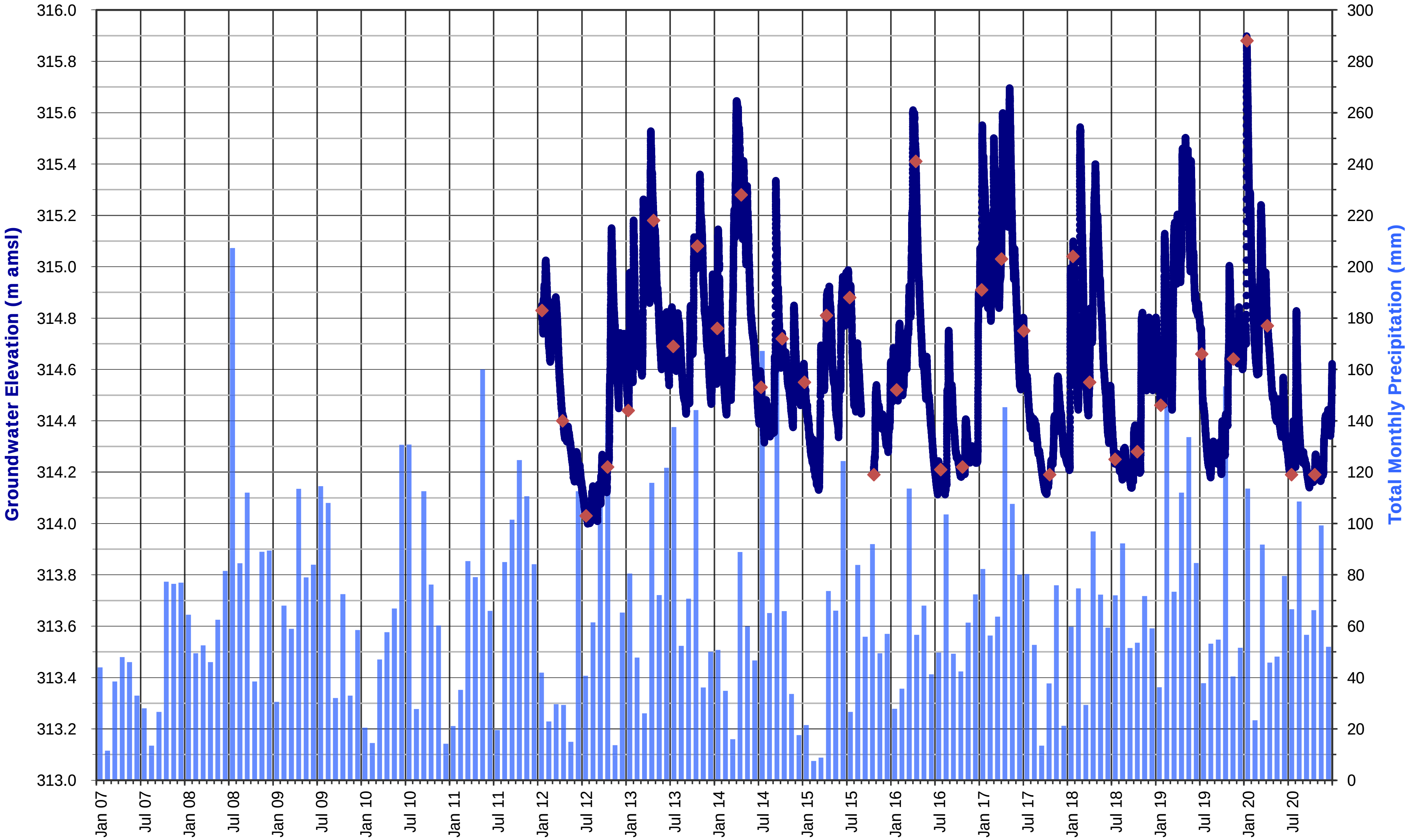
Appendix H

HCBP Perimeter Groundwater Monitoring 2007 – 2020

Banks Groundwater Engineering Limited

Groundwater Elevation & Precipitation - MW125 (January 2012 to December 2020)

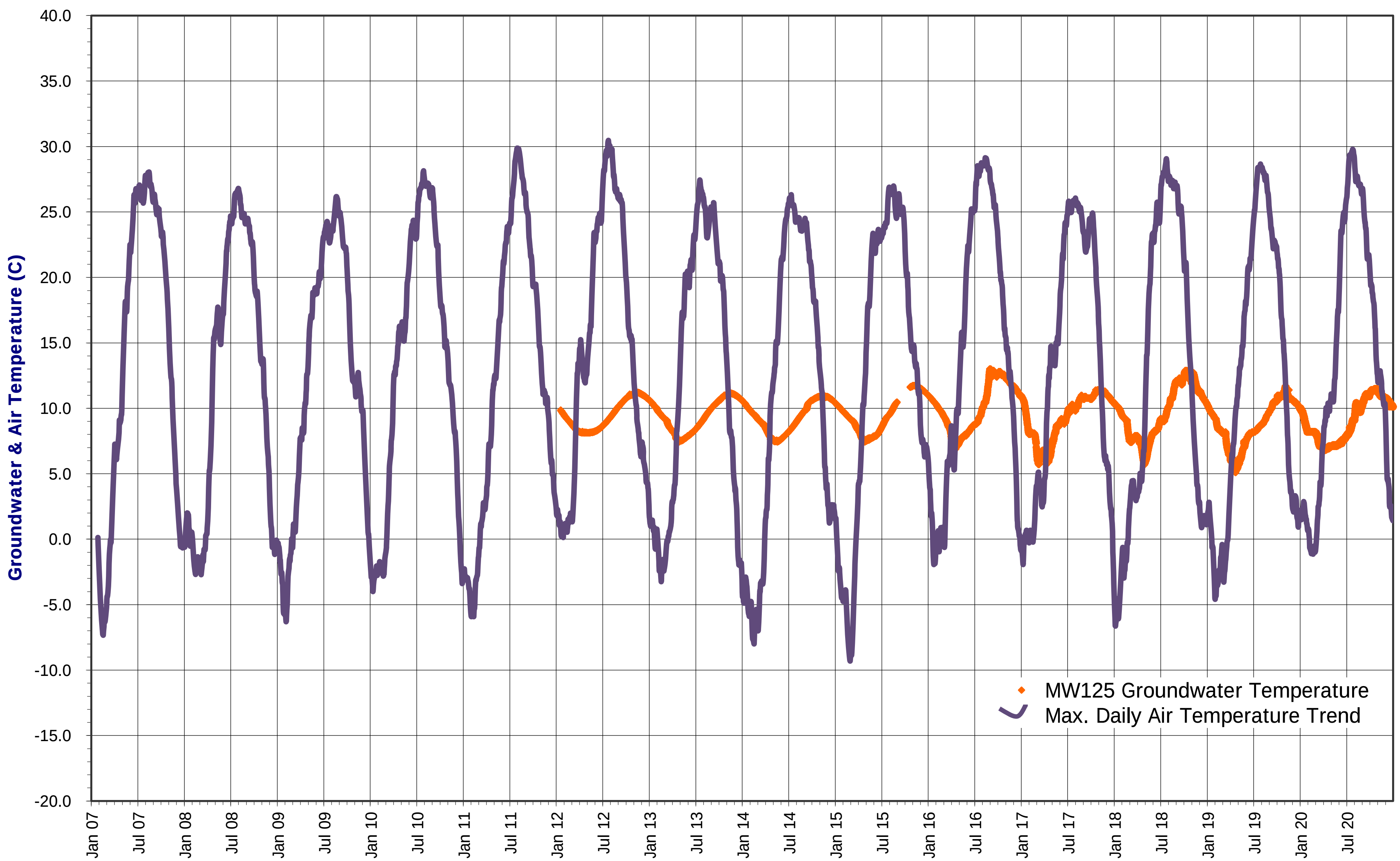


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 1**

Groundwater & Maximum Daily Air Temperature - MW125 (January 2012 to December 2020)

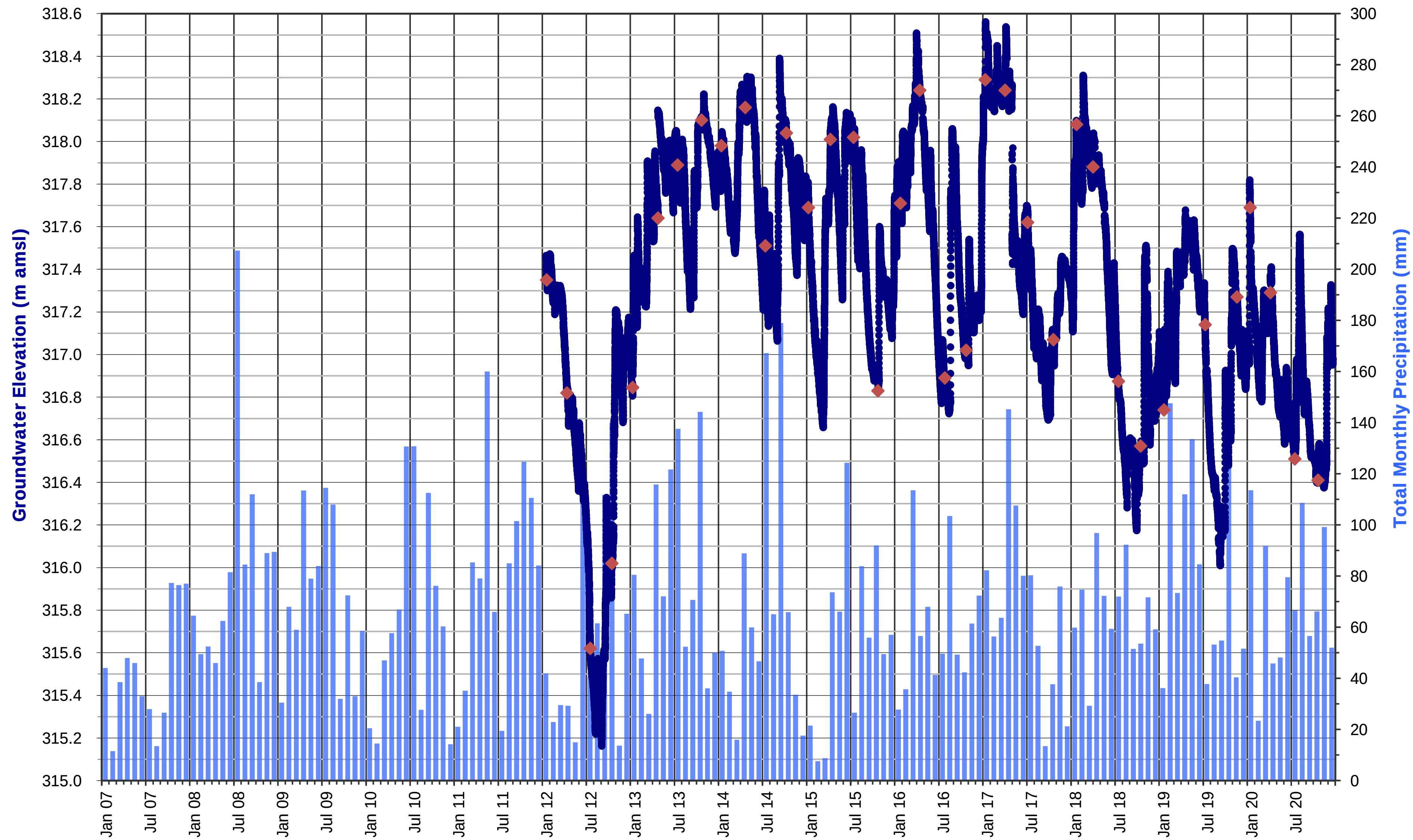


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 1a**

Groundwater Elevation & Precipitation - MW126 (January 2012 to December 2020)

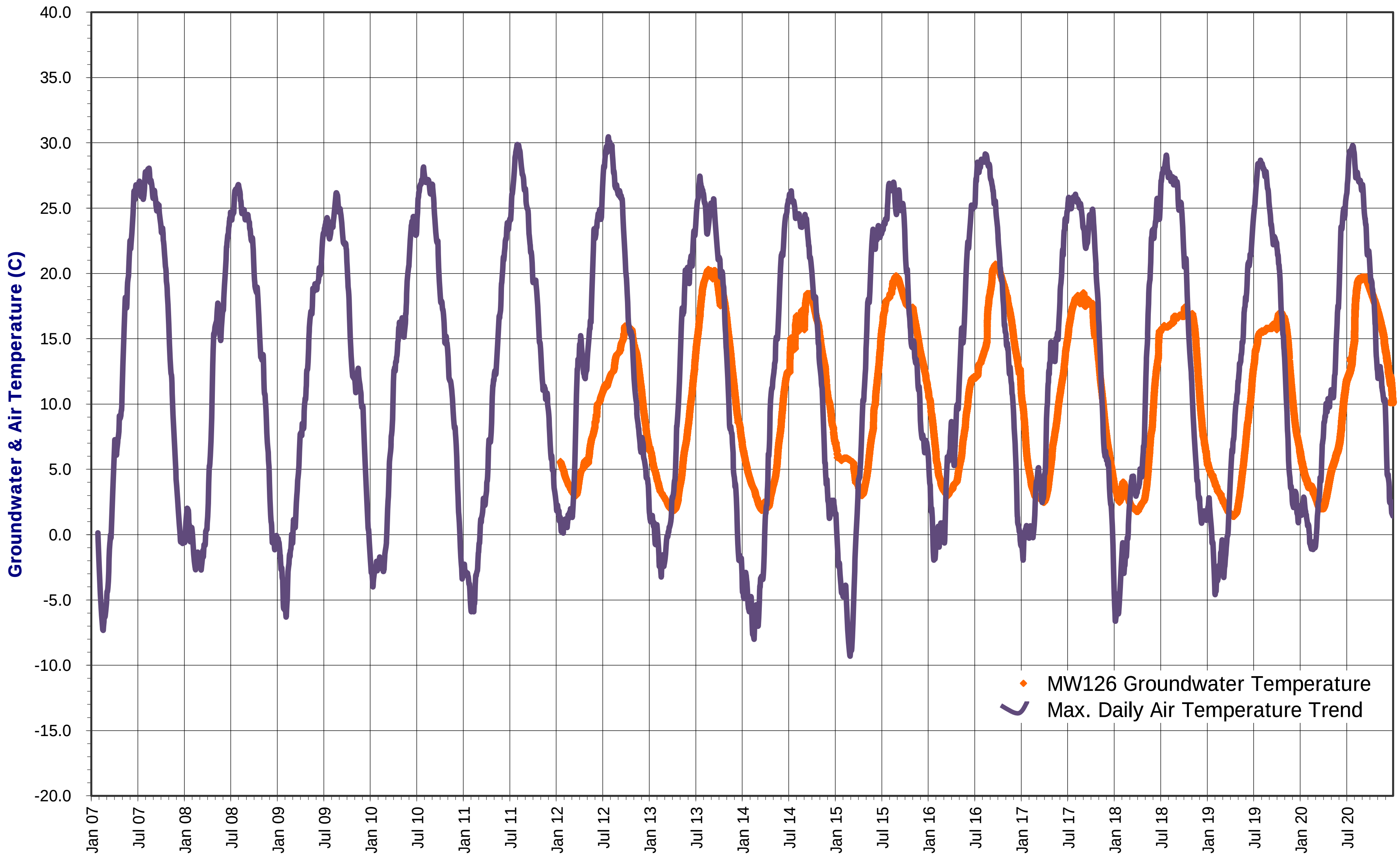


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 2**

Groundwater & Maximum Daily Air Temperature - MW126 (January 2012 to December 2020)

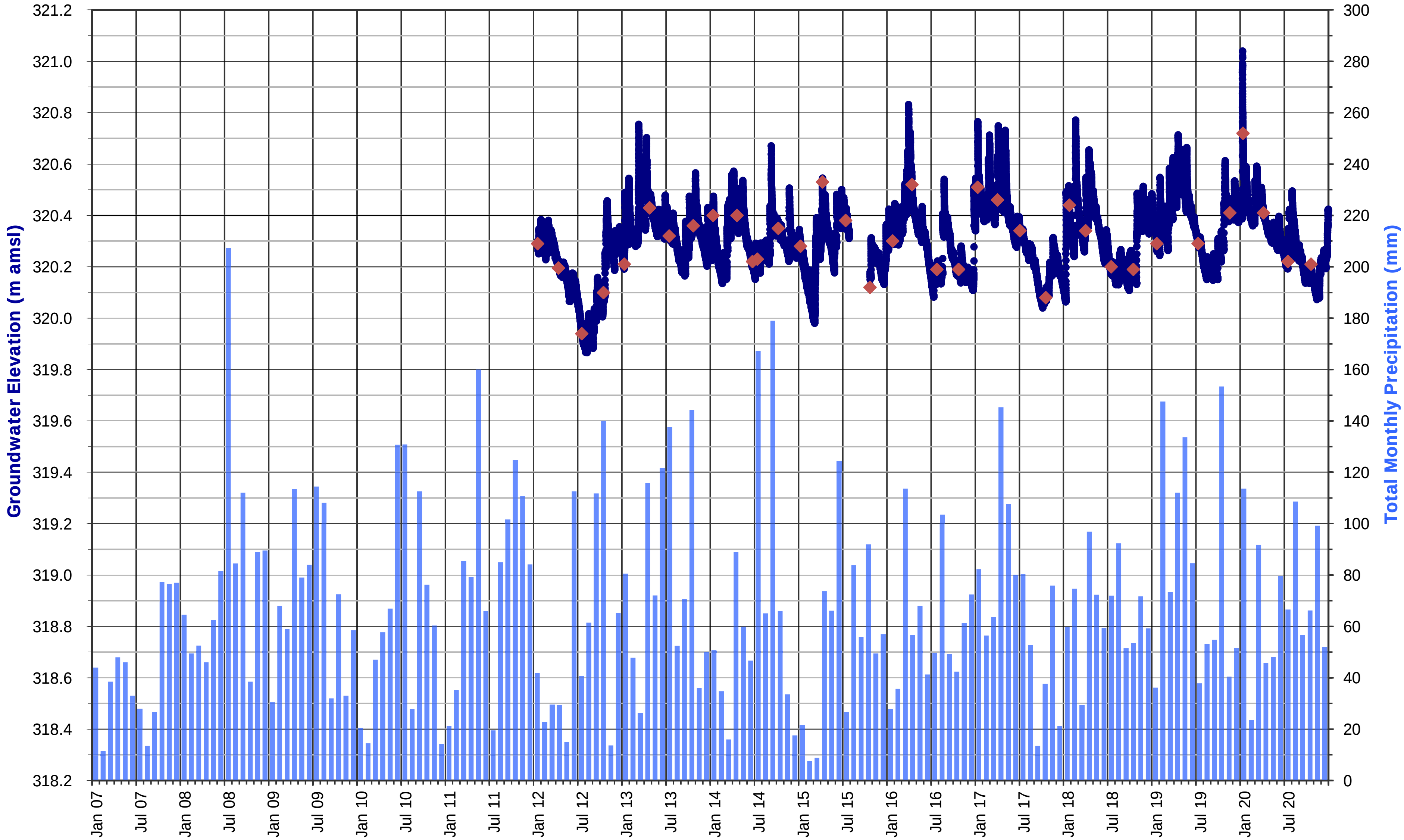


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 2a**

Groundwater Elevation & Precipitation - MW128 (January 2012 to December 2020)

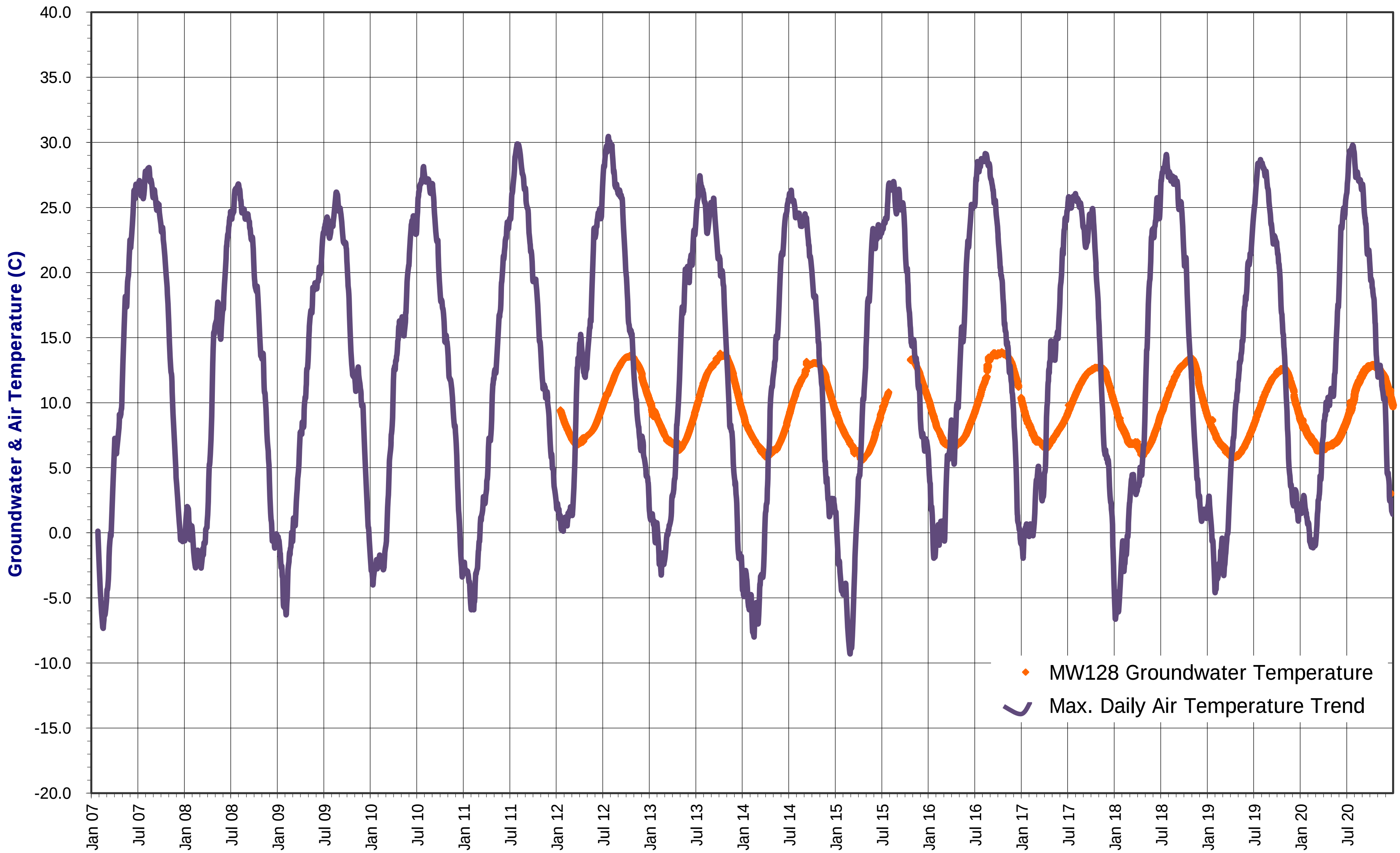


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 3**

Groundwater & Maximum Daily Air Temperature - MW128 (January 2012 to December 2020)



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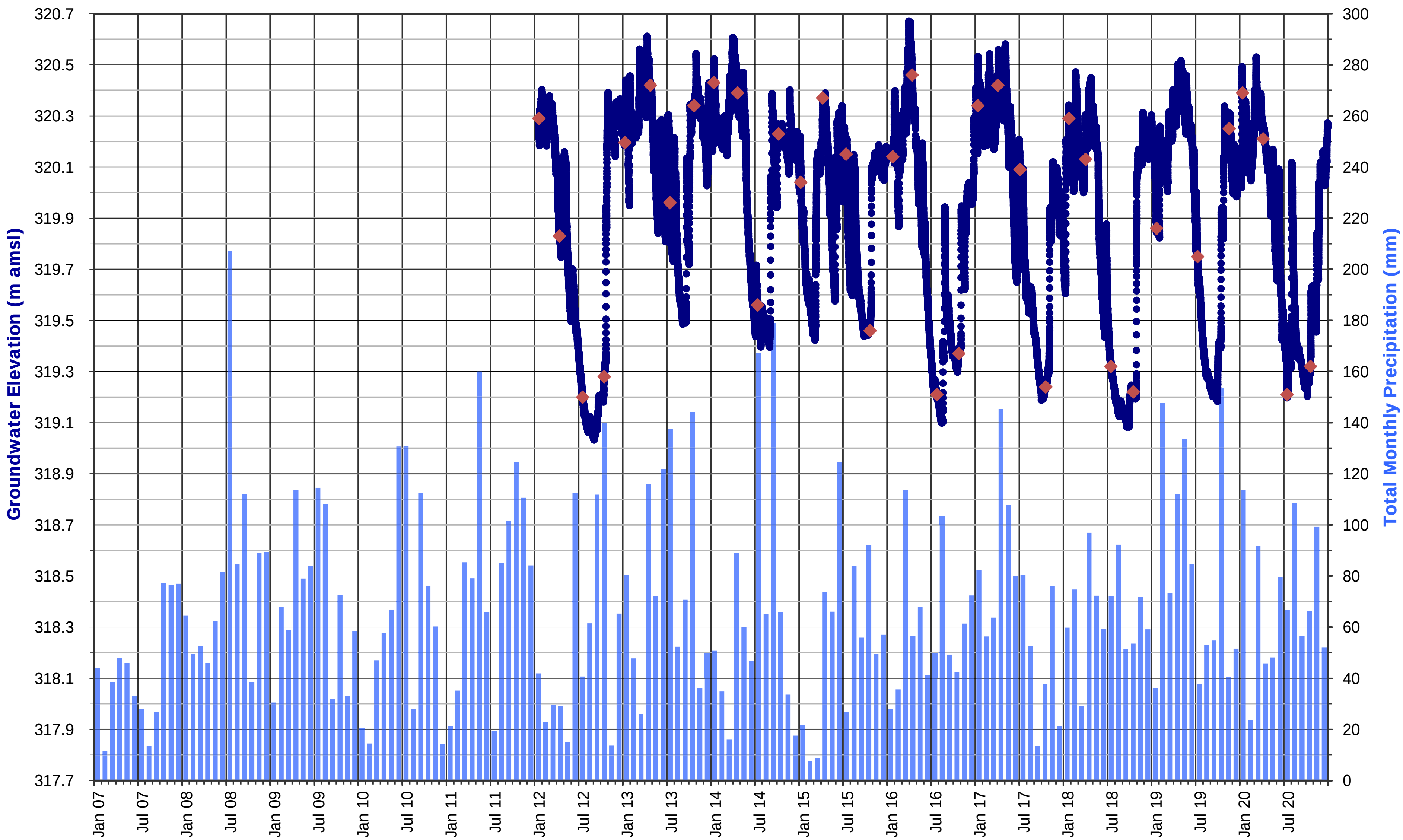
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Phase 1 - Perimeter Graph H 3a

Groundwater Elevation & Precipitation - MW124 (January 2012 to December 2020)

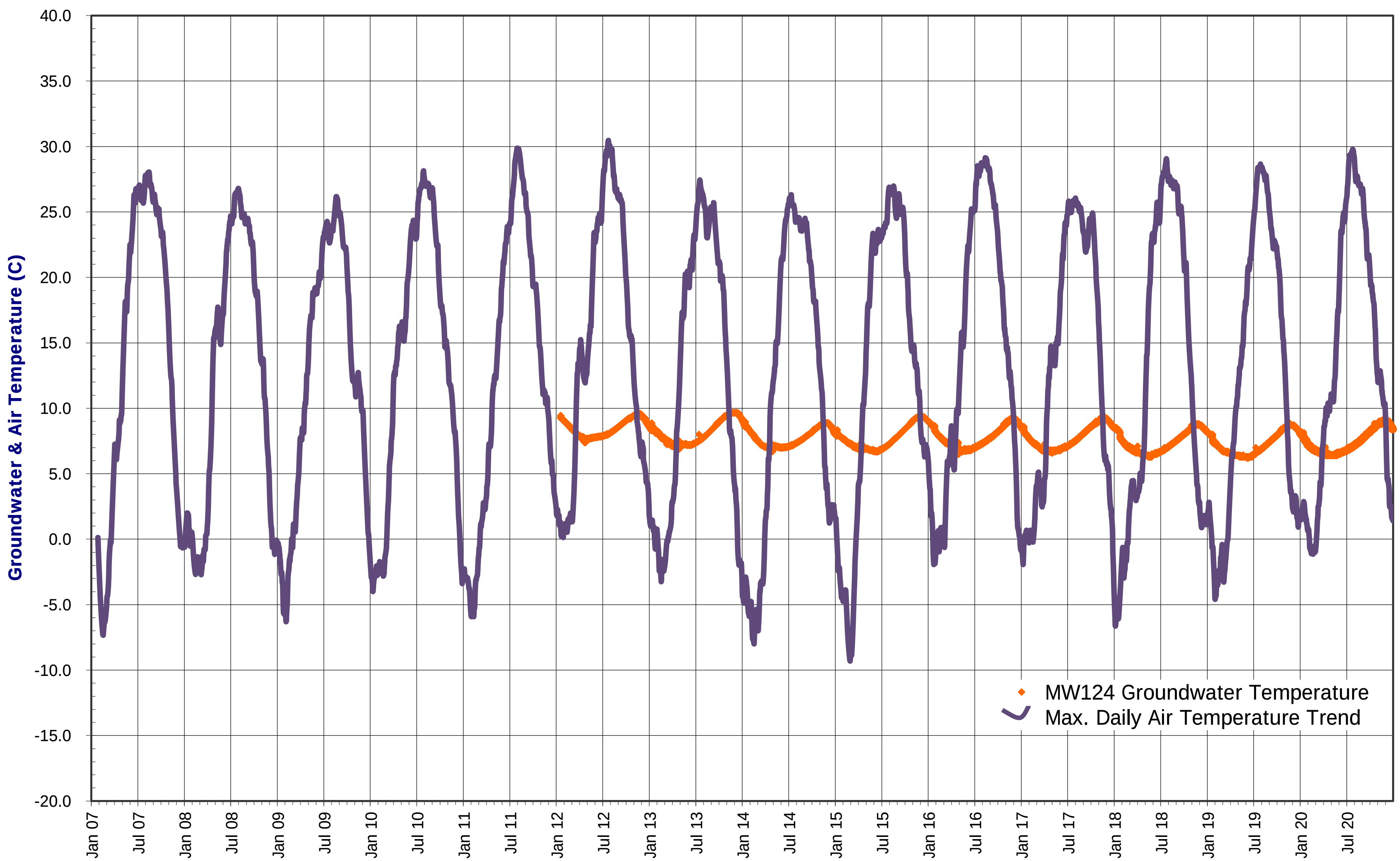


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 4**

Groundwater & Maximum Daily Air Temperature - MW124 (January 2012 to December 2020)

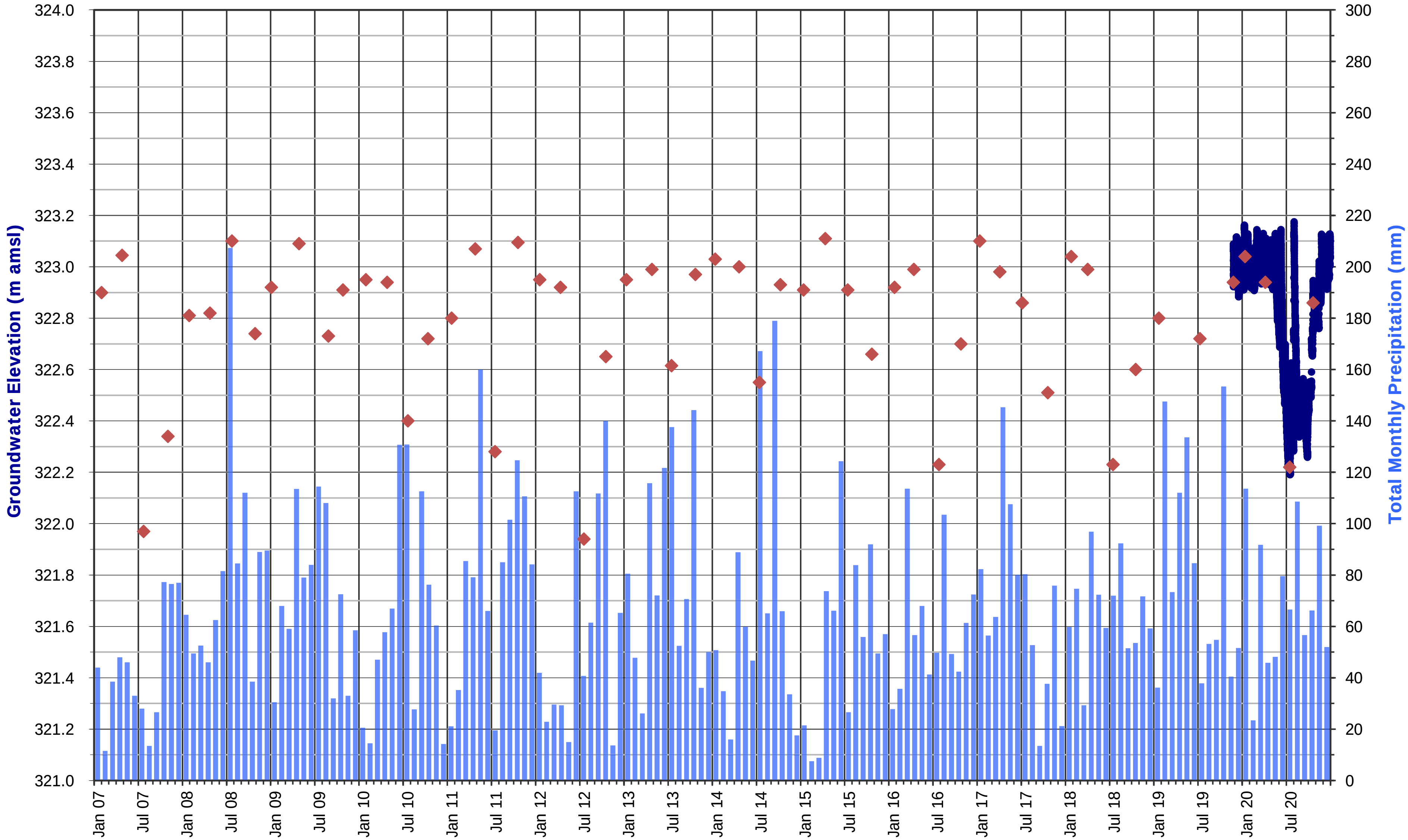


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 4a**

Groundwater Elevation & Precipitation - MW115A (November 2019 to December 2020)

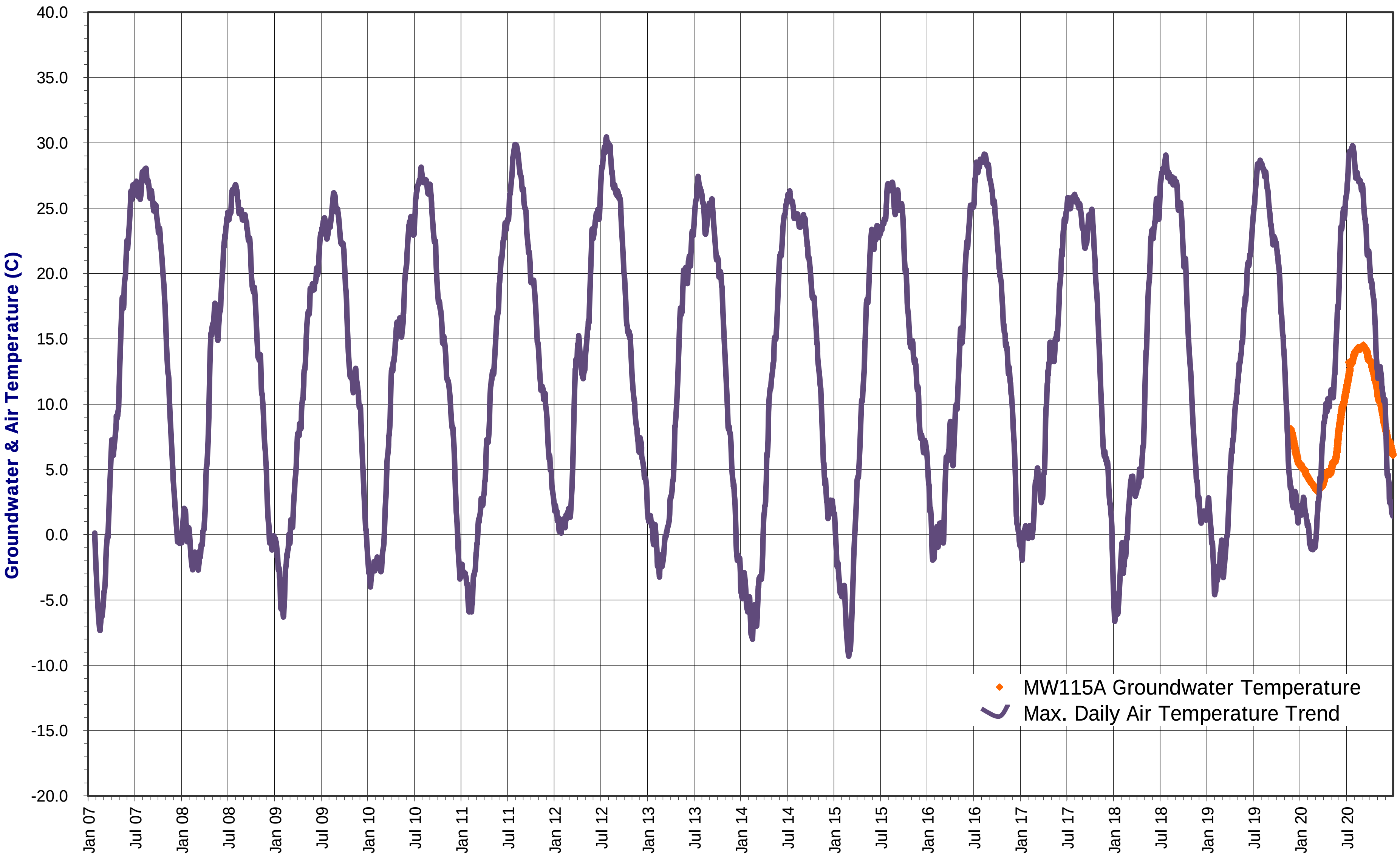


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter Graph H 5**

Groundwater & Maximum Daily Air Temperature - MW115A (November 2019 to December 2020)

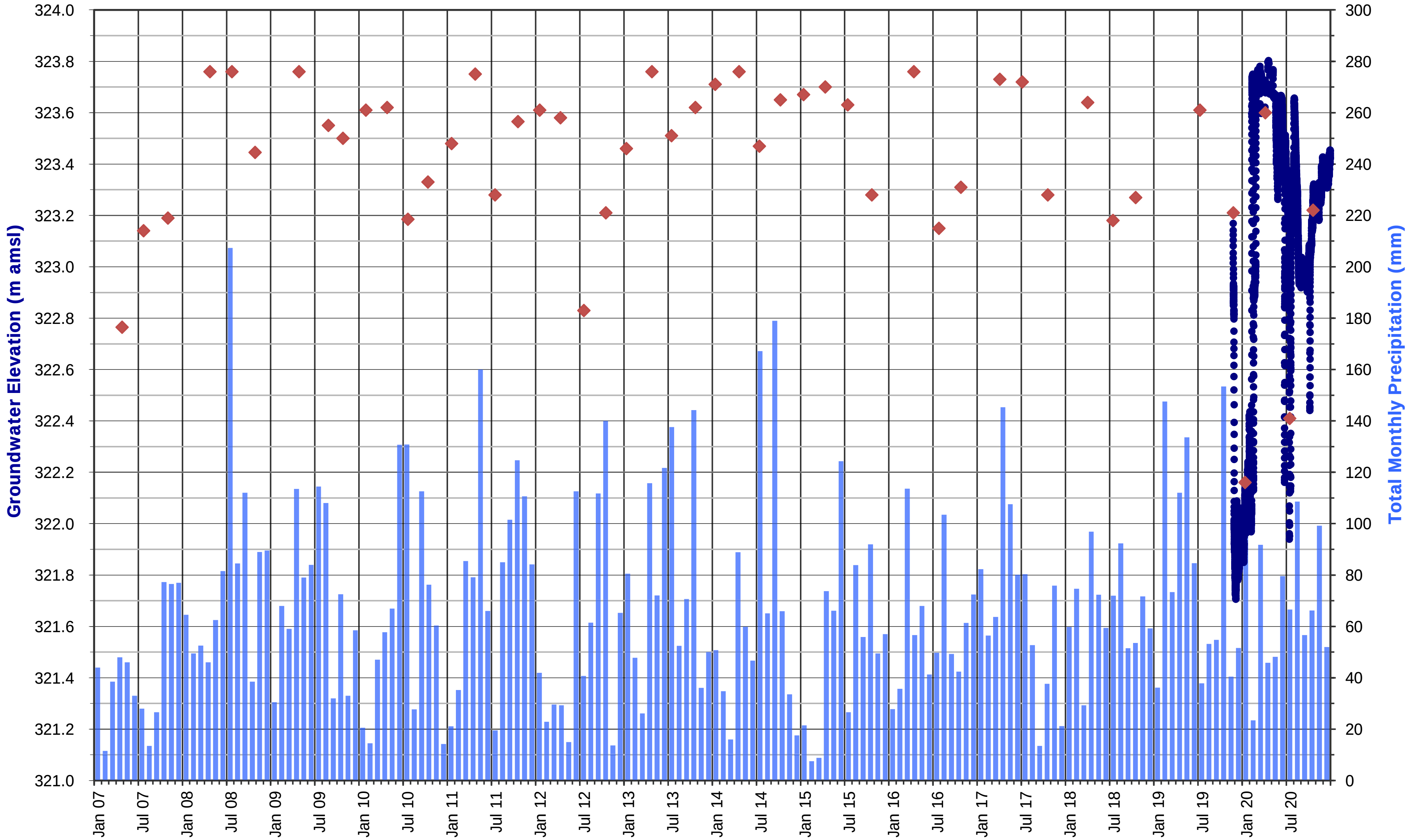


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 5a**

Groundwater Elevation & Precipitation - MW115 (November 2019 to December 2020)

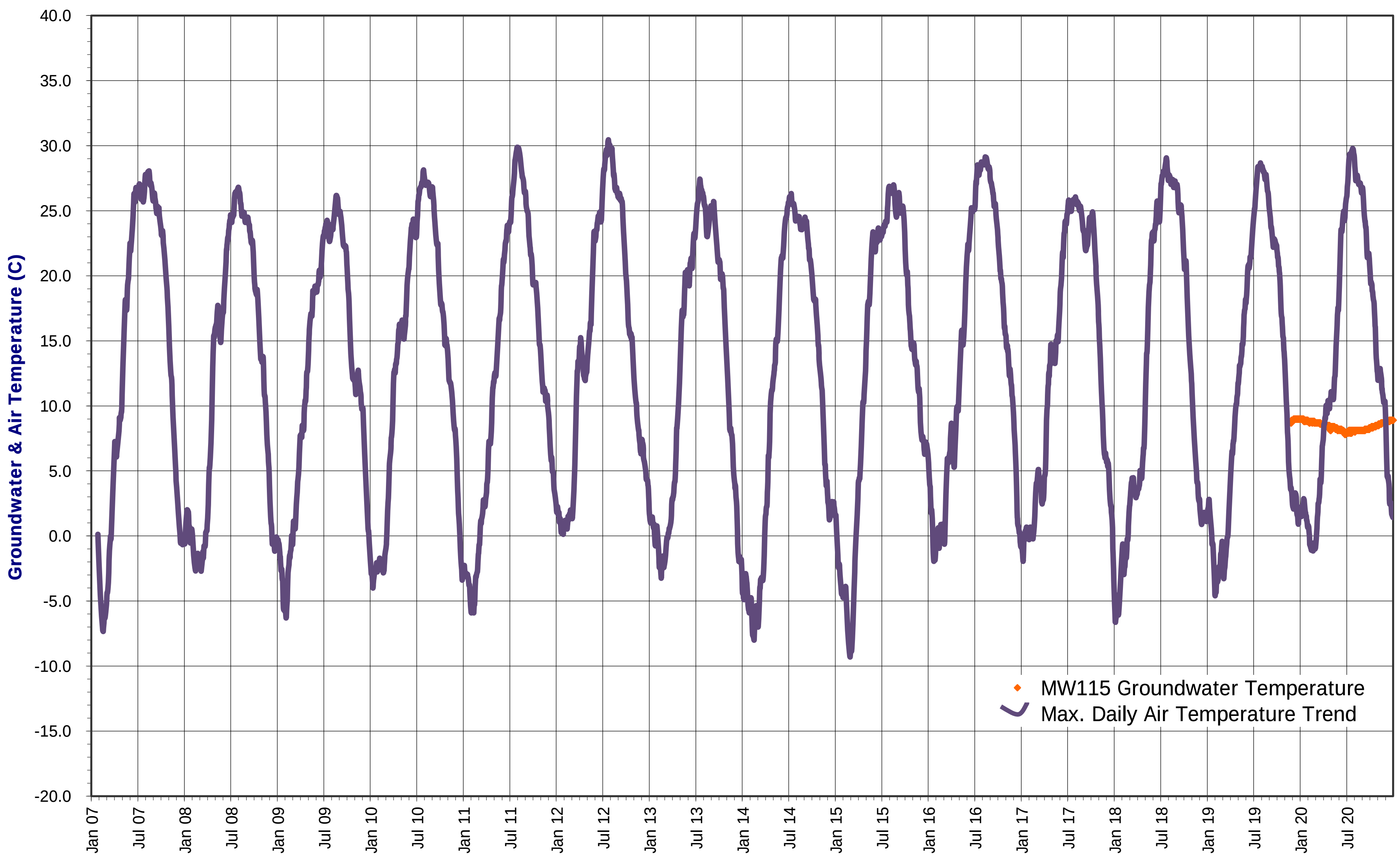


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 6**

Groundwater & Maximum Daily Air Temperature - MW115 (November 2019 to December 2020)

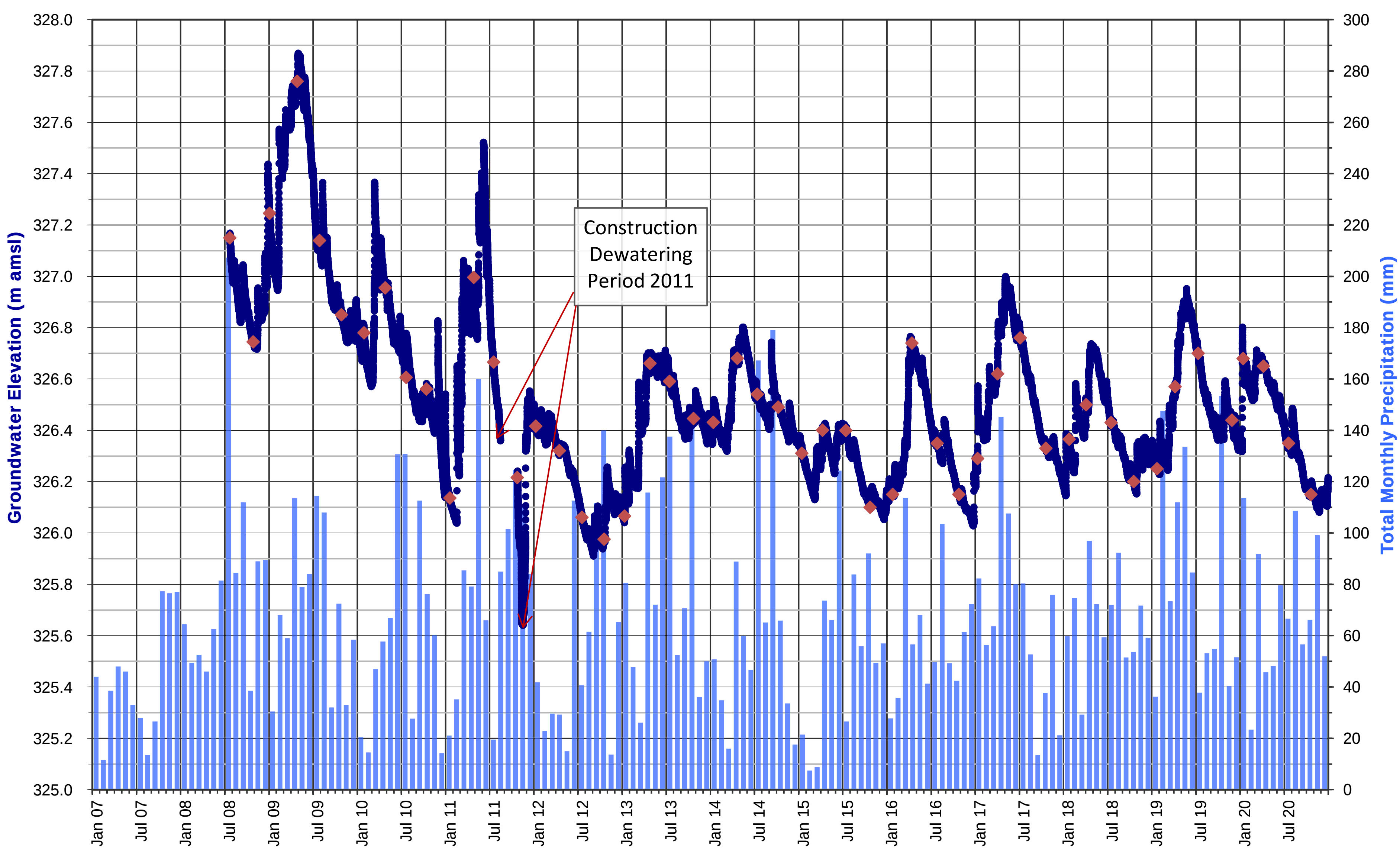


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 1 - Perimeter** **Graph H 6a**

Groundwater Elevation & Precipitation - MW107 (July 2008 to December 2020)

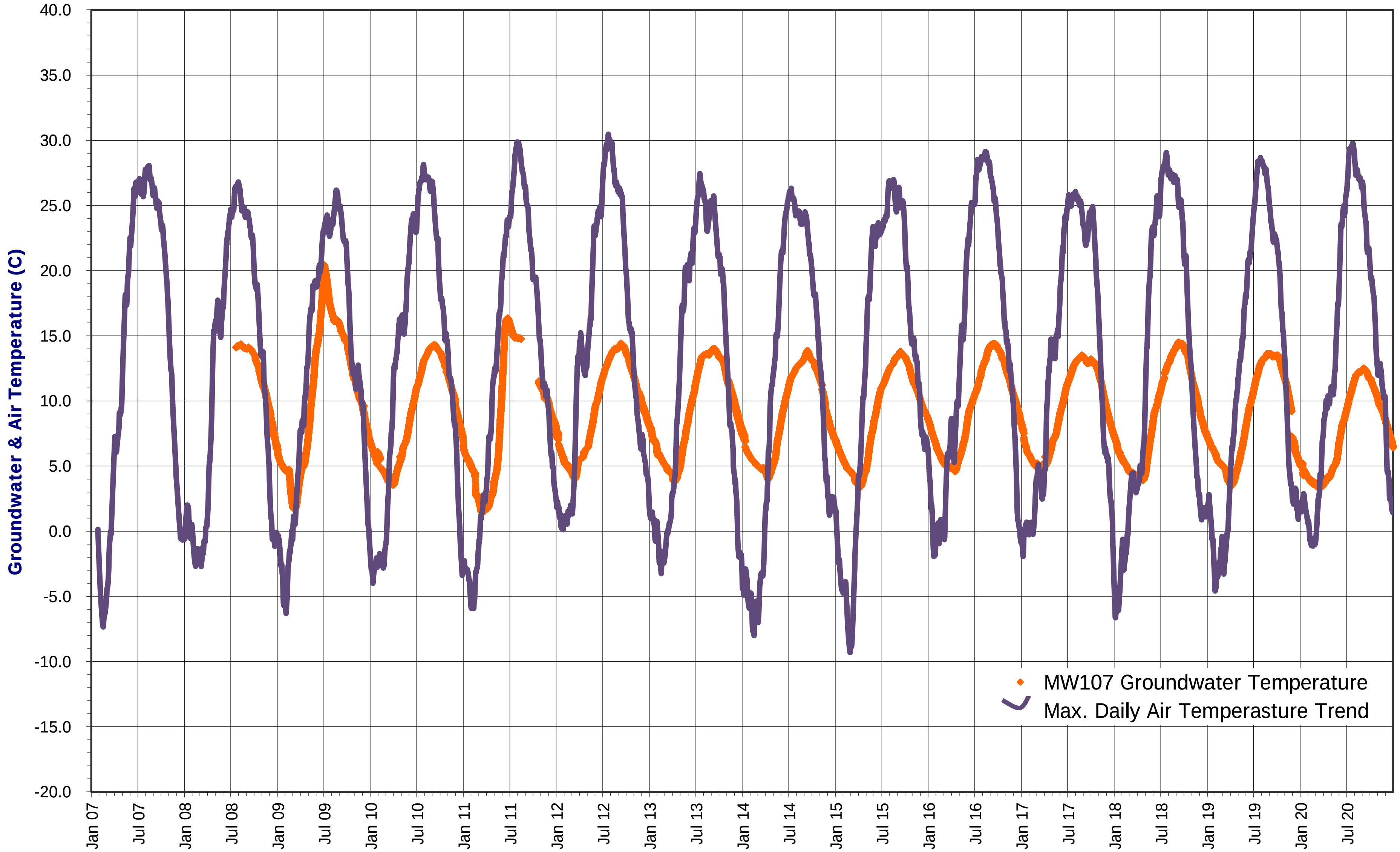


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 2 - Perimeter** **Graph H 7**

Groundwater & Maximum Daily Air Temperature - MW107 (July 2008 to December 2020)

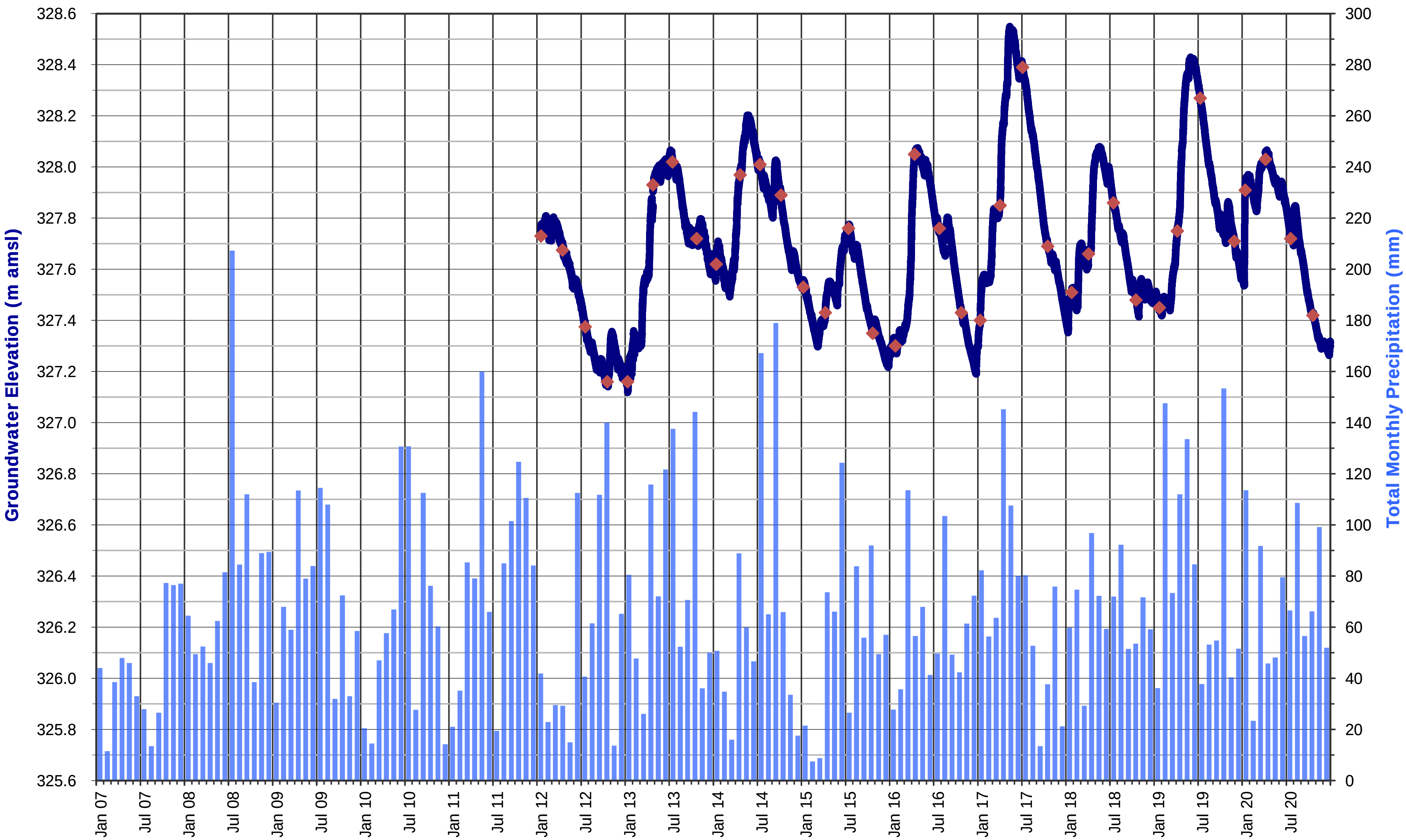


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 2 - Perimeter** **Graph H 7a**

Groundwater Elevation & Precipitation - MW132 (January 2012 to December 2020)

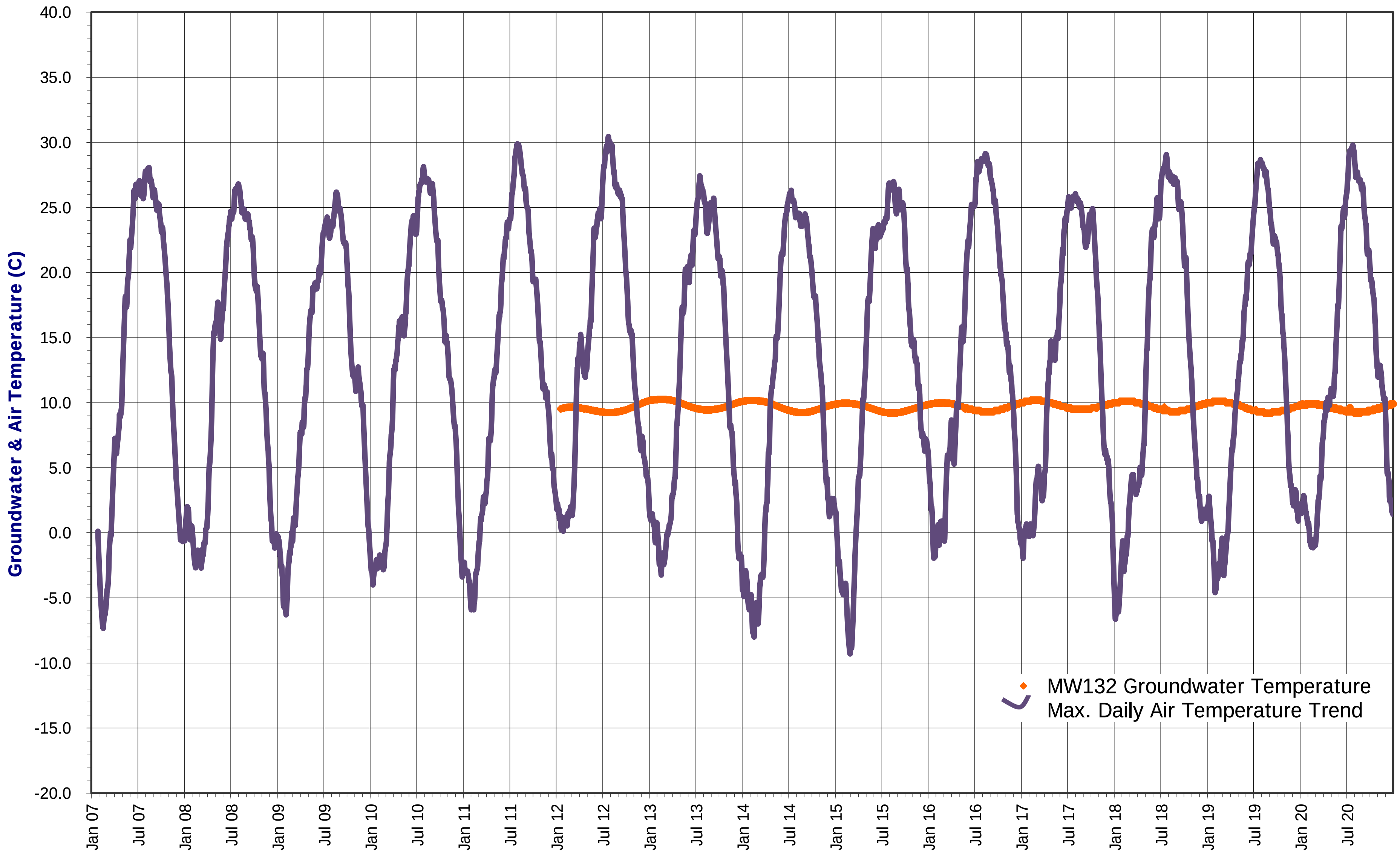


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 2 - Perimeter** **Graph H 8**

Groundwater & Maximum Daily Air Temperature - MW132 (January 2012 to December 2020)



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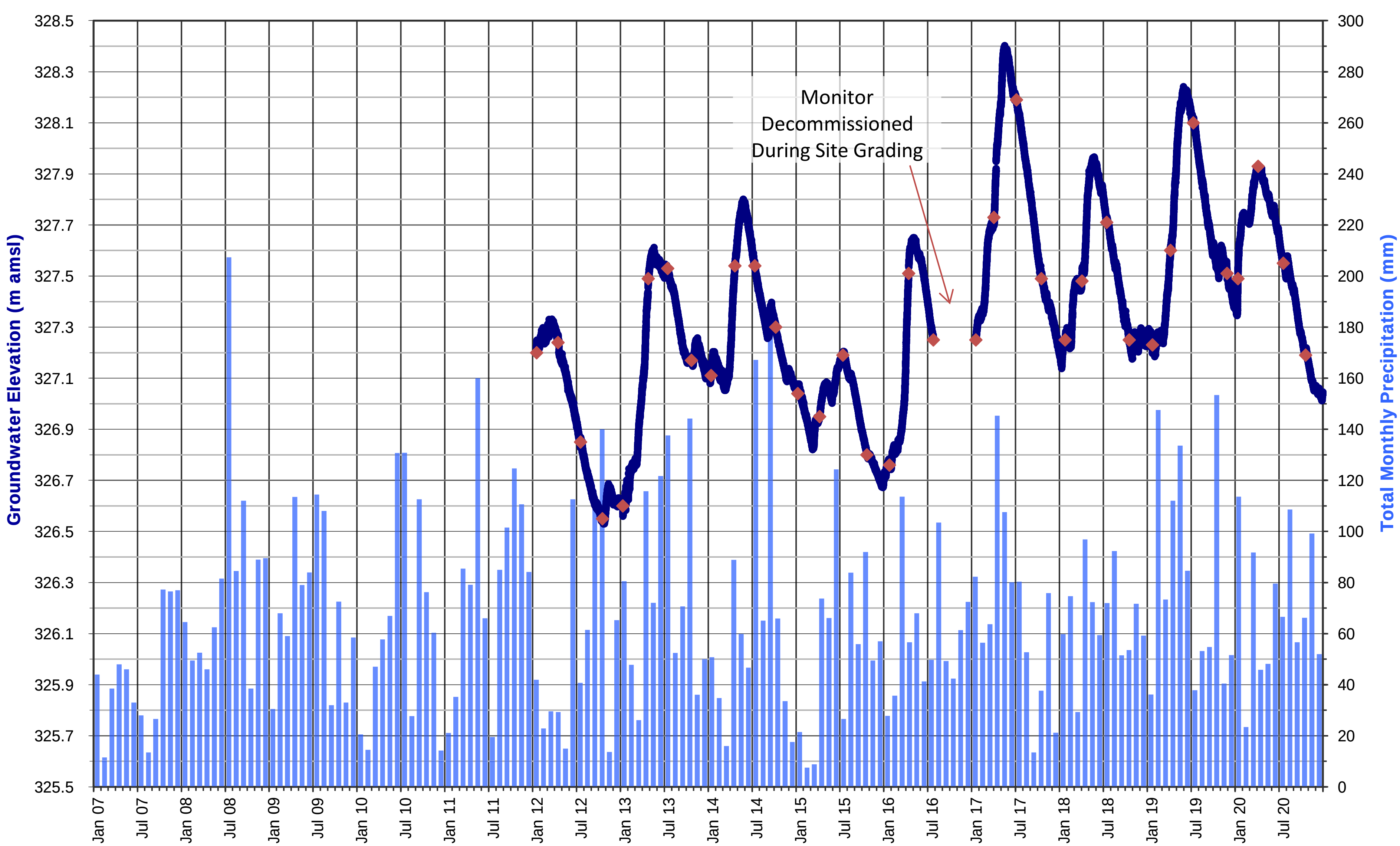
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Phase 2 - Perimeter Graph H 8a

Groundwater Elevation & Precipitation - MW135 (January 2012 to December 2020)



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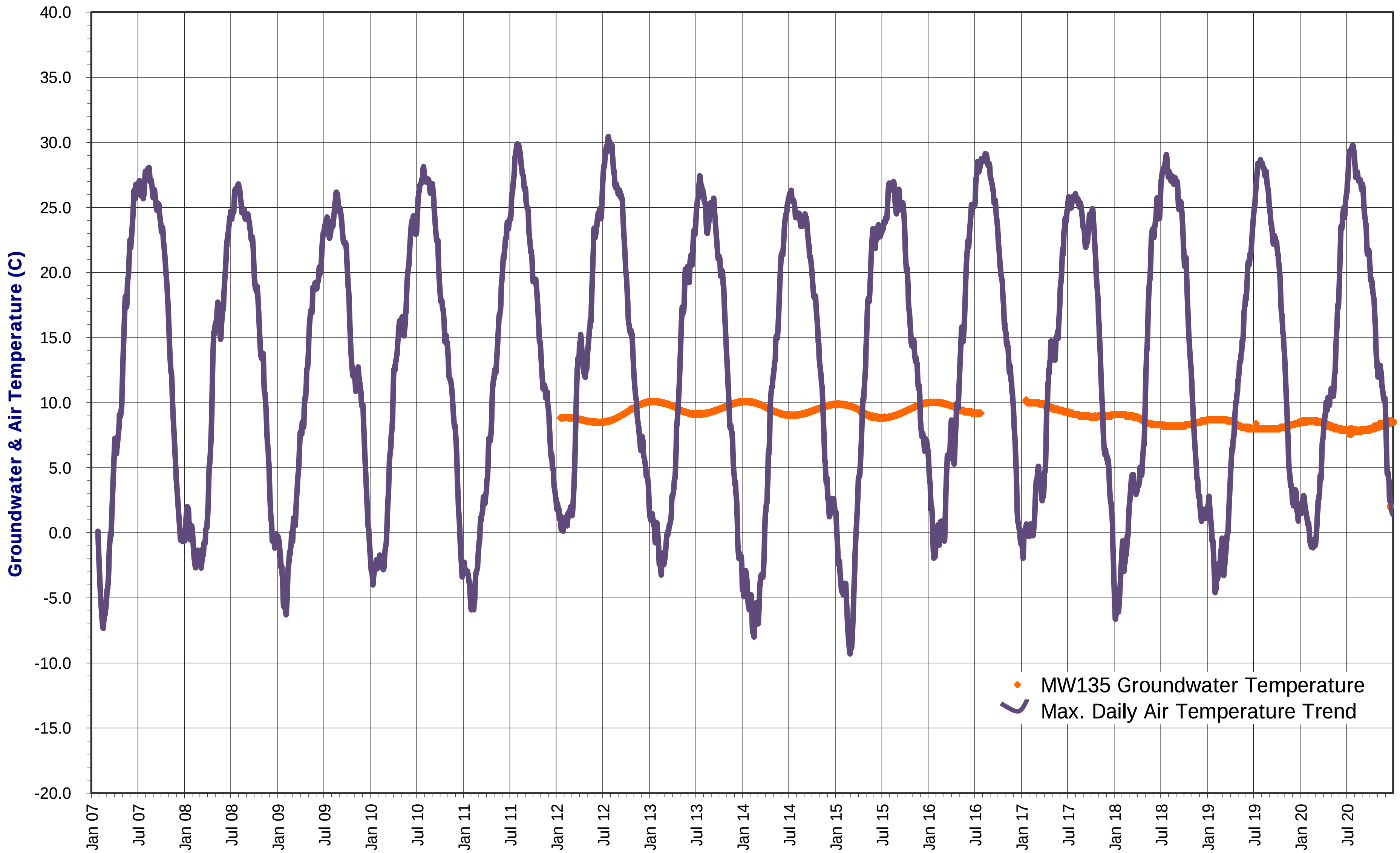
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 2 - Perimeter** **Graph H 9**

Groundwater & Maximum Daily Air Temperature - MW135 (January 2012 to December 2020)



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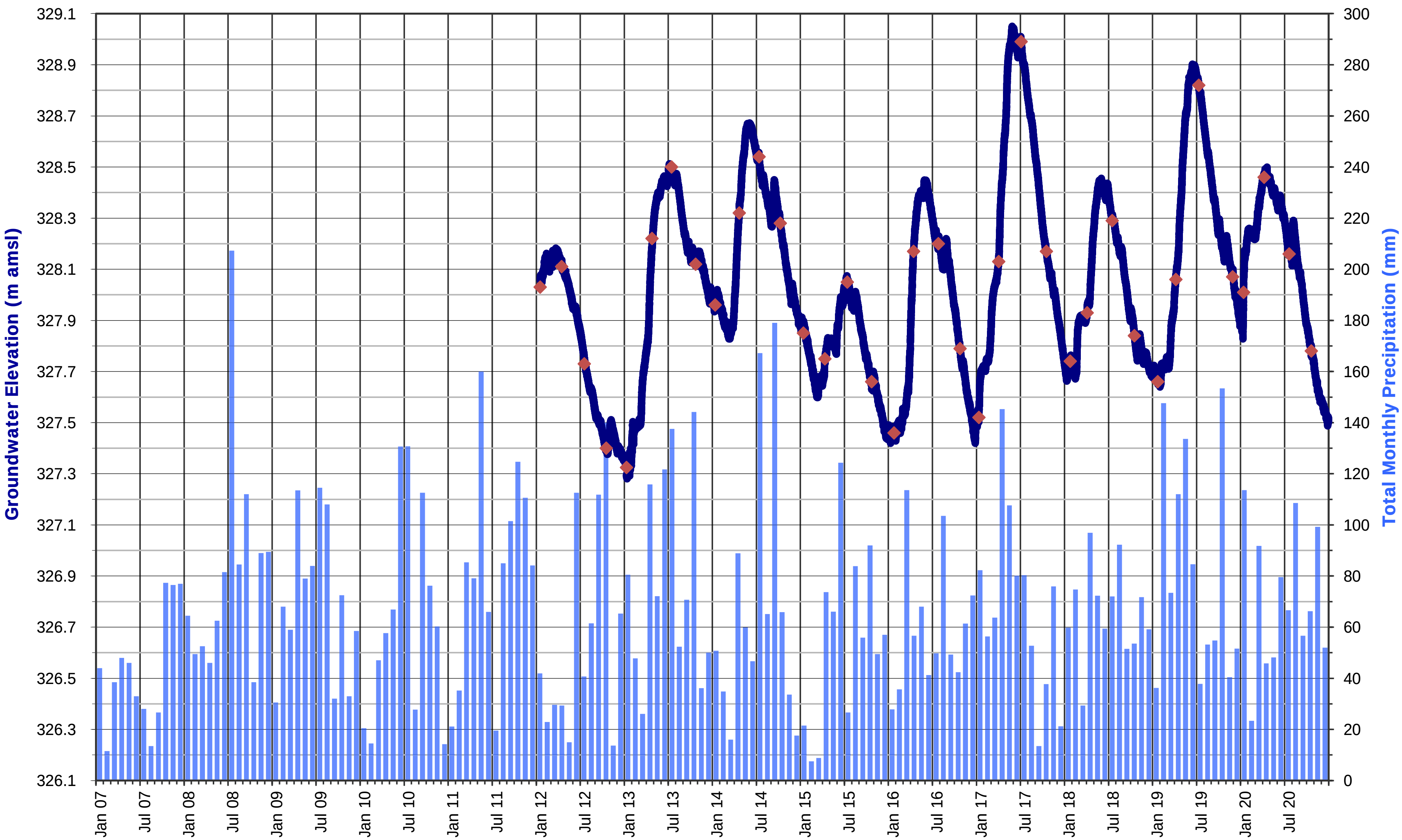
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 2 - Perimeter** **Graph H 9a**

Groundwater Elevation & Precipitation - MW133 (January 2012 to December 2020)



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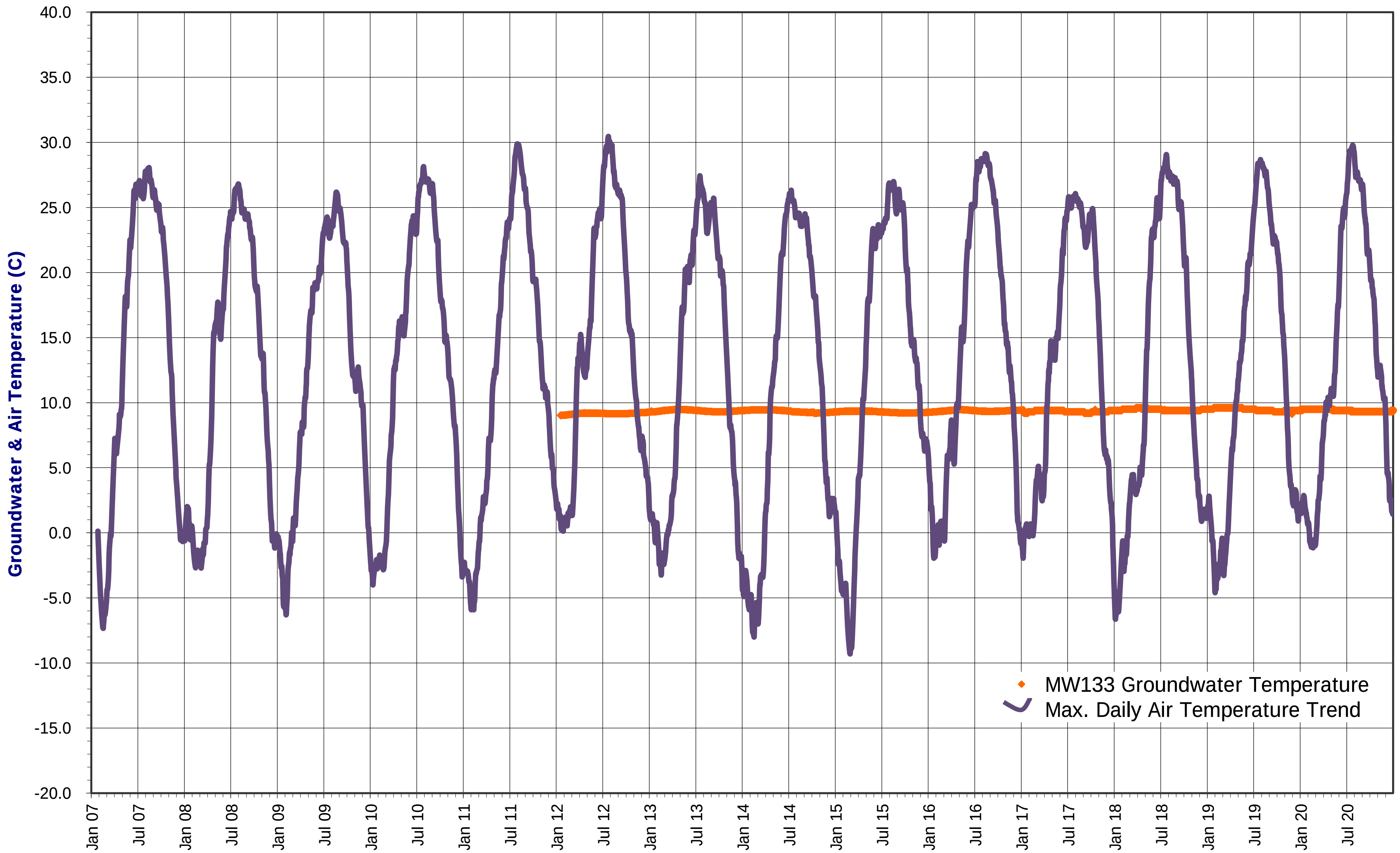
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 2 - Perimeter** **Graph H 10**

Groundwater & Maximum Daily Air Temperature - MW133 (January 2012 to December 2020)



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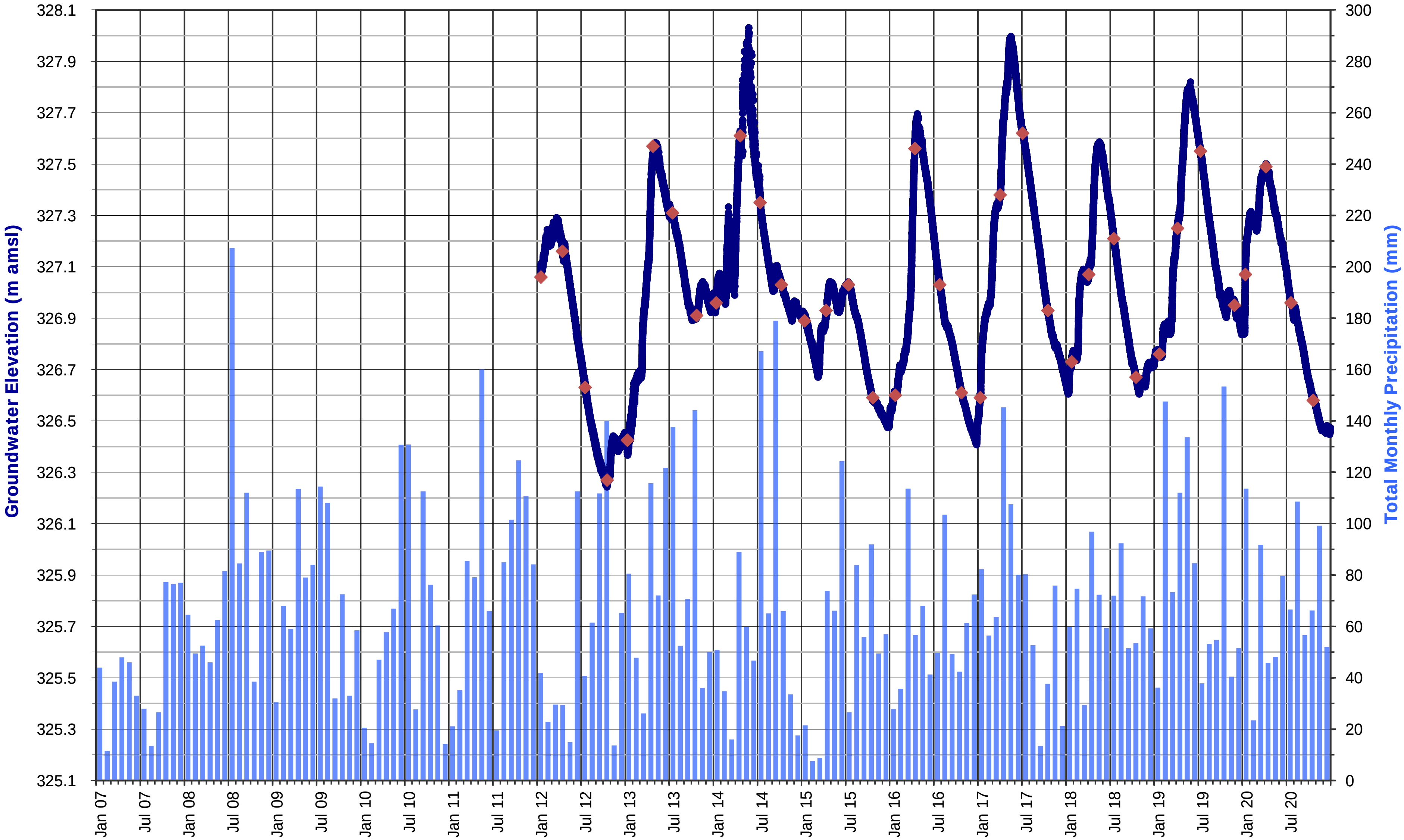
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 2 - Perimeter** **Graph H 10a**

Groundwater Elevation & Precipitation - MW134 (January 2012 to December 2020)



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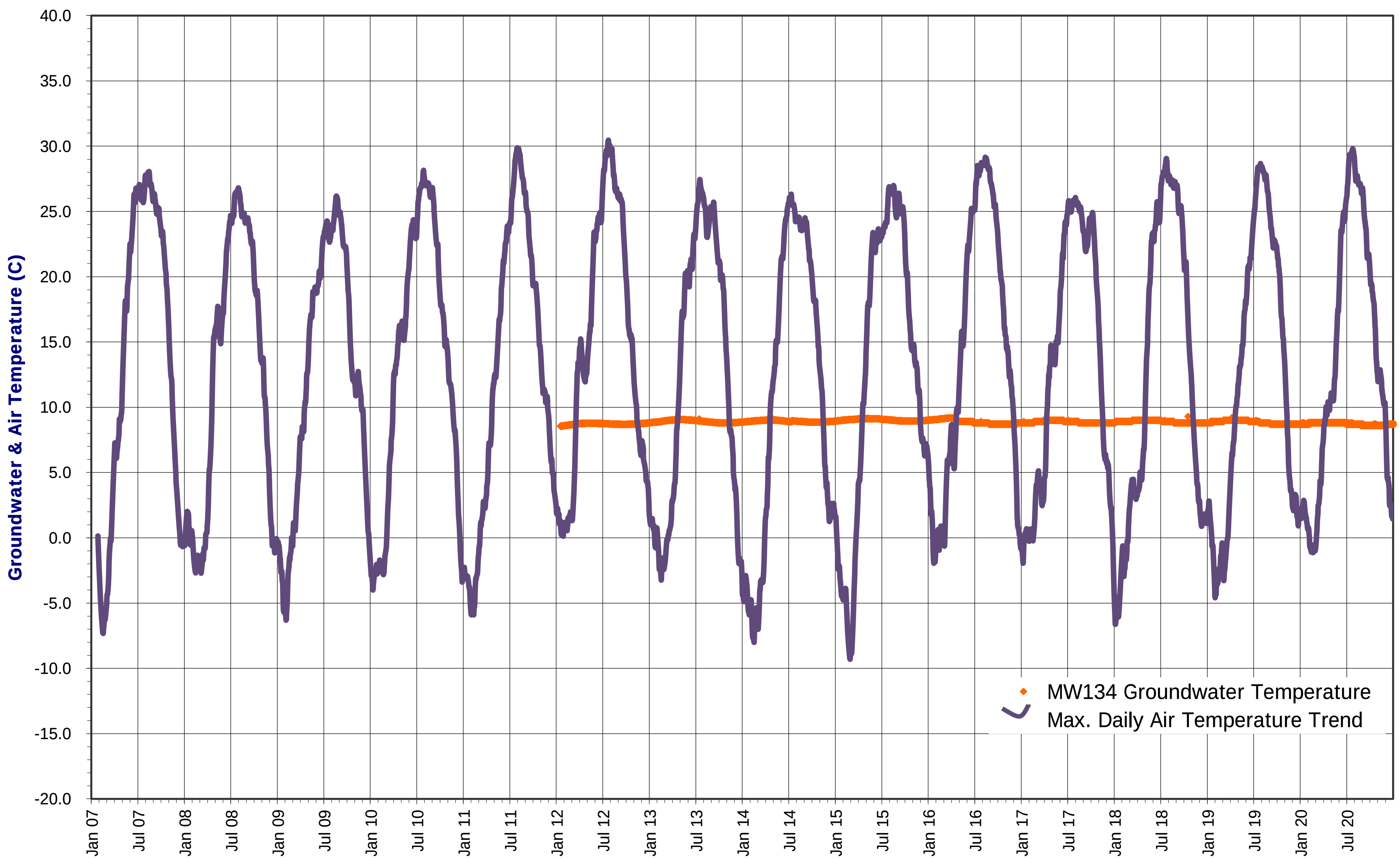
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 2 - Perimeter** **Graph H 11**

Groundwater & Maximum Daily Air Temperature - MW134 (January 2012 to December 2020)

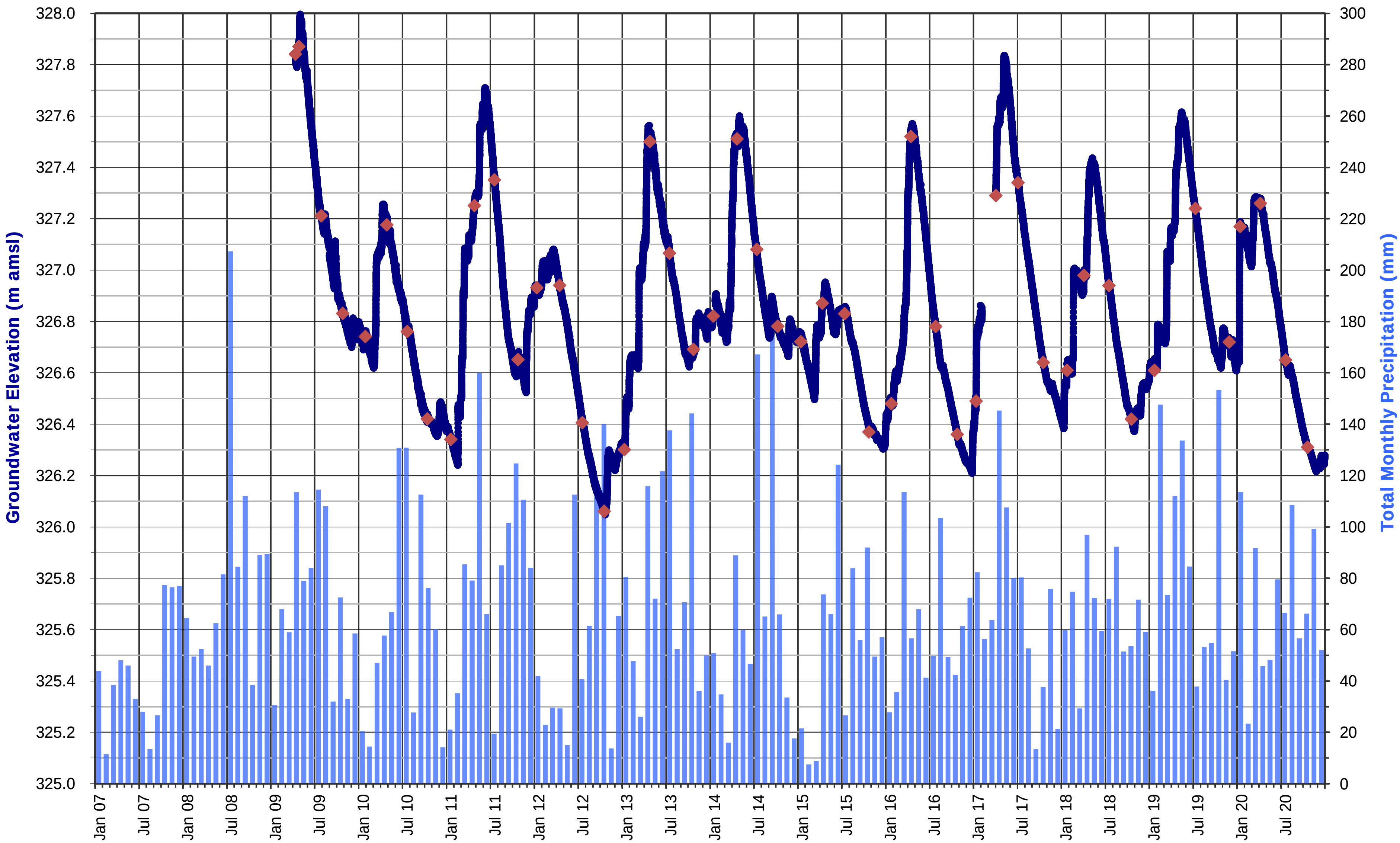


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 2 - Perimeter** **Graph H 11a**

Groundwater Elevation & Precipitation - MW109 (April 2009 to December 2020)



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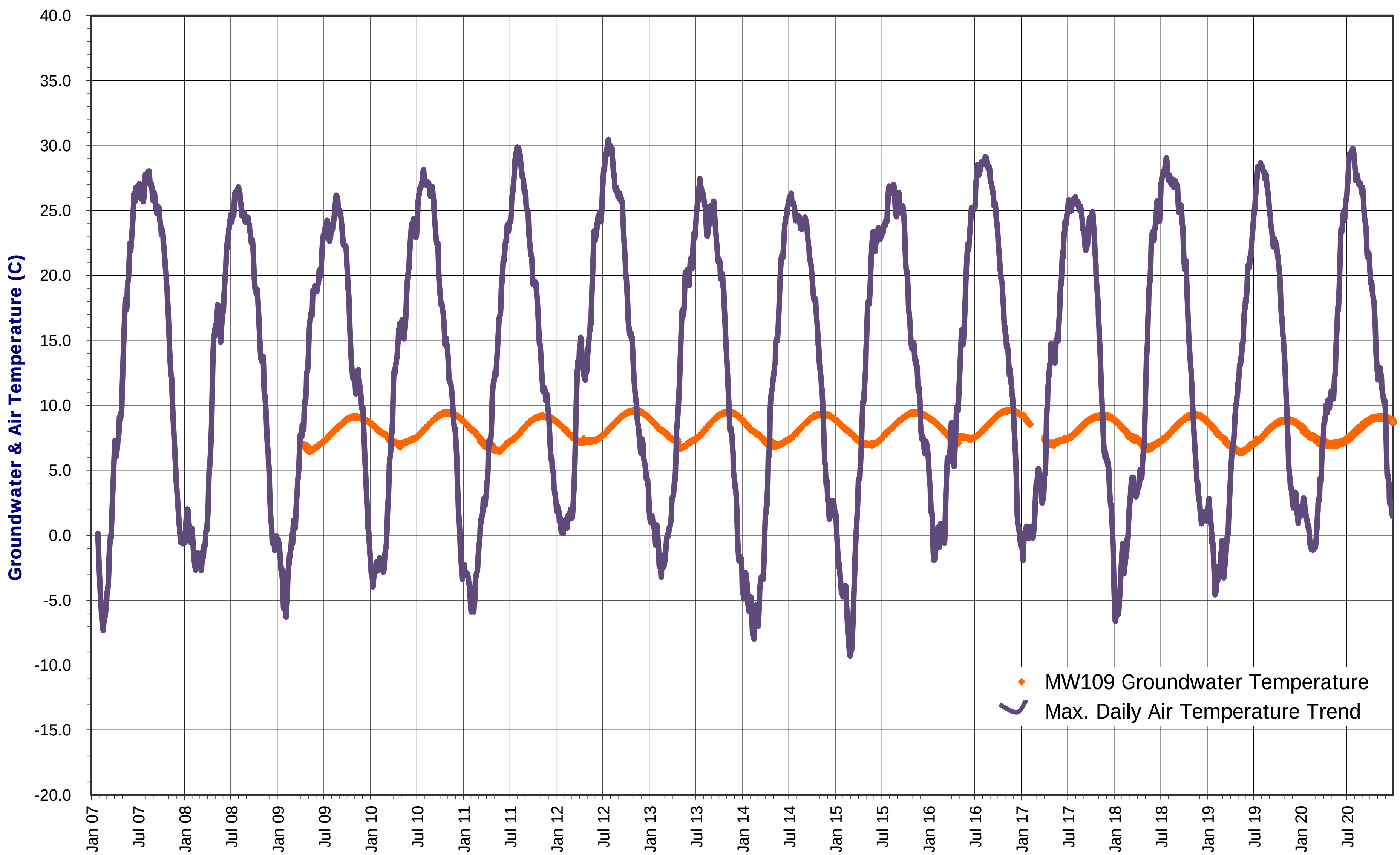
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 3 - Perimeter** **Graph H 12**

Groundwater & Maximum Daily Air Temperature - MW109 (April 2009 to December 2020)



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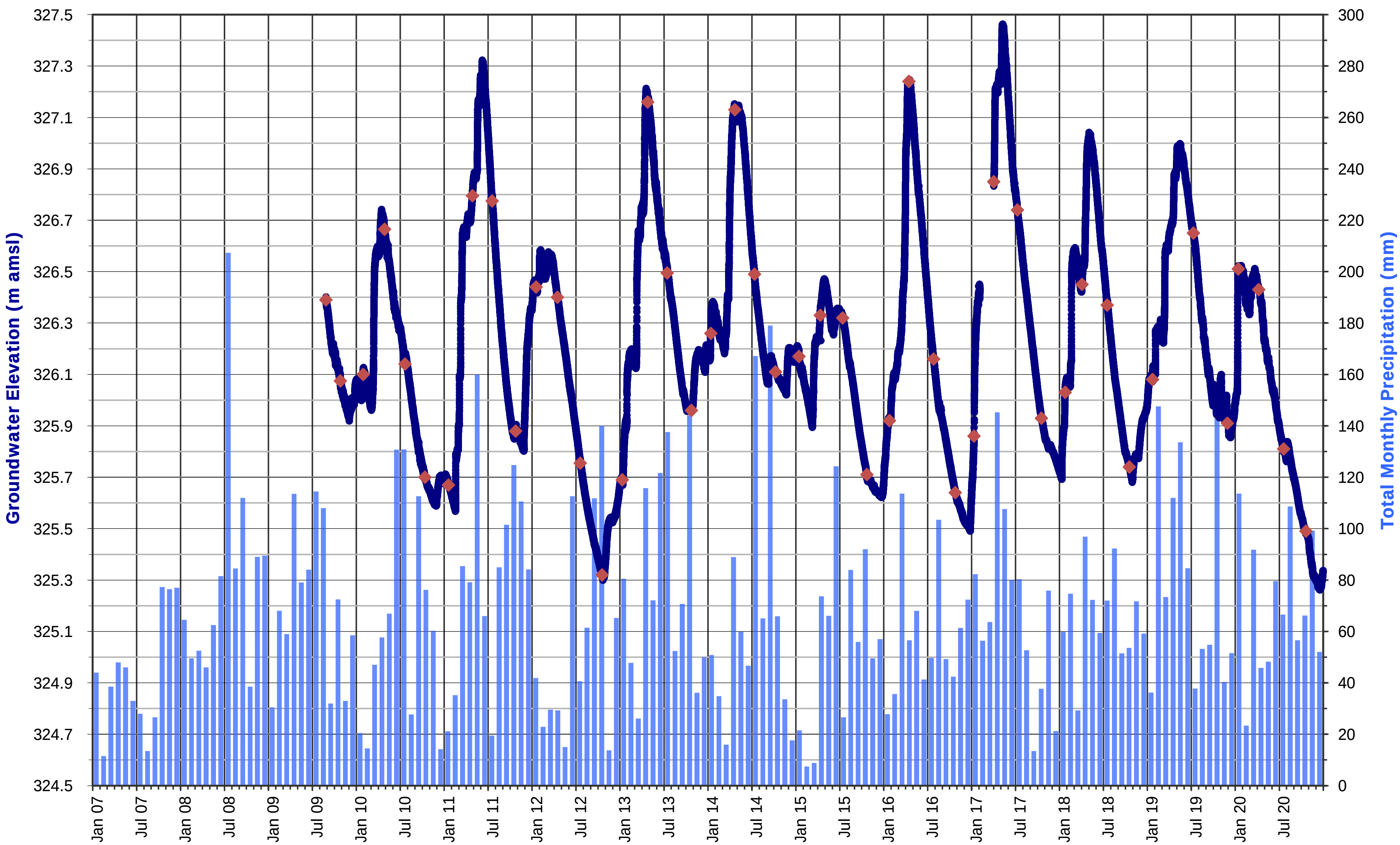
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 3 - Perimeter** **Graph H 12a**

Groundwater Elevation & Precipitation - MW004 (August 2009 to December 2020)



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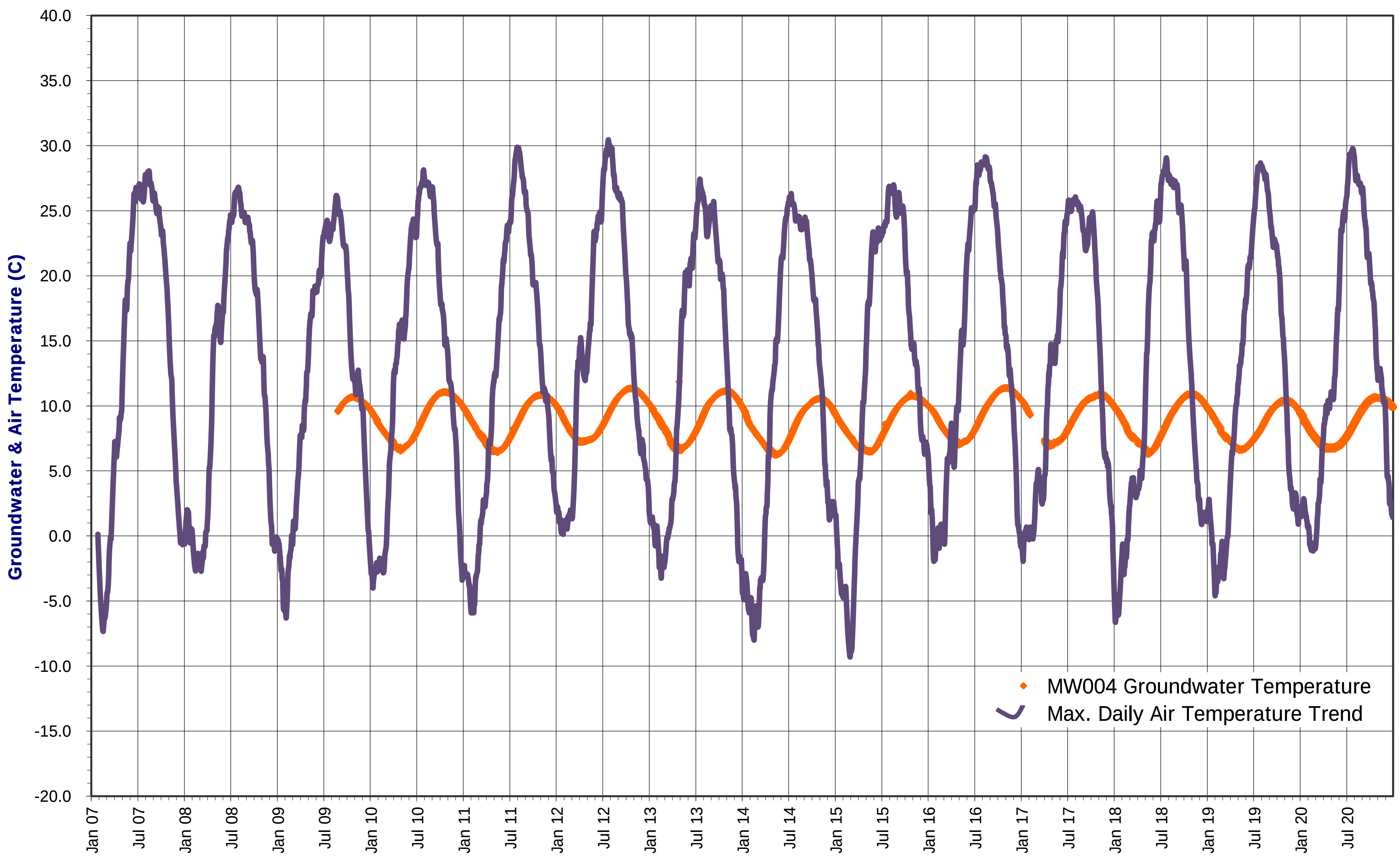
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 3 - Perimeter** **Graph H 13**

Groundwater & Maximum Daily Temperature - MW004 (August 2009 to December 2020)

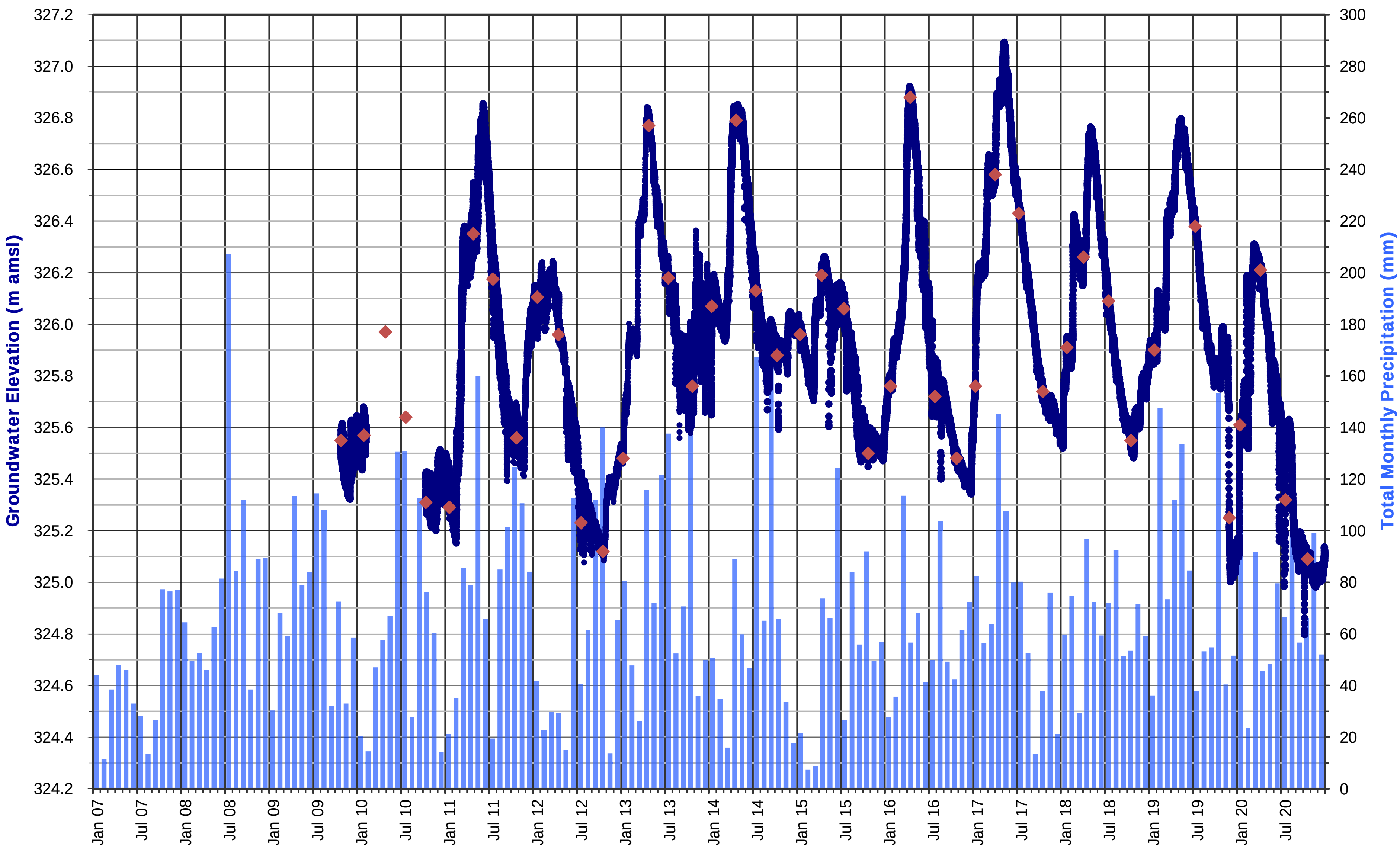


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 3 - Perimeter** **Graph H 13a**

Groundwater Elevation & Precipitation - MW112 (October 2009 to December 2020)



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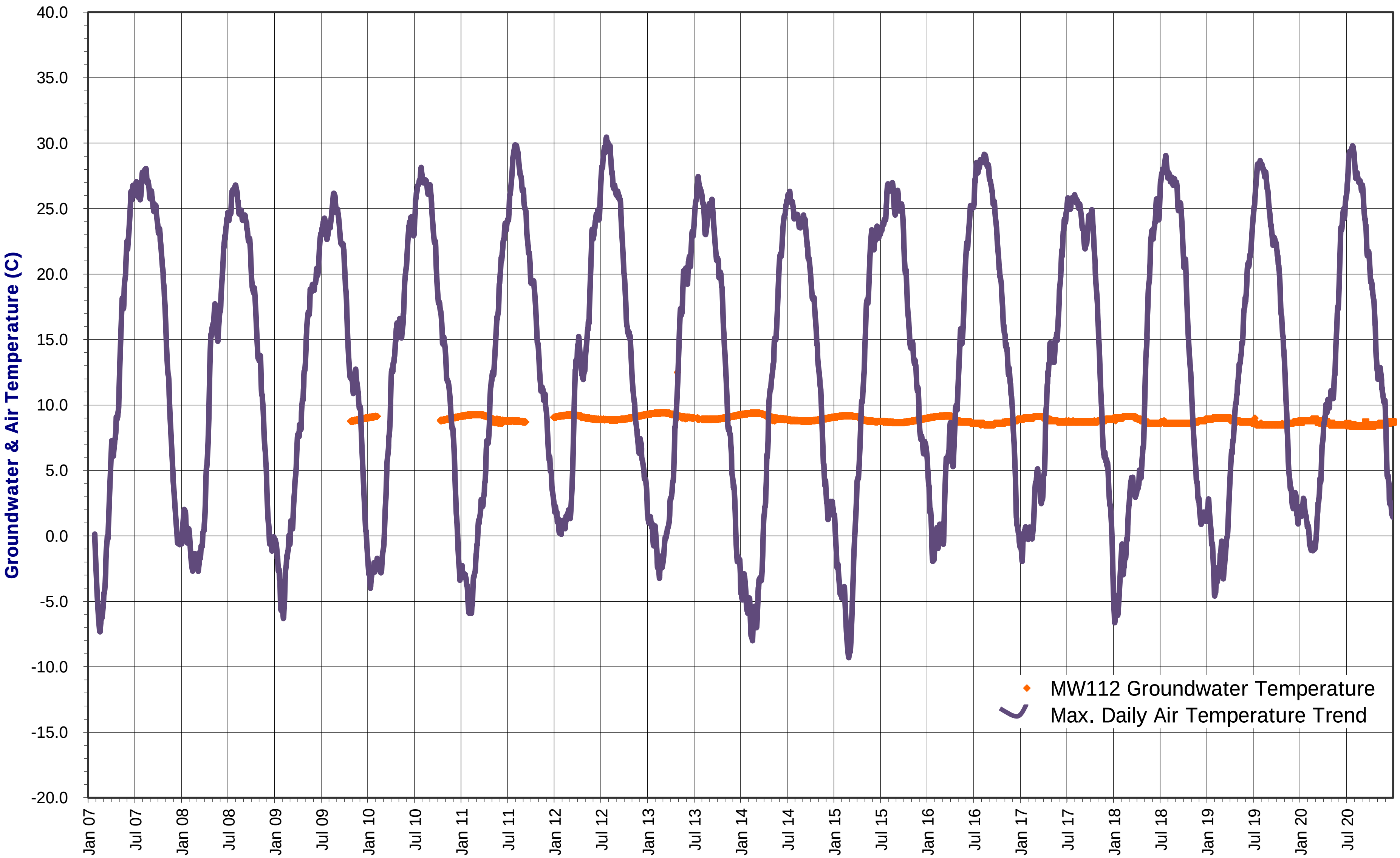
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 3 - Perimeter** **Graph H 14**

Groundwater & Maximum Daily Air Temperature - MW112 (October 2009 to December 2020)



Banks Groundwater Engineering Limited

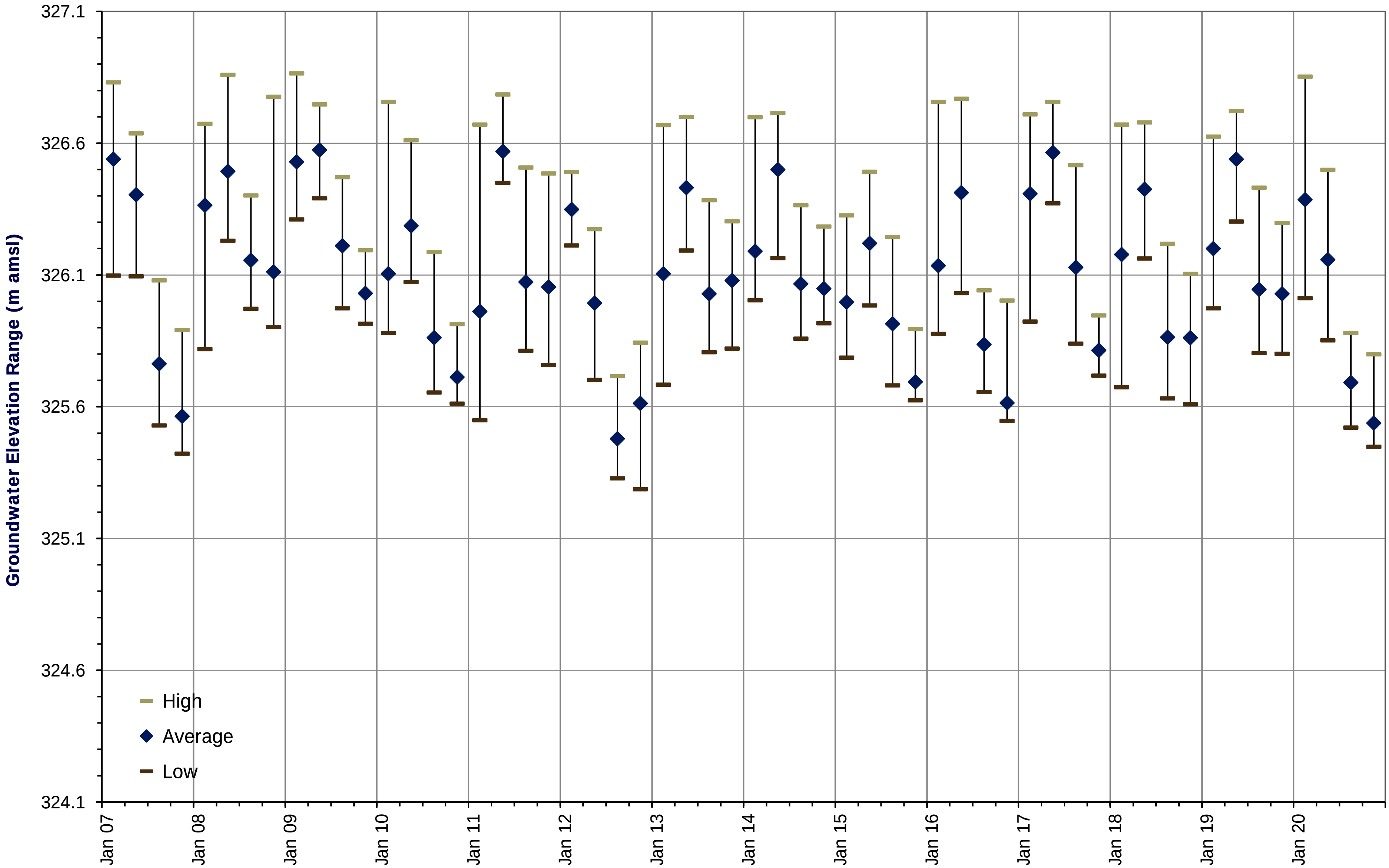
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Phase 3 - Perimeter** **Graph H 14a**

Appendix I

Quarterly Groundwater Elevation Range
2007 – 2020

Quarterly Groundwater Elevation Range - MW003



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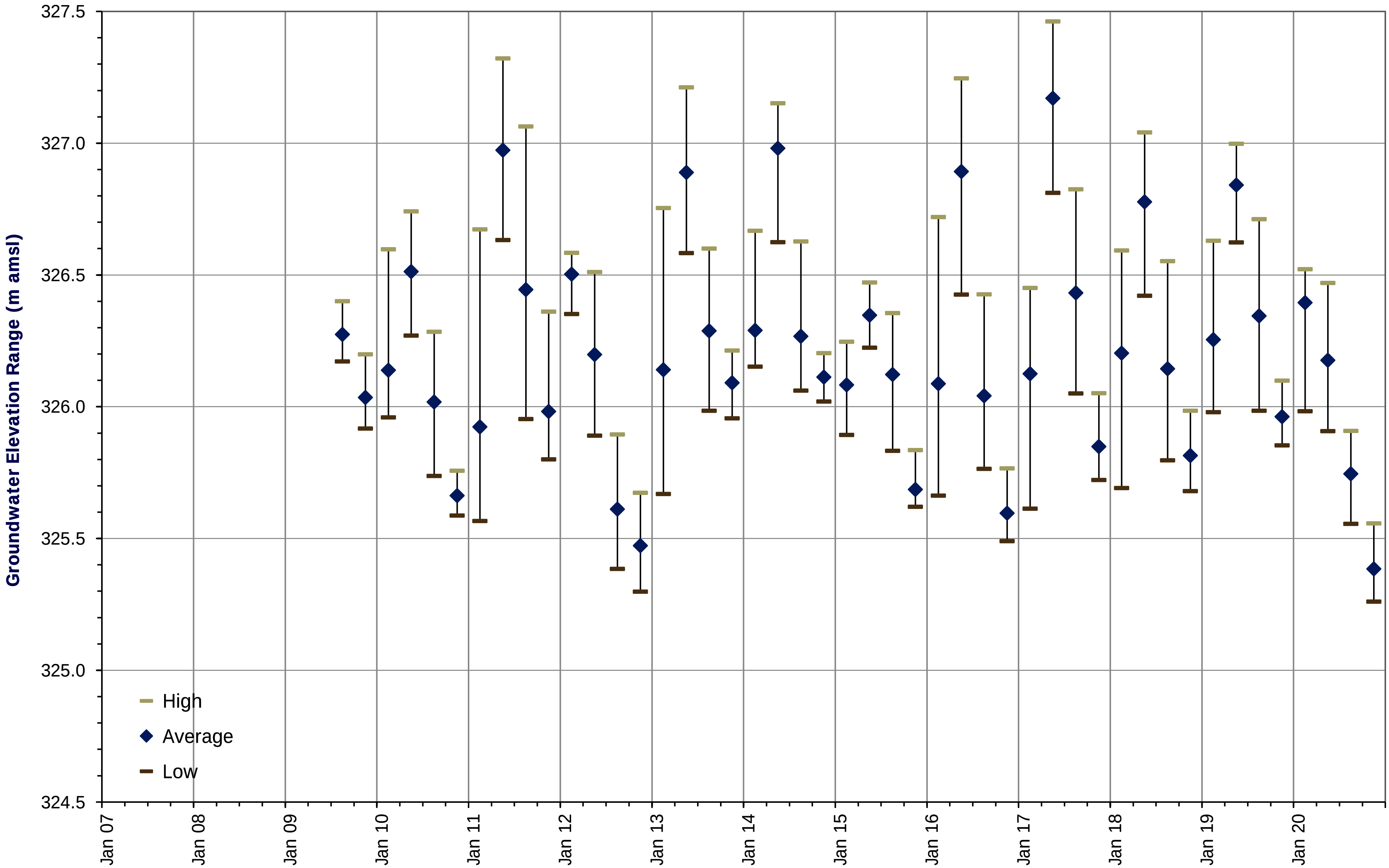
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-1**

Quarterly Groundwater Elevation Range - MW004



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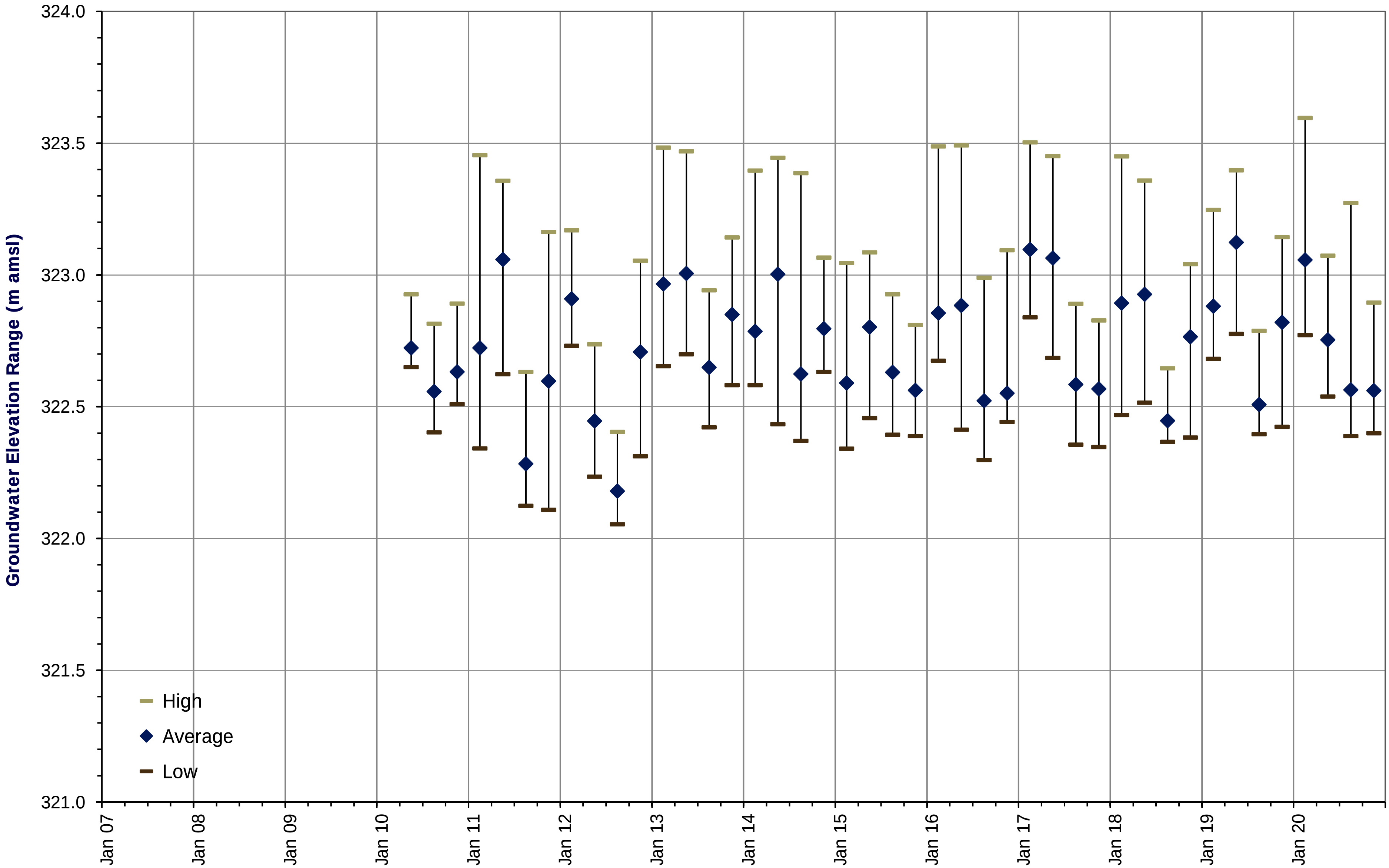
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-2**

Quarterly Groundwater Elevation Range - MW103



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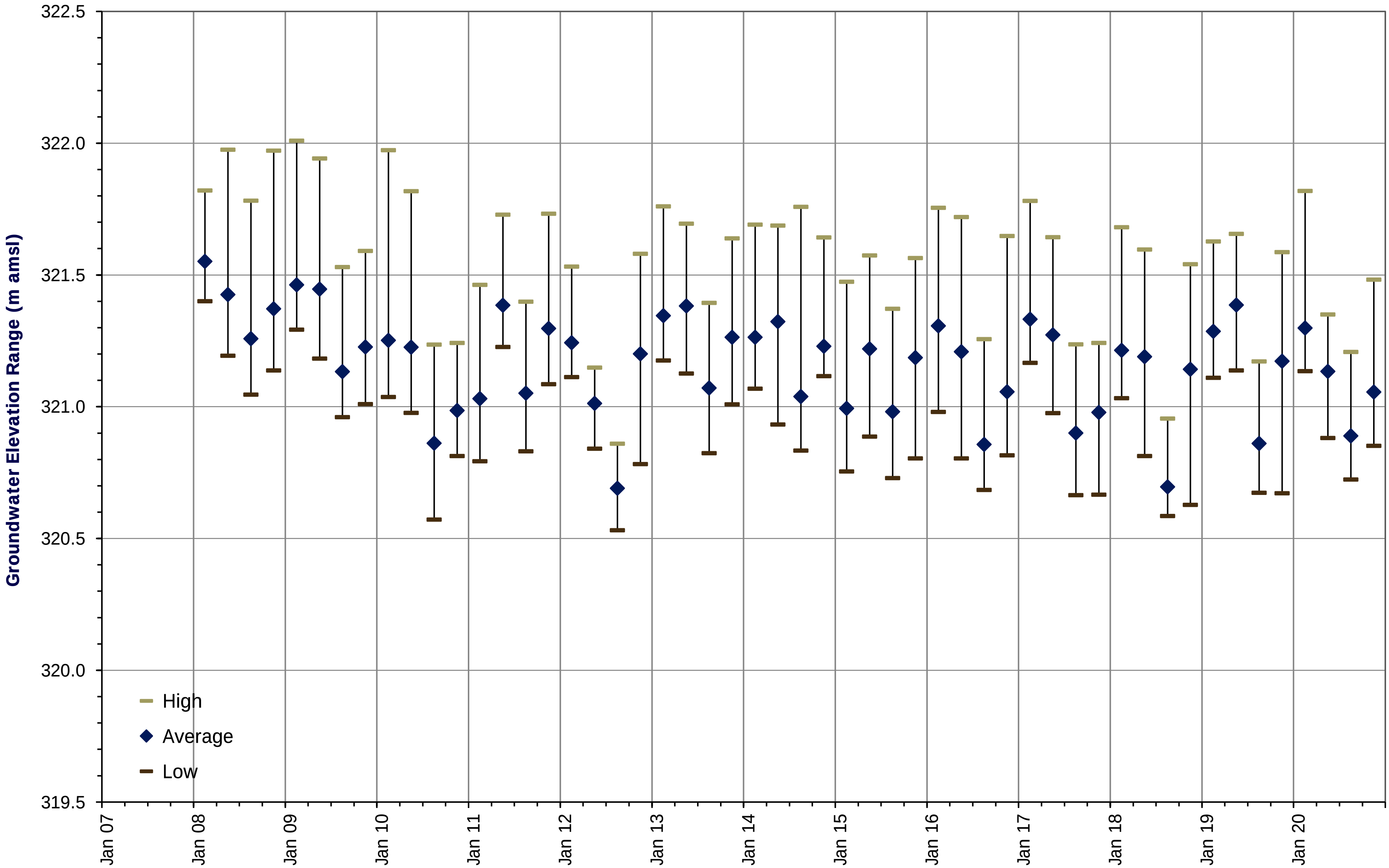
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-3**

Quarterly Groundwater Elevation Range - MW104



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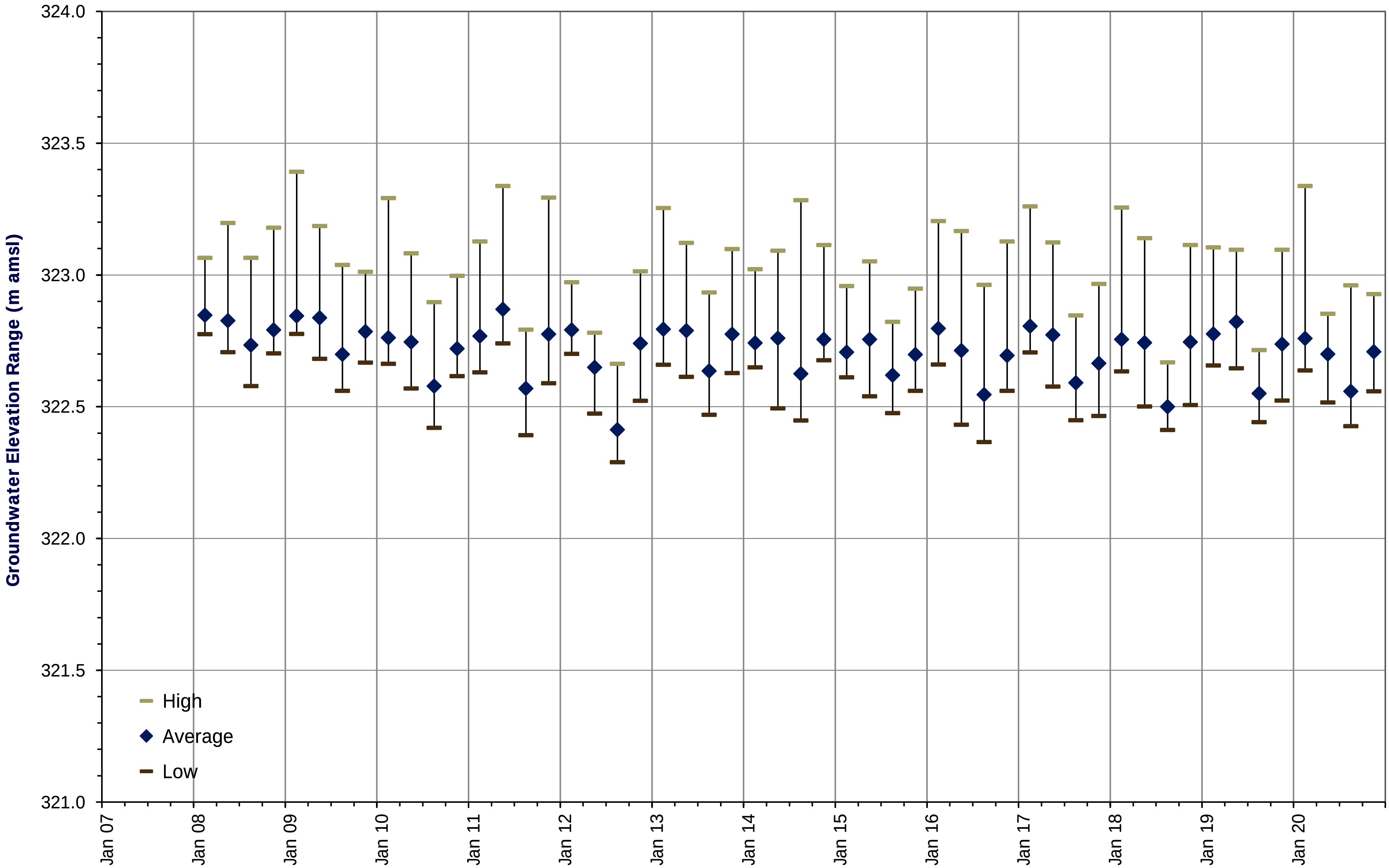
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-4

Quarterly Groundwater Elevation Range - MW105



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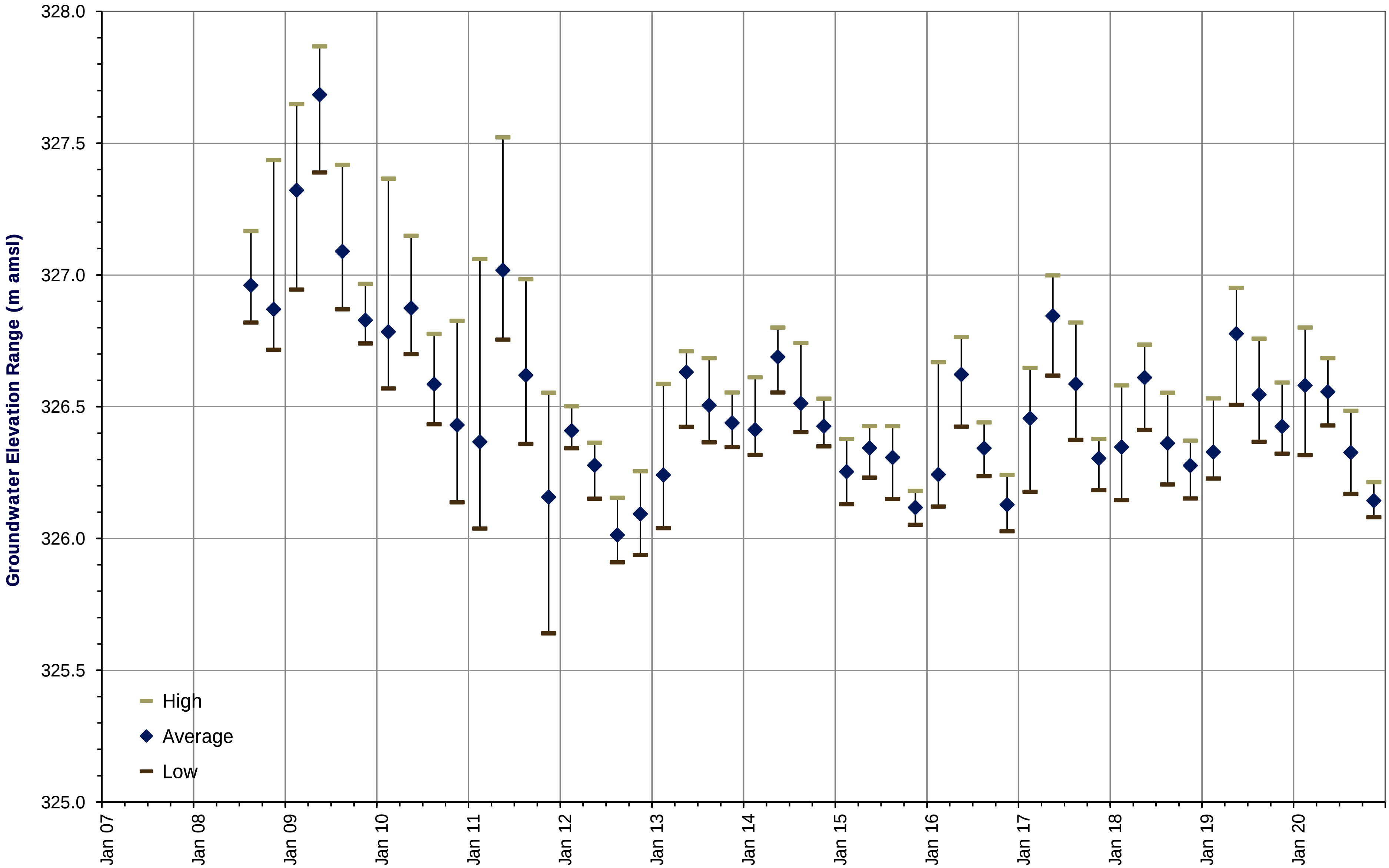
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-5

Quarterly Groundwater Elevation Range - MW107



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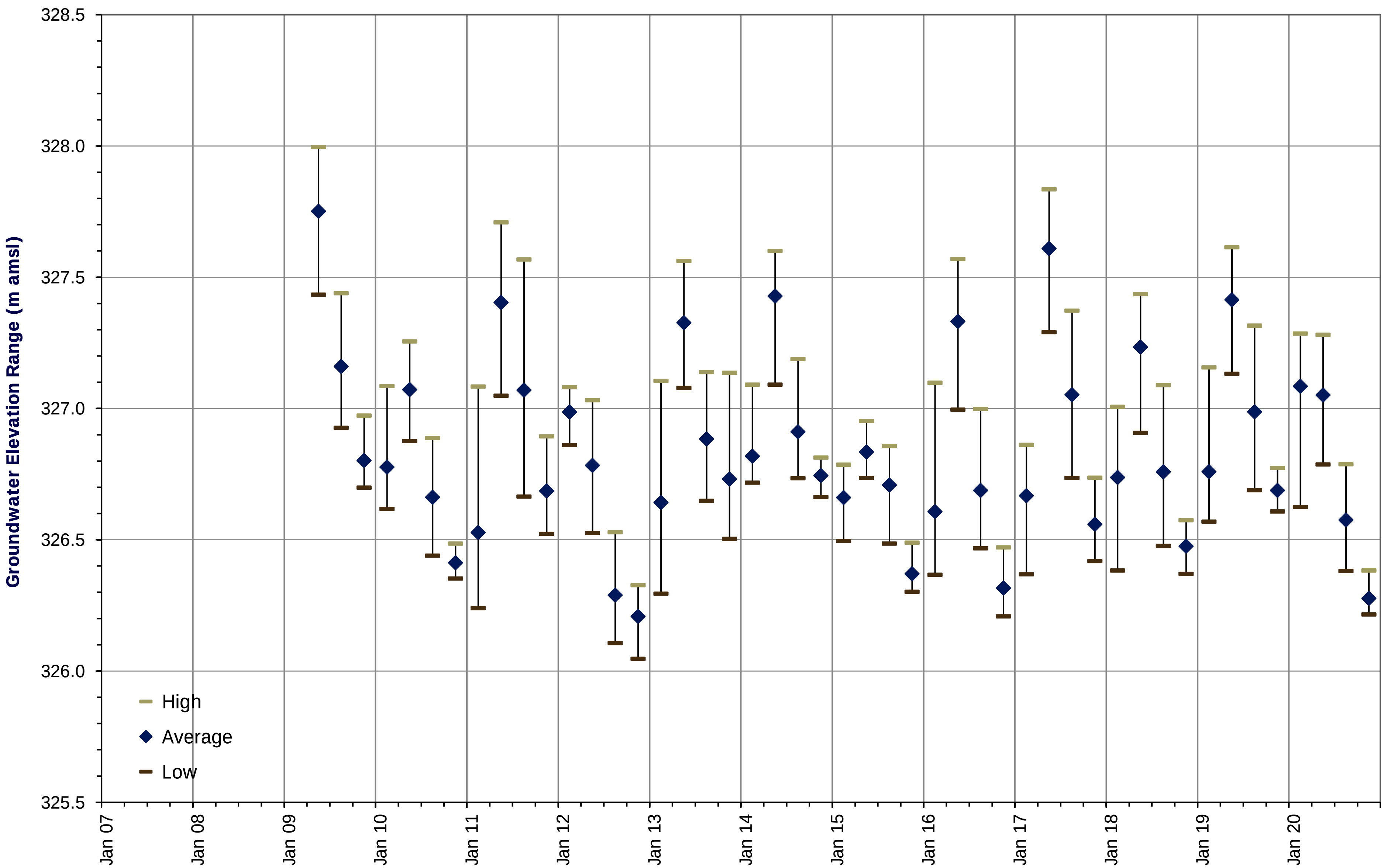
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-6

Quarterly Groundwater Elevation Range - MW109

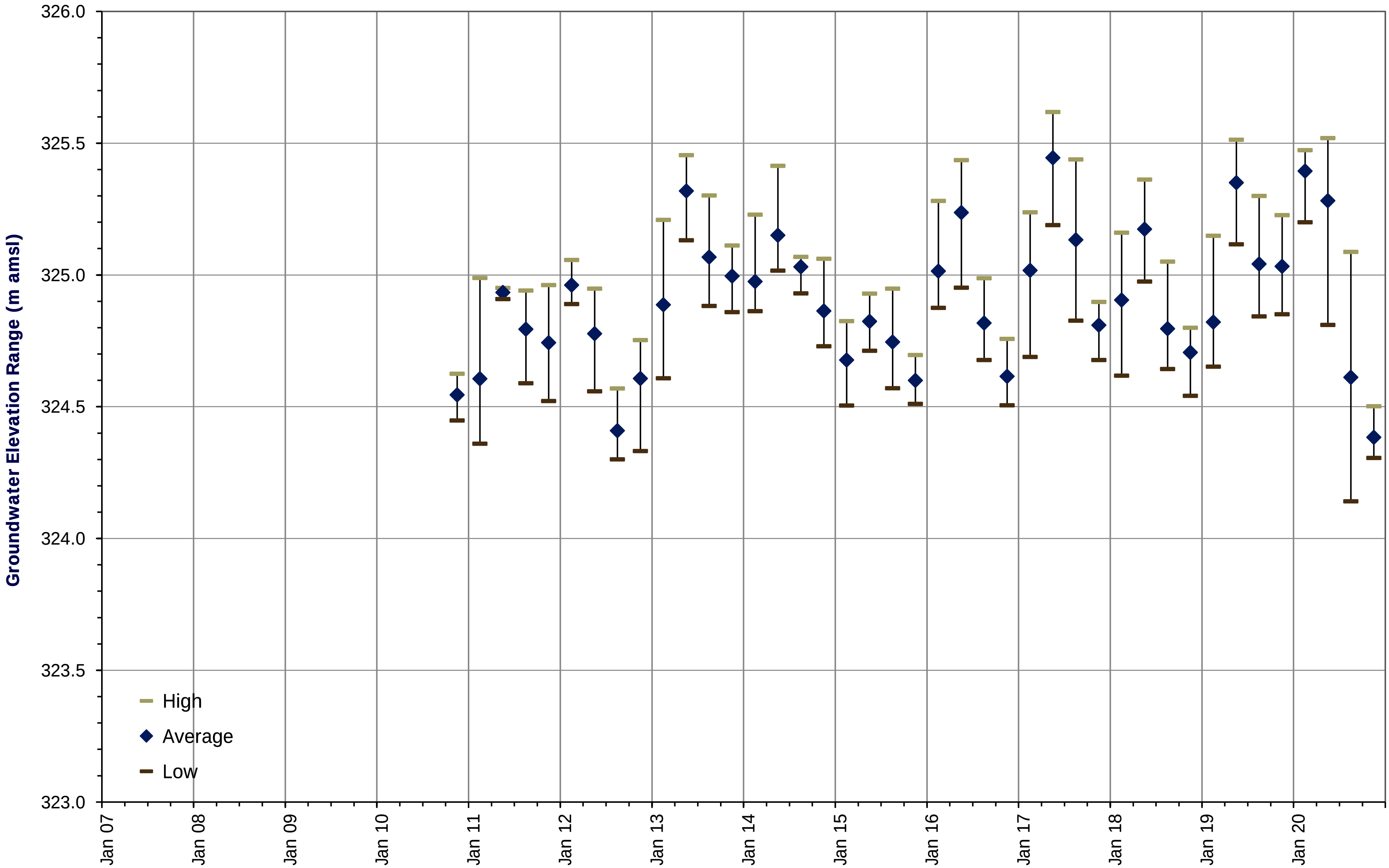


Banks Groundwater Engineering Limited

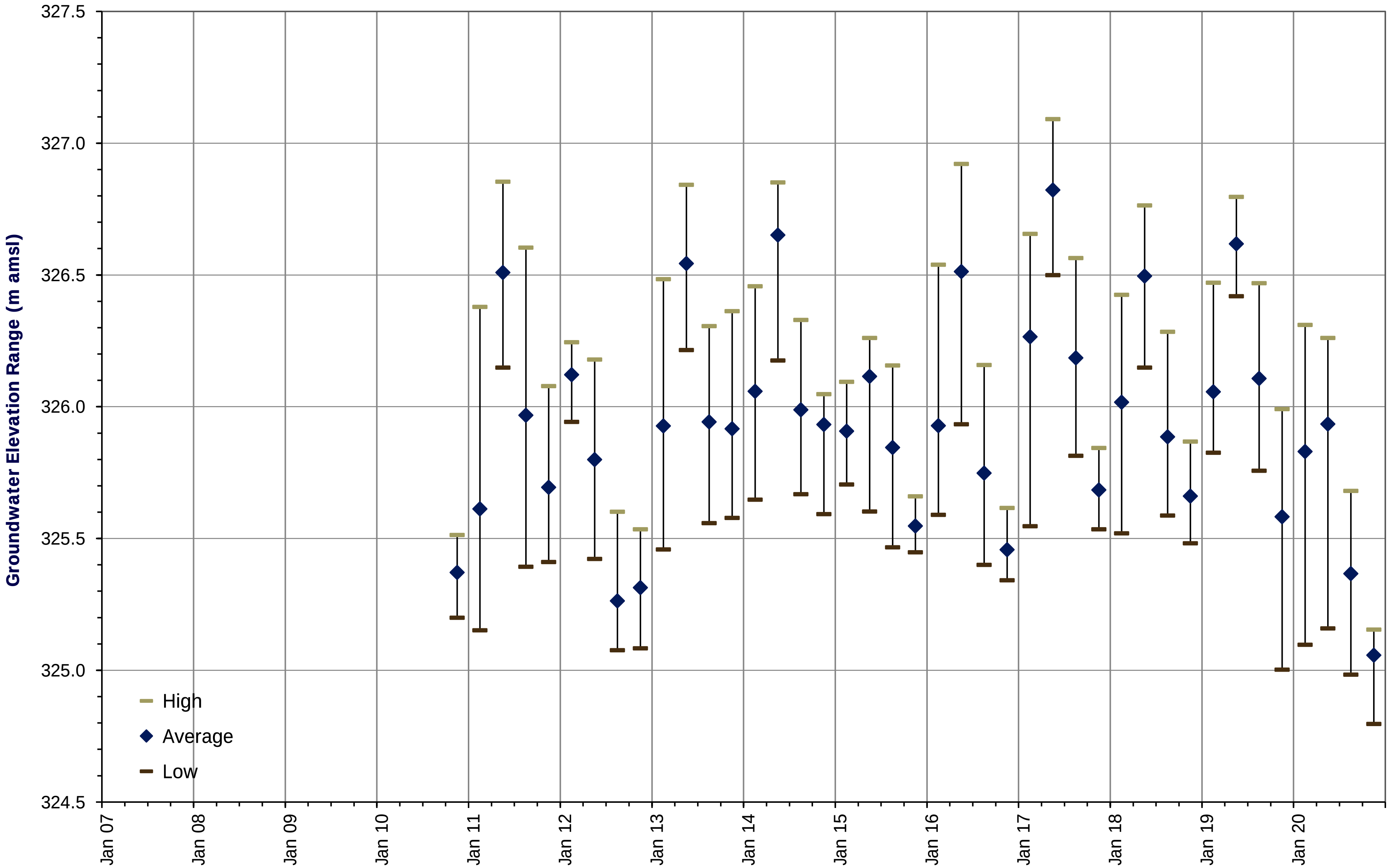
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-7**

Quarterly Groundwater Elevation Range - MW111



Quarterly Groundwater Elevation Range - MW112



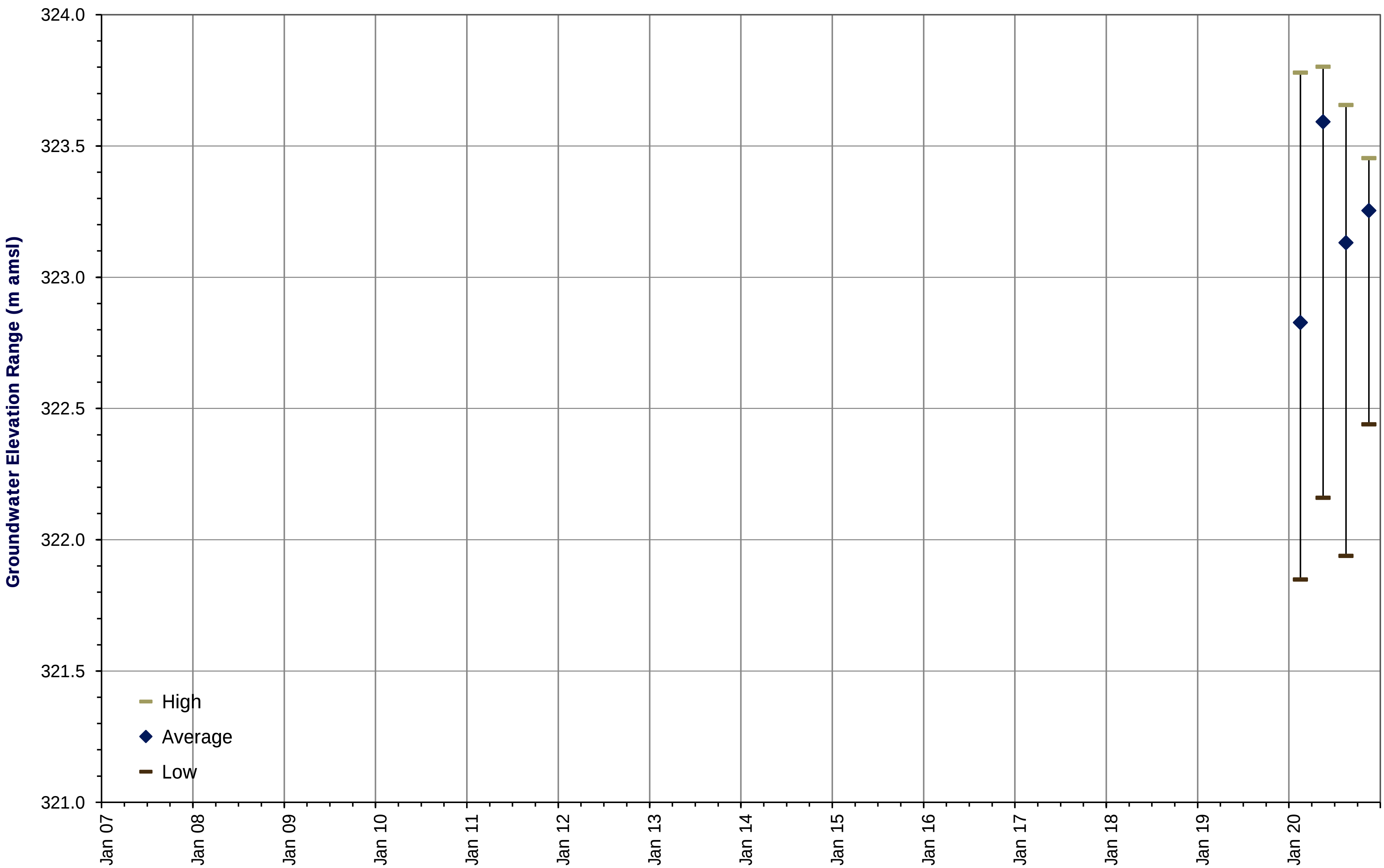
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

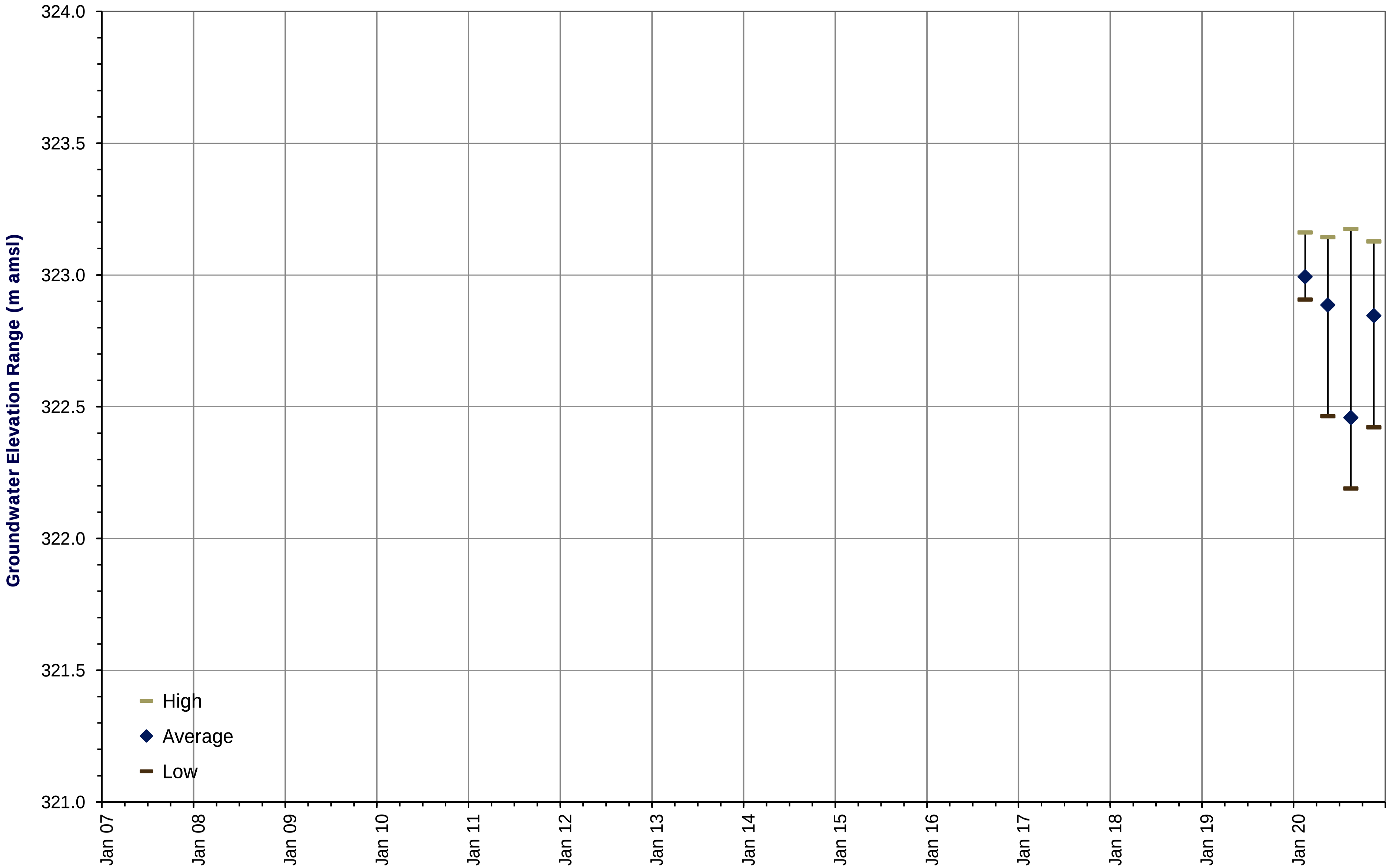
December 2020

Graph I-9

Quarterly Groundwater Elevation Range - MW115



Quarterly Groundwater Elevation Range - MW115A



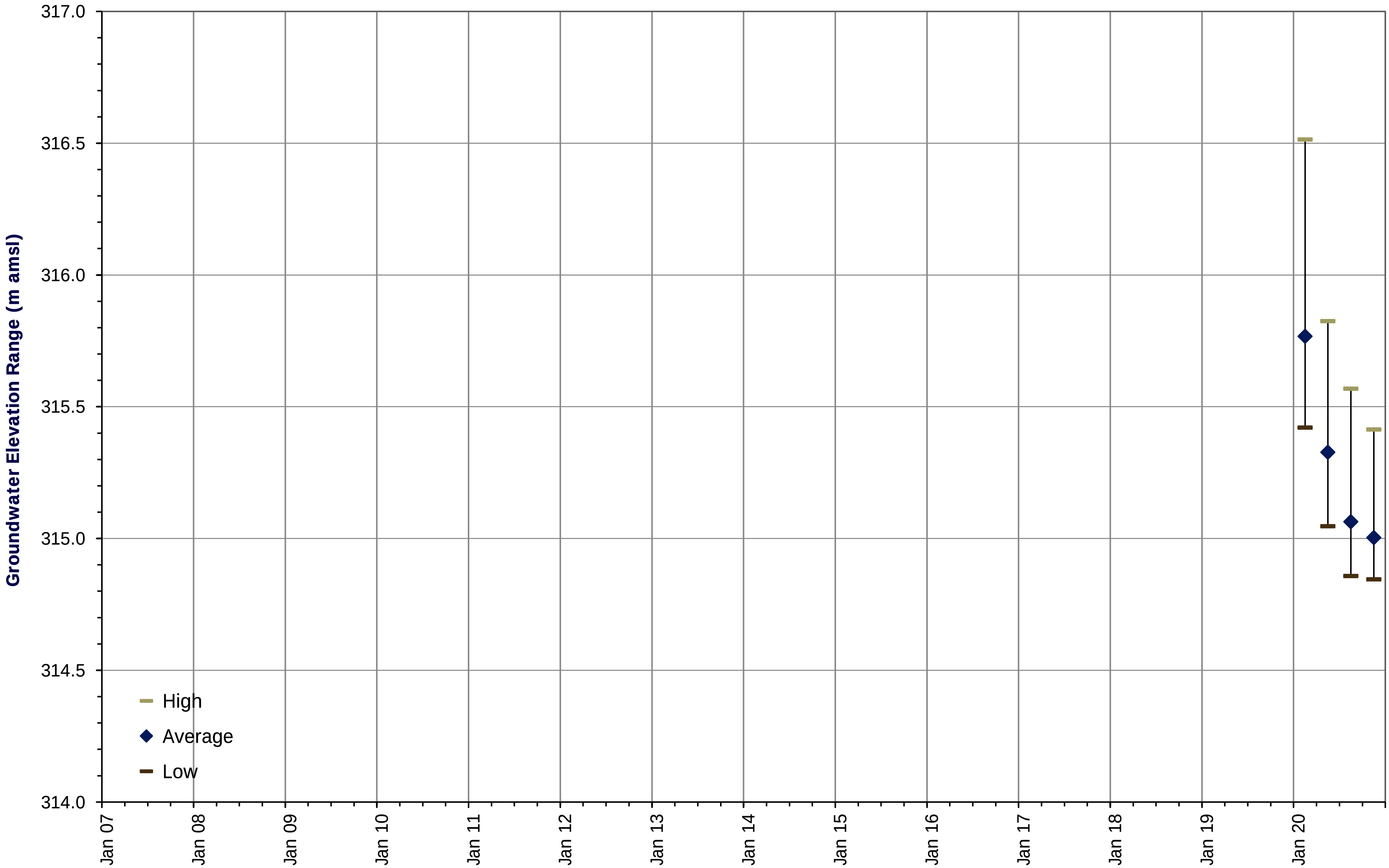
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-11

Quarterly Groundwater Elevation Range - MW116



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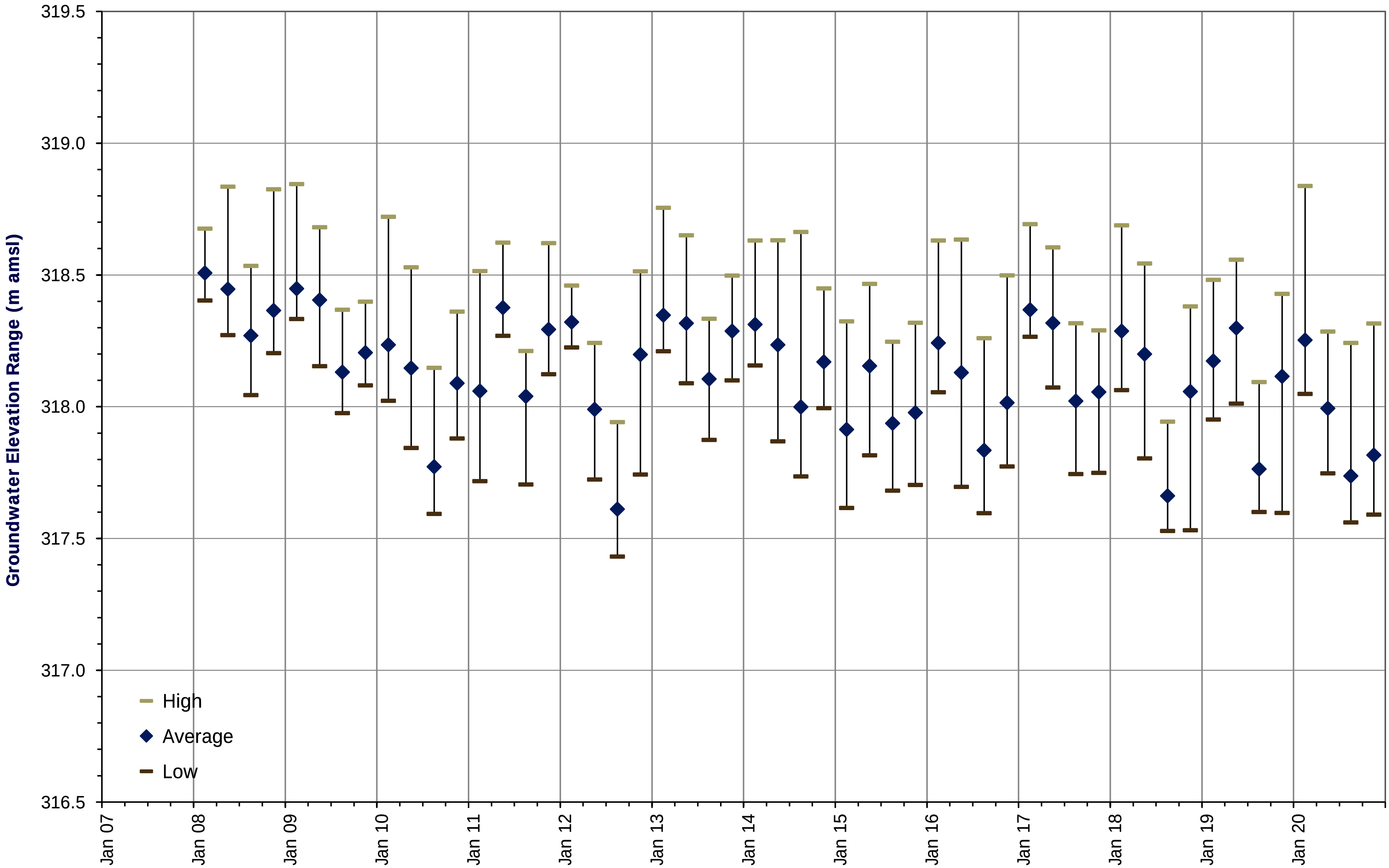
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-12

Quarterly Groundwater Elevation Range - MW116A



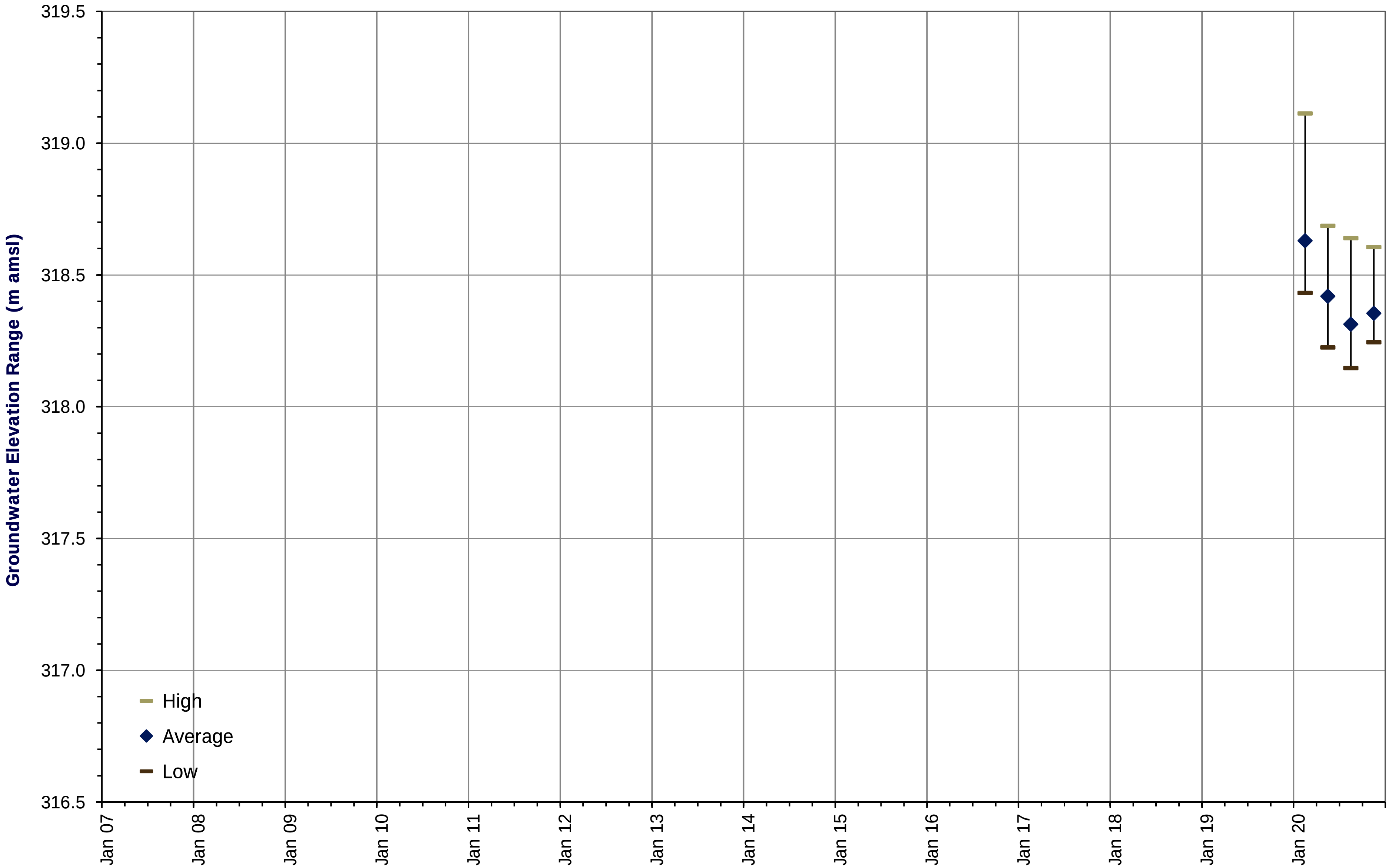
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-13

Quarterly Groundwater Elevation Range - MW117



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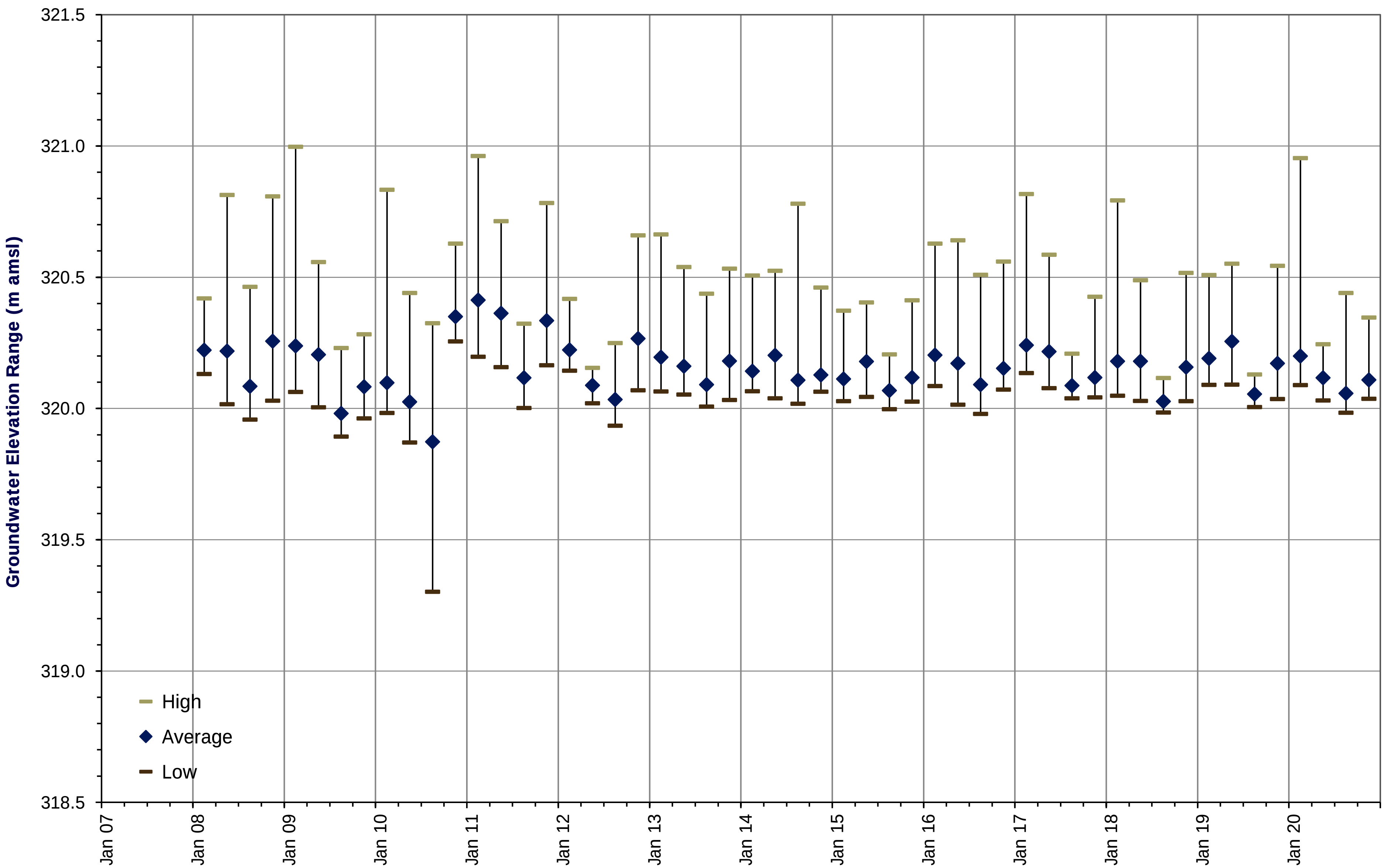
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-14**

Quarterly Groundwater Elevation Range - MW117A



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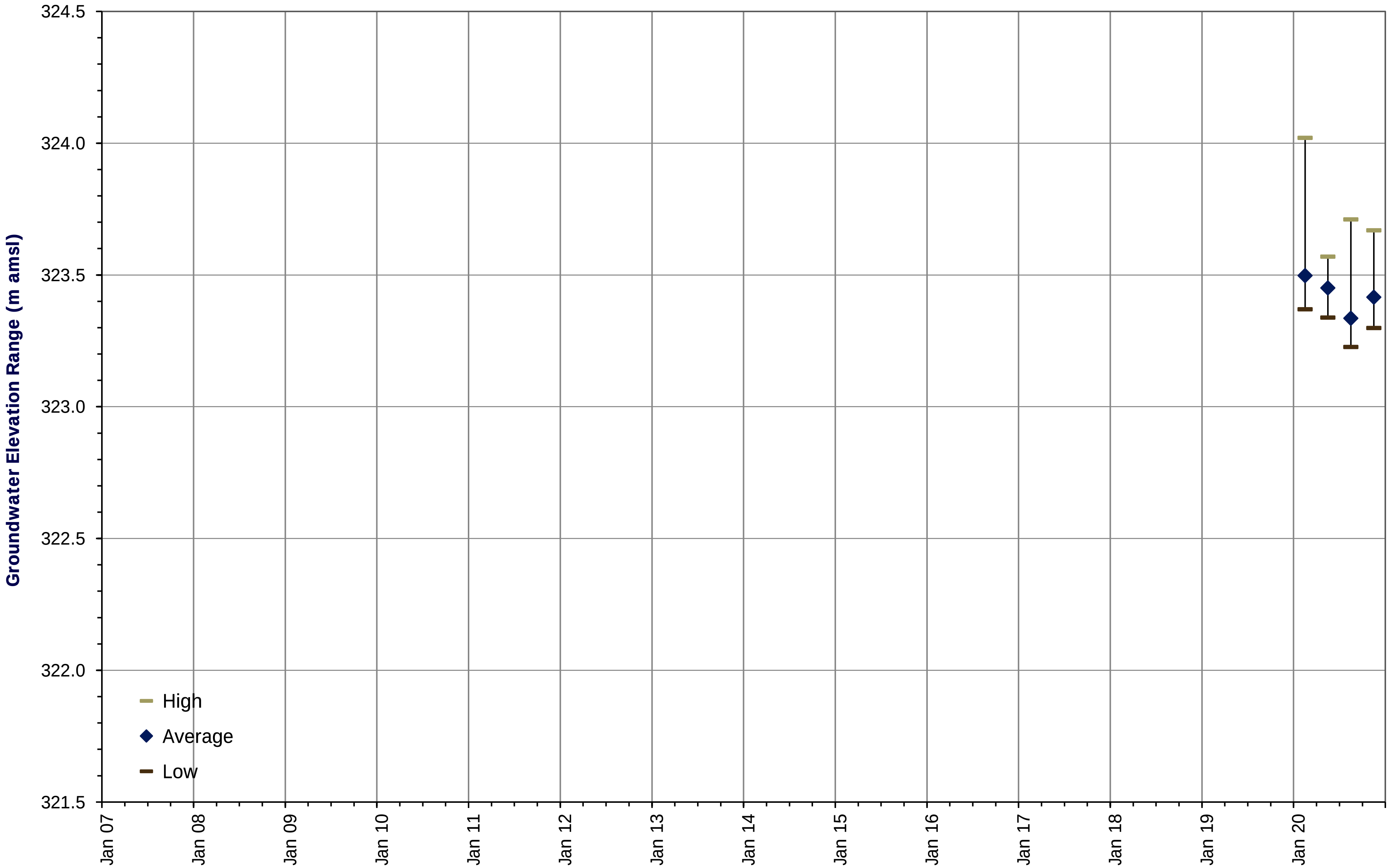
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-15**

Quarterly Groundwater Elevation Range - MW118



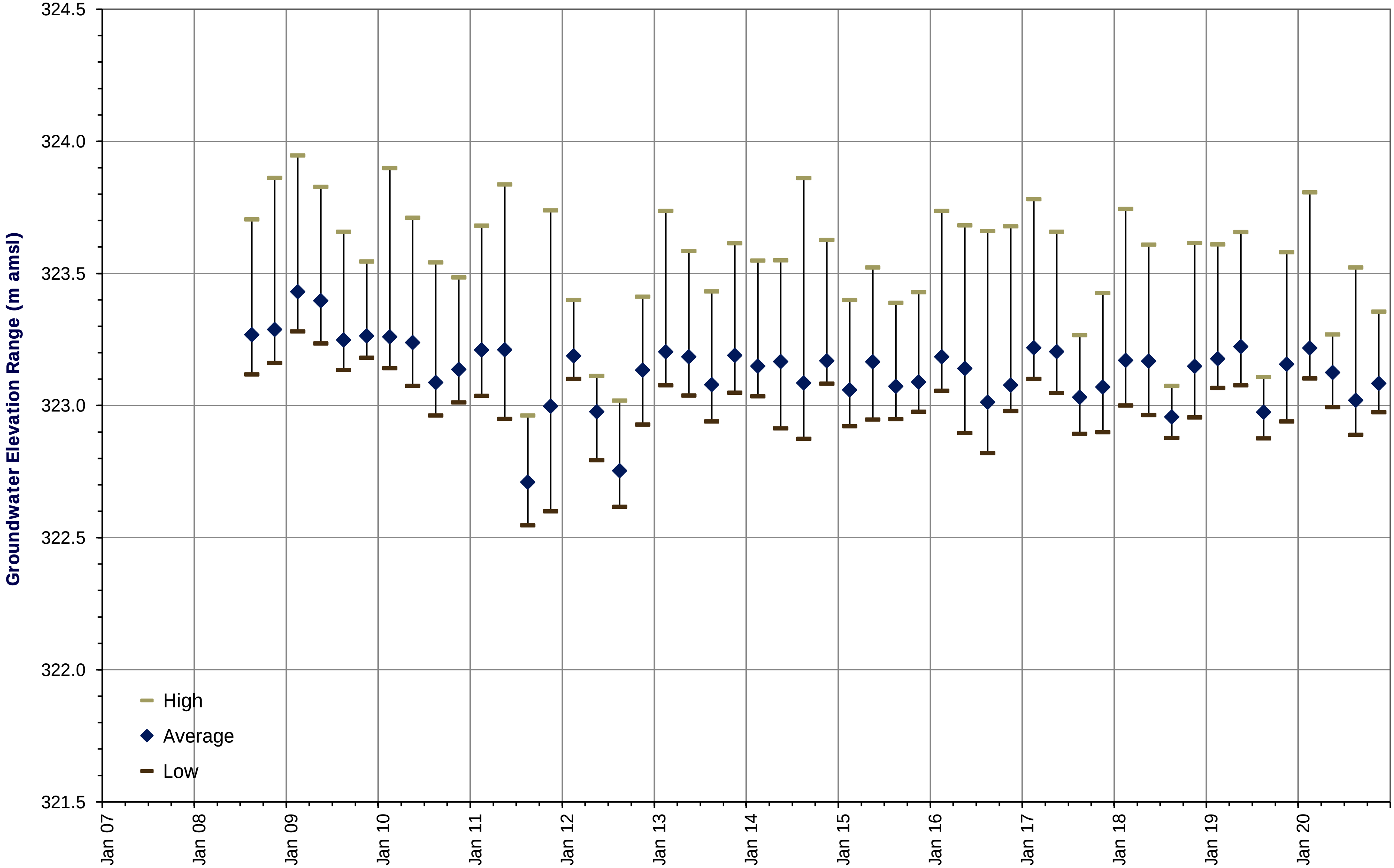
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-16

Quarterly Groundwater Elevation Range - MW118A



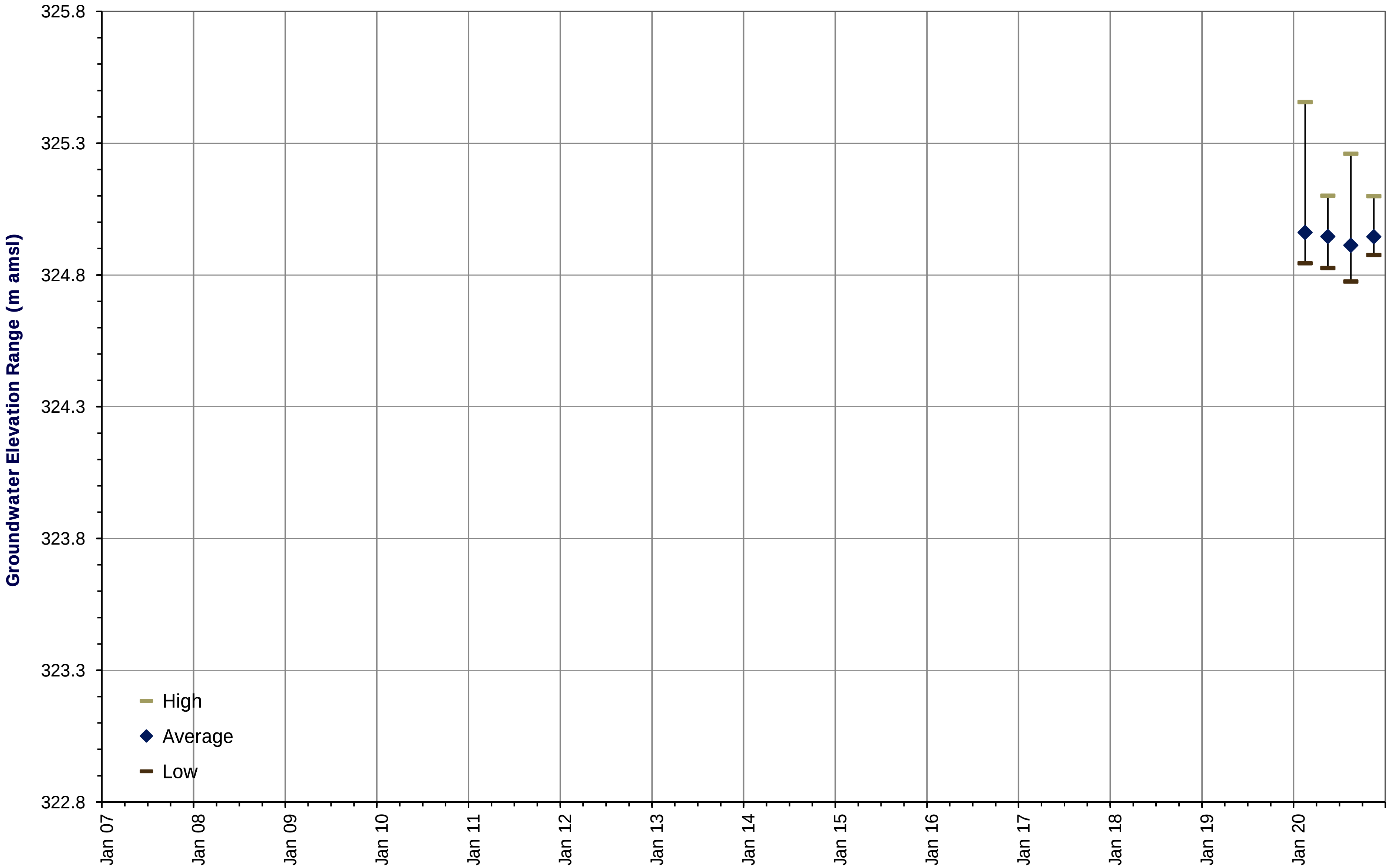
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-17

Quarterly Groundwater Elevation Range - MW119

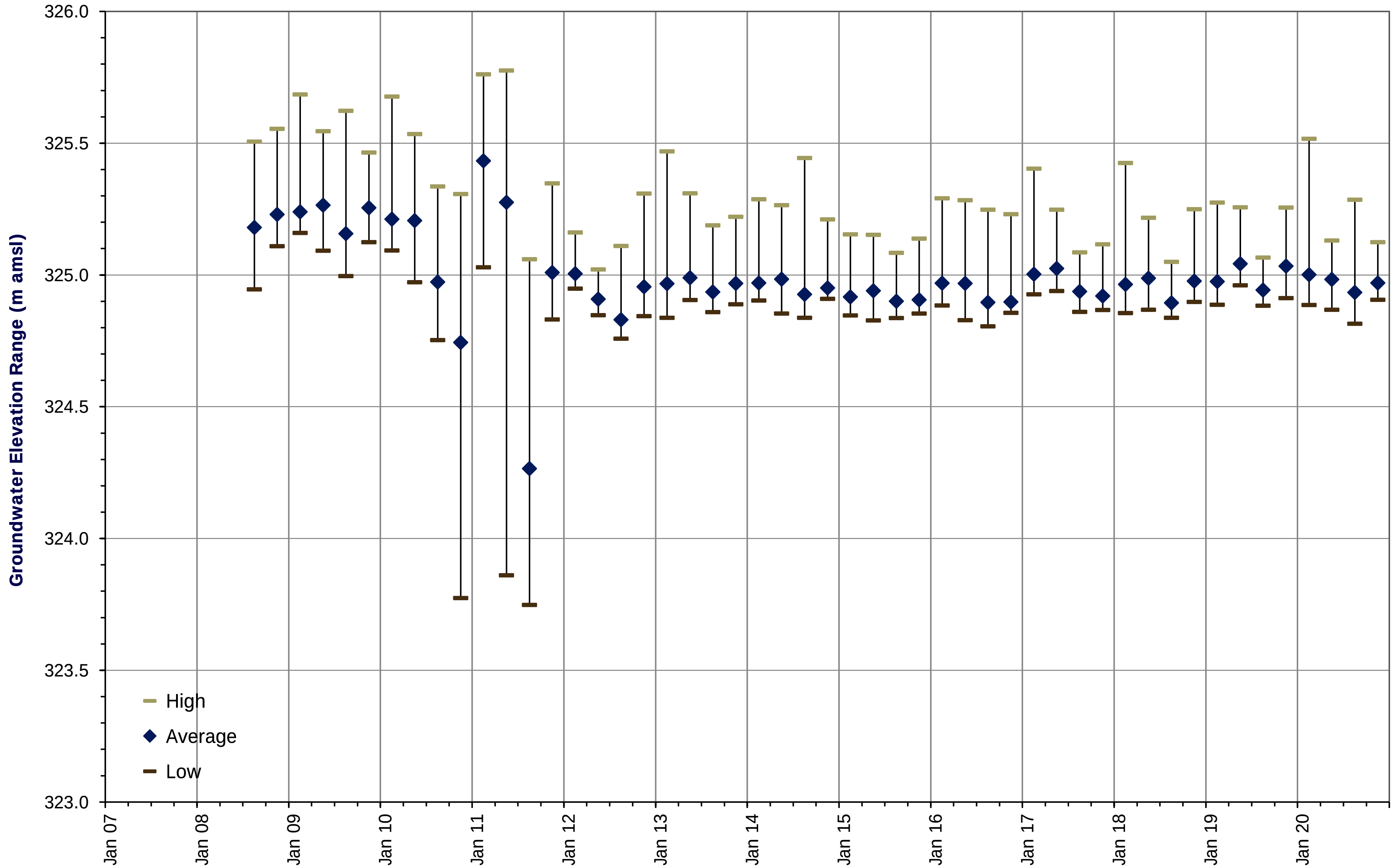


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-18**

Quarterly Groundwater Elevation Range - MW119A



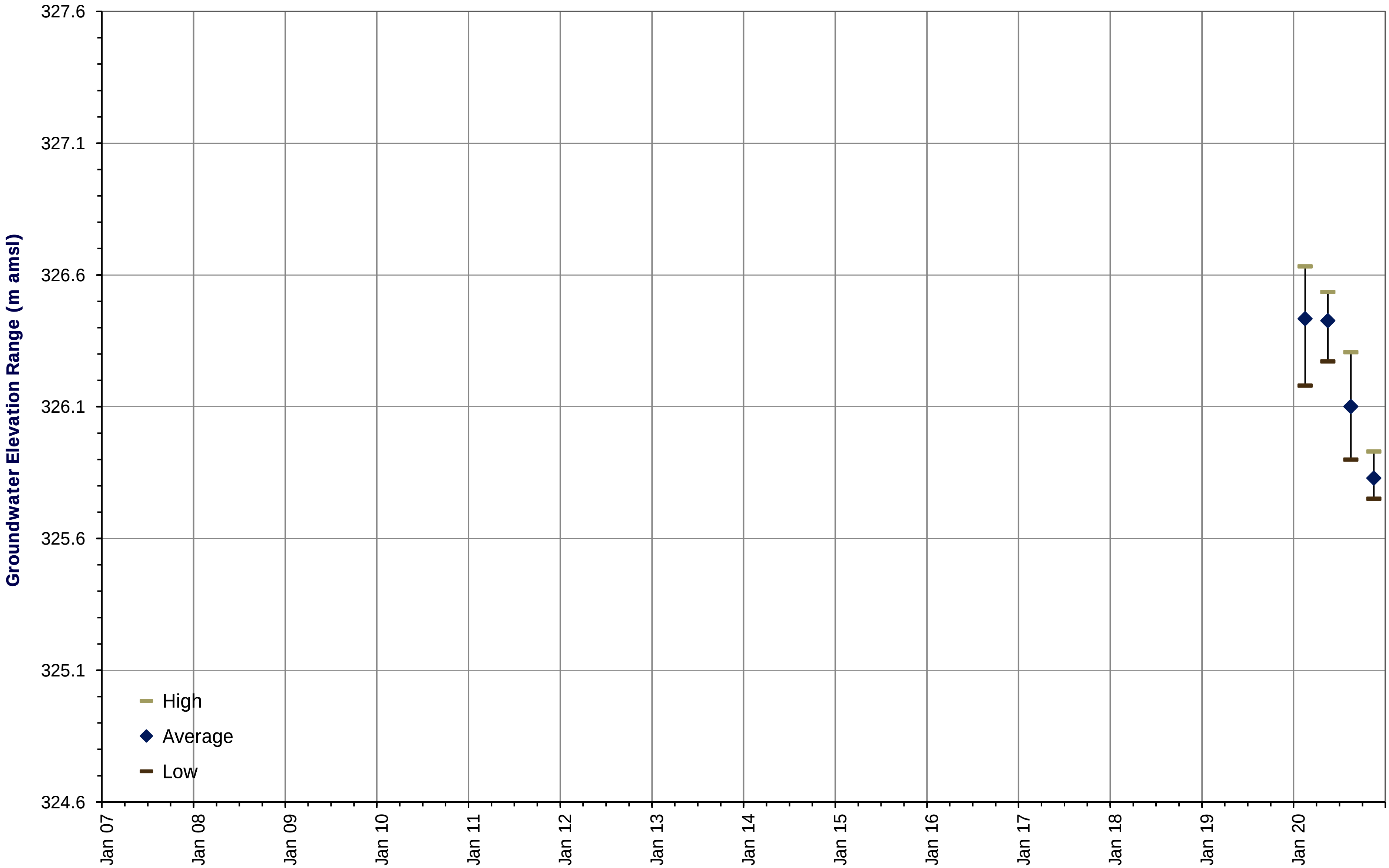
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-19

Quarterly Groundwater Elevation Range - MW121

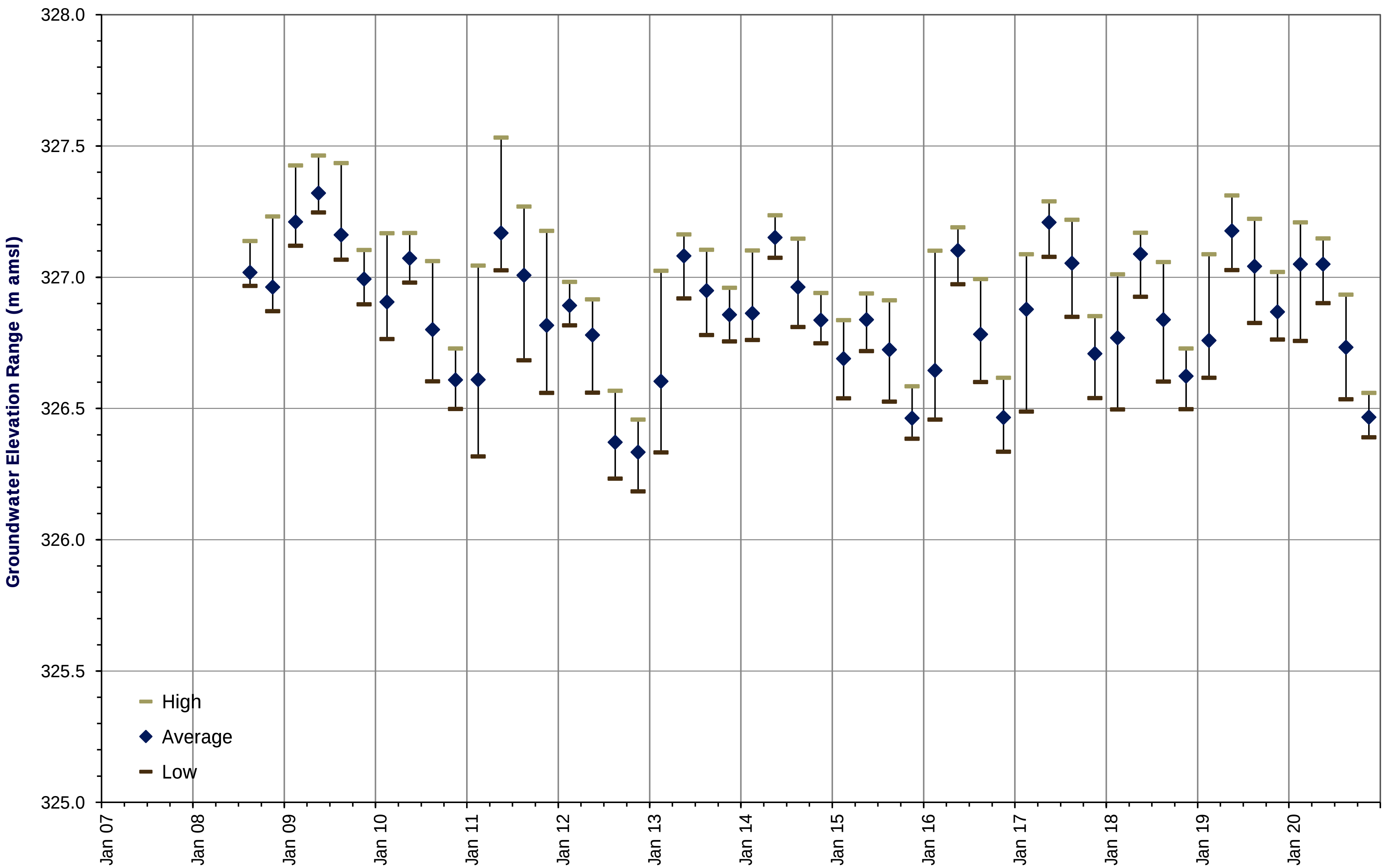


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-20**

Quarterly Groundwater Elevation Range - MW121A

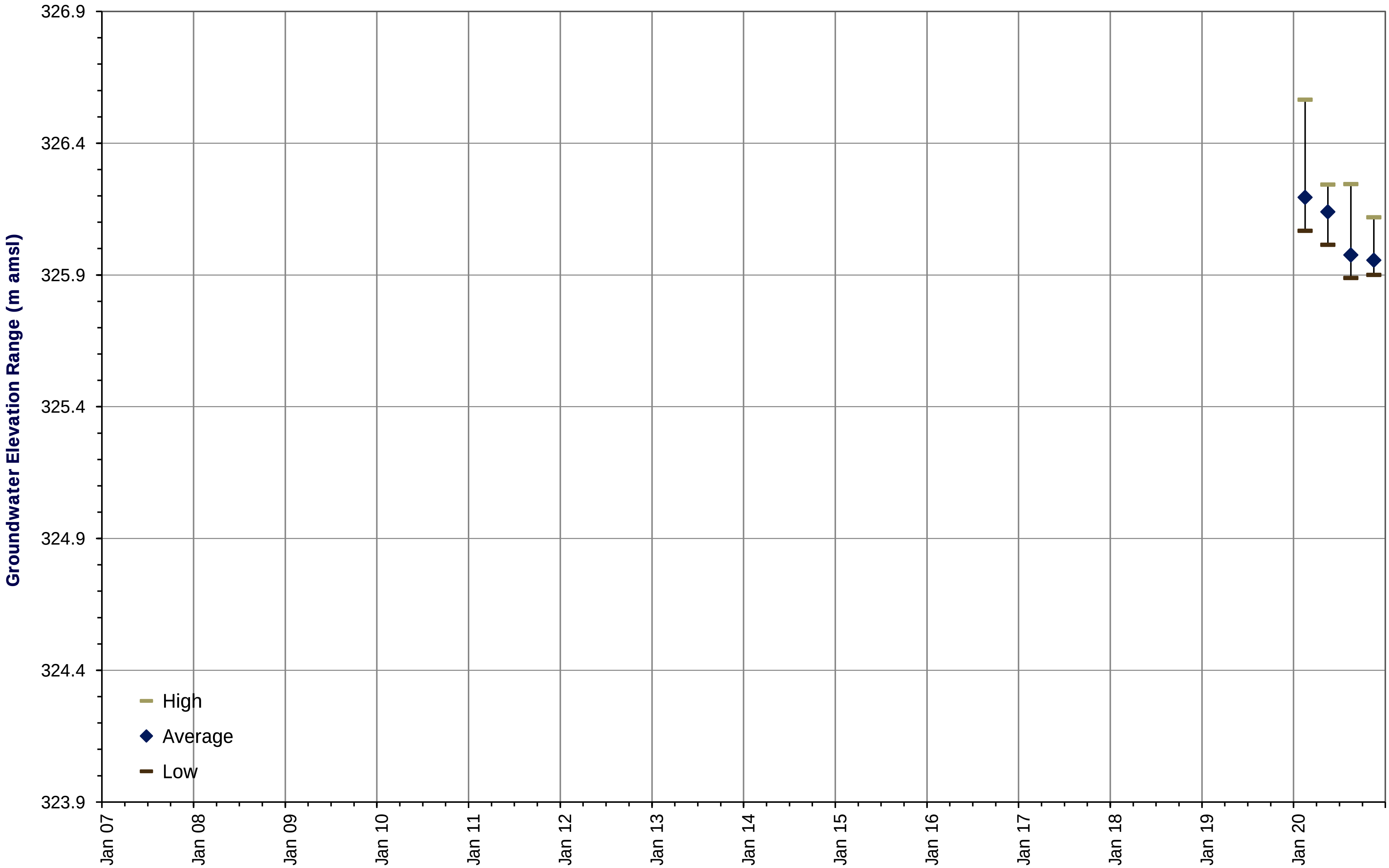


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-21**

Quarterly Groundwater Elevation Range - MW122

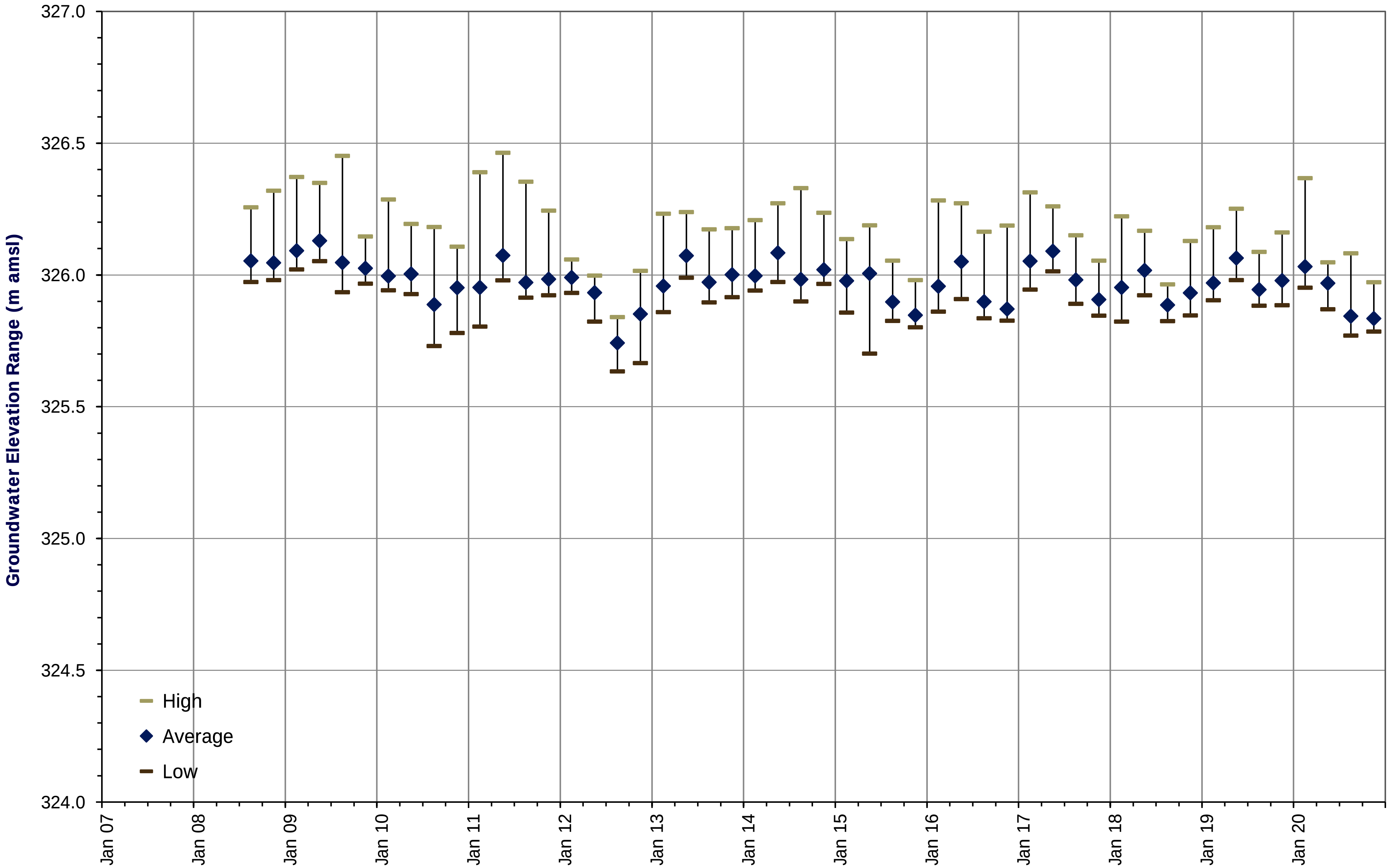


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-22**

Quarterly Groundwater Elevation Range - MW122A



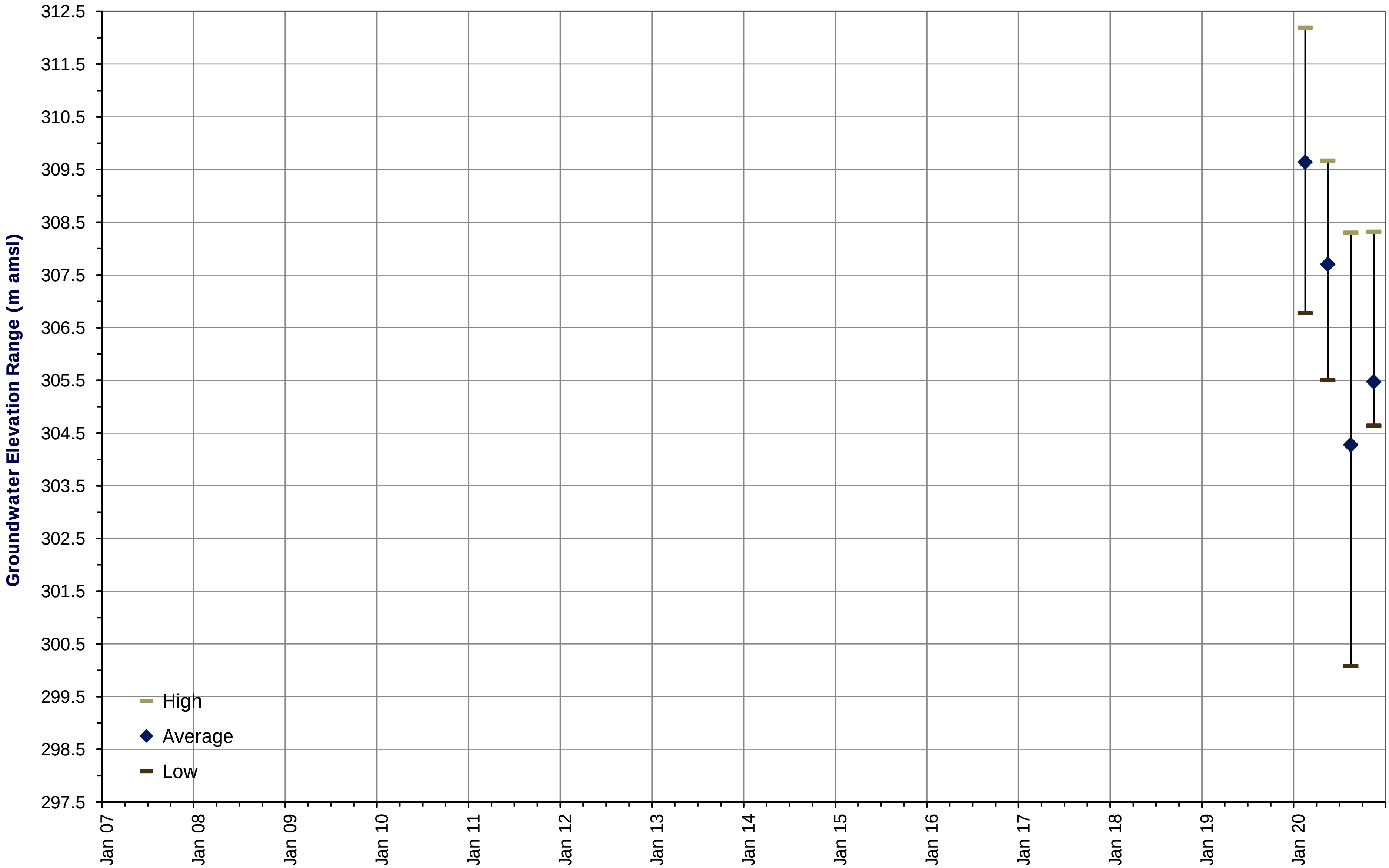
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-23

Quarterly Groundwater Elevation Range - MW123



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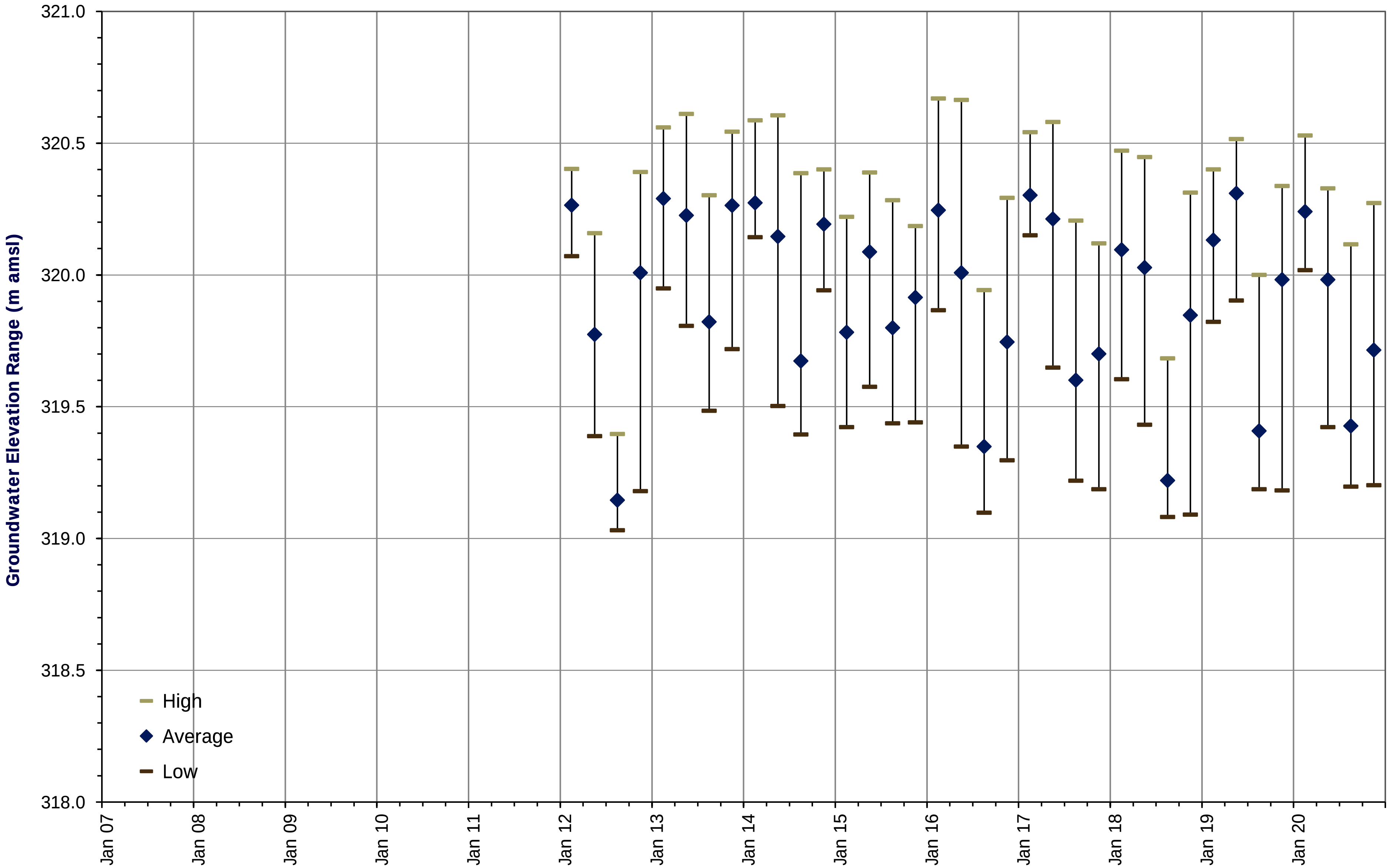
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-24

Quarterly Groundwater Elevation Range - MW124



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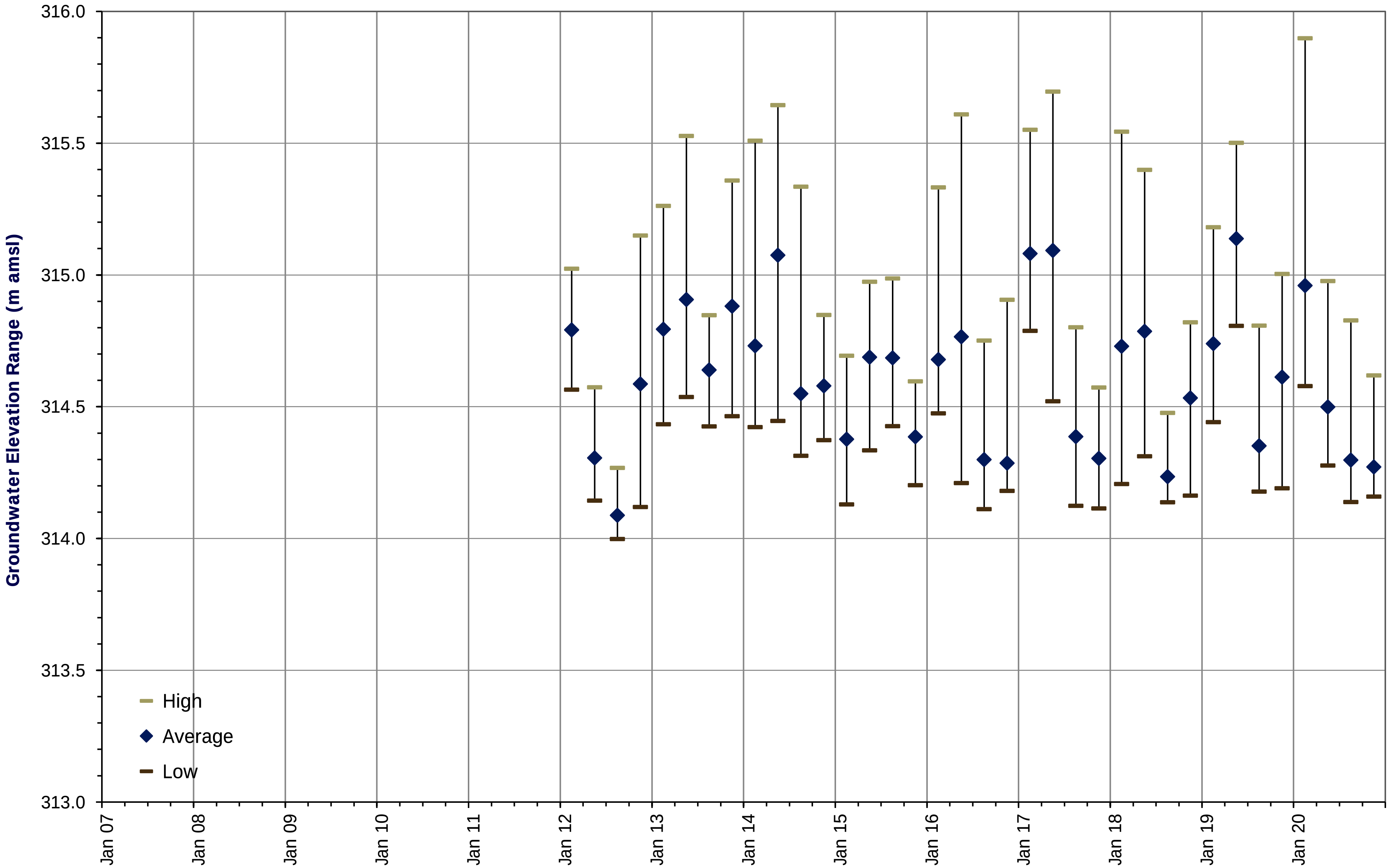
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-25**

Quarterly Groundwater Elevation Range - MW125



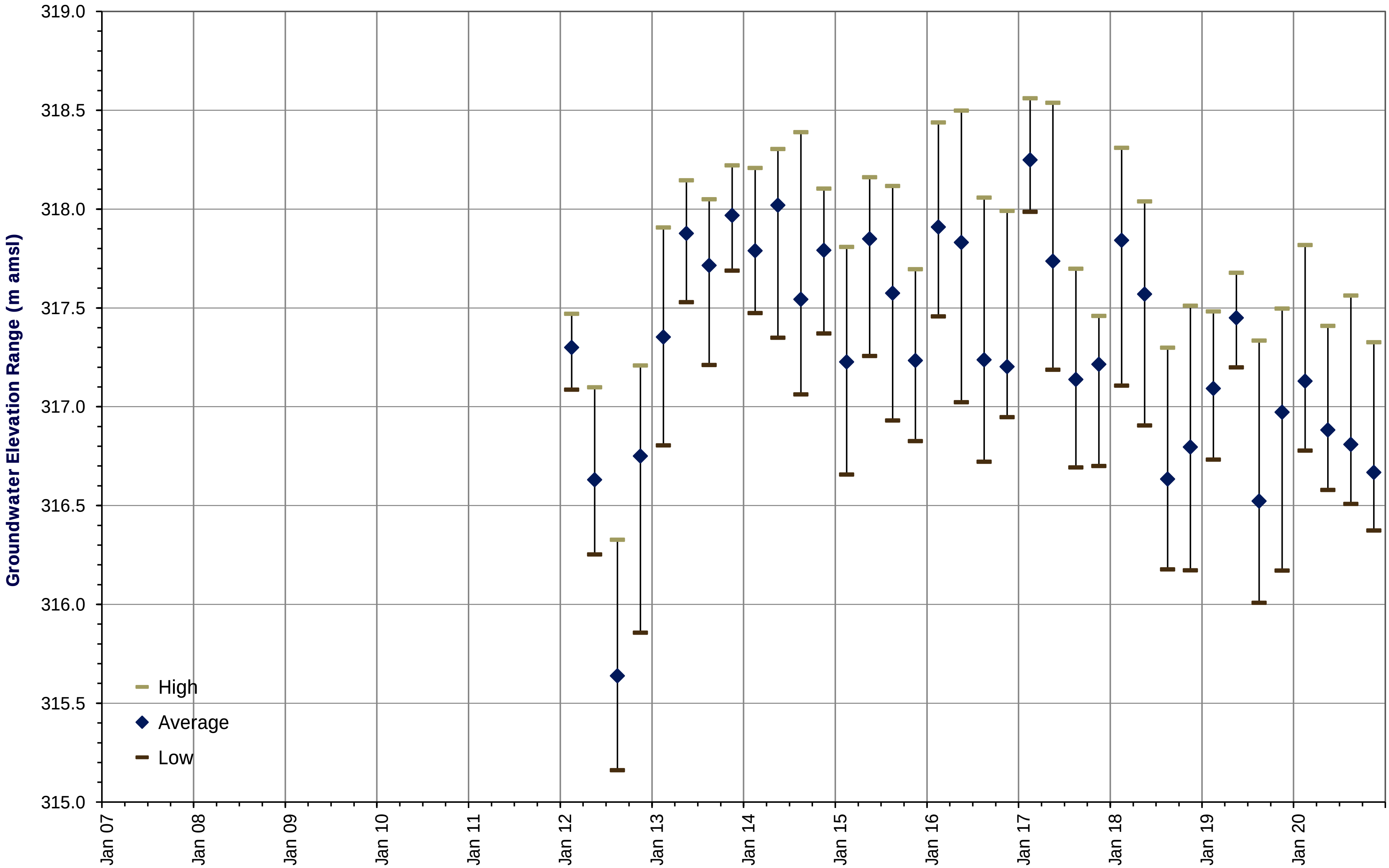
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-26

Quarterly Groundwater Elevation Range - MW126

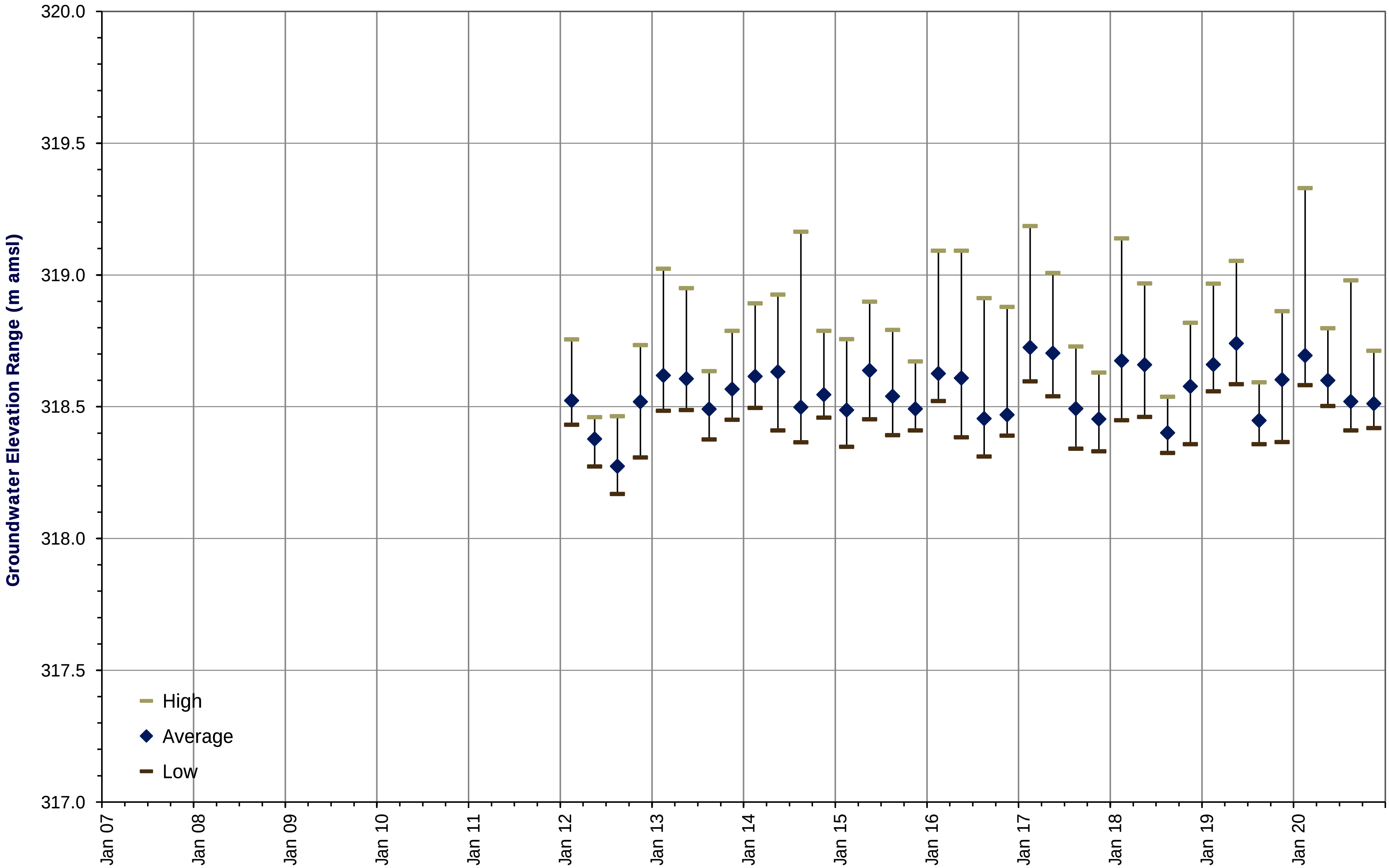


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-27**

Quarterly Groundwater Elevation Range - MW127



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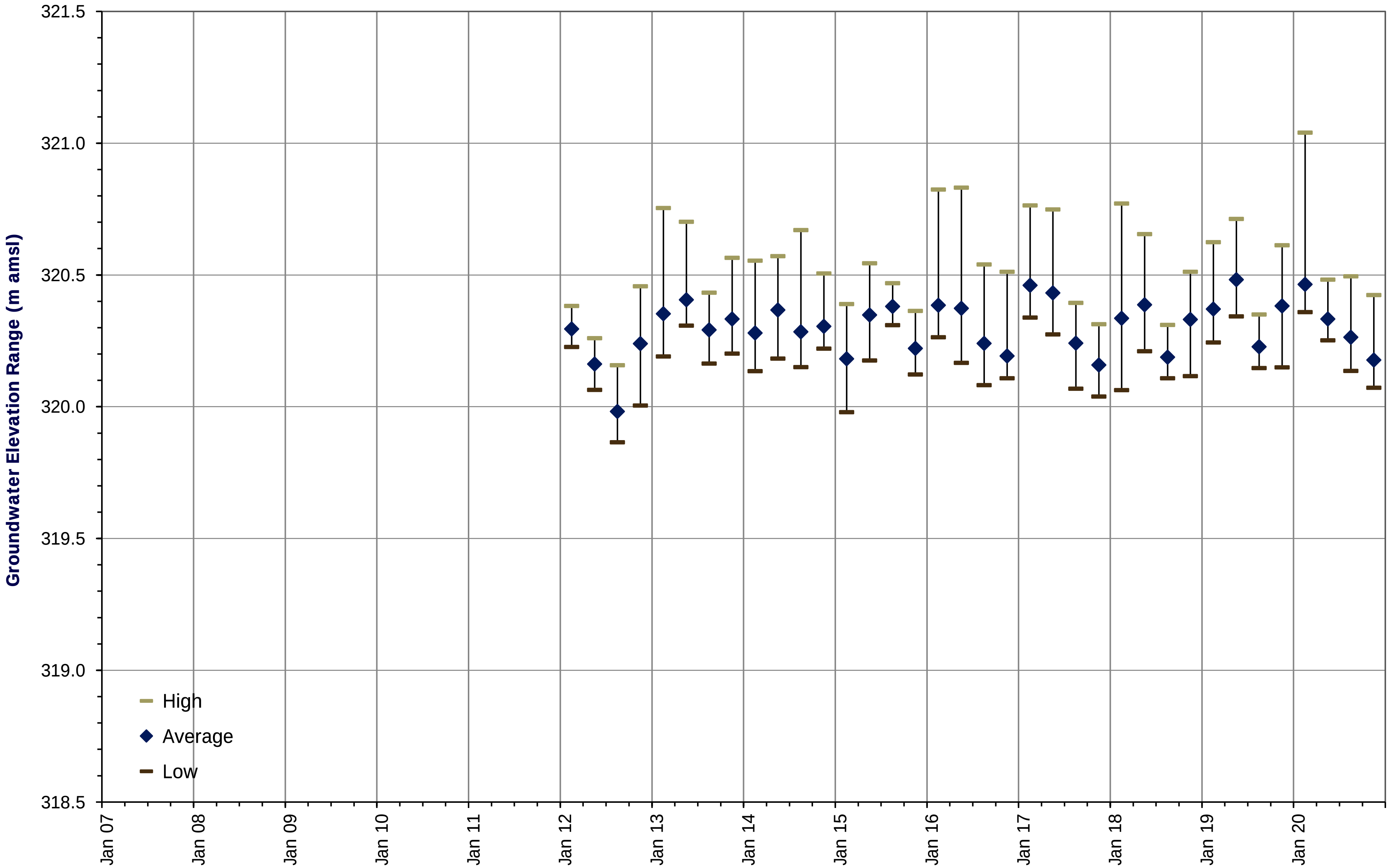
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-28

Quarterly Groundwater Elevation Range - MW128

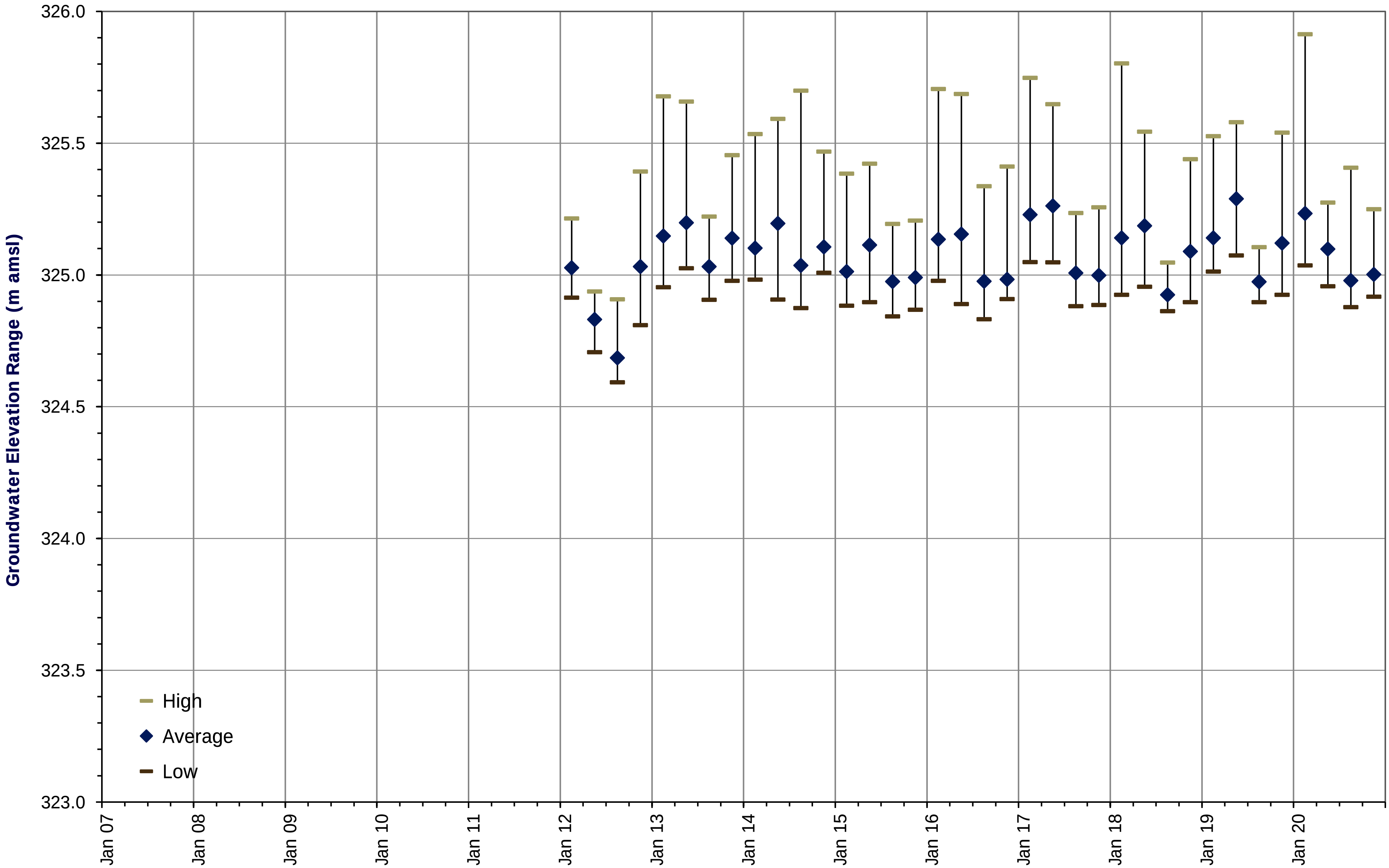


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-29**

Quarterly Groundwater Elevation Range - MW129



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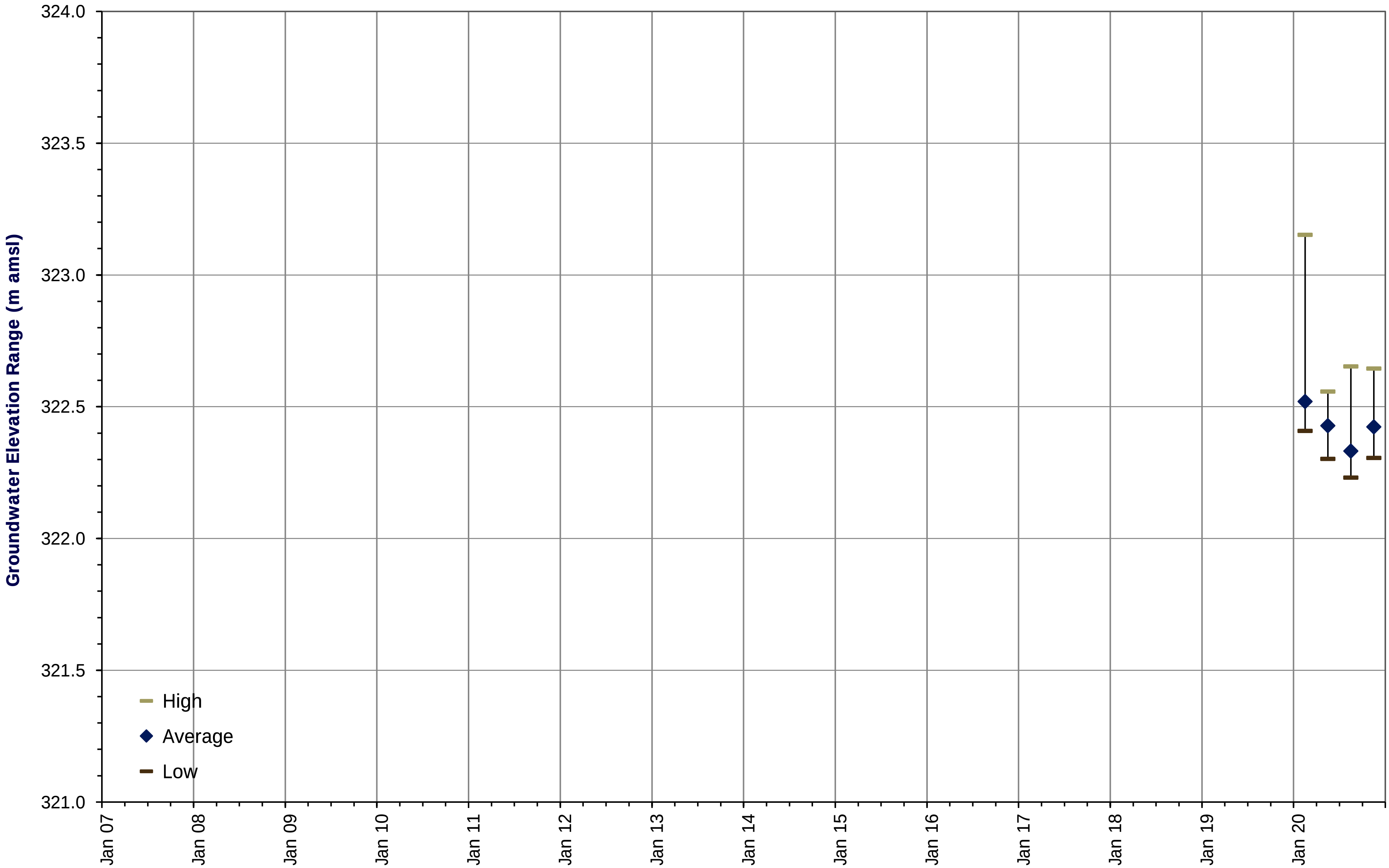
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-30**

Quarterly Groundwater Elevation Range - MW130



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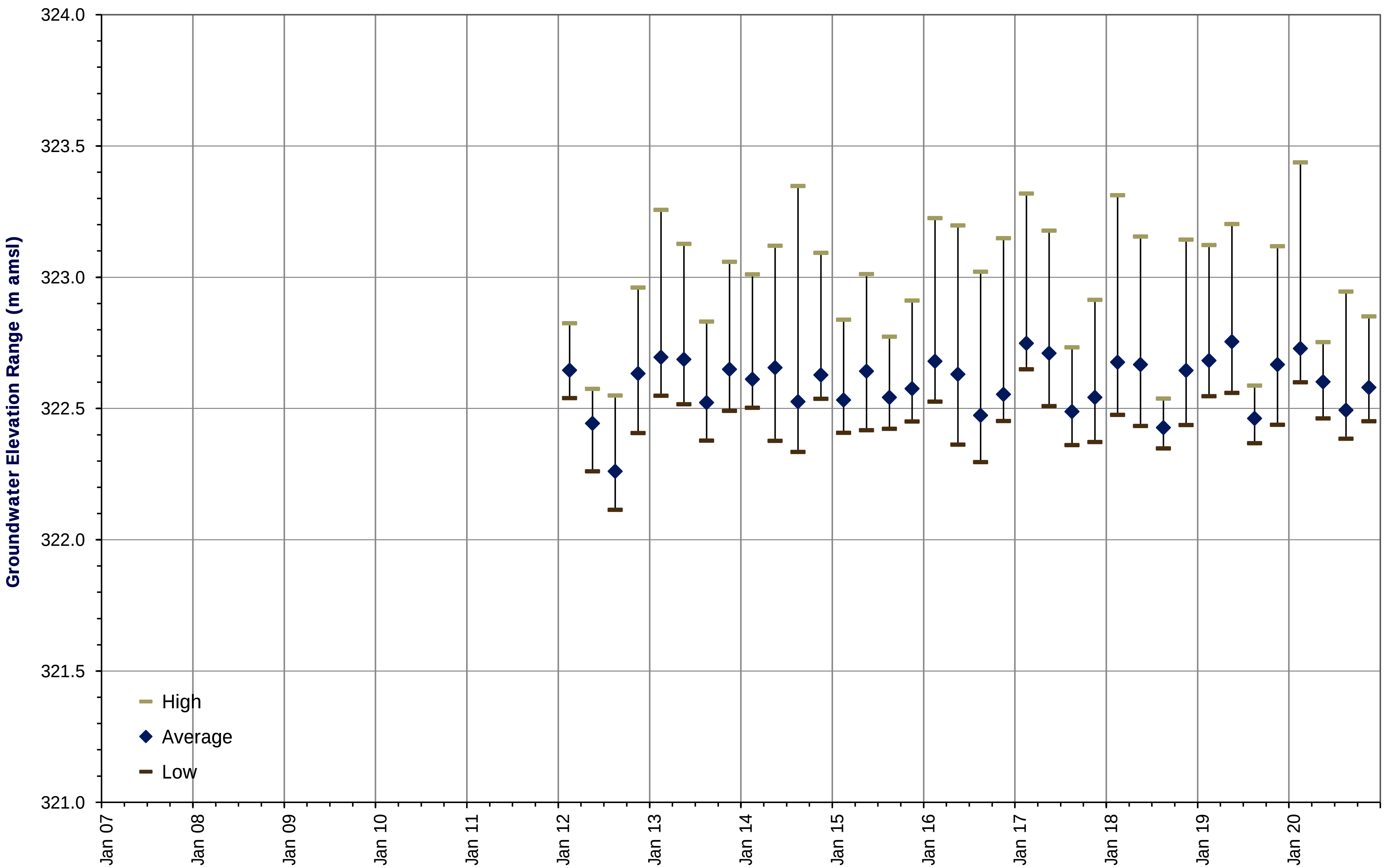
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-31

Quarterly Groundwater Elevation Range - MW130A



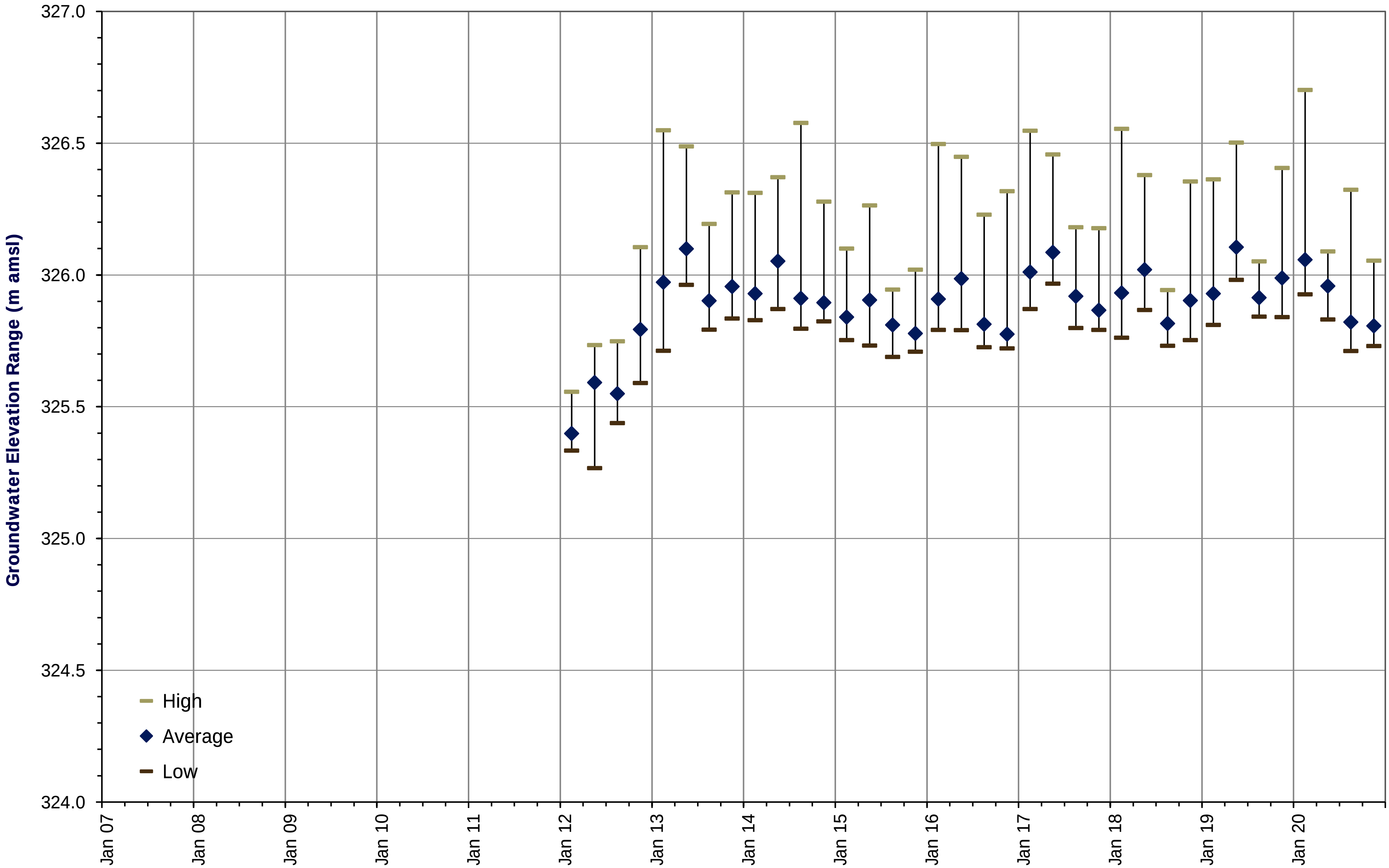
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-32

Quarterly Groundwater Elevation Range - MW131



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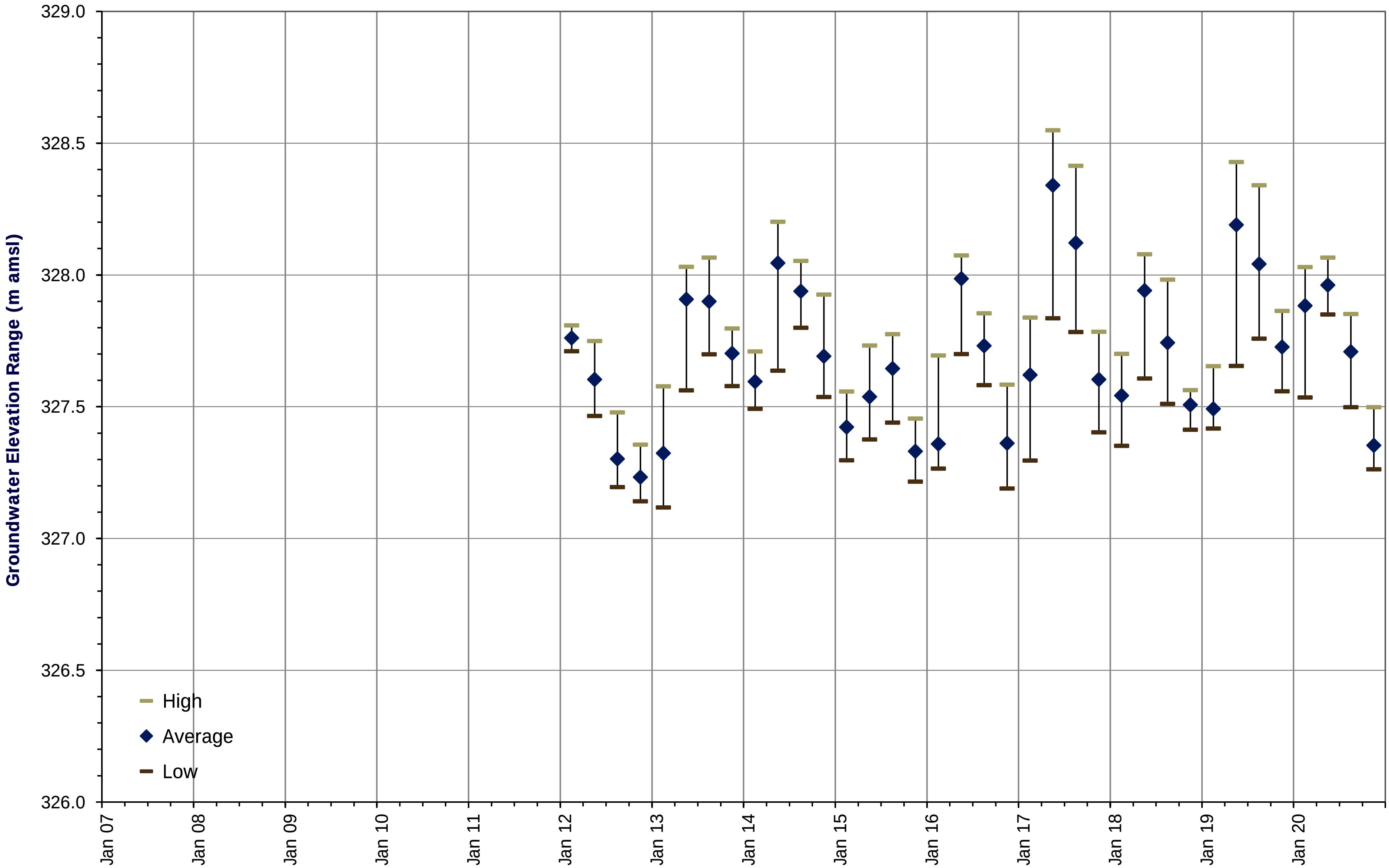
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-33

Quarterly Groundwater Elevation Range - MW132



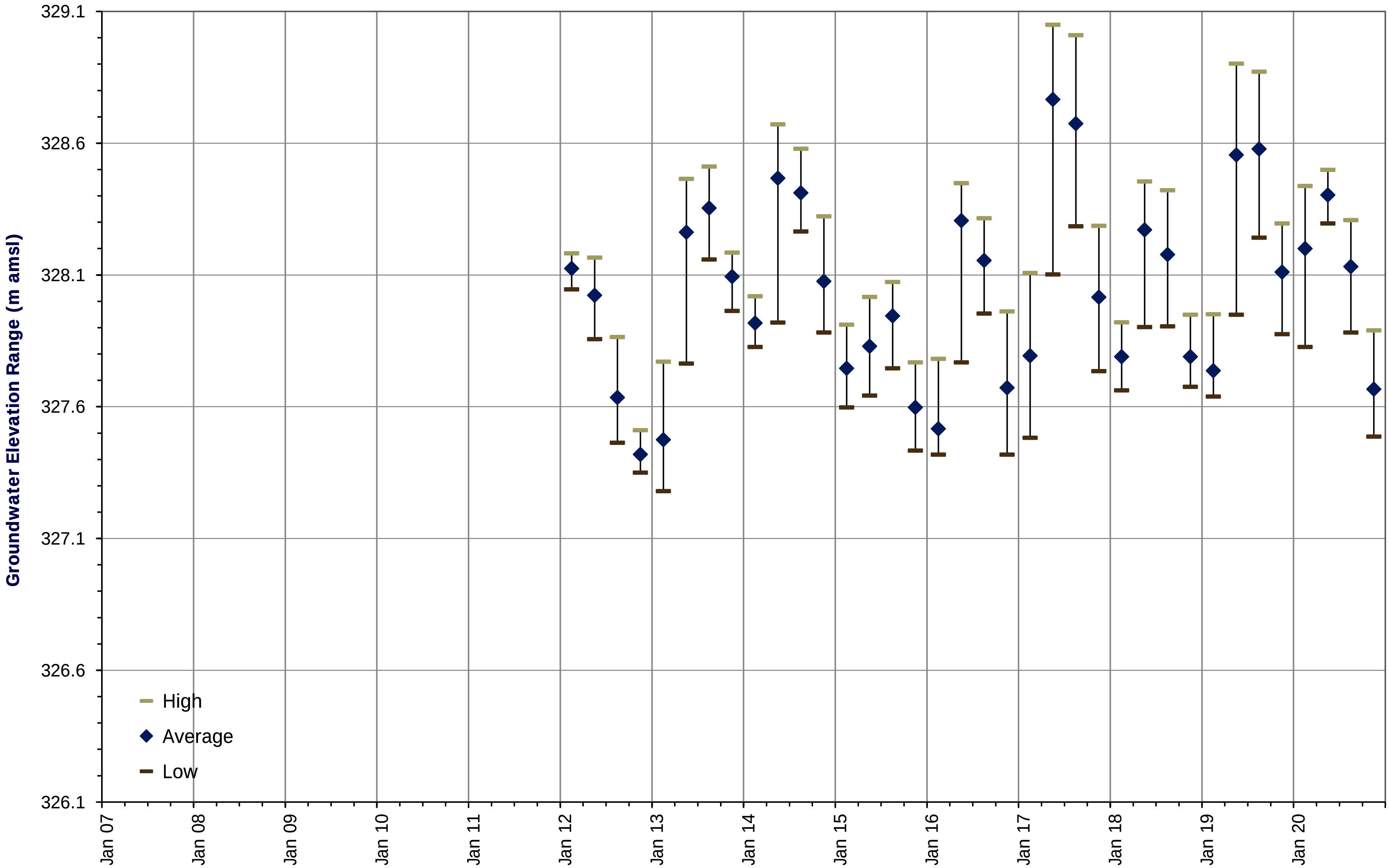
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-34

Quarterly Groundwater Elevation Range - MW133



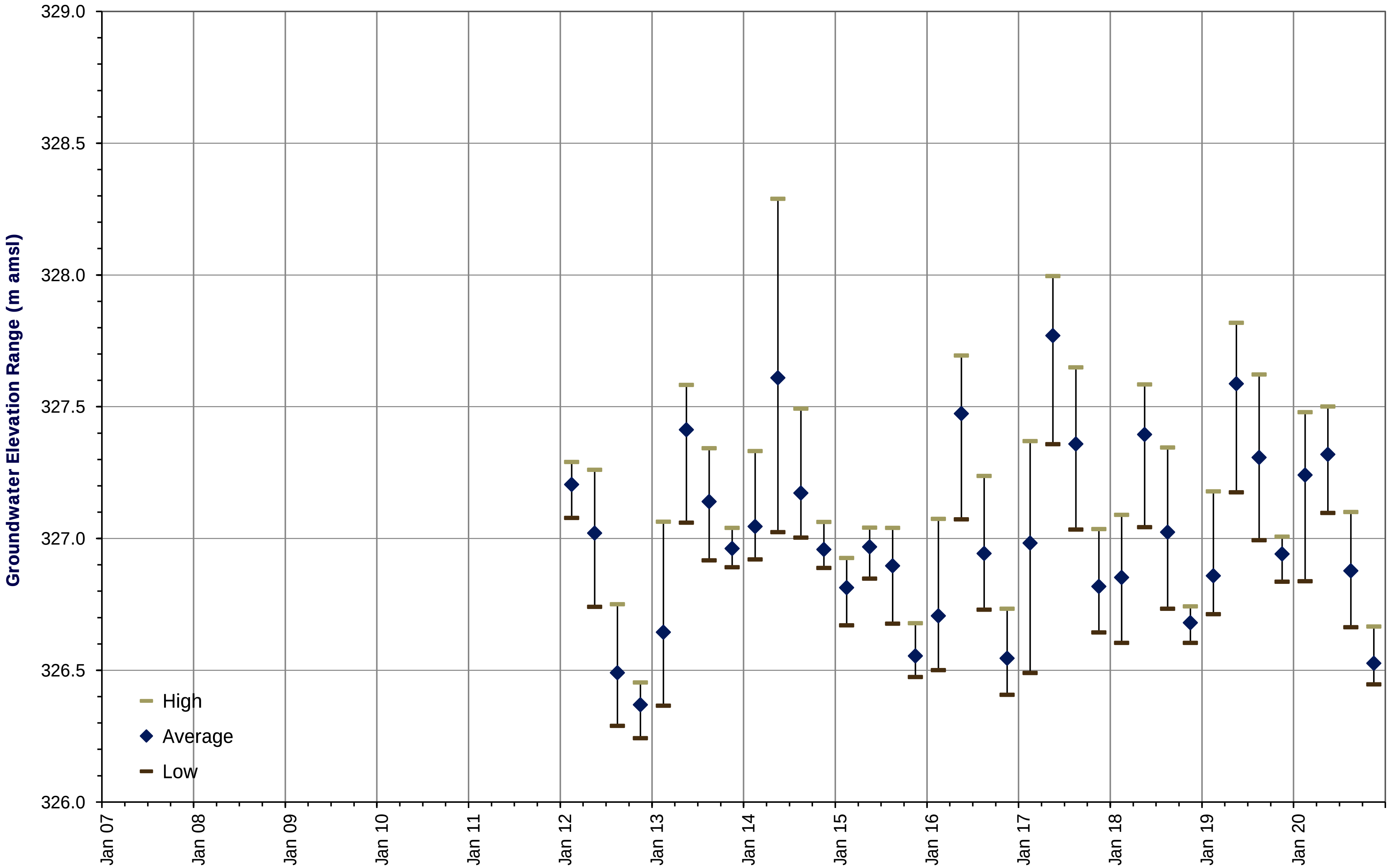
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-35

Quarterly Groundwater Elevation Range - MW134

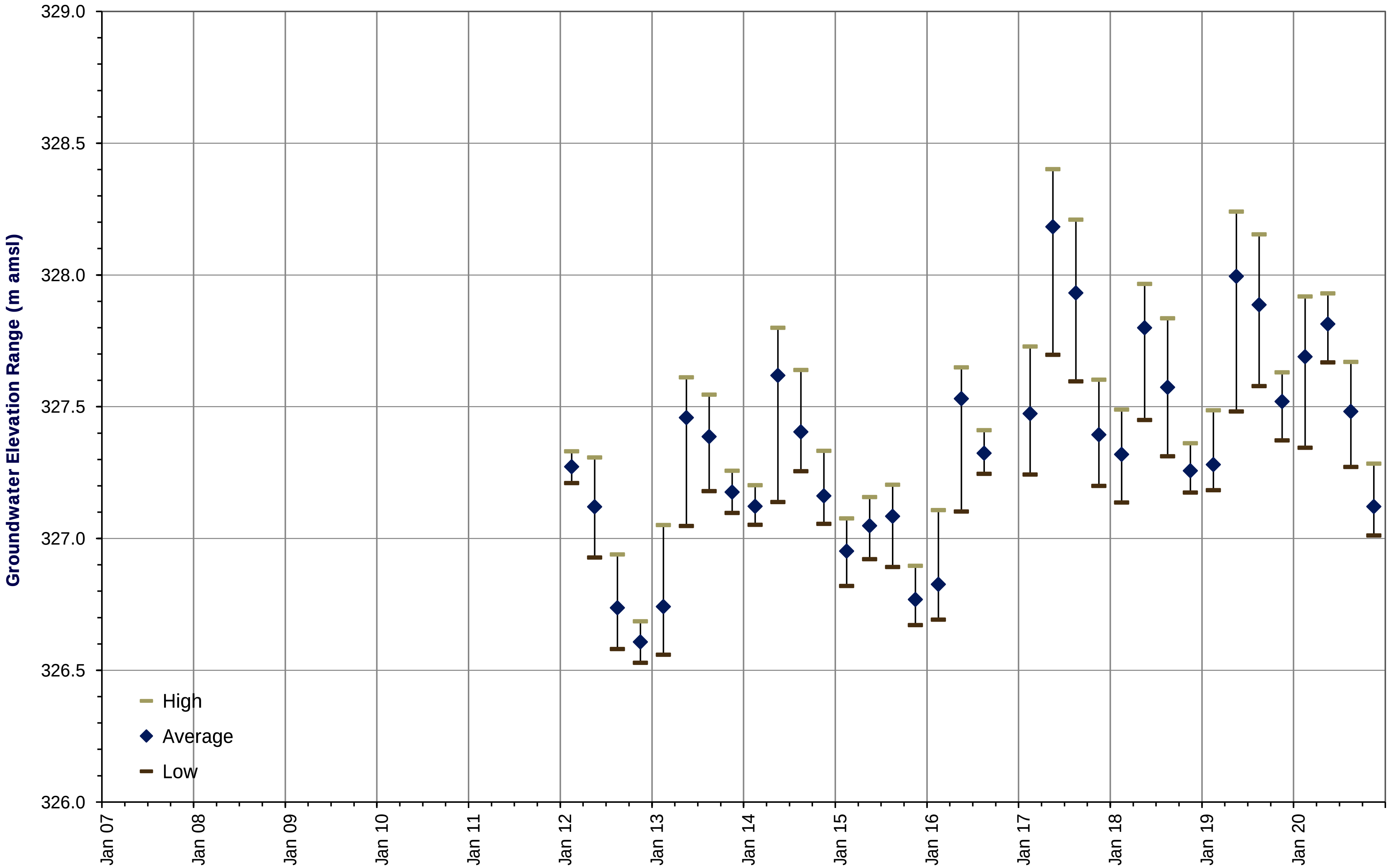


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-36**

Quarterly Groundwater Elevation Range - MW135



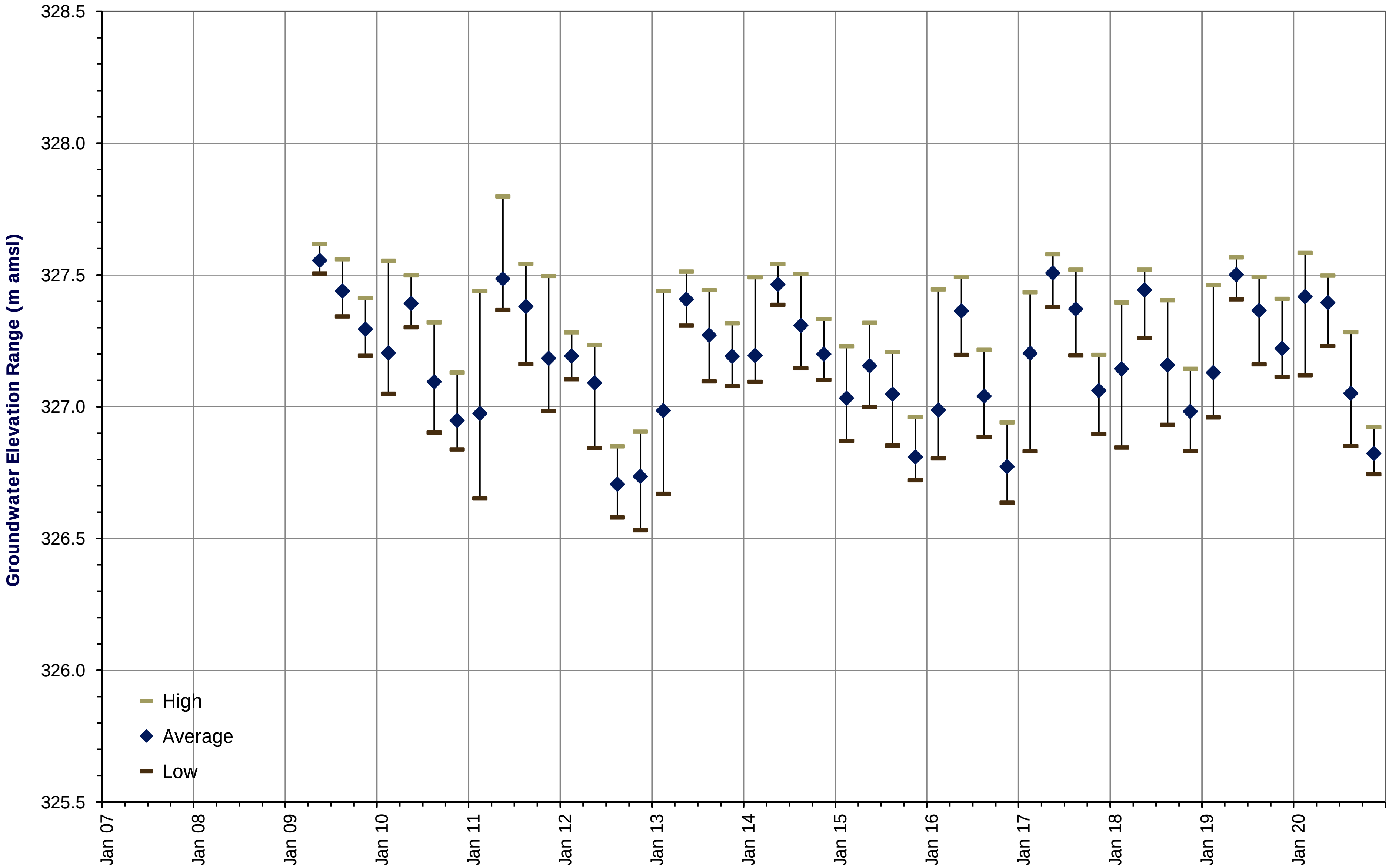
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

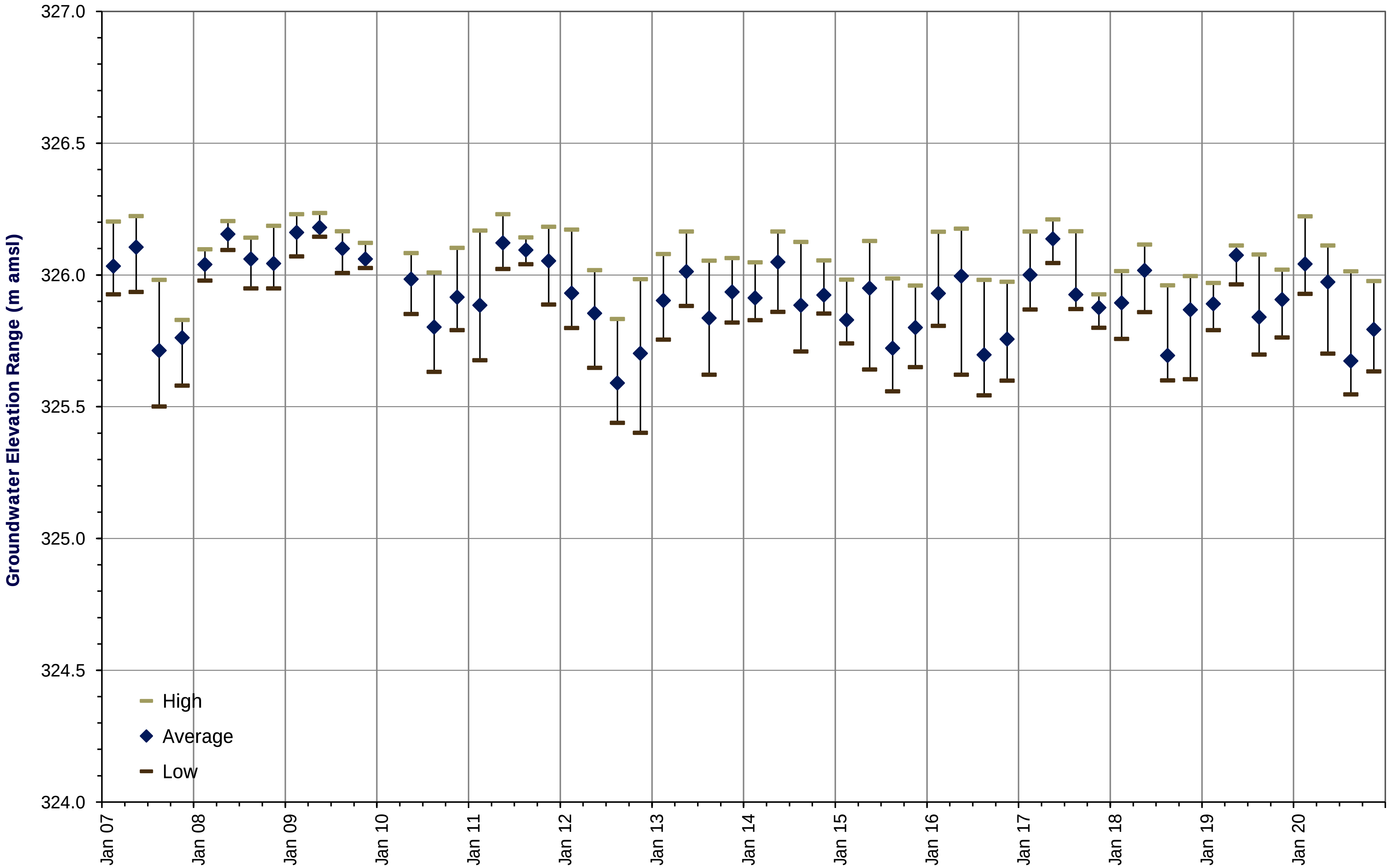
December 2020

Graph I-37

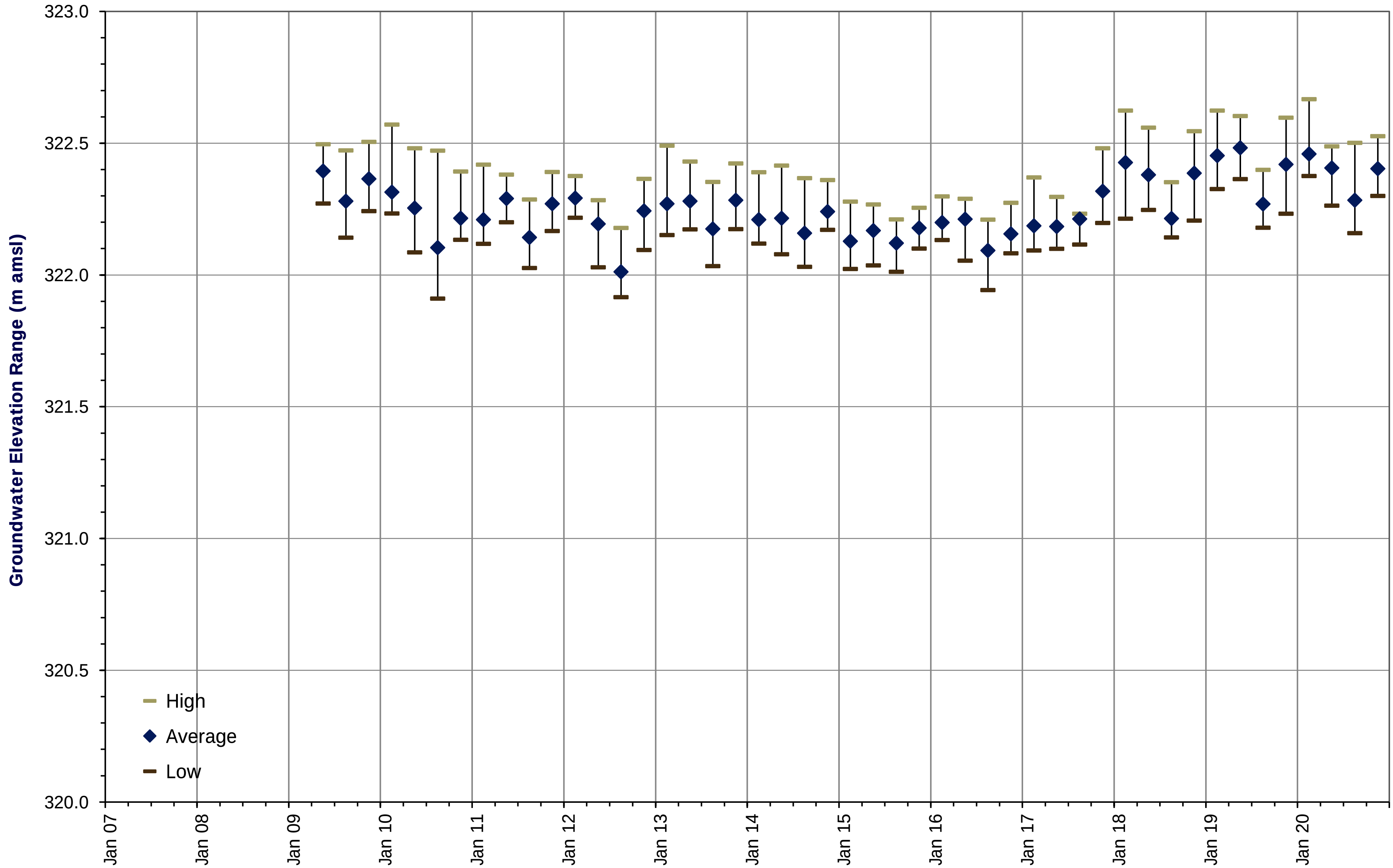
Quarterly Groundwater Elevation Range - PZ-1D



Quarterly Groundwater Elevation Range - PZ-2D



Quarterly Groundwater Elevation Range - PZ-4D

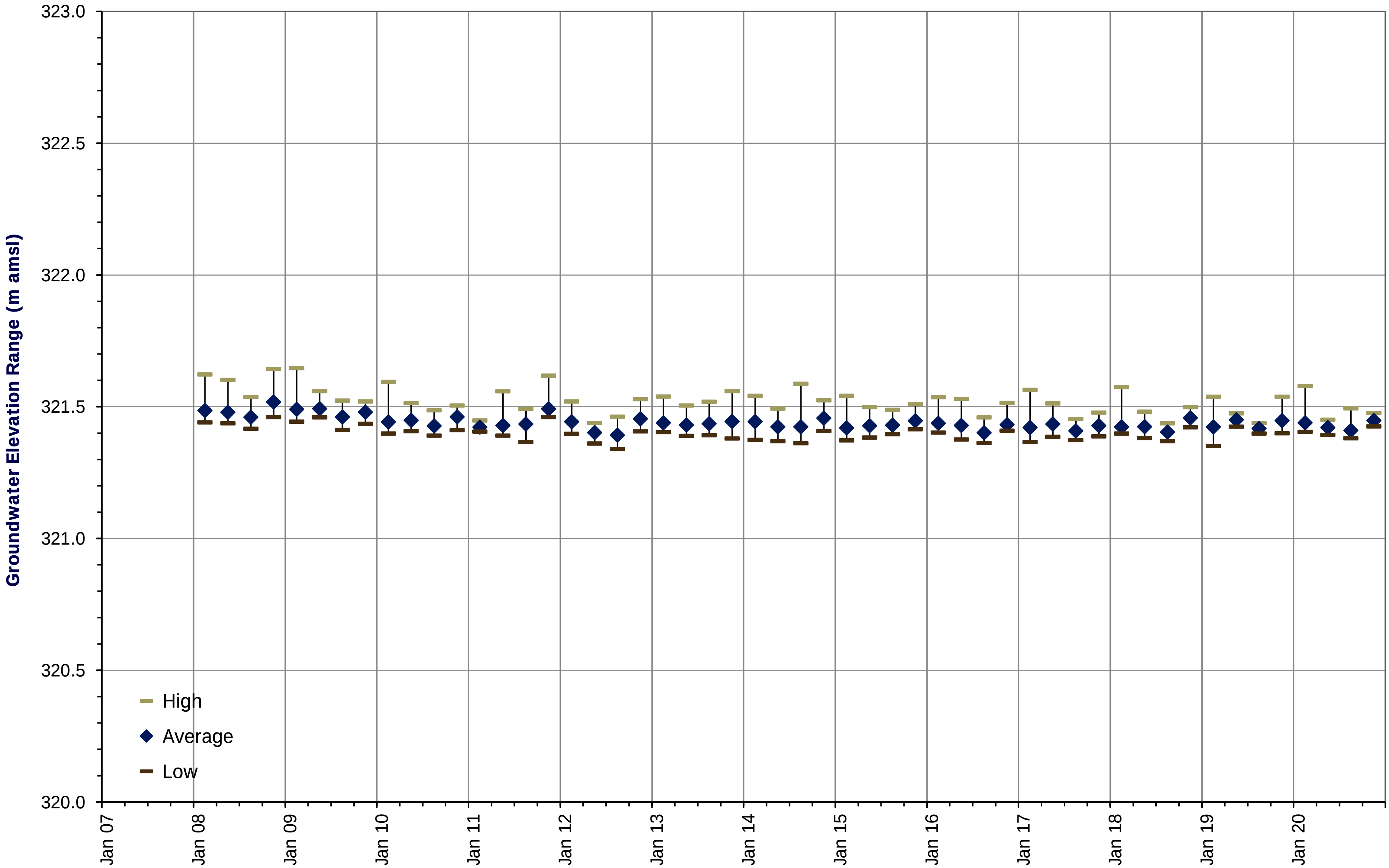


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-40**

Quarterly Groundwater Elevation Range - PZ-7D



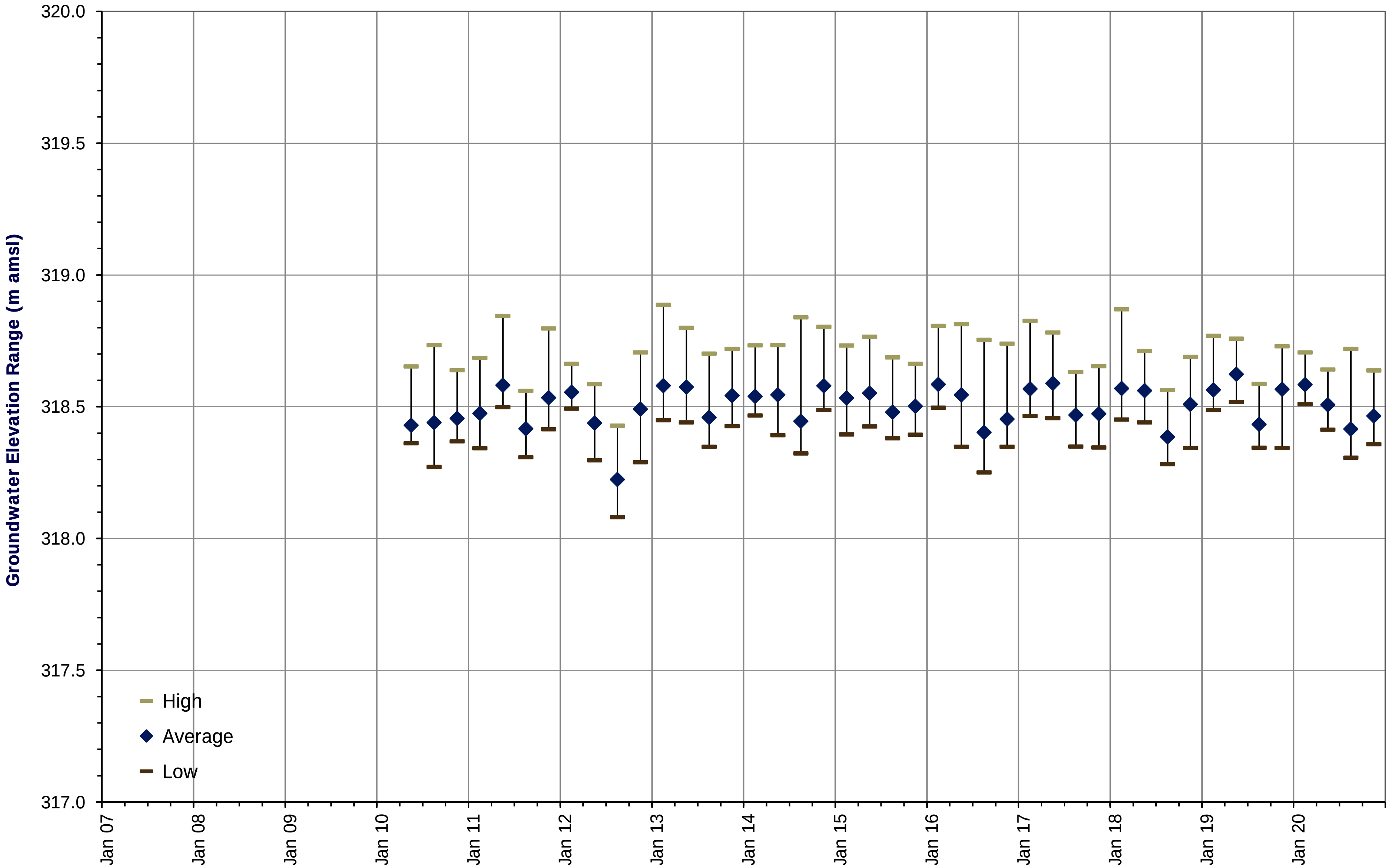
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-41

Quarterly Groundwater Elevation Range - PZ-8D

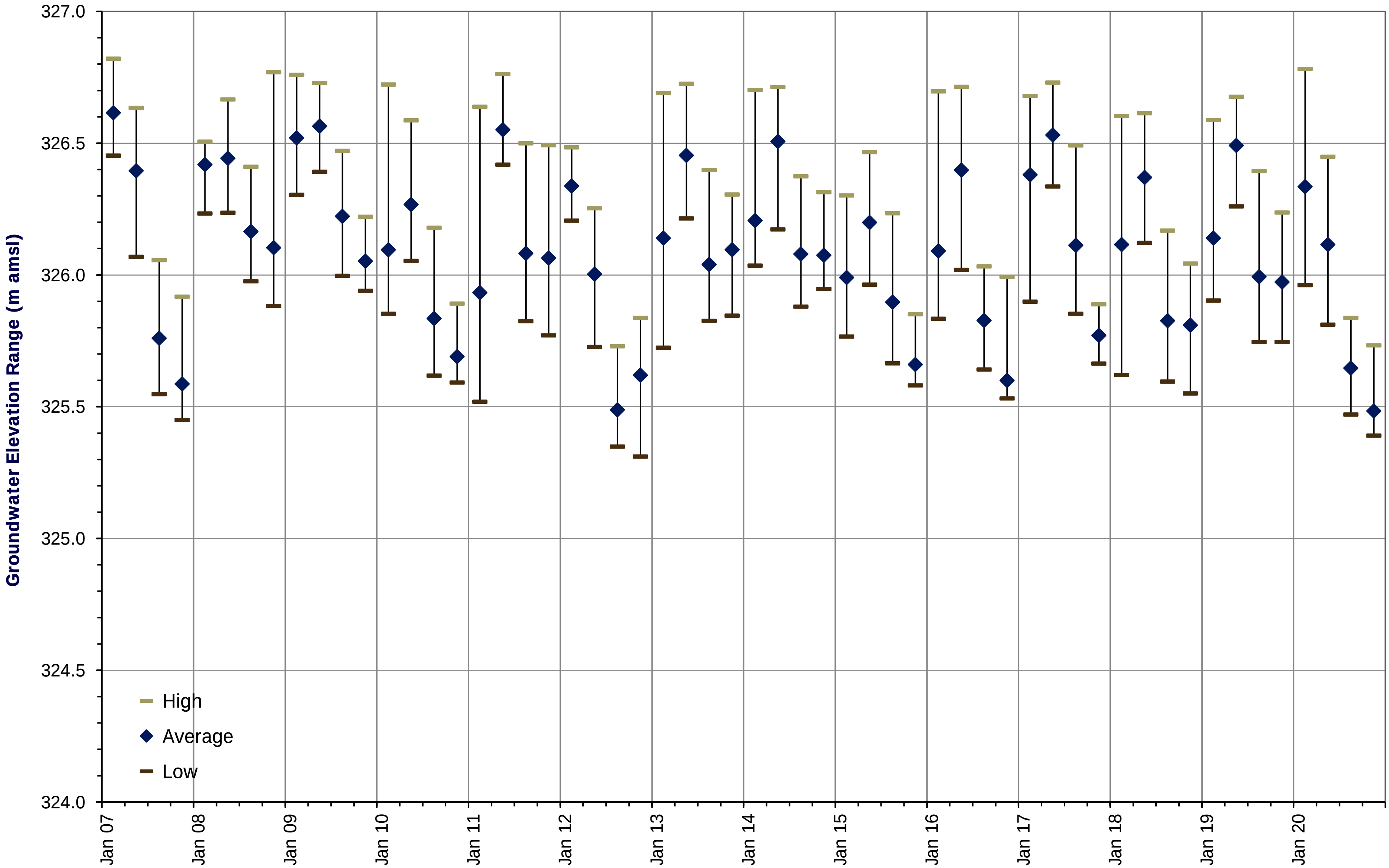


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-42**

Quarterly Groundwater Elevation Range - PZ-9D

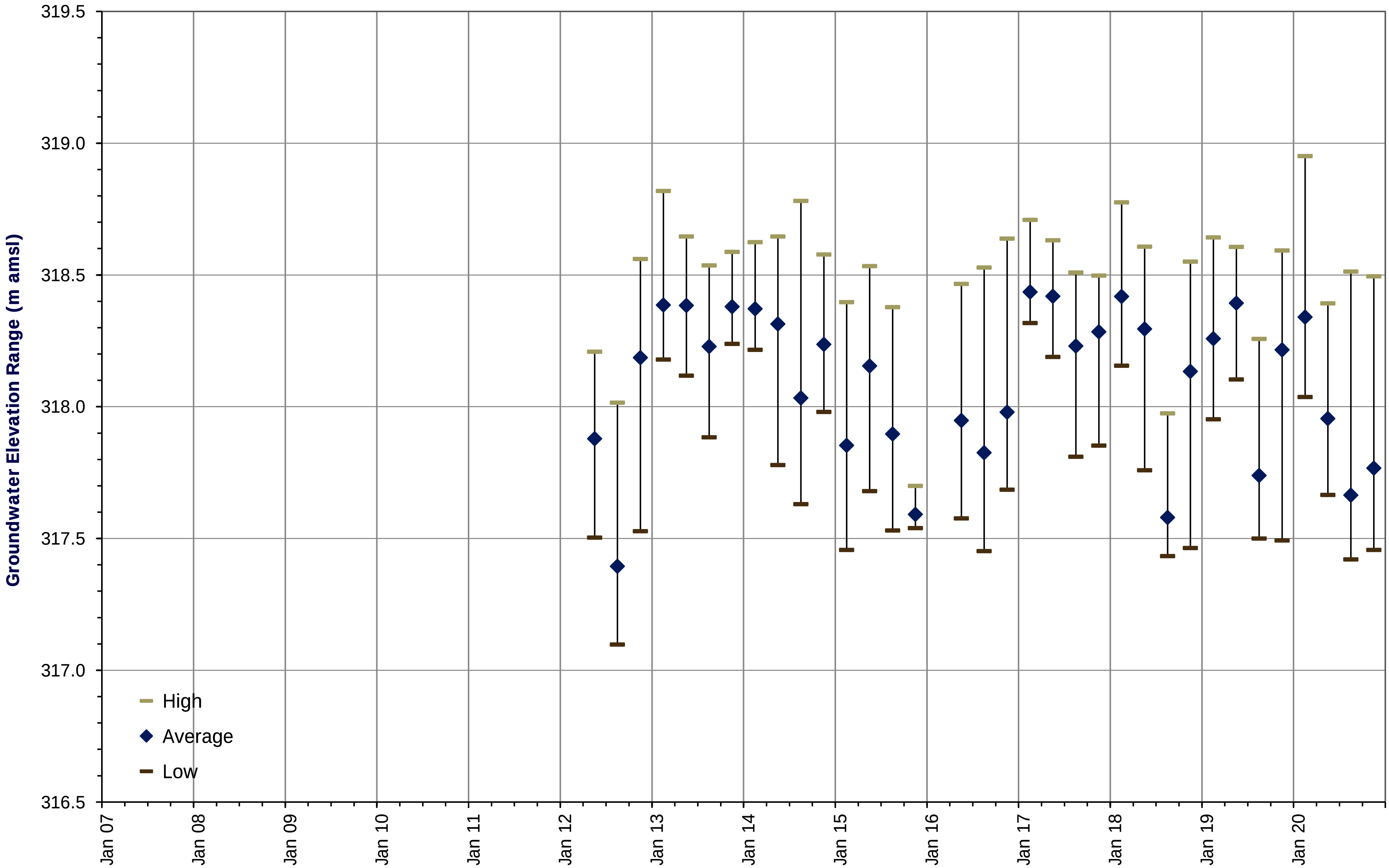


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-43**

Quarterly Groundwater Elevation Range - PZ-10D

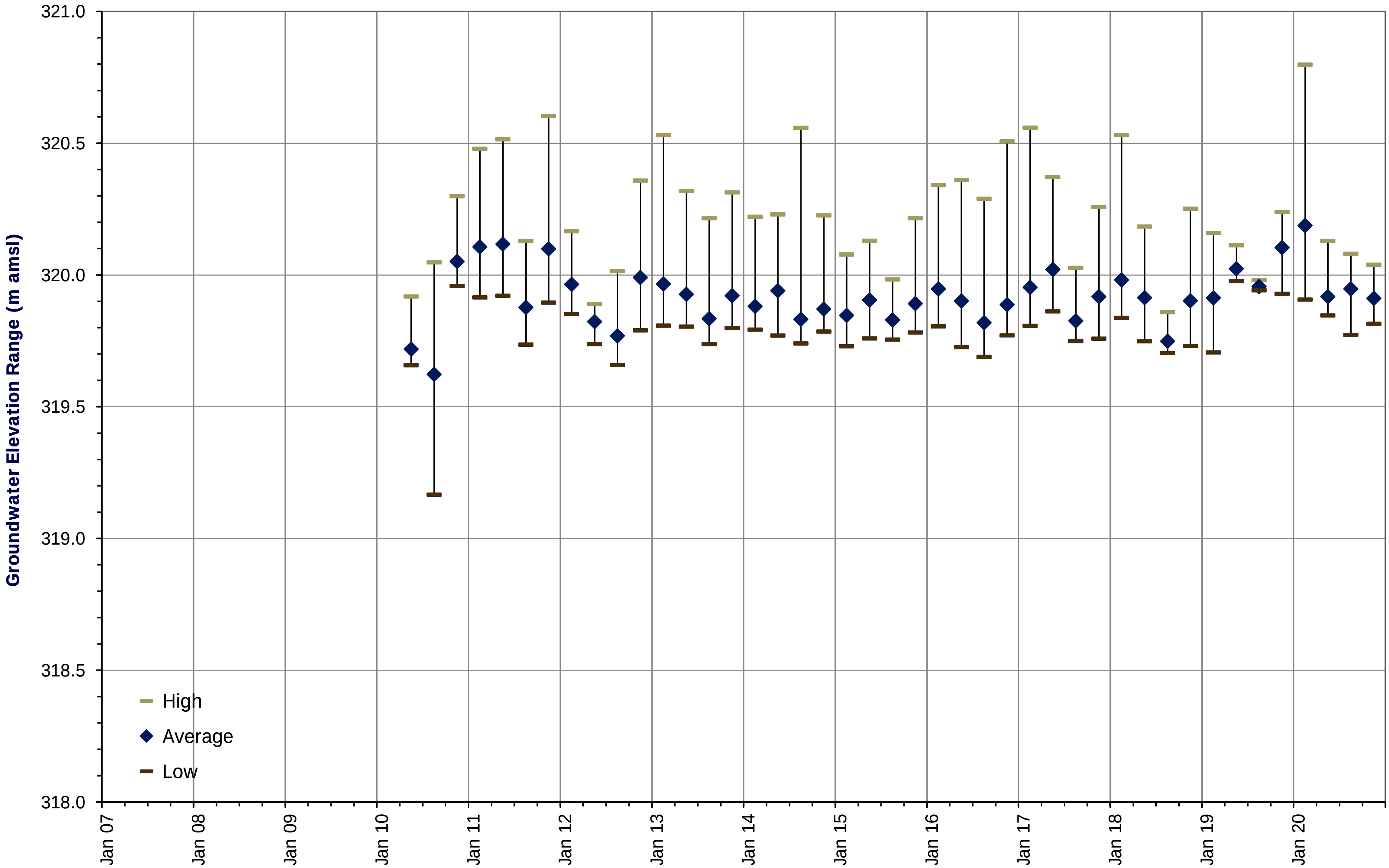


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020 **Graph I-44**

Quarterly Groundwater Elevation Range - PZ-11D



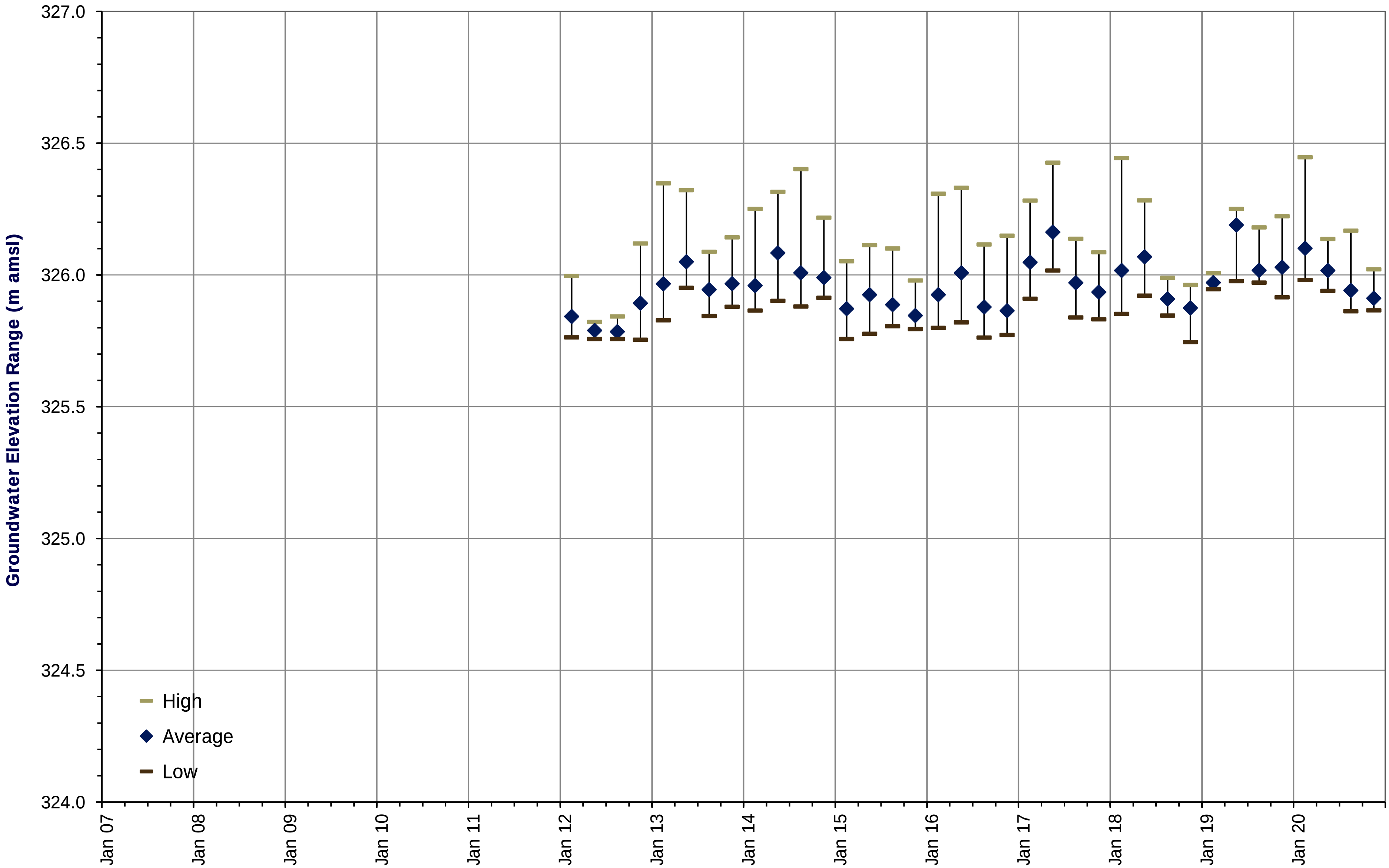
Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-45

Quarterly Groundwater Elevation Range - PZ-12D



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2020

Graph I-46

Appendix J

Groundwater Quality Monitoring Data
2003 – 2020

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells															
						001 (Decommissioned)					003										
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	221	245	311	300	ns	37.6	37.4	38.8	39.5	36.9	38.6	40.5	41.7	42.9	36.9
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.08	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.50	<0.25	<0.25	<0.05
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	4.88	3.93	3.09	3.36	ns	11.9	7.79	5.66	4.73	5.80	5.34	6.44	4.57	7.02	1.43
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.50	<0.25	<0.25	<0.10
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<1.00	<0.50	<0.50	<0.20
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	28.4	24	24.2	23.7	ns	18.0	16.3	14.3	16.9	14.4	14.2	13.5	10	11.9	7.95
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	0.063	<0.004	<0.004	0.009	ns	2.56	<0.004	<0.004	0.018	0.006	0.004	<0.004	<0.004	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	<0.003	<0.003	<0.003	<0.003	ns	0.010	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.627	0.108	0.142	0.12	ns	0.312	0.057	0.052	0.049	0.056	0.046	0.053	0.048	0.053	0.059
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.015	0.012	0.015	0.01	ns	0.016	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.011
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	0.006	<0.002	<0.002	<0.002	ns	0.010	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.0001
	Calcium (mg/L)		0.5	0.05	0.05	ns	86.2	95.7	115	97.8	ns	87.2	86.6	87	80.5	74.8	83.6	75.4	82	84.4	73.9
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	0.016	0.004	<0.003	<0.003	ns	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.008	<0.001	<0.001	<0.001	ns	0.027	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	0.004	<0.003	<0.003	<0.003	ns	0.082	<0.003	<0.003	<0.003	0.002	<0.003	<0.003	<0.003	<0.003	0.001
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	0.63	<0.010	<0.010	<0.010	ns	3.20	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	<0.001	<0.002	<0.002	<0.002	ns	0.325	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0005
	Magnesium (mg/L)		0.5	0.05	0.05	ns	27.3	28.9	34.7	29.4	ns	24.3	27.3	24.8	22.4	21.1	23.5	22.1	22.4	23.3	19.9
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	4.87	<0.002	<0.002	<0.002	ns	3.53	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	ns	0.028	<0.003	0.005	<0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	0.13	<0.05	<0.05	<0.05	ns	0.97	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	ns	3.07	1.73	2.06	1.85	ns	2.24	1.79	1.67	1.57	1.51	1.77	1.58	1.57	1.83	1.78
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	ns	0.006	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.001
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.0001	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	127	105	162	167	ns	14	17.4	15.4	13.7	14.8	14.9	15.5	17.3	16.9	15.6
	Strontium (mg/L)		0.001	0.005	0.005	ns	1.91	0.113	0.155	0.128	ns	0.994	0.094	0.096	0.106	0.109	0.091	0.095	0.092	0.098	0.087
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.0003	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.005	<0.002	<0.002	<0.002	ns	0.016	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0005
	Vanadium (mg/L)		0.001	0.002	0.002	ns	0.002	<0.002	0.003	<0.002	ns	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.309	0.023	0.016	0.012	ns	1.19	0.011	0.015	0.033	0.02	0.014	0.011	0.009	0.01	0.008
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	299	275	297	298	ns	252	262	272	248	259	254	243	252	255	277
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	299	275	297	298	ns	252	262	272	248	259	254	243	252	255	277
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	<5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	ns	<5	<5	5	<5	ns	<5	<5	7	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	ns	36.6	1.4	1.8	1.5	ns	2.6	4.2	1.6	1	6.4	2	2.4	2	1.5	2.1
	DOC (mg/L)	5	0.7	0.5	0.5	ns	1.4	1.5	1.8	1.5	ns	2.6	1.9	1.6	0.9	2	1	2.2	2.1	1.6	1.6
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	328	358	430	365	ns	318	329	319	293	274	306	279	297	307	266
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	<0.02	0.15	<0.02	ns	<0.02	<0.02	<0.02	0.59	<0.02	<0.02	0.03	<0.02	0.04	<0.02
	Conductivity (us/cm)		3	2	2	ns	1160	1290	1450	1360	ns	658	667	617	623	616	666	622	679	652	656
	pH	8.5	0.1	N/A	N/A	ns	7.84	8.18	8.11	7.76	ns	8.14	7.90	8.05	7.98	7.94	8.23	8.07	7.97	8.15	7.64
Calculated Values	Anion sum (meq/L)		0.01			ns	12.20	13.20	14.50	15.20	ns	7.33	7.19	6.34	6.76	6.93	6.85	6.74	6.75	6.91	6.85
	Cation sum (meq/L)		0.01			ns	12.10	11.80	15.70	14.60	ns	7.02	7.37	7.10	6.54	6.15	6.80	6.30	6.73	7.06	6.05
	% Difference (%)		0.01	0.1	0.1	ns	0.1	5.7	0.8	1.8	ns	2.1	1.2	1.0	1.7	6.0	0.3	3.4	0.2	1.04	6.19
	Langelier Index		0.0001			ns	0.94	1.28	1.32	0.91	ns	1.18	0.98	1.13	0.98	0.93	1.26	1.04	0.98	1.18	0.648
	Saturation pH (pH units)		0.01			ns	6.9	6.9	6.79	6.85	ns	6.96	6.92	6.92	7.0	7.01	6.97	7.03	6.99	6.97	6.99
	Silica (mg/L)			0.05	0.05 - 0.10	ns	10.6	3.79	9.4	8.49	ns	8.30	3.60	8.11	6.62	6.89	7.5	6.59	6.61	6.94	7.63

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 004											005-I (Decommissioned)			
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2020	2003	2008	2009	2010
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	63.0	48.9	55.3	48.5	59.7	64.1	64.5	61.8	60.8	69.4	67.1	190	163	182	233
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	0.08	<0.05	0.07	<0.05	<0.05	<0.25	<1.25	<0.25	<0.25	<0.05	0.10	<0.05	<0.05	<0.05
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	19.0	10.7	12	9.6	7.85	9.43	13.3	13.7	10.7	12.1	5.04	6.80	6.95	4.71	3.72
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.25	<0.25	<0.30	<0.05	<0.05	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50	<0.50	<0.50	<0.30	<0.10	<0.10	<0.10
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	25.0	20.3	21.4	18.9	18.2	18.8	17.9	20.4	19.4	17	17.7	20.0	18.4	17.2	18.2
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.648	0.009	<0.004	0.008	0.005	0.008	<0.004	<0.004	<0.004	0.005	<0.01	1.09	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.005	<0.006	<0.006	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.001	0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.001	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.15	0.371	0.126	0.116	0.087	0.115	0.098	0.113	0.121	0.096	0.076	0.10	0.366	0.095	0.11
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	<0.05	0.016	0.013	0.011	0.01	0.012	<0.010	0.012	0.012	<0.010	0.012	<0.05	0.015	<0.010	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.011	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.0001	<0.0001	0.020	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	130	92.5	119	103	93.7	98.5	110	111	104	100	91.7	110	83.6	103	99.6
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.004	0.004	0.004	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.002	0.004	0.012	0.006	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.017	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.0008	0.028	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.002	0.009	0.003	<0.003	<0.003	0.002	<0.003	<0.003	<0.003	<0.003	0.002	0.005	0.058	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.13	0.592	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.12	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0005	<0.001	0.082	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	36	25	32.2	29.1	26.9	27.2	30.5	31.2	28.6	28.2	25.0	44	27	31.9	30.9
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.012	3.38	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.058	0.046	3.74	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	<0.001	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	0.022	<0.003	0.009
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.18	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	15	10.3	13.4	12	6.33	10.4	8.32	17.4	16.9	11.1	7.87	3.4	2.26	1.48	1.57
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.002	<0.005	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.0001	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	24	18.6	22.3	20.7	19.5	25	25.6	27.8	27.8	25	27	73	84.6	87.5	123
	Strontium (mg/L)		0.001	0.005	0.005	0.16	1.98	0.138	0.132	0.131	0.129	0.128	0.123	0.129	0.112	0.129	0.19	1.69	0.117	0.126
	Thallium (mg/L)		0.0003	0.006	0.006	0.0004	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	0.0008	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.005	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.0008	<0.005	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.018	0.835	0.042	0.032	0.027	0.031	0.032	0.026	0.026	0.023	0.01	0.013	1.32	0.02	0.024
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	320	293	326	305	303	330	297	338	319	299	338	290	306	261	278
	Bicarbonate (CaCO3) (mg/L)		10	5	5	319	293	326	305	303	330	297	338	319	299	338	289	306	261	278
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5
	Colour (TCU)	5	1	5	5	27	<5	<5	7	<5	<5	<5	<5	<5	<5	<5	16	<5	<5	6
	Total Organic Carbon (mg/L)			0.5	0.5	na	1.0	2	1.8	1.2	4.9	2.4	2	1.4	1.6	2.1	na	9.9	5.4	1.4
	DOC (mg/L)	5	0.7	0.5	0.5	1.3	1.0	2	1.6	1	1.8	1.5	2.1	1.3	1.7	1.5	<0.7	0.8	3.9	1.5
	Hardness (CaCO3) (mg/L)	100	10	10	10	473	334	430	377	345	358	400	406	377	366	332	456	320	389	376
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	0.17	<0.02	<0.02	<0.02	0.03	<0.02	0.04	<0.02	0.04	<0.02	<0.05	<0.02	<0.02	<0.02
	Conductivity (us/cm)		3	2	2	950	739	897	762	785	859	936	965	933	843	909	1100	1050	1110	1200
	pH	8.5	0.1	N/A	N/A	7.3	8.11	7.83	8.05	7.72	7.99	7.87	8.04	7.87	8.1	7.67	7.5	7.82	8.01	8.07
Calculated Values	Anion sum (meq/L)		0.01			10.1	8.43		7.55	8.68	9.47	9.08	9.91	9.26	8.69	9.38	12.1	11.60		11.90
	Cation sum (meq/L)		0.01			10.9	7.76		8.74	7.90	8.51	9.33	9.76	9.19	9.16	8.01	12.4	10.10		12.90
	% Difference (%)		0.01	0.1	0.1	7.93	4.1	2.7	1.1	4.7	5.4	1.3	0.7	0.4	2.64	7.89	2.62	6.8	2.5	0.5
	Langelier Index		0.0001			-0.17	1.24	1.28	1.25	0.85	1.17	1.09	1.29	1.06	1.28	0.83	-0.10	0.92	1.59	1.2
	Saturation pH (pH units)		0.01			7.47	6.87	6.55	6.8	6.87	6.82	6.78	6.75	6.81	6.82	6.84	7.60	6.9	6.42	6.87
	Silica (mg/L)			0.05	0.05 - 0.10	20.2	9.64	4.37	9.09	9.27	9.27	10.2	9.32	9.13	8.86	9.74	12.9	11.4	8.94	10.2

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,
ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 006 (Decommissioned)				101 (Decommissioned)				102 (Decommissioned)			
			2003	2008-10	2011-20	2003	2008	2009	2010	2003	2008	2009	2010	2003	2008	2009	2010
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	22.9	36.8	45.3	ns	82.5	101	85.0	ns	46.3	39.9	41.9
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.06	<0.05	<0.05	ns	0.10	0.08	0.07	ns	0.09	<0.05	0.05
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	2.36	5.83	3.38	ns	2.57	2.03	1.72	ns	<0.05	0.05	<0.05
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05	ns	<0.05	<0.05	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	ns	<0.10	<0.10	<0.10	ns	<0.10	<0.10	<0.10
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	9.85	13.8	11.6	ns	23.2	22.3	21.1	ns	38.7	25.6	32.4
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	0.067	<0.004	<0.004	ns	0.048	<0.004	<0.004	ns	0.037	0.022	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	0.005	<0.003	<0.003	ns	<0.003	<0.003	<0.003	ns	0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.480	0.043	0.047	ns	0.558	0.043	0.042	ns	0.332	0.056	0.062
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.016	<0.010	<0.010	ns	0.012	0.011	0.012	ns	0.012	0.011	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	0.008	<0.002	<0.002	ns	0.001	<0.002	<0.002	ns	0.0012	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	ns	67.5	78.3	78.4	ns	76.2	83.5	84.4	ns	83.7	85.1	82.4
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	<0.003	<0.003	<0.003	ns	0.013	<0.003	<0.003	ns	0.013	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.008	<0.001	<0.001	ns	0.006	<0.001	<0.001	ns	0.015	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	<0.003	<0.003	<0.003	ns	<0.003	<0.003	<0.003	ns	0.005	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	<0.010	<0.010	<0.010	ns	0.40	<0.010	<0.010	ns	4.65	0.684	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	ns	<0.001	<0.002	<0.002	ns	<0.001	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	ns	22.4	24.5	23.7	ns	24.4	27	27.2	ns	24.9	26.9	25.9
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	2.50	<0.002	<0.002	ns	4.13	<0.002	<0.002	ns	4.26	0.152	0.076
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	0.003	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	ns	<0.003	<0.003	<0.003	ns	0.009	<0.003	0.004	ns	0.022	<0.003	0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	<0.05	<0.05	<0.05	ns	0.03	<0.05	<0.05	ns	1.07	0.02	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	ns	1.11	0.81	0.79	ns	2.46	1.41	1.32	ns	2.12	1.01	1.64
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.002	<0.002	<0.002	ns	<0.0001	<0.002	<0.002	ns	<0.0001	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	16	24.9	32.5	ns	53.9	53.5	55.4	ns	39.5	35	37.9
	Strontium (mg/L)		0.001	0.005	0.005	ns	2.13	0.073	0.089	ns	1.79	0.11	0.132	ns	1.89	0.13	0.127
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.006	<0.006	<0.006	ns	<0.0003	<0.006	<0.006	ns	<0.0003	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.004	<0.002	<0.002	ns	0.004	<0.002	<0.002	ns	0.003	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	0.003	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.498	0.008	0.009	ns	0.015	0.01	0.006	ns	0.08	0.042	0.009
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	264	251	266	ns	275	285	284	ns	307	300	300
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	264	251	266	ns	275	285	284	ns	307	300	300
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	ns	<5	<5	<5	ns	<5	<5	<5
	Colour (TCU)	5	1	5	5	ns	<5	<5	5	ns	<5	<5	<5	ns	<5	<5	5
	Total Organic Carbon (mg/L)			0.5	0.5	ns	1.2	1.6	1.5	ns	12.4	5.4	2.1	ns	19.7	3	2.6
	DOC (mg/L)	5	0.7	0.5	0.5	ns	1.2	1.5	1.3	ns	1.5	4.8	1.6	ns	2.9	3	1.5
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	261	296	293	ns	291	320	323	ns	312	323	312
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	1.05	<0.02	<0.02	ns	<0.02	<0.02	0.31	ns	<0.02	<0.02	0.05
	Conductivity (us/cm)		3	2	2	ns	547	642	623	ns	775	823	774	ns	695	728	669
	pH	8.5	0.1	N/A	N/A	ns	8.13	8.18	8.20	ns	7.89	8.13	8.17	ns	8.01	8.19	8.03
Calculated Values	Anion sum (meq/L)		0.01			ns	6.30	6.76	6.21	ns	7.60	9.16	7.71	ns	7.25		6.87
	Cation sum (meq/L)		0.01			ns	6.01	7.03	7.3	ns	8.22	8.75	8.91	ns	8.00		7.94
	% Difference (%)		0.01	0.1	0.1	ns	2.4	1.9	1.5	ns	3.9	2.3	1.5	ns	4.9	2.2	0.5
	Langelier Index		0.0001			ns	1.14	1.19	1.23	ns	0.93	1.23	1.27	ns	1.13	1.32	1.14
	Saturation pH (pH units)		0.01			ns	6.99	6.99	6.97	ns	6.96	6.9	6.9	ns	6.88	6.87	6.89
	Silica (mg/L)			0.05	0.05 - 0.10	ns	8.53	3.56	8.81	ns	11.0	4.33	10.1	ns	9.93	3.82	8.44

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 103												
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	143	173	237	246	212	289	301	342	408	453	483	448
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.16	<0.05	0.11	<0.05	<0.05	<0.5	<1.25	<0.25	<0.5			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	0.27	0.14	0.23	0.2	0.26	<0.5	<1.25	<0.25	<0.5			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.5	<1.25	<0.25	<0.5			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<1.0	<2.50	<0.50	<1.0			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	37.0	18.5	19.5	23.9	41.6	60	27.4	24.6	27			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	3.29	0.009	0.006	0.012	0.024	0.006	<0.004	0.004	0.005			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	0.028	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.232	0.097	0.112	0.094	0.094	0.09	0.126	0.123	0.128			
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.012	0.014	0.012	<0.010	0.01	0.011	0.013	0.011	<0.010			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	0.0015	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	ns	91.2	109	124	103	110	110	109	128	112			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	0.025	0.003	<0.003	<0.003	0.005	<0.003	<0.003	<0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.013	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	0.097	0.005	0.005	0.005	0.004	<0.003	0.004	0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	11.0	0.109	0.275	0.272	0.247	0.271	0.27	0.566	0.36			
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	0.149	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	ns	27.4	34.2	38.8	32.9	34	34.3	35.2	39.8	34.9			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	1.52	0.103	0.151	0.122	0.121	0.110	0.139	0.151	0.129			
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	ns	0.020	<0.003	0.006	<0.003	<0.003	<0.003	<0.003	0.004	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	2.43	0.02	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	ns	1.96	1.18	1.4	1.13	1.3	1.19	1.24	1.32	1.36			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	90.4	98.4	121	121	118	134	139	170	210	234	223	212
	Strontium (mg/L)		0.001	0.005	0.005	ns	0.741	0.126	0.168	0.152	0.145	0.17	0.174	0.17	0.163			
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.046	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	ns	0.047	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.983	0.013	0.02	0.013	0.035	0.009	0.014	0.01	0.008			
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	325	381	360	327	332	305	339	334	332			
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	325	381	360	327	332	305	339	334	332			
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	ns	20	34	25	29	37	13	29	41	30			
	Total Organic Carbon (mg/L)			0.5	0.5	ns	22.2	7.8	6.3	5	6.4	5	6.6	8.5	5.6			
	DOC (mg/L)	5	0.7	0.5	0.5	ns	9.0	7.5	6.6	5	4.8	3.9	6.5	8.1	5.4			
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	341	413	469	393	415	416	417	484	423			
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	0.05	0.04	0.03			
	Conductivity (us/cm)		3	2	2	ns	1010	1240	1300	1260	1230	1520	1570	1690	1810			
	pH	8.5	0.1	N/A	N/A	ns	7.61	7.83	7.92	7.65	8.17	7.99	7.82	7.56	8.03			
Calculated Values	Anion sum (meq/L)		0.01			ns	10.30		13.10	14.00	13.50	15.50	15.80	16.80	18.70			
	Cation sum (meq/L)		0.01			ns	10.80		14.70	13.10	13.50	14.20	14.40	17.10	17.60			
	% Difference (%)		0.01	0.1	0.1	ns	2.5	1.3	1.3	3.1	0.2	4.5	4.7	0.7	2.98			
	Langelier Index		0.0001			ns	0.79	1.14	1.26	0.87	1.42	1.19	1.07	0.87	1.28			
	Saturation pH (pH units)		0.01			ns	6.82	6.69	6.66	6.78	6.75	6.8	6.75	6.69	6.75			
	Silica (mg/L)			0.05	0.05 - 0.10	ns	9.87	4.31	11.6	10.1	4.56	10.2	10.3	10.9	10.1			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 104												
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	49.9	47.1	48.7	46.7	65.4	79.7	123	104	127	109	127	152
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.19	<0.05	0.09	<0.05	<0.05	<0.10	<1.25	<0.25	<0.25			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	0.06	<0.05	<0.05	<0.10	<1.25	<0.25	<0.25			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<1.25	<0.25	<0.25			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<2.50	<0.50	<0.50			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	89.4	20.7	25.5	22	15.9	14.9	9.78	4.86	12			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	0.630	0.005	0.005	0.072	0.008	0.007	0.005	0.005	0.006			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	0.013	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.368	0.095	0.116	0.077	0.067	0.082	0.091	0.083	0.083			
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.016	<0.010	<0.010	<0.010	<0.010	0.014	<0.010	<0.010	<0.010			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	0.0049	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	ns	97.8	91.4	99.1	83	76.1	77.7	83.3	94.8	79.4			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.022	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	0.167	<0.003	0.014	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	12.2	1.12	0.061	0.738	0.771	1.45	1.42	2.62	3.06			
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	0.014	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	ns	30.4	28.8	31	26.4	25.2	24.2	27.7	30.5	26.4			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	3.25	0.196	0.358	0.339	0.203	0.414	0.358	0.484	0.37			
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	ns	0.036	<0.003	0.009	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	2.11	0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	ns	1.72	0.67	1.02	0.67	0.88	0.87	1	1.03	1.14			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	18.9	19.6	22.1	19.4	34.9	37	46.8	43.1	58.9	50.8	57.5	64.9
	Strontium (mg/L)		0.001	0.005	0.005	ns	1.6	0.117	0.171	0.117	0.09	0.115	0.131	0.127	0.123			
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.003	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.46	0.016	0.503	0.005	0.006	<0.005	0.006	<0.005	<0.005			
Wet	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	259	297	320	275	268	242	279	308	266			
Chemistry	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	259	297	320	275	268	242	279	308	266			
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	ns	10	27	19	42	44	6	33	23	21			
	Total Organic Carbon (mg/L)			0.5	0.5	ns	22.6	11.9	11.3	5.2	6.9	6.7	6	7.1	5.9			
	DOC (mg/L)	5	0.7	0.5	0.5	ns	6.9	11.1	5.4	4.8	4.8	5.5	5.9	6.4	5.6			
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	369	347	375	316	294	294	322	362	307			
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	0.09	0.03	0.06	0.08	0.07	0.17	0.2	0.24			
	Conductivity (us/cm)		3	2	2	ns	731	717	711	642	675	778	898	875	868			
	pH	8.5	0.1	N/A	N/A	ns	7.67	7.97	8.02	7.71	8.1	7.85	7.87	7.62	8.06			
Calculated	Anion sum (meq/L)		0.01			ns	7.61		7.26	7.28	7.54	7.40	9.25	9.19	9.15			
Values	Cation sum (meq/L)		0.01			ns	8.25		8.49	7.18	7.42	7.50	8.51	9.15	8.74			
	% Difference (%)		0.01	0.1	0.1	ns	4.0	0.7	1.0	0.7	0.8	0.7	4.2	0.2	2.3			
	Langelier Index		0.0001			ns	0.76	1.12	1.24	0.79	1.14	0.84	0.96	0.81	1.11			
	Saturation pH (pH units)		0.01			ns	6.91	6.85	6.78	6.92	6.96	7.01	6.91	6.81	6.95			
	Silica (mg/L)			0.05	0.05 - 0.10	ns	12.0	4.65	13.3	10.7	4.16	10.3	10.2	12	9.64			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 105										106 (Decommissioned)			
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2003	2008	2009	2010
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	25.6	39.6	51.0	70.4	56.1	50.6	41.7	58.3	67.7	ns	182	288	241
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.26	0.22	0.18	<0.05	<0.05	<0.25	<0.25	<0.25	<0.25	ns	0.05	<0.05	0.1
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.25	<0.25	<0.25	ns	5.20	1.94	3.6
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.25	<0.25	<0.25	ns	<0.05	1.0	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.50	<0.50	<0.50	ns	<0.10	<0.10	<0.10
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	17.5	20.3	20.2	17.5	19.1	19.1	16.6	21.1	17.5	ns	26.5	24.4	31.1
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	1.31	0.013	<0.004	0.007	0.007	0.005	<0.004	<0.004	<0.004	ns	1.90	<0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	<0.006	<0.006	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	0.011	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	0.009	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.173	0.088	0.084	0.087	0.078	0.065	0.063	0.077	0.082	ns	0.275	0.091	0.091
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.014	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	ns	0.021	0.013	0.012
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001	ns	0.008	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	ns	69.7	84.5	83.4	81.3	75.4	72.6	68.9	79.3	78.4	ns	85.4	85.3	83.1
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	0.004	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	ns	0.009	0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	0.027	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	0.028	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	0.060	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	4.09	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	ns	3.92	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	0.066	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	0.126	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	ns	25.2	29.2	30	29.5	29.3	26.7	26.3	29.1	28.2	ns	24.4	24.6	24.5
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	1.47	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	5.00	0.006	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	ns	0.025	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	1.41	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ns	3.94	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	ns	1.11	0.74	0.81	0.78	0.89	0.69	0.67	0.86	0.83	ns	2.44	1.63	1.52
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	ns	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	18.9	21.8	23.3	22.5	26.7	30	27.7	28.1	28.8	ns	99.9	151	158
	Strontium (mg/L)		0.001	0.005	0.005	ns	0.653	0.129	0.142	0.172	0.157	0.131	0.117	0.147	0.144	ns	1.26	0.117	0.134
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	ns	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.015	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	0.021	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	ns	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ns	0.006	<0.002	0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.201	0.028	<0.005	<0.005	0.007	0.007	<0.005	<0.005	0.005	ns	1.06	0.014	0.019
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	281	290	285	277	278	279	286	274	294	ns	263	277	293
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	267	290	285	277	278	279	286	274	294	ns	263	277	293
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	14	<5	<5	<5	<5	<5	<5	<5	<5	ns	<5	<5	<5
	Colour (TCU)	5	1	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5	ns	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	ns	1.1	1.9	1.2	1	3	1	1.7	1	1.2	ns	1.4	1.3	1.4
	DOC (mg/L)	5	0.7	0.5	0.5	ns	1.1	2.2	1.2	0.9	2.9	1	1.6	0.9	1.4	ns	1.4	1.3	1.5
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	278	331	332	324	309	291	280	318	312	ns	314	314	308
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.04	<0.02	0.05	ns	<0.02	<0.02	<0.02
	Conductivity (us/cm)		3	2	2	ns	585	684	651	724	668	716	664	705	730	ns	1070	1380	1260
	pH	8.5	0.1	N/A	N/A	ns	8.31	8.06	8.00	7.68	8.25	8.15	8.02	7.82	8.06	ns	7.99	8.13	8.13
Calculated Values	Anion sum (meq/L)		0.01			ns	6.71	7.34	6.63	7.89	7.54	7.40	7.24	7.56	7.51	ns	11.30	14.40	12.60
	Cation sum (meq/L)		0.01			ns	6.40	7.59	7.66	7.48	7.36	7.14	6.83	7.59	8.15	ns	10.70	12.90	13.10
	% Difference (%)		0.01	0.1	0.1	ns	2.3	1.6	0.6	2.7	1.2	1.8	3.0	0.2	4.12	ns	2.9	5.5	1.9
	Langelier Index		0.0001			ns	1.34	1.18	1.12	0.77	1.32	1.2	1.06	0.9	1.16	ns	1.02	1.18	1.2
	Saturation pH (pH units)		0.01			ns	6.97	6.88	6.88	6.91	6.93	6.95	6.96	6.92	6.9	ns	6.97	6.95	6.93
	Silica (mg/L)			0.05	0.05 - 0.10	ns	14.3	5.14	12.9	11.9	5.19	12.1	10.9	11.1	11.7	ns	10.5	3.69	8.51

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

Monitoring Wells – 107

	Parameter (units)	ODWQS	RDL 2003	RDL 2008-10	RDL 2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	63.4	69.1	85.3	80.9	117	174	166	144	164	187	168
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	0.06	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.10	<0.25		
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	2.42	1.43	5.1	3.11	3.25	2.82	2.71	2.18	1.78		
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.10	<0.25		
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.20	<0.50		
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	18.2	11	15.1	17.4	16.9	18.6	17.7	15.9	16.2		
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	1.16	0.108	<0.004	0.007	0.013	0.006	<0.004	<0.004	< 0.004		
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.429	0.081	0.082	0.054	0.075	0.064	0.075	0.074	0.07		
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010		
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	0.0039	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001		
	Calcium (mg/L)		0.5	0.05	0.05	ns	76.4	84.5	93.3	71.9	80.9	86	89.7	86.4	88.2		
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	0.012	<0.003	<0.003	<0.003	0.005	<0.003	0.006	<0.003	<0.003		
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	0.075	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	2.58	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010		
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	0.091	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		
	Magnesium (mg/L)		0.5	0.05	0.05	ns	23.4	26.7	29.8	22.6	26.4	26.2	28.5	26.8	28		
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	1.50	0.067	0.038	<0.002	0.005	0.003	0.004	<0.002	<0.002		
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		
	Nickel (mg/L)		0.002	0.003	0.003	ns	0.056	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	0.54	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		
	Potassium (mg/L)		0.5	0.05	0.05	ns	1.76	1.33	1.08	0.81	1.22	1.3	1.41	1.27	1.32		
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004		
	Silver (mg/L)		0.0001	0.002	0.002	ns	0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	35.1	36.2	40.2	32	61.3	73.1	77.9	87.4	91.7	84.9	86.4
	Strontium (mg/L)		0.001	0.005	0.005	ns	0.247	0.091	0.113	0.095	0.106	0.123	0.105	0.096	0.111		
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006		
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		
	Titanium (mg/L)		0.002	0.002	0.002	ns	0.073	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		
	Vanadium (mg/L)		0.001	0.002	0.002	ns	0.01	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002		
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.669	0.231	0.021	0.008	0.029	0.016	0.011	0.011	0.013		
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	262	279	297	219	273	250	275	272	295		
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	262	279	297	219	266	283	275	272	295		
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	<5	8	<5	<5	<5	<5		
	Colour (TCU)	5	1	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5		
	Total Organic Carbon (mg/L)			0.5	0.5	ns	5.4	2.7	1.4	0.9	3.7	2	3.2	0.8	3		
	DOC (mg/L)	5	0.7	0.5	0.5	ns	2.6	2.8	1.4	1.1	0.9	1.8	1.8	1	1.4		
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	287	321	356	273	311	323	341	326	336		
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	<0.02	<0.02		
	Conductivity (us/cm)		3	2	2	ns	671	733	790	685	849	1100	1050	1040	1080		
	pH	8.5	0.1	N/A	N/A	ns	7.89	8.15	8.11	7.66	8.34	8.05	8.12	7.95	8.26		
Calculated Values	Anion sum (meq/L)		0.01			ns	6.72	7.86	8.05	7.25	9.34	10.50	10.70	9.99	11.00		
	Cation sum (meq/L)		0.01			ns	7.31	8.02	8.88	6.86	8.91	9.66	10.20	10.30	10.70		
	% Difference (%)		0.01	0.1	0.1	ns	4.2	1.0	0.8	2.7	2.4	4.2	2.4	1.8	1.22		
	Langelier Index		0.0001			ns	0.91	1.24	1.27	0.58	1.38	1.07	1.2	1.01	1.37		
	Saturation pH (pH units)		0.01			ns	6.98	6.91	6.84	7.08	6.96	6.98	6.92	6.94	6.89		
	Silica (mg/L)			0.05	0.05 - 0.10	ns	10.6	3.15	8.49	6.39	3.91	9.66	8.61	8.8	8.91		

Monitoring Wells – 109

	Parameter (units)	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016
Anions	Chloride (mg/L)	ns	86.6	113	82.1	92.7	120	93.5	105	97.2	112
	Fluoride (mg/L)	ns	0.06	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25
	Nitrate as N (mg/L)	ns	5.69	5.53	4.41	4.42	4.05	4.18	3.72	3.76	4.15
	Nitrite as N (mg/L)	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25
	Phosphate-P (ortho) (mg/L)	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	0.56	<0.50
	Sulphate (mg/L)	ns	21.8	22.5	20.6	18.4	19.1	18.8	18.4	17.7	19.1
Metals	Aluminum (mg/L)	ns	1.65	<0.004	<0.004	0.008	<0.004	<0.004	<0.004	<0.004	<0.004
	Antimony (mg/L)	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	ns	0.007	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	ns	0.309	0.094	0.095	0.085	0.086	0.089	0.083	0.091	0.095
	Beryllium (mg/L)	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	ns	0.016	0.011	0.011	0.012	<0.010	0.01	0.013	0.012	0.012
	Cadmium (mg/L)	ns	0.014	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001
	Calcium (mg/L)	ns	94.8	112	94.4	91.3	101	81.4	95.5	97.3	86.2
	Chromium (mg/L)	ns	0.006	0.004	<0.003	<0.003	0.003	<0.003	0.005	<0.003	<0.003
	Cobalt (mg/L)	ns	0.034	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	ns	0.058	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	ns	2.12	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	ns	0.21	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)	ns	27.2	32.4	27.7	27.8	30	23.6	27.7	27	26
	Manganese (mg/L)	ns	3.74	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)	ns	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)	ns	1.69	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)	ns	2.36	1.61	1.73	1.8	1.81	1.42	1.99	1.65	1.7
	Selenium (mg/L)	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	ns	30.9	39.0	35.2	37.8	48.9	36.4	46.9	42.6	45.3
	Strontium (mg/L)	ns	1.12	0.123	0.123	0.119	0.11	0.117	0.111	0.121	0.123
	Thallium (mg/L)	ns	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)	ns	0.019	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)	ns	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	ns	1.15	0.019	0.017	0.016	0.016	0.02	0.019	0.022	0.02
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	ns	279	279	278	266	295	284	301	298	312
	Bicarbonate (CaCO3) (mg/L)	ns	279	279	278	266	295	284	301	298	312
	Carbonate (CaCO3) (mg/L)	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)	ns	1.2	3.2	0.9	0.7	1.4	0.9	4	1.3	1.2
	DOC (mg/L)	ns	1.2	2.4	0.9	0.6	1	0.7	3.6	1.2	1.2
	Hardness (CaCO3) (mg/L)	ns	349	413	350	342	376	300	353	354	322
	Ammonia as N (mg/L)	ns	0.15	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	0.04
	Conductivity (us/cm)	ns	579	899	771	770	901	862	939	950	919
	pH	ns	8.03	7.83	8.09	7.74	8.25	8.16	8.07	8.17	8.18
Calculated Values	Anion sum (meq/L)	ns	8.88		7.71	8.63	9.97	9.01	9.63	9.34	8.46
	Cation sum (meq/L)	ns	8.38		8.57	8.53	9.68	7.62	9.14	8.97	10.10
	% Difference (%)	ns	2.9	1.8	0.3	0.6	1.5	8.3	2.6	2.0	8.82
	Langelier Index	ns	1.16	1.19	1.22	0.84	1.4	1.23	1.24	1.33	1.32
	Saturation pH (pH units)	ns	6.87	6.64	6.87	6.9	6.85	6.93	6.83	6.84	6.86
	Silica (mg/L)	ns	11.3	4.6	10.1	9.96	4.21	10.8	10.1	9.92	10.3

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

						Monitoring Wells													
	Parameter (units)	ODWQS		RDL		110 (Decommissioned)				111									
			2003	2008-10	2011-20	2003	2008	2009	2010	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	91.0	75.8	78.3	86.5	3.00	1.27	1.23	1.32	2.77	5.79	5.07	4.16	5.85	14.8
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.10	0.06	<0.05	<0.05	0.71	1.08	1.22	0.97	1.08	0.9	0.87	1.07	1.25	0.79
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	7.70	7.48	5.38	4.91	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.05	<0.25
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.05	<0.25
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.10	<0.50
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	27.0	19.5	18.5	16.8	27.0	21.1	21	22	25.6	29.5	28.6	23	24.4	29.5
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.981	<0.004	<0.004	0.210	0.614	<0.004	<0.004	0.007	0.087	0.005	0.011	<0.004	0.026
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.001	<0.003	<0.003	<0.003	0.004	0.004	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.10	0.126	0.086	0.084	0.08	0.093	0.067	0.064	0.071	0.089	0.072	0.056	0.06	0.05
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.10	0.010	<0.010	<0.010	0.06	0.016	0.019	0.015	0.016	0.011	0.013	0.019	0.017	0.016
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001
	Calcium (mg/L)		0.5	0.05	0.05	91.0	81.6	91.5	93.6	53.0	43.3	57.8	55.8	53.3	56.5	56	54.4	55.2	50.9
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.008	0.004	<0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.017	<0.001	<0.001	<0.0008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.001	0.026	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.06	3.71	<0.010	<0.010	0.27	1.55	0.023	0.02	0.122	0.071	0.28	0.054	0.266	0.014
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.129	<0.002	<0.002	<0.001	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	29	25.7	28.3	29.2	23	20.8	25.1	25.2	24	25.9	25.7	24.4	24.8	23
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.075	0.843	<0.002	<0.002	0.024	0.051	0.006	0.005	0.010	0.018	0.011	0.006	0.005	0.023
	Molybdenum (mg/L)		0.001	0.002	0.001	0.006	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	0.002	0.010	<0.003	0.017	<0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.36	<0.05	<0.05	<0.05	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	2.7	2.87	1.92	2.12	1.2	0.84	1.41	1.37	1.33	1.31	1.46	1.34	1.31	0.76
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	27	34.4	34.4	37.4	5.2	10.2	3.80	4.51	3.9	4.79	5.17	5.27	6.24	21.5
	Strontium (mg/L)		0.001	0.005	0.005	0.19	0.234	0.115	0.107	0.16	0.205	0.134	0.146	0.172	0.161	0.144	0.132	0.161	0.188
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	0.006	0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.067	<0.002	<0.002	0.009	0.034	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	<0.005	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.008	0.004	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.011	0.521	0.021	0.024	0.008	0.015	<0.005	<0.005	<0.005	0.106	0.007	<0.005	<0.005	<0.005
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	270	277	266	277	240	225	218	219	216	225	219	218	212	226
	Bicarbonate (CaCO3) (mg/L)		10	5	5	269	277	266	277	239	225	213	219	216	225	219	218	212	226
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<10	<5	5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	<1	<5	<5	<5	65	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	2.9	1.3	1.7	na	1.5	0.7	0.7	0.6	3.5	11	0.9	0.6	2
	DOC (mg/L)	5	0.7	0.5	0.5	<0.7	1.0	1.1	1.6	540	0.8	0.6	0.9	0.6	0.9	11	0.9	<0.5	2
	Hardness (CaCO3) (mg/L)	100	10	10	10	347	310	345	354	227	194	248	243	232	248	246	236	240	222
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.02	<0.02	<0.02	0.08	<0.02	<0.02	<0.02	<0.02	<0.02	0.08	0.03	0.03	0.1
	Conductivity (us/cm)		3	2	2	860	758	817	771	450	416	437	415	441	451	483	469	464	501
	pH	8.5	0.1	N/A	N/A	7.7	7.93	7.89	8.08	7.8	8.09	8.34	8.14	7.87	8.17	8.19	8.03	8.09	8.16
Calculated Values	Anion sum (meq/L)		0.01			9.08	8.62		7.77	5.49	4.97	4.83	4.21	4.99	5.32	5.16	5.01	4.98	5.39
	Cation sum (meq/L)		0.01			8.17	7.76		8.75	4.80	4.33	5.15	5.09	4.84	5.19	5.17	4.99	5.10	5.59
	% Difference (%)		0.01	0.1	0.1	-10.55	5.3	0.8	0.4	-13.41	6.9	3.2	1.6	1.5	1.3	0.1	0.3	1.2	1.83
	Langelier Index		0.0001			0.02	1.0	1.15	1.21	-0.10	0.90	1.24	1.04	0.74	1.09	1.09	0.91	0.97	1.03
	Saturation pH (pH units)		0.01			7.68	6.93	6.74	6.87	7.90	7.19	7.1	7.1	7.13	7.08	7.1	7.12	7.12	7.13
	Silica (mg/L)			0.05	0.05 - 0.10	11.3	11.5	4.65	12.1	18.4	18.4	7.86	16.8	17.1	6.93	19.1	15.9	17.4	17.5

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells																	
						112										113 (Decommissioned)				114 (Decommissioned)			
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2003	2008	2009	2010	2003	2008	2009	2010
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	<2.0	1.88	1.92	1.66	2.57	2.93	3.1	3.1	3.43	3.22	2.30	0.88	0.82	0.71	5.40	0.55	0.42	0.58
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.67	0.73	0.8	0.67	0.7	0.82	0.61	0.68	0.52	0.69	0.68	1.33	1.4	1.14	0.82	0.77	0.81	0.7
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.05	<0.10	<0.05	<0.05	<0.05	0.13	<0.05	<0.05	<0.05
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.05	<0.10	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	0.16	<0.10	<0.50	<0.20	<0.10	<0.30	<0.10	0.37	<0.10	<0.30	<0.10	0.64	<0.10
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	15.0	16.4	18.1	12.2	20.6	22.5	21.9	22.7	20.9	23.7	34.0	19.5	20.3	20.3	70.0	4.54	4.73	5.48
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.041	0.005	<0.004	0.007	0.006	0.007	<0.004	<0.004	<0.004	<0.01	0.145	0.011	<0.004	<0.01	0.046	0.004	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.005	<0.006	<0.006	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.003	0.004	0.005	0.004	0.005	0.005	0.004	0.004	0.004	0.004	0.005	<0.003	<0.003	<0.003	0.001	0.008	0.008	0.007
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.01	0.038	0.041	0.041	0.038	0.036	0.037	0.033	0.036	0.038	0.09	0.082	0.082	0.082	0.08	0.050	0.056	0.064
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	<0.05	0.037	0.039	0.043	0.043	0.039	0.038	0.042	0.039	0.037	<0.05	<0.010	<0.010	<0.010	<0.05	0.016	0.017	0.015
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.0001	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002
	Calcium (mg/L)		0.5	0.05	0.05	28.0	22.9	32	27	28.7	28.7	31.8	31	31.8	31.9	59.0	51.6	59.9	62	25.0	40.8	49.5	53.9
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	<0.003	<0.003	<0.003	0.002	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0018	<0.001	<0.001	<0.001	0.0016	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.001	<0.003	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	0.149	0.120	0.073	0.117	0.118	0.077	0.098	0.077	0.099	0.07	0.400	0.162	0.184	0.06	1.32	1.09	1.27
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.035	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	22	22.7	27.9	25.1	25.2	25	26.9	26.7	25.7	26.1	22	21	23.6	24.6	18	20.3	23.1	25.3
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.034	0.039	0.031	0.029	0.031	0.032	0.030	0.03	0.031	0.03	0.029	0.028	0.004	0.002	0.097	0.004	0.003	0.003
	Molybdenum (mg/L)		0.001	0.002	0.001	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.001	<0.002	<0.002	<0.002	0.016	0.002	0.002	0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.06	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	<0.05	0.05	0.06	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	0.9	0.96	0.81	0.91	0.84	0.72	0.8	0.78	0.87	0.86	1.0	1.06	0.94	0.98	1.0	1	0.83	0.95
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	11	12.1	12.5	14.5	11.5	11.9	12.1	12.7	13.2	12.0	4.2	3.64	3.00	3.47	34	6.55	5.08	4.83
	Strontium (mg/L)		0.001	0.005	0.005	0.38	0.426	0.361	0.41	0.436	0.373	0.395	0.363	0.386	0.381	0.30	0.193	0.172	0.169	16	0.361	0.289	0.325
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	<0.002	<0.002	<0.002	0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.005	<0.002	<0.002	<0.002	0.005	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.004	0.015	0.009	0.01	0.01	0.013	0.01	0.008	0.009	0.009	0.006	0.008	0.019	<0.005	0.007	0.014	0.007	0.013
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	200	185	193	180	181	189	186	186	181	192	240	228	234	228	220	226	222	226
	Bicarbonate (CaCO3) (mg/L)		10	5	5	199	185	193	180	181	189	186	186	181	192	239	228	234	228	220	226	222	226
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<10	<5	<5	<5
	Colour (TCU)	5	1	5	5	79	<5	<5	6	<5	<5	<5	<5	<5	<5	4	<5	<5	<5	85	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	0.6	0.7	1.1	0.6	4	1.1	0.7	0.7	0.6	na	0.7	0.6	0.9	na	1.2	1.1	2
	DOC (mg/L)	5	0.7	0.5	0.5	46.0	0.5	0.7	1	0.6	1.7	0.7	0.7	0.7	0.7	56.0	0.6	0.7	0.8	51.0	1.2	1.2	1.6
	Hardness (CaCO3) (mg/L)	100	10	10	10	161	151	195	171	175	175	190	187	185	187	238	215	247	256	137	185	219	239
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.33	0.37	0.07	0.13	0.2	0.13	0.16	0.3	0.29	0.3	0.06	<0.02	<0.02	0.02	0.15	0.67	0.45	0.24
	Conductivity (us/cm)		3	2	2	380	358	379	335	374	374	416	403	401	384	480	402	450	426	530	383	413	390
	pH	8.5	0.1	N/A	N/A	7.7	8.13	8.21	8.26	8.15	8.11	8.12	8.11	8.09	8.17	7.8	8.05	8.12	8.14	7.2	8.07	8.10	8.21
Calculated Values	Anion sum (meq/L)		0.01			4.41	4.09		3.35	4.16	4.37	4.30	4.32	4.18	4.30	5.62	4.99		4.31	6.06	4.63		3.95
	Cation sum (meq/L)		0.01			3.73	3.58		4.07	4.04	4.03	4.35	4.33	4.31	4.46	4.97	4.49		5.29	4.24	4.06		5.02
	% Difference (%)		0.01	0.1	0.1	-16.71	6.7	1.9	1.7	1.5	4.1	0.7	0.2	1.6	1.84	-12.28	5.3	0.4	2.2	-35.34	6.5	1.0	3.4
	Langelier Index		0.0001			-0.54	0.75	1.09	0.92	0.82	0.8	0.84	0.82	0.79	0.9	-0.06	0.91	1.18	1.08	-1.07	0.86	1.09	1.11
	Saturation pH (pH units)		0.01			8.24	7.38	7.12	7.34	7.33	7.31	7.28	7.29	7.3	7.27	7.86	7.14	6.94	7.06	8.27	7.21	7.01	7.1
	Silica (mg/L)			0.05	0.05 - 0.10	12.8	14.7	6.56	12.8	14.2	13.5	16	13.2	13.8	13.5	18.0	18.5	7.96	17.2	11.3	17.3	7.38	9.31

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,
ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells																						
						115										115A												
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	6.80	2.33	2.42	2.72	3.23	3.27	2.96	2.95	3.44	2.97	150	237	156	72.4	135	137	223	199	264	237	286	165	94.8
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.34	0.38	0.38	0.3	0.34	0.31	0.3	0.28	0.23	0.32	<0.10	0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.25			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	0.14	<0.05	9.10	2.12	1.3	1.28	0.88	1.96	0.5	<1.25	0.53	0.32			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.05	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.25			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.10	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50	<0.50			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	45.0	30.9	32.1	31.8	33.3	34.4	32.5	32.7	34.1	33.4	29.0	22.7	14.8	11.9	13.7	24.8	18.8	15.6	13.7	13.5			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.031	0.004	0.006	0.077	0.006	0.007	<0.004	<0.004	<0.004	<0.01	2.41	0.012	<0.004	0.01	0.022	0.005	<0.004	<0.004	<0.004			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.001	0.013	0.005	0.004	0.006	0.005	0.004	0.004	0.004	0.003	<0.001	0.013	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.12	0.957	0.113	0.09	0.093	0.084	0.084	0.069	0.08	0.069	0.08	0.191	0.057	0.043	0.05	0.045	0.053	0.047	0.059	0.054			
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.11	0.020	0.012	0.01	0.013	0.011	0.011	0.013	0.012	0.012	<0.05	0.018	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.0001	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	63.0	52.7	57.4	57.2	56.1	55.9	56.5	53.9	56.8	53.7	110	109	93.4	83.1	95.9	77.9	98.9	83.2	89.3	81.8			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	0.010	0.003	<0.003	<0.003	0.006	<0.003	<0.003	<0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.023	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.001	0.082	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	3.25	0.176	0.246	0.51	0.397	0.314	0.347	0.347	0.418	0.08	3.68	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.208	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	21	22.6	24.2	24.2	24	24.1	23.5	23.4	23.2	22	28	29.8	26.5	22.5	27.4	21.9	27.5	24.1	23.4	22.9			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.047	4.94	0.01	0.011	0.031	0.012	0.012	0.011	0.012	0.011	<0.001	3.19	0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002			
	Molybdenum (mg/L)		0.001	0.002	0.001	0.009	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	0.013	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.1	<0.05	<0.050	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	9.2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	2.2	2.04	1.17	1.15	1.04	1.09	1.04	0.9	1.05	0.97	1.4	1.68	0.94	0.99	0.83	0.78	0.95	0.89	0.97	0.96			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	7.6	4.56	4.54	5.4	4.69	4.68	4.44	4.76	4.86	4.48	53	79.7	111	77.3	77.1	82.4	92.1	147	192	161	164	96.2	61.3
	Strontium (mg/L)		0.001	0.005	0.005	0.25	2.41	0.123	0.13	0.164	0.14	0.128	0.119	0.131	0.139	0.16	1.16	0.114	0.11	0.14	0.115	0.145	0.112	0.134	0.127			
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.003	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.019	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	0.011	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	0.025	0.055	0.005	0.007	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	0.011	0.49	0.007	0.008	<0.005	0.028	<0.005	<0.005	<0.005	0.005			
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	230	214	206	205	213	212	208	210	205	214	270	251	351	359	335	278	303	358	363	375			
	Bicarbonate (CaCO3) (mg/L)		10	5	5	229	200	206	205	213	212	208	210	205	214	269	251	351	359	335	278	303	358	363	375			
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	14	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	15	<5	<5	<5	<5	<5	<5	<5	<5	<5	<1	<5	<5	<5	<5	<5	<5	<5	<5	<5			
	Total Organic Carbon (mg/L)			0.5	0.5	na	0.8	12.9	2.1	2.6	25	2	1.5	1.2	1.2	na	3.8	2	2.3	1.1	3.9	2	1.6	1.6	2			
	DOC (mg/L)	5	0.7	0.5	0.5	2.2	0.8	12.3	1.2	2.6	3	2	1.5	1.2	1.2	1.3	3.8	2	2.1	1	2.9	2	1.6	1.5	2			
	Hardness (CaCO3) (mg/L)	100	10	10	10	244	225	243	242	239	239	238	231	237	225	390	395	342	300	352	285	360	307	319	299			
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.07	<0.02	<0.02	0.02	0.06	0.04	0.08	0.06	0.06	0.02	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02			
	Conductivity (us/cm)		3	2	2	470	425	441	412	419	427	464	460	454	452	1000	1160	1130	807	963	910	1280	1310	1510	1340			
	pH	8.5	0.1	N/A	N/A	7.7	8.32	8.21	8.16	7.95	8.21	8.04	8.07	8.01	8.05	7.5	8.27	8.02	8.08	7.71	8.01	8.12	8.2	7.93	8.11			
Calculated Values	Anion sum (meq/L)		0.01			5.75	4.99	4.86	4.18	5.06	5.06	4.94	4.98	4.93	4.71	10.9	12.3	11.8	8.38	10.90	10.10	12.80	13.10	15.00	13.00			
	Cation sum (meq/L)		0.01			5.26	4.74	5.08	5.11	5.01	5.00	4.98	4.85	4.98	5.08	10.1	11.4	11.7	9.39	10.40	9.29	11.20	12.50	14.80	14.50			
	% Difference (%)		0.01	0.1	0.1	-8.90	2.6	2.3	2.6	0.5	0.6	0.4	1.3	0.6	3.74	-7.13	3.9	0.5	0.9	2.1	4.1	6.5	2.1	0.9	5.45			
	Langelier Index		0.0001			-0.15	1.17	1.08	1.03	0.83	1.08	0.9	0.93	0.87	0.9	-0.13	1.38	1.21	1.25	0.89	1.05	1.27	1.35	1.1	1.27			
	Saturation pH (pH units)		0.01			7.85	7.15	7.13	7.13	7.12	7.13	7.14	7.14	7.14	7.15	7.63	6.89	6.81	6.83	6.82	6.96	6.85	6.85	6.83	6.84			
	Silica (mg/L)			0.05	0.05 - 0.10	6.67	17.6	8.38	17.5	18.3	7.45	20.4	17.5	18.4	18.8	10.6	6.41	3.25	8.72	7.06	2.94	7.44	6.83	6.38	6.82			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells																							
						116											116A												
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2020	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	68.0	27.2	31.3	29.3	35.6	36.9	46.4	56.8	55.1	90.1	131	15.0	13.1	9.23	13.9	13	33.2	44.8	43.9	83.6	73.3	55.7	89.1	123
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	0.15	0.11	0.12	<0.05	0.17	<0.25	<1.25	<0.25	<0.25	<0.05	<0.10	0.12	<0.05	0.08	0.12	0.09	<0.25	<1.25	<0.25	<0.25			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	2.30	0.12	0.08	<0.05	0.1	<0.05	<0.25	<1.25	<0.25	<0.25	<0.25	0.54	0.10	<0.05	<0.05	0.06	0.33	0.36	<1.25	<0.25	<0.25			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	0.45	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.25	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.25			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50	<0.50	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50	<0.50			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	57.0	33.6	24.1	23.5	16.9	21.5	20.7	20.4	17.1	17.1	15.7	57.0	25.4	8.82	10.2	15.7	16.9	14.6	7.92	9.46	7.42			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	3.20	0.006	<0.004	0.007	0.03	0.004	<0.004	<0.004	0.005	<0.004	<0.01	1.84	<0.004	0.016	0.008	0.007	<0.004	0.189	<0.004	<0.004			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.001	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	0.002	0.007	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.06	0.170	0.039	0.052	0.037	0.047	0.068	0.043	0.056	0.058	0.099	0.04	0.122	0.031	0.041	0.044	0.044	0.036	0.041	0.053	0.043			
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.09	0.011	0.013	<0.010	<0.010	0.011	<0.010	0.013	0.011	0.013	0.014	<0.05	0.011	<0.010	<0.010	0.019	<0.010	<0.010	0.011	<0.010	<0.010			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.0027	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001	<0.0001	<0.0001	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	94.0	81.1	90.6	82.2	88.8	85.2	97.1	94.7	98.2	106	89.3	84.0	74.6	84.8	94.9	66.3	94.7	98.4	93	107	90.2			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.015	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.003	0.012	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	0.0008	0.012	<0.001	0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.0005	<0.0008	0.012	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.002	0.057	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.001	0.002	0.136	<0.003	0.003	<0.003	<0.003	<0.003	0.005	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.06	7.45	<0.010	<0.010	1.62	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.05	5.07	0.265	<0.010	<0.010	0.038	0.300	1.35	0.308	0.541			
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.114	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0005	<0.001	0.154	<0.002	<0.002	<0.002	<0.002	<0.002	0.007	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	34	25.7	27.5	26.4	29.1	27.4	30.7	31.1	30.7	33.1	27.6	22	22.5	24.7	28.4	19	31.3	32.1	29.9	32.1	27.1			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.14	1.66	0.002	0.386	0.069	0.042	1.97	0.148	0.023	0.04	<0.002	0.021	1.11	0.078	0.046	0.044	0.055	0.062	0.127	0.158	0.103			
	Molybdenum (mg/L)		0.001	0.002	0.001	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	0.002	0.017	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.002	0.030	<0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.97	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.6	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	2.7	1.58	1.57	1.2	0.74	1.28	1.42	1.18	1.48	1.57	1.42	1.0	0.9	0.69	0.81	1.87	0.75	0.76	0.7	0.83	0.82			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.002	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	25	13	16.5	16.4	11.8	14.1	17.2	22.0	24.0	34.1	58.1	5.8	7.69	7.97	8.20	10.30	16.00	20.70	30.2	44.1	50.1	33.2	56.0	80.0
	Strontium (mg/L)		0.001	0.005	0.005	0.21	0.419	0.106	0.16	0.12	0.117	0.158	0.115	0.128	0.134	0.127	0.12	0.467	0.095	0.118	0.11	0.134	0.141	0.125	0.141	0.112			
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.081	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.059	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	0.002	<0.002	<0.002	<0.002	0.002	<0.002	0.002	<0.002	<0.002	<0.0005	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	0.009	0.023	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.008	0.021	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	0.019	0.649	0.020	0.038	<0.005	0.021	0.02	0.025	0.02	0.023	0.019	0.031	0.467	0.012	0.052	0.008	0.009	0.017	0.032	<0.005	0.005			
Wet	Alkalinity (CaCO3) (mg/L)	500	10	5	5	280	276	298	280	307	292	295	314	317	352	325	250	262	268	336	228	341	323	356	367	356			
Chemistry	Bicarbonate (CaCO3) (mg/L)		10	5	5	279	276	268	280	307	292	295	314	317	352	325	249	262	268	336	228	341	323	356	367	356			
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	18	<5	<5	5	<5	<5	<5	<5	<5	<5	<5	11	<5	<5	<5	<5	<5	<5	<5	<5	<5			
	Total Organic Carbon (mg/L)			0.5	0.5	na	6.3	7.5	5	1.6	14.4	2.9	2.2	2.4	2.2	3.2	na	8.2	3.1	9.2	2.3	22.2	3.2	3.7	2.4	2.5			
	DOC (mg/L)	5	0.7	0.5	0.5	6.6	2.4	4.4	2	1.5	7	2.5	2.1	2.3	2.1	3.2	1.9	3.0	3.1	2.5	2.3	2.2	1.9	2.5	2.4	2.7			
	Hardness (CaCO3) (mg/L)	100	10	10	10	375	308	339	314	342	326	369	365	372	401	337	300	279	313	354	244	365	378	355	399	337			
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.02	<0.02	0.56	<0.02	0.02	<0.02	0.03	0.03	<0.02	<0.02	<0.05	<0.02	<0.02	0.09	<0.02	<0.02	<0.02	0.06	<0.02	<0.02			
	Conductivity (us/cm)		3	2	2	830	604	624	589	629	635	726	818	801	911	1050	600	526	524	615	471	700	759	826	927	875			
	pH	8.5	0.1	N/A	N/A	7.6	7.66	7.84	8.00	7.68	8.11	8.03	8.12	7.77	8.14	7.6	7.5	7.63	7.98	7.93	8.05	8.01	8.08	8.01	7.64	8.13			
Calculated	Anion sum (meq/L)		0.01			8.87	6.10	6.76	6.00	7.50	7.34	7.64	8.31	8.25	9.54	10.5	6.65	5.29	5.80	6.23	5.26	8.14	8.05	8.52	9.90	8.93			
Values	Cation sum (meq/L)		0.01			8.65	6.77	7.54	7.06	7.36	7.15	8.16	8.27	8.51	9.94	9.29	6.28	5.93	6.63	7.46	5.37	8.02	8.47	8.44	9.92	9.34			
	% Difference (%)		0.01	0.1	0.1	-2.51	5.2	5.5	1.0	1.0	1.3	3.3	0.2	1.5	2.06	6.22	-5.72	5.7	6.6	0.9	1.0	0.8	2.5	0.5	0.1	2.25			
	Langelier Index		0.0001			-0.06	0.73	0.94	1.08	0.84	1.23	1.21	1.32	0.98	1.43	0.749	-0.21	0.63	1.07	1.15	0.96	1.25	1.31	1.25	0.95	1.35			
	Saturation pH (pH units)		0.01			7.66	6.93	6.90	6.92	6.84	6.88	6.82	6.8	6.79	6.71	6.85	7.71	7.0	6.91	6.78	7.09	6.76	6.77	6.76	6.69	6.78			
	Silica (mg/L)			0.05	0.05 - 0.10	10.5	9.79	3.99	8.88	7.21	3.55	9.31	8.43	8.29	9.89	8.43	7.90	8.38	3.41	8.06	8.01	3.67	8.45	8.0	7.4	7.4			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,
ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 117										117A												
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	8.10	17.3	17.5	21.2	27.4	27.1	30.5	32.3	36.3	37.9	35.0	31.8	41.2	49.4	37.5	19.1	37.8	29.2	66.8	65.4	82.4	90.8	88.6
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.13	0.16	<0.05	0.13	<0.05	<0.05	<0.10	<0.10	<0.25	<0.25	0.12	0.23	<0.05	0.17	0.19	0.27	<0.10	0.21	0.28	<0.25			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	<0.10	0.11	<0.05	0.12	<0.05	<0.05	<0.10	<0.10	<0.25	<0.25	3.30	0.88	0.51	0.22	0.33	<0.05	<0.10	<0.10	<0.05	<0.25			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<0.10	<0.25	<0.25	0.23	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<0.10	<0.05	<0.25			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.20	<0.50	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.20	<0.10	<0.50			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	35.0	37.8	34.3	37.7	38.7	38.5	35.3	36.4	37	37.1	40.0	20.2	24.3	24.6	16.7	30	25.2	22.8	26.2	21.2			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.02	<0.004	<0.004	0.009	0.008	0.005	<0.004	<0.004	<0.004	<0.01	2.04	<0.004	<0.004	0.007	0.005	0.004	0.008	<0.004	0.011			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.001	<0.003	<0.003	<0.003	<0.003	0.005	<0.003	<0.003	<0.003	<0.003	<0.001	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.10	0.970	0.114	0.155	0.082	0.139	0.088	0.096	0.096	0.107	0.12	0.387	0.092	0.106	0.085	0.073	0.07	0.059	0.078	0.082			
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	<0.05	0.013	0.012	<0.010	<0.010	0.011	<0.010	0.014	<0.010	<0.010	<0.05	0.014	<0.010	<0.010	<0.010	<0.010	<0.010	0.01	<0.010	<0.010			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.0006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001	<0.0001	0.0025	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	79.0	79.9	79.4	82.8	80.7	83.5	91.5	82.6	90.6	86.9	90.0	70.8	78.4	82.4	75.5	71.5	77.8	62.4	80.9	71.4			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.014	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.003	0.018	<0.003	<0.003	<0.003	<0.003	<0.003	0.003	<0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.020	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.001	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.070	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	1.61	0.532	<0.010	1.65	0.195	1.3	1.17	1.33	1.25	0.06	2.47	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.591	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	24	27.4	28.3	29.8	29.9	30	32.2	28.8	32	30	27	23.7	27.3	28.2	26.7	25.6	28.6	22.9	30.9	27.2			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.097	4.08	0.046	0.356	0.062	0.049	0.054	0.058	0.052	0.06	0.013	2.09	<0.002	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Molybdenum (mg/L)		0.001	0.002	0.001	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	0.002	0.037	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.023	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.04	0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	2.03	0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	1.5	2.27	0.83	1.38	0.73	1.06	0.84	0.87	0.83	0.78	1.2	1.28	0.77	1.06	0.88	0.82	0.86	0.8	0.88	0.89			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.0002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	5.5	6.27	7.16	4.97	5.09	4.45	4.64	4.5	4.5	4.44	18	15.4	18.7	23.6	16.8	12.3	21.7	17.5	26.6	32	39.5	37.4	39.2
	Strontium (mg/L)		0.001	0.005	0.005	0.17	2.04	0.117	0.213	0.143	0.146	0.13	0.128	0.129	0.139	0.15	0.765	0.103	0.149	0.113	0.099	0.108	0.089	0.12	0.133			
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.022	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	0.010	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	0.013	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	0.004	0.038	0.009	0.01	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	0.012	0.328	0.016	0.018	0.007	0.009	0.01	0.01	0.01	0.009			
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	280	271	264	276	259	268	263	275	263	268	280	243	255	274	263	256	256	232	249	260			
	Bicarbonate (CaCO3) (mg/L)		10	5	5	279	271	264	276	259	268	263	275	263	268	279	243	255	274	263	256	256	232	249	260			
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	14	<5	<5	7	<5	<5	<5	<5	<5	5	11	5	<5	5	<5	<5	<5	<5	<5	<5			
	Total Organic Carbon (mg/L)			0.5	0.5	na	34.2	7.9	3.5	1.9	21.9	2.9	50.4	3.3	2.8	na	15.7	2.5	4.3	1.4	13	3.2	39.2	2	2.1			
	DOC (mg/L)	5	0.7	0.5	0.5	2.5	1.6	6.9	1.6	1.7	9.6	2.5	21.7	3.2	2.5	1.7	3.0	2.2	1.9	1.4	3.2	1.6	15.6	1.9	2.1			
	Hardness (CaCO3) (mg/L)	100	10	10	10	296	312	315	329	325	332	361	325	358	341	336	274	308	322	298	284	312	250	329	290			
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.02	<0.02	0.09	0.06	0.07	0.05	0.18	0.17	0.12	<0.05	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	0.05	<0.02	<0.02			
	Conductivity (us/cm)		3	2	2	570	563	602	577	596	597	646	642	664	655	730	551	645	645	592	544	643	565	731	700			
	pH	8.5	0.1	N/A	N/A	7.6	7.83	8.06	8.06	7.89	8.21	8.12	7.88	7.87	8.09	7.5	7.78	8.08	7.96	7.71	8.13	7.98	7.9	7.89	8.15			
Calculated Values	Anion sum (meq/L)		0.01			6.57	5.82		6.01	6.76	6.93	6.86	7.17	7.05	7.20	7.66	5.46		6.51	6.70	6.3	6.71	5.95	7.42	7.49			
	Cation sum (meq/L)		0.01			6.20	6.57		6.84	6.73	6.86	7.44	6.72	7.38	7.03	7.53	6.18		7.49	6.72	6.23	7.20	5.78	7.76	7.21			
	% Difference (%)		0.01	0.1	0.1	-5.79	6.1	1.0	0.6	0.2	0.5	4.1	3.2	2.3	1.23	-1.71	6.3	1.3	0.5	0.1	0.5	3.5	1.4	2.2	1.85			
	Langelier Index		0.0001			-0.07	0.9	1.12	1.16	0.95	1.3	1.24	0.97	0.98	1.19	-0.04	0.74	1.12	1.05	0.74	1.13	1.02	0.83	0.94	1.17			
	Saturation pH (pH units)		0.01			7.68	6.93	6.94	6.9	6.94	6.91	6.88	6.91	6.89	6.9	7.65	7.04	6.96	6.91	6.97	7	6.96	7.07	6.95	6.98			
	Silica (mg/L)			0.05	0.05 - 0.10	14.2	15.9	7.48	15.7	16.1	6.87	19.1	16.5	17.3	17.8	12.5	9.9	3.94	10.6	7.91	3.77	10.6	9.2	10.3	10.4			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 118										118A												
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	6.40	0.44	12	0.73	0.82	0.98	0.99	1.06	1.18	0.99	220	137	217	195	185	285	292	336	396	362	372	464	426
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	0.50	0.59	0.53	0.46	0.54	0.58	0.46	0.52	0.4	0.49	0.11	0.06	<0.05	<0.05	<0.05	<0.05	<0.5	<0.5	<0.5	<0.25			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	<0.10	0.11	0.28	<0.05	<0.05	<0.05	<0.05	<0.10	<0.10	<0.05	11.0	4.02	3.82	3.41	3.03	2.18	1.84	1.48	1.70	1.85			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<0.10	<0.05	<0.30	<0.05	<0.05	<0.05	<0.05	<0.05	<0.5	<0.5	<0.5	<0.25			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	0.23	<0.10	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<1.0	<1.0	1.5	<0.50			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	20.0	12.7	11.2	10.4	10.6	10.3	10.3	10.3	11	10.9	23.0	25.8	20.7	18.2	20.7	26.7	39.1	31.4	32.5	30.5			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.035	0.344	<0.004	0.009	0.007	0.006	<0.004	0.005	<0.004	<0.01	1.20	<0.004	<0.004	0.008	0.004	0.008	<0.004	<0.004	0.007			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.003	0.004	0.006	0.009	0.009	0.01	0.008	0.009	0.007	0.006	<0.001	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.15	1.190	0.137	0.142	0.099	0.124	0.115	0.09	0.095	0.095	0.10	0.938	0.093	0.113	0.09	0.1	0.087	0.094	0.116	0.106			
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	<0.05	0.018	0.023	0.025	0.027	0.025	0.024	0.026	0.025	0.02	<0.05	0.013	0.01	0.011	<0.010	0.011	<0.010	0.014	0.012	0.011			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.0012	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.0001	0.0154	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	46.0	38.3	47.3	41.5	40	39	40.8	38.2	38.5	37	100	89.7	102	107	98.1	101	92.5	95.6	99.8	103			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.013	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	0.014	0.003	<0.003	<0.003	0.01	<0.003	<0.003	0.006	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.017	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.001	<0.003	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.115	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	5.6	1.06	0.032	0.283	0.098	0.037	0.182	0.207	0.217	0.09	2.35	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	< 0.010	0.017			
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.001	0.027	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.032	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	25	25.6	26.2	28.4	27.6	27.2	27.6	25.5	25.1	25.3	29	27.2	31	32.6	30.8	31	28.2	29.4	28.2	30.2			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.003	4.87	0.191	0.008	0.008	0.016	0.012	0.008	0.009	0.013	0.003	3.3	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Molybdenum (mg/L)		0.001	0.002	0.001	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	0.038	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.066	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	2.0	1.67	1.04	1.1	0.91	1.08	0.94	0.95	0.89	0.86	2.3	2.52	1.67	1.59	1.44	1.82	1.45	1.95	1.77	1.8			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.0003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	11	6.41	11.9	6.41	6.41	6.41	6.46	6.77	6.31	6.24	110	80.7	105	99.7	91.1	160	152	206	224	199	216	218	213
	Strontium (mg/L)		0.001	0.005	0.005	0.28	1.97	0.265	0.285	0.284	0.245	0.258	0.226	0.241	0.24	0.14	0.94	0.11	0.14	0.124	0.113	0.116	0.118	0.13	0.14			
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.003	0.026	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	0.010	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	0.018	0.067	0.114	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	0.011	2.14	0.086	0.026	0.01	0.012	0.019	0.012	0.012	0.012			
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	230	237	208	213	216	214	213	207	217	213	270	296	282	316	305	313	316	329	325	335			
	Bicarbonate (CaCO3) (mg/L)		10	5	5	228	237	203	209	216	214	211	207	217	213	269	296	282	316	305	313	316	329	325	335			
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	5	5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	14	<5	<5	<5	<5	<5	<5	<5	<5	<5	<1	<5	<5	10	<5	<5	<5	<5	<5	<5			
	Total Organic Carbon (mg/L)			0.5	0.5	na	6.1	1.8	1.7	1.9	4.1	3	13.8	1.8	2.1	na	27.5	5.9	1.3	1	18.3	2	24.7	1.2	1.6			
	DOC (mg/L)	5	0.7	0.5	0.5	1.8	0.8	1.2	1.3	1.5	2.3	3	9.4	1.7	2	0.8	4.8	6.0	1.6	0.9	2.7	2	11.3	0.9	1.6			
	Hardness (CaCO3) (mg/L)	100	10	10	10	218	201	226	221	214	209	216	200	199	197	369	336	382	401	372	380	347	360	365	382			
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.13	0.26	0.16	<0.02	0.21	0.1	0.33	0.33	0.34	0.19	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.03	0.03	<0.02			
	Conductivity (us/cm)		3	2	2	400	388	439	379	383	387	414	412	409	402	1300	935	1220	1130	1070	1430	1560	1690	1840	1710			
	pH	8.5	0.1	N/A	N/A	7.9	8.2	8.35	8.31	8.01	8.09	8.31	8.02	8.17	8.03	7.5	7.92	8.04	8.05	7.73	8	8.16	8.1	8.05	8			
Calculated Values	Anion sum (meq/L)		0.01			5.23	4.28	4.75	3.92	4.59	4.55	4.53	4.41	4.62	4.23	12.9	9.64	12.50	11.40	12.00	15.00	15.50	16.80	18.50	16.30			
	Cation sum (meq/L)		0.01			4.89	4.35	5.07	4.71	4.58	4.49	4.63	4.34	4.30	4.54	12.2	10.30	12.20	12.40	11.40	14.60	13.60	16.20	17.10	17.70			
	% Difference (%)		0.01	0.1	0.1	-6.72	0.8	3.2	2.0	0.1	0.7	1.1	0.8	3.6	3.53	-5.18	3.2	0.9	0.2	2.3	1.4	6.6	1.9	3.9	3.98			
	Langelier Index		0.0001			-0.06	1.05	1.19	1.15	0.84	0.91	1.14	0.81	0.98	0.82	-0.18	1.03	1.18	1.26	0.89	1.19	1.31	1.27	1.22	1.21			
	Saturation pH (pH units)		0.01			7.97	7.15	7.16	7.16	7.17	7.18	7.17	7.21	7.19	7.21	7.69	6.89	6.86	6.79	6.84	6.81	6.85	6.83	6.83	6.79			
	Silica (mg/L)			0.05	0.05 - 0.10	15.8	19.4	8.8	18.7	20.6	8.54	23.1	21.8	21.8	21.8	10.9	8.08	3.78	9.59	8.84	3.45	9.33	7.99	8.1	8.57			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 119												
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	32.0	28.7	28.9	29.4	29.8	29.4	82	132	234	262	226	218	277
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	0.25	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	0.19	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.50	<0.50			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	96.0	67.7	61.8	61.7	61.9	53.1	37.9	28.4	25.5	18			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	1.06	0.01	0.006	0.016	0.017	0.01	<0.004	0.005	< 0.004			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.002	0.01	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.07	0.169	0.048	0.046	0.041	0.043	0.04	0.04	0.081	0.063			
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.11	0.018	0.011	0.01	0.01	<0.010	<0.010	0.01	0.013	0.012			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	110	94.4	98.2	103	96.6	100	102	85.6	105	108			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.004	<0.003	<0.003	<0.003	0.004	<0.003	0.004	<0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	0.0009	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.08	10.1	1.02	1.22	1.22	1.14	1.07	0.722	1.18	1.15			
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	31	29.3	30.7	32.5	30.6	31.6	30.6	26.2	32.1	33.4			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.16	3.75	0.124	0.154	0.108	0.11	0.12	0.094	0.113	0.106			
	Molybdenum (mg/L)		0.001	0.002	0.001	0.010	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	0.005	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	1.74	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	1.9	1.64	0.99	0.99	1.08	1.06	1.02	1.41	1.53	1.64			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	21	8.52	7.79	8.89	9.15	10.7	18.7	52.5	86.2	113	91.5	94.2	116
	Strontium (mg/L)		0.001	0.005	0.005	0.73	2	0.12	0.145	0.141	0.143	0.133	0.118	0.176	0.172			
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.029	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	0.010	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	0.011	0.217	0.013	0.006	0.01	0.011	0.007	<0.005	<0.005	<0.005			
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	300	296	298	303	289	312	274	226	258	281			
	Bicarbonate (CaCO3) (mg/L)		10	5	5	299	278	298	303	289	312	274	226	258	281			
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	18	<5	<5	<5	<5	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	19	8	13	14	15	25	<5	6	<5	6			
	Total Organic Carbon (mg/L)			0.5	0.5	na	4.9	9.8	6.1	7	7.5	4	4.3	2.3	2.8			
	DOC (mg/L)	5	0.7	0.5	0.5	3.1	4.9	9.6	5.8	6.4	6	4	3.6	2.2	2.8			
	Hardness (CaCO3) (mg/L)	100	10	10	10	402	356	372	391	367	380	381	322	394	407			
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	0.21	<0.02	0.03	0.05	0.04	0.17	0.12	0.1	0.09			
	Conductivity (us/cm)		3	2	2	800	676	722	679	671	695	839	899	1220	1360			
	pH	8.5	0.1	N/A	N/A	7.4	8.36	7.95	8.02	7.61	8.18	8.05	8.04	7.92	8.15			
Calculated Values	Anion sum (meq/L)		0.01			8.92	8.14	8.06	7.18	7.91	8.17	8.58	8.83	12.30	13.40			
	Cation sum (meq/L)		0.01			9.01	7.55	7.79	8.23	7.77	8.09	8.46	8.75	11.70	13.10			
	% Difference (%)		0.01	0.1	0.1	1.00	3.8	1.7	0.3	0.9	0.5	0.7	0.5	2.6	1.08			
	Langelier Index		0.0001			-0.17	1.52	1.13	1.23	0.78	1.39	1.21	1.04	1.04	1.32			
	Saturation pH (pH units)		0.01			7.57	6.84	6.82	6.79	6.83	6.79	6.84	7.0	6.88	6.83			
	Silica (mg/L)			0.05	0.05 - 0.10	11.1	10.3	3.94	9.45	8.42	4.11	9.76	8.69	8.89	8.32			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 119A												
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	30.0	19.3	23.1	27.2	74.4	127	108	165	202	188	192	214	229
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	0.06	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	1.95	0.19	<0.25	<0.10	<0.25	<0.25			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.50	<0.50			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	81.0	25.5	15.7	7.83	26.6	43.4	23.8	22.9	15.2	11.9			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	1.74	0.004	0.004	0.014	0.025	0.013	<0.004	<0.004	< 0.004			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	0.002	0.008	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.09	0.339	0.06	0.076	0.065	0.071	0.051	0.086	0.106	0.088			
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	<0.05	0.013	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	110	89.0	94.1	97.9	70.5	86.6	69	79.6	84.5	77.5			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.005	0.004	<0.003	<0.003	<0.003	0.007	<0.003	0.004	<0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.002	0.007	<0.003	<0.003	0.003	<0.003	0.004	<0.003	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.08	8.68	0.259	0.875	0.024	<0.010	<0.010	0.029	0.206	0.2			
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.044	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	35	26.6	28.6	30	22.8	27.7	21.5	25.6	26.1	25.3			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.20	5.2	0.573	0.536	0.057	0.34	0.369	0.701	0.573	0.42			
	Molybdenum (mg/L)		0.001	0.002	0.001	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	<0.003	0.005	0.007	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.21	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	2.5	1.6	1.05	1.01	1.21	1.4	1.33	1.73	1.66	1.63			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	12	6.23	7.56	9.19	31	52.4	51.3	83.3	101	109	97.4	106	117
	Strontium (mg/L)		0.001	0.005	0.005	0.21	2.17	0.087	0.104	0.077	0.094	0.078	0.104	0.114	0.101			
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	0.006	0.002	<0.002	<0.002	0.003	<0.002	<0.002	0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	0.013	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	0.014	0.519	0.035	0.03	0.015	0.042	0.023	0.017	0.015	0.012			
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	350	312	303	330	210	240	212	236	256	254			
	Bicarbonate (CaCO3) (mg/L)		10	5	5	349	294	303	330	210	235	212	236	256	254			
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	18	<5	<5	<5	6	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	28	10	10	11	5	6	<5	5	5	6			
	Total Organic Carbon (mg/L)			0.5	0.5	na	5.1	5.5	6.4	4.4	6.1	6	5.3	3.2	1.9			
	DOC (mg/L)	5	0.7	0.5	0.5	7.3	5.1	5.4	5.8	3.8	2.8	5	4.5	3	1.9			
	Hardness (CaCO3) (mg/L)	100	10	10	10	419	332	353	368	270	330	261	304	318	298			
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.02	<0.02	<0.02	0.03	<0.02	0.05	0.05	0.03	<0.02			
	Conductivity (us/cm)		3	2	2	850	611	646	634	632	853	796	1020	1120	1080			
	pH	8.5	0.1	N/A	N/A	7.4	8.35	8.05	8.23	8.04	8.32	8.14	8.08	7.91	8.28			
Calculated Values	Anion sum (meq/L)		0.01			9.54	7.32	7.04	6.45	6.99	9.3	7.78	9.85	11.10	10.60			
	Cation sum (meq/L)		0.01			8.96	6.94	7.40	7.78	6.77	8.91	7.48	9.75	10.80	10.70			
	% Difference (%)		0.01	0.1	0.1	-6.27	2.6	2.5	1.6	1.6	2.1	2.0	0.5	1.5	0.462			
	Langelier Index		0.0001			-0.10	1.5	1.22	1.45	0.93	1.36	1.02	1.05	0.93	1.27			
	Saturation pH (pH units)		0.01			7.50	6.85	6.83	6.78	7.11	6.96	7.12	7.03	6.98	7.01			
	Silica (mg/L)			0.05	0.05 - 0.10	11.9	6.42	2.47	6.45	4.31	2.18	4.52	4.48	5.1	5.27			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,
ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells																					
						120 (D)	120A (D)	121										121A									
			2003	2008-10	2011-20	2003	2003	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	17.0	34.0	52.0	45.2	105	54.3	61.2	68.9	60.9	68.3	84	90.1	38.0	62.7	48.5	81.1	96.1	89.8	42.8	53.4	63.7	46.6
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	<0.10	<0.10	0.08	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.25	<0.10	0.06	<0.05	0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.10
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	0.22	4.40	2.40	3.00	4.45	3.63	3.66	3.34	3.26	3.54	3.51	4.11	10.0	4.62	2.85	2.44	1.91	2.53	1.10	1.71	1.37	1.54
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	0.13	<0.10	0.26	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<1.25	<0.25	<0.10
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.30	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<2.50	<0.50	<0.20
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	67.0	51.0	55.0	41.5	15.8	35.4	36.7	28.2	28.3	32	24.3	25.2	27.0	16.3	41.6	15	17.5	12.9	8.89	10.4	11.2	9.14
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	<0.01	<0.01	0.533	<0.004	<0.004	0.007	0.008	0.006	<0.004	<0.004	< 0.004	<0.01	4.19	1.48	<0.004	0.007	0.011	0.02	<0.004	<0.004	< 0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.005	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.001	<0.001	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.003	0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.16	0.08	0.10	0.325	0.064	0.119	0.116	0.086	0.068	0.095	0.10	0.099	0.09	0.310	0.163	0.078	0.079	0.061	0.038	0.043	0.053	0.042
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.23	<0.05	0.17	0.012	0.011	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.05	<0.010	<0.010	0.013	0.013	0.011	<0.010	0.01	0.011	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	<0.0001	<0.0001	0.0043	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001	<0.0001	0.0071	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.001
	Calcium (mg/L)		0.5	0.05	0.05	72.0	89.0	77.0	84.9	92.9	90.6	86.8	80.6	80.5	88.3	96.9	91	95.0	83.3	89.3	97.2	91.3	79.7	71	77.9	87	76.3
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.003	0.003	0.010	0.004	<0.003	<0.003	0.006	<0.003	<0.003	<0.003	<0.003	0.003	0.023	0.011	<0.003	<0.003	0.007	<0.003	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	<0.0008	0.0011	0.010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.042	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.001	0.001	0.002	0.016	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	<0.003	0.001	0.134	0.017	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.05	0.06	<0.05	5.16	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.07	11.8	5.44	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	<0.001	<0.001	0.017	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.528	0.079	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	22	24	26	28.9	27.4	31.6	31	26.7	26.5	30.8	30.1	30.8	25	23.8	31.8	30	30.9	24.5	20.8	22.7	23.7	21.1
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.063	0.004	0.29	2.61	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	0.020	3.14	0.721	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	0.013	<0.001	0.014	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	<0.002	0.003	0.010	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.036	0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	<0.05	<0.05	2.78	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.02	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	2.8	3.3	2.2	2.03	1.52	1.34	1.51	1.37	1.25	1.3	1.52	1.53	4.3	3.89	1.36	2.45	3.71	1.02	1.19	0.96	1.12	1.05
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.005	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	16	12	24	13.4	38.8	15.4	17.4	24.9	19.6	22.0	28.9	33.3	18	30.2	12.1	38.4	41.2	39.5	22.8	30.1	34.2	25.6
	Strontium (mg/L)		0.001	0.005	0.005	0.13	0.11	0.22	1.04	0.108	0.12	0.104	0.091	0.114	0.104	0.112	0.123	0.13	0.469	0.318	0.119	0.111	0.105	0.101	0.08	0.093	0.089
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.0003	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	0.002	<0.001	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.062	0.045	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.005	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.009	0.008	0.008	0.003	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	0.009	0.012	0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.005	0.007	0.010	0.434	0.017	0.031	0.025	0.031	0.034	0.03	0.032	0.033	0.028	1.79	0.272	0.017	0.012	0.023	0.018	0.008	0.01	0.01
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	240	250	250	259	273	261	251	267	261	259	264	285	280	266	244	305	293	284	274	265	290	276
	Bicarbonate (CaCO3) (mg/L)		10	5	5	239	249	249	259	273	261	251	267	261	259	264	285	279	266	244	305	293	284	274	265	290	276
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<10	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	35	26	22	<5	<5	<5	<5	<5	<5	<5	<5	<5	23	<5	<5	5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	na	na	9.4	5.6	1.2	<0.5	2	1	1.2	1.2	1.3	na	9.4	2.5	1.6	0.8	1.4	2	1.5	1	1.4
	DOC (mg/L)	5	0.7	0.5	0.5	1.3	1.1	2.1	1.2	1.9	1.3	<0.5	1	1.1	1.1	1.1	1.3	1.1	1.9	0.7	1.5	0.8	0.9	2	1.4	1	1.4
	Hardness (CaCO3) (mg/L)	100	10	10	10	270	321	299	331	345	356	344	311	310	347	366	354	340	306	354	366	355	300	263	288	315	277
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.05	<0.05	0.15	<0.02	0.02	<0.02	<0.02	<0.02	0.03	0.02	<0.02	<0.05	0.25	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	<0.02
	Conductivity (us/cm)		3	2	2	540	700	720	643	845	671	699	736	745	790	847	883	770	694	684	794	811	789	652	703	774	678
	pH	8.5	0.1	N/A	N/A	7.7	7.5	7.6	7.76	7.87	8.16	8.04	8.04	8.13	8.19	7.95	8.23	7.5	7.73	7.88	8.07	7.92	8.04	8.11	8.09	7.92	8.22
Calculated Values	Anion sum (meq/L)		0.01			6.69	7.34	7.78	6.69		6.89	7.77	8.11	7.76	8.03	8.41	9.06	7.95	6.89		7.88	9.07	8.66	6.95	7.14	7.93	7.13
	Cation sum (meq/L)		0.01			6.17	7.03	7.09	7.26		7.83	7.68	7.34	7.08	7.93	8.61	8.56	7.69	7.55		9.05	8.98	7.74	6.28	7.09	7.81	6.68
	% Difference (%)		0.01	0.1	0.1	-8.09	-4.31	-9.28	4.1	2.6	0.5	0.6	5.0	4.6	0.6	1.2	2.83	-3.32	4.6	2.1	1.0	0.5	5.6	5.1	0.4	0.8	3.26
	Langelier Index		0.0001			-0.09	-0.19	-0.17	0.83	1.14	1.27	1.12	1.1	1.18	1.28	1.07	1.37	-0.12	0.78	1.12	1.26	1.08	1.11	1.11	1.11	1.02	1.24
	Saturation pH (pH units)		0.01			7.80	7.70	7.77	6.93	6.73	6.89	6.92	6.94	6.95	6.91	6.88	6.86	7.62	6.95	6.76	6.81	6.84	6.93	7.0	6.98	6.9	6.98
	Silica (mg/L)			0.05	0.05 - 0.10	11.2	10.0	10.1	13.4	3.77	12.8	13	11.5	13.4	12.2	12.5	11.8	11.0	8.03	5.73	9.03	8.22	8.98	8.27	7.6	7.97	7.29

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 122										122A									
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	44.0	63.6	66.1	62.6	66.7	64.4	66.7	67.6	62.7	61.1	32.0	48.7	41.9	48.3	51.2	48.9	46.4	38.7	49.1	38.4
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.10	0.05	<0.05	0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	7.80	11.6	8.71	7.08	6.45	5.41	5.64	4.55	4.00	4.2	9.10	4.53	3.79	3.41	2.52	2.24	2.06	1.75	2.23	2.17
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	0.26	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25	<0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.10	<0.25	<0.25
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.50	<0.50	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.20	<0.50	<0.50
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	63.0	22.1	22.7	22.2	22.1	19.8	19.1	18.2	16.8	17	20.0	16.2	16.2	15.1	13.3	13	11.8	10.8	11	9.7
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.01	0.831	0.004	<0.004	0.008	0.007	<0.004	<0.004	<0.004	<0.004	<0.01	0.964	0.004	<0.004	0.008	0.004	<0.004	<0.004	<0.004	0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.09	0.156	0.093	0.099	0.095	0.081	0.089	0.076	0.085	0.088	0.07	0.089	0.049	0.058	0.05	0.051	0.047	0.042	0.049	0.045
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.05	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.05	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001
	Calcium (mg/L)		0.5	0.05	0.05	89.0	85.4	101	95.4	86.7	88.7	81.1	86	86.6	86.5	92.0	72.3	79.7	85.2	78.3	78.9	68.4	71.5	83.2	78
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	0.006	0.003	<0.003	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	0.003	0.004	<0.003	<0.003	<0.003	0.006	<0.003	0.004	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.0008	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0008	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	0.001	0.015	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.001	0.036	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	0.06	2.54	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.07	1.86	<0.010	<0.010	<0.010	<0.010	0.012	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.001	0.06	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.091	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	28	26.8	30.6	29.3	26.9	28.1	24.8	25.5	24.6	25.9	26	22.6	24.6	26.1	23.8	24.2	20.4	21.5	24	23
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.14	0.864	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	0.399	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.002	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	0.86	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.68	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	1.5	1.79	1.29	1.42	1.34	1.39	1.14	1.33	1.27	1.35	1.5	1.31	0.9	1.08	1.03	1.03	0.88	0.97	0.96	1.01
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	27	19.4	20.6	22.5	21.2	24.3	22.1	25.8	26.5	25.7	15	17.9	15.3	19.0	19.8	20.8	19.0	19.5	22.4	18.7
	Strontium (mg/L)		0.001	0.005	0.005	0.20	0.407	0.111	0.119	0.109	0.099	0.11	0.096	0.1	0.092	0.14	0.222	0.089	0.1	0.087	0.095	0.086	0.083	0.091	0.087
	Thallium (mg/L)		0.0003	0.006	0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	0.015	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.018	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	0.009	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.010	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.019	0.229	0.037	0.02	0.016	0.019	0.015	0.016	0.014	0.016	0.005	0.212	0.007	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	270	267	255	274	258	259	262	268	262	278	280	247	242	263	244	256	252	265	272	267
	Bicarbonate (CaCO3) (mg/L)		10	5	5	269	267	255	274	258	259	262	268	262	278	279	247	242	263	244	251	252	265	272	267
	Carbonate (CaCO3) (mg/L)		10	5	5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	27	<5	<5	5	<5	<5	<5	<5	<5	<5	79	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	na	3.5	5.6	1.2	0.9	1.1	1.2	3.6	0.9	1.1	na	8.2	1.4	1.8	0.8	1	1.2	3.9	1	1.1
	DOC (mg/L)	5	0.7	0.5	0.5	2.1	0.9	4.9	1.2	0.7	1	0.8	3.1	0.9	1.1	0.9	1.7	1.3	1.3	0.7	1.1	1	3.9	0.9	1.1
	Hardness (CaCO3) (mg/L)	100	10	10	10	338	324	378	359	327	337	305	320	318	323	337	274	300	320	294	297	255	267	307	289
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	<0.02	0.04	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	0.04
	Conductivity (us/cm)		3	2	2	780	695	773	712	728	701	755	755	780	718	720	597	637	636	615	619	644	638	723	609
	pH	8.5	0.1	N/A	N/A	7.7	8.0	7.88	8.14	7.84	8.11	8.18	8.08	8.16	8.13	7.5	7.99	8.04	8.18	7.99	8.31	8.22	8.06	8.21	8.14
Calculated Values	Anion sum (meq/L)		0.01			8.51	8.42		7.32	7.96	7.8	7.92	7.97	7.64	7.60	7.57	6.97		6.32	6.78	6.93	6.74	6.74	7.21	6.63
	Cation sum (meq/L)		0.01			7.96	7.36		8.19	7.50	7.83	7.08	7.55	7.53	7.94	7.42	6.28		7.25	6.75	6.86	5.94	6.21	7.13	6.78
	% Difference (%)		0.01	0.1	0.1	-6.68	6.8	2.6	0.2	3.0	0.2	5.6	2.7	0.7	2.15	-2.00	5.2	0.4	0.5	0.2	0.5	6.3	4.1	0.6	1.14
	Langelier Index		0.0001			0.02	1.08	1.16	1.27	0.91	1.19	1.22	1.15	1.22	1.22	-0.13	0.96	1.2	1.25	0.99	1.33	1.17	1.05	1.27	1.17
	Saturation pH (pH units)		0.01			7.68	6.92	6.72	6.87	6.93	6.92	6.96	6.93	6.94	6.91	7.63	7.03	6.84	6.93	7	6.98	7.05	7.01	6.94	6.97
	Silica (mg/L)			0.05	0.05 - 0.10	11.4	12.1	4.82	10.6	10.5	4.18	10.7	9.75	10	10	11.1	8.42	3.29	7.65	6.88	3.44	7.6	6.89	7.19	7.27

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 123									124					125							
			2003	2008-10	2011-20	2003	2008	2009	2010	2011	2012	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	ns	4.22	3.86	3.7	3.94	4.18	4.24	4.3	4.6	294	324	290	285	305	120	4.2	254	262	427	450	229	119
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	ns	1.22	1.39	1.1	1.38	1.4	1.28	0.94	1.23	<0.05	<0.5	<1.25	<0.25	<0.25	<0.05	1.18	<0.25	<0.25	<0.5			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.25	<0.05	<0.05	<0.5	<1.25	<0.25	<0.25	1.06	<0.05	3.26	0.86	<0.5			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	<0.25	<0.05	<0.05	<0.5	<1.25	<0.25	<0.25	<0.05	<0.05	<0.25	<0.25	0.94			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	ns	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.50	<0.10	<0.10	<1.0	<2.50	<0.50	<0.50	<0.10	<0.10	<0.50	<0.50	<1.0			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	ns	21.7	22.1	22.1	22.9	23.5	22.4	19.8	22.7	46	44.3	39.4	35.3	36.3	23.2	22.5	20	21.9	20.6			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	ns	0.02	0.009	<0.004	0.009	0.007	<0.004	<0.004	0.005	0.014	0.012	<0.004	<0.004	<0.004	0.021	0.005	<0.004	<0.004	0.004			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	ns	<0.006	<0.006	<0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	ns	0.009	0.005	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	ns	0.067	0.076	0.07	0.07	0.075	0.063	0.074	0.071	0.163	0.107	0.113	0.129	0.131	0.065	0.065	0.062	0.054	0.048			
	Beryllium (mg/L)		0.001	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	ns	0.02	0.017	0.015	0.019	0.02	0.016	0.017	0.019	0.014	<0.010	0.012	<0.010	<0.010	0.017	0.015	0.03	0.013	0.018			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	ns	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.001	<0.001	<0.001	<0.002	<0.002	<0.001	<0.001	<0.002	<0.002	<0.002	<0.001	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	ns	45.9	56.6	56.8	50.5	50	53.2	55.5	53.6	139	157	148	148	144	92	54	110	104	78.6			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	ns	<0.003	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003	0.013	<0.003	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	ns	<0.003	<0.003	0.008	<0.003	<0.002	<0.003	<0.003	<0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	ns	0.113	0.1	0.082	0.177	0.043	0.057	0.069	0.062	0.223	3.42	2.92	3.24	3.33	<0.010	0.078	<0.010	<0.010	<0.010			
	Lead (mg/L)	0.010	0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	ns	26.5	28.7	28.3	25.6	24.9	26.4	26.6	25.2	40.2	45.2	43.6	42.4	41.6	34.6	26.1	32.3	30.2	19.2			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	ns	0.004	0.003	<0.002	0.002	0.003	<0.002	0.002	0.002	0.197	0.222	0.204	0.206	0.219	0.057	<0.002	0.009	<0.002	<0.002			
	Molybdenum (mg/L)		0.001	0.002	0.001	ns	0.003	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	ns	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	ns	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	ns	1.42	1.24	1.26	1.15	0.99	1.11	1.14	1.19	1.14	0.96	0.83	0.83	0.9	1.63	1.1	1.89	1.86	1.73			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	ns	4.6	4.13	4.61	3.66	3.8	4.36	4.54	4.25	82.5	100	103	99.4	99.1	50.5	3.88	124	122	232	272	119	64.0
	Strontium (mg/L)		0.001	0.005	0.005	ns	0.547	0.448	0.481	0.566	0.508	0.439	0.539	0.488	0.264	0.255	0.226	0.259	0.26	0.178	0.456	0.16	0.149	0.129			
	Thallium (mg/L)		0.0003	0.006	0.006	ns	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	ns	0.023	0.007	0.007	<0.005	0.011	<0.005	<0.005	<0.005	0.02	0.024	<0.005	<0.005	<0.005	0.039	<0.005	<0.005	0.006	<0.005			
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	ns	235	223	237	223	233	228	219	227	313	318	332	333	337	309	225	306	288	237			
	Bicarbonate (CaCO3) (mg/L)		10	5	5	ns	235	223	237	223	233	228	219	227	313	318	332	333	337	309	225	306	288	237			
	Carbonate (CaCO3) (mg/L)		10	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	ns	<5	<5	<5	<5	<5	<5	<5	<5	12	6	10	10	10	<5	<5	<5	<5	<5			
	Total Organic Carbon (mg/L)			0.5	0.5	ns	0.5	1.8	0.8	0.5	2.2	0.6	0.8	1.1	25.8	7	6.8	7.4	6.6	5	1	33.5	1.9	1.9			
	DOC (mg/L)	5	0.7	0.5	0.5	ns	0.5	1.6	0.9	0.5	1.2	0.7	0.7	1.1	13.7	5	6.1	6.8	6	3.8	1	20.7	1.8	2			
	Hardness (CaCO3) (mg/L)	100	10	10	10	ns	224	260	258	232	227	242	248	238	513	578	549	544	531	372	242	408	384	275			
	Ammonia as N (mg/L)		0.05	0.02	0.02	ns	<0.02	<0.02	0.03	0.04	0.04	0.07	0.07	0.11	0.17	0.12	0.22	0.24	0.12	<0.02	0.14	0.05	<0.02	<0.02			
	Conductivity (us/cm)		3	2	2	ns	399	464	429	456	447	481	468	457	1440	1560	1570	1530	1530	896	479	1380	1330	1770			
	pH	8.5	0.1	N/A	N/A	ns	8.2	8.28	8.15	8.05	8.18	8.1	8.19	8.2	8.07	7.71	8.08	7.58	7.98	8.25	8.25	7.67	7.93	8.27			
Calculated Values	Anion sum (meq/L)		0.01			ns	5.27	5.03	4.58	5.12	5.34	5.21	4.96	4.97	15.50	16.40	15.60	15.40	15.00	10.10	5.15	13.90	13.70	15.60			
	Cation sum (meq/L)		0.01			ns	4.70	5.39	5.39	4.81	4.73	5.05	5.19	5.21	13.90	15.90	15.50	15.20	16.10	9.67	5.05	13.60	13.00	17.30			
	% Difference (%)		0.01	0.1	0.1	ns	5.7	3.5	0.3	3.1	6.0	1.6	2.2	2.34	5.6	1.5	0.5	0.6	3.7	2.3	1.0	1.2	2.4	5			
	Langelier Index		0.0001			ns	1.09	1.21	1.11	0.93	1.07	1.01	1.1	1.1	1.38	1.07	1.44	0.94	1.33	1.45	1.16	0.88	1.08	1.18			
	Saturation pH (pH units)		0.01			ns	7.11	7.07	7.04	7.12	7.11	7.09	7.09	7.1	6.69	6.64	6.64	6.64	6.65	6.8	7.09	6.79	6.85	7.09			
	Silica (mg/L)			0.05	0.05 - 0.10	ns	15.6	6.59	15.1	14.4	15	14.3	14.7	14.4	13.2	14.2	12.9	13.2	13.1	4.65	16.1	8.05	9.2	5.53			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS		RDL		Monitoring Wells 126								127								128							
			2003	2008-10	2011-20	2012	2013	2014	2015	2016	2017	2018	2020	2012	2013	2014	2015	2016	2017	2018	2020	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	175	185	229	242	344	374	462	256	131	163	232	299	278	283	362	357	177	225	426	472	444	395	461	326
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.05	<0.25	<1.25	<0.25	<0.25				<0.05	<0.25	<1.25	<0.5	<0.25				<0.05	<0.25	<0.25	<0.5	<0.5			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	0.18	0.62	<1.25	0.34	0.71				1.4	1.0	<1.25	<0.5	1.02				0.17	1.0	1.76	1.3	1.9			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.05	<0.25	<1.25	<0.25	<0.25				<0.05	<0.25	<1.25	<0.5	<0.25				<0.05	<0.25	<0.25	<0.5	<0.5			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.10	<0.50	<2.50	0.62	<0.50				<0.10	<0.50	<2.50	3.4	<0.50				<0.10	<0.50	<0.50	1.8	<1.0			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	16.4	15.6	16.6	17.2	19.6				16.6	16.1	16.7	21.8	17.5				56.7	48.7	41.9	44.4	43			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	0.012	0.004	<0.004	0.041	<0.004				0.019	0.005	<0.004	0.004	<0.004				0.006	0.004	<0.004	0.006	0.008			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.003	<0.003	<0.003	<0.003	<0.003				<0.003	<0.003	<0.003	<0.003	<0.003				<0.003	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003				<0.003	<0.003	<0.003	<0.003	<0.003				<0.003	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.054	0.046	0.053	0.046	0.059				0.057	0.043	0.054	0.057	0.052				0.122	0.08	0.104	0.125	0.114			
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.014	<0.010	0.012	0.011	0.011				0.013	<0.010	0.011	0.01	<0.010				0.01	<0.010	0.017	0.018	0.012			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.001				<0.002	<0.002	<0.002	<0.002	<0.001				<0.002	<0.002	<0.002	<0.002	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	64.9	73.9	59.5	60.6	74.4				87.9	90.2	75.9	81.8	78.6				97.7	107	124	124	120			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.003	<0.003	<0.003	0.004	<0.003				0.005	<0.003	<0.003	<0.003	<0.003				0.003	<0.003	0.005	<0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003				<0.003	<0.003	<0.003	<0.003	<0.003				<0.003	<0.003	<0.003	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.010	<0.010	<0.010	< 0.010	<0.010				<0.010	<0.010	<0.010	< 0.010	<0.010				0.05	<0.010	<0.010	< 0.010	<0.010			
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	0.003	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	22.4	24.5	22.4	22.7	23.8				28.8	28.5	26.3	24.5	23.6				38.8	37.9	39.9	37.3	36.5			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				0.003	<0.002	<0.002	<0.002	<0.002				0.049	0.017	0.008	0.005	0.003			
	Molybdenum (mg/L)		0.001	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003				<0.003	<0.003	<0.003	<0.003	<0.003				<0.003	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	< 0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	2.13	2.05	1.49	2.07	2.12				1.14	1.06	1.22	1.02	1.02				1.76	1.95	2.67	2.57	2.61			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004				<0.004	<0.004	<0.004	<0.004	<0.004				<0.004	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	89.5	94.1	111	131	192	221	219	117	64.7	75.5	119	152	163	166	192	156	63	94.4	175	198	206	209	210	146
	Strontium (mg/L)		0.001	0.005	0.005	0.121	0.121	0.175	0.129	0.166				0.123	0.109	0.116	0.11	0.111				0.169	0.173	0.184	0.199	0.197			
	Thallium (mg/L)		0.0003	0.006	0.006	<0.006	<0.006	<0.006	<0.006	<0.006				<0.006	<0.006	<0.006	<0.006	<0.006				<0.006	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002				0.012	<0.002	<0.002	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002				0.002	<0.002	<0.002	<0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	0.01	<0.005	0.023	0.006	<0.005				0.031	0.008	0.009	0.006	0.006				0.008	0.007	0.014	0.021	0.014			
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	213	229	210	204	243				288	277	267	256	289				267	286	316	298	320			
	Bicarbonate (CaCO3) (mg/L)		10	5	5	213	229	210	204	243				288	277	267	256	289				267	286	316	298	320			
	Carbonate (CaCO3) (mg/L)		10	5	5	<5	<5	<5	<5	<5				<5	<5	<5	<5	<5				<5	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	<5	<5	<5	<5	<5				<5	<5	<5	<5	<5				<5	<5	<5	<5	<5			
	Total Organic Carbon (mg/L)			0.5	0.5	5.3	1.9	3.8	2.6	2.2				4.2	3	3	2.3	1.6				4.3	2.4	6.5	2.1	2.2			
	DOC (mg/L)	5	0.7	0.5	0.5	4.7	1.6	3.6	2.5	2.2				2.3	2.6	3	2.1	1.5				3.3	1.2	5.6	1.9	2.1			
	Hardness (CaCO3) (mg/L)	100	10	10	10	254	285	241	245	284				338	343	298	305	293				404	423	474	463	450			
	Ammonia as N (mg/L)		0.05	0.02	0.02	<0.02	<0.02	0.06	0.04	<0.02				<0.02	<0.02	0.03	0.03	0.03				<0.02	<0.02	0.07	0.05	0.04			
	Conductivity (us/cm)		3	2	2	904	1040	1120	1160	1530				894	1040	1200	1420	1350				1040	1310	1890	2030	1920			
	pH	8.5	0.1	N/A	N/A	8.23	8.14	8	8.13	8.12				8.11	8.09	8.01	8.06	8.21				8.22	8.09	8.15	8.09	8.09			
Calculated Values	Anion sum (meq/L)		0.01			9.55	10.20	11.00	11.30	15.00				9.90	10.50	12.20	14.00	14.10				11.50	13.20	19.30	20.30	20.00			
	Cation sum (meq/L)		0.01			9.03	9.85	9.68	10.60	14.10				9.60	10.20	11.20	12.70	13.00				10.80	12.60	17.20	17.90	18.00			
	% Difference (%)		0.01	0.1	0.1	2.8	1.6	6.4	2.9	3.26				1.6	1.9	4.6	4.8	3.99				3.0	2.1	6.0	6.2	5.1			
	Langelier Index		0.0001			1.07	1.07	0.81	0.94	1.07				1.21	1.18	1.02	1.06	1.25				1.36	1.28	1.43	1.33	1.35			
	Saturation pH (pH units)		0.01			7.16	7.07	7.19	7.19	7.05				6.9	6.91	6.99	7.00	6.96				6.86	6.81	6.72	6.76	6.74			
	Silica (mg/L)			0.05	0.05 - 0.10	1.38	4.08	2.6	1.92	2.91				3.37	6.75	6.25	5.39	6.54				5.09	11.9	8.28	8.36	8.64			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 129								130							
			2003	2008-10	2011-20	2012	2013	2014	2015	2016	2017	2018	2020	2012	2013	2014	2015	2016	2017	2018	2020
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	116	128	139	175	232	284	406	447	ns	75.5	196	206	238	171	349	417
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.05	<0.25	<0.25	<0.25	<0.25				ns	<0.25	<0.25	<0.5	<0.25			
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	4.5	4.58	4.11	3.15	2.6				ns	<0.25	0.45	<0.5	0.49			
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.05	<0.25	<0.25	<0.25	<0.25				ns	<0.25	<0.25	<0.5	<0.25			
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.10	<0.50	<0.50	1.1	<0.50				ns	<0.50	<0.50	2	<0.50			
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	39.4	33.7	26.6	36.9	40.9				ns	17	19.3	21.6	20.4			
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	0.01	0.007	<0.004	<0.004	<0.004				ns	0.004	0.241	0.006	<0.004			
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.003	<0.003	<0.003	<0.003	<0.003				ns	<0.003	<0.003	<0.003	<0.003			
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003				ns	<0.003	<0.003	<0.003	<0.003			
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.107	0.078	0.077	0.107	0.118				ns	0.062	0.078	0.103	0.076			
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001				ns	<0.001	<0.001	<0.001	<0.001			
	Bismuth (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				ns	<0.002	<0.002	<0.002	<0.002			
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.011	<0.010	<0.010	0.01	<0.010				ns	0.013	0.014	0.012	<0.010			
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.001				ns	<0.002	<0.002	<0.002	<0.001			
	Calcium (mg/L)		0.5	0.05	0.05	98.5	101	93.9	107	114				ns	80.8	85.2	95.9	92.3			
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.004	<0.003	0.003	<0.003	<0.003				ns	<0.003	<0.003	0.003	<0.003			
	Cobalt (mg/L)		0.0008	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001				ns	<0.001	<0.001	<0.001	<0.001			
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.003	<0.003	<0.003	<0.003	<0.003				ns	<0.003	<0.003	<0.003	<0.003			
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.010	<0.010	<0.010	< 0.010	<0.010				ns	<0.010	0.464	< 0.010	<0.010			
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				ns	<0.002	0.005	<0.002	<0.002			
	Magnesium (mg/L)		0.5	0.05	0.05	33.3	33.5	31.5	35.1	38.7				ns	33.5	30.6	32.6	32.1			
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.097	0.054	0.032	0.047	0.036				ns	<0.002	0.172	0.023	0.005			
	Molybdenum (mg/L)		0.001	0.002	0.001	<0.002	<0.002	<0.002	<0.002	<0.002				ns	<0.002	<0.002	<0.002	<0.002			
	Nickel (mg/L)		0.002	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003				ns	<0.003	<0.003	<0.003	<0.003			
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05				ns	<0.05	<0.05	<0.05	<0.05			
	Potassium (mg/L)		0.5	0.05	0.05	2.17	2.13	2.11	2.06	2.29				ns	0.71	1.2	0.79	0.92			
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004				ns	<0.004	<0.004	<0.004	<0.004			
	Silver (mg/L)		0.0001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				ns	<0.002	<0.002	<0.002	<0.002			
	Sodium (mg/L)	20	0.5	0.05	0.05	45.4	55.5	63.4	64.7	85.4	125	204	211	ns	77.3	135	155	147	110	174	202
	Strontium (mg/L)		0.001	0.005	0.005	0.152	0.121	0.105	0.132	0.147				ns	0.221	0.197	0.205	0.161			
	Thallium (mg/L)		0.0003	0.006	0.006	<0.006	<0.006	<0.006	<0.006	<0.006				ns	<0.006	<0.006	<0.006	<0.006			
	Tin (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				ns	<0.002	<0.002	<0.002	<0.002			
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				ns	<0.002	0.015	<0.002	<0.002			
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				ns	<0.002	<0.002	<0.002	<0.002			
	Vanadium (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002				ns	<0.002	0.002	<0.002	<0.002			
	Zinc (mg/L)	5	0.003	0.005	0.005	0.015	0.029	0.007	0.01	0.009				ns	0.043	0.146	0.022	0.01			
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	280	285	290	284	298				ns	395	352	379	375			
	Bicarbonate (CaCO3) (mg/L)		10	5	5	280	285	290	284	298				ns	395	352	379	375			
	Carbonate (CaCO3) (mg/L)		10	5	5	<5	<5	<5	<5	<5				ns	<5	<5	<5	<5			
	Colour (TCU)	5	1	5	5	<5	<5	<5	<5	<5				ns	<5	<5	<5	<5			
	Total Organic Carbon (mg/L)			0.5	0.5	13.8	3.3	38.9	2.4	2				ns	2.6	43.2	1.8	2.1			
	DOC (mg/L)	5	0.7	0.5	0.5	6.5	2	37.7	2.3	2				ns	1.5	21.4	1.7	2.1			
	Hardness (CaCO3) (mg/L)	100	10	10	10	383	390	364	412	444				ns	340	339	374	363			
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.06	<0.02	0.12	0.08	<0.02				ns	<0.02	0.03	0.02	<0.02			
	Conductivity (us/cm)		3	2	2	896	1000	1060	1190	1280				ns	974	1260	1500	1380			
	pH	8.5	0.1	N/A	N/A	8.27	8.01	8.06	8.07	8.04				ns	8.1	8.07	8.03	8.15			
Calculated Values	Anion sum (meq/L)		0.01			10.00	10.30	10.60	11.60	12.60				ns	10.40	13.00	13.80	13.70			
	Cation sum (meq/L)		0.01			9.69	10.30	10.10	11.10	13.50				ns	10.20	12.70	14.20	14.70			
	% Difference (%)		0.01	0.1	0.1	1.7	0.4	2.3	2.3	3.43				ns	1.1	1.3	1.4	3.57			
	Langelier Index		0.0001			1.41	1.17	1.19	1.25	1.27				ns	1.37	1.26	1.29	1.39			
	Saturation pH (pH units)		0.01			6.86	6.84	6.87	6.82	6.77				ns	6.73	6.81	6.74	6.76			
	Silica (mg/L)			0.05	0.05 - 0.10	5.16	11.7	10.4	10.5	10.6				ns	5.84	6.29	6.63	7.01			

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells									
						131					132				
			2003	2008-10	2011-20	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	75.8	59.6	52.1	59.2	46.8	376	333	460	350	445
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.05	<0.25	<0.10	<0.25	<0.25	<0.05	<0.5	<2.5	<0.5	<0.50
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	1.41	1.2	1.44	1.56	1.02	2.42	1.93	2.54	2.1	1.95
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.05	<0.25	<0.10	<0.25	<0.25	<0.05	<0.5	<2.5	<0.5	<0.50
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.10	<0.50	<0.20	<0.50	<0.50	<0.10	<1.0	<5.0	<1.0	<1.0
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	29.5	22.6	18.3	15.7	16	26.1	50.3	34.1	28.4	38.4
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	<0.004	0.006	<0.004	<0.004	< 0.004	0.005	0.006	<0.004	<0.004	< 0.004
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.045	0.032	0.033	0.037	0.034	0.123	0.087	0.146	0.121	0.117
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.017	<0.010	0.011	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.011
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.001	<0.002	<0.002	<0.002	<0.001	<0.001	<0.002	<0.002	<0.002	<0.001
	Calcium (mg/L)		0.5	0.05	0.05	70.2	80.9	81.9	86.1	82.4	85.8	91.5	113	110	110
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.007	<0.003	0.003	<0.003	<0.003	0.013	<0.003	<0.003	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.002	<0.003	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	0.05	28.1	26.5	28	28.8	27	25.7	27.2	37.5	31.9	32.7
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.317	0.090	0.075	0.036	0.053	0.016	<0.002	<0.002	<0.002	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.001	0.007	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Potassium (mg/L)		0.5	0.05	0.05	2.02	1.36	1.08	1	0.88	1.56	1.64	2.3	1.8	1.89
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	0.05	31.8	27.4	24.9	28	28	196	161	253	165	230
	Strontium (mg/L)		0.001	0.005	0.005	0.116	0.115	0.096	0.101	0.101	0.118	0.143	0.164	0.143	0.17
	Thallium (mg/L)		0.0003	0.006	0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	0.003	<0.002	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.005	0.006	0.009	<0.005	<0.005	0.007	0.021	0.019	0.018	0.017	0.019
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	263	289	300	298	312	286	276	274	272	305
	Bicarbonate (CaCO3) (mg/L)		10	5	5	263	289	300	298	311	286	276	274	272	305
	Carbonate (CaCO3) (mg/L)		10	5	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Colour (TCU)	5	1	5	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Total Organic Carbon (mg/L)			0.5	0.5	4.2	3	8.4	1.7	1.2	4.9	1.2	2.2	1.6	1.6
	DOC (mg/L)	5	0.7	0.5	0.5	1.9	2.8	5.8	1.6	1.2	1.4	1.2	2.1	1.5	1.5
	Hardness (CaCO3) (mg/L)	100	10	10	10	291	311	320	334	317	320	340	437	406	409
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.03	<0.02	0.04	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02
	Conductivity (us/cm)		3	2	2	724	768	745	783	753	1660	1610	1920	1610	1980
	pH	8.5	0.1	N/A	N/A	8.26	8.18	8.01	7.89	8.25	8.05	8.13	8.06	7.95	8.26
Calculated Values	Anion sum (meq/L)		0.01			8.11	8.02	7.95	8.07	7.97	17.00	16.10	19.30	16.10	19.60
	Cation sum (meq/L)		0.01			7.25	7.44	7.50	7.91	7.57	15.00	13.80	19.80	15.30	18.20
	% Difference (%)		0.01	0.1	0.1	5.6	3.7	2.9	1.0	2.53	6.5	7.5	1.1	2.3	3.6
	Langelier Index		0.0001			1.28	1.27	1.13	1.03	1.39	1.11	1.2	1.24	1.09	1.46
	Saturation pH (pH units)		0.01			6.98	6.91	6.88	6.86	6.86	6.94	6.93	6.82	6.86	6.8
	Silica (mg/L)			0.05	0.05 - 0.10	10	9.38	7.97	8.05	7.48	10.1	10.8	9.91	10	9.64

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter (units)	ODWQS	RDL			Monitoring Wells 133					134					135								max	min	average
			2003	2008-10	2011-20	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2017	2018	2020			
Anions	Chloride (mg/L)	250	2.0	0.10	0.10 - 0.50	99.4	91.5	78.1	88.2	68.9	anom	190	109	114	170	122	180	180	166	205	213	227	310	483	0.42	123.9
	Fluoride (mg/L)	1.5	0.10	0.05	0.05 - 1.25	<0.05	<0.25	0.17	<0.25	<0.25	<0.50	<0.25	<1.25	<0.25	<0.25	<0.05	<0.25	<1.25	<0.25	<0.25				1.4	0.05	0.47
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.05 - 1.25	0.3	2.16	3.12	1.89	2.37	anom	0.32	<1.25	1.36	1.57	1.97	2.81	2.93	2.46	2.39				19.0	0.05	3.20
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.05 - 1.25	<0.05	<0.25	0.26	<0.25	<0.25	<0.50	<0.25	<1.25	<0.25	<0.25	<0.05	<0.25	<1.25	<0.25	<0.25				1.0	0.08	0.57
	Phosphate-P (ortho) (mg/L)		0.30	0.10	0.10 - 2.50	<0.10	<0.50	<0.20	<0.50	<0.50	<1.00	<0.50	<2.50	<0.50	<0.50	<0.10	<0.50	<2.50	<0.50	<0.50				3.4	0.16	1.13
	Sulphate (mg/L)	500	2.0	0.10	0.10 - 0.50	34.2	19	15.5	10	13.6	79.5	40.7	37.1	24	26	59.4	21	19.8	21.7	20.8				89.4	4.54	23.4
Metals	Aluminum (mg/L)	0.1	0.01	0.004	0.004	0.024	0.007	<0.004	<0.004	0.006	0.029	0.008	<0.004	<0.004	0.005	0.037	0.007	<0.004	<0.004	< 0.004				4.19	0.004	0.23
	Antimony (mg/L)	0.006	0.005	0.006	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003				0	0	0
	Arsenic (mg/L)	0.025	0.001	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003				0.028	0.003	0.007
	Barium (mg/L)	1.0	0.01	0.002	0.002	0.084	0.086	0.075	0.087	0.086	0.357	0.069	0.064	0.078	0.092	0.066	0.065	0.1	0.104	0.097				1.190	0.031	0.108
	Beryllium (mg/L)		0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				0	0	0
	Bismuth (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002				0	0	0
	Boron (mg/L)	5.0	0.05	0.010	0.010	0.044	0.035	0.032	0.017	0.017	0.087	0.099	0.055	0.069	0.048	0.024	<0.010	<0.010	0.01	<0.010				0.099	0.01	0.018
	Cadmium (mg/L)	0.005	0.0001	0.002	0.001	<0.001	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001	<0.002	<0.002	<0.002	<0.001				0.020	0.0006	0.006
	Calcium (mg/L)		0.5	0.05	0.05	53.3	48.4	54.2	57.7	62	anom	88.1	67.3	63.8	76.9	80.2	80.7	77.1	88.8	92.3				157	22.9	81.7
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.008	<0.003	0.004	<0.003	<0.003	anom	<0.003	<0.003	<0.003	<0.003	0.012	<0.003	<0.003	<0.003	<0.003				0.025	0.002	0.007
	Cobalt (mg/L)		0.0008	0.001	0.001	0.002	0.001	<0.001	<0.001	<0.001	0.016	0.005	0.002	0.001	0.001	0.002	<0.001	<0.001	<0.001	<0.001				0.0419	0.0007	0.011
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.002	<0.003	<0.003	<0.003	<0.003	0.01	0.005	<0.003	<0.003	<0.003	<0.002	<0.003	<0.003	<0.003	<0.003				0.167	0.001	0.031
	Iron (mg/L)	0.3	0.05	0.010	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.983	1.34	0.552	0.702	<0.010	<0.010	<0.010	<0.010	<0.010				12.2	0.012	1.434
	Lead (mg/L)	0.010	0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002				0.591	0.001	0.111
	Magnesium (mg/L)		0.5	0.05	0.05	31.4	34.1	36	31.2	31.2	anom	42.3	35.2	38.7	38.5	32.7	26.4	26.8	27	29.7				45.2	19	28.0
	Manganese (mg/L)	0.05	0.001	0.002	0.002	0.404	0.239	0.204	0.132	0.158	0.018	0.638	0.196	0.115	0.182	0.385	0.043	<0.002	<0.002	<0.002				5.2	0.002	0.56
	Molybdenum (mg/L)		0.001	0.002	0.001	0.022	0.024	0.018	0.01	0.01	0.029	0.013	0.009	0.013	0.006	0.009	0.002	<0.002	<0.002	<0.002				0.029	0.002	0.007
	Nickel (mg/L)		0.002	0.003	0.003	0.004	<0.003	<0.003	<0.003	<0.003	0.059	0.008	<0.003	0.003	<0.003	0.005	<0.003	<0.003	<0.003	<0.003				0.066	0.003	0.014
	Phosphorus (mg/L)		0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				9.2	0.02	0.97
	Potassium (mg/L)		0.5	0.05	0.05	5.89	6.04	6.56	5.48	6.25	11.7	4.11	3.25	3.41	3.59	2.55	1.7	1.61	1.54	1.6				17.4	0.67	1.82
	Selenium (mg/L)	0.01	0.005	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004				0.006	0.002	0.004
	Silver (mg/L)		0.0001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002				0.0003	0.0001	0.0002
	Sodium (mg/L)	20	0.5	0.05	0.05	48.8	35.6	37.3	37.7	27	anom	58	79.5	57.6	77.8	50.8	75.8	91.5	85.4	101	94	104	129	272	3.00	62.0
	Strontium (mg/L)		0.001	0.005	0.005	0.177	0.184	0.161	0.149	0.148	1.37	0.229	0.142	0.189	0.178	0.176	0.136	0.121	0.111	0.118				2.410	0.073	0.261
	Thallium (mg/L)		0.0003	0.006	0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006				0	0	0
	Tin (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002				0.006	0.002	0.003
	Titanium (mg/L)		0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002				0.081	0.002	0.019
	Uranium (mg/L)	0.02	0.005	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002				0.01	0.0008	0.003
	Vanadium (mg/L)		0.001	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002				0.047	0.002	0.007
	Zinc (mg/L)	5	0.003	0.005	0.005	0.036	0.013	<0.005	<0.005	0.007	0.073	0.017	<0.005	0.007	0.007	0.048	0.012	0.009	0.013	0.012				2.14	0.005	0.089
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	5	237	240	259	240	243	anom	272	289	282	300	269	268	270	271	289				395	180	273
	Bicarbonate (CaCO3) (mg/L)		10	5	5	237	240	259	240	243	anom	272	289	282	300	269	268	270	271	289				395	180	273
	Carbonate (CaCO3) (mg/L)		10	5	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5				18	5	10
	Colour (TCU)	5	1	5	5	<5	<5	<5	<5	<5	12	18	5	<5	8	<5	<5	<5	<5	<5				65	5	15
	Total Organic Carbon (mg/L)			0.5	0.5	4.4	2.9	5.4	3.1	1.4	anom	18	4.2	5.3	4.8	5.7	2.4	1.9	0.9	1.3				50.4	0.5	4.8
	DOC (mg/L)	5	0.7	0.5	0.5	2.6	2.1	3.3	3.1	1.4	182	18	4.4	4.9	5.1	5.1	2.1	1.8	0.8	1.2				540	0.5	5.3
	Hardness (CaCO3) (mg/L)	100	10	10	10	262	261	284	273	283	anom	394	313	319	351	335	310	303	333	353				578	151	320
	Ammonia as N (mg/L)		0.05	0.02	0.02	0.19	0.33	0.17	0.02	0.07	<0.02	0.38	0.23	0.36	0.22	<0.02	<0.02	0.03	<0.02	<0.02				1.05	0.02	0.12
	Conductivity (us/cm)		3	2	2	764	751	751	788	684	anom	1160	962	964	1060	920	1110	1060	1070	1190				2030	335	843
	pH	8.5	0.1	N/A	N/A	8.18	8.15	8.15	8.28	8.15	7.58	8.15	8.11	8.22	8.14	8	8.15	7.98	7.97	8.26				8.36	7.5	8.0
Calculated Values	Anion sum (meq/L)		0.01			8.28	7.93	7.96	7.63	7.00	anom	11.70	9.63	9.45	10.50	10.20	11.10	11.10	10.70	12.20				20.3	3.35	8.86
	Cation sum (meq/L)		0.01			7.52	6.94	7.46	7.22	7.26	anom	10.50	9.81	8.98	11.40	8.96	9.54	10.10	10.40	11.50				19.8	3.58	8.74
	% Difference (%)		0.01	0.1	0.1	4.8	6.7	3.2	2.7	1.82	2.4	5.2	0.9	2.6	4.37	6.4	7.5	4.8	1.5	2.9				8.82	-35.34	2.34
	Langelier Index		0.0001			1.11	1.09	1.16	1.24	1.13	2.18	1.29	1.21	1.31	1.27	1.06	1.18	1.0	1.04	1.38				2.18	-0.1	1.11
	Saturation pH (pH units)		0.01			7.07	7.06	6.99	7.04	7.02	5.4	6.86	6.9	6.91	6.87	6.94	6.97	6.98	6.93	6.88				7.9	5.4	6.93
	Silica (mg/L)			0.05	0.05 - 0.10	8.13	8.95	8.91	9.67	10.2	7.13	13.8	12.1	12.8	12.1	12.6	12.4	10.7	10.6	10.4				23.1	1.38	9.6

At or Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit,

ns: not sampled, na: not analyzed, anom: anomolous result caused by drilling fluid in well

APPENDIX III 2019 Surface Water Monitoring Report

Hanlon Creek Business Park-
2019 Surface Water Monitoring Report

City of Guelph

Project number: 60611735

March 2020

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("AECOM") for the benefit of the Client ("Client") in accordance with the agreement between AECOM and Client, including the scope of work detailed therein (the "Agreement").

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AECOM: 2015-04-13

Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position

Distribution List

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1. Introduction

1.1 Background

AECOM was retained by the City of Guelph to complete the 2019 Surface Water Monitoring component of the Hanlon Creek Business Park (HCBP) monitoring program, which is comprised of the lands between Downey Road and the Hanlon Expressway, and between Forestell Road and the south end of the Kortright subdivision along Teal Drive in the City of Guelph.

This monitoring program follows from the recommendations made in the HCBP Consolidated Environmental Impact Study (NRSI 2004), Draft Plan Conditions (OMB 2006), Ministry of Environment, Conservation and Parks (MECP) Environmental Compliance Approval (ECA) No. 1384-7QFPZQ and review comments from agencies during various stages of the planning process.

This surface water monitoring work plan includes collection of temperature, flow, and water quality conditions within both Hanlon Creek Tributary A and HCBP Stormwater Management (SWM) Facilities 1, 2 and 4. The monitoring program is intended to provide an understanding of surface water flow, water quality and thermal conditions within HCBP's stormwater management and natural watercourse systems.

1.2 Surface Water Monitoring Program History

In 2003 AECOM was retained by the City of Guelph (City) to establish and carry out a surface water monitoring program at Hanlon Creek Tributary A in anticipation of construction at the Hanlon Creek Business Park. The purpose of this program was to characterize pre-construction flows and temperature characteristics. The surface water monitoring program has evolved since 2003 and is now included as the surface water monitoring component of the Consolidated Monitoring Program established for the HCBP. Other components of this monitoring program include groundwater (completed by Banks Groundwater); and aquatic and terrestrial ecology, completed by Natural Resource Solutions Inc. (NRSI).

In 2003-2004 monitoring data was reported in separate memoranda to the City and a consolidated Environmental Impact Study (EIS) was prepared by NRSI for the Hanlon Creek Business Park in 2004. Monitoring continued in 2006 and 2007 with continuous temperature measurements at six (6) stations between the outlet of the online pond (Road A) and 150 m upstream of Laird Road (monitoring location figure is shown in **Section 2**). Depth and velocity were continuously measured at the Laird Road culvert (HC-A(05)) and periodic depth measurements were also recorded at this location. Sampling completed in 2006-2007 was summarized in a technical memorandum, submitted to the City of Guelph in February 2008.

The 2008 monitoring plan included temperature monitoring at the previous 6 stations along Tributary A and an additional temperature monitoring station (HC-A(14)) located downstream of the existing SWM pond (Pond 2) outlet. This additional station provided background information to identify the temperature impacts of proposed Ponds 1 and 2. Depth and velocity were monitored at the Laird Road culvert (HC-A(05)) and water depth was monitored at station HC-A(10). High flow measurements were collected to establish a rating curve for HC-A(10). Through June-September 2008, sites were visited monthly to download data, perform regular maintenance, and collect baseflow measurements and water quality parameters (dissolved oxygen (DO), pH, specific conductivity) at all stations. Monitoring results from 2008 were presented in a memorandum to the City of Guelph, dated February 3, 2009.

The 2009 monitoring plan included temperature monitoring at the 7 stations monitored in 2008. Temperature monitoring consisted of logging temperature readings every 15 or 30 minutes at the 7 site locations. Temperature loggers deployed during winter months were set at a 30-minute interval to ensure adequate memory would be available throughout the winter months. Loggers re-deployed during later (spring) months were programmed to collect data at 15-minute intervals. A continuous level/temperature logger (HC-A(10)) and the depth and velocity monitoring equipment at HC-A(05) were used to monitor flows during 2009. From May-October 2009, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality measurements for several parameters (DO, pH, specific conductivity). The flow/velocity instrument stopped logging data November

22nd due to battery failure and was removed from the culvert December 14, 2009. The remainder of the data loggers continued to collect continuous data at 30-minute intervals throughout the winter.

The 2010 monitoring plan included temperature monitoring at the 7 stations monitored in 2009, as well as a new depth and temperature monitoring station at SR-1(01). The existing station HC-A(14) was supplemented with the installation of a level logger, and continuous depth/velocity monitoring was completed at the Laird Road culvert (HC-A(05)). Temperature monitoring consisted of logging temperature readings every 15 minutes from April until December and every 30 minutes during the winter months at the eight site locations. During May-October 2010, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity). High flow measurements were collected to develop rating curves for HC-A(10) and HC-A(14).

In 2011 a number of additional stations were installed in Tributary A at the beginning of the monitoring season. Monitoring in the stormwater management facilities (SWMFs) was initiated as Ponds 1, 2 and 4 were brought online and began functioning as SWMFs. Within this report the terms "SWMFs" and "ponds" are used interchangeably. The same surface water monitoring program completed in 2011 was also carried out in 2012 and 2013.

In August 2010, the Hanlon Creek Business Park Consolidated Monitoring Program (NRSI, AECOM, Banks Groundwater) was submitted to the City of Guelph. This monitoring plan included the location, parameters and naming convention for all surface monitoring works to be completed as part of the implementation of servicing and construction at the HCBP.

The 2015 monitoring program followed the station setup used during the 2012, 2013 and 2014 monitoring years as no new stations were deemed to be necessary at that time. A small number of stations were relocated based on recommendations from the 2012 monitoring report to improve the data collection methodology. Additionally, a tipping bucket rain gauge (Model TB3) was installed for the 2015 monitoring season. The rain gauge was installed on the roof of the Clair Road Emergency Services Centre, located approximately 2 km east of the Hanlon Creek Business Park.

In 2016, two additional sites were added at the upstream and downstream ends of the culvert where Tributary A crosses Laird Road. Later in 2017, Ponds 1 and 2's loggers that previously recorded the thermal profile in the deep cell of each pond were removed; however, Pond 4's thermal profile loggers were retained. In the spring of 2017, sites in which water samples were recorded were narrowed to only include Tributary A sites. With the removal of sampling at pond outlets, two additional water sampling sites were added immediately upstream of the confluence of Pond 1 and Pond 4 outlets into Tributary A, respectively. This program was also followed in 2018.

In March of 2019, the Hanlon Monitoring Program was put to bid by the City of Guelph. AECOM was eventually retained to complete the surface water monitoring portion of the program and, due to a delay in the awarding of the program, field work officially commenced in August of 2019 with a condensed field season.

1.3 Site Construction History

In July 2009 tree cover upstream of stations HC-A(11) and HC-A(14) was removed as part of the initial clearing for the Hanlon Creek Boulevard culvert construction. In the summer of 2010 construction of the site began with the works being completed at the culvert crossing in August of that year. In 2011, construction of the Phase 1 site was completed with construction of Phase 2 completed by early 2012. The first lot level development began in the Phase 1 lands in May 2012 and no developments were constructed in Phase 2 during 2012. Construction of the Laird Road overpass occurred in the Phase 2 lands in 2013. Development continued through 2017 with construction of some buildings and related parking areas occurring in Phase 1.

2. 2019 Surface Water Monitoring Program

The surface water monitoring program consisted of the following components:

- Continuous data collection using water level, temperature and turbidity loggers
- Baseflow and high flow measurements
- SWM facility water quantity and temperature monitoring
- Tributary A water quality monitoring

There are currently 13 stations for the Hanlon Creek Tributary A, seven (7) stations for Pond 1, four (4) stations for Pond 2 and six (6) stations for Pond 4. Monitoring station locations are illustrated in **Figure 2.4.1**.

2.1 Tributary A Continuous Monitoring Stations

Table 1 summarizes the continuous monitoring program completed for Tributary A during the 2019 monitoring season. The following is a description and history of each station:

Station HC-A(03) is located in the upper reaches of Hanlon Creek Tributary A1 (Trib. A1) within the site, about 10 m upstream of Pond 4 in a partially forested area.

Station HC-A(04) is located approximately 75 m downstream of Pond 4 and 150 m upstream of Laird Road in a partially forested area. Tributary A then passes through an open area and a low-lying wetland.

Following the recommendations made by 2015 Hanlon Creek Tributary A Surface Water Monitoring Report, two new continuous temperature monitoring stations were included in the 2016 surface water monitoring program. Station HC-A(04A) was installed in Tributary A upstream of the Laird Rd. culvert and station HC-A(04B) was installed directly downstream of the Laird Road culvert. The stations were installed to aid in the understanding of the temperature characteristics of Tributary A between stations HC-A(04) and HC-A(06). Station HC-A(04A) is located approximately 100m downstream of Station HC-A(04) and approximately 50m upstream of the Laird Road Crossing. Tributary A then passes under Laird Road. Station HC-A(04B) is located directly downstream of the Laird Road culvert.

Station HC-A(06) is located approximately 100 m downstream of Laird Road. Along this stretch the stream passes through a cedar wetland.

Station HC-A(08) is located in the same cedar wetland on a tributary of the main branch of Tributary A1.

Station HC-A(09) is located within a cedar wetland.

Station HC-A(10) is located approximately 50 m downstream of the confluence of the main branch and the tributary and just upstream of the Hanlon Creek Boulevard crossing.

Station HC-A(11) is located at the downstream end of the Hanlon Creek Boulevard culvert. From the culvert, the stream passes through another cedar wetland area.

Station HC-A(12) is located in an open wetland area at the outlet of cedar wetland and upstream of Pond 1.

Station HC-A(13) is located approximately 200 m downstream of HC-A(12) and immediately downstream of the outlet of Pond 1 in an open field.

Station HC-A(14) is located at the downstream end of the study site, approximately 150 m upstream of Teal Drive.

Station SR-1(01) is located on an unnamed tributary on the west side of Downey Road across from the Downey Road Provincially Significant Wetland (PSW).

During the winter months, the telemetry stations were removed and replaced with temperature/depth loggers set to record at 30-minute intervals. Telemetry systems at stations HC-A(03), HC-A(06), HC-A(11), and HC-A(14) were reinstalled in May 2017.

Depth loggers were removed during the winter months from any stations where the flow is intermittent and replaced with temperature logger. This was done to prevent damage from occurring to the logger and primarily included the outlets of Pond 1 and Pond 2 as well as a number of pond inlets.

Telemetry stations with alarm capabilities are used at four stations (HC-A(03), HC-A(06), HC-A(11) and HC-A(14)). Each telemetry station monitors water quality (temperature and turbidity) and relative quantity (water level) leaving each stormwater pond and provides remote access to all data. Telemetry stations were programmed to provide real-time alerts when temperature and turbidity parameters exceeded acceptable standards.

Table 1: Tributary A Continuous Monitoring Stations

Station ID	Station ID Prior to 2010	Data Collected*	Date installed	Notes
HC-A(03)	-	Temperature, Depth, Turbidity	March 2011	-
HC-A(04)	1	Temperature, Depth	March 2011	-
HC-A(04A)	-	Temperature	July 2016	-
HC-A(04B)	-	Temperature	July 2016	-
HC-A(06)	2	Temperate, Depth, Turbidity	March 2011	-
HC-A(08)	3	Temperature	May 2006	-
HC-A(09)	4	Temperature	May 2006	-
HC-A(10)	5	Temperature, Depth	May 2006	-
HC-A(11)	6	Temperate, Depth, Turbidity	March 2011	-
HC-A(12)	7	Temperature, Depth	April 2011	-
HC-A(13)	-	Temperature, Depth	March 2011	-
HC-A(14)	-	Temperate, Depth, Turbidity	March 2011	-
SR-1(01)	-	Temperature, Depth	June 2010	Logger went missing in 2019 but was replaced for the winter in December 2019.

Notes
A station HC-A(05) was previously monitored for flow through the area/velocity method.

2.2 SWMF Continuous Monitoring Stations

Table 2 summarizes the continuous monitoring program completed for the SWM facilities during the 2019 monitoring season. The 2019 program included the following stations:

Monitoring at SWM Pond 1 included loggers at the outlet from the pond and two cooling trench outlets. The two inlet loggers had previously been removed in 2018.

Monitoring at SWM Pond 2 included loggers at the pond outlet. The three inlet loggers had been removed in 2018.

Monitoring at SWM Pond 4 included temperature loggers at three discrete depths within the pond, as well as monitoring at the outlets from the pond and the cooling trench. The inlet logger had previously been removed in 2018.

Originally, all three SWMF included in-pond temperature monitoring, as well as water temperature and/or level loggers at the pond inlet(s), outlet and the cooling trench outlet (where applicable). After five years of thermal data were collected and a preliminary understanding of the overall thermal regime has been established, in-pond loggers were removed from the program for both the Pond 1 and Pond 2 locations.

Table 2: Continuous Pond Monitoring Stations

SWMF	Station	Data Collected	Year Installed	Year Removed	Location
Pond 1	HC-P1(01)	Temperature	2011	2018	In pond; close to bottom
	HC-P1(02)	Temperature	2011	2018	In pond; near mid-depth
	HC-P1(03)	Temperature	2011	2018	In pond; at surface
	HC-P1(04)	Temperature, Depth	2011	2018	Inlet
	HC-P1(05)	Temperature, Depth	2011	2018	Inlet
	HC-P1(06)	Temperature, Depth	2011	-	Pond outlet
	HC-P1(07)	Temperature, Depth	2011	-	Cooling trench outlet
	HC-P1(08)	Temperature, Depth	2011	-	Cooling trench outlet
Pond 2	HC-P2(01)	Temperature	2011	2018	In pond; close to bottom
	HC-P2(02)	Temperature	2011	2018	In pond; near mid-depth
	HC-P2(03)	Temperature	2011	2018	In pond; at surface
	HC-P2(04)	Temperature, Depth	2011	2018	Inlet
	HC-P2(05)	Temperature, Depth	2012	2018	Inlet
	HC-P2(06)	Temperature, Depth	2011	2018	Inlet
	HC-P2(07)	Temperature, Depth	2011	-	Pond outlet
Pond 4	HC-P4(01)	Temperature	2011	-	In pond; close to bottom
	HC-P4(02)	Temperature	2011	-	In pond; near mid-depth
	HC-P4(03)	Temperature	2011	-	In pond; at surface
	HC-P4(04)	Temperature, Depth	2012	2018	Inlet
	HC-P4(05)	Temperature, Depth	2011	-	Pond outlet
	HC-P4(06)	Temperature	2011	-	Cooling trench outlet

2.3 Flow Measurement and Water Quality Sampling

Throughout the 2019 monitoring period, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity) at all in-stream stations.

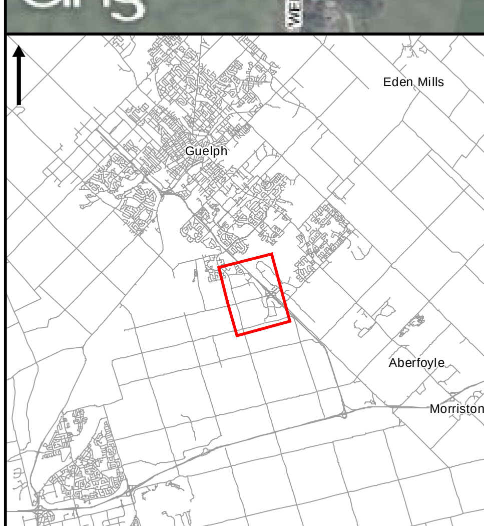
Baseflow measurements were collected at stations HC-A(03), HC-A(04), HC-A(06), HC-A(10), HC-A(11), HC-A(12), HC-A(13) and HC-A(14).

High flow measurements were collected at stations HC-A(03), HC-A(04), HC-A(06), HC-A(10), HC-A(11), HC-A(12), HC-A(13), and HC-A(14) to develop rating curves for each respective location.

Influent and effluent water quality monitoring was completed at the SWM pond inlets and outlets and Tributary A downstream of the SWM ponds. Sampling stations included HC-A(03), HC-A(04), HC-A(12), HC-A(13) and HC-A(14).

2.4 2019 Data Gaps

Despite the delayed start to the 2019 field monitoring season and concerns regarding long-term logger integrity (mainly related to logger age and remaining battery levels and potential vandalism), most loggers continued logging without issue over the 8 months between the end of the 2018 season (December) and commencement of the 2019 season (August). Only two loggers were lost (SR1-1 and HC-P2(07)) due to presumed tampering/vandalism and another site's data was partially lost due to a faulty sensor (HC-P4(01)).



Legend

- Temp
- Temp/Level
- Temp/Level/Water Qaulity
- Temp/Turbidity/Level
- Temp/Turbidity/Level/Water Quality
- Watercourses
- Property
- Ponds
- Access Paths
- Multi-Use Trails
- Cooling Trench
- Wetlands

N

Hanlon Creek Business Park

2019 Surface Water Monitoring Sites

January 2020	1:8,000	Datum: NAD '83 Zone 17 Source: AECOM, GRCA
P#: 60265453	V#: 001	

AECOM

Figure 2.4.1

0 250 500
Meters

3. Precipitation and Creek Flow

3.1 Precipitation

Table 3 provides a comparison of the Canadian Climate Normals and monthly precipitation data over a thirty-year period.

Climate Normals are shown for the Guelph Arboretum station for the period of 1971-2000. More recent data are not available for this station. The second closest station with recent Climate Normals is the Waterloo Wellington Airport, with data for the period of 1981-2010. Monthly precipitation is similar between the two stations over the two separate periods.

Precipitation data from the Hanlon Creek Rain Gauge was first used in 2016; consequently, this was the first year a complete set of data is available for the Hanlon Creek Rain Gauge.

Compared to the Canadian Climate Normals, the Hanlon creek rain gauge recorded high rainfall totals in 2019. A total of 6 months measured precipitation higher than the Canadian Climate monthly Normals. Five of these exceedances occurred over a five-month period, starting with a record high rainfall in February (147.6mm). Lower than average precipitation values were recorded in the latter half of the year, with the exception of an additional high rainfall total in the month of October (153.4mm).

Table 3: Observed Precipitation Trends for 2019 Compared to Canadian Climate Normals (mm)

Station	Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Canadian Climate Normals- Guelph Arboretum	1971-2000	56.4	50.8	72.1	78.3	79.9	76	88.5	95.9	92.1	69.2	86.3	77.7	923.3
Canadian Climate Normals- Waterloo Wellington A	1981-2010	65.2	54.9	61	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.1	71.2	916.5
Elora Research Station (RS)	2008	98.5	57.4	85.5	64.6	86.1	81.6	131.3	120.7	119.3	68.4	103.1	100.4	1116.9
	2009	66.1	82.0	72.7	106.2	79.3	69.2	79.5	92.1	53.7	91.5	37.3	65.8	895.4
	2010	27.2	24.4	41.3	47.5	99.9	184.1	89.4	12.1	117.8	52.6	50.8	21.1	768.2
	2011	47.6	58.2	86.1	100.7	113.3	87.0	31.9	158.6	76.1	128.9	90.5	85.5	1064.4
Guelph Turf Grass Institute (TGI)	2011	20	23.8	89.6	92.8	147.4	100.4	26.8	51.2	71.4	93.4	84.6	59.2	860.6
Elora RS	2012	46.8	32.0	31.0	30.0	28.2	64.6	30.4	62.6	106.2	127.3	40.2	79.9	679.2
Guelph TGI	2012	39.2	17.0	28.4	31.0	32.2	90.0	54.6	98.4	127.0	129.0	11.6	57.8	716.2
Elora RS	2013	80.5	71.2	40.6	123.8	102.0	122.3	130.9	69.5	142.9	133.6	33.7	43.2	1094.2
Guelph TGI	2013	72.4	41.4	25.2	98.6	70.8	82.4	173.6	54.8	79.4	116.4	26.4	44.0	885.8
Elora RS	2014	51.2	58.1	46.7	101.7	54.1	68.8	133.7	51.1	27.9	74.3	63.3	45.8	776.7
U of Waterloo (UoW) Weather Station	2014	74.2	30.7	17.5	90.9	63.6	52.4	165.9	91.5	159.8	79.6	90.6	33.3	950
Elora RS	2015*	77.0	58.2	34.4	77.3	48.0	175.9	66.8	80.6	53.1	111.5	78.2	66.7	927.7
UoW Station	2015	49.6	48.2	23.9	77	61.6	117.9	60	78.2	53.8	109.6	68.2	66.2	814.2
Hanlon Creek Rain Gauge	2016	46.6	67.4	124.6	69.2	104.4	31.6	62	137.6	56.8	50.4	63.6	96	910.2
	2017	126.8	106.8	96.8	145.6	157.2	87.4	43.4	52.2	29.4	89	113.4	61.4	1109
	2018	93	75.2	37	131	150.4	74.8	48.6	99.4	50	111.2	114.8	17.4	1002.8
	2019	36.2	147.6	73.4	112	133.6	84.6	37.8	53.2	54.8	153.4	40.4	51.6	978.6

*Precipitation data gaps for the Elora RCS: Jan 17, Jun 28, Jul 23, Jul 31, Aug 2, Sept 4, Sept 30, Dec 8, Dec 23, Dec 25 – 26, Dec 28 – 29
Precipitation data above and below Climate Normals are shown in blue and red, respectively.

3.2 Continuous Depth and Flow Measurement Results

Depth loggers (model HOBO U20-001-001 Water Level logger) were installed to monitor water levels at HC-A(04), HC-A(10), HC-A(12), HC-A(13) and SR-1(01) throughout 2019. Depth measurements were also collected at telemeterized monitoring stations (Instrumentation Northwest, PS9800), namely the HC-A(03), HC-A(06), HC-A(11) and HC-A(14) sites. However, redundant depth loggers have also been used since 2015 to provide back-up data collection in the event of a faulty sensor.

One baseflow, two dry weather, and two high flow measurements were taken between October 2nd and November 4th, 2019 at each station using a FlowTracker2 Handheld-ADV® (Acoustic Doppler Velocimeter). Prior to 2010, a depth/velocity meter (ISCO 2100) was installed at HC-A(05); however, this method was discontinued as the station was producing unreliable data due to high sedimentation rates. Flow measurement results are shown in **Figure 3.2.1** and **Table 4.** Average flow in the Creek ranges from approximately 4 L/s at the upstream end (station HC-A(03)) to 13-17 L/s downstream of the Pond 4 outlet (station HC-A(04)/(06)). Due to the high rainfall measured in October, relatively high flows were also measured downstream of the wetland complex.

The measured flow values from 2019 and previous years were used to develop stage (level) - discharge relationships (rating curves) for each station as shown in **Appendix A.**

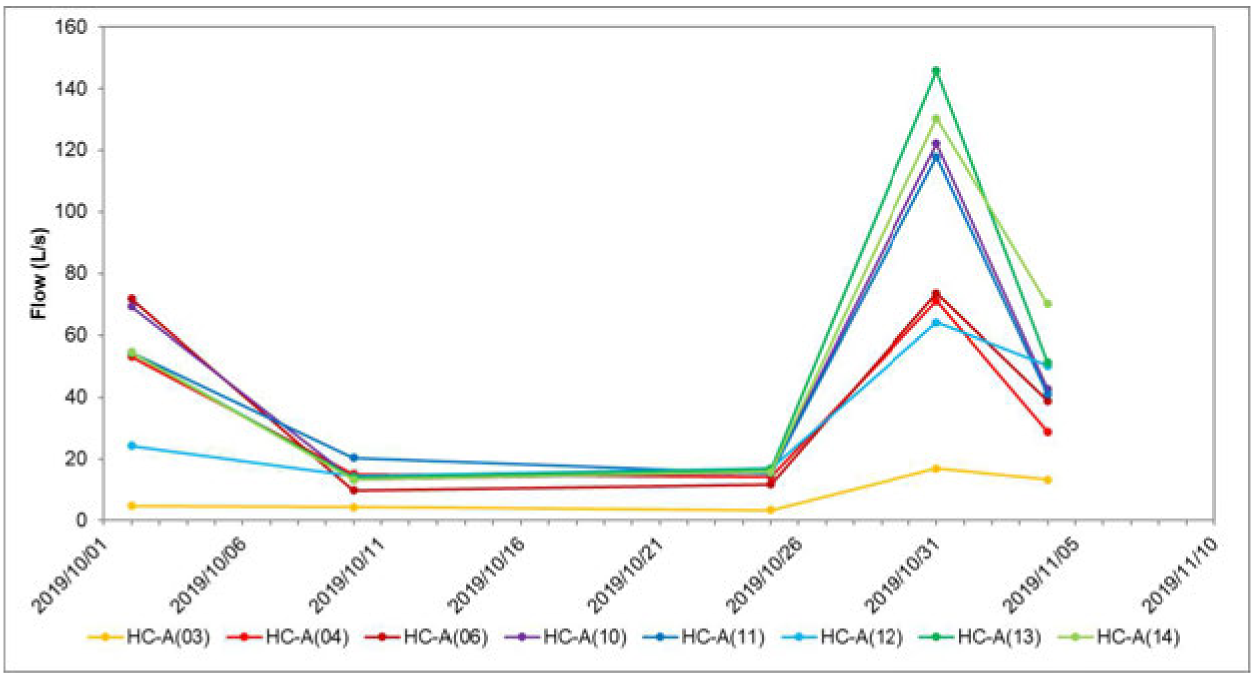


Figure 3.2.1: Hanlon Tributary A Flow Measurements – 2019

Table 4: 2019 Hanlon Creek Flow Monitoring (L/s)

Station	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
2019/10/02	4.8	53.1	71.8	69.3	54.6	24.3	54.4	54.6
2019/10/10	4.4	15.1	9.8	13.2	20.3	14.4	13.9	13.3
2019/10/25	3.4	14.3	11.8	15.5	15.4	16.9	16.7	15.7
2019/10/31	16.9	71.1	73.6	122.2	117.8	64.1	145.8	130.4
2019/11/04	13.2	28.9	38.8	42.8	41.1	50.3	51.3	70.2
Average	8.5	36.5	41.2	52.6	49.8	34.0	56.4	56.8

Average baseflow measurements are shown for the period of 2008 to 2019 in **Figure 3.2.2** and **Table 5.**

With respect to the following graphs and table, one important consideration to note is that, due to the late start to the 2019 monitoring season and coincidental high rainfall totals in the month of October, flow results shown for 2019 are somewhat inflated compared to the averages from previous years, and this is due in part to the smaller observation window. This is particularly evident in the average baseflow measurement summary presented in **Figure 3.2.2** where sites downstream of the wetland complex have average flows which are approximately three times higher than any of the average flows observed during previous years of monitoring.

Baseflow was influenced only in 2011 by construction impacts such as dewatering activities.

Historical and recent baseflow measurements have been used to assess which reaches are losing surface flows (contributing to groundwater) or gaining surface flow (receiving groundwater). The reaches are summarized as follows:

Given that **HC-A(03)** is upstream of the outlet to Pond 4's outlet, baseflows measured at the downstream **HC-A(04)** are indicative of outflow contributions to the Hanlon Creek tributary from Pond 4. Prior to 2013, measured annual baseflows at HC-A(04) measured 450% higher when compared to measured annual baseflows upstream at HC-A(03), primarily due to outflow from Pond 4's outlet. In 2013, retrofits of the Pond 4 outlet were undertaken to reduce the outflow from Pond 4, however, pond discharge was still observed to be nearly continuous, contributing to elevated baseflow levels at HC-A(04) relative to recorded upstream baseflows at station HC-A(03). In 2019, measured baseflows at HC-A(04) averaged an increase of 327% when compared to upstream measurements at HC-A(03). A low of 119% was measured on November 4th and a high of 1006% measured on October 2nd.

From station HC-A(04) to HC-A(06) baseflow increased slightly (except during the month of October, which followed a period of low precipitation during the month of September prior). The annual average increase in baseflow is estimated to be 13% for the 2019 period.

The reach between **HC-A(09) and HC-A(10)** receives input from a small groundwater-fed tributary in the cedar swamp which contributes baseflow between **HC-A(06) and HC-A(10)**. In 2019, average baseflows at **HC-A(10)** measured 28% higher than those measured at **HC-A(06)** due to the aforementioned groundwater recharge.

Stations **HC-A(10) and HC-A(11)** have historically been understood to be groundwater discharge areas and this appeared to remain the case in 2019.

With respect to **HC-A(12)** specifically, it is noted that, during high flow events, the stream banks are regularly overtopped, and flows spill into the surrounding low-lying wetland. This causes flow contributions to be underestimated in some instances relative to sites **HC-A(11)** and **HC-A(13)**.

HC-A(12), HC-A(13) and **HC-A(14)** were all identified to be areas of groundwater recharge/infiltrating reaches in 2019, and this is generally consistent with observations made throughout the duration of monitoring at these locations. The annual average increase in runoff between **HC-A(13)** and **HC-A(14)** was estimated to be approximately 1% for the 2019 period.

Error! Reference source not found. provides a summary of flows estimated using the recorded water level and rating curves for stations **HC-A(03)**, **HC-A(04)**, **HC-A(06)**, **HC-A(10)**, **HC-A(11)**, **HC-A(12)**, **HC-A(13)** and **HC-A(14)** as well as recorded precipitation from the Hanlon Creek rain gauge station. The figure illustrates that flows generally increase from upstream to downstream stations.

Error! Reference source not found. illustrates that, due to the extreme precipitation events in February, May, and October of 2019, recorded water levels at sites **HC-A(13)** and **HC-A(14)** exceeded the maximum range of water levels used for each sites' corresponding rating curve. Given that flow monitoring commences in May of each year, spring freshet high flows are often missed and, therefore, each site's rating curves cannot accurately model for these largest events. As such, flows are expected to be overestimated during these periods as the historic rating curves did not extend to include the depths measured on these dates.

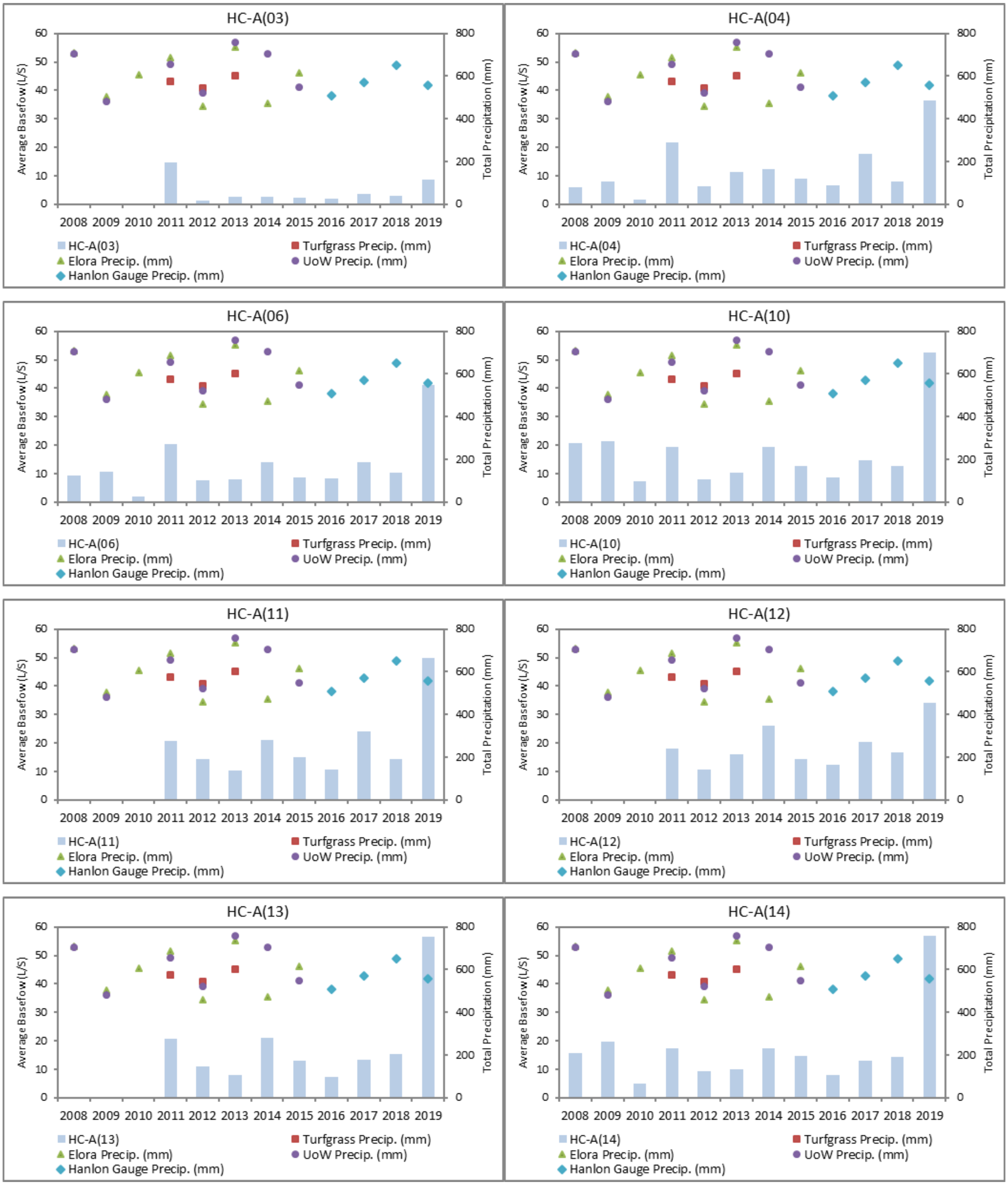


Figure 3.2.2: Average Annual Baseflow and May-November Precipitation from 2008 to 2019

Table 5: Hanlon Creek Baseflow Monitoring – 2008-2019 Summary (L/s)

Station	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
2008 Min	n/a	3.5	2.7	2.1	3.8	7.7	n/a	n/a	n/a	0.9
2009 Min	n/a	3.9	1.2	3.0	4.2	5.0	n/a	n/a	n/a	1.8
2010 Min	n/a	0.4	0.4	-7.3	1.1	0.8	n/a	n/a	n/a	0.9
2011 Min[2]	2.8	5.5	0.8	1.5	n/a	2.4	4.6	5.0	2.8	1.5
2012 Min	0.1	3.2	3.1	0.5	n/a	1.3	0.7	1.7[1]	0.6[1]	0.7[1]
2013 Min	1.2	8.2	5.5	n/a	n/a	6.4	2.7	12.5	3.4	3.4
2014 Min	1.6	9.5	10.1	n/a	n/a	10.8	14.8	15.7	12.7	9.3
2015 Min	1.4	4.1	4.2	n/a	n/a	7.0	9.5	6.8	8.1	5.6
2016 Min	0.6	2.8	3.4	n/a	n/a	3.7	4.7	2.8	1.6	1.3
2017 Min	2.0	6.0	7.0	n/a	n/a	9.7	10.5	9.5	6.0	7.0
2018 Min	0.6	3.2	3.7	n/a	n/a	5.1	4.4	5.1	3	3.6
2019 Min	3.4	14.3	9.8	n/a	n/a	13.2	15.4	14.4	13.9	13.3
2008 Max	n/a	11.3	10.7	10.0	9.4	16.8	n/a	n/a	n/a	12.1
2009 Max	n/a	14.9	25.6	22.1	18.7	56.3	n/a	n/a	n/a	53.8
2010 Max	n/a	2.9	4.9	12.3	6.7	22.2	n/a	n/a	n/a	1.2
2011 Max[2]	47.4	56.6	50.0	5.9	n/a	31.5	46.0	31.9	18.2	48.0
2012 Max	2.5	10.5	14.6	7.4	n/a	13.2	45.6	17.6	36.6	20.7
2013 Max	4.4	16.8	10.3	n/a	n/a	16.9	16.0	21.7	15.8	15.7
2014 Max	3.6	15.4	16.9	n/a	n/a	27.7	27.3	33.1	30.0	28.2
2015 Max	4.2	11.9	11.9	n/a	n/a	17.4	18.9	18.6	17.2	19.7
2016 Max	3.1	13.3	15.7	n/a	n/a	16.4	24.6	35.8	14.7	16.1
2017 Max	6.5	36.8	21.9	n/a	n/a	21.9	46.1	39.3	20.9	19.9
2018 Max	7	15.9	19	n/a	n/a	26.3	31.1	34.5	37.4	34.6
2019 Max	16.9	71.1	73.6	n/a	n/a	122.2	117.8	64.1	145.8	130.4
2008 Average	n/a	6.0	9.3	9.0	8.5	20.5	n/a	n/a	n/a	15.8
2009 Average	n/a	7.8	10.7	9.3	10.6	21.3	n/a	n/a	n/a	19.7
2010 Average	n/a	1.6	2.0	2.4	3.6	7.1	n/a	n/a	n/a	5.0
2011 Average[2]	14.6	21.7	20.2	2.7	n/a	19.3	20.6	18.0	20.5	17.2
2012 Average	1.1	6.1	7.5	3.1	n/a	8.0	14.4	10.6	10.9	9.1
2013 Average	2.7	11.2	7.9	n/a	n/a	10.4	10.4	16.1	8.0	9.9
2014 Average	2.6	12.3	14.0	n/a	n/a	19.3	21.1	26.1	21.0	17.2
2015 Average	2.2	9.0	8.7	n/a	n/a	12.6	14.9	14.4	12.9	14.5
2016 Average	1.8	6.5	8.2	n/a	n/a	8.7	10.7	12.2	7.4	8.0
2017 Average	3.7	17.5	13.9	n/a	n/a	14.7	24.0	20.3	13.2	13.1
2018 Average	2.9	7.8	10.3	n/a	n/a	12.7	14.1	16.5	15.3	14.3
2019 Average	8.5	36.5	41.2	n/a	n/a	52.6	49.8	34.0	56.4	56.8

Notes:
[1] Hanlon Creek was noted to be dry or flows were below the measurement threshold flow at stations HC-A(03), HC-A(12), HC-A(13) and HC-A(14)
[2] Baseflows were influenced by construction activities

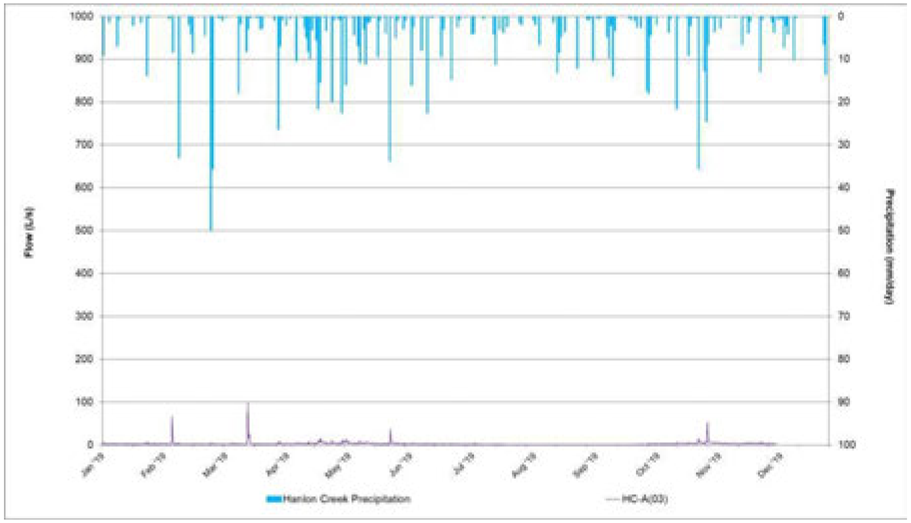


Figure 3.2.3: 2019 Flow Monitoring for HC-A(03)

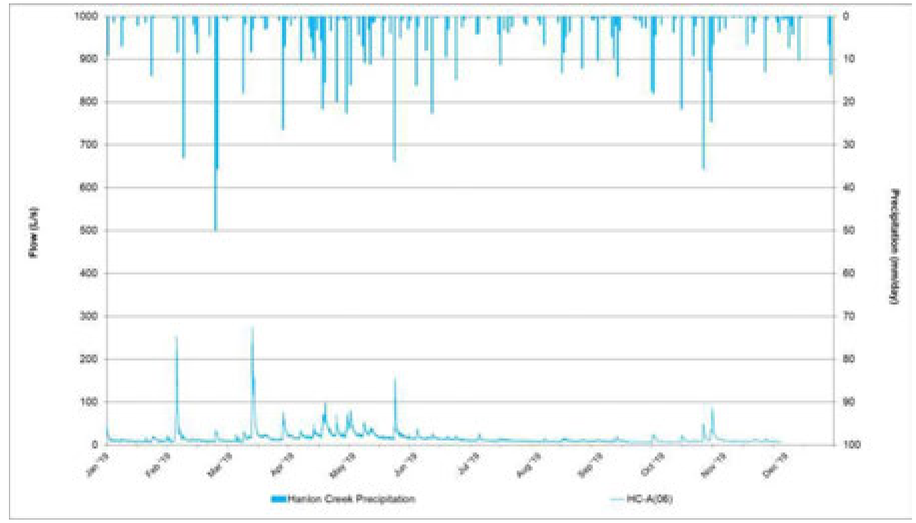


Figure 3.2.5: 2019 Flow Monitoring for HC-A(06)

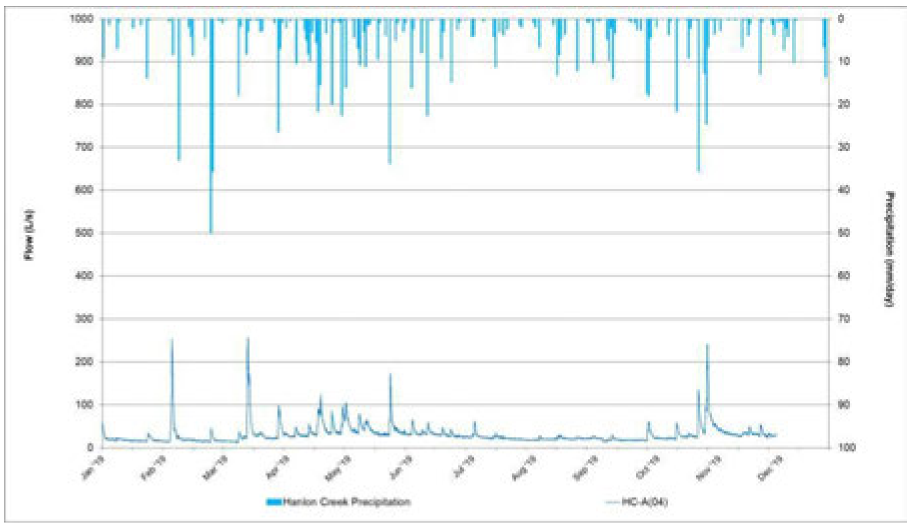


Figure 3.2.4: 2019 Flow Monitoring for HC-A(04)

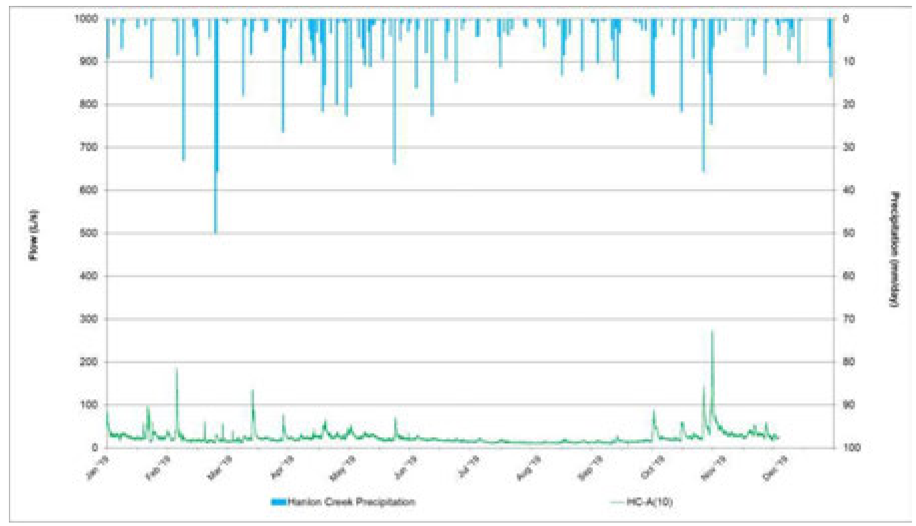


Figure 3.2.6: 2019 Flow Monitoring for HC-A(10)

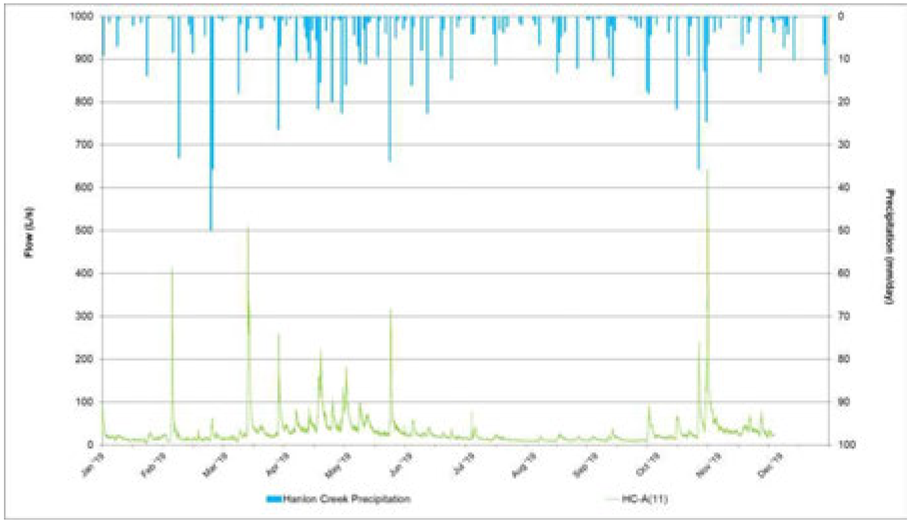


Figure 3.2.7: 2019 Flow Monitoring for HC-A(11)

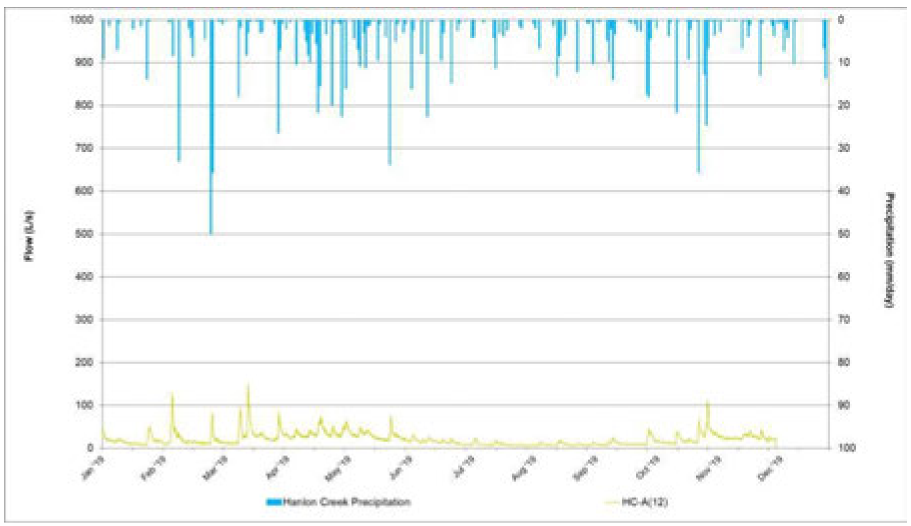


Figure 3.2.8: 2019 Flow Monitoring for HC-A(12)

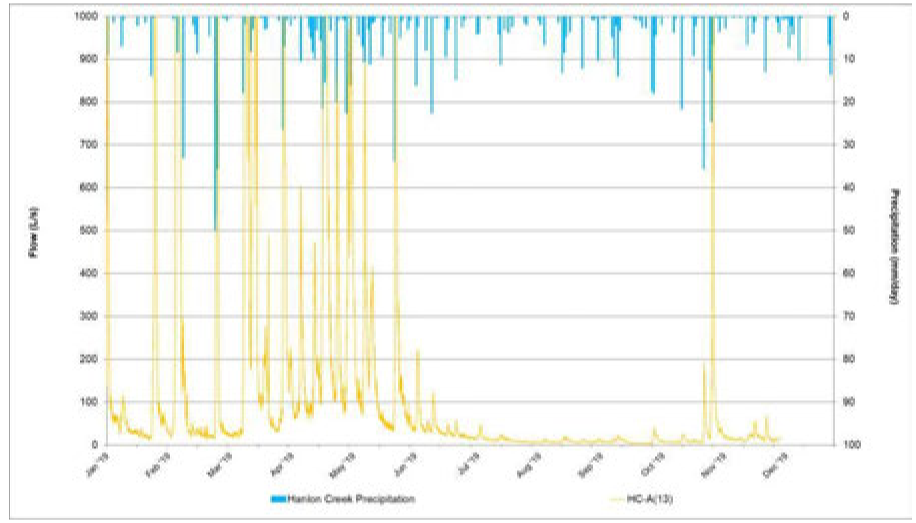


Figure 3.2.9: 2019 Flow Monitoring for HC-A(13)

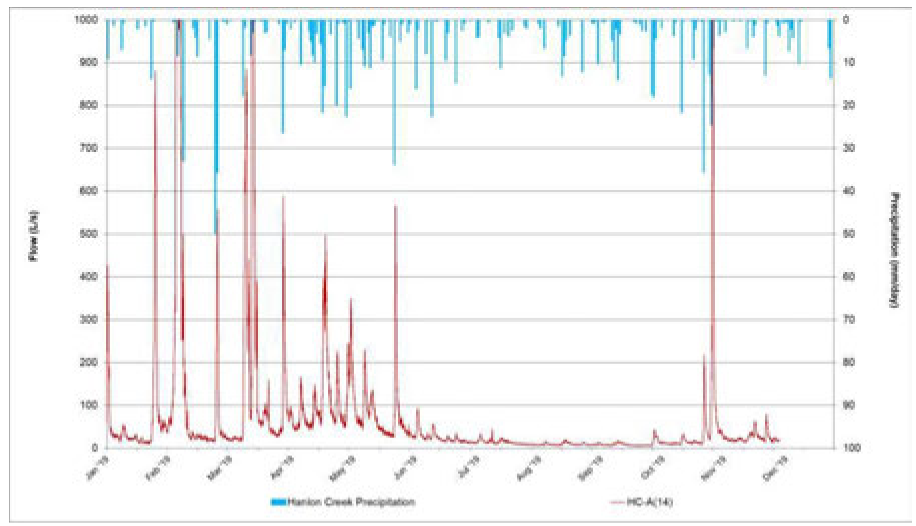


Figure 3.2.10: 2019 Flow Monitoring for HC-A(14)

4. In-Stream Temperature Monitoring

The locations of the temperature monitoring stations for 2019 are shown in **Figure 2.4.1** and station descriptions are included in **Section 2**. The temperature loggers (HOBO Pendant Temperature/Light Logger and HOBO 64-bit Temperature Smart Sensors) and level/temperature loggers (HOBO U20 Water Level Data Logger) were placed in the creek and secured to steel stakes driven into the native substrate. Data were collected in 30-minute intervals during the winter months and at 15-minute intervals for the remainder of the year.

4.1 In-Stream Thermal Conditions

A plot of the continuous temperature monitoring throughout the period of monitoring in 2019 is included in **Figure 4.1.1** and a summary depiction of conditions observed during the summer months is shown in **Figure 4.1.2**. Daily average temperature ranges are summarized in **Table 6**.

Monthly plots of stream temperature and hourly air temperature as recorded at the Guelph Turfgrass Institute Station are included in **Appendix D**. this plot provides a clear comparison between thermal conditions observed at each station. These plots show the daily diurnal pattern of temperature variation, with temperatures increasing during the day and decreasing at night.

Temperature data during the winter months (January to March) appears to have been at or around freezing (0°C) for most of the winter indicating that a large portion of Tributary A periodically experienced frozen conditions. Most stations on Tributary A consistently exhibited temperatures above 0°, even during periods of sub-0° air temperature. This strongly suggests that these stations are likely most impacted by groundwater inputs.

During the 2019 monitoring period, station HC-A(03) exhibited higher daily fluctuations in temperatures compared to the downstream station of HC-A(06). In-stream thermal conditions between these two stations (specifically sites HC-A(04), HC-A(04A), and HC-A(04B)) are clearly impacted by the continuous discharge from Pond 4 as far less pronounced temperature fluctuations were observed in addition to higher overall temperatures on average compared to HC-A(03). In fact, temperature readings at HC-A(03) closely match readings at HC-A(08), a site that is located offline of the main Hanlon Creek system and, as a result, is upstream and independent of any outflows from the Hanlon Business Park SWM facilities. HC-A(03) is also upstream of the initial outflow from the Business Park's most upstream facility which explains the similarities of these two site's thermal conditions.

General trends in the in-stream thermal monitoring data indicates that the discharge from Pond 4 impacts thermal conditions in the stream from downstream of the pond outlet to station HC-A(09). Downstream of this station, the cool groundwater-fed tributary and the elimination of online ponding downstream of Hanlon Creek Boulevard provide for slight improvements. Further downstream, the open, unshielded nature of the creek and its exposure to insolation have resulted in little variation to in-stream thermal conditions observed since monitoring has begun.

Downstream stations ((HC-A(10), HC-A(12), HC-A(13) and HC-A(14))) which are more exposed and those stations with a wider flow channel and relatively shallow flow depth (e.g. HC-A(09)) are the stations which exhibited the highest daily variation in surface water temperature. This is to be expected, since these stations are located in areas where there is greater opportunity for solar radiation to be absorbed by the open channel flows. Diurnal temperature variations are further exacerbated by the fact that there is little indication of groundwater inputs at these locations.

A comparison between the number of 24°C exceedance events per monitoring site to the average summer temperatures for 2019 has been provided in **Figure 4.1.3**. A comparison between the recorded number of hours with in-stream temperatures exceeding 22 °C and 19°C to the average summer temperatures at each site are shown in **Figure 4.1.4** and **Figure 4.1.5**, respectively. The number of 24°C exceedances are notably reduced in 2019 compared to previous years, and the figures illustrate that only site HC-A(09) had any exceedances which lasted more than 5 hours above the threshold (at 51 hours).

Notably, sites surrounding the Laird Road crossing (including the newly added sites of HC-A(04A) and HC-A(04B)) had the highest number of exceedances above 19°C; HC-A(04), HC-A(04A), HC-A(04B), and

HC-A(06) exceeded 19°C for 973, 1242.5, 1079.5, and 1097.5 total hours, respectively. Additionally, HC-A(03) and HC-A(08), both of which are upstream of the Hanlon SWMPs, had zero exceedances in 2019.

Information regarding SWM ponds and their observed thermal conditions are included in **Section 6.2**.

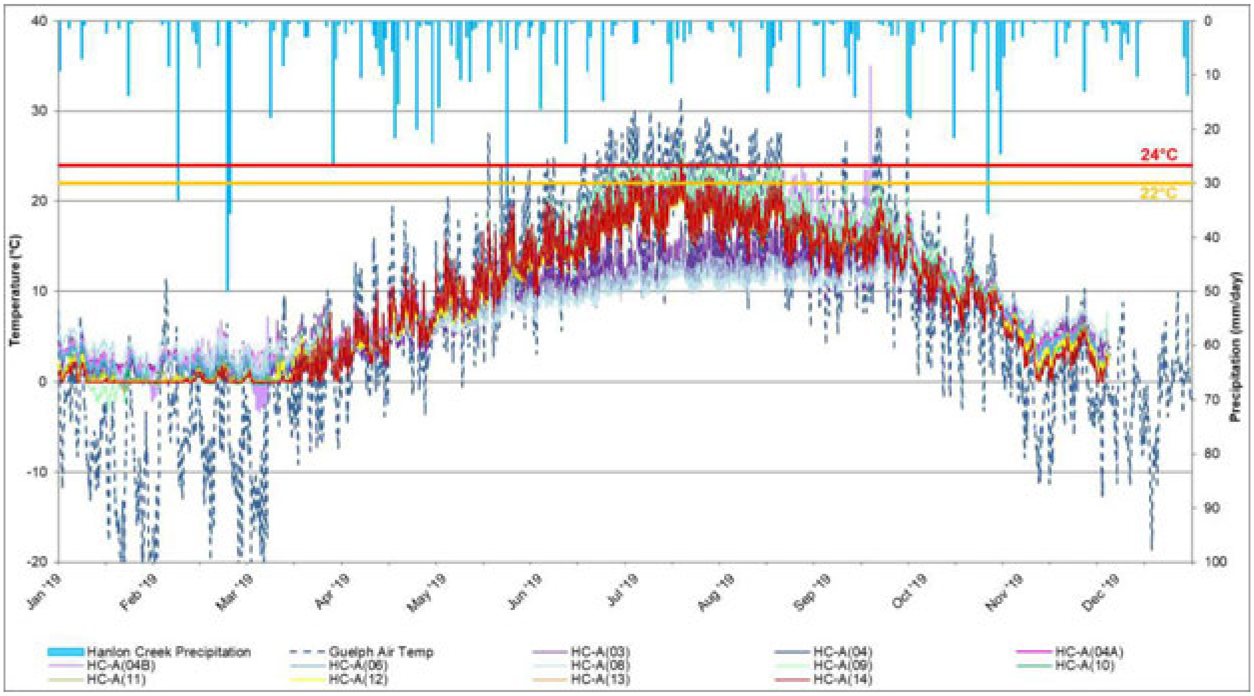


Figure 4.1.1: Hanlon Creek Temperature Monitoring in 2019

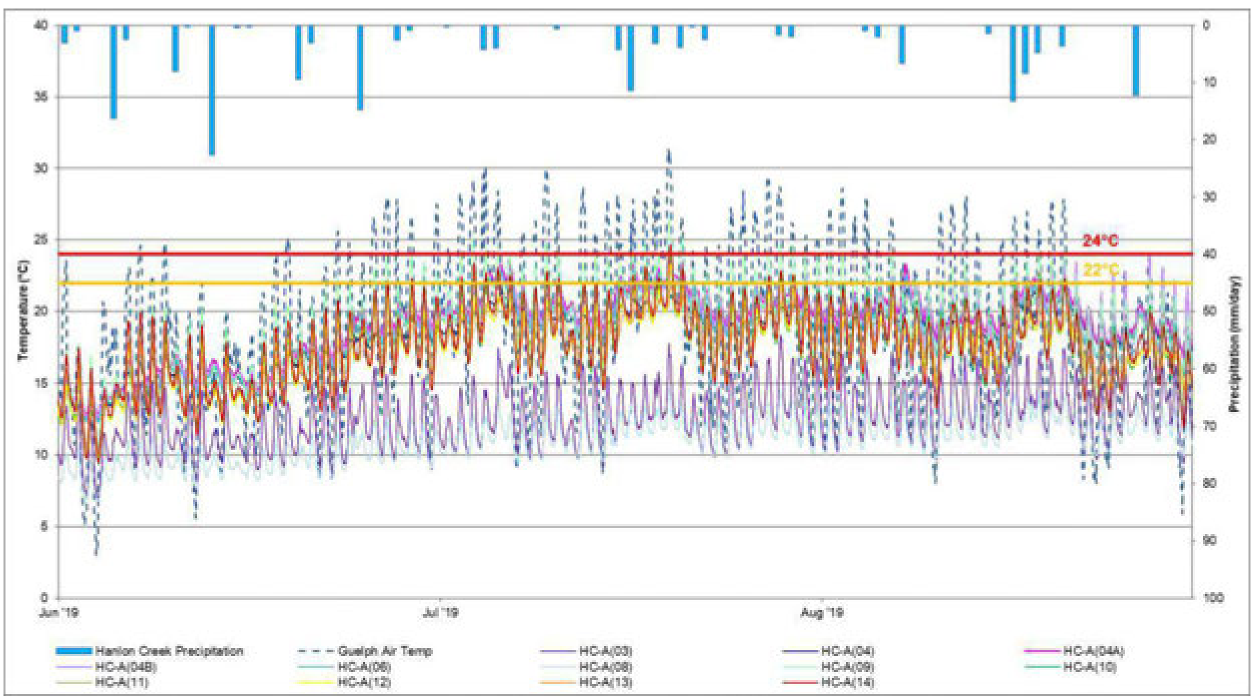


Figure 4.1.2: Hanlon Creek Temperature Monitoring – June-September 2019

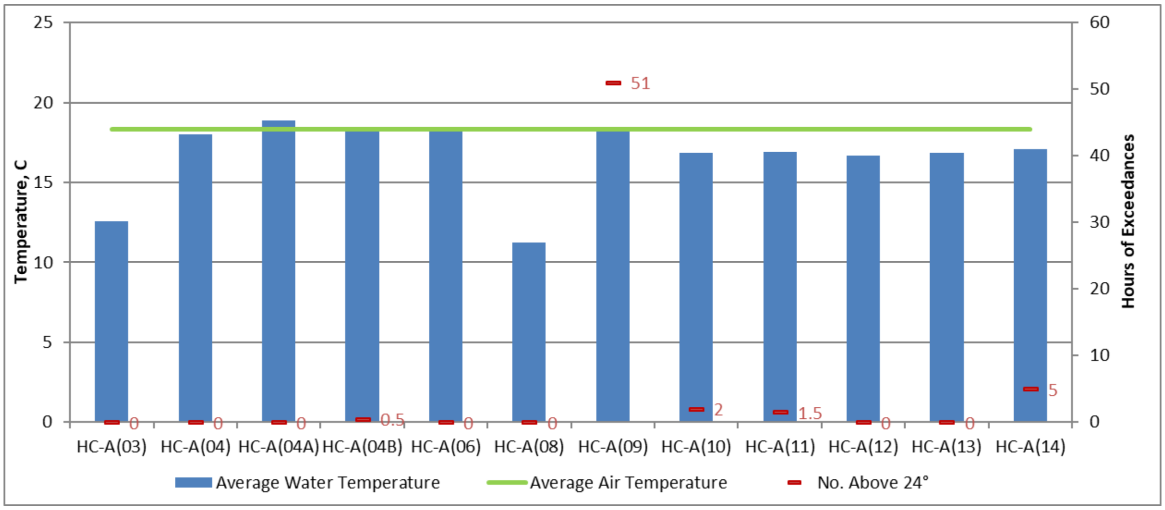


Figure 4.1.3: Number of Hours Stream Temperature Exceeded 24°C in the Summer of 2019

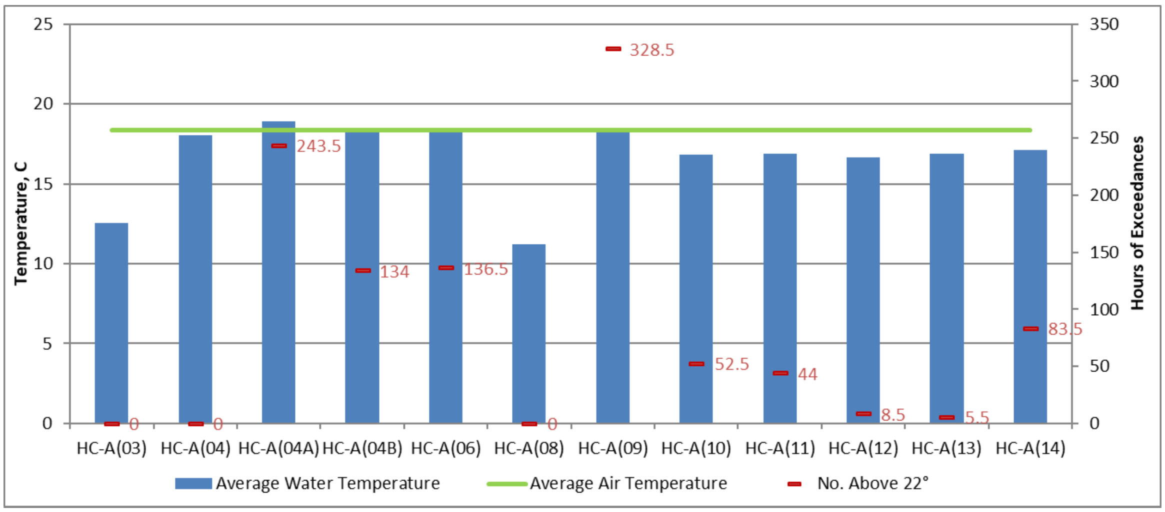


Figure 4.1.4: Number of Hours Stream Temperature Exceeded 22°C in the Summer of 2019

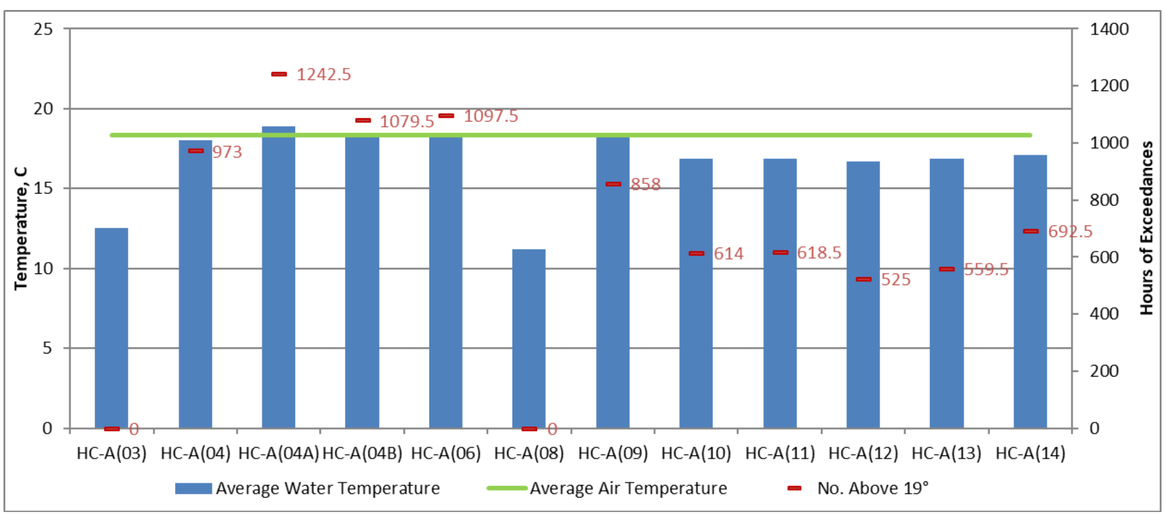


Figure 4.1.5: Number of Hours Stream Temperature Exceeded 19°C in the Summer of 2019

4.2 In-stream Thermal Conditions and Predictive Thermal Modeling Comparison

The ability of a stream to support a cold-water fish species is often best characterized by the summer (July and August) and autumn (mid-October – end of November) temperature regime. The 2009 Hanlon Business Park Stream Temperature Impact Report (AECOM, 2009) provided a summary of the reach-based statistical stream temperature modeling results for future mitigated site conditions. This summary included targets for daily averages, maximums, minimums, the number of hours target temperatures are exceeded, and exceedance frequencies during both the summer and autumn seasons.

The Hanlon Creek Business Park Consolidated Monitoring Plan recommends:

- Any single temperature exceedance of 22°C is analyzed in an annual temperature and flow monitoring report, including an investigation of the cause of the exceedance and recommendations for contingency measures as warranted. The investigation should consider the frequency, duration and spatial distribution of the exceedance.
- Any single temperature exceedance of 24°C triggers an investigation commencing within 2 days of acquiring the information. This investigation should consider the frequency, duration and spatial distribution of the exceedance, seek to identify the cause of the temperature exceedance, and provide recommendations for adaptive management measures as warranted. If contingency measures are warranted, the design and implementation of selected measures should be completed as soon as possible. At the latest, the selected measures should be implemented in the year following the 24°C exceedance.

A summary comparison of overall modeled existing and future mitigated conditions of average temperature conditions throughout the creek were included in the modeling report. The same statistical analysis applied to the modeling results has been applied to the 2019 data and is included in **Table 6** and **Table 7** where sufficient data are available. To monitor the changes to Hanlon Creek over time, a comparison of 2018 data to historical conditions has been included in **Appendix C**. **Table 8** includes a comparison of monthly ambient air temperatures and Canadian Climate Normals.

Average in-stream summer temperatures (17.45°C) deceased in 2019 by 0.67°C from the 18.12°C recorded in 2018. An overall decrease in in-stream temperatures are largely a result of an overall drop in ambient temperatures in 2019 compared to the year prior, where average daily maximums exceeded climate Normals for the entire summer period, as shown in **Table 8**.

Further discussion regarding the historical significance and aforementioned temperature trend exceedances is provided in Sections **4.3** and **4.4**.

Table 6: Temperature Summary for 2019 Summer (July-August)

Temperature Parameter	Modeled Values[1]	Station ID											
		HC-A(03)	HC-A(04)	HC-A(04A)	HC-A(04B)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
Summer (July-August) average maximum (ºC)	14.5 - 19.9	18.3	21.6	23.6	23.9	23.6	14.7	26.7	24.4	24.2	23.3	22.2	24.6
Summer (July-August) average (ºC)	12.5 - 14.5	13.1	19.4	20.6	19.8	20.1	11.7	20.2	18.4	18.4	18.2	18.4	18.6
Summer (July-August) average minimum (ºC)	9.0 - 12.0	9.0	16.9	16.8	12.9	15.7	9.1	13.5	12.3	12.6	14.6	13.9	11.9
Maximum 3-day mean (ºC)	14.0 - 19.0	14.3	20.9	22.5	21.9	22.2	12.8	22.8	20.9	20.9	20.7	20.7	21.4
Maximum 7-day mean (ºC)	13.0 - 17.0	14.0	20.4	22.1	21.6	21.8	12.5	22.1	20.3	20.3	20.0	20.0	20.7
Maximum 7-day mean of daily maximums (ºC)	15.0 - 23.5	17.0	21.0	22.9	22.6	22.7	13.9	24.5	22.6	22.5	21.5	21.0	22.7
Temperature Exceedance over 19°C for July and August													
Hours over 19°C	0 - 130	0	957	1320	1066	1133	0	1007	611	605	497	544	675
Percent of Time over 19°C	0 - 9%	0%	64%	89%	72%	76%	0%	68%	41%	41%	33%	37%	45%
Frequency of Exceedance over 19°C (Days)	0 - 27	0	41	57	45	51	0	50	19	19	15	17	22
Average Duration of Event Over 19°C (h)	3 - 6	0.0	53.1	94.3	71.1	55.5	0.0	30.8	21.3	21.4	24.6	26.4	21.7
Maximum duration of event over 19ºC (h)	<<130	0.0	191.0	284.5	281.0	208.5	0.0	163.5	133.0	132.5	132.5	138.0	133.5
Temperature Exceedance over 22°C for July and August													
Hours over 22°C		0	0	244	130	137	0	351	55	46	9	6	85
Percent of Time over 22°C		0%	0%	16%	9%	9%	0%	24%	4%	3%	1%	0%	6%
Frequency of Exceedance over 22°C (Days)		0	0	8	3	4	0	6	0	0	0	0	1
Average Duration of Event Over 22°C (h)		0.0	0.0	12.7	3.9	5.1	0.0	4.7	2.5	2.5	4.5	3.0	3.1
Maximum duration of event over 22ºC (h)	<<130	0.0	0.0	60.5	16.5	18.0	0.0	18.5	9.0	8.5	8.5	5.5	11.5
Temperature Exceedance over 24°C for July and August													
Hours over 24°C	0 -3.2	0	0	0	0	0	0	51	2	2	0	0	5
Percent of Time over 24°C	0 - 0.21%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%
Frequency of 24°C Exceedance (Days)		0	0	0	0	0	0	0	0	0	0	0	0
Average Duration of Event Over 24°C (h)		0.0	0.0	0.0	0.0	0.0	0.0	2.2	2.0	1.5	0.0	0.0	5.0
Maximum duration of event over 24ºC (h)	<3.2	0.0	0.0	0.0	0.0	0.0	0.0	9.0	2.0	1.5	0.0	0.0	5.0

1 Modeled range refers to the results of the Hanlon Creek Business Park Stream Temperate Impact Report Continuous Modeling with HSP-F (AECOM, 2009)

Table 7: Temperature Summary for 2018 Fall (October-November)

Station	Modeled Values[1]	HC-A(03)	HC-A(04)	HC-A(04A)	HC-A(04B)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
Max Temp. (°C)	11.9 - 13.0	18.3	17.7	18.1	17.9	18.4	16.0	21.0	18.8	18.6	17.4	17.8	0.0
Frequency of 11°C Exceedance (days)	2.1 - 5.6	5	18	20	17	19	7	13	11	12	11	9	9
Hours Over 11°C	16 – 27	169	443	461	434	870	175	313	252	267	249	244	245
Average Hrs. Over 11°C per Event	4.8 - 5.9	11.5	137.5	131.2	136.1	215.1	13.6	29.6	25.9	27.9	30.3	27.5	26.1
Maximum duration of event over 11°C (h)	5.9	50.0	342.5	340.0	338.0	592.5	54.5	96.5	94.0	95.0	97.0	96.5	94.5

Table 8: Comparison of Monthly Ambient Air Temperatures to the Canadian Climate Normals

Year	Daily Average (°C)					Average Daily Maximum (°C)					Average Daily Minimum (°C)				
	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep
Climate Normals - Guelph Arboretum [1]	12.3	16.9	19.7	18.6	14.1	18.6	23.3	25.9	24.5	19.8	6.0	10.6	13.5	12.6	8.4
Climate Normals - Waterloo Wellington A[2]	12.5	17.6	20.0	18.9	14.5	18.5	23.6	26.0	24.8	20.4	6.4	11.5	14.0	12.9	8.6
2007	12.7	18.3	18.5	19.3	15.8	20.5	25.9	26.0	26.5	23.7	4.9	10.6	10.9	12.1	7.8
2008	10.1	17.9	19.7	17.5	14.9	16.3	23.3	25.7	23.7	21.1	3.9	12.5	13.6	11.2	8.7
2009	11.2	15.9	16.5	17.4	13.5	18	21.7	22.1	23.7	20	4.2	10	10.8	11	7
2010	n/a	n/a	20.3	19.8	14.1	n/a	n/a	26.4	26.1	19.6	n/a	n/a	14.2	13.3	8.5
2011	12.7	16.7	21.4	19.3	15.2	17.7	22.7	28.6	25.8	20.9	7.8	10.6	14.1	12.6	9.6
2012	15.2	18.6	22	19.3	14.4	22.8	25.2	30.1	26.6	21.1	7.5	12	13.9	11.9	7.6
2013	13.5	16.9	19.9	18	13.7	20.4	22.3	25.3	24.5	20.2	6.2	11.4	14.5	11.4	7.1
2014	12.3	17.8	17.6	17.6	14.1	18.5	24.6	23.6	23.6	20.5	5.9	10.9	11.5	11.4	7.7
2015	15.1	16.0	18.7	18.0	17.0	22.7	22.0	25.6	23.7	23.7	7.3	9.8	11.7	12.2	10.3
2016	12.3	16.9	20.6	20.8	16.2	19.5	24.8	27.7	27.6	23.2	5.2	9.1	13.4	14.1	9.2
2017	10.1	17.4	19.1	17.3	16.3	15.1	23.2	25.2	23.8	24.2	5.2	11.5	13.0	10.7	8.4
2018	13.8	17.3	20.4	20.7	16.8	21.5	23.8	27.4	26.6	22.6	6.5	10.9	13.4	14.8	11.1
2019	11.2	17.1	21.4	18.9	15.8	16.5	22.2	27.1	24.6	21.0	5.3	11.1	14.9	12.4	9.5

[1] Canadian Climate Normals for the Guelph Arboretum are for the period of 1971-2000. Data for the Waterloo Wellington Airport stations are for 1981-2010.
2007 to 2019 data was collected at the Guelph Turfgrass station
Temperatures highlighted in blue represent temperatures lower than Climate Normals and temperatures highlighted in red represents temperatures higher than the Climate Normals.

4.3 Summary of Historical Thermal Exceedances

A summary of stream thermal exceedances over the years is provided in this section. Trends (if any) are discussed in general terms. Statistical analysis of trend will be possible as more data are collected.

2009-2010: A single occurrence of 22°C was recorded at station HC-A(14) in 2009, with no exceedances of 24°C in 2010.

In 2011, exceedances above 24°C were observed, with eight of ten stations experiencing temperature exceedances.

The 2012 summer recorded the highest number of exceedances to date within the main branch of Hanlon Creek. It was noted that, unlike previous years, the 24°C threshold was exceeded in the headwater reaches of the creek, downstream of Pond 4 as opposed to the exceedances occurring in the furthest downstream reaches. These issues were noted in July of 2012 and the RAAP team was assembled to investigate the cause of the exceedances. It was determined that the cause of the temperature exceedances was the continuous discharge of Pond 4. Mitigation measures were put into place with a goal to decrease the quantity and temperature of water entering Tributary A via Pond 4. The weir in Pond 4 was raised during the summer in attempt to decrease continuous outflow from the SWMF into Tributary A. Vegetation along the cooling trench was installed during the fall 2012 with hopes it would act as a cooling agent once it became established.

In 2013, water temperature exceedances decreased relative to 2012; however, temperatures were still above the ideal habitat conditions documented for brook trout in the Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F (AECOM, 2009). The greatest contributor to stream temperature increases was the continuous discharge of warm water into the headwater of the creek from Pond 4. An exceedance of 24ºC at station HC-A(14) led to a RAAP meeting being called. It was determined that cooling trench discharge from Pond 1 combined with high air temperatures could have factored into the exceedance. Further monitoring of cooling trench temperatures was suggested in order to determine the true effectiveness of the Pond 1 cooling trenches.

In 2014, annual climate conditions were cooler than in 2013 and slightly below the long-term Canadian Climate Normals. Higher than average precipitation levels were recorded in 2014 compared to both 2013 and the Canadian Climate Normals. As a result, fewer exceedance events occurred in 2014. Temperatures remained higher at stations found farthest downstream while the trend of increasing temperatures at reaches downstream of Pond 4, observed in 2012, continued.

Higher average air temperatures during the summer months and lower precipitation levels compared to 2014 were observed in 2015. The combination of higher air temperatures and lower precipitation levels led to higher in-stream temperatures and an increase in the number of temperature exceedances in 2015. Even though average air temperatures were still below the Canadian Climate Normals as shown in **Table 8**, station's HC-A(06), HC-A(09) and HC-A(14) recorded in stream temperatures higher than 24ºC. A RAAP meeting was called in late July of 2015 to discuss the temperature exceedances recorded at HC-A(06). It was found that the temperature exceedance was not a direct result of Pond 4's continuous discharge as an increase in stream temperature between HC-A(04) and HC-A(06) was observed. It was suggested that a cut-off drain be installed along the south side of Pond 4 to intercept groundwater prior to entering the pond and discharge the groundwater directly to Tributary A. It was noted that this retrofit may not directly address the 24°C exceedance; however, it would help to decrease overall temperatures in Tributary A. Alternatively, it was discussed that temperature monitors be placed between the two stations to determine whether the cause of the temperature discrepancy was the result of groundwater discharge or exposure to solar radiation.

In 2016, higher average air temperatures during the summer months and low precipitation levels in June and July compared to the Canadian Climate Normals were observed. Precipitation levels for 2016 compared to previous years and the Canadian Climate Normals are provided in **Table 3**. The combination of higher air temperatures and lower precipitation levels led to higher in-stream temperatures and an increase in the number of temperature exceedances in 2016. Recorded average daily mean temperatures and recorded average daily maximum temperatures provided in **Table 8** were either at or above the Canadian climate normal for the months of June, July and August. Stations HC-A(04), HC-A(04A), HC-A(04B), HC-A(06), HC-A(09), HC-A(10), HC-A(11), HC-A(13), and HC-A(14) recorded in stream temperatures higher than 24ºC.

Following a notably cool May, **Table 8** shows that the summer of 2017 remained relatively cool compared to the previous year. Given the lower average temperatures for most of the summer, no exceedances of 24ºC were recorded for any sites except for a small blip at HC-A(09) which was likely a result of its shallower profile and exposure to air. **Table 3** shows that following record rainfall totals in March, April, and May, rainfall totals dropped significantly in the summer months and included only 8.4mm total rainfall in the month of June (compared to the Canadian Climate Normal of 76mm for that same period).

Considering the lower ambient and in-stream temperatures, no RAAP meetings were called in 2017 beyond a response triggered by a false alarm caused by a faulty telemetry station temperature sensor at site HC-A(11). With the change of practice in 2015 to include back-up temperature or temperature/depth loggers installed at each telemetry site, the sensor was quickly identified as providing false measurements and was replaced without any loss of data.

HOBO loggers at stations HC-A(09), HC-A(13) and HC-A(14) recorded 106, 17 and 61 hours of total exceedance time in the summer of 2018, respectively. During the summer period, telemetry stations HC-A(03), HC-A(06) and HC-A(11), recorded zero, one and eight hours of exceedance, respectively. Station HC-A(03) had four hours of exceedance in May, and the follow-up investigations concluded that this was due to very low water levels (<1 cm) within the channel, and hence the readings were due to the exposure of loggers to the ambient air. The exceedances at stations HC-A(06) and HC-A(11) occurred on August 7th and July 1st, respectively. A notification was received for station HC-A(06), but a RAAP call was not set up. No notification was received for the exceedance at station HC-A(11).

Due to the late installation of the telemetry stations in 2019, AECOM had no access to real-time alerts of temperature exceedances at any of the sites at Hanlon Creek. Despite, only 4 sites saw relatively minor exceedances in 2019. Specifically, sites HC-A(09), HC-A(10), HC-A(11), and HC-A(14) all saw exceedance on the same day on July 20th, 2019. The exceedance initially began at site HC-A(09) due to it's shallow, slow flowing water column, and lasted approximately 9 hours. Temperatures cooled at the sites downstream of HC-A(09) as the water flowed into the wetland complex. Temperatures at HC-A(14) began around the same time, lasting for 5 hours, due to the minimal creek shading between sites HC-A(13) and HC-A(14). Several additional, much smaller exceedances were recorded at site HC-A(09), starting in later June and ending in early August.

Appendix C includes a comparison of historical conditions at each station. This summary shows that overall stations HC-A(09), HC-A(06) HC-A(04B), and HC-A(04A) have experienced and increased number of hours above 22°C since the construction of Pond 4 and HC-A(09) has also experienced an increased number of hours above 24°C.

4.4 In-stream Thermal Regime Classification

The method described in Stoneman and Jones (1996) and later revised by Chu *et al.* (2009) was used to determine the temperature regime. Classification for each station was based on a comparison of daily maximum air temperature and maximum in-stream water temperature measured between 16:00 and 18:00 during the summer months (July 1 – August 31) when maximum daily air temperatures exceed 24.5°C. A nomograph is then used to classify results based upon water thermal characteristics of coldwater, cold-coolwater, coolwater, cool-warmwater and warmwater systems. **Appendix D** includes a graphical representation of this analysis. **Table 9** summarizes the thermal regime classification associated with each station within the study area. Noted trend changes in the thermal classification of each site are also included in **Table 9** below. These changes are based upon trends in the thermal regime. These are generalized trends that could change as more years of data become available.

The comparison included in **Table 9** indicates no notable change in thermal regime besides a slight cooling at each of HC-A(03) and HC-A(13) and a slight warming at HC-A(09).

Table 9: Temperature Classification Summary

Station	Based on C. Chu et al. (2009)												Based on Stoneman and Jones (1996)		Overall Change in Thermal Regime
	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	
HC-A(03)	Cool-Cold	Cool	Cold	Cool-Cold	Cool	Cool-Cold	Cool-Cold	Cool	Cool	n/a	n/a	n/a	n/a	n/a	Cool to Cold-Cool
HC-A(04)	Cool	n/a	Cool	Cool-Warm	Cool-Warm	Cool	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cold	Cold	No trend[1]
HC-A(04A)	Cool-Warm	n/a	Cool-Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No trend[1]
HC-A(04B)	Cool-Warm	n/a	Cool-Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No trend[1]
HC-A(06)	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cool	Cool	No trend
HC-A(08)	Cold	Cold	Cold	Cold	Cold	Cold	Cold	Cool-Cold	Cold	Cold	Cold	Cold	Cold	Cold	No trend
HC-A(09)	Cool-Warm	Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool-Warm	Cool-Warm	n/a	Cool	Cold	Cool	Warm to Cool-Warm
HC-A(10)	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Cold	n/a	Cool-Cold	Cool	Cool	No trend
HC-A(11)	Cool-Warm	Cool-Warm	Cool	Cool	Cool	Cool	Cool	Cool-Warm	Cool	Cool	Cool-Warm	Cool	Warm	Warm	No trend
HC-A(12)	Cool	Cool	Cool-Warm	Cool	Cool	Cool	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	No trend
HC-A(13)	Cool	Cool-Warm	Cool	Cool-Warm	Cool	Cool-Warm	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	Cool-Warm to Cool
HC-A(14)	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool-Warm	Cool-Warm	Cool	Cool	n/a	n/a	No trend

[1] Comparison excludes 2018

5. In-stream Water Quality Data

In-stream water quality measurements included in-situ measurements of dissolved oxygen, pH, and specific conductivity, as well as a collection of water samples for chemical analysis.

5.1 In-Situ Measurements

During each field visit, a YSI multi-parameter probe (556R) was used to collect dissolved oxygen, pH, and specific conductivity measurements at each site. The 2019 results and historic site comparisons are shown in **Figure 5.1.1** through **Figure 5.1.6**. Most of the sites were within the ranges of the Provincial Water Quality Objectives (PWQO). The average annual comparisons provided show only the general trends of water quality parameters measured during baseflow conditions and do not provide a definitive characterization of instream conditions.

During the 2019 baseflow monitoring events, there was one occurrence where dissolved oxygen (DO) was found to be below the PWQO; this occurred on October 2nd at station HC-A(11). Lower DO levels observed on this date are attributable to a combination of low flow rates, high temperatures, and below average precipitation. The average annual dissolved oxygen levels summarized in **Figure 5.1.2** indicate that DO levels have been relatively stable since 2010, with the exception of 2012 which was noted to be a particularly warm summer.

pH readings were within the PWQO guideline range of between 6.5 and 8.5 for all sites and dates in 2019.

There is no PWQO for conductivity; however, conductivity is a good surrogate measure for the presence of ions such as chloride. Overall in 2019, the same trend as observed in previous years was noted: upstream reaches recorded lower conductivity readings than their downstream counterparts. While peak conductivity readings did not reach the same highs as were recorded in 2018, readings in 2019 were higher than years prior to 2018.

In 2019, four turbidity monitoring stations were reinstated at the Hanlon Creek Business Park project site at stations HC-A(03), HC-A(06), HC-A(11) and HC-A(14). The Turner Designs Cyclops turbidity sensors which were installed use an optical scattered light method to determine turbidity.

The PWQO for turbidity is based on Secchi depth readings not decreasing more than 10% due to the addition of suspended matter. The CCME Guidelines for the Protection of Aquatic Life allow for a maximum increase of 8 Nephelometric Turbidity Units (NTUs) above background levels for short-term exposure and an increase of 2 NTUs above background levels for long-term exposure.

Similar to monitoring years 2017 and 2018, issues were again encountered with the collection of turbidity data in 2019. Therefore, comprehensive comparison of data between monitoring stations is not possible. It appears that the sensor at HC-A(11) was partially covered with sediment between site visits, and that this caused the sensor to record erroneous turbidity readings. Furthermore, the turbidity sensor itself may be at the end of its useful service life, as both the sensors and the telemetry stations are beyond the manufacturer's recommended expiry date.

Due to the flow inputs from Pond 4, turbidity readings typically increased by an average of 7 NTUs moving downstream from HC-A(03) to HC-A(06) (refer to **Figure 5.1.7**Error! Reference source not found.). Discounting sensor noise, readings generally decreased at HC-A(14), likely due to the decreased turbulence associated with the increased depth and slower current at HC-A(14) as well as possible sediment retention in the upstream wetland complex.

During site visits, turbidity sensors were checked and cleaned regularly, however, sediment buildup in between visits invariably occurred. HC-A(06) recorded a turbidity profile with fewer irregularities than the profiles observed at HC-A(03) and HC-A(14), possibly due to the rock-lined channel at HC-A(06). While the profile irregularities at HC-A(03) and HC-A(14) can be explained by faulty/aging sensors, it is also suspected that biofouling and vegetation growth in the stream at these locations interfered with the sensor readings. Station HC-A(03) is also relatively shallow, so it is possible that the sensor did not always remain submerged during extended dry periods. HC-A(14) specifically saw extensive vegetation growth within the channel during 2019, and AECOM plans to perform some minor vegetation removal prior to monitoring in 2020. Due to the reduced onsite activity in 2019 associated with the later installation, excessive vegetation growth was identified as a problematic issues at multiple sites along Hanlon Creek, notably HC-A(04), HC-A(11), HC-A(12), HC-A(13), and HC-A(14). Minor, manual clearing was already required in 2019 to facilitate monitoring tasks and travel between sites, however, more extensive clearing may need to be completed at most sites in 2020.

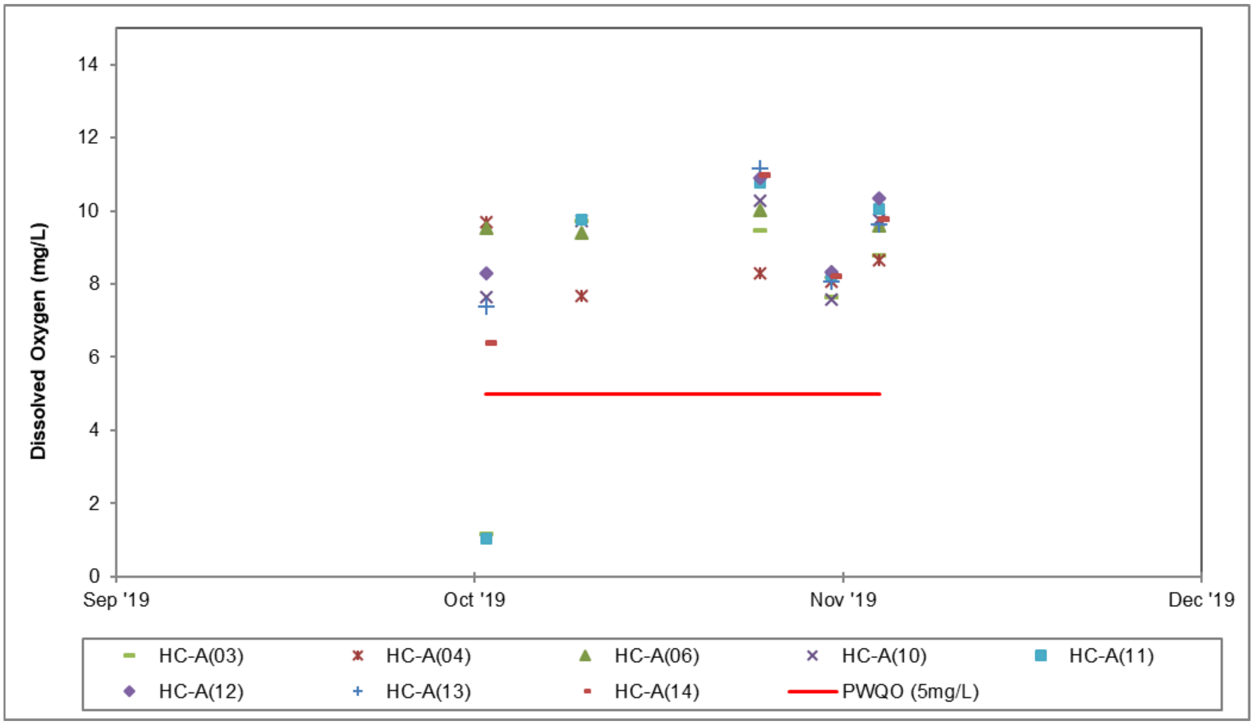


Figure 5.1.1: 2019 YSI Dissolved Oxygen Readings

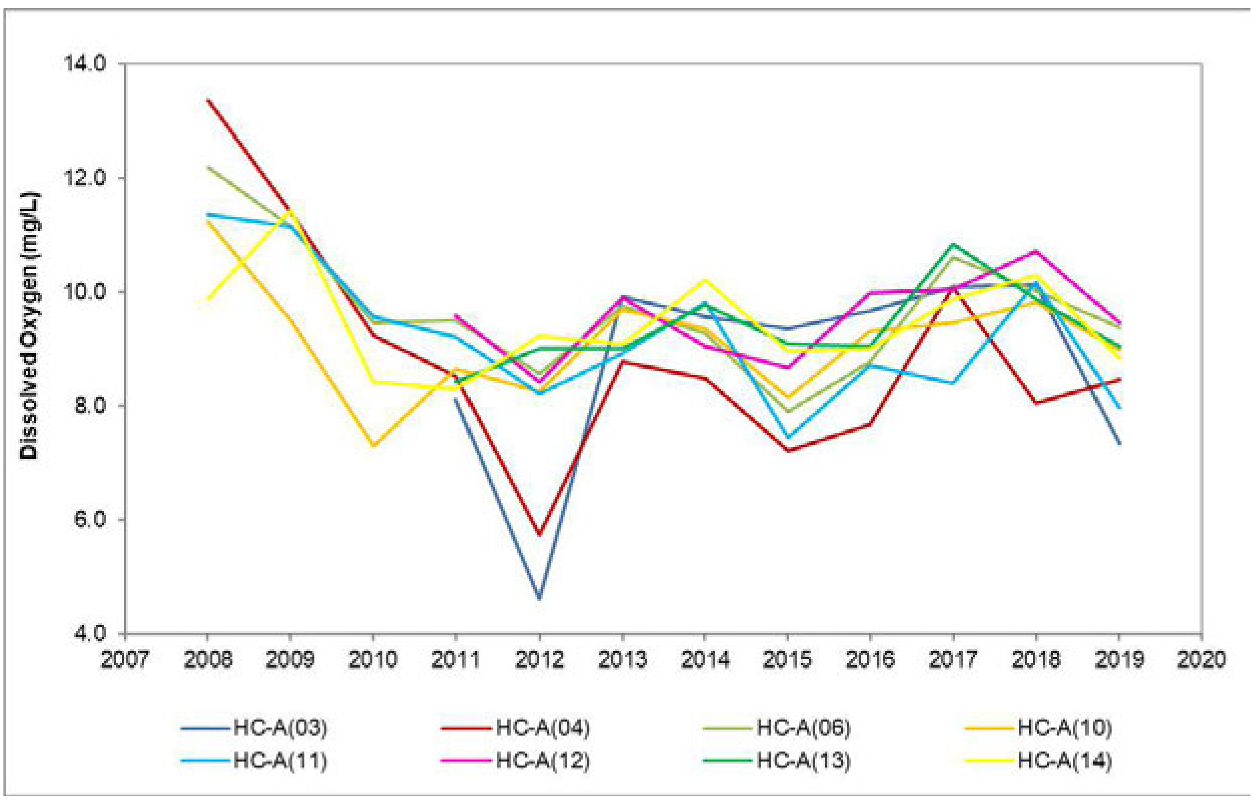


Figure 5.1.2: Average Annual YSI Dissolved Oxygen Readings from 2008 to 2019

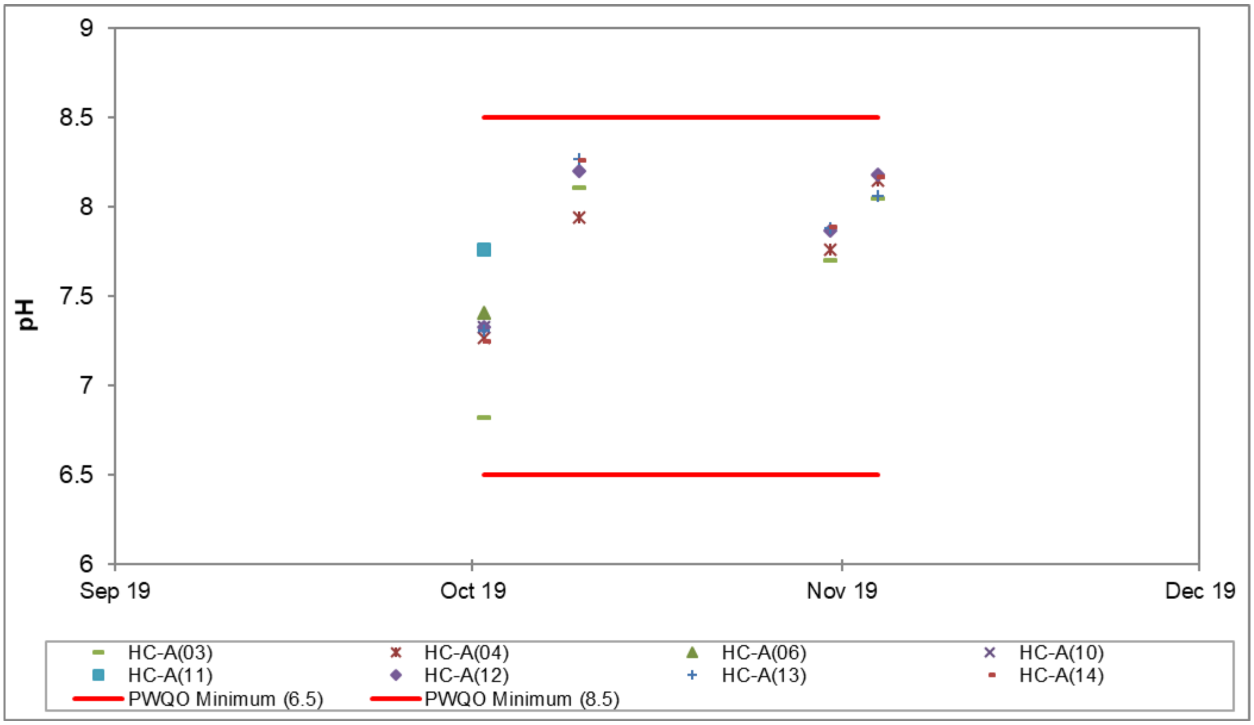


Figure 5.1.3: 2019 YSI pH Readings

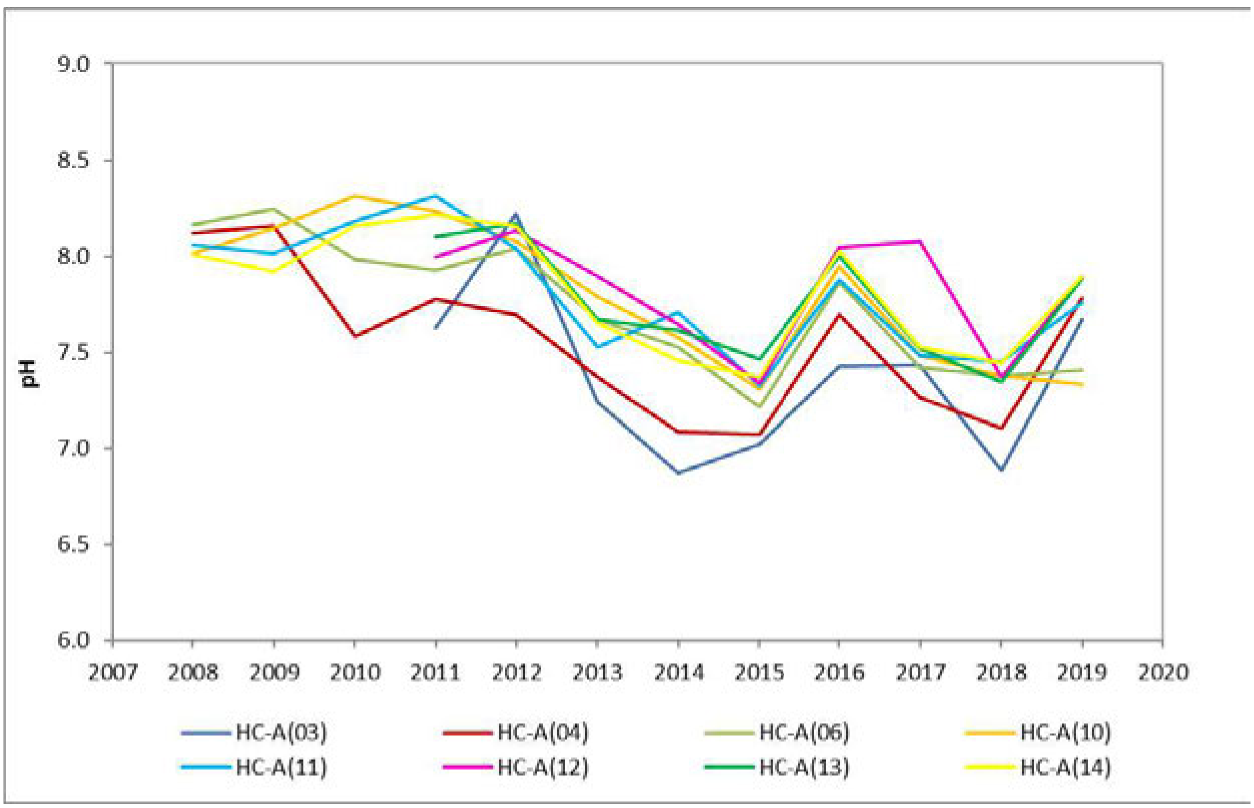


Figure 5.1.4: Average Annual YSI pH Readings from 2008 to 2019

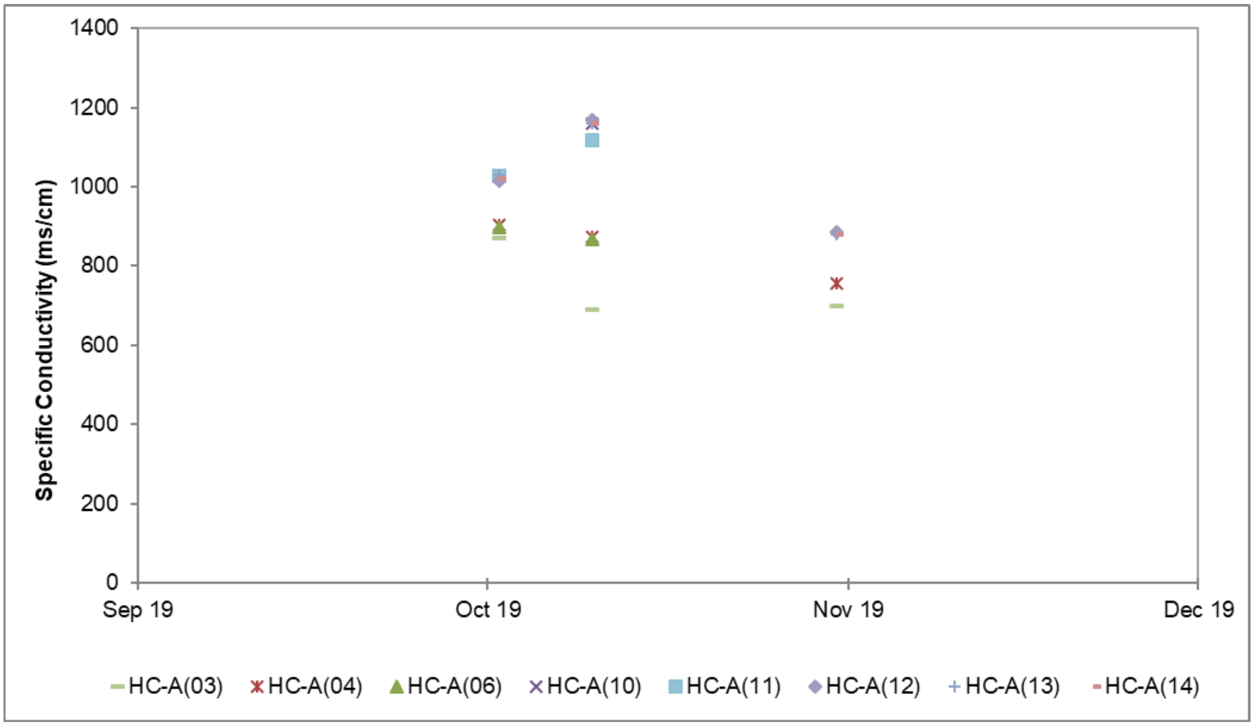


Figure 5.1.5: 2019 YSI Conductivity Reading

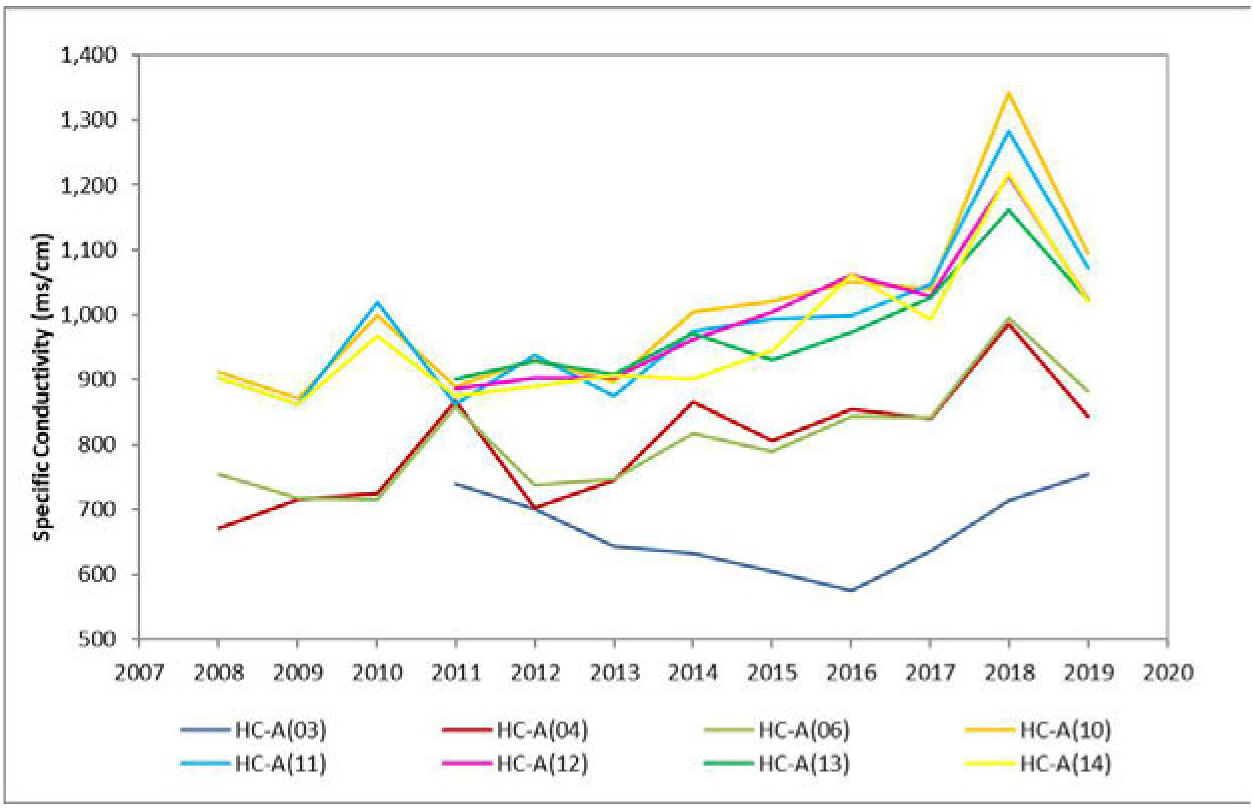


Figure 5.1.6: Average Annual YSI Conductivity Readings from 2008 to 2019

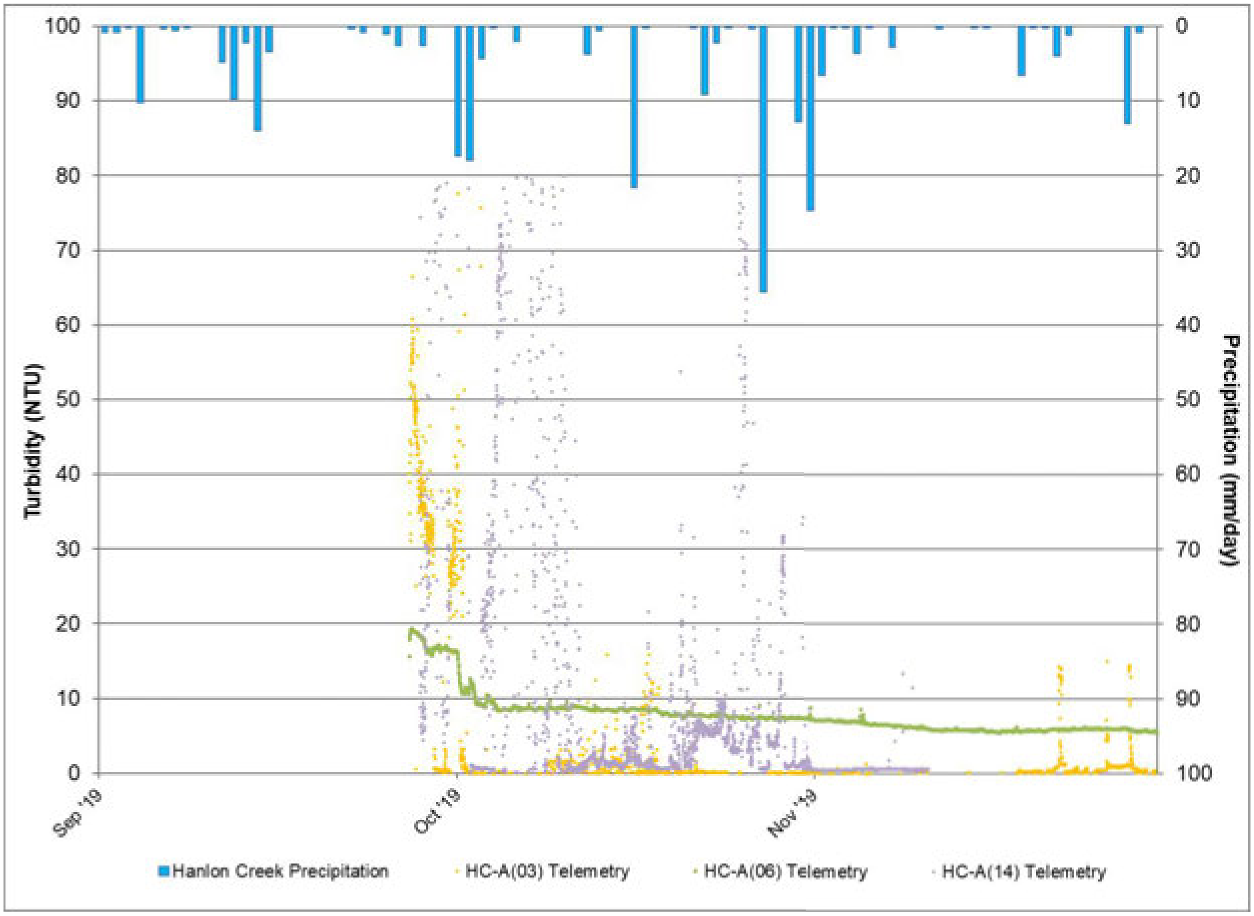


Figure 5.1.7: Turbidity in the Upstream Telemetry Station

5.2 Grab Samples for Water Quality Analysis

To establish estimates of the performance efficiency of the SWM facilities and to satisfy the MECP Environmental Compliance Approval (ECA) requirements, the water quality sampling program includes grab samples collected upstream and downstream of each pond outlet. Sampling locations included HC-A(03), HC-A(04), HC-A(12), HC-A(13) and HC-A(14).

In accordance with the Consolidated Monitoring Program completed in years past, parameters that were analyzed during sampling included:

- CBOD5
- Total Suspended Solids
- Total Phosphorus
- Dissolved Phosphorus
- Metals (total and dissolved, lead, zinc and copper)
- Escherichia coli
- Nitrate as N
- Chlorides

Additionally, past program years included the following water quality sampling event requirements:

- Three (3) dry weather sampling events completed after a minimum of 72 elapsed hours since the last rainfall (between the months of May and November);
- Eight (8) seasonal wet sampling events, with five (5) spread out during the summer season; and
  - Historically, one (1) wet weather sample was collected during the winter, however, this was shifted to fall within the May to November sampling period.

Due to the delayed start in 2019, sampling efforts proceeded with the intention of collecting as many of the above sampling events as possible given the shortened sampling season. A specific focus was placed on retaining monthly baseflow/dry weather samples, in addition to the wet weather samples collected normally.

While sampling parameters first assessed in 2019 included all parameters noted in the above list due to carry over from the previous monitoring program, the list was eventually shortened to reflect the extensive sampling history and the City's request to reduce the overall monitoring program budget (as noted in the 2019 Program RFP). Specific changes to the 2019 parameters list included:

- Total metals analysis to be completed only for the following: lead, zinc, and copper (no dissolved fractionation)

Given the shortened field season, only three wet weather samples were collected over the course of the 2019 monitoring period (between September and November). Due to the relative frequency of rainfall events during the condensed schedule, only one dry weather sample was collected on November 4th. The tabular results of the water quality sampling have been included in **Appendix E**.

Water quality sampling results are presented as the number of exceedances as compared to the PWQOs in **Table 10.** E.coli concentrations exceeded the recommended PWQO guidelines applicable for recreational use during wet weather events in 27% of the samples. Total phosphorus levels exceeded the PWQO during both wet and dry weather sampling events. However; this is not uncommon for streams in the Grand River watershed (GRCA, 2012). Total copper and lead also exceeded their respective PWQO, however, zinc did not exceed the applicable PWQO for any sampling event in 2019.

Chloride concentrations exceeded the longer-term duration exposure target of 120 mg/L (CCME 2011) for most events at all locations. One exception to this observation if for HC-A(03), which did not exhibit exceedances in samples collected for either wet weather or dry weather events. All samples were below the short-term exposure target of 640 mg/L (CCME 2011).

Table 10: Number of Guideline Exceedances per Water Quality Sampling Location

Parameter	Unit	Guideline	Number of Exceedances for Wet Weather Sampling Events (out of 10)					Number of Exceedances for Dry Weather Sampling Events (out of 3)					Total
			HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)	HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)	
Dissolved Oxygen(DO)	mg/L	5	0	0	0	0	0	0	0	0	0	0	0
pH	pH units	6.5-8.5	1	0	0	0	0	2	2	2	1	1	9
Chloride	mg/L	120-640	0	2	2	2	2	0	1	2	2	2	15
Total Suspended Solids	mg/L	25+	0	0	0	0	1	0	1	0	0	1	3
Total Phosphorus	mg/L	0.03	1	1	1	1	1	1	1	0	0	1	8
E. Coli	CFU/100mL	100	1	0	1	1	1	0	0	0	0	0	4
Copper (Cu)-Total	mg/L	0.001	2	2	2	2	2	2	2	2	2	2	20
Lead (Pb)-Total	mg/L	0.001	0	1	1	1	1	0	2	0	0	1	7
Zinc (Zn)-Total	mg/L	0.02	0	1	1	1	1	0	1	0	0	1	6

Notes:
-Exceedances based upon the PWQO limits, Chloride exceedances were based upon the CCME short term level. TSS based on exceedance from the upstream station
* Objectives for total phosphorus/metals

TSS concentration comparisons are summarized for each corresponding upstream and downstream location in **Figure 5.2.1**. Both the wet and dry weather samples collected in early October (on the 2nd and 10th, respectively) saw large TSS concentration spikes at HC-A(14) compared to the upstream station of HC-A(13). Considerably lower suspended solids totals were witnessed for all sites during the two subsequent events, with the exception of a potential outlier at station HC-A(04) on October 2nd. This TSS decrease observed later in the month of October may be explained by the significant rainfall events that occurred on October 27th (35mm) and October 31st (24.6mm), which may have remobilized retained sediments throughout the Hanlon Creek system.

A notable TSS spike was observed at HC-A(04) on October 10th. Immediately upstream of HC-A(04) there is a relatively deep, slow-moving section of creek that regularly accumulates appreciable sediment deposits. Given the relatively dry period preceding this sampling event, this TSS spike may be explained by the remobilization of retained sediment within the channel in this area. Furthermore, the aforementioned vegetation growth at sites HC-A(13) and HC-A(14) in 2019 was noted to retain sediment during site visits. Planned vegetation pruning in 2020 within some of the more heavily vegetated site sections may result in overall reductions in observed TSS concentrations and the affected sites.

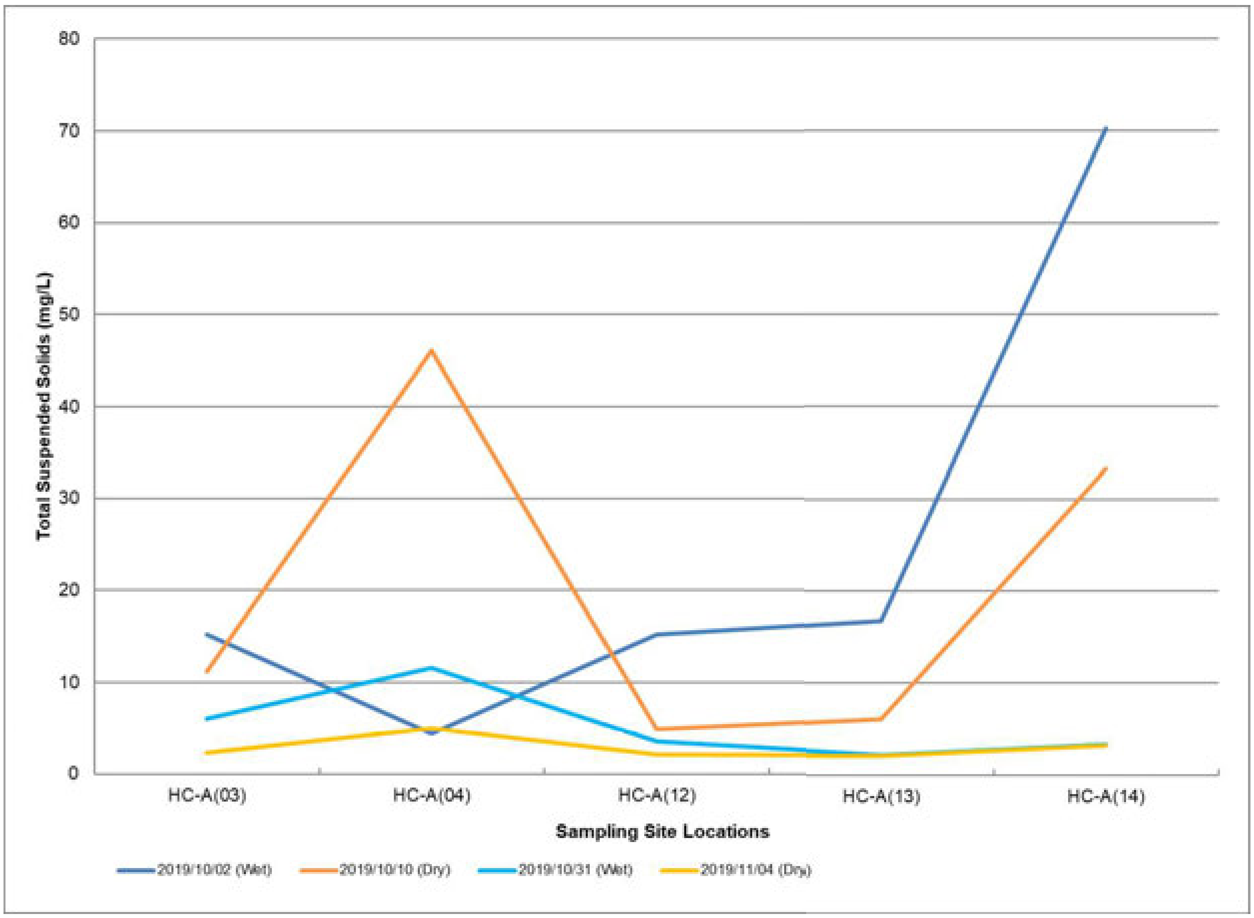


Figure 5.2.1: Total Suspended Solids (TSS) Concentration by Sampling Site

6. Stormwater Management Facility Monitoring

In fulfillment of the requirements of MECP ECA 1384-7QFPZQ, as well as those of the Grand River Conservation Authority (GRCA), monitoring was completed at each of the SWM facilities (Ponds 1, 2 and 4). The monitoring program originally included three discrete components: monitoring of inflow and discharge flow rates, measurement of water temperature, and water quality sampling. Pond water chemistry and inlet monitoring was removed from the monitoring program as per the recommendations of the 2017 report, however, temperature and outflow monitoring at each ponds' outlet remains ongoing.

6.1 SMWF Water Level and Flow

Water level loggers were installed at each facility's outlet structure. This continuous depth data was used to estimate outflows from the facilities.

In 2019, neither Pond 1 nor Pond 2 water levels were ever high enough to trigger a pond discharge event.

For Pond 4, flow was calculated for the outlet (HC-P4(05)) structure using the orifice equation based on the water level recorded by a level logger that was placed inside of the outlet control structure. Pond 4 continuously discharged water throughout the majority of the 2019 monitoring season. Flows from Pond 4 are summarized in Error! Reference source not found..

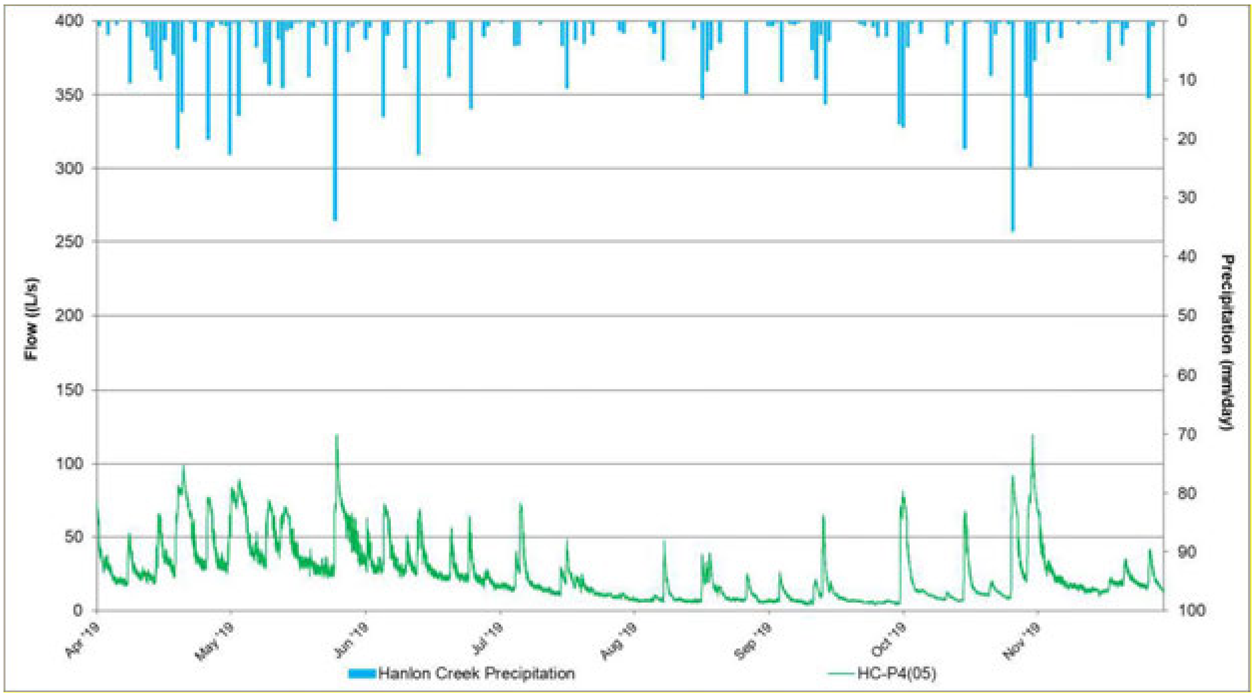


Figure 6.1.1: Estimated Flow for Pond 4

6.2 SWMF Water Temperature

Water temperature was monitored at the outlet of each SWM facility. Monitoring facility components included the following, as applicable:

- Cooling trench outlets;
- Outflow structures; and
- Pond stratification temperate monitoring clusters (only Pond 4).

The purpose of monitoring temperature within the SWM facilities is to provide performance data related to the mitigation measures that were incorporated into the SWM servicing design for the Hanlon Creek Tributary A area, and the determine whether or not such mitigative measures are effective in mitigating against the discharge of warm waters which would otherwise cause warming of the steam. Inlet structures were not monitored in 2019 as the inflows are well characterized through historical data collected to date.

6.2.1 SWM Pond 1

Pond 1 was designed with multiple thermal mitigation features. Stormwater is conveyed to the SWM facility via two grass drainage swales that discharge into the settling forebays. Before water can pass though to the main body of the pond, the flow must pass though a planted wetland area. The water is discharged via a bottom draw structure into one of two cooling trenches prior to being discharged into the wetland areas. These measures allow for maximum infiltration and minimize the amount of water directly discharged from the SWMF to the creek.

Water temperatures were monitored in the pond outflow catch basin structure (HC-P1(06)) and at the cooling trench outflows (HC-P1(07,08)). The thermal profile in the pond was not measured through 2017 - 2019, as per a recommendation from the 2016 report, which concluded that the shallow waters in Pond 1 did not warrant temperature profile measurements.

No discharge was recorded at the outlet of Pond 1 during the 2019 monitoring season. Therefore, conclusions regarding the function of Pond 1's cooling trench cannot be determined for the current monitoring period.

6.2.2 SWM Pond 2

The Pond 2 design was based on the retrofit of an existing SWM facility. There are three inlets to the SWM facility, two storm sewer outlets (HC-P2(04,05)) and one grass drainage swale (HC-P2(06)). Each inlet discharges into it a separate sediment forebay. Before the water can pass through to the main body of the pond, it must flow through a planted wetland area. Eventually, the water is discharged via a bottom draw structure into an infiltration gallery that was constructed as part of the initial pond design. Similar to Pond 1, depth loggers were placed at the Pond 2 outlet (HC-P2(07)). Temperature profile was not measured in Pond 2.

6.2.3 SWM Pond 4

Pond 4 was designed with multiple thermal mitigation features. Stormwater is first conveyed to the SWM facility via a grass drainage swale and discharged into a pre-treatment forebay. Before the water can pass though to the main body of the pond, it first flows though a wetland area (see below). The water is discharged via a bottom draw structure into a cooling trench prior to being discharged into Hanlon Creek Tributary A.

In September 2012, the outlet weir was raised to stop Pond 4 from continuously discharging, and to avoid warming of the outflow water for extended periods. This has not been achieved however, due to high levels of groundwater which continuously inputs additional flows to the pond.

Vegetation was also planted in this pond, and vines and other flora were installed on and around the cooling trench to shade the exposed rock. The plantings have not yet matured to cover the cooling trench. However, through 2016-2019, progressive enhancements were noted in terms of the amount of vegetation taking root along the cooling trench. Although the current impact is understood to be minor, these features are anticipated to provide additional cooling of the pond's discharge water during future summer seasons.

Water temperatures were monitored in the inlet channel (HC-P4(04)), at the pond outflow structure (HC-P4(05)) and at the cooling trench outflow (HC-P4(06)). Temperature loggers were installed in the pond's main cell to collect measurements of the pond's temperature profile. The complete temperature monitoring records at the Pond 4 stations for 2019 are shown in Error! Reference source not found..

Recorded temperature at the bottom-draw outlet (HC-P4(05)) was generally lower (during summer months) than the temperature readings collected by the in-pond loggers (HC-P4(01-03)); it appears that the bottom draw outlet allows for the discharge of the coldest (deepest) water first. Only minor temperature variations were noted between the deepest (HC-P4(01)) and shallowest (HC-P4(03)) in-pond thermal profile loggers, therefore, it may be recommended to remove these loggers during future monitoring seasons.

The temperature recorded at the outlet of the cooling trench (HC-P4(06)) tended to exhibit the least variation: it appears that the cooling trench did have somewhat of a moderating – and generally cooling – effect on the flow discharged to Hanlon Creek Tributary A.

Despite the cooling effects of the trench and bottom draw outlet (as well as the cooling impact of groundwater input), temperatures leaving the pond were still higher than the in-stream water temperatures upstream of Pond 4. The temperatures recorded at the creek station HC-A(06) located downstream of Pond 4 were higher than those recorded upstream of the pond outlet (HC-A(03)). This highlights the pond's thermal impacts on HC-A(06), which exhibited a lower magnitude of diurnal temperature fluctuation than those observed in the creek sites upstream (HC-A(03)) and downstream (HC-A(06)).

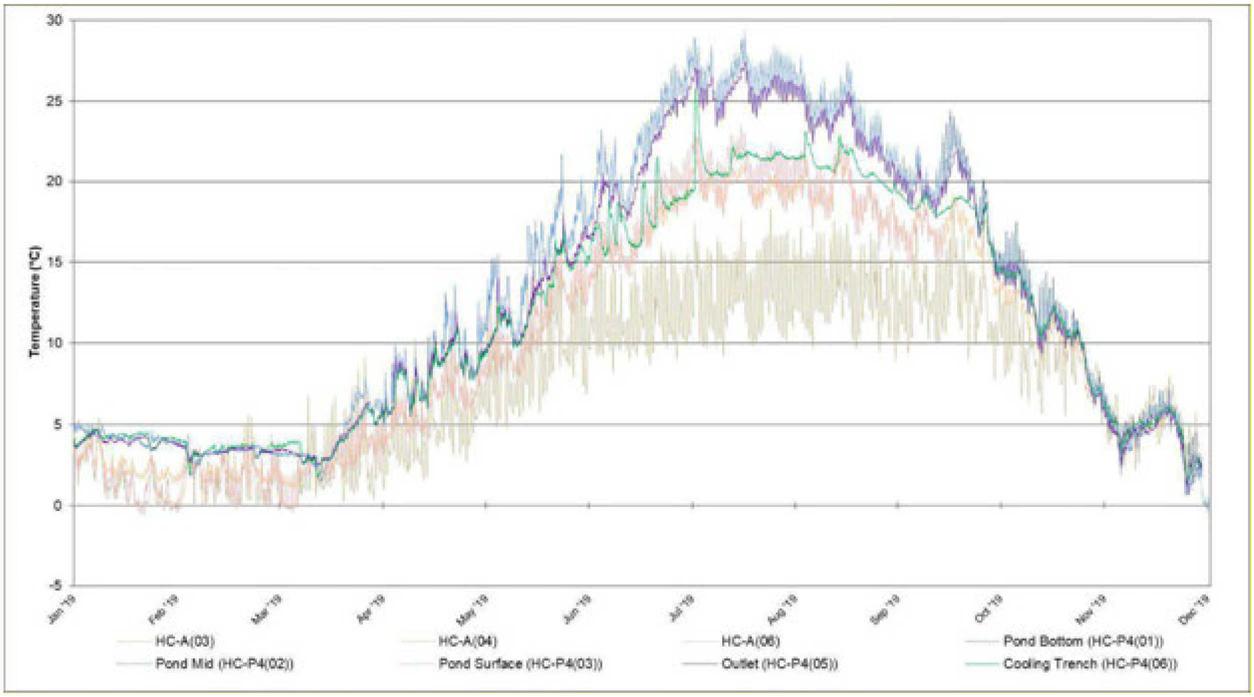


Figure 6.2.1: Measured Temperatures through Pond 4 and Upstream/ Downstream of Pond Outlet

7. Conclusions and Recommendations

7.1 Conclusions

In-stream flow conditions in 2019 were generally consistent with those observed in previous years when interannual climatic variability is considered. Low precipitation during the summer of 2019 resulted in drier conditions overall throughout the study site.

The monitored temperature results suggest that the system overall experienced warmer temperatures than in previous years. Monitoring results show that summer temperatures largely did not exceed suitable conditions for brook trout habitat based on the ranges provided in the Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F (AECOM, 2009). Thermal monitoring field results consistently yielded data exhibiting higher temperatures than those predicted by the HSP-F model in terms of average summer temperatures, exceedances above 19°C during the summer, and for predicted vs. observed autumn values across all in-stream monitoring stations.

Pond 4 continuously discharged into Hanlon Creek Tributary A during the summer of 2019 and this is likely a contributing factor to the increased temperatures observed at stations downstream of the pond outflow. The bottom-draw outlet and cooling trench design employed at Pond 4 appears to be functioning well and is overall observed to be reducing outflow temperatures. While the resulting discharges are cooler than water in the pond, they are still higher than the temperatures recorded at the creek monitoring station upstream of the pond. Vegetation that was planted on the banks of the pond and along its cooling trench in 2012 have continued to mature, however, it has yet to provide significant cooling benefits to the discharge water draining from Pond 4. Slight improvements were observed from 2016-2019, and it is expected that with the added vegetation growth around the channel, water temperatures will slowly continue to decrease over time. It is worth mentioning that increased vegetation growth within the channel itself is currently negatively impacting flow monitoring activities, therefore, increased vegetation growth is not without its attendant challenges.

In August 27, 2015, AECOM provided a memo to the City outlining recommended improvements to Pond 4 in order to reduce overall thermal impacts to the Creek. Following discussion with stakeholders, AECOM recommended that the water level in Pond 4 be lowered to its original design elevation and that plantings be provided throughout the pond to provide shading as originally intended. As was recommended, two additional thermal monitoring stations were installed between HC-A(04) and HC-A(06). These additional stations were implemented to further evaluate causes of temperature exceedances beyond the 24°C threshold at station HC-A(06). Data collected at station HC-A(06) showed that, further downstream, water temperature did not experience any exceedance of 24°C.

A number of measures were discussed for further evaluation, including interception and re-routing of groundwater from the pond to the outlet of the cooling trench, lowering water level in the pond and re-establishing the vegetation (including exclusionary fencing to discourage waterfowl so that the vegetation can become fully established), as well as various shading structures (e.g. floating islands, screening, etc.). These activities have yet to be pursued since they were originally suggested in 2017.

Collected data from Pond 1 shows that there was no measurable surface runoff in 2019. Site inspections confirmed low water levels in the pond in the summer and fall months. Previous annual monitoring reports have assumed that infrequent flows at Pond 1 may have contributed to high temperatures observed at HC-A(13) and HC-A(14). Pond 2 also experience no discharge during the summer and fall of 2019.

Of the three parameters collected via in-stream monitoring during baseflow sampling (DO, pH and specific conductivity), pH levels within the system continue to appear to be decreasing since 2012, while conductivity appears to be increasing. Additional data collection is required to confirm these trends.

The water quality samples collected upstream and downstream of the SWMFs are indicative of the conditions which typically arise following SWMF construction within the Grand River watershed for both dry and wet weather conditions. Several exceedance events for chloride, total phosphorous, *E.coli*, total copper, total lead and total zinc were recorded within Tributary A downstream of each pond.

7.2 Recommendations

The following recommendations were formulated based on observations made during the 2019 monitoring program.

7.2.1 In-stream Monitoring Program

Going forward, it is recommended that water depth/temperature loggers remain deployed and continue to collect data at each telemetry station (HC-A(03), HC-A(06), HC-A(11) and HC-A(14). While each telemetry station is thoroughly checked each year before installation, field conditions are taxing on equipment resources and equipment periodically malfunctions. Furthermore, theft and vandalism have occurred in the past and this has resulted in data gaps of varying duration within the datasets for several parameters collected at various sites. It is recommended that stations which have experienced equipment failure be upgraded with new equipment, and that stations which have experienced tampering be redesigned in order to limit exposed wires, accessible sensors, etc.

Several of the turbidity loggers have not been performing well due to localized sediment accumulations at some instream locations, and this has caused the sensors to record erroneous (very high) turbidity readings. Biofouling and vegetation growth are also suspected to be interfering with turbidity sensor readings at some stations. Furthermore, it has previously been noted by the manufacturers of the telemetry equipment that the original design of the telemetry stations may not provide sufficient electrical current to power the turbidity sensors which are in use. Therefore, a combination of modifications to or replacement of the turbidity sensors at the stations should be considered.

AECOM recommends that telemetry stations be replaced during the 2020 field season, should funding be available.

Given the inability to apply all noted changes specified in the 2019 Monitoring Program due to the condensed schedule, AECOM's goal for the 2020 season will be to apply all of the proposed monitoring changes outlined previously. Through discussion and agreement with the City of Guelph, one noteworthy change that will be implemented is that sampling and flow monitoring will be collected 72-hours following wet sampling and flow monitoring events in order to assess the rebound of sites downstream of pond discharge locations. Historically, dry weather events/samples were collected following a minimum of 72-hours with no rainfall and were scheduled independent of wet events, therefore, no flow response/recession relationship could be discerned at the stations. AECOM will aim to ensure that these two event types will be collected as part of the 2020 monitoring program.

7.2.2 Stormwater Management Facility Monitoring Program

Outflow conditions of the Ponds should continue to be monitored in order to provide an understanding of the impacts of the SWMFs on the creek system. As outflow from Ponds 1 and 2 have been observed to be infrequent, it is recommended that a single depth logger be installed within each SWMF in order to provide a continuous record of water levels within each SWMF. Available design information may be used to establish a rating curve for each pond.

The overall SWMF temperature monitoring program has collected a robust data set over the course of several monitoring seasons. Previous years of data collection have provided confirmatory evidence of thermal stratification within the SWMF, and therefore, the in-pond temperature monitoring of Ponds 1 and 2 was ceased in 2017. Thermal monitoring within the Pond 1 cooling trench is required to verify the effectiveness of the cooling trench design at this location.

Prior to any rehabilitation works being completed at Pond 4, a multidisciplinary review is required to establish what bet benefit is sought through the implementation of any proposed design modifications.

8. References

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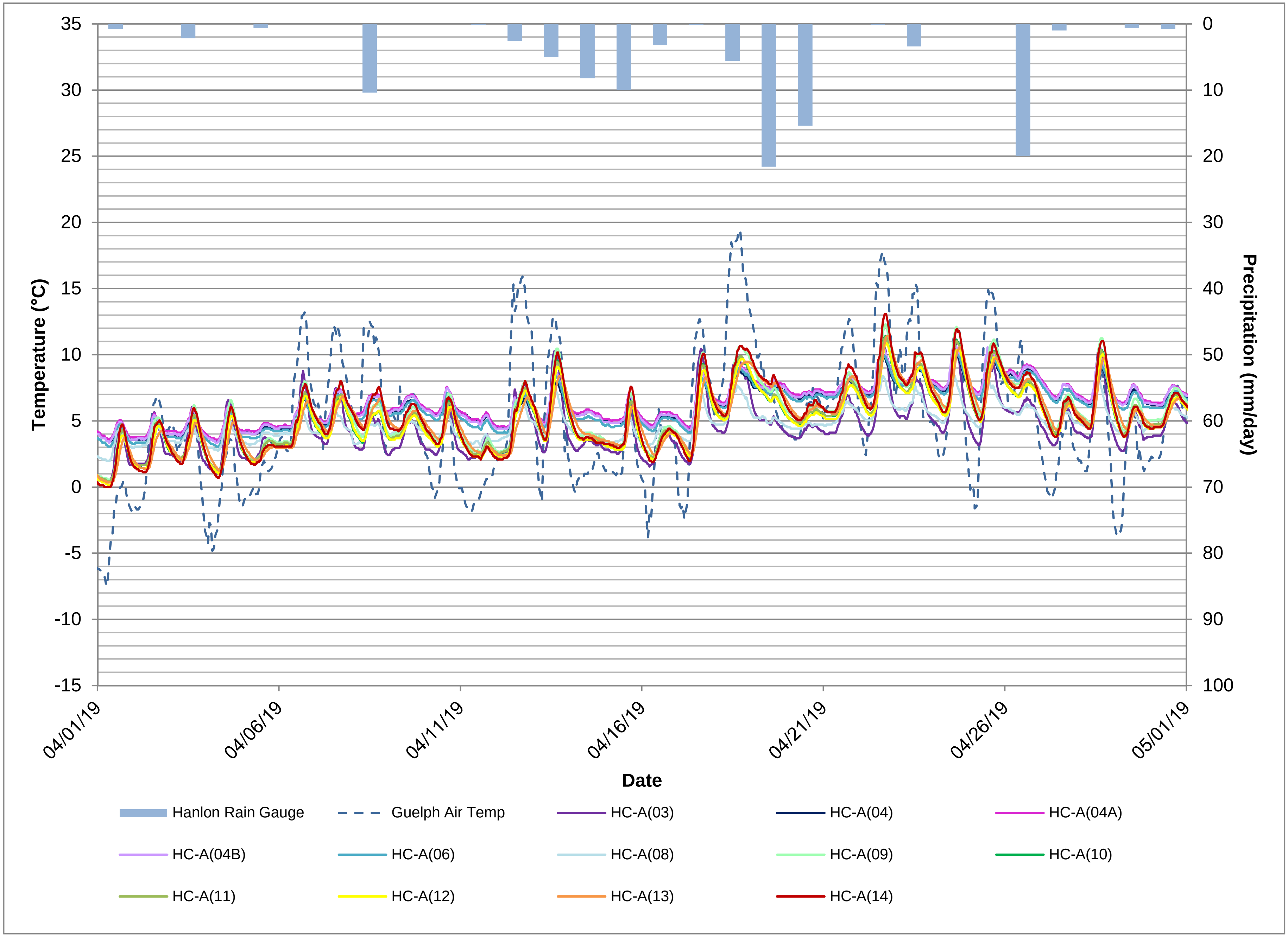
Appendix A

Monthly Temperature Plots



Temperature (°C)
Precipitation (mm/day)
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05/01/19
Date
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
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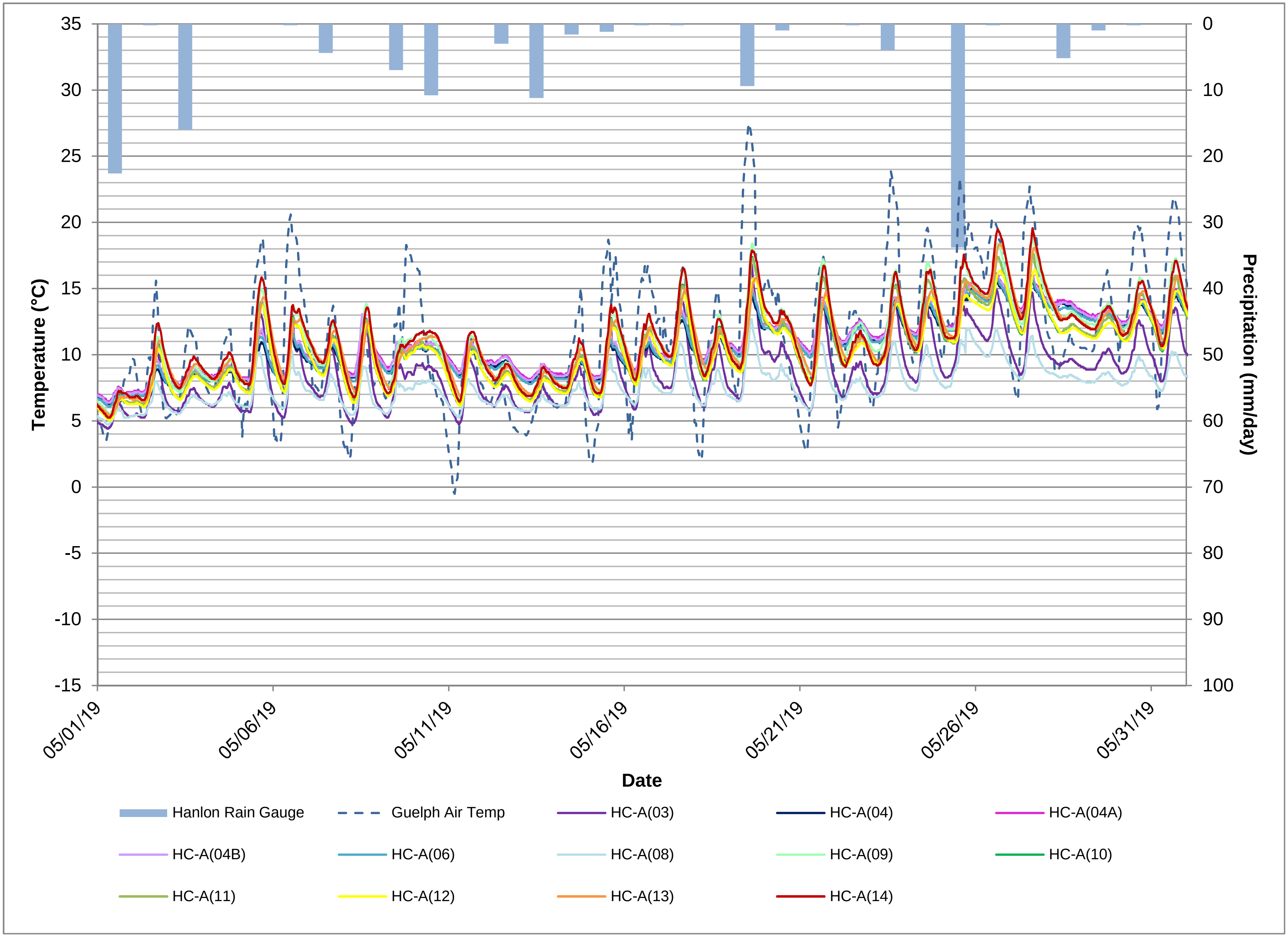

Temperature (°C)
Precipitation (mm/day)
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Hanlon Rain Gauge
Guelph Air Temp
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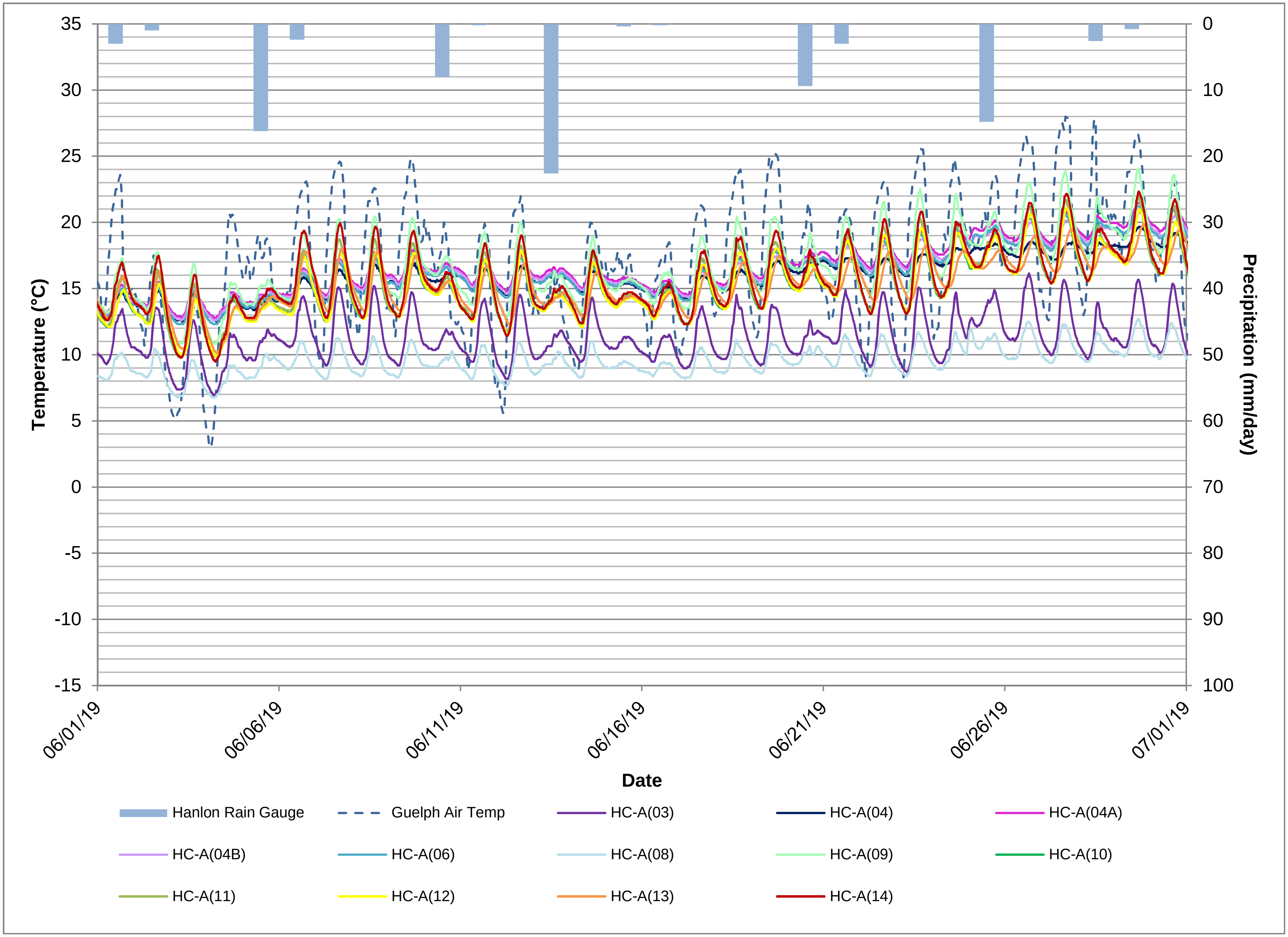

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Hanlon Rain Gauge
Guelph Air Temp
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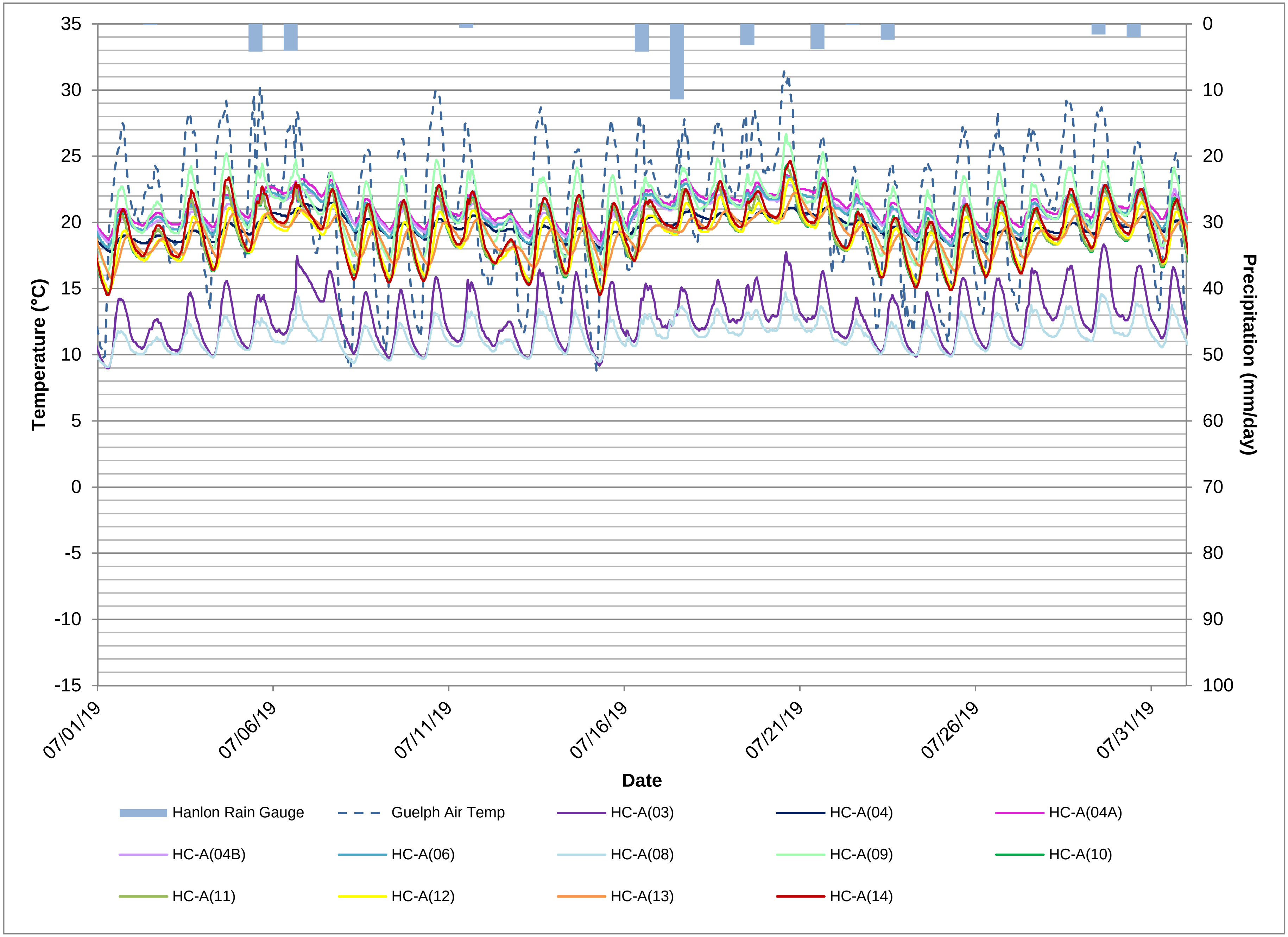

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Hanlon Rain Gauge
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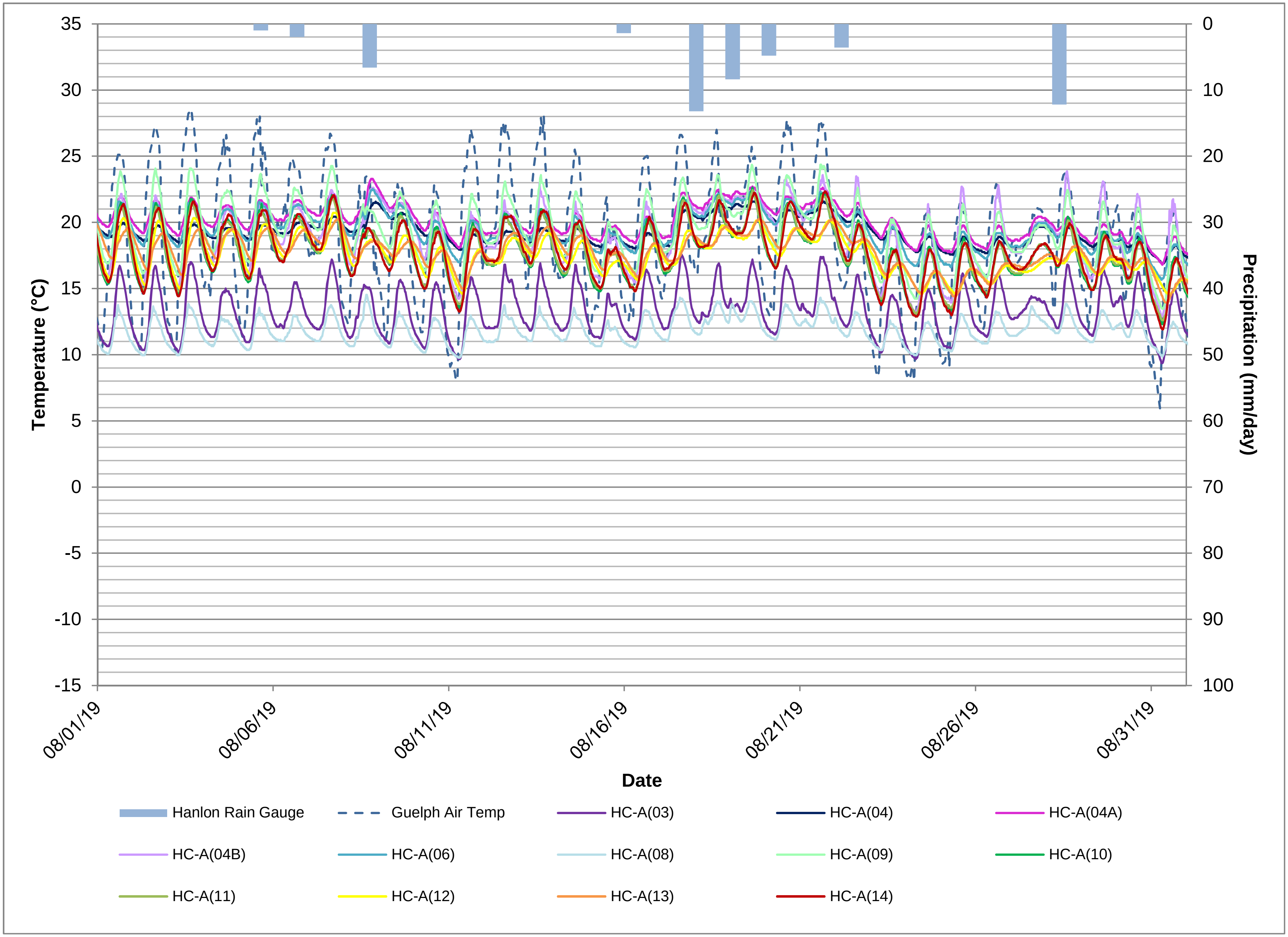

Temperature (°C)
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Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
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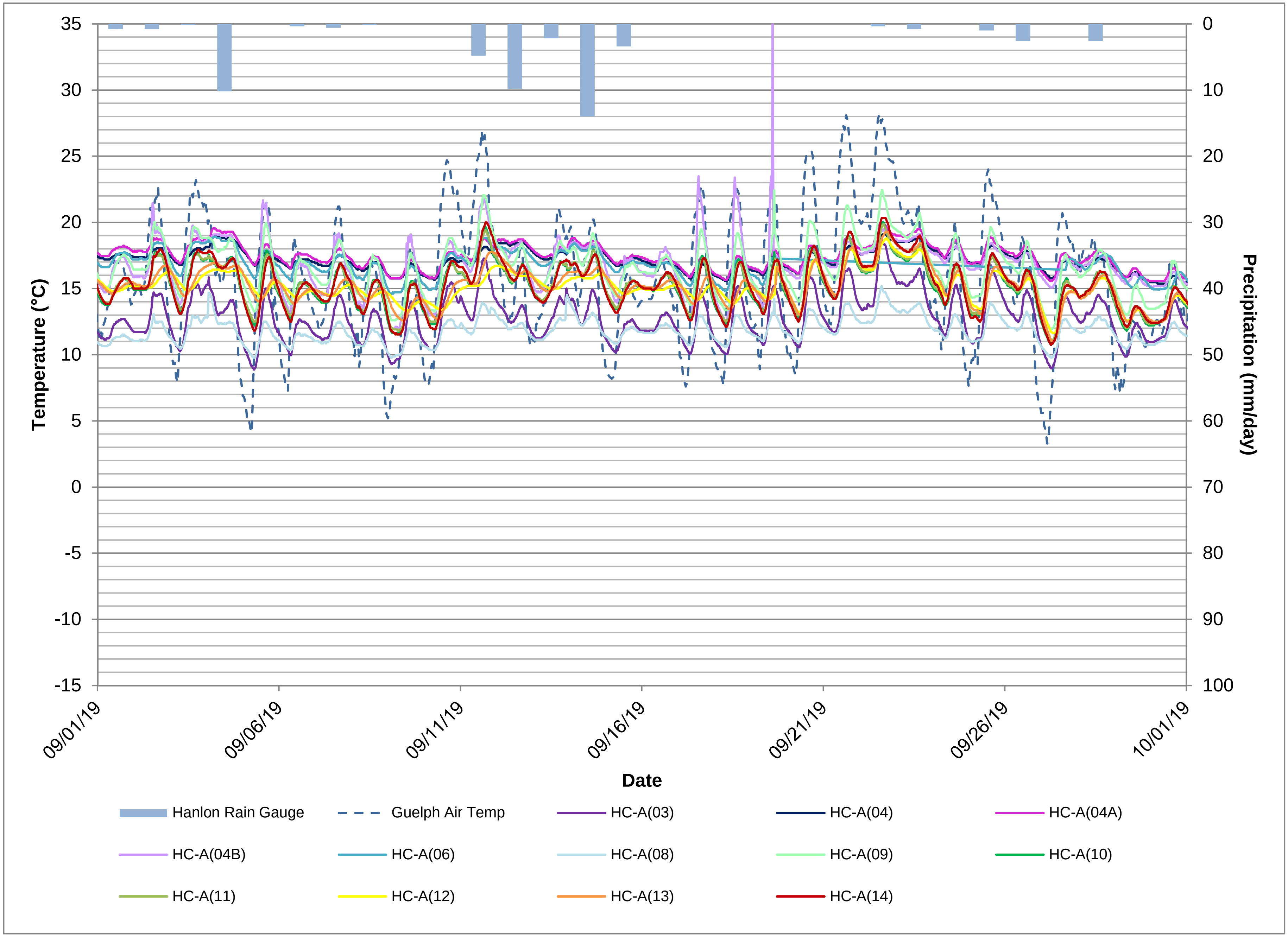

Temperature (°C)
Precipitation (mm/day)
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Hanlon Rain Gauge
Guelph Air Temp
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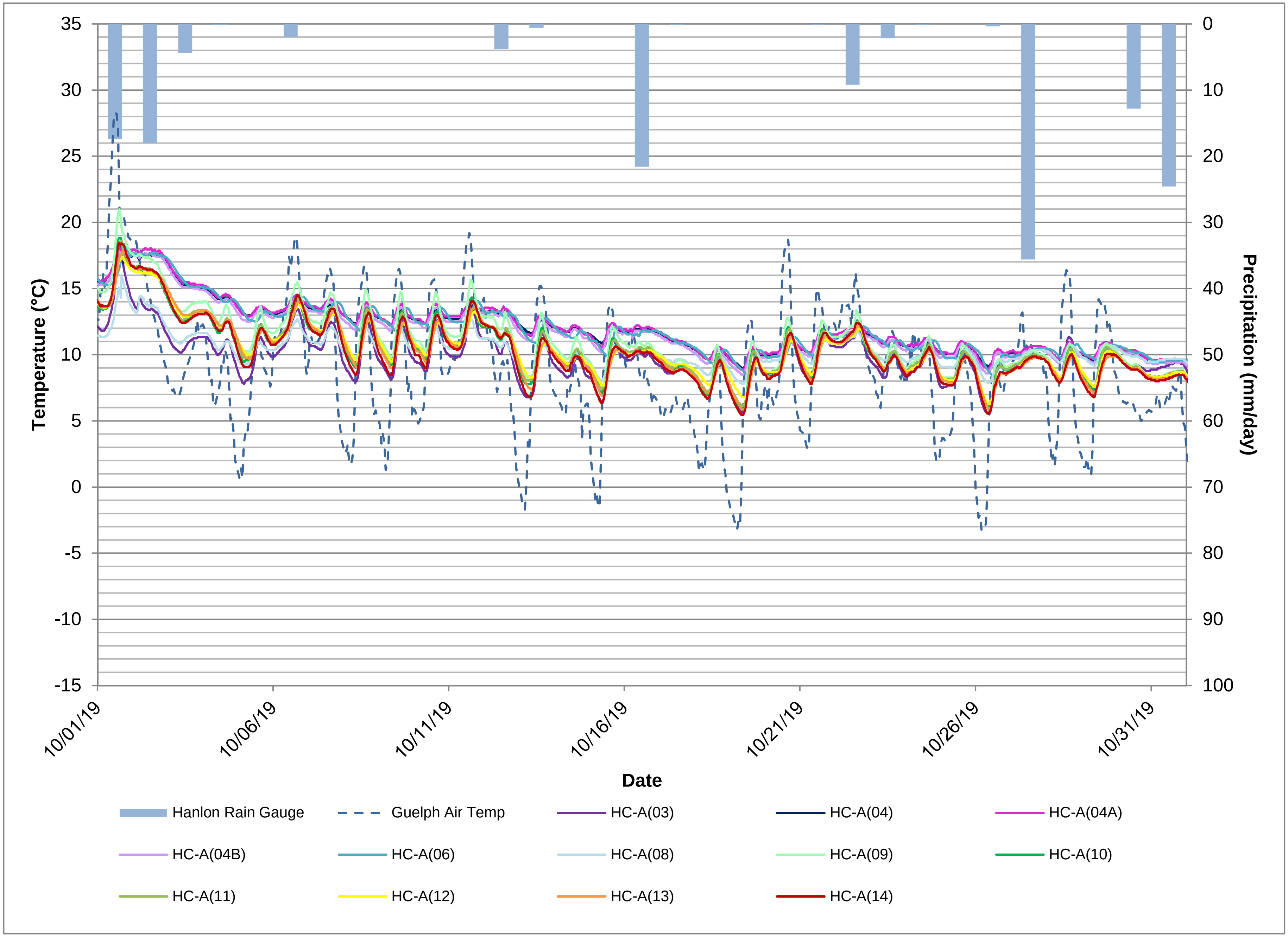

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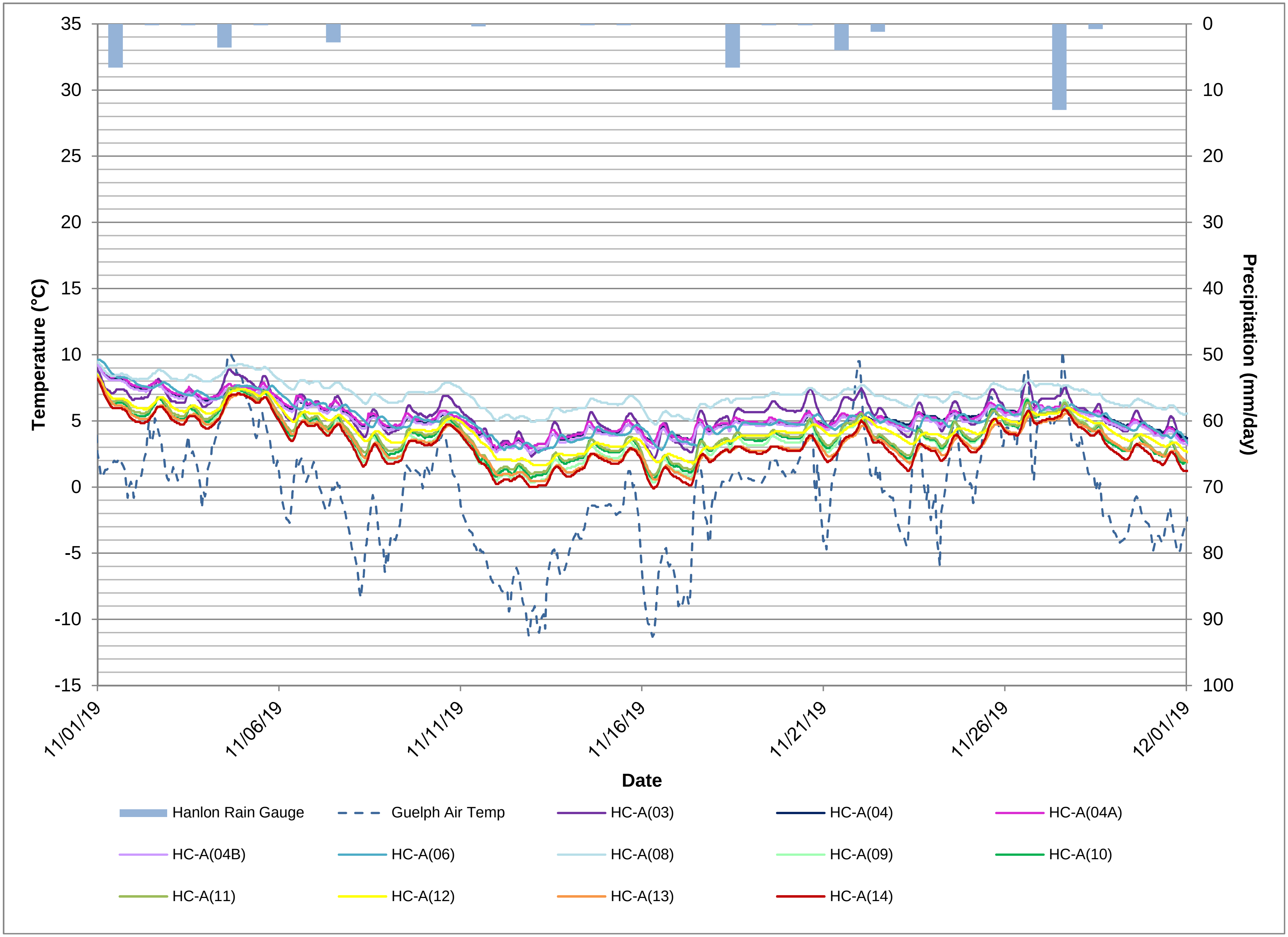

Temperature (°C)
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Date
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
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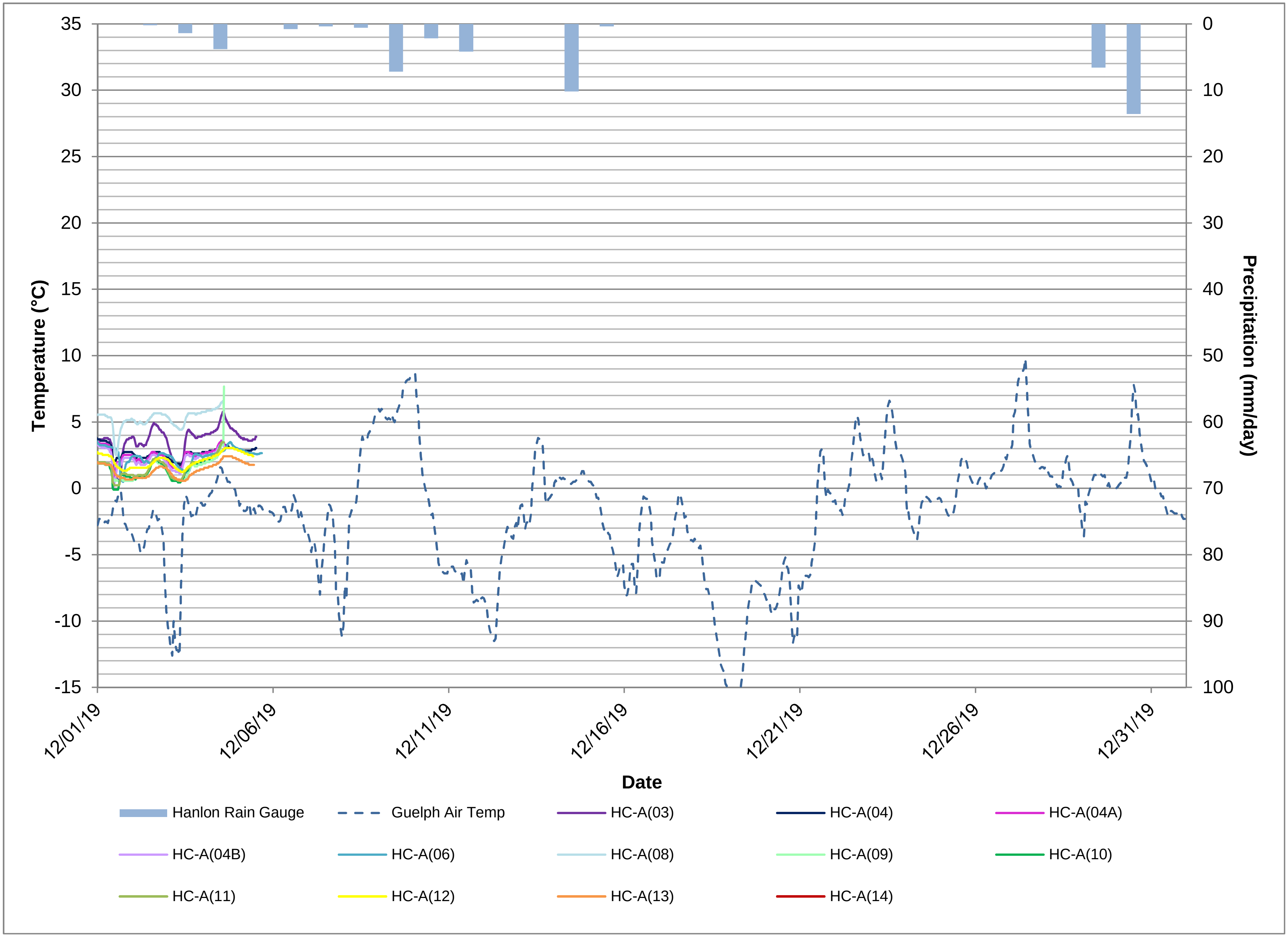

Temperature (°C)
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Date
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
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Appendix B

Historical Comparison of Statistical Stream Temperatures

Station	**HC-A(03)**									
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011***
Summer (July-August) average maximum	14.5 - 19.9	15.87	17.66	14.42	17.87	18.03	15.68	15.60	19.34	19.01
Summer (July-August) average	12.5 - 14.5	13.06	14.53	12.71	15.59	14.56	13.13	13.59	18.00	18.28
Summer (July-August) average minimum	9.0 - 12.0	11.06	12.32	11.42	13.25	11.83	11.23	12.02	16.66	16.67
Maximum 3-day mean	14.0 - 19.0	14.33	16.96	13.59	18.75	17.27	14.72	16.03	20.39	21.50
Maximum 7-day mean	13.0 - 17.0	14.00	15.70	13.29	17.93	16.69	14.28	15.09	19.38	20.77
Maximum 7-day mean of daily maximums	15.0 - 23.5	16.97	18.83	15.35	19.84	21.05	16.88	18.05	20.81	21.94
Hours over 19°C	15.4	0.00	25.50	0.00	76.00	84.25	0.00	5.00	384.50	237.50
Percent of Time over 19°C	1.04%	0.00%	1.71%	0.00%	5.00%	5.66%	0.00%	0.34%	25.84%	41.00%
Frequency of Exceedance over 19°C (Days/yr)	4.1	0.00	10.00	0.00	13.00	19.00	0.00	1.00	40.00	17.00
Average Duration of Event Over 19°C (h)	3.1	0.00	2.55	0.00	5.43	4.01	0.00	5.00	9.86	14.84
Hours over 22°C		0.00	0.00	0.00	0.00	0.25	0.00	0.00	4.25	32.00
Percent of Time over 22°C		0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.29%	6.00%
Frequency of Exceedance over 22°C (Days/yr)		0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	6.00
Average Duration of Event Over 22°C (h)		0.00	0.00	0.00	0.00	0.25	0.00	0.00	1.81	5.33
Hours over 24°C	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.25
Percent of Time over 24°C	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Average Duration of Event Over 24°C (h)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.25

Station	**HC-A(04)**											
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	20.02		19.38	22.47	20.91	20.03	20.52	23.56	19.63	18.30	15.50
Summer July-August) average	12.5 - 14.5	19.45	N/A	18.84	21.28	19.54	19.02	19.55	22.41	17.74	15.50	13.80
Summer (July-August) average minimum	9.0 - 12.0	18.91	N/A	18.31	18.70	18.21	18.06	18.66	21.29	16.10	13.40	12.60
Maximum 3-day mean	14.0 - 19.0	20.93	N/A	20.12	23.40	21.73	20.27	23.23	24.18	21.45	15.00	13.20
Maximum 7-day mean	13.0 - 17.0	20.37	N/A	19.54	22.87	21.47	19.61	22.36	23.53	19.77	14.50	12.80
Maximum 7-day mean of daily maximums	15.0 - 23.5	20.96	N/A	20.17	23.54	22.83	21.05	23.35	25.65	21.57	16.80	14.80
Hours over 19°C	51.1	956.50	N/A	600.00	1329.50	920.00	771.00	924.00	1477.50	452.50	101.50	0.00
Percent of Time over 19°C	3.44%	64.28%	N/A	40.98%	90.00%	61.83%	51.81%	62.10%	99.39%	30.00%	8.80%	0.00%
Frequency of Exceedance over 19°C (Days/yr)	9.4	41.00	N/A	40.00	61.00	55.00	53.00	55.00	62.00	40.00	19.00	0.00
Average Duration of Event Over 19°C (h)	5	53.06	N/A	20.69	73.86	21.90	16.76	27.18	295.50	14.60	5.30	0.00
Hours over 22°C		0.00	N/A	0.00	564.25	96.75	3.75	101.00	901.00	35.75	0.00	0.00
Percent of Time over 22°C		0.00%	N/A	0.00%	38.00%	6.50%	0.25%	6.79%	60.61%	2.00%	0.00%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		0.00	N/A	0.00	41.00	16.00	2.00	6.00	48.00	7.00	0.00	0.00
Average Duration of Event Over 22°C (h)		0.00	N/A	0.00	15.94	5.17	0.95	35.28	45.03	5.11	0.00	0.00
Hours over 24°C	0	0.00	N/A	0.00	21.00	0.00	0.00	20.50	182.25	4.50	0.00	0.00
Percent of Time over 24°C	0.00%	0.00%	N/A	0.00%	1.42%	0.00%	0.00%	1.38%	12.26%	0.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	N/A	0.00	2.00	0.00	0.00	2.00	24.00	1.00	0.00	0.00
Average Duration of Event Over 24°C (h)		0.00	N/A	0.00	21.00	0.00	0.00	10.25	5.88	4.50	0.00	0.00

Station	**HC-A(04A)**				
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**
Summer (July-August) average maximum	14.5 - 19.9	21.59	N/A	16.30	22.77
Summer (July-August) average	12.5 - 14.5	20.62	N/A	19.81	21.33
Summer (July-August) average minimum	9.0 - 12.0	19.70	N/A	15.07	18.90
Maximum 3-day mean	14.0 - 19.0	22.47	N/A	21.20	23.40
Maximum 7-day mean	13.0 - 17.0	22.14	N/A	20.48	22.99
Maximum 7-day mean of daily maximums	15.0 - 23.5	22.94	N/A	21.47	23.91
Hours over 19°C		1319.50	N/A	934.50	1312.75
Percent of Time over 19°C		88.68%	N/A	63.83%	89.00%
Frequency of Exceedance over 19°C (Days/yr)		57.00	N/A	49.00	62.00
Average Duration of Event Over 19°C (h)		94.28	N/A	35.94	65.64
Hours over 22°C		243.50	N/A	5.25	604.00
Percent of Time over 22°C		16.36%	N/A	0.36%	41.00%
Frequency of Exceedance over 22°C (Days/yr)		8.00	N/A	1.00	47.00
Average Duration of Event Over 22°C (h)		12.73	N/A	5.25	23.96
Hours over 24°C		0.00	N/A	0.00	29.25
Percent of Time over 24°C		0.00%	N/A	0.00%	1.99%
Frequency of 24°C Exceedance (Days/yr)		0.00	N/A	0.00	3.00
Average Duration of Event Over 24°C (h)		0.00	N/A	0.00	14.63

Station	HC-A(04B)				
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**
Summer (July-August) average maximum	14.5 - 19.9	21.78	N/A	16.44	22.83
Summer July-August) average	12.5 - 14.5	19.79	N/A	19.89	21.44
Summer (July-August) average minimum	9.0 - 12.0	18.29	N/A	15.11	18.48
Maximum 3-day mean	14.0 - 19.0	21.94	N/A	21.27	23.36
Maximum 7-day mean	13.0 - 17.0	21.59	N/A	20.57	22.94
Maximum 7-day mean of daily maximums	15.0 - 23.5	22.57	N/A	21.68	24.02
Hours over 19°C		1065.50	N/A	956.50	1338.00
Percent of Time over 19°C		71.61%	N/A	65.33%	91.00%
Frequency of Exceedance over 19°C (Days/yr)		45.00	N/A	49.00	62.00
Average Duration of Event Over 19°C (h)		71.05	N/A	43.48	63.71
Hours over 22°C		130.00	N/A	6.50	600.75
Percent of Time over 22°C		8.74%	N/A	0.44%	41.00%
Frequency of Exceedance over 22°C (Days/yr)		3.00	N/A	1.00	50.00
Average Duration of Event Over 22°C (h)		3.91	N/A	6.50	23.89
Hours over 24°C		0.00	N/A	0.00	30.25
Percent of Time over 24°C		0.00%	N/A	0.00%	2.06%
Frequency of 24°C Exceedance (Days/yr)		0.00	N/A	0.00	4.00
Average Duration of Event Over 24°C (h)		0.00	N/A	0.00	10.08

Station	HC-A(06)											
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	21.26	22.23	20.31	22.77	21.64	20.42	20.63	24.07	19.98	19.70	16.10
Summer July-August) average	12.5 - 14.5	20.14	20.69	19.26	20.97	18.86	18.95	19.48	21.88	18.02	16.70	13.90
Summer (July-August) average minimum	9.0 - 12.0	19.07	19.43	18.33	17.11	16.31	17.79	18.49	20.22	16.01	14.30	12.50
Maximum 3-day mean	14.0 - 19.0	22.15	22.78	20.97	22.90	21.39	20.10	23.12	24.18	21.65	16.00	13.30
Maximum 7-day mean	13.0 - 17.0	21.79	21.75	20.24	22.46	21.11	19.51	22.29	23.32	19.96	15.20	12.80
Maximum 7-day mean of daily maximums	15.0 - 23.5	22.66	23.21	21.38	23.76	25.43	21.58	23.60	26.17	21.90	17.70	15.10
Hours over 19°C	0.9	1133.00	1322.50	911.00	1263.00	753.25	728.75	902.25	1386.75	512.00	269.75	0.00
Percent of Time over 19°C	0.00%	76.14%	88.88%	62.23%	86.00%	50.62%	48.98%	60.64%	93.20%	35.00%	18.10%	0.00%
Frequency of Exceedance over 19°C (Days/yr)	0.3	51.00	62.00	53.00	61.00	57.00	56.00	57.00	62.00	46.00	38.00	0.00
Average Duration of Event Over 19°C (h)	3	55.47	49.16	23.36	52.63	10.46	12.35	24.39	99.05	12.80	7.10	0.00
Hours over 22°C		136.50	269.00	4.25	473.50	107.00	5.00	99.25	685.25	55.50	19.25	0.00
Percent of Time over 22°C		9.17%	18.08%	0.29%	32.00%	7.19%	0.34%	6.67%	46.05%	4.00%	1.30%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		4.00	40.00	2.00	49.00	24.00	2.00	7.00	55.00	8.00	7.00	0.00
Average Duration of Event Over 22°C (h)		5.12	6.56	2.13	9.60	3.39	1.01	23.21	14.35	6.94	2.75	0.00
Hours over 24°C	0	0.00	0.50	0.00	17.25	14.75	0.00	12.50	193.50	6.50	0.00	0.00
Percent of Time over 24°C	0.00%	0.00%	0.03%	0.00%	1.17%	0.99%	0.00%	0.84%	13.00%	0.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	1.00	0.00	1.00	8.00	0.00	2.00	35.00	1.00	0.00	0.00
Average Duration of Event Over 24°C (h)		0.00	0.50	0.00	17.25	1.64	0.00	6.25	5.23	6.50	0.00	0.00

Station	HC-A(08)											
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	13.28	14.01	13.15	8.24	14.45	8.55	18.16	15.00	14.40	14.10	13.90
Summer July-August) average	12.5 - 14.5	11.70	12.37	11.89	13.07	12.60	12.21	16.03	13.56	12.56	13.00	13.00
Summer (July-August) average minimum	9.0 - 12.0	10.58	11.25	11.00	6.53	11.28	6.17	14.37	12.40	11.21	12.10	12.20
Maximum 3-day mean	14.0 - 19.0	12.78	13.96	12.75	14.36	16.18	13.38	20.82	16.57	14.43	12.40	12.60
Maximum 7-day mean	13.0 - 17.0	12.49	13.34	12.63	13.97	15.48	12.95	20.23	15.46	13.42	12.00	12.30
Maximum 7-day mean of daily maximums	15.0 - 23.5	13.89	14.67	13.91	15.59	19.12	15.53	22.42	17.28	16.00	12.90	12.30
Hours over 19°C		0.00	0.00	0.00	0.00	3.75	0.00	393.25	8.50	0.00	19.25	0.00
Percent of Time over 19°C		0.00%	0.00%	0.00%	0.00%	0.25%	0.00%	26.43%	0.57%	0.00%	1.60%	0.00%
Frequency of Exceedance over 19°C (Days/yr)		0.00	0.00	0.00	0.00	5.00	0.00	38.00	2.00	0.00	3.00	0.00
Average Duration of Event Over 19°C (h)		0.00	0.00	0.00	0.00	0.63	0.00	10.63	4.25	0.00	6.40	0.00
Hours over 22°C		0.00	0.00	0.00	0.00	0.00	0.00	41.75	0.00	0.00	0.00	0.00
Percent of Time over 22°C		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.81%	0.00%	0.00%	0.00%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00
Average Duration of Event Over 22°C (h)		0.00	0.00	0.00	0.00	0.00	0.00	2.69	0.00	0.00	0.00	0.00
Hours over 24°C		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent of Time over 24°C		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average Duration of Event Over 24°C (h)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Station	HC-A(09)										
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	23.09	23.69	21.37	23.37	22.34	21.80	21.75	23.70	20.72	19.70	17.20
Summer July-August) average	12.5 - 14.5	20.17	20.83	19.07	20.79	19.18	18.62	19.24	20.33	18.85	17.90	15.00
Summer (July-August) average minimum	9.0 - 12.0	17.97	18.61	17.36	18.68	16.76	16.36	17.31	17.57	17.11	16.30	13.10
Maximum 3-day mean	14.0 - 19.0	22.81	22.50	20.69	22.81	21.97	20.43	23.46	23.92	22.26	17.10	n/a
Maximum 7-day mean	13.0 - 17.0	22.14	21.86	20.17	22.02	21.31	19.47	22.63	22.45	20.67	16.20	n/a
Maximum 7-day mean of daily maximums	15.0 - 23.5	24.55	25.86	23.22	24.69	25.49	23.03	25.67	26.75	23.00	18.90	n/a
Hours over 19°C	10	1006.50	1163.00	738.00	1200.00	742.25	621.50	784.00	1014.75	701.00	506.25	11.75
Percent of Time over 19°C	0.67%	67.64%	78.16%	50.41%	81.00%	49.88%	41.77%	52.69%	68.20%	47.00%	34.00%	215.00%
Frequency of Exceedance over 19°C (Days/yr)	2.8	50.00	62.00	55.00	62.00	58.00	60.00	59.00	62.00	54.00	28.00	3.00
Average Duration of Event Over 19°C (h)	3.4	30.75	30.32	13.92	37.50	14.55	10.90	16.33	23.06	17.10	18.10	3.90
Hours over 22°C		350.50	439.50	85.00	448.50	223.75	106.25	171.25	417.50	115.50	52.00	0.00
Percent of Time over 22°C		23.56%	29.54%	5.81%	30.00%	15.04%	7.14%	11.51%	28.06%	8.00%	3.40%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		6.00	54.00	21.00	57.00	38.00	26.00	22.00	46.00	13.00	6.00	0.00
Average Duration of Event Over 22°C (h)		4.75	30.21	4.05	6.42	3.90	2.66	8.22	7.90	8.88	8.70	0.00
Hours over 24°C	0	50.50	105.50	1.75	80.50	47.50	13.50	41.75	169.00	10.75	5.50	0.00
Percent of Time over 24°C	0.00%	3.39%	7.09%	0.12%	5.41%	3.19%	0.91%	2.81%	11.36%	1.00%	0.40%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	24.00	2.00	17.00	10.00	6.00	6.00	26.00	1.00	2.00	0.00
Average Duration of Event Over 24°C (h)		2.22	4.22	0.88	4.74	4.75	2.25	6.96	6.50	10.75	2.75	0.00

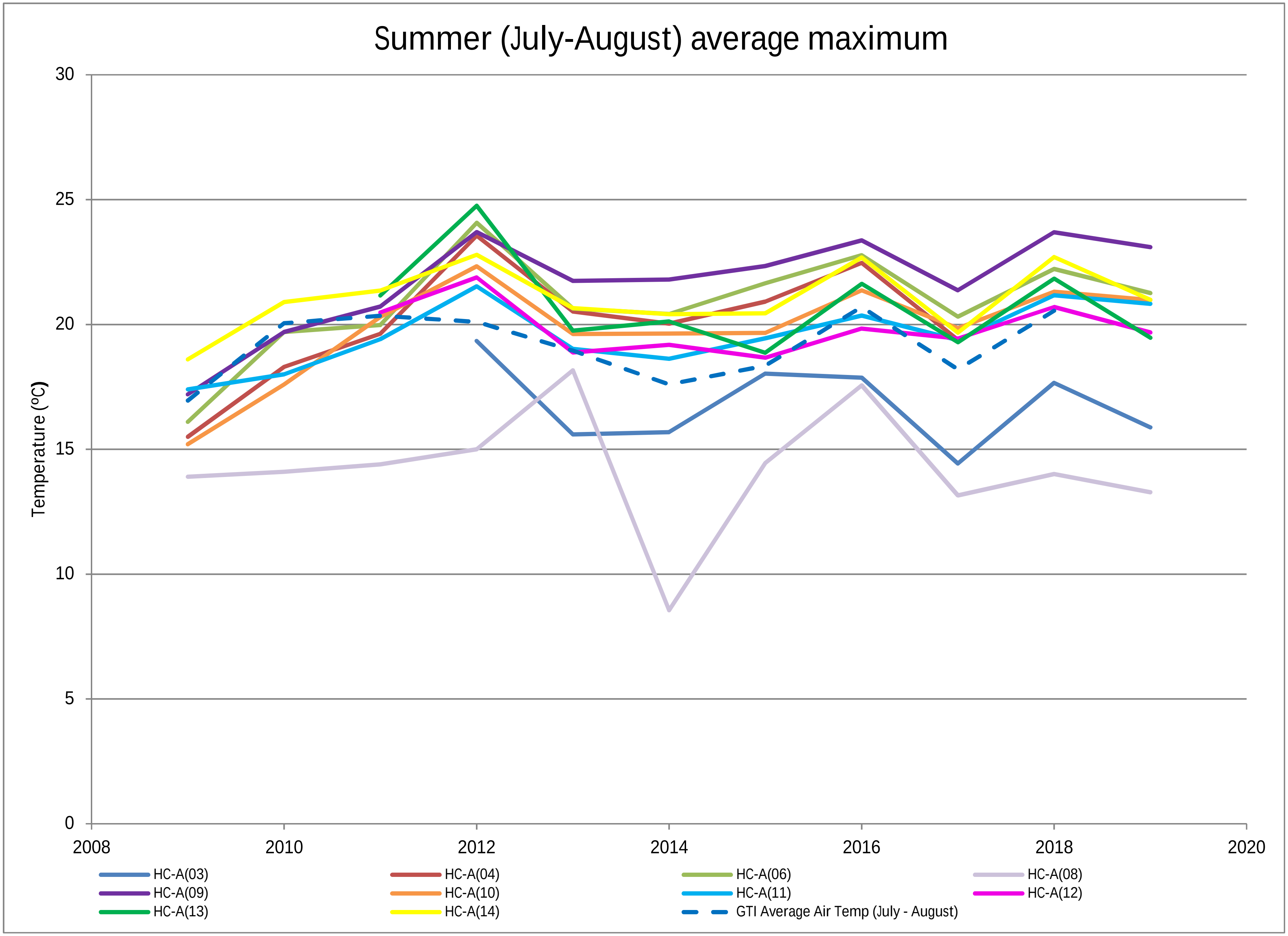
Station	HC-A(10)											
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	20.98	21.32	19.86	21.37	19.66	19.63	19.62	22.33	20.30	17.60	15.20
Summer July-August) average	12.5 - 14.5	18.40	18.60	17.59	18.67	16.89	16.88	17.34	18.00	18.28	14.70	13.70
Summer (July-August) average minimum	9.0 - 12.0	16.39	16.53	15.89	16.50	14.81	14.82	15.59	14.99	16.47	12.50	12.70
Maximum 3-day mean	14.0 - 19.0	20.94	20.44	19.08	20.60	19.34	18.74	21.06	20.64	21.93	14.00	n/a
Maximum 7-day mean	13.0 - 17.0	20.33	19.67	18.50	19.79	18.85	17.76	20.31	19.48	20.26	13.40	n/a
Maximum 7-day mean of daily maximums	15.0 - 23.5	22.58	22.95	21.34	22.65	21.31	21.20	23.20	29.53	22.67	14.80	n/a
Hours over 19°C	58.4	611.00	636.25	298.75	692.75	260.25	221.75	295.00	513.50	573.75	18.75	0.00
Percent of Time over 19°C	3.93%	41.06%	42.76%	20.41%	47.00%	17.49%	14.90%	19.83%	34.67%	39.00%	1.20%	0.00%
Frequency of Exceedance over 19°C (Days/yr)	10.3	19.00	57.00	45.00	61.00	44.00	40.00	33.00	53.00	50.00	7.00	0.00
Average Duration of Event Over 19°C (h)	5.2	21.29	11.63	6.36	12.60	5.66	5.28	9.52	9.01	13.99	2.70	0.00
Hours over 22°C		54.50	75.25	3.75	84.25	12.50	9.50	36.00	121.25	92.50	0.00	0.00
Percent of Time over 22°C		3.66%	5.06%	0.26%	6.00%	0.84%	0.64%	2.42%	8.19%	6.00%	0.00%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		0.00	16.00	2.00	20.00	6.00	4.00	6.00	25.00	14.00	0.00	0.00
Average Duration of Event Over 22°C (h)		2.45	4.70	1.88	3.28	1.40	1.97	3.27	3.28	6.61	0.00	0.00
Hours over 24°C	0.4	2.00	1.00	0.00	0.00	0.00	0.00	2.00	46.75	9.50	0.00	0.00
Percent of Time over 24°C	0.03%	0.13%	0.07%	0.00%	0.00%	0.00%	0.00%	0.13%	3.16%	1.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	1.00	0.00	0.00	0.00	0.00	2.00	12.00	1.00	0.00	0.00
Average Duration of Event Over 24°C (h)		1.25	1.00	0.00	0.00	0.00	0.00	1.00	3.60	9.50	0.00	0.00

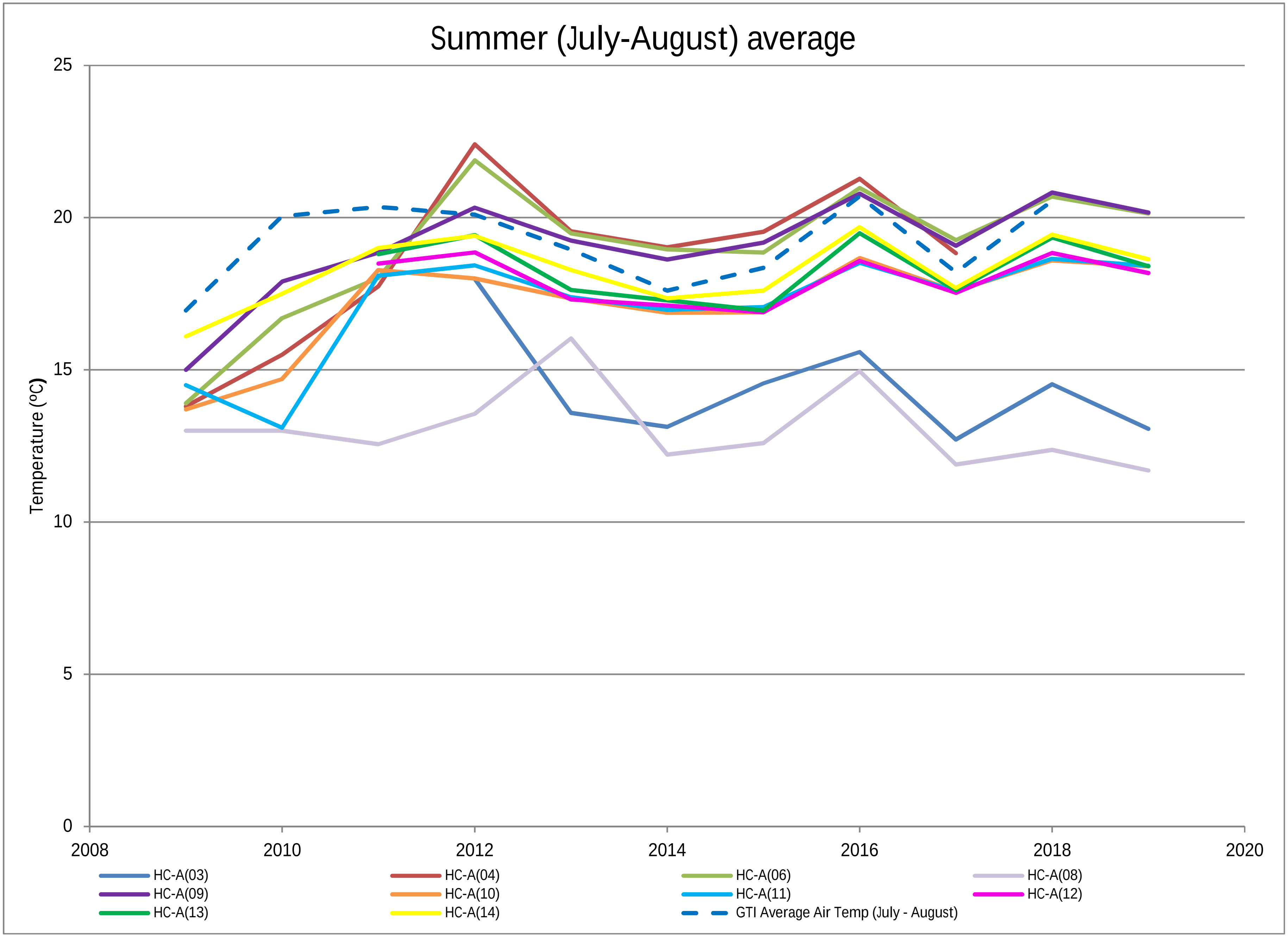
Station	HC-A(11)											
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	20.82	21.17	19.37	20.36	19.45	18.63	19.03	21.53	19.41	18.00	17.40
Summer July-August) average	12.5 - 14.5	18.41	18.65	17.59	18.51	17.06	16.97	17.39	18.43	18.09	13.10	14.50
Summer (July-August) average minimum	9.0 - 12.0	16.49	16.68	16.18	16.95	15.19	15.60	16.10	16.04	16.84	15.10	12.30
Maximum 3-day mean	14.0 - 19.0	20.95	20.45	19.02	20.31	19.40	18.89	20.67	21.09	20.96	14.40	n/a
Maximum 7-day mean	13.0 - 17.0	20.34	19.73	18.49	19.61	18.94	17.87	20.00	19.90	19.97	13.80	n/a
Maximum 7-day mean of daily maximums	15.0 - 23.5	22.49	22.84	20.56	21.23	21.00	19.88	21.69	23.43	20.79	15.30	n/a
Hours over 19°C	57.8	605.00	649.00	259.25	611.50	259.00	135.50	264.25	587.75	457.25	61.50	11.75
Percent of Time over 19°C	3.89%	40.66%	43.62%	17.71%	41.00%	17.41%	9.11%	17.76%	39.50%	31.00%	4.10%	215.00%
Frequency of Exceedance over 19°C (Days/yr)	9.8	19.00	57.00	38.00	55.00	43.00	23.00	30.00	56.00	37.00	12.00	6.00
Average Duration of Event Over 19°C (h)	5.6	21.43	12.08	6.65	12.48	5.89	5.89	9.44	11.09	9.33	5.10	2.00
Hours over 22°C		45.50	67.75	0.00	15.25	3.25	0.00	11.00	117.50	13.50	11.25	0.00
Percent of Time over 22°C		3.06%	4.55%	0.00%	1.00%	0.22%	0.00%	0.74%	7.90%	1.00%	0.80%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		0.00	15.00	0.00	6.00	1.00	0.00	4.00	26.00	3.00	4.00	0.00
Average Duration of Event Over 22°C (h)		2.46	4.52	0.00	2.34	1.75	0.00	1.77	3.40	4.50	2.80	0.00
Hours over 24°C	0.8	1.50	1.00	0.00	0.00	0.00	0.00	0.00	23.75	0.00	1.00	0.00
Percent of Time over 24°C	0.06%	0.10%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%	1.60%	0.00%	0.07%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	1.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	1.00	0.00
Average Duration of Event Over 24°C (h)		1.00	1.00	0.00	0.00	0.00	0.00	0.00	3.96	0.00	1.00	0.00

Station	HC-A(12)									
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**
Summer (July-August) average maximum	14.5 - 19.9	19.68	20.70	19.44	19.83	18.67	19.18	18.88	21.88	20.48
Summer July-August) average	12.5 - 14.5	18.18	18.84	17.52	18.58	16.89	17.11	17.31	18.86	18.49
Summer (July-August) average minimum	9.0 - 12.0	16.83	17.19	15.95	17.43	15.33	15.41	15.97	16.21	16.71
Maximum 3-day mean	14.0 - 19.0	20.69	20.53	18.99	20.34	19.23	19.36	21.53	22.40	22.02
Maximum 7-day mean	13.0 - 17.0	20.04	19.93	18.48	19.70	18.62	18.38	20.68	20.90	20.32
Maximum 7-day mean of daily maximums	15.0 - 23.5	21.53	22.80	20.86	20.66	21.23	21.12	23.45	25.79	23.04
Hours over 19°C	57.8	497.00	701.00	292.00	615.75	184.00	218.00	226.75	636.50	597.25
Percent of Time over 19°C	3.89%	33.40%	47.11%	19.95%	41.00%	12.37%	14.65%	15.24%	42.89%	40.00%
Frequency of Exceedance over 19°C (Days/yr)	9.8	15.00	55.00	41.00	48.00	25.00	28.00	26.00	51.00	49.00
Average Duration of Event Over 19°C (h)	5.6	24.59	15.31	7.12	16.64	7.36	7.52	9.86	12.48	15.31
Hours over 22°C		8.50	60.25	1.00	0.00	2.50	10.75	43.00	205.00	105.00
Percent of Time over 22°C		0.57%	4.05%	0.07%	0.00%	0.17%	0.72%	2.89%	13.81%	7.00%
Frequency of Exceedance over 22°C (Days/yr)		0.00	12.00	1.00	0.00	1.00	3.00	6.00	30.00	15.00
Average Duration of Event Over 22°C (h)		4.50	5.02	1.00	0.00	1.38	2.06	4.05	4.66	7.00
Hours over 24°C	0.8	0.00	0.00	0.00	0.00	0.00	0.00	9.00	78.50	10.00
Percent of Time over 24°C	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	5.29%	1.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	0.00	0.00	0.00	0.00	0.00	3.00	18.00	1.00
Average Duration of Event Over 24°C (h)		0.00	0.00	0.00	0.00	0.00	0.00	3.00	3.74	10.00

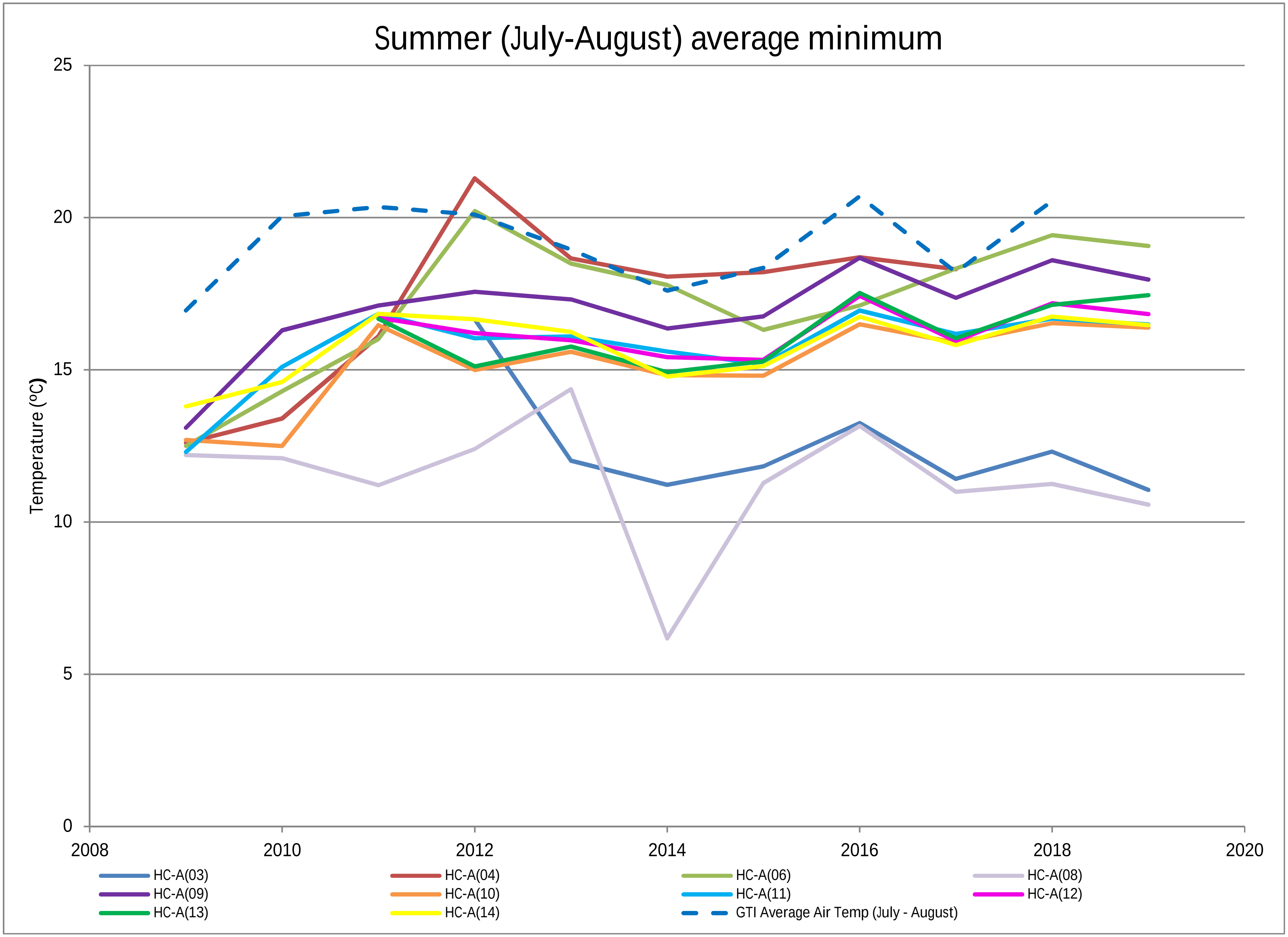
Station	HC-A(13)									
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**
Summer (July-August) average maximum	14.5 - 19.9	19.47	21.84	19.28	21.63	18.87	20.12	19.75	24.76	21.16
Summer July-August) average	12.5 - 14.5	18.40	19.34	17.62	19.49	16.95	17.29	17.63	19.43	18.80
Summer (July-August) average minimum	9.0 - 12.0	17.46	17.14	16.04	17.53	15.28	14.92	15.77	15.11	16.68
Maximum 3-day mean	14.0 - 19.0	20.75	21.01	18.98	21.54	19.23	19.52	21.93	23.42	22.30
Maximum 7-day mean	13.0 - 17.0	20.05	20.43	18.59	20.64	18.62	18.37	21.05	22.01	20.67
Maximum 7-day mean of daily maximums	15.0 - 23.5	20.97	23.66	20.72	23.66	21.23	21.76	24.11	29.89	23.56
Hours over 19°C	57.8	544.00	825.50	299.75	930.50	198.50	350.00	365.75	713.50	690.75
Percent of Time over 19°C	3.89%	36.56%	55.48%	20.47%	63.00%	13.34%	23.52%	24.58%	48.20%	46.00%
Frequency of Exceedance over 19°C (Days/yr)	9.8	17.00	59.00	41.00	61.00	28.00	46.00	35.00	57.00	55.00
Average Duration of Event Over 19°C (h)	5.6	26.39	16.56	7.69	19.80	7.09	7.61	11.43	12.30	14.70
Hours over 22°C		5.50	164.50	0.00	142.75	2.50	28.00	62.25	352.00	138.50
Percent of Time over 22°C		0.37%	11.06%	0.00%	10.00%	0.17%	1.88%	4.18%	23.78%	9.00%
Frequency of Exceedance over 22°C (Days/yr)		0.00	29.00	0.00	22.00	1.00	6.00	9.00	41.00	18.00
Average Duration of Event Over 22°C (h)		3.00	5.67	0.00	4.11	1.38	2.87	4.45	4.90	7.69
Hours over 24°C	0.8	0.00	17.00	0.00	24.25	0.00	0.00	18.00	207.00	16.25
Percent of Time over 24°C	0.06%	0.00%	1.14%	0.00%	1.63%	0.00%	0.00%	1.21%	13.98%	1.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	7.00	0.00	4.00	0.00	0.00	4.00	30.00	4.00
Average Duration of Event Over 24°C (h)		0.00	2.43	0.00	6.06	0.00	0.00	4.50	6.27	4.06

Station	HC-A(14)											
Year	**Modeled**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	20.99	22.70	19.67	22.68	20.44	20.41	20.65	22.79	21.36	20.90	18.60
Summer July-August) average	12.5 - 14.5	18.63	19.44	17.69	19.69	17.60	17.35	18.28	19.40	19.00	17.50	16.10
Summer (July-August) average minimum	9.0 - 12.0	16.47	16.75	15.81	16.74	15.13	14.78	16.24	16.66	16.84	14.60	13.80
Maximum 3-day mean	14.0 - 19.0	21.39	21.26	19.13	21.90	20.23	19.55	22.51	22.67	22.45	16.70	15.40
Maximum 7-day mean	13.0 - 17.0	20.66	20.56	18.74	20.99	19.57	18.46	21.65	21.45	20.86	15.80	14.80
Maximum 7-day mean of daily maximums	15.0 - 23.5	22.68	25.09	20.90	24.70	23.31	22.43	24.66	26.40	23.78	18.30	17.80
Hours over 19°C	130.7	674.50	824.75	357.25	927.75	431.00	383.00	578.50	778.50	741.25	422.25	187.00
Percent of Time over 19°C	8.78%	45.33%	55.43%	24.40%	62.00%	28.97%	26.00%	38.88%	52.32%	50.00%	28.40%	1257.00%
Frequency of Exceedance over 19°C (Days/yr)	26.8	22.00	61.00	46.00	62.00	49.00	50.00	50.00	55.00	56.00	49.00	29.00
Average Duration of Event Over 19°C (h)	4.3	21.71	15.59	7.94	18.56	8.98	7.37	13.15	16.56	12.15	8.60	6.20
Hours over 22°C		84.50	237.25	0.00	260.00	59.00	41.00	86.50	287.25	157.75	95.00	0.50
Percent of Time over 22°C		5.68%	15.94%	0.00%	17.00%	3.97%	3.00%	5.81%	19.30%	11.00%	6.40%	0.03%
Frequency of Exceedance over 22°C (Days/yr)		1.00	39.00	0.00	37.00	14.00	9.00	11.00	37.00	19.00	20.00	1.00
Average Duration of Event Over 22°C (h)		3.06	5.65	0.00	4.57	2.91	4.50	5.15	5.09	8.30	4.75	0.50
Hours over 24°C	3.2	5.00	60.50	0.00	59.00	3.25	3.00	26.75	113.50	28.00	25.75	0.00
Percent of Time over 24°C	0.21%	0.34%	4.07%	0.00%	3.97%	0.22%	0.00%	1.80%	7.63%	2.00%	0.30%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0.00	14.00	0.00	12.00	1.00	1.00	5.00	24.00	9.00	5.00	0.00
Average Duration of Event Over 24°C (h)		2.75	4.32	0.00	4.54	3.25	1.50	5.35	4.37	2.15	5.15	0.00

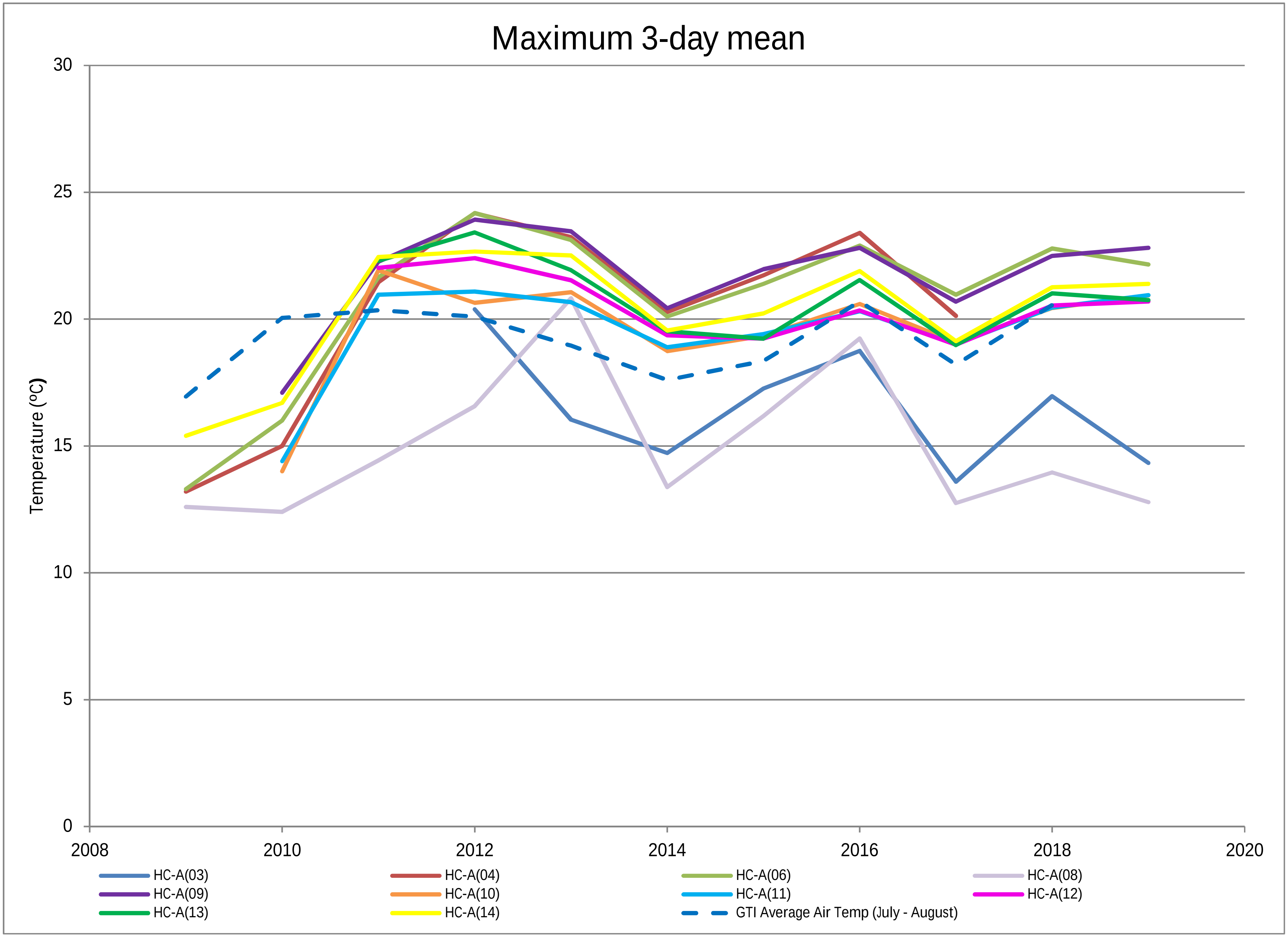

Summer (July-August) average maximum
Temperature (ºC)
30
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



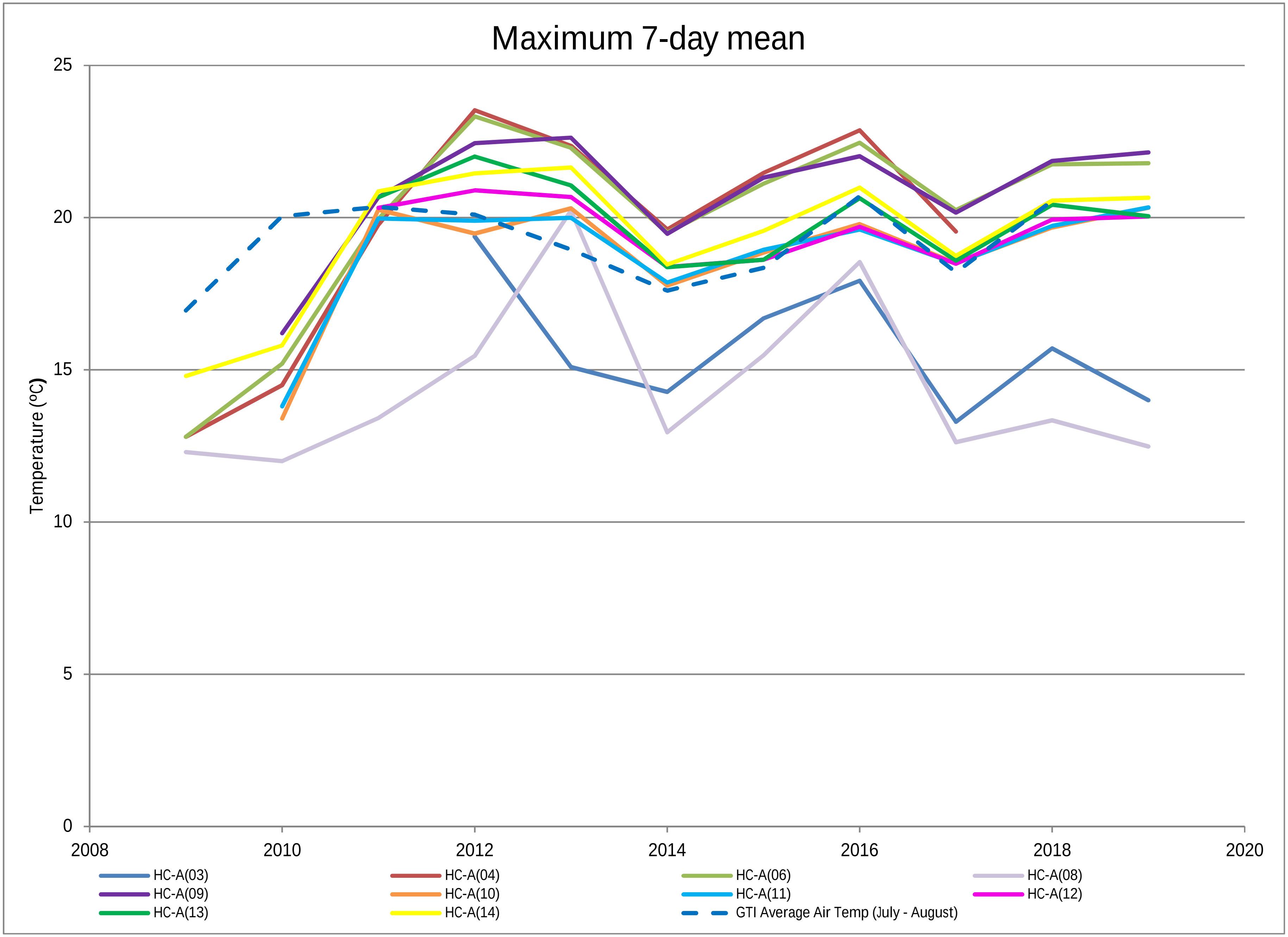
Summer (July-August) average
Temperature (°C)
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

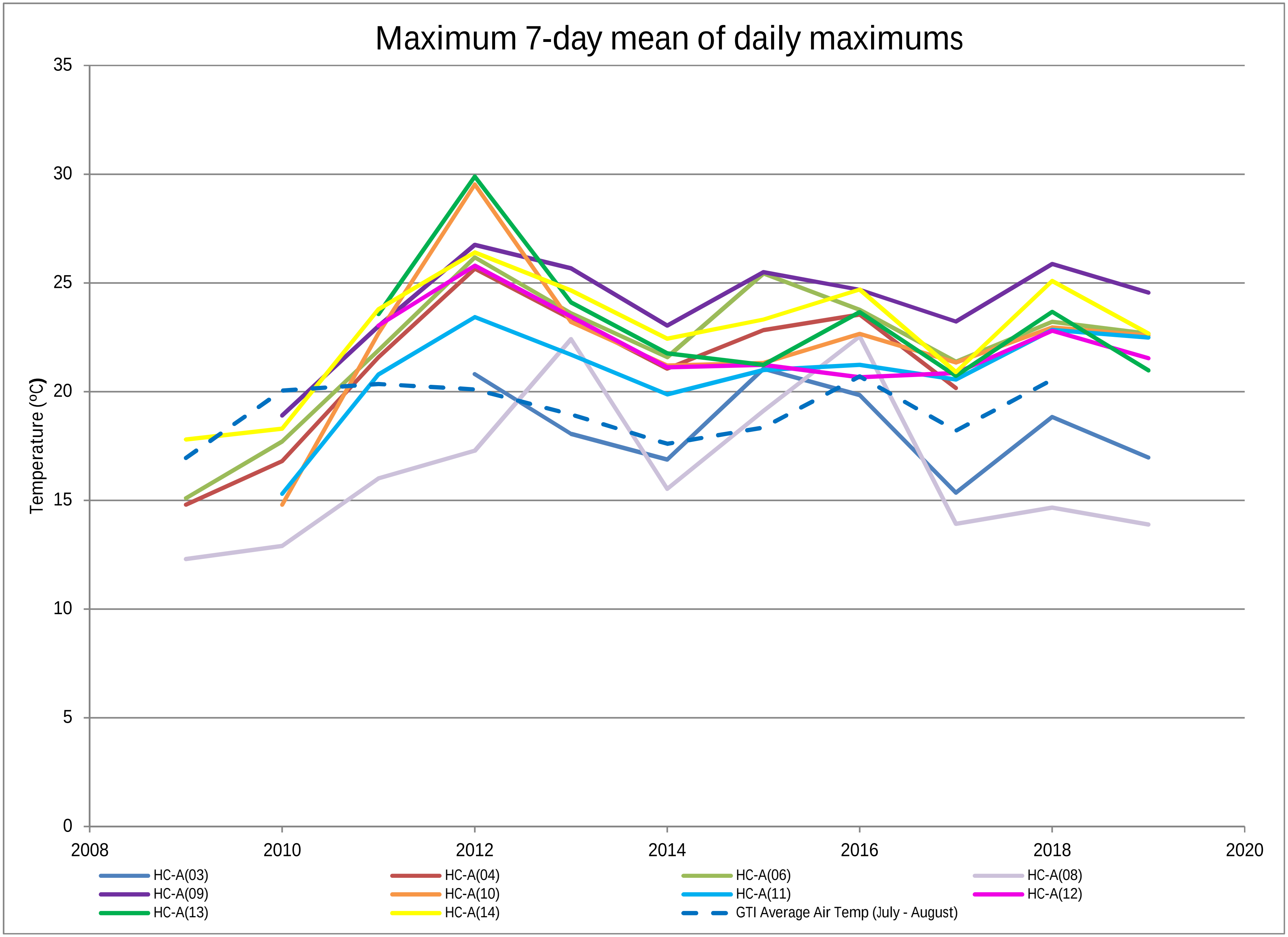


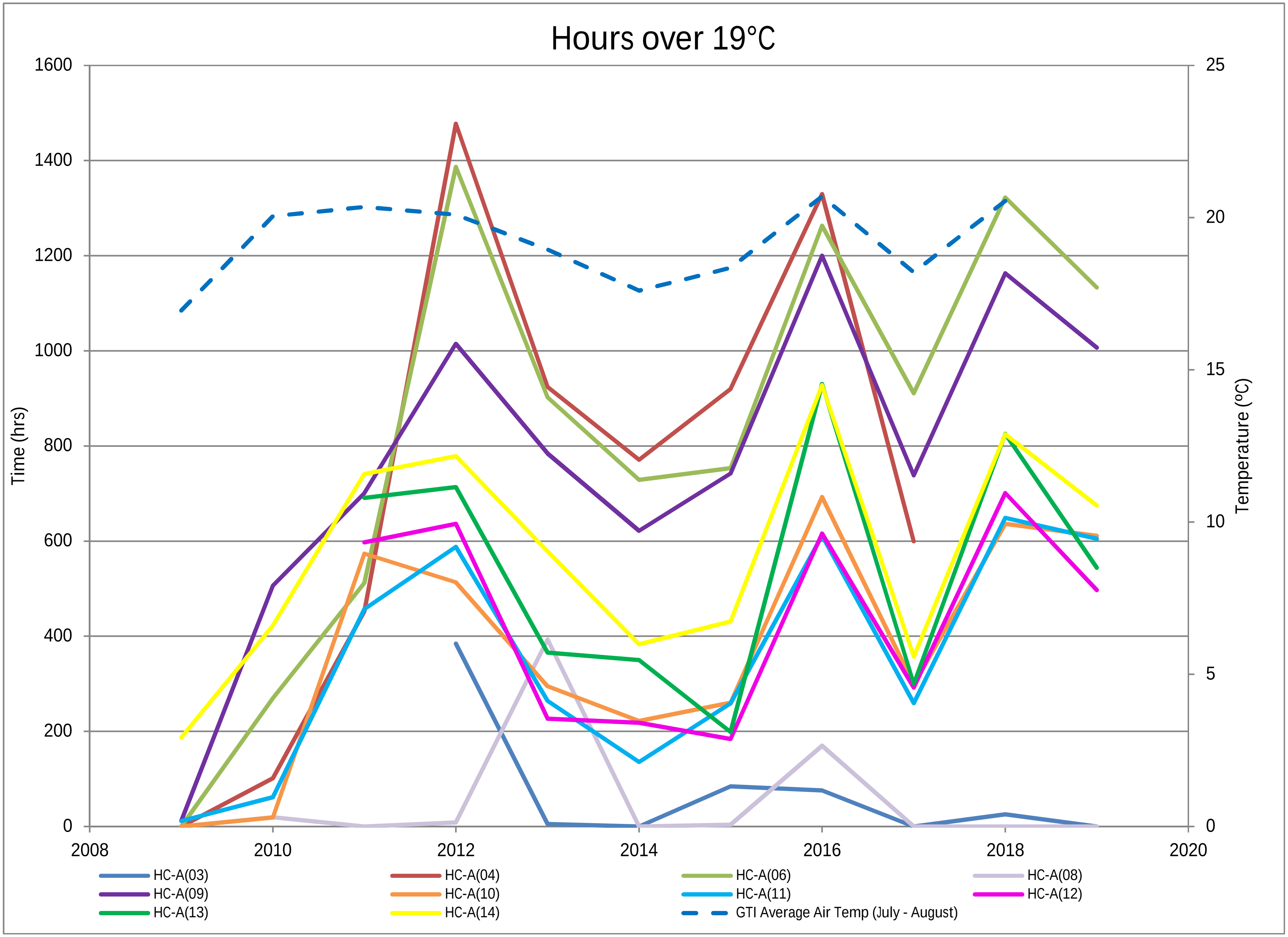
Summer (July-August) average minimum
Temperature (ºC)
0
5
10
15
20
25
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

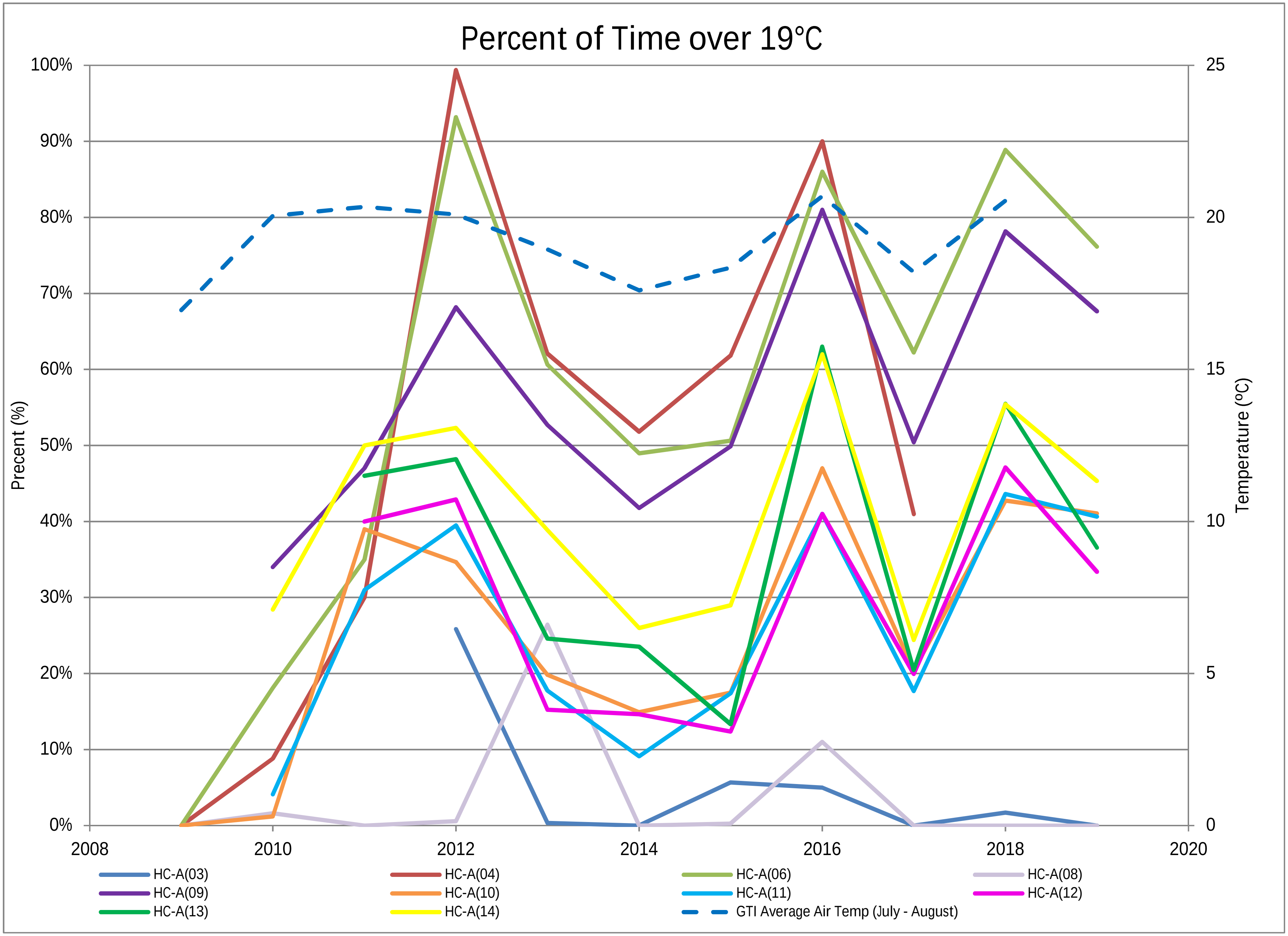


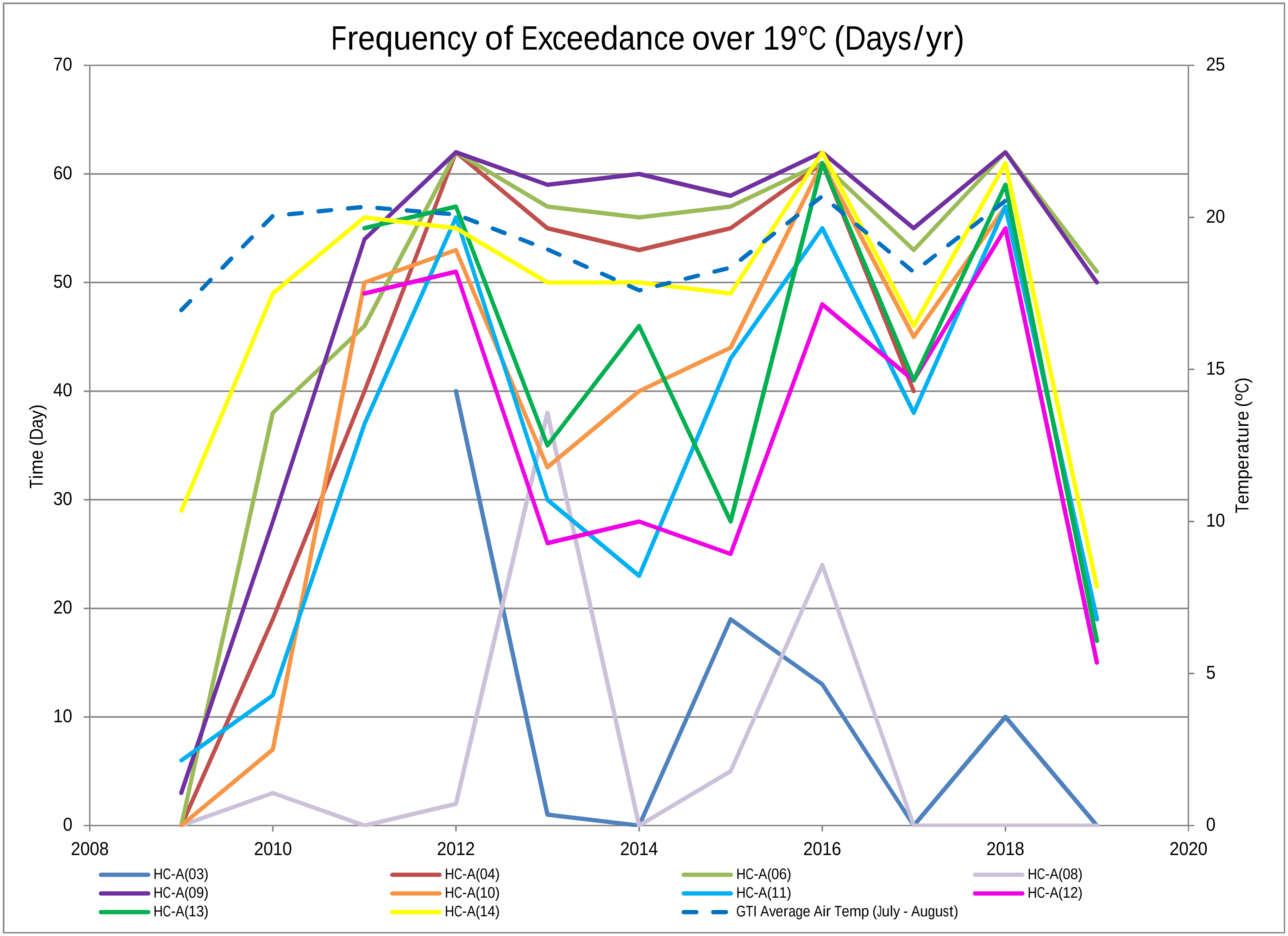
Maximum 3-day mean
Temperature (ºC)
30
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)


Maximum 7-day mean
Temperature (ºC)
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

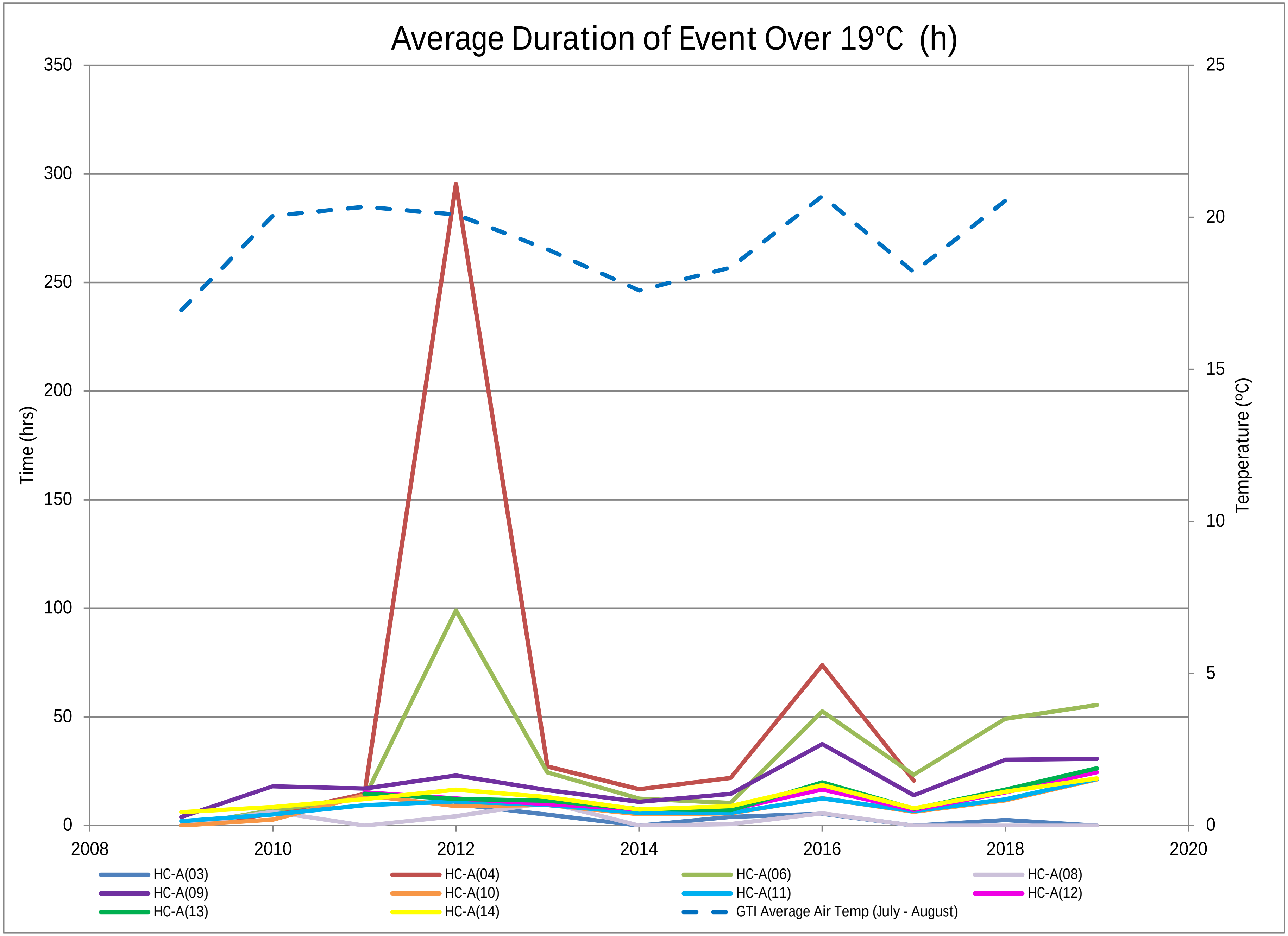

Maximum 7-day mean of daily maximums
Temperature (ºC)
35
30
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)


Hours over 19°C
Time (hrs)
Temperature (°C)
1600
1400
1200
1000
800
600
400
200
0
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

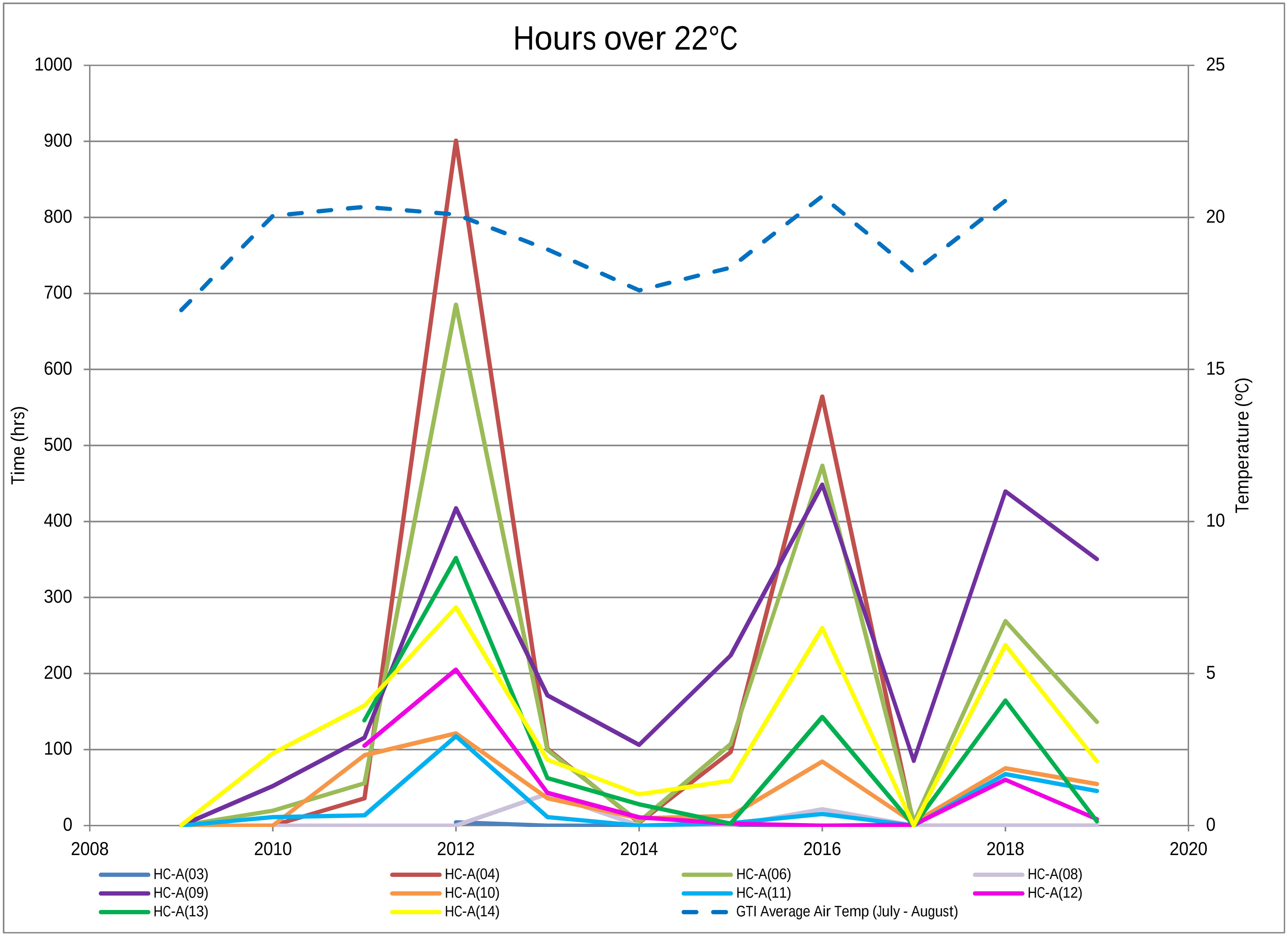

Percent of Time over 19°C
Precent (%)
Temperature (°C)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



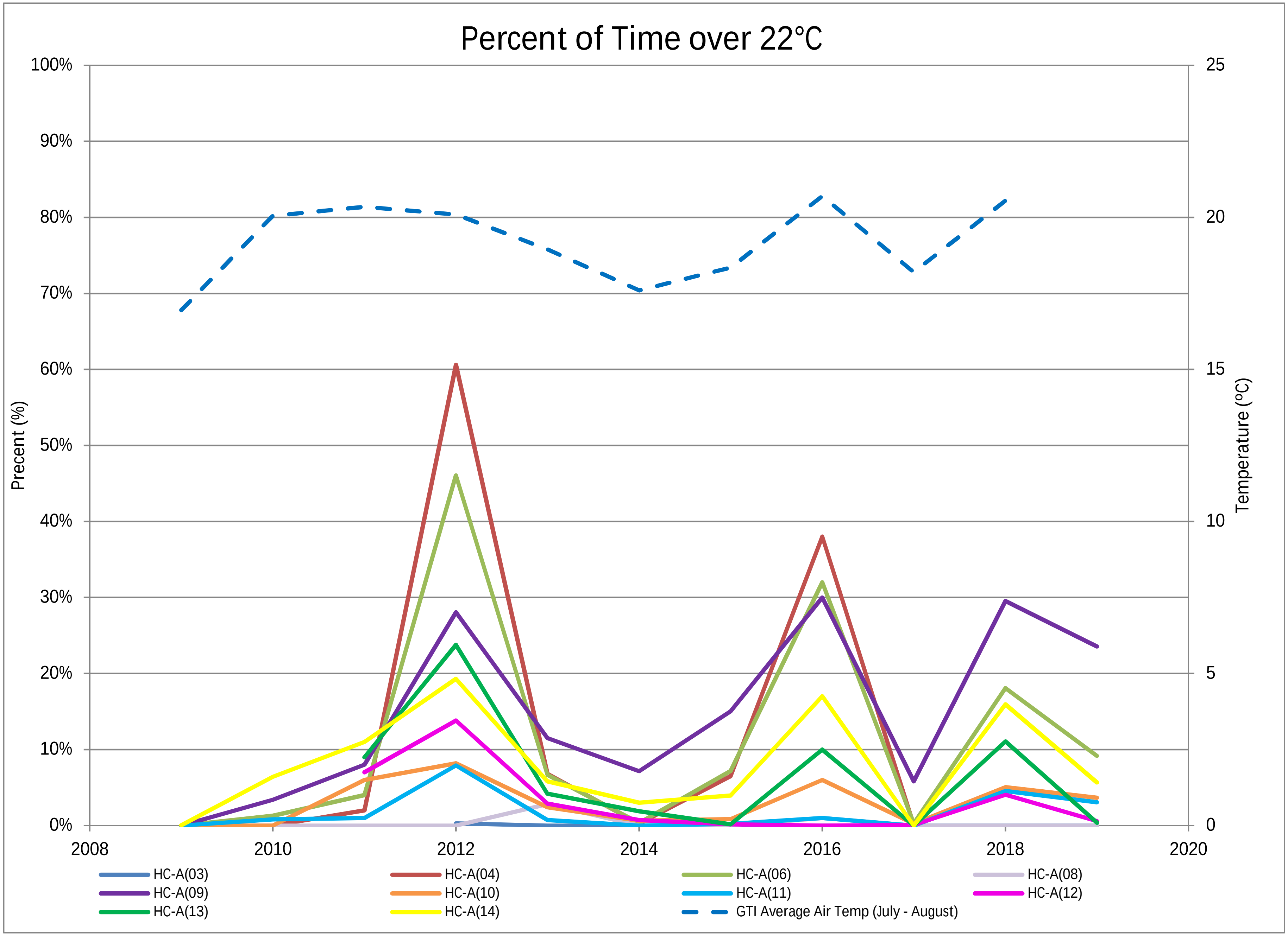
Frequency of Exceedance over 19°C (Days/yr)
Time (Day)
Temperature (°C)
70
60
50
40
30
20
10
0
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

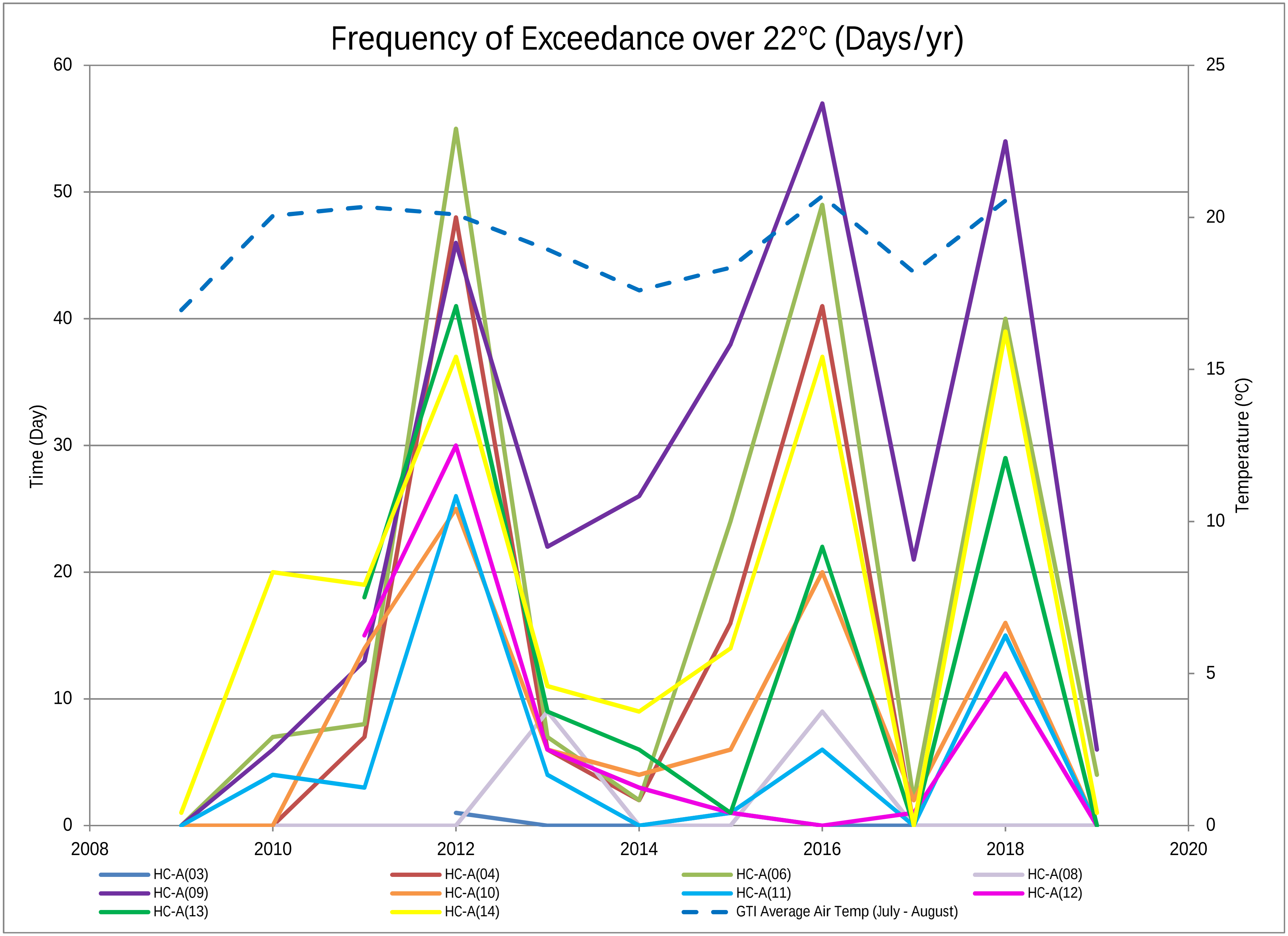


Average Duration of Event Over 19°C (h)
Time (hrs)
Temperature (°C)
350
300
250
200
150
100
50
0
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

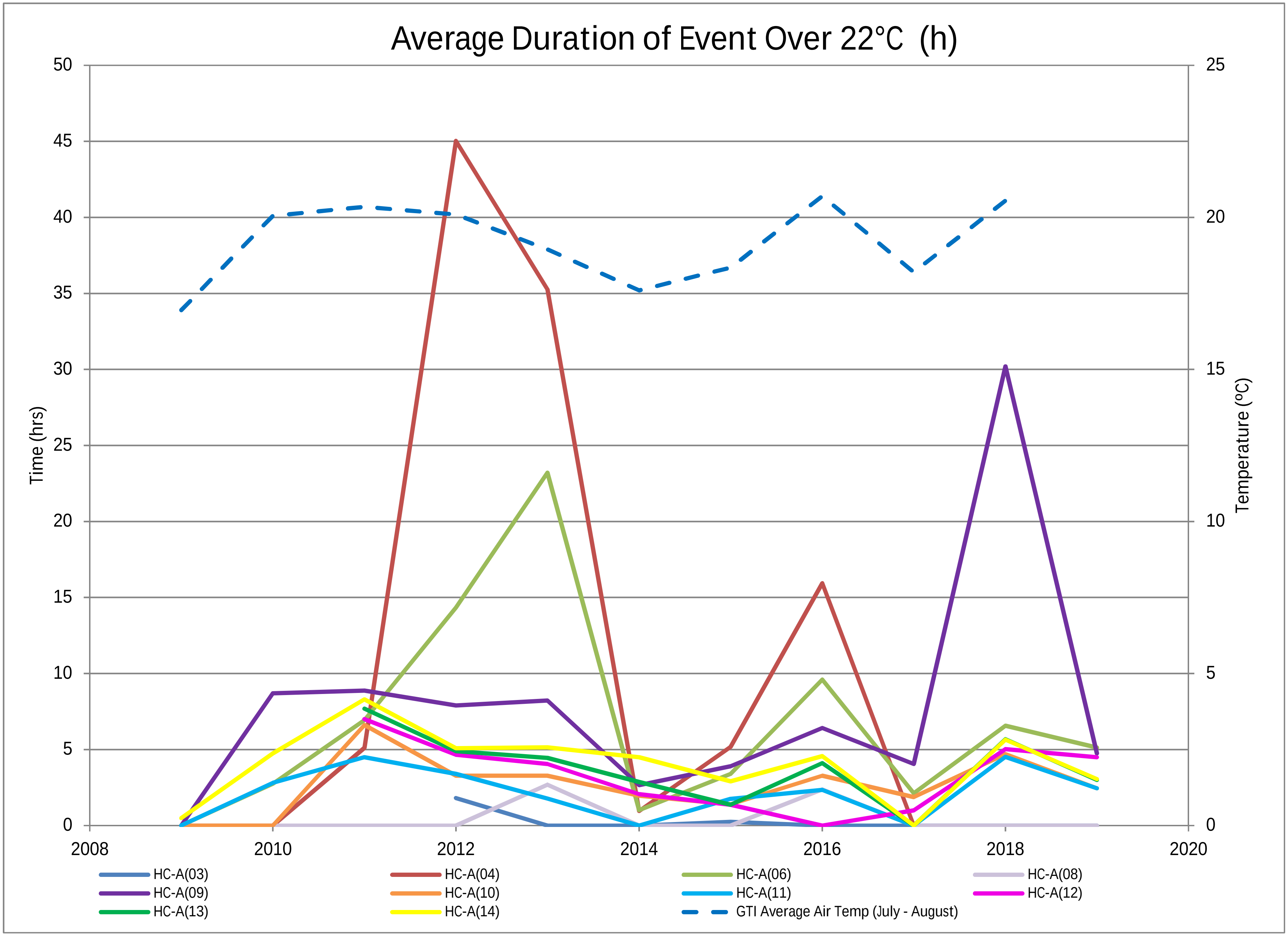


Hours over 22°C
Time (hrs)
Temperature (°C)
1000
900
800
700
600
500
400
300
200
100
0
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

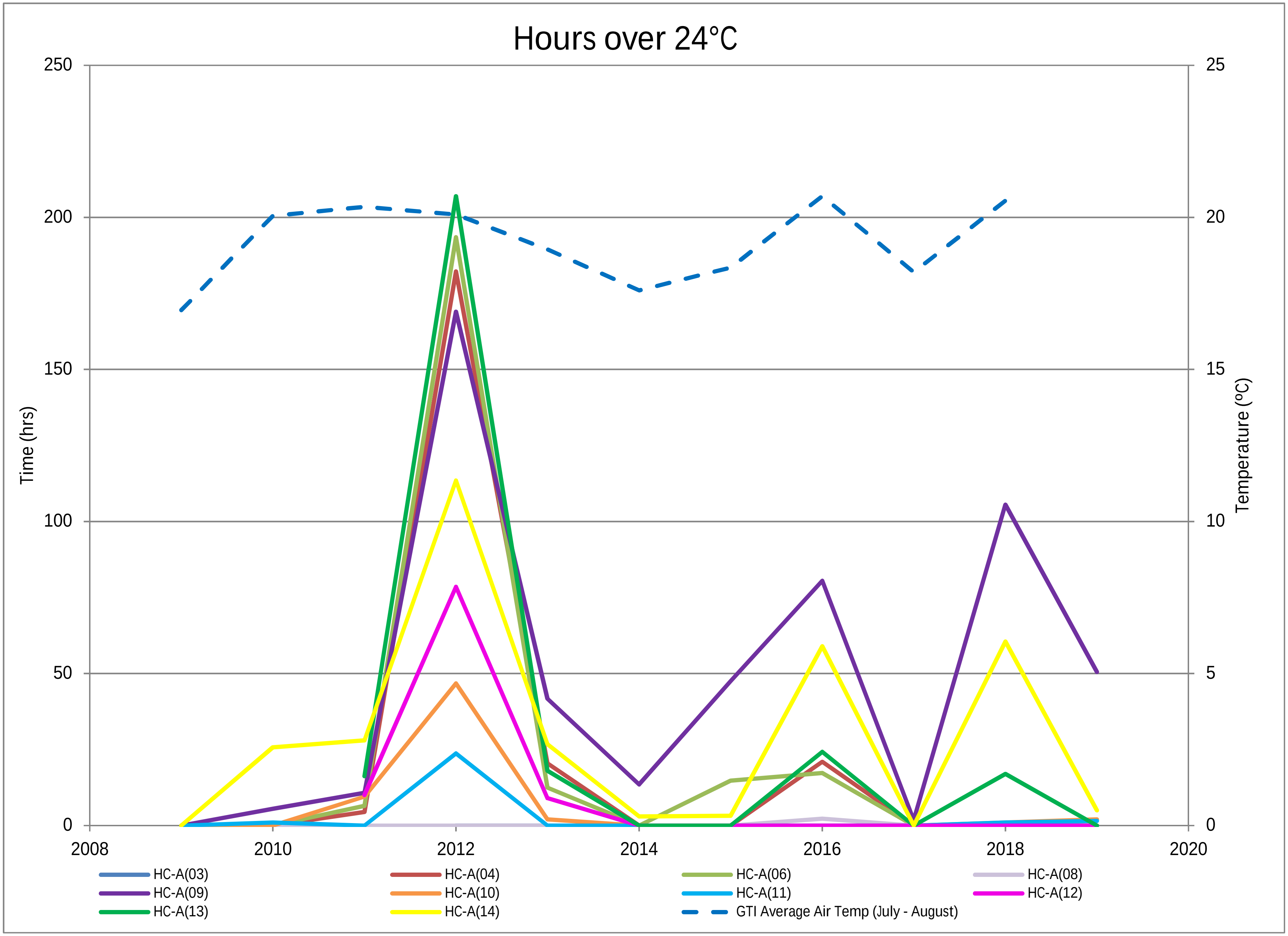

Percent of Time over 22°C
Precent (%)
Temperature (°C)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



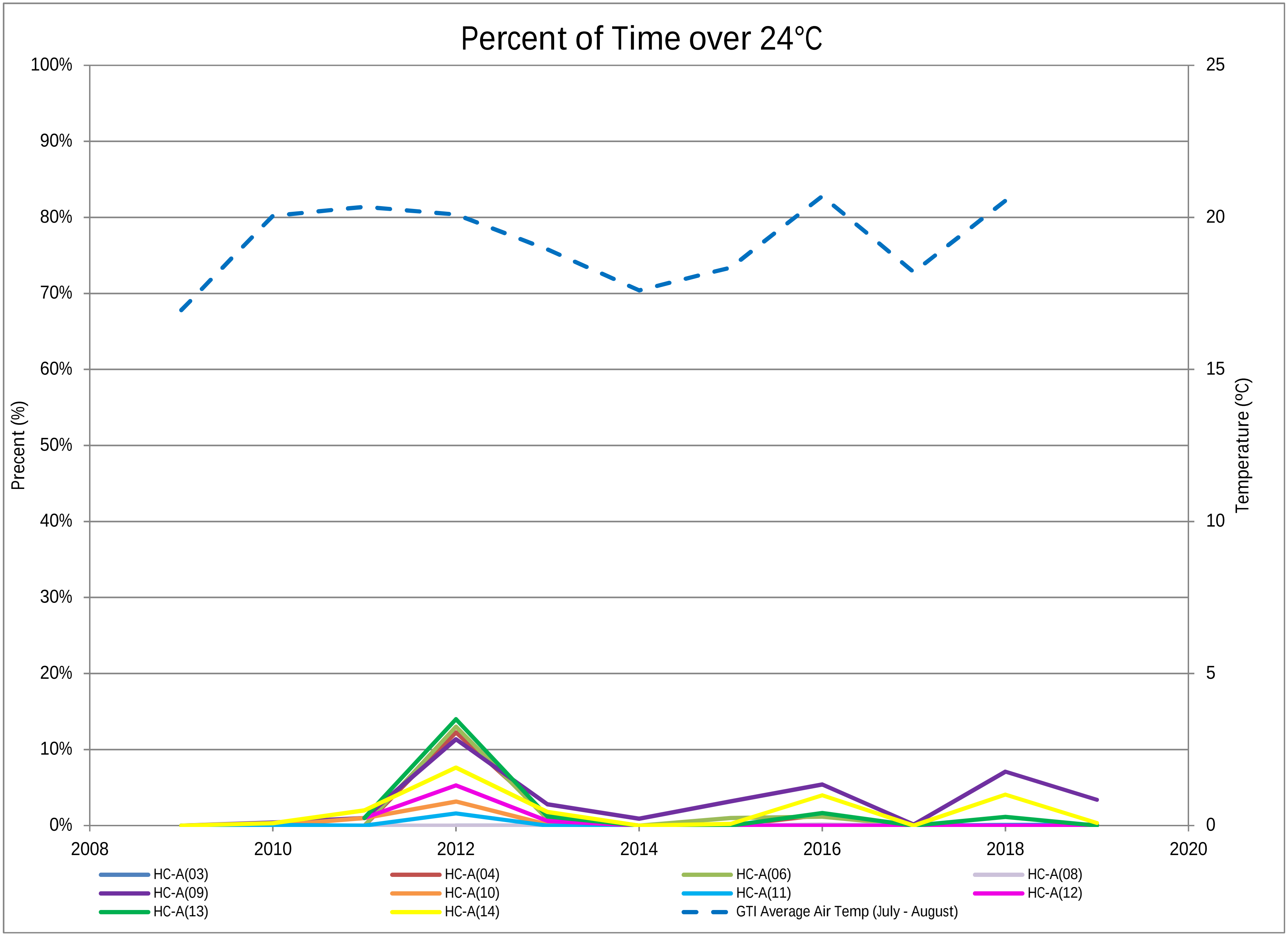
Frequency of Exceedance over 22°C (Days/yr)
Time (Day)
Temperature (°C)
60
50
40
30
20
10
0
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



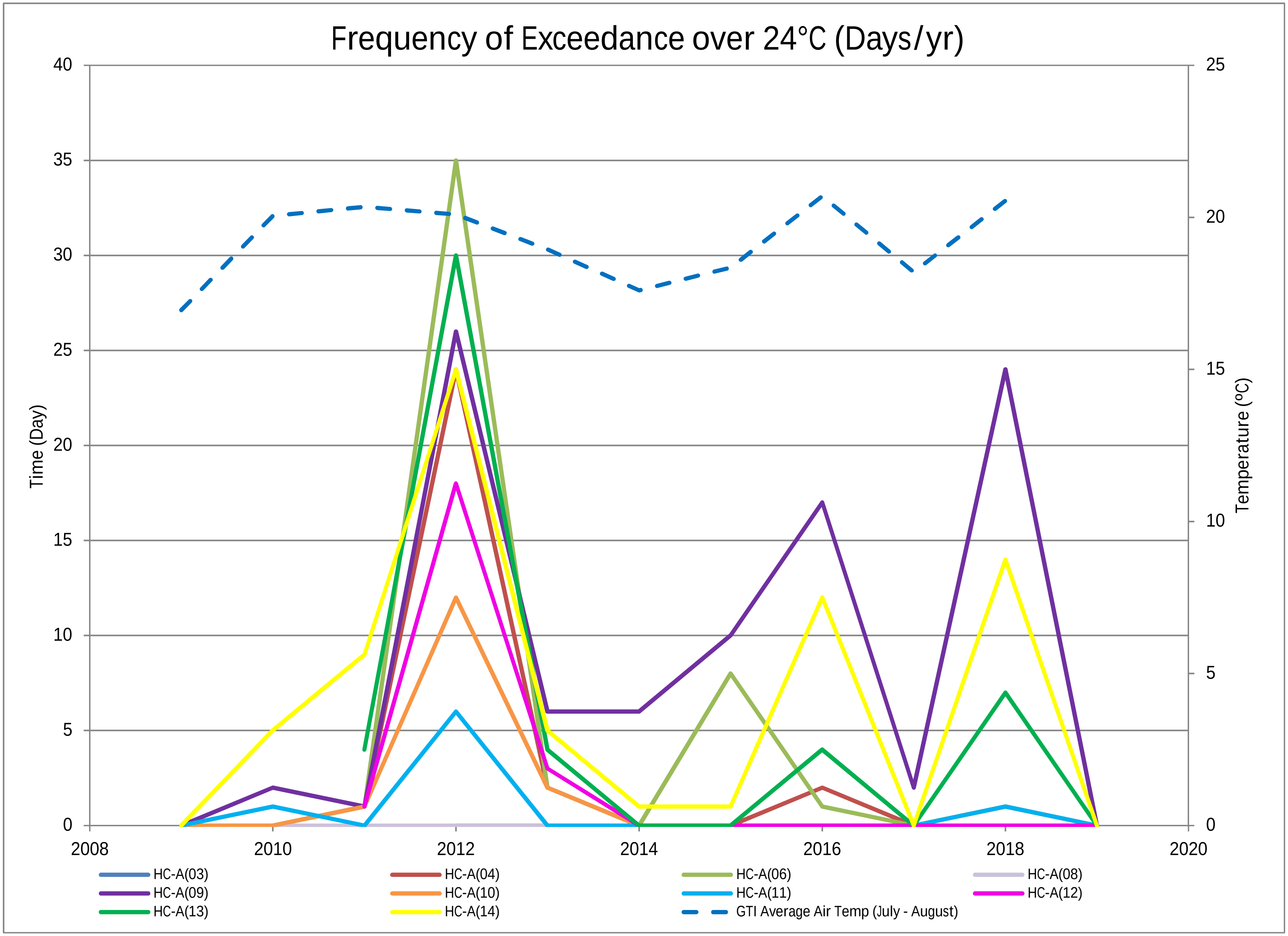
Average Duration of Event Over 22°C (h)
Time (hrs)
Temperature (°C)
0
5
10
15
20
25
30
35
40
45
50
0
5
10
15
20
25
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



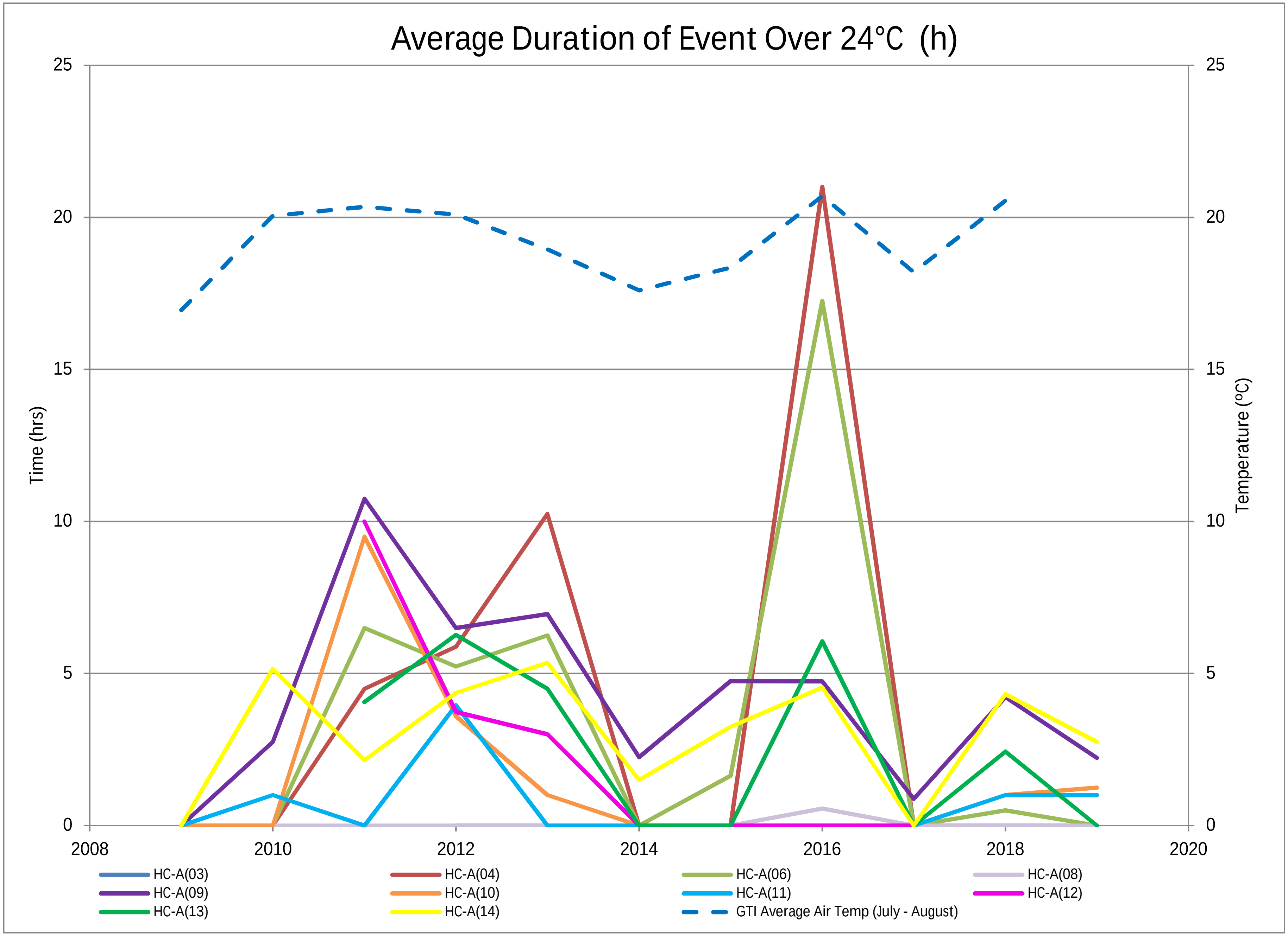
Hours over 24°C
Time (hrs)
Temperature (°C)
250
200
150
100
50
0
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



Percent of Time over 24°C
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Precent (%)
25
20
15
10
5
0
Temperature (°C)
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

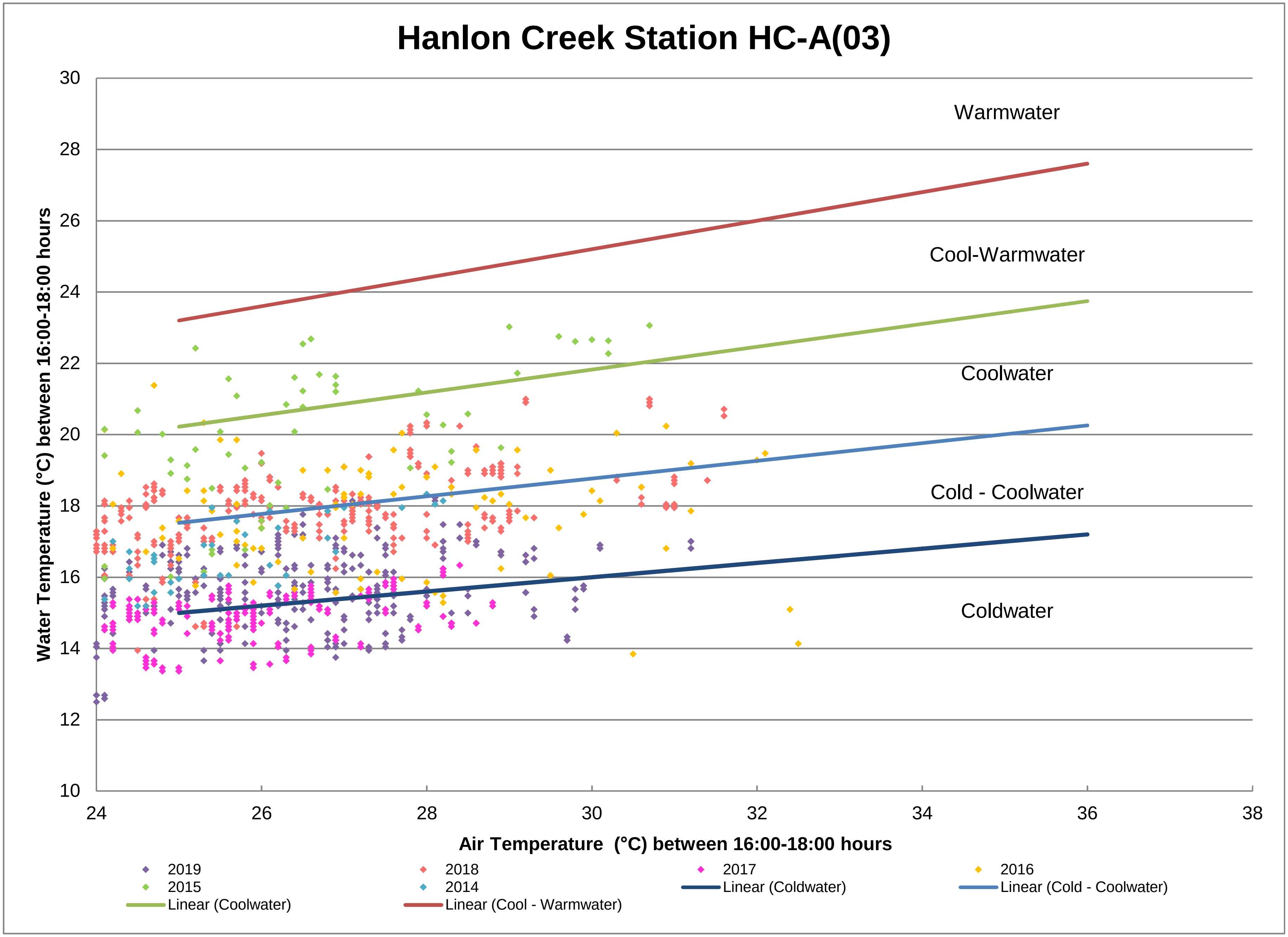


Frequency of Exceedance over 24°C (Days/yr)
Time (Day)
Temperature (°C)
40
35
30
25
20
15
10
5
0
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

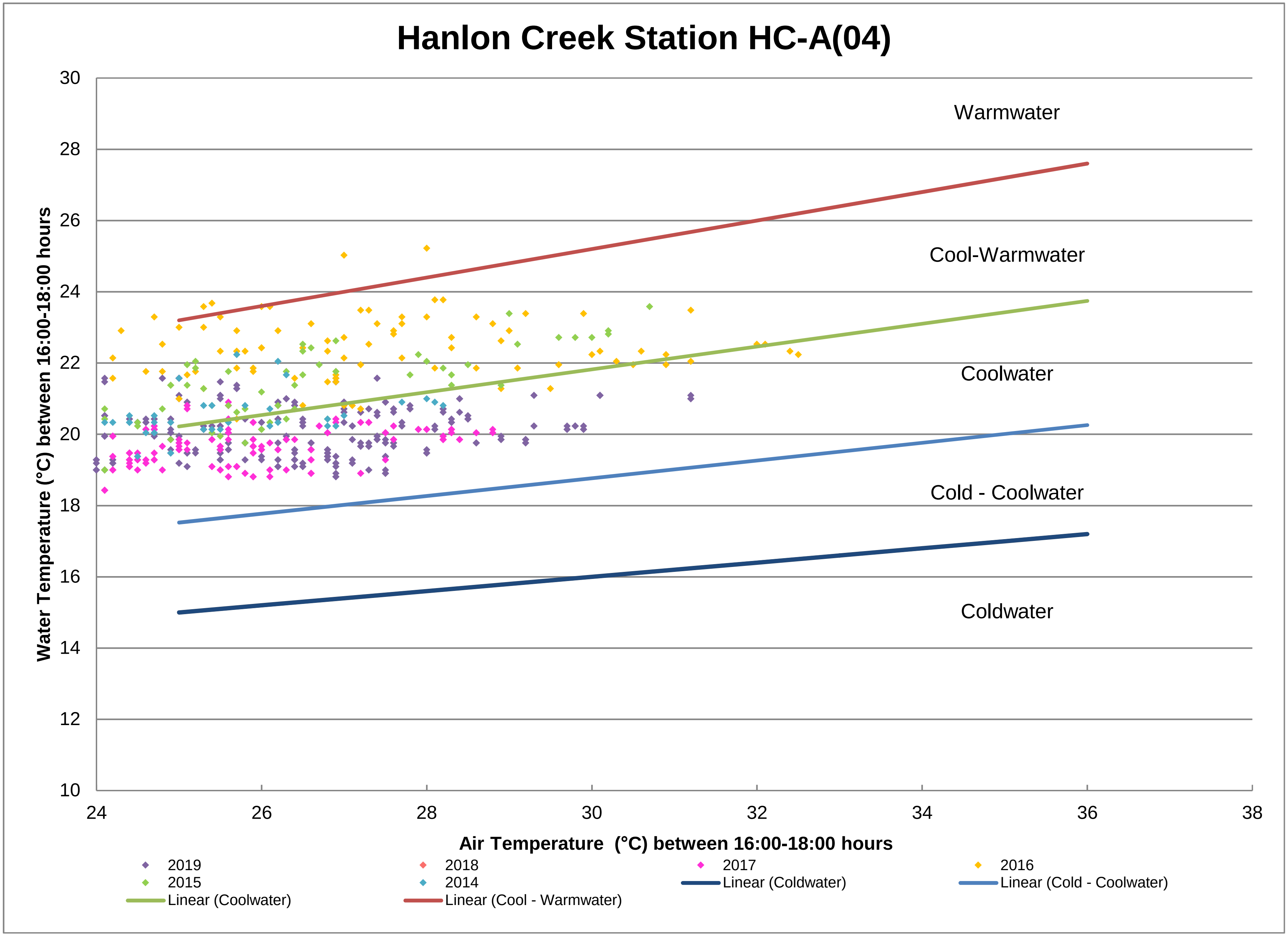

Average Duration of Event Over 24°C (h)
Time (hrs)
Temperature (ºC)
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

Appendix C

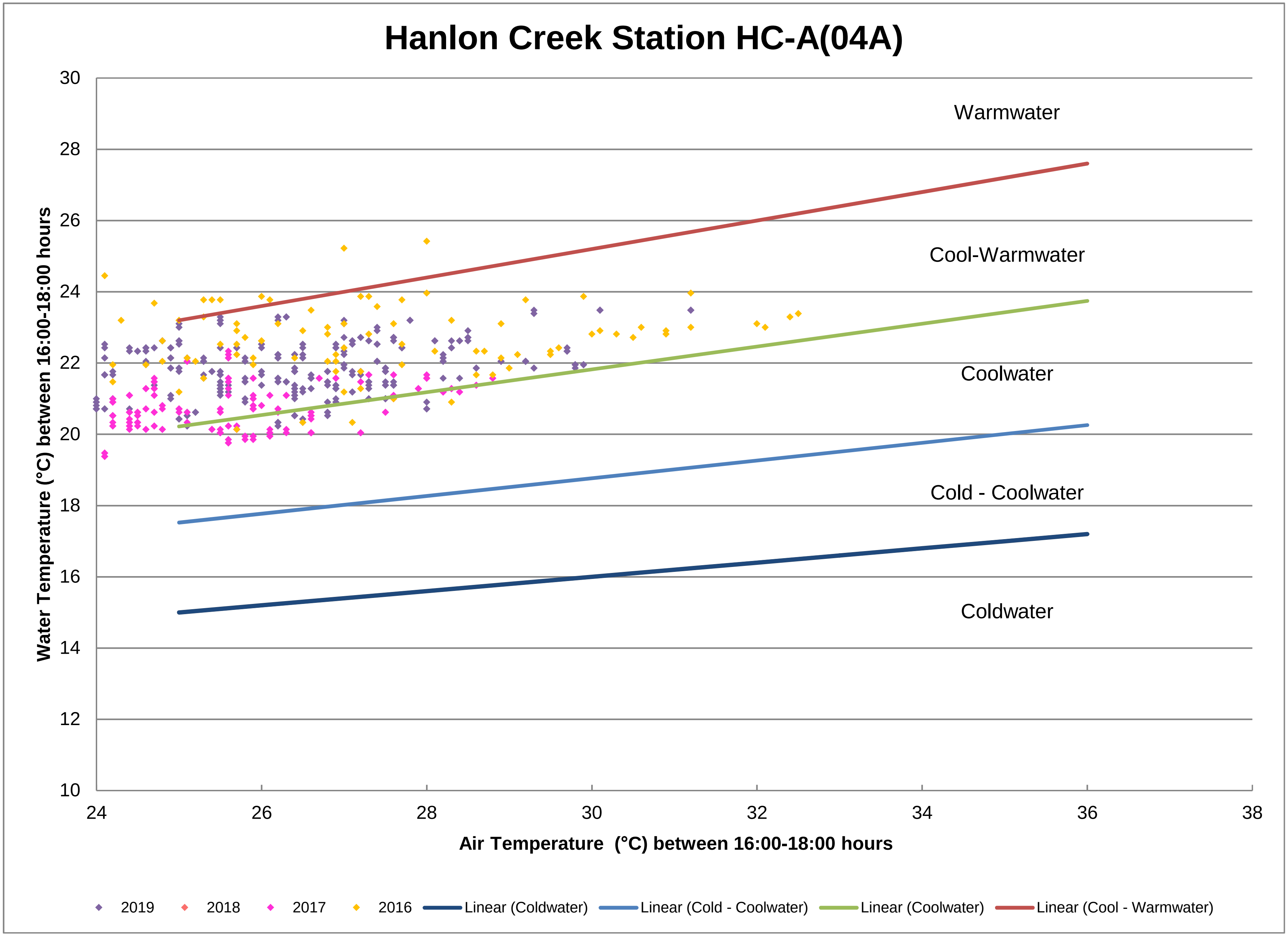
Thermal Regime Classification

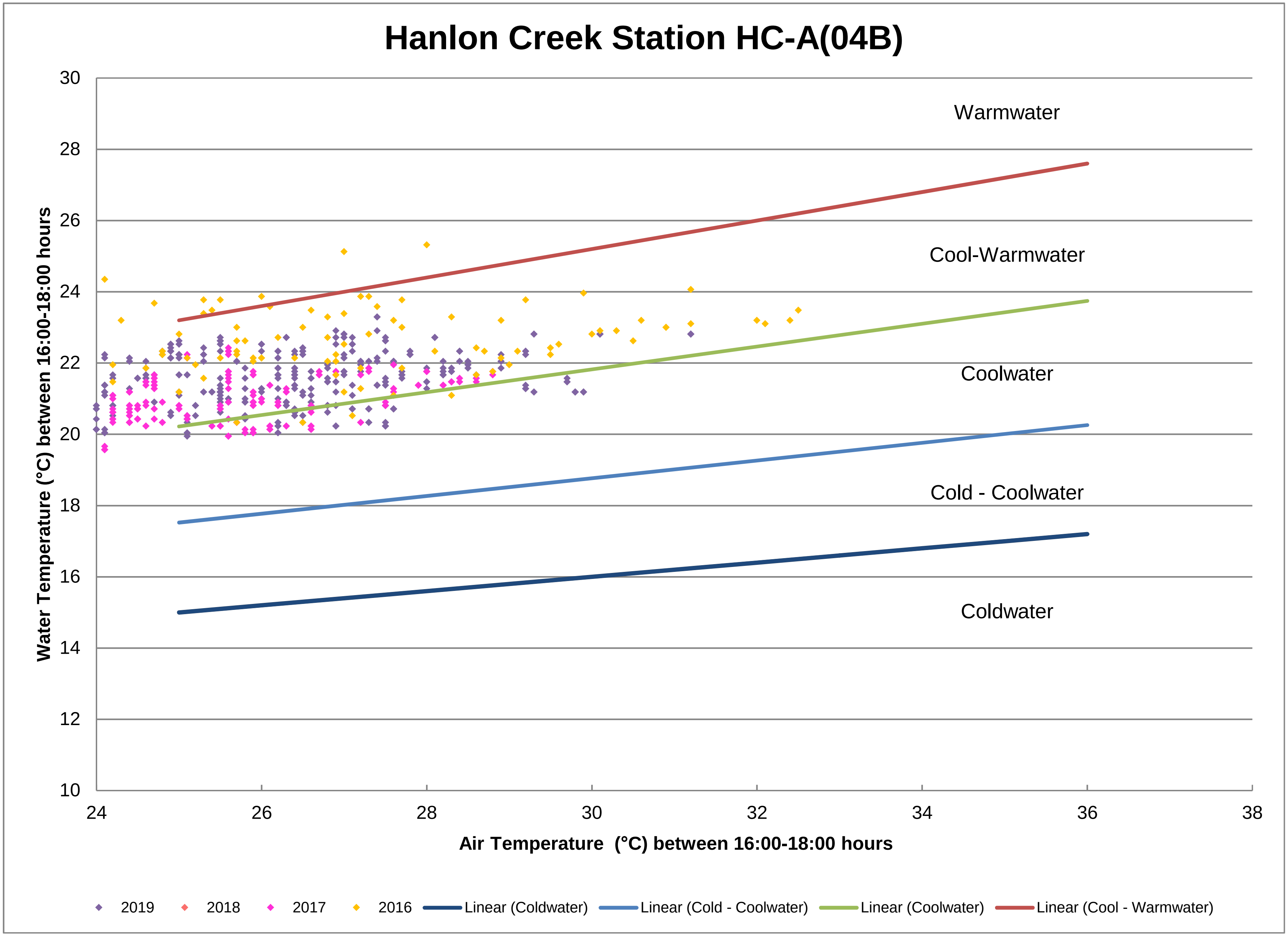


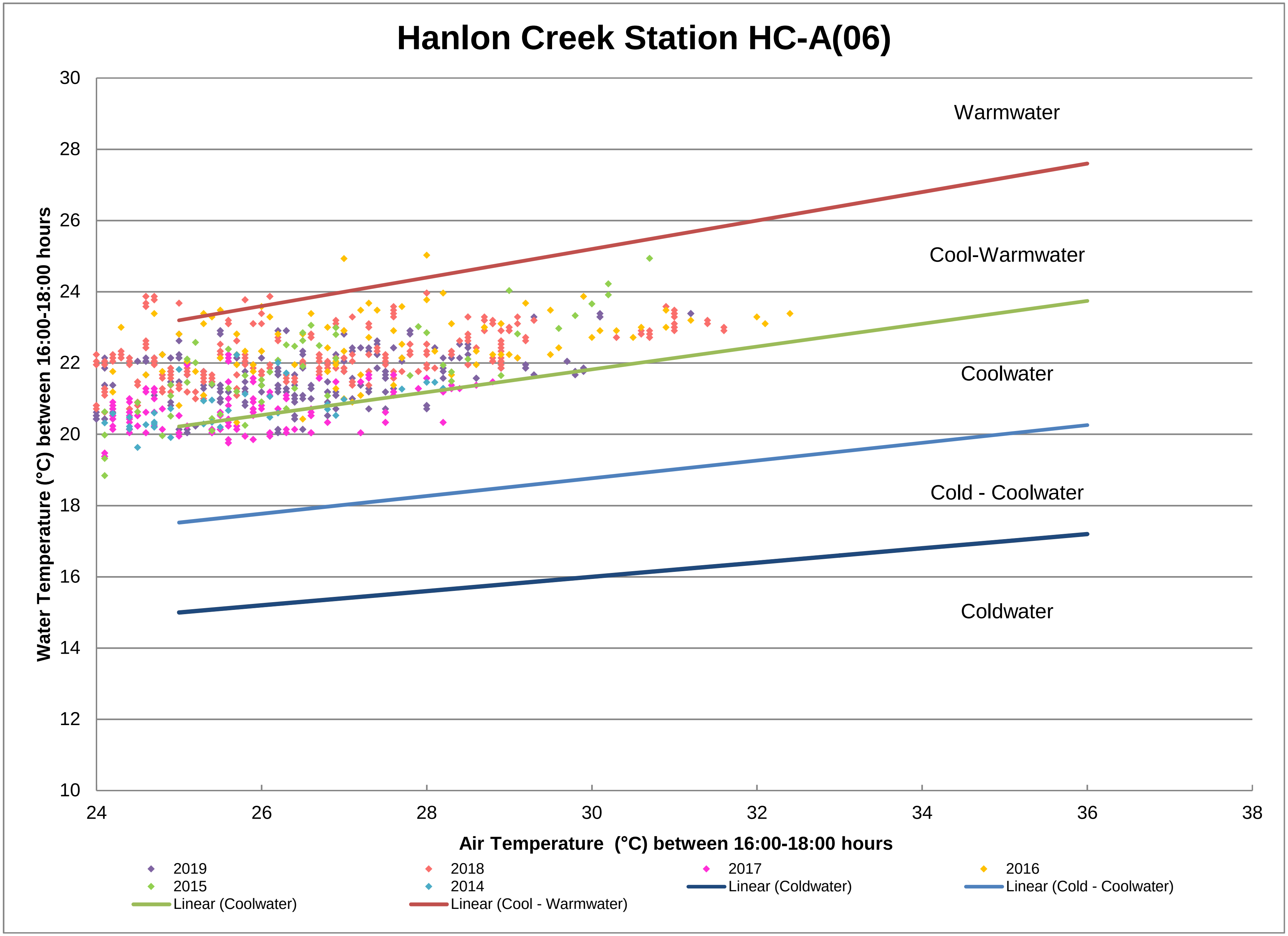
Hanlon Creek Station HC-A(03)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

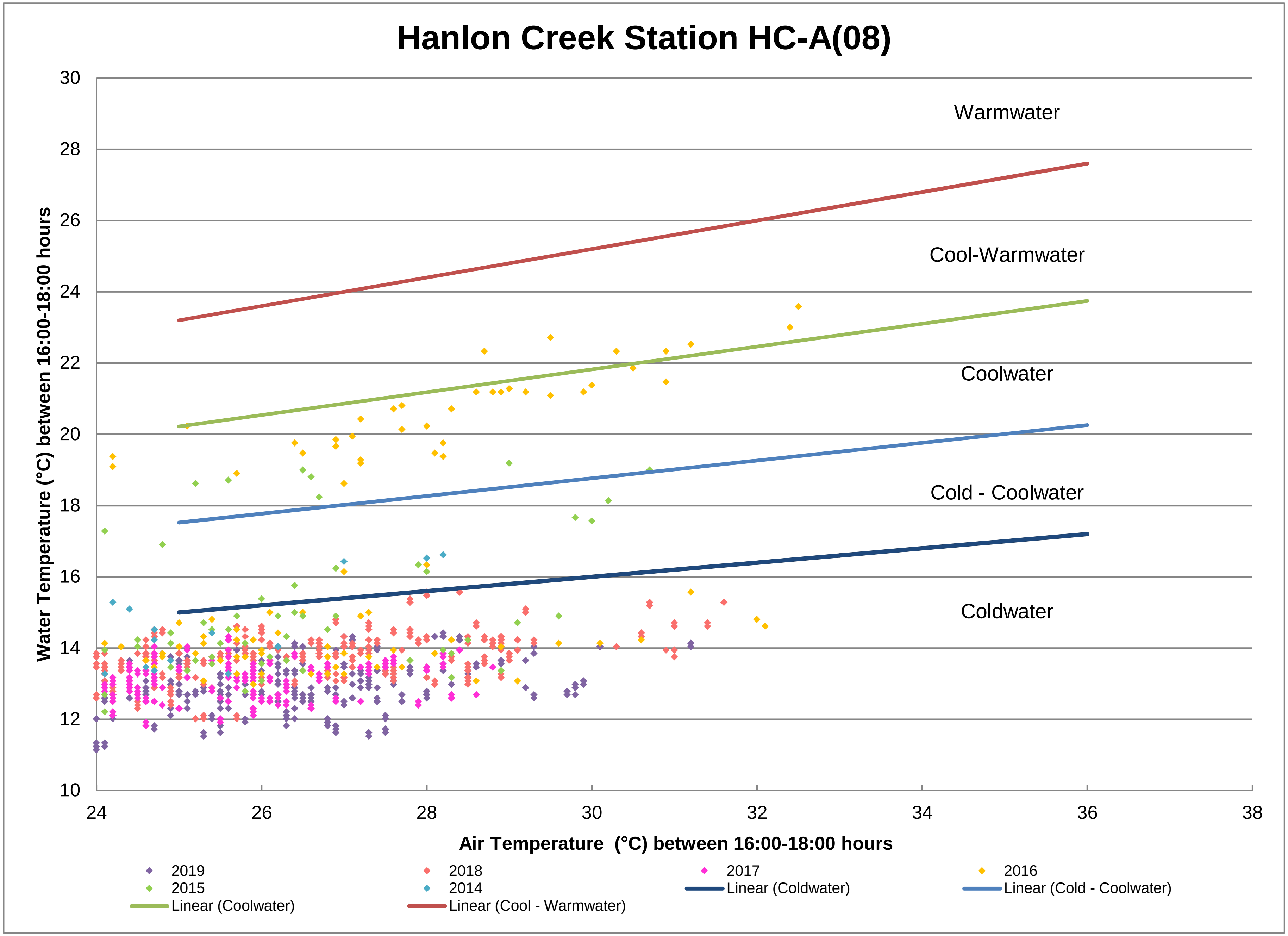


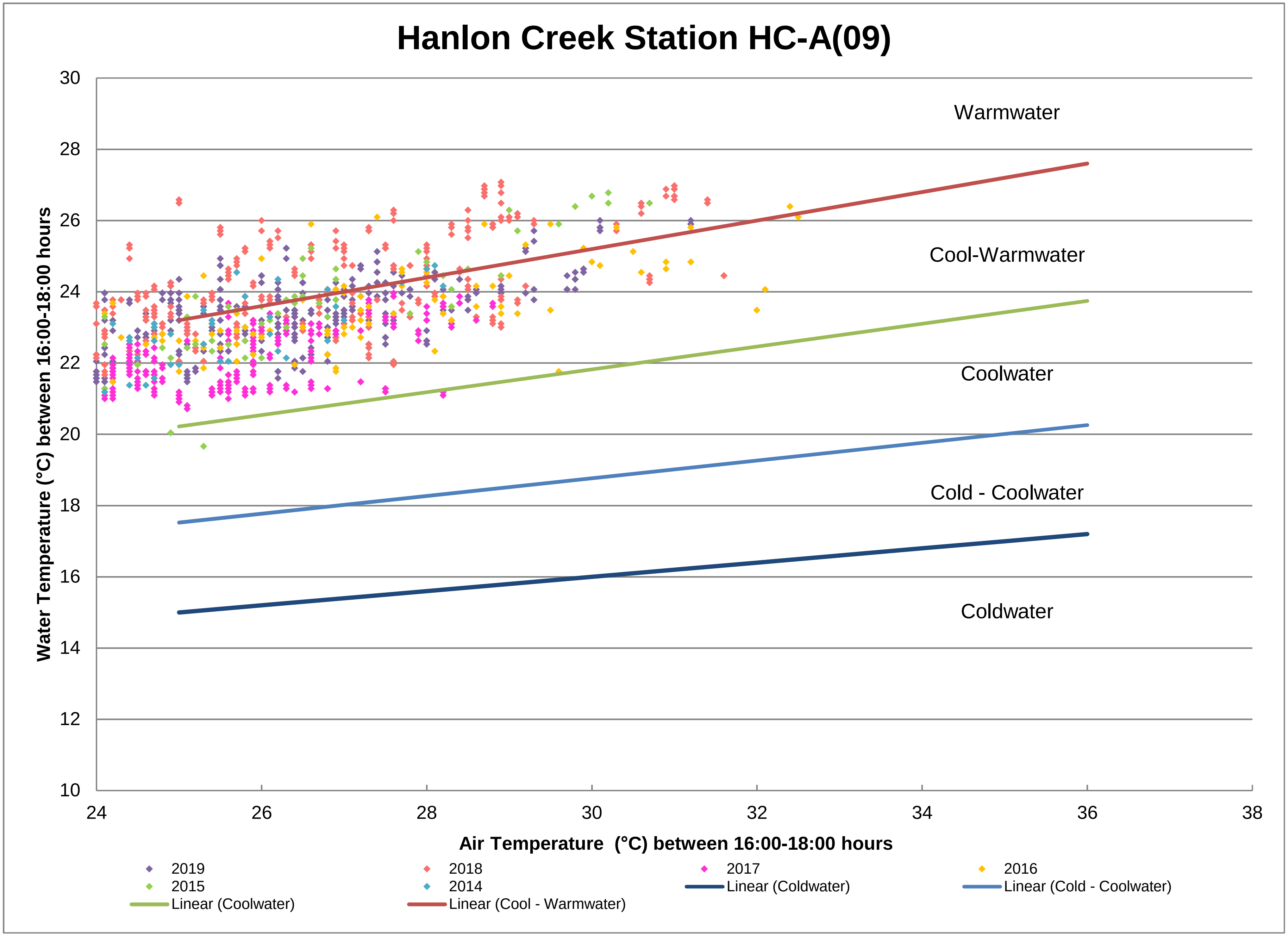
Hanlon Creek Station HC-A(04)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
Air Temperature (°C) between 16:00-18:00 hours
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)


Hanlon Creek Station HC-A(04A)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2019
2018
2017
2016
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

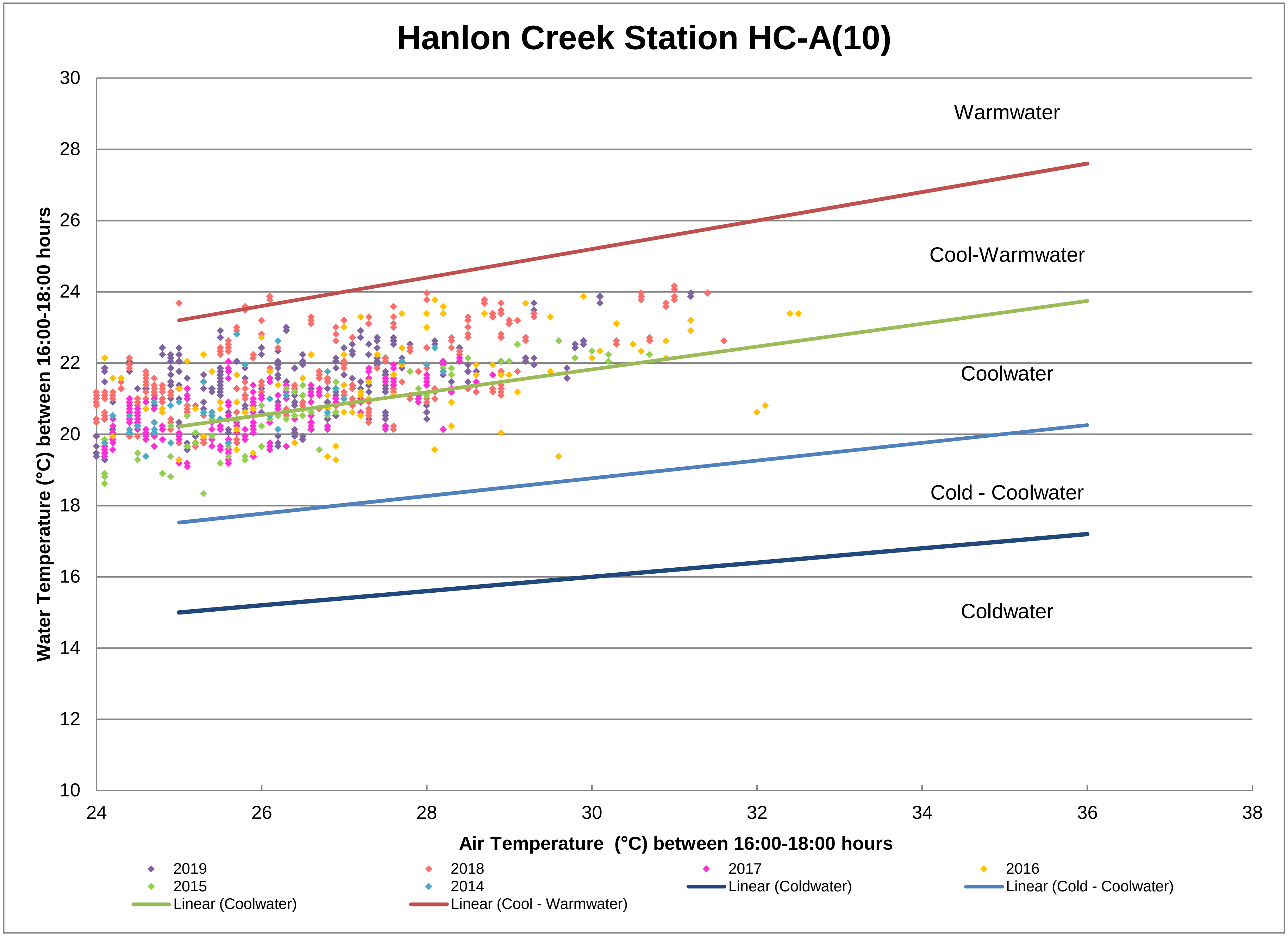

Hanlon Creek Station HC-A(04B)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2019
2018
2017
2016
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

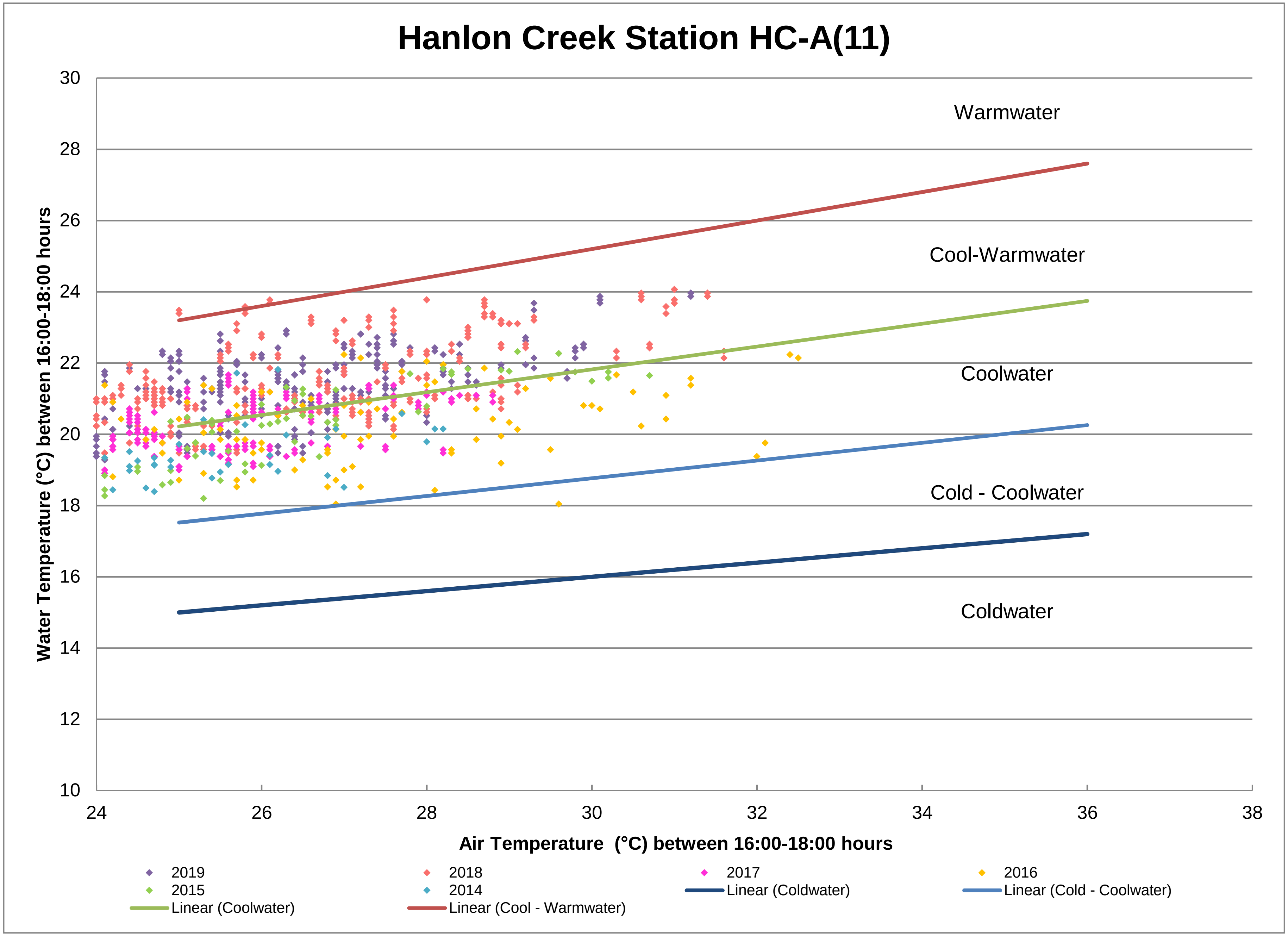

Hanlon Creek Station HC-A(06)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
Air Temperature (°C) between 16:00-18:00 hours
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)


Hanlon Creek Station HC-A(08)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
10
12
14
16
18
20
22
24
26
28
30
24
26
28
30
32
34
36
38
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

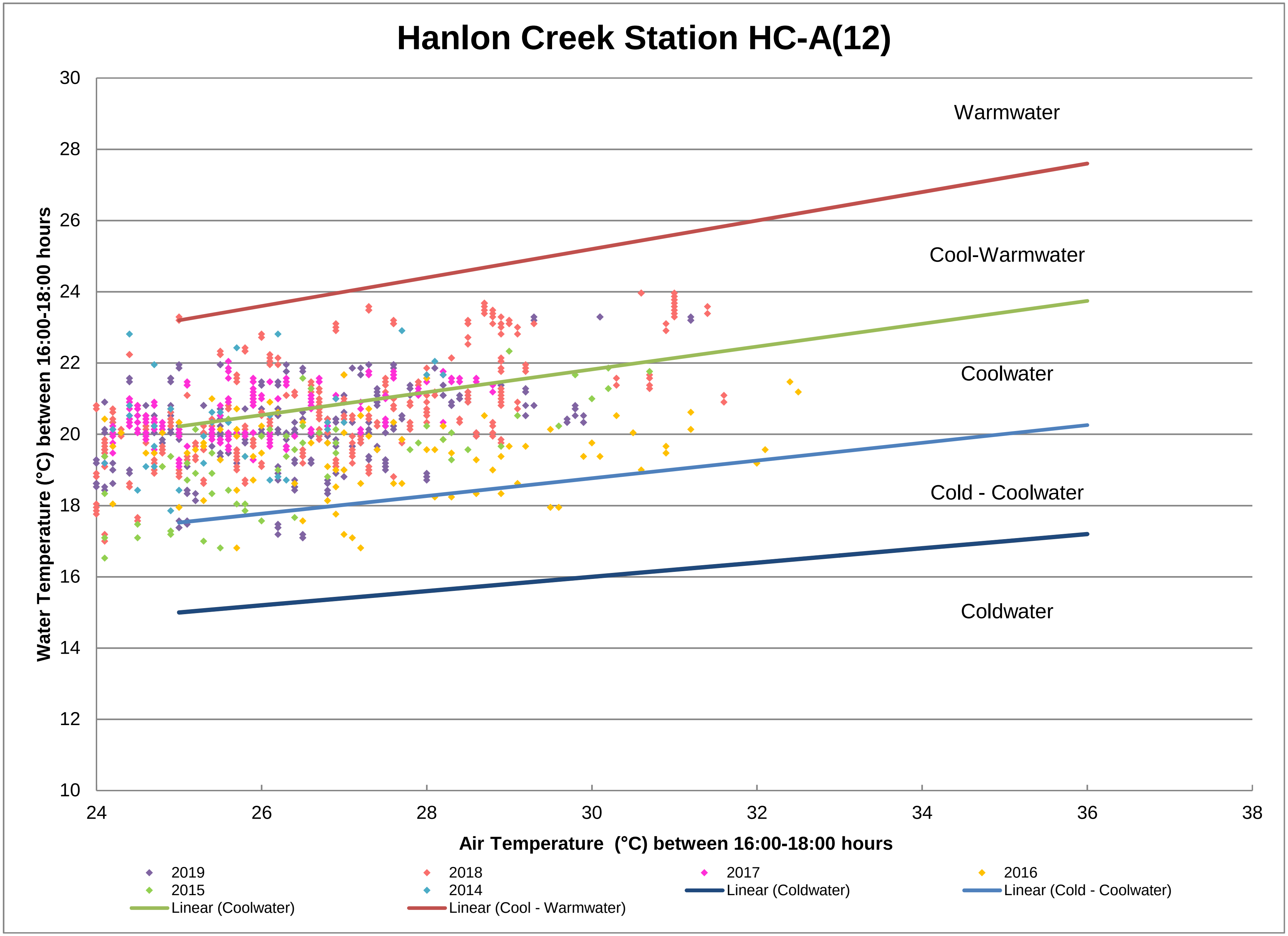


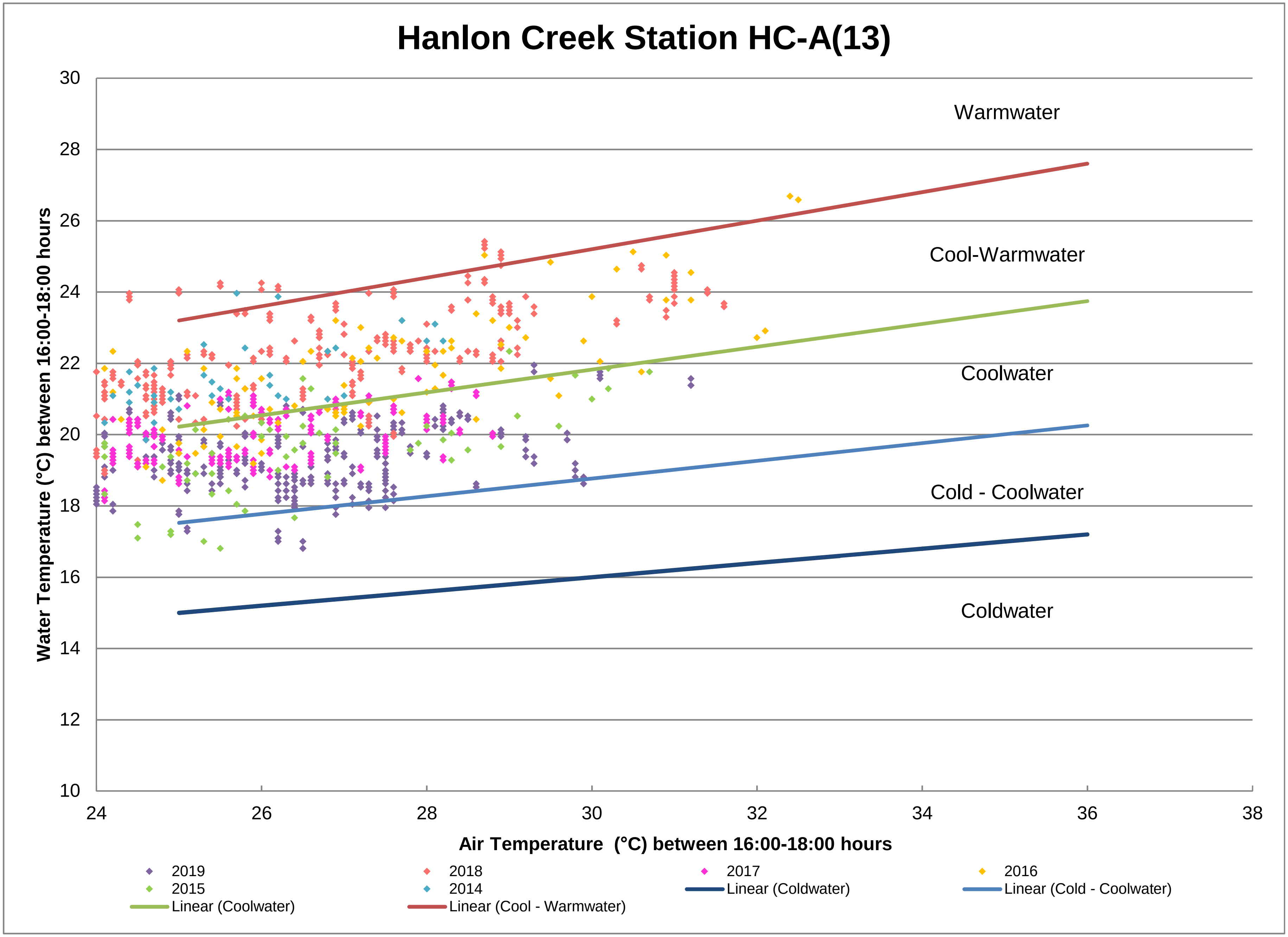
Hanlon Creek Station HC-A(09)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
Air Temperature (°C) between 16:00-18:00 hours
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)


Hanlon Creek Station HC-A(10)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
Air Temperature (°C) between 16:00-18:00 hours
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

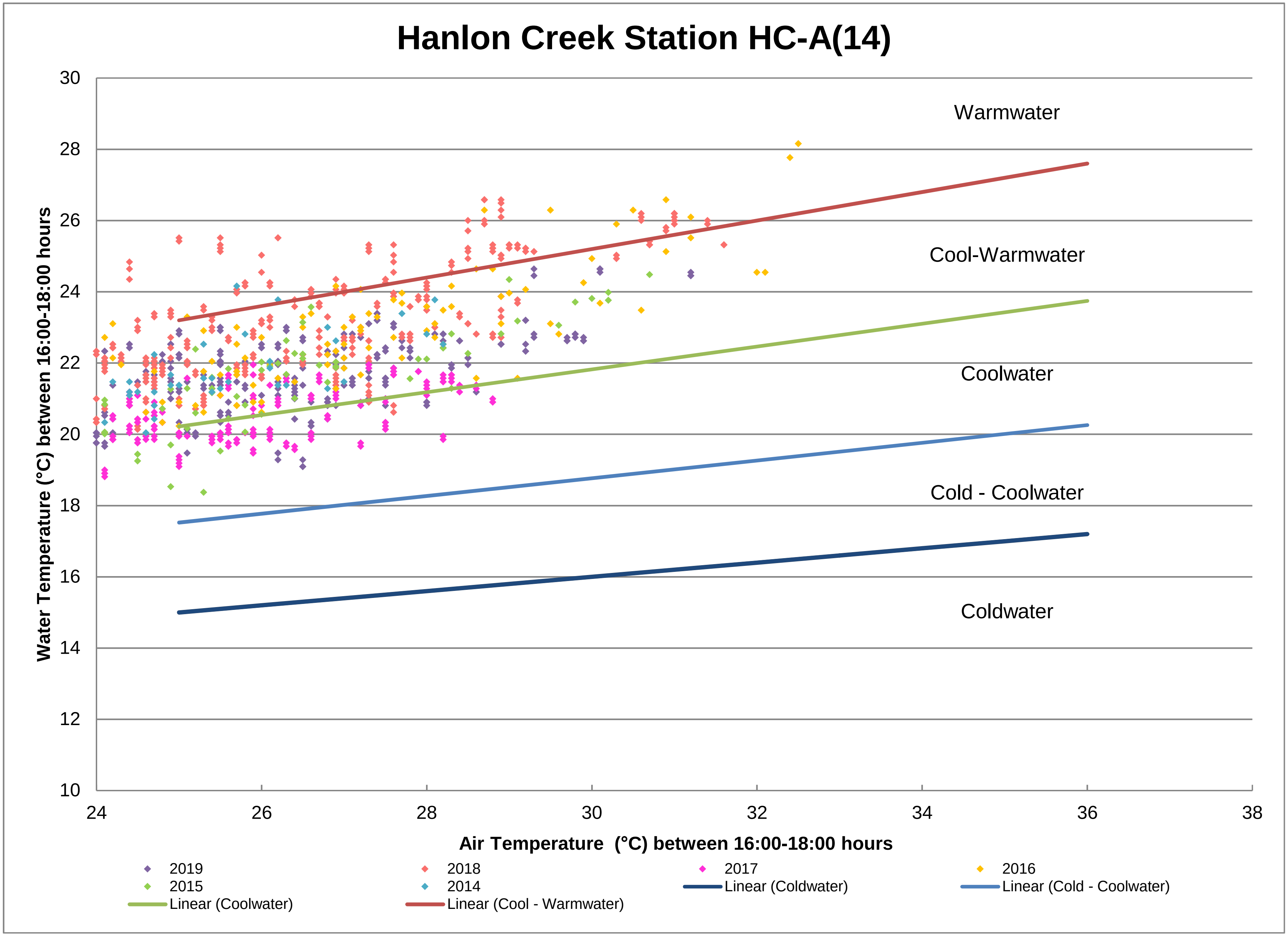


Hanlon Creek Station HC-A(11)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

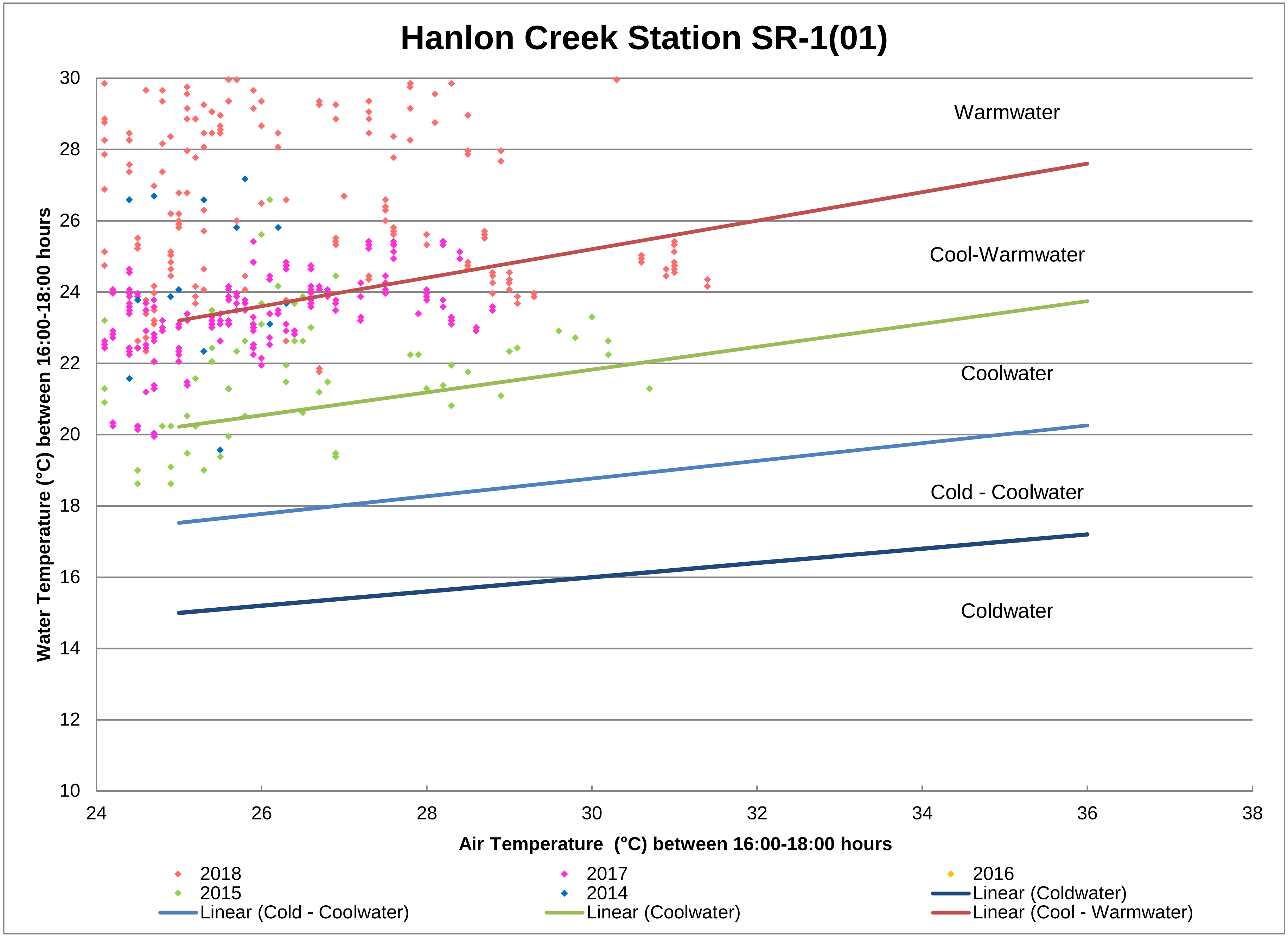

Hanlon Creek Station HC-A(12)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)



Hanlon Creek Station HC-A(13)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)



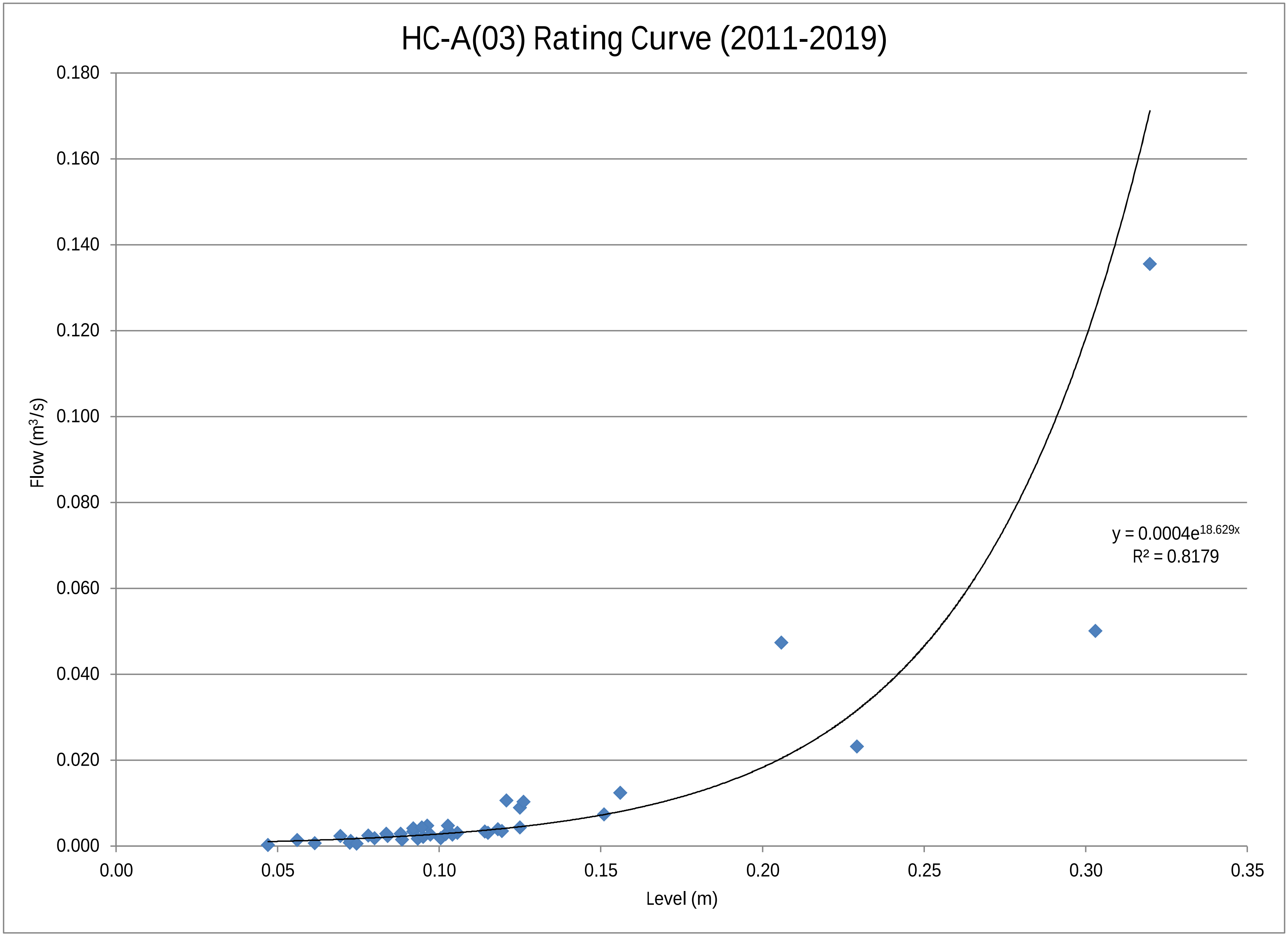
Hanlon Creek Station HC-A(14)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)



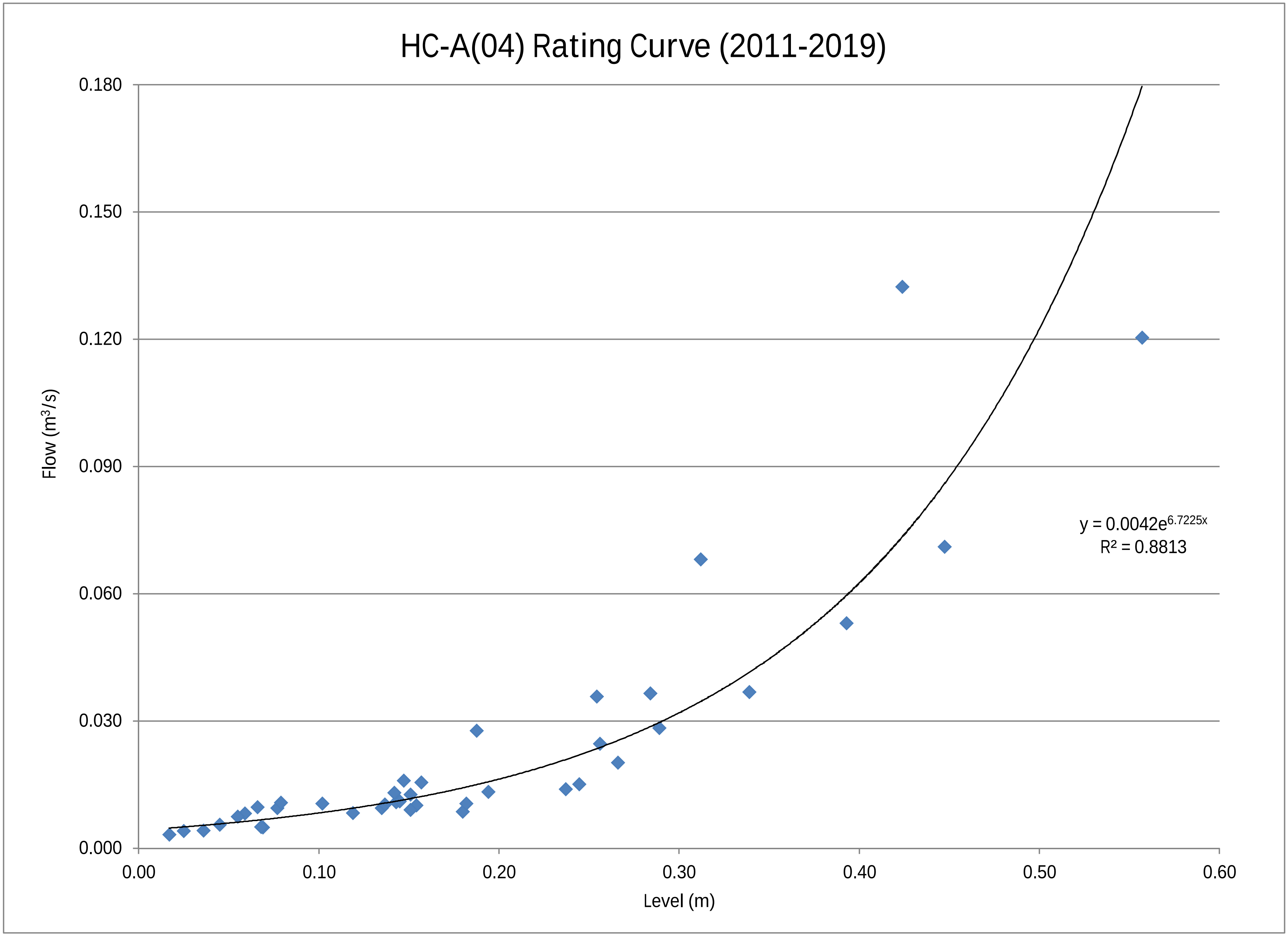
Hanlon Creek Station SR-1(01)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

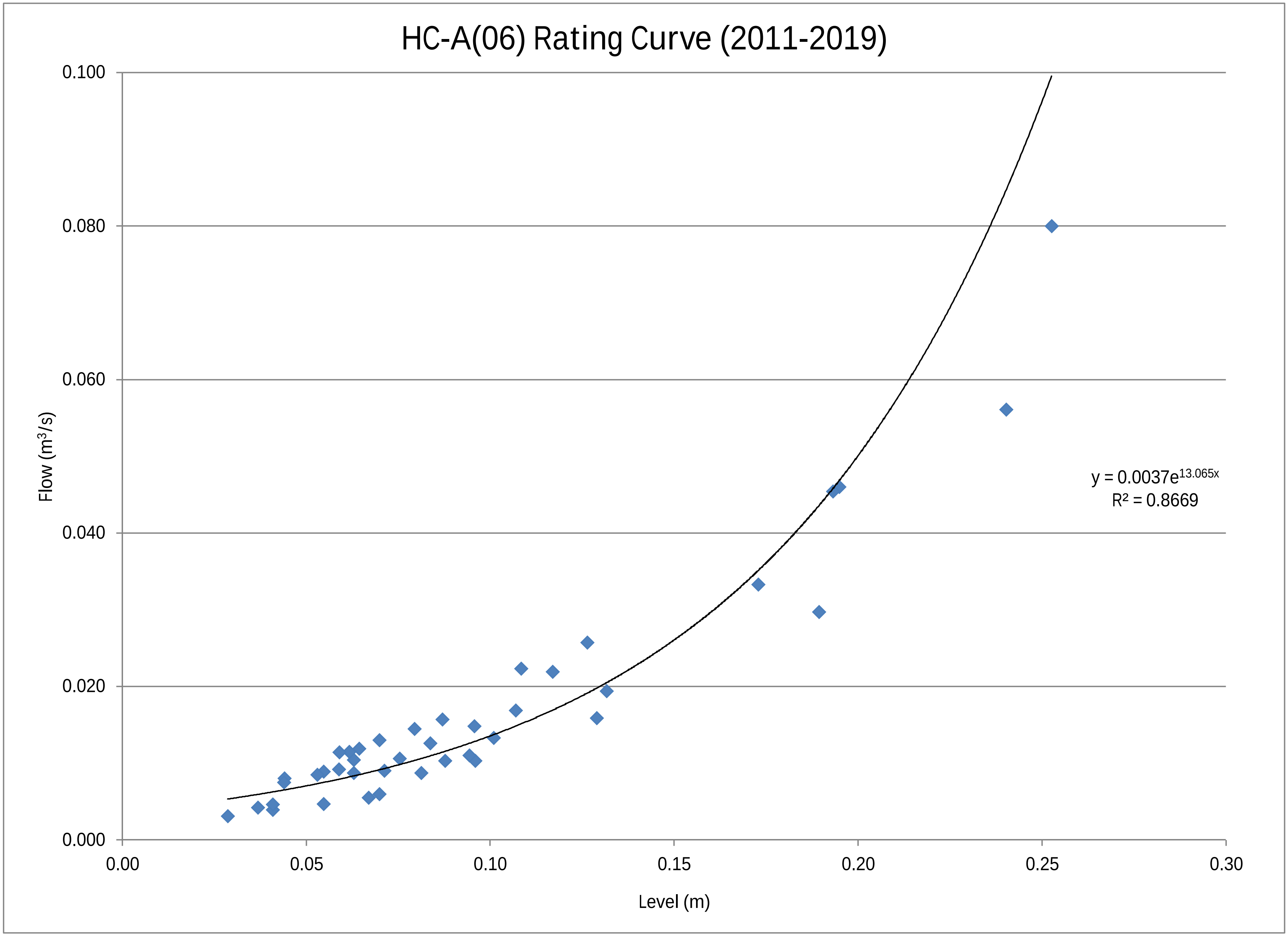
Appendix D

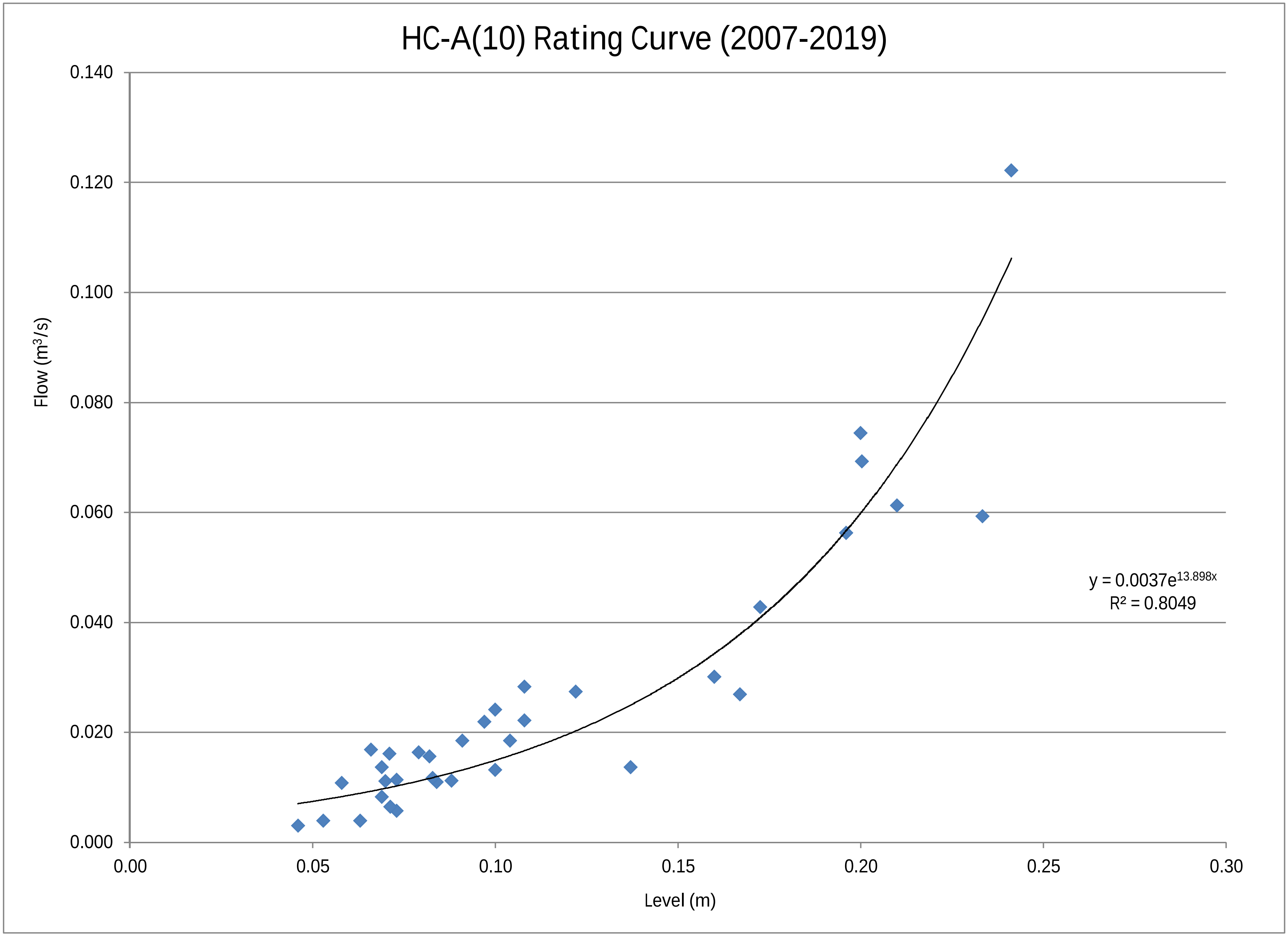
Stage (level) – Discharge Relationship Plots

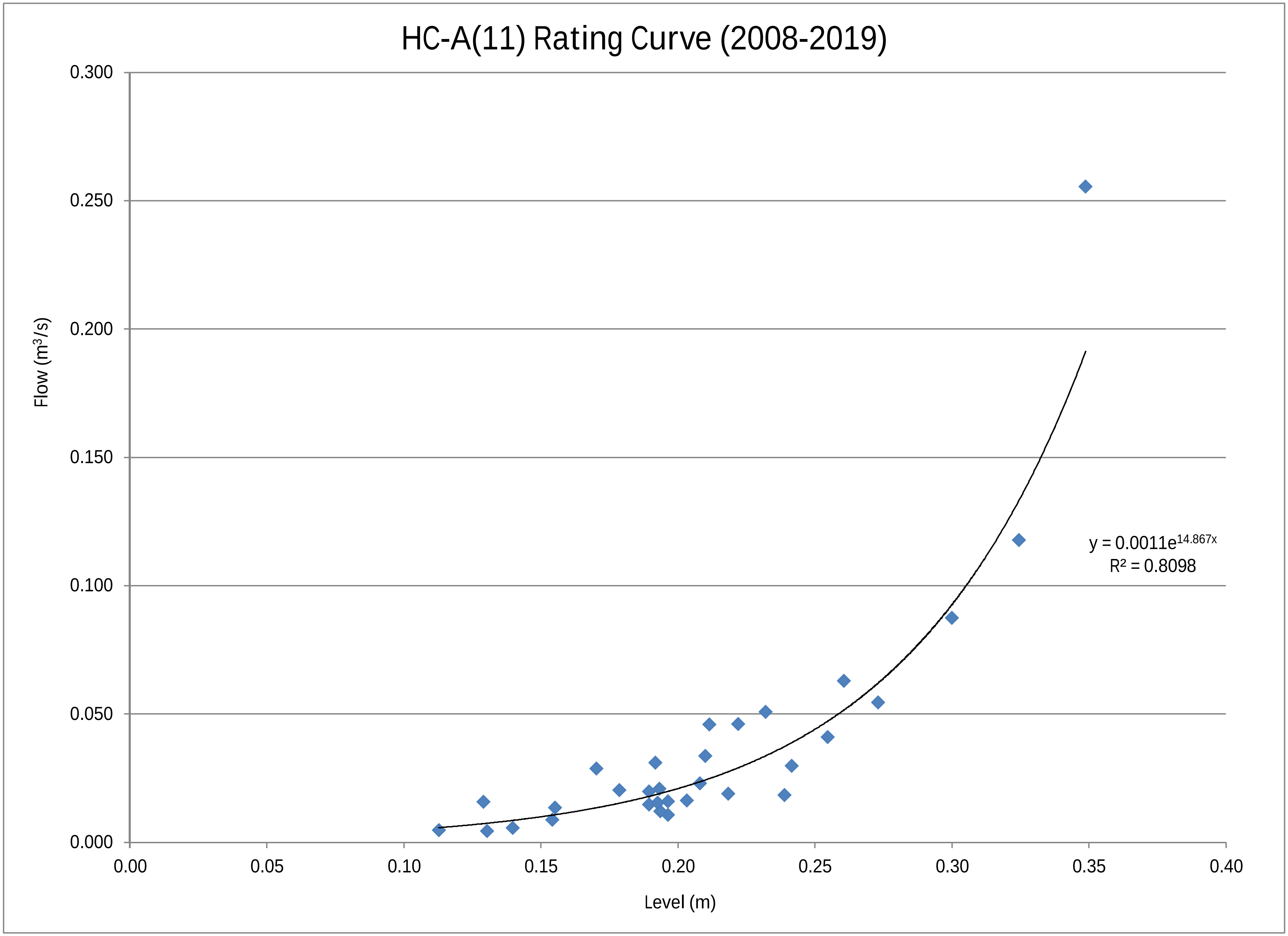


HC-A(03) Rating Curve (2011-2019)
Flow (m³/s)
Level (m)
0.000
0.020
0.040
0.060
0.080
0.100
0.120
0.140
0.160
0.180
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
y = 0.0004e^18.629x
R² = 0.8179

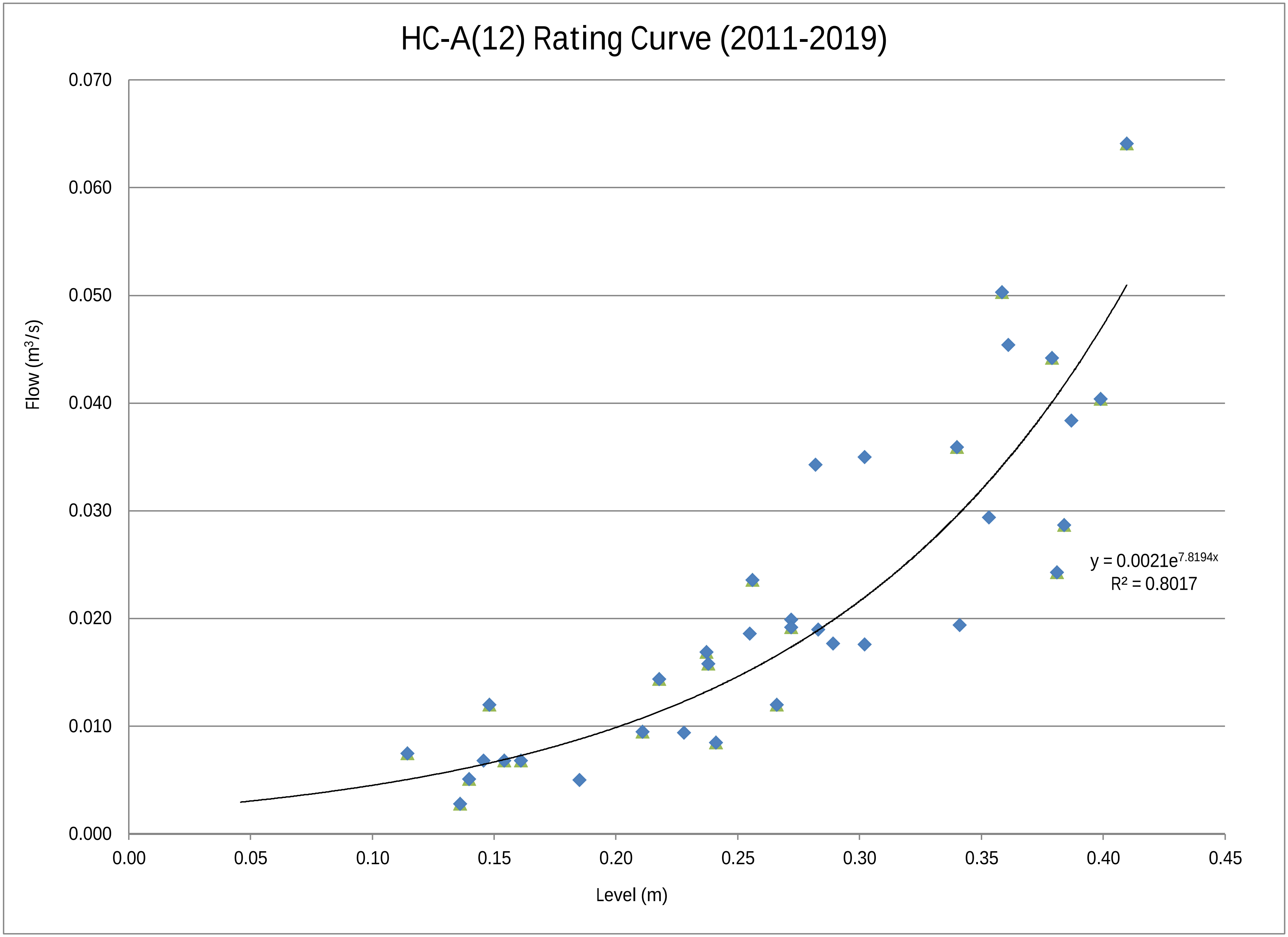

HC-A(04) Rating Curve (2011-2019)
Flow (m³/s)
Level (m)
0.180
0.150
0.120
0.090
0.060
0.030
0.000
0.00
0.10
0.20
0.30
0.40
0.50
0.60
y = 0.0042e^6.7225x
R² = 0.8813


HC-A(06) Rating Curve (2011-2019)
0.100
0.080
0.060
0.040
0.020
0.000
Flow (m³/s)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Level (m)
y = 0.0037e^13.065x
R² = 0.8669

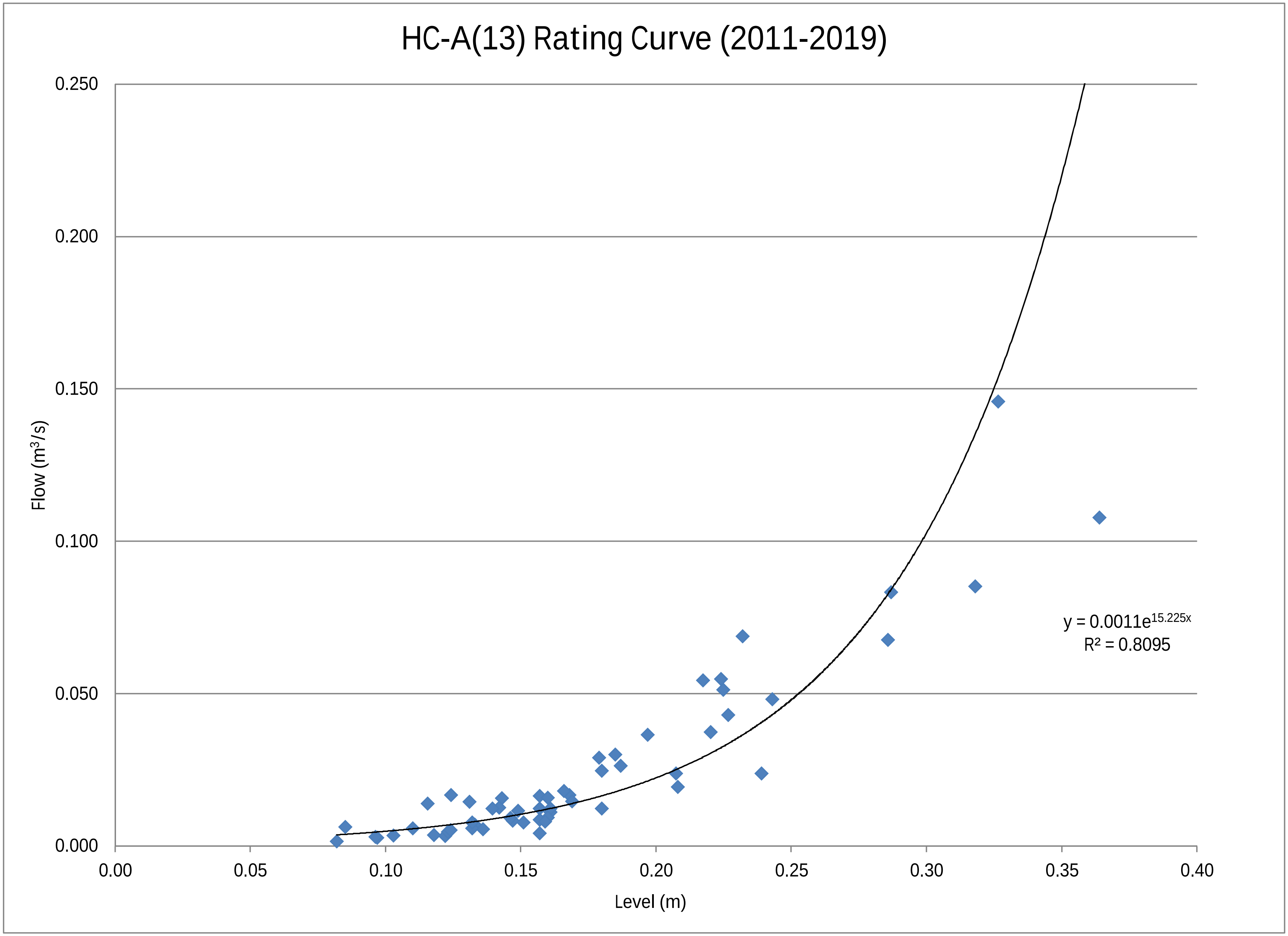

HC-A(10) Rating Curve (2007-2019)
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Flow (m³/s)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Level (m)
y = 0.0037e^13.898x
R² = 0.8049



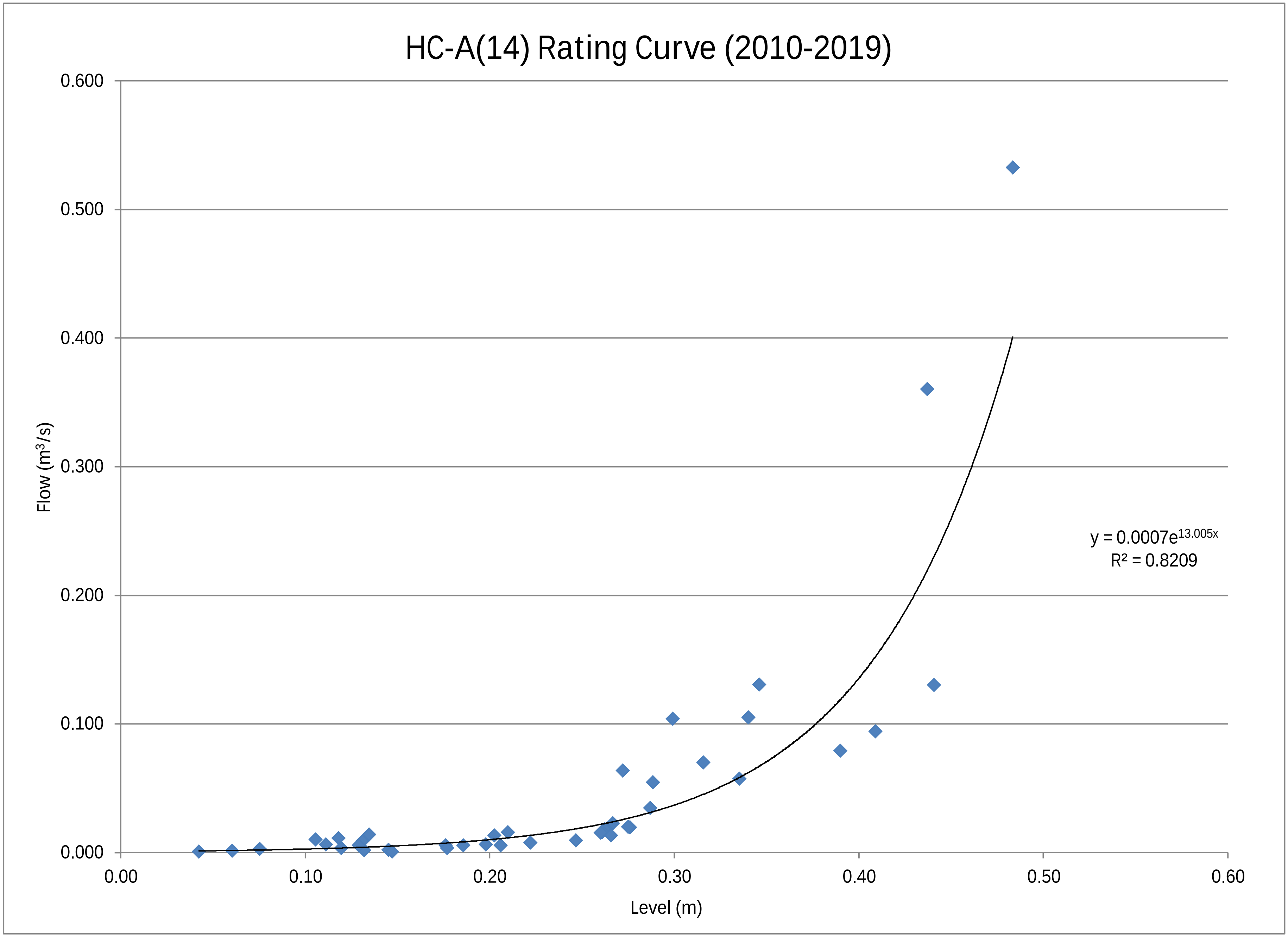
HC-A(11) Rating Curve (2008-2019)
Flow (m³/s)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Level (m)
$y = 0.0011e^{14.867x}$
$R^2 = 0.8098$



HC-A(12) Rating Curve (2011-2019)
Flow (m3/s)
Level (m)
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
y = 0.0021e7.8194x
R² = 0.8017



HC-A(13) Rating Curve (2011-2019)
Flow (m3/s)
0.250
0.200
0.150
0.100
0.050
0.000
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Level (m)
y = 0.0011e15.225x
R² = 0.8095



HC-A(14) Rating Curve (2010-2019)
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Flow (m3/s)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Level (m)
y = 0.0007e13.005x
R² = 0.8209

AECOM

Appendix E

Tabular Water Quality Sampling Results

AECOM CANADA LTD. - KITCHENER
ATTN: Steven Scott
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 03-OCT-19
Report Date: 11-OCT-19 09:28 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L2359227

Project P.O. #: 60611735
Job Reference: 60611735
C of C Numbers:
Legal Site Desc:

Emily Hansen
Account Manager

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1			
L2359227-1	HC-A(03)									
Sampled By:	S.SCOTT on 02-OCT-19 @ 10:00									
Matrix:	WATER									
Physical Tests										
	Total Suspended Solids	15.2		2.0	mg/L	10-OCT-19				
Anions and Nutrients										
	Ammonia, Total (as N)	<0.010		0.010	mg/L	07-OCT-19				
	Chloride (Cl)	47.4		0.50	mg/L	07-OCT-19				
	Nitrate (as N)	0.973		0.020	mg/L	07-OCT-19				
	Phosphorus (P)-Total Dissolved	0.0069		0.0030	mg/L	10-OCT-19				
	Phosphorus, Total	0.0334		0.0030	mg/L	10-OCT-19	*0.01			
Bacteriological Tests										
	E. Coli	450	DLM	10	CFU/100mL	03-OCT-19	*100			
Total Metals										
	Aluminum (Al)-Total	0.150		0.0050	mg/L	04-OCT-19	*0.015			
	Antimony (Sb)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.02			
	Arsenic (As)-Total	0.00042		0.00010	mg/L	04-OCT-19	0.005			
	Barium (Ba)-Total	0.0590		0.00010	mg/L	04-OCT-19				
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.011			
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	04-OCT-19				
	Boron (B)-Total	0.013		0.010	mg/L	04-OCT-19	0.2			
	Cadmium (Cd)-Total	0.0000834		0.0000050	mg/L	04-OCT-19	0.0001			
	Calcium (Ca)-Total	82.9		0.050	mg/L	04-OCT-19				
	Cesium (Cs)-Total	0.000014		0.000010	mg/L	04-OCT-19				
	Chromium (Cr)-Total	0.00174		0.00050	mg/L	04-OCT-19				
	Cobalt (Co)-Total	0.00017		0.00010	mg/L	04-OCT-19	0.0009			
	Copper (Cu)-Total	0.0021		0.0010	mg/L	04-OCT-19	*0.001			
	Iron (Fe)-Total	0.334		0.010	mg/L	04-OCT-19	*0.3			
	Lead (Pb)-Total	0.000720		0.000050	mg/L	04-OCT-19	0.001			
	Lithium (Li)-Total	0.0014		0.0010	mg/L	04-OCT-19				
	Magnesium (Mg)-Total	24.1		0.0050	mg/L	04-OCT-19				
	Manganese (Mn)-Total	0.0510		0.00050	mg/L	04-OCT-19				
	Molybdenum (Mo)-Total	0.000357		0.000050	mg/L	04-OCT-19	0.04			
	Nickel (Ni)-Total	0.00056		0.00050	mg/L	04-OCT-19	0.025			
	Phosphorus (P)-Total	<0.050		0.050	mg/L	04-OCT-19	**0.01			
	Potassium (K)-Total	1.78		0.050	mg/L	04-OCT-19				
	Rubidium (Rb)-Total	0.00183		0.00020	mg/L	04-OCT-19				
	Selenium (Se)-Total	0.000281		0.000050	mg/L	04-OCT-19	0.1			
	Silicon (Si)-Total	4.62		0.10	mg/L	04-OCT-19				
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	04-OCT-19	0.0001			
	Sodium (Na)-Total	20.6		0.050	mg/L	04-OCT-19				
	Strontium (Sr)-Total	0.0999		0.0010	mg/L	04-OCT-19				
	Sulfur (S)-Total	5.54		0.50	mg/L	04-OCT-19				
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	04-OCT-19				
	Thallium (Tl)-Total	<0.000010		0.000010	mg/L	04-OCT-19	0.0003			
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	04-OCT-19				
	Tin (Sn)-Total	0.00010		0.00010	mg/L	04-OCT-19				
	Titanium (Ti)-Total	0.00341		0.00030	mg/L	04-OCT-19				
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.03			

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

ANALYTICAL GUIDELINE REPORT

60611735

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1
L2359227-1	HC-A(03)						
Sampled By:	S.SCOTT on 02-OCT-19 @ 10:00						
Matrix:	WATER						
Total Metals							
	Uranium (U)-Total	0.000848		0.000010	mg/L	04-OCT-19	0.005
	Vanadium (V)-Total	0.00077		0.00050	mg/L	04-OCT-19	0.006
	Zinc (Zn)-Total	0.0136		0.0030	mg/L	04-OCT-19	0.02
	Zirconium (Zr)-Total	0.00130		0.00020	mg/L	04-OCT-19	0.004
Aggregate Organics							
	BOD Carbonaceous	<2.0		2.0	mg/L	09-OCT-19	
L2359227-2	HC-A(04)						
Sampled By:	S.SCOTT on 02-OCT-19 @ 10:30						
Matrix:	WATER						
Physical Tests							
	Total Suspended Solids	4.4		2.0	mg/L	10-OCT-19	
Anions and Nutrients							
	Ammonia, Total (as N)	0.020		0.010	mg/L	07-OCT-19	
	Chloride (Cl)	184		0.50	mg/L	07-OCT-19	
	Nitrate (as N)	0.104		0.020	mg/L	07-OCT-19	
	Phosphorus (P)-Total Dissolved	0.0045		0.0030	mg/L	10-OCT-19	
	Phosphorus, Total	0.0153		0.0030	mg/L	10-OCT-19	*0.01
Bacteriological Tests							
	E. Coli	84		0	CFU/100mL	03-OCT-19	100
Total Metals							
	Aluminum (Al)-Total	0.0763		0.0050	mg/L	04-OCT-19	*0.015
	Antimony (Sb)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.02
	Arsenic (As)-Total	0.00065		0.00010	mg/L	04-OCT-19	0.005
	Barium (Ba)-Total	0.0524		0.00010	mg/L	04-OCT-19	
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.011
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	04-OCT-19	
	Boron (B)-Total	0.010		0.010	mg/L	04-OCT-19	0.2
	Cadmium (Cd)-Total	0.0000170		0.0000050	mg/L	04-OCT-19	0.0001
	Calcium (Ca)-Total	53.5		0.050	mg/L	04-OCT-19	
	Cesium (Cs)-Total	<0.000010		0.000010	mg/L	04-OCT-19	
	Chromium (Cr)-Total	0.00141		0.00050	mg/L	04-OCT-19	
	Cobalt (Co)-Total	0.00014		0.00010	mg/L	04-OCT-19	0.0009
	Copper (Cu)-Total	<0.0010		0.0010	mg/L	04-OCT-19	0.001
	Iron (Fe)-Total	0.234		0.010	mg/L	04-OCT-19	0.3
	Lead (Pb)-Total	0.000379		0.000050	mg/L	04-OCT-19	0.001
	Lithium (Li)-Total	0.0016		0.0010	mg/L	04-OCT-19	
	Magnesium (Mg)-Total	24.7		0.0050	mg/L	04-OCT-19	
	Manganese (Mn)-Total	0.0218		0.00050	mg/L	04-OCT-19	
	Molybdenum (Mo)-Total	0.000405		0.000050	mg/L	04-OCT-19	0.04
	Nickel (Ni)-Total	<0.00050		0.00050	mg/L	04-OCT-19	0.025
	Phosphorus (P)-Total	<0.050		0.050	mg/L	04-OCT-19	**0.01
	Potassium (K)-Total	1.50		0.050	mg/L	04-OCT-19	
	Rubidium (Rb)-Total	0.00136		0.00020	mg/L	04-OCT-19	

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits			
L2359227-2	HC-A(04)									
Sampled By:	S.SCOTT on 02-OCT-19 @ 10:30									
Matrix:	WATER						#1			
Total Metals										
	Selenium (Se)-Total	0.000084		0.000050	mg/L	04-OCT-19	0.1			
	Silicon (Si)-Total	1.09		0.10	mg/L	04-OCT-19				
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	04-OCT-19	0.0001			
	Sodium (Na)-Total	92.3		0.050	mg/L	04-OCT-19				
	Strontium (Sr)-Total	0.0962		0.0010	mg/L	04-OCT-19				
	Sulfur (S)-Total	6.05		0.50	mg/L	04-OCT-19				
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	04-OCT-19				
	Thallium (Tl)-Total	<0.000010		0.000010	mg/L	04-OCT-19	0.0003			
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	04-OCT-19				
	Tin (Sn)-Total	<0.00010		0.00010	mg/L	04-OCT-19				
	Titanium (Ti)-Total	<0.0020	DLUI	0.0020	mg/L	04-OCT-19				
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.03			
	Uranium (U)-Total	0.000403		0.000010	mg/L	04-OCT-19	0.005			
	Vanadium (V)-Total	<0.00050		0.00050	mg/L	04-OCT-19	0.006			
	Zinc (Zn)-Total	0.0108		0.0030	mg/L	04-OCT-19	0.02			
	Zirconium (Zr)-Total	<0.00020		0.00020	mg/L	04-OCT-19	0.004			
Aggregate Organics										
	BOD Carbonaceous	<2.0		2.0	mg/L	09-OCT-19				
L2359227-3	HC-A(12)									
Sampled By:	S.SCOTT on 02-OCT-19 @ 14:30									
Matrix:	WATER						#1			
Physical Tests										
	Total Suspended Solids	15.2		2.0	mg/L	10-OCT-19				
Anions and Nutrients										
	Ammonia, Total (as N)	0.095		0.010	mg/L	07-OCT-19				
	Chloride (Cl)	201		0.50	mg/L	07-OCT-19				
	Nitrate (as N)	0.082		0.020	mg/L	07-OCT-19				
	Phosphorus (P)-Total Dissolved	0.0160		0.0030	mg/L	10-OCT-19				
	Phosphorus, Total	0.178		0.0030	mg/L	10-OCT-19	*0.01			
Bacteriological Tests										
	E. Coli	1500	DLM	100	CFU/100mL	03-OCT-19	*100			
Total Metals										
	Aluminum (Al)-Total	0.740		0.0050	mg/L	04-OCT-19	*0.015			
	Antimony (Sb)-Total	0.00011		0.00010	mg/L	04-OCT-19	0.02			
	Arsenic (As)-Total	0.00154		0.00010	mg/L	04-OCT-19	0.005			
	Barium (Ba)-Total	0.0937		0.00010	mg/L	04-OCT-19				
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.011			
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	04-OCT-19				
	Boron (B)-Total	0.016		0.010	mg/L	04-OCT-19	0.2			
	Cadmium (Cd)-Total	0.000433		0.0000050	mg/L	04-OCT-19	*0.0001			
	Calcium (Ca)-Total	72.2		0.050	mg/L	04-OCT-19				
	Cesium (Cs)-Total	0.000063		0.000010	mg/L	04-OCT-19				
	Chromium (Cr)-Total	0.00156		0.00050	mg/L	04-OCT-19				

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits			
L2359227-3	HC-A(12)									
Sampled By:	S.SCOTT on 02-OCT-19 @ 14:30									
Matrix:	WATER						#1			
Total Metals										
	Cobalt (Co)-Total	0.00067		0.00010	mg/L	04-OCT-19	0.0009			
	Copper (Cu)-Total	0.0052		0.0010	mg/L	04-OCT-19	*0.001			
	Iron (Fe)-Total	1.84		0.010	mg/L	04-OCT-19	*0.3			
	Lead (Pb)-Total	0.00477		0.000050	mg/L	04-OCT-19	*0.001			
	Lithium (Li)-Total	0.0024		0.0010	mg/L	04-OCT-19				
	Magnesium (Mg)-Total	26.5		0.0050	mg/L	04-OCT-19				
	Manganese (Mn)-Total	0.341		0.00050	mg/L	04-OCT-19				
	Molybdenum (Mo)-Total	0.000393		0.000050	mg/L	04-OCT-19	0.04			
	Nickel (Ni)-Total	0.00174		0.00050	mg/L	04-OCT-19	0.025			
	Phosphorus (P)-Total	0.212		0.050	mg/L	04-OCT-19	*0.01			
	Potassium (K)-Total	2.31		0.050	mg/L	04-OCT-19				
	Rubidium (Rb)-Total	0.00250		0.00020	mg/L	04-OCT-19				
	Selenium (Se)-Total	0.000404		0.000050	mg/L	04-OCT-19	0.1			
	Silicon (Si)-Total	3.79		0.10	mg/L	04-OCT-19				
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	04-OCT-19	0.0001			
	Sodium (Na)-Total	102	DLHC	0.50	mg/L	04-OCT-19				
	Strontium (Sr)-Total	0.112		0.0010	mg/L	04-OCT-19				
	Sulfur (S)-Total	8.14		0.50	mg/L	04-OCT-19				
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	04-OCT-19				
	Thallium (Tl)-Total	0.000027		0.000010	mg/L	04-OCT-19	0.0003			
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	04-OCT-19				
	Tin (Sn)-Total	<0.00010		0.00010	mg/L	04-OCT-19				
	Titanium (Ti)-Total	0.0163		0.00030	mg/L	04-OCT-19				
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.03			
	Uranium (U)-Total	0.000392		0.000010	mg/L	04-OCT-19	0.005			
	Vanadium (V)-Total	0.00194		0.00050	mg/L	04-OCT-19	0.006			
	Zinc (Zn)-Total	0.100		0.0030	mg/L	04-OCT-19	*0.02			
	Zirconium (Zr)-Total	0.00025		0.00020	mg/L	04-OCT-19	0.004			
Aggregate Organics										
	BOD Carbonaceous	<2.0		2.0	mg/L	09-OCT-19				
L2359227-4	HC-A(13)									
Sampled By:	S.SCOTT on 02-OCT-19 @ 15:15									
Matrix:	WATER						#1			
Physical Tests										
	Total Suspended Solids	16.7		2.0	mg/L	10-OCT-19				
Anions and Nutrients										
	Ammonia, Total (as N)	0.012		0.010	mg/L	07-OCT-19				
	Chloride (Cl)	199		0.50	mg/L	07-OCT-19				
	Nitrate (as N)	0.052		0.020	mg/L	07-OCT-19				
	Phosphorus (P)-Total Dissolved	0.0201		0.0030	mg/L	10-OCT-19				
	Phosphorus, Total	0.0490		0.0030	mg/L	10-OCT-19	*0.01			
Bacteriological Tests										
	E. Coli	680	DLM	10	CFU/100mL	03-OCT-19	*100			
Total Metals										

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1
L2359227-4	HC-A(13)						
Sampled By:	S.SCOTT on 02-OCT-19 @ 15:15						
Matrix:	WATER						
Total Metals							
	Aluminum (Al)-Total	0.156		0.0050	mg/L	04-OCT-19	*0.015
	Antimony (Sb)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.02
	Arsenic (As)-Total	0.00072		0.00010	mg/L	04-OCT-19	0.005
	Barium (Ba)-Total	0.0571		0.00010	mg/L	04-OCT-19	
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.011
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	04-OCT-19	
	Boron (B)-Total	0.015		0.010	mg/L	04-OCT-19	0.2
	Cadmium (Cd)-Total	0.0000759		0.0000050	mg/L	04-OCT-19	0.0001
	Calcium (Ca)-Total	66.1		0.050	mg/L	04-OCT-19	
	Cesium (Cs)-Total	0.000014		0.000010	mg/L	04-OCT-19	
	Chromium (Cr)-Total	0.00126		0.00050	mg/L	04-OCT-19	
	Cobalt (Co)-Total	0.00016		0.00010	mg/L	04-OCT-19	0.0009
	Copper (Cu)-Total	0.0019		0.0010	mg/L	04-OCT-19	*0.001
	Iron (Fe)-Total	0.340		0.010	mg/L	04-OCT-19	*0.3
	Lead (Pb)-Total	0.00105		0.000050	mg/L	04-OCT-19	*0.001
	Lithium (Li)-Total	0.0016		0.0010	mg/L	04-OCT-19	
	Magnesium (Mg)-Total	24.5		0.0050	mg/L	04-OCT-19	
	Manganese (Mn)-Total	0.0405		0.00050	mg/L	04-OCT-19	
	Molybdenum (Mo)-Total	0.000378		0.000050	mg/L	04-OCT-19	0.04
	Nickel (Ni)-Total	0.00069		0.00050	mg/L	04-OCT-19	0.025
	Phosphorus (P)-Total	0.077		0.050	mg/L	04-OCT-19	*0.01
	Potassium (K)-Total	2.85		0.050	mg/L	04-OCT-19	
	Rubidium (Rb)-Total	0.00222		0.00020	mg/L	04-OCT-19	
	Selenium (Se)-Total	0.000186		0.000050	mg/L	04-OCT-19	0.1
	Silicon (Si)-Total	3.39		0.10	mg/L	04-OCT-19	
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	04-OCT-19	0.0001
	Sodium (Na)-Total	100	DLHC	0.50	mg/L	04-OCT-19	
	Strontium (Sr)-Total	0.107		0.0010	mg/L	04-OCT-19	
	Sulfur (S)-Total	7.87		0.50	mg/L	04-OCT-19	
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	04-OCT-19	
	Thallium (Tl)-Total	<0.000010		0.000010	mg/L	04-OCT-19	0.0003
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	04-OCT-19	
	Tin (Sn)-Total	<0.00010		0.00010	mg/L	04-OCT-19	
	Titanium (Ti)-Total	0.00432		0.00030	mg/L	04-OCT-19	
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.03
	Uranium (U)-Total	0.000322		0.000010	mg/L	04-OCT-19	0.005
	Vanadium (V)-Total	0.00062		0.00050	mg/L	04-OCT-19	0.006
	Zinc (Zn)-Total	0.0202		0.0030	mg/L	04-OCT-19	*0.02
	Zirconium (Zr)-Total	<0.00020		0.00020	mg/L	04-OCT-19	0.004
Aggregate Organics							
	BOD Carbonaceous	<2.0		2.0	mg/L	09-OCT-19	
L2359227-5	HC-A(14)						
Sampled By:	S.SCOTT on 02-OCT-19 @ 15:45						
Matrix:	WATER						
Physical Tests							

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits			
L2359227-5	HC-A(14)									
Sampled By:	S.SCOTT on 02-OCT-19 @ 15:45									
Matrix:	WATER						#1			
Physical Tests										
	Total Suspended Solids	70.2		2.0	mg/L	10-OCT-19				
Anions and Nutrients										
	Ammonia, Total (as N)	0.051		0.010	mg/L	07-OCT-19				
	Chloride (Cl)	198		0.50	mg/L	07-OCT-19				
	Nitrate (as N)	0.050		0.020	mg/L	07-OCT-19				
	Phosphorus (P)-Total Dissolved	0.0165		0.0030	mg/L	10-OCT-19				
	Phosphorus, Total	0.148		0.0030	mg/L	10-OCT-19	*0.01			
Bacteriological Tests										
	E. Coli	1100	DLM	100	CFU/100mL	03-OCT-19	*100			
Total Metals										
	Aluminum (Al)-Total	0.648		0.0050	mg/L	04-OCT-19	*0.015			
	Antimony (Sb)-Total	0.00012		0.00010	mg/L	04-OCT-19	0.02			
	Arsenic (As)-Total	0.00118		0.00010	mg/L	04-OCT-19	0.005			
	Barium (Ba)-Total	0.0706		0.00010	mg/L	04-OCT-19				
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.011			
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	04-OCT-19				
	Boron (B)-Total	0.017		0.010	mg/L	04-OCT-19	0.2			
	Cadmium (Cd)-Total	0.000285		0.0000050	mg/L	04-OCT-19	*0.0001			
	Calcium (Ca)-Total	69.3		0.050	mg/L	04-OCT-19				
	Cesium (Cs)-Total	0.000053		0.000010	mg/L	04-OCT-19				
	Chromium (Cr)-Total	0.00219		0.00050	mg/L	04-OCT-19				
	Cobalt (Co)-Total	0.00048		0.00010	mg/L	04-OCT-19	0.0009			
	Copper (Cu)-Total	0.0044		0.0010	mg/L	04-OCT-19	*0.001			
	Iron (Fe)-Total	1.11		0.010	mg/L	04-OCT-19	*0.3			
	Lead (Pb)-Total	0.00402		0.000050	mg/L	04-OCT-19	*0.001			
	Lithium (Li)-Total	0.0021		0.0010	mg/L	04-OCT-19				
	Magnesium (Mg)-Total	25.1		0.0050	mg/L	04-OCT-19				
	Manganese (Mn)-Total	0.122		0.00050	mg/L	04-OCT-19				
	Molybdenum (Mo)-Total	0.000441		0.000050	mg/L	04-OCT-19	0.04			
	Nickel (Ni)-Total	0.00141		0.00050	mg/L	04-OCT-19	0.025			
	Phosphorus (P)-Total	0.159		0.050	mg/L	04-OCT-19	*0.01			
	Potassium (K)-Total	2.96		0.050	mg/L	04-OCT-19				
	Rubidium (Rb)-Total	0.00294		0.00020	mg/L	04-OCT-19				
	Selenium (Se)-Total	0.000341		0.000050	mg/L	04-OCT-19	0.1			
	Silicon (Si)-Total	3.98		0.10	mg/L	04-OCT-19				
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	04-OCT-19	0.0001			
	Sodium (Na)-Total	98.3	DLHC	0.50	mg/L	04-OCT-19				
	Strontium (Sr)-Total	0.109		0.0010	mg/L	04-OCT-19				
	Sulfur (S)-Total	8.02		0.50	mg/L	04-OCT-19				
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	04-OCT-19				
	Thallium (Tl)-Total	0.000021		0.000010	mg/L	04-OCT-19	0.0003			
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	04-OCT-19				
	Tin (Sn)-Total	<0.00010		0.00010	mg/L	04-OCT-19				
	Titanium (Ti)-Total	0.0149		0.00030	mg/L	04-OCT-19				
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	04-OCT-19	0.03			

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1			
L2359227-5	HC-A(14)									
Sampled By:	S.SCOTT on 02-OCT-19 @ 15:45									
Matrix:	WATER									
Total Metals										
	Uranium (U)-Total	0.000390		0.000010	mg/L	04-OCT-19	0.005			
	Vanadium (V)-Total	0.00153		0.00050	mg/L	04-OCT-19	0.006			
	Zinc (Zn)-Total	0.0657		0.0030	mg/L	04-OCT-19	*0.02			
	Zirconium (Zr)-Total	0.00021		0.00020	mg/L	04-OCT-19	0.004			
Aggregate Organics										
	BOD Carbonaceous	<2.0		2.0	mg/L	09-OCT-19				

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
DLUI	Detection Limit Raised: Unknown Interference generated an apparent false positive test result.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Method Reference***
BOD-C-WT	Water	BOD Carbonaceous	APHA 5210 B (CBOD)

This analysis is carried out using procedures adapted from APHA Method 5210B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h. Method ID: WT-TM-1200

EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

*** ALS test methods may incorporate modifications from specified reference methods to improve performance.

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA		

Reference Information

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information. Guideline limits are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BOD-C-WT	**Water**							
Batch R4863471								
WG3182559-2 DUP		**L2359300-1**						
BOD Carbonaceous		3.2	3.0		mg/L	5.2	20	09-OCT-19
WG3182559-3 LCS								
BOD Carbonaceous			90.4		%		85-115	09-OCT-19
WG3182559-1 MB								
BOD Carbonaceous			<2.0		mg/L		2	09-OCT-19
CL-IC-N-WT	**Water**							
Batch R4861651								
WG3184071-4 DUP		**WG3184071-3**						
Chloride (Cl)		17.0	17.0		mg/L	0.2	20	07-OCT-19
WG3184071-2 LCS								
Chloride (Cl)			100.9		%		90-110	07-OCT-19
WG3184071-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	07-OCT-19
WG3184071-5 MS		**WG3184071-3**						
Chloride (Cl)			102.5		%		75-125	07-OCT-19
EC-MF-WT	**Water**							
Batch R4859290								
WG3181203-3 DUP		**L2359263-6**						
E. Coli		5	3		CFU/100mL	50	65	03-OCT-19
WG3181203-1 MB								
E. Coli			0		CFU/100mL		1	03-OCT-19
MET-T-CCMS-WT	**Water**							
Batch R4860298								
WG3181559-4 DUP		**WG3181559-3**						
Aluminum (Al)-Total		0.0297	0.0286		mg/L	3.7	20	04-OCT-19
Antimony (Sb)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	04-OCT-19
Arsenic (As)-Total		0.00039	0.00038		mg/L	2.1	20	04-OCT-19
Barium (Ba)-Total		0.0447	0.0429		mg/L	4.0	20	04-OCT-19
Beryllium (Be)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	04-OCT-19
Bismuth (Bi)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	04-OCT-19
Boron (B)-Total		0.015	0.015		mg/L	0.7	20	04-OCT-19
Cadmium (Cd)-Total		<0.0000050	0.0000055	RPD-NA	mg/L	N/A	20	04-OCT-19
Calcium (Ca)-Total		46.1	45.9		mg/L	0.3	20	04-OCT-19
Chromium (Cr)-Total		0.00199	0.00168		mg/L	17	20	04-OCT-19
Cesium (Cs)-Total		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	04-OCT-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4860298								
WG3181559-4 DUP		**WG3181559-3**						
Cobalt (Co)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	04-OCT-19
Copper (Cu)-Total		0.0046	0.0046		mg/L	1.3	20	04-OCT-19
Iron (Fe)-Total		0.083	0.080		mg/L	3.9	20	04-OCT-19
Lead (Pb)-Total		0.000218	0.000285	J	mg/L	0.000067	0.0001	04-OCT-19
Lithium (Li)-Total		0.0011	0.0010		mg/L	5.2	20	04-OCT-19
Magnesium (Mg)-Total		5.57	5.31		mg/L	4.6	20	04-OCT-19
Manganese (Mn)-Total		0.0277	0.0265		mg/L	4.7	20	04-OCT-19
Molybdenum (Mo)-Total		0.000253	0.000248		mg/L	1.9	20	04-OCT-19
Nickel (Ni)-Total		0.00066	0.00054		mg/L	20	20	04-OCT-19
Phosphorus (P)-Total		<0.050	<0.050	RPD-NA	mg/L	N/A	20	04-OCT-19
Potassium (K)-Total		1.58	1.52		mg/L	3.8	20	04-OCT-19
Rubidium (Rb)-Total		0.00195	0.00205		mg/L	5.1	20	04-OCT-19
Selenium (Se)-Total		0.000092	0.000075	J	mg/L	0.000017	0.0001	04-OCT-19
Silicon (Si)-Total		3.16	3.10		mg/L	1.8	20	04-OCT-19
Silver (Ag)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	04-OCT-19
Sodium (Na)-Total		35.2	34.2		mg/L	2.9	20	04-OCT-19
Strontium (Sr)-Total		0.156	0.158		mg/L	1.1	20	04-OCT-19
Sulfur (S)-Total		3.54	3.45		mg/L	2.6	25	04-OCT-19
Thallium (Tl)-Total		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	04-OCT-19
Tellurium (Te)-Total		<0.00020	<0.00020	RPD-NA	mg/L	N/A	20	04-OCT-19
Thorium (Th)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	25	04-OCT-19
Tin (Sn)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	04-OCT-19
Titanium (Ti)-Total		0.00104	0.00109		mg/L	4.9	20	04-OCT-19
Tungsten (W)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	04-OCT-19
Uranium (U)-Total		0.000237	0.000236		mg/L	0.7	20	04-OCT-19
Vanadium (V)-Total		0.00056	0.00054		mg/L	3.3	20	04-OCT-19
Zinc (Zn)-Total		0.0050	0.0053		mg/L	6.2	20	04-OCT-19
Zirconium (Zr)-Total		<0.00020	<0.00020	RPD-NA	mg/L	N/A	20	04-OCT-19
WG3181559-2 LCS								
Aluminum (Al)-Total			106.3		%		80-120	04-OCT-19
Antimony (Sb)-Total			104.3		%		80-120	04-OCT-19
Arsenic (As)-Total			101.1		%		80-120	04-OCT-19
Barium (Ba)-Total			102.0		%		80-120	04-OCT-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4860298								
WG3181559-2 LCS								
Beryllium (Be)-Total			102.6		%		80-120	04-OCT-19
Bismuth (Bi)-Total			99.98		%		80-120	04-OCT-19
Boron (B)-Total			101.5		%		80-120	04-OCT-19
Cadmium (Cd)-Total			99.99		%		80-120	04-OCT-19
Calcium (Ca)-Total			103.8		%		80-120	04-OCT-19
Chromium (Cr)-Total			102.3		%		80-120	04-OCT-19
Cesium (Cs)-Total			102.0		%		80-120	04-OCT-19
Cobalt (Co)-Total			101.0		%		80-120	04-OCT-19
Copper (Cu)-Total			100.2		%		80-120	04-OCT-19
Iron (Fe)-Total			97.7		%		80-120	04-OCT-19
Lead (Pb)-Total			103.2		%		80-120	04-OCT-19
Lithium (Li)-Total			104.9		%		80-120	04-OCT-19
Magnesium (Mg)-Total			107.4		%		80-120	04-OCT-19
Manganese (Mn)-Total			104.6		%		80-120	04-OCT-19
Molybdenum (Mo)-Total			101.9		%		80-120	04-OCT-19
Nickel (Ni)-Total			101.0		%		80-120	04-OCT-19
Phosphorus (P)-Total			109.1		%		70-130	04-OCT-19
Potassium (K)-Total			98.1		%		80-120	04-OCT-19
Rubidium (Rb)-Total			103.3		%		80-120	04-OCT-19
Selenium (Se)-Total			101.6		%		80-120	04-OCT-19
Silicon (Si)-Total			105.2		%		60-140	04-OCT-19
Silver (Ag)-Total			105.3		%		80-120	04-OCT-19
Sodium (Na)-Total			106.0		%		80-120	04-OCT-19
Strontium (Sr)-Total			104.4		%		80-120	04-OCT-19
Sulfur (S)-Total			102.2		%		80-120	04-OCT-19
Thallium (Tl)-Total			98.8		%		80-120	04-OCT-19
Tellurium (Te)-Total			101.4		%		80-120	04-OCT-19
Thorium (Th)-Total			103.1		%		70-130	04-OCT-19
Tin (Sn)-Total			102.2		%		80-120	04-OCT-19
Titanium (Ti)-Total			101.9		%		80-120	04-OCT-19
Tungsten (W)-Total			100.9		%		80-120	04-OCT-19
Uranium (U)-Total			99.5		%		80-120	04-OCT-19
Vanadium (V)-Total			103.8		%		80-120	04-OCT-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4860298								
WG3181559-2 LCS								
Zinc (Zn)-Total			102.7		%		80-120	04-OCT-19
Zirconium (Zr)-Total			103.6		%		80-120	04-OCT-19
WG3181559-1 MB								
Aluminum (Al)-Total			<0.0050		mg/L		0.005	04-OCT-19
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	04-OCT-19
Arsenic (As)-Total			<0.00010		mg/L		0.0001	04-OCT-19
Barium (Ba)-Total			<0.00010		mg/L		0.0001	04-OCT-19
Beryllium (Be)-Total			<0.00010		mg/L		0.0001	04-OCT-19
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	04-OCT-19
Boron (B)-Total			<0.010		mg/L		0.01	04-OCT-19
Cadmium (Cd)-Total			<0.0000050		mg/L		0.000005	04-OCT-19
Calcium (Ca)-Total			<0.050		mg/L		0.05	04-OCT-19
Chromium (Cr)-Total			<0.00050		mg/L		0.0005	04-OCT-19
Cesium (Cs)-Total			<0.000010		mg/L		0.00001	04-OCT-19
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	04-OCT-19
Copper (Cu)-Total			<0.0010		mg/L		0.001	04-OCT-19
Iron (Fe)-Total			<0.010		mg/L		0.01	04-OCT-19
Lead (Pb)-Total			<0.000050		mg/L		0.00005	04-OCT-19
Lithium (Li)-Total			<0.0010		mg/L		0.001	04-OCT-19
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	04-OCT-19
Manganese (Mn)-Total			<0.00050		mg/L		0.0005	04-OCT-19
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	04-OCT-19
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	04-OCT-19
Phosphorus (P)-Total			<0.050		mg/L		0.05	04-OCT-19
Potassium (K)-Total			<0.050		mg/L		0.05	04-OCT-19
Rubidium (Rb)-Total			<0.00020		mg/L		0.0002	04-OCT-19
Selenium (Se)-Total			<0.000050		mg/L		0.00005	04-OCT-19
Silicon (Si)-Total			<0.10		mg/L		0.1	04-OCT-19
Silver (Ag)-Total			<0.000050		mg/L		0.00005	04-OCT-19
Sodium (Na)-Total			<0.050		mg/L		0.05	04-OCT-19
Strontium (Sr)-Total			<0.0010		mg/L		0.001	04-OCT-19
Sulfur (S)-Total			<0.50		mg/L		0.5	04-OCT-19
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	04-OCT-19
Tellurium (Te)-Total			<0.00020		mg/L		0.0002	04-OCT-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4860298								
WG3181559-1 MB								
Thorium (Th)-Total			<0.00010		mg/L		0.0001	04-OCT-19
Tin (Sn)-Total			<0.00010		mg/L		0.0001	04-OCT-19
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	04-OCT-19
Tungsten (W)-Total			<0.00010		mg/L		0.0001	04-OCT-19
Uranium (U)-Total			<0.000010		mg/L		0.00001	04-OCT-19
Vanadium (V)-Total			<0.00050		mg/L		0.0005	04-OCT-19
Zinc (Zn)-Total			<0.0030		mg/L		0.003	04-OCT-19
Zirconium (Zr)-Total			<0.00020		mg/L		0.0002	04-OCT-19
WG3181559-5 MS		**WG3181559-6**						
Aluminum (Al)-Total			105.0		%		70-130	07-OCT-19
Antimony (Sb)-Total			102.4		%		70-130	07-OCT-19
Arsenic (As)-Total			108.0		%		70-130	07-OCT-19
Barium (Ba)-Total			96.7		%		70-130	07-OCT-19
Beryllium (Be)-Total			96.8		%		70-130	07-OCT-19
Bismuth (Bi)-Total			105.1		%		70-130	07-OCT-19
Boron (B)-Total			98.1		%		70-130	07-OCT-19
Cadmium (Cd)-Total			98.4		%		70-130	07-OCT-19
Calcium (Ca)-Total			N/A	MS-B	%		-	07-OCT-19
Chromium (Cr)-Total			109.2		%		70-130	07-OCT-19
Cesium (Cs)-Total			102.4		%		70-130	07-OCT-19
Cobalt (Co)-Total			99.5		%		70-130	07-OCT-19
Copper (Cu)-Total			102.7		%		70-130	07-OCT-19
Iron (Fe)-Total			N/A	MS-B	%		-	07-OCT-19
Lead (Pb)-Total			104.6		%		70-130	07-OCT-19
Lithium (Li)-Total			97.8		%		70-130	07-OCT-19
Magnesium (Mg)-Total			109.0		%		70-130	07-OCT-19
Manganese (Mn)-Total			N/A	MS-B	%		-	07-OCT-19
Molybdenum (Mo)-Total			98.8		%		70-130	07-OCT-19
Nickel (Ni)-Total			101.7		%		70-130	07-OCT-19
Phosphorus (P)-Total			111.8		%		70-130	07-OCT-19
Potassium (K)-Total			108.6		%		70-130	07-OCT-19
Rubidium (Rb)-Total			104.7		%		70-130	07-OCT-19
Selenium (Se)-Total			115.7		%		70-130	07-OCT-19
Silicon (Si)-Total			99.6		%		70-130	07-OCT-19

ALS Environmental

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4860298								
WG3181559-5 MS		**WG3181559-6**						
Silver (Ag)-Total			99.9		%		70-130	07-OCT-19
Sodium (Na)-Total			101.9		%		70-130	07-OCT-19
Strontium (Sr)-Total			103.6		%		70-130	07-OCT-19
Sulfur (S)-Total			100.9		%		70-130	07-OCT-19
Thallium (Tl)-Total			101.3		%		70-130	07-OCT-19
Tellurium (Te)-Total			102.7		%		70-130	07-OCT-19
Thorium (Th)-Total			103.7		%		70-130	07-OCT-19
Tin (Sn)-Total			100.4		%		70-130	07-OCT-19
Titanium (Ti)-Total			100.3		%		70-130	07-OCT-19
Tungsten (W)-Total			101.5		%		70-130	07-OCT-19
Uranium (U)-Total			101.7		%		70-130	07-OCT-19
Vanadium (V)-Total			105.5		%		70-130	07-OCT-19
Zinc (Zn)-Total			98.7		%		70-130	07-OCT-19
Zirconium (Zr)-Total			99.97		%		70-130	07-OCT-19
NH3-F-WT	**Water**							
Batch R4860725								
WG3183728-11 DUP		**L2359231-1**						
Ammonia, Total (as N)		14.6	15.4		mg/L	5.5	20	07-OCT-19
WG3183728-10 LCS								
Ammonia, Total (as N)			99.8		%		85-115	07-OCT-19
WG3183728-9 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	07-OCT-19
WG3183728-12 MS		**L2359231-1**						
Ammonia, Total (as N)			N/A	MS-B	%		-	07-OCT-19
NO3-IC-WT	**Water**							
Batch R4861651								
WG3184071-4 DUP		**WG3184071-3**						
Nitrate (as N)		0.127	0.125		mg/L	2.1	20	07-OCT-19
WG3184071-2 LCS								
Nitrate (as N)			100.5		%		90-110	07-OCT-19
WG3184071-1 MB								
Nitrate (as N)			<0.020		mg/L		0.02	07-OCT-19
WG3184071-5 MS		**WG3184071-3**						
Nitrate (as N)			101.5		%		75-125	07-OCT-19
P-T-COL-WT	**Water**							

ALS Environmental

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
P-T-COL-WT	**Water**							
Batch R4866366								
WG3185802-3 DUP		**L2359394-11**						
Phosphorus, Total		0.0559	0.0571		mg/L	2.2	20	10-OCT-19
WG3185802-2 LCS								
Phosphorus, Total			99.6		%		80-120	10-OCT-19
WG3185802-1 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	10-OCT-19
P-TD-COL-WT	**Water**							
Batch R4866371								
WG3185803-3 DUP		**L2359394-5**						
Phosphorus (P)-Total Dissolved		0.0313	0.0290		mg/L	7.6	20	10-OCT-19
WG3185803-2 LCS								
Phosphorus (P)-Total Dissolved			99.4		%		80-120	10-OCT-19
WG3185803-1 MB								
Phosphorus (P)-Total Dissolved			<0.0030		mg/L		0.003	10-OCT-19
WG3185803-4 MS		**L2359394-5**						
Phosphorus (P)-Total Dissolved			83.6		%		70-130	10-OCT-19
SOLIDS-TSS-WT	**Water**							
Batch R4865170								
WG3186121-3 DUP		**L2360181-1**						
Total Suspended Solids		2570	2510		mg/L	2.5	20	10-OCT-19
WG3186121-2 LCS								
Total Suspended Solids			100.5		%		85-115	10-OCT-19
WG3186121-1 MB								
Total Suspended Solids			<2.0		mg/L		2	10-OCT-19

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

C of C # 00000

60 NORTHLAND ROAD, U
WATERLOO, ON N2V 2B8
Phone: (519) 886- 6910
Fax: (519) 886- 9047
Toll Free: 1- 800- 668- 9878

L2359227-COFC

ALS

USTODY / ANALYTICAL SERVICES REQUEST FORM

Page ___ of ___

Note: ... is in business days which exclude statutory holidays and weekends. TAT samples received past 3:00 pm or Saturday/Sunday begin the next day.

Specify date required	Service requested			
	5 day (regular)	X	2 day TAT (50%)	
	3-4 day (regular)		Next day TAT (100%)	
			Same day TAT (200%)	

COMPANY NAME	AECOM
OFFICE	Kitchener
PROJECT MANAGER	Steven Scott
PROJECT #	60611735
PHONE	519-650-8637 OR 519-569-9388
FAX	
ACCOUNT #	15884
Q72311	PO #

CRITERIA — Criteria on report YESX__ NO___

Reg 153/11
Table 1 2 3

TCLP _____ MISA ______ PWQO ___X__
ODWS _____ OTHER ______

REPORT FORMAT/DISTRIBUTION

EMAIL _X_ FAX ___ BOTH ___
SELECT: PDF ___ DIGITAL ___ BOTH _X_
EMAIL 1 Tara.Roumeliotis@aecom.com
EMAIL 2 Steve.Scott2@aecom.com
EMAIL 3 Tochi.Azubuike@aecom.com

PLEASE INDICATE FILTERED, PRESERVED OR BOTH <----- (F, P, F/P)

SUBMISSION #: L2359227
ENTERED BY: SM
DATE/TIME ENTERED:
BIN #:

SAMPLING INFORMATION

Date (dd-mm-yy)	Time (24hr) (hh:mm)	COMP	GRAB	WATER	SOIL	OTHER	SAMPLE DESCRIPTION TO APPEAR ON REPORT	NUMBER OF CONTAINERS	TSS	CBOD5	E. Coli	Total Metals by ICPMS (Lead, Zinc, Coppe	Total and Dissolved P (Lab Filter)	Total Ammonia Nitrogen, NO^3, and CL					COMMENTS	LAB ID
02-10-19	10:00			X			HC-A(03)	7	X	X	X	X	X	X					See Special Instructions	
02-10-19	10:30			X			HC-A(04)	7	X	X	X	X	X	X					See Special Instructions	
02-10-19	14:30			X			HC-A(12)	7	X	X	X	X	X	X					See Special Instructions	
02-10-19	15:15			X			HC-A(13)	7	X	X	X	X	X	X					See Special Instructions	
02-10-19	15:45			X			HC-A(14)	7	X	X	X	X	X	X					See Special Instructions	

SPECIAL INSTRUCTIONS/COMMENTS

Surface water samples, so colforms counts may be high.

Bottles were recycled from another project so please be aware the bottle labels may not match CoC.

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (CHECK Yes OR No)

Are any samples taken from a regulated DW System? Yes ___ No ___
If yes, an authorized drinking water COC MUST be used for this submission.
Is the water sample intended to be potable for human consumption? Yes ___ No ___

SAMPLE CONDITION

___ FROZEN
___ COLD
___ COOLING INITIATED
___ AMBIENT

MEAN TEMP 9.3

SAMPLED BY: Steven Scott	DATE & TIME -12-18	RECEIVED BY:	DATE & TIME	OBSERVATIONS: Yes___ No___ If yes add SIF
RELINQUISHED BY: Steven Scott	DATE & TIME 01-12-18	RECEIVED AT LAB BY: [signature]	DATE & TIME 02/3/19 15:15	INIT

Notes
1. Quote number must be provided to ensure proper pricing
2. TAT may vary dependent on complexity of analysis and lab workload at time of submission. Please contact the lab to confirm TATs.
3. Any known or suspected hazards relating to a sample must be noted on the chain of custody in comments section.

ALS		Sample ID					HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)
1/11/2020		ALS ID					L2110610-1	L2110610-2	L2110610-3	L2110610-4	L2110610-5
L2359227		Date Sampled	PWQO		Guelph Storm		6/12/2018 10:50:00 AM	6/12/2018 11:10:00 AM	6/12/2018 11:25:00 AM	6/12/2018 2:45:00 PM	6/12/2018 3:15:00 PM
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Water	Water	Water	Water	Water
Total Suspended Solids	mg/L	2	-	-	-	15	15.2!!	4.4	15.2!!	16.7!!	70.2!!
Ammonia, Total (as N)	mg/L	0.01	-	-	-	-	0.01	0.02	0.095	0.012	0.051
Chloride (Cl)	mg/L	0.5	-	-	-	-	47.4	184	201	199	198
Nitrate (as N)	mg/L	0.02	-	-	-	-	0.973	0.104	0.082	0.052	0.05
Phosphorus (P)-Total Dissolved	mg/L	0.003	-	-	-	-	0.0069	0.0045	0.016	0.0201	0.0165
Phosphorus, Total	mg/L	0.003	-	0.02	-	-	0.0334!	0.0153	0.178!	0.049!	0.148!
E. Coli	CFU/100mL	0	-	100	-	-	450!	84	1500!	680!	1100!
Aluminum (Al)-Total	mg/L	0.005	-	0.015	-	-	0.15!	0.0763!	0.74!	0.156!	0.648!
Antimony (Sb)-Total	mg/L	0.0001	-	0.02	-	-	0.0001	0.0001	0.00011	0.0001	0.00012
Arsenic (As)-Total	mg/L	0.0001	-	0.005	-	-	0.00042	0.00065	0.00154	0.00072	0.00118
Barium (Ba)-Total	mg/L	0.0001	-	-	-	-	0.059	0.0524	0.0937	0.0571	0.0706
Beryllium (Be)-Total	mg/L	0.0001	-	0.011	-	-	0.0001	0.0001	0.0001	0.0001	0.0001
Bismuth (Bi)-Total	mg/L	0.00005	-	-	-	-	0.00005	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	0.01	-	0.2	-	-	0.013	0.01	0.016	0.015	0.017
Cadmium (Cd)-Total	mg/L	0.000005	-	0.0001	-	0.001	0.0000834	0.000017	0.000433!	0.0000759	0.000285!
Calcium (Ca)-Total	mg/L	0.05	-	-	-	-	82.9	53.5	72.2	66.1	69.3
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	0.000014	0.00001	0.000063	0.000014	0.000053
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	0.00174	0.00141	0.00156	0.00126	0.00219
Cobalt (Co)-Total	mg/L	0.0001	-	0.0009	-	-	0.00017	0.00014	0.00067	0.00016	0.00048
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.0021!	0.001	0.0052!	0.0019!	0.0044!
Iron (Fe)-Total	mg/L	0.01	-	0.3	-	-	0.334!	0.234	1.84!	0.34!	1.11!
Lead (Pb)-Total	mg/L	0.00005	-	0.001	-	0.05	0.00072	0.000379	0.00477!	0.00105!	0.00402!
Lithium (Li)-Total	mg/L	0.001	-	-	-	-	0.0014	0.0016	0.0024	0.0016	0.0021
Magnesium (Mg)-Total	mg/L	0.005	-	-	-	-	24.1	24.7	26.5	24.5	25.1
Manganese (Mn)-Total	mg/L	0.0005	-	-	-	-	0.051	0.0218	0.341	0.0405	0.122
Molybdenum (Mo)-Total	mg/L	0.00005	-	0.04	-	-	0.000357	0.000405	0.000393	0.000378	0.000441
Nickel (Ni)-Total	mg/L	0.0005	-	0.025	-	0.05	0.00056	0.0005	0.00174	0.00069	0.00141
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	0.05	0.05	0.212	0.077	0.159
Potassium (K)-Total	mg/L	0.05	-	-	-	-	1.78	1.5	2.31	2.85	2.96
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	0.00183	0.00136	0.0025	0.00222	0.00294
Selenium (Se)-Total	mg/L	0.00005	-	0.1	-	-	0.000281	0.000084	0.000404	0.000186	0.000341
Silicon (Si)-Total	mg/L	0.1	-	-	-	-	4.62	1.09	3.79	3.39	3.98
Silver (Ag)-Total	mg/L	0.00005	-	0.0001	-	-	0.00005	0.00005	0.00005	0.00005	0.00005
Sodium (Na)-Total	mg/L	0.05	-	-	-	-	20.6	92.3	102	100	0.983
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.0999	0.0962	0.112	0.107	0.109
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	5.54	6.05	8.14	7.87	8.02
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	0.0002	0.0002	0.0002	0.0002	0.0002
Thallium (Tl)-Total	mg/L	0.00001	-	0.0003	-	-	0.00001	0.00001	0.000027	0.00001	0.000021
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	0.0001	0.0001	0.0001	0.0001	0.0001
Tin (Sn)-Total	mg/L	0.0001	-	-	-	-	0.0001	0.0001	0.0001	0.0001	0.0001
Titanium (Ti)-Total	mg/L	0.0003	-	-	-	-	0.00341	.	0.0163	0.00432	0.0149
Tungsten (W)-Total	mg/L	0.0001	-	0.03	-	-	0.0001	0.0001	0.0001	0.0001	0.0001
Uranium (U)-Total	mg/L	0.00001	-	0.005	-	-	0.000848	0.000403	0.000392	0.000322	0.00039
Vanadium (V)-Total	mg/L	0.0005	-	0.006	-	-	0.00077	0.0005	0.00194	0.00062	0.00153
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.0136	0.0108	0.1!!	0.0202!	0.0657!!
Zirconium (Zr)-Total	mg/L	0.0002	-	0.004	-	-	0.0013	0.0002	0.00025	0.0002	0.00021
BOD Carbonaceous	mg/L	2	-	-	-	15	2	2	2	2	2

	Ontario Provincial Water Quality Objectives	
Applied Guideline:	**(JULY, 1994) - Surface Water PWQO**	
Color Key:	Within Guideline	Exceeds Guidline
	Ontario City of Guelph	
Applied Guideline:	**Storm Sewer Guidelines 15202 (1996)**	
Color Key:	Within Guideline	Exceeds Guidline

AECOM CANADA LTD. - KITCHENER
ATTN: Steven Scott
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 10-OCT-19
Report Date: 21-OCT-19 13:58 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L2363957

Project P.O. #: NOT SUBMITTED
Job Reference: 60609021
C of C Numbers:
Legal Site Desc:

Emily Hansen
Account Manager

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits			
L2363957-1	HC-A(03)									
Sampled By:	T.AZUBUIKE on 10-OCT-19									
Matrix:	WATER						#1			
Physical Tests										
	Conductivity	691		3.0	umhos/cm	12-OCT-19				
	pH	8.11		0.10	pH units	12-OCT-19	6.5-8.5			
	Total Suspended Solids	11.2		2.0	mg/L	17-OCT-19				
Anions and Nutrients										
	Ammonia, Total (as N)	<0.010		0.010	mg/L	15-OCT-19				
	Chloride (Cl)	49.8		0.50	mg/L	16-OCT-19				
	Nitrate (as N)	1.30		0.020	mg/L	16-OCT-19				
	Phosphorus (P)-Total Dissolved	0.0030		0.0030	mg/L	21-OCT-19				
	Phosphorus, Total	0.0322		0.0030	mg/L	18-OCT-19	*0.01			
Bacteriological Tests										
	E. Coli	38		0	CFU/100mL	11-OCT-19	100			
Total Metals										
	Aluminum (Al)-Total	0.152		0.0050	mg/L	11-OCT-19	*0.015			
	Antimony (Sb)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.02			
	Arsenic (As)-Total	0.00032		0.00010	mg/L	11-OCT-19	0.005			
	Barium (Ba)-Total	0.0616		0.00010	mg/L	11-OCT-19				
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.011			
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	11-OCT-19				
	Boron (B)-Total	0.011		0.010	mg/L	11-OCT-19	0.2			
	Cadmium (Cd)-Total	0.000140		0.0000050	mg/L	11-OCT-19	*0.0001			
	Calcium (Ca)-Total	84.3		0.050	mg/L	11-OCT-19				
	Cesium (Cs)-Total	0.000017		0.000010	mg/L	11-OCT-19				
	Chromium (Cr)-Total	<0.00050		0.00050	mg/L	11-OCT-19				
	Cobalt (Co)-Total	0.00021		0.00010	mg/L	11-OCT-19	0.0009			
	Copper (Cu)-Total	0.0021		0.0010	mg/L	11-OCT-19	*0.001			
	Iron (Fe)-Total	0.369		0.010	mg/L	11-OCT-19	*0.3			
	Lead (Pb)-Total	0.000967		0.000050	mg/L	11-OCT-19	0.001			
	Lithium (Li)-Total	<0.0010		0.0010	mg/L	11-OCT-19				
	Magnesium (Mg)-Total	25.7		0.0050	mg/L	11-OCT-19				
	Manganese (Mn)-Total	0.0848		0.00050	mg/L	11-OCT-19				
	Molybdenum (Mo)-Total	0.000212		0.000050	mg/L	11-OCT-19	0.04			
	Nickel (Ni)-Total	<0.00050		0.00050	mg/L	11-OCT-19	0.025			
	Phosphorus (P)-Total	<0.050		0.050	mg/L	11-OCT-19	**0.01			
	Potassium (K)-Total	1.21		0.050	mg/L	11-OCT-19				
	Rubidium (Rb)-Total	0.00142		0.00020	mg/L	11-OCT-19				
	Selenium (Se)-Total	0.000258		0.000050	mg/L	11-OCT-19	0.1			
	Silicon (Si)-Total	4.60		0.10	mg/L	11-OCT-19				
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	11-OCT-19	0.0001			
	Sodium (Na)-Total	22.8		0.050	mg/L	11-OCT-19				
	Strontium (Sr)-Total	0.103		0.0010	mg/L	11-OCT-19				
	Sulfur (S)-Total	4.53		0.50	mg/L	11-OCT-19				
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	11-OCT-19				
	Thallium (Tl)-Total	0.000011		0.000010	mg/L	11-OCT-19	0.0003			
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	11-OCT-19				
	Tin (Sn)-Total	0.00012		0.00010	mg/L	11-OCT-19				

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
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Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits			
L2363957-1 HC-A(03)										
Sampled By: T.AZUBUIKE on 10-OCT-19							#1			
Matrix: WATER										
Total Metals										
	Titanium (Ti)-Total	0.00393		0.00030	mg/L	11-OCT-19				
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.03			
	Uranium (U)-Total	0.000601		0.000010	mg/L	11-OCT-19	0.005			
	Vanadium (V)-Total	0.00073		0.00050	mg/L	11-OCT-19	0.006			
	Zinc (Zn)-Total	0.0168		0.0030	mg/L	11-OCT-19	0.02			
	Zirconium (Zr)-Total	<0.00020		0.00020	mg/L	11-OCT-19	0.004			
Aggregate Organics										
	BOD Carbonaceous	<2.0		2.0	mg/L	16-OCT-19				
L2363957-2 HC-A(04)										
Sampled By: T.AZUBUIKE on 10-OCT-19							#1			
Matrix: WATER										
Physical Tests										
	Conductivity	873		3.0	umhos/cm	12-OCT-19				
	pH	7.94		0.10	pH units	12-OCT-19	6.5-8.5			
	Total Suspended Solids	46.1		2.0	mg/L	17-OCT-19				
Anions and Nutrients										
	Ammonia, Total (as N)	<0.010		0.010	mg/L	15-OCT-19				
	Chloride (Cl)	148		0.50	mg/L	16-OCT-19				
	Nitrate (as N)	0.345		0.020	mg/L	16-OCT-19				
	Phosphorus (P)-Total Dissolved	<0.0030		0.0030	mg/L	21-OCT-19				
	Phosphorus, Total	0.0513		0.0030	mg/L	21-OCT-19	*0.01			
Bacteriological Tests										
	E. Coli	25		0	CFU/100mL	11-OCT-19	100			
Total Metals										
	Aluminum (Al)-Total	0.168		0.0050	mg/L	11-OCT-19	*0.015			
	Antimony (Sb)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.02			
	Arsenic (As)-Total	0.00097		0.00010	mg/L	11-OCT-19	0.005			
	Barium (Ba)-Total	0.0584		0.00010	mg/L	11-OCT-19				
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.011			
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	11-OCT-19				
	Boron (B)-Total	0.012		0.010	mg/L	11-OCT-19	0.2			
	Cadmium (Cd)-Total	0.000104		0.0000050	mg/L	11-OCT-19	*0.0001			
	Calcium (Ca)-Total	66.5		0.050	mg/L	11-OCT-19				
	Cesium (Cs)-Total	0.000017		0.000010	mg/L	11-OCT-19				
	Chromium (Cr)-Total	<0.00050		0.00050	mg/L	11-OCT-19				
	Cobalt (Co)-Total	0.00022		0.00010	mg/L	11-OCT-19	0.0009			
	Copper (Cu)-Total	0.0019		0.0010	mg/L	11-OCT-19	*0.001			
	Iron (Fe)-Total	0.602		0.010	mg/L	11-OCT-19	*0.3			
	Lead (Pb)-Total	0.00109		0.000050	mg/L	11-OCT-19	*0.001			
	Lithium (Li)-Total	<0.0010		0.0010	mg/L	11-OCT-19				
	Magnesium (Mg)-Total	25.6		0.0050	mg/L	11-OCT-19				
	Manganese (Mn)-Total	0.0657		0.00050	mg/L	11-OCT-19				
	Molybdenum (Mo)-Total	0.000396		0.000050	mg/L	11-OCT-19	0.04			

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* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

ALS Environmental

ANALYTICAL GUIDELINE REPORT

60609021

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits
L2363957-2 HC-A(04)							
Sampled By: T.AZUBUIKE on 10-OCT-19							
Matrix: WATER							#1
Total Metals							
	Nickel (Ni)-Total	0.00069		0.00050	mg/L	11-OCT-19	0.025
	Phosphorus (P)-Total	<0.050		0.050	mg/L	11-OCT-19	**0.01
	Potassium (K)-Total	1.58		0.050	mg/L	11-OCT-19	
	Rubidium (Rb)-Total	0.00142		0.00020	mg/L	11-OCT-19	
	Selenium (Se)-Total	0.000149		0.000050	mg/L	11-OCT-19	0.1
	Silicon (Si)-Total	2.37		0.10	mg/L	11-OCT-19	
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	11-OCT-19	0.0001
	Sodium (Na)-Total	77.9		0.050	mg/L	11-OCT-19	
	Strontium (Sr)-Total	0.106		0.0010	mg/L	11-OCT-19	
	Sulfur (S)-Total	5.66		0.50	mg/L	11-OCT-19	
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	11-OCT-19	
	Thallium (Tl)-Total	<0.000010		0.000010	mg/L	11-OCT-19	0.0003
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	11-OCT-19	
	Tin (Sn)-Total	0.00018		0.00010	mg/L	11-OCT-19	
	Titanium (Ti)-Total	0.00502		0.00030	mg/L	11-OCT-19	
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.03
	Uranium (U)-Total	0.000468		0.000010	mg/L	11-OCT-19	0.005
	Vanadium (V)-Total	0.00075		0.00050	mg/L	11-OCT-19	0.006
	Zinc (Zn)-Total	0.0325		0.0030	mg/L	11-OCT-19	*0.02
	Zirconium (Zr)-Total	<0.00020		0.00020	mg/L	11-OCT-19	0.004
Aggregate Organics							
	BOD Carbonaceous	<2.0		2.0	mg/L	16-OCT-19	
L2363957-3 HC-A(12)							
Sampled By: T.AZUBUIKE on 10-OCT-19							
Matrix: WATER							#1
Physical Tests							
	Conductivity	1170		3.0	umhos/cm	12-OCT-19	
	pH	8.20		0.10	pH units	12-OCT-19	6.5-8.5
	Total Suspended Solids	4.9		2.0	mg/L	17-OCT-19	
Anions and Nutrients							
	Ammonia, Total (as N)	<0.010		0.010	mg/L	15-OCT-19	
	Chloride (Cl)	226	DLDS	2.5	mg/L	16-OCT-19	
	Nitrate (as N)	0.43	DLDS	0.10	mg/L	16-OCT-19	
	Phosphorus (P)-Total Dissolved	0.0071		0.0030	mg/L	21-OCT-19	
	Phosphorus, Total	0.0127		0.0030	mg/L	21-OCT-19	*0.01
Bacteriological Tests							
	E. Coli	27		0	CFU/100mL	11-OCT-19	100
Total Metals							
	Aluminum (Al)-Total	0.0281		0.0050	mg/L	11-OCT-19	*0.015
	Antimony (Sb)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.02
	Arsenic (As)-Total	0.00048		0.00010	mg/L	11-OCT-19	0.005
	Barium (Ba)-Total	0.0731		0.00010	mg/L	11-OCT-19	
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.011
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	11-OCT-19	

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits			
L2363957-3	HC-A(12)									
Sampled By:	T.AZUBUIKE on 10-OCT-19									
Matrix:	WATER						#1			
Total Metals										
	Boron (B)-Total	0.013		0.010	mg/L	11-OCT-19	0.2			
	Cadmium (Cd)-Total	0.0000183		0.0000050	mg/L	11-OCT-19	0.0001			
	Calcium (Ca)-Total	79.6		0.050	mg/L	11-OCT-19				
	Cesium (Cs)-Total	<0.000010		0.000010	mg/L	11-OCT-19				
	Chromium (Cr)-Total	<0.00050		0.00050	mg/L	11-OCT-19				
	Cobalt (Co)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.0009			
	Copper (Cu)-Total	0.0011		0.0010	mg/L	11-OCT-19	*0.001			
	Iron (Fe)-Total	0.100		0.010	mg/L	11-OCT-19	0.3			
	Lead (Pb)-Total	0.000212		0.000050	mg/L	11-OCT-19	0.001			
	Lithium (Li)-Total	0.0010		0.0010	mg/L	11-OCT-19				
	Magnesium (Mg)-Total	27.9		0.0050	mg/L	11-OCT-19				
	Manganese (Mn)-Total	0.0268		0.00050	mg/L	11-OCT-19				
	Molybdenum (Mo)-Total	0.000324		0.000050	mg/L	11-OCT-19	0.04			
	Nickel (Ni)-Total	<0.00050		0.00050	mg/L	11-OCT-19	0.025			
	Phosphorus (P)-Total	<0.050		0.050	mg/L	11-OCT-19	**0.01			
	Potassium (K)-Total	1.60		0.050	mg/L	11-OCT-19				
	Rubidium (Rb)-Total	0.00112		0.00020	mg/L	11-OCT-19				
	Selenium (Se)-Total	0.000094		0.000050	mg/L	11-OCT-19	0.1			
	Silicon (Si)-Total	3.12		0.10	mg/L	11-OCT-19				
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	11-OCT-19	0.0001			
	Sodium (Na)-Total	118	DLHC	0.50	mg/L	11-OCT-19				
	Strontium (Sr)-Total	0.123		0.0010	mg/L	11-OCT-19				
	Sulfur (S)-Total	6.95		0.50	mg/L	11-OCT-19				
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	11-OCT-19				
	Thallium (Tl)-Total	<0.000010		0.000010	mg/L	11-OCT-19	0.0003			
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	11-OCT-19				
	Tin (Sn)-Total	0.00016		0.00010	mg/L	11-OCT-19				
	Titanium (Ti)-Total	<0.00070	DLUI	0.00070	mg/L	11-OCT-19				
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.03			
	Uranium (U)-Total	0.000437		0.000010	mg/L	11-OCT-19	0.005			
	Vanadium (V)-Total	<0.00050		0.00050	mg/L	11-OCT-19	0.006			
	Zinc (Zn)-Total	0.0057		0.0030	mg/L	11-OCT-19	0.02			
	Zirconium (Zr)-Total	<0.00020		0.00020	mg/L	11-OCT-19	0.004			
Aggregate Organics										
	BOD Carbonaceous	<2.0		2.0	mg/L	16-OCT-19				
L2363957-4	HC-A(13)									
Sampled By:	T.AZUBUIKE on 10-OCT-19									
Matrix:	WATER						#1			
Physical Tests										
	Conductivity	1160		3.0	umhos/cm	12-OCT-19				
	pH	8.27		0.10	pH units	12-OCT-19	6.5-8.5			
	Total Suspended Solids	6.0		2.0	mg/L	17-OCT-19				
Anions and Nutrients										
	Ammonia, Total (as N)	<0.010		0.010	mg/L	15-OCT-19				

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
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Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1
L2363957-4	HC-A(13)						
Sampled By:	T.AZUBUIKE on 10-OCT-19						
Matrix:	WATER						
Anions and Nutrients							
	Chloride (Cl)	235	DLDS	2.5	mg/L	16-OCT-19	
	Nitrate (as N)	0.44	DLDS	0.10	mg/L	16-OCT-19	
	Phosphorus (P)-Total Dissolved	0.0071		0.0030	mg/L	21-OCT-19	
	Phosphorus, Total	0.0146		0.0030	mg/L	21-OCT-19	*0.01
Bacteriological Tests							
	E. Coli	43		0	CFU/100mL	11-OCT-19	100
Total Metals							
	Aluminum (Al)-Total	0.0376		0.0050	mg/L	11-OCT-19	*0.015
	Antimony (Sb)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.02
	Arsenic (As)-Total	0.00055		0.00010	mg/L	11-OCT-19	0.005
	Barium (Ba)-Total	0.0736		0.00010	mg/L	11-OCT-19	
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.011
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	11-OCT-19	
	Boron (B)-Total	0.013		0.010	mg/L	11-OCT-19	0.2
	Cadmium (Cd)-Total	0.0000374		0.0000050	mg/L	11-OCT-19	0.0001
	Calcium (Ca)-Total	81.1		0.050	mg/L	11-OCT-19	
	Cesium (Cs)-Total	<0.000010		0.000010	mg/L	11-OCT-19	
	Chromium (Cr)-Total	<0.00050		0.00050	mg/L	11-OCT-19	
	Cobalt (Co)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.0009
	Copper (Cu)-Total	<0.0010		0.0010	mg/L	11-OCT-19	0.001
	Iron (Fe)-Total	0.100		0.010	mg/L	11-OCT-19	0.3
	Lead (Pb)-Total	0.000302		0.000050	mg/L	11-OCT-19	0.001
	Lithium (Li)-Total	0.0010		0.0010	mg/L	11-OCT-19	
	Magnesium (Mg)-Total	28.5		0.0050	mg/L	11-OCT-19	
	Manganese (Mn)-Total	0.0191		0.00050	mg/L	11-OCT-19	
	Molybdenum (Mo)-Total	0.000313		0.000050	mg/L	11-OCT-19	0.04
	Nickel (Ni)-Total	<0.00050		0.00050	mg/L	11-OCT-19	0.025
	Phosphorus (P)-Total	<0.050		0.050	mg/L	11-OCT-19	**0.01
	Potassium (K)-Total	1.62		0.050	mg/L	11-OCT-19	
	Rubidium (Rb)-Total	0.00114		0.00020	mg/L	11-OCT-19	
	Selenium (Se)-Total	0.000089		0.000050	mg/L	11-OCT-19	0.1
	Silicon (Si)-Total	3.13		0.10	mg/L	11-OCT-19	
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	11-OCT-19	0.0001
	Sodium (Na)-Total	120	DLHC	0.50	mg/L	11-OCT-19	
	Strontium (Sr)-Total	0.124		0.0010	mg/L	11-OCT-19	
	Sulfur (S)-Total	6.83		0.50	mg/L	11-OCT-19	
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	11-OCT-19	
	Thallium (Tl)-Total	<0.000010		0.000010	mg/L	11-OCT-19	0.0003
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	11-OCT-19	
	Tin (Sn)-Total	0.00021		0.00010	mg/L	11-OCT-19	
	Titanium (Ti)-Total	<0.00080	DLUI	0.00080	mg/L	11-OCT-19	
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.03
	Uranium (U)-Total	0.000436		0.000010	mg/L	11-OCT-19	0.005
	Vanadium (V)-Total	<0.00050		0.00050	mg/L	11-OCT-19	0.006
	Zinc (Zn)-Total	0.0064		0.0030	mg/L	11-OCT-19	0.02

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Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping / Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits			
L2363957-4 HC-A(13) Sampled By: T.AZUBUIKE on 10-OCT-19 Matrix: WATER						#1			
Total Metals									
Zirconium (Zr)-Total	<0.00020		0.00020	mg/L	11-OCT-19	0.004			
Aggregate Organics									
BOD Carbonaceous	<2.0		2.0	mg/L	16-OCT-19				
L2363957-5 HC-A(14) Sampled By: T.AZUBUIKE on 10-OCT-19 Matrix: WATER						#1			
Physical Tests									
Conductivity	1160		3.0	umhos/cm	12-OCT-19				
pH	8.26		0.10	pH units	12-OCT-19	6.5-8.5			
Total Suspended Solids	33.3		2.0	mg/L	17-OCT-19				
Anions and Nutrients									
Ammonia, Total (as N)	<0.010		0.010	mg/L	15-OCT-19				
Chloride (Cl)	230	DLDS	2.5	mg/L	16-OCT-19				
Nitrate (as N)	0.44	DLDS	0.10	mg/L	16-OCT-19				
Phosphorus (P)-Total Dissolved	0.0060		0.0030	mg/L	21-OCT-19				
Phosphorus, Total	0.0619		0.0030	mg/L	21-OCT-19	*0.01			
Bacteriological Tests									
E. Coli	44		0	CFU/100mL	11-OCT-19	100			
Total Metals									
Aluminum (Al)-Total	0.299		0.0050	mg/L	11-OCT-19	*0.015			
Antimony (Sb)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.02			
Arsenic (As)-Total	0.00071		0.00010	mg/L	11-OCT-19	0.005			
Barium (Ba)-Total	0.0805		0.00010	mg/L	11-OCT-19				
Beryllium (Be)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.011			
Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	11-OCT-19				
Boron (B)-Total	0.013		0.010	mg/L	11-OCT-19	0.2			
Cadmium (Cd)-Total	0.000138		0.0000050	mg/L	11-OCT-19	*0.0001			
Calcium (Ca)-Total	81.6		0.050	mg/L	11-OCT-19				
Cesium (Cs)-Total	0.000029		0.000010	mg/L	11-OCT-19				
Chromium (Cr)-Total	0.00063		0.00050	mg/L	11-OCT-19				
Cobalt (Co)-Total	0.00025		0.00010	mg/L	11-OCT-19	0.0009			
Copper (Cu)-Total	0.0034		0.0010	mg/L	11-OCT-19	*0.001			
Iron (Fe)-Total	0.534		0.010	mg/L	11-OCT-19	*0.3			
Lead (Pb)-Total	0.00195		0.000050	mg/L	11-OCT-19	*0.001			
Lithium (Li)-Total	0.0014		0.0010	mg/L	11-OCT-19				
Magnesium (Mg)-Total	28.5		0.0050	mg/L	11-OCT-19				
Manganese (Mn)-Total	0.0580		0.00050	mg/L	11-OCT-19				
Molybdenum (Mo)-Total	0.000342		0.000050	mg/L	11-OCT-19	0.04			
Nickel (Ni)-Total	0.00082		0.00050	mg/L	11-OCT-19	0.025			
Phosphorus (P)-Total	0.071		0.050	mg/L	11-OCT-19	*0.01			
Potassium (K)-Total	1.67		0.050	mg/L	11-OCT-19				
Rubidium (Rb)-Total	0.00166		0.00020	mg/L	11-OCT-19				
Selenium (Se)-Total	0.000160		0.000050	mg/L	11-OCT-19	0.1			

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1			
L2363957-5	HC-A(14)									
Sampled By:	T.AZUBUIKE on 10-OCT-19									
Matrix:	WATER									
Total Metals										
	Silicon (Si)-Total	3.45		0.10	mg/L	11-OCT-19				
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	11-OCT-19	0.0001			
	Sodium (Na)-Total	124	DLHC	0.50	mg/L	11-OCT-19				
	Strontium (Sr)-Total	0.123		0.0010	mg/L	11-OCT-19				
	Sulfur (S)-Total	7.00		0.50	mg/L	11-OCT-19				
	Tellurium (Te)-Total	<0.00020		0.00020	mg/L	11-OCT-19				
	Thallium (Tl)-Total	0.000013		0.000010	mg/L	11-OCT-19	0.0003			
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	11-OCT-19				
	Tin (Sn)-Total	<0.00010		0.00010	mg/L	11-OCT-19				
	Titanium (Ti)-Total	0.00732		0.00030	mg/L	11-OCT-19				
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	11-OCT-19	0.03			
	Uranium (U)-Total	0.000485		0.000010	mg/L	11-OCT-19	0.005			
	Vanadium (V)-Total	0.00090		0.00050	mg/L	11-OCT-19	0.006			
	Zinc (Zn)-Total	0.0306		0.0030	mg/L	11-OCT-19	*0.02			
	Zirconium (Zr)-Total	<0.00020		0.00020	mg/L	11-OCT-19	0.004			
Aggregate Organics										
	BOD Carbonaceous	<2.0		2.0	mg/L	16-OCT-19				

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Surface Water PWQO

#1: Surface Water PWQO

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLUI	Detection Limit Raised: Unknown Interference generated an apparent false positive test result.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Method Reference***
BOD-C-WT	Water	BOD Carbonaceous	APHA 5210 B (CBOD)

This analysis is carried out using procedures adapted from APHA Method 5210B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h. Method ID: WT-TM-1200

EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

EC-WT	Water	Conductivity	APHA 2510 B

Water samples can be measured directly by immersing the conductivity cell into the sample.

MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-WT	Water	pH	APHA 4500 H-Electrode

Water samples are analyzed directly by a calibrated pH meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

*** ALS test methods may incorporate modifications from specified reference methods to improve performance.

Reference Information

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA		

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information. Guideline limits are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

ALS Environmental

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BOD-C-WT	**Water**							
Batch R4871823								
WG3189057-6 DUP		**L2363957-3**						
BOD Carbonaceous		<2.0	<2.0	RPD-NA	mg/L	N/A	20	16-OCT-19
WG3189057-7 LCS								
BOD Carbonaceous			95.5		%		85-115	16-OCT-19
WG3189057-5 MB								
BOD Carbonaceous			<2.0		mg/L		2	16-OCT-19
CL-IC-N-WT	**Water**							
Batch R4873303								
WG3192005-10 DUP		**WG3192005-8**						
Chloride (Cl)		148	148		mg/L	0.1	20	16-OCT-19
WG3192005-7 LCS								
Chloride (Cl)			101.5		%		90-110	16-OCT-19
WG3192005-6 MB								
Chloride (Cl)			<0.50		mg/L		0.5	16-OCT-19
WG3192005-9 MS		**WG3192005-8**						
Chloride (Cl)			N/A	MS-B	%		-	16-OCT-19
EC-MF-WT	**Water**							
Batch R4867988								
WG3188802-3 DUP		**L2363758-1**						
E. Coli		0	0		CFU/100mL	0.0	65	11-OCT-19
WG3188802-1 MB								
E. Coli			0		CFU/100mL		1	11-OCT-19
EC-WT	**Water**							
Batch R4869009								
WG3189995-4 DUP		**WG3189995-3**						
Conductivity		409	405		umhos/cm	1.0	10	12-OCT-19
WG3189995-2 LCS								
Conductivity			103.2		%		90-110	12-OCT-19
WG3189995-1 MB								
Conductivity			<3.0		umhos/cm		3	12-OCT-19
MET-T-CCMS-WT	**Water**							
Batch R4867318								
WG3188512-4 DUP		**WG3188512-3**						
Aluminum (Al)-Total		0.0075	0.0075		mg/L	0.1	20	11-OCT-19
Antimony (Sb)-Total		0.00013	0.00013		mg/L	6.1	20	11-OCT-19
Arsenic (As)-Total		0.00058	0.00057		mg/L	1.8	20	11-OCT-19
Barium (Ba)-Total		0.0309	0.0303		mg/L	1.9	20	11-OCT-19

ALS Environmental

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4867318								
WG3188512-4 DUP		**WG3188512-3**						
Beryllium (Be)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	11-OCT-19
Bismuth (Bi)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	11-OCT-19
Boron (B)-Total		0.023	0.024		mg/L	2.2	20	11-OCT-19
Cadmium (Cd)-Total		<0.0000050	<0.000005C	RPD-NA	mg/L	N/A	20	11-OCT-19
Calcium (Ca)-Total		43.1	42.9		mg/L	0.4	20	11-OCT-19
Chromium (Cr)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	11-OCT-19
Cesium (Cs)-Total		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	11-OCT-19
Cobalt (Co)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	11-OCT-19
Copper (Cu)-Total		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	11-OCT-19
Iron (Fe)-Total		0.011	0.011		mg/L	2.6	20	11-OCT-19
Lead (Pb)-Total		0.000197	0.000205		mg/L	4.2	20	11-OCT-19
Lithium (Li)-Total		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	11-OCT-19
Magnesium (Mg)-Total		7.85	7.69		mg/L	2.1	20	11-OCT-19
Manganese (Mn)-Total		0.0311	0.0302		mg/L	2.9	20	11-OCT-19
Molybdenum (Mo)-Total		0.000278	0.000272		mg/L	2.0	20	11-OCT-19
Nickel (Ni)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	11-OCT-19
Phosphorus (P)-Total		<0.050	<0.050	RPD-NA	mg/L	N/A	20	11-OCT-19
Potassium (K)-Total		2.44	2.37		mg/L	2.9	20	11-OCT-19
Rubidium (Rb)-Total		0.00122	0.00122		mg/L	0.1	20	11-OCT-19
Selenium (Se)-Total		0.000058	<0.000050	RPD-NA	mg/L	N/A	20	11-OCT-19
Silicon (Si)-Total		0.46	0.46		mg/L	1.2	20	11-OCT-19
Silver (Ag)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	11-OCT-19
Sodium (Na)-Total		109	109		mg/L	0.1	20	11-OCT-19
Strontium (Sr)-Total		0.184	0.180		mg/L	1.8	20	11-OCT-19
Sulfur (S)-Total		6.57	6.51		mg/L	0.9	25	11-OCT-19
Thallium (Tl)-Total		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	11-OCT-19
Tellurium (Te)-Total		<0.00020	<0.00020	RPD-NA	mg/L	N/A	20	11-OCT-19
Thorium (Th)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	25	11-OCT-19
Tin (Sn)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	11-OCT-19
Titanium (Ti)-Total		<0.00030	<0.00030	RPD-NA	mg/L	N/A	20	11-OCT-19
Tungsten (W)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	11-OCT-19
Uranium (U)-Total		0.000286	0.000277		mg/L	3.2	20	11-OCT-19
Vanadium (V)-Total		0.00050	0.00051		mg/L			11-OCT-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4867318								
WG3188512-4 DUP		**WG3188512-3**						
Vanadium (V)-Total		0.00050	0.00051		mg/L	0.1	20	11-OCT-19
Zinc (Zn)-Total		<0.0030	<0.0030	RPD-NA	mg/L	N/A	20	11-OCT-19
Zirconium (Zr)-Total		<0.00020	<0.00020	RPD-NA	mg/L	N/A	20	11-OCT-19
WG3188512-2 LCS								
Aluminum (Al)-Total			104.5		%		80-120	11-OCT-19
Antimony (Sb)-Total			99.98		%		80-120	11-OCT-19
Arsenic (As)-Total			96.0		%		80-120	11-OCT-19
Barium (Ba)-Total			100.7		%		80-120	11-OCT-19
Beryllium (Be)-Total			92.1		%		80-120	11-OCT-19
Bismuth (Bi)-Total			94.1		%		80-120	11-OCT-19
Boron (B)-Total			96.9		%		80-120	11-OCT-19
Cadmium (Cd)-Total			101.3		%		80-120	11-OCT-19
Calcium (Ca)-Total			99.6		%		80-120	11-OCT-19
Chromium (Cr)-Total			101.4		%		80-120	11-OCT-19
Cesium (Cs)-Total			100.2		%		80-120	11-OCT-19
Cobalt (Co)-Total			98.1		%		80-120	11-OCT-19
Copper (Cu)-Total			99.3		%		80-120	11-OCT-19
Iron (Fe)-Total			97.4		%		80-120	11-OCT-19
Lead (Pb)-Total			95.9		%		80-120	11-OCT-19
Lithium (Li)-Total			86.9		%		80-120	11-OCT-19
Magnesium (Mg)-Total			100.5		%		80-120	11-OCT-19
Manganese (Mn)-Total			99.6		%		80-120	11-OCT-19
Molybdenum (Mo)-Total			98.1		%		80-120	11-OCT-19
Nickel (Ni)-Total			98.9		%		80-120	11-OCT-19
Phosphorus (P)-Total			101.6		%		70-130	11-OCT-19
Potassium (K)-Total			95.9		%		80-120	11-OCT-19
Rubidium (Rb)-Total			97.5		%		80-120	11-OCT-19
Selenium (Se)-Total			100.1		%		80-120	11-OCT-19
Silicon (Si)-Total			116.6		%		60-140	11-OCT-19
Silver (Ag)-Total			99.4		%		80-120	11-OCT-19
Sodium (Na)-Total			102.7		%		80-120	11-OCT-19
Strontium (Sr)-Total			100.9		%		80-120	11-OCT-19
Sulfur (S)-Total			100.1		%		80-120	11-OCT-19
Thallium (Tl)-Total			96.5				80-120	

Quality Control Report

Workorder: L2363957 Report Date: 21-OCT-19

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4867318								
WG3188512-2 LCS								
Thallium (Tl)-Total			96.5		%		80-120	11-OCT-19
Tellurium (Te)-Total			94.9		%		80-120	11-OCT-19
Thorium (Th)-Total			95.4		%		70-130	11-OCT-19
Tin (Sn)-Total			96.5		%		80-120	11-OCT-19
Titanium (Ti)-Total			94.9		%		80-120	11-OCT-19
Tungsten (W)-Total			96.5		%		80-120	11-OCT-19
Uranium (U)-Total			98.6		%		80-120	11-OCT-19
Vanadium (V)-Total			101.7		%		80-120	11-OCT-19
Zinc (Zn)-Total			96.4		%		80-120	11-OCT-19
Zirconium (Zr)-Total			96.0		%		80-120	11-OCT-19
WG3188512-1 MB								
Aluminum (Al)-Total			<0.0050		mg/L		0.005	11-OCT-19
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	11-OCT-19
Arsenic (As)-Total			<0.00010		mg/L		0.0001	11-OCT-19
Barium (Ba)-Total			<0.00010		mg/L		0.0001	11-OCT-19
Beryllium (Be)-Total			<0.00010		mg/L		0.0001	11-OCT-19
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	11-OCT-19
Boron (B)-Total			<0.010		mg/L		0.01	11-OCT-19
Cadmium (Cd)-Total			<0.0000050		mg/L		0.000005	11-OCT-19
Calcium (Ca)-Total			<0.050		mg/L		0.05	11-OCT-19
Chromium (Cr)-Total			<0.00050		mg/L		0.0005	11-OCT-19
Cesium (Cs)-Total			<0.000010		mg/L		0.00001	11-OCT-19
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	11-OCT-19
Copper (Cu)-Total			<0.0010		mg/L		0.001	11-OCT-19
Iron (Fe)-Total			<0.010		mg/L		0.01	11-OCT-19
Lead (Pb)-Total			<0.000050		mg/L		0.00005	11-OCT-19
Lithium (Li)-Total			<0.0010		mg/L		0.001	11-OCT-19
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	11-OCT-19
Manganese (Mn)-Total			<0.00050		mg/L		0.0005	11-OCT-19
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	11-OCT-19
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	11-OCT-19
Phosphorus (P)-Total			<0.050		mg/L		0.05	11-OCT-19
Potassium (K)-Total			<0.050		mg/L		0.05	11-OCT-19
Rubidium (Rb)-Total			<0.00020		mg/L		0.0002	11-OCT-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4867318								
WG3188512-1 MB								
Selenium (Se)-Total			<0.000050		mg/L		0.00005	11-OCT-19
Silicon (Si)-Total			<0.10		mg/L		0.1	11-OCT-19
Silver (Ag)-Total			<0.000050		mg/L		0.00005	11-OCT-19
Sodium (Na)-Total			<0.050		mg/L		0.05	11-OCT-19
Strontium (Sr)-Total			<0.0010		mg/L		0.001	11-OCT-19
Sulfur (S)-Total			<0.50		mg/L		0.5	11-OCT-19
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	11-OCT-19
Tellurium (Te)-Total			<0.00020		mg/L		0.0002	11-OCT-19
Thorium (Th)-Total			<0.00010		mg/L		0.0001	11-OCT-19
Tin (Sn)-Total			<0.00010		mg/L		0.0001	11-OCT-19
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	11-OCT-19
Tungsten (W)-Total			<0.00010		mg/L		0.0001	11-OCT-19
Uranium (U)-Total			<0.000010		mg/L		0.00001	11-OCT-19
Vanadium (V)-Total			<0.00050		mg/L		0.0005	11-OCT-19
Zinc (Zn)-Total			<0.0030		mg/L		0.003	11-OCT-19
Zirconium (Zr)-Total			<0.00020		mg/L		0.0002	11-OCT-19
WG3188512-5 MS		**WG3188512-6**						
Aluminum (Al)-Total			110.5		%		70-130	11-OCT-19
Antimony (Sb)-Total			99.1		%		70-130	11-OCT-19
Arsenic (As)-Total			100.6		%		70-130	11-OCT-19
Barium (Ba)-Total			N/A	MS-B	%		-	11-OCT-19
Beryllium (Be)-Total			94.3		%		70-130	11-OCT-19
Bismuth (Bi)-Total			90.0		%		70-130	11-OCT-19
Boron (B)-Total			97.4		%		70-130	11-OCT-19
Cadmium (Cd)-Total			103.4		%		70-130	11-OCT-19
Calcium (Ca)-Total			N/A	MS-B	%		-	11-OCT-19
Chromium (Cr)-Total			107.0		%		70-130	11-OCT-19
Cesium (Cs)-Total			98.6		%		70-130	11-OCT-19
Cobalt (Co)-Total			102.5		%		70-130	11-OCT-19
Copper (Cu)-Total			97.4		%		70-130	11-OCT-19
Iron (Fe)-Total			N/A	MS-B	%		-	11-OCT-19
Lead (Pb)-Total			93.1		%		70-130	11-OCT-19
Lithium (Li)-Total			98.6		%		70-130	11-OCT-19
Magnesium (Mg)-Total			N/A	MS-B	%		-	11-OCT-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4867318								
WG3188512-5 MS		**WG3188512-6**						
Manganese (Mn)-Total			N/A	MS-B	%		-	11-OCT-19
Molybdenum (Mo)-Total			103.0		%		70-130	11-OCT-19
Nickel (Ni)-Total			101.1		%		70-130	11-OCT-19
Phosphorus (P)-Total			112.7		%		70-130	11-OCT-19
Potassium (K)-Total			N/A	MS-B	%		-	11-OCT-19
Rubidium (Rb)-Total			101.7		%		70-130	11-OCT-19
Selenium (Se)-Total			33.8	K	%		70-130	11-OCT-19
Silicon (Si)-Total			N/A	MS-B	%		-	11-OCT-19
Silver (Ag)-Total			94.6		%		70-130	11-OCT-19
Sodium (Na)-Total			N/A	MS-B	%		-	11-OCT-19
Strontium (Sr)-Total			N/A	MS-B	%		-	11-OCT-19
Sulfur (S)-Total			N/A	MS-B	%		-	11-OCT-19
Thallium (Tl)-Total			91.2		%		70-130	11-OCT-19
Tellurium (Te)-Total			63.6	K	%		70-130	11-OCT-19
Thorium (Th)-Total			91.6		%		70-130	11-OCT-19
Tin (Sn)-Total			96.4		%		70-130	11-OCT-19
Titanium (Ti)-Total			103.9		%		70-130	11-OCT-19
Tungsten (W)-Total			100.3		%		70-130	11-OCT-19
Uranium (U)-Total			93.9		%		70-130	11-OCT-19
Vanadium (V)-Total			110.4		%		70-130	11-OCT-19
Zinc (Zn)-Total			84.1		%		70-130	11-OCT-19
Zirconium (Zr)-Total			91.9		%		70-130	11-OCT-19
NH3-F-WT	**Water**							
Batch R4870133								
WG3191096-23 DUP		**L2364001-1**						
Ammonia, Total (as N)		0.020	0.019		mg/L	7.1	20	15-OCT-19
WG3191096-22 LCS								
Ammonia, Total (as N)			102.0		%		85-115	15-OCT-19
WG3191096-21 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	15-OCT-19
WG3191096-24 MS		**L2364001-1**						
Ammonia, Total (as N)			92.9		%		75-125	15-OCT-19
NO3-IC-WT	**Water**							

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-WT	**Water**							
Batch R4873303								
WG3192005-10 DUP		**WG3192005-8**						
Nitrate (as N)		0.345	0.356		mg/L	2.9	20	16-OCT-19
WG3192005-7 LCS								
Nitrate (as N)			100.7		%		90-110	16-OCT-19
WG3192005-6 MB								
Nitrate (as N)			<0.020		mg/L		0.02	16-OCT-19
WG3192005-9 MS		**WG3192005-8**						
Nitrate (as N)			103.8		%		75-125	16-OCT-19
P-T-COL-WT	**Water**							
Batch R4874026								
WG3194619-3 DUP		**L2363957-1**						
Phosphorus, Total		0.0322	0.0285		mg/L	12	20	18-OCT-19
WG3194619-2 LCS								
Phosphorus, Total			100.1		%		80-120	18-OCT-19
WG3194619-1 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	18-OCT-19
WG3194619-4 MS		**L2363957-1**						
Phosphorus, Total			94.4		%		70-130	18-OCT-19
Batch R4875553								
WG3195061-5 DUP		**L2363266-13**						
Phosphorus, Total		N/A	0.0106		mg/L	3.7	20	21-OCT-19
WG3195061-2 LCS								
Phosphorus, Total			96.1		%		80-120	21-OCT-19
WG3195061-1 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	21-OCT-19
WG3195061-4 MS		**L2363266-13**						
Phosphorus, Total			92.9		%		70-130	21-OCT-19
P-TD-COL-WT	**Water**							
Batch R4875557								
WG3195071-7 DUP		**L2363957-1**						
Phosphorus (P)-Total Dissolved		0.0030	0.0031		mg/L	2.6	20	21-OCT-19
WG3195071-6 LCS								
Phosphorus (P)-Total Dissolved			96.4		%		80-120	21-OCT-19
WG3195071-5 MB								
Phosphorus (P)-Total Dissolved			<0.0030		mg/L		0.003	21-OCT-19
WG3195071-8 MS		**L2363957-1**						
Phosphorus (P)-Total Dissolved			94.6		%		70-130	21-OCT-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH-WT	**Water**							
Batch R4869009								
WG3189995-4 DUP		**WG3189995-3**						
pH		7.26	7.09	J	pH units	0.17	0.2	12-OCT-19
WG3189995-2 LCS								
pH			7.00		pH units		6.9-7.1	12-OCT-19
SOLIDS-TSS-WT	**Water**							
Batch R4872410								
WG3191884-3 DUP		**L2364644-2**						
Total Suspended Solids		4120	4120		mg/L	0.0	20	17-OCT-19
WG3191884-2 LCS								
Total Suspended Solids			99.8		%		85-115	17-OCT-19
WG3191884-1 MB								
Total Suspended Solids			<2.0		mg/L		2	17-OCT-19

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
K	Matrix Spike recovery outside ALS DQO due to sample matrix effects.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

60 NOR
WATERL
Phone: (
Fax: (51
Toll Free: 1-800-668-9878

L2363957-COFC

C of C # 00000

CHAIN OF CUSTODY / ANALYTICAL SERVICES REQUEST FORM

Page ___ of ___

TAT Quoted material is in business days which exclude statutory holidays and weekends. TAT samples received past 3:00 pm or Saturday/Sunday begin the next day.

Specify date required	Service requested			
	5 day (regular)	X	Next day TAT (100%)	
	3-4 day (regular)		Same day TAT (200%)	
			2 day TAT (50%)	

COMPANY NAME	AECOM
OFFICE	Kitchener
PROJECT MANAGER	Steven Scott
PROJECT #	60609021
PHONE	519-650-8637 OR 519-569-9388
FAX	
ACCOUNT #	15884
QUOTATION #	Q59209
PO #	

CRITERIA Criteria on report YESX__ NO___

Reg 153/11
Table 1 2 3

TCLP ____ MISA _____ PWQO __X__
ODWS ____ OTHER _____

REPORT FORMAT/DISTRIBUTION

EMAIL _X_ FAX ___ BOTH ___
SELECT: PDF ___ DIGITAL ___ BOTH _X_
EMAIL 1 zahra.parhizgari@aecom.com
EMAIL 2 steve.scott2@aecom.com
EMAIL 3

PLEASE INDICATE FILTERED, PRESERVED OR BOTH <---- (F, P, F/P)

SUBMISSION #: L2363957
ENTERED BY: 8J
DATE/TIME ENTERED:
BIN #:

SAMPLING INFORMATION / **ANALYSIS REQUEST**

Date (dd-mm-yy)	Time (24hr) (hh:mm)	COMP	GRAB	WATER	SOIL	OTHER	SAMPLE DESCRIPTION TO APPEAR ON REPORT	NUMBER OF CONTAINERS	CBOD, TSS	TP(LL), NH3	P-SOL	ECOLI	Total Metals	~~Dissolved Metals~~	NO3, Cl	pH	Conductivity		COMMENTS	LAB ID
10/10/19				X			HC-A(03)	7	X	X	X	X	X	~~X~~	X	X	X			
10/10/19				X			HC-A(04)	7	X	X	X	X	X	~~X~~	X	X	X			
10/10/19				X			HC-A(12)	7	X	X	X	X	X	~~X~~	X	X	X			
10/10/19				X			HC-A(13)	7	X	X	X	X	X	~~X~~	X	X	X			
10/10/19				X			HC-A(14)	7	X	X	X	X	X	~~X~~	X	X	X			

SPECIAL INSTRUCTIONS/COMMENTS

Surface water samples, so colforms counts may be high. Added pH and Conductivity as additional parameters as our YSI is in for repairs.

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (CHECK Yes OR No)

Are any samples taken from a regulated DW System? Yes ___ No ___
If yes, an authorized drinking water COC MUST be used for this submission.
Is the water sampled intended to be potable for human consumption? Yes ___ No ___

SAMPLE CONDITION

___ FROZEN
___ COLD
X COOLING INITIATED
___ AMBIENT

MEAN TEMP: 12.6

OBSERVATIONS: Yes ___ No ___ If Yes add SIF

INIT

SAMPLED BY: ~~Steven Scott~~ Tochi Azubuike	DATE & TIME ~~16-07-18~~ 10/10/19	RECEIVED BY:	DATE & TIME 10/10/19 @16:45
RELINQUISHED BY: Steven Scott Tochi Azubuike	DATE & TIME ~~16-07-18~~ 10/10/19	RECEIVED AT LAB BY:	DATE & TIME

Notes

1. Quote number must be provided to ensure proper pricing

2. TAT may vary dependent on complexity of analysis and lab workload at time of submission. Please contact the lab to confirm TATs.

3. Any known or suspected hazards relating to a sample must be noted on the chain of custody in comments section.

ALS		Sample ID					HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)
1/11/2020		ALS ID					L2110610-1	L2110610-2	L2110610-3	L2110610-4	L2110610-5
L2363957		Date Sampled	PWQO		Guelph Storm		6/12/2018 10:50:00 AM	6/12/2018 11:10:00 AM	6/12/2018 11:25:00 AM	6/12/2018 2:45:00 PM	6/12/2018 3:15:00 PM
Analyte	**Units**	**LOR**	**Lower Limit**	**Upper Limit**	**Lower Limit**	**Upper Limit**	Water	Water	Water	Water	Water
Conductivity	umhos/cm	3					691	873	1170	1160	1160
pH	pH units	0.1					8.11	7.94	8.2	8.27	8.26
Total Suspended Solids	mg/L	2	-	-	-	15	11.2	46.1!!	4.9	6	33.3!!
Ammonia, Total (as N)	mg/L	0.01	-	-	-	-	0.01	0.01	0.01	0.01	0.01
Chloride (Cl)	mg/L	0.5	-	-	-	-	49.8	148	226	235	230
Nitrate (as N)	mg/L	0.02	-	-	-	-	1.3	0.345	0.43	0.44	0.44
Phosphorus (P)-Total Dissolved	mg/L	0.003	-	-	-	-	0.003	0.003	0.0071	0.0071	0.006
Phosphorus, Total	mg/L	0.003	-	0.02	-	-	0.0322!	0.0513!	0.0127	0.0146	0.0619!
E. Coli	CFU/100mL	0	-	100	-	-	38	25	27	43	44
Aluminum (Al)-Total	mg/L	0.005	-	0.015	-	-	0.152!	0.168!	0.0281!	0.0376!	0.299!
Antimony (Sb)-Total	mg/L	0.0001	-	0.02	-	-	0.0001	0.0001	0.0001	0.0001	0.0001
Arsenic (As)-Total	mg/L	0.0001	-	0.005	-	-	0.00032	0.00097	0.00048	0.00055	0.00071
Barium (Ba)-Total	mg/L	0.0001	-	-	-	-	0.0616	0.0584	0.0731	0.0736	0.0805
Beryllium (Be)-Total	mg/L	0.0001	-	0.011	-	-	0.0001	0.0001	0.0001	0.0001	0.0001
Bismuth (Bi)-Total	mg/L	0.00005	-	-	-	-	0.00005	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	0.01	-	0.2	-	-	0.011	0.012	0.013	0.013	0.013
Cadmium (Cd)-Total	mg/L	0.000005	-	0.0001	-	0.001	0.00014!	0.000104!	0.0000183	0.0000374	0.000138!
Calcium (Ca)-Total	mg/L	0.05	-	-	-	-	84.3	66.5	79.6	81.1	81.6
Cesium (Cs)-Total	mg/L	0.00001	-	-	-	-	0.000017	0.000017	0.00001	0.00001	0.000029
Chromium (Cr)-Total	mg/L	0.0005	-	-	-	0.2	0.0005	0.0005	0.0005	0.0005	0.00063
Cobalt (Co)-Total	mg/L	0.0001	-	0.0009	-	-	0.00021	0.00022	0.0001	0.0001	0.00025
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.0021!	0.0019!	0.0011!	0.001	0.0034!
Iron (Fe)-Total	mg/L	0.01	-	0.3	-	-	0.369!	0.602!	0.1	0.1	0.534!
Lead (Pb)-Total	mg/L	0.00005	-	0.001	-	0.05	0.000967	0.00109!	0.000212	0.000302	0.00195!
Lithium (Li)-Total	mg/L	0.001	-	-	-	-	0.001	0.001	0.001	0.001	0.0014
Magnesium (Mg)-Total	mg/L	0.005	-	-	-	-	25.7	25.6	27.9	28.5	28.5
Manganese (Mn)-Total	mg/L	0.0005	-	-	-	-	0.0848	0.0657	0.0268	0.0191	0.058
Molybdenum (Mo)-Total	mg/L	0.00005	-	0.04	-	-	0.000212	0.000396	0.000324	0.000313	0.000342
Nickel (Ni)-Total	mg/L	0.0005	-	0.025	-	0.05	0.0005	0.00069	0.0005	0.0005	0.00082
Phosphorus (P)-Total	mg/L	0.05	-	-	-	-	0.05	0.05	0.05	0.05	0.071
Potassium (K)-Total	mg/L	0.05	-	-	-	-	1.21	1.58	1.6	1.62	1.67
Rubidium (Rb)-Total	mg/L	0.0002	-	-	-	-	0.00142	0.00142	0.00112	0.00114	0.00166
Selenium (Se)-Total	mg/L	0.00005	-	0.1	-	-	0.000258	0.000149	0.000094	0.000089	0.00016
Silicon (Si)-Total	mg/L	0.1	-	-	-	-	4.6	2.37	3.12	3.13	3.45
Silver (Ag)-Total	mg/L	0.00005	-	0.0001	-	-	0.00005	0.00005	0.00005	0.00005	0.00005
Sodium (Na)-Total	mg/L	0.05	-	-	-	-	22.8	77.9	118	120	124
Strontium (Sr)-Total	mg/L	0.001	-	-	-	-	0.103	0.106	0.123	0.124	0.123
Sulfur (S)-Total	mg/L	0.5	-	-	-	-	4.53	5.66	6.95	6.83	7
Tellurium (Te)-Total	mg/L	0.0002	-	-	-	-	0.0002	0.0002	0.0002	0.0002	0.0002
Thallium (Tl)-Total	mg/L	0.00001	-	0.0003	-	-	0.000011	0.00001	0.00001	0.00001	0.000013
Thorium (Th)-Total	mg/L	0.0001	-	-	-	-	0.0001	0.0001	0.0001	0.0001	0.0001
Tin (Sn)-Total	mg/L	0.0001	-	-	-	-	0.00012	0.00018	0.00016	0.00021	0.0001
Titanium (Ti)-Total	mg/L	0.0003	-	-	-	-	0.00393	0.00502	0.0007	0.0008	0.00732
Tungsten (W)-Total	mg/L	0.0001	-	0.03	-	-	0.0001	0.0001	0.0001	0.0001	0.0001
Uranium (U)-Total	mg/L	0.00001	-	0.005	-	-	0.000601	0.000468	0.000437	0.000436	0.000485
Vanadium (V)-Total	mg/L	0.0005	-	0.006	-	-	0.00073	0.00075	0.0005	0.0005	0.0009
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.0168	0.0325!	0.0057	0.0064	0.0306!
Zirconium (Zr)-Total	mg/L	0.0002	-	0.004	-	-	0.0002	0.0002	0.0002	0.0002	0.0002
BOD Carbonaceous	mg/L	2	-	-	-	15	2	2	2	2	2

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key: Within Guideline | Exceeds Guidline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key: Within Guideline | Exceeds Guidline

AECOM CANADA LTD. - KITCHENER
ATTN: Steven Scott
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 01-NOV-19
Report Date: 11-NOV-19 12:18 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L2375905
Project P.O. #: NOT SUBMITTED
Job Reference: 60611735
C of C Numbers:
Legal Site Desc:

Emily Hansen
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2375905-1 HC-A (03) Sampled By: SS on 31-OCT-19 @ 10:49 Matrix: WATER							
Physical Tests							
Conductivity	700		3.0	umhos/cm		02-NOV-19	R4896331
pH	7.70		0.10	pH units		02-NOV-19	R4896331
Total Suspended Solids	6.0		2.0	mg/L	06-NOV-19	07-NOV-19	R4902205
Anions and Nutrients							
Ammonia, Total (as N)	0.013		0.010	mg/L		06-NOV-19	R4900268
Chloride (Cl)	52.1		0.50	mg/L		05-NOV-19	R4900686
Nitrate (as N)	0.823		0.020	mg/L		05-NOV-19	R4900686
Phosphorus (P)-Total Dissolved	0.0064		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904293
Phosphorus, Total	0.0284		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904288
Bacteriological Tests							
E. Coli	90	DLM	10	CFU/100mL		02-NOV-19	R4896543
Total Metals							
Copper (Cu)-Total	0.0020		0.0010	mg/L	04-NOV-19	04-NOV-19	R4897851
Lead (Pb)-Total	0.000339		0.000050	mg/L	04-NOV-19	04-NOV-19	R4897851
Zinc (Zn)-Total	0.0139		0.0030	mg/L	04-NOV-19	04-NOV-19	R4897851
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L	02-NOV-19	07-NOV-19	R4902408
L2375905-2 HC-A (04) Sampled By: SS on 31-OCT-19 @ 11:09 Matrix: WATER							
Physical Tests							
Conductivity	756		3.0	umhos/cm		02-NOV-19	R4896331
pH	7.76		0.10	pH units		02-NOV-19	R4896331
Total Suspended Solids	11.6		2.0	mg/L	06-NOV-19	07-NOV-19	R4902205
Anions and Nutrients							
Ammonia, Total (as N)	0.042		0.010	mg/L		06-NOV-19	R4900268
Chloride (Cl)	120		0.50	mg/L		05-NOV-19	R4900686
Nitrate (as N)	0.377		0.020	mg/L		05-NOV-19	R4900686
Phosphorus (P)-Total Dissolved	0.0042		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904293
Phosphorus, Total	0.0315		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904288
Bacteriological Tests							
E. Coli	70	DLM	10	CFU/100mL		02-NOV-19	R4896543
Total Metals							
Copper (Cu)-Total	0.0024		0.0010	mg/L	04-NOV-19	04-NOV-19	R4897851
Lead (Pb)-Total	0.00158		0.000050	mg/L	04-NOV-19	04-NOV-19	R4897851
Zinc (Zn)-Total	0.0313		0.0030	mg/L	04-NOV-19	04-NOV-19	R4897851
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L	02-NOV-19	07-NOV-19	R4902408
L2375905-3 HC-A (12) Sampled By: SS on 31-OCT-19 @ 14:05 Matrix: WATER							
Physical Tests							
Conductivity	885		3.0	umhos/cm		02-NOV-19	R4896332

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2375905-3 HC-A (12) Sampled By: SS on 31-OCT-19 @ 14:05 Matrix: WATER							
Physical Tests							
pH	7.87		0.10	pH units		02-NOV-19	R4896332
Total Suspended Solids	3.5		2.0	mg/L	06-NOV-19	07-NOV-19	R4902205
Anions and Nutrients							
Ammonia, Total (as N)	0.012		0.010	mg/L		06-NOV-19	R4900268
Chloride (Cl)	147		0.50	mg/L		05-NOV-19	R4900686
Nitrate (as N)	0.120		0.020	mg/L		05-NOV-19	R4900686
Phosphorus (P)-Total Dissolved	0.0096		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904293
Phosphorus, Total	0.0171		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904288
Bacteriological Tests							
E. Coli	50	DLM	10	CFU/100mL		02-NOV-19	R4896543
Total Metals							
Copper (Cu)-Total	0.0022		0.0010	mg/L	04-NOV-19	04-NOV-19	R4897851
Lead (Pb)-Total	0.000304		0.000050	mg/L	04-NOV-19	04-NOV-19	R4897851
Zinc (Zn)-Total	0.0076		0.0030	mg/L	04-NOV-19	04-NOV-19	R4897851
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L	02-NOV-19	07-NOV-19	R4902408
L2375905-4 HC-A (13) Sampled By: SS on 31-OCT-19 @ 15:00 Matrix: WATER							
Physical Tests							
Conductivity	879		3.0	umhos/cm		02-NOV-19	R4896332
pH	7.88		0.10	pH units		02-NOV-19	R4896332
Total Suspended Solids	2.1		2.0	mg/L	06-NOV-19	07-NOV-19	R4902205
Anions and Nutrients							
Ammonia, Total (as N)	0.010		0.010	mg/L		06-NOV-19	R4900268
Chloride (Cl)	143		0.50	mg/L		05-NOV-19	R4900686
Nitrate (as N)	0.069		0.020	mg/L		05-NOV-19	R4900686
Phosphorus (P)-Total Dissolved	0.0209		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904293
Phosphorus, Total	0.0234		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904288
Bacteriological Tests							
E. Coli	70	DLM	10	CFU/100mL		02-NOV-19	R4896543
Total Metals							
Copper (Cu)-Total	0.0016		0.0010	mg/L	04-NOV-19	04-NOV-19	R4897851
Lead (Pb)-Total	0.000150		0.000050	mg/L	04-NOV-19	04-NOV-19	R4897851
Zinc (Zn)-Total	0.0069		0.0030	mg/L	04-NOV-19	04-NOV-19	R4897851
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L	02-NOV-19	07-NOV-19	R4902408
L2375905-5 HC-A (14) Sampled By: SS on 31-OCT-19 @ 14:45 Matrix: WATER							
Physical Tests							
Conductivity	881		3.0	umhos/cm		02-NOV-19	R4896332
pH	7.89		0.10	pH units		02-NOV-19	R4896332

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2375905-5 HC-A (14) Sampled By: SS on 31-OCT-19 @ 14:45 Matrix: WATER							
Physical Tests							
Total Suspended Solids	3.3		2.0	mg/L	06-NOV-19	07-NOV-19	R4902205
Anions and Nutrients							
Ammonia, Total (as N)	<0.010		0.010	mg/L		06-NOV-19	R4900268
Chloride (Cl)	143		0.50	mg/L		05-NOV-19	R4900686
Nitrate (as N)	0.065		0.020	mg/L		05-NOV-19	R4900686
Phosphorus (P)-Total Dissolved	0.0201		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904293
Phosphorus, Total	0.0216		0.0030	mg/L	08-NOV-19	09-NOV-19	R4904288
Bacteriological Tests							
E. Coli	61		0	CFU/100mL		02-NOV-19	R4896543
Total Metals							
Copper (Cu)-Total	0.0012		0.0010	mg/L	04-NOV-19	04-NOV-19	R4897851
Lead (Pb)-Total	0.000142		0.000050	mg/L	04-NOV-19	04-NOV-19	R4897851
Zinc (Zn)-Total	0.0070		0.0030	mg/L	04-NOV-19	04-NOV-19	R4897851
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L	02-NOV-19	07-NOV-19	R4902408

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Chloride (Cl)	MS-B	L2375905-1, -2, -3, -4, -5

Sample Parameter Qualifier key listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BOD-C-WT	Water	BOD Carbonaceous	APHA 5210 B (CBOD)

This analysis is carried out using procedures adapted from APHA Method 5210B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

ALS Test Code	Matrix	Test Description	Method Reference**
CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

ALS Test Code	Matrix	Test Description	Method Reference**
EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h. Method ID: WT-TM-1200

ALS Test Code	Matrix	Test Description	Method Reference**
EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

ALS Test Code	Matrix	Test Description	Method Reference**
EC-WT	Water	Conductivity	APHA 2510 B

Water samples can be measured directly by immersing the conductivity cell into the sample.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

ALS Test Code	Matrix	Test Description	Method Reference**
NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

ALS Test Code	Matrix	Test Description	Method Reference**
P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-WT	Water	pH	APHA 4500 H-Electrode

Water samples are analyzed directly by a calibrated pH meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

Reference Information

SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BOD-C-WT	**Water**							
Batch R4902408								
WG3209228-6 DUP		**L2375619-1**						
BOD Carbonaceous		<2.0	<2.0	RPD-NA	mg/L	N/A	20	07-NOV-19
WG3209228-7 LCS								
BOD Carbonaceous			99.5		%		85-115	07-NOV-19
WG3209228-5 MB								
BOD Carbonaceous			<2.0		mg/L		2	07-NOV-19
CL-IC-N-WT	**Water**							
Batch R4900686								
WG3210882-4 DUP		**L2375905-2**						
Chloride (Cl)		120	120		mg/L	0.1	20	05-NOV-19
WG3210882-2 LCS								
Chloride (Cl)			101.9		%		90-110	05-NOV-19
WG3210882-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	05-NOV-19
WG3210882-5 MS		**L2375905-2**						
Chloride (Cl)			N/A	MS-B	%		-	05-NOV-19
EC-MF-WT	**Water**							
Batch R4896543								
WG3208893-1 MB								
E. Coli			0		CFU/100mL		1	02-NOV-19
EC-WT	**Water**							
Batch R4896331								
WG3208924-4 DUP		**WG3208924-3**						
Conductivity		756	762		umhos/cm	0.8	10	02-NOV-19
WG3208924-2 LCS								
Conductivity			101.8		%		90-110	02-NOV-19
WG3208924-1 MB								
Conductivity			<3.0		umhos/cm		3	02-NOV-19
Batch R4896332								
WG3208925-4 DUP		**WG3208925-3**						
Conductivity		603	604		umhos/cm	0.2	10	02-NOV-19
WG3208925-2 LCS								
Conductivity			101.5		%		90-110	02-NOV-19
WG3208925-1 MB								
Conductivity			<3.0		umhos/cm		3	02-NOV-19
MET-T-CCMS-WT	**Water**							

ALS Environmental

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4897851								
WG3209437-4 DUP		**WG3209437-3**						
Copper (Cu)-Total		<0.010	<0.010	RPD-NA	mg/L	N/A	20	04-NOV-19
Lead (Pb)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	04-NOV-19
Zinc (Zn)-Total		<0.030	<0.030	RPD-NA	mg/L	N/A	20	04-NOV-19
WG3209437-2 LCS								
Copper (Cu)-Total			98.4		%		80-120	04-NOV-19
Lead (Pb)-Total			99.99		%		80-120	04-NOV-19
Zinc (Zn)-Total			97.9		%		80-120	04-NOV-19
WG3209437-1 MB								
Copper (Cu)-Total			<0.0010		mg/L		0.001	04-NOV-19
Lead (Pb)-Total			<0.000050		mg/L		0.00005	04-NOV-19
Zinc (Zn)-Total			<0.0030		mg/L		0.003	04-NOV-19
WG3209437-5 MS		**WG3209437-6**						
Copper (Cu)-Total			93.4		%		70-130	04-NOV-19
Lead (Pb)-Total			96.6		%		70-130	04-NOV-19
Zinc (Zn)-Total			88.2		%		70-130	04-NOV-19
NH3-F-WT	**Water**							
Batch R4900268								
WG3211981-16 DUP		**L2375851-7**						
Ammonia, Total (as N)		0.087	0.086		mg/L	0.5	20	06-NOV-19
WG3211981-20 DUP		**L2375877-1**						
Ammonia, Total (as N)		0.054	0.055		mg/L	2.6	20	06-NOV-19
WG3211981-14 LCS								
Ammonia, Total (as N)			99.1		%		85-115	06-NOV-19
WG3211981-18 LCS								
Ammonia, Total (as N)			93.5		%		85-115	06-NOV-19
WG3211981-13 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	06-NOV-19
WG3211981-17 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	06-NOV-19
WG3211981-15 MS		**L2375851-7**						
Ammonia, Total (as N)			102.2		%		75-125	06-NOV-19
WG3211981-19 MS		**L2375877-1**						
Ammonia, Total (as N)			104.5		%		75-125	06-NOV-19
NO3-IC-WT	**Water**							

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-WT	**Water**							
Batch R4900686								
WG3210882-4 DUP		**L2375905-2**						
Nitrate (as N)		0.377	0.377		mg/L	0.1	20	05-NOV-19
WG3210882-2 LCS								
Nitrate (as N)			101.0		%		90-110	05-NOV-19
WG3210882-1 MB								
Nitrate (as N)			<0.020		mg/L		0.02	05-NOV-19
WG3210882-5 MS		**L2375905-2**						
Nitrate (as N)			99.3		%		75-125	05-NOV-19
P-T-COL-WT	**Water**							
Batch R4904288								
WG3214795-3 DUP		**L2375905-5**						
Phosphorus, Total		0.0216	0.0234		mg/L	8.1	20	09-NOV-19
WG3214795-2 LCS								
Phosphorus, Total			90.7		%		80-120	09-NOV-19
WG3214795-1 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	09-NOV-19
WG3214795-4 MS		**L2375905-5**						
Phosphorus, Total			98.1		%		70-130	09-NOV-19
P-TD-COL-WT	**Water**							
Batch R4904293								
WG3214808-3 DUP		**L2375905-3**						
Phosphorus (P)-Total Dissolved		0.0096	0.0092		mg/L	4.0	20	09-NOV-19
WG3214808-2 LCS								
Phosphorus (P)-Total Dissolved			98.6		%		80-120	09-NOV-19
WG3214808-1 MB								
Phosphorus (P)-Total Dissolved			<0.0030		mg/L		0.003	09-NOV-19
WG3214808-4 MS		**L2375905-3**						
Phosphorus (P)-Total Dissolved			103.0		%		70-130	09-NOV-19
PH-WT	**Water**							
Batch R4896331								
WG3208924-4 DUP		**WG3208924-3**						
pH		7.76	7.75	J	pH units	0.01	0.2	02-NOV-19
WG3208924-2 LCS								
pH			6.99		pH units		6.9-7.1	02-NOV-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH-WT	**Water**							
Batch R4896332								
WG3208925-4 DUP		**WG3208925-3**						
pH		7.28	7.27	J	pH units	0.01	0.2	02-NOV-19
WG3208925-2 LCS								
pH			7.00		pH units		6.9-7.1	02-NOV-19
SOLIDS-TSS-WT	**Water**							
Batch R4902205								
WG3212177-3 DUP		**L2375486-4**						
Total Suspended Solids		393	379		mg/L	3.6	20	07-NOV-19
WG3212177-2 LCS								
Total Suspended Solids			100.6		%		85-115	07-NOV-19
WG3212177-1 MB								
Total Suspended Solids			<2.0		mg/L		2	07-NOV-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

60 NORTHLAND R(
WATERLOO, ON N2
Phone: (519) 886-(
Fax: (519) 886-9047
Toll Free: 1-800-668-9878

L2375905-COFC

C of C # 00000 84

OF CUSTODY / ANALYTICAL SERVICES REQUEST FORM

Page ___ of ___

Note: all TAT Quoted material is in business days which exclude statutory holidays and weekends. TAT samples received past 3:00 pm or Saturday/Sunday begin the next day.

Specify date required	Service requested			
	5 day (regular)	X	*2 day TAT (50%)*	
	3-4 day (regular)		*Next day TAT (100%)*	
			Same day TAT (200%)	

COMPANY NAME	AECOM
OFFICE	Kitchener
PROJECT MANAGER Steven Scott	
PROJECT # 60611735	
PHONE 519-650-8637 OR 519-569-9388	FAX
ACCOUNT # 15884	
QUOTATION # Q59209	PO #

CRITERIA Criteria on report YESX__ NO___

Reg 153/11
Table 1 2 3

TCLP _____ MISA _____ PWQO ___X__
ODWS _____ OTHER ______

REPORT FORMAT/DISTRIBUTION

EMAIL _X_ FAX ___ BOTH ___
SELECT: PDF ___ DIGITAL ___ BOTH _X_
EMAIL 1 Tara.Roumeliotis@aecom.com
EMAIL 2 Steve.Scott2@aecom.com
EMAIL 3 Tochi.Azubuike@aecom.com

PLEASE INDICATE FILTERED, PRESERVED OR BOTH <----- (F, P, F/P)

SUBMISSION #: L2375905
ENTERED BY: 84 RD
DATE/TIME ENTERED:
BIN #:

SAMPLING INFORMATION

Date (dd-mm-yy)	Time (24hr) (hh:mm)	TYPE: COMP	TYPE: GRAB	MATRIX: WATER	MATRIX: SOIL	MATRIX: OTHER	SAMPLE DESCRIPTION TO APPEAR ON REPORT	NUMBER OF CONTAINERS	TSS	CBOD5	E. Coli	Total Metals by ICPMS (Lead, Zinc, Coppe	Total and Dissolved P (Lab Filter)	Total Ammonia Nitrogen, NO^3, and CL					COMMENTS	LAB ID
31-10-19	10:49			X			HC-A(03)	7	X	X	X	X	X	X					Please provide	
31-10-19	11:09			X			HC-A(04)	7	X	X	X	X	X	X					pH and conductivity	
31-10-19	14:05			X			HC-A(12)	7	X	X	X	X	X	X					as YSI measurements	
31-10-19	15:00			X			HC-A(13)	7	X	X	X	X	X	X					are faulty	
31-10-19	14:45			X			HC-A(14)	7	X	X	X	X	X	X						

SPECIAL INSTRUCTIONS/COMMENTS

Surface water samples, so colforms counts may be high. Please also provide pH measurement as field measurements seemed high.

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (CHECK Yes or No)

Are any samples taken from a regulated DW System? Yes ___ No ___
If yes, an authorized drinking water COC MUST be used for this submission.
Is the water sampled intended to be potable for human consumption? Yes ___ No ___

SAMPLE CONDITION

___ FROZEN
___ COLD
___ COOLING INITIATED
___ AMBIENT
OBSERVATIONS
Yes ___ No ___
If yes add SIF

SAMPLED BY: Steven Scott	DATE & TIME 31-10-19	RECEIVED BY:	DATE & TIME
RELINQUISHED BY: Steven Scott	DATE & TIME 31-10-19	RECEIVED AT LAB BY: 84	DATE & TIME: 01-Nov-19 1430

Notes
1. Quote number must be provided to ensure proper pricing
2. TAT may vary dependent on complexity of analysis and lab workload at time of submission. Please contact the lab to confirm TATs.
3. Any known or suspected hazards relating to a sample must be noted on the chain of custody in comments section.

ALS		Sample ID					HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)
1/11/2020		ALS ID					L2110610-1	L2110610-2	L2110610-3	L2110610-4	L2110610-5
L2375905		Date Sampled	PWQO		Guelph Storm		6/12/2018 10:50:00 AM	6/12/2018 11:10:00 AM	6/12/2018 11:25:00 AM	6/12/2018 2:45:00 PM	6/12/2018 3:15:00 PM
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Water	Water	Water	Water	Water
Conductivity	umhos/cm	3					700	756	885	879	881
pH	pH units	0.1					7.7	7.76	7.87	7.88	7.89
Total Suspended Solids	mg/L	2	-	-	-	15	6	11.6	3.5	2.1	3.3
Ammonia, Total (as N)	mg/L	0.01	-	-	-	-	0.013	0.042	0.012	0.01	0.01
Chloride (Cl)	mg/L	0.5	-	-	-	-	52.1	120	147	143	143
Nitrate (as N)	mg/L	0.02	-	-	-	-	0.823	0.377	0.12	0.069	0.065
Phosphorus (P)-Total Dissolved	mg/L	0.003	-	-	-	-	0.0064	0.0042	0.0096	0.0209	0.0201
Phosphorus, Total	mg/L	0.003	-	0.02	-	-	0.0284!	0.0315!	0.0171	0.0234!	0.0216!
E. Coli	CFU/100mL	0	-	100	-	-	90	70	50	70	61
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.002!	0.0024!	0.0022!	0.0016!	0.0012!
Lead (Pb)-Total	mg/L	0.00005	-	0.001	-	0.05	0.000339	0.00158!	0.000304	0.00015	0.000142
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.0139	0.0313!	0.0076	0.0069	0.007
BOD Carbonaceous	mg/L	2	-	-	-	15	2	2	2	2	2

Applied Guideline: Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO

Color Key: Within Guideline | Exceeds Guidline

Applied Guideline: Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)

Color Key: Within Guideline | Exceeds Guideline

AECOM CANADA LTD. - KITCHENER
ATTN: STEVEN SCOTT
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 05-NOV-19
Report Date: 18-NOV-19 13:23 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L2377538

Project P.O. #: NOT SUBMITTED
Job Reference: 60611735
C of C Numbers:
Legal Site Desc:

Emily Hansen
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2377538-1 HC-A (03) Sampled By: TA on 04-NOV-19 @ 10:46 Matrix: WATER							
Physical Tests							
pH	8.05	PEHT	0.10	pH units		12-NOV-19	R4904581
Total Suspended Solids	2.3		2.0	mg/L	11-NOV-19	12-NOV-19	R4904606
Anions and Nutrients							
Ammonia, Total (as N)	<0.010		0.010	mg/L		11-NOV-19	R4904317
Chloride (Cl)	50.6		0.50	mg/L		07-NOV-19	R4903422
Nitrate (as N)	0.845		0.020	mg/L		07-NOV-19	R4903422
Phosphorus (P)-Total Dissolved	0.0041		0.0030	mg/L	12-NOV-19	13-NOV-19	R4905786
Phosphorus, Total	0.0081		0.0030	mg/L	12-NOV-19	13-NOV-19	R4906776
Bacteriological Tests							
E. Coli	52		0	CFU/100mL		06-NOV-19	R4901555
Total Metals							
Copper (Cu)-Total	0.0013		0.0010	mg/L	06-NOV-19	06-NOV-19	R4902348
Lead (Pb)-Total	0.000196		0.000050	mg/L	06-NOV-19	06-NOV-19	R4902348
Zinc (Zn)-Total	0.0095		0.0030	mg/L	06-NOV-19	06-NOV-19	R4902348
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L	06-NOV-19	11-NOV-19	R4904363
L2377538-2 HC-A (04) Sampled By: TA on 04-NOV-19 @ 11:33 Matrix: WATER							
Physical Tests							
pH	8.15	PEHT	0.10	pH units		12-NOV-19	R4904581
Total Suspended Solids	5.0		2.0	mg/L	11-NOV-19	12-NOV-19	R4904606
Anions and Nutrients							
Ammonia, Total (as N)	0.058		0.010	mg/L		11-NOV-19	R4904317
Chloride (Cl)	110		0.50	mg/L		07-NOV-19	R4903422
Nitrate (as N)	0.423		0.020	mg/L		07-NOV-19	R4903422
Phosphorus (P)-Total Dissolved	0.0077		0.0030	mg/L	12-NOV-19	13-NOV-19	R4905786
Phosphorus, Total	0.0179		0.0030	mg/L	12-NOV-19	13-NOV-19	R4905783
Bacteriological Tests							
E. Coli	9		0	CFU/100mL		06-NOV-19	R4901555
Total Metals							
Copper (Cu)-Total	0.0014		0.0010	mg/L	06-NOV-19	06-NOV-19	R4902348
Lead (Pb)-Total	0.00104		0.000050	mg/L	06-NOV-19	06-NOV-19	R4902348
Zinc (Zn)-Total	0.0152		0.0030	mg/L	06-NOV-19	06-NOV-19	R4902348
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L	06-NOV-19	11-NOV-19	R4904363
L2377538-3 HC-A (12) Sampled By: TA on 04-NOV-19 @ 14:44 Matrix: WATER							
Physical Tests							
pH	8.18	PEHT	0.10	pH units		12-NOV-19	R4904581
Total Suspended Solids	2.1		2.0	mg/L	11-NOV-19	12-NOV-19	R4904606
Anions and Nutrients							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2377538-3 HC-A (12) Sampled By: TA on 04-NOV-19 @ 14:44 Matrix: WATER							
Anions and Nutrients							
Ammonia, Total (as N)	0.018		0.010	mg/L		11-NOV-19	R4904317
Chloride (Cl)	170		0.50	mg/L		07-NOV-19	R4903422
Nitrate (as N)	0.331		0.020	mg/L		07-NOV-19	R4903422
Phosphorus (P)-Total Dissolved	0.0055		0.0030	mg/L	12-NOV-19	13-NOV-19	R4905786
Phosphorus, Total	0.0181		0.0030	mg/L	12-NOV-19	13-NOV-19	R4905783
Bacteriological Tests							
E. Coli	10	DLM	10	CFU/100mL		06-NOV-19	R4901555
Total Metals							
Copper (Cu)-Total	0.0015		0.0010	mg/L	06-NOV-19	06-NOV-19	R4902348
Lead (Pb)-Total	0.000243		0.000050	mg/L	06-NOV-19	06-NOV-19	R4902348
Zinc (Zn)-Total	0.0059		0.0030	mg/L	06-NOV-19	06-NOV-19	R4902348
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L	12-NOV-19	17-NOV-19	R4915090
L2377538-4 HC-A (13) Sampled By: TA on 04-NOV-19 @ 15:25 Matrix: WATER							
Physical Tests							
pH	8.06	PEHT	0.10	pH units		12-NOV-19	R4904581
Total Suspended Solids	<2.0		2.0	mg/L	11-NOV-19	12-NOV-19	R4904606
Anions and Nutrients							
Ammonia, Total (as N)	0.020		0.010	mg/L		11-NOV-19	R4904317
Chloride (Cl)	169		0.50	mg/L		07-NOV-19	R4903422
Nitrate (as N)	0.244		0.020	mg/L		07-NOV-19	R4903422
Phosphorus (P)-Total Dissolved	0.0101		0.0030	mg/L	12-NOV-19	13-NOV-19	R4905786
Phosphorus, Total	0.0125		0.0030	mg/L	12-NOV-19	13-NOV-19	R4905783
Bacteriological Tests							
E. Coli	11		0	CFU/100mL		06-NOV-19	R4901555
Total Metals							
Copper (Cu)-Total	<0.0010		0.0010	mg/L	06-NOV-19	06-NOV-19	R4902348
Lead (Pb)-Total	0.000137		0.000050	mg/L	06-NOV-19	06-NOV-19	R4902348
Zinc (Zn)-Total	0.0056		0.0030	mg/L	06-NOV-19	06-NOV-19	R4902348
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L	12-NOV-19	17-NOV-19	R4915090
L2377538-5 HC-A (14) Sampled By: TA on 04-NOV-19 @ 16:02 Matrix: WATER							
Physical Tests							
pH	8.17	PEHT	0.10	pH units		12-NOV-19	R4904581
Total Suspended Solids	3.2		2.0	mg/L	11-NOV-19	12-NOV-19	R4904606
Anions and Nutrients							
Ammonia, Total (as N)	0.012		0.010	mg/L		08-NOV-19	R4904182
Chloride (Cl)	169		0.50	mg/L		07-NOV-19	R4903422
Nitrate (as N)	0.239		0.020	mg/L		07-NOV-19	R4903422

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2377538-5 HC-A (14) Sampled By: TA on 04-NOV-19 @ 16:02 Matrix: WATER							
Anions and Nutrients							
Phosphorus (P)-Total Dissolved	0.0104		0.0030	mg/L	12-NOV-19	13-NOV-19	R4905786
Phosphorus, Total	0.0139		0.0030	mg/L	12-NOV-19	13-NOV-19	R4905783
Bacteriological Tests							
E. Coli	6		0	CFU/100mL		06-NOV-19	R4901555
Total Metals							
Copper (Cu)-Total	0.0022		0.0010	mg/L	06-NOV-19	06-NOV-19	R4902348
Lead (Pb)-Total	0.000306		0.000050	mg/L	06-NOV-19	06-NOV-19	R4902348
Zinc (Zn)-Total	0.0074		0.0030	mg/L	06-NOV-19	06-NOV-19	R4902348
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L	06-NOV-19	11-NOV-19	R4904363

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Phosphorus, Total	K	L2377538-1
Matrix Spike	Ammonia, Total (as N)	MS-B	L2377538-5

Sample Parameter Qualifier key listed:

Qualifier	Description
BODL	Limit of Reporting for BOD was increased to account for the largest volume of sample tested.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
K	Matrix Spike recovery outside ALS DQO due to sample matrix effects.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
PEHT	Parameter Exceeded Recommended Holding Time Prior to Analysis

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BOD-C-WT	Water	BOD Carbonaceous	APHA 5210 B (CBOD)

This analysis is carried out using procedures adapted from APHA Method 5210B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

ALS Test Code	Matrix	Test Description	Method Reference**
CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

ALS Test Code	Matrix	Test Description	Method Reference**
EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h. Method ID: WT-TM-1200

ALS Test Code	Matrix	Test Description	Method Reference**
EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

ALS Test Code	Matrix	Test Description	Method Reference**
NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

ALS Test Code	Matrix	Test Description	Method Reference**
P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-WT	Water	pH	APHA 4500 H-Electrode

Water samples are analyzed directly by a calibrated pH meter.

Reference Information

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: STEVEN SCOTT

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BOD-C-WT	**Water**							
Batch R4904363								
WG3212563-2 DUP		**L2376470-1**						
BOD Carbonaceous		<2.0	<2.0	RPD-NA	mg/L	N/A	20	11-NOV-19
WG3212563-3 LCS								
BOD Carbonaceous			97.5		%		85-115	11-NOV-19
WG3212563-1 MB								
BOD Carbonaceous			<2.0		mg/L		2	11-NOV-19
Batch R4915090								
WG3216680-2 DUP		**L2380365-1**						
BOD Carbonaceous		<2.0	<2.0	RPD-NA	mg/L	N/A	20	17-NOV-19
WG3216680-3 LCS								
BOD Carbonaceous			99.5		%		85-115	17-NOV-19
WG3216680-1 MB								
BOD Carbonaceous			<2.0		mg/L		2	17-NOV-19
CL-IC-N-WT	**Water**							
Batch R4903422								
WG3213287-10 DUP		**WG3213287-8**						
Chloride (Cl)		6.89	6.90		mg/L	0.1	20	07-NOV-19
WG3213287-7 LCS								
Chloride (Cl)			102.0		%		90-110	07-NOV-19
WG3213287-6 MB								
Chloride (Cl)			<0.50		mg/L		0.5	07-NOV-19
WG3213287-9 MS		**WG3213287-8**						
Chloride (Cl)			103.3		%		75-125	07-NOV-19
EC-MF-WT	**Water**							
Batch R4901555								
WG3211911-3 DUP		**L2377538-3**						
E. Coli		10	10		CFU/100mL	0.0	65	06-NOV-19
WG3211911-1 MB								
E. Coli			0		CFU/100mL		1	06-NOV-19
MET-T-CCMS-WT	**Water**							
Batch R4902348								
WG3211574-4 DUP		**WG3211574-3**						
Copper (Cu)-Total		0.0020	0.0011	J	mg/L	0.0009	0.002	06-NOV-19
Lead (Pb)-Total		0.000179	0.000228	J	mg/L	0.000049	0.0001	06-NOV-19
Zinc (Zn)-Total		0.0036	<0.0030	RPD-NA	mg/L	N/A	20	06-NOV-19
WG3211574-2 LCS								
Copper (Cu)-Total			96.9		%		80-120	06-NOV-19

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: STEVEN SCOTT

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4902348								
WG3211574-2 LCS								
Lead (Pb)-Total			98.7		%		80-120	06-NOV-19
Zinc (Zn)-Total			95.0		%		80-120	06-NOV-19
WG3211574-1 MB								
Copper (Cu)-Total			<0.0010		mg/L		0.001	06-NOV-19
Lead (Pb)-Total			<0.000050		mg/L		0.00005	06-NOV-19
Zinc (Zn)-Total			<0.0030		mg/L		0.003	06-NOV-19
WG3211574-5 MS		**WG3211574-3**						
Copper (Cu)-Total			85.6		%		70-130	06-NOV-19
Lead (Pb)-Total			91.6		%		70-130	06-NOV-19
Zinc (Zn)-Total			81.4		%		70-130	06-NOV-19
NH3-F-WT	**Water**							
Batch R4904182								
WG3214333-3 DUP		**L2378668-1**						
Ammonia, Total (as N)		0.129	0.131		mg/L	1.2	20	08-NOV-19
WG3214333-2 LCS								
Ammonia, Total (as N)			103.0		%		85-115	08-NOV-19
WG3214333-1 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	08-NOV-19
WG3214333-4 MS		**L2378668-1**						
Ammonia, Total (as N)			N/A	MS-B	%		-	08-NOV-19
Batch R4904317								
WG3215916-19 DUP		**L2377538-1**						
Ammonia, Total (as N)		<0.010	<0.010	RPD-NA	mg/L	N/A	20	11-NOV-19
WG3215916-18 LCS								
Ammonia, Total (as N)			97.9		%		85-115	11-NOV-19
WG3215916-17 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	11-NOV-19
WG3215916-20 MS		**L2377538-1**						
Ammonia, Total (as N)			104.6		%		75-125	11-NOV-19
NO3-IC-WT	**Water**							
Batch R4903422								
WG3213287-10 DUP		**WG3213287-8**						
Nitrate (as N)		0.215	0.212		mg/L	1.0	20	07-NOV-19
WG3213287-7 LCS								
Nitrate (as N)			101.2		%		90-110	07-NOV-19
WG3213287-6 MB								

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: STEVEN SCOTT

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-WT	**Water**							
Batch R4903422								
WG3213287-6 MB								
Nitrate (as N)			<0.020		mg/L		0.02	07-NOV-19
WG3213287-9 MS		**WG3213287-8**						
Nitrate (as N)			102.5		%		75-125	07-NOV-19
P-T-COL-WT	**Water**							
Batch R4905783								
WG3216593-7 DUP		**L2377538-2**						
Phosphorus, Total		0.0179	0.0149		mg/L	18	20	13-NOV-19
WG3216593-6 LCS								
Phosphorus, Total			108.5		%		80-120	13-NOV-19
WG3216593-5 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	13-NOV-19
WG3216593-8 MS		**L2377538-2**						
Phosphorus, Total			104.5		%		70-130	13-NOV-19
Batch R4906776								
WG3218462-3 DUP		**WG3218462-5**						
Phosphorus, Total		0.0294	0.0267		mg/L	9.5	20	13-NOV-19
WG3218462-2 LCS								
Phosphorus, Total			103.1		%		80-120	13-NOV-19
WG3218462-1 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	13-NOV-19
WG3218462-4 MS		**WG3218462-5**						
Phosphorus, Total			62.2	K	%		70-130	13-NOV-19
P-TD-COL-WT	**Water**							
Batch R4905786								
WG3216598-3 DUP		**L2377538-1**						
Phosphorus (P)-Total Dissolved		0.0041	0.0033	J	mg/L	0.0008	0.006	13-NOV-19
WG3216598-2 LCS								
Phosphorus (P)-Total Dissolved			103.1		%		80-120	13-NOV-19
WG3216598-1 MB								
Phosphorus (P)-Total Dissolved			<0.0030		mg/L		0.003	13-NOV-19
WG3216598-4 MS		**L2377538-1**						
Phosphorus (P)-Total Dissolved			106.1		%		70-130	13-NOV-19
PH-WT	**Water**							

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: STEVEN SCOTT

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH-WT	**Water**							
Batch R4904581								
WG3216210-4 DUP		**WG3216210-3**						
pH		7.21	7.12	J	pH units	0.09	0.2	12-NOV-19
WG3216210-2 LCS								
pH			7.00		pH units		6.9-7.1	12-NOV-19
SOLIDS-TSS-WT	**Water**							
Batch R4904606								
WG3215803-3 DUP		**L2378724-1**						
Total Suspended Solids		1390	1380		mg/L	0.6	20	12-NOV-19
WG3215803-2 LCS								
Total Suspended Solids			100.3		%		85-115	12-NOV-19
WG3215803-1 MB								
Total Suspended Solids			<2.0		mg/L		2	12-NOV-19

Client:	AECOM CANADA LTD. - KITCHENER 50 Sportsworld Crossing Road Suite 290 KITCHENER ON N2P 0A4
Contact:	STEVEN SCOTT

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
K	Matrix Spike recovery outside ALS DQO due to sample matrix effects.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH							
	1	04-NOV-19 10:46	12-NOV-19 09:00	4	8	days	EHT
	2	04-NOV-19 11:33	12-NOV-19 09:00	4	8	days	EHT
	3	04-NOV-19 14:44	12-NOV-19 09:00	4	8	days	EHT
	4	04-NOV-19 15:25	12-NOV-19 09:00	4	8	days	EHT
	5	04-NOV-19 16:02	12-NOV-19 09:00	4	8	days	EHT
Aggregate Organics							
BOD Carbonaceous							
	3	04-NOV-19 14:44	17-NOV-19 12:00	4	13	days	EHT
	4	04-NOV-19 15:25	17-NOV-19 12:00	4	13	days	EHT

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2377538 were received on 05-NOV-19 15:00.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

60 NORTHLAND ROAD, UNIT 1
WATERLOO, ON N2V 2B8
Phone: (519) 886-6910
Fax: (519) 886-9047
Toll Free: 1-800-668-9878

ALS

L2377538-COFC

C of C # 00000

CAL SERVICES REQUEST FORM Page ___ of ___

N... statutory holidays and weekends ... 3:00 pm or Saturday/Sunday begin the next day.

Specify date required	Service requested		
	5 day (regular)	X	2 day TAT (50%)
	3-4 day (regular)		Next day TAT (100%)
			Same day TAT (200%)

COMPANY NAME	AECOM
OFFICE	Kitchener
PROJECT MANAGER	Steven Scott
PROJECT #	60611735
PHONE	519-650-8637 OR 519-569-9388
FAX	
ACCOUNT #	15884
QUOTATION #	Q59209
PO #	

CRITERIA — Criteria on report YESX__ NO___

Reg 153/11
Table 1 2 3

TCLP _____ MISA _____ PWQO __X__
ODWS _____ OTHER _____

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PLEASE INDICATE FILTERED, PRESERVED OR BOTH <----- (F, P, F/P)

SUBMISSION #: L2377538
ENTERED BY: RD
DATE/TIME ENTERED:
BIN #: WT-NOV-05B

SAMPLING INFORMATION

Date (dd-mm-yy)	Time (24hr) (hh:mm)	COMP	GRAB	WATER	SOIL	OTHER	SAMPLE DESCRIPTION TO APPEAR ON REPORT	NUMBER OF CONTAINERS	TSS	CBOD5	E. Coli	Total Metals by ICPMS (Lead, Zinc, Coppe	Total and Dissolved P (Lab Filter)	Total Ammonia Nitrogen, NO^3, and CL					COMMENTS	LAB ID
04-11-19	10:46			X			HC-A(03)	7	X	X	X	X	X	X					See Special Instructions	
04-11-19	11:33			X			HC-A(04)	7	X	X	X	X	X	X					See Special Instructions	
04-11-19	14:44			X			HC-A(12)	7	X	X	X	X	X	X					See Special Instructions	
04-11-19	15:25			X			HC-A(13)	7	X	X	X	X	X	X					See Special Instructions	
04-11-19	16:02			X			HC-A(14)	7	X	X	X	X	X	X					See Special Instructions	

SPECIAL INSTRUCTIONS/COMMENTS

Surface water samples, so colforms counts may be high.

Please also provide pH measurement as field measurements seemed high.

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (CHECK Yes OR No)

Are any samples taken from a regulated DW System? Yes ___ No ___
If yes, an authorized drinking water COC MUST be used for this submission.
Is the water sampled intended to be potable for human consumption? Yes ___ No ___

SAMPLE CONDITION
___ FROZEN
___ COLD
___ COOLING INITIATED
___ AMBIENT
MEAN TEMP 4.6
OBSERVATIONS Yes___ No___ If yes add SIF
INIT

SAMPLED BY: Tochi Azubuike	DATE & TIME 4-11-19	RECEIVED BY:	DATE & TIME
RELINQUISHED BY: Steven Scott	DATE & TIME 4-11-19	RECEIVED AT LAB BY: AP	DATE & TIME 5-NOV-19 15:00

Notes
1. Quote number must be provided to ensure proper pricing
2. TAT may vary dependent on complexity of analysis and lab workload at time of submission. Please contact the lab to confirm TATs.
3. Any known or suspected hazards relating to a sample must be noted on the chain of custody in comments section.

ALS		Sample ID					HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)
1/11/2020		ALS ID					L2110610-1	L2110610-2	L2110610-3	L2110610-4	L2110610-5
L2377538		Date Sampled	PWQO		Guelph Storm		6/12/2018 10:50:00 AM	6/12/2018 11:10:00 AM	6/12/2018 11:25:00 AM	6/12/2018 2:45:00 PM	6/12/2018 3:15:00 PM
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Water	Water	Water	Water	Water
pH	pH units	0.1					8.05	8.15	8.18	8.06	8.17
Total Suspended Solids	mg/L	2	-	-	-	15	2.3	5	2.1	2	3.2
Ammonia, Total (as N)	mg/L	0.01	-	-	-	-	0.01	0.058	0.018	0.02	0.012
Chloride (Cl)	mg/L	0.5	-	-	-	-	50.6	110	170	169	169
Nitrate (as N)	mg/L	0.02	-	-	-	-	0.845	0.423	0.331	0.244	0.239
Phosphorus (P)-Total Dissolved	mg/L	0.003	-	-	-	-	0.0041	0.0077	0.0055	0.0101	0.0104
Phosphorus, Total	mg/L	0.003	-	0.02	-	-	0.0081	0.0179	0.0181	0.0125	0.0139
E. Coli	CFU/100mL	0	-	100	-	-	52	9	10	11	6
Copper (Cu)-Total	mg/L	0.001	-	0.001	-	0.01	0.0013!	0.0014!	0.0015!	0.001	0.0022!
Lead (Pb)-Total	mg/L	0.00005	-	0.001	-	0.05	0.000196	0.00104!	0.000243	0.000137	0.000306
Zinc (Zn)-Total	mg/L	0.003	-	0.02	-	0.05	0.0095	0.0152	0.0059	0.0056	0.0074
BOD Carbonaceous	mg/L	2	-	-	-	15	3	3	2	2	3

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**
Color Key: Within Guideline | Exceeds Guidline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**
Color Key: Within Guideline | Exceeds Guidline

APPENDIX IV 2020 Surface Water Monitoring Report

Hanlon Creek Business Park-2020 Surface Water Monitoring Report

City of Guelph

Project number: 60611735

March 2020

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("AECOM") for the benefit of the Client ("Client") in accordance with the agreement between AECOM and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations");
- represents AECOM's professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to AECOM which has not been independently verified;
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
- was prepared for the specific purposes described in the Report and the Agreement; and
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time..

AECOM shall be entitled to rely upon the accuracy and completeness of information that was provided to it and has no obligation to update such information. AECOM accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, environmental or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

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This Statement of Qualifications and Limitations is attached to and forms part of the Report and any use of the Report is subject to the terms hereof.

AECOM: 2015-04-13

Quality information

Prepared by	Checked by	Verified by	Approved by
Steven Scott, M.Sc. Water Resource Specialist	Bill Trenouth, P.Eng. Water Resources Engineer/Project Manager		

Revision History

Revision	Revision date	Details	Authorized	Name	Position

Distribution List

# Hard Copies	PDF Required	Association / Company Name

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1. Introduction

1.1 Background

AECOM has been retained by the City of Guelph to complete the 2020 Surface Water Monitoring component of the Hanlon Creek Business Park (HCBP) Monitoring Program, which comprises the lands between Downey Road and the Hanlon Expressway, between Forestell Road and the south end of the Kortright subdivision along Teal Drive in the City of Guelph.

This monitoring program follows the recommendations made in the HCBP Consolidated Environmental Impact Study (NRSI 2004), Draft Plan Conditions (OMB 2006), Ministry of Environment, Conservation and Parks (MECP) Environmental Compliance Approval (ECA) No. 1384-7QFPZQ and review comments from agencies during various stages of the planning process.

This surface water monitoring work plan includes collection of temperature, flow, and water quality conditions within both Hanlon Creek Tributary A and HCBP Stormwater Management (SWM) Facilities 1, 2 and 4. The monitoring program is intended to provide an understanding of surface water flows, water quality and thermal conditions within HCBP's stormwater management and natural watercourse systems.

1.2 Surface Water Monitoring Program History

In 2003 AECOM was retained by the City of Guelph (City) to establish and carry out a surface water monitoring program at Hanlon Creek Tributary A in anticipation of construction at the Hanlon Creek Business Park. The purpose of this program was to characterize pre-construction flow and temperature conditions. The surface water program has evolved since 2003 and is now included within the surface water monitoring component of the Consolidated Monitoring Program established for the HCBP. Other components of this monitoring program include groundwater monitoring (completed by Banks Groundwater); and aquatic and terrestrial ecology monitoring (completed by Natural Resource Solutions Inc. (NRSI)).

In 2003-2004 monitoring data was reported in separate memoranda to the City and a consolidated Environmental Impact Study (EIS) was prepared by NRSI for the Hanlon Creek Business Park in 2004. Monitoring continued in 2006 and 2007 with continuous temperature measurements at six (6) stations between the outlet of the online pond (Road A) and 150 m upstream of Laird Road (monitoring location figure is shown in **Section 2**). Depth and velocity were continuously measured at the Laird Road culvert (HC-A(05)) and periodic depth measurements were also recorded at this location. Sampling completed in 2006-2007 was summarized in a technical memorandum, submitted to the City of Guelph in February 2008.

The 2008 monitoring plan included temperature monitoring at the previous 6 stations along Tributary A and the inclusion of an additional temperature monitoring station (HC-A(14)) located downstream of the existing SWM pond (Pond 2) outlet. This additional station provided background information to identify the temperature impacts of proposed Ponds 1 and 2. Depth and velocity were monitored at the Laird Road culvert (HC-A(05)) and water depth was monitored at station HC-A(10). High flow measurements were collected to establish a rating curve for HC-A(10). Through June-September 2008, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity) at all stations. Monitoring results from 2008 were presented in a memorandum to the City of Guelph, dated February 3, 2009.

The 2009 monitoring plan included temperature monitoring at the 7 stations monitored in 2008. Temperature monitoring consisted of logging temperature readings every 15 to 30 minutes at the 7 site locations. Temperature loggers deployed during winter months were set to collect readings at a 30-minute interval to ensure adequate memory would be available to store all readings throughout the winter months. Loggers re-deployed during later months were programmed to collect data at a 15-minute interval. A continuous level/temp logger (HC-A(10)) and the depth and velocity monitoring equipment at HC-A(05) were used to monitor flow during 2009. During May-October 2009, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity). The flow/velocity instrument stopped logging data November

22nd due to battery failure and was removed from the culvert December 14, 2009. The remainder of the data loggers continued to collect continuous data at 30-minute intervals throughout the winter.

The 2010 monitoring plan included temperature monitoring at the 7 stations monitored in 2009, a new depth and temperature monitoring station at SR-1(01), existing station HC-A(14) being supplemented with the installation of a level logger, and continuous depth/velocity monitoring at the Laird Road culvert (HC-A(05)). Temperature monitoring consisted of logging temperature readings every 15 minutes from April until December and every 30 minutes during the winter months at the eight site locations. During May-October 2010, sites were visited monthly to download data, perform maintenance, and collect baseflow and water quality parameter measurements (DO, pH, specific conductivity). High flow measurements were collected to develop rating curves for HC-A(10) and HC-A(14).

In August 2010, the Hanlon Creek Business Park Consolidated Monitoring Program (NRSI, AECOM, Banks Groundwater) was submitted to the City of Guelph. This monitoring plan included the location, parameters and naming convention for all surface monitoring works to be completed as part of the implementation of servicing and construction at the HCBP.

In 2011, a number of additional stations were installed within Tributary A at the beginning of the monitoring season. Monitoring in the stormwater management facilities (SWMFs) was initiated as Ponds 1, 2 and 4 were functioning as SWMFs. Within the remainder of this report, the terms ‘SWMF’ and ‘ponds’ are used interchangeably, unless otherwise specified. The same surface water monitoring program completed in 2011 was also carried out in 2012 and 2013.

The 2015 monitoring program maintained the stations utilized during the 2012, 2013 and 2014 monitoring years as no new stations were deemed to be required. A small number of stations were relocated based on recommendations from the 2012 monitoring report to improve data collection. Additionally, a tipping bucket rain gauge (Model TB3) was installed for the 2015 monitoring season. The rain gauge was installed on the roof of the Clair Road Emergency Services Centre, located approximately 2 km west of the Hanlon Creek Business Park.

In 2016, two additional sites were added at the upstream and downstream ends of the culvert where Tributary A crosses Laird Road. Later in 2017, Ponds 1 and 2’s loggers that previously recorded the thermal profile in the deep cell of each pond were removed; however, Pond 4’s thermal profile loggers were retained. In the spring of 2017, sites at which water samples were collected were reduced to only include locations within Tributary A. With the removal of sampling at the SWMF outlets, two additional water sampling sites were added immediately upstream of the confluence of Pond 1 and Pond 4 outlets into Tributary A, respectively. This program was also followed in 2018.

In March of 2019, the Hanlon Monitoring Program was put to bid by the City of Guelph. AECOM was retained to complete the surface water monitoring portion of the program and, due to a delay in the awarding of the program, field work officially commenced in August of 2019 with a condensed field season.

In 2020, the Hanlon Monitoring Program was impacted by the onset of the global COVID-19 pandemic. In March of 2020, the Ontario Government initiated the first of many stay-at-home mandates that delayed much of the initial preparatory work prior to the onset of the 2020 monitoring season. As a result of the mandate, many companies and governing bodies within Ontario, including the City of Guelph and AECOM, were left unsure of the ramifications on existing programs. Given that a significant portion of preparatory work would normally commence in March/April, many portions of the project experienced delays despite the eventual clarification that the Hanlon Monitoring Program was considered “essential work”.

Most notably, delays regarding the renewal of the four instream telemetry station cellular plans resulted in the expiration of the plans, which are hosted through Onset Scientific. Despite the expiration of 2G networks in Canada by all cellular carriers prior to 2020, the HOBO U30 stations were still provided service according to a “grandfather clause”. Given the delayed renewal of the monitoring program in 2020, the annual renewal of the cellular plan lapsed and, as a result, the telemetry stations became obsolete as Onset Scientific declined to renew the 2G cellular subscriptions. Therefore, the 10 year-old telemetry stations became obsolete.

The expiration of the Hanlon telemetry stations facilitated an upgrade of the overall telemetry program. A change order request was submitted during the summer of 2020 to replace the existing telemetry stations with FTS LT1 Cell stations (as well as replace several level loggers), with the change order being approved on November 1st, 2020. As the approval date coincides with the end of the field monitoring season, upgraded telemetric data could not be collected in 2020. Despite this, AECOM deployed depth loggers as a stop gap measure for the provision of water level data in the absence of telemetric water level data. The interim depth loggers provide temperature and depth readings, but lack the turbidity and live alarm capabilities of the telemetry platforms. As a result of the need for additional loggers in the place of telemetry stations, available equipment was over-allocated, resulting in some notable data gaps (discussed in **Section 2.4**).

1.3 Site Construction History

In July 2009, tree cover upstream of stations HC-A(11) and HC-A(14) was removed as part of the initial clearing for the Hanlon Creek Boulevard culvert construction. In the summer of 2010 construction of the site began with the works being completed at the culvert crossing in August. In 2011, construction of the Phase 1 site was completed, and construction of Phase 2 was completed by early 2012. The first lot level development was initiated within the Phase 1 lands in May 2012 and no developments were constructed within the Phase 2 lands in 2012. Construction of the Laird Road overpass occurred in the Phase 2 lands in 2013. Development continued throughout 2017 with construction of some buildings and related parking areas occurring within the Phase 1 lands.

As of 2021, AECOM is not aware of any definitive plans or current activity involving the development of Phase 3.

2. 2020 Surface Water Monitoring Program

The surface water monitoring program consists of the following components:

- Continuous data collection using water level, temperature and turbidity loggers
- Baseflow and high flow measurements
- SWM facility water quantity and temperature monitoring
- Tributary A water quality monitoring

There are currently 12 stations within the Hanlon Creek Tributary A system: three (3) stations located at Pond 1, one (1) station located at Pond 2 and five (5) stations located at Pond 4. Monitoring station locations are illustrated in **Figure 2.1.1**.

2.1 Tributary A Continuous Monitoring Stations

Table 1 summarizes the continuous monitoring program completed for Tributary A during the 2019 monitoring season. The following is a description and history of each station:

Station HC-A(03) is located in the upper reaches of Hanlon Creek Tributary A1 (Trib. A1) within the site, about 10 m upstream of Pond 4 in a partially forested area.

Station HC-A(04) is located approximately 75 m downstream of Pond 4 and 150 m upstream of Laird Road in a partially forested area. Tributary A then passes through an open area low-lying/wetland.

Following the recommendations provided within the 2015 Hanlon Creek Tributary A Surface Water Monitoring Report, two new continuous temperature monitoring stations were included in the 2016 surface water monitoring program. Station **HC-A(04A)** was installed in Tributary A upstream of the Laird Rd. culvert and station **HC-A(04B)** was installed directly downstream of the Laird Road culvert. The stations were installed to aid in the understanding of the temperature characteristics of Tributary A between stations HC-A(04) and HC-A(06).

Station HC-A(04A) is located approximately 100m downstream of Station HC-A(04) and approximately 50m upstream of the Laird Road Crossing. Tributary A then passes under Laird Road.

Station HC-A(04B) is located directly downstream of the Laird Road culvert.

Station HC-A(06) is located approximately 100 m downstream of Laird Road. Along this stretch the stream passes through a cedar wetland.

Station HC-A(08) is located in the same cedar wetland on a secondary tributary off the main branch of Tributary A1.

Station HC-A(09) is located within a cedar wetland along the main Tributary A.

Station HC-A(10) is located approximately 50 m downstream of the confluence of the main branch and the tributary and just upstream of the Hanlon Creek Boulevard crossing.

Station HC-A(11) is located at the downstream end of the Hanlon Creek Boulevard culvert. From the culvert, the stream passes through another cedar wetland area.

Station HC-A(12) is located in an open wetland area at the outlet of the cedar wetland and upstream of Pond 1.

Station HC-A(13) is located approximately 200 m downstream of HC-A(12) and immediately downstream of the outlet of Pond 1 in an open field.

Station HC-A(14) is located at the downstream end of the study site, approximately 150 m upstream of Teal Drive.

Station SR-1(01) was located on an unnamed tributary on the west side of Downey Road across from the Downey Road Provincially Significant Wetland (PSW), however, it has since been permanently removed due to continued vandalism.

During the winter months, the telemetry stations are removed and replaced with temperature/depth loggers set to record at 30-minute intervals. Telemetry stations at stations HC-A(03), HC-A(06), HC-

A(11), and HC-A(14) are typically reinstalled prior to the commencement of the field season in May of each year.

Depth loggers are removed during the winter months from any stations where the flow is intermittent and replaced with a temperature logger. This is done to prevent freezing/ice damage from occurring to the logger and primarily includes the outlets of Pond 1 and Pond 2 and, historically, from a number of pond inlets.

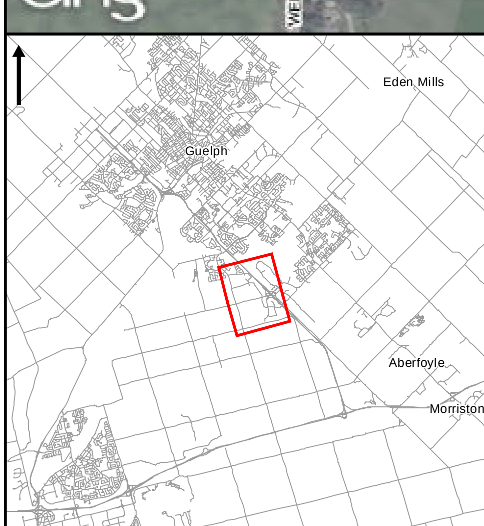
Telemetry stations with alarm capabilities are used at four stations (HC-A(03), HC-A(06), HC-A(11) and HC-A(14)). Each telemetry station monitors water quality (temperature and turbidity) and quantity (water level) associated with the outflows leaving each stormwater pond. The telemetric capabilities of the stations also provide remote access to all data routed through the stations. Telemetry stations are programmed to provide real-time alerts when temperature and turbidity parameters exceed acceptable standards.

In spring of 2021, AECOM will install the newly purchased FTS LT1 Cell telemetry stations at each of HC-A(03), HC-A(06), HC-A(11), and HC-A(14) stations. Going forward, this should restore alarm functionality at these sites, in addition to allowing for the continued collection of real-time turbidity, temperature and level data.

Table 1: Tributary A Continuous Monitoring Stations

Station ID	Station ID Prior to 2010	Data Collected*	Year Installed	Year Removed	Notes
HC-A(03)	-	Temperature, Depth, Turbidity	2011	-	Temporarily removed (2020 season) prior to upgrade to FTS system
HC-A(04)	1	Temperature, Depth	2011	-	-
HC-A(04A)	-	Temperature	2016	-	-
HC-A(04B)	-	Temperature	2016	-	-
HC-A(06)	2	Temperature, Depth, Turbidity	2011	-	Temporarily removed (2020 season) prior to upgrade to FTS system
HC-A(08)	3	Temperature	2006	-	-
HC-A(09)	4	Temperature	2006	-	-
HC-A(10)	5	Temperature, Depth	2006	-	-
HC-A(11)	6	Temperature, Depth, Turbidity	2011	-	Temporarily removed (2020 season) prior to upgrade to FTS system
HC-A(12)	7	Temperature, Depth	2011	-	-
HC-A(13)	-	Temperature, Depth	2011	-	-
HC-A(14)	-	Temperature, Depth, Turbidity	2011	-	Temporarily removed (2020 season) prior to upgrade to FTS system
SR-1(01)	-	Temperature, Depth	2010	2020	Logger went missing in 2019 and again in 2020 and was, therefore, permanently removed.

Notes: A station HC-A(05) was previously monitored for flow through the area/velocity method.



Legend

- Temp
- Temp/Level
- Temp/Level/Water Qaulity
- Temp/Turbidity/Level
- Temp/Turbidity/Level/Water Quality
- Watercourses
- Property
- Ponds
- Access Paths
- Multi-Use Trails
- Cooling Trench
- Wetlands

N

Hanlon Creek Business Park		
2019 Surface Water Monitoring Sites		
January 2020	1:8,000	Datum: NAD '83 Zone 17 Source: AECOM, GRCA
P#: 60265453	V#: 001	**Figure 1**

AECOM

0 250 500
Meters

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2.2 SWMF Continuous Monitoring Stations

Table 2 summarizes the continuous monitoring program completed for the SWM facilities during the 2020 monitoring season. The 2020 program included the following stations:

SWM Pond 1 monitoring included level and temperature loggers installed at the outlet of the pond as well as two cooling trench outlets. The two inlet loggers were removed in 2018.

SWM Pond 2 monitoring included loggers installed at the pond outlet. The three inlet loggers had been removed in 2018.

SWM Pond 4 monitoring included three in-pond temperature loggers (to characterize the thermal profile within the SWMF) as well the outlets from the pond and the cooling trench. The inlet logger had been removed in 2018.

Originally, all three SWMFs included in-pond temperature monitoring, as well as water temperature and/or level loggers at the pond inlet(s), outlet and outlet cooling trench (where applicable). After five (5) years of thermal monitoring data were collected and an overall understanding of the thermal regime was established, in-pond loggers were removed from the program for Ponds 1 and 2.

Table 2: Continuous Pond Monitoring Stations

SWMF	Station ID	Data Collected	Year Installed	Year Removed	Location
Pond 1	HC-P1(01)	Temperature	2011	2018	In pond close to bottom
	HC-P1(02)	Temperature	2011	2018	In pond near mid-depth
	HC-P1(03)	Temperature	2011	2018	In pond at surface
	HC-P1(04)	Temperature, Depth	2011	2018	Inlet
	HC-P1(05)	Temperature, Depth	2011	2018	Inlet
	HC-P1(06)	Temperature, Depth	2011	-	Pond outlet
	HC-P1(07)	Temperature, Depth	2011	-	Cooling trench outlet
	HC-P1(08)	Temperature, Depth	2011	-	Cooling trench outlet
Pond 2	HC-P2(01)	Temperature	2011	2018	In pond close to bottom
	HC-P2(02)	Temperature	2011	2018	In pond near mid-depth
	HC-P2(03)	Temperature	2011	2018	In pond at surface
	HC-P2(04)	Temperature, Depth	2011	2018	Inlet
	HC-P2(05)	Temperature, Depth	2012	2018	Inlet
	HC-P2(06)	Temperature, Depth	2011	2018	Inlet
	HC-P2(07)	Temperature, Depth	2011	-	Pond outlet
Pond 4	HC-P4(01)	Temperature	2011	-	In pond close to bottom
	HC-P4(02)	Temperature	2011	-	In pond near mid-depth
	HC-P4(03)	Temperature	2011	-	In pond at surface
	HC-P4(04)	Temperature, Depth	2012	2018	Inlet
	HC-P4(05)	Temperature, Depth	2011	-	Pond outlet
	HC-P4(06)	Temperature	2011	-	Cooling trench outlet

2.3 Flow Measurement and Water Quality Sampling

During the 2020 monitoring year, sites were visited monthly to download data (where possible), perform maintenance, and to collect baseflow measurements and information related to in situ water quality parameters (DO, pH, and specific conductivity) at all in-stream stations.

Baseflow and high flow measurements were collected at stations HC-A(03), HC-A(04), HC-A(06), HC-A(10), HC-A(11), HC-A(12), HC-A(13) and HC-A(14) to develop respective rating curves.

Influent and effluent water quality was monitored at the SWM pond inlets and outlets and Tributary A downstream of the SWM ponds. Sampling stations included HC-A(03), HC-A(04), HC-A(12), HC-A(13) and HC-A(14).

2.4 2020 Data Gaps

Normally, winter logger downloads would be completed in April of 2020 (following the spring thaw at the monitoring sites) in anticipation of the monitoring season's start in May. Due to the government mandated stay-at-home order in late March of 2020 and the resulting late declaration of the Hanlon Monitoring Program as "essential work", the planned spring downloads were instead completed in late May 2020. Despite this delay, no loggers were lost over the winter of 2020.

Given the expiration of the original HOBO U30 telemetry stations, additional depth loggers were required to collect data on an interim basis at sites HC-A(03), HC-A(06), HC-A(11), and HC-A(14) and, therefore, depth loggers that would have otherwise been deployed at other sites were moved to these stations. For example, the pond outlets for Pond 1 (HC-P1(08)) and Pond 2 (HC-P2(07)) were selected for logger removals due to the expectation (based on the results of previous data collection activities) that low water levels at the outlets would not produce any measurable outflow from these ponds, as this has been the case for the past several years. As was also the case in 2019, the logger at SR-1(01) was not found in May of 2020 as it was presumed stolen or destroyed. Therefore, the depth logger that would normally have been installed there was used elsewhere.

As per the contract change order finalized in November of 2020, a resupply of loggers was included to account for the age of some of the loggers used for the monitoring program. With the deployment of depth loggers at the telemetry stations, some of the aforementioned loggers (several of which were well beyond their typical service life expectancy) were required for deployment on an interim basis. While efforts were made to ensure data collection continuity, logger failures at several sites did occur. This resulted in the formation of data gaps in some of the continuous monitoring datasets collected over the 2020 monitoring period.

Table 3: Data Gap Summary: 2020 Field Logger Files

SWMF	Station ID	Parameter	Data Gap	Note
Tributary A	HC-A(03)	Turbidity	Jan. – Dec.	Telemetry cell network expiration
	HC-A(04A)	Temperature	May 27 – Dec.	Lost to attrition / coincidental Laird Road work
	HC-A(06)	Turbidity	Jan.– Dec.	Telemetry cell network expiration
	HC-A(09)	Temperature	Jan. – May 27	Logger failure
	HC-A(11)	Turbidity	Jan.– Dec.	Telemetry cell network expiration
	HC-A(14)	A) Turbidity B) Temperature, Depth	A) Jan.– Dec. B) May 27 – Dec.	A) Telemetry cell network expiration B) Logger failure / Limited Supply
	SR-1(01)	Temperature, Depth	Jan.– Dec.	Lost to attrition
Pond 1	HC-P1(08)	Temperature, Depth	May 27 – Dec.	Removed due to limited logger supply and annually insufficient water levels at pond outlet
Pond 2	HC-P2(07)	Temperature, Depth	May 27 – Dec.	Removed due to limited logger supply and insufficient water levels at pond outlet
Pond 4	HC-P4(01)	Temperature	May 27 – July 16	Logger failure
	HC-P4(02)	Temperature	May 27 – July 16	Logger failure
	HC-P4(03)	Temperature	July 16 – Dec.	Logger failure
	HC-P4(05)	A) Temperature B) Depth	A) Jan – May 27 B) May 27 – Dec.	A) Logger lost to attrition B) Only temperature logger was available for reinstallation in Spring due to limited logger supply

3. Precipitation and Creek Flow

3.1 Precipitation

Table 4 provides a comparison of the Canadian Climate Normals and monthly precipitation data over the years.

Climate Normals are shown for the Guelph Arboretum station for the period of 1971-2000. More recent data are not available for this station. The second closest station with recent Climate Normals is the Waterloo Wellington Airport, with data available for the period between 1981-2010. Monthly precipitation totals are similar between the two stations for the two periods.

Precipitation data from the Hanlon Creek Rain Gauge was first used in 2016; consequently, this was the first year a complete set of data is available for the Hanlon Creek Rain Gauge.

Compared to the Canadian climate normals, the Hanlon creek rain gauge recorded below average rainfall totals in 2020 and had the sixth lowest annual total since 2008. A total of 7 months measured precipitation lower than the Canadian climate monthly normals. Only two of the four months where rainfall totals exceeded climate normals occurred within the May-November monitoring season in 2020. Aside from a total of 91.8mm falling in March of 2020, Guelph experienced a relatively dry spring with less than 50mm falling in both April and May. While both August and November of 2020 saw monthly totals higher than the long-term average for those months, with 108.6 mm and 99.2 mm of rainfall respectively, both months were largely fueled by singular events with 51.6 mm falling on August 1st and 46.2 mm falling on November 14th. Beside these two major rainfall events, Guelph experienced a relatively dry summer and fall overall. This occurred in addition to the aforementioned dry spring.

Table 4: Observed Precipitation Trends for 2020 Compared to Canadian Climate Normals (mm)

Station	Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Canadian Climate Normals - Guelph Arboretum	1971-2000	56.4	50.8	72.1	78.3	79.9	76	88.5	95.9	92.1	69.2	86.3	77.7	923.3
Canadian Climate Normals - Waterloo Wellington A	1981-2010	65.2	54.9	61	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.1	71.2	916.5
Elora Research Station (RS)	2008	98.5	57.4	85.5	64.6	86.1	81.6	131.3	120.7	119.3	68.4	103.1	100.4	1116.9
	2009	66.1	82.0	72.7	106.2	79.3	69.2	79.5	92.1	53.7	91.5	37.3	65.8	895.4
	2010	27.2	24.4	41.3	47.5	99.9	184.1	89.4	12.1	117.8	52.6	50.8	21.1	768.2
	2011	47.6	58.2	86.1	100.7	113.3	87.0	31.9	158.6	76.1	128.9	90.5	85.5	1064.4
Guelph Turf Grass Institute (TGI)	2011	20	23.8	89.6	92.8	147.4	100.4	26.8	51.2	71.4	93.4	84.6	59.2	860.6
Elora RS	2012	46.8	32.0	31.0	30.0	28.2	64.6	30.4	62.6	106.2	127.3	40.2	79.9	679.2
Guelph TGI	2012	39.2	17.0	28.4	31.0	32.2	90.0	54.6	98.4	127.0	129.0	11.6	57.8	716.2
Elora RS	2013	80.5	71.2	40.6	123.8	102.0	122.3	130.9	69.5	142.9	133.6	33.7	43.2	1094.2
Guelph TGI	2013	72.4	41.4	25.2	98.6	70.8	82.4	173.6	54.8	79.4	116.4	26.4	44.0	885.8
Elora RS	2014	51.2	58.1	46.7	101.7	54.1	68.8	133.7	51.1	27.9	74.3	63.3	45.8	776.7
U of Waterloo (UoW) Weather Station	2014	74.2	30.7	17.5	90.9	63.6	52.4	165.9	91.5	159.8	79.6	90.6	33.3	950
Elora RS	2015*	77.0	58.2	34.4	77.3	48.0	175.9	66.8	80.6	53.1	111.5	78.2	66.7	927.7
UoW Station	2015	49.6	48.2	23.9	77	61.6	117.9	60	78.2	53.8	109.6	68.2	66.2	814.2
Hanlon Creek Rain Gauge	2016	46.6	67.4	124.6	69.2	104.4	31.6	62	137.6	56.8	50.4	63.6	96	910.2
	2017	126.8	106.8	96.8	145.6	157.2	87.4	43.4	52.2	29.4	89	113.4	61.4	1109
	2018	93	75.2	37	131	150.4	74.8	48.6	99.4	50	111.2	114.8	17.4	1002.8
	2019	36.2	147.6	73.4	112	133.6	84.6	37.8	53.2	54.8	153.4	40.4	51.6	978.6
	2020	113.6	23.4	91.8	45.8	48.2	79.6	66.6	108.6	56.6	66.2	99.2	52	851.6

*Precipitation data gaps for the Elora RCS: Jan 17, Jun 28, Jul 23, Jul 31, Aug 2, Sept 4, Sept 30, Dec 8, Dec, 23, Dec 25 – 26, Dec 28 – 29
Precipitation data above and below Climate Normals are shown in blue and red, respctively.

3.2 Continuous Depth and Flow Measurement Results

Depth loggers (model HOBO U20-001-001 Water Level logger) were deployed to monitor water levels at HC-A(04), HC-A(10), HC-A(12), HC-A(13) and SR-1(01) during the 2020 field season. Traditionally, depth measurements are also collected at telemetry monitoring stations HC-A(03), HC-A(06), HC-A(11) and HC-A(14), however, due to the aforementioned sunsetting of the HOBO U30 telemetry stations, spare depth loggers were required to measure depths at these sites on an interim basis. Prior to 2010, a depth/velocity meter (ISCO 2100) was installed at HC-A(05); however, collection of this data was discontinued as the station was producing unreliable results, which were suspected to be caused by high sedimentation rates within the reach.

Three baseflow, one dry, and three high flow measurements were taken by AECOM staff between June and November at each station using a FlowTracker2 Handheld-ADV® (Acoustic Doppler Velocimeter). Flow measurement results are shown in **Figure 3.2.1** and **Table 5.** The measured flow values from 2020 and previous years were used to develop stage (level) - discharge relationships (rating curves) for each station as shown in **Appendix A**.

Figure 3.2.1: Hanlon Tributary A Flow Measurements – 2020

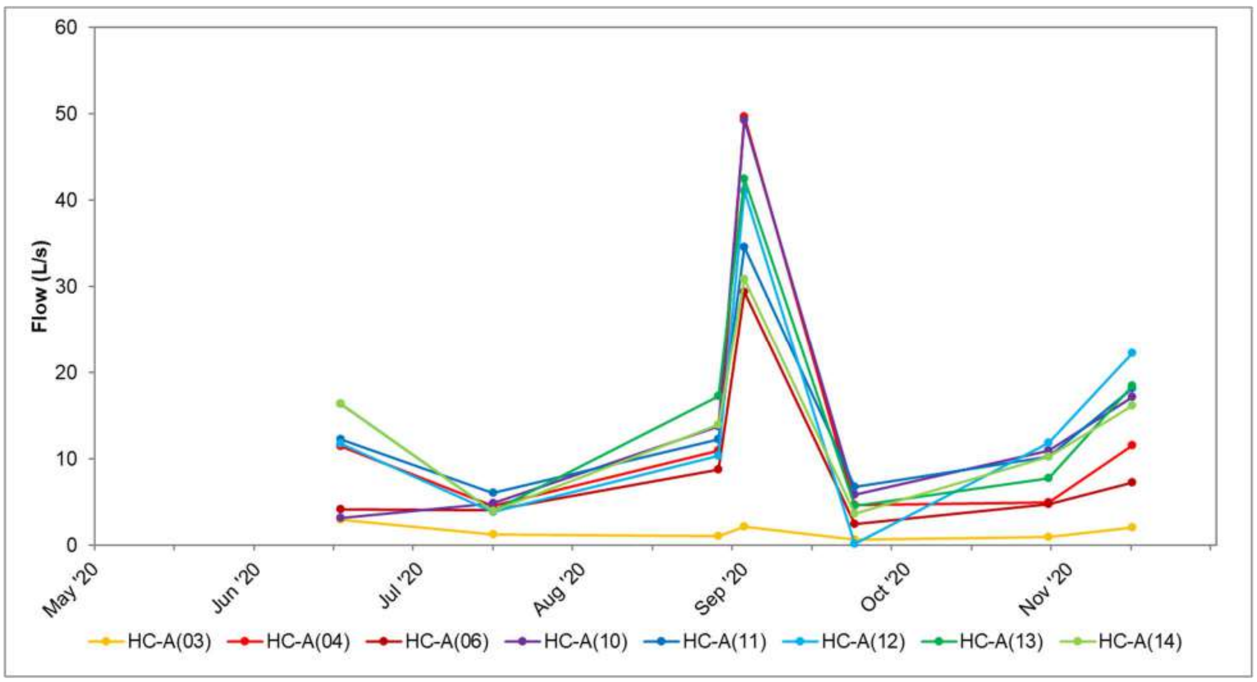


Table 5: 2020 Hanlon Creek Flow Monitoring (L/s)

Station	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
2020/06/17	3.0	11.5	4.2	3.2	12.3	11.8	16.4	16.4
2020/07/16	1.3	4.6	4.1	4.9	6.1	3.9	4.0	4.0
2020/08/28	1.1	11.0	8.8	13.8	12.3	10.4	17.3	14.0
2020/09/02	2.2	49.7	29.4	49.3	34.6	41.1	42.5	30.9
2020/09/23	0.7	4.7	2.5	5.9	6.8	0.2	4.6	3.7
2020/10/30	1.0	5.0	4.8	11.0	10.3	11.9	7.8	10.3
2020/11/15	2.1	11.6	7.3	17.2	18.2	22.3	18.5	16.2
Average	1.6	14.0	8.7	15.0	14.4	14.5	15.9	13.6

Average baseflow measurements are shown for the period of 2008 to 2020 in **Figure 3.2.2** and **Table 6.** Baseflow was impacted in 2011 by construction activities, such as dewatering. Historic and recent baseflow measurements have been used to assess which reaches are losing (contributing groundwater) or gaining (receiving groundwater) flows. Observations from this assessment are as follows:

From station HC-A(03) to HC-A(04) baseflow exhibited a slight but consistent increase heading from the upstream to downstream station during the 2020 monitoring season. In the context of the longer-term dataset, the baseflow increased between 50% and 450% (in 2012) from station HC-A(03) to HC-A(04). In 2013, measures were taken to reduce the outflow from Pond 4, however, pond discharge was still observed to be nearly continuous due to presumed groundwater upwelling, which resulted in high baseflow levels at HC-A(04) compared to the recorded upstream baseflow at station HC-A(03). In 2020, an average increase of approximately 760% in baseflow was measured between HC-A(03) and HC-A(04) with the smallest measured increase understood to be in the order of 254% between these stations (measured on July 16th, 2020), and the largest increase estimated to be 2159% (measured on September 2nd, 2020).

From station HC-A(04) to HC-A(06) flow measurements suggest that there was a consistent decrease in channel flows throughout 2020. While previous years exhibited sporadic, event-specific decreases in flows, each of the 2020 events monitored indicated that flows decrease heading in a downstream direction, with the annual average decrease estimated to be approximately 38%.

The reach between **HC-A(09) and HC-A(10)** receives input from a small groundwater-fed tributary in the cedar swamp which contributes to the increased baseflow between **HC-A(06) and HC-A(10)**. Despite this, the annual average increase is estimated to be approximately 3% for the 2020 period.

Stations **HC-A(10) and HC-A(11)** have historically been groundwater discharge areas and this continued to be the case in 2020, with an annual average increase in flows of approximately 15% from the upstream to downstream sections of the reach.

With respect to **HC-A(12)**, AECOM notes that during high flows, the stream banks are regularly overtopped and drainage spills into the surrounding low-lying wetland areas. This causes flows from such events to be underestimated relative to surrounding sites **HC-A(11)** and **HC-A(13)**.

HC-A(12), HC-A(13) and **HC-A(14)** were all identified to be located within areas of groundwater recharge/losing reaches in 2019, as they have been over the period of monitoring for the most part. However, a marginal annual average baseflow increase of 6% was measured between **HC-A(13)** and **HC-A(14)** during the 2020 monitoring period. This suggests that nominal groundwater inputs contributed baseflow within the reach segment in 2020.

Figure 3.2.3 summarizes flow estimates using the recorded water level and rating curves for stations **HC-A(03)**, **HC-A(04)**, **HC-A(06)**, **HC-A(10)**, **HC-A(11)**, **HC-A(12)**, **HC-A(13)** and **HC-A(14)** as well as the recorded precipitation from the Hanlon Creek rain gauge station. This figure shows flows which generally increase in the direction of the downstream stations. Overall, the seasonal impact of relatively low rainfall totals from June through November are apparent in **Figure 3.2.3**; the low precipitation totals over this period were likely an important factor in explaining the reduced field discharge measurements during visits completed in 2020 relative to previous seasons, with several sites likely contributing a higher proportion of their total flows to groundwater recharge.

Figure 3.2.3, includes notable peaks in flows which have been estimated for several of the 2020 spring rainfall / freshet events. Because the pre-defined monitoring season commences in May of each year, the largest annual events are almost always missed during the field monitoring period. While discussed in greater detail the **Section 7.2**, it is AECOM's opinion that historically there is sufficient data for the estimation of dry and baseflow events and that a more emphasis should be placed on capturing field-measured data for wet weather flows - including those events prior to the typical field season commencement in May of each year. Generally, these events act as flushing flows which redistribute bed gravels, flush debris and contribute to channel morphology.

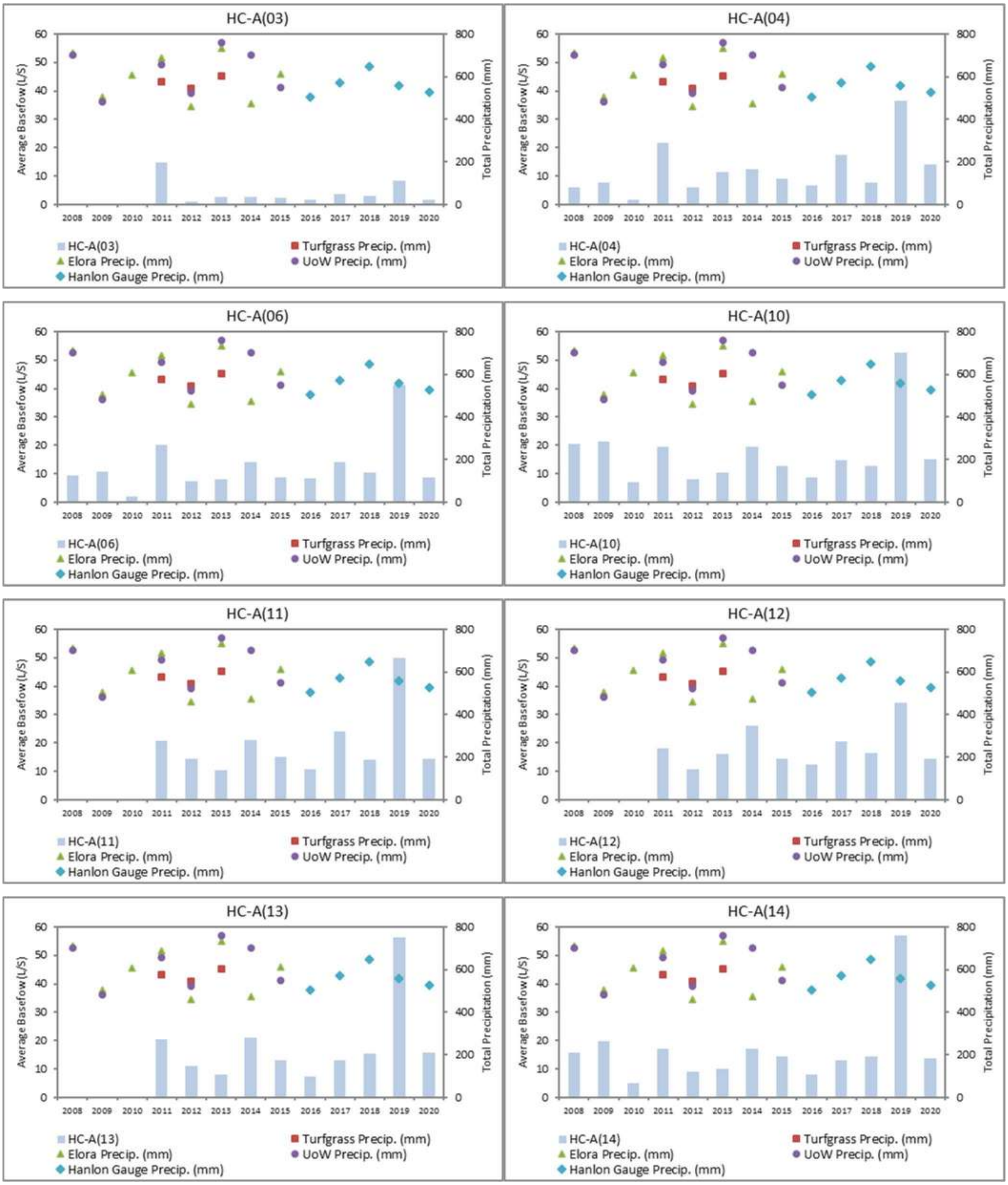


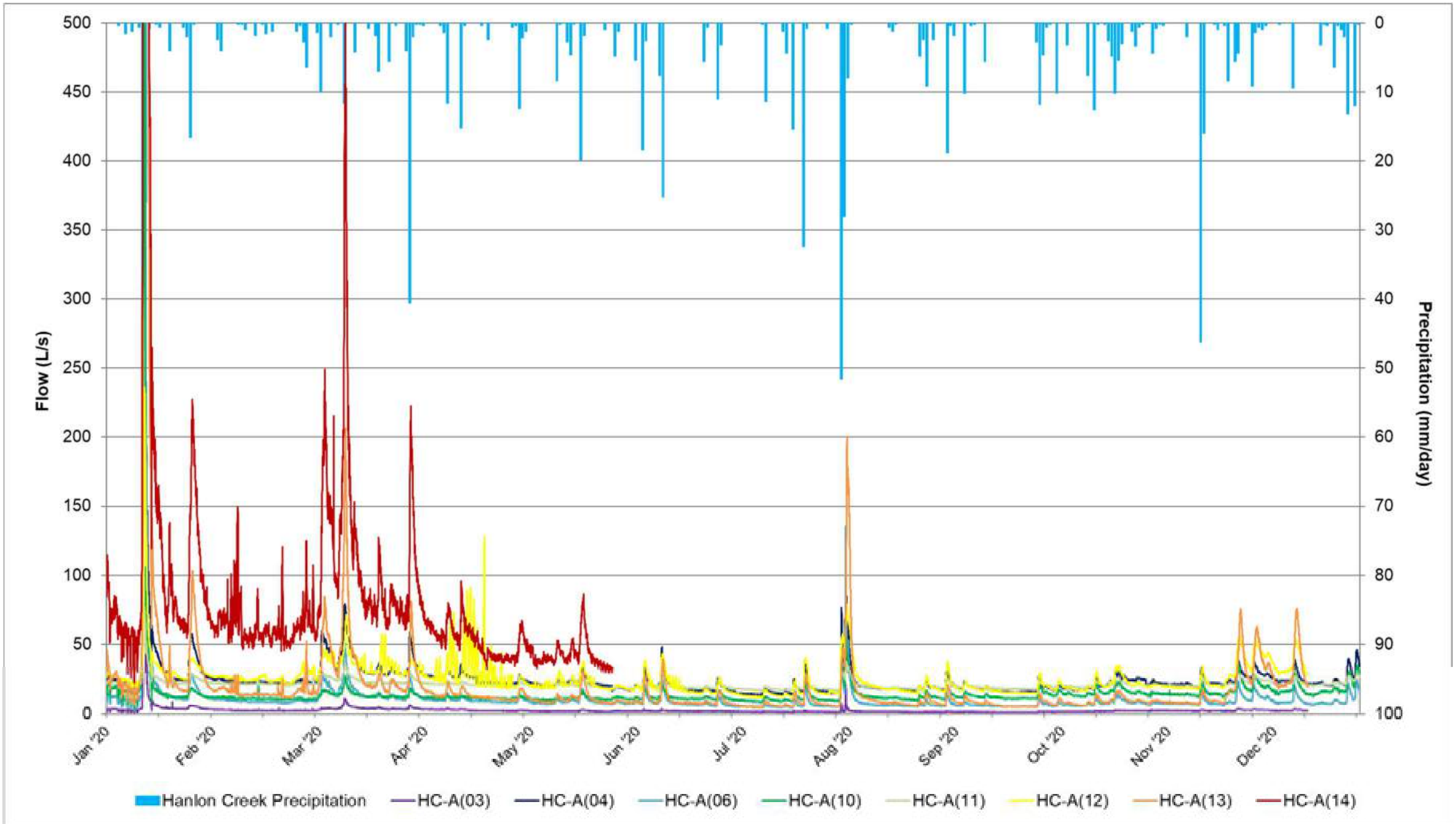
Figure 3.2.2: Average Annual Baseflow and May-November Precipitation from 2008 to 2020

Table 6: Hanlon Creek Baseflow Monitoring – 2008-2020 Summary (L/s)

Station	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
2008 Min	n/a	3.5	2.7	2.1	3.8	7.7	n/a	n/a	n/a	0.9
2009 Min	n/a	3.9	1.2	3.0	4.2	5.0	n/a	n/a	n/a	1.8
2010 Min	n/a	0.4	0.4	-7.3	1.1	0.8	n/a	n/a	n/a	0.9
2011 Min[2]	2.8	5.5	0.8	1.5	n/a	2.4	4.6	5.0	2.8	1.5
2012 Min	0.1	3.2	3.1	0.5	n/a	1.3	0.7	1.7[1]	0.6[1]	0.7[1]
2013 Min	1.2	8.2	5.5	n/a	n/a	6.4	2.7	12.5	3.4	3.4
2014 Min	1.6	9.5	10.1	n/a	n/a	10.8	14.8	15.7	12.7	9.3
2015 Min	1.4	4.1	4.2	n/a	n/a	7.0	9.5	6.8	8.1	5.6
2016 Min	0.6	2.8	3.4	n/a	n/a	3.7	4.7	2.8	1.6	1.3
2017 Min	2.0	6.0	7.0	n/a	n/a	9.7	10.5	9.5	6.0	7.0
2018 Min	0.6	3.2	3.7	n/a	n/a	5.1	4.4	5.1	3	3.6
2019 Min	3.4	14.3	9.8	n/a	n/a	13.2	15.4	14.4	13.9	13.3
2020 Min	0.7	4.6	2.5	n/a	n/a	3.2	6.1	0.2	4.0	3.7
2008 Max	n/a	11.3	10.7	10.0	9.4	16.8	n/a	n/a	n/a	12.1
2009 Max	n/a	14.9	25.6	22.1	18.7	56.3	n/a	n/a	n/a	53.8
2010 Max	n/a	2.9	4.9	12.3	6.7	22.2	n/a	n/a	n/a	1.2
2011 Max[2]	47.4	56.6	50.0	5.9	n/a	31.5	46.0	31.9	18.2	48.0
2012 Max	2.5	10.5	14.6	7.4	n/a	13.2	45.6	17.6	36.6	20.7
2013 Max	4.4	16.8	10.3	n/a	n/a	16.9	16.0	21.7	15.8	15.7
2014 Max	3.6	15.4	16.9	n/a	n/a	27.7	27.3	33.1	30.0	28.2
2015 Max	4.2	11.9	11.9	n/a	n/a	17.4	18.9	18.6	17.2	19.7
2016 Max	3.1	13.3	15.7	n/a	n/a	16.4	24.6	35.8	14.7	16.1
2017 Max	6.5	36.8	21.9	n/a	n/a	21.9	46.1	39.3	20.9	19.9
2018 Max	7	15.9	19	n/a	n/a	26.3	31.1	34.5	37.4	34.6
2019 Max	16.9	71.1	73.6	n/a	n/a	122.2	117.8	64.1	145.8	130.4
2020 Max	3.0	49.7	29.4	n/a	n/a	49.3	34.6	41.1	42.5	30.9
2008 Average	n/a	6.0	9.3	9.0	8.5	20.5	n/a	n/a	n/a	15.8
2009 Average	n/a	7.8	10.7	9.3	10.6	21.3	n/a	n/a	n/a	19.7
2010 Average	n/a	1.6	2.0	2.4	3.6	7.1	n/a	n/a	n/a	5.0
2011 Average[2]	14.6	21.7	20.2	2.7	n/a	19.3	20.6	18.0	20.5	17.2
2012 Average	1.1	6.1	7.5	3.1	n/a	8.0	14.4	10.6	10.9	9.1
2013 Average	2.7	11.2	7.9	n/a	n/a	10.4	10.4	16.1	8.0	9.9
2014 Average	2.6	12.3	14.0	n/a	n/a	19.3	21.1	26.1	21.0	17.2
2015 Average	2.2	9.0	8.7	n/a	n/a	12.6	14.9	14.4	12.9	14.5
2016 Average	1.8	6.5	8.2	n/a	n/a	8.7	10.7	12.2	7.4	8.0
2017 Average	3.7	17.5	13.9	n/a	n/a	14.7	24.0	20.3	13.2	13.1
2018 Average	2.9	7.8	10.3	n/a	n/a	12.7	14.1	16.5	15.3	14.3
2019 Average	8.5	36.5	41.2	n/a	n/a	52.6	49.8	34.0	56.4	56.8
2020 Average	1.6	14.0	8.7	n/a	n/a	15.0	14.4	14.5	15.9	13.6

Notes:
[1] Hanlon Creek was noted to be dry or flows were below the measurement threshold flow at stations HC-A(03), HC-A(12), HC-A(13) and HC-A(14)
[2] Baseflows were influenced by construction activities

Figure 3.2.3: 2020 Flow Monitoring for Hanlon Creek



4. In-Stream Temperature Monitoring

The locations of the temperature monitoring stations for 2020 are shown in **Figure 2.1.1** and station descriptions are included in **Section 2**. The temperature loggers (HOBO Pendant Temperature/Light Logger and HOBO 64-bit Temperature Smart Sensors) and level/temperature loggers (HOBO U20 Water Level Data Logger) were placed in the creek secured to steel stakes driven into the substrate. Data were collected in 30-minute intervals during the winter months and 15-minute intervals for the remainder of the year.

4.1 In-Stream Thermal Conditions

A plot of the continuous temperature monitoring completed throughout the 2020 monitoring period is provided in **Figure 4.1.1**. Highlights pertaining to summer conditions is provided in **Figure 4.1.2**. A summary of daily average temperature ranges is provided in **Table 7**.

Monthly plots of stream temperature and hourly air temperature data from the Guelph Turfgrass Institute Station are included in **Appendix D** and illustrate the thermal regime observed at each station. These plots show the daily diurnal pattern of temperature variation, with temperatures increasing during the day and decreasing at night.

Temperature data during the winter months (January to March) appears to have been at or around freezing (0°C) for most of the winter monitoring period, indicating that a large portion of Tributary A periodically experienced frozen conditions. Most stations on Tributary A showed consistent trends with temperatures above 0°, even during sub-zero air temperature conditions. This indicates that these stations are likely impacted by groundwater inputs (upwelling).

During the 2020 monitoring period, Station HC-A(03) exhibited higher daily fluctuations in temperatures compared to station HC-A(06). This demonstrates that in-stream thermal conditions between these two stations (station HC-A(04), HC-A(04A), and HC-A(04B)) are likely impacted by the frequent and prolonged discharge from Pond 4.

Downstream stations which are more exposed to insolation include (HC-A(10), HC-A(12), HC-A(13) and HC-A(14)) and those with a wider flow channel and relatively shallow flow depths (HC-A(09)). Collectively, these stations exhibit the highest daily variation in temperature as they are located in areas where there is greater opportunity for solar radiation to impact the monitoring station. Field monitoring results also suggest that there is little groundwater input in these areas, and this may be contributing to the observed diurnal temperature fluctuations.

A comparison between the number of 24°C exceedance events per monitoring site to the average summer temperatures for 2020 has been provided in **Figure 4.1.3**. In addition, a comparison between the recorded number of hours of instream temperatures exceeding 22 °C and 19°C in the context of the average summer temperatures at each site are shown in **Figure 4.1.4** and **Figure 4.1.5**, respectively.

The number of 24°C exceedances increased significantly in 2020 as sites HC-A(04), HC-A(04B), HC-A(06), and HC-A(09) all experienced 24°C exceedances over 5% of the summer with 180, 150, 147, and 269 hours, respectively. Additionally, each of these sites exceeded 19°C over 80% of the summer with 2939, 2779, 2728, and 2368 hours, respectively. Unlike 2019, all sites (except HC-A(08)) recorded at least one hour over 19°C. For those sites which did exhibit temperature exceedance above 19^{o}C, HC-A(03) recorded the smallest number of total hours at 329.

Information regarding SWM ponds and their observed thermal conditions are included in **Section 6.2**.

Figure 4.1.1: Hanlon Creek Temperature Monitoring in 2020

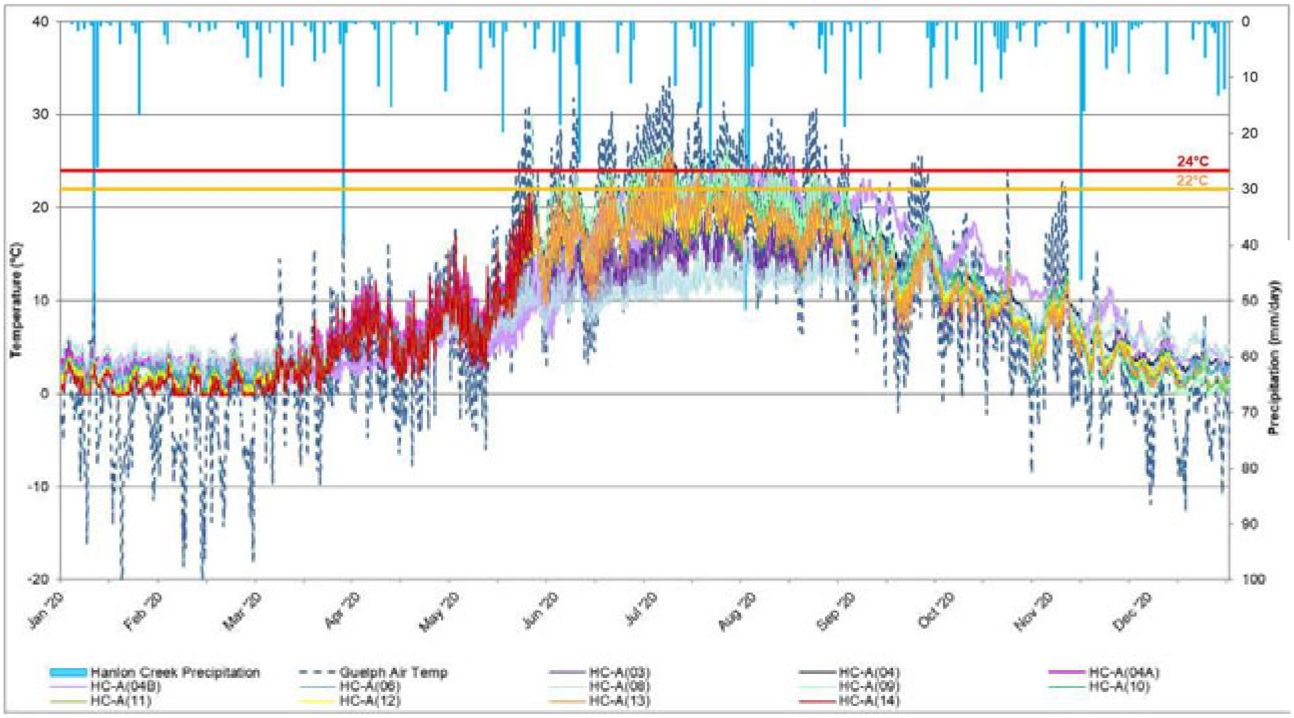


Figure 4.1.2: Hanlon Creek Temperature Monitoring – June-September 2020

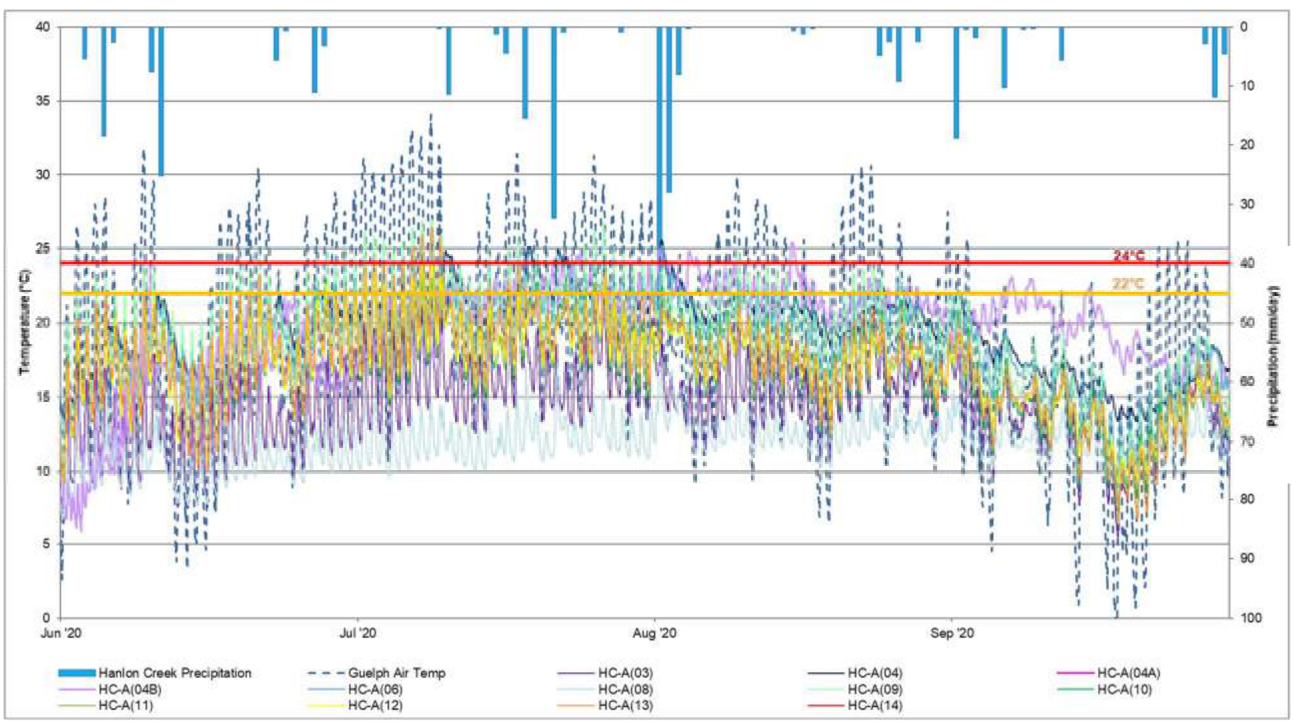


Figure 4.1.3: Number of Hours Stream Temperature Exceeded 24°C in the Summer of 2020

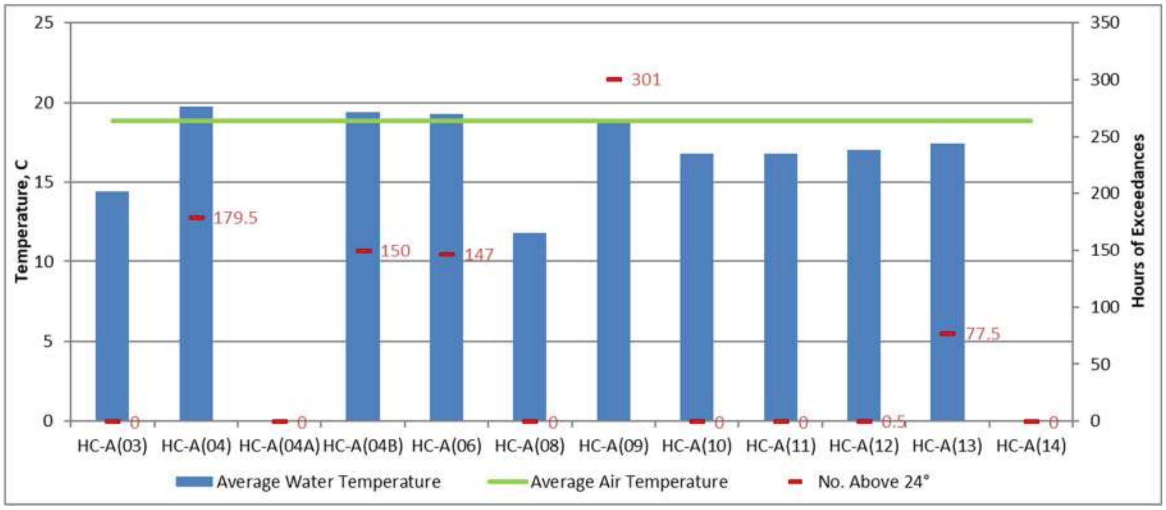


Figure 4.1.4: Number of Hours Stream Temperature Exceeded 22°C in the Summer of 2020

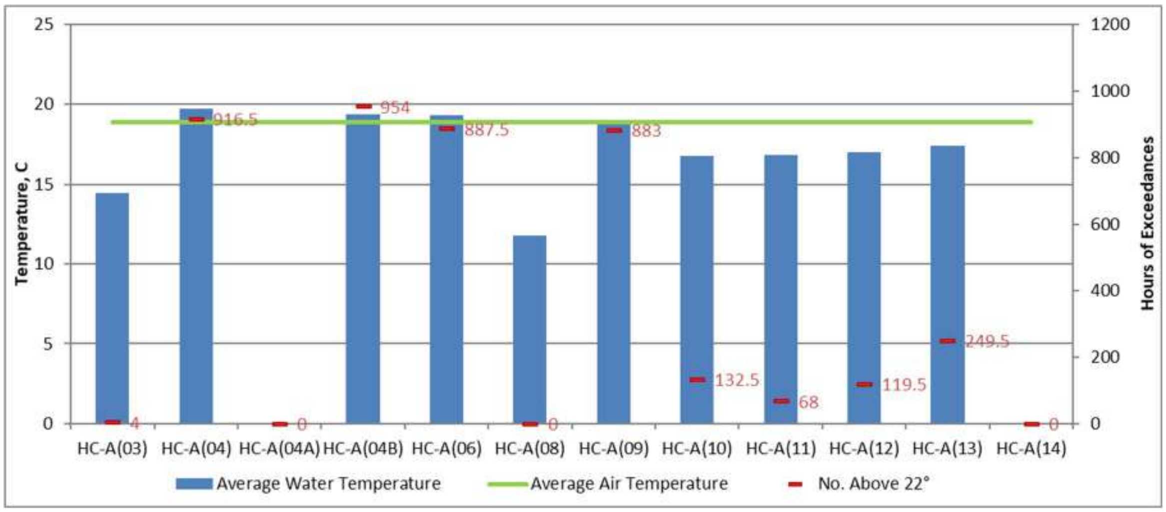
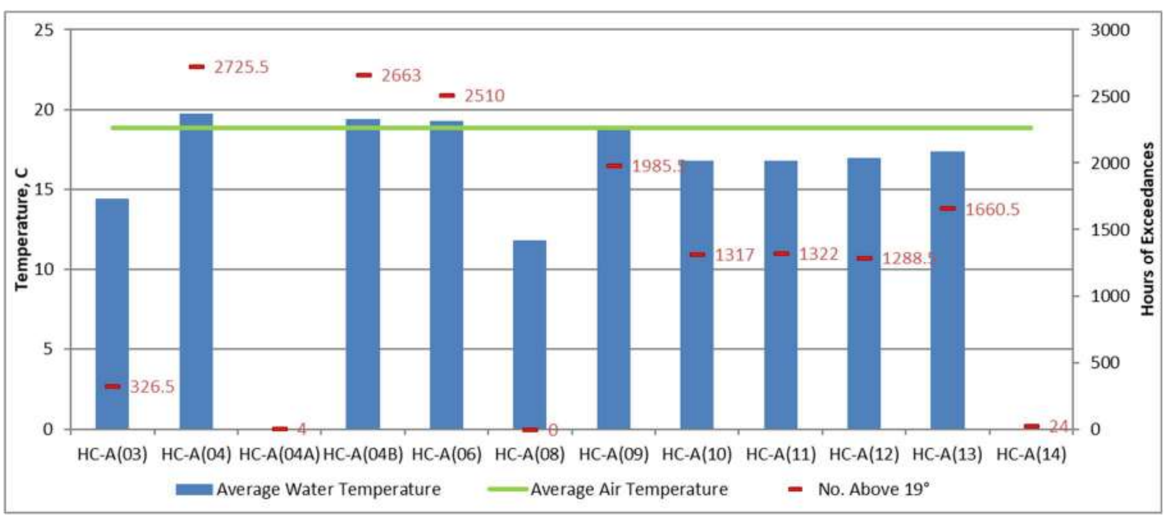


Figure 4.1.5: Number of Hours Stream Temperature Exceeded 19°C in the Summer of 2020



4.2 In-stream Thermal Conditions in Comparison to Thermal Modeling Prediction

The ability of a stream to support a cold-water fish species is often defined by the temperatures throughout the summer (July and August) and autumn (mid-October – end of November) months. The 2009 Hanlon Business Park Stream Temperature Impact Report (AECOM, 2009) provided a summary of reach-based statistical stream temperature modeling results for future mitigated site conditions. This summary included targets for daily averages, maximums, minimums, the number of hours target temperatures are exceeded, and exceedance frequencies during both the summer and autumn.

The Hanlon Creek Business Park Consolidated Monitoring Plan recommends:

- Any single temperature exceedance of 22°C is analyzed in an annual temperature and flow monitoring report, including an investigation of the cause of the exceedance and recommendations for contingency measures as warranted. The investigation should consider the frequency, duration and spatial distribution of the exceedance.
- Any single temperature exceedance of 24°C triggers an investigation commencing within 2 days of acquiring the information. This investigation should consider the frequency, duration and spatial distribution of the exceedance, seek to identify the cause of the temperature exceedance, and provide recommendations for adaptive management measures as warranted. If contingency measures are warranted, the design and implementation of selected measures should be completed as soon as possible. At the latest, the selected measures should be implemented in the year following the exceedance of 24°C.

A summary comparison of overall modeled existing and future mitigated conditions of average temperature conditions throughout the Creek were included in the modeling report. The same statistical analysis applied to the modeling results has been applied to the 2020 data and is included in **Table 7** and **Table 8** where sufficient data are available. To monitor the changes within Hanlon Creek over time, a comparison of 2020 data to historical conditions has been included in **Appendix C**. **Table 9** includes a comparison of monthly ambient air temperatures and Canadian climate normals.

Average in-stream summer temperatures in 2020 (18.79°C) increased by 0.72°C from the 18.07°C recorded in 2019. A combination of higher than average air temperatures (as shown in **Table 9**) and lower rainfall totals (as shown in **Table 4**) may have contributed to the increase in stream temperatures and temperature exceedance events.

Table 7: Temperature Summary for 2020 Summer (July-August)

Station	Modeled Values[1]	HC-A(03)	HC-A(04)	HC-A(04A)	HC-A(04B)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
Summer (July-August) average maximum (ºC)	14.5 - 19.9	22.2	25.6	N/A	25.4	25.9	17.4	27.0	23.1	22.5	24.1	26.4	N/A
Summer (July-August) average (ºC)	12.5 - 14.5	15.9	21.6	N/A	21.4	21.2	12.5	20.9	18.3	18.3	18.5	19.3	N/A
Summer (July-August) average minimum (ºC)	9.0 - 12.0	10.4	18.4	N/A	15.8	16.0	9.6	13.8	12.2	12.6	13.8	12.6	N/A
Maximum 3-day mean (ºC)	14.0 - 19.0	17.9	23.4	N/A	23.2	22.9	14.7	23.6	20.2	20.1	20.9	22.9	N/A
Maximum 7-day mean (ºC)	13.0 - 17.0	17.3	23.2	N/A	23.0	22.7	13.4	22.8	19.8	19.7	20.2	21.6	N/A
Maximum 7-day mean of daily maximums (ºC)	15.0 - 23.5	20.5	24.4	N/A	24.1	24.7	15.2	26.1	22.4	21.9	23.0	24.9	N/A
Temperature Exceedance over 19°C for July and August													
Hours over 19°C	0 - 130	329	2939	N/A	2779	2728	0	2368	1086	1054	1085	1549	N/A
Percent of Time over 19°C	0 - 9%	11%	99%	N/A	93%	92%	0%	80%	36%	35%	36%	52%	N/A
Frequency of Exceedance over 19°C (Days)	0 - 27	1	62	N/A	58	59	0	54	21	18	25	38	N/A
Average Duration of Event Over 19°C (h)	3 - 6	6.8	1022.3	N/A	1128.9	260.8	0.0	92.5	22.8	23.2	25.8	33.1	N/A
Maximum duration of event over 19ºC (h)	<<130	21.5	2404.5	N/A	2498.0	809.0	0.0	424.5	131.0	130.0	122.5	136.0	N/A
Temperature Exceedance over 22°C for July and August													
Hours over 22°C		4	1042	N/A	1002	970	0	986	119	61	109	294	N/A
Percent of Time over 22°C		0%	35%	N/A	34%	33%	0%	33%	4%	2%	4%	10%	N/A
Frequency of Exceedance over 22°C (Days)		0	21	N/A	17	15	0	14	0	0	0	3	N/A
Average Duration of Event Over 22°C (h)		2.3	34.1	N/A	27.8	22.2	0.0	14.2	4.9	3.8	6.4	10.4	N/A
Maximum duration of event over 22ºC (h)	<<130	4.0	124.5	N/A	121.5	116.0	0.0	72.5	12.5	9.5	17.0	28.5	N/A
Temperature Exceedance over 24°C for July and August													
Hours over 24°C	0 -3.2	0	180	N/A	150	147	0	269	0	0	1	78	N/A
Percent of Time over 24°C	0 - 0.21%	0%	6%	N/A	5%	5%	0%	9%	0%	0%	0%	3%	N/A
Frequency of 24°C Exceedance (Days)		0	3	N/A	1	1	0	0	0	0	0	0	N/A
Average Duration of Event Over 24°C (h)		0.0	20.6	N/A	13.9	8.0	0.0	7.1	0.0	0.0	0.5	8.9	N/A
Maximum duration of event over 24ºC (h)	<3.2	0.0	56.5	N/A	38.5	25.5	0.0	22.0	0.0	0.0	0.5	21.0	N/A

1 Modeled range refers to the results of the Hanlon Creek Business Park Stream Temperate Impact Report Continuous Modeling with HSP-F (AECOM, 2009)

Table 8: Temperature Summary for 2018 Fall (October-November)

Station	Modeled Values[1]	HC-A(03)	HC-A(04)	HC-A(04A)	HC-A(04B)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
Max Temp. (°C)	11.9 - 13.0	22.2	25.6	0.0	25.4	25.9	17.4	27.0	23.1	22.5	24.1	26.4	0.0
Frequency of 11°C Exceedance (days)	2.1 - 5.6	7	18	0	31	16	6	7	6	7	6	5	0
Hours Over 11°C	16 - 27	2960	2976	0	2976	2976	2661	2976	2976	2976	2976	2976	0
Average Hrs. Over 11°C per Event	4.8 - 5.9	997	1488	0.0	1488	1488	233	1488	1488	1488	1488	1488	0
Maximum duration of event over 11ºC (h)	5.9	2365	2976	0.0	2976	2976	851	2976	2976	2976	2976	2976	0

Table 9: Comparison of Monthly Ambient Air Temperatures to the Canadian Climate Normals

Year	Daily Average (°C)					Average Daily Maximum (°C)					Average Daily Minimum (°C)				
	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep
Climate Normals- Guelph Arboretum [1]	12.3	16.9	19.7	18.6	14.1	18.6	23.3	25.9	24.5	19.8	6.0	10.6	13.5	12.6	8.4
Climate Normals- Waterloo Wellington A[2]	12.5	17.6	20.0	18.9	14.5	18.5	23.6	26.0	24.8	20.4	6.4	11.5	14.0	12.9	8.6
2007	12.7	18.3	18.5	19.3	15.8	20.5	25.9	26.0	26.5	23.7	4.9	10.6	10.9	12.1	7.8
2008	10.1	17.9	19.7	17.5	14.9	16.3	23.3	25.7	23.7	21.1	3.9	12.5	13.6	11.2	8.7
2009	11.2	15.9	16.5	17.4	13.5	18	21.7	22.1	23.7	20	4.2	10	10.8	11	7
2010	n/a	n/a	20.3	19.8	14.1	n/a	n/a	26.4	26.1	19.6	n/a	n/a	14.2	13.3	8.5
2011	12.7	16.7	21.4	19.3	15.2	17.7	22.7	28.6	25.8	20.9	7.8	10.6	14.1	12.6	9.6
2012	15.2	18.6	22	19.3	14.4	22.8	25.2	30.1	26.6	21.1	7.5	12	13.9	11.9	7.6
2013	13.5	16.9	19.9	18	13.7	20.4	22.3	25.3	24.5	20.2	6.2	11.4	14.5	11.4	7.1
2014	12.3	17.8	17.6	17.6	14.1	18.5	24.6	23.6	23.6	20.5	5.9	10.9	11.5	11.4	7.7
2015	15.1	16.0	18.7	18.0	17.0	22.7	22.0	25.6	23.7	23.7	7.3	9.8	11.7	12.2	10.3
2016	12.3	16.9	20.6	20.8	16.2	19.5	24.8	27.7	27.6	23.2	5.2	9.1	13.4	14.1	9.2
2017	10.1	17.4	19.1	17.3	16.3	15.1	23.2	25.2	23.8	24.2	5.2	11.5	13.0	10.7	8.4
2018	13.8	17.3	20.4	20.7	16.8	21.5	23.8	27.4	26.6	22.6	6.5	10.9	13.4	14.8	11.1
2019	11.2	17.1	21.4	18.9	15.8	16.5	22.2	27.1	24.6	21.0	5.3	11.1	14.9	12.4	9.5
2020	11.3	18.6	22.5	19.7	14.6	16.4	24.8	28.5	25.5	20.2	5.1	11.1	15.9	13.2	8.5

[1] Canadian Climate Normals for the Guelph Arboretum are for the period of 1971-2000. Data for the Waterloo Wellington Airport stations are for 1981-2010. 2007 to 2020 data was collected at the Guelph Turfgrass station. Temperatures highlighted in blue represent average monthly temperatures which are lower than Climate Normals and temperatures highlighted in red represents temperatures higher than the Climate Normals.

4.3 Summary of Historical Thermal Exceedances

A summary of stream thermal exceedances over the years is provided in this section. Trends (if any) are discussed in general terms. Statistical analysis of trends will be possible as more data are collected.

2009-2010: A single occurrence of 22°C was recorded at station HC-A(14) in 2009, with no exceedances of 24°C in 2010.

In 2011, exceedances above 24°C were observed, with eight of ten stations experiencing temperature exceedances.

The 2012 summer recorded the highest number of exceedances to date within the main branch of Hanlon Creek. It was noted that, unlike previous years, the 24°C threshold was exceeded in the headwater reaches of the Creek, downstream of Pond 4 as opposed to the exceedances occurring in the furthest downstream reaches. These issues were noted in July of 2012 and the RAAP team was assembled to investigate the cause of the exceedances. It was determined that the cause of the temperature exceedances was the continuous discharge of Pond 4. Mitigation measures were put into place with a goal to decrease the quantity and temperature of water entering Tributary A via Pond 4. The weir in Pond 4 was raised during the summer in an attempt to decrease continuous outflow from the SWMF to Tributary A. Vegetation along the cooling trench was installed during the fall of 2012 with the intent that it would provide shade and act as a cooling feature once it became established.

In 2013, water temperature exceedances decreased in comparison to 2012; however temperatures were still above the ideal habitat conditions documented for brook trout in the Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F (AECOM, 2009). The greatest contributor to stream temperature increases was the continuous discharge of warm water into the headwaters of the Creek from Pond 4. An exceedance of 24ºC at station HC-A(14) led to a RAAP meeting been called. It was determined that cooling trench discharge from Pond 1 combined with high air temperatures could have factored into the exceedance. Further monitoring of cooling trench temperatures was suggested in order to determine the true effectiveness of the Pond 1 cooling trenches.

In 2014, overall climate conditions were cooler than in 2013, as well as those reported by the Canadian climate normals. Higher than average precipitation levels were recorded in 2014 compared to both calendar year 2013 and the Canadian climate normals. As a result, fewer exceedance events occurred in 2014. Temperatures remained higher at stations found farthest downstream while the trend of increasing temperatures at reaches downstream of Pond 4, observed in 2012, also continued.

Higher average air temperatures during the summer months and lower precipitation levels compared to 2014 were observed in 2015. The combination of higher air temperatures and lower precipitation levels led to higher in-stream temperatures and an increase in the number of temperature exceedances in 2015. Even though average air temperatures were still below the Canadian climate normal (as shown in **Table 9**), stations HC-A(06), HC-A(09) and HC-A(14) recorded instream temperatures higher than 24ºC. A RAAP meeting was called in late July to discuss the temperature exceedances recorded at HC-A(06). It was found that the temperature exceedance was not a direct result of Pond 4’s continuous discharge, but rather an increase in stream temperature between HC-A(04) and HC-A(06) was observed. It was suggested that a cut-off drain could be installed along the south side of Pond 4 to intercept groundwater prior to entering the pond and discharge the groundwater directly to Trib A. It was noted that this retrofit may not directly address the 24°C exceedance; however, it would help to decrease overall temperatures in Trib A. Alternatively, it was discussed that temperature monitors be placed between the two stations to determine whether the cause of the temperature discrepancy was a result of groundwater discharge or exposure to solar radiation.

In 2016, higher average air temperatures during the summer months and low precipitation levels in June and July compared to the Canadian climate normal were observed. Precipitation levels in 2016 compared to both previous monitoring years as well as the Canadian climate normals are provided in Table 4. The combination of higher air temperatures and lower precipitation levels led to higher in-stream temperatures and an increase in the number of temperature exceedances in 2016. Recorded average daily mean temperatures and recorded average daily maximum temperatures provided in **Table 9** were either at or above the Canadian climate normal for the months of June, July and August. Stations HC-A(04), HC-A(04A), HC-A(04B), HC-A(06), HC-A(09), HC-A(10), HC-A(11), HC-A(13), and HC-A(14) all recorded in stream temperatures higher than 24ºC.

Following a notably cool May, **Table 9** shows that the summer of 2017 was relatively cool compared to the previous year. Given the lower average temperatures throughout most of the summer, no exceedances of 24ºC were recorded for any sites except for a small, transient fluctuation at HC-A(09), likely owing to the station's shallower profile and exposure to air. **Table 4** shows that following record rainfall totals in March, April, and May, monthly rainfall totals dropped markedly for the remaining summer months, which included only 8.4 mm total in June (compared to the applicable Canadian climate normal of 76 mm).

Considering the lower ambient and in-stream temperature, no RAAP meetings were called in 2017 beyond a single false alarm caused by a faulty telemetry station temperature sensor at site HC-A(11). With the change of practice in 2015 to include back-up temperature or temperature/depth loggers installed at each telemetry site, the sensor was quickly identified as providing false measurements and was later replaced without any missing data.

HOBO loggers at stations HC-A(09), HC-A(13) and HC-A(14) recorded 106, 17 and 61 hours of exceedance in the summer of 2018, respectively. During the summer period, telemetry stations (HC-A(03), HC-A(06) and HC-A(11), recorded zero, one and eight hours of exceedance. Station HC-A(03) had four hours of exceedance in May, and the follow-up response concluded that this was due very low water levels (<1 cm) that were attributed to the exposure of loggers to the ambient air. The exceedances at stations HC-A(06) and HC-A(11) occurred on August 7th and July 1st, respectively. A notification was received for station HC-A(06), but a RAAP call was not set up. No notification was received for the exceedance at station HC-A(11).

Due to the delayed redeployment of the telemetry stations in 2019, AECOM had no access to real-time alerts for temperature exceedances at any of the sites at Hanlon Creek. Despite this, only 4 sites saw relatively minor exceedances in 2019. Specifically, sites HC-A(09), HC-A(10), HC-A(11), and HC-A(14) all saw exceedance on July 20th, 2019. The exceedance initially began at site HC-A(09), suspected to have been triggered by the shallow, slow flowing water at this station, and lasted approximately 9 hours. Temperatures cooled at the sites downstream of HC-A(09) as the water flowed into and through the wetland complex. Temperatures at HC-A(14) began to exceed the 22ºC threshold around the same time and lasting for 5 hours. This exceedance is understood to have been the result of minimal creek shading between sites HC-A(13) and HC-A(14). Several additional, sporadic, short- duration exceedances were recorded at site HC-A(09), starting in late June and ending in early August.

As previously mentioned, due to the expiration of the HOBO U30 telemetry station data plans, real-time alerting was again not available in 2020. Compared to 2019, every stations saw a notable increase in exceedances in 2020, due in large part to lower rainfall totals throughout the monitoring season, in addition to higher overall air temperatures compared to previous years. Despite some missing temperature data for sites HC-A(04A) and HC-A(14), it is expected that the general trend of a higher number of total exceedance hours would have also been observed at these sites. The sites in the vicinity of Laird Road (sites HC-A(04) through HC-A(09), but excluding HC-A(08) which is not located on the main Hanlon Creek tributary), exhibited temperatures which exceeded 19°C for nearly the entire summer. As for exceedances above 24°C, most were measured at the same station locations. Exceedances above 24ºC were spread throughout the period from late June to early August. While most sites experienced periods where daily maximums greater than 24°C were measured episodically over a few consecutive days, HC-A(09) experienced daily maximum temperatures greater than 24°C almost daily between late June and early August.

Appendix C includes a comparison of historical conditions at each station. The comparative summary demonstrates that that overall, stations HC-A(04A), HC-A(04B), HC-A(06), and HC-A(09) have had the greatest number of total exceedance hours above 22°C since the construction of Pond 4, and HC-A(09) has also had a greater number of hours above 24°C.

4.4 In-stream Thermal Regime Classification

The method described in Stoneman and Jones (1996), and later revised by Chu *et al.*(2009) was used to classify the temperature regime. Classification for each station was based on a comparison of daily maximum air temperature and maximum in-stream water temperature measured between 16:00 and 18:00 during the summer months (July 1 – August 31) when maximum daily air temperatures exceed 24.5°C. A nomograph is then used to classify results based upon water thermal characteristics of coldwater, cold-coolwater, coolwater, cool-warmwater and warmwater systems. **Appendix D** includes a graphical representation of this analysis. **Table 10** summarizes the thermal regime classification associated with each station within the study area. Noted trend changes in the thermal classification of each site are also included in **Table 10** below. These changes are based upon trends in the thermal regime. These are generalized trends that could change as more years of data become available.

The comparison included in **Table 10** indicates a slight warming at sites HC-A(03), HC-A(04), HC-A(09), and HC-A(13). However, despite the higher ambient air temperatures in 2020 relative to 2019, sites HC-A(04B), HC-A(10), and HC-A(11) experienced a slight overall cooling.

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Table 10: Temperature Classification Summary

Station	Based on C. Chu et al. (2009)													Based on Stoneman and Jones (1996)		Overall Change in Thermal Regime
	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	
HC-A(03)	Cool	Cool-Cold	Cool	Cold	Cool-Cold	Cool	Cool-Cold	Cool-Cold	Cool	Cool	n/a	n/a	n/a	n/a	n/a	Cool-Cold to Cool
HC-A(04)	Cool-Warm	Cool	n/a	Cool	Cool-Warm	Cool-Warm	Cool	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cold	Cold	Cool to Cool-Warm
HC-A(04A)[1]	n/a	Cool-Warm	n/a	Cool-Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No trend[1]
HC-A(04B)	Cool	Cool-Warm	n/a	Cool-Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Cool-Warm to Cool
HC-A(06)	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cool	Cool	No trend
HC-A(08)	Cold	Cold	Cold	Cold	Cold	Cold	Cold	Cold	Cool-Cold	Cold	Cold	Cold	Cold	Cold	Cold	No trend
HC-A(09)[2]	Warm	Cool-Warm	Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool-Warm	Cool-Warm	n/a	Cool	Cold	Cool	Cool-Warm to Warm[2]
HC-A(10)[3]	Cool	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Cold	n/a	Cool-Cold	Cool	Cool	Cool-Warm to Cool[3]
HC-A(11)	Cool	Cool-Warm	Cool-Warm	Cool	Cool	Cool	Cool	Cool	Cool-Warm	Cool	Cool	Cool-Warm	Cool	Warm	Warm	Cool-Warm to Cool
HC-A(12)	Cool	Cool	Cool	Cool-Warm	Cool	Cool	Cool	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	No trend
HC-A(13)	Cool-Warm	Cool	Cool-Warm	Cool	Cool-Warm	Cool	Cool-Warm	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a	Cool to Cool-Warm
HC-A(14)[1]	n/a	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Warm	Warm	Cool-Warm	Cool-Warm	Cool	Cool	n/a	n/a	No trend[1]

[1] Dataset not available due to logger failure
[2] Thermal trendline for HC-A(09) fell directly on the boundary between warm and cool-warmwater (see Appendix D). Classification was rounded up to warm.
[3] Thermal trendline for HC-A(10) fell directly on the boundary between cool-warmwater and coolwater (see Appendix D). Classification was rounded dpwm to cool.

5. In-stream Water Quality Data

In-stream water quality measurements included the collection of in-situ measurements of dissolved oxygen (DO), pH, and specific conductivity, as well as the collection of water samples for chemical analysis at a CALA-accredited laboratory.

5.1 In-Situ Measurements

During each field visit, a YSI multi-parameter probe (556R) was used to collect dissolved oxygen, pH, and specific conductivity readings at each site. The 2020 results and historic site comparisons are shown in **Figure 5.1.1** through **Figure 5.1.6**. All sites fell within the acceptable ranges of the Provincial Water Quality Objectives (PWQO) for all applicable parameters. It is noted that the average annual comparisons provided show general trends of water quality parameters measured during baseflow conditions and do not provide an adequate characterization of the full range of dynamic, instream water quality conditions.

There were no occurrences in 2020 where DO was found to be below the applicable PWQO. The average annual dissolved oxygen levels shown in **Figure 5.1.2** show a moderate increase in DO concertation in 2020 compared to 2019, congruent with a slight upward trend which appears to have begun in 2010. 2012 is the exception to this general trend, but as noted previously 2012 was a particularly warm summer.

pH readings were within the range of the PWQO (6.5 to 8.5) for all sites in 2020, with a slight downward trend continuing.

There is no PWQO for conductivity; however, conductivity is a good measure for ions such as chloride. Station-specific trends noted in previous years continued to be observed in 2020, with upstream reaches recording relatively lower conductivity readings and downstream reaches recording relatively higher conductivity readings. It appears that Hanlon Creek Boulevard is an important driver causing increased conductivity readings within the lower reaches of the watercourse. HC-A(10) typically records some of the highest conductivity readings despite being upstream of the Hanlon Creek Boulevard crossing, therefore, it is currently assumed that the secondary tributary (where HC-A(08) is located, as shown in **Figure 2.1.1**) may be contributing increased chloride loads to the watercourse via development which is occurring to the east/southeast.

Further, it is noted that Hanlon Creek overall is exhibiting a steadily increasing trend in chloride concentrations year round. This trend of increasing in-stream chloride concentrations is typically correlated with increased road network density. Therefore, as build out within Phases 1, 2, and 3 continue over time, it is expected that the year-round chloride concentrations will also continue to increase. Furthermore, the solubility of chloride means that it will continue to leach from soils and the shallow groundwater table even during the summer months. For example, Credit Valley Conservation (CVC, 2017) has been monitoring the summertime baseflow chloride concentration of Sheridan Creek, and it is regularly observed to be in excess of 1,000 mg/L. During the winter months the chloride concentration can at times be roughly equivalent to concentrations found in the world's oceans.

In 2020, the four turbidity monitoring stations were not reinstalled in Hanlon Creek at stations HC-A(03), HC-A(06), HC-A(11) and HC-A(14). Historically, the Turner Designs Cyclops turbidity sensor installed as part of the HOBO U30 telemetry stations used an optical scatter method to determine turbidity. In addition to the coincidental expiration of the HOBO telemetry data plans, the turbidity sensors themselves were determined to be largely outmoded, as they were more than 10 years old and had been providing unreliable data during the year prior. The turbidity sensors will be reinstalled in 2021 as part of the new FTS LT1 Cell telemetry stations and it is expected that turbidity results will yield more useful data.

The PWQO for turbidity is based on Secchi depth reading not decreasing more than 10% due to the addition of suspended matter. Based on the CCME Guidelines for the Protection of Aquatic Life a nephelometric turbidity increase of 8 NTUs above background levels for short-term exposure (i.e. up to 30 days) and of 2 NTUs for long-term exposure (>30 days) is considered acceptable. Historically, due to the inputs from Pond 4, turbidity readings typically increased by 7 NTUs from HC-A(03) to HC-A(06) (see Error! Reference source not found.). Disregarding sensor noise, readings generally receded at HC-A(14), possibly attributable to sediment retention within the upstream wetland complex.

During site visits, turbidity sensors were checked and cleaned regularly, however, sediment buildup in between visits inevitably occurred. A notable improvement of the FTS LT1 Cell turbidity sensors is that they feature a built-in wiper attachment which lessens the need to complete manual cleaning. The FTS wiper cleans the measurement aperture between every reading, thereby helping to reduce biofouling. HC-A(06) historically exhibited a less variable turbidity profile compared to HC-A(03) and HC-A(14), possibly due to the rock-lined nature of the channel at HC-A(06). While the irregular turbidity plots at HC-A(03) and HC-A(14) can be partially explained by the faulty/aging sensors, there is also potential that biofouling and vegetation growth in the stream interfered with the sensor readings. HC-A(03) is also situated within a shallow reach section, so ensuring the station sensors remained submerged during dry periods was difficult. Minor excavation of the channel has been considered in 2021 at the sensor site in order to ensure that a small pool of water will be present to submerge the sensor, especially given that the FTS turbidity sensor is slightly larger than the original HOBO unit. AECOM will also need to continue to monitor the vegetation growth within the channel at all flow sites with a specific focus on reed growth at both HC-A(11) and HC-A(14).

Figure 5.1.1: 2020 YSI Dissolved Oxygen Readings

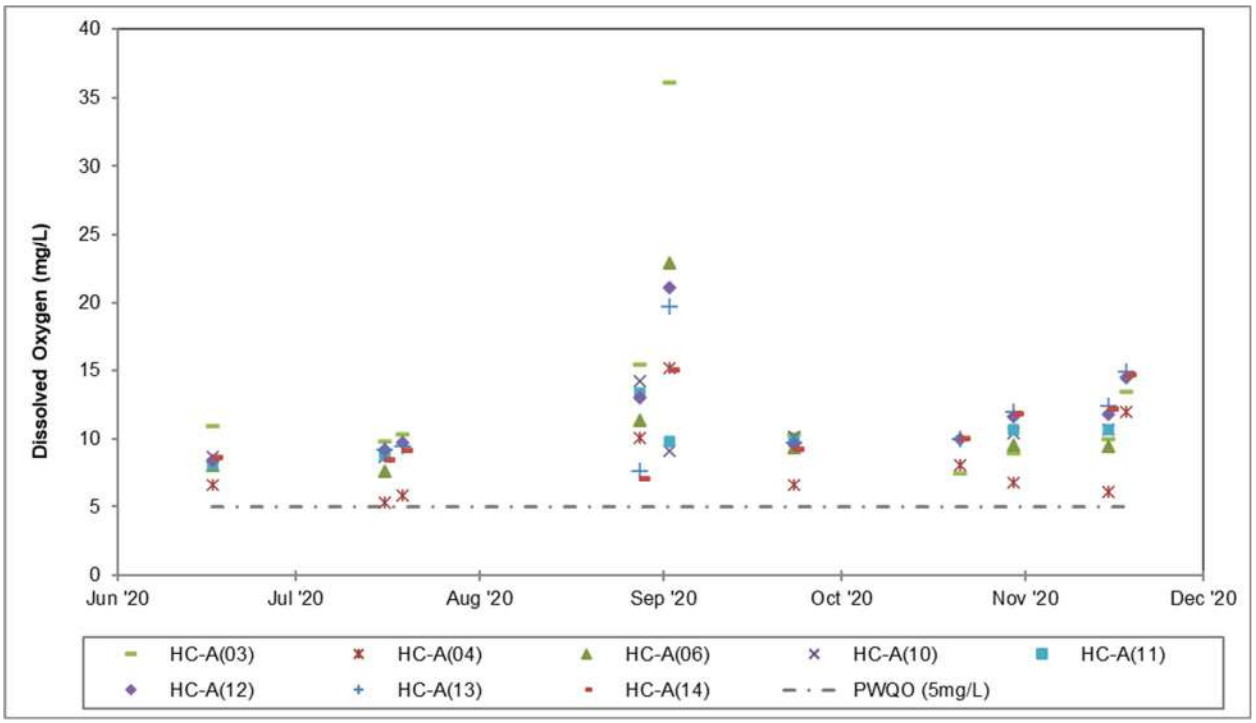


Figure 5.1.2: Average Annual YSI Dissolved Oxygen Readings from 2008 to 2020

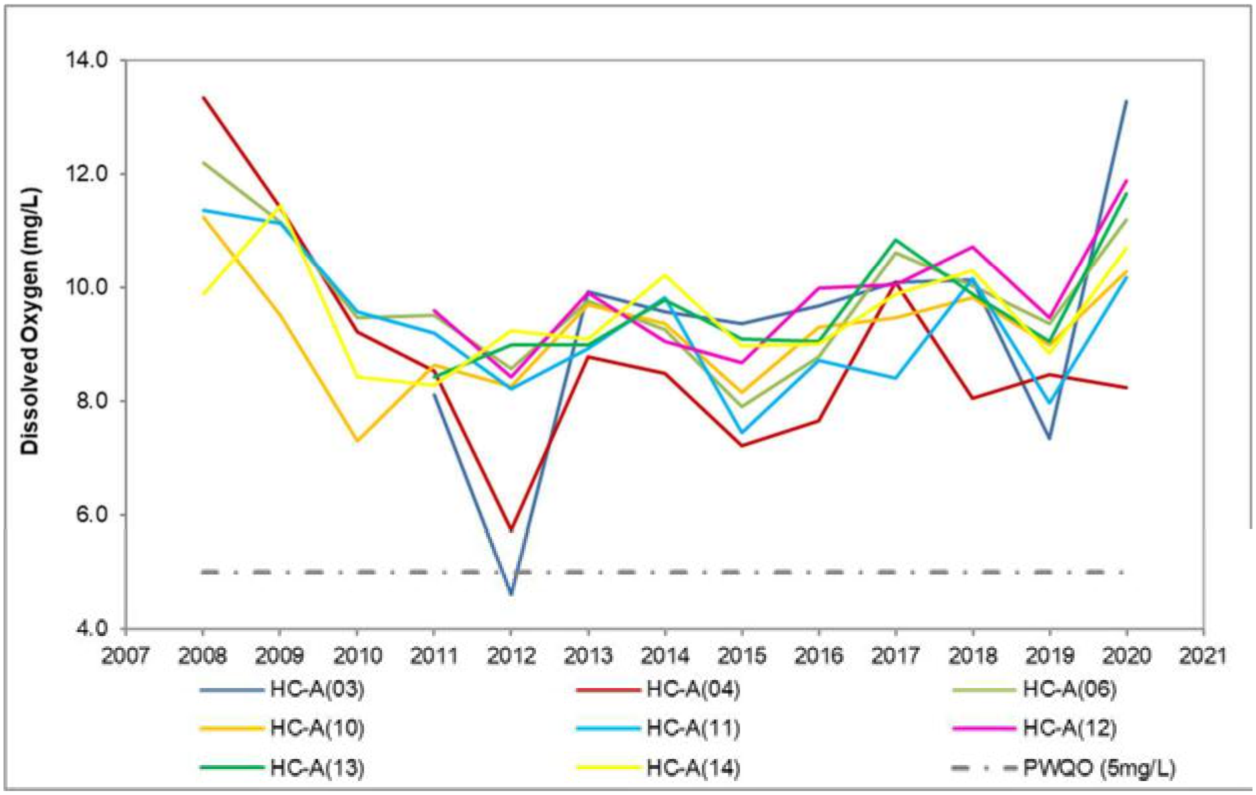


Figure 5.1.3: 2020 YSI pH Readings

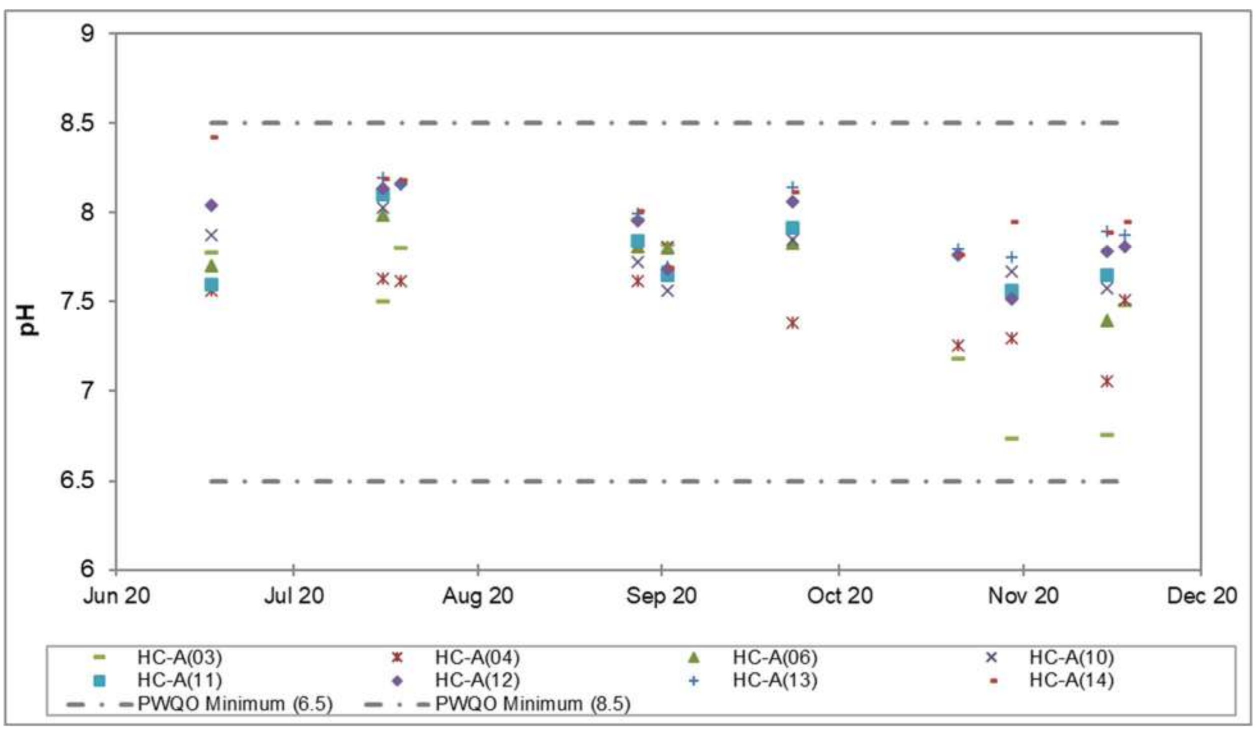


Figure 5.1.4: Average Annual YSI pH Readings from 2008 to 2020

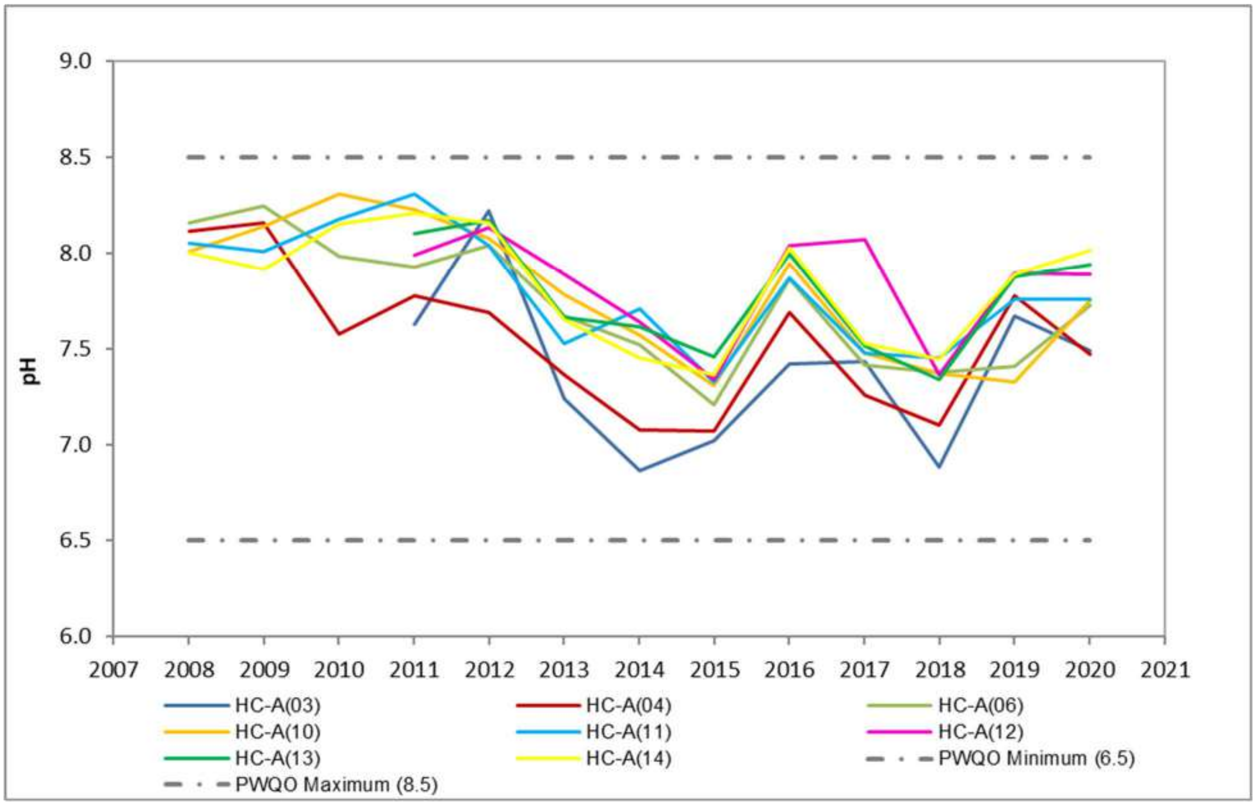


Figure 5.1.5: 2020 YSI Conductivity Reading

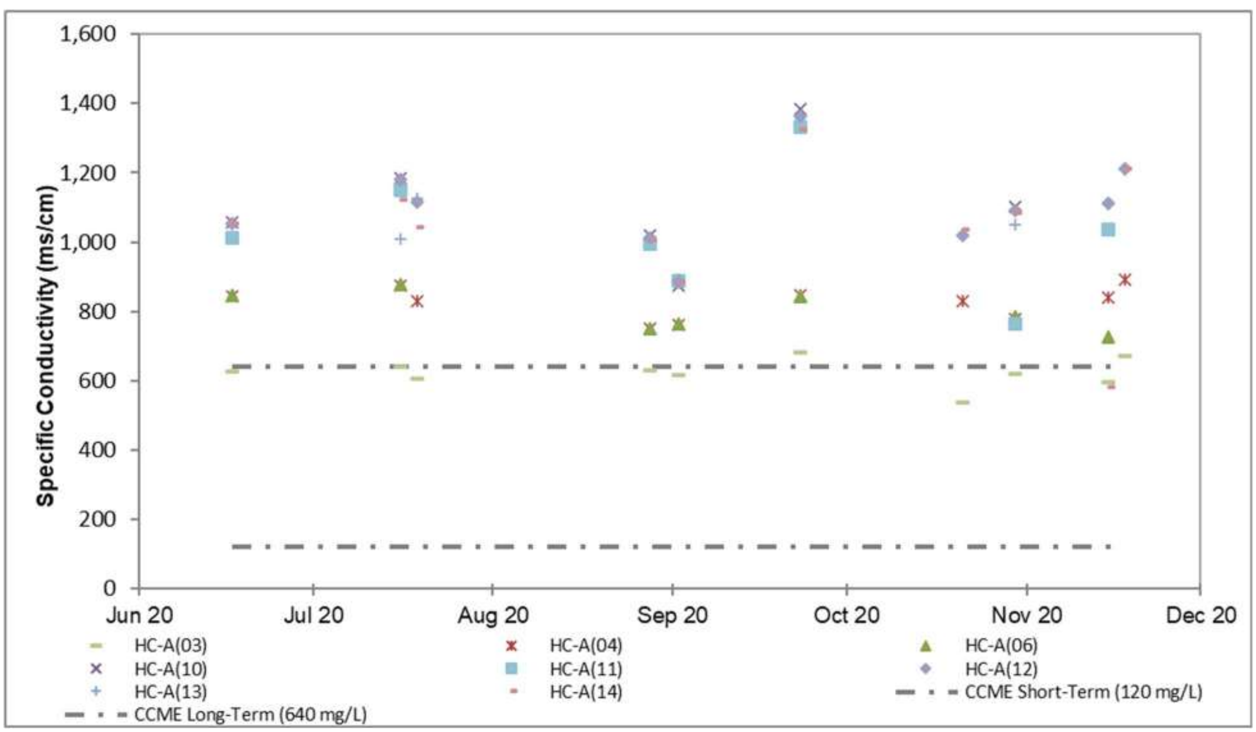
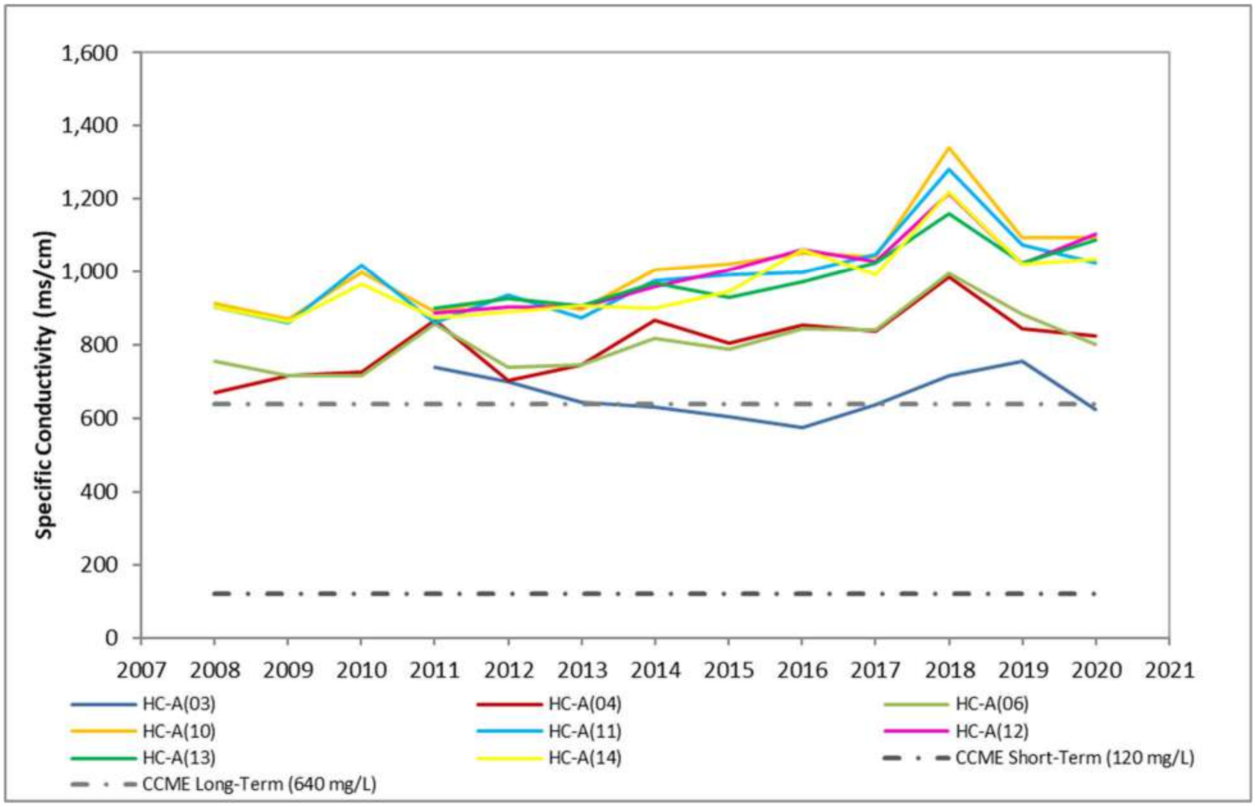


Figure 5.1.6: Average Annual YSI Conductivity Readings from 2008 to 2020



5.2 Grab Samples for Water Quality Analysis

To establish the performance efficiency of the SWM facilities and to satisfy the MECP Environmental Compliance Approval, the water quality sampling program consists of grab samples collected upstream and downstream of each pond outfall. Sampling locations included HC-A(03), HC-A(04), HC-A(12), HC-A(13) and HC-A(14).

As part of the the Consolidated Monitoring Program, parameters that were analyzed during sampling included:

- CBOD5
- Total Suspended Solids
- Total Phosphorus
- Dissolved Phosphorus
- Metals (total and dissolved, lead, zinc and copper)
- *Escherichia* coli.
- Nitrate as N
- Chloride

Additionally, past programs would include the following water quality sampling event requirements:

- Three (3) dry weather sampling events with at least 72 hours since the last rainfall (between May and November)
- Eight (8) seasonal wet weather sampling events, with five (5) spread out during the summer season.
- Historically, one (1) wet weather sample was collected during the winter, however, this was shifted to within the May to November time period.

Due to the delayed start in 2020, sampling efforts proceeded with the intention of collecting as many of the above sampling events as possible given the reduced sampling window. A specific focus was placed on retaining monthly baseflow/dry samples and any applicable wet weather samples.

Additionally, while sampling using the parameters noted above began in 2019, the list was eventually shortened given the extensive historical data availability and the changes to the monitoring program made in 2019. Specific changes to the 2019 parameter list included:

- Only total lead, zinc, and copper metals are to be sampled/reported (no dissolved)
- Historical samples also included an extensive list of additional metals testing

Given the reduced 2020 season, only three wet weather samples and two 72-hour response samples were collected over the course of the monitoring season. As mentioned previously, Guelph experienced a relatively dry summer and fall so viable rainfall events (typically aiming for >5mm) weren't sufficient to complete the required wet samples. The tabular results of the water quality sampling have been included in **Appendix E**.

Water quality sampling results are presented as the number of exceedances as compared to the PWQOs in **Table 11.**

E.coli concentrations exceeded the recommended PWQO for recreational uses for 17 of the 25 total samples in 2020 (11 wet / 6 dry). Total phosphorus levels exceed the PWQO during both wet and dry weather sampling events, however, they most exceedances were detected during wet weather events; this is not uncommon for streams in the Grand River watershed (GRCA, 2012). Total copper and lead also exceeded their respective PWQO, however, zinc never exceeded the PWQO in 2020.

Chloride concentrations again exceeded the long-duration exposure guideline of 120 mg/L (CCME 2011) for all events at all locations except for HC-A(03) during both dry and wet weather events. All samples were below the short-term exposure target of 640 mg/L (CCME 2011).

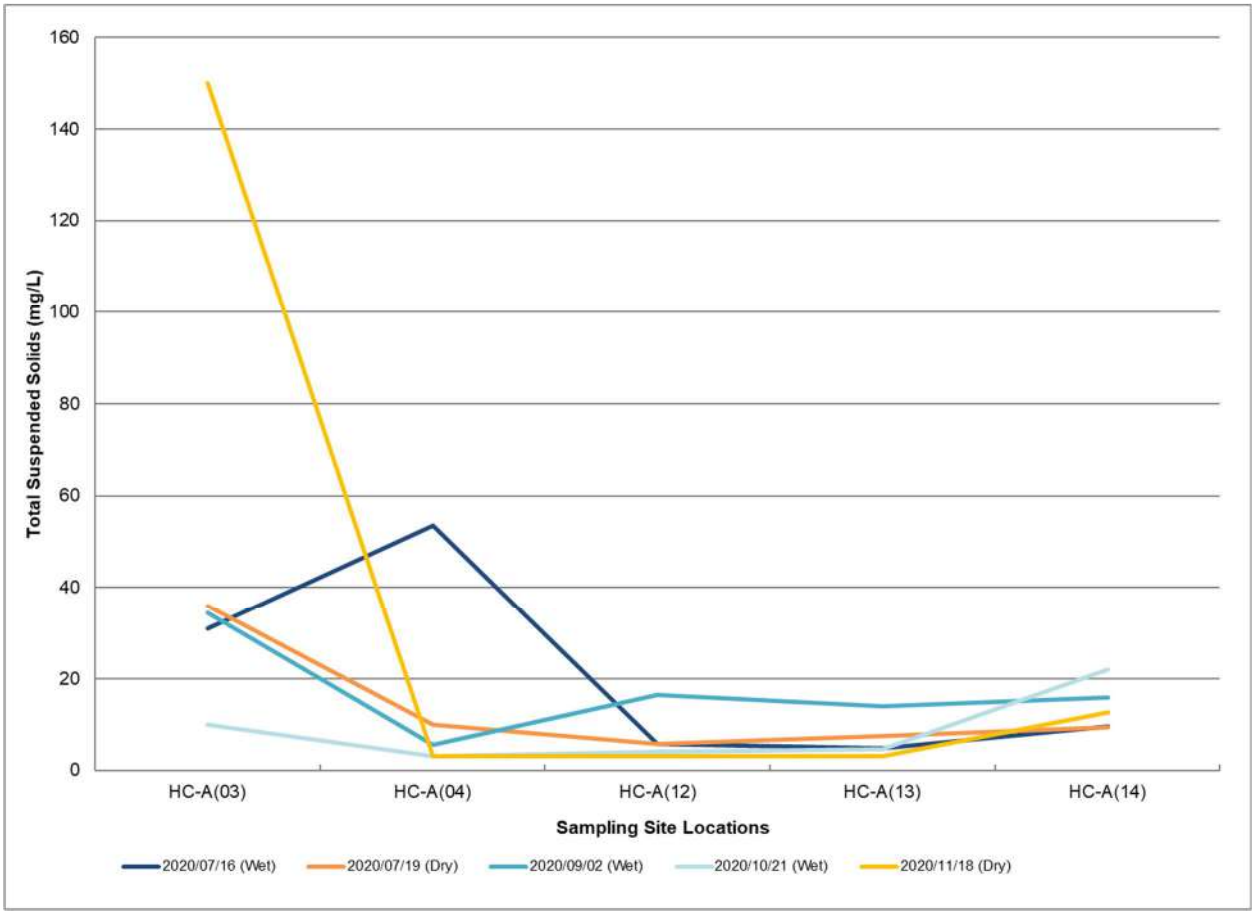
Table 11: Number of Guideline Exceedances per Water Quality Sampling Location

Parameter	Unit	Guideline	Number of Exceedances for Wet Weather Sampling Events (out of 10)					Number of Exceedances for Dry Weather Sampling Events (out of 3)					Total
			HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)	HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)	
Dissolved Oxygen(DO)	mg/L	5	0	0	0	0	0	0	0	0	0	0	***0***
pH	pH units	6.5-8.5	0	0	0	0	0	0	0	0	0	0	***0***
Chloride	mg/L	120-640	0	3	3	3	3	0	2	2	2	2	***20***
Total Suspended Solids	mg/L	25+	2	1	0	0	0	2	0	0	0	0	***5***
Total Phosphorus	mg/L	0.03	2	1	1	1	3	2	0	0	0	0	***10***
E. Coli	CFU/100mL	100	3	2	2	2	2	2	1	1	1	1	***17***
Copper (Cu)-Total	mg/L	0.001	3	1	1	1	3	2	1	1	1	2	***16***
Lead (Pb)-Total	mg/L	0.001	2	1	0	0	1	2	1	0	0	2	***7***
Zinc (Zn)-Total	mg/L	0.02	1	1	0	0	0	2	1	0	0	0	***5***

Notes:
-Exceedances based upon the PWQO limits, Chloride exceedances were based upon the CCME short term level. TSS based on exceedance from the upstream station
* Objectives for total phosphorus/metals

TSS concentrations were compared in **Figure 5.2.1** between each respective upstream and downstream location. Relatively high TSS concentrations were measured at HC-A(03), with a notable increase detected during a dry sample event on November 18th, with all instances suspected to be the result of a combination of low water levels and rainfall totals throughout the year (i.e. runoff generated turbulence within the channel producing elevated suspended sediment concentrations). Overall, aside from the aforementioned spikes at HC-A(03) and HC-A(04), both dry and wet weather samples exhibited a decreasing TSS concertation trend as the year progressed. Additionally, TSS concentrations at HC-A(12), HC-A(13), and HC-A(14) remained relatively consistent across most events. While HC-A(14) exhibited a slight increasing trend in TSS concentrations across all sample events, it cannot conclusively be determined whether or not the increase was due to cumulative watershed effects.

Figure 5.2.1: Total Suspended Solids (TSS) Concentration by Sampling Site



With two consecutive years having fewer than the anticipated number of water sampling events - each as a result of shortened seasons caused by unforeseen issues (a late award date in 2019 and COVID-19 related shutdowns in 2020) - AECOM's aim will be to sample for the allotted number of events in 2021. The plan to sample for the allotted number of events is discussed in more detail in **Section 7.2**, however, the focus will mainly be on increased sampling frequency earlier in the spring and potentially prior to the traditional season start in May.

6. Stormwater Management Facility Monitoring

As part of the MECP ECA #1384-7QFPZQ and the Grand River Conservation Authority's (GRCA) requirements, monitoring was completed at each of the SWM facilities (Ponds 1, 2 and 4). The monitoring included three components: inflow and discharge flow rate monitoring, water temperature assessment, and water quality sampling. As per the recommendations of the 2017 report, pond water chemistry was not monitored.

6.1 SMWF Water Level and Flow

Water level loggers were installed at each facility's outlet structure. This continuous depth data was used to estimate outflows from the facilities.

In 2020, neither Pond 1 nor Pond 2 water levels were ever high enough to produce discharge from either facility.

For Pond 4, flow is typically calculated for the outlet structure using the orifice equation based on the water level recorded by a level logger that was placed inside the outlet control structure, however, the level logger at HC-P4(05) was unfortunately not retrievable in the spring of 2020. Due to the reduced logger inventory as a result of the need to maintain data collection at the telemetry sites, no additional loggers were available to install for the 2020 season.

Given the ongoing issues with near-constant outflow from Pond 4, AECOM has internally discussed changing the current setup at HC-P4(05). Details regarding the recommended changes to the Pond 4 outlet logger will be discussed further in Section 7.2, however, the intent of changes to the monitoring approach is to more accurately model outflow from Pond 4 while also allowing for the collection of active pond water level data relative to the outlet catchbasin and outflow weir.

6.2 SWMF Water Temperature

Water temperature was monitored at the outlet of each SWM facility.

- Cooling trench outlets;
- Outflow structures; and
- Pond stratification temperate monitoring clusters (only Pond 4).

The purpose of monitoring temperature in the SWM facilities is to illustrate that the mitigation measures that were incorporated into Hanlon Creek Tributary A are effective and that the water being discharged to the creek will not contributing to the warming of the steam. Inlet structures were not monitored in 2019 as the inflows are well characterized through historical data that has been collected to date.

6.2.1 SWM Pond 1

Pond 1 was designed with multiple themral mitigation features. Stormwater is conveyed to the SWM facility via two grass drainage swales that discharge into settling forbays. Before runoff can pass though to the main body of the pond, flows must pass though a planted wetland area. The water is discharged via a bottom draw structure into one of two cooling trenches prior to being discharged into the wetland areas. These measures allow for maximum infiltratration, and minimize the amount of water directly discharged from the SWMF to the creek.

Water temperatures were monitored in the pond outflow catchbasin structure (HC-P1(06)) and at the cooling trench outflows (HC-P1(07,08)). The thermal profile in the pond was not measured through 2017 - 2020, as per the recommendations from the 2016 report, indicating that the shallow water in Pond 1 does not warrant temperature profile measurements.

No discharge was recorded at the outlet of Pond 1 during the 2020 monitoring season**.** Therefore, conclusions regarding the function of Pond 1's cooling trench cannot be determined for this year.

6.2.2 SWM Pond 2

The design of Pond 2 was a retrofit of an existing SWM facility. There are three inlets to this SWM facility: two storm sewer inlets (HC-P2(04,05)) and one grass drainage swale (HC-P2(06)). Each inlet discharges into its own sediment forebay. Before the water can pass through to the main body of the pond, the flow must pass through a planted wetland area. The water is discharged via a bottom draw structure into an infiltration gallery that was constructed as part of the pond design for the original SWM facility. Depth loggers were placed at the Pond 2 outlet (HC-P2(07)) and, similar to Pond 1, temperature profile was not measured in in Pond 2 as it was removed in 2017 following recommendations within the 2016 report.

6.2.3 SWM Pond 4

Pond 4 was designed with mutiple thermal mitigation features. Stormwater is first conveyed to the SWM facility via a grass drainage swale and discharged into a settling forebay. Before the water can pass though to the main body of the pond, the flow must pass though a wetland area (see below). The water is discharged via a bottom draw structure into a cooling trench prior to being discharged into Hanlon Creek Tributary A.

In September 2012, the outlet weir was raised to stop Pond 4 from continuously discharging, and to avoid warming of the outflow over extended periods – particularly during the summer months. This has not been achieved however, due to suspected groundwater inputs to the pond.

Additionally, vegetation was planted in the pond and vines and other flora were planted on and around the cooling trench in order to shade the exposed rock. The plantings have not yet matured to cover the cooling trench. However, through 2016-2020, improvements were noted in the amount of vegetation taking hold along the cooling trench**.** Although the current impact is minor, these features are anticipated to provide additional cooling of the pond's discharge in future summer seasons.

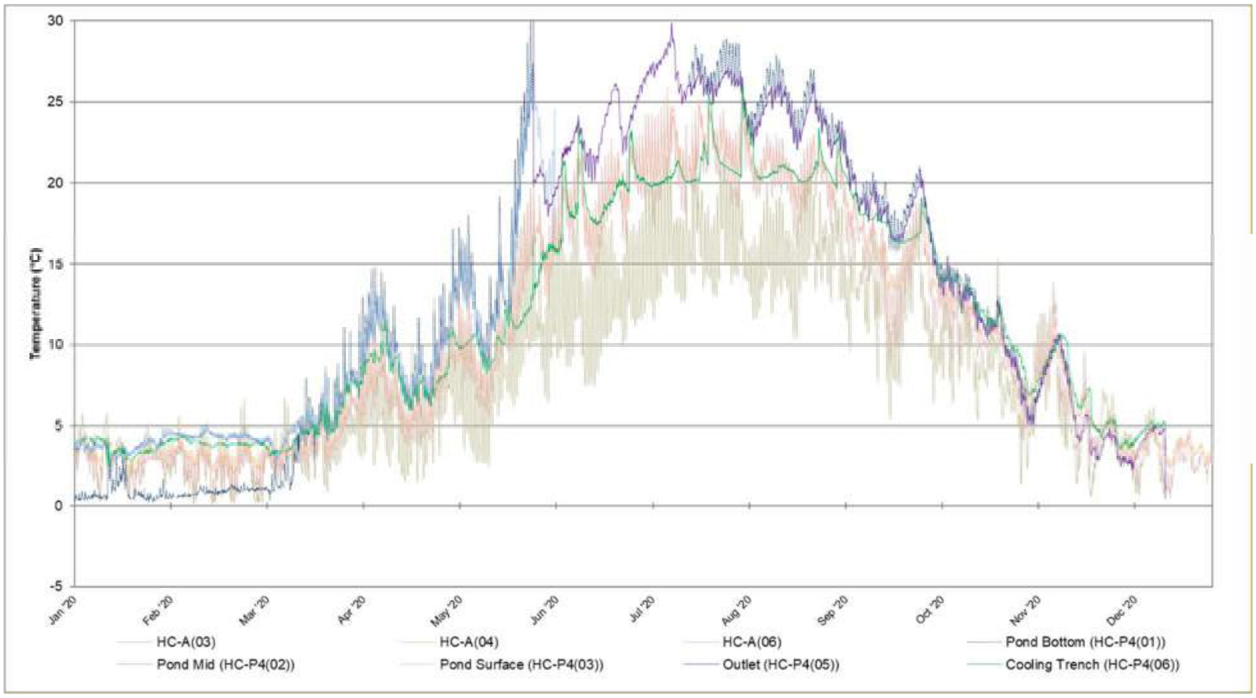
Water temperatures were monitored at the pond outflow structure (HC-P4(05)) and at the cooling trench outflow (HC-P4(06)). Temperature loggers were installed in the pond's main cell to record the pond's temperature profile. The complete temperature monitoring records at the Pond 4 stations for 2020 are shown in **Figure 6.2.1.**

Recorded temperature at the bottom-draw outlet (HC-P4(05)) was generally lower (during summer months) than the in-pond loggers (HC-P4(01-03)); it appears that the bottom draw outlet allows for the discharge of the coldest (deepest) water first. Only minor temperature variation was noted between the deepest (HC-P4(01)) and shallowest (HC-P4(03)) in-pond thermal profile loggers. Therefore, it may be recommended to redeploy these loggers during future monitoring seasons.

The temperature recorded at the outlet of the cooling trench (HC-P4(06)) tended to have the least variation: it appears that the cooling trench did have a moderating, and generally cooling, effect (approximately -3.5°C between May and September) on the flow discharged to Hanlon Creek Tributary A.

Despite the cooling effects of the trench and the benefits provided by the bottom draw outlet structure (as well as the cooling effect of groundwater inputs), temperatures leaving the pond were still higher than the in-stream water temperatures upstream of Pond 4. The temperatures recorded at the creek station HC-A(06) downstream of Pond 4 were higher than those recorded upstream of the pond outlet (HC-A(03)). This highlights the pond's thermal impacts on station HC-A(06). While HC-A(06) exhibited a smaller diurnal temperature fluctuation compared to other areas within the Tributary system, it is currently understood that this is the result of the near-continuous inputs from Pond 4.

Figure 6.2.1: Measured Temperatures through Pond 4 and Upstream/ Downstream of Pond Outlet



7. Conclusions and Recommendations

7.1 Conclusions

Low precipitation and warmer temperatures during the summer months resulted in a drier and warmer condition throughout the Hanlond Creek Tributary system. Consequently, this resulted in reduced flows compared to previous years.

The monitored temperature results suggest that the system as a whole experienced warmer temperatures as compared to previous years. Unlike 2019, there was a notable increase in temperature exceedances during the past season resulting in potentially unsuitable temperature conditions for brook trout habitat (based on the ranges provided in the Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F (AECOM, 2009)). Thermal monitoring results consistently produce higher thermal conditions than those predicted by the HSP-F model for average summer temperatures. This includes exceedances above 19°C in the summer as well as for all predicted autumnal values at all in-stream monitoring stations.

Pond 4 has been discharging directly into Hanlon Creek Tributary A on a semi-continuous basis during the summer of 2020 and this is likely a contributing factor to the observed increase in temperatures at stations downstream of the pond outflow. The bottom-draw and cooling trench design of Pond 4 appears to be functioning well and these SWM facility components are reducing outflow temperatures, although discharge temperatures are still higher than the creek monitoring station temperatures upstream of the pond. Vegetation that was planted on the banks of the pond and along the Pond 4 cooling trench in 2012 have continued to mature and provide additional cover, however, they still have yet to provide significant cooling benefits to Pond 4's discharge. Slight improvements were observed through 2016-2020, and it is expected that with the added vegetation growth, water temperatures may eventually decrease.

General trends observed in the in-stream thermal monitoring data indicate that the discharge from Pond 4 impacts thermal conditions in the stream from downstream of the pond outlet to station HC-A(09). Downstream of this station the cool groundwater-fed tributary and the elimination of online ponding downstream of Hanlon Creek Boulevard provide slight improvements. Further downstream, the open nature of the creek and its exposure to ambient air temperatures and solar radiation have resulted in little change to in-stream thermal conditions since monitoring has begun.

On August 27, 2015, AECOM provided a memo to the City outlining recommended improvements to Pond 4 in order to reduce overall thermal impacts to the Creek. Following discussion with stakeholders, AECOM recommended that the water level in Pond 4 be lowered to its original design elevation and that plantings be provided throughout the pond to provide shading as originally intended. As was recommended, two additional thermal monitoring stations were installed between HC-A(04) and HC-A(06). These additional stations were implemented to further evaluate causes of temperature exceedances of 24°C at station HC-A(06). Data collected at station HC-A(06) showed that, further downstream, water temperature did not experience any exceedance of the 24°C threshold.

In the recent years, a number of measures were discussed for further evaluation, including interception and re-routing of groundwater from the pond to the outlet of the cooling trench, lowering water levels in the pond and re-establishing the vegetation (including exclusionary fencing to discourage waterfowl until such time that the vegetation becomes established), as well as various shading structures (e.g. floating island, shade screening, etc.). These activities have yet to be pursued since their initial recommendation in 2017.

Data from Pond 1 shows that no water exited through a surface pathway from this facility in 2020. Site inspections confirmed low water levels in the pond in the summer and fall months. Previous annual monitoring reports have assumed that infrequent flows at Pond 1 may have contributed to high temperatures observed at HC-A(13) and HC-A(14). Similarly, Pond 2 also experienced no outflow in 2020.

Of the three parameters collected in-stream during baseflow measurements (DO, pH and specific conductivity), pH levels within the system appear to have been decreasing since 2012, while conductivity and dissolved oxygen both appear to be increasing.

Overall, water quality samples collected upstream and downstream of the SWMF are indicative of conditions typically associated with SWMFs located with the Grand River watershed for both dry and wet weather conditions. Several exceedance events for chloride, total phosphorous, *E.coli*, total copper, total lead and total zinc were recorded throughout Tributary A downstream of each pond.

7.2 Recommendations

The following recommendations were formulated based on observations made during the 2020 monitoring program.

7.2.1 In-Stream Monitoring Program

A general trend has been observed in recent years where late summer and fall rainfall totals have resulted in suboptimal high flow monitoring opportunities later in the field season. Conversely, high rainfall totals – and higher monthly flow monitoring opportunities - during the months of March and April are missed due to the proposed monitoring season kickoff in May. Because high flow monitoring days have historically been scheduled in such a way to spread them out evenly over the course of a typical field season, this may be producing an underestimation of flows for each site as the higher spring rainfalls are missed in favour of smaller, gentler wet weather sampling events in the late fall. It has been noted in previous years that the current rating curves are largely incapable of capturing higher water levels events as the largest historical events fall within the spring period. For this reason, AECOM suggests making better use of spring rainfalls in future years in order to bolster the high flow event monitoring totals while simultaneously elaborating on the upper portion of each site's rating curves. Despite a proposed early start to high flow monitoring, water quality sampling and baseflow measurements can still adhere to the existing May to November timing window.

AECOM has also discussed the possibility of installing a level logger at the bottom of the catch basin outlet for Pond 4 in order to more accurately measure catch basin water depth. Currently, the level logger provides a dual purpose: measuring the presence of water within the outlet weir of the catch basin as well as measuring the temperature of the water exiting the pond. The limitation associated with the current setup is that the water level logger may be overestimating depth within the weir due to the velocity head associated with the cascading water coming over the weir lip.

By installing a logger in the bottom of the catchbasin upstream of the weir, logger depth readings will more accurately model the amount of water spilling over the weir while also providing an active reading of the pond water level. The purpose of the proposed change is to provide an improved understanding of the frequency at which Pond 4 is generating outflow. To ensure that outflow temperature readings are still collected, a new temperature-only logger is recommended to be installed at the previous HC-P4(05) location. A better understanding of the water levels in Pond 4 will provide better insight regarding its impacts on the portions of Hanlon Creek that are immediately downstream of its outlet.

Prior to any rehabilitation works to Pond 4, a multidisciplinary review is required to establish the overall net benefit of any such proposed works.

Lastly, as has been previously discussed, the upgrade of the telemetry stations at sites HC-A(03), HC-A(06), HC-A(11), and HC-A(14) should improve the quality and utility of data that was previously being collected by the aged HOBO systems. While the original HOBO U30 platforms did collect turbidity data, more recent historic data appears to be increasingly spurious and is of questionable vlaue. AECOM has shown that the new FTS systems provide a more usable dataset and the installation of these systems in the spring of 2021 is expected to provide additional insight into suspended solids concentrations at each of the monitoring sites.

7.2.2 Stormwater Management Facility Monitoring Program

Outflow conditions at the Ponds should continue to be monitored to provide an understanding of the impacts of the SWMFs on the Creek system. However, as outflow from Ponds 1 and 2 are largely non-existent due to the low water levels within the pond cells, it is recommended that the depth logger installed within each SWMF's outlet be removed. As has been discussed in **Section 7.2.1**, if the loggers are decided to be retained at the outlets of Pond 1 and 2, a better option may be move the depth logger either to the inlet of the bottom draw pipe or to the bottom of the catch basin. By moving it to the bottom draw inlet, the logger will provide an estimate of water leaving the pond through the pipe and companion weir.

The overall SWMF temperature monitoring program has collected a robust data set over the past several monitoring seasons. Historical data collected for Ponds 1 and 2 were deemed adequate to satisfy the requirements necessary to accurately model their respective thermal profiles. Therefore, AECOM and the City of Guelph agreed that the in-pond temperature monitoring of Ponds 1 and 2 would cease in 2017. Thermal monitoring of conditions within the Pond 1 cooling trench are recommended to continue in order to verify the effectiveness of the Pond 1 cooling trench.

Given the restrictions imposed by the ongoing COVID-19 pandemic, the Hanlon rain gauge located at the Clair Road Emergency Services Centre was inaccessible for large periods of 2020. Additionally, AECOM's original point of contact (S. Free) who provided access to the Clair Road Emergency Services Centre appears to no longer work at this location. Therefore, AECOM will need to be provided with a new point of contact from the City of Guelph in order to access the rain gauge in 2021.

AECOM has previously discussed including the rain gauge data within the existing FlowWorks network in order for it to be integrated within a larger rainfall monitoring network. However, the City has expressed hesitation given that the data falls under a separate data agreement compared to concurrent operations through the Guelph SWM Monitoring Program. The implementation of the Hanlon rain gauge and creek telemetry stations' live data into a customizable online platform like FlowWorks would allow for enhanced alarm capabilities and visualization of the Hanlon Creek live flow, temperature, and turbidity data. The FlowWorks platform also includes internal data analysis and post-processing capabilities. Such tools could be used to partially-process some of the data included within the annual reporting documents on a shorter timeframe, thereby allowing such information to be actionable during the field monitoring period. It is recommended that the City consider further integration within FlowWorks.

8. References

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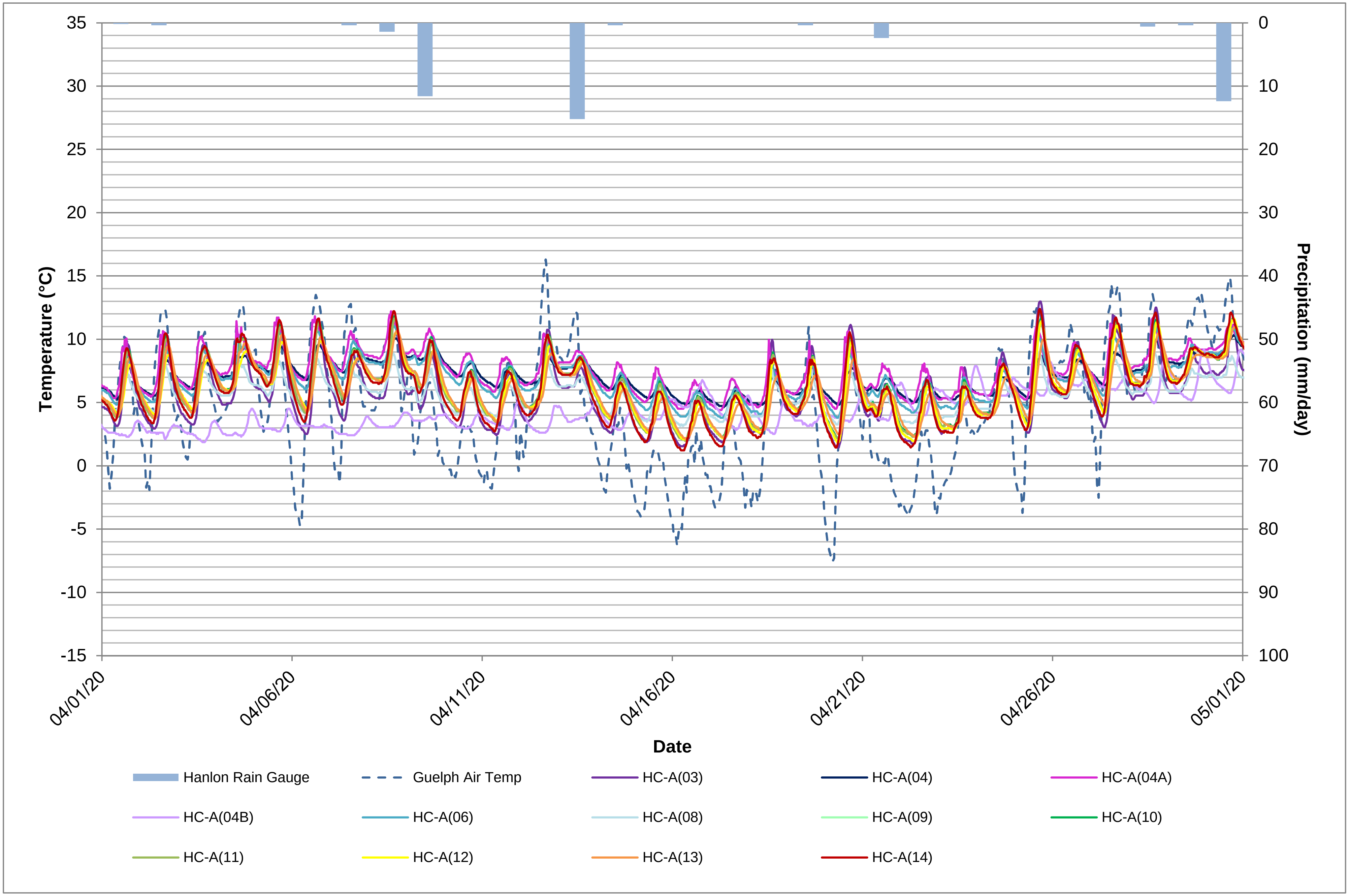
Appendix A

Monthly Temperature Plots



Temperature (°C)
35
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Precipitation (mm/day)
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04/11/20
04/16/20
04/21/20
04/26/20
05/01/20
Date
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
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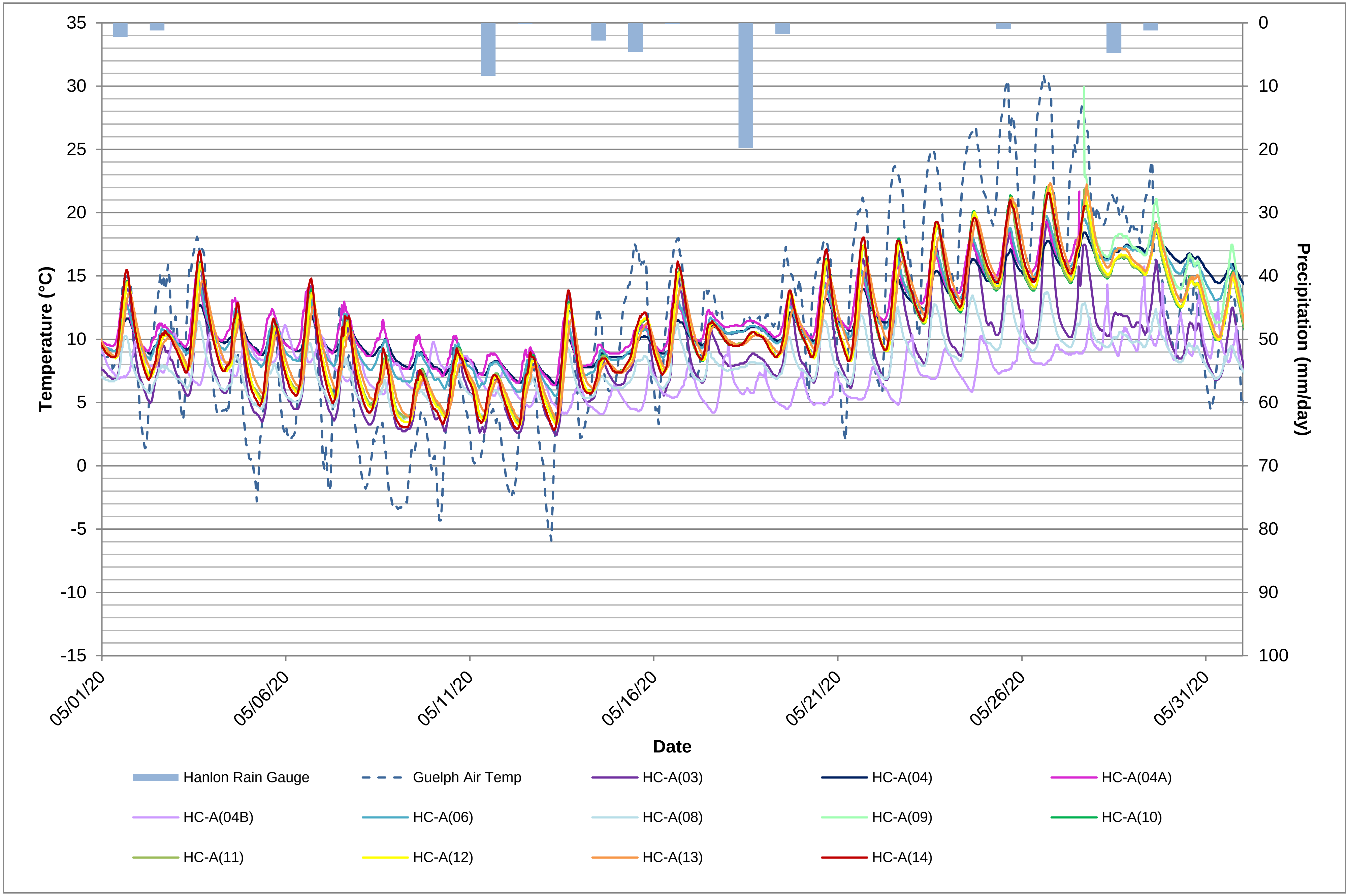

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Temperature (°C)
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Precipitation (mm/day)
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05/06/20
05/11/20
05/16/20
05/21/20
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Date
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
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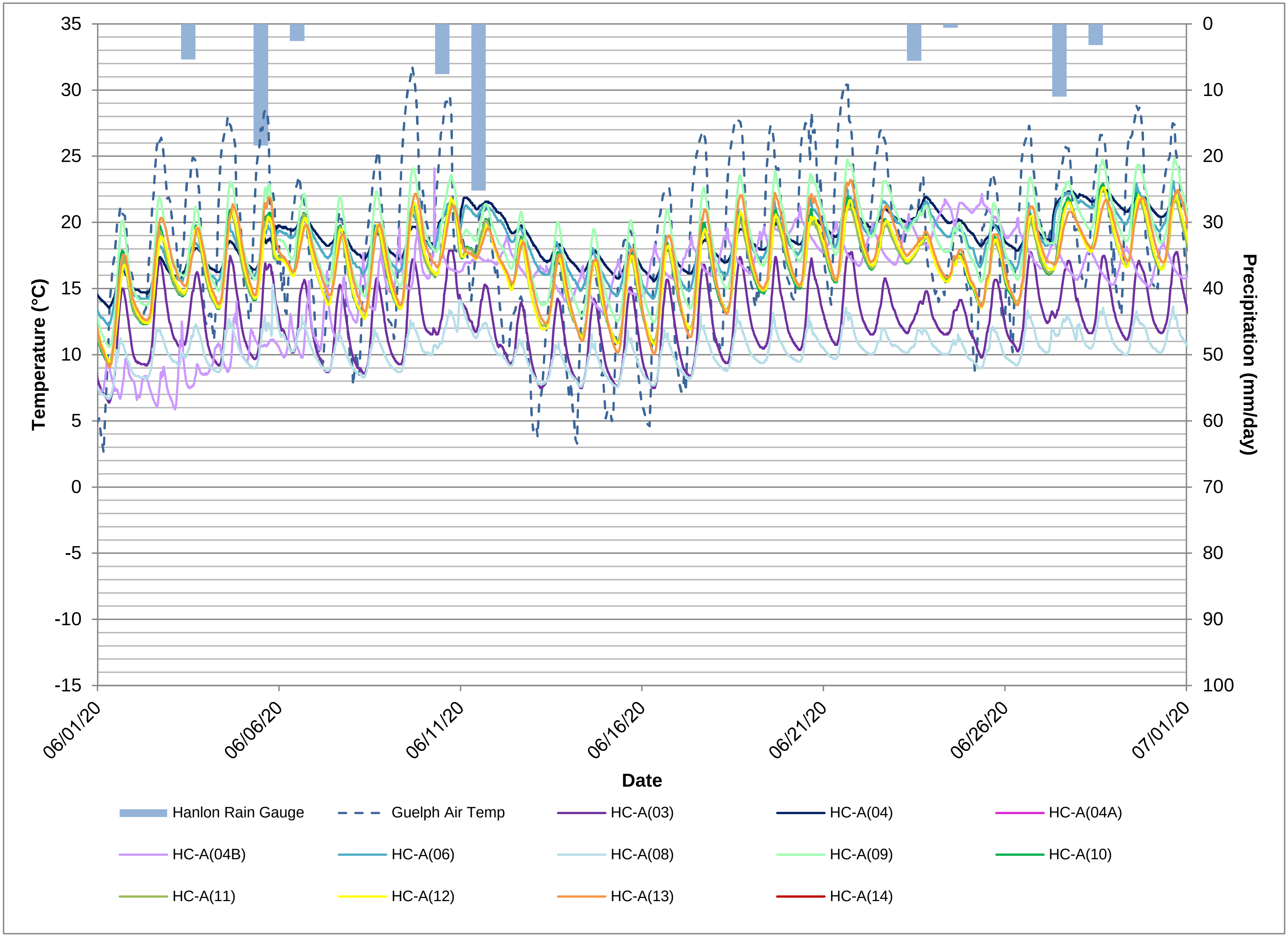

Temperature (°C)
Precipitation (mm/day)
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06/21/20
06/26/20
07/01/20
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(04A)
HC-A(04B)
HC-A(06)
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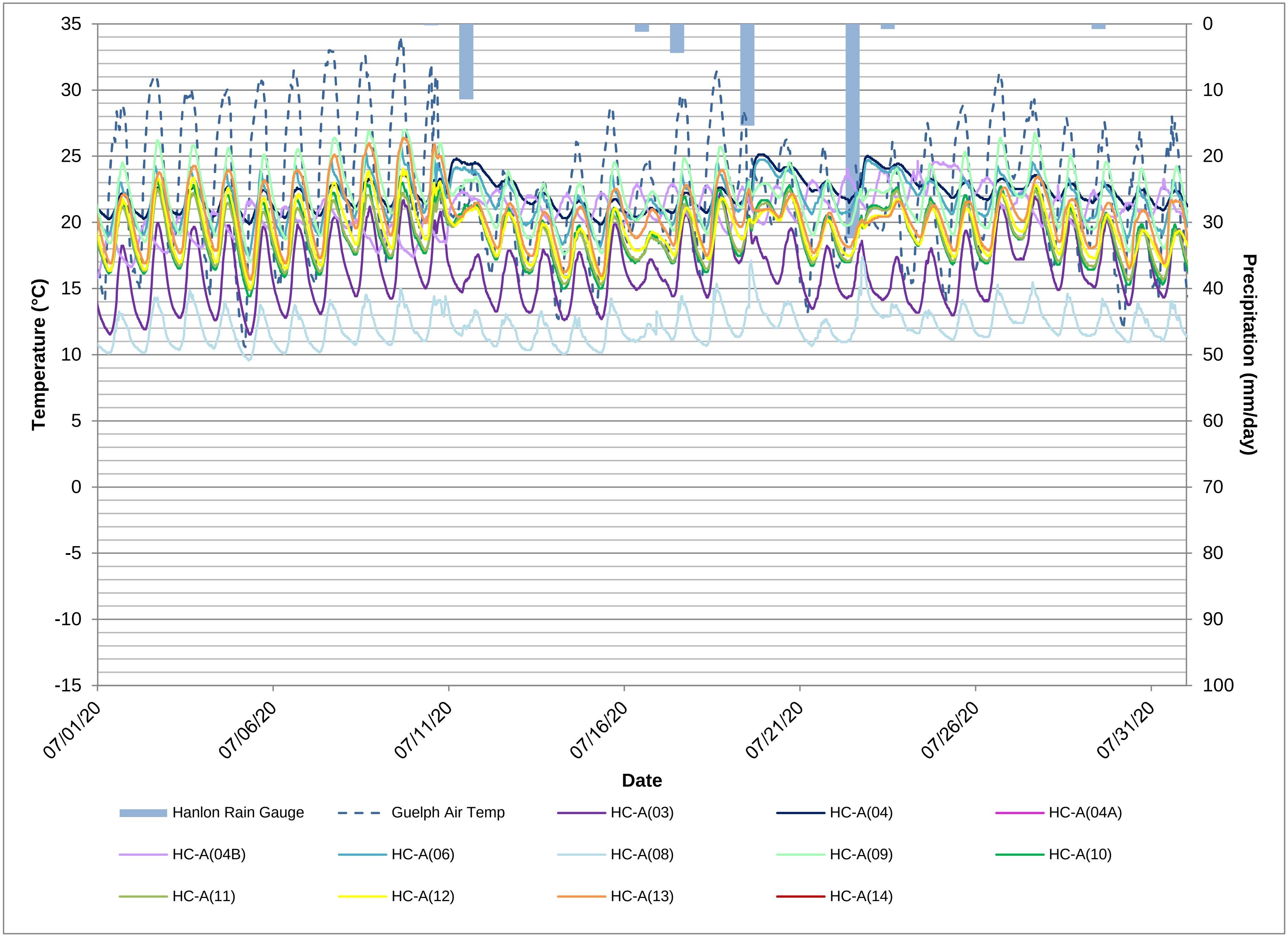

Temperature (°C)
Precipitation (mm/day)
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Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(04A)
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HC-A(06)
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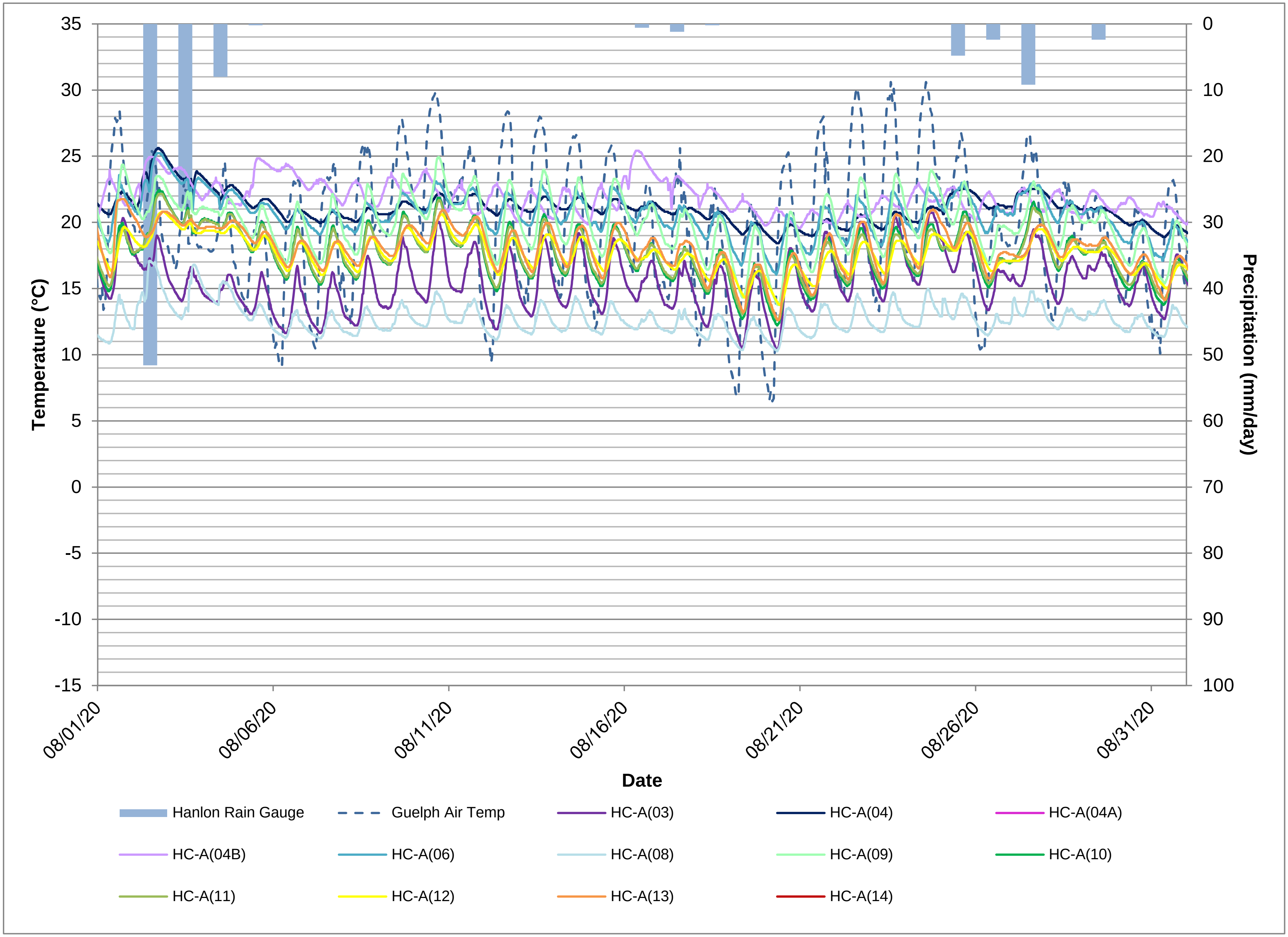

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Temperature (°C)
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100
Precipitation (mm/day)
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08/06/20
08/11/20
08/16/20
08/21/20
08/26/20
08/31/20
Date
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(04A)
HC-A(04B)
HC-A(06)
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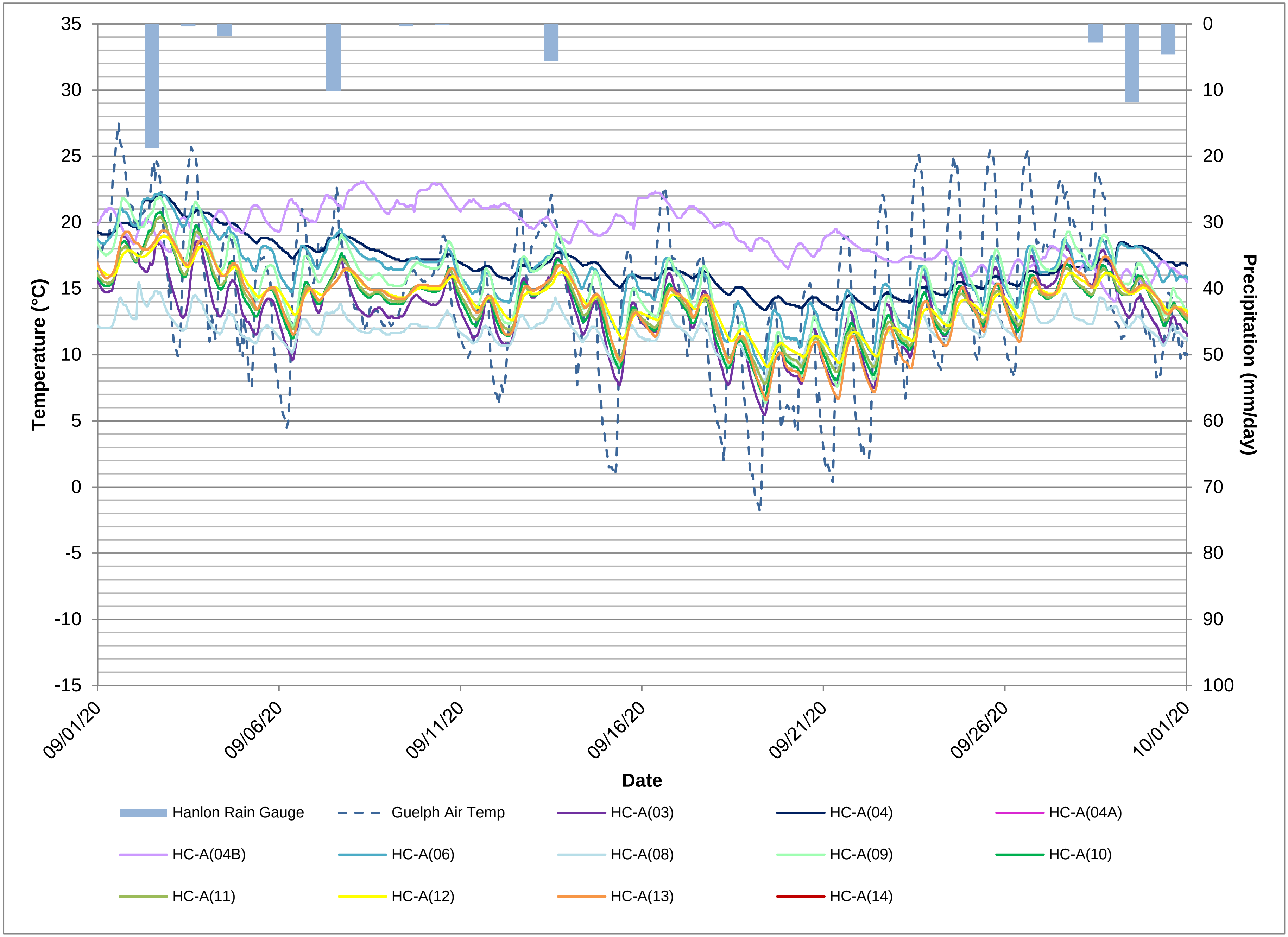

Temperature (°C)
Precipitation (mm/day)
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09/26/20
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Date
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
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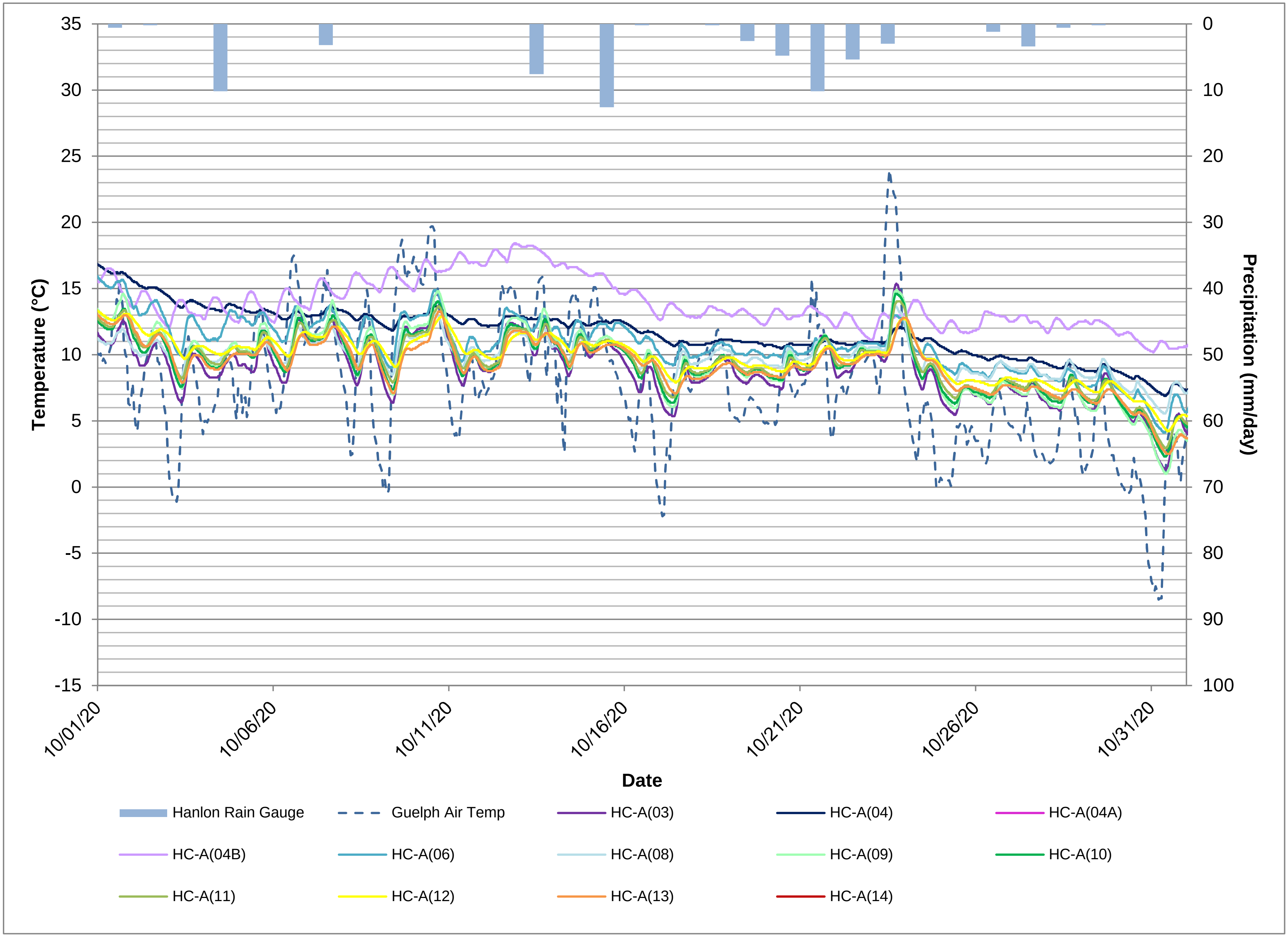

Temperature (°C)
Precipitation (mm/day)
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Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
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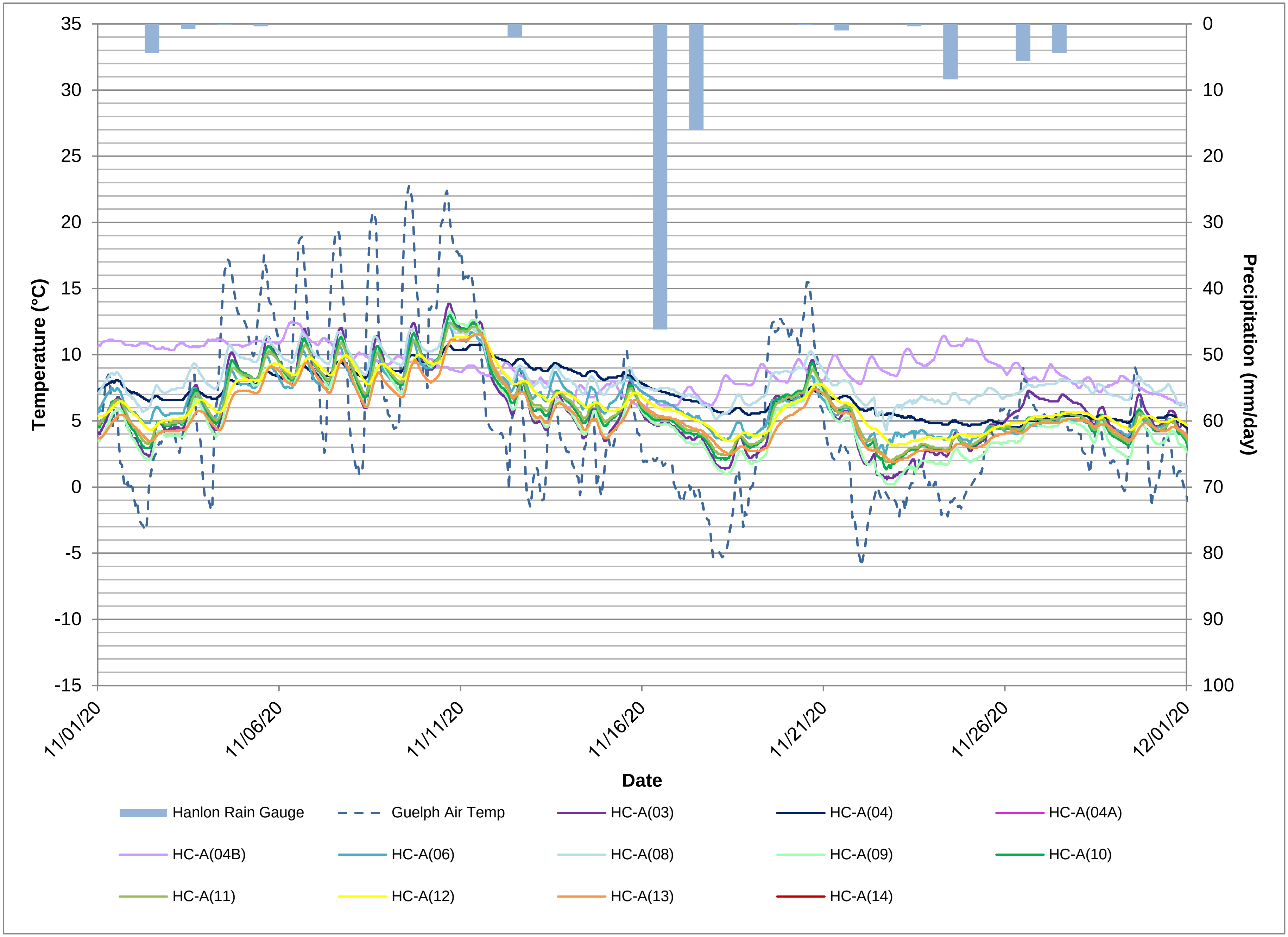
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Temperature (°C)
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Precipitation (mm/day)
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11/06/20
11/11/20
11/16/20
11/21/20
11/26/20
12/01/20
Date
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
HC-A(04)
HC-A(04A)
HC-A(04B)
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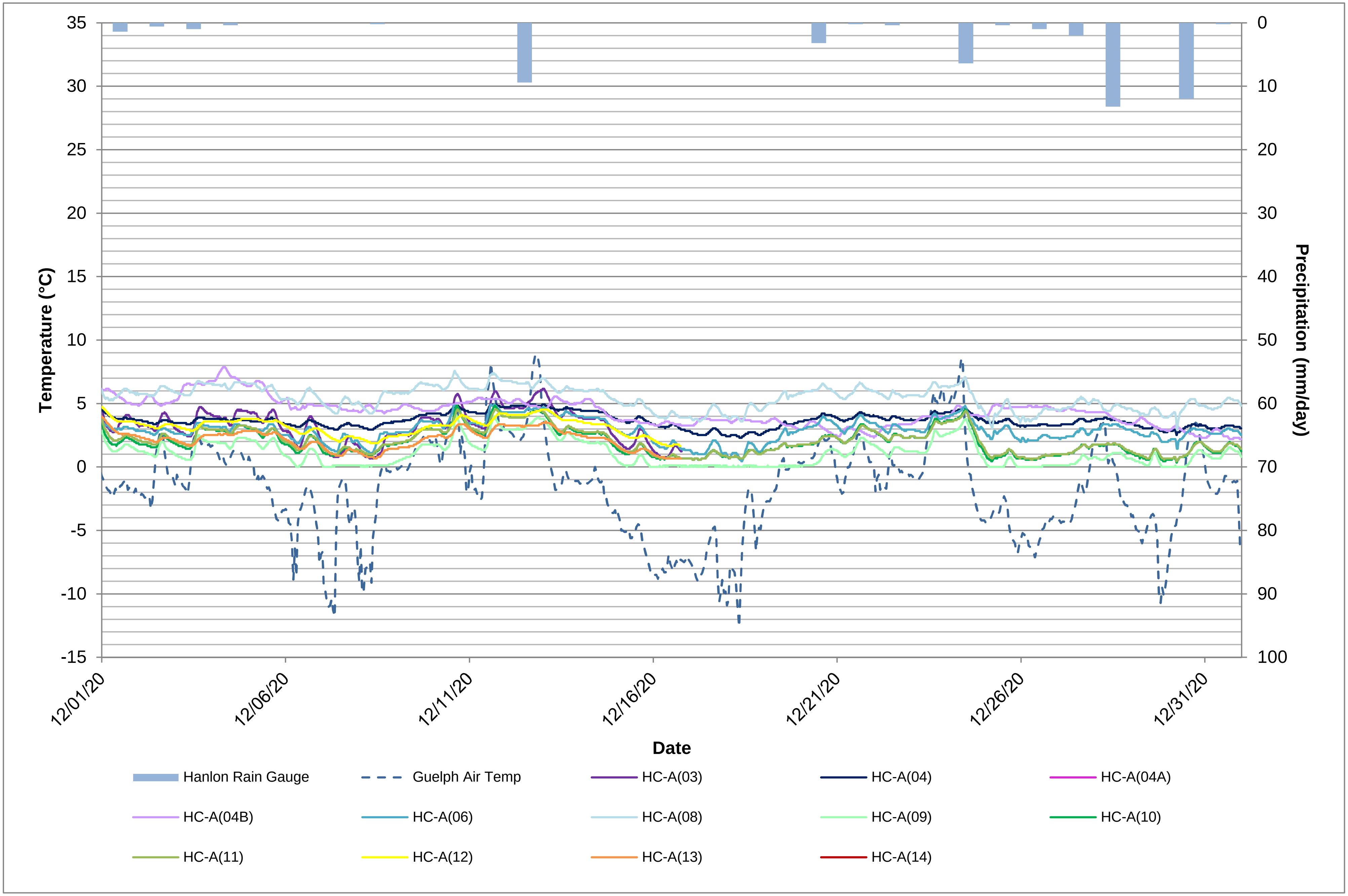
Temperature (°C)
Precipitation (mm/day)
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Date
Hanlon Rain Gauge
Guelph Air Temp
HC-A(03)
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AECOM

Appendix B

Historical Comparison of Statistical Stream Temperatures

Station	HC-A(03)										
Year	**Modeled**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011***
Summer (July-August) average maximum	14.5 - 19.9	22.2	15.87	17.66	14.42	17.87	18.03	15.68	15.60	19.34	19.01
Summer (July-August) average	12.5 - 14.5	15.9	13.06	14.53	12.71	15.59	14.56	13.13	13.59	18.00	18.28
Summer (July-August) average minimum	9.0 - 12.0	10.4	11.06	12.32	11.42	13.25	11.83	11.23	12.02	16.66	16.67
Maximum 3-day mean	14.0 - 19.0	17.9	14.33	16.96	13.59	18.75	17.27	14.72	16.03	20.39	21.50
Maximum 7-day mean	13.0 - 17.0	17.3	14.00	15.70	13.29	17.93	16.69	14.28	15.09	19.38	20.77
Maximum 7-day mean of daily maximums	15.0 - 23.5	20.5	16.97	18.83	15.35	19.84	21.05	16.88	18.05	20.81	21.94
Hours over 19°C	15.4	329	0.00	25.50	0.00	76.00	84.25	0.00	5.00	384.50	237.50
Percent of Time over 19°C	1.04%	11.00%	0.00%	1.71%	0.00%	5.00%	5.66%	0.00%	0.34%	25.84%	41.00%
Frequency of Exceedance over 19°C (Days/yr)	4.1	1	0.00	10.00	0.00	13.00	19.00	0.00	1.00	40.00	17.00
Average Duration of Event Over 19°C (h)	3.1	6.8	0.00	2.55	0.00	5.43	4.01	0.00	5.00	9.86	14.84
Hours over 22°C		4	0.00	0.00	0.00	0.00	0.25	0.00	0.00	4.25	32.00
Percent of Time over 22°C		0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.29%	6.00%
Frequency of Exceedance over 22°C (Days/yr)		0	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	6.00
Average Duration of Event Over 22°C (h)		2.3	0.00	0.00	0.00	0.00	0.25	0.00	0.00	1.81	5.33
Hours over 24°C	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.25
Percent of Time over 24°C	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%
Frequency of 24°C Exceedance (Days/yr)		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Average Duration of Event Over 24°C (h)		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.25

Station	HC-A(04)												
Year	**Modeled**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	25.6	20.02		19.38	22.47	20.91	20.03	20.52	23.56	19.63	18.30	15.50
Summer July-August) average	12.5 - 14.5	21.6	19.45	N/A	18.84	21.28	19.54	19.02	19.55	22.41	17.74	15.50	13.80
Summer (July-August) average minimum	9.0 - 12.0	18.4	18.91	N/A	18.31	18.70	18.21	18.06	18.66	21.29	16.10	13.40	12.60
Maximum 3-day mean	14.0 - 19.0	23.4	20.93	N/A	20.12	23.40	21.73	20.27	23.23	24.18	21.45	15.00	13.20
Maximum 7-day mean	13.0 - 17.0	23.2	20.37	N/A	19.54	22.87	21.47	19.61	22.36	23.53	19.77	14.50	12.80
Maximum 7-day mean of daily maximums	15.0 - 23.5	24.4	20.96	N/A	20.17	23.54	22.83	21.05	23.35	25.65	21.57	16.80	14.80
Hours over 19°C	51.1	2939	956.50	N/A	600.00	1329.50	920.00	771.00	924.00	1477.50	452.50	101.50	0.00
Percent of Time over 19°C	3.44%	99.00%	64.28%	N/A	40.98%	90.00%	61.83%	51.81%	62.10%	99.39%	30.00%	8.80%	0.00%
Frequency of Exceedance over 19°C (Days/yr)	9.4	62	41.00	N/A	40.00	61.00	55.00	53.00	55.00	62.00	40.00	19.00	0.00
Average Duration of Event Over 19°C (h)	5	1022.3	53.06	N/A	20.69	73.86	21.90	16.76	27.18	295.50	14.60	5.30	0.00
Hours over 22°C		1042	0.00	N/A	0.00	564.25	96.75	3.75	101.00	901.00	35.75	0.00	0.00
Percent of Time over 22°C		35.00%	0.00%	N/A	0.00%	38.00%	6.50%	0.25%	6.79%	60.61%	2.00%	0.00%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		21	0.00	N/A	0.00	41.00	16.00	2.00	6.00	48.00	7.00	0.00	0.00
Average Duration of Event Over 22°C (h)		34.1	0.00	N/A	0.00	15.94	5.17	0.95	35.28	45.03	5.11	0.00	0.00
Hours over 24°C	0	180	0.00	N/A	0.00	21.00	0.00	0.00	20.50	182.25	4.50	0.00	0.00
Percent of Time over 24°C	0.00%	6.00%	0.00%	N/A	0.00%	1.42%	0.00%	0.00%	1.38%	12.26%	0.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		3	0.00	N/A	0.00	2.00	0.00	0.00	2.00	24.00	1.00	0.00	0.00
Average Duration of Event Over 24°C (h)		20.6	0.00	N/A	0.00	21.00	0.00	0.00	10.25	5.88	4.50	0.00	0.00

Station	HC-A(04A)					
Year	**Modeled**	**2020**	**2019**	**2018**	**2017**	**2016**
Summer (July-August) average maximum	14.5 - 19.9	N/A	21.59	N/A	16.30	22.77
Summer (July-August) average	12.5 - 14.5	N/A	20.62	N/A	19.81	21.33
Summer (July-August) average minimum	9.0 - 12.0	N/A	19.70	N/A	15.07	18.90
Maximum 3-day mean	14.0 - 19.0	N/A	22.47	N/A	21.20	23.40
Maximum 7-day mean	13.0 - 17.0	N/A	22.14	N/A	20.48	22.99
Maximum 7-day mean of daily maximums	15.0 - 23.5	N/A	22.94	N/A	21.47	23.91
Hours over 19°C		N/A	1319.50	N/A	934.50	1312.75
Percent of Time over 19°C		N/A	88.68%	N/A	63.83%	89.00%
Frequency of Exceedance over 19°C (Days/yr)		N/A	57.00	N/A	49.00	62.00
Average Duration of Event Over 19°C (h)		N/A	94.28	N/A	35.94	65.64
Hours over 22°C		N/A	243.50	N/A	5.25	604.00
Percent of Time over 22°C		N/A	16.36%	N/A	0.36%	41.00%
Frequency of Exceedance over 22°C (Days/yr)		N/A	8.00	N/A	1.00	47.00
Average Duration of Event Over 22°C (h)		N/A	12.73	N/A	5.25	23.96
Hours over 24°C		N/A	0.00	N/A	0.00	29.25
Percent of Time over 24°C		N/A	0.00%	N/A	0.00%	1.99%
Frequency of 24°C Exceedance (Days/yr)		N/A	0.00	N/A	0.00	3.00
Average Duration of Event Over 24°C (h)		N/A	0.00	N/A	0.00	14.63

Station	HC-A(04B)					
Year	Modeled	2020	2019	2018	2017	2016
Summer (July-August) average maximum	14.5 - 19.9	25.4	21.78	N/A	16.44	22.83
Summer July-August) average	12.5 - 14.5	21.4	19.79	N/A	19.89	21.44
Summer (July-August) average minimum	9.0 - 12.0	15.8	18.29	N/A	15.11	18.48
Maximum 3-day mean	14.0 - 19.0	23.2	21.94	N/A	21.27	23.36
Maximum 7-day mean	13.0 - 17.0	23	21.59	N/A	20.57	22.94
Maximum 7-day mean of daily maximums	15.0 - 23.5	24.1	22.57	N/A	21.68	24.02
Hours over 19°C		2779	1065.50	N/A	956.50	1338.00
Percent of Time over 19°C		93.00%	71.61%	N/A	65.33%	91.00%
Frequency of Exceedance over 19°C (Days/yr)		58	45.00	N/A	49.00	62.00
Average Duration of Event Over 19°C (h)		1128.9	71.05	N/A	43.48	63.71
Hours over 22°C		1002	130.00	N/A	6.50	600.75
Percent of Time over 22°C		34.00%	8.74%	N/A	0.44%	41.00%
Frequency of Exceedance over 22°C (Days/yr)		17	3.00	N/A	1.00	50.00
Average Duration of Event Over 22°C (h)		27.8	3.91	N/A	6.50	23.89
Hours over 24°C		150	0.00	N/A	0.00	30.25
Percent of Time over 24°C		5.00%	0.00%	N/A	0.00%	2.06%
Frequency of 24°C Exceedance (Days/yr)		1	0.00	N/A	0.00	4.00
Average Duration of Event Over 24°C (h)		13.9	0.00	N/A	0.00	10.08

Station	HC-A(06)												
Year	Modeled	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009
Summer (July-August) average maximum	14.5 - 19.9	25.9	21.26	22.23	20.31	22.77	21.64	20.42	20.63	24.07	19.98	19.70	16.10
Summer July-August) average	12.5 - 14.5	21.2	20.14	20.69	19.26	20.97	18.86	18.95	19.48	21.88	18.02	16.70	13.90
Summer (July-August) average minimum	9.0 - 12.0	16	19.07	19.43	18.33	17.11	16.31	17.79	18.49	20.22	16.01	14.30	12.50
Maximum 3-day mean	14.0 - 19.0	22.9	22.15	22.78	20.97	22.90	21.39	20.10	23.12	24.18	21.65	16.00	13.30
Maximum 7-day mean	13.0 - 17.0	22.7	21.79	21.75	20.24	22.46	21.11	19.51	22.29	23.32	19.96	15.20	12.80
Maximum 7-day mean of daily maximums	15.0 - 23.5	24.7	22.66	23.21	21.38	23.76	25.43	21.58	23.60	26.17	21.90	17.70	15.10
Hours over 19°C	0.9	2728	1133.00	1322.50	911.00	1263.00	753.25	728.75	902.25	1386.75	512.00	269.75	0.00
Percent of Time over 19°C	0.00%	92.00%	76.14%	88.88%	62.23%	86.00%	50.62%	48.98%	60.64%	93.20%	35.00%	18.10%	0.00%
Frequency of Exceedance over 19°C (Days/yr)	0.3	59	51.00	62.00	53.00	61.00	57.00	56.00	57.00	62.00	46.00	38.00	0.00
Average Duration of Event Over 19°C (h)	3	260.8	55.47	49.16	23.36	52.63	10.46	12.35	24.39	99.05	12.80	7.10	0.00
Hours over 22°C		970	136.50	269.00	4.25	473.50	107.00	5.00	99.25	685.25	55.50	19.25	0.00
Percent of Time over 22°C		33.00%	9.17%	18.08%	0.29%	32.00%	7.19%	0.34%	6.67%	46.05%	4.00%	1.30%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		15	4.00	40.00	2.00	49.00	24.00	2.00	7.00	55.00	8.00	7.00	0.00
Average Duration of Event Over 22°C (h)		22.2	5.12	6.56	2.13	9.60	3.39	1.01	23.21	14.35	6.94	2.75	0.00
Hours over 24°C	0	147	0.00	0.50	0.00	17.25	14.75	0.00	12.50	193.50	6.50	0.00	0.00
Percent of Time over 24°C	0.00%	5.00%	0.00%	0.03%	0.00%	1.17%	0.99%	0.00%	0.84%	13.00%	0.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		1	0.00	1.00	0.00	1.00	8.00	0.00	2.00	35.00	1.00	0.00	0.00
Average Duration of Event Over 24°C (h)		8	0.00	0.50	0.00	17.25	1.64	0.00	6.25	5.23	6.50	0.00	0.00

Station	HC-A(08)												
Year	Modeled	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009
Summer (July-August) average maximum	14.5 - 19.9	17.4	13.28	14.01	13.15	8.24	14.45	8.55	18.16	15.00	14.40	14.10	13.90
Summer July-August) average	12.5 - 14.5	12.5	11.70	12.37	11.89	13.07	12.60	12.21	16.03	13.56	12.56	13.00	13.00
Summer (July-August) average minimum	9.0 - 12.0	9.6	10.58	11.25	11.00	6.53	11.28	6.17	14.37	12.40	11.21	12.10	12.20
Maximum 3-day mean	14.0 - 19.0	14.7	12.78	13.96	12.75	14.36	16.18	13.38	20.82	16.57	14.43	12.40	12.60
Maximum 7-day mean	13.0 - 17.0	13.4	12.49	13.34	12.63	13.97	15.48	12.95	20.23	15.46	13.42	12.00	12.30
Maximum 7-day mean of daily maximums	15.0 - 23.5	15.2	13.89	14.67	13.91	15.59	19.12	15.53	22.42	17.28	16.00	12.90	12.30
Hours over 19°C		0	0.00	0.00	0.00	0.00	3.75	0.00	393.25	8.50	0.00	19.25	0.00
Percent of Time over 19°C		0.00%	0.00%	0.00%	0.00%	0.00%	0.25%	0.00%	26.43%	0.57%	0.00%	1.60%	0.00%
Frequency of Exceedance over 19°C (Days/yr)		0	0.00	0.00	0.00	0.00	5.00	0.00	38.00	2.00	0.00	3.00	0.00
Average Duration of Event Over 19°C (h)		0	0.00	0.00	0.00	0.00	0.63	0.00	10.63	4.25	0.00	6.40	0.00
Hours over 22°C		0	0.00	0.00	0.00	0.00	0.00	0.00	41.75	0.00	0.00	0.00	0.00
Percent of Time over 22°C		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.81%	0.00%	0.00%	0.00%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		0%	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00
Average Duration of Event Over 22°C (h)		0	0.00	0.00	0.00	0.00	0.00	0.00	2.69	0.00	0.00	0.00	0.00
Hours over 24°C		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent of Time over 24°C		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average Duration of Event Over 24°C (h)		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Station	HC-A(09)												
Year	**Modeled**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	27	23.09	23.69	21.37	23.37	22.34	21.80	21.75	23.70	20.72	19.70	17.20
Summer July-August) average	12.5 - 14.5	20.9	20.17	20.83	19.07	20.79	19.18	18.62	19.24	20.33	18.85	17.90	15.00
Summer (July-August) average minimum	9.0 - 12.0	13.8	17.97	18.61	17.36	18.68	16.76	16.36	17.31	17.57	17.11	16.30	13.10
Maximum 3-day mean	14.0 - 19.0	23.6	22.81	22.50	20.69	22.81	21.97	20.43	23.46	23.92	22.26	17.10	n/a
Maximum 7-day mean	13.0 - 17.0	22.8	22.14	21.86	20.17	22.02	21.31	19.47	22.63	22.45	20.67	16.20	n/a
Maximum 7-day mean of daily maximums	15.0 - 23.5	26.1	24.55	25.86	23.22	24.69	25.49	23.03	25.67	26.75	23.00	18.90	n/a
Hours over 19°C	10	2368	1006.50	1163.00	738.00	1200.00	742.25	621.50	784.00	1014.75	701.00	506.25	11.75
Percent of Time over 19°C	0.67%	80.00%	67.64%	78.16%	50.41%	81.00%	49.88%	41.77%	52.69%	68.20%	47.00%	34.00%	215.00%
Frequency of Exceedance over 19°C (Days/yr)	2.8	54	50.00	62.00	55.00	62.00	58.00	60.00	59.00	62.00	54.00	28.00	3.00
Average Duration of Event Over 19°C (h)	3.4	92.5	30.75	30.32	13.92	37.50	14.55	10.90	16.33	23.06	17.10	18.10	3.90
Hours over 22°C		986	350.50	439.50	85.00	448.50	223.75	106.25	171.25	417.50	115.50	52.00	0.00
Percent of Time over 22°C		33.00%	23.56%	29.54%	5.81%	30.00%	15.04%	7.14%	11.51%	28.06%	8.00%	3.40%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		14	6.00	54.00	21.00	57.00	38.00	26.00	22.00	46.00	13.00	6.00	0.00
Average Duration of Event Over 22°C (h)		14.2	4.75	30.21	4.05	6.42	3.90	2.66	8.22	7.90	8.88	8.70	0.00
Hours over 24°C	0	269	50.50	105.50	1.75	80.50	47.50	13.50	41.75	169.00	10.75	5.50	0.00
Percent of Time over 24°C	0.00%	9.00%	3.39%	7.09%	0.12%	5.41%	3.19%	0.91%	2.81%	11.36%	1.00%	0.40%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0	0.00	24.00	2.00	17.00	10.00	6.00	6.00	26.00	1.00	2.00	0.00
Average Duration of Event Over 24°C (h)		7.1	2.22	4.22	0.88	4.74	4.75	2.25	6.96	6.50	10.75	2.75	0.00

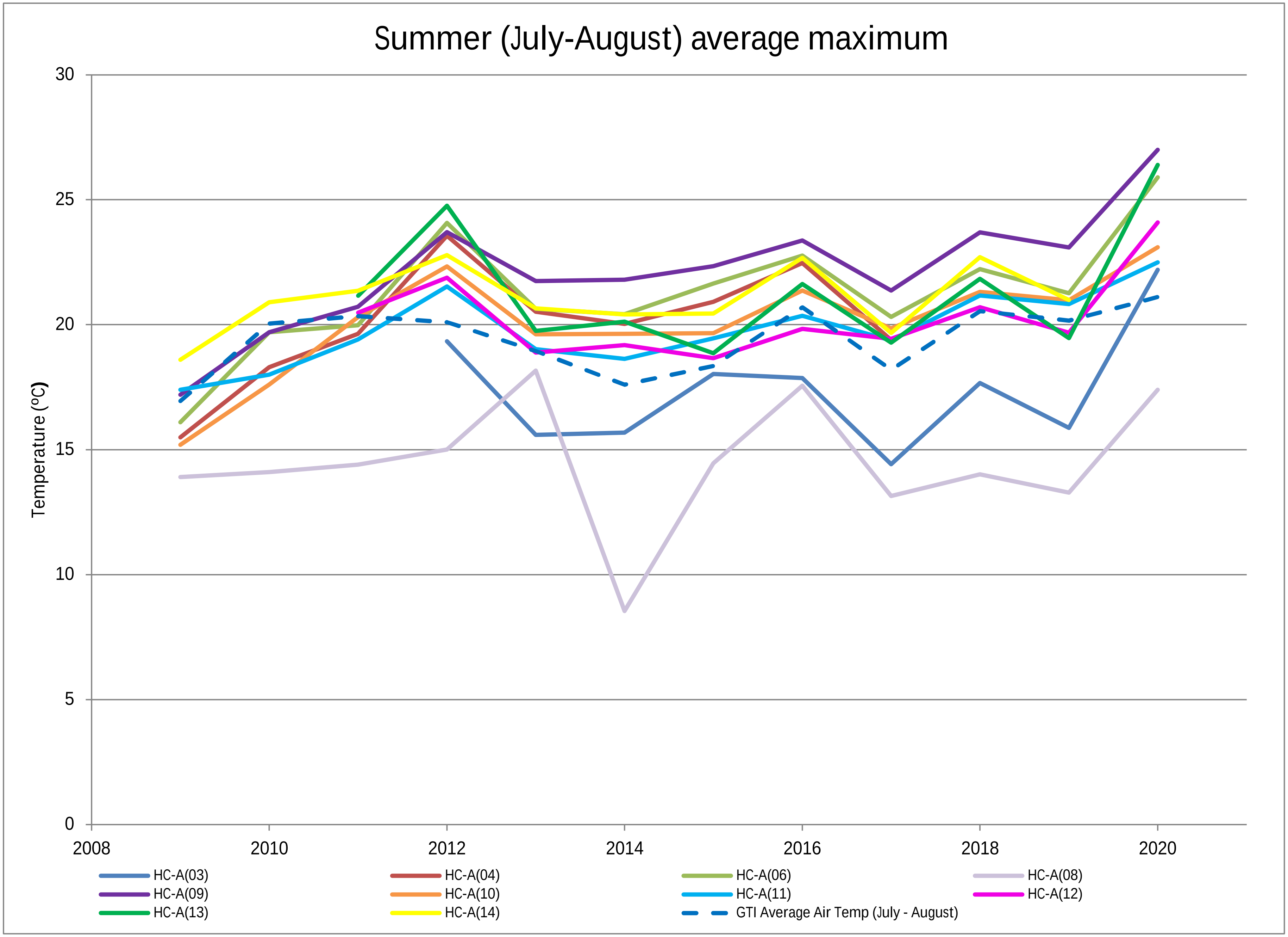
Station	HC-A(10)												
Year	**Modeled**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	23.1	20.98	21.32	19.86	21.37	19.66	19.63	19.62	22.33	20.30	17.60	15.20
Summer July-August) average	12.5 - 14.5	18.3	18.40	18.60	17.59	18.67	16.89	16.88	17.34	18.00	18.28	14.70	13.70
Summer (July-August) average minimum	9.0 - 12.0	12.2	16.39	16.53	15.89	16.50	14.81	14.82	15.59	14.99	16.47	12.50	12.70
Maximum 3-day mean	14.0 - 19.0	20.2	20.94	20.44	19.08	20.60	19.34	18.74	21.06	20.64	21.93	14.00	n/a
Maximum 7-day mean	13.0 - 17.0	19.8	20.33	19.67	18.50	19.79	18.85	17.76	20.31	19.48	20.26	13.40	n/a
Maximum 7-day mean of daily maximums	15.0 - 23.5	22.4	22.58	22.95	21.34	22.65	21.31	21.20	23.20	29.53	22.67	14.80	n/a
Hours over 19°C	58.4	1086	611.00	636.25	298.75	692.75	260.25	221.75	295.00	513.50	573.75	18.75	0.00
Percent of Time over 19°C	3.93%	36.00%	41.06%	42.76%	20.41%	47.00%	17.49%	14.90%	19.83%	34.67%	39.00%	1.20%	0.00%
Frequency of Exceedance over 19°C (Days/yr)	10.3	21	19.00	57.00	45.00	61.00	44.00	40.00	33.00	53.00	50.00	7.00	0.00
Average Duration of Event Over 19°C (h)	5.2	22.8	21.29	11.63	6.36	12.60	5.66	5.28	9.52	9.01	13.99	2.70	0.00
Hours over 22°C		119	54.50	75.25	3.75	84.25	12.50	9.50	36.00	121.25	92.50	0.00	0.00
Percent of Time over 22°C		4.00%	3.66%	5.06%	0.26%	6.00%	0.84%	0.64%	2.42%	8.19%	6.00%	0.00%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		0	0.00	16.00	2.00	20.00	6.00	4.00	6.00	25.00	14.00	0.00	0.00
Average Duration of Event Over 22°C (h)		4.9	2.45	4.70	1.88	3.28	1.40	1.97	3.27	3.28	6.61	0.00	0.00
Hours over 24°C	0.4	0	2.00	1.00	0.00	0.00	0.00	0.00	2.00	46.75	9.50	0.00	0.00
Percent of Time over 24°C	0.03%	0.00%	0.13%	0.07%	0.00%	0.00%	0.00%	0.00%	0.13%	3.16%	1.00%	0.00%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0	0.00	1.00	0.00	0.00	0.00	0.00	2.00	12.00	1.00	0.00	0.00
Average Duration of Event Over 24°C (h)		0	1.25	1.00	0.00	0.00	0.00	0.00	1.00	3.60	9.50	0.00	0.00

Station	HC-A(11)												
Year	**Modeled**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	22.5	20.82	21.17	19.37	20.36	19.45	18.63	19.03	21.53	19.41	18.00	17.40
Summer July-August) average	12.5 - 14.5	18.3	18.41	18.65	17.59	18.51	17.06	16.97	17.39	18.43	18.09	13.10	14.50
Summer (July-August) average minimum	9.0 - 12.0	12.6	16.49	16.68	16.18	16.95	15.19	15.60	16.10	16.04	16.84	15.10	12.30
Maximum 3-day mean	14.0 - 19.0	20.1	20.95	20.45	19.02	20.31	19.40	18.89	20.67	21.09	20.96	14.40	n/a
Maximum 7-day mean	13.0 - 17.0	19.7	20.34	19.73	18.49	19.61	18.94	17.87	20.00	19.90	19.97	13.80	n/a
Maximum 7-day mean of daily maximums	15.0 - 23.5	21.9	22.49	22.84	20.56	21.23	21.00	19.88	21.69	23.43	20.79	15.30	n/a
Hours over 19°C	57.8	1054	605.00	649.00	259.25	611.50	259.00	135.50	264.25	587.75	457.25	61.50	11.75
Percent of Time over 19°C	3.89%	35.00%	40.66%	43.62%	17.71%	41.00%	17.41%	9.11%	17.76%	39.50%	31.00%	4.10%	215.00%
Frequency of Exceedance over 19°C (Days/yr)	9.8	18	19.00	57.00	38.00	55.00	43.00	23.00	30.00	56.00	37.00	12.00	6.00
Average Duration of Event Over 19°C (h)	5.6	23.2	21.43	12.08	6.65	12.48	5.89	5.89	9.44	11.09	9.33	5.10	2.00
Hours over 22°C		61	45.50	67.75	0.00	15.25	3.25	0.00	11.00	117.50	13.50	11.25	0.00
Percent of Time over 22°C		2.00%	3.06%	4.55%	0.00%	1.00%	0.22%	0.00%	0.74%	7.90%	1.00%	0.80%	0.00%
Frequency of Exceedance over 22°C (Days/yr)		0	0.00	15.00	0.00	6.00	1.00	0.00	4.00	26.00	3.00	4.00	0.00
Average Duration of Event Over 22°C (h)		3.8	2.46	4.52	0.00	2.34	1.75	0.00	1.77	3.40	4.50	2.80	0.00
Hours over 24°C	0.8	0	1.50	1.00	0.00	0.00	0.00	0.00	0.00	23.75	0.00	1.00	0.00
Percent of Time over 24°C	0.06%	0.00%	0.10%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%	1.60%	0.00%	0.07%	0.00%
Frequency of 24°C Exceedance (Days/yr)		0	0.00	1.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	1.00	0.00
Average Duration of Event Over 24°C (h)		0	1.00	1.00	0.00	0.00	0.00	0.00	0.00	3.96	0.00	1.00	0.00

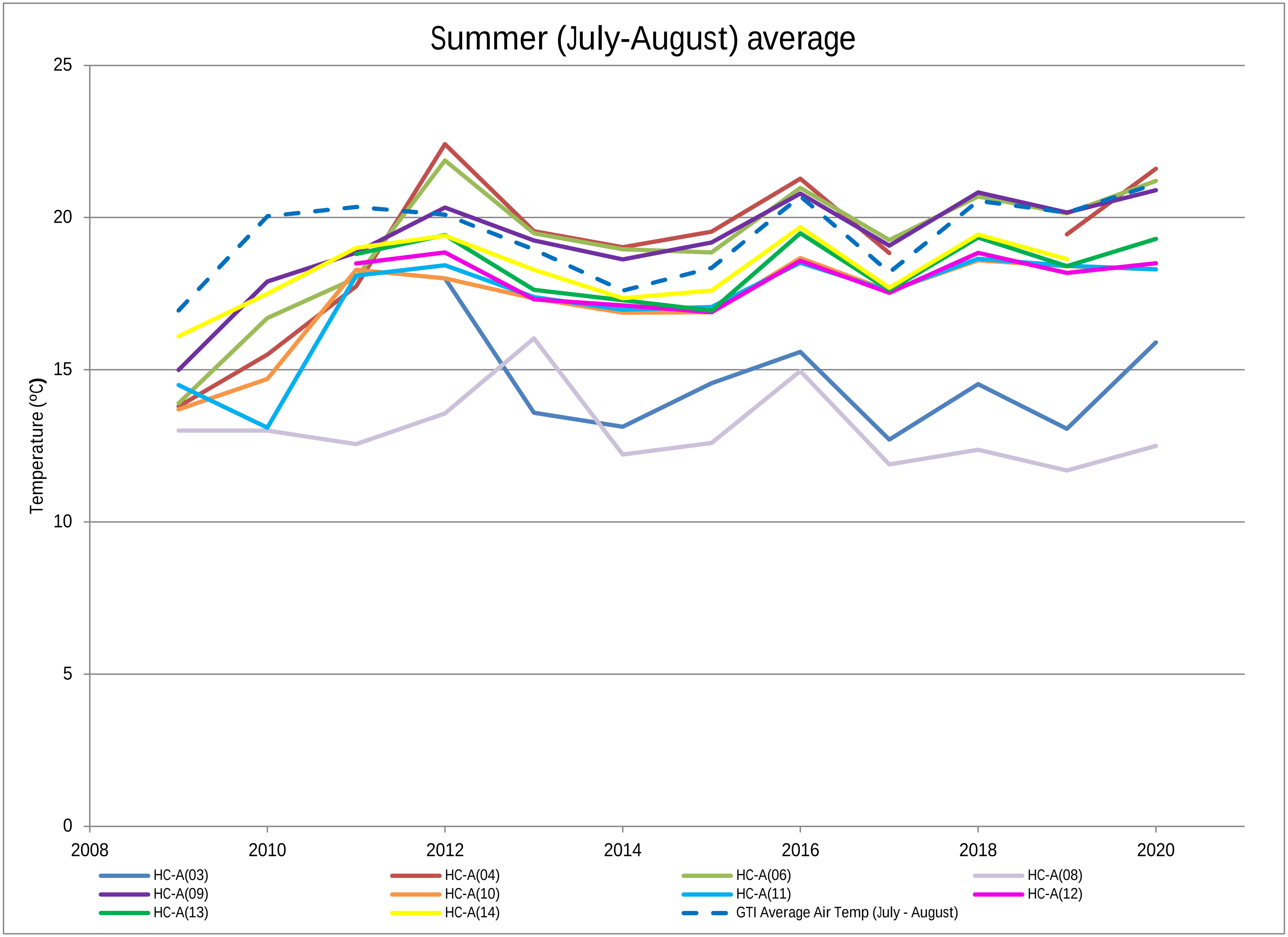
Station	HC-A(12)										
Year	**Modeled**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**
Summer (July-August) average maximum	14.5 - 19.9	24.1	19.68	20.70	19.44	19.83	18.67	19.18	18.88	21.88	20.48
Summer July-August) average	12.5 - 14.5	18.5	18.18	18.84	17.52	18.58	16.89	17.11	17.31	18.86	18.49
Summer (July-August) average minimum	9.0 - 12.0	13.8	16.83	17.19	15.95	17.43	15.33	15.41	15.97	16.21	16.71
Maximum 3-day mean	14.0 - 19.0	20.9	20.69	20.53	18.99	20.34	19.23	19.36	21.53	22.40	22.02
Maximum 7-day mean	13.0 - 17.0	20.2	20.04	19.93	18.48	19.70	18.62	18.38	20.68	20.90	20.32
Maximum 7-day mean of daily maximums	15.0 - 23.5	23	21.53	22.80	20.86	20.66	21.23	21.12	23.45	25.79	23.04
Hours over 19°C	57.8	1085	497.00	701.00	292.00	615.75	184.00	218.00	226.75	636.50	597.25
Percent of Time over 19°C	3.89%	36.00%	33.40%	47.11%	19.95%	41.00%	12.37%	14.65%	15.24%	42.89%	40.00%
Frequency of Exceedance over 19°C (Days/yr)	9.8	25	15.00	55.00	41.00	48.00	25.00	28.00	26.00	51.00	49.00
Average Duration of Event Over 19°C (h)	5.6	25.8	24.59	15.31	7.12	16.64	7.36	7.52	9.86	12.48	15.31
Hours over 22°C		109	8.50	60.25	1.00	0.00	2.50	10.75	43.00	205.00	105.00
Percent of Time over 22°C		4.00%	0.57%	4.05%	0.07%	0.00%	0.17%	0.72%	2.89%	13.81%	7.00%
Frequency of Exceedance over 22°C (Days/yr)		0	0.00	12.00	1.00	0.00	1.00	3.00	6.00	30.00	15.00
Average Duration of Event Over 22°C (h)		6.4	4.50	5.02	1.00	0.00	1.38	2.06	4.05	4.66	7.00
Hours over 24°C	0.8	1	0.00	0.00	0.00	0.00	0.00	0.00	9.00	78.50	10.00
Percent of Time over 24°C	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	5.29%	1.00%
Frequency of 24°C Exceedance (Days/yr)		0	0.00	0.00	0.00	0.00	0.00	0.00	3.00	18.00	1.00
Average Duration of Event Over 24°C (h)		0.5	0.00	0.00	0.00	0.00	0.00	0.00	3.00	3.74	10.00

Station	HC-A(13)										
Year	**Modeled**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**
Summer (July-August) average maximum	14.5 - 19.9	26.4	19.47	21.84	19.28	21.63	18.87	20.12	19.75	24.76	21.16
Summer July-August) average	12.5 - 14.5	19.3	18.40	19.34	17.62	19.49	16.95	17.29	17.63	19.43	18.80
Summer (July-August) average minimum	9.0 - 12.0	12.6	17.46	17.14	16.04	17.53	15.28	14.92	15.77	15.11	16.68
Maximum 3-day mean	14.0 - 19.0	22.9	20.75	21.01	18.98	21.54	19.23	19.52	21.93	23.42	22.30
Maximum 7-day mean	13.0 - 17.0	21.6	20.05	20.43	18.59	20.64	18.62	18.37	21.05	22.01	20.67
Maximum 7-day mean of daily maximums	15.0 - 23.5	24.9	20.97	23.66	20.72	23.66	21.23	21.76	24.11	29.89	23.56
Hours over 19°C	57.8	1549	544.00	825.50	299.75	930.50	198.50	350.00	365.75	713.50	690.75
Percent of Time over 19°C	3.89%	52.00%	36.56%	55.48%	20.47%	63.00%	13.34%	23.52%	24.58%	48.20%	46.00%
Frequency of Exceedance over 19°C (Days/yr)	9.8	38	17.00	59.00	41.00	61.00	28.00	46.00	35.00	57.00	55.00
Average Duration of Event Over 19°C (h)	5.6	33.1	26.39	16.56	7.69	19.80	7.09	7.61	11.43	12.30	14.70
Hours over 22°C		294	5.50	164.50	0.00	142.75	2.50	28.00	62.25	352.00	138.50
Percent of Time over 22°C		10.00%	0.37%	11.06%	0.00%	10.00%	0.17%	1.88%	4.18%	23.78%	9.00%
Frequency of Exceedance over 22°C (Days/yr)		3	0.00	29.00	0.00	22.00	1.00	6.00	9.00	41.00	18.00
Average Duration of Event Over 22°C (h)		10.4	3.00	5.67	0.00	4.11	1.38	2.87	4.45	4.90	7.69
Hours over 24°C	0.8	78	0.00	17.00	0.00	24.25	0.00	0.00	18.00	207.00	16.25
Percent of Time over 24°C	0.06%	3.00%	0.00%	1.14%	0.00%	1.63%	0.00%	0.00%	1.21%	13.98%	1.00%
Frequency of 24°C Exceedance (Days/yr)		0	0.00	7.00	0.00	4.00	0.00	0.00	4.00	30.00	4.00
Average Duration of Event Over 24°C (h)		8.9	0.00	2.43	0.00	6.06	0.00	0.00	4.50	6.27	4.06

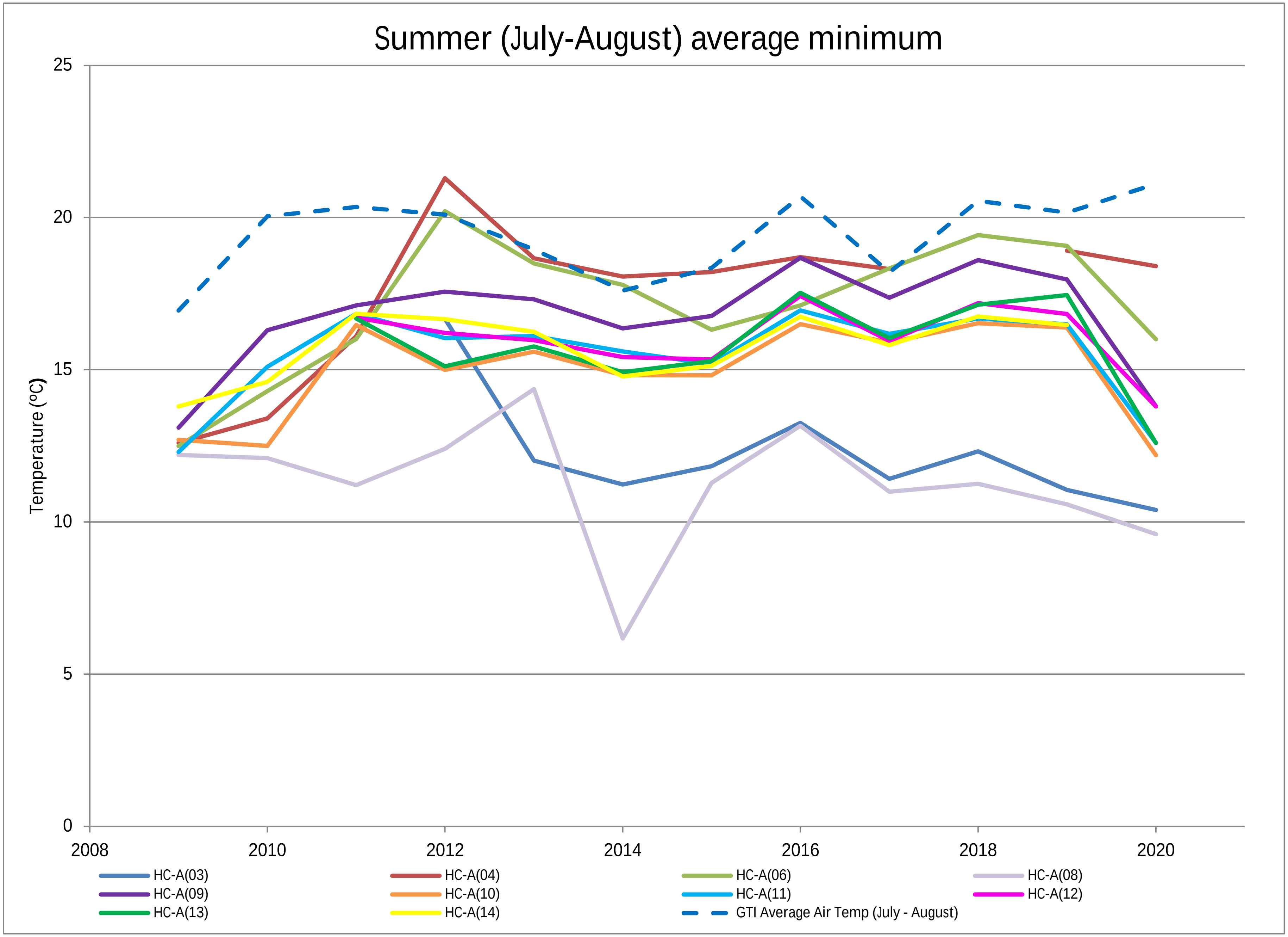
Station	HC-A(14)												
Year	**Modeled**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
Summer (July-August) average maximum	14.5 - 19.9	N/A	20.99	22.70	19.67	22.68	20.44	20.41	20.65	22.79	21.36	20.90	18.60
Summer July-August) average	12.5 - 14.5	N/A	18.63	19.44	17.69	19.69	17.60	17.35	18.28	19.40	19.00	17.50	16.10
Summer (July-August) average minimum	9.0 - 12.0	N/A	16.47	16.75	15.81	16.74	15.13	14.78	16.24	16.66	16.84	14.60	13.80
Maximum 3-day mean	14.0 - 19.0	N/A	21.39	21.26	19.13	21.90	20.23	19.55	22.51	22.67	22.45	16.70	15.40
Maximum 7-day mean	13.0 - 17.0	N/A	20.66	20.56	18.74	20.99	19.57	18.46	21.65	21.45	20.86	15.80	14.80
Maximum 7-day mean of daily maximums	15.0 - 23.5	N/A	22.68	25.09	20.90	24.70	23.31	22.43	24.66	26.40	23.78	18.30	17.80
Hours over 19°C	130.7	N/A	674.50	824.75	357.25	927.75	431.00	383.00	578.50	778.50	741.25	422.25	187.00
Percent of Time over 19°C	8.78%	N/A	45.33%	55.43%	24.40%	62.00%	28.97%	26.00%	38.88%	52.32%	50.00%	28.40%	1257.00%
Frequency of Exceedance over 19°C (Days/yr)	26.8	N/A	22.00	61.00	46.00	62.00	49.00	50.00	50.00	55.00	56.00	49.00	29.00
Average Duration of Event Over 19°C (h)	4.3	N/A	21.71	15.59	7.94	18.56	8.98	7.37	13.15	16.56	12.15	8.60	6.20
Hours over 22°C		N/A	84.50	237.25	0.00	260.00	59.00	41.00	86.50	287.25	157.75	95.00	0.50
Percent of Time over 22°C		N/A	5.68%	15.94%	0.00%	17.00%	3.97%	3.00%	5.81%	19.30%	11.00%	6.40%	0.03%
Frequency of Exceedance over 22°C (Days/yr)		N/A	1.00	39.00	0.00	37.00	14.00	9.00	11.00	37.00	19.00	20.00	1.00
Average Duration of Event Over 22°C (h)		N/A	3.06	5.65	0.00	4.57	2.91	4.50	5.15	5.09	8.30	4.75	0.50
Hours over 24°C	3.2	N/A	5.00	60.50	0.00	59.00	3.25	3.00	26.75	113.50	28.00	25.75	0.00
Percent of Time over 24°C	0.21%	N/A	0.34%	4.07%	0.00%	3.97%	0.22%	0.00%	1.80%	7.63%	2.00%	0.30%	0.00%
Frequency of 24°C Exceedance (Days/yr)		N/A	0.00	14.00	0.00	12.00	1.00	1.00	5.00	24.00	9.00	5.00	0.00
Average Duration of Event Over 24°C (h)		N/A	2.75	4.32	0.00	4.54	3.25	1.50	5.35	4.37	2.15	5.15	0.00

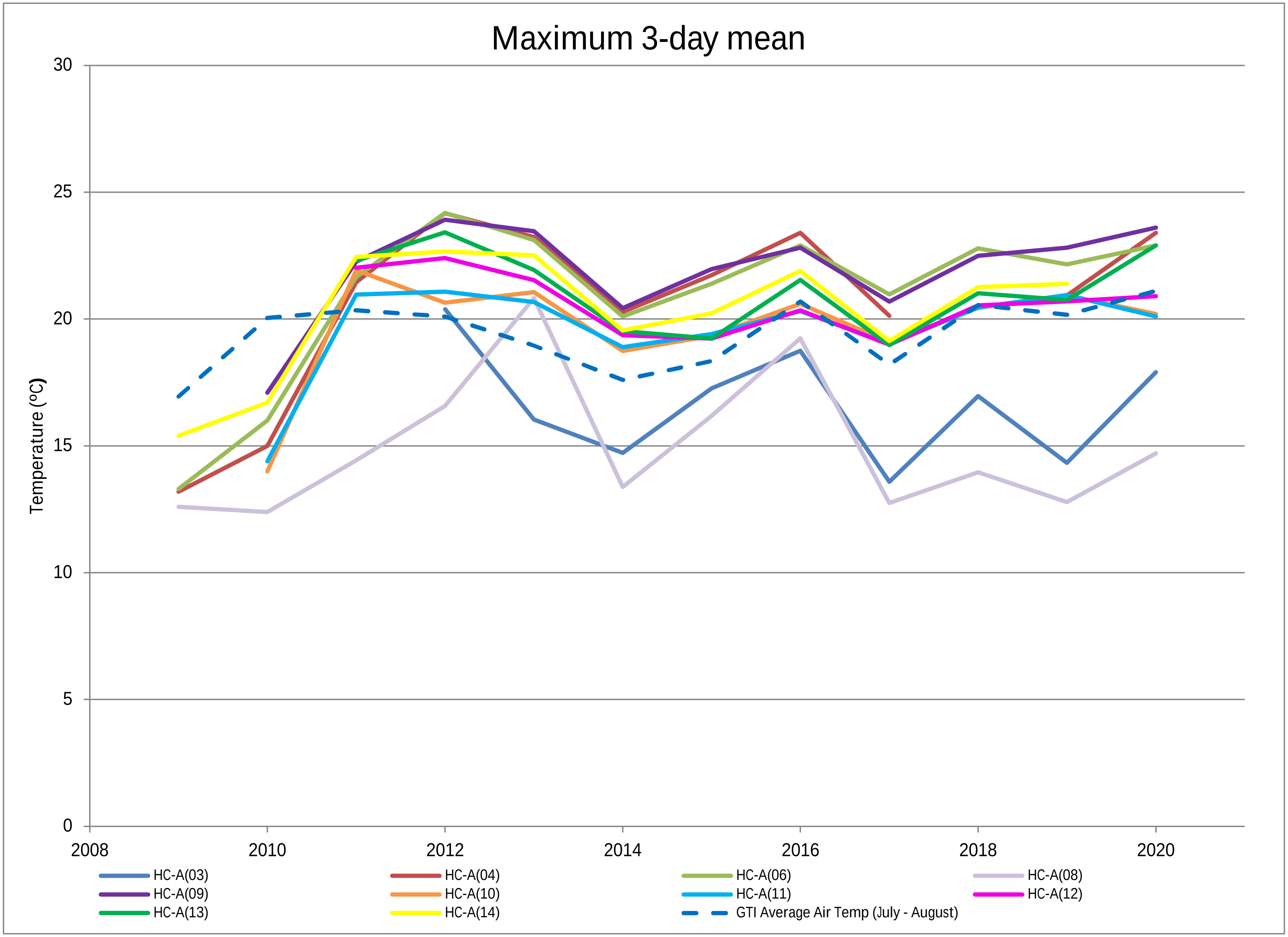


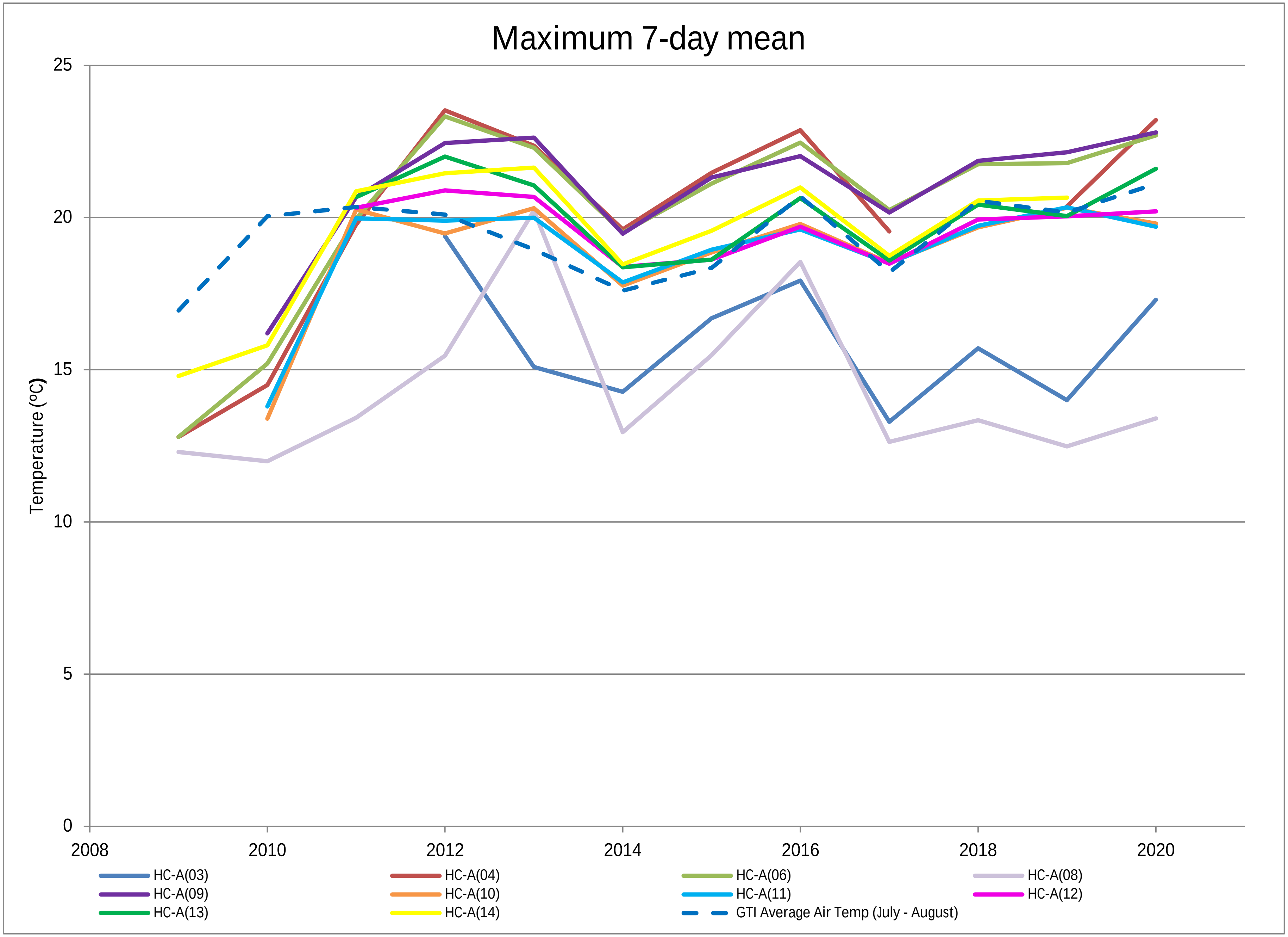
Summer (July-August) average maximum
Temperature (°C)
30
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



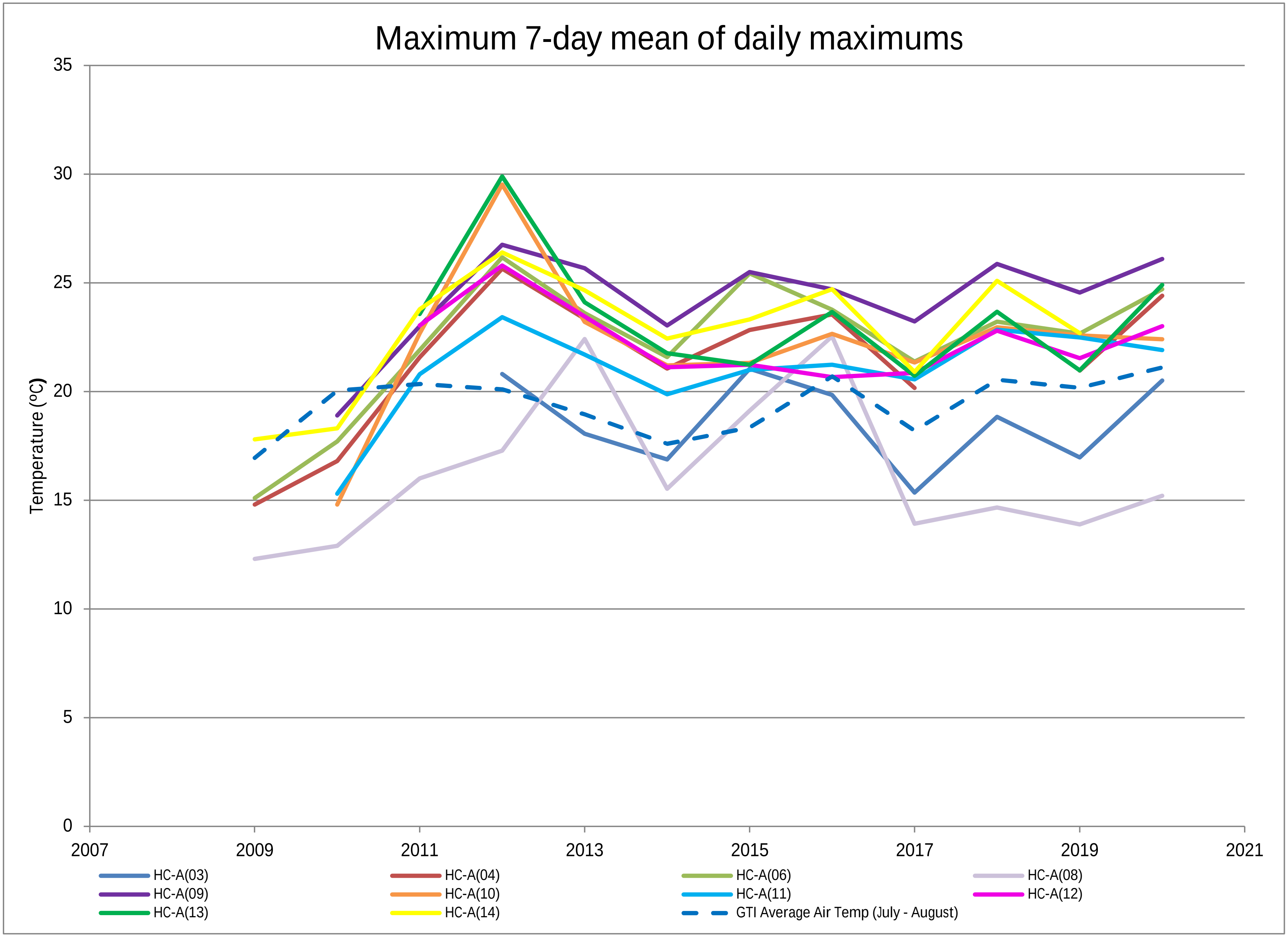
Summer (July-August) average
Temperature (ºC)
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)


Summer (July-August) average minimum
Temperature (°C)
0
5
10
15
20
25
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

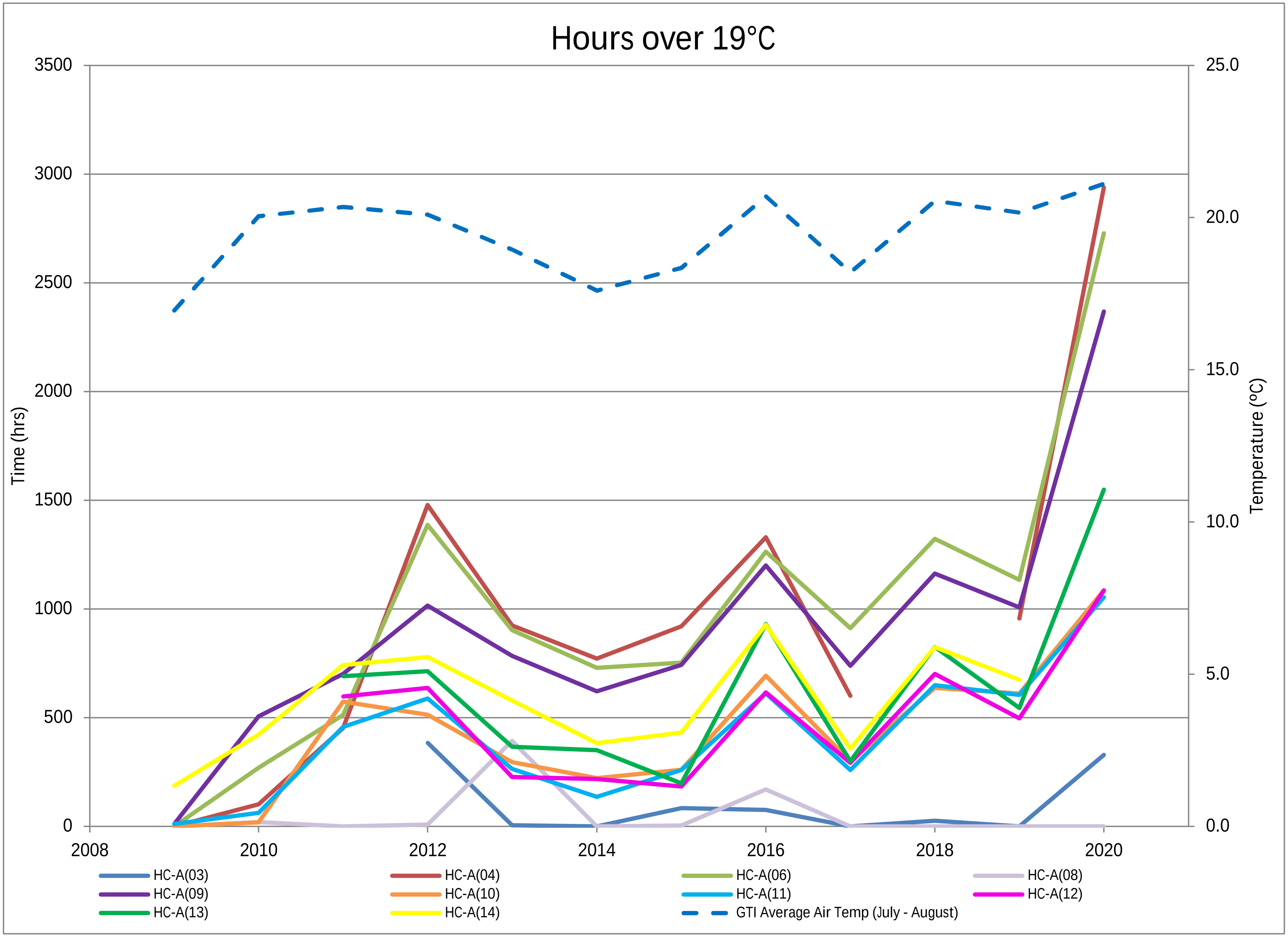

Maximum 3-day mean
Temperature (ºC)
30
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



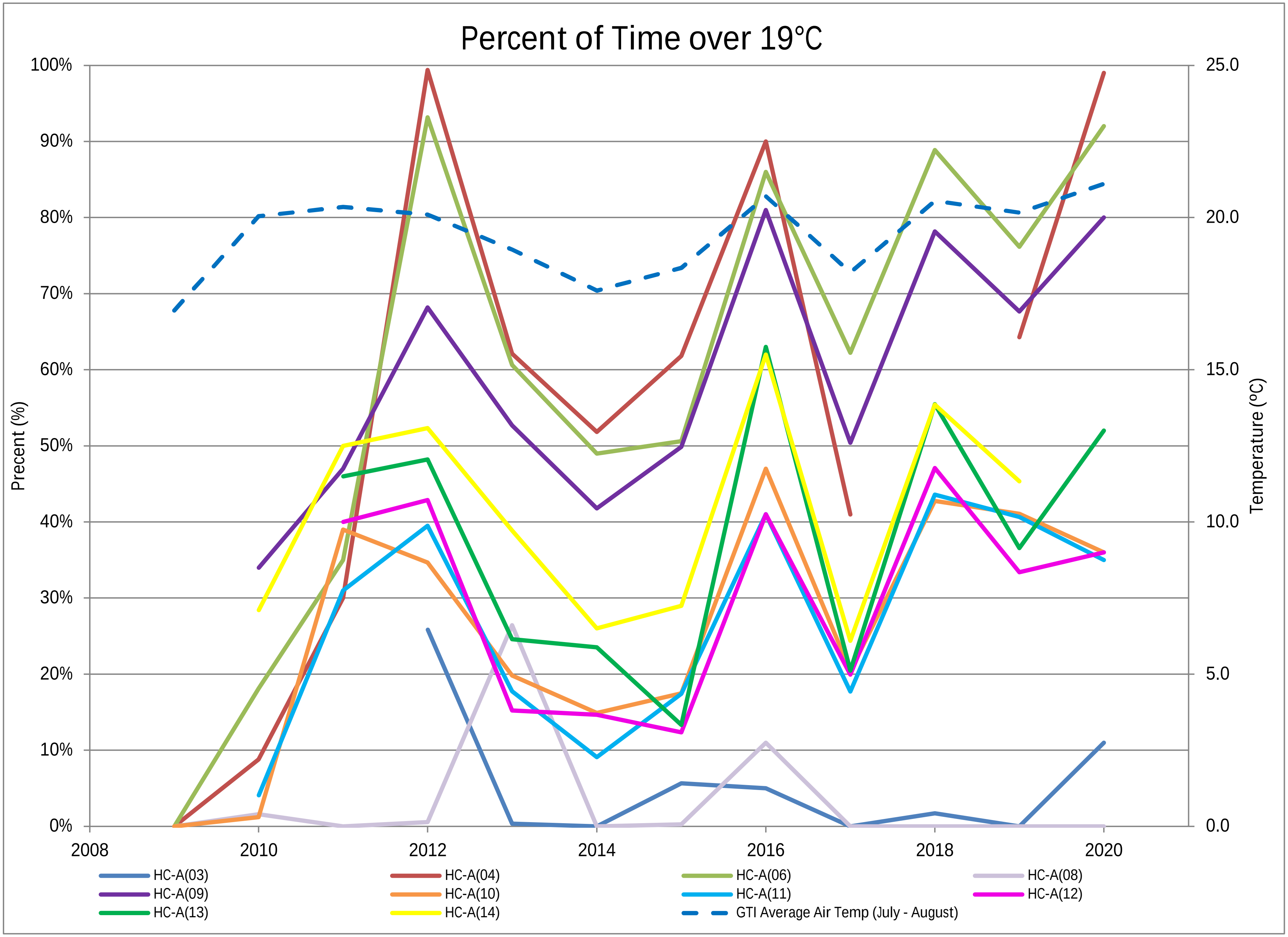
Maximum 7-day mean
Temperature (ºC)
0
5
10
15
20
25
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

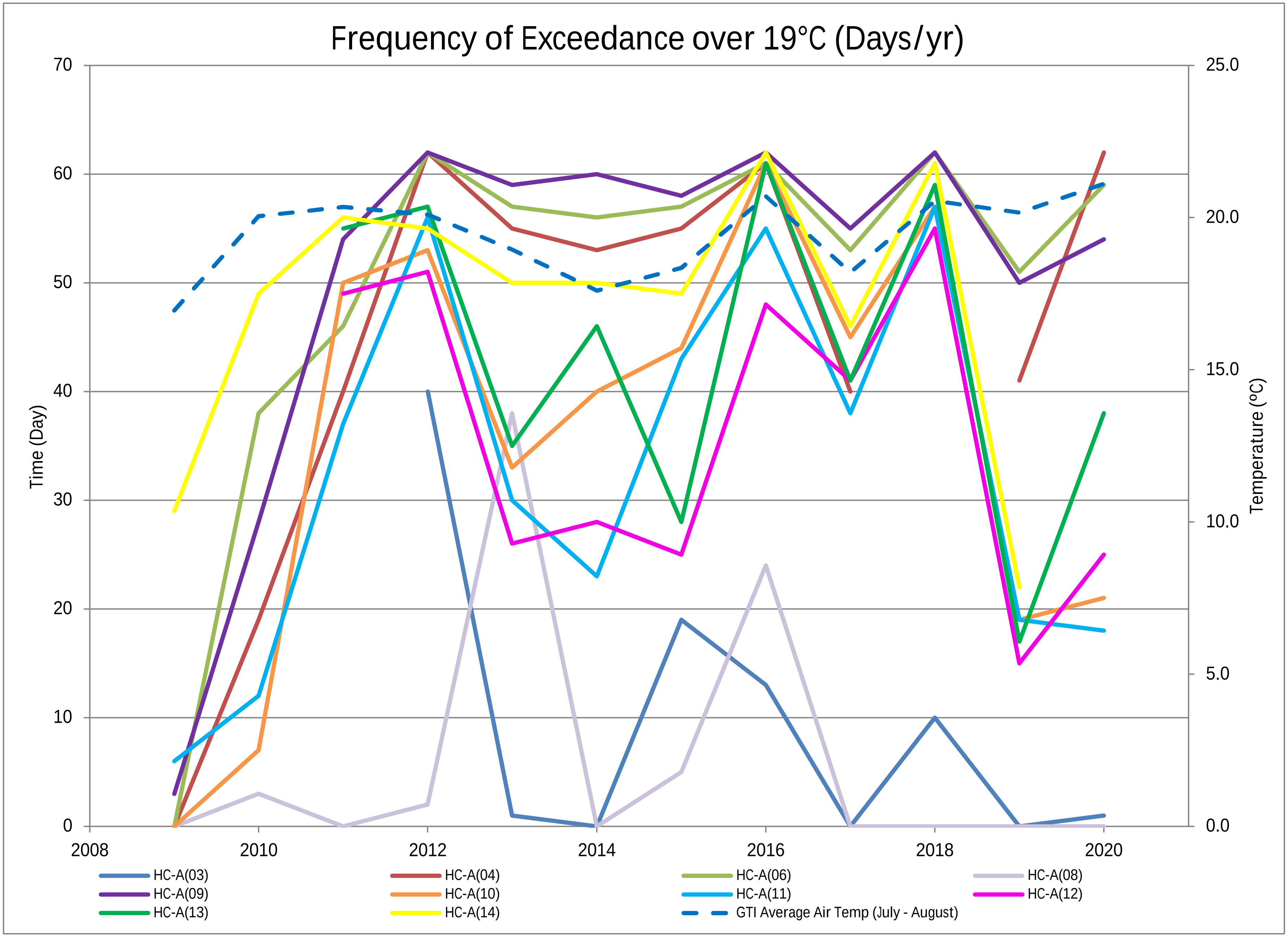


Maximum 7-day mean of daily maximums
Temperature (ºC)
0
5
10
15
20
25
30
35
2007
2009
2011
2013
2015
2017
2019
2021
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

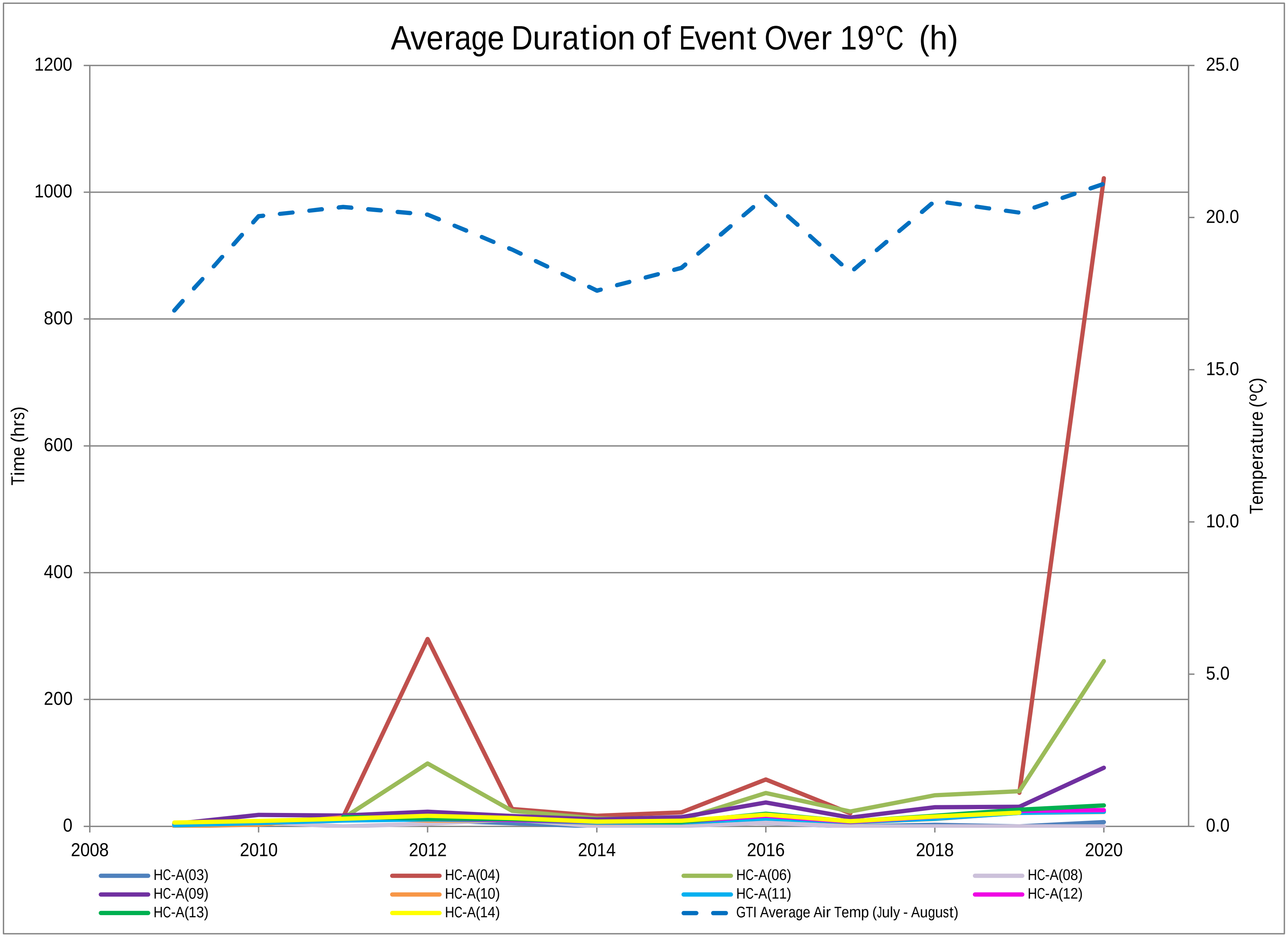


Hours over 19°C
Time (hrs)
Temperature (°C)
3500
3000
2500
2000
1500
1000
500
0
25.0
20.0
15.0
10.0
5.0
0.0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

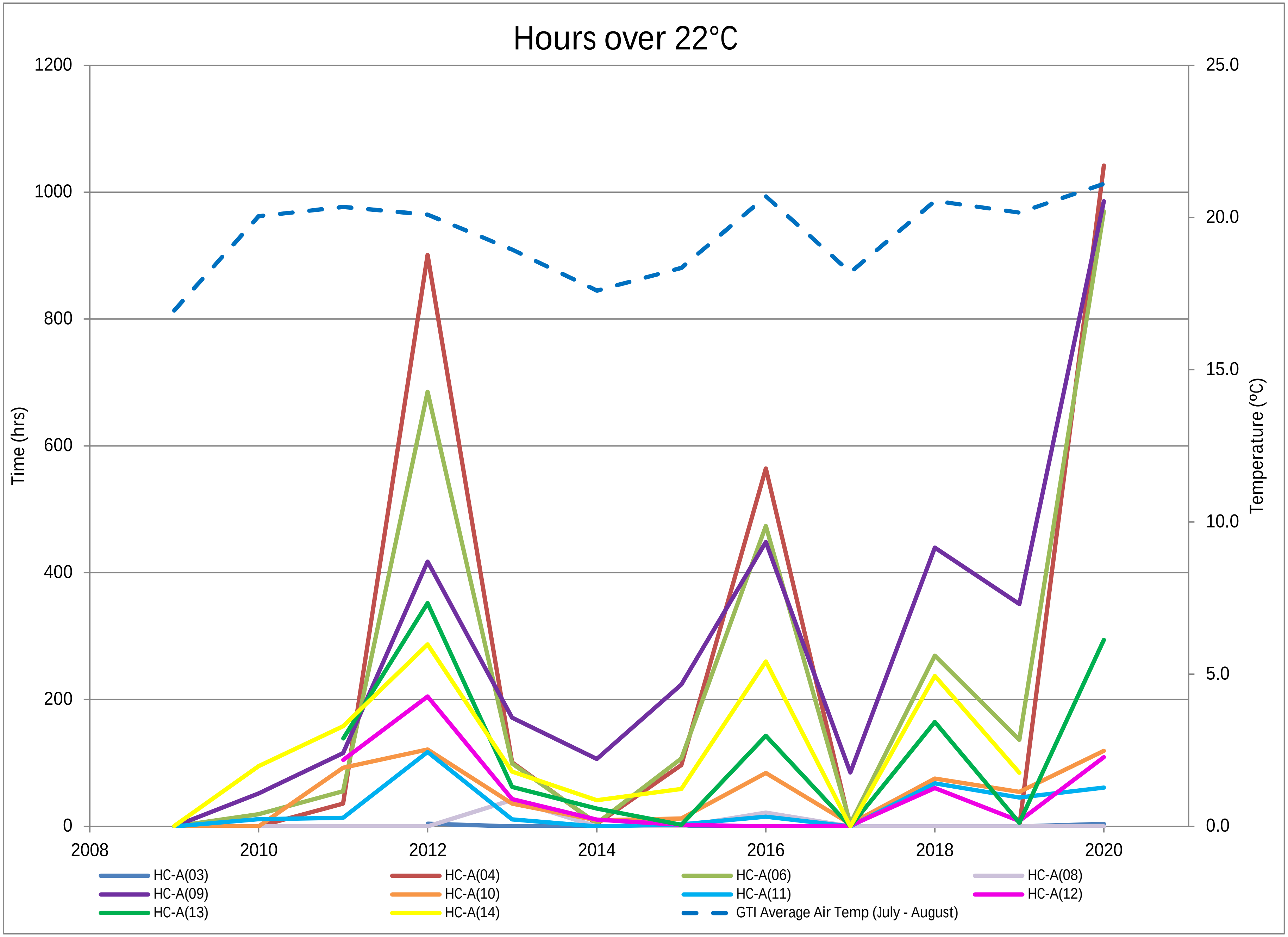

Percent of Time over 19°C
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Precent (%)
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (°C)
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

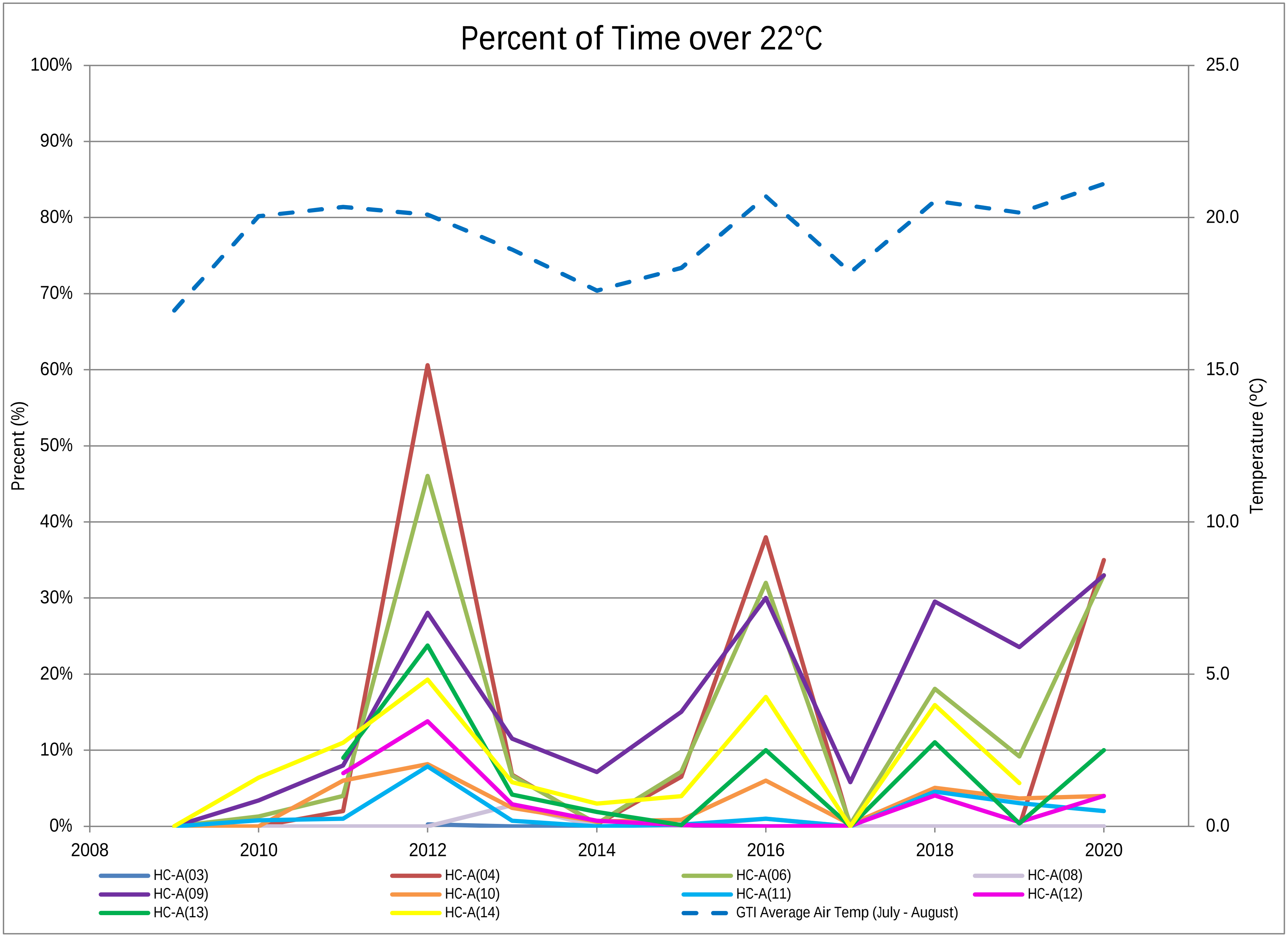


Frequency of Exceedance over 19°C (Days/yr)
Time (Day)
Temperature (ºC)
0
10
20
30
40
50
60
70
0.0
5.0
10.0
15.0
20.0
25.0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)



Average Duration of Event Over 19°C (h)
Time (hrs)
Temperature (°C)
1200
1000
800
600
400
200
0
25.0
20.0
15.0
10.0
5.0
0.0
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

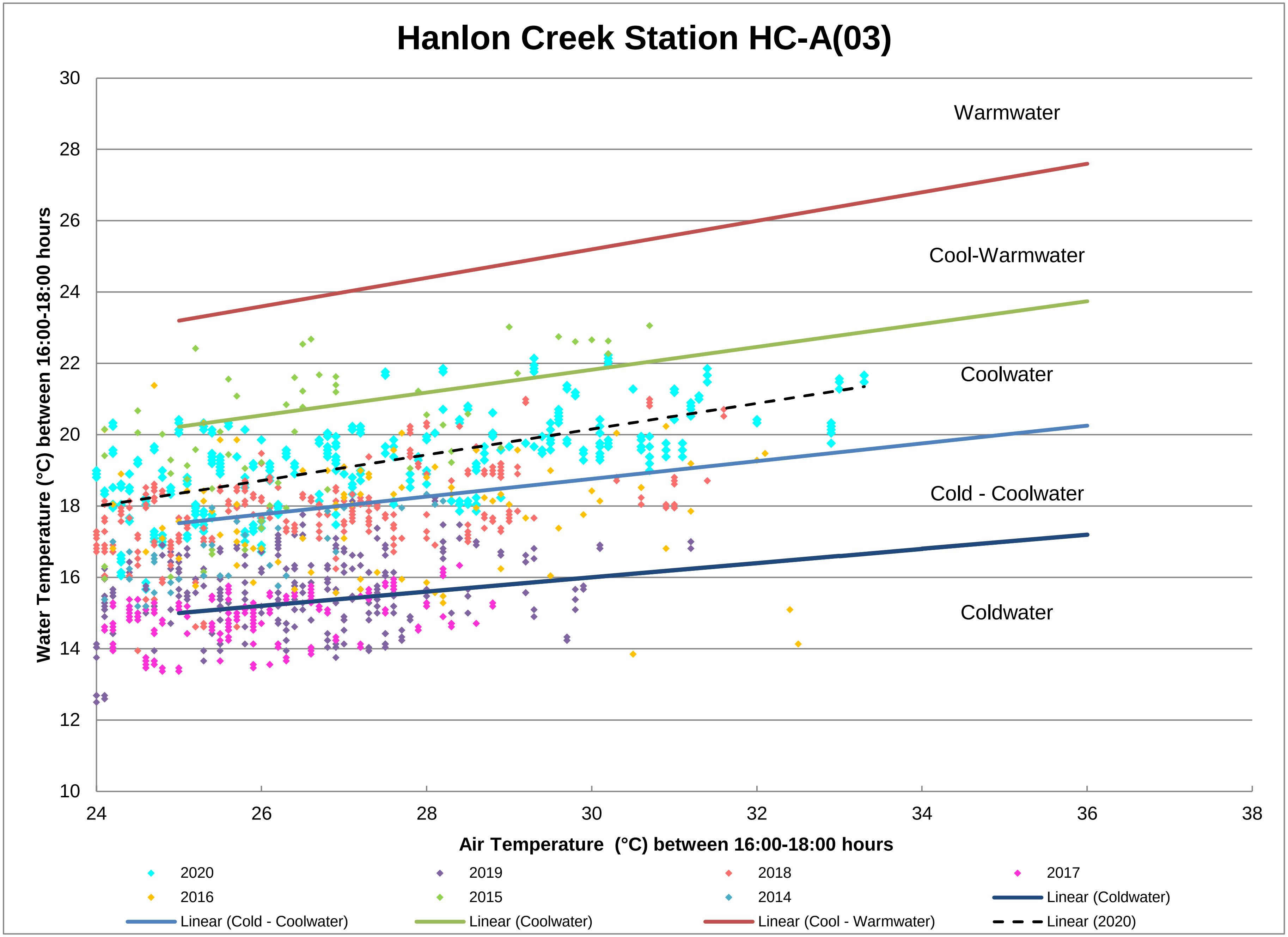

Hours over 22°C
Time (hrs)
1200
1000
800
600
400
200
0
2008
2010
2012
2014
2016
2018
2020
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (°C)
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

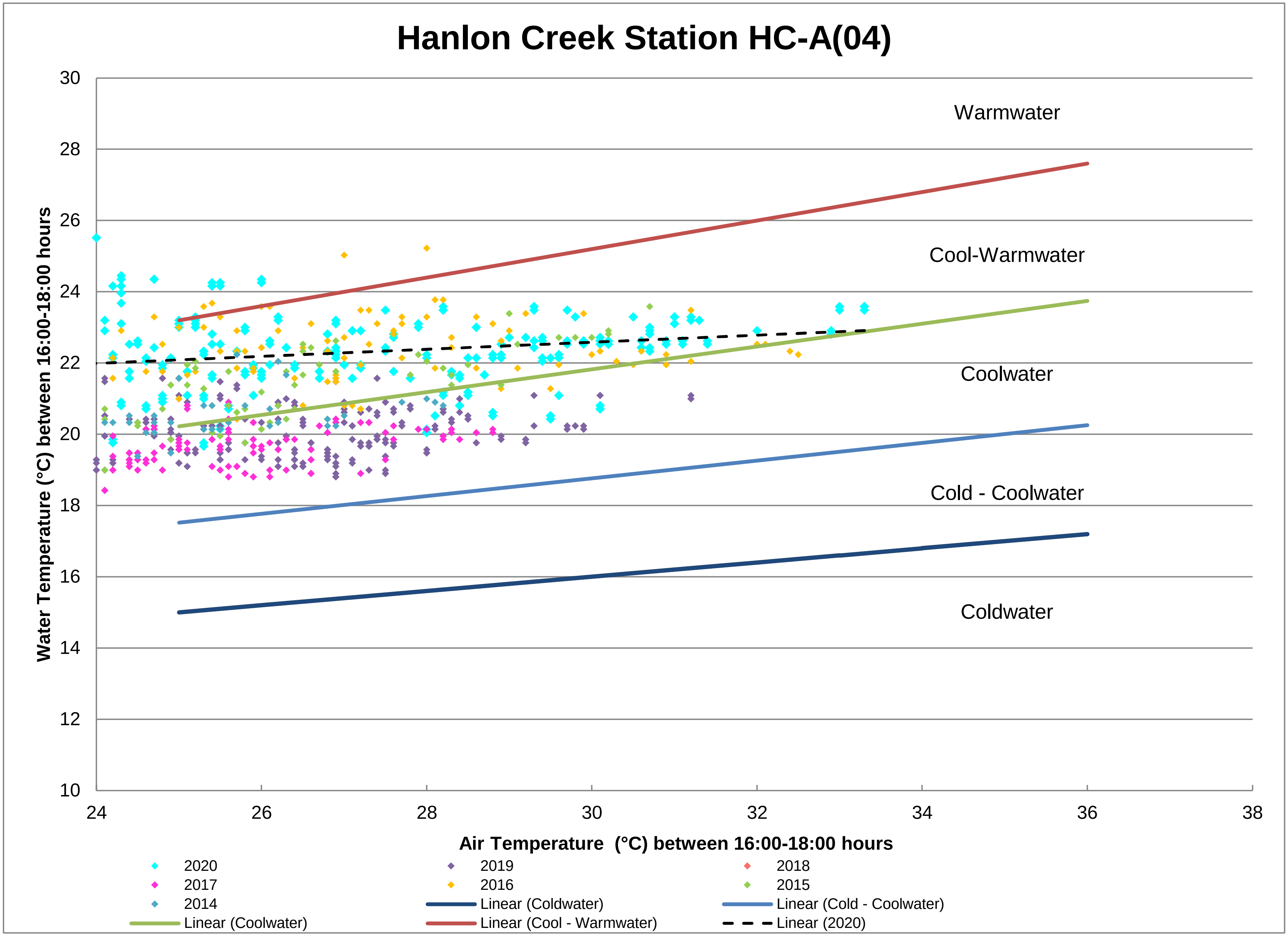


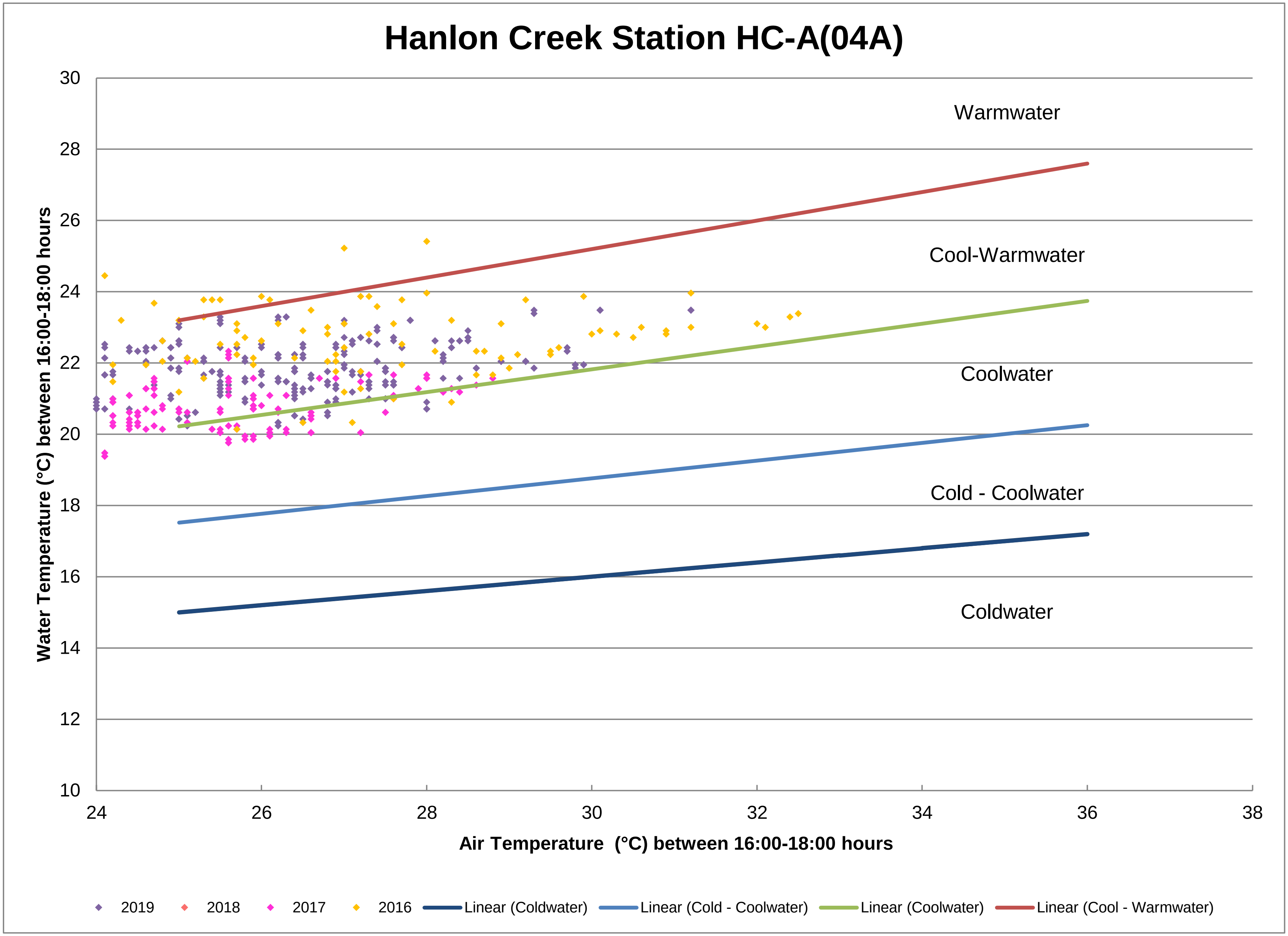
Percent of Time over 22°C
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Precent (%)
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (ºC)
2008
2010
2012
2014
2016
2018
2020
HC-A(03)
HC-A(04)
HC-A(06)
HC-A(08)
HC-A(09)
HC-A(10)
HC-A(11)
HC-A(12)
HC-A(13)
HC-A(14)
GTI Average Air Temp (July - August)

Appendix C

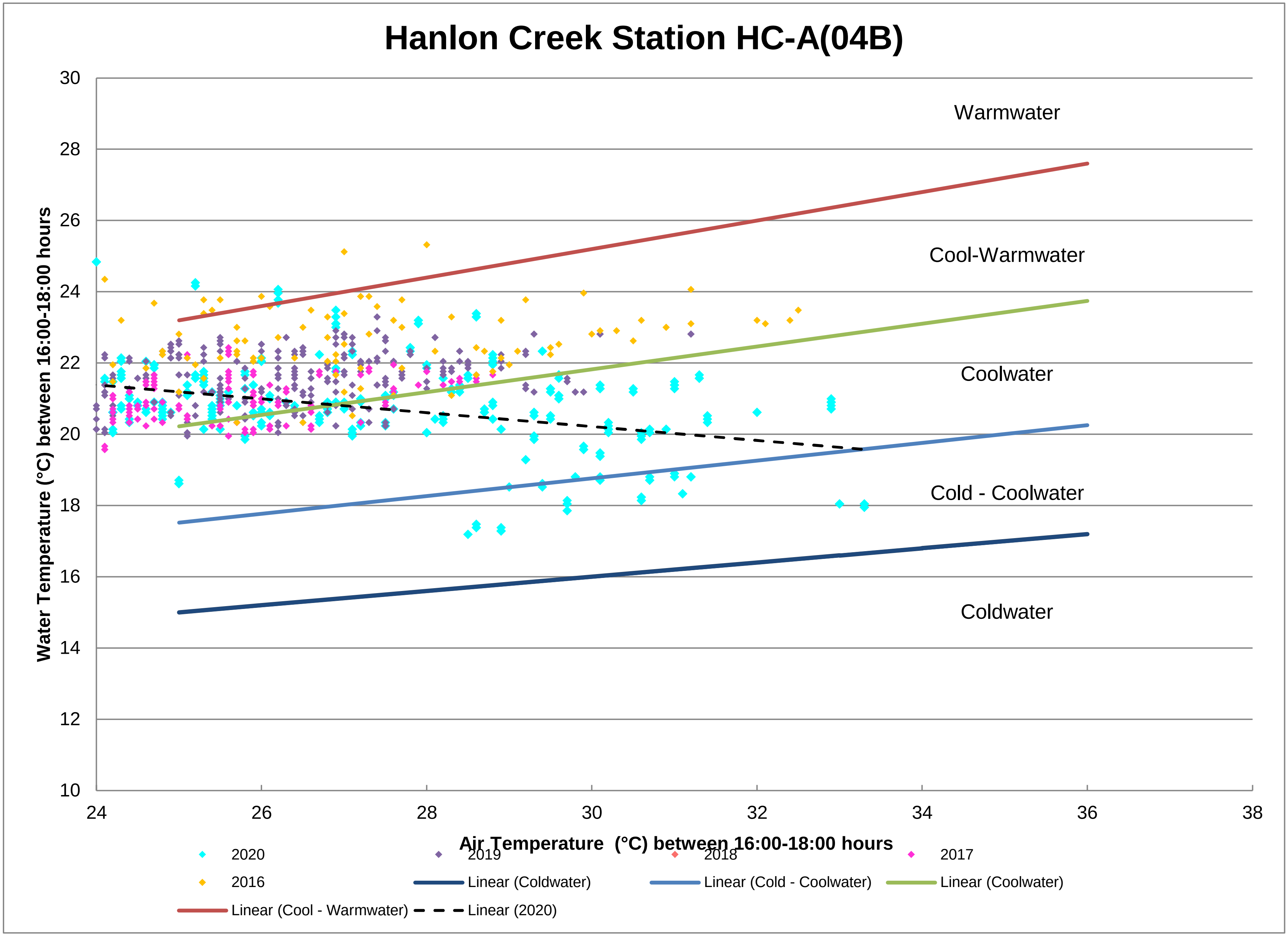
Thermal Regime Classification


Hanlon Creek Station HC-A(03)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2020
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)

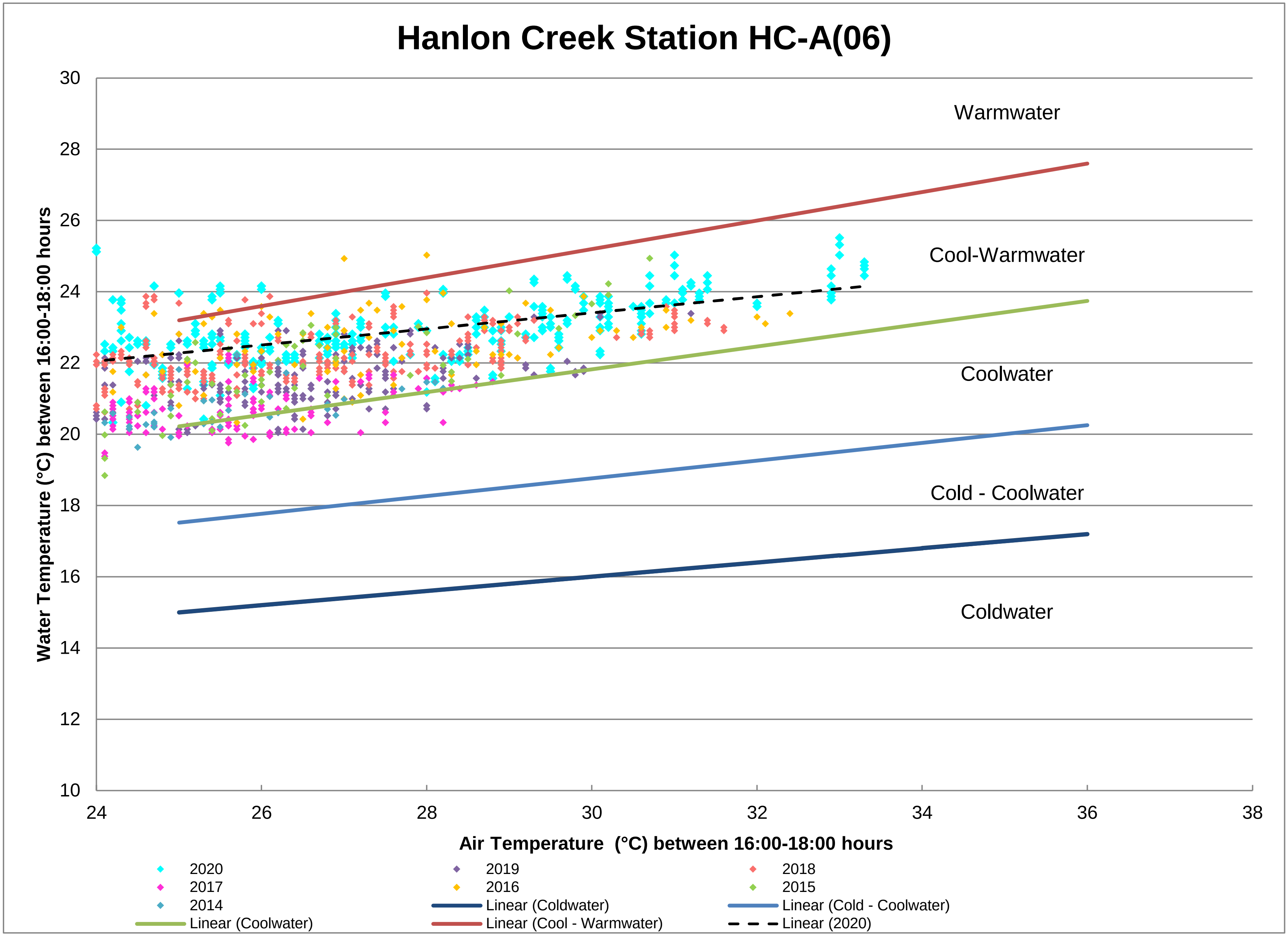

Hanlon Creek Station HC-A(04)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
Air Temperature (°C) between 16:00-18:00 hours
2020
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)



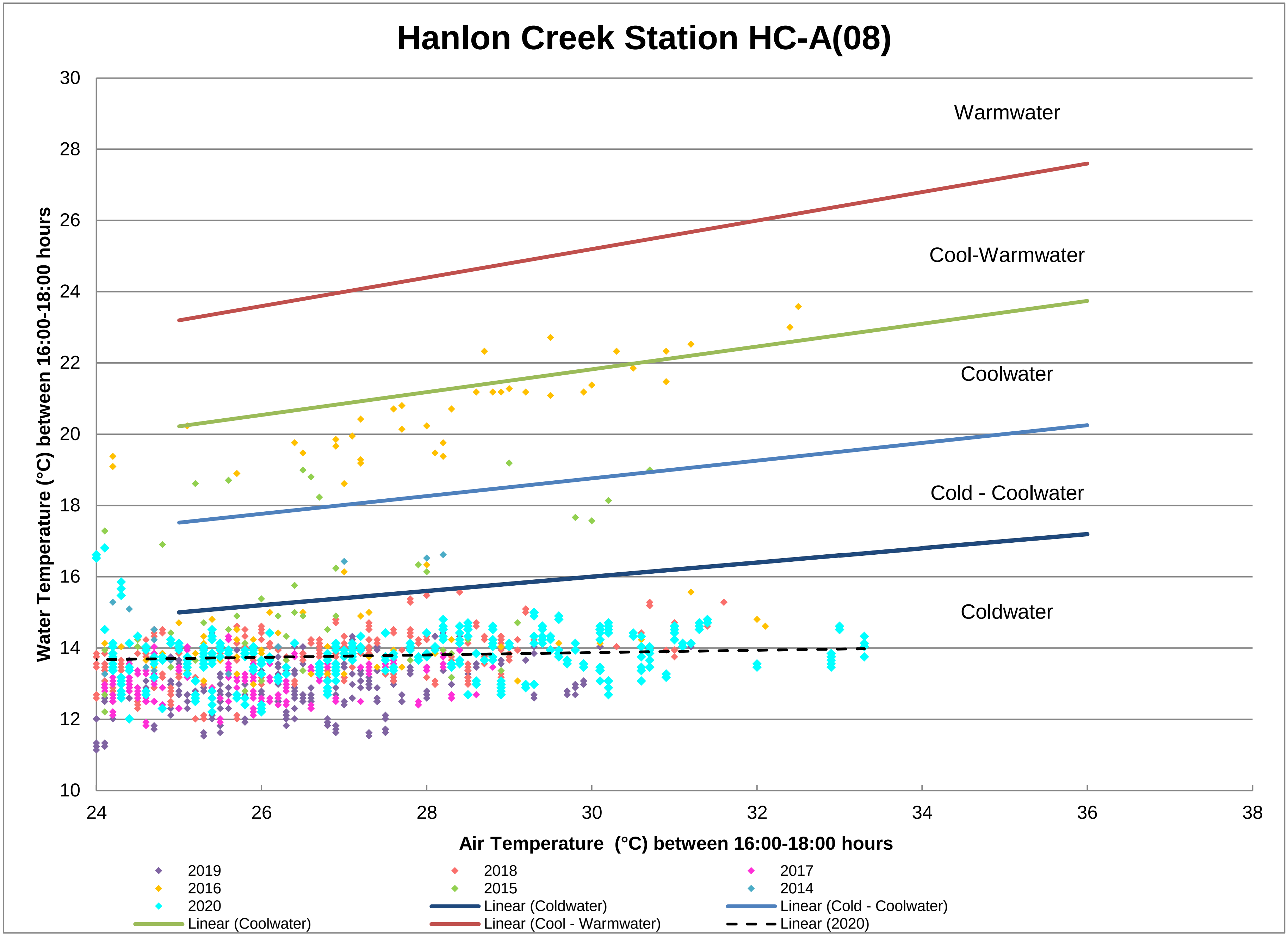
Hanlon Creek Station HC-A(04A)
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
2019
2018
2017
2016
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)



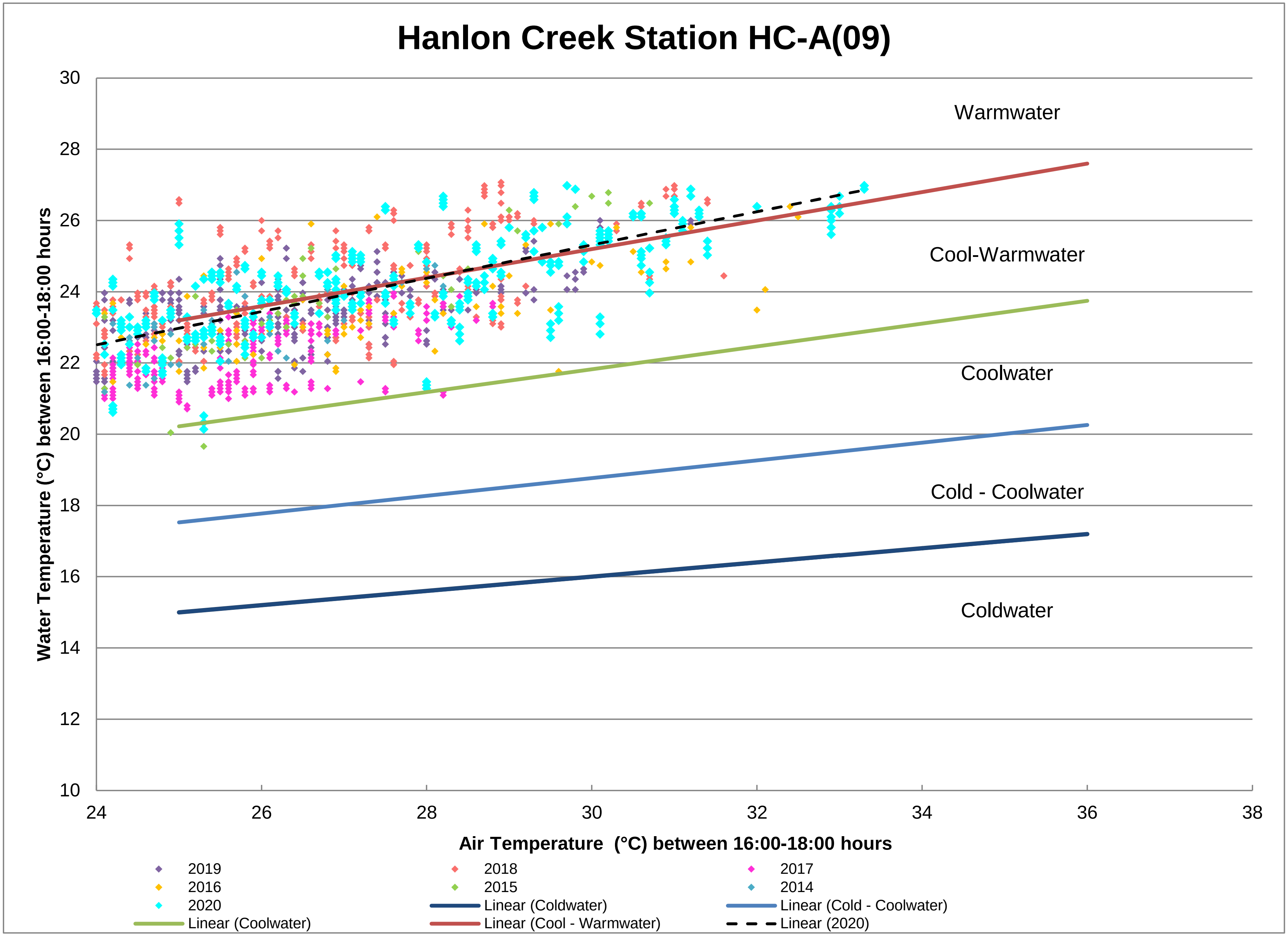
Hanlon Creek Station HC-A(04B)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2020
2019
2018
2017
2016
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)



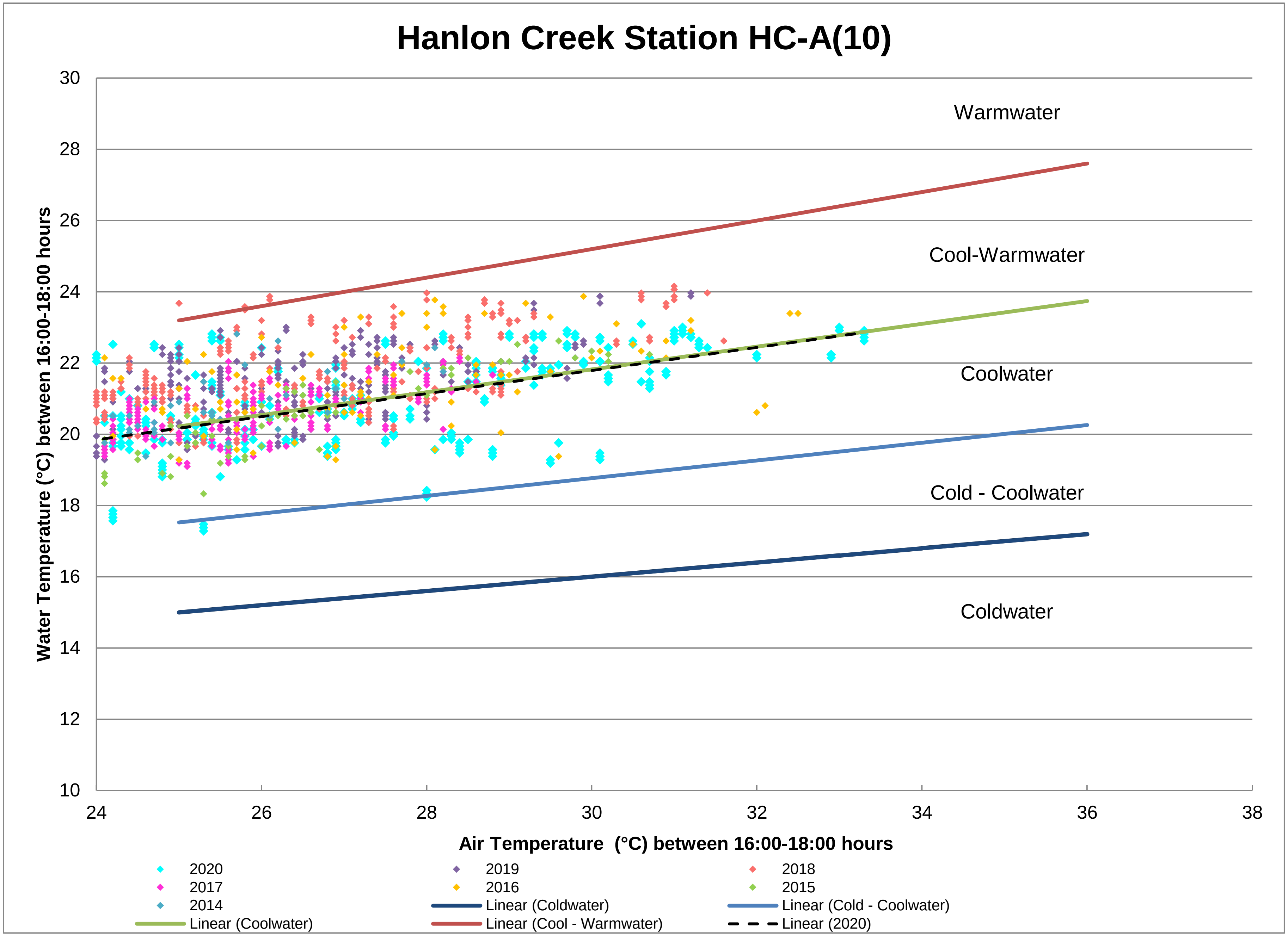
Hanlon Creek Station HC-A(06)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
30
28
26
24
22
20
18
16
14
12
10
Water Temperature (°C) between 16:00-18:00 hours
24
26
28
30
32
34
36
38
Air Temperature (°C) between 16:00-18:00 hours
2020
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)



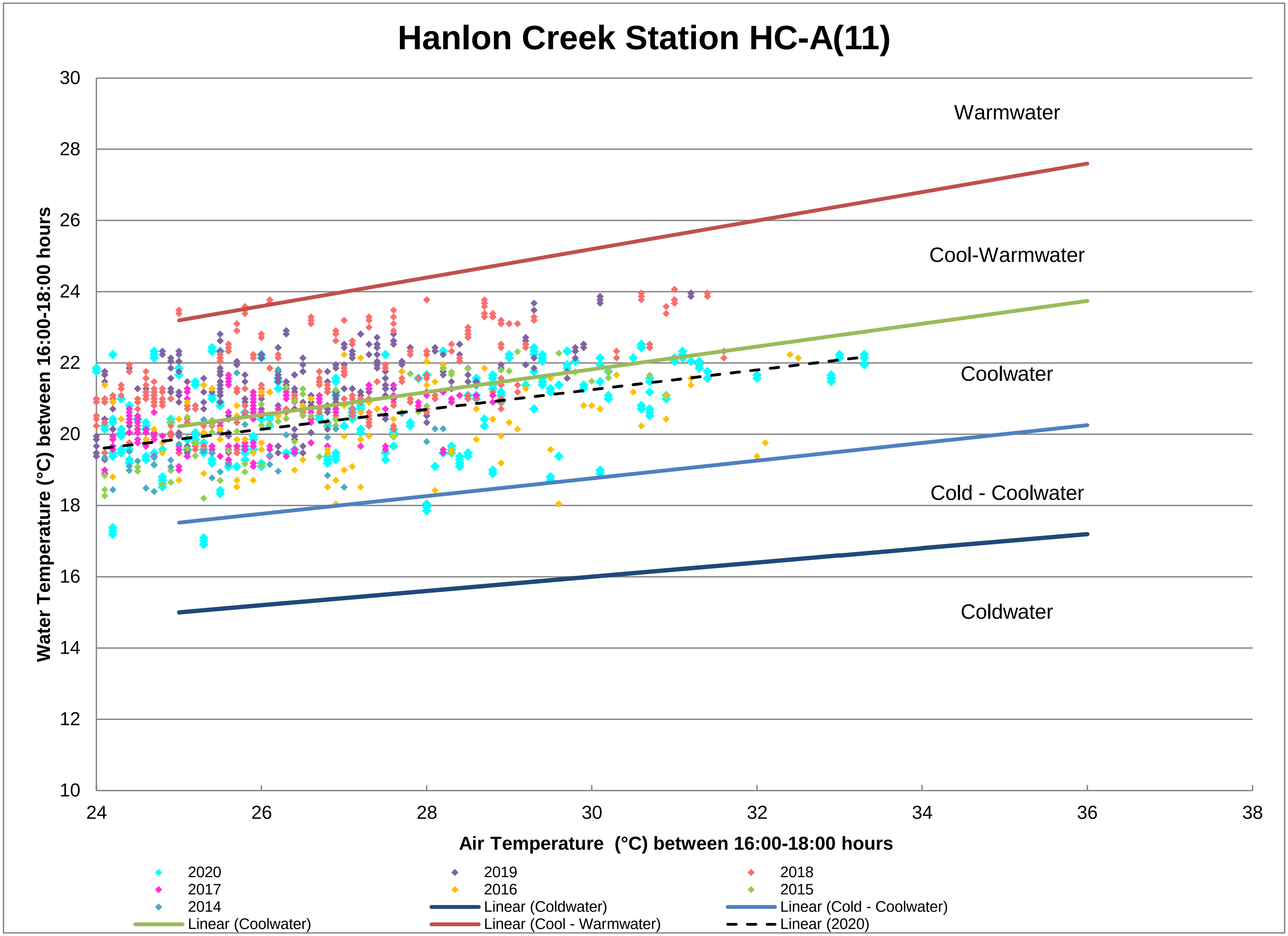
Hanlon Creek Station HC-A(08)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
Air Temperature (°C) between 16:00-18:00 hours
2019
2018
2017
2016
2015
2014
2020
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)



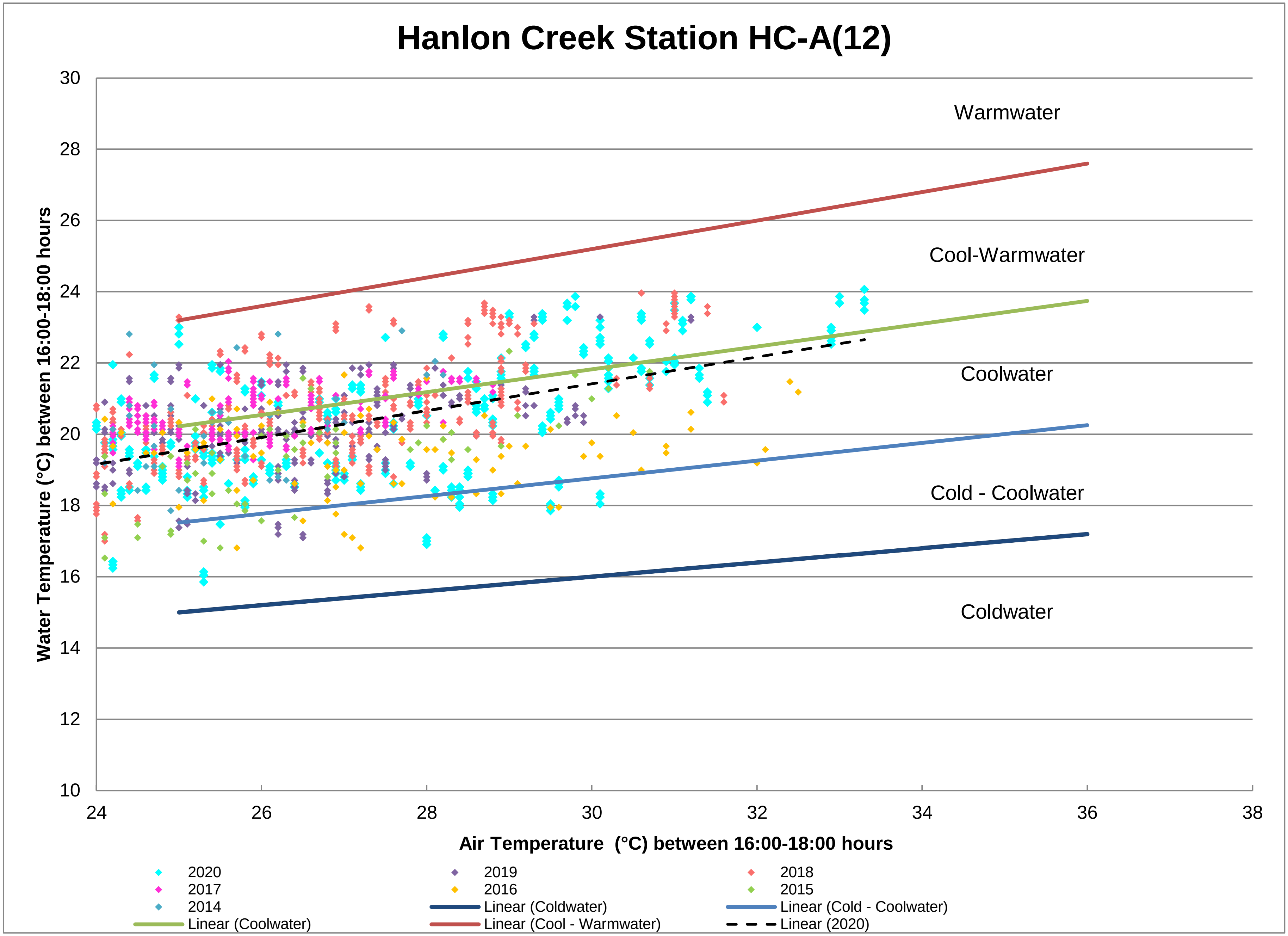
Hanlon Creek Station HC-A(09)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2019
2018
2017
2016
2015
2014
2020
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)



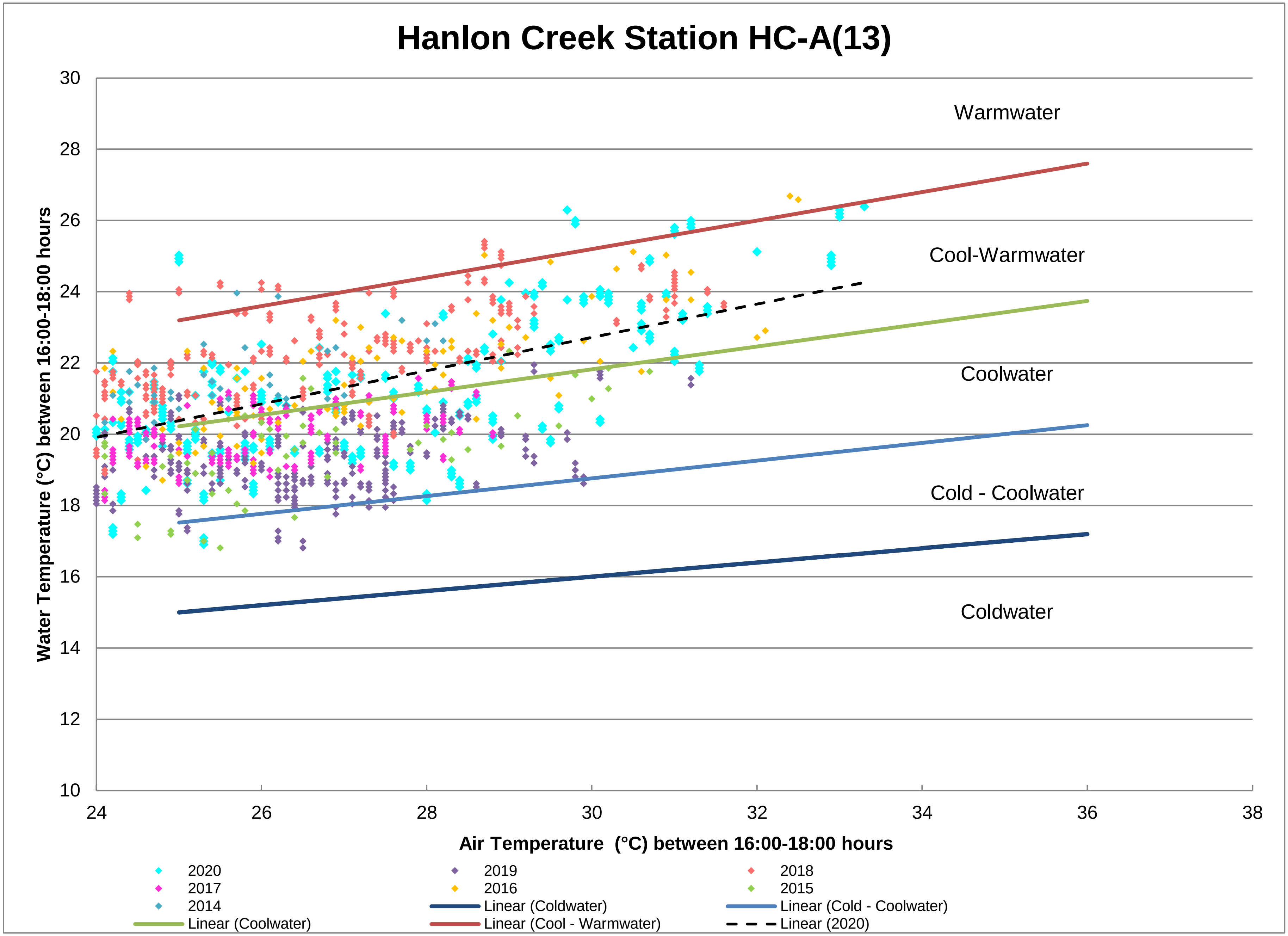
Hanlon Creek Station HC-A(10)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2020
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)



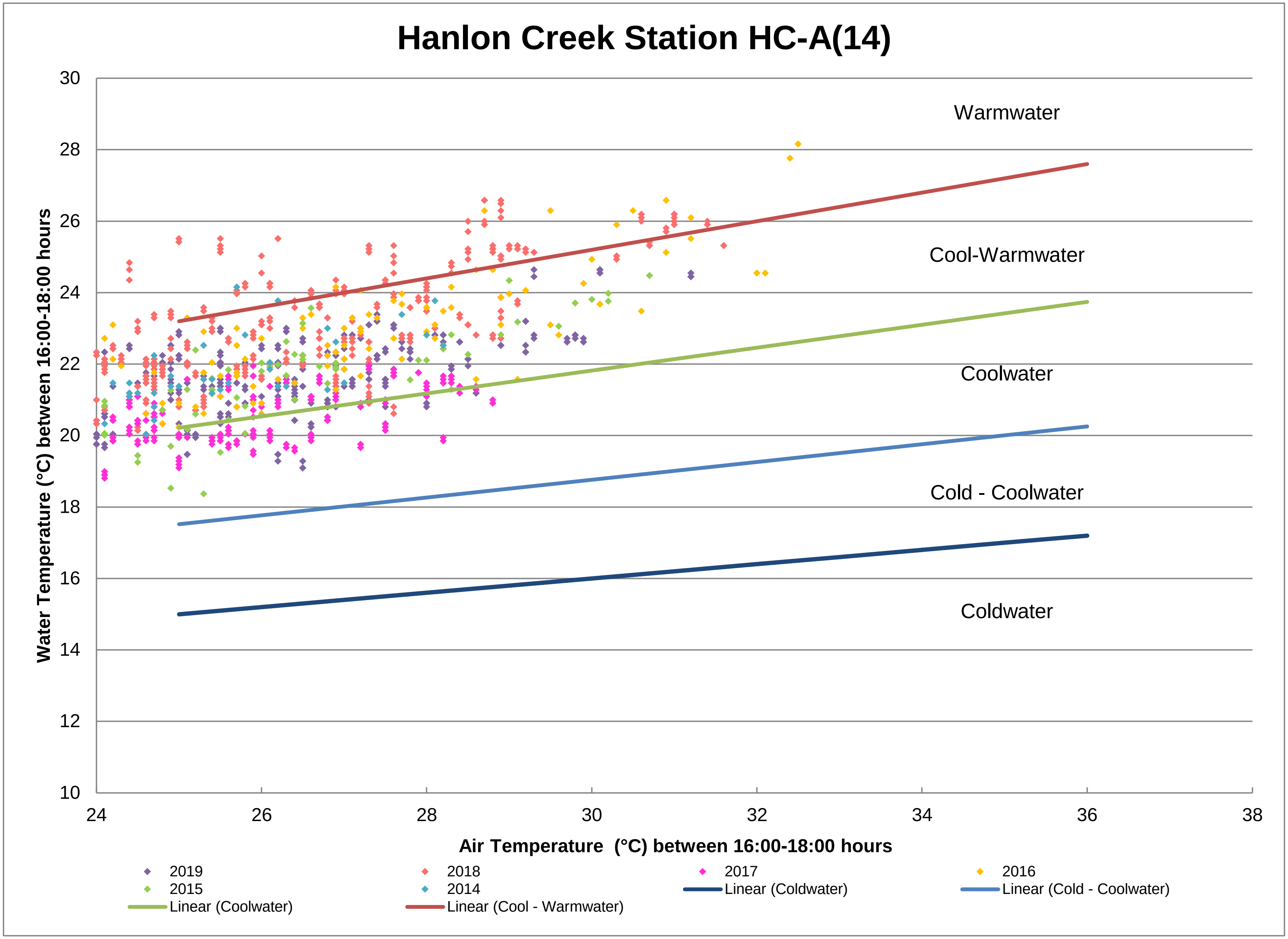
Hanlon Creek Station HC-A(11)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2020
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)



Hanlon Creek Station HC-A(12)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
10
12
14
16
18
20
22
24
26
28
30
24
26
28
30
32
34
36
38
2020
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)

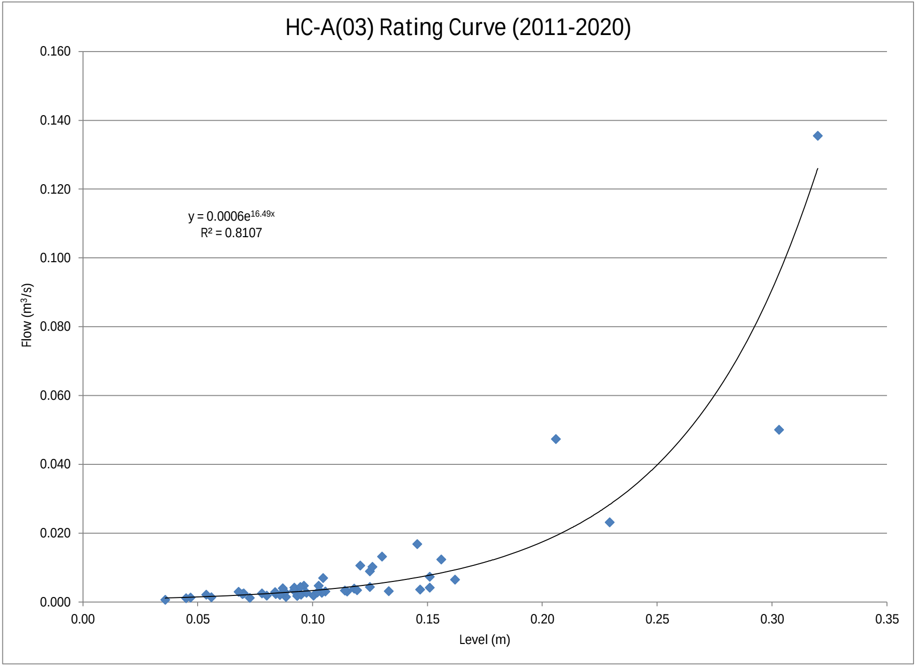


Hanlon Creek Station HC-A(13)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
Air Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
2020
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)
Linear (2020)

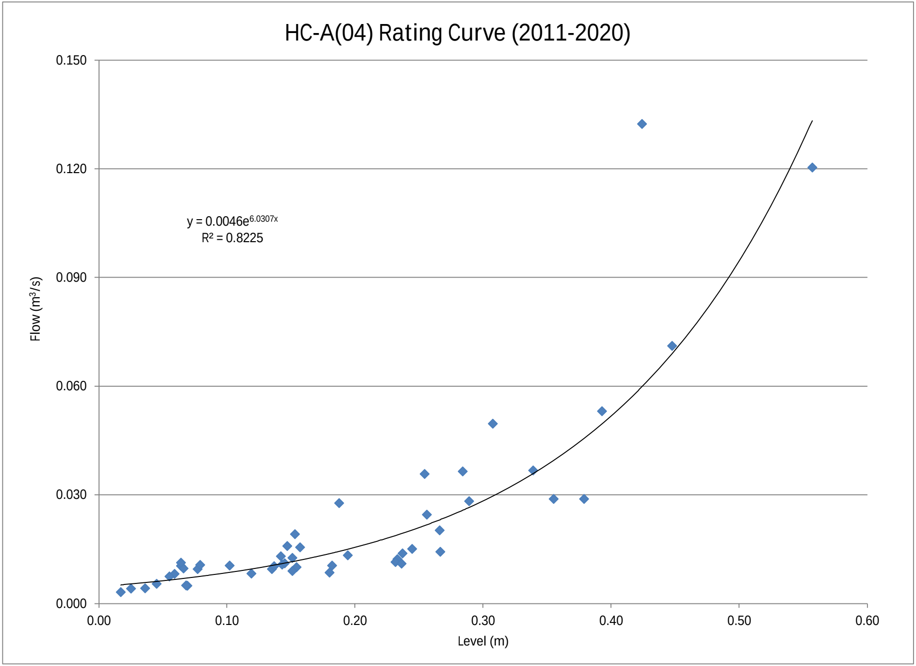

Hanlon Creek Station HC-A(14)
Warmwater
Cool-Warmwater
Coolwater
Cold - Coolwater
Coldwater
Water Temperature (°C) between 16:00-18:00 hours
30
28
26
24
22
20
18
16
14
12
10
24
26
28
30
32
34
36
38
Air Temperature (°C) between 16:00-18:00 hours
2019
2018
2017
2016
2015
2014
Linear (Coldwater)
Linear (Cold - Coolwater)
Linear (Coolwater)
Linear (Cool - Warmwater)

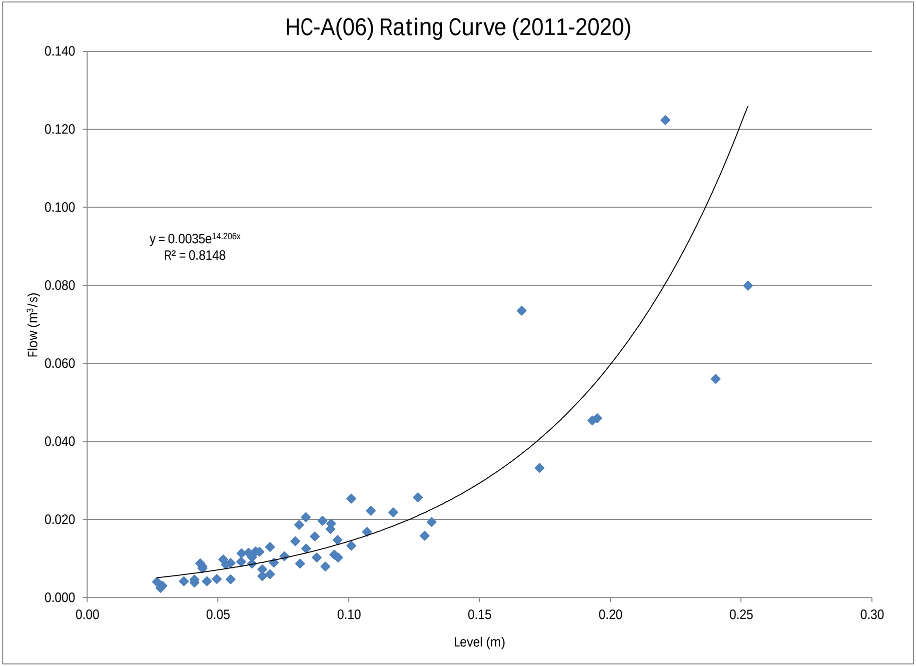
Appendix D

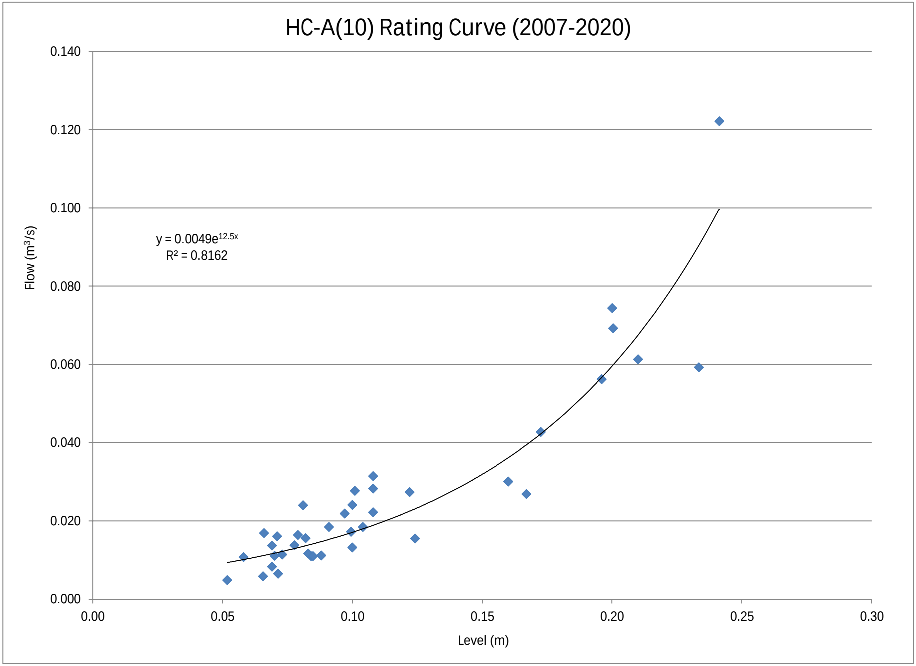
Stage (level) – Discharge Relationship Plots



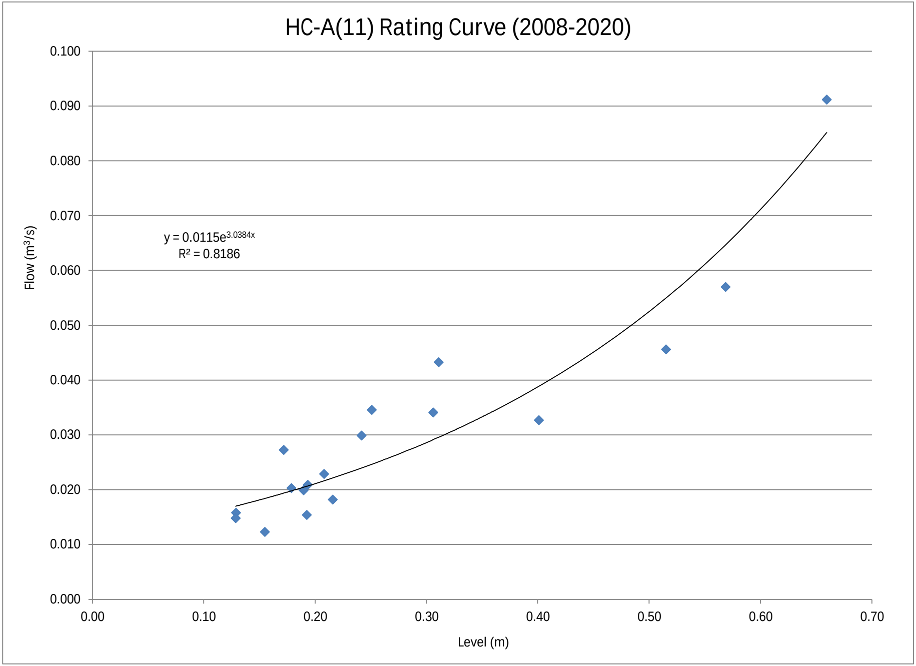
HC-A(03) Rating Curve (2011-2020)
y = 0.0006e^16.49x
R² = 0.8107
Flow (m³/s)
Level (m)
0.000
0.020
0.040
0.060
0.080
0.100
0.120
0.140
0.160
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35

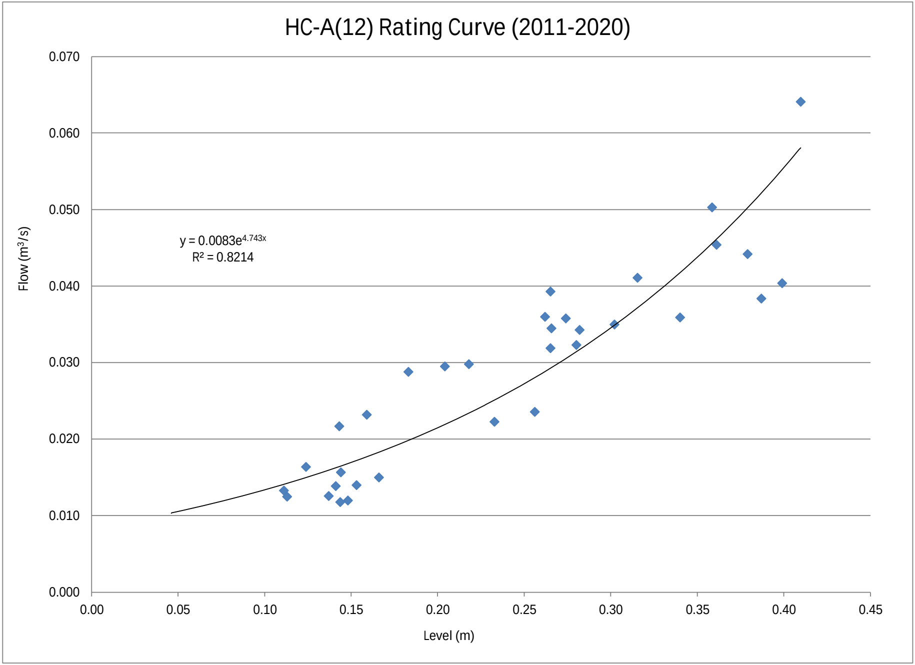

HC-A(04) Rating Curve (2011-2020)
y = 0.0046e^6.0307x
R² = 0.8225
Flow (m³/s)
0.150
0.120
0.090
0.060
0.030
0.000
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Level (m)


HC-A(06) Rating Curve (2011-2020)
y = 0.0035e^14.206x
R² = 0.8148
Flow (m³/s)
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Level (m)

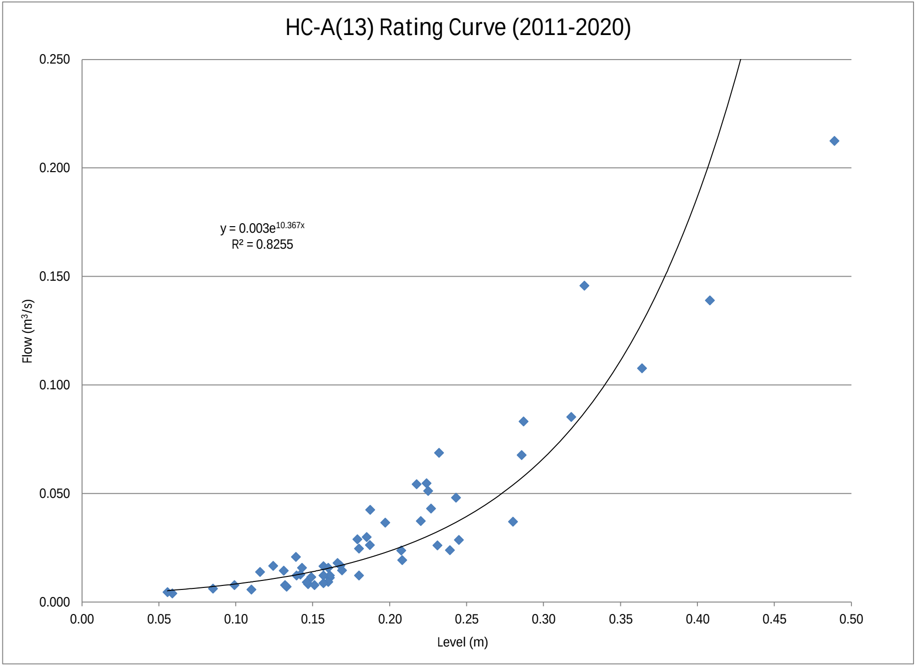


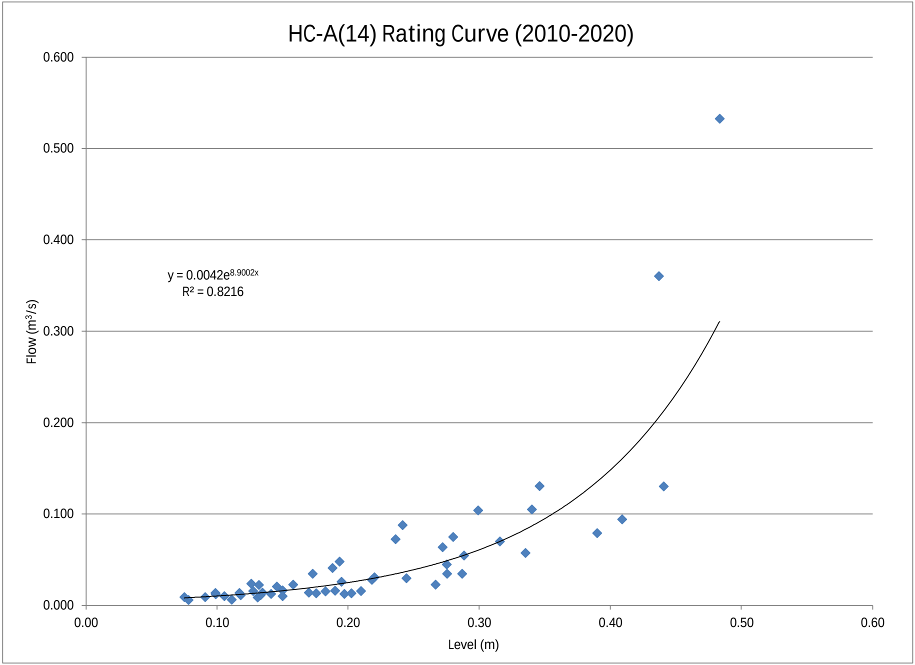
HC-A(10) Rating Curve (2007-2020)
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Flow (m³/s)
y = 0.0049e^12.5x
R² = 0.8162
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Level (m)


HC-A(11) Rating Curve (2008-2020)
y = 0.0115e^3.0384x
R² = 0.8186
Flow (m³/s)
Level (m)
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70



HC-A(12) Rating Curve (2011-2020)
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
Flow (m3/s)
y = 0.0083e4.743x
R² = 0.8214
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
Level (m)


HC-A(13) Rating Curve (2011-2020)
y = 0.003e^10.367x
R² = 0.8255
Flow (m³/s)
Level (m)
0.250
0.200
0.150
0.100
0.050
0.000
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50



HC-A(14) Rating Curve (2010-2020)
y = 0.0042e^8.9002x
R² = 0.8216
Flow (m³/s)
Level (m)
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.00
0.10
0.20
0.30
0.40
0.50
0.60

Appendix E

Tabular Water Quality Sampling Results

AECOM CANADA LTD. - KITCHENER
ATTN: Steve Scott
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 16-JUL-20
Report Date: 23-JUL-20 10:37 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L2475468

Project P.O. #: NOT SUBMITTED

Job Reference: 60611735

C of C Numbers:

Legal Site Desc:

Emily Hansen
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2475468-1 HC-A(03)							
Sampled By: T. AZUBUIKE on 16-JUL-20 @ 10:20							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	0.052		0.010	mg/L		20-JUL-20	R5159863
BOD Carbonaceous	<2.0		2.0	mg/L		17-JUL-20	R5162320
Chloride (Cl)	49.9		0.50	mg/L		20-JUL-20	R5159617
E. Coli	190	DLM	10	CFU/100mL		17-JUL-20	R5157596
Nitrate (as N)	1.09		0.020	mg/L		20-JUL-20	R5159617
Total Suspended Solids	31.0		2.0	mg/L	21-JUL-20	22-JUL-20	R5160400
Phosphorus (P)-Total Dissolved	0.0107		0.0030	mg/L	17-JUL-20	21-JUL-20	R5159647
Phosphorus, Total	0.0572		0.0030	mg/L	17-JUL-20	21-JUL-20	R5159663
pH	8.35		0.10	pH units		17-JUL-20	R5157206
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0027		0.0010	mg/L	17-JUL-20	17-JUL-20	R5156953
Lead (Pb)-Total	0.00162		0.000050	mg/L	17-JUL-20	17-JUL-20	R5156953
Zinc (Zn)-Total	0.0194		0.0030	mg/L	17-JUL-20	17-JUL-20	R5156953
L2475468-2 HC-A(04)							
Sampled By: T. AZUBUIKE on 16-JUL-20 @ 10:33							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	0.079		0.010	mg/L		22-JUL-20	R5161939
BOD Carbonaceous	<2.0		2.0	mg/L		17-JUL-20	R5162320
Chloride (Cl)	172		0.50	mg/L		20-JUL-20	R5159617
E. Coli	170	DLM	10	CFU/100mL		17-JUL-20	R5157596
Nitrate (as N)	0.354		0.020	mg/L		20-JUL-20	R5159617
Total Suspended Solids	53.5		2.0	mg/L	21-JUL-20	22-JUL-20	R5160400
Phosphorus (P)-Total Dissolved	0.0063		0.0030	mg/L	17-JUL-20	21-JUL-20	R5159647
Phosphorus, Total	0.0473		0.0030	mg/L	17-JUL-20	21-JUL-20	R5159663
pH	8.05		0.10	pH units		17-JUL-20	R5157206
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0049		0.0010	mg/L	17-JUL-20	17-JUL-20	R5156953
Lead (Pb)-Total	0.00402		0.000050	mg/L	17-JUL-20	17-JUL-20	R5156953
Zinc (Zn)-Total	0.0907		0.0030	mg/L	17-JUL-20	17-JUL-20	R5156953
L2475468-3 HC-A(12)							
Sampled By: T. AZUBUIKE on 16-JUL-20 @ 11:00							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	0.032		0.010	mg/L		22-JUL-20	R5161939
BOD Carbonaceous	<2.0		2.0	mg/L		17-JUL-20	R5162320
Chloride (Cl)	240	DLDS	2.5	mg/L		20-JUL-20	R5159617
E. Coli	670	DLM	10	CFU/100mL		17-JUL-20	R5157596
Nitrate (as N)	0.54	DLDS	0.10	mg/L		20-JUL-20	R5159617
Total Suspended Solids	5.7		2.0	mg/L	21-JUL-20	22-JUL-20	R5160400
Phosphorus (P)-Total Dissolved	0.0167		0.0030	mg/L	17-JUL-20	21-JUL-20	R5159647
Phosphorus, Total	0.0241		0.0030	mg/L	17-JUL-20	21-JUL-20	R5159663
pH	7.87		0.10	pH units		17-JUL-20	R5157608
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.0010		0.0010	mg/L	17-JUL-20	17-JUL-20	R5156953
Lead (Pb)-Total	0.000316		0.000050	mg/L	17-JUL-20	17-JUL-20	R5156953
Zinc (Zn)-Total	0.0063		0.0030	mg/L	17-JUL-20	17-JUL-20	R5156953

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2475468-4 HC-A(13)							
Sampled By: T. AZUBUIKE on 16-JUL-20 @ 11:15							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	0.036		0.010	mg/L		22-JUL-20	R5161939
BOD Carbonaceous	<2.0		2.0	mg/L		17-JUL-20	R5162320
Chloride (Cl)	240	DLDS	2.5	mg/L		20-JUL-20	R5159617
E. Coli	460	DLM	10	CFU/100mL		17-JUL-20	R5157596
Nitrate (as N)	0.52	DLDS	0.10	mg/L		20-JUL-20	R5159617
Total Suspended Solids	4.8		2.0	mg/L	21-JUL-20	22-JUL-20	R5160400
Phosphorus (P)-Total Dissolved	0.0187		0.0030	mg/L	17-JUL-20	21-JUL-20	R5159647
Phosphorus, Total	0.0247		0.0030	mg/L	17-JUL-20	20-JUL-20	R5158343
pH	8.08		0.10	pH units		17-JUL-20	R5157608
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.0010		0.0010	mg/L	17-JUL-20	17-JUL-20	R5156953
Lead (Pb)-Total	0.000268		0.000050	mg/L	17-JUL-20	17-JUL-20	R5156953
Zinc (Zn)-Total	0.0049		0.0030	mg/L	17-JUL-20	17-JUL-20	R5156953
L2475468-5 HC-A(14)							
Sampled By: T. AZUBUIKE on 16-JUL-20 @ 11:24							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	0.039		0.010	mg/L		22-JUL-20	R5161939
BOD Carbonaceous	<2.0		2.0	mg/L		17-JUL-20	R5162320
Chloride (Cl)	257	DLDS	2.5	mg/L		20-JUL-20	R5159617
E. Coli	580	DLM	10	CFU/100mL		17-JUL-20	R5157596
Nitrate (as N)	0.55	DLDS	0.10	mg/L		20-JUL-20	R5159617
Total Suspended Solids	9.5		2.0	mg/L	21-JUL-20	22-JUL-20	R5160400
Phosphorus (P)-Total Dissolved	0.0177		0.0030	mg/L	17-JUL-20	21-JUL-20	R5159647
Phosphorus, Total	0.0302		0.0030	mg/L	17-JUL-20	20-JUL-20	R5158343
pH	8.37		0.10	pH units		17-JUL-20	R5157206
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0011		0.0010	mg/L	17-JUL-20	17-JUL-20	R5156953
Lead (Pb)-Total	0.000555		0.000050	mg/L	17-JUL-20	17-JUL-20	R5156953
Zinc (Zn)-Total	0.0087		0.0030	mg/L	17-JUL-20	17-JUL-20	R5156953

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BOD-C-WT	Water	BOD Carbonaceous	APHA 5210 B (CBOD)

This analysis is carried out using procedures adapted from APHA Method 5210B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h.
Method ID: WT-TM-1200

EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-WT	Water	pH	APHA 4500 H-Electrode

Water samples are analyzed directly by a calibrated pH meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

C of C # 00000 WH

60 NORTHLAND ROAD, UNIT 1
WATERLOO, ON N2V 2B8
Phone: (519) 886-6910
Fax: (519) 886-9047
Toll Free: 1-800-668-9878

C[illegible] L2475468-COFC VICES REQUEST FORM Page ___ of ___

Note: all TAT ([illegible] statutory holia[illegible] [illegible] samples received past 3:00 pm or Saturday/Sunday begin the next day.

[illegible] date required	Service requested			
	5 day (regular)	X	2 day TAT (50%)	
	3-4 day (regular)		Next day TAT (100%)	
			Same day TAT (200%)	

COMPANY NAME	AECOM
OFFICE	Kitchener
PROJECT MANAGER Steven Scott	
PROJECT # 60611735	
PHONE 519-650-8637 OR 519-569-9388	FAX
ACCOUNT # 15884	
QUOTATION # Q59209	PO #

CRITERIA Criteria on report YESX__ NO__
Reg 153/11
Table 1 2 3
TCLP _____ MISA ______ PWQO ___X__
ODWS _____ OTHER ______

REPORT FORMAT/DISTRIBUTION
EMAIL _X_ FAX ___ BOTH ___
SELECT: PDF ___ DIGITAL ___ BOTH _X_
EMAIL 1 Tara.Roumeliotis@aecom.com
EMAIL 2 Steve.Scott2@aecom.com
EMAIL 3 Tochi.Azubuike@aecom.com

ANALYSIS REQUEST

PLEASE INDICATE FILTERED, PRESERVED OR BOTH <---- (F, P, F/P)

SUBMISSION #: L2475468
ENTERED BY: AO
DATE/TIME ENTERED:
BIN #:

SAMPLING INFORMATION

Date (dd-mm-yy)	Time (24hr) (hh:mm)	COMP	GRAB	WATER	SOIL	OTHER	SAMPLE DESCRIPTION TO APPEAR ON REPORT	NUMBER OF CONTAINERS	TSS	CBOD5	E. Coli	Total Metals by ICPMS (Lead, Zinc, Coppe	Total and Dissolved P (Lab Filter)	Total Ammonia Nitrogen, NO^3, and CL					COMMENTS	LAB ID
16-07-20	10:20		X	X			HC-A(03)	7	X	X	X	X	X	X						
16-07-20	10:33		X	X			HC-A(04)	7	X	X	X	X	X	X						
16-07-20	11:00		X	X			HC-A(12)	7	X	X	X	X	X	X						
16-07-20	11:15		X	X			HC-A(13)	7	X	X	X	X	X	X						
16-07-20	11:24		X	X			HC-A(14)	7	X	X	X	X	X	X						

SPECIAL INSTRUCTIONS/COMMENTS
Surface water samples, so colforms counts may be high.

Please also provide pH measurement as field measurements seemed high.

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (CHECK Yes OR No)
Are any samples taken from a regulated DW System? Yes ___ No ___
If yes, an authorized drinking water COC MUST be used for this submission.
Is the water sampled intended to be potable for human consumption? Yes ___ No ___

SAMPLE CONDITION
__ FROZEN
__ COLD
__ COOLING INITIATED
__ AMBIENT
MEAN TEMP 14.8
OBSERVATIONS Yes ___ No ___ yes add SIF
INIT

SAMPLED BY: Tochi Azubuike	DATE & TIME 16-07-20 / 3pm	RECEIVED BY:	DATE & TIME
RELINQUISHED BY: Tochi Azubuike	DATE & TIME 16-07-20 / 3pm	RECEIVED AT LAB BY:	DATE & TIME 16/07/20 1500

Notes
1. Quote number must be provided to ensure proper pricing
2. TAT may vary dependent on complexity of analysis and lab workload at time of submission. Please contact the lab to confirm TATs.
3. Any known or suspected hazards relating to a sample must be noted on the chain of custody in comments section.

ALS		Sample ID					HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)
2/5/2021		ALS ID					L2110610-1	L2110610-2	L2110610-3	L2110610-4	L2110610-5
L2475468		Date Sampled	PWQO		Guelph Storm		6/12/2018 10:50:00 AM	6/12/2018 11:10:00 AM	6/12/2018 11:25:00 AM	6/12/2018 2:45:00 PM	6/12/2018 3:15:00 PM
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Water	Water	Water	Water	Water
pH	pH units	0.1	-	-	-	15	8.35	8.05	7.87	8.08	8.37
Total Suspended Solids	mg/L	2	-	-	-	-	31	53.5	5.7	4.8	9.5
Ammonia, Total (as N)	mg/L	0.01	-	-	-	-	0.052	0.079	0.032	0.036	0.039
Chloride (Cl)	mg/L	0.5	-	-	-	-	49.9	172	240	240	257
Nitrate (as N)	mg/L	0.02	-	-	-	-	1.09	0.354	0.54	0.52	0.55
Phosphorus (P)-Total Dissolved	mg/L	0.003	-	0.02	-	-	0.0107	0.0063	0.0167	0.0187	0.0177
Phosphorus, Total	mg/L	0.003	-	100	-	-	0.0572	0.0473	0.0241	0.0247	0.0302
E. Coli	CFU/100mL	10	-	0.015	-	-	190!	170!	670!	460!	580!
Copper (Cu)-Total	mg/L	0.001	-	0.02	-	-	0.0027	0.0049	0.001	0.001	0.0011
Lead (Pb)-Total	mg/L	0.00005	-	0.005	-	-	0.00162	0.00402	0.000316	0.000268	0.000555
Zinc (Zn)-Total	mg/L	0.003	-	-	-	-	0.0194	0.0907	0.0063	0.0049	0.0087
BOD Carbonaceous	mg/L	2	-	0.011	-	-	2!	2!	2!	2!	2!
* = Result Qualified	Mouse-over the result to see the qualification.										

Applied Guideline: Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO

Color Key: Within Guideline | Exceeds Guidline

Applied Guideline: Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)

Color Key: Within Guideline | Exceeds Guidline

AECOM CANADA LTD. - KITCHENER
ATTN: Steven Scott
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 20-JUL-20
Report Date: 31-JUL-20 14:31 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L2476444

Project P.O. #: NOT SUBMITTED
Job Reference: 60611735
C of C Numbers:
Legal Site Desc:

Emily Hansen
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2476444-1 HC-A(03) Sampled By: CLIENT on 19-JUL-20 @ 08:20 Matrix: WATER							
Physical Tests							
Total Suspended Solids	36.0		2.0	mg/L	23-JUL-20	24-JUL-20	R5166327
Anions and Nutrients							
Ammonia, Total (as N)	0.041		0.010	mg/L		24-JUL-20	R5169382
Chloride (Cl)	49.3		0.50	mg/L		22-JUL-20	R5165162
Nitrate (as N)	0.983		0.020	mg/L		22-JUL-20	R5165162
Phosphorus (P)-Total Dissolved	0.0141		0.0030	mg/L	20-JUL-20	22-JUL-20	R5161397
Phosphorus, Total	0.0571		0.0030	mg/L	22-JUL-20	24-JUL-20	R5166379
Bacteriological Tests							
E. Coli	220	DLM	10	CFU/100mL		20-JUL-20	R5159587
Total Metals							
Copper (Cu)-Total	0.0033		0.0010	mg/L	20-JUL-20	21-JUL-20	R5159748
Iron (Fe)-Total	0.700		0.010	mg/L	20-JUL-20	21-JUL-20	R5159748
Lead (Pb)-Total	0.00201		0.000050	mg/L	20-JUL-20	21-JUL-20	R5159748
Manganese (Mn)-Total	0.0763		0.00050	mg/L	20-JUL-20	21-JUL-20	R5159748
Zinc (Zn)-Total	0.0243		0.0030	mg/L	20-JUL-20	21-JUL-20	R5159748
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		21-JUL-20	R5167552
L2476444-2 HC-A(04) Sampled By: CLIENT on 19-JUL-20 @ 08:40 Matrix: WATER							
Physical Tests							
Total Suspended Solids	10.0		2.0	mg/L	23-JUL-20	24-JUL-20	R5166327
Anions and Nutrients							
Ammonia, Total (as N)	0.028		0.010	mg/L		24-JUL-20	R5169382
Chloride (Cl)	176		0.50	mg/L		22-JUL-20	R5165162
Nitrate (as N)	0.270		0.020	mg/L		22-JUL-20	R5165162
Phosphorus (P)-Total Dissolved	0.0076		0.0030	mg/L	20-JUL-20	22-JUL-20	R5161397
Phosphorus, Total	0.0277		0.0030	mg/L	22-JUL-20	24-JUL-20	R5166379
Bacteriological Tests							
E. Coli	220	DLM	10	CFU/100mL		20-JUL-20	R5159587
Total Metals							
Copper (Cu)-Total	0.0028		0.0010	mg/L	20-JUL-20	21-JUL-20	R5159748
Iron (Fe)-Total	1.16		0.010	mg/L	20-JUL-20	21-JUL-20	R5159748
Lead (Pb)-Total	0.00209		0.000050	mg/L	20-JUL-20	21-JUL-20	R5159748
Manganese (Mn)-Total	0.0987		0.00050	mg/L	20-JUL-20	21-JUL-20	R5159748
Zinc (Zn)-Total	0.0544		0.0030	mg/L	20-JUL-20	21-JUL-20	R5159748
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L		21-JUL-20	R5167552
L2476444-3 HC-A(12) Sampled By: CLIENT on 19-JUL-20 @ 08:50 Matrix: WATER							
Physical Tests							
Total Suspended Solids	5.7		2.0	mg/L	23-JUL-20	24-JUL-20	R5166327

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2476444-3 HC-A(12)							
Sampled By: CLIENT on 19-JUL-20 @ 08:50							
Matrix: WATER							
Physical Tests							
Anions and Nutrients							
Ammonia, Total (as N)	0.060		0.010	mg/L		24-JUL-20	R5169382
Chloride (Cl)	245	DLDS	2.5	mg/L		22-JUL-20	R5165162
Nitrate (as N)	0.48	DLDS	0.10	mg/L		22-JUL-20	R5165162
Phosphorus (P)-Total Dissolved	0.0157		0.0030	mg/L	20-JUL-20	22-JUL-20	R5161397
Phosphorus, Total	0.0289		0.0030	mg/L	22-JUL-20	24-JUL-20	R5166379
Bacteriological Tests							
E. Coli	210	DLM	10	CFU/100mL		20-JUL-20	R5159587
Total Metals							
Copper (Cu)-Total	<0.0010		0.0010	mg/L	20-JUL-20	21-JUL-20	R5159748
Iron (Fe)-Total	0.117		0.010	mg/L	20-JUL-20	21-JUL-20	R5159748
Lead (Pb)-Total	0.000320		0.000050	mg/L	20-JUL-20	21-JUL-20	R5159748
Manganese (Mn)-Total	0.0242		0.00050	mg/L	20-JUL-20	21-JUL-20	R5159748
Zinc (Zn)-Total	0.0068		0.0030	mg/L	20-JUL-20	21-JUL-20	R5159748
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L		21-JUL-20	R5167552
L2476444-4 HC-A(13)							
Sampled By: CLIENT on 19-JUL-20 @ 09:00							
Matrix: WATER							
Physical Tests							
Total Suspended Solids	7.5		2.0	mg/L	23-JUL-20	24-JUL-20	R5166327
Anions and Nutrients							
Ammonia, Total (as N)	0.023		0.010	mg/L		24-JUL-20	R5169382
Chloride (Cl)	245	DLDS	2.5	mg/L		22-JUL-20	R5165162
Nitrate (as N)	0.46	DLDS	0.10	mg/L		22-JUL-20	R5165162
Phosphorus (P)-Total Dissolved	0.0183		0.0030	mg/L	20-JUL-20	22-JUL-20	R5161397
Phosphorus, Total	0.0285		0.0030	mg/L	22-JUL-20	24-JUL-20	R5166379
Bacteriological Tests							
E. Coli	420	DLM	10	CFU/100mL		20-JUL-20	R5159587
Total Metals							
Copper (Cu)-Total	0.0014		0.0010	mg/L	20-JUL-20	21-JUL-20	R5159748
Iron (Fe)-Total	0.237		0.010	mg/L	20-JUL-20	21-JUL-20	R5159748
Lead (Pb)-Total	0.000860		0.000050	mg/L	20-JUL-20	21-JUL-20	R5159748
Manganese (Mn)-Total	0.0257		0.00050	mg/L	20-JUL-20	21-JUL-20	R5159748
Zinc (Zn)-Total	0.0129		0.0030	mg/L	20-JUL-20	21-JUL-20	R5159748
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L		21-JUL-20	R5167552
L2476444-5 HC-A(14)							
Sampled By: CLIENT on 19-JUL-20 @ 09:05							
Matrix: WATER							
Physical Tests							
Total Suspended Solids	9.3		2.0	mg/L	23-JUL-20	24-JUL-20	R5166327
Anions and Nutrients							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2476444-5 HC-A(14)							
Sampled By: CLIENT on 19-JUL-20 @ 09:05							
Matrix: WATER							
Anions and Nutrients							
Ammonia, Total (as N)	0.028		0.010	mg/L		24-JUL-20	R5169382
Chloride (Cl)	251	DLDS	2.5	mg/L		22-JUL-20	R5165162
Nitrate (as N)	0.48	DLDS	0.10	mg/L		22-JUL-20	R5165162
Phosphorus (P)-Total Dissolved	0.0155		0.0030	mg/L	20-JUL-20	22-JUL-20	R5161397
Phosphorus, Total	0.0274		0.0030	mg/L	22-JUL-20	24-JUL-20	R5166379
Bacteriological Tests							
E. Coli	620	DLM	10	CFU/100mL		20-JUL-20	R5159587
Total Metals							
Copper (Cu)-Total	0.0015		0.0010	mg/L	20-JUL-20	21-JUL-20	R5159748
Iron (Fe)-Total	0.325		0.010	mg/L	20-JUL-20	21-JUL-20	R5159748
Lead (Pb)-Total	0.00115		0.000050	mg/L	20-JUL-20	21-JUL-20	R5159748
Manganese (Mn)-Total	0.0336		0.00050	mg/L	20-JUL-20	21-JUL-20	R5159748
Zinc (Zn)-Total	0.0171		0.0030	mg/L	20-JUL-20	21-JUL-20	R5159748
Aggregate Organics							
BOD Carbonaceous	<2.0		2.0	mg/L		21-JUL-20	R5167552

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Phosphorus (P)-Total Dissolved	MS-B	L2476444-1, -2, -3, -4, -5

Sample Parameter Qualifier key listed:

Qualifier	Description
BODL	Limit of Reporting for BOD was increased to account for the largest volume of sample tested.
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BOD-C-WT	Water	BOD Carbonaceous	APHA 5210 B (CBOD)

This analysis is carried out using procedures adapted from APHA Method 5210B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

ALS Test Code	Matrix	Test Description	Method Reference**
CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

ALS Test Code	Matrix	Test Description	Method Reference**
EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h.
Method ID: WT-TM-1200

ALS Test Code	Matrix	Test Description	Method Reference**
EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

ALS Test Code	Matrix	Test Description	Method Reference**
NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

ALS Test Code	Matrix	Test Description	Method Reference**
P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

ALS Test Code	Matrix	Test Description	Method Reference**
SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

Reference Information

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

mg/kg - milligrams per kilogram based on dry weight of sample

mg/kg wwt - milligrams per kilogram based on wet weight of sample

mg/kg lwt - milligrams per kilogram based on lipid weight of sample

mg/L - unit of concentration based on volume, parts per million.

< - Less than.

D.L. - The reporting limit.

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L2476444 Report Date: 31-JUL-20

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BOD-C-WT	**Water**							
Batch R5167552								
WG3367307-2 DUP		**L2476444-4**						
BOD Carbonaceous		<2.0	<2.0	RPD-NA	mg/L	N/A	30	21-JUL-20
WG3367307-6 DUP		**L2476444-5**						
BOD Carbonaceous		<2.0	<2.0	RPD-NA	mg/L	N/A	30	21-JUL-20
WG3367307-3 LCS								
BOD Carbonaceous			107.6		%		85-115	21-JUL-20
WG3367307-7 LCS								
BOD Carbonaceous			109.6		%		85-115	21-JUL-20
WG3367307-1 MB								
BOD Carbonaceous			<2.0		mg/L		2	21-JUL-20
WG3367307-5 MB								
BOD Carbonaceous			<2.0		mg/L		2	21-JUL-20
CL-IC-N-WT	**Water**							
Batch R5165162								
WG3368402-10 DUP		**WG3368402-8**						
Chloride (Cl)		15.9	15.9		mg/L	0.2	20	22-JUL-20
WG3368402-7 LCS								
Chloride (Cl)			102.8		%		90-110	22-JUL-20
WG3368402-6 MB								
Chloride (Cl)			<0.50		mg/L		0.5	22-JUL-20
WG3368402-9 MS		**WG3368402-8**						
Chloride (Cl)			102.1		%		75-125	22-JUL-20
EC-MF-WT	**Water**							
Batch R5159587								
WG3366107-3 DUP		**L2476444-1**						
E. Coli		220	190		CFU/100mL	15	65	20-JUL-20
WG3366107-1 MB								
E. Coli			0		CFU/100mL		1	20-JUL-20
MET-T-CCMS-WT	**Water**							
Batch R5159748								
WG3366571-4 DUP		**WG3366571-3**						
Copper (Cu)-Total		0.00132	0.00131		mg/L	1.0	20	21-JUL-20
Iron (Fe)-Total		<0.010	<0.010	RPD-NA	mg/L	N/A	20	21-JUL-20
Lead (Pb)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	21-JUL-20
Manganese (Mn)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	21-JUL-20
Zinc (Zn)-Total		0.0049	0.0047		mg/L	2.9	20	21-JUL-20
WG3366571-2 LCS								

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R5159748								
WG3366571-2 LCS								
Copper (Cu)-Total			98.9		%		80-120	21-JUL-20
Iron (Fe)-Total			99.6		%		80-120	21-JUL-20
Lead (Pb)-Total			100.2		%		80-120	21-JUL-20
Manganese (Mn)-Total			101.9		%		80-120	21-JUL-20
Zinc (Zn)-Total			99.1		%		80-120	21-JUL-20
WG3366571-1 MB								
Copper (Cu)-Total			<0.00050		mg/L		0.0005	21-JUL-20
Iron (Fe)-Total			<0.010		mg/L		0.01	21-JUL-20
Lead (Pb)-Total			<0.000050		mg/L		0.00005	21-JUL-20
Manganese (Mn)-Total			<0.00050		mg/L		0.0005	21-JUL-20
Zinc (Zn)-Total			<0.0030		mg/L		0.003	21-JUL-20
WG3366571-5 MS		**WG3366571-3**						
Copper (Cu)-Total			88.0		%		70-130	21-JUL-20
Iron (Fe)-Total			93.0		%		70-130	21-JUL-20
Lead (Pb)-Total			90.8		%		70-130	21-JUL-20
Manganese (Mn)-Total			95.4		%		70-130	21-JUL-20
Zinc (Zn)-Total			88.1		%		70-130	21-JUL-20
NH3-F-WT	**Water**							
Batch R5169382								
WG3366545-3 DUP		**L2476611-2**						
Ammonia, Total (as N)		<0.010	<0.010	RPD-NA	mg/L	N/A	20	24-JUL-20
WG3366545-2 LCS								
Ammonia, Total (as N)			91.7		%		85-115	24-JUL-20
WG3366545-1 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	24-JUL-20
WG3366545-4 MS		**L2476611-2**						
Ammonia, Total (as N)			95.5		%		75-125	24-JUL-20
NO3-IC-WT	**Water**							
Batch R5165162								
WG3368402-10 DUP		**WG3368402-8**						
Nitrate (as N)		<0.020	<0.020	RPD-NA	mg/L	N/A	20	22-JUL-20
WG3368402-7 LCS								
Nitrate (as N)			102.5		%		90-110	22-JUL-20
WG3368402-6 MB								
Nitrate (as N)			<0.020		mg/L		0.02	22-JUL-20

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-WT	**Water**							
Batch R5165162								
WG3368402-9 MS		**WG3368402-8**						
Nitrate (as N)			98.0		%		75-125	22-JUL-20
P-T-COL-WT	**Water**							
Batch R5166379								
WG3367268-3 DUP		**L2476895-2**						
Phosphorus, Total		0.0161	0.0141		mg/L	14	20	24-JUL-20
WG3367268-2 LCS								
Phosphorus, Total			97.9		%		80-120	24-JUL-20
WG3367268-1 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	24-JUL-20
WG3367268-4 MS		**L2476895-2**						
Phosphorus, Total			89.0		%		70-130	24-JUL-20
P-TD-COL-WT	**Water**							
Batch R5161397								
WG3366471-3 DUP		**L2476177-2**						
Phosphorus (P)-Total Dissolved		94	0.955		mg/L	1.6	20	22-JUL-20
WG3366471-2 LCS								
Phosphorus (P)-Total Dissolved			97.4		%		80-120	22-JUL-20
WG3366471-1 MB								
Phosphorus (P)-Total Dissolved			<0.0030		mg/L		0.003	22-JUL-20
WG3366471-4 MS		**L2476177-2**						
Phosphorus (P)-Total Dissolved			N/A	MS-B	%		-	22-JUL-20
SOLIDS-TSS-WT	**Water**							
Batch R5166327								
WG3368658-3 DUP		**L2476767-2**						
Total Suspended Solids		<2.0	<2.0	RPD-NA	mg/L	N/A	20	24-JUL-20
WG3368658-2 LCS								
Total Suspended Solids			91.3		%		85-115	24-JUL-20
WG3368658-1 MB								
Total Suspended Solids			<2.0		mg/L		2	24-JUL-20

Quality Control Report

Workorder: L2476444 Report Date: 31-JUL-20

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

C of C # 00000

60 NORTHLAND R
WATERLOO, ON N
Phone: (519) 886-
Fax: (519) 886-9047
Toll Free: 1-800-668-9878

L2476444-COFC

OF CUSTODY / ANALYTICAL SERVICES REQUEST FORM

Page ___ of ___

3:00 p... material is in business days which exclude ...d weekends. TAT samples received past .../Sunday begin the next day.

Specify date required	Service requested			
	5 day (regular)	X	2 day TAT (50%)	
	3-4 day (regular)		Next day TAT (100%)	
			Same day TAT (200%)	

COMPANY NAME	AECOM
OFFICE	Kitchener
PROJECT MANAGER Steven Scott	
PROJECT # 60611735	
PHONE 519-650-8637 OR 519-569-9388	FAX
ACCOUNT # 15884	
QUOTATION # Q59209	PO #

CRITERIA Criteria on report YESX__ NO___

Reg 153/11
Table 1 2 3

TCLP _____ MISA ______ PWQO ___X__
ODWS _____ OTHER ______

REPORT FORMAT/DISTRIBUTION

EMAIL _X_ FAX ___ BOTH ___
SELECT: PDF ___ DIGITAL ___ BOTH _X_
EMAIL 1 [redacted]
EMAIL 2 Steve.Scott2@aecom.com
EMAIL 3 Tochi.Azubuike@aecom.com

PLEASE INDICATE FILTERED, PRESERVED OR BOTH <---- (F, P, F/P)

SUBMISSION #: L2476444
ENTERED BY:
DATE/TIME ENTERED:
BIN #:

SAMPLING INFORMATION / **ANALYSIS REQUEST**

Date (dd-mm-yy)	Time (24hr) (hh:mm)	TYPE: COMP	TYPE: GRAB	MATRIX: WATER	MATRIX: SOIL	MATRIX: OTHER	SAMPLE DESCRIPTION TO APPEAR ON REPORT	NUMBER OF CONTAINERS	TSS	CBOD5	E. Coli	Total Metals by ICPMS (Lead, Zinc, Coppe	Total and Dissolved P (Lab Filter)	Total Ammonia Nitrogen, NO^3, and CL					COMMENTS	LAB ID
19-07-20	9:20		X	X			HC-A(03)	7	X	X	X	X	X	X						
19-07-20	8:40		X	X			HC-A(04)	7	X	X	X	X	X	X						
19-07-20	8:50		X	X			HC-A(12)	7	X	X	X	X	X	X						
19-07-20	9:00		X	X			HC-A(13)	7	X	X	X	X	X	X						
19-07-20	9:05		X	X			HC-A(14)	7	X	X	X	X	X	X						

SPECIAL INSTRUCTIONS/COMMENTS

Surface water samples, so colforms counts may be high.

Please also provide pH measurement as field measurements seemed high.

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (CHECK Yes OR No)

Are any samples taken from a regulated DW System? Yes ___ No ___
If yes, an authorized drinking water COC MUST be used for this submission.
Is the water sampled intended to be potable for human consumption? Yes ___ No ___

SAMPLE CONDITION

___ FROZEN
___ COLD
___ COOLING INITIATED
___ AMBIENT
MEAN TEMP 18
OBSERVATIONS Yes ___ No ___ If yes add SIF

ICE PACKS

SAMPLED BY: Tochi Azubuike	DATE & TIME 19-7-20	RECEIVED BY:	DATE & TIME
RELINQUISHED BY: Tochi Azubuike	DATE & TIME 19-7-20	RECEIVED AT LAB BY: DB	DATE & TIME 07/20/20 9:00

Notes

1. Quote number must be provided to ensure proper pricing
2. TAT may vary dependent on complexity of analysis and lab workload at time of submission. Please contact the lab to confirm TATs.
3. Any known or suspected hazards relating to a sample must be noted on the chain of custody in comments section.

ALS		Sample ID					HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)
2/5/2021		ALS ID					L2110610-1	L2110610-2	L2110610-3	L2110610-4	L2110610-5
L2476444		Date Sampled	PWQO		Guelph Storm		6/12/2018 10:50:00 AM	6/12/2018 11:10:00 AM	6/12/2018 11:25:00 AM	6/12/2018 2:45:00 PM	6/12/2018 3:15:00 PM
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Water	Water	Water	Water	Water
Total Suspended Solids	mg/L	2	-	-	-	15	36!!	10	5.7	7.5	9.3
Ammonia, Total (as N)	mg/L	0.01	-	-	-	-	0.041	0.028	0.06	0.023	0.028
Chloride (Cl)	mg/L	0.5	-	-	-	-	49.3	176	245	245	251
Nitrate (as N)	mg/L	0.02	-	-	-	-	0.983	0.27	0.48	0.46	0.48
Phosphorus (P)-Total Dissolved	mg/L	0.003	-	-	-	-	0.0141	0.0076	0.0157	0.0183	0.0155
Phosphorus, Total	mg/L	0.003	-	0.02	-	-	0.0571!	0.0277!	0.0289!	0.0285!	0.0274!
E. Coli	CFU/100mL	10	-	100	-	-	220!	220!	210!	420!	620!
Copper (Cu)-Total	mg/L	0.001	-	0.015	-	-	0.0033	0.0028	0.001	0.0014	0.0015
Iron (Fe)-Total	mg/L	0.01	-	0.02	-	-	0.7!	1.16!	0.117!	0.237!	0.325!
Lead (Pb)-Total	mg/L	0.00005	-	0.005	-	-	0.00201	0.00209	0.00032	0.00086	0.00115
Manganese (Mn)-Total	mg/L	0.0005	-	-	-	-	0.0763	0.0987	0.0242	0.0257	0.0336
Zinc (Zn)-Total	mg/L	0.003	-	0.011	-	-	0.0243!	0.0544!	0.0068	0.0129!	0.0171!
BOD Carbonaceous	mg/L	2									
* = Result Qualified	Mouse-over the result to see the qualification.										

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key: Within Guideline | Exceeds Guidline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key: Within Guideline | Exceeds Guidline

AECOM CANADA LTD. - KITCHENER
ATTN: Steven Scott
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 02-SEP-20
Report Date: 29-SEP-20 12:59 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L2498044

Project P.O. #: NOT SUBMITTED

Job Reference: 60611735

C of C Numbers:

Legal Site Desc:

Emily Hansen
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2498044-1 HC-A(03) Sampled By: TA on 02-SEP-20 @ 10:36 Matrix: WATER							
Physical Tests							
Total Suspended Solids	34.4		3.0	mg/L	09-SEP-20	10-SEP-20	R5219558
Anions and Nutrients							
Ammonia, Total (as N)	0.025		0.010	mg/L		04-SEP-20	R5213680
Chloride (Cl)	43.8		0.50	mg/L		04-SEP-20	R5214259
Nitrate (as N)	0.609		0.020	mg/L		04-SEP-20	R5214259
Phosphorus (P)-Total Dissolved	0.0092		0.0030	mg/L	04-SEP-20	08-SEP-20	R5213638
Phosphorus, Total	0.101		0.0030	mg/L	03-SEP-20	04-SEP-20	R5210131
Bacteriological Tests							
E. Coli	4800	DLM	100	CFU/100mL		03-SEP-20	R5210247
Total Metals							
Copper (Cu)-Total	0.0040		0.0010	mg/L	03-SEP-20	03-SEP-20	R5209560
Iron (Fe)-Total	0.997		0.010	mg/L	03-SEP-20	03-SEP-20	R5209560
Lead (Pb)-Total	0.00250		0.000050	mg/L	03-SEP-20	03-SEP-20	R5209560
Manganese (Mn)-Total	0.124		0.00050	mg/L	03-SEP-20	03-SEP-20	R5209560
Zinc (Zn)-Total	0.0318		0.0030	mg/L	03-SEP-20	03-SEP-20	R5209560
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		04-SEP-20	R5218096
L2498044-2 HC-A(04) Sampled By: TA on 02-SEP-20 @ 11:09 Matrix: WATER							
Physical Tests							
Total Suspended Solids	5.6		3.0	mg/L	09-SEP-20	10-SEP-20	R5219558
Anions and Nutrients							
Ammonia, Total (as N)	0.034		0.010	mg/L		04-SEP-20	R5213680
Chloride (Cl)	162		0.50	mg/L		04-SEP-20	R5214259
Nitrate (as N)	0.048		0.020	mg/L		04-SEP-20	R5214259
Phosphorus (P)-Total Dissolved	<0.0030		0.0030	mg/L	04-SEP-20	08-SEP-20	R5213638
Phosphorus, Total	0.0140		0.0030	mg/L	03-SEP-20	04-SEP-20	R5210131
Bacteriological Tests							
E. Coli	900	DLM	100	CFU/100mL		03-SEP-20	R5210247
Total Metals							
Copper (Cu)-Total	<0.0010		0.0010	mg/L	03-SEP-20	03-SEP-20	R5209560
Iron (Fe)-Total	0.212		0.010	mg/L	03-SEP-20	03-SEP-20	R5209560
Lead (Pb)-Total	0.000354		0.000050	mg/L	03-SEP-20	03-SEP-20	R5209560
Manganese (Mn)-Total	0.0217		0.00050	mg/L	03-SEP-20	03-SEP-20	R5209560
Zinc (Zn)-Total	0.0104		0.0030	mg/L	03-SEP-20	03-SEP-20	R5209560
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		04-SEP-20	R5218096
L2498044-3 HC-A(12) Sampled By: TA on 02-SEP-20 @ 09:38 Matrix: WATER							
Physical Tests							
Total Suspended Solids	16.4		3.0	mg/L	09-SEP-20	10-SEP-20	R5219558

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2498044-3 HC-A(12) Sampled By: TA on 02-SEP-20 @ 09:38 Matrix: WATER							
Physical Tests							
Anions and Nutrients							
Ammonia, Total (as N)	0.037		0.010	mg/L		04-SEP-20	R5213680
Chloride (Cl)	180		0.50	mg/L		04-SEP-20	R5214259
Nitrate (as N)	0.116		0.020	mg/L		04-SEP-20	R5214259
Phosphorus (P)-Total Dissolved	0.0182		0.0030	mg/L	04-SEP-20	08-SEP-20	R5213638
Phosphorus, Total	0.0565		0.0030	mg/L	03-SEP-20	04-SEP-20	R5210131
Bacteriological Tests							
E. Coli	2500	DLM	100	CFU/100mL		03-SEP-20	R5210247
Total Metals							
Copper (Cu)-Total	0.0014		0.0010	mg/L	03-SEP-20	03-SEP-20	R5209560
Iron (Fe)-Total	0.367		0.010	mg/L	03-SEP-20	03-SEP-20	R5209560
Lead (Pb)-Total	0.000699		0.000050	mg/L	03-SEP-20	03-SEP-20	R5209560
Manganese (Mn)-Total	0.0590		0.00050	mg/L	03-SEP-20	03-SEP-20	R5209560
Zinc (Zn)-Total	0.0144		0.0030	mg/L	03-SEP-20	03-SEP-20	R5209560
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		04-SEP-20	R5218096
L2498044-4 HC-A(13) Sampled By: TA on 02-SEP-20 @ 09:51 Matrix: WATER							
Physical Tests							
Total Suspended Solids	14.0		3.0	mg/L	09-SEP-20	10-SEP-20	R5219558
Anions and Nutrients							
Ammonia, Total (as N)	0.018		0.010	mg/L		04-SEP-20	R5213680
Chloride (Cl)	182		0.50	mg/L		04-SEP-20	R5214259
Nitrate (as N)	0.112		0.020	mg/L		04-SEP-20	R5214259
Phosphorus (P)-Total Dissolved	0.0191		0.0030	mg/L	04-SEP-20	08-SEP-20	R5213638
Phosphorus, Total	0.0423		0.0030	mg/L	03-SEP-20	04-SEP-20	R5210131
Bacteriological Tests							
E. Coli	1200	DLM	100	CFU/100mL		03-SEP-20	R5210247
Total Metals							
Copper (Cu)-Total	0.0014		0.0010	mg/L	03-SEP-20	03-SEP-20	R5209560
Iron (Fe)-Total	0.266		0.010	mg/L	03-SEP-20	03-SEP-20	R5209560
Lead (Pb)-Total	0.000603		0.000050	mg/L	03-SEP-20	03-SEP-20	R5209560
Manganese (Mn)-Total	0.0312		0.00050	mg/L	03-SEP-20	03-SEP-20	R5209560
Zinc (Zn)-Total	0.0116		0.0030	mg/L	03-SEP-20	03-SEP-20	R5209560
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		04-SEP-20	R5218096
L2498044-5 HC-A(14) Sampled By: TA on 02-SEP-20 @ 10:01 Matrix: WATER							
Physical Tests							
Total Suspended Solids	15.8		3.0	mg/L	09-SEP-20	10-SEP-20	R5219558
Anions and Nutrients							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2498044-5 HC-A(14)							
Sampled By: TA on 02-SEP-20 @ 10:01							
Matrix: WATER							
Anions and Nutrients							
Ammonia, Total (as N)	0.031		0.010	mg/L		04-SEP-20	R5213680
Chloride (Cl)	181		0.50	mg/L		04-SEP-20	R5214259
Nitrate (as N)	0.115		0.020	mg/L		04-SEP-20	R5214259
Phosphorus (P)-Total Dissolved	0.0207		0.0030	mg/L	04-SEP-20	08-SEP-20	R5213638
Phosphorus, Total	0.0472		0.0030	mg/L	03-SEP-20	04-SEP-20	R5210131
Bacteriological Tests							
E. Coli	900	DLM	100	CFU/100mL		03-SEP-20	R5210247
Total Metals							
Copper (Cu)-Total	0.0013		0.0010	mg/L	03-SEP-20	03-SEP-20	R5209560
Iron (Fe)-Total	0.281		0.010	mg/L	03-SEP-20	03-SEP-20	R5209560
Lead (Pb)-Total	0.000685		0.000050	mg/L	03-SEP-20	03-SEP-20	R5209560
Manganese (Mn)-Total	0.0331		0.00050	mg/L	03-SEP-20	03-SEP-20	R5209560
Zinc (Zn)-Total	0.0133		0.0030	mg/L	03-SEP-20	03-SEP-20	R5209560
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		04-SEP-20	R5218096

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Iron (Fe)-Total	MS-B	L2498044-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Total	MS-B	L2498044-1, -2, -3, -4, -5

Sample Parameter Qualifier key listed:

Qualifier	Description
BODL	Limit of Reporting for BOD was increased to account for the largest volume of sample tested.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BOD-C-WT	Water	BOD Carbonaceous	APHA 5210 B (CBOD)

This analysis is carried out using procedures adapted from APHA Method 5210B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h. Method ID: WT-TM-1200

EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

Reference Information

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L2498044 Report Date: 29-SEP-20

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BOD-C-WT	**Water**							
Batch R5218096								
WG3398477-2 DUP		**L2498044-2**						
BOD Carbonaceous		<3.0	<3.0	RPD-NA	mg/L	N/A	30	04-SEP-20
WG3398477-6 DUP		**L2498044-5**						
BOD Carbonaceous		<3.0	<3.0	RPD-NA	mg/L	N/A	30	04-SEP-20
WG3398477-3 LCS								
BOD Carbonaceous			93.4		%		85-115	04-SEP-20
WG3398477-7 LCS								
BOD Carbonaceous			93.4		%		85-115	04-SEP-20
WG3398477-1 MB								
BOD Carbonaceous			<2.0		mg/L		2	04-SEP-20
WG3398477-5 MB								
BOD Carbonaceous			<2.0		mg/L		2	04-SEP-20
CL-IC-N-WT	**Water**							
Batch R5214259								
WG3398634-10 DUP		**WG3398634-8**						
Chloride (Cl)		76.5	76.5		mg/L	0.0	20	04-SEP-20
WG3398634-7 LCS								
Chloride (Cl)			103.3		%		90-110	04-SEP-20
WG3398634-6 MB								
Chloride (Cl)			<0.50		mg/L		0.5	04-SEP-20
WG3398634-9 MS		**WG3398634-8**						
Chloride (Cl)			98.2		%		75-125	04-SEP-20
EC-MF-WT	**Water**							
Batch R5210247								
WG3397419-3 DUP		**L2497892-1**						
E. Coli		7	6		CFU/100mL	15	65	03-SEP-20
WG3397419-1 MB								
E. Coli			0		CFU/100mL		1	03-SEP-20
MET-T-CCMS-WT	**Water**							
Batch R5209560								
WG3397174-4 DUP		**WG3397174-3**						
Copper (Cu)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	03-SEP-20
Iron (Fe)-Total		0.657	0.666		mg/L	1.4	20	03-SEP-20
Lead (Pb)-Total		0.000265	0.000264		mg/L	0.7	20	03-SEP-20
Manganese (Mn)-Total		0.113	0.114		mg/L	1.1	20	03-SEP-20
Zinc (Zn)-Total		<0.0030	<0.0030	RPD-NA	mg/L	N/A	20	03-SEP-20
WG3397174-2 LCS								

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R5209560								
WG3397174-2 LCS								
Copper (Cu)-Total			99.8		%		80-120	03-SEP-20
Iron (Fe)-Total			101.2		%		80-120	03-SEP-20
Lead (Pb)-Total			98.5		%		80-120	03-SEP-20
Manganese (Mn)-Total			103.9		%		80-120	03-SEP-20
Zinc (Zn)-Total			99.1		%		80-120	03-SEP-20
WG3397174-1 MB								
Copper (Cu)-Total			<0.00050		mg/L		0.0005	03-SEP-20
Iron (Fe)-Total			<0.010		mg/L		0.01	03-SEP-20
Lead (Pb)-Total			<0.000050		mg/L		0.00005	03-SEP-20
Manganese (Mn)-Total			<0.00050		mg/L		0.0005	03-SEP-20
Zinc (Zn)-Total			<0.0030		mg/L		0.003	03-SEP-20
WG3397174-5 MS		**WG3397174-3**						
Copper (Cu)-Total			88.4		%		70-130	03-SEP-20
Iron (Fe)-Total			N/A	MS-B	%		-	03-SEP-20
Lead (Pb)-Total			91.4		%		70-130	03-SEP-20
Manganese (Mn)-Total			N/A	MS-B	%		-	03-SEP-20
Zinc (Zn)-Total			90.7		%		70-130	03-SEP-20
NH3-F-WT	**Water**							
Batch R5213680								
WG3397082-3 DUP		**L2497892-1**						
Ammonia, Total (as N)		0.093	0.093		mg/L	0.4	20	08-SEP-20
WG3397082-2 LCS								
Ammonia, Total (as N)			103.7		%		85-115	04-SEP-20
WG3397082-1 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	04-SEP-20
WG3397082-4 MS		**L2497892-1**						
Ammonia, Total (as N)			106.7		%		75-125	08-SEP-20
NO3-IC-WT	**Water**							
Batch R5214259								
WG3398634-10 DUP		**WG3398634-8**						
Nitrate (as N)		0.829	0.829		mg/L	0.0	20	04-SEP-20
WG3398634-7 LCS								
Nitrate (as N)			103.9		%		90-110	04-SEP-20
WG3398634-6 MB								
Nitrate (as N)			<0.020		mg/L		0.02	04-SEP-20

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-WT	**Water**							
Batch R5214259								
WG3398634-9 MS		**WG3398634-8**						
Nitrate (as N)			101.1		%		75-125	04-SEP-20
P-T-COL-WT	**Water**							
Batch R5210131								
WG3397258-3 DUP		**L2498014-2**						
Phosphorus, Total		0.0422	0.0393		mg/L	7.2	20	04-SEP-20
WG3397258-2 LCS								
Phosphorus, Total			100.9		%		80-120	04-SEP-20
WG3397258-1 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	04-SEP-20
WG3397258-4 MS		**L2498014-2**						
Phosphorus, Total			95.6		%		70-130	04-SEP-20
P-TD-COL-WT	**Water**							
Batch R5213638								
WG3398770-3 DUP		**L2498044-1**						
Phosphorus (P)-Total Dissolved		0.0092	0.0100		mg/L	8.2	20	08-SEP-20
WG3398770-2 LCS								
Phosphorus (P)-Total Dissolved			102.6		%		80-120	08-SEP-20
WG3398770-1 MB								
Phosphorus (P)-Total Dissolved			<0.0030		mg/L		0.003	08-SEP-20
WG3398770-4 MS		**L2498044-1**						
Phosphorus (P)-Total Dissolved			100.5		%		70-130	08-SEP-20
SOLIDS-TSS-WT	**Water**							
Batch R5219558								
WG3400577-3 DUP		**L2499690-1**						
Total Suspended Solids		<3.0	<3.0	RPD-NA	mg/L	N/A	20	10-SEP-20
WG3400577-2 LCS								
Total Suspended Solids			91.7		%		85-115	10-SEP-20
WG3400577-1 MB								
Total Suspended Solids			<3.0		mg/L		3	10-SEP-20

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: Steven Scott

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

C of C # 00000

60
WA
Ph
Fa
Toll Free: 1-800-668-9878

L2498044-COFC

CHAIN OF CUSTODY / ANALYTICAL SERVICES REQUEST FORM

Page ___ of ___

Note: all TAT Quoted material is in business days which exclude statutory holidays and weekends. TAT samples received past 3:00 pm or Saturday/Sunday begin the next day.

Specify date required	Service requested			
	5 day (regular)	X	2 day TAT (50%)	
	3-4 day (regular)		Next day TAT (100%)	
			Same day TAT (200%)	

COMPANY NAME	AECOM
OFFICE	Kitchener
PROJECT MANAGER	Steven Scott
PROJECT #	60611735
PHONE	519-650-8637 OR 519-569-9388
FAX	
ACCOUNT #	15884
QUOTATION #	Q59209
PO #	

CRITERIA Criteria on report YESX__ NO___

Reg 153/11
Table 1 2 3

TCLP _____ MISA ______ PWQO ___X__
ODWS _____ OTHER ______

REPORT FORMAT/DISTRIBUTION

EMAIL _X_ FAX ___ BOTH ___
SELECT: PDF ___ DIGITAL ___ BOTH _X_
~~EMAIL 1~~
EMAIL 2 Steve.Scott2@aecom.com
EMAIL 3 Tochi.Azubuike@aecom.com

PLEASE INDICATE FILTERED, PRESERVED OR BOTH <----- (F, P, F/P)

SUBMISSION #: L2498044
ENTERED BY: RD
DATE/TIME ENTERED:
BIN #:

SAMPLING INFORMATION / **ANALYSIS REQUEST**

Date (dd-mm-yy)	Time (24hr) (hh:mm)	COMP	GRAB	WATER	SOIL	OTHER	SAMPLE DESCRIPTION TO APPEAR ON REPORT	NUMBER OF CONTAINERS	TSS	CBODS	E. Coli	Total Metals by ICPMS (Lead, Zinc, Coppe	Total and Dissolved P (Lab Filter)	Total Ammonia Nitrogen, NO^3, and CL	COMMENTS	LAB ID
02-09-20	10:36		X	X			HC-A(03)	7	X	X	X	X	X	X		
02-09-20	11:09		X	X			HC-A(04)	7	X	X	X	X	X	X		
02-09-20	09:38		X	X			HC-A(12)	7	X	X	X	X	X	X		
02-09-20	09:51		X	X			HC-A(13)	7	X	X	X	X	X	X		
02-09-20	10:01		X	X			HC-A(14)	7	X	X	X	X	X	X		

SPECIAL INSTRUCTIONS/COMMENTS

Surface water samples, so colforms counts may be high.

Please also provide pH measurement as field measurements seemed high.

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (CHECK Yes OR No)

Are any samples taken from a regulated DW System? Yes ___ No ___
If yes, an authorized drinking water COC MUST be used for this submission.
Is the water sampled intended to be potable for human consumption? Yes ___ No ___

SAMPLE CONDITION

FROZEN
COLD
COOLING INITIATED
AMBIENT
MEAN TEMP
OBSERVATIONS Yes ___ No ___
yes add SIF

SAMPLED BY: Tochi Azubuike	DATE & TIME 02/09/20	RECEIVED BY:	DATE & TIME	
RELINQUISHED BY: Tochi Azubuike	DATE & TIME 02/09/20	RECEIVED AT LAB BY:	DATE & TIME 9-2-2020 1700	

Notes

1. Quote number must be provided to ensure proper pricing

2. TAT may vary dependent on complexity of analysis and lab workload at time of submission. Please contact the lab to confirm TATs.

3. Any known or suspected hazards relating to a sample must be noted on the chain of custody in comments section.

ALS		Sample ID					HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)
2/5/2021		ALS ID					L2110610-1	L2110610-2	L2110610-3	L2110610-4	L2110610-5
L2498044		Date Sampled	PWQO		Guelph Storm		6/12/2018 10:50:00 AM	6/12/2018 11:10:00 AM	6/12/2018 11:25:00 AM	6/12/2018 2:45:00 PM	6/12/2018 3:15:00 PM
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Water	Water	Water	Water	Water
Total Suspended Solids	mg/L	3	-	-	-	15	34.4!!	5.6	16.4!!	14	15.8!!
Ammonia, Total (as N)	mg/L	0.01	-	-	-	-	0.025	0.034	0.037	0.018	0.031
Chloride (Cl)	mg/L	0.5	-	-	-	-	43.8	162	180	182	181
Nitrate (as N)	mg/L	0.02	-	-	-	-	0.609	0.048	0.116	0.112	0.115
Phosphorus (P)-Total Dissolved	mg/L	0.003	-	-	-	-	0.0092	0.003	0.0182	0.0191	0.0207
Phosphorus, Total	mg/L	0.003	-	0.02	-	-	0.101!	0.014	0.0565!	0.0423!	0.0472!
E. Coli	CFU/100mL	100	-	100	-	-	4800!	900!	2500!	1200!	900!
Copper (Cu)-Total	mg/L	0.001	-	0.015	-	-	0.004	0.001	0.0014	0.0014	0.0013
Iron (Fe)-Total	mg/L	0.01	-	0.02	-	-	0.997!	0.212!	0.367!	0.266!	0.281!
Lead (Pb)-Total	mg/L	0.00005	-	0.005	-	-	0.0025	0.000354	0.000699	0.000603	0.000685
Manganese (Mn)-Total	mg/L	0.0005	-	-	-	-	0.124	0.0217	0.059	0.0312	0.0331
Zinc (Zn)-Total	mg/L	0.003	-	0.011	-	-	0.0318!	0.0104	0.0144!	0.0116!	0.0133!
BOD Carbonaceous	mg/L	3	-	-	-	-	3	3	3	3	3
							.	.	.	.	.
* = Result Qualified	Mouse-over the result to see the qualification.						.	.	.	.	.

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key: Within Guideline | Exceeds Guidline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key: Within Guideline | Exceeds Guidline

AECOM CANADA LTD. - KITCHENER
ATTN: STEVE SCOTT
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 21-OCT-20
Report Date: 27-OCT-20 16:30 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L2519550
Project P.O. #: NOT SUBMITTED
Job Reference: 60611735
C of C Numbers:
Legal Site Desc:

Emily Hansen
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2519550-1 HC-A (03) Sampled By: CLIENT on 21-OCT-20 @ 09:23 Matrix: WATER							
Physical Tests							
Total Suspended Solids	10.0		3.0	mg/L	26-OCT-20	27-OCT-20	R5269163
Anions and Nutrients							
Ammonia, Total (as N)	0.012		0.010	mg/L		22-OCT-20	R5263820
Chloride (Cl)	37.9		0.50	mg/L		23-OCT-20	R5268459
Nitrate (as N)	0.326		0.020	mg/L		23-OCT-20	R5268459
Phosphorus (P)-Total Dissolved	0.0058		0.0030	mg/L	21-OCT-20	22-OCT-20	R5264318
Phosphorus, Total	0.0249		0.0030	mg/L	22-OCT-20	23-OCT-20	R5267103
Bacteriological Tests							
E. Coli	490	DLM	10	CFU/100mL		22-OCT-20	R5266261
Total Metals							
Copper (Cu)-Total	0.0015		0.0010	mg/L	22-OCT-20	23-OCT-20	R5266003
Iron (Fe)-Total	0.244		0.010	mg/L	22-OCT-20	23-OCT-20	R5266003
Lead (Pb)-Total	0.000415		0.000050	mg/L	22-OCT-20	23-OCT-20	R5266003
Manganese (Mn)-Total	0.0473		0.00050	mg/L	22-OCT-20	23-OCT-20	R5266003
Zinc (Zn)-Total	0.0092		0.0030	mg/L	22-OCT-20	23-OCT-20	R5266003
Aggregate Organics							
BOD Carbonaceous	3.9		3.0	mg/L		22-OCT-20	R5269515
L2519550-2 HC-A (04) Sampled By: CLIENT on 21-OCT-20 @ 09:33 Matrix: WATER							
Physical Tests							
Total Suspended Solids	<3.0		3.0	mg/L	26-OCT-20	27-OCT-20	R5269163
Anions and Nutrients							
Ammonia, Total (as N)	0.027		0.010	mg/L		22-OCT-20	R5263820
Chloride (Cl)	161		0.50	mg/L		23-OCT-20	R5268459
Nitrate (as N)	0.093		0.020	mg/L		23-OCT-20	R5268459
Phosphorus (P)-Total Dissolved	0.0030		0.0030	mg/L	21-OCT-20	22-OCT-20	R5264318
Phosphorus, Total	0.0109		0.0030	mg/L	22-OCT-20	23-OCT-20	R5267103
Bacteriological Tests							
E. Coli	60	DLM	10	CFU/100mL		22-OCT-20	R5266261
Total Metals							
Copper (Cu)-Total	<0.0010		0.0010	mg/L	22-OCT-20	23-OCT-20	R5266003
Iron (Fe)-Total	0.215		0.010	mg/L	22-OCT-20	23-OCT-20	R5266003
Lead (Pb)-Total	0.000263		0.000050	mg/L	22-OCT-20	23-OCT-20	R5266003
Manganese (Mn)-Total	0.0342		0.00050	mg/L	22-OCT-20	23-OCT-20	R5266003
Zinc (Zn)-Total	0.0101		0.0030	mg/L	22-OCT-20	23-OCT-20	R5266003
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		22-OCT-20	R5269515
L2519550-3 HC-A (12) Sampled By: CLIENT on 21-OCT-20 @ 09:56 Matrix: WATER							
Physical Tests							
Total Suspended Solids	4.0		3.0	mg/L	26-OCT-20	27-OCT-20	R5269163

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2519550-3 HC-A (12) Sampled By: CLIENT on 21-OCT-20 @ 09:56 Matrix: WATER							
Physical Tests							
Anions and Nutrients							
Ammonia, Total (as N)	0.029		0.010	mg/L		22-OCT-20	R5263820
Chloride (Cl)	202	DLDS	2.5	mg/L		23-OCT-20	R5268459
Nitrate (as N)	0.19	DLDS	0.10	mg/L		23-OCT-20	R5268459
Phosphorus (P)-Total Dissolved	0.0064		0.0030	mg/L	21-OCT-20	22-OCT-20	R5264318
Phosphorus, Total	0.0167		0.0030	mg/L	22-OCT-20	23-OCT-20	R5267103
Bacteriological Tests							
E. Coli	80	DLM	10	CFU/100mL		22-OCT-20	R5266261
Total Metals							
Copper (Cu)-Total	<0.0010		0.0010	mg/L	22-OCT-20	23-OCT-20	R5266003
Iron (Fe)-Total	0.140		0.010	mg/L	22-OCT-20	23-OCT-20	R5266003
Lead (Pb)-Total	0.000270		0.000050	mg/L	22-OCT-20	23-OCT-20	R5266003
Manganese (Mn)-Total	0.0221		0.00050	mg/L	22-OCT-20	23-OCT-20	R5266003
Zinc (Zn)-Total	0.0074		0.0030	mg/L	22-OCT-20	23-OCT-20	R5266003
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		22-OCT-20	R5269515
L2519550-4 HC-A (13) Sampled By: CLIENT on 21-OCT-20 @ 10:10 Matrix: WATER							
Physical Tests							
Total Suspended Solids	4.6		3.0	mg/L	26-OCT-20	27-OCT-20	R5269163
Anions and Nutrients							
Ammonia, Total (as N)	0.049		0.010	mg/L		23-OCT-20	R5263820
Chloride (Cl)	203		0.50	mg/L		23-OCT-20	R5268459
Nitrate (as N)	0.185		0.020	mg/L		23-OCT-20	R5268459
Phosphorus (P)-Total Dissolved	0.0116		0.0030	mg/L	21-OCT-20	22-OCT-20	R5264318
Phosphorus, Total	0.0152		0.0030	mg/L	22-OCT-20	23-OCT-20	R5267103
Bacteriological Tests							
E. Coli	50	DLM	10	CFU/100mL		22-OCT-20	R5266261
Total Metals							
Copper (Cu)-Total	<0.0010		0.0010	mg/L	22-OCT-20	23-OCT-20	R5266003
Iron (Fe)-Total	0.106		0.010	mg/L	22-OCT-20	23-OCT-20	R5266003
Lead (Pb)-Total	0.000243		0.000050	mg/L	22-OCT-20	23-OCT-20	R5266003
Manganese (Mn)-Total	0.0123		0.00050	mg/L	22-OCT-20	23-OCT-20	R5266003
Zinc (Zn)-Total	0.0068		0.0030	mg/L	22-OCT-20	23-OCT-20	R5266003
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		22-OCT-20	R5269515
L2519550-5 HC-A (14) Sampled By: CLIENT on 21-OCT-20 @ 10:17 Matrix: WATER							
Physical Tests							
Total Suspended Solids	22.0		3.0	mg/L	26-OCT-20	27-OCT-20	R5269163
Anions and Nutrients							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2519550-5 HC-A (14) Sampled By: CLIENT on 21-OCT-20 @ 10:17 Matrix: WATER							
Anions and Nutrients							
Ammonia, Total (as N)	0.024		0.010	mg/L		23-OCT-20	R5263820
Chloride (Cl)	203		0.50	mg/L		23-OCT-20	R5268459
Nitrate (as N)	0.191		0.020	mg/L		23-OCT-20	R5268459
Phosphorus (P)-Total Dissolved	0.0098		0.0030	mg/L	21-OCT-20	22-OCT-20	R5264318
Phosphorus, Total	0.0352		0.0030	mg/L	22-OCT-20	23-OCT-20	R5267103
Bacteriological Tests							
E. Coli	40	DLM	10	CFU/100mL		22-OCT-20	R5266261
Total Metals							
Copper (Cu)-Total	0.0015		0.0010	mg/L	22-OCT-20	23-OCT-20	R5266003
Iron (Fe)-Total	0.276		0.010	mg/L	22-OCT-20	23-OCT-20	R5266003
Lead (Pb)-Total	0.00111		0.000050	mg/L	22-OCT-20	23-OCT-20	R5266003
Manganese (Mn)-Total	0.0355		0.00050	mg/L	22-OCT-20	23-OCT-20	R5266003
Zinc (Zn)-Total	0.0178		0.0030	mg/L	22-OCT-20	23-OCT-20	R5266003
Aggregate Organics							
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		22-OCT-20	R5269515

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Manganese (Mn)-Total	MS-B	L2519550-1, -2, -3, -4, -5
Matrix Spike	Ammonia, Total (as N)	MS-B	L2519550-4, -5

Sample Parameter Qualifier key listed:

Qualifier	Description
BODL	Limit of Reporting for BOD was increased to account for the largest volume of sample tested.
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BOD-C-WT	Water	BOD Carbonaceous	APHA 5210 B (CBOD)

This analysis is carried out using procedures adapted from APHA Method 5210B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h. Method ID: WT-TM-1200

EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

Reference Information

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: STEVE SCOTT

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BOD-C-WT	**Water**							
Batch R5269515								
WG3430243-2 DUP		**L2519202-1**						
BOD Carbonaceous		3.2	3.2		mg/L	1.9	30	22-OCT-20
WG3430243-6 DUP		**L2519550-2**						
BOD Carbonaceous		<3.0	<3.0	RPD-NA	mg/L	N/A	30	22-OCT-20
WG3430243-3 LCS								
BOD Carbonaceous			97.5		%		85-115	22-OCT-20
WG3430243-7 LCS								
BOD Carbonaceous			98.0		%		85-115	22-OCT-20
WG3430243-1 MB								
BOD Carbonaceous			<2.0		mg/L		2	22-OCT-20
WG3430243-5 MB								
BOD Carbonaceous			<2.0		mg/L		2	22-OCT-20
CL-IC-N-WT	**Water**							
Batch R5268459								
WG3431080-10 DUP		**WG3431080-8**						
Chloride (Cl)		56.2	56.4		mg/L	0.4	20	23-OCT-20
WG3431080-4 DUP		**WG3431080-3**						
Chloride (Cl)		24.6	24.7		mg/L	0.0	20	23-OCT-20
WG3431080-2 LCS								
Chloride (Cl)			99.8		%		90-110	23-OCT-20
WG3431080-7 LCS								
Chloride (Cl)			100.3		%		90-110	23-OCT-20
WG3431080-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	23-OCT-20
WG3431080-6 MB								
Chloride (Cl)			<0.50		mg/L		0.5	23-OCT-20
WG3431080-5 MS		**WG3431080-3**						
Chloride (Cl)			100.8		%		75-125	23-OCT-20
WG3431080-9 MS		**WG3431080-8**						
Chloride (Cl)			98.7		%		75-125	23-OCT-20
EC-MF-WT	**Water**							
Batch R5266261								
WG3429917-3 DUP		**L2519765-3**						
E. Coli		300	270		CFU/100mL	11	65	22-OCT-20
WG3429917-4 DUP		**L2519765-24**						
E. Coli		140	100		CFU/100mL	33	65	22-OCT-20
WG3429917-1 MB								
E. Coli			0		CFU/100mL		1	22-OCT-20

ALS Environmental

Quality Control Report

Workorder: L2519550 Report Date: 27-OCT-20

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4

Contact: STEVE SCOTT

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R5266003								
WG3429685-4 DUP		**WG3429685-3**						
Copper (Cu)-Total		0.0080	0.0079		mg/L	1.0	20	23-OCT-20
Iron (Fe)-Total		5.09	5.06		mg/L	0.6	20	23-OCT-20
Lead (Pb)-Total		0.00268	0.00262		mg/L	2.0	20	23-OCT-20
Manganese (Mn)-Total		0.0636	0.0640		mg/L	0.6	20	23-OCT-20
Zinc (Zn)-Total		0.054	0.054		mg/L	0.9	20	23-OCT-20
WG3429685-2 LCS								
Copper (Cu)-Total			92.5		%		80-120	23-OCT-20
Iron (Fe)-Total			96.0		%		80-120	23-OCT-20
Lead (Pb)-Total			99.8		%		80-120	23-OCT-20
Manganese (Mn)-Total			95.2		%		80-120	23-OCT-20
Zinc (Zn)-Total			94.6		%		80-120	23-OCT-20
WG3429685-1 MB								
Copper (Cu)-Total			<0.00050		mg/L		0.0005	23-OCT-20
Iron (Fe)-Total			<0.010		mg/L		0.01	23-OCT-20
Lead (Pb)-Total			<0.000050		mg/L		0.00005	23-OCT-20
Manganese (Mn)-Total			<0.00050		mg/L		0.0005	23-OCT-20
Zinc (Zn)-Total			<0.0030		mg/L		0.003	23-OCT-20
WG3429685-5 MS		**WG3429685-6**						
Copper (Cu)-Total			90.6		%		70-130	23-OCT-20
Iron (Fe)-Total			95.3		%		70-130	23-OCT-20
Lead (Pb)-Total			93.0		%		70-130	23-OCT-20
Manganese (Mn)-Total			N/A	MS-B	%		-	23-OCT-20
Zinc (Zn)-Total			87.2		%		70-130	23-OCT-20
NH3-F-WT	**Water**							
Batch R5263820								
WG3429343-3 DUP		**L2519442-5**						
Ammonia, Total (as N)		0.041	0.041		mg/L	0.2	20	22-OCT-20
WG3429408-3 DUP		**L2519479-3**						
Ammonia, Total (as N)		162	163		mg/L	1.1	20	26-OCT-20
WG3429343-2 LCS								
Ammonia, Total (as N)			97.0		%		85-115	22-OCT-20
WG3429408-2 LCS								
Ammonia, Total (as N)			107.8		%		85-115	22-OCT-20
WG3429343-1 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	22-OCT-20

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: STEVE SCOTT

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NH3-F-WT	**Water**							
Batch R5263820								
WG3429408-1 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	22-OCT-20
WG3429343-4 MS		**L2519442-5**						
Ammonia, Total (as N)			107.1		%		75-125	22-OCT-20
WG3429408-4 MS		**L2519479-3**						
Ammonia, Total (as N)			N/A	MS-B	%		-	26-OCT-20
NO3-IC-WT	**Water**							
Batch R5268459								
WG3431080-10 DUP		**WG3431080-8**						
Nitrate (as N)		1.65	1.65		mg/L	0.1	20	23-OCT-20
WG3431080-4 DUP		**WG3431080-3**						
Nitrate (as N)		0.075	0.073		mg/L	2.1	20	23-OCT-20
WG3431080-2 LCS								
Nitrate (as N)			100.4		%		90-110	23-OCT-20
WG3431080-7 LCS								
Nitrate (as N)			99.9		%		90-110	23-OCT-20
WG3431080-1 MB								
Nitrate (as N)			<0.020		mg/L		0.02	23-OCT-20
WG3431080-6 MB								
Nitrate (as N)			<0.020		mg/L		0.02	23-OCT-20
WG3431080-5 MS		**WG3431080-3**						
Nitrate (as N)			96.1		%		75-125	23-OCT-20
WG3431080-9 MS		**WG3431080-8**						
Nitrate (as N)			97.8		%		75-125	23-OCT-20
P-T-COL-WT	**Water**							
Batch R5267103								
WG3429377-3 DUP		**L2519353-4**						
Phosphorus, Total		0.0122	0.0126		mg/L	3.2	20	23-OCT-20
WG3429377-2 LCS								
Phosphorus, Total			98.1		%		80-120	23-OCT-20
WG3429377-1 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	23-OCT-20
WG3429377-4 MS		**L2519353-4**						
Phosphorus, Total			92.2		%		70-130	23-OCT-20
P-TD-COL-WT	**Water**							

Quality Control Report

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: STEVE SCOTT

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
P-TD-COL-WT	**Water**							
Batch R5264318								
WG3429468-3 DUP		**L2519267-3**						
Phosphorus (P)-Total Dissolved		0.0046	0.0059	J	mg/L	0.0013	0.006	22-OCT-20
WG3429468-2 LCS								
Phosphorus (P)-Total Dissolved			98.7		%		80-120	22-OCT-20
WG3429468-1 MB								
Phosphorus (P)-Total Dissolved			<0.0030		mg/L		0.003	22-OCT-20
WG3429468-4 MS		**L2519267-3**						
Phosphorus (P)-Total Dissolved			98.6		%		70-130	22-OCT-20
SOLIDS-TSS-WT	**Water**							
Batch R5269163								
WG3431987-3 DUP		**L2520753-3**						
Total Suspended Solids		1250	1260		mg/L	0.6	20	27-OCT-20
WG3431987-2 LCS								
Total Suspended Solids			95.3		%		85-115	27-OCT-20
WG3431987-1 MB								
Total Suspended Solids			<3.0		mg/L		3	27-OCT-20

Client: AECOM CANADA LTD. - KITCHENER
50 Sportsworld Crossing Road Suite 290
KITCHENER ON N2P 0A4
Contact: STEVE SCOTT

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

L2519550-COFC

C of C # 00000

60 NORTHLAND ROAD, UNIT 1
WATERLOO, ON N2V 2B8
Phone: (519) 886-6910
Fax: (519) 886-9047
Toll Free: 1-800-668-9878

ALS

CHAIN ... REQUEST FORM

Page ___ of ___

Note: all TAT Quoted material is in business days which exclude statutory holidays and weekends. TAT samples received past 3:00 pm or Saturday/Sunday begin the next day.

Specify date required

Service requested			
5 day (regular)	X	2 day TAT (50%)	
3-4 day (regular)		Next day TAT (100%)	
		Same day TAT (200%)	

COMPANY NAME	AECOM
OFFICE	Kitchener
PROJECT MANAGER	Steven Scott
PROJECT #	60611735
PHONE	519-650-8637 OR 519-569-9388
FAX	
ACCOUNT #	15884
QUOTATION #	Q59209
PO #	

CRITERIA — Criteria on report YESX_ NO___

Reg 153/11 Table 1 2 3

TCLP ____ MISA ______ PWQO ___X__
ODWS _____ OTHER ______

REPORT FORMAT/DISTRIBUTION

EMAIL _X_ FAX ___ BOTH ___
SELECT: PDF ___ DIGITAL ___ BOTH _X_
EMAIL 1 Tara.Roumeliotis@aecom.com
EMAIL 2 Steve.Scott2@aecom.com
EMAIL 3 Tochi.Azubuike@aecom.com

PLEASE INDICATE FILTERED, PRESERVED OR BOTH <---- (F, P, F/P)

SUBMISSION #: L2519550
ENTERED BY: ML
DATE/TIME ENTERED:
BIN #:

SAMPLING INFORMATION / **ANALYSIS REQUEST**

Date (dd-mm-yy)	Time (24hr) (hh:mm)	COMP	GRAB	WATER	SOIL	OTHER	SAMPLE DESCRIPTION TO APPEAR ON REPORT	NUMBER OF CONTAINERS	TSS	CBOD5	E. Coli	Total Metals by ICPMS (Lead, Zinc, Coppe	Total and Dissolved P (Lab Filter)	Total Ammonia Nitrogen, NO^3, and CL					COMMENTS	LAB ID
21-10-20	9:23		X	X			HC-A(03)	7	X	X	X	X	X	X						
21-10-20	9:33		X	X			HC-A(04)	7	X	X	X	X	X	X						
21-10-20	9:56		X	X			HC-A(12)	7	X	X	X	X	X	X						
21-10-20	10:10		X	X			HC-A(13)	7	X	X	X	X	X	X						
21-10-20	10:17		X	X			HC-A(14)	7	X	X	X	X	X	X						

SPECIAL INSTRUCTIONS/COMMENTS

Surface water samples, so colforms counts may be high.

Please also provide pH measurement as field measurements seemed high.

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (CHECK Yes OR No)

Are any samples taken from a regulated DW System? Yes ___ No ___
If yes, an authorized drinking water COC MUST be used for this submission.
Is the water sampled intended to be potable for human consumption? Yes ___ No ___

SAMPLE CONDITION

___ FROZEN
___ COLD
___ COOLING INITIATED
___ AMBIENT

MEAN TEMP: 9.3

OBSERVATIONS Yes___ No___ If yes add SIF

INIT

10 packs

SAMPLED BY: Tochi Azubuike	DATE & TIME 21/10/20	RECEIVED BY:	DATE & TIME	
RELINQUISHED BY: Tochi Azubuike	DATE & TIME 21/10/20	RECEIVED AT LAB BY: AP	DATE & TIME 21-10-20 11:45	

Notes

1. Quote number must be provided to ensure proper pricing

2. TAT may vary dependent on complexity of analysis and lab workload at time of submission. Please contact the lab to confirm TATs.

3. Any known or suspected hazards relating to a sample must be noted on the chain of custody in comments section.

ALS		Sample ID					HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)
2/5/2021		ALS ID					L2110610-1	L2110610-2	L2110610-3	L2110610-4	L2110610-5
L2519550		Date Sampled	PWQO		Guelph Storm		6/12/2018 10:50:00 AM	6/12/2018 11:10:00 AM	6/12/2018 11:25:00 AM	6/12/2018 2:45:00 PM	6/12/2018 3:15:00 PM
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Water	Water	Water	Water	Water
Total Suspended Solids	mg/L	3	-	-	-	15	10	3	4	4.6	22!!
Ammonia, Total (as N)	mg/L	0.01	-	-	-	-	0.012	0.027	0.029	0.049	0.024
Chloride (Cl)	mg/L	0.5	-	-	-	-	37.9	161	202	203	203
Nitrate (as N)	mg/L	0.02	-	-	-	-	0.326	0.093	0.19	0.185	0.191
Phosphorus (P)-Total Dissolved	mg/L	0.003	-	-	-	-	0.0058	0.003	0.0064	0.0116	0.0098
Phosphorus, Total	mg/L	0.003	-	0.02	-	-	0.0249!	0.0109	0.0167	0.0152	0.0352!
E. Coli	CFU/100mL	10	-	100	-	-	490!	60	80	50	40
Copper (Cu)-Total	mg/L	0.001	-	0.015	-	-	0.0015	0.001	0.001	0.001	0.0015
Iron (Fe)-Total	mg/L	0.01	-	0.02	-	-	0.244!	0.215!	0.14!	0.106!	0.276!
Lead (Pb)-Total	mg/L	0.00005	-	0.005	-	-	0.000415	0.000263	0.00027	0.000243	0.00111
Manganese (Mn)-Total	mg/L	0.0005	-	-	-	-	0.0473	0.0342	0.0221	0.0123	0.0355
Zinc (Zn)-Total	mg/L	0.003	-	0.011	-	-	0.0092	0.0101	0.0074	0.0068	0.0178!
BOD Carbonaceous	mg/L	3	-	-	-	-	3.9	3	3	3	3
							.	.	.	.	.
* = Result Qualified	Mouse-over the result to see the qualification.						.	.	.	.	.

Applied Guideline: **Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO**

Color Key: Within Guideline | Exceeds Guidline

Applied Guideline: **Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)**

Color Key: Within Guideline | Exceeds Guidline

AECOM CANADA LTD. - KITCHENER
ATTN: Steve Scott
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 18-NOV-20
Report Date: 25-NOV-20 09:38 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L2530789

Project P.O. #: NOT SUBMITTED
Job Reference: 60611735
C of C Numbers:
Legal Site Desc:

Emily Hansen
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2530789-1 HC-A(03)							
Sampled By: T. AZUBUIKE on 18-NOV-20 @ 10:39							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	0.016		0.010	mg/L		19-NOV-20	R5289339
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		19-NOV-20	R5297002
Chloride (Cl)	49.3		0.50	mg/L		19-NOV-20	R5290773
E. Coli	220	DLM	10	CFU/100mL		19-NOV-20	R5291870
Nitrate (as N)	0.835		0.020	mg/L		19-NOV-20	R5290773
Total Suspended Solids	150		3.0	mg/L	21-NOV-20	24-NOV-20	R5295357
Phosphorus (P)-Total Dissolved	<0.0030		0.0030	mg/L	18-NOV-20	19-NOV-20	R5288826
Phosphorus, Total	0.0728		0.0030	mg/L	19-NOV-20	20-NOV-20	R5290998
pH	8.17		0.10	pH units		19-NOV-20	R5292937
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0056		0.0010	mg/L	19-NOV-20	19-NOV-20	R5288397
Iron (Fe)-Total	1.87		0.010	mg/L	19-NOV-20	19-NOV-20	R5288397
Lead (Pb)-Total	0.00401		0.000050	mg/L	19-NOV-20	19-NOV-20	R5288397
Manganese (Mn)-Total	0.874		0.00050	mg/L	19-NOV-20	19-NOV-20	R5288397
Zinc (Zn)-Total	0.0756		0.0030	mg/L	19-NOV-20	19-NOV-20	R5288397
L2530789-2 HC-A(04)							
Sampled By: T. AZUBUIKE on 18-NOV-20 @ 10:52							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	0.027		0.010	mg/L		20-NOV-20	R5294259
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		19-NOV-20	R5297002
Chloride (Cl)	152		0.50	mg/L		19-NOV-20	R5290773
E. Coli	13		0	CFU/100mL		19-NOV-20	R5291870
Nitrate (as N)	0.337		0.020	mg/L		19-NOV-20	R5290773
Total Suspended Solids	<3.0		3.0	mg/L	21-NOV-20	24-NOV-20	R5295357
Phosphorus (P)-Total Dissolved	0.0032		0.0030	mg/L	18-NOV-20	19-NOV-20	R5288826
Phosphorus, Total	0.0064		0.0030	mg/L	19-NOV-20	20-NOV-20	R5290998
pH	8.20		0.10	pH units		19-NOV-20	R5292937
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0010		0.0010	mg/L	19-NOV-20	19-NOV-20	R5288397
Iron (Fe)-Total	0.171		0.010	mg/L	19-NOV-20	19-NOV-20	R5288397
Lead (Pb)-Total	0.000218		0.000050	mg/L	19-NOV-20	19-NOV-20	R5288397
Manganese (Mn)-Total	0.0219		0.00050	mg/L	19-NOV-20	19-NOV-20	R5288397
Zinc (Zn)-Total	0.0111		0.0030	mg/L	19-NOV-20	19-NOV-20	R5288397
L2530789-3 HC-A(12)							
Sampled By: T. AZUBUIKE on 18-NOV-20 @ 11:16							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	0.012		0.010	mg/L		20-NOV-20	R5294259
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		19-NOV-20	R5297002
Chloride (Cl)	233	DLDS	2.5	mg/L		19-NOV-20	R5290773
E. Coli	27		0	CFU/100mL		19-NOV-20	R5291870
Nitrate (as N)	0.45	DLDS	0.10	mg/L		19-NOV-20	R5290773
Total Suspended Solids	<3.0		3.0	mg/L	21-NOV-20	24-NOV-20	R5295357
Phosphorus (P)-Total Dissolved	0.0072		0.0030	mg/L	18-NOV-20	19-NOV-20	R5288826
Phosphorus, Total	0.0078		0.0030	mg/L	19-NOV-20	20-NOV-20	R5290998
pH	8.35		0.10	pH units		19-NOV-20	R5292937
Total Metals in Water by CRC ICPMS							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2530789-3 HC-A(12)							
Sampled By: T. AZUBUIKE on 18-NOV-20 @ 11:16							
Matrix: WATER							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0015		0.0010	mg/L	19-NOV-20	19-NOV-20	R5288397
Iron (Fe)-Total	0.073		0.010	mg/L	19-NOV-20	19-NOV-20	R5288397
Lead (Pb)-Total	0.000226		0.000050	mg/L	19-NOV-20	19-NOV-20	R5288397
Manganese (Mn)-Total	0.0118		0.00050	mg/L	19-NOV-20	19-NOV-20	R5288397
Zinc (Zn)-Total	0.0063		0.0030	mg/L	19-NOV-20	19-NOV-20	R5288397
L2530789-4 HC-A(13)							
Sampled By: T. AZUBUIKE on 18-NOV-20 @ 11:34							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	0.011		0.010	mg/L		20-NOV-20	R5294259
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		19-NOV-20	R5297002
Chloride (Cl)	229	DLDS	2.5	mg/L		19-NOV-20	R5290773
E. Coli	18		0	CFU/100mL		19-NOV-20	R5291870
Nitrate (as N)	0.42	DLDS	0.10	mg/L		19-NOV-20	R5290773
Total Suspended Solids	<3.0		3.0	mg/L	21-NOV-20	24-NOV-20	R5295357
Phosphorus (P)-Total Dissolved	0.0055		0.0030	mg/L	18-NOV-20	19-NOV-20	R5288826
Phosphorus, Total	0.0078		0.0030	mg/L	19-NOV-20	20-NOV-20	R5290998
pH	8.40		0.10	pH units		19-NOV-20	R5292937
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.0010		0.0010	mg/L	19-NOV-20	19-NOV-20	R5288397
Iron (Fe)-Total	0.040		0.010	mg/L	19-NOV-20	19-NOV-20	R5288397
Lead (Pb)-Total	0.000114		0.000050	mg/L	19-NOV-20	19-NOV-20	R5288397
Manganese (Mn)-Total	0.00466		0.00050	mg/L	19-NOV-20	19-NOV-20	R5288397
Zinc (Zn)-Total	0.0041		0.0030	mg/L	19-NOV-20	19-NOV-20	R5288397
L2530789-5 HC-A(14)							
Sampled By: T. AZUBUIKE on 18-NOV-20 @ 11:41							
Matrix: WATER							
Miscellaneous Parameters							
Ammonia, Total (as N)	<0.010		0.010	mg/L		20-NOV-20	R5294259
BOD Carbonaceous	<3.0	BODL	3.0	mg/L		19-NOV-20	R5297002
Chloride (Cl)	228	DLDS	2.5	mg/L		19-NOV-20	R5290773
E. Coli	26		0	CFU/100mL		19-NOV-20	R5291870
Nitrate (as N)	0.42	DLDS	0.10	mg/L		19-NOV-20	R5290773
Total Suspended Solids	12.6		3.0	mg/L	21-NOV-20	24-NOV-20	R5295357
Phosphorus (P)-Total Dissolved	0.0043		0.0030	mg/L	18-NOV-20	19-NOV-20	R5288826
Phosphorus, Total	0.0239		0.0030	mg/L	19-NOV-20	20-NOV-20	R5290998
pH	8.40		0.10	pH units		19-NOV-20	R5292937
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0048		0.0010	mg/L	19-NOV-20	19-NOV-20	R5288397
Iron (Fe)-Total	0.238		0.010	mg/L	19-NOV-20	19-NOV-20	R5288397
Lead (Pb)-Total	0.00106		0.000050	mg/L	19-NOV-20	19-NOV-20	R5288397
Manganese (Mn)-Total	0.0171		0.00050	mg/L	19-NOV-20	19-NOV-20	R5288397
Zinc (Zn)-Total	0.0165		0.0030	mg/L	19-NOV-20	19-NOV-20	R5288397

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
BODL	Limit of Reporting for BOD was increased to account for the largest volume of sample tested.
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BOD-C-WT	Water	BOD Carbonaceous	APHA 5210 B (CBOD)

This analysis is carried out using procedures adapted from APHA Method 5210B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h. Method ID: WT-TM-1200

EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-WT	Water	pH	APHA 4500 H-Electrode

Water samples are analyzed directly by a calibrated pH meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

60 NORTHLAND ROAD, UNIT 1
WATERLOO, ON N2V 2B8
Phone: (519) 886-6910
Fax: (519) 886-9047
Toll Free: 1-800-668-9878

ALS

C of C # 00000

CHAIN OF CUSTODY / ANALYTICAL SERVICES REQUEST FORM

Page ___ of ___

AP

Note: all TAT Quoted material is in business days which exclude statutory holidays and weekends. TAT samples received past 3:00 pm or Saturday/Sunday begin the next day.

Specify date required	Service requested			
			2 day TAT (50%)	
	5 day (regular)	X	Next day TAT (100%)	
	3-4 day (regular)		Same day TAT (200%)	

COMPANY NAME	AECOM
OFFICE	Kitchener
PROJECT MANAGER	Steven Scott
PROJECT #	60611735
PHONE	519-650-8637 OR 519-569-9388
FAX	
ACCOUNT #	15884
QUOTATION #	Q59209
PO #	

CRITERIA Criteria on report YESX__ NO___

Reg 153/11
Table 1 2 3

TCLP _____ MISA ______ PWQO ___X__
ODWS _____ OTHER ______

REPORT FORMAT/DISTRIBUTION

EMAIL _X_ FAX ___ BOTH ___
SELECT: PDF ___ DIGITAL ___ BOTH _X_
EMAIL 1 Tara.Roumeliotis@aecom.com
EMAIL 2 Steve.Scott2@aecom.com
EMAIL 3 Tochi.Azubuike@aecom.com

PLEASE INDICATE FILTERED, PRESERVED OR BOTH
<----- (F, P, F/P)

SUBMISSION #: L2530787
ENTERED BY: AP
DATE/TIME ENTERED:
BIN #:

SAMPLING INFORMATION / **ANALYSIS REQUEST**

Date (dd-mm-yy)	Time (24hr) (hh:mm)	COMP	GRAB	WATER	SOIL	OTHER	SAMPLE DESCRIPTION TO APPEAR ON REPORT	NUMBER OF CONTAINERS	TSS	CBOD5	E. Coli	Total Metals by ICPMS (Lead, Zinc, Coppe	Total and Dissolved P (Lab Filter)	Total Ammonia Nitrogen, NO^3, and CL					COMMENTS	LAB ID
18-11-20	10:39		X	X			HC-A(03)	7	X	X	X	X	X	X						
18-11-20	10:52		X	X			HC-A(04)	7	X	X	X	X	X	X						
18-11-20	11:16		X	X			HC-A(12)	7	X	X	X	X	X	X						
18-11-20	11:34		X	X			HC-A(13)	7	X	X	X	X	X	X						
18-11-20	11:41		X	X			HC-A(14)	7	X	X	X	X	X	X						

L2530789-COFC

SPECIAL INSTRUCTIONS/COMMENTS

Surface water samples, so colforms counts may be high.

Please also provide pH measurement as field measurements seemed high.

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (C

Are any samples taken from a regulated DW System? Yes ___ No ___
If yes, an authorized drinking water COC MUST be used for this submission.
Is the water sampled intended to be potable for human consumption? Yes ___ No ___

___ FROZEN
___ COLD
___ COOLING INITIATED
___ AMBIENT
TEMP 5.3

OBSERVATIONS Yes ___ No ___
If yes add SIF

SAMPLED BY: Tochi Azubuike	DATE & TIME 18-11-20	RECEIVED BY:	DATE & TIME	
RELINQUISHED BY: Tochi Azubuike	DATE & TIME 18-11-20	RECEIVED AT LAB BY: AP	DATE & TIME 18 NOV 20 12:35	

Notes

1. Quote number must be provided to ensure proper pricing

2. TAT may vary dependent on complexity of analysis and lab workload at time of submission. Please contact the lab to confirm TATs.

3. Any known or suspected hazards relating to a sample must be noted on the chain of custody in comments section.

ALS		Sample ID					HC-A(03)	HC-A(04)	HC-A(12)	HC-A(13)	HC-A(14)
2/5/2021		ALS ID					L2110610-1	L2110610-2	L2110610-3	L2110610-4	L2110610-5
L2530789		Date Sampled	PWQO		Guelph Storm		6/12/2018 10:50:00 AM	6/12/2018 11:10:00 AM	6/12/2018 11:25:00 AM	6/12/2018 2:45:00 PM	6/12/2018 3:15:00 PM
Analyte	Units	LOR	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Water	Water	Water	Water	Water
pH	pH units	0.1	-	-	-	15	8.17	8.2	8.35	8.4	8.4
Total Suspended Solids	mg/L	3	-	-	-	-	150	3	3	3	12.6
Ammonia, Total (as N)	mg/L	0.01	-	-	-	-	0.016	0.027	0.012	0.011	0.01
Chloride (Cl)	mg/L	0.5	-	-	-	-	49.3	152	233	229	228
Nitrate (as N)	mg/L	0.02	-	-	-	-	0.835	0.337	0.45	0.42	0.42
Phosphorus (P)-Total Dissolved	mg/L	0.003	-	0.02	-	-	0.003	0.0032	0.0072	0.0055	0.0043
Phosphorus, Total	mg/L	0.003	-	100	-	-	0.0728	0.0064	0.0078	0.0078	0.0239
E. Coli	CFU/100mL	0	-	0.015	-	-	220!	13!	27!	18!	26!
Copper (Cu)-Total	mg/L	0.001	-	0.02	-	-	0.0056	0.001	0.0015	0.001	0.0048
Iron (Fe)-Total	mg/L	0.01	-	0.005	-	-	1.87!	0.171!	0.073!	0.04!	0.238!
Lead (Pb)-Total	mg/L	0.00005	-	-	-	-	0.00401	0.000218	0.000226	0.000114	0.00106
Manganese (Mn)-Total	mg/L	0.0005	-	0.011	-	-	0.874!	0.0219!	0.0118!	0.00466	0.0171!
Zinc (Zn)-Total	mg/L	0.003	-	-	-	-	0.0756	0.0111	0.0063	0.0041	0.0165
BOD Carbonaceous	mg/L	3	-	0.2	-	-	3!	3!	3!	3!	3!
							.	.	.	.	.
* = Result Qualified	Mouse-over the result to see the qualification.						.	.	.	.	.

Applied Guideline: Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO

Color Key: Within Guideline | Exceeds Guidline

Applied Guideline: Ontario City of Guelph Storm Sewer Guidelines 15202 (1996)

Color Key: Within Guideline | Exceeds Guidline

APPENDIX V 2020 Aquatic Monitoring Report

Hanlon Creek Business Park

2020 Construction-Phase Aquatic Monitoring

Prepared for:

Planning and Building Services, Infrastructure, Development and Enterprise
City of Guelph,
1 Carden Street, City Hall
Guelph, ON

Project No. 1033I | December 2021

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Hanlon Creek Business Park

2020 Construction-Phase Aquatic Monitoring

Project Team

Tara Brenton	Senior Manager, Terrestrial & Wetland Biologist/Certified Arborist, Project Manager
Stephen Burgin	Aquatic Coordinator, Aquatic Biologist
Blair Baldwin	Field Survey Coordinator, Benthic Taxonomist
Monica Varga	G.I.S. Analyst, Mapping

Report submitted on December 17, 2021

Tara Brenton
Project Manager
Senior Terrestrial & Wetland Biologist/Certified Arborist

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Aquatic Coordinator
Aquatic Biologist

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1.0 Introduction

The need for aquatic monitoring for the Hanlon Creek Business Park (HCBP) development was identified in the *Hanlon Creek Business Park Consolidated Environmental Impact Study* (NRSI 2004), which recommended benthic invertebrate sampling and more frequent fish sampling at the state-of-the-watershed fish sampling site (PEIL 2003). Monitoring of aquatic habitat was also recommended in the conditions for the Draft Plan approval of the Hanlon Creek Business Park as set by the Ontario Municipal Board (2006). Specifically, Draft Plan Condition #12 requires that the potential thermal impact of stormwater management ponds be monitored.

A multi-disciplinary monitoring program was developed for the Hanlon Creek Business Park development to achieve a variety of objectives, including the aquatic habitat. The overall monitoring program includes terrestrial features, hydrogeology, surface water flows, surface water temperatures, benthic invertebrates and fish.

This monitoring report addresses the benthic invertebrate and fish communities. The aquatic monitoring components were implemented prior to construction to establish an adequate baseline data set against which development conditions can be compared. The pre-construction data includes the years 2006 - 2009. Data has been collected annually at 5 stations (3 stations prior to 2009) up to and including 2016. One of the stations coincides with the aforementioned state-of-the-watershed fish sampling station. Monitoring will continue until 75% of the development is built by area in Phases I, II and III of the HCBP, plus an additional 2 years.

In 2016, the aquatic monitoring program was adjusted to include biennial sampling of aquatic conditions instead of annual sampling. Biological components are end points that are functions of the physical surface and groundwater conditions, and they tend to be slower to respond. Therefore, monitoring the aquatic conditions every two years is suitable for capturing changes in the fish and benthic communities. Physical parameters including surface and groundwater monitoring are still being conducted annually. The existing aquatic biology stations are all relevant to the ongoing development at the HCBP, and therefore all of these monitoring stations are being maintained.

Construction activities began in 2010 with grading, servicing, and building construction initiated. As a result, aquatic monitoring conducted since 2010 is considered construction-phase monitoring. Construction activities continued within the Hanlon Creek Business Park through 2020 and 2021.

This report provides a summary of findings from the 2020 monitoring year, as well as a comparison of the data to previous baseline and during construction years.

The terrestrial and wetland monitoring program that supplements the overall monitoring requirements within the HCBP is provided under separate cover (NRSI 2021b).

2.0 Study Area

The Hanlon Creek Business Park is located in the south end of the City of Guelph. As shown on Map 1, the project area is bounded to the east by Hanlon Expressway, to the north by the Kortright IV subdivision, to the west by Downey Road and to the south by Forestell Road. Laird Road runs parallel to Forestell Road, dividing the project area into north and south sections. The project area comprises forested areas and swamp/marsh pockets, as well as lands to be developed. The project area also includes a system of tributary streams that is part of the Hanlon Creek watershed. These streams are the subject of the aquatic monitoring. The watercourses are shown on Map 1.

The aquatic monitoring program is being conducted primarily in the northern portion (Phase I) of the business park development, north of Laird Road. The interest in this location is based on the historic presence of Brook Trout (*Salvelinus fontinalis*) in the coldwater habitat provided by Tributary A1, and Tributary A north of Laird Road. One of the stations, added in 2009, is south of Laird Road, situated downstream of the outlet of Stormwater Management (SWM) Pond 4.

2.1 Construction Activity

Construction within Phases 1 and 2 of the Business Park commenced in late 2010 and has continued each year to the present. Recent development has occurred in Phase 1 Stage 2, where additional office buildings are now occupied near the intersection of Hanlon Creek Boulevard and Downey Road. In the southeast corner of Phase 2, several additional warehouse buildings were occupied or under construction in 2020. Throughout the summer of 2021, site grading had commenced in Phase 1, Stage 3, to the east of Hanlon Creek, on the south side of Hanlon Creek Boulevard. Operational buildings within Phases 1 and 2 are indicated on Map 2. The Laird Road overpass has been open since 2014. To date, no construction activity has occurred within Phase 3.

3.0 Methods

A total of 3 sampling sites in the northern portion of the subject property were selected during the 2006 field season, which include BTH/EMS-001, BTH/EMS-002, and BTH/EMS-003. The same sites were sampled again annually from 2007 to 2016, and then biennially in 2018 and 2020. Two sites were added in 2009 to expand the monitoring program and have been sampled concurrently with the original 3 stations, including in 2020. These sites include BTH/EMS-004 and BTH/EMS-005. At each site, there is a benthic invertebrate sampling station (BTH) and a quantitative fish sampling station (EMS).

- Site 1 (BTH-001 and EMS-001) is located on Tributary A approximately 150m downstream (north) of Laird Road.
- Site 2 (BTH-002 and EMS-002) is located on Tributary A immediately downstream of the confluence with Tributary A1 and upstream (south) of Hanlon Creek Boulevard.
- Site 3 (BTH-003 and EMS-003) is located on Tributary A1.
- Site 4 (BTH-004 and EMS-004) is located on Tributary A downstream (north) of the Hanlon Creek Boulevard crossing.
- Site 5 (BTH-005 and EMS-005) is located on Tributary A upstream (south) of Laird Road

Fish sampling and benthic invertebrate collections were conducted at each site, but they occurred in separate areas of the stream to facilitate collection of both parameters on the same day without disturbing or negatively influencing results of sampling (Map 1).

The original selection of stations was based in part on historic knowledge of Brook Trout inhabitance. The stations were also positioned to help locate sources of future impacts, should any occur. To the extent possible, station selection followed the recommendation in the Ontario Stream Assessment Protocol (Stanfield 2005) to establish the upstream and downstream extents of a site at a crossover point of the thalweg (concentration of flow). The specific sections of stream were selected to represent the habitat types in the vicinity of each station.

3.1 Benthic Invertebrate Community

There are a number of advantages in sampling benthic invertebrates for water quality monitoring:

- They reflect local aquatic conditions as a result of their limited mobility;

- They integrate all the surrounding parameters of their environment into one easily assessable sampling unit;
- They integrate the physical and chemical aspects of water quality over annual time periods due to their short life spans (approximately 1 year); and
- They may indicate the probable cause of impairment because many benthic invertebrate species have known environmental sensitivities and/or tolerances.

3.1.1 Benthic Invertebrate Sampling

Sampling for the benthic invertebrate monitoring took place between September 14 and 17, 2020. It employed the sampling methodology from the Ontario Benthos Biomonitoring Network (OBBN) protocols (Jones et al 2005). Most of the following procedures have been taken from these protocols. Some of the specimen processing procedures are not covered by the OBBN protocols.

According to the OBBN methods for streams, a total of 3 subsamples are collected at each station in stream habitats: 2 from riffles, and 1 from a pool. Where riffle and pool habitats are not clearly defined (as is the case at some of the subject stations) pools and riffles can be functionally defined as slow/deep and fast/shallow sections, respectively. For wadable streams, the OBBN protocol employs a Travelling Transect Kick and Sweep method. For each subsample, a total of at least 10 linear metres of transect must be sampled in approximately 3 minutes. For small streams such as those within this study, this requires that several transects be positioned in the same riffle or pool in order to sample 10 linear metres of transect. Beginning at one bank and moving across each transect, the substrate is disturbed to a depth of approximately 0.05m by vigorously kicking the substrate. A 500-µm-mesh D-net is held downstream of and close to the disturbed area by the person sampling. The net is held on or close to the bottom, and is swept back and forth so that dislodged invertebrates will be carried by the stream flow into the net. In areas of slow current, the sweeping motion is important for collecting the invertebrates into the net. A stopwatch is used to time the sampling.

When sampling is complete, the net is rinsed and the sample is placed in plastic jars. The sample is then preserved with a 75% concentration of ethyl alcohol and sent to a professional taxonomist for identification. Benthic samples collected in 2020 were processed and identified in the NRSI laboratory. Samples are identified to the lowest practical taxonomic level. Between 2006 and 2012 as well as in 2015, 2016, 2018 and 2020 all samples were identified to genus. In 2013 and 2014, samples were identified to genus with the exception of chironomids, which were identified to sub-family. Subsampling is conducted by randomly dipping a small portion of the sample from a container until at least 200 organisms are obtained. After reaching the 200th organism, the portion being sampled is completed in order to facilitate measurement of the proportion of the total sample that is subsampled and identified. This also helps to ensure that samples are not biased towards larger individuals. The subsample proportion is determined by measuring the total sample weight/volume before identification and the remaining sample weight/volume after identification. The difference between those 2 measurements represents the portion sampled, which is recorded as a percentage of the total sample. While the OBBN protocol requires that a minimum of 100 organisms be collected, 200 organisms per subsample are collected to provide a robust sample for this program's use of the Percent Model Affinity analysis.

The OBBN data form was used to record habitat information at the benthic invertebrate sampling stations. The form includes both measured and visually estimated parameters, and facilitates comparison with other years provided the estimated parameters are treated as approximations.

3.1.2 Benthic Invertebrate Data Analysis

Analysis was performed using the Percent Model Affinity (PMA) method developed in New York State by Novak and Bode (1992). This method was adapted for southern Ontario by Dr. David Barton (1996) of the University of Waterloo.

In his 1996 paper, Dr. Barton sampled over 200 streams in southern Ontario, 69 of which were used as the reference streams for the model community. Instead of using the 7 groupings originally used by Novak and Bode (1992), Dr. Barton compared the use of model communities at the order, family, genus, and 'lowest practical' taxonomic levels. He found that there was an improvement with increasing taxonomic resolution, particularly between the family and genus levels. He also analyzed seasonal differences (Barton 1996).

The model communities used for analysis in this study are based on values from Dr. Barton for streams with mud and cobble/gravel substrates sampled in August (Barton 2007). The model community for mud substrates was used for BTH-001, BTH-003, BTH-004 and BTH-005, and the model community for cobble/gravel substrates was used for BTH-002. The family level of taxonomic resolution was used because many of the invertebrates are very small in August and

September, making it difficult or impossible to identify some of the specimens beyond their family.

The equation used to determine the percent similarity of community (PSC) is as follows:

$$PSC = 100 - 0.5 \Sigma \left| a - b \right|$$

Where: a is the model community value for a taxonomic group expressed as a percentage of the organisms in the model community; and

b is the percentage of the same taxonomic group in a sample from the stream being studied.

The sample PSC value is calculated by summing the absolute differences between the family model values and the families in the sample, multiplying the sum by 0.5 and subtracting this number from 100 (Novak and Bode 1992). The sample PSC value is then compared to the critical PSC value for the chosen model community.

Each critical PSC value is effectively a lower confidence limit of the mean for the expected community. It is essentially a statistical one-tailed t-test comparing a single observation with the mean of the sample, where the P-Value = 0.05 (Zar 1999). The critical PSC values were provided by Dr. Barton along with the model community data (Barton 2007).

This index does not assign a degree of impairment or non-impairment. Rather, significant impact at a sample site is determined when the calculated sample PSC value is less than the critical PSC value. Significant impact implies that the sample community is statistically significantly different from the model community. A determination of no significant impact occurs when the calculated sample PSC value is greater than the critical PSC value (Barton 1996).

The PMA analysis was conducted for each station with the 3 subsamples (riffles and pool) combined into one sample, which is the intention of the OBBN protocol.

In addition to PMA analysis, three other indices were calculated to provide additional insight into the water quality conditions at the sampling sites. They were:

- The number of taxa present in each sample (taxonomic richness);

- The percentage of individuals in each sample belonging to the taxonomic groups Ephemeroptera, Plecoptera, and Tricoptera (Proportion EPT) as well as the number of taxa (EPT richness); and
- The percentage of individuals in each sample that were the dominant taxon (% dominant taxon).

Taxonomic richness is a measure used to determine the number of different species that are present in a sampled area and provide an indication of the diversity of a given site. Generally, a higher number of taxa present in a sample reflect a more diverse habitat and/or better water quality.

The assessment of the percentage of Ephemeroptera, Plecoptera, and Trichoptera (proportion EPT) and their taxa richness is based on the premise that EPT taxa are less tolerant of pollution. Therefore, a higher proportion EPT and richness value suggests better water quality and/or habitat conditions.

The dominant taxon and its percentage of the sample are very helpful in characterizing the benthic community at a site. It describes an aspect of the diversity of the community, and can provide some indication of habitat and/or water quality at the site.

3.2 Fish Community

NRSI biologists conducted quantitative fish sampling at the 5 stations to provide population estimates that can be compared over the years of monitoring.

3.2.1 Fish Community Sampling

Fish sampling was conducted between September 14 and 16, 2020 using a depletion sampling method that is outlined in the Ontario Stream Assessment Protocol (Stanfield 2010). At each quantitative station, the chosen stream length was isolated from the rest of the stream using block nets. The block nets were small seine nets with a mesh size similar to the size of mesh on the dip net used with the electrofisher. The rope across the bottom of the net was weighted to keep it against the bottom of the channel, and the top of the net was a floating line. The nets were secured to trees or woody material on each shore.

A 2-person electrofishing crew conducted multiple passes of the enclosed area using a Smith-Root LR-20B backpack electrofisher set to a pulsating frequency between 40 to 60Hz, and an electric potential of 150 volts. Once collected, the fish were identified, measured on site, and released outside of the isolated sampling area downstream of the block nets. This process was repeated until the number of individuals caught exhibited a downward trend, or a minimum of three times. The number of individual fish, minimum and maximum lengths were recorded for each species. The water quality conditions, electrofisher settings, and number of shocking seconds for each pass were recorded. An effort was made to keep the sampling effort the same for each subsequent pass with respect to shocking seconds and netting technique.

Habitat information for the stations included classifications of adjacent lands, and basic visual estimates of macrohabitats (riffles, pools, etc.), instream vegetation, instream cover and overhead canopy shading. General flow conditions were also determined by measuring the wetted width, bankfull width, and five equally spaced depths, at five transects along the station. These habitat parameters provide a basic description of the conditions and help to understand the fish data. This information is intended to help interpret the fish community data for the quantitative stations. Because the focus of the monitoring is on the fish community, they are approximate and not intended for detailed comparison among years of monitoring but may provide some insight regarding changes to fish communities.

Brook trout spawning surveys were carried out during the spawning season in the fall of 2020. Three site visits were conducted, occurring on October 23, November 6, and November 19, 2020 to document redds and observe any Brook Trout that might be exhibiting spawning behaviour within the Hanlon Creek tributaries. The survey was conducted at several locations along Tributary A and Tributary A1 within the HCBP and covered approximately 650 m of creek.

3.2.2 Fish Community Data Analysis

The analysis of the data for the sampling stations provides estimates of the population of the fish at each station. A simple method for these calculations uses a regression of the data, which is plotted on a 2-dimensional graph with the catch from an individual fishing (1 pass) on the y-axis and the previous total catch (sum of previous passes) on the x-axis. This method is described by Zippen (1958) in the context of trapping small mammals. This calculation assumes a constant probability (P) of capture with each fishing pass. However, this method is generally considered inferior because it does not give valid estimates of the standard error of the estimated population size. A better method employs maximum likelihood estimates, as described by Schnute (1983). This method calculates the probability of capture, and this probability can be either constant or variable. For 2020, the data collected at each of the five sampling sites was limited to 3 passes since they exhibited a consistent downward trend. This data is well suited to the maximum likelihood constant P method. All five stations met the necessary criteria required for estimating population size under the constant P method, and the population estimates are considered reliable.

A computer software package called *Removal Sampling 2* by Pisces Conservation Ltd. was used to perform the calculations using the maximum likelihood – constant probability method. The estimated population calculations were carried out separately for each station, and estimates were made for all species combined. Capture of Brook Trout warrants a separate estimate, but none were captured in 2020.

4.0 Results and Discussion

4.1 Benthic Invertebrate Community

4.1.1 Habitat and Sampling Conditions

Station BTH-001 is situated within a White Cedar – Hardwood Mixed Swamp as defined in the Ecological Land Classification for Southern Ontario Guide (ELC, Lee et al. 1998). This swamp extends up to 100 m to the west, but a fallow agricultural field occupies land within 50 m to the southeast of the station. The riparian vegetative community is predominantly coniferous forest which was estimated to provide 50-74% shade. The channel is comprised of shallow runs, riffles, and pools. At the time of sampling no aquatic macrophytes or algae were observed within the channel. Woody debris and detritus were present throughout the entire site. The sampling conditions are summarized in Table 1.

Table 1. Benthic Invertebrate Sampling Conditions for Station BTH-001

Sampling Conditions	BTH-001		
Date	September 16, 2020		
Time (24hr Clock)	10:30		
Air Temperature (°C)	23.0[1]		
Water Temperature (°C)	15.5		
Dissolved Oxygen (mg/L, % saturation)	8.5, 84.0		
Conductivity (µS/cm)	Not Collected		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	1.75	1.0	1.1
Maximum Depth (m)	0.07	0.19	0.10
Maximum Hydraulic Head (mm)	10	0	7
Dominant Substrate	Gravel	Cobble	Sand
Second Dominant Substrate	Sand	Gravel	Silt
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	3:00
Number of Jars to Retain Sample	1	1	2

[1]As recorded by the University of Guelph Turfgrass Institute Monitoring Station

Station BTH-002 is situated within a white cedar – hardwood mixed swamp (Lee et al. 1998). The vegetative community adjacent to the stream is mainly deciduous forest from 1.5 to 30 m on the west side and 1.5 to 10 m on the east side. Beyond 30 m to the west a 100 m meadow buffer separates forest from a newly developed block of land with a recently built Fusion Homes corporate office building. Beyond 10 m of forest to the east exists a strip of meadow approximately 10 m wide and a recently constructed gravel walking trail, which runs parallel to Tributary A and A1 and is fenced along both sides. The overhead canopy at this station provides an estimated 75 to 100% shade. The channel includes shallow riffle, pool, and run features. Within the channel aquatic macrophytes and algae are generally absent with some crusted algae covering the substrate. Detritus was noted to be abundant and woody debris is present throughout the sample location. In 2016, a large branch was noted to have fallen across the channel midway through the sampling site and just downstream from the sampled Pool, creating a slight backwater effect. This fallen branch and accumulated debris was noted again in 2018 and 2020. The ponding upstream resulted in some accumulation of some silt and detritus. Sampling conditions are summarized in Table 2.

Table 2. Benthic Invertebrate Sampling Conditions for Station BTH-002

Sampling Conditions	BTH-002		
Date	September 14, 2020		
Time (24 hr Clock)	13:30		
Air Temperature (°C)	15.5[1]		
Water Temperature (°C)	14.6		
Dissolved Oxygen (ppm, % saturation)	8.5, 85.0		
Conductivity (µS/cm)	Not Collected		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	3.16	2.70	3.71
Maximum Depth (m)	0.07	0.21	0.12
Maximum Hydraulic Head (mm)	2	0	1
Dominant Substrate	Gravel	Silt	Cobble
Second Dominant Substrate	Cobble	Sand	Gravel
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	3:00
Number of Jars to Retain Sample	1	3	1

[1]As recorded by the University of Guelph Turfgrass Institute Monitoring Station

Station BTH-003 is situated within a white cedar – hardwood mixed swamp (Lee et al. 1998). The riparian community is dominated by deciduous forest along both banks of the creek, providing up to 100% canopy cover. To the west this vegetative community extends beyond 100m while to the east it extends to approximately 30m. Beyond the trees a 30m strip of meadow habitat separates the forest from the gravel walking path described under station BTH-002, which occurs within the Phase 1 construction area. The channel includes shallow flats, runs and pools a result of the sites location within a headwater tributary. There is limited to no aquatic vegetation or algae in the channel, however woody debris and detritus are both abundant throughout the site. This abundance of woody debris, provided by fallen logs and branches, adds complexity to the instream habitat. Sampling conditions for this site are provided in Table 3.

Table 3. Benthic Invertebrate Sampling Conditions for Station BTH-003

Sampling Conditions	BTH-003		
Date	September 15, 2020		
Time (24hr Clock)	13:40		
Air Temperature (°C)	18.0[1]		
Water Temperature (°C)	11.6		
Dissolved Oxygen (ppm / % saturation)	7.30, 73.0		
Conductivity (µS/cm)	Not Collected		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	0.8	0.9	1.0
Maximum Depth (m)	0.10	0.22	0.14
Maximum Hydraulic Head (mm)	2	2	2
Dominant Substrate	Silt	Silt	Silt
Second Dominant Substrate	Sand	Sand	Sand
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	3:00
Number of Jars to Retain Sample	2	3	1

[1]As recorded by the University of Guelph Turfgrass Institute Monitoring Station

Station BTH-004 is situated in a white cedar – hardwood mixed swamp (Lee et al. 1998). The vegetative community adjacent to the stream is a white cedar – hardwood mixed swamp along both banks and extending approximately 30m from the watercourse. Beyond this to the west exists a section of mineral meadow marsh and fallow agricultural land. To the east this transitions to a predominantly deciduous forest and then to meadow. Beyond this lies the Phase 1 construction area which includes a gravel walking trail. The forest adjacent to the creek is estimated to provide approximately 75 to 100% shade over the station. The channel at this station includes a variety of shallow flats, runs and pool features. Isolated patches of watercress sp. were observed throughout the site, along with dense deposits of detritus and woody material. Sampling conditions for BTH-004 are summarized in Table 4.

Table 4. Benthic Invertebrate Sampling Conditions for Station BTH-004

Sampling Conditions	BTH-004		
Date	September 15, 2020		
Time (24hr Clock)	9:10		
Air Temperature (°C)	18.0[1]		
Water Temperature (°C)	9.1		
Dissolved Oxygen (ppm / % saturation)	10.3, 91.0		
Conductivity (µS/cm)	Not Collected		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	1.2	1.47	1.1
Maximum Depth (m)	0.11	0.24	0.12
Maximum Hydraulic Head (mm)	2	3	5
Dominant Substrate	Sand	Silt	Sand
Second Dominant Substrate	Silt	Sand	Silt
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	3:00
Number of Jars to Retain Sample	1	1	2

[1]As recorded by the University of Guelph Turfgrass Institute Monitoring Station

Station BTH-005 is situated in a fresh – moist poplar deciduous forest which provides from 75 to 100% canopy cover across the site, depending on the sample location. Smaller areas of reed canary grass mineral meadow marsh and willow mineral thicket swamp communities occur from 1.5 to 10m on both sides of the channel (Lee et al. 1998). Fallow agricultural land occurs beyond 30m to the southwest, and Laird Road is approximately 30m to the north. Instream habitat is characterized by flat and run features with a small amount of emergent and rooted floating vegetation within the channel. An abundance of detritus and variable amounts of woody debris were also observed. BTH-005 is located approximately 40m downstream from the outlet of stormwater management pond (SWM) 4 cooling trench. Sampling conditions are summarized in Table 5.

Table 5. Benthic Invertebrate Sampling Conditions for Station BTH-005

Sampling Conditions	BTH-005		
Date	September 17, 2020		
Time (24hr Clock)	10:20		
Air Temperature (°C)	17.5[1]		
Water Temperature (°C)	16.5		
Dissolved Oxygen (ppm / % saturation)	Not Collected		
Conductivity (µS/cm)	Not Collected		
	Riffle 1	**Pool 2**	**Riffle 3**
Wetted Width (m)	0.9	1.5	1.3
Maximum Depth (m)	0.12	0.13	0.11
Maximum Hydraulic Head (mm)	8	5	8
Dominant Substrate	Sand	Sand	Sand
Second Dominant Substrate	Silt/Gravel	Silt/Gravel	Silt/Gravel
Total Transect Length (m)	10	10	10
Kick & Sweep Sampling Time (min:sec)	3:00	3:00	3:00
Number of Jars to Retain Sample	2	2	2

[1]As recorded by the University of Guelph Turfgrass Institute Monitoring Station

4.1.2 Benthic Invertebrate Community Data

The identification and enumeration of benthic invertebrates are summarized in tabular format in Appendix I.

The Percent Model Affinity (PMA) index calculation generates Percent Similar Community (PSC) values, which are summarized in Table 6. Values that are higher than the critical PSC value indicate no impact, while values that are lower than the critical PSC value indicate impact. The impact determinations for the years 2006 through 2018 are provided along with the 2020 results for comparison.

Table 6. Percent Similar Community Values and Impact Determination

Station	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020 Critical PSC	2020 Sample PSC	2020 Result
BTH – 001	NI	NI	NI	NI	NI	NI	NI	NI	NI	I	NI	NI	42.12	66.58	NI
BTH – 002	I	NI	I	I	NI	I	I	I	I	I	I	NI	50.7	51.44	NI
BTH – 003	NI	NI	NI	NI	NI	NI	I	I	NI	NI	NI	NI	42.12	61.68	NI
BTH – 004	-	-	-	NI	NI	NI	I	I	I	NI	NI	NI	42.12	61.10	NI
BTH – 005	-	-	-	NI	NI	NI	NI	NI	I	I	NI	NI	42.12	55.90	NI

NI – No Impact I – Impact

The additional indices that were calculated include taxonomic richness, proportion EPT, EPT richness, and % dominant taxon. These results are summarized on Table 7 through Table 11 and are shown in Figure 1, Figure 2, Figure 3, and Figure 4. The results are discussed by station in the text that follows.

Table 7. Benthic Invertebrate Metrics for Station BTH-001 for the Years 2006 to 2020

	BTH-001												
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
Taxonomic Richness	40	42	38	38	47	46	48	25	25	26	27	31	33
EPT Richness	7	5	10	7	9	10	12	5	6	4	5	5	8
% EPTs	21.3	25.0	41.8	37.2	23.6	27.0	11.9	9.1	3.9	6.7	9.2	10.6	13.6
% Dominant Taxon	27.8	19.4	25.5	20.5	23.8	17.2	16.6	16.4	27.5	11.8	9.9	11.0	9.3

Table 8. Benthic Invertebrate Metrics for Station BTH-002 for the Years 2006 to 2020

	BTH-002												
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
Taxonomic Richness	47	42	39	32	49	42	43	23	19	27	30	36	41
EPT Richness	17	8	13	13	17	11	10	8	8	9	7	11	9
% EPTs	42.9	16.4	44.4	48.8	29.6	47.6	25.1	31.6	21.3	31.4	25.0	26.1	20.4
% Dominant Taxon	18.5	32.0	20.2	19.1	14.4	16.3	31.2	16.8	30.0	14.3	11.3	14.2	11.5

Table 9. Benthic Invertebrate Metrics for Station BTH-003 for the Years 2006 to 2020

	BTH-003												
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
Taxonomic Richness	21	28	30	35	42	19	22	16	13	15	28	32	36
EPT Richness	4	4	6	7	10	2	10	6	1	3	5	8	7
% EPTs	6.9	16.3	25.4	22.2	15.3	2.8	2.0	6.7	0.8	3.5	7.3	7.2	14.9
% Dominant Taxon	66.3	37.2	42.4	30.7	34.9	68.4	54.9	57.9	41.2	37.8	18.3	11.4	9.2

Table 10. Benthic Invertebrate Metrics for Station BTH-004 for the Years 2006 to 2020

	BTH-004												
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
Taxonomic Richness	-	-	-	39	43	41	27	18	15	19	21	30	31
EPT Richness	-	-	-	8	11	9	4	6	1	5	3	4	4
% EPTs	-	-	-	12.5	10.0	8.2	0.8	3.9	1.3	7.5	3.5	1.2	10
% Dominant Taxon	-	-	-	29.0	19.0	29.3	49.7	56.8	34.3	20.6	11.5	9.6	11.2

Table 11. Benthic Invertebrate Metrics for Station BTH-005 for the Years 2006 to 2020

	BTH-005												
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**
Taxonomic Richness	-	-	-	42	26	34	31	14	18	14	20	25	35
EPT Richness	-	-	-	6	4	3	3	3	3	3	2	5	8
% EPTs	-	-	-	14.8	2.8	5.1	16.9	9.3	1.4	35.3	6.7	6.1	20.4
% Dominant Taxon	-	-	-	22.5	31.6	24.9	26.9	22.2	31.6	29.1	23.7	11.9	16.2

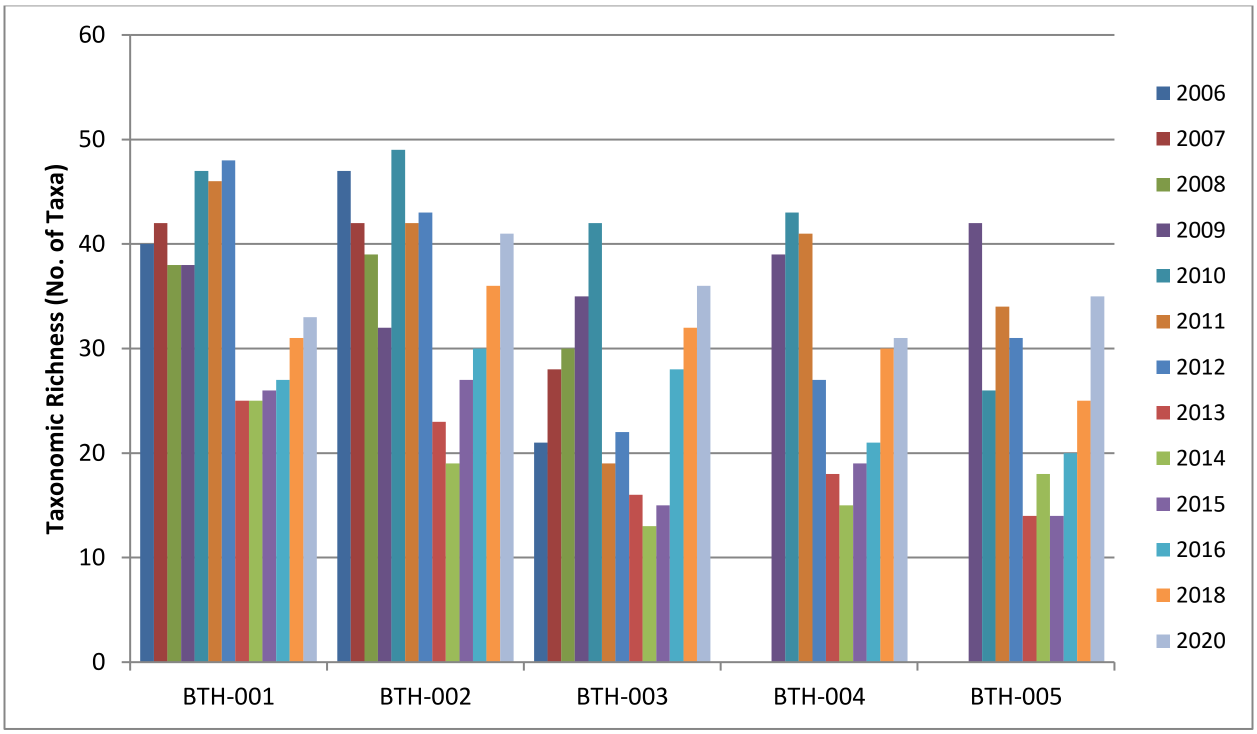

Figure 1. Benthic Invertebrate Taxonomic Richness for the Years 2006 to 2020

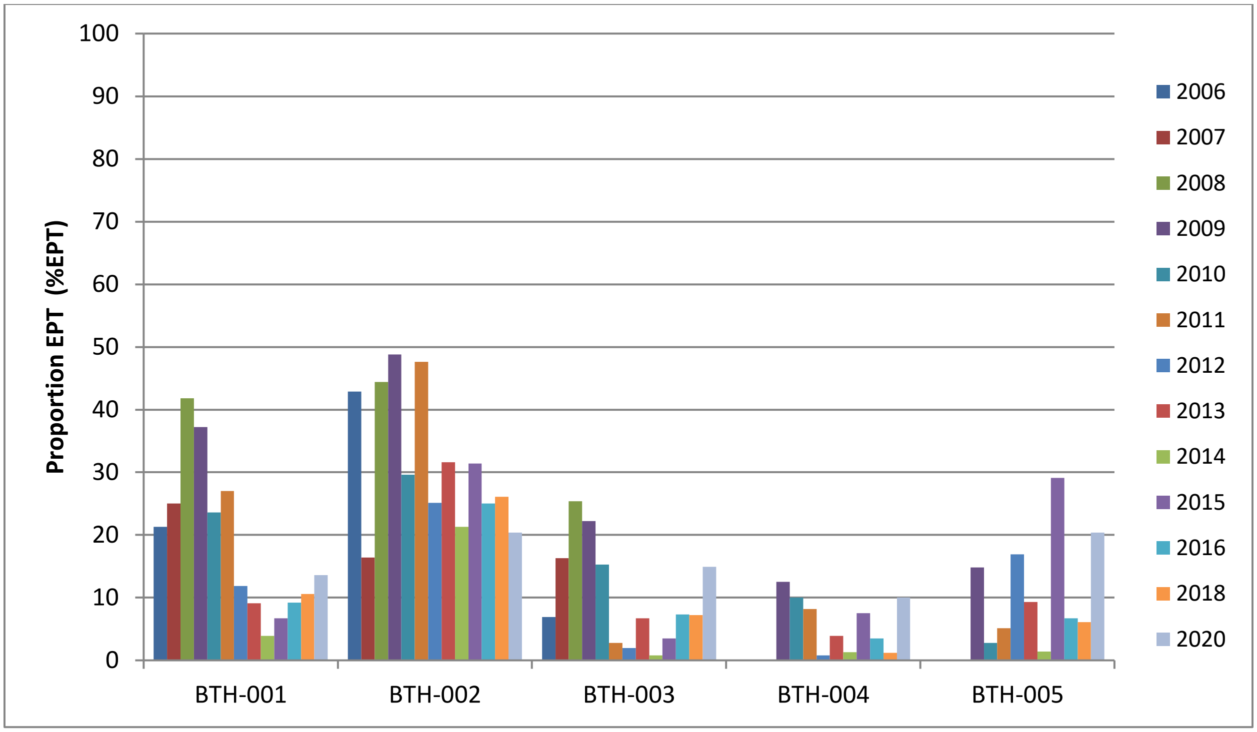

Figure 2. Benthic Invertebrate Proportion EPT for the Years 2006 to 2020

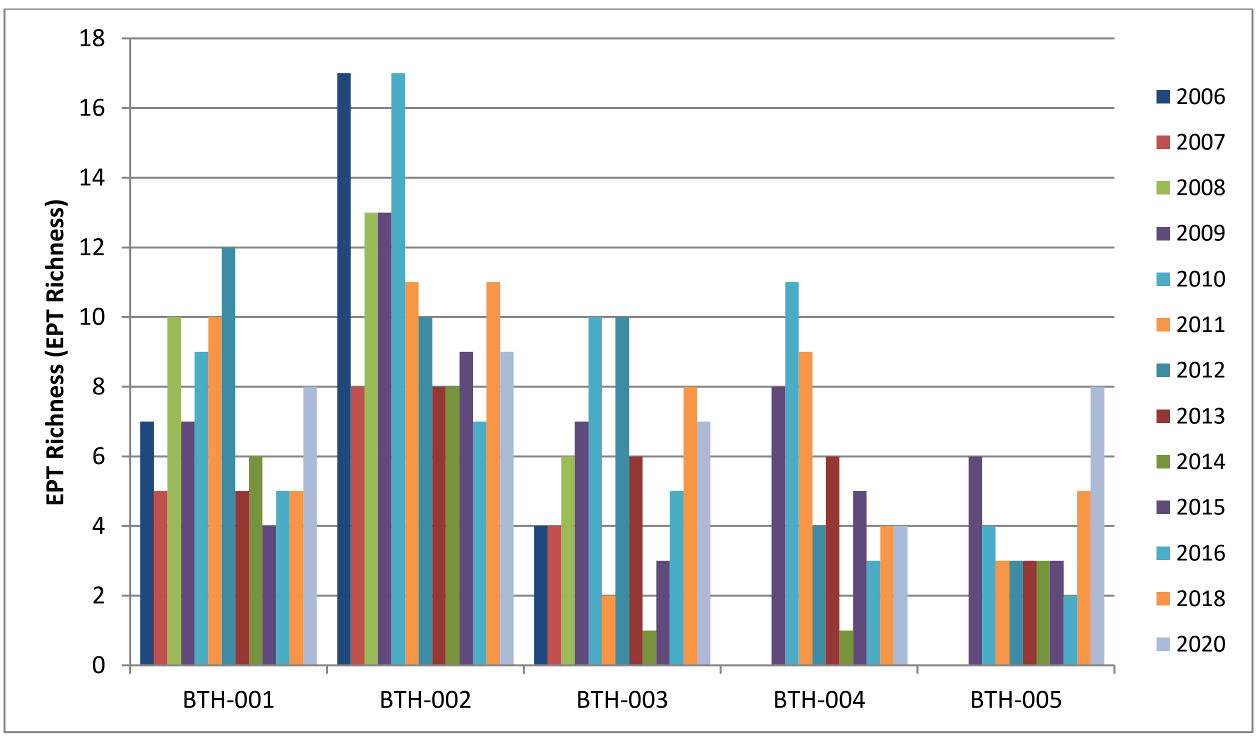

Figure 3. Benthic Invertebrate EPT Taxa Richness for the Years 2006 to 2020

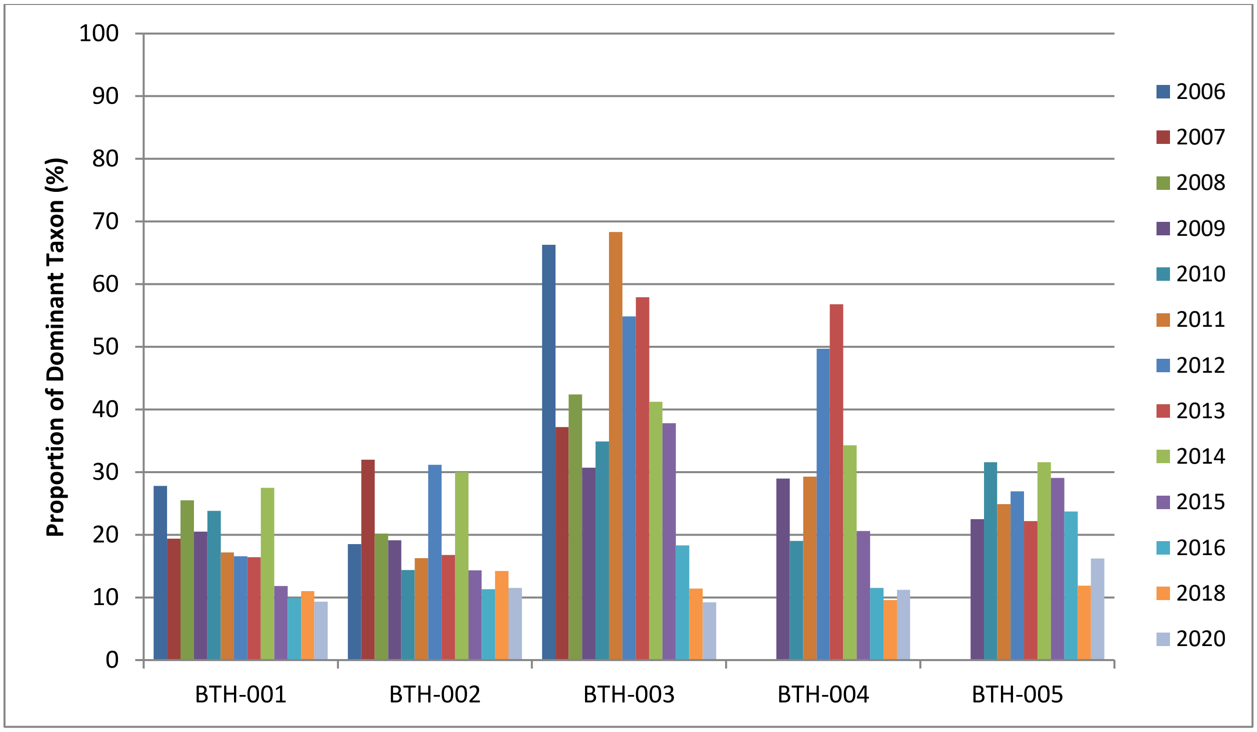

Figure 4. Benthic Invertebrate Proportion of Dominant Taxa for the Years 2006 to 2020

<u>Station BTH-001</u>

Taxonomic richness at station BTH-001 has varied from 25 to 48 over the 13 monitoring years. Between 2006 and 2012 the taxa richness at this station remained fairly consistent with an increase observed in 2010. The highest taxa richness occurred in 2012 with a high of 48 (Figure 1). In 2013 and 2014, taxonomic richness was 25 for each of those years. These values were lower due to a sub-family level of identification of the family Chironomidae in 2013 and 2014, compared to genus-level identification for all other years. Between 2015 and 2020, taxa richness remained relatively low for station BTH-001, with a slight increasing trend in spite of the genus-level identification of all specimens. The variation in numbers has been further discussed in Section 4.1.3.

The EPT richness at BTH-001 has been highly variable during both the pre-construction and construction phases with a minimum of 4 EPT taxa in 2015, a maximum of 12 taxa in 2012, and an average of 7 taxa across all monitoring years (Figure 3). The proportion of the benthic invertebrate community represented by EPT taxa (%EPT) has also varied greatly between 2006 and 2020. Pre-construction values ranged from a low of 21.3% in 2006 to a high of 41.8% in

2008 (Figure 2). Following 2008 the EPT richness declined to below 10% with the lowest proportion of EPT taxa (3.9%) occurring in 2014. The proportion of EPT taxa has since increased consistently up to and including 2020, but overall remains lower than what had been observed during pre-construction monitoring.

The dominant taxon in 2020 was the same dominant taxon observed in 2016 and 2018; the genus *Chironomus*, belonging to the family Chironomidae (midges) and sub-family Chironominae of the order Diptera (true flies). Species belonging to this sub-family may be associated with a variety of habitats but can generally be found in the littoral and profundal areas of lentic systems as well as the depositional areas of lotic systems (Merritt et al. 2008), typically associated with finer substrates including silt and sand. The conditions at station BTH-001 are consistent with this generalized habitat description providing silt, sand and gravel substrates, as well as moderately abundant detritus and woody debris. *Chironomus* can occur in systems with poor water quality and severe organic pollution (Mandaville 2002). This species represented 9.30% of the total number of individuals within the sample in 2020 (Figure 4). Species of Dipterans (true flies) have also previously comprised large proportions of the samples at BTH-001, and did again in 2020 with approximately 61.7% of the sample contributed to Dipteran species. Dipteran species previously dominated the samples in 2006, 2007, 2013, 2014, 2016, and 2018. Previously observed dominant taxa have also included a species of caddisfly (Trichopteran) of the family Hydropsychidae in 2008 and 2009. Families that have also historically been found at BTH-001 include Amphipods (*Gammarus pseudolimnaeus*), Isopods (*Caecidotea intermedius*), and Coleopterans (*Optioservus fastiditus*). These species have all historically comprised a large proportion of the samples at this station and have dominated the samples during different years from 2010 to 2012. A species of Megalopteran of the family Sialidae dominated the sample in 2015.

The PMA index showed 'no impact' in 2020 as the calculated PSC value of 66.58 was higher than the critical PSC value of 42.12 (Table 6). The PMA index has consistently shown 'no impact at BTH-001 with the exception of 2015, which was the first year the results have shown an 'impact' determination. A decrease in EPT species at this site between 2012 and 2014 indicated a potential change in conditions, and continued low EPT richness combined with the PMA impact determination in 2015 suggests that conditions may have changed. However, the general increasing trend in the proportion of EPT between 2014 and 2020 suggests improvement in the overall water quality at BTH-001 over the course of construction following the initial decrease.

Station BTH-002

Taxonomic richness at station BTH-002 was 41 in 2020 (Figure 1). Results show a continued trend of increasing taxonomic richness following two consecutive years of decreasing taxa richness in 2013 and 2014. In 2013 and 2014, taxonomic richness was 23 and 19, respectively for each of those years. These values were lower than previous years due to sub-family level of identification of the family Chironomidae in 2013 and 2014, compared to genus-level identification for all other years, including 2015 through 2020. An increasing trend in taxa richness has been observed between 2015 and 2020 with the 2020 taxa richness exceeding the level observed during 2008 and 2009 pre-construction monitoring. Generally, it appears that taxonomic richness has been relatively consistent between pre-construction and construction-phase monitoring at BTH-002. The variation in numbers has been further discussed in Section 4.1.3.

The EPT richness at BTH-002 has been highly variable during both the pre-construction and construction phases with a minimum of 7 taxa (2016) and a maximum of 17 taxa (2006 and 2010) (Figure 3). In 2020 a total of 9 EPT taxa were identified, slightly lower than what was observed in 2018. Low EPT taxa richness values have been observed throughout the years, including during pre-construction monitoring in 2007, but in general taxa richness has remained below 10 during construction-phase monitoring. The proportion of the invertebrate community EPT (%EPT) was 20.4 % in 2020, a slight decrease from the proportions observed in 2016 and 2018 and generally similar to what has been observed since 2012 with EPT proportions between 20 and 30% (Figure 2). The proportion of EPT had frequently been high (above 40%) prior to 2010, but has remained below 32% during the construction-phase, with the exception of 2011. Large declines have been noted in 2007 (16.4%), 2010 (29.6%), and in 2012 but the site has never experienced declining trends in richness values over consecutive year. The lowest levels in EPT richness at BTH-002 were seen during a pre-construction year in 2007 suggesting that the observed declines in EPT taxa are within the natural variations of the station. Station BTH-002 has consistently shown the highest EPT richness values of the five monitoring stations since substrates are primarily cobble and gravel. The site has experienced a slight change in condition due to a large tree branch falling across the channel part way through the site. This has created a slight backwater effect, which has resulted in some additional siltation within the site that appears to have limited the EPT population at BTH-002 over the past several years, although not construction-related.

The dominant taxa at station BTH-002 in 2020 was consistent with the 2018 dominant taxa G. pseudolimnaeus, of the family Gammaridae of the order Amphipoda. Species belonging to this family have historically been seen as the dominant taxa prior to 2015. High proportions of the G. pseudolimnaeus are often indicative of very good water quality (Mandaville 2002). Previous dominant taxa within BTH-002 (Sialidae in 2016) are also considered to be indicative of very good water quality suggesting a stable aquatic habitat (Mandaville 2002) at this monitoring station. This species represented 11.5% of the benthic community within BTH-002 (Figure 4) and has also dominated the sample in 2012, 2014, and 2018. Species belonging to the family Sialidae from the order Megaloptera dominated the sample in 2016 and 2018 and represented a large portion of the sample again in 2020. The result for % dominant taxon has generally been lower at this station over the years of monitoring with 2007, 2012 and 2014 being relatively high (32.0%, 31.2% and 30.0%, respectively). The dominant taxonomic group has changed several times at BTH-002 including *Micropsectra sp.* (Diptera) in 2007 and 2008, *Cheumatopsyche spp.* (Trichoptera) in 2009, and *Leuctra spp.* (Plecoptera) in 2010 and 2011. In 2013 two species dominated the sample including *G. pseudolimnaeus* and *Diplectrona modesta*, a species of Trichoptera. Prior to 2015 *Gammarus pseudolimnaeus* had been the dominant taxa at this station between 2012 and 2014. EPT species, and specifically Trichopteran species, have typically been well represented within the sample at BTH-002 over the years and were again in 2018 including species of Hydropsychidae and Philopotamidae. The site characteristics associated with BTH-002 are well suited for EPT taxa and include gravel and cobble riffles. As noted in Section 4.1.1 a large branch was observed to have fallen across the channel which created a slight backwater effect. This may affect the proportion of EPT species over time.

The PMA index in 2020 showed ‘no impact’, as the calculated PSC value of 51.45 was higher than the critical PSC value of 50.7 (Table 6). The PMA index has consistently shown ‘impact’ at BTH-002 including six consecutive years between 2011 and 2016. Two consecutive monitoring years of PMA results showing ‘no impact’ at BTH-002 suggest a slight improvement in water quality from conditions that had been observed between 2011 to 2016. Results since pre-construction monitoring began in 2006 have been inconsistent up until 2011 with results showing no reliable trend of ‘impact’ or ‘no impact’. Since 2011 results have consistently indicated ‘impact’, which has been the most common result, with ‘no impact’ observed only four out of thirteen years of monitoring (2007, 2010, 2018, and 2020) (Table 6). Taxonomic richness, EPT richness and % EPT are somewhat lower in recent years, corroborating the PMA results. Monitoring using the PMA analysis should continue with the intention of determining whether or not a 'no impact' determination is observed again. The other metrics must also be considered along with the results of the PMA analysis.

Lastly, the predominance of the 'impact' result should not be construed to mean that station BTH-002 is in poorer condition than the other stations. Station BTH-002 is the only station that uses the cobble/gravel model community for PMA index, and it was chosen based on the habitat characteristics of the station. Because of this difference, comparisons among the other four stations using the PMA index are not valid. The monitoring program is intended to provide temporal comparison within stations.

Station BTH-003

Taxonomic richness at station BTH-003 was 36 in 2020. This minor increase builds on the trend of increasing taxa richness seen between 2015 and 2018 (Figure 1). Taxa richness has experienced a general decrease that began in 2011, which followed an exceptionally high year in 2010 where the richness was 42. The lowest result occurred in 2014 with a value of 13. In 2013 and 2014, taxonomic richness values were lower than previous years due to sub-family level of identification of the family Chironomidae, compared to genus-level identification for all other years. Over the 5 years of monitoring prior to 2011 species richness had increased steadily by 50%, beginning in 2006 with a measure of 21 and increasing to 42 in 2010. The results observed in 2011 and 2012 appeared to be a return to the degree of taxonomic richness that was observed during pre-construction monitoring. Although, between 2016 and 2020 taxa richness was noted to increase year-over-year to levels consistent with the high pre-construction monitoring values in 2009 and 2010.

The EPT richness at BTH-003 has been highly variable during both the pre-construction and construction phases of the project. A low of 1 taxa was observed in 2014 followed by a steady increase in EPT richness to 8 taxa in 2018 and 7 taxa in 2020, levels which are similar to, and slightly higher than, pre-construction values. The highest EPT richness was observed in 2010 and 2012 when 10 EPT taxa were collected (Figure 3). The proportion EPT was 14.9% in 2020, an increase from what was observed in 2018 and comparable to preconstruction years (2007 and 2010) (Figure 2). Results have varied throughout the years with a decreasing trend between 2008 and 2014 and increasing trends between 2006 and 2008, and then again between 2014 and 2020. The proportion EPT values seen during construction-phase monitoring between 2011 and 2015 generally show levels that were lower than the results from pre-construction monitoring but the increasing trend over the previous four monitoring years shows a return to pre-construction levels.

The dominant taxon in 2020 was the genus *Polypedilum sp.* subfamily Chironominae of family Chironomidae of the order Diptera (true flies), which comprised 9.2% of the total sample and is similar to 2018 (Figure 4). This is a marked change from the five consecutive years of dominance by the genus *G. pseudolimnaeus* which had comprised between 37.8% and 68.4% of the samples since 2012. Species belonging to the sub-family Chironominae can be associated with a variety of habitats but are generally found in the littoral and profundal areas of lentic systems as well as the depositional areas of lotic systems (Merritt et al. 2008), typically associated with finer substrates including silt and sand. The preference of this species for depositional areas explains its abundance at station BTH-003, which occurs in a slow-flowing, groundwater-fed headwater tributary with abundant detritus and underlying substrates dominated by silt and sand. Prior to 2012, the dominant taxon was *Micropsectra* spp., a Dipteran species that had previously been the dominant taxon throughout all six years of pre-construction monitoring. In 2015 a variety of Chironomid species comprised the majority of the subdominant groups including several species belonging to the *Prodiamesinae* and *Orthocladiinae* subfamilies. The 2020 dominant taxa value marks the lowest that has been observed since sampling began, continuing a trend in decreasing proportion of the dominant taxa observed at BTH-003 between 2011 and 2020. This indicates that the species found at station BTH-003 were more evenly distributed in 2020 when compared to previous years, which includes an increasing proportion of EPT taxa, as described above.

The PMA index showed ‘no impact’ in 2020 as the calculated PSC value of 61.68 was higher than the critical PSC value of 42.12 (Table 6). The result of ‘no impact’ is consistent with the results between 2014 and 2020. This is a change from 2012 and 2013, both of which showed ‘impact’. Prior to 2011 the results suggested that habitat and/or water quality conditions at station BTH-003 were generally improving as evidenced by a consistent increase in species diversity (taxonomic richness) and a similarly consistent result of ‘no impact’. Results in 2011 and 2012, however, suggested a change in the habitat conditions at this site leading to results that are similar to those observed in 2006. This was demonstrated through a decrease in taxonomic richness and EPT taxa richness, and a large increase in the proportion of the dominant taxon, *Micropsectra* spp in 2011, and *G. pseudolimnaeus* in 2012 and 2013. However, since this change was consistent with pre-construction monitoring results in 2006, it was attributed to natural variation. Results between 2015 and 2020 show an increase in taxa richness and EPT richness, which suggest an improvement in overall water quality. Habitat conditions have generally remained consistent from year to year.

Station BTH-004

Taxonomic richness at Station BTH-004 was 31 in 2020, continuing the trend of increasing taxa richness that began in 2014 (Figure 1). The highest taxa richness at BTH-004 was 43 in 2010 and results in 2009 and 2011 were similarly high. A decrease in taxa richness at BTH-004 began in 2010 and continued to 2014. However, in 2013 and 2014, taxonomic richness values were lower than previous years due to sub-family level of identification of the family Chironomidae, compared to genus-level identification for all other years. Between 2014 and 2016 taxa richness remained relatively low overall, but increased substantially in 2018, which continued in 2020. The variation in numbers has been further discussed in Section 4.1.3.

The EPT richness at BTH-004 has been highly variable during both the pre-construction and construction phases with a minimum of 1 taxa observed in 2014, a maximum of 11 taxa in 2010, and an average of 5.5 EPT taxa across all monitoring years (Figure 3). EPT richness values have experienced substantial variation between years but although there appears to be a decreasing trend over time there has never been a decrease over consecutive years of sampling. The proportion of EPT was 10.0% in 2020, a substantial increase from 2018 results (Figure 2) and similar to the levels previously observed in 2009 and 2010. The highest proportion of EPT taxa (12.5%) occurred in 2009 while the lowest occurred in 2012 with a value of 0.78%. In general, the proportion of EPT taxa has been relatively low at BTH-004, remaining at or below 10% for most monitoring years.

The dominant taxon at BTH-004 in 2020 was *Chironomus sp.* consistent with the results of 2018 monitoring, a species of Diptera belonging to the sub-family *Chironominae* representing the second consecutive year of the dominant taxon being represented by members of the highly tolerant family Chironomidae. Species belonging to this family are generally associated with the erosional and depositional areas of lotic systems (Merritt et al. 2008). The conditions at station BTH-004 are consistent with this generalized habitat preference providing silt and sand substrates, as well as moderately abundant detritus and woody debris. This species represented 11.2% of the total number of individuals within the sample in 2020 (Figure 4). *Gammarus pseudolimnaeus* was previously the dominant taxa at this site for four consecutive years between 2012 and 2015, although its proportion within the sample had decreased by over

35.0% since 2013. Prior to 2012, the dominant taxa was identified as *Caecidotea intermedius*, a species of aquatic sowbug, which dominated the sample in 2010 and 2011. Both *C. intermedius* and *G. pseudolimnaeus* inhabit shallow waters where detritus is present and are likely to coexist in such habitat. Several other members of the family Chironomidae also comprised large proportions of the sample at BTH-004 in 2020 including *Microtendipes sp.* and *Tribelos sp.*, both taxa belonging to the subfamily Chironominae. EPT taxa have consistently represented low proportions of the samples at BTH-004, generally less than 10% (Figure 2) and have never been the dominant taxa.

The PMA index showed 'no impact' in 2020 as the calculated PSC value of 61.09 was higher than the critical PSC value of 42.12 (Table 6). This is the fourth consecutive year of a 'no impact' determination following three consecutive years of 'impact' (2012, 2013, and 2014) which resulted in two years of threshold exceedances at this station. Prior to 2012 the PMA analysis had shown 'no impact', which is the most consistent determination for BTH-004. The return to a "no impact" determination since 2015 indicates that conditions at BTH-004 are generally good, and are being maintained as such or improving, as evidenced by the increasing proportion of EPT taxa.

<u>Station BTH-005</u>

Taxonomic richness at Station BTH-005 was 35 in 2020, continuing an increasing trend that began in 2015. Taxonomic richness appears to be increasing to the high levels observed during pre-construction monitoring between 2009 and 2012. Similar to other monitoring stations, taxa richness values experienced a sharp decline in 2013 due to sub-family level of identification of the family Chironomidae, compared to genus-level identification for all other years. The variation in numbers has been further discussed in Section 4.1.3.

In 2020 the EPT richness at BTH-005 reached its highest level observed since 2009, with 8 taxa. This high EPT richness is reflected by similar increases and high richness values observed at other monitoring stations in 2020 (Figure 3). The proportion of EPT has been highly variable since 2009 with a low of 1.4% in 2014 and a high on 29.1% in 2015. Results indicate that the proportion of EPT taxa experience a spike every third year, followed by two years of lower levels. This trend continued in 2020 with another spike in the proportion of EPT at BTH-005 to a level higher than what had been observed during pre-construction monitoring.

The dominant taxon at BTH-005 in 2020 continued to be represented by *Chironomus sp.*, a species of Diptera belonging to the sub-family *Chironominae* of the highly tolerant family Chironomidae. This is consistent with 2018 results. Species belonging to this family are generally associated with the erosional and depositional areas of lotic systems (Merritt et al. 2008). The conditions at station BTH-005 are consistent with this generalized habitat preference providing primarily sand substrates with some silt and occasional gravel. Detritus and woody debris are also moderately abundant. This species represented 16.2% of the total number of individuals within the sample in 2020 (Figure 4). This is a marked change from 2014 through 2016 monitoring where the dominant taxon was represented by *G. pseudolimnaeus* which represented the subdominant taxon during 2018 monitoring. Prior to 2014 the dominant taxa had been *Caecidotea* sp., which includes a variety of sowbug species (Asellidae spp.). In 2014 and 2015 this species continued to comprise a large proportion of the sample. In 2015 the subdominant species was a species of Trichoptera (caddisfly) belonging to the family *Hydropsychidae*. This is reflected in the unusually high proportion of EPT seen in 2015.

The PMA index showed 'no impact' in 2020 as the calculated PSC value of 55.90 was higher than the critical PSC value of 42.12 (Table 6), representing the third consecutive year of 'no impact' at BTH-005. Results from 2014 and 2015 showed 'impact' for two consecutive years, which resulted in a threshold exceedance in 2015. Between 2009 and 2013 results had consistently shown 'no impact', which was again seen in 2016, 2018, and 2020. Overall, the results between 2016 and 2020 suggest an improvement in the conditions at BTH-005 compared to 2014 and 2015.

4.1.3 Benthic Invertebrate Threshold Analysis

The HCBP Consolidated Monitoring Program includes thresholds for various monitoring parameters. For benthic invertebrate monitoring, thresholds were developed for three benthic invertebrate metrics based on the degree of variation observed in the pre-construction monitoring data. The thresholds are as follows:

1. For the Percent Model Affinity (PMA) analysis, the threshold is an 'impact' determination at a station for 2 consecutive years following 2 consecutive years where the determination was 'no impact' at that station.
2. For Total Taxonomic Richness, the threshold is a 50% decline in the total number of taxa at a station, as compared to the results from the previous year.
3. For EPT Taxonomic Proportion, the threshold is a 50% decline in the proportion of EPT taxa at a station, as compared to the average results from the previous 2 years.

Benthic Invertebrate Threshold 1

Based on the criteria for the exceedance of threshold number one, none of the stations experienced an exceedance in 2020 as no station experienced two consecutive years of ‘impact’ following two years of ‘no impact’. All 5 monitoring stations in 2020 experienced ‘no impact’ determinations.

Benthic Invertebrate Threshold 2

For the second benthic invertebrate threshold, no stations experienced an exceedance as none of the stations exhibited a 50% reduction in the total number of benthic taxa in 2020 compared to 2018. All five stations exhibited increases in benthic taxa when compared to 2018 levels with taxonomic richness increasing by between 3.3% (BTH-004) and 40.0% (BTH-005).

The taxonomic richness was noted to decrease across the HCBP in 2013. These relatively low numbers persisted through 2014, 2015 and 2016 at most of the stations with minor increasing and decreasing values. The results for 2013 and 2014 are explained by the different level of identification for chironomids that occurred in those years. Prior to 2013 and following 2014, chironomids were identified to genus, while in 2013 and 2014 chironomids were identified to sub-family. It is interesting to note that the taxa richness remained low at several stations in 2015 and 2016, including at BTH-001, BTH-004 and BTH-005. It has been demonstrated that SWM Pond 4 has been continuously discharging water to Tributary A since 2012 upstream from BTH-005. This continuous discharge has resulted in increased flows and warmer overall stream temperatures within Tributary A, which are most notable in the vicinity of BTH-005 and BTH-001 (to a lesser extent). Although taxa richness remained relatively low throughout 2015 and 2016 it is difficult to determine if these low numbers were attributable to the continuous outflow from Pond 4 due to the potential inherent variability resulting from natural changes in conditions and sampling variance (date of sampling, sampler bias etc.). With that said, taxa richness values have increased consistently since 2016, a trend that has continued through 2020, particularly at BTH-005, which is located nearest to the Pond 4 outlet. In 2020 the taxa richness value at BTH-005 was higher than that observed during pre-construction monitoring in 2010, comparable to that observed at other monitoring stations. These increases in taxa richness, which have been observed at all monitoring stations across the site, suggest a return towards pre-construction conditions. Further to this, EPT richness and proportion of EPT taxa have also generally shown a trend of increasing values, supporting the idea that conditions at these stations are generally improving.

Benthic Invertebrate Threshold 3

For the third benthic invertebrate threshold, no stations experienced a 50% decrease in the proportion of EPT taxa in 2020 when compared to the average of the previous two monitoring years. The only monitoring station to experience a decrease in EPT proportion during 2020 was BTH-002 which experienced a 22% decrease when compared to the previous two monitoring years, which remains within the established thresholds. During 2018 monitoring, BTH-005 was observed to exceed this threshold, however in 2020 the proportion of EPT at BTH-005 was observed to increase over 2016 and 2018 proportions and was generally higher than all previous monitoring years, with the exception of 2015, which had the highest EPT proportion that has been observed to date. This is primarily a result of the high degree of variability in EPT richness and proportion observed at BTH-005 throughout the course of benthic invertebrate community monitoring. It is important to note that the change in level of identification that affected the overall taxonomic richness in 2013 did not apply to the EPT richness since Ephemeroptera, Plecoptera and Trichoptera groups were identified to the same taxonomic resolution throughout all years of monitoring.

4.2 Fish Sampling

4.2.1 Habitat Conditions

Station EMS-001 starts and ends within a riffle feature, though pools and runs are present throughout the station. Channel substrates are dominated by gravel, along with some silt, clay, sand and cobble. Instream habitat and cover is provided by woody debris, shallow pools and riffles, undercut banks, with some cover offered by cobble, overhanging terrestrial vegetation and backwater areas. At this monitoring station the creek exhibits a low to medium-gradient and a meandering channel. At the time of sampling, the wetted width ranged from 1.1 to 3.5m. Riffles were measured no deeper than 0.05m while a maximum depth of 18cm was measured within one of the pools at this station. Watercress was also observed at this station in low abundance.

Fish sampling was conducted on September 16, 2020. Water quality measurements were made at 0850hrs and are provided in Table 12.

Station EMS-002 was noted to have variable channel substrates consisting mainly of gravel with some cobble, sand, silt and clay. Riffles mark the upstream and downstream extents of the station throughout which pools, cobble, backwater areas and aquatic vegetation provide instream habitat and cover. The creek at this location exhibits a meandering channel with a moderate gradient. Wetted widths ranged from 1.4 to 2.0m. A maximum water depth of 0.20m was measured within a pool at this station while the average water depth was approximately 0.12m. Dense mats of watercress were observed growing throughout nearly the entire length of the station, which made electrofishing and netting difficult in some areas.

Fish sampling was conducted at this location on September 16, 2020. Water quality measurements were made at 1045hrs and are provided in Table 12.

Station EMS-003 was noted to have channel substrates comprised of silt and detritus with some sand. Riffles mark the upstream and downstream extents of the station throughout which instream habitat and cover are provided by woody debris, undercut banks, backwater areas, and pools. At this monitoring station the creek exhibits a low gradient through a meandering channel. At the time of sampling, it had a wetted width ranging from 1.2 to 2.0m and a maximum depth of 0.12m. The average water depth was approximately 0.08m.

Fish sampling was conducted at this location on September 15, 2020. Water quality measurements were made at 1420hrs and are provided in Table 12.

Station EMS-004 was noted to have a variety of channel substrates, dominated by sand and gravel with some cobble and silt. Detritus and muck are also present throughout the site. Riffles mark the upstream and downstream extents of the station. Woody debris provides the majority of instream habitat and cover but additional cover is present in the form of shallow riffles, small backwater areas, undercut banks, and cobble. At this monitoring station the creek exhibits a moderate gradient, meandering channel. At the time of sampling, it had a wetted width ranging from 1.3 to 3.8m. A maximum water depth of 0.16m was measured within a pool at this station while the average water depth was approximately 0.10m.

Fish sampling was conducted at this location on September 14, 2020. Water quality measurements were made at 1230hrs and are provided in Table 12.

Station EMS-005 exhibited channel substrates comprised mainly of gravel with some cobble, clay and silt and small amounts of sand. Riffles mark the upstream and downstream extents of the station throughout which riffles provide the majority of instream habitat and cover in the channel. Additional instream habitat and cover at EMS-005 is provided by a combination of pools undercut banks, woody debris, aquatic vegetation, and cobble. At this monitoring station the creek exhibits a moderate gradient, meandering channel. At the time of sampling, it had a wetted width ranging from 1.0 to 1.7m. A maximum water depth of 0.17m was measured within a pool at this station while the average water depth was approximately 0.10m.

Fish sampling was conducted at this location on September 16, 2020. Water quality measurements are provided in Table 12.

4.2.2 Fish Community Data

The water conditions during electrofishing, electrofishing settings, and sampling effort/duration are all important to document for comparing fish sampling results from year to year. This information is summarized in Table 12.

Table 12. Water Quality Measurements, Electrofishing Settings, and Shocking Times.

	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Date	September 16, 2020	September 16, 2020	September 15, 2020	September 14, 2020	September 16, 2020
Sampling Start Time	0850	1045	1420	1230	1150
Sampling End Time	1015	1200	1520	1450	1400
Air Temperature (°C)	18.0	15.0	18.0	16.0	22.0
Water Temperature (°C)	15.5	11.0	11.6	14.0	16.8
Time Water Temp. Taken	1015	1200	1520	1450	1400
Electrofisher Type	Smith-Root LR-20B	Smith-Root LR-20B	Smith-Root LR-20B	Smith-Root LR-20B	Smith-Root LR-20B
Number of Netters	1	1	1	1	1
Voltage (V)	150	100	100	100	100
Pulsating Frequency (Hz)	40	60	50	50	40
Shocking Time (sec.) – Pass 1	542	557	270	795	528
Shocking Time (sec.) – Pass 2	455	581	319	867	597
Shocking Time (sec.) – Pass 3	397	509	Not completed*	816	630

* Third pass could not be completed due to backpack electrofisher malfunction.

During 2020 construction-phase aquatic monitoring, a total of 545 fish were captured across the five monitoring stations (Figure 5). The catch was represented by eight different species; Blacknose Dace (*Rhinichthys obtusus*), Brook Stickleback (*Culaea inconstans*), Central Mudminnow (*Umbra limi*), Creek Chub (*Semotilus atromaculatus*), Fathead Minnow (*Pimephales promelas*), Mottled Sculpin (*Cottus bairdii*), Pumpkinseed (*Lepomis gibbosus*), and White Sucker (*Catostomus commersonii*). All nine species have been captured during previous monitoring years. Although, pre-construction monitoring between 2006 and 2011 typically saw four to six species. Prior to 2009 only three stations were sampled. The addition of EMS-004 and EMS-005 in 2009 would be expected to increase the total catch numbers, but monitoring between 2009 and 2020 is expected to be comparable across years.

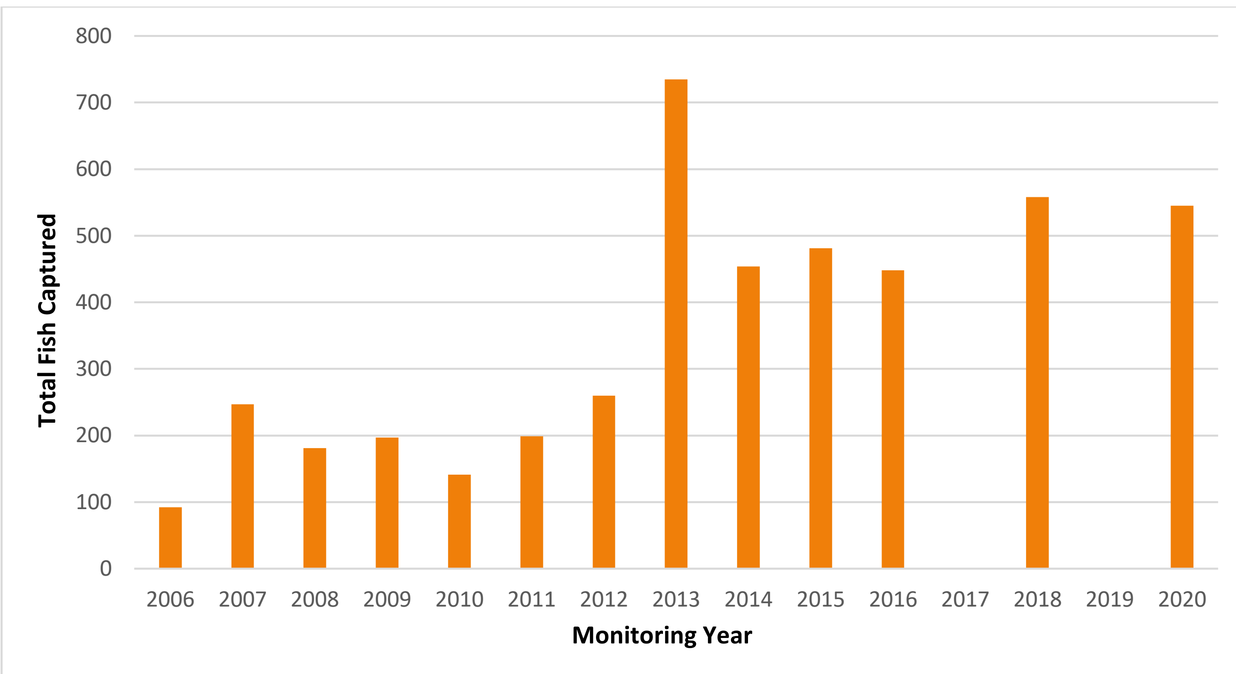

Figure 5. Comparison of the total numbers of fish captured across all five monitoring stations by year.

The total catch in 2020 represents a slight decrease from the total catch in 2018 but still maintains a relatively high level compared to previous years of monitoring, with the exception of 2013, which exhibited an uncharacteristically high catch of 735 fish. Prior to 2013, the total catches were relatively low in comparison, including during pre-construction monitoring years, ranging from 92 in 2006 (3 stations) to 260 in 2012 (5 stations). In spite of the two stations added in 2009 (EMS-004 and EMS-005), it generally appears that fish numbers have increased since sampling began. A description of electrofishing results for each station in 2020 can be found below.

The data collected during 2020 monitoring produced reliable statistical models for all five electrofishing monitoring stations using the maximum likelihood constant P model. The results for 2020 are provided in Table 18 along with the results from all past years of monitoring and have been described below. Results from the model output are provided in Appendix II. Some of the results in the past years could not be reported as estimates because a statistical model could not produce a reliable estimate. Methods for determining population estimates are indicated in Table 18 where applicable.

Station EMS-001

Electrofishing in 2020 resulted in the capture of seven species; Blacknose Dace, Brook Stickleback, Central Mudminnow, Creek Chub, Fathead Minnow, Pumpkinseed, and White Sucker. In total, 126 fish were captured over the course of three successive passes. This combined catch total represents a slight increase from the total numbers observed between 2015 and 2018. All species have been captured previously at EMS-001 with Blacknose Dace being the only species captured every year since sampling began in 2006. The detailed results are provided in Table 13. This site has consistently seen between three and five species during any given monitoring year with 2020 being the first year that seven species have been captured. The fish species that have been consistently captured at EMS-001 are coolwater species. Warmwater species are also occasionally captured, which include Fathead Minnow in 2011 and Pumpkinseed in 2018 and 2020.

Fish population estimates at this station have varied greatly between 2006 and 2020, and have generally been higher during construction-phase monitoring, which began in 2010, than they were during pre-construction monitoring. The lowest population estimates have been observed during pre-construction monitoring years 2006 and 2010 where estimates were approximately nine and five, respectively. The highest population estimate was 184, which was observed in 2013. 2013 was the third consecutive year of increasing population estimates that began in 2011 following a very low estimate in 2010. The high estimate in 2013 was attributed to increased baseflows at EMS-001 following a year of above-average precipitation. In addition, continuous discharge from stormwater management (SWM) pond 4 has increased water levels and slightly elevated water temperatures at EMS-001, which has increased habitat availability at this station. Following 2013 the population estimates have remained relatively high between 100 and 125 and appear to be relatively stable. Detailed fish population estimates by station for all years are provided in Table 13.

Table 13. Fish Sampling Results for EMS-001 in 2020

Fish Name		Number Captured				Fork Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthys obtusus*	41	9	4	54	27	72
Central Mudminnow	*Umbra limi*	1	1	0	2	43	59
Creek Chub	*Semotilus atromaculatus*	28	8	2	38	36	132
Pumpkinseed	*Lepomis gibbosus*	2	0	0	2	56	60
White Sucker	*Catostomus commersonii*	7	2	1	10	49	56
Fathead Minnow	*Pimephales promelas*	14	2	2	18	44	57
Brook Stickleback	*Culaea inconstans*	0	2	0	2	40	42
	Combine Total	93	24	9	**126**		

<u>Station EMS-002</u>

Electrofishing in 2020 resulted in the capture of seven fish species and combined for a total of 195 fish over three successive passes. The species captured were Blacknose Dace, Brook Stickleback, Central Mudminnow, Creek Chub, Fathead Minnow, Mottled Sculpin, and White Sucker. Blacknose Dace and Brook Stickleback have been captured at this station every year, while Creek Chub have been captured sporadically prior to 2012 and observed every year since. Pumpkinseed and Northern Redbelly Dace (*Chrosomus eos*) have also been previously captured throughout the years at this station but were not observed during 2020 monitoring. Mottled Sculpin, a coldwater species has also captured at this site in 2011, 2016, and 2018. Pumpkinseed, a warmwater fish species, has previously been captured at this station but was not observed during 2020 monitoring. The detailed results are provided in Table 14. Prior to 2013 this station had typically seen between three or four species with five species being captured in 2013. Species richness has increased slightly since 2013 with six species captured in 2014 and 2018, and seven species captured in 2016 and 2020.

The estimated fish population at EMS-002 has exhibited no consistent increasing or decreasing trend since sampling began in 2006 with contrasting years of high estimates followed by years of low estimates. The estimated numbers have experienced a great deal of variation with the lowest estimate occurring in 2009 (approximately 40) and the highest estimate of approximately 241 occurring in 2013. The estimate calculated in 2020 is similar to the high estimates that were seen in 2013 and 2014 and is a slight increase from the estimate in 2018. Although no consistent increases or decreases have been observed, a general increasing trend has been observed over the years. Detailed fish population estimates by station for all years are provided in Table 14.

Table 14. Fish Sampling Results for EMS-002 in 2020

Fish Name		Number Captured				Fork Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthys obtusus*	95	43	18	156	24	80
Brook Stickleback	*Culaea inconstans*	2	1	0	3	46	49
Central Mudminnow	*Umbra limi*	1	1	0	2	65	72
Creek Chub	*Semotilus atromaculatus*	14	11	6	31	42	128
Fathead Minnow	*Pimephales promelas*	0	0	1	1		57
Mottled Sculpin	*Cuttus bairdii*	1	1	0	2	79	81
White Sucker	*Catostomus commersonii*	0	1	0	1		59
	Combine Total	113	58	25	**195**		

Station EMS-003

Electrofishing in 2020 resulted in the capture of one fish species and a combined total of five fish over two successive passes. A third pass could not be completed due to equipment issues. The species captured was Blacknose Dace. Electrofishing results at this station have maintained a low species diversity relative to the other stations over the years and this was again evident in 2020. One or two species have been captured consistently since monitoring began with three species captured on only two occasions; in 2006 and 2016. In total, three fish species have been captured at EMS-003 over the course of monitoring, consisting exclusively of coolwater species. Brook Stickleback has also been captured regularly at this station while Creek Chub have being captured occasionally. Station EMS-003 is located along a headwater feature, which maintains cool water temperatures throughout the year and between years but also provides less available habitat compared to the other monitoring stations (i.e., more narrow and relatively shallow). The detailed results are provided in Table 15.

Population estimates at EMS-003 have been consistently low relative to the other stations within the HCBP study area. The estimate calculated in 2020 shows a decrease from 2018, but is consistent with other years of monitoring, including 2010 and 2011. In addition, a third electrofishing pass was not able to be completed in 2020, which could artificially lower the estimate. Overall, the pre-construction population estimates have been generally higher than during-construction; however, results from 2013 and 2018 are similar to what was observed during pre-construction years. Detailed fish population estimates by station for all years are provided in Table 15.

Table 15. Fish Sampling Results for EMS-003 in 2020

Fish Name		Number Captured				Fork Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthys obtusus*	3	2	n/a	5	47	67
	Combine Total	3	2	n/a	**5**		

n/a – not applicable. A third pass could not be completed due to equipment failure.

Station EMS-004

Electrofishing took place at this site for the first time in 2009 and has been sampled every year since. Electrofishing in 2020 resulted in the capture of five fish species and a combined total of 119 fish over three successive passes. The species captured included Backnose Dace, Brook Stickleback, Central Mudminnow, Creek Chub, and Mottled Sculpin. These five species were also captured in 2018 and have been consistently captured over the previous years of monitoring. Mottled sculpin, a coldwater fish species, was captured at EMS-004 for the first time in 2018. White sucker has also been captured at this station in previous years. The detailed results are provided in Table 16. This site has typically seen three or four species with five species being captured in 2013, 2018 and 2020.

Fish population estimates had remained relatively consistent at EMS-004 between 2009 and 2014, with the exception of 2013, which saw the population estimate increase substantially to 266, the highest estimate that has been recorded at any of the five monitoring stations since sampling began in 2006. Estimates increased in 2015 and have generally remained consistent up to and including 2020. However, overall, the population estimates at EMS-004 have exhibited an increasing trend. Detailed fish population estimates by station for all years are provided in Table 16.

Table 16. Fish Sampling Results for EMS-004 in 2020

Fish Name		Number Captured				Fork Length (mm)	
Common	Scientific	Pass 1	Pass 2	Pass 3	Total	Smallest	Largest
Blacknose Dace	*Rhinichthys obtusus*	39	21	11	71	23	79
Brook Stickleback	*Culaea inconstans*	6	2	0	8	36	51
Central Mudminnow	*Umbra limi*	1	0	0	1		57
Creek Chub	*Semotilus atromaculatus*	21	12	4	37	27	98
Mottled Sculpin	*Cuttus bairdii*	2	0	0	2	83	94
	Combined Total	69	35	15	**119**		

Station EMS-005

Electrofishing took place at this site for the first time in 2009 and has been sampled every year since. Electrofishing in 2020 resulted in the capture of five fish species and a combined total of 100 fish over three successive passes. The species captured included Blacknose Dace, Central Mudminnow, Creek Chub, Fathead Minnow, and White Sucker. Between 2009 and 2013 this station had typically contained between two and three species. In 2013, seven species were captured including Brook Stickleback and Northern Redbelly Dace. Blacknose Dace is the only species that has been captured during every year of sampling at this station while Brook Stickleback, Central Mudminnow and Creek Chub have also been captured regularly. The detailed results are provided in Table 17.

The population estimate at station EMS-005 in 2020 was 115, a substantial decrease from the 2018 monitoring. However, this follows a year (2016) that saw the highest population estimate that had been recorded at the station to date. This estimate is also below what had been observed between 2013 and 2015 but is still above the relatively low estimates calculated for the monitoring years between 2009 and 2012. Similar to EMS-001, continuous discharge from SWM pond 4 has increased habitat availability at this station, which has been reflected by the relatively high population estimates since 2013. Detailed fish population estimates by station for all years are provided in Table 17.

Table 17. Fish Sampling Results for EMS-005 in 2020

Fish Name		Number Captured				Fork Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthys obtusus*	23	15	7	45	35	86
Central Mudminnow	*Umbra limi*	2	1	1	4	54	61
Creek Chub	*Semotilus atromaculatus*	16	7	7	30	46	77
Fathead Minnow	*Pimephales promelas*	17	2	1	20	59	98
White Sucker	*Catostomus commersonii*	0	1	0	1		100
	Combined Total	58	26	16	**100**		

Species Biology

Eight fish species were captured during the 2020 monitoring program: Blacknose Dace, Brook Stickleback, Central Mudminnow, Creek Chub, Fathead Minnow, Mottled Sculpin, Pumpkinseed, and White Sucker. Descriptions of each species' habitat preferences have been provided below.

Blacknose Dace are known to inhabit small to medium-sized, clear, swiftly flowing streams with gravelly substrate. These typically exhibit a moderate to steep gradient and provide a variety riffle habitat. This species is considered to be benthic and an invertivore, feeding primarily on aquatic insect larvae (Scott and Crossman 1998, Eakins 2021).

Brook Stickleback are a native species to Ontario that inhabit the "clear, cold, densely vegetated waters of small streams and spring-fed ponds and may also be found along the swampy margins of beach ponds of larger lakes" (Scott and Crossman 1998). This species is considered to be benthopelagic and a planktivore/invertivore, feeding on a variety of aquatic insects and crustaceans. This species is tolerant of low dissolved oxygen, acidity and alkalinity but is generally intolerant of turbidity (Scott and Crossman 1998, Eakins 2021).

The Central Mudminnow is a native species common to Ontario that inhabits "heavily vegetated ponds, wetlands or pools of small creeks and quiet, shallow (0.5 m) areas of lakes with mud and organic substrates" (Eakins 2021). It is considered to be a benthic species and an invertivore, which feeds primarily on benthic invertebrates. This species is tolerant of low dissolved oxygen, low pH and high-water temperatures (29°C) and is moderately tolerant of turbidity (Scott and Crossman 1998, Eakins 2021).

The Creek Chub is a species known to inhabit the pools of small, clear streams and rivers with preferred water temperatures around 21°C (Eakins 2021). It is considered to be benthopelagic and an invertivore/carnivore, feeding on a variety of aquatic and terrestrial invertebrates. This species is tolerant of pollution and low dissolved oxygen but is moderately intolerant of turbidity (Scott and Crossman 1998, Eakins 2021).

The Fathead Minnow is a species that generally inhabits the still waters of ponds and flowing waters of streams with soft substrates. It is considered to be benthopelagic and a detritivore/invertivore and prefers warm water with temperatures between 23 and 29°C in the warm period of the year (Scott and Crossman 1998, Eakins 2021).

The Mottled Sculpin is a native species to Ontario that is known to inhabit the cobble and gravel riffles of cool creeks, small rivers and rocky shorelines of lakes. It is a benthic species that feeds primarily on aquatic insect larvae and some crustaceans. Mottled Sculpin generally prefer cold water with temperatures ranging from 13 to 18°C in the warm period of the year (Scott and Crossman 1998, Eakins 2021).

Pumpkinseed typically inhabit the warm, shallow areas of lakes and ponds as well as the quiet pools of creeks and small rivers where aquatic vegetation and organic debris is present. This is a warm water species with a preferred temperature range of 22 to 30°C. Pumpkinseed are moderately tolerant of turbidity (Eakins 2021).

The White Sucker is a species known to inhabit the pools and riffles of creeks and rivers, warm shallow lakes and embayments of larger lakes with preferred water temperature range from 17 to 23°C (Eakins 2021). White suckers are considered to be benthic fish and are invertivore/detritivores, feeding on a variety of benthic invertebrates. This species is tolerant of pollution and is moderately tolerant of turbidity (Scott and Crossman 1998, Eakins 2021).

The eight fish species captured in 2020 are previously known from the monitoring program and exhibit a variety of thermal preferences. However, most of these species prefer a cool-water thermal regime (Eakins 2021). The Pumpkinseed was the only warmwater fish species captured during 2018 monitoring. This species has previously been captured at monitoring stations EMS-002 in 2014 and EMS-005 in 2015 and 2016. One coldwater species, Mottled Sculpin, was also captured in 2020. This species has been previously captured at EMS-002 in 2011, 2016 and 2018 but was captured for the first time at EMS-004 in 2018 and then again in 2020. The thermal preferences of the fish captured in 2020 are generally consistent with the cool to cold water temperatures known from these watercourses, in spite of the incidental occurrences of warmwater species.

Fish species previously captured within the study area but not observed in 2020 also include the Northern Redbelly Dace. A description of this species' habitat preferences have been provided below.

The Northern Redbelly Dace is a species known to inhabit lakes, bogs, ponds and pools of creeks with organic substrates and aquatic vegetation. This species is often found in tea-stained waters and has a preferred water temperature of 25.3°C (Eakins 2021). It is considered to be benthopelagic and an invertivore/planktivore, feeding on a combination of algae, zooplankton and aquatic insects (Scott and Crossman 1998, Eakins 2021).

No Brook Trout were captured during monitoring in 2020, which is consistent with sampling at the quantitative stations in previous years.

<u>Population Estimates</u>

Population estimates have fluctuated over the years but have generally shown an overall increase in the numbers of fish within Tributary A, particularly beginning in 2013. The population estimates at Station EMS-003, located on Tributary A1, have remained consistently low between pre-construction and construction-phase monitoring.

The estimated fish population has remained relatively stable at EMS-001 and EMS-003, albeit with some expected variability between years. Station EMS-002 has shown substantial variability between years but has generally shown an increasing trend. The population at EMS-004 has shown the most consistent increasing trend with the population estimate for 2013 standing out as a notable outlier. Lastly, EMS-005 has shown population estimates higher than pre-construction during the construction phase, but has exhibited a decreasing trend since 2015.

Table 18. Fish Population Estimates by Station for the Years 2006 to 2020

Station	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
EMS – 001	9.1	> 87[1]	80	48.5	5.2	59.4	129.3	184.2[2]	101.6	122.8	124.1[2]	118.1	129.2
EMS – 002	55.6	173.1	>53[1]	40.2	76.9	100.3	73.8[2]	241.1	210.1	123.0	119.4[2]	182.7	220.5
EMS – 003	>31[1]	13.9	31	32.7	>5[1]	8.4	1	33.0	16.1	5.0	9.2	26.6	5.2
EMS – 004				29.4[2]	58.3	54.5	53.5	266.4	62.8	114.1	108.1	112.4	133.4
EMS – 005				82.3	2.2	10.2	42.9	167.5	203.8[2]	168.4	151.4	226.8	115.1

[1] Population estimate was not statistically valid. The number represented is the total catch.
[2] Estimate based on least squares regression method.

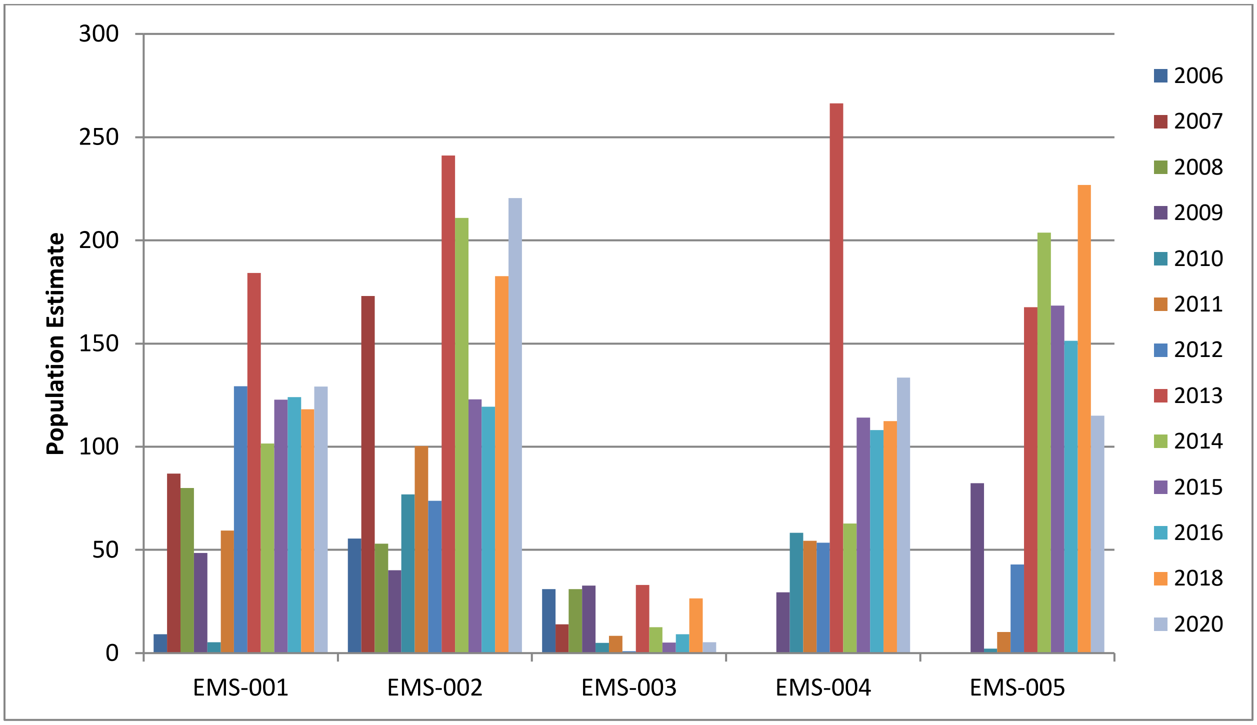

Figure 6. Population Estimates at Electrofishing Stations for the Years 2006 to 2020.

Brook Trout Spawning Survey

Brook Trout spawning surveys were conducted on three separate occasions during the fall of 2020. These were conducted on October 23, November 6, and November 19, 2020. No Brook Trout, Brook Trout redds, or evidence of Brook Trout spawning were observed during any of the surveys. The survey area shown on Map 1 includes the sections of Tributary A and Tributary A1 from the swamp north of the newly constructed Road A – Tributary A crossing to the tile drain outlet located approximately 400m north of Laird Road. A summary of the survey conditions is provided in Table 19.

Table 19. 2020 Brook Trout Spawning Survey Summary

Date (2020)	Location	Start Time	End Time	Water Temperature (°C)	Air Temperature (°C)	Spawning/Evidence Observed
October 23	Tributary A	0950	1030	8.0 – 8.5	11.0	None
	Tributary A1	1030	1110	8.5 – 9.2	11.0	None
November 6	Tributary A	0835	0920	8.0 – 9.0	10.0	None
	Tributary A1	0920	0945	9.8 – 10.0	10.0	None
November 23	Tributary A	0745	0830	3.0 – 4.5	3.0	None
	Tributary A1	0835	0900	6.0 – 6.5	3.0	None

Spawning survey and habitat conditions were found to vary within the survey area based on differences in flow rates, water temperatures, substrate composition, and habitat availability.

In 2020 water temperatures were lowest on Tributary A, ranging from 3.0 to 9.0°C, while along Tributary A1 water temperatures were slightly higher and ranged from 6.0 to 10.0°C (Table 19). At the upstream extent of the surveyed reach, along Tributary A1, the dominant substrates consisted of silt, muck, and detritus (primarily leaf litter). Woody debris was also found throughout the channel and a small amount of watercress was present along the margins of the creek in several locations. This section does not offer suitable spawning substrates for Brook Trout but does provide groundwater inputs, which is reflected in the relatively consistent water temperatures observed over the three surveys.

Throughout the centre of the site, near the Hanlon Creek Boulevard Road crossing (Tributary A), water velocities were noted to be higher than at the upstream limit due to the higher gradient and substrates were dominated by cobble and gravel with small amounts of silt and sand, which created areas of riffle and run habitat. The water temperature here was generally the lowest observed throughout the entire reach and watercress was observed in very high abundance at this location. The water temperature at this location is typically lower than what is seen in Tributary A1 since Tributary A1 is more heavily influenced by groundwater, which maintains a more consistent temperature since it doesn't react as strongly to fluctuating air temperatures. This section of creek offered the most suitable spawning habitat for Brook Trout, although the relatively shallow water depths could be a limiting factor. A pool, aquatic vegetation, and woody debris provided a relatively high amount of instream cover at the Hanlon Creek Boulevard crossing. Schools of small cyprinids (10-15) were observed throughout this section of Tributary A within the woody debris and aquatic vegetation. It was noted in 2020 that the presence of cattail (*Typha sp.*) has increased over time within the channel both immediately upstream and downstream of the road crossing. At both locations cattail have established across the channel and have reduced the ability of fish to freely move upstream and downstream. In general, it appears that silt is being deposited in the vicinity of the Hanlon Creek Boulevard crossing, which has allowed for the establishment of cattail, and has worked to fill in the large pool that was previously existing at the downstream side of the bridge.

Near the downstream extent of the survey area (Tributary A), substrates were similar to the upstream extent, comprised of silt, sand and detritus. Flow at this location is evident and velocity is greater than the upstream extent, but less than what was observed throughout the middle section. At this location there was a high density of fallen trees and woody debris across and throughout the channel. It appeared that there was more woody debris throughout this section than what has been observed in past years. This added woody debris created a slight backwater effect on the upstream side of some of the log jams.

Within the surveyed reaches of Hanlon Creek Tributaries A and A1, the most suitable Brook Trout habitat was observed upstream and downstream of the Hanlon Creek Boulevard culvert crossing of Tributary A. In spite of the silt deposition and cattail establishment this area continues to provide the most appropriate spawning conditions within the surveyed reaches, which included predominantly gravel substrates, groundwater inputs, and oxygenation of the water as a result of the variety of shallow riffle sections. These features are typically considered to provide the most suitable spawning habitat for Brook Trout (Scott and Crossman 1998). However, relatively shallow water depths and the establishment of cattail within the channel are limiting factors. Tributary A1 offers little to no suitable spawning habitat as a result of sand and silt substrates and abundance of detritus, despite the high groundwater input. Although conditions throughout Tributary A appeared suitable for Brook Trout spawning, no Brook Trout or Brook Trout spawning activities (i.e., redds, visible eggs, etc.) were observed during any of the three spawning surveys.

4.2.3 Fish Threshold Analysis

The HCBP Consolidated Monitoring Program (NRSI 2010) includes thresholds for various monitoring parameters. For fish monitoring, pre-construction and initial construction-phase fish monitoring did not result in capture of any Brook Trout at the quantitative monitoring stations. A specific quantitative threshold for Brook Trout is not appropriate unless sufficient numbers of Brook Trout become established such that they can be monitored in a quantitative manner.

Although a threshold is not provided for Brook Trout, the overall fish community is being monitored as a surrogate indicator of the suitability of the aquatic habitat for Brook Trout. The results will be evaluated and compared to previous year's data from the same stations. If any anomalies are seen, these will be discussed in light of monitoring results from other disciplines including the surface water and groundwater monitoring components and will be addressed as needed within the consolidated report. Two thresholds have been developed as follows:

1. A 50% change in the number of taxa represents a potential decline in the suitability of the habitat for Brook Trout. Because coldwater fish communities typically have a lower species diversity, an increase in species diversity may represent a negative change in relation to the Brook Trout management objective. Specifically, the warm-water fish community may increase in species richness as a result of warmer water temperatures, which indicates that the habitat is becoming less suitable for Brook Trout. A decrease in species diversity may also represent a negative change in the suitability of the habitat for Brook Trout, likely attributable to some cause other than water temperature.
2. A 50% reduction in the number of fish captured represents a potential decline in the fish community resulting from habitat impacts. However, it may also represent an improvement in habitat suitability for Brook Trout based on temperature changes, as discussed above.

Fish Threshold 1

For the first threshold, one station, EMS-003, exhibited a 50% reduction in the number of taxa captured in 2020 compared to 2018. This occurred due to a decrease in the number of taxa from 2 to 1.

The number of taxa at EMS-003 has been consistently low relative to the other monitoring stations and has fluctuated regularly between one and three species since sampling began in 2006, including both pre-construction and construction-phase monitoring. As such it is not believed that this threshold exceedance is of concern as results are within the expected range for the site.

Fish Threshold 2

For the second fish threshold, two stations; EMS-003 and EMS-005, exhibited at least a 50% reduction in the number of fish captured in 2020 when compared to 2018, which resulted in threshold exceedances for these stations.

The total catch at EMS-003 declined from 20 in 2018 to 5 in 2020, resulting in a 75% reduction. Similar to the low numbers of taxa at EMS-003, as discussed for Threshold 1, total fish caught has consistently been low relative to the other monitoring stations. This is due to the limiting habitat along Tributary A1 that includes relatively low water levels, silt/sand/detritus-dominated substrates, and a consistently cool thermal regime that are typical for a first order (headwater) watercourse. These naturally low catch numbers are more likely to experience threshold exceedances following minor fluctuations in taxa a numbers of fish observed between years. In addition to these factors, during 2020 monitoring only two electrofishing passes could be completed for the station due to equipment malfunction rather than the three passes that have been completed in previous years. This reduction in effort in 2020 compared to 2018 is also likely to have reduced the total fish caught at the station, further increasing the potential for an exceedance. Threshold exceedances have also been observed at this station in 2012, 2014, and 2015. It appears that the exceedance observed at EMS-003 is still within the previously observed natural fluctuations for the site and it is not believed to be a cause for concern.

The total catch at EMS-005 declined from 199 in 2018 to 100 in 2020, resulting in a 50% reduction and an exceedance of threshold 2. The reduction follows an uncharacteristically high total catch number that was observed in 2018, which was substantially higher than the catch numbers during previous years of monitoring at the station and the highest total catch that had been observed across all five monitoring stations since sampling began. The threshold exceedance appears to be the result of a reduction in the total catch to a more ‘typical’ number, and one that is more consistent with previous years of construction-phase monitoring prior to 2018. It should be noted that EMS-005 has been the most highly influenced by the continuous outflow from Pond 4 and as such, the species richness and total catch numbers have increased since pre-construction sampling in response. The reduction in total catch in 2020 is likely attributed to the lower-than-normal monthly precipitation for September, which saw groundwater levels decline from early-August to late-November. Continuous outflow from Pond 4 continued throughout 2020 but based on surface and groundwater monitoring, lower-than-normal precipitation levels from mid-August through September and November appear to have reduced groundwater levels and baseflow within Tributary A, which is likely to have influenced the available fish habitat at EMS-005. Apart from natural fluctuations in surface flow within Tributary A, habitat conditions have remained consistent across monitoring years, characterized by gravel and cobble substrates, riffles and relatively deep pools, slight bank undercutting, and abundant overhanging bank vegetation comprised primarily of terrestrial grasses and forbs. It is, therefore, likely that the 50% reduction in total catch in 2020 compared to 2018 is a result of lower surface water within Tributary A following a year of higher flow in 2018. Further, the total catch in 2020 is more in line with the catch numbers between 2013 and 2016.

5.0 Conclusions and Recommendations

The 2020 construction-phase monitoring program was successful in providing informative aquatic monitoring data on conditions during the eighth year of construction at the Hanlon Creek Business Park.

A great deal of variation has been observed between 2006 and 2020 in both benthic invertebrate and fish communities within Hanlon Creek Tributary A and A1. This has largely been attributed to natural variation caused by inconsistencies in abiotic factors (i.e., temperature, precipitation etc.) and stream dynamics across years in which monitoring occurred. The 2014 monitoring results indicated that a dry winter and lower than average precipitation between March and October likely impacted benthic and fish habitat suitability at many of the stations, which resulted in both benthic and fish threshold exceedances. In 2015 precipitation levels were once again lower than average throughout the summer months and were lower than what had been observed in 2014. Although benthic and fish threshold exceedances were observed in 2015, generally the 2015 monitoring results indicate improvements in both the benthic and fish communities. Additionally, continuous outflow from stormwater management (SWM) pond 4 has increased the levels of baseflow and slightly increased overall water temperatures, particularly at stations 1 and 5, which are located downstream of, and nearest to, the outlet. This effect is most notable between 2013 and 2020, during which time the pond was continuously discharging. The effects are particularly reflected through the increase in fish populations at EMS-001 and EMS-005 due to the increase in water levels, which has increased the overall available fish habitat.

None of the three benthic invertebrate thresholds were reached in 2020. For threshold 1, none of the five monitoring stations experienced ‘no impact’ determinations. For threshold 2, all five stations exhibited increases in benthic taxa when compared to 2018 levels with taxonomic richness increasing by between 3.3% (BTH-004) and 40.0% (BTH-005). For threshold 3, none of the stations experienced a 50% decrease in the proportion of EPT taxa in 2020 when compared to the average of the previous two monitoring years. Further, four of the five stations experienced increases in the proportion of EPT, with the exception of BTH-002 which experienced a 22%, albeit still within the established threshold.

Both fish community thresholds were exceeded in 2020. For the first threshold, station EMS-003 experienced a 50% decrease in the number of taxa from 2 in 2018 to 1 in 2020. For the second threshold, station EMS-003 experienced a 75% reduction in the total catch from 20 in

2018 to 5 in 2020 while EMS-005 experienced a 50% decline from 199 in 2018 to 100 in 2020. As detailed in section 4.2.3 the taxa richness and total catch numbers at EMS-003 are regularly low due to the nature of Tributary A1 and available habitat, which is limited compared to the other monitoring stations. Due to the naturally low numbers at this station, it is not uncommon to observe declines that exceed the fish monitoring thresholds and it is not believed that the exceedances observed in 2020 are cause for concern, or related to construction activity at the site. The threshold exceedance at EMS-005 was noted to be a return to more 'typical' levels following an exceptionally high total catch in 2018. Based on precipitation data for the site, it appears that the levels experienced through September were below the 'normals' observed for the site, which in turn caused a reduction in groundwater levels and, subsequently, baseflow across the site. This is likely to have resulted in less available habitat and a lower total catch.

We recommend the following regarding future monitoring:

1. Aquatic biological monitoring should continue biennially during the construction and build-out of the HCBP until 75% of the development is built (by area) in Phases 1, 2 and 3 of the HCBP, plus an additional 2 years. The aquatic biological monitoring will continue to be one component of the complete monitoring program, which is outlined in the HCBP Consolidated Monitoring Program.

2. Fish and benthic invertebrate monitoring should continue to occur biennially at the five sites sampled in 2020, with the next round of monitoring occurring in 2022.

A Brook Trout spawning survey should continue to be conducted in autumn throughout the months of October and November. Even if Brook Trout are not captured during fish sampling at the five biomass stations, the spawning survey will provide an additional opportunity to observe the presence/absence of Brook Trout on the subject property during a different part of the Brook Trout life cycle.

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Appendix I
Benthic Invertebrate Raw Data

GROUP	FAMILY	TAXON	BTH001 riffle 1	BTH001 pool	BTH001 riffle 2	BTH001 Pooled	Proportion	BTH002 riffle 1	BTH002 pool	BTH002 riffle 2	BTH002 Pooled	Proportion	BTH003 riffle 1	BTH003 pool	BTH003 riffle 2	BTH003 Pooled	Proportion	BTH004 riffle 1	BTH004 pool	BTH004 riffle 2	BTH004 Pooled	Proportion	BTH005 riffle 1	BTH005 pool	BTH005 riffle 2	BTH005 Pooled	Proportion
AMPHIPODA	Gammaridae	Gammarus pseudolimnaeus	14	45	9	68	**8.3%**	58	49	32	139	**11.5%**	9	12	49	70	**6.3%**	25	8	5	38	**3.8%**	10	15	35	60	**5.4%**
ISOPODA	Asellidae	Caecidotea intermedius	7		5	12	**1.5%**		18		18	**1.5%**	39	28	5	72	**6.4%**				0	**0.0%**	1	8	16	25	**2.3%**
RHYNCHOBDELLIDA	Glossiphoniidae	Helobdella				0	**0.0%**	2		3	5	**0.4%**	4			4	**0.4%**				0	**0.0%**	15	5		20	**1.8%**
COLEOPTERA	Elmidae	Dubiraphia quadrinotata	35	10	15	60	**7.3%**	19	49	12	80	**6.6%**			9	9	**0.8%**			12	12	**1.2%**	9			9	**0.8%**
		Optioservus fastiditus	4	5	6	15	**1.8%**	25	5	10	40	**3.3%**		15		15	**1.3%**				0	**0.0%**				0	**0.0%**
		Stenelmis crenata				0	**0.0%**	23	14	27	64	**5.3%**	5		9	14	**1.3%**	15	15		30	**3.0%**	14	10		24	**2.2%**
ARHYCHOBDELLIDA	Haemopidae	Haemopis				0	**0.0%**		9		9	**0.7%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
HEMIPTERA	Veliidae	Rhagovelia				0	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
DIPTERA	Ceratopogonidae	Ceratopogonidae type I		5		5	**0.6%**		11		11	**0.9%**				0	**0.0%**	1	1	2	4	**0.4%**		9		9	**0.8%**
	Chironomidae					**0**	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
	Chironominae	Chironomus	34	28	14	76	**9.3%**	9	12	39	60	**4.9%**	12	9	5	26	**2.3%**	49	28	36	113	**11.2%**	49	58	72	179	**16.2%**
		Microtendipes	24	12	24	60	**7.3%**	3	11	5	19	**1.6%**	9	35	14	58	**5.2%**		39	39	78	**7.8%**		18	5	23	**2.1%**
		Paratendipes	15	7		22	**2.7%**				0	**0.0%**	15		25	40	**3.6%**	15	19		34	**3.4%**	9	4	2	15	**1.4%**
		Polypedilum	10	8	9	27	**3.3%**	14	12	9	35	**2.9%**	19	45	39	103	**9.2%**	5		5	10	**1.0%**	39	28	49	116	**10.5%**
		Tribelos		7	5	12	**1.5%**	9	23		32	**2.6%**	7	17		24	**2.1%**	10		15	25	**2.5%**	4	12	2	18	**1.6%**
		Tanytarsus	10		15	25	**3.1%**		37		37	**3.1%**	4	24	14	42	**3.8%**	16	5	16	37	**3.7%**		2		2	**0.2%**
	Prodiamesinae	Prodiamesa sp		10		10	**1.2%**	14		13	27	**2.2%**	10	10	13	33	**2.9%**	16	15	9	40	**4.0%**	15	11	13	39	**3.5%**
	Orthocladiinae	Thienemanniella	5		15	20	**2.4%**	23		24	47	**3.9%**	5		17	22	**2.0%**		5	5	10	**1.0%**	5			5	**0.5%**
		Parametrocnemus	12	25	35	72	**8.8%**	7		4	11	**0.9%**		5	39	44	**3.9%**	55		9	64	**6.4%**	4	16	18	38	**3.4%**
	Tanypodinae	Apsectrotanypus				0	**0.0%**	4			4	**0.3%**	19		27	46	**4.1%**		7	39	46	**4.6%**				0	**0.0%**
		Natarsia	10	10	9	29	**3.5%**		7	22	29	**2.4%**	5	5	13	23	**2.1%**	15			15	**1.5%**	15	12	19	46	**4.2%**
		Conchapelopia	17	19	7	43	**5.3%**	11		13	24	**2.0%**	9		24	33	**2.9%**	18	38	28	84	**8.4%**	6	9	5	20	**1.8%**
		Macropelopia	12	16	8	36	**4.4%**	25	11	16	52	**4.3%**	14	24	9	47	**4.2%**	14	19	21	54	**5.4%**	4	4		8	**0.7%**
	Empididae	Hemerodromia sp				0	**0.0%**	9	4		13	**1.1%**				0	**0.0%**				0	**0.0%**	14	16	16	46	**4.2%**
	Simulidae	Simulium sp juv		9		9	**1.1%**	2		9	11	**0.9%**	35	24	19	78	**7.0%**	15	15		30	**3.0%**		5		5	**0.5%**
	Tabanidae	Chrysops sp			4	4	**0.5%**				0	**0.0%**		13		13	**1.2%**			25	25	**2.5%**		9		9	**0.8%**
	Stratiomyidae	Odontomyia				0	**0.0%**	5		14	19	**1.6%**	15		5	20	**1.8%**	9	22		31	**3.1%**	15		15	30	**2.7%**
	Tipulidae	Tipula	12	19	16	47	**5.8%**	27			27	**2.2%**	7		13	20	**1.8%**	15			15	**1.5%**		9		9	**0.8%**
		Dicranota		7		7	**0.9%**			16	16	**1.3%**		28		28	**2.5%**			13	13	**1.3%**	4		4	8	**0.7%**
MEGALOPTERA	Sialidae	Sialis sp	5	5	5	15	**1.8%**	13	11	2	26	**2.1%**	5	5	5	15	**1.3%**		2		2	**0.2%**		9		9	**0.8%**
	Corydalidae	Nigronia				0	**0.0%**			9	9	**0.7%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
ODONATA	Aeshnidae	Boyeria		7		7	**0.9%**	2		2	4	**0.3%**		7		7	**0.6%**				0	**0.0%**				0	**0.0%**
	Aeshnidae	Aeshna				0	**0.0%**		4		4	**0.3%**	4		4	8	**0.7%**	15	5		20	**2.0%**	14		24	38	**3.4%**
	Calopterygidae	Calopteryx		18		18	**2.2%**	27	14	5	46	**3.8%**		13		13	**1.2%**				0	**0.0%**				0	**0.0%**
PLECOPTERA	Leuctridae	Leuctra sp				0	**0.0%**		13		13	**1.1%**				0	**0.0%**				0	**0.0%**			9	9	**0.8%**
	Nemouridae	Malenka				0	**0.0%**	5			5	**0.4%**	10	5	19	34	**3.0%**	5		15	20	**2.0%**	29		29	58	**5.2%**
TRICHOPTERA	Glossosomatidae	Glossosoma	9			9	**1.1%**				0	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
	Hydropsychidae	Cheumatopsyche	25	10	7	42	**5.1%**	15	17	37	69	**5.7%**	19	9		28	**2.5%**	5		5	10	**1.0%**	18		18	36	**3.3%**
		Hydropsyche	16	10		26	**3.2%**	11	4	5	20	**1.6%**				0	**0.0%**				0	**0.0%**	9		14	23	**2.1%**
		Diplectrona				0	**0.0%**	9	19		28	**2.3%**	4			4	**0.4%**				0	**0.0%**		18		18	**1.6%**
	Lepidostomatidae	Lepidostoma sp				0	**0.0%**			14	14	**1.2%**	14		5	19	**1.7%**				0	**0.0%**	14		14	28	**2.5%**
	Limnephilidae	Frenesia sp		4		4	**0.5%**				0	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
	Philopotamidae	Chimarra sp	2			2	**0.2%**	49		12	61	**5.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
	Phryganeidae	Phryganea				0	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
	Polycentropodidae	Polycentropus		2		2	**0.2%**	5		4	9	**0.7%**	14	8	15	37	**3.3%**	21			21	**2.1%**		25		25	**2.3%**
	Rhyacophilidae	Rhyacophila	4	4	4	12	**1.5%**				0	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
	Hydroptilidae	Hydroptila				0	**0.0%**	24		4	28	**2.3%**		24		24	**2.1%**	25		25	50	**5.0%**	14		14	28	**2.5%**
GASTROPODA	Physidae	Physella gyrina		7		7	**0.9%**				0	**0.0%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
						0	**0.0%**	9			9	**0.7%**				0	**0.0%**				0	**0.0%**				0	**0.0%**
EPHEMEROPTERA	Isonychiidae	Isonychia	9	5		14	**1.7%**				0	**0.0%**	9	12		21	**1.9%**				0	**0.0%**				0	**0.0%**
BIVALVIA	Sphaeriidae	Pisidium sp				0	**0.0%**				0	**0.0%**	25			25	**2.2%**			39	39	**3.9%**				0	**0.0%**
LUMBRICULIDA	immature LUMBRICULIDA					0	**0.0%**				0	**0.0%**				0	**0.0%**		15		15	**1.5%**		35	35	70	**6.3%**
PLATYHELMINTHES	Tricladida	Planariidae				0	**0.0%**	14	25		39	**3.2%**				0	**0.0%**	10		10	20	**2.0%**				0	**0.0%**
		TOTALS	291	314	212	817	100.0%	472	379	362	1213	100.0%	346	377	396	1119	100.0%	374	258	373	1005	100.0%	330	347	428	1105	100.0%
		Number of Taxa	22	27	19	33		31	23	27	41		28	23	24	36		22	17	21	31		24	24	22	35	
		Percentage picked	4.55%	2.94%	8.57%			2.78%	2.86%	5.88%			6.45%	5.88%	11.11%			27.27%	4.88%	2.86%			41.67%	25.71%	7.41%		
		% Dominant Taxa	*Chironominae*	Chironomus		9.30%		Gammaridae	Gammarus pseudolimnaeus		11.5%		*Chironominae*	Polypedilum		9.2%		*Chironominae*	Chironomus		11.2%		*Chironominae*	Chironomus		16.2%	
		% EPT				13.59%					20.4%					14.9%					10.0%					20.4%	
		EPT richness				8					9					7					4					8	

Appendix II

Fish Population and Biomass Estimate Data

Fish Population Estimates Using Maximum Likelihood Constant P – 2006

Results	EMS-001	EMS-002	EMS-003
Estimated Population	9.07	55.56	34.81
Chi-squared	0.52	1.44	2.57
Standard error	0.3	3.05	3.82
Degrees of freedom	1	1	1
Number observed	9	52	31
Lower 95% conf. interval	9.00	52.00	31.00
Upper 95% conf. interval	9.66	61.53	42.30
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4724 (accept)	0.2305 (accept)	0.1089 (reject)

Fish Biomass Estimates Using Maximum Likelihood Constant P – 2006

Results	EMS-001	EMS-002	EMS-003
Estimated Biomass (g)	5.03	66.10	67.21
Chi-squared	0.23	0.03	14.37
Standard error	0.19	1.30	2.05
Degrees of freedom	1	1	1
Number observed	5	65	65
Lower 95% conf. interval	5.00	65.00	65.00
Upper 95% conf. interval	5.40	68.65	71.22
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.6319 (accept)	0.8638 (accept)	0.0002 (reject)

Fish Population Estimates Using Maximum Likelihood Constant P – 2007

Results	EMS-001	EMS-002	EMS-003
Estimated Population	88.76	173.07	13.89
Chi-squared	3.42	0.44	0.23
Standard error	1.68	3.84	1.53
Degrees of freedom	1	1	1
Number observed	87	166	13
Lower 95% conf. interval	87.00	166.00	13.00
Upper 95% conf. interval	92.05	180.59	16.88
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.0646 (reject)	0.5073 (accept)	0.6315 (accept)

Fish Biomass Estimates Using Maximum Likelihood Constant P – 2007

Results	EMS-001	EMS-002	EMS-003
Estimated Biomass (g)	52.51	158.46	18.45
Chi-squared	3.97	1.06	0.02
Standard error	1.65	5.28	0.88
Degrees of freedom	1	1	1
Number observed	51	148	18
Lower 95% conf. interval	51.00	148.11	18.00
Upper 95% conf. interval	55.75	168.81	20.17
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.0463 (reject)	0.3040 (accept)	0.8853 (accept)

Fish Population Estimates Using Maximum Likelihood Constant P – 2008

Results	EMS-001	EMS-002	EMS-003
Estimated Population	80.02	91.84	30.93
Chi-squared	1.08	3.39	0.58
Standard error	4.17	35.62	5.22
Degrees of freedom	1	1	1
Number observed	74	53	26
Lower 95% conf. interval	74.00	53.00	26.00
Upper 95% conf. interval	88.20	161.65	41.15
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.2922 (accept)	0.0655 (reject)	0.4444 (accept)

Fish Biomass Estimates Using Maximum Likelihood Constant P – 2008

Results	EMS-001	EMS-002	EMS-003
Estimated Biomass (g)	55.82	105.00	36.08
Chi-squared	1.13	9.30	5.39
Standard error	4.63	1.17	9.68
Degrees of freedom	1	1	1
Number observed	50	104	27
Lower 95% conf. interval	50.00	104.00	27.00
Upper 95% conf. interval	64.89	107.29	55.05
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.2870 (accept)	0.0023 (reject)	0.0202 (reject)

Fish Population Estimates Using Maximum Likelihood Variable P – 2009

Results	EMS-001	EMS-002	EMS-003	EMS-005
Estimated Population	48.51	40.19	32.73	82.31
Chi-squared	0.56	0.35	0.24	0.17
Standard error	0.90	7.84	5.71	23.13
Degrees of freedom	1	1	1	2
Number observed	48	33	28	61
Lower 95% conf. interval	48.00	33.00	28.00	61.00
Upper 95% conf. interval	50.28	55.56	43.93	127.64
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4550 (accept)	0.5516 (accept)	0.6234 (accept)	0.9179 (accept)

** Constant P method used for Population Estimate due to only 3 passes.

Fish Population Estimates Using Least Squares Regression – 2009

Results	EMS-004
Estimated Population	29.42
Slope	- 0.596
Y – Intercept	17.55
r^2 (Coefficient of Determination)	0.969
Residual Sum of Squares	3.916
Regression Sum of Squares	124.084
Degrees of Freedom	1
F	31.687

Fish Population Estimates Using Maximum Likelihood Constant P – 2010

Results	EMS-001	EMS-002	EMS-003	EMS-005
Estimated Population	5.22	76.95	-	2.18
Chi-squared	1.03	0.44	-	0.68
Standard error	0.67	1.17	-	0.74
Degrees of freedom	1	1	-	1
Number observed	5	76	-	2
Lower 95% conf. interval	5.00	76.00	-	2.00
Upper 95% conf. interval	6.54	79.24	-	3.63
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.3111 (accept)	0.5073 (accept)	-	0.4096 (accept)

Fish Population Estimates Using Maximum Likelihood Variable P – 2010

Results	EMS-004
Estimated Population	58.33
Chi-squared	0.47
Standard error	6.45
Degrees of freedom	1
Number observed	52
Lower 95% conf. interval	52.00
Upper 95% conf. interval	70.97
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4929 (accept)

Fish Population Estimates Using Maximum Likelihood Constant P – 2011

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	59.37	100.31	8.35	54.47	10.16
Chi-squared	0.29	0.55	0.14	0.05	0.14
Standard error	7.99	7.22	9.69	5.16	2.15
Degrees of freedom	1	1	1	1	1
Number observed	49	88	5	48	9
Lower 95% conf. interval	49	88	5	48	9
Upper 95% conf. interval	75.03	114.46	27.33	64.58	14.37
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.59 (accept)	0.4565 (accept)	0.7095 (accept)	0.8316 (accept)	0.7105 (accept)

Fish Population Estimates Using Maximum Likelihood Constant P – 2012

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	129.32	70.08	1.00	53.46	42.95
Chi-squared	0.09	3.54	0.00	4.11	0.37
Standard error	5.57	11.05	0.00	5.78	3.55
Degrees of freedom	1	1	1	3	2
Number observed	119	55	1	46	39
Lower 95% conf. interval	119.00	55.00	1.00	46.00	39.00
Upper 95% conf. interval	140.24	91.74	1.00	64.80	49.90
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.7649 (accept)	0.0597 (**reject**)	0.9748 (accept)	0.2496 (accept)	0.8294 (accept)

Fish Population Estimates Using Least Squares Regression – 2012

Results	EMS-002
Estimated Population	73.78
Intercept (a)	27.35
Probable uncertainty of Intercept (a)	5.54
Gradient (b)	-0.37
Probable uncertainty of Gradient (b)	0.18
Chi-squared	36.24
Number observed	55.00

Fish Population Estimates Using Maximum Likelihood Constant P – 2013

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	190.10	241.10	33.03	266.39	159.89
Chi-squared	3.48	0.34	0.29	1.07	0.46
Standard error	5.62	18.73	5.14	27.56	9.46
Degrees of freedom	1	1	1	1	2
Number observed	178	193	28	197	139
Lower 95% conf. interval	179.09	204.40	28.00	212.37	141.34
Upper 95% conf. interval	201.11	277.81	43.11	320.40	178.44
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.0619 (**reject**)	0.5593 (accept)	0.5903 (accept)	0.3001 (accept)	0.7933 (accept)

Fish Population Estimates Using Least Squares Regression – 2013

Results	EMS-001
Estimated Population	184.20
Intercept (a)	117.69
Probable uncertainty of Intercept (a)	7.13
Gradient (b)	-0.64
Probable uncertainty of Gradient (b)	0.06
Chi-squared	52.59
Number observed	178.00

Fish Population Estimates Using Maximum Likelihood Constant P – 2014

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	101.57	210.10	16.05	62.84	198.34
Chi-squared	0.01	1.73	0.72	1.35	3.64
Standard error	4.16	6.72	11.68	8.95	67.17
Degrees of freedom	1	2	2	1	1
Number observed	95	194	10	51	104
Lower 95% conf. interval	95.00	196.93	10.00	51.00	104.00
Upper 95% conf. interval	109.72	223.27	38.93	80.38	329.99
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.9142 (accept)	0.4221 (accept)	0.6993 (accept)	0.2450 (accept)	0.0564 **(reject)**

Fish Population Estimates Using Least Squares Regression – 2014

Results	EMS-005
Estimated Population	203.77
Intercept (a)	43.22
Probable uncertainty of Intercept (a)	8.91
Gradient (b)	-0.21
Probable uncertainty of Gradient (b)	0.17
Chi-squared	97.29
Number observed	104.00

Fish Population Estimates Using Maximum Likelihood Constant P – 2015

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	122.78	123.02	5.04	114.08	168.35
Chi-squared	0.00	0.05	2.66	0.27	0.26
Standard error	4.04	5.07	0.23	12.43	6.73
Degrees of freedom	1	1	2	1	1
Number observed	116	114	5	92	154
Lower 95% conf. interval	116.00	114.00	5.00	92.00	155.17
Upper 95% conf. interval	130.70	132.95	5.50	138.45	181.53
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.9903 (accept)	0.8229 (accept)	0.2650 (accept)	0.6034 (accept)	0.6129 (accept)

Fish Population Estimates Using Maximum Likelihood Constant P – 2016

Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	128.53	113.92	9.22	108.11	151.39
Chi-squared	2.31	5.25	1.24	0.24	0.39
Standard error	5.68	7.14	0.62	8.52	11.40
Degrees of freedom	1	1	1	1	2
Number observed	118	101	9	93	127
Lower 95% conf. interval	118.00	101.00	9.00	93.00	129.04
Upper 95% conf. interval	139.65	127.92	10.44	124.81	173.73
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.1288 **(reject)**	0.0220 **(reject)**	0.2664 (accept)	0.6231 (accept)	0.8232 (accept)

Fish Population Estimates Using Least Squares Regression – 2016

Results	EMS-001	EMS-002
Estimated Population	124.07	119.37
Intercept (a)	75.00	56.84
Probable uncertainty of Intercept (a)	5.08	7.97
Gradient (b)	-0.60	-0.48
Probable uncertainty of Gradient (b)	0.07	0.13
Chi-squared	26.80	71.57
Number observed	118.00	101.00

Fish Population Estimates Using Maximum Likelihood Constant P – 2018

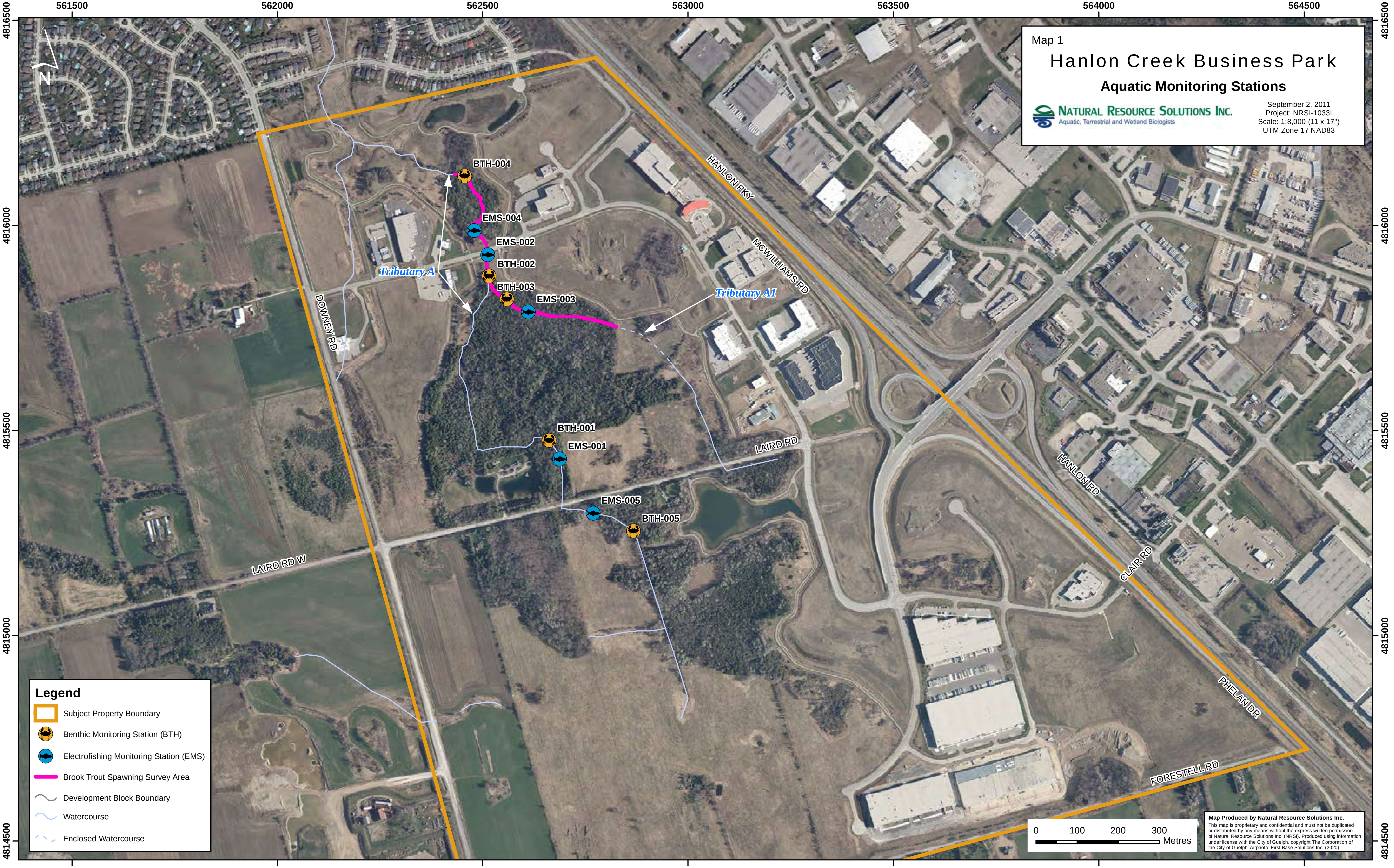
Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	118.12	182.67	25.56	112.42	226.78
Chi-squared	0.46	0.0	0.01	0.68	0.39
Standard error	12.18	7.82	8.10	22.57	10.84
Degrees of freedom	1	1	1	1	1
Number observed	96	165	20	78	199
Lower 95% conf. interval	96.00	167.34	20.00	78.00	205.54
Upper 95% conf. interval	141.98	197.99	42.45	156.67	24.01
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4956 (accept)	0.9452 (accept)	0.91.68 (accept)	0.4103 (accept)	0.5317 (accept)

Fish Population Estimates Using Maximum Likelihood Constant P – 2020

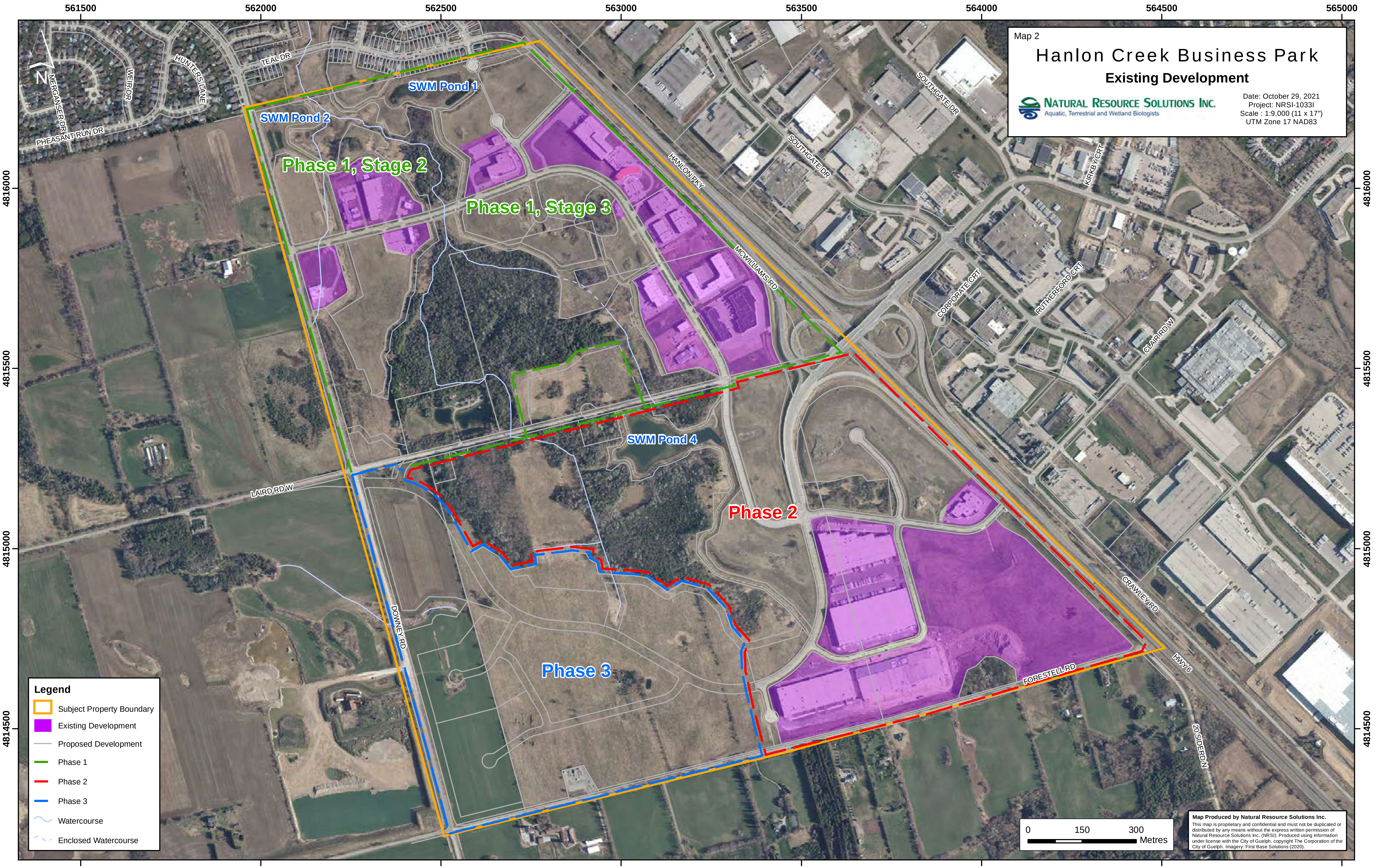
Results	EMS-001	EMS-002	EMS-003	EMS-004	EMS-005
Estimated Population	129.15	220.53	5.22	133.43	115.10
Chi-squared	0.49	0.26	1.03	0.15	0.43
Standard error	2.32	9.76	0.67	7.39	8.25
Degrees of freedom	1	1	1	1	1
Number observed	126	196	5	119	100
Lower 95% conf. interval	126.00	201.41	5.00	119.00	100.00
Upper 95% conf. interval	133.69	239.65	6.54	147.92	131.27
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4855 (accept)	0.6108 (accept)	0.3111 (accept)	0.7029 (accept)	0.5116 (accept)

Map 1 Aquatic Monitoring Stations

Map 2 Existing Development and Construction Areas



NRSI_0682H_AquaticMonitoring_8K_2011_09_02_GCS



Path: X:\0682_HanlonTerrestrialandAquaticMonitoring\NRSI_1033H_Map2_ExistingDev_9K_2021_10_29_MV.mxd

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APPENDIX VI 2020 Terrestrial and Wetland Monitoring Report

Hanlon Creek Business Park 2020 During-Construction

Terrestrial and Wetland Monitoring

Prepared for:

Economic Development & Tourism Services
City of Guelph
1 Carden Street, City Hall
Guelph, ON

Project No. 1033I l October 2021

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Hanlon Creek Business Park
2020 During-Construction

Terrestrial and Wetland Monitoring

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Report submitted on October 26, 2021

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1.0 Introduction

Terrestrial and wetland monitoring in the Hanlon Creek Business Park (HCBP) has been ongoing between 2006 to 2020. Between 2006 to 2016, monitoring was conducted annually. A meeting was held with Natural Resource Solutions Inc. (NRSI) and the City of Guelph on November 4, 2016 where NRSI recommended that the monitoring program be undertaken on a biennial basis. This recommendation was to reduce potential impact imposed by surveyors within the monitoring plots (trampling, etc.) and to reduce the monitoring effort/costs as the during-construction phase of the project has been longer than initially planned. The objective of terrestrial and wetland monitoring is to identify and track any changes that may occur to the terrestrial and wetland ecology resulting from the ongoing industrial development of the HCBP. The terrestrial and wetland monitoring program focuses on assessing features within the entire subject property; however, it is noted that development of the Business Park is occurring in phases (Phases 1 (Stages 2 & 3), 2, and 3) (Map 1). To date, development has occurred in the Phase 1 and Phase 2 lands. Development is not anticipated in Phase 3 for a number of years.

Baseline (pre-construction) monitoring was conducted from 2006 to 2009. During construction monitoring commenced in 2010, making 2020 the eleventh during construction monitoring year. The monitoring program also includes components related to the Mast-Snyder Gravel Pit, located west of the HCBP. These components of the monitoring are tied to the timing of the pit's operation and restoration.

Over time, the terrestrial and wetland monitoring program has expanded to address concerns and recommendations made by reviewing groups and agencies. In line with the baseline monitoring, vascular flora, breeding birds and calling anurans were monitored in 2020 and are documented in this report. In addition to the biennial terrestrial and wetland monitoring program, wildlife movement (night-time road mortality) and interim wildlife culvert effectiveness monitoring was conducted along Laird Road in 2021 (NRSI 2021). Species that were documented during the Laird Road monitoring have been incorporated into this report.

This report provides a summary of findings from the 2020 monitoring year, as well as a comparison of the data to previous baseline and during construction years. Recommendations related to the terrestrial and wetland monitoring program are summarized.

The aquatic monitoring program that supplements the overall monitoring requirements within the HCBP is provided under separate cover (NRSI 2021b).

1.1 Construction Activity

Construction within Phases 1 and 2 of the Business Park commenced in late 2009 and has continued each year to the present. Recent development has occurred in Phase 1 Stage 2, where additional office buildings are now occupied near the intersection of Hanlon Creek Boulevard and Downey Road. In the southeast corner of Phase 2, several additional warehouse buildings were occupied or under construction in 2020. Throughout the summer of 2021, site grading had commenced in Phase 1, Stage 3, to the east of Hanlon Creek, on the south side of Hanlon Creek Boulevard. Operational buildings within Phases 1 and 2 are indicated on Map 2. The Laird Road overpass has been open since 2014. To date, no construction activity has occurred within Phase 3.

2.0 Methodology

Since 2006, the terrestrial and wetland monitoring program has focused on plot-based surveys to document vascular flora (herbaceous, shrubs and trees), breeding birds and calling anurans as well as incidental wildlife throughout the property. Soil profiles were characterized in each of the monitoring plots between 2006 and 2014.

For plot set-up and annual monitoring survey methodologies, the reader is referred to Section 3.0 in the HCBP Terrestrial and Wetland Monitoring Reports submitted to the City for the 2011-2013 monitoring years (NRSI 2011 – 2015).

Table 1 provides a summary of the plots that have been monitored in each year and the monitoring focus. Map 3 identifies the Ecological Land Classification (ELC) vegetation communities throughout the Business Park and the location of monitoring stations.

2.1 Incidental Observations

Incidental observations of all wildlife (i.e., birds, mammals, butterflies, dragonflies, anurans and reptiles) were documented during all field visits conducted in 2020. This report also incorporates species data from the wildlife movement surveys conducted along Laird Road in 2021 (NRSI 2021). Results from these surveys have been compiled under a separate cover; however, species observations have been incorporated into this report.

Table 1. Summary of Plot Monitoring

Plot	2006				2007-2008				2009-2010				2011-2020			
	A	V	S	B	A	V	S	B	A	V	S	B	A	V	S	B
1	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
3		■	■	■		■	■	■		■	■	■		■	■	■
4	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5		■	■	■		■	■	■		■	■	■		■	■	■
6	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
8	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
9					■	■	■	■	■	■	■	■	■	■	■	■
10									■		■		■		■	
11									■		■	■	■		■	■
12									■		■		■		■	
13									■		■		■		■	
14									■		■		■		■	
15									■		■		■		■	
16									■		■		■	■	■	■
17									■		■		■		■	
18													■	■	■	
19																■
20																■

*Surveys were not conducted in 2017 or 2019

- Calling anuran monitoring
- Vegetation monitoring
- Soil monitoring (discontinued after 2014)
- Breeding bird monitoring

3.0 Monitoring Results

3.1 Vascular Flora Surveys

The ELC vegetation community codes and descriptions for each monitoring plot are shown on Map 3.

Refer to Appendix I for a comprehensive list of vascular flora species observed within the monitoring plots between 2006 and 2020. Table 2 lists the number of species that were observed each year. In 2020, 152 vascular plant species were observed within the 11 vegetation monitoring plots, of which, 11 species had not been previously recorded, including;

Plot 1

- Three-petalled bedstraw (*Galium trifidum*), an inconspicuous plant that may have been documented only to genus in previous monitoring years.
- Small-flowered Willowherb (*Epilobium parviflorum*), a benign introduced species with seeds that are easily dispersed.

Plot 3

- Black Walnut (*Juglans nigra*), a small sapling that likely arrived through seed caching by mammals. This species occurs along hedgerows and forest edges within the study area.

Plot 4

- Fringed Brome (*Bromus ciliatus*), a relatively conservative species that either recently seeded into the plot, or was vegetative and unidentifiable in previous monitoring years.

Plot 6

- Smooth Bedstraw (*Galium mollugo*), a common introduced species that favours mesic meadow habitat and was likely present in the vicinity of the plot for some time.

Plot 7

- Common White Snakeroot (*Ageratina altissima*), likely arriving in the plot by way of lightweight seeds that are wind-dispersed.

- Finely-nerved Sedge (*Carex leptonervia*), potentially overlooked as vegetative plants in previous monitoring years, or present in the vicinity of the plot and seeded-in. Considered rare in Wellington County (Dougan & Associates 2009).

Plot 8

- Stiff Marsh Bedstraw (*Galium tinctorium*), potentially arriving through seasonal watercourse flows depositing seed or root material on the banks within the plot.

Plot 16

- Common Ragweed (*Ambrosia artemisiifolia*), present in small numbers within the plot but exemplifying the trend toward drier conditions within this feature.
- Catling's Avens (*Geum* X *catlingii*), a common hybrid with barbed seeds that are easily transported by mammals.

Table 2. Number of Vascular Plant Species Observed by Year

Year	Number of Species
2006	96
2007	109
2008	108
2009	117
2010	123
2011	138
2012	146
2013	146
2014	135
2015	141
2016	127
2018	136
2020	152

Plant specimens cannot always be identified to species level due to a lack of diagnostic features at the time of the survey (i.e., sedge or grass species lacking an inflorescence or fully developed fruits) and as such some plants were only identified to genus. A small number of species that were previously only recorded to genus (i.e., Baneberry (*Actaea* sp.)), were identified to species in 2020 and are not considered to be new additions to the plots.

3.1.1 Significant Vascular Flora Species

In 2020, Finely-nerved Sedge – a new addition to the plot data set, Clinton's Wood-fern (*Dryopteris clintoniana*) and Rough-leaved Goldenrod (*Solidago patula*) were observed and are considered rare within Wellington County (Dougan 2009). Clinton's Wood-fern was observed in Plot 2 in 2020 and Plot 1 in 2018 and occurs sporadically throughout the central feature. Regionally rare species documented from the site are listed in Table 3. No federally or provincially significant species of vascular plants were observed during 2020 monitoring.

3.1.2 Floristic Indices

The assessment of the floristic composition of a site is commonly used to characterize and evaluate natural features. This method is based on the character of the flora of a given site. Plant species display varying degrees of fidelity to specific habitats, which is expressed by species conservatism. Species conservatism is the degree of fidelity a plant displays to a set of environmental conditions. The quality of a natural area is reflected in the number of conservative species found within a certain habitat (Wilhem and Ladd 1988 *In* Oldham et al. 1995). There are several floristic indices which can be used to describe the character of the vegetation in each of the plots. These include the Coefficient of Wetness (CW), the Coefficient of Conservatism (CC), and the Natural Area Index (NAI). All species (herbaceous, shrubs, and trees) from each plot are considered in these equations.

<u>Coefficient of Wetness</u>

The CW is based on wetland values given to each individual plant species. Values range from -5 to +5, where -5 indicates an obligate wetland species, and +5 indicates an obligate upland species. “0” is assigned to facultative species, those that are just as likely to be found in wetland or upland habitats. The CW values used are based on Oldham et al. (1995). Changes in the average CW value for a plot could indicate changes in the hydrology of that site (becoming wetter or drier). Figure 1 shows the average wetness per plot, based on the wetness coefficients of all species found within a plot. All of the monitoring plots, with the exception of Plot 3 and Plot 5, are located within wetland communities.

Table 3. Significant Vascular Flora Species Recorded

Common Name	Scientific Name	SRANK[1]	Wellington[2]		Year of Observation												Plot
				2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020	
Finely-nerved Sedge	*Carex leptonervia*	S5	R													x	7
Clinton's Wood Fern	*Dryopteris clintoniana*	S4	R		x			x	x						x	x	2
Hay-scented Fern	*Dennstaedtia punctilobula*	S5	R										x				
Marsh Horsetail	*Equisetum palustre*	S5	R	x	x				x								
Meadow Horsetail	*Equisetum pratense*	S5	R	x		x	x	x	x	x		x	x	x	x		
Woodland Horsetail	*Equisetum sylvaticum*	S5	R											x	x		
Rough Avens	*Geum laciniatum*	S4	R		x				x	x				x	x		
Witch Hazel	*Hamamelis virginiana*	S5	R			x		x									
Pale Jewelweed	*Impatiens pallida*	S5	R		x	x			x								
Clearweed	*Pilea pumila*	S5	R			x					x		x	x	x		
Yellow Water-crowfoot	*Ranunculus flabellaris*	S4?	R			x			x								
Bristly Buttercup*	*Ranunculus hispidus* var. *hispidus*	S3				x*											
Smooth Gooseberry	*Ribes hirtellum*	S5	R				x										
Rough-leaved Goldenrod	*Solidago patula*	S5	R		x	x			x	x		x	x			x	7
Mountain Ash	*Sorbus americana*	S5	R					x					x				

*Likely *R. hispidus* var. *caricetorum*, a common species.
[1]MNRF 2021; [2]Dougan & Associates 2009

LEGEND	
SRANK	**Wellington Status**
S3 Vulnerable	R Rare
S4 Apparently Secure	
S5 Secure	
#? Uncertainty about rank	

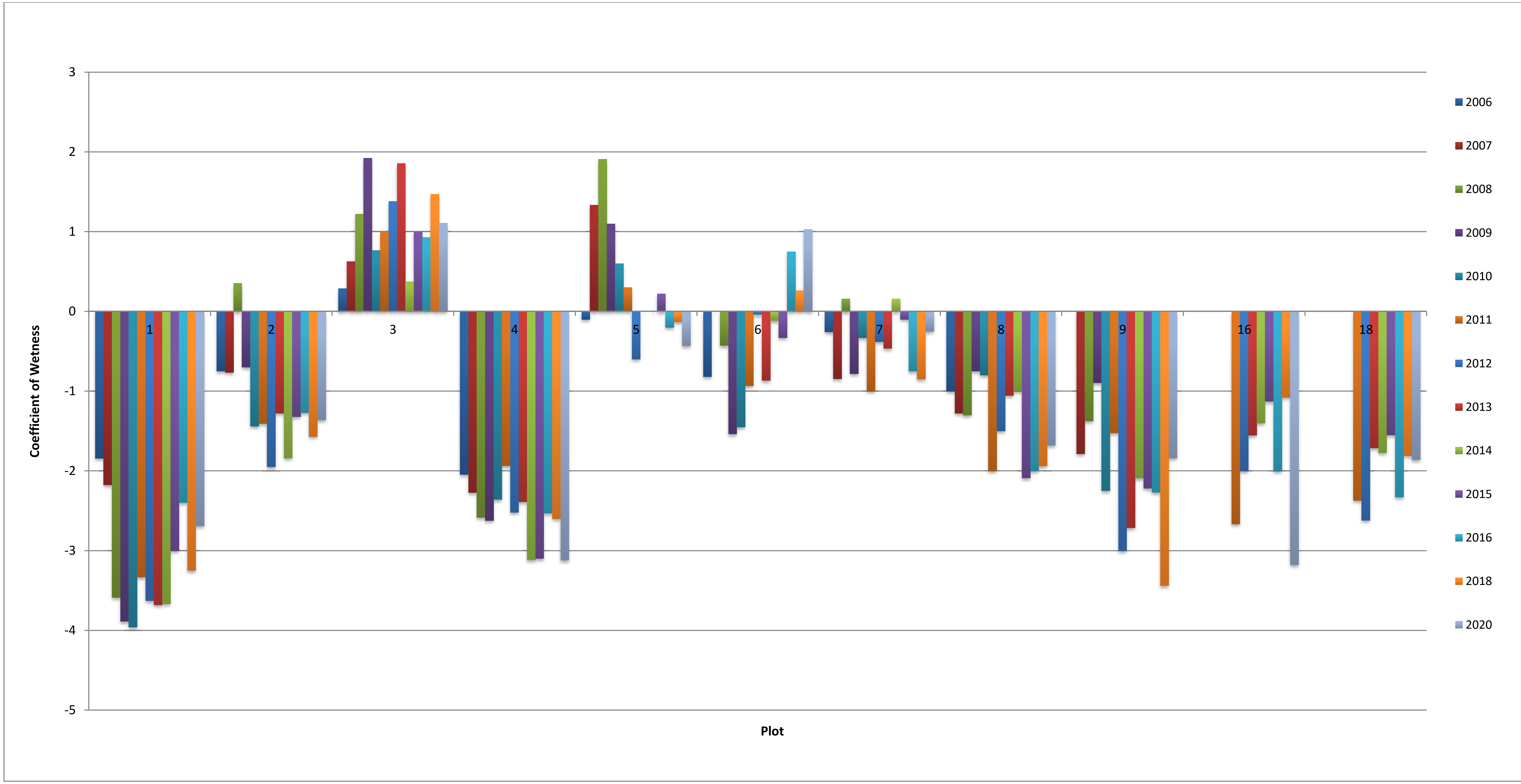

Figure 1. Coefficient of Wetness by Plot 2006 - 2020

A number of plots have shown a trend of decreased average wetness values (i.e., becoming wetter) over the last several years including Plots 2, 4, 5, 8 and 9. Plots 1 and 4 are consistently among the wettest monitoring plots each year, with standing water present in a large proportion of these plots throughout the spring. Many of the herbaceous species with a CW value of -5 have been present over much of the monitoring period in these plots. Those species with a CW value of 0 or higher, often found on the upland hummocks or banks at these plots, tend to be present intermittently and in small numbers.

A trend of drier conditions is most apparent at Plot 6 and Plot 16 where average CW values have steadily increased across monitoring years. In Plot 6 in 2009, the average CW value was -1.54 which had increased to a value of +1.03 in 2020. The transition to more upland species at Plot 6 may be the result of site grading to the east which included a conveyance swale on the east side of the recreational trail berm that directs overland flow toward stormwater ponds. Based on recent field surveys, the upland species diversity is not increasing, so much as the wetter species (which always comprised a small proportion of the cover) are disappearing from the plot. Prior to site development, overland flow would have moved west through Plot 6 during melt and high precipitation events. As this area was previously used for agriculture and is comprised of a mixture of native and non-native species, the transition to drier conditions within Plot 6 does not constitute a negative trend for this early successional habitat.

Plot 16 has demonstrated a shift to drier conditions which previous monitoring reports have attributed to site grading. The average CW value in 2011 was -2.67, which was as high as -1.08 in 2018 before a significant decrease to -3.18 in 2020. Ample precipitation in 2019 and 2020 saw a resurgence of obligate wetland species within the plot as indicated by the spike in Figure 1. A total of 9 species with a CW value of -5 were recorded in 2020 including Water Parsnip (*Sium suave*), False Nettle (*Boehmeria cylindrica*) and newly documented Retrorse Sedge (*Carex retrorsa*). Following several years of dry conditions through the spring, the increase in wetland forbs and graminoids in 2020 suggests that the plants are somewhat tolerant by way of senescence and recruitment from adjacent plants outside of the plot and a persistent seed bank.

Changes in tree and shrub composition and health have not been observed within Plot 16.

Anuran data outlined in Section 3.5 and 3.6 provides further discussion of how conditions in Plot 16 have changed between the pre- and during-construction periods. The plot is within a swamp feature which is physically separate from the core Provincially Significant Wetland (PSW) but considered part of the Hanlon Swamp Wetland Complex (Map 3).

The analysis of groundwater levels at Plot 16 in recent years indicates that the water table is generally below the plot elevation and the larger wetland feature (Banks Groundwater Engineering Limited 2021). The previous monitoring report noted that standing water would be documented during the anuran call surveys. In 2020 it was noted that standing water was patchy but with depths of up to 20cm in April, slightly decreased by May and no standing water but with saturated peat soil by June. In 2016, it was suggested that altered surface water inputs may be contributing to the changes in herbaceous vegetation within this plot. The site drainage has been designed to direct all surface water flow from the adjacent developable land and new Hanlon Creek Boulevard into the conveyance swales that then flow into the SWM ponds. This in turn has reduced the amount of surface water entering the wetland feature where Plot 16 is located. While groundwater levels have remained relatively steady, the surface water inputs have likely decreased and led to drier conditions overall. Although 2020 water levels and herbaceous vegetation represent a return to pre-construction hydroperiod, we expect that the long-term drying trend will continue unless adjustments are made to the stormwater drainage surrounding the Plot 16 feature. The wetland tree and shrub cover will likely persist based on seasonal pooling of water and the water table elevation. The herbaceous cover may succumb to drought stress with a long-term shift toward higher CW value species and a permanent reduction in obligate wetland species.

The remaining plots show annual fluctuation in average CW values that do not suggest a notable shift toward wetter or drier conditions. Those plots that are located within the core of the natural feature, or are comprised of relatively few species all of which are tolerant of fluctuation, show resilience to changes in hydrology which may or may not be associated with the development.

<u>Coefficient of Conservatism</u>

The CC is also based on Oldham et al. (1995). Each species is given a rank between 0 and 10, based on its degree of fidelity to a range of synecological parameters (Oldham et al. 1995). Synecology is the study of the structure, development, and distribution of ecological communities. Species ranked between 0 and 3 are found in a variety of plant communities, including disturbed sites. Species ranked between 4 and 6 are those associated with a specific plant community, but which can tolerate moderate disturbance. Species ranked from 7 to 8 are found in plant communities in an advanced stage of succession and tolerant of minor disturbance. Plants with a rank of 9 or 10 have high degrees of fidelity to a narrow range of synecological factors.

The average CC per plot is shown on Figure 2. Plots 1, 2, 3, 4, 5, 7 and 8 have all shown a steady average CC value over the course of monitoring. All of these plots are located within the core natural feature and are generally not subject to edge effects which can often mean the presence or introduction of non-native or low-CC value species as a result of edge disturbance.

The highest average CC value in 2018 and 2020 was found in Plot 7 (4.97 and 4.87, respectively). This plot is located at the transition between Fresh-Moist Sugar Maple Deciduous Forest and White Cedar-Hardwood Mineral Mixed Swamp habitats and is bisected by a watercourse (Map 3). The diversity of microhabitat within this plot facilitates a high diversity of plant species. The invasive shrubs Common Buckthorn (*Rhamnus cathartica*) and Glossy Buckthorn (*R. frangula*) have long been present as seedlings which have not grown to mature seed-producing shrubs as a result of the closed canopy and limited sunlight availability.

The lowest average CC value occurred in Plot 6 (1.81 in 2020) which is consistently among the lowest CC values. As discussed with coefficient of wetness values, the plot appears to be undergoing a reduction in the few moderately conservative wetland species as the site becomes drier; in turn the average CC is also decreasing as non-native cool season grasses and low CC value species such as Canada Goldenrod (*Solidago canadensis*) become more dominant. As a plot in a stage of early succession, the fluctuation in composition is expected and it is likely that conservative species will colonize the plot in time once canopy begins to form.

Plot 5 has been discussed in previous monitoring reports as being subject to large fluctuations on account of the few species present within the plot where a White Cedar canopy limits herbaceous species cover.

Both Plot 16 and, to some degree, Plot 18 appear to be exhibiting a gradual resurgence in average CC values since low values were recorded in 2015. With the alterations to surface hydrology considered, we suspect that sufficient precipitation has facilitated a flush of seed bank germination for conservative species in these plots. It is possible that initial impacts of the conveyance swale construction, coupled with dry spring conditions, led to a brief reduction in conservative species as stressors were too great for a period of several years. The presence of single high-CC value species such as Tufted Loosestrife (*Lysimachia thyrsifolia*), CC 7, in 2020, has a notable effect on the average value for the plot. This species was limited to a several stems within the plot in 2020 and occurred in sparse patches around the perimeter of the feature, roughly correlating with the limit of standing water during the spring.

The overall trend between 2006 to 2020 is that average CC values have remained relatively steady for most plots with Plot 5 and Plot 6 apparently decreasing and Plot 16 and Plot 18 apparently increasing.

<u>Natural Area Index</u>

The NAI, or floristic quality index, allows the objective comparison of 2 or more natural areas or vegetation types (Oldham et al. 1995). The NAI is calculated by multiplying the average CC value by the square root of the total number of *native* species. Whereas the abundance and frequency of species can fluctuate greatly by season and year, the NAI is more stable and offers a more accurate picture of the quality of a plot. The NAI for each plot is shown on Figure 3.

The Ministry of Natural Resources and Forestry (MNRF) reports that natural areas with NAI values of over 35 are considered significant at the provincial level (Wilhelm and Ladd 1988 *in* Oldham et. al 1995). For comparison, an old successional field may score as low as <5 (Andreas et al. 2002). Although Plot 7 has regularly exhibited an NAI value above 30, none of the plots within the HCBP have scored a value of 35 or higher. Analysis of the NAI values for a given plot over the course of monitoring gives an indication of whether or not the quality of the habitat is being maintained. Plot 1, Plot 4 and Plot 8 have all shown recent increases in NAI value. These plots are all located within the core natural feature which aside from the decline in Ash (*Fraxinus* spp.) canopy and a subsequent increase in non-native shrubs, is not showing negative effects resulting from the development.

It is notable that Plot 16 and Plot 18 have shown a rebound in NAI values. There is potential that a shift away from wetland conditions as substrates become drier could result in decreases in NAI. These plots have maintained their NAI value as conservative upland or wetland fringe species colonized areas that had been wetter in past years. The exclusion of non-native species, and the re-establishment of wetter conservative species, when conditions allow, demonstrates the resiliency of these communities.

The widespread establishment of non-native species has the potential to structurally alter vegetation communities and can result in native vegetation being outcompeted and failing to regenerate. This trend would be apparent in decreasing NAI values for a given plot. At this time, NAI values for all plots vary within reason and the data set does not indicate a major shift in the quality of habitats on account of the development.

3.1.3 Non-Native Vegetation Species

In total, 27 non-native species were recorded within vegetation plots in 2020 (18% of the 152 species documented). The number of non-native species found in each plot is compared on Figure 4. In general, non-native species have been present in all plots over the course of monitoring, with the exception of Plot 5 which periodically contains 1 or 2 invasive species but in very low numbers and not present every year.

Plot 6 remains dominated by non-native species which include Coltsfoot (*Tussilago farfara*), Smooth Brome (*Bromus inermis*), Tall Fescue (*Festuca arundinacea*), Orchard Grass (*Dactylis glomerata*) and Bird's-foot Trefoil (*Lotus corniculatus*), all of which are abundant and widespread throughout the plot. The reduction in native wetland species has allowed these non-native species to increase, but other aggressive native species such as Canada Goldenrod have also increased.

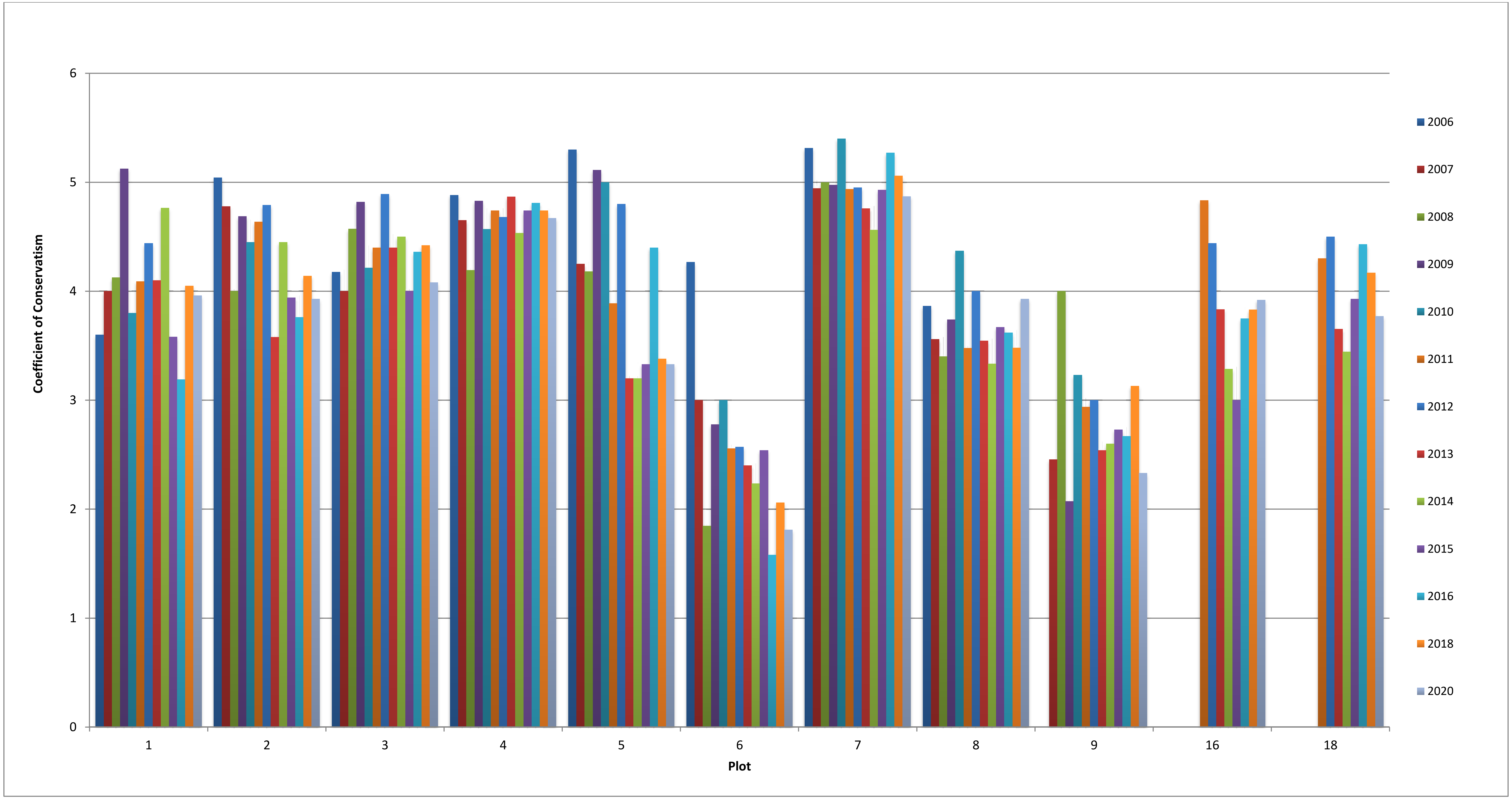

Figure 2. Coefficient of Conservatism by Plot 2006 - 2020

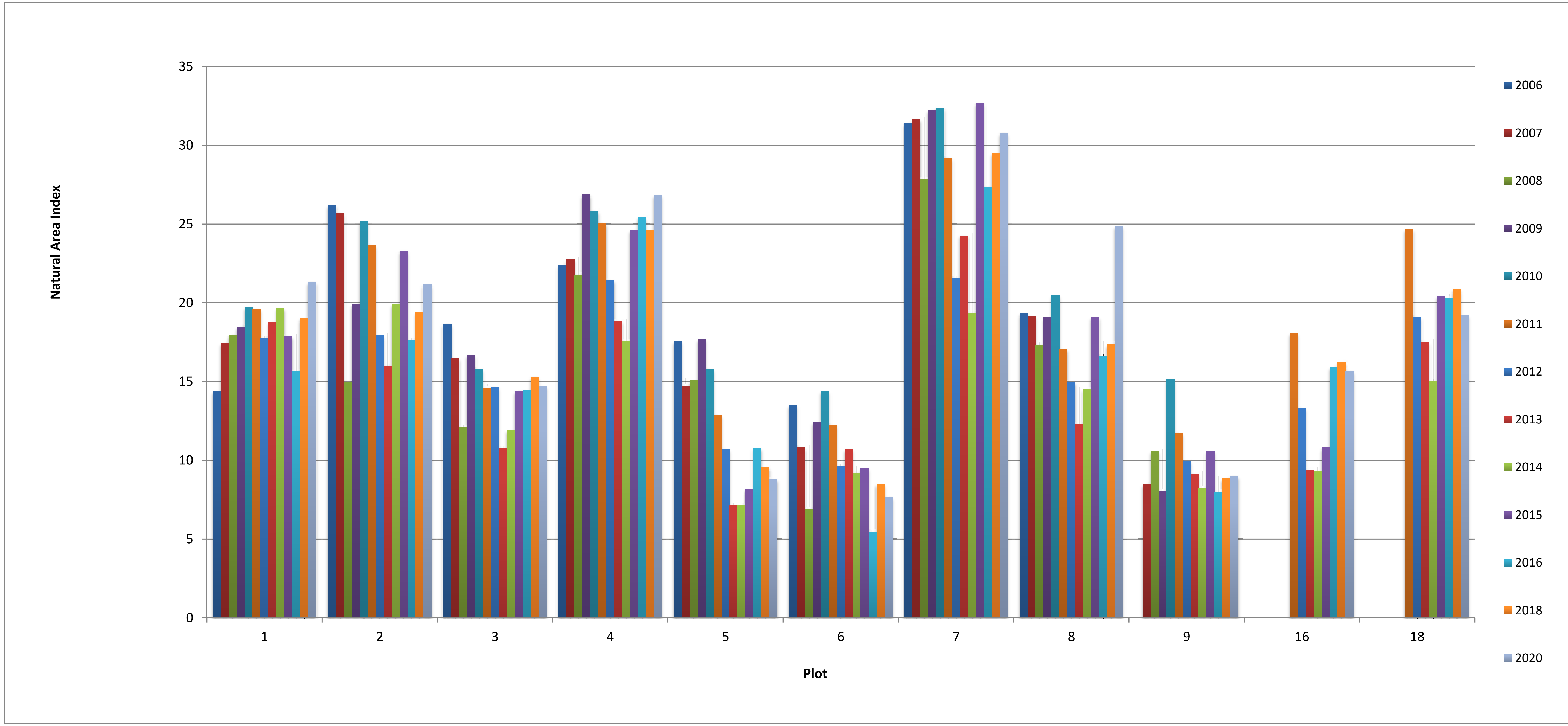

Figure 3. Natural Area Index by Plot 2006 - 2020

Glossy Buckthorn and Common Buckthorn remain widespread with many plots containing first year seedlings and mature, fruit-producing shrubs present along the edges of natural features. These species are widespread throughout southern Ontario and are often found on calcium-rich soils and occur in a range of soil moisture and sunlight conditions (Anderson 2012). The prevalence of these species is not a result of the development and the maturing native species buffer plantings will help to compete with the Buckthorn in time. The control of Buckthorn or any other woody invasive species is not recommended for the site due to the current extent of plants, feasibility and long-term cost and commitment to properly manage these species. The removal of saplings within the core feature could be undertaken, but the presence of Buckthorn is not attributed to the development and the effort required for minimal long-term gains does not make this exercise worthwhile. The disturbance of soil from pulling Buckthorn can also facilitate germination of new seedlings.

To the east of Plot 6, a small stand of Common Reed (*Phragmites australis* ssp. *australis*) was noted in 2016 and remains present having spread slightly over the intervening years. Additionally, several small stands were noted at the fringe of SWM Pond 4 in 2018 and 2020. This aggressive non-native species has the potential to spread into adjacent wetlands and meadows and create monocultures which compromise native species diversity. The stand near Plot 6 is approximately 10m x 10m in size and is located in the ditch on the north side of an access gate leading toward the plot. The stands within SWM Pond 4 are at several locations along the perimeter of the pond. To date, the Business Park, including the SWM features and roadside ditches, has remained free of this species. This item has been brought to the attention of City staff.

It is imperative that these populations of Common Reed be managed and removed as soon as possible if effective eradication is to occur. Given that the species occurs in a recently engineered ditch feature and SWM pond associated with the development, the introduction of this species is likely a result of recent grading activities during the construction of Phase 1 and Phase 2. Control of this species will require repeated herbicide application by a licensed professional. It is recommended that a full site inspection be conducted to document all stands of Common Reed, with particular attention on SWM ponds. Monitoring of the effectiveness of management efforts should also be continued annually until the species is no longer present. The full removal of all live rootstock is required or the species will re-establish and continue to spread. Any grading that will occur for new developments should ensure that equipment arrives to the site clean and the movement of topsoil and plant material on site is kept to a minimum where feasible.

Garlic Mustard (*Alliaria petiolata*) was only recorded in Plot 18 during the 2011 monitoring year. This invasive species is very common in southern Ontario and it is rare to find upland wooded areas that do not contain this plant. It is noted that this species has been observed within the subject property, but for the most part has not established in high numbers within the natural features, many of which are swamp or marsh which would not support widespread populations of the species. Most of the non-native species present within the monitoring plots are common agricultural weeds or shrubs which produce prolific amounts of berries that are distributed by deer, birds and other wildlife.

Certain non-native species are considered particularly invasive, and are given a score of '-3' on a weediness scale ranging from '-1' to '-3'. The invasive species found within the HCBP vegetation monitoring plots include 6 shrub species (4 species with a weediness value of -3) and 16 herbaceous species. In general, those species with weediness values of -2 or -3 tend to be present year after year, while less invasive species with a value of -1 are present intermittently and often in low numbers.

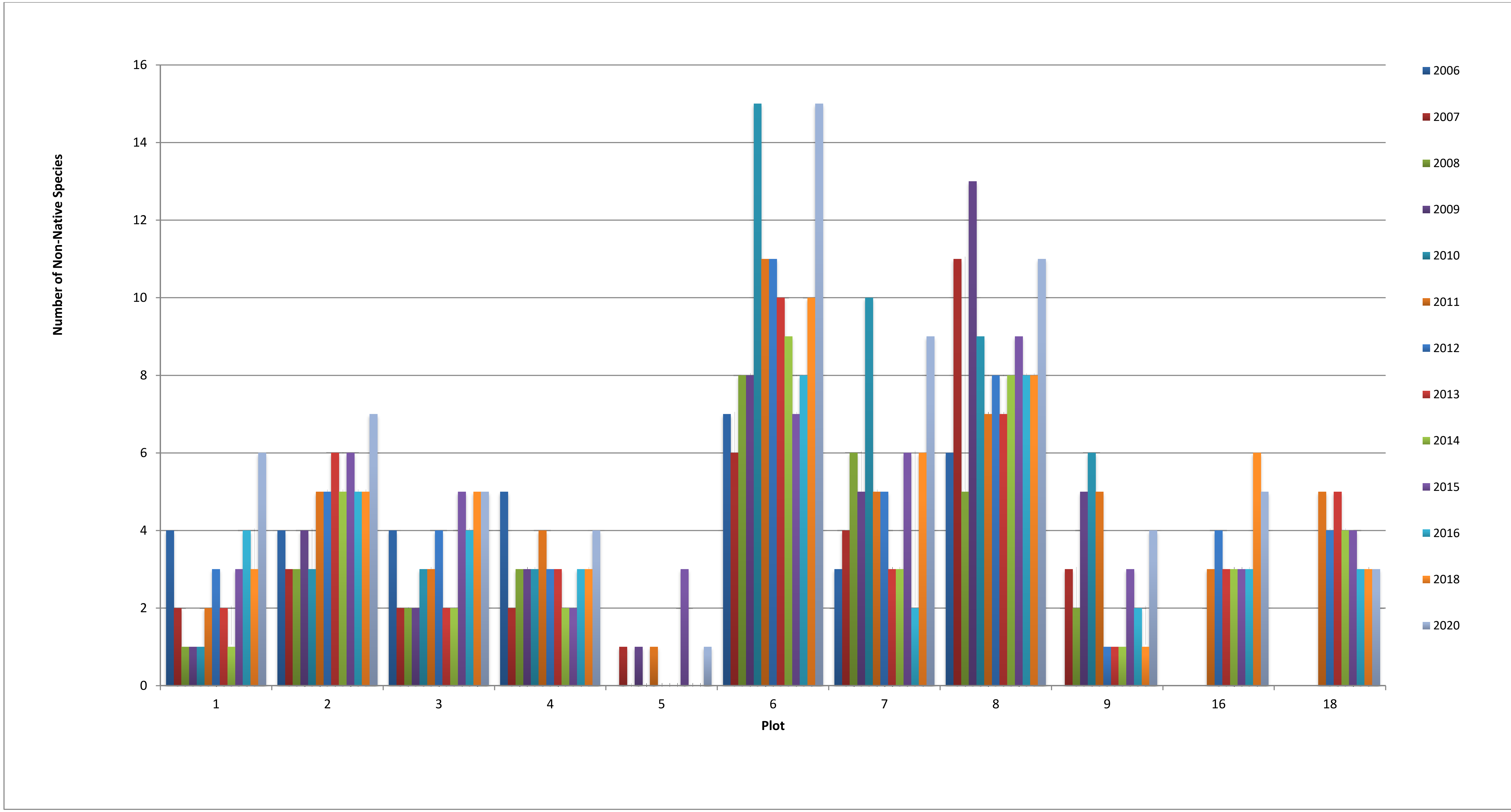

Figure 4. Non-Native Species by Plot 2006 - 2020

3.1.4 Herbaceous Inventory

Appendix I summarizes all species observed during the plot-based monitoring in the subject property from 2006 – 2020, while Appendix II summarizes the herbaceous species observed within each monitoring plot in 2020. During vegetation surveys some species were only identified to genus as the identifying traits of the plant may not have been apparent at the time of the survey. These have included Avens species (*Geum* spp.), Sedge species (*Carex* spp.), Willow Herb species (*Epilobium* spp.) and unidentifiable grass species.

Appendix III compares the herbaceous species recorded in each subplot between 2006 and 2020. Although the same subplot is monitored each year, a slight shift in the location of the subplot from one year to the next, can result in the inclusion or exclusion of species near the edges of the quadrat.

3.1.5 Shrub Inventory

The number of shrub species found within each monitoring plot and their approximate percent cover was recorded. In 2020, 27 shrub species were recorded; all of which had been documented from monitoring plots in past years. To date there has been little change in shrub diversity and cover across all monitoring plots. With the exception of Plot 2 and Plot 18, the majority of plots contain a similar number of shrub species each year and with little change in their distribution and abundance from one year to the next. In Plot 2 and Plot 18, the decline of Ash had resulted in an increase in European Buckthorn seedling growth, but the in-filling of canopy from other tree species will partially suppress the flush of invasive shrubs. Refer to Appendix IV for shrub species recorded within each monitoring plot in 2020 and Appendix V for a comparison between all years.

3.1.6 Tree Inventory

Following the 2014 monitoring, the scope of tree inventory work was reduced to collect only canopy cover data. Any decline in canopy cover could result in increases in invasive non-native species or shifts in the diversity and structure of herbaceous species within a plot. The canopy at Plot 8 was found to be 75% which shows steady increase from the tree clearing that occurred as part of the construction of the Hanlon Creek

Boulevard. The canopy had been approximately 90% prior to 2009 and is slowly returning as tree and shrub growth fills in on both sides of the creek which bisects the plot. Restoration plantings which were installed in the riparian area between the plot and the bridge have yet to form canopy but are all in healthy condition and will contribute to canopy cover in an estimated 10-20 years. An assessment of tree canopy change is outlined in further detail in Section 3.2.3.

Emerald Ash Borer (*Agrilus planipennis*) (EAB) has been present within the site for a number of years and contributed to the decline of Ash, in particular within Plot 2 and Plot 18. While many of these trees are now dead, the canopy cover from adjacent White Cedar (*Thuja occidentalis*), Red Maple (*Acer rubrum*) and Yellow Birch (*Betula alleghaniensis*) has filled in gaps that had been created as the Ash declined. The increase in canopy will suppress the growth of Buckthorn shrubs which had accelerated during the temporary increase in available sunlight. The buffer plantings which were installed at the periphery of the natural features are a benefit to the site as they provide diversity in tree species which makes the feature more resilient to single-species diseases and declines.

3.2 Vegetation Threshold Assessment

The thresholds for vegetation and soils established in the *HCBP Consolidated Monitoring Program* (NRSI 2010) are as follows:

- A change in herbaceous cover by more than 25%.
- A change in species diversity by more than 25%.
- A change in canopy cover by more than 25%.

3.2.1 Herbaceous Cover

The average herbaceous cover per year and plot is shown on Figure 5. The herbaceous cover fluctuates annually, with large fluctuations observed even in the pre-construction monitoring years (2006 - 2009). Herbaceous cover by plot in 2020 was generally consistent with the overall average among monitoring years. Figure 6 represents the change in herbaceous cover from 2010 to 2020 in comparison to the preconstruction year average (2006 - 2009). A range bar on the preconstruction average column on Figure 6 shows an increase and decrease of 25% herbaceous cover.

An increase in herbaceous cover can be ecologically positive, as it means greater plant matter for foraging and refuge for wildlife, as well as a generally well-being of the plant species. An increase can be negative if the increase is due to an introduction or expansion of a non-native and/or invasive species. A decrease in herbaceous cover is generally negative as it means removal of soil protection, forage and refuge material, as well as a potential decrease in biodiversity. A decrease in herbaceous cover can be due to direct vegetation removal, annual fluctuation in climatic conditions, trampling, erosion, flooding, or the effects of sun (sun scald) or salt, among other reasons.

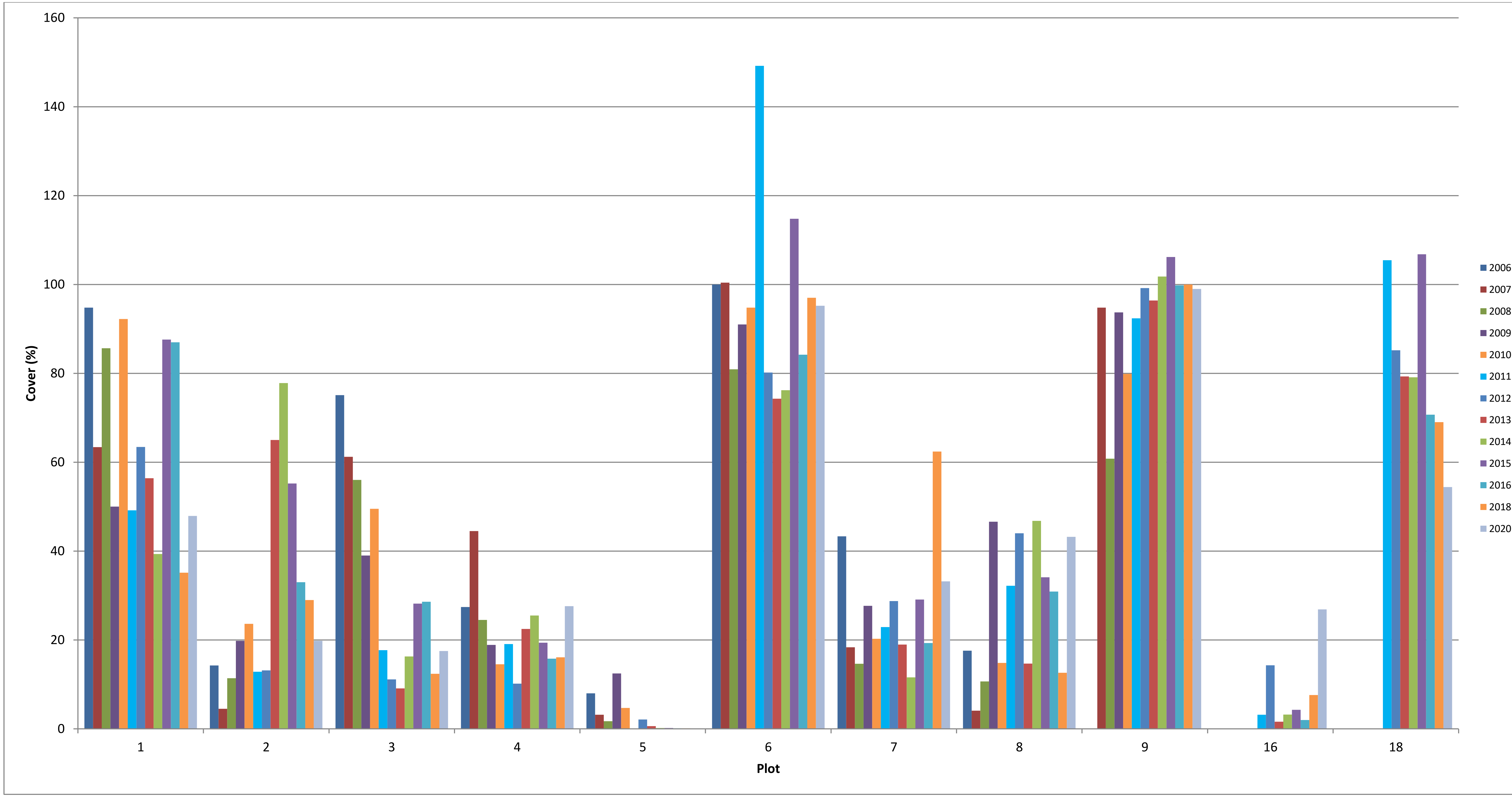

Figure 5. Change in Herbaceous Cover from 2006 to 2020

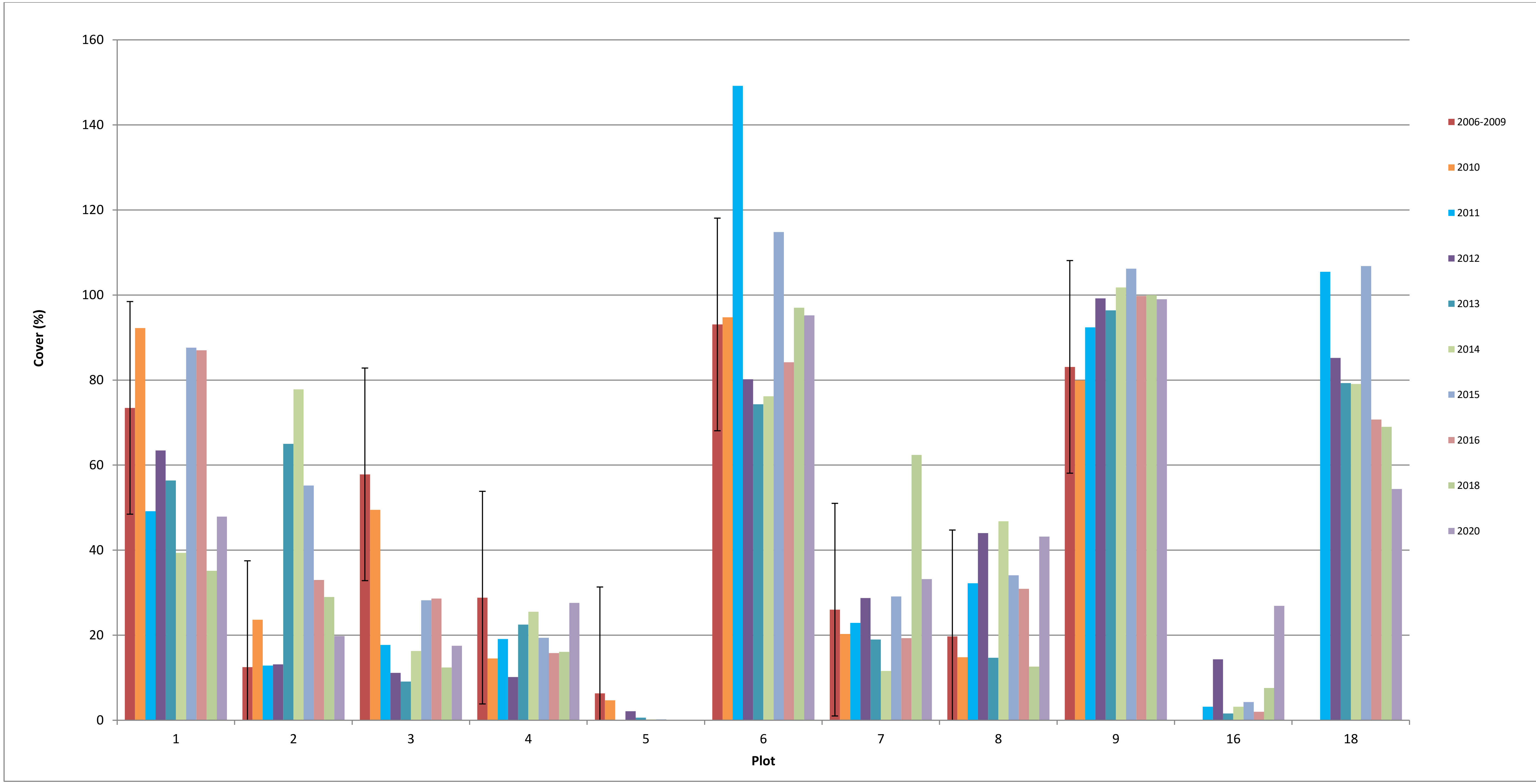

Figure 6. Change in Herbaceous Cover Pre- and During Construction

(The range bar shows a 25% increase and decrease in herbaceous cover)

In 2020, Plot 1 showed an increase in cover from 2018 (from 35.1% to 47.9%) which constitutes a return to the low end of the threshold. Across all monitoring years changes in cover ranging from 30-40% are not uncommon and are largely a reflection of the hydroperiod within the plot. The plot is situated within a swamp thicket which contained 15-20cm of standing water during the July 2020 surveys. In other years, the plot has shown higher herbaceous species cover on saturated detritus (with minimal to no water present). The changes in cover correlate strongly with the depth of water present within the plot from one year to the next.

Plot 3 showed 2 monitoring years of improved cover with 28.2% in 2015 and 28.6% in 2016 as a result of a flush of Ostrich Fern (*Matteuccia struthiopteris*) returning to the plot. In 2018 the cover decreased to 12.4% and increased slightly in 2020 to 17.5%. We suspect that browse by White-tailed Deer (*Odocoileus virginianus*) continues to influence herbaceous cover within the plot. Where many Sugar Maple (*Acer saccharum*) dominated forests should have layers of saplings, seedlings and young trees beneath the canopy, Plot 3 has limited woody species in the lower strata of the forest. This supports the assumption that deer browse is very high within this area.

3.2.2 Vegetation Species Diversity

Species diversity is the number of species observed within each monitoring plot. Figure 7 compares vegetation species diversity per plot for each year since 2006. Figure 8 shows the vegetation diversity during the construction period (2010 to 2020) compared to the pre-construction average (2006 – 2009). All species recorded in each plot are included in this data, which includes herbaceous species recorded within the overall 10m x 10m plot. In 2020, Plot 7 had the highest diversity at 40 species. This plot contains hummocky swamp and a watercourse which provides a variety of micro habitats for upland and wetland species in close proximity.

Positive exceedances or increases within the threshold were observed in most plots in 2020. Plot 5 remained below the threshold for species diversity in 2020. As discussed in previous years, Plot 5 is situated within a very low-diversity conifer stand which limits groundcover within the plot to several species each year. As a result, the low diversity observed in 2020 is not a concern for this plot.

Overall, variation in species diversity can likely be attributed to a number of factors including changes in canopy cover or soil moisture which may encourage or discourage sensitive species and periodic establishment of small numbers of a given species which do not persist within the plot in subsequent years. Additionally, the current approach of taking a compass bearing of 0°, 45° and 90° to determine corner locations based on the permanent t-bar stake may lead to the inclusion and exclusion of certain species located at the fringe of each plot.

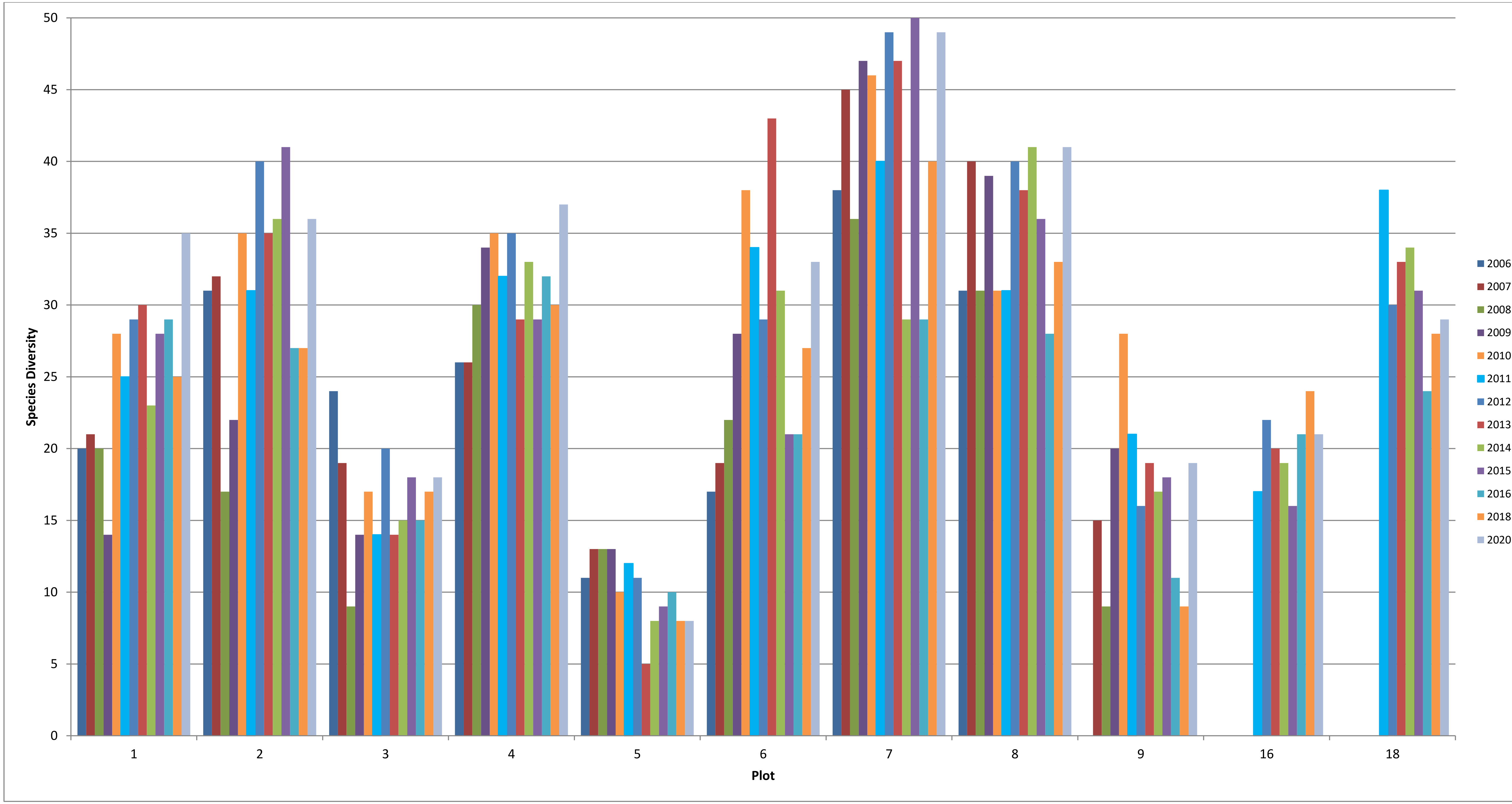

Figure 7. Change in Vegetation Diversity from 2006 to 2020

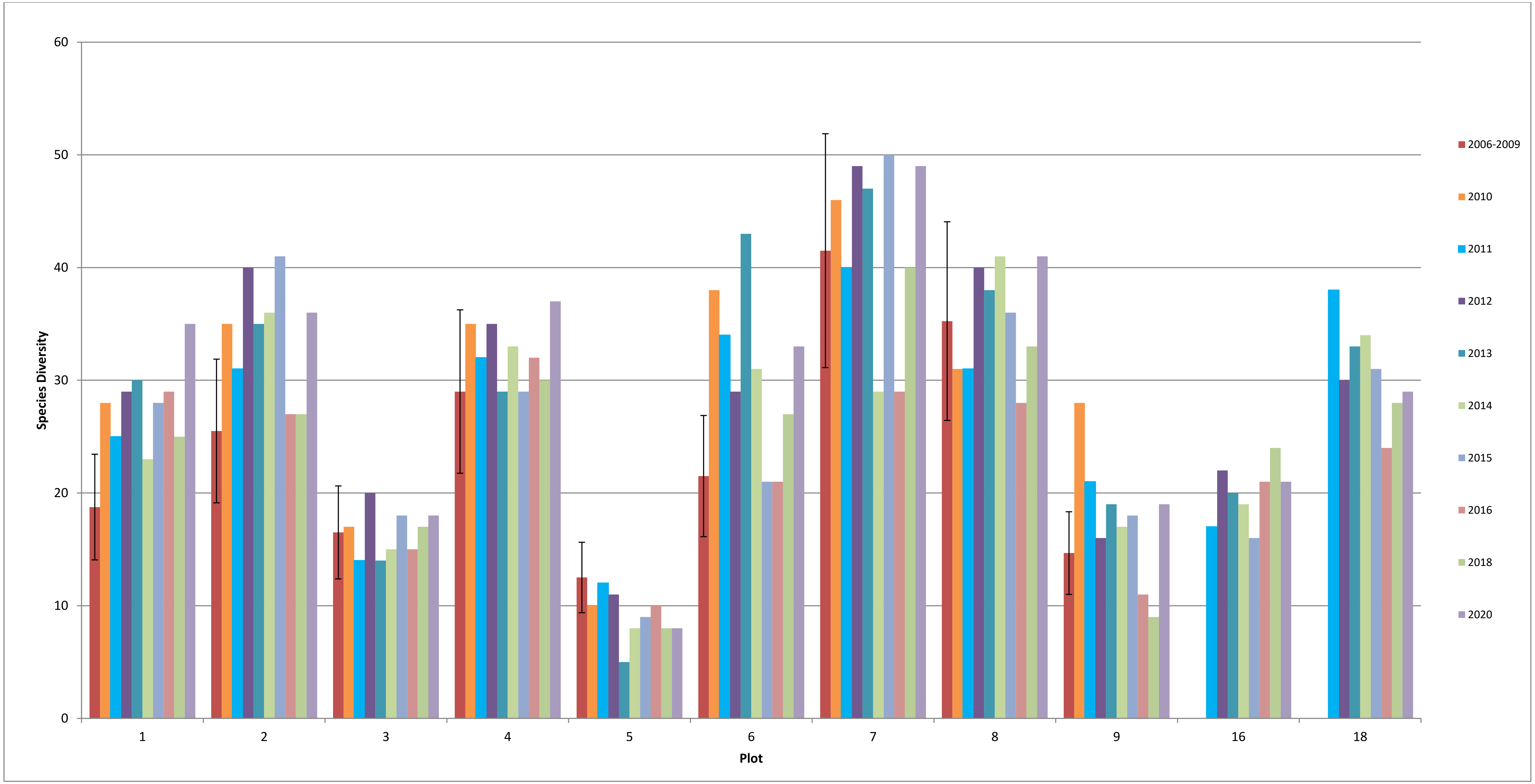

Figure 8. Change in Vegetation Diversity Pre- and During Construction

(The preconstruction average column shows a 25% range bar)

3.2.3 Canopy Cover

The canopy cover per plot is shown on Figure 9. Plots 1, 6, and 9 have no trees and therefore canopy cover is 0%. With the exception of tree removal which occurred to the south of Plot 8 and the decline of Ash trees due to EAB in Plots 2 and 18, the canopy cover in most plots has remained relatively steady. Tree blow downs have also occurred in the vicinity of some plots as a result of wind storms and the soft mucky substrates limiting tree root support.

Figure 10 compares the canopy cover during the construction period (2010 to 2020) to the pre-construction average (2006 – 2009). A range bar shows a 25% increase and decrease from the average in canopy cover for each plot on the pre-construction column. All plots are within the threshold range at this time.

3.2.4 Vegetation Threshold Summary and Contingency Measures

The HCBP Consolidated Monitoring Program (NRSI 2010, p. 37) suggests the following measures when there is a change in vegetation or a shift in species composition beyond the established threshold:

- *“Initiate restoration efforts to enhance number of native wetland/woodland species.*
- *Provide educational material to neighbouring properties outlining importance of natural features and their protection.*
- *Provide additional signage regarding trail closures, etc.*
- *Refer to Section 6.1 Groundwater for the contingency measures associated with groundwater thresholds.”*

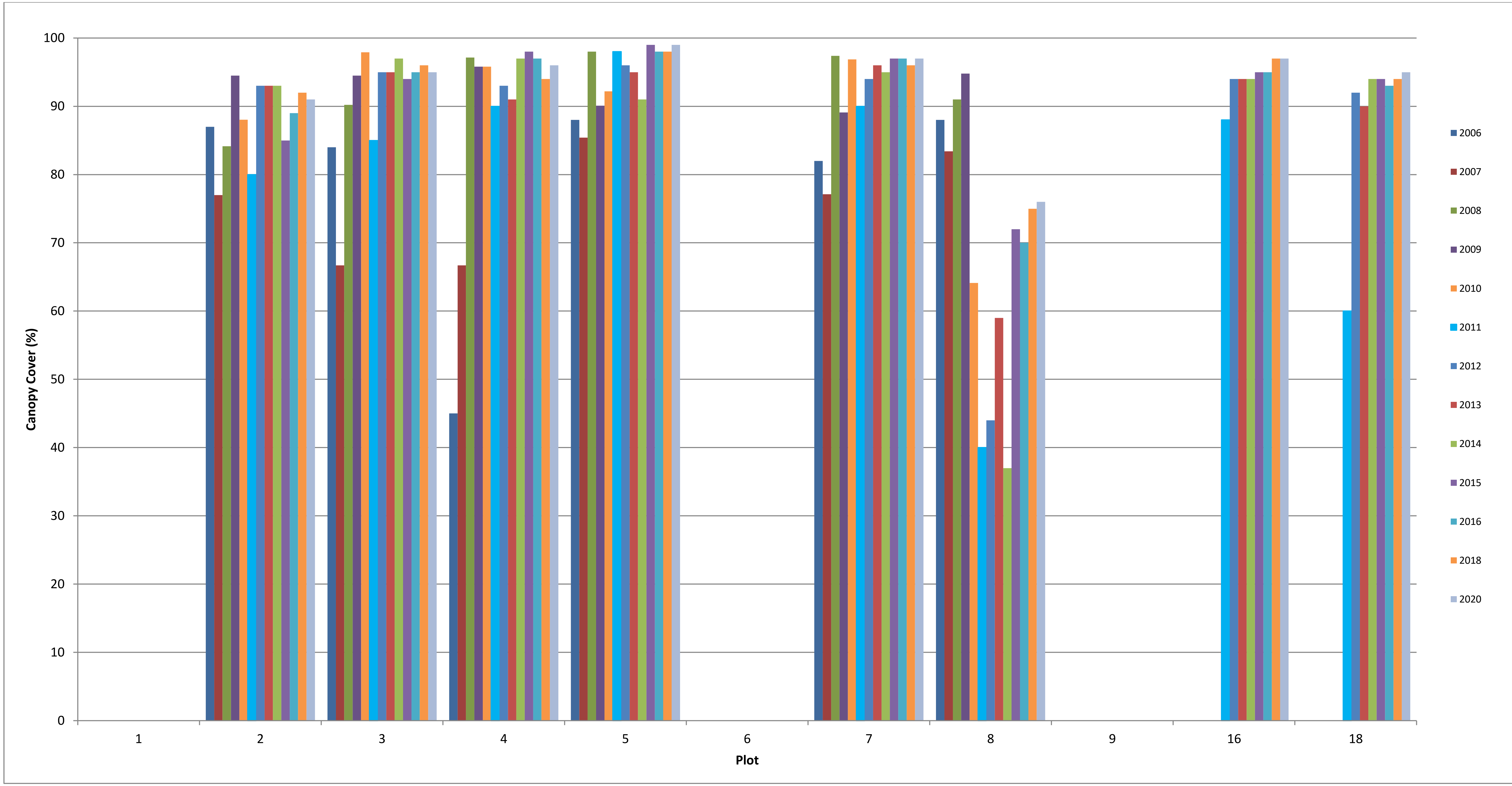

Figure 9. Change in Canopy Cover from 2006 to 2020

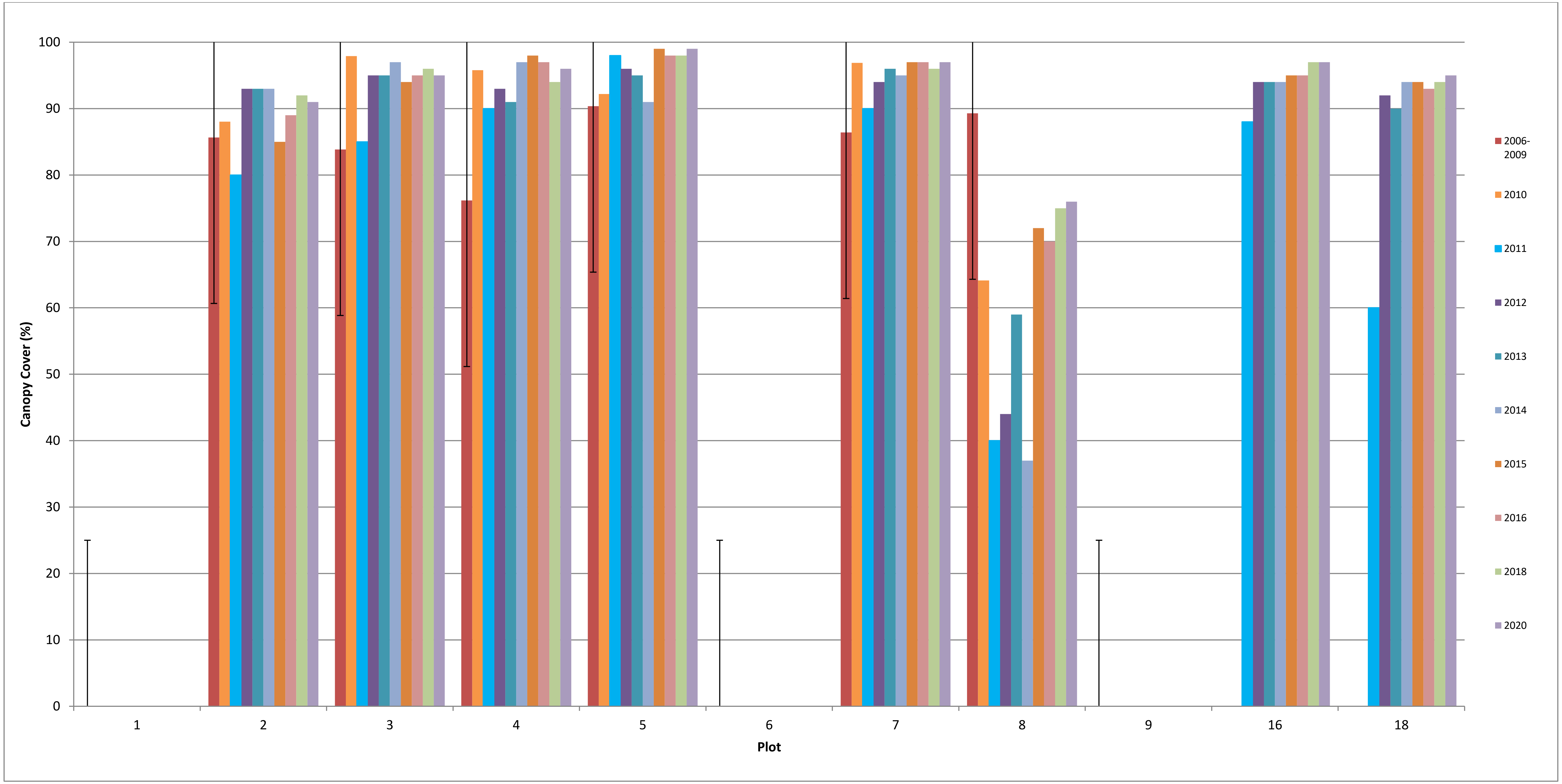

Figure 10. Change in Canopy Cover Pre- and During Construction

(The range bar shows a 25% increase and decrease in canopy cover)

In 2020 the negative threshold exceedances for herbaceous cover at Plot 1 and Plot 3 (similar to 2018) and for species diversity at Plot 5 (similar to 2018) are generally attributed to natural fluctuation in seasonal standing water, the sustained impacts of deer browse and data fluctuation on account of very low species diversity, respectively.

It is not recommended that any of the above-mentioned contingency measures be carried out at this time. It is recommended that monitoring of vegetation and groundwater continue at these plots in order to better understand the influence that groundwater may have on the wetlands.

The aggressive invasive species Common Reed was identified east of Plot 6 and at the fringe of SWM Pond 4 in 2016 and remains present. It is recommended that these stands be eradicated as soon as possible and periodic monitoring for reoccurrence considered. Having been detected early in their establishment, it is most practical and cost effective to manage these stands at this time.

3.3 Breeding Bird Surveys

In total, 57 species of birds were observed during the breeding bird monitoring that was conducted in 2020 (Appendix VI). A summary of highest breeding bird evidence by species across all monitoring years is provided in Appendix VII. Table 5 summarizes the number of birds observed during breeding bird point count surveys under each breeding evidence code.

The 10 most abundant species observed during 2020 surveys are comprised of the same 10 species observed in 2018 and many of the previous years. The most abundant species during the breeding bird point counts in 2020 were Red-winged Blackbird (*Agelaius phoeniceus*) 11%, American Goldfinch (*Spinus tristis*) and Song Sparrow (*Melospiza melodia*) 8% respectively and European Starling (*Sturnus vulgaris*) 6%. These species are consistently the most abundant within the point counts largely due to the presence of suitable habitat and the large populations of these species within southern Ontario. Figure 11 represents the 12 most abundant species observed in 2020, with all other birds observed less frequently compiled as ‘Other Bird Species’.

Table 4. Breeding Bird Evidence

Breeding Evidence	Number of Species												
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**
Possible	30	12	20	21	20	21	25	21	15	19	23	18	24
Probable	11	15	14	20	18	22	21	24	23	25	19	20	21
Confirmed	0	11	2	4	2	2	4	3	2	3	6	5	7
None*	0	8	4	0	5	2	1	2	2	3	4	5	5
TOTAL	**41**	**46**	**40**	**45**	**46**	**47**	**51**	**50**	**42**	**49**	**55**	**48**	**57**

*Species observed with no breeding evidence (i.e., flying overhead)

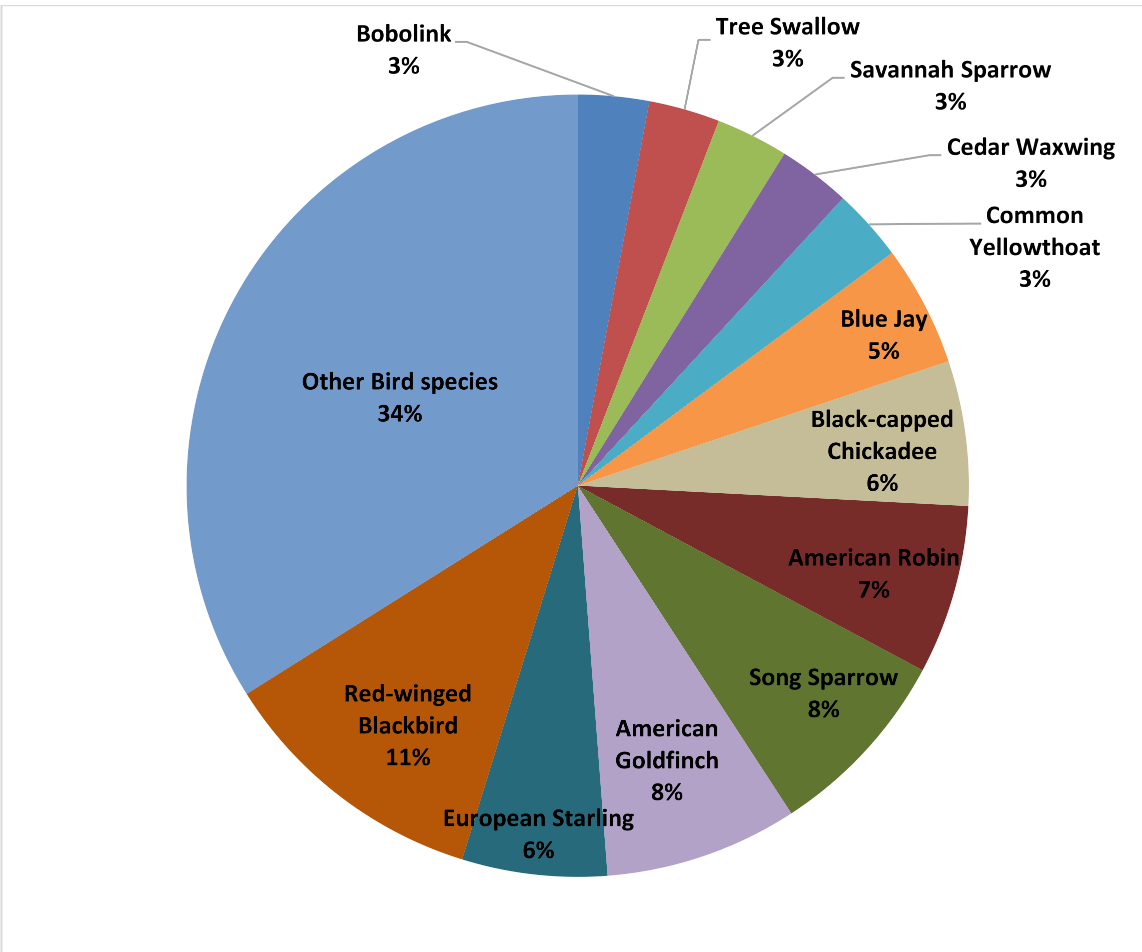

Figure 11. Most Abundant Bird Species Observed in 2020

3.3.1 Breeding Bird Species Diversity

Species diversity continues to be highest in Plot 1 where 25 species were recorded in 2020. A total of 23 species had been recorded in 2018 as well as in 2013. Plot 6 and

Plot 11 also had greater than 20 species during the 2020 monitoring (22 species and 21 species respectively). Plot 1 consistently records higher species diversity than most of the other monitoring stations as a result of the combination of adjacent habitats (forest, meadow, wetland). The unobstructed sight lines to the west and south of the plot allow surveyors to document birds within a large area of the old field meadow as well as fly-by individuals. It is expected that diversity for Plot 1 (as well as Plot 9 and Plot 20) will decrease once the Phase 3 lands are graded and development commences. Figure 12 indicates the species diversity of breeding birds at each plot since monitoring began in 2006.

The lowest bird diversity documented in 2020 was within Plot 5 and Plot 7 (11 species and 12 species respectively). Both plots exhibit relatively low diversity in most years and the 2020 data reflects the average diversity over the duration of monitoring conducted to date. Both plots are located in the core of the natural feature in areas with moderate to dense conifer cover which limits bird diversity to forest-dwelling species.

Across all of the breeding bird monitoring plots, 2020 data indicates that diversity remains stable or has increased in comparison to the overall plot average values. With the exception of Plot 7, where the 12 species observed in 2020 reflects the long-term average, all other plots are above the long-term average. In 2020, 5 plots showed diversity increases of 6-8 species above the long-term average.

Blue-headed Vireo (*Vireo solitarius*) was documented from the site for the first time in 2020. An individual was singing at Plot 5, Plot 7 and Plot 16. Although Plot 5 and Plot 7 regularly show the lowest diversity, the presence of this species indicates that the habitat quality remains high and unaffected by the development to the north. This species inhabits conifer stands with dense canopy that can include Balsam Fir (*Abies balsamea*), White Pine (*Pinus strobus*) and Hemlock (*Tsuga canadensis*) or mixed forest that also includes Birch (*Betula* spp.) and Maple (*Acer* spp.) (Morton & James 2020). The stand composition at Plot 5 and Plot 7 is ideal for Blue-headed Vireo with all of the aforementioned tree species present. The use of the core area of mixed forest and mixed swamp within Phase 1 suggests that the habitat composition and structure are of high quality and development has not negatively impacted the core habitat.

Sharp-shinned Hawk (*Accipiter striatus*) was documented for the first time in 2020; an individual was present in the vicinity of Plot 11 in the southeast of the site where meadow habitat adjacent to the treed feature provides good foraging habitat. Black-billed Cuckoo (*Coccyzus erythropthalmus*) had been documented from the site in 2009 and 2014, but showed confirmed breeding evidence for the first time in 2020. On July 3, an individual was observed carrying food in suitable breeding habitat in the vicinity of Plot 19.

Under current build-out, 7 of the breeding bird monitoring plots are adjacent to active development or occupied buildings within Phase 1 and Phase 2. Those habitats within clear view of development, such as Plot 6, Plot 16 or Plot 11 have all seen progressive increases in bird species diversity. The data set indicates that a core group of common species remain present year after year, with species indicative of higher quality habitats present intermittently between pre-, during and post-construction settings. The continued presence of species such as American Redstart (*Setophaga ruticilla*), Common Yellowthroat (*Geothlypis trichas*), Savannah Sparrow (*Passerculus sandwichensis*), Willow Flycatcher (*Empidonax traillii*), Red-eyed Vireo (*Vireo olivaceus*), Warbling Vireo (*Vireo gilvus*) and Eastern Wood-pewee (*Contopus virens*) is a good indicator that habitats next to development remain functional to support a diversity of bids.

The old field meadow that contains Plot 20 continues to support a diversity of open country bird species including Eastern Meadowlark (*Sturnella magna*), Bobolink (*Dolichonyx oryzivorus*) and Savannah Sparrow. Other species which use open country for foraging including Barn Swallow (Hirundo rustica) and Cooper's Hawk (*Accipiter cooperii*) were documented in the large area of meadow in 2020. Ongoing maintenance work at the farmhouse access from Forestell Road which included pump hoses running through the field toward Plot 9, did not affect bird diversity with 19 species documented in 2020.

3.3.2 Breeding Bird Abundance

The abundance of breeding birds (the number of individual birds at a given plot) between monitoring years is shown on Figure 13. Bird abundance has remained relatively stable across all plots since monitoring began with some plots showing minor fluctuation over the course of monitoring and small increases or decreases between individual monitoring years. Plot 1, Plot 6 and Plot 9 have shown the highest abundance for a number of years with surveys in 2020 documenting 62, 55 and 60 species at these plots respectively. Those species which have tended to comprise much of the abundance value for each plot, including European Starling, Red-winged Blackbird, American Goldfinch, Song Sparrow, Cedar Waxwing (*Bombycilla cedrorum*), Black-capped Chickadee (*Poecile atricapillus*) and American Robin (*Turdus migratorius*), continue to be most abundant across the site. Spikes in bird abundance have been observed in past monitoring years due to large flocks of a single species, such as a flock of 35 European Starlings at Plot 9 in 2018.

As the core natural feature remains essentially unchanged in terms of size and composition, consistent bird abundance is to be expected. Changes in habitat cover and extent have occurred in the area surrounding the core feature including the planting of the naturalized buffer, the maturation of the old field in Phase 3, the short-term presence of graded lands on a lot-by-lot basis and recent landscaping associated with occupied lots. Sites that have been graded typically produce an abundance of early successional weeds which provides an ephemeral habitat with increased forage opportunity (seeds and insects). Areas of lawn may attract flocks of blackbirds including European Starlings, Brown-headed Cowbirds (*Molothrus ater*) and Common Grackle (*Quiscalus quiscula*). Isolated landscape trees and natural feature buffer plantings can provide habitat for common species like American Robin. These types of habitat changes add diversity to the development area which increases the potential to support a larger abundance of common bird species.

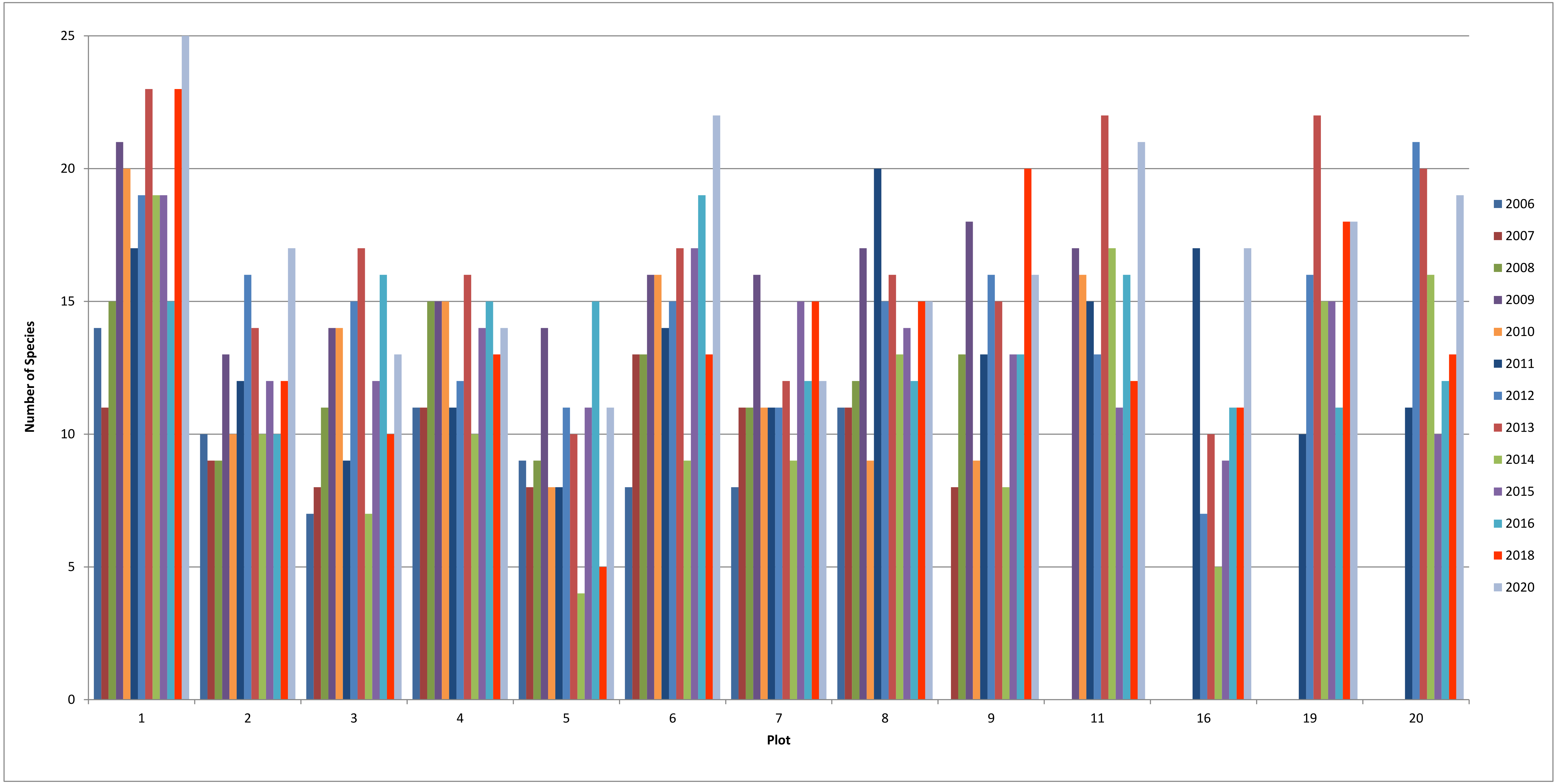

Figure 12. Breeding Bird Species Diversity 2006 – 2020

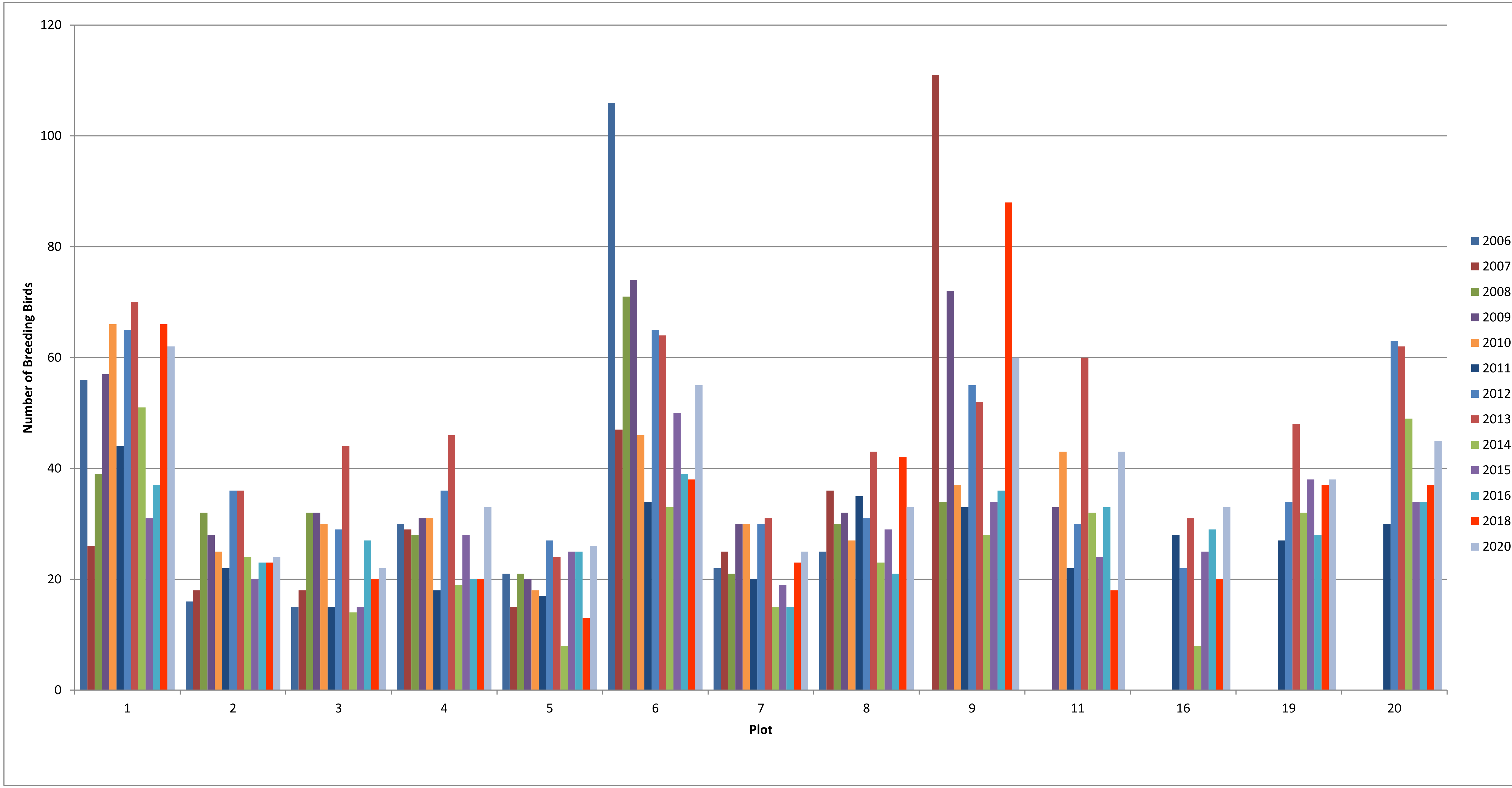

Figure 13. Breeding Bird Abundance 2006 - 2020

3.3.3 Significant Bird Species

In 2020, NRSI observed 4 bird species that are considered Species at Risk (SAR) or Species of Conservation Concern (SCC) (COSEWIC 2021, MNRF 2021): Eastern Meadowlark, Bobolink and Barn Swallow are designated Threatened both provincially and federally and Eastern Wood-pewee is designated as Special Concern provincially and federally.

In 2020, Eastern Meadowlark showed probable breeding evidence at Plot 20 and possible breeding evidence at Plot 1, Plot 6 and Plot 9. With the exception of Plot 6, all observations were made within the large expanse of old field meadow in Phase 3. Eastern Meadowlark requires grassy meadows, farmland, pastures or hayfields and will utilize open country less than 5ha in size (OMNR 2000; McCracken et al. 2013). The observation at Plot 6 may have been a bird foraging in the small meadow clearings, but nesting is unlikely at this location. As many as 2 individuals were observed in the Phase 3 lands. Eastern Meadowlark has been recorded within the site each year since 2007.

Similar to Eastern Meadowlark, Bobolink observations were focused in the large old field meadow within Phase 3. As many as 8 individuals were observed during a single survey; all in close proximity to Plot 9 and Plot 20. Probable breeding evidence was recorded at Plot 20. This species has been observed in every monitoring year since 2006 with the exception of 2018 when open country SAR bird observations were limited to Eastern Meadowlark.

Barn Swallow was observed at Plot 11, Plot 19 and Plot 20 during the 2020 surveys. Although the Crawley farmhouse to the south of Plot 20 was being worked on throughout much of the 2020 breeding bird season, it is possible that the species nested on the structure. Nesting may also occur off-site at nearby farms. To date, no nests have been observed on the business park buildings which generally lack suitable conditions for nest building. As many as 5 individuals were documented from Plot 11, including fledged young. As this species often forages in open country near water (OMNR 2000, Brown and Brown 2020), the stormwater ponds and meadow areas within the business park provide good habitat for the species.

Eastern Wood-pewee was documented showing possible breeding evidence at Plot 2, Plot 3, Plot 5 and Plot 16. This species has been recorded on site during every monitoring year. Eastern Wood-pewee prefers forest clearings or edge habitat with a semi-open canopy and is generally not limited by patch size (Watt et al. 2020). The core feature as well as smaller, isolated treed features continue to provide suitable habitat for this species. The natural feature buffer plantings have enhanced the edge habitat as a transitional area of sparse tree cover that varies in height and composition. Areas where Ash have declined (e.g., Plot 2) remain suitable for Eastern Wood-pewee as the canopy remains semi-open.

In total, 23 bird species were observed which are considered significant within the City of Guelph (Dougan & Associates 2009). Of these species, 2 species showed confirmed breeding evidence, 6 species showed probable breeding evidence and 13 species showed possible breeding evidence. Great Blue Heron (*Ardea herodias*) and Belted Kingfisher (*Megaceryle alcyon*), also considered significant in the City of Guelph, were observed but did not display any breeding evidence (i.e., observed as a fly-over).

Table 6 lists the nationally, provincially, and locally significant bird species that were observed by NRSI in 2020.

Table 5. Significant Bird Species Observed in 2020

Common Name	Scientific Name	SRANK[1]	SARO[1]	COSEWIC[2]	Wellington [3]	City of Guelph[3]	NRSI Observed
Cooper's Hawk	*Accipiter cooperii*	S4	NAR	NAR	√*	X	PO
Sharp-shinned Hawk	*Accipiter striatus*	S5	NAR	NAR	√*	X	PO
Great Blue Heron	*Ardea herodias*	S4B			**	X	X
Brown Creeper	*Certhia americana*	S5B			√*	X	PO
Black-billed Cuckoo	*Coccyzus erythropthalmus*	S5B			√*	X	CO
Northern Flicker	*Colaptes auratus*	S4B			√*	X	PO
Eastern Wood-pewee	*Contopus virens*	S4B	SC	SC	√	X	PO
Bobolink	*Dolichonyx oryzivorus*	S4B	THR	T	√*	X	PR
Willow Flycatcher	*Empidonax traillii*	S5B			√	X	PR
Barn Swallow	*Hirundo rustica*	S4B	THR	T		X	CO
Baltimore Oriole	*Icterus galbula*	S4B			√*	X	PO
Belted kingfisher	*Megaceryle alcyon*	S4B			√	X	X
Red-bellied Woodpecker	*Melanerpes carolinus*	S4			√	X	PO
Savannah Sparrow	*Passerculus sandwichensis*	S4B			√*	X	PR
Vesper Sparrow	*Pooecetes gramineus*	S4B			√*	X	(PO)
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	S4B			√*	X	PR
Hairy Woodpecker	*Picoides villosus*	S5			√*	X	PO
American Redstart	*Setophaga ruticilla*	S5B			√*	X	PO
Red-breasted Nuthatch	*Sitta canadensis*	S5			√*	X	PR
Eastern Meadowlark	*Sturnella magna*	S4B	THR	T	√*	X	PR
Winter Wren	*Troglodytes hiemalis*	S5B			√*	X	PO
Eastern Kingbird	*Tyrannus tyrannus*	S4B			√*	X	PO

Common Name	Scientific Name	SRANK[1]	SARO[1]	COSEWIC[2]	Wellington [3]	City of Guelph[3]	NRSI Observed
Blue-headed Vireo	*Vireo solitarius*	S5B			√	X	PO

[1]MNRF 2021; [2]COSEWIC 2021; [3]Dougan and Associates 2009

Legend
SRANK
S4 Apparently Secure
S5 Secure
B Breeding Population
N Non-breeding Population
COSEWIC/SARO
T/THR Threatened
SC Special Concern
NAR Not at Risk
Local Status (Wellington)
√ Significant and rare
√* Significant but not rare
Breeding Evidence Codes
CO Confirmed
PO Possible
PR Probable
X No breeding evidence
() Incidental observation

3.4 Bird Threshold Assessment

3.4.1 Breeding Bird Species Diversity

The threshold for breeding birds established in the HCBP Consolidated Monitoring Program (NRSI 2010) is a change of 25% in species diversity (number of different species). A decrease in species diversity beyond the threshold is considered to represent a potential concern. An increase beyond the threshold is considered to be positive and does not warrant that any remedial action be taken. Figure 12 indicates the species diversity for breeding birds since monitoring began in 2006. Figure 14 compares the 2010 to 2020 breeding bird species diversity to the preconstruction (2006-2009) average species diversity. Those plots that were added after 2009 do not have a threshold identified based on pre-construction data.

3.4.2 Breeding Bird Abundance

The threshold for breeding birds established in the HCBP 2010 Consolidated Monitoring Report (NRSI 2010) is a change of 25% in breeding bird abundance (the number of individual birds). Figure 13 indicates breeding bird abundance since 2006. Bird abundance in 2020 reflects the average abundance across the various monitoring plots including in comparison with the pre-construction average. Figure 15 compares 2010 to 2020 during construction data with breeding bird abundance from the preconstruction years (2006 – 2009). The preconstruction average column shows the 25% range bar, indicating the threshold.

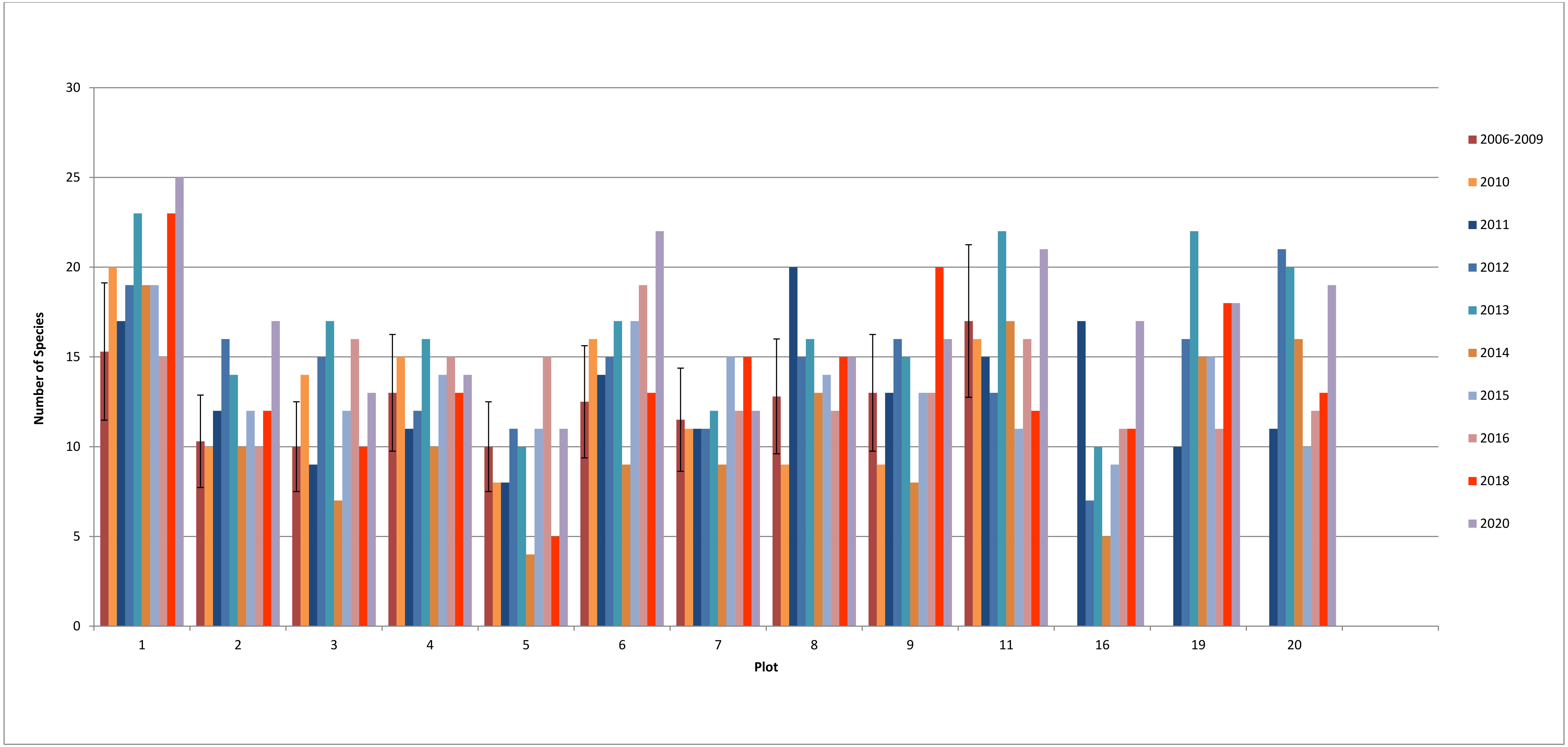

Figure 14. Breeding Bird Species Diversity Pre- and During Construction

(The range bar shows a 25% change in the number of breeding bird species)

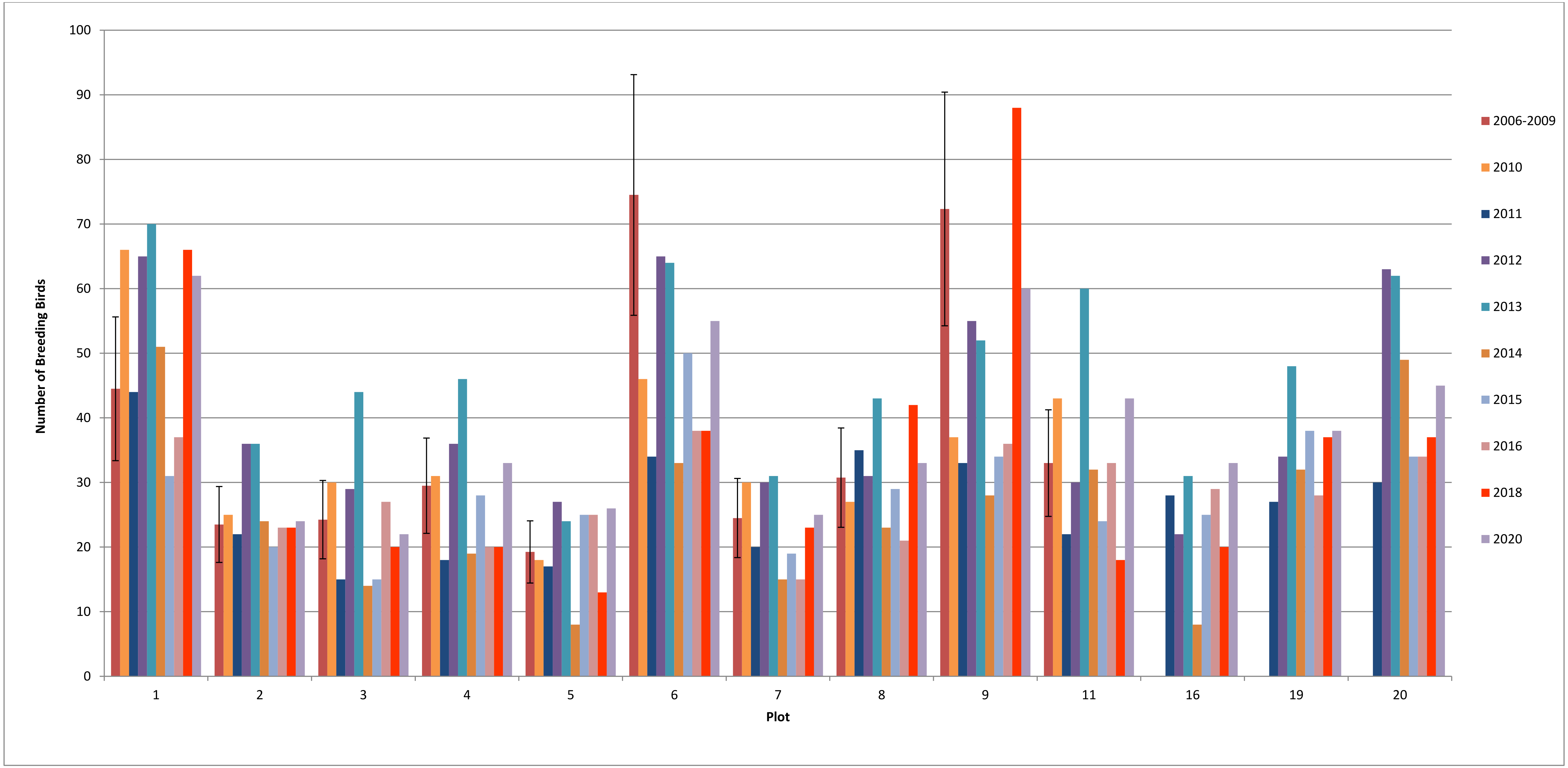

Figure 15. Breeding Bird Abundance 2006 - 2020

(The range bar shows a 25% change in the number of breeding birds)

3.4.3 Bird Threshold Summary and Contingency Measures

The HCBP Consolidated Monitoring Program (NRSI 2010, p. 39) suggests the following measures when bird species decline beyond the established threshold:

- *"Assess success of naturalization/restoration plantings. If plantings are not establishing, increase buffer/natural area plantings.*
- *Assess status of restoration plantings (e.g. if shrub and tree species are beginning to proliferate in open meadow areas, return naturalized area to intended habitat type).*
- *Increase buffer plantings or alter if necessary.*
- *Provide educational material to neighbouring properties outlining importance of natural features, wildlife and their protection.*
- *Provide additional signage regarding trail closures, etc."*

<u>Breeding Bird Species Diversity</u>

The bird species diversity in 2020 was within or above the threshold at all monitoring plots. For those plots which do not have a pre-construction threshold (Plot 16, Plot 19 and Plot 20), the 2020 diversity was above average since monitoring commenced in 2011.

Both Plot 5 and Plot 11 had dropped below the diversity threshold in 2018 with surveys documenting 5 species and 12 species respectively. In 2020, these figures increased to 11 and 21 species respectively. Given that construction adjacent to the natural features has been limited between 2018 and 2020, we do not attribute these fluctuations to the development of the site.

In 2020, the presence of Blue-headed Vireo and Eastern Wood-pewee in Plot 5 and Warbling Vireo in Plot 11 indicate that these features continue to support bird species that require specific habitat conditions. As noted in previous monitoring years, some species are documented as a fly-over and are not directly utilizing the habitat containing the monitoring plot. For example, American Crow (*Corvus brachyrhynchos*), Barn Swallow, Savannah Sparrow and Red-winged Blackbird were documented from Plot 11 in 2020, but none of these species exhibited signs of nesting or foraging within the feature.

Plots 1, 2, 3 and 6 positively exceeded the threshold during the 2020 breeding bird surveys. Plot 1 has maintained notably higher diversity since 2010 when the adjacent agricultural lands were taken out of production and the site transitioned to old field meadow. The willow thicket community at the centre of the plot remains dominated by dense shrubs with seasonal standing water and the changes in diversity are attributed to the adjacent habitat. The steady increase in bird diversity in Plot 6, adjacent to operational and recently constructed buildings is a good indicator that the development has not resulted in declines in bird diversity. The pre-construction average of 12.5 species has been consistently surpassed with 22 species present in 2020.

Breeding Bird Abundance

In 2020, breeding bird abundance data indicated average numbers of birds at each plot. During the surveys, no large flocks of a certain species were observed and as such the abundance numbers largely reflect common species at a given plot as shown in Figure 11. Plot 6 was the only negative threshold exceedance in 2020. This is largely in part due to the pre-construction average being elevated on account of large flocks of European Starlings and Red-winged Blackbirds. As noted previously, species abundance at Plot 6 positively exceeded the threshold and was the second most diverse plot in 2020 with 22 species.

Plots 1, 5 and 11 were above the positive 25% threshold for bird abundance in 2020. Plot 1 and 11 showed high diversity; 25 species and 21 species respectively, which included good numbers of many of the species that were documented. Although less diverse at 11 species, the abundance for Plot 5 did include a flock of 10 foraging Tree Swallows (*Tachycineta bicolor*) which was largely responsible for the positive exceedance.

3.5 Anuran Surveys

3.5.1 Call Count Surveys

Four anuran species were recorded during evening call count surveys in 2020; Spring Peeper (*Pseudacris crucifer crucifer*), Wood Frog (*Lithobates sylvatica*), Gray Treefrog (*Hyla versicolor*) and American Toad (*Anaxyrus americanus*). A fifth species, Green

Frog (*Lithobates clamitans*) was observed as an incidental during other surveys but was not heard calling. Green Frog has been documented from the site each monitoring year since 2012. Northern Leopard Frog (*Rana pipiens*) has been occasionally documented within the site in low numbers (2010, 2011, 2013, 2014, 2018), but was not heard or observed during the 2020 surveys.

Anuran diversity has fluctuated since 2006 with 3 or fewer species recorded in some monitoring years (2006, 2010, 2012), and as many as 6 species documented in 2009. Over the entire monitoring period, 4 to 5 species can be expected in most years and this was the case in 2020.

Anuran species abundance recorded each year is shown in Table 6. It should be noted that although 2006 surveys studied 6 amphibian monitoring stations, additional stations were added in subsequent years bringing the total number of stations monitored since 2011 to 16. Appendix VIII provides a list of anuran species and their associated call count information observed by NRSI biologists during surveys from 2006 to 2020.

Table 6. Number of Calling Anuran Species Recorded During Call Count Surveys

Year	# of Species
2006	0
2007	5
2008	4
2009	6
2010	3
2011	4
2012	3
2013	4
2014	5
2015	5
2016	5
2018	5
2020	4

In order to compare species abundance over time and between stations, the maximum call code is used. The maximum call code is used to provide an estimate of abundance, as estimating numbers of individuals is not accurate. The three call codes as per the Marsh Monitoring Protocol (BSC 2008) are:

Call Level 1. Calls can be counted; not simultaneous

Call Level 2. Some simultaneous calls; yet distinguishable

Call Level 3. Calls not distinguishable; overlapping (i.e., “full chorus”)

By comparing the number of stations at which a species was observed, and the maximum call code over time, increases or decreases in species abundance can be determined (Tables 8 and 9). The following is a brief discussion of trends observed by species:

Spring Peeper

- The most widespread (has been recorded from every plot except Plot 13) and often most abundant calling anuran across all monitoring years. Recorded in 7 of 16 plots in 2020;
- A full chorus (many individuals; too many to count accurately) recorded at Plots 15 and 16 in 2020;
- Presence in large numbers at Plot 16 suggests the feature still provides a suitable hydroperiod in the spring which is notable given the drying trend observed during vegetation monitoring;
- Appears to use stormwater ponds with deep, warmer water as well as shallow pockets of seasonal standing water within areas of swamp (preferred habitat). The use of stormwater ponds suggests that the ponds are naturalizing (egg attachment sites available) and water temperature and quality is within the tolerance range for this species.

Green Frog

- Not recorded in 2020, but observed incidentally on Laird Road and during wildlife movement surveys (NRSI 2021);
- This species has been documented sporadically between 2007 and 2018, always in low numbers and limited to 1 or 2 plots in those years when it is documented.

Gray Treefrog

- Only documented from Plot 1 in 2020 (a single calling frog);
- Had been documented calling at many more plots in recent years (9 plots in 2015) and seemingly numbers of calling individuals fluctuate in cycles;

- Calling numbers are likely dependent upon suitable standing water being present in May to June when this species breeds;
- Plot 1 provides standing water among a dense stand of inundated willow shrubs and represents the best habitat for Gray Treefrog within the site;
- A number of individuals were observed during the Laird Road wildlife movement surveys and this species likely remains widespread throughout the site and will continue to have years of higher and lower abundance.

Wood Frog

- Present at 4 plots in 2020 which is about average over the course of monitoring;
- Plot 1, 10 and 15 have documented Wood Frog in each of the last 3 monitoring years; Plot 1 and 15 are adjacent to recent development;

American Toad

- Presence in large numbers at Plot 16 suggests the feature still provides a suitable hydroperiod in the spring which is notable given the drying trend observed during vegetation monitoring;
- Although this species has fluctuated in numbers and distribution among plots, it is now documented from SWM ponds and water-filled ditches which provide suitable breeding habitat.

Northern Leopard Frog

- Northern Leopard Frog was documented at the site as an incidental observation during other surveys including the Laird Road wildlife movement surveys, but was not heard calling;
- This species was documented calling from Plot 4 in 2014 as well as at other locations in 2012 and 2009;
- It is likely that Northern Leopard Frog numbers have always been relatively low at the site.

Other Species

- No Pickerel Frog (*Lithobates palustris*) or Western Chorus Frog (*Pseudacris triseriata*) were documented during call surveys or incidentally in 2020 and have not been documented since 2012;

- Each of these species have been recorded intermittently within the subject property in previous years, with a call code of 1 or 2 and in low numbers;

With regard to the plots:

- 8 of the 16 plots recorded calling anuran species in 2020, down from 11 in 2018;
- Plot 1 recorded 3 species of anurans in 2020;
- No calling anurans were recorded in 2020 at Plots 2, 6, 7, 8, 9, 12, 13 and 18. Many of these plots have not contained any standing water for a number of years.
- Plot 12 contained standing water in 2020, but no anurans were heard calling. American Toad, Gray treefrog and Spring Peeper had all been documented here in recent monitoring years.
- A full chorus of American Toad and Spring Peeper at Plot 16 is a good indicator that although the hydrology of this feature was affected by site grading, a suitable early season hydroperiod supports anuran breeding.

3.5.2 Amphibian Call Survey Site Conditions

Amphibians breed in several types of wetland habitat. All require the presence of water for some duration of the spring. Some species, such as Spring Peeper, Western Chorus Frog, and Wood Frog, take advantage of temporary, seasonal pools created by spring rains and melting snow. The temporary pools dry up by mid to late summer, at which time the tadpoles have metamorphosed into adults and moved to upland habitats. Some species of anurans, such as Leopard Frog, Green Frog, and Bullfrog (*Lithobates catesbeianus*), require semi-permanent to permanent water bodies in order for the tadpoles to develop into adults, which can take up to 2 years.

Since monitoring of calling anurans began in 2006, the hydro-period, depth and spatial extent of pooled water has varied greatly from one year to the next. These factors are subject to seasonal weather patterns including snow melt and spring precipitation. Research shows that prolonged periods of dry weather may reduce adult breeding populations either directly or through reduced juvenile recruitment and a shortened larval period (Berven 1990). Permanent standing water is present within the constructed SWM pond in Phase 2 (SWM Pond 4) and SWM Ponds 1 and 2 in Phase 1 (Map 2), as well as the 2 manicured ponds within the residential property north of Laird Road. Incidental observations of amphibians continue to be recorded within the SWM ponds (in particular SWM Pond 4). An increase in Leopard Frog and Green Frog has not been observed since the construction of the SWM ponds and this may be a result of the water temperature, water quality, and the lack of egg attachment sites being unsuitable for these species in particular. As buffer plantings and SWM pond naturalization progresses, these constructed features may be more suitable in the years ahead. In their current state, the SWM ponds support American Toad and Spring Peeper which serve as good indicators that the ponds can provide anuran habitat.

With respect to groundwater levels within the core PSW, Banks Groundwater Engineering Ltd. (2020) notes that groundwater levels generally rose in January through March and declined in April through August. Additionally, the groundwater monitoring report states:

> "*Climate had the greatest influence on groundwater levels within the Core PSW in 2020 … . There were no apparent short-term and/or longer-term changes in groundwater levels that could be attributed to construction activities during 2020 within the HCBP (i.e. there were no abnormal changes in groundwater elevations that would have suggested otherwise).".*

Although most of the peripheral wetland features rely largely on surface water input (either within their own sub-catchment, or online with a watercourse), the decrease in groundwater elevation that occurs in early spring and continues through May into late summer suggests that groundwater does not play a major role in the diversity and numbers of anuran present within monitored wetlands. Climate factors, namely the amount of snowmelt and the rate of melt, as well as the magnitude and frequency of rain storms in the late winter or early spring are the major drivers behind hydroperiod and in turn anuran breeding activity.

Table 7. Maximum Call Code Recorded

American Toad

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1						1				2		1	
2													
4			1				2						
6		1				1				1			
7													
8													
9			3			1							
10										2			
11										3			
12										2	2		
13													
14				1									
15													
16							2	1		2			3
17													
18							3						

Gray Treefrog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1				1		1		2	3	2	3		1
2									1	2	2	3	
4													
6			3	1					1	2			
7								2		2			
8							1				2		
9			1	1						2			
10										2			
11										2	1		
12								1	1	2	1	2	
13								1					
14													
15					2						2		
16							2	2		2	3	2	
17									1		2	3	
18								2	1				

Green Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1													
2													
4									1			1	
6			1	1									
7													
8							1						
9		1											
10													
11													
12				1									
13											2		
14										1		1	
15									1				
16							2			1			
17													
18													

Spring Peeper

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1		3	3	1	2	3		3	3	2	1	3	1
2			1		1							3	
4			3	1									2
6		3	1	3	3	3		2		2			
7			1										
8							1						
9		2	1	1	1	1		2	3	3		2	
10					1								
11				1	2	1		1	1			1	1
12				3	3	3		3	2			3	
13													
14									2			1	1
15					1	3		1	2	2	3	2	3
16				3	1	3	2	3	1		3	1	3
17									1			2	2
18						3					3		

Leopard Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1													
2													
4									1				
6													
7													
8							1						
9				1									
10													
11				1									
12				1									
13													
14													
15													
16							2						
17													
18													

Pickerel Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1													
2													
4													
6													
7													
8							1						
9													
10													
11					1								
12													
13													
14													
15													
16							2						
17													
18													

Western Chorus Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1													
2													
4													
6		1											
7													
8							1						
9													
10													
11													
12													
13													
14													
15													
16							2						
17													
18													

Wood Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1		1		1		2		2	1		1	1	1
2													
4						1							2
6						1		3		1			
7													
8							1						
9		1		1		1				2			
10				1		1					1	1	1
11				1									
12				1		1		1					
13													
14													
15								1	1	2	3	1	2
16						2	2	3		2			
17				1		1					1	2	
18						1							

Table 8. Number of Individual Anurans Recorded During Call Count Surveys

American Toad

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1						1				2		1	
2													
4			1				2						
6		4				6				1			
7													
8													
9			+			1							
10										5			
11										+			
12										2	2		
13													
14				1									
15													
16							5	1		2			+
17													
18							+						
	0	4	1+	1	0	8	7+	1	0	12+	2	1	+

Gray Treefrog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1				1		1		10	+	9	+		1
2									3	3	6	+	
4													
6			+	1					2	4			
7								6		3			
8							1				2		
9			1	2						5			
10										8			
11										7	1		
12								1	3	8	4	3	
13								1					
14													
15					3						6		
16							6	7		9	+	5	
17									2		5	+	
18								2	1				
	0	0	1+	4	3	1	7	27	11+	56	24+	8+	1

Green Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1													
2													
4									2			1	
6			2	1									
7													
8							1						
9		1											
10													
11													
12				2									
13											2		
14										2		2	
15									5				
16							6			2			
17													
18													
	0	1	2	3	0	0	7	0	7	2	2	3	0

Spring Peeper

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1		+	+	4	14	+		+	+	2	8	+	3
2			2		4							+	
4			+	2									4
6		+	5	+	+	+		4		4			
7			1										
8							1						
9		12	3	11	1	6		5	+	+		4	
10					2								
11				1	6	8		1	1			2	1
12				+	+	+		+	6			+	
13													
14									6			2	2
15					3	+		1	4	4	+	11	+
16				+	3	+	6	+	1		+	4	+
17									2			5	6
18						+					+		
	0	12+	11+	18+	33+	14+	7	11+	20+	10+	8+	28+	16+

Leopard Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1													
2													
4									1				
6													
7													
8							1						
9				1									
10													
11				1									
12				2									
13													
14													
15													
16							6						
17													
18													
	0	0	0	4	0	0	7	0	1	0	0	0	0

Pickerel Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1													
2													
4													
6													
7													
8							1						
9													
10													
11					1								
12													
13													
14													
15													
16							6						
17													
18													
	0	0	0	0	1	0	7	0	0	0	0	0	0

Western Chorus Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1													
2													
4													
6		1											
7													
8							1						
9													
10													
11													
12													
13													
14													
15													
16							6						
17													
18													
	0	1	0	0	0	0	7	0	0	0	0	0	0

Wood Frog

Plot	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
1		7		1		10		3	1		1	2	1
2													
4						1							2
6						2		+		1			
7													
8							1						
9		2		4		2				3			
10				2		1						3	2
11				1							1		
12				2		2		1					
13													
14													
15								1	1	5	+	3	2
16						8	6	+		5			
17				2		5					1	6	
18						1							
	0	9	0	12	0	31	7	5+	2	14	3+	14	7

'+' =Many individuals; too many to be able to count accurately (cannot distinguish calls - Calling Code 3)

3.6 Anuran Threshold Assessment

The thresholds for amphibians established in the HCBP Consolidated Monitoring Program (NRSI 2010) and the HCBP 2011 Consolidated Monitoring Report (NRSI 2012a) are a decrease in species diversity (number of species) by more than 2 species and a significant change in species abundance, measured by a decrease in 2 call codes. Such changes may constitute a concern.

3.6.1 Anuran Species Diversity

Figure 16 graphs the species diversity for anurans since 2006. The 2020 monitoring documented anuran diversity above the threshold in 6 of the plots (Plots 1, 4, 14-17), within the threshold at 1 plot (Plot 10) and below the threshold in 9 plots (Plots 2, 6-9, 11-13, and 18). Plots 2, 6, 13 and 18 did not have standing water for most of the surveys, as has been the case for a number of years.

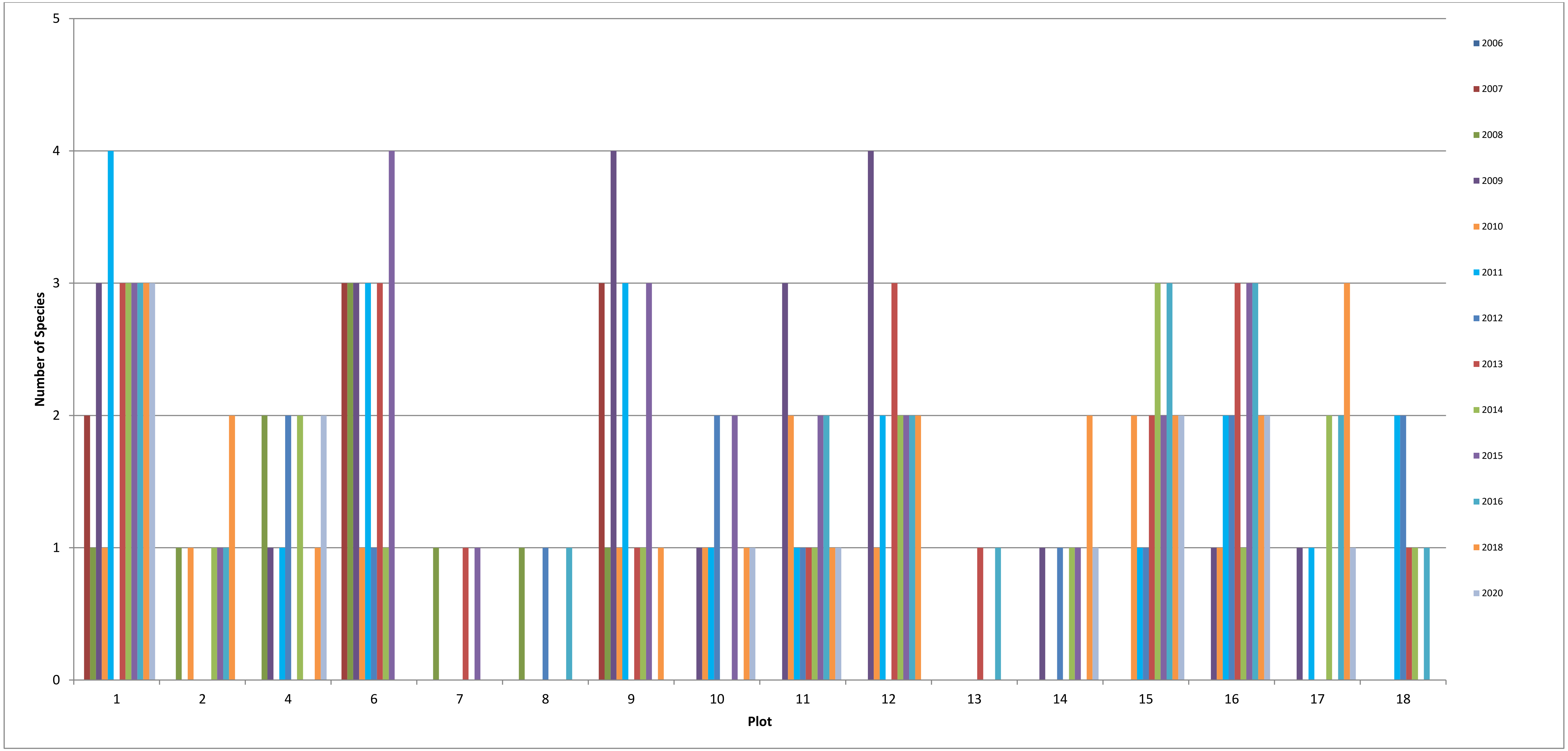

Figure 16. Anuran Species Diversity 2006 - 2020

Although diversity on a plot-by-plot basis saw decreases at many plots, it is important to note that 6 anuran species were documented from across the entire site in 2020. Some of the plots, such as Plot 4, 9, 14 and 15 contain shallow standing water that often dries up before June. These shallow pools, often with abundant grasses available for egg mass attachment, are part of the diversity of anuran breeding habitat available on site. In years with exceptional melt and precipitation they provide an extended hydroperiod and in drier years suitable habitat (and calling anurans) are not present.

3.6.2 Anuran Species Abundance

A drop in 2 calling codes was established as the threshold in the HCBP Consolidated Monitoring Program (NRSI 2010). 8 of these threshold exceedances were observed in 2020 as follows:

- Gray Treefrog in Plots 2, 12, 16, 17 – no individuals recorded during 2020 at any of these plots. In comparison with the 2018 data, this includes a decrease from call code of 3 (Plots 2 and 17) and call code 2 in Plots 12 and 16;
- Spring Peeper in Plots 2, 9, 12 – no individuals recorded in 2020, down from a call code 3 at Plots 2 and 12 and call code 2 at Plot 9 in 2018;
- Wood Frog in Plot 17 – no individuals recorded in 2020, down from a call code of 2 in 2018.

In reference to Table 7, there was a clear spike in Gray Treefrog abundance between 2015-2018 which was preceded by lower numbers and more scattered distribution. The changes in abundance between 2018 and 2020 are attributed to natural fluctuation as a result of precipitation and temperature from one year to the next.

The decrease in Spring Peeper abundance at Plots 2 and 9 is likely a result of the dry conditions observed in the spring of 2020 whereby these plots contained very little standing water in April and were dry by mid-May. The decrease in Plot 1 from a full chorus to call code 1 is not concerning for a single monitoring year as Spring Peepers have been present in this plot in varying numbers since monitoring began. Plot 12 did contain standing water in April and May and the absence of both Spring Peeper and Gray Treefrog (which were present in 2018), as well as American Toad (present in 2016) may indicate that anuran numbers are declining here. As an isolated wetland feature that is now encompassed by developed, graded areas and road, consecutive years of reduced hydroperiod may lead to declines in species abundance and diversity with limited potential for recolonization from the core natural feature.

As Plot 17 contained standing water through April and May of 2020, the absence of Wood Frog is likely a result of this species dispersing to other areas within the site. Table 7 indicates that Wood Frog numbers remained steady at Plots 1 and 10, and increased at Plots 4 and 15. There is also potential that conditions in the spring of 2019, when monitoring was not conducted, were unfavourable and saw a decrease in Wood Frog recruitment which affected numbers in 2020.

As previous monitoring reports have noted, the creation and naturalization of the SWM ponds on site has led to increased use of these features for anuran breeding and foraging, in particular by Spring Peepers and American Toads.

The remaining identified species, Northern Leopard Frog, Pickerel Frog and Western Chorus Frog have all been observed intermittently within the subject property dating back to the 2007 monitoring year. In general, these species have been observed in low numbers at a call code of 1 or 2. It is likely that these species have always existed in low numbers within the property and are subject to natural population fluctuations.

3.6.3 Anuran Threshold Summary and Contingency Measures

The HCBP Consolidated Monitoring Program (NRSI 2010, p. 41) suggests the following measures when amphibian species decline beyond the established threshold:

- *“Wetland creation where feasible.*
- *Enhancement plantings to improve wetland condition.*
- *Additional monitoring – broaden range of parameters (i.e. water quality).*
- *Increase buffer plantings or alter if necessary.*
- *Provide educational material to neighbouring properties outlining importance of natural features, wildlife and their protection.*
- *Provide additional signage regarding trail closures, etc.”*

In general, we assume that a positive threshold exceedance in anuran diversity or abundance is an improvement; the following discussion focuses on negative exceedances.

Assessing the drops in species diversity and abundance on a plot-by-plot basis, we note the following:

- Plot 2 has not contained standing water during any of the 3 spring surveys for a number of years and the habitat is not suitable for anuran breeding.
- Plot 6 also does not contain standing water and the vegetation community has shifted to wet meadow. This habitat is not suitable for anuran breeding.
- Plot 7 has open water within the watercourse, but is otherwise surrounded by swamp with hummocky soils but no standing water.
- Plot 8 is similar to Plot 7 in that the watercourse constitutes flowing water within the plot but there are no pools of standing water in the vicinity.
- Plot 9 often contains shallow standing water in the early spring and this was the case in 2020. As the feature is somewhat isolated, anuran populations are susceptible to significant decreases when recruitment is poor due to dry conditions or cold temperatures resulting in egg or tadpole mortality.
- Plot 11 typically varies between 1-2 anuran species, but has an elevated pre-monitoring average of 2.5 as a result of 3 anuran species being documented during pre-construction. Although a single Spring Peeper was documented, two Wood Frog were present at Plot 10. These plots being in close proximity within the small natural feature, species are able to move between the two vernal pools.
- Plot 12 is similar to Plot 9 in that it contains shallow standing water (wetted grasses) and is somewhat isolated. Where Plot 9 is separated from the core natural feature by agricultural field, Plot 12 is now separated by Laird Road and development lands.
- Some of the plots, such as Plot 4, 6, 9, 14 and 15 contain shallow standing water that often dries up before June.

Species diversity decreased to below the pre-construction average threshold in 7 plots including Plots 6-9, 11, 13, and 18. Decreases in diversity at Plots 6, 7, 8, 13 and 18 were likely a result of these areas being dry for much of the breeding period in 2018 and thus numbers have stayed low in the years to follow. Plots 9 and 11 recorded slightly below average diversity, but did not record more than 2 species below the pre-construction average.

The decrease in abundance of amphibian species described in Section 3.6.2 above is likely a reflection of the reduced amounts of seasonal standing water at these specific locations. The apparent reduction in standing water at Plot 16 and Plot 18 may be a result of the stormwater design which decreased surface water inputs into these wetland features. It is recommended that surface water inputs to these plots be quantified and monitored; however, baseline data would not be available for comparison. It is noted that increases in abundance were documented for both Gray Treefrog and Spring Peeper at other monitoring plots, and all of these species are regularly documented outside of plots, with American Toads tending to utilize the SWM ponds during their breeding period. The thresholds that were exceeded are summarized as follows along with recommendations for continued monitoring.

<u>Amphibian Species Abundance</u>

A decrease in species abundance beyond the established threshold from 2018 to 2020 was recorded for:

- American Toad at Plot 12;
- Gray Treefrog at Plots 1, 8, 13, and 15;
- Green Frog at Plot 13,
- Spring Peeper at Plot 18, and
- Wood Frog at Plot 15.

As mentioned above, the decreases in species abundance at these particular plots is largely a result of decreased water levels within these specific locations, particularly for Gray Treefrog and Spring Peeper which were recorded in good numbers at other locations where water was present for the breeding period. The other species continue to occur sporadically throughout the subject property.

Monitoring of all anuran plots should continue with a particular focus on noting the spatial extent and depth of vernal pools at all plots. As it is noted previously, the design of the Business Park does not direct surface water from the development into the wetlands and a trend of lower-than-normal precipitation is contributing to less suitable anuran breeding habitat. Monitoring of surfacewater and groundwater inputs toward the wetlands at Plot 16 and Plot 18 is recommended. In the case that anuran diversity and abundance is found to be impacted by development activities, management recommendations may be made in order to mitigate or reverse negative trends.

3.7 Incidental Wildlife Observations

Surveys conducted throughout 2020 as well as the 2021 Laird Road wildlife surveys, resulted in the documentation of a variety of incidental wildlife observations. These observations included birds, herpetofauna, butterflies and mammals.

Birds

The birds that were observed incidentally in 2020 are denoted by brackets in Appendix VII. These species were observed on site incidentally during calling anuran surveys, vegetation surveys, Laird Road surveys or during breeding bird point count surveys but beyond the 100m limit of the survey station.

Amphibians

A consolidated list of all herpetofaunal species observed by NRSI within the subject property since 1998 is included in Appendix IX. Similar to previous monitoring years, numerous calling Spring Peepers were noted from within the SWM ponds present on site. SWM ponds with regular mention of calling anuran activity include those directly east of Downey Road (SWM Pond 2), the SWM swale directly north of Plot 7, and south of Laird Road near Plot 13 (SWM Pond 4). Over the last several years the establishment of a fringe of aquatic and wetland vegetation within these features has begun to improve their function as habitat for anuran breeding. SWM pond locations are shown on Map 2.

The 2021 Laird Road wildlife movement surveys (NRSI 2021) identified seven anuran species (with 27 individuals observed) during the night-time road mortality surveys. This data suggests that the core natural feature continues to provide suitable habitat for a diversity of frog and toad species. A breakdown of the Laird Road movement data collected between 2009 and 2021 indicates that of the 221 identifiable anuran species observations, species representation was 30% American Toad, 21% Northern Leopard Frog, 19% Gray Treefrog, 12% Spring Peeper, 11% Northern Green Frog, 7% Wood Frog and a single American Bullfrog observed.

<u>Reptiles</u>

In addition to an Eastern Gartersnake observed at Plot 9 during a breeding bird survey, the 2021 Laird Road wildlife movement surveys documented an Eastern Gartersnake (*Thamnophis sirtalis sirtalis*). Several unidentified snake observations were recorded on video at the wildlife culvert locations along Laird Road. It is likely that the observations were either Eastern Gartersnake or Dekay’s Brownsnake (*Storeria dekayi*). Given the cessation of mowing and grazing and the establishment of meadow habitat adjacent to the PSW, it is possible that foraging habitat for snakes has improved since 2006. Overall, the variety of habitats within the site (wetland, meadow, forest and basking sites) provides suitable conditions for these common snake species. Several species of snake have been observed in previous monitoring years (Appendix IX).

Both Snapping Turtle (*Chelydra serpentina serpentina*) and Midland Painted Turtle (*Chrysemys picta marginata*) were documented as road mortalities during the 2018 and 2021 Laird Road wildlife movement surveys. An individual of each species had been struck by vehicle traffic in each of the two monitoring years (NRSI 2021). The naturalization of the SWM ponds may make these features useful to turtles as well; however, movement across laird Road and Hanlon Creek Boulevard will continue to pose threats to turtles, snakes and other wildlife.

<u>Butterflies</u>

During the 2020 surveys incidental observations of several butterfly species were noted including Monarch (*Danaus plexippus*), Great Spangled Fritillary (*Speyeria cybele*), Red Admiral (*Vanessa atalanta*), Mourning Cloak (*Nymphalis antiopa*) and Cabbage White (*Pieris rapae*). The host plants for Monarch, Common Milkweed (*Asclepias syriaca*) and

Swamp Milkweed (*A. incarnata*) are present in meadows and wetlands throughout the site.

A number of butterfly species have been recorded from the site over the course of terrestrial and wetland monitoring. The ditches, successional meadows and vegetated periphery of SWM ponds all provide an abundance of nectar-producing plants throughout the late spring into fall. Host plants are found both within the cultural areas as well as within the swamps and forests.

<u>Odonates</u>

No odonates (dragonflies or damselflies) were identified to species during the 2020 surveys. Odonates were observed within areas of marsh and wet meadow, open water features (including SWM ponds) and along the SWM channels along the eastern edge of the natural feature.

<u>Mammals</u>

During 2020 surveys, Eastern Cottontail (*Sylvilagus floridanus*), Raccoon (*Procyon lotor*), White-tailed Deer, Eastern Chipmunk (*Tamias striatus*), Grey Squirrel (*Sciurus carolinensis*) and Red Squirrel (*Tamiasciurus hudsonicus*) were noted throughout the site. These species are documented in most monitoring years (direct observation, tracks, scat).

4.0 Conclusions and Recommendations

The 2020 monitoring year was successful in providing the eleventh year of during construction data, contributing to a useful data set that can be compared to pre-construction data and data collected during future during construction years.

Vegetation

With the exception of Common Reed stands within SWM Pond 4 and in the swale east of Plot 6, no new invasive species of concern were noted in 2020. Given the ability of Common Reed to spread and drastically alter marsh and wet meadow communities, we propose that the existing populations be assessed, mapped and managed as soon as possible.

In general, vegetation plot monitoring indicates that species diversity and cover remains somewhat stable across most of the plots with minor changes between monitoring years. Monitoring plots within the core PSW continue to be comprised of a rich assortment of wetland and forest forbs and graminoids while peripheral monitoring locations remain moderately diverse. Buffer naturalization plantings continue to establish and contribute to the enhancement of the core feature.

Plot 16 remains a focus for vegetation monitoring as a result of the altered surface water inputs and potential repercussions for the swamp community at this location. Wet conditions through 2019 and early 2020 resulted in an increase in wetland forbs within the plot, suggesting that a seed bank and senescent plants are present and these species thrive during years when the feature receives sufficient precipitation. As discussed in previous reports, the swales directing surface water to the SWM ponds have diverted water away from this wetland as well as the Plot 18 wetland. We recommend that the team investigate any options for alterations in conjunction with input from City staff. From an ecological perspective, NRSI is of the opinion that additional surface water input could be beneficial, but is not necessary to maintain a healthy vegetation community at this location. To some extent, the herbaceous vegetation has adjusted to the new catchment and hydroperiod. The continued monitoring of Plot 16 and 18 will quantify to what degree the features change.

Birds

In 2020, the bird species diversity was within or above the established threshold at all monitoring plots. Notably, Blue-headed Vireo and Eastern Wood-pewee were documented within the core feature suggesting that the swamp and forest habitat continues to provide high quality habitat for significant bird species.

Bird abundance data in 2020 showed average numbers across all plots. Development and occupation of newly constructed buildings does not appear to have impacted bird numbers.

Anurans

The 2020 anuran call count monitoring documented anuran diversity above the threshold in 6 of the plots, within the threshold at 1 plot and below the threshold in 9 plots. Of the 9 plots with a negative exceedance, 4 have been dry for many years and do not provide suitable hydroperiod for anurans. We continue to see anuran use of the SWM ponds and swales, both calling individuals and incidental observation of frogs among the damp swales during other surveys. It is likely that the continued naturalization of the SWM ponds will increase the capacity for anuran use. It is possible that increased salt use as the development grows may result in a decrease in SWM pond water quality that compromises egg development.

Combining the call count data with the Laird Road wildlife movement data (NRSI 2021), the presence of 7 anuran species within the study area confirms that the natural features continue to support a high diversity of species.

Recommendations

Based upon the results of the 2020 terrestrial and wetland monitoring, the following actions should be considered:

- The extent of Common Reed should be documented across the entire business park and this data mapped and provided to the City for management consideration. A contractor should be retained to manage the Common Reed near Plot 6, at the edge of SWM Pond 4 and in any other locations where stands are identified within the business park. If feasible, this work should be commenced as soon as possible.

- Terrestrial and wetland should continue in 2022; however, we propose that anuran monitoring be discontinued at Plots 6, 7, 8, 10 and 13, where conditions are generally unsuitable (flowing watercourse) or dry and do not support anuran breeding.

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APPENDIX I

Vegetation Species Observed in the Subject Property 2006 - 2020

Appendix I. Vegetation Species Observed in the Subject Property 2006 - 2020

SCIENTIFIC NAME	COMMON NAME	CC	CW	Weed	+	SRANK[1]	Wellington County[2]	NRSI 2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
Abies balsamea	Balsam Fir	5	-3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Acer rubrum	Red Maple	4	0			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Acer saccharinum	Silver Maple	5	-3			S5		√	√	√	√	√	√	√	√	√	√	√	√	
Acer saccharum	Sugar Maple	4	3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Acer X freemanii	Freeman Maple	6	-5			SNA														√
Actaea rubra	Red Baneberry	6	3			S5														√
Actaea sp.	Baneberry species								√		√					√				
Ageratina altissima	Common White Snakeroot	5	3			S5														√
Agrostis gigantea	Redtop	*	-3	-2	+	SE5										√		√	√	√
Alisma sp.	Water Plantain species									√										
Alliaria petiolata	Garlic Mustard	*	0	-3	+	SE5							√							
Allium tricoccum	Wild Leek	7	2			S5			√											
Ambrosia artemisiifolia	Common Ragweed	0	3			S5														√
Amelanchier arborea	Downy Serviceberry	5	3			S5									√					
Arabis glabra	Tower-mustard	0	0			S5				√										
Aralia nudicaulis	Wild Sarsaparilla	4	3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Aralia racemosa	Spikenard	7	5			S5											√			√
Arctium minus	Common Burdock	*	5	-2	+	SE5			√						√					
Arctium sp.	Burdock species													√						
Arisaema triphyllum	Jack-in-the-pulpit	5	-2			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Aronia melanocarpa	Black Chokeberry	7	-3			S5								√						
Asclepias incarnata	Swamp Milkweed	6	-5			S5		√	√						√	√	√	√	√	√
Asclepias syriaca	Common Milkweed	0	5			S5		√								√	√	√	√	√
Athyrium filix-femina	Northeastern Lady Fern	4	0			S5					√	√					√	√	√	√
Betula alleghaniensis	Yellow Birch	6	0			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Bidens cernua	Nodding Beggarticks	2	-5			S5						√				√				
Bidens frondosa	Devil's beggarticks	3	-3			S5								√	√	√	√	√	√	
Bidens tripartita	Beggarticks	4	-3			S5			√	√									√	
Bidens sp.	Beggarticks species																		√	√
Boehmeria cylindrica	False Nettle	4	-5			S5								√		√	√	√		√
Brachyelytrum erectum	Bearded Shorthusk	7	5			S4S5												√	√	
Bromus ciliatus	Fringed Brome	6	-3			S5														√
Bromus inermis ssp. *inermis*	Smooth Brome	*	5	-3	+	SE5			√				√			√	√	√	√	√
Calamagrostis canadensis	Canada Blue-joint	4	-5			S5		√	√	√	√	√	√	√	√	√	√		√	√
Caltha palustris	Marsh Marigold	5	-5			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Cardamine pensylvanica	Pennsylvania Bitter Cress	6	-3			S5					√									
Carex albursina	White bear Sedge	7	5			S5								√						
Carex aquatilis	Water Sedge	7	-5			S5					√	√	√	√	√	√	√		√	
Carex arctata	Compressed Sedge	5	5			S5					√									
Carex bebbii	Bebb's Sedge	3	-5			S5									√					
Carex blanda	Smooth Sedge	3	0			S5								√	√	√			√	
Carex eburnea	Bristle-leaved Sedge	6	4			S5											√			
Carex flava	Yellow Sedge	5	-5			S5								√	√					√
Carex gracillima	Graceful Sedge	4	3			S5					√	√		√	√	√	√	√	√	√
Carex hystercina	Porcupine Sedge	5	-5			S5								√						
Carex intumescens	Bladder Sedge	6	-4			S5					√		√	√						
Carex lacustris	Lake Sedge	5	-5			S5		√		√	√	√	√	√	√	√	√	√	√	√
Carex laxiflora	Loose-flowered Sedge	5	0			S5					√				√	√	√	√	√	
Carex leptalea	Bristle-stalked Sedge	8	-5			S5												√	√	√
Carex leptonervia	Finely-nerved Sedge	5	0			S5	R													√
Carex lupulina	Hop Sedge	6	-5			S5								√	√	√		√	√	
Carex pedunculata	Long-stalked Sedge	5	5			S5											√			√
Carex pensylvanica	Pennsylvania Sedge	5	5			S5								√			√			
Carex radiata	Radiate Sedge	4	5			S5											√			
Carex retrorsa	Retrorse Sedge	5	-5			S5														√

SCIENTIFIC NAME	COMMON NAME	CC	CW	Weed	+	SRANK[1]	Wellington County[2]	NRSI												
								2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
Carex sp.	Sedge species							√	√	√	√	√	√		√		√	√		√
Carex stipata	Awl-fruited Sedge	3	-5			S5		√	√	√	√	√	√	√		√	√	√	√	√
Carex stricta	Stiff Sedge	4	-5			S5				√	√	√			√		√			√
Carex utriculata	Beaked Sedge	7	-5			S5			√		√		√							
Carex vulpinoidea	Fox Sedge	3	-5			S5				√	√	√	√	√	√	√				
Carpinus caroliniana	Blue Beech	6	0			S5								√						
Cerastium fontanum	Mouse-eared Chickweed	*	3	-1	+	SE5									√					
Chelone glabra	Turtlehead	7	-5			S5								√	√	√	√		√	√
Cicuta bulbifera	Bulbous Water-hemlock	5	-5			S5				√	√	√	√	√		√	√	√	√	√
Cicuta maculata	Spotted Water Hemlock	6	-5			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Circaea alpina	Dwarf Enchanter's Nightshade	6	-3			S5		√			√			√	√	√	√			√
Circaea canadensis	Yellowish Enchanter's Nightshade	3	3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Cirsium arvense	Canada Thistle	*	3	-1	+	SE5		√	√	√	√	√	√	√	√	√	√	√		√
Cirsium muticum	Swamp Thistle	8	-5			S5									√	√			√	
Cirsium sp.	Thistle species													√						
Cirsium vulgare	Bull Thistle	4	5			S5									√					
Clintonia borealis	Bluebead Lily	7	-1			S5			√	√	√	√	√	√	√	√	√	√	√	√
Coptis trifolia	Goldthread	7	-3			S5			√											
Cornus alternifolia	Alternate-leaved Dogwood	6	5			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Cornus amomum	Silky Dogwood	5	-4			S5								√	√	√	√	√	√	√
Cornus foemina	Gray Dogwood	2	-2			S5									√		√			√
Cornus stolonifera	Red-Osier Dogwood	2	-3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Corylus americana	American Hazel	5	4			S5						√								
Crataegus sp.	Hawthorn species							√	√				√							
Cypripedium calceolus var. *parviflorum*	Small Yellow Lady's Slipper	7	-1			S5					√									
Cysptopteris tenuis	Mackay's Fragile Fern	6	5							√						√				
Cystopteris bulbifera	Bulblet Fern	5	-2			S5		√	√		√	√	√	√	√	√	√	√	√	√
Dactylis glomerata	Orchard Grass	*	3	-1	+	SE5								√	√	√	√	√	√	√
Daucus carota	Queen Anne's Lace	*	5	-2	+	SE5			√		√	√	√	√	√	√			√	√
Dennstaedtia punctilobula	Hay-scented fern					S5	R										√			
Doellingeria umbellata	Flat-top White Aster	6	-3			S5								√						
Dryopteris carthusiana	Spinulose Wood Fern	5	-2			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Dryopteris clintoniana	Clinton's Wood Fern	7	-4			S4	R		√			√	√						√	√
Dryopteris cristata	Crested Wood Fern	7	-5			S5		√	√	√	√	√	√		√	√	√	√	√	√
Dryopteris intermedia	Evergreen Wood Fern	5	0			S5											√			
Dryopteris marginalis	Marginal Wood Fern	5	3			S5					√	√	√	√	√	√	√			
Dryopteris sp.	Wood Fern Species															√				
Echinochloa crusgalli	Barnyard Grass	*	3	-1	+	SE5					√	√				√				
Echinocystis lobata	Wild Cucumber	3	-2			S5			√	√	√		√	√	√	√	√		√	
Eleocharis smallii	Small's Spike-rush	6	-5			S5						√								
Elymus repens	Quack Grass	*	3	-3	+	SE5				√					√					√
Epilobium ciliatum	Willow-herb	6	3			SU								√		√				
Epilobium hirsutum	Hairy Willow-Herb	*	-4	-2	+	SE5					√	√	√	√	√		√	√		
Epilobium parviflorum	Small-flowered Willowherb	*	3	-1	+	SE4														√
Epilobium sp.	Willow-Herb species														√		√	√	√	
Epipactis helleborine	Helleborine	*	5	-2	+	SE5				√	√	√		√		√	√	√	√	√
Equisetum arvense	Field Horsetail	0	0			S5			√	√	√	√	√	√	√	√	√	√	√	√
Equisetum palustre	Marsh Horsetail	10	-3			S5	R	√	√				√							
Equisetum pratense	Meadow Horsetail	8	-3			S5	R	√		√	√	√	√	√		√	√	√	√	
Equisetum scirpoides	Dwarf Scouring-rush	7	-1			S5						√			√	√	√			√
Equisetum sylvaticum	Woodland Horsetail	7	-3			S5	R											√	√	
Erigeron annuus	Daisy Fleabane															√				
Erigeron philadelphicus	Philadelphia Fleabane	1	-3			S5											√			
Erigeron sp.	Fleabane species								√					√						
Eupatorium maculatum	Spotted Joe-Pye Weed	3	-5					√	√	√	√	√	√	√	√	√	√	√	√	√
Eupatorium perfoliatum	Boneset	2	-4			S5			√	√				√	√	√	√	√	√	√
Eurybia macrophylla	Large-leaved Aster	5	5			S5		√			√									

							Wellington	NRSI												
SCIENTIFIC NAME	**COMMON NAME**	**CC**	**CW**	**Weed**	**+**	**SRANK[1]**	**County[2]**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**
Euthamia graminifolia	Grass-leaved Goldenrod	2	-2			S5				√	√	√	√	√	√	√	√	√	√	√
Fagus grandifolia	American Beech	6	3			S5			√											
Fragaria vesca	Woodland Strawberry	4	4					√	√	√	√		√	√	√	√				
Fragaria virginiana	Wild Strawberry	2	1			S5			√	√	√	√	√	√	√	√			√	√
Fraxinus americana	White Ash	4	3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Fraxinus nigra	Black Ash	7	-4			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Fraxinus pennsylvanica	Green Ash	3	-3										√	√	√	√	√	√	√	√
Galium aparine	Cleavers	4	3			S5												√		
Galium asprellum	Rough Bedstraw	6	-5			S5		√		√	√									
Galium mollugo	Smooth Bedstraw	0	5	-2	+	SE5														√
Galium palustre	Marsh Bedstraw	5	-5			S5		√	√	√	√	√	√	√	√	√	√	√	√	
Galium sp.	Bedstraw species																			√
Galium tinctorium	Stiff Marsh Bedstraw	5	-5			S5														√
Galium trifidum	Three-petalled Bedstraw	5	-3			S5														√
Galium triflorum	Sweet-scented Bedstraw	4	2			S5		√		√	√	√						√	√	
Geranium robertianum	Herb Robert	*	5	-2	+	SE5		√	√	√	√	√	√		√	√	√			√
Geum aleppicum	Yellow Avens	2	-1			S5				√	√	√	√	√	√	√	√	√	√	
Geum canadense	White Avens	3	0			S5			√						√	√				
Geum laciniatum	Rough Avens	4	-3			S4	R		√				√	√				√	√	
Geum sp.	Avens species							√							√	√	√	√		√
Geum X catlingii	Catling's Avens	0	3			SNA														√
Glyceria sp.	Manna Grass species												√						√	
Glyceria striata	Fowl Manna Grass	3	-5			S5			√		√		√	√	√	√	√	√		√
Gymnocarpium dryopteris	Oak Fern	7	0			S5			√	√	√	√		√	√		√	√	√	√
Hamamelis virginiana	Witch Hazel	6	3			S5	R						√							
Heracleum lanatum	Cow Parsnip	3	-3			S5								√						
Hesperis matronalis	Dame's Rocket		5	-1	+	SE5													√	
Hieracium sp.	Hawkweed species									√										
Hydrocotyle americana	Marsh-Water Pennywort	7	-5			S5		√			√						√		√	
Hydrophyllum virginianum	Virginia Waterleaf	6	-2			S5				√		√								
Ilex verticillata	Winterberry	5	-4			S5							√	√	√	√	√	√	√	√
Impatiens capensis	Spotted Jewelweed	4	-3			S5		√	√		√	√	√	√	√	√	√	√	√	√
Impatiens pallida	Pale Jewelweed	7	-3			S5	R		√	√			√							
Iris sp.	Iris species	0	0						√											
Juglans nigra	Black Walnut	5	3			S4?														√
Juncus effusus	Soft Rush	4	-5								√	√			√			√		
Juncus dudleyi	Dudley's Rush	1	0			S5											√			
Juncus sp.	Rush species							√	√											
Juncus tenuis	Path Rush	0	0			S5		√		√	√	√	√	√	√	√		√		√
Lactuca serriola	Prickly Lettuce	*	0			SE5		√			√									
Lactuca sp.	Lettuce species																			√
Leersia oryzoides	Rice Cutgrass	3	-5			S5		√			√		√	√	√	√	√	√	√	√
Leucanthemum vulgare	Ox-eye Daisy	*	5	-1	+	SE5													√	√
Linaria vulgaris	Butter-and-eggs	*	5	-1	+	SE5				√										
Liparis loeselii	Fen Twayblade	5	-4			S4S5									√					
Lobelia siphilitica	Great Lobelia	6	-4			S5						√		√						√
Lolium arundinaceum	Tall Fescue	*	2	-1	+	SE5									√	√		√	√	
Lolium pratense	Meadow Fescue	*	4	-1	+	SE5											√			√
Lonicera canadensis	Fly Honeysuckle	6	3			S5								√						
Lonicera tatarica	Tartarian Honeysuckle	*	3	-3	+	SE5		√	√	√	√	√	√	√	√	√	√	√	√	√
Lonicera X bella	Bell's Honeysuckle	*	5	-3	+	SE2													√	√
Lotus corniculatus	Bird's-foot Trefoil	*	1	-2	+	SE5		√	√	√	√	√	√	√	√	√		√	√	√
Lycopus americanus	American Water-horehound	4	-5			S5									√	√		√	√	√
Lycopus uniflorus	Northern Bugleweed	5	-5			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Lysimachia borealis	Starflower	6	-1					√	√		√		√	√	√		√	√	√	√
Lysimachia ciliata	Fringed Loosestrife	4	-3			S5			√	√	√	√	√	√	√	√	√		√	√
Lysimachia nummularia	Moneywort	*	-4	-3	+	SE5			√											

							Wellington	NRSI												
SCIENTIFIC NAME	**COMMON NAME**	**CC**	**CW**	**Weed**	**+**	**SRANK[1]**	**County[2]**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**
Lysimachia terrestris	Swamp Candles	6	-5			S5			√		√		√	√	√				√	
Lysimachia thyrsiflora	Tufted Loosestrife	7	-5						√	√	√	√	√	√		√	√	√	√	√
Lythraceae	Loosestrife species									√										
Lythrum salicaria	Purple loosestrife	*	-5	-3	+	SE5								√			√			√
Maianthemum canadense	Canada Mayflower	5	0			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Maianthemum racemosum	False Solomon's Seal	4	3					√	√	√			√	√		√			√	√
Maianthemum stellatum	Star Flowered False Solomon's-seal	6	1			S5				√	√	√					√			√
Malva neglecta	Common Mallow	*	5	-1	+	SE5							√							
Matteuccia struthiopteris	American Ostrich Fern	5	-3					√	√	√	√	√	√	√	√	√	√	√	√	√
Medicago lupulina	Black Medick	*	1	-1	+	SE5						√	√	√	√					
Mentha canadensis	Common Mint	3	-3					√	√		√	√	√	√	√	√	√	√	√	√
Mentha X piperita	Pepper Mint	*	-5	-1		SE4								√						
Mitella nuda	Naked Miterwort	6	-3			S5								√	√	√				√
Myosotis sp.	Forget-me-not species															√				
Nasturtium officinale	Watercress	*	-5	-1	+	SE?					√	√	√	√	√	√	√	√	√	√
Onoclea sensibilis	Sensitive Fern	4	-3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Osmunda cinnamomea	Cinnamon Fern	7	-3			S5			√		√	√	√	√	√	√	√	√	√	√
Ostrya virginiana	Ironwood	4	4			S5		√		√									√	
Oxalis stricta	Upright Yellow Wood Sorrel	0	3			S5								√					√	
Parthenocissus vitacea	Woodbine	3	3			S5									√	√	√	√	√	√
Parthenocissus quinquefolia	Virginia Creeper	6	1			S4?		√	√	√	√	√	√	√			√	√	√	√
Phalaris arundinacea	Reed Canary Grass	0	-4			S5			√	√	√	√	√	√	√	√	√	√	√	
Phleum pratense	Timothy	*	3	-1	+	SE5				√		√	√	√	√	√	√	√	√	√
Physocarpus opulifolius	Ninebark	5	-2			S5											√			√
Picea glauca	White Spruce	6	3			S5		√	√	√	√	√	√				√			
Pilea pumila	Clearweed	5	-3			S5	R			√					√		√	√	√	
Pilea sp.	Clearweed species																			√
Pinus strobus	Eastern White Pine	4	3			S5		√	√	√	√	√	√	√	√			√	√	
Plantago lanceolata	English Plantain	*	0	-1	+	SE5						√								
Plantago major	Common Plantain	*	-1	-1	+	SE5						√	√							
Poa nemoralis	Woodland Spear Grass	0	0	-1		SE3					√									
Poa palustris	Fowl Meadow Grass	5	-4			S5							√	√	√	√	√	√	√	√
Poa pratensis	Kentucky Blue Grass	0	1						√	√	√	√	√	√	√	√	√	√		√
Poaceae	Grass species							√	√	√	√	√	√	√	√	√	√	√	√	√
Polygonatum pubescens	Hairy Solomon's Seal	5	5			S5			√	√			√	√	√		√	√	√	√
Polygonum amphibium var. *emersum*	Water Smartweed	5	-5										√							√
Polygonum sp.	Smartweed species														√					
Polygonum virginianum	Jumpseed	6	0			S4								√						
Polystichum acrostichoides	Christmas Fern	5	5			S5		√		√	√	√	√							
Populus balsamifera	Balsam Poplar	4	-3			S5											√	√	√	
Populus tremuloides	Trembling Aspen	2	0			S5								√		√				√
Potentilla recta	Sulphur Cinquefoil	*	5	-2	+	SE5								√	√					
Prenanthes alba	White Rattlesnake-root	6	3			S5		√												
Prunella vulgaris ssp. lanceolata	Selfheal	5	5			S5						√	√	√	√	√	√	√	√	√
Prunus pensylvanica	Pin Cherry	3	4			S5						√								
Prunus serotina	Black Cherry	3	3			S5		√	√	√	√	√	√	√	√	√			√	
Prunus virginiana	Chokecherry	2	1							√	√		√		√	√	√	√	√	√
Quercus macrocarpa	Bur Oak	5	1			S5										√	√	√		
Quercus rubra	Red Oak	6	3			S5						√								
Quercus sp.	Oak species														√	√				
Ranunculus abortivus	Small-flowered Buttercup	2	-2			S5		√	√						√			√		
Ranunculus acris	Tall Buttercup	*	-2	-2	+	SE5		√	√		√	√	√	√	√	√	√			√
Ranunculus flabellaris	Yellow Water-crowfoot	7	-5			S4?	R			√			√							
Ranunculus caricetorum	Swamp Buttercup	5	-5					√			√			√	√	√			√	√
Ranunculus pensylvanicus	Bristly Buttercup	3	-5			S5				√										
Ranunculus recurvatus	Hooked Buttercup	4	-3						√	√				√			√			√
Ranunculus repens	Creeping Buttercup	0	-1	-1		SE5			√			√		√	√		√	√		√

SCIENTIFIC NAME	COMMON NAME	CC	CW	Weed	+	SRANK[1]	Wellington County[2]	NRSI												
								2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
Ranunculus sceleratus	Cursed Crowfoot	2	-5						√		√	√								
Ranunculus sp.	Buttercup species												√							
Rhamnus cathartica	Common Buckthorn	*	3	-3	+	SE5		√	√	√	√	√	√	√	√	√	√	√	√	√
Rhamnus frangula	Glossy Buckthorn	*	-1	-3	+			√	√	√	√	√	√	√	√	√	√	√	√	√
Rhynchospora alba	White Beaked-rush	10	-5			S5								√						
Ribes americanum	Wild Black Currant	4	-3			S5		√	√	√		√	√	√		√	√	√	√	√
Ribes hirtellum	Smooth Gooseberry	6	-3			S5	R				√									
Ribes lacustre	Bristly Black Currant	7	-3			S5			√											
Ribes rubrum	Red Currant	*	5	-2	+	SE5				√			√							
Ribes sp.	Currant species							√	√			√	√							
Ribes triste	Swamp Red Currant	6	-5			S5							√	√				√	√	√
Rubus allegheniensis	Common Blackberry	2	2			S5			√				√							
Rubus idaeus	Red Raspberry	0	-2					√	√	√	√	√	√		√	√	√	√		√
Rubus occidentalis	Black Raspberry	2	5			S5					√			√				√		
Rubus parviflorus	Sparse-flowered Thimbleberry	7	2			S4							√							
Rubus pubescens	Dwarf Raspberry	4	-4			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Rumex crispus	Curled Dock	*	-1	-2	+	SE5				√		√	√							
Sagittaria latifolia	Common Arrowhead	4	-5			S5								√	√	√	√			
Salix bebbiana	Bebb's Willow	4	-4			S5				√			√							
Salix discolor	Pussy Willow	3	-3			S5														√
Salix eriocephala	Heart-leaved Willow	4	-3			S5						√	√	√	√	√		√	√	√
Salix exigua	Sandbar Willow	3	-5			S5		√												
Salix lucida	Shining Willow	5	-4			S5							√							
Salix petiolaris	Slender Willow	3	-4			S5		√		√	√	√	√	√	√	√	√	√	√	√
Salix sp.	Willow species								√			√	√							
Sambucus canadensis	Common Elderberry	5	-2			S5		√				√	√		√	√	√	√		√
Sanguinaria canadensis	Bloodroot	5	4			S5							√							
Scirpus americanus	Common Three Square	6	-5					√												
Scirpus atrovirens	Dark Green Bulrush	3	-5			S5				√	√	√	√	√	√	√	√	√		
Scirpus cyperinus	Wool-grass	4	-5			S5										√				
Scutellaria galericulata	Common Skullcap	6	-5			S5		√		√	√		√	√	√	√	√	√		
Scutellaria lateriflora	Mad-dog Skullcap	5	-5			S5		√	√			√		√			√	√	√	√
Scutellaria sp.	Skullcap species							√												
Silene cucubalus	Bladder Campion	*	5	-1	+			√												
Sium suave	Water Parsnip	4	-5			S5		√	√	√		√	√		√	√	√	√	√	√
Solanum dulcamara	Bittersweet Nightshade	*	0	-2	+	SE5		√	√	√	√	√	√	√	√	√	√	√	√	√
Solidago altissima	Tall Goldenrod	1	3					√				√	√	√	√	√	√	√	√	√
Solidago caesia	Blue-stem Goldenrod	5	3			S5								√						
Solidago canadensis	Canada Goldenrod	1	3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Solidago flexicaulis	Zig-zag Goldenrod	6	3			S5		√				√	√	√	√	√	√	√	√	√
Solidago gigantea	Late Goldenrod	4	-3			S5							√		√	√	√	√	√	√
Solidago nemoralis	Gray Goldenrod	2	5							√										
Solidago patula	Rough-leaved Goldenrod	8	-5			S5	R		√	√			√	√		√	√			√
Solidago rugosa	Rough-stemmed Goldenrod	4	-1			S5								√	√	√	√	√	√	√
Solidago sp.	Goldenrod species							√	√	√	√	√								
Solidago uliginosa	Bog Goldenrod	9	-5			S5									√					
Sonchus arvensis	Field Sow Thistle	*	1	-1	+					√		√			√				√	
Sonchus sp.	Sow Thistle species																			√
Sorbus americana	Mountain Ash	8	-1			S5	R					√					√			
Spirodela polyrhiza	Duckweed	4	-5			S5			√		√	√								
Stachys sp.	Hedge Nettle species													√						
Symphyotrichum lanceolatum	Panicled Aster	3	-3									√	√	√	√	√	√	√	√	√
Symphyotrichum lateriflorum	Calico Aster	3	-2										√	√	√	√	√	√	√	√
Symphyotrichum novae-angliae	New England Aster	2	-3			S5			√	√		√	√	√	√	√	√	√	√	√
Symphyotrichum puniceum	Purple Stemmed Aster	6	-5			S5		√	√		√	√	√	√	√	√	√	√	√	√
Symphyotrichum sp.	Aster species										√		√		√				√	
Taraxacum officinale	Common Dandelion	*	3	-2	+	SE5		√	√	√	√	√	√	√	√	√	√	√	√	√

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Thelypteris palustris	Marsh Fern	5	-4					√	√	√	√		√	√	√	√	√	√	√	√
Thuja occidentalis	Eastern White Cedar	4	-3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Tiarella cordifolia	Foam Flower	6	1			S5			√			√	√				√	√	√	
Tilia americana	Basswood	4	3			S5											√	√	√	
Toxicodendron radicans	Poison Ivy	5	-1					√	√		√		√	√		√		√	√	
Toxicodendron rydbergii	Western Poison-ivy	0	0			S5									√		√			√
Trifolium hybridum	Alsike Clover	*	1	-1	+			√				√	√		√					
Trifolium pratense	Red Clover	*	2	-2	+	SE5				√										
Trifolium repens	White Clover	*	2	-1	+	SE5						√								
Trifolium sp.	Clover species																			√
Trillium grandiflorum	White Trillium	5	5			S5													√	
Trillium sp.	Trillium species														√	√				
Tsuga canadensis	Eastern Hemlock	7	3			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Tussilago farfara	Coltsfoot	*	3	-2	+	SE5		√	√	√	√	√	√	√	√	√	√	√	√	√
Typha angustifolia	Narrow-leaved Cattail	3	-5			S5						√	√		√	√	√			
Typha latifolia	Common Cattail	3	-5			S5		√	√	√	√	√			√			√	√	√
Ulmus americana	White Elm	3	-2			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Urtica dioica ssp. gracilis	American Stinging Nettle	2	-1			S5									√					
Verbascum thapsus	Common Mullein	*	5	-2	+	SE5									√					
Veronica americana	American Brooklime	6	-5			S5								√						
Veronica anagallis-aquatica	Water Speedwell	*	-5	-1	+	SE5		√					√	√				√	√	√
Veronica officinalis	Common Speedwell	*	5	-2	+	SE5				√	√		√	√	√		√		√	√
Veronica persica	Bird's-eye Speedwell	*	5	-1	+	SE4								√						
Veronica scutellata	Marsh Speedwell	7	-5			S5		√		√							√			
Veronica sp.	Speedwell species								√	√	√	√								
Viburnum trilobum	High-bush Cranberry	5	-3			S5		√			√	√	√		√	√		√	√	√
Viburnum opulus	Guelder-rose	*	0	-1	+	SE4								√	√		√	√	√	√
Vicia cracca	Tufted Vetch	*	5	-1	+	SE5													√	√
Viola sp.	Violet Species												√							
Vitis riparia	Riverbank Grape	0	-2			S5		√	√	√	√	√	√	√	√	√	√	√	√	√
Waldsteinia fragarioides	Barren Strawberry	5	5			S5			√			√	√							
Total					**51**		**14**	**96**	**109**	**108**	**117**	**123**	**138**	**146**	**146**	**135**	**141**	**127**	**136**	**152**

[1]MNRF 2021; [2]Dougan & Associates 2009

LEGEND	
Floristic Information	
CC	Coefficient of Conservatism
CW	Coefficient of Wetness
Weed	Weediness Index
+	non-native species
SRANK	
S3	Vulnerable
S4	Apparently Secure
S5	Secure
?	Uncertainty about rank
SE	Exotic species
Wellington Status	
R	Rare

APPENDIX II

Herbaceous Species Observed by Plot 2020

Vegetation Plot 001		MAMM1-3	Reed-canary Grass Graminoid Mineral Meadow Marsh					
Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)*
1	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	40	15	60
	Lycopus uniflorus	Northern Bugleweed	5	-5	0	3	1	60
	Galium trifidum	Three-petalled Bedstraw	5	-3	0	3	4	40
	Lythrum salicaria	Purple Loosestrife	*	-5	-3	2	1	20
	Carex stricta	Stiff Sedge	4	-5	0		5	40
	Equisetum arvense	Field Horsetail	0	0	0	3	3	40
	Cicuta bulbifera	Bulbous Water-hemlock	5	-5	0	15	4	60
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	3	2	40
2	*Carex lacustris*	Lake Sedge	5	-5	0		30	100
	Sium suave	Water Parsnip	4	-5	0	1	2	20
	Lycopus uniflorus	Northern Bugleweed	5	-5	0	10	5	60
	Cicuta bulbifera	Bulbous Water-hemlock	5	-5	0	12	3	60
	Galium sp.	Bedstraw species				4	0.5	40
	Bidens sp.	Beggers-ticks species				6	2	20
	Lysimachia thrysiflora	Tufted Loosestrife	7	-5	0	1	1	20
	Scutellaria galericulata	Common Skullcap	6	-5	0	20	5	20
3	*Lycopus uniflorus*	Northern Bugleweed	5	-5	0	15	10	60
	Dryopteris cristata	Crested Wood Fern	7	-5	0	3	3	20
	Impatiens capensis	Spotted Jewelweed	4	-3	0	6	2	60
	Solidago canadensis	Canada Goldenrod	1	3	0	5	3	40
	Carex lacustris	Lake Sedge	5	-5	0		1	100
	Poa palustris	Fowl Meadow Grass	5	-4	0		1	40
4	*Carex lacustris*	Lake Sedge	5	-5	0		5	100
	Galium sp.	Bedstraw species				1	1	40
5	*Carex lacustris*	Lake Sedge	5	-5	0		50	100
	Poa palustris	Fowl Meadow Grass	5	-4	0		2	40
	Impatiens capensis	Spotted Jewelweed	4	-3	0	14	5	60
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	6	15	40
	Equisetum arvense	Field Horsetail	0	0	0	2	2	40
	Solidago canadensis	Canada Goldenrod	1	3	0	2	2	40
	Taraxacum officinale	Common Dandelion	*	3	-2	1	2	20
	Cicuta bulbifera	Bulbous Water-hemlock	5	-5	0	9	1	60
	Grass sp.	Grass species					2	20
	Carex stricta	Stiff Sedge	4	-5	0		25	40
	Galium trifidum	Three-petalled Bedstraw	5	-3	0	1	4	40

Vegetation Plot 002		SWCO1-2	White Cedar - Conifer Organic Coniferous Swamp					
Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
1	*Caltha palustris*	Marsh Marigold	5	-5	0	7	15	100
	Symphyotrichum lateriflorum	Calico Aster	3	-2	0	1	1	20
	Impatiens capensis	Spotted Jewelweed	4	-3	0	1	1	100
2	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	9	5	100
	Onoclea sensibilis	Sensitive Fern	4	-3	0	3	3	20
	Thelypteris palustris	Marsh Fern	5	-4	0	1	2	20
	Caltha palustris	Marsh Marigold	5	-5	0	1	3	100
3	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	25	55	100
	Caltha palustris	Marsh Marigold	5	-5	0	1	1	100
4	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	8	5	100
	Scutellaria galericulata	Common Skullcap	6	-5	0	3	2	20
	Caltha palustris	Marsh Marigold	5	-5	0	1	1	100
5	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	1	1	100
	Maianthemum canadense	Canada Mayflower	5	0	0	3	1	20
	Caltha palustris	Marsh Marigold	5	-5	0	1	1	100
	Symphyotrichum novae-angliae	New England Aster	2	-3	0	1	1	20
	Epipactis helleborine	Helleborine	*	5	-2	1	1	20

Vegetation Plot 003		FODM6	Fresh-Moist Sugar Maple Deciduous Forest					
Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
1	*Matteuccia struthiopteris*	American Ostrich Fern	5	-3	0	4	15	100
	Solidago flexicaulis	Zig-zag Goldenrod	6	3	0	12	5	20
	Veronica officinalis	Common Speedwell	*	5	-2	1	0.5	20
	Symphyotrichum lateriflorum	Calico Aster	3	-2	0	2	1	20
2	*Matteuccia struthiopteris*	American Ostrich Fern	5	-3	0	9	40	100
	Taraxacum officinale	Common Dandelion	*	3	-2	1	1	20
3	*Matteuccia struthiopteris*	American Ostrich Fern	5	-3	0	5	5	100
4	*Matteuccia struthiopteris*	American Ostrich Fern	5	-3	0	4	15	100
	Arisaema triphyllum	Jack-in-the-pulpit	5	-2	0	2	1	20
5	*Matteuccia struthiopteris*	American Ostrich Fern	5	-3	0	2	4	100

Vegetation Plot 004		SWMM1-1	White Cedar - Hardwood Mineral Mixed Swamp					
Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
1	*Lysimachia thrysiflora*	Tufted Loosestrife	7	-5	0	6	4	40
	Onoclea sensibilis	Sensitive Fern	4	-3	0	1	1	80
2	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	1	2	40
	Maianthemum canadense	Canada Mayflower	5	0	0	1	1	20
	Dryopteris cristata	Crested Wood Fern	7	-5	0	1	1	40
	Onoclea sensibilis	Sensitive Fern	4	-3	0	1	1	80
	Dryopteris carthusiana	Spinulose Wood Fern	5	-2	0	1	1	20
	Bidens sp.	Beggars-ticks species				5	1	40
3	*Onoclea sensibilis*	Sensitive Fern	4	-3	0	10	15	80
	Thelypteris palustris	Marsh Fern	5	-4	0	14	20	60
	Lysimachia thrysiflora	Tufted Loosestrife	7	-5	0	5	5	40
	Dryopteris cristata	Crested Wood Fern	7	-5	0	1	2	40
	Leersia oryzoides	Rice Cutgrass	3	-5	0		1	40
4	*Carex lacustris*	Lake Sedge	5	-5	0		5	20
	Carex stipata	Awl-fruited Sedge	3	-5	0		1	20
	Galium tinctorium	Stiff Marsh Bedstraw	5	-5	0	30	15	20
	Calamagrostis canadensis	Canada Blue-joint	4	-5	0		2	20
	Impatiens capensis	Spotted Jewelweed	4	-3	0	6	6	40
	Onoclea sensibilis	Sensitive Fern	4	-3	0	3	5	80
	Thelypteris palustris	Marsh Fern	5	-4	0	7	15	60
	Cicuta maculata	Spotted Water Hemlock	6	-5	0	1	5	20
	Leersia oryzoides	Rice Cutgrass	3	-5	0		10	40
	Lycopus uniflorus	Northern Bugleweed	5	-5	0	6	6	20
	Bidens sp.	Beggars-ticks species				8	2	40
	Carex stricta	Stiff Sedge	4	-5	0		5	20
5	*Thelypteris palustris*	Marsh Fern	5	-4	0	3	6	60

Vegetation Plot 005		FOMM6	Fresh-Moist White Cedar Coniferous Forest					
Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
1	None							0
2	*None*							0
3	*None*							0
4	*None*							0
5	*None*							0

Vegetation Plot 006		MAMM1-3	Reed-canary Grass Graminoid Mineral Meadow Marsh					
Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
1	*Phleum pratense*	Timothy	*	3	-1		1	20
	Agrostis gigantea	Redtop	*	0	-2		10	100
	Bromus inermis ssp. *inermis*	Smooth Brome	*	5	-3		30	20
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	12	6	100
	Symphyotrichum novae-angliae	New England Aster	2	-3	0	6	4	80
	Tussilago farfara	Coltsfoot	*	3	-2	25	25	80
	Lotus corniculatus	Bird's-foot Trefoil	*	1	-2	35	25	100
	Solidago canadensis	Canada Goldenrod	1	3	0	11	11	100
	Asclepias syriaca	Common Milkweed	0	5	0	1	1	20
	Equisetum arvense	Field Horsetail	0	0	0	1	1	40
	Poa pratensis	Kentucky Blue Grass	0	1	0		1	80
2	*Lotus corniculatus*	Bird's-foot Trefoil	*	1	-2	5	15	100
	Elymus repens	Quack grass	*	3	-3		1	20
	Vicia cracca	Cow Vetch	*	5	-1	4	4	20
	Solidago altissima	Tall Goldenrod	1	3	0	2	2	20
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	15	10	100
	Euthamia graminifolia	Grass-leaved Goldenrod	2	-2	0	10	10	80
	Agrostis gigantea	Redtop	*	0	-2		1	100
	Tussilago farfara	Coltsfoot	*	3	-2	25	25	80
	Symphyotrichum novae-angliae	New England Aster	2	-3	0	5	5	80
	Galium mollugo	Bedstraw	*	5	-2	6	3	60
	Lolium pratense	Meadow Fescue	*	3	-1		5	80
	Equisetum arvense	Field Horsetail	0	0	0	6	4	40
	Taraxacum officinale	Common Dandelion	*	3	-2	1	2	60
	Solidago canadensis	Canada Goldenrod	1	3	0	7	5	100
	Poa pratensis	Kentucky Blue Grass	0	1	0		1	80
	Dactylis glomerata	Orchard Grass	*	3	-1		2	40
3	*Agrostis gigantea*	Redtop	*	0	-2		5	100
	Poa pratensis	Kentucky Blue Grass	0	1	0		1	80
	Lotus corniculatus	Bird's-foot Trefoil	*	1	-2	5	5	100
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	30	40	100
	Tussilago farfara	Coltsfoot	*	3	-2	30	30	80
	Symphyotrichum novae-angliae	New England Aster	2	-3	0	1	2	80
	Solidago canadensis	Canada Goldenrod	1	3	0	7	5	100
	Lolium pratense	Meadow Fescue	*	3	-1		6	80
	Ranunculus acris	Tall Buttercup	*	-2	-2	8	2	40
	Sonchus sp.	Sow-thistle species				3	1	60
	Euthamia graminifolia	Grass-leaved Goldenrod	2	-2	0	4	4	80
	Taraxacum officinale	Common Dandelion	*	3	-2	3	3	60
4	*Dactylis glomerata*	Orchard Grass	*	3	-1		10	40
	Symphyotrichum novae-angliae	New England Aster	2	-3	0	4	5	80
	Daucus carota	Queen Anne's Lace	*	5	-2	1	2	40
	Poa pratensis	Kentucky Blue Grass	0	1	0		2	80
	Agrostis gigantea	Redtop	*	0	-2		3	100
	Galium mollugo	Bedstraw	*	5	-2	4	5	60
	Euthamia graminifolia	Grass-leaved Goldenrod	2	-2	0	4	3	80
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	25	20	100
	Phalaris arundinacea	Reed Canary Grass	0	-4	0		3	40
	Lotus corniculatus	Bird's-foot Trefoil	*	1	-2	8	10	100
	Sonchus sp.	Sow-thistle species				4	4	60
	Geum sp.	Avens species				1	1	20
	Solidago canadensis	Canada Goldenrod	1	3	0	15	10	100
	Mentha arvensis	Common Mint	3	-3	0	1	1	20
	Ranunculus acris	Tall Buttercup	*	-2	-2	2	1	40
	Lolium pratense	Meadow Fescue	*	3	-1		3	80
5	*Cirsium arvense*	Canada Thistle	*	3	-1	2	2	20
	Daucus carota	Queen Anne's Lace	*	5	-2	2	2	40
	Solidago canadensis	Canada Goldenrod	1	3	0	20	15	100
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	8	8	100
	Euthamia graminifolia	Grass-leaved Goldenrod	2	-2	0	10	10	80
	Sonchus sp.	Sow-thistle species				1	1	60
	Galium mollugo	Bedstraw	*	5	-2	8	4	60
	Agrostis gigantea	Redtop	*	0	-2		3	100
	Tussilago farfara	Coltsfoot	*	3	-2	30	20	80
	Taraxacum officinale	Common Dandelion	*	3	-2	3	3	60
	Lotus corniculatus	Bird's-foot Trefoil	*	1	-2	5	5	100
	Lolium pratense	Meadow Fescue	*	3	-1		4	80
	Phalaris arundinacea	Reed Canary Grass	0	-4	0		2	40

Vegetation Plot 007		SWMM1-1	White Cedar - Hardwood Mineral Mixed Swamp					
Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
1	None							
2	*Ranunculus caricetorum*	Swamp Buttercup	5	-5	0	2	4	20
3	*Carex leptonervia*	Finely-nerved Sedge	5	0	0		10	40
	Aralia nudicaulis	Wild Sarsaparilla	4	3	0	15	30	60
	Dryopteris carthusiana	Spinulose Wood Fern	5	-2	0	1	5	20
	Scutellaria galericulata	Common Skullcap	6	-5	0	4	2	20
	Cystopteris bulbifera	Bulblet Fern	5	-2	0	2	5	20
	Maianthemum canadense	Canada Mayflower	5	0	0	1	1	60
4	*Equisetum arvense*	Field Horsetail	0	0	0	1	1	40
	Aralia nudicaulis	Wild Sarsaparilla	4	3	0	14	40	60
	Maianthemum canadense	Canada Mayflower	5	0	0	10	3	60
	Carex pedunculata	Peduncled Sedge	5	5	0		2	20
	Gymnocarpium dryopteris	Oak Fern	7	0	0	3	2	20
	Epipactis helleborine	Helleborine	*	5	-2	1	1	40
	Arisaema triphyllum	Jack-in-the-pulpit	5	-2	0	1	1	20
5	*Glyceria striata*	Fowl Manna Grass	3	-5	0		4	20
	Epipactis helleborine	Helleborine	*	5	-2	1	1	40
	Prunella vulgaris ssp. lanceolata	Selfheal	0	0	0	12	6	20
	Carex leptonervia	Finely-nerved Sedge	5	0	0		1	40
	Taraxacum officinale	Common Dandelion	*	3	-2	3	1	20
	Maianthemum canadense	Canada Mayflower	5	0	0	25	5	60
	Equisetum arvense	Field Horsetail	0	0	0	1	1	40
	Aralia nudicaulis	Wild Sarsaparilla	4	3	0	16	40	60

Vegetation Plot 008		SWMM1-1	White Cedar - Hardwood Mineral Mixed Swamp					
Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
1	*Tussilago farfara*	Coltsfoot	*	3	-2	20	10	20
	Ranunculus repens	Creeping Buttercup	0	-1	-1	25	70	40
	Mentha arvensis	Common Mint	3	-3	0	15	15	20
	Carex lacustris	Lake Sedge	5	-5	0		5	20
	Nasturtium officinale	Watercress	*	-5	-1	10	4	40
	Impatiens capensis	Spotted Jewelweed	4	-3	0	1	1	40
2	None							
3	*Impatiens capensis*	Spotted Jewelweed	4	-3	0	1	1	40
	Taraxacum officinale	Common Dandelion	*	3	-2	1	1	20
4	*None*							
5	*Nasturtium officinale*	Watercress	*	-5	-1	25	10	40
	Ranunculus repens	Creeping Buttercup	0	-1	-1	50	95	40
	Veronica anagallis-aquatica	Water Speedwell	*	-5	-1	2	4	20

Vegetation Plot 009		MASM1-1	Cattail Mineral Shallow Marsh					
Sub plot #	Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
1	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		50	100
	Typha latifolia	Cattail	3	-5	0		25	80
	Eupatorium maculatum	Spotted Joe-Pye Weed	3	-5	0	9	20	20
	Symphyotrichum puniceum	Purple Stemmed Aster	6	-5	0	3	3	60
	Equisetum arvense	Field Horsetail	0	0	0	3	4	60
2	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		45	100
	Typha latifolia	Cattail	3	-5	0		55	80
3	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		50	100
	Typha latifolia	Cattail	3	-5	0		30	80
	Lysimachia ciliata	Fringed Loosestrife	4	-3	0	10	10	60
	Equisetum arvense	Field Horsetail	0	0	0	1	1	60
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	8	8	60
4	*Phalaris arundinacea*	Reed Canary Grass	0	-4	0		80	100
	Symphyotrichum puniceum	Purple Stemmed Aster	6	-5	0	9	9	60
	Lysimachia ciliata	Fringed Loosestrife	4	-3	0	12	6	60
	Equisetum arvense	Field Horsetail	0	0	0	2	2	60
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	1	1	60
	Lycopus americanus	American Water-horehound	4	-5	0	1	1	20
5	*Symphyotrichum lanceolatum*	Panicled Aster	3	-3	0	1	1	60
	Phalaris arundinacea	Reed Canary Grass	0	-4	0		60	100
	Typha latifolia	Cattail	3	-5	0		30	80
	Lysimachia ciliata	Fringed Loosestrife	4	-3	0	1	2	60
	Symphyotrichum puniceum	Purple Stemmed Aster	6	-5	0	1	2	60

Vegetation Plot 016		SWDM3-2	Silver Maple Mineral Deciduous Swamp					
Sub plot #	**Scientific Name**	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
1	*Pilea sp.*	Clearweed species				30	5	80
	Boehmeria cylindrica	False Nettle	4	-5	0	4	8	40
	Thelypteris palustris	Marsh Fern	5	-4	0	7	5	20
	Phalaris arundinacea	Reed Canary Grass	0	-4	0		2	40
2	*Pilea* sp.	Clearweed species				2	0.5	80
	Bidens sp.	Beggars-ticks species				1	0.5	80
3	*Bidens* sp.	Beggars-ticks species				3	0.5	80
	Taraxacum officinale	Common Dandelion	*	3	-2	1	0.5	40
4	*Pilea* sp.	Clearweed species				2	1	80
	Bidens sp.	Beggars-ticks species				4	2	80
	Trifolium sp.	Clover species				1	0.5	20
	Lycopus uniflorus	Northern Bugleweed	5	-5	0	1	1	20
5	*Boehmeria cylindrica*	False Nettle	4	-5	0	2	8	40
	Pilea sp.	Clearweed species				200	85	80
	Phalaris arundinacea	Reed Canary Grass	0	-4	0		10	40
	Bidens sp.	Beggars-ticks species				6	2	80
	Taraxacum officinale	Common Dandelion	*	3	-2	1	2	40
	Scutellaria galericulata	Common Skullcap	6	-5	0	1	1	20

Vegetation Plot 018		SWDO2-2	Silver Maple Organic Deciduous Swamp					
Sub plot #	**Scientific Name**	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
1	*Caltha palustris*	Marsh Marigold	5	-5	0	20	7	100
	Solidago gigantea	Late Goldenrod	4	-3	0	12	15	40
2	*Caltha palustris*	Marsh Marigold	5	-5	0	7	40	100
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	4	4	40
	Symphyotrichum lateriflorum	Calico Aster	3	-2	0	2	4	20
	Onoclea sensibilis	Sensitive Fern	4	-3	0	3	2	80
	Mentha arvensis	Common Mint	3	-3	0	1	1	80
3	*Mentha arvensis*	Common Mint	3	-3	0	1	2	80
	Glyceria striata	Fowl Manna Grass	3	-5	0		20	40
	Caltha palustris	Marsh Marigold	5	-5	0	5	20	100
	Onoclea sensibilis	Sensitive Fern	4	-3	0	3	3	80
	Maianthemum stellatum	Star Flowered False Solomon's-seal	6	1	0	1	2	60
4	*Glyceria striata*	Fowl Manna Grass	3	-5	0		40	40
	Onoclea sensibilis	Sensitive Fern	4	-3	0	3	40	80
	Caltha palustris	Marsh Marigold	5	-5	0	2	10	100
	Solidago gigantea	Late Goldenrod	4	-3	0	5	5	40
	Equisetum arvense	Field Horsetail	0	0	0	1	1	20
	Maianthemum stellatum	Star Flowered False Solomon's-seal	6	1	0	8	8	60
	Mentha arvensis	Common Mint	3	-3	0	3	3	80
5	*Cicuta maculata*	Spotted Water Hemlock	6	-5	0	1	5	20
	Lycopus uniflorus	Northern Bugleweed	5	-5	0	7	4	20
	Solidago canadensis	Canada Goldenrod	1	3	0	1	2	20
	Symphyotrichum lanceolatum	Panicled Aster	3	-3	0	11	10	40
	Onoclea sensibilis	Sensitive Fern	4	-3	0	2	8	80
	Maianthemum stellatum	Star Flowered False Solomon's-seal	6	1	0	11	10	60
	Caltha palustris	Marsh Marigold	5	-5	0	3	5	100
	Mentha arvensis	Common Mint	3	-3	0	1	1	80

APPENDIX III
Herbaceous Species Observed by Subplot 2006 - 2020

Appendix III. Herbaceous Species Observed by Sub-Plot (2006 - 2020)

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-001	1	*Asclepias incarnata*	Swamp Milkweed								√	√				
		Calamagrostis canadensis	Canada Blue-joint		√	√	√	√	√		√	√				
		Carex aquatilis	Water Sedge				√		√	√	√	√				
		Carex lacustris	Lake Sedge	√									√	√	√	
		Carex stipata	Awl-fruited Sedge			√		√								
		Carex stricta	Tussock Sedge										√			√
		Carex sp.	Sedge species											√		
		Cicuta bulbifera	Bulbous Water-hemlock						√					√		√
		Cirsium arvense	Canada Thistle	√												
		Epilobium hirsutum	Hairy Willow-Herb											√		
		Epilobium species	Willow-Herb species								√	√				
		Equisetum arvense	Field Horsetail		√	√					√	√	√	√	√	√
		Equisetum pratense	Meadow Horsetail	√						√						
		Galium palustre	Marsh Bedstraw								√	√		√	√	
		Galium trifidum	Three-petalled Bedstraw													√
		Impatiens capensis	Spotted Jewelweed		√	√	√	√	√	√	√	√	√	√	√	√
		Lycopus americanus	American Water-horehound											√	√	
		Lycopus uniflorus	Northern Bugleweed					√	√				√			√
		Lysimachia thrysiflora	Tufted Loosestrife					√	√				√		√	
		Lythrum salicaria	Purple Loosestrife													√
		Phalaris arundinacea	Reed Canary Grass							√						
		Poa palustris	Fowl Meadow Grass								√	√				
		Poa pratensis	Kentucky Blue Grass											√		
			Grass species	√										√		
		Ranunculus abortivus	Kidney-leaf Buttercup											√		
		Scutellaria galericulata	Common Skullcap							√				√		
		Solidago canadensis	Canada Goldenrod	√										√		
		Solidago sp.	Goldenrod species			√										
		Symphyotrichum lanceolatum	Panicled Aster							√			√	√	√	√
		Symphyotrichum novae-angliae	New England Aster							√						
		Symphyotrichum sp.	Aster species		√	√	√									
		Taraxacum officinale	Common Dandelion											√		
		Veronica sp.	Speedwell species				√									
	2	*Asclepias incarnata*	Swamp Milkweed								√	√				
		Bidens sp.	Beggarticks species													√
		Calamagrostis canadensis	Canada Blue-joint	√	√											
		Carex aquatilis	Water Sedge				√		√	√	√	√				
		Carex lacustris	Lake Sedge			√	√							√	√	√
		Carex stipata	Awl-fruited Sedge	√	√											
		Carex utriculata	Beaked Sedge		√											
		Carex sp.	Sedge species											√		
		Cicuta bulbifera	Bulbous Water-hemlock					√	√	√			√	√		√
		Dryopteris cristata	Crested Wood Fern										√			
		Epilobium hirsutum	Hairy Willow-Herb							√	√	√				
		Epilobium leptophyllum	Narrow-leaved Willow-herb					√								
		Equisetum arvense	Field Horsetail		√						√	√			√	
		Equisetum pratense	Meadow Horsetail	√						√						
		Galium palustre	Marsh Bedstraw			√		√			√	√		√		
		Galium sp.	Bedstraw species													√
		Impatiens capensis	Spotted Jewelweed	√	√	√		√		√	√	√	√	√	√	
		Juncus sp.	Rush species	√												
		Lemna sp.	Duckweed species				√									
		Lycopus americanus	American Water-horehound											√	√	
		Lycopus uniflorus	Northern Bugleweed			√		√	√							√
		Lysimachia thrysiflora	Tufted Loosestrife					√		√					√	√
		Lythrum salicaria	Purple Loosestrife							√			√			
		Phalaris arundinacea	Reed Canary Grass						√	√					√	
			Grass species	√				√								
		Scutellaria galericulata	Common Skullcap													√
		Sium suave	Water Parsnip								√	√				√
		Solanum dulcamara	Bittersweet Nightshade	√												
		Solidago canadensis	Canada Goldenrod	√									√			
		Symphyotrichum lanceolatum	Panicled Aster										√			
	3	*Bidens frondosa*	Devil's Beggarticks							√						
		Calamagrostis canadensis	Canada Blue-joint	√	√											
		Carex aquatilis	Water Sedge						√		√	√				
		Carex lacustris	Lake Sedge	√		√	√				√	√	√	√	√	√
		Carex stipata	Awl-fruited Sedge	√												
		Carex utriculata	Beaked Sedge		√											
		Carex vulpinoidea	Fox Sedge								√	√				
		Cicuta bulbifera	Bulbous Water-hemlock							√						
		Cirsium sp.	Thistle species							√						
		Dryopteris clintoniana	Clinton's Wood Fern													
		Dryopteris cristata	Crested Wood Fern													√
		Epilobium hirsutum	Hairy Willow-Herb							√						
		Equisetum arvense	Field Horsetail								√	√				
		Equisetum pratense	Meadow Horsetail	√												
		Galium palustre	Marsh Bedstraw							√	√	√		√		
		Impatiens capensis	Spotted Jewelweed	√	√	√				√	√	√		√	√	√
		Lycopus americanus	American Water-horehound								√	√		√	√	
		Lycopus uniflorus	Northern Bugleweed		√			√		√			√			√
		Lysimachia terrestris	Swamp Candles							√						
		Lysimachia thrysiflora	Tufted Loosestrife		√											
		Phalaris arundinacea	Reed Canary Grass					√	√	√						
		Poa palustris	Fowl Meadow Grass													√
			Grass species	√												
		Scutellaria galericulata	Common Skullcap							√						
		Sium suave	Water Parsnip		√						√	√				
		Solanum dulcamara	Bitter Nightshade												√	
		Solidago canadensis	Canada Goldenrod	√							√	√	√		√	√
		Solidago sp.	Goldenrod species				√									
		Spirodela polyrhiza	Duckweed					√								
		Symphyotrichum lanceolatum	Panicled Aster							√						
		Symphyotrichum puniceum	Purple Stemmed Aster								√	√				
		Symphyotrichum sp.	Aster species				√									

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-001	4	*Asclepias incarnata*	Swamp Milkweed		√											
		Bidens frondosa	Devil's Beggarticks							√						
		Calamagrostis canadensis	Canada Blue-joint	√	√											
		Carex aquatilis	Water Sedge							√	√	√				
		Carex lacustris	Lake Sedge			√	√	√	√		√	√	√	√	√	√
		Carex stipata	Awl-fruited Sedge	√	√											
		Cicuta bulbifera	Bulbous Water-hemlock							√						
		Dryopteris cristata	Crested Wood Fern								√	√				
		Epilobium hirsutum	Hairy Willow-Herb							√						
		Equisetum arvense	Field Horsetail						√					√		
		Galium aparine	Cleavers											√		
		Galium palustre	Marsh Bedstraw					√		√	√	√				
		Galium sp.	Bedstraw species													√
		Impatiens capensis	Spotted Jewelweed	√	√			√		√	√	√	√	√	√	
		Leersia oryzoides	Rice Cutgrass	√												
		Lycopus americanus	American Water-horehound												√	
		Lycopus uniflorus	Northern Bugleweed		√			√	√	√						
		Lysimachia terrestris	Swamp Candles								√	√				
		Lysimachia thrysiflora	Tufted Loosestrife						√							
		Lythraceae	Loosestrife species													
		Scutellaria galericulata	Common Skullcap	√						√						
		Sium suave	Water Parsnip			√		√								
		Solanum dulcamara	Bitter Nightshade												√	
		Spirodela polyrhiza	Duckweed					√								
		Symphyotrichum lanceolatum	Panicled Aster								√	√				
		Symphyotrichum novae-angliae	New England Aster							√						
	5	*Asclepias incarnata*	Swamp Milkweed								√	√				
		Calamagrostis canadensis	Canada Blue-joint	√	√	√	√	√	√							
		Carex aquatilis	Water Sedge				√			√	√	√				
		Carex lacustris	Lake Sedge		√				√				√	√	√	√
		Carex stipata	Awl-fruited Sedge	√	√	√	√	√	√							
		Carex stricta	Stiff Sedge		√								√			√
		Carex sp.	Sedge species											√		
		Cicuta bulbifera	Bulbous Water-hemlock										√	√		√
		Cirsium arvense	Canada Thistle	√												
		Epilobium hirsutum	Hairy Willow-Herb										√			
		Equisetum arvense	Field Horsetail		√	√					√	√	√	√	√	√
		Equisetum palustre	Marsh Horsetail						√							
		Galium palustre	Marsh Bedstraw												√	
		Galium trifidum	Three-petalled Bedstraw													√
		Impatiens capensis	Spotted Jewelweed		√	√	√	√	√	√	√	√	√	√	√	√
		Lycopus americanus	American Water-horehound								√	√	√	√		
		Lysimachia terrestris	Swamp Candles							√					√	
		Lysimachia thrysiflora	Tufted Loosestrife					√	√							
		Phalaris arundinacea	Reed Canary Grass							√	√	√				
		Poa palustris	Fowl Meadow Grass													√
			Grass species													√
		Sium suave	Water Parsnip								√	√				
		Solidago altissima	Tall Goldenrod							√						
		Solidago canadensis	Canada Goldenrod	√									√		√	√
		Solidago sp.	Goldenrod species		√											
		Symphyotrichum lanceolatum	Panicled Aster							√				√		√
		Symphyotrichum sp.	Aster species		√											
		Taraxacum officinale	Common Dandelion										√			√
VEG-002	1	*Caltha palustris*	Marsh Marigold	√		√	√	√	√	√	√	√	√	√	√	√
		Circaea canadensis	Enchanter's Nightshade							√	√	√	√	√	√	
		Cirsium sp.	Thistle species							√	√	√				
		Epilobium hirsutum	Hairy Willow-Herb							√	√	√				
		Equisetum arvense	Field Horsetail								√	√				
		Equisetum palustre	Marsh Horsetail		√			√								
		Geum sp.	Avens species											√	√	
		Impatiens capensis	Spotted Jewelweed										√		√	√
		Lycopus americanus	American Water-horehound											√	√	
		Lycopus uniflorus	Northern Bugleweed					√	√	√						
		Scutellaria galericulata	Common Skullcap							√						
		Solidago altissima	Tall Goldenrod											√	√	
		Solidago canadensis	Canada Goldenrod								√	√				
		Symphyotrichum lateriflorum	Calico Aster													√
		Symphyotrichum novae-angliae	New England Aster								√	√				
		Symphyotrichum sp.	Aster species		√											
	2	*Caltha palustris*	Marsh Marigold	√				√	√				√	√	√	√
		Cirsium sp.	Thistle species							√	√	√				
		Cysptopteris tenuis	Mackay's Fragile Fern		√											
		Dryopteris carthusiana	Spinulose Wood Fern								√	√		√	√	
		Epipactis helleborine	Helleborine				√									
		Equisetum pratense	Meadow Horsetail	√				√		√						
		Fragaria vesca	Woodland Strawberry	√												
		Geum sp.	Avens species											√	√	
		Impatiens capensis	Spotted Jewelweed								√	√	√	√	√	√
		Lycopus uniflorus	Northern Bugleweed	√												
		Maianthemum canadense	Wild Lily-of-the-Valley	√	√	√	√			√						
		Onoclea sensibilis	Sensitive Fern					√	√							√
			Grass species		√											
		Solidago sp.	Goldenrod species		√			√								
		Taraxacum officinale	Common Dandelion		√	√				√						
		Thelypteris palustris	Marsh Fern					√								√
	3	*Caltha palustris*	Marsh Marigold	√	√		√	√		√						√
		Cirsium muticum	Swamp Thistle								√	√			√	
		Cirsium sp.	Thistle species							√						
		Epilobium hirsutum	Hairy Willow-Herb							√						
		Equisetum pratense	Meadow Horsetail	√												
		Eupatorium maculatum	Spotted Joe-Pye Weed											√	√	
		Eupatorium perfoliatum	Boneset								√	√				
		Glyceria striata	Fowl Manna Grass										√	√	√	
		Impatiens capensis	Spotted Jewelweed							√	√	√	√	√	√	√
		Lycopus uniflorus	Northern Bugleweed	√												
		Mitella nuda	Naked Miterwort							√						
		Pilea pumila	Clearweed								√	√			√	
		Scutellaria lateriflora	Mad-dog Skullcap							√			√			
		Taraxacum officinale	Common Dandelion										√	√	√	
	4	*Caltha palustris*	Marsh Marigold		√	√		√								√
		Epilobium hirsutum	Hairy Willow-Herb							√						
		Erigeron sp.	Fleabane species							√						
		Eupatorium maculatum	Spotted Joe-Pye Weed										√			
		Impatiens capensis	Spotted Jewelweed							√	√	√	√	√	√	√
		Maianthemum canadense	Canada Mayflower						√							
			Grass species						√							
		Scutellaria galericulata	Common Skullcap													√
		Scutellaria lateriflora	Mad-dog Skullcap							√						
		Solidago altissima	Tall Goldenrod											√	√	
		Solidago canadensis	Canada Goldenrod										√			
		Taraxacum officinale	Common Dandelion							√				√	√	

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-002	5	*Arctium sp.*	Burdock species							√						
		Bidens frondosa	Devil's Beggarticks							√						
		Caltha palustris	Marsh Marigold	√	√	√	√	√	√		√	√	√	√	√	√
		Circaea canadensis	Yellowish Enchanter's Nightshade										√		√	
		Circaea quadrisulcata	Enchanter's Nightshade											√		
		Cirsium sp.	Thistle species							√		√				
		Dryopteris carthusiana	Spinulose Wood Fern		√											
		Epipactis helleborine	Helleborine													√
		Eupatorium perfoliatum	Boneset								√	√			√	
		Geum sp.	Avens species											√	√	
		Impatiens capensis	Spotted Jewelweed							√	√	√	√	√	√	√
		Lycopus americanus	American Water-horehound								√	√				
		Lycopus uniflorus	Northern Bugleweed		√											
		Maianthemum canadense	Canada Mayflower	√		√		√	√							√
		Scutellaria lateriflora	Mad-dog Skullcap										√			
		Solidago altissima	Tall Goldenrod											√	√	
		Solidago sp.	Goldenrod species								√	√				
		Symphyotrichum novae-angliae	New England Aster													√
		Taraxacum officinale	Common Dandelion		√				√							
VEG-003	1	*Arisaema triphyllum*	Jack-in-the-pulpit				√	√	√				√			
		Circaea canadensis	Yellowish Enchanter's Nightshade								√	√				
		Circaea quadrisulcata	Enchanter's Nightshade						√							
		Glyceria striata	Fowl Manna Grass											√		
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√	√	√	√	√	√	√	√	√	√
		Solanum dulcamara	Bittersweet Nightshade	√												
		Solidago canadensis	Canada Goldenrod						√							
		Solidago flexicaulis	Zig-zag goldenrod						√					√	√	√
		Symphyotrichum lateriflorum	Calico Aster												√	√
		Taraxacum officinale	Common Dandelion						√	√					√	
		Thelypteris palustris	Marsh Fern			√										
		Trillium sp.	Trillium species								√	√				
		Veronica officinalis	Common Speedwell													√
	2	*Arisaema triphyllum*	Jack-in-the-pulpit						√					√		
		Dryopteris marginalis	Marginal Wood Fern							√						
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√	√	√	√	√	√	√	√	√	√
		Taraxacum officinale	Common Dandelion							√						√
	3	*Arisaema triphyllum*	Jack-in-the-pulpit				√	√		√					√	
		Circaea quadrisulcata	Enchanter's Nightshade							√						
		Dryopteris cristata	Crested Wood Fern						√							
		Dryopteris marginalis	Marginal Wood Fern				√									
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√		√	√	√	√	√	√	√	√
		Taraxacum officinale	Common Dandelion							√						
	4	*Arisaema triphyllum*	Jack-in-the-pulpit				√			√						√
		Dryopteris clintoniana	Clinton's Wood Fern		√											
		Dryopteris marginalis	Marginal Wood Fern				√			√						
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√	√	√	√	√	√		√	√	√
		Onoclea sensibilis	Sensitive Fern										√			
		Taraxacum officinale	Common Dandelion							√						
	5	*Arisaema triphyllum*	Jack-in-the-pulpit				√		√							
		Dryopteris clintoniana	Clinton's Wood Fern		√											
		Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√	√	√	√	√	√	√	√	√	√
		Trillium sp.	Trillium species								√	√				
VEG-004	1	*Asclepias incarnata*	Swamp Milkweed										√			
		Dryopteris clintoniana	Clinton's Wood Fern		√											
		Dryopteris cristata	Crested Wood Fern					√					√			
		Galium palustre	Marsh Bedstraw										√			
		Lysimachia thrysiflora	Tufted Loosestrife													√
		Onoclea sensibilis	Sensitive Fern								√	√	√		√	√
		Parthenocissus quinquefolia	Virginia Creeper	√												
		Bidens sp.	Beggarsticks species													√
	2	*Cicuta maculata*	Spotted Water hemlock		√											
		Circaea quadrisulcata	Enchanter's Nightshade		√			√								
		Cystopteris bulbifera	Bulblet Fern		√											
		Dryopteris carthusiana	Spinulose Wood Fern			√				√	√	√		√	√	√
		Dryopteris cristata	Crested Wood Fern													√
		Dryopteris marginalis	Marginal Wood Fern								√	√				
		Equisetum arvense	Field Horsetail		√											
		Equisetum pratense	Meadow Horsetail	√												
		Galium palustre	Marsh Bedstraw		√											
		Impatiens capensis	Spotted Jewelweed													√
		Maianthemum canadense	Wild Lily-of-the-Valley			√				√						√
		Onoclea sensibilis	Sensitive Fern	√	√	√		√	√	√	√	√			√	√
		Pilea pumila	Clearweed			√										
		Scirpus americanus	Common Three Square		√											
		Scutellaria lateriflora	Mad-dog Skullcap	√									√			
		Thelypteris palustris	Marsh Fern								√	√				
	3	*Asclepias incarnata*	Swamp Milkweed										√			
		Carex aquatilis	Water Sedge								√	√				
		Carex lacustris	Lake Sedge								√	√	√			
		Cystopteris bulbifera	Bulblet Fern		√											
		Dryopteris carthusiana	Spinulose Wood Fern	√				√	√	√				√	√	
		Dryopteris cristata	Crested Wood Fern			√	√	√	√					√	√	√
		Dryopteris marginalis	Marginal Wood Fern							√						
		Equisetum arvense	Field Horsetail		√											
		Equisetum pratense	Meadow Horsetail	√			√									
		Galium palustre	Marsh Bedstraw		√											
		Impatiens capensis	Spotted Jewelweed		√											
		Leersia oryzoides	Rice Cutgrass								√	√	√			√
		Lysimachia terrestris	Swamp Candles						√							
		Lysimachia thrysiflora	Tufted Loosestrife													√
		Maianthemum canadense	Canada Mayflower				√									
		Onoclea sensibilis	Sensitive Fern	√	√	√	√	√	√	√	√	√	√	√	√	√
		Osmunda cinnamomea	Cinnamon Fern										√			
			Grass species	√		√	√	√								
		Scirpus americanus	Common Three Square	√	√											
		Taraxacum officinale	Common Dandelion				√									
		Thelypteris palustris	Marsh Fern	√		√	√			√				√	√	√
		Tiarella cordifolia	Foam Flower		√											

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-004	4	*Bidens frondosa*	Devil's Beggarticks										√			
		Bidens sp.	Beggarsticks species													√
		Brachyelytrum erectum	Bearded Shorthusk											√	√	
		Calamagrostis canadensis	Canada Blue-joint													√
		Carex aquatilis	Water Sedge				√			√	√	√	√			
		Carex lacustris	Lake Sedge			√	√	√	√	√	√	√	√			√
		Carex leptalea	Bristle-stalked Sedge											√	√	
		Carex stipata	Awl-fruited Sedge											√	√	√
		Carex stricta	Stiff Sedge													√
		Cicuta maculata	Spotted Water hemlock		√				√					√	√	√
		Dryopteris carthusiana	Spinulose Wood Fern	√					√	√				√	√	
		Dryopteris clintoniana	Clinton's Wood Fern		√											
		Dryopteris cristata	Crested Wood Fern			√		√								
		Equisetum arvense	Field Horsetail		√	√										
		Equisetum pratense	Meadow Horsetail	√			√							√		
		Eupatorium maculatum	Spotted Joe-Pye Weed	√												
		Galium palustre	Marsh Bedstraw	√	√	√	√	√	√	√				√	√	
		Galium tinctorium	Stiff Marsh Bedstraw													√
		Impatiens capensis	Spotted Jewelweed		√		√	√		√			√			√
		Leersia oryzoides	Rice Cutgrass							√				√	√	√
		Lycopus uniflorus	Northern Bugleweed	√		√	√	√		√				√	√	√
		Lysimachia terrestris	Swamp Candles		√											
		Onoclea sensibilis	Sensitive Fern	√	√	√	√	√		√					√	√
		Parthenocissus quinquefolia	Virginia Creeper	√		√										
		Poa palustris	Fowl Meadow Grass								√	√		√	√	
			Grass species		√	√		√		√						
		Ranunculus sp.	Buttercup species						√							
		Rubus pubescens	Dwarf Raspberry					√								
		Scirpus americanus	Common Three Square	√	√	√										
		Scutellaria galericulata	Common Skullcap			√	√			√	√	√	√			
		Scutellaria lateriflora	Mad-dog Skullcap							√						
		Sium suave	Water Parsnip										√	√	√	
		Solidago rugosa	Rough-stemmed Goldenrod							√						
		Solanum dulcamara	Bittersweet Nightshade			√										
		Symphyotrichum racemosum	Small White Aster					√								
		Taraxacum officinale	Common Dandelion	√												
		Thelypteris noveboracensis	New York Fern		√											
		Thelypteris palustris	Marsh Fern	√		√	√			√				√	√	√
		Veronica scutellata	Marsh Speedwell	√				√								
	5	*Dryopteris carthusiana*	Spinulose Wood Fern						√		√	√				
		Onoclea sensibilis	Sensitive Fern						√					√		
		Thelypteris palustris	Marsh Fern							√						√
VEG-005	1	*Arisaema triphyllum*	Jack-in-the-pulpit		√											
		Athyrium filix-femina	Northeastern Lady Fern		√											
		Equisetum pratense	Meadow Horsetail	√	√		√	√		√						
	2	*Equisetum arvense*	Field Horsetail		√	√		√								
		Equisetum pratense	Meadow Horsetail							√						
		Maianthemum canadense	Wild Lily-of-the-Valley		√	√										
	3	*Equisetum arvense*	Field Horsetail		√						√	√				
		Equisetum pratense	Meadow Horsetail	√				√		√						
		Equisetum pratense	Meadow Horsetail													
	4	*Equisetum arvense*	Field Horsetail		√	√							√		√	
		Equisetum pratense	Meadow Horsetail	√			√			√						
		Maianthemum canadense	Canada Mayflower				√									
		Carex sp.	Sedge species										√			
			Grass species				√									
		Equisetum pratense	Meadow Horsetail													
	5		No species recorded to date													
VEG-006	1	Agrostis gigantea	Redtop													√
		Asclepias syriaca	Common Milkweed											√		√
		Bromus inermis ssp. inermis	Smooth Brome						√					√		√
		Calamagrostis canadensis	Canada Blue-joint								√	√				
		Carex blanda	Smooth Sedge								√	√				
		Carex stipata	Awl-fruited Sedge					√								
		Carex vulpinoidea	Fox Sedge		√		√		√	√	√	√				
		Cirsium arvense	Canada Thistle	√	√				√	√						
		Dactylis glomerata	Orchard Grass							√	√	√				
		Daucus carota	Queen Anne's Lace						√							
		Echinochloa crusgalli	Barnyard Grass				√	√								
		Epilobium hirsutum	Hairy Willow-Herb					√			√	√				
		Equisetum arvense	Field Horsetail		√	√	√		√		√	√				√
		Equisetum pratense	Meadow Horsetail							√						
		Euthamia graminifolia	Grass-leaved Goldenrod				√	√	√	√					√	
		Festuca arundinacea	Tall Fescue								√	√		√	√	
		Geum aleppicum	Yellow Avens											√		
		Juncus effusus	Soft Rush								√	√				
		Juncus tenuis	Path Rush	√					√	√	√	√				
		Lotus corniculatus	Bird's-foot Trefoil		√		√	√							√	√
		Mentha arvensis	Common Mint					√					√			
		Phalaris arundinacea	Reed Canary Grass								√	√				
		Phleum pratense	Timothy							√						√
		Poa pratensis	Kentucky Blue Grass			√		√		√	√	√				√
			Grass species	√	√											
		Scirpus atrovirens	Dark Green Bulrush						√							
		Solidago altissima	Tall Goldenrod	√					√	√			√		√	
		Solidago canadensis	Canada Goldenrod	√	√	√	√	√	√		√	√		√		√
		Symphyotrichum lanceolatum	Panicled Aster			√				√	√	√	√	√	√	√
		Symphyotrichum novae-angliae	New England Aster		√										√	√
		Symphyotrichum puniceum	Purple Stemmed Aster		√								√			
		Taraxacum officinale	Common Dandelion						√		√				√	
		Tussilago farfara	Coltsfoot	√	√	√	√	√	√	√	√	√	√	√	√	√

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-006	2	*Agrostis gigantea*	Redtop													√
		Asclepias syriaca	Common Milkweed										√			
		Bromus inermis ssp. inermis	Smooth Brome						√							
		Calamagrostis canadensis	Canada Blue-joint								√	√	√			
		Carex stipata	Awl-fruited Sedge	√												
		Carex trisperma var. trisperma	Three-seeded Sedge		√											
		Carex vulpinoidea	Fox Sedge				√	√	√	√						
		Cirsium arvense	Canada Thistle	√	√	√	√				√	√				
		Dactylis glomerata	Orchard Grass											√		√
		Daucus carota	Queen Anne's Lace					√		√						
		Echinochloa crusgalli	Barnyard Grass				√	√								
		Elymus repens	Quack Grass													√
		Epilobium hirsutum	Hairy Willow-Herb					√	√	√	√	√				
		Equisetum arvense	Field Horsetail		√	√			√		√	√				√
		Equisetum pratense	Meadow Horsetail							√						
		Euthamia graminifolia	Grass-leaved Goldenrod				√	√	√	√				√		√
		Festuca arundinacea	Tall Fescue								√	√	√	√		
		Galium mollugo	Smooth Bedstraw													√
		Galium palustre	Marsh Bedstraw				√									
		Hieracium pratense	King Devil Hawkweed			√										
		Juncus dudleyii	Dudley's Rush										√			
		Juncus tenuis	Path Rush				√	√	√	√	√	√		√		
		Lactuca serriola	Prickly Lettuce	√												
		Lolium pratense	Meadow Fescue													√
		Lotus corniculatus	Bird's-foot Trefoil			√		√		√	√	√				√
		Lycopus americanus	American Water-horehound								√	√				
		Medicago lupulina	Black Medick					√	√		√	√				
		Mentha arvensis	Common Mint			√		√	√	√	√	√				
		Phalaris arundinacea	Reed Canary Grass				√									
		Plantago major	Common Plantain						√							
		Poa pratensis	Kentucky Blue Grass		√	√					√	√				√
			Grass species	√												
		Potentilla recta	Sulphur Cinquefoil							√						
		Scirpus atrovirens	Dark Green Bulrush						√	√						
		Solidago altissima	Tall Goldenrod	√						√			√	√		√
		Solidago canadensis	Canada Goldenrod			√			√		√	√		√		√
		Symphyotrichum lanceolatum	Panicled Aster			√				√	√	√	√	√	√	√
		Symphyotrichum novae-angliae	New England Aster			√				√				√		√
		Symphyotrichum puniceum	Purple Stemmed Aster		√				√							
		Taraxacum officinale	Common Dandelion	√	√		√		√	√	√	√				√
		Trifolium hybridum	Alsike Clover					√								
		Trifolium repens	White Clover					√								
		Tussilago farfara	Coltsfoot	√	√	√	√	√	√		√	√	√	√	√	√
		Vicia cracca	Tufted Vetch													√
		Waldsteinia fragarioides	Barren Strawberry		√											
	3	*Agrostis gigantea*	Redtop											√		√
		Asclepias syriaca	Common Milkweed										√			
		Bromus inermis ssp. inermis	Smooth Brome						√				√			
		Calamagrostis canadensis	Canada Blue-joint								√	√				
		Carex stipata	Awl-fruited Sedge	√												
		Carex stricta	Stiff Sedge			√										
		Carex vulpinoidea	Fox Sedge			√		√			√	√				
		Cirsium arvense	Canada Thistle	√	√					√						
		Dactylis glomerata	Orchard Grass								√	√		√		
		Daucus carota	Queen Anne's Lace								√	√				
		Echinochloa crusgalli	Barnyard Grass				√	√								
		Eleocharis smallii	Small's Spike-Rush					√								
		Epilobium hirsutum	Hairy Willow-Herb				√	√			√	√				
		Equisetum arvense	Field Horsetail		√	√	√		√		√	√				
		Equisetum pratense	Meadow Horsetail	√												
		Euthamia graminifolia	Grass-leaved Goldenrod			√	√	√	√					√		√
		Festuca arundinacea	Tall Fescue								√	√	√	√	√	
		Galium palustre	Marsh Bedstraw						√							
		Geum aleppicum	Yellow Avens						√	√						
		Juncus effusus	Soft Rush								√	√				
		Juncus tenuis	Path Rush				√	√	√	√	√	√		√		
		Lolium pratense	Meadow Fescue													√
		Lotus corniculatus	Bird's-foot Trefoil	√	√	√		√								√
		Phalaris arundinacea	Reed Canary Grass				√				√	√				
		Phleum pratense	Timothy					√		√						
		Plantago major	Common Plantain					√								
		Poa palustris	Fowl Meadow Grass					√								
		Poa pratensis	Kentucky Blue Grass							√	√	√				√
			Grass species	√	√											
		Ranunculus acris	Tall Buttercup													√
		Scirpus atrovirens	Dark Green Bulrush			√										
		Solidago altissima	Tall Goldenrod	√						√			√	√	√	
		Solidago canadensis	Canada Goldenrod						√		√	√		√		√
		Sonchus sp.	Sow Thistle species													√
		Symphyotrichum lanceolatum	Panicled Aster			√				√			√	√	√	√
		Symphyotrichum novae-angliae	New England Aster							√				√		√
		Symphyotrichum puniceum	Purple Stemmed Aster		√				√							
		Taraxacum officinale	Common Dandelion		√		√	√		√	√	√				√
		Tussilago farfara	Coltsfoot	√	√	√	√		√	√	√	√	√	√	√	√
		Typha angustifolia	Narrow-leaved Cattail					√								
		Vicia cracca	Cow Vetch												√	
		Waldsteinia fragarioides	Barren Strawberry		√											

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-006	4	*Agrostis gigantea*	Redtop												√	√
		Asclepias syriaca	Common Milkweed										√			
		Bromus inermis ssp. inermis	Smooth Brome						√				√			
		Calamagrostis canadensis	Canada Blue-joint								√	√				
		Carex stipata	Awl-fruited Sedge						√							
		Carex vulpinoidea	Fox Sedge						√	√						
		Cirsium arvense	Canada Thistle	√	√						√	√				
		Dactylis glomerata	Orchard Grass								√	√		√		√
		Daucus carota	Queen Anne's Lace													
		Echinochloa crusgalli	Barnyard Grass					√								
		Eleocharis smallii	Small's Spike-Rush		√											
		Epilobium hirsutum	Hairy Willow-Herb				√	√	√	√	√	√				
		Equisetum arvense	Field Horsetail		√			√	√		√	√				
		Equisetum pratense	Meadow Horsetail	√						√						
		Euthamia graminifolia	Grass-leaved Goldenrod			√	√	√	√	√						√
		Festuca arundinacea	Tall Fescue								√	√		√	√	
		Galium mollugo	Smooth Bedstraw													√
		Galium palustre	Marsh Bedstraw						√						√	
		Geum aleppicum	Yellow Avens								√	√		√		
		Geum sp.	Avens species													√
		Juncus tenuis	Path Rush				√		√		√	√				
		Lactuca serriola	Prickly Lettuce	√												
		Lotus corniculatus	Bird's-foot Trefoil	√	√	√				√	√	√		√	√	√
		Lolium pratense	Meadow Fescue													√
		Lycopus americanus	American Water-horehound												√	
		Medicago lupulina	Black Medick					√			√	√				
		Mentha arvensis	Common Mint							√						√
		Phalaris arundinacea	Reed Canary Grass				√									√
		Plantago major	Common Plantain					√								
		Poa pratensis	Kentucky Blue Grass					√			√	√				√
			Grass species	√	√	√			√							
		Ranunculus acris	Tall Buttercup													√
		Scirpus atrovirens	Dark Green Bulrush						√							
		Sonchus arvensis	Field Sow Thistle												√	
		Solidago altissima	Tall Goldenrod	√									√		√	
		Solidago canadensis	Canada Goldenrod	√	√						√	√		√		√
		Sonchus sp.	Sow Thistle species													√
		Symphyotrichum lanceolatum	Panicled Aster							√			√	√	√	√
		Symphyotrichum novae-angliae	New England Aster							√						√
		Symphyotrichum puniceum	Purple Stemmed Aster		√				√				√			
		Taraxacum officinale	Common Dandelion					√	√	√	√	√	√			
		Trifolium hybridum	Alsike Clover	√				√								
		Tussilago farfara	Coltsfoot	√	√	√	√				√	√	√	√	√	
		Typha angustifolia	Narrow-leaved Cattail					√								
		Typha latifolia	Common Cattail				√									
		Vicia cracca	Cow Vetch												√	
	5	*Agrostis gigantea*	Redtop											√		√
		Bromus inermis ssp. inermis	Smooth Brome						√				√	√		
		Calamagrostis canadensis	Canada Blue-joint								√	√				
		Carex blanda	Smooth Sedge								√	√				
		Carex flava	Yellow Sedge								√	√				
		Carex gracillima	Graceful Sedge												√	
		Carex sp.	Sedge species						√							
		Carex stricta	Stiff Sedge				√				√	√				
		Carex trisperma var. trisperma	Three-seeded Sedge		√											
		Carex vulpinoidea	Fox Sedge				√		√		√	√				
		Cerastium fontanum	Mouse-eared Chickweed								√	√				
		Cirsium arvense	Canada Thistle	√		√										√
		Dactylis glomerata	Orchard Grass							√	√	√				
		Daucus carota	Queen Anne's Lace							√	√	√				√
		Echinochloa crusgalli	Barnyard Grass				√	√								
		Eleocharis smallii	Small's Spike-Rush					√								
		Epilobium hirsutum	Hairy Willow-Herb					√			√	√				
		Epipactis helleborine	Helleborine							√						
		Equisetum arvense	Field Horsetail		√	√	√	√	√		√	√			√	
		Equisetum pratense	Meadow Horsetail							√						
		Erigeron philadelphicus	Philadelphia Fleabane		√											
		Euthamia graminifolia	Grass-leaved Goldenrod				√	√	√	√	√	√			√	√
		Festuca arundinacea	Tall Fescue								√	√	√	√	√	
		Galium mollugo	Smooth Bedstraw													√
		Geum aleppicum	Yellow Avens											√		
		Juncus tenuis	Path Rush			√		√	√	√	√	√		√		
		Lolium pratense	Meadow Fescue													√
		Lotus corniculatus	Bird's-foot Trefoil		√		√	√							√	√
		Medicago lupulina	Black Medick						√		√	√				
		Phalaris arundinacea	Reed Canary Grass				√									√
		Phleum pratense	Timothy			√										
		Poa pratensis	Kentucky Blue Grass			√		√	√	√	√	√				
			Grass species	√	√				√							
		Scirpus atrovirens	Dark Green Bulrush					√	√							
		Solidago altissima	Tall Goldenrod	√					√	√	√	√	√	√	√	
		Solidago canadensis	Canada Goldenrod	√	√	√			√		√	√		√		√
		Solidago rugosa	Rough-stemmed Goldenrod											√		
		Sonchus arvensis	Field Sow thistle					√								
		Sonchus sp.	Sow Thistle species													√
		Symphyotrichum lanceolatum	Panicled Aster			√				√	√	√		√	√	√
		Symphyotrichum novae-angliae	New England Aster		√									√		
		Symphyotrichum puniceum	Purple Stemmed Aster		√								√			
		Taraxacum officinale	Common Dandelion					√	√		√	√			√	√
		Tussilago farfara	Coltsfoot	√	√	√	√	√	√	√	√	√	√	√	√	√
VEG-007	1	*Aralia nudicaulis*	Wild Sarsaparilla			√	√	√			√	√			√	
		Arisaema triphyllum	Jack-in-the-pulpit				√									
		Carex laxiflora	Loose-flowered Sedge								√	√				
		Carex sp.	Sedge species						√							
		Cicuta maculata	Spotted Water hemlock	√	√					√			√	√	√	
		Circaea quadrisulcata	Enchanter's Nightshade		√		√									
		Cystopteris bulbifera	Bulblet Fern				√		√							
		Dryopteris carthusiana	Spinulose Wood Fern		√								√			
		Geum sp.	Avens species								√	√				
		Impatiens capensis	Spotted Jewelweed		√					√						
		Impatiens pallida	Pale Jewelweed						√							
		Lycopus americanus	American Water-horehound	√												
		Ranunculus caricetorum	Swamp Buttercup	√												
		Scutellaria lateriflora	Mad-dog Skullcap	√										√		
		Taraxacum officinale	Common Dandelion		√										√	
		Thelypteris palustris	Marsh Fern	√												
		Veronica americana	American Brooklime							√						

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-007	2	*Alisma plantago*	Water Plantain			√										
		Aralia nudicaulis	Wild Sarsaparilla				√									
		Arisaema triphyllum	Jack-in-the-pulpit								√	√	√			
		Bidens frondosa	Devil's Beggarticks										√			
		Carex laxiflora	Loose-flowered Sedge								√	√				
		Caltha palustris	Marsh Marigold	√												
		Cicuta maculata	Spotted Water hemlock	√	√		√	√		√	√	√	√	√	√	
		Circaea alpina	Dwarf Enchanter's Nightshade				√									
		Circaea canadensis	Enchanter's Nightshade	√	√				√							
		Cystopteris bulbifera	Bulblet Fern				√		√		√	√	√			
		Dryopteris carthusiana	Spinulose Wood Fern	√				√					√			
		Fragaria vesca	Woodland Strawberry								√	√				
		Hydrocotyle americana	Marsh-Water Pennywort	√			√	√					√		√	
		Hydrophyllum virginianum	Virginia Waterleaf			√										
		Impatiens capensis	Spotted Jewelweed	√	√	√	√	√		√	√	√	√		√	
		Lycopus uniflorus	Northern Bugleweed			√	√									
		Lythraceae sp.	Loosestrife species			√										
		Maianthemum canadense	Canada Mayflower	√					√							
		Mitella nuda	Naked Miterwort								√	√				
		Parthenocissus quinquefolia	Virginia Creeper	√												
			Grass species		√											
		Polystichum acrostichoides	Christmas Fern	√												
		Prunella vulgaris ssp. lanceolata	Selfheal								√	√	√		√	
		Ranunculus caricetorum	Swamp Buttercup							√					√	√
		Scutellaria galericulata	Common Skullcap						√							
		Scutellaria lateriflora	Mad-dog Skullcap					√						√	√	
		Stachys sp.	Hedge Nettle species							√						
		Taraxacum officinale	Common Dandelion						√							
		Thelypteris palustris	Marsh Fern	√												
		Trientalis borealis	Starflower	√					√							
		Veronica americana	American Brooklime							√						
		Veronica officinalis	Common Speedwell			√		√								
		Viola sp.	Violet Species						√							
			Fern species						√							
	3	*Aralia nudicaulis*	Wild Sarsaparilla		√	√	√	√	√	√	√	√	√	√	√	√
		Arisaema triphyllum	Jack-in-the-pulpit			√	√	√								
		Carex blanda	Smooth Sedge							√						
		Carex gracillima	Graceful Sedge					√								
		Carex laxiflora	Loose-flowered Sedge				√						√		√	
		Carex leptonervia	Finely-nerved Sedge													√
		Clintonia borealis	Bluebead lily		√			√								
		Cystopteris bulbifera	Bulblet Fern		√					√	√	√			√	√
		Dryopteris carthusiana	Spinulose Wood Fern					√			√	√	√	√	√	√
		Dryopteris intermedia	Intermediate Wood Fern										√			
		Dryopteris marginalis	Marginal Wood Fern				√									
		Impatiens capensis	Spotted Jewelweed	√							√	√	√	√		
		Impatiens pallida	Pale Jewelweed						√							
		Maianthemum canadense	Canada Mayflower		√			√	√				√	√	√	√
		Matteuccia struthiopteris	American Ostrich Fern											√		
		Mitella nuda	Naked Miterwort								√	√				
		Osmunda cinnamomea	Cinnamon Fern								√	√				
			Grass species		√											
		Scutellaria galericulata	Common Skullcap								√	√				√
		Scutellaria lateriflora	Mad-dog Skullcap										√		√	
		Taraxacum officinale	Common Dandelion						√						√	
		Trientalis borealis	Starflower						√		√	√		√	√	
	4	*Aralia nudicaulis*	Wild Sarsaparilla	√	√	√	√	√	√		√	√	√	√	√	√
		Arisaema triphyllum	Jack-in-the-pulpit	√		√										√
		Carex laxiflora	Loose-flowered Sedge								√	√		√		
		Carex pedunculata	Long-stalked Sedge													√
		Carex pensylvanica	Pennsylvania Sedge										√			
		Carex sp.	Sedge species							√	√	√				
		Cystopteris bulbifera	Bulblet Fern						√		√	√				
		Dryopteris carthusiana	Spinulose Wood Fern	√	√								√	√		
		Epipactis helleborine	Helleborine				√	√		√						√
		Equisetum arvense	Field Horsetail													√
		Fragaria virginiana	Wild Strawberry						√							
		Gymnocarpium dryopteris	Oak Fern				√			√						√
		Impatiens capensis	Spotted Jewelweed								√	√				
		Impatiens pallida	Pale Jewelweed						√							
		Maianthemum canadense	Wild Lily-of-the-Valley		√		√	√		√			√	√	√	√
		Maianthemum stellatum	Star Flowered False Solomon's-seal			√										
			Grass species		√		√		√							
		Prunella vulgaris ssp. lanceolata	Selfheal						√							
		Taraxacum officinale	Common Dandelion					√								
		Thelypteris palustris	Marsh Fern	√												
		Trientalis borealis	Starflower						√		√	√		√		
	5	*Aralia nudicaulis*	Wild Sarsaparilla	√	√	√	√	√	√	√	√	√	√	√	√	√
		Arisaema triphyllum	Jack-in-the-pulpit		√											
		Carex sp.	Sedge species		√	√		√								
		Carex laxiflora	Loose-flowered Sedge								√	√		√		
		Carex leptonervia	Finely-nerved Sedge													√
		Carex gracillima	Graceful Sedge										√			
		Circaea canadensis	Enchanter's Nightshade	√	√											
		Cystopteris bulbifera	Bulblet Fern				√		√		√	√		√		
		Dryopteris carthusiana	Spinulose Wood Fern		√			√		√	√	√	√			
		Dryopteris clintoniana	Clinton's Wood Fern		√											
		Dryopteris intermedia	Intermediate Wood Fern										√			
		Epipactis helleborine	Helleborine				√	√								√
		Equisetum arvense	Field Horsetail													√
		Equisetum pratense	Meadow Horsetail													
		Fragaria virginiana	Wild Strawberry						√							
		Glyceria striata	Fowl Manna Grass							√			√		√	√
		Impatiens pallida	Pale Jewelweed						√							
		Maianthemum canadense	Canada Mayflower	√	√	√	√	√	√	√	√	√	√	√	√	√
		Maianthemum racemosum	False Solomon's seal		√	√			√							
		Maianthemum stellatum	Star Flowered False Solomon's-seal			√	√	√								
		Polygonatum pubescens	Hairy Solomon's Seal											√		
		Prunella vulgaris ssp. lanceolata	Selfheal										√	√	√	√
		Taraxacum officinale	Common Dandelion	√						√			√		√	√
		Thelypteris palustris	Marsh Fern	√												
		Tiarella cordifolia	Foam Flower					√					√			
		Trientalis borealis	Starflower		√						√	√			√	
		Veronica officinalis	Common Speedwell												√	

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-008	1	*Bidens frondosa*	Devil's beggarticks								√	√				
		Caltha palustris	Marsh Marigold							√						
		Carex lacustris	Lake Sedge								√	√				√
		Carex stipata	Awl-fruited Sedge				√									
		Echinochloa crusgalli	Barnyard Grass				√									
		Eupatorium maculatum	Spotted Joe-Pye Weed				√									
		Galium palustre	Marsh Bedstraw				√	√								
		Geranium robertianum	Herb Robert	√												
		Glyceria striata	Fowl Manna Grass							√	√	√				
		Impatiens capensis	Spotted Jewelweed	√			√	√		√			√			√
		Leersia oryzoides	Rice Cutgrass										√	√		
		Lobelia siphilitica	Great Lobelia							√						
		Lysimachia nummularia	Moneywort		√											
		Lysimachia thrysiflora	Tufted Loosestrife		√											
		Mentha arvensis	Common Mint				√	√			√	√	√	√	√	√
		Mentha X piperita	Pepper Mint							√						
		Nasturtium officinale	Watercress							√	√	√				√
		Poa nemoralis	Wood Bluegrass				√									
		Poa palustris	Fowl Meadow Grass					√		√						
			Grass species		√			√								
		Polygonum sp.									√	√				
		Ranunculus acris	Tall Buttercup				√									
		Ranunculus repens	Creeping Buttercup					√		√			√			√
		Solidago canadensis	Canada Goldenrod										√	√		
		Symphyotrichum puniceum	Purple Stemmed Aster				√	√		√					√	
		Tussilago farfara	Coltsfoot							√	√	√	√	√	√	√
	2	*Dryopteris carthusiana*	Spinulose Wood Fern			√										
		Daucus carota	Queen Anne's Lace												√	
		Geranium robertianum	Herb Robert		√	√										
		Solidago canadensis	Canada Goldenrod						√							
		Taraxacum officinale	Common Dandelion				√	√					√	√		
	3	*Caltha palustris*	Marsh Marigold						√							
		Cystopteris bulbifera	Bulblet Fern				√				√	√				
		Fragaria vesca	Woodland Strawberry			√										
		Impatiens capensis	Spotted Jewelweed													√
		Lactuca serriola	Prickly Lettuce				√									
		Leersia oryzoides	Rice Cutgrass						√							
		Mentha X piperita	Pepper Mint							√						
		Nasturtium officinale	Watercress						√							
			Grass species						√							
		Polygonum amphibium	Water Smartweed						√							
		Ranunculus flabellaris	Yellow Water-crowfoot						√							
		Scutellaria galericulata	Common Skullcap						√							
		Solidago canadensis	Canada Goldenrod										√	√		
		Taraxacum officinale	Common Dandelion				√		√							√
		Tussilago farfara	Coltsfoot				√			√	√	√	√	√	√	
		Veronica anagallis-aquatica	Water Speedwell						√							
	4	*Galium palustre*	Marsh Bedstraw						√							
		Geum laciniatum	Rough Avens						√							
			Grass species		√				√							
		Ranunculus flabellaris	Yellow Water-crowfoot						√							
		Scirpus americanus	Common Three Square	√												
		Solidago canadensis	Canada Goldenrod						√							
		Taraxacum officinale	Common Dandelion	√	√											
		Tussilago farfara	Coltsfoot						√		√	√				
	5	*Caltha palustris*	Marsh Marigold	√		√			√							
		Carex aquatilis	Water Sedge				√									
		Carex lacustris	Lake Sedge			√										
		Daucus carota	Queen Anne's Lace												√	
		Eupatorium maculatum	Spotted Joe-Pye Weed												√	
		Galium palustre	Marsh Bedstraw				√									
		Impatiens capensis	Spotted Jewelweed	√	√					√			√		√	
		Leersia oryzoides	Rice Cutgrass				√									
		Lycopus uniflorus	Northern Bugleweed			√										
		Mentha arvensis	Common Mint	√	√		√	√						√	√	
		Mentha X piperita	Pepper Mint							√						
		Nasturtium officinale	Watercress					√	√	√	√	√	√	√	√	√
		Phalaris arundinacea	Reed Canary Grass										√			
		Poa nemoralis	Wood Bluegrass				√									
			Grass species		√			√								
		Ranunculus acris	Tall Buttercup				√									
		Ranunculus flabellaris	Yellow Water-crowfoot			√										
		Ranunculus caricetorum	Swamp Buttercup												√	
		Ranunculus repens	Creeping Buttercup					√		√	√	√	√	√		√
		Symphyotrichum lanceolatum	Tall White Aster	√												
		Symphyotrichum lateriflorum	Calico Aster												√	
		Symphyotrichum puniceum	Purple Stemmed Aster				√									
		Taraxacum officinale	Common Dandelion	√				√								
		Tussilago farfara	Coltsfoot		√									√	√	
		Veronica anagallis-aquatica	Water Speedwell						√				√	√		√
		Veronica officinalis	Common Speedwell			√										
		Waldsteinia fragarioides	Barren Strawberry		√											
VEG-009	1	*Carex stipata*	Awl-fruited Sedge							√						
		Circaea canadensis	Enchanter's Nightshade		√											
		Cirsium arvense	Canada Thistle							√						
		Equisetum arvense	Field Horsetail								√	√				√
		Equisetum palustre	Marsh Horsetail		√											
		Equisetum pratense	Meadow Horsetail							√						
		Eupatorium maculatum	Spotted Joe-Pye Weed								√	√	√			√
		Galium palustre	Marsh Bedstraw						√							
		Lysimachia ciliata	Fringed Loosestrife			√		√	√							
		Mentha arvensis	Common Mint		√				√	√						
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√	√	√	√
		Scirpus atrovirens	Dark Green Bulrush							√						
		Symphyotrichum novae-angliae	New England Aster		√			√	√							
		Symphyotrichum puniceum	Purple Stemmed Aster													√
		Typha angustifolia	Narrow-leaved Cattail					√	√	√	√	√	√			
		Typha latifolia	Cattail											√	√	√
	2	*Carex sp.*	Sedge species			√										
		Carex stipata	Awl-fruited Sedge				√									
		Circaea canadensis	Enchanter's Nightshade		√											
		Equisetum arvense	Field Horsetail								√	√				
		Equisetum pratense	Meadow Horsetail							√						
		Mentha arvensis	Common Mint					√	√							
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√	√	√	√
		Poa palustris	Fowl Meadow Grass										√			
		Symphyotrichum lanceolatum	Panicled Aster										√			
		Typha angustifolia	Narrow-leaved Cattail					√	√	√	√	√				
		Typha latifolia	Common Cattail		√		√						√	√	√	√

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-009	3	*Carex stipata*	Awl-fruited Sedge				√									
		Equisetum arvense	Field Horsetail								√	√				√
		Equisetum palustre	Marsh Horsetail		√											
		Eupatorium maculatum	Spotted Joe-Pye Weed										√			
		Euthamia graminifolia	Grass-leaved Goldenrod					√								
		Lysimachia ciliata	Fringed Loosestrife			√			√							√
		Mentha arvensis	Common Mint				√									
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√	√	√	√
		Ranunculus acris	Tall Buttercup					√	√							
		Solanum dulcamara	Bittersweet Nightshade											√		
		Solidago canadensis	Canada Goldenrod				√	√								
		Sonchus arvensis	Field Sow thistle			√										
		Symphyotrichum lanceolatum	Panicled Aster										√			√
		Symphyotrichum novae-angliae	New England Aster						√							
		Symphyotrichum puniceum	Purple Stemmed Aster										√			
		Taraxacum officinale	Common Dandelion				√									
		Tussilago farfara	Coltsfoot				√									
		Typha angustifolia	Narrow-leaved Cattail						√	√	√	√				
		Typha latifolia	Common Cattail		√										√	√
	4	*Arabis glabra*	Tower-mustard			√										
		Carex sp.	Sedge species			√										
		Carex stipata	Awl-fruited Sedge		√		√	√								
		Circaea canadensis	Enchanter's Nightshade		√											
		Equisetum arvense	Field Horsetail													√
		Eupatorium maculatum	Spotted Joe-Pye Weed								√	√				
		Euthamia graminifolia	Grass-leaved Goldenrod			√		√	√	√						
		Lycopus americanus	American Water-horehound													√
		Lysimachia ciliata	Fringed Loosestrife			√	√	√		√	√	√	√			√
		Mentha arvensis	Common Mint				√	√	√							
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√	√	√	√
		Poa palustris	Fowl Meadow Grass					√								
		Scutellaria lateriflora	Mad-dog Skullcap					√								
		Solidago canadensis	Canada Goldenrod						√							
		Symphyotrichum lanceolatum	Panicled Aster							√	√	√	√			√
		Symphyotrichum novae-angliae	New England Aster						√	√						
		Symphyotrichum puniceum	Purple Stemmed Aster		√											√
		Tussilago farfara	Coltsfoot						√							
		Typha angustifolia	Narrow-leaved Cattail							√						
		Typha latifolia	Common Cattail		√		√	√			√	√			√	
	5	*Equisetum arvense*	Field Horsetail			√							√	√		
		Equisetum sp.	Horsetail species						√							
		Galium palustre	Marsh Bedstraw					√								
		Lycopus uniflorus	Northern Bugleweed					√								
		Lysimachia ciliata	Fringed Loosestrife					√								√
		Mentha arvensis	Common Mint					√	√		√	√	√			
		Phalaris arundinacea	Reed Canary Grass		√	√	√	√	√	√	√	√	√	√	√	√
		Solidago canadensis	Canada Goldenrod								√	√				
		Symphyotrichum lanceolatum	Panicled Aster													√
		Symphyotrichum puniceum	Purple Stemmed Aster								√	√	√		√	√
		Typha angustifolia	Narrow-leaved Cattail					√	√	√						
		Typha latifolia	Common Cattail				√				√	√	√		√	√
VEG-016	1	*Boehmeria cylindrica*	False Nettle							√						√
		Carex lupulina	Hop Sedge							√	√	√				
		Carex sp.	Sedge species						√							
		Cicuta maculata	Spotted Water Hemlock							√						
		Circaea canadensis	Enchanter's Nightshade												√	
		Geum laciniatum	Rough Avens												√	
		Heracleum lanatum	Cow Parsnip							√						
		<aianthemum racemosum	False Solomon's Seal												√	
		Onoclea sensibilis	Sensitive Fern						√	√	√	√		√		
		Phalaris arundinacea	Reed Canary Grass							√						√
		Pilea sp.	Clearweed species													√
		Thelypteris palustris	Marsh Fern						√	√				√		√
	2	*Bidens* sp.	Beggarticks species													√
		Boehmeria cylindrica	False Nettle							√						
		Cicuta maculata	Spotted Water Hemlock							√					√	
		Impatiens capensis	Spotted Jewelweed										√			
		Geum laciniatum	Rough Avens											√		
		Onoclea sensibilis	Sensitive Fern										√			
		Pilea sp.	Clearweed species													√
		Phalaris arundinacea	Reed Canary Grass						√	√						
		Taraxacum officinale	Common Dandelion							√						
		Thelypteris palustris	Marsh Fern						√	√				√		
	3	*Bidens* sp.	Beggarticks species													√
		Cicuta maculata	Spotted Water Hemlock							√						
		Onoclea sensibilis	Sensitive Fern						√							
		Scutellaria galericulata	Common Skullcap						√							
		Taraxacum officinale	Common Dandelion													√
		Thelypteris palustris	Marsh Fern							√						
	4	*Bidens* sp.	Beggarticks species													√
		Boehmeria cylindrica	False Nettle							√						
		Carex lupulina	Hop Sedge											√	√	
		Cicuta maculata	Spotted Water Hemlock							√						
		Circaea canadensis	Enchanter's Nightshade												√	
		Geum laciniatum	Rough Avens												√	
		Impatiens capensis	Spotted Jewelweed							√						
		Lycopus uniflorus	Northern Bugleweed													√
		Mentha arvensis	Common Mint											√		
		Onoclea sensibilis	Sensitive Fern						√	√	√				√	
		Phalaris arundinacea	Reed Canary Grass						√	√	√	√	√	√		
		Pilea sp.	Clearweed species													√
		Sium suave	Water Parsnip						√							
		Trifolium sp.	Clover species													√
	5	*Bidens* sp.	Beggarticks species													√
		Boehmeria cylindrica	False Nettle							√						√
		Carex lupulina	Hop sedge							√	√	√				
		Carex sp.	Sedge species						√							
		Cicuta maculata	Spotted Water Hemlock							√						
		Circaea canadensis	Enchanter's Nightshade												√	
		Onoclea sensibilis	Sensitive Fern							√					√	
		Phalaris arundinacea	Reed Canary Grass						√							√
		Pilea sp.	Clearweed species													√
		Scutellaria galericulata	Common Skullcap						√							√
		Taraxacum officinale	Common Dandelion												√	√
		Thelypteris palustris	Marsh Fern						√	√	√	√				
VEG-018	1	*Caltha palustris*	Marsh Marigold						√	√	√	√	√	√	√	√
		Equisetum pratense	Meadow Horsetail						√	√			√			
		Glyceria striata	Fowl Manna Grass								√	√	√	√		
		Lycopus uniflorus	Northern Bugleweed						√							
		Mentha arvensis	Common Mint										√			
		Onoclea sensibilis	Sensitive Fern						√	√			√	√		
		Solidago gigantea	Late Goldenrod											√	√	√
		Symphyotrichum puniceum	Purple Stemmed Aster										√	√		
		Symphyotrichum sp.	Aster species						√							
		Taraxacum officinale	Common Dandelion								√	√				
		Toxicodendron radicans	Poison Ivy						√							

Plot #	Sub plot #	Scientific Name	Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
VEG-018	2	*Caltha palustris*	Marsh Marigold						√	√	√	√	√	√	√	√
		Daucus carota	Queen Anne's Lace								√	√				
		Echinocystis lobata	Wild Cucumber								√	√				
		Epilobium hirsutum	Hairy Willow-Herb						√							
		Equisetum arvense	Field Horsetail								√	√				
		Equisetum pratense	Meadow Horsetail						√				√	√	√	
		Impatiens capensis	Spotted Jewelweed						√	√						
		Lycopus uniflorus	Northern Bugleweed						√						√	
		Mentha arvensis	Common Mint								√	√				√
		Onoclea sensibilis	Sensitive Fern						√	√		√	√	√	√	√
		Phalaris arundinacea	Reed Canary Grass						√							
		Solidago canadensis	Canada Goldenrod						√							
		Solidago gigantea	Late Goldenrod						√		√	√			√	
		Symphyotrichum lanceolatum	Panicled Aster							√	√	√	√			√
		Symphyotrichum lateriflorum	Calico Aster													√
		Symphyotrichum puniceum	Purple Stemmed Aster											√		
		Symphyotrichum sp.	Aster species						√						√	
		Toxicodendron radicans	Poison Ivy						√							
	3	*Caltha palustris*	Marsh Marigold						√	√	√	√	√	√	√	√
		Equisetum arvense	Field Horsetail								√	√				
		Equisetum pratense	Meadow Horsetail						√	√			√	√		
		Galium palustre	Marsh Bedstraw						√	√	√	√				
		Glyceria striata	Fowl Manna Grass							√	√	√	√			√
		Impatiens capensis	Spotted Jewelweed						√	√						
		Maianthemum stellatum	Star Flowered False Solomon's-seal													√
		Mentha arvensis	Common Mint						√		√	√		√	√	√
		Onoclea sensibilis	Sensitive Fern						√	√	√	√	√		√	√
			Grass species						√						√	
		Symphyotrichum lanceolatum	Panicled Aster								√	√				
		Symphyotrichum puniceum	Purple Stemmed Aster								√	√				
	4	*Caltha palustris*	Marsh Marigold						√	√	√	√	√		√	√
		Dryopteris cristata	Crested Wood Fern											√		
		Equisetum arvense	Field Horsetail								√	√				√
		Equisetum pratense	Meadow Horsetail						√	√			√	√		
		Impatiens capensis	Spotted Jewelweed						√	√						
		Galium palustre	Marsh Bedstraw								√	√				
		Glyceria striata	Fowl Manna Grass							√	√	√	√	√		√
		Maianthemum stellatum	Star Flowered False Solomon's-seal										√			√
		Mentha arvensis	Common Mint						√				√	√		√
		Onoclea sensibilis	Sensitive Fern						√	√	√	√	√	√	√	√
			Grass species						√							
		Polygonatum pubescens	Hairy Solomon's Seal							√				√		
		Solidago gigantea	Late Goldenrod										√	√		√
	5	*Aralia nudicaulis*	Wild Sarsaparilla			√	√	√			√	√				
		Caltha palustris	Marsh Marigold												√	√
		Cicuta maculata	Spotted Water Hemlock							√				√		√
		Dryopteris carthusiana	Spinulose Wood Fern						√		√	√				
		Dryopteris marginalis	Marginal Wood Fern						√							
		Epilobium hirsutum	Hairy Willow-Herb						√	√						
		Equisetum arvense	Field Horsetail								√	√				
		Equisetum pratense	Meadow Horsetail						√					√	√	
			Grass species												√	
		Glyceria striata	Fowl Manna Grass							√			√	√		
		Impatiens capensis	Spotted Jewelweed								√	√				
		Lycopus uniflorus	Northern Bugleweed						√	√	√	√		√	√	√
		Maianathemum racemosum	False Solomon's Seal												√	
		Maianthemum stellatum	Star Flowered False Solomon's-seal										√			√
		Mentha arvensis	Common Mint													√
		Onoclea sensibilis	Sensitive Fern						√	√	√	√	√	√	√	√
		Polygonatum pubescens	Hairy Solomon's Seal						√	√	√	√		√		
		Solidago altissima	Tall Goldenrod							√						
		Solidago canadensis	Canada Goldenrod													√
		Solidago gigantea	Late Goldenrod								√	√				
		Solidago patula	Rough-Leaved Goldenrod						√							
		Solidago rugosa	Rough-stemmed Goldenrod							√	√	√		√	√	
		Symphyotrichum lanceolatum	Panicled Aster							√	√	√	√	√	√	√
		Symphyotrichum lateriflorum	Calico Aster						√							
		Symphyotrichum puniceum	Purple Stemmed Aster								√	√				
		Taraxacum officinale	Common Dandelion								√	√				
		Toxicodendron radicans	Poison Ivy						√							

APPENDIX IV
Shrub Species Observed by Plot 2020

Appendix IV. Shrub Species By Plot (2020)

Plot #	Scientific Name	Common Name	CC	CW	Weed	Data	
						Number	Cover (%)
1	*Cornus amomum*	Silky Dogwood	5	-4		6	2
	Parthenocissus vitacea	Woodbine	3	3		2	1
	Rhamnus frangula	Glossy Buckthorn	*	-1	-3	3	0.5
	Ribes trsite	Swamp Red Currant	6	-5		1	1
	Salix discolor	Pussy Willow	3	-3		10	45
	Salix petiolaris	Slender Willow	3	-4		10	45
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	25	5
2	*Cornus stolonifera*	Red-osier Dogwood	2	-3		1	0.5
	Lonicera X bella	Bell's Honeysuckle	-	-	-	1	0.5
	Rhamnus cathartica	Common Buckthorn	*	3	-3	75	5
	Rhamnus frangula	Glossy Buckthorn	*	-1	-3	150	10
	Sambucus canadensis	Common Elder	5	-2		3	1
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	50	3
	Viburnum opulus	Guelder-rose	*	0	-1	1	0.5
	Vitis riparia	Riverbank Grape	0	-2		6	1
3	*Cornus alternifolia*	Alternate-leaved Dogwood	6	5		4	1
	Prunus virginiana	Chokecherry	2	1		1	0.5
	Rhamnus frangula	Glossy Buckthorn	*	-1	-3	10	1
	Rhamnus cathartica	Common Buckthorn	*	3	-3	20	3
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	2	0.5
4	*Parthenocissus vitacea*	Woodbine	3	3		1	1
	Rhamnus cathartica	Common Buckthorn	*	3	-3	10	1
	Rhamnus frangula	Glossy Buckthorn	*	-1	-3	60	15
	Ribes americanum	Wild Black Currant	4	-3		1	1
	Rubus pubescens	Dwarf Raspberry	4	-4		10	2
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	8	1
	Vitis riparia	Riverbank Grape	0	-2		5	1
5	No shrubs present		-	-	-	-	-
6	*Cornus alternifolia*	Alternate-leaved Dogwood	6	5		1	1
	Cornus stolonifera	Red-osier Dogwood	2	-3		5	5
	Rhamnus cathartica	Common Buckthorn	*	3	-3	1	1
	Vitis riparia	Riverbank Grape	0	-2		1	1
7	*Cornus alternifolia*	Alternate-leaved Dogwood	6	5		6	1
	Parthenocissus vitacea	Woodbine	3	3		3	1
	Rhamnus frangula	Glossy Buckthorn	*	-1	-3	30	3
	Rhamnus cathartica	Common Buckthorn	*	3	-3	10	1
	Rubus pubescens	Dwarf Raspberry	4	-4		16	2
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	4	1
	Vitis riparia	Riverbank Grape	0	-2		2	1
8	*Cornus alternifolia*	Alternate-leaved Dogwood	6	5		15	5
	Cornus stolonifera	Red-osier Dogwood	2	-3		1	2
	Lonicera tatarica	Tartarian Honeysuckle	*	3	-3	3	5
	Parthenocissus vitacea	Woodbine	3	3		1	1
	Physocarpus opulifolius	Ninebark	5	-2		1	4
	Prunus virginiana	Chokecherry	2	1		3	1
	Rhamnus cathartica	Common Buckthorn	*	3	-3	300	10
	Rhamnus frangula	Glossy Buckthorn	*	-1	-3	30	20
	Sambucus canadensis	Common Elder	5	-2		1	1
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	10	2
	Viburnum opulus	Guelder-rose	*	0	-1	1	0.5
	Vitis riparia	Riverbank Grape	0	-2		15	5
9	*Cornus stolonifera*	Red-osier Dogwood	2	-3		10	15
	Cornus racemosa	Gray Dogwood	2	-2		20	15
	Rhamnus cathartica	Common Buckthorn	*	3	-3	1	1
	Rhamnus frangula	Glossy Buckthorn	*	-1	-3	1	1
	Rubus idaeus	Red Raspberry	0	-2		2	1
16	*Rhamnus cathartica*	Common Buckthorn	*	3	-3	3	0.5
	Rhamnus frangula	Glossy Buckthorn	*	-1	-3	8	0.5
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	50	15
18	*Ilex verticillata*	Winterberry	5	-4		1	5
	Parthenocissus vitacea	Woodbine	3	3		3	2
	Rhamnus cathartica	Common Buckthorn	*	3	-3	30	10
	Rhamnus frangula	Glossy Buckthorn	*	-1	-3	40	10
	Rubus pubescens	Dwarf Raspberry	4	-4		25	3
	Solanum dulcamara	Bittersweet Nightshade	*	0	-2	10	2
	Toxicodendron rydbergii	Western Poison-ivy	5	-1		25	5
	Vitis riparia	Riverbank Grape	0	-2		20	3

APPENDIX V

Shrub Species Observed by Plot 2006 - 2020

Appendix V. Shrub Species by Plot 2006-2020

			Year												
Plot #	**Scientific Name**	**Common Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**
1	*Cornus amomum*	Silky Dogwood								√	√	√		√	√
	Parthenocissus quinquefolia	Virginia Creeper	√	√											
	Parthenocissus vitacea	Woodbine													√
	Rhamnus frangula	Glossy Buckthorn												√	√
	Ribes americanum	Wild Black Currant									√		√	√	
	Ribes triste	Swamp Red Currant						√	√						√
	Rubus idaeus	Red Raspberry	√	√			√	√					√		
	Salix discolor	Pussy Willow													√
	Salix eriocephala	Heart-leaved Willow					√						√	√	
	Salix lucida	Shining Willow						√							
	Salix petiolaris	Slender Willow	√		√	√	√		√	√	√	√	√	√	√
	Sambucus canadensis	Common Elderberry	√												
	Solanum dulcamara	Bittersweet Nightshade	√	√	√	√	√	√	√	√	√	√	√	√	√
2	*Cornus alternifolia*	Alternate-leaved Dogwood	√	√											
	Cornus stolonifera	Red-osier Dogwood					√					√			√
	Lonicera tatarica	Tartarian Honeysuckle								√	√				
	Lonicera X bella	Bell's Honeysuckle													√
	Parthenocissus quinquefolia	Virginia Creeper	√	√			√								
	Parthenocissus vitacea	Woodbine								√					
	Prunus virginiana	Chokecherry										√			
	Rhamnus cathartica	Common Buckthorn	√	√	√	√		√	√	√	√	√	√	√	√
	Rhamnus frangula	Glossy Buckthorn	√				√	√	√	√	√	√	√	√	√
	Ribes americanum	Wild Black Currant	√	√			√	√				√			
	Rubus allegheniensis	Common Blackberry		√											
	Rubus idaeus	Red Raspberry	√												
	Rubus pubescens	Dwarf Raspberry	√	√		√	√	√		√	√	√	√	√	
	Sambucus canadensis	Common Elderberry								√	√				√
	Solanum dulcamara	Bittersweet Nightshade	√	√	√	√	√	√	√	√	√	√	√	√	√
	Viburnum opulus	Guelder-ros													√
	Viburnum trilobum	High-bush cranberry									√	√			
	Vitis riparia	Riverbank Grape						√	√	√	√	√	√	√	√

			Year												
Plot #	**Scientific Name**	**Common Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**
3	*Carpinus caroliniana*	Blue Beech							√						
	Cornus alternifolia	Alternate-leaved Dogwood	√	√	√	√	√	√	√	√		√	√	√	√
	Cornus stolonifera	Red-osier Dogwood					√								
	Parthenocissus quinquefolia	Virginia Creeper	√	√	√	√	√		√						
	Prunus virginiana	Chokecherry												√	√
	Rhamnus cathartica	Common Buckthorn	√	√	√	√	√	√	√	√	√	√	√	√	√
	Rhamnus frangula	Glossy Buckthorn	√				√	√	√	√	√	√	√	√	√
	Ribes triste	Swamp Red Currant					√								
	Solanum dulcamara	Bittersweet Nightshade							√			√			√
	Viburnum trilobum	High-bush cranberry	√												
	Vitis riparia	Riverbank Grape	√	√											
4	*Cornus amomum*	Silky Dogwood							√	√	√				
	Cornus stolonifera	Red-osier Dogwood	√	√	√	√	√	√							
	Parthenocissus quinquefolia	Virginia Creeper	√	√		√	√	√	√						
	Parthenocissus vitacea	Woodbine								√	√				√
	Rhamnus cathartica	Common Buckthorn	√		√		√	√	√	√			√	√	√
	Rhamnus frangula	Glossy Buckthorn	√			√	√	√	√	√	√	√	√	√	√
	Ribes americanum	Wild Black Currant							√						√
	Ribes triste	Swamp Red Currant											√	√	
	Ribes sp.	Currant species		√											
	Rubus pubescens	Dwarf Raspberry	√	√		√			√	√	√	√		√	√
	Sambucus canadensis	Common Elderberry					√								
	Solanum dulcamara	Bittersweet Nightshade	√	√	√	√	√	√	√	√	√	√	√	√	√
	Virbunum trilobum	High-bush cranberry											√	√	
	Vitis riparia	Riverbank Grape					√				√		√	√	√
5	*Cornus alternifolia*	Alternate-leaved Dogwood		√											
	Rhamnus cathartica	Common Buckthorn		√		√		√				√			
	Rhamnus frangula	Glossy Buckthorn										√			
6	*Cornus alternifolia*	Alternate-leaved Dogwood													√
	Cornus stolonifera	Red-osier Dogwood	√	√	√	√		√	√	√	√	√	√	√	√
	Lonicera tatarica	Tartarian Honeysuckle										√			
	Rhamnus cathartica	Common Buckthorn							√						√
	Rhamnus frangula	Glossy Buckthorn										√			
	Salix bebbiana	Bebb's Willow			√			√							
	Salix eriocephala	Heart-leaved Willow							√	√	√		√	√	
	Salix petiolaris	Slender Willow							√	√	√	√	√		
	Salix sp.	Willow species		√				√							
	Vitis riparia	Riverbank Grape													√

			Year												
Plot #	**Scientific Name**	**Common Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**
7	*Amelanchier arborea*	Downy Serviceberry								√					
	Cornus alternifolia	Alternate-leaved Dogwood	√	√	√		√		√	√	√	√	√	√	√
	Hamamelis virginiana	Witch Hazel			√		√								
	Parthenocissus quinquefolia	Virginia Creeper	√	√	√		√	√	√						
	Parthenocissus vitacea	Woodbine									√	√		√	√
	Prunus virginiana	Chokecherry								√					
	Rhamnus cathartica	Common Buckthorn				√	√		√	√	√	√		√	√
	Rhamnus frangula	Glossy Buckthorn	√				√	√	√	√	√	√	√	√	√
	Ribes americanum	Wild Black Currant			√										
	Rubus pubescens	Dwarf Raspberry	√	√					√	√	√	√	√		√
	Solanum dulcamara	Bittersweet Nightshade	√	√		√	√	√	√	√		√		√	√
	Viburnum trilobum	High-bush cranberry				√				√					
	Vitis riparia	Riverbank Grape													√
8	*Aronia melanocarpa*	Black Chokeberry							√						
	Cornus alternifolia	Alternate-leaved Dogwood	√			√		√	√	√	√	√			√
	Cornus amomum	Silky Dogwood										√	√	√	
	Cornus stolonifera	Red-osier Dogwood	√	√	√		√	√							√
	Crataegus sp.	Hawthorn species	√												
	Echinocystis lobata	Wild Cucumber		√	√										
	Lonicera tatarica	Tartarian Honeysuckle	√	√	√	√	√	√	√	√			√	√	√
	Parthenocissus vitacea	Woodbine									√				√
	Physocarpus opulifolius	Ninebark										√			√
	Prunus virginiana	Chokecherry			√	√				√	√		√	√	√
	Rhamnus cathartica	Common Buckthorn	√	√		√			√	√	√	√	√	√	√
	Rhamnus frangula	Glossy Buckthorn	√	√		√	√		√	√	√	√	√	√	√
	Ribes americanum	Wild Black Currant		√											
	Ribes triste	Swamp Red Currant	√												
	Rubus idaeus	Red Raspberry	√	√	√		√	√							
	Rubus occidentalis	Black Raspberry							√				√		
	Rubus parviflorus	Sparse-flowered Thimbleberry				√	√								
	Rubus pubescens	Dwarf Raspberry	√												
	Sambucus canadensis	Common Elderberry													√
	Solanum dulcamara	Bittersweet Nightshade	√	√	√	√	√	√	√	√	√	√			√
	Viburnum opulus	Guelder-rose							√	√	√		√		√
	Viburnum trilobum	High-bush cranberry				√	√					√		√	
	Vitis riparia	Riverbank Grape	√	√	√	√	√	√	√		√		√	√	√

			Year												
Plot #	**Scientific Name**	**Common Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**
9	*Cornus amomum*	Silky Dogwood								√	√		√		
	Cornus racemosa	Gray Dogwood								√		√			√
	Cornus stolonifera	Red-osier Dogwood		√	√	√	√	√	√			√		√	√
	Rhamnus cathartica	Common Buckthorn					√	√			√	√	√		√
	Rhamnus frangula	Glossy Buckthorn			√										√
	Rubus idaeus	Red Raspberry				√	√	√		√	√		√		√
	Rubus occidentalis	Black Raspberry									√		√		
	Solanum dulcamara	Bittersweet Nightshade				√		√		√			√		
16	*Echinocystis lobata*	Wild Cucumber						√							
	Lonicera X bella	Bell's Honeysuckle												√	
	Parthenocissus quinquefolia	Virginia Creeper						√	√					√	
	Parthenocissus vitacea	Woodbine								√	√	√	√		
	Rhamnus cathartica	Common Buckthorn						√	√	√	√	√	√	√	√
	Rhamnus frangula	Glossy Buckthorn						√	√	√	√	√	√	√	√
	Solanum dulcamara	Bittersweet Nightshade						√	√	√	√	√	√	√	√
	Viburnum opulus	Guelder-rose												√	
	Vitis riparia	Riverbank Grape									√	√	√		
18	*Ilex verticillata*	Winterberry						√	√	√	√	√	√	√	√
	Parthenocissus quinquefolia	Virginia Creeper						√	√					√	
	Parthenocissus vitacea	Woodbine								√	√	√	√	√	√
	Rhamnus cathartica	Common Buckthorn						√	√	√	√	√	√	√	√
	Rhamnus frangula	Glossy Buckthorn						√	√	√	√	√	√	√	√
	Rubus pubescens	Dwarf Raspberry						√	√	√	√	√	√	√	√
	Solanum dulcamara	Bittersweet Nightshade						√	√	√	√	√	√	√	√
	Toxicodendron radicans	Poison Ivy							√		√		√	√	
	Toxicodendron rydbergii	Western Poison-ivy								√		√			√
	Viburnum opulus	Guelder-rose											√		
	Vitis riparia	Riverbank Grape						√		√	√	√	√	√	√

APPENDIX VI

Bird Species Observed by Plot 2020

Appendix VII. Bird Species Observed by Plot in 2006 - 2020

Breeding Bird Plot 001	MAMM1-3																
		Breeding Evidence															Incidental Observations
														2020			
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020	June 15	July 3	2020
Alder Flycatcher	*Empidonax alnorum*						PR	PO					PO				Northern Cardinal
American Crow	*Corvus brachyrhynchos*													CO		3	Warbling Vireo
American Goldfinch	*Spinus tristis*	PR	X	PO	PO		PO	PR	PO	PO	PR	PR	X	PR	3	2	
American Robin	*Turdus migratorius*			PR	PR	PR	PR	PO	PR	PO	PO		PO	PR	1	3	
Baltimore Oriole	*Icterus galbula*		PR			PO	PO	PR		PR				PO		1	
Bank Swallow	*Riparia riparia*						PO										
Barn Swallow	*Hirundo rustica*	PO	PR				PR	PO	PO		PO						
Black-billed Cuckoo	*Coccyzus erythropthalmus*									PR							
Black-capped Chickadee	*Poecile atricapillus*	PO			PO	PO				PR	PO	PO		PO		2	
Blue Jay	*Cyanocitta cristata*											PO		PO		1	
Bobolink	*Dolichonyx oryzivorus*		PO		PO	PO											
Brown-headed Cowbird	*Molothrus ater*			PR			PO	PR		PO	PO	PO		PO		1	
Cedar Waxwing	*Bombycilla cedrorum*	PO	PO		PR	PR		PO	PR	PR	PO	PO	PR	PR	2	2	
Chipping Sparrow	*Spizella passerina*			PR					PO								
Common Grackle	*Quiscalus quiscula*					PO	PO							PO	1		
Common Yellowthroat	*Geothylpis trichas*		PO	PR	PR	PR	PO	PR	CO	PR	PO	PR	PR	PO		2	
Downy Woodpecker	*Picoides pubescens*				PO				PO	PO	PR		PO				
Eastern Kingbird	*Tyrannus tyrannus*	PO			PR	PO	PO	PO					PO	PO	1	1	
Eastern Meadowlark	*Sturnella magna*		PO	PO		PO		PO	PO		PO	PO	PO	PO	2		
Eastern Wood-pewee	*Contopus virens*			PO			PO	PO					PO				
European Starling	*Sturnus vulgaris*				X	X					PO	PO		CO		1	
Flycatcher species		PO		X													
Grasshopper Sparrow	*Ammodramus savannarum*								PO			PO					
Gray Catbird	*Dumetella carolinensis*				PO		PO		PO	PO			PR	PR	1	1	
Hairy Woodpecker	*Picoides villosus*								PR					PO		1	
House Wren	*Troglodytes aedon*					PO			PO		PO	PR					
House Finch	*Carpodacus mexicanus*			CO													
Indigo Bunting	*Passerina cyanea*												PR				
Killdeer	*Charadrius vociferus*								PO				PR				
Least Flycatcher	*Empidonax minimus*			PO													
Mallard	*Anas platyrhynchos*					X			PR	PO							
Mourning Dove	*Zenaida macroura*			PO				PO	PO	PO	PO		X	PO	1		
Northern Cardinal	*Cardinalis cardinalis*				PO				PO	PO	PO	PO	PO				
Northern Flicker	*Colaptes auratus*	PR						PO	PO					PO		1	
Swallow	*Stelgidopteryx serripennis*												X				
Northern Waterthrush	*Parkesia noveboracensis*									PO							
Passerine species		PO															
Red-eyed Vireo	*Vireo olivaceus*				X												
Red-winged Blackbird	*Agelaius phoeniceus*	PR	CO	PR	PR	PR	CO	PR	PR	PO	PR	PO	CO	CO	3	4	
Ring-billed Gull	*Larus delawarensis*						X										
Rock Pigeon	*Columba livia*					X				PO							
Rose-breasted Grosbeak	*Pheucticus ludovicianus*				PO									PO		1	
Savannah Sparrow	*Passerculus sandwichensis*		PR		PO	PR		PR	PR		PO		PO	PO		1	
Scarlet Tanager	*Piranga olivacea*	PO															
Song Sparrow	*Melospiza melodia*	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	2	2	
Swamp Sparrow	*Melospiza georgiana*	PO	PO		PO			PR			PO		PR	PO		1	
Tennessee Warbler	*Oreothlypis peregrina*	PO															
Tree Swallow	*Tachycineta bicolor*			PO	PO	PO								CO		10	
Warbling Vireo	*Vireo gilvis*				PO	PR	PR	PR	PR				PO				
Willow Flycatcher	*Empidonax traillii*				PR	PR			PR	PR	PO	PR	PR	PR	1	1	

Breeding Bird Plot 001 (continued)																	
		Breeding Evidence															Incidental Observations
															2020		
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020	June 15	July 3	2020
Yellow Warbler	*Setophaga petechia*		X	PO	PR	PR	PO	PR	PR	PR	PR	PR	PO	PR	1	1	
Yellow-billed Cuckoo	*Coccyzus americanus*	PO															
Total	**43**	16	13	16	22	21	18	20	24	20	20	16	23	26	**2039**	**43**	
															2082		

Breeding Bird Plot 002	SWCO1-2																
		Breeding Evidence															Incidental Observations
															2020		
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020	June 15	July 3	2020
American Crow	*Corvus brachyrhynchos*		PO	PO		PO			PO			PO					
American Goldfinch	*Spinus tristis*						PR				PO	PO	PO				
American Robin	*Turdus migratorius*		PR	PR	PR	PO		PO	PO	PO	PO	PO		PR	1	1	
Baltimore Oriole	*Icterus galbula*		PR		PO								PO	PO		1	
Bank Swallow	*Riparia riparia*						X										
Black-capped Chickadee	*Poecile atricapillus*		PO	PR	PO	PO	PO	PR	PR	PR	PR	PR	PR	PO	1	2	
Blue Jay	*Cyanocitta cristata*	PO			PR	PO		PR	PO	PO	PO	PR	CO	PO		1	
Brown-headed Cowbird	*Molothrus ater*						PO							PO		1	
Cedar Waxwing	*Bombycilla cedrorum*	PO					PR	PO				PR		PO	1		
Chestnut-sided Warbler	*Setophaga pensylvanica*	PO															
Chipping Sparrow	*Spizella passerina*										PO						
Common Grackle	*Quiscalus quiscula*			PO				PO		PO							
Common Yellowthroat	*Geothylpis trichas*			PR	PO		PO		PR	PR	PO		PO	PO		1	
Cuckoo species													PO				
Downy Woodpecker	*Picoides pubescens*	PO		PO					PO				PO				
Eastern Kingbird	*Tyrannus tyrannus*								PO								
Eastern Meadowlark	*Sturnella magna*						PO										
Eastern Wood-pewee	*Contopus virens*	PO	PO		PO	PR		PO	PR	PR		PO	PR	PO	1		
European Starling	*Sturnus vulgaris*								PO								
Great Crested Flycatcher	*Myiarchus crinitus*		PO		PO			PO		PR	PO			PO	1		
Hairy Woodpecker	*Picoides villosus*							PO									
House Wren	*Troglodytes aedon*		PO	PO	PO	PO		PR	PO	PR				PO	1		
Indigo Bunting	*Passerina cyanea*	PO		PO													
Killdeer	*Charadrius vociferus*				PR			PO									
Mourning Dove	*Zenaida macroura*					PO		PR									
Northern Cardinal	*Cardinalis cardinalis*		PO		PO			PO	PR		PO			PR	1	1	
Northern Flicker	*Colaptes auratus*				PO							PO	PO				
Northern Waterthrush	*Parkesia noveboracensis*					PR		PR	PR	PR	PO		PO	PR	1	1	
Passerine species		PO															
Red-bellied Woodpecker	*Melanerpes carolinus*								PO								
Red-breasted Nuthatch	*Sitta canadensis*							PO			PO						
Red-winged Blackbird	*Agelaius phoeniceus*	PO			PO		PO	PO			PO	PR	PO	PO	1		
Rose-breasted Grosbeak	*Pheucticus ludovicianus*					PR				PR				PR	1	1	
Song Sparrow	*Melospiza melodia*	PR	PR	PR	PR	PR	PR	PR	PR		PR				1	1	
Turkey Vulture	*Cathartes aura*						X										
Wabler species		PO															
Warbling Vireo	*Vireo gilvis*						PO										
White-breasted Nuthatch	*Sitta carolinensis*											PO		PO		1	
Winter Wren	*Troglodytes hiemalis*													PO		1	
Yellow Warbler	*Setophaga petechia*						PO										
Total	**35**	10	9	9	13	10	12	16	14	10	12	10	11	16	**11**	**13**	
															24		

Breeding Bird Plot 003	**FODM6**																
		Breeding Evidence															**Incidental Observations**
															2020		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**	June 15	July 3	**2020**
American Crow	*Corvus brachyrhynchos*	PR	PO		PR	PO	PO		PO			PO		PO		1	
American Goldfinch	*Spinus tristis*									PO			PO	PO	1		
American Robin	*Turdus migratorius*		PR	PR	PO	PO	PO	PO	PO	PR		PR	PR	PO		1	
Baltimore Oriole	*Icterus galbula*		PO						PO								
Black-billed Cuckoo	*Coccyzus erythropthalmus*				PO												
Black-capped Chickadee	*Poecile atricapillus*	PR		PO		PO	PO	PO	PR	PO	PO	PO	PO				
Blue Jay	*Cyanocitta cristata*			PR	PO	X		PO	PO	PO	PO	PO	PO	PO	1	4	
Brown-headed Cowbird	*Molothrus ater*					PO	PO					PO		PO		1	
Cedar Waxwing	*Bombycilla cedrorum*						PO	PO	PO			PO					
Common Grackle	*Quiscalus quiscula*			PO				PO				CO		PO		1	
Common Yellowthroat	*Geothylpis trichas*				PO	PR	PR	PO	PO				PR				
Downy Woodpecker	*Picoides pubescens*					CO		PO	PO		PO	PO		PO		1	
Eastern Wood-pewee	*Contopus virens*	PO	PO	PR	PR	PR		PR		PO	PO	PO	PR	PO		1	
European Starling	*Sturnus vulgaris*			PO				PO									
Gray Catbird	*Dumetella carolinensis*			PO													
Great Crested Flycatcher	*Myiarchus crinitus*	PO			PO	PR	PO	PO	PO		PO		PO	PO	1		
Great Horned Owl	*Bubo virgianus*											CO					
House Wren	*Troglodytes aedon*			PR	PR	PO		PO	PR		PR			PO		1	
Indigo Bunting	*Passerina cyanea*					PO		PR				PO					
Northern Cardinal	*Cardinalis cardinalis*	PO			PR				PR		PO	PR	PO				
Northern Flicker	*Colaptes auratus*										PO		PR				
Red-bellied Woodpecker	*Melanerpes carolinus*								PO			CO					
Red-breasted Nuthatch	*Sitta canadensis*								PO								
Red-eyed Vireo	*Vireo olivaceus*	PR	PO		PO	PR		PO	PR	PR	PO	PR		PR	1	2	
Red-tailed Hawk	*Buteo jamaicensis*		PR		PO						PO						
Red-winged Blackbird	*Agelaius phoeniceus*			PO	PR	PO						PO					
Ring-billed Gull	*Larus delawarensis*								PO								
Rose-breasted Grosbeak	*Pheucticus ludovicianus*				PO									PR	1	1	
Song Sparrow	*Melospiza melodia*	PR	PO	PR	PO	PR	PR	PO	PR	PO	PR		PO	PR	1	2	
Warbling Vireo	*Vireo gilvis*							PO									
White-breasted Nuthatch	*Sitta carolinensis*						PO										
Winter Wren	*Troglodytes hiemalis*											PO					
Wood Thrush	*Hylocichla mustelina*		PR														
Yellow-bellied Sapsucker	*Sphyrapicus varius*										PO						
Yellow Warbler	*Setophaga petechia*			PO					PO								
Total	**35**	7	8	11	14	14	9	15	17	7	12	16	10	13	**6**	**16**	
															22		

Breeding Bird Plot 004	SWMM1-1																
		Breeding Evidence															Incidental Observations
														2020			
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020	June 15	July 3	2020
American Crow	*Corvus brachyrhynchos*	PO	PR	PO	PO	X	PO		PO								Yellow Warbler
American Goldfinch	*Spinus tristis*		PO	X	PO	PO		PO	PO	PO	PO	PO	PO	PR	2	1	Northern Cardinal
American Robin	*Turdus migratorius*	PO	PO	PO	PO	PO	PR	PR	PR	PR	PR	PR	PR	PR	2	1	Savannah Sparrow
Belted Kingfisher	*Megaceryle alcyon*											X					Common Grackle
Black-capped Chickadee	*Poecile atricapillus*	PO	PO	PR	CO	PO		CO		PR	PR	PO	PR	PR	2	1	Chipping Sparrow
Blue-gray Gnatcatcher	*Polioptila caerulea*				PO												Song Sparrow
Blue Jay	*Cyanocitta cristata*	PR	PR		PO	PO	PO	PO	PO	PR		PR	PR	PO	1		Eastern Meadowlark
Brown-headed Cowbird	*Molothrus ater*				PO	X			PO	PO	PO			PR	1	2	American Robin
Cedar Waxwing	*Bombycilla cedrorum*			PO		PO				PO		PO	PO	PR	2	1	Black-capped Chickadee
Chipping Sparrow	*Spizella passerina*		PO	PO					PR		PO		PO	PR	2		Common Yellowthroat
Common Grackle	*Quiscalus quiscula*	PO		X	CO		PO		PO		PR	PO	PO				Willow Flycatcher
Common Yellowthroat	*Geothylpis trichas*	CO	PO	PR	PR	PR		PR	PO	PO	PO			PO	1		Vesper Sparrow
Downy Woodpecker	*Picoides pubescens*			PO													Blue Jay
European Starling	*Sturnus vulgaris*						PR		CO					PO	3		American Goldfinch
Gray Catbird	*Dumetella carolinensis*				PO			PO									Mallard
Great Crested Flycatcher	*Myiarchus crinitus*										PO	PO	PO				
Hairy Woodpecker	*Picoides villosus*	PO											PO				
House Wren	*Troglodytes aedon*								PO								
Killdeer	*Charadrius vociferus*													PO		1	
Mallard	*Anas platyrhynchos*		X									X					
Mourning Dove	*Zenaida macroura*								PO				PO				
Northern Cardinal	*Cardinalis cardinalis*	PO		PO	PR	PO		PO	PO	PO							
Northern Flicker	*Colaptes auratus*					PO		PO									
Northern Waterthrush	*Parkesia noveboracensis*				PO	PO	PO				PR						
Orchard Oriole	*Icterus spurius*											PO					
Pine Warbler	*Setophaga pinus*					PO											
Red-eyed Vireo	*Vireo olivaceus*						PO										
Red-tailed Hawk	*Buteo jamaicensis*		PO														
Red-winged Blackbird	*Agelaius phoeniceus*	PR	PR	PO	PO	PO	PO		PO	PO	PR	PR		PO	3		
Rose-breasted Grosbeak	*Pheucticus ludovicianus*																
Savannah Sparrow	*Passerculus sandwichensis*			PO				PO	PO		PO	PO		PO		1	
Scarlet Tanager	*Piranga olivacea*							PO									
Song Sparrow	*Melospiza melodia*	PO	PO	PR	PO	PR	PO	PR	PR		PR	PR	PR	PR	2	3	
Swamp Sparrow	*Melospiza georgiana*	PO			PO			PR			PO			PO		1	
White-breasted Nuthatch	*Sitta carolinensis*						PO					PO					
Wood Thrush	*Hylocichla mustelina*			PO													
Yellow-bellied Sapsucker	*Sphyrapicus varius*						PO										
Yellow Warbler	*Setophaga petechia*			PO		PO			PO	PR	PO	X					
Total	**38**	11	11	15	15	15	11	12	16	10	14	15	11		**21**	**12**	
														33			

Breeding Bird Plot 005	**FOMM6**																
		Breeding Evidence															**Incidental Observations**
															2020		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**	June 15	July 3	**2020**
American Crow	*Corvus brachyrhynchos*	PO		PO	PO	PO								PO		4	Killdeer
American Goldfinch	*Spinus tristis*	PO	PO					PR	PO			X		PO	3		Savannah Sparrow
American Robin	*Turdus migratorius*	PO		PR	PO	PR	PR	PR	PR	PR	PR	PR		PR	2	1	
Black-capped Chickadee	*Poecile atricapillus*	PR	PR	PO	PO	PR	PO	PR	PR	PO	PR	PR	PR	PO		3	
Blue Jay	*Cyanocitta cristata*	PR	PO	PO	PO	X	PO	PR	PR		PR	PO	PO	PO	2	2	
Blue-headed Vireo	*Vireo solitarius*													PO		1	
Brown Creeper	*Certhia americana*								PO								
Brown-headed Cowbird	*Molothrus ater*											PO					
Cedar Waxwing	*Bombycilla cedrorum*			PO							PO	PO					
Chipping Sparrow	*Spizella passerina*				PR												
Common Grackle	*Quiscalus quiscula*				CO							PO		PO		2	
Common Yellowthroat	*Geothylpis trichas*		PO		PO			PO			PO		PO				
Cooper's Hawk	*Accipiter cooperii*											PO					
Downy Woodpecker	*Picoides pubescens*			PO													
Eastern Wood-pewee	*Contopus virens*													PO	1		
Gray Catbird	*Dumetella carolinensis*							PO									
Great Crested Flycatcher	*Myiarchus crinitus*	PO	PR	PO	PO	PO	PR	PO		PO	PR	PO		PR	1	1	
Hairy Woodpecker	*Picoides villosus*								PO								
House Wren	*Troglodytes aedon*	PO															
Killdeer	*Charadrius vociferus*	PO					X		PO								
Mourning Dove	*Zenaida macroura*		PO						PO	PO		PO		PO		1	
Northern Cardinal	*Cardinalis cardinalis*	PO	PO		PO		PR	PR			PO		PO	PO		2	
Northern Flicker	*Colaptes auratus*					PO			PO		PO						
Northern Waterthrush	*Parkesia noveboracensis*											PO					
Pine Warbler	*Setophaga pinus*			PR				PO				PO					
Red-breasted Nuthatch	*Sitta canadensis*				PO	X		PO			PO	PO					
Red-eyed Vireo	*Vireo olivaceus*				PR		PO	PO				PO	PR				
Red-winged Blackbird	*Agelaius phoeniceus*				PO						PO						
Rose-breasted Grosbeak	*Pheucticus ludovicianus*						PR					PO					
Song Sparrow	*Melospiza melodia*			PO		PO			PO								
Swamp Sparrow	*Melospiza georgiana*				PO												
Tree Swallow	*Tachycineta bicolor*										PO						
White-breasted Nuthatch	*Sitta carolinensis*		PO		PO												
Total	**33**	9	8	9	14	8	8	11	10	4	11	15	5	11	**9**	**17**	
															26		

Breeding Bird Plot 006	MAMM1-3																	
		Breeding Evidence															Incidental Observations
															2020		
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020	June 15	July 3	2020
Alder Flycatcher	*Empidonax alnorum*											PO					Savannah Sparrow
American Crow	*Corvus brachyrhynchos*					PO			PO				PR	PO		1	Killdeer
American Goldfinch	*Spinus tristis*	PR	PR	PR	PO	PO	PO	PR	PR	PR	PR	PR	PR	PR	2	4	Common Yellowthroat
American Redstart	*Setophaga ruticilla*					PO								PO		1	American Crow
American Robin	*Turdus migratorius*	PR	PO	PO	PR	CO	PO	PR	PR	PR	PO	PR	PR	PR	1	4	House Wren
Baltimore Oriole	*Icterus galbula*			PO			PR					PO					American Redstart
Bank Swallow	*Riparia riparia*										PO						Cedar Waxwing
Barn Swallow	*Hirundo rustica*	PO	PR	PR													American Goldfinch
Belted Kingfisher	*Megaceryle alcyon*													X		1	Yellow Warbler
Black-capped Chickadee	*Poecile atricapillus*			PO	PO	PO				PO	PO			PO	4		Baltimore Oriole
Blue Jay	*Cyanocitta cristata*	PO	PO					PO						PO	1		
Brown-headed Cowbird	*Molothrus ater*				X	PO	PO		PR		PO	PO	PO	PO	2		
Cedar Waxwing	*Bombycilla cedrorum*				X	X		PO			PR	PO					
Common Grackle	*Quiscalus quiscula*			PO	X		PO				PO	X	PO				
Common Yellowthroat	*Geothylpis trichas*		PO	PR	PO	PO	PO	PR	PR	PR	PO	PO	PR	PR	2	2	
Downy Woodpecker	*Picoides pubescens*										PO						
Eastern Meadowlark	*Sturnella magna*								PO					PO		1	
Eastern Wood-pewee	*Contopus virens*			PO				PO									
European Starling	*Sturnus vulgaris*			X	PO			PO			X	X	X	PO	2		
Field Sparrow	*Spizella pusilla*		PO				PO					PO					
Gray Catbird	*Dumetella carolinensis*			PO			PO		PO			PO		PO		1	
Great Crested Flycatcher	*Myiarchus crinitus*		PO						PO								
Hairy Woodpecker	*Picoides villosus*							PO									
House Wren	*Troglodytes aedon*						PO							PO		1	
Indigo Bunting	*Passerina cyanea*				PO					PO		PO					
Killdeer	*Charadrius vociferus*								PO	PO			PR				
Mallard	*Anas platyrhynchos*	PO	PR														
Mourning Dove	*Zenaida macroura*								PO				PO	X		1	
Northern Cardinal	*Cardinalis cardinalis*	PO	PR		PO						PO	PO		PO		1	
Northern Flicker	*Colaptes auratus*		CO			PO											
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*				PR			PO				PO		X		1	
Northern Waterthrush	*Parkesia noveboracensis*					PO											
Red-tailed Hawk	*Buteo jamaicensis*						PR		PO								
Red-winged Blackbird	*Agelaius phoeniceus*	PR	CO	CO	CO	PR	PR	CO	PR	PR	PR	PR	PR	PR	4	7	
Ring-billed Gull	*Larus delawarensis*		X										X				
Rock Pigeon	*Columba livia*					X						X					
Savannah Sparrow	*Passerculus sandwichensis*				PO			PO	PO					PO		1	
Song Sparrow	*Melospiza melodia*	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	2	2	
Spotted Sandpiper	*Actitis macularia*							PO					PO				
Tree Swallow	*Tachycineta bicolor*			PO		PO		PO			PO			X	1		
Warbling Vireo	*Vireo gilvis*					PR	PR	PR	PO		PO	PO					
Willow Flycatcher	*Empidonax traillii*								PO		PR			PO		1	
Vesper Sparrow	*Pooecetes gramineus*				PO												
Yellow Warbler	*Setophaga petechia*				PR	PO	PR		PR	PO	PO	PR		PR	2	2	
Total	**43**	8	13	13	16	16	14	15	17	9	17	19	13	22	**23**	**32**	
															55		

Breeding Bird Plot 007	SWMM1-1																
		Breeding Evidence															Incidental Observations
															2020		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**	June 15	July 3	**2020**
American Crow	*Corvus brachyrhynchos*	PR	PO														Winter Wren (P)
American Goldfinch	*Spinus tristis*	PO	PO	PR	PO	PO		PR			PO	PO		PO		2	
American Robin	*Turdus migratorius*	PR		PO	PO	PR	PR	PR	PR	PR	PR	PO	PO	PO	2		
Baltimore Oriole	*Icterus galbula*				CO					PO							
Bank Swallow	*Riparia riparia*									PO							
Black-capped Chickadee	*Poecile atricapillus*		PR	PO	PR	PO	PO	PO	PR		PO	PO	PR	PR	5	3	
Blue Jay	*Cyanocitta cristata*	PR	PO		PR	PO	PO	PO	PO	PO	PR		PO	PR	1	2	
Blue-headed Vireo	*Vireo solitarius*													PO		1	
Brown Creeper	*Certhia americana*					PO	PO	PO	PO					PO		1	
Brown-headed Cowbird	*Molothrus ater*											PO					
Canada Goose	*Branta canadensis*		X														
Cedar Waxwing	*Bombycilla cedrorum*			PO		PO		PO	PO		PO						
Chipping Sparrow	*Spizella passerina*			PO	PO						PO						
Common Grackle	*Quiscalus quiscula*				X		PO				PO			PO	1		
Common Yellowthroat	*Geothylpis trichas*												PO	PO	1		
Downy Woodpecker	*Picoides pubescens*		X	PO							PO						
Eastern Kingbird	*Tyrannus tyrannus*		PO														
Eastern Meadowlark	*Sturnella magna*			PO									PO				
Eastern Wood-pewee	*Contopus virens*				PO	PO							PO				
European Starling	*Sturnus vulgaris*												PO				
Field Sparrow	*Spizella pusilla*			PO	PO												
Gray Catbird	*Dumetella carolinensis*				PO												
Great Crested Flycatcher	*Myiarchus crinitus*		PR		PO	PO	PO	PO		PO		PO					
Hairy Woodpecker	*Picoides villosus*	PO							PO								
Indigo Bunting	*Passerina cyanea*	PO			PO						PO	PO	PO				
Killdeer	*Charadrius vociferus*						PO	PO	PO		PO						
Northern Cardinal	*Cardinalis cardinalis*		PO	PO	PO		PO		PO	PR				PO		1	
Northern Flicker	*Colaptes auratus*								PO								
Mourning Dove	*Zenaida macroura*								PO	PO		PO					
Passerine Species		PO		PO		PO											
Red-breasted Nuthatch	*Sitta canadensis*					PR			PO		PO			PR	1	1	
Red-eyed Vireo	*Vireo olivaceus*				PO		PO			PR	PO	PO	PO				
Ring-billed Gull	*Larus delawarensis*										OB		X				
Red-winged Blackbird	*Agelaius phoeniceus*										PO	PO	PO				
Savannah Sparrow	*Passerculus sandwichensis*							PO					PO				
Song Sparrow	*Melospiza melodia*	PR	PO	PR	PR	PR	PR	PR	PR	PO	PO	PO	PR	PO		2	
Spotted Sandpiper	*Actitis macularia*							PO									
Warbling Vireo	*Vireo gilvis*											PO					
Winter Wren	*Troglodytes hiemalis*											PO	PR	PO	1		
White-breasted Nuthatch	*Sitta carolinensis*		PO		PR		PR					PO	PO				
Total	**33**	8	11	11	16	11	11	11	12	9	15	13	15	12	**12**	**13**	
															25		

Breeding Bird Plot 008	SWMM1-1																
		Breeding Evidence															Incidental Observations
														2020			
Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020	June 15	July 3	2020
American Crow	*Corvus brachyrhynchos*		PR		PO		PO			PO							Song Sparrow
American Goldfinch	*Spinus tristis*	PR	PO	PR	PR	PO	PO	PR	PR	PO	PO	CO	PO	PR	2	1	Red-winged Blackbird
American Robin	*Turdus migratorius*	PO	PO	PR	PO	PO	PO	PR	PR	PR	PR	PR	CO	PO	1	1	Common Yellowthroat
American Woodcock	*Scolopax minor*							PO									Black-capped Chickadee
Bank Swallow	*Riparia riparia*											PO					European Starling
Barn Swallow	*Hirundo rustica*								X								Gray Catbird
Belted Kingfisher	*Megaceryle alcyon*					PO			PO	CO							Eastern Meadowlark
Black-billed Cuckoo	*Coccyzus erythropthalmus*				PO												American Robin
Black-capped Chickadee	*Poecile atricapillus*		PR	PR	PR	PO	PO		PR	PO	PO	PO	CO	PR	2	4	Savannah Sparrow
Blue Jay	*Cyanocitta cristata*	PO	PO		PR	PO	PO	PO		PO	PR						American Goldfinch
Brown-headed Cowbird	*Molothrus ater*		PO		PO	PO	PO		PO	PR	PO	PO	PR				Mourning Dove
Cedar Waxwing	*Bombycilla cedrorum*	PO			PO			PO					PR	PO		1	
Chipping Sparrow	*Spizella passerina*	PO															
Common Grackle	*Quiscalus quiscula*		PR	X	X		PO			PO	CO		PO	X		2	
Common Yellowthroat	*Geothylpis trichas*	PO		PO	PO	PO	PO	PO	PO	PO	PR	PO	PR	PO		1	
Eastern Kingbird	*Tyrannus tyrannus*									PO							
Eastern Meadowlark	*Sturnella magna*			PR	PO												
Eastern Wood-pewee	*Contopus virens*						PO						PO				
European Starling	*Sturnus vulgaris*													PO	2		
Gray Catbird	*Dumetella carolinensis*	CO	PR		PR		CO	PO			PO						
Great Crested Flycatcher	*Myiarchus crinitus*							PO						PO	1		
Hairy Woodpecker	*Picoides villosus*	PO		PO										PO		1	
House Wren	*Troglodytes aedon*						PO	PO			PO		PR				
Killdeer	*Charadrius vociferus*						PO		PO				PO				
Mallard	*Anas platyrhynchos*		X			X	X		X								
Mourning Dove	*Zenaida macroura*						PO		PO	PO	PR	PR					
Northern Cardinal	*Cardinalis cardinalis*	PO		PO	PR		PO	PR	PO	PO	PR	PO	PO	PO		1	
Northern Flicker	*Colaptes auratus*						PO		PO								
Northern Waterthrush	*Parkesia noveboracensis*							PO									
Red-eyed Vireo	*Vireo olivaceus*						PO	PO				PO					
Red-winged Blackbird	*Agelaius phoeniceus*	PO	PR	PR	PO		PO	PO	PR			PO	PO	PO	1	4	
Ring-billed Gull	*Larus delawarensis*								X		X			X		1	
Savannah Sparrow	*Passerculus sandwichensis*			PO	PO			PR			PO		PO				
Song Sparrow	*Melospiza melodia*	PR	PR	PR	PR	PR	PR	PR	PR	PR	PR	PO	PR	PR	2	2	
White-breasted Nuthatch	*Sitta carolinensis*											PO					
Wood Duck	*Aix sponsa*													X	1		
Yellow Warbler	*Setophaga petechia*			PR	PO		PO		PR					PO	2		
Total	**37**	11	11	12	17	9	20	15	16	13	14		14	15	**14**	**19**	
															33		

Breeding Bird Plot 009	MASM1-1																
		Breeding Evidence															Incidental Observations
														2020			
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**	June 15	July 3	**2020**
American Crow	*Corvus brachyrhynchos*			PO	PO	CO			PO					PO		1	Turkey Vulture
American Goldfinch	*Spinus tristis*				PR	PO	PO		PR		PO	PR	PO	PO	1	1	Northern Cardinal
American Robin	*Turdus migratorius*			PO	PR	PO	PR	PO	PO	PR			PR	PR	1	1	Barn Swallow (X)
Baltimore Oriole	*Icterus galbula*				PR		PO										Indigo Bunting
Barn Swallow	*Hirundo rustica*			PR	PO	PO		PO		X	X		X				Brown-headed Cowbird
Black-capped Chickadee	*Poecile atricapillus*			PO													
Blue Jay	*Cyanocitta cristata*								X		PO		PO				
Bobolink	*Dolichonyx oryzivorus*				PO				PR			X		PO	2	1	
Canada Goose	*Branta canadensis*		CO														
Cedar Waxwing	*Bombycilla cedrorum*									PO	PR		PO				
Chipping Sparrow	*Spizella passerina*						PO										
Common Grackle	*Quiscalus quiscula*				X		PO	PO			PR	X		PO		4	
Common Yellowthroat	*Geothylpis trichas*		PR	PO	PO	PR	PR	PO	PO	PR	PR	PR	PO	PR	1	1	
Eastern Kingbird	*Tyrannus tyrannus*				PR			PO						PO	1		
Eastern Meadowlark	*Sturnella magna*				PR		PO	PR	PO				PO	PO		1	
Eastern Wood-pewee	*Contopus virens*				PO												
European Starling	*Sturnus vulgaris*				PO		PO	PO			PO	PO	X	CO	5	7	
Great Blue Heron	*Ardea herodias*													X	1		
Horned Lark	*Eremophila alpestris*												PO				
House Wren	*Troglodytes aedon*						PO										
Indigo Bunting	*Passerina cyanea*												PO				
Killdeer	*Charadrius vociferus*		PR		PR			PO	PO			PO	PR				
Mallard	*Anas platyrhynchos*		X			X	PO					X					
Mourning Dove	*Zenaida macroura*													PO	1	1	
Northern Cardinal	*Cardinalis cardinalis*			PO													
Northern Flicker	*Colaptes auratus*						PO										
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*												X				
Red-tailed Hawk	*Buteo jamaicensis*			PO	PO												
Red-winged Blackbird	*Agelaius phoeniceus*		CO	CO	CO	PR	PR	PR	PR	PR	PR	PR	PR	CO	6	9	
Ring-billed Gull	*Larus delawarensis*		X	X													
Rock Pigeon	*Columba livia*							PO				X					
Savannah Sparrow	*Passerculus sandwichensis*		PR	PO	PO	PR	PO	PR	PR	PO	PO	PO	PR	PR	3	2	
Song Sparrow	*Melospiza melodia*			PO	PR	PR		PO	PR	PO	PR	PR	PO	PR	2	3	
Swamp Sparrow	*Melospiza georgiana*												PO				
Tree Swallow	*Tachycineta bicolor*		CO	PO				PO	PO		PO			PR		2	
Turkey Vulture	*Cathartes aura*							PO					X				
Warbling Vireo	*Vireo gilvis*								PO				PO				
Wild Turkey	*Meleagris gallopavo*								PO								
Willow Flycatcher	*Empidonax traillii*				PO			PR	PO	PR	PO	PR	PO	PR	1	1	
Yellow Warbler	*Setophaga petechia*			PO	PO			PO			PR	PR	PO				
Total	**40**		8	13	19	9	13	16	15	8	13	13	20	16	**25**	**35**	
															60		

Breeding Bird Plot 011	FODR1-1																
		Breeding Evidence															**Incidental Observations**
															2020		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**	June 15	July 3	**2020**
American Crow	*Corvus brachyrhynchos*				PO	PO						PO		PO		1	
American Goldfinch	*Spinus tristis*				X	PO	PO	PR	PR	PR	PO	PR	PO	PR	1	1	
American Redstart	*Setophaga ruticilla*				PO			PO		PR	PR	PR	PR	PO		1	
American Robin	*Turdus migratorius*				PO	PR	PR	PR	PR	PO	PO	PO	PO	CO	3	2	
Baltimore Oriole	*Icterus galbula*					PO	PO		PR			PO		PO	1		
Barn Swallow	*Hirundo rustica*					PO			X					CO		5	
Black-capped Chickadee	*Poecile atricapillus*					PO	PO	PO	PR	PO	PO	PO	PR	PO		1	
Blue Jay	*Cyanocitta cristata*				PO				PO								
Brown-headed Cowbird	*Molothrus ater*									PO		PO		PO		1	
Cedar Waxwing	*Bombycilla cedrorum*					PO			PO	PO			PO	PR	2	4	
Chestnut-sided Warbler	*Setophaga pensylvanica*						PO										
Chipping Sparrow	*Spizella passerina*						PO			PO				PO		1	
Cliff Swallow	*Petrochelidon pyrrhonota*								X								
Common Grackle	*Quiscalus quiscula*				X			PO	PO								
Common Yellowthoat	*Geothlypis trichas*										PO						
Downy Woodpecker	*Picoides pubescens*						PO				PO						
Eastern Kingbird	*Tyrannus tyrannus*					PR											
Eastern Meadowlark	*Sturnella magna*				PO				PO								
Eastern Wood-pewee	*Contopus virens*				PO	PO			PO								
European Starling	*Sturnus vulgaris*							PO	CO	PO		PO		CO	5	1	
Gray Catbird	*Dumetella carolinensis*				PO	PO	PO	CO	PO	PO	PR	PO	PR				
Great Crested Flycatcher	*Myiarchus crinitus*											PR					
Horned Lark	*Eremophila alpestris*								PO								
House Finch	*Carpodacus mexicanus*													PO		1	
House Wren	*Troglodytes aedon*				PR	PO											
Killdeer	*Charadrius vociferus*				PO					PO							
Mourning Dove	*Zenaida macroura*					PO	PR		PO			PO	PO	PO	1		
Northern Cardinal	*Cardinalis cardinalis*				PO			PO		PO				PO		1	
Northern Flicker	*Colaptes auratus*				PO				PO	PO		PO		PO		1	
Red-eyed Vireo	*Vireo olivaceus*						PO	PO	PO	PO			PR	PR	1	2	
Red-winged Blackbird	*Agelaius phoeniceus*				PO	PO	PO	PO	PR		PR	PO	PO	PO	2		
Rose-breasted Grosbeak	*Pheucticus ludovicianus*				PO					PO	PO						
Savannah Sparrow	*Passerculus sandwichensis*					PR			PO				PO	PO		1	
Sharp-shinned hawk	*Accipiter striatus*													PO	1		
Song Sparrow	*Melospiza melodia*				PR	PO	PO		PR	PR	PO	PR	PO	PO		1	
Tree Swallow	*Tachycineta bicolor*						PR				PO						
Turkey Vulture	*Cathartes aura*								X								
Warbling Vireo	*Vireo gilvis*				PO	PO	PO	PO		PO		PO	PO	PO		1	
White-breasted Nuthatch	*Sitta carolinensis*							PO									
Yellow Warbler	*Setophaga petechia*						PO	PR	PR	PO		PR					
Total	**40**				17	16	15	13	22	17	11	16	12	21	**17**	**26**	
															43		

Breeding Bird Plot 016	SWDM3-2																
		Breeding Evidence															Incidental Observations
														2020			
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**	June 15	July 3	**2020**
American Crow	*Corvus brachyrhynchos*						PO		PO								Indigo Bunting
American Goldfinch	*Spinus tristis*						PO	PO		PR	PR	PO	PR	PO		2	Cedar Waxwing
American Redstart	*Setophaga ruticilla*						PO							PO		1	Killdeer
American Robin	*Turdus migratorius*						PR	CO	PR	PO	PR	PO	PR	PR	3	2	Savannah Sparrow
Baltimore Oriole	*Icterus galbula*						PO		PO			PO					
Black-capped Chickadee	*Poecile atricapillus*						PO	PR				PO	PO	PO	1		
Blue Jay	*Cyanocitta cristata*						PR				PO			PO		1	
Blue-headed Vireo	*Vireo solitarius*													PO	1		
Brown-headed Cowbird	*Molothrus ater*						PO		PO				PO				
Cedar Waxwing	*Bombycilla cedrorum*						PO					PO					
Common Grackle	*Quiscalus quiscula*											PO					
Common Yellowthroat	*Geothylpis trichas*												PO	PO		1	
Downy Woodpecker	*Picoides pubescens*							PO									
Eastern Wood-pewee	*Contopus virens*							PO					PO	PO	2		
European Starling	*Sturnus vulgaris*											CO		PO	2		
Hairy Woodpecker	*Picoides villosus*						PO										
Horned Lark	*Eremophila alpestris*								PO								
House Wren	*Troglodytes aedon*													PO		1	
Indigo Bunting	*Passerina cyanea*										PO	PO					
Killdeer	*Charadrius vociferus*						PO	PR	PO		PO		PR	PO		2	
Mourning Dove	*Zenaida macroura*												PO				
Northern Cardinal	*Cardinalis cardinalis*													PR	1	1	
Northern Flicker	*Colaptes auratus*													PO		1	
Red-eyed Vireo	*Vireo olivaceus*						PO		PO	PO	PO			PO		1	
Red-winged Blackbird	*Agelaius phoeniceus*										PR	PO	PO	PR	2	4	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*									PO							
Savannah Sparrow	*Passerculus sandwichensis*						PO		PO		PO		PO	PO		1	
Song Sparrow	*Melospiza melodia*						PR	PR	PR	PO	PR	PR	PR	PR	2	1	
Tree Swallow	*Tachycineta bicolor*						PO										
Warbling Vireo	*Vireo gilvis*						PR		PR			PR					
Yellow-bellied Sapsucker	*Sphyrapicus varius*						PO										
Yellow Warbler	*Setophaga petechia*								PR								
Total	**32**						17	7	10	5	9	11	11	17	**14**	**19**	
															33		

Breeding Bird Plot 019	**MEM**																
		Breeding Evidence															**Incidental Observations**
															2020		
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**	June 15	July 3	**2020**
American Crow	*Corvus brachyrhynchos*							PR	PO			X	PO				Turkey Vulture
American Goldfinch	*Spinus tristis*						PO	PO	PR	PO		PO	PR	PR	4	4	Winter Wren
American Robin	*Turdus migratorius*						PO	PO	PR	PO			PO	PO		1	
American Woodcock	*Scolopax minor*								PO								
Baltimore Oriole	*Icterus galbula*								PR		CO			PO		1	
Bank Swallow	*Riparia riparia*						PO										
Barn Swallow	*Hirundo rustica*						PO	PO	PO	X	CO			X		1	
Black-billed Cuckoo	*Coccyzus erythropthalmus*													CO		1	
Black-capped Chickadee	*Poecile atricapillus*												PR				
Blue Jay	*Cyanocitta cristata*							PO	PO	PO	PR		PR	PR	1	4	
Bobolink	*Dolichonyx oryzivorus*							PR									
Brown-headed Cowbird	*Molothrus ater*						PO				PO	PO		PO	1		
Cedar Waxwing	*Bombycilla cedrorum*							PO		PO	PR		X	PR		2	
Common Grackle	*Quiscalus quiscula*						PO	X	PO	PO		PO					
Common Yellowthroat	*Geothylpis trichas*						PR	PO	PR	PO	PO	PR	PR	PO		1	
Downy Woodpecker	*Picoides pubescens*												PR				
Eastern Kingbird	*Tyrannus tyrannus*									PO							
Eastern Meadowlark	*Sturnella magna*							PR									
Eastern Wood-pewee	*Contopus virens*						PO		PR	PO			PR				
European Starling	*Sturnus vulgaris*								PO								
Gray Catbird	*Dumetella carolinensis*									PO	PO						
Great Blue Heron	*Ardea herodias*										X						
Great Crested Flycatcher	*Myiarchus crinitus*								PO	PO							
House Wren	*Troglodytes aedon*								PO					PO	2		
Indigo Bunting	*Passerina cyanea*							PO		PR		PR	PR	PO		1	
Killdeer	*Charadrius vociferus*												PO				
Northern Cardinal	*Cardinalis cardinalis*								PR			PR	PO				
Northern Flicker	*Colaptes auratus*								PO		PO			PO		1	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*								PO								
Red-bellied Woodpecker	*Melanerpes carolinus*								PO		PO			PO	1		
Red-eyed Vireo	*Vireo olivaceus*										PR		PO	PO		1	
Red-winged Blackbird	*Agelaius phoeniceus*						PO	PR	PR	PO	PR	PR		PO	4		
Rose-breasted Grosbeak	*Pheucticus ludovicianus*												PO	PR	1	1	
Rock Pigeon	*Columba livia*											X					
Savannah Sparrow	*Passerculus sandwichensis*							PO				PR	PR	PO	1		
Song Sparrow	*Melospiza melodia*						PR	PR	CO	PR	PR	PR	PR	PR	2	2	
Tree Swallow	*Tachycineta bicolor*							PO	PO		PO						
Vesper Sparrow	*Pooecetes gramineus*												PO				
Warbling Vireo	*Vireo gilvis*								PO								
White-breasted Nuthatch	*Sitta carolinensis*												PO				
Willow Flycatcher	*Empidonax traillii*									PO							
Wood Thrush	*Hylocichla mustelina*								PO								
Yellow-bellied Sapsucker	*Sphyrapicus varius*										PO						
Yellow Warbler	*Setophaga petechia*							PO									
Total	**44**						10	16	22	15	15	11	18	18	**17**	**21**	
															38		

Breeding Bird Plot 020	Agricultural Field																
		Breeding Evidence															Incidental Observations
														2020			
Common Name	**Scientific Name**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2018**	**2020**	June 15	July 3	**2020**
American Crow	*Corvus brachyrhynchos*								PO	PO				PO	1		Bobolink
American Goldfinch	*Spinus tristis*						PR	PR	PR		PR	PR	PO	PR	1	2	
American Robin	*Turdus migratorius*						PO	PO	PR	PO	PO	PO	1	PO		1	
Baltimore Oriole	*Icterus galbula*							PR									
Barn Swallow	*Hirundo rustica*							X	X	X			PR	PR	1	2	
Black-capped Chickadee	*Poecile atricapillus*							PO	PO								
Blue Jay	*Cyanocitta cristata*							PO	PR				PO	PO	1		
Bobolink	*Dolichonyx oryzivorus*						PO	PO	PR	PR	PR	PR		PR	2	8	
Brown-headed Cowbird	*Molothrus ater*							PO									
Chipping Sparrow	*Spizella passerina*						PR										
Cedar Waxwing	*Bombycilla cedrorum*							PO				PO					
Cliff Swallow	*Petrochelidon pyrrhonota*													X		1	
Common Grackle	*Quiscalus quiscula*						PO	PO	PO	PO			PO				
Cooper's Hawk	*Accipiter cooperii*													PO		1	
Common Yellowthroat	*Geothylpis trichas*							PR	PO	PR	PO		PR	PO		1	
Downy Woodpecker	*Picoides pubescens*							PO									
Eastern Kingbird	*Tyrannus tyrannus*								PR	PO	PO	CO		PO	1		
Eastern Meadowlark	*Sturnella magna*						PO	PO	PR	PO	PR	PO	CO	PR	2	2	
European Starling	*Sturnus vulgaris*								PO			PO					
Great Crested Flycatcher	*Myiarchus crinitus*							PO									
House Wren	*Troglodytes aedon*						PR	PO		PO				PR	1	1	
Indigo Bunting	*Passerina cyanea*							PO				PO	PO	PO		1	
Killdeer	*Charadrius vociferus*								PO	PO			PO				
Mallard	*Anas platyrhynchos*									X							
Northern Flicker	*Colaptes auratus*													PO		1	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*								X			PO		PO	2		
Red-tailed Hawk	*Buteo jamaicensis*								PR								
Red-winged Blackbird	*Agelaius phoeniceus*						PR	CO	PR	CO	PO		PR	PO	1	1	
Ring-billed Gull	*Larus delawarensis*								PO								
Rock Pigeon	*Columba livia*									X							
Rose-breasted Grosbeak	*Pheucticus ludovicianus*													PR	1	1	
Savannah Sparrow	*Passerculus sandwichensis*						PR	CO	PR	PR	PR	PR	PR	PR	2	4	
Song Sparrow	*Melospiza melodia*						PO	PR	CO	PO	PR	PO	PO	PR	1	1	
Tree Swallow	*Tachycineta bicolor*							X	X	X	X	PO	X				
Turkey Vulture	*Cathartes aura*												X				
Warbling Vireo	*Vireo gilvis*							PO	PO			PO					
Yellow Warbler	*Setophaga petechia*						PO										
Total	**37**						11	21	20	16	10	13	14	19	**17**	**28**	
															45		

Incidentals

Common Name	Scientific Name	Breeding Evidence												
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
Alder Flycatcher	*Empidonax alnorum*							PO						
American Crow	*Corvus brachyrhynchos*	PO		PO	PO	PO	PO	PO					PO	X
American Goldfinch	*Spinus tristis*	PR	X	PO	PO	PO	PO	PR			PO			PO
American Redstart	*Setophaga ruticilla*													PO
American Robin	*Turdus migratorius*	PO		PO	PO	PR	PO	PR			PO	PO		PO
American Woodcock	*Scolopax minor*											CO		PR
Baltimore Oriole	*Icterus galbula*	PR	PR		PO		PO	PO						PO
Barn Swallow	*Hirundo rustica*			X			PO				X			X
Black-capped Chickadee	*Poecile atricapillus*			PO	PO		PO					PO		PO
Blue Jay	*Cyanocitta cristata*	PO			PO	PO	PO	PO			PO	PO	PO	PO
Bobolink	*Dolichonyx oryzivorus*	PO		PO		PR	PR	PR			PR	PR		PR
Brown-headed Cowbird	*Molothrus ater*	PO	PO	PO	PO	PR	PO	PR				PO	PO	PO
Canada Goose	*Branta canadensis*		PR			X		PO				X		
Cedar Waxwing	*Bombycilla cedrorum*		PR	PO		PO	PO							PO
Chimney Swift	*Chaetura pelagica*										PR			
Chipping Sparrow	*Spizella passerina*				PO		PO							PO
Common Grackle	*Quiscalus quiscula*		X	PO			PO	PO						PO
Common Yellowthroat	*Geothylpis trichas*		PO	PO		PR	PO	PO						PO
Cuckoo sp.											PO			
Downy Woodpecker	*Picoides pubescens*			PO										
Eastern Bluebird	*Sialia sialis*										PR			
Eastern Kingbird	*Tyrannus tyrannus*	PO	PO			PR					PO			
Eastern Meadowlark	*Sturnella magna*		PO	PO	PO	PR	PO	PO			PO	PO	PO	PO
Eastern Wood-pewee	*Contopus virens*		PO		PO	PO		PO				PO		
European Starling	*Sturnus vulgaris*	PO		PO	PO		PO	PO					PO	PO
Field Sparrow	*Spizella pusilla*		PO	PO			PO							
Grasshopper Sparrow	*Ammodramus savannarum*										PO			
Gray Catbird	*Dumetella carolinensis*		PO	PO	PO		PO	PO				PO		PO
Great Blue Heron	*Ardea herodias*			X			X				X		X	
Great Crested Flycatcher	*Myiarchus crinitus*			PO			PO				PO	PO		
Great Horned Owl	*Bubo virginianus*											X		
Gull sp.								X						
Hairy Woodpecker	*Picoides villosus*						PO	PO						
Horned Lark	*Eremophila alpestris*												PO	
House Wren	*Troglodytes aedon*				PO		PO	PO				PO		PO
Indigo Bunting	*Passerina cyanea*	PO	PR	PR			PO				PO			PO
Killdeer	*Charadrius vociferus*						PR	PR			PO	PO		PR
Mallard	*Anas platyrhynchos*		X		PR	X	X							PO
Mourning Dove	*Zenaida macroura*			PO	PO	PO		PR						PO
Nashville Warbler	*Leiothlypis ruficapilla*										PR			
Northern Cardinal	*Cardinalis cardinalis*	PO		PO	PO		PO				PR	PO		PO
Northern Flicker	*Colaptes auratus*				PO	PR	PO	PO					PO	
Northern Waterthrush	*Parkesia noveboracensis*					PO								
Pine Warbler	*Setophaga pinus*			PO										
Red-eyed Vireo	*Vireo olivaceus*											PO	PO	
Red-tailed Hawk	*Buteo jamaicensis*	PR		PO	PO		PR	PO			PO			

Common Name	Scientific Name	Breeding Evidence												
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
Red-winged Blackbird	*Agelaius phoeniceus*	PO		PO	CO	PR	PO	CO			PR			PR
Ring-billed Gull	*Larus delawarensis*						X	X				X		
Rock Pigeon	*Columba livia*					X								
Ruffed Grouse	*Bonasa umbellus*						PO							
Savannah Sparrow	*Passerculus sandwichensis*		PO	PO	PO	PR	PO	PO			PO	PR	PO	PO
Song Sparrow	*Melospiza melodia*	PO	PO	PO	PO	PR	PO	PO				PO		PO
Spotted Sandpiper	*Actitis macularia*						PO	PO						
Tree Swallow	*Tachycineta bicolor*	PR			CO	PO	PO	PO						
Turkey Vulture	*Cathartes aura*			X		X		X			X	X		X
Vesper Sparrow	*Pooecetes gramineus*				PO									PO
Warbling Vireo	*Vireo gilvis*					PO	PO							PO
Wild Turkey	*Meleagris gallopavo*							PO						
Willow Flycatcher	*Empidonax traillii*					PO								PO
Winter Wren	*Troglodytes hiemalis*					PO	PO							PR
White-breasted Nuthatch	*Sitta carolinensis*	PO					PO							
Wood Thrush	*Hylocichla mustelina*			PO										
Yellow Warbler	*Setophaga petechia*			PO	PO	PR	PO							PO
Total	**67**	18	17	29	25	28	39	31	0	0	22	21	11	34

APPENDIX VII
Bird Species Observed in the Study Area 2006 - 2020

Appendix VII. Bird Species Observed in the Study Area

Common Name	Scientific Name	SRANK[1]	COSEWIC[2]	SARO[1]	Local Status[3]	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
HERONS & BITTERNS																		
Great Blue Heron	*Ardea herodias*	S4B			**			X			X				X		X	X
Green Heron	*Butorides virescens*	S4B			**									(X)				
GEESE																		
Canada Goose	*Branta canadensis*	S5					PR			X	*	(PO)	*	(PO)		X		
DUCKS																		
Wood Duck	*Aix sponsa*	S5							X	*			*					X
Mallard	*Anas platyrhynchos*	S5				PO	PR		X	X	PO		PR	PO	PO	X		(PO)
Bufflehead	*Bucephala albeola*	S4								*								
Hooded Merganser	*Lophodytes cucullatus*	S5B, S5N											*					
VULTURES																		
Turkey Vulture	*Cathartes aura*	S5B			√	PO	X	X	X	X	X	PO	X	(X)	X	X	X	
HAWKS, KITES & EAGLES																		
Northern Harrier	*Circus cyaneus*	S4B	NAR	NAR	√*					*								
Cooper's Hawk	*Accipiter cooperii*	S4	NAR	NAR	√*					*						PO		PO
Sharp-shinned Hawk	*Accipiter striatus*	S5		NAR	√*													PO
Red-tailed Hawk	*Buteo jamaicensis*	S5	NAR	NAR		PO	CO	PO	CO	PO	PR	(PO)	PR	(PO)	PO			
CARACARAS & FALCONS																		
American Kestrel	*Falco sparverius*	S4			√*				X		*							
PARTRIDGES, GROUSE & TURKEY																		
Ruffed Grouse	*Bonasa umbellus*	S4									(PO)							
Wild Turkey	*Meleagris gallopavo*	S5								*	*		PO		PO			
OWLS																		
Great Horned Owl	*Bubo virgianus*	S4														CO		
PLOVERS																		
Killdeer	*Charadrius vociferus*	S5B, S5N				PO	CO		PO		PO	PR	PO	PO	PO	PO	PR	PO
Solitary Sandpiper	*Tringa solitaria*	S4B												(PR)				
SANDPIPERS & PHALAROPES																		
Spotted Sandpiper	*Actitis macularia*	S5								*	(PO)	PO	*		PO		PO	
American Woodcock	*Scolopax minor*	S4B					PO	PO	PR		*	PO	PO	(PR)	PO	CO		
GULLS																		
Ring-billed Gull	*Larus delawarensis*	S5B, S4N					X	X		*	X	X	PO		X	X	X	X
Herring Gull	*Larus argentatus*	S5B, S5N			**					*								
DOVES																		
Rock Pigeon	*Columba livia*	SNA					X			X		PO		PO		X		
Mourning Dove	*Zenaida macroura*	S5					PO	PO	PO	PO	PR	PR	PO	PO	PR	PR	PO	PO

Common Name	Scientific Name	SRANK[1]	COSEWIC[2]	SARO[1]	Local Status[3]	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
CUCKOOS																		
Yellow-billed Cuckoo	*Coccyzus americanus*	S4B			√	PO												
Black-billed Cuckoo	*Coccyzus erythropthalmus*	S5B			√*								X	PR	PO			CO
SWIFTS																		
Chimney Swift	*Chaetura pelagica*	T	THR	√											PR			
TYPICAL OWLS																		
Barred Owl	*Strix varia*	S5			√									(X)				
Great Horned Owl	*Bubo virginianus*	S4																
KINGFISHERS																		
Belted Kingfisher	*Megaceryle alcyon*	S4B			√					PO			PO	CO		X		X
WOODPECKERS																		
Red-bellied Woodpecker	*Melanerpes carolinus*	S4			√								PO		PO	CO		PO
Yellow-bellied Sapsucker	*Sphyrapicus varius*	S5B			√*					*	PO		*		PO			
Downy Woodpecker	*Picoides pubescens*	S5				PO	X	PO		CO	PO	PO	PO	PO	PR	PO	PR	PO
Hairy Woodpecker	*Picoides villosus*	S5			√*	PO	X	PO	PO		PO	PO	PR				PO	PO
Northern Flicker	*Colaptes auratus*	S4B			√*	PR	CO		PO	PO	PO	PO	PO	PO	PO	PO	PR	PO
Pileated Woodpecker	*Dryocopus pileatus*	S5			√*					*			*					
FLYCATCHERS																		
Flycatcher spp						PO		X										
Eastern Wood-pewee	*Contopus virens*	S4B	SC	SC		PO	PO	PR	PO	PR	PO	PR	PR	PR	PO	PO	PR	PO
Alder Flycatcher	*Empidonax alnorum*	S5B									PR	PO					PO	
Willow Flycatcher	*Empidonax traillii*	S5B			√				PO	PR		PR	PR	PR	PR	PR	PR	PR
Least Flycatcher	*Empidonax minimus*	S4B			√	PO		PO										
Eastern Phoebe	*Sayornis phoebe*	S5B					PO			*				(PO)	PO			
Great Crested Flycatcher	*Myiarchus crinitus*	S4B				PO	PR	PO	PO	PR	PR	PO	PO	PR	PR	PR	PO	PR
Eastern Kingbird	*Tyrannus tyrannus*	S4B			√*	PO	PO		PR	PR	PO	PO	PR	PO	PO	CO	PO	PO
LARKS																		
Horned Lark	*Eremophila alpestris*	S5B								*			PO		PO		PO	
SWALLOWS																		
Tree Swallow	*Tachycineta bicolor*	S4B				PO	CO	PO	PO	PO	PR	PO	PO	X	PO	PO	X	CO
Bank Swallow	*Riparia riparia*	S4B			√*[1]						PR			PO	PO	PO		
Barn Swallow	*Hirundo rustica*	S4B	T	THR		PO	PR	PR		PO	(PO)	PO	PO	X	CO		PR	CO
Cliff Swallow	*Petrochelidon pyrrhonota*	S4B			**[2]								X					X
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	S4B							PR			PO	PO			PO	X	PO
CROWS & JAYS																		
Blue Jay	*Cyanocitta cristata*	S5				PR	CO	PR	PR	PO	PR	PR	PR	PR	PR	PR	CO	PR
American Crow	*Corvus brachyrhynchos*	S5B				PR	CO	PO	PR	CO	PO	PR	PO	PO	X	X	PR	CO
CHICKADEES																		
Common Redpoll	*Carduelis flammea*	S4B											*					
Black-capped Chickadee	*Poecile atricapillus*	S5				PR	PR	PR	PO	PO	PO	CO	PR	PR	PR	PR	CO	PR

Common Name	Scientific Name	SRANK[1]	COSEWIC[2]	SARO[1]	Local Status[3]	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
NUTHATCHES																		
Red-breasted Nuthatch	*Sitta canadensis*	S5			√*					PR	*	PO	PO		PO	PO		PR
White-breasted Nuthatch	*Sitta carolinensis*	S5				PO	PO		PO		PR	PO				PO	PO	PO
CREEPERS																		
Brown Creeper	*Certhia americana*	S5B			√*				PO	PO	PO	PO	PO					PO
WRENS																		
House Wren	*Troglodytes aedon*	S5B				PO	PR	PR	PO	PO	PR	PR	PR	PR	PR	PR	PR	PR
Winter Wren	*Troglodytes hiemalis*	S5B			√*					PO	(X)					PO	PR	PO
KINGLETS																		
Golden-crowned Kinglet	*Regulus satrapa*	S5B											*					
Ruby-crowned Kinglet	*Regulus calendula*	S4B			√					*			*					
THRUSHES																		
Swainson's Thrush	*Catharus ustulatus*	S4B			√					*								
Hermit Thrush	*Catharus guttatus*	S5B			√					*								
Wood Thrush	*Hylocichla mustelina*	S4B	T		√*		CO	PO		*			PO		PR			
American Robin	*Turdus migratorius*	S5B				PR	CO	PR	PR	CO	PR	CO	PR	PR	PR	PR	CO	CO
MIMIDS																		
Gray Catbird	*Dumetella carolinensis*	S4B				PR	PR	PO	PO	PO	CO	CO	PO	PO	PR	PO	PR	PR
Brown Thrasher	*Toxostoma rufum*	S4B			√					*								
WAXWINGS																		
Cedar Waxwing	*Bombycilla cedrorum*	S5B				PO	PR	PO	PO	PR	PR	PO	PR	PR	PR	PR	PR	PR
STARLINGS																		
European Starling	*Sturnus vulgaris*	SNA				PO	X	PO	PO	X	PR	PO		PO	PO	CO	PO	CO
VIREOS																		
Warbling Vireo	*Vireo gilvis*	S5B								PR	PR	PR	PR	PO	PO	PR	PO	PO
Red-eyed Vireo	*Vireo olivaceus*	S5B				PR	PO	PO	PO	PR	PO	PO	PR	PR	PR	PR	PR	PR
Blue-headed Vireo	*Vireo solitarius*	S5B			√													PO
WOOD WARBLERS																		
Warbler spp.						PO												
Tennessee Warbler	*Oreothlypis peregrina*	S5B			√	PO				X								
Nashville Warbler	*Oreothlypis ruficapilla*	S5B								*					PR			
Yellow Warbler	*Setophaga petechia*	S5B					X	PR	PR	PR	PR	PR	PR	PR	PR	PR	PO	PR
Chestnut-sided Warbler	*Setophaga pensylvanica*	S5B				PO					PO							
Yellow-rumped Warbler	*Setophaga coronata*	S5B								*								
Black-throated Green Warbler	*Setophaga virens*	S5B			√					*								
Pine Warbler	*Setophaga pinus*	S5B			√*			PR		PO		PO				PO		
American Redstart	*Setophaga ruticilla*	S5B			√*					PO	PO	PO		PR	PR	PR	PR	PO
Ovenbird	*Seiurus aurocapillus*	S4B			√*		PO			*								
Northern Waterthrush	*Parkesia noveboracensis*	S5B								PR	PO	PR	PR	PR	PR	PO	PO	PR
Common Yellowthroat	*Geothlypis trichas*	S5B				PR	PR	PR	PO	PR	PR	PR	CO	PR	PR	PR	PR	PR

Common Name	Scientific Name	SRANK[1]	COSEWIC[2]	SARO[1]	Local Status[3]	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020
CARDINALS & ALLIES																		
Northern Cardinal	*Cardinalis cardinalis*	S5				PO	PR	PO	PO	PO	PR	PR	PR	PR	PR	PR	PO	PR
Scarlet Tanager	*Piranga olivacea*	S4B			√	PO						PO						
SUMMER FINCHES																		
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	S4B			√*				PO	PR	PR			PR	PO	PO	PO	PR
Indigo Bunting	*Passerina cyanea*	S4B				PO	PR	PR		PO	(PO)	PR		PR	PO	PR	PR	PO
SPARROWS																		
Grasshopper Sparrow	*Ammodramus savannarum*	S4B			√								PO	(PO)	PO	PO		
American Tree Sparrow	*Spizella arborea*	S4B								*								
Chipping Sparrow	*Spizella passerina*	S5B				PO	PO	PR	PO	X	PR		PR	PO	PO		PO	PR
Field Sparrow	*Spizella pusilla*	S4B			√*		PO	PO		X	PO				PO	PO		
Vesper Sparrow	*Pooecetes gramineus*	S4B			√*				PO								PO	(PO)
Savannah Sparrow	*Passerculus sandwichensis*	S4B			√*		PR	PO	PO	PR	PR	PR	PR	PR	PR	PR	PR	PR
Song Sparrow	*Melospiza melodia*	S5B				PR	CO	PR	PO	PR	PR	PR	CO	PR	PR	PR	PR	PR
Swamp Sparrow	*Melospiza georgiana*	S5B				PO						PR			PO		PR	PO
White-throated Sparrow	*Zonotrichia albicollis*	S5B								*								
Dark-eyed Junco	*Junco hyemalis*	S5B			√		X			*			*					
BLACKBIRDS																		
Bobolink	*Dolichonyx oryzivorus*	S4B	T	THR	√*	PO	PO	PO	PO	PR	PO	PR	PR	PR	PR	PR		PR
Red-winged Blackbird	*Agelaius phoeniceus*	S4				PR	CO	CO	CO	PR	CO	CO	PR	CO	PR	PR	CO	CO
Eastern Meadowlark	*Sturnella magna*	S4B	T	THR	√*		PO	PR	PO	PR	PO	PR	PR	PO	PR	PO	CO	PR
Rusty Blackbird	*Euphagus carolinus*	S4B	SC	NAR						*								
Common Grackle	*Quiscalus quiscula*	S5B				PO	PR	PO	X	PO	PO	PO	PO	PO	CO	CO	PO	PO
Brown-headed Cowbird	*Molothrus ater*	S4B				PO	PR	PR	PO	PR	PO	PR	PR	PR	PO	PO	PR	PR
ORIOLES																		
Baltimore Oriole	*Icterus galbula*	S4B			√*	PO	PR	PO	PO	PO	PR	PR	PR	PR	CO	PO	PO	PO
Orchard Oriole	*Icterus spurius*	S4B			√											PO		
WINTER FINCHES																		
House Finch	*Carpodacus mexicanus*	SNA						CO										PO
Pine Siskin	*Spinus pinus*	S4B							PO									
American Goldfinch	*Spinus tristis*	S5B				PR	CO	PR	PR	PO	PR	PR	PR	PR	PR	CO	PR	PR
OLD WORLD SPARROWS																		
House Sparrow	*Passer domesticus*	SNA								*			*					
					Total	**41**	**46**	**41**	**43**	**74**	**57**	**51**	**61**	**51**	**58**	**54**	**48**	**57**

[1]MNRF 2021; [2]COSEWIC 2021; [3]Dougan & Associates 2009

Legend
* Incidental birds recorded during other surveys
(breeding evidence) Species and breeding evidence recorded outside of point count

SRANK

S1 Critically Imperiled
S2 Imperiled
S3 Vulnerable
S4 Apparently Secure
S5 Secure
? Rank Uncertain
S#S# Range Rank —Numeric range rank (e.g., S2S3) used to indicate any range of uncertainty about the status of the species

B Breeding
SZ Not of practical conservation concern
SE Exotic
SAN Non-breeding accidental
SZN Non-breeding migrants/vagrants

COSEWIC, SARO Codes
E, END Endangered
T, THR Threatened
SC, SC Special Concern
NAR Not at Risk

Local Status (Wellington) (Dougan 2009)
√ Significant and rare
√* Significant but not rare
** Only habitats that support or have recently supported active nests should be considered signficant
[1] Only significant in nesting colonies of >100
[2] Only significant in nesting colonies >8

Breeding Evidence Codes
X Observed, no breeding evidence
PO Possible breeder
PR Probable breeder
CO Confirmed breeder

APPENDIX VIII

Amphibian Species Observed by Plot 2006 - 2020

Appendix XI. Amphibian Species Observed by Plot 2006 - 2020

Station #1	2006	2007			2008			2009			2010		
COMMON NAME	June 22	April 29	May 16	June 5	April 24	May 15	June 4	April 23	May 11	June 2	April 24	May 13	June 3
American Toad	Nothing Heard			Nothing Heard			Nothing Heard		Nothing Heard				Nothing Heard
Northern Spring Peeper		3	1 (4)		3	1 (5)		1 (4)			1 (7)	2 (7)	
Tetraploid Gray Treefrog										1 (1)			
Western Chorus Frog													
Northern Leopard Frog													
Pickerel Frog													
Green Frog													
Mink Frog													
Bullfrog													
Wood Frog		1 (7)						1 (1)					
Beaufort Wind Scale	0	5	0	1	0	0	3	1	0	2	1	2	2
%Cloud Cover	98	98	100	25	65	100	100	10	5	15	5	100	100
Air temp. (^oC)	21	13	10	10	7	9	16	2	3	12	10	10	18
Water temp. (^oC)	19.9	8.0	10.1	10.3			11.8	3.4	6.2	10.5		7.7	
Water pH	7.2	7.4	7.1	7.2			8.2	9.1	8.6	9.4		6.5	
Precipitation?		Light rain	Very light rain									Light rain	

Station #1	2011			2012			2013			2014		
COMMON NAME	April 27	May 18	June 2	April 19	May 15	June 4	April 17	May 9	June 10	April 29	May 21	June 9
American Toad	1 (1)			Nothing Heard	Nothing Heard	Nothing Heard						
Northern Spring Peeper	3	1 (10)					3	2 (6)		3	1 (4)	
Tetraploid Gray Treefrog			1 (1)					2 (3)				3
Western Chorus Frog												
Northern Leopard Frog												
Pickerel Frog												
Green Frog									2 (5)			
Mink Frog												
Bullfrog												
Wood Frog	2 (10)						2 (3)			1 (1)		
Beaufort Wind Scale	3	3	1	1	3	2	1	0	1	4	1	1
%Cloud Cover	20	100	5	100	35	100	70	10	100	20	100	0
Air temp. (^oC)	15	13	12	12	16	12	6	15	13	5	15	17.5
Water temp. (^oC)	13	12	11.6				5.6	11.2	13.7	5	10.3	12.8
Water pH		7.6	7.5				7.4	7.3	8.2	7.4	7.4	8
Precipitation?		Mod. Rain							Rain			

Station #1	2015			2016			2018			2020		
COMMON NAME	April 29	May 21	June 16	April 20	May 23	June 16	April 24	May 16	June 19	April 30	May 21	June 22
American Toad	2(2)	Nothing Heard				Nothing Heard		1(1)	Nothing Heard			
Northern Spring Peeper	2(2)			1(8)				3		1 (1)	1 (2)	
Tetraploid Gray Treefrog			2(9)		3							1 (1)
Western Chorus Frog												
Northern Leopard Frog												
Pickerel Frog												
Green Frog												
Mink Frog												
Bullfrog												
Wood Frog				1(1)			1 (2)			1 (1)		
Beaufort Wind Scale	1	1	1	1	1	0	2	1	0	1	0	1
%Cloud Cover	0	15	0	30	60	5	100	10	80	100	20	100
Air temp. (^oC)	12	12	18	11	18	18	8.5	21	19	9	15	22
Water temp. (^oC)	9.1			5.8	17		3.4	9.5	15.4	9		
Water pH	7.8			9.5	7.3		8.5	7.1	7.7			
Precipitation?							Light rain			Rain		Rain

Station #2	2006	2007			2008			2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	June 22	April 29	May 16	June 5	April 24	May 15	June 4	April 23	May 11	June 2	April 24	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16	April 20	May 23	June 16	April 24	May 16	June 19	April 30	May 21	June 22
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard		Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper					1 (2)							1 (4)																					3				
Tetraploid Gray Treefrog																								1 (3)				2(3)		2(6)			3				
Western Chorus Frog																																					
Northern Leopard Frog																																					
Pickerel Frog																																					
Green Frog																																					
Mink Frog																																					
Bullfrog																																					
Wood Frog																																					
Beaufort Wind Scale	2	4	2	1	1	0	4	1	0	2	0	2	0	3	3	0	1	0	2	1	0	2	3	1	1	0	1	1	0	1	0	2	1	0	1	0	1
%Cloud Cover	98	98	100	25	65	100	100	20	10	25	10	100		20	100	5	100	35	100	0	10	100	20	100	0	0	15	0	10	60	5	100	10	80	100	10	100
Air temp. (^oC)	23	12	10	10	7	11	17	2	4	12	13	10	18	15	12.5	12	13	16	12	5.5	13	16	8	22	20	14	12	18	11.5	18	18	9.5	19	19	11	18	22
Water temp. (^oC)		10.0	12.1	11.7	7	7.8	13.2	5.2	6.3	8.5	8.6	6.9	11.3	9	8.7	8.1				3.6		18.3	5	9.2	13		9.1		8.8			3.5	9		6		
Water pH		7.6	7.5	7.3		7.9	8.3	8.4	8.5	9.8	7.6	6.7	8.5		7.9	7.6				7.9		8.6	7.7	7.7	8.3		7.48		9.5			8.5	7				
Precipitation?												Light rain			Mod. Rain				Light rain			Mod. Rain										Mod. rain			Light rain		Rain

Station #4	2006	2007			2008			2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	June 22	April 29	May 16	June 6	April 24	May 15	June 4	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16	April 20	May 30	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		1 (1)	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	2 (2)	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard			Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard				Nothing Heard
Northern Spring Peeper					3				1 (2)								1 (1)																		1 (1)	2 (3)	
Tetraploid Gray Treefrog																																					
Western Chorus Frog																																					
Northern Leopard Frog																								1 (1)													
Pickerel Frog																																					
Green Frog																									1 (2)									1(1)			
Mink Frog																																					
Bullfrog																																					
Wood Frog														1 (1)																					2 (2)		
Beaufort Wind Scale	1	3	2	1	1	1	1	1	0	1	0	2	0	3	2	0	1	0	1	0	0	2	3	1	0	3	1	2	0	0	0	3	0	0	0	1	1
%Cloud Cover	80	20	100	20	65	5	100	40	40	50	5	100	100	40	100	5	100	0	100	60	15	100	5	0	90	90	5	10	35	5	20	60	10	100	100	0	100
Air temp. (^oC)	20	14	10	9	12	17	16	5	8	16	5	8	24	15	14	12	12	22	15	7	15	14	7.5	20	19	12	13	18	11	23	20	10	18.5	19	11	14	22
Water temp. (^oC)		11.4	11.5	11.2	9	10.5	14.5	7.1	9.1	11.8	6.2	6		10		8.1				4.8		14.7	5.5	18.8	10.4	7.8				17			13.8		9.3	10	
Water pH		7.6	7.7	7.6		7.8	8.3	8.2	9.3	9	7.8	7.6				7.6				8.1		8.4	7.2	8	8.2	7.3				7.2			8				
Precipitation?												Rain					Light rain					Light rain										Rain			Light rain		Light rain

Station #6	2006	2007			2008			2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	June 22	April 29	May 16	June 6	April 24	May 15	June 4	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16	April 20	May 30	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad	Nothing Heard	1(4)		Nothing Heard					Nothing Heard				Nothing Heard	1 (6)		Nothing Heard	Nothing Heard	Nothing Heard				Nothing Heard	Nothing Heard	Nothing Heard			Nothing Heard	1(1)	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper		3	2(3)		1 (2)	1(1)	1(2)	3			3	2 (5)		3	3				1 (1)	2 (4)	1 (2)					2(4)											
Tetraploid Gray Treefrog							3			1 (1)															1 (2)			2(4)									
Western Chorus Frog		1(1)																																			
Northern Leopard Frog																																					
Pickerel Frog																																					
Green Frog							1(2)			1 (1)																											
Mink Frog																																					
Bullfrog																																					
Wood Frog														1 (2)						3						1(1)											
Beaufort Wind Scale	1	3	2	1	1	0	3	0	0	0	1	1	0	1	3	1	2	0	2	1	1	1	3	1	0	2	3	2	0	0	0	2	0	0	0	2	1
%Cloud Cover	2	40	100	20	65	100	100	30	10	50	10	100	100	40	100	0	100	0	100	70	5	100	5	0	90	0	5	10	35	0	20	100	10	85	100	0	100
Air temp. (^oC)	18	12	9	9	11	13	16	2	5	15	8	8	24	14	13.5	12	11	19	15	6	13	14	7.5	20	17	11	14	20	11	19	20	10	21.3	19.5	11	14	21
Water temp. (^oC)	23.6	14.4	14.1	15.3		13.8	16.3	8.9	7.7	16.7	13.3	9	19.1	13.5		10				10.5			6.7														
Water pH	7.8	7.8	7.8	7.6		8.0	8.5	8.1	8.7	9.8	7.9	8.5	7.2			8.3				7.4			8.1														
Precipitation?															Rain		Light rain					Rain										Light rain			Light rain		

Station #7	2006	2007			2008			2009			2010			2011			2012		
COMMON NAME	June 22	April 29	May 16	June 6	April 24	May 15	June 4	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper						1(1)													
Tetraploid Gray Treefrog																			
Western Chorus Frog																			
Northern Leopard Frog																			
Pickerel Frog																			
Green Frog																			
Mink Frog																			
Bullfrog																			
Wood Frog																			
Beaufort Wind Scale	1	3	2	1	1	0	2	0	0	0	1	1	0	1	1	2	1	0	2
%Cloud Cover	75	15	100	20	65	50	100	30	10	50	0	100	100	10	100	0	100	0	100
Air temp. (^oC)	18	13	10	7	11	13	16	4	7	15	8	8	24	13	14	13	12	20	15
Water temp. (^oC)	11.4	9.3	10.5	10.4		10.9	10.8	5.9		12	8.6	6		8	9.5	11.6	7.6		
Water pH	8.2	7.7	7.7	7.6		8.2	8.4	8		9.7	7.6	7.9			8	8.4	7.8		
Precipitation?															Rain		Light rain		

Station #7	2013			2014			2015			2016			2018			2020		
COMMON NAME	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16	April 20	May 30	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper																		
Tetraploid Gray Treefrog			2 (6)						2(3)									
Western Chorus Frog																		
Northern Leopard Frog																		
Pickerel Frog																		
Green Frog																		
Mink Frog																		
Bullfrog																		
Wood Frog																		
Beaufort Wind Scale	1	0	2	3	1	0	2	1	3	0	0	0	2	0	0	0	1	1
%Cloud Cover	80	15	100	5	0	90	100	5	10	35	0	20	30	10	100	100	0	100
Air temp. (^oC)	7	14	14	7.5	20	18	12	13	18	11	19	20	10	17	19	11	14	21
Water temp. (^oC)	5.3	7.7		5.4	8.5	11.9	6	12.3		6.9	15			9.3		7.1	8.5	
Water pH	8.1	8.6		7.3	7.8	7.8	7.8	8.9		8.3	7.1			8.1				
Precipitation?			Rain										Light rain			Light rain		

Station #8	2006	2007			2008			2009			2010			2011			2012		
COMMON NAME	June 22	April 29	May 16	June 6	April 24	May 15	June 4	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard
Northern Spring Peeper																			
Tetraploid Gray Treefrog																		1 (1)	
Western Chorus Frog																			
Northern Leopard Frog																			
Pickerel Frog																			
Green Frog																			
Mink Frog																			
Bullfrog																			
Wood Frog																			
Beaufort Wind Scale	1	2	2	1	1	0	1	0	0	1	1	2	0	2	2	1	1	1	2
%Cloud Cover	80	15	100	20	65	50	100	30	30	50	0	100	100	40	100	0	100	5	100
Air temp. (^{o}C)	18.5	13	10	9	11	14	16	3	7	16	8	8	24	14	13	13	12	22	15
Water temp. (^{o}C)	14.5	11.5	11.4	11	10	12.1	13	7.6	8.9	12.4	9.4	7	13.6	12	12	13	12.9		
Water pH	8	7.7	7.8	7.8		8.2	8.5	8.1	9.4	9.4	7.6	8.6	7.1		8.4	8.4	8.4		
Precipitation?															Rain		Light rain		

Station #8	2013			2014			2015			2016			2018			2020		
COMMON NAME	April 16	May 9	June 10	April 29	May 21	June 9	Apr 20	May 21	June 16	Apr 20	May 30	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper																		
Tetraploid Gray Treefrog											2(2)							
Western Chorus Frog																		
Northern Leopard Frog																		
Pickerel Frog																		
Green Frog																		
Mink Frog																		
Bullfrog																		
Wood Frog																		
Beaufort Wind Scale	0	0	1	2	1	0	3	1	2	1	0	0	2	0	0	0	1	1
%Cloud Cover	80	15	100	5	0	90	100	5	10	30	5	20	50	10	100	100	0	100
Air temp. (^{o}C)	7	14	14	8	20	18	12	13	18	11	19	20	10	19.8	19	11	14	22
Water temp. (^{o}C)	7	14.6	14	6.4	13.2	14.2	8.3	12.3		10.4	16				15.7	9.8	13	19
Water pH	8.4	8.4	8.5	7.2	7.2	7.3	7.4	8.9		8.1	7.3				8.8			
Precipitation?			Light rain										Light rain			Light rain		Light rain

Station #9

COMMON NAME	2007 April 29	2007 May 16	2007 June 6	2008 April 24	2008 May 15	2008 June 4	2009 April 23	2009 May 11	2009 June 2	2010 April 24	2010 May 13	2010 June 3	2011 April 27	2011 May 18	2011 June 2
American Toad				Nothing Heard		3					Nothing Heard	Nothing Heard	1 (1)		
Northern Spring Peeper	2(10)	1(2)			1(3)		1 (7)	1 (4)		1 (1)			1 (2)	1 (4)	
Tetraploid Gray Treefrog						1 (1)			1 (2)						
Western Chorus Frog															
Northern Leopard Frog							1 (1)								
Pickerel Frog															
Green Frog			1(1)												
Mink Frog															
Bullfrog															
Wood Frog	1(2)						1 (4)						1 (2)		
Beaufort Wind Scale	5	2	1	1	0	1	0	0	2	0	2	0	3	3	2
%Cloud Cover	70	100	20	65	50	100	10	20	25	5	100	100	20	100	5
Air temp. (°C)	13	10	9	11	14	16	2	6	14	1	10	18	15	9.4	11
Water temp. (°C)	12.5	12.2	13.7	10	12.1	13	5.4	7.7	14.3	8.5					12.9
Water pH	7.7	7.5	7.3		8.2	8.5	8.2	8.7	9.6	8					6.6
Precipitation?											Rain			Heavy Rain	

COMMON NAME	2012 April 19	2012 May 15	2012 June 4	2013 April 16	2013 May 9	2013 June 10	2014 April 29	2014 May 21	2014 June 9	2015 April 29	2015 May 21	2015 June 16	2016 April 20	2016 May 23	2016 June 21	2018 April 24	2018 May 16	2018 June 19	2020 April 30	2020 May 21	2020 June 22
American Toad	Nothing Heard	Nothing Heard	Nothing Heard			Nothing Heard			Nothing Heard		Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper				1 (2)	2 (5)		3	1 (5)		3							2 (4)				
Tetraploid Gray Treefrog												2(5)									
Western Chorus Frog																					
Northern Leopard Frog																					
Pickerel Frog																					
Green Frog																					
Mink Frog																					
Bullfrog																					
Wood Frog										2(3)											
Beaufort Wind Scale	1	3	2	1	0	1	4	1	1	3	1	1	1	1	0	2	1	0	0	1	1
%Cloud Cover	100	40	100	80	10	100	35	100	0	0	15	0	35	50	5	100	10	80	100	20	100
Air temp. (°C)	12	16	12	5	16	17	5	22	18	11	12.6	18	11	18	18	9	18	17	9	13	22
Water temp. (°C)	N/A			6.3	14.5		5.2	17.6		13				18		6.2	18.6	20.1			
Water pH	N/A			7.5	7.6		7.4	7.6		7.1				7.2		8.8	7.1	8			
Precipitation?	Light rain					Light rain										Light rain			Light rain		

Station #10	2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16	April 20	May 23	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad		Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard		Nothing Heard	Nothing Heard			Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	2(3)	Nothing Heard	2(2)	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard
Northern Spring Peeper					1 (2)					1 (1)	1 (1)																			
Tetraploid Gray Treefrog																					2(8)									
Western Chorus Frog																														
Northern Leopard Frog																														
Pickerel Frog																														
Green Frog																														
Mink Frog																														
Bullfrog																														
Wood Frog	1 (2)						1 (2)																		1 (3)			1 (2)		
Beaufort Wind Scale	0	0	2	0	2	0	3	4	3	1	3	2	1	0	0	3	1	0	1	1	1	2	1	0	2	1	0	0	1	0
%Cloud Cover	20	10	15	5	100	100	90	100	5	100	40	100	60	10	100	35	100	90	10	15	0	20	60	5	100	10	80	100	10	100
Air temp. (^oC)		3	12	4	10	24	14.5	13.8	12	13	16	12	5	13	17	5	15	17	12	12.5	18	11	17	19	9.5	18	17	9	15	21
Water temp. (^oC)	8.5	10.7	14.1	12.1	9.3	19	12	13.1	16.5	14.3	17		9.3	18.9		8.4	17.9	15	13.2			13			3.5	18.5	20.7	10		
Water pH	8.8	8.6	9.5	7.8	7	7.4		8	8.1	7.6	8.2		7.9	7.9			8	7.7	7.8			9			8.5	7.5	8.1			
Precipitation?					Light rain			Mod. rain							Light rain										Mod. rain, fog			Light rain		

Station #11

COMMON NAME	2009 April 23	2009 May 11	2009 June 2	2010 April 22	2010 May 13	2010 June 3	2011 April 27	2011 May 18	2011 June 2	2012 April 19	2012 May 15	2012 June 4	2013 April 16	2013 May 9	2013 June 10
American Toad		Nothing Heard	Nothing Heard			Nothing Heard			Nothing Heard		Nothing Heard	Nothing Heard			
Northern Spring Peeper	1 (1)			1 (1)	2 (5)		1 (4)	1 (4)		2 (5)			1 (1)	1 (1)	1 (1)
Tetraploid Gray Treefrog															
Western Chorus Frog															
Northern Leopard Frog	1 (1)														
Pickerel Frog				1 (1)											
Green Frog															
Mink Frog															
Bullfrog															
Wood Frog	1 (1)														
Beaufort Wind Scale	0	0	2	0	2	0	3	4	1	1	3	2	1	0	0
%Cloud Cover	20	10	25	5	100	100	40	100	5	100	40	100	60	10	100
Air temp. (^{o}C)	3	3	12	4	10	24	14.5	13	12	13	16	12	5	13	17
Water temp. (^{o}C)	6.6			6	9.5		12	12	14.3	14.5	16.7		8.2	18.6	
Water pH	7.8			8.1	7.8			7.1	8.0	7.8	8		7.9	7.8	
Precipitation?					Light rain			Moderate Rain							Light rain

COMMON NAME	2014 April 29	2014 May 21	2014 June 9	2015 April 29	2015 May 21	2015 June 16	2016 April 20	2016 May 23	2016 June 21	2018 April 24	2018 May 16	2018 June 19	2020 April 30	2020 May 21	2020 June 22
American Toad		Nothing Heard	Nothing Heard	3	Nothing Heard	2(2)			Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard
Northern Spring Peeper	1 (1)									1 (2)				1 (1)	
Tetraploid Gray Treefrog						2(7)		1(1)							
Western Chorus Frog															
Northern Leopard Frog															
Pickerel Frog															
Green Frog															
Mink Frog															
Bullfrog															
Wood Frog							1(1)								
Beaufort Wind Scale	3	1	0	0	1	1	2	1	0	2	1	0	0	1	0
%Cloud Cover	40	100	90	0	15	0	0	60	5	100	10	80	100	20	100
Air temp. (^{o}C)	6	16	17	11	12.9	18	11	17	19	8	19	18	9	15	22
Water temp. (^{o}C)	6.5	18.1	16	12	12.5		6.9			10	18.5	18.2	7		
Water pH	7.9	7.7	7.6	7.4	7.81		9.4			8.5	7.5	8.1			
Precipitation?										Mod. rain, fog			Light rain		Rain

Station #12	2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16	April 20	May 23	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad						Nothing Heard			Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard							2(2)	Nothing Heard		Nothing Heard	2(2)				Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper	3	1 (3)		1 (6)	3		3	3					3	3		2 (6)	1 (1)								1(3)	3				
Tetraploid Gray Treefrog															1 (1)		1 (3)	1 (2)			2(8)			1(4)		2(3)				
Western Chorus Frog																														
Northern Leopard Frog	1 (2)																													
Pickerel Frog																														
Green Frog			1 (2)																											
Mink Frog																														
Bullfrog																														
Wood Frog	1 (2)						1 (2)						1 (1)																	
Beaufort Wind Scale	0	0	2	2	2	0	4	4	2	1	3	2	2	0	1	3	1	1	2	1	1	2	1	0	2	1	0	0	0	1
%Cloud Cover	20	10	15	30	100	100	50	100	0	100	15	100	70	10	100	10	100	0	0	15	0	20	60	5	100	10	70	100	20	100
Air temp. (^oC)	2	3	10	5	10	24	14.5	13.5	10	10.5	16	12	7	12	17	5	15	17.5	12	12	18	11	17	18	9	21	19	9	13	22
Water temp. (^oC)	6.9	11.5	14.6	11.1	10.4	19.8			10				9.7	12.3			13.4						18		6.7	19.7				
Water pH	8	9.2	9.9	7.8	6.8	8			8.4				7.4	7.5			7.5						7.2		8.8	7				
Precipitation?					Light rain			Mod. Rain		Light rain					Light rain										Light rain			Light rain		

Station #13	2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16	April 20	May 30	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper																														
Tetraploid Gray Treefrog															1 (1)															
Western Chorus Frog																														
Northern Leopard Frog																														
Pickerel Frog																														
Green Frog																							2(2)							
Mink Frog																														
Bullfrog																														
Wood Frog																														
Beaufort Wind Scale	0	0	0	1	1	0	1	2	1	2	0	1	0	1	3	3	1	0	2	3	1	0	0	0	2	1	0	0	1	0
%Cloud Cover	30	10	50	10	100	100	30	100	0	90	0	100	60	5	100	5	0	90	90	5	10	35	0	5	100	10	100	100	20	100
Air temp. (^oC)	3	5	14	5	8	24	14	13	12	10	17	15	6	13	14	7	21	17	10	14	18	11	19	20	10	16	18	11	14	22
Water temp. (^oC)	6.2	8	11.3	6.6	8	14.5	11		12							5.9														
Water pH	8	8.8	9.9	7.8	7.9	7.2			8.2							7.6														
Precipitation?															Rain										Light rain					

Station #14	2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16	April 20	May 30	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad	Nothing Heard	Nothing Heard	1 (1)	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard			Nothing Heard		Nothing Heard
Northern Spring Peeper										2 (2)							2 (6)									1 (2)			1 (2)	
Tetraploid Gray Treefrog																					1(2)						1(2)			
Western Chorus Frog																														
Northern Leopard Frog																														
Pickerel Frog																														
Green Frog																														
Mink Frog																														
Bullfrog																														
Wood Frog																														
Beaufort Wind Scale	0	0	0	0	1	0	1	N/A	1	1	0	2	0	1	2	3	1	0	2	2	1	0	0	0	2	0	0	0	1	0
%Cloud Cover	20	10	50	5	100	100	30	100	0	90	0	100	50	5	100	5	0	90	90	5	10	35	0	5	100	10	100	100	20	100
Air temp. (^oC)	2	5	14	5	8	24	15	13	12	11	17	12	7	13	14	7	18	17	10	13	18	11	19	20	9	17	18.5	11	14	22
Water temp. (^oC)	6.6	8.8		7.1	7	13.7			12							6.9										14.4		9.6		
Water pH	8	8.5		8.1	8	7.4			8.5							7.8										7.9				
Precipitation?												Light rain			Light rain										Light rain					

Station #15	2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16	April 20	May 30	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard					Nothing Heard		Nothing Heard	Nothing Heard			Nothing Heard		Nothing Heard			Nothing Heard	Nothing Heard			Nothing Heard						Nothing Heard
Northern Spring Peeper					1(3)		3	2 (4)		3			1 (1)	1 (1)		2 (4)			2(4)			3			2 (5)	2 (5)	1 (1)	3	1 (4)	
Tetraploid Gray Treefrog						2 (3)																	2(6)							
Western Chorus Frog																														
Northern Leopard Frog																														
Pickerel Frog																														
Green Frog																		1 (5)												
Mink Frog																														
Bullfrog																														
Wood Frog													1 (1)			1 (1)			2(5)			3			1 (3)			2 (2)		
Beaufort Wind Scale	0	0	0	0	2	0	3	2	0	1	0	1	0	0	1	3	0	0	2	1	1	0	0	0	2	0	0	0	1	0
%Cloud Cover	20	10	50	5	100	100	40	100	0	100	0	100	50	10	100	5	0	90	90	5	10	30	0	5	100	10	100	100	20	100
Air temp. (^oC)	2	5	14	5	10	24	15	13	14	12	16	12	7	16	17	7	18	17	10	13	18	11	19	20	9	17	18.5	11	14	22
Water temp. (^oC)	5.7	8.3	10.4		8.9	17.9										6.2	17.3								9	15.9		9.2		
Water pH	8	9	9.8		7.2	6.9										7.9	7.9								8.2	7.9				
Precipitation?					Light rain			Hard Rain		Light rain															Light rain			Light rain		

Station #16	2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	April 23	May 11	June 2	April 22	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16	April 20	May 30	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad		Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard			Nothing Heard	*2 (2)*	Nothing Heard	2 (3)						Nothing Heard		Nothing Heard	2(2)			Nothing Heard			Nothing Heard	Nothing Heard	3	Nothing Heard
Northern Spring Peeper	3			1 (3)			2 (4)	3					2 (3)	3		1 (1)	1 (1)					3			1(1)	3			3	
Tetraploid Gray Treefrog												2 (6)			2 (7)						2(11)		3			2(5)				
Western Chorus Frog																														
Northern Leopard Frog																														
Pickerel Frog																														
Green Frog																							1(2)							
Mink Frog																														
Bullfrog																														
Wood Frog							2 (8)						3						2(5)											
Beaufort Wind Scale	0	0	0	1	1	0	2	2	1	2	0	1	0	1	1	3	0	0	3	3	2	1	0	0	1	0	0	0	2	2
%Cloud Cover	30	10	50		100	100	10	100	0	100	0	100	80	5	100	5	0	90	100	5	10	40	0	5	100	10	90	100	0	100
Air temp. (^oC)	4	7	16	8	8	24	14	13.5	13	11	20	16	6	14	14	7	18	17	12	14	20	11	19	20	10	20.8	18.5	11	14	21
Water temp. (^oC)	7.5	8.8	13.7	11.2	7.5		14	13.7	11.2				9.4	17.8					11.6			12.3	17			20.5		9.2	12	
Water pH	8.1	9.1	9.5	7.5	7.9			8.1	8.4				7.9	8.4					7.5			8.2	7.2			7.9				
Precipitation?								Hard Rain		Light rain					Rain										Light rain			Light rain		

Station #17	2009			2010			2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	April 23	May 11	June 2	April 24	May 13	June 3	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 29	May 21	June 16	April 20	May 23	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad		No Datasheet	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard			Nothing Heard			Nothing Heard			Nothing Heard
Northern Spring Peeper																	1 (2)								1(3)	2(2)		2 (4)	1 (2)	
Tetraploid Gray Treefrog																	1 (2)						2(5)			3				
Western Chorus Frog																														
Northern Leopard Frog																														
Pickerel Frog																														
Green Frog																														
Mink Frog																														
Bullfrog																														
Wood Frog	1 (2)						1 (5)															1(1)			2(6)					
Beaufort Wind Scale	0		2	0	2	0	3	3	1	1	3	2	0	0	0	4	1	1	2	1	1	2	1	0	2	1	0	0	1	0
%Cloud Cover	10		25	10	100	100	20	100	10	100	40	100	0	10	100	30	100	0	0	15	0	20	50	5	100	10	80	100	20	100
Air temp. (^oC)			12	12	10	18	15	13.2	12	11	16	12	6	16	17	6	22	20	11	13.5	18	11	18	18	9	17	17	9	13	21
Water temp. (^oC)	6.3		n/a	15	8		12	12.5					8.5	16		6.2	18.6					9.8			10	14.1		9		
Water pH	8.2		n/a	7.9	6.9			8.1					7.8	7.7		7.4	8					9.1			8.5	7.2				
Precipitation?					Rain			Heavy Rain				Light rain			Light rain										Light Rain			Light rain		

Station #18	2011			2012			2013			2014			2015			2016			2018			2020		
COMMON NAME	April 27	May 18	June 2	April 19	May 15	June 4	April 16	May 9	June 10	April 29	May 21	June 9	April 20	May 21	June 16	April 20	May 30	June 21	April 24	May 16	June 19	April 30	May 21	June 22
American Toad			Nothing Heard	3	Nothing Heard		Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard		Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard	Nothing Heard
Northern Spring Peeper		3				1 (1)										3								
Tetraploid Gray Treefrog									2 (2)			1 (1)												
Western Chorus Frog																								
Northern Leopard Frog																								
Pickerel Frog																								
Green Frog																								
Mink Frog																								
Bullfrog																								
Wood Frog	1 (1)																							
Beaufort Wind Scale	1	2	2	1	0	1	1	1	2	3	1	0	2	1	3	1	0	0	1	0	0	0	1	2
%Cloud Cover	10	100	0	100	0	100	80	15	100	5	0	90	90	5	10	40	0	5	100	10	95	100	0	100
Air temp. (^{o}C)	14	14	13	11	20	15	6	16	14	7.5	20	18	12	14	20	11	19	20	10	20.8	19	11	14	21
Water temp. (^{o}C)	12		10							5.5			8.9											
Water pH			8							7.6			7.9											
Precipitation?		Hard Rain																	Light rain			Light rain		

LEGEND		
X individual seen, but not calling		
# (_) call intensity and estimated number of individuals		
Call Level Codes		
1 Calls can be counted; not simultaneous		
2 Some simultaneous calls; yet distinguishable		
3 Calls not distinguishable individually; overlapping		
NA: (Not Applicable) denotes lack of water or not recorded		
Beaufort #	**KPH**	**Description**
0	0-2	Calm; smoke rises vertically
1	3 to 5	Light air movement; smoke drifts
2	6 to 11	Slight Breeze; felt on face, leaves rustle
3	12 to 19	Gentle breeze; leaves and small twigs in constant
4*	20-30	Moderate breeze; small branches are moving, raises
5*	31-39	Fresh breeze; small trees in leaf begin to sway, crested
6*	40-50	Strong breeze, large branches in motion
	*	Unacceptable wind strengths for amphibian surveys

APPENDIX IX

Herpetofaunal Species Observed in the Subject Property 2016 - 2020

Appendix IX. Herptofaunal Species Observed in the Subject Property

Common Name	Scientific Name	SRANK[1]	COSEWIC[2]	COSSARO[1]	NRSI													
					1998 - 2004	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	2020 / 2021
Turtles																		
Common Snapping Turtle	*Chelydra serpentina*	S5	SC		√												√	+
Midland Painted Turtle	*Chrysemys picta marginata*	S5								√	√						√	+
Snakes																		
Eastern Milksnake	*Lampropeltis triangulum*	S3	SC	SC														
Eastern Gartersnake	*Thamnophis sirtalis sirtalis*	S5			√					√	√		√			√		√
Northern Brownsnake	*Storeria dekayi*	S5	NAR	NAR						√								
Northern Red-belied Snake	*Storeria occipitomaculata*	S5								√								
Salamanders																		
Jefferson/Blue-spotted Salamdander Polyploids	*Ambystoma jeffersonianum-laterale polyploids*	S2									√							
Eastern Red-backed Salamander	*Plethodon cinereus*	S5			√				√									
Toads and Frogs																		
American Toad	*Anaxyrus americanus*	S5								√	√	√	√	√	√	√	√	√
Tetraploid Gray Treefrog	*Hyla versicolor*	S5			√	√	√	√	√	√	√	√	√	√	√	√	√	√
Western Chorus Frog*	*Pseudacris triseriata* pop.2	S3	T	NAR	√	√												
Northern Spring Peeper	*Pseudarcris crucifer*	S5					√	√	√	√	√	√	√	√	√	√	√	√
American Bullfrog	*Lithobates catesbeianus*	S4			√	√	√	√	√	√								+
Green Frog	*Lithobates clamitans*	S5								√		√	√	√	√	√	√	√
Pickerel Frog	*Lithobates palustris*	S4	NAR	NAR	√	√	√	√	√	√								
Northern Leopard Frog	*Lithobates pipiens*	S5	NAR	NAR						√	√		√	√			√	+
Mink Frog	*Lithobates septentrionalis*	S5			√	√			√	√								
Wood Frog	*Lithobates sylvatica*	S5			√		√	√	√	√	√	√	√	√	√	√	√	√

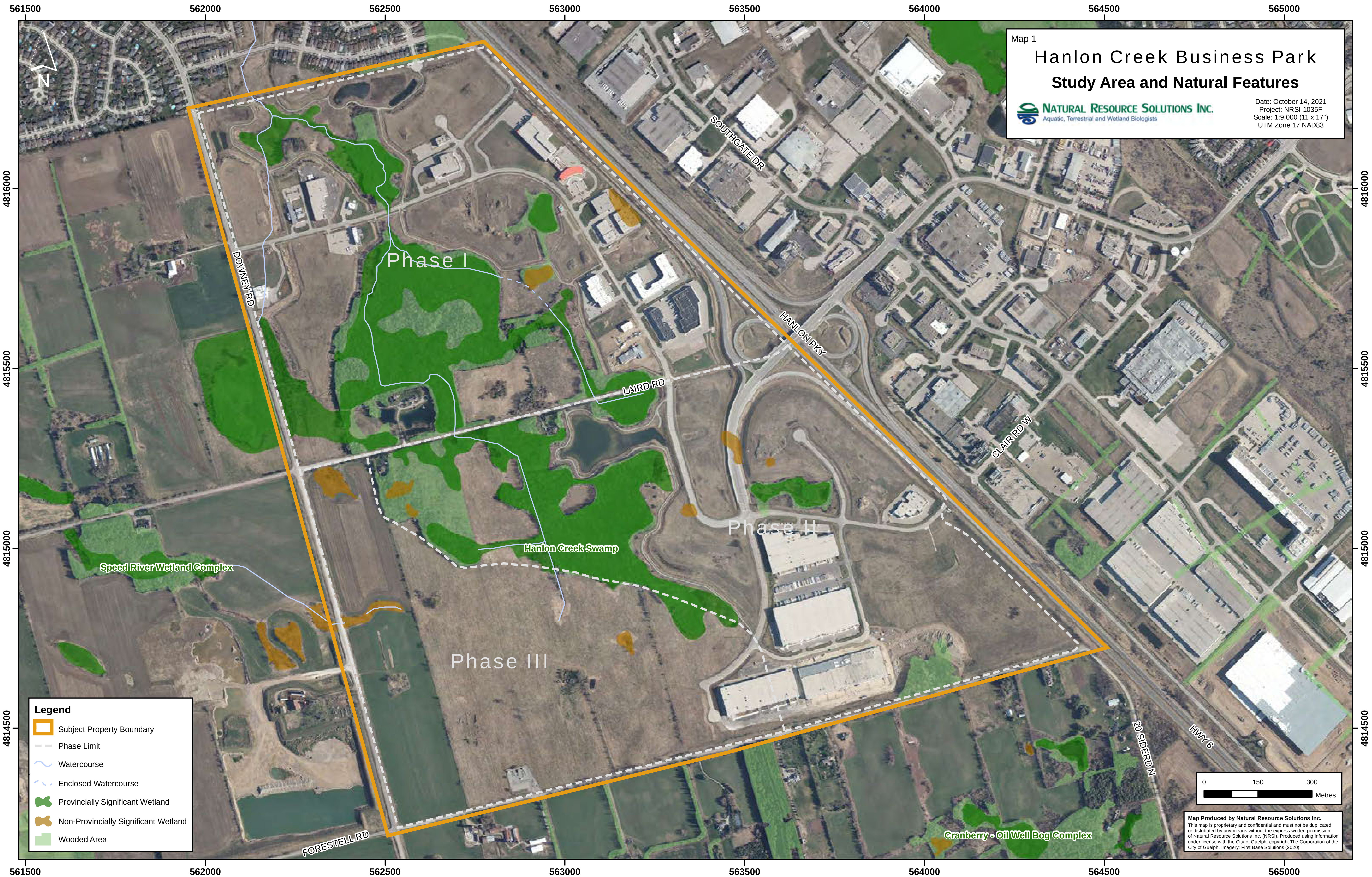
[1]MNRF 2021; [2]COSEWIC 2021

*Great Lakes/ St. Lawrence - Canadian Shield Pop.

+Observed only during 2021 Laird Road surveys

Legend	
SRANK	
S2 Imperiled	S4 Apparently Secure
S3 Vulnerable	S5 Secure
COSEWIC, SARO	
NAR Not at Risk	SC Special Concern
T/THR Threatened	

MAPS



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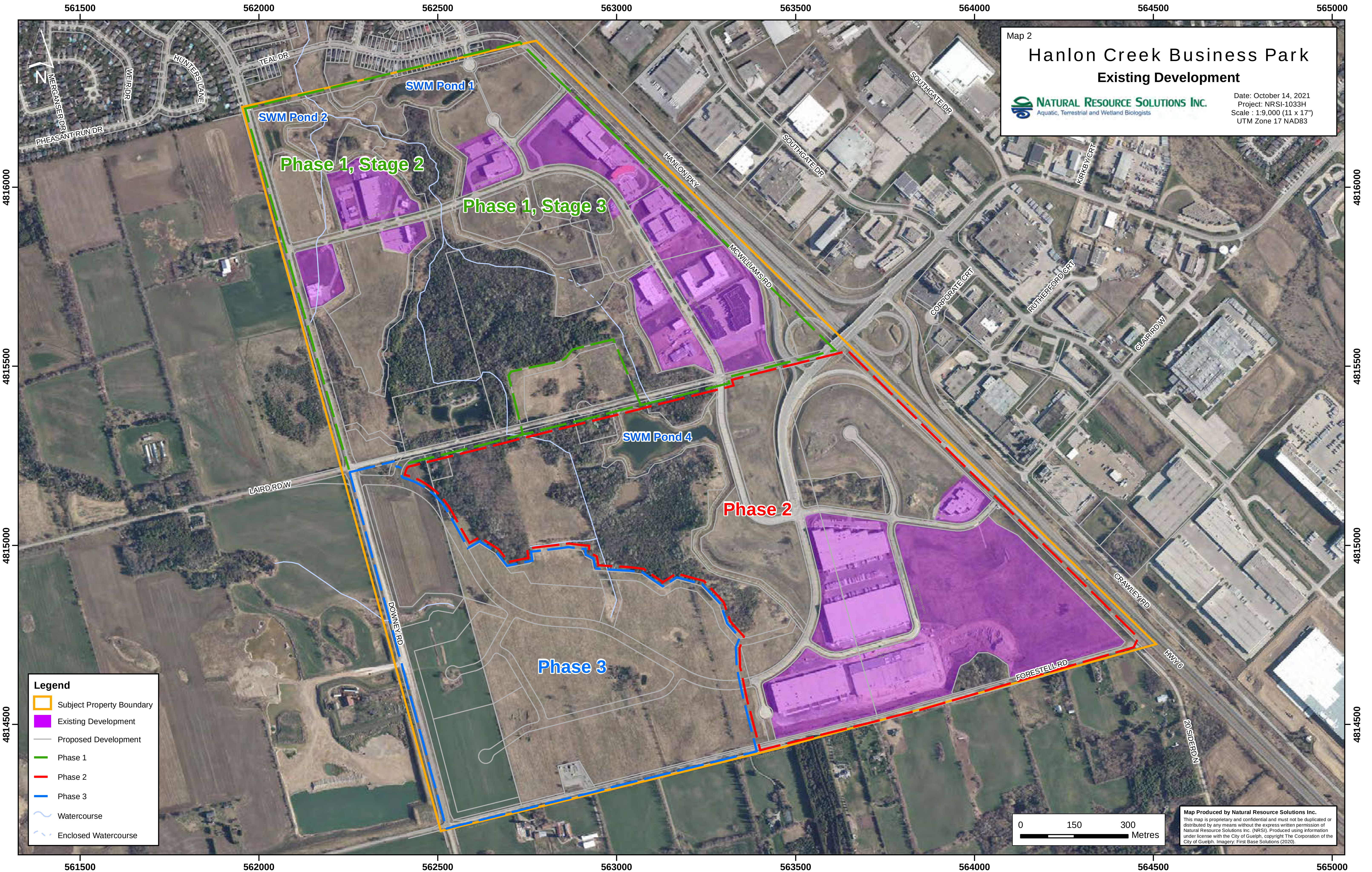

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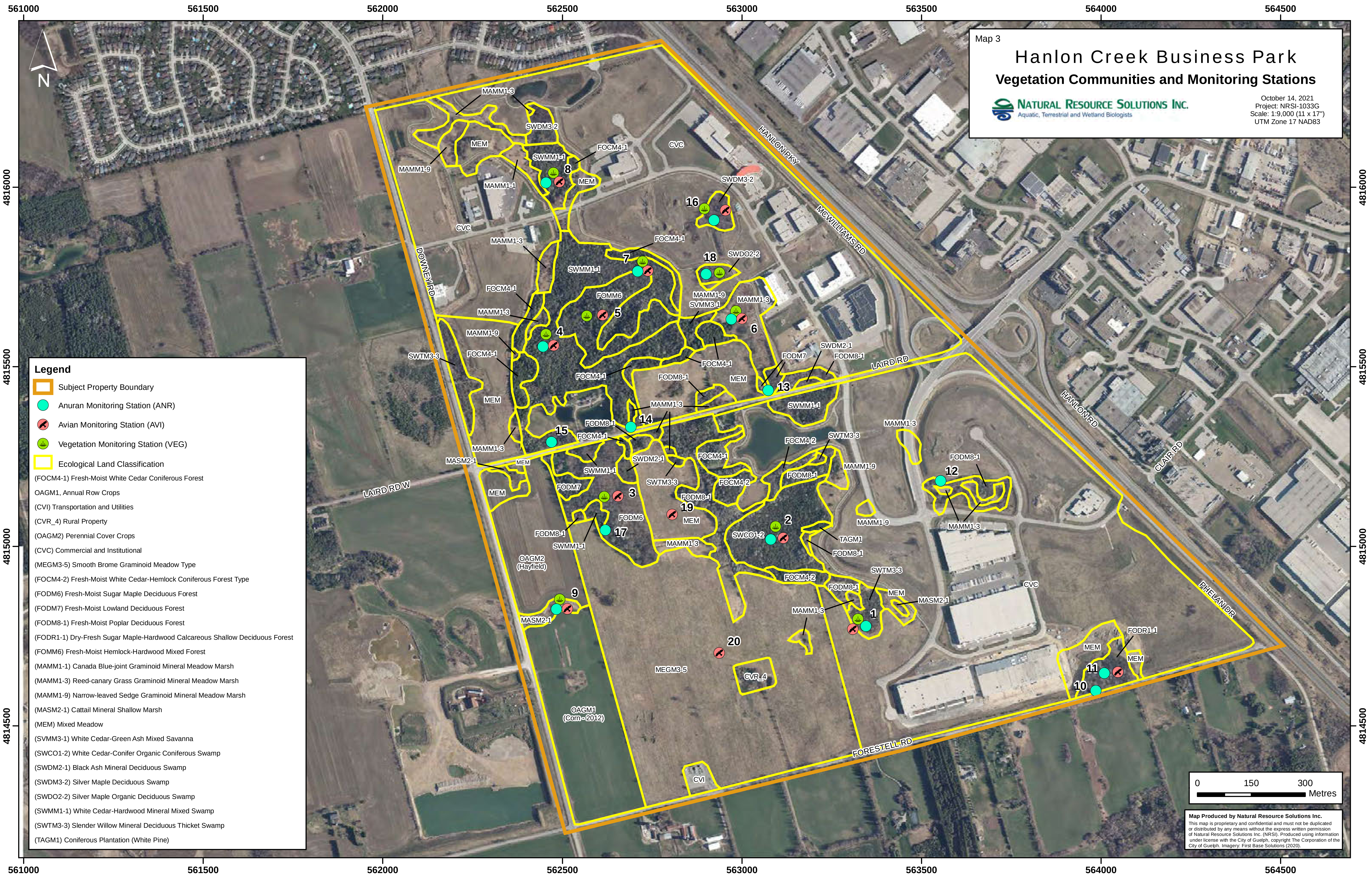

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APPENDIX VII 2021 Laird Road Wildlife Movement Monitoring Report

Hanlon Creek Business Park Laird Road Wildlife Movement Surveys

2021 Effectiveness Monitoring Summary Report

Prepared for:

Planning and Building Services, Infrastructure, Development and Enterprise
City of Guelph,
1 Carden Street, City Hall
Guelph, ON

Project No. 1033I | November 2021

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Hanlon Creek Business Park Laird Road Wildlife Movement Surveys

2021 Effectiveness Monitoring Summary Report

Project Team

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1.0 Introduction

Road mortality is a very common and real threat to wildlife species, especially within southern Ontario, where the road network is dense due to urban development (MNRF 2016). Roads often bisect natural areas, making it necessary for wildlife to travel over road surfaces to move between their breeding and/or over-wintering habitats. The amount of time it can take individuals to move across roads can vary greatly between species (Hels and Buchwald 2001), depending on the mobility of the species, and their tendency to become immobile in response to approaching vehicles (Mazerolle et al. 2005). The amount of time individuals spend crossing roads is likely closely correlated with rates of road mortality, leading to increased impacts on slow-moving reptile and amphibians species (Mazerolle et al. 2005). Studies throughout Ontario have demonstrated significant levels of road mortality for amphibians and reptiles, and modeling suggests that many species are declining as a result (MNRF 2016).

Laird Road is a two-lane road in southwest Guelph, Ontario, where high numbers of amphibian mortalities have been documented by citizen scientists and Natural Resource Solutions Inc. (NRSI) during the amphibian breeding season and fall movement season. In 2009, 2010, 2013, and 2018, NRSI conducted night-time road mortality monitoring for the City of Guelph along Laird Road. Following the installation of interim culverts by the City in 2010, NRSI conducted three years of wildlife camera monitoring (2011, 2013, and 2018) to evaluate the effectiveness of the culverts in facilitating wildlife movement under the road.

NRSI was contracted by the City of Guelph in 2020 to conduct a fourth year of road mortality and wildlife camera monitoring along Laird Road. The spring 2020 monitoring was postponed due to the COVID-19 pandemic and monitoring commenced once more in the spring of 2021. This report provides a summary of NRSI's 2021 monitoring results, and an analysis of all monitoring years in order to evaluate the overall effectiveness of the interim mitigation measures employed by the City of Guelph to reduce road mortalities on Laird Road.

1.1 Background

1.1.1 Rationale for Laird Road Monitoring

In the fall of 2008, it was noted by local residents/naturalists that a high number of amphibian mortalities were occurring along Laird Road between Downey Road and the eastern end of Laird Road (Map 1). This information was compiled and presented in the Natural Heritage Strategy (NHS) for the City of Guelph (Dougan & Associates 2009). Information from this report was incorporated into the City of Guelph's March 2018 Official Plan Consolidation (2018). Schedule 4 within the Official Plan identifies three Amphibian Crossing areas along Laird Road where amphibians are likely to be concentrated moving across the road (City of Guelph 2018) (Map 1). These areas are associated with the Hanlon Creek Provincially Significant Wetland (PSW) complex which is present to the north and south of Laird Road. The baseline surveys that NRSI conducted along Laird Road in 2009 and 2010 (NRSI 2009a, NRSI 2010) helped refine these amphibian crossing locations.

In 2009, NRSI (2009a) prepared the Environmental Implementation Report (EIR) for Phases 1 and 2 of the City of Guelph's Hanlon Creek Business Park (HCBP) which is bisected by Laird Road. The EIR was reviewed by the City of Guelph Environmental Advisory Committee (EAC) and approved on April 8, 2009 based on the satisfaction of 17 conditions. The following two conditions pertained to Laird Road:

- *"As part of Phase 3, the road bed in the closed portion of the old Laird Road be removed and restored. If complete removal is not feasible, the road height and width should be reduced, road surfacing should be converted to a non-paved surface, road verges naturalized and wildlife/amphibian crossings be considered;*
- *That interim mitigation measures be employed to limit amphibian crossing until the closure of the old Laird Road."*

Until the road network within Phase 3 of the HCBP is constructed, permanent closure of the existing Laird Road is not feasible as it is utilized by local residents, and is a major aggregate haul route for pits located to the west.

1.1.2 Night-time Road Mortality Surveys - 2009

To address the EAC's conditions for the installation of wildlife/amphibian crossings and interim mitigation measures, as well as to determine areas of concentrated movement, NRSI was retained by the City of Guelph in 2009 to conduct night-time road mortality surveys along Laird Road. These surveys were conducted during the spring amphibian breeding/movement season from April to June. During these surveys, one dead salamander was observed on the road. Genetic analysis indicated that this individual was a Unisexual Ambystoma - Jefferson Salamander dependent population (*Ambystoma laterale* - (2) *jeffersonianum*). Although Unisexual Ambystoma - Jefferson Salamander dependent population were not added to the Species at Risk in Ontario list until 2017 (Ministry of Environment, Conservation and Parks

[MECP] 2021), the presence of these salamanders could indicate that the Jefferson Salamander (*Ambystoma jeffersonianum*), which was listed as threatened when the *Endangered Species Act* (*ESA*) (Government of Ontario 2007) took effect in 2008, could also be present within the study area.

1.1.3 Salamander Monitoring - 2009

In response to the discovery of this individual, NRSI carried out salamander surveys using unbaited minnow traps within the HCBP in March and April, 2009 (NRSI 2009b). Larval surveys were also conducted in potential salamander breeding habitat over six days in June and July. No salamanders were captured during the 2009 surveys.

Although concentrated amphibian movements in Ontario are known to occur during the spring, typically in concert with the breeding period of more ‘explosive’ breeders, such as Spring Peepers (*Pseudacris crucifer*) and American Toads (*Anaxyrus americanus*), and decrease during the summer (June – August), there is evidence that a second period of movement occurs between late August and November. This movement period likely corresponds with juvenile dispersal and movement to over-wintering areas (Regosin et al. 2005). In an attempt to reduce the number of road mortalities and provide an interim mitigation measure during this fall movement period, the City of Guelph temporarily closed Laird Road from September 22 to October 2, 2009.

1.1.4 Salamander Monitoring - 2010

Based on a preliminary analysis of road mortalities recorded by NRSI during the Laird Road surveys in 2009, a number of interim wildlife culverts were proposed in primary movement areas as a mitigation measure for road mortalities. Upon review of the proposed mitigation plan, the Ministry of Natural Resources (MNR), Guelph District expressed concern that installing the culverts prior to the habitat use study may alter the current natural movement patterns of salamanders across the road. The MNR thus recommended against installing the new culverts at the time (Pickett pers. comm. 2009). Although no salamanders were captured in 2009, the MNR requested that an additional season of salamander monitoring be conducted in spring 2010 to re-assess the presence/absence of suitable habitat for Jefferson Salamander and Unisexual Ambystoma, and determine the locations of any salamander movement corridors to and from natural areas within the HCBP (NRSI 2010).

To address these recommendations, NRSI undertook a comprehensive salamander monitoring program in the spring of 2010 that was reviewed and approved by the MNR. This program included barrier fencing with pitfall traps along the north and south sides of Laird Road during the amphibian breeding season (NRSI 2010, NRSI 2011). The fence was constructed using silt fencing and acted as a temporary barrier to restrict movement of wildlife across the road during the peak spring movement season. Therefore, no road mortality surveys were conducted in 2010. A number of wildlife species were captured within the pitfall traps along the north and south sides of Laird Road, including American Toad, Eastern Gartersnake (*Thamnophis sirtalis sirtalis*), Green Frog (*Lithobates clamitans melanota*), Northern Leopard Frog (*Lithobates pipiens*), Spring Peeper, Wood Frog (*Lithobates sylvaticus*), Unisexual Ambystoma – Blue Spotted Salamander dependent population (*Ambystoma* (2) *laterale – jeffersonianum*), Meadow Vole (*Microtus pennsylvanicus*) and Northern Short-tailed Shrew (*Blarina brevicauda*). No Jefferson Salamander or Unisexual Ambystoma – Jefferson Salamander dependent population individuals were captured during the 2010 surveys (NRSI 2010).

1.1.5 Interim Culvert Installation - 2010

Information from the 2009 road mortality surveys and 2010 salamander movement surveys was compiled to identify wildlife movement corridors across Laird Road. Concentrated movement areas were identified by NRSI and discussed with the City of Guelph Environmental Planner and their engineering consultants (AECOM) in preparation for installation of mitigative strategies along Laird Road. Following the 2010 survey findings, the MNR noted that the monitoring program was rigorous enough to confirm the absence of Jefferson salamander and their habitat within the study area (Hagman pers. comm. 2010). Further development activities on-site did not require *Endangered Species Act* (Government of Ontario 2007) permitting, therefore, the MNR was no longer consulted regarding the placement and design of the wildlife culverts.

In August 2010, five interim wildlife culverts, with approximately 12m of silt fence on either side, were installed along Laird Road in areas where concentrated movement was observed (Map 2). The interim wildlife culverts were placed according to where wildlife was generally observed crossing in large numbers during NRSI's monitoring in 2009 and 2010. The placement of the interim wildlife culverts, along with the silt fence was intended to facilitate wildlife movement, particularly of small mammals and amphibians, and to reduce traffic-related wildlife mortalities until the closure of the road. The installation and design of the interim wildlife culverts, in conjunction with the silt fence, was not intended to completely control wildlife movement across

Laird Road, but rather to direct more wildlife through the culverts than if no silt fence was installed.

The City also installed wildlife crossing signs along Laird Road in an attempt to alert motorists to potential wildlife crossing. The signs were almost immediately removed by vandals, and were not replaced.

1.1.6 Interim Culvert and Night-time Road Mortality Monitoring – 2011 and 2013

To assess the effectiveness of the interim wildlife culverts, and one existing culvert (Culvert A1, associated with Tributary A1), and to determine what species were using them, monitoring undertaken in 2011 and 2013 included a combination of wildlife camera monitoring, animal track identification, and night-time road mortality surveys.

Wildlife cameras were placed at the openings of the culverts in 2011 and within the culverts in 2013. These cameras were effective at capturing the movement of small mammals through the culverts; however, no amphibian or reptile species were recorded in either year. The night-time road mortality data from 2011 and 2013 indicated that amphibians were continuing to move across Laird Road during the spring breeding period; however, the number of individuals observed, including overall mortality, was less than what was observed during the baseline monitoring in 2009. This suggested that, although effective at capturing small mammals, the motion-activated and continuous video cameras used respectively in 2011 and 2013 may not have been effective at capturing amphibian movement. This may be due to amphibians' ability to blend into the substrate and leaf litter within the culverts. Small-bodied ectothermic amphibians also emit a lower heat signature and are more likely to be missed by the infrared sensors (Hobbs & Brehme 2017). In 2011 and 2013, the cameras were set to take a photo every 15 seconds, 24 hours a day; however, the camera batteries were draining too quickly (i.e., between camera checks). This meant that early on in the monitoring period some monitoring days were missed.

Mitigation Measure Maintenance - 2016

In advance of the 2016 fall amphibian movement period, general maintenance activities were undertaken by NRSI at each of the interim wildlife culverts, including debris clean-up and vegetation removal. The interim directional fencing was also replaced or repaired by Town & Country Fencing to better encourage movement of wildlife into the culverts. Laird Road was anticipated to remain open for a number of years; therefore, it was recommended by NRSI that the City consider more permanent and longer lengths of wildlife exclusion/directional fencing at each of the interim wildlife culverts. More permanent wildlife fencing options can be more expensive up front than silt fence; therefore, the City opted to maintain the existing silt fences. Wildlife camera and road mortality surveys were not requested by the City at this time.

1.1.7 Interim Culvert and Night-time Road Mortality Monitoring - 2018

The City requested that an additional year of wildlife culvert monitoring and road mortality surveys be undertaken in spring 2018 to determine if the temporary silt fence and associated repairs were effectively mitigating road mortality and directing wildlife into the interim culverts.

NRSI was contracted by the City in 2018 to undertake an eighth year of during-construction monitoring to track ecological changes to the terrestrial and wetland communities within the HCBP study area. Since wildlife movement had not been studied since 2013, the City requested that NRSI conduct interim culvert monitoring and night-time road mortality monitoring along Laird Road once more in 2018.

In 2018, the Laird Road cameras were set to use time-lapse technology rather than using motion-triggered (as in 2011) or continuous video cameras (as in 2013) in the hopes of better capturing wildlife movement. The time-lapse cameras had the capability to take photos on a pre-determined time interval. Time-lapse photography has been demonstrated as effective for monitoring amphibians (Pagnucco et al. 2011) and reptiles (White pers. comm. 2018). In 2011 and 2013, wildlife were more active in crossing Laird Road between dusk and dawn, with 67% of the passage events occurring between 1900 and 0700hrs in 2011 and between 2030 and 0214hrs in 2013. Therefore, on April 24, 2018, after consulting with the City (Labbé pers. comm. 2018), the camera settings were adjusted to take photos every 30 seconds, from 2000 until 0700hrs. This resulted in a greater number of overall observations of all species in 2018 compared to 2011 and 2013. However, due to image quality and other technical issues, a number of photographs were corrupted, lost, or too unclear to identify species.

1.1.8 Mitigation Measure Maintenance - 2020

By 2020, the silt fencing had not been replaced or maintained since 2016 and it had fallen into disrepair, providing little to no use in directing wildlife to the interim culverts. Taking into consideration the recommendations made by NRSI following the 2018 surveys (NRSI 2019), the City met with NRSI in the fall of 2020 to mark out potential locations for new fencing and fencing extensions. The new fencing lengths were staked in the field by the City in advance of installation and the locations were selected with the intention to intercept more travelling wildlife, and direct them towards the culverts.

The City retained Town and Country Fencing to replace the existing light-duty silt fencing with heavy-duty Erosion and Sediment Control (ESC) fencing with paige wire backing in late winter 2021, in advance of the spring monitoring. The more robust heavy-duty ESC fencing material is likely to be less prone to fall into disrepair and is more weather-proof (i.e., able to withstand winds and some snow load) than the light-duty fencing.

At several of the culvert locations, the new ESC fencing is longer than the original fences, ranging from 10-20m in length on either side of the culverts, with an additional 2m tie-back, or fence end. The lengths of the ESC fences vary by culvert; however, in total, approximately 509m of fencing has been installed along Laird Road. In an effort to reduce potential harm to nearby trees and roots, the fences were held down with rocks and gravel instead of being keyed in. As a result, NRSI staff had to do significant repairs to re-bury the fence throughout the monitoring season when heavy winds pulled the fence free from the substrate.

1.1.9 Interim Culvert and Night-time Road Mortality Monitoring – 2020 Postponement

Although NRSI was retained by the City in 2020 to complete another year of effectiveness monitoring along Laird Road, NRSI biologists suspected that overall traffic volume would be reduced as a result of provincial Covid-19 lockdown protocols. This could potentially impact the utility of the data when comparing data year-to-year and completing analyses. As a result, NRSI recommended postponing the surveys to the spring of 2021 with the expectation that traffic would resume to normal levels at that time.

1.2 Purpose of this Report

Surveys were undertaken once again in 2021 to continue assessing the effectiveness of interim culverts for wildlife movement, and determine whether the longer and more permanent fencing installed in 2020 would affect wildlife mortality on Laird Road. The purpose of this report is to provide a summary of the methods and results from the 2021 monitoring, provide an analysis of results over all monitoring years, and provide recommendations for possible future mitigation options.

2.0 Methods

To assess the effectiveness of the culvert crossings (five interim wildlife culverts) and newly installed ESC fencing, and to determine what species were utilizing the culverts, the 2021 monitoring included a combination of night-time road mortality surveys and wildlife camera monitoring in the culverts. This approach is similar to the previous years of monitoring on Laird Road. Methods for each component of the monitoring program are detailed below.

2.1 Night-time Road Mortality Surveys

The 2021 night-time road mortality surveys were conducted following the same protocol used by NRSI in 2009 (prior to culvert installation), 2011, 2013, and 2018 (post culvert installation). Night-time road mortality surveys were conducted on nights when conditions for amphibian movement were favourable. These conditions included rainfall prior to or during the survey, average night-time temperatures above 5˚C, and low winds.

Surveys involved two NRSI staff walking along Laird Road from Hanlon Creek Boulevard Road to Downey Road (Map 2), recording all wildlife species observed. Searches commenced at least one-half hour after sunset and ended before midnight. Each of the culvert openings was also inspected for signs of wildlife movement (i.e., direct observations, tracks, or scat). For each visit, detailed field notes were taken which included:

- Weather conditions;
- Species observed on the road, road shoulder and/or around a culvert opening;
- Location of each individual observed using a hand-held GPS and air-photo map;
- Individual status (i.e., dead, alive or injured);
- Direction of movement (when feasible), and;
- A tally of the number of passing vehicles during the survey period.

In 2021, 12 road mortality surveys were conducted between April 11 and June 18. Table 1 provides a summary of the survey dates in 2021, the length of time the road was monitored each night, and the number of vehicles passing while surveys were being conducted.

Table 1. Road Mortality Survey Information for 2021

Date	Duration (hr)	Person Hours[1]	Traffic Count	Traffic/Hour
April 11	0:50	1:40	20	24
April 19	0:58	1:56	15	15.5
April 24	0:38	1:16	15	23.7
April 28	0:57	1:54	18	18.9
April 29	0:55	1:50	26	28.4
May 3	1:03	2:06	6	5.71
May 20	0:35	1:10	19	32.6
May 26	0:50	1:40	23	27.6
June 2	0:39	1:18	25	38.5
June 3	0:39	1:18	25	38.5
June 8	1:15	2:30	50	40
June 18	0:51	1:42	30	35.3
Total	**10:10**	**20:20**	**272**	**329**
Average			**22.7**	**27.4**

[1]Person hours are calculated based on two biologists being present during each survey.

2.2 Wildlife Camera Monitoring

As in the previous years of wildlife camera monitoring, in 2021, two wildlife cameras were mounted facing inwards within the openings of each interim wildlife culvert (Culverts 1 – 5) under Laird Road (Map 2, Figure 1). Culvert A1 was not monitored in 2018 or 2021 as the culvert is in disrepair/crushed and is no longer suitable for wildlife passage or mounting the cameras. Cameras were mounted on April 6, 2021 and were left running until June 30, 2021.

Figure 1. Wildlife camera setup

In 2021, in addition to the Reconyx Hyperfire 2 cameras, two new Reconyx Hyperfire Pro cameras (cameras 1N and 4N) were purchased for the project (Map 2). These cameras were custom focused at 2m to optimize capturing photos of wildlife within culverts and set to take photos every 30 seconds continuously, 24 hours a day. The remaining cameras were set to take photos every minute, 24 hours a day.

Every several weeks, NRSI staff checked the battery power of each camera and retrieved the memory cards, replacing them with new cards. Due to culvert flooding, there was one instance in which the camera battery short-circuited and corrupted the image files. Dead camera batteries also resulted in several days with missing or partially missing data. Table 2 summarizes the dates within the monitoring period when wildlife monitoring cameras were not taking photos due to these issues.

After the monitoring period, NRSI staff used Timelapse 2 software to review the photos looking for signs of herpetofauna, birds or mammals. Given that the photos were taken every 30-60 seconds, wildlife could be seen moving within the culverts in consecutive photographs, aiding in detection. Invertebrates were observed but were not recorded for analysis in this report.

Table 2. Monitoring Dates Missed Due to Battery or Camera Issues in 2021

Culvert	Camera	Monitoring Dates Missed	Days Missed[1]	Camera Issue	Total Days Missed/Camera
1	1N	May 4-12	9	Batteries Dead	22
		June 18-30	13	Batteries Dead	
	1S	June 27-30	4	Batteries Dead	4
2	2N	None	0	N/A	0
	2S	June 26-30	5	Batteries Dead	5
3	3N	June 19-30	12	Batteries Dead	12
	3S	June 26-30	5	Batteries Dead	5
4	4N	June 23-30	8	Batteries Dead	8
	4S	June 22-30	9	Batteries Dead	9
5	5N	April 6-19	14	Corrupted Images	23
		June 22-30	9	Batteries Dead	
	5S	June 21-30	10	Batteries Dead	10

[1]Monitoring days are considered to have been missed if the camera was not operating during the evening of that date.

3.0 Results

3.1 Night-time Road Mortality Surveys

During night-time road surveys conducted in 2021, thirty-two wildlife observations were made along and adjacent to the road surface. Wildlife observations were generally evenly distributed along the length of Laird Road, with one small concentration of observations located just west of Culvert 5, and around Culvert A1 (Map 3). The locations of these observations correspond with Amphibian Crossing areas as designated by the City of Guelph's Official Plan (2018) (Map 1).

The majority of observations in 2021 were anurans (frogs and toads) (n=27; 85%), while only 15% (n=5) of all observations consisted of birds or reptiles (Figure 2, Table 3). The anuran observations included seven common frog and toad species. No salamanders of any species were observed during night-time road mortality surveys in 2021. Non-amphibian road mortalities observed during the 2021 surveys included two dead birds (one Black-capped Chickadee (*Poecile atricapillus*) and one American Redstart (*Setaphaga ruticilla*)), and three dead reptiles (one Snapping Turtle (*Chelydra serpentina serpentina*), one Midland Painted Turtle (*Chrysemys picta marginata*), and one Eastern Gartersnake (*Thamnophis sirtalis sirtalis*)) (Figure 2, Table 3). No mammals were observed during the night-time road mortality surveys.

Of all the observations made in 2021, 53.2% (n=17) were found alive, and 46.9% (n=15) were dead (Table 3). One Northern Green Frog (*Lithobates clamitans melanota*) was found injured but died during the survey, and is considered among the dead observations.

Appendix I provides a full list of species observed, their condition (dead, alive, injured) and probable direction of movement.

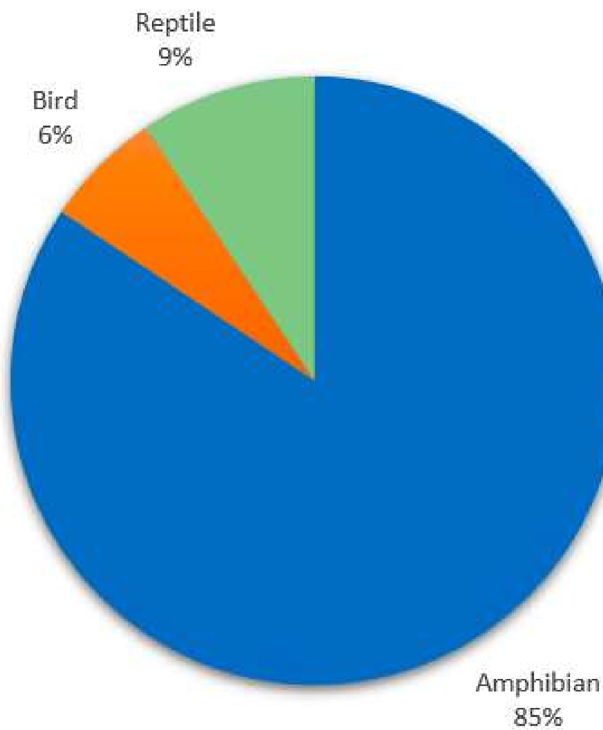

Figure 2. Proportion of Road Mortality Observations by Species Group in 2021

Table 3. Number of Observations by Species Group and Species During 2021 Road Mortality Surveys

Scientific Name	Common Name	Condition		Total
		Alive	Dead	
Amphibians		**18**	**9**	**27**
Anaxyrus americanus	American Toad	9	1	**10**
Hyla versicolor	Tetraploid Gray Treefrog		3	**3**
Lithobates catesbeianus	American Bullfrog	1		**1**
Lithobates clamitans melanota	Northern Green Frog	6	2	**8**
Lithobates pipiens	Northern Leopard Frog		1	**1**
Lithobates sylvaticus	Wood Frog	2	1	**3**
Pseudacris crucifer	Spring Peeper		1	**1**
Birds		**0**	**2**	**2**
Poecile atricapillus	Black-capped Chickadee		1	**1**
Setophaga ruticilla	American Redstart		1	**1**
Reptiles		**0**	**3**	**3**
Chelydra serpentina serpentina	Snapping Turtle		1	**1**
Chrysemys picta marginata	Midland Painted Turtle		1	**1**
Thamnophis sirtalis sirtalis	Eastern Gartersnake		1	**1**
Total		**18**	**14**	**32**

3.2 Wildlife Camera Monitoring Results

Wildlife was documented in all five of the interim wildlife culverts monitored in 2021. Wildlife camera observation data from 2021 is provided in Appendix II. Representative photos showing the use of the culverts by wildlife are shown in Appendix III.

Over the course of the 2021 wildlife camera monitoring period 1,248,373 photos were taken. Of these photos, 1,113 contained amphibians, birds, mammals, reptiles, or unidentifiable wildlife (i.e., photos where the individual could not be identified due to lighting conditions, distance from the camera, angle of the individual, etc.). In 2021, 79% (n=354) of mammals, 66.4% (n=81) of amphibians, 25% of birds (n=1), and 58% of reptiles (n=7) were identifiable to the species level.

Mammals (n=448, 75%) were the most commonly observed species group (Figure 3), with a majority being Eastern Cottontail (*Sylvilagus floridanus*) (n=201), followed by Eastern Chipmunk (*Tamias striatus*) (n=72), small mammals (n=55), Eastern Grey Squirrel (*Sciurus carolinensis*) (n=44), and Northern Raccoon (*Procyon lotor*) (n=34) (Table 4). Striped Skunk (*Mephitis mephitis*) (n=3) was observed less frequently. There were 39 instances in which it was clear that the photographed animal was a mammal, but the species could not be determined.

Of the observations in the 2021 monitoring period, 122 (20%) were amphibians. American Toad (*Anaxyrus americanus*) represented 66% (n=80) of amphibian observations. There was one Northern Green Frog (*Lithobates clamitans melanota*) and six occurrences of undistinguishable *Lithobates* sp. Among the amphibian observations, 29% (n=35) were anurans that could not be identified. No salamanders were observed utilizing the culverts.

There were 12 (2%) reptiles observed in 2021, 41.5% (n=5) of which were Eastern Gartersnake (*Thamnophis sirtalis sirtalis*), 17% (n=2) of which were Snapping Turtle (*Chelydra serpentina*), and the remaining 41.5% (n=5) of which were unidentifiable snake species.

Of the four (0.67%) birds recorded in 2021, one was identified as American Robin (*Turdus migratorius*).

In addition to these observations, there were 12 (2%) instances where animals were observed but could not be identified to any species group because of photo quality or angle. These observations were documented as ‘unknown’ (Figure 3).

Culvert 5 had the highest number of observations in 2021 (n=159), followed by Culvert 2 (n=153), Culvert 4 (n=122), Culvert 1 (n=100), and Culvert 3 (n=64) (Figure 4, Map 8). Culvert 4 had the highest number of amphibians, with 46 individuals or 38% of all amphibians observed in 2021. Culvert 1 had the lowest number of amphibians (n=3). Culverts 2 and 5 respectively had 30% (n=133) and 27% (n=121) of all mammals observed.

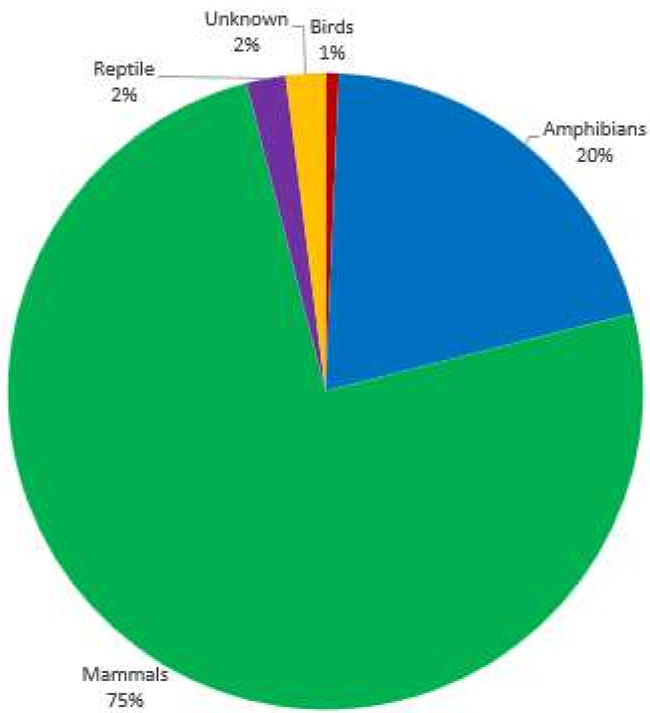

Figure 3. Proportion of Wildlife Camera Observations by Species Group in 2021

Table 4. Number of Wildlife Camera Observations by Species for All Culverts in 2021

Scientific Name	Common Name	Culvert					Total
		1	2	3	4	5	
Amphibians		**3**	**19**	**17**	**46**	**37**	**122**
Anaxyrus americanus	American Toad		10	7	39	24	**80**
Lithobates clamitans melanota	Northern Green Frog		1				**1**
Lithobates sp.	Lithobates sp.[1]			3	1	2	**6**
	Anuran sp.[1]	3	8	7	6	11	**35**
Birds		**4**					**4**
Turdus migratorius	American Robin	1					**1**
	Bird sp.	3					**3**
Mammals		**79**	**133**	**44**	**71**	**121**	**448**
Mephitis mephitis	Striped Skunk	3					**3**
Procyon lotor	Northern Raccoon	5	10	3	9	7	**34**
Sciurus carolinensis	Eastern Gray Squirrel	4	18	5	3	14	**44**
Sylvilagus floridanus	Eastern Cottontail	11	73	26	32	59	**201**
Tamias striatus	Eastern Chipmunk	26	13	5	10	18	**72**
	Mammal sp.[1]	8	10	3	2	16	**39**
	Small mammal sp.[1]	22	9	2	15	7	**55**
Reptiles		**4**	**1**	**3**	**4**		**12**
Chelydra serpentina	Snapping Turtle				2		**2**
Thamnophis sirtalis sirtalis	Eastern Gartersnake	3		2			**5**
	Snake sp.[1]	1	1	1	2		**5**
Unknown[2]		**10**			**1**	**1**	**12**
	Unknown	10			1	1	**12**
Total		**100**	**153**	**64**	**122**	**159**	**598**

[1]Image not clear enough to identify species
[2]Image not clear enough to identify to animal group or species

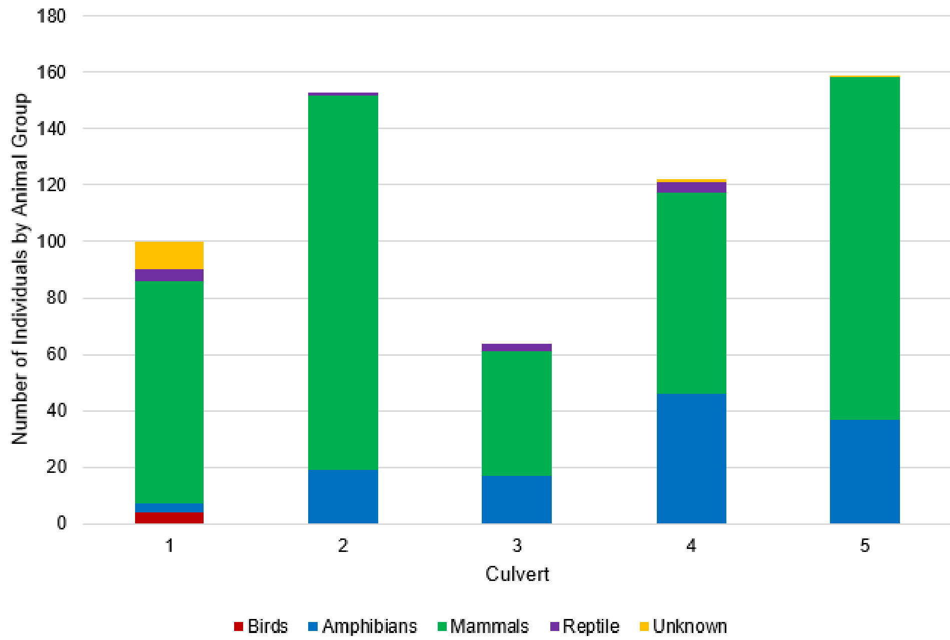

Figure 4. Number of Wildlife Camera Observations by Species Group in Culverts in 2021

3.2.1 Hourly Wildlife Movement Timing

The analysis of photograph timestamps from the 2021 culvert monitoring indicate that wildlife use of the Laird Road culverts peaks at 0500hrs and again around 2100hrs (Figure 5). The lowest wildlife activity occurs in the early hours of the morning, at 0300hrs, and again between 1000 and 1500hrs. In general, the wildlife activity is highest in the culverts between 1900 and 0700hrs.

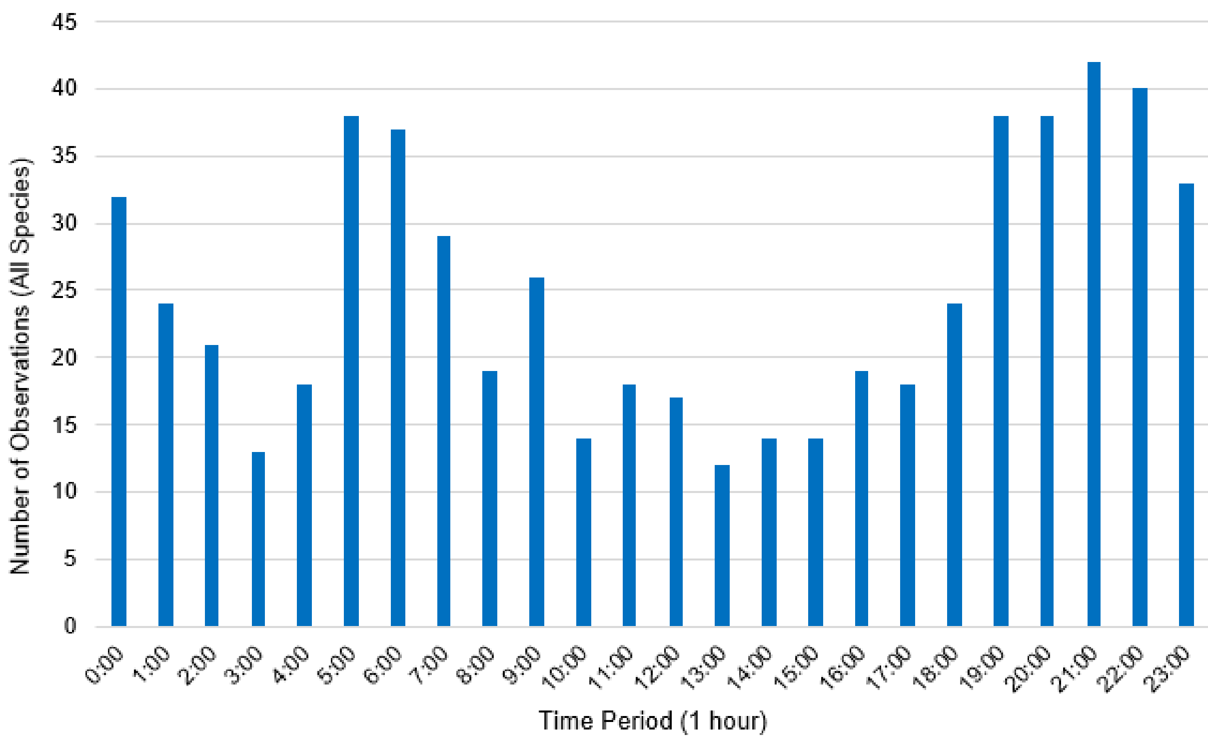

Figure 5. Number of Wildlife Camera Observations over the Daily Monitoring Period in 2021

3.3 Incidental Wildlife Observations

NRSI biologists documented direct and indirect (i.e., tracks) evidence of incidental wildlife during night-time road mortality surveys and visits to maintain wildlife cameras in 2021. A total of 12 incidental wildlife observations were recorded during the survey period (Table 5). These included American Toad, Gray Treefrog (*Hyla versicolor*), Spring Peeper, and Wood Frog. American Woodcock (*Scolopax minor*), Eastern Meadowlark (*Sturnella magna*), and Savannah Sparrow (*Passerculus sandwichensis*) were heard calling from the open habitats adjacent to the road on April 11, 2021 (Table 5). A Yellow-billed Cuckoo (*Coccyzus americanus*) was also heard calling near Culvert 3 on June 1, 2021.

Table 5. Incidental Wildlife Observations in 2021

Date	Species Group	Scientific Name	Common Name	Observation	Location
April 11	Amphibian	*Anaxyrus americanus*	American Toad	Calling	SWM4
	Amphibian	*Lithobates sylvaticus*	Wood Frog	Calling	South of Laird Rd
	Bird	*Passerculus sandwichensis*	Savannah Sparrow	Calling	North of Laird Rd
	Amphibian	*Pseudacris crucifer*	Spring Peeper	Calling	n/a[1]
	Bird	*Scolopax minor*	American Woodcock	Calling	North of Laird Rd
	Bird	*Scolopax minor*	American Woodcock	Calling	East of Laird Rd
	Bird	*Sturnella magna*	Eastern Meadowlark	Calling	East of Laird Rd
	Bird	*Turdus migratorius*	American Robin	Calling	n/a[1]
June 1	Bird	*Coccyzus americanus*	Yellow-billed Cuckoo	Calling	n/a[1]
June 2	Amphibian	*Hyla versicolor*	Gray Treefrog	Calling	n/a[1]

[1]No location recorded. Observation made within the Laird Road monitoring area, between Hanlon Creek Boulevard Road and Downey Road.

4.0 Comparison of Results Over All Monitoring Years

4.1 Night-time Road Mortality Surveys

Road mortality surveys on Laird Rd. have occurred over five years since 2009, with varying numbers of surveys and durations. Table 6 provides a comparison of the number of surveys and person hours for all monitoring years.

Due to the presence of natural habitats along the length of both sides of Laird Road, wildlife movement observed over all monitoring years was fairly evenly distributed (Map 7a, Map 7b). There was one area with more concentrated wildlife observations across all years, in the western portion of Laird Road, west of interim Culvert 5 (Map 7a, Map 7b). These results were also supported by the movement zones documented during the 2010 pitfall trapping monitoring program (NRSI 2010).

The number of wildlife mortalities documented along Laird Road varied greatly from year to year, from a high of 79 in 2009 to a low of 14 in 2021. Table 7 provides a summary of the number of species observed during all years of road mortality surveys, along with species condition (dead, alive or injured). This variability is likely due to differences in weather in each year of monitoring, and whether conditions were ideal for amphibian migration. Overall, the annual number of individual wildlife mortalities decreased following the culvert installation in 2010 (Table 7, Map 7a, Map 7b). Compared to pre-culvert installation wildlife mortality numbers in 2009 (n=79) (Map 4), wildlife mortality decreased by 88% (n=17) in 2011, 42% (n=46) in 2013, 61% (n=31) in 2018, and 82% (n=14) in 2021 (Map 5a, Map 5b).

Over all monitoring years, the observations during night-time road mortality monitoring were predominantly amphibians (87%) with the majority of these (97.9%) being frogs and toads. Table 8 provides a summary of the road mortality monitoring observations by species over all study years.

Table 6. Road Mortality Survey Summary for All Years

Year	Number of Surveys	Duration (hr)	Person Hours[1]	Survey Effort[2]	Traffic Count	Traffic/Hour
2009	16	15:20	29:02	1:49	N/A[3]	N/A[3]
2011	7	7:12	14:24	2:03	297	41.2
2013	13	12:13	24:26	1:53	347	28.4
2018	11	11:17	22:34	2:03	524	57
2021	12	10:10	20:20	1:41	272	27.4
Total	**47**	**56:12**	**110:36**	**9:29**	**1,440**	**154.0**
Average				**1:53**	**360**	**38.5**

[1]Person hours are calculated based on two biologists being present during each survey, which was true for all surveys except for two visits in 2009, where only one biologist conducted the survey, and one survey on May 3, 2018, where three biologists were present.

[2]Survey effort is calculated by dividing the person hours by the number of surveys.

[3]The 2009 surveys did not document the number of vehicles passing during the surveys; therefore, a comparison is not available. The traffic count in 2011 and 2013 has been normalized to provide a count per hour.

Table 7. Condition of Wildlife Observed During Night-time Road Mortality Surveys in All Study Years

Year	Condition			Total
	Alive/Tracks	Dead	Injured	
Pre-culvert Installation				
2009	22	79		101
Post culvert Installation				
2011	6	17		23
2013	26	46	1	73
2018	10	31		41
2021	17	14	1	32
Total	**81**	**187**	**2**	**270**

Table 8. Wildlife Species Observed During Night-time Road Mortality Surveys in All Study Years

Scientific Name	Common Name	SRANK[1]	SARO[2]	COSEWIC[3]	Number of Individuals					
					2009	2011	2013	2018	2021	Total
Amphibians										
Ambystoma laterale - (2) jeffersonianum	Unisexual *Ambystoma* - Jefferson Salamander dependent population	S2			1					**1**
Anaxyrus americanus	American Toad	S5			35	6	11	4	10	**66**
Anuran ssp	Anuran species	-			7		8	2		**17**
Hyla versicolor	Tetraploid Gray Treefrog	S5				2	31	5	3	**41**
Lithobates catesbeianus	American Bullfrog	S4							1	**1**
Lithobates clamitans melanota	Northern Green Frog	S5			3		6	7	8	**24**
Lithobates pipiens	Northern Leopard Frog	S5	NAR	NAR	33	2	6	5	1	**47**
Lithobates sylvaticus	Wood frog	S5			2		6	5	3	**16**
Pseudacris crucifer	Spring Peeper	S5			16		1	8	1	**26**
	Unknown species	-				4				**4**
Amphibian Total					**97**	**14**	**69**	**36**	**27**	**239**
Birds										
Poecile atricapillus	Black-capped Chickadee	S5							**1**	**1**
Scolopax minor	American Woodcock	S4B					1			**1**
Setophaga ruticilla	American Redstart	S5B							**1**	**1**
	Sparrow species	-				1				**1**
	Unknown species	-						2		**2**
Bird Total					**0**	**1**	**1**	**2**	**2**	**6**
Mammals										
Mephitis mephitis	Striped Skunk	S5				1				**1**
Odocoileus virginianus	White-tailed Deer (tracks)	S5				1	1			**2**
Procyon lotor	Northern Raccoon (tracks)[4]	S5				3				**3**
Sciurus carolinensis	Eastern Gray Squirrel	S5						1		**1**
Sylvilagus floridanus	Eastern Cottontail	S5				2				**2**
Tamias striatus	Eastern Chipmunk	S5			1	1				**2**
	Mouse species	-			2					**2**
	Mammal species	-					1			**1**
Mammal Total					**3**	**8**	**2**	**1**	**0**	**14**
Reptiles										

Scientific Name	Common Name	SRANK[1]	SARO[2]	COSEWIC[3]	Number of Individuals					
					2009	2011	2013	2018	2021	Total
Chelydra serpentina serpentina	Snapping Turtle	S3	SC	SC				1	1	**2**
Chrysemys picta marginata	Midland Painted Turtle	S5		SC				1	1	**2**
Lampropeltis triangulum	Eastern Milksnake	S4	NAR	SC	1					**1**
Thamnophis sirtalis sirtalis	Eastern Gartersnake	S5					1		1	**2**
Reptile Total					**1**	**0**	**1**	**2**	**3**	**7**
Total					**101**	**23**	**73**	**41**	**32**	**270**

[1]Subnational Rank (MNRF 2021);
[2]Species at Risk in Ontario (MNRF 2020);
[3]Committee on the Status of Endangered Wildlife in Canada (Government of Canada 2021);
[4]Fresh raccoon tracks observed at three separate locations, may have been one individual

LEGEND		
SRANK		**SARO/COSEWIC**
S2 Imperiled	S4 Apparently Secure	NAR Not at Risk
S3 Vulnerable	S5 Secure	SC Special Concern

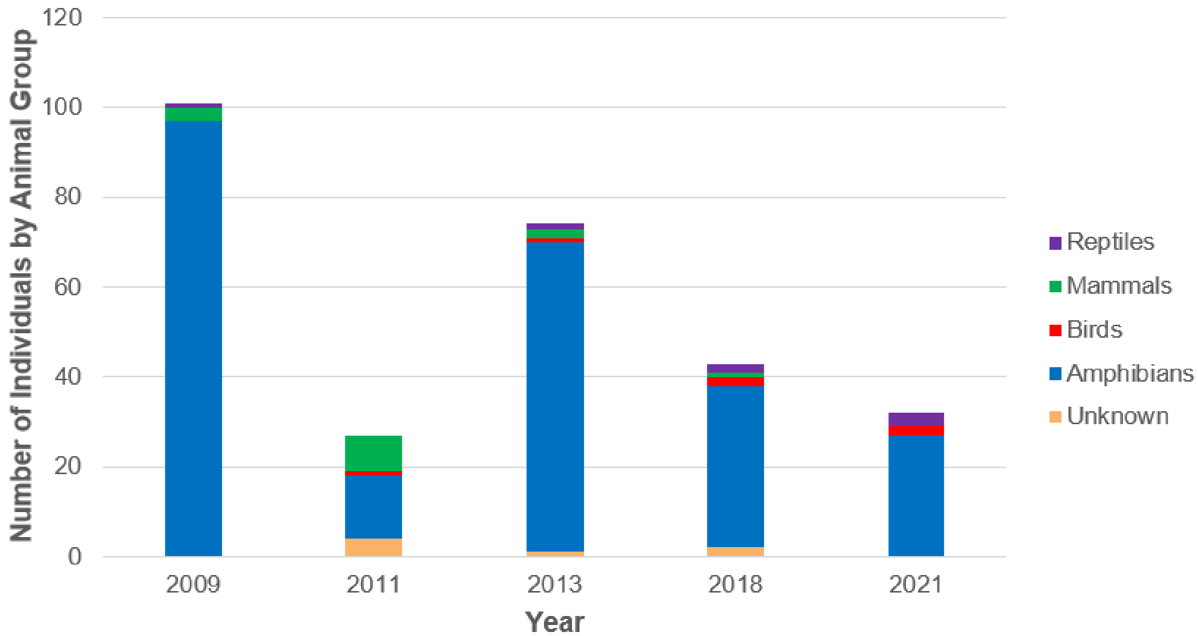

Figure 6. The Number of Individuals Observed during Night-time Road Mortality Surveys by Species Group for All Study Years

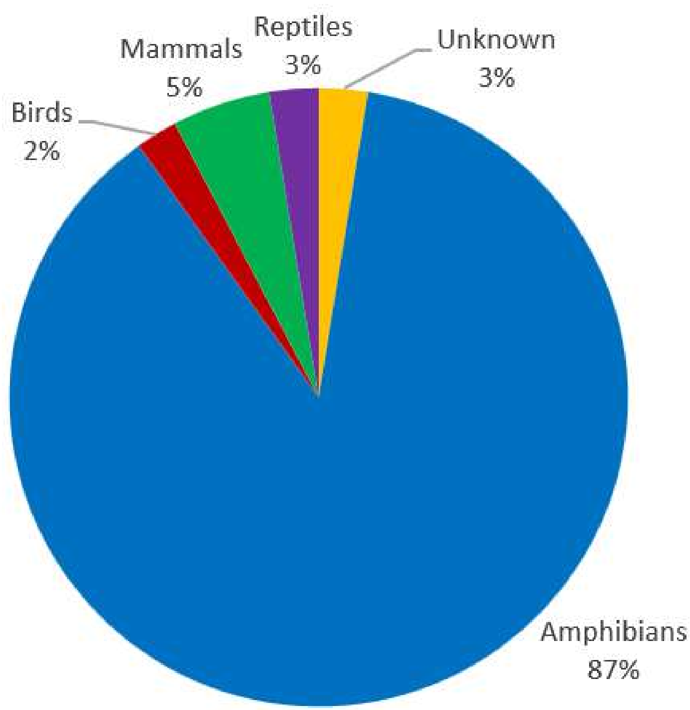

Figure 7. Proportion of Observations by Species Group during Night-time Road Mortality Surveys for All Study Years

4.1.1 Species at Risk

Over the course of the night-time road mortality monitoring surveys, two provincially-listed and one federally-listed Species at Risk (SAR) were observed.

One *Ambystoma* complex salamander was found dead on Laird Road during a night-time road mortality survey in 2009. As discussed in Section 1.1.3, genetic analysis determined that this individual belonged to the Unisexual Ambystoma - Jefferson Salamander dependent population. Unisexual Ambystoma - Jefferson Salamander dependent population are listed as endangered in Ontario (MECP 2021), and their presence could also indicate the presence of the endangered Jefferson Salamander. No other Unisexual *Ambystoma* or Jefferson Salamander individuals were documented in the area, however, despite targeted surveys in 2010 and ongoing road mortality surveys in 2011, 2013, 2018 and 2021.

In 2018 and 2021, NRSI staff observed four dead turtles, two Snapping Turtles and two Midland Painted Turtles, along Laird Road. Snapping Turtle is listed provincially and federally as a species of Special Concern (MNRF 2021, Government of Canada 2021). Snapping Turtles prefer permanent or semi-permanent freshwater marshes, swamps, rivers, and streams with soft muddy banks or bottoms (MNR 2000). Midland Painted Turtle, listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (2019) as Special Concern, prefers quiet, warm, shallow water with abundant aquatic vegetation such as ponds, large pools, streams, ditches, swamps, and marshy meadows (MNR 2000). Suitable habitat is present for both turtle species within the adjacent natural areas north and south of Laird Road, as well as in the man-made ponds in the residential property north of Laird Road, and the Stormwater Management (SWM) pond south of Laird Road (SWM Pond 4).

4.1.2 Direction of Movement

The majority of movements across all monitoring years was in the north or south directions across Laird Road (Table 9). This is consistent with the east-west Laird Road bisecting habitats required by wildlife at different times of the year. Most wildlife is likely travelling across Laird Road to move between overwintering habitats and breeding ponds. In all study years, there was also a relatively high number of individuals (n= 108, 40%) with an unknown direction of movement. In cases where road-killed carcasses were unidentifiable the direction of movement, unless quite obvious, was recorded as unknown.

Table 9. Direction of Wildlife Movement During Night-time Road Mortality Surveys in All Study Years

Direction of Movement	Number of Individuals Observed					
	2009	2011	2013	2018	2021	Total
North	28	3	20	15	13	**79**
Northeast			1			**1**
East	2			1	3	**6**
Southeast			3			**3**
South	32	4	19	6	4	**65**
Southwest			2			**2**
West	2	1			2	**5**
Northwest			1			**1**
Unknown	37	15	27	19	10	**108**
Total	**101**	**23**	**73**	**41**	**32**	**270**

4.1.3 Seasonal Wildlife Movement Timing

In the Guelph area, the amphibian breeding season generally begins in mid to late March or early April, depending on the weather, for a number of amphibian species (i.e., Jefferson Salamander, American Toad, and Spring Peeper) and tapers off in early July for summer breeding species such as Green Frog (Bird Studies Canada (BSC) 2009). In cases where wetlands are adjacent to busy roadways, there is often a correlation between increased amphibian road mortalities and peak breeding seasons, as anurans move from their overwintering habitats to breeding habitats (Mazerolle et al. 2005). The data collected from all monitoring years, including the 2010 pitfall trapping data, indicates a much higher rate of amphibian movement during the month of April, as opposed to late May and June, when movement of species moving to and from breeding ponds has decreased considerably (Table 10).

Road mortality surveys were not conducted during the fall movement period (late August through November) associated with some amphibian species. Due to the variability in amphibian life cycles (i.e., breeding period, tadpole maturation time and over-wintering habitat preferences), it is likely that the number of species moving back across Laird Road during the summer and fall would be more dispersed than what has been observed during the peak spring breeding period.

Table 10. Wildlife Movement by Month from Night-time Road Mortality Surveys over All Study Years

Month	Number of Individuals Observed[2]						
	2009	2010[1]	2011	2013	2018	2021	Total
March	-	14	-	-	-	-	14
April	50	163	17	29	16	11	286
May	34	-	6	44	24	4	112
June	17	-	-	-	1	17	35
Total	**101**	**177**	**23**	**73**	**41**	**32**	**447**

[1]Data from pitfall trapping rather than night-time road mortality surveys

[2]Months where surveys were not completed are indicated by a '-'

4.1.4 Volume of Traffic

The number of vehicles travelling along Laird Road during the 2011, 2013, 2018, and 2021 night-time road surveys was recorded and tallied (this data was not recorded during the night-time road surveys in 2009). Overall, it appeared that traffic volumes had increased from 2011 to 2018, since Laird Road monitoring began. At its peak, a total of 564 vehicles were observed during the 11 hours and 17 minutes of monitoring in 2018 (approximately one vehicle per minute), compared to 347 vehicles during the 12 hours and 13 minutes of monitoring in 2013 (approximately 0.5 vehicles per minute), and 297 vehicles during the 7 hours and 12 minutes in 2011 (approximately 0.75 vehicles per minute). In 2021, a total of 272 vehicles were counted during the 10 hours and 10 minutes of surveying (approximately 0.45 vehicles per minute). This represents the lowest traffic volume recorded so far across the four years of monitoring. This reduction in traffic may be a result of the COVID-19 pandemic (provincial stay at home orders and increase in people working from home), and may not necessarily indicate an overall downward trend in traffic volume.

4.2 Wildlife Camera Monitoring

Across the monitoring years, various cameras and camera settings have been used in an effort to best capture wildlife movement. Table 12 provides a summary of these cameras over the years. The new camera settings used in 2018 and 2021, using time-lapse photography rather than video or motion-triggered photography, were successful in capturing wildlife using the interim wildlife culverts. With the use of time-lapse photography, the total number of wildlife camera observations (all species) was much higher in 2018 than in previous years, with 325 observations compared to 150 in 2011 and 11 in 2013. In 2021, the cameras were set to use time-lapse photography all day, instead of between the hours of 2000 and 0700, resulting in a greater total of 598 observations. In order to compare wildlife camera observations between 2018 and 2021, the number of observations recorded must be analyzed across the same daily time period; in 2021, 336 observations occurred between 2000 and 0700hrs, compared to 325 during this same time period in 2018. As such, the total number of overall wildlife observations in the culverts is similar across these two monitoring years.

In 2018, due to image quality and the distance of animals from the camera, most of the amphibians and none of the birds and reptiles could be identified to the species level. Overall, the 2021 monitoring period was more successful than previous years in identifying the species captured on camera.

In 2011, 2018, and 2021, wildlife was documented in all five interim wildlife culverts, while in 2013, wildlife was only documented in Culverts 3, 4, and 5 (Figure 9). In 2011, 2013, and 2021, the greatest number of individuals was documented using Culvert 5 (Figure 9). In 2018, however, Culvert 2 and 3 had the highest number of observations (n=93 and n=92, respectively), and these culverts had more than double the number of observations than at Culvert 5 (n= 38). Culvert 3, in turn, had the lowest number of observations (n=64) in 2021. Table 12 summarizes the number of observations for all species and species groups over each of the years of wildlife camera monitoring.

While camera monitoring in 2011 and 2013 was successful in documenting the use of the culverts by common mammals, such as Eastern Cottontail, Northern Raccoon and Ermine (*Mustela erminea*), no amphibian or reptile species were documented. Mammals were by far the most commonly observed species group in all years of monitoring (Figure 8). In 2018 and 2021, the cameras were successful at confirming the use of the culverts by amphibians and reptiles, though they make up a relatively small proportion of the documented use of the culverts. Of the observations in the 2021 monitoring period, 122 (20%) were amphibians, which marks a notable increase from the 12 (4%) observed in 2018. Figure 10 shows the occurrence of amphibians and reptiles in each of the culverts across the monitoring years.

In 2018, amphibians were observed in Culverts 1 (n=6), 2 (n=2), 3 (n=2), and 4 (n=2). In 2021, the number of amphibian observations increased significantly, especially in Culverts 4 and 5. Amphibians were observed in Culverts 1 (n=3), 2 (n=19), 3 (n=17), 4 (n=46), and 5 (n=37) in 2021. In 2018, reptiles were only observed in Culvert 1 (n=1), 2 (n=1), and 4 (n=3) whereas in 2021, reptiles were observed in Culvert 1 (n=4), 2 (n=1), 3 (n=3), and 4 (n=4).

Table 11. Wildlife Camera Monitoring Summary for All Study Years

Year	Camera Type	Camera Settings	Date of Setup	Date Removed	Total Number of Monitoring Days
2011	Moultrie D55-IR Game Spy	Motion-triggered	March 30, 2011	Beginning of June, 2011	~63
2013	Sony Handycam HDR-PJ710 - infrared	Real-time video	April 15, 2013	May 23, 2013	38
2018	Stealth Cam DS4 4K	Time-lapse	April 3, 2018	June 5, 2018	63
2021	8x Reconyx Hyperfire 2 and 2x Reconyx Hyperfire 2 Pro	Time-lapse	April 6, 2021	June 30, 2021	85

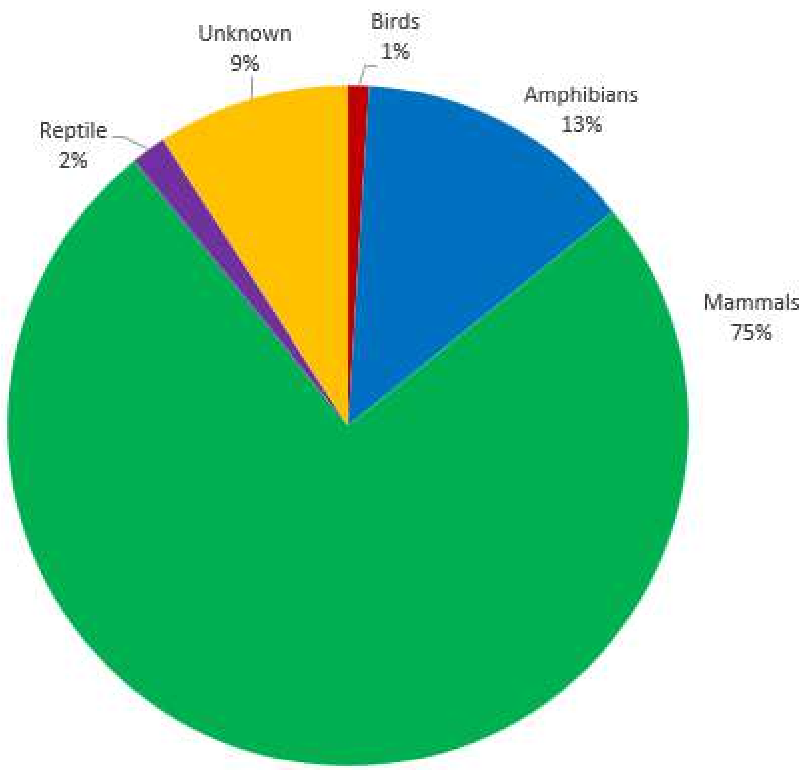

Figure 8. Wildlife Camera Observations by Species Group for all Study Years

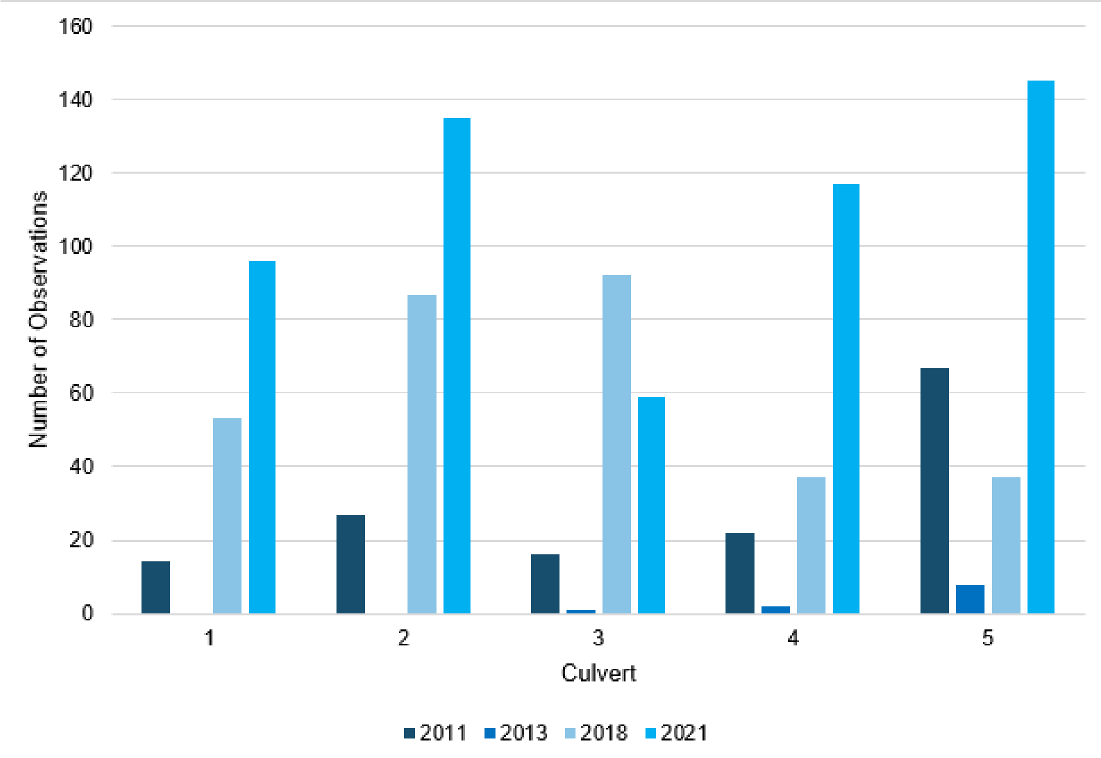

Figure 9. Wildlife Camera Observations Across Culverts for all Years of Monitoring

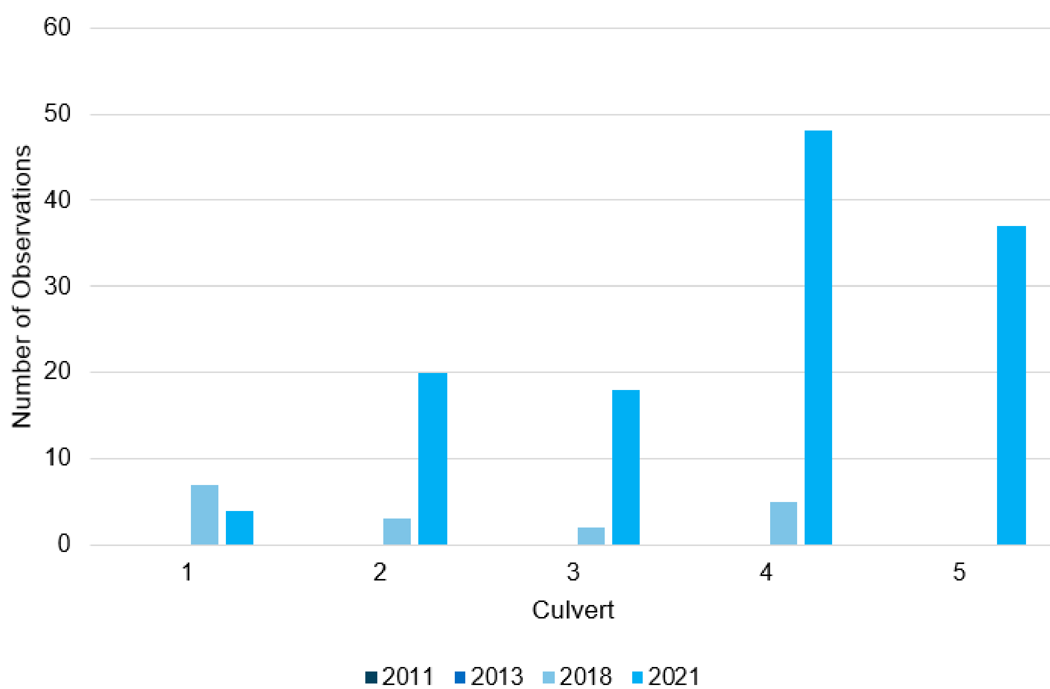

Figure 10. Amphibian and Reptile Wildlife Camera Observations Across Culverts for all Years of Monitoring

Table 12. Number of Culvert Camera Observations by Species over All Years

Scientific Name	Common Name	Number of Individuals Observed Using Culverts																				Total
		1				2				3				4				5				
		2011	2013	2018	2021	2011	2013	2018	2021	2011	2013	2018	2021	2011	2013	2018	2021	2011	2013	2018	2021	
Amphibians																						
Anaxyrus americanus	American Toad			1					10				7				39				24	**81**
Lithobates clamitans	Green Frog								1													**1**
Lithobates sp.	Lithobates sp.[1]							2					3			1	1				2	**9**
	Anuran sp.[1]			5	3				8			2	7				6				11	**42**
	Salamander sp.[1]															1						**1**
Birds																						
Turdus migratorius	American Robin**				1	1																**2**
Quiscalus quiscula	Common Grackle**					1																**1**
Anas platyrhynchos	Mallard**													1								**1**
	Bird sp.[1]			2	3			1														**6**
Mammals																						
Tamias striatus	Eastern Chipmunk			1	26			1	13			2	5	2		2	10			1	18	**81**
Sylvilagus floridanus	Eastern Cottontail	11		17	11	7		51	73	10		45	26			5	32	40	2	19	59	**408**
Sciurus carolinensis	Eastern Gray Squirrel			1	5			1	10			4	3			1	9			1	7	**42**
Mustela erminea	Ermine										1											**1**
Procyon lotor	Northern Raccoon	3		3		9		6		1		4		12	2	13		20	6	4		**83**
Mephitis mephitis	Striped Skunk				3	3						1		2								**9**
Mustela sp.	Weasel sp.[1]							5												5		**10**
	Mammal sp.[1]				8				10			2	3			5	2				16	**46**
	Mouse sp.[1]			2		1		2				8				1				2		**16**
	Small mammal sp.[1]			12	22			6	9			12	2				13			1	7	**65**
Reptiles																						
Thamnophis sirtalis sirtalis	Eastern Gartersnake				3								2									**5**
Chelydra serpentina	Snapping Turtle																2					**2**
	Snake sp.[1]			1	1			1	1				1			3	2					**10**
Unknown[2]																						
	Unknown spp.			20	10	5		17		5		12		5		5	1	7		5	1	**93**
		14	**0**	**53**	**96**	**27**	**0**	**87**	**135**	**16**	**1**	**92**	**59**	**22**	**2**	**37**	**117**	**67**	**8**	**37**	**145**	**1015**

[1]Image not clear enough to identify species
[2]Image not clear enough to identify to animal group or species

4.3 Incidental Wildlife Observations

NRSI biologists began recording incidental wildlife observations during surveys in 2013. The same four common species of anurans were heard calling throughout the monitoring period in 2013, 2018, and 2021 from the wetlands in the area surrounding Laird Road. Other incidental species varied between the years. American Bullfrog (*Lithobates catesbeianus*), for example, was only documented in the area in 2013. American Woodcock, on the other hand, was only observed calling in the vicinity of the study area in 2018 and 2021, although it was documented during terrestrial and wetland monitoring within the HCBP study area (NRSI 2017).

No mammals were incidentally observed in 2021. This likely does not reflect changes in the presence or abundance of these species, but rather the nature of a chance encounter with these highly mobile mammal species. Table 13 provides a summary of all incidental observations from 2013, 2018, and 2021 monitoring.

Table 13. Incidental Wildlife Observations in 2013, 2018, and 2021

Scientific Name	Common Name	Number of Incidental Observations[1]			Total
		2013	2018	2021	
Lithobates catesbeianus		1			1
Tamiasciurus hudsonicus	American Bullfrog		1		1
Turdus migratorius	American Red Squirrel			1	1
Anaxyrus americanus	American Robin	2	3		5
Scolopax minor	American Toad		4	2	6
Sylvilagus floridanus	American Woodcock		3		3
Sturnella magna	Eastern Cottontail			1	1
Hyla versicolor	Eastern Meadowlark	1	2	1	4
Procyon lotor	Gray Treefrog	5			5
Passerculus sandwichensis	Northern Raccoon			1	1
Pseudacris crucifer	Savannah Sparrow	4	5	3	12
Didelphis virginiana	Spring Peeper	1			1
Odocoileus virginianus	Virginia Opossum		1		1
Lithobates sylvaticus	White-tailed Deer	1	2	1	4
Coccyzus americanus	Wood Frog			2	2
Total		**15**	**21**	**12**	**48**

[1]Incidental wildlife observations were not recorded in 2011.

5.0 Effectiveness of Existing Mitigation

Road mortality observations were relatively evenly distributed along the length of Laird Road for all monitoring years, although several areas with higher concentrations of amphibian mortality were observed. In 2013, a greater number of amphibian road mortalities were observed around Culvert 3 and around Culvert 1 (Map 6). In 2018 and 2021, a concentrated amphibian mortality area was located just west of Culvert 5, where there is a longer expanse of unfenced road (Map 6, Map 7b). In 2021, there were road mortalities somewhat concentrated west of Culvert A1 (Map 3). This concentration area may be correlated to the fact that Culvert A1 is in poor condition/crushed and is therefore not allowing the movement of wildlife under the road, combined with the fact that no heavy-duty wildlife exclusion/directional fencing was installed in the vicinity of this culvert prior to the 2021 monitoring season.

Wildlife mortalities observed along Laird Road have generally continued to decrease following the interim wildlife culvert installation in August 2010, with the exception of reptile mortalities (n=3 in 2021). In 2021, NRSI biologists found that 43.8% of all wildlife observations during road surveys were dead, marking a substantial decrease in overall mortality from the 75.6% dead in 2018, 63.0% in 2013, 73.9% in 2011, and 78.2% in 2009. The reduction in road mortality may be a result of reduced overall vehicle traffic volume in 2021. Although this decrease could also indicate that the interim wildlife culverts are successfully mitigating road mortality along Laird Road, the decreases in road mortality were not correlated with overall increases in documented culvert use by wildlife. The wildlife camera data showed only a slight increase (n=11) in culvert observations during comparable time periods between 2018 (n=325) and 2021 (n=336). However, despite the overall number of culvert observations remaining mostly static between 2018 and 2021, there was an increase in the proportion of amphibians observed vs. other fauna in the culverts in 2021 (from 3.9% in 2018 to 22.1% in 2021).

The increase in the proportion of amphibians observed in 2021 camera surveys could be related to the wildlife camera settings used. The first two years of wildlife camera monitoring had technical issues in documenting amphibians; however, the time-lapse photography used in the 2018 and 2021 monitoring has been demonstrated to effectively document and photograph amphibians (Pagnucco et al. 2011). In 2018, the species group most impacted by road mortality, frogs and toads, were seldom observed using the interim wildlife culverts. Anurans made up 87.8% of the 2018 road mortalities but only 3% of wildlife camera monitoring observations. In 2021, there was an increase in observed anuran culvert use; anurans made up 84.4% of the observations during road mortality surveys and 22.1% of wildlife camera monitoring observations. When comparing amphibian wildlife camera observations across the same survey time period between 2021 and 2018, there was a significant increase in the number of amphibians that were observed in 2021 (n=98) compared to 2018 (n=11). While accounting for the greater number of monitoring days in 2021 (n=85, compared to n=63 in 2018), this is still a substantial increase in amphibian observations. Since similar camera settings were used in 2018 and 2021 but there was still variation in amphibian observations, better detection technology is unlikely to be the only factor explaining the high amount of amphibian wildlife camera observations in 2021.

The increase in amphibian observations in 2021 may have been also due to the favourable environmental conditions for the emergence and movement of some amphibians in the spring. Through the During Construction - Terrestrial and Wetland Monitoring (NRSI 2019, NRSI 2021), NRSI documented year to year variation in frog and toad breeding activity during the calling anuran monitoring. The 2018 results indicated that species diversity and abundance had declined at many of the monitoring stations throughout the HCBP study area, likely as a result of drier conditions at all monitoring plots (NRSI 2019). In 2018, it was assumed that seasonal variations in temperature, snowmelt, spring precipitation, as well as amphibian population fluctuations over time, could be affecting the observed trends in amphibian movements across Laird Road. The HCBP results suggest that the movement of anurans across Laird Road could increase in years with more suitable conditions for breeding amphibians (such as higher levels of snowmelt and spring precipitation, depending on the species).

Among these species is American Toad, which was present in large numbers during 2020 anuran surveys and was the most observed anuran in both road mortality surveys and wildlife camera monitoring in 2021 (NRSI 2021). Although the dry conditions of spring 2021 were generally less favourable for most amphibians, they were highly suitable for American Toad emergence. American Toads in southern Ontario require a minimum air temperature of 8°C and relatively dry conditions for emergence in the spring (Green et al. 2016). The average air temperatures in Guelph in April 2020 and April 2021 respectively were 10°C and 12.4°C, both warm enough to encourage early spring emergence of the species (Environment and Climate Change Canada 2021a). Both these years also had overall dry springs with few appreciable rain events that could have encouraged both emergence and movement for breeding (Environment and Climate Change Canada 2020, 2021b). Despite the dryness of the early spring conditions, 2021 marked the year with most amphibian movement in the culverts across the four monitoring years. This increase in anuran movement was mostly driven by American

Toad. The concentration of wildlife movement within Culverts 2, 4, and 5, are likely owed to the proximity of shallow standing water and suitable breeding habitat adjacent to these culverts. The abundance of American Toad in several culverts is an indicator that the local conditions (i.e. lower water levels and low velocity from snow-melt) of these culverts were highly suitable for toad use this year (Patrick et al. 2010).

Since the installation of longer and more robust heavy-duty fencing with fence ends, combined with lower traffic volume and other environmental factors, overall wildlife mortality on Laird Road dropped 27% from 2018. While, as in previous years, the western part of Laird Road also had a high concentration of wildlife on the road, the overall wildlife mortality in 2021 in this portion of the study area was 86% lower than pre-culvert installation. It is possible that the increased length and improved quality of the directional fencing in 2021 may have contributed to reducing overall mortalities and encouraging the redirection of wildlife towards the culverts. However, the decrease in mortalities is likely also attributed to the all-time low vehicle traffic volumes, dry spring conditions, and overall decreased abundance of local anuran populations.

6.0 Mitigation Options and Recommendations

A combined approach of suitable wildlife crossing structures and fencing is ideal for reducing wildlife mortality on Laird Road (Dodd et al. 2004, Aresco 2005). While a combination of factors related to vehicle traffic volumes and environmental conditions were also at play, the 2021 monitoring season saw continued use of the interim wildlife culverts and a reduction in overall road mortality following the installation of longer extents of heavy-duty fencing. Therefore, it is recommended that the fencing be upkept in future years until Laird Road is eventually closed. Supplementary monitoring and mitigation measures that can be implemented include adjusting monitoring protocols to include improving the ESC fencing, assessing the movement or congregation of wildlife along the fence on the non-roadside, and efforts to reduce traffic during peak wildlife movement periods. These recommended approaches are detailed below.

6.1 Anuran Call Survey Monitoring

The During Construction Terrestrial and Wetland Monitoring anuran call surveys indicate an overall reduction in anuran species abundance and diversity in the adjacent lands to Laird Road (NRSI 2019, NRSI 2021). Fluctuations in populations surrounding Laird Road are likely to have an impact on the abundances and diversity of species observed during road and culvert monitoring. Due to the influence of environmental conditions and broader population dynamics on annul amphibian abundances, it is difficult to draw conclusions as to the effectiveness of road mitigation measures based solely on anuran observation data in road mortality and wildlife camera surveys. It is recommended that anuran call surveys are continued in conjunction with road mortality and wildlife camera surveys to ascertain whether trends in observations are a result of road mitigation measures, or can be attributed to overall population fluctuations.

6.2 Wildlife Exclusion Fencing

The 2021 survey results validate past research indicating that wildlife crossing structures are significantly more effective at reducing road mortality when combined with longer lengths of exclusion fencing on either side of the tunnel openings (Rytwinski et al. 2016). The heavy-duty ESC fencing used in 2021 proved much more effective at directing wildlife, and required fewer repairs than previous years with shorter lengths of light-duty fencing. In an effort to minimize potential damage to tree roots below the fences, the City directed that the ESC fencing be held down with rocky aggregate instead of being trenched and buried. There were several instances in the 2021 monitoring season where the fence was pulled out from the rocks due to heavy wind, and had to be repaired by NRSI staff. To reduce the need for repair and the opportunity for wildlife to travel through these gaps, it is recommended that the fence be hand-trenched into the ground. If trenching is not feasible, additional stone will be required to hold down the fencing in advance of movement periods.

ESC fencing should continue to be used and its condition should be monitored in the future to assess the long-term efficacy of the fence and durability of the material. Fence maintenance ahead of the wildlife movement season may also include trimming vegetation and removing litter around the fence to ensure wildlife can't climb over it (Toronto and Region Conservation Authority (TRCA) et al. 2016, Ottburg and van der Grift 2019). Fences should be examined ahead of the wildlife movement season to ensure that they are securely attached and buried along the length of the road, and that there are no gaps as a result of ripping, wear, or washout (MNRF 2016). Failure to find and repair these gaps can have an amplifying effect on wildlife road mortality by concentrating wildlife passage on the road where the gap is found, and requiring wildlife to spend more time on the road in search of another exit point (Baxter-Gilbert et al. 2015). If the ESC fencing proves to be prone to gaps, even more permanent barriers can be considered (i.e., Animex, ACO, concrete or steel gravity walls) (Baxter-Gilbert et al. 2015).

For amphibians, the MNR (2013) recommends that fencing:

- Be buried at least 10-20cm where feasible to discourage wildlife from digging;
- Be approximately 50-60cm in height;
- Include an overhang lip that extends away from the road to deter climbing; and,
- Be higher than the high-water level in the spring.

The increased length of the fencing also appeared effective in reducing road mortality in 2021, and continuing to increase the length of the fencing where feasible is recommended. This is especially recommended from Culvert 5 westward, where there tends to be a concentration of wildlife observations on the road. This extension should at minimum reach the end of the adjacent forest, but ideally go as far west as possible. Fencing could also be installed to direct wildlife from Culvert A1 to Culvert 1, where clusters of mortalities were observed, possible from a lack of fencing. Longer lengths of fencing may reduce the 'fence end effect', where increased mortality occurs at the fence ends (Huijser et al. unpublished data 2013 in MTO 2017; Gunson et al. 2014).

Overall fence length should be determined based on the movement distances of the target species (MNRF 2016). For the largest, most mobile anuran species observed during Laird

Road surveys in 2018, movement distances can be greater than several hundred metres. American Toads, for example, were found to move up to several hundred metres in 1 day when moving between different habitats (Forester et al. 2006). Northern Leopard Frogs moved up to 396m in 1 day and moved up to 3,316m over the course of the active season (Knutson et. al 2018). Northern Green Frogs were documented to make movements of up to 560m from their summer habitats back to their overwintering sites (Lamoureux and Madison 1999). Therefore, to improve the effectiveness of the Laird Road exclusion fencing, the fencing should:

- Span between the existing wildlife culverts (MNRF 2016);
- Be extended along the length of the road where wildlife mortalities were observed, especially further west of Culvert 5, and between Culvert A1 and Culvert 1;
- Extend beyond the areas where suitable habitat is present on either side of the road, ending at a point where habitat types transition (MNRF 2016) (i.e., where the agricultural fields begin in the west, and at Hanlon Creek Blvd in the east).

To discourage wildlife from travelling along fences and escaping onto the road ("fence end effect"), it is recommended that:

- Fencing extended beyond the identified areas of road mortality wherever feasible;
- Fence ends be angled away from the road ('U' ends). This can include wrapping fence ends back at a 45-90° angle (MNRF 2016; MNR 2013). In some cases, fence ends are even wrapped around at a 90° angle twice, such that the fence end runs parallel to the main fence (Huijser, et al., 2015);
- Fence ends be situated in habitats that are less habitable for turtles and amphibians, such as unnatural habitats, or densely treed or shrubby areas.

Escapes or exits in fences are important features to allow individuals that manage to get around a fence and onto the road a way to get back off the road once more. Without these features fencing can actually increase road mortality in areas by trapping individuals on the road surface. One common design for reptiles and amphibians is to have a curved fence that faces away from the road surface. The road side of the fence is back-filled with topsoil or gravel so that individuals can walk over the top of the fence from the road surface but not from the other side (MNRF 2016).

6.3 Monitoring of Non-Road Side of Fence

During road mortality surveys in previous years, NRSI biologists typically walk adjacent to the directional fences on Laird Road to observe wildlife. As a result, little is known about how wildlife interacts with the fencing on the non-road side of the fence, adjacent to the natural features along Laird Road. Checking the non-road side of the fence during road mortality surveys would fill in this knowledge gap of whether there are unobserved wildlife mortalities here or if wildlife is spending a lot of time stuck along the fence. It is recommended that future road mortality surveys involve walking along the nature features to assess the impact, if any, of the fence on wildlife on the non-road side.

6.4 Wildlife Camera Settings

The all-day camera monitoring attempted in 2021 showed that the highest rates of wildlife activity occurred between 1900 and 0700hrs (Figure 5). While the new cameras allowed for clearer images that facilitated easier species identification, they were still prone to battery drainage similar to the other, older cameras. One of these new camera's batteries also failed as a result of culvert flooding. In an effort to reduce lost data as a result of battery drainage and other malfunctions, it is recommended that cameras be set to capture photos at 30-60 second intervals from the hours of 1900 to 0700hrs, and that cameras be checked more frequently.

6.5 Temporary Road Closures

Temporary road closures may be employed during peak wildlife movements, such as amphibian migrations, in areas where alternate routes are available to motorists (OREG 2010). Road closures have been successful at mitigating road mortality of snakes and turtles in Rondeau Provincial Park (OREG 2010), and of Jefferson Salamanders in Burlington, Ontario (CBC News 2017, Rundle 2018). Given the alternative routes to the north and south, closing Laird Road to non-local traffic during peak amphibian movement periods may be a viable option to reducing road mortality along this stretch of road.

6.6 Reducing the Speed of Traffic

Reducing the speed of traffic may not be suitable for Laird Road, as speed reductions are only effective at mitigating road mortality of amphibians on low volume roads (MNRF 2016) (i.e., despite reduced speeds, high volumes of traffic still prevent amphibians from safely crossing roads). Reducing traffic speeds, however, may form one component of an effective road mortality mitigation strategy. Laird Road is currently posted as a 70km/hr road and so it may help mitigate road mortality if the speed limit were reduced to 50 or 60km/hr. A reduced speed zone is typically combined with public education and/or wildlife crossing signage to educate motorists about road mortality of local wildlife (MNRF 2016). Traffic speed reduction may only be effectively implemented with regular enforcement (MNRF 2016).

6.7 Wildlife Crossing Signage

The City previously installed wildlife crossing signs along Laird Road in an attempt to alert traffic to potential wildlife crossing. The signs were almost immediately removed by vandals, and as such, were not replaced. The City may consider re-installing wildlife crossing signs using anti-theft installation methods, such as greased bolts, or bolts which require specialized wrenches (MTO 2017). Motorists typically respond to signs by initially reducing vehicle speeds, however the longer-term responses to and effectiveness of wildlife crossing signs are unknown (MTO 2017; Rytwinski et al. 2016). To avoid motorist-habituation, wildlife crossing signs could be set out on a seasonal basis to warn motorists during peak periods of amphibian movement. Signs with flashing lights, or peak movement periods identified on them are also another mitigation option.

6.8 Public Education & Volunteer Engagement

Public are more likely to respect their surroundings and go to greater extents to preserve nature and wildlife when they are educated on the importance of the natural environment and wildlife. It is highly recommended that, in addition to any of the other mitigation measures decided upon (i.e., temporary road closures, wildlife signs), the City engage local residents in the project. This could include involving citizen scientists/volunteers in the effectiveness monitoring program alongside NRSI staff, holding public education sessions to raise awareness of the important natural features within their neighbourhood, and of the wildlife relying on these habitats and impacts that Laird Road and speeding traffic are having on wildlife populations.

Public education can also be achieved through the distribution of educational brochures to local residents. Such brochures could summarize where wildlife vehicle collisions are most frequent along Laird Road, the times of year wildlife vehicle collisions are most likely to occur, what to do to reduce the likelihood of being involved in collisions with wildlife, what to know about animal behaviour in order to anticipate locations where wildlife vehicle collisions may occur, and what to do when an animal is hit. A brochure could include what wildlife species are known to cross Laird Road and provide a summary of species and habitat identification, species biology, and species sightings reporting protocol. Well planned public education and engagement is likely to have an effect on the public’s perception on the impacts of wildlife vehicle collisions on wildlife populations and subsequently, driving behavior.

7.0 Summary

NRSI was contracted by the City of Guelph in 2020 to conduct a fourth year of night-time road mortality surveys and interim wildlife culvert monitoring, using wildlife cameras, along Laird Road. Monitoring was postponed in 2020 due to the COVID-19 pandemic and was initiated in the spring of 2021. This report provides a summary of NRSI's 2021 monitoring results, and provides an analysis of all monitoring years in order to evaluate the overall effectiveness of the mitigation measures employed by the City to reduce road mortalities along Laird Road.

Following the protocols used in previous monitoring years, NRSI recorded 32 wildlife observations along Laird Road during night-time road mortality surveys conducted between April and June, 2021. In 2021, surveyors recorded the lowest vehicle traffic across the four years of monitoring, as well as the lowest relative amount of wildlife mortalities. Overall, there was an 86% reduction in road mortalities in 2021 compared to pre-culvert installation data in 2009. Frogs and toads were by far the most commonly observed species group during night-time road mortality surveys. One dead Snapping Turtle, one dead Midland Painted Turtle, and one dead Eastern Gartersnake were also found. No salamanders were observed. Wildlife observations in 2021 were relatively evenly distributed along the length of Laird Road, with a small concentration of amphibian mortality observations located just west of Culvert 5 and surrounding the unmonitored Culvert A1, both near Amphibian Crossing areas as identified in the City of Guelph Official Plan (2018).

The 2021 wildlife camera monitoring on Laird Road documented a total of 598 observations of amphibians, birds, mammals, reptiles, or unidentifiable wildlife using the City's five interim wildlife culverts. Mammals were the most commonly observed species group in the wildlife camera monitoring, but there was a notable increase in the proportion of amphibian observations from previous years. Monitoring 24 hours a day in 2021 showed that wildlife activity peaked between 1900 and 0700hrs.

The reduction in road mortalities and slight increase in the number of observations of wildlife using culverts in 2021 is likely owed to the fencing upgrades in 2020, overall reduction in traffic volume, as well as year to year environmental conditions and population fluctuations. There is no clear correlation between increased culvert use by all wildlife and reduction in road mortalities. While the 2021 monitoring season saw a reduction in amphibian road mortality, it is inconclusive whether this is a result of increased culvert use. Year to year variation in weather, habitat conditions, and population fluctuations could be affecting the observed trends in amphibian movements across Laird Road. This suggests that levels of road mortality on Laird Road could increase in years with more suitable conditions for breeding amphibians, such as wetter spring conditions. This is especially true if in conjunction with higher traffic volumes.

It is recommended that close monitoring and upkeep of the ESC is continued to ensure that wildlife mortality does not incur as a result of poor fence condition, especially ahead of peak wildlife movement periods. Fences should also be extended to target areas of high road mortality to the west of Culvert 5, and potentially from Culvert A1 to Culvert 1. It is also recommended that future assessments of road mortality monitor the sides of the fence opposite to the road to determine whether other mortalities are occurring that were previously unobserved. Finally, to better understand trends observed over the course of the monitoring period, it is recommended that road mortality surveys and wildlife camera monitoring in the culverts using time-lapse photography be continued in conjunction with the biennial terrestrial, wetland and aquatic monitoring program.

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Appendix I

Night-time Road Mortality Observation Data from 2021

Appendix I: Night-time Road Mortality Observation Data from 2021

Date	Species Group	Scientific Name	Common Name	Number of Individuals	State or Condition	Direction of Movement	Location (UTM; Zone 17)		Sex	Age	Behaviour
							Easting	Northing			
April 11	Amphibian	*Lithobates sylvaticus*	Wood Frog	1	Alive	North	562470	4815260	Unknown	Adult	Sitting
		Lithobates clamitans melanota	Northern Green Frog	1	Alive	North	562354	4815234	Unknown	Juvenile	Sitting
April 19	Reptile	*Thamnophis sirtalis sirtalis*	Eastern Gartersnake	1	Dead	Unknown	563233	4815458	Unknown	Juvenile	N/A
	Amphibian	*Pseudacris crucifer*	Spring Peeper	1	Dead	North	563088	4815412	Unknown	Adult	N/A
April 28	Amphibian	*Anaxyrus americanus*	American Toad	1	Alive	Unknown	562751	4815333	Unknown	Adult	Sitting
		Anaxyrus americanus	American Toad	1	Alive	North	562338	4815234	Unknown	Adult	Sitting
		Lithobates clamitans melanota	Northern Green Frog	1	Alive	North	562320	4815236	Unknown	Adult	Sitting
		Lithobates sylvaticus	Wood Frog	1	Alive	North	562402	4815258	Unknown	Adult	Sitting
		Anaxyrus americanus	American Toad	1	Alive	West	562432	4815260	Unknown	Adult	Sitting
April 29	Amphibian	*Lithobates catesbeianus*	American Bullfrog	1	Alive	North	562965	4815381	Unknown	Adult	Moving
		Lithobates clamitans melanota	Northern Green Frog	1	Alive	North	562808	4815339	Unknown	Adult	Moving
May 3	Amphibian	*Anaxyrus americanus*	American Toad	1	Alive	North	563090	4815418	Unknown	Adult	Moving
May 20	Amphibian	*Hyla versicolor*	Tetraploid Gray Treefrog	1	Dead	Unknown	563187	4815445	Unknown	Unknown	N/A
May 26	Amphibian	*Lithobates clamitans melanota*	Northern Green Frog	1	Alive	North	562481	4815275	Male	Adult	Sitting
		Lithobates clamitans melanota	Northern Green Frog	1	Dead	South	562372	4815248	Female	Adult	N/A
June 2	Amphibian	*Lithobates clamitans melanota*	Northern Green Frog	1	Alive	East	562722	4815313	Male	Adult	Sitting
		Anaxyrus americanus	American Toad	1	Alive	South	562644	4815310	Unknown	Juvenile	Sitting
June 3	Amphibian	*Anaxyrus americanus*	American Toad	1	Alive	West	562646	4815310	Unknown	Unknown	Moving
		Lithobates pipiens	Northern Leopard Frog	1	Dead	East	563055	4815413	Unknown	Adult	N/A
		Lithobates clamitans melanota	Northern Green Frog	1	Injured	East	563054	4815412	Female	Adult	N/A
June 8	Reptile	*Chelydra serpentina serpentina*	Snapping Turtle	1	Dead	North	562914	4815369	Female	Adult	N/A
	Amphibian	*Hyla versicolor*	Tetraploid Gray Treefrog	1	Dead	South	562420	4815252	Unknown	Adult	N/A
		Lithobates clamitans melanota	Northern Green Frog	1	Dead	Unknown	562610	4815287	Unknown	Adult	N/A
		Anaxyrus americanus	American Toad	1	Alive	North	562806	4815352	Male	Adult	Moving
		Anaxyrus americanus	American Toad	1	Alive	North	563044	4815408	Unknown	Juvenile	Moving
		Anaxyrus americanus	American Toad	1	Dead	Unknown	563085	4815416	Unknown	Adult	N/A
		Hyla versicolor	Tetraploid Gray Treefrog	1	Dead	Unknown	563278	4815462	Unknown	Adult	N/A
June 18	Amphibian	*Anaxyrus americanus*	American Toad	1	Alive	Unknown	562328	4815224	Unknown	Adult	Moving
		Lithobates sylvaticus	Wood Frog	1	Dead	South	562469	4815269	Unknown	Adult	N/A
	Bird	*Poecile atricapillus*	Black-capped Chickadee	1	Dead	Unknown	562737	4815330	Unknown	Adult	N/A
		Setophaga ruticilla	American Redstart	1	Dead	Unknown	563010	4815396	Unknown	Adult	N/A
	Reptile	*Chrysemys picta marginata*	Midland Painted Turtle	1	Dead	Unknown	563029	4815404	Unknown	Adult	N/A

Appendix II

Wildlife Camera Monitoring Observation Data from 2021

Appendix II: Wildlife Camera Monitoring Observation Data from 2021

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
1	N	1	11-Jun	0:09:30	Mammal	*Mephitis mephitis*	Striped Skunk	1	Adult	Moving
1	N	1	22-May	0:58:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
1	N	1	23-May	1:01:30	Mammal		Rodent sp.	1	Adult	Moving
1	N	1	20-Apr	1:23:00	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	9-Jun	1:59:00	Mammal		Mammal sp.	1	Adult	Moving
1	N	1	12-Jun	2:09:30	Mammal	*Mephitis mephitis*	Striped Skunk	1	Adult	Moving
1	N	1	10-Jun	3:01:30	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
1	N	1	25-May	3:11:30	Mammal		Rodent sp.	1	Adult	Moving
1	N	1	27-Apr	3:40:00	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	29-May	4:07:30	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
1	N	1	11-Apr	4:10:00	Amphibian		Anuran sp.	1	Unknown	Moving
1	N	1	11-Apr	4:17:30			Unknown	1	Unknown	Moving
1	N	1	30-May	4:27:30	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
1	N	1	20-Apr	5:02:30	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	11-Apr	5:23:30	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	30-Apr	5:29:30	Mammal		Mammal sp.	1	Unknown	Moving
1	N	1	11-Apr	5:36:30	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	9-Apr	5:44:30	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
1	N	1	22-May	6:31:30	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
1	N	1	28-May	6:40:30	Mammal		Mammal sp.	1	Adult	Moving
1	N	1	22-Apr	6:58:30			Unknown	1	Unknown	Moving
1	N	1	11-Jun	7:02:00	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	26-Apr	7:24:30	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	19-Apr	7:39:30	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	8-Jun	8:06:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	11-Apr	9:02:00	Mammal		Rodent sp.	1	Adult	Moving
1	N	1	10-Apr	9:14:00			Unknown	1	Unknown	Unknown
1	N	1	20-Apr	9:34:00	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	11-Jun	9:34:00			Anuran sp.	1	Unknown	Moving
1	N	1	29-May	9:47:30	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	10-Apr	9:53:30			Anuran sp.	1	Unknown	Moving
1	N	1	4-Jun	9:57:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	4-Jun	10:05:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	27-May	10:22:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	6-Jun	10:42:30	Bird	*Turdus migratorius*	American Robin	1	Adult	Foraging
1	N	1	19-Apr	11:01:30	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	2-Jun	11:01:30			Unknown	1	Unknown	Moving
1	N	1	2-Jun	11:04:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	25-May	11:26:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	13-May	11:31:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	24-May	11:35:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	9-Apr	11:57:30	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
1	N	1	5-Jun	12:04:00			Unknown	1	Unknown	Moving
1	N	1	2-Jun	13:06:30	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	12-Jun	14:06:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
1	N	1	14-May	14:24:00	Mammal		Mammal sp.	1	Adult	Moving
1	N	1	1-May	14:29:00	Bird		Bird sp.	1	Adult	Moving
1	N	1	29-Apr	14:34:00	Mammal		Mammal sp.	1	Unknown	Moving
1	N	1	18-Apr	14:34:30	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	31-May	14:57:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	2-Jun	14:58:00			Unknown	1	Unknown	Moving
1	N	1	26-Apr	15:21:30	Reptile		Snake sp.	1	Adult	Moving
1	N	1	2-Jun	15:57:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	25-May	16:35:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	25-May	16:44:30	Mammal		Mammal sp.	1	Adult	Unknown
1	N	1	21-May	17:33:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	2-Jun	17:59:30	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	12-Apr	18:00:30			Unknown	1	Unknown	Moving
1	N	1	12-Jun	18:27:00	Reptile	*Thamnophis sirtalis sirtalis*	Eastern Gartersnake	1	Juvenile	Moving
1	N	1	14-Apr	18:39:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
1	N	1	2-Jun	18:40:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	N	1	18-Apr	19:01:00			Unknown	1	Unknown	Moving
1	N	1	2-Jun	19:49:30			Unknown	1	Unknown	Unknown
1	N	1	28-Apr	19:59:00	Mammal	*Sciurus carolinensis*	Gray Squirrel	2	Adult	Mating
1	N	1	12-Jun	20:17:00	Mammal		Rodent sp.	1	Unknown	Moving
1	N	1	6-Jun	20:58:30	Reptile	*Thamnophis sirtalis sirtalis*	Eastern Gartersnake	1	Adult	Moving
1	N	1	23-Apr	21:49:00	Mammal		Rodent sp.	1	Adult	Moving
1	N	1	29-Apr	22:31:00	Mammal		Mammal sp.	1	Unknown	Moving
1	N	1	2-Jun	22:44:00	Mammal		Rodent sp.	1	Adult	Moving
1	N	1	18-Apr	22:49:30	Mammal		Mammal sp.	1	Adult	Moving
1	N	1	6-Apr	23:44:30	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Unknown
1	S	2	28-Apr	2:41:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
1	S	2	12-Jun	3:22:00	Mammal	*Mephitis mephitis*	Striped Skunk	1	Adult	Moving
1	S	2	30-Apr	6:20:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
1	S	2	11-Jun	7:01:00	Mammal		Rodent sp.	1	Unknown	Moving
1	S	2	23-Jun	7:29:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
1	S	2	22-May	7:48:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	28-May	8:02:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	7-Apr	8:36:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	27-Jun	8:44:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	29-May	9:09:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	20-Jun	10:09:00	Bird		Bird sp.	1	Adult	Moving
1	S	2	2-Jun	11:04:00	Mammal		Rodent sp.	1	Unknown	Moving
1	S	2	10-Jun	11:19:00	Mammal		Rodent sp.	1	Adult	Moving
1	S	2	23-May	11:20:00	Mammal	*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
1	S	2	5-Jun	11:52:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	20-Jun	12:44:00	Bird		Bird sp.	1	Adult	Moving
1	S	2	21-Jun	13:12:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	18-Jun	15:45:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Moving
1	S	2	1-Jun	16:56:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	22-May	18:24:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	21-Jun	18:53:00	Mammal	*Thamnophis sirtalis sirtalis*	Eastern Gartersnake	1	Adult	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
1	S	2	25-May	19:21:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	3-Jun	19:28:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
1	S	2	12-May	19:48:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
1	S	2	28-Apr	19:54:00	Mammal	*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
1	S	2	26-Apr	20:23:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
1	S	2	28-May	22:10:00			Unknown	1	Unknown	Moving
1	S	2	7-May	22:48:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	2-May	0:08:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	3-Jun	0:14:00	Amphibian	*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
2	N	3	17-Jun	0:14:00	Mammal		Rodent sp.	1	Unknown	Moving
2	N	3	15-Apr	0:27:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	29-Apr	0:48:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	9-Apr	0:57:00	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	N	3	19-Jun	1:07:00	Mammal		Rodent sp.	1	Adult	Moving
2	N	3	21-Apr	1:28:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	16-Apr	1:36:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
2	N	3	19-Apr	1:41:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	19-Apr	2:02:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	2-May	2:51:00	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	N	3	16-Apr	3:45:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	11-Apr	4:21:00	Mammal		Rodent sp.	1	Unknown	Moving
2	N	3	31-May	4:59:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	21-Apr	5:06:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	9-Apr	5:22:00	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	N	3	11-Apr	5:37:00	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	N	3	16-May	5:49:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	8-May	5:55:00	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	N	3	26-May	5:59:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	3-Jun	6:06:00	Mammal	*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	N	3	14-Apr	6:37:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	9-Jun	6:50:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	N	3	26-Jun	6:51:00	Amphibian	*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
2	N	3	19-Jun	6:59:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Moving
2	N	3	17-May	7:01:00	Mammal		Mammal sp.	1	Adult	Moving
2	N	3	10-Jun	7:37:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	N	3	14-Apr	7:50:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	N	3	14-Apr	7:58:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	19-May	8:04:00	Mammal		Mammal sp.	1	Adult	Moving
2	N	3	26-Jun	8:18:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	21-Apr	9:36:00	Mammal		Mammal sp.	1	Unknown	Moving
2	N	3	26-May	9:41:00	Mammal		Rodent sp.	1	Adult	Moving
2	N	3	14-May	9:45:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	N	3	19-May	10:51:00	Mammal	*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	N	3	30-May	11:03:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	N	3	17-May	12:28:00	Mammal	*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	N	3	10-Jun	13:29:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	N	3	11-Apr	13:44:00	Amphibian		Anuran sp.	1	Adult	Sitting

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
2	N	3	6-May	14:43:00	Mammal	*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	N	3	3-May	14:59:00	Mammal	*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	N	3	27-Apr	15:06:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
2	N	3	12-Jun	16:00:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	28-May	16:04:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
2	N	3	24-May	16:15:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	4-Jun	16:29:00	Mammal	*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	N	3	30-May	17:08:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Moving
2	N	3	30-May	17:09:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Moving
2	N	3	21-Apr	17:39:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	21-Jun	17:40:00	Mammal		Mammal sp.	1	Adult	Moving
2	N	3	6-Jun	17:49:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	14-Apr	18:18:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
2	N	3	23-May	18:25:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	10-Jun	18:28:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	20-Apr	19:14:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	7-May	19:27:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	2-Jun	19:40:00	Mammal	*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	N	3	23-Jun	19:43:00	Mammal		Mammal sp.	1	Adult	Moving
2	N	3	19-Apr	20:01:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	18-May	20:12:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	18-Apr	20:14:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	12-May	20:40:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
2	N	3	24-May	21:02:00	Mammal	*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	N	3	19-Apr	21:03:00	Mammal	*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	24-Jun	21:33:00		*Lithobates clamitans melanota*	Green Frog	1	Adult	Moving
2	N	3	20-Apr	21:35:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
2	N	3	3-Jun	21:35:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
2	N	3	26-Jun	21:56:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	24-May	22:13:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	11-May	22:15:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	N	3	5-May	22:20:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	7-Apr	22:33:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	N	3	21-May	22:33:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	10-Apr	22:35:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	15-Apr	23:18:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
2	N	3	3-May	23:32:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	N	3	19-Apr	23:36:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	15-Apr	23:38:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	12-Jun	23:44:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	N	3	2-Jun	23:46:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
2	S	4	10-Apr	22:36:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	13-Apr	7:53:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	14-Apr	6:24:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	15-Apr	0:32:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	15-Apr	23:23:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	16-Apr	16:34:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
2	S	4	16-Apr	19:19:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	16-Apr	19:35:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	18-Apr	4:56:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	18-Apr	20:02:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	21-Apr	9:37:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	23-Apr	23:33:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	27-Apr	13:12:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	27-Apr	15:13:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	28-Apr	1:44:00			Mammal sp.	1	Adult	Moving
2	S	4	29-Apr	23:05:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	2-May	3:28:00			Mammal sp.	1	Unknown	Moving
2	S	4	5-May	22:18:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Moving
2	S	4	6-May	5:37:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	6-May	18:06:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	8-May	12:07:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	S	4	10-May	5:46:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	11-May	2:03:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	11-May	6:11:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	12-May	15:20:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	15-May	18:04:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	17-May	5:13:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	17-May	12:29:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	18-May	12:33:00			Mammal sp.	1	Adult	Moving
2	S	4	18-May	20:49:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	19-May	8:57:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	20-May	18:28:00			Rodent sp.	1	Adult	Sitting
2	S	4	21-May	8:02:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	21-May	22:37:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	23-May	22:30:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
2	S	4	26-May	18:43:00			Rodent sp.	1	Unknown	Moving
2	S	4	26-May	19:19:00			Anuran sp.	1	Juvenile	Moving
2	S	4	27-May	6:23:00			Mammal sp.	1	Adult	Sitting
2	S	4	27-May	9:00:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	S	4	30-May	9:22:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	S	4	31-May	22:46:00			Rodent sp.	1	Adult	Moving
2	S	4	2-Jun	8:53:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	2-Jun	10:22:00			Snake sp.	1	Adult	Moving
2	S	4	2-Jun	21:03:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
2	S	4	2-Jun	23:39:00			Anuran sp.	1	Unknown	Moving
2	S	4	3-Jun	0:09:00			Anuran sp.	1	Unknown	Moving
2	S	4	3-Jun	21:42:00			Anuran sp.	1	Unknown	Moving
2	S	4	4-Jun	4:23:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	6-Jun	6:48:00			Mammal sp.	1	Adult	Moving
2	S	4	6-Jun	17:48:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	7-Jun	12:04:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	7-Jun	21:21:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Unknown	Moving
2	S	4	8-Jun	7:37:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
2	S	4	9-Jun	20:49:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Moving
2	S	4	10-Jun	20:10:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	11-Jun	10:11:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	11-Jun	14:59:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	S	4	11-Jun	15:24:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	S	4	14-Jun	19:44:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
2	S	4	15-Jun	12:29:00			Rodent sp.	1	Adult	Moving
2	S	4	15-Jun	14:39:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	21-Jun	5:12:00			Rodent sp.	1	Unknown	Moving
2	S	4	21-Jun	8:49:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
2	S	4	23-Jun	15:13:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
2	S	4	25-Jun	4:59:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
2	S	4	25-Jun	5:12:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
2	S	4	25-Jun	6:20:00			Anuran sp.	1	Adult	Moving
2	S	4	25-Jun	6:25:00			Anuran sp.	1	Juvenile	Moving
2	S	4	25-Jun	6:26:00			Anuran sp.	1	Juvenile	Moving
2	S	4	25-Jun	19:42:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
2	S	4	26-Jun	5:43:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
2	S	4	26-Jun	8:12:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
3	N	5	9-Apr	9:42:00			Anuran sp.	1	Unknown	Moving
3	N	5	9-Apr	10:51:00		*Lithobates sp.*	Lithobates sp.	1	Adult	Moving
3	N	5	10-Apr	3:01:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	13-Apr	6:13:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	14-Apr	5:37:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	26-Apr	0:36:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	13-May	19:39:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	15-May	9:42:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Moving
3	N	5	17-May	8:03:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Sitting
3	N	5	18-May	7:14:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	26-May	0:59:00			Anuran sp.	1	Unknown	Moving
3	N	5	26-May	15:11:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
3	N	5	2-Jun	21:21:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
3	N	5	2-Jun	22:53:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
3	N	5	2-Jun	23:01:00		*Lithobates sp.*	Lithobates sp.	1	Adult	Moving
3	N	5	3-Jun	1:27:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
3	N	5	3-Jun	5:34:00			Anuran sp.	1	Unknown	Moving
3	N	5	3-Jun	17:17:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	4-Jun	16:18:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
3	N	5	10-Jun	23:55:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
3	N	5	11-Jun	19:34:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Moving
3	N	5	15-Jun	6:13:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	15-Jun	23:14:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	16-Jun	7:41:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	N	5	18-Jun	7:18:00			Mammal sp.	1	Adult	Moving
3	S	6	9-Apr	10:58:00		*Lithobates sp.*	Lithobates sp.	1	Adult	Moving
3	S	6	14-Apr	7:22:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
3	S	6	14-Apr	21:24:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
3	S	6	18-Apr	0:11:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	19-Apr	0:35:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	20-Apr	10:18:00			Mammal sp.	1	Unknown	Moving
3	S	6	26-Apr	2:04:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
3	S	6	1-May	18:33:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
3	S	6	4-May	0:49:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	10-May	23:18:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
3	S	6	12-May	13:23:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
3	S	6	13-May	23:44:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	14-May	21:18:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Juvenile	Moving
3	S	6	17-May	8:05:00		*Tamias striatus*	Eastern Chipmunk	1	Juvenile	Moving
3	S	6	20-May	6:12:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	22-May	2:04:00			Mammal sp.	1	Adult	Moving
3	S	6	22-May	11:49:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
3	S	6	25-May	13:38:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
3	S	6	26-May	0:56:00			Anuran sp.	1	Unknown	Moving
3	S	6	26-May	16:01:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
3	S	6	30-May	22:59:00			Rodent sp.	1	Unknown	Moving
3	S	6	2-Jun	6:46:00			Rodent sp.	1	Adult	Moving
3	S	6	3-Jun	0:55:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
3	S	6	3-Jun	1:32:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
3	S	6	3-Jun	21:22:00			Anuran sp.	1	Adult	Moving
3	S	6	3-Jun	21:23:00			Anuran sp.	1	Adult	Sitting
3	S	6	3-Jun	21:24:00			Anuran sp.	1	Adult	Moving
3	S	6	5-Jun	22:38:00		*Thamnophis sirtalis sirtalis*	Eastern Gartersnake	1	Adult	Moving
3	S	6	10-Jun	20:42:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	10-Jun	22:32:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	11-Jun	19:02:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	11-Jun	19:35:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	12-Jun	8:24:00		*Thamnophis sirtalis sirtalis*	Eastern Gartersnake	1	Juvenile	Moving
3	S	6	12-Jun	20:03:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	15-Jun	7:46:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
3	S	6	20-Jun	12:07:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
3	S	6	21-Jun	19:52:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
3	S	6	24-Jun	12:26:00			Snake sp.	1	Juvenile	Moving
3	S	6	24-Jun	14:28:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	N	7	23-Apr	21:40:30		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
4	N	7	28-Apr	22:40:30		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	28-Apr	23:18:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	29-Apr	0:40:30		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	29-Apr	2:57:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
4	N	7	29-Apr	9:24:30		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	29-Apr	17:25:30		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	4-May	6:08:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
4	N	7	9-May	16:57:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	10-May	18:04:30		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	19-May	19:05:30		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
4	N	7	20-May	1:14:00			Rodent sp.	1	Adult	Moving
4	N	7	20-May	10:03:30		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	N	7	21-May	18:13:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	21-May	21:49:30		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	22-May	20:00:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	23-May	6:13:30		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	N	7	23-May	12:11:00		*Chelydra serpentina serpentina*	Snapping Turtle	1	Juvenile	Moving
4	N	7	23-May	16:29:30			Anuran sp.	1	Unknown	Moving
4	N	7	23-May	19:27:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	25-May	0:11:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging
4	N	7	25-May	19:34:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	N	7	25-May	21:49:30		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging
4	N	7	26-May	0:03:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	26-May	5:24:30		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
4	N	7	26-May	22:07:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging
4	N	7	26-May	22:07:30		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging
4	N	7	26-May	22:08:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging
4	N	7	26-May	22:08:30		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging
4	N	7	26-May	22:09:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	2-Jun	5:00:30		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging
4	N	7	2-Jun	21:45:30			Rodent sp.	1	Adult	Moving
4	N	7	3-Jun	21:37:00		*Lithobates sp.*	Lithobates sp.	1	Adult	Moving
4	N	7	4-Jun	2:57:30		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging
4	N	7	7-Jun	5:16:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	7-Jun	6:22:30		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	7-Jun	23:11:30		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
4	N	7	8-Jun	5:18:30		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	15-Jun	7:21:30		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
4	N	7	15-Jun	19:27:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	16-Jun	7:20:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	19-Jun	0:59:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
4	N	7	19-Jun	1:23:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	20-Jun	4:18:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	N	7	21-Jun	1:54:30			Rodent sp.	1	Adult	Moving
4	N	7	21-Jun	2:03:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	21-Jun	5:34:30		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	21-Jun	5:35:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	23-Jun	17:17:30		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	N	7	8-Apr	21:05:30		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	8-Apr	22:59:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	9-Apr	21:02:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	N	7	10-Apr	0:07:00			Anuran sp.	1	Juvenile	Moving
4	N	7	10-Apr	3:55:00			Anuran sp.	1	Unknown	Moving
4	S	8	7-Apr	22:41:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	S	8	8-Apr	21:02:00			Anuran sp.	1	Adult	Moving
4	S	8	9-Apr	20:58:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	9-Apr	21:21:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
4	S	8	10-Apr	2:18:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	10-Apr	3:59:00			Anuran sp.	1	Unknown	Moving
4	S	8	10-Apr	20:22:00			Snake sp.	1	Adult	Moving
4	S	8	10-Apr	20:50:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	11-Apr	1:45:00			Snake sp.	1	Adult	Moving
4	S	8	26-Apr	23:34:00			Unknown	1	Unknown	Moving
4	S	8	28-Apr	20:55:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	28-Apr	22:38:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	28-Apr	23:14:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	29-Apr	0:36:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	29-Apr	20:11:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	29-Apr	20:32:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	S	8	5-May	2:10:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
4	S	8	5-May	21:22:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
4	S	8	9-May	1:46:00			Mammal sp.	1	Adult	Moving
4	S	8	13-May	8:16:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	S	8	13-May	23:50:00			Rodent sp.	1	Adult	Moving
4	S	8	16-May	7:15:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	S	8	18-May	4:31:00			Rodent sp.	1	Unknown	Moving
4	S	8	21-May	2:01:00			Rodent sp.	1	Unknown	Moving
4	S	8	21-May	4:35:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
4	S	8	21-May	19:08:00			Rodent sp.	1	Adult	Moving
4	S	8	21-May	21:50:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	23-May	5:16:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	23-May	6:23:00			Anuran sp.	1	Unknown	Moving
4	S	8	23-May	7:36:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	23-May	12:07:00		*Chelydra serpentina serpentina*	Snapping Turtle	1	Juvenile	Moving
4	S	8	23-May	16:07:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	23-May	16:08:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	23-May	16:13:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	23-May	16:37:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	23-May	19:21:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	S	8	25-May	0:02:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	S	8	25-May	9:52:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	S	8	25-May	13:30:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	25-May	20:04:00			Mammal sp.	1	Unknown	Moving
4	S	8	29-May	3:50:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	S	8	29-May	4:50:00			Rodent sp.	1	Unknown	Moving
4	S	8	29-May	11:21:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
4	S	8	29-May	14:44:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	S	8	29-May	17:33:00			Rodent sp.	1	Unknown	Moving
4	S	8	29-May	18:09:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Unknown
4	S	8	31-May	22:40:00			Rodent sp.	1	Adult	Moving
4	S	8	1-Jun	2:24:00			Rodent sp.	1	Unknown	Moving
4	S	8	3-Jun	3:11:00			Rodent sp.	1	Adult	Moving
4	S	8	4-Jun	23:58:00			Rodent sp.	1	Unknown	Moving
4	S	8	6-Jun	5:08:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
4	S	8	6-Jun	5:50:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	6-Jun	17:47:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	7-Jun	5:07:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	7-Jun	19:20:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	7-Jun	20:42:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	14-Jun	18:28:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	S	8	15-Jun	1:30:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	S	8	15-Jun	2:06:00			Rodent sp.	1	Adult	Moving
4	S	8	16-Jun	6:46:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	S	8	18-Jun	11:15:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	S	8	18-Jun	12:17:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
4	S	8	19-Jun	11:49:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
4	S	8	19-Jun	21:25:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	S	8	19-Jun	23:57:00			Rodent sp.	1	Adult	Moving
4	S	8	20-Jun	4:05:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
4	S	8	21-Jun	5:28:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
4	S	8	22-Jun	8:43:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	N	9	8-Apr	1:11:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	9-Apr	4:13:00		*Lithobates sp.*	Lithobates sp.	1	Adult	Moving
5	N	9	10-Apr	9:18:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	11-Apr	6:29:00			Anuran sp.	1	Adult	Moving
5	N	9	12-Apr	0:30:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
5	N	9	12-Apr	5:56:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	N	9	20-Apr	5:47:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	21-Apr	6:16:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	21-Apr	20:54:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	22-Apr	0:19:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	22-Apr	4:00:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	23-Apr	17:40:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	24-Apr	19:47:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	25-Apr	3:27:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	26-Apr	0:11:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	27-Apr	7:49:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	27-Apr	22:20:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
5	N	9	29-Apr	20:37:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	18-May	1:52:00			Mammal sp.	1	Unknown	Moving
5	N	9	20-May	10:20:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	N	9	22-May	15:38:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	N	9	22-May	17:23:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	N	9	23-May	11:52:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	N	9	24-May	8:19:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
5	N	9	25-May	11:11:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	N	9	26-May	7:15:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	N	9	26-May	15:15:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	N	9	28-May	16:37:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	N	9	28-May	19:30:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	30-May	18:15:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
5	N	9	31-May	6:11:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Unknown
5	N	9	31-May	20:57:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
5	N	9	2-Jun	21:46:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	N	9	3-Jun	0:24:00			Anuran sp.	1	Adult	Moving
5	N	9	3-Jun	0:39:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	N	9	3-Jun	2:40:00		*Lithobates sp.*	Lithobates sp.	1	Juvenile	Moving
5	N	9	3-Jun	22:51:00			Rodent sp.	1	Adult	Moving
5	N	9	3-Jun	23:06:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
5	N	9	4-Jun	20:39:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	5-Jun	19:48:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	N	9	6-Jun	19:46:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	7-Jun	16:28:00			Mammal sp.	1	Unknown	Moving
5	N	9	8-Jun	18:00:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	8-Jun	22:26:00			Anuran sp.	1	Unknown	Moving
5	N	9	13-Jun	18:43:00			Rodent sp.	1	Unknown	Moving
5	N	9	13-Jun	23:27:00			Rodent sp.	1	Adult	Moving
5	N	9	15-Jun	15:06:00			Rodent sp.	1	Adult	Moving
5	N	9	18-Jun	9:54:00			Mammal sp.	1	Adult	Moving
5	N	9	19-Jun	21:18:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	N	9	20-Jun	0:02:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	9-Apr	1:20:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	9-Apr	1:35:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	9-Apr	2:45:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	9-Apr	9:09:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	9-Apr	21:04:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	9-Apr	21:10:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	11-Apr	2:23:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	11-Apr	4:49:00			Anuran sp.	1	Adult	Moving
5	S	10	11-Apr	21:32:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	11-Apr	21:34:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	15-Apr	23:54:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
5	S	10	16-Apr	4:05:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Foraging
5	S	10	23-Apr	17:40:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	24-Apr	6:52:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	25-Apr	6:12:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	25-Apr	8:21:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	25-Apr	9:01:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	26-Apr	2:46:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	27-Apr	0:04:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	27-Apr	7:48:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	27-Apr	20:22:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	27-Apr	21:02:00			Mammal sp.	1	Unknown	Moving
5	S	10	28-Apr	18:57:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Sitting
5	S	10	29-Apr	1:57:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
5	S	10	29-Apr	17:48:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	29-Apr	20:30:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	29-Apr	20:35:00			Anuran sp.	1	Unknown	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
5	S	10	29-Apr	23:00:00			Anuran sp.	1	Unknown	Moving
5	S	10	30-Apr	9:48:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Unknown	Moving
5	S	10	3-May	6:20:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	3-May	23:37:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	4-May	2:45:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	4-May	7:09:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	5-May	20:37:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	7-May	13:55:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	7-May	23:10:00			Mammal sp.	1	Unknown	Moving
5	S	10	8-May	1:24:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	8-May	7:55:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	9-May	21:56:00			Mammal sp.	1	Unknown	Moving
5	S	10	10-May	7:44:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	13-May	21:39:00			Unknown	1	Unknown	Moving
5	S	10	14-May	6:55:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	14-May	9:59:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	16-May	19:34:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	18-May	20:21:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	19-May	20:15:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	20-May	13:04:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	20-May	22:35:00			Anuran sp.	1	Adult	Moving
5	S	10	20-May	22:36:00			Anuran sp.	1	Adult	Sitting
5	S	10	20-May	22:37:00			Anuran sp.	1	Adult	Sitting
5	S	10	20-May	22:40:00			Mammal sp.	1	Adult	Moving
5	S	10	21-May	6:20:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	21-May	8:56:00			Mammal sp.	1	Unknown	Moving
5	S	10	21-May	10:51:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	21-May	21:13:00			Anuran sp.	1	Juvenile	Moving
5	S	10	22-May	5:22:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	22-May	23:37:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	23-May	3:51:00			Mammal sp.	1	Unknown	Moving
5	S	10	24-May	9:51:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	24-May	18:08:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	24-May	18:13:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	24-May	23:42:00			Mammal sp.	1	Adult	Moving
5	S	10	25-May	21:06:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	25-May	21:34:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
5	S	10	25-May	22:14:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
5	S	10	25-May	23:19:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
5	S	10	27-May	15:44:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	28-May	20:09:00		*Sciurus carolinensis*	Gray Squirrel	1	Adult	Moving
5	S	10	29-May	12:10:00			Mammal sp.	1	Adult	Moving
5	S	10	29-May	19:31:00			Mammal sp.	1	Adult	Moving
5	S	10	30-May	6:38:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	31-May	5:29:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	31-May	13:34:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	31-May	14:41:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving

Culvert	Culvert End	Camera	Date (2021)	Observation Time	Species Group	Scientific Name	Common Name	Individuals	Age	Behaviour
5	S	10	31-May	19:04:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	1-Jun	7:01:00			Mammal sp.	1	Adult	Moving
5	S	10	2-Jun	7:57:00			Mammal sp.	1	Adult	Moving
5	S	10	2-Jun	12:11:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	2-Jun	19:37:00		*Procyon lotor*	Northern Raccoon	1	Adult	Moving
5	S	10	2-Jun	21:20:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
5	S	10	3-Jun	1:14:00			Rodent sp.	1	Adult	Moving
5	S	10	3-Jun	1:59:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	3-Jun	23:20:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
5	S	10	4-Jun	15:49:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	4-Jun	20:38:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	4-Jun	20:49:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	6-Jun	19:47:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	8-Jun	0:25:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	8-Jun	2:41:00			Anuran sp.	1	Unknown	Moving
5	S	10	8-Jun	5:07:00		*Anaxyrus americanus*	American Toad	1	Adult	Moving
5	S	10	8-Jun	5:13:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
5	S	10	8-Jun	5:16:00		*Anaxyrus americanus*	American Toad	1	Juvenile	Moving
5	S	10	8-Jun	12:59:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	8-Jun	17:54:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	9-Jun	6:19:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	10-Jun	10:49:00			Mammal sp.	1	Adult	Moving
5	S	10	10-Jun	20:59:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	10-Jun	21:39:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	12-Jun	9:42:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	12-Jun	13:37:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	13-Jun	16:51:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	13-Jun	20:48:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	14-Jun	6:41:00		*Tamias striatus*	Eastern Chipmunk	1	Adult	Moving
5	S	10	14-Jun	20:52:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	16-Jun	12:38:00			Mammal sp.	1	Adult	Moving
5	S	10	17-Jun	5:19:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	20-Jun	6:58:00		*Sylvilagus floridanus*	Eastern Cottontail	1	Adult	Moving
5	S	10	20-Jun	22:04:00			Rodent sp.	1	Adult	Moving
5	S	10	21-Jun	22:18:00			Rodent sp.	1	Adult	Moving

Appendix III

Representative Wildlife Camera Monitoring Photographs from 2021

1. Wildlife Camera Photograph of an American Toad

2. Wildlife Camera Photograph of an Eastern Cottontail

3. Wildlife Camera Photograph of a Snapping Turtle

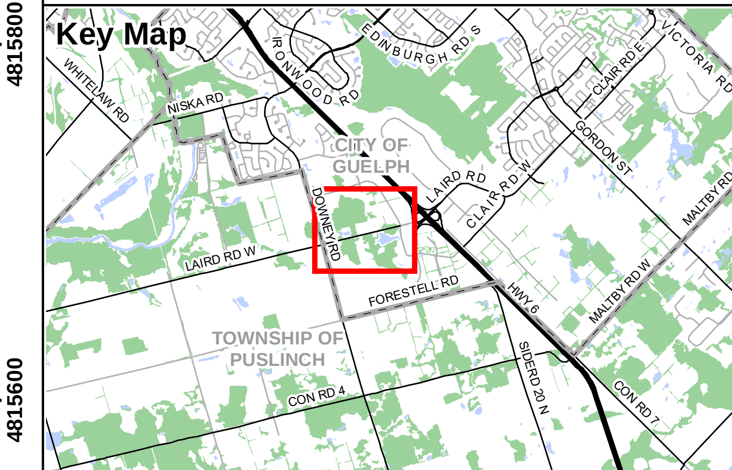
4. Wildlife Camera Photograph of a Northern Raccoon

Path: X:\1033_HCBP_TerrestrialWetlandMonitoring\NRSI_1033I_Map1_StudyArea_5K_2021_10_15_GCS.mxd

Map 1

Laird Road Wildlife Movement Survey

Study Area



Legend

- Watercourse
- Enclosed Watercourse
- Provincially Significant Wetland (PSW)
- Unevaluated Wetland
- Wooded Area
- Natural Heritage System (City of Guelph OPA 42)
- Amphibian Crossing (City of Guelph OPA 42)

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Project: 1033 Date: October 15, 2021	NAD83 - UTM Zone 17 Size: 11x17" **1:4,250**

0 50 100 150 200 250 Metres

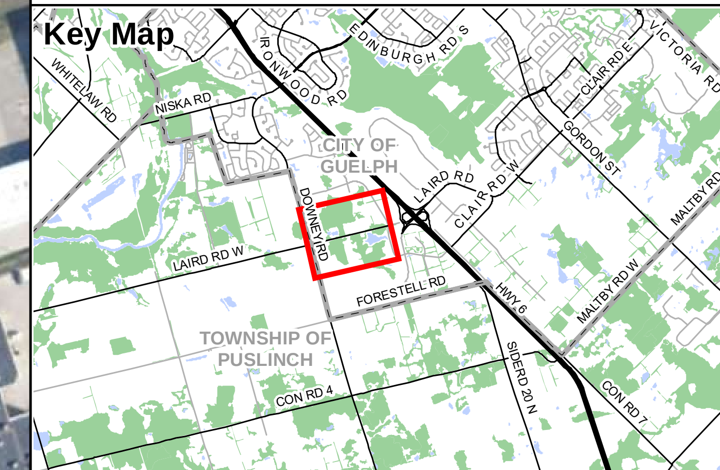
N

Map 2

Laird Road Wildlife Movement Survey

2021 Wildlife Culvert and Camera Monitoring Locations

Key Map



Legend

- Night-time Road Mortality Survey Area
- Culvert Camera
- Existing Culvert
- Interim Wildlife Culverts (August 2010)
- Directional Silt Fence
- Watercourse
- Enclosed Watercourse
- Provincially Significant Wetland (PSW)
- Unevaluated Wetland
- Wooded Area

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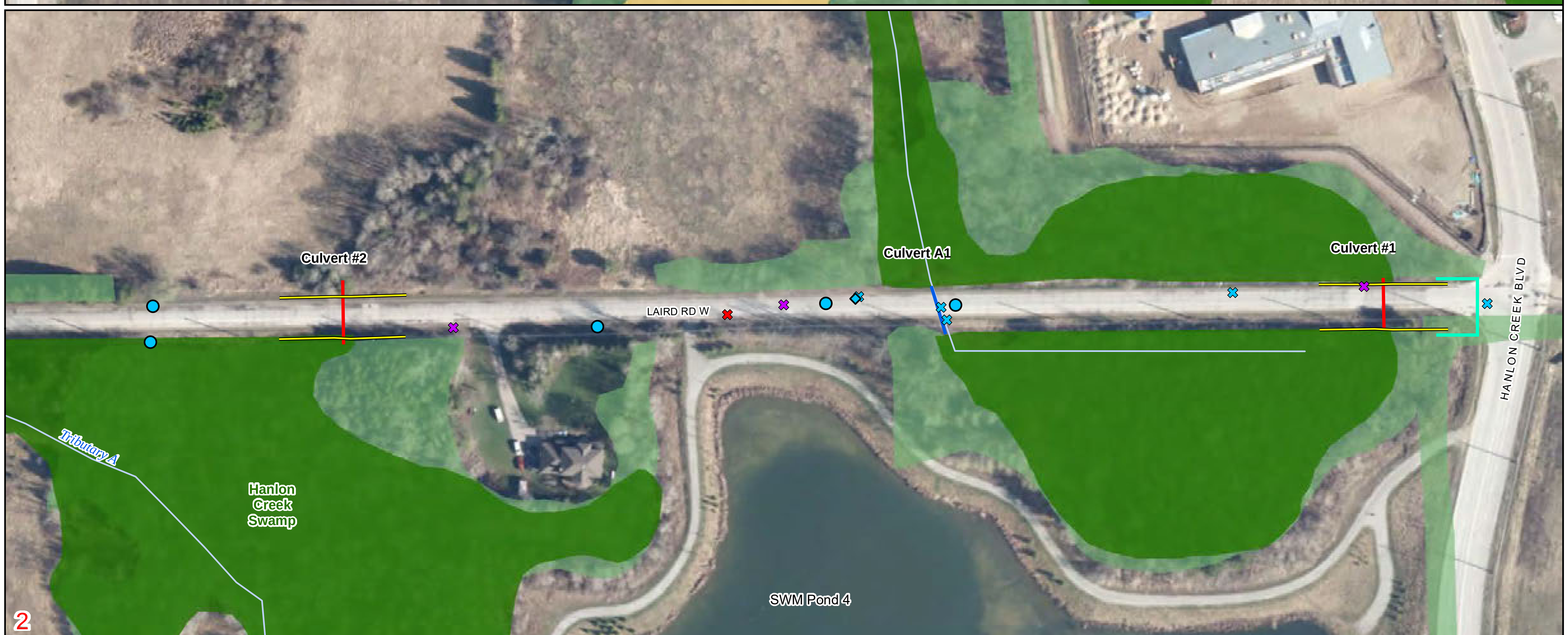
Aquatic, Terrestrial and Wetland Biologists

Project: 1033
Date: November 3, 2021

NAD83 - UTM Zone 17
Size: 11x17"
1:3,500

0 50 100 150 200 Metres

N

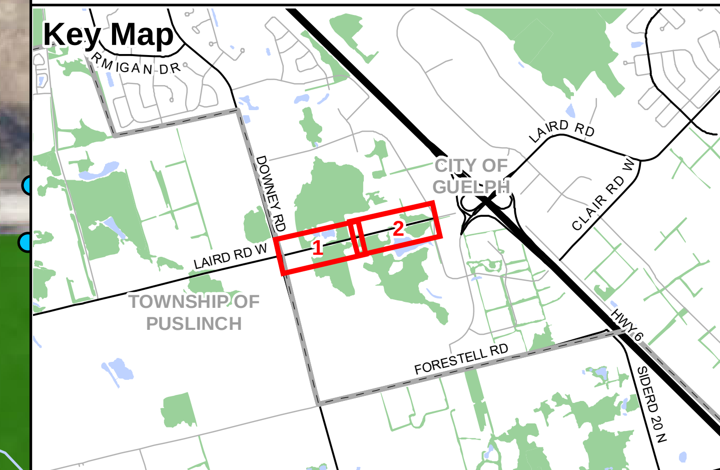


Map 3

Laird Road Wildlife Movement Survey

Distribution of Wildlife Observed Along Laird Road (2021)

Key Map



Legend

- Night-time Road Mortality Survey Area
- Existing Culvert
- Interim Wildlife Culverts (August 2010)
- Directional Silt Fence
- Watercourse
- Provincially Significant Wetland (PSW)
- Unevaluated Wetland
- Wooded Area
- Amphibian (Alive)
- Amphibian (Injured)
- Amphibian (Dead)
- Bird (Dead)
- Reptile (Dead)

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Project: 1033 Date: November 12, 2021	NAD83 - UTM Zone 17 Size: 11x17" 1:1,750

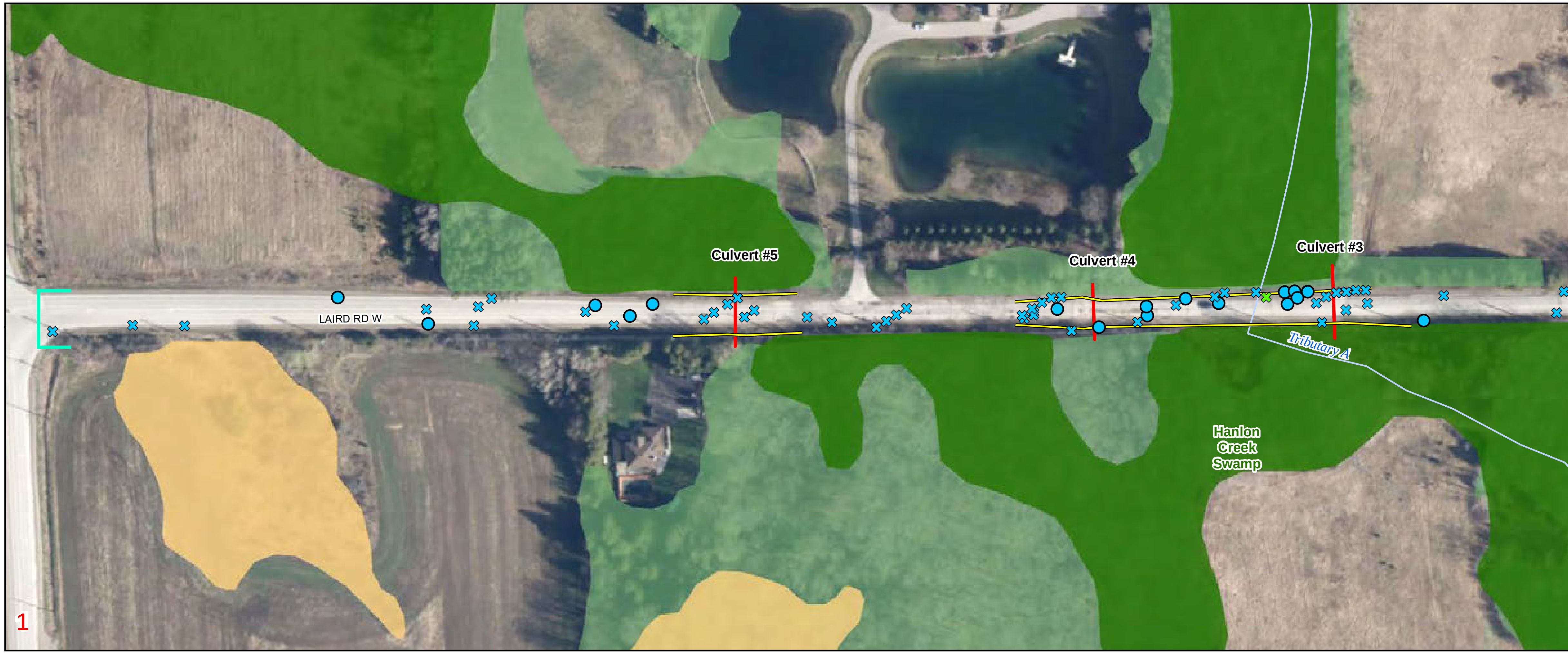
0 20 40 60 80 100 Metres

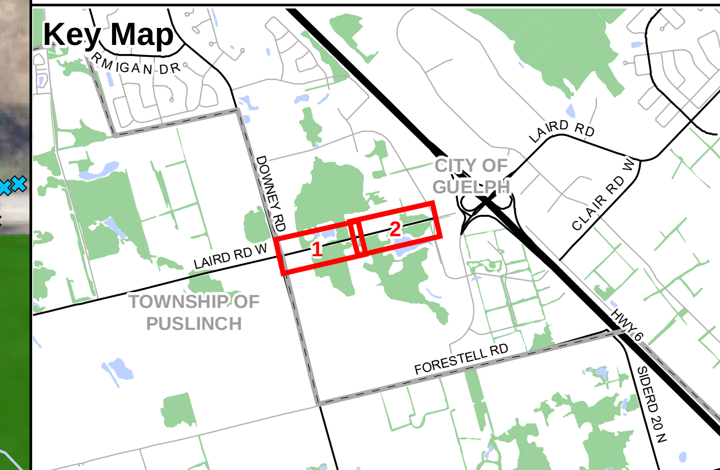
N

Map 4

Laird Road Wildlife Movement Survey

Road Mortality Observations (Pre-culvert Installation, 2009)





Legend

- Night-time Road Mortality Survey Area
- Existing Culvert
- Interim Wildlife Culverts (August 2010)
- Directional Silt Fence (~15m)
- Watercourse
- Provincially Significant Wetland (PSW)
- Unevaluated Wetland
- Wooded Area
- Mammal (Dead)
- Reptile (Dead)
- Amphibian (Alive)
- Amphibian (Dead)

Natural Resource Solutions Inc.
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Project: 1033
Date: November 12, 2021

NAD83 - UTM Zone 17
Size: 11x17"
1:1,750

0 20 40 60 80 100 Metres

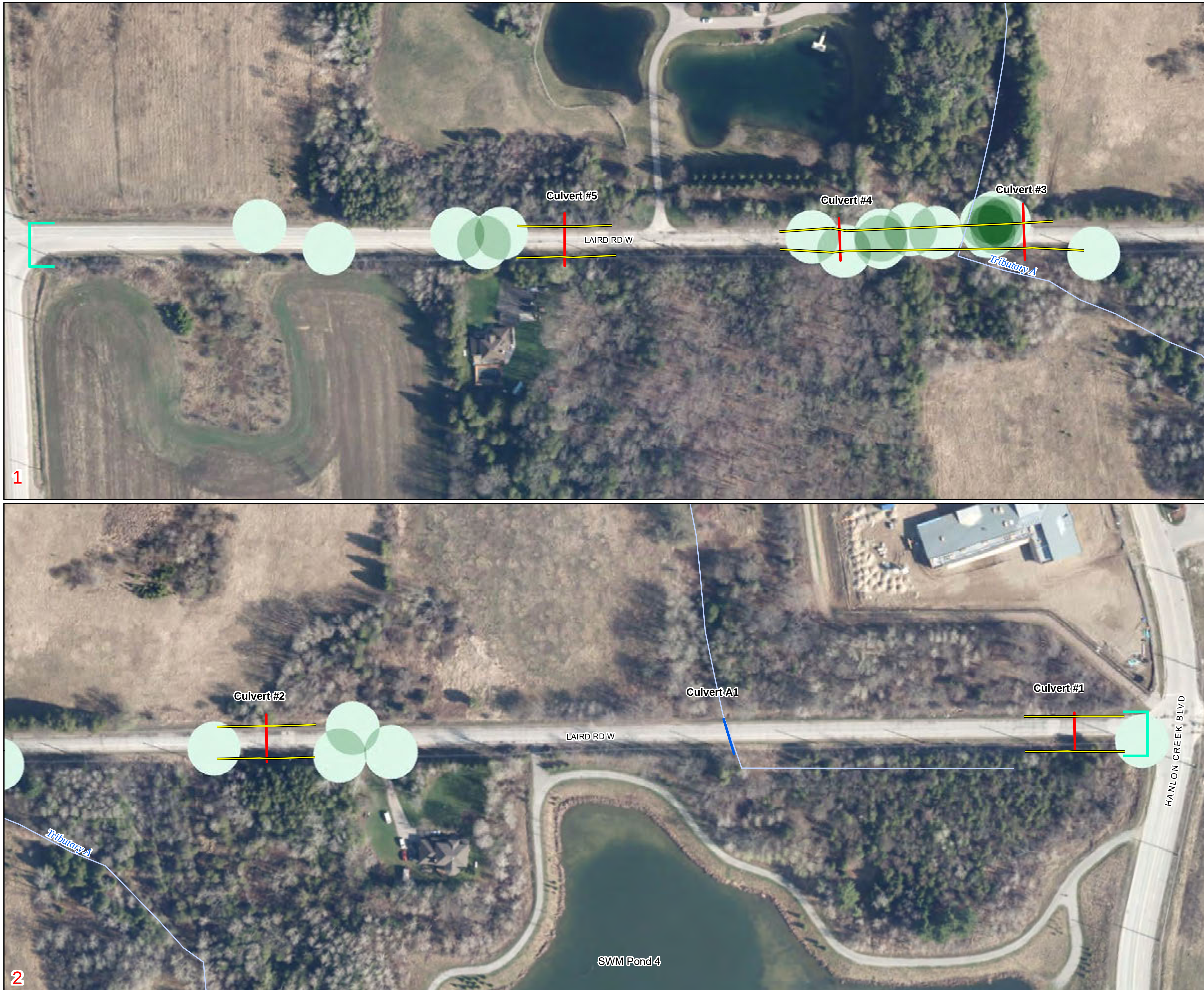
N

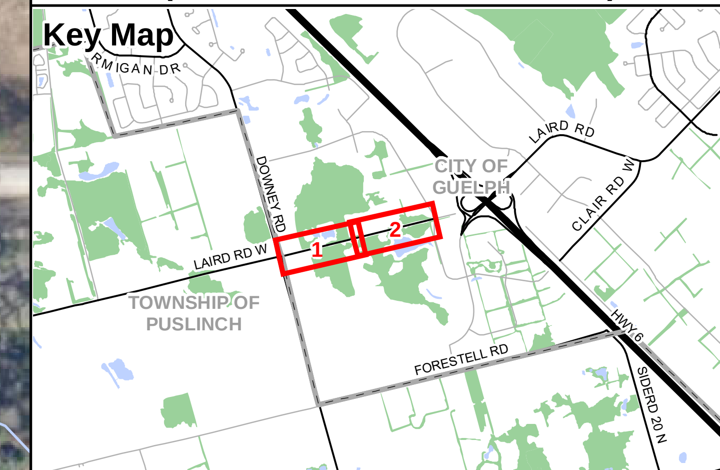
Path: X:\1033_HCBP_TerrestrialWetlandMonitoring\NRSI_1033I_Map4_2009MortalityObs_5K_2021_11_12_MV.mxd

Map 5a

Laird Road Wildlife Movement Survey

Live Amphibian Road Mortality Observations (Pre-culvert installation, 2009)





Legend

- Night-time Road Mortality Survey Area
- Existing Culvert
- Interim Wildlife Culverts (August 2010)
- Directional Silt Fence (~15m)
- Watercourse

Amphibian Observation Point Density

Alive

High

Low

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Project: 1033 Date: November 12, 2021	NAD83 - UTM Zone 17 Size: 11x17" **1:1,750**

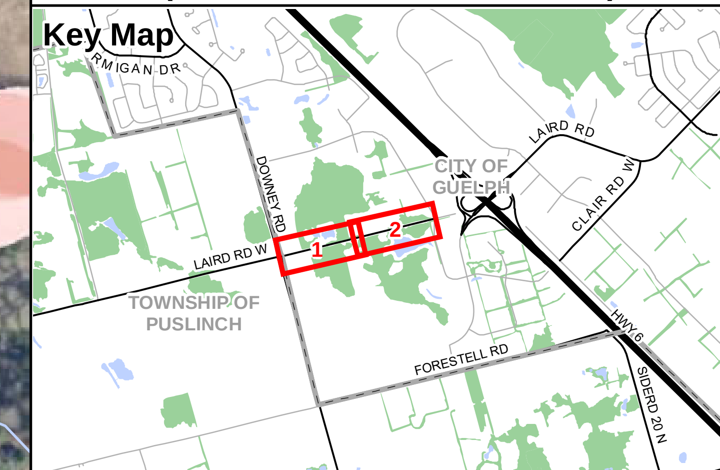
0 20 40 60 80 100 Metres

N

Map 5b

Laird Road Wildlife Movement Survey

Dead Amphibian Road Mortality Observations (Pre-culvert installation, 2009)



Legend

- Night-time Road Mortality Survey Area
- Existing Culvert
- Interim Wildlife Culverts (August 2010)
- Directional Silt Fence (~15m)
- Watercourse

Amphibian Observation Point Density

Dead

High

Low

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Project: 1033 Date: November 12, 2021	NAD83 - UTM Zone 17 Size: 11x17" **1:1,750**

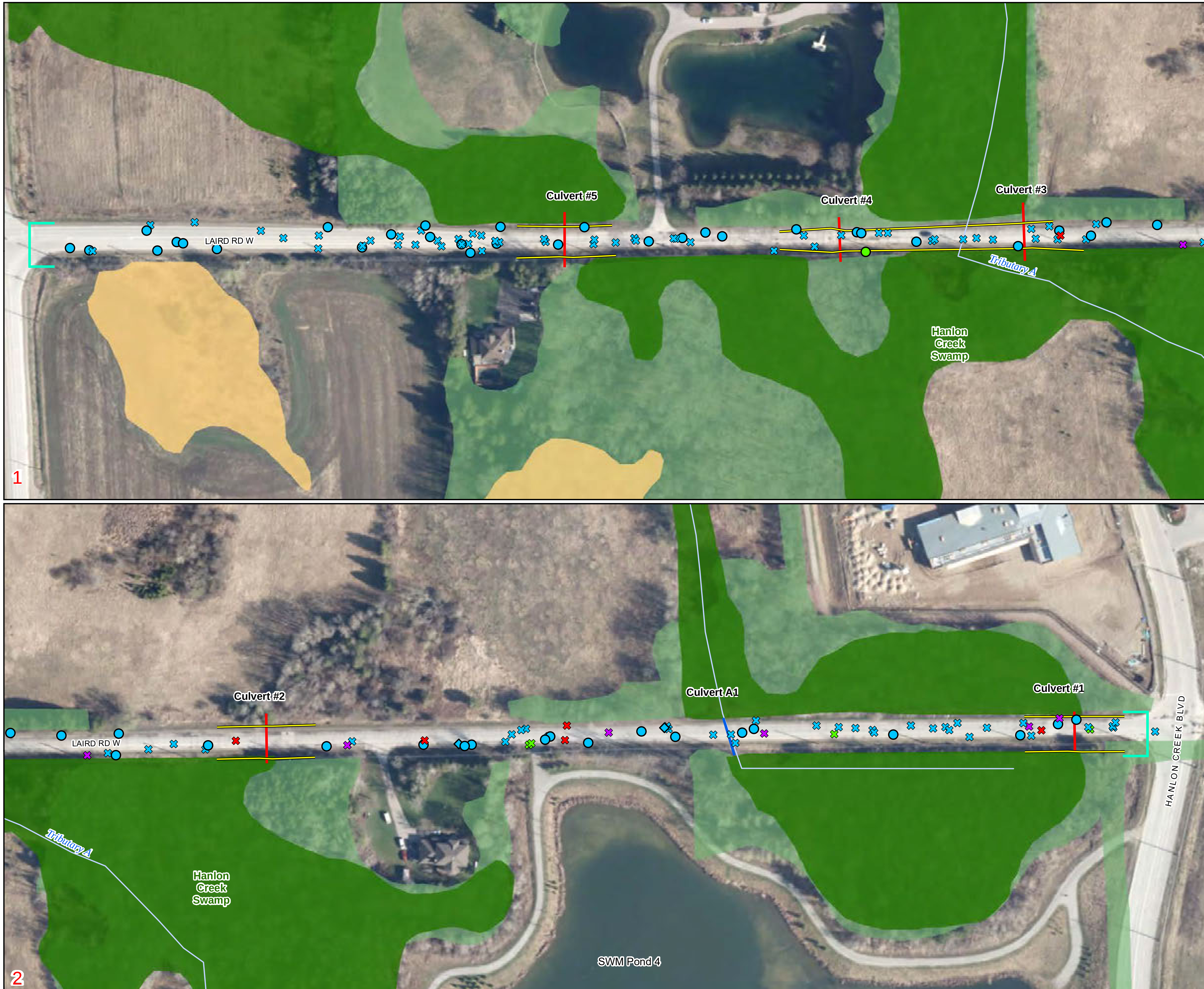
0 20 40 60 80 100 Metres

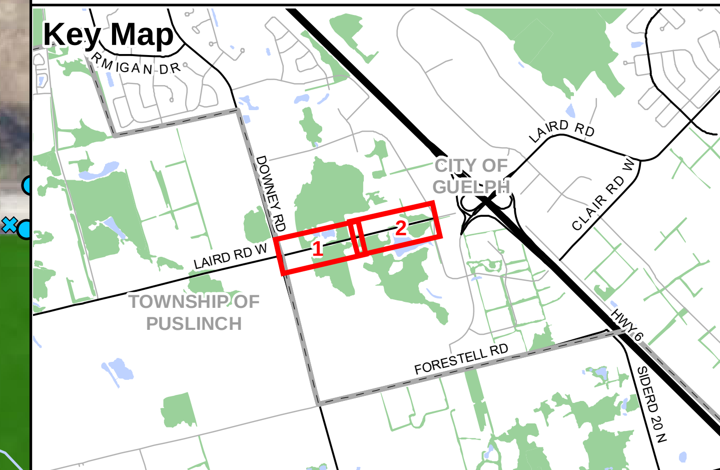
N

Map 6

Laird Road Wildlife Movement Survey

Road Mortality Observations (Post-culvert installation, 2011, 2013, 2018, 2021)





Legend

- Night-time Road Mortality Survey Area
- Existing Culvert
- Interim Wildlife Culverts (August 2010)
- Directional Silt Fence
- Watercourse
- Provincially Significant Wetland (PSW)
- Unevaluated Wetland
- Wooded Area
- Amphibian (Alive)
- Amphibian (Injured)
- Amphibian (Dead)
- Reptile (Dead)
- Mammal (Alive)
- Mammal (Dead)
- Bird (Dead)

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Aquatic, Terrestrial and Wetland Biologists

Project: 1033
Date: November 12, 2021

NAD83 - UTM Zone 17
Size: 11x17"
1:1,750

0 20 40 60 80 100 Metres

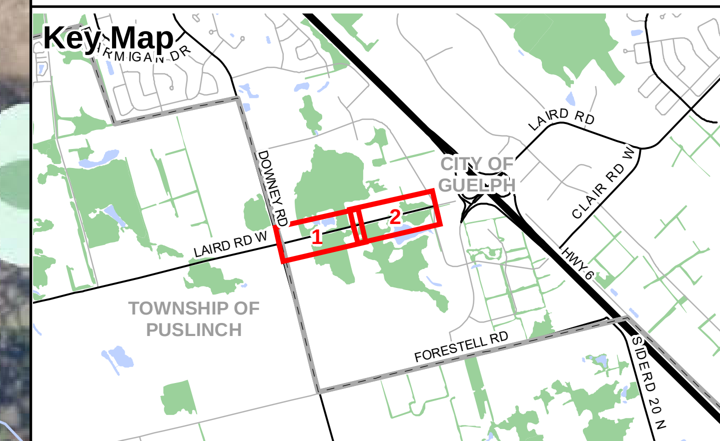
Path: X:\1033_HCBP_TerrestrialWetlandMonitoring\NRSI_1033I_Map6_RoadMortalityObs_5K_2021_11_12_MV.mxd

Map 7a

Laird Road Wildlife Movement Survey

Live Amphibian Road Mortality Observations (Post-culvert installation, 2011, 2013, 2018, and 2021)

Key Map



Legend

- Night-time Road Mortality Survey Area
- Existing Culvert
- Interim Wildlife Culverts (August 2010)
- Directional Silt Fence (~15m)
- Watercourse

Amphibian Observation Point Density

Alive

High

Low

NATURAL RESOURCE SOLUTIONS INC.
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Project: 1033 Date: November 12, 2021	NAD83 - UTM Zone 17 Size: 11x17" **1:1,750**

0 20 40 60 80 100 Metres

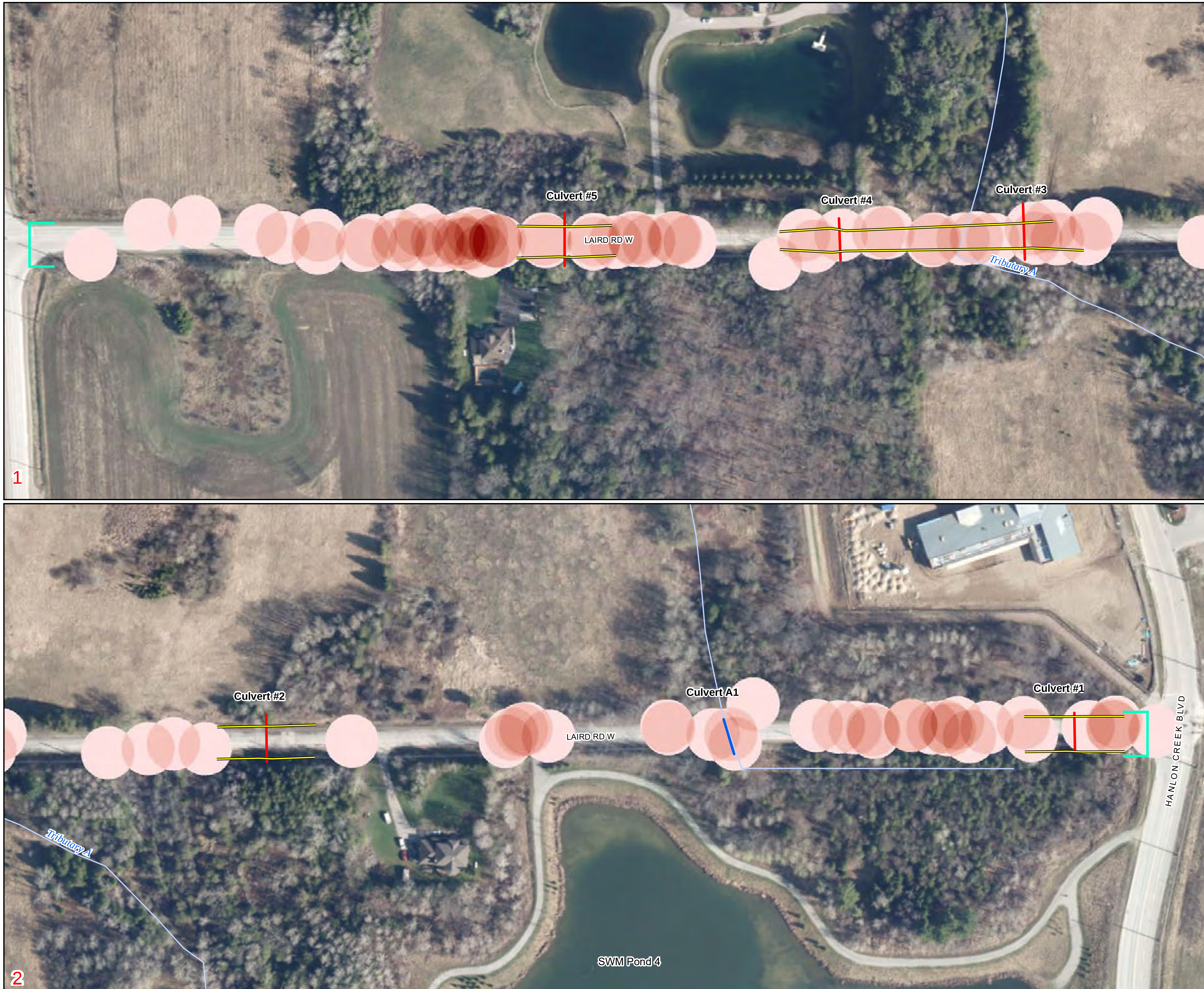
N

Path: X:\1033_HCBP_TerrestrialWetlandMonitoring\NRSI_1033I_Map7a_2011-2021MortalityObs_AliveDensity_5K_2021_11_12_MV.mxd

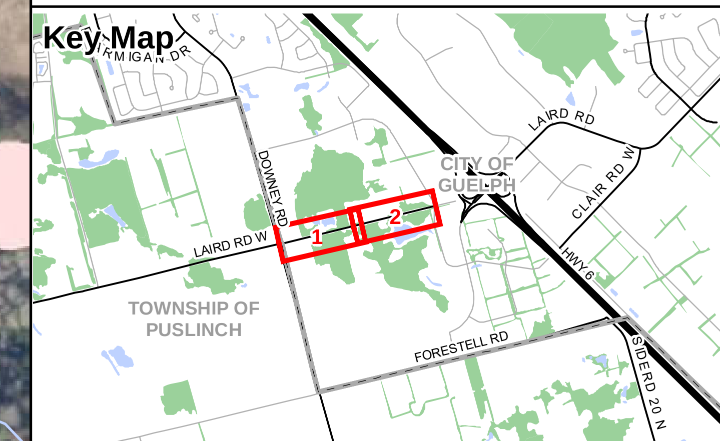
Map 7b

Laird Road Wildlife Movement Survey

Dead Amphibian Road Mortality Observations (Post-culvert installation, 2011, 2013, 2018, and 2021)



Key Map



Legend

- Night-time Road Mortality Survey Area
- Existing Culvert
- Interim Wildlife Culverts (August 2010)
- Directional Silt Fence (~15m)
- Watercourse

Amphibian Observation Point Density

Dead

High

Low

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Project: 1033 Date: November 12, 2021	NAD83 - UTM Zone 17 Size: 11x17" **1:1,750**

0 20 40 60 80 100 Metres

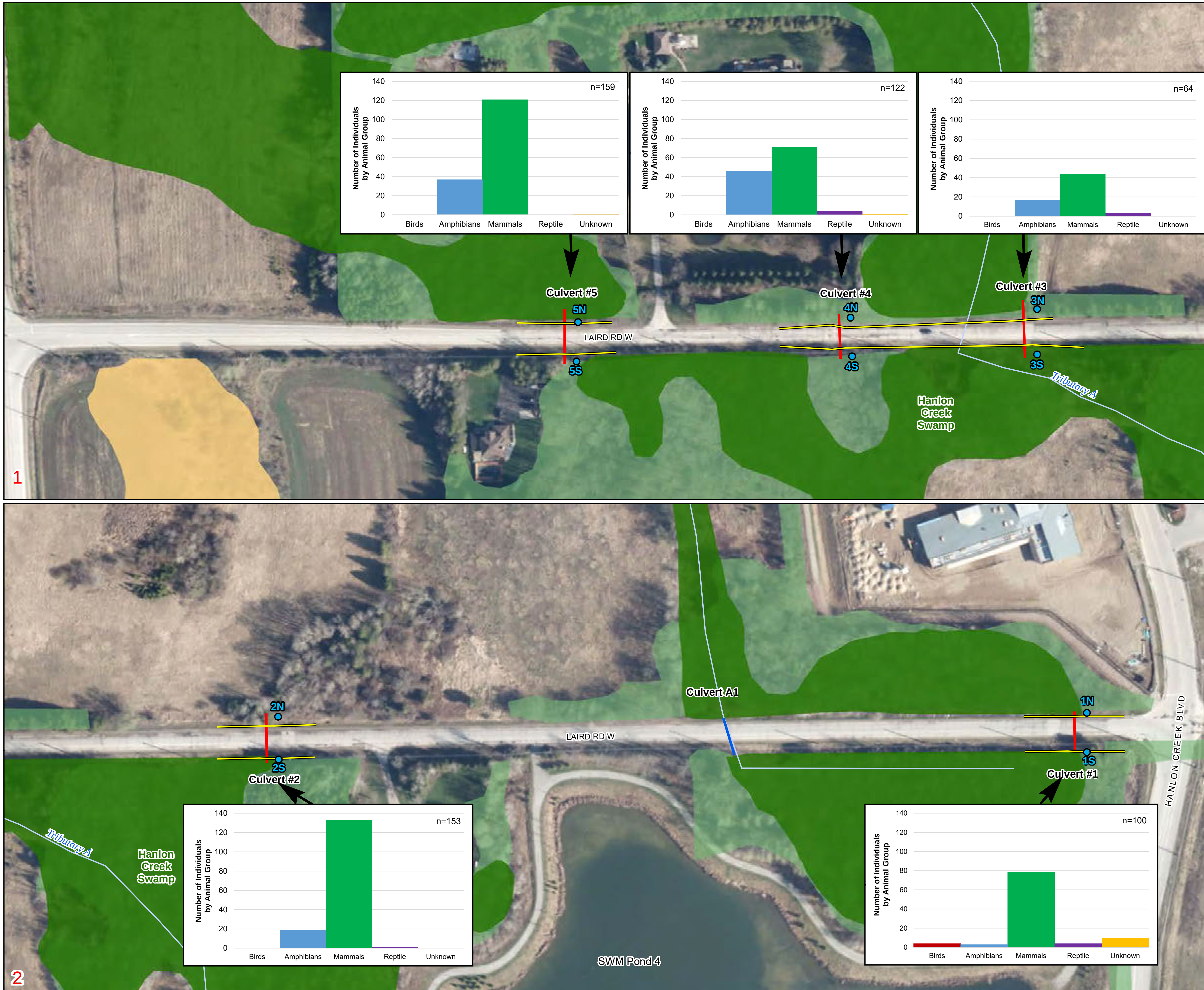
N

Path: X:\1033_HCBP_TerrestrialWetlandMonitoring\NRSI_1033I_Map7b_2011-2021MortalityObs_DeadDensity_5K_2021_11_12_MV.mxd

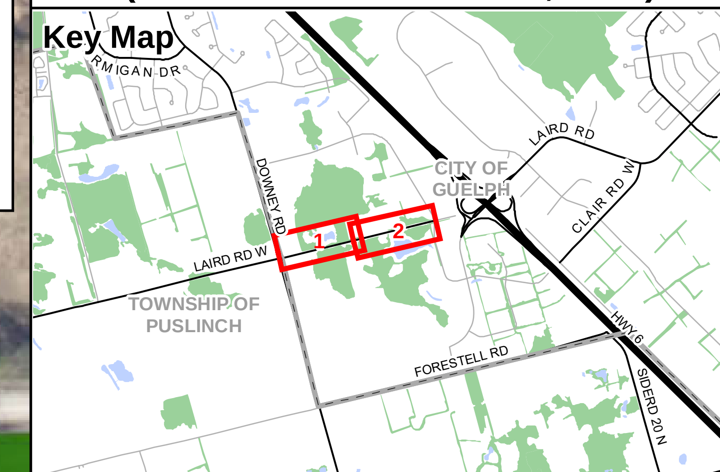
Map 8

Laird Road Wildlife Movement Survey

Wildlife Camera Monitoring Observations (Post-culvert installation, 2021)



Key Map



Legend

- Culvert Camera
- Existing Culvert
- Interim Wildlife Culverts (August 2010)
- Directional Silt Fence
- Watercourse
- Provincially Significant Wetland (PSW)
- Unevaluated Wetland
- Wooded Area

Natural Resource Solutions Inc.
Aquatic, Terrestrial and Wetland Biologists

Project: 1033
Date: November 3, 2021

NAD83 - UTM Zone 17
Size: 11x17"
1:1,750

0 20 40 60 80 100 Metres

N

Path: X:\1033_HCBP_TerrestrialWetlandMonitoring\NRSI_1033I_Map8_2021WildlifeCameraObs_5K_2021_11_03_LEH.mxd