

***FINAL
STREAM DISCHARGE AND
WATER SUPPLY ESTIMATES
CITRONEN FJORD
DEVELOPMENT PROJECT***



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1.0 Introduction

Hydrological investigations were conducted during the summer of 2010 at the Citronen Development Site. These data were needed to complete a detailed water management plan for the project. It is currently estimated that the project will require 1.4 gigaliters (GL) per year. Melting and runoff events only occur for a short period in the summer months, so it is anticipated that water supplies will need to be captured and stored so they can be used throughout the year. The location of potential water supply developments will also be used for the design and layout of the facility, as well as size site water control structures.

This report provides stream discharge (flow) and water supply estimates that were developed from the site measurements.

2.0 Background

Instantaneous discharge of streams was to be conducted using the standard mid-section method. In summary, discharge is determined by measuring stream flow velocity at a number of measured intervals across the stream channel. However, based on the field notes, flow velocity as well as other site conditions made it extremely difficult to conduct accurate or meaningful flow estimates at many of the identified sites. In many cases, the velocity of the flow was too high to allow for a person to safely enter the channel to obtain depth and velocity measurements. In many cases, only one velocity measurement could be taken near the edge of the flow. Discharge was measured at 7 sites:

- MP-04 – North East corner of airstrip
- MP-05 – Eastern River
- MP-06 – South side of tailing dam
- MP-07 – Lake Platinova overflow
- MP-08 -- Lake Platinova inflow
- MP-09 -- West Lake Platinova inflow
- MP-10 – West of explosive storage

The location of these sites are shown in Figure 3-1 and site photographs are shown in Figures 3-3 through 3-9.

3.0 Estimation Methods

Instantaneous discharge was calculated and estimated by examining the data and notes in the field sheets that were provided for each of the measurement sites. Copies of these field sheets are provided in Appendix A. For each site, discharge was calculated and/or estimated for dates where adequate data were available to make an estimate. In most cases, a number of assumptions were required to calculate the discharge and provide an estimate. Assumptions were developed in many cases by examining site photos which were provided with the field data, reviewing the notes in the field sheets, and from Tetra Tech's experience in conducting field discharge measurements under a wide range of conditions.

Under ideal conditions, instantaneous discharge measurements using the mid-section method can provide data with an accuracy of ± 5 to 15 percent. Because of the difficult site conditions and the large number of assumptions used to analyze these data, it is anticipated that the

discharge and water supply estimates provided in this report could have ± 25 to 50 percent error. However, these data should provide good initial information for site planning and for determining adequate sources for water supply needs.

For each site, seasonal water supply was estimated by using available instantaneous discharge estimates across several dates to develop an annual runoff hydrograph and by evaluation of the notes and other measurements in the field sheets. Figure 3-2 shows a graphical depiction of an annual runoff hydrograph developed for station MP-05. The seasonal volume of water available for this site was estimated by tabularly integrating the area under the annual discharge hydrograph.

4.0 Results

Results for calculations and estimates of instantaneous discharge for each station are provided in Sections 4.1 through 4.7 below. Tables showing calculations/estimates of instantaneous discharge and seasonal water supply are provided for each station in Section 4.8 at the end of the text. Figure 4-1 depicts a map of station locations showing estimated maximum discharge and estimated percentage of error. Error estimates were made by examining the field notes for each site and the site photographs. A summary of estimated seasonal water supply was made from the discharge measurements and is provided in Table 4-1, below.

Table 4-1. Summary of Annual Water Supply Estimates				
Station	Total Annual Discharge		Station Name	Assumed Period of Flow
	Cubic Meters	Gigaliters		
MP-04	39,545	0.04	North East Corner of Airstrip	14 days in June
MP-05	15,671,648	16	Eastern River behind office	June 2 through September 15
MP-06	21,366,081	21	South side of tailings dam	June 14 through September 15
MP-07	522,039	0.52	Lake Platinova overflow	June 14 through September 15
MP-08	94,341	0.09	Lake Platinova inflow	20 days in June
MP-09	30,240	0.03	West Lake Platinova inflow	7 days in June
MP-10	1,236,116	1.24	West of explosive storage	20 days in June

Total	39,023,491	39.0
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4.1 MP-04

Based on site notes and measurements, MP-04 is a very shallow drainage that conveyed a small amount of runoff for approximately two weeks in June. No flow was reported after June 26th. A single discharge estimate of 0.09 cubic meters per second (m^3/s) could be made from a site measurement made on June 23, 2010. This calculation and data assumptions are provided in Table 4-2.

4.2 MP-05

MP-05 is a relatively large drainage which flowed for most of the summer season. Site measurements and photos suggest that flow velocities in this drainage are relatively high (up to 1 meter per second). High velocities often prevented proper discharge measurements to be conducted in a safe manner. Instantaneous discharge was calculated from available site data for four dates throughout the summer season. Discharge estimates and assumptions are provided in Tables 4-3 through 4-6. Seasonal water supply estimates are provided in Table 4-7.

4.3 MP-06

MP-06 is also a relatively large drainage which flowed for most of the summer season. Similar to MP-05, site measurements and photos suggest that flow velocities in this drainage are relatively high. High velocities sometimes prevented proper discharge measurements to be conducted in a safe manner. Instantaneous discharge was calculated from available site data for six dates throughout the summer season. Discharge estimates and assumptions are provided in Tables 4-8 through 4-13. Seasonal water supply estimates are provided in Table 4-14.

4.4 MP-07

MP-07 is a wide very shallow drainage which flows from the melt in June through July. The channel was mostly dry by August. Instantaneous discharge was calculated from available site data for six dates in June and July. Discharge estimates and assumptions are provided in Tables 4-15 through 4-20. Seasonal water supply estimates are provided in Table 4-21.

4.5 MP-08

MP-08 is a very shallow drainage that conveyed a small amount of runoff for approximately three weeks in June. Site photos suggest that the channel is not well defined. Drainage basically conveys along site gravel and cobbles. A single discharge estimate of $0.05 \text{ m}^3/\text{s}$ was made from a measurement made on June 28, 2010. This calculation and data assumptions are provided in Table 4-22.

4.6 MP-09

MP-09 is also a very shallow drainage that conveyed a small amount of runoff for approximately one week in June. Like MP-08, there is not a strongly defined channel and drainage occurs across gravels and cobbles. No flow was reported after June 22, 2010. A single discharge estimate of $0.05 \text{ m}^3/\text{s}$ was made by evaluating site measurements taken June 13 and June 22, 2010. This calculation and data assumptions are provided in Table 4-23.

4.7 MP-10

MP-10 is also a very shallow drainage that conveyed a small amount of runoff for approximately three weeks in June. Like MP-08, there is not a strongly defined channel and drainage occurs across gravels and cobbles. Drainage occurs into July, however the flow was reported to be too shallow (just a few centimeters) and wide to measure. A single discharge estimate of $0.72 \text{ m}^3/\text{s}$ was made by evaluating site measurements taken on June 22, 2010. This calculation and data assumptions are provided in Table 4-24.

4.8 *Instantaneous Discharge and Water Supply Tables*

Table 4-2. Discharge and Water Supply Estimates for Station MP-04 on June 23, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	
5.5	18.0	0.90	3.0	61.32	18.7	5.1	55.19	0.01	0.02	0.03	0.91	Velocity estimated
11.4	37.4	0.15	0.5	33.89	10.3	0.5	5.08	0.02	0.05	0.01	0.25	
11.8	38.7	0.00	0.0	1.31	0.4	0.0	0.00	0.00	0.00	0.00	0.00	

Total	0.03	1.16
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Estimated volume assuming 14 days of flow:	39,545 m ³
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Table 4-3. Discharge Estimate for Station MP-05 on June 4, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
17.6	57.7	0.00	0.0	0.03	0.1	0.0	0.00	0.00	0.00	0.00	0.0	
17.7	58.1	0.11	0.4	0.20	0.7	0.0	0.24	0.18	0.57	0.00	0.1	
18	59.0	0.14	0.5	0.20	0.7	0.0	0.30	0.21	0.70	0.01	0.2	
18.1	59.4	0.00	0.0	0.10	0.3	0.0	0.00	0.00	0.00	0.00	0.0	

Total	0.01	0.3
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Table 4-4. Discharge Estimate for Station MP-05 on June 12, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
16.4	53.8	0.00	0.0	0.03	0.1	0.0	0.00	0.00	0.00	0.00	0.0	
16.5	54.1	0.12	0.4	0.30	1.0	0.0	0.39	0.18	0.57	0.01	0.2	
17	55.8	0.23	0.8	0.75	2.5	0.2	1.86	0.21	0.70	0.04	1.3	
18	59.0	0.25	0.8	1.00	3.3	0.2	2.69	0.45	1.47	0.11	4.0	
19	62.3	0.16	0.5	2.25	7.4	0.4	3.87	0.37	1.20	0.13	4.6	
22.5	73.8	0.12	0.4	3.50	11.5	0.4	4.52	0.77	2.53	0.32	11.4	
26	85.3	0.12	0.4	3.40	11.2	0.4	4.39	0.20	0.66	0.08	2.9	Estimated by Tetra Tech from interval at 17m
29.3	96.1	0.00	0.0	3.30	10.8	0.0	0.00	0.00	0.00	0.00	0.0	

Total Discharge	0.69	24.4
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Table 4-5. Discharge Estimate for Station MP-05 on June 14, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft		ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
11.0	36.1	0.00	0.0	0.15	0.5	0.0	0.00	0.00	0.00	0.00	0.00	
11.5	37.7	0.12	0.4	0.80	2.6	0.1	1.03	0.18	0.57	0.02	0.59	
12.6	41.3	0.23	0.8	1.70	5.6	0.4	4.21	0.21	0.70	0.08	2.94	
14.9	48.9	0.25	0.8	2.08	6.8	0.5	5.61	1.01	3.33	0.53	18.64	
15 to 29	50 to 95	0.00	--	13.72	45.0	--	--	--	--	0.63	22.18	Estimated by Tetra Tech from discharge from 11 to 14.9 meters

Total Discharge	1.26	44.4
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Table 4-6. Discharge Estimate for Station MP-05 on July 26, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
12.3	40.3	0.00	0.0	0.03	0.1	0.0	0.00	0.00	0.00	0.00	0.0	
12.4	40.7	0.13	0.4	0.55	1.8	0.1	0.77	0.01	0.04	0.00	0.0	
13.4	44.0	0.18	0.6	1.00	3.3	0.2	1.94	0.11	0.35	0.02	0.7	
14.4	47.2	0.20	0.7	1.00	3.3	0.2	2.15	0.16	0.51	0.03	1.1	
15.4	50.5	0.30	1.0	1.00	3.3	0.3	3.23	0.45	1.49	0.14	4.8	
16.4	53.8	0.34	1.1	1.00	3.3	0.3	3.66	0.77	2.53	0.26	9.3	
17.4	57.1	0.40	1.3	1.00	3.3	0.4	4.30	0.92	3.01	0.37	12.9	
18.4	60.4	0.40	1.3	1.00	3.3	0.4	4.30	1.14	3.74	0.46	16.1	
19.4	63.6	0.40	1.3	1.00	3.3	0.4	4.30	0.45	1.48	0.18	6.4	
20.4	66.9	0.28	0.9	1.00	3.3	0.3	3.01	0.54	1.75	0.15	5.3	
21.4	70.2	0.40	1.3	1.00	3.3	0.4	4.30	0.00	0.00	0.00	0.0	
22.4	73.5	0.50	1.6	1.00	3.3	0.5	5.38	1.05	3.44	0.52	18.5	
23.4	76.8	0.24	0.8	1.00	3.3	0.2	2.58	0.98	3.23	0.24	8.3	
24.4	80.0	0.22	0.7	1.00	3.3	0.2	2.37	1.06	3.48	0.23	8.2	
25.4	83.3	0.20	0.7	1.00	3.3	0.2	2.15	1.08	3.55	0.22	7.6	
26.4	86.6	0.12	0.4	0.55	1.8	0.1	0.71	0.52	1.72	0.03	1.2	
26.5	86.9	0.00	0.0	0.10	0.3	0.0	0.00	0.00	0.00	0.00	0.0	

	Total Discharge	2.84	100.4
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Table 4-7. Water Supply Estimate for Station MP-05

Interval Date	Estimated Discharge	Number of Days	Interval Volume
	m ³ /day		m ³
2-Jun-10	847	1	1
7-Jun-10	30,232	5	151,158
12-Jun-10	59,616	4	208,656
14-Jun-10	108,864	5	489,888
21-Jun-10	131,616	7	921,312
28-Jun-10	154,368	7	1,080,576
5-Jul-10	177,120	7	1,239,840
12-Jul-10	199,872	7	1,399,104
19-Jul-10	222,624	7	1,558,368
26-Jul-10	245,376	7	1,717,632
2-Aug-10	243,516	7	1,582,852
8-Aug-10	241,921	7	1,572,487
15-Aug-10	197,357	7	1,381,496
22-Aug-10	152,792	7	1,069,545
29-Aug-10	108,228	7	757,595
5-Sep-10	63,663	9	541,139
15-Sep-10	0	1	0

Total	15,671,648
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Table 4-8. Discharge Estimate for Station MP-06 on June 14, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	1.52	5.0	0.0	0.00	0.00	0.00	0.05	0.0	
5	16.4	0.12	0.4	5.30	17.4	0.6	6.84	0.30	0.98	0.19	6.7	Estimated by Tetra Tech
10.6	34.8	0.26	0.9	5.00	16.4	1.3	13.99	1.24	4.06	1.61	56.8	
15	49.2	0.12	0.4	4.70	15.4	0.6	6.07	0.30	0.98	0.17	6.0	Estimated by Tetra Tech
20	65.6	0.00	0.0	5.00	16.4	0.0	0.00	0.00	0.00	0.05	0.0	

	Total Discharge	2.07	69.5
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Table 4-9. Discharge Estimate for Station MP-06 on July 5, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
1.0	3.3	0.00	0.0	0.40	1.3	0.0	0.00	0.00	0.00	0.05	0.0	
2.3	7.5	0.30	1.0	4.00	13.1	1.2	12.91	0.52	1.71	0.62	22.1	
9	29.5	0.30	1.0	5.85	19.2	1.8	18.88	0.52	1.71	0.91	32.2	Estimated by Tetra Tech
14	45.9	0.30	1.0	4.50	14.8	1.3	14.52	0.52	1.71	0.70	24.8	Estimated by Tetra Tech
18	59.0	0.00	0.0	4.00	13.1	0.0	0.00	0.00	0.00	0.05	0.0	

	Total Discharge	2.34	79.0
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Table 4-10. Discharge Estimate for Station MP-06 on July 11, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	0.15	0.5	0.0	0.00	0.00	0.00	0.1	0.0	
0.5	1.6	0.30	1.0	25.00	82.0	7.5	80.69	0.54	1.76	4.0	142	
50	164.0	0.50	1.6	48.75	159.9	24.4	262.24	0.50	1.64	12.2	430	Estimated by Tetra Tech
98	321.4	0.30	1.0	25.00	82.0	7.5	80.69	0.50	1.64	3.7	132	Estimated by Tetra Tech
100	328.0	0.00	0.0	2.00	6.6	0.0	0.00	0.00	0.00	0.0	0.0	Estimated by Tetra Tech

	Total Discharge	20	705
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Table 4-11. Discharge Estimate for Station MP-06 on July 19, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	0.91	3.0	0.0	0.00	0.00	0.00	0.1	0.0	
3	9.8	0.10	0.3	5.00	16.4	0.5	5.38	0.29	0.94	0.1	5	
10	32.8	0.20	0.7	6.00	19.7	1.2	12.91	0.30	0.98	0.4	13	Estimated by Tetra Tech
15	49.2	0.10	0.3	5.00	16.4	0.5	5.38	0.20	0.66	0.1	4	Estimated by Tetra Tech
20	65.6	0.00	0.0	5.00	16.4	0.0	0.00	0.00	0.00	0.0	0.0	Estimated by Tetra Tech

	Total Discharge	1	21
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Table 4-12. Discharge Estimate for Station MP-06 on July 26, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	1.01	3.3	0.0	0.00	0.00	0.00	0.1	0.0	
3.3	10.8	0.16	0.5	5.00	16.4	0.8	8.61	0.29	0.94	0.2	8	
10	32.8	0.25	0.8	5.85	19.2	1.5	15.73	0.35	1.15	0.5	18	Estimated by Tetra Tech
15	49.2	0.16	0.5	5.00	16.4	0.8	8.61	0.25	0.82	0.2	7	Estimated by Tetra Tech
20	65.6	0.00	0.0	5.00	16.4	0.0	0.00	0.00	0.00	0.0	0.0	Estimated by Tetra Tech

	Total Discharge	1.0	33
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Table 4-13. Discharge Estimate for Station MP-06 on August 1, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	1.28	4.2	0.0	0.00	0.00	0.00	0.05	0.0	
4.2	13.8	0.36	1.2	5.00	16.4	1.8	19.37	0.36	1.19	0.65	23	
10	32.8	0.40	1.3	5.40	17.7	2.2	23.24	0.40	1.31	0.86	30	Estimated by Tetra Tech
15	49.2	0.36	1.2	5.00	16.4	1.8	19.37	0.20	0.66	0.36	13	Estimated by Tetra Tech
20	65.6	0.00	0.0	5.00	16.4	0.0	0.00	0.00	0.00	0.00	0.0	Estimated by Tetra Tech

	Total Discharge	1.93	66
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Table 4-14. Water Supply Estimate for Station MP-06

Interval Date	Estimated Discharge	Number of Days	Interval Volume
	m ³ /day		m ³
2-Jun-10	0	1	0
14-Jun-10	178,564	11	1,874,926
23-Jun-10	188,563	11	1,979,914
5-Jul-10	201,895	9	1,817,056
11-Jul-10	1,726,946	7	12,088,623
19-Jul-10	56,435	8	423,259
26-Jul-10	85,622	7	556,541
1-Aug-10	166,462	7	1,082,001
8-Aug-10	30,540	7	213,783
15-Aug-10	33,834	11	355,252
29-Aug-10	62,886	16	974,726
15-Sep-10	0	1	0

Total	21,366,080
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Table 4-15. Discharge Estimate for Station MP-07 on June 14, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	0.15	0.5	0.0	0.00	0.00	0.00	0.00	0.0	
0.5	1.6	0.10	0.3	1.65	5.4	0.2	1.78	0.10	0.33	0.02	0.6	
3.3	10.8	0.14	0.5	2.00	6.6	0.3	3.01	0.19	0.61	0.05	1.8	Estimated by Tetra Tech
4.5	14.8	0.10	0.3	0.80	2.6	0.1	0.86	0.10	0.33	0.01	0.3	Estimated by Tetra Tech
4.9	16.1	0.00	0.0	0.40	1.3	0.0	0.00	0.00	0.00	0.00	0.0	Estimated by Tetra Tech

	Total Discharge	0.08	2.7
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Table 4-16. Discharge Estimate for Station MP-07 on June 20, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	0.30	1.0	0.0	0.00	0.00	0.00	0.00	0.0	
1.0	3.3	0.15	0.5	0.65	2.1	0.1	1.05	0.10	0.32	0.01	0.3	
1.3	4.3	0.18	0.6	0.40	1.3	0.1	0.77	0.60	1.95	0.04	1.5	
1.8	5.9	0.12	0.4	0.35	1.1	0.0	0.45	0.16	0.54	0.01	0.2	
2	6.6	0.19	0.6	0.45	1.5	0.1	0.92	0.42	1.39	0.04	1.3	
2.7	8.9	0.20	0.7	0.50	1.6	0.1	1.08	0.15	0.50	0.02	0.5	
3	9.8	0.22	0.7	0.25	0.8	0.1	0.59	0.39	1.28	0.02	0.8	
3.2	10.5	0.16	0.5	0.25	0.8	0.0	0.43	0.14	0.46	0.01	0.2	
3.5	11.5	0.00	0.0	0.30	1.0	0.0	0.00	0.00	0.00	0.00	0.0	

	Total Discharge	0.14	4.9
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Table 4-17. Discharge Estimate for Station MP-07 on June 23, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	0.30	1.0	0.0	0.00	0.00	0.00	0.00	0.0	
1.0	3.3	0.14	0.5	0.65	2.1	0.1	0.98	0.36	1.19	0.03	1.2	
1.3	4.3	0.14	0.5	0.40	1.3	0.1	0.60	0.60	1.95	0.03	1.2	
1.8	5.9	0.14	0.5	0.35	1.1	0.0	0.53	0.59	1.95	0.03	1.0	
2	6.6	0.12	0.4	0.45	1.5	0.1	0.58	0.17	0.56	0.01	0.3	
2.7	8.9	0.12	0.4	0.50	1.6	0.1	0.65	0.16	0.52	0.01	0.3	
3	9.8	0.14	0.5	0.25	0.8	0.0	0.38	0.21	0.70	0.01	0.3	
3.2	10.5	0.02	0.1	0.15	0.5	0.0	0.03	0.05	0.16	0.00	0.0	
3.3	10.8	0.00	0.0	0.10	0.3	0.0	0.00	0.00	0.00	0.00	0.0	

	Total Discharge	0.12	4.3
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Table 4-18. Discharge Estimate for Station MP-07 on June 26, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	0.30	1.0	0.0	0.00	0.00	0.00	0.00	0.0	
1.0	3.3	0.14	0.5	0.65	2.1	0.1	0.98	0.17	0.57	0.02	0.6	
1.3	4.3	0.14	0.5	0.40	1.3	0.1	0.60	0.26	0.85	0.01	0.5	
1.8	5.9	0.14	0.5	0.35	1.1	0.0	0.53	0.19	0.62	0.01	0.3	
2	6.6	0.10	0.3	0.45	1.5	0.0	0.48	0.44	1.44	0.02	0.7	
2.7	8.9	0.10	0.3	0.50	1.6	0.0	0.54	0.20	0.65	0.01	0.4	
3	9.8	0.04	0.1	0.25	0.8	0.0	0.11	0.02	0.07	0.00	0.0	
3.2	10.5	0.03	0.1	0.15	0.5	0.0	0.05	0.02	0.07	0.00	0.0	
3.3	10.8	0.00	0.0	0.10	0.3	0.0	0.00	0.00	0.00	0.00	0.0	

	Total Discharge	0.07	2.5
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Table 4-19. Discharge Estimate for Station MP-07 on July 2, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	0.30	1.0	0.0	0.00	0.00	0.00	0.00	0.0	
1.0	3.3	0.09	0.3	0.65	2.1	0.1	0.63	0.06	0.21	0.00	0.1	
1.3	4.3	0.12	0.4	0.40	1.3	0.0	0.52	0.12	0.40	0.01	0.2	
1.8	5.9	0.11	0.4	0.35	1.1	0.0	0.41	0.26	0.85	0.01	0.4	
2	6.6	0.11	0.4	0.45	1.5	0.0	0.53	0.32	1.03	0.02	0.6	
2.7	8.9	0.11	0.4	0.50	1.6	0.1	0.59	0.21	0.70	0.01	0.4	
3	9.8	0.11	0.4	0.25	0.8	0.0	0.30	0.19	0.63	0.01	0.2	
3.2	10.5	0.03	0.1	0.15	0.5	0.0	0.05	0.05	0.16	0.00	0.0	
3.3	10.8	0.00	0.0	0.10	0.3	0.0	0.00	0.00	0.00	0.00	0.0	

	Total Discharge	0.05	1.8
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Table 4-20. Discharge Estimate for Station MP-07 on July 8, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
0.0	0.0	0.00	0.0	0.30	1.0	0.0	0.00	0.00	0.00	0.00	0.0	
1.0	3.3	0.10	0.3	0.65	2.1	0.1	0.70	0.15	0.50	0.01	0.3	
1.3	4.3	0.06	0.2	0.40	1.3	0.0	0.26	0.29	0.96	0.01	0.2	
1.8	5.9	0.03	0.1	0.35	1.1	0.0	0.11	0.03	0.10	0.00	0.0	
2	6.6	0.06	0.2	0.45	1.5	0.0	0.29	0.05	0.16	0.00	0.0	
2.7	8.9	0.03	0.1	0.50	1.6	0.0	0.16	0.23	0.74	0.00	0.1	
3	9.8	0.00	0.0	0.30	1.0	0.0	0.00	0.24	0.80	0.00	0.0	

	Total Discharge	0.02	0.8
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Table 4-21. Water Supply Estimate for Station MP-07

Interval Date	Estimated Discharge	Number of Days	Interval Volume
	m ³ /day		m ³
2-Jun-10	0	1	0
14-Jun-10	6,607.5	11	69,379
23-Jun-10	8,865.7	11	93,089
5-Jul-10	11,876.5	9	106,889
11-Jul-10	10,513	7	73,594
19-Jul-10	6,001	8	45,004
26-Jul-10	4,522.7	7	29,398
1-Aug-10	1,899.2	7	12,345
8-Aug-10	5,705	7	39,935
15-Aug-10	3,932	11	41,284
29-Aug-10	717	16	11,121
15-Sep-10	0	1	0

Total	522,039
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Table 4-22. Discharge and Water Supply Estimate for Station MP-08 on June 28, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
4.4	14.4	0.00	0.0	0.03	0.1	0.0	0.00	0.00	0.00	0.00	0.0	
4.5	14.8	0.13	0.4	4.30	14.1	0.6	6.01	0.01	0.02	0.00	0.1	
13	42.6	0.09	0.3	5.75	18.9	0.5	5.57	0.05	0.16	0.03	0.9	Estimated by Tetra Tech
16	52.5	0.13	0.4	4.00	13.1	0.5	5.59	0.05	0.16	0.03	0.9	Estimated by Tetra Tech
21	68.9	0.00	0.0	5.00	16.4	0.0	0.00	0.00	0.00	0.00	0.0	Estimated by Tetra Tech

	Total Discharge	0.05	1.9
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Estimated volume assuming 20 days of flow:

94,341 m³

Table 4-23. Discharge and Water Supply Estimate for Station MP-09 on June 22, 2010.

Assumed Average Depth		0.1	meters
Assumed Stream Width		5	meters
Assumed Velocity		0.10	m/s
Discharge		0.05	m ³ /s
Estimated volume assuming 7 days of flow:			
30,240 m ³			

Table 4-24. Discharge Estimate for Station MP-10 on June 22, 2010.

Distance		Depth		Width		Area		Velocity		Discharge		Notes
m	ft	m	ft	m	ft	m ²	ft ²	m/sec	ft/sec	m ³ /sec	cfs	
8.5	27.9	0.00	0.0	1.34	4.4	0.0	0.00	0.00	0.00	0.00	0.0	
12.9	42.3	0.10	0.3	2.55	8.4	0.3	2.74	0.03	0.11	0.01	0.3	
13.6	44.6	0.11	0.4	3.55	11.6	0.4	4.20	0.02	0.07	0.01	0.3	Estimated by Tetra Tech
18.8	61.7	0.10	0.3	12.20	40.0	1.2	13.13	0.56	1.85	0.69	24.2	
20	65.6	0.05	0.2	12.20	40.0	0.6	6.56	0.02	0.07	0.01	0.4	Estimated by Tetra Tech
38	124.6	0.00	0.0	18.00	59.0	0.0	0.00	0.00	0.00	0.00	0.0	Estimated by Tetra Tech

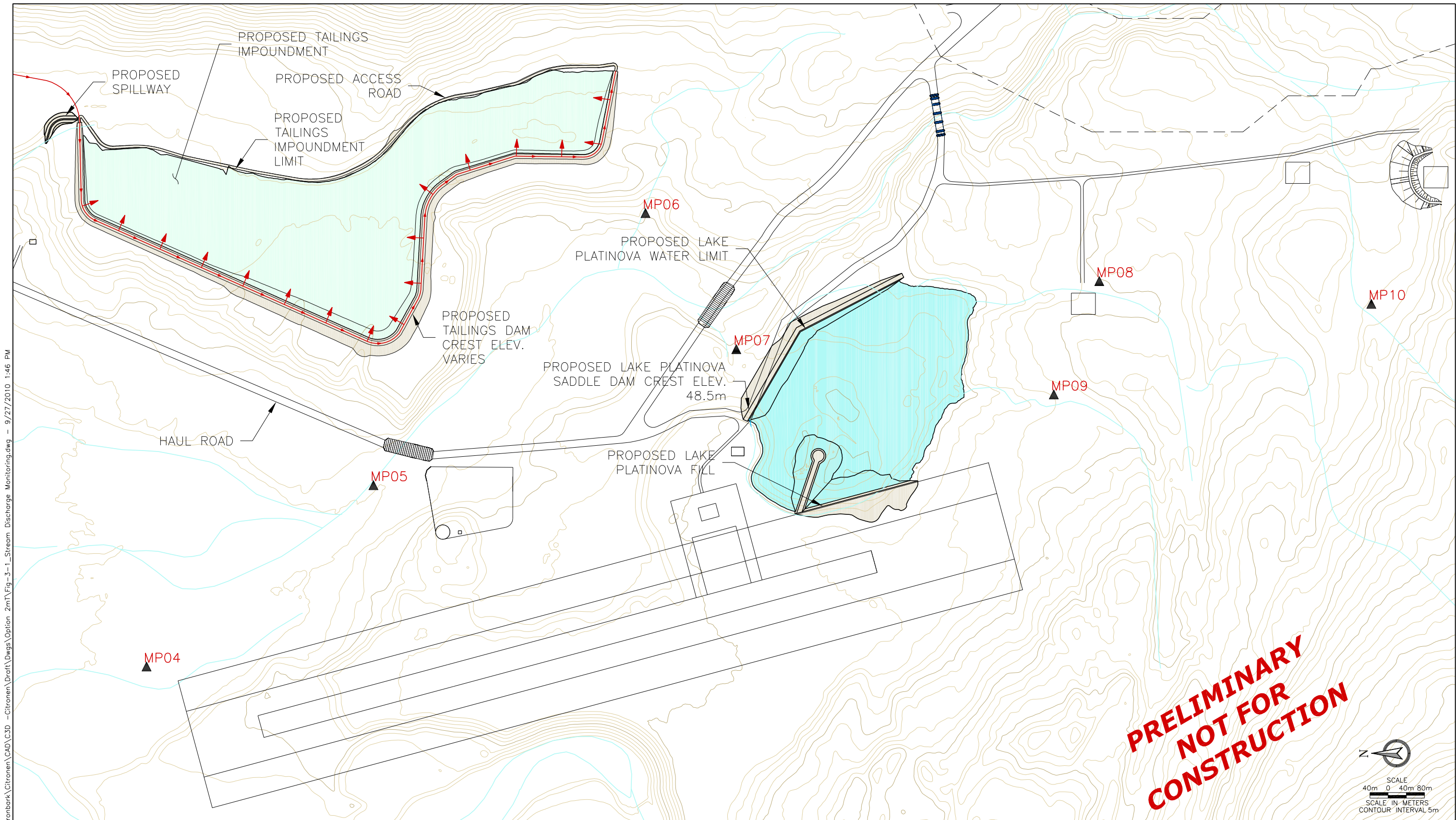
	Total Discharge	0.72	25.3
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Estimated volume assuming 20 days of flow:

1,236,116 m³

Figures

Santos, Londo - I:\Clients\Ironbark\Citronen\CAD\C3D -Citronen\Draft\Draws\Option 2mT\Fig-3-1_Stream Discharge Monitoring.dwg - 9/27/2010 1:46 PM



Santos, Londo - T: Clients	ENGINEER'S SEAL		Scale: As Shown		Issued for: 	Issued by:  350 Indiana Street, Suite 500 Golden, Colorado 80401 (303) 217-5700 (303) 217-5705 fax	Title: STREAM DISCHARGE MONITORING LOCATIONS			 REVISION
			Designed by: LAS							
			Drawn by: LAS							
			Checked by: BGB							
			Approved by: BGB							

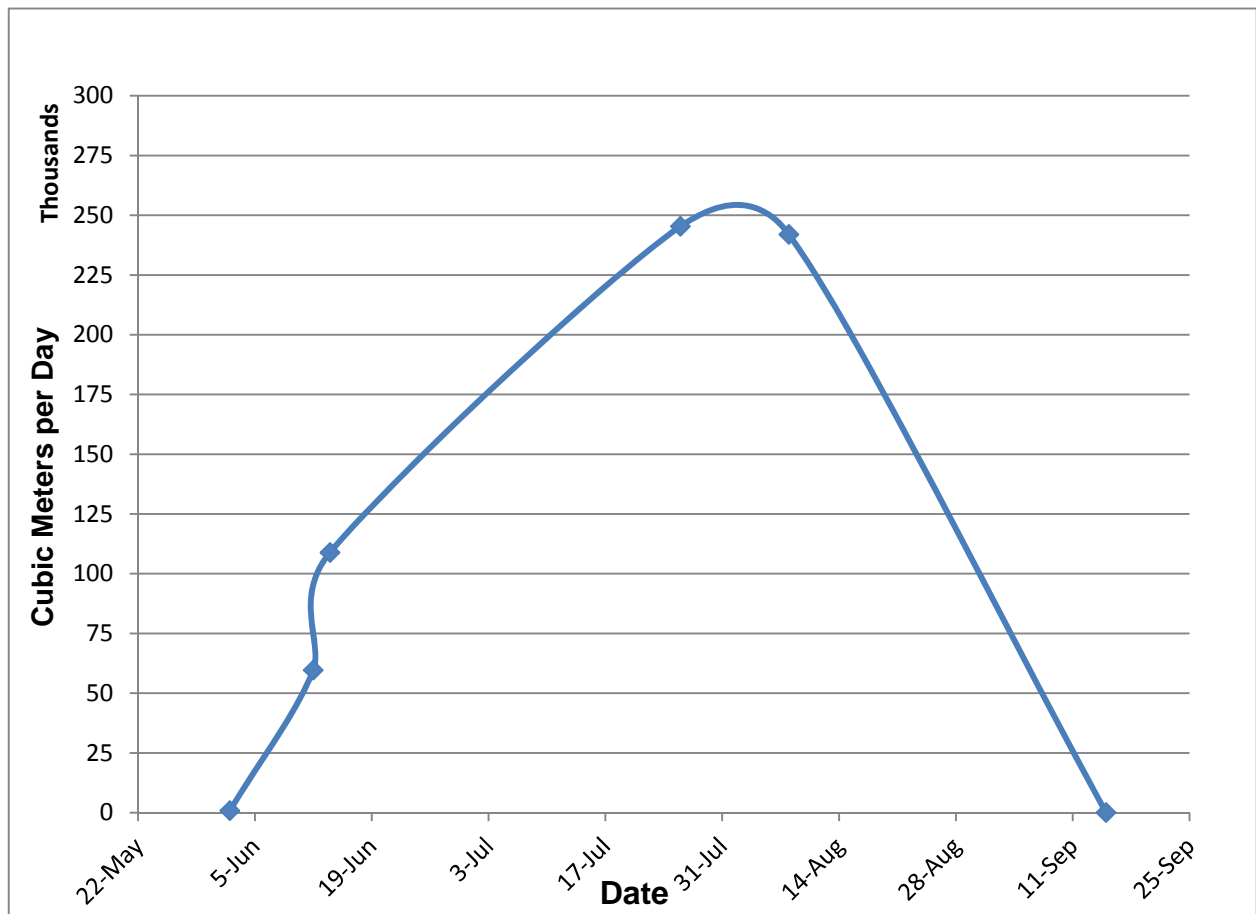


Figure 3-2. Estimated Seasonal Hydrograph for Station MP-05



Figure 3-3. Photograph of Station MP04 in June 2010



Figure 3-4. Photograph of Station MP05 in June 2010



Figure 3-5. Photograph of Station MP06 in June 2010



Figure 3-6. Photograph of Station MP07 in June 2010



Figure 3-7. Photograph of Station MP08 in June 2010



Figure 3-8. Photograph of Station MP09 in June 2010



Figure 3-9. Photograph of Station MP10 in June 2010

Appendix A

Supplied Field Sheets

Water Flow Testing
Citronen Fjord - 2010 Field Season
Site Name: North East corner of airstrip
MTH Site Number: MP-4
UTM Location: 482190E 9227600N

Date	Interval (m)	Depth (m)	Flow Velocity (m/s)	Air Temp (°C)	Comments
6/14/2010		<0.5		3	Total width 12.1
					Flow Area 0.4 - 11.3m
					Very shallow snow melt/ run off
6/17/2010				4	Very shallow, all snow melted now. Looks like the drainage has been used as a road or the road has become the drainage channel
6/20/2010		<0.5		3	Very shallow, very little flow
6/23/2010	5.5	0.9	0	8	Very little flow
	11.4	0.15	0.015		Flow width 1.0m - 11.8m
6/26/2010		< 0.05m			Mainly still pools. A quad bike with trailer has driven through site since last test leaving deep tyre marks
6/29/2010		<0.05m			No flow
7/2/2010		< 0.05m			No flow
7/5/2010		<0.05m			No flow. Water dried up.
					Continuing to monitor for changes.
8/1/2010		<0.05	0	3	Dry. Photos taken
					No change documented site see Flow Images

Water Flow Testing
Citronen Fjord - 2010 Field Season
Site Name: Eastern River Behind Office south
MTH Site Number: MP-05
UTM Location: 482975 9226290

Date	Interval (m)	Depth (m)	Flow Velocity (m/s)	Air Temp (°C)	Comments
6/2/2010	17.7	0.11	0.206	-3	Frozen/ Shallow. Taking readings at intervals where possible
	18	0.14	0.133		
6/4/2010	17.1	0.08	0.374	-3	Frozen/ Shallow
	17.4	0.08	0.453		
	17.8	0.08	0.019		
6/6/2010	17.3	0.06	0.294	1	Thawing/Very shallow
6/8/2010	16.8	0.07	0.096	-1	Thawing flowing slightly more
	17.2	0.07	0.196		
6/10/2010	17	0.1	0.241	1	Main stream has become 2
	17.3	0.11	0.216		
6/12/2010	16.5	0.12	0.175	3	Total Width: 16.4m - 29.3m
	17	0.23	0.213		Brown water
	18	0.25	0.449		
	19	0.16	0.365		
	22.5	0.12	0.77		
6/14/2010	11.5	0.14	1.17	3	Total width of flow 18m.
	12.6	0.14	0.74		Start at 11.0m
	14.9	0.16	1.014		Couldn't finish as too dangerous
6/17/2010	1500	0.21	0.758	4	Blue/ green water
	1600	0.3	0.77		
6/20/2010	11	0.5	0.771	3	Still water
6/23/2010	10	0.22	0.365	8	Flowing fast. Too fast to test properly.
6/26/2010	10	0.32	1.049	3	Fast flow
6/29/2010	10.05	0.36	0.815	4	Flow reading does not reflect flow observations which were that it is flowing fast
7/2/2010	10.05	0.32	0.473	4	Flow reading does not reflect flow observations which were that it is flowing fast
7/5/2010	8.5	0.3	0.52	6	Estimated flow width 7.50 - 18.0m
					Lots of surges in the water.
7/8/2010	7.9	0.31	0.779	9	Fast flow

7/11/2010	7.3	0.31	0.537	9	Estimated flow width 6.20- 24.0m
					Fast flow
					Actual width using Helicopter from marker peg 35.25m (marker peg to water edge 7.30m)
7/15/2010	7.5	0.4	0.244	13	Fast flow
					high sediments
7/19/2010	10.7	0.12	0.154	3	low sediments
7/22/2010	10.5	0.08	0.225	2	water now clean of sediments
					fast flowing
7/26/2010	12.4	0.13	0.011	8	Water level dropped considerably. No sediment
	13.4	0.18	0.106		
	14.4	0.2	0.157		
	15.4	0.3	0.453		
	16.4	0.34	0.771		
	17.4	0.4	0.917		
	18.4	0.4	1.14		
	19.4	0.4	0.45		
	20.4	0.28	0.535		
	21.4	0.4	-0.09		
	22.4	0.5	1.048		
	23.4	0.24	0.984		
	24.4	0.22	1.06		
	25.4	0.2	1.083		
	26.4	0.12	0.523		
7/29/2010	10.4	0.18	0.475	6	Water rising, fast flow, mod. sediment
8/1/2010	10.4	n/a			
	12.4	0.25	0.311	3	Documented site see Flow Images
	13.4	0.31	0.546		

Water Flow Testing
Citronen Fjord - 2010 Field Season
Site Name: South side of tailings dam
MTH Site Number: MP-6
UTM Location: 482555E 9227090N

Date	Interval (m)	Depth (m)	Flow Velocity (m/s)	Air Temp (°C)	Comments
6/14/2010	10.6	0.26	1.238	4	Total width of flow 20m
					Couldn't finish as too dangerous
6/17/2010	4.5	0.32	0.373	4	Flow fast, can't cross
6/20/2010	8.8	0.5	0.809	3	
6/23/2010	2.3	0.32	0.828		Flowing fast.
6/26/2010	2.3	0.32	0.393	3	Repeated flow test several times as test reading did not seem to reflect flow
6/29/2010	2.3	0.44	0.863	4	Flow was dragging the machine out of my hands
7/2/2010	2.3	0.32	0.446	4	
7/5/2010	2.3	0.3	0.521	6	Level of water is significantly lower.
					Estimated total width of flow 1m - 18m
					Lots of surges in the water
7/8/2010	1	0.29	0.283	8	Width now approx 55metres.
					Lots of surges in the water
					Can only test near edge.
7/11/2010	0.5	0.3	0.537	6	River now over 100 metres wide. Made up of main flow and 2 smaller flows.
					Marker Pegs waste away.
					Large rock slip at hill on East side.
7/15/2010	0.4	0.39	0.764	13	
7/19/2010	approx. 3 m	0.1	0.288	2	water level dropped
					width now approx 20-23metres.
					water crystal clear.
	approx. 2.4m	0.22	0.192	3	
7/22/2010	2.4	0.22	0.192	3	
7/26/2010	3.3	0.16	0.161	10	No sediment
					Total width of flow 20m
7/29/2010	2.5	0.2	0.336	6	Mod sediment.
8/1/2010	4.2	0.36	0.364	3	Photos taken. Peg needs replacing.
					Documented site see Flow Images

Water Flow Testing
Citronen Fjord - 2010 Field Season
Site Name: Lake Platinova overflow
MTH Site Number: MP-7
UTM Location: 482840E 9226300N

Date	Interval (m)	Depth (m)	Flow Velocity (m/s)	Air Temp (°C)	Comments
6/14/2010	3.3	0.14	0.186	3	Total width 0m - 7.2m
					Total flow width from 1m - 4.9m
					Shallow
6/17/2010	1.2	0.23	0.442	4	Moved 10m north due to some damming activity
	1.5	0.3	0.109		Total width 3.5m
					Flow width 0.70 - 3.5m
6/20/2010	1	0.15	0.097	3	
	1.3	0.18	0.595		
	1.8	0.12	0.164		
	2	0.19	0.424		
	2.7	0.2	0.152		
	3	0.22	0.39		
	3.2	0.16	0.139		
6/23/2010	1	14	0.363	8	Flow width 0.70 - 3.5m
	1.3	14	0.595		
	1.8	14	0.593		
	2	12	0.171		
	2.7	12	0.16		
	3	14	0.213		
	3.2	<5cm	No test		
6/26/2010	1	0.14	0.174	3	
	1.3	0.14	0.259		
	1.8	0.14	0.188		
	2	0.1	0.439		
	2.7	0.1	0.199		
	3	<0.05	0		
	3.2	<0.05	0		
6/29/2010	1	0.12	0.047		Total width: 0.8 - 3.3m
	1.3	0.12	0.086		
	1.8	0.12	0.568		
	2	0.1	0.625		
	2.7	0.12	0.217		
	3	0.09	0.218		
	3.2	<0.05m			

7/2/2010	1	0.09	0.063		
	1.3	0.12	0.123		
	1.8	0.11	0.258		
	2	0.11	0.315		
	2.7	0.11	0.214		
	3	0.11	0.193		
	3.2	<0.05m			
7/5/2010	1	<0.05m		6	Total width of flow 0.8 - 3.2m
	1.3	0.1	0.026		Flow decreased
	1.8	0.06	0.262		
	2	<0.05m			
	2.7	0.09	0.167		
	3	<0.05m			
	3.2	<0.05m			
7/8/2010	1	<0.05	0.152	7	width 0.9- 3m
	1.3	0.1	0.294		
	1.8	0.06	0.032		
	2	<0.05			
	2.7	0.06	0.2262		
	3	<0.05	0.244		
7/11/2010	1	<0.05		8	Water level has dropped.
	1.6	0.06	0.455		Stream width 0.8- 3.2 metres
	2.8	0.06	0.285		
7/15/2010	1	0.05m	0.116	13	water level dropping.
	1.6	<0.05			
	2.8	<0.05			
7/19/2010	1.3	0.11	0.136	3	water level is dropping.
					stream width 0.9- 3.1 metres
7/22/2010	1.3	<0.05		2	
7/26/2010		<0.05			Drills pumping from lake may affect level of water
7/29/2010		< 0.05			Will continue to monitor
8/1/2010		<0.05			No flow. Small stream approximately 10cm wide
					No change documented site see Flow Images

Water Flow Testing
Citronen Fjord - 2010 Field Season
Site Name: Lake Platinova inflow
MTH Site Number: MP-8
UTM Location: 483050E 9225500N

Date	Interval (m)	Depth (m)	Flow Velocity (m/s)	Air Temp (°C)	Comments
6/13/2010	0	< 0.5		3	Too shallow to test - flow good. Total width 23m. Total width of flow 4.3m - 21m
6/16/2010	4.5	0.15	0.001	3	Very shallow and cold
	9.2	0.09	0.202	3	Very shallow and cold
	16	0.13	-0.02	3	Very shallow and cold
6/19/2010	4.5	0.15	0.002	3	
	13.1	0.11			Too shallow to test
	16	0.12	0.047	0	
6/22/2010	4.5	0.14	-0.002		
	16	0.1	-0.004		Width of flow 4.4m - 21.2m
25/062010	4.5	0.2	0.285	14	
	16	0.2	0.001	14	
6/28/2010	4.5	0.13	-0.001	5	Flow width 4.6m - 21.0m
	13	0.09	0.002		
	16	0.13	0.045		
7/1/2010	4.5	0.15	0.001	7	Flow width 4.7 - 21.0m
	13	0.1	-0.03		
	16	0.11	-0.011		
7/4/2010		<0.05m		8	Flow and depth significantly reduced.
					Flow width 4.7 - 21.0m
					Stream divided into 5 small streamlets
7/7/2010		<0.05m			As above
7/10/2010		<0.05m		9	as above
7/13/2010	13.1	<0.05m		8	flow width 4.7 to 21.0m
7/17/2010		<0.05m		7	
7/21/2010		<0.05		12	reduced flow and depth of water.
7/25/2010		<0.05m		4	flow width- 4.5 - 19.5m
					4.2m very low flow
					9.0m low flow
					12.8m low flow
					19.5m low flow.
					Will continue to monitor
7/31/2010				2	No change documented site see Flow Images

Water Flow Testing
 Citronen Fjord - 2010 Field Season
 Site Name: West Lake Platinova Inflow
 MTH Site Number: MP-9
 UTM Location: 482790E 9225550N

Date	Interval (m)	Depth (m)	Flow Velocity (m/s)	Air Temp (°C)	Comments
6/13/2010	11	0.13	0.496	3	Total width of stream 27.3m Flow area currently 10.3 - 11.3m
6/19/2010				3	Too shallow to test
6/22/2010	20.2	0.1	0.096		Flow width 10.4m - 20.8m
6/25/2010					Too shallow to test, 2 streams total 2m wide
6/28/2010		<0.05m			Too shallow. Flow width 13.3 - 20.6m
					2 Streams only
7/1/2010		<0.05m			Too shallow. Flow width 13.3 - 20.6m
					2 Streams only
7/4/2010		<0.05m			
7/7/2010		<0.05m			2 streams, total 1.2m moderate flow.
7/10/2010		<0.05m		9	as above
7/13/2010		<0.05m		8	2 streams 13.6m to 20.4(total width 27.3m).
7/17/2010		<0.05m		7	medium flow
7/21/2010		<0.05m		12	reduced to one small stream with low water volume
7/25/2010		<0.05m		4	close to "no flow"
7/31/2010				2	No change documented site see Flow Images

Water Flow Testing
Citronen Fjord - 2010 Field Season
Site Name: West of Explosive Storage
MTH Site Number: MP-10
UTM Location: 483000E 9224900N

Date	Interval (m)	Depth (m)	Flow Velocity (m/s)	Air Temp (°C)	Comments
6/13/2010		< 0.5		3	Large flood plain. No flow at all. A few snow melt streams to the south.
6/16/2010	13.2	0.19	-0.007	3	Snow melting. Toal measured width 40m. Total width of flow 8.5 - 30m
6/19/2010	12.9	0.11	0.011	2	
	18.3	0.08	0.445	3	Large lake formed to the NW of site.
6/22/2010	12.9	0.1	0.034	0	Total width of flow 8.5 - 38.2m
	13.6	0.11	0.022		
	18.8	0.1	0.563	0	Lake to west of site approx 50m across
6/25/2010	13	0.1	0.025	14	
	18.5	0.12	0.638	14	Main stream high flow.
	29.5			14	To shallow.
6/28/2010	13	0.08	-0.32	4	Flow width 7.2 - 32.0m
	18.4	0.08	0.399		Small shalow divided streamlets
					Large lake to west of site contains most of the water. Stream is flowing in to lake from S/ SW
7/1/2010	13	0.014			Flow width 7.1m - 32.0m
	18.4	0.311			Stream now bypassing lake
7/4/2010		<0.05m		8	Stream is bypassing lake. Lake approx. 30m across.
					All streamlets coming from stream to SW. 3 Streams.
					Main flow is due west of site and appears to be mainly fed from snow melt. Snow still in some areas to south and west.
					Flow width 13.3 - 32.0m
7/7/2010		<0.05m			To shallow, stream very spread out, 50m past 2. "flag"
7/10/2010		<0.05m		9	as above
7/13/2010		<0.05m			Main stream at 18.0m 3 smaller flows at 29.0m, 35.0m & 40m.
7/17/2010		<0.05m		7	
7/21/2101		<0.05m		12	dried up
					some small streams further East of 2nd peg flowing from sub soil
7/25/2010		<0.05m		4	as above
					Will continue to monitor for changes
7/31/2010				2	No change documented site see Flow Images