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Memorandum

TO: Selwyn District Council
Attention: Murray England

FROM: Andrew Brough

DATE: 24 June 2010

RE: Rainfall Analysis

Pattle Delamore Partners Ltd (PDP) has been engaged by Selwyn District Council (SDC) to undertake an analysis of rainfall data at two locations and provide information regarding the frequency at which rainfall intensities have been exceeded. This analysis has been carried out to establish an appropriate rainfall intensity to use when calculating the size of flow based stormwater treatment devices. SDC requested that we analyse the rainfall data assuming sites at Rolleston and Darfield.

Methodology

The separation between two storms in the rainfall data sets was defined as the period where there is no rainfall for greater than three hours. Therefore, rainfall events that were separated by a period of no rainfall for three hours or less were considered to be of the same storm event.

The peak rainfall intensity relates to the peak rainfall intensity observed in a storm event, there is one peak rainfall intensity for each storm event. Similarly, the average rainfall intensity is representative of the average rainfall intensity over the duration of the storm event. All average and peak rainfall intensities for each storm event in the monitoring period was found using MATLAB code.

Rainfall for Rolleston and Darfield was obtained by scaling rainfall data from the Christchurch Aero and Ridgens Road sites respectively. Scaling factors were obtained from Opus 2010, “Design Rainfall Scale Factors”. Christchurch Aero was multiplied by a factor of 1.03 to obtain rainfall representative of Rolleston rainfall and Ridgens Road rainfall was multiplied by a factor of 1.20 to obtain a representative rainfall for Darfield.

Rainfall for Darfield was in 15 minute events, it was noted that from November 2005, 95% of all rainfall data is present. However, prior to this date (May 1990 to November 2005) less than 5% is present. Prior to November 2005, 40% of data entries contain a rainfall depth greater than 0 mm, after November 2005 3% of data entries contain a rainfall depth greater than 0 mm. Therefore it was assumed that the majority of the data missing prior to November 2005 did not contain rainfall data. The rainfall data for Darfield was given in whole mm for each 15 minute event which suggests the use of a tipping bucket with 1 mm increments. Therefore, the 15 minute data is considered unreliable as it could be an aggregate of more than 15 minutes rainfall which forces the bucket to tip. By aggregating four 15 minute intervals together the potential error is reduced (although not eliminated).

It is worth noting that rainfall data for Darfield was measured to the nearest mm.

Results and Discussion

Figures 1 and 2 present plots of the percentage of times rainfall intensity is below the given intensity for both the average and the peak rainfall intensity respectively. It can be seen that the Darfield rainfall intensities are greater than Rolleston. There is also a noticeable difference in the smoothness of the two lines. This is because the Darfield rainfall data is measured in one mm increments.

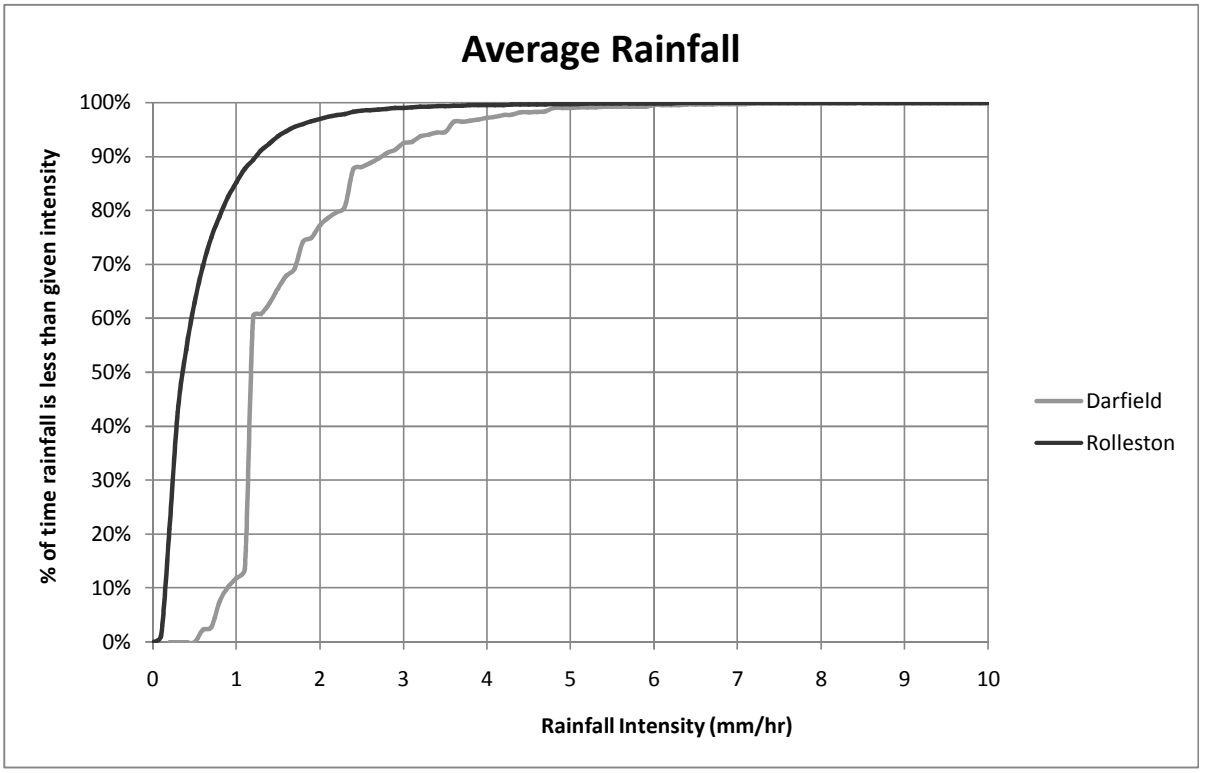

Figure 1: Average Rainfall Intensities of Storm Events

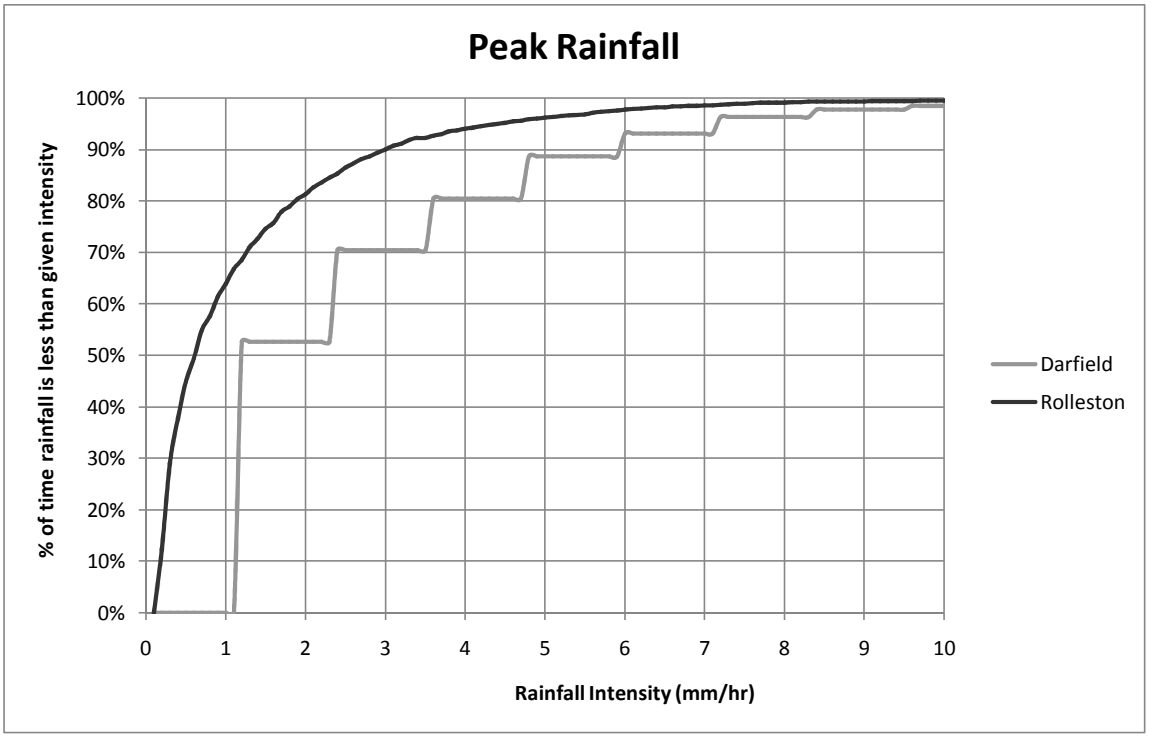

Figure 2: Peak Rainfall Intensities of Storm Events

Table 1 (tabulated data of Figures 1 and 2) presents the percentage of rainfall intensities that are less than the given rainfall intensity in the far left column. It can be seen that 99.7% of all storms at Rolleston over the monitoring period have an average intensity of less than 5 mm/hr, whilst 96.2 % of storms have a peak intensity that is less than 5 mm/hr. For Darfield, 99.0% of storms have an average intensity that is less than 5 mm/hr and 88.6% of storms have a peak intensity that is below 5 mm/hr.

Table 1: Percentage of Rainfall Intensities

	Percentage of events that do not exceed rainfall intensity			
	Rolleston		Darfield	
Rainfall Intensity (mm/hr)	Average	Peak	Average	Peak
0.50	62.9%	44.8%	0.0%	0.0%
1.00	85.2%	63.9%	11.9%	0.0%
1.10	87.7%	66.8%	13.6%	0.0%
1.20	89.3%	68.6%	60.4%	52.7%
1.30	91.1%	71.0%	60.8%	52.7%
1.50	93.7%	74.5%	65.5%	52.7%
2.00	96.9%	81.3%	77.1%	52.7%
2.50	98.5%	86.5%	88.0%	70.5%
3.00	99.0%	90.0%	92.4%	70.5%
3.50	99.3%	92.2%	94.6%	70.5%
4.00	99.5%	94.0%	97.2%	80.4%
5.00	99.7%	96.2%	99.0%	88.6%
10.0	100.0%	99.5%	99.9%	98.5%
20.0	100.0%	99.9%	100.0%	99.8%
30.0	100.0%	100.0%	100.0%	100.0%

The analysis above used hourly data, however some catchments will have a time of concentration that is sub-hourly. Therefore, a comparison of a sub-hourly rainfall data set (namely the 15 minute rainfall recorder at Christchurch Airport), with the correction factor described above, was made with the hourly Rolleston data set. Due to the large amount of data associated with a 15 minute rainfall data set, two 5 year periods of rainfall were examined, a wet period (1974 – 1979) and a dry period (2004 – 2009). The results for the peak rainfall analysis are shown in Figure 3 (1974 - 1979) and Figure 4 (2004 – 2009). The 15 minute data set was converted to mm/hr intensities by multiplying the rainfall depth by a factor of 4.

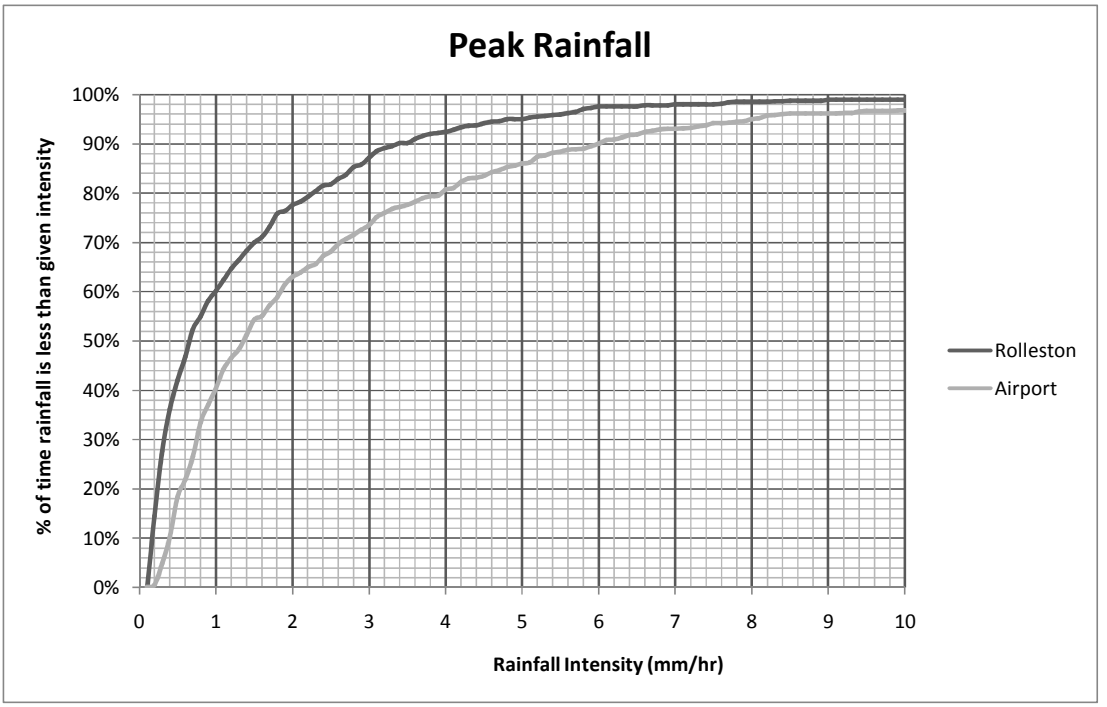

Figure 3: Peak Rainfall Intensity of Storm Events, Comparison for Years 1974 to 1979

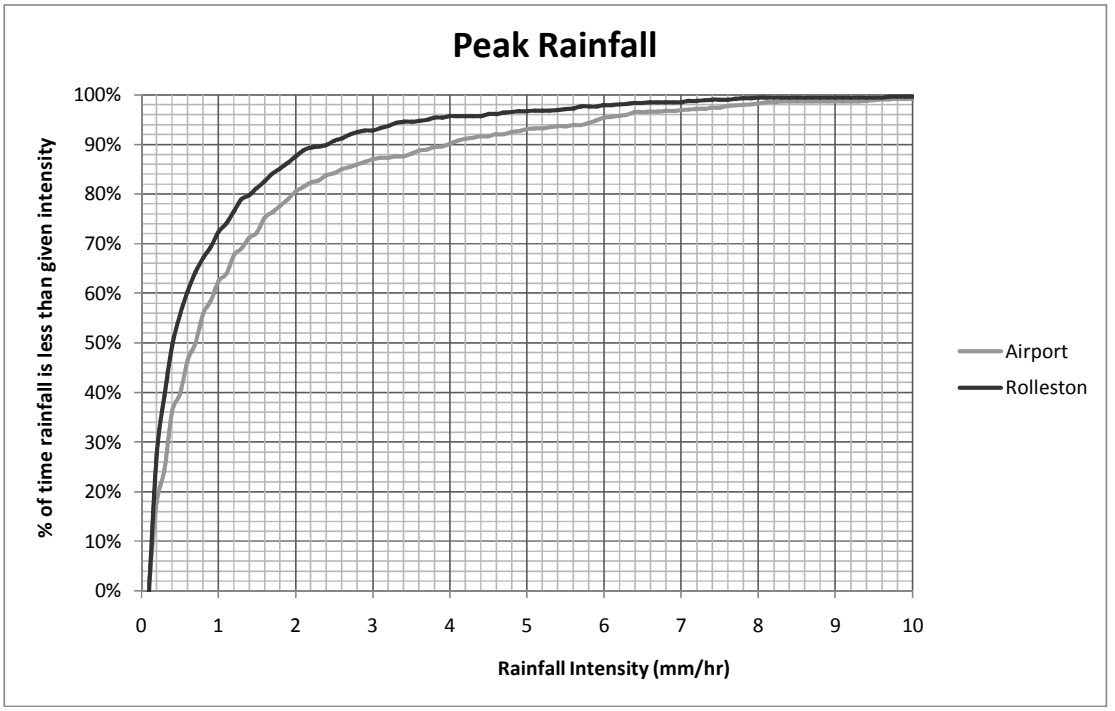

Figure 4: Peak Rainfall Intensity of Storm Events, Comparison for Years 2004 to 2009

Figures 3 shows that to treat 95% of all peak rainfall events, an intensity of 8 mm/hr should be used to size flow based treatment devices, Figure 4 shows that an intensity of 6 mm/hr should be used to treat the peak rainfall in 95% of all events. Both figures show that the 15 minute data gives higher rainfall intensities than compared with using the hourly data set. Table 2 shows the tabulated data of Figures 3 and 4.

Table 2: Percentage of Rainfall Intensities for Rolleston and the Airport

	Percentage of Events that do not Exceed Rainfall Intensity			
	Rolleston		Airport	
Rainfall Intensity (mm/hr)	Peak 04-09	Peak 75-79	Peak 04-09	Peak 75-79
0.50	55.7%	42.0%	39.7%	18.4%
1.00	72.4%	60.1%	62.5%	40.4%
1.10	74.1%	62.4%	64.0%	44.3%
1.20	76.6%	64.7%	67.7%	46.6%
1.30	78.9%	66.4%	69.0%	48.4%
1.50	81.2%	69.9%	72.2%	54.3%
2.00	87.5%	77.6%	80.4%	63.1%
2.50	90.7%	81.8%	84.2%	68.1%
3.00	92.8%	87.2%	87.0%	73.5%
3.50	94.6%	90.2%	88.1%	77.6%
4.0	95.7%	92.5%	90.1%	80.7%
5.0	96.7%	95.0%	93.1%	86.0%
8.0	99.45	98.5%	98.2%	95.0%
10.0	99.6%	98.9%	99.2%	96.8%
20.0	100.0%	99.7%	100.0%	99.1%
30.0	100.0%	100.0%	100.0%	99.2%

Conclusion

Whilst Figure 2 shows that a rainfall intensity peak of 4.5 mm/hr is the 95th percentile, it is important to recognise that this data comes from an hourly data set and therefore, stormwater devices designed in a catchment with a time of concentration that is less than an hour, will be required to treat a higher rainfall intensity if they are to provide the same level of service. For a 15 minute time of concentration, to provide treatment for 95% of all peak rainfall events, it is considered that a minimum rainfall intensity of 8 mm/hr should used to size flow based treatment devices.