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FLOOD STORAGE OFFSET BY STORMWATER INFILTRATION INTO IMPORTED SAND FILL

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Abstract

This Paper explains the physical basis for the use of the "continuing loss" concept applied to rainfall in stormwater modelling for catchments with soils sufficiently permeable to allow infiltration to occur. After explaining the policy background established by the State Government and presenting an alternative interpretation of what this should be, the Paper then develops the concept of "initial loss" in a catchment defined as the depression storage (above or below ground) together with vegetation interception loss.

Whereas in impermeable catchments, such as bitumen, clay or solid rock surfaces, the concept of continuing loss is invalid, in catchments with permeable soils there will naturally be an ongoing rainfall loss to stormwater (and a corresponding gain to groundwater) by infiltration.

Although invisible to the eye and difficult to comprehend by those accustomed to impermeable catchments, the concept of stormwater infiltration (represented by a continuing loss rate in modelling) is paramount to proper WSUD and water management generally.

Introduction

In WA the Department of Water and Environmental Regulation (DWER) has legislative responsibility for water resources management and provides advice to local government in the area of land use change proposals through a process known as Better Urban Water Management [1].

DWER has published a Stormwater Management Manual which includes a Decision Process for Stormwater Management in Western Australia which has gone through 3 editions, namely 2005, 2009 and the current edition November 2017 [2], which divides rainfall events into 3 categories:

- Small (<15mm) Chapter 4.1
- Minor (previously 1 to 5 or 10yr ARI, now to be specified by infrastructure provider, usually local government) Chapter 4.2
- Major (1% AEP) Chapter 4.3

Page 6 [2] contains the direction:

"Design for the small, then minor, then major rainfall events and aim to replicate how water moves in the natural landscape."

It is this author's view that the direction above is quite inappropriate for most catchments subject to land use change on the Swan Coastal Plain (to which the publication is mostly directed) where the processes of runoff generation are so different between pre-development and post-development, largely as a result of the importation of between 1 and 2 m of highly permeable sand fill material to effectively "fill a swamp".

It follows that the corresponding notion of "mimicking natural processes" [2] (pages 6 to 11) is also considered inappropriate by this author.

In particular the statement [2] (page 6):

"Scientific and case study investigations find that when stormwater management systems mimic natural hydrological processes, the best economic, social and ecological outcomes are achieved."

The author considers this unsupported statement to be inappropriate in the areas of WA to which guideline [2] is intended to apply.

The Paper argues that the fundamentally flawed approach to water resources management in major storm events presented in [2] has resulted in a

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reluctance of the authorities to accept infiltration of stormwater into the imported sand fill as a viable, indeed unavoidable, consequence of land use change.

With respect to major rainfall events [2] states:

- "Maintain the 1% AEP pre-development flood regime (flood level, peak flow rates and storage volumes) for catchments that do not have a published catchment plan. Alteration to the pre-development flood regime dependents (sic) on the constraints of the catchment and the receiving environment. Any proposed alterations to the flood regime will require assessment and/or modelling of the capacity of the entire system and the cumulative impacts from the change, to the satisfaction of DWER and other relevant agencies.
- Safely convey the critical 1% event flow through natural water bodies and constructed stormwater conveyance systems (e.g. providing overland flow from lots to road reserves; overland flow along roads and road reserves; public open space detention and conveyance systems; and living streams)."

The above dot points do not allow for infiltration of stormwater in major rainfall events into the imported sand fill as described earlier in this Paper. Such infiltration is termed in WA retention of stormwater, as opposed to detention where water is temporarily stored but later released.

In direct contrast to the above policy statements the vast majority of land use change on the Swan Coastal Plain has in fact occurred through the very process of infiltration of both small, minor and major rainfall events into sandy soils.

In summary the Report [2] proposes infiltration for small rainfall events but not for minor or major events. In reality the infiltration process does not recognize these artificial distinctions between small, minor and major storm events but rather occurs as a continuum depending on the physical processes of the soil water environment.

The argument is distilled in this Paper to the view that [2] denies that flood storage can be offset by stormwater infiltration into natural or imported sandy soils.

Author's Experience

Tables 1 to 4 below present the author's experience with flood storage offset of stormwater infiltration into natural or imported sand fill over a range of geographical settings since 1995.

The lack of peer reviewed journal articles on infiltration of major rainfall events into imported sand fill on the Swan Coastal Plain of Western Australia is due to the historic acceptance of infiltration as a legitimate process of stormwater management by DWER and predecessor Department of Water until recent months when an apparent change of attitude and direction has been perceived by the author at officer level although it has not yet been built into any substantive policy directive by DWER.

Table 1. Selected JDA Reports to WA Local Government on Major Storm Runoff Infiltration

Year	Client	Report Title
2017	City of Nedlands for WESROC	Enhanced Stormwater Infiltration Project Plan
2016	City of Nedlands	Nedlands Drainage Catchment NE 37 Review
2010	City of Wanneroo	Wangara Industrial Estate - Stormwater Catchment Study
2009	City of Stirling	ECU Churchlands Infiltration Basin Analysis
2007	City of Stirling	Sump Undergrounding Suitability Study
2007	City of Stirling	Millet Selina Community Park - Undergrounding of Compensating Basin
2004	City of Wanneroo	Savona Grove Overflow Drainage Sump Investigation
2004	City of Fremantle	Annie St & O'Hara St Sumps, Beaconsfield - Infiltration Modelling
2004	City of Fremantle	City of Fremantle Sump Infiltration Testing
2002	City of Wanneroo	Review of City of Wanneroo Design Guidelines for Infiltration Basins (Drainage Sumps)
2002	City of Subiaco for WESROC	Regional Strategy for Management of Stormwater Quality
2001	City of Wanneroo	Quinns Rocks Stormwater Drainage Catchment Study
1995	City of Melville	McGregor Road Sump Redesign

Note: The local authorities listed are primarily in areas with suitable natural soils for infiltrations. In local authorities with unsuitable natural soils, JDA reports are generally produced for land developers.

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Table 2. JDA Staff Publications on Major Storm Runoff Infiltration

Year	Reference
2016	DAVIES, J.R., ROGERS, A.R., BARNETT, J.C. (2016) How Many Holes Does One Soakwell Need? Institute of Public Works Engineering Australasia (IPWEA) State Conference Perth, March 2016
2014	SERAFINI, G., DAVIES, J.R., ROGERS, A.R. (2014) Perched Water Table Mounding Between Subsoil Drains in Sand Fill for Urban Development. Engineers Australia Hydrology and Water Resources Conference Perth, February 2014
2013	DAVIES, J.R. (2013) Review of Paper titled "An Efficient and Sustainable Stormwater Management Approach to Infill Development" presented by Markus Botte, Dumal Kannangara and Amitha Tennakoon at the 2012 IPWEA WA State Conference. Institute of Public Works Engineering Australia (WA) Annual State Conference March 2013
2012	DAVIES, J.R., ROGERS A., SERAFINI, G. (2012) Perched Water Table Mounding Between Subsoil Drains in Sand Fill over Guildford Formation. Institute of Public Works Engineering Australia (WA) Annual State Conference March 2012
2012	ROGERS, A., DAVIES, J.R. (2012) Stormwater Harvesting by Infiltration – Soil and Groundwater Limitations. Institute of Public Works Engineering Australia (WA) Annual State Conference March 2012
2007	DAVIES, J.R. & ROGERS, A. (2007) Infiltration Basins: Application to W.A. Basins of a French Procedure for Infiltration Assessment. Institute of Public Works Engineering Australia (WA) State Conference, Perth, March 2007
2005	MARTENS, S., DAVIES, J.R., O'DONNELL, M. (2005) Monitoring for Total Water Cycle Management: The WESROC Experience. Institute of Public Works Engineering Australia (WA) State Conference, March 2005
1998	DAVIES, J.R., SCHOLZ, J. & PIERCE, D. (1998) Infiltration Opportunities. 3rd SIA Regional Conference on Stormwater Management, Stormwater – Keeping it Clean, Perth, Oct 1998
1997	DAVIES, J.R. & VAN HALL, S. (1997) Design of stormwater infiltration basins with shallow water tables-Comparisons of models – MODRET and PCSUMP. Institution of Engineers Australia, Hydrology and Water Resources Symposium, New Zealand, Nov 1997
1996	DAVIES, J.R., DAVIES, P.K., ROBINSON, J.S. & SIM, D. (1996) Design of infiltration basins, swales and trenches. 13th Annual State Municipal Engineering Conference, Perth Local Government Infrastructure, March 1996 [1]

1. Winner of Best Paper Award

Table 3. JDA Software for Major Storm Event Infiltration

Year	Item
1995	Development of inhouse model for design of infiltration basins with deep water table - INFIL
2000 Onwards	Application of commercially available MODRET model for shallow water table case
1995 Onwards	Review of commercially available PCSUMP software for deep and shallow water table and clogged base cases
2018 Current	JDA developing next version of PCSUMP incorporating: ·ARR 2016 Rainfall IFD and temporal patterns ·Swale Option calibrated to monitored site ·Revised algorithms for both deep and shallow water table cases from INFIL and MODRET models

Table 4. JDA Experiments on Hydraulic Conductivity and Infiltration Rates

Year	Client	Report Title
2017	MRWA	Measurement of Infiltration Rates into Swale, Reid Hwy, City of Swan
2015	Tunnelwell	Measurement of Infiltration Rates into Tunnelwell Infiltration Device at Harrisdale Green, City of Armadale
2016	Cedar Woods Properties Limited	Measurement of Infiltration Rates into Soakwells at Harrisdale Green, City of Armadale
2015	Cedar Woods Properties Limited	Rainfall Runoff Testing at Rivergums, Baldivis, City of Rockingham

The author looks forward to constructive dialogue regarding the efficacy of sub-storage offset by stormwater infiltration into imported sand fill in Western Australia in the context of historically accepted practice.

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References

[1] WAPC. *Better Urban Water Management*, 2008.

[2] DWER. *Decision Process for Stormwater Management in Western Australia*, November 2017

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