Document Id: **A1355380**

MEMORANDUM

To: **Kirstyn Lindsay**

From: **Sarah McCrorie**

Date: **11/06/2020**

Re: **RM20007 - Park Burn historical water use analysis**

This memorandum is in relation to application RM20.007 to replace deemed permit 94394 and consent RM15.007.01 from Park Burn for the purpose of irrigation and stock drinking. Abstraction of water under this permit occurs through water meter WM0952.

All analyses, graphs, and calculations were performed using RStudio version1.2.5033 and RGui version 3.6.3.

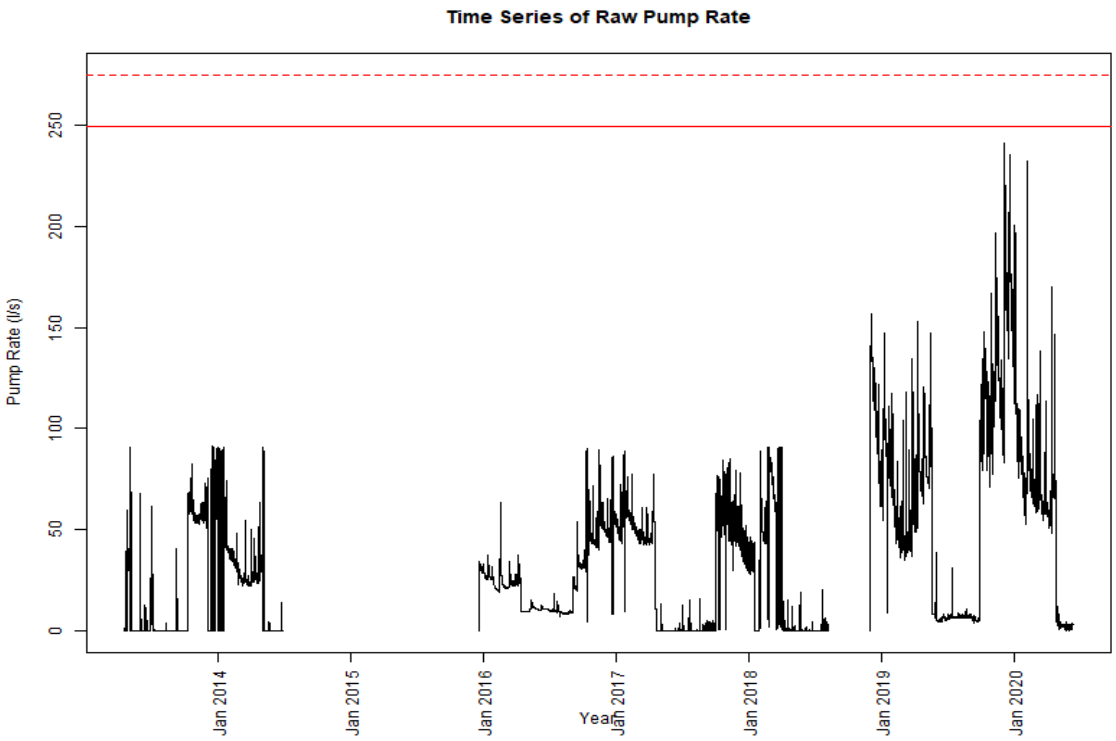
Data taken through WM0952 extends from 19 April 2013 to 10 June 2020 with a total of 46,863 hourly measurements.

The gap in the data from mid-2014 to the start of 2016 appears to be due to a faulty data logger which was replaced. The gap at the end of 2018 was a failure of the data logger it was reset.

In addition to analysing the raw data, the following steps were taken:

- Rates less than, or equal to zero were set to NA.
- The maximum average rate of take authorized by the permit this application seeks to replace is 249.8 l/s and water is taken through an open channel. A 10% margin of error was applied to this and rates in excess of 274.78 l/s were set to NA.
- Rates between 249.8l/s and 274.78l/s were set to 249.8l/s.
- The resultant data set had 38542 hourly measurements.

A time series showing the pump rate, the maximum consented rate, and the upper error limit is presented below:

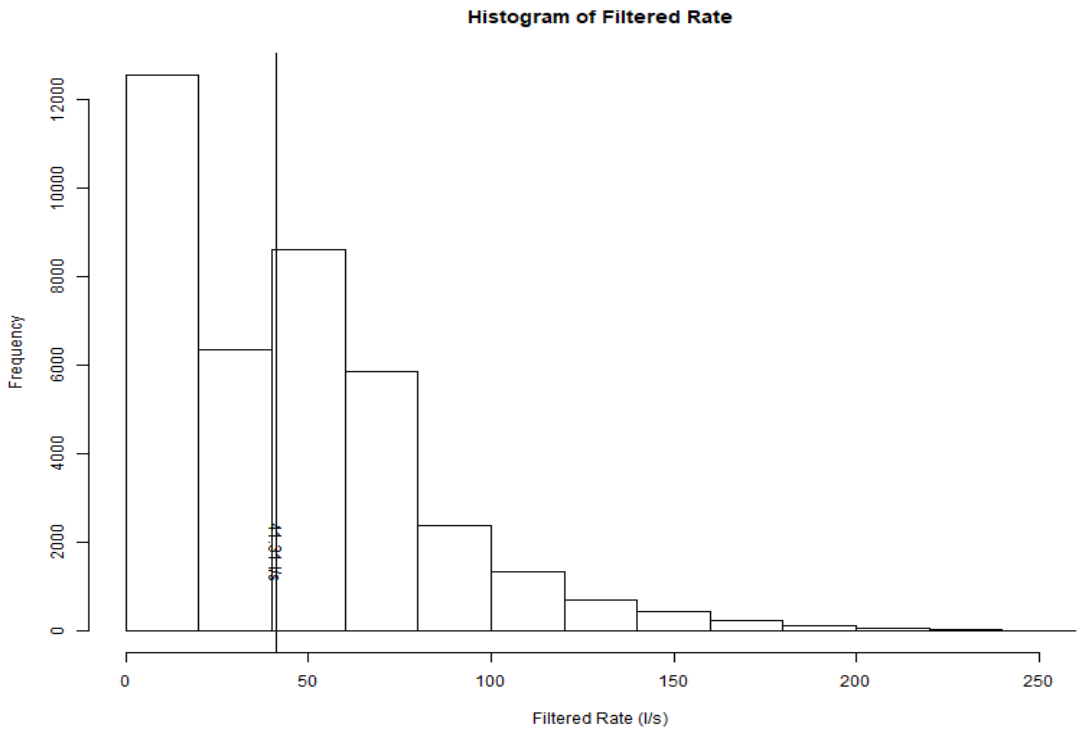


The solid red line represents the consented maximum rate of 249.8 l/s, and the broken red line represents 249.8 + 10% (274.78 l/s).

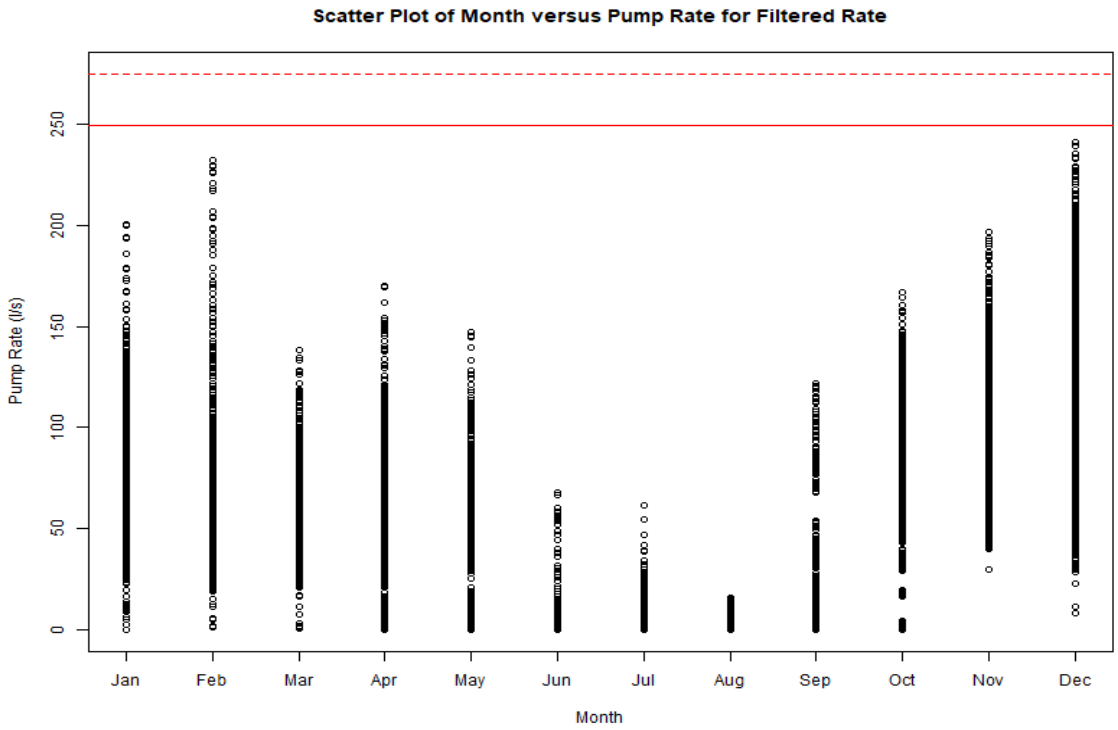
There is a pattern of seasonality visible in the raw time series graph. This would be consistent with irrigation. Rates of take have increased in the last couple of seasons.

The filtered data set contains 38,542 measurements with an average take of 43.2 l/s, a median rate of take of 41.3 l/s, and a modal (most common) rate of take of 0.01 l/s.

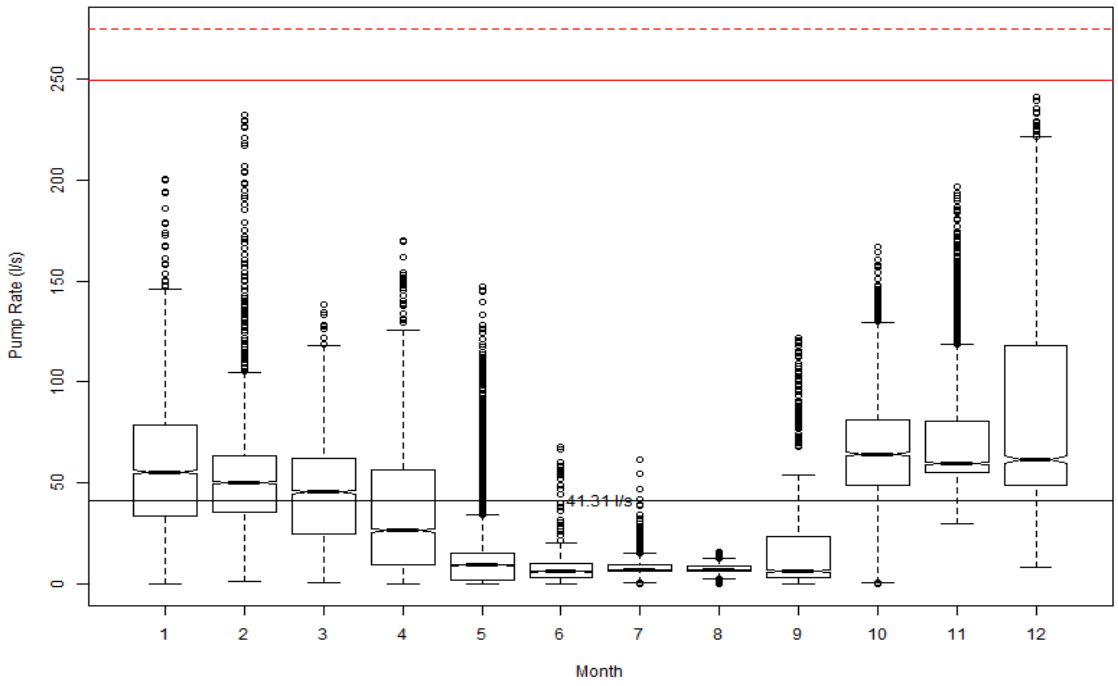
The histogram is slightly positively skewed but also a bimodal distribution with the highest peak at 0-20 l/s and a secondary peak at 40-60 l/s. This would be consistent with use for both stock drinking most of the time and irrigation during the season.



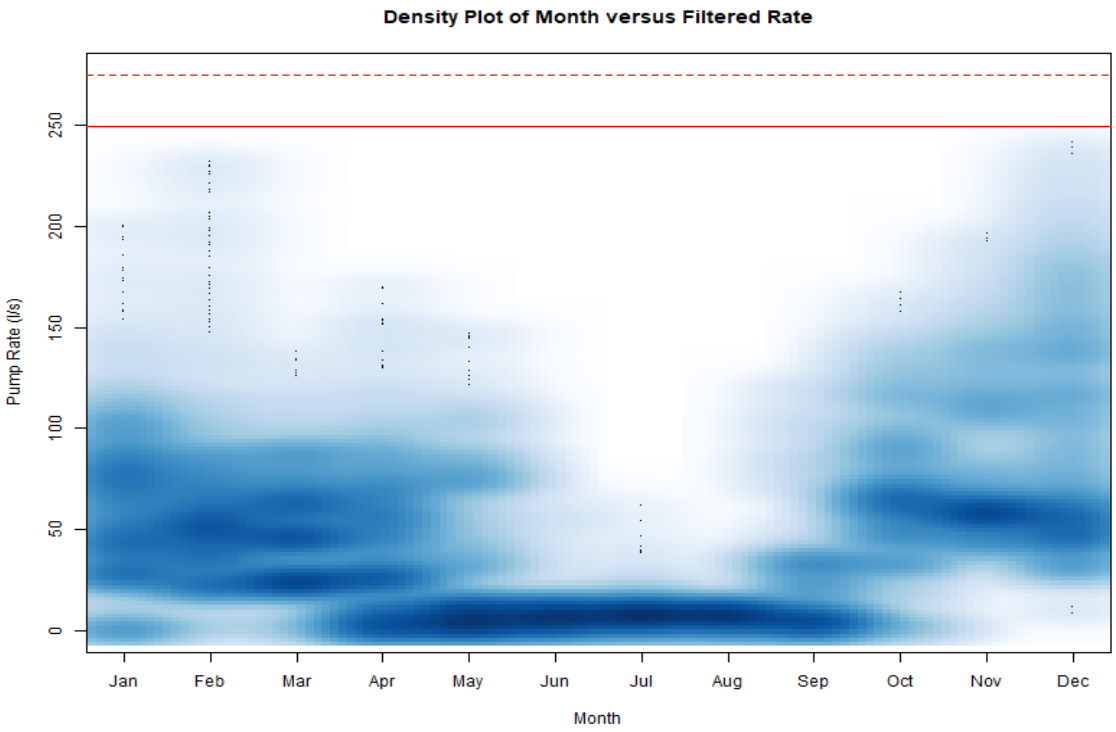
The scatter plot shows a strong seasonality, with higher rates likely to occur between September and May. The highest rates are likely to occur between November and February



The box plot supports the conclusions drawn from the scatter plot, the rate of take is likely to be above the average rate of take during October to March, this would be consistent with irrigation. The lower rates during the off-season would be consistent with stock drinking.



The density plot supports the data shown on the box plot.



The high use data set was selected by filtering for those months in which the median usage exceeded the median for the filtered data set. The mean for the high use data set is 61.6l/s, the median is 56.48 l/s and the modal value is 28.72 l/s.

Percentiles are not a percentage of the maximum rate, but rather the rate that is exceeded x% of the time. Percentiles are calculated by ranking the data from lowest to highest and taking the weighted average of the nth highest and the n+1th highest values. The 80th percentile is the pump rate that is exceeded 20% of the time. The 90th percentile is the pumping rate that is exceeded 10% of the time. The 95th Percentile is exceeded 5% of the time. What this means in terms of the analysis is that if the applicant is pumping at the maximum consented rate more than 5% of the time, the 95th percentile will equal the maximum consented rate. If they are pumping at the maximum consented rate more than 10% of the time, the 90th percentile will equal the maximum consented rate. If they are pumping at the maximum consented rate more than 20% of the time, then the 80th percentile will equal the maximum consented rate. In practical terms if the applicant is pumping 24 hours/day and 2160 hours for a 90-day season then:

- The 80th percentile is the rate that is exceeded for 5 hours per day, or 432 hours per season.
- The 90th percentile is the rate that is exceeded for 2.5 hours per day, or 216 hours per season.
- The 95th percentile is the rate that is exceeded for 1.5 hours per day, or 108 hours per season.

What this means is that if a consent holder is consistently using their maximum consented rate for more than 5%, 10%, or 20% of the time they are pumping, it will show up in the table of percentiles.

The 80th, 90th, and 95th percentiles for the flow rate were calculated, without modelling the distribution, for the raw data set, the filtered data set, and the high rate data set. The results are presented to three significant figures below.

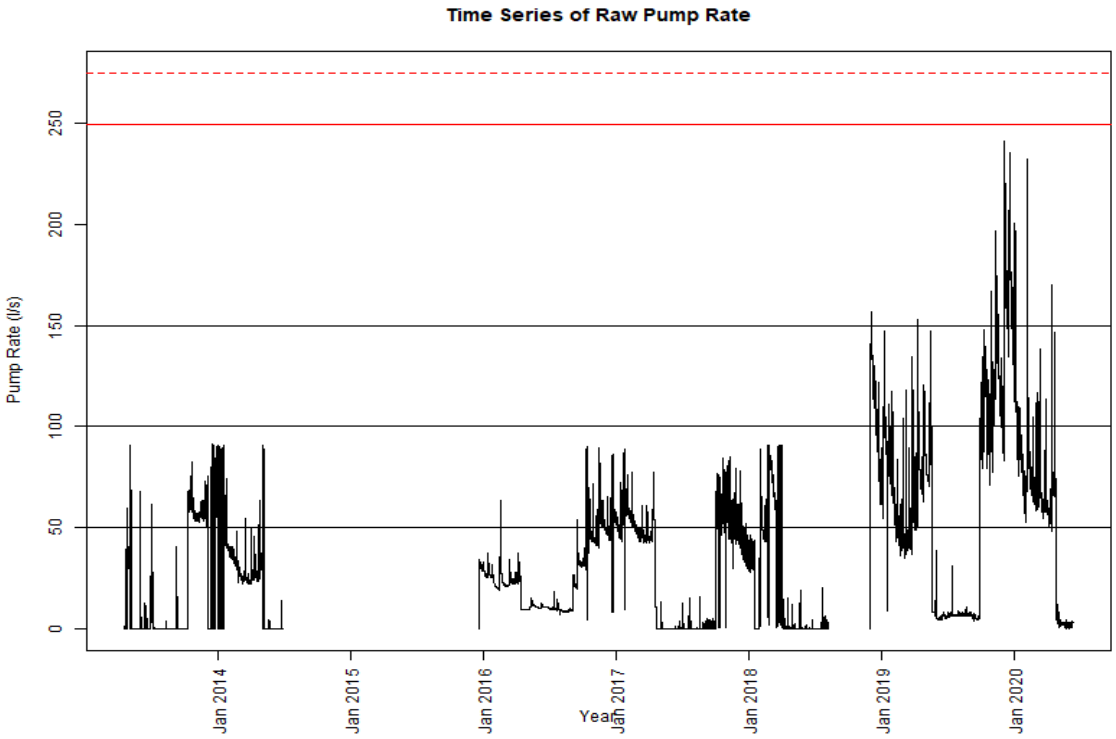
	80th %ile	90th %ile	95th %ile
Raw rate	64	83.3	107
Filtered rate	69	88.2	114
High use rate	81.4	107	132

A summary of rates and volumes for the period 1 July 2012 to 30 June 2017, prepared according to proposed Method 10.A.4 is presented below:

V1	Max Take Rate	Max Daily Volume	Max Monthly Volume	Max Annual Volume
2012/2013	90.9	6030	37200	62300
2013/2014	91.1	7120	158000	759000
2014/2015	NA	NA	NA	NA
2015/2016	63.4	5470	75300	324000
2016/2017	90.2	6620	151000	1010000
Mean	83.9	6310	105375	538825

The rate of take has increased since 2018, this should be considered.

A time series with reference lines at 50 l/s, 100 l/s, & 150 l/s is presented below to provide context for the percentiles and where they sit in relation to the history of taking by the resource consent holder.


Time Series of Raw Pump Rate
Pump Rate (l/s)
0
50
100
150
200
250
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018
Jan 2019
Jan 2020
Year

The number of days in each month of the historical record that the 80th, 90th, and 95th percentiles have been exceeded for all three data sets is presented below:

64 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	0	4	1	0	0	0	10	3	14
2014	21	0	0	0	4	0	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2016	0	0	0	0	0	0	0	0	0	5	5	8
2017	11	3	0	2	0	0	0	0	0	28	15	1
2018	0	13	24	3	0	0	0	0	NA	NA	NA	31
2019	31	8	8	25	17	0	0	0	5	31	30	31
2020	31	29	27	14	0	0	NA	NA	NA	NA	NA	NA

83.3 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	0	2	0	0	0	0	0	0	6
2014	10	0	0	0	3	0	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2016	0	0	0	0	0	0	0	0	0	2	2	1
2017	3	0	0	0	0	0	0	0	0	1	2	0
2018	0	10	12	3	0	0	0	0	NA	NA	NA	26
2019	22	3	5	13	8	0	0	0	4	30	30	31
2020	23	13	8	4	0	0	NA	NA	NA	NA	NA	NA

107 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

107 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	NA	NA	NA	20
2019	5	1	3	3	4	0	0	0	2	18	28	31
2020	8	6	5	3	0	0	NA	NA	NA	NA	NA	NA

69 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	0	2	0	0	0	0	2	1	12
2014	19	0	0	0	4	0	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2016	0	0	0	0	0	0	0	0	0	4	4	2
2017	8	2	0	1	0	0	0	0	0	20	10	1
2018	0	12	20	3	0	0	0	0	NA	NA	NA	31
2019	31	5	8	20	17	0	0	0	5	31	30	31
2020	30	28	14	13	0	0	NA	NA	NA	NA	NA	NA

88.2 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	0	1	0	0	0	0	0	0	5
2014	7	0	0	0	2	0	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2016	0	0	0	0	0	0	0	0	0	1	1	0
2017	1	0	0	0	0	0	0	0	0	0	0	0
2018	0	8	10	0	0	0	0	0	NA	NA	NA	24
2019	18	2	5	8	6	0	0	0	3	28	29	31
2020	20	11	7	3	0	0	NA	NA	NA	NA	NA	NA

114 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	NA	NA	NA	15
2019	3	0	2	3	2	0	0	0	2	15	26	30
2020	5	4	2	3	0	0	NA	NA	NA	NA	NA	NA

81.4 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	0	2	0	0	0	0	1	0	6
2014	10	0	0	0	3	0	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2016	0	0	0	0	0	0	0	0	0	2	3	1
2017	3	0	0	0	0	0	0	0	0	1	2	0
2018	0	10	15	3	0	0	0	0	NA	NA	NA	28
2019	22	3	6	13	8	0	0	0	4	30	30	31
2020	24	13	8	4	0	0	NA	NA	NA	NA	NA	NA

107 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	NA	NA	NA	19

107 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019	4	1	3	3	4	0	0	0	2	18	28	31
2020	8	5	5	3	0	0	NA	NA	NA	NA	NA	NA

132 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	NA	NA	NA	5
2019	1	0	1	2	1	0	0	0	0	7	12	27
2020	3	3	1	3	0	0	NA	NA	NA	NA	NA	NA

A summary of daily volumes, in m^3, filtered for a maximum daily take of 21600 m^3 and then rounded to three significant figures is presented below:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	2.41	1100	53.3	0.5	0.1	0.1	0.1	0.13	1.26	59.8	3550	410
Mean	4950	4440	4060	3020	1400	374	445	451	1200	5650	6330	7100
Median	4690	4340	3950	2290	331	248	528	593	503	5500	5130	5190
80%	7120	5880	5620	5330	2500	877	820	743	2320	7690	9370	11700
90%	8250	6610	6630	6330	5750	911	855	776	2790	9060	10600	13700
95%	8940	7250	7110	7200	6760	940	905	795	3160	10600	12300	15200
Max	13800	15100	8330	10200	9600	2610	2340	844	8390	11900	15300	17700

A summary of monthly volumes based on daily volumes that have been filtered for a maximum daily take of 21600m^3 and then rounded to three significant figures is presented below.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	NA	NA	NA	17100	37200	7950	8020	25.7	2250	106000	149000	76900
2014	158000	86100	68200	71200	33500	146	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	24400
2016	75300	61800	60700	45000	29300	27500	26300	23600	68500	117000	133000	144000
2017	151000	133000	126000	84500	1930	434	3980	1680	3860	149000	162000	129000
2018	64900	132000	178000	28500	2760	256	2650	738	NA	NA	NA	272000
2019	222000	132000	139000	189000	137000	13900	17800	18600	37200	277000	316000	419000
2020	250000	210000	183000	138000	6410	2170	NA	NA	NA	NA	NA	NA

In summary:

- The seasonal pattern is consistent with irrigation.
- The pattern of taking indicates that water is also being taken for stock drinking water.
- The maximum volume taken in any day is 17,700 m^3
- The maximum volume taken in any month is 419,000 m^3.
- The maximum taken in any irrigation year is 1,875,180 m^3
- The applicant has applied for 120 l/s with a ±10% accuracy.
- The lowest rate at which water can be taken and still be in the range 120 l/s ±10% is 108 l/s.
- Historic data indicates that actual average maximum water use for the period 1 July 2012 to 30 June 2017 is 83.9 l/s.
- The highest rate at which water can be taken and still be in the range 83.9 l/s ±10% is 92.3 l/s.
- These ranges do not overlap and are therefore they cannot be considered 'The Same'.