Ymir Water System

2020 Quartz Creek Flow and Water Quality Monitoring Report

Date of Report:	February 11, 2021
Reporting Period:	2020 Year End Report October 16, 2020 to January 07, 2021
Owner:	Regional District of Central Kootenay
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1. Quartz Creek Flow Monitoring

1.1 Flow Monitoring Weir

In 2019 a flow monitoring weir was installed on Quartz Creek at the intake for the Ymir water system with funding provided by BC Timber Sale and the water service.

The Kindsvater-Carter Formula was adopted to calculate flow through the sharp crested aluminum weir installed in the concreate water system intake weir. Flow depth through the aluminum flow monitoring weir is measured by an ultrasonic level transmitter. The aluminum weir will measure flows up to about 560 mm or 742 L/s. Above this level the concrete intake weir will overtop.

Wing plates were added to the ends of the concrete weir in spring 2020. The wing plate opening was later widened in August 2020 to accommodate higher peak flows of up to 710 mm or 1,515 L/s.

1.2 Reporting Period Data Quality

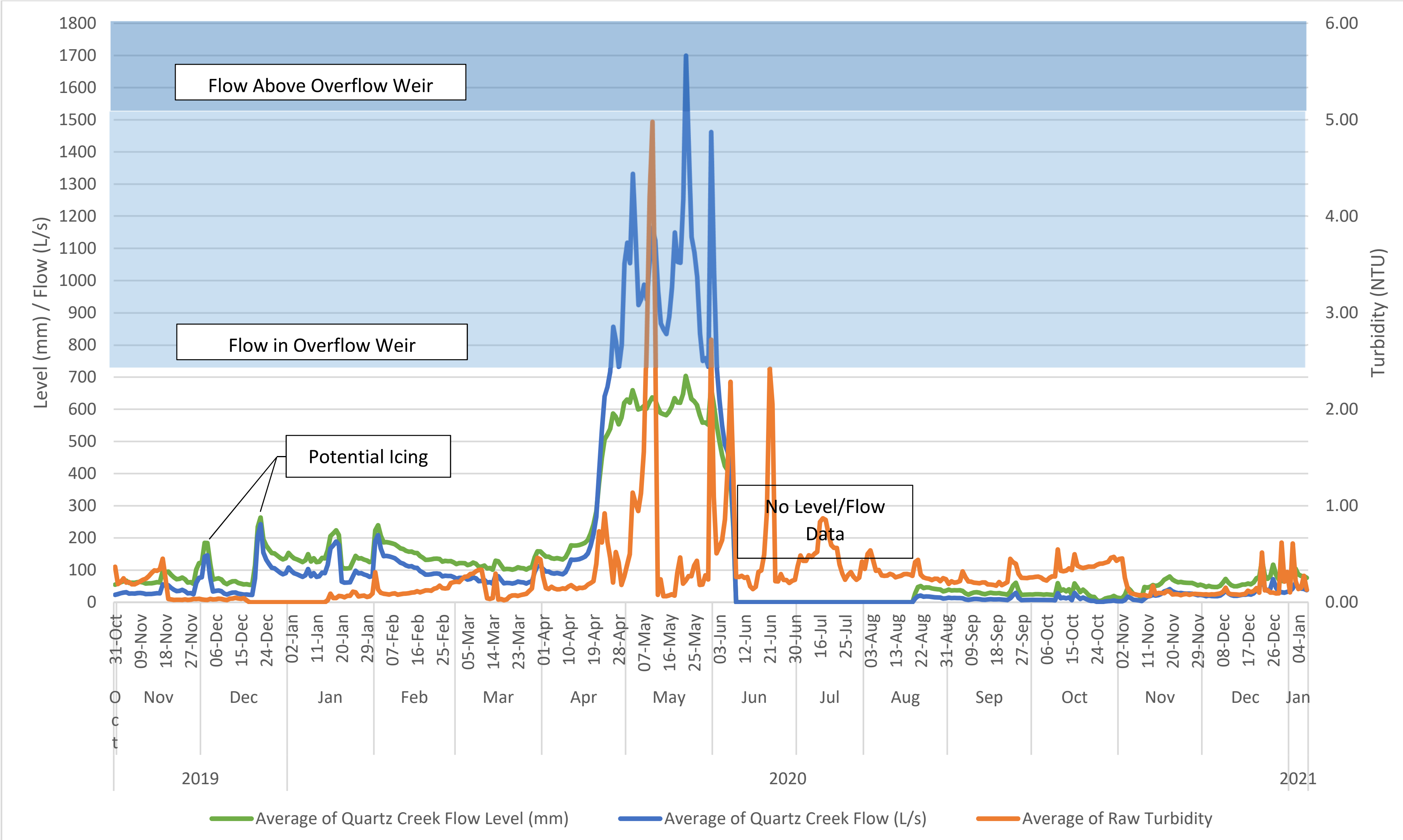
The level transmitter failed on June 8, 2020 and was replaced on August 20, 2020. The level and flow data during this period is considered incorrect. A third quarter 2020 report was drafted but not issued since there was no flow data for much of the reporting period.

It appears that during winter, periodic pond and intake weir icing might be interfering with water level readings. Unfortunately these icing periods might be corresponding with low creek flow periods.

During update of the Kindsvater-Carter Formula for the overflow weir widening, a calculation error was noted in the prior second 2020 reporting period for flows in the overflow weir (>560mm or >742 L/s). The Kindsvater-Carter Formula was updated to provide a revised calculation for overflows from spring 2020 to August 2020, and a new formula has been provided for overflows after August 2020. See attached Ymir Water System Quartz Creek Flow Monitoring Weir Formula, revised 31 August 2020 for widened Overflow.

1.3 Flow Graphs

The Quartz Creek level and flow data is provided in 15 minute intervals, which is too much data to chart. The digital flow data is provided in a separate Excel file. An Excel pivot table was used to present the follow daily average weir flow level, creek flows and turbidity data.



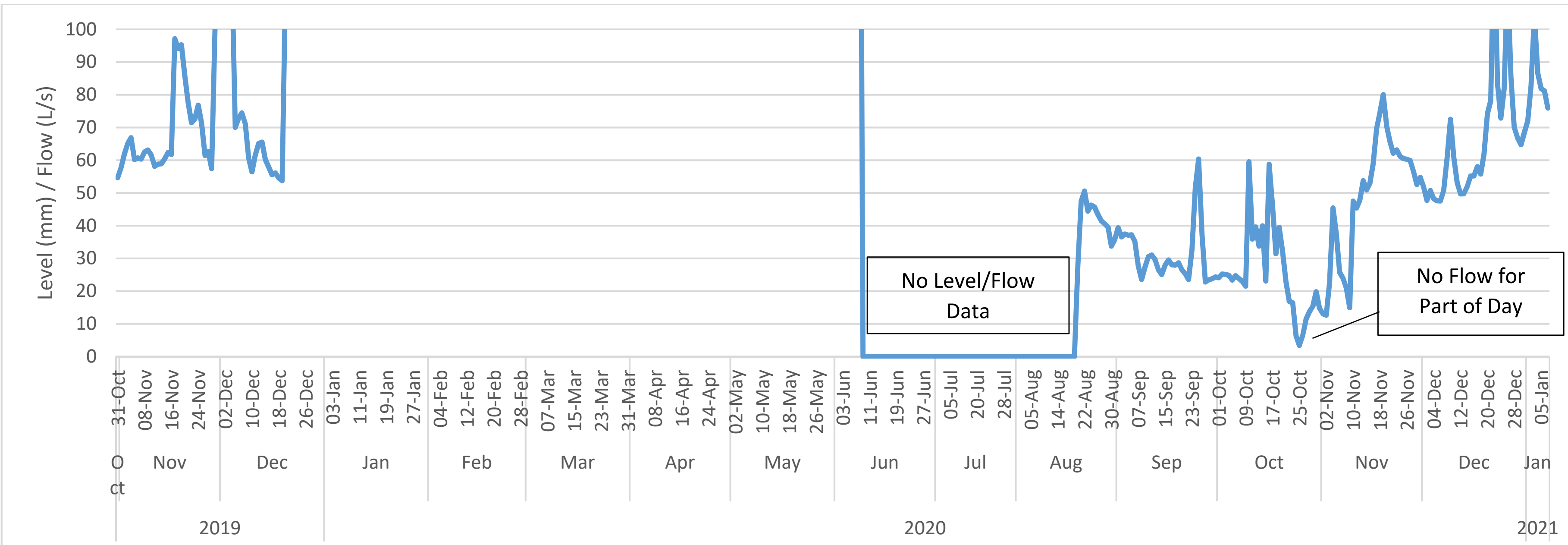
The following table provides the minimum and maximum average daily weir flow level and creek flows measured to date.

	Quartz Creek Flow Level (mm)	Quartz Creek Flow (L/s)	Date
Min	22	Undetermined	
Max	703	1,699	22 May 2020

Note the flow was above the overflow weir on 22 May 2020 and the maximum flow recorded is not considered accurate.

It appears that low flows for Quartz Creek in 2020 occur in late October or early November. Due to intake pond and weir icing during the winter, it is difficult to determine minimum flows. The lowest daily average flow recorded, excluding the known level senor failure period, was on 25 October 2020 at 0.8 L/s; however, there was a level of zero recorded for much of this day and icing is suspected. The average daily flow on 24 and 26 October was 1.3 L/s, which also could have been affected by icing.

The flow chart presented as follow has the vertical scale set for better clarity of low flow data.



2. Quartz Creek Water Quality Monitoring

The Regional District is monitoring the following water quality parameters in association with the Quartz Creek Flow and Water Quality Monitoring initiative.

Water Quality Monitoring Parameter	Description	Desired Frequency
Raw Water Turbidity	Online turbidity meter	15 minutes
pH	Manual testing	When Technician on Site
Treated Water Bacteriological	Total Coliforms, E.coli & Fecal Coliform	Weekly
Raw Water Bacteriological	Total Coliforms, E.coli & Fecal Coliform	Bi-weekly
Raw Water Full Comprehensive	Chemical and physical parameters based on Guidelines for Canadian Drinking Water Quality	Quarterly
Treated Water THM & HAA	Trihalomethanes (THMs) and haloacetic acids (HAAs)	Quarterly

2.1 Raw Water Turbidity

Raw water turbidity is monitored online in the treatment plant.

Raw water turbidity is presented on the flow charts in the previous section. The maximum daily average turbidity for 2020 was 4.98 NTU recorded on May 10, 2020.

2.2 pH

pH is hand measured when water technicians are onsite at the Ymir water treatment plant. The following table provides the pH test results for the monitoring period.

Test Date	pH
19-Aug-19	7.31
27-Aug-19	7.36
4-Sep-19	7.3
11-Sep-19	7.5
16-Sep-19	8.0
17-Sep-19	7.5
25-Sep-19	7.8
30-Sep-19	7.4
7-Oct-19	7.5
15-Oct-19	7.7
22-Oct-19	7.6
28-Oct-19	7.5
5-Nov-19	7.6
11-Nov-19	7.5
18-Nov-19	7.3
25-Nov-19	7.4
3-Dec-19	7.6
17-Dec-19	7.5
23-Dec-19	7.6
3-Jan-20	7.5
7-Jan-20	7.4
15-Jan-20	7.6
20-Jan-20	7.7
27-Jan-20	7.7
3-Feb-20	7.4

Test Date	pH
12-Feb-20	7.8
18-Feb-20	7.6
25-Feb-20	7.6
3-Mar-20	7.6
11-Mar-20	7.4
18-Mar-20	7.5
24-Mar-20	7.2
30-Mar-20	7.3
6-Apr-20	7.4
15-Apr-20	7.4
22-Apr-20	7.3
28-Apr-20	7.4
4-May-20	7.5
20-May-20	7.6
19-May-20	7.7
26-May-20	7.5
8-Jun-20	7.5
17-Jun-20	7.4
22-Jun-20	7.0
29-Jun-20	7.4
7-Jul-20	7.3
13-Jul-20	7.3
20-Jul-20	7.4
28-Jul-20	7.4
4-Aug-20	7.5

Test Date	pH
10-Aug-20	7.4
19-Aug-20	7.3
24-Aug-20	7.4
31-Aug-20	7.4
9-Sep-20	7.2
14-Sep-20	7.4
21-Sep-20	7.5
30-Sep-20	7.5
6-Oct-30	7.5
14-Oct-20	7.3
19-Oct-20	7.3
26-Oct-20	7.2
3-Nov-20	7.5
9-Nov-20	7.4
16-Nov-20	7.3
24-Nov-20	7.3
1-Dec-20	7.4
7-Dec-20	7.5
15-Dec-20	7.4
21-Dec-20	7.2
30-Dec-20	7.5
4-Jan-21	7.4
11-Jan-21	7.5
18-Jan-21	7.5

2.3 Treated Water Bacteriological

A treated water sample is taken weekly for Total Coliforms, and E.coli bacteria testing. Testing is provided by the BC Centre for Disease Control through Interior Health. Only adverse sample results are reported to the Regional District. There has been no adverse treated water sample results during the monitoring period.

2.4 Raw Water Bacteriological

A raw water sample is taken bi-weekly for Total Coliforms, E.coli and Fecal Coliform bacteria testing. Testing is conducted by Passmore Laboratory Ltd. Sample test results for the monitoring period are summarized in the following table.

Sample Date	Total Coliform (Colony Count per 100 ml)	E.coli (Colony Count per 100 ml)	Fecal Coliforms (Colony Count per 100 ml)
2019-08-14	92	Less than 1	Less than 1
2019-08-28	45	Less than 1	Less than 1
2019-09-11	101	Less than 1	Less than 1
2019-09-25	83	Less than 1	Less than 1
2019-10-08	10	Less than 1	Less than 1
2019-10-22	63	Less than 1	Less than 1
2019-11-05	06	Less than 1	Less than 1
2019-11-19	13	Less than 1	Less than 1
2019-12-03	10	Less than 1	Less than 1
2019-12-17	11	Less than 1	Less than 1
2020-01-07	07	Less than 1	Less than 1
2020-01-21	02	Less than 1	Less than 1
2020-02-04	9	1	1
2020-02-18	25	Less than 1	Less than 1
2020-03-03	3	1	1
2020-03-18	3	Less than 1	Less than 1
2020-04-01	17	Less than 1	Less than 1
2020-04-15	11	Less than 1	Less than 1
2020-04-28	1	Less than 1	Less than 1
2020-05-13	4	Less than 1	Less than 1
2020-05-26	7	1	1
2020-06-09	13	7	7
2020-06-24	15	Less than 1	Less than 1
2020-07-07	26	Less than 1	1
2020-07-20	98	Less than 1	Less than 1
2020-08-10	19	Less than 1	Less than 1

Sample Date	Total Coliform (Colony Count per 100 ml)	E.coli (Colony Count per 100 ml)	Fecal Coliforms (Colony Count per 100 ml)
2020-08-19	22	Less than 1	Less than 1
2020-08-31	19	Less than 1	Less than 1
2020-09-14	28	Less than 1	Less than 1
2020-09-30	37	Less than 1	Less than 1
2020-10-14	26	Less than 1	Less than 1
2020-10-26	9	Less than 1	Less than 1
2020-11-09	23	Less than 1	Less than 1
2020-11-24	6	Less than 1	Less than 1
2020-12-07	4	Less than 1	Less than 1
2021-01-04	17	Less than 1	Less than 1
2021-01-19	4	Less than 1	Less than 1
2021-02-01	2	Less than 1	Less than 1

2.5 Raw Water Full Comprehensive

Raw Water Full Comprehensive test results are summarized in the following table.

Sample Date	Comments
2019-07-26	Test results within Canadian Drinking Water Quality Guidelines.
2019-10-22	Total Coliform count of 11. All other test results within Canadian Drinking Water Quality Guidelines.
2019-12-09	Test results within Canadian Drinking Water Quality Guidelines.
2020-03-30	Test results within Canadian Drinking Water Quality Guidelines.
2020-07-28	Total Coliform count of 71. Test results within Canadian Drinking Water Quality Guidelines.
2020-10-19	Test results within Canadian Drinking Water Quality Guidelines.

2.6 Treated Water THM & HAA

Some studies have identified a potential link between disinfection byproducts, primarily trihalomethanes (THMs) and haloacetic acids (HAAs) and certain forms of cancer. Disinfection byproducts can be formed when chlorine reacts with source water that has higher levels or organic material.

Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Trihalomethanes, April 2009 addendum, identifies the maximum acceptable concentration (MAC) for trihalomethanes (THMs) in drinking water as 0.100 mg/L (100 µg/L) based on a locational running annual average of a minimum of quarterly samples taken at the point in the distribution system with the highest potential THM levels. The maximum acceptable concentration (MAC) for bromodichloromethane (BDCM) in drinking water is 0.016 mg/L (16 µg/L) monitored at the point in the distribution system with the highest potential THM levels.

Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Haloacetic Acids, 2008 identifies the maximum acceptable concentration (MAC) for total haloacetic acids in drinking water at 0.08 mg/L (80 µg/L) based on a locational running annual average of a minimum of quarterly samples taken in the distribution system.

Sample test results for the monitoring period are summarized in the following table.

Sample Date	Total Trihalomethanes (mg/L)	Bromodichloromethane (mg/L)	Total Haloacetic Acids (mg/L)
2019-01-28	0.0109	< 0.0010	0.00774
2019-07-17	0.0207	< 0.0010	0.0145
2020-06-18	0.0227	< 0.0010	0.0205
2020-09-21	0.0118	< 0.0010	0.0106
2021-01-04	0.0188	< 0.0010	0.0130

Appendix A

Quartz Creek Flow Monitoring Weir Formula

Ymir Water System
Quartz Creek Flow Monitoring Weir Formula
Jason McDiarmid, revised 31 August 2020 for widened Overflow

There are two commonly used formulas for calculation of flows over contracted rectangular weirs provided by the US Burrow of Land Reclamation. The following simplified formula could be used if dimensions of the weir and flow meet certain criteria. The proposed weir opening for Quartz Creek is 40 inches wide x 22 inches high. One of the requirements of the simplified formula is that the width of the weir be at least 3 times greater than the flow height. This means that the formula could only be used for flows heights of less than 7.33 inches (186 mm), which would not work for the Quartz Creek flow weir.

$$Q = 3.33(L - 0.2H)H^{3/2}$$

Kindsvater-Carter Formula

The Kindsvater-Carter formula as follows is more complicated:

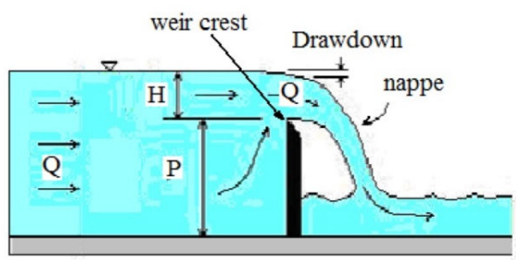


Figure 1: Weir Profile

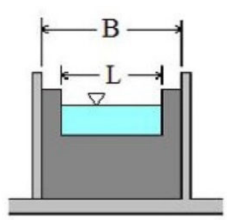


Figure 2: Weir Elevation

$$Q = C_e L_e {H_e}^{3/2}$$

Where:

Q is the discharge in ft^3/s.

C_e is the effective coefficient of discharge.

$L_e = L + k_b$

$H_e = H + k_h$

L is the length of the weir crest in feet, 3.333 feet.

B is the average width of the approach channel in ft, 30 feet.

H is the head measured above the weir crest in feet, 0 to 1.833 feet to top of weir.

k_h is a correction factor having a value of 0.003 feet.

k_b depends on the ratio of crest length to average width of approach channel (L/B), (3.333 / 30) = 0.111

P is the depth from the weir invert to the bottom of the approach pool in feet, 7 feet when pool has no sediment.

k_b can be determined from L/B and Figure 3. L/B = 3.333 / 30 = 0.111; therefore, k_b = 0.0083.

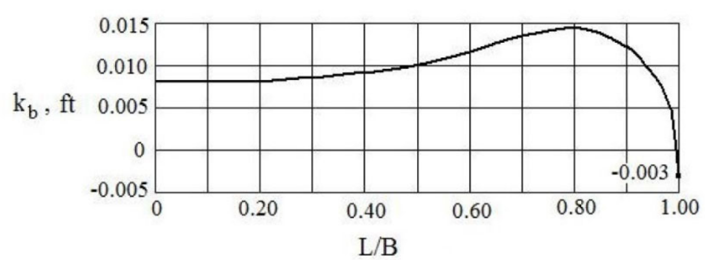


Figure 3: k_b, Bureau of Land Reclamation Water Measurement Manual

C_e can be determined from Figure 4 based on L/B and H/P. L/B = 3.333 / 30 = 0.111, P = 7 feet and H varies from 0 to 1.833 feet; therefore, H/P varies from 0 to (1.833/7) or 0 to 0.262.

With an L/B of 0.111, C_e can be interpreted as being about constant at 3.15 for an H/P of 0 to 0.262.

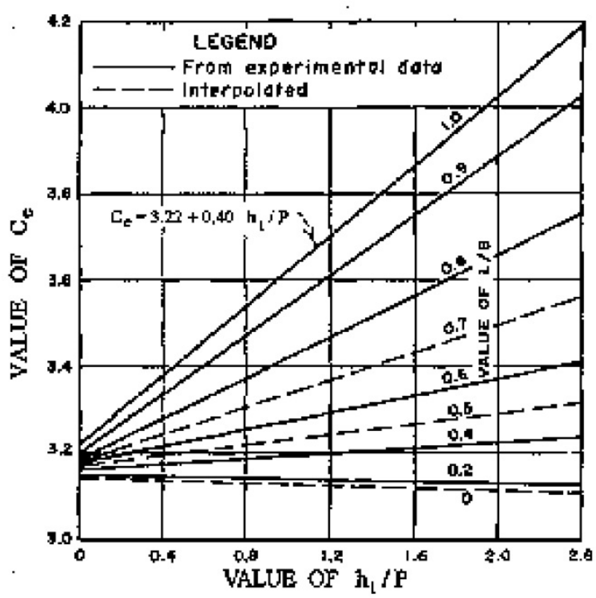


Figure 4: C_e, Bureau of Land Reclamation Water Measurement Manual

With the known information for the proposed Quartz Creek weir the flow formula and be provided as follows for dimensions in feet and flow rate of cubic feet per second:

$$Q = C_e L_e H_e^{3/2}$$

$$Q = C_e(L + k_b)(H + k_h)^{3/2}$$

$$Q = 3.15(3.333 + 0.0083)(H + 0.003)^{3/2}$$

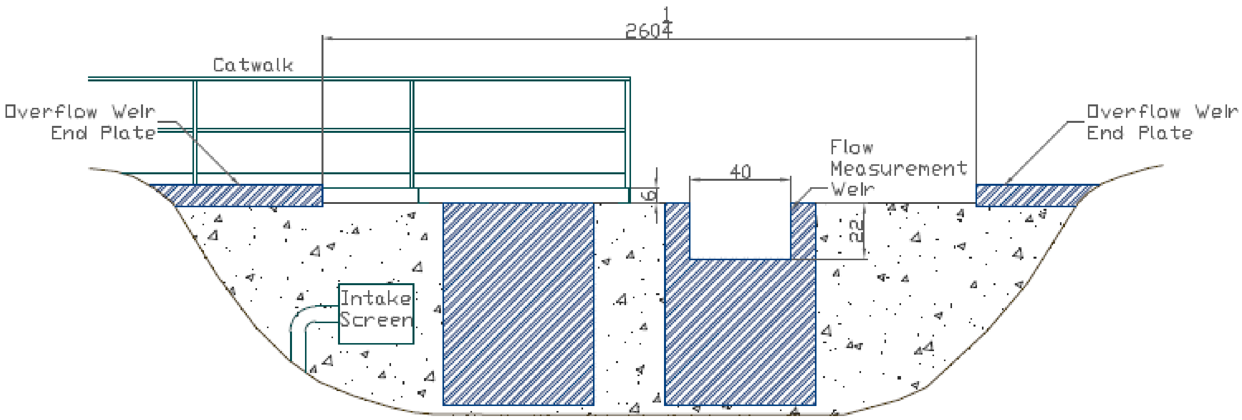
$$\boldsymbol{Q = 10.525(H + 0.003)^{3/2}}$$

The calculated flow rate in cubic feet per second can then be multiplied by 28.317 to convert it to L/s.

Overflow Weir – Up to 20 August 2020

The flow measurement weir has been sized for better accuracy on low flows. Because the flow measurement weir is smaller than the previous concrete intake weir openings, it is likely that the flow measurement weir will overtop during high flow events. End plates were added to the concrete intake weir to create a second wider flow weir above the main flow weir to capture higher flow events.

The Kindsvater-Carter Formula was not likely intended for complex weirs, so flow calculation might only be considered an estimation only for the overflow weir. In addition, supports for a catwalk above the concrete weir would slightly disrupt flow and the catwalk would only accommodate 6” of overflow before the flow is significantly disrupted.



The following assumes that two separate Kindsvater-Carter calculations can be done: one for flow through the main flow measurement weir; and one for over topping flows. The two flow calculations could then added together to get an estimation of total flow.

The Kindsvater-Carter formula for overflow flows would be as follows:

$$Q = C_e L_e {H_e}^{3/2}$$

Where:

Q is the discharge in ft^3/s.

C_e is the effective coefficient of discharge.

$L_e = L + k_b$

$H_e = H + k_h$

L is the length of the weir crest in feet, 21.688 feet.

B is the average width of the approach channel in ft, 30 feet.

H is the head measured above the weir crest in feet, 0 to 0.500 feet to top of weir.

k_h is a correction factor having a value of 0.003 feet.

k_b depends on the ratio of crest length to average width of approach channel (L/B), (21.688 / 30) = 0.723

P is the depth from the weir invert to the bottom of the approach pool in feet, 7 feet when pool has no sediment.

k_b can be determined from L/B and Figure 3. L/B = 21.688 / 30 = 0.723; therefore, k_b = 0.014.

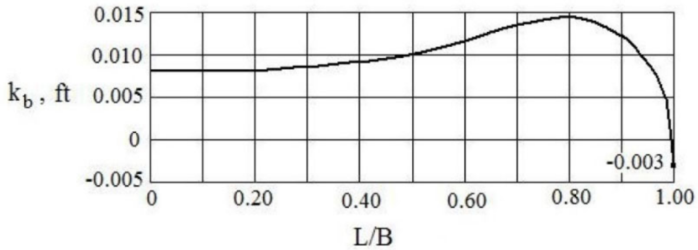


Figure 3: k_b, Bureau of Land Reclamation Water Measurement Manual

C_e can be determined from Figure 4 based on L/B and H/P. L/B = 21.688 / 30 = 0.723, P = 7 feet and H varies from 0 to 0.500 feet; therefore, H/P varies from 0 to (0.500/7) or 0 to 0.071.

With an L/B of 0.723, C_e can be interpreted as about 3.18 for an H/P of 0 to 0.071.

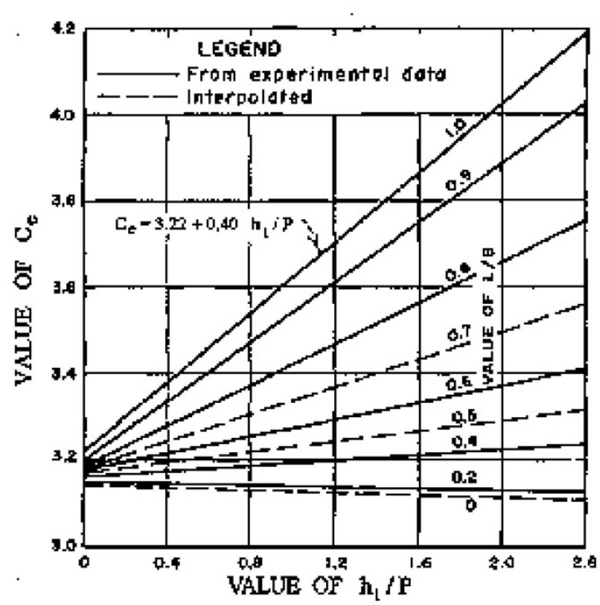


Figure 4: C_e, Bureau of Land Reclamation Water Measurement Manual

With the known information for the proposed Quartz Creek overflow weir the flow formula and be provided as follows for dimensions in feet and flow rate of cubic feet per second:

$$Q = C_e L_e H_e{}^{3/2}$$

$$Q = C_e(L + k_b)(H + k_h)^{3/2}$$

$$Q = 3.18(21.688 + 0.014)(H + 0.003)^{3/2}$$

$$\boldsymbol{Q = 69.012(H + 0.003)^{3/2}}$$

The calculated flow rate in cubic feet per second can then be multiplied by 28.317 to convert it to L/s.

Stage Discharge Curve

Figures 5 and 6 provide the Kindsvater – Carter Formula Stage Discharge Curve for Quartz Creek, Ymir BC, in Imperial units and SI Units

Table 1: Quartz Creek Kindsvater-Carter Formula Flows Before 20 August 2020

Kindsvater-Carter Formula	**Flow Height**	
Q (cfs)	**H** (inches)	**H** (feet)
0	0	0
0.27	1	0.08
0.74	2	0.17
1.34	3	0.25
2.05	4	0.33
2.86	5	0.42
3.75	6	0.50
4.73	7	0.58
5.77	8	0.67
6.88	9	0.75
8.05	10	0.83
9.28	11	0.92
10.6	12	1.00
11.9	13	1.08
13.3	14	1.17
14.8	15	1.25
16.3	16	1.33
17.8	17	1.42
19.4	18	1.50
21.0	19	1.58
24.4	21	1.75
26.2	22	1.83
27.9	23	1.92
31.0	24	2.00
35.0	25	2.08
39.7	26	2.17
45.0	27	2.25
50.8	28	2.33

Kindsvater-Carter Formula	**Flow Height**
Q (L/s)	**H** (mm)
0	0
8	25
21	51
38	76
58	102
81	127
106	152
134	178
163	203
195	229
228	254
263	279
299	305
337	330
377	356
418	381
460	406
504	432
549	457
595	483
692	533
742	559
791	584
878	610
990	635
1,123	660
1,273	686
1,439	711

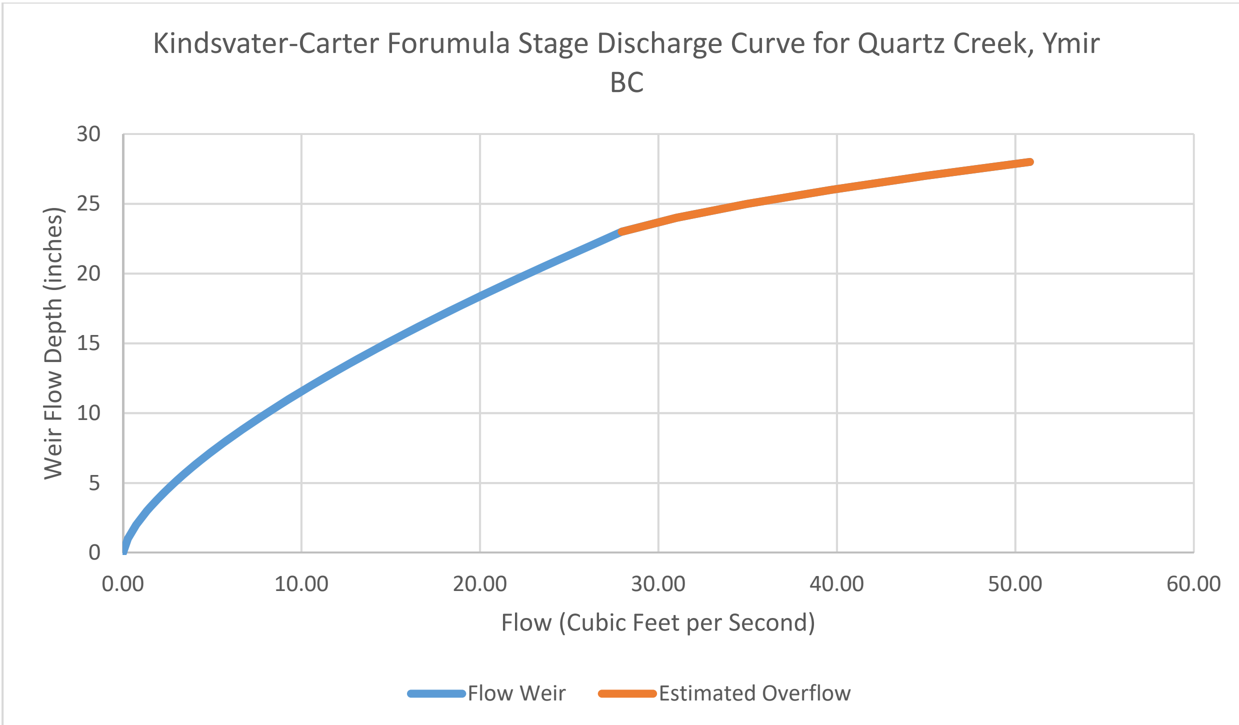


Figure 5: Kindsvater–Carter Formula Stage Discharge Curve for Quartz Creek, Ymir BC, Imperial Units Before 20 August 2020

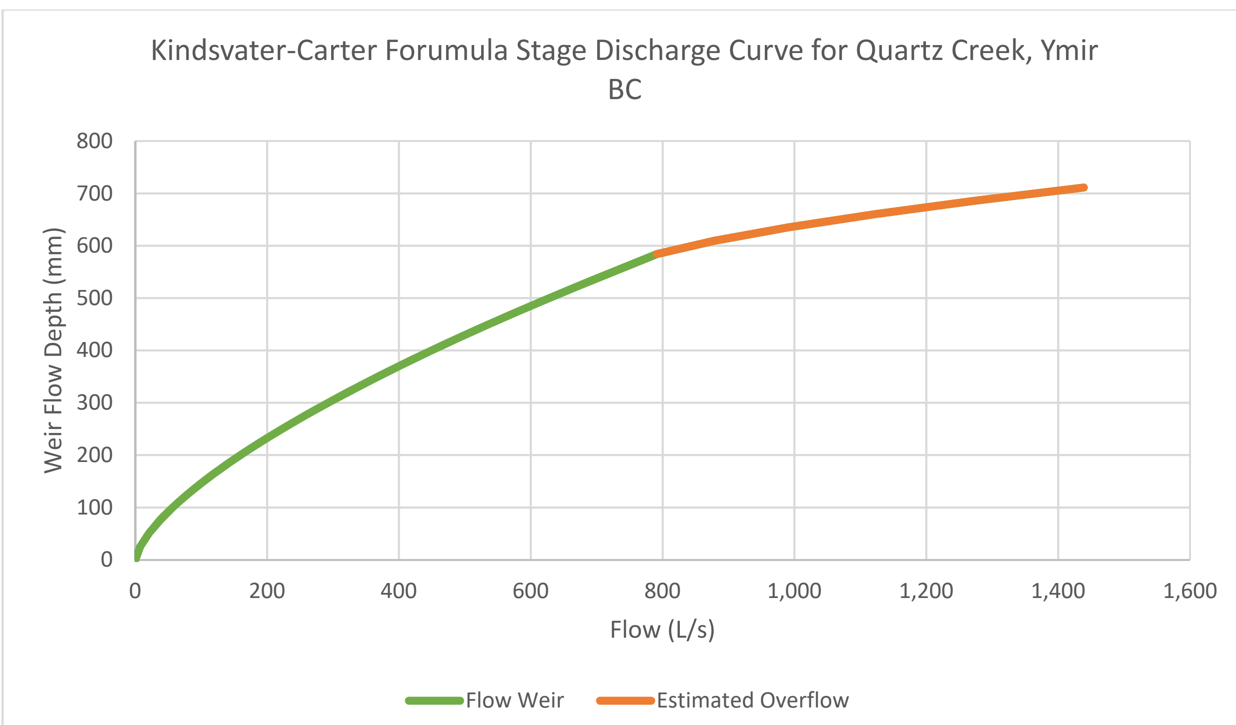


Figure 6: Kindsvater – Carter Formula Stage Discharge Curve for Quartz Creek, Ymir BC, SI Units Before 20 August 2020

Overflow Weir – Starting 20 August 2020

On 20 August 2020 a failed level sensor was replaced and the overflow weir was widened from 260 ¼” (21.688 feet) to 288 ¾” (24.063 feet) to accommodate more flow.

The Kindsvater-Carter formula for overflow flows would be as follows:

$$Q = C_e L_e H_e^{3/2}$$

Where:

Q is the discharge in ft^3/s.

C_e is the effective coefficient of discharge.

$L_e = L + k_b$

$H_e = H + k_h$

L is the length of the weir crest in feet, 24.063 feet.

B is the average width of the approach channel in ft, 30 feet.

H is the head measured above the weir crest in feet, 0 to 0.500 feet to top of weir.

k_h is a correction factor having a value of 0.003 feet.

k_b depends on the ratio of crest length to average width of approach channel (L/B), (24.063 / 30) = 0.802

P is the depth from the weir invert to the bottom of the approach pool in feet, 7 feet when pool has no sediment.

k_b can be determined from L/B and Figure 3. L/B = 24.063 / 30 = 0.802; therefore, k_b = 0.014.

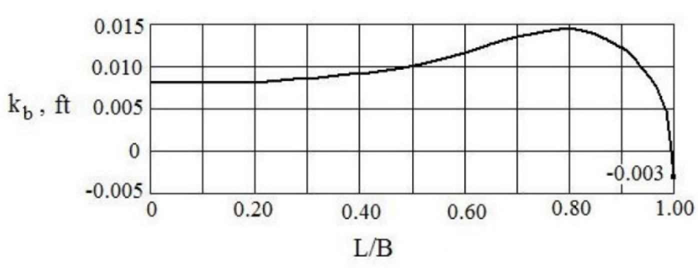


Figure 3: k_b, Bureau of Land Reclamation Water Measurement Manual

C_e can be determined from Figure 4 based on L/B and H/P. L/B = 24.063 / 30 = 0.802, P = 7 feet and H varies from 0 to 0.500 feet; therefore, H/P varies from 0 to (0.500/7) or 0 to 0.071.

With an L/B of 0.802, C_e can be interpreted as about 3.18 for an H/P of 0 to 0.071.

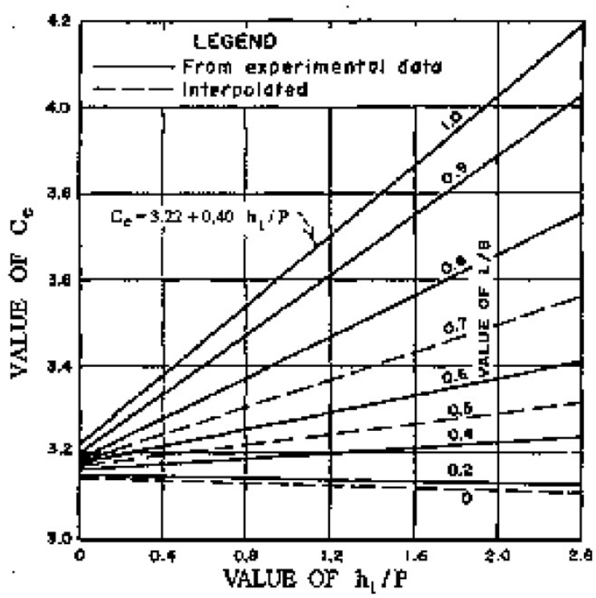


Figure 4: C$_e$, Bureau of Land Reclamation Water Measurement Manual

With the known information for the proposed Quartz Creek overflow weir the flow formula and be provided as follows for dimensions in feet and flow rate of cubic feet per second:

$$Q = C_e L_e H_e{}^{3/2}$$

$$Q = C_e(L + k_b)(H + k_h)^{3/2}$$

$$Q = 3.18(24.063 + 0.014)(H + 0.003)^{3/2}$$

$$\boldsymbol{Q = 76.565(H + 0.003)^{3/2}}$$

The calculated flow rate in cubic feet per second can then be multiplied by 28.317 to convert it to L/s.

Stage Discharge Curve

Figures 7 and 8 provide the Kindsvater – Carter Formula Stage Discharge Curve for Quartz Creek, Ymir BC, in Imperial units and SI Units

Table 2: Quartz Creek Kindsvater-Carter Formula Flows After 20 August 2020

Kindsvater-Carter Formula	Flow Height	
Q (cfs)	**H** (inches)	**H** (feet)
0	0	0
0.27	1	0.08
0.74	2	0.17
1.34	3	0.25
2.05	4	0.33
2.86	5	0.42
3.75	6	0.50
4.73	7	0.58
5.77	8	0.67
6.88	9	0.75
8.05	10	0.83
9.28	11	0.92
10.6	12	1.00
11.9	13	1.08
13.3	14	1.17
14.8	15	1.25
16.3	16	1.33
17.8	17	1.42
19.4	18	1.50
21.0	19	1.58
24.4	21	1.75
26.2	22	1.83
28.1	23	1.92
31.5	24	2.00
35.9	25	2.08
41.1	26	2.17
47.0	27	2.25
53.5	28	2.33

Kindsvater-Carter Formula	Flow Height
Q (L/s)	**H** (mm)
0	0
8	25
21	51
38	76
58	102
81	127
106	152
134	178
163	203
195	229
228	254
263	279
299	305
337	330
377	356
418	381
460	406
504	432
549	457
595	483
692	533
742	559
797	584
893	610
1,018	635
1,165	660
1,331	686
1,515	711

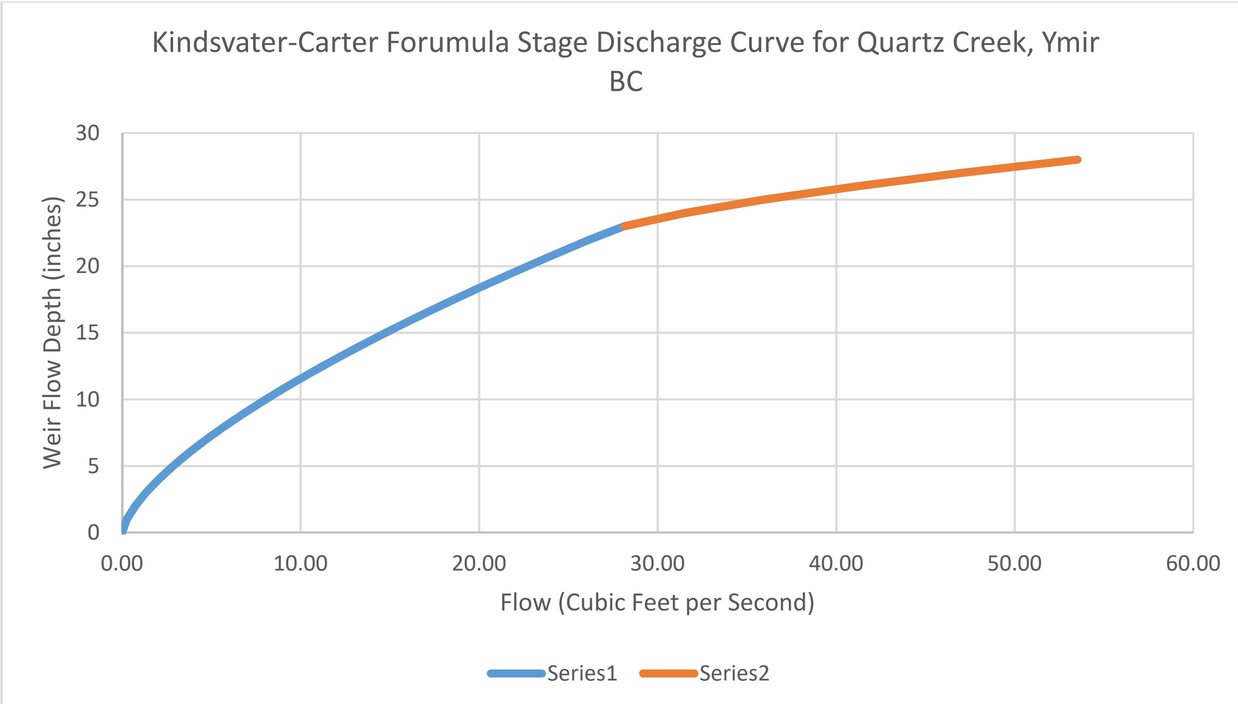


Figure 7: Kindsvater–Carter Formula Stage Discharge Curve for Quartz Creek, Ymir BC, Imperial Units After 20 August 2020

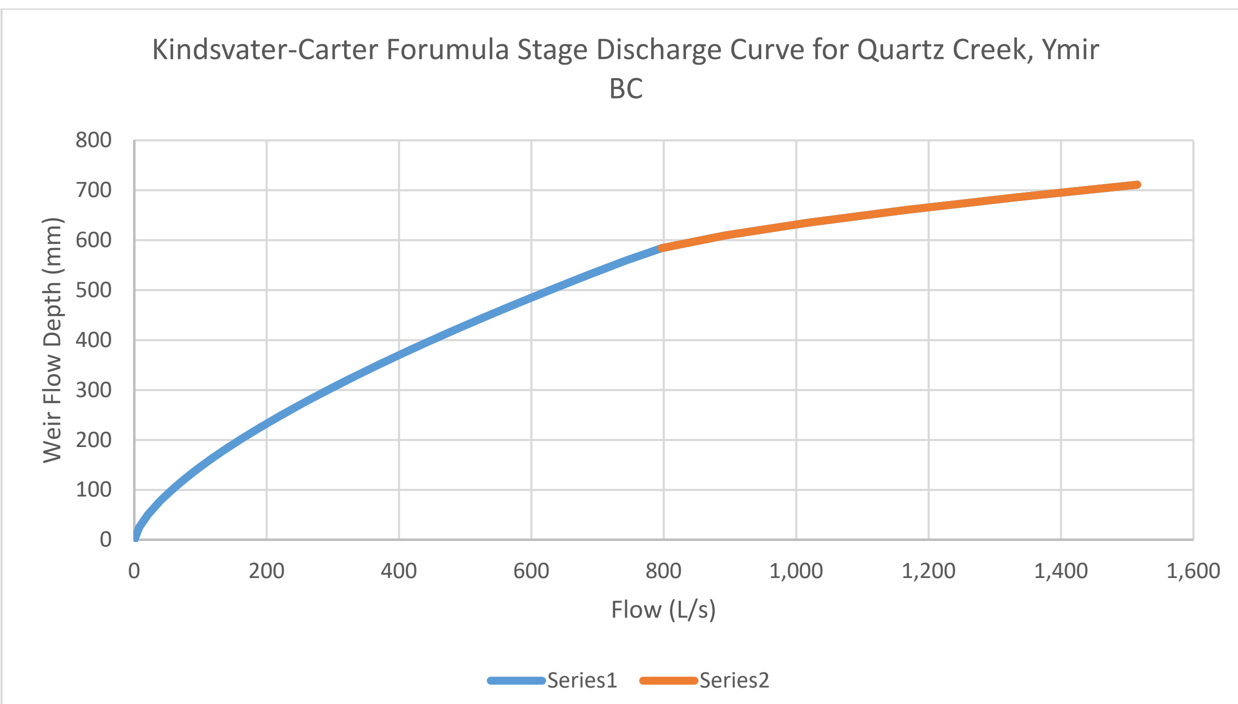


Figure 8: Kindsvater – Carter Formula Stage Discharge Curve for Quartz Creek, Ymir BC, SI Units After 20 August 2020

Quartz Creek Ymir Water Intake – 31 March 2020

Quartz Creek Flow Weir Discharge – 31 March 2020