2.2 Modelling the benefits of stormwater control measures on reducing flooding

Summary

Urban flooding is a problem in many catchments. Current efforts to alleviate or mitigate urban flooding often involve expenisve infrastructure upgrades. Such upgrades could potentially be avoided using dispersed source-control stormwater management measures (e.g. rainwater tanks, rain-gardens, etc.). This project aims to test this potential. This project aims to test this potential. It will combine a spatially distributed hydrologic model with a 2-D hydraulic model (developed by the University of California [Irvine]). The project will develop a methodology by which the flood impacts of souce-control measures can be assessed. It could be applied to existing and new urban areas in the Melbourne Water region.

Research Theme

Flow and water quality management

Timing

2013-2015

Project Team

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Deliverables

- Development of probability distributions of stormwater source control (e.g. rainwater tanks) performance based on monitoring in the catchment
- Compilation of detailed GIS layers of the catchment—DEM, drainage network, and soil types
- Development of a spatially distributed hydrologic model of the catchment. Develop

Background

Urban catchments are characterised by extensive impervious surfaces, producing excessive stormwater runoff that is directly channeled to receiving waters through efficient drainage systems. As a consequence, urban stream management often involves site-scale, symptomatic works aimed at addressing channel stability and hydraulic efficiency through channel modification and hard-lining. However, this results in a degraded ecosystem with flashy hydrology and increased contaminant loads. These changes impact flood risk throughout the urban catchment as stormwater runoff from rooftops and streets has to be dealt with locally (at the property or neighborhood level) and flow capacity within urban streams is exceeded, increasing the risks of pluvial flooding and overbank flow during storm conditions.

In an effort to restore urban riverine habitats and promote catchment sustainability, it has been argued that impervious surfaces should be effectively 'disconnected' (via appropriate stormwater control measures; Walsh et al., 2005) from conventional drainage systems and concrete lined channels converted to soft-bottom vegetated streams (or preventing these changes to greenfield developments). The so-called flow-regime management approach (Burns et al, 2012) relying on stormwater source-control measures (SCMs) may be implemented to deliver appropriate quality and quantity of flows to receiving waters, reducing peak flows (both in the drainage system and in the stream) during heavy rainfall. Thus, in terms of this approach's effects on flood control, the following important questions arise:

1) What is the impact of SCMs on flow within the (i) drainage system and (ii) stream channel during storm events, and how does the impact vary with the exceedance probability of the storm event?
2) How will SCMs affect the occurrence and extent of (i) overbank flows, particularly those flows that represent a hazard to development ("flooding")?, and (ii) localized urban flooding (within the drainage network)? Which SCMs appear most promising relative to flood hazard

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reduction? How does the spatial distribution of SCMs in the catchment affect the potential to reduce downstream flooding? Likewise, how do SCMs reduce the stream-power experienced by the channel and how does this relate to the severity and extent of erosion?

3) Given a hydrologic/hydraulic modeling framework such as MUSIC+BreZo, does it become possible to link specific SCMs to specific flood risk reduction benefits (e.g., shallower flooding at a factory)? Could this information help with the development of more effective SCM incentive and implementation programs?

Methods

We will use the LSC as a case-study catchment to study the effect of SCM implementation on flooding within (i) the stream channel and (ii) the drainage network. The data used for the catchment will thus include a GIS layers detailing the drainage network, engineered flow models and in particular connected/disconnected impervious areas—spatial modeler Joshphar Kunapo has constructed these models). It will also include details of the channel (through a 1m LiDAR-based DEM with a vertical accuracy of +/- 20cm, supported by channel cross-sections surveyed by the LSC team). Data on the implementation and performance of SCMs will be provided through the following sources:

1. Overall data on the implementation of SCMs within the catchment will be provided through the LSC team's database of implemented projects (more than 200 allotment systems have been constructed, along with more than 25 larger-scale [streetscape and precinct] systems).
2. Data on performance of rainwater tanks will come from monitoring of 12 tanks undertaken by Burns et al. The data provide probabilistic descriptions of rainwater tank performance relative to factors such as water end-uses, tank and catchment size, and number of residents. The probabilistic models developed by Burns will be used as primary input data.
3. Data on performance of rain-gardens (Rangeview Rd, Hereford Rd, Wattle Valley Road); data collected by the LSC team for these systems will be used, along with modelling by Burns et al, to create flow time series for infiltration-style systems.

Thus, flow-time series will be generated for given parcels of land. Each of these parcels of land will be attributed to a given Hydrological Response Unit (HRU) in a distributed physically based hydrologic model—SWAT (Soil and Water Assessment Tool). In SWAT, the flow at any point in the catchment can be predicted. The SWAT model will be calibrated against observed hydrologic data. There is then the need to:

1. Route these through the drainage network (Joshphar Kunapo will construct a GIS-based modeling approach to do this)
2. Simulate channel and floodplain flooding dynamics using a 2D hydraulic model, in response to routed inflows into open channel drainages (this will be undertaken by the UCI [University of California Irvine] team in California, led by Brett Sanders, Jochen Schubert and Amir Aghacouchak).

We will use this collaboration to combine these components, building a model which can predict the impacts of SCM impact on flood hydrology (GIS model) and localized flood depths and velocities (2D hydraulic model) at any given point within the catchment. We will consider a number of scenarios:

1. LSC catchment in its current state of urbanization but without any SCMs in place.
2. LSC catchment with the current SCMs in place.
3. LSC with various levels of future SCM implementation, in terms of (i) % of land parcels treated, (ii) type of SCMs put in place