The potential for using natural flood management & SuDS techniques at the landscape scale: an application to the Tutta Beck catchment, County Durham

This briefing note provides an overview of the research being undertaken by Mr Alex Fraser, Dr Sim Reaney and Dr Richard Hardy at Durham University to understand the opportunities to mitigate flood risk using natural flood management (NFM), Sustainable Drainage Systems (SuDS) and land management changes. This work is focused on the Tutta Beck catchment, Co. Durham, which has suffered flooding as recently as 2012. The research is based on two complementary approaches: 1: rapid connectivity and risk mapping assessment (SCIMAP-Flood) and 2: detailed physically based, fully spatially distributed, simulation of water flow within the catchment (CRUM3). These methods combine to provide a powerful toolkit to effectively target mitigation measures within the catchment and to predict the potential reduction in the flood peak from actions.

Key Project Investigations

- Investigate the most efficient and effective ways to reduce flood magnitude
  - Change in land management practices treatment for soil erosion (linking with Catchment Sensitive Farming/CSF)
  - Effectiveness of change in land use (such as grassland to woodland transition)
  - Use of SuDs features in a rural setting within the catchment (attenuation basins)
  - Use of NFM based in channel mitigation measures (debris dams)
- SCIMAP can be used to target and inform initiatives to reduce the formation of runoff and sediment transport within the catchment.
  - Therefore there is the potential to generate multiple benefits from the flood risk reduction actions including water quality improvements.
- CRUM3 can be used to quantify the potential changes in flow and flood peaks.
- Evaluation of the suitability of the different assessment tools for different stakeholder's needs.
  - Community groups value the spatial detail of the SCIMAP-Flood results
  - Environment Agency and the local authority require detailed prediction of flows pre and post mitigation from flow summations (CRUM3).

Fieldwork

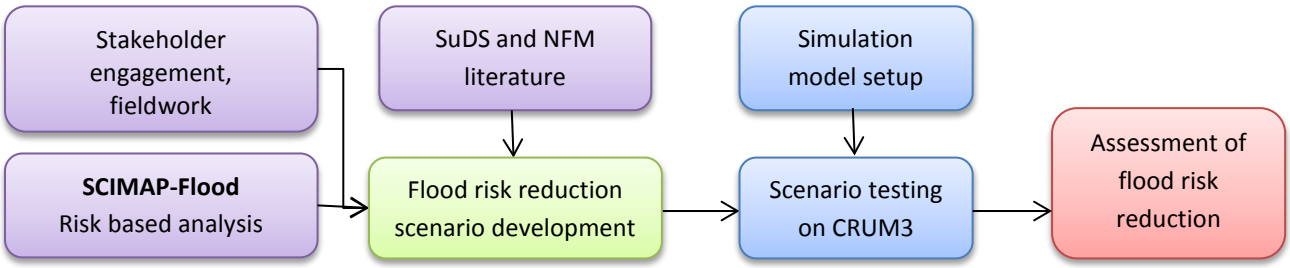
To simulate the impact of catchment management requires the accurate calculation of discharge and knowledge of catchment characteristics, the following points are key project milestones for fieldwork and engagement activities.

23rd December 2014- Pre-project site meeting with Ben Lamb and William Salvin to discuss the issues faced and some stakeholder ideas.
30th January 2015- Baro-diver inserted in Tutta beck channel collecting water depth information.
30th March 2015- Meeting with Parish Council to discuss project and discuss thoughts on flooding
June 2015- discussion with property owners to identify the flood mechanisms, extent and damage
October-January 2016- targeted site visits to flood alerts for upper Tees (EA flood warning system),
4th & 5th December 2015- Visited site during Storm Desmond. Near miss reported during Desmond, qualitative information.
4th January 2016- Visited the site during Storm Frank
1st March 2016- Tees CSF Steering Group meeting discuss synergy between CSF, Tees Rivers Trust and Flood Management

2015-16:
- Periodic flow monitoring to develop depth-discharge relationship
- Periodic infiltrometer testing to ascertain infiltration rate across the catchment
- Site walkovers for qualitative assessment
- Issues reported to William Salvin, maintenance performed on watercourse

Methodology

The project methodology was developed to produce a suite of measures that could be applied to similar catchments across the country and in a format accessible to flood risk management authorities. There are two components to this approach:



SCIMAP-Flood: risk mapping framework that enables analysis on a sub-field scale but across the catchment's extent using limited data inputs. It identifies key sources and flow routes through analysis of topography and land use, to give an understanding of the surface runoff regime at a catchment scale (www.scimap.org.uk)

CRUM3: a fully distributed hydrological simulation model operating at the catchment scale, predicting time series of river flows. CRUM3 has been used for a variety of academic and industry research relevant to this project. More information on CRUM3 is available in Lane et al. (2009)

There are a number of steps required to prepare data for simulating within CRUM3 some of these are as follows-

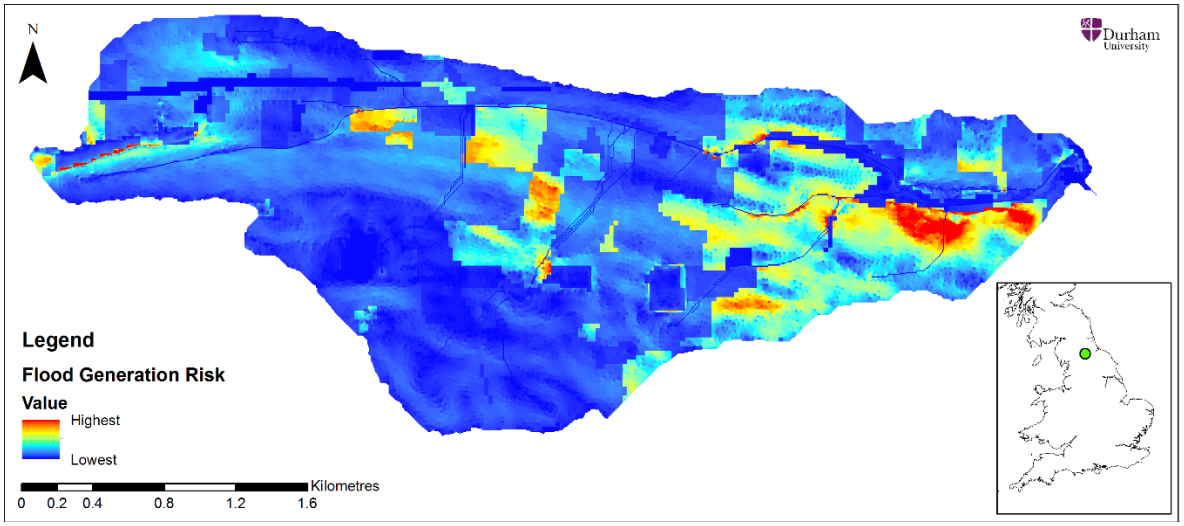
- Discharge produced for time period of flow monitoring, this is subsequently compared to depth readings taken from in situ diver and produces a depth-discharge relationship.
- Weather data taken from nearby stations,
  - Investigated using Vaisala rain gauge at North Bitts farm (10 minute acoustic rain gauge) damage throughout year and specifically December made data accuracy unsuitable
  - Rain data from nearest weather stations at Brignall, Barnard Castle, Lartington Filters, Raby Castle, Forcett and Richmond. Statistical assessment performed to predict missing data
- Preparing catchment maps
  - Delineating the catchment accurately difficult due to artificial drainage of A66 and New Cut to South West of catchment.
- Catchment parameter sets developed
- General Likelihood Uncertainty Estimation (GLUE) run, performs an assessment of the whole dataset using maps produced with various parameters adjusted to create distinct 'runs', from this the most suitable 'runs' are chosen to be brought forward to simulate catchment changes. This simulation chose the 10 with the highest Nash-Sutcliffe rating, 10 with the highest Peak Discharge

Rating and 10 with the highest combined Nash-Sutcliffe-Peak Discharge rating so 30 have been selected for simulations.

- A change simulation is produced by amending the input map (reducing the height of some areas to simulate ponds/depressions) or changing the land cover map by changing the land use of certain areas.
- Each change is then simulated against the 30 'runs' to produce a results file for each run, this is performed to give a rage of potential results though each adjustment. From this a graph and table of results is produced using Python for post processing.

The Tutta Beck Catchment

The project will appraise the effectiveness of the modelled scenarios on reducing peak discharge at Greta Bridge. Flooding was suffered in 2012, anecdotal records show that levels reached close to the properties on a number of occasions. This appraisal will be achieved through a comparison of maximum modelled discharge using existing catchment characteristics against the maximum modelled discharge using the flood mitigation scenarios.



Scenario Development: SCIMAP Output of Flood Risk Generation high connectivity and flood risk to the South East of catchment where land use is predominantly arable farmland. Land cover from CEH Land Cover Map 2007 data. UK outline Crown Copyright 2016

Key flood risk reduction scenarios to be tested using CRUM3 include large scale and spatially targeted land cover change and soil aeration, other measures investigated will be woody debris dams, and spatially targeted attenuation & interception of overland flows.

Recommendations and Outcomes

It is widely accepted that changes in land management can have some effect on flood magnitude, however in many cases there needs to be a complementary hard engineering scheme. A key aim of this research is to deliver catchment management in more palatable way for flood risk management authorities; it is to this end that a range of mitigation features are being investigated.

The outcomes for this research are expected to be a series of options that could result in reduced discharge; the research will assess the costs and benefits of these to highlight the most effective measures. However stakeholder engagement and take up is imperative and will require negotiation between land owner, Durham County Council FCERM team and Tees Rivers Trust particularly

concerning the long term maintenance or land use changes required of chosen measures. To reduce the counteracting desires of land use stakeholders have been engaged to discuss preferred options and what they wish to see investigated as potential outputs. Following this special focus is being given to the currently unused areas of the catchment that could be adapted to provide a function reducing discharge and runoff.

Project Relevance

The strategy employed within this project has been devised to support the production of a catchment management toolkit that can be applied elsewhere in other catchments. The project had additional aims to provide multiple benefits, most specifically reducing diffuse pollution from agricultural land. It is important that such measures do not severely impact farmers and where possible measures should be tailored to improve both diffuse pollution and agricultural sustainability. To this end Catchment Sensitive Farming (CSF) and SuDS approaches that promote the dropping out of suspended sediments, grits and pollutants have been of key investigation. SuDS literature widely sites the volumetric storage capacity of such features and therefore similar principles have been adopted for CSF techniques such as the Ditch of the Future Structures and attenuation ponds.

Furthermore because these features have a clear volume they are able to have a quantifiable impact upon the flooded volume arriving at the watercourse that can be validated alongside the CRUM3 simulation software. The principle of providing attenuation and multiple flow controls to meet an end discharge rate is well established within SuDS known as the treatment train. This thesis aims to deliver the outputs in such a way that an discharge rate and volume of storage can be allocated to an area and then the Flood Risk Authority can enter negotiation with the land owner as to the detailed design of a structure and flow restriction in each area.

Further Information

The thesis associated with this Masters project, which contains a full breakdown of the methodology employed, results attained and suggestions for areas of further research will be made available once the acceptance process is finished at http://etheses.dur.ac.uk/

Any questions can be directed to a.r.fraser@durham.ac.uk or sim.reaney@durham.ac.uk

Lane, S.N., Reaney, S.M. & Heathwaite, A.L., 2009. Representation of landscape hydrological connectivity using a topographically driven surface flow index. *Water Resources Research*, 45(8). Available at: http://doi.wiley.com/10.1029/2008WR007336.