



Palliser Environmental Services Ltd.

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Dear Sarah,

RE: Horse Creek Baseline Water Monitoring Letter Report

Palliser Environmental Services Ltd. completed the 2015 water monitoring at Horse Creek for the Little Creeks and Rough Fescue Appreciation Society (LCARF) on October 13, 2015. The results for 2015 have been compiled in this letter report, and the historical data were provided for reference.

METHODS

Water monitoring occurred twice per month in April, May and June and once per month from July to October at three sites in the Horse Creek watershed in 2015. Sites represent upstream (Upper), middle (Middle) and downstream (Lower) water quality. Samples were analysed for total phosphorus, total dissolved phosphorus, total nitrogen, total suspended solids and fecal coliform bacteria at an accredited laboratory in Calgary. A multi-meter was used to collect dissolved oxygen, pH, specific conductivity and total dissolved solids data at each site. Discharge measurements were also collected to quantify streamflow using a Swiffer water velocity meter.

RESULTS

Streamflow

In 2015, streamflow in Horse Creek was the lowest recorded since 2012. Median flow at the Upper site was 0.001 m³/s, 0.024 m³/s at the Middle site and 0.030 m³/s at the Lower site (Table 1).

Table 1. Summary of streamflow data at Horse Creek, 2012-2015.

Year	Streamflow (m ³ /s)			
	Upper	Middle - AG	Middle	Lower
2012	-	0.061 (0.022-0.221)	0.126 (0.030-0.364)	0.089 (0.043-0.338)
2013	0.002 (0.001-0.008)	-	0.097 (0.032-0.561)	0.122 (0.032-0.852)
2014	0.005 (0.001-0.068)	-	0.191 (0.053-1.869)	0.290 (0.060-1.869)
2015	0.001 (0.001-0.001)	-	0.024 (0.002-0.033)	0.030 (0.002-0.055)

*Note: Flows were below detection at the original Upper site in 2012. The Upper site was relocated in 2013.



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Temperature

Median temperature was 8.95°C at the Upper site, 9.25°C at the Middle site and 9.85°C at the Lower site. Maximum water temperatures recorded were less than 18°C and suitable for trout species. Note that water temperature tends to fluctuate throughout the day and night; these measurements represent water temperature at the time of sampling.

Table 2. Summary of temperature data at Horse Creek, 2012-2015.

Year	Temperature (°C)			
	Upper	Middle - AG	Middle	Lower
2012	10.2 (3.85-14.34)	9.88 (3.04-15.73)	10.04 (0.87-16.36)	10.50 (0.36-16.19)
2013	9.27 (2.25-11.66)	-	11.67 (0.50-14.77)	11.1 (0.00-15.67)
2014	7.75 (1.80-12.00)	-	7.50 (2.50-16.30)	8.7 (1.40-15.60)
2015	8.95 (5.40-14.90)	-	9.25 (3.50-17.00)	9.85 (4.30-15.00)

pH

The median pH was higher at the Lower site (8.35) compared to the Upper (7.85) and Middle (8.15) sites in 2015 (Table 3). All values were within the water quality guidelines for the protection of aquatic life (≥ 6.5 and ≤ 9.0) (ESRD 2014).

Table 3. Summary of pH data at Horse Creek, 2012-2015.

Year	pH (Value)			
	Upper	Middle - AG	Middle	Lower
2012	8.34 (8.13-8.98)	8.37 (7.95-9.03)	8.17 (7.84-8.61)	7.90 (6.99-8.42)
2013	8.07 (7.74-9.50)	-	8.28 (7.85-9.60)	8.53 (8.05-8.67)
2014	7.90 (7.30-8.30)	-	8.50 (7.50-8.30)	8.50 (7.30-8.90)
2015	7.85 (6.90-8.20)	-	8.15 (6.70-8.70)	8.35 (6.60-8.70)

Dissolved Oxygen

In 2015, the median dissolved oxygen concentration was 9.26 mg/L at the Upper site, 10.09 mg/L at the Middle site and 11.41 mg/L at the Lower site. All values were within the water quality guidelines for the protection of aquatic life (>5.0 mg/L acute guideline or 6.5 mg/L chronic guideline).

Table 4. Summary of dissolved oxygen data at Horse Creek, 2012-2015.

Year	Dissolved Oxygen (mg/L)			
	Upper	Middle - AG	Middle	Lower
2012	10.20 (3.85-14.34)	9.88 (3.04-15.73)	10.04 (0.87-16.36)	10.50 (0.36-16.19)
2013	7.33 (3.00-10.43)	-	7.66 (0-11.05)	8.85 (4.10-12.79)
2014	8.80 (7.30-10.27)	-	9.36 (5.93-11.15)	10.36 (8.77-11.87)
2015	9.26 (8.76-10.76)	-	10.09 (7.80-11.95)	11.41 (9.99-13.91)



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Specific Conductivity

Median specific conductivity was 633 $\mu\text{S}/\text{cm}$ at the Upper site, 664 $\mu\text{S}/\text{cm}$ at the Middle site and 656 $\mu\text{S}/\text{cm}$ at the Lower site in 2015 (Table 5). All values were below the water quality guideline for irrigation of general crops ($<1000 \mu\text{S}/\text{cm}$) in 2015. The water quality guideline for irrigation of sensitive crops ($<700 \mu\text{S}/\text{cm}$) was exceeded once at the Upper site in mid-July (717 $\mu\text{S}/\text{cm}$) and twice at the Middle site with values of 702 $\mu\text{S}/\text{cm}$ and 739 $\mu\text{S}/\text{cm}$ in May. The irrigation guideline for sensitive crops was exceeded three times at the Lower sites with values of 746 $\mu\text{S}/\text{cm}$ in July, 705 $\mu\text{S}/\text{cm}$ in August and 704 $\mu\text{S}/\text{cm}$ in October.

Table 5. Summary of specific conductivity data at Horse Creek, 2012-2015.

Year	Specific Conductivity ($\mu\text{S}/\text{cm}$)			
	Upper	Middle - AG	Middle	Lower
2012	561 (401-1013)	615 (394-719)	638 (414-713)	699 (467-1077)
2013	614 (434-650)	-	586 (393-799)	627 (435-953)
2014	581 (143-630)	-	588 (222-648)	659 (260-822)
2015	633 (555-717)	-	664 (551-739)	656 (539-746)

Total Phosphorus

In 2015, median total phosphorus concentration was 0.017 mg/L at the Upper site, 0.051 mg/L at the Middle site and 0.017 mg/L at the Lower site (Table 6). Although there is no total phosphorus guideline specified in the updated water quality guidelines for Alberta (ESRD 2014), the historical water quality guideline for the protection of aquatic life was 0.05 mg/L (AENV 1999). All samples met the historical water quality guidelines at the Upper and Lower sites, while 5 of the 10 samples collected exceeded the guideline at the Middle site (May through August samples).

Table 6. Summary of total phosphorus data at Horse Creek, 2012-2015.

Year	Total Phosphorus (mg/L)			
	Upper	Middle - AG	Middle	Lower
2012	0.028 (0.009-0.063)	0.061 (0.012-0.135)	0.056 (0.011-0.145)	0.038 (0.004-0.121)
2013	0.012 (0.004-0.026)	-	0.051 (0.009-0.108)	0.032 (0.006-0.521)
2014	0.012 (0.006-0.298)	-	0.048 (0.013-0.277)	0.041 (0.027-0.691)
2015	0.017 (0.008-0.022)	-	0.051 (0.023-0.085)	0.017 (0.012-0.025)

Total Nitrogen

Median total nitrogen concentration was highest at the Upper site (0.870 mg/L), and decreased in the downstream direction: 0.640 mg/L at the Middle site and 0.385 mg/L at the Lower site (Table 7). Although there is no total nitrogen guideline specified in the updated water quality guidelines for Alberta (ESRD 2014), the historical water quality guideline for the protection of aquatic life was 1.0 mg/L (AENV 1999).



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Nitrate+nitrite nitrogen contributes to the majority of the total nitrogen concentrations observed at the Upper site, while organic nitrogen (total kjeldahl nitrogen) contributes the majority of total nitrogen at the Middle and Lower sites. The increased nitrate-nitrite nitrogen in the headwaters is likely due to the contribution of groundwater to baseflows in the Upper reaches of the watershed.

Table 7. Summary of total nitrogen data at Horse Creek, 2012-2015.

Year	Total Nitrogen (mg/L)			
	Upper	Middle - AG	Middle	Lower
2012	0.640 (0.460-1.300)	1.010 (0.790-1.330)	1.090 (0.620-1.240)	0.880 (0.410-1.630)
2013	0.945 (0.780-1.100)	-	0.810 (0.540-1.540)	0.740 (0.038-1.440)
2014	0.810 (0.600-1.280)	-	0.785 (0.620-1.370)	0.755 (0.550-2.540)
2015	0.870 (0.650-1.430)	-	0.640 (0.450-1.160)	0.385 (0.250-0.940)

Total Suspended Solids

Median total suspended solids concentration (TSS) was 6.5 mg/L at the Upper site, 5.7 mg/L at the Middle site and 2.4 mg/L at the Lower site (Table 8). The median total suspended solids concentration was the highest in 2015 compared to previous years, at the Upper and Middle sites. This is likely due to low flows and very fine organic sediments, particularly at the Upper site. Wind action can re-suspend some of the organic fines found at this site.

The median concentration at the Lower site in 2015 was the lowest since the baseline monitoring program was initiated in 2012. The range of values observed at the Lower site was also substantially lower in 2015 compared to previous years. In 2015, the maximum concentration was 6.7 mg/L at the Lower site compared to 476.0 mg/L in 2014, 119.0 mg/L in 2013 and 51.0 mg/L in 2012. This is probably due to the absence of a spring freshet which can increase TSS through sediment resuspension, bank erosion and runoff. Further, low summer and fall flows likely reduced erosion and sediment transport to the creek from runoff events.

Table 8. Summary of total suspended solids data at Horse Creek, 2012-2015.

Year	Total Suspended Solids (mg/L)			
	Upper	Middle - AG	Middle	Lower
2012	2.0 (1.5-10.0)	18 (2.0-104.0)	5.0 (1.5-23.0)	11.5 (1.5-51.0)
2013	2.0 (2.0-4.0)	-	2.0 (2.0-12.0)	3.0 (2.0-119.0)
2014	2.0 (1.5-11.9)	-	4.1 (1.5 -14.5)	13.7 (3.6-476.0)
2015	6.5 (1.5-17.3)	-	5.7 (1.5-14)	2.4 (1.5-6.7)



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Fecal Coliform Bacteria

The median fecal coliform bacteria count was 1.5 cfu/100 mL at the Upper site, 172 cfu/100 mL at the Middle site and 121 cfu/100 mL at the Lower site (Table 9). The water quality guideline for irrigation is ≤ 100 cfu/100 mL. All samples were below this guideline at the Upper site, 6 of 10 samples exceeded the guideline at the Middle site and 7 of 10 samples exceeded the guideline at the Lower site. The sources of fecal coliform bacteria are unknown at Horse Creek, but are likely a combination of waterfowl, wildlife (e.g., muskrats, beaver and ungulates), livestock and environmental sources.

Table 9. Summary of fecal coliform bacteria data, 2012-2015.

Year	Fecal Coliform Bacteria (cfu/100 mL)			
	Upper	Middle - AG	Middle	Lower
2012	64.5 (1-1300)	54 (4-6000)	64 (1-16000)	115 (1-16000)
2013	8 (0.5-106)	-	170 (0.5-2400)	105 (2-3100)
2014	23 (0.5-196)	-	130 (0.5-1700)	334 (36-1400)
2015	1.5 (0.5-37)	-	172 (1-5200)	121 (8-12400)

SUMMARY

Median streamflow was substantially lower in 2015 ($0.030 \text{ m}^3/\text{s}$) compared to previous years (from $0.089 \text{ m}^3/\text{s}$ in 2012 to $0.290 \text{ m}^3/\text{s}$ in 2014). The upper range of specific conductivity values were lower in 2015 compared to previous years at the Lower site and most samples were below or near the irrigation guideline for sensitive crops ($700 \mu\text{S}/\text{cm}$). Median total phosphorus concentration was also substantially lower in 2015 compared to previous years; the maximum concentration at the Lower site was $0.025 \text{ mg}/\text{L}$ and half the historic water quality guideline concentration for the protection of aquatic life ($0.05 \text{ mg}/\text{L}$). Similar to total phosphorus, median total nitrogen was also substantially lower in 2015 compared to previous years. Similar to previous years, fecal coliform bacteria counts were mainly above the recommended value for irrigation ($100 \text{ cfu}/100 \text{ mL}$ at the Middle and Lower sites). The source of bacteria is unknown at this time, but likely waterfowl, wildlife, livestock and environmental sources contribute to these counts.

RECOMMENDATIONS

1. Continue water monitoring at Horse Creek.

Water monitoring should continue in 2016 as 2015 represented the first year of data collection with no external inputs from either construction activity or water from Cochrane Lake. In addition, streamflow was low in 2015. A series of “normal”, high and low streamflow years without external inputs will help establish baseline conditions at Horse Creek.

2. Establish water quality objectives for Horse Creek.

Water quality in Horse Creek should be maintained to meet agricultural use guidelines, including those established for livestock drinking water and irrigation, as well as contact recreation guidelines and guidelines established for the protection of aquatic life.



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CLOSURE

We trust that this report meets expectations. Please contact me at 403-921-5667 or email at sandi@palliserenvironmental.com if you have any questions regarding this report.

Sincerely,

A handwritten signature in black ink that reads "S. Riemersma".

Sandi Riemersma

Appendix A. Raw data for the Horse Creek baseline water monitoring program, 2015. Blue values indicate a value of half the detection limit.

DATE	SITE	TIME	Discharge	pH	TDS	COND	DO	DO	TEMP	FC	TP	TDP	TKN	NO3+NO2	NO3-N	NO2-N	TN	TSS
			m ³ /s	Value	mg/L	µS/cm	mg/L	%	°C	cfu/100 mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
14-Apr-15	Upper	12:15	0.001	7.7	420	646	9.0	72.0	5.4	0.5	0.0121	0.0085	0.30	0.473	0.473	0.005	0.77	1.5
14-Apr-15	Middle	11:10	0.025	7.9	391	603	11.0	83.0	3.9	1	0.0461	0.019	0.75	0.223	0.223	0.005	0.97	1.5
14-Apr-15	Lower	9:50	0.044	8.0	408	624	12.0	94.0	5.1	14	0.021	0.0072	0.47	0.025	0.01	0.005	0.47	1.5
28-Apr-15	Upper	12:00	0.001	7.0	403	618	8.93	77.8	9.3	0.5	0.0197	0.0073	0.32	0.481	0.481	0.005	0.8	6
28-Apr-15	Middle	11:00	0.027	8.1	421	649	11.95	100.4	7.8	16	0.0404	0.0184	0.42	0.062	0.062	0.005	0.48	6.7
28-Apr-15	Lower	10:00	0.036	8.5	417	641	11.97	99.4	7.3	8	0.0155	0.0059	0.34	0.025	0.01	0.005	0.34	3.3
11-May-15	Upper	11:30	0.001	8.1	406	627	9.44	78.7	7.5	0.5	0.0172	0.0054	0.58	1	0.423	0.005	1	9.3
11-May-15	Middle	10:45	0.033	8.4	457	702	11.07	86.5	4.9	40	0.033	0.0173	0.69	0.087	0.087	0.005	0.77	3.3
11-May-15	Lower	9:50	0.055	8.5	423	651	13.91	110.7	5.6	61	0.0127	0.0042	0.51	0.422	0.422	0.005	0.94	1.5
26-May-15	Upper	11:35	0.001	7.9	425	651	9.08	77.8	8.6	2	0.0221	0.0111	0.86	0.567	0.567	0.005	1.43	17.3
26-May-15	Middle	10:45	0.032	8.7	481	739	10.25	92.4	10.8	157	0.0609	0.0295	1.07	0.088	0.088	0.005	1.16	6
26-May-15	Lower	9:40	0.035	8.7	449	691	10.26	94.2	11.5	122	0.0178	0.0043	0.74	0.025	0.01	0.005	0.74	6
8-Jun-15	Upper	11:30	NC	7.8	401	616	8.76	86.7	14.9	6	0.0212	0.0074	0.24	0.625	0.625	0.005	0.87	6.7
8-Jun-15	Middle	10:45	0.018	7.8	432	664	9.93	99.1	15.3	89	0.081	0.0782	0.64	0.025	0.01	0.005	0.64	5.3
8-Jun-15	Lower	9:40	0.025	8.3	429	660	9.99	97.6	14.2	119	0.0161	0.0068	0.36	0.025	0.01	0.005	0.36	1.5
22-Jun-15	Upper	12:10	NC	7.6	401	618	8.82	82.8	12.5	10	0.0203	0.0082	0.39	0.476	0.476	0.005	0.87	6.7
22-Jun-15	Middle	11:15	0.023	8.2	431	664	9.48	85.3	10.7	234	0.0565	0.0255	0.58	0.064	0.064	0.005	0.64	8.7
22-Jun-15	Lower	10:15	0.039	8.2	415	637	10.35	94.1	11.1	394	0.0178	0.0061	0.34	0.025	0.01	0.005	0.34	5.3
14-Jul-15	Upper	11:35	NC	8.2	466	717	9.95	97.7	14.6	37	0.0162	0.0064	0.23	0.666	0.666	0.005	0.9	13.3
14-Jul-15	Middle	10:50	0.015	8.2	437	672	7.8	80.7	16.9	5200	0.0847	0.0402	0.85	0.061	0.061	0.005	0.91	14

DATE	SITE	TIME	Discharge	pH	TDS	COND	DO	DO	TEMP	FC	TP	TDP	TKN	NO3+NO2	NO3-N	NO2-N	TN	TSS
			m ³ /s	Value	mg/L	µS/cm	mg/L	%	°C	cfu/100 mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
14-Jul-15	Lower	9:50	0.002	8.4	486	746	11.77	116.7	15	12400	0.0246	0.0122	0.25	0.089	0.089	0.089	0.25	1.5
11-Aug-15	Upper	11:35	NC	6.9	436	639	10.76	99.8	12	5	0.0082	0.0032	0.1	0.654	0.654	0.005	0.65	5.3
11-Aug-15	Middle	10:50	0.002	6.7	379	584	8.54	88.4	17	600	0.0633	0.0297	0.62	0.025	0.01	0.005	0.62	8.0
11-Aug-15	Lower	9:50	0.002	6.6	458	705	11.32	109.3	13.8	1600	0.0162	0.0056	0.3	0.025	0.027	0.005	0.33	6.7
14-Sep-15	Upper	11:35	NC	8.0	360	555	10.01	81.2	6.4	1	0.0154	0.0059	0.42	0.291	0.291	0.005	0.72	3.3
14-Sep-15	Middle	10:50	0.031	7.3	358	551	8.9	74.6	7.7	186	0.0234	0.0113	0.45	0.025	0.01	0.005	0.45	4.7
14-Sep-15	Lower	9:55	0.023	7.0	349	539	10	85.6	8.6	500	0.0206	0.0053	0.48	0.025	0.01	0.005	0.48	4.0
13-Oct-15	Upper	11:15	NC	8.2	430	663	10.11	79.9	5.4	0.5	0.0163	0.0015	0.35	0.63	0.63	0.005	0.98	6.3
13-Oct-15	Middle	10:30	0.010	8.3	445	684	10.56	79.5	3.5	193	0.0237	0.0068	0.42	0.025	0.035	0.005	0.46	1.5
13-Oct-15	Lower	9:30	0.020	8.4	459	704	11.49	88.4	4.3	120	0.0117	0.0069	0.41	0.025	0.01	0.005	0.41	1.5