European Commission

NWRM

Natural Water Retention Measures

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Case Study

Órbigo River ecological status improvement (Stretch I): Duero River Basin

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I. Basic Information

Application ID	*Spain_02*			
Application Name	**Órbigo River ecological status improvement (Stretch I): Duero River Basin**			
Application Location	Country:	Spain	Country 2:	*No*
	NUTS2 Code		ES41-Castilla y León	
	River Basin District Code		ES020-DUERO	
	WFD Water Body Code		Water body: 02R11037_08 [Source: INFRAECO (2011a)]	
	Description		*This application has been implemented in a 23.5 km long stretch (stretch I) of the Órbigo River (Duero River Basin) located in the northwest of Spain.*	
Application Site Coordinates	Latitude: *NOTE: Action was implemented in a segment (A= initial point; B= terminal point) • A (42,65652004N [ETRS89 (UTM 30M)] • B (42,49623126N [ETRS89 (UTM 30M)]		Longitude: *NOTE: Action was implemented in a segment (A= initial point; B= terminal point): • A (-5,82186704 [ETRS89 (UTM 30M)] • B (-5,88084182 [ETRS89 (UTM 30M)]	
Target Sector(s)	Primary:	Hydromorpology		
	Secondary:	Forest		
Implemented NWRM(s)	Measure #1:	N3 (Floodplain reconnection)		
	Measure #2:	N5 (Revitalisation of flowing waters)		
	Measure #3:	N9 (Levelling of dam/longitudinal barriers)		
	Measure #4:	N10 (Natural bank stabilisation)		
	Measure #5:	N11 (Elimination of riverbank protection)		
	Measure #6:	F1 (Riparian buffer restoration and maintenance)		
Application short description	Bundle of measures aimed to promote: floodplain reconnection and restoration, revitalisation of flowing water, levelling of longitudinal barriers, natural bank stabilisation, elimination of riverbank protection and restoration and to the riparian buffer restoration and maintenance. Intended impact: 1. Improving the river connectivity (lateral and longitudinal) and dynamics; 2. Improving the riverbank stabilization. An example of integrated implementation of the Floods and Water Framework Directives.			

II. Policy context and design targets

Brief description of the problem to be tackled	The municipalities of Cimanes del Tejar, Llamas de la Ribera, Carrizo de la Ribera, Turcia and Santa Marina del Rey located by the Órbigo River (León province, Castilla y León Region) were suffering from the effects of hydromorphological (weirs, channels…) and land-use patterns change pressures for this water body: loss of lateral (main derived problem: floods) and transversal connectivity, river dynamics (derived problems: erosion and sedimentation) alteration, flow alteration and riparian forest loss and fragmentation.		
What were the primary & secondary targets when designing this application?	Primary target #1:	Flood control and flood risk mitigation As a final aim. Recovering morphology and hydraulic capacity of the former stream bed of the river and its connectivity with the floodplain and improving longitudinal continuity (by means of works to 1) improve lateral connectivity and dynamics; 2) improve longitudinal continuity; 3) forest actions (revegetation)	
	Secondary target #1:	Mass stabilisation and control of erosion rates	
	Secondary target #2:	Biodiversity and gene-pool conservation in riparia More accurately: improve ecological status of the river	
	Remarks		
Which specific types of pressures did you aim at mitigating?	Pressure #1:	Floods Directive indetified pressure	Natural exceedence
	Pressure #2:	Floods Directive indetified pressure	Blockage /restriction
	Pressure #3:	WFD indentified pressure	4.1.1 Physical alteration of channel/bed/riparian area/shore of water body for flood protection
	Pressure #4:	WFD indentified pressure	4.2.2 Dams, barriers and locks for flood protection
	Remarks		
Which specific types of adverse impacts did you aim at mitigating?	Impact #1:	Floods Directive indetified impact	Waterbody status (adverse permanent or long-term consequences **ecological** or chemical status of surface water bodies or chemical status of ground water bodies affected, as of concern under the WFD due to the **hydromorphological impacts of flooding)**
	Impact #2:	Floods Directive indetified impact	Infrastructure (adverse consequences to infrastructural assets such as utilities, power generation, transport, storage and communication)
	Impact #3:	Floods Directive	Other environmental

		indetified impact	impacts: other potential permanent or long-term adverse environmental impacts, such as those on soil, biodiversity, flora and **fauna**, etc.
	Impact #4:	WFD indentified impact	Altered habitats due to morphological changes
	Impact #5:	WFD indentified impact	Altered habitats due to hydrological changes
	Remarks		
Which EU requirements and EU Directives were aimed at being addressed?	Requirement #1:	Floods Directive-mitigating Flood Risk	By means of measures aimed at giving river more space
	Requirement #2:	WFD-achievement of good ecological status	By means of measures aimed at improving the hydromorphological conditions of the water body (river continuity and morphological conditions, mainly)
Which national and/or regional policy challenges and/or requirements aimed to be addressed?	National Strategy for River Restoration (Estrategia Nacional de Restauración de Río, ENRR), Sub-programme 3 (improvement of the longitudinal continuity of the rivers within the Duero basin) and 4 (improvement of the lateral continuity of the rivers within the Duero basin) [Source: Rodríguez et al., 2012a]		

III. Site characteristics

Dominant Land Use type(s) *CORINE LU types and codes*	Dominant land use	311-Broad-leaved forest
	Secondary land use	212-Permanently irrigated land
	Other important land use	322-Moors and heathland
		111-Continuous urban fabric
	Remarks: **If a more specific scale (e.g. Project) was taken into account dominant selected land use would have been "511-Water courses". • Category 311: 48% of the floodplain («preferential flow area» or «zona de flujo preferente») of the Órbigo River, Stretch I (42%: Irrigated Poplar plantations; 6% riparian vegetation) [Source: INFRAECO (2011a)]. This CLC category includes both "natural" riparian vegetation and irrigated poplar plantations that should be considered as crops. • Category 212: 35% of the preferential flow movement area of the Órbigo River, Stretch I (herbaceous crops) [Source: INFRAECO (2011a)] • Category 322: 9% of the preferential flow movement area of the Órbigo River, Stretch I [Source: INFRAECO (2011a)] • Category 111: 8% of the preferential flow movement area of the Órbigo River, Stretch I [Source: INFRAECO (2011a)]	
Climate zone	cool temperate moist	
Soil type	Site FAO Soil Type: Fluvisols. Second selection: Cambisols. Source for FAO Taxonomy information: JRC European Soil Portal Database (http://eusoils.jrc.ec.europa.eu). According to INFRAECO (2011a) most relevant soil types (USDA Soil	

	Taxonomy) at the site (Órbigo River, Stretch I) are Xerorthent and Xerofluvent (Entisols) (at Órbigo river basin scale: Entisols, inceptisols and Alfisols).
Average Slope	nearly level (0-1%) This is the average slope of the Órbigo River Stretch I: 0.3%. Maximum value: 1.82%; minimum value: around 0% (Source: INFRAECO (2011c, p. 22). • Average slope of the Órbigo River Basin: 27% (INFRAECO (2011a, p. 8).
Mean Annual Rainfall	300 - 600 mm Annual mean rainfall (Órbigo River, Stretch I) from a representative pluviometric station (Carrizo de la Ribera) on the basis of data from 33 years: 534.7 mm/yr. Other relevant data: 162.3 mm (Winter); 84.9 mm (Summer). [Source: INFRAECO (2011a, p. 17)]
Mean Annual Runoff	Select the Mean Annual Runoff value
Average Runoff coefficient (or % imperviousness on site)	Select the Average Runoff Coefficient value | Select the % imperviousness on site Remarks
Characterization of water quality status (prior to the implementation of the NWRMs)	According to technical project [Source: INFRAECO (2011a) initial water quality status for the Stretch I (chemical/physical status / microinvertebrates / diatoms) was rated as good-very good so no specific measures were designed for this purpose. Values (2005-2007) prior to the implementation of the NWRM [Source: INFRAECO, 2011a]: 1. Physico-chemical status: • Oxygen: 9.79 mg/l (Good or very good; reference value: >5 mg/l) • pH: 7.71 (Good or very good; reference value: 6-9) • Ammonium: 0.05 mg/l (Good or very good; reference value: <1 mg/l) • BOD5: 2.00 mg/l (Good or very good; reference value: <6 mg/l) • Nitrate: 1.12 mg/l (Good or very good; reference value: <25 mg/l) • Phosphorus: -- mg/l (Good or very good; reference value: <0.4mg/l) 2. Diatom index: • EQR IPS 2007: 1.17 (Good or very good; reference value: > 0.92). 3. Macroinvertebrates: • EQR IBMWP: 1.53 (Good or very good; reference value: > 0.83).
Comment on any specific site characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way	*Positive way:* - *Flow:* permanent regime (during dry years fluvial ecosystem is not under stress). - Good water quality (in terms of dissolved oxygen, transparency, suspended solids and mineralization). [Source: INFRAECO (2011a)] - Compatible land uses (irrigated poplar plantation instead of human settlements) in the majority of the floodplain areas.
	Negative way: - *River morphology.* According to Rosgen Classification, this is a "C" Stream type (with some "D segments". This means that the river can be easily and rapidly destabilized due to bank stability destabilization or changes in flow/sediment regime. - *Poorly preserved natural riparian vegetation.* Natural riparian vegetation has been replaced in many areas by irrigated crops (beet, corn, sunflower, cereals and poplar -*Populus x euroamericana*- plantations). In the remaining areas a very

	narrow riparian forest band has been preserved. - Infrastructures: 23% of the river stretch length contains regulating infrastructures [Source: INFRAECO (2011a)]

IV. Design & implementation parameters

Project scale	Medium (eg. public park, new development district)	Length of the stretch to be improved by means of this specific project: 23.5 km. Area: around 45 ha. In the near future (already passed environmental and technical assessment and pending to obtain funding) similar projects will be carried out in downstream stretches (segment II: 27.5 km; and segment III: 57.8 km)
Time frame	Date of installation/construction: 28.09.2012 (works were finalized)	• 28.09.2012 (works were finalized). Other relevant dates: • 2008 -2010: project was drafted; public participation and information phase; environmental assessment phase. • 2010: final version of the project approved. • 03.10.2011: construction works started
	Expected average lifespan (life expectancy) of the application in years	This concept does not make sense for the river restoration as a whole (it would be the lifespan of the river where the restoration is being implemented). However, specific values for certain elements are commonly used. Examples: 50 years for civil works, 25 years for electromechanical compounds, 0 years for alive vegetation [Source: García et al., 2013]
Responsible authority and other stakeholders involved	*Name of responsible authority/ stakeholder*	*Role, responsibilities*
	1. Ministry of Environment and Rural and Marine Affairs (Ministerio de Medio Ambiente, Medio Rural y Marino): MARM	National Water Authority. Responsible for the following actions: 1. Initiation of the measure by providing a general framework (drawing up the National Strategy on River Restoration/Estrategia Nacional de Restauración de Ríos, ENRR) in which this initiative

		can take place. 2. Implementation (participation during preparatory, diagnosis, public hearing process and implementation works). 3. Financing the works within the framework of the National Strategy on River Restoration/Estrategia Nacional de Restauración de Ríos, ENRR).
	2. River Basin Authority (Confederación Hidrográfica del Duero): CHD	Responsible for the following tasks: 1. Determination of design details of the measure (selecting a candidate project to be developed within the framework of the National Strategy on River Restoration. Selection criteria based on IMPRESS, Methodological Guide on River Restoration and priority areas aimed at improving connectivity). 2. Implementation (preparatory, diagnosis, public hearing process, works, environmental education and volunteering program). 3. Monitoring.
	3. Municipalities (Ayuntamientos de Cimanes del Tejar, Llamas de la Ribera, Carrizo de la Ribera, Turcia and Santa María del Rey)	Local authorities supporting during the implementation process (participation during preparatory, diagnosis and public hearing process).
	4. Local entities: Juntas vecinales	Local entities supporting during the implementation process (participation during preparatory, diagnosis and public hearing process).
	5. Neighbourhood associations	NGOs supporting during the implementation process (participation during preparatory, diagnosis and public hearing process).
	6. Environmental NGOs	NGOs supporting during the implementation process (including environmental river restoration volunteering).
The application was	- Initiated by the Ministry of Environment and Rural and Marine Affairs	

initiated and financed by	(MARM: Ministerio de Medio Ambiente, Medio Rural y Marino) and the River Basin Authority (CHD: Confederación Hidrográfica del Duero). - Funded by the Ministry of Environment and Rural and Marine Affairs (MARM: Ministerio de Medio Ambiente, Medio Rural y Marino) within the framework of the National Strategy on River Restoration (ENRR).	
What were specific principles that were followed in the design of this application?	Security, functionality, innovation.	
Area (ha)	Number of hectares treated by the NWRM(s).	• Stretch I, Órbigo River Sub-basin (32% of the whole Órbigo River basin): 160500 ha. • Órbigo River basin: 499000 ha. [Source: INFRAECO, 2011a]
		Application area treated by the NWRM: Around 45 ha; Length of stretch to be improved: 23.5 km. **1) Works to improve lateral connectivity and dynamics:** a) rock armour removal: 4,720 m (85.8% reduction); earth embankments removal 8,710 m (98.7% reduction); c) movement of earth embankments away from the channel: 5,220 m; d) deflectors removed: 7 (90.4% reduction); e) flood-prone areas recovery (infrastructure): 480 ha (this is the area frequently flooded nowadays due to the implementation of the works – prior to that, because of the existence of earth embankments this area was disconnected from the river bed–). **2) Works to improve longitudinal continuity:** a) Modification of transversal obstacles to allow the passage of fauna (fish) and sediment transport (in 2 insurmountable weirs: Alcoba de la Ribera and Santa María del Rey). b) Secondary arms (side-arms) recovery: 26 arms reconnected, equivalent to 10,063 m (recovered channel); c) Revegetation with riparian vegetation (*Salix alba*, *Populus nigra*, *Alnus glutinosa*, *Fraxinus angustifolia*): 7.2 ha (recovery of riparian vegetation: 0.6%)

			d) Treatments for improving riparian vegetation health (24640 m). **3) Works to improve riverbank stabilization** (bioengineering): willow (salix) live stakes and fascines (4912 m).
Design capacity	Variable volume of retained water according to circulating water flow. For this kind of intervention it is more appropriate to use the concept of "slow down river flow" (flow attenuation) and the use of simulation models (different water volumes and return periods). E.g. Flood lamination: 4-5 hm3; Water volume: 590 m3/s; Return period: 500 years [Source: River Basin Authority, personal communication]		
Reference to existing engineering standards, guidelines and manuals that have been used during the design phase	*Reference*		*URL*
	1.	González del Tánago M., García de Jalón, D., 2007. Restauración de Ríos: Guía metodológica para la elaboración de proyectos. Ministerio de Medio Ambiente, Madrid.	
	2.	Guía Técnica para la Conservación y Recuperación ambiental del Dominio Público Hidráulico (Ministerio de medio Ambiente, 2007),	
	3.	Sear D.A., Newson M.D., Thorne C.R., 2003. Guidebook of Applied Fluvial Geomorphology. Defra/Environment Agency Flood and Coastal Defence R&D Programme, R&D Technical Report FD1914. DEFRA	[1]
	4.	Lara F., Garilleti R., Calleja JA., 2004. La vegetación de ribera de la mitad norte Española. CEDEX, Ministerio de Medio Ambiente.	
	5	Rosgen D.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.	
	6	Rosgen D.L. 1994. A classification of natural rivers. Catena, 22(3): 169-199.	

[1] sciencesearch.defra.gov.uk/Document.aspx?Document=FD1914_1147_TRP.pdf

	7	BOE, 2008. Orden ARM/2656/2008, de 10 de septiembre, por la que se aprueba la Instrucción de Planificación Hidrológica,	[2]
	8	MARM, 2005. Manual para la identificación de las presiones y análiais del impacto de aguas superficiales.	[3]
	9	MARM, 2010. Bases de la Estrategia Nacional de Restauración de Ríos (Basis of the National Strategy for River Restoration)	[4]
	10	Martínez C., Fernández J.A., 2006. Índices de Alteración Hidrológica en ríos. CEDEX, Madrid.	
	11	Alba-Tercedor J., Jáimez-Cuéllar P., Álvarez M., Avilés J., Bonada N. Casas J., Mellado A., Ortega M., Pardo I., Prat N., Rieradevall M., Robles S., Sáinz-Cantero C.E., Sánchez-Ortega A., Suárez,M.L., Toro M., Vidal-Abarca M.R., Vivas S., Zamora-Múñoz C., 2004. Caracterización del estado ecológico de ríos mediterráneos ibéricos mediante el índice IBMWP antes BMWP'. Limnética 21 (3-4): 175-185.	
	12	Chow V.T., Maidment D.R., Mays L.W., 1988. Applied hydrology. McGraw- Hill, NY.	
	13	HEC-RAS 2.0 Model (Hydrologic Engineering Centers River Analysis System , US Army Corps of Engineers	[5]
	14	SIMPA Model ("Sistema Integrado de Modelización	[6]

2 https://www.boe.es/diario_boe/txt.php?id=BOE-A-2008-15340

3 www.magrama.gob.es/es/agua/publicaciones/Informe_Impres_con_mapas_tcm7-27445.pdf

4 www.magrama.gob.es/es/agua/publicaciones/River_B_Restoration_tcm7-27571.pdf

5 http://www.hec.usace.army.mil/software/hec-ras/

6 http://hercules.cedex.es/hidrologia/pub/proyectos/simpa.htm

		Precipitación-Aportación"/ "Integrated System for Rainfall-Runoff Modelling")	
	15	Software: IAHRIS ("Índices de Alteración Hidrológica en RIoS", Indexes of Hydrologic Alteration in Rivers)	[7]
	16	HEC-RAS Model 2.0 (Hydrologic Engineering Centers River Analysis System, US Army Corps of Engineers)	[8]
	17	REAL DECRETO 289/2003, de 7 de marzo, sobre comercialización de los materiales forestales de reproducción (on the marketing of forest reproductive material)	[9]
	18	Instrucción 02/DGN/05 Dirección General de Medio Natural de la Junta de Castilla y León	
	19	Real Decreto 105/2008, de 1 de febrero, por el que se regula la producción y gestión de los residuos de construcción y demolición (on demolition debris management)	[10]
	20	Ley 30/2007, de 30 de abril, de Contratos del Sector Público (Public tender regulation)	[11]
	21	Ley 31/1995, de 8 de noviembre, de prevención de Riesgos Laborales (health and safety regulation)	[12]
Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application?	- Funding for specific priorities. - Attitude of decision makers (willingness to implement innovative approach) and staff/consultant knowledge. - Active public participation.		

7 http://www.ecogesfor.org/IAHRIS_es.html

8 http://www.hec.usace.army.mil/software/hec-ras/downloads.aspx

9 http://www.boe.es/buscar/doc.php?id=BOE-A-2003-4785

10 http://www.boe.es/diario_boe/txt.php?id=BOE-A-2008-2486

11 http://www.boe.es/buscar/act.php?id=BOE-A-2011-17887

12 http://www.boe.es/buscar/doc.php?id=BOE-A-1995-24292

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			
Peak flow rate reduction			
Impact on groundwater			
Impact on soil moisture and soil storage capacity			
Restoring hydraulic connection	Positive effects in terms of connectivity after the implementation of the NWRM. **1) Works to improve lateral connectivity and dynamics:** a) Rock armour removal b) Earth embankments removal c) Movement of earth embankments away from the channel d) Deflectors removed **2) Works to improve longitudinal continuity:** a) Modification of transversal obstacles to allow the sediment transport (in 2 insurmountable weirs: Alcoba de la Ribera and Santa María del Rey). b) Secondary arms (side-arms) recovery: 26 arms reconnected (equivalent meters recovered channel) c) Revegetation with riparian vegetation (*Salix alba*, *Populus nigra*, *Alnus glutinosa*, *Fraxinus angustifolia*) (revegetated area; % riparian vegetation recovery) **3) Works to improve riverbank stabilization** a) Bioengineering: willow (salix) live stakes and fascines	*1a) 4720m* *1b) 8710m* *1c) 5220m* *1d) 7* *2a) 2* *2b) 10063m* *2c) 7.2ha* *3a) 4912m*	*1a) -85.8%* *1b) -98.7%* *1d) -90.4%* *2c) +0,6%*
Water quality Improvements	*Not relevant for this application*		
WFD Ecological Status and objectives	Not relevant for this application. According to technical project [Source: INFRAECO (2011a) initial water quality status for the Stretch I (chemical/physical status /micro invertebrates/diatoms) was rated as good-very good.		

	First evaluation results show that the ecological status of this water body has been improved.		
Reducing flood risks (Floods Directive)	Recovery of 480 flood prone areas with a high capacity to attenuate floods naturally (this is the area frequently flooded nowadays due to the implementation of the works –prior to that, because of the existence of earth embankments this area was disconnected from the river bed–). According to the Planning Office (River Basin Authority) (on-going evaluation) NRWM have performed properly against floods that took place during Winter 2013 (160 m3/s flood: same as those in 1995 and 2000 causing serious damage) and during Spring 2014 (300 m3/s; April). These were successfully abated (in terms of favourably laminated floods and lack of material damage –and, subsequently, of local population´s complaints–) thanks to NWRM [Source: River Basin Authority, Personal communication].	*480ha*	
Mitigation of other biophysical impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.)	Positive effects in terms of connectivity and habitat improvement after the implementation of the NWRM (**2) Works to improve longitudinal continuity)**: a) Modification of transversal obstacles to allow the passage of fauna (fish) and sediment transport (in 2 insurmountable weirs: Alcoba de la Ribera and Santa María del Rey). b) Revegetation with riparian vegetation (*Salix alba*, *Populus nigra*, *Alnus glutinosa*, *Fraxinus angustifolia*): revegetated area (ha) and recovery of riparian vegetation (%). c) Treatments for improving riparian vegetation health. **3) Works to improve riverbank stabilization** (bioengineering): willow (*Salix*) live stakes and fascines.	*2a) 2* *2b) 7.2ha* *2c) 24640m* *3) 4912m*	*2b)+0.6%*
Soil Quality Improvements	Positive impact-SQ improvement. Expected greater infiltration rate and rate of recharge of the alluvial natural floodplains, soil fertilization [Source: CHD (2013b]		
Other			

VI. Socio-Economic Information

What are the benefits and co-benefits of NWRMs in this application?	- Flood protection (material damage reduction) - Habitat diversification		
Financial costs	***Total:***	3,084,697.20 €	•This is the total ***projected budget***. Budget breakdown: 1. Lateral connectivity and dynamics improvement works (52.01%); 2. Longitudinal continuity improvement works (15.70%); 3. Riverbank stabilization works (7.52%); 4. Site access improvement (11.14%); 4. Supplementary works (2.57%); 5. Other items: monitoring of works (3.89%); environmental monitoring (3.89%); risk prevention (2.23%); waste management (1.06%) [Source: INFRAECO (2011d)] • ***Executed budget:*** 2065264.81 € [River Basin Representative Personal communication]
	Capital:	*Value in €*	
	Land acquisition and value:	*0 €*	Intervention were carried out in Public domain land [INFRAECO (2011d)]
	Operational:	*Value in €*	Commonly no operational cost is associated with this kind of project (river restoration).[Source: García et al. (2013)]
	Maintenance:	*Value in €*	Variable according to the specific element considered (average values for Spanish river basins: 1.2% of initial investment cost for fishladders; 20% of total investment cost for revegetation works; 15% of total investment cost for bioengineering works) [Source: García et al., 2013]. Due to the implementation of the project maintenance costs have been drastically reduced (CHD, 2013a). These costs are assumed by the Duero River Basin Authority within the framework of its Public Domain Conservation Programme (Source: River Basin Authority Personal communication).
	Other:	*Value in €*	*Text / Specify*
Were financial compensations required? What amount?	*Was financial compensation required?* No financial compensations were required as works were implemented in public domain lands.		
	Total amount of money paid (in €): --		
	Compensation schema: --		

	Comments / Remarks: --
Economic costs	*Actual income loss:*
	Additional costs:
	Other opportunity costs:
	Comments / Remarks:
Which link can be made to the ecosystem services approach?	- Flood security and protection. - Biomass production (wood /fish). - Amenities. - Sediment retention. - Nutrient retention.

VII. Monitoring & maintenance requirements

Monitoring requirements	1) From 2012 onwards periodic monitoring of: - Hydrodynamic processes such as erosion and sedimentation (in those areas suffering actively from these processes). - Reconnected secondary arms (side-arms): operation according to variable water flow volume. - Flood events: wet-areas cartography and assessment. - Social perception (stakeholders) regarding implemented actions (and their evolution). 2) From 2013 onwards: floods events (drone photography *vs* ortophotography). 3) From 2014 onwards: river dynamics (most active areas) topography for monitoring changes in channel patterns (e.g. new erosion and sedimentation processes derived from restoration works). This works are assumed by the Duero River Basin Authority (Confederación Hidrógrafica del Duero)
Maintenance requirements	Maintenance requirements include: - Channel maintenance works (clearance works): natural and dumped obstructions/debris regular removal; excessive vegetation regular clearance; removal of dead vegetation (e.g. fallen trees), occasional sediment removal. - Shoreline Vegetation/plants: regular inspection required (in order to check that new vegetation has been properly established) and replacement of damaged vegetation when required. - Fish ladders: inspection and structure repair/rehabilitation when necessary This works are assumed by the Duero River Basin Authority (Confederación Hidrógrafica del Duero) within the framework of a specific Program (Public Domain Preservation Programme).
What are the administrative costs?	N/A info. Expenses were assumed by The Duero River Basin Authority (Confederación Hidrográfica del Duero).

VIII. Performance metrics and assessment criteria

Which assessment methods and practices are used for assessing the biophysical impacts?	Pre vs. Post implementation: field visits, drone images (comparison before/after floods), ortophotos, and information from stakeholders.
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	N/A information
How cost-effective are NWRM's compared to "traditional / structural" measures?	Structural measures for flood protection traditionally applied in urban river stretches have resulted in very negative effects (flooding and/or reduction in the natural capacity for attenuating floods, unsustainable maintenance, negative impacts on the aquatic ecosystems…) in other stretches (rural stretches where urban pressure is low and highly localized). Applied approach was assessed to a more cost-effective option than the traditional one. (Rodríguez et al., 2012b).
How do (if applicable) specific basin characteristics influence the effectiveness of measures?	
What is the standard time delay for measuring the effects of the measures?	1 - 4 years According to the Planning Office (River Basin Authority) (on-going evaluation) NRWM have performed properly against floods that took place during the Winter of 2013 (160 m3/s flood: same as those in 1995 and 2000 causing serious damage) and the Winter of 2014 (300 m3/s). These were successfully abated thanks to NWRM. [Source: River Basin Authority personal communication]

IX. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	Attitude of relevant stakeholders. At first, local population was reluctant to the implementation of the project: they didn´t understand the theory (intervention was very different -aim was to create "room for the river"- to anything else carried out previously in the river) and how it would work in practical terms. [Source: CHD (2013a]]
What were the main enabling and success factors?	- Public participation (active participation process during the whole life-cycle of the project). - Attitude of decision makers (innovative approach, strong involvement and will to promote participation). - Existing staff and consultant knowledge (Innovative approach, strong involvement and will to promote participation). - Existing institutional framework (coordination between Ministry of the Environment and River Basin Authority). - Financing possibilities (action was carried out within the framework of the National Strategy for River Restoration).
Financing	This measure is implemented within the framework of the National Strategy for River Restoration (ENRR, Estrategia Nacional de Restauración de Ríos). Funding: 100% Ministry of Environment and Rural and Marine Affairs (Ministerio de Medio Ambiente, Medio Rural y Marino), MARM.

Flexibility & Adaptability	
Transferability	In the near future (already passed environmental and technical assessment and pending to obtain funding) similar projects will be carried out in downstream stretches (segment II: 27.5 km; and segment III: 57.8 km)

X. Lessons learned

Key lessons	A 2013 IRF European Riverprize finalist. a) Good practice of integrated water management and land use policies. b) Implementation of innovative concepts (e.g. "room for the river", green infrastructure…). c) Relevance of management and planning tasks. d) Example of integrated approach in WFD and FD implementation e) Example of the relevance of public involvement during the whole process (public participation during the planning cycle and volunteering within the framework of environmental programme linked to the Project). f) Impact on the media. g) Replicability potential. (Source: CHD, 2013a)

XI. References

Acknowledgement: This case study has been elaborated in close cooperation with Ignacio Rodríguez Muñoz (Duero River Basin Authority, Confederación Hidrográfica del Duero) whose outstanding contributions have been key for the proper understanding of the measures implemented and the outcomes of their implementation.

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Key People	1.	*Ignacio Rodríguez Muñoz* Duero River Basin Authority (Confederación Hidrográfica del Duero)	<irm@chduero.es>
	2.		

Source Type	Project Report
Source Author(s)	INFRAECO
Source Title	Proyecto para la mejora del estado ecológico del río Órbigo. Tramo I (León). Documento 1_ Memoria (Clave 02.434-229/2111) (Órbigo River ecologic status improvement. Stretch I (León). Document 1 (Technical Report)
Year of publication	2011 *[INFRAECO, 2011a]*
Editor/Publisher	MARM (Ministerio de Medio Ambiente, Medio Rural y Marino/Ministry of the Environment)/CHD (Confederación Hidrográfica del Duero/Duero River Basin Authority)
Source Weblink	Weblink

Source Type	Project Report
Source Author(s)	INFRAECO
Source Title	Proyecto para la mejora del estado ecológico del río Órbigo. Tramo I

	(León). Documento 1, Memoria: Anejo 4 (Estudio hidrológico e hidraúlico). (Órbigo River ecologic status improvement. Stretch I (León). Document 1 (Technical Report. Annex 4)
Year of publication	2011 *[INFRAECO, 2011b]*
Editor/Publisher	MARM (Ministerio de Medio Ambiente, Medio Rural y Marino/Ministry of the Environment)/CHD (Confederación Hidrográfica del Duero/Duero River Basin Authority)
Source Weblink	Weblink

Source Type	Project Report
Source Author(s)	INFRAECO
Source Title	Proyecto para la mejora del estado ecológico del río Órbigo. Tramo I (León). Documento 1, Memoria: Anejo 5 (Estudio morfológico). (Órbigo River ecologic status improvement. Stretch I (León). Document 1 (Technical Report. Annex 5)
Year of publication	2011 *[INFRAECO, 2011bc]*
Editor/Publisher	MARM (Ministerio de Medio Ambiente, Medio Rural y Marino/Ministry of the Environment)/CHD (Confederación Hidrográfica del Duero/Duero River Basin Authority)
Source Weblink	Weblink

Source Type	Project Report
Source Author(s)	INFRAECO
Source Title	Proyecto para la mejora del estado ecológico del río Órbigo. Tramo I (León). Documento 4 (Presupuesto). (Órbigo River ecologic status improvement. Stretch I (León). Document 4 (Budget).
Year of publication	2011 *[INFRAECO, 2011d]*
Editor/Publisher	MARM (Ministerio de Medio Ambiente, Medio Rural y Marino/Ministry of the Environment)/CHD (Confederación Hidrográfica del Duero/Duero River Basin Authority)
Source Weblink	

Source Type	Project Report
Source Author(s)	CHD (Confederación Hidrográfica del Duero. Duero River Basin Authority)
Source Title	Estrategia Nacional de Restauración de Ríos (ENRR). Demarcación Hidrográfica del Duero
Year of publication	2010
Editor/Publisher	MMA (Ministerio de Medio Ambiente/Ministry of the Environment)/CHD (Confederación Hidrográfica del Duero/Duero River Basin Authority)
Source Weblink	www.chduero.es/descarga.aspx?fich=/Voluntariado/ENRR_rio%20Orbigo_v0.2.pdf

Source Type	Project Report
Source Author(s)	CHD (Confederación Hidrográfica del Duero. Duero River Basin Authority)
Source Title	Proyecto para la mejora del estado ecológico del río Órbigo. Tramo I

	(León). Instrucción para la elaboración y tramitación de los informes de viabilidad previstos en el artículo 46.5 de la Ley de Aguas). [Clave: 02.434-229/2111]
Year of publication	2009 [updated version, November]
Editor/Publisher	MMA (Ministerio de Medio Ambiente/Ministry of the Environment)
Source Weblink	www.magrama.gob.es/es/agua/planes-y-estrategias/informes-de-viabilidad-de-obras-hidraulicas/944_%C3%93rbigo_tramo__i_tcm7-177298.pdf

Source Type	Journal
Source Author(s)	Barquero J.P., Santillán I.
Source Title	El Proyecto de mejora ecológica del río Órbigo (tramo I).
Year of publication	2012
Editor/Publisher	Sauce (Boletín de la Estrategia Nacional de Restauración de Ríos) 6: 15-17
Source Weblink	http://servicios.mpr.es/documentacion/visordocumentosicopo.aspx?NIPO=280122343&SUBNIPO=0001

Source Type	Journal
Source Author(s)	Rodríguez I., Santillán J.I., Huertas R., Ortega L.
Source Title	Ecological Improvement Project in the Órbigo River (Stretch I)
Year of publication	2012 *[Rodríguez et al., 2012a]*
Editor/Publisher	ECRR News 1/2012: 2-4
Source Weblink	http://www.ecrr.org/publication/newsletter/03-12.pdf

Source Type	Other (specify) (WGF Thematic Workshop: Stakeholder Involvement in Flood Risk Management. 17, 18 April, 2012. Bucharest-Romania. Session 4: Working with institutional stakeholders and other sectors, in particular in land use)
Source Author(s)	Rodríguez I., Santillán J.I., Huertas R., Ortega L.
Source Title	The Órbigo River Restoration Project and its implications in flood risk prevention
Year of publication	2012 *[Rodríguez et al., 2012b]*
Editor/Publisher	CIS Working Group F (WGF)
Source Weblink	www.riverfoundation.org.au/admin/multipart_forms/mpf__resource_55_1___Reference%20H___rbigo%20project%20implications%20in%20flood%20risk%20prevention.pdf

Source Type	Other (specify) (Dissemination material (video) on the restoration project)
Source Author(s)	CHD (Confederación Hidrográfica del Duero. Duero River Basin Authority)
Source Title	Case Study: Improvement of the Ecological Status of the River Órbigo (León, Spain)
Year of publication	2013 *[CHD, 2013a]*
Editor/Publisher	CHD (Confederación Hidrográfica del Duero. Duero River Basin

	Authority)
Source Weblink	http://www.chduero.es/VerVideo-previo-orb2.aspx

Source Type	Other (specify) (Presentation at the IRF European Riverprize Conference, September 2013, Vienna, Austria)
Source Author(s)	CHD (Confederación Hidrográfica del Duero. Duero River Basin Authority)
Source Title	River Órbigo Restoration Project
Year of publication	2013 *[CHD, 2013b]*
Editor/Publisher	IRF (International River Foundation)
Source Weblink	www.restorerivers.eu/Portals/27/Final%20version%20Orbigo%20European%20Riverprize%20Finalist.pdf

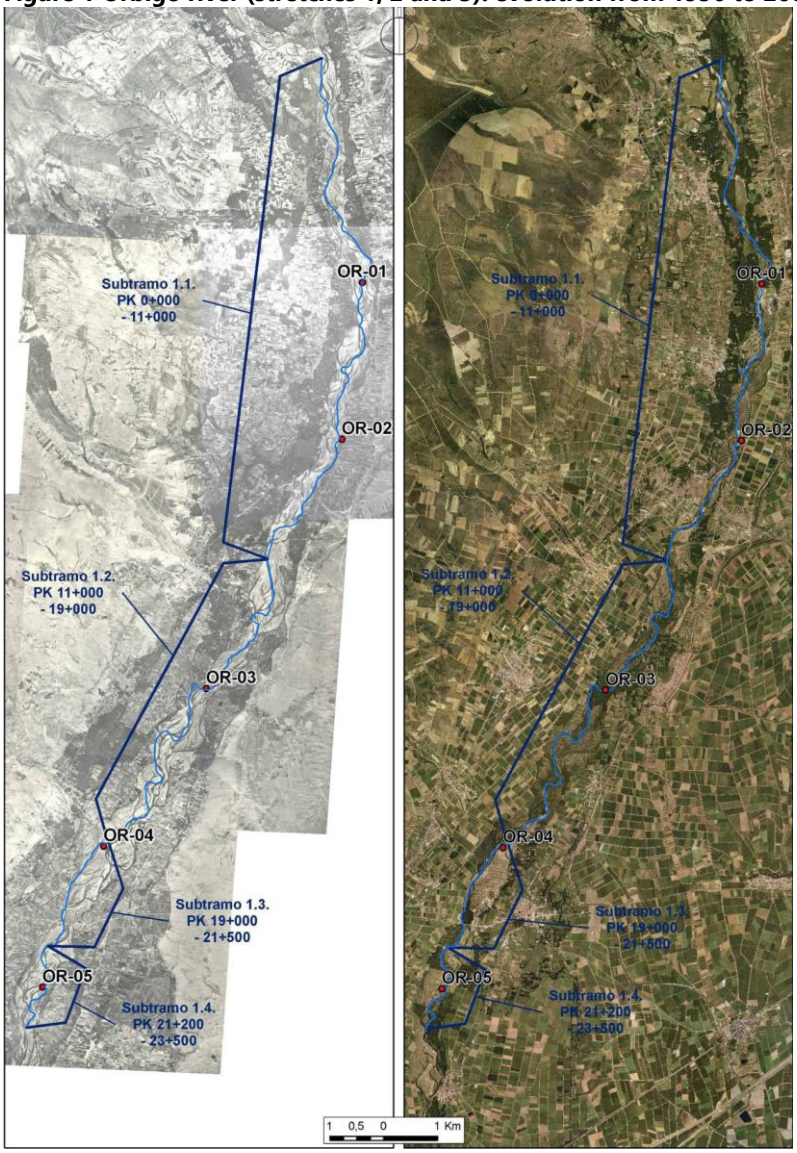
Source Type	Book
Source Author(s)	García A., Catalinas M., Alonso M.E., Gallego P.
Source Title	Guía técnica para la caracterización de las actuaciones a considerar en planes hidrológicos y estudios de viabilidad
Year of publication	2013
Editor/Publisher	CEDEX
Source Weblink	

Source Type	Other (specify) (Strategy)
Source Author(s)	MARM
Source Title	Bases de la Estrategia Nacional de Restauración de Ríos (Basis of the National Strategy for River Restoration)
Year of publication	2010
Editor/Publisher	Ministerio de Medio Ambiente, Medio Rural y Marino/ Ministry of the Environment and Rural and Marine Affairs)
Source Weblink	www.magrama.gob.es/es/agua/publicaciones/River_B_Restoration_tcm7-27571.pdf

Source Type	Project Report
Source Author(s)	MAGRAMA
Source Title	Informe de situación de la Estrategia Nacional de Restauración de Ríos (Noviembre 2012)
Year of publication	2012
Editor/Publisher	MAGRAMA (Ministerio de Agricultura, Alimentación y Medio Ambiente)
Source Weblink	http://www.magrama.gob.es/es/agua/temas/delimitacion-y-restauracion-del-dominio-publico-hidraulico/Informe_semestral_ENRR_noviembre_2012_tcm7-186863.pdf

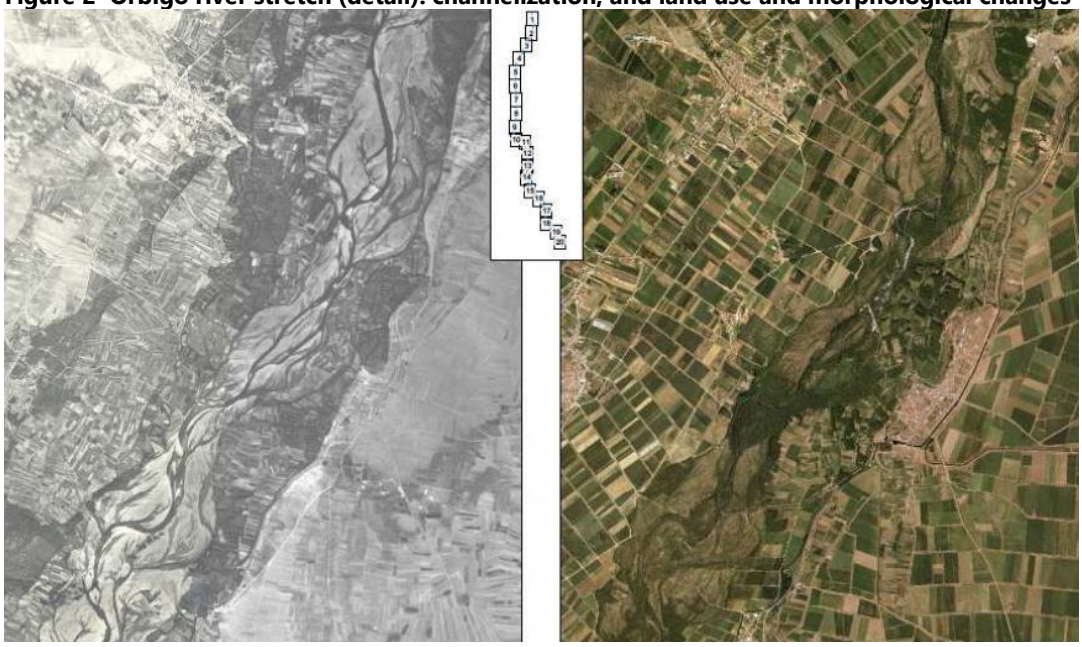
XII. Photos Gallery

Figure 1 Órbigo river (stretches 1, 2 and 3): evolution from 1956 to 2006



Source: Duero River Basin Authority (Confederación Hidrográfica del Duero, CHD)

Figure 2 Órbigo river stretch (detail): channelization, and land use and morphological changes (1956-2006)



Source: Duero River Basin Authority (Confederación Hidrográfica del Duero, CHD)

Figure 3 Works to improve lateral connectivity and dynamics: earth embankments removal

Source: Duero River Basin Authority (Confederación Hidrográfica del Duero, CHD)

Figure 4 Works to improve longitudinal continuity: revegetation with riparian vegetation

Source: Duero River Basin Authority (Confederación Hidrográfica del Duero, CHD)

Figure 5 Recovery of flood prone areas: natural attenuation of floods

Source: Duero River Basin Authority (Confederación Hidrográfica del Duero, CHD)