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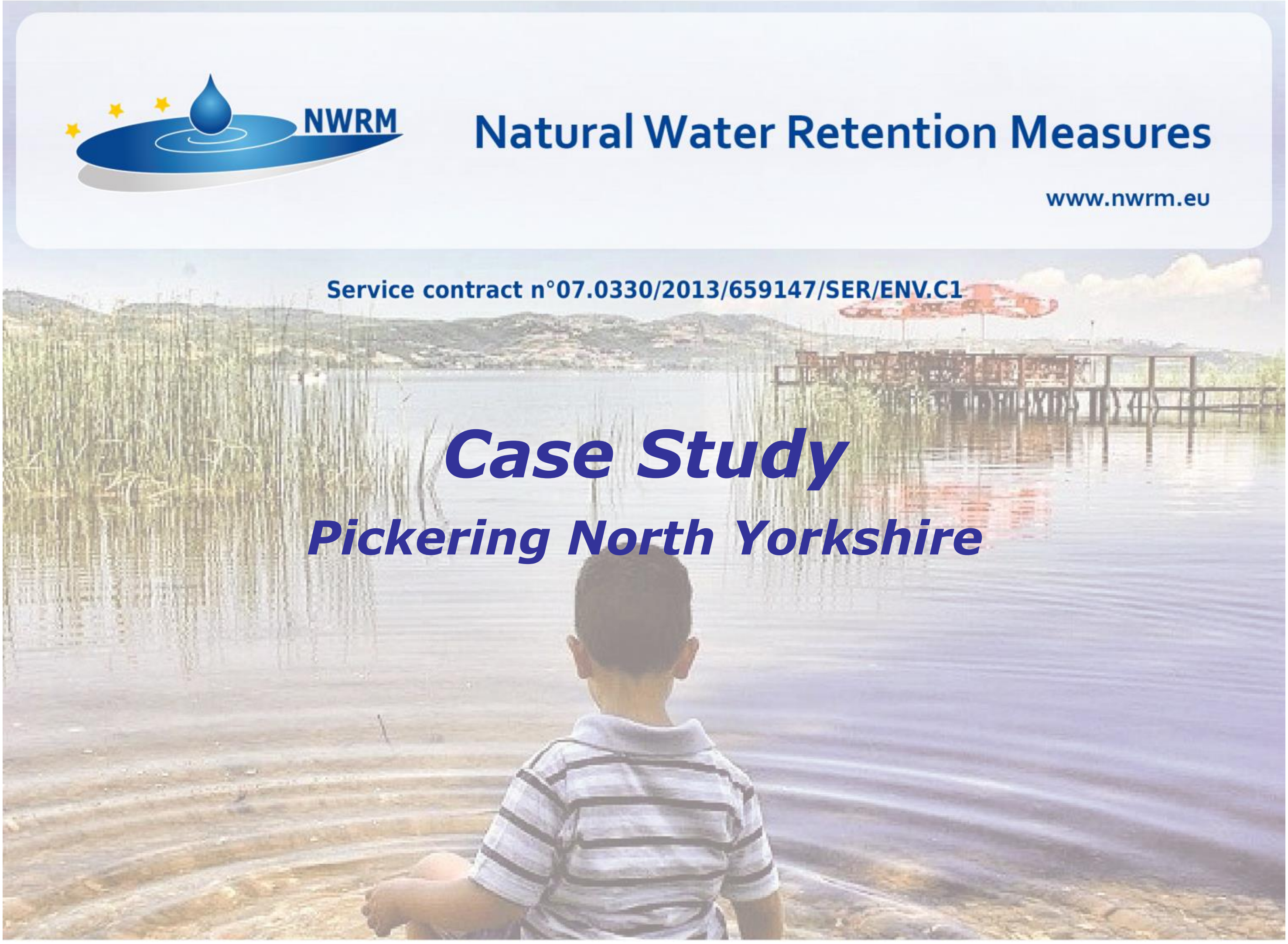

Natural Water Retention Measures

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Service contract n°07.0330/2013/659147/SER/ENV.C1

Case Study

Pickering North Yorkshire

Environment

This report was prepared by the NWRM project, led by Office International de l'Eau (OIEau), in consortium with Actéon Environment (France), AMEC Foster Wheeler (United Kingdom), BEF (Baltic States), ENVECO (Sweden), IACO (Cyprus/Greece), IMDEA Water (Spain), REC (Hungary/Central & Eastern Europe), REKK inc. (Hungary), SLU (Sweden) and SRUC (UK) under contract 07.0330/2013/659147/SER/ENV.C1 for the Directorate-General for Environment of the European Commission. The information and views set out in this report represent NWRM project's views on the subject matter and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this report. Neither the Commission nor any person acting on the Commission's behalf may be held Key words: Biophysical impact, runoff, water retention, effectiveness - Please consult the NWRM glossary for more information.

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I. Basic Information

Application ID	*UK_03*			
Application Name	**Pickering_NorthYorkshire**			
Application Location	Country:	United Kingdom	Country 2:	
	NUTS2 Code		*UKE2*	
	River Basin District Code		*UK04*	
	WFD Water Body Code		GB104027068470	
	Description		*Pickering, North Yorkshire*	
Application Site Coordinates	Latitude: *54.25*		Longitude: *-0.77*	
Target Sector(s)	Primary:	Forest		
	Secondary:	Hydromorphology		
Implemented NWRM(s)	Measure #1:	*N1*		
	Measure #2:	*F10*		
	Measure #3:	*F1*		
Application short description	The Project 'Slowing the Flow at Pickering' implements multiple natural flood risk measures including low level bunds, large woody debris dams, planting riparian and floodplain woodland, planting farm woodland, blocking moorland drains and establishing no-burn buffer zones, blocking forest drains and implementing farm-scale measures. The aim of the project is to show how land management measures can help to reduce flood risk from a river in the town and is implemented in close cooperation with local stakeholders. The project involved both the Pickering Beck and adjacent River Seven catchments, the description of measures described below relate to the former.			

II. Policy context and design targets

Brief description of the problem to be tackled	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.		
What were the primary & secondary targets when designing this application?	Primary target #1:	Flood control and flood risk mitigation	
Which specific types of pressures did you aim at mitigating?	Pressure #1:	Floods Directive identified pressure	*Natural Exceedence*
	Remarks	This project pre-dated transposition of the Flood Directive into UK law	
Which specific types of adverse impacts did you aim at mitigating?	Impact #1:	Floods Directive identified impact	*Property*
Which EU requirements and EU	Requirement #1:	Floods Directive-	

Directives were aimed at being addressed?		mitigating Flood Risk	
Which national and/or regional policy challenges and/or requirements aimed to be addressed?	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.		

III. Site characteristics

Dominant Land Use type(s)	Dominant land use	*231*	
	Secondary land use	*211*	
	Other important land use	*313, 322*	
	Catchment of Pickering Beck is characterised as wooded valleys surrounded by agricultural land (arable and pasture) and moorland in up catchment.		
Climate zone	cool temperate moist		
Soil type	*Gleysols*		
Average Slope	strong (10-15%)		
Mean Annual Rainfall	600 - 900 mm		
Mean Annual Runoff	300 - 450 mm		
Average Runoff coefficient (or % imperviousness on site)	0.3 - 0.5		
	Remarks		
Characterization of water quality status (prior to the implementation of the NWRMs)	Waterbody Summary Data	Current Overall Status	Moderate
		Ecological Status	Moderate
	Waterbody Characterisations	Hydromorphological Designation	Heavily Modified
	Biological Elements	Fish	Poor
		Invertebrates	High
		Macrophytes	High
		Phytobenthos	High
	Supporting Elements	Ammonia (Phys-Chem)	High
		Dissolved Oxygen	High
		pH	High
		Phosphate	High
		Temperature	High
		Specific Pollutants	High
	Supporting Conditions	Hydrology	Not High
	Mitigation Measures Assessment		Moderate
Comment on any specific site	*Positive way:*		

characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way	*Negative way:* The river channel is incised/deep which has led to disconnection from its floodplain. The low level bunds (N1) therefore require an artificial structure (pipe bridge) to ensure their effectiveness.

IV. Design & implementation parameters

Project scale	Large (e.g. watershed, city, entire water system)	*Project applied across a 68.6km² catchment*	
Time frame	Date of installation/construction (MM.YYYY)	*06.2011*	
	Expected average lifespan (life expectancy) of the application in years	*50 years*	
Responsible authority and other stakeholders involved	*Name of responsible authority/ stakeholder*	*Role, responsibilities*	
	1. Forest Research	Project lead	
	2. Forestry Commission (England)	Funding and land owner	
	3. North York Moors National Park Authority (NYMNPA)	Land owner and local authority	
	4. Environment Agency	Funding	
	5. Natural England	Funding and management agreements	
The application was initiated and financed by	Department for Environmental, Food and Rural Affairs (Defra)		
What were specific principles that were followed in the design of this application?	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.		
Area (ha)	Number of hectares treated by the NWRM(s).	*Number of ha*	
	Text to specify		
Design capacity	Low level bunds (N1): 85000 m³ flood storage Riparian woodland (F1): 15000 to 53000 m³ flood volume reduction (0.8 to 2.2 cumecs peak flow reduction) Floodplain woodland (F15): 14% increase in storage (20 minute flood peak delay)		
Reference to existing engineering standards, guidelines and manuals that have been used during the design phase		*Reference*	*URL*
	1.	The Robinwood Robinflood report: Evaluation of Large Woody debris in Watercourses	http://www.robin-wood.eu/uploads/robinwood_flood.pdf
Main factors and/or constraints that influenced the selection	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)		

and design of the NWRM(s) in this application?	or the Duchy of Lancaster Estates. Mapping data and catchment models from previous research had been used to identify sites for low level bunds (N1). 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.

V. Biophysical impacts

Impact category (short name) Select from the **drop-down menu** below:	**Impact description** (Text, approx. 200 words)	**Impact quantification** (specifying units)	
		Parameter value; units	% change in parameter value as compared to the state prior to the implementation of the NWRM(s)
Runoff attenuation / control	Sites were identified using modelling for two low level bunds (N1) between 1.5 and 2.5m in height, this would provide 85,000m^3 of flood storage sufficient for the flood events of 1999, 2000 and 2002. Larger events such as 2007 would require 650,000m^{3}of 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 (F1) and 100 large wood debris dams (F10) is estimated at between 15,000 and 53,000m^3 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.	N1: 85000m^3 F1 & F10: 53000m^3 (2007 flood level) 15000m^3 (2000 flood level)	13% (2007 flood level) 34% (2000 flood level) 8% (2007 flood level) 6% (2000 flood level)
Peak flow rate reduction	The combined peak flow reductions of for a modelled 50ha of riparian woodland (F1) and 100 large wood debris dams (F10) was estimated at 0.8 and 2.2 cumecs for the	F1 & F10: 0.8 to 2.2 cumecs	6.7% to 14.7% of 2000 and 2007 events

	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 project documentation it is not possible to disaggregate the impacts of measures F1 and F10 so care is advised in using these values.		respectively
Impact on groundwater			*Not measured*
Impact on soil moisture and soil storage capacity			*Not measured*
Restoring hydraulic connection			*Not measured*
Water quality Improvements	The project is expected to improve water quality. The impacts are not specified but could include reduced sediment loading due to riparian woodland.		*Not measured*
WFD Ecological Status and objectives	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.		*Not measured*
Reducing flood risks (Floods Directive)	The degree of peak flow rate reduction associated with the low level bunds (N1) 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.	N1: 6 or 50 properties protected from 1 in 25 year flood	
Mitigation of other biophysical impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.)	A number of potential sites for riparian woodland were discounted due to existing designations (Sites of Special Scientific Interest or Scheduled Monuments), the specific constraints being the need to maintain iconic open moorland landscapes in the upper catchment; the need to conserve water vole habitat and wetland flushes; and the protection of nationally important archaeological sites. Therefore, although in general the measures are expected to have positive habitat benefits there are some constraints on specific sites.		*Not measured*
Soil Quality Improvements	The project is expected to reduce soil erosion risk through riparian woodland planting.		*Not measured*
Other			*Not measured*

VI. Socio-Economic Information

<table>
<tr><td>What are the benefits and co-benefits of NWRMs in this application?</td><td colspan="3">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)</td></tr>
<tr><td rowspan="6">Financial costs</td><td>Total:</td><td>€1.58m including:
€1.32m
€17,951

€27,782</td><td>N1: low level bunds
F1: riparian woodland (€2070/ha for native broadleaved, plus €2300/ha for flood risk management)
F10: LWD dams (labour costs)</td></tr>
<tr><td>Capital:</td><td>€1.32m
€17,951</td><td>N1: design and construction
F1: woodland planting grants</td></tr>
<tr><td>Land acquisition and value:</td><td></td><td></td></tr>
<tr><td>Operational:</td><td></td><td></td></tr>
<tr><td>Maintenance:</td><td></td><td>F10: ongoing costs expected but not specified</td></tr>
<tr><td>Other:</td><td>€27,782</td><td>F10: labour costs for Forestry Commission and North York Moors NPA</td></tr>
<tr><td rowspan="4">Were financial compensations required? What amount?</td><td colspan="3">Was financial compensation required: No</td></tr>
<tr><td colspan="3">Total amount of money paid (in €):</td></tr>
<tr><td colspan="3">Compensation schema:</td></tr>
<tr><td colspan="3">Comments / Remarks: 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.</td></tr>
<tr><td rowspan="4">Economic costs</td><td colspan="3">Actual income loss:</td></tr>
<tr><td colspan="3">Additional costs:</td></tr>
<tr><td colspan="3">Other opportunity costs:</td></tr>
<tr><td colspan="3">Comments / Remarks: Losses of agricultural production were estimated and values are given below with respect to the ecosystem services assessment. These were in relation to a specific implementation scenario.</td></tr>
<tr><td>Which link can be made to the ecosystem services approach?</td><td colspan="3">The primary aim of the project is to mitigate flood risk, however to improve the cost-effectiveness of the project a wider set of ecosystem service benefits were assessed. These were assessed on the basis of 85ha of woodland creation (riparian, floodplain and farm woodland) and construction of 150 LWD dams across both the Pickering Back and River Seven catchments; low level bunds were not evaluated. Consequently the estimated ecosystem service benefits should be treated with caution as they do not reflect all the planned measures or the actual extent of implementation. Furthermore, they are estimates based on specific assumptions and transferred values rather than on site measurements.
The ecosystem service categories and estimated values are presented below:</td></tr>
</table>

	Mean annual (€/yr) / Central over 100 years (€k) Habitat creation 139,683 3,187 Flood regulation 6,855 201 Climate regulation 123,029 3,218 Erosion regulation 236 6 Education and knowledge 16 1 Community development 631 18 Agricultural production -36,326 -1,047 Forestry costs -620 **Net present value** **4,967** The estimates indicate that considering flood regulation benefits alone would not justify the expenditure on forest planting, a situation that becomes worse when lost agricultural production is included. However substantial public benefits from habitat creation and climate regulation are estimated that yield high net benefits. The basis of the ecosystem service benefit estimates are outlined below: **Habitat creation**: Unadjusted benefit transfer from estimated values for similar habitats. **Flood regulation**: Avoided damage cost of flood events based on percent of flood level mitigated and flood return period. **Climate regulation**: UK DECC non-ETS sector carbon values applied to biomass, soils and woody debris. **Erosion regulation**: Avoided dredging costs due to assumed reduction in sediment delivery following riparian woodland planting. **Education and knowledge**: Potential cost savings for educational/training visits over alternative sites, these are assumed to decline over time. **Community development**: Assumed ongoing volunteering time multiplied by zero wage (100% local deadweight loss), national minimum wage or mean local district wage. **Agricultural production**: Value of lost farm gross margin, net farm income or an intermediate value is applied to floodplain woodland (cereal farms), farm woodland (lowground beef and sheep) or riparian woodland (50% of Less Favoured Areas cattle and sheep values).

VII. Monitoring & maintenance requirements

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.
Maintenance requirements	No maintenance requirements are outlined in the project references.
What are the administrative costs?	Costs of existing monitoring and data management are met from the budgets of relevant agencies.

VIII. Performance metrics and assessment criteria

Which assessment methods and practices are used for	Impacts have currently only been assessed using hydrological models comparing pre and post implementation scenarios.

assessing the biophysical impacts?	
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	The costs of measures have been based on estimated capital costs (N1), woodland grant payments (F1) and labour costs (F10). 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 outlined in section 6. The overall assessment is based on a cost-benefit test of net present values of benefits over 100 years.
How cost-effective are NWRM's compared to "traditional / structural" measures?	A traditional flood alleviation scheme proposal did not pass current cost-benefit thresholds for England. The NWRM scheme was not assessed ex ante but the scenarios tested does pass a cost-benefit test with respect to public benefits.
How do (if applicable) specific basin characteristics influence the effectiveness of measures?	The channel of the Pickering Beck was found to be incised/deep with the result that had become disconnected from its floodplain. The low level bunds (N1) therefore needed an adjacent pipe bridge to constrict flow sufficiently to allow the river to spill into the bunded areas. The LWD dams (N12) similarly allowed reconnection of the river with the floodplain. This measure was constrained to channels less than 5m wide to avoid risk of debris washout.
What is the standard time delay for measuring the effects of the measures?	The impacts of low level bunds (N1) and LWD dams (F10) should be immediate. Flood regulation benefits of woodland creation are assumed to accrue in full after three years.

IX. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	The low level bunds (N1) construction was delayed until January 2014 with completion due in April 2015. This was in part due to the reliance on another flood protection scheme for provision of the clay needed for construction. The size of the scheme (>25,000m^3) also 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. Woodland planting (F1) was constrained due to existing conservation designations covering landscapes, habitats, species and archaeological heritage. There were also 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. There were no barriers reported with respect to implementing LWD dams (F10). The design of these did take into consideration potential interference with fish movement and risk of washout of materials.
What were the main enabling and success factors?	The project was enabled by several factors. 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. The catchment had been subject to hydrological modelling as part of a previous academic study. Opportunity mapping of woodland creation had been undertaken by

	Forest Research. There was also an ongoing process of stakeholder and community engagement in both the aims and delivery of the project.
Financing	The main funders of the project are: Forestry Commission: €127,675 Environment Agency: €93,103 Regional Flood Defence Committee: €179,310 North York Moors NPA: €58,046 Ryedale District Council: €1,094,368 Natural England: €25,287 The financing was entirely from public sector sources. The majority of the funding was to cover construction of the low level bunds. The funding includes woodland creation grants
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	Ongoing promotion of the project is planned to disseminate the benefits of catchment-based flood management.

X. Lessons learned

Key lessons	The main lessons learned as reported in the phase 1 final report (Nisbet etal., 2011) can be summarised as: • Two years is too short to execute a demonstration project. A minimum of three years, and ideally five years, is recommended to allow for data gathering, modelling, ground truthing of model results, designing, consultation, persuading landowners, funding bids and planning applications. • A short duration project is problematic for monitoring and evaluation work. Baseline data collection cannot begin until final sites are selected. Evaluation of the impact of woodland creation necessitates long-term monitoring. • Partners need to adopt a 'can do' attitude and not be risk averse. Good communication is vital to ensure that plans are understood by all and incorporate local knowledge. • Community expectations need to be carefully managed. Representation on the Programme Delivery Group, a community engagement plan and events, assisted in this regard. • Local communities appear ready to embrace the concept of a whole-catchment approach to flood risk management. The concept 'makes sense' and fits the green agenda. However, there is a need to be clearer in communicating flood risk.

	• Decision making over the selection and siting of flood management measures often relies on good data and robust models. Where ground truthing finds deficiencies in data and models, care is required in communicating subsequent changes to minimise the risk of confusion and loss of confidence. • It was not possible for the modelling to integrate the effects of the different measures, mainly due to lack of time/resources. It would have helped if agreement had been reached at the outset on data requirements and on the preferred modelling framework, including which flood events should be modelled. • Slowing the flow at some sites can increase rather than decrease flood flows as a result of synchronising catchment contributions. In general, siting measures closer to flood prone locations is more likely to increase flood risk. Measures are expected to be most effective when placed in the upper half of a catchment (with the exception of large flood storage bunds). • While public ownership of land can smooth decision making over woodland creation, a range of barriers still exist. Planting in the Pickering Beck catchment was hampered by the sensitive nature of the landscape, especially by its existing high biodiversity and landscape values. • LWD dams can exert a stronger effect on flood flows than woodland vegetation, although both are complementary. LWD dams are particularly valuable for raising water levels within incised river channels and reconnecting floodplains. They offer a useful measure in river reaches where there are constraints on planting woodland, but need active management in the absence of natural inputs of dead wood. • Demonstration projects should include a formal ecosystem services assessment, which needs to be carefully planned from the start of the project. An initial qualitative assessment of the expected costs and benefits would help to guide data collection, assisting a final quantitative evaluation. • The ecosystem services assessment suggests that it is unlikely to be cost effective to implement forestry measures solely for flood regulation, highlighting the need to factor in other ecosystem benefits such as for habitat creation and climate change mitigation. However, while the wider public benefits appear to greatly outweigh the costs, the opposite applies to private landowners. • To be most effective, land management measures need to be carefully targeted. This is often problematic for land owners, who have their own site preferences. To secure change requires a higher incentive/compensation. • It remains a challenge to persuade farmers to implement slowing the flow/diffuse pollution measures, with limited take-up of Catchment Sensitive Farming Capital Grants.

XI. References

Source Type	*Website*	
Source Author(s)	Nisbet TR, Marrington S, Thomas H, Broadmeadow S and Valatin G	
Source Title	Project RMP5455: Slowing the Flow at Pickering, Final Report to Defra, Forest Research	
Year of publication	2011	
Editor/Publisher		
Source Weblink	http://www.forestry.gov.uk/website/forestresearch.nsf/ByUnique/INFD-7YML5R	
Key People	*Name / affiliation*	*Contact details*
	1.	