Case study 25. Brackenhurst Natural Flood Management

Authors: Jillian Labadz, Josh Wells, Andy Disney

Main driver: Flood risk management/academic research

Project stage: Constructed November 2016 (monitoring November 2015)

Photo 1: Flooding in Southwell in 1922 (source: Southwell Flood Forum)

Project summary:

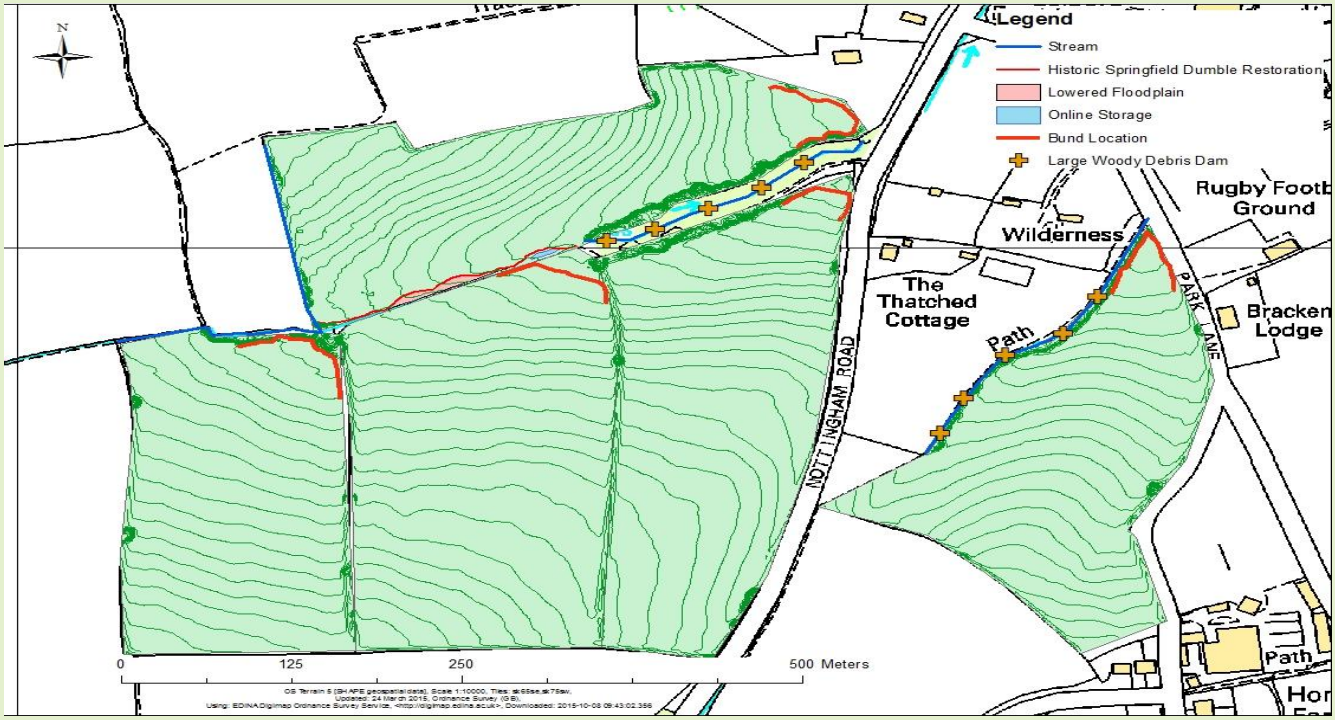
This project is a PhD research project being conducted at Nottingham Trent University by Josh Wells, supervised by Dr Jillian Labadz (Nottingham Trent University) and advised by Andy Disney (Environment Agency) and Professor Colin Thorne (University of Nottingham). It was developed on Nottingham Trent University's Brackenhurst Campus following a summer 2013 extreme flood event in the catchment, which affected the nearby market town of Southwell, immediately downstream (Map 1). A total of 107.6mm of rain fell within a 2-hour period and resulted in the flooding of up to 300 homes.

The aim is to aims assess the extent to which Natural Flood Management (NFM) can help to reduce future fluvial flood occurrence in Southwell. A NFM scheme was developed for the Potwell Dyke catchment (Southwell, Nottinghamshire) as part of the PhD project. In summer 2016, 10 large woody debris dams were installed within the streams. In autumn 2016, a river restoration programme was implemented with the excavation of original meandering stream morphology along a reach plus the provision of some additional online storage capacity and the construction of 5 earth bunds in field corners. These interventions are designed to store and slow water while promoting ecological gains. A network of hydrological monitoring was installed to enable pre and post intervention stage (water level) and rainfall data to be compared. Around a year's worth of pre-intervention stage data have been collected at most locations, with one site being monitored for 2.5 years.

Key facts:

The catchment for the Potwell Dyke is around 6km^2. The NFM interventions by Nottingham Trent University are in 2 subcatchments: Springfield Dumble and Parklane Close Dumble.

To date, an estimated 3,000m^3 of storage has been created within these subcatchments. There is an intention to roll out further NFM measures on multiple land holdings within the Potwell Dyke catchment. Work is being carried out by Trent Rivers Trust to liaise with local landowners, with funding obtained from the Regional Flood and Coastal Committee.



Map 1: Location of Brackenhurst interventions, upstream of Southwell, Nottinghamshire (**source: Ordnance Survey 2015; Edina Digimap)**

1. Contact details

Contact details	
Names:	Jillian Labadz, Josh Wells, Andy Disney
Lead organisations:	Nottingham Trent University, Environment Agency
Partners:	Nottingham Trent University, Environment Agency, Trent Rivers Trust, Southwell Flood Forum and Nottinghamshire County Council
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2. Location and catchment description

Catchment summary	
National Grid Reference:	SK 692 524
Town, County, Country:	Southwell, Nottinghamshire, UK
Regional Flood and Coastal Committee (RFCC) region:	Trent
Catchment name(s) and size (km^2):	Potwell Dyke (6km^2)
River name(s) and typology:	Potwell Dyke, Springfield Dumble, Parklane Dumble (tributaries of the River Greet)
Water Framework Directive water body reference:	River Greet GB104028053410
Land use, soil type, geology, mean annual rainfall:	Mixed agricultural Clay, Mercia Mudstone Seasonal average annual rainfall: 633mm

3. Background summary of the catchment

Socioeconomic/historic context

The historic market town of Southwell lies in the catchment of the River Greet and is famous for its Minster and its racecourse, as well as for being the original home of the Bramley apple. The catchment continues to be dominated by mixed agriculture, including fruit production. The town has experienced multiple flood events, including one fatality documented in the *Nottinghamshire Guardian* in August 1857. Photo 1 shows flooding in Southwell in 1922.

Flood risk problem(s)

There is a mixture of fluvial flooding and pluvial/surface water. Characteristic wooded streams have formed in deep ravines in the Mercia Mudstone and are known locally as 'Dumbles'. Extremely flashy muddy fluvial floods occur due the small size of these tributary catchments, combined with impermeable clay soils and relatively steep gradients. Events in 2007 and 2013 caused significant

disruption and damage to property downstream in the town of Southwell. The 2007 flood event was due to prolonged rainfall on saturated soil. The 2013 event was caused by extreme high intensity rainfall event on dry crusted clay soils.

Other environmental problems

The Water Framework Directive classification for the River Greet is poor for Cycle 2 of river basin management plans. The chemical aspects are good, but the biological elements are poor.

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood risk problem(s) and solution(s)

After the July 2013 flood event, a local flood action group (Southwell Flood Forum) was established and collected evidence of the flood locations and severity in the town. Nottingham Trent University has worked closely with Southwell Flood Forum since this time.

Stage monitoring was installed at an urban location on the Potwell Dyke tributary in December 2013. As part of the PhD research project, 4 four more monitoring points were installed in November 2015 – 2 on the Springfield Dumble and 2 on the Parklane Dumble upstream tributaries on agricultural land owned by Nottingham Trent University. After rainfall events, data were analysed to identify lag times and tributary timings.

Working with Natural Processes (WWNP/Natural Flood Management (NFM) measures were implemented on the agricultural land within the research after a period of baseline monitoring. JBA Consulting have adapted an existing 1d-2d hydraulic model to evaluate the effects of woodland planting in the catchment on downstream flood risk impacts.

What was the design rationale?

While primarily a research project, the project has the additional aim of providing measurable benefits to the community downstream by delaying and reducing hydrograph peaks from an agricultural subcatchment. To enable comparison of pre and post project hydrographs, about a year of pre-intervention monitoring took place before NFM interventions were installed.

A catchment partnership group was set up including Nottingham Trent University, the Southwell Flood Forum, the Environment Agency, Nottinghamshire County Council (the Lead Local Flood Authority) and the Trent Rivers Trust. After discussion with this group, NFM in the upstream catchment was considered a justifiable option, alongside further consideration of the need for a more traditional flood risk management scheme in the town.

In summer 2016, 10 large woody debris dams were installed within the streams on Nottingham Trent University land. In autumn 2016, a river restoration programme was implemented with excavation of original meandering stream morphology along a reach plus provision of some additional online storage capacity and construction of 5 earth bunds in field corners.

The interventions were chosen using a mixture of methods.

The corner of the fields were selected for construction of the bunds after site walkovers during rainfall events demonstrated appropriate positions. LiDAR (light ranging and detection) data were then used to model flow accumulations and confirmed the appropriate positioning of the bunds.

The stream restoration was selected after discussions with members of the Southwell Flood Forum, which had a historic Ordnance Survey map. The restoration could therefore return the stream to a pre-defined planform, provide additional storage capacity and at the same time provide soil for the construction of bunds.

Woody debris dams were installed due to their low cost and ease of construction, and their ability to pass low flows undisturbed. Because the streams have steep, high banks, raised water levels would still not flood onto nearby agricultural land.

The project is designed to provide evidence from hydrological data and act as a legacy for further NFM measures within the catchment and neighbouring catchments. Trent Rivers Trust has followed up initial awareness raising by Nottingham Trent University with the local community and is currently approaching landowners to ascertain their willingness to employ NFM on their land. Nottinghamshire County Council has led a bid for further RFCC Local Levy funding to incorporate further NFM measures as part of a wider scheme to provide improved flood protection to the Southwell community.

For more detail see Wells and Labadz (2016), and for information on the modelling see JBA (2017).

Project summary	
Area of catchment (km^2) or length of river benefitting from the project:	$6km^2$
Types of measures/interventions used (both WWNP and traditional):	Large woody debris dams Bunds in corners fields Stream restoration Online storage Conifer woodland planting (modelled) Deciduous woodland planting (modelled)
Numbers of measures/interventions used (both WWNP and traditional):	10 large woody debris dams 5 bunds ~200m reach of stream restoration with additional online storage Up to 150ha mature conifer woodland planting (modelled) Up to 150ha mature deciduous woodland planting (modelled)
Standard of protection for project as a whole:	Unknown as yet
Estimated number of properties protected:	Modelling study reported that 25 fewer properties would be flooded in Southwell during a 75 year flood event if 150ha of woodland (conifers or deciduous) was planted in strategic locations across the catchment.

How effective has the project been?

Construction is recent and so monitoring is ongoing. However, observations from a recent event (Storm Angus, 21November 2016) show that the project is capable of holding back water. In the future, the research will further analyse the impacts of the measures on lag times, flow peaks and tributary timings.

The project has already been successful in promoting the use of NFM to the wider community, with several other willing landowners coming forward to construct interventions on their land.

Nottinghamshire County Council has been successful in its bid for further Local Levy funding and is currently working with partners to consider the future design of NFM and how this can be integrated into a wider flood risk scheme for Southwell.

5. Project construction

How were individual measures constructed?

Sites were first selected for the large woody debris dams by undertaking a site walkover with the farm manager. Favoured sites contained trees against which to place logs to maximise stability but also had some floodplain to increase storage potential. The dams were installed using hand tools and a hand winch. Two people were required to carry out this work. A tractor was used to move logs close to the installation site and the logs were winched into position. To increase stability, wooden stakes were installed downstream of the dams.

The bunds in the field corners were created by first digging a trench and then creating a clay core within it. Soil was then put in place using heavy machinery and compacted/shaped. The outlet pipe was installed after construction to maximise stability and to reduce damage to the pipe during construction.

How long were measures designed to last?

Ongoing topographical monitoring will determine any changes to the restored stream section, the bunds and the large woody debris dams. The situation will be reviewed in 3 years' time and the findings reported to Nottinghamshire County Council (as the Lead Local Flood Authority) and the Local Planning Authority.

Were there any landowner or legal requirements which needed consideration?

Drainage consent was required by and agreed with the Lead Local Flood Authority.

Planning issues were raised by the Local Planning Authority, as planning remains a sensitive subject following the 2013 floods, which adopted the pragmatic solution to review the project in 3 years' time.

All work has been subject to the willingness to be involved of relevant landowners.

6. Funding

Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (WWNP/NFM) measures	
Year project was undertaken/completed:	2016
How was the project funded:	Local Levy funding (Environment Agency), Vice-Chancellor scholarship (Nottingham Trent University), Nottingham Trent Student's Union Green Leaders Grant
Total cash cost of project (£):	~£100,000 Estimated actual cost of NFM was £11,000 plus PhD student time (3 years, includes work on project management, design and implementation of measures, data collection and analysis): £65,000
Overall cost and cost breakdown for WWNP/NFM measures (£):	Hydrological monitoring equipment: £17,500 Stream restoration and bunds: £4,000 Large woody debris dams: £700 Nottingham Trent University also supplied staff and machinery for NFM construction and a local contractor (Smiths JCB Hire) worked at a discounted rate for community benefits. It is estimated that these contributions saved around £6,000. In addition, £17,000 has been allocated by Trent RFCC for Trent Rivers Trust landowner liaison and construction works for future NFM in the catchment.

WWNP/NFM costs as a % of overall project costs:	~15%
Unit breakdown of costs for WWNP/NFM measures:	Not yet available.
Cost–benefit ratio (and timescale in years over which it has been estimated):	In modelling study the results indicated that for all planting combinations and three cost assumptions, the flood benefits outweighed the planting costs with a benefit-cost range between 1.0 to 8.3 per hectare. This was the same for the environmental benefits with a benefit-cost ranging between 4.8 and 40.3 per hectare. NB. No land payment costs nor optimism bias were included in these calculations.

7. Wider benefits

What wider benefits has the project achieved?

The project's wider benefits are still being monitored, with invertebrate community and sediment movement studies taking place. However, greater variation of flow levels and velocities has been produced, which should create a wider variety of habitats.

Community awareness has increased and the work has attracted wider partners to the initial project. The speed in which the measures have been constructed compared with a traditional scheme has invoked a very positive response form the local community.

How much habitat has been created, improved or restored?

- 214m of new watercourse
- Riparian trees have been planted and will continue to be planted in 2017.
- Land behind the bunds will also be planted with trees.

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

At present, the PhD student and Nottingham Trent University are maintaining the project. However, a management plan will be developed to pass on to guide future maintenance.

Is the project being monitored?

The project is being monitored as part of the PhD research. Five stage loggers have been installed, located upstream and downstream of the NFM measures in both subcatchments. A further 2 telemetric monitors were recently installed at other locations upstream of the town. These are all set to record at 5-minute intervals, due to the flashy nature of the flows. Three logging rain gauges are situated on the Brackenhurst campus (~700m uphill) to allow for lag time comparisons. Invertebrate communities and stream morphology are also being studied.

Has adaptive management been needed?

During the event on the 21 November 2016, it was noticed that run-off was being channelled by a farm track past one of the bund locations. A water diversion mound will be installed on the track to divert this water into the bund, while still allowing farm machinery to pass.

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

Stakeholder engagement and interaction has been vital in reducing the costs for this project. Working with a local contractor and Nottingham Trent University has greatly reduced capital costs. Local knowledge and support has been very valuable within this project. The Southwell Flood Forum has a competent technical group, which offered support during the process. This voluntary flood action group has also provided funding for monitoring equipment for the future analysis of the scheme. This highlights how, through good project management by the researchers and efforts to include the local community, greater benefits have been achieved.

Monitoring is crucial to the project in terms of understanding tributary timings before NFM interventions can be considered, but also to demonstrate any actual reduction in flood risk. It is recommended that future projects have sufficient monitoring built into their funding to allow for more evidence to be gathered.

Planning permission was an issue within this project and delayed the construction of the stream restoration and bunds. It is recommended that talks with the Local Planning Authority are started well before any project commences.

The modelling study has shown that the effects of woodland planting on hydrological processes and flow pathways can be adequately represented in an industry standard hydraulic model to assess downstream flood risk and economic impacts.

10. Bibliography

JBA (2017). *Flood Management and Woodland Creation - Southwell Case Study. Report to Forestry Commission*. JBA Consulting.

WELLS, J.N. AND LABADZ, J.C., 2016. *Report to the Southwell Flood Forum: Natural Flood Management proposals on Brackenhurst land*. Southwell, Nottinghamshire: School of Animal, Rural and Environmental Sciences, Nottingham Trent University.

Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's Joint Flood and Coastal Erosion Risk Management Research and Development Programme.