Water Quality of Seven Persons Creek at Two Riparian Restoration Sites

Spring-Summer 2018

March 2021

South East Alberta Watershed Alliance
Rm 41, 419 – 3rd St. SE, Medicine Hat, AB T1A0G9
www.seawa.ca   executive@seawa.ca   403-580-8980

Acknowledgement

The South East Alberta Watershed Alliance (SEAWA) is grateful for the financial support of Plains Midstream Canada that paid for the entire cost of laboratory analysis. Wages for our summer field staff in 2018 were paid through an ongoing riparian restoration project with cash contribution from Recreational Fisheries Conservation Partnerships Program, Government of Canada. Wage subsidy for our summer staff in 2019 who helped in data compilation and organization was provided through the Canada Summer Jobs program, Government of Canada. Thanks are due to the City of Medicine Hat for lending SEAWA a field water quality multi-meter. We thank the Government of Alberta for the continued support of SEAWA as one of the eleven Water Planning and Advisory Councils in Alberta.

Thanks to members of the SEAWA Technical Committee who reviewed this document: Karen Saffran (Chair), Natalie Kromrey, and Ryan Davison.

Thanks to the Gordon Foundation DataStream for providing the platform to share the water quality data of this project as part of the Lake Winnipeg Basin https://gordonfoundation.ca/initiatives/datastream/ . Thank you to Mary Kruk, for data processing and providing guidance to data upload.

Project team: Marilou Montemayor (Project Lead), Natasha Rogers (Stewardship Intern 2018), Brooklyn Neubeker (Stewardship Intern 2019), Seline Solis (summer student 2018) and Ben White (Stewardship & Communication Assistant 2021). This report was written by Marilou Montemayor.

Table of Contents

Figures

Table

Abstract

Water quality of Seven Persons Creek at two riparian restoration sites was assessed to provide baseline information, identify water quality issues, and for educational purposes. At the Saamis Archaeological Site (SAS), City of Medicine Hat, there were two water sampling locations, upstream and downstream, 1.25 km apart. A third location was adjacent to a private agricultural land 61 km upstream of the two SAS locations. The SAS is a recreational trail park and was used as an off-leash dog park at the time of the study. Upstream of the SAS are two riparian golf courses, and within SAS are two draws utilized for stormwater conveyance into the creek. Land use in the watershed is predominantly agriculture. Water samples were collected from the two SAS locations on 4 Apr, 20 Jun, and 8 Aug 2018, and field measurements were also taken on 4 Apr. The Private land location was sampled on 29 May, 16 Jul and 13 Aug 2018. Samples were sent to a laboratory for analysis. Results were compared with provincial guidelines for surface waters or literature. For all locations, key water quality issues in creek were bacteria and nutrients (nitrogen (N) and phosphorus (P)). Except for bacteria and pH, highest values of water quality variables occurred at the start of the snowmelt in Apr. At the SAS, there were differences in water quality between locations depending on the season and a number of variables. In terms of bacteria, the downstream location had better water quality than the upstream location throughout the season. The downstream location also had lower values for nitrate, total nitrogen, total Kjeldahl nitrogen, total phosphorus and total dissolved phosphorus at the start of the snowmelt. In contrast, based on total dissolved and suspended solids, dissolved oxygen, conductivity, chloride and oxidation-reduction potential, the upstream location was of better quality at the start of the snowmelt. By late summer, total N and total Kjeldahl N were lower at the upstream location. Pesticides could not be evaluated due to detection limits of laboratory tests. Using Seven Persons Creek water to irrigate crops intended to be eaten raw is not recommended due concentrations of fecal coliform and *E. coli* bacteria that exceeded guideline values. Water quality tests should be conducted at 3-5 years post riparian restoration to check for any improvement in water quality. These results are useful for educational and awareness campaigns about water quality in relation to riparian areas stewardship.

Introduction

Seven Persons Creek is a tributary of the South Saskatchewan River (SSR). It starts at a diversion structure at Murray Lake dam and winds its way northeast towards the city of Medicine Hat where it is joined by Ross Creek close to where it discharges to the SSR at Medicine Hat (Fig. 1). Tributaries with headwaters from Cypress Hills join Seven Persons Creek (Paradise Creek) and Ross Creek (Bullshead and Gros Ventre), while Peigan Creek flows into Murray Lake, located south of the hamlet of Seven Persons. Unnamed smaller creeks and draws flow into these creeks and Murray Lake. Murray Lake was built at approximately the confluence of Peigan Creek from the south and a creek from the west as shown in this historical map from 1911 (Fig. 2).

Flows in Seven Persons Creek are primarily influenced by the management of the irrigation reservoir, Murray Lake, by the St. Mary River Irrigation District (SMRID). Seasonal baseflow, surface runoff, irrigation spills and returns, and stormwater runoff contribute to flows of the Seven Persons Creek. Land use within the watershed is primarily agriculture (irrigated crop production and rangelands). Closer to the city of Medicine Hat, Seven Persons Creek flows through recreational areas such as golf courses and recreational parks.

Southeastern Alberta has had water quality issues in recent years. For example, Alberta Health Services issued health advisories for toxic *Cyanobacteria* (also known as blue-green algae) in the Bullshead Reservoir in 2015, 2017 and 2018 (Fig. 3). The development of *Cyanobacteria* usually indicates high nutrient loading, especially phosphorus. Nutrient enrichment of waterbodies is called eutrophication. Fertile water bodies support more plants and algae. Based on the amount of nutrients (phosphorus and nitrogen) available for organisms, water bodies (especially lakes and reservoirs) can be classified as oligotrophic (very little nutrients), mesotrophic (medium amount of nutrients), eutrophic (high amount of nutrients), and hypertrophic (very high amount of nutrients) (Anonymous, 2018). Based on mean annual average phosphorus concentrations, Alberta Environment and Parks grouped lakes within Alberta into four trophic categories. Waterbodies in the SEAWA watershed were monitored and sorted: Cavan Lake Reservoir measured hypereutrophic, Elkwater Lake measured eutrophic, Murray Lake measured eutrophic, Forty Mile Coulee measured oligotrophic, and Sauder Reservoir measured eutrophic (Alberta Environment and Parks, 2018).

Jain and Surya (2019) provided a review of studies on sources of non-point source pollution (NPS). NPS is complex, diffuse in nature, and is a world-wide issue. NPS pollution is known to cause degradation of water quality of surface water bodies as well as groundwater. It is primarily caused by stormwater runoff and/or rain or snowmelt runoff from agricultural lands, forest lands, urban settlements, mining areas, and highways. Some common pollutants are: sediments, agricultural chemicals (fertilizers – nitrogen and phosphorus and pesticides), salts, acid-mine drainage, atmospheric deposition, heavy metals, and other elements. Similarly, golf courses have many environmental impacts and those relevant to this report are nutrients, pesticides, and bacteria (Salgot and Tapias, 2006; Mallin and Wheeler, 2000). Runoff from intensive livestock operations can input excess phosphorus and *E. coli* into nearby water bodies if not controlled by a catch basin (Miller et al. 2004).

Pesticides have been detected in agricultural and urban surface runoff, tributaries and the SSR, wastewater, and in groundwater in southern Alberta (Sheddy et al. 2019, Basiuk et al. 2017, Miller et al. 1995), and occasionally detected in drinking water (Alberta Environment Report, 2003; Miller et al. 1995). Sheddy et al. 2019 detected pesticides in the Bow, Oldman, Red Deer, and South Saskatchewan Rivers and noted contributions to these main stem rivers from wastewater treatment plant effluents and tributaries.

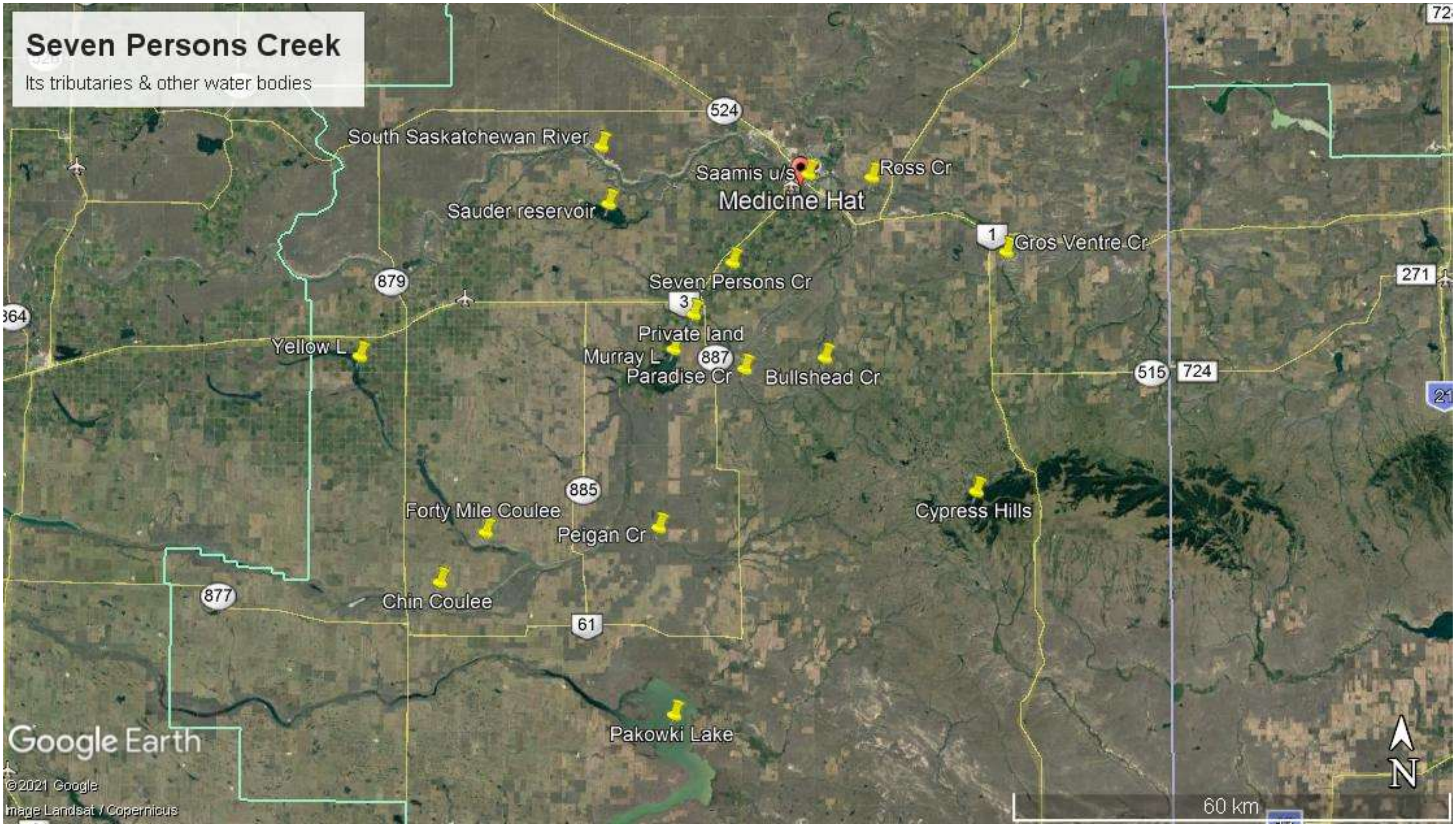

Fig. 1 Location of Seven Persons Creek, its tributaries, and other water bodies.

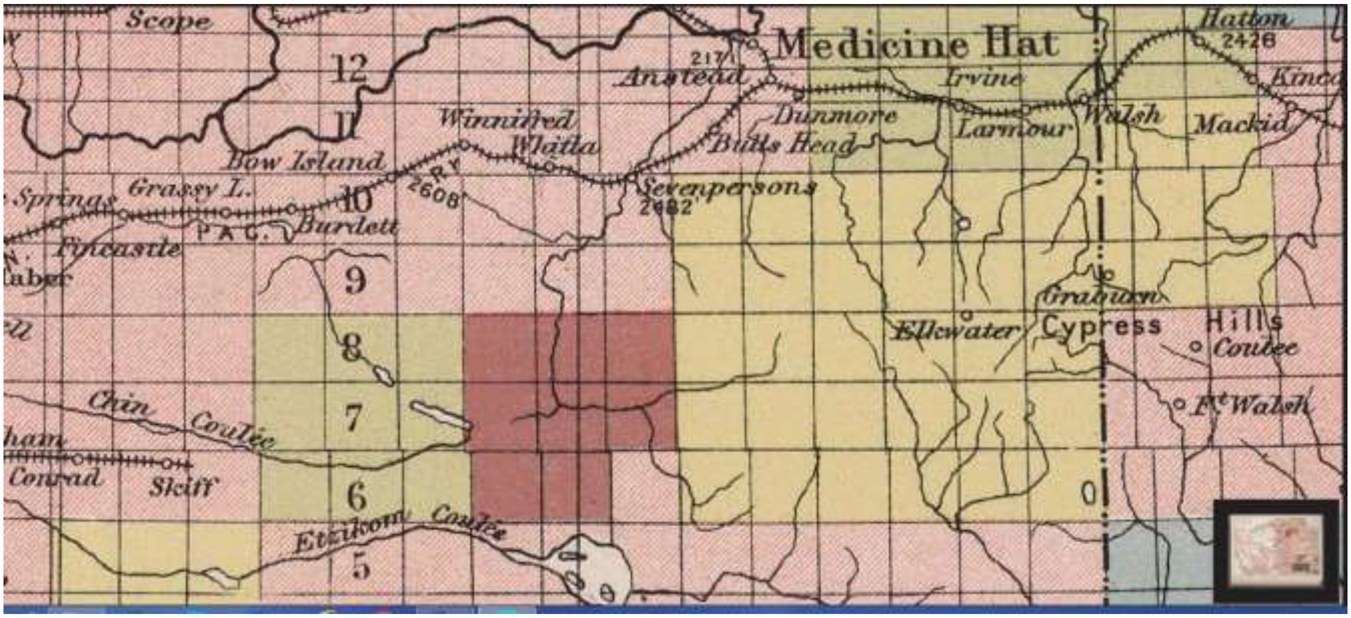

Fig. 2 An extract from a 1911 map of Alberta, showing the network of streams before the construction of Murray Lake. Copied from David Rumsey Map Collection Cartography Associates, www.davidrumsey.com

Fecal coliform and *Escherichia coli* (*E. coli*) counts are important indicators of the suitability of surface water for irrigation, recreation, and municipal use. Certain strains of *E. coli* can cause severe illness in humans (Public Health Agency of Canada, 2016). High counts (over 200 CFU/100mL) of fecal coliform bacteria and *E. coli* were detected every year during a three-year study of tributaries to the Oldman River and irrigation canals around southeastern Alberta (Hyland et al. 2003). Trends indicate that improvements in wastewater treatment have reduced fecal coliform and *E. coli* outputs from municipalities, and high numbers recorded in agricultural locations are linked to seasonal land usage (Turnbull and Ryan, 2012).

Urban stormwater is a known source of many contaminants including nutrients, heavy metals, bacteria, chlorophenols, and polycyclic aromatic hydrocarbons (PAHs) (Masoner et al. 2019). Pet and wildlife wastes may be potential sources of fecal bacteria in stormwater runoff (Giacalone et al. 2010, Selvakumar and Borst, 2006).

A study by Kerr, 2017 on the salinity trends in the Bow, Oldman, Red Deer and South Saskatchewan Rivers found that among all the concentrations of ions studied, the rate of change was highest for chloride (Cl^-). At their confluence, Cl^- median concentration ($meqL^{-1}$) for the Bow River (0.34) was twice as high as for the Oldman River (0.17), and the concentration for the SSR (0.26) was three-quarters that of the Bow. The study suggested that the key contributor to increasing salinization was road salt; and to a lesser extent municipal wastewater effluent. The study also found that sodium (Na^+) and sulfate ($SO4^{2-}$) ions could come from cropland with potential sources being return flows from irrigated fields, long-term manure application, or disturbance of saline soils by the oil and gas industry.

The purpose of this study was to determine the water quality of Seven Persons Creek at the Saamis Archaeological Site (SAS), Medicine Hat, and at a private agricultural land site, 61 km upstream of it.

The intent was to provide a snapshot that can also be used as a baseline for future assessments. This study complements the co-occurring riparian restoration projects at two sites: fencing at SAS, and revegetation with native shrubs and trees adjacent to the private agricultural land. According to a review by Dosskey et al. 2010, riparian vegetation can help improve stream water quality. Therefore, riparian restoration is expected to improve water quality, and this can be re-assessed post-restoration. This study was only for the period April to August 2018 and was not intended to be a continuing monitoring exercise.

The specific objectives of this study were to: a) measure concentrations of routine surface water quality parameters; b) compare them with Environmental Quality Guidelines for Alberta Surface Waters 2018 values; c) identify water quality issues; and d) obtain data for educational and awareness campaigns about water quality that are directly relevant to SEAWA stakeholders.

Fig. 3 *Cyanobacteria* growth, Bullshead reservoir, August 3, 2018

Methods and Materials

Study Areas

A key component of the flow in Seven Persons Creek is the discharge from the irrigation reservoir, Murray Lake, operated by the St. Mary River Irrigation District (SMRID). This discharge has been regulated as part of the management of the irrigation infrastructure since 1955 (Northwest Hydraulic Consultants Ltd., 2019). The creek's flows and levels are monitored by Water Survey of Canada station

05AH005 at Medicine Hat;
https://wateroffice.ec.gc.ca/google_map/google_map_e.htmL?search_type=province&province=AB

For this study, three water sampling locations on Seven Persons Creek were selected: two were within the SAS, city of Medicine Hat; the third was adjacent to a private agricultural land 61 km upstream of centre of the two SAS locations, south of Township Rd. 104, and south of the hamlet of Seven Persons (Fig. 4).

The two SAS sampling locations were 1.25 km apart. The upstream site was near the boundary of an adjacent golf course, and the downstream site was near a pair of culverts under the TransCanada highway through which the creek flows. Two draws drain into Seven Persons Creek between the two sampling locations (Fig. 5). Stormwater outfalls, surface runoff, and natural springs drain into these draws. Bank slumping and erosion at the mouths of these draws into Seven Persons Creek were observed.

The Saamis Archaeological Site (SAS) is a recreational park that has a network of paved and informal trails and was an off-leash dog area at the time of the study (Fig. 6). Trampling pressure on vegetation and soil compaction were issues found along riparian areas and the adjacent uplands. Bank slumping and erosion as a result of previous flood events were also observed. Subsequently, the city of Medicine Hat fenced off degraded portions of the creek's riparian areas as well as heavily trafficked upland areas criss-crossed by informal or self-made trails and implemented an on-leash only use policy in 2019.

The private agricultural land had a history of cattle grazing as well as organic crop production. There were cattle trails on the adjacent riparian area. In 2018, the landowner was preparing to sell the property and so cattle were removed and there was no crop cultivation. The riparian areas were essentially bare of woody vegetation, and heavily infested with leafy spurge, and to a lesser extent with Canada thistle. The adjacent upland areas were also infested with Canada thistle.

In May 2018, SEAWA staff planted 805 bare root year-old native shrubs, and willow stakes along a south-facing section of the riparian area adjacent to this private property. Staff performed post-planting care throughout the season: watering, weeding, and applying mulch. This planted section was upstream of the water sampling site.

Sampling and Analysis

SAS sampling locations were designated Saamis u/s (upstream) and Saamis d/s (downstream), and the private property site was designated Private land 61 km u/s.

A swing sampler was used to take grab samples from the middle of the creek. All grab samples were combined in a container and sample bottles were filled. The two SAS locations and only those collected on 4 Apr 2018 had three composite samples each. While replicate samples are preferable, this was found too costly and so subsequent samples were collected as single composite samples. For the 4 Apr data, the average value for each water quality variable was used in the presentation of results for consistency with subsequent data. Samples were stored in standard bottles sent by ALS Environmental - Calgary laboratory. Samples were kept in a cooler with ice packs inside. Samples were transported to the ALS laboratory in Calgary right after collection on the same day they were collected.

Prior to the water sample collection at the SAS locations on 4 April, field measurements were made using an YSI Professional Plus water quality multi-meter. Three measurements were taken for each site per variable. Saamis u/s measurements were taken at: 11:30, 11:34, and 11.38 am while Saamis d/s measurements were taken at: 12:40, 12:44, and 12:48 pm. The following variables were measured and their averages calculated: temperature, conductivity, specific conductivity, total dissolved solids

(TDS), salinity, dissolved oxygen (DO), pH, and redox potential (ORP). These measurements were discontinued for the subsequent sampling dates due to staff and time constraints.

Saamis u/s and d/s were sampled on 4 Apr, 20 Jun and 8 Aug, 2018. The Private land 61 km u/s was sampled on 29 May, 16 Jul, and 13 Aug, 2018. Different sets of sampling dates for the two restoration sites were to facilitate work within a limited staff capacity, and meet the time constraint for delivery of samples to the lab within the day of sample collection. Therefore, in the presentation of results, Saamis d/s and u/s could be compared directly since they were sampled on the same days. Results of the site Private land 61 km u/s could not be directly compared with Saamis u/s and d/s because of different sampling days.

Water samples were analyzed for routine water quality variables and pesticides. Physical tests included total suspended solids and total dissolved solids. Tested anions and nutrients included total alkalinity, bicarbonate, carbonate, chloride, conductivity, hydroxide, nitrate and nitrite (combined), nitrate, nitrite, total Kjedahl nitrogen (TKN), total nitrogen, pH, total dissolved phosphorus, and total phosphorus. Bacteriological tests include MPN - *E. coli* and fecal coliform bacteria. Ten pesticides were tested (from the ALS suite of pesticides): Bromoxynil, 2,4-D, Dicamba, 2,4-DP, Dinoseb, MCPA, Mecoprop, Picloram, 2,4,5-T, and 2,4,5-TP. Conventional urban stormwater variables such as PAHs and heavy or toxic metals were out of scope of this study.

Laboratory analysis performed by ALS Environmental followed methodology based on procedures used by the United States Environmental Protection Agency (USEPA), American Public Health Association (APHA), and the Ontario Ministry of the Environment (MOE). The testing was completed at ALS Environmental - Calgary, except for the Phenoxyacid herbicides, which were tested by ALS Environmental - Waterloo. ALS Environmental – Calgary is BC EWQA and CALA certified. ALS Environmental – Waterloo is CALA certified and has a MOE Drinking-Water Testing License. Their websites are:

https://www.alsglobal.com/locations/americas/north-america/canada/ontario/waterloo-environmental

https://www.alsglobal.com/locations/americas/north-america/canada/alberta/calgary-environmental

Laboratory analysis values for each water quality variable were compared to the Environmental Quality Guidelines for Alberta Surface Waters, 2018, referred to as guidelines or guideline in this document. Supplemental guidelines were obtained from Canadian Council of Ministers of Environment (CCME) guidelines as needed. Literature was referenced for variables with no guideline values.

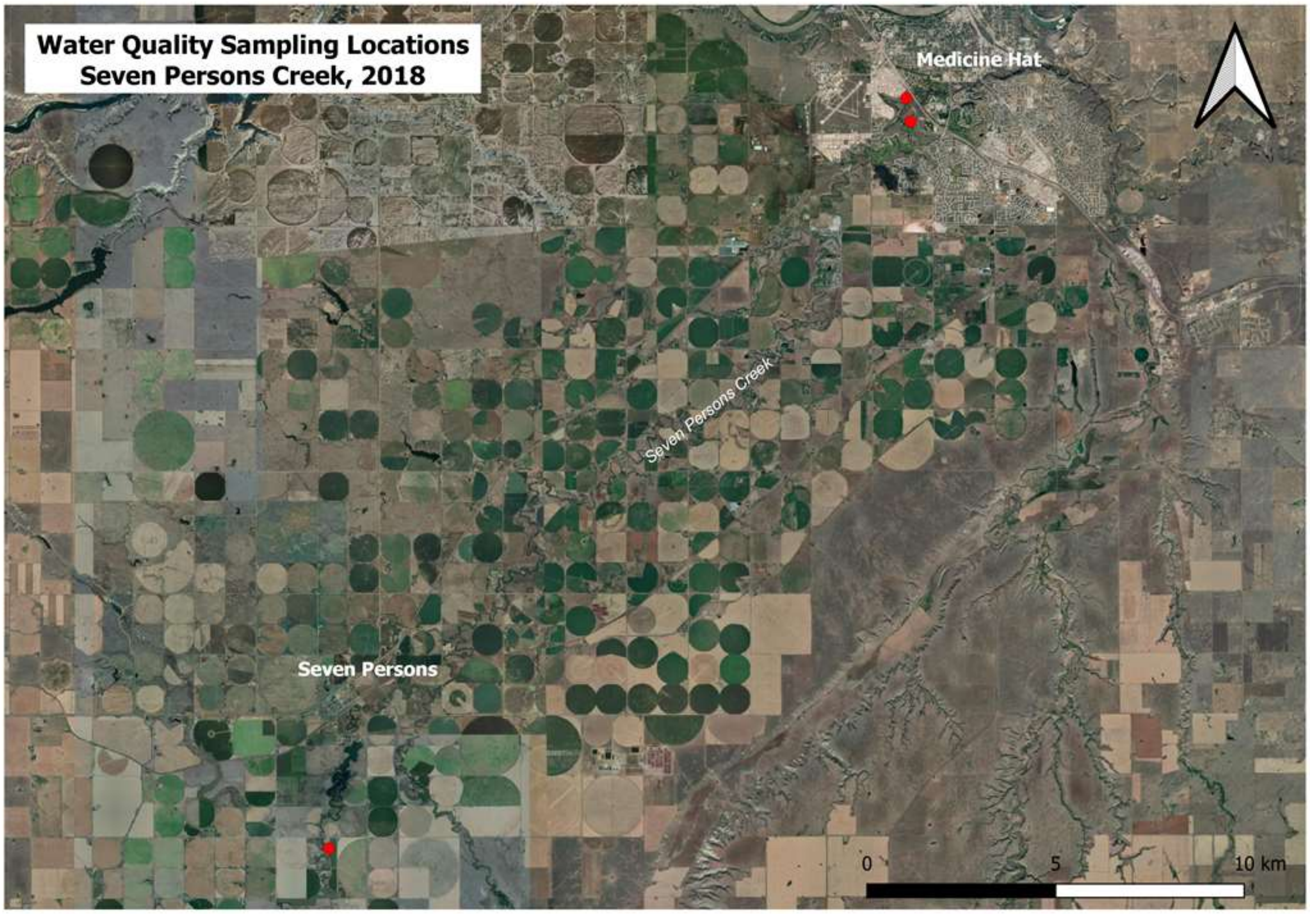

Fig. 4 Three water sampling locations are indicated by red dots. Streamflow travels northeast through the city of Medicine Hat and eventually to the South Saskatchewan River. This map was produced using QGIS.

Fig. 5 Two draws that drain into Seven Persons Creek, located between the two SAS sampling locations.

Fig. 6 A close-up image of Saamis u/s and Saamis d/s sampling locations. Streamflow travels northward. This map was produced using QGIS.

Results and Discussion

Water sampling results are presented in groups: physical tests, nutrients, bacteria, anions and associated parameters, and variables that tested below detection limit of laboratory instruments. Field multi-meter results are presented last.

Results are displayed graphically with values of Environmental Water Quality Guidelines for Alberta Surface Waters 2018 (https://open.alberta.ca/publications/9781460138731) shown as a red dotted line for comparison when sample values exceeded, or were close to, guideline values. However, there are no numeric guideline values for nutrients. Instead, a narrative of maintain or improve is recommended. Guideline values shown are for the protection of freshwater aquatic life (PAL), unless otherwise indicated that it is for agriculture (irrigation and livestock watering), or aesthetics and recreation.

For each water quality variable, results of all the three sampling locations are displayed together in a graph. This provides an overview of the patterns of each water quality parameter during the spring/summer period of 2018.

Physical Tests

Total Suspended Solids (TSS) (mg/L), Fig. 7. None of the conditions of the Guidelines (quoted below) apply to the values found in the study. TSS was not an issue during the sampling period.

> "During clear flows or for clear waters: Maximum increase of 25 mg/L from background for any short-term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from background levels for longer term exposures (greater than 24 h). During high flow or for turbid waters: Maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. Should not increase more than 10% of background levels when background is ≥250 mg/L."

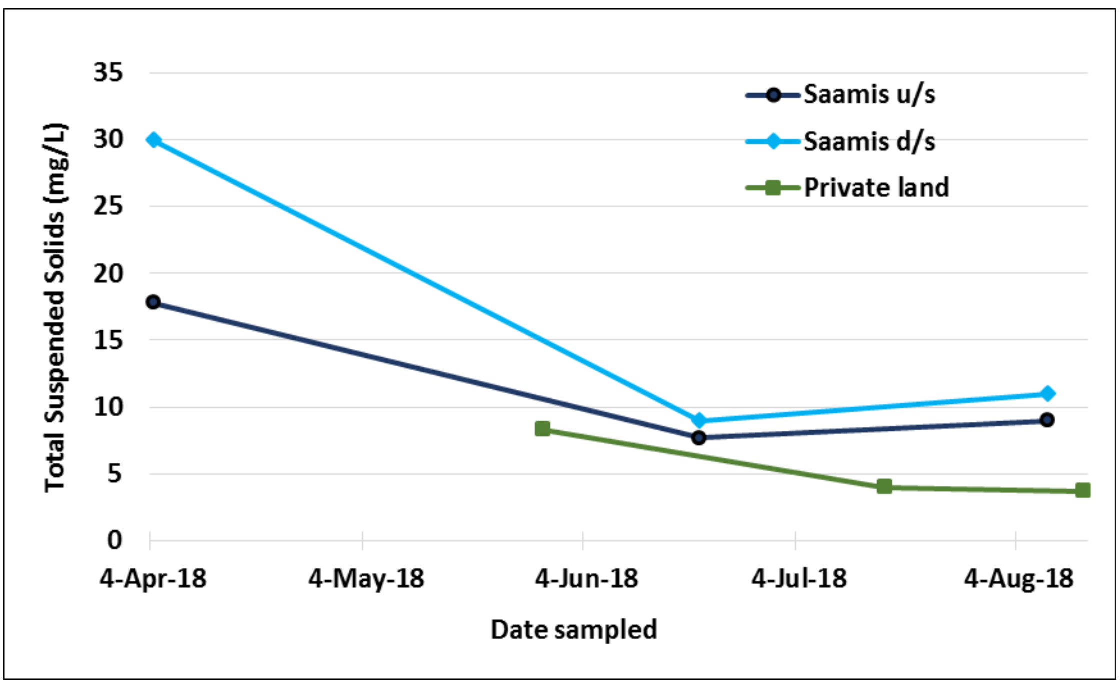

Fig. 7 Total Suspended Solids (mg/L), detection limit 3.0mg/L

Total Dissolved Solids (TDS) (mg/L), Fig. 8. Maximum irrigation values are crop specific and range from 500-3500mg/L. Guideline value for the maximum dissolved solids for irrigation of strawberries, raspberries, beans, and carrots is 500mg/L. The maximum dissolved solids for livestock water is 3000mg/L. TDS measurements on 04-Apr-2018 at Saamis u/s and d/s were higher than the guideline maximum value for certain crop species but fell below the maximum during the subsequent sampling dates. These high TDS values are not a concern because crops are not ready to be planted outdoors in the month of April. They may be a concern if the water is used to irrigate indoor-grown crops, as in greenhouses, within the SAS area and downstream of it.

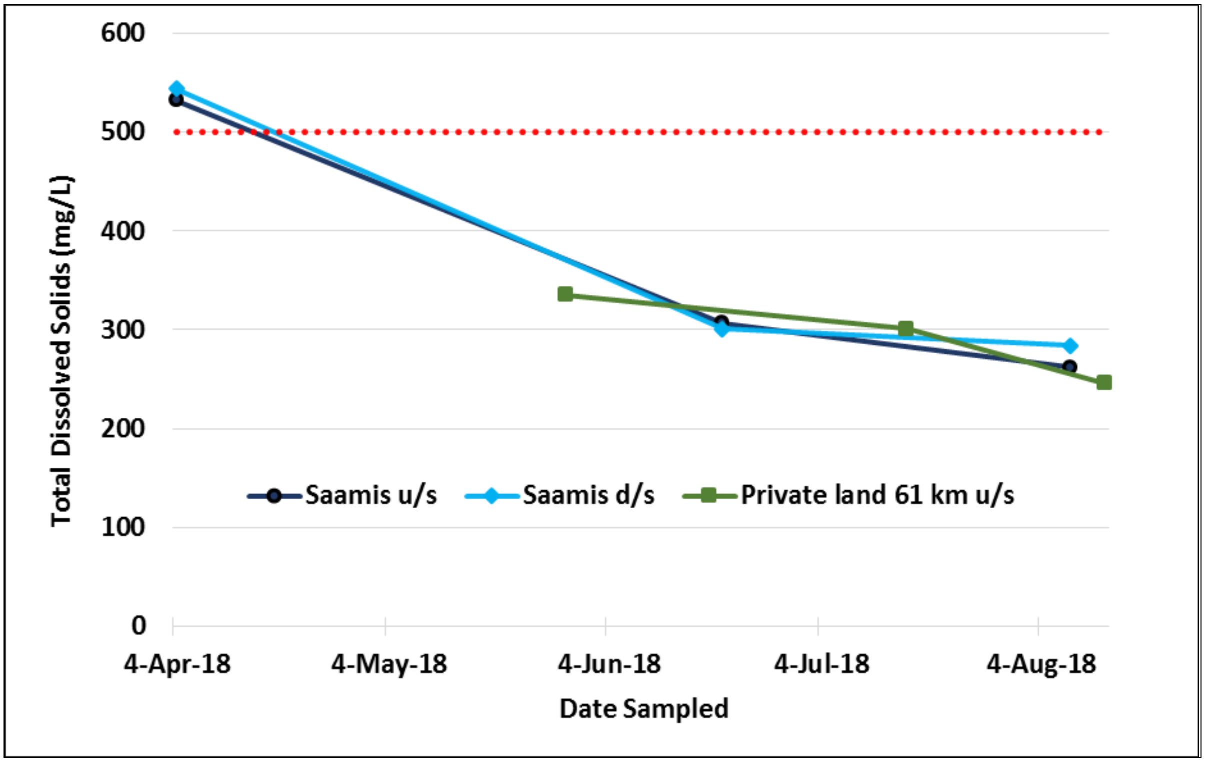

Fig. 8 Total Dissolved Solids (mg/L), detection limit 20mg/L. Guideline value is for agricultural uses; range is 500-3500 mg/L and is crop-specific.

Nutrients

Nitrate (mg/L), Fig. 9. The Guideline maximum chronic value of nitrate for PAL is 3.0 mg/L. The short term acute maximum value is 124 mg/L. These values only consider toxicity due to nitrate, and do not take into consideration the effects on eutrophication. Nitrates measured in Seven Persons Creek at sampled locations did not exceed this toxicity level. Nitrate is a form of Nitrogen (N) that is readily utilized by plants.

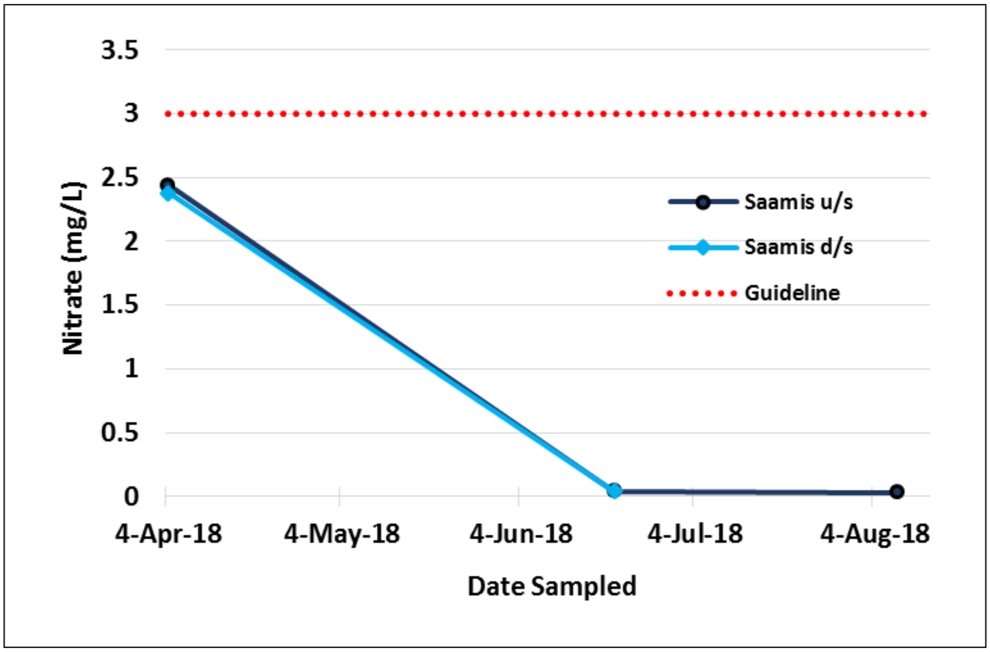

Fig. 9 Nitrate (mg/L), detection limit of 0.10 mg/L on 4 Apr, then 0.020mg/L thereafter. Saamis d/s was below detection limit on the last sampling date, 3 Aug. The Private land 61 km u/s location was below detection for all the three sampling dates.

Total nitrogen (TN) (mg/L), Fig. 10. Total Nitrogen includes organic nitrogen (N), ammonia, nitrate, and nitrite. Saamis u/s and d/s locations had very high values during the spring flow on 04-April-2018 sampling but these values decreased to less than 1.0 mg/L on the subsequent sampling dates. Results showed that after the spring flow period, all three sampling locations had similar TN values that were between 0.5 to 1.0 mg/L.

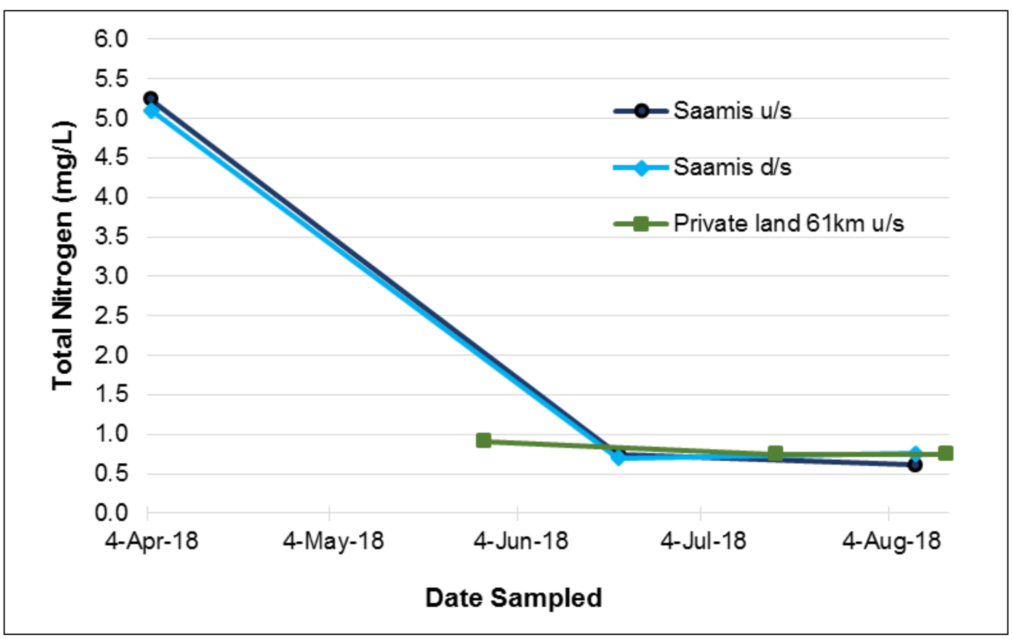

Fig. 10 Total Nitrogen (mg/L), detection limit of 0.42mg/L on 4 Apr sampling and changed to detection limit of 0.20mg/L subsequently.

Total Kjedahl nitrogen (TKN) (mg/L), Fig. 11. TKN measures both organic N and ammonia and is usually an indicator of fresh pollution of freshwater. According to the CCME (2016), human-caused nitrogen (N) pollution to surface waters mainly occurs as organic N, total ammonia and nitrate from municipal effluent, total ammonia and nitrate from agricultural runoff, and as nitrogen oxides (NOx) from atmospheric deposition. In certain areas, groundwater can also be a contributor. A variety of natural biochemical processes are involved in the transformation between different forms of nitrogen.

Highest values (between 2.5 and 3 mg/L) were on 4 Apr 2018 sampling at both the Saamis u/s and d/s. Thereafter, values stabilized between 0.5 to 1 mg/L for all sampling locations. TKN biochemical processes by microorganisms gradually convert organic N to ammonia, then ammonia is converted into nitrites and finally to nitrates. Ammonia is toxic to fish and is affected by other parameters such as pH and temperature (CCME, 2010 – Ammonia). There is no guideline value for TKN but there is a guideline value for ammonia (Un-ionized NH_3, 0.016 mg/L, Long-term chronic). However, ammonia was not measured separately in this study.

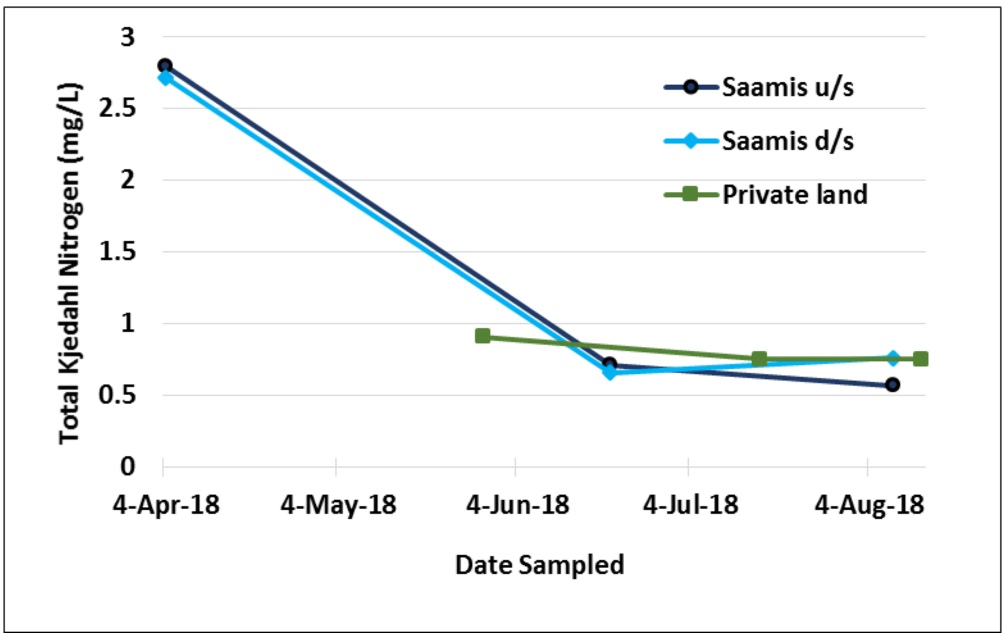

Fig. 11 Total Kjedahl Nitrogen (mg/L), detection limit 0.40 mg/L on 4 Apr, subsequently was changed to 0.20mg/L

Dissolved phosphorus is what remains in the water sample that has been filtered to remove particulate matter. Total phosphorus is the sum of dissolved and particulate phosphorus. Dissolved phosphorus is the form that is readily available (bioavailable) to aquatic plants, especially algae. In freshwaters, excess amounts of dissolved phosphorus can result in increased algal growth to a concentration that can result in eutrophication. It is quite possible that together, nitrogen and phosphorus can cause nutrient enrichment of waters that can trigger eutrophication (CCME, 2016). In the case of *Cyanobacteria*, they can fix nitrogen from the atmosphere making phosphorus the limiting nutrient.

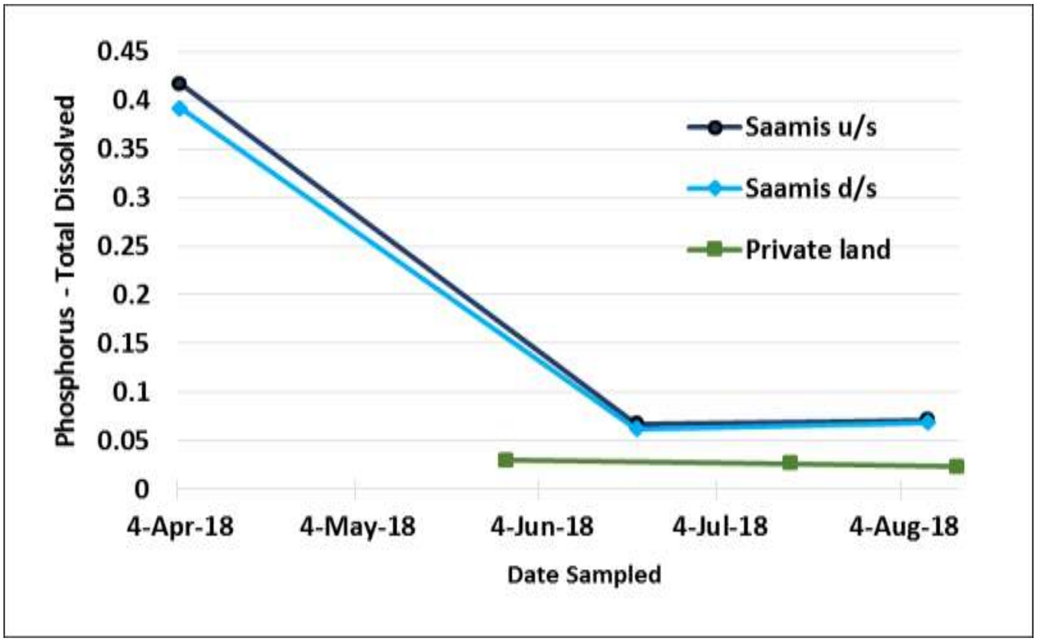

Fig. 12 Total Dissolved Phosphorus (mg/L), detection limits of 0.020mg/L for 4 Apr and 29 May samples; detection limit of 0.0050mg/L subsequently

Total phosphorus (TP), Fig. 13 and Total dissolved phosphorus (TDP) mg/L, Fig. 12. Similar to the pattern of TN and TKN, Saamis u/s and d/s had very high values during the start of snow melt period on 4 Apr 2018. Values at both locations stabilized on the subsequent sampling dates for TDP at 0.07 mg/L and TP 0.09 mg/L. Samples from the Private land 61km u/s were less than 0.05 mg/L for TDS and decreased slightly from May to August. For TP, the Private land location also showed a decreasing trend with 0.08 mg/L in May which dropped to 0.03 mg/L in August.

Guidelines for nutrients (e.g., Nitrogen and Phosphorus) are not numeric values (quoted below). A narrative is provided for water bodies other than lakes and major rivers; Seven Persons Creek falls into this category:

> "For surface waters not covered by specific guidelines, nitrogen (total) and phosphorus concentrations should be maintained so as to prevent detrimental changes to algal and aquatic plant communities, aquatic biodiversity, oxygen levels, and recreational quality. Where priorities warrant, develop site-specific nutrient objectives and management plans."

Therefore, based on this narrative, nitrogen and phosphorus levels should at least be maintained. However, TP of 0.035 to 0.1 mg/L is the Canadian trigger range for eutrophic status (CCME, 2004) that should in turn direct efforts towards nutrient management.

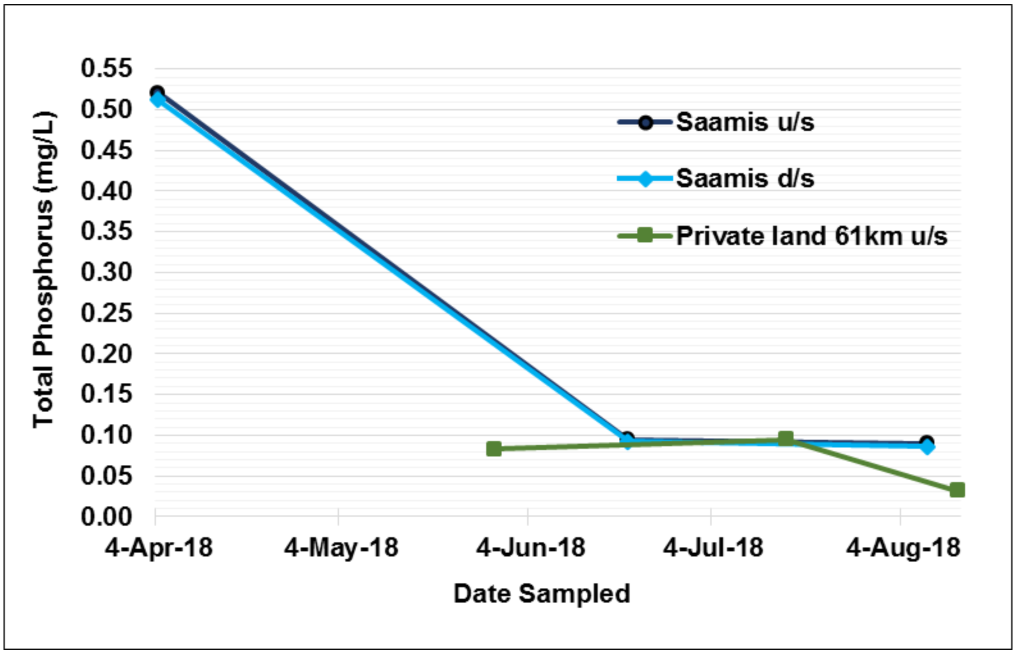

Fig. 13 Total Phosphorus (mg/L), detection limits of 0.020mg/L for 4 Apr and 29 May samples; detection limit of 0.0050mg/L subsequently.

Bacteria

Escherichia coli (Mean Probable Number (MPN)/100 mL), Fig. 14. Guidelines state that for irrigation, fecal coliforms *(E. coli)* should not exceed count 100/100mL. This is to avoid issues with irrigating produce that will be consumed raw. Saamis u/s exceeded this value for all sample dates, while Saamis d/s exceeded this number on 04 Apr and 08 Aug. The Private land 61km u/s location did not exceed this value on any of the sampling dates. The guideline value for aesthetics and recreation is 126 MPN/100mL, which is a "geometric mean (30-d interval), and a minimum of weekly samples is recommended". The frequency of sampling in this study did not meet these stipulations such that geometric means could not be derived.

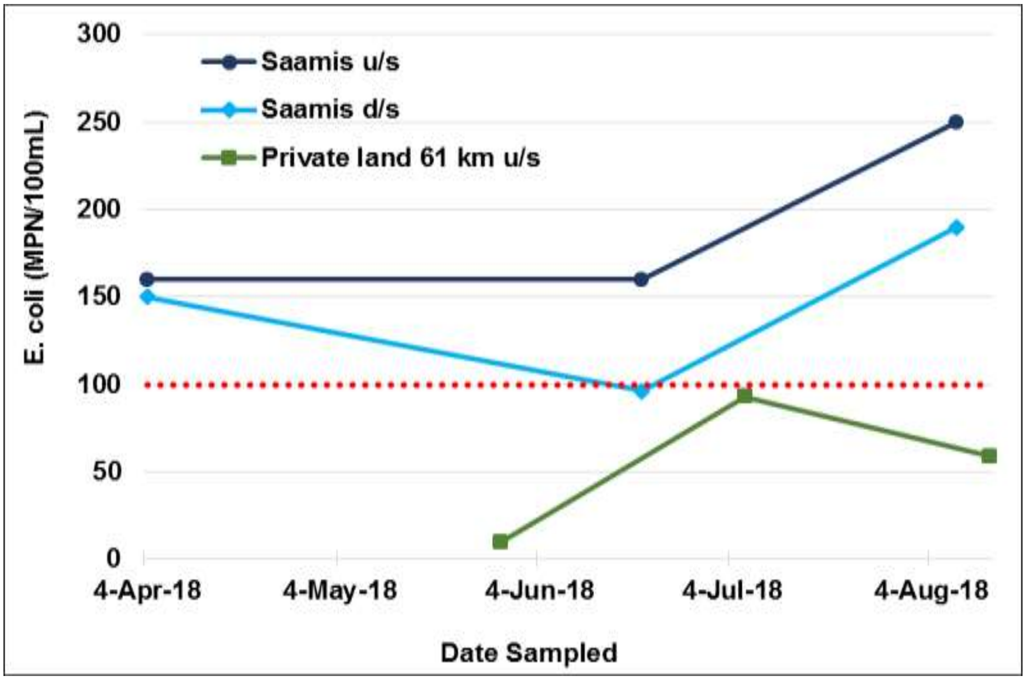

Fig. 14 *Escherichia coli* (MPN/100mL), with a detection limit of 1MPN/100mL. Guideline value is for protection of agricultural uses (irrigation for raw produce).

Fecal coliforms (including *E. coli*) Colony forming units (CFU)/100mL, Fig. 15. Guideline value for irrigation is not to exceed the count 100/100mL. This is to avoid issues with irrigating produce that will be consumed raw. Both Saamis u/s and d/s exceeded guideline values for all sampling dates. The Private land location exceeded the guideline value except on 29 May 2018. The sampling frequency was not sufficient to derive geometric means, the metric for aesthetics and recreation uses. The recommendation is a minimum of weekly samples which was beyond the scope of the study.

Both *E. coli* and Fecal coliform bacteria counts at Saamis u/s were consistently higher than at Saamis d/s. Bacterial counts at the Private land location were sometimes lower and sometimes higher than the guideline value. Creek water should not be used for irrigating crops that are intended to be consumed as raw produce.

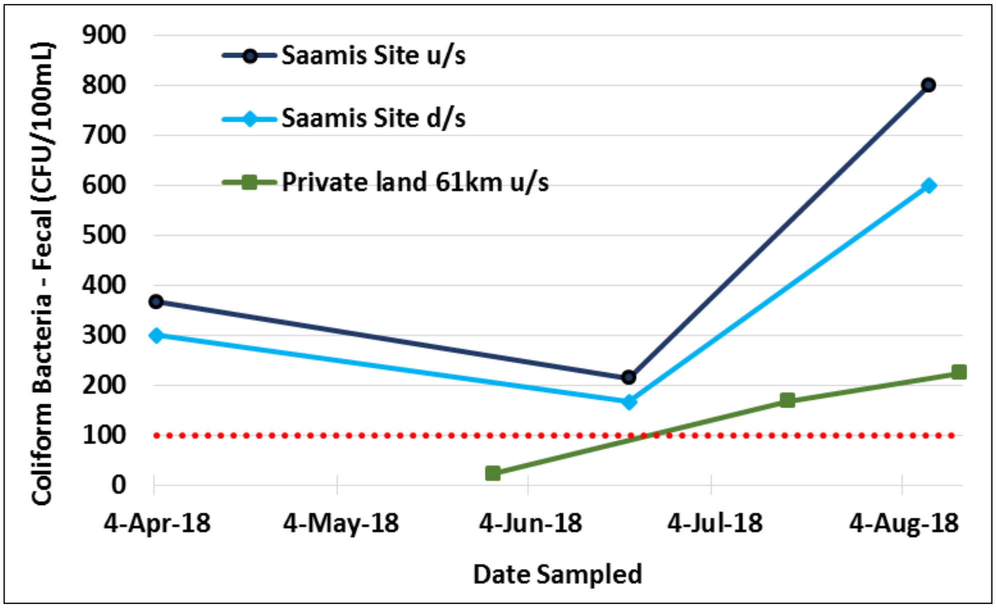

Fig. 15 Coliform bacteria – fecal (CFU/100mL), April 4, 2018 had a detection limit of 100CFU/100mL; detection limit of 1CFU/100mL subsequently. Guideline value is for protection of agricultural uses (irrigation for raw produce)

Anions and associated parameters

Alkalinity (mg/L), Fig. 16. Alkalinity of samples from all locations and all sampling dates were well above the minimum Guideline value of 20 mg/L.

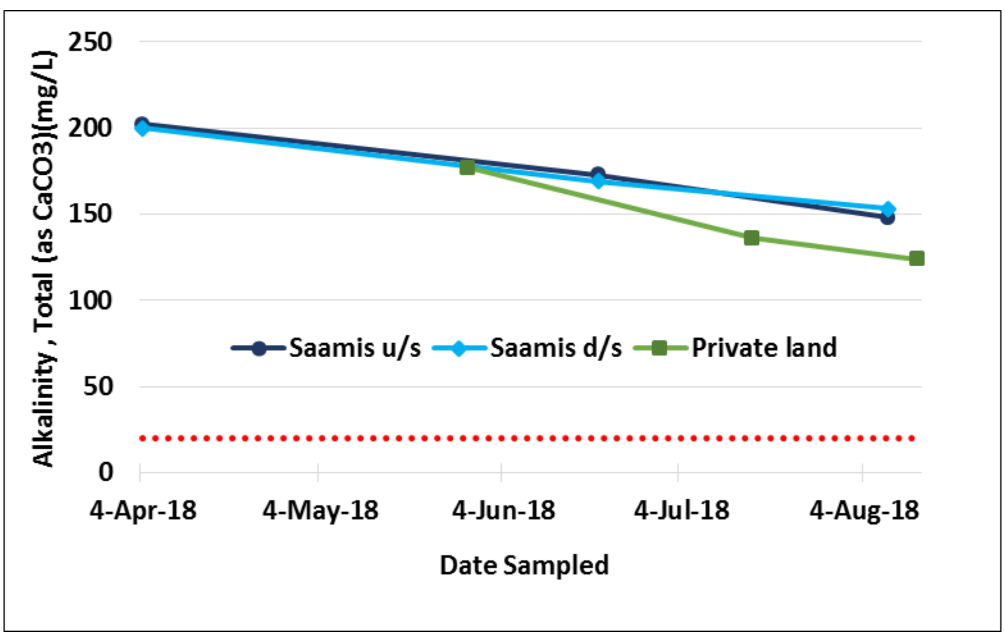

Fig. 16 Total Alkalinity (CaCo3) (mg/L), detection limit 5.0mg/L. The guideline value is for minimum.

Bicarbonate (mg/L), Fig. 17. Saamis u/s and d/s did not differ and both showed a decreasing trend as the season progressed. The Private land location showed the same decreasing pattern as the season progressed. There is no Guideline value for this parameter.

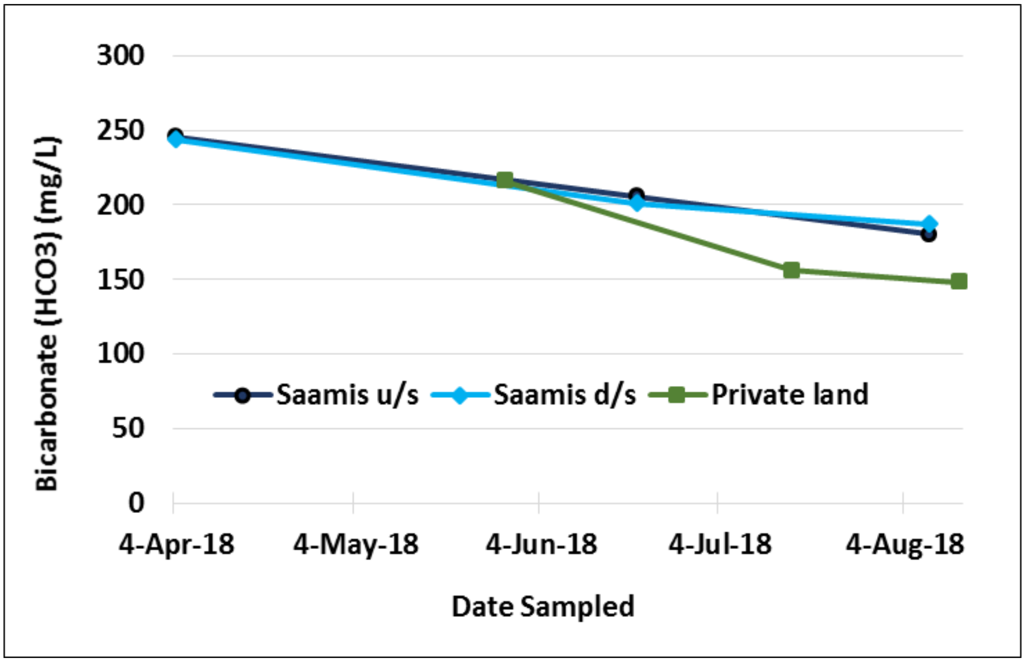

Fig. 17 Bicarbonate (mg/L), with a detection limit 5.0mg/L, no guideline value

Chloride (mg/L), Fig. 18. The maximum Guideline values of chloride for PAL is 120mg/L chronic and 640mg/L acute. The maximum Guideline values of chloride for irrigation ranges from 100-700mg/L and is crop specific. Chloride from all sampling locations and all sampling dates were well below Guideline values for both PAL and irrigation.

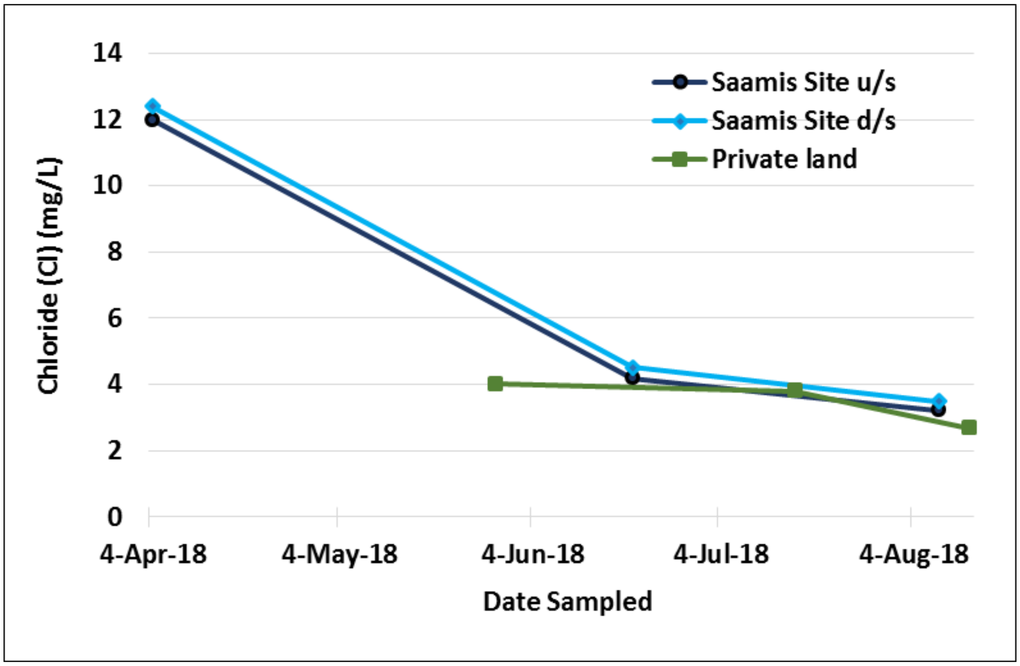

Fig. 18 Chloride (mg/L), with a detection limit of 0.50mg/L. Saamis locations on 4-Apr-2018 had a detection limit of 2.5mg/L. Guideline values are 120 mg/L (Long-term) and 640 mg/L (Short-Term; Acute)

Conductivity (µS/cm), Fig. 19. Irrigation water guideline for conductivity is less than 2.0dS/m or less than 2000µS/cm. Conductivity measured at all sampling dates and taken from all locations were well below the safe range.

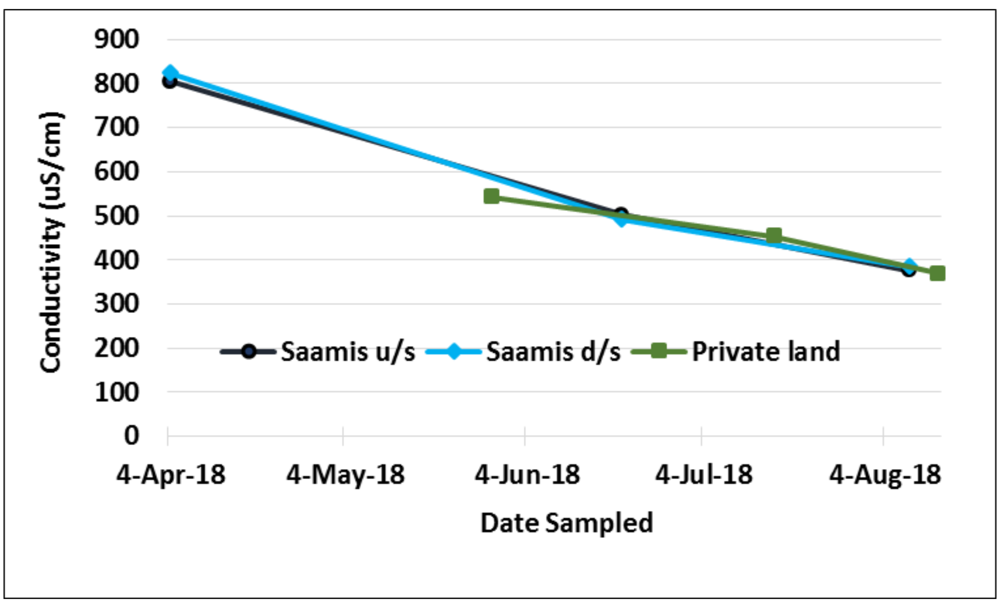

Fig. 19 Conductivity (µS/cm), detection limit of 2.0µS/cm, no guideline value (freshwater).

pH, Fig. 20. Guideline values for PAL: pH should remain between 6.5 and 9.0, and should not change more than 0.5 units from background. pH measurements from all locations and all sampling dates were within Guideline values.

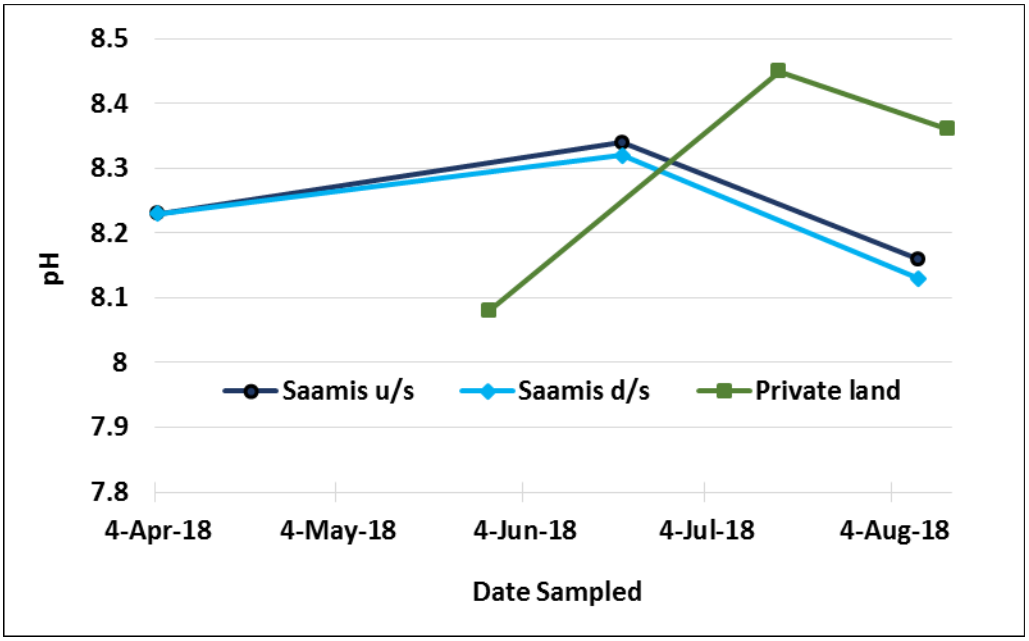

Fig. 20 pH, with a detection limit of 0.10; guideline value is 6.5 to 9.

Variables that tested below detection limit of laboratory tests

Nitrate and Nitrite (mg/L)

On 4 Apr, Saamis u/s and d/s both had detectable concentrations of Nitrate and Nitrite. The average values were: 2.44 mg/L at Saamis u/s, and 2.38 mg/L at Saamis d/s. After 4 Apr, all locations and sampling dates were below the detection limit of 0.11mg/L.

Nitrite (mg/L)

All locations and sampling dates were below the initial detection limit of 0.05 mg/L. After 4 Apr, the limit was changed to 0.010mg/L for all subsequent dates. Maximum guideline values range from 0.06 to 0.6 mg/L, depending on the Chloride concentration (from less than 2 to greater than 10 mg/L).

Carbonate (mg/L)

All locations and all sampling dates were below detection limit of 5.0mg/L.

Hydroxide (mg/L)

All locations and all sampling dates were below detection limit of 5.0mg/L.

Pesticides

All locations and all sampling dates were below detection limit of 0.50μg/L for all the ten pesticides tested. Guideline values are: Bromoxynil, 5μg/L; 2,4-D, 4μg/L; Dicamba, 10 μg/L; 2,4-DP, 25μg/L; Dinoseb, 0.05μg/L; MCPA, 2.6 μg/L; Mecoprop, 13μg/L; and Picloram, 29 μg/L. There are no guideline values for 2,4,5-T and 2,4,5-TP.

Therefore, in future water quality tests, samples for pesticide detection should be sent to a laboratory that is equipped to measure less than 0.50μg/L concentrations. This is important because Dinoseb has a guideline value of 0.05μg/L.

Creek flows (cms) and water levels (m), Fig. 21.

Peak flow and water level occurred in the latter half of April. A smaller peak occurred on 1 Jun. There was no sampling date that coincided with these peak events. Calculated flows during the sampling dates were between 0 to less than 2 cms.

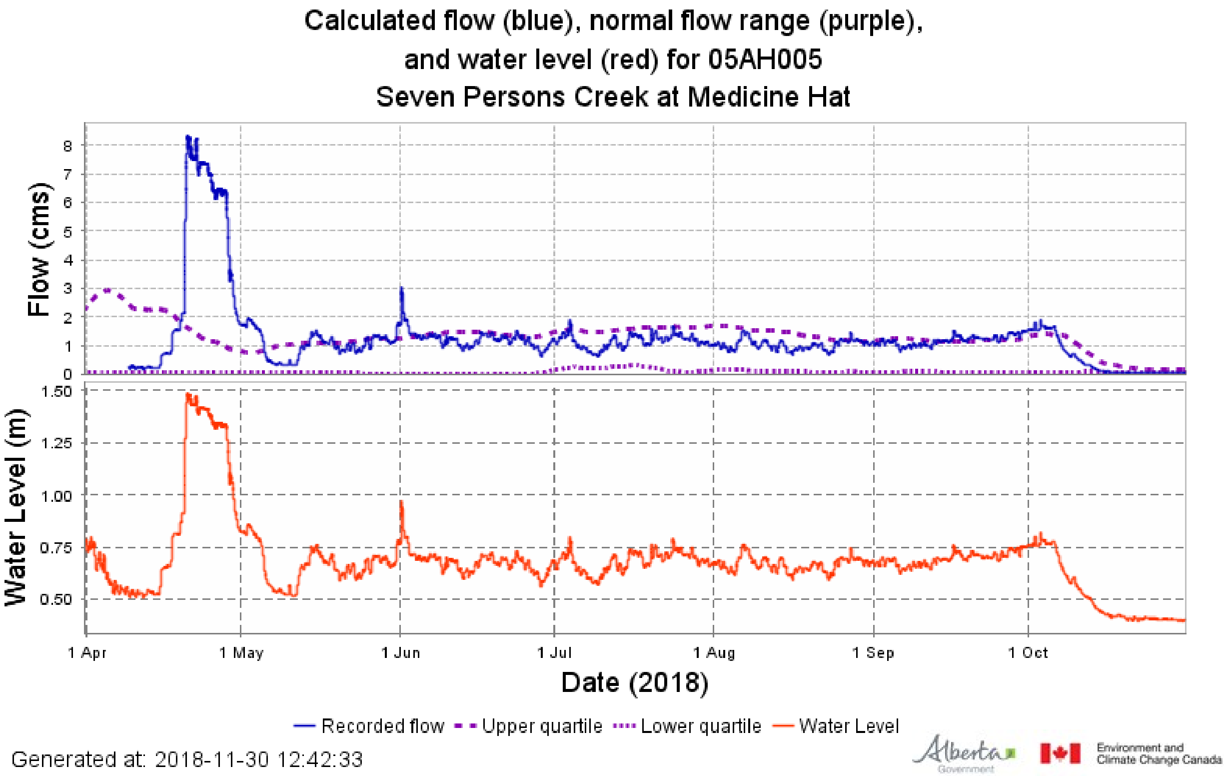

Fig. 21 Recorded flow and water level of Seven Persons Creek in Medicine Hat from 01-Apr-2018 to 31-Oct-2018, retrieved from the Alberta River Basins website, Government of Alberta.

Precipitation (mm), Fig. 22

All sampling dates were not affected by prior rainfall events.

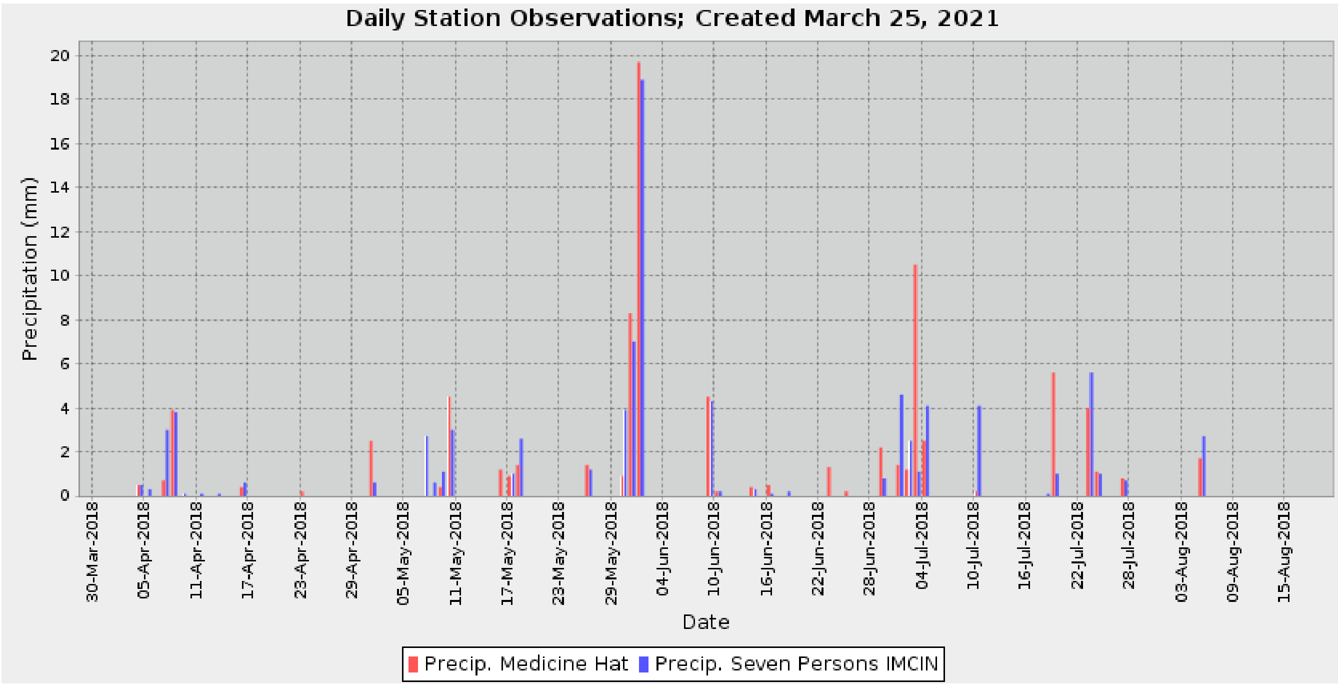

Fig. 22. Precipitation data and graph generated through Current and Historical Alberta Weather Station Data Viewer, https://acis.alberta.ca/weather-data-viewer.jsp

Field measurements

Table 1 Average of Field Variables Measured on 4 Apr at SAS Locations

Location	Temperature (°C)	Conductivity μS/cm	Specific Conductivity μS/cm	TDS mg/L	Salinity parts per thousand	DO % air saturation	DO mg/L	pH	ORP mV
Saamis u/s	-0.15	806	419	524	0.39	103.2	15.1	8.3	-57.1
Saamis d/s	0.45	816.7	433.7	531	0.39	101.7	14.6	8.4	-65.2

At the start of the snow melt, Saamis d/s was slightly warmer than Saamis u/s. Colder water holds more DO; therefore, Saamis u/s had more DO than Saamis d/s. DO values exceeded the minimum value for larval fish development which is 9.5 mg/L. DO % air saturation exceeded 100%. According to YSI 2019, "Dissolved oxygen readings of greater than 100% air saturation can occur in environmental water because of the production of pure oxygen by photosynthetically-active organisms and/or because of non-ideal equilibration of dissolved oxygen between the water and the air above it. In YSI's experience, this "over saturation" is quite common, with photosynthesis being the factor most often responsible for its existence."

Salinity was measured in different ways. Conductivity agreed with those measured in the laboratory with Saamis d/s slightly higher than Saamis u/s. Specific conductivity is conductivity with temperature correction (to 25°C). Contamination from road salt could likely be from stormwater originating from the residential area and light industrial area as well as from the application on paved trails. This slight difference in salinity determined as electrical conductivity was not detected when measured as parts per thousand. However, salinity (.039%) was not an issue since freshwater is defined as having less than 0.05% to less than 1% dissolved salts (New World Encyclopedia).

TDS agreed with the measurements in the laboratory. TDS (mg/L) can be derived from Conductivity (µS/cm) by multiplying it with a constant TDS factor, usually 0.65 (Fondriest Environmental Inc.).

pH was slightly higher by 0.1 to 0.15 unit than what were obtained in the laboratory.

Oxidation reduction potential (ORP) measures the ability of a water body to break down dead plants and animals, and contaminants that may originate from stormwater, municipal or industrial effluents. ORP depends on the amount of DO that is in the water and the amount of other elements that function similar to oxygen. Temperature also affects ORP. Low ORP increases the toxicity of certain metals, and dead plants and animals do not get decomposed. In healthy waters ORP should be between 300 to 500 mV (Environment and Natural Resources, NT).

At the start of the snowmelt, ORP values were negative and were lower at Saamis d/s than at Saamis u/s. Although DO values were acceptable for fish requirements, decomposition of organic matter would not proceed effectively as indicated by negative ORP. This is not unusual early in the season. ORP measurements as the season progressed could have provided more information.

Saamis u/s and d/s

There were notable differences in water quality between the upstream and downstream locations as well as between the start of the snowmelt (April) and late summer (August). Based on bacteria (Figs. 14 and 15), Saamis d/s had better water quality than Saamis u/s throughout the season. At the start of the snowmelt, based on nutrients, Nitrate (Fig. 9), TN (Fig. 10), TKN (Fig. 11) and TDP (Fig. 12), Saamis d/s had better water quality than Saamis u/s. In contrast, based on TSS (Fig. 7), TDS (Fig. 8, Table 1), Cl^- (Fig. 18), Conductivity (Fig. 19, Table 1), DO (Table 1), and ORP (Table 1), the upstream location was of better quality at the start of the snowmelt. By August, concentrations of both TN (Fig. 10) and TKN (Fig. 11) increased at Saamis d/s, and so, Saamis u/s was of better water quality than d/s.

TKN indicates a fresh load of organic N and ammonia, and in this case, coming from upstream of the Saamis d/s location. There could be several potential sources of contamination: pet wastes left on the ground, wildlife wastes (deer, ducks, geese, beaver, muskrats), and stormwater (from residential and light industrial areas) conveyed through the two draws (Fig. 5) that discharge into the Seven Persons Creek.

Usually, nutrient concentrations are expected to decrease as the season progresses as they are being utilized by vegetation. This held true for TN, TKN, TP and TD at the Private land 61km u/s. However, TN and TKN at Saamis d/s showed increases as well as slight increases in TP and TDP at the last sampling in August. There was no precipitation during the days prior to the August sampling (Fig. 22), so surface runoff effect on contaminant transport would have been insignificant.

Highest values of various parameters, except for bacteria and pH, were found during the 4 Apr sampling at these two locations. According to Meyer, 2011, during winter months contaminants accumulate in the snow. When the snow melts, these chemicals are released into the environment at high concentrations. Snow and surface ice in the creek started to melt on 4 Apr. Bacteria usually multiply with warmer temperatures, and at these two locations higher counts were found in August (Figs. 14 and 15).

Changes in pH were minor (not more than 0.5 units as per Guidelines) at these locations. However, higher values occurred after the peak snowmelt around mid-April and a small peak at the beginning of June (Fig. 21). Soil particles, sediments, and other contaminants are readily transported during higher flows and any of these could have contributed to the slight increase in pH.

Private land 61km u/s

The first sample was collected on 29 May 2018, more than a month after the snowmelt period, (Fig. 21). This location had some nutrient issues, but remarkably, TDP was consistently less than 0.05 mg/L throughout the study period (Fig. 12) and TP decreased to below 0.05 mg/L in August (Fig. 13). It is important to note that this location, in contrast to the urban Saamis locations, is surrounded by agricultural land and is directly downstream from Murray Lake. Bacteria counts and pH were higher in July and August than in May. Remarkably, *E. coli* remained below guideline value (Fig. 14) but Fecal Coliform bacteria exceeded the guideline value in July and August. Potential sources of contamination could be wildlife wastes, irrigation water, or livestock operations. The increase in pH in July with a slight decrease in August could not be associated with flows. It is possible that a disturbance occurred that stirred the soil on the creek banks and sediments prior to the July sampling.

Draws

The use of draws to convey stormwater runoff was observed to be an issue. The channel walls of draws had visible erosion and slumping with the downstream draw being the worse of the two. The banks of the Seven Persons Creek where the draws discharge were eroded. In a semi-climate as in Southeastern Alberta, draws have a great importance in maintaining the biodiversity of the grassland ecoregion. Along with riparian areas, draws add to the total of small areas that can support woody vegetation – native shrubs and trees. Their topography allows the accumulation and conservation of limited moisture supply. In addition, shrubs and trees are protected from the physical and drying stress of strong winds. Stormwater flows need additional management to allow practical use and ecological functions to co-exist.

Conclusion

For all locations tested, key water quality issues in Seven Persons Creek were bacteria (*E. coli* and total fecal coliforms) and nutrients (nitrogen and phosphorus). Except for bacteria and pH, highest values of water quality variables occurred at the start of the snowmelt in April. At the SAS, there were differences in water quality between locations depending on the season and a number of variables. In terms of bacteria, the downstream location had better water quality than the upstream location throughout the season. The downstream location also had lower values for nitrate, total nitrogen, total Kjeldahl nitrogen, total phosphorus and total dissolved phosphorus at the start of the snowmelt. In contrast, based on total dissolved and suspended solids, dissolved oxygen, conductivity, chloride and oxidation-reduction potential, the upstream location was of better quality at the start of the snowmelt. By late summer, total N and total Kjeldahl N were lower at the upstream location. Pesticides could not be evaluated detection limits of specific laboratory tests. Creek water should not be used to irrigate crops intended to be eaten raw due to unsafe levels of fecal coliform and *E. coli* bacteria.

Recommendations

Improvement in water quality is one of the expected outcomes of riparian restoration. Therefore, it is recommended that: a) Test water quality again at the SAS and Private land locations in 3-5 years. Any major disturbance(s) or new improvements to the creek or creek flow, riparian areas, and draws.

Seven Persons Creek is being used for recreation by the public (kayaking, canoeing, dogs playing or cooling off). Water may be tested to provide guidance to users, especially on bacteria concentrations for aesthetics and recreation.

Stormwater conveyance through draws should be provided with structures that dissipate and reduce the combined eroding energy of stormwater and surface runoff before discharging into Seven Persons Creek.

Stakeholder education about water quality in relation to maintaining healthy riparian areas should be continued through various SEAWA communication tools and stewardship projects. These should include recreation management in riparian areas, planting of native shrubs and trees where needed, and invasive plant management. In addition, urban stormwater awareness should be promoted (for example, a virtual version of the Yellow Fish Road initiative may be developed), as well as beneficial management practices for golf courses.

References

Alberta Environment. 2003. A Summary of Pesticide Residue Data from the Alberta Treated Water Survey, 1995 - 2003. Available from https://open.alberta.ca/publications/0778522865

Alberta Environment and Parks. (2018). Trophic condition of Alberta lakes, all years. Surface Water Quality Data. Available from https://www.alberta.ca/surface-water-quality-data.aspx

Anonymous. 2018. Trophic Status overview. Science Direct, Elsevier. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/trophic-status accessed February 16, 2021.

Basiuk, M., Brown, R. A., Cartwright, D., Davison, R. and Wallis, P. M. 2017. Trace organic compounds in rivers, streams, and wastewater in southeastern Alberta, Canada. Inland Waters, 7(3): 283-296. Available from https://www.tandfonline.com/doi/abs/10.1080/20442041.2017.1329908?journalCode=tinw20

Canadian Council of Ministers of the Environment. 2004. Canadian water quality guidelines for the protection of aquatic life: Phosphorus: Canadian Guidance Framework for the Management of Freshwater Systems. In: Canadian environmental quality guidelines, 2004, Canadian Council of Ministers of the Environment, Winnipeg. http://ceqg-rcqe.ccme.ca/download/en/205

Canadian Council of Ministers of the Environment, 2016. Guidance Manual for Developing Nutrient Guidelines for Rivers and Streams. https://www.ccme.ca/files/Resources/water/water_nutrients/Guidance%20Manual%20For%20Developing%20Nutrient%20Guidelines%20for%20Rivers%20and%20Streams.pdf

Canadian Council of Ministers of the Environment. 2010. Canadian water quality guidelines for the protection of aquatic life: Ammonia. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. http://ceqg-rcqe.ccme.ca/download/en/141

Dosskey, M. G., Vidon, P., Gurwick, N. P., Allan, C. G., Duval, T. P., and Lawrence, R., 2010. The role of riparian vegetation in protecting and improving chemical water quality in streams. Journal of the American Water Resources Association, 46(2): 261-277.

Environment and Natural Resources, Government of Northwest Territories. Oxidation-Reduction Potential (ORP), Factsheet. Available from: https://www.enr.gov.nt.ca/sites/enr/files/oxidation-reduction_potential.pdf

Environment and Natural Resources, Government of Northwest Territories. Dissolved Oxygen, Factsheet. Available from: https://www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf

Fondriest Environmental Inc. Conductivity, salinity, and total dissolved solids. Fondriest Environmental Learning Centre. Available from: https://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/

Giacalone, K., Mobley, C., Sawyer, C., Witte, J. and Eidson, G. 2010. Survey says: Implication of a public perception survey on stormwater education programming. Journal of Contemporary Water Research & Education, 146: 92-102. Available from https://www.researchgate.net/publication/227628204_Survey_Says_Implications_of_a_Public_Perception_Survey_on_Stormwater_Education_Programming

Government of Alberta. (2018). Calculated flow (blue), normal range flow (purple), and water level (red) for 05AH005 Seven Persons Creek at Medicine Hat. *Alberta River Basins*. Available from https://rivers.alberta.ca/. Accessed November 2019.

Government of Alberta. 2018. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Alberta Environment and Parks. Edmonton, Alberta. Available from https://open.alberta.ca/publications/9781460138731

Hyland, R., Byrne, J., Selinger, B., Graham, T., Thomas, J., Townshend, I., and Gannon, V. 2003. Spatial and temporal distribution of fecal indicator bacteria within the Oldman river basin of southern Alberta, Canada. Water Quality Research Journal of Canada, 38(1): 15-32. Available from https://www.researchgate.net/publication/242591785_Spatial_and_Temporal_Distribution_of_Fecal_Indicator_Bacteria_within_the_Oldman_River_Basin_of_Southern_Alberta_Canada

Jain, K. J. and Singh, S. 2019. Best management practices for agricultural nonpoint source pollution: Policy interventions and way forward. World Water Policy, 5:207228. Available from https://www.researchgate.net/publication/337626591_Best_management_practices_for_agricultural_nonpoint_source_pollution_Policy_interventions_and_way_forward

Mallin, M., and Wheeler, T. 2000. Nutrient and fecal coliform discharge from coastal North Carolina golf courses. JEQ 29(3): 979-986. Available from https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/jeq2000.00472425002900030037x

Masoner, J. R., Kolpin, D. W., Cozzarelli, I. M., Barber, L. B., Burden, D. S., Foreman, W. T., Forshay, K. J., Furlong, E. T., Groves, J. F., Hladik, M. L., Hopton, M. E., Jaeschke, J. B., Keefe, S. H., Krabbenhoft, D. P., Lowrance, R., Romanok, K. M., Rus, D. L., Selbig, W. R., Williams, B. H., Bradley, P. M. 2019. Urban Stormwater: An overlooked pathway of extensive mixed contaminants to surface and groundwaters in the United States. Environmental Science and Technology, 53: 10070-10081. Available from https://pubs.acs.org/doi/10.1021/acs.est.9b02867

Meyer, T. 2011. Melting snow reveals high concentration of harmful pollutants. https://environment.utoronto.ca/melting-snow-reveals-high-concentration-of-harmful-pollutants/ . Accessed December 20, 2020.

Meyer, T. 2011. Dark side of spring? Pollution in our melting snow. Science Daily, 28 March 2011. <www.sciencedaily.com/releases/2011/03/110328162031.htm>. Accessed December 20, 2020.

Miller, J., Foroud, N., Hill, B., and Lindwall, C. 1995. Herbicides in surface runoff and groundwater under surface irrigation in southern Alberta. Can. J. Soil. Sci. 75(1): 145-148. Available from https://cdnsciencepub.com/doi/abs/10.4141/cjss95-018

Miller, J., Handerek, B., Beasley, B., Olson, E., Yanke, L., Larney, F., McAllister, T., Olson, B., Selinger, B., Chanasyk, D., and Hasselback, P. 2004. Quantity and quality of runoff from a beef cattle feedlot in southern Alberta. JEQ 33(3): 1088-1097. Available from https://acsess.onlinelibrary.wiley.com/doi/10.2134/jeq2004.1088

New World Encyclopedia. Freshwater. Available from: https://www.newworldencyclopedia.org/entry/Freshwater

Northwest Hydraulic Consultants Ltd., 2019. Medicine Hat River Hazard Study Open Water Hydrology Assessment Report – draft submitted to Alberta Environment and Parks https://www.alberta.ca/assets/documents/aep-draft-medicine-hat-open-water-hydrology-report.pdf; accessed December 20, 2020 (Document temporarily unavailable).

Public Health Agency of Canada. (2016). Infographic: Food-related illnesses, hospitalizations and deaths in Canada. Publications – Food and nutrition. Available from https://www.canada.ca/en/public-health/services/publications/food-nutrition/infographic-food-related-illnesses-hospitalizations-deaths-in-canada.htmL. Accessed December 20, 2020.

Selvakumar, A. and Borst, M. 2006. Variations in microorganism concentrations in urban stormwater runoff with land use and seasons. Journal of Water and Health, 4(1): 109-124. Available from https://www.researchgate.net/publication/325222525_Variation_of_microorganism_concentrations_in_urban_stormwater_runoff_with_land_use_and_seasons

Sheedy, C., Kromrey, N., Nilsson, D. and Armitage, T. 2019. From peaks to prairies: a time-of-travel synoptic survey of pesticides in watersheds of southern Alberta, Canada. Inland Waters, 9(4): 438-452. Available from https://www.researchgate.net/publication/336192099_From_peaks_to_prairies_a_time-of-travel_synoptic_survey_of_pesticides_in_watersheds_of_southern_Alberta_Canada

Salgot, M and Tapias, J. C. 2006. Golf courses: Environmental Impacts. Tourism and Hospitality Research, 6(3): 216-226. Available from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.872.8364&rep=rep1&type=pdf

Grant, S. B., Rekhi, n. V., Pise, N. R. and Reeves, R. L. 2003. A Review of the Contaminants and Toxicity Associated with Particles in Stormwater Runoff. A Report prepared for: California Department of Transportation 1120 N Street Sacramento, CA 95826. 172 pp. Available from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.638.8477&rep=rep1&type=pdf

Turnbull, B., and Ryan, M. 2012. Decadal and seasonal water quality trends downstream of urban and rural areas in southern Alberta rivers. Water Qual. Res. J. Can. 47(3-4): 406-420. Available from https://iwaponline.com/wqrj/article/47/3-4/406/31444/Decadal-and-seasonal-water-quality-trends

YSI Inc. / Xylem Inc. 2019. Environmental dissolved oxygen – Values greater than 100% air saturation, Technical Note T602-01, 1700/1725 Brannum Lane Yellow Springs, OH 45387. Available from: https://www.ysi.com/file%20library/documents/technical%20notes/t602-environmental-dissolved-oxygen-values-above-100-percent-air-saturation.pdf

YSI Inc. /Xylem Inc. 2021. ORP/Redox parameter. 1700/1725 Brannum Lane Yellow Springs, OH 45387. Available from: https://www.ysi.com/parameters/orp-redox