Improving Water Quality by Improving Watershed Health

by

The Swift Current Creek Watershed Stewards

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1.0 Introduction

One of the most critical and influential sources of the semi-arid prairie region of the Southwest Saskatchewan landscape is the availability of freshwater. Freshwater is further influenced by its surrounding landscape, or watershed, in ways that can both negatively affect water quality or provide beneficial outcomes. A watershed is an area of drainage which is divided apart from other drainage areas according to the direction of flow from precipitation and run-off (SCCWS 2018). A watershed may be large or small in total area but the water in that particular region will all flow towards one common direction. These can also encompass tributary or secondary flows such as small streams and creeks that flow into larger systems such as rivers, and in some cases underground water sources such as aquifers.

Water, in any of its physical forms, will be influenced throughout its cycle by contaminants such as sedimentation, chemicals, and various pollutants. This may cause concern about the quality and safety of the water when used for irrigation, livestock, recreation, or other general uses and human consumption. It can also be a concern for the aquatic organisms and wildlife that depend on watershed areas for life cycles, habitat, and forage. Since water is consumed in colossal amounts with a variety of uses all users want to be sure that the water is safe, dependable, and the health of the watershed it comes from is healthy and functioning to keep water quality at acceptable levels. Watershed function turns to an assortment of factors such as soils, hydrology, vegetation, diversity, and even fauna.

The purpose of this project was to determine, based on previous data collected in a series of monitoring projects on the Swift Current Creek (SCC) by the Swift Current Creek Watershed Stewards (SCCWS), if there is a point between the City of Swift Current, SK and the Village of Waldeck , SK where water quality degrades or is negatively impacted. Since initial projects started in 2004 SCCWS has conducted a series of biomonitoring and water quality monitoring projects all aimed at answering the question, “Is the SCC and watershed health acceptable, being maintained, or degrading?” The Swift Current Creek Monitoring Projects (SCCMP) have looked at the water quality, flows, riparian health, fish populations and diversity, and benthic macroinvertebrate populations from 2004-2007, 2013, and 2017. In 2006 it was identified that water quality showed abnormalities between a stretch of monitoring sites, and in 2017 this was also the case, which prompted SCCWS to investigate this area of the SCC further in 2018.

1.1 Background information

a.) The Swift Current Creek Watershed Stewards

Officially formed in 2001, Swift Current Creek Watershed Stewards Incorporated was composed of stakeholders in a non-profit, non-governmental organization driven to achieve three main goals:

1. To Educate users of the SCCW on a continuous basis about issues and impacts that affect water quality;
2. Monitor water quality and riparian health to assist in co-operative solutions regarding water management; and
3. Foster an attitude of individual responsibility towards watershed stewardship.

These goals all pertain to the SCCWS mission statement, "To enhance water quality and stream health of the SCCW by promoting awareness and understanding among water users." This mission statement was put into place in the early beginnings of SCCWS and since 2004 monitoring projects along the entirety of the SCC have been done to identify or address any issues that may be having negative impacts on the SCC.

In addition to these projects SCCWS has also partnered with the Water Security Agency (WSA), which was formally known as the Saskatchewan Watershed Authority (SWA), in 2007 to compile a Source Water Protection Plan (SWPP) for the SCC. This was released in 2009 and continues to be the focal point of projects planned by SCCWS. Since 2007 SCCWS has been involved in the promotion and delivery of Beneficial Management Practices (BMP's) which mitigate negative impacts from agriculture in Saskatchewan through the Ministry of Agriculture (MoA) and the Government of Canada. Funding available through Growing Forward I and II and now the Canadian Agricultural Partnership (CAP) allow SCCWS to work with producers in the SCCW area to help them apply for funding under the Farm Stewardship (FSP) and Farm and Ranch Water Infrastructure (FRWIP) Programs to implement these BMPs.

These funding projects help mitigate the agricultural affects on the SCC; therefore aid in the goals of SCCWS. The development of monitoring projects has also helped SCCWS reach the public and industry in addition to agricultural sectors and helped them to understand and be aware of the dependence on the SCC in this region. This has created increased interest in the overall health of the watershed and a desire to maintain or improve its various functions.

b.) Monitoring projects

Since the pioneering monitoring projects of 2004-2007 SCCWS has followed set protocols established from this three-year study to continue looking at any changes or issues that may be affecting the SCC and water quality. These projects have encompassed the entire watershed and included water quality, flow, riparian health, fish populations and diversity, and benthic macroinvertebrate surveys. At the end of the three years it was not only a benchmark set for the overall look of the SCC, but also was found that the creek was in good health with various issues that did arise in the final conclusions.

In 2013 a comparative study was done to assess if the operation of the City of Swift Current's Waste Water Treatment Plant (WWTP) was effective in improving water quality downstream. The plant was built and began operation in 2006 (City of Swift Current 2018). This was a small-scale project using two sites, one upstream and one downstream of the WWTP, to compare results in all aspects of the project. The conclusions of this project showed that the plant's operation did not have any outstanding ill effects on the creek, and that downstream water quality and fish and benthic macroinvertebrate populations were in better health than upstream of the plant.

In 2017 a successor project to the 2004-2007 monitoring was established to see if the health of the creek had improved, been maintained, or degraded over the last ten years. Sites used in the original study were selected to be sampled. Protocols used in 2004 were again used in this comparative study, with minor changes due to changes in technology and methodology. This study found that the SCC presented similar issues to that of the 2004-2007 project, but with overall good health. Certain sections of the SCC are presenting as degrading and SCCWS is looking to find any outstanding issues or sources that may be causing this in the 2018 project.

1.2 The Swift Current Creek Watershed- Site description

The SCCW encompasses an area of approximately 5,592 km² and is the largest tributary to the South Saskatchewan River with a mainstream length of 302 km (MacKeil [Agriculture and Agri-Food Canada (AAFC) Prairie Farm Rehabilitation Administration (PFRA) 2005 as cited by SCCWS 2008). The headwaters are located near the Cypress Hills northeast of Eastend, SK and the creek is fed into by three smaller tributaries: Bone, Jones, and Rock Creeks. The SCC also includes resorts, villages, a major reservoir, Duncarin Dam (Figure 1), and a regional park upstream of the City of Swift Current.

Figure 1. Spillway at Duncarin Dam Reservoir

Once downstream of the city's weir the creek flows northward through the village of Waldeck and continues, dropping drastically in elevation, to the mouth which empties into the South Saskatchewan River near Stewart Valley, SK, as shown in Figure 2. The SCCW falls into the prairie eco-zone with characteristics such as open grasslands, semiarid climate, little topographic relief, low rainfall/precipitation and long, hot summers and cold, dry winters. The summer of 2018 was again hot and dry similar to 2017 with averages and total rainfall shown in Table 1.

The creek flows through a variety of land uses which includes in vast majority agricultural land (crop, hay, and pasture), urban areas, recreational areas, industry such as oil and gas, and also contributes to the Highfield Dam Reservoir by a series of canals that can contribute to the Rush Lake flood irrigation areas.

Figure 2. Mouth of the SCC emptying into the South Saskatchewan River

Table 1. Average weather conditions in Swift Current, SK in the summer of 2018

Average weather data in Swift Current, SK in summer of 2018					
Month	**Average high (°C)**	**Average low (°C)**	**# days over 30°C**	**Rainfall (mm)**	**Evaporation (mm)**
June	24	10.2	2	16.9	273.5
July	26.1	11.5	8	51.2	284.7
August	16.8	10.9	12	31	283
September	14.4	4.1	0	41.6	133.6

Information provided by L Nimegeers [Agriculture and Agri-Food Canada Swift Current Research and Development Centre] in email document to D Peters dated January 8, 2019 16:24; (unreferenced, see Acknowledgments).

1.3 Reach scale

Monitoring sites were pre-determined from the 2017 project, as well as two sites that were decided to be re-visited from the projects in 2006. All sites were downstream of the city of Swift Current and ended north of the village of Waldeck (Figures 3 and 4). Four sites were chosen by SCCWS to try and determine possible causes of degraded water quality that was found in 2017, especially at site I80, which was the last site north of Waldeck. Other site options were explored but in terms of accessibility and location they were not utilized.

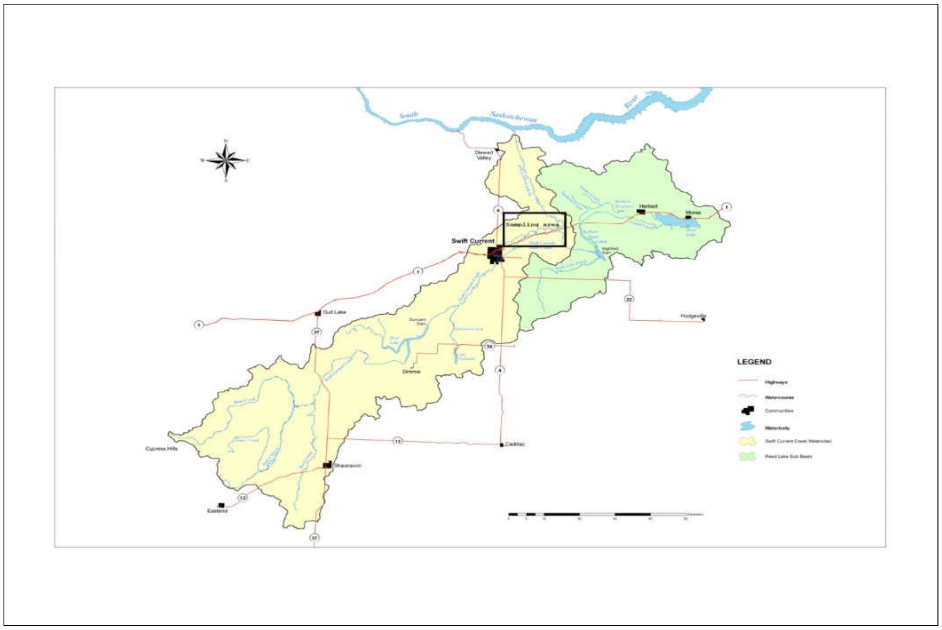

Figure 3. Map of the Swift Current Creek Watershed

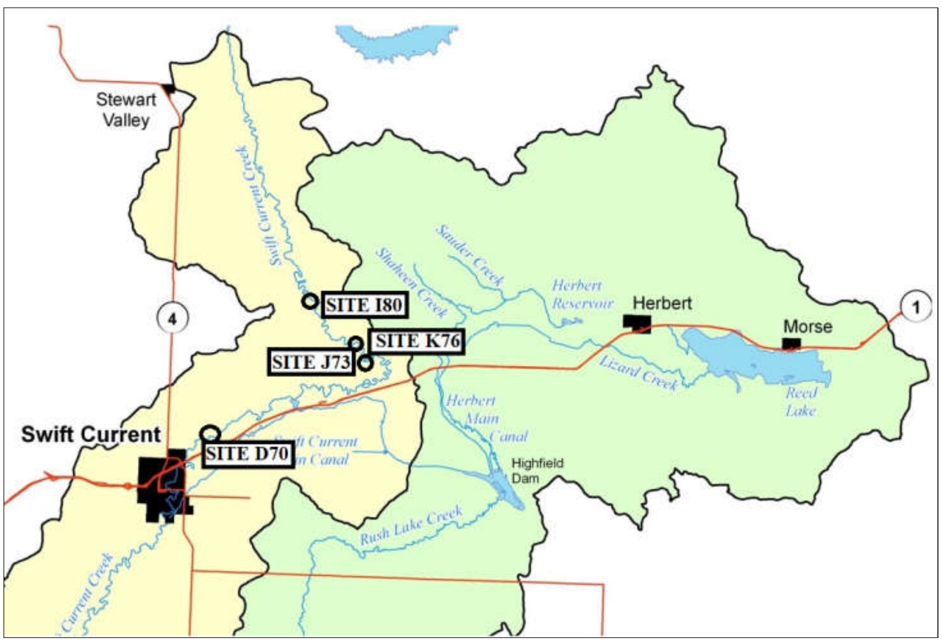

Figure 4. Four monitoring sites of 2018 project east of Swift Current

Tables 2 and 3 are summaries of the average elevation, depth, and wetted width for each site sampled in 2018 over the four-month sampling period. It is also important to note that the years of 2017 and 2018 were in drought with very little precipitation and high summer temperatures. The flow rates were averaged monthly and taken from June.24th, 2018 at 0.5 cubic meters per second, July 26th, 2018 at 0.32 cubic meters per second, August 29th, 2018 at 1.0 cubic meters per second, and September 25th, 2018 at 1.02 cubic meters per second (Flow rates provided by B Schafer [Agriculture and Agri-Food Canada Water Infrastructure Division] in email document to D Peters dated January 15, 2019 15:22; unreferenced, see acknowledgments).

Table 2. Site descriptions of the 2018 monitoring sites downstream of the City of Swift Current

Descriptions of monitoring sites on the Swift Current Creek summer 2018 downstream of the city of Swift Current				
Sites	**D70**	**J73**	**K76**	**I80**
GPS location	N 50°19.513' W 107°44.641'	N 50°22.05.40'' W 107°36'31.58''	N 50°22.290' W 107°36.661'	N 50°24.394' W 107°35.309'
Elevation (m)	732	724	724	709
Average depth (m)	0.47	0.48	0.3	0.53

Table 3. Average wetted widths of Swift Current Creek summer 2018 downstream of the city of Swift Current

Average wetted width (m) of bank sin Swift Current Creek summer 2018					
Site	**June**	**July**	**August**	**September**	**Overall**
D70	14	14	13.7	14.3	14
J73*	14.5	11.9	11.6	12.8	12.7
K76	7.9	8.5	7.34	8.2	8
I80	16.8	16.8	13.1	15.8	15.8

*Field measurements after June were taken slightly downstream due to high water level

1.4 Plausible point and non-point stressors

In 2007 the stressors that were identified as affecting the SCC were contributed to the various land uses in the watershed. Sources such as industry in oil and gas development, livestock production and agricultural lands for annual crop and hay production, irrigation, and recreation were identified as a few of the possibilities throughout the entire watershed. In terms of the degrading water quality pattern seen downstream of the city of Swift Current and north Waldeck it was speculated that irrigation run-off, agricultural run-off, and lagoon effluent may be affecting the quality through the stretch east of Swift Current and flowing past Waldeck to the north. In addition to these, other non-point sources may include the multiple Canadian Pacific Railway (CPR) weirs and dams, and the Duncairn Dam reservoir.

1.5 Riparian areas and health

Riparian areas are the transitional points along a waterbody or watercourse where aquatic or "more wet" meets terrestrial or "more dry" uplands. The soil, vegetation, and water interact in variation to define the riparian area (Saskatchewan PCAP Greencover Committee 2008). There are three common defining features to all riparian areas according to PCAP Greencover Committee (2008):

1. The combined presence and abundance of water (either surface or shallow underground);
2. Vegetation present requires and survives in various abundances of water; and
3. The soils are often modified by the abundance of water (such as high water tables), stream processes, and the lush vegetated areas.

A healthy functioning riparian area preforms many key ecological functions:

- Trap sediment
- Build and maintain streambanks
- Store floodwater and energy
- Recharge the aquifer
- Filter and buffer water
- Reduce and dissipate stream energy
- Maintain biodiversity
- Create primary productivity

These functions, according to PCAP Greencover Committee (2008), offer resiliency, ecological services, and stability. If the health is degraded due to human or natural causes, one or more of the functions will become impaired and ultimately affect what remains.

An Riparian Health Assessment (RHA) is a key component to the overall observation of the health of a river, creek, or waterbody. According to the PCAP Greencover Committee (2008), the term "health" refers to the impression that something is functioning or performing properly and at optimal conditions. If an area is deemed "unhealthy" there are issues or problems that affect the function or performance and would need to be mitigated before attempting to return the area to normal. Incorporating health assessments into a water quality project helps analyze the areas of degrading water quality.

Areas showing degraded water quality in the SCCMP 2018 project included downstream of the City of Swift Current and within the limits of the Village of Waldeck. The assessments help to determine if the riparian areas along the entirety of the SCC are functioning at proper levels. This would indicate if there are issues or problems on a larger scale that might need to be mitigated Each monitoring site only provides a snapshot in the entirety of the watershed but certain indictors found at each site may help point to previous or existing problems that may be affecting the overall health and function of the riparian areas. This would adversely affect water quality as riparian areas play important roles directly related to the quality of water.

RHAs are scored based on a series of twelve questions that encompass both vegetation and soils and hydrology. Seven of these refer to vegetation composition, density, and species present, and the remaining five refer to the soils and hydrology (channel incisement, exposed soils, streambank alterations, and flood events). There are three categories in scoring overall riparian health:

- <60% unhealthy and non-functional
- 60-79% healthy with problems (functioning at risk)
- 80-100% healthy (proper functioning)

The totals for both sections of vegetation and soils and hydrology help to determine the health of each of these areas, and the overall total score for the entire reach assessed sums up the health of the site. Vegetation scores total 33 points and soils and hydrology total 30 points, for a grand total of 63 points possible for the entire assessment. Vegetation totals can be modified to not include the presence of woody species (trees and/or shrubs) if none are present at the site.

Riparian areas demand attention as they are important to the benefits of agriculture, biodiversity, and can also represent concerns for water quality (Saskatchewan PCAP Greencover Committee 2008). The various functions provided and assessed in the RHA do not provide an in-depth look at the entire watershed riparian areas, but will help to provide critical informational points along the Swift Current Creek, and if further investigation may be required.

1.6 Water quality

The health of a water body can be determined by numerous indicators. One of which SCCWS has used for all the monitoring projects is water quality; both physical and chemical parameters. Sample results are then used to determine a Water Quality Index (WQI) in which the "health" range is scored based on set limits. WQI's for irrigation, livestock water, aquatic life and wildlife, and general use have been used in the previous monitoring projects with various results from poor to excellent. SCCWS has developed written protocols for these samples and by recommendations, have established a system in which both physical and chemical parameters can be assed at each site being monitored.

2.0 Methods and materials

2.1 Site assessments- riparian health assessment methodology

Assessments were completed using the *Riparian Health Assessment-Streams and Small Rivers Protocols* composed by the Saskatchewan Prairie Conservation Action Plan (PCAP) Greencover Committee (2008). This manual of protocols was adapted from an original document titled the *Cows and Fish Program: Riparian Health Assessment for Streams and Small Rivers* by the Alberta Riparian Habitat Management Society. Before 2008 RHAs were conducted using this field workbook. Since 2008 and the publication of the PCAP Greencover Committee field workbook all RHAs conducted since have used this protocol. For more detailed information on the assessment process please refer to Appendix 1.

All RHAs were completed in late August of 2018. At each of the four monitoring sites a 200 m reach was determined 100 m upstream and 100 m downstream of the site hub. The 200 m reach was measured using a Westward® 100 m/330 ft. measuring tape. RHAs were conducted by walking the entirety of the sample reach and noting plant species, densities, woody species, evidence of erosion, bare ground, alterations, and the condition of the creek banks as according to the field workbook. Scores were then totalled at the end of the reach walk and then converted to percentages to classify the reach as healthy, healthy with problems, or unhealthy. Picture documentation was also a part of the RHAs, as seen in Figure 5.

Figure 5. Walking and measuring the 200 m reach at site K76

2.2 Water quality assessment

a.) Water samples

Water samples were taken once a month from the end of June until the end of September 2018. Sampling times were kept to the same period of dates each month to keep timing consistent. The four sites and five month sampling period totalled 20 samples. Sites were chosen based on the 2017 and 2004-2007 projects, as well as accessibility and depth of the creek.

Samples were collected using standard grab sample protocol. Two types of sampling containers were used: a 1-Litre plastic and a preserved sterile bacteria sample bottle, as seen in Figure 6. These were provided by the Provincial Disease Control Laboratory (now the Roy Romanow Provincial Laboratory) in Regina, SK. Samples were taken at the site hub by wading into the center of the creek flow. The collector faced upstream to avoid debris entering the sample bottle. For the non-sterile samples, the bottle was partially filled, capped, shaken, and discarded downstream for a total of three times to thoroughly rinse the bottle. The final sample was taken by filling the bottle approximately 20 cm below the surface and then capped securely underwater. Bacteria sampling was done with a partial sample from the 1 L bottle, without any rinsing due to the preservative already contained. The collector was careful not to touch the inside of either bottle or caps to avoid contamination, especially with the sterilized bacteria bottle. Bacteria samples were placed in a protective container after being securely capped for shipping. Both samples from each site were placed in large Ziploc® bags labelled with time, date, and site. Immediately after sampling was completed bottles were placed in a cooler with ice packs. Reference numbers and chemical requisition forms were also provided by the lab and each sample was labelled with a corresponding reference number for analysis. Field data such as time samples were taken, weather, and water and air temperature were also recorded on field sheets with parameter readings.

Samples were shipped to the lab for analysis on the same day they were taken as many are time critical tests. Preparation for shipping was ensuring all bottles and bags were securely shut to eliminate leaking of water samples, and fresh ice packs were placed around the samples and covered with newspaper to ensure the temperature of the cooler stayed consistently cool. The chemical requisitions forms were completed, dated, signed, and also placed in a separate Ziploc® bag to avoid water damage if leaks occurred while in transit. These were placed on top of the newspaper in the cooler and then taped securely shut. The cooler was not only labelled for transit by courier, but also “time critical water samples” and “keep cool” stickers. Delivery was always indicated for the next day as early as possible.

Quality control protocols at the lab includes testing blanks with high purity water and random samples that are tested in duplicates for a set number of samples. This will not only confirm sample to sample variation, but the lab also tests control samples of known concentrations made in house to verify sample concentrations are measured correctly (P Bailey [Roy Romanow Provincial Laboratory], in email document to D Peters dated June 2, 2017 11:16 AM; unreferenced, see Acknowledgments). The same lab was also used in the 2017 sampling to keep quality control and protocols consistent.

Figure 6. Sample bottles provided by the Roy Romanow Provincial Lab

b.) Water parameters

In addition to time, weather, and water and air temperatures taken at each site during sampling, standard water parameters were also measured directly in the creek. These included dissolved oxygen [DO in (mg/L)], pH (pH units), and conductivity (µS/cm). Water temperature, DO, and pH were measured using a Thermo Scientific Orion RDO® meter with an optical dissolved oxygen sensor and a ROSS Ultra®, ROSS Ultra Triode™, ROSS®, and PerpHecT® ROSS pH electrode. Due to the time expiration of the optical DO sensor, DO could no longer be measured after July. To obtain accurate and calibrated readings, the Thermo Scientific Orion RDO® meter was programmed to read water temperature, DO, and pH all at once. Calibration for the RDO® optical DO sensor included an air saturation calibration in the storage sleeve with a moistened sponge (distilled water was used to moisten the sponge if dry). To take readings the sensor was removed from the protective storage sleeve and a heavier, metal protective cover was placed on the end to allow the sensor to sink into the water while protecting the delicate sensor. pH was calibrated on the ROSS® electrode by using two buffer solutions of 10.00 and 7.00 pH units respectively. The electrode was transported in a protective case with storage solution. To take readings the storage case was removed and the electrode was carefully placed in the water since it has no protective casing. Readings for both DO and pH were taken at an approximate depth of 10-15 cm below the water surface. Calibrations and troubleshooting were followed from the user manual, and the meter was shut off and placed back in the protective case after each sampling, as were the RDO® sensor and ROSS® electrode after both being rinsed with distilled water.

Conductivity was measured in June and July using a YSI EcoSense® EC300 portable conductivity, salinity, and temperature meter. This meter was on loan from the WSA in Swift Current until it became unreliable. August and September readings were taken using a EC YSI Pro30 conductivity meter on loan from the Ministry of Agriculture (MoA) in Swift Current. This meter could be programmed to adjust conductivity readings to water temperature and the probe required no calibration or protective storage casings. Readings were taken at the same depth as DO and pH and the user guide was followed for readings and troubleshooting. The probe was rinsed with distilled water after each use and the unit turned off and placed back in the protective case.

Each parameter was taken a total of three times at each site for each sample date. Readings were taken at right bank, center, and left bank and then averaged. To determine bank sides the collector faced downstream and made sure all the probes from each meter stayed at the same depth and stabilized before taking the final reading.

3.0 Results and discussion

3.1 Site assessments - riparian health assessment

a. Site assessments - riparian health assessment at D70

Site D70 was assessed for riparian health in 2004, 2013, and in 2017. The site features a single-family dwelling along the creek and is the first site downstream of the City of Swift Current and the WWTP. This site in the past, as well as presently, has had issues with lateral cutting, a partially decommissioned low-level crossing, culvert installation, and unstable banks and erosion. These issues all occur just upstream of the reach assessed in 2017 and 2018 but were likely included in the reaches assessed in 2004 and 2013. A small number of horses are present and often cross the creek into adjacent pastureland in a shallow crossing area downstream in the reach. Corrals and open access for horses are also located near the downstream end of the reach. The site was assessed on August 22, 2018. Figures 7 and 8 following show the upstream and downstream view of the 200 m reach assessed in 2018.

Figure 7. Site D70 facing downstream at the center of the 200 m assessment reach

Figure 8. Site D70 facing upstream. Active lateral cutting and erosion is present upstream

Vegetation at the site scored an overall 66%, which was similar to 2017 at 64%. The low scores may indicate that there are issues with the vegetation diversity and developing a lack of deep rooted and soil binding plants. Invasive species such as Common Burdock *(Arctium minus)* pictured in Figure 9 and Common Tansy *(Tanacetum vulgare)* are increasing in density and spreading in one portion of the reach. Other invasive species such as Crested Wheat Grass *(Agropyron cristatum),* Absinthe *(Artemesia absinthium,)* and Smooth Brome *(Bromus inermis)* are also well established, and do not provide the proper root binding masses to stabilize the banks. In addition to not providing stability in protecting against erosion these species also will displace native vegetation and degrade the habitat and diversity of the site (PCAP Greencover Committee 2008). Vegetation cover for the entire reach was full and right to the waters' edge in many places, and the presence of deep rooted and soil binding species were still abundant despite the increasing presence of invasive and disturbance indictor species. Though the section of reach where these species were most dense was only a portion, the invaders will continue to spread and indicate that this site is problematic in its function.

Native and desirable woody species and forbs were observed in this reach and included an abundance of willows *(Salix spp.)* and Wolf Willow *(Elaeagnus commutate)* , Red-Osier Dogwood *(Cornus stolonifera),* Chokecherry *(Prunus virginiana),* Cattails (*Typha latifolia),* Seaside Buttercup *(Ranunculus cymbalaria* Pursh*.),* Marsh Hedge Nettle *(Stachys palustris),* and Wild Mint *(Mentha arvensis).* In total 48 species were observed and a full list is included in Table 4. It is important to keep in mind for all sites that this is only a small section and many other species were also likely present in addition to the documented tables following each site assessment.

Figure 9. Common Burdock at site D70

Table 4. Type and species of riparian vegetation found at site D70 August 22, 2018

Vegetation type	Latin name	Common name
Preferred trees and shrubs		
	Acer negundo	Manitoba Maple
	Amelanchier alnifolia	Saskatoon
	Cornus stolonifera	Red Osier Dogwood
	Elaeagnus commutata	Wolf Willow
	Populus deltoides	Cottonwood
	Prunus virginiana	Chokecherry
	Ribes oxyacanthoides	Northern Gooseberry
	Salix spp.	Willow
	Sambucus racemose L.	Red Elder
Non-preferred trees and shrubs		
	Rosa woodsii	Wood's Rose
	Symphoricarpos occidentalis	Western Snowberry
Invasive species		
	Agropyron cristatum	Crested Wheat Grass
	Arctium minus	Common Burdock
	Artemesia absinthium	Absinth
	Bromus inermis	Smooth Brome
	Cirsium arvense	Canada Thistle
	Tanacetum vulgare	Common Tansy
Disturbance-increaser undesirable herbaceous species		
	Brassica kaber	Wild Mustard
	Convulvulus sepium	Bindweed
	Chenopodium album	Lamb's quarters
	Descurainia sophia	Flixweed
	Hordeum jubatum	Foxtail Barley
	Medicago lupulina	Black medic
	Melilotus alba	Sweet White Clover
	Phalaris arundinacea	Reed Canary Grass
	Plantago spp.	Plantain
	Sonchus arvensis	Perennial Sow Thistle
	Taraxacum officinale	Dandelion
	Thalpsi arvense	Stinkweed
	Trifolium pratense	Clovers
	Urtica dioica	Stinging Nettle
Native graminoids		
	Carex spp.	Sedge spp.
	Equisetum hyemale	Common Scouring Rush
	Glyceria striata	Fowl Manna Grass
	Juncus balticus	Baltic Rush
	Typha latifolia	Cattails
	Scirpus validus	Great Bulrush
	Equisetum arvense	Common Horsetail
Native forbs		
	Artemesia frigida	Pasture Sage
	Artemesia ludoviciana	Prairie Sage
	Aster spp.	Aster
	Erigeron caespitosus Nutt.	Tufted fleabane
	Gaillardia aristata	Gaillardia
	Helianthus spp.	Sunflower
	Mentha arvensis	Wild Mint
	Rumex occidentalis	Western Dock
	Solidago canadensis	Canada Goldenrod
	Stachys pulustris	Marsh hedge-nettle

Soils and hydrology scored an 80%. This score has increased from the assessment done in 2017. Banks are well vegetated on this reach despite the invasive Smooth Brome being the dominant species. This vegetation minimizes the exposed bare ground, and willows along the banks near the upstream point of the reach help hold and bind the banks together to prevent erosion and sedimentation. Channel incisement and active lateral cutting further upstream have impacted the reach greatly in the past and the man-made alterations to the low level crossing have seemed to have failed in terms of holding the creek's new engineered path. Because of this the crossing has been closed and a culvert installed. The flow of the creek has created a scour pool and lateral cutting is eroding the south and north banks. This activity has affected the reach downstream in terms of deposition of sediments and perhaps even flow alteration. Pugging and hummocking is also present though it is minimal.

Combining the vegetation and soil and hydrology scores the site had a overall 67% health rating, which deems it healthy with problems. The problems are mainly due to increased invasive and disturbance species present, as well as the active lateral cutting and incisement taking place upstream of the reach.

b. Site assessments- riparian health assessment at J73

Site J73 is the next site downstream of site D70. This site was only previously assessed in 2006 when it scored 68%, with vegetation and soils and hydrology ratings at 64% and 75% respectively. This site is located adjacent to a rural grid road and bridge and downstream of farmyards that include livestock. The lack of woody species and an abundance of invasive or undesirable species had placed this site in a healthy with problems category in 2006. The site was assessed on August 22, 2018. Figure 10 shows the upstream view of Site J73, in which an irrigation intake is seen for the adjacent field in the uplands.

Figure 10. Upstream view of site J73 with irrigation intake

The 64% vegetation rating from 2006 was higher than the 2018 rating of 51%. The dominant species was Smooth Brome, same as 2006, with other species that do not provide stable or root-binding qualities present. These included Reed Canary Grass *(Phalaris arundinacea),* Crested Wheat Grass, and Sow Thistle *(Sonchus arvensis).* Due to the hot and dry summers of 2017 and 2018 Kochia *(Kochia scoparia)* was also very prevalent at many of the sites. Diversity was not high at this site but native or desirable species were present and included sedges *(Carex spp.)*, Wild Licorice *(Glycyrrhiza lepidota),* and Cattails. Woody species included Red-Osier Dogwood, Wolf Willow and other willow species, Manitoba Maple *(Acer negundo),* and Thorny Buffaloberry *(Shepherdia argentea).* Table 5 lists the 32 species documented.

Table 5. Type and species of riparian vegetation found at site J73 August 22, 2018

Vegetation type	**Latin name**	**Common name**
Preferred trees and shrubs		
	Acer negundo	Manitoba Maple
	Cornus stolonifera	Red Osier Dogwood
	Elaeagnus commutata	Wolf Willow
	Salix spp.	Willow
	Shepherdia argentea	Thorny Buffaloberry
Non-preferred trees and shrubs		
	Rosa woodsii	Wood's Rose
	Symphoricarpos occidentalis	Western Snowberry
Invasive species		
	Agropyron cristatum	Crested Wheat Grass
	Artemesia absinthium	Absinth
	Bromus inermis	Smooth Brome
	Cirsium arvense	Canada Thistle
Disturbance-increaser undesirable herbaceous species		
	Convulvulus sepium	Bindweed
	Descurainia sophia	Flixweed
	Melilotus alba	Sweet White Clover
	Kocihia scoparia	Kochia
	Phalaris arundinacea	Reed Canary Grass
	Sonchus arvensis	Perennial Sow Thistle
	Thalpsi arvense	Stinkweed
	Trifolium pratense	Clovers
	Urtica dioica	Stinging Nettle
Native graminoids		
	Carex spp.	Sedge spp.
	Typha latifolia	Cattails
	Scirpus validus	Great Bulrush
	Equisetum arvense	Common Horsetail
Native forbs		
	Artemesia frigida	Pasture Sage
	Artemesia ludoviciana	Prairie Sage
	Helianthus spp.	Sunflower
	Mentha arvensis	Wild Mint
	Rumex occidentalis	Western Dock
	Solidago canadensis	Canada Goldenrod
	Stachys pulustris	Marsh hedge-nettle
	Vicia Americana Muhl.	Wild vetch

Soils and hydrology scores ranged similarly between 2006 and 2018. In 2006 the site was given a rating of 75%. In 2018 the rating was given at 73%. Vegetated cover is good at this site and active lateral cutting was observed in portions of the reach. Banks are steep on both east and west banks and minimal floodplain was observed in 2006 on inside meanders (Hansen 2006). The lowest scores occurred in the active lateral cutting and channel incisement in 2018, which would suggest that this site has not improved significantly since the 2006 assessment.

The overall comparison of scores between 2006 and 2018 do suggest that this site has degraded enough to put it close, but not quite, into the unhealthy category in 2018, with an overall score of 61%. In 2006 the score was in the healthy with problems category with a 68% score. It is apparent that the health of this site may be contributing to the downstream water quality due to the riparian not functioning at proper levels. Figures 11 and 12 show the downstream view of J73 and the vegetated cover of the banks.

Figure 11. The downstream view of site J73

Figure 12. The east banks of site J73 are well vegetated right to the water's edge

c. Site assessments- riparian health assessment at K76

In 2006 both sites J73 and K76 were assessed for riparian health. This was the only monitoring year since 2018 that these sites were used as part of the monitoring project. Vegetative cover in 2006 scored a 70% and soils and hydrology at 72%. Both of these scores rank in the healthy with problems category, in which the total overall score also reflected at a 72%. In the 2018 RHAs the vegetative score was lower than that in 2006 at a 54%, which puts it close to being rated as unhealthy. Site K76 is surrounded by irrigated tame forage hay land, and livestock were fenced off but present on the south end of the reach. Irrigation canals and gates were eon the north end of the reach, and the northwest floodplain area was more accessible than the south bank, which was steep and displayed lateral cutting and erosion. Further northeast the banks also became very steep.

Vegetative cover was well established on the north bank but was comprised of mainly Smooth Brome and reed grasses. Many invasive and disturbance caused indicator species were present and included Absinthe, Kochia, Canada Thistle *(Cirsium arvense),* Stinging Nettle *(Urtica dioica),* and Flixweed *(Descurainia Sophia).* The 32 species documented are listed in Table 6.

Table 6. Type and species of riparian vegetation found at site K76 August 22, 2018

Vegetation type	**Latin name**	**Common name**
Preferred trees and shrubs		
	Acer negundo	Manitoba Maple
	Prunus virginiana	Chokecherry
	Salix spp.	Willow
Non-preferred trees and shrubs		
	Rosa woodsii	Wood's Rose
	Symphoricarpos occidentalis	Western Snowberry
Invasive species		
	Agropyron cristatum	Crested Wheat Grass
	Artemesia absinthium	Absinth
	Bromus inermis	Smooth Brome
	Cirsium arvense	Canada Thistle
Disturbance-increaser undesirable herbaceous species		
	Brassica kaber	Wild Mustaard
	Convulvulus sepium	Bindweed
	Descurainia sophia	Flixweed
	Hordeum jubatum	Foxtail Barley
	Melilotus alba	Sweet White Clover
	Kocihia scoparia	Kochia
	Phalaris arundinacea	Reed Canary Grass
	Sonchus arvensis	Perennial Sow Thistle
	Thalpsi arvense	Stinkweed
	Trifolium pratense	Clovers
	Urtica dioica	Stinging Nettle
Native graminoids		
	Carex spp.	Sedge spp.
	Equisetum hyemale	Common Scouring Rush
	Typha latifolia	Cattails
	Scirpus validus	Great Bulrush
Native forbs		
	Artemesia frigida	Pasture Sage
	Artemesia ludoviciana	Prairie Sage
	Glycyrrhiza lepidota (Nutt.) Pursh	Wild Licorice
	Helianthus spp.	Sunflower
	Mentha arvensis	Wild Mint
	Rumex occidentalis	Western Dock
	Solidago canadensis	Canada Goldenrod
	Stachys pulustris	Marsh hedge-nettle

The soils score in 2018 rated at 66%, falling within a healthy with problems category. In 2006 this site also rated within this category at 72%. The lower score in 2018 compared to 2006 indicates that this site may be degrading in riparian function. Desirable and woody species to improve bank stability, root binding, and erosion prevention were not present. This site shows lateral cutting, steep bare banks, and vegetative cover is not well established in various points along the reach. Channel incisement was rated at a Stage 3 in both 2006 and 2018, which indicates moderate incisement and 1-2 year flows may not be able to access the floodplain. In Figures 13 and 14 it can be seen both in the upstream and downstream views the steepness of the banks along this riparian reach.

Overall the 2018 assessment scored a 60%, which ranks it in the healthy with problems category but is borderline unhealthy. The fact that many undesirable and invasive species are dominant at this site does show that the function is declining and this site has become more unhealthy since 2006. Since both site J73 and K76 fall between sites D70 and I80 and the scores are borderline unhealthy, this may indicate that water quality issues could be worsening along this section of the Swift Current Creek.

Figure 13. Upstream view of site K76 with a more accessible floodplain on the north bank

Figure 14. Site K76 view downstream with steep banks towards the northeast

d. Site assessments- riparian health assessment at I80

Site I80 is the final and most downstream location in which the 2018 monitoring encompassed. In 2017 the exact monitoring location was changed from the site used in the 2004-2007 project, so comparisons of RHAs cannot be done in accuracy. The new site done in 2017 was approximately 150 m downstream of the 624 Grid bridge and the reach carried downstream for about 200 m or more. This reach was approximately one kilometer from the original site assessed in 2005. Site I80 was assessed in only one year for riparian health in 2005.

Comparison between 2017 and 2018 shows that this site is unhealthy in many aspects of the RHA. The site is adjacent to annual cultivated cropland and steep banks on both the south and north sides of the creek do not allow the channel to expand into its floodplain easily. In 2017 the vegetative score was 45%, as is the same in 2018. The dominance of invasive and undesirable species such as Smooth Brome, Absinthe, Canada Thistle, Reed Canary Grass, Western Snowberry *(Symphoricarpos occidentalis)*, and Stinging Nettle show that this site lacks proper root binding masses to stabilize banks and prevent erosion. There was also a very low abundance of woody species but those found included Red-Osier Dogwood and Wolf Willow. In total 18 species were identified which are documented in Table 7.

Table 7. Type and species of riparian vegetation found at site I80 August 22, 2018

Vegetation type	Latin name	Common name
Preferred trees and shrubs		
	Cornus stolonifera	Red-Osier Dogwood
	Elaeagnus commutata	Wolf Willow
Non-preferred trees and shrubs		
	Rosa woodsii	Wood's Rose
	Symphoricarpos occidentalis	Western Snowberry
Invasive species (noxious weeds)		
	Agropyron cristatum	Crested Wheat Grass
	Artemesia absinthium	Absinth
	Bromus inermis	Smooth Brome
	Cirsium arvense	Canada Thistle
Disturbance-increaser undesirable herbaceous species		
	Phalaris arundinacea	Reed Canary Grass
	Urtica dioica	Stinging Nettle
Native graminoids		
	Carex spp.	Sedge spp.
	Equisetum arvense	Common Horsetail
	Scirpus validus	Great Bulrush
	Typha latifolia	Cattails
Native forbs		
	Artemesia frigida	Pasture Sage
	Glycyrrhiza lepidota	Wild Licorice
	Solidago canadensis	Canada Goldenrod
	Rumex occidentalis	Western Dock

Soils and hydrology scored 70% as there was minimal human caused bare ground and active lateral cutting in close proximity to the creek. The most significant land use is annual crop land above the riparian buffer on the north bank. The land alteration by human activity had the lowest possible score. This upland use could also pose a problem in the potential for agricultural run-off and flooding. The channel is moderately incised and the 1-2-year flow may not be able to access the floodplain.

Overall this new reach of Site I80 scored 57% which rates it as unhealthy, which was the same range as 2017. This is due to the dominating presence of invasive and disturbance increaser vegetation which lack deep roots and soil binding capabilities along the banks. There was also a lack of preferred trees and shrubs including regeneration of these species observed. It is apparent that the further downstream of the four monitoring sites the RHAs declined. This may help indicate that water quality has been negatively affected by lack of proper functioning riparian areas along this stretch of the SCC. Figures 15 and 16 show the upland use of site I80 and the minimal riparian buffer that is present.

Figure 15. South banks vegetated but slumping due to lack of root binding vegetation

Figure 16. Minimal riparian vegetation adjacent to cropland

3.2 Water quality

a.) Saskatchewan water quality index and parameters

The Water Quality Index (WQI) plays an important role in determining the health of the SCC for various water uses. These include:

- Irrigation water use
- Livestock watering
- Protection of aquatic life and wildlife
- General water quality

In 2017 SCCWS calculated these four indices based on the 2006 guidelines and also discussed changes made since the 2006 guidelines were created. Table 8 lists the water quality guidelines and ratings for Saskatchewan.

Table 8.Water quality ratings for the Saskatchewan Water Quality Index

Saskatchewan Water Quality Index ratings		
Rating	Index	Description of Water Quality
Poor	0-44	Almost always threatened or impaired; conditions usually depart from natural or desirable levels
Marginal	45-64	Frequently threatened or impaired; conditions often depart from natural or desirable levels
Fair	65-79	Usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels
Good	80-94	Protected with only a minor threat or impairment; conditions rarely depart from natural or desirable levels
Excellent	94-100	Protected with a virtual absence of threat or impairment; conditions are very close to pristine or natural levels

*Table adapted from Saskatchewan Environment 2006 as cited by SCCWS 2008, 2017, and 2018)

i.) Irrigation water use

The Saskatchewan Environment 2006 guidelines for irrigation water use can be found in Table 9 and the 2006 calculated indices scores can be seen in Figure 17. Index percentage scores ranged from the lower 40% with the lowest taken at site K76 with 40.6%. Sites J73 and I80 both scored 41.3%. Site D70 had the best overall score at 57.7%. All sites with the exception of D70 are in the poor range of irrigation water use quality. In 2017 site D70 also scored in the marginal range as it did again in 2018. Site I80 remained in the poor range through 2017 to 2018.

Marginal and poor irrigation water use ratings are a concern for producers that depend on irrigation water pumped directly from the creek to grow various crops. If the 2015 guidelines were assessed, however, all scores become fair with the exception of site I80 which just falls short and rates as marginal. Irrigation water use ratings in either the 2006 or 2015 ranges do point out that there are significant issues that are contributing to the low scores. *E.coli* counts had nine occurrences among the four sites over 100 ct/100ml. Sodium levels were also high at all sites throughout the summer with the exception of September. The highest sodium levels were recorded at 196 mg/L at site I80 in June. The limit in the 2006 guidelines state sodium should not exceed 115 mg/L. The final contributor to the poor irrigation water use ratings is total coliforms. All sites, with the exception of D70, J73, and K76 in the month of September, were all significantly above the 1000 ct/100ml limit.

Table 9. Irrigation water use parameter guidelines

Irrigation water parameter guidelines		
Parameter	2006 guideline	Units
Boron	>0.5	mg/L
Chloride	>100	mg/L
Fecal Coliform	>100	orgs/100 mL
Sodium	>100	mg/L
Total Coliform	>1000	orgs/100 mL
Total Dissolved Solids	>700	mg/L

*Table adapted from Saskatchewan Environment 2006 as cited by SCCWS 2008, 2017, and 2018)

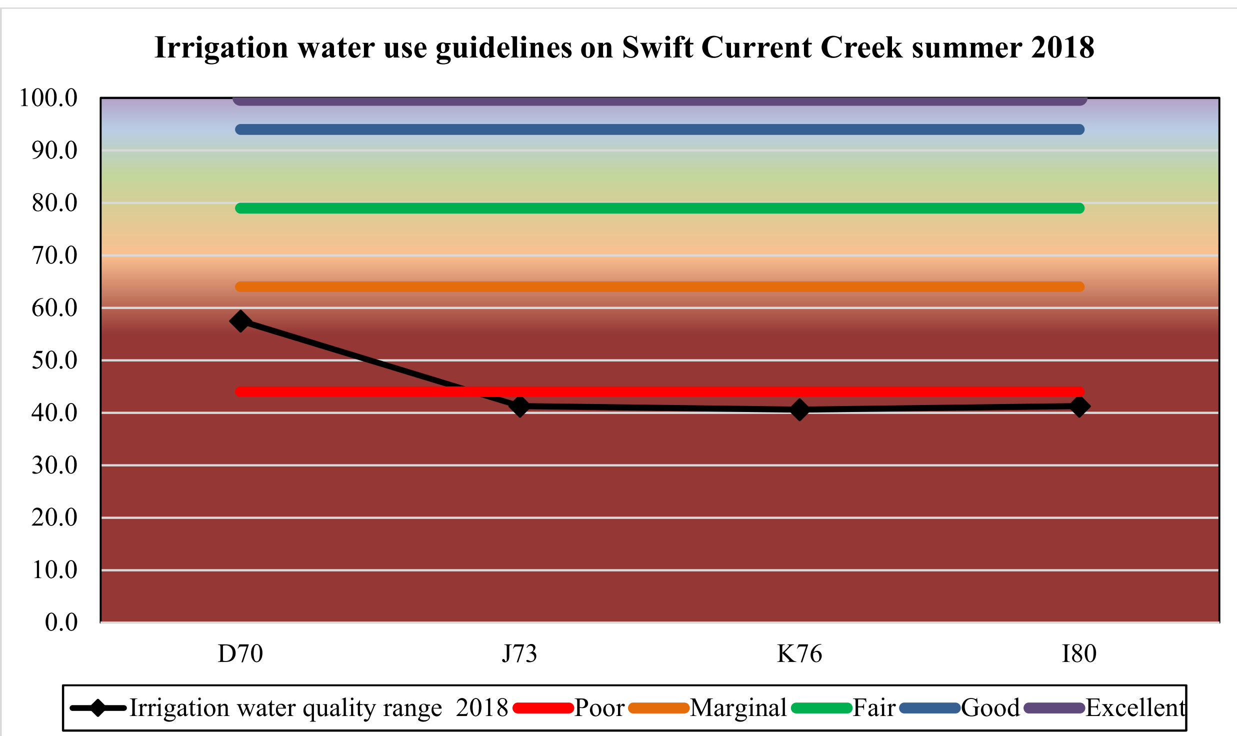

Figure 17. Irrigation water use guidelines on Swift Current Creek summer 2018

ii.) Livestock watering

Table 10 list the 2006 guidelines for the livestock watering index. These guidelines are intended for protection of different livestock types as well as the end consumer of products from these animals (Saskatchewan Environment 2006 as cited by SCCWS (2008) and SCCWS (2018). There were a number of changes proposed by WSA in the *2015 Surface Water Quality Objectives Interim Edition EPB 356, June 2015.* Additional parameters and limits were added such as aluminum at 5000µg/L, arsenic at 25 µg/L and boron at 5 mg/L. The limit for copper was also changed to a defined 0.1 µg/L. The most impactful change made was the limit for Total Dissolved Solids (TDS) was increased to 3000 mg/L from 1000 mg/L. Figure 18 shows that according to the 2006 guidelines all sites were in the good range except for site D70 which scored the lowest at 54%. All parameters were below the guidelines.

Table. 10 Livestock water guidelines

Livestock Water Parameter Guidelines		
Parameter	2006 guideline	Units
Copper	>0.5	mg/L
Nitrite + Nitrate Nitrogen	>100	mg/L
Sulfate	>1000	mg/L
Total Dissolved Solids	>1000	mg/L

*Table adapted from Saskatchewan Environment 2006 as cited by SCCWS 2008, 2017, and 2018)

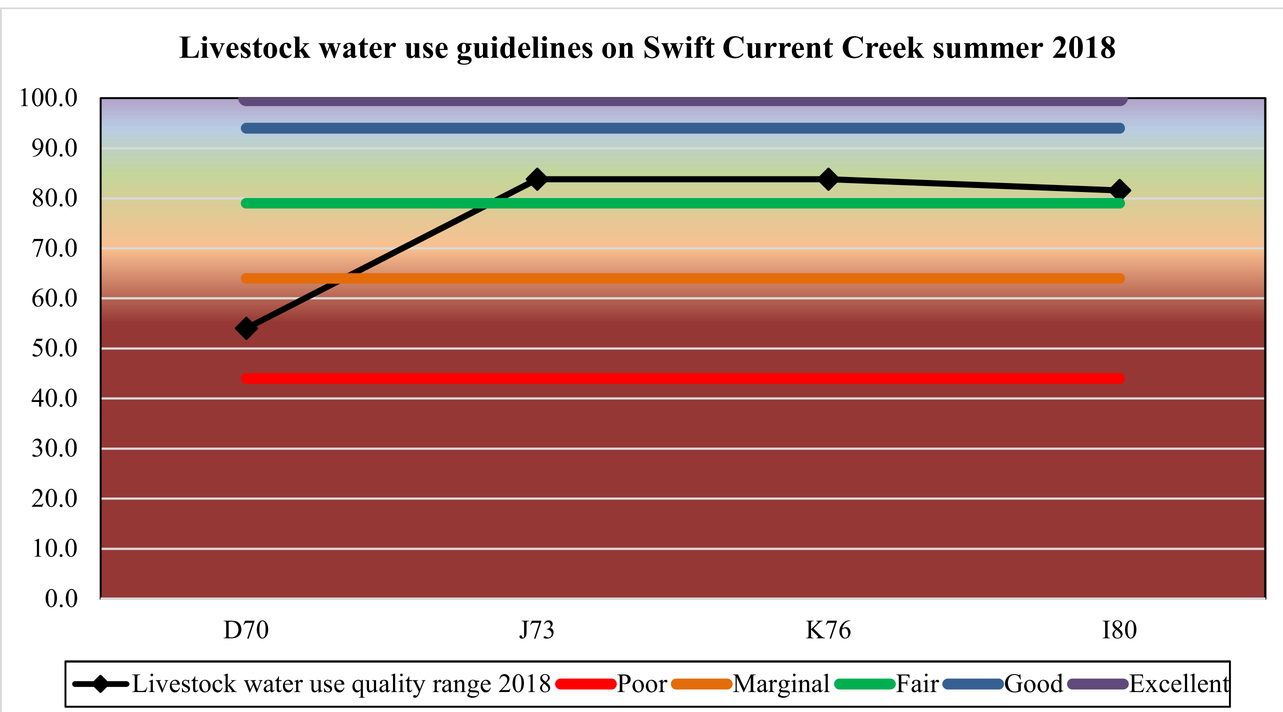

Figure 18. Livestock water use guidelines on Swift Current Creek summer 2018

Site I80 again showed the highest in amounts of sulfate every month sampled. Aluminum was the highest at site K76 for June, July, and August, with D70 taking a higher value in September at 198 µg/L. The highest aluminum levels were at site K76 in the month of August at 494 µg/L. In 2017 the general trend of livestock watering gradually deteriorated after site D70. In 2018 the data shows that the scores actually increase after site D70. The scores do, however, indicate that issues are present with the quality of water to livestock in this area, and the hot dry summer may be contributed to increased levels of Total Dissolved Solids (TDS) in the SCC in 2017.

iii.) Protection of aquatic life and wildlife

According to the Saskatchewan Surface Water Quality Objectives as cited by Saskatchewan Environment (2006) as cited by SCCWS (2008) and SCCWS (2018) the protection of aquatic life and wildlife contributes to parameter levels that are suitable for all stages of life and development, which is important for healthy populations and diversity. Table 11 highlights these guidelines which includes many other parameters such as DO, pH and mercury.

Table.11 Protection of aquatic life and wildlife guidelines

Protection of Aquatic Life and Wildlife Water Parameter Guidelines		
Parameter	2006 guideline	Units
Nitrogen as ammonia	*	mg/L
Arsenic	>5	µg/L
Chloride	>100	mg/L
Chromium	>1	µg/L
Dissolved Oxygen	<5.5	mg/L
Mercury	>0.026	µg/L
pH	<> 6.5-8.5	pH Units
Sodium	>100	mg/L
* Nitrogen as ammonia guideline is dependent on water temperature and pH		

Mercury is a difficult measure and though the set limit is <0.026 µg/L, the lab results can at best only show values < or > 0.04 µg/L. This still puts mercury above the 2006 guidelines, and a severe outlier occurred at site J73 in the month of July at 52.4 µg/L. Despite this oddity, all sites rated in the good ranges. A slight decline was observed at site K76 and towards I80. Site D70 had the highest score of 92.6%, which is an increase from the fair rating it received in 2017. Site I80 also saw a significant decline in 2017 and again in 2018 it showed the lowest score at 90.4%. Figure 19 shows the rated indices from 2018. The 2015 guidelines were not significantly changed therefore are not compared to the 2006 guidelines.

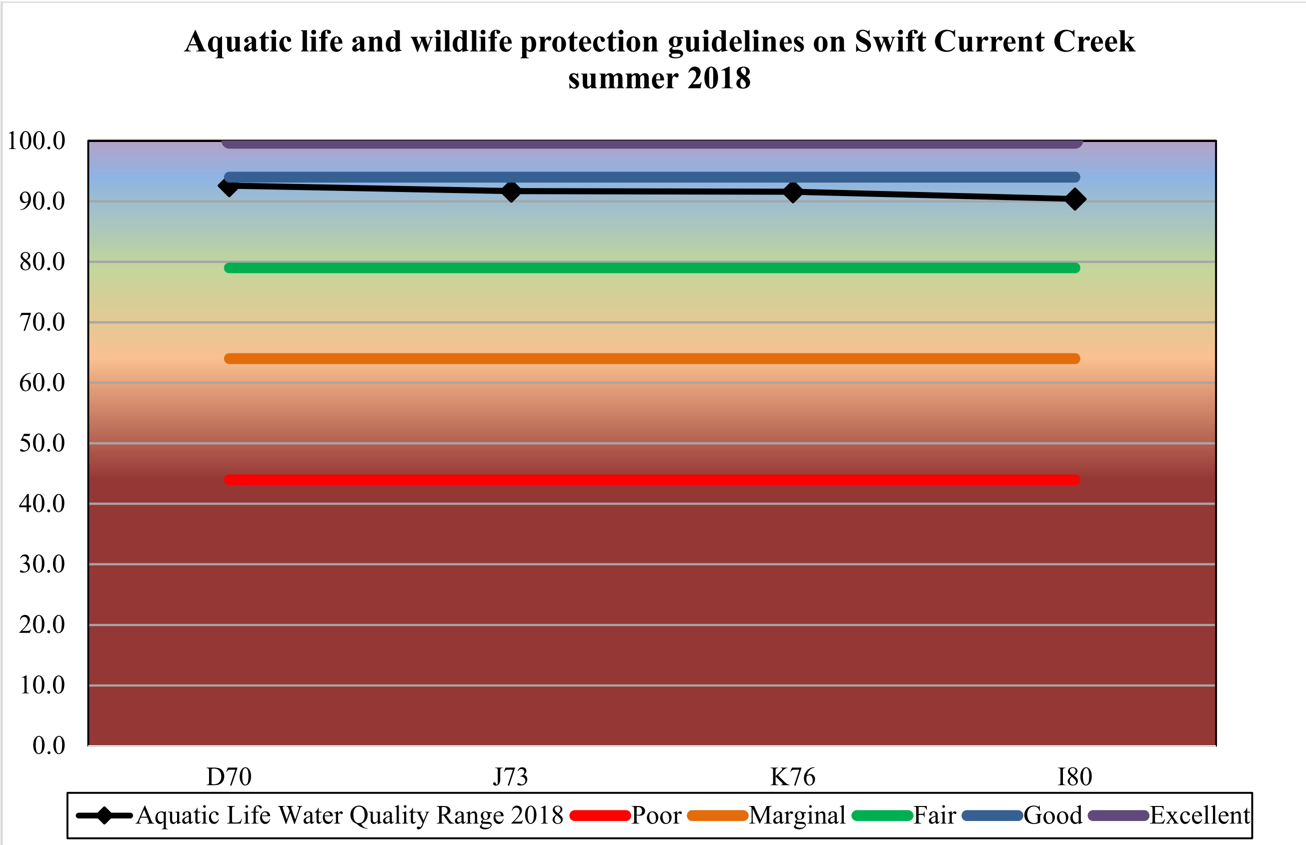

Figure 19. Aquatic life and wildlife protection guidelines on Swift Current Creek 2018

iv.) General water quality

The general water quality guideline uses the parameters of the protection of aquatic life and wildlife index plus aluminum, *E.coli* bacteria, nitrate plus nitrite nitrogen, dissolved phosphorus, and sulfate (SCCWS 2018). These guidelines were set in 2006 and not updated in 2015. Table 12 gives an overview of the parameters and limits this guideline is based on. General water quality at all sites in 2018 ranked in the good or fair ranges, with site D70 having the highest score at 81.9%. The trend of quality has been to decline towards site I80 in the other three guidelines, often with the lowest score occurring at I80. However the general water quality scores show that site J73 had the lowest score at 78.7%. Sites K76 and I80 slightly increased from J73 at 79.2 and 79.7 respectively. Compared to 2017 the site D70 was the start of downward trend in the index data. The results kept site D70 and I80 in the good range, in which they both still remain. The slight decrease at site J73 between D70 and I80 may be contributed to increasing irrigation use, livestock operations, and alteration/erosion of the creek banks. Figure 20 shows the index ratings.

Table 12. General water parameter guidelines

General Water Parameter Guidelines		
Parameter	2006 guideline	Units
Aluminum	>5000	µg/L
Nitrogen as ammonia	*	mg/L
Arsenic	>50	µg/L
Chloride	>100	mg/L
Chromium	>20	µg/L
Dissolved Oxygen	<5	mg/L
Fecal Coliform	>200	orgs/100mL
Mercury	>0.1	µg/L
Nitrite + Nitrate as Nitrogen	>1	mg/L
pH	<> 6.5-9	pH Units
Phosphorus Dissolved	>0.1	mg/L
Sodium	>100	mg/L
Sulfate	>500	mg/L
Total Dissolved Solids	>700	mg/L
* Nitrogen as ammonia guideline is dependent on water temperature and pH		

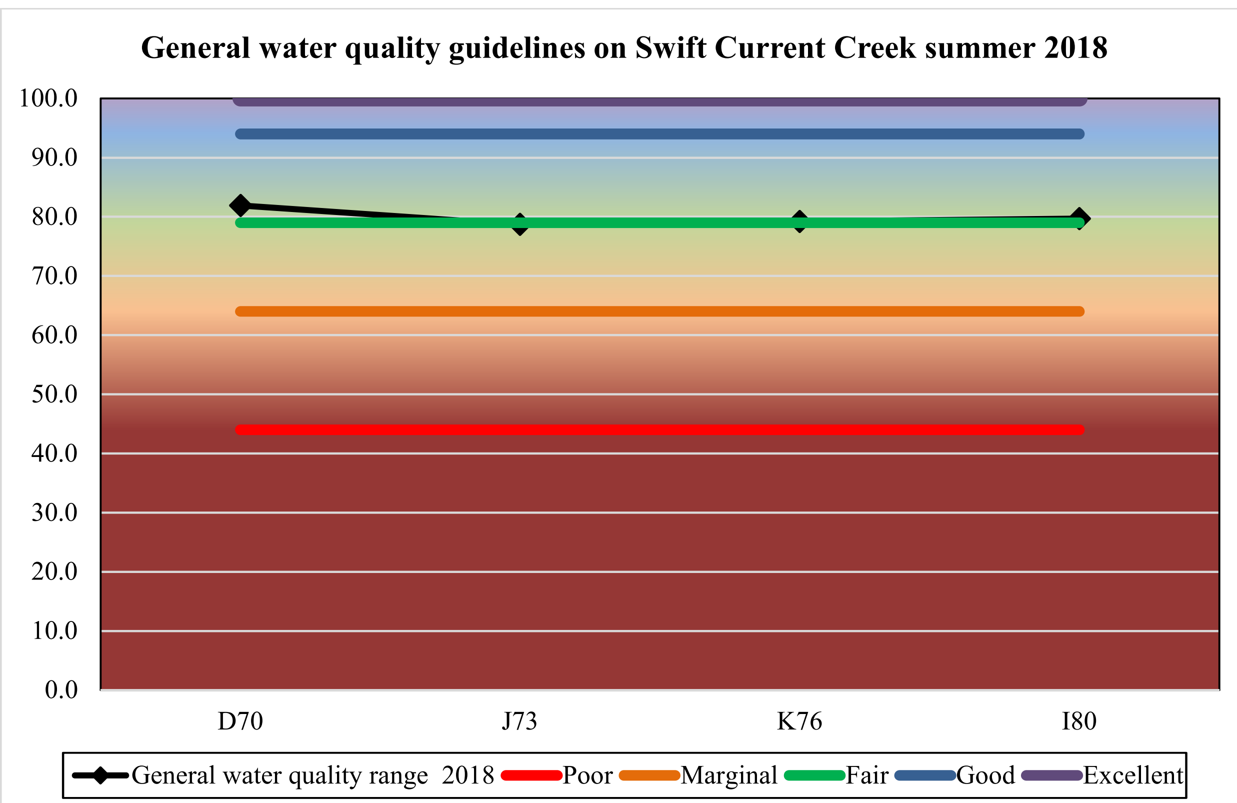

Figure 20. General water quality guidelines on Swift Current Creek summer 2018

The ratings of each of the four guidelines are based on levels of each parameter listed to be an important contributor. In the following Table 13 the deviations in each quality index have been identified and numerated as to the amount of time they were above the guideline. In nearly all cases TDS was a major factor in the quality indices. Sodium and aluminum also occurred in many instances as being deviations.

Table 13. Deviations in each of the water indices

Water use	**D70**	**J73**	**K76**	**I80**
Irrigation water use	**Marginal (57.5)**	**Poor (41.3)**	**Poor (40.6)**	**Poor (41.3)**
Deviations	TDS (4/4) Fecal coliform (2/4) Total coliform (3/4)	Sodium (2/4) TDS (4/4) Fecal coliform (3/4) Total coliform (3/4)	Sodium (2/4) TDS (4/4) Fecal coliform (3/4) Total coliform (3/4)	Sodium (3/4) TDS (4/4) Fecal coliform (1/4) Total coliform (4/4)
Water use	**D70**	**J73**	**K76**	**I80**
Livestock watering use	**Marginal (54)**	**Good (83.8)**	**Good (83.8)**	**Good (81.6)**
Deviations	Copper (1/4)	TDS (2/4)	TDS (2/4)	TDS (3/4)
Water use	**D70**	**J73**	**K76**	**I80**
Aquatic life and wildlife	**Good (92.6)**	**Good (91.7)**	**Good (91.6)**	**Good (90.4)**
Deviations	Sodium (1/4) Aluminum (4/4)	Sodium (2/4) Aluminum (4/4)	Sodium (2/4) Aluminum (4/4)	Sodium (3/4) Aluminum (4/4)
Water use	**D70**	**J73**	**K76**	**I80**
General water use	**Good (81.9)**	**Fair (78.7)**	**Fair (79.2)**	**Fair (79.7)**
Deviations	TDS (4/4) Sodium (1/4) Dissolved Phosphorus (1/4) Aluminum (4/4) Fecal coliform (1/4)	TDS (4/4) Sodium (2/4) Sulfate (2/4) Aluminum (4/4) Fecal coliform (3/4)	TDS (4/4) Sodium (2/4) Sulfate (2/4) Aluminum (4/4) Fecal coliform (2/4)	TDS (4/4) Sodium (3/4) Sulfate (2/4) Aluminum (4/4) TDS (1/4) Fecal coliform (1/4)

b.) Water parameters

As with any sampling projects SCCWS has conducted the water chemistry and physical properties of the SCC play valuable roles in helping to explain different results or identify outliers in the data. This project was based on such outliers that occurred at site I80 in 2017. These results or health indicators have shown historically that many of the monitoring sites included through the 2004-2007 projects and 2017 in the SCCW were at or above acceptable limits in terms of water quality indices. The following parameters were determined to be important watershed health indicators and each has a set limit for what is acceptable in a healthy functioning creek. Other important data that can play a role in the chemical values include water temperature, dissolved oxygen, conductivity, and pH. The pH value will also be discussed in further detail as it is part of the water quality indices calculated to determine the state of each monitoring site. The following sections give a breakdown of the importance of water temperature, dissolved oxygen, pH, and conductivity to the overall system of the SCC.

Water temperature (Table 14) is important in the values measured for dissolved oxygen, conductivity, and pH. According to Stewart and Watkinson (2004) the water bodies of the prairies are often warmer and more turbid than other regions of North America. The streams of the prairies also tend to have lower gradients, low to moderate velocity in flow, and meandering courses (Stewart & Watkinson 2004). According to Nelson & Paetz (1992) streams often are more similar in water temperature from the bottom to the surface, and this also depends on the strength of current and depth.

Table 14. Average water temperature of monitoring sites on the Swift Current Creek summer 2018 downstream of the city of Swift Current

Average water temperature (°C) in Swift Current Creek summer 2018				
Site	**June**	**July**	**August**	**September**
D70	21.1	19.8	16.5	8.5
J73	18.6	18.9	15.9	7.9
K76	19.1	18.3	15.4	7.6
I80	19.9	18.1	14.8	7.3

Dissolved oxygen is the reference to the amount of free, non-compound oxygen present in water (Fondriest Environmental 2016). It is important for aquatic organisms for respiration and streams are often found to provide sufficient DO (Nelson & Paetz 1992). As the values show in Table 15 all monitoring sites provided enough DO to support aquatic life. However, the opposite of DO depletion is “super-saturation” which can cause stress to fish if it is for a prolonged period of time (Nelson & Paetz 1992). According to Nelson & Paetz (1992) this can occur during mid-summer when algae growths are high and oxygen is being produced from photosynthesises. DO also lowers during the winter months and depletes most rapidly at the bottoms of lakes and streams, where there is more decomposing organic matter and bacteria that consume oxygen (Nelson & Paetz 1992).

Table 15. Average dissolved oxygen levels in Swift Current Creek summer 2018

Average dissolved oxygen (mg/L) in Swift Current Creek summer 2018				
Site	**June**	**July**	**August**	**September**
D70	9.27	8.57	n/d	n/d
J73	6.97	8.28	n/d	n/d
K76	7.51	8.79	n/d	n/d
I80	6.34	8.53	n/d	n/d

n/d: no data due to meter failure

According to Fondriest Environmental (2016) the "power of Hydrogen" or pH is a determined value on a defined scale. This value is determined by the effect of hydrogen ions and hydroxyl ions, or how acidic or basic a substance is (Fondriest Environmental 2016). The defined scale values range from 0 to 14, the low end being acidic and the high end being basic. The value of 7 is neutral on the scale, and optimal ranges of pH for aquatic organisms in freshwater is between 6.5 and 9. According to Fondriest Environmental (2016) anything outside of this range can either stress or cause death in aquatic organisms.

The pH can change naturally or from human causes. Natural impacts to pH include temperature, precipitation, surrounding rock, limestone, and soil which can contain calcium carbonate or other bicarbonates. Human causes that impact pH include many pollution based point sources as the most common impact, an example being acid rain (Fondriest Environmental 2016). The values of pH taken from the SCC in the summer of 2018 are shown in Table 16 below, and all ranges are within the optimal levels for aquatic life.

Table 16. Average pH values in Swift Current Creek summer 2018

Average pH (pH units) values in Swift Current Creek summer 2018								
Month	**June**		**July**		**August**		**September**	
Site	**Field Average**	**Lab**	**Field Average**	**Lab**	**Field Average**	**Lab**	**Field Average**	**Lab**
D70	8.4	8.4	8.4	8.4	8.4	8.4	8.1	8.5
J73	8.2	8.2	8.4	8.3	8.0	8.3	8.3	8.4
K76	8.1	8.1	8.3	8.3	8.4	8.3	8.5	8.4
I80	8.1	8.2	8.3	8.3	8.3	8.3	8.4	8.3

The conductivity, or the measure of water's ability to conduct electrical current, provides a measure of what is dissolved in the water in terms of salts, minerals, and other inorganic chemicals (Fondriest Environmental 2019). Salinity is also an indicator of conductivity and the link between them is the increase in salinity, the increase in conductivity. Common ions that conduct electricity in water are sodium, chloride, calcium, and magnesium (Fondriest Environmental 2019). Average conductivity levels can be seen in the following Table 17 .

Table 17. Average conductivity values in SCC summer 2018

Average conductivity (µs/cm) values in Swift Current Creek summer 2018								
Month	**June**		**July**		**August**		**September**	
Site	**Field Average**	**Lab**	**Field Average**	**Lab**	**Field Average**	**Lab**	**Field Average***	**Lab**
D70	1131	1120	1202	1176	925	916	655	947
J73	1594	1558	1584	1536	1017	1004	673	984
K76	1692	1642	1620	1567	1048	1043	677	1003
I80	1932	1902	1727	1669	1362	1354	755	1141

* Meter was not calibrated for adjustments to temperature

c.) Water chemistry

The following water chemistry results have proven to be key indicators of watershed health throughout the monitoring projects. These are results that have often exceeded acceptable limits. Each will be discussed in detail and how it affects the watershed health and a comparison of sites D70 and I80 to those results from 2017 at the same locations.

i.) Chloride

Chloride is often an indicator of increased urbanization in a watershed (KDW 2007 as cited by SCCWS 2008). Sources of chloride can be natural and/or human caused. Natural contributors in the SCCW include highly saline soils that could increase the amount of chloride in surface water. According to WHO (2003) as cited by SCCWS (2008) the most common and widespread sources of human caused increases in chloride are application of road salt, effluent leaching, release of treated water, and drainage of excess irrigation water.

Chloride in water quality indices are important to the irrigation water use index, protection of aquatic life and wildlife index, and the general water protection index. Maximum amounts in all these indices is 100mg/L. In 2017 the highest level was recorded at site I80 with 67 mg/L in the month of July. In 2017 the levels of chloride increased downstream of the city of Swift Current with the most probable explanation being the WWTP discharge. The levels decreased again after site I80, indicating that perhaps the highest amounts were occurring between the city of Swift Current and just north of the village of Waldeck.

In 2018 similar results were recorded, with the highest levels of chloride at site J73 in July. This site is the first site downstream of site D70, which also had high levels of chloride in 2017. The highest level recorded in 2018 was 52.4 mg/L, which is still under the maximum acceptable limit of 100mg/L. Figure 21 shows that the highest levels were consistent between sites D70 and I80 at J73 and K76. The months of June and July showed the highest levels which maybe due to the saline areas surrounding those two sites.

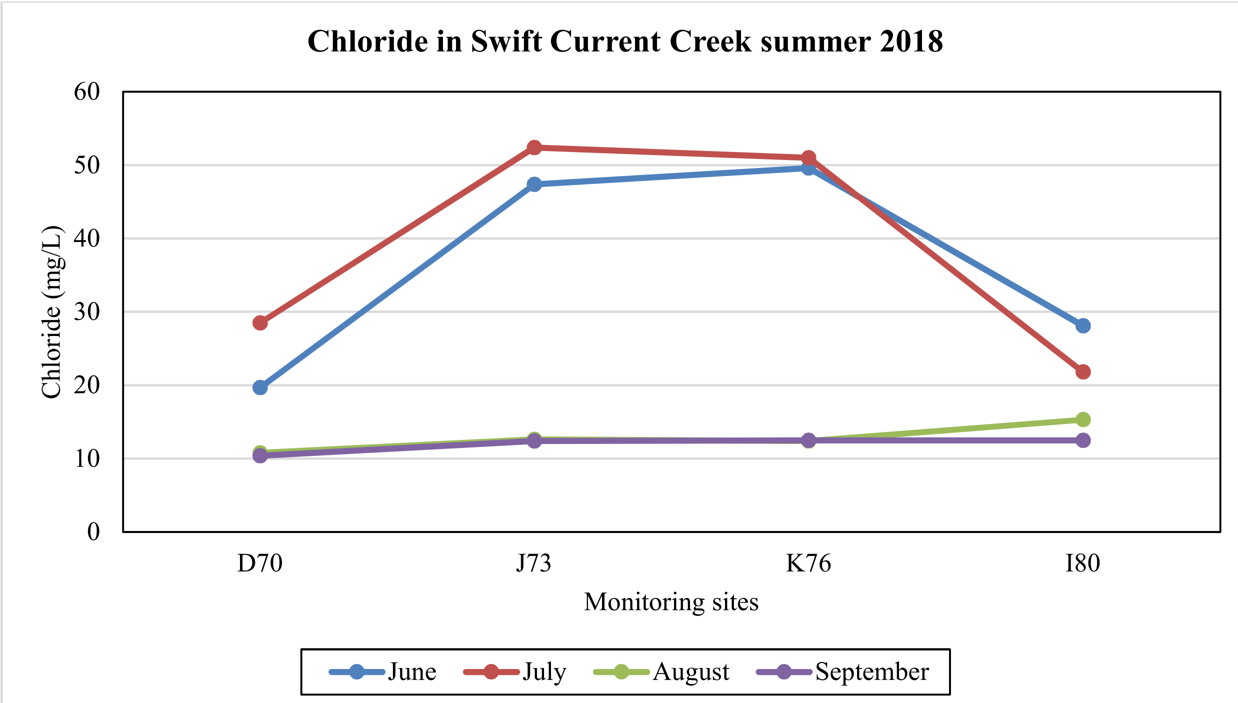

Figure 21. Chloride in Swift Current Creek summer 2018.

ii.) Sodium

One of the essential elements for life, sodium is a member of the alkali metals and though it is essential, too much can cause stress to organisms (The British Columbia Groundwater Association 2007 as cited by SCCWS 2008). WQI's for irrigation water use has a maximum of 115mg/L and protection of aquatic life and wildlife and general water protection have a maximum of 110mg/L of sodium.

Sodium levels do show a gradual increase from site D70 through to site I80. The sites of J73 and K76 show a plateau of values before increasing again at site I80. In 2017 the highest recorded levels of sodium that were over the guidelines occurred at sites D70, I80, and the furthest downstream site of E90. In 2018 the highest level was observed at site I80 at 196mg/L in the month of June. Site D70 had the lowest concentrations of sodium and with the exception of July at 102mg/L, all values remained under the acceptable levels. Levels at sites J73 and K76 were less than that of site I80, but were over the maximum acceptable limits in June and July by a large factor. This pattern can be seen in Figure 22.

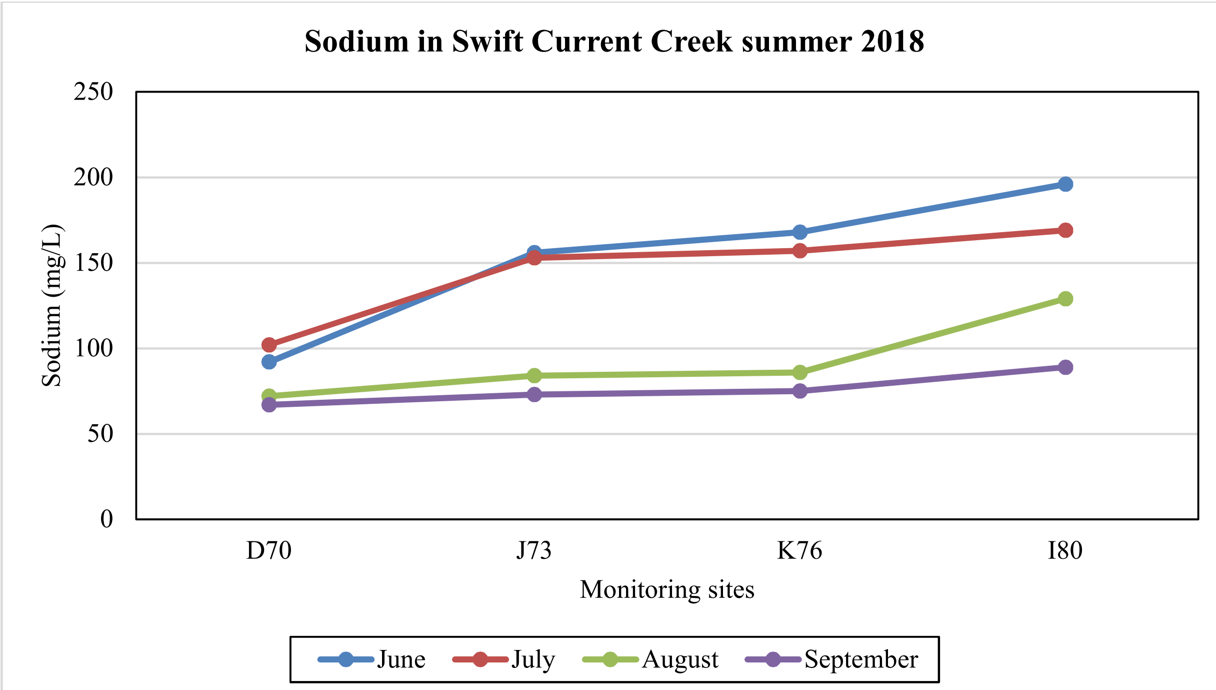

Figure 22. Sodium levels in Swift Current Creek summer 2018

iii.) Sulfate

Sulfate formed by oxidation of sulfate ore is found naturally in almost all water sources and is found in shales and industrial wastes (Lenntech 2019). It occurs in various minerals in soils, decaying plant and animal material, water treatments that use alum, sulfate fertilizers, and the combustion of fossil fuels and sour gas processing (U.S Environmental Protection Agency 2006 as cited by SCCWS 2008). According to Lenntech (2019) sulfate is also a major dissolved component of rain. In 1993 the World Health Organization (WHO) determined a set limit of 500 mg/L of sulfate, as it can cause intestinal discomfort and diarrhea if consumed with higher amounts and hydrogen gas (H_2S) is formed when bacteria attack and break down sulfates (Lenntech 2019). For livestock water use the maximum limit before stress or death of the animal is 1000mg.L.

In 2017 the highest concentration of sulfate was taken from site I80 in July at 967 mg/L. No other samples taken in 2017 were as close to 1000mg/L as site I80, and livestock watering may have caused issues with the high sulfate levels. Site D70 had concentration higher than the 500mg/L limit in both June and July, while site I80 was over the limits during every month of sampling. In 2018 site I80 once again showed the highest concentrations with the highest recorded in June at 730.5 mg/L. Site D70 had the lowest concentrations and sites J73 and K76 were both significantly higher in June and July then August and September. Figure 23 shows the increases in sulfate from site D70 to I80.

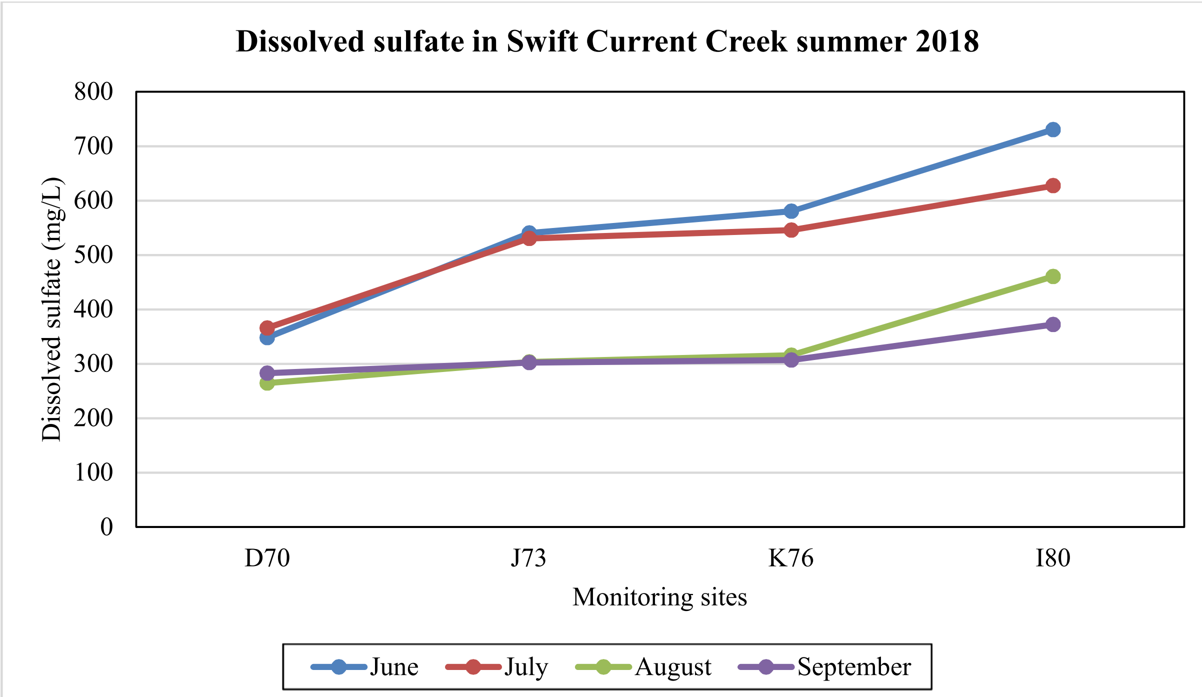

Figure 23. Sulfate in Swift Current Creek summer 2018

iv.) Nitrite and Nitrate Nitrogen

Similar to sodium nitrogen is an essential building block for proteins in living organisms and can exist in many forms (Kentucky Division of Water 2008 as cited by SCCWS 2008). In addition to the natural forms and sources of nitrogen such as decaying organic matter, human-caused sources can include fertilizer, sewage, and livestock manure (SCCWS 2008 as cited by SCCWS 2017). According to SCCWS (2008) as cited by SCCWS (2018) major sources of excess nitrite and nitrate nitrogen can come from excessive rainfall and runoff through agricultural lands and soil leaching. Not only does excess nitrite and nitrate nitrogen affect water quality, but it also promotes algal "blooms" in which toxic algae benefit from the excess nutrients, but in their decaying process emit toxins that can effect other aquatic organisms, even causing death.

General water quality has a limit of nitrite nitrate nitrogen set at 1mg/L. Ammonia as nitrogen falls under the aquatic life and wildlife index but must be calculated according to temperature and pH. In the 2017 results site D70 was the only site identified downstream with high levels of nitrite nitrate nitrogen. In 2018 the results showed the same pattern as site D70 had all of the highest concentrations and levels dropped significantly at site J73. Though site D70 had the highest levels none exceeded the 1.0mg/L limit, with the highest reaching 0.36 mg/L in July and the remaining sites at <0.04 mg/L (shown in Figure 24).

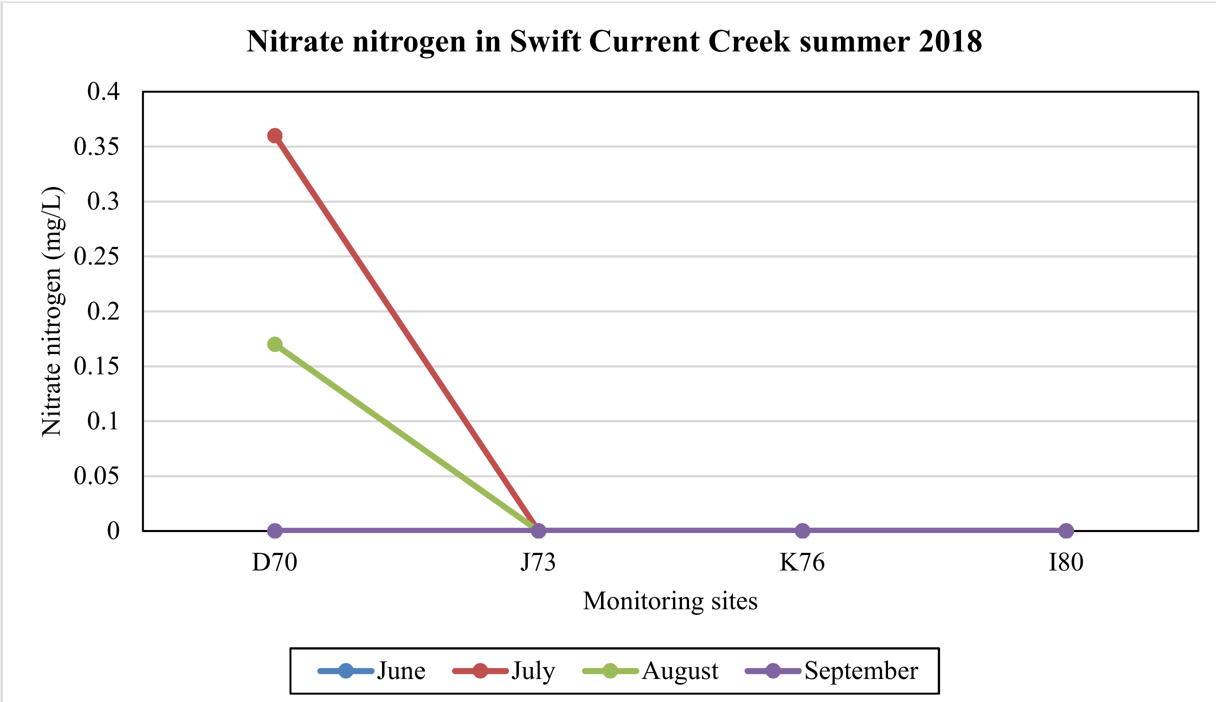

Figure 24. Nitrate nitrogen in Swift Current Creek summer 2018

v.) Total Dissolved Solids

TDS do not pose a health issue to human consumption, with the exception of causing diarrhea when in high concentration (SaskH_2O 2008), but it does have set limits for irrigation and livestock watering. The total amount of dissolved minerals and even organic material remaining after the evaporation of water is referred to as TDS (SaskH_2O 2008). These contributors to TDS are commonly natural such as leaching and erosion from soils and sedimentary rock (making groundwater usually higher in TDS than surface water) and decaying organic material, and according to SaskH_2O (2008) the most common particles in TDS are sodium, chloride, sulphate, calcium, magnesium, potassium, and bicarbonates.

Human-caused contributors to TDS include agricultural run-off and municipal and industrial discharges and even though TDS levels are not an immediate health risk to human consumption, the Saskatchewan Ministry of Environment Drinking Water Quality Standards have an aesthetic limit of 1500mg/L (SaskH_2O 2008). Aesthetic appearance, odor, and taste are categorized under this limit. In 2015 WSA issued new limits for TDS for livestock watering to 3000mg/L from 1000mg/L, as high TDS can be fatal in livestock (SCCWS 2018). Once again site I80 showed some of the highest TDS readings in 2017 occurring in July at a value of 1895mg/L. The irrigation index was also changed in 2015 from 700mg/L to a range of 500-3500mg/L depending on the crop being irrigated (SCCWS 2018). In 2018 site D70 consistently stayed as the lowest value, all reading under 1000mg/L. Sites J73 and K76 gradually increased moving downstream to site I80, which had the highest reading in June at 1584 mg/L. While this value is the highest, all remain within the set limits of the indices, as shown in Figure 25.

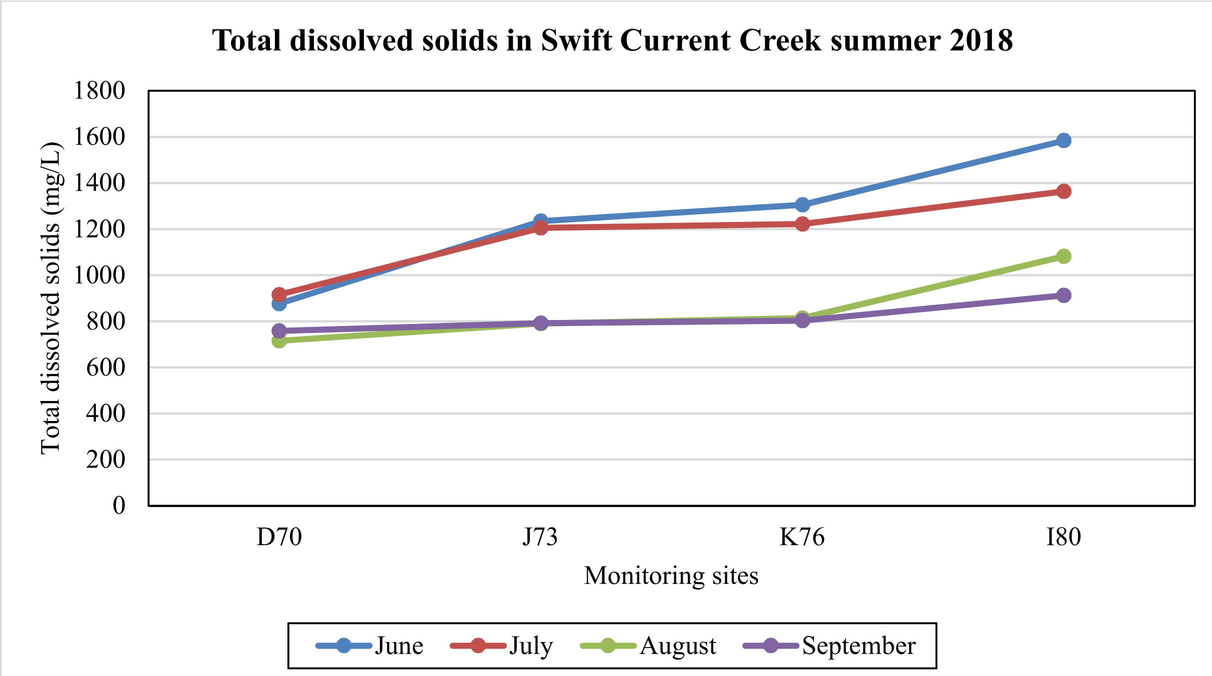

Figure 25. Total Dissolved Solids in Swift Current Creek summer 2018

vi.) Inorganic (Ortho) Phosphorous

According to Murphy (2007) as cited by SCCWS (2008) phosphorous is required by all organisms for basic processes of life, and orthophosphate is an inorganic form of phosphate which normally occurs in freshwater systems. This form of phosphate is also readily used by plants and can be produced by natural processes or human-caused such as agricultural fertilizers and sewage (Murphy 2007 as cited by SCCWS 2008).

One issue that orthophosphate can cause is algal blooms, especially the toxic blue-green algae (cyanobacteria) which can be fatal to aquatic life and also livestock that consume the water (Murphy 2007 as cited by SCCWS 2008). The maximum level of orthophosphate in the general water quality index is 0.1 mg/L. Sites upstream of the city of Swift Current showed higher levels than the limit, and downstream sites such as D70 and I80 showed lower results. The 2018 data show similar results with no levels at the maximum limit. The highest reading was taken at site D70 in September at 0.13 mg/L. If any increases occurred it was often started at site J73 and towards sites K76 and I80, and the highest values were recorded in the month of September (Figure 26). The lowest levels were recorded in June, with increases at site I80 from site K76 which was <0.02 mg/L to 0.03 mg/L.

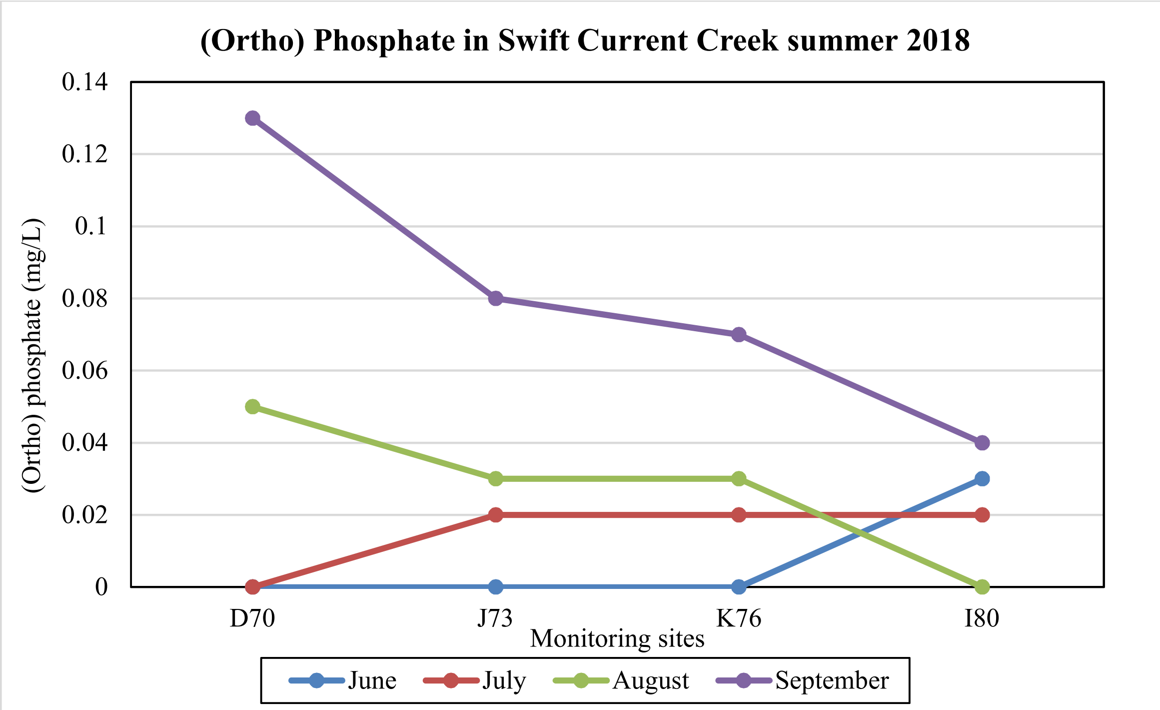

Figure 26. Orthophosphate in Swift Current Creek summer 2018

vii.) Aluminum

In 2017 levels of aluminum were found to be higher than those taken in 2007. The most common cause of high aluminum is from water treatment processes and waste water treatment where it is added as a form of alum. If this is added in excessive amounts it can lower the pH pose a threat to the aquatic life (KDW 2007 as cited by SCCWS 2008).

General water quality has a limit of 5mg/L or 5000 µg/L. Concentrations were expected to be higher at the city sites and downstream in 2017, which they proved to be. However, aluminum also tested high upstream of the city of Swift Current. No values in 2017 were over the limit and the highest concentration was documented at site I80 in May at 4.22 8mg/L. In 2018 the sites showing the highest concentrations of aluminum are D70 and J73. The highest value was taken in August at site J73 with a concentration of 494 mg/L. As shown in Figure 27 aluminum levels stayed fairly consistent within the sampling areas and none were over the 5000 mg/L limit. For every month with the exception of July the concentration lowered between sites K76 and I80. As the sites are moving further downstream of the WTP and WWTP in Swift Current, it may suggest that the higher concentrations make sense coming directly downstream of the city at site D70 and gradually decreasing as the creek flows east towards Waldeck.

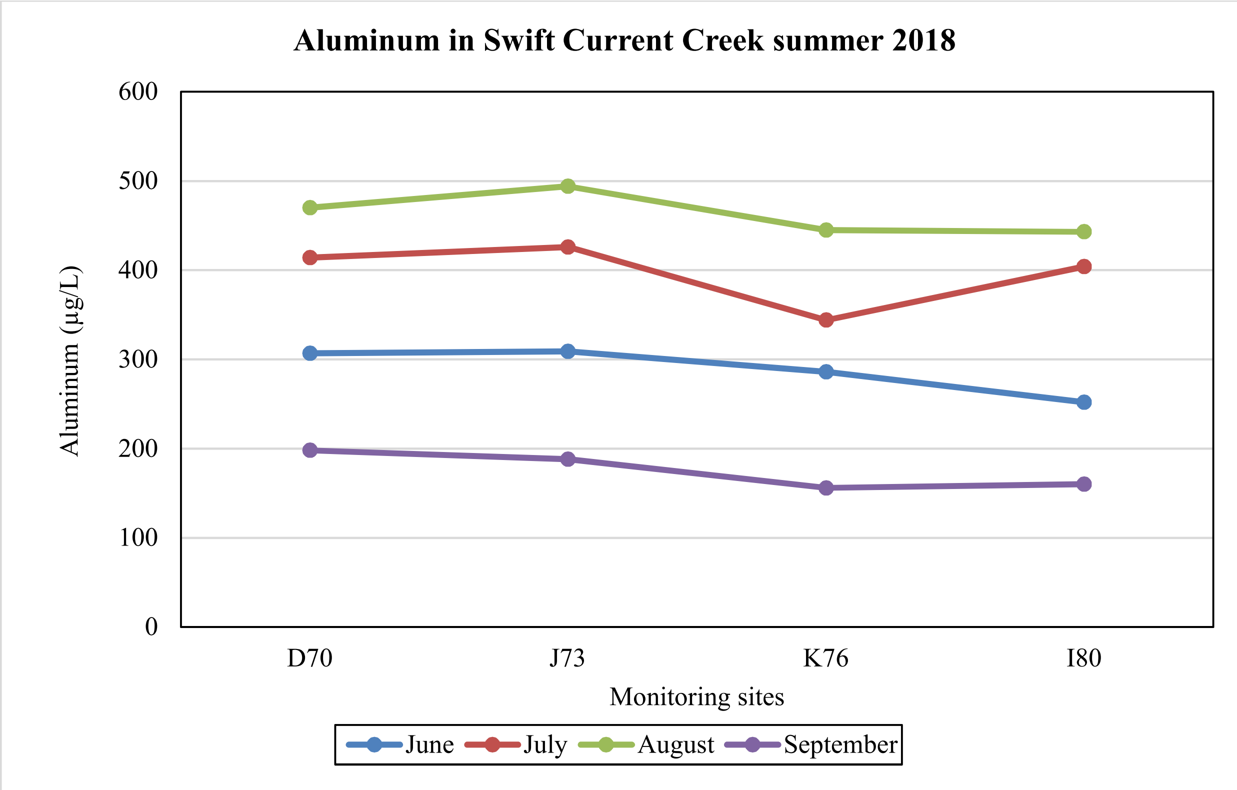

Figure 27. Aluminum in Swift Current Creek summer 2018

viii.) pH

As discussed pH is an important parameter that can affect many other components of water chemistry. pH is also dependant on water temperature and DO. Human-caused factors that affect the pH and the proper primary respiration of aquatic organisms include agricultural, wastewater, and industrial run-off (Fondriest Environmental Inc. 2013 as cited by SCCWS 2018). The ideal range of pH is between 6.5 to 8.5 or 9 pH units, and the protection of aquatic life and wildlife guideline indicates a range of 6.5 to 8.5.

In the southwest water naturally has a range of pH up to and including 9 pH units and the aquatic life has adapted to these levels (J-M Davies in email document to K Steinley dated June 11 2018 11:21 AM; unreferenced as cited by SCCWS 2018). There were no sites in 2017 or 2018 that showed limits exceeding or falling below the limits. Samples were also taken in the morning to ensure same day shipping, so pH levels may have been slightly higher due to the time of day than the normal average. No values exceeded over 8.5 pH units and none fell below 8.0 pH units. The highest recording was at site D70 in September at 8.5 pH units and the entire summer sampling range was consistent in the 8 pH unit range with no outliers. Figure 28 shows the pH levels from each site though the summer of 2018.

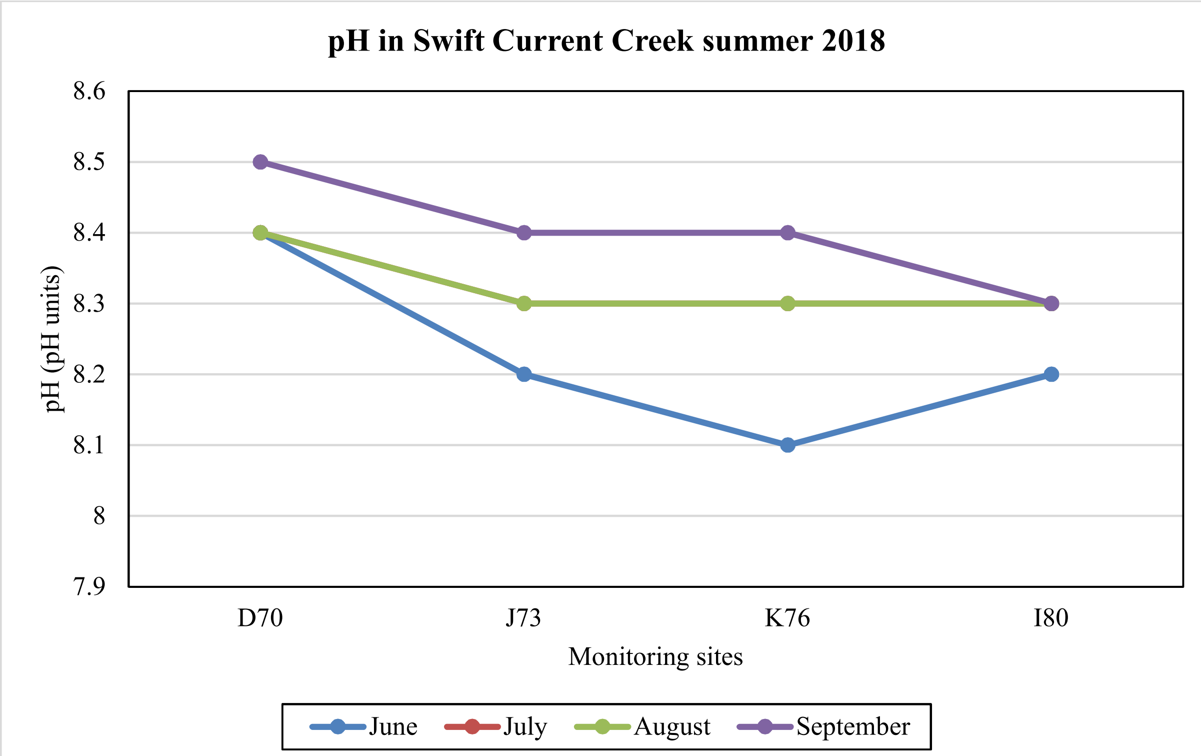

Figure 28. pH in Swift Current Creek summer 2018

ix.) Arsenic

Arsenic occurs naturally and can also be human-caused in certain types of industry. In the SCCW arsenic levels tend to be higher, as in the rest of southwest Saskatchewan surface water (J-M Davies in email document to K Steinley dated June 11 2018 11:21 AM; unreferenced as cited by SCCWS 2018). According to the World Health Organization (2017) as cited by SCCWS (2018) arsenic in its inorganic form is toxic and often monitoring for drinking water and aquatic and environmental health. The protection of aquatic life and wildlife limit is set at 5µg/L and general water guidelines are set at 50 µg/L. The highest levels of arsenic recorded in 2017 were at site I80 with an occurrence at 10.3 µg/L in June and levels over the aquatic life and wildlife limit in July.

In 2018 no sites exceeded the 5 µg/L limit. However, close occurrences recorded in September at site D70 with a reading of 4.8 µg/L and also site I80 at 4.8 µg/L in both July and September. Sites J73 and K76 had a maximum of 4.6 µg/L also occur in September at site J73 specifically. All other values were 4.5 µg/L and below. The lowest arsenic value was taken at site I80 in August, just before the highest value peaked in September. This one occurrence at site I80 is much lower than the remaining summer test results, which were consistent in the 4.6-4.8 µg/L range, as shown in Figure 29.

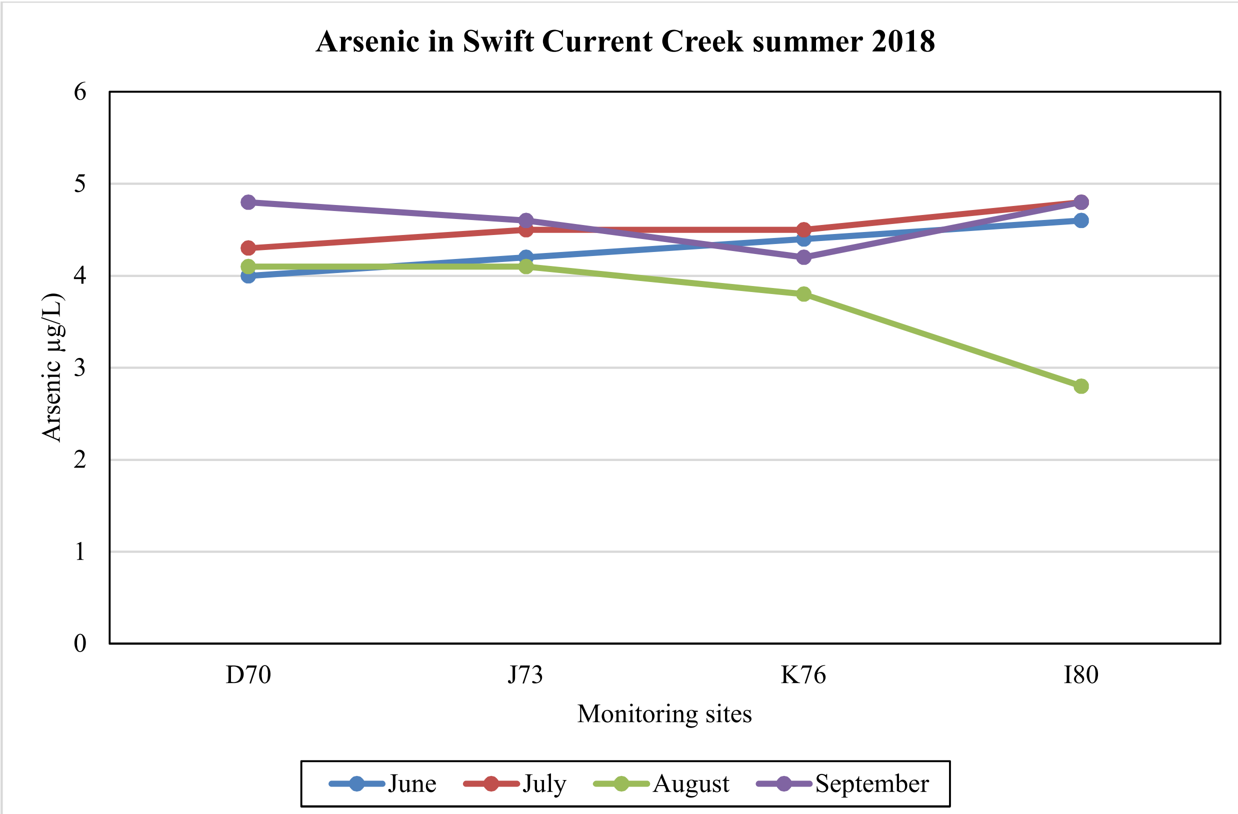

Figure 29. Arsenic in Swift Current Creek summer 2018

4.0 Conclusions and recommendations

4.1 Riparian health

The following conclusions were made after analyzing the RHA data:

- Site D70 had the highest overall score with 67%. This site was ranked as healthy but with problems. In 2017 the rating was 63%. This site has remained in the healthy with problems category and gradually has been decreasing and maintaining in the 60 per cent range.
- Site I80 had the lowest RHA score of all the sites, as it also did in 2017. The overall score was 57% which ranks it as unhealthy.
- All sites show increased presence and species of invasive or unwanted plants.
- Disturbance species are more dominate, indicating a decline in health.
- Sites were at the lower end of healthy with problems, trending towards unhealthy if not ranked there already due to poor binding root masses and invasive species.
- Continued erosion and invasion of unwanted plants seem to be in a continuing trend, limited the biodiversity especially at site I80.
- New and increasing invasive species found at site D70 were Common Tansy and Common Burdock. Burdock was also common in the city upstream so it is moving downstream.

- Due to the dry years many disturbance plants such as Kochia were present in more abundance due to their adaptation to dry conditions.
- Drought conditions can not be mitigated, but suppression of the common tansy and burdock can help slow the spread of these invasives.

4.2 Saskatchewan water quality index and parameters

The following conclusions were made after analyzing the water quality data and field readings:

- The irrigation water use index stayed consistently low among all four sites with a drop in percentage after site D70.
- Deviations in the irrigation water use mainly attributed to TDS and fecal and total coliforms.
- The protection of aquatic life and wildlife index does not appear to be a concern as all percentages remained in the good range. DO and pH were both at levels in which species can thrive.
- Sodium and aluminum were the main deviations for the protection of aquatic life and wildlife.
- Livestock watering had a lower score (marginal) at site D70 than the remaining three sites, which all were consistent in the good range. The highest scores included both sites J73 and K76 at 83.8% each.
- Deviations for livestock watering included only TDS and copper.
- General water use ranked fro the good (site D70) to fair ranges. The lowest score occurred at site J73 at a 78.7%.
- Deviations in general water use quality included: TDS, fecal coliform, aluminum, and sodium at all sites.

It is unclear as to the levels of aluminum remain high at all points along the SCC as found in the 2017 study. Aluminum would theoretically increase after the WTP but high amounts were also found upstream of the WTP in 2017. Improvements to the livestock operations along the SCC in the 2018 study area would be beneficial in limiting the fecal and total coliforms, sedimentation, and amount of nutrients entering the SCC. Cattle operations upstream of site J73 and K76 may be contributing to the lower water quality with these deviations, and removal or limited access by cattle directly to the creek may help lessen the contributions. It has been observed that this stretch within the watershed appears to be in the poorest of health, but the health increases again closer to the mouth of the creek at site E90. There may be other factors affecting this section of creek that continue to lessen the health in both the riparian and water quality.

4.3 Water chemistry

There were no indications of any chemistry results that would raise immediate alarm. Similar trends were seen in this small section of the creek as there was in 2017. The conclusions made after analyzing the 2018 data are:

- Chloride is not a major contributing factor the degradation of water quality. All values were under the limit and trended as increasing downstream of the city of Swift Current.

This would suggest that chlorides are increased in the SCC due to the water treatment processes and the urban run-off of the city.

- Sodium trends to increase downstream of site D70, with the highest values occurring at site I80 and levels at this site stayed consistently over the maximum allowable limit. Run-off from agricultural operations and urban areas may attribute to this increase in sodium.
- Sulfates were over the limit every month of sampling at site I80. Since this is the most downstream site of multiple agricultural operations it is possible that contributions of sulfates increase as the creek flows towards the mouth through agricultural operations. Site D70 however also showed high levels in June and July, which were both over the limit.
- Nitrite Nitrate Nitrogen showed the highest concentrations at site D70 but none exceeded the limit. Site D70 had the highest concentration in the month of July, which may indicate that the high summer temperatures and dry conditions contributed to the concentrations. The water temperature was also the highest at site D70.
- TDS all remained within the limits but tended to increase downstream from site D70. The highest levels recorded at site I80 and the lowest occurred at site D70.
- Ortho Phosphorus showed no values over the limit. September recorded the highest values and the trend of increasing from site J73 to I80.
- Aluminum had no levels over the limit, but has been consistently on the higher end in terms of the entire SCC. Water treatment processes often incorporate aluminum but levels were also trending high upstream of the city of Swift Current in 2017.
- pH levels all remain in the optimum range for southwest water bodies with no levels approaching lethal limits to aquatic organisms.
- Arsenic has no values exceeding the limits and is a naturally occurring substance in the soils of the southwest.
- Trends in nearly all parameters and chemistry readings showed a lower value at site D70 with a plateau occurring between sites J73 and K76, then often increases at site I80.
- The trend may indicate that there are no substantial factors within this reach of the SCC to conclude any major problematic sources. Livestock operations and irrigation are the main land uses, and the increase in values at site I80 may be attributed to increases in these operations between the upstream sites and downstream sites.

4.4 Recommendations

This study was initiated in response to data gathered in the 2017 Swift Current Creek Water Monitoring Project (SCCWMP) which showed that the stretch of the SCC between Swift Current and North of Waldeck had significant issues with water quality and watershed health. To investigate this phenomenon further funding from Agriculture and Agri-Food Canada Green Farms Internship Program was obtained to determine where the water quality issues are and why the area has the issues it does. Once data was collected, this report was compiled to detail the issues and their origins. From the information in this report recommendations for BMP's to be implemented to improve water quality and watershed health were made. BMPs are eligible for funding through Canadian Agriculture Partnership. SCCWS Agri-Environmental Technical Services (AETS) Technician is available to assist producers to apply for the funding to implement these BMPs. SCCWS's recommended BMPs are as follows:

- Development of livestock watering systems to pump water from the creek into water troughs to reduce livestock access to the creek
  - This will reduce impact of cattle moving to spots in the creek to drink. This will reduce lateral cutting of the creek bank and pugging and hummocking at spots in the creek. In turn sedimentation will be decreased and water holding capacity especially in flood prone areas will be increased.
  - Limits livestock access to creek to reduce impacts of cattle defecation and urination into the creek to improve water quality by reducing nitrogen, phosphorous and coliforms in downstream water.
- Pipeline to move water from creek to different pastures
  - Allows better use of forage. Reduces overgrazing riparian areas which will improve the function of that area.
- Relocate livestock confinement areas to at least 300 m from the creek and improve run-off management within farm yards.
  - Reduces chance for run-off from facilities to enter creek which keeps excess nitrogen, phosphorous, coliforms and TDS from creek water.
- Riparian Grazing Management
  - Protect riparian areas by managing timing, intensity and length of time cattle graze riparian areas to improve function and keep vegetation on banks to maintain integrity of banks to reduce sedimentation and erosion.
- Targeted Grazing
  - Graze sheep and goats to control infestations of invasive plant species.
  - Invasive weeds are usually shallow rooted and replace deep rooted native species to alter function of riparian areas and increase chances of erosion of creek bank.

BMPs not eligible for funding but implementation would provide long term protection of water quality and watershed health in this part of the creek are as follows:

- Engineered wetland to filter irrigation drainage water before it enters the creek to decrease nitrogen, phosphorous, TDS, sodium, chloride and sedimentation entering the creek improving water quality.
- SCCWS did not test for pesticides in the water in this project, but there are concerns about pesticides entering the creek. To protect against this producers should look at the development of Bio Beds to filter sprayer rinseate. Bio Beds are a mixture of straw or wood chips, soil, and compost or peat that neutralizes any pesticides left in the rinseate. Sprayer tanks are rinsed in a specified area that catches the rinseate, stores it and slowly distributes it through the mixture rather than having it sprayed out in an area close to water sources.

Further study is also recommended to determine the impact of the excess water being drained off of the flood irrigation area. Two sampling sites, one upstream and one downstream of the spot where the excess water from the Waldeck Irrigation Project drains into the SCC should be added to the monitoring project. This may give a clearer indication if this excess water is impacting the creek as it may be high in nitrogen, phosphorous, TDS and other minerals. This water entering the creek may also be causing increased sedimentation and bank erosion reducing water quality. Further study of the impact of this drainage may provide answers to the water quality issue on the creek downstream of the project. The results of such a study may provide impetus to find methods to mitigate or eliminate the impact of this drainage on the creek.

When researching the causes of the degraded water quality at site I80 from the 2017 project one of the suggestions was that the sewage from the Village of Waldeck lagoon was leaking into the creek causing water quality issues. In discussions with the Village of Waldeck, several tests that they have conducted showed that this was not the case. During the 2018 project the Village of Waldeck was awarded a Federal-Provincial Grant to upgrade the lagoon. This work may start in 2019. SCCWS would suggest to work with the Village of Waldeck to sample before and after these upgrades to determine if there was impact or not and to determine the effectiveness of the upgrades.

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