Case study 3

Holnicote demonstration project - Somerset

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1. Catchment summary

Study location

The National Trust Holnicote Estate covers the majority of 2 study catchments, the Horner (also known as Horner Water) and the Aller (Figure 1). The catchments are located on the north-east edge of Exmoor National Park and flow down to the sea at Porlock Bay. The Horner catchment has an area of about 22km2. Horner is about 15km long and drains the hills of Exmoor to the confluence with the River Aller, from where the combined river flows into Porlock Bay by seeping through a large shingle ridge.

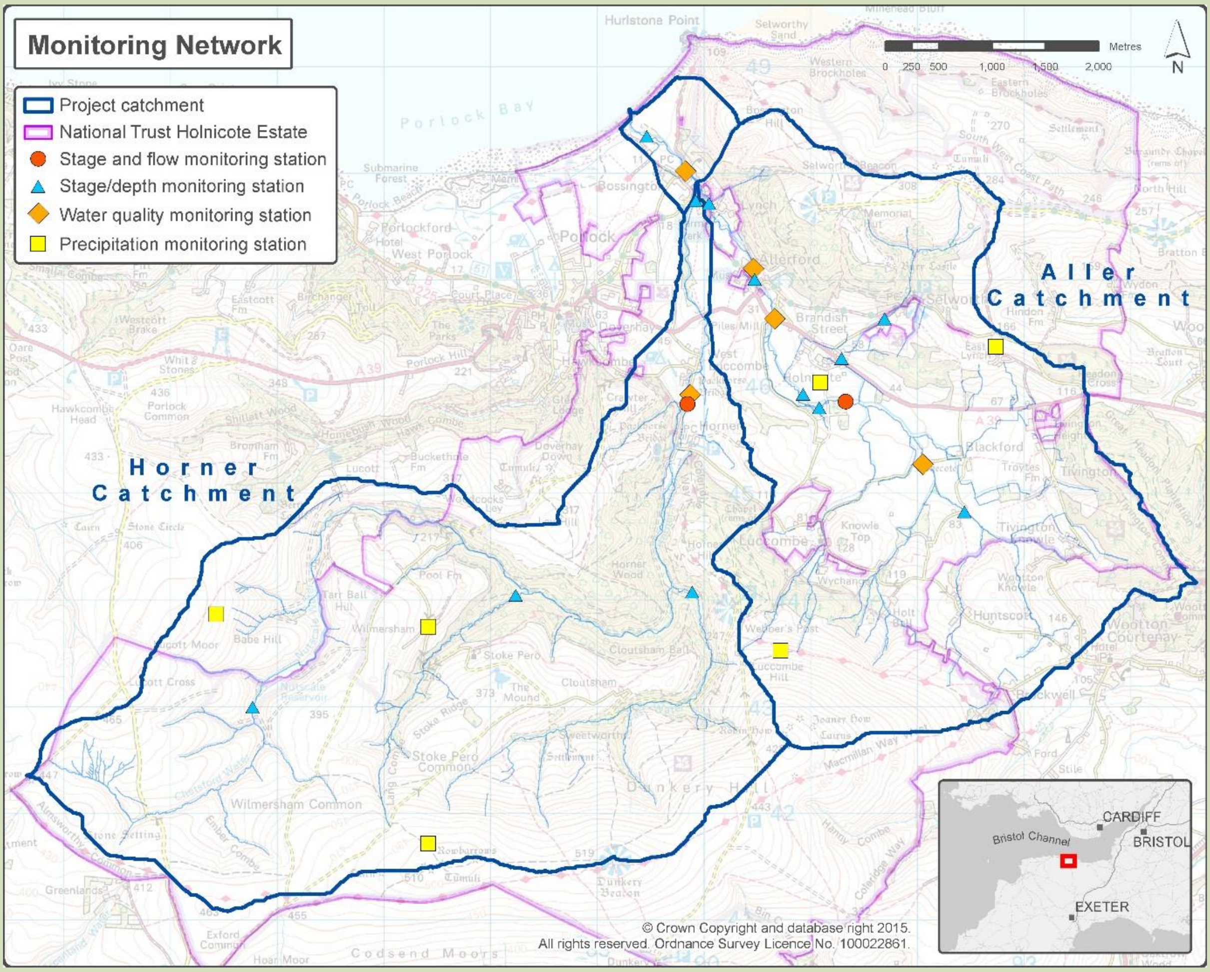

Figure 1: Catchment orientation

Source: JBA Consulting

Catchment summary

The topography of the Horner catchment is characterised by extensive high upland moors at the headwaters (Exmoor) at about 500 metres above Ordnance Datum (mAOD). There are rapid response steep wooded gullies and combes further downstream at about 300mAOD with very confined floodplains and sloping down through woodland, grassland and arable land uses towards the low lying areas (around 20mAOD) at the confluence with the River Aller. The uppermost 20% of the Horner catchment flows through a small water supply reservoir Nutscale Reservoir, which is currently not operational. The reservoir is managed by Wessex Water and exerts a control on stream flows in this area before passing through a nationally important area of ancient oak woodland called Horner Wood. Most of the Horner catchment is a Site of Special Scientific Interest, a Special Area of Conservation and a National Nature Reserve. It also includes a high concentration of nationally important archaeological features.

The Aller catchment has an area of about 18km2 and the river is about 7km long. The topography of the catchment is generally lower than that of the Horner Water catchment, ranging from about

400mAOD in the moorland headwaters to around 40–50mAOD in the middle reach of the Aller. It encompasses a range of woodland, grassland and arable land uses, together with the villages of Allerford and West Lynch. The middle and lower Aller catchment contains a wider floodplain than the Horner catchment; parts of this floodplain have been actively managed in the past as flood meadows. The catchment area downstream of the confluence of the Aller and the Horner drops down from about 20mAOD in the river valley to sea level. It contains mostly grassland and arable land uses, with woodland on the eastern valley side and the village of Bossington.

The Environment Agency Flood Map prior to 2009 indicated that almost 100 properties were at risk of flooding within a number of historic villages in the Horner and Aller catchments. The National Trust owns over half of the properties at risk, with an insurance value of about £30 million.

The most important flood risk receptors are the villages of Horner, West Luccombe, Allerford, West Lynch and Bossington. Properties in these villages are at risk of flooding from the watercourses which are influenced by:

- a legacy of flow constrictions within the drainage networks such as narrow historic stone bridges
- the lack of undeveloped channel and floodplain capacity through the built-up areas
- There is also evidence of increased run-off from the headwater moorland areas where surface run-off is conveyed rapidly to the arterial drainage network via a dense network of tracks, paths and roads. Severe run-off and sediment transport generated by inappropriate and/or untimely soil and land management activities in vulnerable arable and grass fields is a further problem.

A range of natural flood management interventions (Figure 2) were implemented and monitored across the Horner and Aller catchments between 2011 and 2014. These included:

- moorland headwater storm run-off impedance works
- in-channel woody debris dams and woody debris retention (natural and artificial)
- woodland planting
- online leaky sluices
- floodplain storage bunds (with controlled drainage outlet pipes)
- Molinia (purple moor grass) management
- reversion of arable fields to grassland

Study summary

In response to one of the recommendations of the Pitt Review of the summer 2007 floods, in 2009 Defra commissioned 3 new science projects, including Holnicote, as part the Multi-Objective Flood Management Demonstration Scheme. The aim of the scheme was to generate hard evidence to demonstrate how integrated land management change, working with natural processes (WwNP) (or natural flood management) and partnership working could contribute to reducing local flood risk while producing wider benefits for the environment and communities.

For the Holnicote project, the main objectives were to:

- establish a strong hydrological monitoring programme across the study area
- identify potential catchment (hillslope and floodplain) interventions that may contribute to managing flood risk
- demonstrate practical implementation of catchment interventions
- assemble evidence, both from recorded datasets and hydrological/hydraulic modelling, of the impact of the catchment interventions on run-off and flood dynamics
- assess what the evidence reveals about the potential or actual benefits in terms of both flood risk management and the putting in place of a range of other ecosystem services

A sophisticated monitoring (stage/level, flow and rainfall) and data telemetry system was established across the catchments in 2010, with various improvements and modifications to the system during subsequent years. A PhD student from Exeter University (Miriam Glendell) explored aspects of water quality (that is, nutrients, sediment and macroinvertebrates) in relation to the WwNP interventions across both the Horner and Aller catchments.

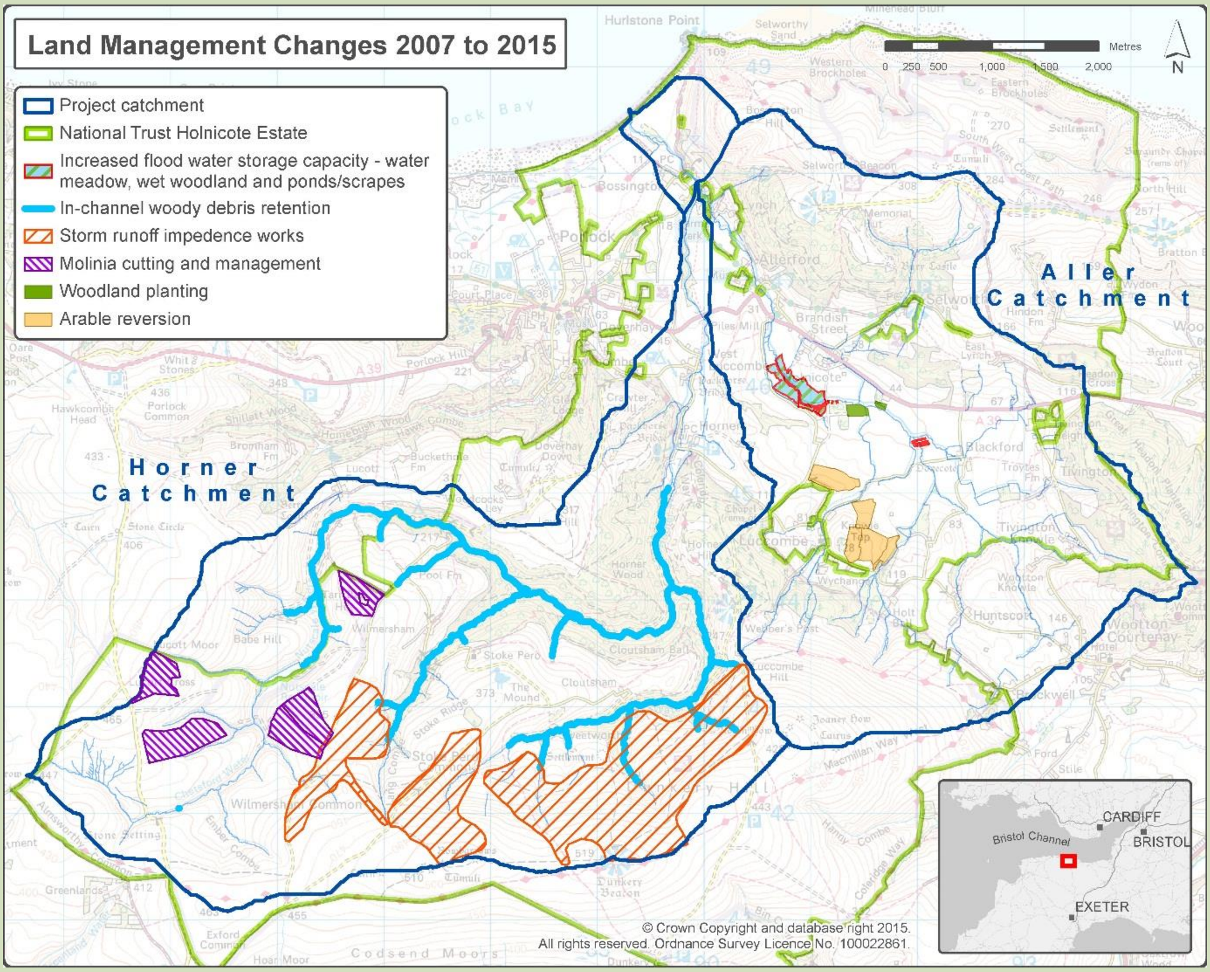

Figure 2: Land management changes

Source: JBA Consulting

Community involvement

Regular and open engagement and consultation with all stakeholder groups from local communities to regulatory and planning authorities was fundamental to every stage of the Holnicote Project. Engagement and consultation activities were co-ordinated through the local National Trust project manager. Numerous meetings, demonstration events, site visits and workshops were organised by the project team.

2. Data summary

Datasets and analysis techniques used

A wide range of datasets were utilised including:

- a high resolution Digital Terrain Model (DTM) over entire catchment (some merging of separate DTMs, from different sources, was required)
- rainfall
- stage (level)
- flow (discharge)
- soils
- land cover

- catchment characteristics from the Flood Estimation Handbook CD-ROM
- high resolution colour aerial photos
- topographic survey – channels, structures, floodplain
- Ordnance Survey MasterMap
- environmental/heritage designations

In addition, 15 minute observational datasets of rainfall, rivers stages and river flows were collected.

Data restrictions

None.

3. Model summary

Catchment processes investigated

The modelling at Holnicote included the simulation of a wide range of design and actual flood events for a number of ‘before’ and ‘after’ WwNP scenarios. Different magnitude design events, together with actual measured events, were considered. Changes in the hydrograph characteristics (shape and timing aspects) were explored along with, for some aspects, the count of properties affected before and after WwNP implementation.

Model assumptions

A range of hydrologic and hydraulic modelling approaches were applied to different aspects of the Holnicote project to explore the various WwNP elements.

Hydraulic models of the Horner and Aller catchments were developed using the ISIS one-dimensional (1D) software based on newly acquired detailed channel and structure survey datasets of all the main watercourses in the catchments. These models also incorporated a representation of hydraulic roughness of the channel and the floodplain, and the meandering nature of the watercourses. The detailed model included the upper, middle and lower reaches of the Horner, together with the middle and lower reaches of the Aller, terminating downstream of the Horner–Aller confluence at the Bossington Beach shingle ridge.

Inflows to the hydraulic models, generated by standard hydrological methods or imported from Probability Distributed Moisture (PDM) outputs were routed downstream. Here the combined of effects of hydraulic capacity, conveyance, connectivity and constrictions can lead to out-of-bank spilling onto floodplain areas. This was mapped spatially using a linked floodplain model implemented in the 2-dimensional (2D) TUFLOW hydraulic model software.

For the proposed Aller flood meadow areas, a fully linked 1D–2D ISIS–TUFLOW model was also developed to explore in detail:

- the temporal flooding dynamics on the floodplain – both with and without the various design options for this scheme in place
- the pathways of flood inundation
- the extent and depths of the flood using a DTM of the floodplain

Use of a PDM model enabled the simulation of long periods of flow that can include both high flows and low flows. More importantly, the model represents the catchment hydrological processes conceptually by a series of stores through which water travels from when it falls as rain on the land surface to when it finally emerging as river flow. This, together with the model’s representation of soil moisture store properties, enables considerable flexibility when investigating the impact of land management changes on run-off.

A range of analytical investigations were applied to the collected data and the modelling being developed. Specific PDM parameters, reflecting both the characteristics of the soil moisture store and the run-off response function, were adjusted to represent a number of theoretical unconstrained land management changes to determine scenario inflow hydrographs that can be applied to the 1D hydraulic models and routed downstream to assess the potential flood risk impacts in the villages.

Data and model outputs

Changes in the hydrograph characteristics (shape and timing aspects) were explored together, for some aspects, the count of properties affected before and after WwNP implementation. The project also identified how the WwNP measures affect the local and catchment provision of ecosystem services.

The flood depth maps in Figure 3 for the major 23 December 2013 flood event show the effects of the construction of the flood storage bunds on the Aller floodplain. Figure 4 shows the effect of the Aller flood storage bund system on the Aller flow hydrograph during the same event.

Model performance

System performance was not directly modelled in terms of failure of the WwNP measures. Most of the WwNP measures under consideration were small and numerous, and distributed across the catchment. The larger bund features were very broad earth embankments with shallow gradients and a maximum elevation of 2m. A reservoir engineer had oversight of their construction.

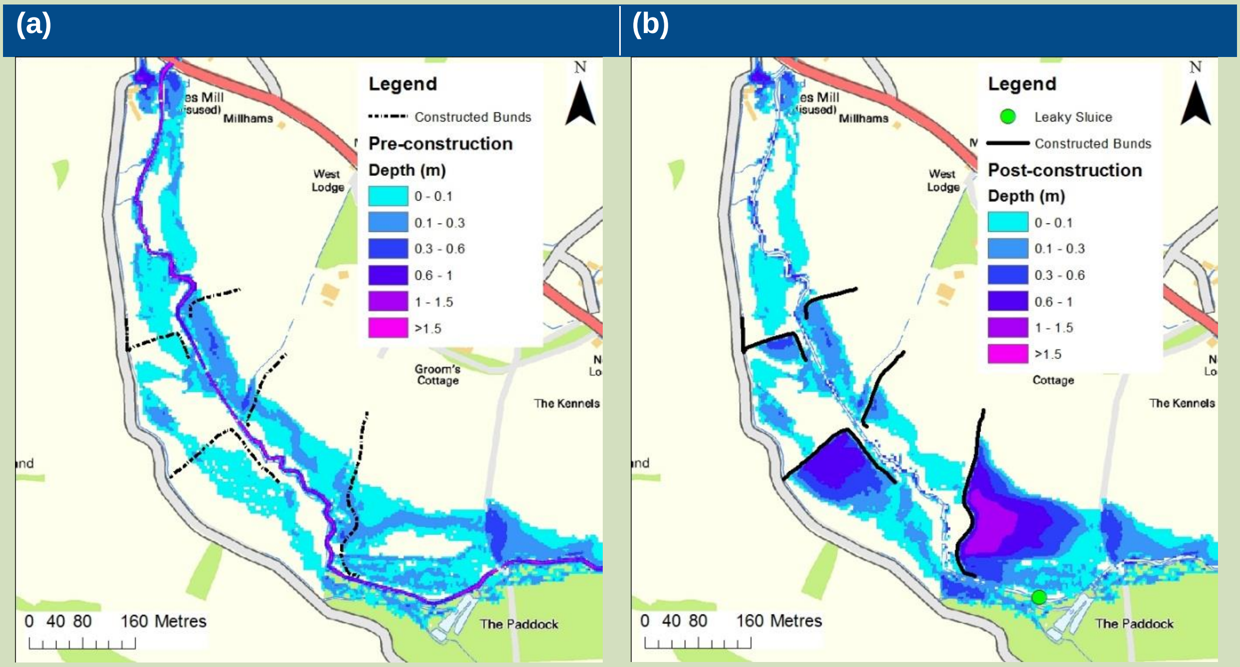

Figure 3: Predicted flooding (a) pre-construction and (b) post-construction

Source: JBA Consulting

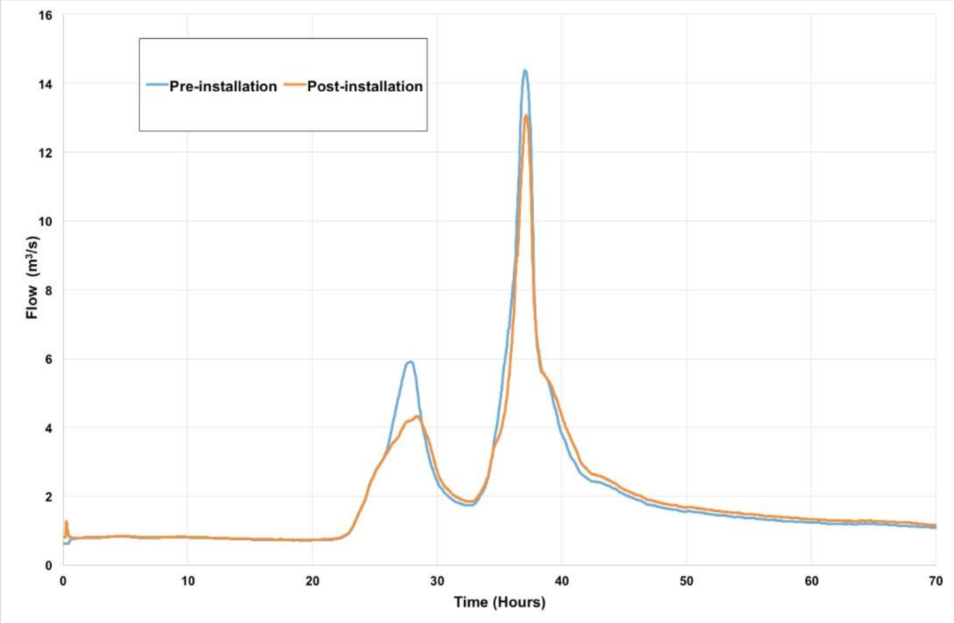

Figure 4: Aller flow hydrographs before and after installation of WwNP measures

Source: JBA Consulting

4. Lesson learnt

Choice of tools

The use of the JFLOW 2D surface water model, linked to the JBA Run-off Attenuation Feature Finder (JRAFF) tool, could easily be applied to similar investigations to speed up the identification of potential storage. The JRAFF tool looks for areas of ponded water in the updated Flood Map for Surface Water outputs (derived from JFLOW 2D surface water flood modelling) that have a surface area between 100m2 and 5000m2, are within headwater areas and are not in urban areas.

Catchment scale and typology

JFLOW was used to consider scaling up with respect to surface water flood modelling. The PDM models will, in part, account for the varying typology at a lumped scale and for some of scale dependence. However, they require flow monitoring for accurate calibration.

Wider benefits

The study describes the application of hydrologic and hydraulic modelling approaches to explore and quantify the implementation of a range of WwNP measures at a small catchment scale. The outputs, including ‘before’ and ‘after’ scenario visualisations, from the linked 1D–2D hydraulic modelling of the more complicated flood storage bund systems will give the regulatory, consenting and planning authorities greater confidence in the practical design and performance of this type of WwNP feature.

The project also identified how the WwNP measures affect the local and catchment provision of ecosystem services. This aspect was also reported through a separate Defra funded project which explored the potential for the establishment of a Payment for Ecosystem Services Scheme at Holnicote.

5. Bibliography

References to the Holnicote Project have been made in various publications and presentations on WwNP in the UK. See for instance the information on the project from the Lancaster Environment Centre (www.lancaster.ac.uk/lec/sites/catchmentchange/news/holnicote/).

ENVIRONMENT AGENCY, 2014. Evaluating the benefits of catchment management for multiple ecosystem services. Report SC120042. Bristol: Environment Agency.

NATIONAL TRUST, 2015. From source to sea: natural flood management – the Holnicote experience. Final Report to Defra. Supported by a range of project publications on an accompanying database.

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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