



THOMSONS CREEK HYDROLOGY

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Table of Contents

1.	General	2
2.	The Thomsons Creek Catchment	3
3.	Flow Measuring Sites	5
4.	Water Temperature Data	6
4.1	Results from Table 4	6
4.2	Glassford Road to Wedding Ford	6
4.3	Wedding Ford to Mawhinney Road Weir Upstream	7
5.	Flow Gauging Analysis	8
5.1	General	8
5.2	Diversion Weir u/s to Diversion Weir 1000m d/s Reach	8
5.3	Diversion Weir 1000m d/s to Glassford Road Reach	9
5.4	Glassford Road to Mawhinney Road 30m Upstream Reach	9
5.5	Loss Estimates in the Glassford Road to Mawhinney Road 30m Upstream Reach	10
6.	Summary and Conclusions	11

1 General

Thomsons Creek is a tributary of the Manuherikia River and its confluence with that river is located just south of the small Ophir settlement. It has a total catchment area of 139 km² to its confluence with the Manuherikia River and has its headwaters in the Dunstan Mountains.

As is typical of rivers and streams flowing from mountain ranges in Central Otago, after the watercourse leaves the mountainous area, they tend to lose water to shallow groundwater and Thomsons Creek is no exception. These rivers and streams usually regain some or all of this lost water as they approach the main stream/river they are a tributary of. Losses to groundwater appear to begin before Thomsons Creek leaves the mountainous area and emerges onto the floodplain. The purpose of this report is to determine if, under natural conditions, Thomsons Creek will dry up due to natural losses to groundwater.

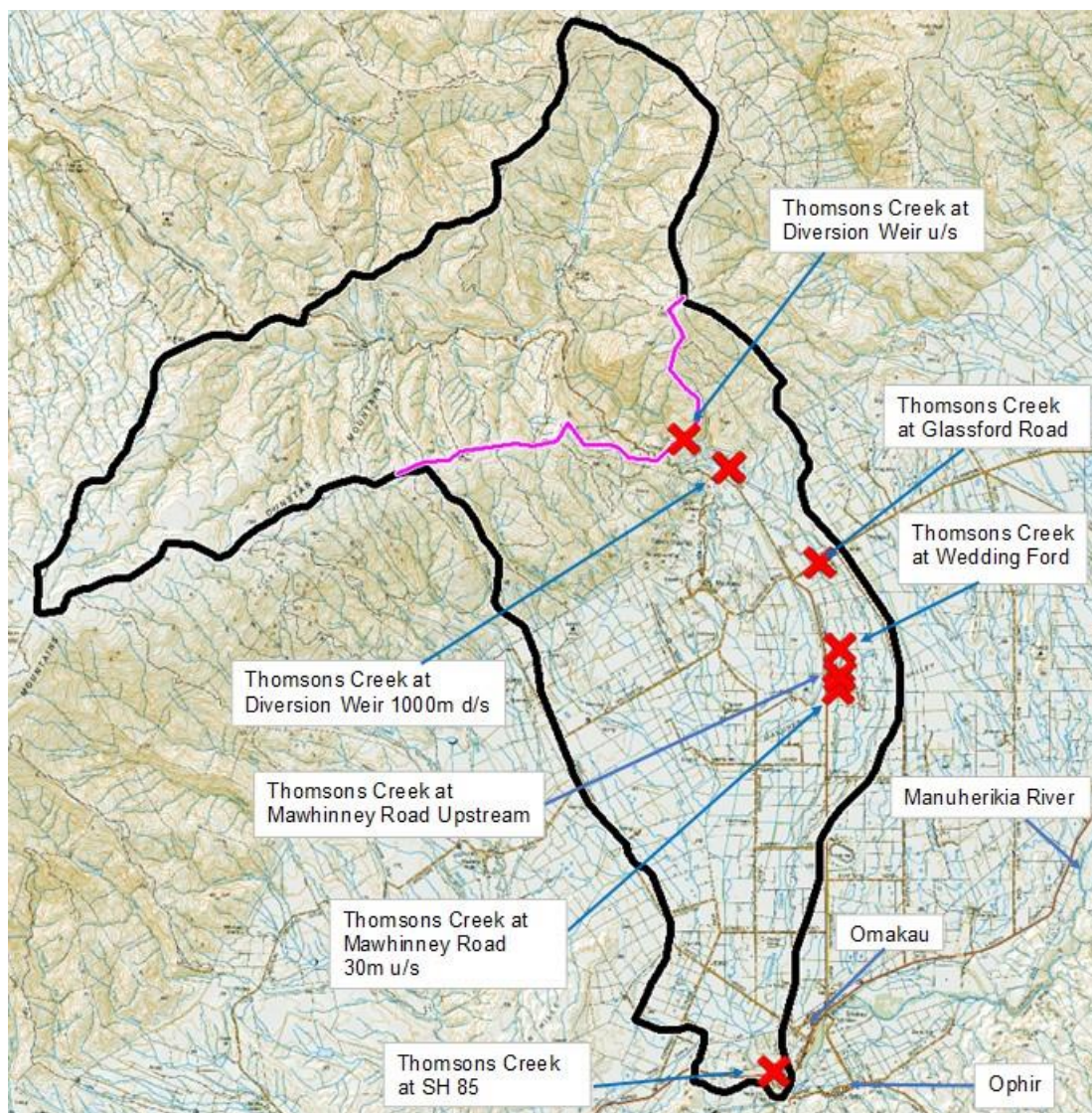
The reach of interest in this watercourse is that from the flow recorder site Thomsons Creek at Diversion weir u/s to the flow measuring site Thomsons Creek at Mawhinney Road. The locations of these sites are provided in the next section of this report. Currently Thomsons Creek dries up every year in several places during the irrigation season in this reach.

2 The Thomsons Creek Catchment

The Thomsons Creek catchment rises in the Dunstan Mountains, flows in a generally easterly direction in its headwaters but changes to a southerly direction to its confluence with the Manuherikia River once out on the floodplain as shown in Figure 1.

This figure also shows the location of the two water level recorders in this catchment, one before Thomsons Creek emerges onto the floodplain (Thomsons Creek at Diversion Weir u/s) and the other well down the catchment near its confluence with the Manuherikia River (Thomsons Creek at SH85). The catchment area to the Diversion Weir u/s site is 64.8 km² while that to the Rail Yards site is 138 km². Catchment elevation ranges from about 300m at its confluence with the Manuherikia River to 1586m in its headwaters.

Figure 1. Thomsons Creek Catchment



Thomsons Creek has a mean flow of 0.701 cumecs at the Diversion Weir u/s recorder site which is situated about 1km upstream of where Thomsons Creek emerges onto the flatter flood-plain section of the Manuherikia River Valley. At the downstream site Thomsons Creek

at SH 85, which is situated just upstream of the confluence with the Manuherikia River, it has a mean flow of 0.946 cumecs.

Thomsons Creek is located in the heart of Central Otago and is subject to typical Central Otago weather conditions with generally hot, dry summers, and cold, frosty, dry winters.

Mean annual rainfalls range from about 420mm at Ophir to a about 800mm in the headwaters of Thomsons Creek so conditions are not so dry in the highest parts of the catchment.

Thomsons Creek has a distinct higher headwaters area in the Dunstan Mountains and a much flatter lower catchment. This lower section passes through lowland farming areas which are heavily irrigated in summer to ensure good crop and pasture growth.

Thomsons Creek contributes significant amounts of its flow to irrigation in the irrigation season. Abstraction records show this contribution can be as much as 0.451 cumecs (5 November 2011). Also as mentioned earlier, there is a natural loss to shallow groundwater as the Creek traverses the flatter section of its catchment before its confluence with the Manuherikia River.

3 Flow Measuring Sites

There are two continuous water level recorder sites in Thomsons Creek, one at the Diversion Weir u/s and the other at the SH 85 as earlier identified. The locations of these sites are shown on Figure 1. The Thomsons Creek at Diversion Weir u/s site records natural flows while the SH 85 site is significantly affected by abstractions.

Both sites have two periods of measurement including between 2008 and 2011, and from 2016 at SH 85 and 2019 at Diversion Weir u/s and they both continue today. The hydrological statistics for Thomsons Creek at Diversion Weir u/s are included in Table 1.

Table 1. Thomsons Creek at Diversion Weir Statistics (cumecs)

Mean	Median	7DMALF*	Min Flow	Max Flow
0.701	0.573	0.214	0.113	8.153

*7DMALF is the 7-day mean annual low flow

The lowest 7-day low flow measured at the Diversion Weir u/s site is 0.135 cumecs from 17-24 April 2010.

Flow statistics for the Thomsons Creek at SH 85 site are not relevant to this analysis because it is well downstream of the reach of interest.

Table 2 is the flow duration table for Thomsons Creek at Diversion Weir u/s for the combined record period, and it shows that flows less than 0.135 cumecs have occurred for less than 1% of the time. Flows less than the 7DMALF occurred for at least 8% of the time.

Table 2. Flow Duration Table for Thomsons Creek at Diversion Weir u/s (cumecs)

Percent	0	1	2	3	4	5	6	7	8	9
0	5.143	2.518	2.000	1.869	1.738	1.658	1.570	1.484	1.437	1.375
10	1.320	1.272	1.225	1.179	1.130	1.106	1.083	1.053	1.032	1.008
20	0.979	0.952	0.930	0.908	0.878	0.864	0.852	0.835	0.823	0.808
30	0.793	0.779	0.762	0.750	0.729	0.716	0.704	0.694	0.687	0.675
40	0.633	0.653	0.647	0.640	0.633	0.622	0.614	0.604	0.592	0.580
50	0.573	0.557	0.548	0.537	0.526	0.513	0.502	0.490	0.478	0.467
60	0.459	0.444	0.436	0.425	0.415	0.404	0.396	0.386	0.376	0.366
70	0.0356	0.349	0.343	0.337	0.332	0.326	0.317	0.313	0.308	0.301
80	0.296	0.289	0.285	0.280	0.274	0.269	0.264	0.258	0.251	0.246
90	0.237	0.227	0.210	0.197	0.182	0.167	0.159	0.151	0.144	0.138
100	0.132									

The Otago Regional Council (ORC) has also undertaken extensive gauging exercises in the reach from the Diversion Weir u/s water level recorder to Mawhinney Road. Many of these gaugings were collected to assist in the investigation as to whether Thomsons Creek would go dry naturally (i.e. without irrigation abstraction). This will be addressed in the next section of this report.

4. Water Temperature Data

Continuous water temperature data can be used to indicate when a reach has gone dry providing the sensor has been installed correctly. Continuous temperature data are available at the Thomsons Creek sites of Diversion Weir u/s, Diversion Weir 1000 d/s, Glassford Road, Wedding Ford and Mawhinney Road Weir Upstream. The Mawhinney Road temperature sensor is situated about 280m upstream of the Mawhinney Road flow gauging site which is 30m upstream of the Mawhinney Road Bridge.

The temperature sensor at Diversion Weir u/s is consistent with the flow record and it has never gone dry at this site. The lowest flow recorded at this site is 0.113 cumecs on 10 March 2010.

At the Wedding Ford site, the sensor was initially installed at a location that subsequently proved to be unsuitable. The temperature recorder was shifted to a new, more suitable location still at Wedding Ford, on 7 May 2020. Data from this site before 7 May 2020 has been excluded from any analysis.

Table 4 attached as Appendix 1 shows the days of no flow according to the temperature sensors. An X in the table indicates the site is dry. The criteria for assuming zero flows during the day were:

- if there is a 12°C temperature difference between highest and lowest daily temperature in a 24-hour period, then the reach was dry; and
- if there were sudden rises in temperature of 4°C or more within an hour, then that also indicated the reach was dry.

4.1 Results from Table 4

The Diversion Weir 1000m d/s site goes dry at times and this is due entirely to abstraction upstream. If there was no abstraction, then this site would not go dry. Calculated losses in the reach from Diversion Weir u/s to Diversion Weir 1000m d/s are 0.020 cumecs while the minimum flow measured at the Diversion Weir site upstream of the Omakau irrigation diversion weir is 0.113 cumecs.

The Glassford Road site goes dry much less frequently than the Diversion Weir 1000m d/s site. This is due to the projected overall flow increase of around 10% due to the increase in catchment area between the two sites.

In Table 4, there are occasions when there is flow at Diversion Weir 1000m d/s but zero flow at Glassford Road at the same time. This situation will be due to very dry conditions in the region meaning the flow increase in the reach down to Glassford Road because of an increase in catchment area is small and this combined with the Diversion Weir 1000m d/s site low flow provide less than the natural losses in this reach.

4.2 Glassford Road to Wedding Ford

From table 4, it is likely that this 2.2km reach is the driest of all and has the greatest losses. The table shows it is dry more frequently than both the downstream Mawhinney Road Weir Upstream site and the upstream Glassford Road site. This site can be dry for long periods as Table 4 shows. It was essentially dry from 25 November 2020 to at least 31 December 2020. Records for January 2021 were not available at the time of writing this report, but it is known flooding occurred in Central Otago in early January 2021 the dry period was unlikely to last long into January 2021.

4.3 Wedding Ford to Mawhinney Road Weir Upstream

At the Mawhinney Road Weir Upstream site, the temperature sensor is about 280m upstream of the flow gauging site which in turn is about 30m upstream of the Mawhinney Road Bridge. This places the Mawhinney Road Upstream site with its temperature sensor upstream of the Omakau Main Race crossing of Thompsons Creek. The flow gauging site has never been dry when flow gaugings were undertaken but Table 4 shows that the Mawhinney Road Weir Upstream temperature recording site can be dry at times. Reference to Table 4 shows that the Mawhinney Road temperature recorder has significantly less days of dryness than Wedding Ford. In the period 7 May 2020 to 31 December 2020, Wedding Ford was dry for 40 days in total while at the Mawhinney Road Weir Upstream temperature recorder for the same period, it was dry for only 17 days. Therefore, the Wedding Ford/Mawhinney Road temperature recorder reach (0.6km long) can be a gaining reach.

5 Flow Gauging Analysis

5.1 General

The ORC flow gauging program at the sites Diversion Weir 1000m d/s, Glassford Road Bridge 100m d/s, and Mawhinney Road Bridge 30m u/s began in August 2018. Thomsons Creek at Diversion Weir u/s was automatically included as it is a continuous water level measurement site (see Figure 1). Gaugings between 6 September 2019 and 18 May 2021 are available and were measured on a regular basis. Table 3 lists most of the gaugings.

Table 3. Flow Gaugings for Thomsons Creek (cumecs)

Date	Diversion Weir u/s	Diversion Weir 1000m d/s	Diversion Weir 1000m d/s Corrected for Irrigation Abstractions	Glassford Road	Mawhinney Road
06/09/2018	0.603	0.523	0.586	0.501	
06/08/2019	1.053	0.912	0.970	1.003	1.021
09/09/2019	0.656	0.565	0.620	0.554	0.552
08/10/2019	0.777	0.628	0.758	0.646	0.854
19/11/2019	1.059	1.047	1.105	1.061	1.436
18/12/2019	1.449	1.350	1.490	1.435	1.664
21/01/2020	0.438	0.093	0.516	0.037	0.051
11/02/2020	0.513	0.253	0.443	0.193	0.174
10/03/2020	0.331	0.273	0.337		0.426
07/05/2020	0.313	0.260	0.305	0.228	0.033
09/06/2020	0.311	0.274	0.316	0.221	0.124
04/08/2020	0.788	0.685	0.740	0.671	0.589
08/09/2020	0.605	0.565	0.618	0.573	0.503
06/10/2020	1.260	1.110	1.154	1.159	1.189
17/11/2020	0.422	0.224	0.395	0.195	0.208
15/12/2020	0.287				0.046
19/01/2021	0.731				
09/02/2021	0.365	0.000		0.000	0.147
09/03/2021	0.301	0.000		0.000	0.117
29/04/2021	0.226	0.033		0.000	0.147
18/05/2021	0.263	0.263		0.237	0.028

5.2 Diversion Weir u/s to Diversion Weir 1000m d/s Reach

There is only a small increase in catchment area between the two sites of 1.8 km².

A review of the gauging results and the corrected gaugings for Diversion Weir 1000m d/s showed some inconsistencies which mainly occurred at higher irrigation abstraction rates. Matt Hickey of Water Resource Management Ltd subsequently identified that the rating for the Omakau Weir diversion is not accurate especially at high abstraction rates. These gaugings were removed from the list and the resultant dataset is Table 3.

The gaugings for the Diversion Weir u/s were then correlated with the corrected gaugings for the Diversion Weir 1000m d/s site excluding those that had major inconsistencies and the relationship between them was:

Diversion Weir 1000m d/s = $1.0205 \times \text{Diversion Weir u/s} - 0.021$ with an R^2 value of 0.993.

This indicates there is a small natural, and probably constant, loss to groundwater in the reach of around 0.021 cumecs. The formula also indicates there is little natural increased runoff in this reach due to the slightly larger catchment area.

5.3 Diversion Weir 1000m d/s to Glassford Road Reach

A correlation between the measured Diversion Weir 1000m d/s and Glassford Road was undertaken using the gaugings listed in Table 3. The resultant equation was:

Glassford Road = $1.076 \times \text{Diversion Weir 1000m d/s} - 0.039$ with an R^2 value of 0.996.

From this equation, natural losses to groundwater are likely to be about 0.040 cumecs and on an average annual basis, flows at the Glassford Road site will be about 8% greater than those at the Diversion Weir 1000m d/s site. Generally, flows at Glassford Road are likely to be less than those measured at the Diversion Weir 1000m d/s site until flows reach about 0.510 cumecs at the Diversion weir 1000m d/s site. Flows more than 0.510 cumecs at Diversion Weir 1000m d/s should result in higher flows at Glassford Road due to the extra runoff from the 8.32 km² increase in catchment area to Glassford Road.

In summary, natural losses to groundwater between the Diversion Weir u/s and Glassford Road is about 0.060 cumecs. Given the minimum recorded flow at the Diversion Weir u/s site is 0.113 cumecs, then this reach is unlikely to go dry naturally.

5.4 Glassford Road to Mawhinney Road 30m Upstream Reach

The reach from Glassford Road to Mawhinney Road is likely to be the reach of greatest loss based on available data. The actual losses are not able to be calculated because there are no flow measurements between the Glassford Road and Mawhinney Road 30m Upstream flow measurement sites. This reach is often dry even though there is flow at both the Glassford Road and Mawhinney Road 30m Upstream sites.

Immediately downstream of the Mawhinney Road temperature recorder, Thomsons Creek runs beneath an Omakau Irrigation Scheme syphon. At this point, returning groundwater becomes apparent (about 0.020 cumecs estimated by Jens Rekker of ORC). Between this syphon and the Mawhinney Road 30m u/s flow site, more groundwater inflow continues to appear in the reach. An estimate can be made of this groundwater return flow using the gaugings and observations undertaken on 18/05/2021 which showed that while there was good flow at Glassford Road, there was no flow at Wedding Ford which means all flow measured at Glassford Road was lost to groundwater. Since there was no bywash, the flow measurement at Mawhinney Road 30m u/s was all returning groundwater only. This flow was 0.028 cumecs and for this exercise, it is assumed that this is a constant.

A bywash from the irrigation scheme also enters Thomsons Creek in this reach. The bywash is highly variable. Some of these bywash flows have been measured and they ranged from 0 cumecs to 0.399 cumecs. Table 5 lists the measured bywash flows. A combination of returning groundwater and bywash flows make it likely that flows at the Mawhinney Road 30m Upstream are permanent.

In Table 5, the bywash values are valid for the time they were measured. It is not known if the bywash flow was constant or variable throughout the day.

Table 5. Measured Bywash Flows (cumecs)

Date	Time	Bywash Flow	Date	Time	Bywash Flow
11/02/2020	13:41	0.092	17/11/2020	14:02	0.108
10/03/2020	12:29	0.399	09/02/2020	12:05	0.058
09/06/2020	14:38	0.017	09/03/2020	12:27	0.054
07/07/2020	15:44	0.088	09/02/2021		0.058
04/08/2020	14:56	0.073	09/03/2021		0.054
08/09/2020	15:34	0.050	29/04/2021		0.101
06/10/2020	13:54	0.163	18/05/2021		0.000

5.5 Loss Estimates in the Glassford Road to Mawhinney Road 30m Upstream Reach.

Using the measured flows at Glassford Road and Mawhinney Road 30m Upstream, the returning groundwater estimate of 0.020 cumecs, and the bywash flows, an estimate can be made of the possible losses in the driest reach. Table 6 lists the data used.

Because the increase in groundwater inflow between the irrigation syphon and the Mawhinney Road flow recording site about 280m downstream has been estimated as cumecs based on only one measurement, the loss estimates will be indicative only of what is occurring.

Temperature data in 2020 on the days the bywash was measured indicate there was continuous flow at Glassford Road, Wedding Ford and Mawhinney Road Upstream. No temperature data were available for 2021. It should be noted that on 18/05/2021, the reach upstream of Wedding Ford was dry despite a flow of 0.237 cumecs being measured at Glassford Road (Malcolm Allan pers. comm.).

Table 6. Estimated Losses (cumecs)

Date	Glassford Road	Mawhinney Road 30m u/s	Bywash	Returning Groundwater	Corrected Mawhinney Road 30m u/s	Estimated Loss
11/02/2020	0.193	0.174	0.092	0.028	0.054	0.139
30/03/2020		0.426	0.399	0.028		
09/06/2020	0.221	0.124	0.017	0.028	0.079	0.142
04/08/2020	0.671	0.589	0.073	0.028	0.488	0.183
08/09/2020	0.573	0.503	0.050	0.028	0.425	0.148
06/10/2020	1.159	1.189	0.163	0.028	0.998	0.161
17/11/2020	0.195	0.208	0.108	0.028	0.072	0.123
09/02/2021	0.000	0.147	0.058	0.028	0.061	0.000
09/03/2021	0.000	0.117	0.054	0.028	0.035	0.000
29/04/2021	0.033	0.147	0.101	0.028		0.033*
18/05/2021	0.237	0.028	0.000	0.028		0.237**

*It is assumed the reach between Glassford Road and Wedding Ford would go dry since the flow at Glassford Road was only 0.033 cumecs and Table 5 shows that losses in that reach are likely to be more than 0.100 cumecs when there is good flows at the two measuring sites.

**Since the reach upstream of Wedding Ford was dry, then the loss was 0.237 cumecs

Correcting the Mawhinney Road 30m u/s data involved subtracting the bywash and estimated groundwater inflows from the flows measured at Mawhinney Road 30m u/s. The resultant corrected flows were then subtracted from the Glassford Road flows to provide an estimate of the potential natural losses in the reach Glassford Road to Wedding Ford.

These losses range from 0 cumecs to 0.237 cumecs. Therefore, initial estimates of natural

losses in the total reach from Diversion Weir u/s to Mawhinney Road 30m u/s range from 0.060 cumecs to 0.297 cumecs based on available data. The lowest flow measured at the natural flow site of Diversion Weir u/s site is 0.113 cumecs.

6. Summary and Conclusions

6.1 Summary

Flows in Thomsons Creek are natural until they reach the Thomsons Creek at Diversion Weir u/s water level recording site. Immediately downstream of that site, the Omakau Irrigation Scheme abstracts water through a large weir. Some flow is abstracted all year round with much less abstracted in the winter months compared with that abstracted in the irrigation season. During the irrigation season, the irrigation scheme has been known to abstract all flow from Thomsons Creek.

Downstream of the irrigation intake, Thomsons Creek is also affected by natural losses to groundwater and these losses appear to be quite variable throughout the downstream reaches.

Available flow information includes two continuous water level recorders, one at Diversion Weir u/s and the other at SH85. In addition to these continuous recorders, 21 gauging exercises have been undertaken targeting the top three sites of Diversion Weir 1000m d/s, Glassford Road and Mawhinney Road 30m u/s. This data collection began in August 2018. Also, since 2018, continuous Thomsons Creek water temperature data has been collected at 5 sites between and including Diversion Weir u/s and Mawhinney Road Upstream sites. The flow and temperature data allowed analysis of flows to determine the cause of the reaches upstream of Mawhinney Road to be dry on occasions.

6.2 Conclusions

- If irrigation abstraction was not occurring, the reach from the Diversion Weir to Glassford Road is very unlikely to go dry. Calculated total natural losses in this reach are about 0.060 cumecs while the lowest flow measured at the Diversion Weir u/s site is 0.113 cumecs.
- The reach from Glassford Road to Wedding Ford is likely to go dry in dry times irrespective of upstream abstraction although abstraction upstream will exacerbate the period of dryness. The available data allowed estimates to be made of natural losses in this reach and these losses ranged from 0.110 cumecs to 0.237 cumecs.
- Total losses in the reach from Diversion Weir u/s to Wedding Ford range from 0.060 cumecs to 0.297 cumecs. The minimum flow recorded at Diversion Weir u/s is 0.113 cumecs.
- The reach from Wedding Ford to the flow measurement site of Mawhinney Road 30m u/s is a natural gaining reach from groundwater and the irrigation scheme bywash in this reach can add significant flow to the natural flow returning from groundwater.

Appendix 1

Table 4. Days of Dryness Based on Temperature

Table 4. Days of Dryness Based on Temperature

Date	Diversion Weir 1000m d/s	Glassford Road	Wedding Ford	Mawhinney Road
18-Jan-20				X
19-Jan-20				X
20-Jan-20				X
21-Jan-20				X
22-Jan-20				X
23-Jan-20				X
24-Jan-20				X
25-Jan-20				X
26-Jan-20				X
27-Jan-20				X
28-Jan-20				X
29-Jan-20				X
30-Jan-20	X			X
31-Jan-20				X
01-Feb-20				X
02-Feb-20				
03-Feb-20	X			X
20-Feb-20	X			
21-Feb-20				
22-Feb-20				
23-Feb-20	X			
24-Feb-20	X			X
25-Feb-20	X			X
26-Feb-20	X			X
27-Feb-20	X			X
28-Feb-20	X			X
29-Feb-20	X			X
01-Mar-20	X			X
02-Mar-20	X	X		X
03-Mar-20	X	X		X
04-Mar-20	X	X		X
05-Mar-20	X	X		X
06-Mar-20	X	X		X
09-Mar-20		X		X
11-Mar-20				X
12-Mar-20				X
13-Mar-20				X
14-Mar-20				X
15-Mar-20				X
16-Mar-20				X
17-Mar-20				X
18-Mar-20				X
23-Mar-20				X

Table 4 Continued

Date	Diversion Weir 1000m d/s	Glassford Road	Wedding Ford	Mawhinney Road
29-Mar-20				X
31-Mar-20				X
01-Apr-20				X
02-Apr-20				X
03-Apr-20	X			X
04-Apr-20	X			X
05-Apr-20				X
07-Apr-20				X
08-Apr-20				X
09-Apr-20	X			
10-Apr-20	X			X
11-Apr-20	X			X
12-Apr-20	X	X		X
15-Apr-20				X
16-Apr-20				X
18-Apr-20				X
21-Apr-20				X
22-Apr-20				X
24-Apr-20				X
28-Apr-20				X
29-Apr-20				X
09-May-20			X	X
10-May-20			X	X
13-May 20			X	
25-Nov-20	X		X	
26-Nov-20	X		X	
27-Nov-20	X		X	
28-Nov-20	X		X	
29-Nov-20	X		X	
01-Dec-20	X		X	
02-Dec-20			X	
03-Dec-20	X		X	
04-Dec-20	X		X	
05-Dec-20	X		X	X
06-Dec-20	X		X	
07-Dec-20	X		X	X
08-Dec-20	X		X	X

Table 4 Continued

Date	Diversion Weir 1000m d/s	Glassford Road	Wedding Ford	Mawhinney Road
09-Dec-20	X		X	X
10-Dec-20	X		X	X
11-Dec-20			X	
12-Dec-20			X	X
13-Dec-20			X	X
14-Dec-20	X		X	X
15-Dec-20	X		X	X
16-Dec-20	X		X	
17-Dec-20			X	X
18-Dec-20			X	X
19-Dec-20		X	X	
20-Dec-20			X	
22-Dec-20	X	X	X	X
23-Dec-20			X	
24-Dec-20		X	X	
25-Dec-20		X	X	
26-Dec-20		X	X	
27-Dec-20	X	X	X	X
28-Dec-20	X	X	X	X
29-Dec-20	X	X	X	X
30-Dec-20		X	X	
31-Dec-20	X	X	X	