Rainfall Statistics for On-site Wastewater Management

DRAFT

Comparison of annual mean and decile data to
the summation of monthly means and deciles

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1. Introduction

Monthly water balance models are in wide use in the design of on-site wastewater management systems. Both the Environment and Health Protection Guidelines (DLG, 1998) for domestic on-site systems and the Draft EPA (1995) guidelines for agricultural use suggest the use of 50th percentile (median) rainfall figures in monthly modelling. The source of the research that supports this statistic is not reported in either document.

This review examines data from a range of rainfall stations across New South Wales and compares selected statistics to the normal statistics that are easily available from published documents and Climatic Averages (B. Meteorology's web site). That data are readily available to consultants and regulators is of more use to modelling than specific data that needs to be sourced from the Bureau. The Bureau's website provides free access to common statistical values for climate generally, rainfall specifically and in some case evaporation. This paper examines only the rainfall data for 13 NSW official recording stations.

These stations include:

Armidale (56002)	Bega (69002)	Byron Bay (58009)
Canberra (70282)	Cessnock (61242)	Coffs Harbour (59040)
Grafton (58130)	Hillston (75032)	Narrabri (53030)
Oberon (63063)	Parkes (65026)	Port Macquarie (60026)
Wagga Wagga (74114)		

Decile rainfall data were sourced directly from Bureau of Meteorology in the form of monthly values and summary analysis.

2. Statistical comparison

The comparisons were made as percentage changes between values as set out below:

Column 2	the sum of the monthly 50th percentile to the mean of the annual values.
Column 3	the sum of the monthly 50th percentile to the 50th percentile ranked on an annual basis.
Column 4	the sum of the monthly 60th percentile to the mean of the annual values
Column 5	the sum of the monthly 70th percentile to the mean of the annual values
Column 6	the sum of the monthly 70th percentile to the 70th percentile ranked on an annual basis
Column 7	the sum of the monthly 90th percentile to the mean of the annual values
Column 8	the sum of the monthly 90th percentile to the highest annual rainfall recorded.

Where the percentage change is:

negative	the sum of the monthly values is less than the value to which they are compared, usually the annual values.
positive	the sum of the monthly values exceeds the value to which they are compared, usually the annual values

Table 1. Comparison of sum of monthly values to an annual statistic.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
Monthly data	**Sum 50th**	**Sum 50th**	**Sum 60th**	**Sum 70th**	**Sum 70th**	**Sum 90th**	**Sum 90th**
Annual data	**to A-mean**	**to A-50th**	**to A-mean**	**to A-mean**	**to A-70th**	**to A-mean**	**to A-highest**
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Armidale	-13	-10	104	121	111	188	189
Bega	-37	-32	-18	111	100	236	299
Byron Bay	-15	-12	102	123	102	190	189
Canberra	-12	-8	101	123	109	193	186
Cessnock	-23	-23	-5	118	101	208	226
Coffs Harbour	-21	-16	-3	123	111	203	207
Grafton	-23	-23	-8	114	104	190	269
Hillston	-26	-24	-3	125	109	221	246
Narrabri	-20	-20	0	126	111	218	245
Oberon	-14	-12	105	129	109	186	194
Parkes	-17	-13	-1	126	112	205	188
Port Macquarie	-18	-13	-1	123	112	199	266
Waggawagga	-17	-16	-1	122	110	198	203

Prefix A refers to annual data

3 Discussion

The comparison of the summation of the rainfall ranked for each month, called the sum of the monthly values, with the values for the ranked annual rainfall show that for the 50th percentile monthly values, the summed monthly total is mostly less than the 50th percentile for the annual total. It would follow that where 50th percentile rainfall values for each month are used in a water balance, the model progressively underestimates the potential impact of each month's rainfall, cumulative over the whole year. As an example, for Armidale, the use of median monthly rainfall in a model is under-estimating the annual rainfall by 10% compared to using the median annual rainfall (Column 3).

The sum of the 50th percentile monthly values also under-estimates the annual effect on a model run using mean annual rainfall by 13% (Column 2).

Some Councils attempt to account for higher rainfall periods by imposing the use of 90th percentile monthly rainfall on the modelling exercise. It can be seen from Column 8 that the summation of the monthly 90th percentile rainfall is, in the case of all the stations selected, more than 186% greater than the highest annual rainfall ever recorded and up to 299% for Bega. Such a selection is nonsense.

The choice of an accurate assessment of monthly rainfall values on which to model the wastewater balance is not without difficulty, irrespective of which statistic is chosen. Rainfall is a truly random and independent event, such that next month or next year may be unlike any other year, although with a reasonable probability of falling between the lowest and highest recorded to date. Even daily rainfall does not ensure that future rainfall events will mimic historic rainfall although probability analysis can provide some indication of likely rainfall, as used in weather forecasting.

The choice of the most appropriate monthly rainfall values will influence the predictability of the model to account for future rainfall and its monthly sequences. As a model tests the sensitivity of the model parameters to changes, the modeller may use several monthly statistics to examine the influence on the water balance. This approach is time consuming and may not provide any greater probability of success.

The accessibility to rainfall statistics needs to be considered in any data selection process. While 6-min, hourly, and daily rainfall data are available from the Bureau of Meteorology, the skill of modelling with such detail is often beyond the resources available for on-site planning. Models based upon median monthly data are accepted by EPA (1995) and DLG (1998) and adequate for on-site wastewater management. The choice therefore is which particular monthly statistic is appropriate.

It is clear from Table 1 that the sum of the median monthly values always underestimates the median annual value, therefore its choice is flawed. The sum of the 90th percentile monthly values significantly overestimates the highest rainfall events recorded to date. This statistic is most inappropriate and reflects a poor understanding of rainfall.

The data in Table 1 show that the sum of the monthly 60th percentile approximates the mean annual rainfall. The sum of the monthly 70th percentile is about 120% of the mean rainfall and could provide sufficient safety factor in a water balance model.

However, as the mean monthly rainfall statistic is more often tabulated by the Bureau of Meteorology in their website "Climatic Averages", it is recommended that the monthly mean values be used for modelling. The 90th percentile has been shown to be absurd compared with probable annual rainfall totals.

As the second step in any modelling process is validation of the model, the used of the various statistics needs to be used and the results compared. This step will be performed in a later paper.

4 Conclusion

The availability of rainfall statistics plays an important role in the selection of an appropriate monthly rainfall value for the water balance model. While two sets of guidelines suggest the median monthly rainfall data, this data set under-estimates the annual rainfall by around 20% for the 13 stations selected.

While some authorities have chosen the monthly 90th percentile values in an effort to account for periods of above average rainfall, this statistic over-estimates rainfall on an annual basis of 200-300%. The use of such a statistic is absurd for on-site wastewater management as it creates unnecessarily large areas, and a significant unwarranted expense.

The ready availability of mean monthly data from the Bureau's website is a consideration that must be carefully weighed. It has been shown that the summation of the monthly 60th percentile approximates the mean annual rainfall. While the sum of the monthly 70th percentile over-estimates the 70th percentile annual rainfall by about 10% in most cases, its use could provide a reasonable degree of security. However, this statistic is not published widely and needs to be sought from the Bureau.

It is recommended that the mean monthly rainfall values are used to model a water balance for on-site wastewater designs. The data are readily available from the Bureau's website and provide for a similar annual rainfall result to using the monthly 60th percentile.

References:

Bureau of Meteorology website http://www.bom.gov.au/

DLG (1998) *Environment and Health Protection Guidelines On-site Sewage Management for Single Households*. Depart. Local Gov't., NSW Environ. Protection Authority, NSW Health, Land & Water Conservation, and Depart.Urban Affairs & Planning Sydney.

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