DAnCE4Water’s BPM
A planning algorithm for decentralised water management options

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Today’s Presentation involves...
Our focus is on Planning...

We must be ready to adapt!

“...The future is uncertain & unpredictable...”
Today’s Presentation

- A different kind of “model”
- DAnCE’s Biophysical Module
- Overview of Methods
- Initial Applications
- Dynamic Planning Example
A different kind of “Modelling”

• Planning for <insert latest buzzword here> implies a need for integration

• Participatory and interdisciplinary approach to planning – how to facilitate?

• Scientific rigour in the thought process, how can modelling help?

• Scenarios should be dynamic and evolving
An Example Scenario

1960
In the Beginning
Not much awareness, deal with sediment and flow where appropriate.

1970
Let’s Manage Water
Some increase in awareness and adoption

1980
Nutrients a pest!
TN and TP management now required to protect the environment

1990
Emergence of Bioretention
New technology emerges, targets become more stringent

2010
Greater Challenge
Revised targets

2000
A New Mandate
Required to treat 70% of the total catchment area

Emergence of Bioretention
New technology emerges, targets become more stringent (V 60%, TSS 80%, TN 30%, TP 30%)

Basin-wide Adoption Status
Systems available:
• Ponds & Basins
• Infiltration Systems
• Wetlands
• Biofiltration Systems

Timeline

An Example Scenario

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Belgrade 2012

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We want a model that can...

- Planning according to Dynamic and Evolving scenarios
Dynamic Adaptation for enabling City Evolution for Water

Strategic Planning Tool
- Scenario assessment on the longer term and city scale
- Software and participatory scenario making
- Integrating biophysical, urban development and societal models

EU FP7 Project
- PREPARED: Enabling Change
- Austria-Australian Collaboration between Innsbruck University and Monash University
The Biophysical Module

Urban Design & Water Infrastructure Adaptation
- Compliance to Legislation, Society
- Integration into the urban form
- Implementation/Removal/Retrofit of Technologies

Within DAnCE4Water as well as Standalone

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Spatial Representation

LOT

• Lot/Parcel: Planning Rules to ‘reconstruct’ the urban form

PARCEL

• Patch/Block: Data and User Input – dependent on size of case study

PATCH

• District/Basin: Data of Geopolitical & Natural Terrain

BLOCK

For more details, see:
The Technology Planning Algorithm

Scenario & User Input

A. User Specifications (Input)
   - Social Situation
   - Toolbox
     - BLOCK 1589
       - Tech 1
       - Tech 2
       - Tech 3
       - ...
   - Technologies Shortlist

B. Design Targets (Input)
   - Site Character (Input Data)
   - Design Curves (Standards)
   - Concept Designs

C. Available Space
   - Urban planning
   - Implementation Issues
   - Opportunities
   - Opportunities Shortlist

Options

Combination of technologies from different scales

MULTI-CRITERIA EVALUATION

- Option A
- Option B
- Option C
- Option D
Some Terminology

• **Target:** Deem-to-comply values, these are set by legislation and must be met for a given area (e.g. % reduction in pollutant loads)

• **Service:** The % of a catchment’s impervious area treated (or population provided for) by a technology or group of technologies

• **Option:** A particular combination of technologies at different scales to provide “Service” to the catchment to prescribed “Target”
The Technology Planning Algorithm

Urban Form

Design Curves & Rules

Lot Scale
implementation of systems in x% of allotments

Management Targets

Precinct/Sub-basin Scale
servicing x% of entire untreated upstream region

Street/Neighbourhood Scale
servicing x% of untreated allotments and public areas

Top Ranked Block Options

Sub-basin Options

Basin/Regional Scale
Applies water management option to achieve a specified target for a % of its total region. Realisations are generated using semi-randomised approach.

Multi-criteria Evaluation

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Case Study – Scotchman’s Creek

INPUTS LAYERS

- Soil Info & Elevation
- Land uses
- Population

LOCATION

Catchment Area: 10km²
Type: Urban – low/medium density residential
Location: Melbourne
Case Study Setup

• 500m x 500m Block Size

• Urban Planning Regulations: Melbourne

• 5 system types: Bioretention, Infiltration, Wetlands, Ponds & Swales (design curves derived from Melbourne guidelines)

• Multi-Criteria Scoring: Adapted version of the DayWater Multi-Criteria Matrix (equal weightings)
Some Basic Outputs

Residential TIF

Elevation [m]

Residential Total Impervious Fraction

- 0.000000
- 0.000001 - 0.263846
- 0.263847 - 0.298113
- 0.298114 - 0.322993
- 0.322994 - 0.375626

- 0.000000
- 0.000001 - 0.010000
- 0.010001 - 0.018420
- 0.018421 - 0.024700
- 0.024701 - 0.031790
- 0.031791 - 0.036900

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Different Technology Options

% of impervious area treated

from 1000 realisations
(avg. = 53%, med. = 56%)
Technology Utilisation

- Utilisation of different technologies reflect the unique characteristics of the catchment

\[
U = \frac{\% \text{imp treated by technology } i}{\text{Total } \% \text{imp treated}}
\]

Utilisation

- 50% increments
- 25% increments
- 10% increments

System Type

500m x 500m

1000m x 1000m
Some Key Findings

- Combined use of Bioretention and Ponds/Wetlands Favoured

- Urban Form of catchment constrains the opportunities for stormwater management

- Choice of block size and level of rigour in assessment dependent on case study and modelling aims
Back to our Scenario

1970
Let’s Manage Water
Targets: V 50%, TSS 50%
Service: 30%
Systems available:
• Ponds & Basins
• Infiltration Systems

1980
Nutrients a pest!
Targets: V 50%, TSS 70%,
TN 20%, TP 20%
Service: 50%
Systems available:
• Ponds & Basins
• Infiltration Systems
• Wetlands

1990
Emergence of Bioretention
Targets: V 60%, TSS 80%,
TN 30%, TP 30%
Service: 50%
Systems available:
• Ponds & Basins
• Infiltration Systems
• Wetlands
• Bioretention

2010
Greater Challenge
Targets: V 80%, TSS 90%,
TN 45%, TP 45%
Service: 70%
Systems available:
• Ponds & Basins
• Infiltration Systems
• Bioretention
• Wetlands

In the Beginning
Targets: V 50%, TSS 50%
Service: 10%
Systems available:
• Infiltration Systems
• Ponds

A New Mandate
Targets: V 70%, TSS 80%,
TN 30%, TP, 30%
Service: 70%
Systems available:
• Ponds & Basins
• Infiltration Systems
• Bioretention
• Wetlands

Let's Manage Water
Targets: V 50%, TSS 50%
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Implementation Rules
• Based on rate of Urban Development

Retrofitting of Existing Areas
• Performance and System Age Dependent
• Three possible dynamics: keep, upgrade, decommission

Simulation Period: 50 years

Dynamics of Urban Development based on Urich et al., 2012 (9UDM)
Some Quantitative Observations

- **Total Impervious Treated [m²]**
- **Year**
  - 1960
  - 1970
  - 1980
  - 1990
  - 2000
  - 2010

- **IMPLEMENTED**
- **IS** = Infiltration System
- **PB** = Ponds & Basins
- **WSUR** = Surface Wetland
- **BF** = Biofiltration System

- **Total Area [ha]**
- **Total Residential Impervious**
- **Total Undeveloped**

**URBAN FORM**

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Future Work

1) Implementation of Water Recycling Technologies (e.g. Rainwater tanks, advanced stormwater harvesting plants)

2) Addition of decentralised wastewater and water supply technologies

3) Detailed coupling with other modules to better incorporate social and urban development feedbacks

4) More rigorous testing on Scotchman’s Creek and other examples
1) Planning for an uncertain future requires the use of dynamic and evolving scenarios

2) DAnCE4Water’s Biophysical Module offers a means for exploring many possible configurations of decentralised urban water technologies and their evolution over time

3) The use of such models in the planning process can build a better understanding of the complexity of our urban environment and water infrastructure
Thank You for your Attention!
Any Questions?

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The Challenge of Calibration

- Difficulty of model development and calibration for urban drainage models
- Data quality and availability may not be sufficient
- Parameters are often difficult to calibrate
- Model complexity and non-linear relationships

Validation Method

- Model parameters are validated through comparison with observed data
- Calibration process involves iterative adjustments to model parameters

Urban Flow Algorithms

- Algorithms simulate flow dynamics in urban environments
- Incorporate factors such as rainfall, urban layout, and drainage systems

How Many Realizations of Options?

- Graphs illustrating different simulation scenarios
- Comparison of model predictions with observed data
The Challenge of Calibration

- Inherently difficult due to data limitations (e.g. we have current state data, old orthophotos of region)
- Aim is train the model to produce realistic possibilities
- Parameter Sensitivity and Uncertainties to be taken into account
- Modelling Exercises would require multiple simulations to produce a spread of results
Validation Method

Planner A
- Possible Design(s)
- Personal Multi-Criteria Scores

Planner B
- Possible Design(s)
- Personal Multi-Criteria Scores

Planner C
- Possible Design(s)
- Personal Multi-Criteria Scores

MODEL

Output
Variable

- Model run output
- Planner A’s ideal design
- Planner B’s ideal design
- Planner C’s ideal design

Possible Design(s)

Personal Multi-Criteria Scores
Urban Form Algorithms

Residential Allotment
- allotment depth
- front setback
- lot frontage
- side/rear setbacks
- patio
- roofed area

Residential Parcel
- parcel width
- parcel depth
- private/public boundary
- ½ residential road reserve

Residential Block
- Block depth
- Block width

lot frontage
allotment width
side/rear setbacks
roofed area
front setback
lot frontage
side/rear setbacks
patio
roofed area
private/public boundary
½ residential road reserve

Residential Allotment

Residential Parcel

Residential Block
How many Realisations of Options?

Relative Proportion of Realisations vs. % imperviousness treated

No. of Realisations
- 50
- 100
- 200
- 500
- 1000
- 1500
- 2000

0 10 20 30 40 50 60 70 80 90 100 110 120 130

relative proportion of realisations
MUSIC Modelling

**DISCHARGES**

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<th>Year</th>
<th>Flow (ML/yr)</th>
<th>TSS (t/yr)</th>
<th>TP (kg/yr)</th>
<th>TN (kg/yr)</th>
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</tbody>
</table>

**Annual Runoff Volume (ML)**

- Flow (ML/yr)
- TSS (t/yr)
- TP (kg/yr)
- TN (kg/yr)
Thank You for your Attention!
Any Questions?

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