NORTH DEVON BIOSPHERE

ENVIRONMENT AGENCY

Westcountry Rivers Trust

North Devon Focus Area Estuary Pollution Project Report

2017/2018

Purpose of report

To review the North Devon Focus Area Estuary Pollution Project, which seeks to reduce diffuse pollution arising from agricultural practices within the River Caen Catchment.

The project was commissioned by Devon County Council through the North Devon Biosphere Reserve Partnership and funded by the Environment Agency on behalf of the Water Environment Investment Fund, which supports the Taw Torridge Catchment Partnership.

The project delivery and reporting was overseen by the North Devon's UNESCO World Biosphere Reserve.

Report complied by Sophia Craddock (SJC Consultancy) Estuary Project Manager with contributions and additions from other members involved in the project.

All photographs by Sophia Craddock or Phil Metcalfe unless otherwise stated.

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Executive Summary

Causes

Poor water quality travelling through farm yard areas.

Soil erosion caused by high run-off.

Although not the only influencing factor causing these issues, agricultural diffuse pollution is one of the major contributors which limit the biodiversity of UK rivers.

The Effects

A severe fall in crayfish populations and abundance, making the species in danger of extinction.

Freshwater pearl mussel near absence from the Taw river, with less than 100 in 1999 (and sparse in the Torridge catchment, 1352 in 2002) (Devon Biodiversity and Geodiversity Action Plan, 2009).

Salmon and trout populations struggle to thrive in headwater streams due to chocked gravel river beds.

Project Action and Benefits

Primary Action

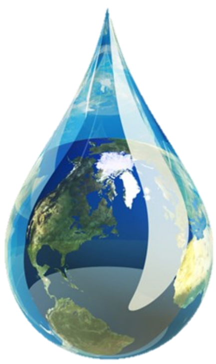
To actively improve water quality and reduce valuable soils leaving agricultural land, within the River Caen Catchment.

Other Benefits

Natural flood management and habitat creation.

Landowners are financially supported while keeping in line with regulations.

Contents



1. Introduction

Water quality and soil erosion problems are complex both environmental and social issues which are persistent and widespread throughout the UK (Inman, et al., 2018). Approaching the physiology aspect is an ambitus task and would require years of detailed research and data collection; which Inman, et al., (2018) has undoubtedly made a robust start in achieving. Complementing this work, the Estuary Project approaches the difficult issue of tackling the environmental factors; such as the decline of in stream native populations and surrounding habitat quality.

Figure 1. Native white-clawed crayfish. Source: Buglife: Mike Drew (2018)

The native white-clawed crayfish (*Austropotamobius pallipes*) population has been in severe decline throughout the UK. Crayfish abundance is limited by poor water quality as they require a specific environmental niche to survive. Freshwater pearl mussels (*Margaritifera margaritifera*) also require particular conditions, however we can learn from them as they make good biological indicators of water quality as stated by Devon BAP (2009):

"Pearl mussels need...low nutrient levels, pH 7.5 or less, nitrate levels [<]1.0mg l-1 and phosphates <0.03mg l-1".

Figure 2. Freshwater Pearl Mussels . Source: Freshwater Biological Association (2018).

Coupled with other factors experienced in British river systems, populations of both crayfish and freshwater pearl mussel struggle to become established.

The diversion of clean roof waters away from yard contaminates can be beneficial for both the landowner and the environment, as less muck spreading is required, inevitably leading to less pollutant loaded run-off entering the watercourse. Otherwise, these dirty waters are likely to contaminate clean roof waters and require containment within a slurry store. This avoidable storage subsequently reduces the capacity for solely yard concentrated waters. Post separation, lightly fouled waters can be cleaned through the construction of baffle ditches, constructed wetlands or sedimentation ponds, see below.

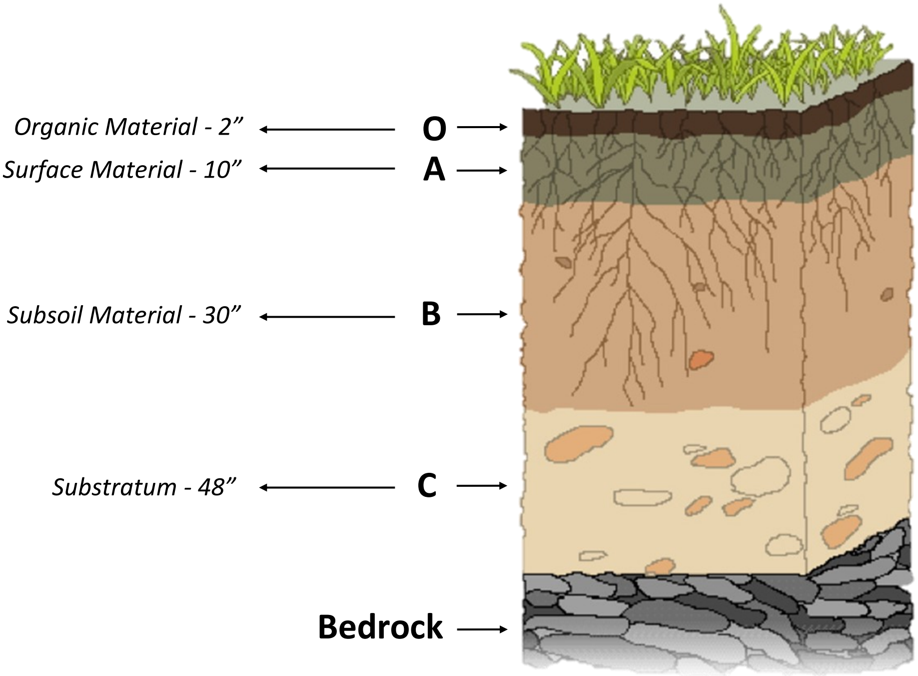
The Water Framework Directive status for water quality in the River Caen has been improving in recent years, however, much more can be done to achieve and maintain a 'Good' status. Water quality began it's decline after the industrial revolution where hedgerows disappeared and agriculture expanded along with associated machinery. This all round expansion produced a highly profitable industry however caused the environment to suffer in its wake. Compaction also poses a high agricultural cost as it is very expensive for landowners to artificially create their own topsoil once naturally accumulating soils have depleted. When soil health is at its worst typically after maize has been cultivated, artificial soils containing slurry are spread to replenish the land with nutrients.

These artificially created soils can be eroded by several processes including sheet wash, rill, or in extreme cases, gully erosion. Particularly in times of heavy rainfall, these processes mobilise the topsoil and additional slurry which has been spread on to the surface. If the ground is also compacted during rainfall, run-off will transport these excess nutrients into the river at a faster rate, due to the lower infiltration capacity of the soil to receive the waters. Infiltration capacity is typically at its lowest at headlands and at field gateways. This is where agricultural traffic is concentrated, whether it is to harvest cereal crops or to enter to feed livestock (see above).

Sediment loss from the land through run-off processes and bank erosion can also have significant effects on river dynamics. Riverbank erosion can disrupt crayfish populations, as they hide in crevasses within the bank. Crayfish are also known to hide between stones in the riverbed, however, this is made difficult by the build up of fine sediment which blocks these gaps between the gravels. These blocked gravelled beds can also effect other species such as salmon and freshwater pearl mussel as they require clean gravel beds to be able to spawn.

Nonetheless soils are very valuable, in terms of both an agricultural and environmental resource, contrary how they have been treated in the past. This is reflected in the time elapsed to build up suitable and workable topsoil depth, as typically it takes 500 years for 2 -3cm of soil to form. Soils which form naturally from chemical and physical weathering of the parent material also require support from appropriate organisms and a suitable relief to aggregate (see below). Many UK soils are approximately two million years old, forming after the last ice age, and contain 50% of the worlds carbon store; thus the preservation of this natural resource is very important and unfortunately often overlooked.

Soil Horizons



To notably tackle these issues, funding by the Environment Agency (EA) enabled the North Devon Biosphere to provide funds and support facilitated by the North Devon Focus Area Estuary Pollution Project (NDFAEPP). These funds also assist farmers to remain compliant with EA regulations, as farming communities within the Nitrate Vulnerable Zone (NVZ) are under pressure from environmental regulations to limit the amount of slurry that is spread on the soils. Thus, if the correct soil management is implemented, this pressure would be greatly reduced.

2. Focus Area

This project primarily aims to deliver advice, guidance and grant aid to landowners to assist in reducing diffuse pollution from agriculture and also limit soil erosion entering the River Caen focus area (see Figure 4 below). Also the secondary benefit, delivering natural flood management strategies, will assist in mitigating downstream flooding. Flood management is of paramount importance in this particular catchment, as downstream communities such as Braunton, have experienced devastating floods which destroyed several homes and businesses. For a village based on tourism, flooding poses a serious threat to the future of this community unless practical and effective solutions are implemented.

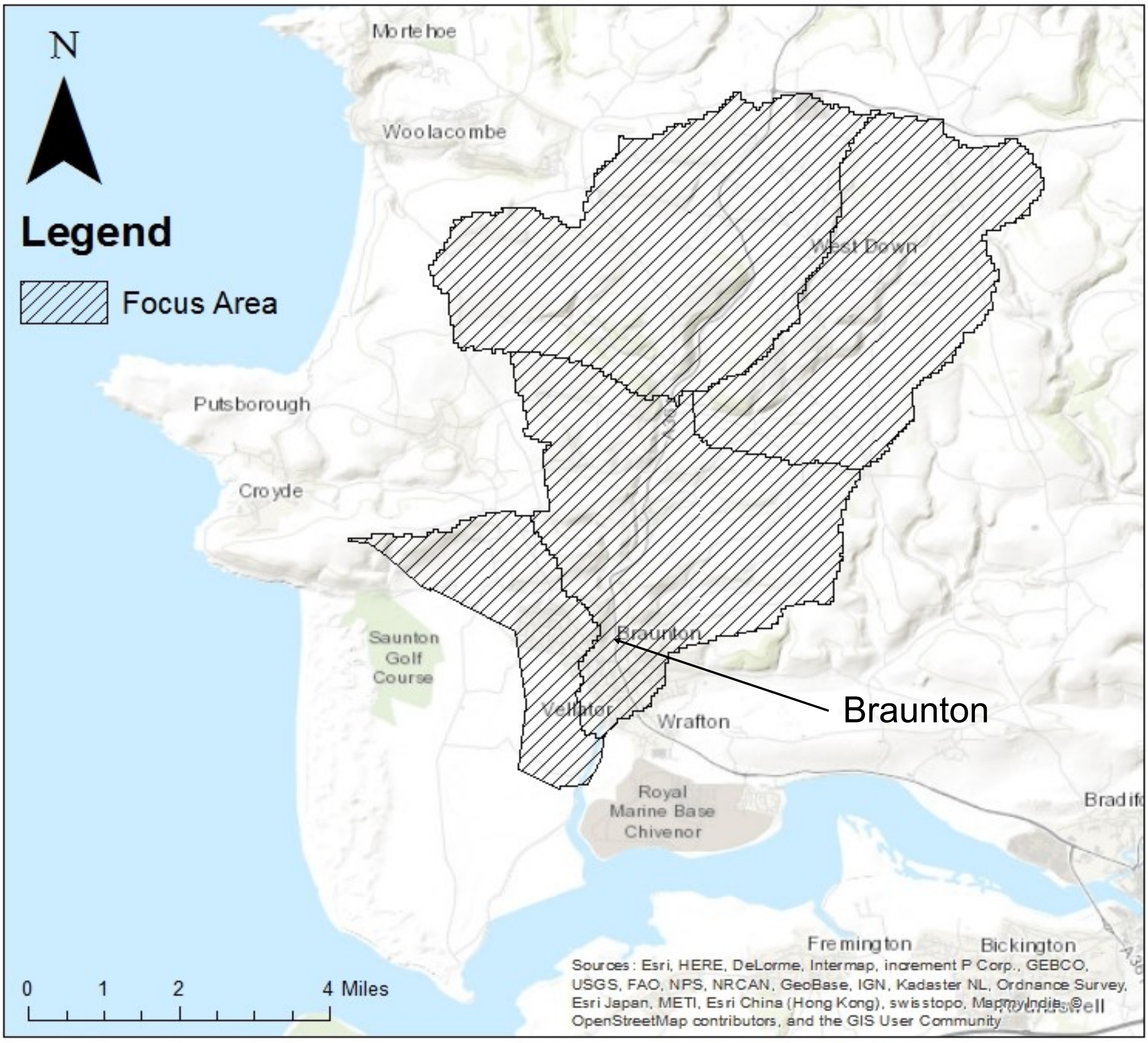


Figure 4. Estuary Project Focus Area Map - the River Caen Catchment.

As stated, the focus area of this project was the River Caen catchment which flows into Braunton. This catchment was chosen due to the various benefits the project could bring to the area, including improvements to the Lower Caen's Water Framework Directive (WFD) water body status . The Lower Caen's current WFD status is 'poor' and thus requires significant improvements to reduce the pressures facing water quality in this area (see Figure 3 below). This is also reflected below in the NVZ as it includes both the Upper and Lower Caen catchments, as well as the rest of the River Taw, where eutrophic waters are being tested and monitored. As the WFD aims to improve the overall waterbody status in this NVZ to 'good' by 2021, measure and interventions need to be adopted to resolve these issues and meet the 2021 target.

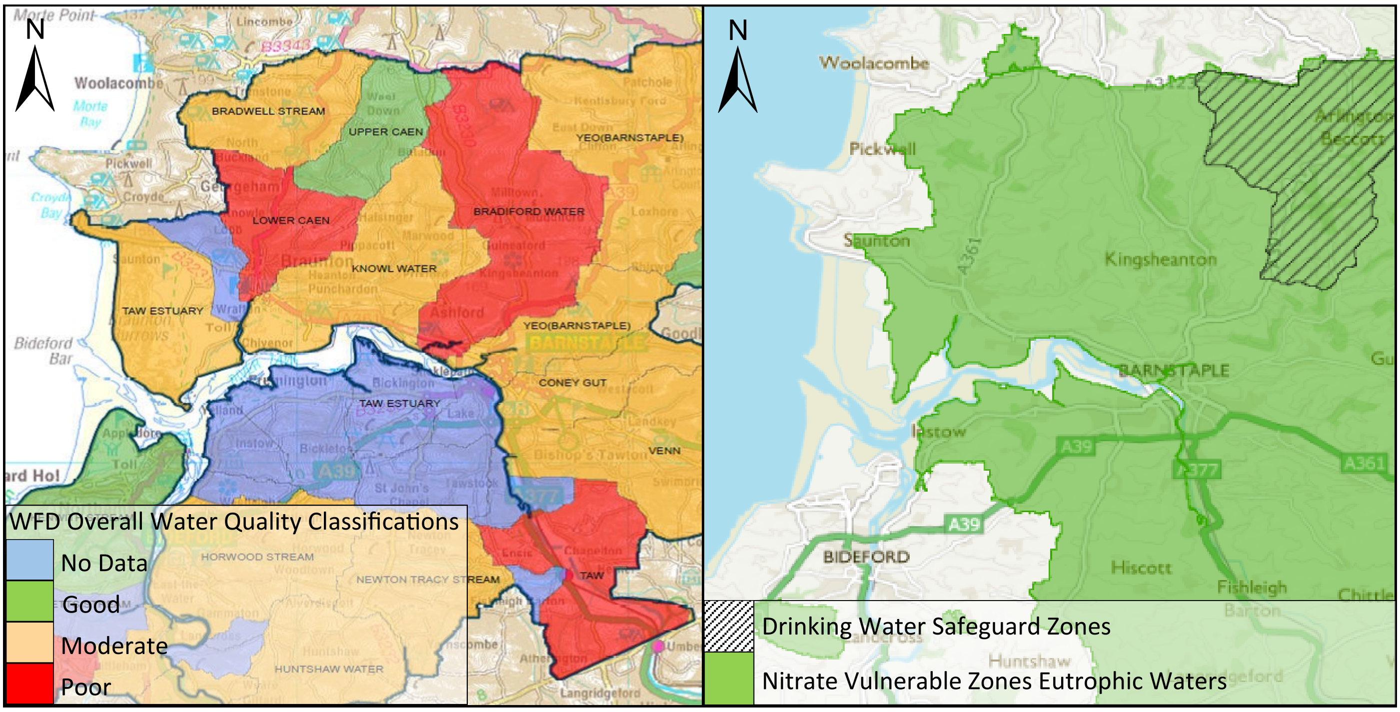


Figure 3a. Water Framework Directive—Overall Water Quality Classifications (2018) and b. Drinking Water Safeguard Zones for surface waters and the Nitrate Vulnerable Zones of Eutrophic Waters (2017 Pre Appeals).

Figure 3a shows how the Upper Caen is of 'good' water quality status already, however the Lower Caen requires improvement, as it is classified as 'poor'. It must be noted that this figure does not assume that the source of the Lower Caen's poor water quality originates from the Lower Caen itself. The Upper Caen could also be the source of some of the pollution, accumulating in the rivers headwaters and then transported into the Lower Caen along with inputs from other land parcels which join the river. Figure 3b depicts just how extensive the Nitrate Vulnerable Zone is, stretching through the Taw catchment right up into the headwaters. This is certainty concerning as these valuable headwater streams carry these eutrophic waters into the main watercourse and the Estuary.

3. Methods

i. Desktop Studies

Table 1. Upper and Lower Caen Overall Water Body Status

Upper Caen - below Snowball Wood	
Year	**Overall water body status**
2009	Moderate
2010	Moderate
2011	Moderate
2012	Moderate
2013	Good
2013	Moderate
2014	Good
2014	Moderate
2015	Good
2016	Good

Lower Caen - below Buckland Barton	
Year	**Overall water body status**
2009	Moderate
2010	Moderate
2011	Moderate
2012	Poor
2013	Poor
2013	Poor
2014	Poor
2014	Poor
2015	Moderate
2016	Moderate

As shown in Table 1 above both the Upper and Lower Caen have experienced fluctuations in water quality status from 2009—2016. The sensor which receives the Upper Caen's data is located below Snowball Wood and shows a 'Good' status for two consecutive years; with the previous year classified as 'Moderate'. This is a positive step for the Caen's water quality, although, as the river flows into the Lower Caen, the water quality classification status falls; in 2014, from 'moderate' to 'poor' and in 2015 and 2016, from 'good' to 'moderate'. Using this study data the farms were targeted accordingly, with the Lower Caen being the primary area the project concentrated upon and the Upper Caen secondary.

ii. Field Studies

The project engaged with 50 farmers who own land within the Caen catchment focus area (see Figure 5 - Map break down in Appendix 1-3).

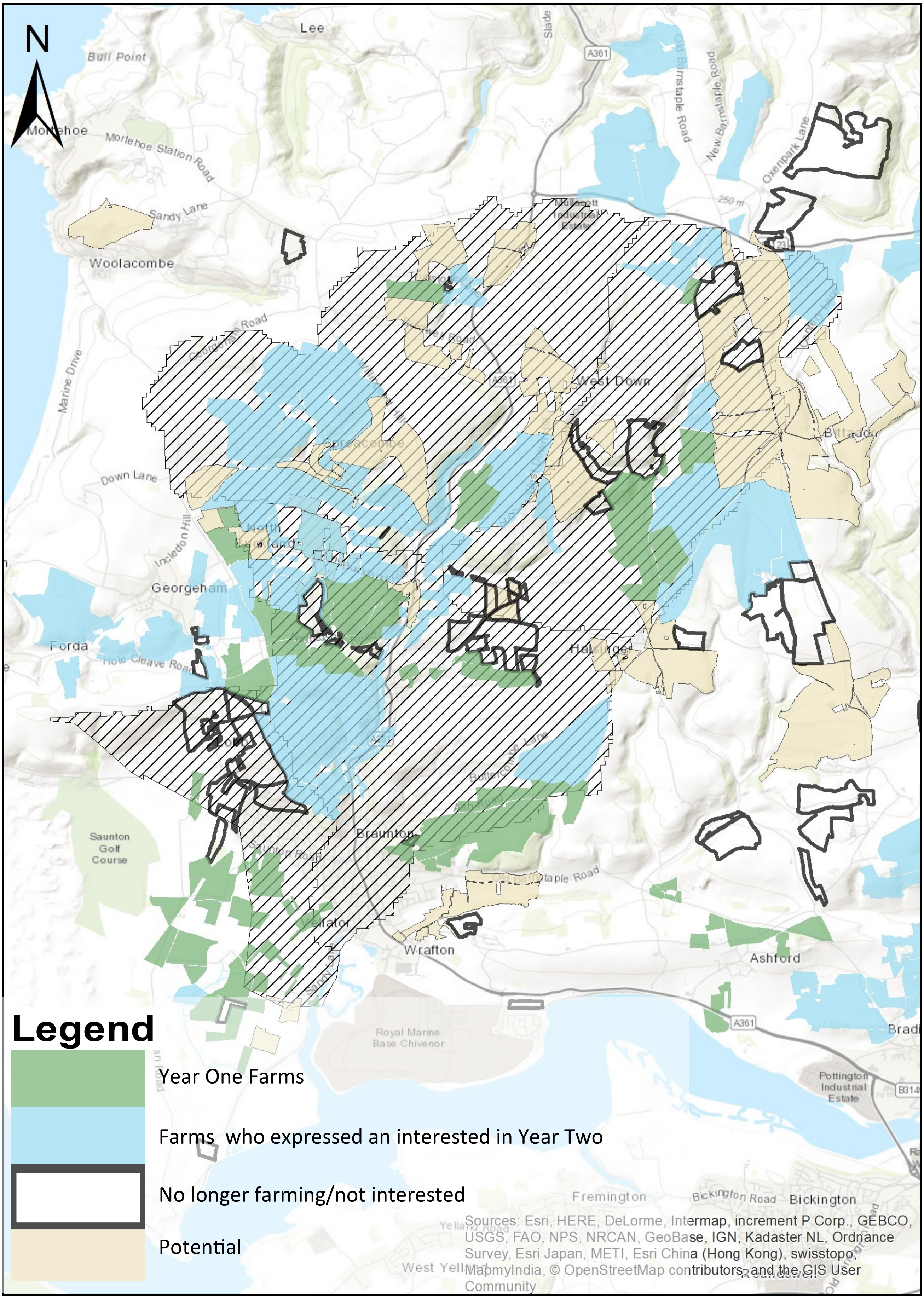


Figure 5. North Devon Focus Area Estuary Pollution Project - All Farms

The project was split into two sections:

1. To deliver advice, guidance and grant aid to landowners to assist in reducing diffuse pollution from agricultural infrastructure and
2. To identify soil erosion by mapping run-off pathways and surveying the River Caen’s watercourse.

Agricultural Infrastructure

In Field Soil Erosion

Agricultural Infrastructure

An initial visit to farm holdings enabled the project to engage with landowners and discuss whether they had any run-off issues. These issues could be, eroding tracks from run-off scour or muddy yard areas from soil heave. After first building a valuable relationship with each landowner and assessing whether they were interested in solving these issues, advisor visits could be conducted.

West country Rivers Trust provided 10 bespoke advisor visits and explored further possibilities with the individual landowners. Subsequently, practical advice was given in the form of a Work Plan and Water Management Report which also included an estimation and intervention breakdown of project costings. Each farm holding Water Management Reports are available on request. When creating workable solutions from both an agricultural and environmental perspective, the following had to be taken into consideration:

- The day to day running of the farm.
- The gradient of the proposed site location, so the appropriate intervention is proposed.
- The catchment area and therefore the volume of run-off which will be received by the intervention. This enables appropriate dimensions and a detailed design to be derived.
- If interventions involve excavating, the soil type, structure and current soil health needed to be considered. This aims to deliver an appropriate lifespan for the intervention.
- An appropriately sized space available for the construction of the works.
- Consideration and allowance of how the landowner will maintain the interventions installed.

Care was undertaken to implement sustainable drainage (SuDs) designs which are available to all landowners, including small scale holdings, which would not be supported by Catchment Sensitive Farming (CSF) funding requirements or agreements. Also designs were not advised if they supported a legal requirement, for example, rectifying breaches in SSAFO regulations.

Soil Erosion Management

Firstly, desktop studies were conducted which involved mapping the catchment and identifying areas of potential high run-off; using GIS and the software ArcMap. This enabled the project to better understand where run-off was more likely to occur and to target these land parcels.

The desktop studies were either supported and/or amended through ground truthing the mapping by conducting wet weather river walkover surveys. River surveys enabled the project to specifically highlight areas of in field compaction and poaching directly into the watercourse. In field compaction was analysed by penetrometer analysis and excavating small soil pits and examining the soil profile, horizons and structure.

More detail can be found about the soil erosion management aspect of the project in the Soil Run-off Mapping Survey Report by Phil Metcalfe.

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Project Results

Grant aid was given to 8 farms within the Caen catchment focus area (see Figure 6 below).

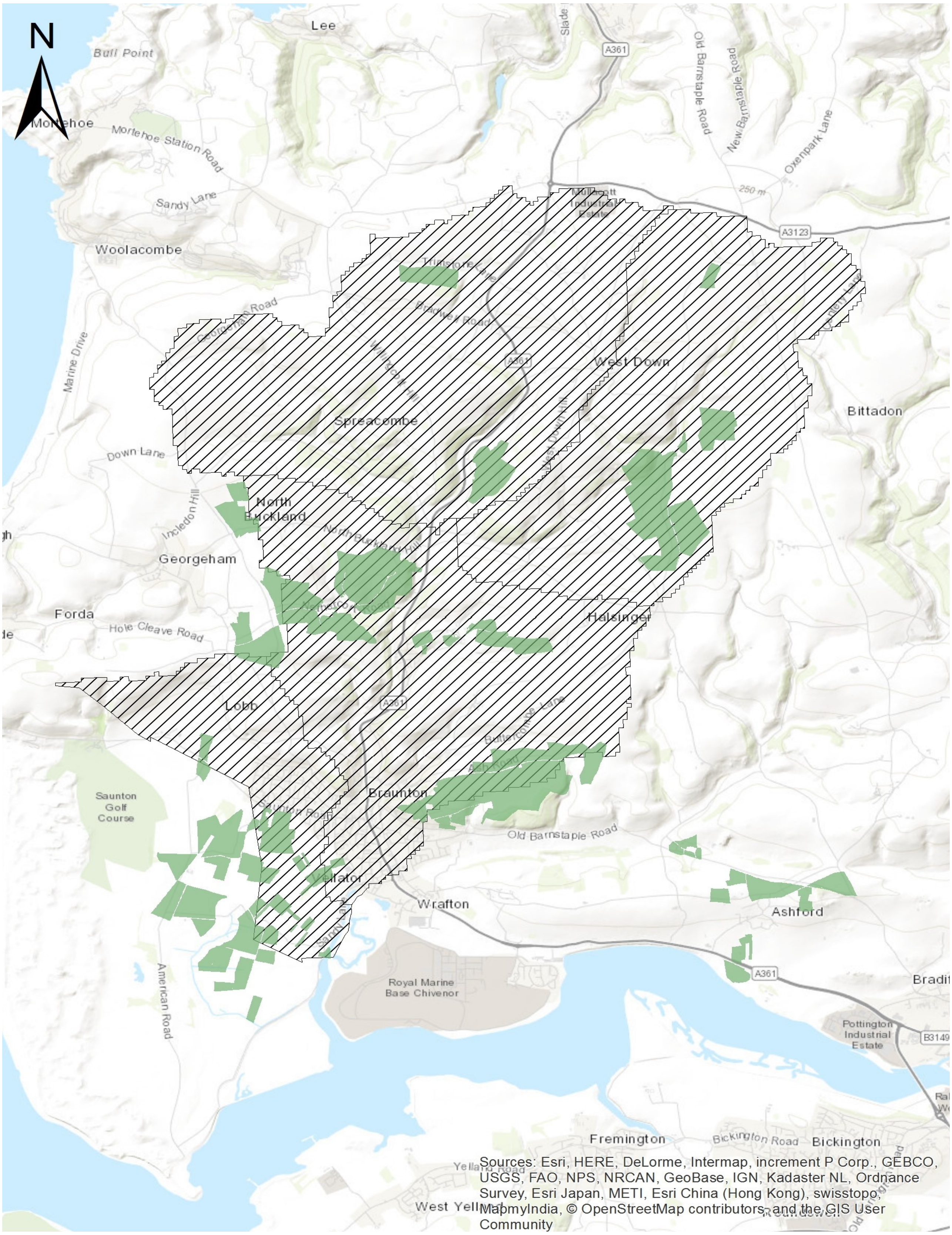


Figure 6. North Devon Focus Area Estuary Pollution Project - Year One Farms

i. Case Study: A

Farm Type: Dairy	
Farm Size: 100-199ha	
Watercourse: Upper Caen	

Initial Farm Issues
Clean rainwaters and dirty yard waters mixing - using up valuable slurry storage
Road waters picking up yard pollutants due to localised yard flooding
Clogged up sediment pond system with flood debris
Highways waters entering cow shed - using up valuable slurry storage as the waters become contaminated (see below).

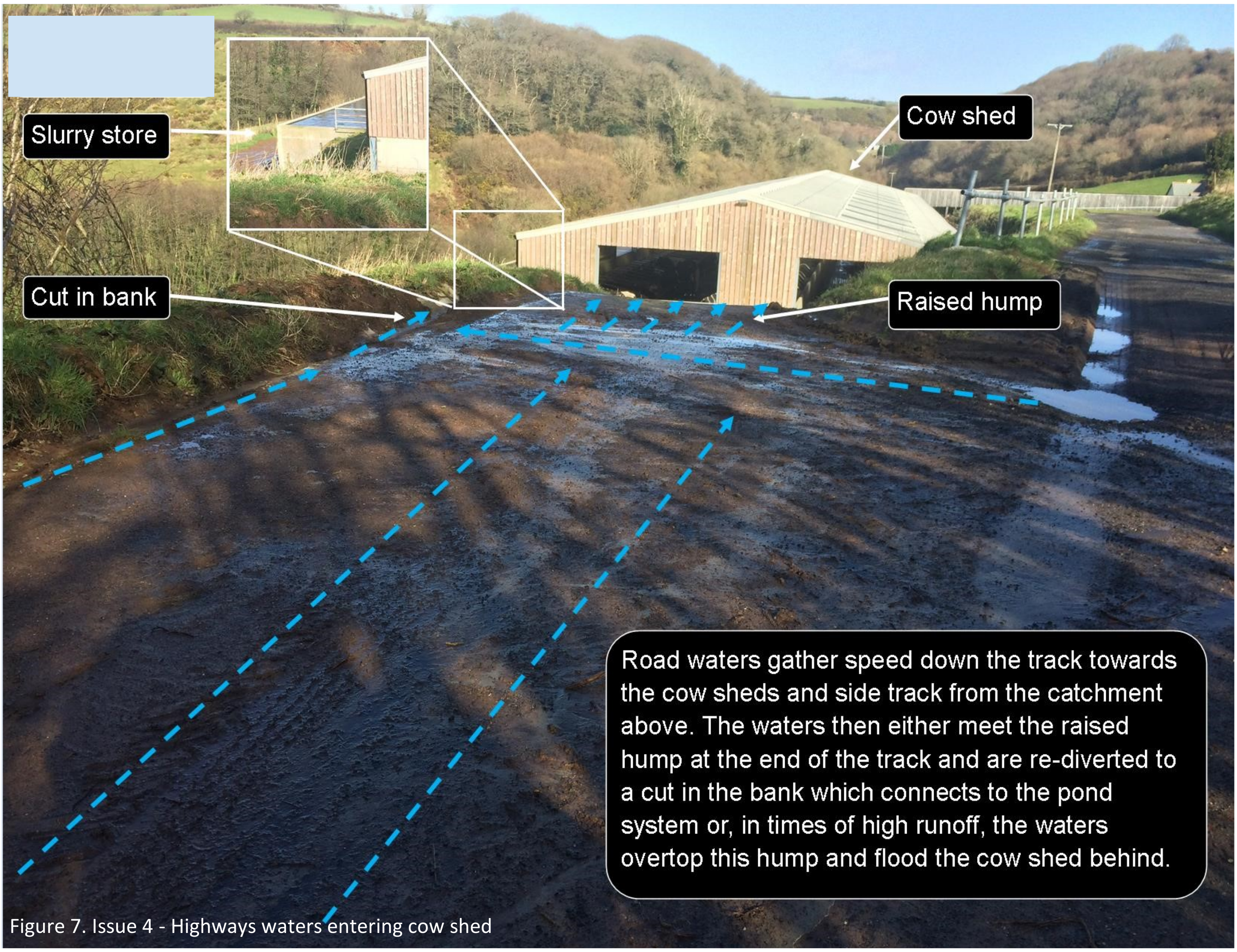


Figure 7. Issue 4 - Highways waters entering cow shed

i. Case Study: A

Code	Project Design
RW1	Install new guttering, drainage system as small wall to divert waters to central drain.
LC2	Enlarge farm culvert to increase the capacity of waters that are able to be received at any one time by the feeder stream, to bypass the yard.
SP3	Remove flood debris from existing sediment pond system.
ST1 4 & ST2 4	Install two sediment tanks - one out flowing into a fenced baffle ditch system and the other directly into the central drain (the later is fed from track diverters and a gully).

Farm A - Work Plan

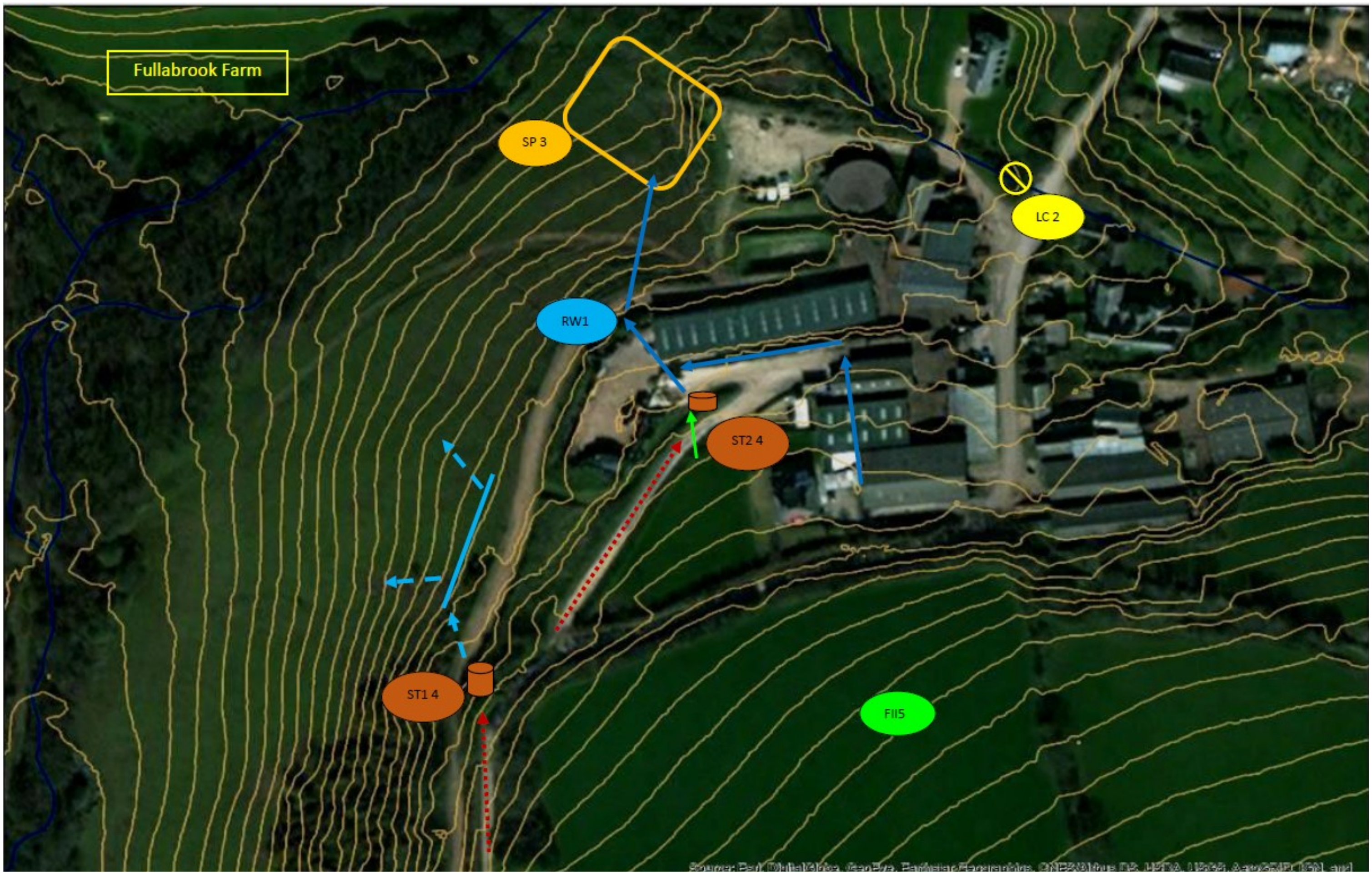


Figure 8. Farm A Water Management Report Work Plan. Source: West country Rivers Trust (2018).

i. Case Study: A

Project Outcome
All yard clean and dirty water separated
Significantly reduced yard flooding and the transport of pollutants
Re-established original functioning of sediment pond system
All channels of road waters diverted away from the cow shed and treated before entering the watercourse

Farm A - After photos

Figure 9. Farm A after photos.

ii. Case Study: B

Farm Type: Beef, Dairy and Cereals	
Farm Size: more than 300ha	
Watercourse: Lower Caen	

Initial Farm Issues
Rainwater from roof buildings are contaminated by sediment loaded yard waters and pollutants.
Untreated lightly fouled yard waters and dirty track waters allowed to head towards the watercourse unmanaged.
Soil heave in yard area add to the amount of contaminated sediment allowed to head towards the watercourse unmanaged.
Compacted fields lead to high run-off volumes leaving the land.

Figure 10. Issues 1 & 2 - Rainwaters mixing with dirty yard waters and allowed to head unmanaged towards the watercourse.

ii. Case Study: B

Code	Project Design
RW1	Replace broken downpipes into under yard drainage.
YRD	Install two sediment tanks. One located in the yard and one adjacent to the field track to catch and treat respective waters.
CY4	Lay remaining section of concrete yard with shallow humps to retain and prevent water contamination.
FC5	Excavate soil profile pits to assess level of compaction and soil aeration.

Farm B - Work Plan

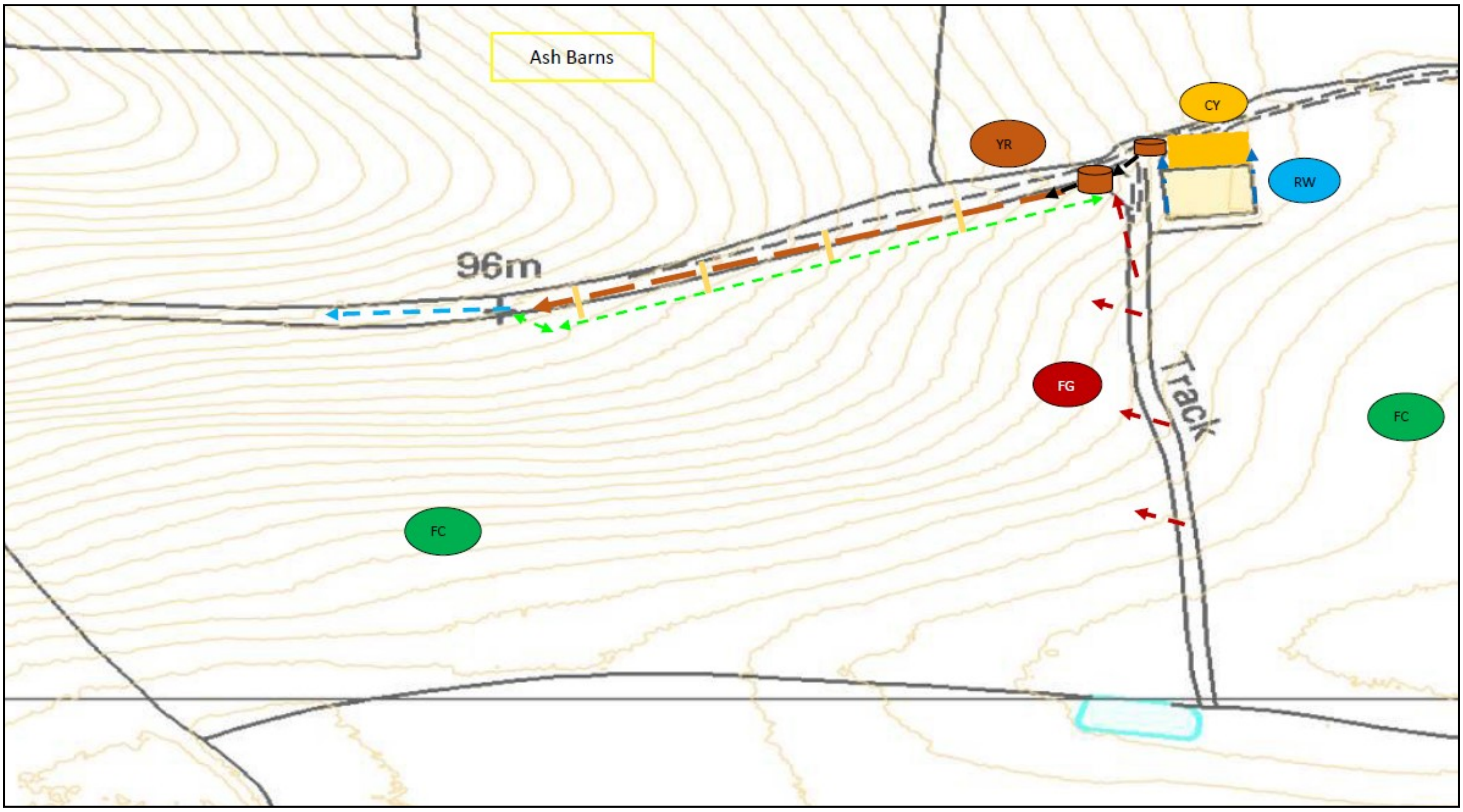


Figure 11. Farm B Water Management Report Work Plan. Source: West country Rivers Trust (2018).

ii. Case Study: B

Project Outcome
Prevented rainwater contamination by sediment loaded yard waters.
Manage, separate and clean yard and track sediment loaded run-off before entering watercourse - to be completed in the projects second year.
Well maintained and clean yard, preventing soil heave and pollution entering the highway.
Reduced in field compaction to allow waters to filtrate into the soil, preventing soil and nutrient loss.

Farm B - After photos

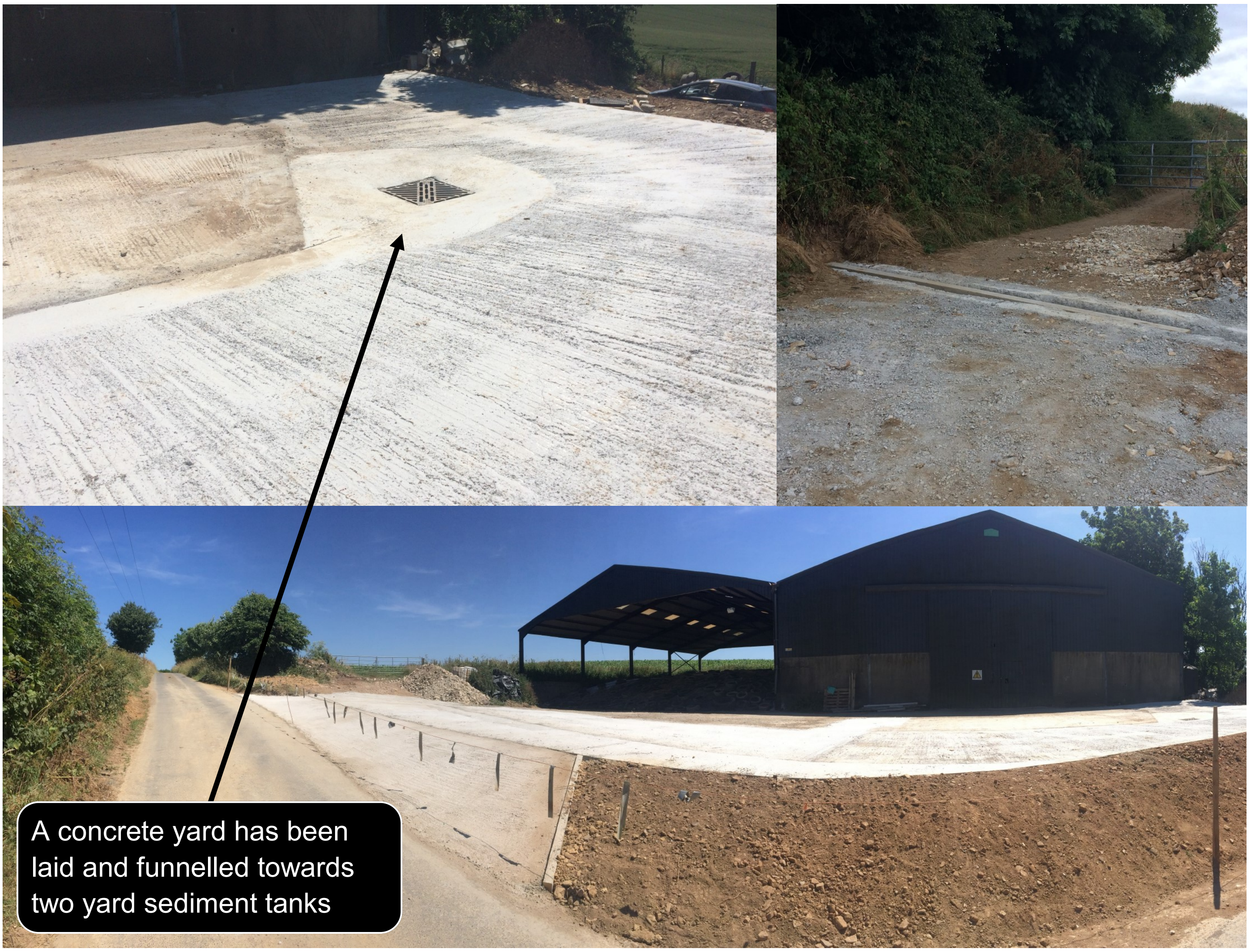


Figure 12. Farm B after photos.

iii. Case Study: C

Farm Type: Beef, Cereals and Horticulture
Farm Size: 200-299ha
Watercourse: Lower Caen/Braunton Marsh

Initial Farm Issues
Cattle drinking from the stream at several points and heavily poaching the river banks.
In yard soil heave causing pollutant and sediment loaded run-off to mobilise and be transported into the watercourse.
Mixing of clean roof waters and sediment loaded yard run-off before entering soakaway.

Figure 13. Issue 2 - pollutants and sediment loaded run-off allowed to mix and head unmanaged towards the watercourse.

iii. Case Study: C

Code	Project Design
DW1	Fence off stream from cattle and install drinking troughs and a solar panel pump.
CY2	Lay remaining section of concrete yard with shallow humps to retain and prevent water contamination.
ST3	Install two open sediment tanks, fenced with gated access. The first located in the front yard and the second adjacent to the hedgerow to treat respective waters.

Farm C - Work Plan

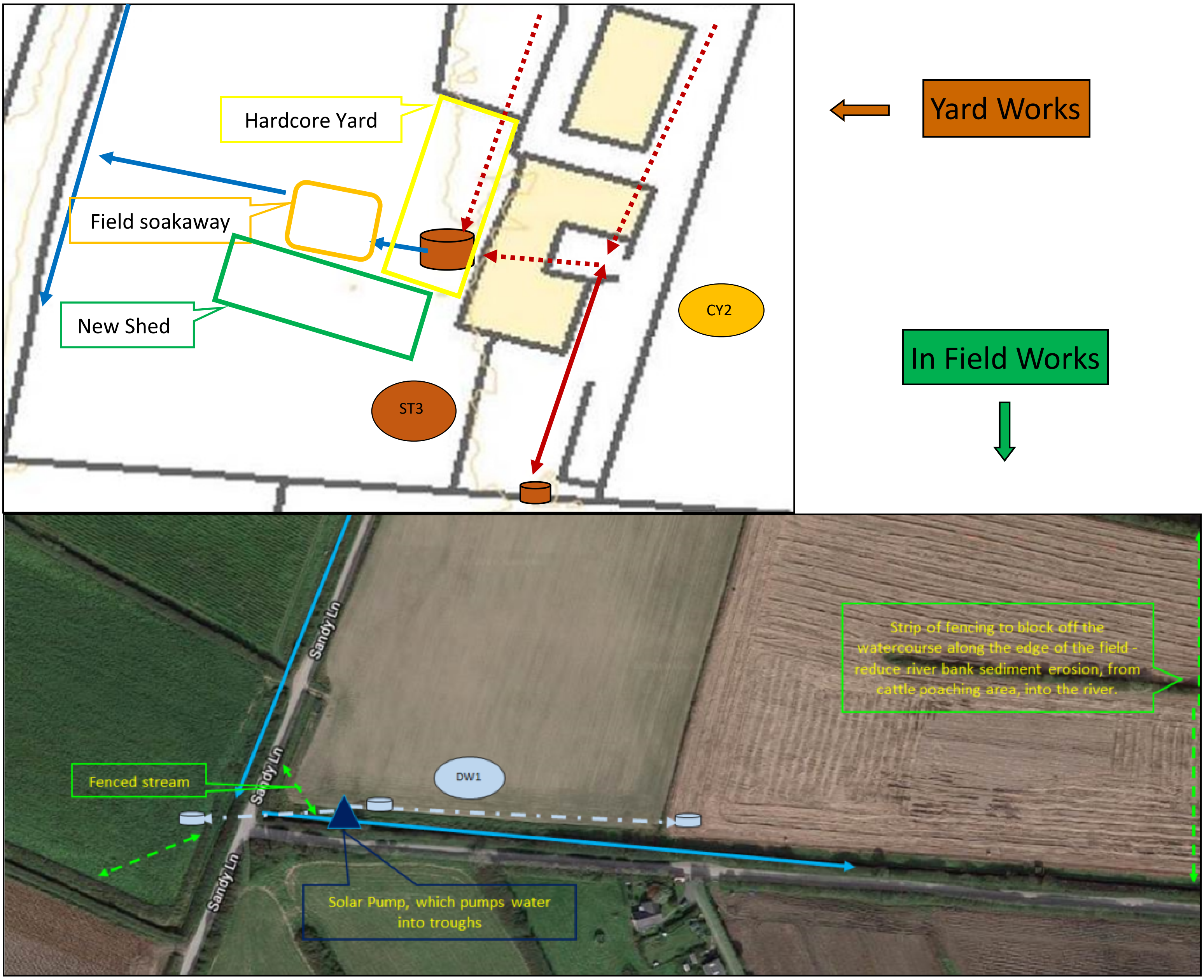


Figure 14. Farm C Water Management Report Work Plan. Source: West country Rivers Trust (2018).

iii. Case Study: C

Project Outcome
Fenced off watercourse at three points and alternative drinking access for cattle.
Well maintained and clean yard, preventing pollutant loaded run-off getting to the watercourse.
Manage, separate and clean yard and track sediment loaded run-off before entering watercourse.

Farm C - After photos

Figure 15. After photos of the works at Farm C.

Project Results - Summary

Farm Yard Issues

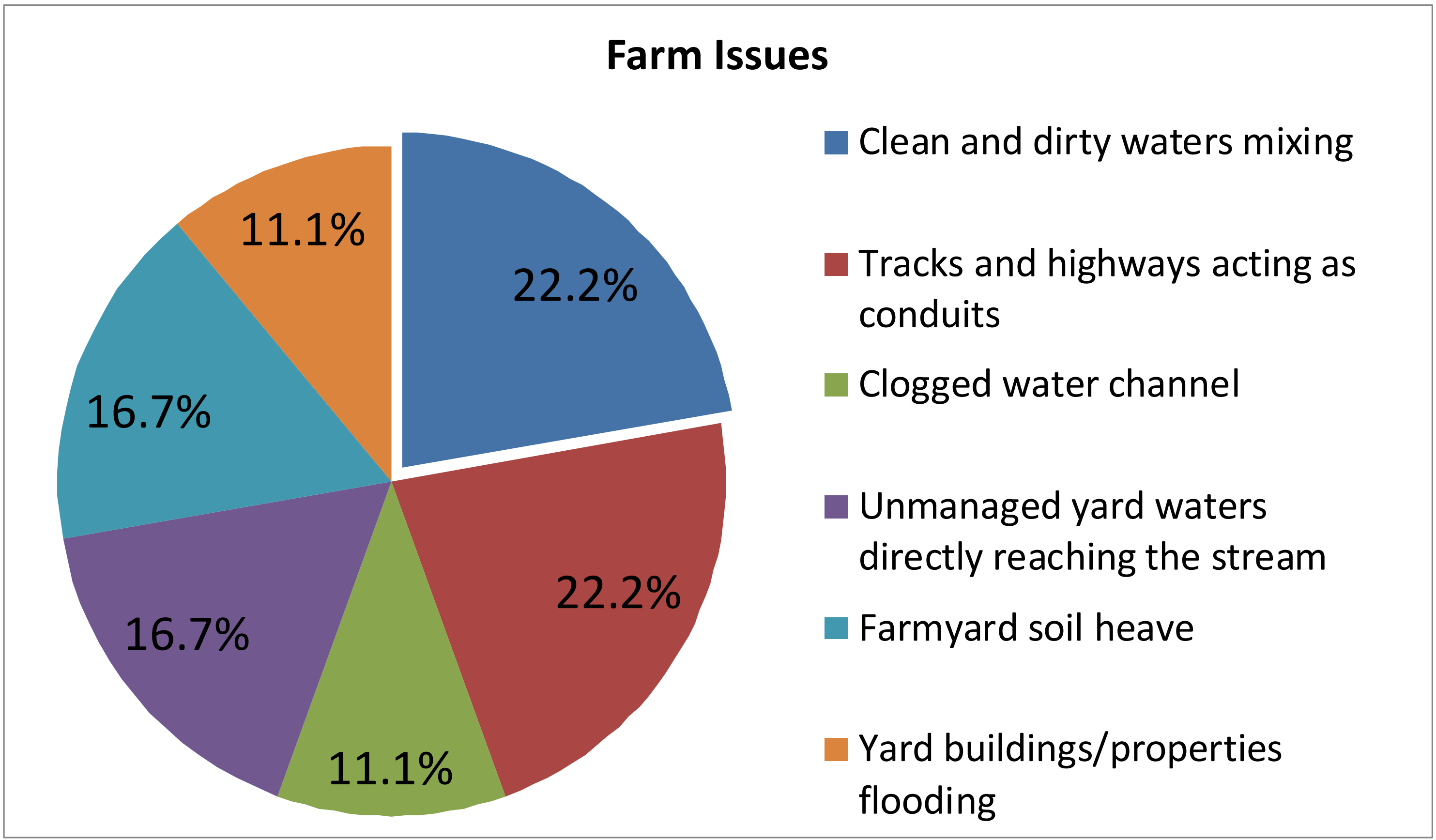


Figure 16. Farmyard issues summary.

As the above chart shows, the major issue we found was clean rainwater from the roofs of yard buildings mixing with dirty waters in the yard. This issue was present in half of the farms grant aid was funded too, highlighting the requirement for a clean water system to be established. Basic interventions such as guttering and downpipes into a central drain can assist in the diversion of clean waters without coming in contact with any contaminated yard surfaces.

Surprisingly in a several instances, track and even highways waters appeared frequently as a water management issue. These conduits contribute to poor water quality as they funnel run-off into yard areas and yard buildings, enabling them to pick up contaminants.

Project Results - Summary

Farm Yard Solutions

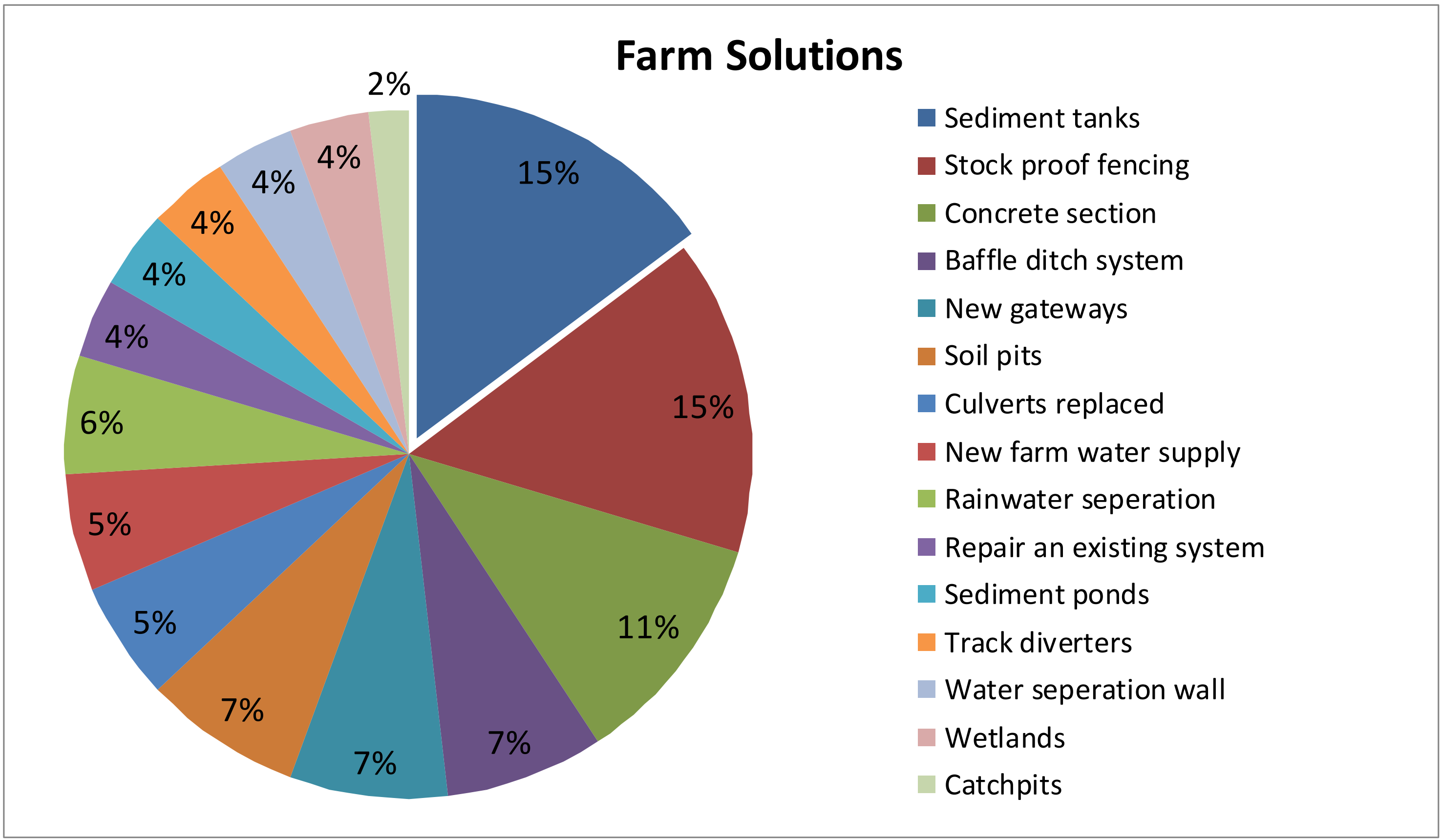


Figure 17. Farmyard solutions summary.

As the above chart shows, there were a variety of solutions adopted to suit the individual landowners requirements. Sediment tanks and stock proof fencing were the interventions taken up by most landowners, whereas catchpits were only adopted at one location. Sediment tanks were found to suit the majority of landowners as they can be discrete within the farm yard. As well as being discrete, they are highly affective at cleaning yard waters and settling out sediment from the water column. Fencing was constructed a lot within the project as it serves several useful purposes including protecting watercourses, wetland ponds and baffle ditches. Catchpits however are a much more bespoke intervention and was adopted in this instance as the landowner was experiencing severe river bed erosion from the outflow of their settlement pond.

5. Discussion

Farm Yard Issue		Farm Yard Solution
Mixing of clean rainwaters from the yard buildings and dirty yard waters	→	Advice given to separate clean and dirty waters using guttering, baffle ditches or track diverters

As a result of this project, we have found that both in yard and wider catchment factors influence yard water contamination. In particular the project focused on in yard factors, and workable scale measures were adopted to suit each land holding. Guttering featured as one of these key small scale measure at several farms which provided an easy and relatively cheap way of catching and diverting clean roof waters before they entered the yard. Although on a small scale, interventions such as this still produced similar water quality and management outputs and were also able to fit in easily with every day agricultural works and routines.

Large amounts of sediment and silt loaded run-off washing down from higher fields into yards during times of rainfall. In these instances, the waters pick up contaminates and pollutants including slurry and silage liquors before travelling to the watercourse	→	Advice given to intercept road waters via concrete humps or sediment tanks where appropriate to settle out the pollutants before they enter the watercourse

The project also adopted larger scale interventions which helped to mitigate sediment loaded run-off from entering yards in the first place from conduits, such as adjacent highways. These strategies diverted waters into more appropriate channels and have severely limited the opportunity for run-off to become contaminated. This subsequently restricts the possibility of waters entering the yard areas and mixing with agricultural pollutants, such as fuel oil. These waters are prevented from reaching the watercourse and causing pollution and in stream eutrophication events to occur.

Soil Management Issue		Soil Management Solution
Compaction of fields facilitates large volumes of run-off, surface sediment loss and therefore nutrients within the topsoil leaving the land	→	Advice given to adopt regular aeration practices on land parcels by using a sub-soiler. Subsoiling breaks up the plough pan and creates fissures within the soil, encouraging worm activity and the infiltration of potential run-off and floodwaters

The most overlooked land management issue we encountered was in-field compaction. In multiple cases this led to high volumes of run-off leaving the land as infiltration capacity was reduced. As waters are unable to infiltrate, we found that this was likely to be a primary contributing factor for localised flooding as the majority of floodwaters are not able to be slowed within the tightly packed topsoil and lack of fissures. During these run-off events, we also found evidence of sheetwash erosion as sediment is mobilised in times of heavy rain. This rain washes loose material from the land and has, in the worst cases, left behind sediment fans feet from the watercourse.

Poaching of fields and at river banks by cattle	→	Advice given to fence off the watercourse and water troughs were installed for new drinking access

The overall sign of poor land management we discovered was poaching, as this was seen both in-field and also directly entering the watercourse.

In-field poaching was found to have serious effects on soil health as it was so widespread. This was visually examined when digging soil pits to view the soil strata and fissures (or lack thereof). This form of dairy or beef cattle poaching was seen in some instances to affect entire fields; especially in wet conditions, as deep hoof indentations can be created. Persistent hoof motions as cattle graze have also led to compaction and, as mentioned earlier, compaction was seen to cause widespread run-off and soil erosion issues.

Small sections at the rivers banks, as cattle drink from the river, direct poaching into the watercourse occurs. This action allows river banks to collapse and topsoil to be mobilised and enter the watercourse. These direct sediment inputs are the most likely cause of the silting up of gravel beds.

As field gateways are used regularly, these areas are known to experience the most damage, creating wheel ruts and producing pathways for run -off and nutrients to leaving the fields during rainfall events

Advised the relocation of gateways to the top of the field, where appropriate, which would not allow waters to gather in low lying and typically muddy areas

The current management which caused the most soil and run-off issues was found to be gateways and associated traffic. Poorly located gateways were found to majorly affect both in-field soil degradation and also the transportation of loose soils out on to the highway. As regular agricultural traffic enters and leaves the gateways, whether it is to feed livestock, sow or harvest crops, this concentrated compaction from large machinery reduces infiltration capacity and soil health. We also found that gateways and particular tracks were used more often due to farmers storing farmyard manure in fields as part of agricultural practice. As machinery entered and left the gateways wheel ruts were created, in some cases approximately 2ft deep. These ruts were found to act as conduits in times of heavy rain, mobilising sediment and nutrient loaded waters on to the highway and towards the watercourse. Further, headlands also experienced vast machinery traffic, similar to gateways, and therefore contribute to wider in-field soil degradation.

Recommendations for Further Work

1. To approach new landowners and continue working with those already engaged in the Caen catchment who expressed an interest in the second year of the project.
2. Potentially expand the projects scope towards the Bradiford catchment and Knowl stream where during this project the following issues were discovered:

- *Bradiford Water:* Muddiford village is prone to flooding potentially due to compacted, sheep poached and tightly grazed fields observed higher in the catchment (see Figure 18 below). These fields, located upslope of a very steep road, enable run-off to gather speed towards the local community.

Figure 18. Tightly grazed fields in the Bradiford Catchment. Inset: water streaming out of the same gateway (Source: Phil Metcalfe).

- *Knowl Water:* a large poached riverbank section was discovered and should be explored further (see Figure 19 below). EA data shows the status of the Knowl water has declined from 2009-2016, from moderate to poor.

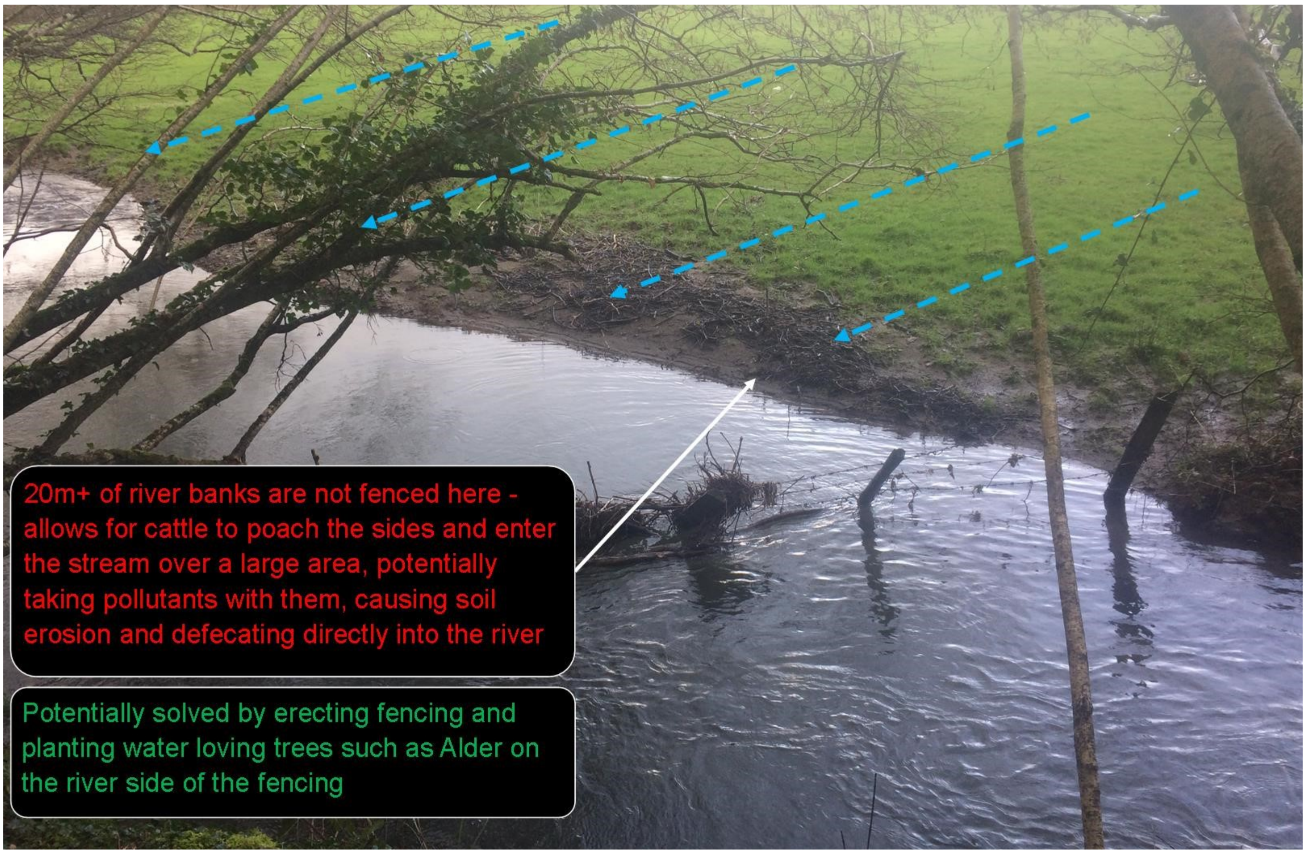


Figure 19. Bankside river poaching in the Knowl Catchment.

6. Conclusion

In light of these findings, the two major yard infrastructure issues the project discovered were the mixing of clean and dirty yard waters, and large amounts of sediment loaded run-off entering yards from adjacent highways. The project addressed these issues by installing new guttering, baffle ditches, track diverters and sediment tanks where appropriate. The major soil management issues that the project found were compaction, poaching and large amounts of traffic at field gateways. To remedy these issues, the advice of the project was to adopt the practice of regular aeration, fencing of the watercourse and relocation of gateways respectively.

On reflection, the interventions adopted in this project could also be used in surrounding catchments which, during this study, we have found experience the same or similar issues as the River Caen. These catchments include, but are not limited too, the Knowl Water and the Bradiford Water. These catchments in particular share similarities such as river bank poaching and compaction from the overgrazing of livestock.

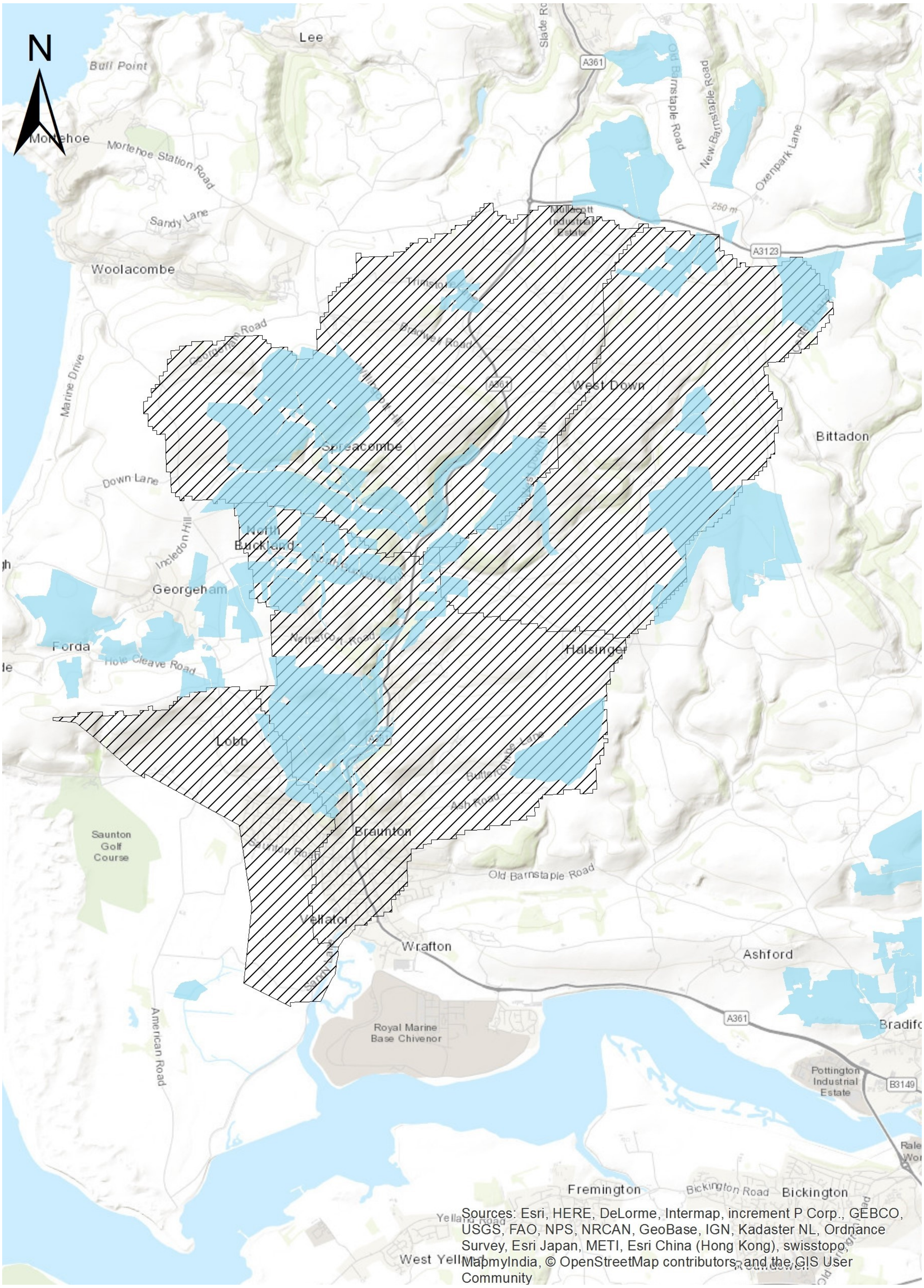
Wider benefits of these measures include providing landowners with resilience interventions in which they are more prepared for the effects of future climatic changes. This can be noted in Case Study A, in which high surface run-off, from the effect of a rare flood event, could become more likely as more dramatic weather events become more frequent across the UK.

Lessons Learnt

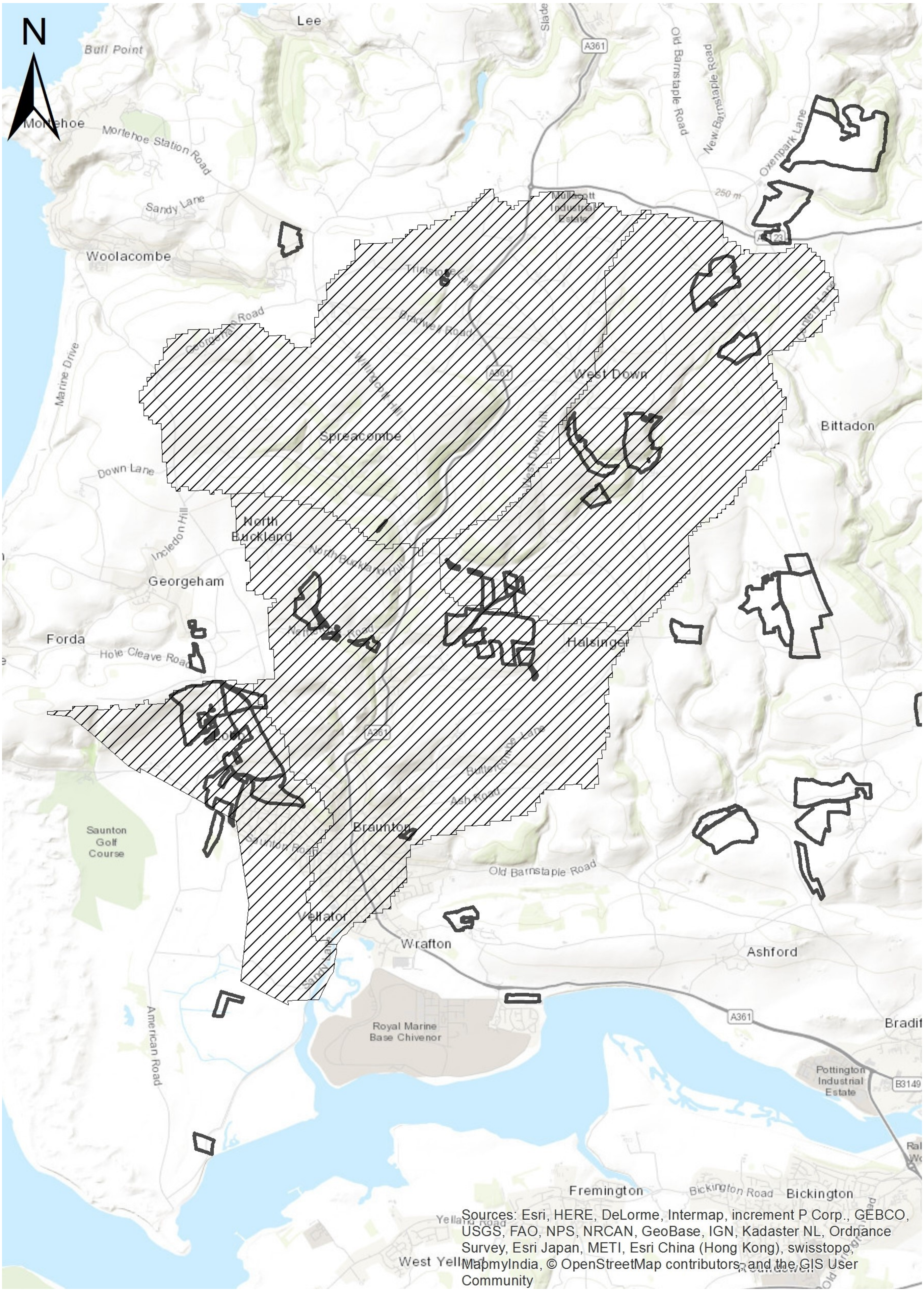
1. Every farm is different and so bespoke measures need to be applied under different conditions.
2. Interventions such as sediment tanks need to be designed to suit the farmer so they are easy to maintain. For example, they could be constructed to the same size as the landowners digger bucket for easy maintenance.
3. The farming calendar needs to be taken in to account when planning works. For example at lambing, calving or ploughing season, landowners will be very busy and potentially too busy to take part in the project, especially if they will be doing the project work themselves as the majority this year have preferred to do.

7. Appendix

i. Farms who expressed an interest in Year Two



ii. No longer farming/not interested



iii. Future potential farms map