Environment | Water Resources Branch

Water Licence Audit Supplementary Report

Dates of site visits: August 30, September 5, October 30, 31, November 2, 2018, and February 15, 2019

Licensee: City of Whitehorse

Licence number: MN18-059

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Distribution List: Government of Yukon – Environment (EC&I, EA, S&A), City of Whitehorse, Hemmera, Yukon Spring, Environment and Climate Change Canada, and Core Geoscience Services

Purpose

- The purpose of this supplementary report is to provide additional information for the water licence audit conducted in 2018 at the City of Whitehorse wastewater treatment facilities (WWTF) that was not available during the initial report. This document addresses artificial sweetener data that was collected during a seep survey performed on November 2, 2018.
- This document does not replace or duplicate any information from the Water License Audit Report dated March 14, 2019 (as provided to this distribution list on March 18, 2019) and therefore, both documents should be examined collectively.

Background & Summary

- It is well documented that municipal wastewater effluent is a point source of artificial sweeteners (Spoelstra et al., 2017). Since artificial sweeteners do not occur naturally in the environment, they are good tracers of wastewater in the receiving environment. The use of artificial sweeteners is a novel approach in a regulatory context, however as Spoelstra et al. (2017) states: "*Numerous studies*

have now demonstrated that artificial sweeteners are powerful tracers of wastewater in the environment." Peer-reviewed studies have been published over the last 10 years demonstrating the efficacy of using artificial sweeteners as a tracer of domestic wastewater. Refer to Spoelstra et al. (2017) and references therein.

- The artificial sweetener results suggest that wastewater from the Livingston Trail Environmental Control Facility (LTECF) is reporting to the Yukon River via groundwater seeps (Figure 1).
- The artificial sweetener results suggest wastewater from the Crestview Wastewater Treatment Facility (CWTF) is reporting to the Yukon River via groundwater seeps (Figure 3).
- **Recommendations:**
    - Relocate surface water monitoring station WH-10 to a location in the Yukon River upstream of LL-Seep1.
    - WRB recommends for the City of Whitehorse to conduct an annual seep survey along the LTECF and CWTF and collect water samples from seeps and the Yukon River to understand flow paths and potential impacts.

Supplementary water quality results

All the objectives from the water licence audit remain the same for the supplementary report, but the supplementary results only address pertinent objectives. These results provide additional information for objectives 2, 3, and 4.

Objective 2: Determine whether additional stations or parameters should be added to the monitoring requirements of MN93-001-13.

As described in the March 14, 2019 audit report, LL-Seep1 was visually identified as upstream of the Yukon River monitoring location WH-10. With the addition of artificial sweetener data for LL-Seep1 (Appendix A), the results indicate the presence of artificial sweeteners, which suggest that water derived from wastewater is present at this seep (Spoelstra et al., 2017). This additional information further supports the need to move surface water quality station WH-10 upstream of all potential discharges from the LTECF.

Objective 3: Determine if the following potential receptors are impacted by the LTECF: the Yukon River, groundwater seeps on the banks of the Yukon River (and presumed to be downgradient of the LTECF), and surface water bodies, including an apparent seepage pond and several pothole lakes.

On October 30th, 2018, four groundwater seeps on the banks of the Yukon River (downgradient of the LTECF) were analyzed for artificial sweeteners (LL-Seep1, LL-Seep2, LL-Seep11, & YRB-1). Figure 1 illustrates that 3 of the 4 seeps had a significant presence of acesulfame, which suggests the presence of water derived from wastewater. These results suggest that water from the LTECF is flowing subsurface to these seeps and into the Yukon River. The acesulfame concentrations at LL-Seep11 and YRB-1 were approximately 6 times greater than LL-Seep2, LL-Seep1 and MW4a, suggesting the majority of wastewater is flowing through LL-Seep11 and YRB-1 as assumed based on the volume of water seeping upon visual inspection at the time of the audit. However, the concentration difference between relatively close seeps illustrates the complex spatial and temporal variability of water discharging from the LTECF.

Figure 2 illustrates the relative percent concentration of saccharin (more degradable artificial sweeteners) to the relative percent contribution of acesulfame (less degradable artificial sweeteners) surrounding the LTECF. According Spoelstra et al. (2017), a greater ratio of degradable sweeteners (saccharin) is a proxy for newer and/or un- or under-treated wastewater. While a greater ratio of less degradable sweeteners (acesulfame) represents older and/or treated wastewater. Figure 2 illustrates that all four groundwater seeps, MW-1, and MW-2 have a greater concentration of acesulfame than saccharin relative to the source concentrations and therefore, suggesting that the wastewater is older and/or treated. The similar acesulfame to saccharin ratios suggests that the water from the seeps may be travelling from MW-1 and MW-2 to the four groundwater seeps identified at the shores of the Yukon River and that this may be a preferential wastewater pathway.

Unlike the upstream monitoring wells (MW-1, MW-2), MW-4a has a greater relative contribution of saccharin (Figure 2). A greater relative contribution of saccharin suggests that the wastewater is less degraded and therefore relatively newer and/or less treated. Therefore, water from the MW-1 and MW-2 may not be travelling to MW-4a, but instead, from a preferential subsurface pathway west of MW-1 and MW-2. This was the second time MW-4a was sampled for artificial sweeteners and both sampling

events had similar sweetener results. The acesulfame concentrations of the first and second sampling events were 494 ng/L and 564 ng/L, respectively.

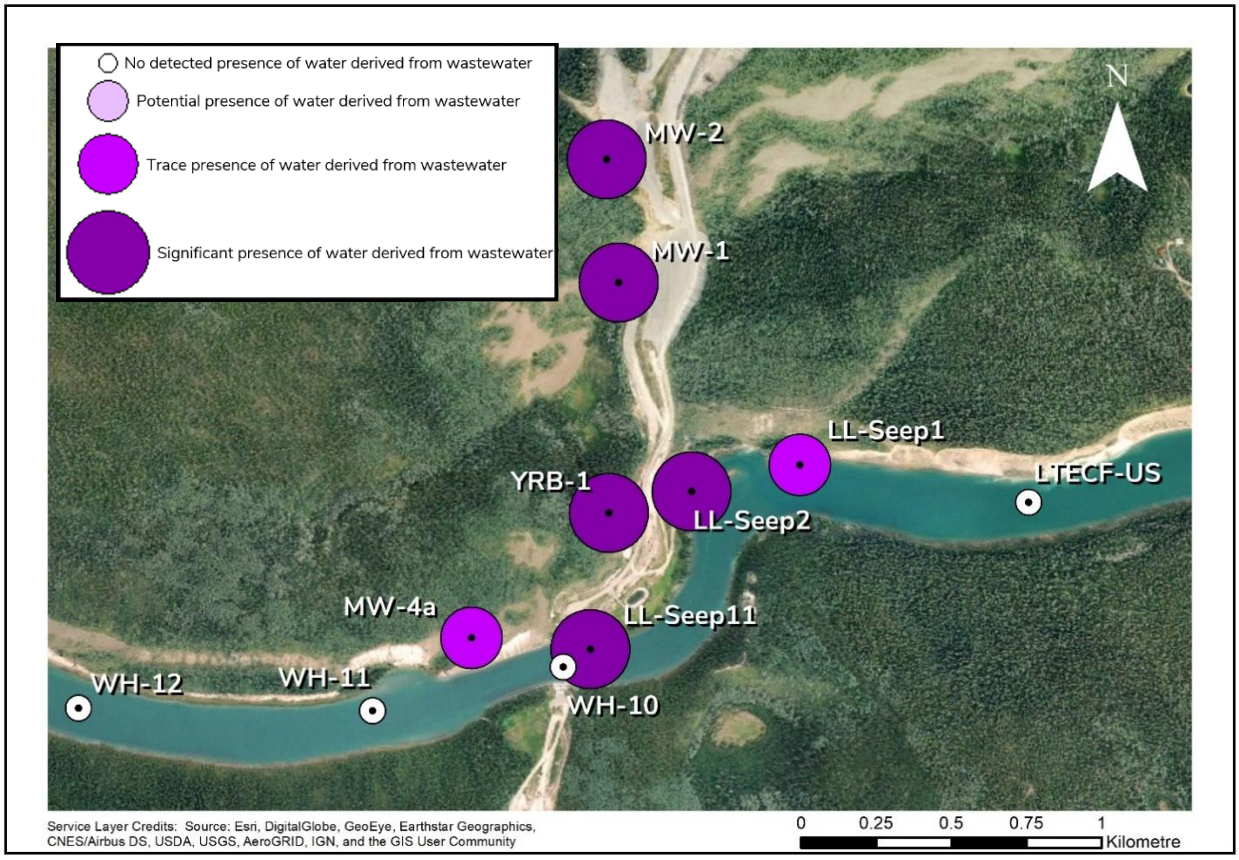

Figure 1: Summary of the presence of water derived from wastewater at stations sampled around the City of Whitehorse wastewater lagoons. The presence of water derived from wastewater is quantified by the relative percent concentration of artificial sweetener acesulfame divided by the average concentrations at the source of wastewater discharge. The source of wastewater discharge at the LTECF is defined as the average of acesulfame concentrations at WH-9b and PHL. The categories are defined as: No detected presence of water derived from wastewater = below method detection limit (<2 ng/L); Potential presence of water derived from wastewater = between method detection limit and practical quantitation limit (2-6 ng/L); Trace presence of water derived from wastewater = below 15% concentration relative to the concentration observed at the source; Significant presence of water derived from wastewater = >16% concentration relative to the concentration observed at the source.

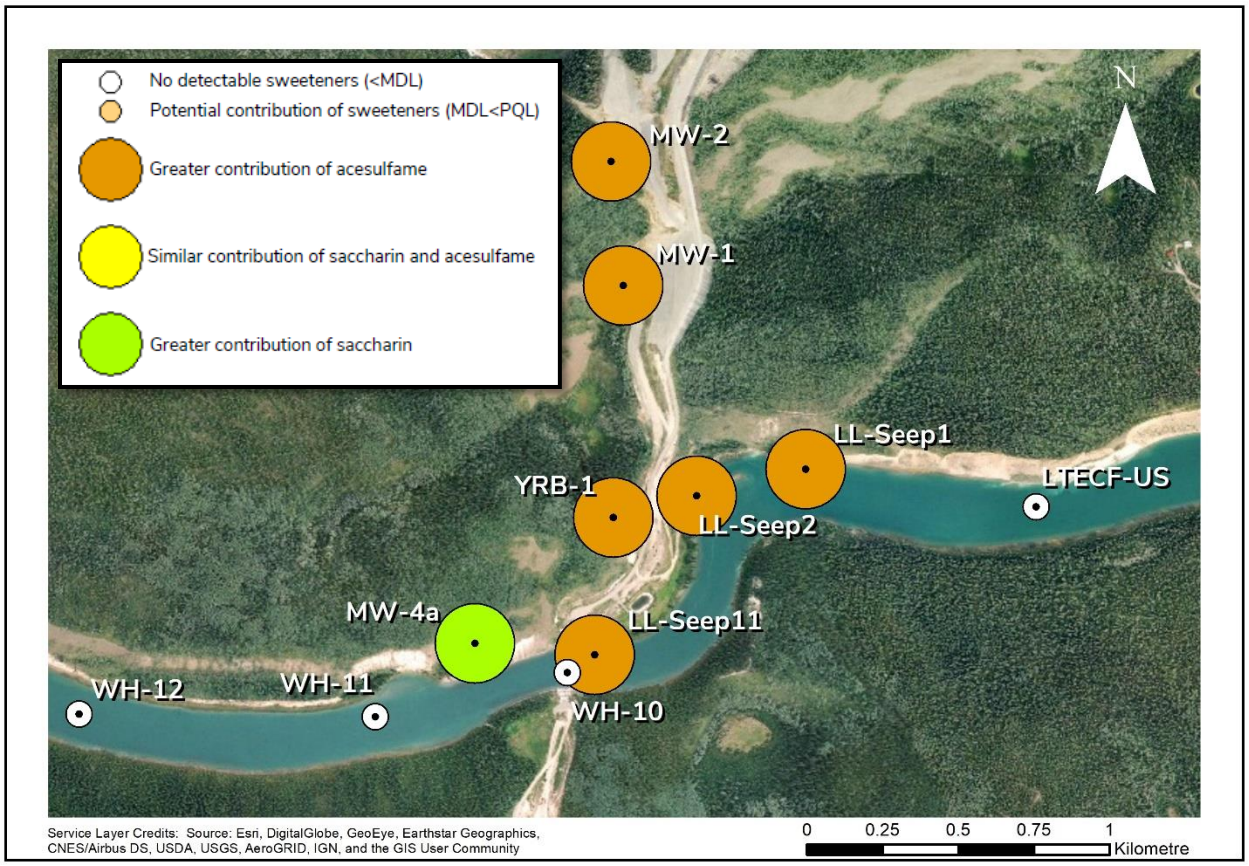

Figure 2: A representation of the ratio of the relative percent concentration of saccharin (more degradable artificial sweeteners) to the relative percent contribution of acesulfame (less degradable artificial sweeteners) surrounding the LTECF. The relative percent concentration of the artificial sweeteners was calculated as the concentration at a station divided by the average concentrations at the source of wastewater discharge. The source of wastewater discharge at the LTECF is defined as the average of acesulfame concentrations at WH-9b and PHL. The categories are defined as: No detected sweeteners = below method detection limit (<2 ng/L); Potential contribution of sweeteners = between method detection limit and practical quantitation limit (2-6 ng/L); Greater contribution of acesulfame = <0.8 ratio of relative concentrations of saccharin to acesulfame; Similar contribution of saccharin and acesulfame = 0.8-1.4 ratio of relative concentrations of saccharin to acesulfame; and Greater contribution of saccharin = >1.4 ratio of relative concentrations of saccharin to acesulfame.

Objective 4: Determine if the following potential receptors are impacted by the CWTF: the Yukon River, a creek that is a tributary of the Yukon River and is presumed to be downgradient of the CWTF, and the Yukon Spring bottled water facility.

On November 2, 2018, two groundwater seeps were sampled for artificial sweeteners along the Crestview side of the Yukon River (CL-Seep1, CL-Seep2). Figure 3 illustrates that both seeps had trace levels of artificial sweeteners, which suggests that water derived from wastewater is flowing subsurface and reporting to the Yukon River via seeps. Although only two seeps were sampled for sweeteners due to seeps being frozen, many seeps were visually apparent along the banks of the Yukon River downgradient of the CWTF. Therefore, there may be a significant amount of wastewater travelling into the Yukon River through seeps downgradient of the lagoons. Further investigation (seep survey and water sampling) is required to ascertain the true extent and direction of flow of wastewater from the CWTF, and any potential impacts to the receiving environment.

Figure 4 displays the ratio of saccharin to acesulfame concentrations relative to the source concentrations (CL-1 and CL-3), thus providing some insight into the age of the wastewater. A greater ratio of degradable sweeteners (saccharin) is a proxy for newer and/or un- or under-treated wastewater. A greater ratio of less degradable sweeteners (acesulfame) represents older and/or treated wastewater. Both seeps had a greater contribution of acesulfame, which suggests the wastewater is older and/or treated.

On August 30, 2018, tap water from the Yukon Springs bottling plant (YS) was tested for artificial sweeteners to determine if YS is impacted by the CWTF. The results indicated that the acesulfame and saccharin concentrations fell between the method detection limit and the practical quantitation limit (2-6 ng/L) (CoW Audit Report, 2018). To validate this sample, another sample was taken from YS on February 15, 2019. The second YS sample showed no detectable concentrations of sweeteners, and therefore, suggest that YS is not influenced by CWTF wastewater (Figures 3 & 4).

As previously mentioned, there are no natural sources of artificial sweeteners, however, there are other potential sources. These include leaky sewage systems, septic fields (Spoelstra et al., 2017), and there is even documentation of artificial sweeteners occurring in precipitation (Gan et al., 2013). These other sources of artificial sweeteners highlight the importance of collectively examining data above and below the influence of WWTP effluent when speculating the possible flow paths of wastewater.

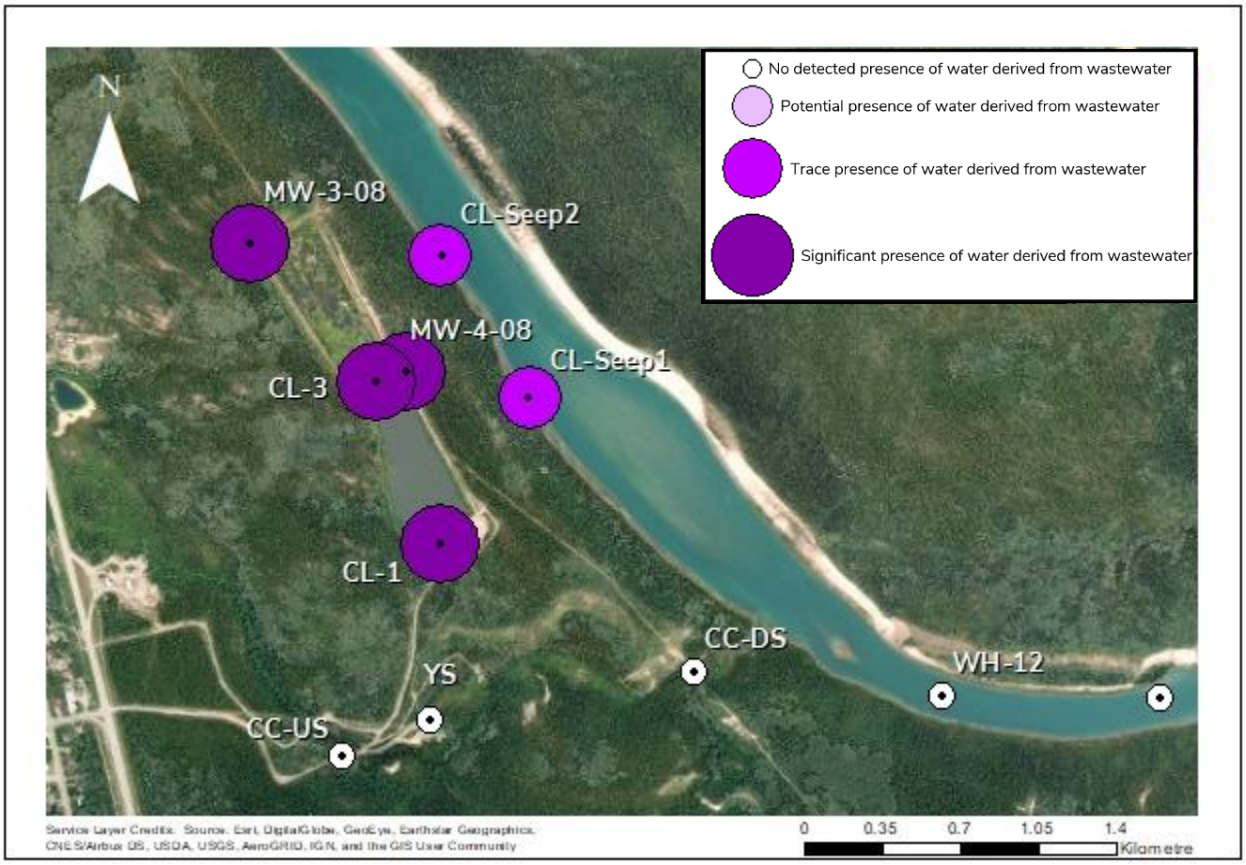

Figure 3: Summary of the presence of water derived from wastewater at stations sampled around the City of Whitehorse wastewater lagoons. The presence of water derived from wastewater is quantified by the relative percent concentration of artificial sweetener acesulfame to the average concentrations at the source of wastewater discharge. The source of wastewater discharge at Crestview lagoons is defined as the average of acesulfame concentrations at CL-1 and CL-3. The categories are defined as: No detected presence of water derived from wastewater = below method detection limit (<2 ng/L); Potential presence of water derived from wastewater = between method detection limit and practical quantitation limit (2-6 ng/L); Trace presence of water derived from wastewater = below 15% concentration relative to the concentration observed at the source; Significant presence of water derived from wastewater = >16% concentration relative to the concentration observed at the source.

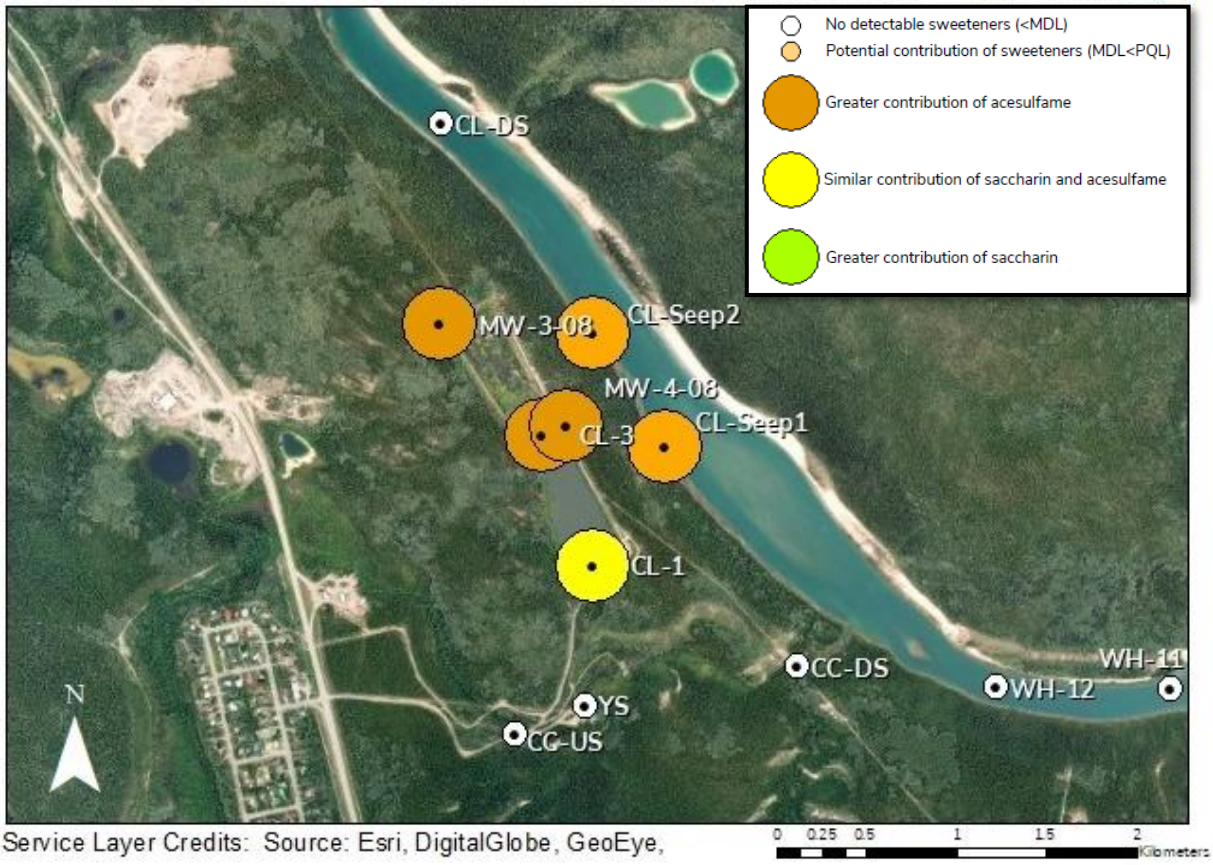

Figure 4: A representation of the ratio of the relative percent concentration of saccharin (more degradable artificial sweeteners) to the relative percent contribution of acesulfame (less degradable artificial sweeteners) surrounding the CWTF. The relative percent concentration of the artificial sweeteners was calculated as the concentration at a station divided by the average concentrations at the source of wastewater discharge. The source of wastewater discharge at the CWTF is defined as the average of acesulfame concentrations at CL-1 and CL-3. The categories are defined as: No detected sweeteners = below method detection limit (<2 ng/L); Potential contribution of sweeteners = between method detection limit and practical quantitation limit (2-6 ng/L); Greater contribution of acesulfame = <0.8 ratio of relative concentrations of saccharin to acesulfame; Similar contribution of saccharin and acesulfame = 0.8-1.4 ratio of relative concentrations of saccharin to acesulfame; and Greater contribution of saccharin = >1.4 ratio of relative concentrations of saccharin to acesulfame.

Conclusions

The artificial sweetener results suggest there may be subsurface flow paths of water deriving from wastewater from both the LTECF and CWTF into the Yukon River via seeps.

Recommendations:

- During the water licensing renewal process for water licence MN18-059 (issued March 19, 2019), WRB recommended moving station WH-10 further upstream due to seeps observed upstream of WH-10. As a result, the Yukon Water Board ("the board"), required the station to be moved upstream and renamed WH-10b. The findings in this report further support our recommendation during licence renewal to relocate the surface water quality monitoring station WH-10 to a location in the Yukon River upstream of LL-Seep1.
- During the water licensing renewal process for water licence MN18-059 (issued March 19, 2019), WRB recommended for a seepage survey to be conducted downgradient of both the LTECF and CWTF and sample for water quality. At that time, this recommendation was based solely on observed seeps. As a result, the board included a licence condition for the City to develop a Seepage Water Quality Monitoring Plan. The results of this report support that water derived from wastewater is travelling from the LTECF and CWTF via groundwater seeps into the Yukon River. This further support's WRB's recommendations for a seepage survey to be conducted to ensure impacts to the receiving environment are characterized and prevented. WRB will review the plan during the water licensing process for the City's 25-year water licence.

We would be pleased to discuss any of these findings and recommendations further in a follow up discussion.

Appendix A: Artificial Sweetener Data

Sample ID	Station ID	Sample Class	Sample Date	Time	Acesulfame (ng/L)	Cyclamate (ng/L)	Saccharin (ng/L)	Sucralose (ng/L)	Total Sweet (ng/L)
2018185	(WH)CL-1	M	30-Aug-18	16:28	15761	3738	11078	20122	50699
2018182	(WH)CL-3	M	30-Aug-18	15:44	9445	1382	3867	13206	27900
2018249	(WH)CL-Seep1	M	2-Nov-18	12:23	2004	630	739	n.d.	3373
2018250	(WH)CL-Seep2	M	2-Nov-18	12:10	401	n.d.	16	94	511
2018204	(WH)PHL	M	5-Sep-18	10:14	4316	155	295	12452	17218
2018155	(WH)WH-9b	P	5-Sep-18	12:06	3322	166	309	13043	16840
2018244	(WH)LL-Seep1	M	30-Oct-18	10:37	501	34	16	n.d.	550
2018246	(WH)LL-Seep11	M	30-Oct-18	12:00	3636	44	11	1930	5621
2018248	(WH)LL-Seep2	M	30-Oct-18	13:56	624	12	18	122	776
2018245	(WH)YRB-1	M	30-Oct-18	11:11	3538	38	3	4888	8467
20190136	(WH)YS	M	15-Feb-19	14:30	n.d.	n.d.	n.d.	n.d.	n.d.

n.d. = non-detect

Appendix B: Calculated Artificial Sweetener Results

Sample ID	Station ID	Relative % Ace	Relative % Sac	SAC_ACE	Lab Name
2018185	(WH)CL-1	1.2505753	1.4825025	1.1854565	ECCC
2018182	(WH)CL-3	0.7494247	0.5174975	0.6905263	ECCC
2018249	(WH)CL-Seep1	0.1589939	0.0988424	0.6216743	ECCC
2018250	(WH)CL-Seep2	0.0318099	0.0021947	0.0689947	ECCC
2018204	(WH)PHL	1.1301388	0.9768212	0.8643374	ECCC
2018155	(WH)WH-9b	0.8698612	1.0231788	1.1762552	ECCC
2018244	(WH)LL-Seep1	0.1310553	0.0519868	0.3966782	ECCC
2018246	(WH)LL-Seep11	0.9521079	0.036755	0.0386038	ECCC
2018248	(WH)LL-Seep2	0.1633412	0.0596026	0.3648966	ECCC
2018245	(WH)YRB-1	0.9263682	0.0099338	0.0107234	ECCC

Appendix C: References

Gan, Z., Sun, H., Feng, B., Wang, R., & Zhang, Y. (2013). Occurrence of seven artificial sweeteners in the aquatic environment and precipitation of Tianjin, China. *Water research*, *47*(14), 4928-4937.

Spoelstra, J., Senger, N.D., and S.L. Schiff. 2017. Artificial Sweeteners Reveal Septic System Effluent in Rural Groundwater. Journal of Environmental Quality. 46:1434-1443.

Water Resources, 2019. City of Whitehorse Water Licence Audit Report. March 2019.