# Case study 18

## Rivers Calder and Brun restoration study - Burnley, Lancashire

**Sebastian Bentley (JBA) and Ribble Rivers Trust**

## 1. Catchment summary

### Study location

Rivers Calder and through Burnley town centre in north-west England.

### Catchment summary

Burnley has a rich industrial heritage but, since the decline of the cotton industry, the rivers have been left in a poor physical state. The Urban River Enhancement Scheme (http://ures-burnley.org.uk) set out to improve fish passage through the town and to help local people get involved and learn more about nature and river conservation.

### Study summary

The study's aim was to identify restoration measures that reduce the high in-channel velocities associated with cobble-lined man-made channels (see Figures 1 and 2). The project had to ensure that the risk of flooding was not increased while allowing the restoration of some natural processes and some gravel bed substrate. This will improve fish passage and provide improved geomorphological diversity and help slow the flow.

### Community involvement

The Ribble Rivers Trust undertook significant stakeholder engagement as part of this project.

**Figure 1: Typical channel form in Burnley**

Source: JBA Consulting

**Figure 2: River Calder reach 1: cobble sett and wide channel**

Source: JBA Consulting

## 2. Data summary

### Datasets and analysis techniques used

The study reused the Environment Agency' one-dimensional (1D)–2-dimensional (2D) ISIS-TUFLOW model and built a new 2D JFLOW model based on new light detection and ranging (LiDAR) data and a topographic survey. Standard Flood Estimation Handbook (FEH) techniques were used for design flood estimates. These were used to drive the different models used to estimate the average velocities (Figure 3) and the bed shear stresses, such that the impacts on different sediment fractions could be understood. A table was developed for each of the restoration reaches, estimating the maximum grain size of the sediments that could be supported with the predicted average shear stresses.

### Data restrictions

The Ribble Rivers Trust were able to source the data and models for free from the Environment Agency under its special licence agreement.

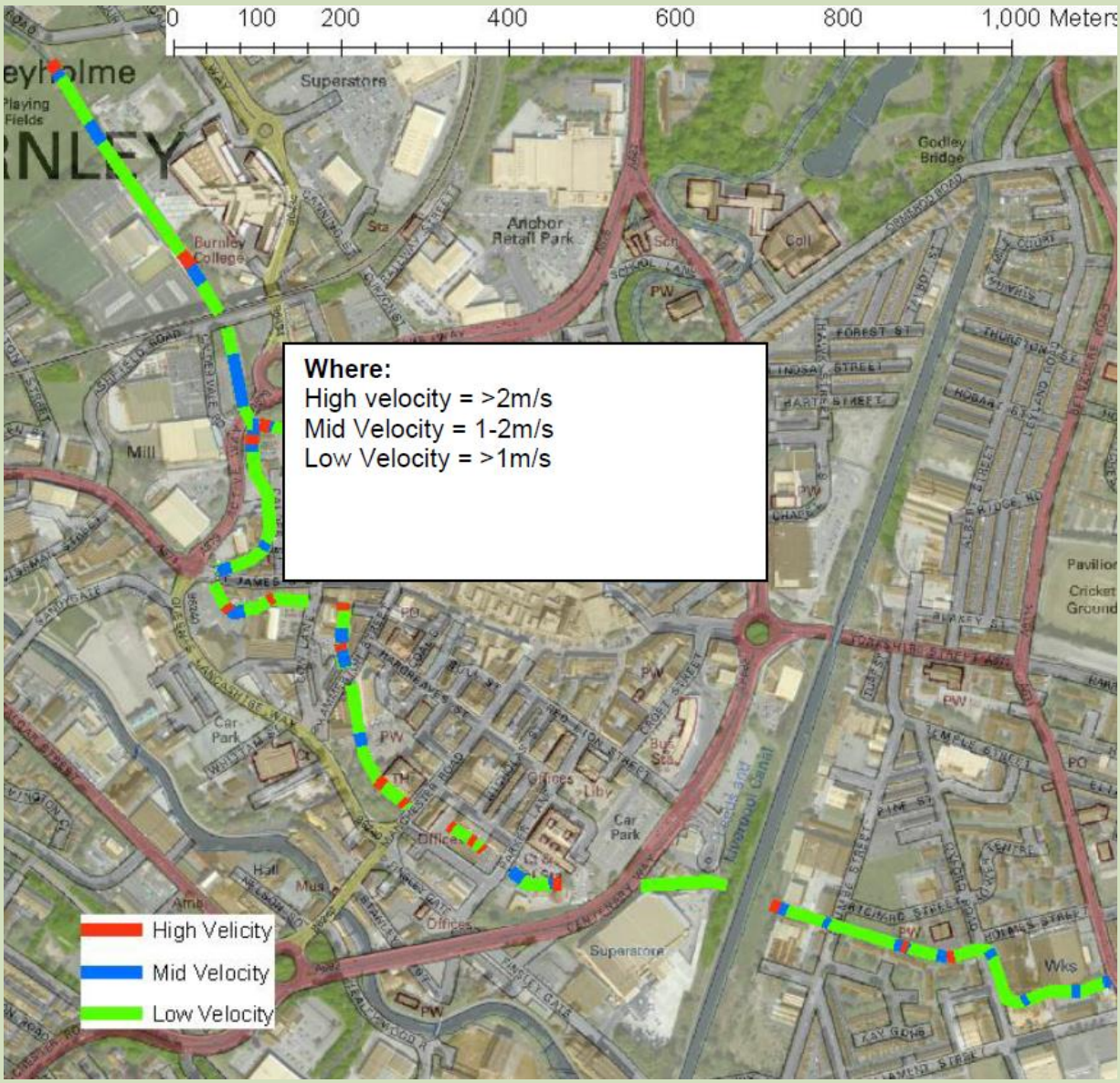


**Figure 3: Velocities along the River Calder during the Q95 (low flow) event**

Notes: Image copyright Google Earth 2012, Infoterra and Bluesky 2012

Contains Ordnance Survey data, © Crown copyright and database right 2012

## 3. Model summary

### Catchment processes investigated

An initial screening exercise was carried out to identify what data were available to enable detailed assessments of the impact on the sediment regime of the proposed restoration. Restoration features such as riffle-pool, channel narrowing/widening and backwaters were modelled for their effect on flood risk, flow velocities and shear stresses so as to understand potential impacts on in-river habitat.

Linked 1D-2D flood modelling was performed using the available ISIS-TUFLOW model to determine impacts on flood risk. The restoration measures were not designed to reduce flood risk, but to improve ecological and geomorphological condition and functioning.

Figure 4 demonstrates the changes to flood levels for an extreme event before and after the scheme, with a net reduction in water surface elevations upstream of the scheme. Figure 5 shows that the detailed ISIS-TUFLOW model predicts some very slight increases to flood extent. However, these correspond to water depths of around 3mm, which are small relative to the model uncertainties for such extreme events (100 year return period with climate change), which might be 2 orders of magnitude higher.

The following catchment processes were investigated as part of this study:

- Sediment sources pathways and receptors
- Catchment changes to the river geomorphology through restoration and impacts on habitat and fish passage

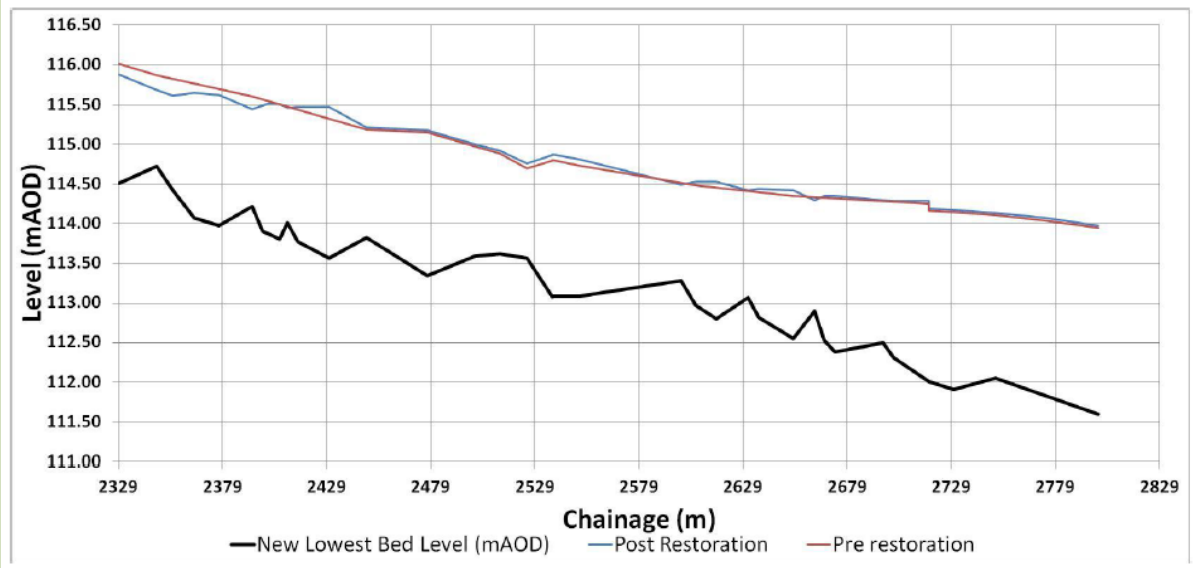


**Figure 4: Modelled flood levels (existing and proposed) for 1 in 25 year flood**

**Source: JBA Consulting**

### Model assumptions

- Fluvial audit to inform design of restoration features
- Interpretation of hydraulic impacts on the sediment regime by an experienced hydromorphologist
- ISIS-TUFLOW – an existing Environment Agency model
- Google Earth imagery
- JFLOW for exploration of wider catchment

### Data and model outputs

A fluvial audit was completed which listed historic influences and current geomorphological features and options for restoration.

The Environment Agency ISIS-TUFLOW model was used to assess potential changes to flood risk (Figure 6) with the proposed river restoration work which aimed to introduce a more natural riffle-pool sequence in the river. This requires an understanding of how the in-stream velocities might change, so a 2D JFLOW model incorporating the restoration features was constructed. This was then used to estimate the impacts on hydraulics and the sediment regime.

**Model performance**

The changes to flood risk before and after the restoration were assessed using the detailed modelling. Defence system failure was not modelled.

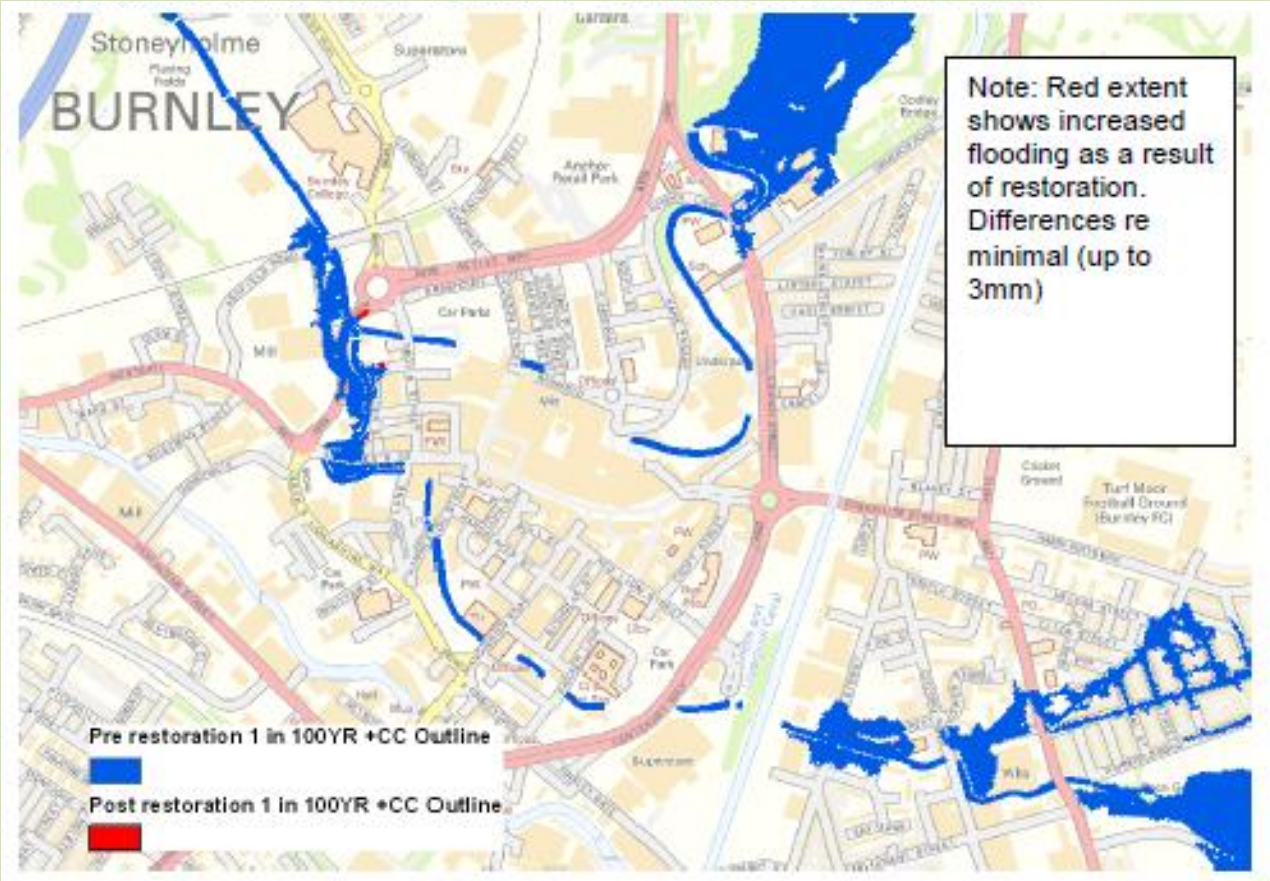


**Figure 5: Comparison of pre and post scheme 2D inundation using TUFLOW model outputs**

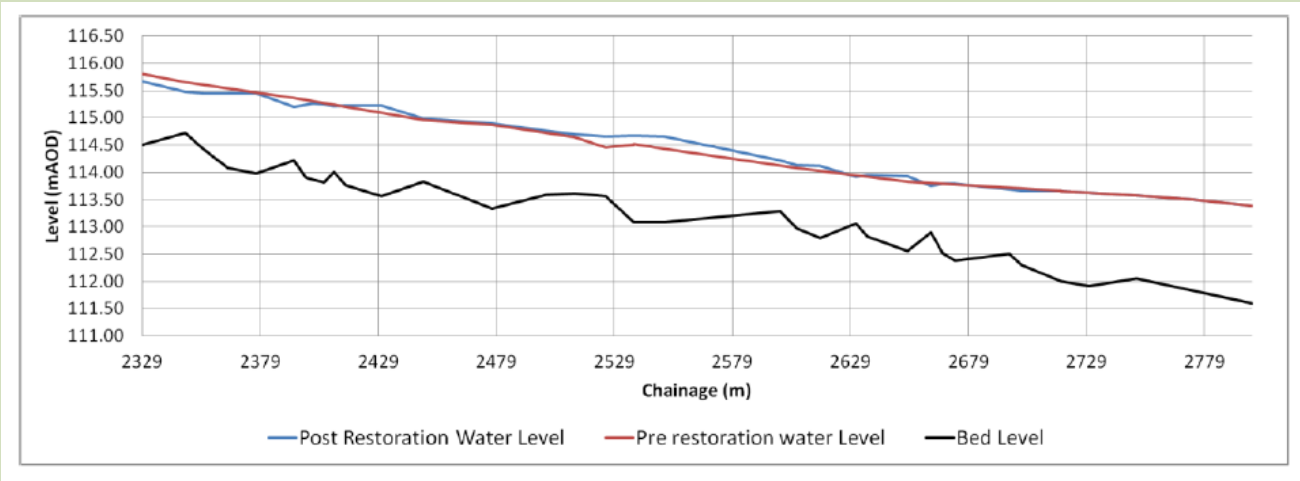


**Figure 6: 1 in 2 year flood levels for existing and proposed conditions**

Source: JBA Consulting

## 4. Lesson learnt

**Choice of tools**

A fixed bed 2D model was chosen to assess impacts of in-channel restoration measures on hydraulics and hydraulic habitat/biotopes. There are some large uncertainties around the interpretation of impacts on the sediment regime, so it was recommended that model results should be supplemented by long-term monitoring.

**Catchment scale and typology**

It was found that the high resolution Digital Terrain Model (DTM), coupled with a 2D flow model, offered a unique opportunity for rapid modelling of catchment scale restoration measures at a fine resolution. This could be repeated elsewhere, provided that LiDAR or different bands of remote sensing data are available to estimate 2D bathymetry.

The river is an active single thread, gravel and fine sediment system which suited the modelling process adopted and was appropriate for modelling of the in-channel restoration features developed.

**Wider benefits**

The restoration plan for the rivers Calder and Brun aims to generate a diverse hydromorphology along the 2 watercourses providing many niche habitats for all riverine species such as invertebrates, otters and kingfisher. It is clear from this modelling exercise that the proposed restoration measures will increase hydromorphic diversity along the study reaches throughout Burnley, creating significant new habitat and increasing the opportunity for fish to pass upstream and to become resident by creating a more diverse set of hydraulic habitats. This will be achieved around the existing constraints presented by the watercourses by altering the existing cobbled central flume, which conveys water through the urban area at high velocities impeding fish passage, to create a series of lower energy environments where appropriate habitats will be allowed to develop.

A range of options have been tested and proposed including deeper pools, wider sections and short steep sections to quickly reduce gradient and in-channel energy. Fish will be able to use bursts of energy to pass up faster flowing sections (such as riffles) and to rest in the lower velocity pools and backwater areas. Sediments will also become stored and will build up to dimensions that will not compromise flood relief levels through the town.

**Future research needs**

This is a good example of where existing flood models have been used for new purposes. It was also found that with the correct data, 2D modelling can be used rapidly to understand distributed velocities. The velocity and shear stress data from 1D and 2D models were also found to be useful for estimating sediment mobility and fish passage. For instance, biological studies estimate that fish can swim in flows up to 2m per second but need to rest after this. With careful design of pool and riffles to remove extensive high velocity areas, the modelling was able to show habitat improvement. Flood risk improvements associated with river restoration were only marginal, with some local increases and decreases in flood extent and inundation depth predicted.

## 5. Bibliography

RIBBLE CATCHMENT CONSERVATION TRUST, 2012. Burnley options appraisal report final (v1.3). Report by JBA Consulting for the Ribble Catchment Conservation Trust.

**Project background**

This case study relates to information from project SC120015 'How to model and map catchment processes when flood risk management planning'.

It was commissioned by the Environment Agency’s Evidence Directorate, as part of the joint Flood and Coastal Erosion Risk Management Research and Development Programme.

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