Assessment of 5-in-30 sampling, comparing Steele Springs (SSWD) to two sites on Deep Creek.

Prepared by: E. Dennis Einarson, RPBio
Impact Assessment Biologist

Date: 7-May-2018

Client name: Inter-Ministry Working Group - Hullcar
File: 76600-20 Armstrong

Executive Summary

The Steele Springs Water District (SSWD) services about 150 people and collects its domestic water from Steele Springs, a cluster of natural spring outflows from the Hullcar aquifer (Einarson, 2016; Golder, 2017). Due to high nitrate levels in the water supply the Interior Health Authority (IHA) issued a water quality advisory to SSWD in March 2014 (Einarson, 2016). Elevated bacterial samples were also reported in the raw source water during two routine sampling events, in March 2017. In response to the high *E. coli* values, the Hullcar Inter-Agency Working Group and partner agencies, conducted three separate initiatives to look at fecal contamination of water in the area. The Ministry of Forests, Lands, Natural Resource Operations, and Rural Development (FLNR) Groundwater Section and the Ministry of Environment and Climate Change Strategy (ENV) Environmental Protection Officers conducted a visual site inspection at SSWD and neighbouring properties in response to the *E. coli* values reported from the domestic water supply. Their assessments identified some pipe connections, in the SSWD upland infrastructure, as a potential risk, however, they were unable to determine the source of fecal contamination. A second initiative by IHA and ENV was an opportunity for private well testing in the Hullcar area to assess nitrate and *E. coli* levels. This program was voluntary and free of cost to the private well owner. For the third initiative, the ENV Monitoring and Assessment staff investigated the potential for contamination of the SSWD from flood waters during high freshet conditions on Deep Creek. This study was unable to establish a link between the two water sources and was also unable to determine the source of fecal contamination. This study did find that the water composition of the creek and springs is significantly different from each other which may indicate that the two sources are unrelated and therefore the risk of contamination of the spring source by Deep Creek is low. The study recommended continued monitoring of the SSWD source water and regular inspection of the upland infrastructure.

Introduction

On March 20, 2017 concerns were raised when the results from routine water sampling of the SSWD water reported high *E. coli* (49 cfu/100 ml) in the Water District's raw source water. While high nitrate values (10.0 to 15.9 mg/L) in the spring water are considered to be in part due to contamination from the lands above the aquifer (Golder, 2017), the source of the high *E.coli* values was unknown. Although there have been similar fecal coliform readings reported in historic samples taken from SSWD, those readings were thought to be a result of contamination from the open, overland creek

flow of the source water before it entered the distribution system. This issue was corrected with the installation of new infrastructure. The new structures diverted the source spring water directly into a covered infiltration gallery and then piped the water to the SSWD pumping facility. There has been no reported bacterial contamination in the raw water since the repairs were made. In response to the March 2017 bacterial measurements, the Hullcar Inter-Agency Working Group and partner agencies, agreed that it was important to: 1) have FLNRO Groundwater Section conduct visual inspections of SSWD works, nearby wells, and neighbouring properties for potential sources of fecal contamination (Pyett, 2017); 2) offer residents in the Hullcar Valley to have their private wells analyzed for nitrates and *E. coli*; and 3) collect additional samples at two sites on Deep Creek and SSWD to assess the potential for contamination from Deep Creek to SSWD during the spring flooding and freshet flows. This report summarizes the results from the additional sampling at SSWD and Deep Creek.

Project Description

ENV conducted surface water sampling following the 5 in 30 protocol (5 samples collected within 30 day period) during high freshet flows and flood conditions on Deep Creek. During this period the creek flooded fields upstream of the Hullcar Valley as well as the upper portions of the fields in the valley along Hullcar Road bordering the creek. Time of day, and day of week of the sampling events were varied to ensure coverage of a number of environmental variables including air temperature, precipitation, snow melt, the daily flow characteristics and other activities along the creek. Samples collected using this protocol allow the parameters to be characterized, the variability assessed, and a comparison can be made to historic values collected using the same method. Water flows were not measured, therefore contaminant loadings could not be calculated. Figure 1 shows the locations of the sample sites and Appendix 1 outlines the sampling schedule, and parameters that were analyzed.

Deep Creek enters the Hullcar Valley at the upper sample site (EMS ID E206908). It then meanders through the upper edges of the fields for approximately 1km eastward along Hullcar Road, before turning south near Pyott Road and cutting across the Hullcar Valley. At Hullcar Road, the creek is quite shallow with low bank heights, which contributes to the spring flooding conditions. As the creek flows across the valley it cuts a deeply incised canyon bisecting the valley north – south. The creek continues down slope to Armstrong and then meanders along the valley to Otter Lake and eventually entering Okanagan Lake. Steele Springs is located in a shallow depression approximately 10m below field level and 50m above the creek bed adjacent to the D. Regehr Farm, off Schubert Road. At this point Steele Springs is approximately 1.3 km south of Hullcar Road and 650m west of Deep Creek. Although Deep Creek is thought to be a significant contributor to the ground water recharge in the Hullcar Aquifer (Golder, 2017), there is no overland connection between Deep Creek and Steele Springs.

Sampling began on April 11th and concluded on May 8th, 2017. Three samples were collected from SSWD during this period in addition to the regular monthly samples collected on March 20th and May 23rd. Although the monthly samples fall outside of the 5 in 30 protocol time constraints, the results were included in the assessment to ensure equal weight of SSWD's data in the analyses.

Assessment

A summary of the key water quality parameters collected from Deep Creek and SSWD are tabulated in Table 1. The effects of inflow of freshet melt water and rainfall can be seen in the tabulated values and in Figures 2 and 3. The dissolved ionic fractions (alkalinity, anions and hardness) and dissolved nitrogen and phosphorus, showed decreases in concentrations following week 1 at the Deep Creek sites. The dilute conditions continued through weeks 2 and 3, but returned to the week 1 concentrations as the freshet flows declined in week 4. With heavy rains in the valley between weeks 4 and 5 there was a return to the dilute conditions observed earlier in the study. The patterns were similar at both

.Figure 1 – Sample locations for water quality samples taken over a 30-day period in April and May, 2017

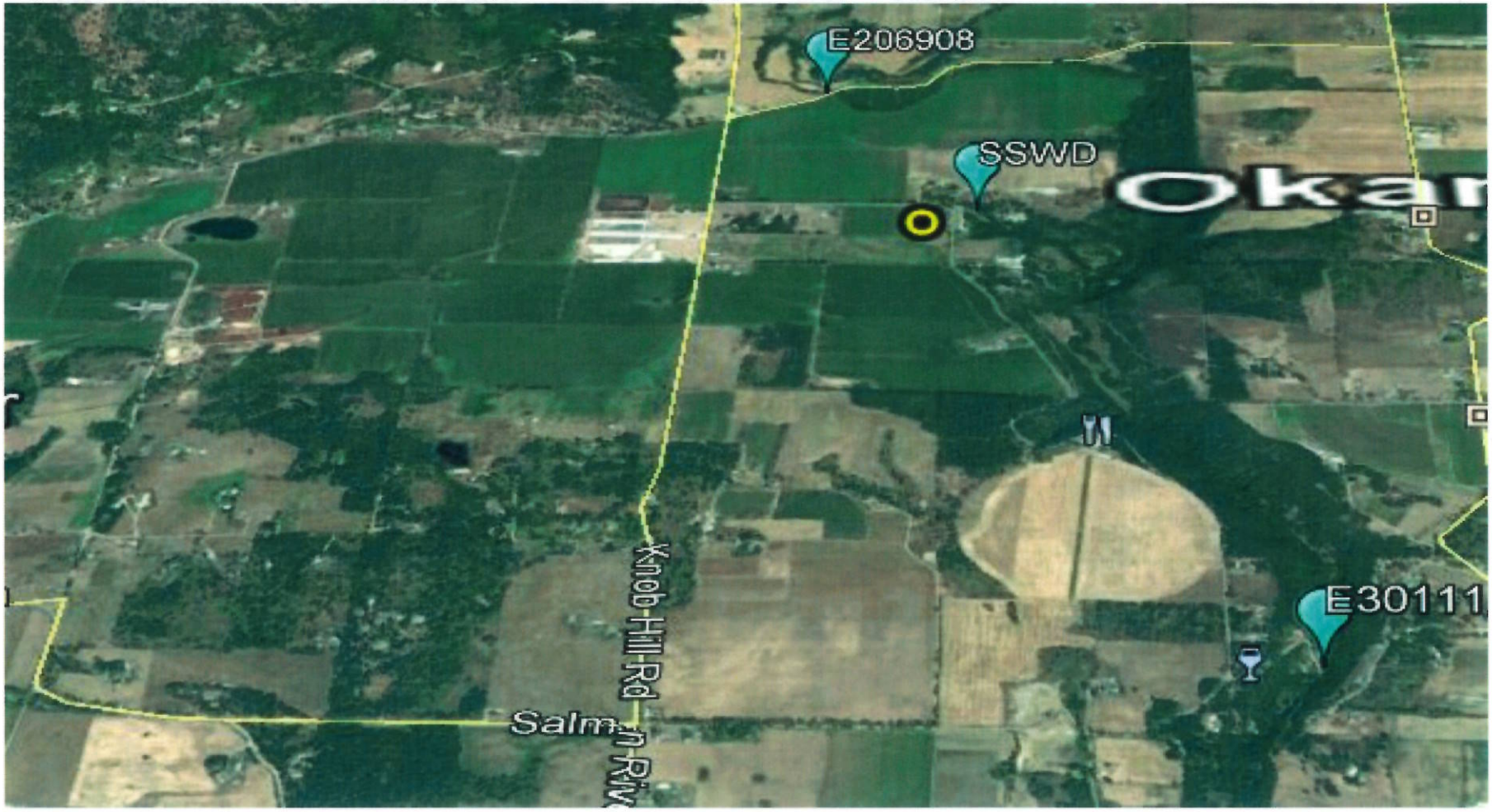

Table 1 - Summary of results for Deep Creek and SSWD samples - April 2017

DATE	H2CO3 Alkalinity mg/L	DOC mg/L	TOC mg/L	Cl mg/L	E Coli CFU/ 100mL	Hardness mg/L	TKN mg/L	N-NO3 mg/L	N-NO2 mg/L	TN mg/L	TP ug/L	SO4 mg/L	Turbidity NTU	pH
E206908 - Deep Creek at Hullcar Road														
11-Apr-17	120	16.5	17	5.83	80	162	0.7	0.909	0.0037	1.610	249.0	47.2	30.1	8.17
18-Apr-17	95.1	18.4	17.2	3.58	50	113	0.508	0.396	0.0024	0.906	216.0	30.9	36.4	7.82
24-Apr-17	93.8	16.2	15.8	3.87	200	123	0.519	0.38	0.0024	0.902	177.0	30.5	32.4	8.07
3-May-17	112	14.6	15.8	5.18	60	155	0.55	0.543	0.0029	1.100	200.0	40.4	20.7	8.09
8-May-17	116	16.6	16.7	5	60	129	0.67	0.545	0.004	1.220	250.0	34.5	27.6	8.1
Monthly Ave	**107.38**	**16.46**	**16.5**	**4.692**	**77.96**	**136**	**0.5894**	**0.5546**	**0.0031**	**1.1476**	**218.4**	**36.7**	**29.44**	**n/a**
E301110 - SSWD														
20-Mar-17	220	3.69	3.66	19.3	49	371	0.300	14.5	0.005	14.800	9.8	119.0	0.52	8.18
11-Apr-17	215	3.28	3.19	19	47	373	0.800	14.2	0.005	15.000	8.7	116.0	< 0.1	7.96
24-Apr-17	217	3.52	3.38	18.6	9	376	1.200	13.8	0.005	15.000	11.0	114.0	0.15	8.18
8-May-17	217	3.24	3.4	18.9	1	316	< 0.005	13.9	0.005	13.100	8.0	114.0	0.51	8.02
23-May-17	222	3.6	3.78	17.9	< 1	356	< 0.005	12.3	0.001	12.300	7.8	109.0	0.34	8.17
Monthly Ave	**218.2**	**3.466**	**3.482**	**18.74**	**7.3**	**358**	**0.462**	**13.74**	**0.0042**	**14.04**	**9.1**	**114.4**	**0.324**	**n/a**
E301112 - Deep Creek at Gulch Road														
11-Apr-17	121	15.8	17.4	6.42	20	168	0.65	1.12	0.0037	1.770	205.0	51.5	27.7	8.25
18-Apr-17	106	16.4	17.9	4.27	86	122	0.49	0.584	0.0022	1.080	231.0	35.5	36.2	7.71
24-Apr-17	103	15.9	16.8	4.42	26	142	0.65	0.555	0.0022	1.210	176.0	34.5	32.5	8.14
3-May-17	117	14.2	14.3	5.84	310	168	0.52	0.753	0.0030	1.270	167.0	44.1	23.7	8.22
8-May-17	118	16.4	18.9	5.22	25	160	0.87	0.685	0.0040	1.560	318.0	36.5	49.3	8.16
Monthly Ave	**113**	**15.74**	**17.06**	**5.234**	**51.05**	**152**	**0.636**	**0.7394**	**0.0030**	**1.378**	**219.4**	**40.42**	**33.88**	**n/a**

the upstream site at Hullcar Road and the downstream site at Gulch Road with concentrations increasing between upstream and downstream sites.

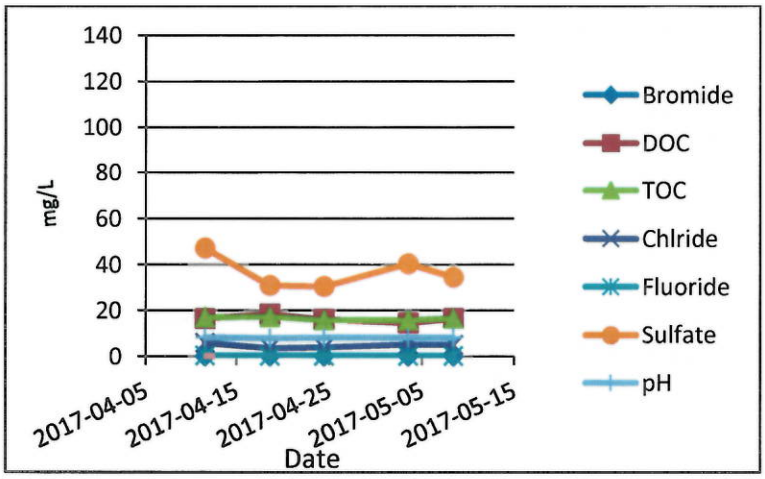

Figure 2 – Anion and organic carbon concentrations (mg/L) at the Deep Creek at Hullcar Road site(E206908) upstream of SSWD measured weekly from April 11, 2017 to May 8, 2017.

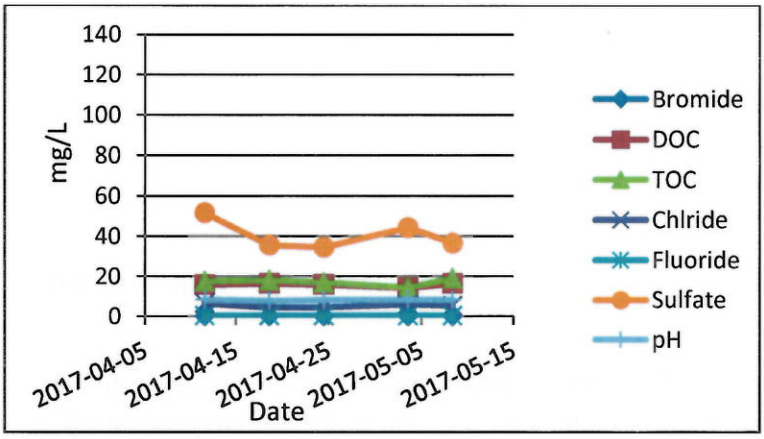

Figure 3 – Anion and organic carbon concentrations (mg/L) from Deep Creek at the Gulch Road site (E301111) downstream of SSWD measured weekly from April 11, 2017 to May 8, 2017.

Although the anion fractions showed dilution effects of snow melt and the spring rains, the organic parameters did not follow this pattern. During freshet the organic fractions (total organic carbon and dissolved organic carbon) remained constant during the study. This would indicate that inflowing melt waters, or water within flooded areas, had picked up sufficient organic content to maintain the instream concentrations.

E. coli and total phosphorus reacted a bit differently. In Figure 4, Total Phosphorus appeared diluted, similar to the anions, at the beginning of freshet conditions, followed by increased concentrations beginning in the third week of the study to a maximum of 250 ug/L at Hullcar Road and 318 ug/L at Gulch Road. The *E. coli* concentrations shown in Figure 5 also display increases in the third and fourth weeks of sampling. The maximum levels of *E. coli* were 200 CFU/100 mL at upper Deep Creek location during the third week of sampling followed by the maximum level of 310 CFU/100 mL at the lower site in week 4. Although these parameters were quite variable during the study, both Total Phosphorus and *E. coli* reached their maximum recorded levels during the study following the late spring rain events. This is consistent with the

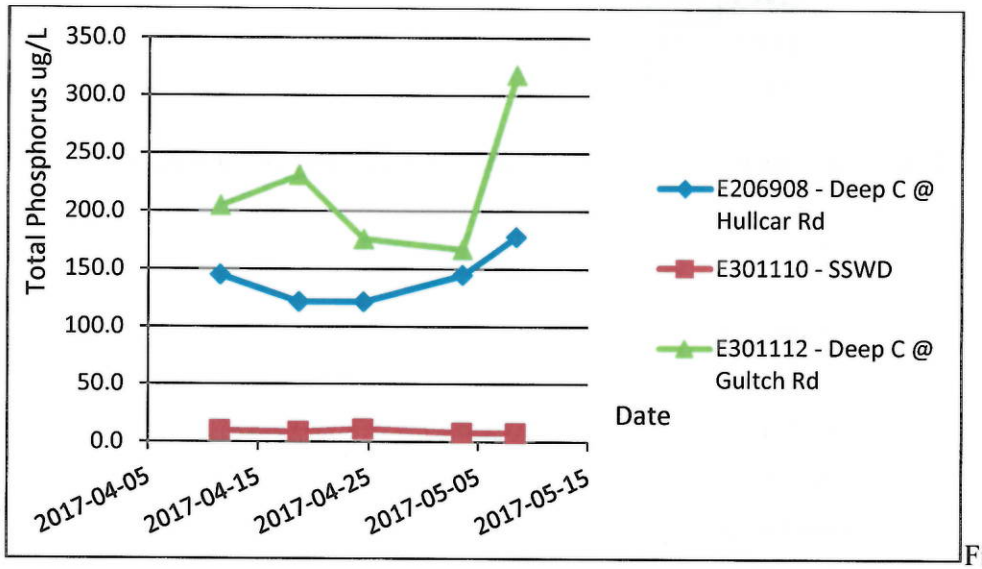

Figure 4 – Total Phosphorus concentrations (ug/L) measured at Deep Creek and Steele Springs SSWD.

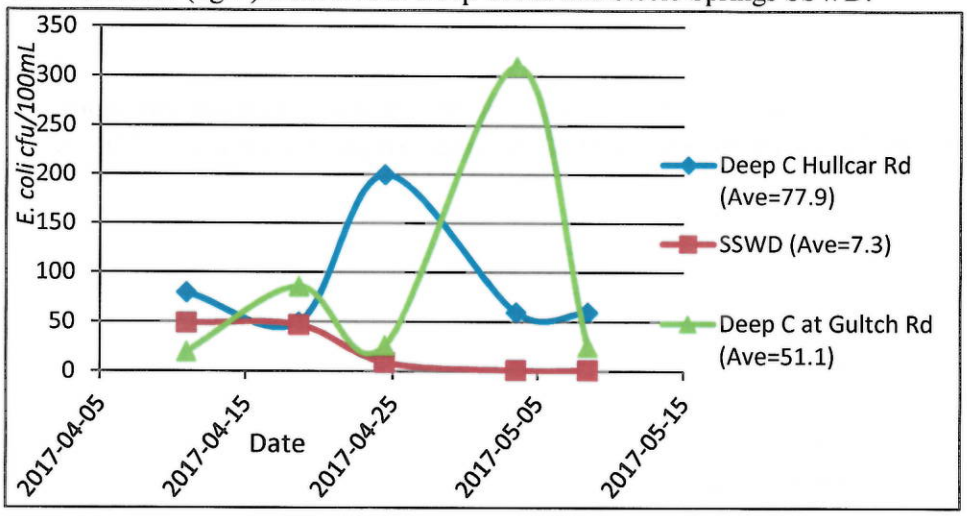

Figure 5 – *E. coli* at Deep Creek and Steele Springs, April 11 to May 8, 2017.

pattern observed with the organic parameters and would support the theory of an increase in contaminant inflow during freshet and as well as gradual increase between the upstream location at Hullcar Road and the downstream sample site at Gulch Road.

The water sampling at SSWD, shown in Figure 6, did not show the trends observed in the creek samples. With the exception of *E. coli* and nitrate, most parameters were unchanged during the study period. There was a slight decline observed in the sulfate concentrations which could be due to intake location adjustments by the SSWD operators. Overall alkalinity, sulphate and chloride concentrations were significantly higher in the SSWD than those measured in the creek water. Alkalinity averaged 218.2 mg/L, twice as high as the average Deep Creek values of 107.4 and 113 mg/L recorded at Hullcar and Gulch roads, respectively. Hardness followed the same trend, with hardness in the SSWD samples averaging 358 mg/L versus 136 and 152 mg/L at Hullcar and Gultch roads respectively. Chloride and sulphate ions in SSWD were 18.7 and 114.4 mg/L respectively, approximately 4 times the Deep Creek averages. Box plots of sulphate, bicarbonate, chloride, magnesium, calcium and sodium are shown in Figure 7. The relative difference in position of the boxes indicates that the water from SSWD exhibits a chemically distinct signature - different from the signature of the water in Deep Creek.

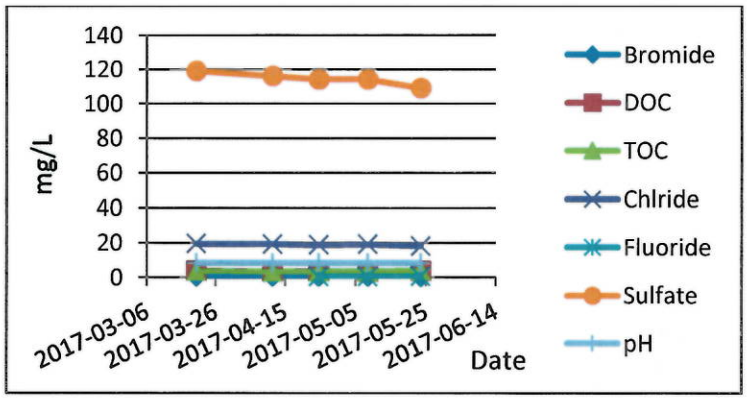

Figure 6 – Anions and organic carbon concentrations at SSWD (E301110) measured from March 20, 2017 to May 23, 2017.

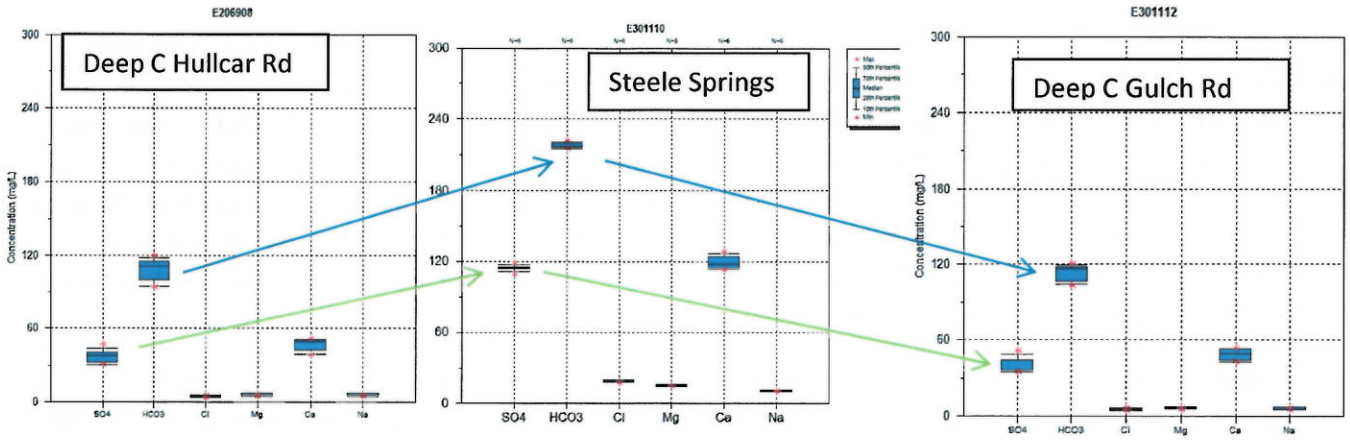

Figure 7 – Box Plots of Monthly averages for SO_4, HCO_3, Cl, Mg, Ca and Na at Deep Creek and SSWD

The plots also illustrate minor differences between the upper and lower sites on Deep Creek. The values noted at Gulch Road are slightly higher than those observed upstream. The average dissolved nitrogen fractions, including N-NO3, shown in Figure 8, were also much higher in the SSWD water. These samples also indicate the differences between the water collected from Deep Creek and the water from SSWD.

The organic fractions in the SSWD water showed the opposite of these trends. Total organic carbon and dissolved organic carbon in SSWD were approximately 25% of the Deep Creek values, while total phosphorus in SSWD averaged about 5% of Deep Creek values. This is typical for ground water chemistry in this aquifer (Einarson, 2016) (Golder, 2017). Total Kjeldahl Nitrogen (TKN) values, representing total organic nitrogen and ammonia, were similar in both SSWD and Deep Creek.

E. coli levels in the SSWD declined significantly from the maximums measured of 49 and 47 cfu/100 mL on March 20th and April 11th, to <1 cfu/100 mL on May 23rd. The geometric mean, shown in Figure 5 is 7.3 cfu/100mL and meets the Canadian drinking water guidelines. The geometric means for *E. coli* at the two sites in Deep Creek were 77.9 cfu/100 mL and 51.0 cfu100 mL, respectively. These values are within contact recreation guidelines but exceed the guidelines for use as domestic water supply.

Comparing the samples it appears there is no correlation between *E. coli* values in Deep Creek and those observed at SSWD. Although similar *E. coli* levels were observed initially, the samples in Deep Creek increased during the last few weeks of the study while those in SSWD were reduced to below detection limits.

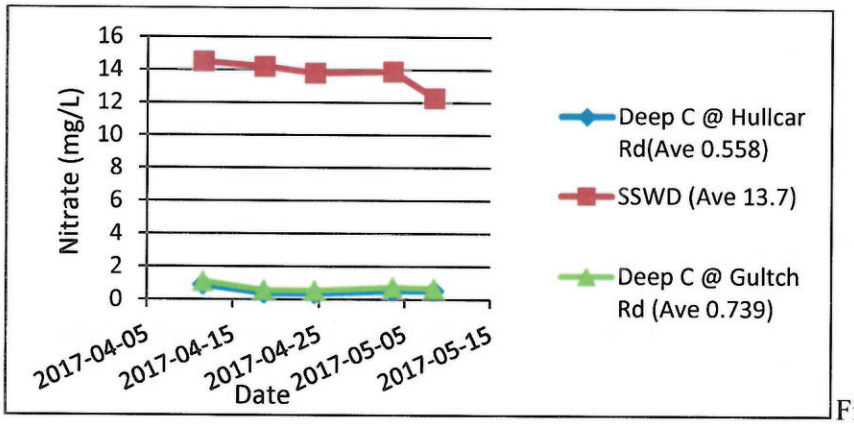

Figure 8 - Nitrate at Deep Creek and Steele Springs, April 11 to May 8, 2017.

Total and dissolved metals were also analyzed. Of the metals detected, most were below water quality guideline values. However, exceedances were noted in Total and Dissolved Copper, Iron, and Zinc. A summary of metals samples that exceeded guidelines are listed in Table 2. The Health Canada maximum of 300 ug/L for total iron was exceeded in all samples from Deep Creek and one sample from SSWD. Short-term maximum (acute) and long-term average (chronic) BC Aquatic Life guidelines for total iron were exceeded in Deep Creek but were met in SSWD. BC drinking water guideline for total copper was exceeded in all samples from SSWD. However, these results were considered suspicious and led to further investigation into the source of metal contamination.

To assess the metal contamination issue samples were collected from the usual sample site within the SSWD pump house and a second location outside the building. Comparison of results showed elevated Copper and Zinc levels of 7.37 and 6.32 ug/L in the pump house sample compared to 1.10 and 0.98 ug/L detected in the outside sample site. It appears that metal contamination occurred during the sample collection inside the SSWD pump house. The source of the contamination appears to be metal taps and fittings in the building. Therefore, the metal samples collected from inside the pump house may not be representative of metal concentrations in the source water of SSWD. The taps and fittings should be replaced with non- metallic fixtures to reduce the potential for metal contamination of future samples.

Comparison to Historic Values

SSWD have been under a water quality advisory since 2014, but the nitrate levels have been above ambient ground water conditions for a number of years. Historical values dating back to March 18, 1987 are shown in Figure 9. Nitrate values during the period of February 1987 to January 1989 were between 4 and 5 mg/L, followed by a dramatic increase to greater than 12.0 mg/L by February 2015 (Einarson, 2016). Between October 20, 2016 and April 24, 2017 the levels have increased from 12.1 to 14.2 mg/L. The *E. coli* levels were below 10 CFU/100 mL during this period.

At the upstream Deep Creek site, this pattern is reversed, with nitrate levels decreasing as depicted in Figure 10. During freshet in 1987, the maximum nitrate levels were 10.1 mg/L, averaging 6.83 mg/L, before dropping to 0.17 mg/L during summer low flows. In 1989, the spring maximums decreased to approximately 9.0 mg/L, while the midsummer low flows were 0.07 mg/L. The pattern of decreasing instream nitrate levels continues through 2017. The maximum instream nitrate value during the 2017 spring sampling was 0.909 mg/L, with an average of 0.554 mg/L – a 92% reduction since 1987. Although there is much shorter historical data record at Gulch Road the maximum nitrate concentration measured was

1.12 mg/L, with a monthly average of 0.739 mg/L. This represents a decrease of 49% since March 26, 2015 when concentrations were 1.92 mg/L.

Table 2 - Summary of Total Copper (Cu) and Total Iron (Fe) analysis. Values in red exceed either aquatic life guideline or drinking water guideline.

		Cu-T (ug/L)	Fe-T (ug/L)	Hardness mg/L
E206908 - Deep Creek @ Hullcar Road				
2017-04-11		4.52	**1680**	162
2017-04-18		4.21	**892**	113
2017-04-24		3.88	**1170**	123
2017-05-03		3.31	**812**	155
2017-05-08		3.37	**680**	129
Count		5	5	5
Average		3.86	**1046.8**	136
95%tile		4.458	1578	161
E301110 - SSWD				
2017-03-20		**18.1**	124	371
2017-04-11		**13.6**	4.8	373
2017-04-24		**56.7**	30.3	376
2017-05-08		**109**	**564**	316
2017-05-23		**9.21**	49.4	356
Count		5	5	5
Average		**41.32**	155	358
95%tile		98.54	476	375
E301112 - Deep Creek @ Gulch Road				
2017-04-11		4.22	**1490**	168
2017-04-18		4.58	**1300**	122
2017-04-24		4.7	**1300**	142
2017-05-03		2.94	**706**	168
2017-05-08		6.2	**1970**	160
Count		5	5	5
Average		4.53	**1353**	152
95%tile		5.90	1874	168
BC Drinking Water		**1000***		
Health Canada		**1000**	**300**	
AL long-term		**7.48**	**350**	
AL short-term		**19.5**	**1000**	

* To prevent laundry and plumbing staining.

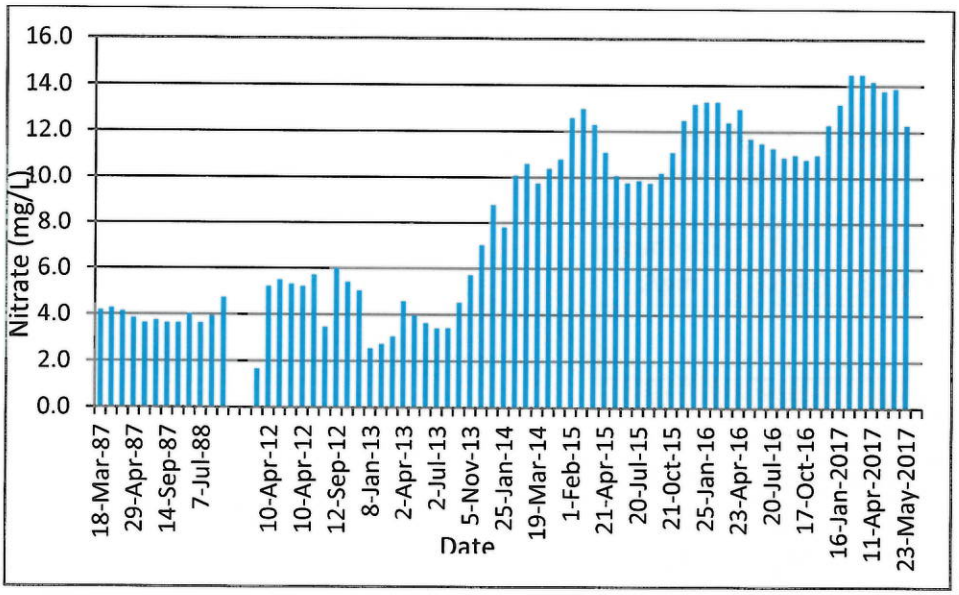

Figure 9 – Nitrate Levels at SSWD, March 18, 1987 to May 23, 2017.

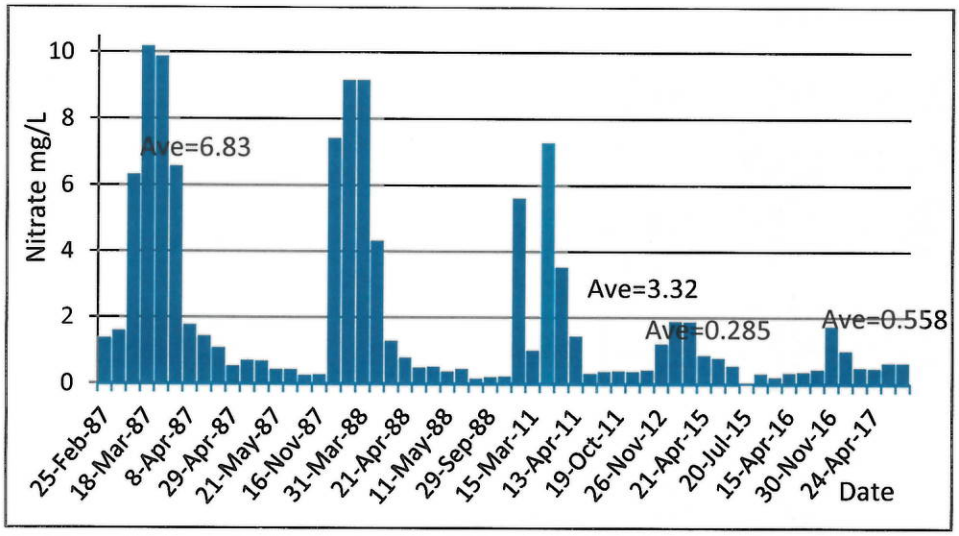

Figure 10 – Nitrate Levels Deep Creek at Hullcar Road February 25, 1987 to May 11, 2017.

To see if this increasing trend for instream nitrate concentrations continues further downstream nitrate values for Deep Creek near the mouth were plotted in Figure 11. This graph clearly shows that the nitrate values also decrease with distance downstream. The average value calculated from the 5 in 30 day sampling conducted at the lower creek site in 2011 is 0.799 mg/L. This is a 83% reduction in the ambient nitrate concentrations between Hullcar Road and the mouth of Deep Creek for the same sample dates.

Conclusions and Recommendations

SSWD is a natural spring outflow from the Hullcar aquifer (Einarson, 2016; Golder, 2017). Domestic use of water from the Hullcar aquifer has been an issue due to high nitrate associated with agricultural contamination to the lands above the aquifer (Golder, 2017). Samples collected on March 20, 2017 at SSWD had high *E. coli* and nitrate values. These values suggested the possibility of overland contamination by surface waters infiltrating the water supply. A review of historical

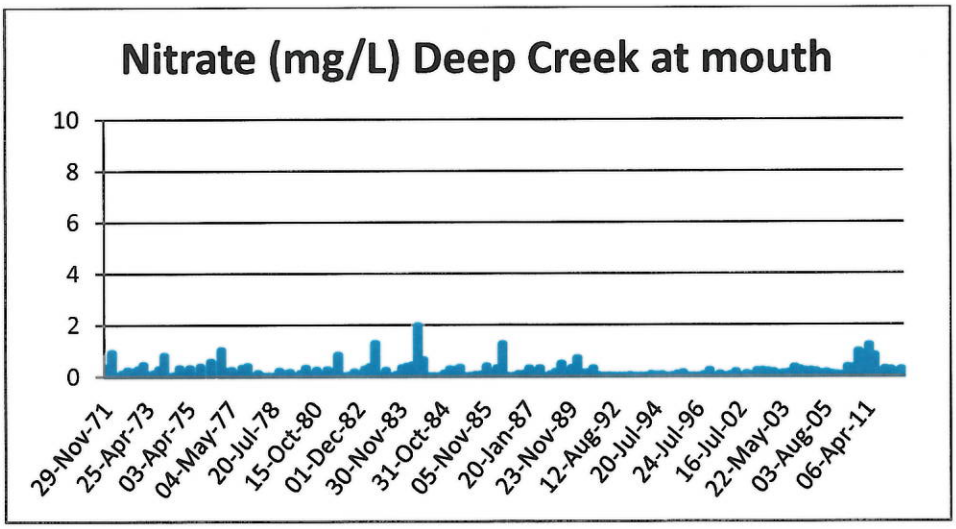

Figure 11 – Deep Creek at Mouth, November 1971 to March 30, 2011.

data, collected from SSWD showed a few samples containing *E.coli*, but none as high as the 49 CFU/100 mL recorded in the March 23, 2017 sample, although a follow-up sample collected on April 11th, reported a second high value of 47 CFU/100 mL, indicating that this was not a single occurrence.

Water samples collected from Deep Creek and SSWD investigated the potential for bacterial contamination from Deep Creek to enter the SSWD source water as a result of freshet flows. During the study water levels were very high; flooding fields where manure had been applied the previous fall. No obvious overland flow or connection to the spring source could be identified. The study was unable to establish a link between the two water sources and was also unable to determine the source of contamination. However, analyses of the chemical composition of water samples revealed that the water from the SSWD source was significantly different then the flood waters of Deep Creek. This indicates that the two sources are not connected and the risk of contamination of the SSWD by Deep Creek is low. Continued monitoring of the SSWD source water is recommended along with and regular inspection of the upland infrastructure.

E. Dennis Einarson, RPBio
Environmental Impact Assessment Biologist
Monitoring, Assessment and Stewardship

Appendix 1: Parameters sampled, project costs and sampling schedule.

Parameter
Bromide
Chloride
Sulphate
Fluoride
Total Alkalinity 4.5
Alkalinity-pcp-ba (speciation)
DOC
TOC
Turbidity
Conductivity
pH
Hardness (ICP)
Total Metals-low
Diss Metals-low
Ammonia
Total Diss N
Kjeldahl N
Nitrite
Nitrate
Nitrate-Nitrite
Total nitrogen
Total P
Total P Dissolved
Ortho P
E. coli

Cost / sample

Hold Times -28 days

Location	EMS ID	**Number of samples**
Steele Springs	E301110	5
Deep Creek @ Hullcar	E206908	5
Deep Creek @ Gulch	E301112	5
Package Cost		$2,392.00
10% QA/QC		$239.20
Totals		$2,631.20

SSWD	March 20, April 11, 25, May 8 and May 23..
Deep Creek	April 11, 18, 25, May 2 and 8.