Promoting Adaptation to Changing Coasts

T 1.5.1: New methodology for evaluating and managing man made historical threats.

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Contents

Foreword

The Promoting Adaptation to Changing Coasts (PACCo) project is a cross-border initiative which is financially supported by the INTERREG VA France (Channel) England project co-financed by the European Regional Development Fund.

The broad aim of PACCo is to demonstrate that it is possible to work with stakeholders in estuarine regions to deliver a range of benefits for people and the environment by adapting pre-emptively to climate change. It has a total value of €27.2m, with €18.8m coming from the European Regional Development Fund (ERDF).

The project focuses on two pilot sites: the Lower Otter Valley, East Devon, England and the Saâne Valley in Normandy, France.

For more information, see Promoting Adaptation to Changing Coasts (pacco-interreg.com)

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Introduction

Coastline and especially estuaries have always been very attractive areas for humans. However, these areas are very fragile and their ecosystems are very important for the biodiversity. They have gradually been artificialized and in some places have become completely urbanised. According to the 2019 IPBES report, more than 85% of the world's wetlands have disappeared between the 18th century and today. The main causes are related to human activities which have destroyed habitats and species.

The Saâne and the Otter valleys are no exception and have faced many developments over the centuries which had a negative impact on the biodiversity. Changes and modifications related to human activities have threatened and impacted the biodiversity in the two valleys and put pressure on the ecosystems. In the Saâne valley, urbanisation and intensive agriculture practices are considered to be the main threat. Other threats such as the uses of the valley and its resources, pollution, and the direct or indirect effects of climate change are putting further pressure on the environment and its species.

The PACCo (Promoting Adaptation to Changing Coast) project developed a new methodology for assessing and managing the historical human threats impacting the ecosystems, human health and the local economy. This new methodology will be incorporated into the PACCo guide and it can be reused by others on different sites.

1. Methodology

The objective of this deliverable is to identify human threats which impacted both valleys and to assess their consequences on the environment, water resources, local economy and human health. In order to do this, a methodology for assessing and managing these threats must be developed.

For each valley, the first step was to identify the threats which have impacted the valley. Solution resulting from the PACCo project or recommendation can then be given. The first step was to identify the geographical perimeter of the threats. For the two valleys, the limits of the downstream catchment area were chosen for the study which enable to understand the impacts of the human practices of the lower valleys.

Each sheet indicates the geographical threat area and its characteristics. In the case of the Basse Saâne, it was decided that the studied area focused on the upstream part of the downstream catchment. For the Otter valley, some studies only focus on the flood plain.

1.1 Definitions

Issue(s): What can be impacted by threats. For example, the water resource (issue) is impacted by intensive agricultural practises (threat).

Issues identified for both valleys:

- Biodiversity and habitat
- Water resource
- Human health
- Local economy

Threat(s): effect of a human activities on the environment. It has been chosen to identify only threats that have occurred in the last 200 years. It is during the last two centuries that the two valleys have major modification that are likely to have a significant impact on the quality of the environment, biodiversity, the water resource, human health or the local economy. WP T2.2.1 Framework deliverable can be read to find further information on the threats located in the two valleys.

Type of threat identified for the Saâne Valley:

- Agriculture
- Other human uses of the site (hunting, tourism)
- River and floodplain modification
- Urbanization
- Afforestation of the floodplain
- Invasive species
- Wastewater discharges

Type of threats to the Otter Valley:

- River modification

- Agriculture
- Invasive species
- Urbanisation
- Public infrastructure
- Utilities (water, electricity and telecommunications)
- Tourism and other activities
- Water abstraction

A threat can impact several issues (e, g, Agriculture can impact the Environment, the Biodiversity and Human Health) and can have different impact (for example for the agriculture: the intensification of practices promotes the water runoff and diffuse pollution, livestock farming can impact the erosion of the bank and the water quality).

Impact/Consequence: Result of the threat impact on the issue.

For example: Agriculture can be responsible for the pollution of the environment, watercourses and bathing water, as well as impacting the biodiversity and the human health. However, some threats can have positive impacts, such as tourism, which has a negative impact on the environment and biodiversity but has a positive effect on the local economy.

Solution: Measure put in place to mitigate the impacts of the threat as part of the PACCo project.

Recommendation: Proposal for a measure to be implemented outside the framework of the PACCo project (different timeframe, different project owner).

1.2 Assessment

One of the aims of this deliverable is to develop a new methodology for assessing historical human threats. To do this, a scoring system was created. It consists of giving a score from 1 to 5 of the impact of the threat on each of the 4 issues. 1 corresponds to a low impact and 5 to a high impact. The addition of the scores will give an overall score out of 20 enabling the importance of the threat. For example, the water runoff in the Saâne valley mainly impact the biodiversity and the quality of the water. This is mainly due to the presence of large arable land on the plateaus and the use phytosanitary products (e, g,. pesticide) which are carry by runoff water in the watercourses and the floodplain. Runoff water also brings a lot of sediment into the Saâne, which causes water quality problems. The bathing water quality is impacted by the livestock grazing near the Saâne river and aggravate the impacts of an existing issue due to untreated or poorly treated discharge of wastewater in the river.

. An example of the scoring system is given below:

Score	1	2	3	4	5
Impact	Low	←	→		Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←	→		Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Water runoff	Saâne	4	5	3	2	14

1.3 Threat sheet

The aim of these sheets is to provide a methodological tool for the identification and assessment of the historical threats. These sheets also direct to others existing documents or deliverables of the different Work Package. To provide a precise assessment, each threat will be treated independently, even if many links exist between them. Each sheet will first describe the threat, give its impacts and consequences, then assess it and finally give the solutions provided by the PACCo project or at least recommendations (solutions that could be implemented in the future).

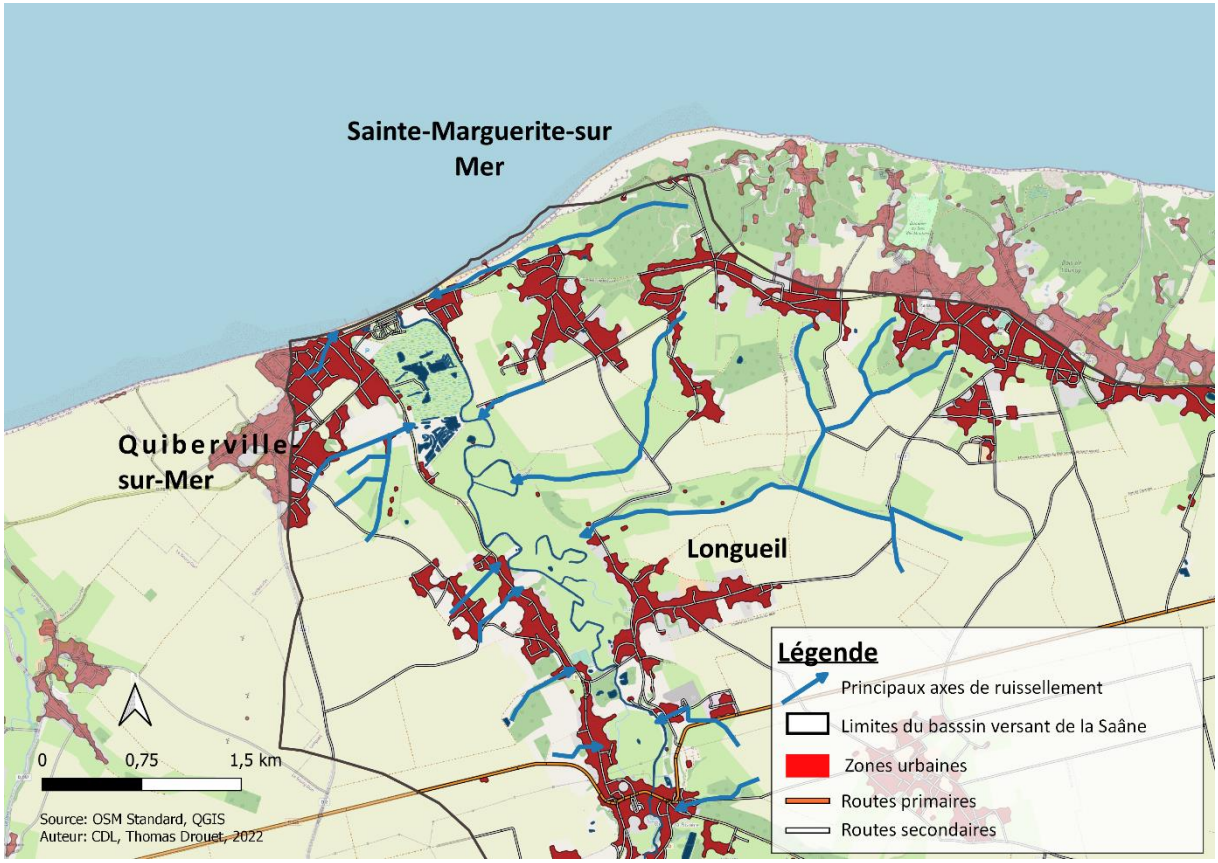
Each valley wrote its own sheets even if the threats are similar, their impacts and consequences may be different on the two valleys.

The sheet is divided into four parts:

1.3.1 Threat identification

Threat identification: this section explains the threat (e. g., water runoff as a result of agricultural practices on the plateaus). It gives a short description of the main characteristics of the threat (location, period when it appeared, etc.)

A map was produced to locate the threat (see below an example of the map of the surface water runoff in the Saâne valley).



1.3.2 Impacts and consequences

This section indicates the impacts and consequences of the threats. It explains which issue(s) is/are affected by the threat. These issues have already been identified before. For example: Runoff has an impact on soil quality, on water quality with the transport of sediments in the watercourse and on bathing water quality. Indirectly, it can affect the local economy which is based on seaside tourism.

1.3.3 Threat evaluation

In this section, the evaluation table (1.2 Evaluation) should be used and included in the threat sheet. The scoring system allows to visualise quickly which threat as the most impact and needs to be prioritise.

1.3.4 Solutions and recommendations

This section describes the solutions and recommendations that can be implemented to reduced or eliminate the threat. In the case of water run-off, mitigation can be implemented (such as the installation of ditches or ponds) or the change in the practices (for example: agroforestry). The solutions (actions implemented within the scope of PACCo project) are more detailed than the recommendations. Links to other existing documents or recommendations can be added at the end of this section. The aim is to offer a wide range of solutions/recommendations.

2. Identification of historical anthropogenic threats

2.1 Historical background to the changes in the two valleys

2.1.1 Saâne Valley

In the lower Saâne valley, the first traces of human activity date back to Antiquity (58-50 BC) with the presence of a Gallo-Roman villa in Sainte-Marguerite-sur-Mer. During the Middle Ages, when the Saâne estuary was freely flowing, the 3 towns were mainly composed of fishermen's huts located around the ports of Longueil and Quiberville. In the 16th century, the first major modifications were undertaken with the construction of dykes and guard posts to prevent a possible attack from England. Two centuries later, embankments were built to extend agricultural land and reduce the wetlands of the estuary. In 1864, the first Saâne wooden drainage pipe was built to drain the valley and prevent the spread of disease as well as developing agriculture and hunting pratices. The valley began to welcome its first recreational bathers in 1856. This was the beginning of seaside tourism. The development of tourism lead to the urbanisation of the seafront with the construction of hotels and villas to accommodate the wealthy tourists. Post-war years (1950-1960), the valley was again modified. The current culvert was built as well as the road embankment, Quiberville campsite was developed just behind the embankment and urbanisation of the 3 towns expended. On the hillsides, grassland and hedgerows areas disappeared and were replaced by large field of crops.

2.1.2 Otter Valley

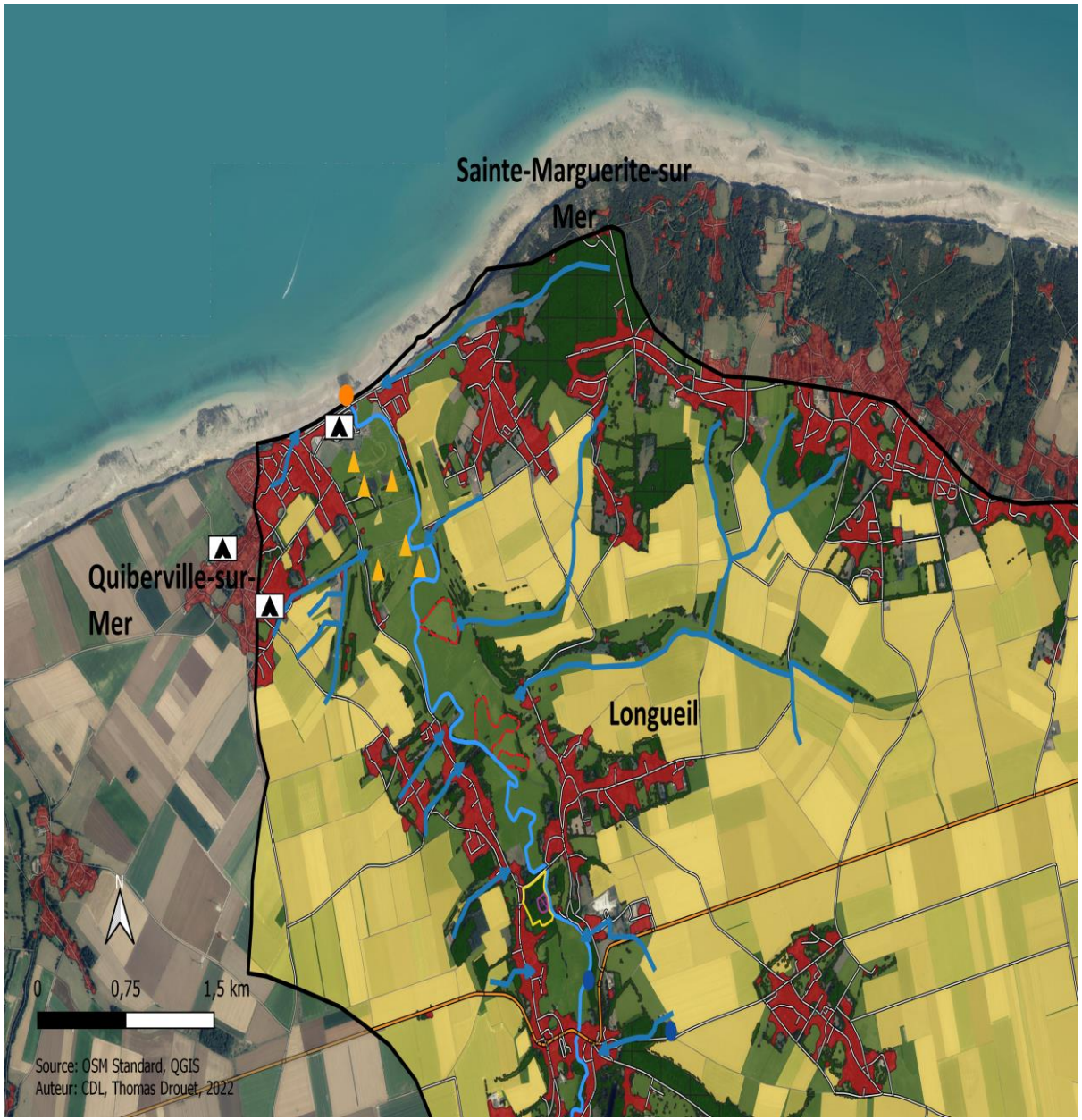
In the Otter Valley, the first settlements date from the 1400s, quays were builtd to allow the exportation of salt and coal. This activity enable East Budleigh to develop and to become, along with Otterton, an important trading centre on the south-west coast of England. In the 18th century, embankments were built in order to disconnect the sea to the floddplain and reclaim land for agricultural purpose. The river was also modified and straighten. This work aims to improve access and navigability on the river and, consequently, trade. In 1888, a railway was built in the western part of the valley. The formation of the pebble beach and the silting up of the Otter riverbed caused a slowdown in trade in the valley. At the same time, Budleigh Salterton became an important seaside resort with rapid population growth. The development of the town led to urbanisation which gradually reached the floodplain. A landfill was created in the floodplain. In 1930, the cricket club was also built within the floodplain to meet the growing demand for outdoor sports and recreation in the area

2.2 The Saâne Valley

In the heart of the Saâne Valley eight main threats have been identified. The eight threats have been summarised in the table below:

	Threat	Consequences on the issues	Solutions / Recommendations	Score
Sheet 1: Agriculture	The plateaus of the Pays de Caux are large areas used for arable farming. Most of the areas around the lower Saâne valley are intensively farmed. In the lower valley, livestock farming has replaced arable farming.	**- Biodiversity and habitat:** Pollution of the environment, soil and air, reduction in biodiversity through the intensive use, homogenisation of the landscape. **- Water resources:** Pollution of watercourses and groundwater by the use of fertilizers and by the trampling of banks by cattle. **- Human health:** Risk of diseases linked to the use of products (e, g, fertilizers) that contaminate the soil (food), air (breathing) and water.	To limit the impact of some of the agricultural practices, new solutions can be implemented. The future reconnection of the Saâne to the sea will change the landscape and impact farming practices and will require adaptation. New and simplified farming techniques can decrease the use of phytosanitary products. Due to climate change, water resources are likely to reduce, farmers will have to adapt their activities.	**13**
Sheet 2: Runoff	Intensive agriculture and urbanisation increase soil erosion and surface water runoff from the hillsides of the valley. This impacts directly the Saâne river.	**- Biodiversity and habitat:** Water runoff is responsible for soil erosion **- Water resources:** Runoff can pollute the watercourse and impact the water quality and bathing water. Runoff can increase sedimentation and the potential for pollutants to reach the watercourse. **- Human health**: Pollution of watercourses can have consequences for human health, especially when bathing waters are located nearby.	In order to reduce runoff, changes in agricultural practices on hillsides and slopes must be reconsidered. To reduce soil erosion solution such as the implementation of hedgerows, water reservoirs and ponds can be implemented to slow the runoff.	**14**
Sheet 3: Modification of the Saâne river	The Saâne riverbed and its floodplain have been modified with the construction of dykes, embankments and culverts. The aim was to reclaim agricultural land.	**- Biodiversity and habitat:** The modifications of the Saâne's watercourse are responsible for the reduction in biodiversity and habitat loss. For example, these modifications impacted fish reproduction and birds' migration by disconnecting the river to its floodplain. - **Human health:** With the river being disconnecting of its floodplain, the risks of flooding have increased around the valley for the local residents.	PACCo and Basse Saâne 2050 aimed to reconnect the river to the sea by replacing the drainage culvert by a bridge which will enable the creation of wetlands habitats. Embankment around the river will be lowered to reconnect the floodplain to its river.	**16**
Sheet 4: Urbanisation	Since the post-war years, urbanisation has accelerated in the lower Saâne valley. Today, the waterfront has been completely urbanised and some constructions have also been built in the floodplain.	**- Biodiversity and habitat:** Urbanisation led to natural environments loss by creating impermeable ground. Urbanised areas have also replaced some of the wetlands. **- Water resources:** Urbanisation increased surface water runoff which can carry pollutants and impact the watercourse. **- Human health**: In the Saâne valley, many houses are built in a flood zone, which increases the risk for humans and their activities.	French regulations and urban planning documents restrict urbanisation on the coast. New legislative tools have been made available to some French coastal towns to enable the implementation of climate change project (Climate and Resilience Act).	**12**
Sheet 5: Sewage network	Monitoring result of the Saâne water have shown that the water quality is poor. This is the result of the sewage network being in a bad state and the sewage treatment plant being non-compliant with the regulation.	**- Water resource:** The state of the sewage network and its plant contribute to decrease the water quality of the river and its surrounding bathing water.	To solve this issue, the PACCo project and Interreg funds enables the Communauté de Communes (which is responsible for the sewage network) to build a new wastewater treatment plant in Longueil and the implementation of a new sewage network. 1500 houses will be connected to the new system.	**14**

Sheet 6: Afforestation in the floodplain	A poplar grove (5 ha) was planted about 40 years ago in the floodplain. Poplars are trees that are not suitable for wetlands and floodplains areas.	**- Biodiversity and habitat:** Poplar plantations are generally intensively exploited, which modified the floodplain. Poplar plantations also leads to landscape and ecological changes (soil depletion, impoverishment of fauna and flora, low biological diversity, etc.). **- Water resources**: Poplar plantations and their related activities required the use of large quantity of water and add pressure on thewater resources.	The trees of the poplar plantation will be cut. When the work is completed, Conservatoire du littoral and its partners are studying the potential to restore this area.	**8**
Sheet 7: Uses	The lower Saâne valley is known for its landscapes and the outdoor activities it offers. During the summer months, the number of visitors increases which can impact the fauna and flora.	**- Biodiversity and habitat:** The outdoor activities can impact the natural environment and harm to the local fauna and flora. High numbers of people can also increase the risk of pollution. **- Water resources**: The various uses and activities can pollute water resources (hunting, fishing, hiking, water sports).	In order to limit the threats to the environment and water resources, rasing awareness and communication around this problem can be implemented. Another solution can be to create fauna and flora areas where activities are limited or prohibited.	**8**
Sheet 8: Invasive species	The introduction of invasive species into the floodplain is often the result of human activity. Invasive species can threat the biodiversity by replacing native species.	**- Biodiversity and habitat:** Invasive species can replace native species and reduce the biodiversity**.**	To eliminate invasive species (animal or plant), solution needs to be implemented. For plant species, this can be done through removal. It is important to plan maintenance of these areas afterwards to ensure that the invasive species has been eradicated.	**6**



Légende

Threat 1: Agriculture
- Arable farming land
- Grassland

Threat 2: Water run-off
- Water run-off

Threat 3: Modification of the watercourse
- Meander removed
- Culvert

Threat 4: Urbanisation
- Urbanized areas
- Main roads
- Secondary roads

Threat 5: Sewage system
- Non-compliant water treatment plant

Threat 6: Afforestation of the floodplain
- Longueil poplar grove

Threat 7: Uses
- Campsite, accommodations
- Hunting areas

Threat 8: Invasive species
- Location of invasive species

Other:
- Wooded area
- Saâne
- Studied area

Map 1: Summary of the different human threats

2.2.1 Agriculture

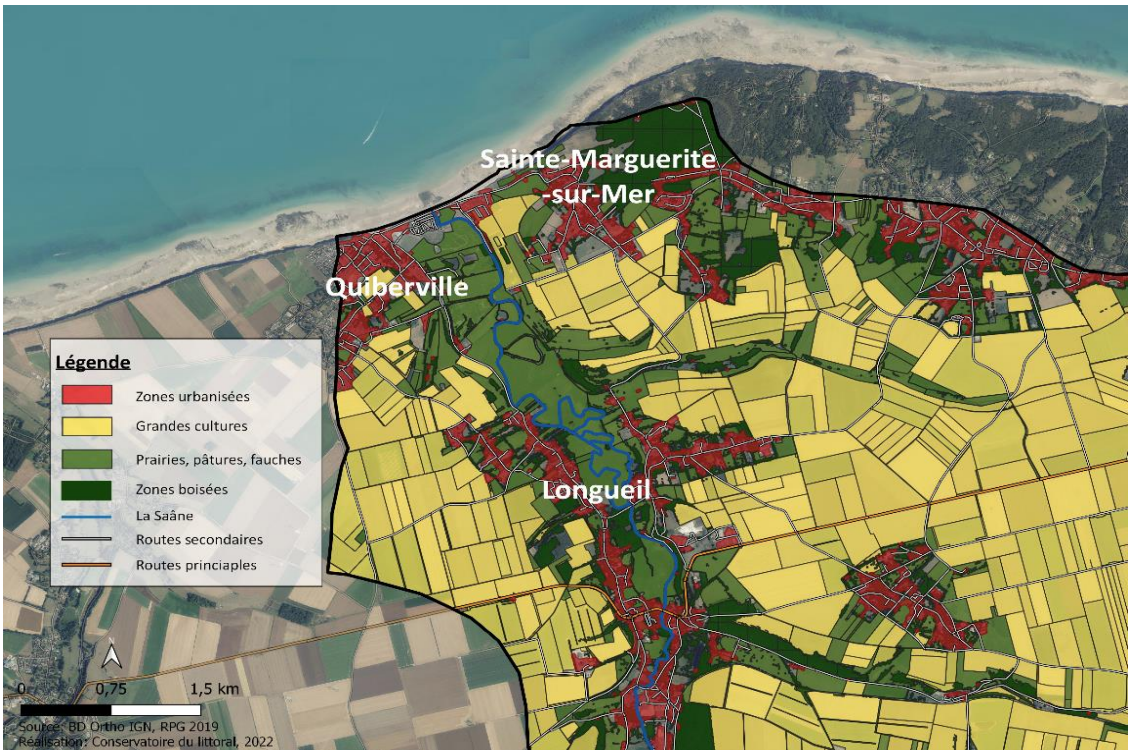
Agricultural activities are present in the lower Saâne valley. On the plateaus, large plots of land are used for intensive farming. In the bottom of the lower valley, which is much wetter, croplands were replaced by grazing land use by cattle.

Identification of the threat

After tourism, agriculture is the second most important economic activity in the lower Saâne valley. Most of the land is used for agriculture purpose within the Pays de Caux and the Basse Saâne valley. Different agriculture practices are undertaken depending on the location (hillside or the lower part of the valley).

On the hillsides and higher ground, agriculture practices are mainly arable farming. In some areas, such as on the outskirts of Sainte-Marguerite-sur-Mer, permanent grasslands are still present. These large areas of land were implemented between the 1960s and 1980s with the reorganisation of the agricultural field encourage by the mechanisation of the activity. During this period, natural obstacle such as hedgerow were removed to increase the size of the fields. In the Saâne valley, many grasslands and woodlands disappeared and were replaced by crops. Today, the main crops grown are wheat, maize, potatoes, beetroot and flax (one of the specialities of the Pays de Caux). All these crops are grown to supply the agro-industrial sector. To improve the yield of these large crops, farmers practice intensive agriculture and use phytosanitary products.

In the lower valley itself, growing crops is impossible due to the ground being too wet. The land is only grazed and sometimes used for silage. There are 125 ha of Useful Agricultural Area (UAA), located in more or less wet areas, which are grazed from April to October. Cattle herds can drink directly from the Saâne in some places.



Map 2 : Crop types in the lower Saâne valley (Cdl, 2022)

For several centuries, the lower Saâne valley has been used for agriculture, particularly for livestock farming. Dykes and embankments were used to change wetlands into farmland. Behind these dykes and embankments, drainage systems were built to convert wetlands into grasslands. In 1864, the first culvert was built along the new drainage works. According to some sources, this drainage work was also intended to prevent the spread of disease by mosquitoes from the wetlands. Today, in addition to the network of dykes that have been built, ditches and sluices have been added to control water levels. To prevent saltwater intrusion, a flap valve was installed at the entrance of the culvert. During a storm in 2009, this was damaged and removed.[1]

Impacts and consequences

Intensive agriculture has greatly evolved over the last sixty years through the mechanisation and intensification of farming practices, which are located on the plateaus of the lower Saâne valley. The wooded areas, orchards and grassy areas have gradually disappeared and were replaced by large crop field. The homogenisation of the agricultural landscape and the reduction of grassed areas have reduced the biodiversity on the plateaux of Pays de Caux.

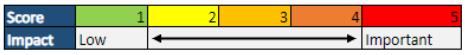
Intensive agriculture combined with the uses of products (fertilisers, plant protection products, herbicides) and undiversified crop rotation, impact directly the biodiversity and

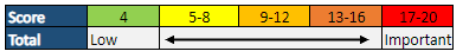
[1] More information: WPT 2.2.1 Framework

human health. They are responsible for the pollution of soil, air, underground water and rivers. During rainy weather, soils loaded with fertilisers and herbicides are washed away and create runoff. Runoff flows into the lower part of the valley and end up in the Saâne, which then flows into the sea. This impacts directly the ecosystems. The spawning grounds for salmonids, for example, are obstructed with fines and can no longer play their role.

While arable farming plays an important role in the loss of biodiversity in the lower valley, cattle farming can also have an impact on the quality of the watercourse. The Saâne flows through many fields where cattle herds graze the ground. These cattle drink directly from the watercourse and trample the banks and damaged it. By trampling the banks, many sediments end up in the Saâne, polluting the river. In addition, faecal matter can also end up in the watercourse and contribute to pollute it.

Threat evaluation





		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Agriculture	Saâne	5	4	3	1	13

Existing agricultural practices affect mainly the biodiversity and water resources by being responsible for the release of pollutants in the watercourse and the soils. Pesticides can also be found in some of the food produce and impact human health.

Solutions and recommendations

To reduce the impacts of agriculture, agricultural practices in the lower valley (livestock farming) and on the plateaus (field crops) need to change. In order to limit trampling and the presence of animal excrement directly in the Saâne, farmers can install fences along the watercourse. They can also create limited access to the watercourse so that the cattle can drink. The opening of the Saâne to the sea will considerably change the features of the lower valley. Current farming practices in these areas will become unsuitable. Agriculture will have to modify their activities by introducing new breeds which can adapt to the future wetlands and saltmarshes. The adaptation of agricultural practices may also involve a change of animals farmed (for example replacing cattle by sheep) which are better adapted to these areas as in was the case in the Bay of Mont-Saint-Michel. The sea reconnection will require providing fallback areas as some of the field may not be available. In addition, the flora will change and may become less palatable to livestock. Marine intrusions at each tide will affect the available drinkable water from the river to the livestock and it will not be possible to use this resource. It will require farmers to set up water troughs. If nothing is implemented following the sea reconnection, breeding could eventually disappear.

On the higher ground, agricultural practices need to change. The promotion of simplified cultivation and sustainable techniques can reduce the use of phytosanitary products, which are currently responsible for the pollution of the watercourse and the sea. For example, farmers can implement natural solution such as using secondary crops to control insect pests. Crop rotation can also be a solution to reduce soil depletion and therefore the use of fertilisers. Climate change will also impact water resource management. Crops such as beetroots and potatoes consume a lot of water, which is often abstracted from rivers and groundwater. In the future, these types of crops will be more difficult to grow as the water available will decrease due to climate change. Careful consideration needs to be undertaken now to anticipate this future problem.

2.2.2 Runoff

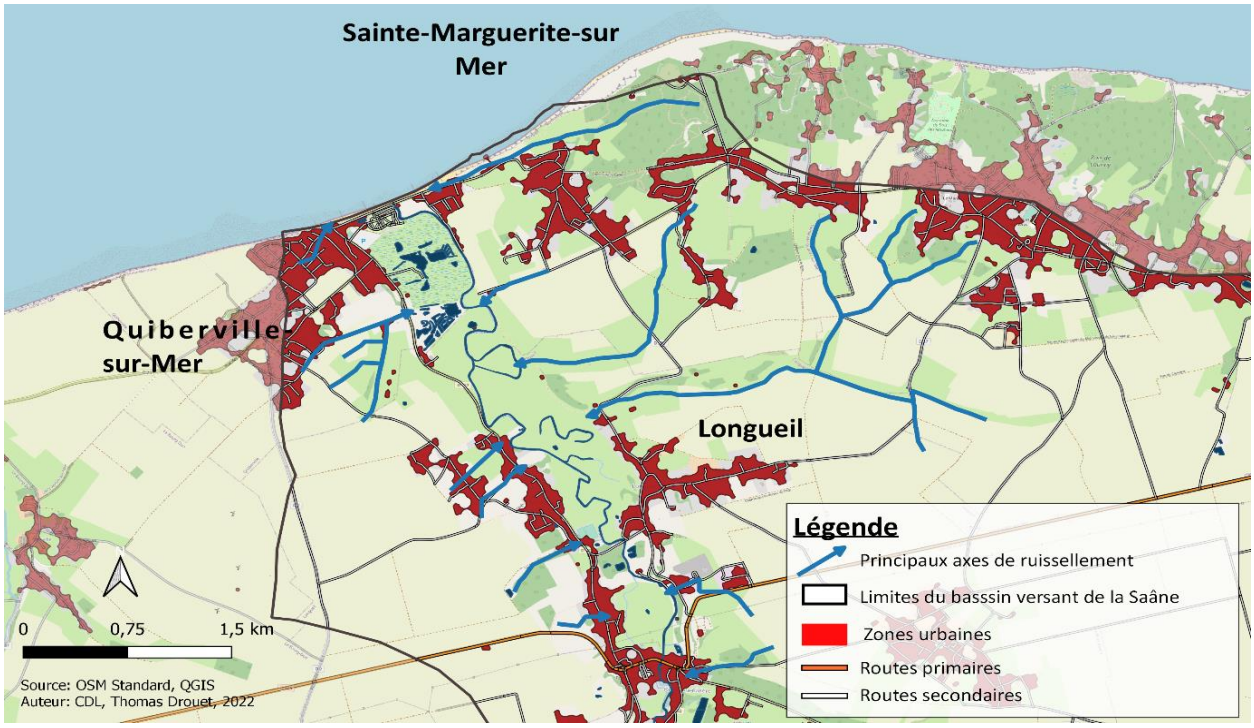
Soil erosion is a natural process following rainfall. Soils and particles are carried by rainwater which leads to runoff. Human activities in recent decades have exacerbated the impacts of these processes, sometimes with significant consequences: quantitatively (flooding by mudslides and fluvial floods of the Saâne river) and qualitatively (inputs of suspended matter and diffuse pollution in the river).

Identification of the threat

Runoff is observed in the Saâne valley and especially in the towns of Sainte-Marguerite-sur-Mer and Longueil. The topographical features, the type of soils as well as human activities increase runoff from the plateaus and its consequences for the inhabitants and the natural environment.

Agricultural activities are located upstream of the valley and on the hillsides. They increase the impacts of this threat. Over the last fifty years, land consolidation (the process of grouping plots together to make them easier to farm) has led to the removal of water flow obstacles and the capacity of water to infiltrate the ground has been reduced. Grassland areas have decreased and replaced by croplands. On these agricultural areas, crops are planted in the direction of the slopes increasing the water runoff.

In addition to the impact of agricultural activities, the road networks, which often follow the landscape and its slope, exacerbate the phenomena and its consequences. The roads channel the runoff and concentrate it. Impermeable and waterproofed pavements prevent water from infiltrating the soil and increase its flow. Over the last fifty years, the artificialization of the soil and urbanization contribute to intensify the runoff.



Map 3 : Main runoff routes in the Saâne valley (76)

Impacts and consequences

Runoff phenomena have an impact on the habitats and biodiversity, by impacting the water quality and carrying sediment from agricultural fields. The water runoff from the hillsides can be loaded with phytosanitary products used in intensive farming. It can also have an impact on human health as it impacts bathing water quality and can be responsible for disease. Indirectly, surface water runoff during heavy rainfall can have an impact on the local economy which is based on tourism and the beach. If the beach is closed for health reasons, visitors may leave the valley.

Runoff from the hillsides of the lower Saâne valley increases flooding. Longueil is the most affected by these phenomena because of its topographical characteristics. Several roads follow the slope of the hillside and guide the water towards the town. It can participate to the fluvial floods from the river Saâne.

Run-off also impacts the water quality in the lower valley. On the hillsides of the Saâne valley, the land is ploughed. The runoff erodes the agricultural ground and carries sediments and particles which end up in the river and then into the sea. It increases the sedimentation and siltation of the Saâne river and the loss of salmonid spawning grounds.

From an agricultural perspective, the runoff phenomena can cause significant losses of soil and fertilisers. The erosion of the topsoil layer can eventually lead to a loss of ground quality. Soil erosion can also affect crops and destroy part of them, causing a drop in yield.

In June 1993 or 1999, the Saâne valley was flooded by surface water following a storm. A lot of damages to the houses and the roads were recorded following this event.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	◄	►		Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	◄	►		Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Runoff	Saâne	4	5	3	2	14

Runoff phenomena have an impact on all the issues. Heavy rainfall events that lead to surface water runoff can have significant consequences for the lower valley. This threat must therefore be carefully monitored, and solutions can be implemented to limit its consequences.

Solutions and recommendations

There are several solutions which can help to reduce water runoff. Agricultural practices are responsible of the impact of the runoff. Ploughed lands without vegetation cover can no longer play its role to control the runoff. They reduce the capacity of the water to infiltrate the ground. Erosion is increased, sediment can be carried by the water and be responsible for pollution events. The solution to this is to put in place solutions on the hillside to reduce the impacts.

Several management plans have been implemented in the Saâne valley. Since 2000, the Syndicat Mixte des Bassins Versants Saâne Vienne et Scie (SMBVSVS) has built a large number of water retention structures in the Saâne catchment area to limit surface water runoff. The commune of Quiberville has two water retention structures with a capacity of 5,000m^3. Another similar structure is located in the commune of Longueil. At the same time, the SMBVSVS is working on natural solution to reduce the flow of water (for example using hedges, ponds, grassy strips, ditches). The aim is to reduce the impact of the water runoff on public and privates building.

Today, many solutions can be implemented to reduce the water runoff, example are given below:

- It may involve farmers to change their practices according to the type of soil or by covering the soil during sensitive periods.
- Natural based solution can be implemented to reduce the flow and speed of water and retain some of the sediment.
- If the first two solutions are not sufficient, it is possible to put in place bigger structure. Grassed channels and ditches can guide and store rainwater. The implementation of

ponds can help to store a large quantity of water from runoff events. They are usually used as part of surface water scheme. Finally, “Runoff Retention Area” (RRA) are also used. They are water storage and infiltration structure. During exceptional events, these structures protect properties and people.

Additional information on existing solutions:

https://hautsdefrance.chambres-agriculture.fr/fileadmin/user_upload/National/FAL_commun/publications/Hauts-de-France/guide-erosion-2018.pdf

2.2.3 Saâne river modification

For many years, rivers in France have been modified with the construction of dykes, embankments and dams in order to protect against flood risks but also to create agricultural land. Like many rivers in France, the Saâne has also been modified, particularly in its downstream section.

Identification of the threat

The riverbed of the Saâne has been modified. Originally, the Saâne river flowed through the middle of the lower valley and its riverbed was much straighter in the middle of the valley. The mouth of the river was completely different from the one we know today: the outfall did not exist and the Saâne flowed directly into the sea. Further upstream, numerous mills and textile factories were built, benefiting from the strong and regular flow of the Saâne. The first modifications of the river took place in the 16th century, when meanders were built to encourage the creation of salterns (salt was used to pay taxes). Over the centuries, the Saâne has been modified and its riverbed was moved towards the commune of Sainte-Marguerite-sur-Mer in order to create agricultural land. The mouth of the river, which used to flow freely into the see, was constrained by the construction of a culvert in 1864. In the 1920s, a road embankment was built to link the different coastal towns. Agricultural lands replaced wetland and the estuary disappeared. Since the end of the Second World War, a number of meanders have been removed. The purpose of removing these meanders was to increase the speed of the flow of the river.

Map 4 Changes of the river the Saâne between 1947 and 2022

Regular maintenance of the Saâne's riverbed was carried out in order to prevent it from silting. During the desilt, the mud and silt were left on the riverbanks or in the floodplain which created taller embankments along the river. This operation created 35km of embankment with a volume of 35,000 m^3 of soil. [2] This disconnected the river to its floodplain and its natural function.

Map 5 Embankments in the lower Saâne valley (CDL, 2022)

Impacts and consequences

These modifications were undertaken mainly to create agricultural ground and reduce the impact of flooding. They have impacted the natural habitats and biodiversity and changed the natural function of the valley. Meanders are important areas for the fauna and flora. They are used as spawning grounds and nurseries for fish. By removing the meanders, the riverbed length was reduced and therefore the flow of water increased. The floodplain which is an important area for certain species and migratory birds was modified and infrastructure were built to modify its natural function. They also help to limit the speed and height of floods.

[2] Global study for the implementation of the territorial project of the lower Saâne valley - Hydraulic and environmental technical note, Version 2, 11.02.2016 - ARTELIA

The construction of the culvert prevents the movement of migratory fish that swim up the rivers. Its installation has also increased flooding. During floods, the flow of the Saône can reach 30m^3/s. The culvert has a maximum discharge capacity of 10m^3/s. As a consequence, floods events have occurred and have been recorded in 1995, 1999, 2000 and 2018, causing damages.

The presence of embankments along the river have disconnected the river to its floodplain and directly impacted the fauna and flora. This also modify the natural function of the floodplain. The embankments are not only an obstacle to the ecological continuity of the environment. The flood plain enabled water to be stored during flood events which can protect surrounding natural and urbanized area. Embankments modified this natural process. Moreover, embankments prevent the water to drain away. In 1999, after the storm, the lower Saône valley remained flooded for 3 weeks while the water drained away. Floodplain wetlands have a major role and limit nitrate inputs to the English Channel.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	◄	►		Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	◄	►		Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Saône river modification	Saône	5	3	4	4	16

The modifications of the watercourse have impacted the biodiversity and natural function of the floodplain. By constraining the watercourse and building embankments, the floodplain was disconnected to the river. Floodplains are suitable areas for the development of nurseries for fish and shorebirds. They are used by migratory birds for feeding. The historical modifications have therefore impacted the ecosystem of the Saône valley. They change the functionality of aquatic and wetland environments and generate risks for property and people.

Solutions

In 2009, following an incident, the culvert flap which prevented marine intrusion into the valley was removed. Today, halophilic vegetation can be seen near the mouth of the river. As part of the Basse Saône 2050 project, the Syndicat Mixte des Bassins Versants Saône Vienne Scie (SMBVSVS) reduced the level of the embankments located on the land owned by the Conservatoire du littoral in the floodplain. This work was combined with other work in order to reconnect the Saône river to its floodplain. Within a few months, results of this work were observed with the arrival of halophilic plants.

Recreating an hydromorphological area similar to an estuary or full-scale restoration of the valley, however, is not possible for economic and environmental reasons as well as local opposition. The different partners will work on the entire downstream part of the Saône

Valley with the restoration of several areas. The project aims to reconnect the floodplain in several places, allowing tidal inundation and improve the habitats. This will allow to create saltmarshes habitats and bass nurseries.

Following the PACCo project and the relocation of the Quiberville campsite, it is planned to reopen the river to the sea. As part of Basse Saâne 2050 project, the Syndicat Mixte des Bassins Versants Saâne Vienne Scie will supervise the implementation of a ten-metre-wide culvert-bridge to reconnect the river and its floodplain to the sea. Restoration work in the floodplain will also be undertaken to reconnect it to the river. This will enable fish migration in the Saâne and encourage the arrival of birds such as waders. Saltmarshes and mudflats vegetation will also be able to develop in the lower Saâne valley as well as feeding areas for bass.

2.2.4 Urbanisation

The Saâne valley has developed and urbanised over the centuries. Today, the waterfront of the valley has been heavily urbanised to accommodate tourists who come to enjoy the surroundings landscapes and leisure activities that the valley and sea offer.

Identification of the threat

The Lower Saâne Valley is surrounded by three towns which two of these are located on the seafront, (Quiberville-sur-Mer and Sainte-Marguerite-sur-Mer on the sea front, Longueil is located inland). The 2015 INSEE census recorded 547 inhabitants in Quiberville, 480 inhabitants in Sainte-Marguerite-sur-Mer and 570 inhabitants in Longueil. In the summer period, the number of inhabitants can be multiplied by four, particularly in the coastal towns.

With the arrival of sea-bathing activities in the 1850s, the coastline was gradually urbanised with the construction of infrastructures to accommodate new tourists. This increased of urban development led to the construction of a road-embankment which linked Quiberville to Sainte-Marguerite-sur-Mer, disconnecting the sea to the river and its floodplain. In the Saâne valley, post-war years, urbanisation increased even more with for example the construction of Quiberville campsite. Today, urbanisation is mainly concentrated on the coastline.

In Quiberville, in 1952, we can observe that urbanisation was located on the hillsides and on the cliff adjacent to the beach. The seafront was developed over the years and new neighbourhood were built on the west of the town. By the 1970's, Quiberville urbanised area look similar to what it looks like today. In the lower valley, the road-embankment was built in the 1920s and then restored between 1957 and 1966. The mouth of the Saâne river was completely changed by the repair of the culvert outfall. In the same years, Quiberville campsite was built behind the road embankment.

In Sainte-Marguerite-sur-Mer, an area named "fond de Saâne” have been urbanised with the construction of numerous bungalows, some of which are located in flood zone area.

In Longueil, urbanisation is mainly concentrated in the lower valley along the road leading to Ouville-la-Rivière (D 127). On the hillsides, some orchards have been replaced by residential areas.

Considered too wet and used for agricultural practices, the floodplain has not been urbanised. The hillsides were developed instead as the risk of flood is considered to be the lowest. The only exception is the seafront, where coastal development has taken place to meet the needs of the tourist industry. The communes bordering the lower valley (Saint-Denis-d'Aclon and Ouville-la-Rivière) located in less humid areas have expanded along the banks of the Saâne.

Map 6 : Urbanised areas between 1952 and 2019

Map 7 : Urbanised areas in the lower Saâne

Impacts and consequences

Urbanisation creates impermeable ground and landscape modification which led to the loss of natural areas. It put pressure on the biodiversity by reducing the natural environments available for the fauna and flora. In addition to the loss of natural areas, urbanisation can also modify the water supply needs and surface water runoff in the lower valley through the creation of new networks or the impermeable ground. Urbanisation constrains spaces and creates boundaries which impacts ecological connections and disturbs the environments and biodiversity. Urbanisation is also a source of accidental or diffuse pollution along the roads. During episodes of heavy rainfall, surface water carries pollutants to the river and the floodplain. Impermeable ground increases the flow speed and the surface water runoff. During the maintenance of the roadside verges or green spaces, phytosanitary products may be used and can end up in natural areas. However, the use of phytosanitary products for maintenance of the roadside tend to decrease in France.

Artificialization and urbanization are also a source of pollution and impact the biodiversity with for example the potential of waste to be left, light pollution from public lighting or noise pollution from human activities.

While urbanisation has a large impact on the environment and biodiversity, it can also put at risk human activities and the safety of the local residents when development does not take into account natural risks. In the lower Saâne valley, around 120 houses have been built in a flood zone which put nearly 200 people at risks. The majority of these houses are located on Quiberville seafront and along the Saâne embankments in Longueil. In Sainte-Marguerite-sur-Mer, bungalows in “allée des crevettes” are at risks of sea and fluvial flood. The economic activities in the lower Saâne valley are mostly seasonal (camping, restaurants, grocery shops, shops, etc.) and mainly focused on tourism. A large part of them is located on Quiberville seafront. Among these activities, a dozen establishments are located in the flood zone.

Built in 1920, then restored after the Second World War, the road-embankment intended to protect the population from flooding and marine submersion. This 700m long embankment located along the beach allows to connect the two coastal towns and their communities. However, the road-embankment modified the Saâne mouth. This infrastructure also increases the effect the flooding (duration and height of the water level).

Every time there is a major storm event, the lower valley is flooded. In 1999 and 2018 the Quiberville campsite was under water for three weeks while the water drained from the valley. The seafront and the road-embankment suffered a lot of damage during these events.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←		→	Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←		→	Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Urbanisation	Saâne	3	2	3	4	12

Urbanisation and soil artificialisation have an impact mainly on the environment, the biodiversity and the local economy. The floodplain has not been urbanised, and development mainly took place on the hillsides of the valley.

Recommendations

Today, urbanisation in France is controlled by the town planning code, which requires compliance with regulation. Urban planning documents such as the PLU(i)[3] and SCOT[4] limit the buildable areas available. Regulation around seafront and floodplains were implemented. They restrict the possibility of building in this area and aim to protect natural environment. In addition, these planning documents and policies aim to avoid urban sprawl and reduce empty spaces.

The Conservatoire du littoral was created in 1975 with the aim of limiting urbanisation on the French coastline. It is a public institution whose mission is to acquire parcels of coastline threatened by urbanisation. It also restored natural areas and developed sites which are

[3] PLU(i) : Local Urban Plan (inter-communal)

[4] SCOT : Schéma de Cohérence Territoriale

open to the public. In the lower Saâne valley, 51 ha are currently protected by the Conservatoire du littoral.

The Littoral Act was created in January 1986. It is applied on more than 1,200 municipalities bordering the sea, but also large lakes or estuaries. It aims to preserve the coastline which are facing urbanisation, erosion or marine submersion. This law is used by planning authority to assess development. Following this regulation, no development can be undertaken within 100m wide strip along the coast (see below)

Article L. 121-16 of the town planning code stipulates that outside urbanised areas, construction or installations are prohibited in a coastal strip of one hundred metres from the high-water mark or the highest water mark for inland water bodies with a surface area of over 1,000 hectares. The aim is to preserve this particularly sensitive area from urbanisation, where the principle of environmental protection must take precedence over the principle of development. [5]

The Climate and Resilience Act of the 22nd of August 2021 planned to provide coastal areas with a framework and tools to adapt their planning policy. One of the tools will be the implementation of a PPA (Plan Partenarial d'Aménagement) which will allow coastal municipalities to deviate from certain planning rules, which prevent the implementation of an operation to relocate goods or activities threatened by erosion of the coastline, further inland. The communes of Quiberville and Sainte-Marguerite-sur-Mer are currently in the process of drawing up this PPA after being identified as communes subject to coastline erosion.

[5] Source: Légifrance

2.2.5 Sewage treatment plant

One of the aims of the Basse Saâne project is to improve the quality of the water otf the river as well as the bathing water in Quiberville and Sainte-Marguerite. To meet this objective, one of the project's operations consists of building a wastewater treatment plant in Longueil to replace the old one which was not compliant with the current regulation, and to connect all of the surrounded houses to the sewage networks.

Identification of the threat

The Saâne has been identified as a first category watercourse because of the quality of its fish population[6] . The area is also classified as a natural zone of ecological, faunistic and floristic interest (ZNIEFF): the ZNIEFF of type I "The lower Saâne valley" (230000220) and the ZNIEFF of type II "The Saâne valley" (2300031022). These ZNIEFFs identify areas of strong ecological interest due to the high number of wet habitats (for example reedbeds, ponds and ditches, hillsides, etc.) and the quality of the watercourse. The lower Saâne valley is therefore an area of high ecological value. However, studies carried out by the Agence de l'eau Seine-Normandy (AESN) have shown that the water quality of the Saâne river is impacted by sewage discharges from houses in the lower valley, particularly during high rainfall. In fact, most of the towns and houses in the Saâne valley do not have access to an efficient wastewater system. In Longueil, one of the three towns included in the Basse Saâne project, no collective sewage system was available until now and poorly treated or untreated sewage water discharged into the river.

The poor quality of the water in the Saâne is not only due to the poor state of the sewage system or the absence of a system.

Some of the wastewater treatment plants in the area no longer meet health standards and discharge poor quality water into the river. Ouville la Rivière has a wastewater treatment plant (activated sludge type treatment plant) dating from the 1970s. With a capacity of 320 inhabitants, this treatment plant is due to be removed and replaced by the future Longueil wastewater treatment plant.

Within other areas such as Gueures, Brachy and Thil Manneville, lagoonings systems (natural treatment technique that consists in the accumulation of wastewater in ponds or basins) are used to treat wastewater and are non-compliant with the current regulations.

[6] In France, a first category river is a watercourse where the dominant fish population is made up of salmonids (trout, Arctic char, grayling).

Impacts and consequences

The absence or non-compliance of collective and individual sewage networks combined with the outdated sewage treatment plant are impacting the Saâne valley.

Direct discharges are released into the Saâne and creates water pollution. They are responsible for bathing water quality to be reduced in Quiberville and Sainte-Marguerite-sur-Mer. In 2016 and 2017, in Sainte-Marguerite-sur-Mer, according to a report by the ARS[7] , the quality of the bathing water was just meeting criteria for public uses Escherichia coli was observed within the water. Escherichia coli is a bacteria that is generally transmitted through food but can also develop in stagnant water or water of poor quality (during periods of flooding) and cause digestive disorders.

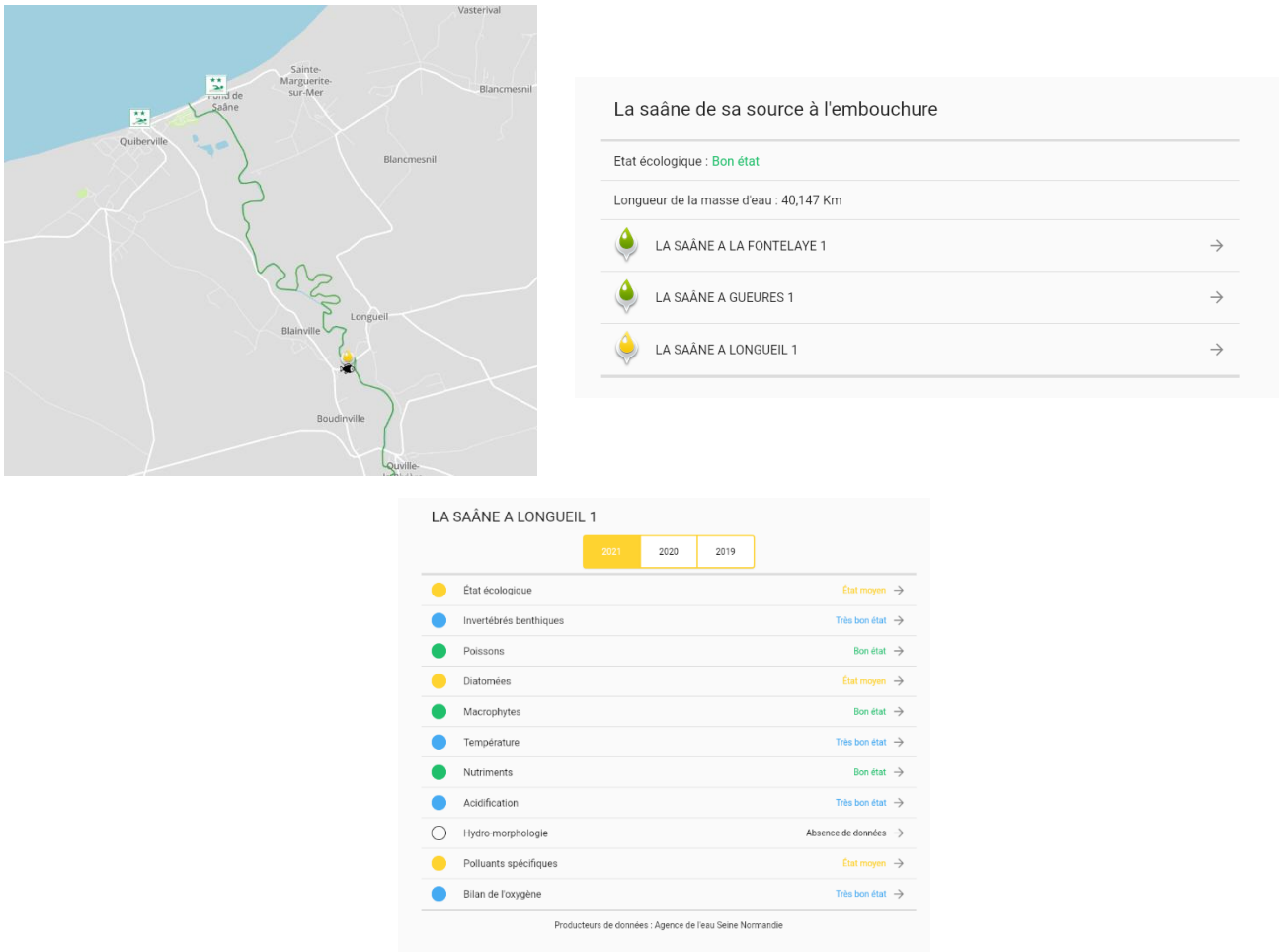


Figure 1 : Source: Agence de l'eau Seine Normandie

[7] Regional Health Agency

These data provided by the AESN (Agence de l'Eau Seine Normandie) show that upstream of the lower Saâne valley, the ecological quality of the watercourse is good. On the other hand, the data from Longueil confirms that the outdated sewage impacts the ecological quality of the Saâne.

Poor bathing water quality can lead to the temporary closure of beaches and prohibit water-based activities. Tourism is one of the main economic industry within the valley, these events cause economic loss and raise concerns around human health. In addition, the attractiveness of the lower valley can decrease quickly if these events occur regularly.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←	→		Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←	→		Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Sanitation	Saâne	3	5	3	3	14

The main impact of this threat is on water quality. Poor wastewater treatment plant and its networks also affect the quality of the nearby bathing water and therefore the local economy which is mainly based on tourism. There were also few cases of human contaminated by the Escherichia coli bacteria.

Solutions

The Communauté de Communes Terroir de Caux is overseeing and responsible for the sewage network and wastewater treatment plant around the Saâne valley since the 1st January 2020. The neighbouring towns of the lower Saâne valley (Ouville- la -Rivière, Gueures, Brachy, Saint Denis d'Aclon, Thil Manneville and Ambrumesnil and Longueil) agreed to improve their wastewater systems and to create are more suitable sewage network. This project involves the removal and demolition of non-compliant sewage systems. These infrastructures will be replaced by a new wastewater treatment plant built near Longueil with a capacity to retain and treat the water of more than 4,000 inhabitants. The rest of the project also includes the installation of several dozens of kilometres of sewer networks connecting the different area of the lower valley (Longueil) and upstream of the river to the new wastewater treatment plant.

Some of the project features can be found below:

- Laying of approximately 24,500 metres of gravity pipes of the sewer network,
- Installation of approximately 4,300 metres of discharge pipes,

- Creation of 16 pumping stations, enabling the wastewater to reach the wastewater treatment plant,
- Implementation of constant water monitoring,
- Creation of 761 new connections, with the local authority carrying out the work on private property,
- Refurbishment of 752 existing connections

The PACCo project and European funding financed the Longueil wastewater treatment plant and part of the sewer network in the Longueil area which includes over 4000 metres of pipe, 5 pumping stations and 158 new sewer connections.

Additional information on existing solutions:

- The website: https://qualite-riviere.lesagencesdeleau.fr/#/map which lists the quality of river water in France and gives access to data from water quality monitoring stations. Seine-Normandy Water Agency.
- Emmanuelle MARTIN, Jérôme LE BOUARD, Sanitary quality of bathing water in Seine Maritime, Assessment of the 2021 season, updated in March 2022, ARS
- Emmanuelle MARTIN, Jérôme LE BOUARD, Sanitary quality of bathing water in Seine Maritime, Assessment of the 2020 season, ARS

2.2.6 Floodplain afforestation

In France, poplar plantations cover approximately 250,000 ha. Floodplain management methods ease their establishment in these areas, which are nevertheless unsuitable for their development. In the lower Saâne valley, a poplar plantation dating from the 1970s is located in Longueil and within the floodplain along the river.

Identification of the threat

A poplar grove of five hectares is located in Longueil and within the floodplain. This poplar grove was planted before the Conservatoire du littoral bought the plot in 2020. It is located on an unauthorised landfill. It is still possible to observe the rubble from a former factory. More than 220 poplars have been planted within this area of the floodplain. In 1998, two governmental texts warned against afforestation activities undertaken within floodplains and explain how afforestation impacts the ecosystem and the fauna and flora. In addition, poplars are not adapted to wet condition.

Map 8 : Location of the poplar grove in Longueil

Impacts and consequences

With the river modification which change wetlands into agricultural lands, it also allowed poplar groves to be planted within the floodplain. After the war, poplars were often planted due to their quick growth which increase the wood production. Poplar plantations impact the

environment. Poplar plantations are generally intensively exploited. This can lead to landscape and ecological changes (e, g,. destruction of environments with high ecological potential, soil depletion, decrease of the fauna and flora, etc.). They are responsible of the reduction of the biodiversity. Poplars are not adapted to wet ground condition which can be found in the floodplain. Their root systems remain on the ground surface as they do not like to be in large amount of water. During a storm, they are more likely to fall as their lateral roots stay close to the ground surfaces.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←		→	Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←		→	Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Floodplain afforestation	Saône	4	2	1	1	8

The main impact of the poplar grove is on the biodiversity and habitat. As the size of the poplar grove plantation in Longueil is small, it does not have much impact on the human health or the local economy. The main risk to human is related with the location of the poplar grove near the town. During storm event, the trees are more likely to fall causing damages to infrastructure or harming people.

Solutions

In October 2022, the Conservatoire du littoral undertook the felling of all the poplars, as well as managing the invasive species located on site such as the Caucasian walnut and bamboo. Following the felling of the trees, careful consideration is being given around the uses of this area. The aim is to use the five hectares to create a suitable area where the fauna and flora can thrive whilst restoring the floodplain.

2.2.7 Human use

The lower Saâne valley is renowned for its landscapes and the activities available around the area. The valley offers a varied range of uses, which can be enjoyed throughout the year.

Identification of the threat

In 1856, the lower Saâne valley welcomed its first bathers. This new activity appeared following the fashion created by the Duchess of Berry which swam in Dieppe. Tourism increased and led to the urbanisation of the seafront to accommodate the new visitors. The beach accesses, beach huts and accommodations started to be developed in Quiberville. The development of tourism and leisure activities have been made easier by the involvement of the town's councils.

Most of the uses in the lower valley are located within the two coastal towns (Quiberville-sur-Mer and Sainte-Marguerite-sur-Mer), which offer more activities than Longueil. The population of the lower Saâne valley is multiply by four during tourism season. The area attracts mainly local visitors or tourist usually from the northwest of France. Tourists and users can enjoy the activities offered by the valley: hiking, water sports, paragliding, cycling, hunting and recreational fishing.

Tourism:

Tourism is one of the main industries located in the valley. Every year many visitors come to enjoy the surroundings landscape. To meet the demand in accommodation, the seafront was developed to host the new visitors. A campsite was built in Quiberville in the 1960s and extend over five hectares. It is located just behind a sea embankment and 30 metres away from the beach. Open from April to October, the campsite attracts the same users every year, some of whom have been coming for 50 years.

Today, the lower valley of the Saâne has many leisure facilities which are mainly related to outdoor activities. A 180km long footpath (the GR 21) crosses the valley and links Le Tréport to Le Havre. In Sainte-Marguerite, another long-distance footpath (70kms) begins, the GR 212. It follows the Saâne river and ends in Duclair near the Seine River.

Located near the lower valley, the Linen Cycle Route go through the Saâne valley at Ouville-la-Rivière and links Dieppe to Fécamp and attract new type of tourism since 2018.

The Saâne valley also offers other activities such as canoeing on the river or in the sea, paragliding, swimming or observing the fauna and flora.

Quiberville has a Yachting Club, which offers nautical activities during the summer. In 1999, the sailing club of Quiberville was created.

All the sea activity are located at the existing facilities at each end of the beach (Quiberville on the west side, Sainte-Marguerite-sur-Mer on the east side). The central area of the beach, on the other hand, is very little used.

Hunting:

Hunting is carried out on private lands within the lower valley. Waterfowls are hunted mainly in these areas. Hunting ground spread over two areas (around 23ha in total) which can be rented by private individual. Hunting on the land owned by Conservatoire du littoral is prohibited except for one educational area.

Recreational fishing:

The Saâne is a 1er category river (dominant salmonids) where sea trout fishing is allowed, but not salmon fishing. Between Longueil and Sainte-Marguerite-sur-Mer, two fishing routes exist. The first, in Longueil, is suitable for children and the second is in Sainte-Marguerite-sur-Mer, along the footpath and the land of the Conservatoire du littoral. As the rest of the banks are privately owned, fishing is not permitted.

Map 9 The different uses of the lower Saâne valley.

Impacts and consequences

The impacts related to tourist activities are not very significant in the Saâne valley. The main risk is the potential for pollution and degradation occurring during the summer period when the number of visitors is at its peak. Outdoor activities can be responsible for pollution with the waste being left along the hiking trails. Outdoors activities can disturb species. River kayaking can lead to the destruction of spawning grounds when the water level is not high

enough. The construction of the campsite between 1960 and 1970 resulted in the destruction of habitats.

Regarding hunting, which is still a popular activity in France, about 250 million cartridges are fired in France every year. The vast majority of these are scattered in the natural environments and the Saâne valley is no exception. In addition, lead shot is responsible for some of the pollution of the floodplain and its natural habitats. Waterbirds that use these areas can eat the lead shot and become intoxicated. However, hunting in the lower Saâne valley is not intensive and therefore its impact is limited.

Fishing can be responsible for the decrease of the fish population. However, like hunting, fishing in the Saâne valley, is not practised enough to have a major impact on the number of fish in the river. The low number of migratory fish is the result of the culvert at the mouth of the river, which limits fish migration.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	◄	►		Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	◄	►		Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Uses	Saâne	3	3	1	1	8

The high numbers of visitors combined with the uses of the valley mainly impacts the biodiversity and water resources. The impact and its intensity of the uses depend on the season. During winter, less activities are available and the number of visitors is low meaning that impacts are reduced. Summer period combined with overcrowded sites can result on greater impact on the environment.

Recommendations

The PACCo and Basse Saâne projects does not aim to reduce the number of activity or impact the uses of the valley. The reconnection of the sea to the Saâne will modify the lower valley, its landscape and its fauna and flora. Uses and management of the site will have to adapt to these changes. To ensure this is the case, raising awareness of the valley's users is key in order to communicate effectively about the new environment and biodiversity.

In order to ensure activities such as hunting or fishing does not damage the biodiversity, hunting and fishing quota need to be respected and controlled.

2.2.8 Invasive species

The Saâne valley has been heavily modified and its ecological potential is now very limited. Human activities within the valley have also led to the arrival of new non-native species, some of which have become invasive.

Identification of the threat

In the lower Saâne valley, the exotic species recognised as invasive are mainly located within the poplar grove and its five hectares. This area was bought by the Conservatoire du littoral. Three invasive species have been identified on these five hectares: the Caucasian walnut, the Bamboo and the Buddleia. These three species were introduced by human activities during the planting of the poplar grove. The non-native plants present in the local environment near the urbanised area can also come from nearby gardens. Therefore, the buddleia present within the poplar plantation may have been introduced by individual which have their garden nearby (buddleia is not considered has an invasive species in France yet).

The Baccharis halimifolia, although a very rare species, has been recorded in Quiberville campsite. This species is considered potentially invasive in France.

Map 10 : Location of the invasive species

Impacts and consequences

These invasive species can impact directly the biodiversity. According to the IUCN[8] , biological invasions are the second cause of biodiversity loss in the world. Most of the time, the introduction of these species is voluntary and due to human action. Adapted to our climate, these species develop rapidly and can create many problems for existing ecosystems. When non-native species colonise an area on a large scale, they compete with native species (animals or plants). In most cases, this leads to the destruction of habitats and the disappearance of existing native species. In the poplar grove, invasive species can weaken the embankment. For example, in just a few decades, Caucasian walnut trees have proliferated along the embankment of the poplar grove of the Saâne river and can leads to watercourse blockages or put the river users (kayakers) at risks if a tree fall. This rapid spread of invasive species prevents native species to become established.

Invasive species can cause the weakening of infrastructures and the reduction in biodiversity. They can disrupt the flow of the watercourse or modify the physical-chemical balance of the area. As a result, biodiversity located within the floodplain can disappeared. If no measures are implemented to reduce the number of invasive species, human activities such as fishing, hunting or agriculture may be affected.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←		→	Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←		→	Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Invasive species	Saâne	2	2	1	1	6

Invasive species are relatively well contained and only found in the poplar grove or on the campsite. Due to the small number located within the valley, they are not considered as an important threat. However, invasive species management needs to be implemented to reduce and keep their number of under control.

[8] International Union for Conservation of Nature (IUCN)

Recommendations

As part of the restoration of Longueil poplar grove, work was undertaken to fell Caucasian walnut. They were cut following the guidance given by the CEN[9] which give recommendation for the treatment of invasive species in Normandy. For the Caucasian walnut trees, it is recommended to remove the bark before felling large trees, and for small tree, uprooting them is strongly advised to avoid any regrowth. Regular maintenance of the area will be undertaken to prevent any regrowth of the trees.

It is necessary to raise public awareness on invasive species and their impacts. Invasive plants very often come from garden centres that sell exotic plants without considering their invasive potential. Invasive animal species are generally bred for hunting or fishing purposes and accidentally or intentionally released into the natural environment without knowing the consequences of this action.

[9] Conservatoire des Espaces Naturels (CEN)

2.3 The Otter Valley

	Threat	Consequences on the issues	Solution/ Recommendation	Score
Sheet 1: River modification	The natural environment of the River Otter and its estuary has been modified by humans for hundreds of years. Modifications include: - Straightening of the river (1.1) - Construction of embankments (1.2) - Modification of the Budleigh Brook (1.3)	**- Biodiversity and habitat:** The original intertidal habitats and associated biodiversity located along the river and its floodplain changed to be replaced by habitats and wildlife of lower conservation value. The aqueduct which diverts the Budleigh Brook across the floodplain restricts the natural movement of species. **- Water resources:** As a result of the modification of the Lower Otter estuary, floods are more frequent and can increase pollution events especially due to the presence of the disused landfill. **- Local economy:** As flood event are more frequent, floods are responsible of economic loss. **- Human health:** The estuary modification has modified the natural function of the floodplain. Flooding is more regular which can have consequences on human health.	The Lower Otter Restoration Project includes good examples of possible solutions to reverse the impacts of the modification of a floodplain. It allows the restoration and reconnection of the sea to the floodplain and restores its natural functions. Major construction has been undertaken to recreate rich inter-tidal habitats and increase biodiversity which should provide socioeconomics benefits for the population as well as reduce the risk around infrastructures, population and economy. On smaller scale projects, targeted restoration and natural flood management measures can be used to help to restore habitats and provide benefits for the environment and adjacent population.	17
Sheet 2: Urbanisation and development	The Otter Valley is a popular area in which to live due to its location. Approximately 150,000 people live within 10km of the site. Many villages and towns have been developed adjacent to the flood plain and river such as: -Budleigh Salterton - East Budleigh - Otterton	**- Biodiversity and habitat:** Urbanisation and development when considering air, water and waste pollution and the introduction of invasive species, decreases the diversity of the fauna and flora present within the valley. **- Water resources**: As the number of people rise, the need for freshwater increases, putting more pressure on resources. Urbanisation and the subsequent ground artificialization increase water run-off which can convey pollutant and decrease water quality.	As the population growth continues to rise, regulatory bodies and major stakeholders will need to evolve policies in order to deliver more sustainable development and to encourage public infrastructure to undergo early adaptation to climate change. Projects like PACCo show the wide range of benefits of early adaptation to climate change and results from these projects can help to encourage/influence the government to evaluate their policies around development and the adaptation of communities. Sustainable development needs to be encouraged to decrease the impact of urbanisation on biodiversity and water resources.	11
Sheet 3: Tourism and uses	Due to its location near the sea, the Otter Valley is a popular destination for tourists. Associated activities and uses have been developed around the valley driven by the local beach and hiking paths. Recreational uses and tourism can negatively impact the valley if not well managed.	**- Biodiversity and habitats**: Tourism can cause a loss of biodiversity due to disproportionate site usage. The high numbers of users (tourists and local) on the public footpath can deter wildlife from creating habitats and breeding in the area. It can also contribute to air pollution due to the increased number of cars. **- Water resources:** Tourism contributes to add pressure on local resources (water), drainage and their infrastructures.	The Lower Otter Restoration Project helps secure the current footpath network around the valley with some raised and improved to All Ability standard. New viewing platforms, carpark and the improvement of the footpath will decrease the impact of climate change and secure the local economy. Information boards have been installed to raise awareness amongst locals and tourists on the best ways to limit impact on the environment. The breaching of the embankment is likely to encourage new leisure activities in the area which could further impact the biodiversity due to an increase in visitor numbers. A Ranger position has been created to ensure eco-tourism and activity-based tourism have a limited impact on the area.	11

Sheet 4: Public infrastructure	The Otter Valley and its floodplain have been heavily modified to support societal needs with public infrastructure impacting the local environment and water quality. There are many public infrastructures within the area, however, the four main infrastructures at risk are: - The disused railway line (4.1) - South Farm Road (4.2) - The disused tip (4.3) - The cricket club (4.4)	**- Biodiversity and habitats:** The different infrastructure contributes to the urbanization of the valley. The construction of these have reduced the habitats available to wildlife, have further divided the flood plain and replaced rich habitat wetland with low value habitat. **- Water resources:** The different infrastructures have different impacts on water resources and quality. The main threat being the disused landfill where there is a potential risk to contaminate surface water and underground aquifer due to fluvial floods and erosion. **- Local economy**: The infrastructures located within the flood plain have different impacts on the local economy. South Farm Road which is subject to flooding, is a vital road for residents and businesses on the east side of Budleigh Salterton. The cricket club has often been flooded due to its location within the floodplain **- Human health**: In an event of accidental breach from the main embankment, the tip could be submerged and erosion could lead to the release of contaminants which can infiltrate the water supply causing a threat to human health.	During the PACCo project and the restoration of the Lower Otter, infrastructures were either moved or secured. The cricket ground was removed from the flood plain and relocated on the northwest of Budleigh Salterton. South Farm Road was raised over the landfill ground and part of the landfill was removed to allow the construction of a bridge allowing the reconnection of Big Marsh. The rest of the landfill was capped and a low gradient bank implemented to limit erosion. A culvert was installed along the previous railway which is used as a farming track to allow better drainage and the water to flow in the flood plain.	13
Sheet 5: Utilities	Utilities were installed around and across the Lower Otter Valley to supply services to Budleigh Salterton and the adjacent area. There are many services around the Otter Valley. Some have a higher impact on the Lower Otter such as the following: - Electric overhead cables (5.1) - Telecom overhead cables (5.2) - Combined sewage outfall (5.3) - South West Water abstraction borehole	**- Biodiversity and habitats:** Overhead cables and water supply have a low impact on biodiversity. However, the combined sewer outfall, which is used in emergency situations, can have major consequences on biodiversity as it releases raw sewage directly into the sea, impacting the whole area. **- Water resources:** With the combined sewer outfall near the beach, its use decreases the water quality around the Lower Otter Valley. In addition, the presence of a freshwater borehole in the valley can be put at risk due to the disused landfill which can release contaminant during fluvial floods. **- Local economy**: The overhead cables can be damaged by wind or even flood which is a problem as they provide services to the local businesses and residents. The combined sewer can impact the water quality of the nearby beach, the local economy and tourism. **- Human health:** Water quality can be impacted by the release of sewage. The location of water supply boreholes can also be an issue in case of accidental breach or fluvial floods with the presence of the landfill in the floodplain. Contaminants can be released and conveyed by the water, infiltrating the water supply and causing health issues for the local population.	With the funding available, and the work undertaken at South Farm Road, cables were buried along the new raised road securing services for residents and businesses. Regarding the South West Water borehole, modelling was used to assess the risk of contaminants reaching the aquifer or the risk related to saline intrusion. Further monitoring will take place to ensure that the Lower Otter Restoration Project and the reconnection of the floodplain to the sea won't impact the water supply. The disused landfill protection was also improved to diminish the risk around water contamination. Regarding the use of the combined sewage outfall, monitoring should be used to understand better its frequency of use. Solutions should be sought to improve the sewage network to separate surface water and wastewater. The Saâne valley can be used as an example of where the PACCo funding was used to improve the sewage network and provide a new wastewater treatment plant.	16
Sheet 6: Invasive species	Invasive species are located in various areas in the Lower Otter and have been introduced by humans. The main invasive species are: - Water Fern (6.1) - Himalayan Balsam (6.2) - Japanese Knotweed (6.3)	**- Biodiversity and habitats:** Invasive species, with their capacity to spread and outcompete native species, contribute to the decrease of biodiversity around the valley.	The landowner (Clinton Devon Estates) and their tenants have managed the spread of invasive species over the past years and will continue post project. With the Lower Otter Restoration project and the floodplain reconnection, the spread and distribution of invasive species across 55 hectares of land will be greatly reduced due to tidal/saltwater ingress and the creation of the saltmarsh and mudflat. Invasive species such as Himalayan Balsam and Water Fern cannot tolerate salt water and should therefore be killed.	8

Sheet 7: Water abstraction	Water abstraction can be divided into two categories within the valley: abstraction from the river and abstraction from the underground aquifer. Across the catchment area, water is extracted from the river primarily to support agriculture and water extracted from underground aquifers is used either for human consumption or agricultural purpose. Outside of the study area, other boreholes and river abstractions are used, for example for spray irrigation and hydro-electric power. With the constant increase in demand of water as well as the change in climate, water resources are put under increased pressure.	**- Biodiversity and habitats**: Whilst abstraction of underground water has little impact on biodiversity, surface water abstraction can modify the flow of watercourses, directly impacting aquifer recharge and river ecology and biodiversity. **- Water resources:** Unsustainable increase in the demand of water where abstraction of groundwater is greater than recharge can result in a drop in the water table. In the Lower Otter, this can also lead to degradation of water quality due to the intrusion of saline water.	The breach undertaken by the Lower Otter Restoration Project will enable tidal water to inundate the valley and become close to the influence zone of a strategic drinking water borehole. There is a risk that saline water will replace fresh water within the aquifer. Studies, including ground water monitoring were conducted as part of the development phase of the scheme to ascertain the level of risk. This risk has been ascertained to be low. However, saline intrusion may be the consequence of over-abstraction of ground water resources. Sustainable abstraction management needs to be implemented to avoid this problem and solutions can be put in place by members of the public and businesses (e, g, the re-use of grey water or rainwater).	12
Sheet 8: Agricultural practices	Except for the urban areas (Budleigh Salterton, East Budleigh and Otterton), the land surrounding the Otter valley is used primarily for agricultural purposes. The land within and surrounding the floodplain is mainly use for grazing and silage. Arable land is located on the higher ground of the valley. Agriculture can impact the valley if it not well managed.	**- Biodiversity and habitats:** The complex inter-tidal wetland system which was located in the estuary was largely replaced by drier, simplified systems of improved grassland. This contributed to reduce biodiversity around the estuary. Impacts of farming are, however, reduced on the Lower Otter. This is due to some of the farms being organic which means negative environmental impacts are minimised **- Water resources:** Large amounts of water are used in agriculture with water abstraction adding pressure on the water resources. Moreover, arable farming on the valley sides brings with it a risk of runoff and water pollution, although these risks have been minimised through good husbandry.	Prior to the PACCo project, Clinton Devon Estates and their tenants have worked to ensure that agricultural activities within and adjacent to the Lower Otter valley are appropriate for the location, with environmental risk minimised. The PACCo project also funded the restructuring of Pulhayes Farm so that it could adapt to climate change.	10

1. River modification		1.1 Straightening of the river and embankment
		1.2 Bank disconnecting the sea to the floodplain
		1.3 Budleigh Brooke Aqueduct
2. Urbanisation and development		Budleigh Salterton, Otterton and East Budleigh
3. Tourism and uses		3.1 South West Coast path
		3.2 Other Hiking path
4. Infrastructure		4.1 Disused Railway line
		4.2 South Farm Road
		4.3 Disused landfill
		4.4 Cricket club
5. Utilities		5.1 Electric overhead cable
		5.2 Telecom overhead cable
		5.3 Combined sewer
6. Invasive species		6.1 Water fern
	Not represented, located along all the water courses within the valley	6.2 Himalayan Balsam
	Located at the tip (see 4.4)	6.3 Japanese knotweed
7. Water abstraction		Borehole
		River abstraction location
8. Agriculture		8.1 Grazing land
		8.2 Crop land

Map 2: Summary of the different human threats

2.3.1 River modification

Estuaries have always been important places for people and wildlife. For thousands of years human activity has altered them. Settlements and sea defences have been built, wetlands have been drained to facilitate agriculture and infrastructure, including roads, sewage treatment works, tips and recreational facilities have been placed in areas which were formerly floodplains. This has resulted in societal benefits but has come at an ecological cost as so often happens. Human development has come without consideration for the impact on the environment. Rivers, estuaries and their associated catchment areas and floodplains are vital areas for wildlife. They also have flood risk management benefits. Past modifications to estuaries have often changed the surrounding environments, impacting natural processes and putting both societal infrastructure and habitats at greater risk of the consequences of climate change.

Threat identification

The natural environment of the River Otter and its estuary has been modified by humans for hundreds of years. Modifications include:

- Straightening of the river

- Construction of embankments

- Modification of the Budleigh Brook

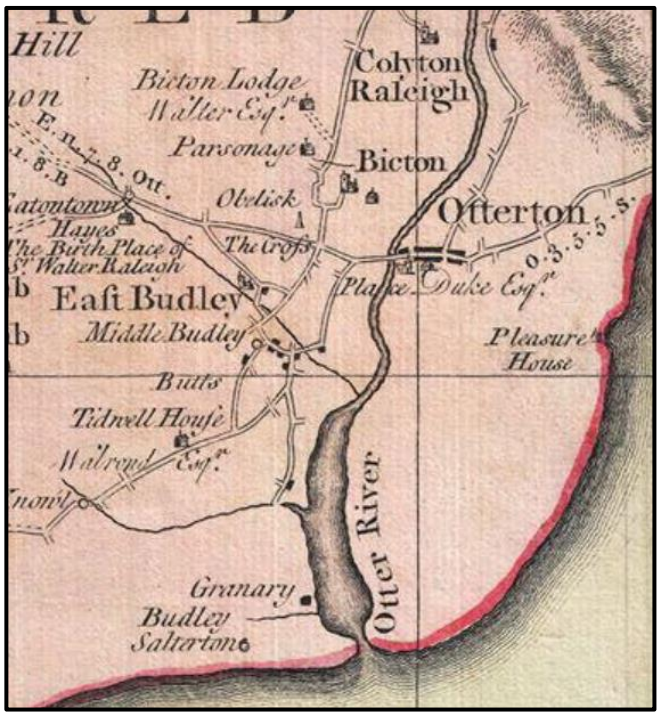
Modifications since the early 19th century have aimed to create agricultural land for the landowner and improve its drainage.

From the 1400s the River Otter was an important trade hub and numerous quays were located along it. Land infrastructure became increasingly important after the natural growth of the shingle bar at the mouth of the Otter Estuary in the mid-1400s, with the silting up of the river and shallowing of the main channel also reducing the importance of water transport. A secondary aim of the flood embankment was to straighten the Otter River which would improve navigability and access for trade; however, although the embankment did serve to create agricultural land, the navigation benefits were never realised with the river largely remaining unnavigable.

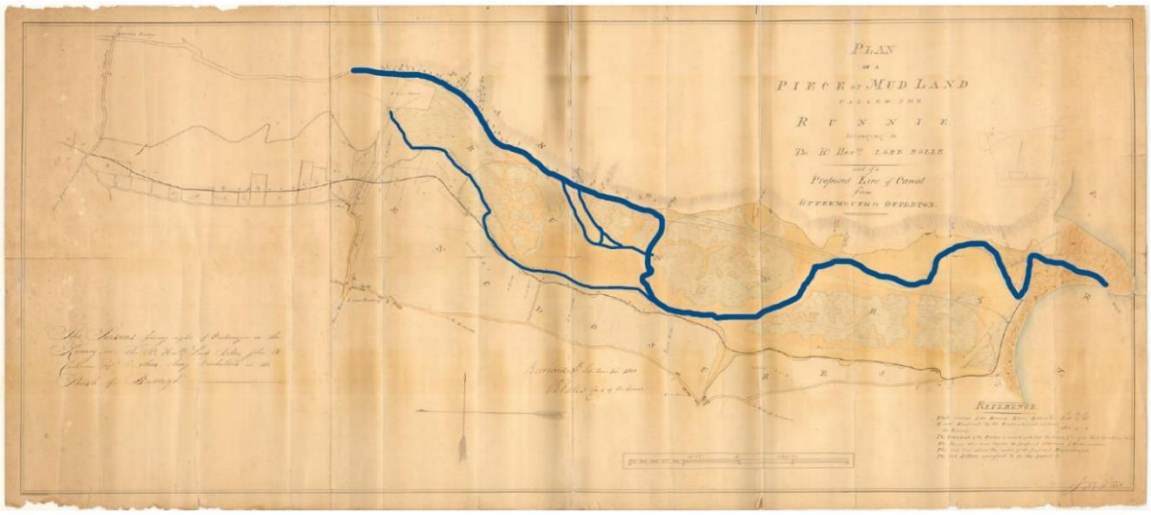
The primary objective of building the flood embankments was to increase the available area for agriculture. This resulted in disconnecting the river from its historic floodplain. The main embankment, starting at Lime Kiln car park, running northwards and ending in Little Bank, was the first one to be built. A further extension (Big Bank) was built at a later stage to try and further improve drainage. An aqueduct was built around 1920 to divert the Budleigh Brook and limit the impact of the channel on the farming land.

With the development of agriculture, the landscape changed from one that was inter-tidal in nature to one that was pastoral. New hedgerows (mainly willow) grew up in association with drainage ditches with a small number of trees growing to maturity.

Further information on The Lower Otter modification can be found in “Promoting Adaptation to Changing Coasts T2.2.1 Socioeconomic Framework”.



Map 1: Lower Otter Estuary, Sources: Benjamin Donn Wall Map of Devonshire and Exeter, England



Map 2: Original route of the river Otter, source: Clinton Devon Estates

Map3: main modifications of the valley.

Impacts and consequences:

The modification of the river and its floodplain has changed the landscape and widely impacted the valley. The original intertidal habitats and associated biodiversity located along the river and its floodplain changed to be replaced by habitats and wildlife of lower conservation value associated with a farmed landscape. The straightening of the river resulted in the conveyance of the channel being increased, which accelerated of sedimentation, impacting the geomorphology of the river ecosystem.

The valley has always been prone to flooding, however the modification of the embankment has meant that any floodwaters within the floodplain are unable to escape resulting in a more prolonged flooding. This has increased the risk to other existing infrastructure including an old tip site, a road, footpaths and a cricket club. After heavy rainfall, flood water can take several days to drain through a small artificial outlet. Floods are also responsible for economic loss and can result in pollution events by conveying large amounts of surface water which may contain contaminants.

The aqueduct which diverts the Budleigh Brook across the floodplain restrict the natural movement of species up the Budleigh Brook, including that of migratory fish such as salmonids and eel. This serves to reduce the biodiversity of the wider valley. The Budleigh Brook stream was known in the past to support good numbers of trout; populations are now much lower.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←			→ Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←			→ Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
River catchment and flood plain modification	Otter Valley	5	5	3	4	17

River modifications have a major impact on the natural functioning of the Otter Valley. The modifications have negatively impacted biodiversity in the valley and a large part of the wetlands. The resulting change in flood water movement also represents a threat to water quality, human health and economy by threatening existing infrastructure.

Solutions and recommendations

The Lower Otter Restoration Project provides good examples of possible solutions to reverse, in part, the impacts of the modification of the floodplain. It allows the restoration and reconnection of the sea to the floodplain and restores its natural functions.

Major construction work was undertaken to assist in restoring the Lower Otter. The flood bank was breached to reconnect the sea to the floodplain. A creek network was excavated in the valley to facilitate the tidal inundation and drainage. Landscape features were designed to encourage wildlife to settle on site (e.g., the creation of bird island). A bridge was created to allow tidal waters to ebb and flow underneath; a road was raised to reduce flood risk. The most northerly section of the embankment (Little bank) was lowered to floodplain level to facilitate the passage of water down the valley, whilst still providing a public footpath. The aqueduct was decommissioned and is now an open channel with a culvert placed in Big Bank to reconnect it to the floodplain. A cricket club was also moved out of the floodplain. The works around the valley and their designs can be found in the PACCo guide – Part 4: Design and construction.

Other potential solutions were studied to restore the Lower Otter (for example, full scale restoration). These were excluded due to technical, financial or social constraints. The different scenarios can be seen in the Environmental Statement (http://www.lowerotterrestorationproject.co.uk/).

Whilst such projects are beneficial for the environment, they can be technically difficult to deliver and involve many challenges. A good example is reaching an agreement with a landowner regarding a change of land use. Finances can also be a constraint.

It might be thought that allowing nature to reclaim the floodplain would present a cheap management solution. However, due to the amount of pre-existing development within and around the valley, uncontrolled natural breaching would have had far-reaching consequences on the infrastructure, local economy and the local population. In addition, legal constraints and the requirement to gain support from public and statutory agencies restrict solutions to some degree.

Smaller-scale projects on other sites with less infrastructure may be less expensive to deliver than the Lower Otter Restoration Project whilst still enabling natural flood management, the reinstatement of natural processes and the enhancement of biodiversity. Projects at a micro-scale could include adding in meanders, placing wooden debris to create a leaky dam which would decrease peak flows and limit sedimentation, the removal of obstacles to wildlife such as weirs or the creation of fish passes (see: CIRIA guidance C802: Natural flood management).

Further reading on the solution:

History relevant to the Otter valley can be found on Ovapedia: Local History | Otter Valley Association (ova.org.uk)

More information on the project in the Lower Otter Valley can be found on: https://www.pacco-interreg.com/

More information on the construction undertaken within the Lower Otter can be found in: PACCo guide – Part 4: Design and construction and PACCo Guide – Technical Annex 1. Lower Otter design and construction

The Lower Otter Restoration project description and Environmental Statement can be found on: http://www.lowerotterrestorationproject.co.uk/

Natural flood management solution can be found in the CIRIA guidance C802: Natural flood management

2.3.2 Urbanisation and development

Many towns and cities were built and developed around watercourses and estuaries. This was largely due to accessible water and food supply and the associated benefits such as water-based trading. As transport evolved and the use of the river for trading decreased, these areas remained popular due to the establishment of new usages and activities, including recreation. Watercourses and estuaries are also well liked by the local population due to their character and attractive landscapes.

Threat identification

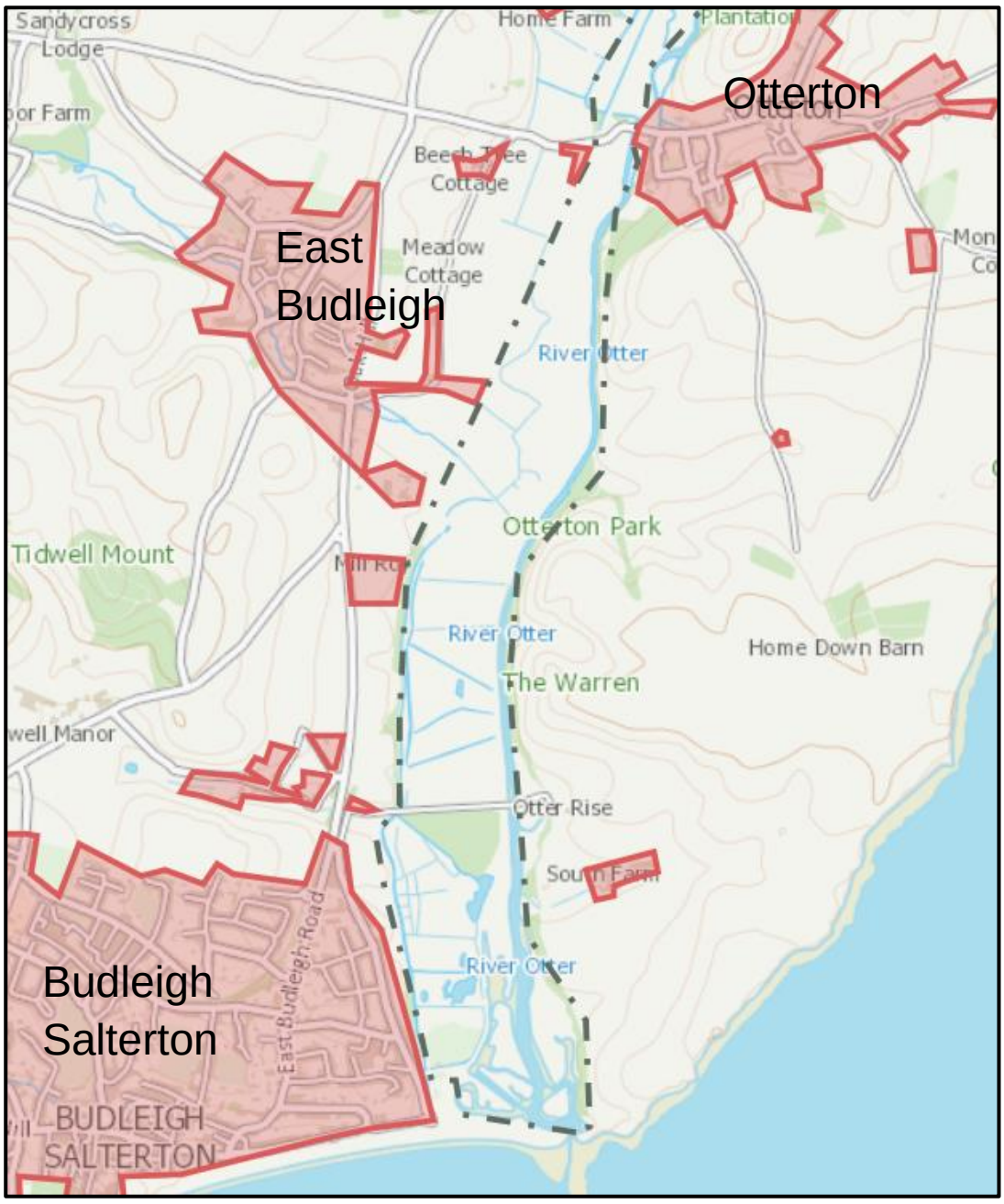
The Otter Valley is a popular area to live due to its location. Located east of Exeter and within half an hour's drive, it is a popular destination and a sought-after location to live. Approximately 150,000 people live within 10km of the site. Many villages and towns have been developed adjacent to the flood plain and river. In the 18th century Otterton and East Budleigh dominated the local settlements with Budleigh Salterton (to the west of the mouth of the river) replacing them as the main urban centre during the 19th century as tourism developed. Budleigh Salterton is located on the B3178; it is situated on the sea front on the western edge of the valley. East Budleigh and Otterton lie further to the northeast and northwest of the low-lying valley, respectively.

Otterton and Budleigh were originally developed at these locations in the valley as there were numerous quays which supported trading and commerce on the estuaries. However, land infrastructure became increasingly important after the natural growth of the shingle bar at the mouth of the Otter estuary from the mid-1400s, with the silting up of the river and shallowing of the channel also reducing the importance of water transport. This silting was progressive from the Middle Ages and was the same across the whole country; boats gradually grew larger too and needed deeper waters to navigate.

Water based activities within the valley also changed with the gradual silting up of the river. River trade had ceased by the time land had been reclaimed for agricultural purposes with the building of the embankment. Since the 19th century all villages and towns have grown significantly in line with national population trends with the growth in Budleigh Salterton being most significant due to both the increase in tourism and the development of the railway (now disused). It is today a popular tourist destination largely due to the combination of its location on the South West Coast Path, its proximity to the sea and valley. There are just under 5000 inhabitants which make it the biggest town in the valley, followed by East Budleigh (780 inhabitants) and Otterton (700 people). The population of Budleigh Salterton has risen by a factor of 2.5 over the last one hundred years; there were 2000 residents in 1905.

To accommodate the high number of people, the area has seen many housing developments and associated infrastructure development including that related to water supply, wastewater treatment and transport.

The development around the estuary has impacted the environment and biodiversity around the valley.



Map 1: Urbanized areas around the valley

Impacts and consequences:

The development of nearby towns has had a major impact on the Otter Valley over the years. Development has been beneficial for the local economy with more people living in the area stimulating new activities and commerce throughout the valley. However, with the increased number of houses and infrastructure, the landscape has become less natural, with drainage impaired, a loss of biodiversity and a reduction in water quality. There has

also been an increase in water run-off due to the creation of man-made paths (roads) with this exacerbating flooding. Water quality has declined over time with this primarily due to diffuse agricultural pollution.

The increase in surface water and run off directly caused by the urbanisation of natural land associated with the disconnection of the river from its floodplain, has created more potential for flooding. In addition, a higher number of people put more pressure on resources and creates more waste, including sewage that needs to be treated and disposed of. A particular issue within the Otter catchment and many others is the sewage system is combined with surface water runoff drainage. This frequently overwhelms water treatment facilities with sewage discharged into the valley when this occurs. Many houses also have private septic tanks; some of these do not adequately safeguard the environment.

In addition, some residential houses and infrastructure are located within the flood zone and become inundated. This incurs financial costs to fix damages.

The urbanisation and development of agricultural and natural ground in the area is impacting the valley's biodiversity and constrains future biodiversity enhancement. This development when considering air, water and waste pollution and the introduction of invasive species, decreases the diversity of the fauna and flora present within the valley. Available habitats – particularly wetland habitats associated with the historic floodplain - have been reduced dramatically throughout the last few centuries.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←			Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←			Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Urbanisation and development	Otter Valley	4	4	2	1	11

Biodiversity and water resources are mainly impacted by urbanization. Human health is also impacted by urbanization with the area having increased pollution.

Solutions and recommendations

The problems caused by urbanisation are varied, nuanced and solutions can be complex. A rise in population demands an increase in accommodation and an improvement of infrastructure. County councils are responsible for planning policies which have generally become stricter over the years. Flood zones and new regulations have been put in place to avoid the uncontrolled development of towns. New policies have also been introduced to ensure that the local environment and risk of flood is considered as part of planning applications and sustainable development is encouraged. Policies for new developments now include those related to sustainable urban drainage to limit water run-off. A

revaluation of land management strategies that can provide natural solutions to flood risk, for example, is essential so that regulatory, public and private bodies communicate better to come to decisions that enhance the environment and socio-economic wellbeing.

Designated environmental areas (such as AONB and SSSI) constrain development and help fauna and flora to be protected.

Development around the Otter Valley has also been limited by Clinton Devon Estates, which owns much of the surrounding area and whose land management objectives include conservation of the local environment as well as agriculture.

As the population growth continues to rise, regulatory bodies and major stakeholders will need to evolve policies in order to deliver ever more sustainable development and to encourage public infrastructure to undergo early adaptation to climate change.

In extreme circumstances this may require ‘at risk’ populations to be relocated.

Projects like PACCo show the wide range of benefits of early adaptation to climate change and results from these projects can help to encourage/influence the government to evaluate their policies around development and the adaptation of communities.

In addition, when considering new developments, it is essential that regulatory bodies do not just assess the impact on environment and water quality but ensure that an area has sufficient infrastructure and services (sanitation, waste management, health) and employment to sustain the population growth.

2.3.3 Tourism and uses

The proximity of the Lower Otter valley to Budleigh Salterton beach, the Jurassic Coast and the South West Coast Path provides a range of water and land-based tourism activities. Tourism is a major source of income for the local economy, however it can also negatively impact the valley if it is not well managed.

Threat identification

The Lower Otter Valley is within easy reach of Exeter and is a popular tourist destination due to its proximity to the sea and the activities available. A primary attraction is the two miles of pebble beach and valley walks along the River Otter. Some of these connect to the Pebblebed Heaths National Nature Reserve and the World Heritage Jurassic Coast.

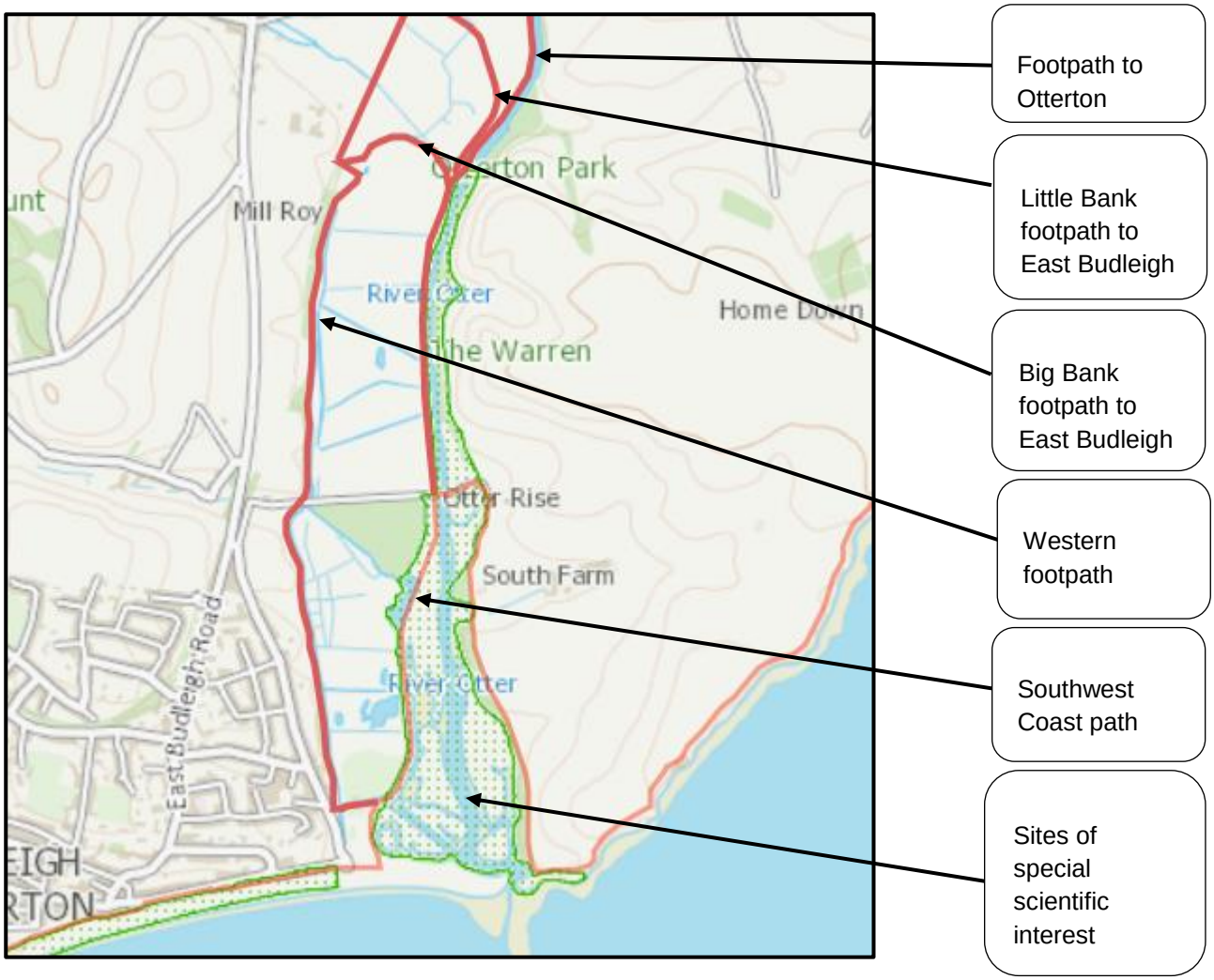
The South West Coast Path is one of the main attractions. It passed through Lime Kiln car park at the estuary mouth, then runs up through the valley along an historic embankment. From here it turns eastwards over White Bridge (South Farm Road) before continuing along the coastal edge towards Sidmouth. A second footpath, - the East Budleigh Footpath, runs along the western edge of the valley and along Big Bank and Little Bank. A third (Otterton footpath) traces the line of the eastern bank of the floodplain towards Otterton.

The South West Coast Path and the surrounding paths around Budleigh Salterton and Otterton, support 250 000+ visitors to the area. The availability of a good network of Public Rights of Way is a tourism draw and thus vital for local businesses.

The Otter Valley is also attractive for its wildlife and surrounding landscape. As the location of the first official wild beaver release in England, the valley offers opportunities for wildlife watchers. The valley lies within the East Devon Area of Outstanding Natural Beauty (AONB) with the lower part of the valley (the last vestiges of saltmarsh and mudflat associated with the estuary mouth) is a designated a SSSI.

Other sites and activities are available in the area such as fishing, land and water-based leisure activities (walking; cycling), cultural events (e.g. Sidmouth Folk Festival; Budleigh Literary festival) and museums (e.g. Fairlynch Museum).

As part of Work Package 2 (2021), a survey was conducted in the Lower Otter to understand how users perceived the valley before the implementation of the project and what recreational activities they undertook. The results of the survey can be found in Promoting Adaptation to Changing Coasts (PACCo) Task 3 Socio-Economic Baseline Results of survey undertaken to gauge stakeholder opinions and perceptions (Work Package 2).



Map 1: Location of the different footpaths in the valley

Impacts and consequences:

Tourism around the valley has been greatly beneficial to the local economy and helps the surrounding businesses to thrive by creating new opportunities. This level of tourism also creates challenges in terms of the impact it has on biodiversity – predominantly disturbance – and water resources. Tourism can also contribute to air pollution through increased traffic and associated vehicle particulates and the emission of nitrogen and sulphur dioxides. The primary car park serving the Lower Otter valley is Lime Kiln which has 400+ spaces.

With high tourism numbers and the associated waste generated, there is a higher risk of pollution in the area. The increase in wastewater also adds to an already struggling local sewer system, particularly during storm events.

The seasonal increase in population puts added pressure on local resources and infrastructure. This is especially true when considering infrastructure surrounding water supply and drainage.

Tourism can also cause a loss of biodiversity due to disproportionate site usage. For example, increased footfall along local paths (along with accompanying dogs straying off

the paths) can deter or reduce breeding productivity. In turn, over time a decrease in wildlife biodiversity in the Lower Valley could reduce its attractiveness and the local 'tourism offer' thereby impacting the local economy.

Recreational use of the valley contributes to the individual wellbeing of its users. A PACCO survey estimates that 50+% of recreation trips are active and provide a health benefit, leading to avoid health costs. In recent decades a number of footpaths have been regularly flooded and eroded from fluvial events with some footpaths within the valley shut for up to six months. Projecting forward with climate change scenarios, path erosion will likely increase. In the event of a catastrophic sea breach some of the footpaths would become tidal. This would serve to limit footpath use which would have a detrimental impact on local health and wellbeing as well as the tourism economy.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←		→	Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←		→	Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Tourism and uses	Otter Valley	4	4	1	1	10

The impacts of tourism can be wide and indirect. Tourism mainly impacts the biodiversity, habitats and water resources of the area with former impacts related to disturbance and pollution and the second to consumption and pollution. Tourism income is skewed towards the summer months and high tourism pressure can serve to erode the natural features upon which the industry depends.

Solutions and recommendations

The Lower Otter Restoration Project offers a wide range of benefits. The restoration will help secure the current footpath network around the valley with some raised and improved to All Ability standard. This is particularly true of the western Budleigh footpath. However, the initiative doesn't entirely remove the future risk of river erosion to all footpaths. Removal of the footpaths or their re-routing away from the floodplain was not an option as extinguishing Public Rights of Way is legally problematic and they are considered vital to support the local socio-economy. Instead, the PACCo project has helped to ensure increased longevity to part of the network and has provided a more sustainable 'fallback' position should the most vulnerable paths fail in the future.

At the location of the embankment breach a footbridge will be constructed to ensure continuity of the South West Coast Path, with this stretch amongst the busiest in Devon. Some sections of the surrounding footpaths most at risk (e.g., along Big Bank) have been redesigned making them more resilient to flooding whilst allowing the flood plain to be inundated. Others have been widened and raised to reduce future flood risk and allow

continued usage (Western Footpath). Where footpaths may flood in future, information has been displayed to warn the public of the risk of the path being inundated with use discouraged at times of high flow.

Sections of existing hedgerow along the footpath that act as a visual screen have also been improved through enrichment planting. This maximises their ability to act as a screen, which will decrease the disturbance impact of visitors.

New viewing platforms have been constructed around the valley to give visitors an opportunity to observe wildlife. A new car park has been built, alleviating the need for alternative parking in the areas along verges.

Information boards have been installed to raise awareness amongst locals and tourists on the best ways to limit impact on the environment. Education is key to ensure that the threat around tourism is managed adequately and does not impact the valley.

The breaching of the embankment is likely to encourage new leisure activities in the area which could further impact the biodiversity due to an increase in visitor numbers. A Ranger position has been created to build links and partnership working between the site and the local community whilst also ensuring eco-tourism and activity-based tourism have a limited impact on the area. It is also important to discuss any risks associated with tourist development with local parishes and councils in order to enlist their help in putting in place sustainable solutions.

A quantitative and qualitative natural capital assessment was undertaken as part of the PACCo work package 2 to understand the socioeconomic benefits of the Lower Otter Restoration project and compared them against different scenarios. The result demonstrates how the project has a positive outcome for tourism uses as well as wellbeing (see further readings section).

Further readings:

More information on the footbridge, footpaths and viewing platforms can be found in PACCo guide – Part 4: Design and construction and PACCo Guide – Technical Annex 1. Lower Otter design and construction

The survey can be viewed as part of Promoting Adaptation to Changing Coasts (PACCo) Task 3 Socio-Economic Baseline Results of survey undertaken to gauge stakeholder opinions and perceptions (Work Package 2)

The socio-economic benefits of the project can be viewed as part of the work package 2: Promoting adaptation to changing coasts T2.2.1 Socioeconomic Framework.

The socio-economic value of the project can be viewed as part of the work package 2: Promoting adaptation to changing coasts T2.2.1 Socioeconomic Protocol.

The explanation on natural capital assessment can be found in the PACCo guide – Part 3. Funding and natural capital

Assessment of the socio-economic benefits can be found in ABP Mer report as part of work package 2: Promoting Adaptation to Changing Coasts (PACCo) Task 3: Lower Otter Baseline Socio-economic Evaluation Assessing and quantifying the socio-economic benefits from adaptive management of estuarine sites (Work Package 2)

2.3.4 Public infrastructure

The development of estuaries over the centuries has coincided with urbanisation of the adjacent landscape, including the building of public infrastructure. In this document public infrastructure relates to structures managed by public bodies for the benefit of local communities, including roads. Within many floodplains, such infrastructure is increasingly at risk due to climate change and more frequent flooding. They are becoming harder to maintain. Some will require being relocated. The threats faced by public utilities has been outlined in another document.

Threat identification

The Otter Valley and its floodplain has been heavily modified to support societal needs with public infrastructure impacting the local environment and water quality. These structures are now threatened due to climate change.

There is much public infrastructure within the area, however we will focus on the four mains structures at risk, which comprise:

- South Farm Road

- South Farm Road disused landfill

- The cricket club

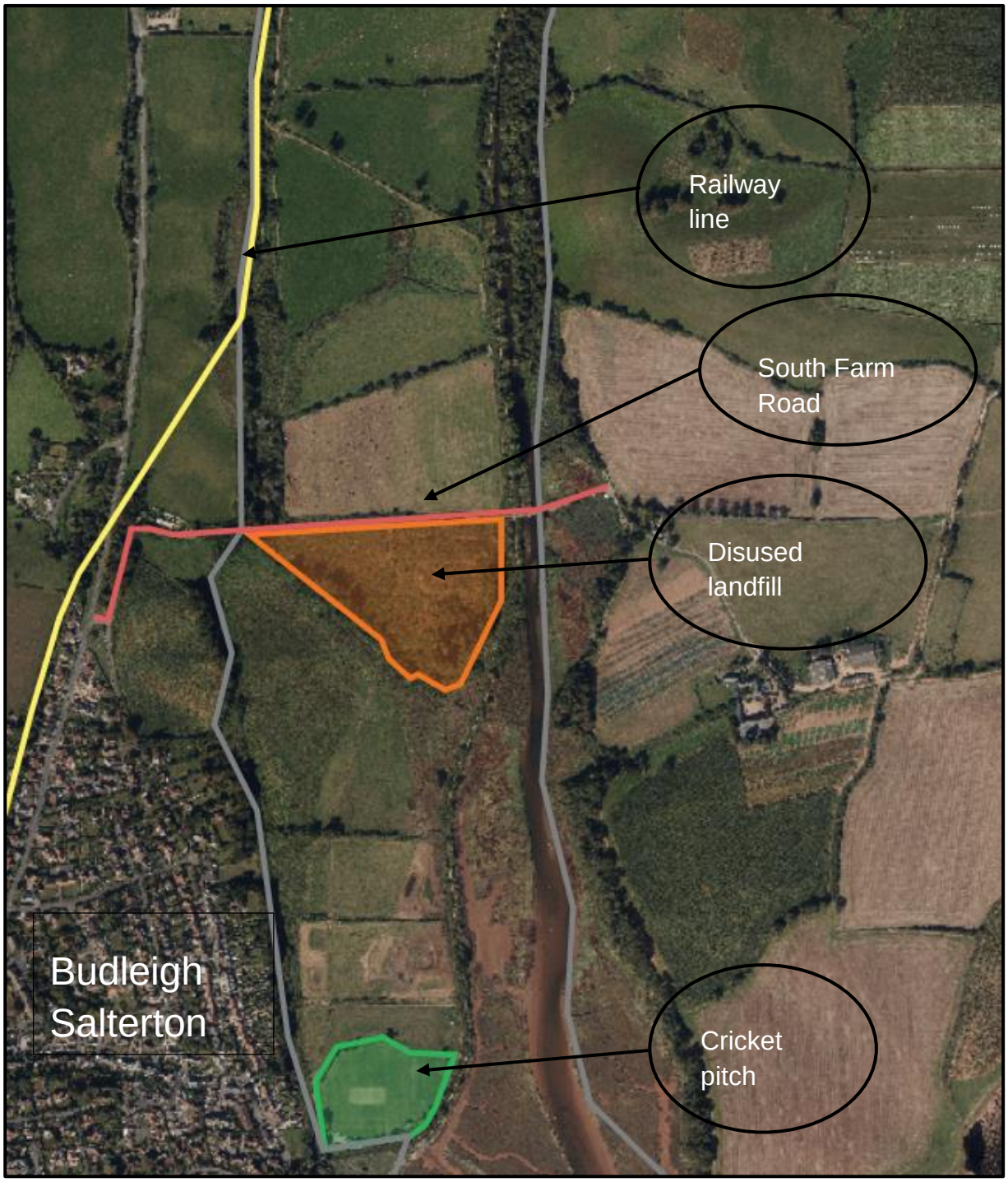
- The railway line

South Farm Road links Budleigh Salterton to houses and businesses located on the east of the Otter Estuary. First developed in the 1800's, it divides the flood plain into two areas, Big Marsh North and Big Marsh South. As well as providing a transport link, the public also informally use the roadside verge to park their cars and then use the paths within the valley. Public access along the road is restricted during heavy fluvial flood events with the road sometimes submerged for many hours or a few days.

The disused tip is located to the south of South Farm Road. First opened in 1928, it gradually expanded westwards throughout the years to meet the increasing waste from Budleigh. The tip was closed in 1978 and includes a range of domestic materials, includes asbestos. Concerns have been raised about erosion risks from fluvial flooding potentially releasing contaminants.

The cricket ground was built in 1934 and the pavilion constructed in 2003. Located near Lime Kiln car park within the Otter floodplain, the ground and its pavilion are frequently heavily impacted by fluvial flooding events, often to a depth of several metres. Due to the floodplain being disconnected from the river, flooding can take days to drain with the only means of drainage being via an insufficiently narrow outfall which is also below the high tide line, allowing water to be discharged only at low tides. In addition, the outfall is frequently covered by longshore drift and draining it requires constant maintenance.

The railway line (part of the Exmouth -Sidmouth line) was built in 1888. Alterations and extensions of the line were built over the years. Located along the western edge of the Otter Valley, it was closed to freight in 1964 and received its last passenger in 1967. The track was dismantled quickly after closure and is now used as a private farm track. The presence of the railway embankment within the floodplain impacts the flow of water.



Map 1: Location of the different infrastructures

Impacts and consequences:

The impacts and consequences of having these structures in the floodplain are significant. South Farm Road acts as a barrier to fluvial flood flows passing down the valley. During heavy flooding, the homes and businesses associated with South Farm are cut off at least for hours and sometimes days, impacting the local economy. The disused landfill site presents the highest threat. The landfill site was used during a period of time when waste management was not fully understood. Hazardous waste has been buried within the landfill. The site is at risk from erosion during floods and as such represents an environmental liability. One significant cause for concern is the risk for ground water contamination with biodiversity also at risk from potential pollutants.

Although originally beneficial to the economy of Budleigh Salterton by improving transport links, the railway now has value as a flood-free farm track. The primary impact of the railway line is that it restricts normal flood flows with water trapped behind it and unable to move freely west to east across the floodplain, other than through culverts.

Finally, the creation of a cricket pitch has further modified the floodplain replacing species-rich wetland with grassland of low wildlife value. Whilst providing recreational use, the ground is subject to frequent flooding with a potential for pollution.

Any pollution from the development of infrastructure on the Otter Valley has the potential to impact surface and ground water quality. This could impact on tourism which is a major local economic driver.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←		→	Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←		→	Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Public Infrastructures	Otter Valley	5	4	2	2	13

Although it has some socio-economic value, infrastructure within the area of the floodplain has had an adverse impact on biodiversity and inhibits the natural function of the floodplain, as well as presents a risk of pollution.

Solutions and recommendations

Removing infrastructure seems an obvious solution when planning to tackle these issues. This is, however, not an easy task especially when structures have become vital to the community, such as South Farm Road. Local communities have been built around this infrastructure and their loss would have great impact.

Regarding South Farm Road, several options were considered, for example the demolition of the road and the subsequent provision of alternative access via a narrow lane. Land constraints and the necessity for the access of large vehicles to South farm meant that this solution was not pursued. The solution implemented was to raise the road up onto an earth embankment and build a 30m span bridge to reconnect Little Marsh (to the south) and Big Marsh (to the north). This solution allows tidal and fluvial waters to move as naturally as possible up and down the floodplain whilst enabling continued safe access to the residents and business owners. More detail on this design and solution can be found in the PACCo Guide – Technical Annex 1. Lower Otter design and construction.

During the appraisal phase of the project, different options were considered when examining how to remove or reduce the environmental risk associated with the disused tip. One option explored was to remove the tip, however the costs of doing so were prohibitive. Part of the western section of the tip, however, has been removed to enable the building of the 30m span bridge. Several ground investigations were undertaken to assess the risks related to the tip before and during construction, including the monitoring of potential leachates and the digging of test pits. Risks related to the tip can be found in the Environmental Statement that accompanied the project's planning application. A detailed case study was developed as part of this work package and further details are given in the document PACCo - Lower Otter Restoration Project – case study of the disused tip.

Regarding the cricket pitch, various solutions were explored to make the clubhouse more flood resilient, if not the ground itself which also suffers from ground water as well as fluvial flooding. These solutions included building an earth bund and pumping away any surface water or raising the ground itself above fluvial and tidal floods (in the event of a catastrophic embankment breach). These solutions, however, were discarded for many obvious reasons; they would require significant maintenance costs, would not enable the restoration of habitats in the lower part of the valley and would not restore the natural functioning of the floodplain. One solution that was discarded was to relocate the pitch to the landfill site. This, however, would have raised issues around land contamination and public and environmental safety. The eventual solution was to relocate the cricket club outside of the floodplain. This will enable the club to prosper and avoid flooding in the future. Finding large areas of flat land adjacent to an urban centre suitable to accommodate a cricket club can be problematic. Success in this instance was dependent on the landowner Clinton Devon Estates restructuring their landholding to accommodate the new cricket ground.

Finally, the old railway line remains a flood-free access route for a local farmer. The removal of the railway embankment would have been prohibitively expensive and detrimental to the functioning of the farm with no viable alternatives. The current disused railway embankment was improved with a new drainage culvert allowing the water to flow in the floodplain.

Further reading:

Lower Otter Restoration project – Environmental Statement: Environmental Statement: Lower Otter Restoration Project

PACCo guide – Part 4 – Design and construction

PACCo Guide – Technical Annex 1. Lower Otter design and construction

PACCo - Lower Otter Restoration Project – case study of the disused tip

2.3.5 Public utilities

The term “utilities” in this document groups all services and infrastructure which supply electricity, gas, telecom and water. Utilities are essential for residential houses and businesses to function. The infrastructures surrounding these utility services have been developed in and around the valley which has had consequences on the local environment and waterways.

Threat identification

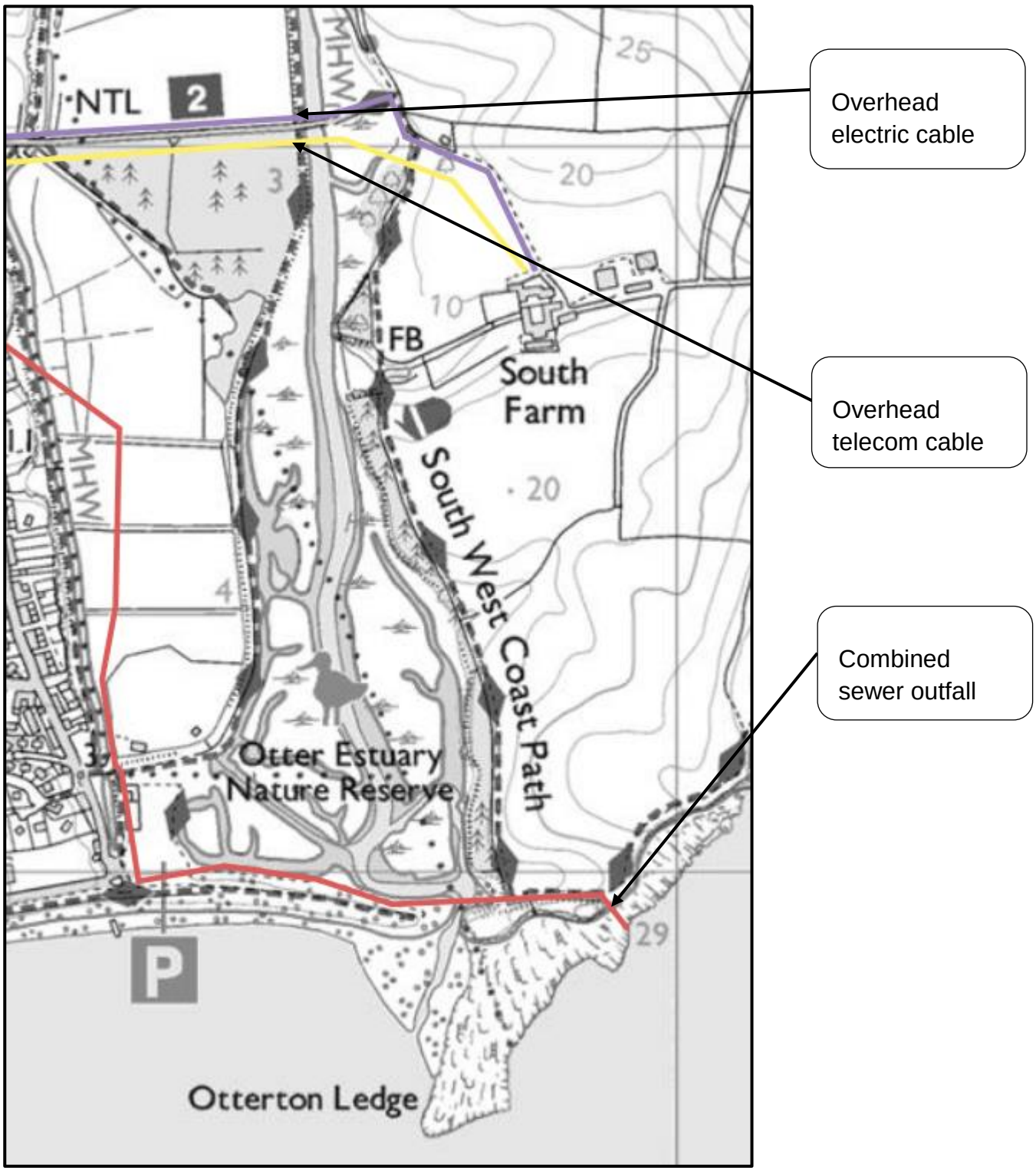
Utilities were installed around and across the Lower Otter Valley to supply services to Budleigh Salterton and the adjacent area, including the community associated with South Farm to the east of the floodplain. They are mainly concentrated around the urbanized areas and follow the road. The main type of utilities encountered are gas, telecom, electricity, water and sewage.

There are many services around the Otter Valley. However, focus will be on the three utilities which have the greatest impact on the area. They are the following:

- Electricity and telecoms: Telecom and high voltage electricity cables cross the flood plain and run along South Farm Road in order to provide services to the community on the eastern part of the valley.

- Water supply: there are extraction boreholes located within the valley. Water is extracted from an aquifer to provide fresh water to the inhabitants and businesses of the surrounding area. The influence zone (i.e., surface water occurring within the influence zone will eventually impact on the aquifer and borehole) of these extraction points includes part of the floodplain.

- Combined sewer outfall and sewage network: Sewage from the local population is transported to a pumping station sited immediately adjacent to the site. From here it is pumped to a treatment station away from the valley. However, the pumping station is serviced with an emergency pipe that discharges both sewage and surface water into the sea if heavy rainfall threatens to overwhelm the pumping facilities. The outfall is located in the cliff on the east side of the Otter Mouth with its pipe going from Lime Kiln carpark across the river mouth. Historically the outfall discharged sewage on every falling tide. Since then, however, the system has been improved and the aging outfall is now used only in emergency situations when the sewage treatment plant cannot cope with high levels of water.



Map 1: Location of the different services

Impacts and consequences:

Overhead cables contribute to the urbanization of the valley. The impact on water quality and biodiversity is low (minor risk to birds) and these cables are vital to our current way of life, especially for businesses and vulnerable people in the area. Having cables exposed and running across and above the floodplain means that they can be damaged by wind and potentially even fluvial floods.

The location of the boreholes within the flood plain presents a potential risk to local health and economy, either through contamination from water pollution (diffuse agricultural pollution including nitrates, for example) or through salination related to a breaching of sea defences. The presence of a landfill site in the valley combined with frequent fluvial floods can cause health issues to residents due to the transportation of contaminants from the landfill which can infiltrate the water supply, or through potential erosion of the landfill contents. The local economy can also be affected due to coastal leisure activities being dependent on clean water.

The presence of a combined sewer has the highest number of adverse effects. Combined sewers collect both water run-off and sewage. The outfall is used mainly during emergency events such as a time of high rainfall and when the network and sewage treatment plant cannot cope with the high level of water. This involves the release of raw sewage directly into the sea and the nearby beach. Budleigh Salterton is a popular tourist location, known for its beautiful beach and bathing water. The impact of raw sewage being released into the sea means that bathing would be prohibited for a period due to a risk to human health. Water quality is also significantly decreased, which has huge impacts on biodiversity, tourism and economy.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←		→	Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←		→	Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Utilities	Otter Valley	5	5	3	3	16

The level of impact on a valley depends on the type of utilities present in the area. During storm events or floods the likelihood is that all utilities will either be impacted or have an impact on the local area.

Solutions and recommendations

Regarding services such as overhead cables (electric and telecom), different approaches can be used. Depending on the configuration they can be diverted or buried. On the Lower Otter, the electric and telecom cables have been buried along the new South Farm Road so they no longer cross the floodplain at height. This also improves the aesthetics of the area. Although burying cables costs money, due to the limited length of cable to bury, it provided the most suitable solution and was undertaken as part of the Lower Otter Restoration Project. It also took advantage of existing work being undertaken to move and raise South Farm Road.

Regarding the water borehole and freshwater extraction, modelling can be used to assess the impact of saline water or pollutant reaching the aquifer. Before the construction started on the Lower Otter, groundwater and surface level modelling was used to understand the impact of the reconnection of the sea to its floodplain. The summary of the model is part of the Environmental Statement and is available on the Lower Otter website (http://www.lowerotterrestorationproject.co.uk/planses.html - Appendix G). Monitoring is used to ensure the water is still suitable for consumption. It is important to understand that even though modelling suggests that saline intrusion to the boreholes is low risk, it is still a possibility and careful monitoring is necessary into the future. Early discussion with water supply companies is necessary to ensure they are aware of the risk. In a worst-case scenario, relocation of the boreholes away from the floodplain is an option.

The combined sewer outfall is the most difficult issue to resolve. The ideal solution would be for water companies to renovate their sewage network by upgrading their system or creating a separate sewage network. The water run-off could be separated, and this would decrease the pressure on the system. However, such an operation requires significant investment and water companies are not always in a position to do so. This solution would also impact the local population during the construction as it would necessitate many road closures. It is possible that funding could be sought to help with costs and early discussion should help find common ground with companies and should result in the most beneficial outcomes.

Funding can be sought to renovate the sewage network. In the Saâne valley, Interreg helped to fund the replacement of individual households' sewage treatment plants (old septic tanks) and to fund anew common sewage treatment plant to which individual houses were to be connected. This contributes to better water quality at that site.

To reduce the likelihood that the combined sewer releases sewage, new regulations can be imposed by the government on controlling the water runoff from dwellings. In England, since 2015, it became compulsory for sustainable urban drainage systems to be considered in planning applications for major developments to decrease the quantity of runoff water.

Another solution is to ensure combined sewage outfalls are monitored to understand their frequency of use. If they are used regularly and large quantities released, enforcement actions should be undertaken.

The Lower Otter restoration impacts the pipe which runs under the mouth of the estuary due to the potential for erosion, although risks already exist from erosional pressures, especially during storms. However, tidal inundation may further erode the soil around the pipe, such a situation would occur in the event of a likely catastrophic breach. The condition of the current pipe is unknown. If the condition is poor, it may have consequences (e.g., major pollution event). Discussion was undertaken with the water company to resolve this problem and directional drilling will be used to provide a newer pipe.

Further reading:

Lower Otter Restoration project – Environmental Statement: Environmental Statement: Lower Otter Restoration Project

PACCo guide – Part 4 – Design and construction

PACCo Guide – Technical Annex 1. Lower Otter design and construction

2.3.6 Invasive species

An invasive species is defined as a non-native species which can cause economic or environmental impacts to an area and can be a major threat to the ecosystem. They can cause the extinction of native plants and animals, reduced biodiversity, compete with native organisms and change habitats. (Useful link: The Great Britain invasive non-native species strategy - GOV.UK (www.gov.uk))

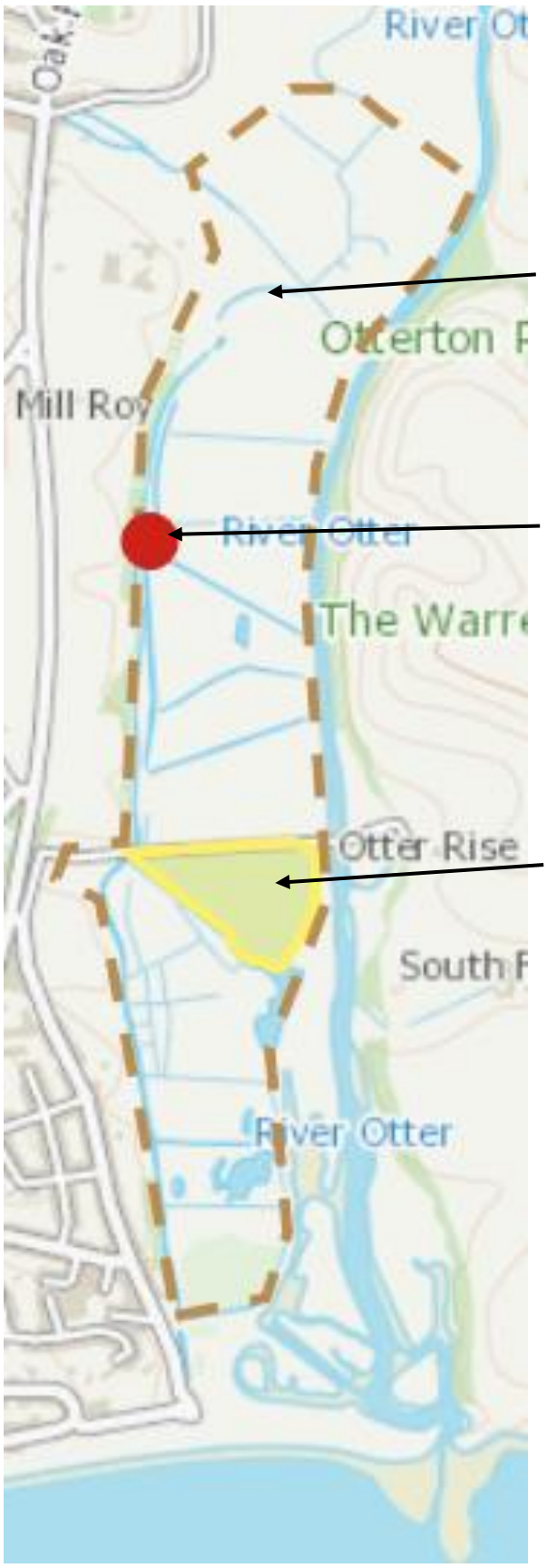
Threat identification

In Britain there are more than 3,000 non-natives species listed. Their introduction is mainly due to the unintentional consequences of bringing in alien species for horticulture or aquaculture or through poor biosecurity of imported biological material. According to The Department for Environment, Food and Rural Affairs (DEFRA), tackling invasive species cost the UK roughly £1.8 billion per year globally. It is therefore not surprising that invasive species are located within the Otter Valley and its surrounding area.

In 2018, part of Budleigh Salterton was cordoned off due to the spread of the brown tailed moth caterpillar. This is just one example of when an invasive species has been located in the area.

The main type of invasive species encountered in Lower Otter Valley is plant.

The spread of invasive species in the valley has been mainly due to human activity. The most common invasive species found is Himalayan Balsam (*Impatiens glandulifera*) which is widespread across the UK. This is common along the River Otter and hedgerows associated with its floodplain. Himalayan Balsam has highly explosive seed pods which cast their seed widely and the spread of this species is facilitated along public rights of way on the tyres of bicycles, on horse's hooves and by mud carried on shoes. Japanese Knotweed (*Fallopia japonica*) is another invasive species scattered across the now disused landfill. In addition, there have been historical sightings of Water Fern (*Azolla filiculoides*) in a ditch near Big Marsh North and unconfirmed sightings of Giant Hogweed (*Heracleum mantegazzianum*) further up the valley.



Himalayan Balsam present on the watercourse is represented by the blue markings within the brown dashed boundary line.

Water Fern

Japanese Knotweed
(on the disused tip)

Map 1: Location of the different invasive species

Impacts and consequences:

Invasive species can colonise rapidly. This is mainly due to their ability to spread either vegetatively (e.g., Japanese Knotweed can spread through stem fragments) or through seed dispersal. When they colonise a new area their rapid growth and dense ground cover means they can often outcompete native species. As a result, they can simplify complex habitats (reduce biodiversity) and when they die back in winter (as is the case of Himalayan Balsam) they can increase the risk of erosion as there is little other vegetation to protect the soil. Himalayan Balsam produces large amounts of nectar which attracts pollinating insects away from competing native plants.

The loss of wildlife resulting from the presence of Himalayan Balsam has the potential to impact the economy of the Lower Valley by reducing the conservation value, and hence the attractiveness of the local area. Many people visit the area to observe the valley's fauna and flora.

The impact can extend to adjacent houses and infrastructure. For example, although confined to the old tip site in the Otter valley, if it spreads, Japanese Knotweed can penetrate hard surfaces with risk of damage to building such as houses, or infrastructure such as roads and flood defences. Even its close proximity to an area can reduce property value and jeopardise the ability for homeowners to get a mortgage.

Water Fern can achieve 100% cover over a water surface, occasionally up to 30cm thick. At such times it blocks out light preventing photosynthesis in other aquatic plants and preventing or compromising oxygen diffusion. It also prevents amphibians and invertebrates from reaching the surface. The main reported health and social impacts of water fern involve disruption of water-based recreation. Although the species is only known to be in a single small location within the Otter valley, it can spread quickly.

The presence of the invasive species cited above have contributed to a decrease in biodiversity and present a socio-economic risk.

Each of these species undergo annual management to control their spreads. This represents a cost to the landowner, Clinton Devon Estates.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←		→	Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←		→	Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Invasive species	Otter Valley	4	1	1	2	8

Invasive species impact the biodiversity of an area. If uncontrolled, they can destroy the habitats present on site, cause soil erosion and present a socio-economic risk. The

impacts on water resources and human health in the Lower Otter valley are currently limited; however, they can have an indirect impact on the local economy by reducing property prices and the attractiveness of the valley to tourists.

Solutions and recommendations

It is important to clarify that the East Devon Pebblebed Heaths Conservation Trust, a conservation charity established by the landowner of the surrounding valley (Clinton Devon Estates) has historically undertaken annual management in an attempt to eradicate or avoid the further spread of invasive species and reduce their numbers. The establishment of this charity pre-dates the Lower Otter Restoration and PACCo initiatives.

Himalayan Balsam can be found in the least saline areas of the valley and is managed annually through pulling. Himalayan Balsam and Japanese Knotweed located on the disused tip are managed annually by Clinton Devon Estate's forestry department, predominantly by chemical means.

As part of the Environmental Statement, studies were conducted to assess the effects of the breach and the potential consequences on invasive species. The Environment Statement section on invasive species can be seen at: Environmental Statement: Lower Otter Restoration Project (Biodiversity Marine Ecology and Fish with its appendices). Within the floodplain the spread and distribution of invasive species across 55 hectares of land will be greatly reduced due to tidal/saltwater ingress and the creation of the saltmarsh and mudflat. The primary species of risk in the Lower Otter Valley are not salt tolerant. The creation of a new saltmarsh and associated habitats will help to increase biodiversity and should strengthen the native ecosystem allowing native species to develop on the wet ground. Himalayan Balsam and Water Fern cannot tolerate salt water and should therefore be killed when the sea reconnects with the floodplain, at least in the lower part of the valley.

During the Lower Otter Restoration Project, special caution was applied during the construction to avoid the spread of invasive species. An invasive species management plan was prepared by the contractor to ensure construction activities did not increase the risk of spread. The management plan gave instructions and bio-security measures to follow on site. Some of the plants (Japanese Knotweed) were sprayed with herbicide and this will be continued after the project finishes.

Post project, the East Devon Pebblebed Heaths Conservation Trust will continue invasive species control to contain and eradicate the remaining invasive species.

The main issue and the most difficult to tackle is the spread of invasive species by people along Public Rights of Way. The limitation of spread by this means is essential. To limit the occurrence of further accidental spread, both education and deterrents are needed. Information can be displayed on site explaining both how to avoid spreading invasive species and the biosecurity measures already in place. Volunteer groups can be created

to help remove invasive species (this has been in place in the Otter valley for several years).

At a regional and national level, new policies and stricter biosecurity controls can be applied at the borders, much like the policies in place in countries such as Australia.

Finally, strategically managed grazing could help reduce the number of invasive species within any remaining areas of permanent grass.

Further reading:

Lower Otter Restoration project – Environmental Statement: Environmental Statement: Lower Otter Restoration Project

Management measures for widely spread Invasive Alien Species (IAS) in England and Wales – Defra - https://consult.defra.gov.uk/wildlife-management/invasive-alien-species-management-measures/

2.3.7 Water abstraction

Water environments including rivers, lakes, estuaries, wetlands and groundwater provide spaces for nature and essential services to society. As such they need to be sustainably managed and resilient to climate change.

Threat identification

Over the centuries water consumption has risen. According to UN Water, the consumption of water globally has increased by an average of 1% each year since the 1980s. This is primarily due to population growth, urbanisation, agricultural irrigation and an increase in recreational and industrial activities. The Lower Otter Valley is no exception.

Water abstraction can be divided into two categories within the valley: abstraction from the river and abstraction from the underground aquifer. On the Lower Otter, water is extracted from the river primarily to support agriculture and water extracted from underground aquifers is used either for human consumption or agricultural purpose. Outside of the study area, other boreholes and river abstractions are present are used for spray irrigation and hydro-electric power for example.

Abstraction of water within a catchment in the UK is generally governed by an abstraction licensing strategy, with one available for East Devon that covers the River Otter. This provides information on how new and existing abstraction licenses are managed, where the water is available for further abstraction and what actions are being taken in unsustainable catchments. As a rule of thumb, permits are not required if 20 cubic metres or less of water are taken per day as part of single or multiple operations.https://www.gov.uk/government/publications/east-devon-abstraction-licensing-strategy

Within any catchment the abstraction strategy is dependent upon:

- the local and regional water needs of communities

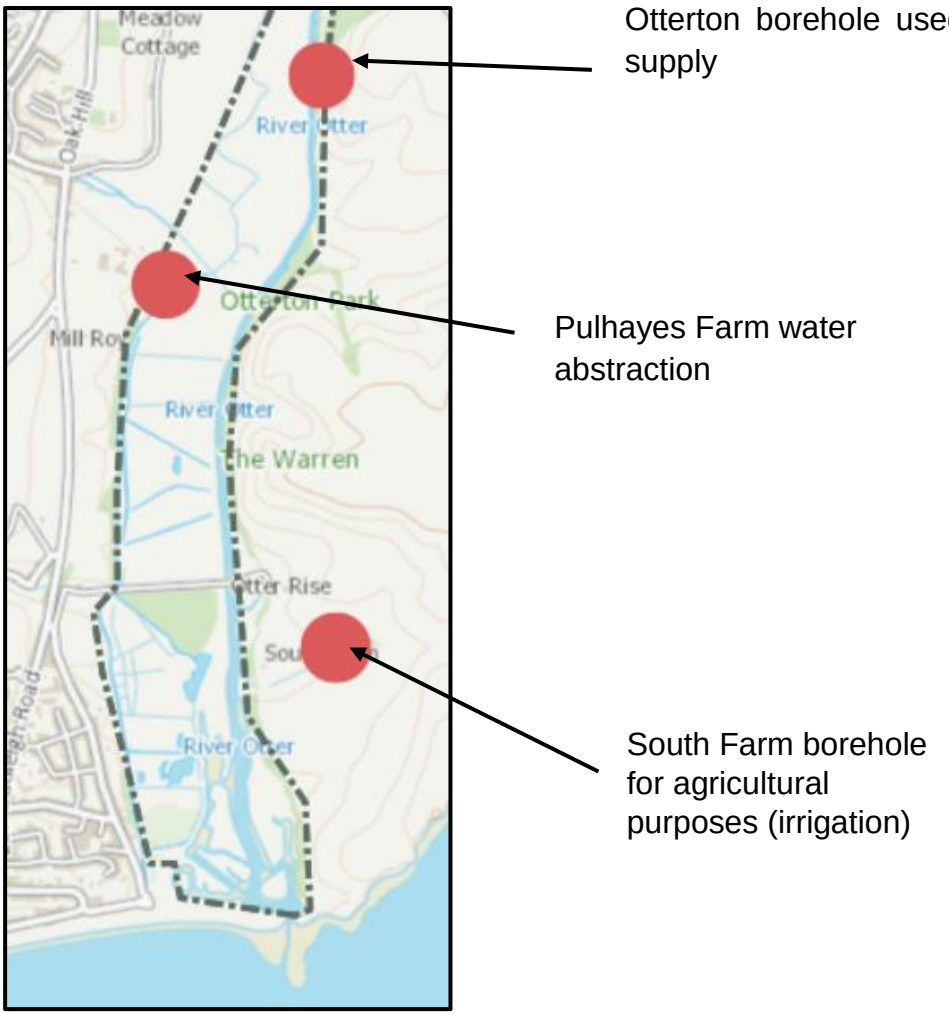
- environmental considerations (e.g., maintaining baseflow of water in rivers during dry periods)

- the needs of agriculture; there are several water extractions points within the valley and its surroundings for agricultural purposes

- the needs of industry and tourism

Three abstraction licences are currently associated with the lower Otter valley. Two of these are used for agricultural purposes and one represents a key asset of South West Water and is used to provide freshwater to Otterton. The Lower Otter valley and its underlying sandstone aquifer provides a strategic regional freshwater source with significant amounts abstracted daily to supply the needs of many local communities.

With a projected constant increase in the demand of water as well as the change in climate, water resources are being increasingly put under more and more pressure.



Map 1: Water abstraction located near or within the Lower Otter valley

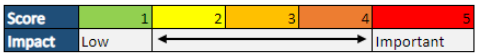
Impacts and consequences:

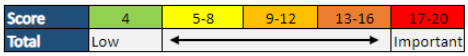
The abstraction of water can affect the surrounding environment in a variety of ways. Abstraction of surface water has an immediate impact upon downstream flows. However, groundwater moves much more slowly and the impact of its abstraction on river flow is delayed. Groundwater provides baseflow to rivers, supporting their flow in times of low rainfall. Excessive abstraction of both surface water and groundwater has the potential to adversely affect the river ecology and biodiversity. A reduced flow caused by water abstraction can also increase sedimentation adversely impacting those species sensitive to sediment loading, including invertebrates and fish. Altered flow regimes can also impact erosion rates and therefore the geomorphology of the channel, which in turn can affect

riverbank ecology. In some circumstances this can help invasive species to develop quicker and outcompete native species. Any impact of water abstraction may be amplified by climate change. For example, during periods of drought rivers are more vulnerable to impacts from abstraction.

Any unsustainable increase in the demand of water, where abstraction of groundwater is greater than the recharge, can result in a drop in the water table. In coastal areas such as the Lower Otter, this can also lead to degradation of water quality due to the intrusion of saline water. Water quality can be impacted to the point where human consumption is prohibited. Local economies can also be affected when drought causes a ban in water-based activities or a decrease of water availability for local industries.

Threat evaluation





		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Water abstraction	Otter Valley	3	5	2	2	12

Water is a vital resource that needs to be constantly considered. If the limits of the water cycle are not reconciled with demand, it can lead to disastrous consequences.

Solutions and recommendations

Local authorities and the regulatory body have been studying the potential risks of water abstraction with the East Devon Abstraction Licensing Strategy outlining policy. Abstractions greater than 20 cubic metres/day are governed by permits which take into consideration the water resource at a catchment scale.

The breach undertaken by the Lower Otter Restoration Project will enable tidal water to inundate the valley and become close to the influence zone of a strategic drinking water borehole. There is a risk that saline water will replace fresh water within the aquifer. Studies, including groundwater monitoring, were conducted as part of the development phase of the scheme to ascertain the level of risk. It has been determined that this risk is low, although monitoring of groundwater will continue after project completion. Saline intrusion may not be the result of the reconnection of the floodplain to the river and the sea, but the consequence of over-abstraction of groundwater resources. Sustainable abstraction management needs to be implemented to avoid this problem.

To reduce abstraction pressure, solutions can be implemented across local populations, industry and agriculture to result in a more sustainable use of water. This is the aim of the local Abstraction Licensing Policy. At a national and regional level there is also the potential to encourage the more efficient use of water with water companies having an important role to play, both in advocacy and education but also in improving the

performance of water infrastructure. Currently, across all networks, water leakages represent a major waste of resources. For example, the Thames water company estimated that 24% of the water they supply is lost through leakage. Investment into upgrading infrastructure will help conserve water resources and increase supply security. Less water wasted will also result in lower costs and a lower carbon footprint as a smaller volume of water will need to be treated to potable standards.

Another aim is to roll out metering throughout the country. Many properties remain unmetered. This lack of recorded water can lead to over-consumption.

Both recycled water and rainwater can be used by private households and industry for uses such as flushing toilets etc. This practice is under-utilised at present. Further adoption of such practices will not only help to decrease consumption but can help control water run-off and its associated impacts.

Having sustainable water management will help our environment in the long term and provide security for future generations.

Further reading:

Environmental Statement – Impact of the project on the water resources – Salinity modelling report available on: Environmental Statement: Lower Otter Restoration Project

East Devon abstraction licencing strategy - https://www.gov.uk/government/publications/east-devon-abstraction-licensing-strategy/east-devon-abstraction-licensing-strategy

2.3.8 Agricultural practices

Agriculture is an essential industry in the United Kingdom as it is our main method of food production. The UK's agricultural industry uses 71% of the land area and employs 1% of the population. The environmental impact of agriculture can be broad and wide; modern practices within this industry are often associated with wildlife declines (birds/pollinators etc.) These practices are also associated with poor water quality due to diffuse pollution including nitrates and soil loss.

Threat identification

With the exception of the urban areas (Budleigh Salterton, East Budleigh and Otterton), the land surrounding the Otter valley is used primarily for agricultural purposes.

As it has been previously explained in the 'River Modifications' document, modifications made within the flood plain had the aim of reclaiming land for agricultural use. Food production has always been an important industry within the Lower Otter Valley and its surrounding towns and villages. Four percent of the population of Budleigh Salterton worked in agriculture in 1891. Farming methods changed in the 18th centuries with the introduction of machinery and a scientific approach to crop and land management.

Although Clinton Devon Estates owns the land, some of the farms on the estate are tenanted, with tenants having land management control.

There are two main tenanted farms located within the Lower Otter Valley:

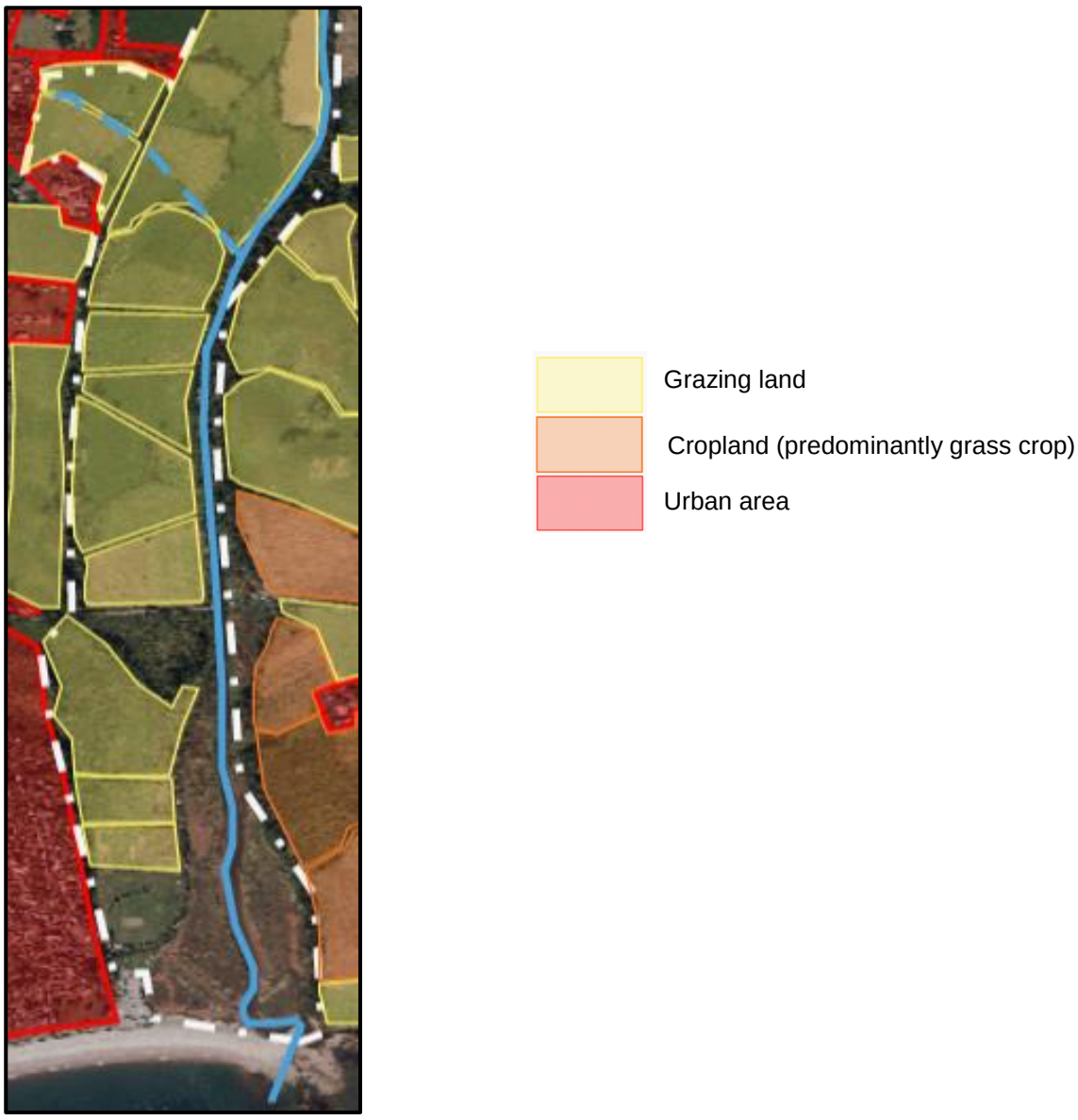
- Pulhayes Farm (organic dairy), located within and to the northwest of the Otter valley

- South Farm (mixed arable farm), located within and to the east side of the valley

Land allocated to the Lower Otter restoration project included 40% of the grassland and grazing platform available to the two farms. During the development phase of the scheme, an agreement was reached with the tenants to release the land. This included the provision of additional grazing land to the farms which was outside the project footprint to compensate for that lost.

Whilst the land and soil located on the hillside is sandy, largely well drained and of a good agricultural grade, the land within the flood plain is considered to be 'poor' (Grade 4), with the exception of the land in the Little Marsh and north of it, which is classed as 'good to moderate' (Grade 3). Being within a floodplain the land is wet and only really of value as permanent grass and grazing and/or cutting for silage. The advantage of wet land is that it can provide good quality grass during dry summers.

Some crops are grown on higher ground within the valley, but they are not within the perimeter of the study.



Map 1: Type of agricultural area (with data from Crop Map of England (CROME) 2021)

Impacts and consequences:

Reclaiming the floodplain for agricultural land in the early 19th century had a major impact on the biodiversity of the valley with much of the original inter-tidal habitats lost which had negative consequences on fish and wading bird populations. Agricultural practices have evolved over the centuries. The land within the Lower Otter Valley has always been wet. Keeping it in reasonable agricultural condition has proven to be difficult, with significant investment required in drainage. Until the 1970s much of the land was drained with the assistance of diesel pumps.

Although land was claimed from inter-tidal habitat wetland for agriculture purpose in the 1800's by the construction of a flood embankment, the quality of grazing land has remained poor, proving the experiment unsuccessful. Draining the land, along with the evolution of new machinery and fertilisers, however, did result in food production. This came at a cost to biodiversity. The complex inter-tidal wetland system was largely replaced by drier simplified

systems of improved grassland. A wetland meadow of local biodiversity value is present in the valley however, and it is classified as a County Wildlife Site. Arable farming on the valley sites brings with it a risk of runoff and water pollution, although these risks have been minimised through good husbandry.

There are multiple consequences to the environment from farming of livestock. These impacts can be either positive or negative depending on the habitat grazed and the husbandry techniques used, such as the intensity and seasonality of grazing. For many biodiverse habitats, grazing is considered essential for their maintenance. The predominant farming operation within the Lower Otter Valley is organic. This has meant that the poor environmental outcomes frequently associated with livestock is minimised. The environmental consequences of dairy farming which is not carried out organically (unlike the Lower Otter Valley site, which is organic) include: the overuse of antibiotics; poaching of the ground (physical destruction of the soil structure under load e.g., of heavy animals or vehicles); diffuse pollution nitrates, phosphates and animal faecal matter. Environmental risk is elevated where farming infrastructure is located within the floodplain (e.g., silage pits), or when there is insufficient storage capacity of slurry (a mixture of manure and water). Large amounts of water can also be used in agriculture with water abstraction contributing to the low river levels and a decrease in the water table in some areas. Like many businesses, farming has a significant carbon footprint through the use of heavy machinery. Dairy farms are also associated with high methane emissions.

Threat evaluation

Score	1	2	3	4	5
Impact	Low	←		→	Important

Score	4	5-8	9-12	13-16	17-20
Total	Low	←		→	Important

		Impact				
Human threat	Site	Biodiversity and habitats	Water resource	Human health	Local economy	Total
Agriculture	Otter Valley	4	3	2	1	10

Agricultural activities can impact biodiversity, habitats and water resources due to the exploitation of the ground and the potential for water contamination. Agricultural activity is part of and a positive contributor to the local economy.

Solutions and recommendations

Prior to the PACCo project, Clinton Devon Estates and their tenants have worked to ensure that agricultural activities within and adjacent to the Lower Otter valley are appropriate for the location. Environmental risks are minimised through good husbandry practices; one of the two farms being organic and both farms are in countryside stewardship schemes known to support populations of rare species (e.g., skylarks).

Agricultural activities in the Lower Otter are focused on livestock (dairy) which includes the cutting of silage. Some arable farming occurs away from the floodplain. This composition

of farming is very different from the Saâne Valley where catchment land outside of the floodplain is mostly dedicated to arable farming. One of the farms immediately adjacent to the restoration area is under organic management which significantly constrains the use of inorganic fertilizers and antibiotics. Cattle are not permanently grazed on land within the floodplain but instead seasonally rotated over the farm dependent on the season and site conditions, with grazing within the floodplain most common in the summer months.

As the breach will allow tidal inundation of the floodplain, reducing the available agricultural land for the current farms, PACCo and Clinton Devon Estates have secured compensatory land. The farms will remain operational and productive. The PACCo project also funded the restructuring of Pulhayes Farm so that it could adapt to climate change. The infrastructure which was funded to allow this transition included:

- a silage clamp located outside of the floodplain to reduce environmental risk

- the creation of a new access to utilise the compensatory land and remove the need for intensive cattle grazing within the floodplain

- fencing of the compensatory fields

- creation of a borehole to abstract water away from the flood plain

- introduction of a three-phase electricity supply

As part of the WPT2, a natural capital assessment study was undertaken which provided information on how the PACCo project impacted agriculture in the area. This information is available on the PACCo website.

Further reading:

Clinton Devon Estates – Farming - https://clintondevon.com/farming/

Work Package T2 – Lower Otter Baseline Socio-economic Evaluation and Natural capital assessment

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http://www.zones-humides.org/milieux-en-danger/menaces#

List of abbreviations

IPBES: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services