Slowing the Flow at Pickering, UK

Year of issue

2025

Summary

The Slowing the Flow at Pickering project (2009–2015) set out to reduce flood peaks in Pickering, North Yorkshire, by harnessing natural processes across the Pickering Beck catchment. Key measures - four low-level earth bunds, over 160 leaky woody dams, moorland and forest drain-blocking, riparian and farm woodland planting, sediment traps and no-burn buffer zones - were installed to slow runoff, boost infiltration and store water temporarily.

Launched after costly floods in 1999-2007, the scheme offered a cheaper, landscape-scale alternative to hard defences. In 2015’s Boxing Day storm, none of the dozens of at-risk properties flooded, demonstrating the network’s effectiveness under extreme rainfall.

After the official end of the project in 2015, the site remained monitored. More recently, beavers have been introduced into a fenced adjacent catchment to work alongside leaky dams-early observations suggest they enhance dam stability and create richer wetland habitats. All measures remain in place, with ongoing monitoring and targeted maintenance ensuring sustained performance.

The site still has not been affected by a storm event of sufficient intensity to demonstrate the expected effectiveness of the measures to their full extent.

Photo Gallery







Location

54.25, -0.77

Project

NWRM

National ID

UK_03

Sector

Hydromorphology

Installation Date

2011, 2015

Implementation status

Ongoing

Contact

Alistair McVittie, SRUC

Overview

Location of the project

Pickering, North Yorkshire.

Country

United Kingdom

NUTS2 Code

North Yorkshire

Sponge measures implemented in the case study

Ponds and scrapes

Peak flow control structures

Forest riparian buffers

Coarse woody debris

Controlled reintroduction and conservation of beavers

Objectives

Reduce flood risk and protect the populations from floods.
Demonstrate the effectiveness of natural flood management methods compared to traditional grey infrastructures.

Involved partners

Authority type	Authority name	Authority role	Comments	Authority responsibility
Other	Forestry Commission	Financing	Forest policy and land management/ownership. Financing of project €127,675	Responsible
National water authority	Environment Agency	Determination of design details of the measure	Expertise on design of measures. National agency responsible for flood management and WFD implementation. Financing of project €93,103	Supporting
Regional / sub-national water authority	Regional Flood Defence Committee	Financing	Provides funding from local levy €179,310	Supporting
Local water authority	North York Moors National Park Authority	Financing	Land management/ownership, planning authority within National Park. Financing of project €58,046	Responsible
—	Ryedale District Council	Financing	Local planning authority and project financing €1,094,368	Responsible
Other	Natural England	Financing	National agency responsible for natural heritage and agri-environment measures cover woodland creation. Financing of project €25,287	Supporting
Other	Forest Research	Initiation of the measure	Project lead	Responsible

Documents

cs-uk-03-final_version.pdf (825.18 KB)

Site Information

Climate Zone

Cool temperate moist

Temperature (°C)

9.60 °C

Runoff coefficient

0.30

Elevation range

60-200 m

Slope range

10 - 15%

Soil type

Gleysols

Vegetation class

Forest vegetation : High trees (pines, spruces)

WFD Ecological status

Moderate

WFD Chemical status

Good

Water quality status

From the 2nd River Basin Management Plans data (2016)

Design and Implementation

Project scale

Large

Project scale specifications

Project applied across a 68.6km2 catchment.

Project area

6860

Basis of design

Protect 50 properties against a 1 in 25 year flood event.

Principles

The main principle of the project is to achieve flood risk management using natural processes. This involves developing an understanding of how land use and management across the entire catchment contribute to flood risk. The project is also concerned with wider environmental, economic and social benefits. These include improved water quality, provision of new and/or improvement of existing habitats, enhanced carbon sequestration, enhanced local skill base in estate management, improved recreation/tourism access and increased public understanding and engagement in land management for flood risk reduction.

Constraints

The river channel is incised/deep which has led to disconnection from its floodplain. The low level bunds therefore require an artificial structure (pipe bridge) to ensure their effectiveness.
The presence of the historical steam train line in Pickering partially built on a fragile enbankement means more risks to take into account when designing projects having an hydrological impact.

Favourable preconditions

The key factor that influenced the choice of site was the nature of land ownership with around half the area owned by either the public sector (Forestry Commission and the North York Moors National Park Authority) or the Duchy of Lancaster Estates.
Mapping data and catchment models from previous research had been used to identify sites for low level bunds. This research also involved stakeholder engagement which may have been important in overcoming barriers. Opportunity mapping for woodland creation for flood risk reduction had also been undertaken.

Financing

Total cost

1580000.00 €

Costs investment

1580000.00 €

Costs investment information

€1.32m : low level bunds
€17,951 : riparian woodland (€2070/ha for native broadleaved, plus €2300/ha for flood risk management)
€27,782 : large woody debris dams (labour costs)

Costs maintenance information

Large woody debris dams are expected to need ongoing maintenance, the costs are not specified

Information on Economic costs other annual

The ecosystem services assessment estimated increaed forestry costs of €620,000 over 100 years

Administrative annual cost information

Costs of existing monitoring and data management are met from the budgets of relevant agencies.

Information on Economic costs - income loss

An ecosystem services assessment estimated impacts of 85ha of woodland creation and 150 large woody debris dams but not the storage bunds. This is a higher area of woodland than actually planted. The estimated loss of agricultural production was €36326 per year or €1047000 over 100 years.

Financing authorities

Authority name	Type of funding	Comments	Financing share
Forestry Commission	National funds	Note that a large part of the local funding will have come from national funding allocations (e.g. block grants) to local authorities	€127,675
Environment Agency	National funds	—	€93,103
Natural England	National funds	—	€25,287
Regional Flood Defence Committee	Sub-national funds	—	€179,310
North York Moors NPA	Local funds	—	€58,046
Ryedale District Council	Local funds	—	€1,094,368

Compensations

No

Compensations annual information

No specific compensation is discussed in the project documentation, but it is noted that given potential losses of agricultural output, compensatory payments may be necessary to ensure sufficient uptake of some measures.

Policy and Governance

Policy description

The town of Pickering in North Yorkshire has a history of flood events, most recently in 1999, 2000, 2002 and 2007; the last of these causing an estimated £7m (€8.05m) of damage. The Slowing the Flow at Pickering project was one of three pilot projects funded by under Defra's multi-objective flood management demonstration programme. A flood alleviation capital scheme was also proposed but deemed unaffordable under current national cost-benefit thresholds.

Land ownership

Most is public ownership or management (Forestry agency, national park authority, ministry of defense, English crown)

Policy targets

Increase Water Storage

Peak-flow reduction

Policy pressure

Directive	Relevant pressure
Floods Directive identified pressure	Natural Exceedence

Pressure remarks

This project pre-dated transposition of the Flood Directive into UK law.

Policy impact

Directive	Relevant impact
Floods Directive identified pressure	Property

Requirement directive

Requirement directive
Floods Directive-mitigating Flood Risk

Policy challenges requirements

The Pitt Review of the 2007 floods in England and Wales called for Defra, the Environment Agency and Natural England to work with partners to deliver flood risk management involving greater working with natural processes.

Part of a wider plan

No

Public consultation

No

Consultation activities

Activity stage	Activity type	Comments
Design phase	Public meeting	Flooding: can local knowledge make a difference? Exhibition held at Pickering Memorial Hall by the Ryedale Flood Research Group. Around 200 people attended the exhibition and were able to read about the group's work, watch video clips, talk to group members and try their hand at modelling
Design phase	Public meeting	Community engagement event. This public event in the Memorial Hall Pickering, was held to enable the project team to engage the community and stakeholders and involve them with identifying and implementing solutions on the ground.
Implementation phase	Media releases	Variey of media (web, press, radio) coverage at local/regional and national levels

Has contractual arrangements

No

Impacts and Monitoring

Monitoring System

Monitoring requirements

The catchments are subject to existing and routine hydrological monitoring and assessment for WFD compliance. Additional monitoring may occur during potential flood events.

Upstream station

Recording of water levels at different points (upstream and downstream from some measures)

Maintenance

Maintenance requirements

Depends on the measures, and the available funds.

Impact Assessment Methodology

Performance impact assessment method

Unknown

Performance impact estimation information

Impacts have currently only been assessed using hydrological models comparing pre and post implementation scenarios.

Cost assessment method

The costs of measures have been based on estimated capital costs, woodland grant payments and labour costs. Maintenance and replacement costs are not taken into account, yet they could weigh significantly on long term costs.
Benefits estimates for flood regulation are based on the actual costs (2007) or estimated per property flooded costs (2000) of previous flood events adjusted by flood return periods and extent of alleviation offered by measures.
Other ecosystem service benefits are estimated using a variety of approaches.
The overall assessment is based on a cost-benefit test of net present values of benefits over 100 years.

Socio-economic Impacts

Benefits and co-benefits

The severe flooding of 2007 caused an estimated €8.05m of damage to property in the town of Pickering.
All values converted using €1 = £0.87 (average 2011 value).

Ancillary benefits

270450

Ancillary benefits information

An ecosystem services assessment estimated impacts of 85ha of woodland creation (F1: riparian, floodplain and farm woodland) and 150 large woody debris dams (F10) but not the storage bunds (N1). This is a higher area of woodland than actually planted.
Mean annual (€/yr)
Habitat creation: 139,683
Flood regulation: 6,855
Climate regulation: 123,029
Erosion regulation: 236
Education and knowledge: 16
Community development: 631

Biophysical impacts: Hydrology

Hydrological effects

It reduced peak flows, delayed runoff, increased temporary water storage, and slightly improved infiltration and baseflows, helping smooth the hydrological response during storms without major changes to the overall water balance.

Information on increased water storage

Source reference gives estimated total storage without time values, these range from 90000 to 138000 m3

Information on runoff reduction

Sites were identified using modelling for two low level bunds between 1.5 and 2.5m in height, this would provide 85,000m3 of flood storage sufficient for the flood events of 1999, 2000 and 2002. Larger events such as 2007 would require 650,000m3of additional storage. The river channel was too incised/deep for the bunds to be effective so these were designed to operate in conjunction with a pipe bridge to constrict flow and reconnect the river with its floodplain.

Based on estimated peak flow reductions, the joint impact of 50 ha of riparian woodland planting and 100 large wood debris dams is estimated at between 15,000 and 53,000m3 for the 2000 and 2007 flood events respectively. However new planting of woodland was only considered to be acceptable at only 4 sites covering 4.1ha. From the source it is not possible to disaggregate the impacts of measures F1 and F10 so care is advised in using these values.

Information on peak flow reduction

Mean estimated combined impact of riparian woodland and woody debris dams, range of 6.7% to 14.7% depends on size of flood event.
The combined peak flow reductions of for a modelled 50ha of riparian woodland and 100 large wood debris dams was estimated at 0.8 and 2.2 cumecs for the 2000 and 2007 flood events respectively. However new planting of woodland was only considered to be acceptable at only 4 sites covering 4.1ha.

Information on increased infiltration

Possible increase in infiltration due to flow reduction effects

Information on soil moisture

Possible increase in soil moisture due to increased retention

Ecosystem flood control return periods

1 in 25

Information on ecosystem flood control return periods

Floodplain storage has sufficient capactiy for a 1 in 25 year flood event.

Information on reducing flood risks quantity

The degree of peak flow rate reduction associated with the low level bunds is dependent on the design of the associated pipe bridge and whether this can restrict a flow of 12 or 15 cumecs. Flows of 12 cumecs are associated with 6 properties being flooded; flows of 15 cumecs would lead to flooding affecting 50 properties.

Reducing flood risks quantity change

The measures have successfully reduced flood peaks in Pickering during moderate to high but non-extreme events. The 2015 Boxing Day flood brought extreme rainfall, and many rivers in the region flooded severely, but in Pickering no properties flooded. The storage bund at Newbridge reached about 85% of its capacity during the event.

Information on peak delay effects

Floodplane woodland estimated to delay flood peak by 20 minutes, considered to be small to significant

Biophysical impacts: Biodiversity

Improved biodiversity

Yes

Information on improved biodiversity

The biodiversity benefits from the Pickering measures are modest but positive. No formal biodiversity index or class shift reported, but anecdotal evidence and local surveys note rises in pollinator species, wading birds, and aquatic invertebrates. Bats and otters also benefited from enhanced woodland cover and watercourse complexity.
The introduction of beavers in an adjacent catchment is being monitored for future biodiversity effects.

Biophysical impacts: Water & Soil Quality

Water quality overall improvements

Neutral impact-no change in WQ status

Information on water quality overall

Limited evidence, but likely minor improvements: reduced sediment transport from blocked drains and woodland planting, and better filtration from leaky dams. No major water quality monitoring was done, so impacts remain mostly assumed, not confirmed.

Soil quality overall improvements

N/A info

Ecosystem erosion control

Yes

Information on WFD ecological status obj quantity

The project is expected to improve WFD ecological status. The impacts are not specified but could include increased shading and reduced sediment loading due to riparian woodland, and improved habitats from LWD dams.

Biophysical impacts: Others

Ecosystem impact climate regulation

Increased permanent biomass

Information on ecosystem impact climate regulation

Increase in woody biomass and soil C storage

Lessons Learned

Key lessons

Two years was too short for the project. At least 3–5 years are needed for planning, consultation, modelling, and implementation.
Long-term monitoring is essential. Impacts take time to show, and baseline data often comes late. The measures still haven’t faced a 1-in-25-year flood.
A proactive, flexible approach from partners is key. Strong communication and willingness to adapt (e.g., to maintain structures) are essential.
Community engagement: Expectations must be managed realistically. Community involvement worked well, but clearer messaging on NFM limitations is needed.

Locals support whole-catchment natural flood management (NFM), but NFM should be seen as part of a wider flood management strategy, not a stand-alone solution.
Maintenance: Structures like bunds and leaky dams need upkeep. Some have decayed as expected; replacements and natural evolution (e.g. with beavers) help.
Support & policy: Volunteer-led projects need long-term funding and integration into national flood management policy to stay effective.

Barriers

Barrier type	Barrier role	Comments
Other	Main barrier	Construction delayed until January 2014 with completion due April 2015. Due to the reliance on another flood protection scheme for provision of the clay needed for construction
Legal obligations / restrictions	Secondary barrier	The size of the scheme (>25,000m3) meant that the measure was subject to the safety requirements of the Reservoirs Act 1975, specifically the risk to lives and property should the bunds fail.
Legal obligations / restrictions	Main barrier	Constrained due to existing conservation designations covering landscapes, habitats, species and archaeological heritage.
Lacking financing sources	Main barrier	Financial barriers due to the loss of agricultural production and a reduction in grants from €4598/ha to €2299/ha due to the closure of the Regional Development Agency.
Attitude of decision makers	Secondary barrier	Potential barrier for the further development of beaver reintroduction is the overall reluctance from the pubic and decision makers to let them develop freely (without an eclosure to contain them). It is seen as a potential source of land conflicts with agriclutral activity for example.

Drivers

Driver type	Driver role	Comments
Past flooding events	Main driver	A flood alleviation capital scheme was also proposed but deemed unaffordable under current national cost-benefit thresholds.
Other	Main driver	Willingness to create a demonstration site to expose and assess the effectiveness of natural flood management methods.

Success factors

Success factor type	Success factor role	Comments
Existing institutional framework	Main factor	Land ownership was relatively concentrated with around 50% of catchment in either public ownership (Forestry Commission and the North York Moors National Park Authority) or the Duchy of Lancaster Estates.
Available support tools	Secondary factor	The catchment had been subject to hydrological modelling as part of a previous academic study.

Success factor type	Success factor role	Comments
Attitude of the public	Secondary factor	Ongoing process of stakeholder and community engagement in both the aims and delivery of the project.
Other	Main factor	Land Control was probably the main success factor. There have been unsuccessful attempts to duplicate these measures on sites with multiple private owners, due to the lack of willingness of owners to participate.

Cost effectiveness

Most effective measure are timber bunds, as they are very cheap (using local wood). Beaver introduction have a lot of potential, being cheaper in work costs and similar hydrological effectiveness.

Flexibility / Adaptability

The catchment is subject to ongoing monitoring, including an Environment Agency gauge station in the lower catchment and Forest Research water level recorders in the upper catchment. These will help to monitor baseline conditions and assess the impact of installed measures, in particular riparian woodland and LWD dams. This may encourage further uptake of measures including better management of existing riparian woodland (in-fill planting, encouraging regeneration).

Transferability

These measures are very transferable to other sites, but special care shall be observed while designing, to avoid land conflicts. Opportunity maps are a good tool for that.

Basin characteristics influence

Pickering Beck iss deeply incised and disconnected from its floodplain. Low bunds (N1) with a pipe bridge and LWD dams (N12) helped reconnect the river by enabling it to spill into adjacent areas.

Sources

Sources

Project RMP5455: Slowing the Flow at Pickering, Final Report to Defra, Forest Research

WFD Surface Water Objectives 2012

National River Flow Archive

NEW: final reports for Slowing the Flow at Pickering project

Written evidence from ‘Slowing the Flow’ Project at Pickering, North Yorkshire (FFP 153)

Slowing the Flow Partnership Briefing: Boxing Day 2015 Flood Event

Slowing The Flow In Pickering: Quantifying The Effect Of Catchment Woodland Planting On Flooding Using The Soil Conservation Service Curve Number Method

Forest Research : Slowing the Flow at Pickering

Slowing the Flow in Pickering ...and now many other places