Ground Water Infiltration: Use of Alternative Drainage to Reduce Infiltration Volume: A Theoretical Overview

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Definition of flows in a sewer network
Ground water infiltration: Impacts on spatial and temporal scale
Current Australian practices to determine ground water infiltration
How Infoworks CS captures GWI
Research Undertaken in this Area
Sewer networks as a drainage system
What are the alternative drainage?
How alternative drains reduce the ground water infiltration?
Negative effects of alternative drains
Future research
Definition of Flows

- Base Flow (Ground Water Infiltration)
- Strict Waste Water Flow (Foul Sewage)
- Rainfall Derived Inflow (RDI)
- Rainfall Derived Infiltration (RII)
Components of Sewer Flow

- Base flow
- Wastewater flow
- Inflow
- Infiltration
- Ground water infiltration

Graph showing flow variations with time.
Ground Water Infiltration – Pipe Scale

Figure: N J Choi

Soil

Ground Water Level

Rate of flow

Clay

Gravel
Pipe Scale – Hydro Geological View

Natural conditions (predevelopment)
recharge = discharge

Safe yield conditions (post-development)
recharge = pumpage
Ground Water Infiltration – Temporal Scale – Weekly

Rainfall

Discharge [l/s]

0 1 2 3 4 5 6

Time [days]

Base Flow – Ground Water Infiltration

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Ground Water Infiltration – Weekly Scale – Wet Weather
Infoworks CS

- Infoworks CS can model GWI (GIM)
- Are we using correct data (Soil porosity, actual ground water depth, soil saturation, other soil properties)
- Provides good understanding in catchment scale
- Flow generated in catchments are discharge to a node
- Interference between pipe and the catchment is cannot be modelled
- Interference between catchments cannot be modelled
- Infoworks is a Hydraulic Model, not hydro geological model
Permanent Ground water Infiltration Rate Estimation

\[ Q_{dwf} = Q_{\text{Ground Water Infiltration}} + Q_{\text{Wastewater flow}} \]

- Waste Water Flow = percentage of Water Consumption ??
- Can we accurately estimate Base flow?
- Base flow estimation is based on minimum overnight flow
- Error associated with current methodology high as 30% (Reference: Benedittis 2005)
- Short term monitoring during spring – can we see the real impact?
- Verify with water consumption
- Daily per property waste water loading < 500 l/lot/day – we consider no base flow
- Flow base methods and pollutant base methods
- There are many methods available, however not widely adopted, some methods are catchment/country specific
- How to calculate water consumption in daily scale?
New Methods

• APUSS Project - Assessing infiltration and exfiltration on the Performance of Urban Sewer Systems
• Study undertaken in Europe with the collaboration of 10 universities
• To comply with European Standard EN 752-2
• Basic performance criteria
  • Receiving waters should be protected against pollution – Exfiltration, sewer spills
  • Structural integrity of urban water systems including water tightness should be guaranteed
• Stable Isotope Method
• Innovative Tracer Methods for Infiltration Monitoring (Kracht et al (2005))
• Auto regression models (Zhang 2007)
Sewer Mains as Alternative Drains

- Sewer mains are acting as drainages
- Allows to reduce ground water level (Karpf, Gustaffson)
- If the network is water tight the ground water table will elevate
- Alternative Drains allows to lower the ground water table, if properly designed?
Alternative Drain - Concept

Ground Level

Initial Ground Water Level

Trench

Sewer Main

Alternative Drain

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Alternative Drains

• We have alternative drains around us
• Stormwater drains
• Creeks along sewers – as sewer mains follows the natural drainage pattern
• Wetlands/bio retention systems
• Some of the sewer mains are below these drains and may have a negative effect
• Needs proper hydro-geological modelling to understand the impact
• Current WSUD concepts encourage storm water to infiltrate
Negative Impacts of Alternative Drains

Sewer Main and the Trench
Alternative Drainages

- Tested and implemented Halmstad, Sweden (Gustafsson)
- Some concept level usage during construction in Australia (Ballast sumps)
- Collaborative approach is required with stormwater design/WSUD
- Concept on gravity sewer design needs rethinking
- New line of thinking: water tightness of sewers in the design stage, no provision for wet weather flows
- Integrated shallow aquifer/network modelling
- Construction of alternative drains in build up areas? Is it effective?
- Improving natural drainage is possible, with collaborative approach, (Increase the depth of creek beds, interceptor drains parallel to the sewer)
- Further research on the alternative drain concept for build up areas
- Backfilling and bedding techniques - needs to be revisited
Current Research Work – University of Ballarat

- Improving the accuracy of Ground Water Infiltration (GWI) volumes in Sewer Network models
- Test catchment
  - Ballarat Sewer Network, may be too big
  - Beaufort Sewer Network, less complex, simple

- See the impact on Ground water table variation on sewer networks
- Ground water monitoring in sewer catchment and establish a relationship between ground water level and sewer flows
- Method to be established, but possibly an auto regressive error model
Acknowledgments

• Rachael Nuttall - CHW
• Andrew Loader - CHW
• Steve Millard - CHW
• Jeff Hayden - CHW
• Dr. Andrew Barton - UB
• Dr. Peter Dahlhuas - UB
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Thanks and Questions ?