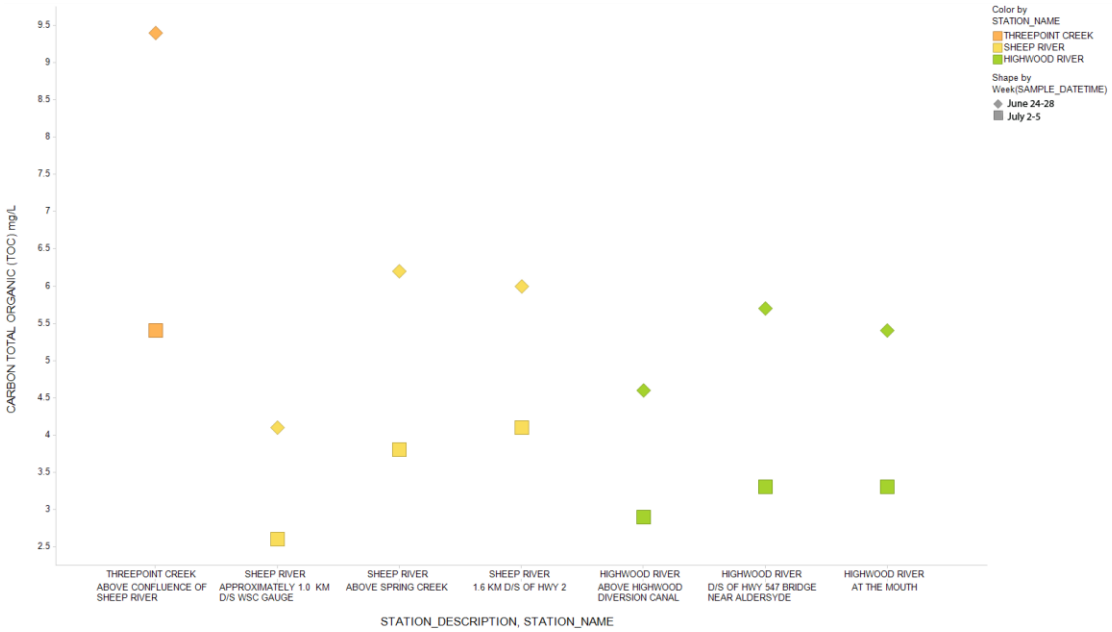

Figure 21. Total Organic Carbon measured at Highwood River, Sheep River and Threepoint Creek sites.

Metals:

For metals, there are exceedances of Protection of Aquatic Life (PAL) chronic guideline values, notably aluminum (Figure 22) and iron at most sites. These variables are known to be high during high runoff periods associated with high Total Suspended Solids. Both dissolved and total metals were analyzed, and based on the data, in most cases the metals are mainly in the particulate form and therefore less available for exposure to organisms. The CCME PAL guidelines are based on chronic exposure values, not acute. Exceedance of chronic values is of lesser concern if subsequent sampling identifies either lower concentrations or non-detections of the specific metals of concern. Most metals were below guideline values, as per arsenic, mercury and selenium (Figure 23-25).

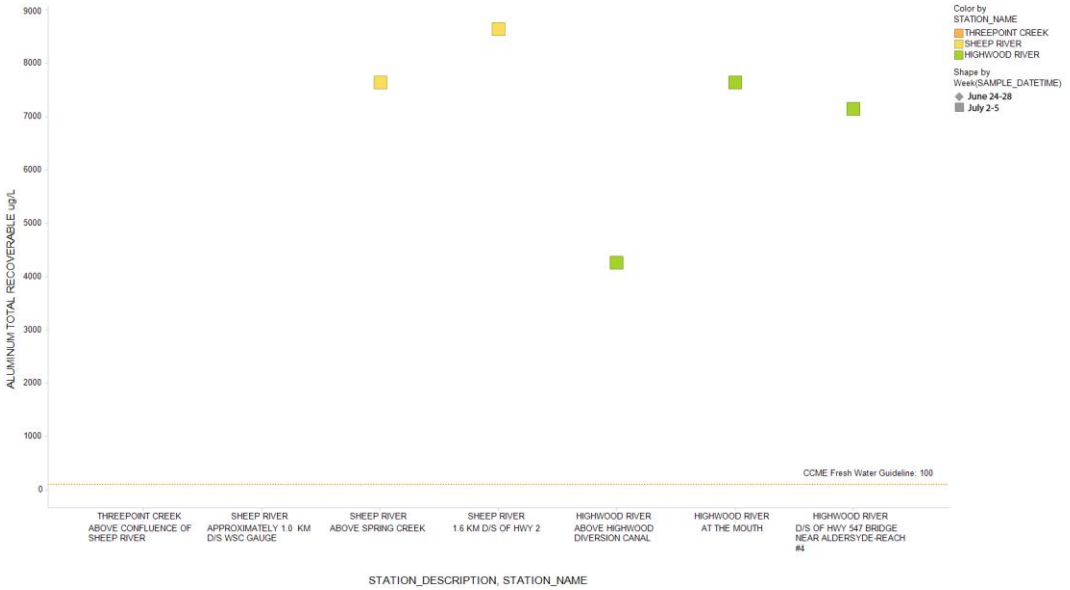

Figure 22. Total Recoverable Aluminum measured at Highwood and Sheep River sites.

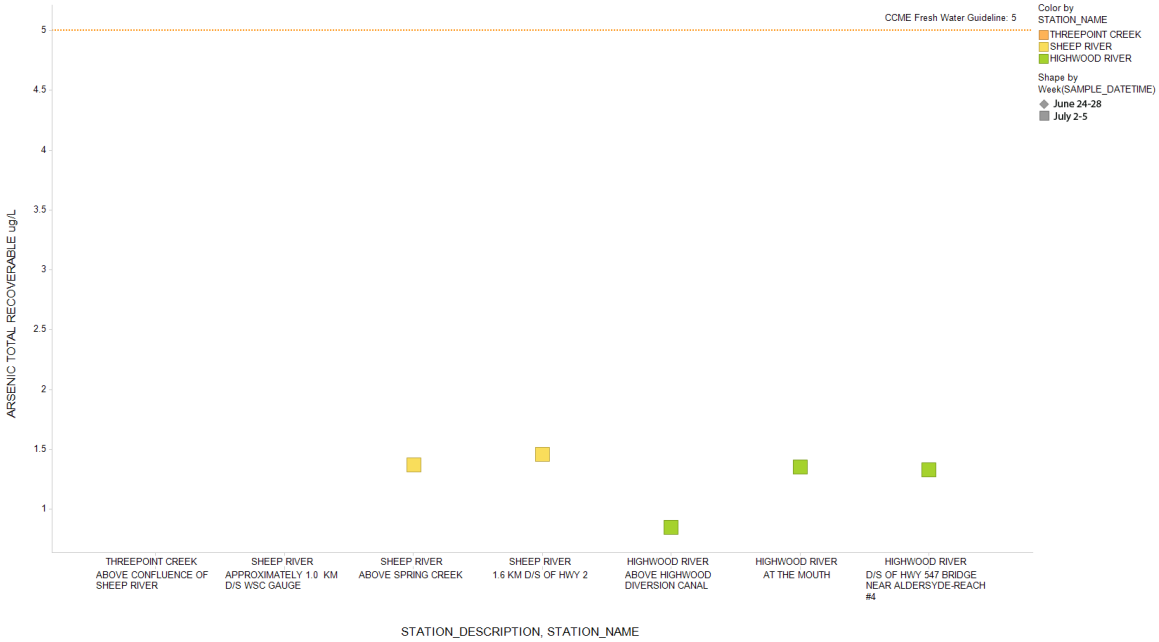

Figure 23, Total Arsenic measured at Highwood and Sheep River sites.

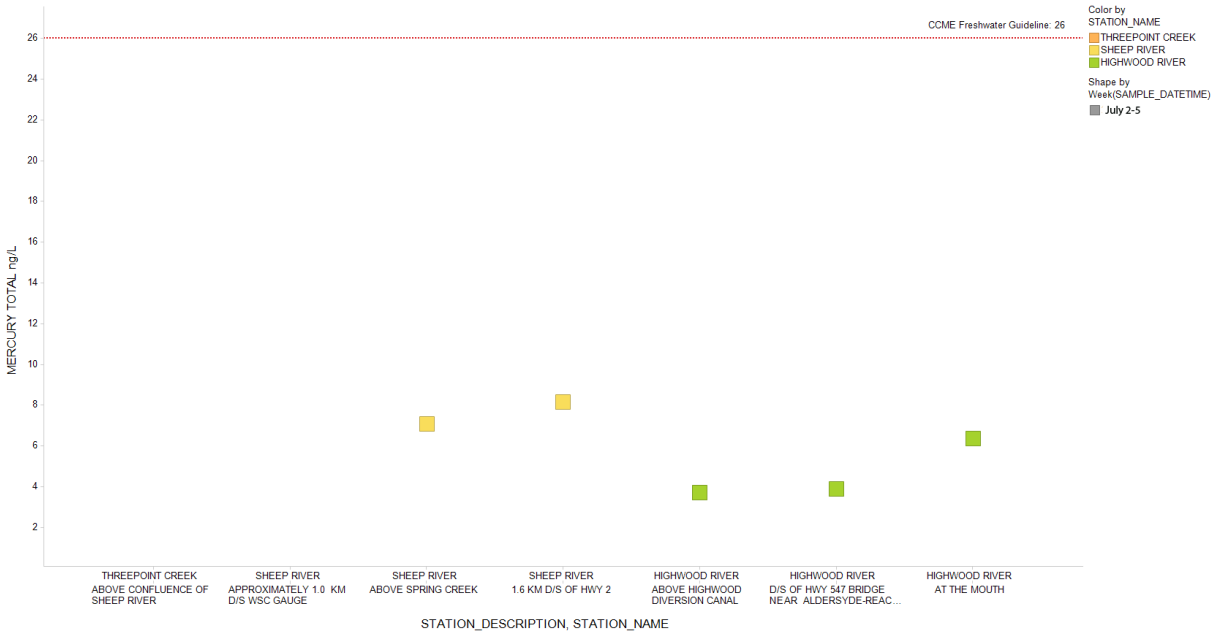

Figure 24, Total Mercury measured at Highwood and Sheep River sites.

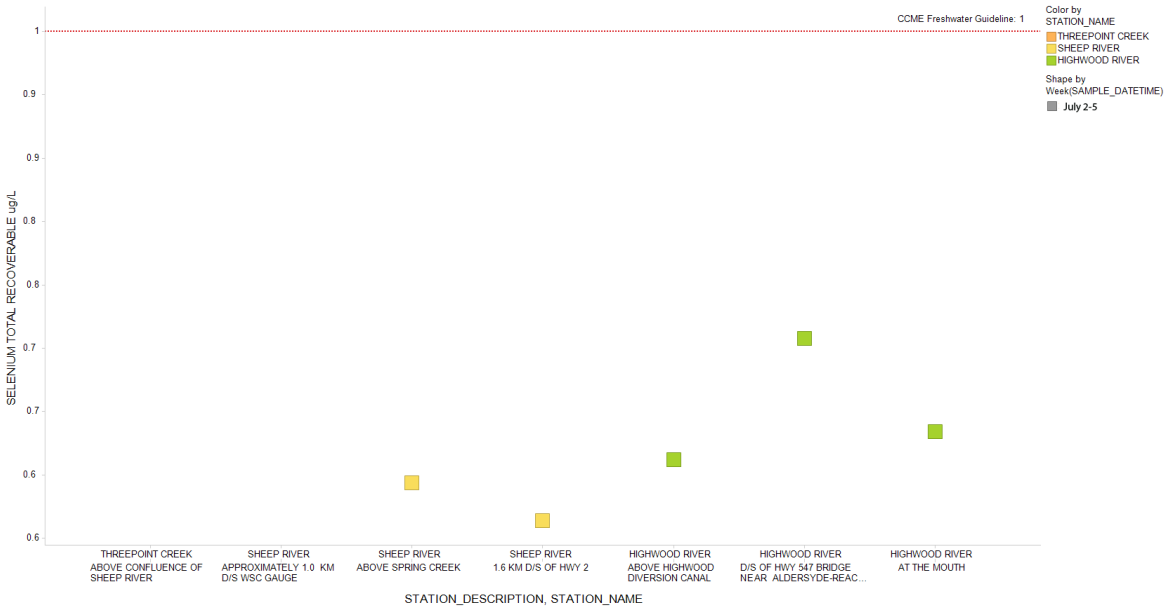

Figure 25, Total Selenium measured at Highwood and Sheep River sites.

Pesticides:

Two sites were sampled, namely, Highwood River above the Diversion, and Sheep River upstream of Spring Creek above the Town of Okotoks. All pesticide values at these two sites were below detection limits (no "hits"). Pesticide monitoring will continue in subsequent weeks and will include all Sheep and Highwood sites.

Organics (PAH's, BTEX and Hydrocarbons):

Polycyclic aromatic hydrocarbons were detected at all Highwood and Sheep river sites (Table 5), similar to the mainstem river sites, reported earlier in this report. The two sites on the Sheep River showed the highest number of detections. Most values are below the CCME guidelines for the protection of aquatic life; and these are chronic, not acute level guidelines. Sampling in subsequent weeks will determine whether levels remain as for July 2 and 3, or are reduced as flows and sediment levels are reduced. Based on raw data from the subsequent week, the number of detections and concentrations at the Sheep River above Spring Creek site are showing a downward trend. This finding is still to be confirmed and more fully described in subsequent water quality reporting. The Sheep River downstream of Black Diamond will also be sampled for organics during the week of July 8.

BTEX and straight chain hydrocarbons (C6-C50) were also part of the organics analysis. To date these have not been detected at any of the sites.

Table 5. Polycyclic aromatic hydrocarbons measured at Highwood and Sheep River sites on July 2 and 3, 2013.

STATION_NAME	STATION_DESCRIPTION	Number of Detections	PHENANTHRENE ug/L	2-METHYL-NAPHTHA-LENE ug/L	1-METHYLNAPHTHALENE ug/L	PYRENE ug/L	NAPHTHALENE ug/L	ACENAPHTHENE ug/L	CHRYSENE ug/L	FLUORANTHENE ug/L	FLUORENE ug/L	BENZO(G,H,I) PERYLENE ug/L	RETENE (7-ISOPROPYL-1-METHY-LPHENANTHRENE) ug/L
SHEEP RIVER	ABOVE SPRING CREEK	9	0.038	0.051	0.031	0.007	0.01	0.005	0.008	L0.10	0.009	L0.10	0.008
SHEEP RIVER	1.6 KM D/S OF HWY 2	11	0.049	0.067	0.041	0.01	0.012	0.006	0.011	0.007	0.011	0.006	0.012
HIGHWOOD RIVER	ABOVE HIGHWOOD DIVERSION CANAL	5	0.023	0.03	0.021	0.006	L0.10	L0.10	0.005	L0.10	L0.10	L0.10	L0.10
HIGHWOOD RIVER	D/S OF HWY 547 BRIDGE NEAR ALDERSYDE	7	0.025	0.036	0.027	0.006	0.009	L0.10	0.005	0.005	L0.10	L0.10	L0.10
HIGHWOOD RIVER	AT THE MOUTH	7	0.03	0.049	0.032	0.006	0.008	L0.10	0.007	L0.10	0.007	L0.10	L0.10
	Number of Detections		5	5	5	5	4	2	5	2	3	1	2

Note: other variables tested for with no "hits" can be found at the end of this report

3.3 Little Bow River, Mosquito Creek and Twin Valley Reservoir

Data was collected during the enhanced monitoring, July 2 to 5 but also two weeks earlier June 17 to 21, prior to the peak flood events in Calgary and High River. Both sets of data are provided here for microbiological and routine variables. The data clearly shows increases in most of the variables post-flood peak.

Microbiological:

Mosquito Creek had exceedances of the fecal coliform (Figure 22) and E coli (Figure 23) guidelines for irrigation and for contact recreation. Cattle were found to be contributing to the fecal bacteria load at both sites but not human sewage (Table 6).

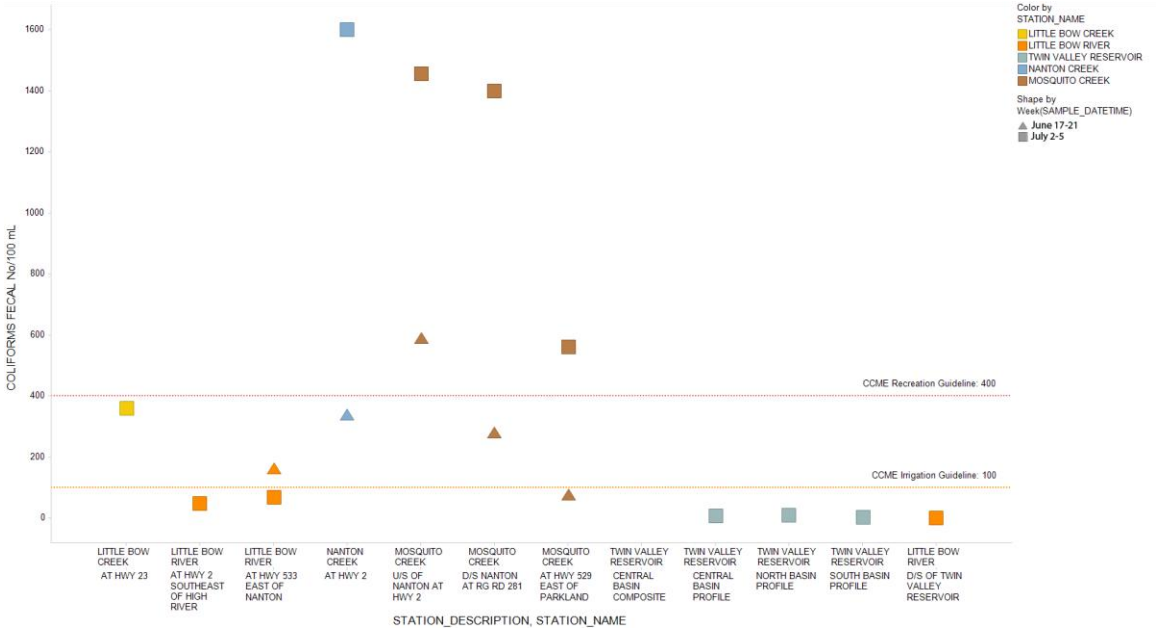

Figure 26. Fecal coliform bacteria measured in Little Bow River, Mosquito Creek and Twin Valley Reservoir

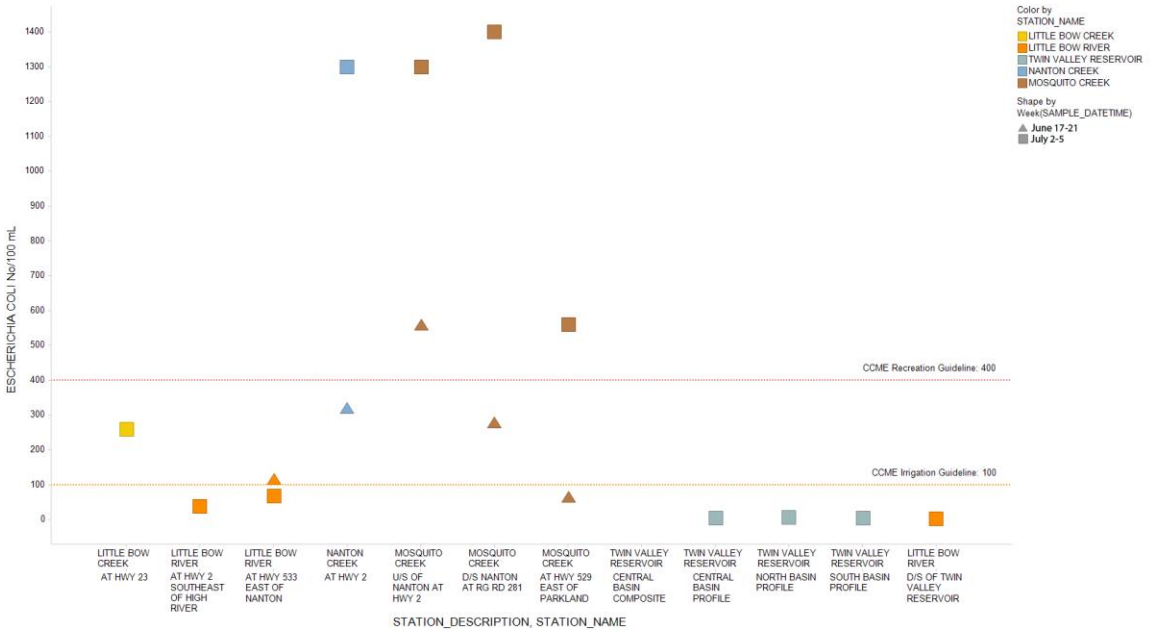

Figure 27. E. coli measured in the Little Bow River, Mosquito Creek and Twin Valley Reservoir.

The Little Bow River sites had fecal bacteria levels (July 2-5) that meet all use guidelines, with the exception of the Little Bow (Creek) Canal at Highway 23 in High River. This site is immediately below the point of discharge of ponded flood water from High River. Fecal coliform counts were 360 cfu/100 mL, and E coli were 260 cfu/100 mL. These levels are above the irrigation guideline, but below the contact recreation guideline.

Cryptosporidium and Giardia were both detected at the two Mosquito Creek sites (Table 6). The Cryptosporidium species found in Mosquito Creek was *C. andersoni*, a species found in cattle but non-infectious to humans.

Table 6. Microbial data, *Cryptosporidium*, Giardia and Bacteroides, July 2-5 measured in the Little Bow River, Mosquito Creek and Twin Valley Reservoir.

Date of Collection	Collection Site	*Crypto-sporidium* oocysts Reportable #'s per 100 L	*Giardia* cysts Reportable #'s per 100L	Crypto-sporidium species detected	Potentially Human infectious ?	Human Bacteroides	Cow Bacteroides
03-Jul-13	Twin Valley Res near Pumphouse North	0	0			NS	NS
03-Jul-13	Mosquito Creek u/s of Nanton at Hwy 2	500	300	*C. andersoni*	No	ND	D
03-Jul-13	Little Bow River at Hwy 533	0	0			ND	ND
03-Jul-13	Mosquito Creek at Hwy 529	800	100	*C. andersoni*	No	D	D
03-Jul-13	Twin Valley Res near Pumphouse South	0	0			NS	NS
03-Jul-13	Little Bow River at Hwy 2	0	0			ND	ND
05-Jul-13	Little Bow River at Hwy 23	0	AI			ND	ND
ND - not detected; D, detected; NS, not sampled; AI, analysis incomplete							

Routine Chemistry:

All salt concentrations are below any use guidelines. The combined salts measurements of TDS (Figure 28) and Electrical conductivity (Specific Conductance) (Figure 29) are also below the irrigation use guideline.

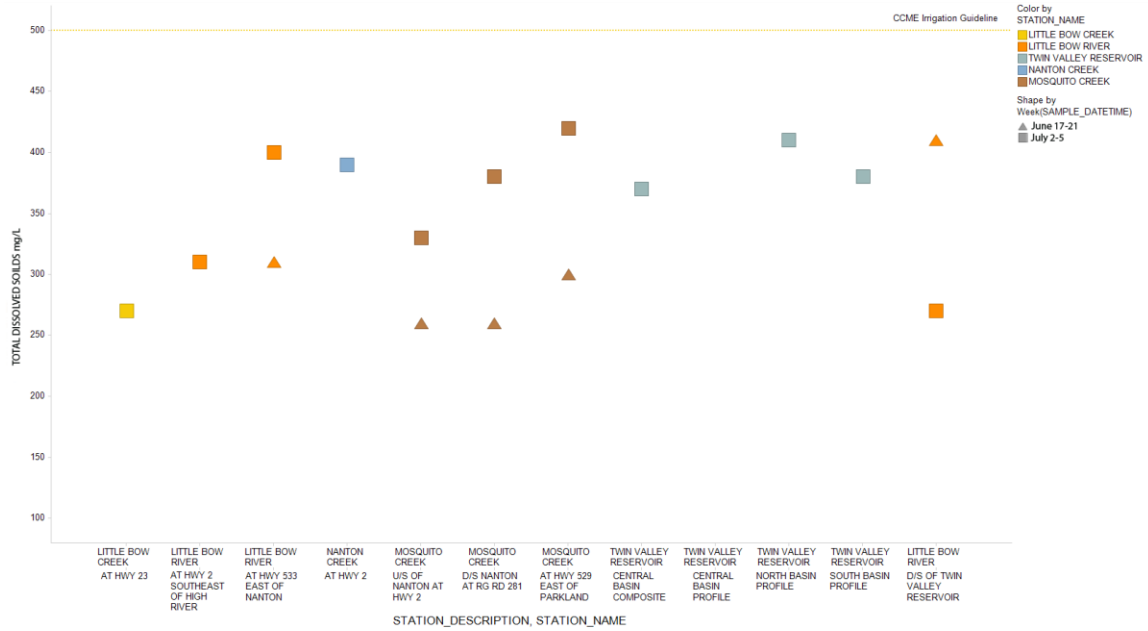

Figure 28. Total Dissolved Solids measured in Little Bow River, Mosquito Creek and Twin Valley Reservoir.

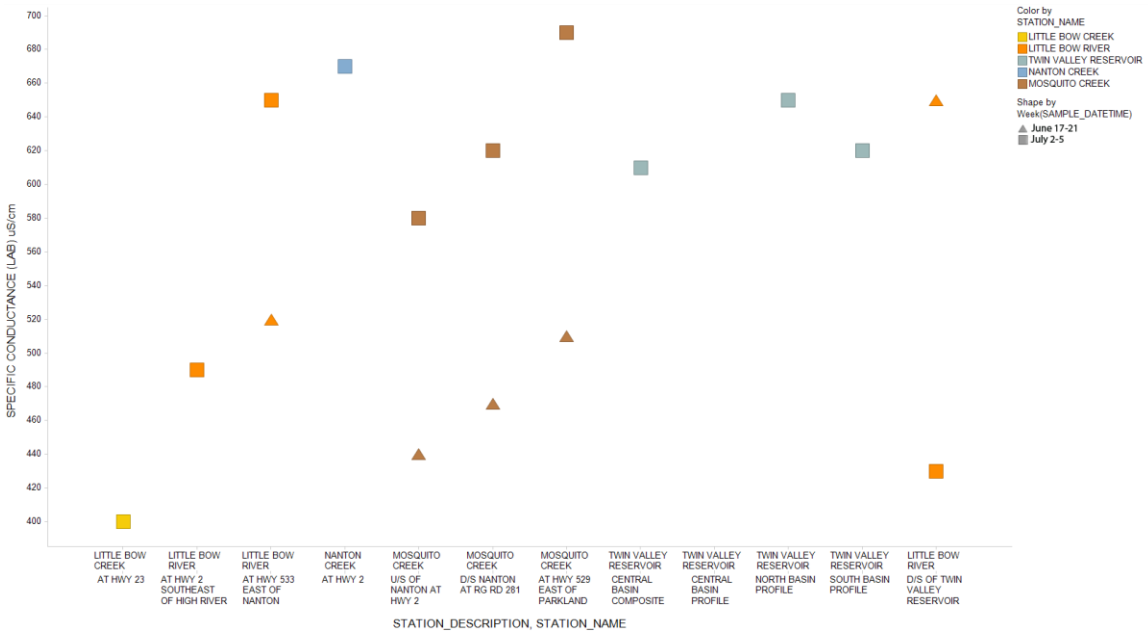

Figure 29. Electrical conductivity (Specific conductance) measured in Little Bow River, Mosquito Creek and Twin Valley Reservoir.

Turbidity (Figure 30) and total suspended sediment (Figure 31) values were higher in Mosquito Creek than in the Little Bow River. This may be due to the fact that Mosquito Creek is the smaller of the tributaries and is, therefore, more susceptible to loading from runoff, (since there is less instream flow to provide dilution). Sediment in Twin Valley

Reservoir is very low as expected, since the incoming sediment would settle out rapidly in the still waters. Below the reservoir the water is very clear as reflected by the values at the site, “Little Bow River downstream of Twin Valley Reservoir”.

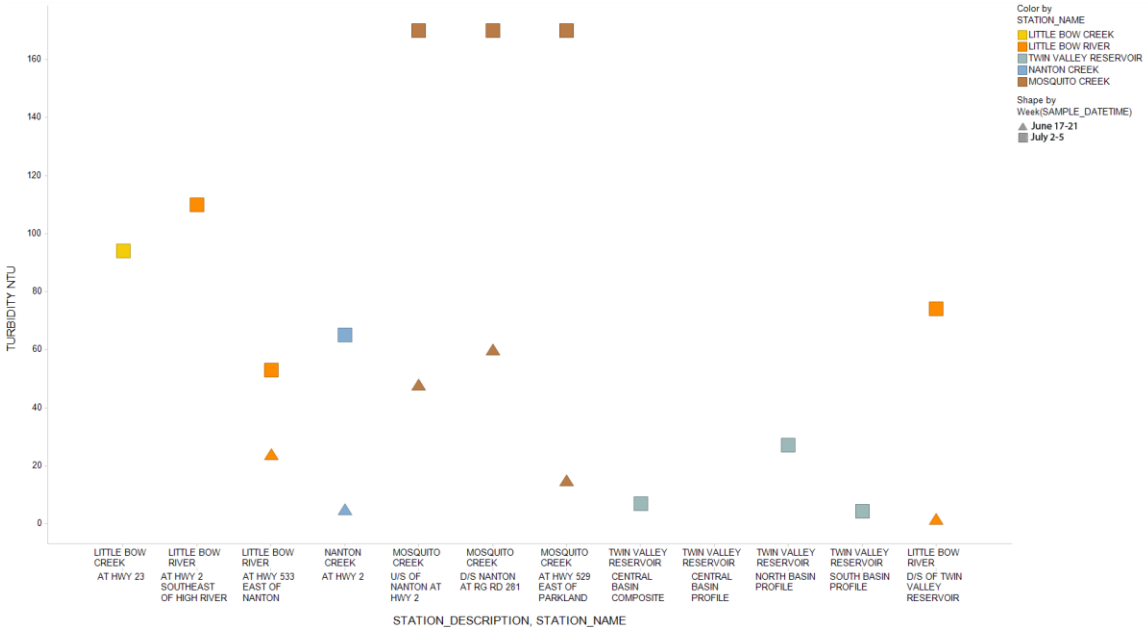

Figure 30. Turbidity measured at Little Bow River, Mosquito Creek and Twin Valley Reservoir sites.

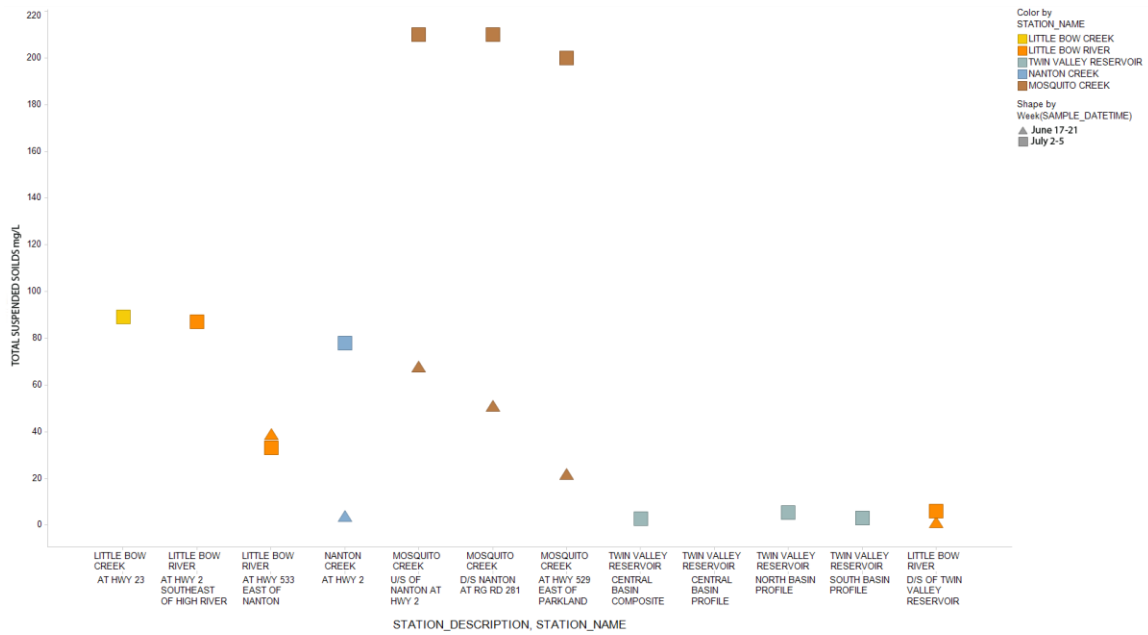

Figure 31. Total Suspended Solids measured at Little Bow River, Mosquito Creek and Twin Valley Reservoir sites.

Total Organic Carbon values at Little Bow River, Mosquito Creek and Twin Valley Reservoir sites (Figure 32) are higher than the data for the mainstem river sites and for the Highwood and Sheep rivers. Although of no toxic concern, this measurement does reflect dissolved and particulate organic matter being carried in the water. This is of

concern to water treatment plant operations. However, the one water treatment plant located in this area, in Vulcan, has a raw water storage reservoir that allows it to close its intake in Twin Valley Reservoir during inclement conditions. This is common infrastructure and practice at many water treatment plants in southern Alberta.

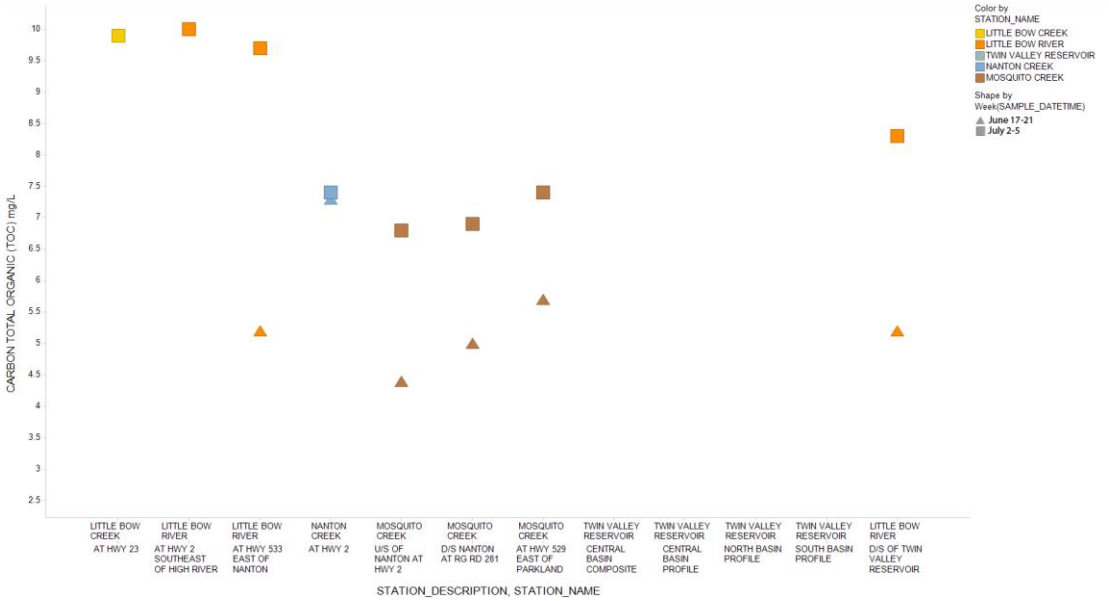

Figure 32. Total Organic Carbon measured at Little Bow River, Mosquito Creek and Twin Valley Reservoir sites.

Metals:

For metals, there are exceedances of Protection of Aquatic Life (PAL) chronic guideline values, notably aluminum (Figure 33) and iron at most sites. These variables are known to be high during high runoff periods associated with high Total Suspended Solids. Both dissolved and total metals were analysed, and based on the data, in most cases the metals are mainly in particulate form and are therefore less available for exposure to organisms. The CCME PAL guidelines are based on chronic exposure values, not acute. Exceedance of chronic values is of lesser concern if subsequent sampling identifies either lower concentrations or non-detections of the specific metals of concern. Most metals were below guideline values, as per arsenic and mercury (Figure 34-35). Selenium values were above guidelines at many of the sites (Figure 36).

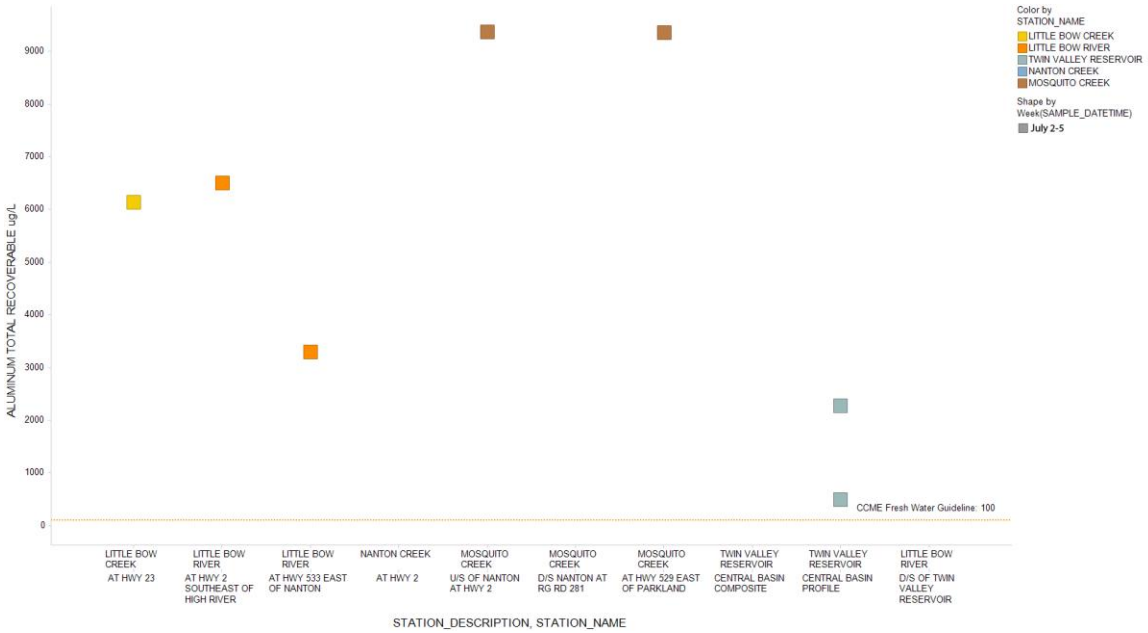

Figure 33. Total Recoverable Aluminum measured at Little Bow River, Mosquito Creek and Twin Valley Reservoir sites.

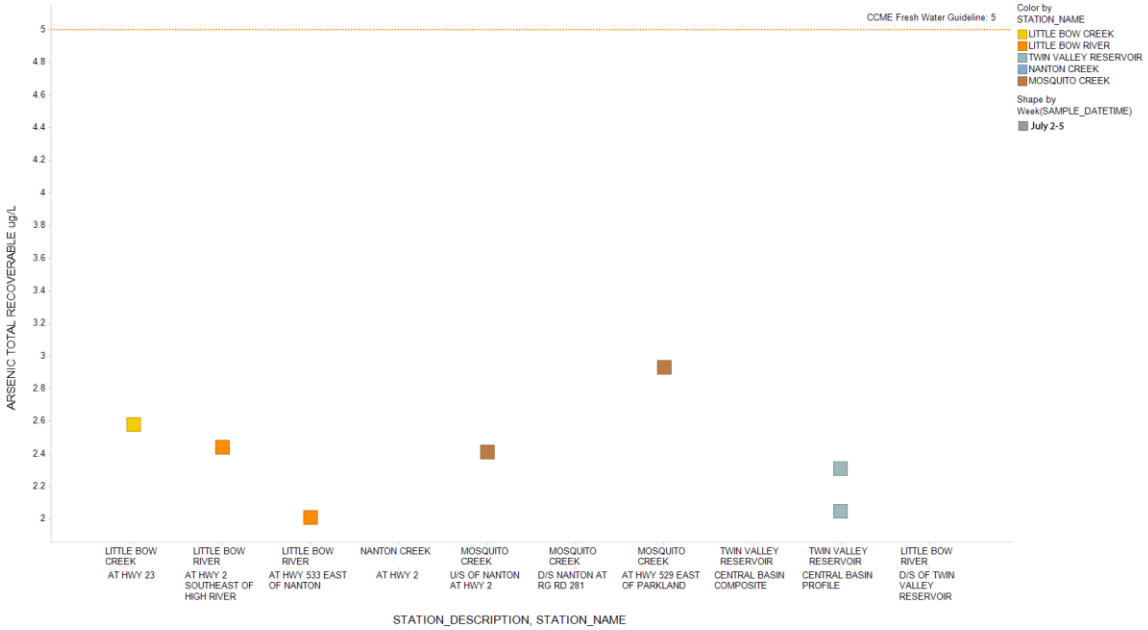

Figure 34. Total Arsenic measured at Little Bow River, Mosquito Creek and Twin Valley Reservoir sites.

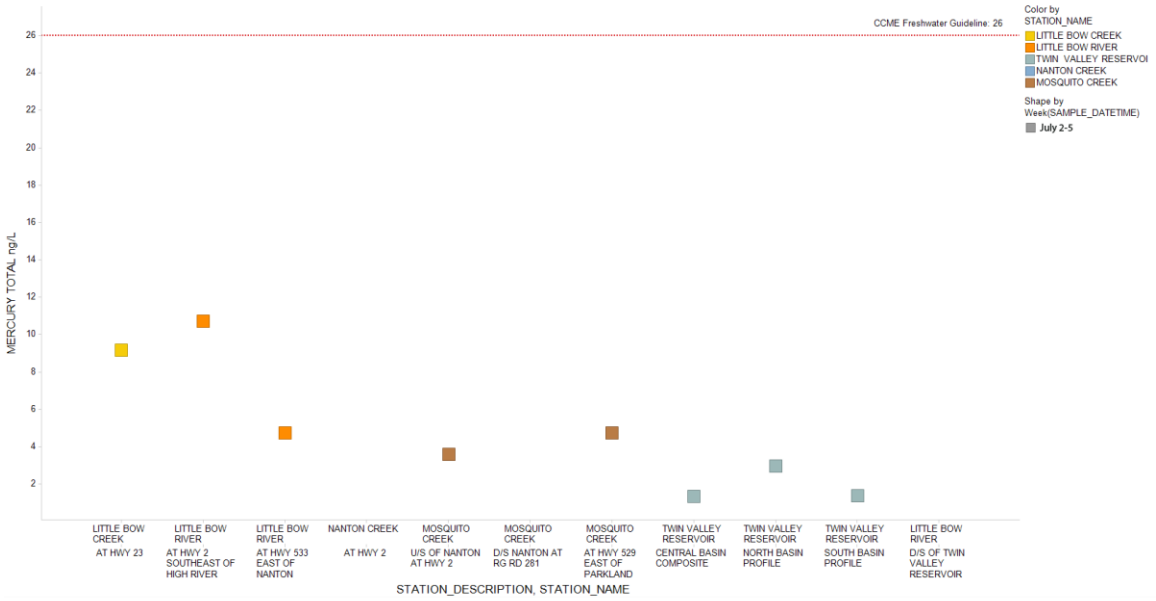

Figure 35. Total Mercury measured at Little Bow River, Mosquito Creek and Twin Valley Reservoir sites.

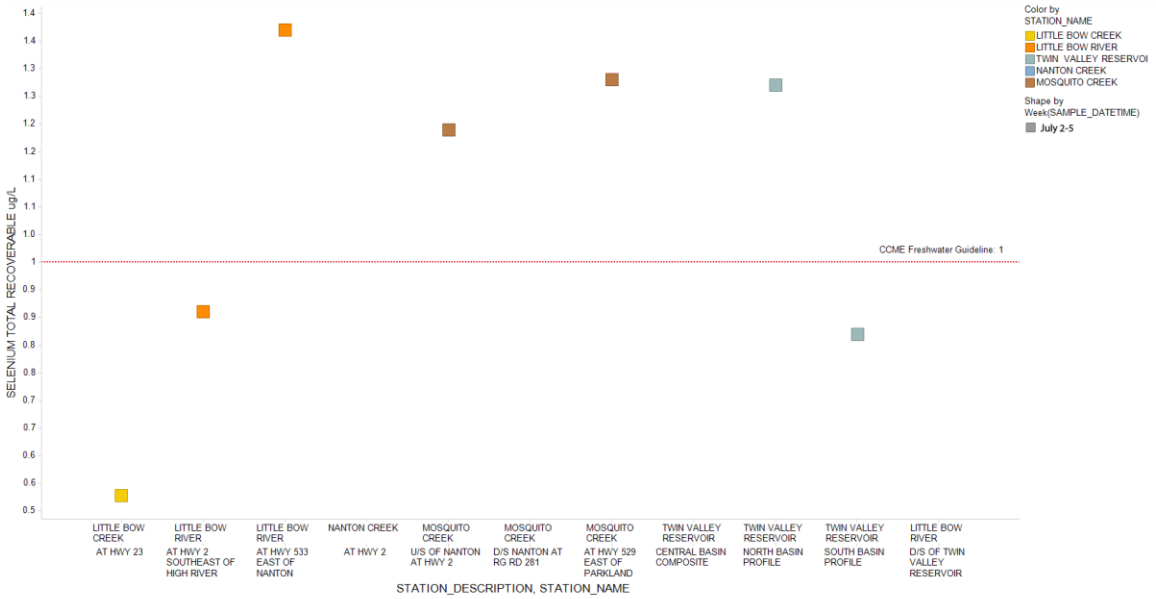

Figure 36. Total Selenium measured at Little Bow River, Mosquito Creek and Twin Valley Reservoir sites.

Pesticides:

The frequency of detections was greatest in the Little Bow River and carried over into the sampling sites in Twin Valley Reservoir (Table 7). Of note, the two Twin Valley Reservoir sites are in the reservoir sub-basin nearest to the influent from the Little Bow River. Mosquito Creek had fewer detections of pesticides. Based on historical data, tributaries generally have higher levels of detection than the larger rivers, and this is

reflected in the Little Bow results. Further sampling is being conducted in subsequent weeks.

Table 7. Pesticides measurements at Little Bow River, Mosquito Creek and Twin Valley Reservoir sites.

STATION_NAME	STATION_DESCRIPTION	Number De-tected	2,4-D ug/L	MCPP (MECOPROP) ug/L	MCPA ug/L	BROMOXYNIL ug/L	FLUROXYPYR ug/L	PICLORAM (TORDON) ug/L	CLODINAFOP ACID METABOLITE ug/L	CLODINAFOP-PROPARGYL ug/L	CLOPYRALID (LONTREL) ug/L	ETHION ug/L	FENOXAPROP-P-ETHYL ug/L	THIAMETHOXAM ug/L	TRIALLATE (AVADEX BW) ug/L
LITTLE BOW RIVER	AT HWY 2 SOUTHEAST OF HIGH R	6	0.164	0.084	0.096	0.004	0.083	L0.005	L0.02	L0.04	L0.02	L0.1	L0.04	L0.05	0.008
LITTLE BOW RIVER	AT HWY 533 EAST OF NANTON	6	0.172	0.099	0.083	0.004	0.085	0.009	L0.02	L0.04	L0.02	L0.1	L0.04	L0.05	L0.005
MOSQUITO CREEK	U/S OF NANTON AT HWY 2	1	0.005	L0.005	L0.005	L0.005	L0.01	L0.005	L0.02	L0.04	L0.02	L0.1	L0.04	L0.05	L0.005
MOSQUITO CREEK	AT OLD HWY 529 EAST OF PARKL	2	0.005	L0.005	0.004	L0.005	L0.01	L0.005	L0.02	L0.04	L0.02	L0.1	L0.04	L0.05	L0.005
TWIN VALLEY RESERVOIR	SOUTH BASIN PROFILE	10	0.022	0.004	0.018	0.004	0.016	L0.005	0.002	0.052	L0.02	0.086	0.036	0.079	L0.005
TWIN VALLEY RESERVOIR	NORTH BASIN PROFILE	7	0.046	0.012	0.022	0.005	0.017	0.025	L0.02	L0.04	0.012	L0.1	L0.04	L0.05	L0.005
	Number of Dectections		6	4	5	4	4	2	1	1	1	1	1	1	1

Note: other variables tested for with no "hits" can be found at the end of this report

Organics (PAH's, BTEX and Hydrocarbons):

Polycyclic aromatic hydrocarbons (PAH) were detected at all sites (Table 8). This is similar to all the other river sites, reported above. The Little Bow River showed the highest number of detections and Twin Valley Reservoir the least number. Most values are below the CCME guidelines for the protection of aquatic life. As at all sites, here and in the mainstem sites and Highwood and Sheep river sites, the main PAH being found is Phenanthrene, followed by various species of Naphthalenes. These are a reflection of contamination from petroleum products. Sampling in subsequent weeks will determine whether levels remain as for July 3, or are reduced as flows and sediment levels are reduced.

BTEX and straight chain hydrocarbons (C6-C50) were also part of the organics analysis. To date these have not been detected at any of the sites.

Table 8. PAH's measured at Little Bow River, Mosquito Creek & Twin Valley Reservoir sites.

STATION_NAME	STATION_DESCRIPTION	Number of Detec-tions	PHENAN-THRENE ug/L	2-METHYL-NAPH-THALENE ug/L	1-METHYL-NAPH-THALENE ug/L	PYRENE ug/L	NAPH-THALENE ug/L	ACENAPH-THENE ug/L	CHRYSENE ug/L	FLUORAN-THENE ug/L	FLUOR-ENE ug/L	BENZO-(G,H,I)-PERY-LENE ug/L
MOSQUITO CREEK	U/S OF NANTON AT HWY 2	3	0.01	L0.10	L0.10	0.004	L0.10	L0.10	L0.10	0.006	L0.10	L0.10
LITTLE BOW CREEK	AT HWY 23	4	0.012	0.006	0.006	L0.10	0.017	L0.10	L0.10	L0.10	L0.10	L0.10
LITTLE BOW RIVER	AT HWY 2 SE OF HIGH RIVER	8	0.02	0.027	0.019	0.006	0.059	L0.10	0.003	0.006	L0.10	0.005
LITTLE BOW RIVER	AT HWY 533 EAST OF NANTON	8	0.014	0.01	0.006	0.006	0.015	0.006	L0.10	0.006	0.006	L0.10
MOSQUITO CREEK	AT HWY 529 EAST OF PARKLAND	1	0.007	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10	L0.10
TWIN VALLEY RES.	NORTH BASIN PROFILE	2	0.008	L0.10	L0.10	L0.10	0.009	L0.10	L0.10	L0.10	L0.10	L0.10
TWIN VALLEY RES.	SOUTH BASIN PROFILE	2	0.006	L0.10	L0.10	L0.10	0.008	L0.10	L0.10	L0.10	L0.10	L0.10
	Number of Detections		7	3	3	3	5	1	1	3	1	1

Note: other variables tested for with no "hits" can be found at the end of this report

4.0 Conclusions

In response to the recent flood events in Southern Alberta, Environment and Sustainable Resource Development (ESRD) has implemented enhanced water quality monitoring programs for both ambient (raw) water in rivers, streams and reservoirs, and treated drinking water. This summary describes the results from monitoring between June 17 and July 5, 2013, for the ambient surface water quality monitoring. Results from monitoring of treated drinking water will be reported separately.

The enhanced monitoring program continues weekly through July 2013. Any changes or additions to the flood monitoring program will be made as the data becomes available. The enhanced monitoring will end when there is sufficient understanding of the flood impact on water quality. Routine ambient monitoring for baseline description and trend assessment, conducted monthly at many sites, will continue as usual.

The first week of sampling of untreated river, stream and reservoir water found levels of monitored variables that have been observed in the past under similar high flow conditions. However, exceedances of Canadian Council of Ministers of the Environment guidelines for Irrigation Water Use and Canadian Recreational Water Use Guidelines for contact recreation were recorded for the Bow River downstream of Calgary, the Oldman River, the South Saskatchewan River and Mosquito Creek.

The recorded guideline exceedances supported recommendations for Albertans not to use the rivers and streams for irrigation of gardens and to avoid them for recreational use given the existing conditions at the time. High flows and turbidity of the water making identification of river hazards difficult combined with eroded, unstable banks also were contributing factors to limit recreational use.

Untreated water from rivers, streams, lakes and reservoirs should never be used for drinking water at any time.

A few exceedances of Protection of Aquatic Life guidelines were also recorded. However, those guidelines are based on longer term, chronic exposure conditions. The observed levels will not cause acute fish mortality.

Ambient water quality monitoring is continuing and all collected data results are being shared with Alberta Agriculture and Rural Development, Alberta Health, Alberta Health Services and Health Canada. Updates of the monitoring results will be provided to the public as they become available.

APPENDICES

Historical data: 1999-2009, Bow, South Saskatchewan and Oldman Rivers Long Term River Network site statistics. Open Season is Apr. to Oct.; Ice is Nov. to Mar.

Table A1: Summary Statistics for Bow River at Cochrane – General Indicators

Note: Unless otherwise noted, all values are in mg/L; n= sample size, P= percentile, BDL=Below analytical detection limit.

General Indicator	Season	Min	25th P	Median	75th P	90th P	Max	n	# Samples BDL
Total Ammonia (NH_{3+4}-N)	Open	0.005	0.005	0.005	0.025	0.041	0.380	70	47
	Ice	0.005	0.005	0.008	0.020	0.025	0.070	50	35
Chloride (Cl^-)	Open	0.7	1.6	1.9	2.3	2.9	9.3	70	0
	Ice	0.5	1.7	2.0	2.2	2.6	4.0	50	1
Nitrate (NO_3-N)	Open	0.014	0.060	0.074	0.088	0.108	3.600	69	0
	Ice	0.007	0.097	0.109	0.122	0.130	0.144	50	0
Total Nitrogen (TN)	Open	0.07	0.12	0.18	0.22	0.40	6.00	70	0
	Ice	0.01	0.12	0.17	0.20	0.23	0.31	50	0
Total Dissolved Phosphorus (TDP)	Open	0.002	0.002	0.002	0.003	0.004	0.005	35	20
	Ice	0.002	0.002	0.002	0.004	0.004	0.005	25	14
Total Phosphorus (TP)	Open	0.002	0.002	0.005	0.006	0.009	0.090	35	9
	Ice	0.002	0.002	0.003	0.005	0.006	0.014	25	9
Sulphate (SO_4^-)	Open	20.7	28.3	33.6	38.8	40.4	43.4	70	0
	Ice	35.6	40.7	42.2	44.5	45.8	52.3	50	0
Sodium Adsorption Ratio (SAR)	Open	0.01	0.06	0.07	0.09	0.12	0.15	70	0
	Ice	0.03	0.07	0.07	0.08	0.10	0.17	50	0
Specific Conductivity µS/cm	Open	217	260	289	310	317	340	70	0
	Ice	290	318	330	342	349	427	50	0
Total Dissolved Solids	Open	122	151	165	180	190	201	70	0
	Ice	177	186	190	197	200	203	50	0
Total Organic Carbon	Open	0.5	0.7	1.0	1.3	1.6	2.8	34	0
	Ice	0.1	0.7	0.8	0.9	0.9	1.8	14	2
Total Suspended Solids	Open	0.2	1.0	2.0	3.4	8.1	149.0	70	6
	Ice	0.2	0.4	0.8	1.2	2.3	22.0	50	11
Turbidity NTU	Open	0.3	1.0	1.8	3.2	10.1	130.0	70	6
	Ice	0.4	0.6	0.8	1.1	1.7	5.3	50	6
pH	Open	7.22	8.12	8.23	8.30	8.38	8.45	70	0
	Ice	7.92	8.10	8.17	8.25	8.30	8.46	50	0
Escherichia coli cfu per 100 mL	Open	1	1	2	8	13	1300	70	18
	Ice	1	1	1	1	2	21	49	41

Table A2: Summary Statistics for the Bow River at Carseland – General Indicators

Note: Unless otherwise noted, all values are in mg/L; n= sample size, P= percentile, BDL=Below analytical detection limit.

General Indicator	Season	Min	25th P	Median	75th P	90th P	Max	n	# Samples BDL
Total Ammonia (NH_{3+4}-N)	Open	0.005	0.021	0.045	0.100	0.160	0.380	70	15
	Ice	0.080	0.175	0.250	0.388	0.472	0.670	50	0
Chloride (Cl^-)	Open	2.6	5.6	7.6	10.2	13.1	30.8	70	0
	Ice	8.6	11.2	12.7	15.2	20.4	29.9	50	0
Nitrate (NO_3-N)	Open	0.111	0.461	0.601	0.830	0.990	1.580	69	0
	Ice	0.155	0.960	1.130	1.285	1.403	1.630	50	0
Total Nitrogen (TN)	Open	0.11	0.81	1.02	1.34	1.72	2.70	70	0
	Ice	0.88	1.43	1.68	1.85	2.17	2.47	50	0
Total Dissolved Phosphorus (TDP)	Open	0.002	0.005	0.007	0.012	0.016	0.050	35	2
	Ice	0.004	0.015	0.017	0.021	0.028	0.083	25	0
Total Phosphorus (TP)	Open	0.007	0.014	0.021	0.050	0.083	1.370	35	0
	Ice	0.007	0.021	0.030	0.037	0.062	0.184	25	0
Sulphate (SO_4^-)	Open	23.6	36.2	42.9	47.6	51.5	63.6	70	0
	Ice	46.1	50.6	53.9	56.2	58.0	64.0	50	0
Sodium Adsorption Ratio (SAR)	Open	0.09	0.25	0.30	0.37	0.45	1.04	69	0
	Ice	0.29	0.34	0.39	0.45	0.58	0.94	50	0
Specific Conductivity µS/cm	Open	235	320	346	384	398	475	69	0
	Ice	287	397	422	433	443	478	50	0
Total Dissolved Solids	Open	151	182	201	223	232	281	70	0
	Ice	218	237	246	253	260	280	50	0
Total Organic Carbon	Open	1.3	1.6	2.0	2.5	3.6	5.1	34	0
	Ice	0.9	1.2	1.5	1.8	1.9	2.4	14	0
Total Suspended Solids	Open	0	3	6	14	64	1660	70	2
	Ice	1	3	5	9	14	44	50	0
Turbidity NTU	Open	0.6	2.0	4.0	12.6	48.4	1090.0	70	0
	Ice	0.6	1.9	2.6	5.5	9.3	33.0	50	0
pH	Open	7.63	8.08	8.20	8.30	8.39	8.79	70	0
	Ice	7.72	7.96	8.06	8.15	8.20	8.28	50	0
Escherichia coli cfu per 100 mL	Open	1	13	28	65	144	2900	67	1
	Ice	1	5	10	14	25	720	47	1

Table A3: Summary Statistics for the Bow River at Cluny – General Indicators

Note: Unless otherwise noted, all values are in mg/L; n= sample size, P= percentile, BDL=Below analytical detection limit.

General Indicator	Season	Min	25th P	Median	75th P	90th P	Max	n	# Samples BDL
Total Ammonia (NH_{3+4}-N)	Open	0.005	0.010	0.025	0.050	0.120	0.430	71	26
	Ice	0.020	0.108	0.195	0.333	0.372	0.720	48	1
Chloride (Cl^-)	Open	2.8	5.9	8.0	9.8	13.0	37.1	71	0
	Ice	7.9	10.4	13.0	18.1	20.9	54.0	43	0
Nitrate (NO_3-N)	Open	0.046	0.354	0.520	0.763	0.837	1.320	59	0
	Ice	0.358	0.982	1.195	1.323	1.455	1.530	40	0
Total Nitrogen (TN)	Open	0.22	0.67	0.94	1.17	1.52	3.84	71	0
	Ice	0.49	1.43	1.68	1.87	2.07	2.39	48	0
Total Dissolved Phosphorus (TDP)	Open	0.002	0.004	0.005	0.009	0.014	0.020	35	6
	Ice	0.002	0.007	0.012	0.015	0.020	0.099	22	0
Total Phosphorus (TP)	Open	0.002	0.011	0.017	0.046	0.128	1.460	35	1
	Ice	0.004	0.013	0.017	0.020	0.025	0.192	22	0
Sulphate (SO_4^-)	Open	29.0	40.6	47.9	53.6	58.1	110.0	48	0
	Ice	49.7	54.0	57.2	60.6	63.1	74.8	32	0
Sodium Adsorption Ratio (SAR)	Open	0.17	0.31	0.35	0.47	0.60	1.12	47	0
	Ice	0.32	0.38	0.42	0.50	0.72	1.35	32	0
Specific Conductivity µS/cm	Open	240	326	360	399	425	581	47	0
	Ice	380	420	441	463	490	556	32	0
Total Dissolved Solids	Open	150	190	210	233	245	354	48	0
	Ice	217	245	257	263	290	323	32	0
Total Organic Carbon	Open	1.5	1.9	2.2	2.9	4.3	4.9	23	0
	Ice	0.8	1.2	1.3	1.5	1.8	2.5	16	0
Total Suspended Solids	Open	1	5	11	36	80	1840	71	1
	Ice	1	3	4	6	9	52	48	0
Turbidity NTU	Open	1.0	3.9	8.5	18.3	62.7	130.0	48	0
	Ice	0.5	2.0	2.8	3.9	7.1	34.0	32	1
pH	Open	7.72	8.21	8.30	8.39	8.46	8.68	48	0
	Ice	7.72	7.94	8.00	8.19	8.23	8.33	37	0
Escherichia coli cfu per 100 mL	Open	1	3	8	23	56	220	67	7
	Ice	1	1	1	3	6	510	48	17

Table A4: Summary Statistics for the Bow River at Ronalane – General Indicators

Note: Unless otherwise noted, all values are in mg/L; n= sample size, P= percentile, BDL=Below analytical detection limit.

General Indicator	Season	Min	25th P	Median	75th P	90th P	Max	n	# Samples BDL
Total Ammonia (NH_{3+4}-N)	Open	0.005	0.010	0.020	0.040	0.081	0.220	70	23
	Ice	0.005	0.040	0.130	0.220	0.292	0.510	49	7
Chloride (Cl^-)	Open	3.0	6.3	8.4	10.0	12.0	22.6	70	0
	Ice	7.1	11.4	13.0	16.0	19.7	28.8	49	0
Nitrate (NO_3-N)	Open	0.002	0.031	0.302	0.504	0.747	0.967	69	6
	Ice	0.540	0.971	1.190	1.300	1.440	1.600	49	0
Total Nitrogen (TN)	Open	0.23	0.43	0.68	0.98	1.26	2.07	70	0
	Ice	0.84	1.32	1.58	1.74	1.91	2.35	49	0
Total Dissolved Phosphorus (TDP)	Open	0.002	0.004	0.005	0.006	0.010	0.029	35	4
	Ice	0.002	0.004	0.005	0.007	0.017	0.130	24	4
Total Phosphorus (TP)	Open	0.008	0.014	0.025	0.050	0.138	0.250	35	0
	Ice	0.004	0.010	0.012	0.022	0.027	0.280	24	0
Sulphate (SO_4^-)	Open	27.7	53.3	62.2	70.8	78.2	121.0	70	0
	Ice	33.0	56.1	60.9	65.2	70.5	89.2	49	0
Sodium Adsorption Ratio (SAR)	Open	0.15	0.41	0.55	0.68	0.80	1.11	70	0
	Ice	0.32	0.42	0.48	0.54	0.67	0.97	49	0
Specific Conductivity µS/cm	Open	274	350	386	410	431	577	70	0
	Ice	220	420	448	473	499	542	49	0
Total Dissolved Solids	Open	163	206	228	244	260	358	70	0
	Ice	120	249	263	273	291	331	49	0
Total Organic Carbon	Open	1.9	2.2	3.0	3.6	4.8	5.6	34	0
	Ice	1.1	1.3	1.5	2.1	2.5	10.0	14	0
Total Suspended Solids	Open	0	6	12	36	72	392	70	1
	Ice	1	3	6	8	18	44	49	0
Turbidity NTU	Open	1.5	4.9	10.4	25.5	73.3	278.0	70	0
	Ice	0.5	2.4	3.8	6.9	17.4	50.6	49	1
pH	Open	7.86	8.20	8.32	8.48	8.58	8.93	70	0
	Ice	7.62	7.96	8.06	8.22	8.30	8.48	49	0
Escherichia coli cfu per 100 mL	Open	1	4	14	36	77	820	69	6
	Ice	1	1	1	3	6	12	49	20

Table A5: Summary Statistics for the Oldman River at Brocket – General Indicators

Note: Unless otherwise noted, all values are in mg/L; n= sample size, P= percentile, BDL=Below analytical detection limit.

General Indicator	Season	Min	25th P	Median	75th P	90th P	Max	n	# Samples BDL
Total Ammonia (NH_{3+4}-N)	Open	0.005	0.005	0.010	0.025	0.030	0.150	78	42
	Ice	0.005	0.005	0.010	0.025	0.030	0.090	51	33
Chloride (Cl^-)	Open	0.3	0.8	0.9	1.4	1.8	4.3	70	5
	Ice	0.3	1.0	1.2	1.5	1.9	4.7	50	3
Nitrate (NO_3-N)	Open	0.024	0.061	0.078	0.109	0.126	0.183	78	0
	Ice	0.002	0.062	0.093	0.118	0.132	0.237	51	1
Total Nitrogen (TN)	Open	0.06	0.17	0.23	0.29	0.35	1.90	70	0
	Ice	0.08	0.16	0.19	0.27	0.32	0.81	50	0
Total Dissolved Phosphorus (TDP)	Open	0.002	0.002	0.003	0.004	0.006	0.028	78	38
	Ice	0.002	0.002	0.003	0.004	0.005	0.012	51	23
Total Phosphorus (TP)	Open	0.002	0.005	0.007	0.012	0.018	0.072	78	8
	Ice	0.002	0.004	0.005	0.008	0.010	0.023	51	7
Sulphate (SO_4^-)	Open	10.4	17.7	22.1	25.5	29.4	34.4	70	0
	Ice	18.9	24.9	29.6	34.2	36.0	41.8	50	0
Sodium Adsorption Ratio (SAR)	Open	0.08	0.14	0.16	0.18	0.22	0.34	70	0
	Ice	0.11	0.16	0.18	0.19	0.20	0.27	50	0
Specific Conductivity µS/cm	Open	207	257	275	298	311	348	78	0
	Ice	261	287	307	334	342	382	51	0
Total Dissolved Solids	Open	111	144	156	172	181	205	70	0
	Ice	146	165	179	196	202	228	50	0
Total Organic Carbon	Open	0.5	1.7	2.0	2.9	3.7	5.3	70	0
	Ice	1.1	1.5	1.6	2.0	2.2	3.2	50	0
Total Suspended Solids	Open	1	2	4	6	10	62	71	8
	Ice	0	1	1	3	6	8	46	9
Turbidity NTU	Open	0.5	3.2	5.0	9.7	18.8	61.7	78	1
	Ice	0.3	1.5	2.3	4.4	8.0	25.3	51	2
pH	Open	7.69	8.15	8.26	8.32	8.35	8.49	78	0
	Ice	7.81	8.13	8.25	8.30	8.34	8.40	51	0
Escherichia coli cfu per 100 mL	Open	1	1	3	8	14	890	70	14
	Ice	0	1	2	8	27	69	49	19

Table A6: Summary Statistics the Oldman River at Hwy 3 – General Indicators

Note: Unless otherwise noted, all values are in mg/L; n= sample size, P= percentile, BDL=Below analytical detection limit.

General Indicator	Season	Min	25th P	Median	75th P	90th P	Max	n	# Samples BDL
Total Ammonia (NH_{3+4}-N)	Open	0.005	0.005	0.020	0.030	0.070	0.270	81	36
	Ice	0.005	0.005	0.020	0.030	0.060	0.100	51	22
Chloride (Cl^-)	Open	0.3	1.2	1.5	2.1	3.2	5.3	70	1
	Ice	1.0	1.7	2.1	2.4	3.0	28.8	50	0
Nitrate (NO_3-N)	Open	0.002	0.002	0.022	0.053	0.110	0.957	81	22
	Ice	0.028	0.180	0.221	0.314	0.349	0.398	51	0
Total Nitrogen (TN)	Open	0.07	0.19	0.25	0.37	0.64	6.39	72	0
	Ice	0.19	0.33	0.40	0.49	0.59	0.89	50	0
Total Dissolved Phosphorus (TDP)	Open	0.002	0.002	0.003	0.005	0.009	0.080	80	32
	Ice	0.002	0.002	0.003	0.004	0.006	0.011	51	22
Total Phosphorus (TP)	Open	0.002	0.008	0.013	0.021	0.147	2.380	81	1
	Ice	0.002	0.007	0.008	0.014	0.022	0.142	51	2
Sulphate (SO_4^-)	Open	14.8	31.3	35.8	44.6	52.1	92.7	70	0
	Ice	17.6	40.6	45.0	50.8	58.0	92.3	50	0
Sodium Adsorption Ratio (SAR)	Open	0.16	0.33	0.42	0.48	0.59	0.84	70	0
	Ice	0.17	0.40	0.46	0.51	0.60	0.80	50	0
Specific Conductivity µS/cm	Open	227	296	323	350	391	492	78	0
	Ice	240	338	358	412	437	497	51	0
Total Dissolved Solids	Open	127	169	182	202	224	308	69	0
	Ice	135	200	217	239	256	305	50	0
Total Organic Carbon	Open	1.3	2.1	2.4	3.0	3.9	19.6	70	0
	Ice	1.0	1.4	1.7	2.0	2.5	5.4	50	0
Total Suspended Solids	Open	1	6	10	24	163	3700	80	3
	Ice	1	3	6	14	34	159	51	3
Turbidity NTU	Open	2.0	5.7	10.0	21.8	143.9	2200.0	78	0
	Ice	2.0	4.0	6.2	14.9	26.2	150.0	51	0
pH	Open	7.30	8.21	8.33	8.42	8.53	8.64	78	0
	Ice	7.88	8.05	8.19	8.23	8.27	8.43	51	0
Escherichia coli cfu per 100 mL	Open	1	4	13	29	77	>6000	73	8
	Ice	1	1	2	8	13	47	48	12

Table A7: Summary Statistics for the Oldman River at Hwy 36 – General Indicators

Note: Unless otherwise noted, all values are in mg/L; n= sample size, P= percentile, BDL=Below analytical detection limit.

General Indicator	Season	Min	25th P	Median	75th P	90th P	Max	n	# Samples BDL
Total Ammonia (NH_{3+4}-N)	Open	0.005	0.005	0.020	0.030	0.090	0.260	78	31
	Ice	0.005	0.010	0.040	0.093	0.135	0.250	56	12
Chloride (Cl^-)	Open	1.4	3.0	4.0	4.8	6.1	13.2	70	0
	Ice	1.7	4.6	6.0	7.1	8.1	13.0	50	0
Nitrate (NO_3-N)	Open	0.002	0.002	0.006	0.030	0.127	1.100	78	28
	Ice	0.005	0.226	0.318	0.407	0.502	0.665	56	0
Total Nitrogen (TN)	Open	0.03	0.21	0.31	0.37	0.75	7.33	70	0
	Ice	0.13	0.45	0.59	0.69	0.96	1.21	55	0
Total Dissolved Phosphorus (TDP)	Open	0.002	0.002	0.003	0.005	0.011	0.131	78	28
	Ice	0.002	0.002	0.003	0.005	0.007	0.022	56	22
Total Phosphorus (TP)	Open	0.002	0.011	0.015	0.021	0.160	2.370	78	1
	Ice	0.002	0.006	0.009	0.012	0.018	0.062	56	5
Sulphate (SO_4^-)	Open	16.3	38.3	44.8	54.3	61.4	118.0	70	0
	Ice	20.4	50.8	58.1	66.8	77.4	96.7	50	0
Sodium Adsorption Ratio (SAR)	Open	0.26	0.45	0.56	0.63	0.78	1.35	70	0
	Ice	0.22	0.56	0.65	0.76	0.80	0.96	50	0
Specific Conductivity µS/cm	Open	238	314	355	387	422	555	78	0
	Ice	259	375	416	467	502	540	51	0
Total Dissolved Solids	Open	134	182	200	225	243	360	70	0
	Ice	151	228	246	279	296	330	50	0
Total Organic Carbon	Open	1.7	2.5	2.9	3.4	4.4	19.8	70	0
	Ice	1.2	1.8	2.2	2.6	3.0	5.2	55	0
Total Suspended Solids	Open	1	6	11	24	190	3700	77	5
	Ice	0	1	3	7	15	58	56	9
Turbidity NTU	Open	2.9	6.7	10.0	19.3	173.0	1520.0	78	0
	Ice	1.1	3.0	4.8	8.0	17.3	55.0	51	0
pH	Open	7.74	8.25	8.36	8.47	8.53	8.64	78	0
	Ice	7.82	8.09	8.21	8.27	8.32	8.44	56	0
Escherichia coli cfu per 100 mL	Open	1	3	14	42	151	>10000	70	6
	Ice	1	1	3	7	17	60	53	15

Table A8: Summary Statistics for the South Saskatchewan River at Medicine Hat-Hwy 1 – General Indicators

Note: Unless otherwise noted, all values are in mg/L; n= sample size, P= percentile, BDL=Below analytical detection limit.

General Indicator	Season	Min	25th P	Median	75th P	90th P	Max	n	# Samples BDL
Total Ammonia (NH_{3+4}-N)	Open	0.005	0.005	0.020	0.030	0.060	0.140	70	33
	Ice	0.005	0.029	0.090	0.180	0.253	0.310	48	10
Chloride (Cl^-)	Open	2.6	5.1	6.4	7.9	9.8	16.7	70	0
	Ice	4.3	10.2	12.6	16.4	19.9	28.0	48	0
Nitrate (NO_3-N)	Open	0.002	0.007	0.103	0.294	0.497	4.300	69	14
	Ice	0.322	0.724	1.015	1.170	1.258	1.970	48	0
Total Nitrogen (TN)	Open	0.17	0.35	0.55	0.71	1.01	4.52	70	0
	Ice	0.45	1.06	1.33	1.54	1.72	2.40	48	0
Total Dissolved Phosphorus (TDP)	Open	0.002	0.003	0.004	0.006	0.009	0.038	70	17
	Ice	0.002	0.002	0.004	0.006	0.010	0.064	48	15
Total Phosphorus (TP)	Open	0.002	0.012	0.023	0.048	0.098	0.472	70	2
	Ice	0.002	0.008	0.011	0.017	0.042	0.148	48	1
Sulphate (SO_4^-)	Open	25.4	49.1	56.5	64.8	76.9	111.0	70	0
	Ice	29.8	58.2	62.4	72.3	77.6	187.0	48	0
Sodium Adsorption Ratio (SAR)	Open	0.24	0.48	0.60	0.70	0.79	1.01	70	0
	Ice	0.29	0.50	0.59	0.69	0.88	1.59	48	0
Specific Conductivity µS/cm	Open	264	337	369	404	436	522	68	0
	Ice	311	415	462	501	519	807	48	0
Total Dissolved Solids	Open	160	199	221	240	252	320	70	0
	Ice	182	246	268	289	316	512	48	0
Total Organic Carbon	Open	2.0	2.4	2.7	3.3	4.0	5.3	34	0
	Ice	1.3	1.6	1.7	2.3	3.0	3.6	13	0
Total Suspended Solids	Open	0	7	19	54	105	696	70	1
	Ice	1	2	5	10	32	205	48	0
Turbidity NTU	Open	2.0	6.5	16.4	32.7	80.5	550.0	70	0
	Ice	1.2	3.0	4.0	10.9	28.3	110.0	48	0
pH	Open	7.73	8.24	8.32	8.39	8.47	8.78	70	0
	Ice	7.76	8.01	8.14	8.23	8.27	8.46	48	0
Escherichia coli cfu per 100 mL	Open	1	3	13	38	99	700	68	7
	Ice	1	1	1	3	7	13	48	20

Additional Parameters analyzed for

(with no detectable levels reported in this report for Pesticides and Organics)

Pesticides also sampled for with no detects
2,4-DB ug/L
2,4-DICHLOROPHENOL ug/L
4-CHLORO-2-METHYLPHENOL ug/L
ALDICARB ug/L
ALDRIN ug/L
ALPHA-BENZENEHEXACHLORIDE(BHC) ug/L
ALPHA-ENDOSULFAN ug/L
AMINOPYRALID ug/L
ATRAZINE ug/L
BENTAZON ug/L
BROMACIL ug/L
CARBATHIIN (CARBOXIN) ug/L
CHLOROTHALONIL ug/L
CHLORPYRIFOS-ETHYL (DURSBAN) ug/L
CYANAZINE ug/L
DESETHYL ATRAZINE ug/L
DESISOPROPYL ATRAZINE ug/L
DIAZINON ug/L
DICAMBA (BANVEL) ug/L
DICHLORPROP(2,4-DP) ug/L
DICLOFOP-METHYL (HOEGRASS) ug/L
DIELDRIN ug/L
DIMETHOATE (CYGON) ug/L
DISULFOTON (DI-SYSTON) ug/L
DIURON ug/L
ETHALFLURALIN (EDGE) ug/L
ETHOFUMESATE ug/L
FLUAZIFOP ug/L
GAMMA-BENZENEHEXACHLORIDE (LINDANE) (GAMMA-BHC) ug/L
GUTHION (AZINPHOS METHYL) (AZINPHOS ETHYL) ug/L
HEXACONAZOLE ug/L
IMAZAMETHABENZ-METHYL ug/L
IMAZAMOX ug/L
IMAZETHAPYR ug/L
IPRODIONE ug/L
LINURON ug/L
MALATHION ug/L
MCPB ug/L
METALAXYL-M ug/L
METHOMYL ug/L
METHOXYCHLOR (P,P'-METHOXYCHLOR) ug/L
METOLACHLOR ug/L

METRIBUZIN ug/L
NAPROPAMIDE ug/L
OXYCARBOXIN ug/L
PARATHION ug/L
PHORATE (THIMET) ug/L
PROPICONAZOLE ug/L
PYRIDABEN ug/L
QUINCLORAC ug/L
QUIZALOFOP ug/L
SIMAZINE ug/L
TERBUFOS ug/L
TRICLOPYR ug/L
TRIFLURALIN(TREFLAN) ug/L
VINCLOZOLIN ug/L

MCPA ug/L
BROMOXYNIL ug/L
FLUROXYPYR ug/L
PICLORAM (TORDON) ug/L
CLODINAFOP ACID METABOLITE ug/L
CLODINAFOP-PROPARGYL ug/L
CLOPYRALID (LONTREL) ug/L
ETHION ug/L
FENOXAPROP-P-ETHYL ug/L
THIAMETHOXAM ug/L
TRIALLATE (AVADEX BW) ug/L

Organic chemicals also tested for with no detects
2,4-DICHLOROPHENOL ug/L
3-METHYLCHOLANTHRENE ug/L
4-CHLORO-2-METHYLPHENOL ug/L
7,12-DIMETHYLBENZ(A)ANTHRACENE ug/L
ACENAPHTHYLENE ug/L
ACRIDINE ug/L
BENZO(C)PHENANTHRENE ug/L
DIBENZO(A,H)ANTHRACENE ug/L
DIBENZO(A,H)PYRENE ug/L
DIBENZO(A,I)PYRENE ug/L
DIBENZO(A,L)PYRENE ug/L
F2, HYDROCARBONS (C10-C16) ug/L
F3, HYDROCARBONS (C16-C34) ug/L
F4, HYDROCARBONS (C34-C50) ug/L

Metals also tested for, data available (see links to websites below)
ALUMINUM DISSOLVED (AL) ug/L
ALUMINUM TOTAL RECOVERABLE ug/L
ANTIMONY DISSOLVED (SB) ug/L
ANTIMONY TOTAL RECOVERABLE ug/L
ARSENIC DISSOLVED ug/L
ARSENIC TOTAL mg/L

ARSENIC TOTAL RECOVERABLE ug/L
BARIUM DISSOLVED mg/L
BARIUM DISSOLVED ug/L
BARIUM TOTAL RECOVERABLE ug/L
BERYLLIUM DISSOLVED ug/L
BERYLLIUM TOTAL RECOVERABLE ug/L
BISMUTH DISSOLVED ug/L
BISMUTH TOTAL RECOVERABLE ug/L
BORON DISSOLVED mg/L
BORON DISSOLVED ug/L
BORON TOTAL RECOVERABLE ug/L
CADMIUM DISSOLVED ug/L
CADMIUM TOTAL RECOVERABLE ug/L
CALCIUM DISSOLVED mg/L
CALCIUM TOTAL RECOVERABLE mg/L
CHLORINE DISSOLVED mg/L
CHLORINE TOTAL RECOVERABLE mg/L
CHROMIUM DISSOLVED mg/L
CHROMIUM DISSOLVED ug/L
CHROMIUM HEXAVALENT mg/L
CHROMIUM TOTAL RECOVERABLE ug/L
COBALT DISSOLVED ug/L
COBALT TOTAL RECOVERABLE ug/L
COPPER DISSOLVED ug/L
COPPER TOTAL RECOVERABLE ug/L
IRON DISSOLVED mg/L
IRON DISSOLVED ug/L
IRON TOTAL RECOVERABLE ug/L
LEAD DISSOLVED ug/L
LEAD TOTAL RECOVERABLE - PB ug/L
LITHIUM DISSOLVED mg/L
LITHIUM DISSOLVED ug/L
LITHIUM TOTAL RECOVERABLE ug/L
MANGANESE DISSOLVED mg/L
MANGANESE DISSOLVED ug/L
MANGANESE TOTAL RECOVERABLE ug/L
MERCURY TOTAL ng/L
MERCURY TOTAL ug/L
MOLYBDENUM DISSOLVED ug/L
MOLYBDENUM TOTAL RECOVERABLE ug/L
NICKEL DISSOLVED ug/L
NICKEL TOTAL RECOVERABLE ug/L
PHOSPHORUS DISSOLVED mg/L
SELENIUM DISSOLVED ug/L
SELENIUM TOTAL mg/L
SELENIUM TOTAL RECOVERABLE ug/L
SELENIUM_82 EXTRACTABLE - SE ug/g
SILICON DISSOLVED mg/L
SILVER DISSOLVED ug/L
SILVER TOTAL RECOVERABLE ug/L

STRONTIUM DISSOLVED mg/L
STRONTIUM DISSOLVED ug/L
STRONTIUM TOTAL RECOVERABLE ug/L
SULPHUR DISSOLVED mg/L
THALLIUM DISSOLVED ug/L
THALLIUM TOTAL RECOVERABLE ug/L
THORIUM DISSOLVED ug/L
THORIUM TOTAL RECOVERABLE ug/L
TIN DISSOLVED ug/L
TIN TOTAL RECOVERABLE ug/L
TITANIUM DISSOLVED ug/L
TITANIUM EXTRACTABLE ug/L
TITANIUM TOTAL RECOVERABLE ug/L
URANIUM DISSOLVED ug/L
URANIUM TOTAL RECOVERABLE ug/L
VANADIUM DISSOLVED ug/L
VANADIUM TOTAL RECOVERABLE ug/L
ZINC DISSOLVED ug/L
ZINC TOTAL RECOVERABLE ug/L

LINKS TO RELEVANT WEBSITES

Spreadsheets with the river, stream and reservoir detailed, complete data collected is available at:
http://environment.alberta.ca/04221.html

Ambient water use guidelines
http://www.ccme.ca/publications/cegg_rcge.html

Specific Canadian Council of Ministers of the Environment guidelines

Contact recreation guidelines: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/guide_water-2012-guide_eau/index-eng.php#a411

General Water Quality information:
http://www.environment.alberta.ca/01256.html

Additional sites with information on flood issues
Alberta Health Services
http://www.albertahealthservices.ca/8644.asp
Alberta Agriculture
http://www.agric.gov.ab.ca/app21/rtw/index.jsp
Alberta Health
http://www.health.alberta.ca/
Health Canada (especially for First Nations)
http://www.hc-sc.gc.ca/index-eng.php