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A Verification of the Hydrological Impact of 50 Years of Development in an Urban Catchment

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Abstract: The drain 18 catchment is a 182 Ha catchment and is one of many urban catchments that had underground drainage installed for the first time as part of the South West Suburbs Drainage Scheme, in the 1960s and 1970s. It is located in the Adelaide metropolitan area, near the seaside suburb of Glenelg. Design was conducted using the rational method, and information is available on the design rainfalls, runoff coefficients and design flows at that time. The 47 ha Frederick Street catchment, representing an upper portion of the drain 18 catchment, was instrumented with rainfall and flow gauging in the 1990s and again in the 2010s, which enabled the calibration of an ILSAX model to both sets of data. The directly connected impervious area (DCI) is the most significant parameter in the model and has demonstrably changed over time due to infill development that has occurred in the catchment. This paper will summarise the changes that have occurred in the catchment due to infill development since the 1960s when the drainage system was designed, with an estimated doubling in DCI, resulting in a significant reduction in the drainage standard.

Keywords: *Urban hydrology, infill development, monitoring*

1. INTRODUCTION

The 47 Ha Frederick Street catchment is fully urbanised, with most initial development occurring in the 1940s and 1950s. The nature of development is almost completely residential with small areas of commercial land use. The underlying soils of the catchment are sandy to silty clays containing some lime. The catchment is relatively flat, with average gutter slopes from 0.2% to 0.5%. The contributing areas of the catchment were first determined in 1993 from digitised aerial photography, with site verification by students of the University of South Australia. More recently GIS have been used to determine contributing impervious areas. The catchment is monitored by two pluviometers and a gauging station within a pipe. There has been significant infill development in the catchment, and this study seeks to quantify the effect of that development.

2. METHODOLOGY

Table 1 summarises the contributing impervious contributions over time. The connected imprevious area was determined by modelling for 1993 and 2013, and estimated for 2023, based on the earlier values.

Table 1 – Summary of catchment properties for the Frederick Street catchment Figures in bold estimated based on 30% roof connected

Case	Description	Impervious Area (ha)	impervious area (%)	connected impervious area (%)	indirectly connected impervious area (%)
1969	Base case – for design of pipe system	17.7	37.6	17.0	20.6
1993	1993 development (calibration case)	24.8	52.8	28.1	24.7
2013	1993 + observed new development	28.7	61.0	32.7	28.3
2023	1993 + observed new development	31.1	69.2	**35.4**	**33.8**

The connected impervious area can be verified by examining the double mass curves of raifall and flow volumes over time. A straight line relationship should be found, with the slope being the volumetric runoff coefficent, which should be close to the percentage on connected impervious area.

3. RESULTS

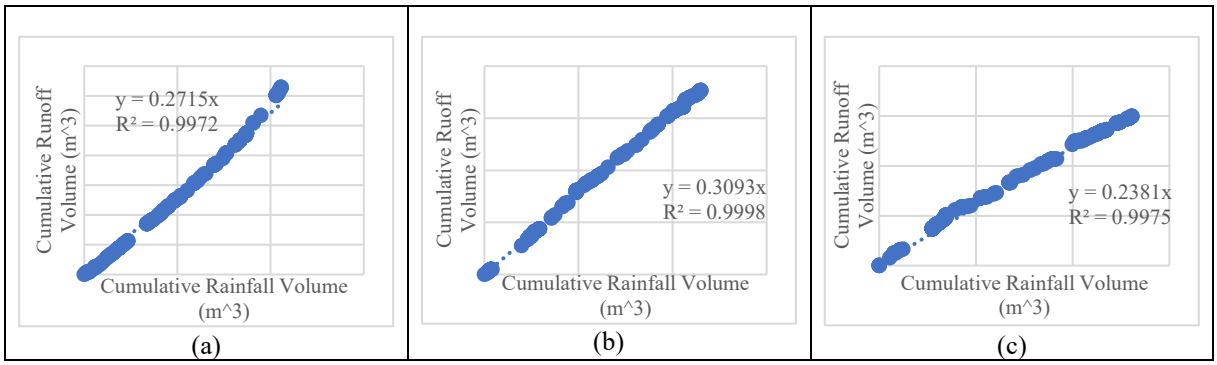

Figure 1 observed cumulative rainfall and runoff volume relationships for (1) 1993, (2), 2013 and (3) 2024

Figure 1 shows the double mass curves of rainfall and runoff. The slope of the trendline gives the volumetric runoff coefficient, and is similar to the directly connected percentage. This shows that over time with the infill development there will be an increased in the volume of runoff from the catchment, in direct relationship to the increase in connected impervious area. The 2024 double mass cuve is not consistent with previous years, or with the estimated percentage of connecetd imprevious area. The reason for this is currently being investigated.

4. DISCUSSION

The changes in catchment response due to infill development are significant without controls being put in place. In 1993, there were 555 allotments in the catchment area. By 2013, there were 632 allotments, including at least 77 new homes. These additional structures associated paved areas and additions to existing housing stock all have an effect on flood damage.

Previous investigation has shown that the 1960s 1 in 5 year Average Recurrence Interval design standard was in 2018 less than a 1 in 2 year standard (Kemp et al, 2018).

There has been ongoing work inivestigating possible mitigation measures including on-site storage in rainwater tanks, and a pilot scheme was run to subsidise the installation of tanks, but it was not successful (Zenghao, 2024). Greater uptake of rainwater tank installation or retrofitting was hindered by factors such as allotment size limitations, competing family budget priorities, a substantial proportion of rental properties and, potentially, the lack of community focus on water savings at the time of the trial given that it was not conducted during a drought or a period of intensive water restrictions.

Although the rainwater tank incentive scheme was not a success, the Councils have implemented an alternative approach to retain stormwater within the catchment. A total of 95 kerb inlet and infiltration systems have been installed along the verges in the City of Marion and Holdfast Bay, within the Frederick Street catchment. These installations are expected to reduce the annual stormwater volume by approximately 10%. Monitoring of rainfall and pipe flow will continue in the catchment to assess the efficacy of the inlets.

5. CONCLUSION

The ongoing study of the Frederick Street catchment since 1993 has proved invaluable in demonstratiing the impact of urban infill development in a catchment. Measures to ameliorate the impact are currently being developed.

6. REFERENCES

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