



# The Application of Integrated Water Cycle Management: An Essential Systems Perspective

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enterprise environment education

# Outline

- Motivation
- Case Studies
- Conclusions

# Motivation

- ‘Business as Usual’ approach to managing urban water supply and demand is becoming less acceptable
- Regulators are encouraging alternative source use and measures
- But how to examine and test/predict how the whole-of-system will work (lot scale up)?
  - Water balances
  - Infrastructure design

# Motivation

- Key issues:
- Scales
  - Varying spatial scales (lot, cluster, suburb, region)
  - Varying temporal scales (<1 minute, 6 minute, daily, long term)
- Processes (all inter-related):
  - Rainwater tank dynamics
  - Stormwater generation
  - Groundwater dynamics
  - Rainfall variability
  - Infrastructure delivery of potable and waste water
  - Security of supply...

# Motivation

- How have these been (and how are these being) captured?
- Case studies
  - Yarrabilba: purely water balance
  - Pimpama Coomera: water balance and related small/cluster scale infrastructure design
  - The Groves: water balance and more detailed infrastructure design

# Case Studies - Yarrabilba

- Delfin Lend Lease has submitted a DA for a master planned residential community called Yarrabilba
- 2,000 hectare greenfield site within Beaudesert Shire, South East Queensland
- ~19,000 lots (~23,000 dwellings ~50,000 p)
  - Residential neighbourhoods
  - Town centre
  - Schools
  - Public open space

**LEGEND**

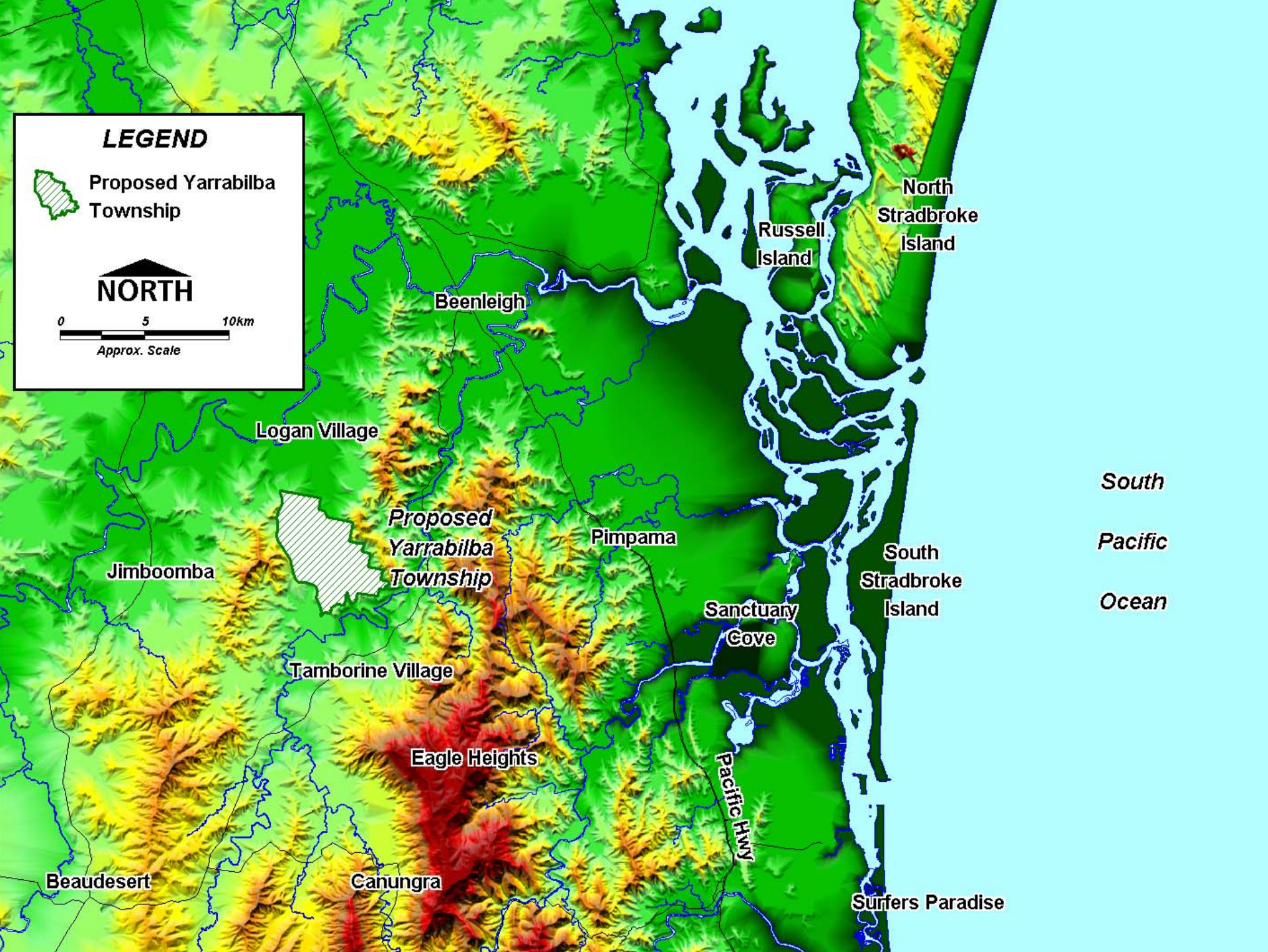


Proposed Yarrabilba  
Township

**NORTH**

0 5 10km

Approx. Scale



Beenleigh

Logan Village

Jimboomba

*Proposed  
Yarrabilba  
Township*

Pimpama

Tamborine Village

Eagle Heights

Beaudesert

Canungra

Sanctuary  
Gove

Pacific Hwy

Surfers Paradise

Russell  
Island

North  
Stradbroke  
Island

South  
Stradbroke  
Island

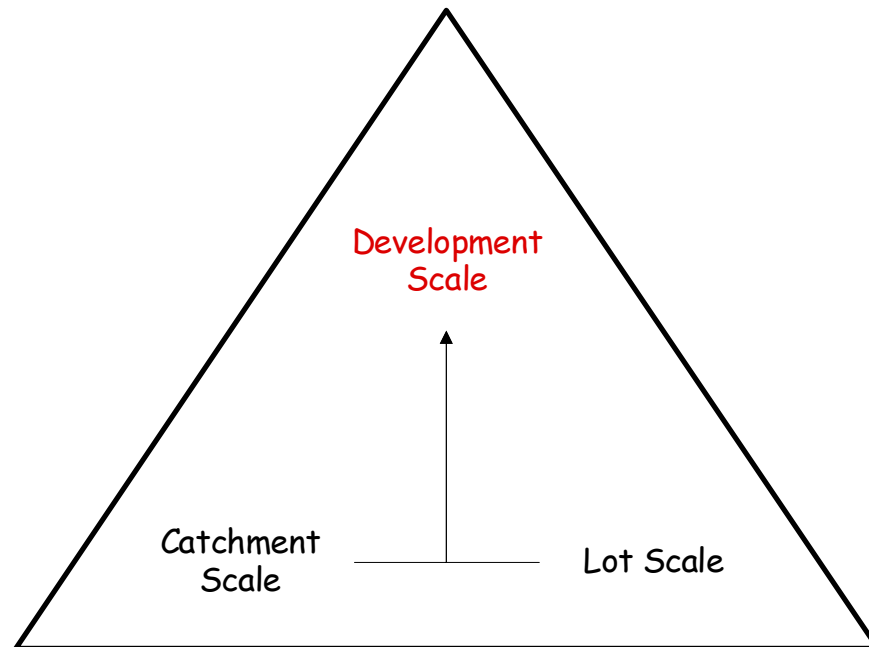
South  
Pacific  
Ocean

# Case Studies - Yarrabilba

- Critical component of the DA feasibility analysis was an assessment of integrated urban water cycle:
  - Likely potable water demands
  - Likely wastewater overflows
- DLL requested an investigation of these with a view to examining opportunities to minimise both

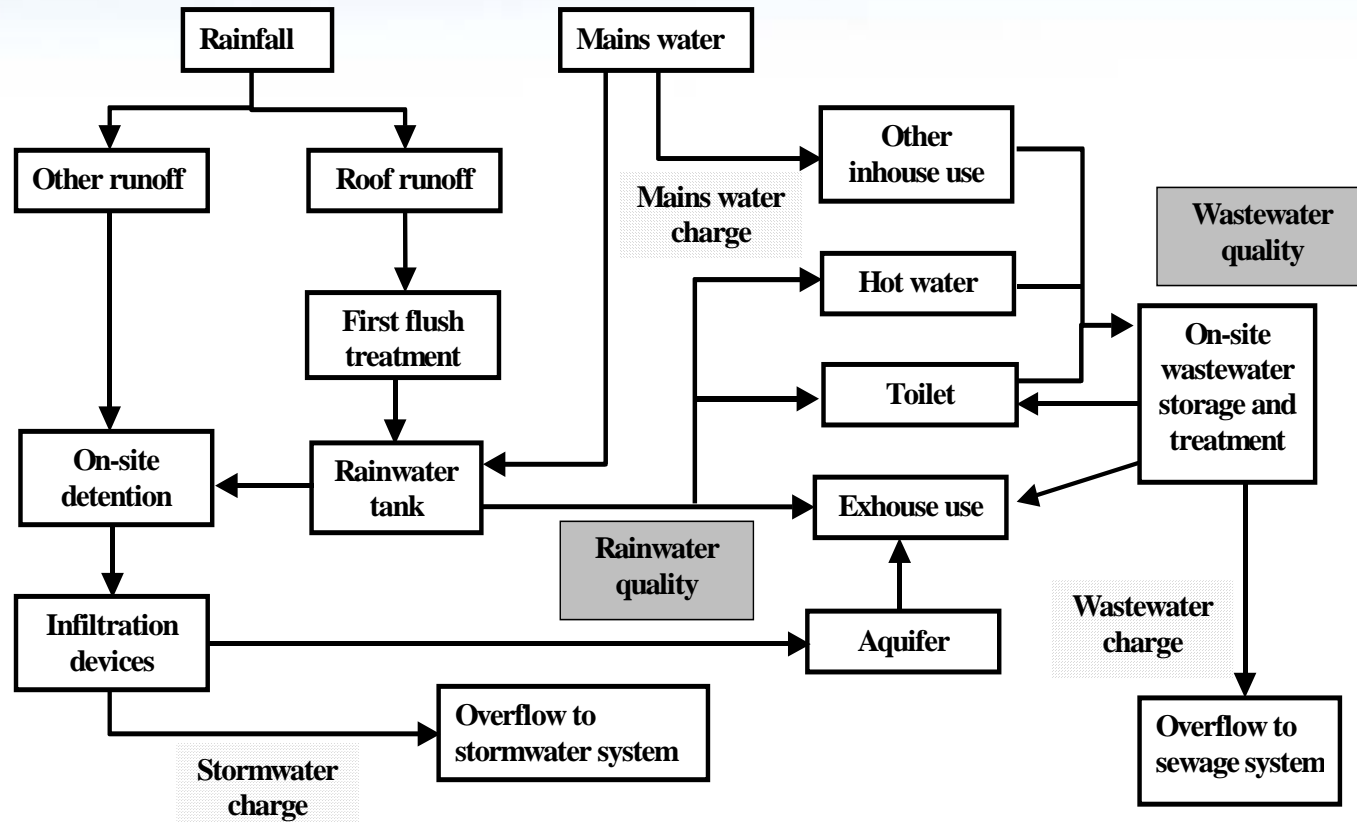
# Case Studies - Yarrabilba

- Integrated three-tier modelling approach:
  - Lot scale (potable water, wastewater)
  - Catchment scale (stormwater)
  - Development scale (all three streams)
- Concept:



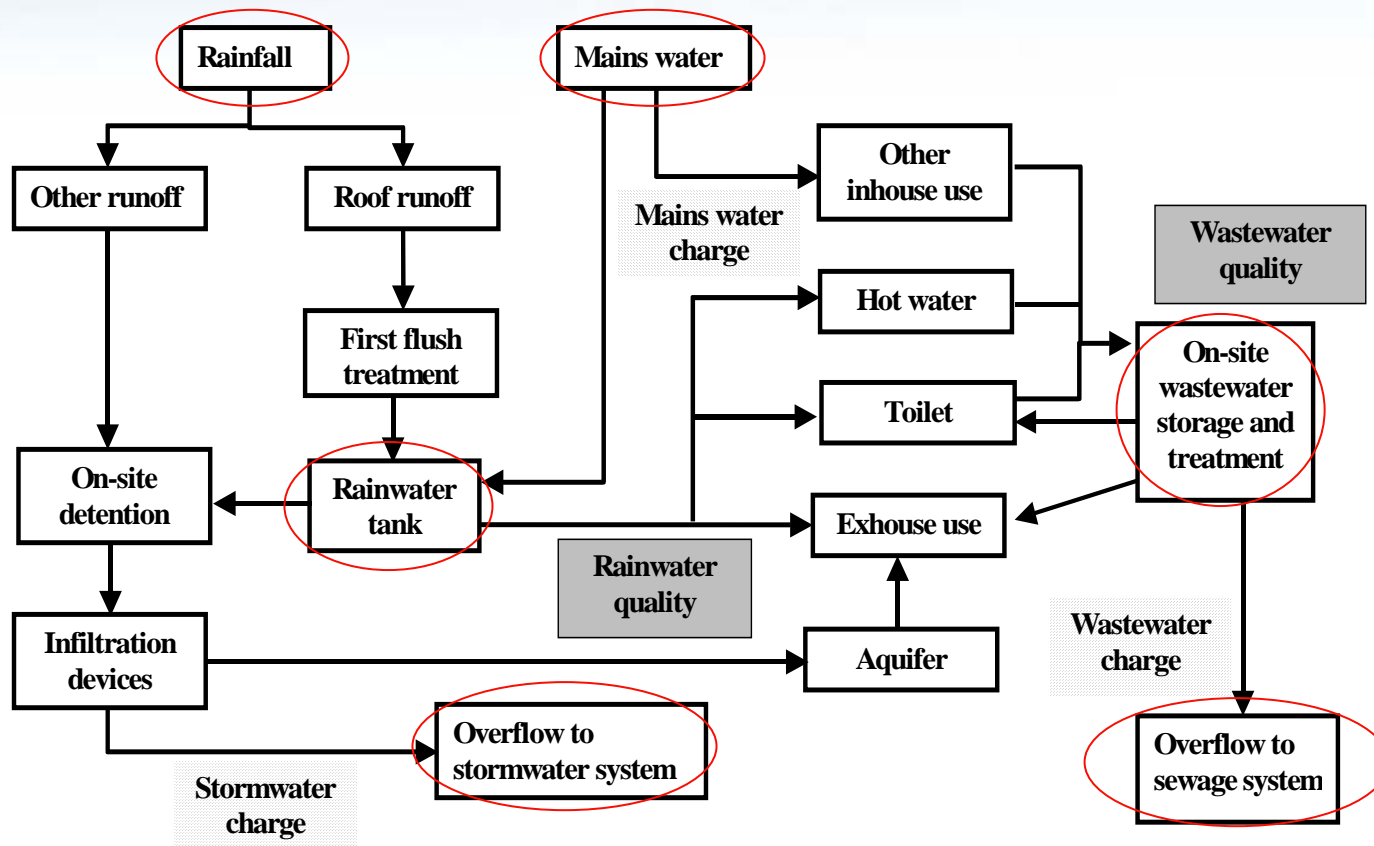
# Case Studies - Yarrabilba

- Lot scale: PURRS



# Case Studies - Yarrabilba

- Lot scale: PURRS

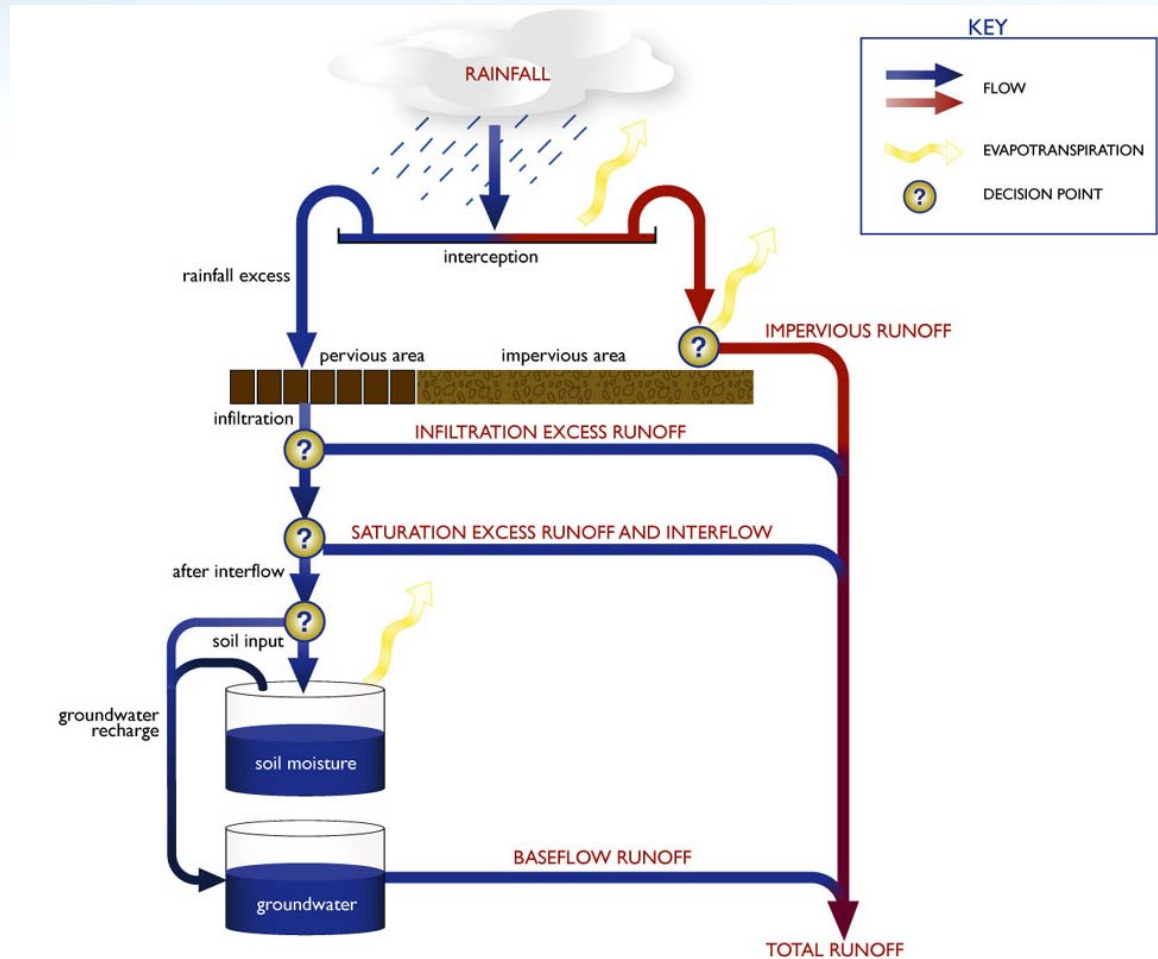


# Case Studies - Yarrabilba

- Lot scale: PURRS
  - Wide range of roof areas, tank sizes
  - Reclaimed water use:
    - Toilet flushing, outdoor use
  - Rainwater tank use:
    - Laundry, bathroom, hot water
  - Potable
    - Kitchen tap, rainwater tank topup

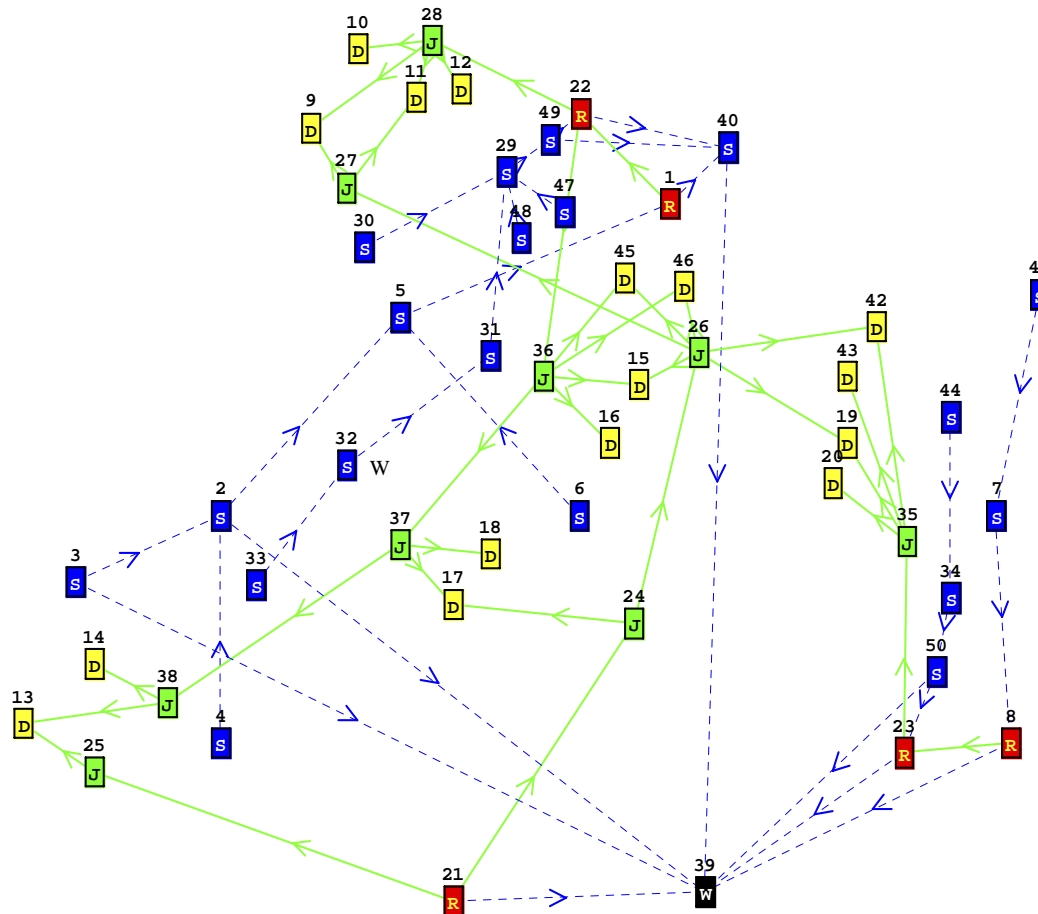
# Case Studies - Yarrabilba

- Catchment scale: SimHyd



# Case Studies - Yarrabilba

- Development scale: WATHNET

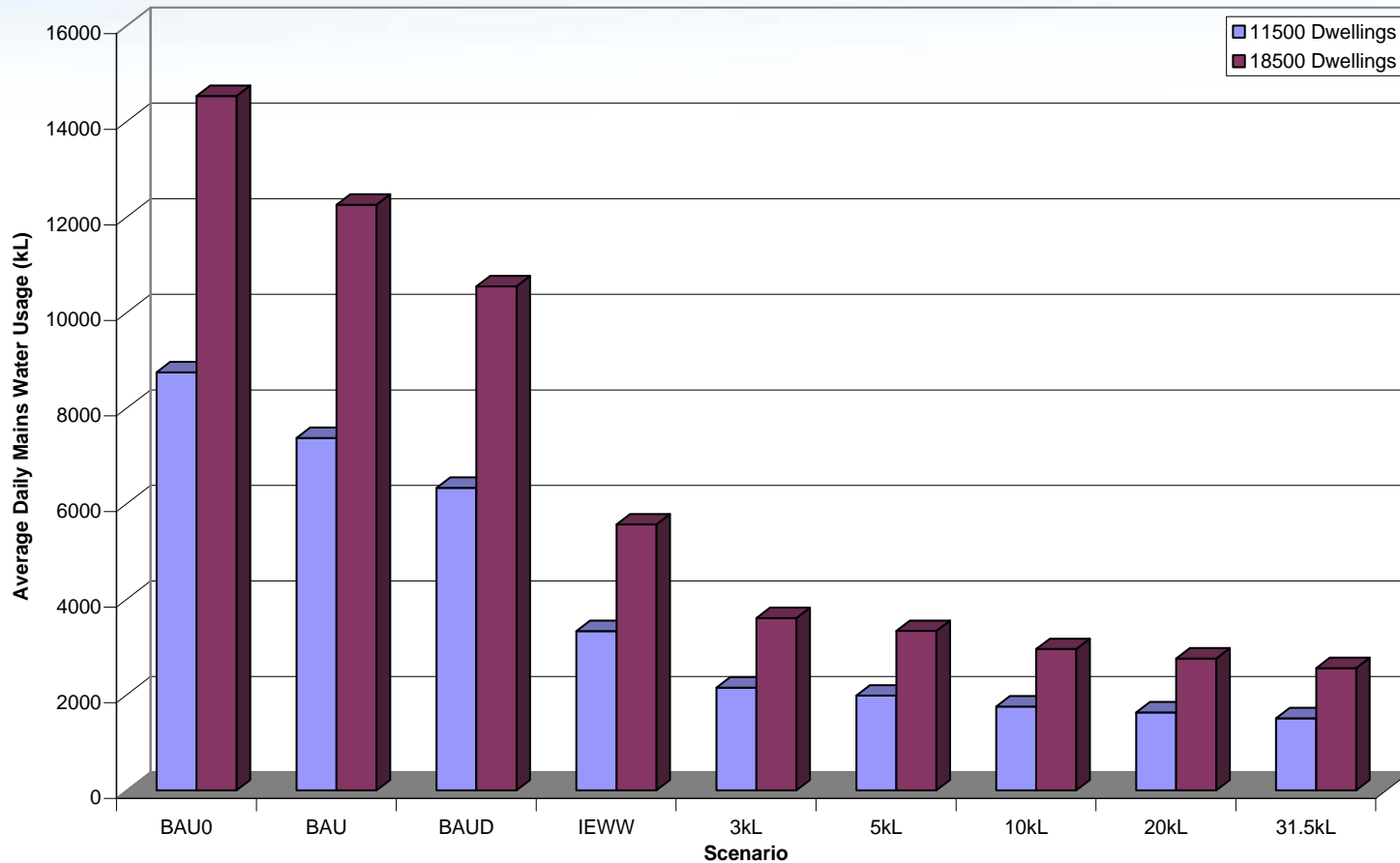


# Case Studies - Yarrabilba

- Development scale: WATHNET
  - Carefully aggregated PURRS modelling in WATHNET model: demand and wastewater nodes
  - Incorporated SimHyd results: stormwater generation nodes
  - Assessed the impacts of a range of water supply, wastewater reuse and stormwater management scenarios on the total system (water balance)
  - Scenario testing

# Case Studies - Yarrabilba

- Development scale: WATHNET



# Case Studies - Yarrabilba

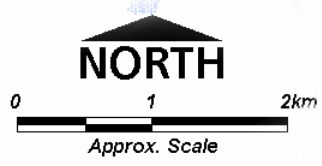
- Integration/systems issues:
  - Critical to capture lot scale demand at short timestep
  - Aggregation of PURRS demands to clusters
    - Used PURRS daily outputs as suite of resource files
    - Non-parametric aggregation (Coombes)
  - Incorporation of three water streams in one model
    - Capture inter-relationships and feedbacks
      - Wastewater
      - Stormwater harvesting
      - Demand
    - Impact on potable water supply security
    - Examine wastewater overflow behaviour

# Case Studies - Yarrabilba

- Integration/systems issues:
  - Replicate analyses
    - 100 replicates of 100 years using different rainfall sequences (same stats)
    - Probabilistic description of processes
      - Potable water security and demand
      - Wastewater overflows
  - Technically challenging study

# Case Studies - PCWF

- Gold Coast City Council was looking to derive the 'optimum' rainwater tank size for different dwelling types in future urban areas of Pimpama Coomera
- Similar to Yarrabilba, but:
  - Started looking towards infrastructure sizing
  - Looked in more detail at stormwater (quality and quantity)
  - Flooding impacts (i.e. ARI events)



# Case Studies - PCWF

- Used a slightly different suite of models:
  - PURRS
  - XP-SWMM
  - MUSIC
  - AS 3500.1 and diversity estimates
  - Pipes + +
  - WATHNET

# Case Studies - PCWF

- Multi-criteria analysis was the goal, with different models/combinations of models to inform MCA
- PURRS: lot based rainwater yield
- PURRS and XP-SWMM: RWT flood mitigation
- MUSIC: Swale performance related to RWTs
- AS 3500.1 : Pipe sizes to supply houses with RWTs (clusters)
- Pipes ++: Local pipe networks (suburb)
- WATHNET: Water security and system wide potable savings issues
- Costing analysis

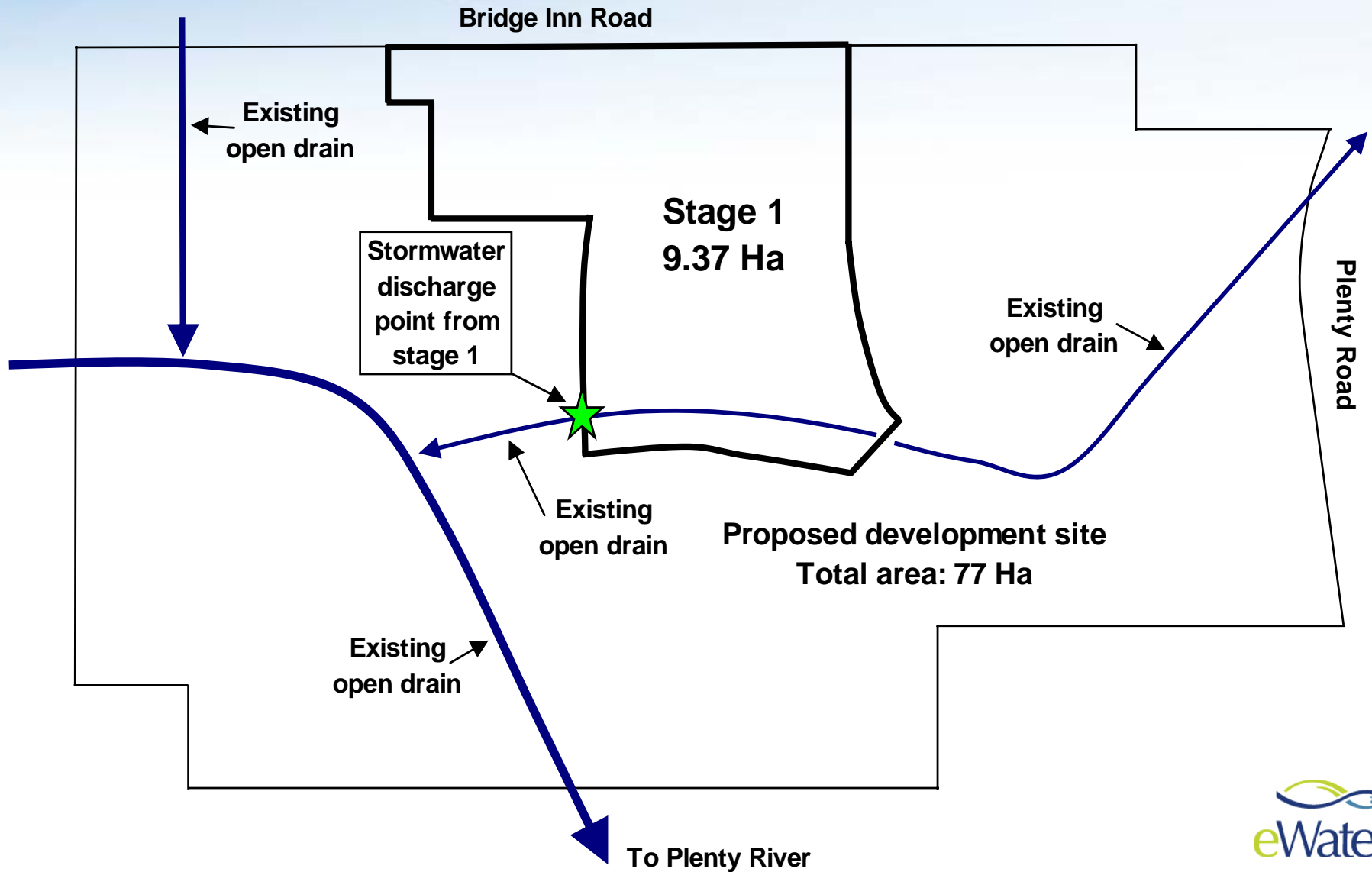
# Case Studies - PCWF

- Integration issues:
  - Integrating PURRS and XP-SWMM was challenging
    - Multiple data handling/re-analysis
    - Multiple people with different skills involved
    - Communication issues
  - MUSIC was quasi-‘standalone’
  - AS 3500.1 assumed diversity factors for houses without RWTs – no data on houses with RWTs
  - Costing was difficult, and quite speculative
- Drawing data together meaningfully in an MCA was very challenging! (the ultimate integration?)

# Case Studies - PCWF

- Good outcomes:
  - Managed to provide guidance on optimal rainwater tank sizes
  - Developed a good understanding of RWT failure conditions
  - Constructed a systems water balance model for Council with ample future use
- But...probably wouldn't go down that route again!

# Case Studies - Grove



# Case Studies - Grove

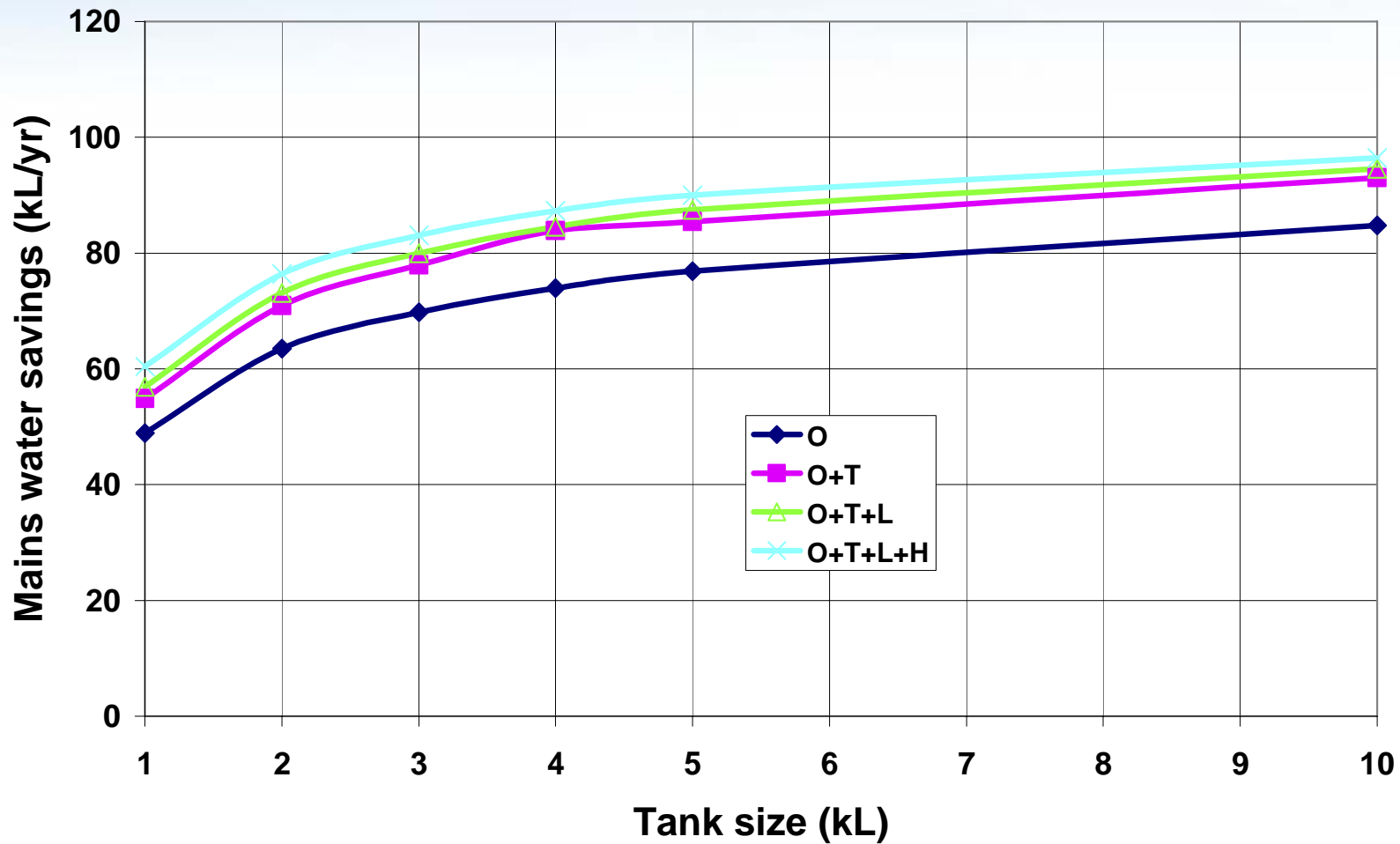
- Stormwater treatment train:
  - Rainwater tanks with mains water back up
    - Supply for domestic toilet and outdoor uses
  - Small contributing stormwater sub-catchments
    - Minimise concentrated flows
  - Traditional pipe drainage
  - Small sediment traps within management train
  - Retention/low flow drainage in gum tree reserves
  - Rain gardens
  - Bio-retention swales/diffusion and sediment traps
  - Small cascading “billabongs” in landscaped waterway

# Case Studies - Grove

- The tools:
  - PURRS: evaluate performance of rainwater tanks
    - Derive initial conditions for stormwater design software
  - MUSIC: stormwater quality at catchment scale
    - Utilised information from PURRS for inclusion of tanks
  - WUFS: rainfall/runoff model for traditional and WSUD infrastructure design
    - Design storm model
    - Utilised initial conditions from PURRS
  - EPANet: Infrastructure (subject of current research)

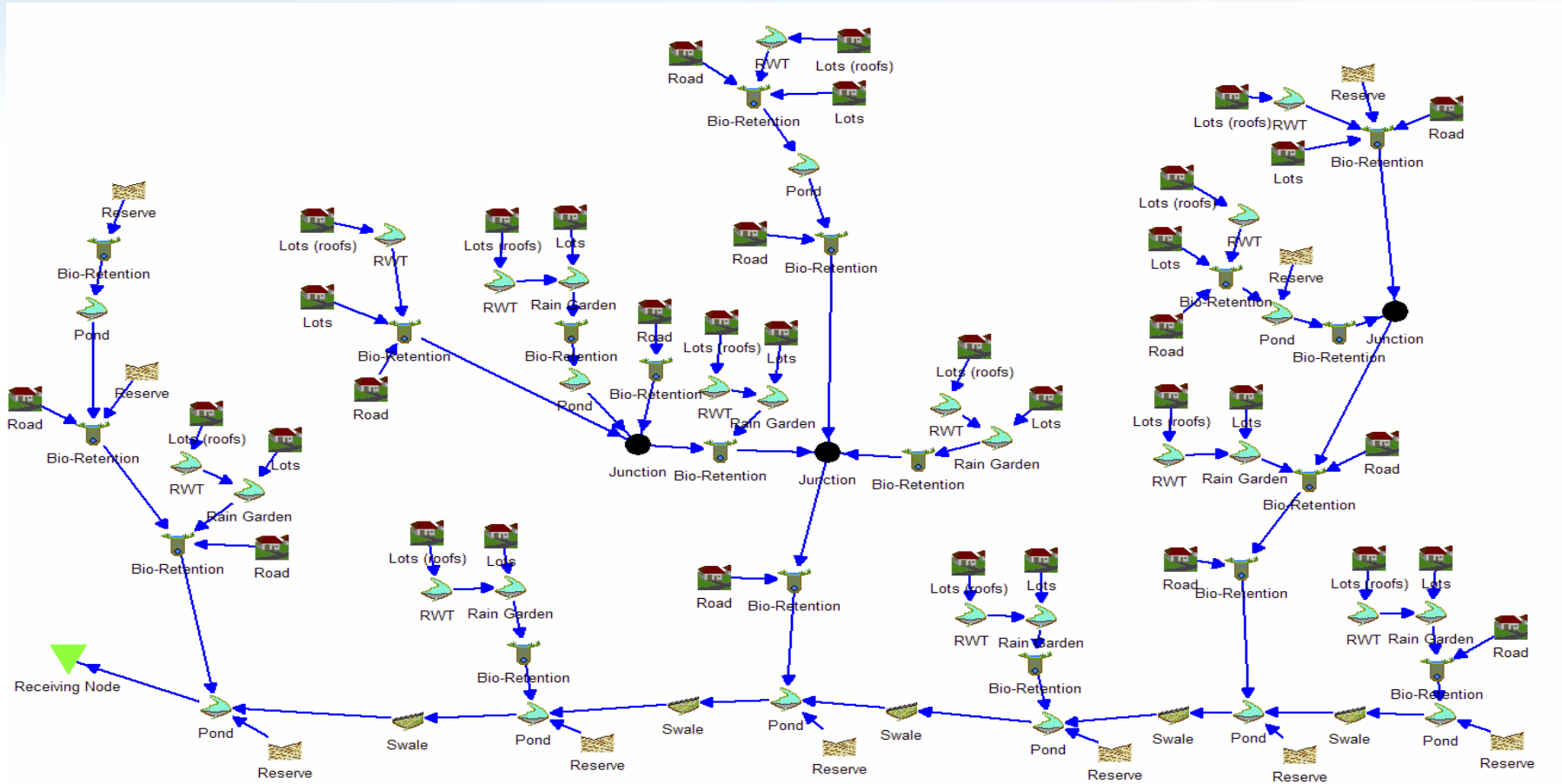
# Case Studies - Grove

- PURRS:



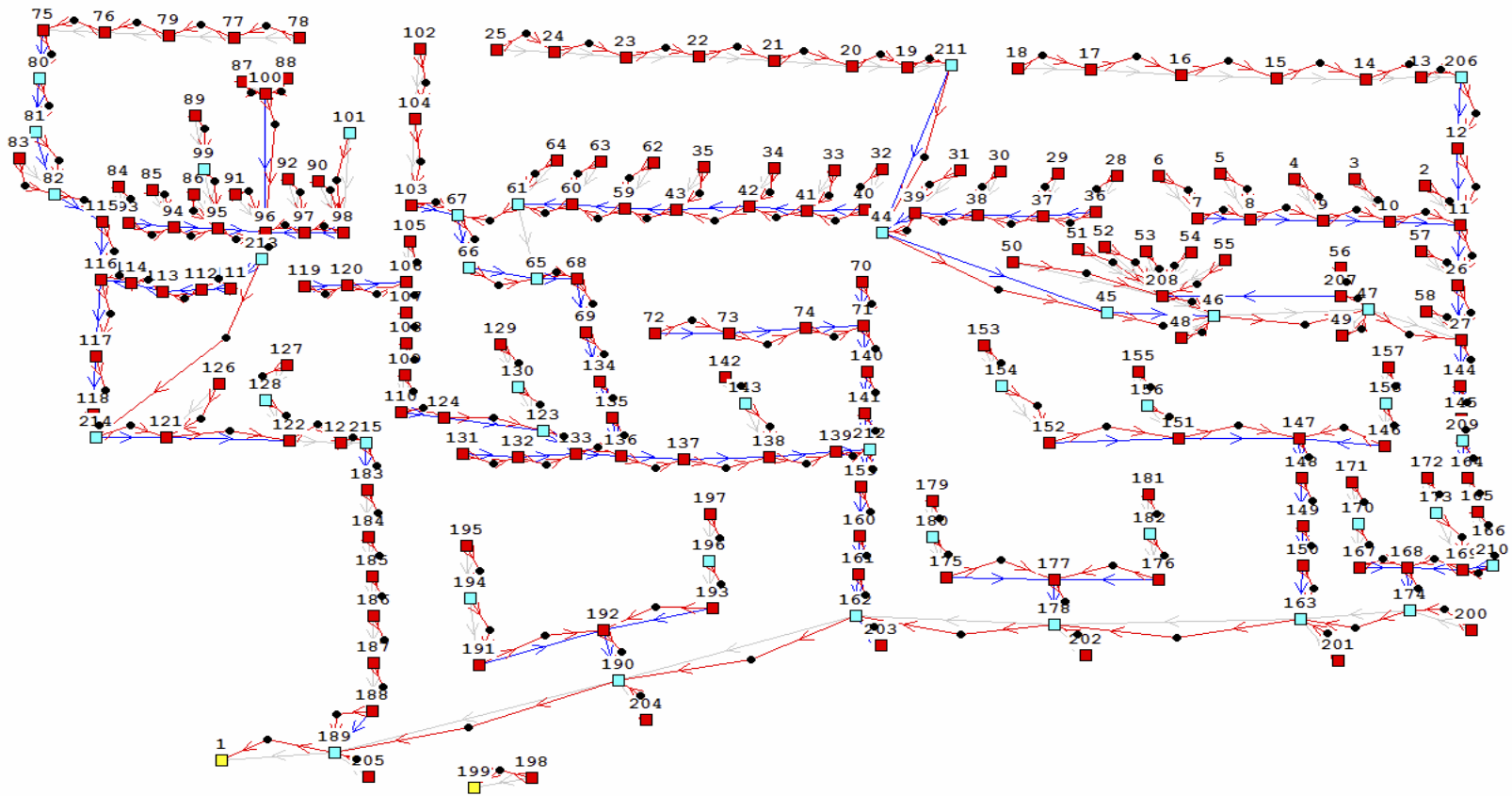
# Case Studies - Grove

- MUSIC:



# Case Studies - Grove

- WUFS:



# Case Studies - Grove

- Preliminary results:

Scenario	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Predevelopment	6.82	324.4	1.13	11.42
Traditional drainage	24.4	4469	7.758	48.01
<b>Increase (%)</b>	<b>357.8</b>	<b>1377.6</b>	<b>686.5</b>	<b>420.4</b>
Traditional + tanks	20.57	3305.6	6.801	43.2
Reduction (%)	15.7	26	12.3	10
Bio-retention	6.44	81.23	0.885	9.807
Reduction (%)	73.6%	98	88.6	79.6
WSUD	5.39	80.69	0.749	7.27
Reduction (%)	77.9	98.2	90.3	84.9

# Conclusions

- Typically we need to bolt several models together to answer the relevant questions
  - Usually weren't designed to be used that way
- Conflicts in
  - Spatial scale
  - Temporal scale
  - Formats
  - Model assumptions
- But can make defensible attempts at integration

# Conclusions

- The good news!
- eWater is aware of the need for integrated tool(s) suitable for addressing integrated water management questions
- Urban cluster scale (P3) and regional scale (P4) products are the key products in this regard
- These tools will also consider
  - Ecological response
  - Scale issues
  - Infrastructure aging issues
  - Climate and behavioural demand model