Stockton Borough Council

Flood Mitigation Options

Lustrum Beck

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Contents

Appendices

1 Introduction

Lustrum Beck (along with Hartburn Beck) is a tributary of the River Tees which flows through the south of Stockton-on-Tees. It is a significant source of fluvial flood risk to nearby properties and infrastructure, particularly within the following three areas:

A. Junction between Darlington Road & Hartburn lane;

B. Area between Ropner Park & Grangerfield Park;

C. Area between Wrensfield Road & Durham Road.

These areas are shown in Figure 1 below.

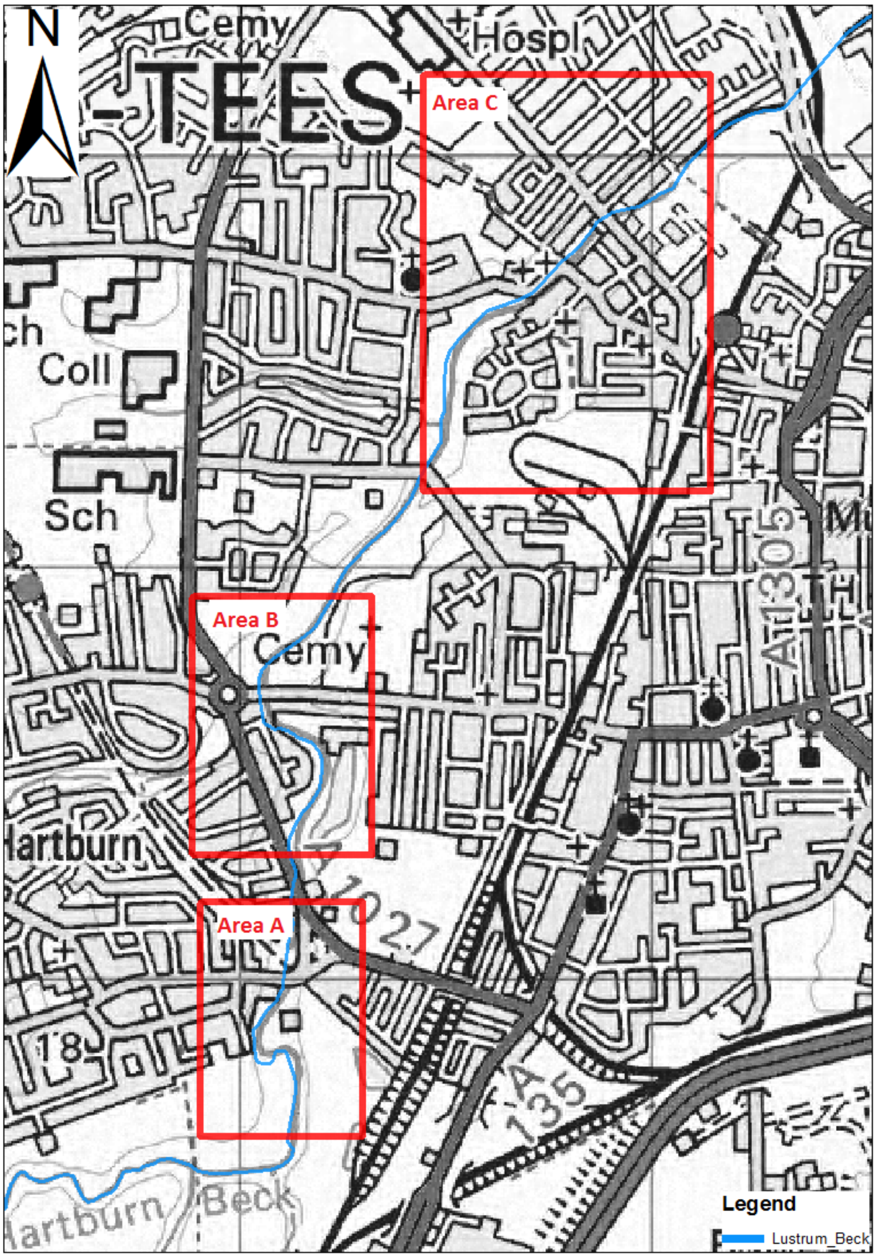


Figure 1: Overview of Lustrum Beck, showing key areas of flood risk (A, B and C)

A formal flood risk management scheme has been identified by the Environment Agency to reduce flood risk from Lustrum Beck. This scheme, incorporating local flood defence structures in the urban area adjacent to the beck, together with an online upstream storage area, is unlikely to gain sufficient external funding to allow it to be promoted using DEFRA Grant in Aid (GiA) funds.

However, Stockton Borough Council (SBC) is keen to promote alternative measures that will reduce flood risk from Lustrum Beck.

This study therefore focuses on measures to reduce the risk of flooding from Lustrum Beck within the three key areas noted above. Sustainable, relatively low-cost solutions have been identified to reduce flood risk; these are grouped into one of four categories for the purpose of this report:

- Catchment interventions – localised measures upstream to slow down the progress of water in the catchment and reduce peak flow during large events (i.e. encouraging flooding in areas that can tolerate it in order to protect susceptible areas downstream);
- Local channel interventions – in-channel measures local to each of the three areas in order to reduce flood risk in the immediate vicinity of the watercourse (i.e. actions such as reducing bed levels, increasing channel capacity, removing obstructions to flow, reducing channel roughness etc);
- Local resistance and resilience measures – local measures in each of the three areas focussing on small-scale flood defence or property/community resilience. (i.e. promoting measures that “live with” flooding by keeping water away from flood-sensitive elements, or allowing properties and infrastructure to return to their original use soon after flooding with minimal repair or cleaning);
- Local emergency measures – local emergency response measures that could be implemented immediately before or during a flood event. (such measures could include demountable walls or gates within fixed frames, and more informal movable temporary barriers).

2 Catchment Interventions

Appendix A includes some generic measures which can be used in catchments to slow the flow of water and help reduce the risk of flooding downstream in urban areas. These measures might be applicable in various forms, to various degrees in the Lustrum Beck catchment. The Lustrum Beck catchment has a number of tributaries, including Hartburn Beck and Coatham Beck. Some potential locations for catchment measures are shown in Figure 2 below.

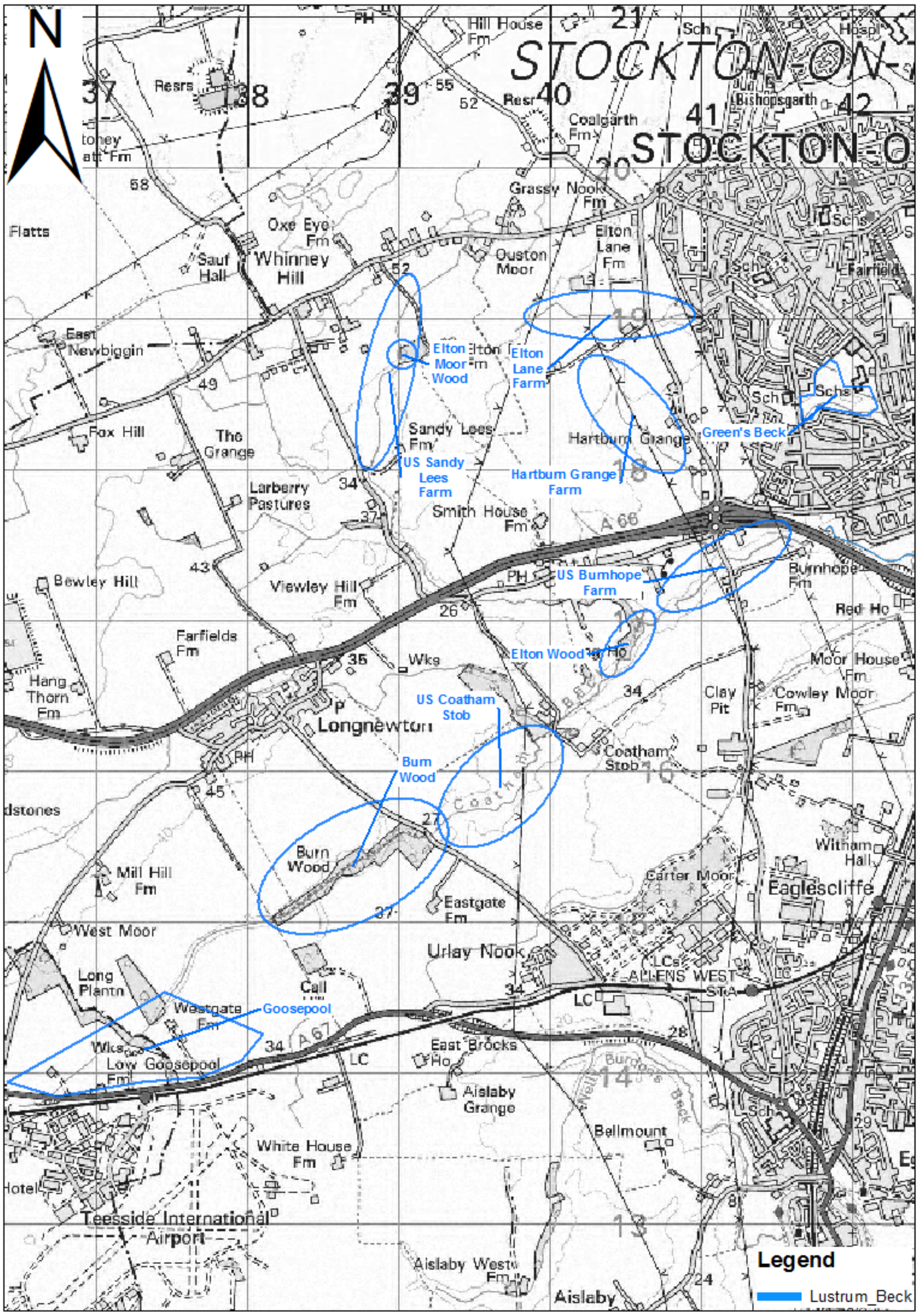


Figure 2: Potential locations for catchment measures in the Lustrum Beck catchment

The catchment has been analysed at a very high level using available mapping and aerial photographs. This has been done in order to identify potential areas where site specific mitigation measures could be implemented; it should be noted that other areas within the catchment are also likely to be suitable for mitigation measures. At some stage further investigation will be required in order to better understand the feasibility and benefit of potential measures. Certain generic measures might be applicable at multiple locations (such as drain blocking, planting, run-off route interception and wetland creation etc). It has not been possible to recommend all potential locations for these measures at this stage due to the high level of information and analysis that would be required to do this.

2.1 Catchment Flood Mitigation

Below is a list of specific locations (shown in Figure 2) and some suggested measures that could be considered at these locations (this list is not exhaustive, and there are likely to be other locations that would have potential to be modified to the benefit of downstream areas that are susceptible to flooding):

Goosepool: Creation of wetland storage upstream of Westgate Farm on the Burnwood Beck.

This could be in the form of on line, or off line pond type storage, or larger swathes of wetland, including floodplain scrapes.

Burn Wood: Creation of wet woodland and addition of large woody debris (LWD) to the channel to slow the water.

A combination of planting, creation of raised channels, floodplain obstructions and positioning of LWD over the channel at bank full would help to store and attenuate floodwaters.

Upstream of Coatham Stob: Wetland storage area

This could be in the form of on line, or off line pond type storage, or larger swathes of wetland, including floodplain scrapes.

Elton Wood: Confluence of Coatham Beck and Hartburn Beck. Create wet woodland.

A combination of planting, creation of raised channels, floodplain obstructions and positioning of LWD over the channel at bank full would help to store and attenuate floodwaters.

Upstream of Burnhope Farm: Wetland storage area.

This could be in the form of on line, or off line pond type storage, or larger swathes of wetland, including floodplain scrapes.

Upstream of Sandy Lees Farm: Wetland storage as well as diverting the stream through Elton Moor Wood to create wet woodland storage

This could be in the form of on line, or off line pond type storage, or larger swathes of wetland, including floodplain scrapes.

A combination of planting, creation of raised channels, floodplain obstructions and positioning of LWD over the channel at bank full would help to store and attenuate floodwaters.

Green's Beck: Wetland storage area

This could be in the form of on line, or off line pond type storage, or larger swathes of wetland, including floodplain scrapes.

Hartburn Grange Farm: Wetland storage area

This could be in the form of on line, or off line pond type storage, or larger swathes of wetland, including floodplain scrapes.

Elton Lane Farm: Wetland storage area

This could be in the form of on line, or off line pond type storage, or larger swathes of wetland, including floodplain scrapes.

2.2 Belford Case Study

Newcastle University and the Environment Agency have done much work looking at small scale, "natural" flood alleviation measures. The below explanatory text (shown in italics) is taken from a paper that explains the Run Off Management Toolkit[1] that was produced as a result of this work, which is available on line. The toolkit document itsself can be accessed on line at http://research.ncl.ac.uk/proactive/belford/papers/, and is included in Appendix C:

The Belford Burn catchment is located the county of Northumberland in north-east England. There is a history of flooding in the town of Belford with records of flood events dating back to 1877. Traditional flood defences are not suitable for Belford because of the high cost, lack of space for flood walls and banks and the low number of properties at risk does not meet the criteria for Grant-in Aid funding. There was a desire by the Local Environment Agency Flood Levy team to deliver an alternative catchment-based solution to the problem. With funding from the Northumbria Regional Flood Defence Committee, the Environment Agency North East Local Levy team and Newcastle University have created a partnership to address the flood problem using soft engineered runoff management features. The partnership project, "Belford proactive flood solutions" are testing novel techniques in reducing flood risk in small sub-catchments for the Environment Agency. The project provides the evidence which is needed to understand whether the mitigation measures are working at the sub-catchment scale. It also provides a demonstration site for interested stakeholders to come and look at and learn about this approach to flood risk management. As the project has progressed and lessons have been learnt, it has been possible to develop a toolkit for implementing these mitigation measures throughout the catchment and into new catchments. The Belford runoff management toolkit provides a step by step guide to implementing mitigation measures in the Belford burn catchment and could be easily applied to other catchments with a similar scale.

The techniques that have been researched by Newcastle University and the Environment Agency will be very useful with regards to informing future stages of this work. A next stage would be to conduct a more detailed catchment analysis in order to establish what catchment interventions could be implemented

[1] Wilkinson ME and Quinn P, 2010, Belford Catchment Proactive Flood Solutions: A toolkit for Managing Runoff in the Rural Landscape, Proceedings of the SAC and SEPA Biennial Conference, Edinburgh. http://research.ncl.ac.uk/proactive/belford/papers/

over the catchment area. It would be recommended that Newcastle University be involved in any early discussions if possible.

2.3 Catchment Intervention Research Outcomes

Recent discussions with researchers at Newcastle University have resulted in a rough process for implementation of catchment measures, and relevant "headlines" being made available to inform this study. These are given below.

2.3.1 Process

- Divide the catchment into sub-catchment areas and identify prominent overland flow pathways (potentially using LiDAR or walkover surveys);
- Begin to design the features for the relevant spatial scales, aiming to skim the peak runoff/flow from the hydrograph (features at some sites have been designed to prevent large flood events – and when that flood event finally arrives they have failed);
- Aim to target the storm hydrograph at growing spatial scales with an aim to reduce its impact throughout the catchment.

2.3.2 Key considerations

The results of the Newcastle University and Environment Agency research shows that:

- Prominent flow pathways at the hillslope and field scale should be targeted at relatively low spatial scales (up to 0.5-1km^2);
- Ditch management and storage at slightly larger scales (up to 1km^2) and; stream and small channel attenuation (like offline storage ponds) at even larger scales (up to 2.5km^2).
- Beyond these scales, more rigorously tested river engineering and floodplain attenuation should occur because the forces involved will cause erosion and undermine the integrity of these soft-engineered features.

3 Area A

3.1 Description of Area

This comprises the area around the bowling green, up to Darlington Road and south to the end of Spring Way. The area is shown on the map below.

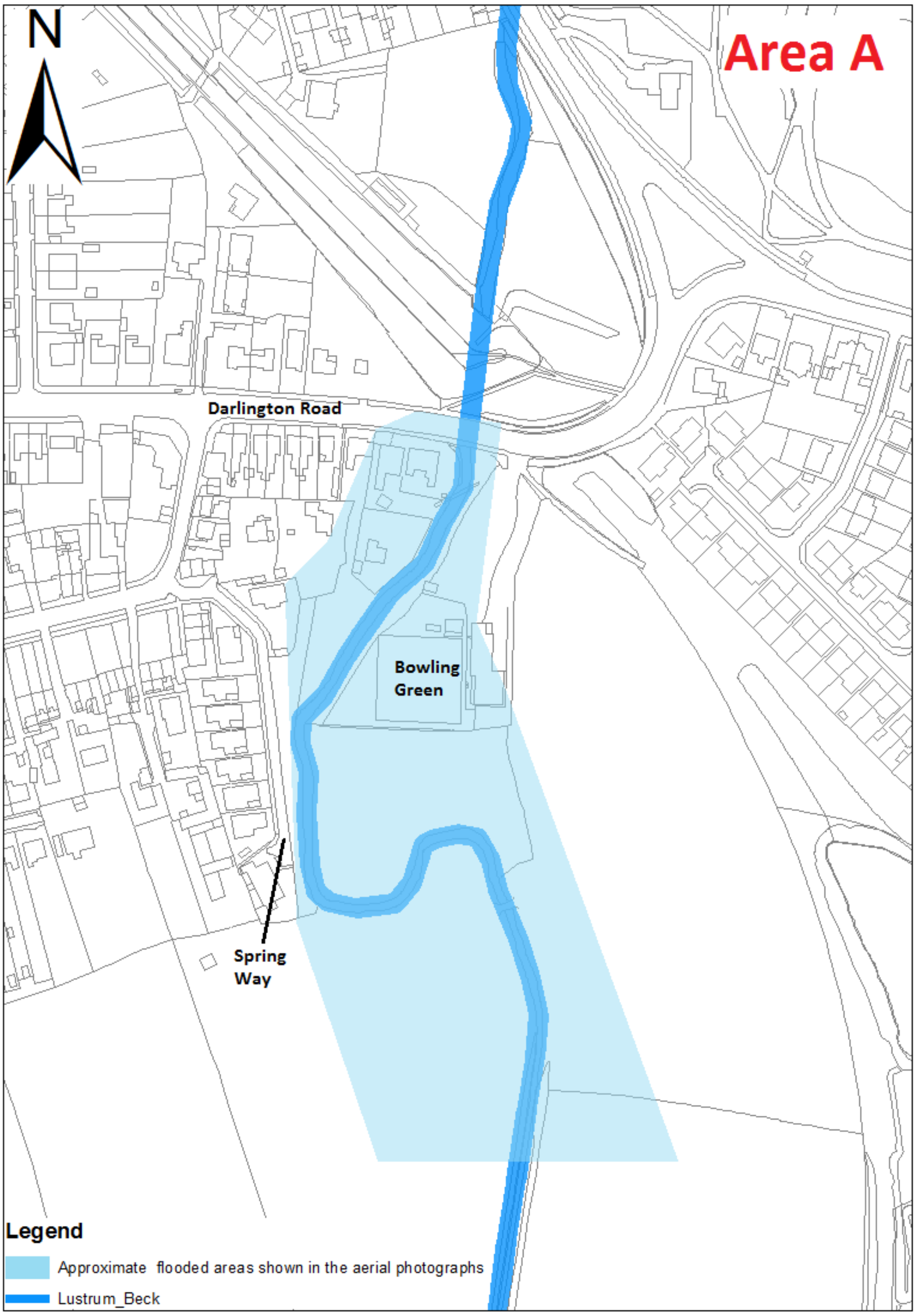


Figure 3 Area A

3.2 Flooding problem at Area A

From the pictures shown below it is clear that the Darlington Road Bridge (and the associated culvert) is restricting the flow and causing flooding upstream, which includes approximately seven houses/buildings. Upstream of these buildings there is considerable flooding in the fields, which should be encouraged to reduce flood risk downstream. If the obstruction at the bridge was reduced or removed, this may cause greater flood risk downstream.

3.3 Potential Mitigation Options

3.3.1 Local channel interventions

Installing a low cost / small scale (i.e. not a Dam) throttle in the channel immediately upstream of the flooded houses would help to reduce downstream flood risk by holding the water back in the fields. This would also reduce the rate of delivery of water to other problem areas downstream.

Several floodplain interventions have the potential to delay floodwaters in the open farmland upstream of the properties that are known to flood. These include:

- Planting and fence building along the existing hedgerow lines to increase floodplain roughness, and to physically impede the passage of flood flows.
- In channel and riparian planting.
- Restoration and re-meandering
- Floodplain scrapes and wetland creation
- Channel blocking at tributary connection points

3.3.2 Local resilience and resistance measures

Possible measures within this category include:

- Potential for flood proofing of properties using adapted or raised air bricks, demountable threshold gates, tanking, and threshold raising;
- Potential for flood resilience to be implemented to individual properties (solid washable floors, raised electrical points, cleanable wall surfaces etc).

3.3.3 Local emergency measures

Individual household measures could be implemented, as outline in Appendix B. Further investigation of flow routes is required in order to specify measures with more confidence.

4 Area B

4.1 Description of Area

This area comprises the open ground north of Oxbridge Lane as well as the housing to the south around Burnside Grove down to the bottom of the pond. The area is shown on the map below.

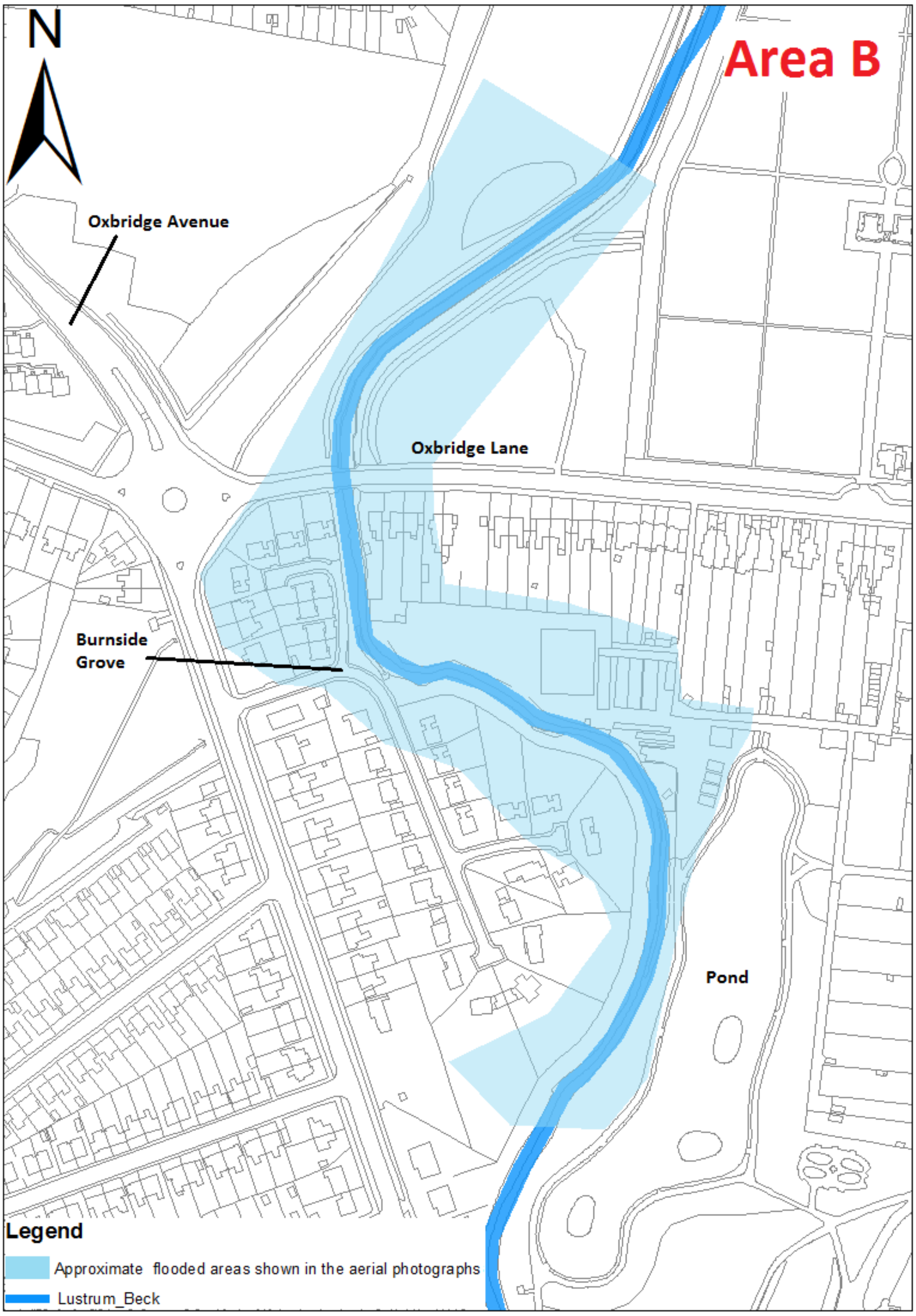
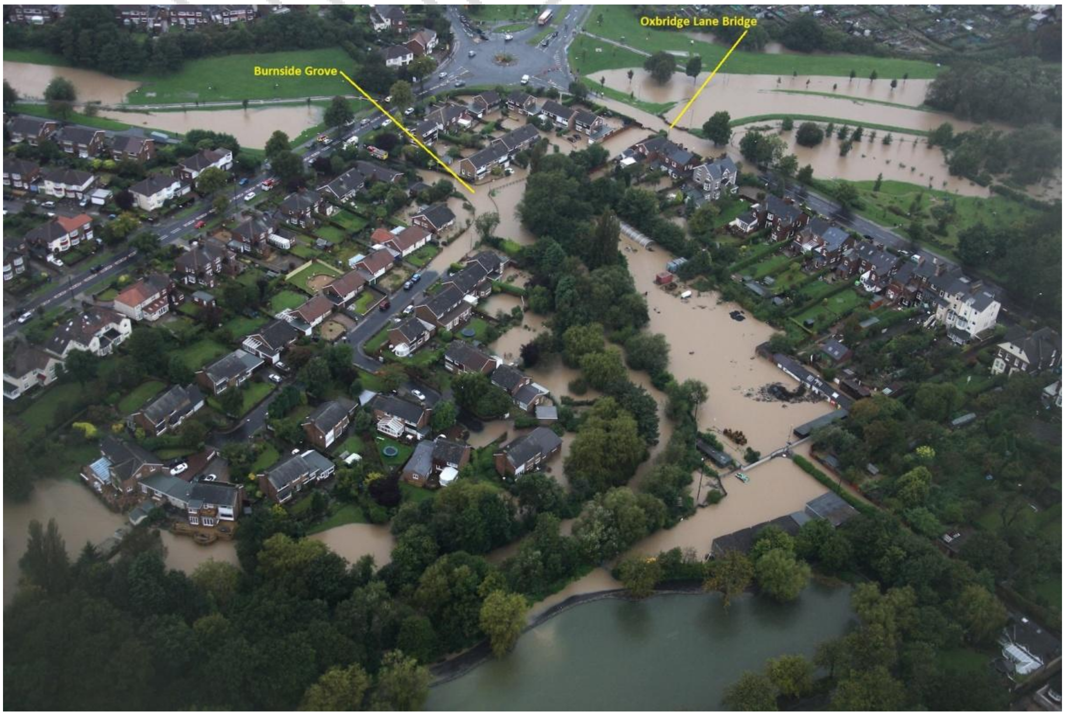


Figure 4 Area B

4.2 Flooding Problem

The most damaging flood area occurs immediately to the south of Oxbridge Lane and around Burnside Grove, where over a dozen houses are impacted upon, as well as an area of allotments and other buildings. The flood reaches the bank of the pond but does not appear to be connected, resulting in only a small amount of flow of flood waters into the pond during the 2012 event (as inferred from the plume of water shown in the aerial photography).



4.3 Potential Mitigation Options

4.3.1 Local channel interventions

The pond does not appear to be formally connected to the stream, and did not flood during the 2012 events (this has been assumed due to the difference in water colour shown in the photographs). The pond could be used as an alleviation scheme if it were to be drained in advance of a flood. It could then be used to store peak flood waters during an event.

4.3.2 Local resilience and resistance measures

- Approximately 11 dwellings were impacted in the Autumn 2012 event by the flooding between Burnside Grove and the roundabout. The impacts of flooding could be reduced by building a low wall around the perimeter, in combination with either a removable barrier or large speed bump crossing the adjoining road

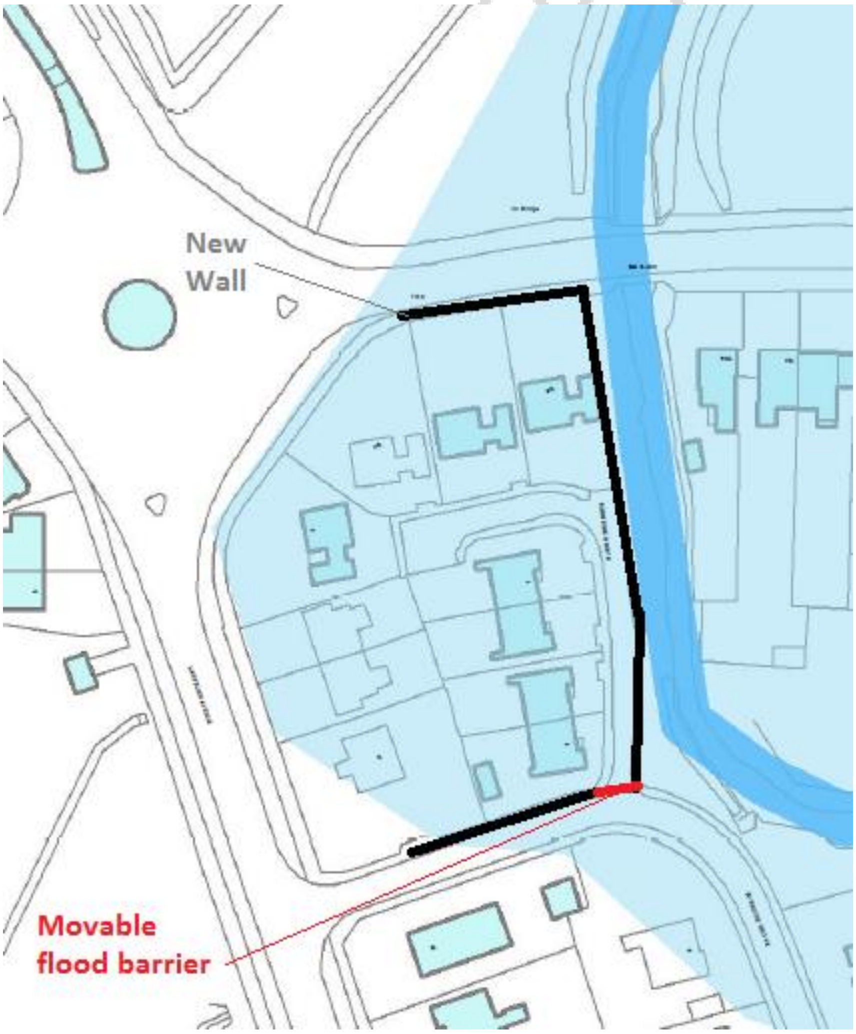


Figure 5: Potential flood solution on Burnside Close

- Individual property protection

- Approximately 4 or 5 dwellings are at a high risk of flooding on the right bank of Lustrum Beck immediately upstream of Oxbridge Lane Bridge. Here, there is potential to modify garden walls and build a short wall along the bank in order to increase the levels of flood protection locally; in addition to this, emergency barriers would also need to be installed on driveways. This would need to be done in partnership with the homeowners.

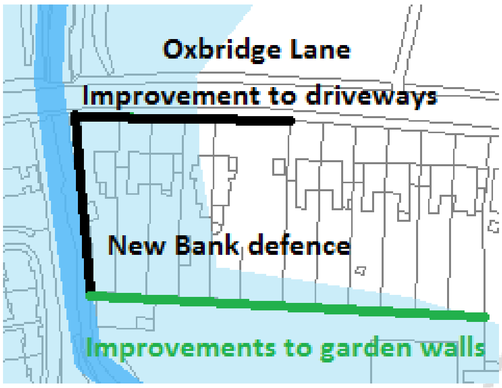


Figure 6: Potential solution on Oxbridge Lane

4.3.3 Local emergency measures

Individual household measures could be implemented, as outline in Appendix B. Further investigation of flow routes is required in order to specify measures with more confidence.

5 Area C

5.1 Description of Area

This area comprises the streets to the northeast of Durham Road; the housing and school between Durham Road Bridge and Bishopton Road Bridge and the open wetland down to Blacksail Close. The area is shown in Figure 7.

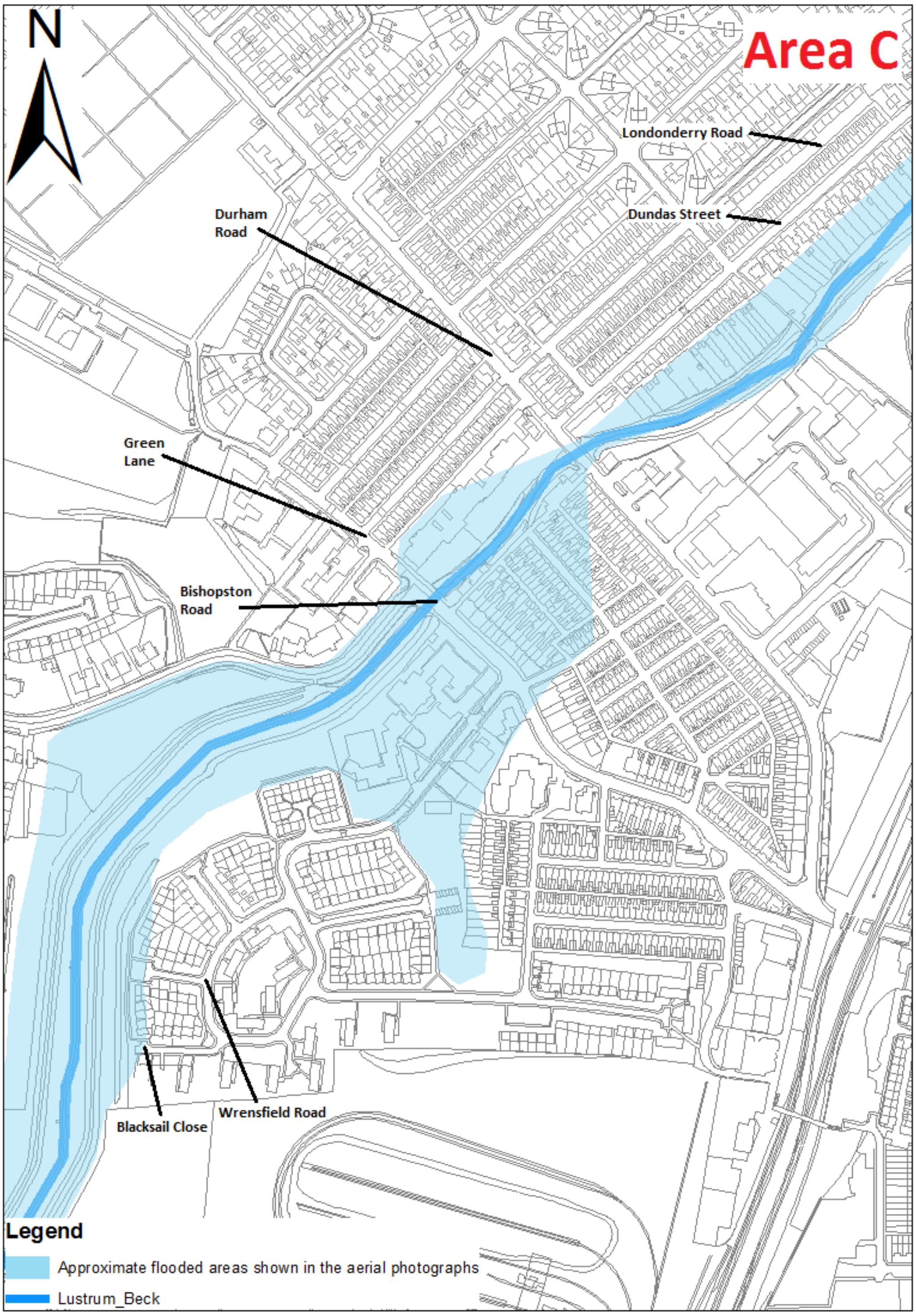


Figure 7 Area C

5.2 The Flooding Problem in Area C

The upstream-most area to flood in Area C is Blacksail Close, at the bottom of Wrensfield Road. Wrensfield Road circles the top of a small hill which is relatively well elevated from known flood levels locally, however the line of houses circling the bottom of the hill are at high risk and some are shown being flooded in the aerial photography. A community centre to the south of Bishopton Road Bridge encountered approximately 1.5m of flood water during the Autumn floods. North of Bishopton Road on the right bank of Lustrum Beck a block of houses was flooded (between Bishopton Road and Durham Road). Beyond Durham Road on the left bank, a line of gardens flooded but the nearby houses appear to be out of the flood cell according to the aerial photography.


Durham Road
Bishopton Road
Bridge
Green Lane


Green Lane
Bishopton
Road Bridge


Wrensfield Road
Green Lane
Bishopton Road
Bridge


Londonderry Road
Dundas Street

5.3 Potential Mitigation Options

5.3.1 Local channel interventions

- Reprofile area of open ground adjacent to beck (scrapes etc) to increase flood storage capacity;
- Using material taken to reprofile the area, low bunds could be made to protect the houses surrounding the bottom of the Wrenfield Road hill. These bunds could have footpaths running along their crest.

5.3.2 Local resilience and resistance measures

- Potential for flood proofing of properties using adapted or raised air bricks, demountable threshold gates, tanking, threshold raising.
- Potential for flood resilience to be implemented in local households (solid washable floors, raised electrical, cleanable wall surfaces etc).

5.3.3 Local emergency measures

More investigation is needed on the flow routes of the floodwater, but there may be potential to use an emergency barrier on Bishopton Road to prevent floodwater from spreading.

6 Conclusions

- Flooding needs to be tackled from "all fronts" if a major flood alleviation scheme cannot be implemented on Lustrum Beck. This will include the implementation of catchment, local, local resilience and resistance and emergency protection interventions.
- More local interventions and "quick wins" could be identified after a site visit by a flood risk specialist.
- The area upstream of Darlington Road offers an opportunity to increase storage, without creating a large, formal on-line storage structure.
- There is much potential to implement catchment interventions upstream of the areas in Stockton that have encountered flooding. Interventions may need to be significant and numerous if they are to have a meaningful positive impact on significant flood risk.
- Discussions with Newcastle University would suggest that larger-scale interventions would be the most likely to be successful in the catchment (on line field storage, off line diverted storage, wet woodland creation, floodplain and wetland restoration etc). Arup have a Memorandum of Understanding (MoU) with Newcastle University, which would allow continued consultation with them during any ongoing work in order to give an insight into the value of catchment interventions in this instance.
- A range of flood resilience and resistance, and emergency measures have been identified (Appendix B) which now need to be appraised for each property, or group of properties, to determine their effectiveness in each situation.

Appendix A

Generic Catchment Measures

A1 Catchment Management

This appendix outlines the generic measures which could be used to manage sediment and water flows in the upstream catchment. These will all require intervention in third party land.

A1.1 Retention ponds and wetlands

The principal aim of any headwater runoff detention feature is to slow the outflow from the smaller sub-catchments, and thereby reduce the peak of the hydrograph. The use of upstream retention ponds and the creation of wetland areas has the potential to attenuate runoff and improve water quality through natural treatment.

A1.2 Gully/ditch management

The creation of ditches, drains, and the channelisation of natural watercourses increase conveyance, leading to the rapid removal of runoff and the loss of the implicit storage capacity of the land and channels. Artificial ditches and drains increase the drainage density of land and enhances the speed of runoff delivery to the main channel network.

Removal of maintenance from drainage ditches to allow them to become overgrown with vegetation can reduce conveyance of runoff to the main river system and promote the ponding (storage) of water and sedimentation. Alternatively, the direct blocking of drainage ditches is a method that can provide on-line storage. Such practices can be used in areas dominated by high runoff and can potentially have significant effects in reducing surface runoff and sediment delivery.

Similarly, the management of gullies in the headlands of the catchment may help to reduce sources of sediment to the river and slow conveyance to the main channel. Blocking and encouraging vegetation growth may help reduce gully erosion.

A1.3 Flood storage areas

In contrast to upland retention features and wetlands, flood storage areas are used to control out-of-channel flows from the main river, rather than intercepting and attenuating runoff from the surrounding catchment. Flood storage areas are engineered washlands within the floodplain that are deliberately inundated and used to hold water during flood events of a certain design magnitude. The implementation of flood storage areas typically involves the creation of set-back flood defence embankments or lateral embankments (dams) across the channel and floodplain to retain flows above a certain level. The overall effect is to change the shape of the flood hydrograph (reducing flood peak and increase flood duration) due to the storage of flood waters and the controlled release downstream. Such features need to be carefully designed, however, to ensure that storage capacity is adequate and discharge mechanisms do not cause secondary problems.

Online flood storage areas may also interrupt the sediment transport regime of the river and promote sedimentation within the channel and across the floodplain upstream of retention structures. However, flood storage areas need to be carefully designed so that erosion is not promoted downstream as a result of reduced sediment load.

Other modifications that can have a similar storage affect include the removal of bunds to open out a floodplain, or to realign or divert all or part of a channel into areas that can contain flood waters.

A1.4 Cover Crops / Mulch

Vegetation cover helps to bind soil together, increases surface roughness and absorbs the energy of rainfall. Plants also remove water from the soil profile through transpiration, and therefore contribute to making it less susceptible to surface runoff generation.

Techniques to maintain crop cover on susceptible soils can also assist in promoting reduced run-off. For example, the use of vegetation (e.g. grass, natural regeneration set-aside or cover crops) could be targeted on vulnerable areas in catchments where runoff and erosion are generated. Grasses and cover crops can be sown as an ‘understorey’ or ‘intercrop’ to row crops but this can reduce yields. As an alternative to cover crops, the application of mulch may be suitable for crops susceptible to competition and the use of such mulches reduces the likelihood of soil capping (i.e. the formation of hard surface ‘crust’ due to compaction of soil by heavy rainfall, machinery or trampling).

A1.5 Minimum tillage

Conservation tillage is a term that refers to leaving previous residues on the soil surface, or only partially incorporating them, thus reducing the overall bare soil, reducing surface sealing and increasing infiltration, aggregation and providing resistance to water movement. The introduction of shallow seedbeds can also maintain a solid soil matrix below, reducing the effects of compaction and maintaining macropore connectivity. Minimal tillage techniques can have significant benefits on soil organic matter content, structure and biological activity and there is evidence that they can significantly reduce surface runoff.

A1.6 Runoff control

Ploughing and the planting of row crops across slopes can reduce overland flow velocity, and increase the potential for infiltration and evaporation. Contour ploughing in most crops can significantly reduce surface runoff, but its effectiveness may decrease over the season as surface sealing occurs.

Cross ridges and bunds can also be used to dam downslope orientated furrows. However, such structures need to be appropriately engineered as overtopping may promote gully erosion.

Contour grass strips may be used as a 'soakaway' in arable systems, braking, filtering and infiltrating runoff (where they are not by-passed by surface drainage routes e.g. drainage ditches). Grass buffers and hedges can slow runoff and increase the likelihood of infiltration.

Intercepting run-off pathways is a major management factor. This can be as simple as relocating farm gates (i.e. up slope rather than at the field bottom), tracks, and animal feeding areas to effectively manage areas where erosion and overland flows are promoted.

A1.7 Grassland / Livestock Control (grazing, poaching)

Runoff is typically higher from arable land compared to grassland, especially where grassland is carefully managed. Conservation of bare or arable land to grassland is a potential mitigation measure that may be applicable to specific soil and landscape conditions. Grassing of land may encourage infiltration and help reduce direct runoff to the drainage network. Grass cover will also provide protection from soil erosion and sediment runoff.

On existing grassland, surface infiltration may be increased by the use of land management techniques such as mini-moling, slot cutting and spiking. In addition, an effective mitigation measure may involve the restriction of the grazing season to avoid those times when the soil is at or near to field capacity and its bearing strength is lowest.

Overgrazing can be a significant problem in relation to promoting surface runoff, erosion and sediment delivery to watercourses due to the removal of protective vegetative cover. Management measures may also involve the reduction of grazing densities on sensitive areas of the catchment, as well as riparian management to control the level of poaching caused by animals. Poaching by animals and livestock can promote bank destabilisation and erosion as well as define surface water runoff routes. The use of buffer strips along watercourses and the encouragement of riparian vegetation growth may help to reduce the degree of poaching occurring in parts of the catchment. However, buffer strips and vegetation may not protect the river from poaching, so watercourses in livestock areas may also need enclosure fencing or hedgerow. Enclosure of the rivers to animals must be matched by provision of suitable alternative water feeding features, or specific zones along watercourses that are protected from poaching effects (e.g. areas where channel banks are armoured with stones).

A1.8 “Leaky Ponds”

Leaky Ponds are a simple way of water attenuation that can be implemented in known overland drainage routes. These small ad-hoc dam structures can be made of a variety of materials (railway sleepers, tree trunks, cut wood) and act as a perpendicular barrier to downhill flows, whilst allowing some seepage around and below. In series, these features can provide additional storage, retain waters in agricultural land, and delay sediment and water runoff.

Appendix B

Generic Resilience, Resistance and Emergency Measures

B1

Appendix C

Runoff Attenuation Features Handbook

C1