Case study 21. Lustrum Beck Flood Alleviation Scheme: Phase 2

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Main driver: Flood risk management

Project stage: Detailed design

Photo 1: Flooding event, September 2012

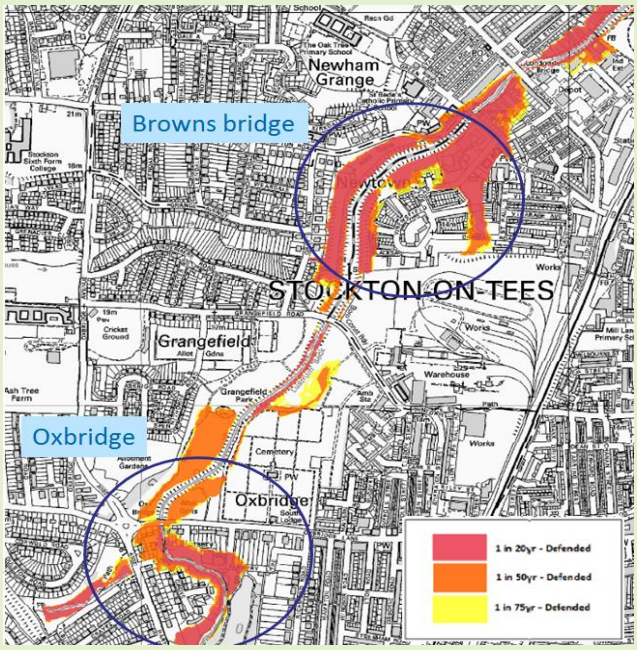
Project summary:

The Lustrum Beck catchment (Map 1) is located in Stockton-on-Tees and is a tributary of the Tees. It has been identified through an ISIS-TUFLOW model that over 150 properties are at risk of flooding in the catchment within 2 main areas: Oxbridge and Browns Bridge. For these sites, the Lustrum Beck Flood Alleviation Scheme (FAS) has been split into 2 phases. Phase 1 is well underway and consists of constructing more traditional flood defences in the urban area of the catchment. Phase 2 is currently in the development stage and will involve storing water at a range of scales in the upstream catchment area using natural processes to attenuate water. This case study focuses on Phase 2 in the Lustrum Beck catchment and how natural processes are being incorporated into the scheme to reduce downstream risk.

Key facts:

The model used identified that a total storage area of around 100,000m³ of storage within the local catchment area could reduce the discharge from the 1 in 100 year return period by 11.5%. This would reduce the peak flow of the 1 in 100 year event to less than 1 in 75 year event.

The Lustrum Beck project is the first flood risk management scheme to develop a business case which includes the use of Natural Flood Management (NFM) to successfully attract Flood Defence Grant in Aid (FDGiA) funding to reduce flood risk.



Map 1: Flood risk in Stockton-on-Tees

1. Contact details

Contact details	
Names:	Ted Thomas
Lead organisation:	Environment Agency
Current partners:	Stockton-on-Tees Borough Council, Forestry Commission, Newcastle University
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2. Location and catchment description

Catchment summary	
National Grid Reference:	NZ3946116268
Town, County, Country:	Stockton-on-Tees, County Durham, UK

Regional Flood and Coastal Committee (RFCC) region:	Northumbria
Catchment name(s) and size (km^2):	Lustrum Beck (tributary of the River Tees), approximately 50km^2 catchment
River name(s) and typology:	Coatham Beck, Hartburn Beck, Lustrum Beck, tributaries of the River Tees
Water Framework Directive water body reference:	GB103025072550
Land use, soil type, geology, mean annual rainfall:	Primarily arable agriculture in the upper catchment, seasonally wet red clay, till/glaciolacutrine, 900mm

3. Background summary of the catchment

Socioeconomic/historic context

Stockton-on-Tees has a strong industrial history, including in the 18th and 19th centuries being known for ship building and repair, and heavy engineering. In the 20th century, these heavy engineering works declined in Stockton-on-Tees as well as in Teesside as a whole. Within Stockton-on-Tees, there are concentrations of neighbourhood deprivation and unemployment rates remain high. Stockton-on-Tees has a growing population, with expected growth of 6.9% by 2021 from 2014.

Flood risk problem(s)

The Stockton-on-Tees community have suffered from repeated flooding for the past 50 years, the most recent of which occurred in 2012 (Photo 1). Other notable flood events have also been recorded in 1941, 1958, 1960 and 1979.

Prior to 2012, a major scheme was developed in the early 2000s to help mitigate the flood risk to the area. The construction of walls, embankments and a large online flood storage area was proposed. However, the predicted cost of the scheme was £8 million and under the current funding schemes the project was not viable with no other obvious solutions.

Now the case for installing flood defences has been re-considered and, from working in partnership with Stockton Council, a potential scheme was developed. This FAS consists of 2 phases. The first involves installing more traditional flood defences within the town itself – work which is nearing completion. The second phase is set to incorporate Natural Flood Management (NFM) and upstream water storage to mitigate the flood risk to the town.

Other environmental problems

Points to note include the fact that the, when developing the upstream water storage for the FAS, a total storage of 115,000m^3 will be required and a commitment was given at appraisal to deliver 30ha of OM4a (water dependent) habitat.

Also, a number of infrastructure assets have been identified as significant sources of rapid run-off. These being the 10km stretch of the A66 road which runs through the catchment and Durham Tees Valley Airport. The impact of these on the flood peak have to be taken into account when considering the water storage quantity required.

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

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

An ISIS-TUFLOW model was developed to help determine the flood risk to the area to the town. The model identified that there were 2 at risk communities in the Lustrum Beck catchment, ~3km apart. The areas at risk were Oxbridge and Browns Bridge. With a total of over 150 properties being at risk, the problem in the catchment was identified. However, this model did not include the upper catchment.

What was the design rationale?

Appraisal design

The first requirement was to determine how much storage was actually required. To develop any type of project proposal, an assessment of the cost and the benefit is required. An understanding of how much storage is required is essential to understand both these elements. As a first pass the modelling consultants added a storage unit at the top of the model. The conditions were then modified until the required reduction in flow was achieved at the point of interest. This found that 340,000m³ would be required to achieve the desired reduction in flood risk. The top of the model coincided with the location of the previously proposed large-scale flood storage reservoir in the early 2000s and it was already known that large-scale storage was not a viable option for the catchment.

Due to the current difficulties in representing large numbers of small features over such a large area, storage was represented using a number of larger storage areas (~8,000m³). The idea was that some of these features may be 8,000m³in size, or they may represent a number of medium or smaller features, which together contribute to that level of storage in that subcatchment. The location and sizes of the storage areas in the subcatchments were manipulated until the required reduction in flow was achieved at the point of interest, for the smallest level of storage volume. This showed a total volume of 115,000m³ would be required to be stored to achieve the desired reduction in flood risk.

Due to this figure being significantly lower than the previous figure of 340,000 m³, multiple smaller scale storage areas further up the catchment were considered as a preferred option. The effects of the storage on the downstream flood risk was extracted from the model and used to assess benefits. A basic Ecosystem Services Assessment was also completed to incorporate the environmental benefits of the NFM features into the scheme appraisal. Examples from previous river restoration and NFM schemes were used to provide costs for the option. These were incorporated into the Project Appraisal Report which gained approval in 2014 (Environment Agency 2014).

Detailed design

More detail was needed to begin detailed discussions with landowners and the Environment Agency supply chain on constructing features.

Newcastle University installed a detailed monitoring network in the catchment to gain an understanding of the flow regime and to monitor the performance of features once constructed. Meanwhile internal staff developed a simplified modelling tool in Microsoft® Excel to understand the synchronicity of the catchment and to determine which subcatchment delivered the most appropriate attenuation. This showed storing water within some of the smaller subcatchments closer to the zone of flood risk could actually increase flood risk by delaying the peak on the tributary to meet the peak on the Lustrum Beck.

Figure 1 shows an example output from the modelling tool. The tool is available for use to project teams who are interested and is best suited to early appraisal of NFM schemes.

Using the tool highlighted that the storage required was actually less than 115,000m³ if the storage was located on the most appropriate subcatchments.

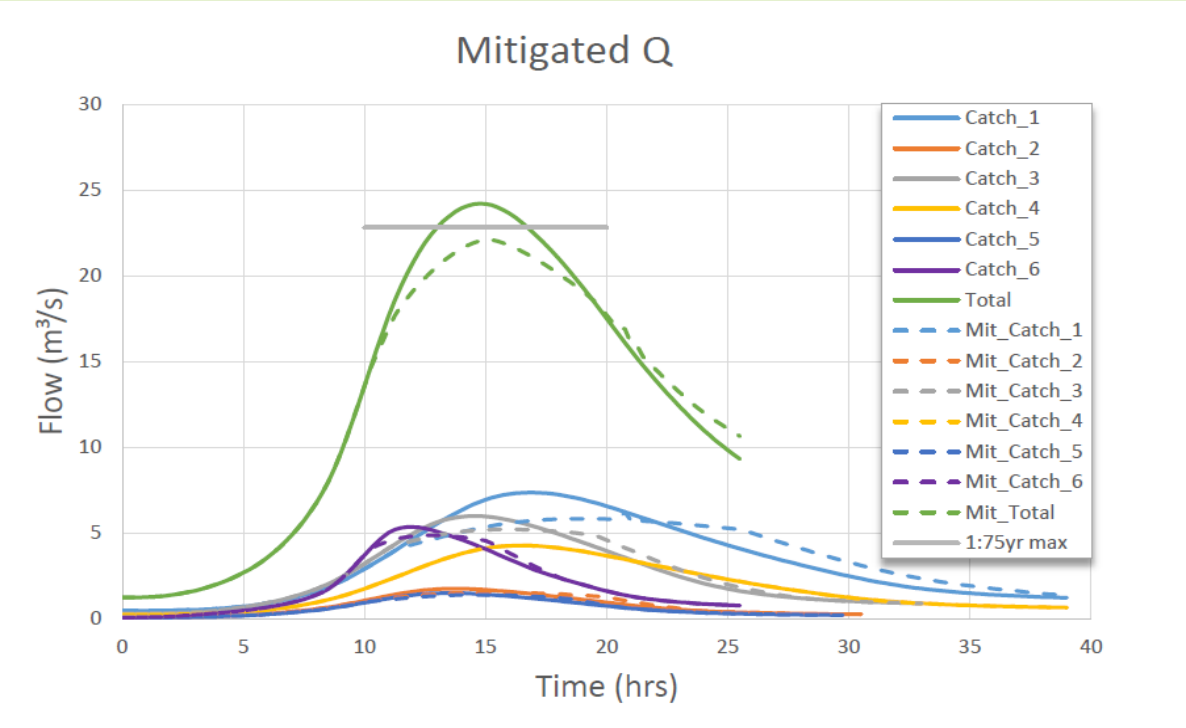

Figure 1: Example output from the NFM modelling tool showing the reduced flows resulting from modelled storage on each subcatchment and the required reduction of the main hydrograph to below the 75 year level

With the multiple landowners in the area, acquiring all the land required would be a time-consuming process. Also maintenance of so many features needed to be considered. In previous whole catchment schemes, there has been an expectation than landowners themselves would undertake maintenance. However, there have been instances where this has not happened and in this instance it needed to be ensured that the features would operate as designed for the lifetime of the scheme. It was therefore desirable that the Environment Agency should inspect and maintain the features. Significant cost, time and carbon efficiencies could be delivered if the features could be concentrated in particular locations.

This approach has a number of other advantages: it simplifies landowner negotiations and makes the construction of the features more appealing to the Environment Agency's traditional supply chain. In this instance, the Forestry Commission has expressed interest in having water storage features on its land at Coatham Woods. Fortunately, this land falls within the subcatchment that has been shown using modelling to deliver the greatest reduction in flow/unit of storage of any of the subcatchments. Initial analysis suggests that a significant proportion of the storage that needs to be achieved could be achieved at Coatham Woods.

Newcastle University is currently building a detailed 2-dimensional model of the site to facilitate the detailed design of a series of offline storage features. In order to spill water into these features, a form of channel throttle is required which is likely to take the form of robustly designed feature using logs to span the upper sections of the channel. The throttles themselves will also impound water within the channel delivering additional online storage.

One drawback of this approach is that the concentrated features will not deliver the 30ha of OM4a water dependent habitat required. This would have posed an issue to the project in any case, as in order to most efficiently reduce a 1 in 100 year event to a 1 in 75 year event, any features would need to begin to fill at not less than the 1 in 50 year flood to be most effective. This would mean that the features would typically impound water once every 50 years and would therefore not create water dependent habitat. NFM does not automatically deliver OM4a compliant habitat; this is not necessarily the case. For the Lustrum Beck scheme, this very much pushed the need to work with the Tees Catchment Partnership.

Through discussions with the Tees Catchment Partnership, a number of opportunities have been

developed across the rest of the catchment. Some primarily deliver water dependent habitat and some primarily deliver flood storage, but all deliver a bit of both:

- **Coatham Woods** – a combination of online and offline storage that will primarily deliver flood risk benefits but will be wetted by overland flows to a low level to create water dependent habitat. This scheme is being designed by Newcastle University and will be managed by the Flood Risk Management function of the Environment Agency whose supply chain will construct the features.
- **Sixfields** – a combination of river restoration and habitat creation, which will involve a partnership between Stockton Council and the Environment Agency. The Council will lead on implementation because it owns the site. There is also potential to store additional flows by installing woody dam features on tributaries of the Lustrum Beck.
- **Work around the A66**. It is hoped to work in partnership with Highways England to mitigate the effects of flooding to the A66 and to attenuate run-off from it.
- **The wider catchment**. The Environment Agency's Environment Programme team will manage the delivery of storage features and habitat across the wider catchment with technical input from Fisheries, Biodiversity and Geomorphology colleagues. This may be in partnership with the Tees Rivers Trust, which has successfully secured European funding to carry out works in the Lustrum Beck catchment.

By working in partnership the most appropriate organisations can be used to put in place elements that suit their expertise.

Project summary	
Area of catchment (km^2) or length of river benefitting from the project:	50km^2
Types of measures/interventions used (Working with Natural Processes and traditional):	Phase 1: traditional harder defences (flood walls, replacement of road bridge and existing security screen) Phase 2: online and offline storage features, woody debris features, run-off attenuation features, wetland creation, and river restoration
Numbers of measures/interventions used (Working with Natural Processes and traditional):	To be confirmed
Standard of protection for project as a whole:	1 in 100 years, although it is a part of a wider solution which includes other defences
Estimated number of properties protected:	Total of 150 properties targeted for both phases

5. Project construction

How were individual measures constructed?

To be confirmed – construction planned for early 2017

How long were measures designed to last?

Significant elements such as the work at Coatham Woods will have a 100 year design life. Other softer features will have shorter design lives but, where possible, these features will be designed to naturalise and be self-maintaining.

Were there any landowner or legal requirements which needed consideration?

Detailed negotiations with landowners have begun.

6. Funding

Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (NFM) measures	
Year project was undertaken/completed:	2014 to 2019 (planned)
How was the project funded:	Currently a combination of local authority contribution, Flood and Coastal Risk Management (FCRM) Grant-in-Aid, Local Levy, research funding Potential contributions in future from Highways England and EU funding through the Tees Rivers Trust
Total cash cost of project (£):	Forecast £4 million
Overall cost and cost breakdown for WWNP/NFM measures (£):	Phase 2 forecast to be ~£660,000
WWNP/NFM costs as a % of overall project costs:	16.5%
Unit breakdown of costs for WWNP/NFM measures:	To be confirmed
Cost–benefit ratio (and timescale in years over which it has been estimated):	100 year appraisal period. B/C ratio: 2.18

7. Wider benefits

What wider benefits has the project achieved?

To be confirmed – likely to include:

- habitat creation
- amenity improvement
- flood risk reduction
- reduced sediment loss from agricultural land
- reduced sedimentation in lower catchment
- reduction in diffuse pollution
- reduced risk to major transport infrastructure

How much habitat has been created, improved or restored?

To be confirmed – 30ha of OM4 water dependent habitat

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

The main features at Cotham Woods will be maintained by the Environment Agency. Activities will include debris removal, inspection and reactive works. Habitat work will be designed to require minimal maintenance.

Is the project being monitored?

Flow monitoring will continue to assess scheme performance.

Has adaptive management been needed?

To be confirmed

9. Lessons leant

What was learnt and how could it be applied elsewhere?

Still early stage in the project, so no information provided at this stage.

10. Bibliography

ENVIRONMENT AGENCY, 2014. *Lustrum Beck Project Appraisal Report*. Newcastle: Environment Agency.

JBA CONSULTING, 2016. *Lustrum Beck options*. Skipton: JBA Consulting.

STOCKTON-ON-TEES BOROUGH COUNCIL, 2014. *Local Economic Assessment*. Stockton-on-Tees: Stockton-on-Tees Borough Council.

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.