Appendix C – Options

Appendix C – Options

C.1.1 Background

Nine Surface Water Risk Areas (SWRAs) were identified by the Partners and Risk Assessment phase of the SWMP to go forward to the Options phase; these are illustrated in **Figure 60155102/OPTIONS/1.1** in Annex C1 and presented in Table C.1.1.

Table C.1.1: Prioritised Surface Water Risk Areas (SWRA)

Code	Location	No. of known flood incidents	Degree of Urbanisation (%)
STA3	East Stanley	15	93%
CLS2	Chester-le-Street	8	37%
CLS3	Chester-le-Street	6	95%
DC1	Durham City - Pity Me	2	99%
DC8	Durham City - Gilesgate, Belmont and Carrville	57	75%
NEW1	Newton Aycliffe	5	74%
BIS3	Bishop Auckland	8	43%
CRO1	Crook	8	73%
RAIL3	Railway Line between Ireshopeburn and Blackett's Gill	15	15%

Many of the known surface water flood incidents have been, or are being, addressed as part of more detailed studies undertaken by Durham County Council and Northumbrian Water. These studies will address flooding up to the 1 in 30 year event therefore; the SWMP has focussed on exceedance events that would overwhelm the surface water infrastructure. Broad areas at risk have been identified based on the surface water modelling undertaken by the SFRA and the Environment Agency's Areas Susceptible to Surface Water Flooding and Flood Map for Surface Water.

C.1.2 General Advice

An assessment for each SWRA is presented in **Section C.4** which should be read in conjunction with the figures contained within **Annex C1**. The assessment was completed at a high level and issues and constraints were not exhaustively considered, refer **Section C1.3**. The works being undertaken by Durham County Council and Northumbrian Water could have an impact on the suitability of proposed measures. Therefore, it is not appropriate for the SWMP to prescribe specific options as this would only be appropriate after a more detailed examination of the existing situation. Additionally, prescribing specific options could also place constraints on potential development sites making development unviable. As such, the details provided in this document are only intended to indicate the elements of a possible solution that could be implemented to reduce surface water flood risk and provide a starting point for further investigations should the Partners wish to take action to address the surface water flood risk across County Durham. **Figure C.1.1** presents a flowchart outlining the process that the findings of this report will need to go through.

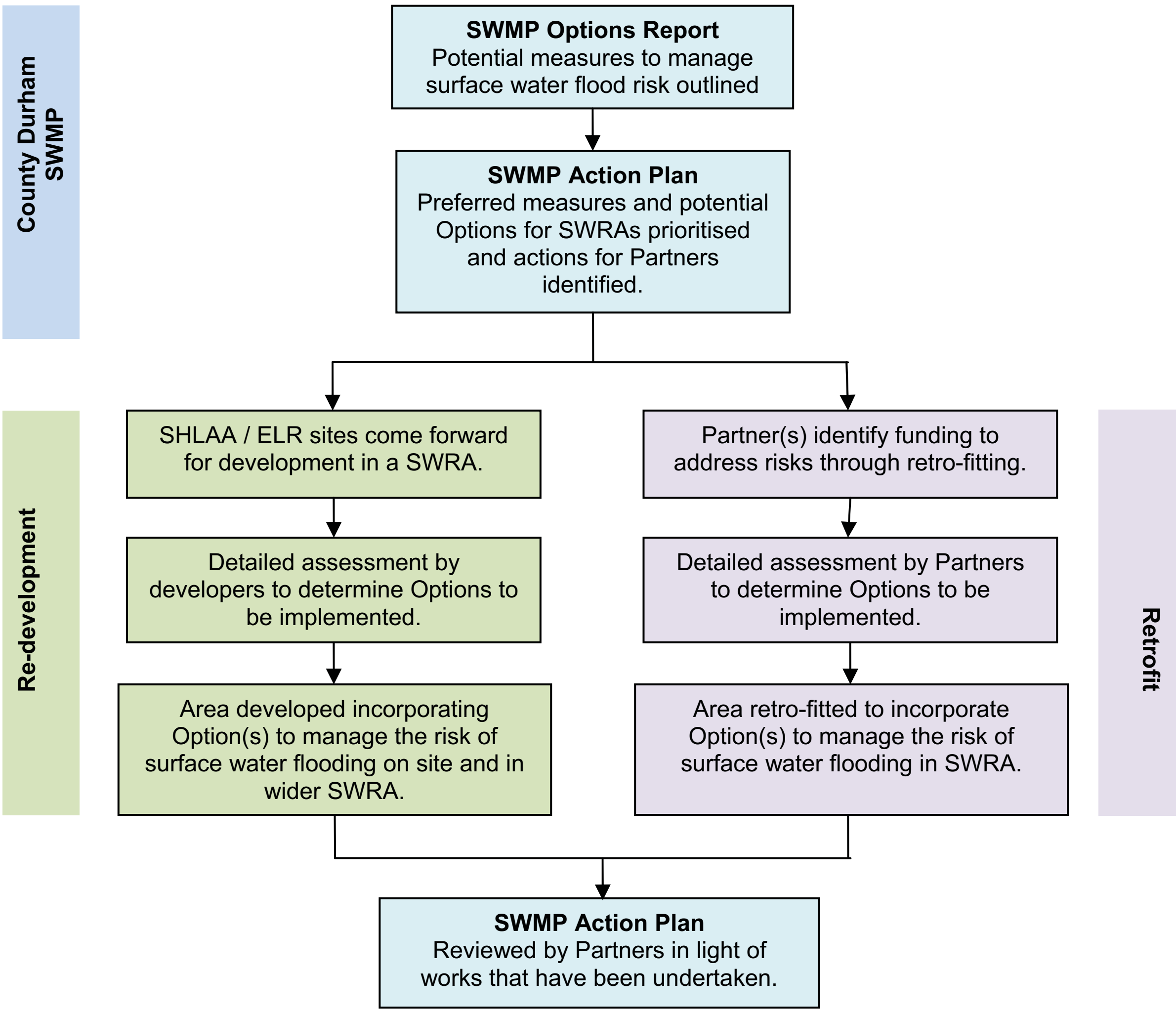


Figure C.1.1 – Development and Implementation of the County Durham SWMP

C.1.3 Assumptions and Limitations

The assessment and development of measures was undertaken as a desktop review. The work involved a high level strategic review of potential constraints based on outputs from the Risk Assessment phase of the SWMP. The list of Options developed is not exhaustive but provides an overview and should be considered as the first step in an iterative process. Site specific engineering constraints and consultation will need to be investigated and resolved as part of the design process.

The following is a list of items that remain as outstanding matters to implementation and should be resolved at an early stage during the detailed assessment.

C.1.3.1 Location of services and sewers

Only a limited amount of information was made available regarding the location, size, condition and configuration of the sewer and drainage networks. This study utilised the information made available however, this information did not provide a complete description of the sewer network. No detailed services searches were undertaken. No site visits were undertaken and it is likely that services are present in or around many of the measures that have been identified. Works below ground in particular will need careful consideration as they would represent a potential leakage point from any storage areas that have been identified. It is recommended that a detailed service search is carried out when the sites are engineered, possibly including non invasive ground penetration surveys to identify the location of any pipes.

C.1.3.2 Archaeological and environmental review

The presence of archaeological remains, environmental impact assessments, water quality impacts and ecological investigations will be required.

C.1.3.3 Geotechnical review plus contamination

A full geotechnical assessment should be undertaken to determine soil conditions, assess the potential for contamination and infiltration of surface water. Additionally, the detailed assessment should consider water coming up to the surface, i.e. groundwater, seepage paths and so forth.

C.1.3.4 Attenuation Basin Design considerations

Depending on their size, storage areas may fall under the Reservoirs Act and issues associated with this will need to be considered.

C1.3.5 Groundwater Source Protection Zones

Measures could be sited within a Zone 1 - Inner Source Protection or within a Zone 2 – Outer Protection Zone of groundwater aquifers. These designations may not prevent works being undertaken but precautionary measures would be required in the design to avoid contamination of groundwater resources.

C.1.4 Planning Policy and Legislation

Planning Policy Statement 25 (PPS25): Development and Flood Risk is the current planning policy for future development. This policy aims to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk. Where new development is necessary in such areas, the policy aims to make it safe without increasing flood risk elsewhere and where possible, reducing flood risk overall. As such, *PPS25* promotes the use of Sustainable Drainage Systems (SuDS) for all developments greater than one hectare and developers must provide a Flood Risk Assessment (FRA) which considers surface water management for the development to prevent increased flood risk from surface drainage.

National planning policy for the prevention of water pollution is set out in *Planning Policy Statement 23 (PPS23) Planning and Pollution Control (ODPM, 1994)*. *PPS23* is a material consideration for proposed planning applications and provides guidance on the location of, and appropriateness of certain “polluting” developments, so as to prevent pollution and ensure that the environment and human health are protected. In particular, *PPS23* Annex 1 encourages the use of SuDS by developers, where appropriate. SuDS are drainage measures but can help to attenuate pollutants contained in surface water runoff reducing the impact of diffuse pollution on receiving watercourses. In terms of planning policy the requirements of *PPS23* have been amended and to some extent superseded by the requirements of *The Flood and Water Management Act 2010*.

The *Flood and Water Management Act* intends to provide better, more comprehensive management of flood risk for people, homes and businesses. In particular, it encourages the uptake of SuDS by removing the automatic right to connect to sewers and providing for unitary and county councils to adopt SuDS for new developments and redevelopments.

The aim of the *Water Framework Directive* (WFD) is to prevent further deterioration and protect and enhance the status of aquatic ecosystems and associated wetlands, promote sustainable water consumption, and contribute to mitigating the effects of floods and droughts. The WFD was transposed into law in England and Wales by the *Water Environment (WFD) Regulations 2003*. These regulations implement a holistic approach to the management, protection and monitoring of the water environment. The key objectives of the WFD are to prevent deterioration in the status of water bodies and aim to achieve good ecological and chemical status/potential (including quantitative status in groundwater bodies) by 2015. Water bodies must also comply with standards and objectives of Protected Areas (i.e. an area designated under another European Directive, such as an SAC or SPA) where these apply.

Capabilities on project:
Water

The SWMP process (refer **Figure C.1.2**) is an opportunity to bring about co-ordinated improvements in water quality, and thus the aquatic ecosystems that depend on it, through a framework of surface water management to control pollution (e.g. control of urban diffuse pollution through site management and the introduction of SuDS) and to reinstate where possible natural flow regimes, riparian habitats, and floodplain connectivity. Through an integrated approach solutions with a dual benefit that address flood and pollution risks can be realised, and thus help to fulfil and comply with the ecology, water quality, and hydromorphology requirements of the WFD.

Mitigation measures for surface water flood risk have the potential to improve water quality or cause deterioration through diffuse pollution or changes in the flow regime and effects on the physical habitat. The WFD requires that effects on water bodies do not cause deterioration nor do they lead to the prevention of a target being achieved, although under certain circumstances there can be exceptions (using Article 4.7). Therefore, it is important that the SWMP considers the implications of the WFD.

Figure C.1.2: SWMP Process (Defra 2010)

C.2 Measures to Manage Surface Water

C.2.1 Introduction

A broad list of structural, non-structural and adaption measures are available for managing surface water flood risk. These measures were assessed as part of the development of the potential Options for each SWRA. A typical drainage system and its associated flood risk can be conceptualised using the source-pathway-receptor model, refer **Figure C.2.1** which has been used for considering measures to manage the flood risk.

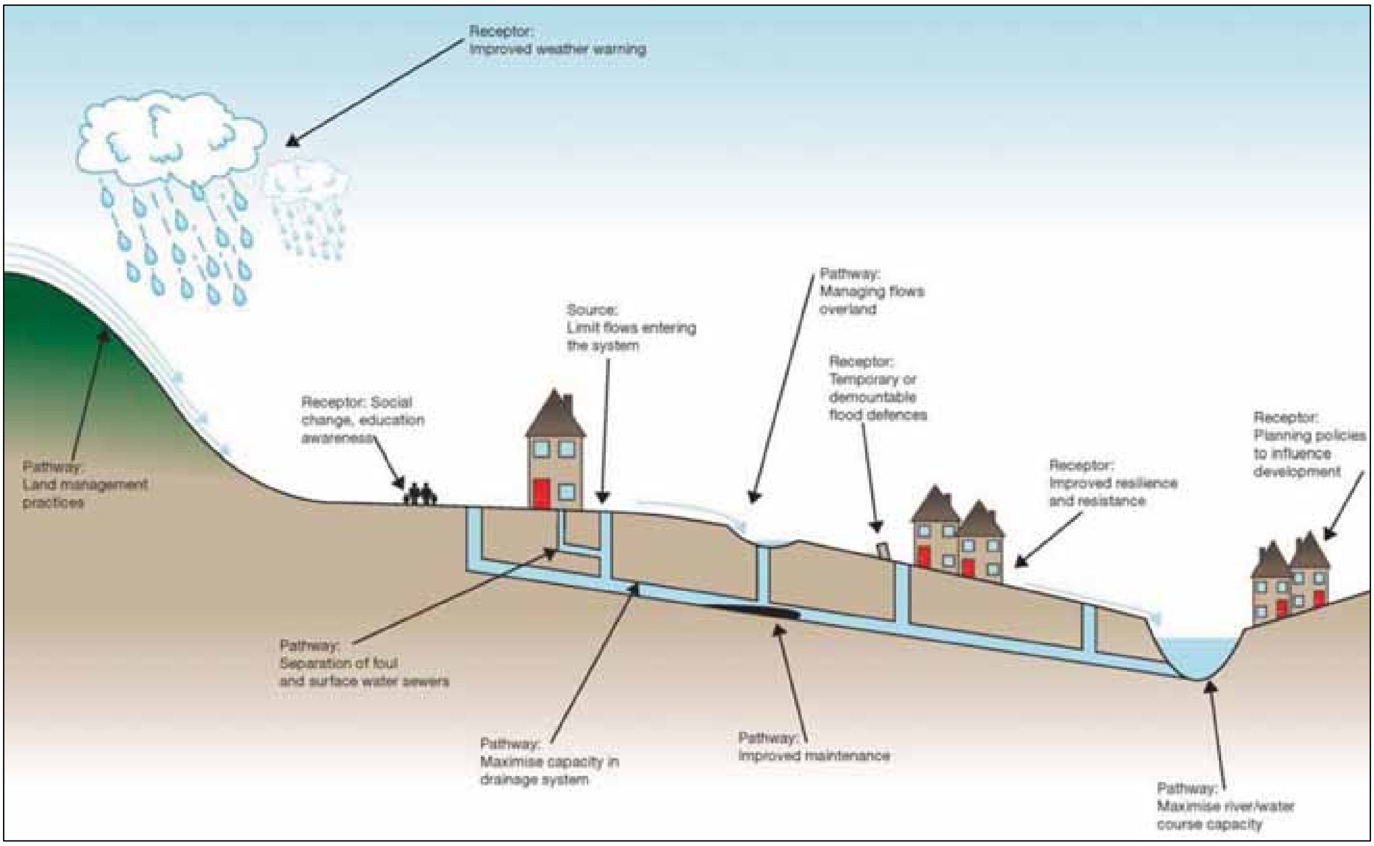


Figure C.2.1: Source – Pathway – Receptor Model (Defra, 2010)

C.2.2 Sustainable Drainage Systems

Government guidance promotes the use of SuDS to manage flooding, protect receiving water quality and provide amenity. SuDS provide protection against flooding downstream of developments by reducing the volume of surface water runoff. In most urban areas, retail and commercial development footprints can create impermeable urban areas of around 70-90%. Therefore, measures that reduce the rate and volume of runoff can be effective approach to stormwater management. SuDS have considerable potential to manage surface water at the source of flooding, along the pathway flood waters take and at the receptors affected by flooding. The incorporation of SuDS measures into new developments would present opportunities to contribute to biodiversity and wildlife corridors thereby contributing to green infrastructure networks. **Annex C2** provides a quick reference guide to the different types of SuDS measures.

C.2.2.1 Management train approach

The most appropriate method to manage surface water is to implement a management train, **Figure C.2.2**. Preventing an increase in surface water runoff can be facilitated by controlling surface water at all stages along the source-pathway-receptor model through a train of management measures. Redevelopment within all SWRAs should seek a reduction in surface water runoff.

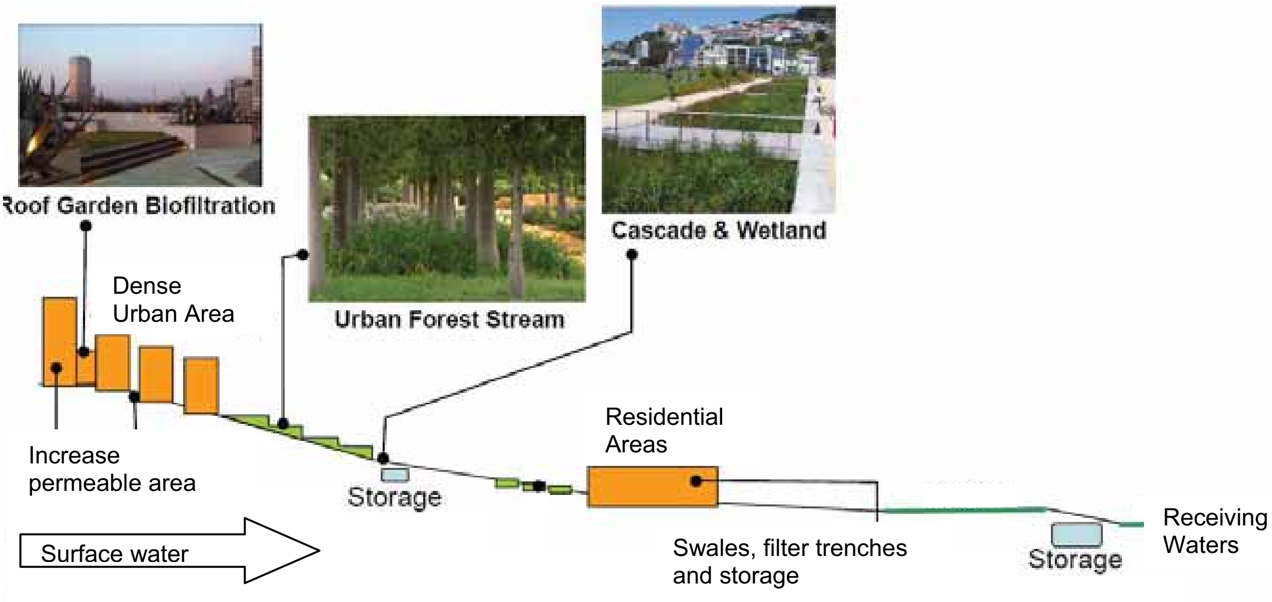
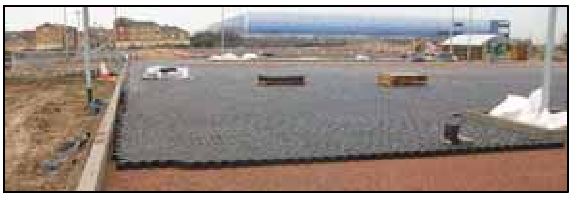


Figure C.2.2: Example of a Management Train

C.2.3 Managing Surface Water at Source

Surface water runoff is generated from roof drainage from buildings, car parks/hardstanding (impermeable areas) or surcharging drainage systems during rainfall events. Sources of surface water will occur within and outside of the SWRAs boundaries. Source control is in line with recent legislation and policy guidance (PPS25) promoting a reduction in impermeable areas, as well as removing the automatic right to connect to sewers. The following measures to control the source of surface water have been considered as part of new developments or retro-fit as part of re-development in the SWRAs;



- Green Roofs
- Rainwater Harvesting
- Ponds and Wetlands
- Permeable Paving (right)
- Attenuation/Storage Basins
- Infiltration

Whilst these measures will provide a means of managing surface water they will only be implemented as quickly as land is re-developed. Additionally they will only be effective if they receive adequate maintenance and management during their lifetime.

In general, these forms of measures are socially favourable as the aesthetic features are more acceptable to the general public. Environmentally, these measures reduce the quantity of flow and pollutants reaching sewers or receiving watercourses. Infiltration and below ground storage measures require additional geo-technical investigation to determine suitability. Where possible, implementation of such measures should become a condition for re-development and new development within surface water risk areas.

Whilst more difficult to implement, existing developments could be encouraged to reduce their runoff by retro-fitting these measures. Particularly, measures such as rainwater harvesting and substituting impermeable driveways with porous paving will reduce surface water runoff. There are economic implications for individual property owners, but it may be a lower cost, and more sustainable outcome than the installation of stormwater sewers or attenuation basins in heavily urbanised areas.

C.2.3.1 Infiltration

Soakaways and filter drains aim to store water below ground in either perforated chambers or stone bedding. Stored water is then disposed of by infiltration into surrounding soils or allowed to enter the surface water system after the peak flows have passed. The key to successful performance of this type of system is the hydraulic gradient and permeability of the soil which governs the speed at which water drains away. Additionally, retrofitting of these systems in areas not being developed would be disruptive and consequentially expensive due to the presence of existing services and reinstatement needs. The use of this type of system is not universally suitable, and engineering investigation will be required.

Use of infiltration measures will require geotechnical assessment to confirm the suitability of the measure. The assessment will also need to confirm whether linings are required to ensure that percolation does not worsen flooding elsewhere. Further, where infiltration is into an aquifer the risk of contamination should be assessed and minimised, particularly where the groundwater is a source of public water supply. Additional measures, such as oil interceptors, may be required. Source Protection Zones (SPZs) are used to protect groundwater resources from pollutants. In areas designated as SPZs, the location and type of discharges into the water environment are closely controlled. The level of control is most stringent close to the point of abstraction.

C2.3.2 Rainwater Harvesting

Rainwater harvesting refers to the collection of surface runoff from the roofs of houses. This is a useful component of the complete water efficiency toolkit as it combines reducing runoff with reducing water usage. Rainwater collected can be used to supply toilets and washing machines, and more commonly for garden irrigation and washing cars. Harvesting rainwater has the additional benefits of reducing:

- the amount of surface water runoff being discharged into drains and watercourses,
- the risk of localised flooding, and
- overall water bills for householders.

C.2.4 Managing Surface Water along Pathways

In many urban areas of County Durham, surface water is taken away by a piped sewer network. Piped conveyance systems are either separate or combined. In the case of combined sewers, surface water and wastewater flows are conveyed together before being treated and discharged. As combined systems are common throughout older areas they usually occupy the available space within existing infrastructure corridors. Separating the flows or increasing the sewer capacity is likely to be technically and economically difficult with a high social impact due to the disruption that this would cause. However, re-development offers opportunities to manage surface water on site rather than putting it into the combined sewer thereby reducing the volume of water in the sewer and increasing its capacity.

A key assumption to the flood risk data that was assessed is that sewer systems are at or near capacity. As such, surface water flows need to be directed away from sewers or stored on site. The general philosophy for reducing flooding from surface water is to reduce (attenuate) peak flows within areas containing combined systems. This may be achieved by reducing runoff (see **Section C2.3**) and by providing stormwater storage and diversions or formal overland flow paths in critical areas.

Surface water sewers are generally designed to accommodate approximately 50-60% of the catchment runoff, but inefficiencies in the system (e.g. blockages) will typically reduce this and can lead to surface water flooding. Flooding can also arise from watercourses when the existing pathway (e.g. culvert) is exceeded or it is blocked. In such instances, surface water flows should be provided with an alternative overland route or stored in an attenuation basin until the flood levels recede.

Transport infrastructure such as embankments (active or disused) can restrict surface water flowpaths where they disrupt the topography and lead to surface water ponding. Typically, roads with higher traffic volumes are built on embankments due to pavement design and structural integrity requirements. Diversion and storage of stormwater can be provided by using low traffic road corridors orientated with the topography and guiding surface water towards suitable locations. This could be achieved by providing kerbing, speed bumps and swales to direct and store water. While this measure is technically challenging in existing urban areas, it could be appropriate for some cases of re-development where flows should be preferentially directed to areas of low risk e.g. parks. There is limited social or environmental impact, though there may be issues relating to disability access. This approach is appropriate if it can avoid traffic disruption or the creation of flood hazards.

Methods to control surface water along pathways include:

- Increase sewer capacity and / or divert existing sewer lines
- Optimise sewer system to remove bottlenecks
- Soakaways/Infiltration
- Flow storage on roadway
- Separation of foul / surface water systems
- Manage overland flows using defined flowpaths
- Encourage proactive maintenance of existing system
- Provide flood attenuation/storage areas for surcharging flood waters

C.2.4.1 Interception

The sources of surface water outside of the surface SWRAs could be intercepted and directed towards designated flow pathways through or around risk areas. Development within SWRAs should seek to formalise overland flow paths to convey runoff through the site where practical. These corridors can be formed from minor roads, parks and / or footpaths laid at a consistent fall (with kerbing/speed bumps) that encourages surface water to drain through the site. The pathway should be located away from possible sources of contaminated sewage that can emanate from an overloaded combined sewer system.

C.2.4.2 Storage of Surface Water

Storage or attenuation of surface water can occur over short periods until after peak flows have passed through the system. This is known as attenuation of flows and its purpose is to prevent overloading existing drainage infrastructure. This reduces the risk of inundating that infrastructure and of flooding elsewhere within the system, and this is the key principle behind many measures proposed by SuDS. As fluvial flooding within rivers may occur during heavy rainfall events, surface water may require storage until after fluvial flood peak and the water level has fallen sufficiently for drainage systems to freely discharge. Storage can be in the form of defined detention/infiltration basins or informal measures such as low traffic roads and recreational areas (playing fields). Care should be taken to avoid contamination around sites that generate pollutants – such as car parks or goods handling areas.

In heavily developed areas, providing storage can be difficult due to limited locations being available above ground. Storage can be provided below ground but it is technically difficult and requires a higher economical outlay than above ground storage. The construction of below ground storage is often socially disruptive and difficult due to the presence of service and geotechnical constraints. Additionally, as it is lower in the ground there are potentially extra maintenance costs and risks associated with silt accumulation. In many areas, high groundwater levels and buoyancy of structures may restrict the use of ponds and storage basins, particularly in areas comprising peaty soils.

Where space allows, above ground storage can be provided within green corridors. While implementation is not technically difficult it does restrict the developable area and may influence the viability of developments, hence why this SWMP is not able to prescribe specific measures and Options. There would be some economic costs associated with this measure and the benefitted area would be significantly smaller than diverting flows straight into a river. There would be limited social disruption. It may be possible to create a multi-purpose design (sports field) as long the flood storage areas had adequate flood warning time. Environmentally, it may be possible to create habitat within the area. A maintenance regime would be required to ensure that they continue to be effective.

C.2.5 Managing Surface Water at Receptors

Receptors are considered to be the properties, people and environment affected by surface water flooding. Management of flood risk does not mean eradicating it within a SWRA, measures to manage surface water include improving the resilience and resistance to flooding when it occurs. The success of this form of measure is dependent on warning, awareness and forward planning. Measures available include:

- Improved weather / flood warning, communication and social education
- Planning policies and development control for managed adaption
- Proactive maintenance regimes, asset management and blockage detection
- Improve resilience and resistance in buildings by using air brick covers, flood gates, temporary / demountable flood defences

Resistance and resilience can be improved by retrofitting existing properties to remove points where surface water enters properties. Combined with flood awareness and warning these measures give residents time to move belongings and reduce damages. Resilience measures include, among others:

- door panels
- window panels
- airbrick covers
- automatic barriers
- self seal airbricks
- absorbent bags
- appliance vent
- pet flap covers
- flood resistant doors
- weep hole covers

The uptake of these measures and realisation of the benefits will be a slow process. However, there are a number of funding mechanisms (e.g. Defra's *Resilience Grants Project*) in place to apply for financial assistance for fitting resilience measures. While these measures benefit the community, it is important that careful co-ordination is utilised to avoid a piecemeal approach. There are no environmental impacts associated with this form of measure.

As part of resilience preparation, mobile pumps could be purchased for deployment to key locations during flood events. This will require training of operatives who can maintain and deploy the pumps. This measure could be less expensive or disruptive than installing new stormwater sewers. The measure should be part of a catchment wide forecasting and management approach. There are limited social and environmental impacts. This approach is risky due to pumps being unavailable, or incorrectly located, when required. Additionally, care should be given to ensuring that pumping does not adversely affect the downstream flood risk.

C.2.5.1 Planning Policy and SuDS

Although SuDS are now commonly considered an essential component of new development drainage systems, the focus has remained on the attenuation of flow, rather than on maximising the treatment potential or the aesthetic qualities that some SuDS techniques offer. However, the implementation of the WFD in 2003 has shifted the emphasis from water quantity towards water quality (and thus holistic improvements to water bodies at the catchment wide scale). Further, the *Flood and Water Management Act* encourages the preferential use of SuDS providing the mechanism for their long term maintenance. SuDS are therefore an essential component of surface water flood management, as well as a key mechanism to protect and enhance the natural water environment (by preventing adverse impacts from diffuse water pollution, maintaining or restoring natural flow regimes, improving water resources, and enhancing amenity).

The implementation of SuDS within the planning framework should be mindful of the following:

- development must be safe from flooding over its whole lifetime, taking into account the impacts of climate change, and use all opportunities to reduce flood risk overall;
- greenfield sites are to be developed, the runoff rates should not exceed the existing greenfield runoff rates wherever possible. Where previously developed (brownfield) sites are to be developed, surface water runoff rates should be reduced (to be agreed with the Environment Agency) by a minimum of 50% of the existing site runoff rate;

- SuDS should be used to control the rate and volume of runoff. Pollution controls should be incorporated within them to protect and improve groundwater quality;
- surface water systems should be expected to cope with events that exceed the design capacity of the system so that excess water can be safely stored or conveyed from the site without adverse impacts; and
- the long term management and responsibility for the maintenance of SuDS systems should be agreed prior to the granting of planning permission.

C.2.6 Application of Infiltration SuDS in County Durham

Durham County Councils Core Evidence base Technical paper 10 (Water) (April 2009) confirms the variability in the potential for infiltration SuDS across the county:

1. Low potential where there is a predominance of low permeability soils (or peaty soils);
2. Medium potential in freely draining loamy soils in Teesdale;
3. Restricted areas of moderate potential are associated with sandy soils in the areas around Hamsterley Forest, and with glacial sand and gravel deposits in the Wear Valley between Stanhope and Walsingham;
4. In the North of the county, most significant areas of moderate infiltration potential are associated with extensive sand and gravel deposits north and east of Durham city; and
5. In eastern part of the county, high SuDS potential is associated with freely draining soils developed directly over major aquifer bedrock on the Magnesian Limestone escarpment.

The Level 1 SFRA for County Durham (Golder Associates, 2010), Chapter 7, included a high level assessment of the potential use of SuDS. It referred to soils, groundwater, topography and catchment area as key issues, but focused the strategic assessment on County wide topography and geology only.

C.3 Assessment Methodology

C.3.1 List of Assessed Measures

The Options phase focuses on assessing potential measures to manage surface water within each SWRA. **Section C.2** outlined a long list of measures that can be used to manage surface water which we have listed out below;

Source	*Pathway*	*Receptor*
Green Roofs	Increase sewer capacity	Improved weather warning
Soakaways / infiltration	Separation of combined sewer	Improve resilience and resistance
Swales / filter drain	Improve maintenance regime	Planning policies
Permeable paving	Attenuation / storage	Development control
Rainwater harvesting	Flow storage on roadway	
	Manage overland flows	
	Improve channel capacity	
	Open up culverts	
	Improve floodplain storage	

From this list, this report has considered those thought to be technically feasible and assessed them to determine which would provide an economically viable, environmentally acceptable and sustainable solution to the surface water flood risk for each SWRA.

C.3.2 Assessment Overview

The assessment process aims to short-list measures that will achieve multiple objectives in the context of site constraints and future development. In accordance with the guidance, a Multi-Criteria Assessment (MCA) screening exercise has considered the relative merits of each measure against the following criteria:

- Technical Feasibility – *is it easily implemented?*
- Relative Cost – *how expensive is it in comparison to other measures?*
- Economic Viability – *is it expensive to implement?*
- Social Impact and Acceptability – *how will it impact on residents*?
- Environmental – *how will it impact the environment*?
- Sustainability – *is it a sustainable approach?*

In line with the guidance, cost estimates are not required since funding and delivery mechanisms are not yet known. Each management option is scored against each of the criteria set out above using relative indicator, in line with the guidance:

U - not applicable or unacceptable outcome
-2 - severely negative outcome
-1 - moderately negative outcome
0 - neutral outcome
+1 - moderately positive outcome, or
+2 - strongly positive outcome

The measures with the lowest overall combined scores from the MCA will be screened out to produce a short list of preferred options. The short-listed mitigation measures provide the starting point for a more detailed economic assessment should the Partners wish to take any of the sites further and implement surface water management measures.

The appraisal utilised the outputs from Environment Agency's Flood Map for Surface Water[6], SFRA Flood Risk Mapping[7] and available background information. The assessment of SWRAs is accompanied by an explanatory figure (**Annex C1**). Selected measures were identified along with locations within the SWRAs where these measures could be applied.

[6] Environment Agency's Flood Map for Surface Water 2010, JBA

It was noted that many of the known surface water flood incidents are currently undergoing detailed investigation by Northumbrian Water. These works will generally provide capacity to a 1 in 30 year event usually through improved sewer capacity. Therefore, the Options Assessment has focussed on the residual risks posed by exceedance events i.e. areas identified by the SFRA modelling or the Environment Agency's Flood Map for Surface Water.

Many potential development sites (SHLAA & ELR) fall within, or are in close proximity to, areas at risk of surface water flooding. During the development phase it is essential that site specific FRAs are undertaken. The future development of SHLAA and ELR sites present opportunities to mitigate surface water flood risk in areas beyond the site boundary.

C.3.3 Environment Agency's Flood Map for Surface Water

This assessment has relied on the Environment Agency's Flood Map for Surface Water. Generally, the type of flooding shown by the Flood Map for Surface Water shows the flooding that takes place from the 'surface runoff' generated by rainfall which:

- is on the surface of the ground (whether or not it is moving), and
- has not yet entered a watercourse, drainage system or public sewer.

Two rainfall events: the 1 in 30 year and the 1 in 200 year were used. The former was mapped (dark purple) showing depths greater than 300mm and the latter was mapped (light purple) showing depths greater than 100mm. Two adjustments are made to calculate effective rainfall:

- In rural areas, runoff equates to 39% of rainfall to represent infiltration;
- In urban areas, runoff equates to 70% of rainfall to represent infiltration then runoff is reduced by 12mm/hr to represent the effects of sewers.

Note that the effect of sewers can be represented by a range of values <1mm/hr to >20mm/hr. No allowance was made for differing infiltration of different soil types and so a single infiltration figure was used in urban or rural areas.

The Flood Map for Surface Water identifies drainage routes and low areas in floodplains, and flooding caused by local rainfall. It does not indicate flooding that occurs from overflowing watercourses, surcharging drainage systems or public sewers caused by catchment-wide rainfall events or river flow. As such, it only shows areas where surface water would be expected to flow or pond. The threshold of 300mm represents the depth that significant property damages begins to occur and it is the depth that moving through floodwater (driving or walking) becomes difficult. The Flood Map for Surface Water shows predictions of flooded areas but does not show whether individual properties will be affected by surface water flooding or have been affected in the past.

C.3.4 Strategic Flood Risk Assessment

While there is a correlation between the Environment Agency's Flood Map for Surface Water Risk Areas and Golder's Surface Water Risk Assessment's Areas High Risk of Surface Water Flooding, a significant discrepancy arose in the areas of water ponding. This can be explained by the differences in the methodology adopted by each assessment.

The SFRA used a storm event equating to the 1 in 100 year and filtered to depths above 100mm. Unlike the Environment Agency's assumption of a constant capacity throughout all urban sites (12mm/h), it utilised a site specific and variable approximation of the drainage capacity. Golder's initial SFRA mapping was interrogated in detail by the Durham Council engineers who reviewed areas that appeared questionable. The SFRA mapping was re-visited and the hydrological assumptions were adjusted accordingly.

A key issue with the SFRA mapping is that many instances of flooding are small, isolated incidents that are difficult to manage at the strategic level of the SWMP.

C.3.5 Flood Damages

The estimated Annual Average Damage (AAD) for each SWRA has been included in the SWRA assessments and is summarised in **Section C.5**. This information is provided to give an initial budgetary damage estimate to compare against the cost for implementing the preferred measures. Further analysis and detailed assessment of the existing problem is still required to determine detailed costs and benefits.

[7] February 2010 Durham County Strategic Flood Risk Assessment (SFRA), Golders

C.4 Site Specific Assessment

C.4.1 Introduction

This assessment has determined a range of indicative measures that will assist in reducing surface water flood risk. The purpose is to put forward measures for the Partners to investigate and encourage their uptake. This report can only provide a high level appraisal of the current surface water issues. As such, the short listed measures are not meant to be prescriptive nor absolute.

Each SWRA assessment should be read in conjunction with the figures contained within **Annex C1**. A summary of the assessment is provided in **Section C.5**. The assessment was completed at a high level and all the issues and constraints were not exhaustively considered, refer **Section C1.3**. The outputs from the Options report is intended to serve as a starting point for the Partners and is dependent on more detail becoming available, refer **Figure C1.1**. The assumptions and limitations to this work as outlined in **Section C.1** should be identified and resolved when the Options and measures are developed further.

C.4.2 Generic Measures

For each SWRA, some measures achieved the same scoring and should be applied throughout. This includes a number of resilience and resistance measures as they can be considered for all areas. In particular, the County Council should develop a policy seeking a net reduction in runoff during redevelopment works. The following measures were identified as being applicable for most of the SWRAs:

- reduction of existing surface water runoff volumes and flow rates from all developments (both greenfield and brownfield);
- encouragement of individual householders to install flood resistance and resilience measures;
- introduction of new flood storage areas where possible;
- management of overland flows; and
- planning polices / development control.

C.4.3 Short listed Measures

Each SWRA was assessed against the long list of measures in Table C.4.1. A brief comment on the measures application is provided, however greater detail is available in **Section C.2** and in **Annex C2**.

Table C.4.1: Long list of possible measures

	Surface Water Risk Measure	Brief Comments on Application
Source	Green roofs	Suitable for new development sites and potential to retro-fit.
	Soakaways/Infiltration	Requires geotechnical investigation, possible to retro-fit.
	Attenuation/Storage	In small open areas it could be suitable. Many areas lack the scale to be cost effective.
	Swales/Filter Drains	Multiple benefits, requires larger land take and maintenance.
	Permeable paving	Requires geotechnical investigation, suited to new development sites.
	Rainwater harvesting	Reduce water consumption, limited benefit for extreme rainfall.
Pathway	Increase Sewer Capacity	Dense urban areas will limit the options and cost effectiveness of this sort of scheme. Detailed modelling will be required to ensure problems are not transferred elsewhere within the network.
	Separation of Foul & Surface Water Flows	A long term solution which would help to resolve drainage network issues. However the cost associated with this work is high if retro-fitting. New development offers greater potential.
	Improved maintenance regimes	Pro-active maintenance such as regular inspections and asset management will help to reduce the likelihood of surface water problems.
	Flow/Storage on Roads	Holding excess surface water within the roadway is preferable to it flooding properties.
	Managing overland flows	A possible option to divert any surface water along roads and less vulnerable areas and away from property and critical infrastructure.
	Improve Channel Capacity	Increasing the carrying capacity of watercourses could provide efficiencies in the drainage network.
	Open Up Culverts	Culverts may present restrictions within the drainage network which could be overcome by daylighting the culvert providing drainage and environmental benefits.
	Improve Floodplain Storage	Increasing the ability of the floodplain to hold surface water could provide benefits in urban areas if the runoff is channelled to the floodplain and avoid passing flood risk further downstream.
Receptor	Improved weather/flood warning	Would only be cost effective for large areas.
	Planning policies to influence development	This should incorporate all green/environmental source measures as it should enforce more stringent drainage restrictions on new developments.
	Improved resilience and resistance measures	Installation and retrofitting of measures to reduce impact of flooding.

C.4.4 Figures

The figures for each SWRA show known incidences of flooding, the Environment Agency's Flood Map for Surface Water and the SFRA surface water flood risk mapping. The figures include indicative locations for options. These are not intended to map specific locations but indicate the general regions in which they may apply. The indicative option of Source locates a general region in which the measures explained in **Section C2.3** may apply. The Pathway indicates the general region for conveying surface water flood, refer to **Section C2.4**. This pathway can be either above or below ground. For example, this could be a combination of measures indirectly linking swales to an enlarged stormwater sewer. All of these indicative measures are subject to further detailed investigation (such as hydraulic modelling, interaction with fluvial flooding, ground investigation and so on) noting their site specific constraints and cost benefit.

C.4.5 STA3: East Stanley

Delineation of the SWRAs was undertaken as part of the Risk Assessment phase of the SWMP and utilised the Environment Agency's Areas Susceptible to Surface Water Flooding. In the interim period the Flood Map for Surface Water has been released which is considered to be more accurate in most situations. The change in flood data from the Areas Susceptible to Surface Water Flooding to the Flood Map for Surface Water has had a significant change in the flood risk situation as illustrated in Figures C.4.1 and C.4.2.

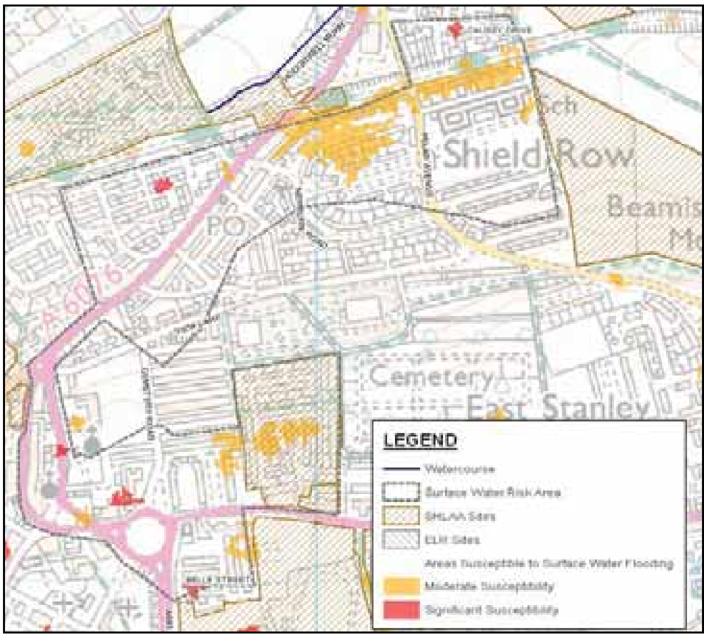


Figure C.4.1: STA3: Areas Susceptible to Surface Water

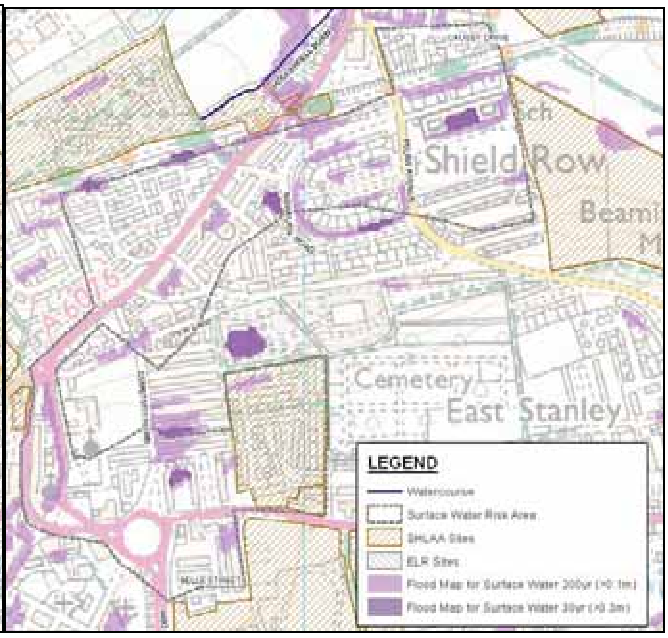


Figure C.4.2: STA3: Flood Map for Surface Water

Whilst the pattern of flooding has changed between Figures 5a and 5b, the two key risk areas have not. The Shield Row area and the streets off Cemetery Road are consistently highlighted as being at risk of surface water and the assessment of potential Options has focused on these two areas.

STA3 is located in East Stanley, is over 90% urbanised and 93 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Based on a simple assessment concerning generic flood damages and the number of properties falling within the 30 year and 200 year Surface Water Flood Maps, Annual Average Damages (AADs) have been estimated to be £95,000.

Whilst parts of STA3 are served by separate sewer systems, the majority is served by combined sewers. 15 known surface water incidences in the area relate to inadequate drainage capacity in the combined sewers. Issues with maintenance have resulted in blocked gullies and collapsed drains.

The source of surface water in this area is primarily from the impermeable surfaces throughout the urbanised area, although Beamish Moor to the east of Shield Row will contribute surface runoff to the urban area. There are a number of SHLAA sites in the area that if (re-)developed could present opportunities to manage the flood risk. **Figure 60155102/OPTIONS/STA3** in Annex C1 presents the flood risk and potential options considered for STA3.

Table C.4.2 illustrates the MCA of the long list of mitigation measures with regard to Shield Row and Cemetery Road. Measures scoring five or higher have been highlighted as being appropriate for further consideration. Measures scoring three or four have been identified as possible candidates that would be worth considering as part of a further assessment.

Table C.4.2: STA3 MCA

	Mitigation Measure	Technical	Relative Cost	Economic	Social Impact	Environmental	Sustainability	Overall	Short List?
Source	Green Roofs	1	1	-2	2	2	2	6	Yes
	Soakaways/Infiltration	1	0	1	2	1	1	6	Yes
	Attenuation/Storage	2	-2	1	-1	2	2	4	Maybe
	Swales/Filter Drain	1	-1	1	0	2	2	5	Yes
	Permeable Paving	1	1	-1	1	0	1	3	Maybe
	Rainwater Harvesting	1	1	-2	1	1	2	4	Maybe
Pathway	Increase Sewer Capacity	0	-2	-2	0	0	-2	-6	
	Separation of foul\surface water systems	1	-1	1	0	1	1	3	Maybe
	Improve maintenance regime	2	2	-1	0	0	0	3	Maybe
	Flow/Storage on Roadway	2	1	2	-1	0	1	5	Yes
	Manage overland flows	0	-1	0	-1	1	1	0	
	Improve channel capacity	U							
	Open up culverts	U							
	Improve Floodplain Storage	U							
Receptor	Improved weather warning	-2	-2	-2	0	0	2	-4	
	Planning policies / development control	0	2	2	0	0	2	6	Yes
	Improve Resilience and resistance	2	2	1	-1	0	1	5	Yes

C.4.5.1 Shield Row

Beamish Moor is clearly a source of surface water that poses a risk to Shield Row. This risk ought to be managed at source or along the pathway before it reaches the receptors in the Shield Row area. Development of the SHLAA site to the east, on Beamish Moor provides an opportunity to manage surface water at source to benefit the wider area and prevent sewer systems downstream spilling, which could introduce pollutants into surface water bodies. In this location the receiving watercourse is thought to be Houghwell Burn, which flows into the River Team. Houghwell Burn is not designated under the WFD but the River Team is failing to meet its WFD target due to phosphate levels, a proportion of which may come from spillages of untreated foul runoff from Combined Sewer Overflows (CSO). The reduction in spills from CSOs will contribute to measures to improve the status of the River Team. Soakaways, storage ponds or swales could all be installed on the SHLAA site to manage the runoff from the land and prevent it from flowing to the Shield Row area. These measures could be combined with green roofs and rainwater harvesting systems for the new development which could be implemented through planning policies. Such measures would effectively treat new urban runoff from the proposed development site. With an appropriate connection, storage could also be provided on the school playing field immediately to the north of the SHLAA site or in the school playing field.

West of Pelaw Avenue surface water flooding could also be a problem but the lack of open space limits the potential to provide storage, nor are there any re-development opportunities. Rather any measures implemented would need to be retro-fitted. In this area the most preferable measures are likely to be improving resilience and resistance or storage of water in the roads. Kerbing could be provided to contain and attenuate surface waters until the combined sewer system has capacity. Retro-fitting permeable pavements may provide some benefit. As above, measures that reduce the frequency of spillages from combined sewers will contribute to water quality improvements in receiving watercourses and achievement of WFD targets

C.4.5.2 Cemetery Road

The roads off Cemetery Road have little opportunity to manage flood risk. The SHLAA development to the east appears to have already been developed therefore it is hoped that peak discharges have been reduced to as low as possible to ensure that the existing drainage capacity is not overwhelmed.

Similar to Shield Row, resilience measures and storage in the roads are the most likely measures. Kerbing could be provided to contain and attenuate surface waters in the roads, until the combined system has capacity. More costly options would be to provide swales or overland flow routes to channel water away from the area, probably to the playing fields located to the south. The SHLAA site on the playing fields may offer opportunities to provide benefits to the Cemetery Road area if the surface water can be routed from Cemetery Road to the SHLAA site.

Where ever possible, home owners should be encouraged to reduce impermeable surfaces, thereby reducing runoff rates from individual properties. In areas where it is not possible to reduce surface water flood risk, resilience and resistance measures should be investigated.

Key Messages

STA3 has experienced 15 known surface water incidences relating to inadequate drainage capacity in the combined sewers. Issues with maintenance have resulted in blocked gullies and collapsed drains. The source of surface water in this area is primarily from the impermeable surfaces throughout the urbanised area. 93 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Annual Average Damages have been estimated at £95,000.

If developed, the SHLAA site to the east, on Beamish Moor provides an opportunity to manage surface water at source to benefit the wider area and prevent sewer systems downstream spilling. It is essential that soakaways, storage ponds or swales are considered on the SHLAA site to manage the runoff and could be combined with green roofs and rainwater harvesting systems.

West of Pelaw Avenue, the lack of open space and redevelopment opportunities means measures would need to be retro-fitted. The preferred measures are likely to be improving resilience and resistance or storage of water in the roads. Kerbing could be provided to contain and attenuate surface waters until the combined sewer system has capacity. Retro-fitting permeable pavements may provide some benefit. Similar measures are preferred at Cemetery Road, notably resilience measures and storage in the roads.

C.4.6 CLS2: Chester-le-Street

The change in flood data from the Environment Agency's Areas Susceptible to Surface Water Flooding to the Flood Map for Surface Water has had a significant change in the over surface water flood risk (Figures C.4.3 and C.4.4).

Capabilities on project:
Water

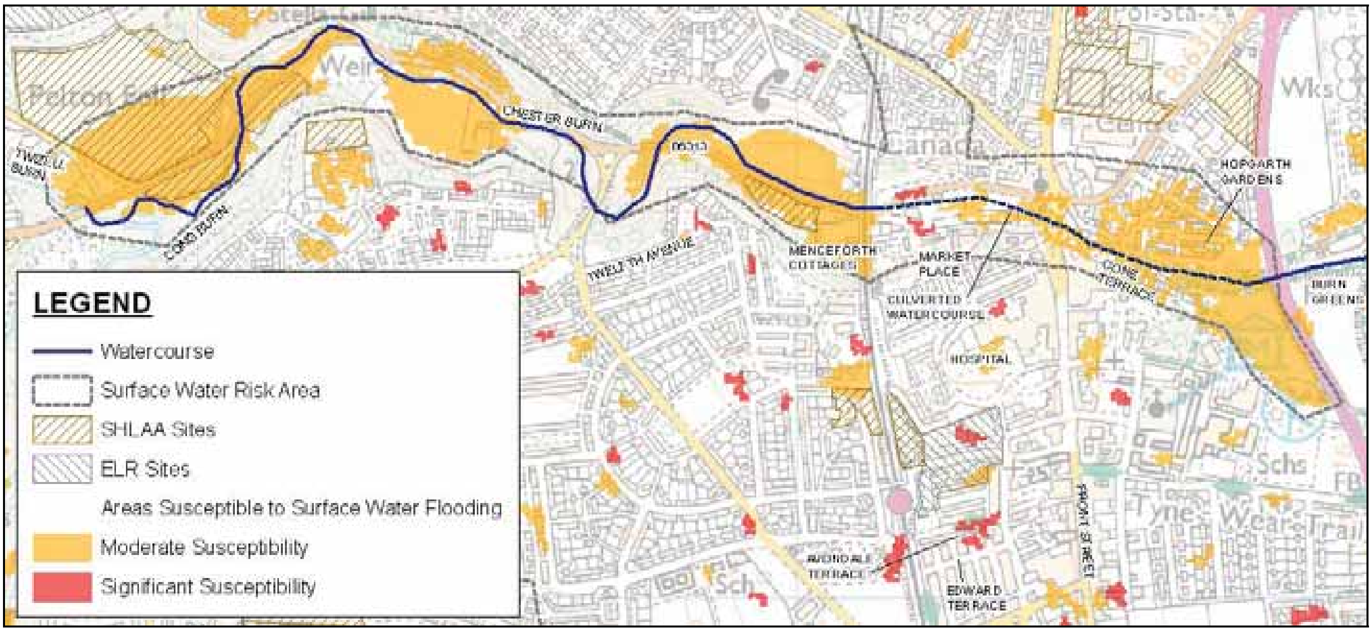


Figure C.4.3: CLS2: Areas Susceptible to Surface Water Flooding

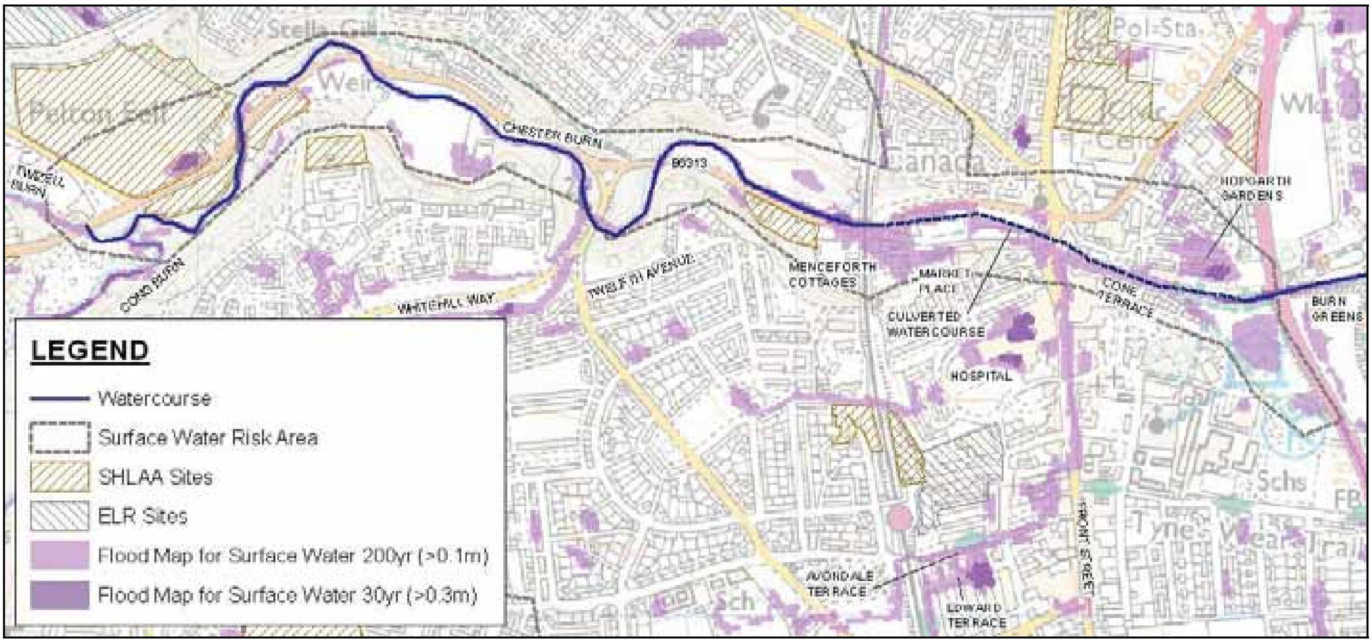


Figure C.4.4: CLS2: Flood Map for Surface Water

Whereas previously large swathes of land either side of Chester Burn were considered to be at risk of surface water flooding; now there are more localised areas that can be targeted for management. There are also areas of risk outside of the previously identified boundary therefore there has been a consideration of a wider area than just the SWRA boundary.

CLS2 is in the north of Chester-le-Street and has experienced a number of known flood instances. Due to development pressures in and around Chester-le-Street, the Environment Agency considers that the frequency of flooding is expected to increase. There are three SHLAA sites alongside Chester Burn although there are a number of others in the vicinity that could provide opportunities to manage the surface water flood risk.

35 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Based on a simple assessment concerning generic flood damages and the number of properties falling within the 30 year and 200 year Surface Water Flood Maps, AADs have been estimated to be £45,000.

Within the previously delineated SWRA there are two key flood risk areas where a number of properties would be affected by an extreme surface water flood event; Market Place and Hopgarth Gardens. There is also an area of flooding outside the SWRA boundary, at Avondale Terrace / Edward Street which links to flooding on Cone Terrace via Front Street. The assessment of potential Options has focused on these three areas. Table C.4.3 presents the MCA, measures scoring five or higher have been highlighted as being appropriate for further consideration. Measures scoring three or four have been identified as possible candidates that would be worth considering as part of a further assessment.

Table C.4.3: CLS2 MCA

	Mitigation Measure	Technical	Relative Cost	Economic	Social Impact	Environmental	Sustainability	Overall	Short List?
Source	Green Roofs	1	0	-2	2	2	2	5	Yes
	Soakaways/Infiltration	-2	0	0	2	1	1	2	
	Attenuation/Storage	1	-2	2	-1	2	2	4	Maybe
	Swales/Filter Drain	-1	-1	1	0	1	2	2	
	Permeable Paving	0	1	0	1	0	1	3	Maybe
	Rainwater Harvesting	0	2	-2	1	1	2	4	Maybe
Pathway	Increase Sewer Capacity	-2	-2	-1	0	0	-2	-7	
	Separation of foul\surface water systems	0	-2	0	0	1	2	1	
	Improve maintenance regime	2	0	-1	0	0	0	1	
	Flow/Storage on Roadway	2	1	2	-1	0	0	4	Maybe
	Manage overland flows	2	1	2	-1	0	1	5	Yes
	Improve channel capacity	-2	-2	1	1	0	0	-2	
	Open up culverts	U							
	Improve Floodplain Storage	0	1	-1	1	2	2	5	Yes
Receptor	Improved weather warning	-2	-2	-2	0	0	1	-5	
	Planning policies / development control	0	2	2	0	0	2	6	Yes
	Improve Resilience and resistance	2	2	2	-1	0	1	6	Yes

At Market Place, Hopgarth Gardens and along Cone Terrace, Chester Burn has been culverted for a length of 630m. The culvert has reduced opportunities for surface runoff to reach Chester Burn, which could consequently pond on the surface. One (albeit extreme) measure to address the flood risk would be to open up the culvert, potentially providing a solution to the surface water flood risk in all three areas that have been identified. However the considerable development that has occurred on top of the culvert leads to the conclusion that opening up the culvert is not technically feasible or economically viable. As a result this measure has been rejected. An alternative would be to provide some form of interceptor grids that would allow surface water to drain into the culvert.

C.4.6.1 Avondale Terrace / Edward Street

Irrespective of the issues associated with the culvert, Front Street clearly represents a flow path that appears to warrant exploiting or addressing. In terms of the Avondale Terrace / Edward Street area a significant flow path would be required to encourage water to drain onto Front Street and down towards Chester Burn although road re-grading and landscaping could facilitate this. Interceptor grids could subsequently allow the water to drain into the culvert. A key consideration is the presence of Chester-le-Street hospital off Front Street and the need to ensure that access is maintained at all times. It is noteworthy that the hospital itself is surrounded by flood water and action ought to be taken to ensure that this can be managed, potentially within the car parks via permeable paving.

It may be that "street architecture" could be employed to channel surface water away from the Avondale Terrace / Edward Street area. Either along Front Street (without posing a constraint to access to the hospital) or immediately to the north where the redevelopment of SHLAA and ELR sites may present opportunities to store water in ponds/wetlands and contribute to the wider green infrastructure networks. Such measures will ensure new development does not introduce additional pollutant loadings to receiving watercourses. If existing surface water runoff is intercepted there may be a reduction in the frequency of spillages from the CSO in Front Street leading to water quality benefits in Chester Burn. Chester Burn is currently failing to achieve its WFD target due to fish, although it is not clear why. Treatment of urban runoff will contribute to the programme of measures to improve the water quality and fish population in Chester Burn. Note that utilising part of the site for storage will place constraints on the viability of the development sites. Runoff from these development sites would also need to be managed on site to avoid contributing to problems elsewhere.

Immediately to the west of Avondale Terrace / Edward Street runs the railway line. If water is able to pass from west to east across the railway it is recommended that measures are put in place to prevent this, such as the creation of a storage area to the west of the railway to capture runoff that would otherwise impact on Avondale Terrace / Edward Street and could pass forward onto Front Street.

Otherwise, in the heavily developed area of Avondale Terrace / Edward Street there are limited opportunities to implement measures other than local storage in roads or improved resilience and resistance of individual properties. Storage of water in the roads scores reasonably well but to store water on Front Street would present issues for the hospital however; storage in the road along Cone Terrace may be more feasible. Incorporated into future capital renewal surfacing works, this would involve roadway re-grading and profiling of the carriageway profile to provide overland flow paths out of the area to reach Front Street and Cone Terrace.

C.4.6.2 Hopgarth Gardens

Immediately to the east of the flood problem in Hopgarth Gardens is what appears to be a playing field, which presents an opportunity to store the water that would otherwise affect Hopgarth Gardens through the creation of a storage area. This could be in the form of a wetland to promote biodiversity or simply lower the level of the area to retain its current social function. In addition to the storage area it would be necessary to provide a formal overland flow path out of the residential area into the storage area.

C.4.6.3 Market Place

In the area around the flooding shown in Market Place there are several car parks and green areas which could be used for flood storage. Alternatively, given the sites proximity to Chester Burn it would be practical to drain excess runoff into the watercourse, although the presence of the culvert is likely to limit the feasibility of this, although interceptor grids may make this possible.

In general there are only a limited number of re-development opportunities in and around the three problem areas however, redevelopment should ensure that peak runoff from the sites is reduced as much as possible and if possible, additional storage should be provided. This could include source control measures such as described in **Section C.3,** namely green roofs, permeable paving, attenuation storage and rainwater harvesting.

Key Messages

35 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Annual Average Damages have been estimated at £45,000. The two key flood risk areas are Market Place and Hopgarth Gardens. Risk areas exist outside the SWRA at Avondale Terrace / Edward Street which links to flooding on Cone Terrace via Front Street.

At Avondale Terrace / Edward Street a significant flow path would be required to encourage water to drain onto Front Street and down towards Chester Burn. Road re-grading and landscaping could facilitate this. Interceptor grids could subsequently allow the water to drain into the culvert. Alternatively "street architecture" could be employed to channel surface water away. Redevelopment of SHLAA and ELR sites to the north may present opportunities to store water in ponds/wetlands. There are limited opportunities to implement measures other than local storage in roads or improved resilience and resistance of individual properties.

At Hopgarth Gardens, a playing field presents an opportunity to store water. In the Market Place there are several car parks and green areas which could be used for flood storage. Interceptor grids could be used to drain excess runoff into the watercourse.

Capabilities on project:
Water

C.4.7 CLS3: Chester-le-Street

The change in flood data from the Environment Agency's Areas Susceptible to Surface Water Flooding to the Flood Map for Surface Water has had a significant change in the area's flood risk (Figures C.4.5 and C.4.6).

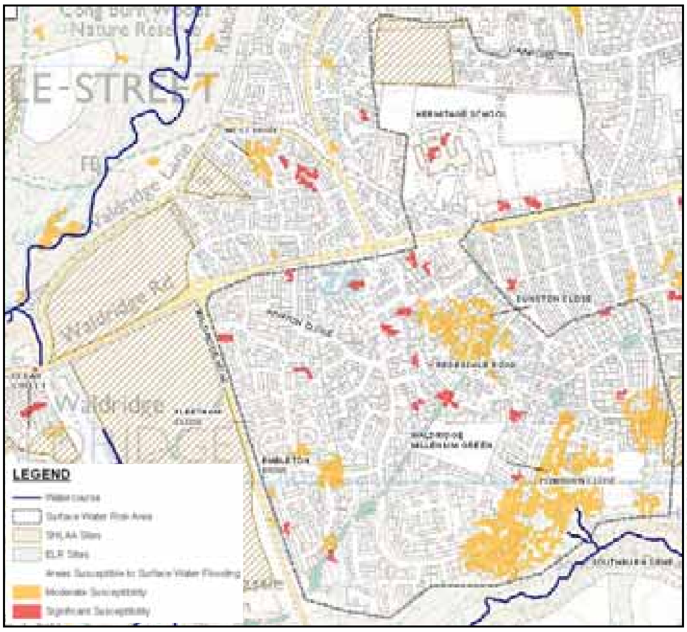


Figure C.4.5: CLS3: Areas Susceptible to Surface Water

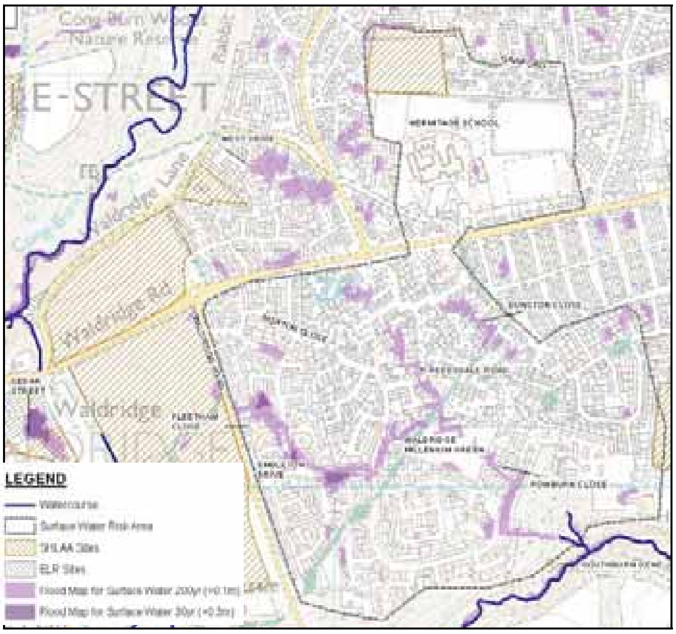


Figure C.4.6: CLS3: Flood Map for Surface Water

CLS3 is in the south of Chester-le-Street, north of Southburn Dene. The area has experienced six known flood incidents many of which can be attributed to inadequate drainage, notably in Gainford and Waldridge.

82 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Based on a simple assessment concerning generic flood damages and the number of properties falling within the 30 year and 200 year Surface Water Flood Maps, AADs have been estimated to be £81,000.

With regard to exceedance events there appears to be low spots creating an overland flow paths through the Embleton Drive, Redesdale Road and Powburn Close areas down towards Southburn Dene. Other notable areas of flooding occur in Waldridge on Cedar Street and surrounding streets and in the West Drive area. The assessment of potential Options has focused on these areas.

It is believed that surface water sewers from the site drains into tributaries of South Burn and South Burn itself. The inclusion of new SuDS features serving urban catchments draining to these watercourses could lead to water quality and biodiversity improvements. There are two CSOs, one at Warkworth Drive discharging into a tributary of South Burn (although since the area is served by separate foul and surface sewers there is limited potential to reduce the frequency of CSO spills), and at Waldridge Road into Cong Burn (which may receive flows from the Cedar Street area, although sewer records for that area have not been provided). Reduced surface water runoff to these sewer systems could reduce the frequency of spillages.

Table C.4.4 presents the MCA. Measures scoring five or higher have been highlighted as being appropriate for further consideration as part of the short listed measures. Measures scoring three or four have been identified as possible candidates that would be worth considering as part of a further assessment.

Table C.4.4: CLS3 MCA

	Mitigation Measure	Technical	Relative Cost	Economic	Social Impact	Environmental	Sustainability	Overall	Short List?
Source	Green Roofs	2	0	-2	2	2	2	6	Yes
	Soakaways/Infiltration	1	0	1	2	1	1	6	Yes
	Attenuation/Storage	2	-2	2	0	2	2	6	Yes
	Swales/Filter Drain	2	-1	1	1	1	2	6	Yes
	Permeable Paving	2	1	0	0	0	1	4	Maybe
	Rainwater Harvesting	2	2	-2	0	1	2	5	Yes
Pathway	Increase Sewer Capacity	0	-2	-1	0	0	-2	-5	
	Separation of foul\surface water systems	0	-2	0	0	1	2	1	
	Improve maintenance regime	2	0	0	0	0	0	2	
	Flow/Storage on Roadway	2	1	1	-1	0	0	3	Maybe
	Manage overland flows	1	1	1	-1	0	1	3	Maybe
	Improve channel capacity	U							
	Open up culverts	U							
	Improve Floodplain Storage	U							
Receptor	Improved weather warning	-2	-2	-2	0	0	1	-5	
	Planning policies / development control	2	2	2	0	0	2	8	Yes
	Improve Resilience and resistance	1	2	2	-1	0	1	5	Yes

C.4.7.1 Embleton Drive, Redesdale Road and Powburn Close

The source of surface water in the Embleton Drive area is the fields to the west of Waldridge Road, refer **Figure 60155102/OPTIONS/CLS3**. Runoff from the fields and the inundated highway drainage are believed to be the cause of several previous surface water incidents. The SHLAA site to the west of Waldridge Road should introduce source control measures such as those described in **Section C.3**. This would include measures such as green roofs, permeable paving, attenuation storage and rainwater harvesting. A geotechnical investigation should investigate the feasibility of infiltration measures such as soakaways, permeable pavements and filter drains. Development of the SHLAA site in the Waldridge area (west of the surface water risk area) should require peak discharges to be maintained to greenfield rates. Surface water flows should be controlled, either through diversion to the Southburn Dene along Waldridge Road or collected and stored. These measures will ensure new development does not introduce additional sources of diffuse urban pollution by treating it on site, as well as dealing with existing runoff issues.

Within the identified flood risk areas of Fleetham Close, Redesdale Road and Powburn Close areas, it may be possible to provide an overland flow route across the existing pavement surface. Incorporated into future capital renewal surfacing works, this would involve roadway re-grading and profiling of the carriageway profile to provide an overland flow path out of the area. Storage of this water could be provided in Millenium Green or the open space between Powburn Close and Southburn Dene. This would provide treatment of storm flows when rainfall has been sufficiently intense or long.

In areas where surface water flood risk cannot be reduced, resilience and resistance measures may be appropriate.

C.4.7.2 Waldridge

In addition to the SHLAA site discussed, there are two smaller SHLAA sites further west which are located in an area of flooding surrounding the Cedar Street area of Waldridge. These two sites are immediately adjacent to Waldridge Road. This road is likely to be a cause of flooding in the Embleton Drive area (**Figure 60155102/OPTIONS/CLS3**). It is likely that the source of surface water is overland runoff from the open land immediately to the south which is subsequently ponding in the residential area.

The two SHLAA sites present several opportunities to manage the potential risk in this area by reducing runoff from the sites themselves but also addressing the risk posed to the existing developed area. In addition to source control methods such as green roofs and permeable paving, storage ponds and swales could capture runoff draining north or the runoff could be diverted towards the allotments to the east of the residential area and the tributary of Southburn Dene. Source control would reduce the flux of diffuse urban pollutants to receiving watercourses from this new development.

C.4.7.3 West Drive

The third area identified is the residential area to the south of Waldridge Lane. The source of flooding is thought to be runoff from land to the west which ponds in low spots on the streets around West Drive. In a similar fashion to Waldridge the SHLAA sites further to the west present opportunities to prevent runoff reaching the residential areas by storing it on site or diverting it northwards onto the Rabbit Banks and down to Chester Burn. Alternatively it may be possible to store water in the roads. The inclusion of SuDS on any new development will provide treatment of new sources of diffuse urban pollution. Some treatment of the existing diffuse pollution load may be achieved if existing runoff can be stored in roads. Although insignificant when compared to the total urban area it is a small improvement to the current situation.

Where possible, owners in these areas should be encouraged to reduce permeable surfaces and implement resilience measures. This would ensure water volumes entering the existing sewer system are minimised.

<u>Key Messages</u>

82 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Average Annual Damages have been estimated at £81,000. SHLAA sites are the preferred measure and it is essential that source control measures are considered if any SHLAA sites are brought forward for development.

There appears to be low spots creating overland flow paths through the Embleton Drive, Redesdale Road and Powburn Close areas. Runoff from the fields and the inundated highway drainage are believed to be the cause of several previous surface water incidents. The SHLAA site to the west of Waldridge Road should introduce source control measures such as green roofs, permeable paving, attenuation storage and rainwater harvesting. It may be possible to provide an overland flow route across the existing pavement surface. Alternatively storage of this water could be provided in Millennium Green.

At Cedar Street, source control methods such as green roofs and permeable paving, storage ponds and swales could capture runoff draining north, or the runoff could be diverted towards the allotments to the east of the residential area and the tributary of Southburn Dene. Similar measures can be employed along West Drive.

C.4.8 DC1: Durham City - Pity Me

The change in flood data from the Environment Agency's Areas Susceptible to Surface Water Flooding to the Flood Map for Surface Water has significantly reduced the area considered to be at risk of flooding as illustrated in Figures C.4.7 and C.4.8.

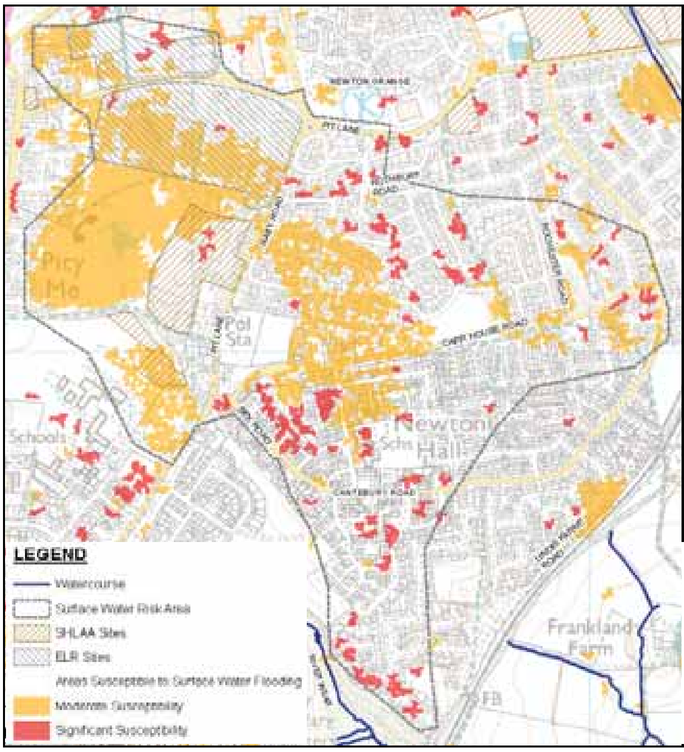


Figure C.4.7: DC1: Areas Susceptible to Surface Water

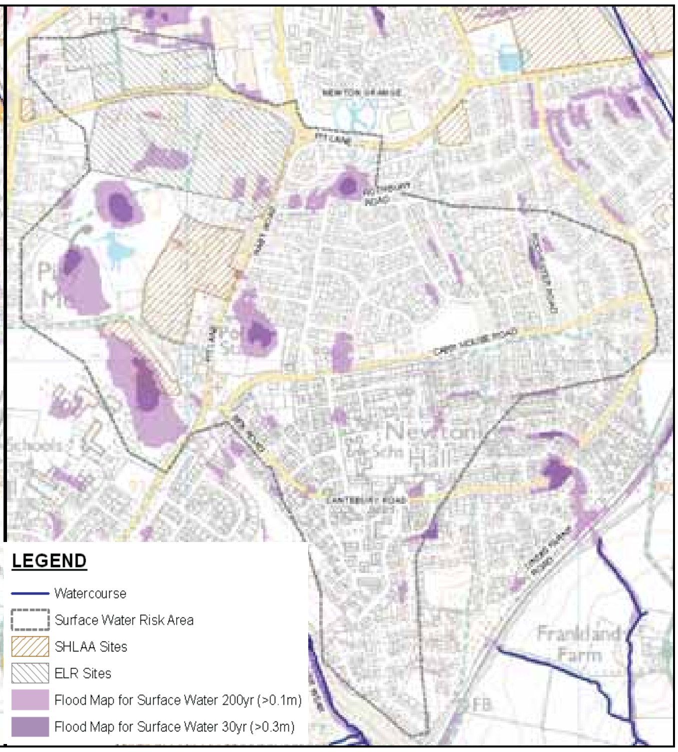


Figure C.4.8: DC1: Flood Map for Surface Water

Whilst the flood extent may have reduced the areas at risk are consistent; Rothbury Road and Raby Road; two areas off Pit Lane, Rochester Road, Canterbury and Lindisfarne Roads and Bek Road are all at risk. 97 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Based on a simple assessment concerning generic flood damages and the number of properties falling within the 30 year and 200 year Surface Water Flood Maps, AADs have been estimated to be £108,000.

DC1 is a heavily urbanised area located north of Durham in the Pity Me area. The western side of the area contains two SHLAA and two ELR sites, refer **Figure 60155102/OPTIONS/DC1**. The Pity Me nature reserve in the west could be a potential source of overland flow for areas to the east off Pit Lane. Northumbrian Water has addressed several known surface water incidents in the area and is currently upsizing the sewer system at Newton Grange which is located to the north.

It is believed that surface water sewers from the site drains into numerous tributaries of the River Wear. The inclusion of new SuDS features serving urban catchments draining to these watercourses could lead to water quality and biodiversity improvements. There is a CSO in Canterbury Road which it is believed discharge into an unnamed tributary of the Wear. Reduced surface water runoff to these sewer systems could reduce the frequency of spillages.

The assessment of potential Options has focused on Pit Lane, Lindisfarne Road, Bek Road and Rochester Road. Table C.4.5 presents the MCA, measures scoring five or higher have been highlighted as being appropriate for further consideration as part of the short listed measures. Measures scoring three or four have been identified as possible candidates that would be worth considering as part of a further assessment.

Table C.4.5: DC1 MCA

	Mitigation Measure	Technical	Relative Cost	Economic	Social Impact	Environmental	Sustainability	Overall	Short List?
Source	Green Roofs	2	0	-2	2	2	2	6	Yes
	Soakaways/Infiltration	0	0	1	2	1	1	5	Yes
	Attenuation/Storage	2	-1	0	0	2	2	5	Yes
	Swales/Filter Drain	1	-1	1	0	1	2	4	Maybe
	Permeable Paving	1	1	0	1	0	1	4	Maybe
	Rainwater Harvesting	2	0	-2	1	1	2	4	Maybe
Pathway	Increase Sewer Capacity	0	-2	-2	0	0	-2	-6	
	Separation of foul\surface water systems	0	-2	0	0	1	2	1	
	Improve maintenance regime	2	0	0	0	0	0	2	
	Flow/Storage on Roadway	2	1	1	-1	0	0	3	Maybe
	Manage overland flows	1	1	1	-1	0	1	3	Maybe
	Improve channel capacity	U							
	Open up culverts	U							
	Improve Floodplain Storage	U							
Receptor	Improved weather warning	-2	-2	-2	0	0	1	-5	
	Planning policies / development control	2	2	2	0	0	2	8	Yes
	Improve Resilience and resistance	1	2	2	-1	0	1	5	Yes

C.4.8.1 Rothbury Road

Rothbury Road is a residential area and local low point where surface water is likely to collect. Sources of surface water will be runoff from the local impermeable surfaces but the SFRA modelling also indicates a flow path originating to the west at the Pity Me Nature Reserve. The flow path follows the line of a public footpath to the Rothbury Road area. A number of measures could be implemented to manage the risk of surface water flooding in this area. Works could be undertaken at the nature reserve to increase its ability to hold water. If the ELR site between the nature reserve and Rothbury Road is re-developed steps ought to be taken to limit runoff from the site through the provision of storage, infiltration, soakaways and potentially green roofs and rainwater harvesting. Source control would also help to reduce the flux of diffuse urban pollutants to receiving watercourses from this proposed new development, although it would not treat runoff from existing urban areas. Planning policies and development control could be utilised to enforce this. The public footpath also presents opportunities for the creation of a swale to manage any overland flows that may occur.

C.4.8.2 Raby Road

Parkland exists immediately to the south of the risk area on Raby Road. The preferable course of action would be to lower the area to provide additional storage capacity so that surface water in the Raby Road area can drain into the parkland.

C.4.8.3 Rochester Road

Rochester Road has a low spot where surface water is likely to accumulate and has had a previous instance of flooding. The source of surface water is likely to be runoff from the impermeable surfaces in the local area. Potential management strategies include holding the excess water in the road until the sewer systems are able to take the water away, or providing an overland flow route to the open land to the east. This would however need to pass between properties and is unlikely to be acceptable. If runoff from urban areas is retained on site for longer it would provide some treatment when rainfall has been sufficiently intense or long by filtering sediments and pollutants attached to them.

C.4.8.4. Canterbury Road & Lindisfarne Road

Surface water is this area will again be a result of runoff from impermeable surfaces. With no potential re-development occurring in the area solutions would need to be retro-fitted. Open land between Canterbury Road and Lindisfarne Road could potentially be used to provide storage either lowering the area or creating a wetland and subsequently channelling overland flows into this area. Alternatively road regrading and kerbing could be used to hold the water in the roads rather than properties. If runoff from urban areas is retained on site for longer it would provide some treatment when rainfall has been sufficiently intense or long by filtering sediments and pollutants attached to them.

C.4.8.5 Bek Road

The same situation is found at Bek Road. A residential area which is a topographic low where surface water is likely to collect. The preferable measures would be to hold water in the roads using kerbing or create an overland flow path to a storage area which could be the thin strip of land to the west of Bek Road.

Where possible, owners in these surface water risk areas should be encouraged to reduce permeable surfaces and implement resilience measures in areas identified as at risk of surface water flooding.

Key Messages

97 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Average Annual Damages have been estimated at £108,000. Surface water tends to be the result of runoff from impermeable surfaces.

Rothbury Road is a low point where surface water is likely to collect. Works could be undertaken at the nature reserve to increase its ability to hold water. If the ELR site between the nature reserve and Rothbury Road is re-developed, it is essential that steps are considered to be taken to limit runoff from the site through the provision of storage, infiltration, soakaways and potentially green roofs and rainwater harvesting. The public footpath presents opportunities for the creation of a swale to manage any overland flows.

At Raby Road the preferred action would be to lower the parkland to provide additional storage capacity for the surface water to drain into. At Rochester Road storage of water in the road or provide an overland flow route to the open land to the east. At Cantebury Road, Lindifarme Road solutions would need to be retro-fitted. Open land is available for storage and road regrading and kerbing could be used to hold the water in the roads rather than properties. The same situation is found at Bek Road where storage in roads, kerbing, creating an overland flow path to a storage area are the preferable measures.

C.4.9 DC8: Durham City - Gilesgate, Belmont and Carrville SWRA

The surface water flood risk has not changed significantly between the Areas Susceptible to Surface Water Flooding and the Flood Map for Surface Water (Figures C.4.9 and C.4.10).

Capabilities on project:
Water

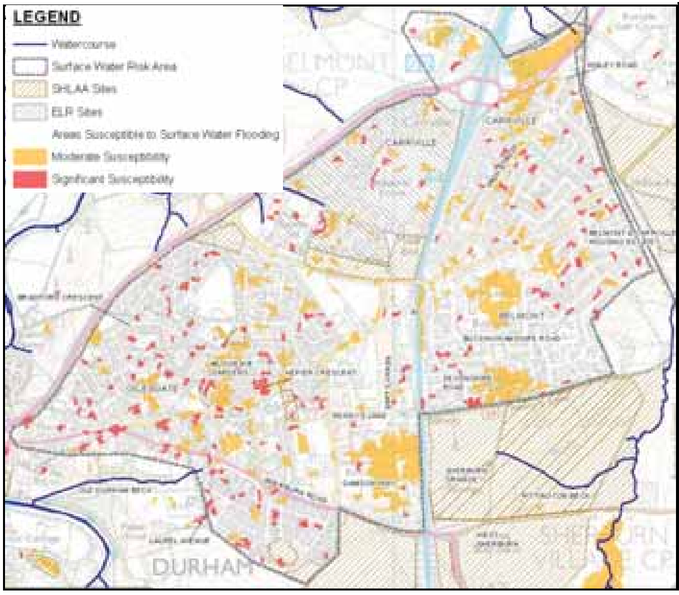


Figure C.4.9: DC8: Areas Susceptible to Surface Water

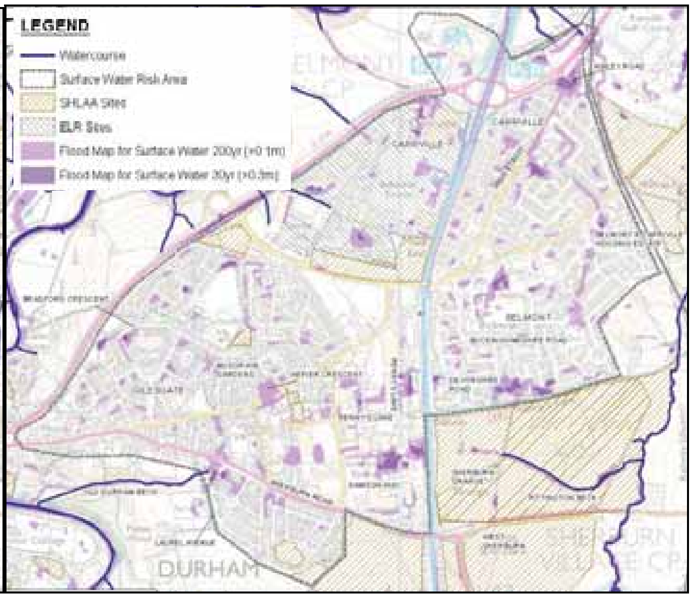


Figure C.4.10: DC8: Flood Map for Surface Water

DC8 includes 57 known flood incidents within the Belmont, Carrville and Gilesgate areas. The majority of known flood incidents at Gilesgate appear to be associated with an inadequate surface water sewer network and highways drainage. Blockages seem to be the main cause for the surface water issues. Northumbrian Water is in the process of completing a flood alleviation scheme involving oversized pipes to provide additional storage in the Belmont and Gilesgate systems. Durham County Council has undertaken works to improve highways drainage. This has included the provision of additional gullies and de-silting blocked highways drains.

The area occupies high ground therefore the source of the surface water risk is rain falling across DC8 rather than flowing into the area from elsewhere. The transport corridors (A1, A690 and railway) prevent overland flow leaving the area, refer **Figure 60155102/OPTIONS/DC8**. This has resulted in an extensive sewer network which outfalls to the River Wear to the west and Pittington Beck to the east.

Extensive development is identified between the southern portion of the SWRA and Pittington Beck.

It is believed that surface water sewers from the site may drain into the following watercourses: an unnamed tributary of the River Wear, an unnamed watercourse (perhaps Pitington Beck), a tributary of Pitington Beck, and Pelawood Beck. The inclusion of new SuDS features serving urban catchments draining to these watercourses could lead to water quality and biodiversity improvements. There are CSOs at Dragon Lane, High Street, Fallsway, Laurel Avenue, and a CSO at Belmont Sewage Disposal Works. Reduced surface water runoff to these sewer systems could reduce the frequency of spillages.

585 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Based on a simple assessment concerning generic flood damages and the number of properties falling within the 30 year and 200 year Surface Water Flood Maps, AADs have been estimated to be £610,000. Key areas are near Devonshire Road and Damson Way and the assessment of potential Options has focused on these areas. Table C.4.6 presents the MCA. Measures scoring five or higher have been highlighted as being appropriate for further consideration as part of the short listed measures. Measures scoring three or four have been identified as possible candidates that would be worth considering as part of a further assessment.

Table C.4.6: DC8 MCA

	Mitigation Measure	Technical	Relative Cost	Economic	Social Impact	Environmental	Sustainability	Overall	Short List?
Source	Green Roofs	2	0	-2	2	2	2	6	Yes
	Soakaways/Infiltration	U							
	Attenuation/Storage	2	-1	0	0	2	2	5	Yes
	Swales/Filter Drain	2	-1	1	0	1	2	5	Yes
	Permeable Paving	1	2	0	1	0	1	5	Yes
	Rainwater Harvesting	2	0	-2	1	1	2	4	Maybe
Pathway	Increase Sewer Capacity	0	-2	-1	0	0	-2	-5	
	Separation of foul\surface water systems	2	-1	0	0	1	2	4	Maybe
	Improve maintenance regime	2	0	-1	0	0	0	1	
	Flow/Storage on Roadway	1	1	1	-1	0	0	2	
	Manage overland flows	1	1	1	-1	0	1	3	Maybe
	Improve channel capacity	U							
	Open up culverts	U							
	Improve Floodplain Storage	U							
Receptor	Improved weather warning	-2	-2	-2	0	0	1	-5	
	Planning policies / development control	2	2	2	0	0	2	8	Yes
	Improve Resilience and resistance	1	2	2	-1	0	1	5	Yes

C.4.9.1 Devonshire Road and Damson Way

The SHLAA site to the south of Renny's Lane on Sherburn Grange presents significant opportunities for surface water management for both Devonshire Road and the industrial estate off Damson Way. The SFRA modelling has identified topographic lows that form overland flow paths which could be formalised to channel flood water out of these areas and into the SHLAA site which could provide storage in the form of ponds and wetlands.

If it is not possible to cross the A1 or Renny's Lane with formal overland flow paths it would be necessary to manage the surface water in situ. Within the Devonshire Road area are a number of small park areas that could be utilised for storage and the industrial estate off Damson Way has large car parking areas that could also provide storage. Alternatively the flat roofs at the industrial estate may present opportunities to retro-fit green roofs. There is the potential to improve water quality in receiving watercourses by treating the source of pollution (i.e. runoff from the industrial estate). Surface water discharges via a combined sewer into a tributary of Pittington Beck. Pittington Beck is not meeting its WFD objectives primarily due to high phosphate levels, which in part could be caused by spills from the CSO east of the industrial estate. By attenuating flows from the industrial estate the spill frequency from this CSO could be reduced, which would contribute to measures to improve the status of Pittington Beck.

Where possible, owners in these surface water risk areas should be encouraged to reduce permeable surfaces and implement resilience measures in areas identified at risk of surface water flooding.

<u>Key Messages</u>

DC8 includes 57 known flood incidents within the Belmont, Carrville and Gilesgate areas, associated to inadequate surface water sewer network, highways drainage and blockages. Northumbrian Water is in the process of completing a flood alleviation scheme involving oversized pipes to provide additional storage in the Belmont and Gilesgate systems, and Durham County Council has created additional gullies and de-silting blocked highways drains.

The area occupies high ground therefore the source of the surface water risk is rain falling across DC8 rather than flowing into the area from elsewhere. The transport corridors (A1, A690 and railway) prevent overland flow leaving the area. 585 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Average Annual Damages have been estimated at £610,000.

Topographic lows have been identified that form overland flow paths which could be formalised to channel flood water out of Devonshire Road and Damson Way and into the SHLAA site on Sherburn Grange which could provide storage. It is essential source control measures are considered if this site is developed on. If the surface water can be managed in situ, there are a number of small park areas or the industrial estate car park off Damson Way could provide storage. Alternatively the flat roofs at the industrial estate may present opportunities to retro-fit green roofs.

C.4.10 BIS3: Bishop Auckland

The change in flood data from the Environment Agency's Areas Susceptible to Surface Water Flooding to the Flood Map for Surface Water has had a significant change in the situation as illustrated in Figures C.4.11 and C.4.12.

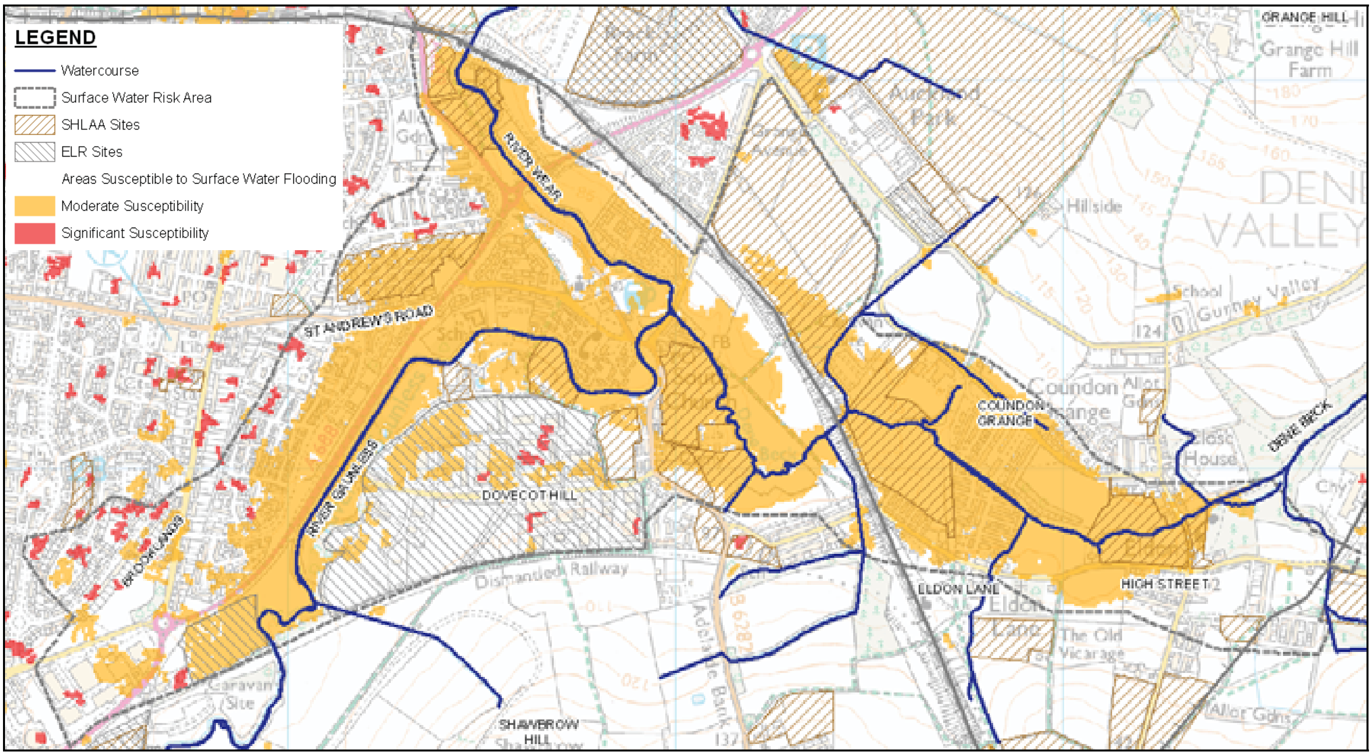


Figure C.4.11: BIS3: Areas Susceptible to Surface Water

Capabilities on project:
Water

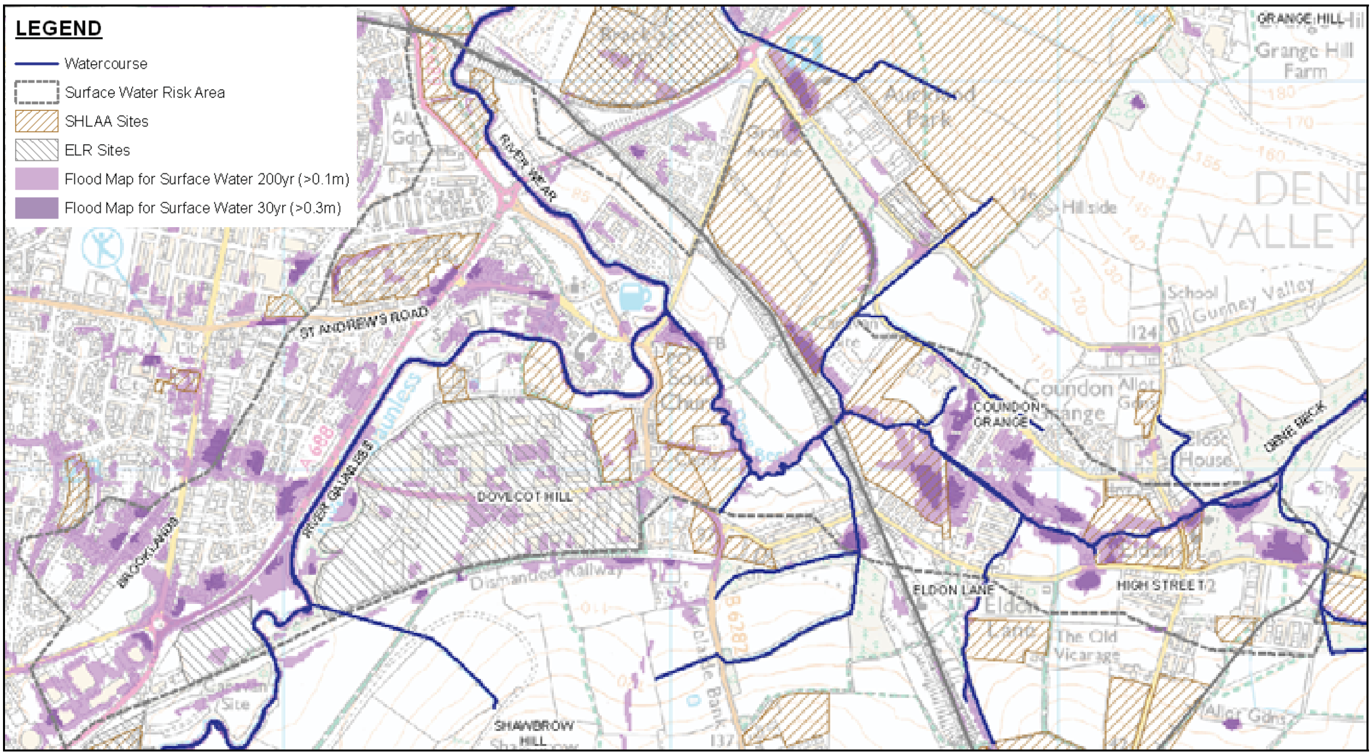


Figure C.4.12: BIS3: Flood Map for Surface Water

The River Gaunless, an Environment Agency Main River, flows in a northerly direction through the SWRA before discharging into the River Wear (north of the study area) (**Figure 60155102/OPTIONS/BI3**). The eastern portion of the SWRA is drained by Dene Beck, a tributary of the River Gaunless. The SWRA is located at the bottom of the steeply sloped Grange Hill and Shawbrow Hill with an urbanised area to the west. BIS3 has experienced eight known flood incidents.

Many of the historical flood incidents in Bishop Auckland are a result of fluvial flooding from the River Gaunless and therefore cannot be solved as part of a SWMP. The Environment Agency has implemented a flood alleviation scheme for Bishop Auckland providing flood storage that now provides a standard of protection of 1 in 200 years. Surface water incidents have occurred in the east of the SWRA near Eldon and have been related to maintenance and insufficient drainage capacity within the sewer system.

The Environment Agency's Flood Map for Surface Water identifies surface water risk areas near Coundon Grange, Brooklands and Dovecot Hill that this assessment has focused upon. Several SHLAA and ELR sites are located near these areas and present opportunities to address the surface water issues. 296 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Based on a simple assessment concerning generic flood damages and the number of properties falling within the 30 year and 200 year Surface Water Flood Maps, AADs have been estimated to be £365,000.

It is believed that surface water sewers from the site drain into the following watercourses: River Gaunless, Dene Beck and a tributary of Dene Beck. The inclusion of new SuDS features serving urban catchments draining to these watercourses could lead to water quality and biodiversity improvements. There are CSOs at Cumberland Street, Close House, Cattle Market, and numerous other sites under the name "Vinovium" (according to data from the Environment Agency). There are CSOs at Hanover Gardens/South Church Road, Fieldon Bridge, and Riverside. Reduced surface water runoff to these sewer systems could reduce the frequency of spillages.

Table C.4.7 presents the MCA. Measures scoring five or higher have been highlighted as being appropriate for further consideration as part of the short listed measures. Measures scoring three or four have been identified as possible candidates that would be worth considering as part of a further assessment.

Table C.4.7: BIS3 MCA

	Mitigation Measure	Technical	Relative Cost	Economic	Social Impact	Environmental	Sustainability	Overall	Short List?
Source	Green Roofs	2	0	-2	2	2	2	**6**	Yes
	Soakaways/Infiltration	U							
	Attenuation/Storage	2	1	1	-1	2	2	**7**	Yes
	Swales/Filter Drain	2	1	1	0	1	2	**7**	Yes
	Permeable Paving	2	2	-1	1	0	1	**5**	Yes
	Rainwater Harvesting	1	0	-2	1	1	2	**3**	Maybe
Pathway	Increase Sewer Capacity	0	-2	-2	0	0	-2	**-6**	
	Separation of foul\surface water systems	2	-1	0	0	1	1	**3**	Maybe
	Improve maintenance regime	2	2	-2	0	0	0	**2**	
	Flow/Storage on Roadway	2	1	1	-1	0	0	**3**	Maybe
	Manage overland flows	1	1	1	-1	0	1	**3**	Maybe
	Improve channel capacity	U							
	Open up culverts	-2	-2	-2	2	2	2	**0**	
	Improve Floodplain Storage	1	-2	-2	1	2	2	**2**	
Receptor	Improved weather warning	-2	-2	-2	0	0	1	**-5**	
	Planning policies / development control	2	2	1	0	0	2	**7**	Yes
	Improve Resilience and resistance	2	2	1	-1	0	1	**5**	Yes

C.4.10.1 Coundon Grange

Surface water in the Coundon Grange area will be a result of rainfall running off Grange Hill to the north. The SHLAA sites on Grange Hill present opportunities for strategic surface water management, reducing runoff from Grange Hill by holding and delaying runoff before it affects residential properties. Storage areas in the form of ponds, wetlands, swales and rainwater harvesting could all be encourage through planning policies and development control. SuDS on new development sites will effectively treat new sources of urban diffuse pollution. However the SHLAA sites are not directly above the area affected in Coundon Grange. Whilst measures implemented on the SHLAA sites would have wider benefits, they would not directly solve the problems at Coundon Grange. It may be possible to put swales or filter drains above the residential area to intercept flows coming off the hill or channel overland flows into storage areas in the SHLAA sites. Measures to reduce runoff to combined sewers may reduce the frequency of spills and lead to improvements in the water quality of receiving watercourses. Dene Beck is not designated under the WFD but any reduction in CSO spills would improve water quality.

C.4.10.2 Brooklands and Wider Area

In the Brooklands area there is little redevelopment in this already heavily urbanised setting. This limits the potential to provide storage ponds or implement mitigation measures through re-development, rather they would have to be implemented through retro-fit schemes. In this area the most preferable measures are likely to be improving resilience and resistance or storage of water in the roads. Kerbing could be provided to contain and attenuate surface waters until the combined sewer system has capacity. Retro-fitting permeable pavements may provide some benefit and it may be possible to provide an overland flow route to the River Gaunless. Incorporated into future capital renewal surfacing works, this would involve roadway re-grading and profiling of the carriageway to provide an overland flow path out of the area to reach the river. Measures to reduce runoff to combined sewers may reduce the frequency of spills and lead to improvements in the water quality of receiving watercourses. Like many of the watercourses in the region, the River Gaunless suffers from high phosphates, which may in part be caused by spillages of untreated foul water. Any reduction in the frequency of spillages from CSOs would contribute to measures to improve the status of the River Gaunless.

C.4.10.3 Dovecot Hill

The ELR site at Dovecot Hill presents opportunities to implement source control measures such as green roofs and storage to manage the risks faced by the site. Any development of SHLAA/ELR sites should introduce source control measures such as those described in **Section C.3**, namely green roofs, permeable paving, attenuation storage and rainwater harvesting. Peak discharges should be reduced and surface water contained within a storage area to reduce water volumes within the existing combined sewer system. The inclusion of SuDS as part of any new development would treat site runoff and would contribute to reducing the frequency of spills from the existing combined sewer system to Dene Beck leading to water quality improvements.

Key Messages

296 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Average Annual Damages have been estimated at £365,000.

Surface water in the Coundon Grange area will be a result of rainfall running off Grange Hill to the north. The SHLAA sites on Grange Hill present opportunities in the form of ponds, wetlands, swales and rainwater harvesting but would not directly solve the problems at Coundon Grange. Swales or filter drains could be used above the residential area to intercept flows coming off the hill or channel overland flows into storage areas in the SHLAA sites.

Brooklands is heavily urbanised therefore measures would likely be implemented through retro-fit schemes. The most preferable measure would be improving resilience and resistance or storage of water in the roads. Kerbing could be provided to contain and attenuate surface waters until the combined sewer system has capacity. Retro-fitting permeable pavements may provide some benefit and it may be possible to provide an overland flow route to the River Gaunless.

The ELR site at Dovecot Hill, if developed, presents opportunities to implement source control measures such as green roofs and storage. It is essential source control measures are considered as there are no alternative options in this area.

C.4.11 NEW1: Newton Aycliffe

The change in flood data from the Environment Agency's Areas Susceptible to Surface Water Flooding to the Flood Map for Surface Water has had a significant change in the situation as illustrated in Figures C.4.13 and C.4.14.

Capabilities on project:
Water

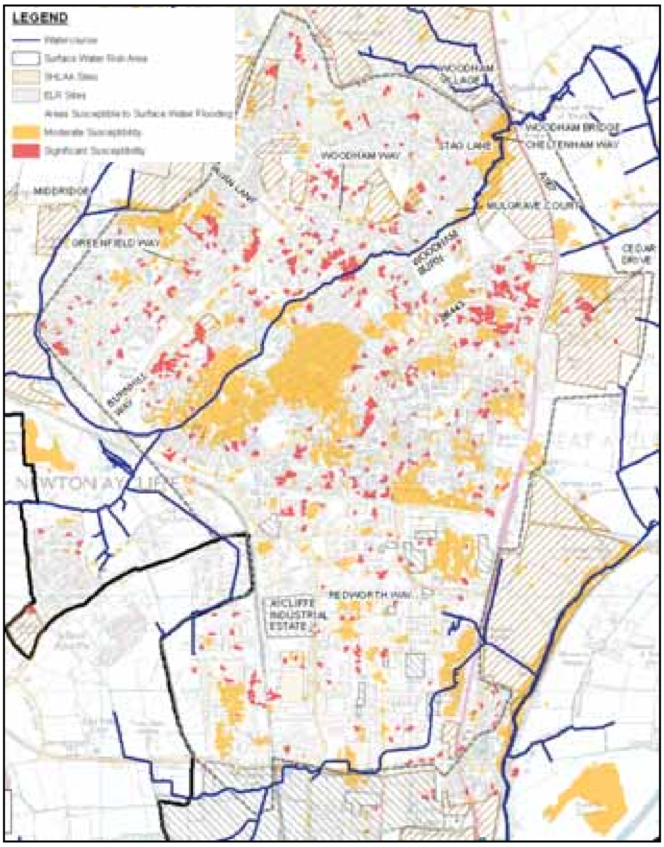


Figure C.4.13: NEW1: Areas Susceptible to Surface Water

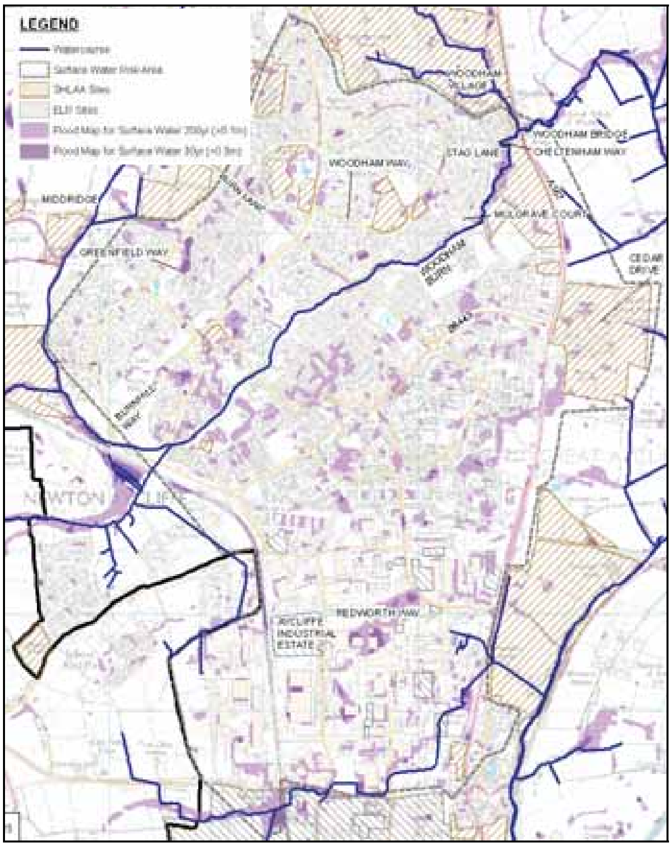


Figure C.4.14: NEW1: Flood Map for Surface Water

Table C.4.8 presents the MCA. Measures scoring five or higher have been highlighted as being appropriate for further consideration as part of the short listed measures. Measures scoring three or four have been identified as possible candidates that would be worth considering as part of a further assessment.

Table C.4.8: NEW1 MCA

	Mitigation Measure	Technical	Relative Cost	Economic	Social Impact	Environmental	Sustainability	Overall	Short List?
Source	Green Roofs	-1	0	-1	2	2	2	4	Maybe
	Soakaways/Infiltration	U							
	Attenuation/Storage	0	-2	1	0	2	2	3	Maybe
	Swales/Filter Drain	-1	-1	1	0	1	2	2	
	Permeable Paving	0	1	0	1	0	1	3	Maybe
	Rainwater Harvesting	0	-2	-2	1	1	2	0	
Pathway	Increase Sewer Capacity	-2	-2	0	0	0	-2	-6	
	Separation of foul\surface water systems	-1	-1	0	0	1	2	1	
	Improve maintenance regime	2	1	-1	0	0	0	2	
	Flow/Storage on Roadway	2	1	2	-1	0	1	5	Yes
	Manage overland flows	2	1	1	-1	0	1	4	Maybe
	Improve channel capacity	1	1	0	-1	-1	0	0	
	Open up culverts	1	-1	-1	-1	2	2	2	
	Improve Floodplain Storage	2	1	0	0	0	2	5	Yes
Receptor	Improved weather warning	-2	-2	-2	0	0	2	-4	
	Planning policies / development control	-1	2	2	0	0	2	5	Yes
	Improve Resilience and resistance	1	2	2	-1	0	1	5	Yes

The results of the MCA reflect the limited options available in these areas.

C.4.11.1 Burnhill Way

The residential area between Burnhill Way and Woodham Burn is a hotspot for surface water. The source of this water may be the playing fields immediately to the north of Burnhill Way, therefore storage in this area could provide benefits. Otherwise it will be necessary to provide storage in roads to prevent surface water flooding properties. Kerbing could be provided to contain and attenuate surface waters until the sewer system has capacity. Storage in roads will provide some treatment of diffuse urban runoff.

The area immediately to the south of Woodham Burn faces similar problems, lots of localised areas of flood risk hence storage in the road is again likely to be the best option given the highly urbanised nature of the area. However there is open floodplain alongside Woodham Burn. So providing storage alongside the river is a possibility, if the water can be transferred from the urban setting to the river setting. This would require the formal overland flow paths to be instated. Storage of water downstream of urban areas and immediately upstream of the receptor will have water quality benefits, the extent of which would depend on how water is stored.

C.4.11.2 Industrial Estate

The industrial estate in the south of Newton Aycliffe contains lots of flat roofs. These could be utilised to install green roofs, however this is unlikely to be cost effective measure. The potential ELR sites should implement source control measures where possible. One option would be to set one aside and create a storage area to hold excess runoff or a wetland to provide the additional benefits of green infrastructure. Source control would also help to reduce the flux of diffuse urban pollutants, such as possible spillages from light industrial activity on this site, into Demon's Beck and ultimately the River Skerne.

Key Messages

The Burnhill Way area is a hotspot for surface water. The playing fields immediately to the north of Burnhill Way could be used for storage. Alternatively, creating storage in the roads is an option to prevent surface water flooding to properties. Kerbing could be provided to contain and attenuate surface waters until the sewer system has capacity. Given the highly urbanised setting, storage in roads can be implemented for the area immediately south of Woodham Burn. There is open floodplain alongside Woodham Burn which can be used to provide storage, if the water can be transferred from the urban setting to the river setting. This would require the formal overland flow paths to be instated.

The flat roof buildings on the industrial estate could retro-fit green roofs, however this is unlikely to be cost effective measure. It is essential that the ELR site, if developed, should implement source control measures wherever possible.

C.4.12 CRO1: Crook

In the case of Crook the area considered to be at risk of surface water is now larger than was previously the case when the SWRA was defined (Figures C4.15 and C.4.16) however the same areas are predicted to be affected in the exceedance events.

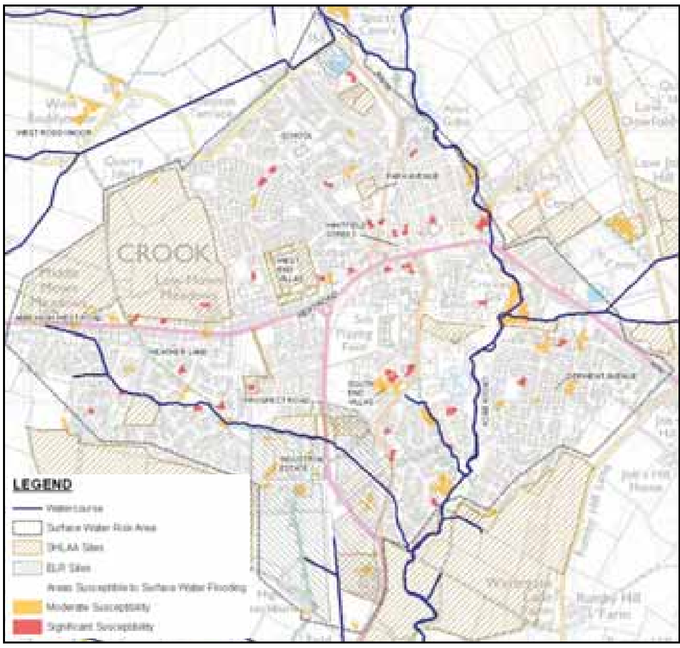


Figure C.4.15: CRO1: Areas Susceptible to Surface Water

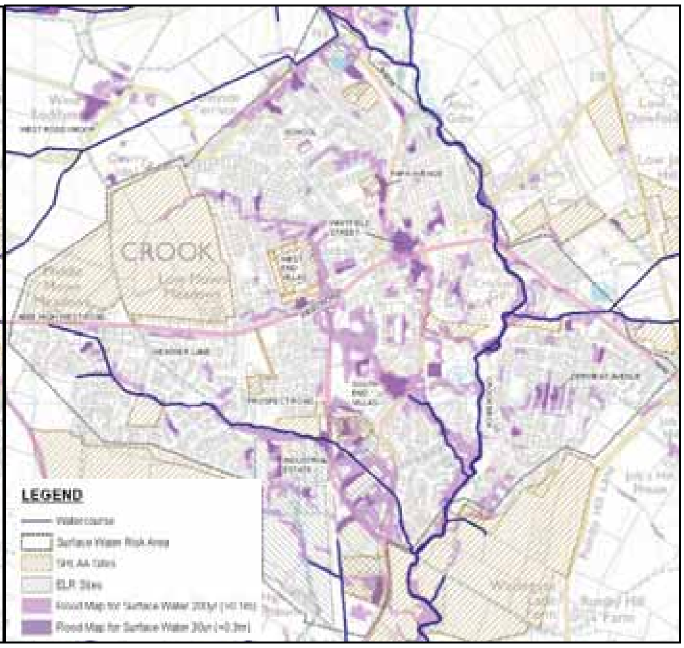


Figure C.4.16: CRO1: Flood Map for Surface Water

Crook Beck flows in a southerly direction across the eastern portion of the SWRA, refer Figure **60155102/OPTIONS/CRO1**, and several watercourses drain into Crook Beck throughout the study area, notably around South End Villas and Middle Mown Meadows. The topography of Crook slopes down toward the south east, where Crook Beck is located.

Crook is predominantly well developed, with room for extensive development around the periphery. 15 SHLAA sites and two ELR sites have been identified in and around Crook. 560 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Based on a simple assessment concerning generic flood damages and the number of properties falling within the 30 year and 200 year Surface Water Flood Maps, AADs have been estimated to be £626,000. The surface water map illustrates two flow paths which presumably follow topographic low points through the middle of Crook.

There have been eight known flood incidents, a number of which appear to be attributable to inadequate drainage into the watercourse running along Prospect Road which resulted in flooding to school playing fields and neighbouring gardens around Heather Lane. The A689, B6298, and A690 converge in the centre of Crook which act as barriers to the flow of surface runoff and cause surface water to back up behind these roads, affecting properties in Park Avenue, Whitfield Street, West Road and South End Villas.

Table C.4.9 presents the MCA, measures scoring five or higher have been highlighted as being appropriate for further consideration as part of the short listed measures. Measures scoring three or four have been identified as possible candidates that would be worth considering as part of a further assessment.

Table C.4.9: CRO1 MCA

	Mitigation Measure	Technical	Relative Cost	Economic	Social Impact	Environmental	Sustainability	Overall	Short List?
Source	Green Roofs	1	1	-1	2	1	2	6	Yes
	Soakaways/Infiltration	U							
	Attenuation/Storage	2	1	1	0	1	1	6	Yes
	Swales/Filter Drain	2	1	1	1	1	1	7	Yes
	Permeable Paving	1	-1	0	1	1	1	3	Maybe
	Rainwater Harvesting	1	0	-2	1	1	2	3	Maybe
Pathway	Increase Sewer Capacity	-1	-2	-1	0	-2	-2	-8	
	Separation of foul\surface water systems	U							
	Improve maintenance regime	2	2	-1	0	0	0	3	Maybe
	Flow/Storage on Roadway	2	1	1	-1	0	1	4	Maybe
	Manage overland flows	1	-1	1	-1	0	1	1	
	Improve channel capacity	-2	-2	-1	0	-1	-1	-7	
	Open up culverts	U							
	Improve Floodplain Storage	U							
Receptor	Improved weather warning	-2	-2	-2	0	0	2	-4	
	Planning policies / development control	2	2	2	0	0	2	8	Yes
	Improve Resilience and resistance	1	2	2	-1	0	0	4	Yes

C.4.12.1 Low & Middle Mown Meadows

The SHLAA site located to the north west of Crook on Low and Middle Mown Meadows provides significant opportunities to manage surface water runoff before it enters the urban area. Source control measures including green roofs, storage basins and swales ought to be considered as part of any development to provide benefits further downstream. Source control would also help to reduce the flux of diffuse urban pollutants to receiving watercourses from new development and may reduce the frequency of CSO spills from areas to the east. Crook Beck is not designated under the WFD until downstream of Crook (where it is named Beechburn Beck). At this point it is failing to meet its WFD target due to fish and because not all available mitigation has been implemented. Measures to treat additional urban runoff from new developments will as a minimum maintain the status quo and any reduction in the frequency of spills from CSOs will lead to improved water quality in receiving watercourses. The SHLAA sites to the north of West Road also present opportunities to manage surface water runoff. This would likely require formal overland flow paths being created along the roads to facilitate drainage away from residential areas. Development control and planning policies ought to implement these measures.

C.4.12.2 South End Villas

The runoff from Low and Middle Mown Meadows makes its way through Crook in the form of two overland flow paths following the topographic low points. South End Villas is identified as being particularly badly affected and in response to the risk it is proposed that the open green space at South End Villas ought to be landscaped so as to be able to provide storage during extreme events to limit water affecting properties. Additional potential opportunities would be to provide upstream storage in the playing fields to the north. Such measures will provide some treatment during higher storm events.

C.4.12.3 Whitfield Street

The area surrounding Whitfield Street is also identified as a key risk area however unlike South End Villas there is a lack of open space to be able to provide storage. Consequently the only real viable option would be to store water in the roads, which will also provide some treatment by helping to remove sediments and pollutants that may be attached to them (such as hydrocarbons and metals).

Any re-development of this area should introduce source control measures such as those described in **Section C.3**, such as green roofs, permeable paving, attenuation storage and rainwater harvesting.

Key Messages

560 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Average Annual Damages have been estimated at £626,000.

It is essential that the SHLAA site on Low and Middle Mown Meadows, if developed, should consider source control measures such as green roofs, storage basins and swales to provide benefits downstream. Similarly the SHLAA sites to the north of West Road also present opportunities to manage surface water runoff. This would likely require formal overland flow paths being created along the roads to facilitate drainage away from residential areas.

South End Villas is at surface water risk and it is proposed that the open green space at South End Villas is landscaped so as to provide storage during extreme events to limit water affecting properties. Additional potential opportunities would be to provide upstream storage in the playing fields to the north.

Due to a lack of open space at Whitfield Street, the only viable option would be to store water in the roads.

C.4.13 RAIL3: Railway Line – Ireshopeburn to Blackett's Gill

RAIL3 is located along a valley from Ireshopeburn to Blackett's Gill containing the River Wear and covers a length of 27km, refer **Figures 60155102/OPTIONS/RAIL3W, RAIL3C and RAIL3E**. There are several villages along the railway line at risk from surface water flooding, notably St John's Chapel, Westgate, Frosterley and Wolsingham which this assessment has focused upon. The surface water flood risk in RAIL3 has increased between the Areas Susceptible to Surface Water Flooding and the Flood Map for Surface Water (Figures C.4.17 – C.4.24).

The railway runs in an easterly direction from Ireshopeburn through the villages and Blackett's Gill and past the town of Bishop Auckland, joining railways lines at Newton Aycliffe. RAIL3 is the rail section that runs through the rural hinterland and is surrounded by steep valley sides to the north and less inclined hillsides to the south. The River Wear runs parallel to the railway. Overland flows run into the River Wear in a south easterly direction from the north and a north easterly direction from the south where the railway and villages reside.

There are 30 potential development sites within the SWRA. These SHLAA and ELR sites should be assessed prior to development due to their close proximity to the River Wear, known incidents and future surface water hotspots.

RAIL3 has experienced 26 known flood incidents the cause of which is a mix of highway issues, overland flow from local fields and overland flow after heavy rainfall. Durham County Council engineers advised that Northumbrian Water has undertaken upsizing of the sewer system and removed Combined Sewer Overflows to alleviate the problems.

384 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Based on a simple assessment concerning generic flood damages and the number of properties falling within the 30 year and 200 year Surface Water Flood Maps, AADs have been estimated to be £368,000. The railway and three main roads (A689, B6278 and B6296) are critical infrastructure at risk from flooding.

Table C.4.10 presents the MCA, measures scoring five or higher have been highlighted as being appropriate for further consideration as part of the short listed measures. Measures scoring three or four have been identified as possible candidates that would be worth considering as part of a further assessment.

Table C.4.10: RAIL3 MCA

	Mitigation Measure	Technical	Relative Cost	Economic	Social Impact	Environmental	Sustainability	Overall	Short List?
Source	Green Roofs	2	0	-2	2	2	2	6	Yes
	Soakaways/Infiltration	1	0	1	2	1	1	6	Yes
	Attenuation/Storage	2	1	1	1	1	1	7	Yes
	Swales/Filter Drain	1	0	1	1	1	1	5	Yes
	Permeable Paving	1	-1	0	1	1	1	3	Maybe
	Rainwater Harvesting	1	0	-2	1	1	2	3	Maybe
Pathway	Increase Sewer Capacity	0	-2	-1	0	-2	-2	-7	
	Separation of foul\surface water systems	0	-2	0	0	1	2	1	
	Improve maintenance regime	2	0	-1	0	0	0	1	
	Flow/Storage on Roadway	2	1	1	0	0	1	5	Yes
	Manage overland flows	2	1	2	-1	0	1	5	Yes
	Improve channel capacity	-2	-2	1	1	0	0	-2	
	Open up culverts	-2	-2	-1	2	2	2	1	
	Improve Floodplain Storage	0	1	-1	1	2	2	5	Yes
Receptor	Improved weather warning	-2	-2	-2	0	0	2	-4	
	Planning policies / development control	2	2	2	0	0	2	8	Yes
	Improve Resilience and resistance	1	2	2	-1	0	0	4	Yes

The villages along the River Wear are at risk from surface water from upland areas flowing overland through the villages. This will be best managed by intercepting water outside of the village areas and diverting it towards the River Wear. There are several examples of this is occurring, namely at Leazes Lane and Durham Road in Wolsingham, Hood Street in St John's Chapel and at Front Street in Westgate and Frosterley. Surface water reaching these areas has no formal flow path to reach the River Wear as the presence of roads and urban settlements has interrupted any natural flow path. While sewers and culverts are capable of handling small flows, their capacity can be exceeded (or become blocked) and risk flooding surrounding areas. Therefore, external watercourses should be diverted around vulnerable areas and directed into the River Wear.

At each village, the surface water flood risk has changed significantly between the Areas Susceptible to Surface Water Flooding and the Flood Map for Surface Water (Figures C.4.17– C.4.24).

C.4.13.1 RAIL3 West: St John's Chapel & Westgate

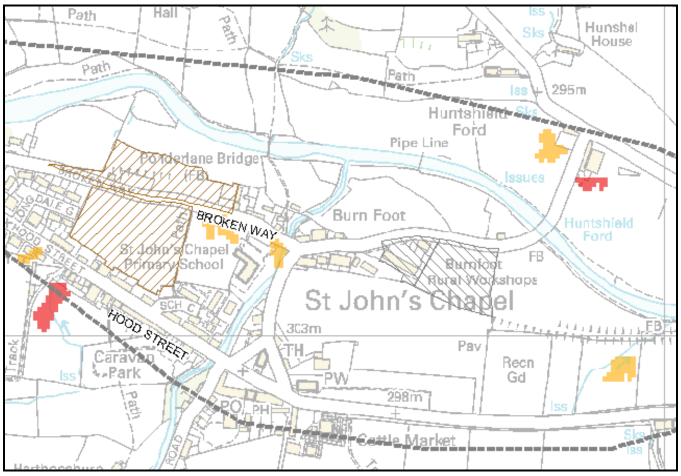


Figure C.4.17: St John's Chapel Areas Susceptible to Surface Water

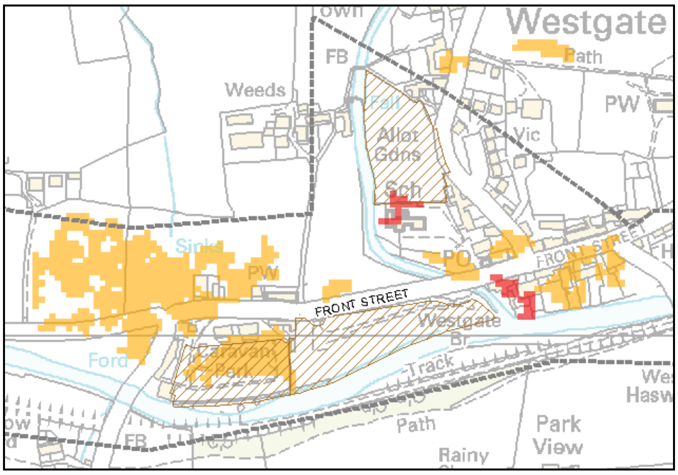


Figure C.4.18: Westgate Areas Susceptible to Surface Water

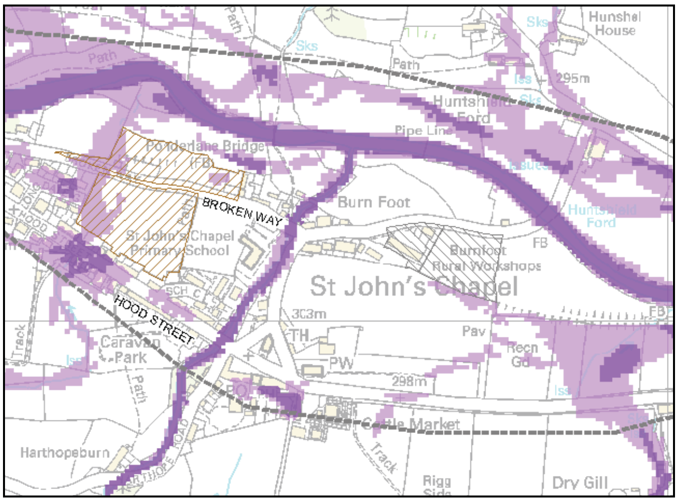


Figure C.4.19: St John's Chapel Flood Map for Surface Water

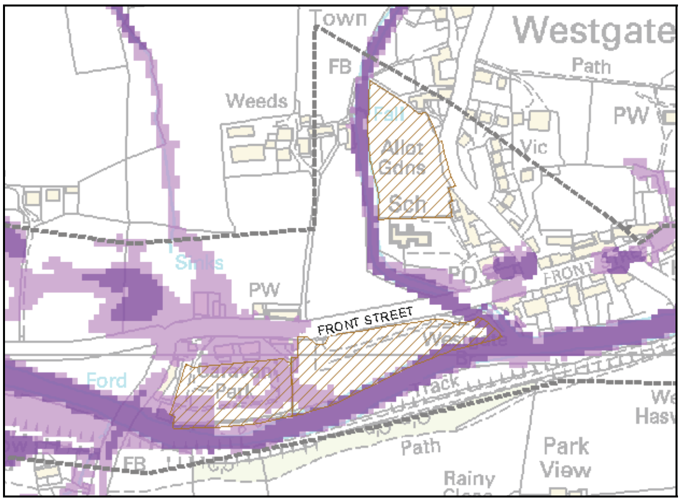


Figure C.4.20: Westgate Flood Map for Surface Water

The SHLAA and ELR sites in St John's Chapel and Westgate could be developed to include storage areas, swales, green roofs to help manage the risks of surface water flooding, as described in **Section C.3**. Alternatively, the development proposed for north of Hood Street in St John's Chapel could be developed to accommodate a formal overland flow path on the western side or storage along the road near the caravan park. This would alleviate the surface water flood risk to the south of Hood Street.

A dismantled railway to east of St John's Chapel appears to be impacting on preventing overland flow. An additional culvert or demolition of a portion of embankment would alleviate the surface water risk in this area and reduce surface water ponding.

Similarly, the proposed developments within Westgate could formalise a flow path around the existing caravan park. There is the opportunity to provide storage along Front Street and an overland flow path on the western side of SHLAA area. Incorporated into future capital renewal surfacing works, this would involve roadway re-grading and profiling of the carriageway profile to provide overland flow paths out of the area.

Capabilities on project:
Water

C.4.13.2: RAIL3 Central: Frosterley

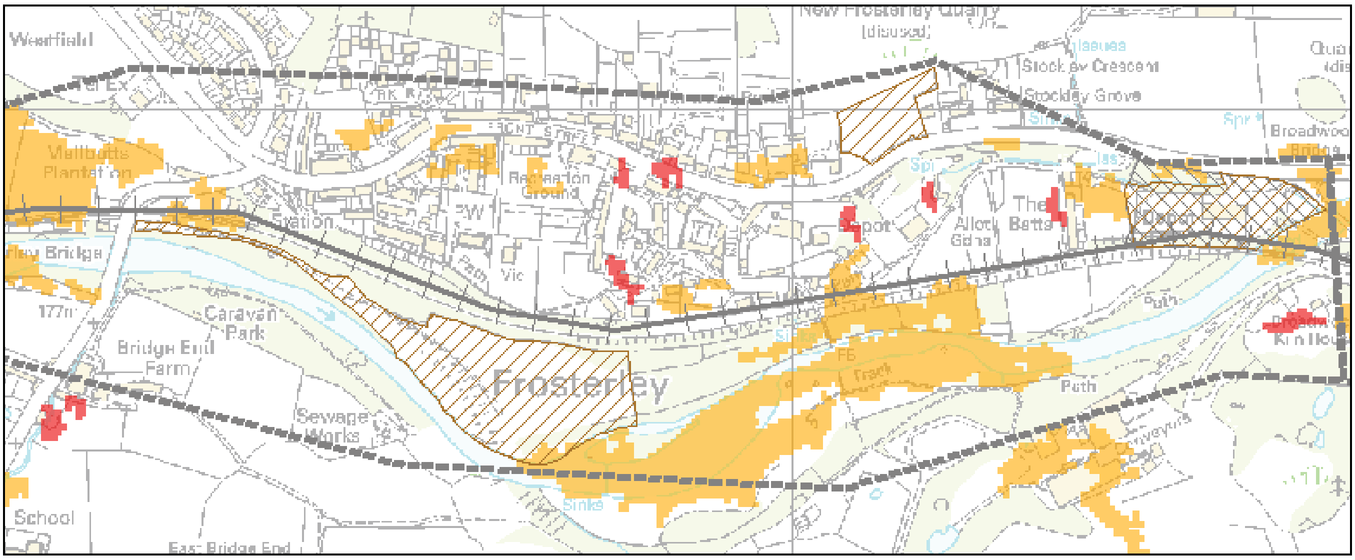


Figure C.4.21: Frosterley Areas Susceptible to Surface Water

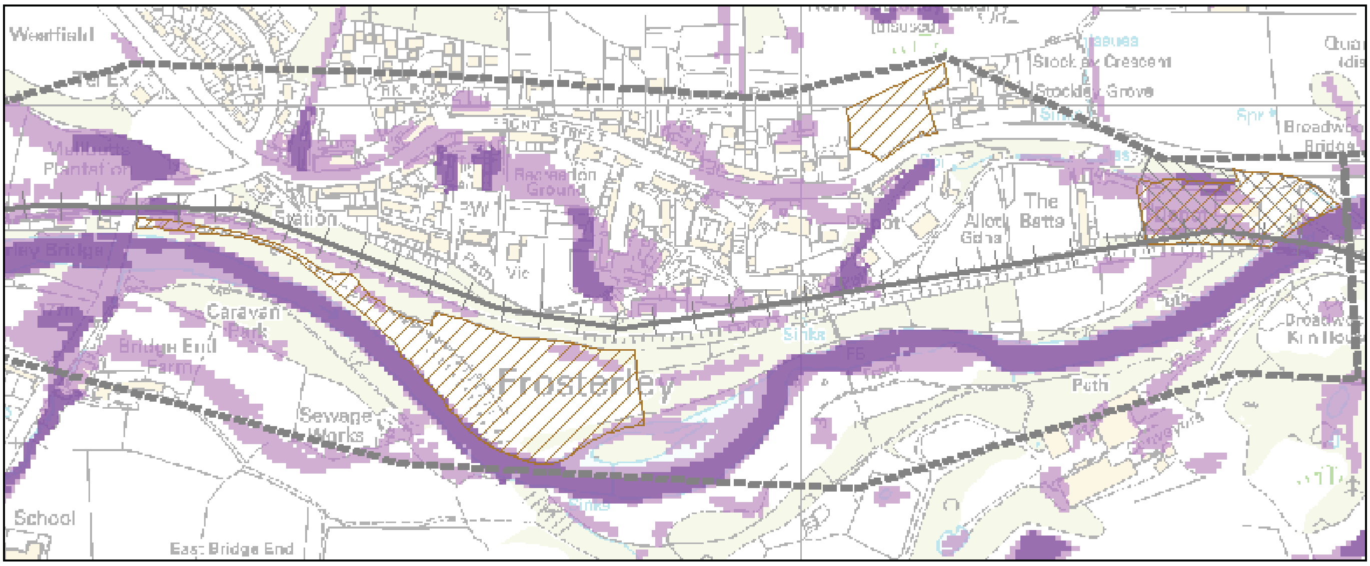


Figure C.4.22: Frosterley Flood Map for Surface Water

The three SHLAA sites in Frosterley could be developed to include storage areas, swales, green roofs to help manage the risks of surface water flooding, encouraged through planning policies and development control. Alternatively, the SHLAA site south of the railway lies adjacent to the River Wear and could be used as floodplain storage in the form of ponds or wetlands.

The active railway that runs through Frosterley appears to be impacting on preventing overland flow, causing surface water ponding at a depot. A culvert would allow the water to pass underneath the railway and into the River Wear to the south. The SHLAA area could alternatively be used for storage in the form of a pond or a wetland.

There is the opportunity to provide storage along the roadway at Front Street or storage in the recreation ground and swales along the plantation at Frosterley Bridge. As per RAIL3 West, roadway re-grading and profiling of the carriageway profile would be required to provide overland flow paths out of the area.

C.4.13.3: RAIL3 East: Wolsingham

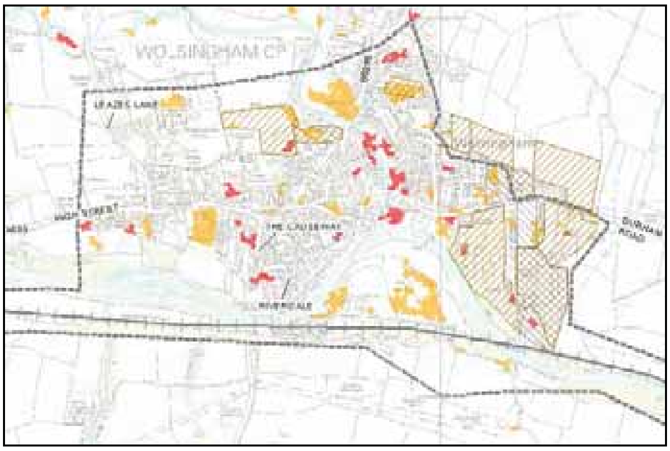


Figure C.4.23: Wolsingham Areas Susceptible to Surface Water

Figure C.4.24: Wolsingham Flood Map for Surface Water

In the Wolsingham area development sites offer the opportunity to implement a suite of source control measures such as green roofs, storage, swales and possibly rainwater harvesting and permeable paving. It may be possible to put swales or filter drains in the residential areas to intercept flows coming off the hill; however the SHLAA sites are not directly linked to the main surface water risk area that affects Leaze's Lane, The Causeway and Riverdale. It may be possible to channel overland flows from the risk area into storage areas in the SHLAA sites.

An alternative is to improve resilience and resistance or storage of water in roads along Leaze's Lane, High Street, The Causeway and Riverdale. Kerbing could be used to contain and attenuate surface waters in these areas until the combined sewer system has capacity. There is also the ability to provide storage between Leaze's Lane and the High Street to alleviate risk in this SWRA.

There is an overland flow path running along the B6296. Two options would include storage of water along the roadway until it feeds into the River Wear, or to utilise the SHLAA site to the east as storage in the form of a pond or wetland.

The railway along Wolsingham is an active line and there is shallow flooding affecting the railway line in the 200 year Flood Map for Surface Water. There is the opportunity to provide a formal overland pathway in the form of a swale or filter drain to the River Wear.

There is the potential for water quality improvements in receiving watercourses in locations where surface water runoff is attenuated before flowing into combined sewers (i.e. reduced spillages from CSOs). In addition, where new development sites are located the provision of SuDS would effectively treat any new source of diffuse urban pollution ensuring the status quo is maintained as a minimum.

Capabilities on project:
Water

Key Messages

RAIL3 has experienced 26 known flood incidents the cause of which is a mix of highway issues, overland flow from local fields and overland flow after heavy rainfall from upland areas. Durham County Council engineers advised that Northumbrian Water has undertaken upsizing of the sewer system and removed Combined Sewer Overflows to alleviate the problems. The railway and the A689, B6278 and B6296 are at risk from flooding. 384 properties fall within the Environment Agency's Flood Map for Surface Water for the 200 year event. Average Annual Damages have been estimated at £368,000.

If developed, it is essential that the SHLAA and ELR sites in St John's Chapel and Westgate should consider implementing source control measures such as storage areas, swales, green roofs to help manage the risks of surface water flooding. Alternatively, the development proposed for north of Hood Street (St John's Chapel) could be developed to accommodate a formal overland flow path on the western side or storage along the road near the caravan park. Removing a section of dismantled railway may reduce surface water ponding in the area. In Westgate there is the potential for storage along Front Street or formalising a flow path around the caravan park.

If developed, it is essential the three SHLAA sites in Frosterley or the SHLAA site to the south of the railway consider implementing source control measures. Storage along Front Street is a possibility and a culvert may be required under the active railway to alleviate the surface water risk in the area.

In Wolsingham it may be possible to channel overland flows from the risk area into SHLAA sites (storage). An alternative is to improve resilience and resistance or storage of water in roads along Leaze's Lane, High Street, The Causeway and Riverdale. Kerbing could be used to contain and attenuate surface waters in these areas until the combined sewer system has capacity. There is also the ability to provide storage between Leaze's Lane and the High Street to alleviate risk. There is an overland flow path running along the B6296. Two options would include storage of water along the roadway until it feeds into the River Wear, or to utilise the SHLAA site to the east as storage in the form of a pond or wetland. The railway along Wolsingham is an active line and there is shallow flooding affecting the railway line. One measure could be the provision of a formal overland pathway in the form of a swale or filter drain to the River Wear.

C.5 Summary of Surface Water Risk Areas

C.5.1 Surface Water Risk Areas

The estimated AADs for each SWRA is presented along with a summary of each area in Table C.5.1 in the order they appeared in section C.4, and in Table C.5.2 in their ranked order. Further detailed assessment of the SWRAs will need to identify options that will reduce AAD more than the measures initial capital expenditure (CAPEX) and ongoing maintenance costs (OPEX). To aid comparison between SWRAs the AAD per area (£/y/ha) of flooding as predicted by the SFRA surface water modelling has been ranked (with 1 being the highest damage ranking).

Table C.5.1: Summary of Surface Water Risk Areas by Location

SWRA	Area (ha)	Degree of Urbanisation	Known Incidences	Properties at Risk		Area of Flood Risk (ha)		Estimated AAD (£/y)	Damage Ranking
				30yr	200yr	30yr	200yr		
STA3	31	93%	15	12	93	0	3	£ 95,000	1
CLS2	42	37%	8	3	35	1	7	£ 45,000	2
CLS3	92	95%	6	1	82	0	4	£ 81,000	5
DC1	133	99%	2	4	97	2	11	£ 108,000	8
DC8	422	75%	57	60	585	3	32	£ 610,000	6
NEW1	1,125	74%	5	19	707	7	90	£ 793,000	7
BIS3	242	43%	8	46	296	7	40	£ 365,000	4
CRO1	271	73%	8	97	563	7	37	£ 626,000	3
RAIL3	844	15%	26	45	384	123	326	£ 368,000	9

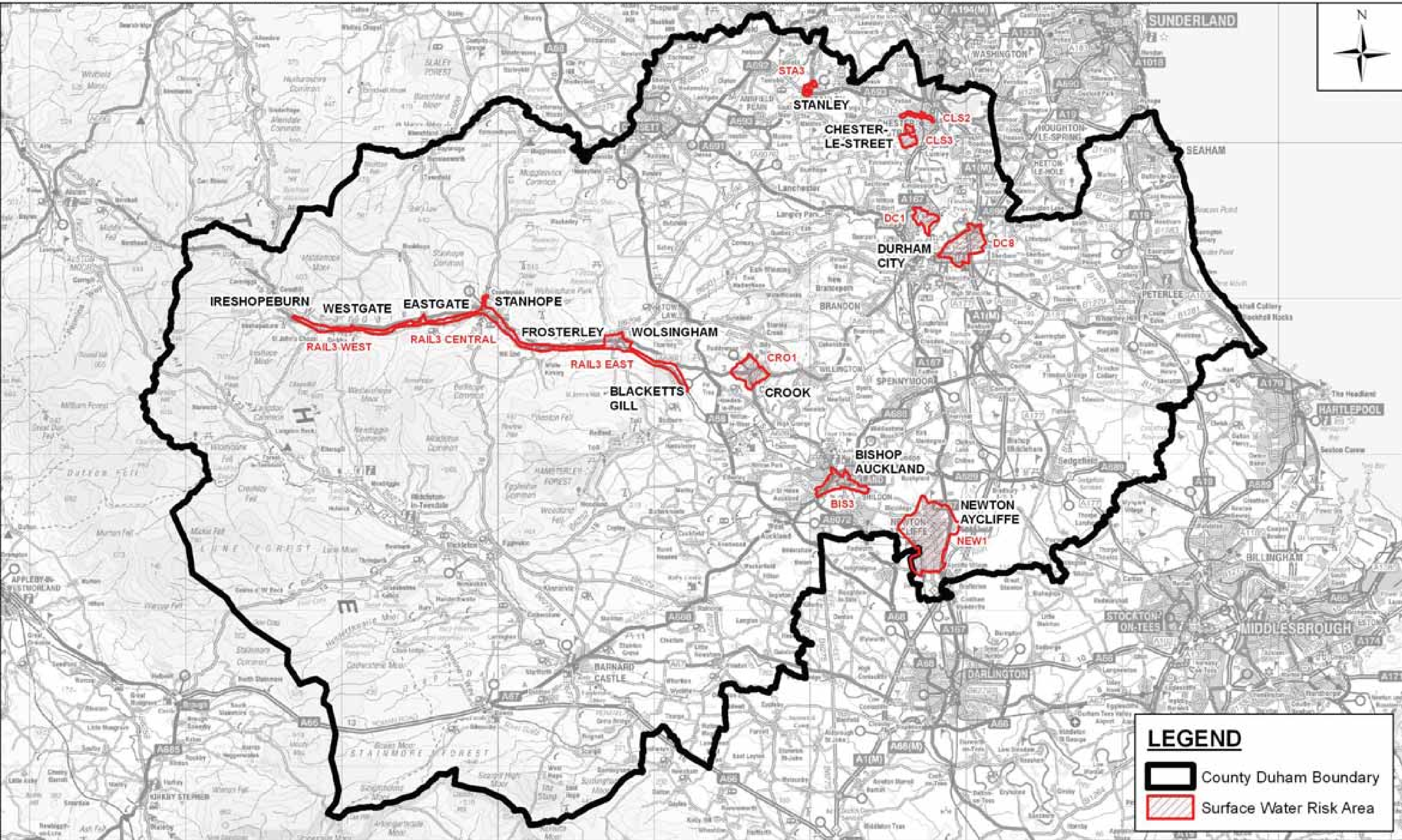
Table C.5.2: Summary of Surface Water Risk Areas by Rank

SWRA	Area (ha)	Degree of Urbanisation	Known Incidences	Properties at Risk		Area of Flood Risk (ha)		Estimated AAD (£/y)	Damage Ranking
				30yr	200yr	30yr	200yr		
STA3	31	93%	15	12	93	0	3	£ 95,000	1
CLS2	42	37%	8	3	35	1	7	£ 45,000	2
CRO1	271	73%	8	97	563	7	37	£ 626,000	3
BIS3	242	43%	8	46	296	7	40	£ 365,000	4
CLS3	92	95%	6	1	82	0	4	£ 81,000	5
DC8	422	75%	57	60	585	3	32	£ 610,000	6
NEW1	1,125	74%	5	19	707	7	90	£ 793,000	7
DC1	133	99%	2	4	97	2	11	£ 108,000	8
RAIL3	844	15%	26	45	384	123	326	£ 368,000	9

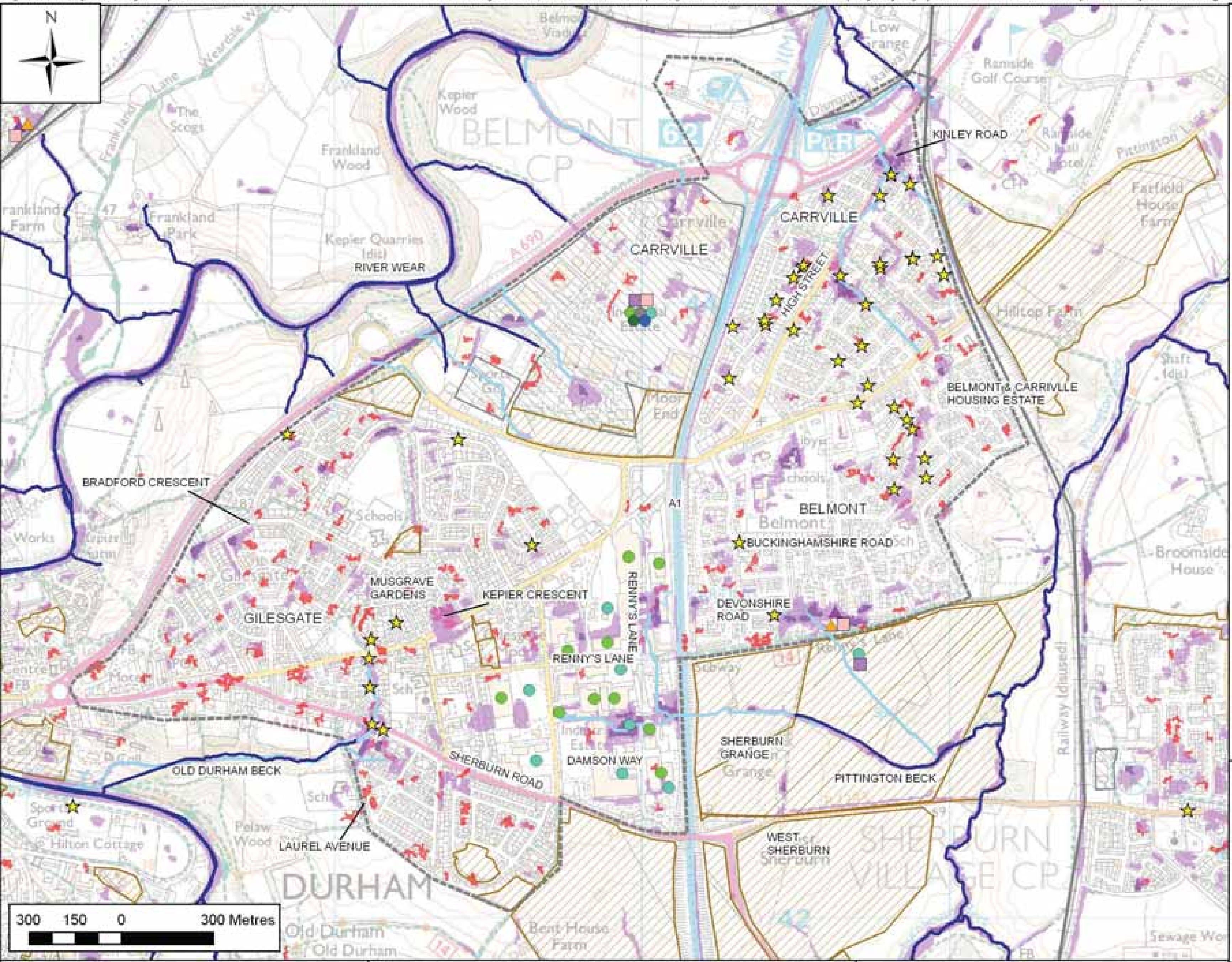
While limited information about proposed development is available, if the Partners decide to take any of the SWRA sites forward to implement measures to manage the risk of surface water flooding, the next phase should identify measures that are cost effective at reducing surface water flood risk. At this stage, it would be inappropriate to prescribe specific options as a more thorough and detailed examination of the existing situation is required. As such, the information provided within this report is only intended to indicate the measures of a possible solution could be implemented to reduce surface water flood risk.

The shortlisted measures identified in this report should serve as the starting point for the Partners and is dependent on more detail becoming available. The measures outlined here will help Partners agree the preferred option for managing surface water flood risk. However, this report should remain as a living document as more detail will become available concerning the changes and future of each.

ANNEX C1 – OPTION FIGURES



Client: DURHAM COUNTY COUNCIL	Title: SURFACE WATER RISK AREAS OPTIONS PHASE	AECOM	Design: ARP	Drawn: ARP
			Chk'd: LM	App'd: GK
Project: DURHAM SWMP		5th Floor, 2 City Walk, LEEDS, LS11 9AR — Tel: +44 (0) 113 391 6800 Fax: +44 (0) 113 391 6899 www.aecom.com	Date: FEB '11	Scale: 1:225,000
			Drawing Number: 60155102/PHASE3/1.1	A3



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage
- Soakaway / Infiltratioı
- Green Roof

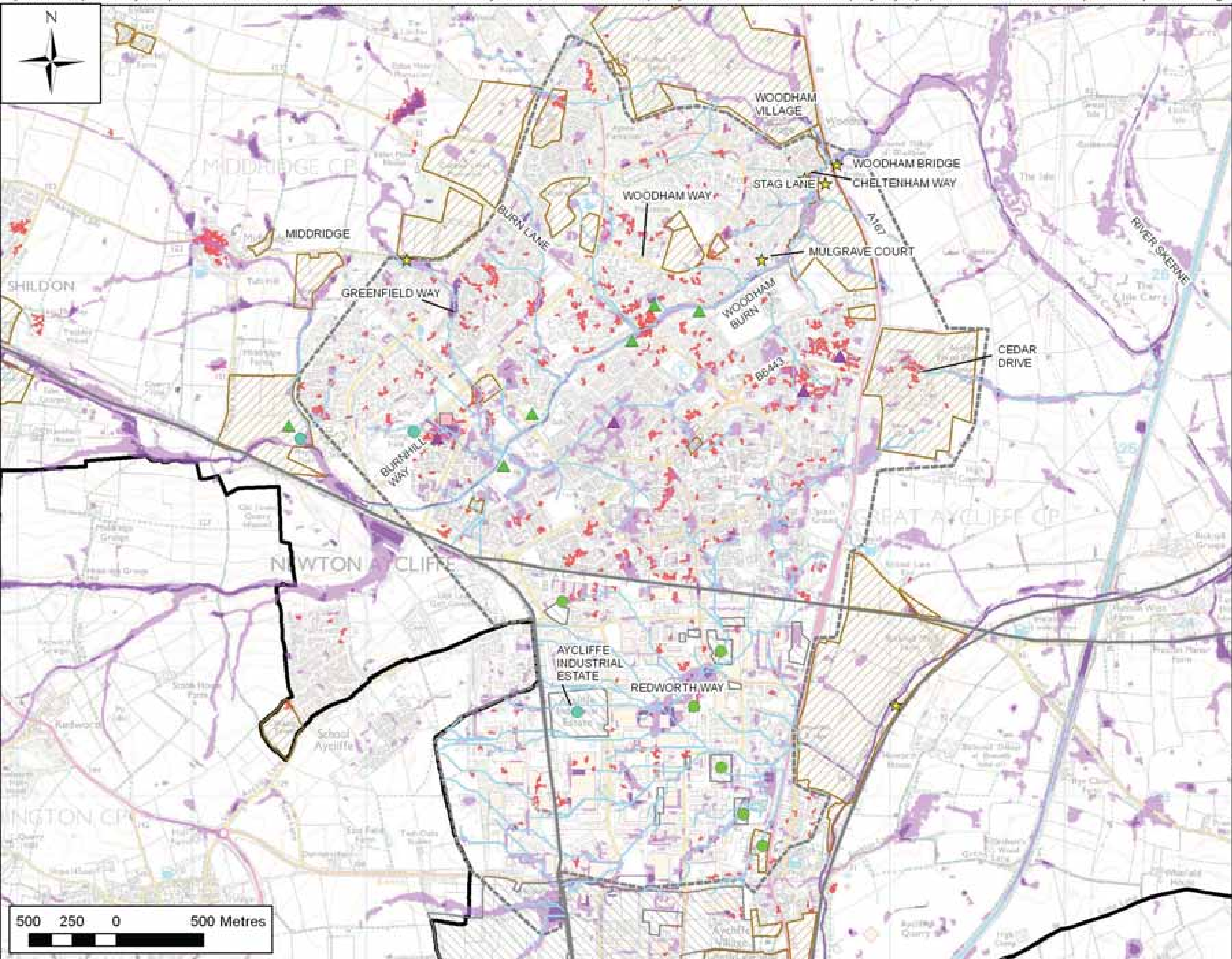
NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client: DURHAM COUNTY COUNCIL	Title: DC8 - DURHAM CITY DRAINAGE STRATEGY OPTIONS KEY COMPONENTS	Design: ARP	Drawn: ARP
Project: DURHAM SWMP		Chk'd: LM	App'd: CSL
		Date: APRIL 2011	Scale: 1:13000
		Drawing Number: 60155102/OPTIONS/DC8	A3

AECOM
5th Floor,
2 City Walk,
LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage
- Soakaway / Infiltratio
- Green Roof

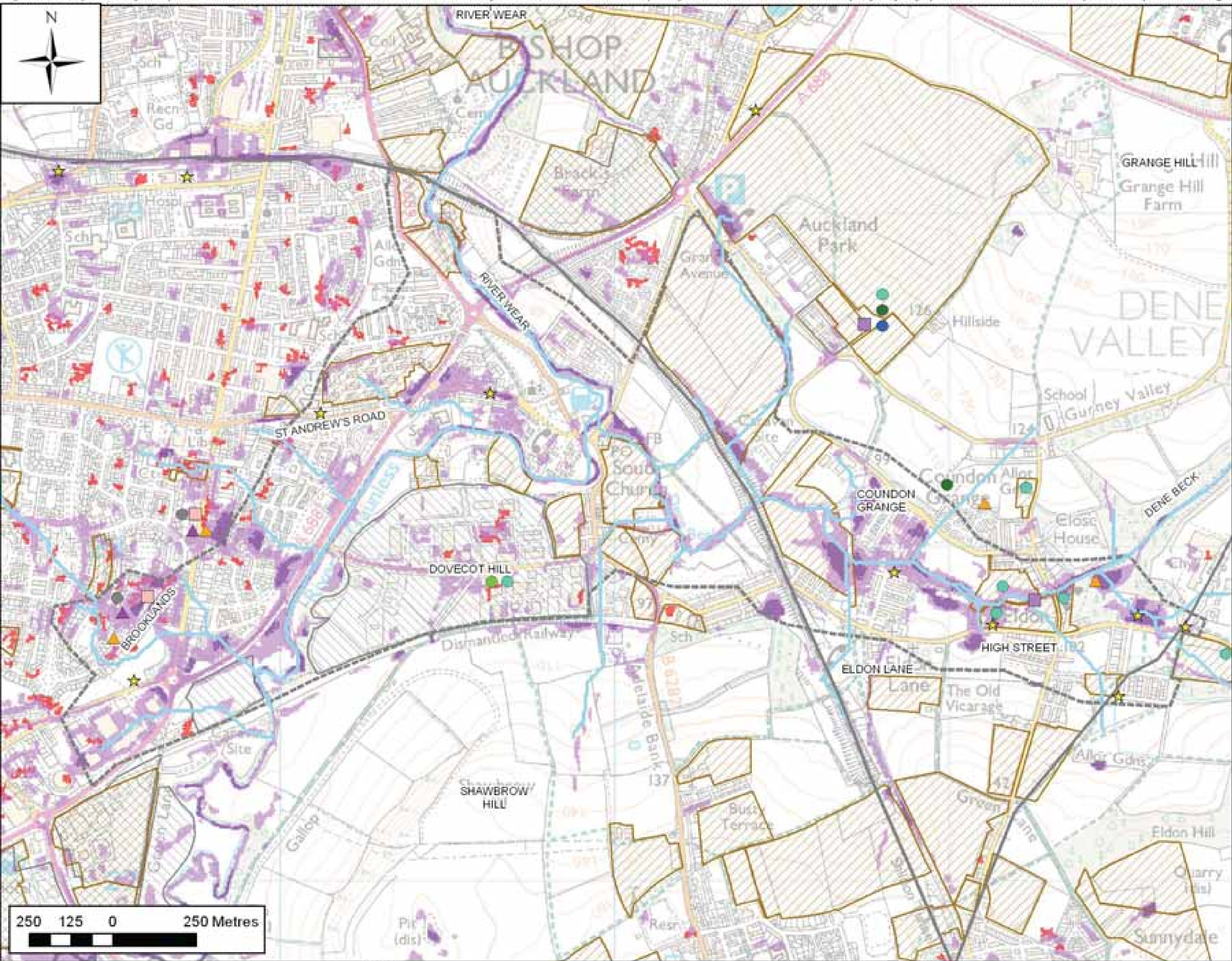
NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client: DURHAM COUNTY COUNCIL	Title: NEW1 - NEWTON AYCLIFFE DRAINAGE STRATEGY OPTIONS KEY COMPONENTS	Design: ARP	Drawn: ARP
		Chk'd: LM	App'd: CSL
Project: DURHAM SWMP		Date: APRIL 2011	Scale: 1:23000
		Drawing Number: 60155102/OPTIONS/NEW1	A3

AECOM
5th Floor,
2 City Walk,
LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage
- Soakaway / Infiltratioi
- Green Roof

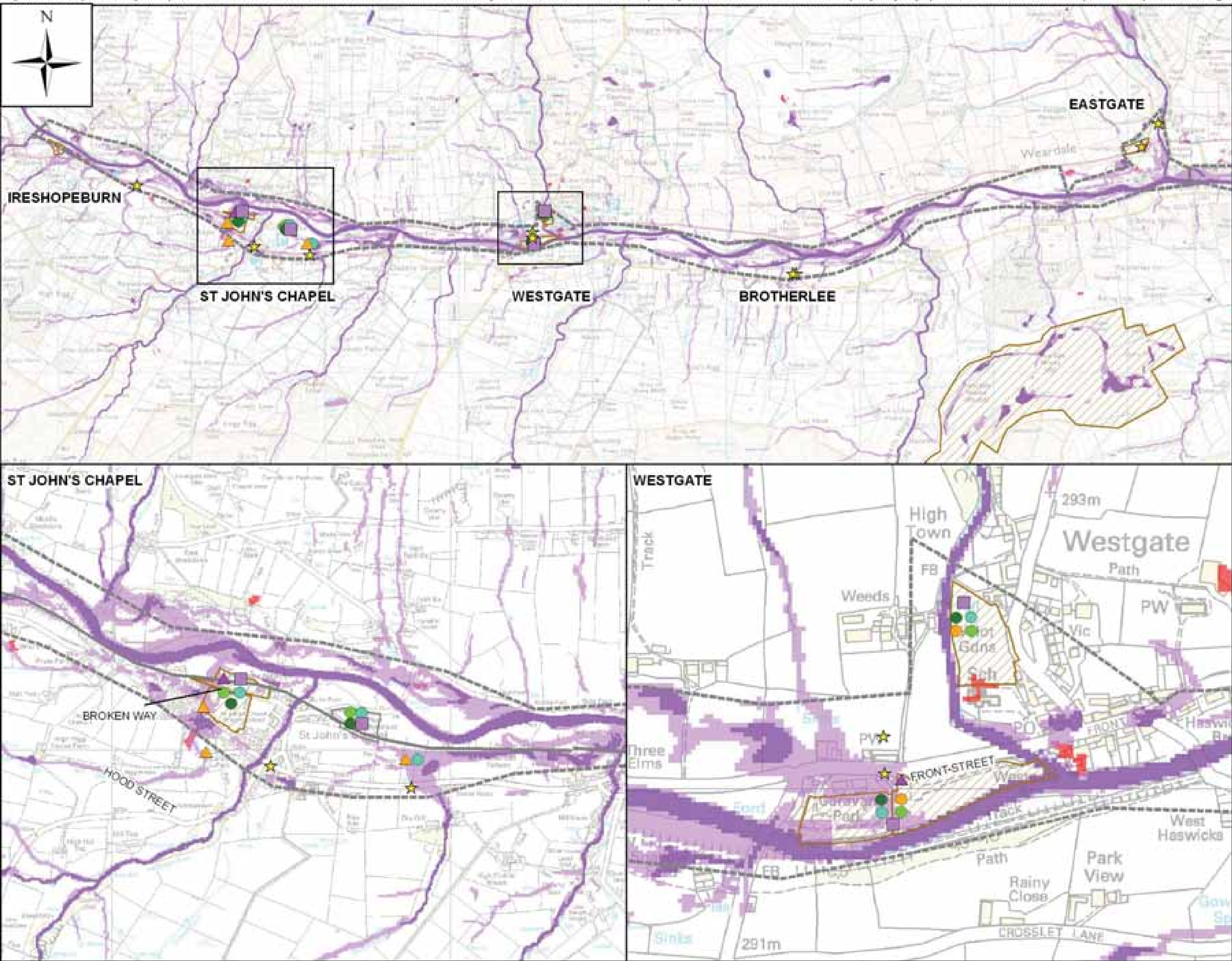
NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client:	DURHAM COUNTY COUNCIL
Project:	DURHAM SWMP
Title:	BIS3 - BISHOP AUCKLAND DRAINAGE STRATEGY OPTIONS KEY COMPONENTS
Design:	ARP
Drawn:	ARP
Chk'd:	LM
App'd:	CSL
Date:	APRIL 2011
Scale:	1:12000
Drawing Number:	60155102/OPTIONS/BIS3
Size	A3

AECOM
5th Floor,
2 City Walk,
LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage
- Soakaway / Infiltratioi
- Green Roof

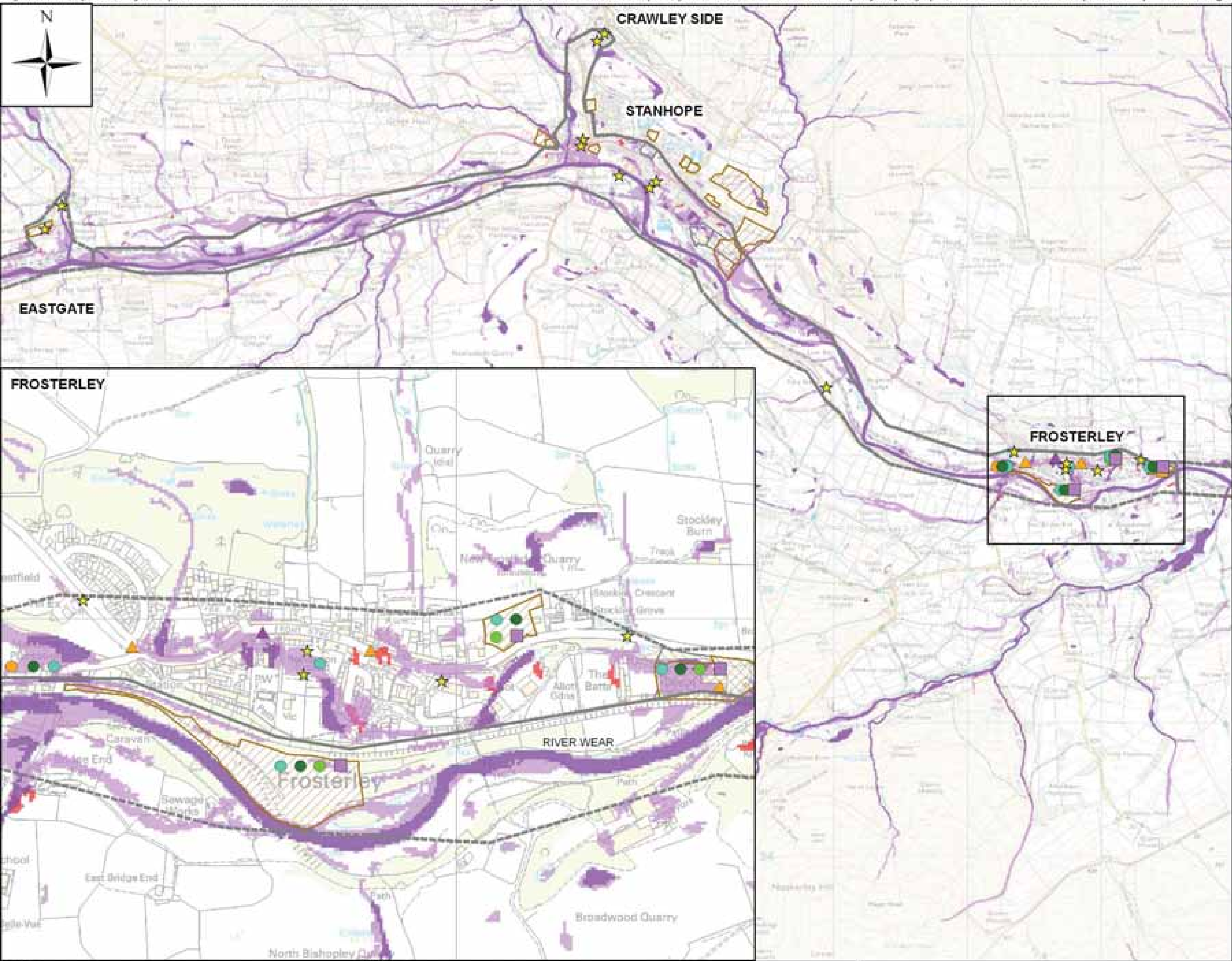
NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client: DURHAM COUNTY COUNCIL	Title: RAIL3 - WESTERN SECTION IRESHOPEBURN TO EASTGATE DRAINAGE STRATEGY OPTIONS KEY COMPONENTS	AECOM	Design: ARP / Drawn: ARP
Project: DURHAM SWMP			Chk'd: LM / App'd: CSL
			Date: APRIL 2011 / Scale: 1:30000
			Drawing Number: 60155102/OPTIONS/RAIL3W / A3

5th Floor,
2 City Walk,
LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage
- Soakaway / Infiltratio
- Green Roof

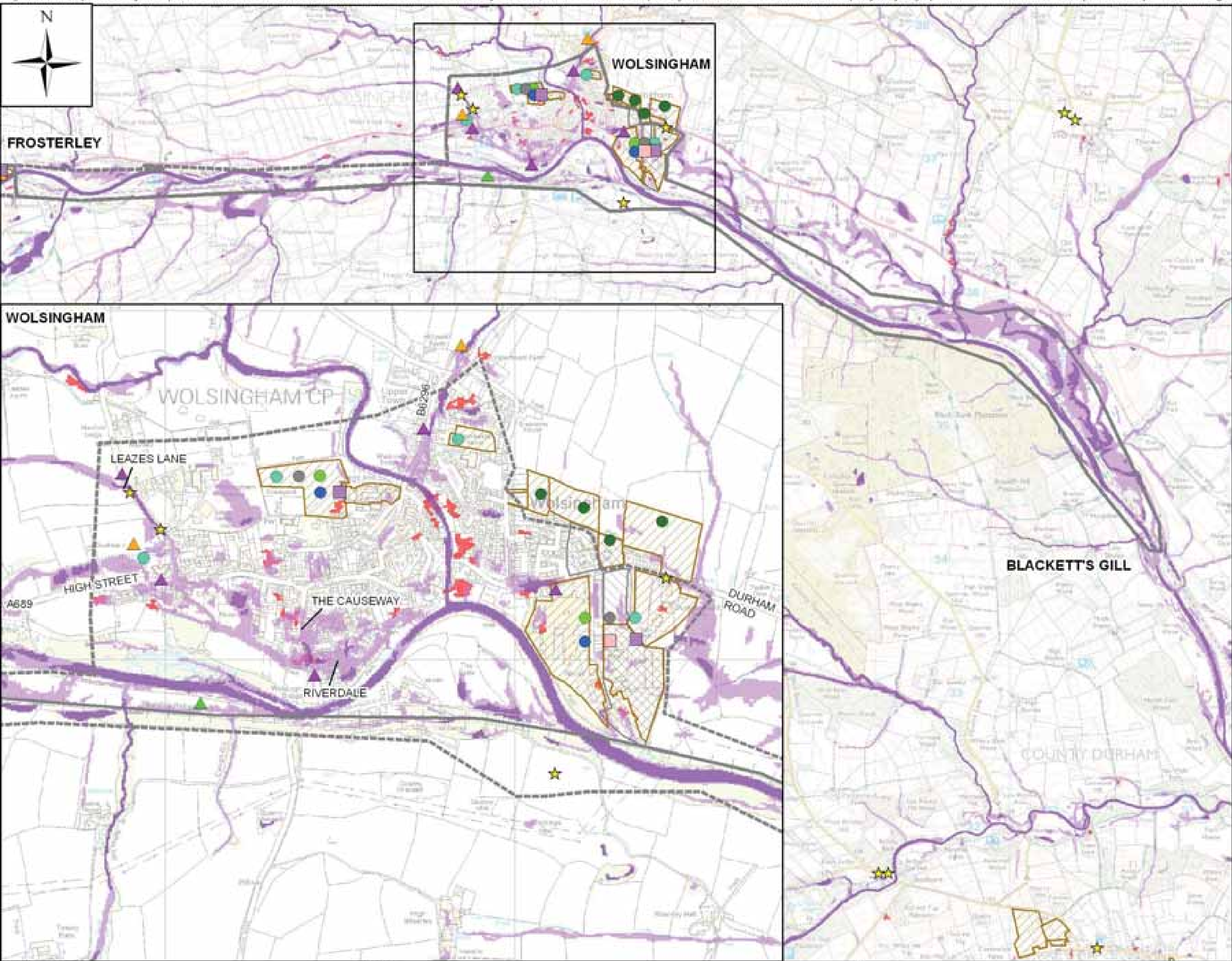
NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client: DURHAM COUNTY COUNCIL	Title: RAIL3 - CENTRAL SECTION EASTGATE TO FROSTERLEY DRAINAGE STRATEGY OPTIONS KEY COMPONENTS	Design: ARP	Drawn: ARP
		Chk'd: LM	App'd: CSL
Project: DURHAM SWMP		Date: APRIL 2011	Scale: 1:30000
		Drawing Number: 60155102/OPTIONS/RAIL3C	A3

AECOM
5th Floor,
2 City Walk,
LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage
- Soakaway / Infiltratioı
- Green Roof

NOTES:

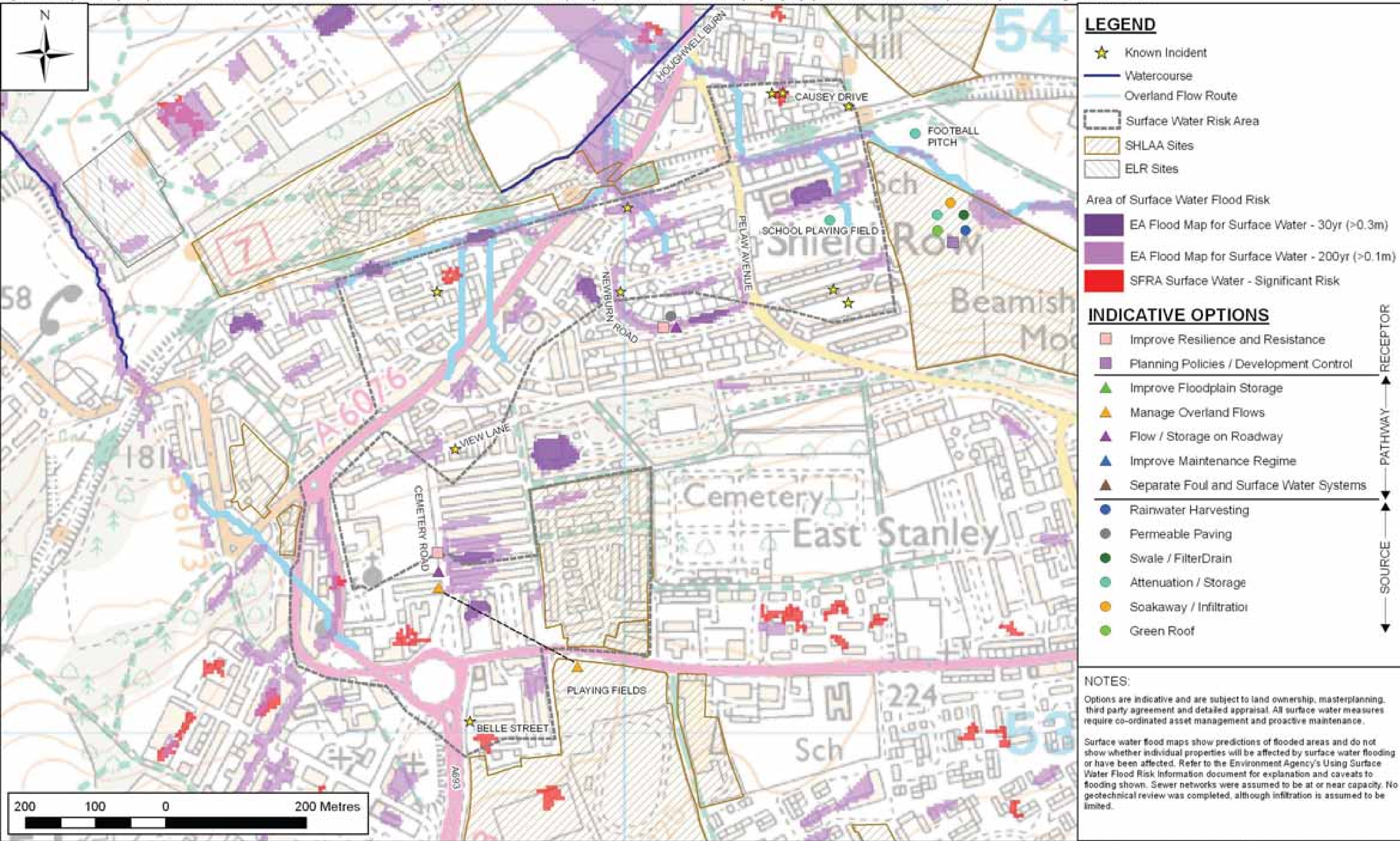
Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client: DURHAM COUNTY COUNCIL	Title: RAIL3 - EASTERN SECTION FROSTERLEY TO BLACKETT'S GILL DRAINAGE STRATEGY OPTIONS KEY COMPONENTS
Project: DURHAM SWMP	

AECOM
5th Floor,
2 City Walk,
LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com

Design:	ARP	Drawn:	ARP
Chk'd:	LM	App'd:	CSL
Date:	APRIL 2011	Scale:	1:30000
Drawing Number:	60155102/OPTIONS/RAIL3E		A3



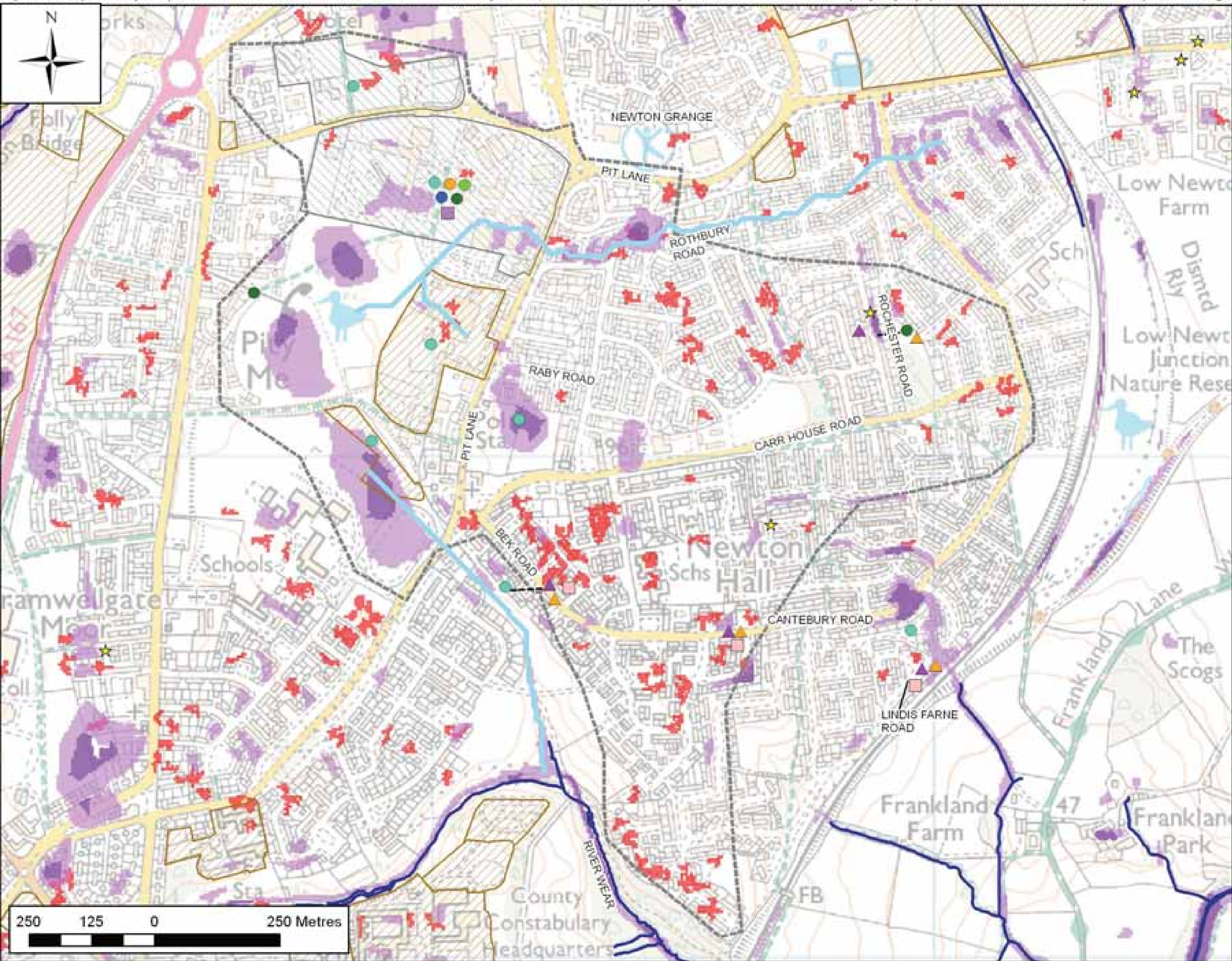
NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client:	DURHAM COUNTY COUNCIL
Project:	DURHAM SWMP
Title:	STA3 - EAST STANLEY DRAINAGE STRATEGY OPTIONS KEY COMPONENTS
Design:	ARP
Drawn:	ARP
Chk'd:	LM
App'd:	CSL
Date:	APRIL 2011
Scale:	1:5000
Drawing Number:	60155102/OPTIONS/STA3
Size	A3

AECOM
5th Floor,
2 City Walk,
LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

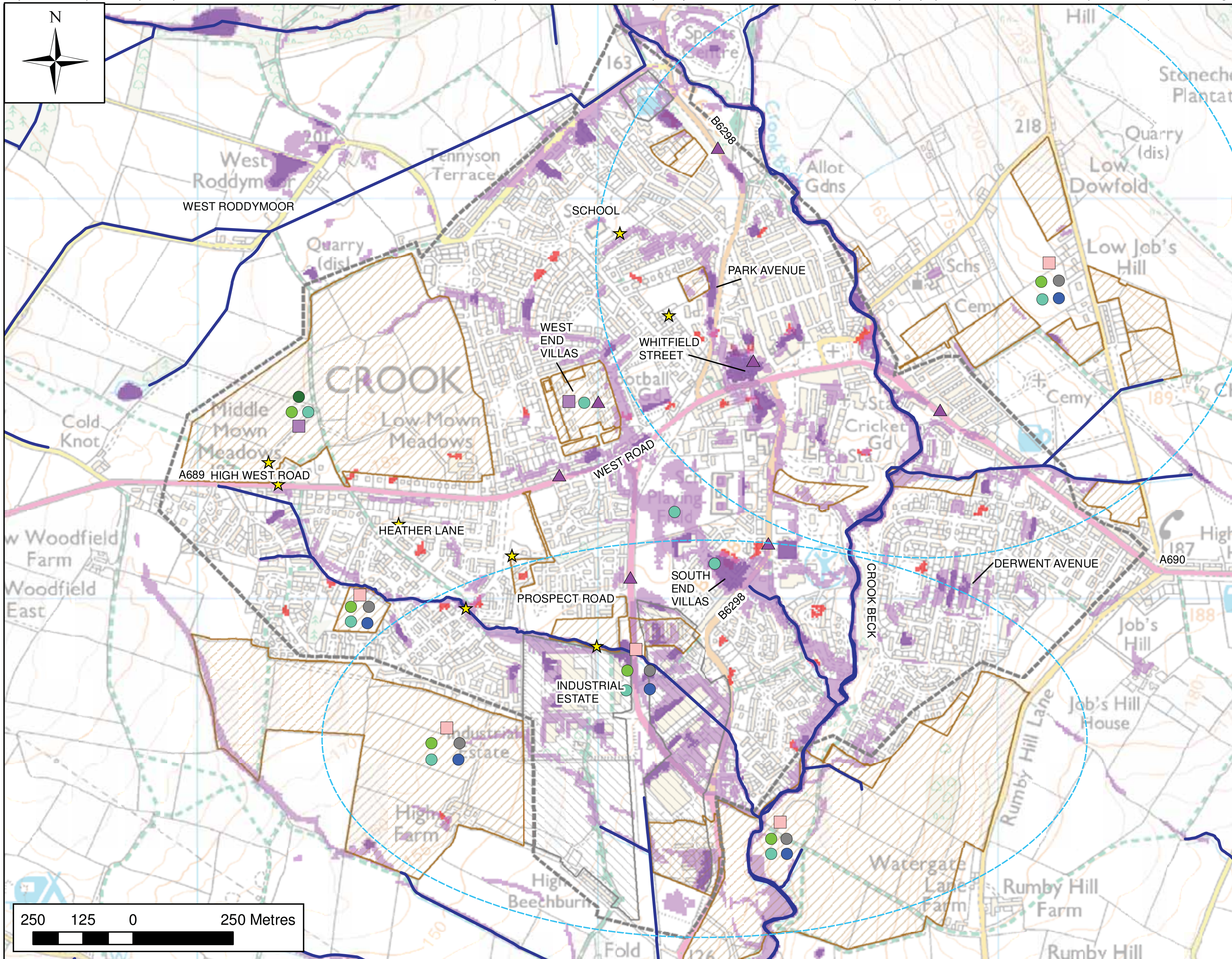
SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage
- Soakaway / Infiltratio
- Green Roof

NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client: DURHAM COUNTY COUNCIL	Title: DC1 - DURHAM CITY DRAINAGE STRATEGY OPTIONS KEY COMPONENTS	AECOM 5th Floor, 2 City Walk, LEEDS, LS11 9AR Tel: +44 (0) 113 391 6800 Fax: +44 (0) 113 391 6899 www.aecom.com	Design: ARP	Drawn: ARP	
			Chk'd: LM	App'd: CSL	
Project: DURHAM SWMP			Date: APRIL 2011	Scale: 1:8000	
			Drawing Number: 60155102/OPTIONS/DC1		A3



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage (including kerbing)
- Soakaway / Infiltratio
- Green Roof

- Area where SHLAA and ELR Sites would benefit from Source Control Measures

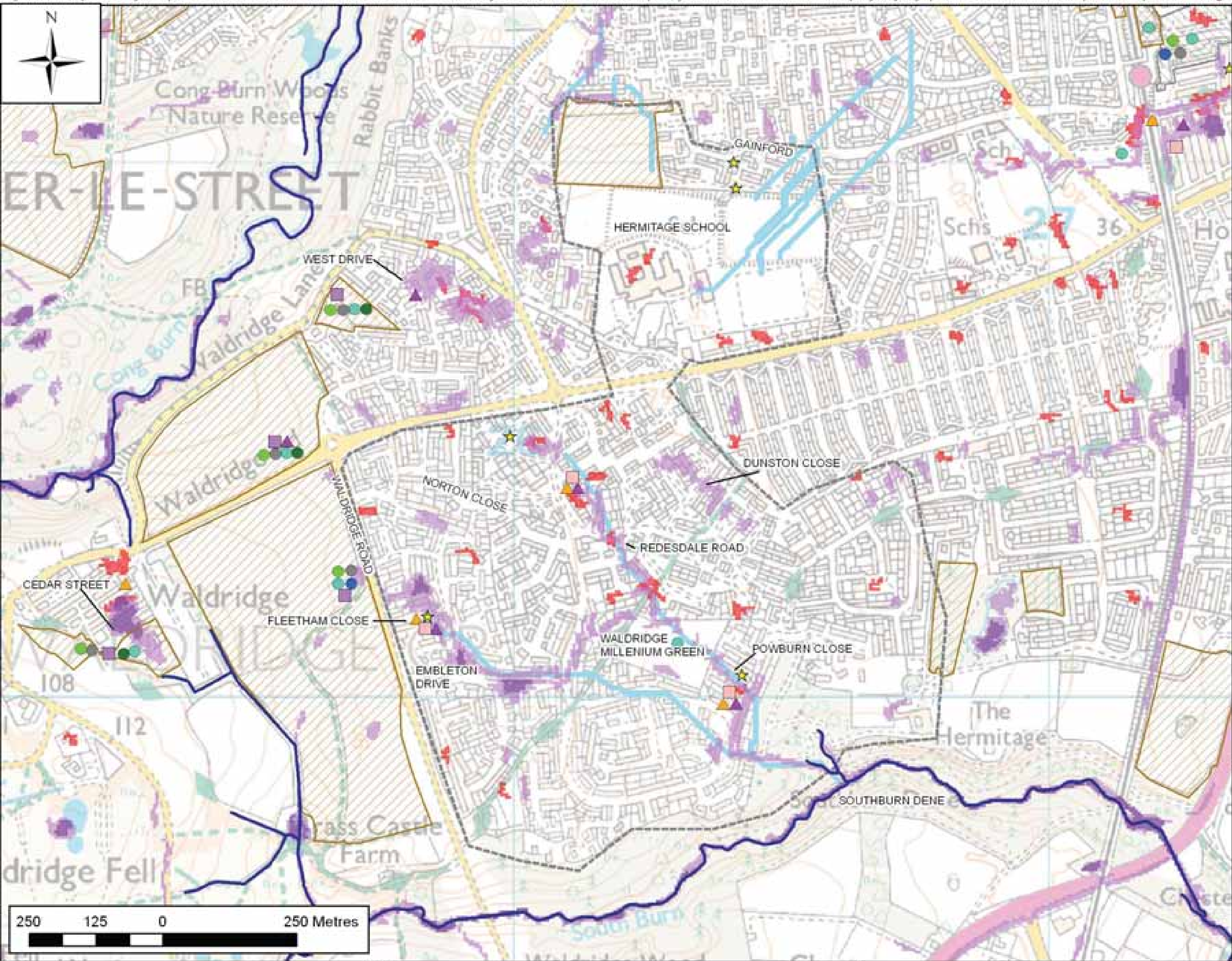
NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client: DURHAM COUNTY COUNCIL	Title: CRO1 - CROOK DRAINAGE STRATEGY OPTIONS KEY COMPONENTS	Design: ARP	Drawn: ARP
Project: DURHAM SWMP		Chk'd: LM	App'd: CSL
		Date: APRIL 2011	Scale: 1:10000
		Drawing Number: 60155102/OPTIONS/CRO1	A3

AECOM
5th Floor,
2 City Walk,
LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage
- Soakaway / Infiltratio
- Green Roof

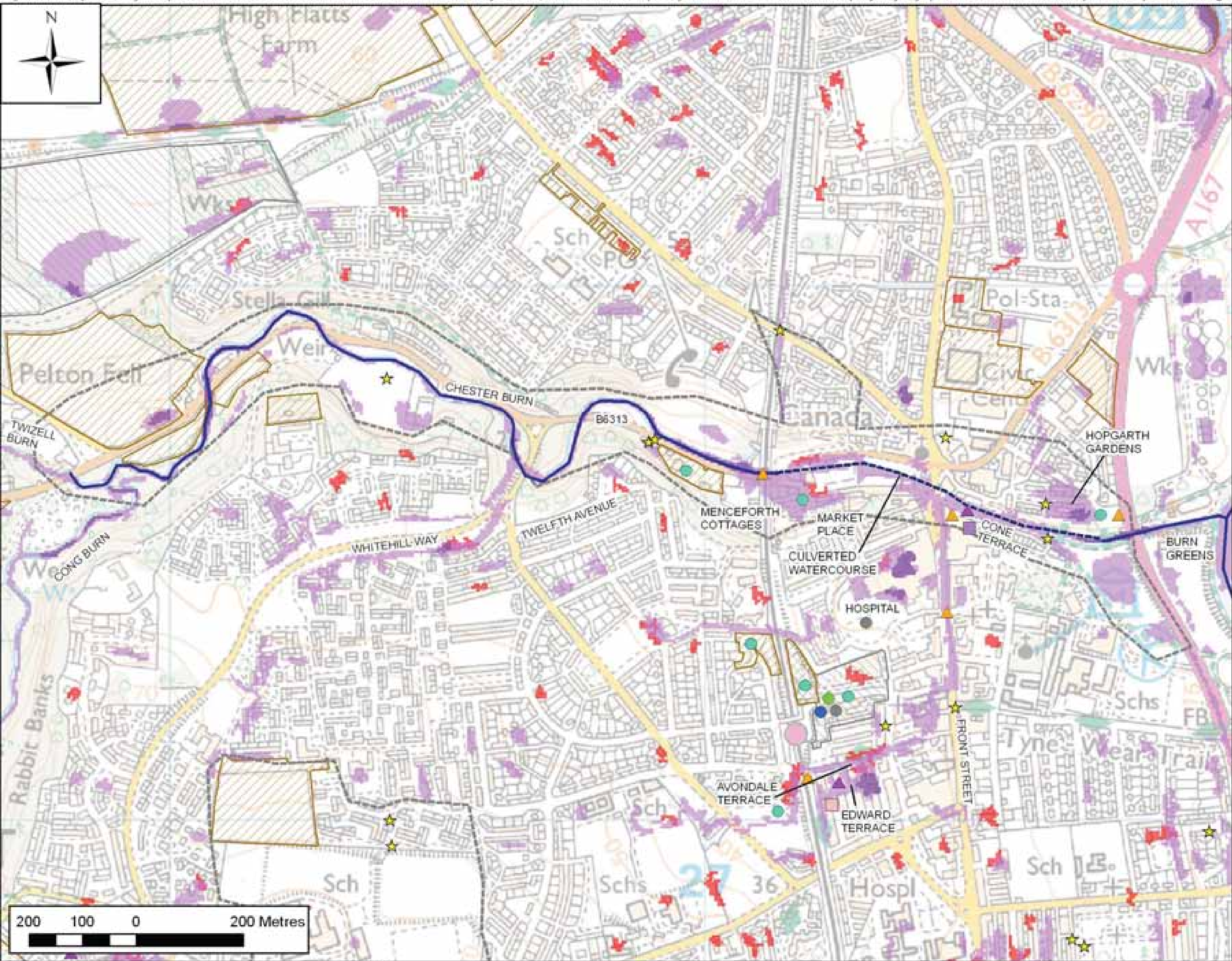
NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client: DURHAM COUNTY COUNCIL	Title: CLS3 - CHESTER-LE-STREET DRAINAGE STRATEGY OPTIONS KEY COMPONENTS	Design: ARP	Drawn: ARP
		Chk'd: LM	App'd: CSL
Project: DURHAM SWMP		Date: APRIL 2011	Scale: 1:7500
		Drawing Number: 60155102/OPTIONS/CLS3	A3

AECOM
5th Floor, 2 City Walk, LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com



LEGEND

- Known Incident
- Watercourse
- Overland Flow Route
- Surface Water Risk Area
- SHLAA Sites
- ELR Sites

Area of Surface Water Flood Risk

- EA Flood Map for Surface Water - 30yr (>0.3m)
- EA Flood Map for Surface Water - 200yr (>0.1m)
- SFRA Surface Water - Significant Risk

INDICATIVE OPTIONS

RECEPTOR
- Improve Resilience and Resistance
- Planning Policies / Development Control

PATHWAY
- Improve Floodplain Storage
- Manage Overland Flows
- Flow / Storage on Roadway
- Improve Maintenance Regime
- Separate Foul and Surface Water Systems

SOURCE
- Rainwater Harvesting
- Permeable Paving
- Swale / FilterDrain
- Attenuation / Storage
- Soakaway / Infiltratioı
- Green Roof

NOTES:

Options are indicative and are subject to land ownership, masterplanning, third party agreement and detailed appraisal. All surface water measures require co-ordinated asset management and proactive maintenance.

Surface water flood maps show predictions of flooded areas and do not show whether individual properties will be affected by surface water flooding or have been affected. Refer to the Environment Agency's Using Surface Water Flood Risk Information document for explanation and caveats to flooding shown. Sewer networks were assumed to be at or near capacity. No geotechnical review was completed, although infiltration is assumed to be limited.

Client: DURHAM COUNTY COUNCIL	Title: CLS2 - CHESTER-LE-STREET DRAINAGE STRATEGY OPTIONS KEY COMPONENTS	Design: ARP	Drawn: ARP
		Chk'd: LM	App'd: CSL
Project: DURHAM SWMP		Date: APRIL 2011	Scale: 1:7500
		Drawing Number: 60155102/OPTIONS/CLS2	A3

AECOM
5th Floor, 2 City Walk, LEEDS, LS11 9AR
Tel: +44 (0) 113 391 6800
Fax: +44 (0) 113 391 6899
www.aecom.com

ANNEX C2 - SuDS Potential from SFRA Level 1 (Golder Associates, 2010)

Table C2: SuDS Potential from SFRA Level 1 (Golder Associates, 2010)

Area	Superficial Geology	Solid Geology	Topography	Possible SuDS
Hamsterley, Ebchester, Burnopfield, Tanfield LEA	Till within river valley (low permeability)	Limestone & Coal Measures	Falls relatively steeply north	Infiltration devices unlikely to function efficiently. Basin/ponds need to take into account topography.
Urpeth, Pelton,Ouston	Glacial Till. Soils on higher ground low permeability drift deposits. In the river valleys soils are thicker with relatively high permeability	Limestone (variable permeability)	Falls relatively steeply from west to east; relatively flat along River Wear corridor.	Infiltration systems should operate in low lying areas, taking into account local topography; ponds/basins more suitable on higher ground (Stanley)
Cowshill	Peat on higher ground – permeable but often supersaturated	Limestone (variable permeability)	Elevated	Infiltration techniques are unlikely to function effectively. High groundwater levels and buoyancy of structures key issues for ponds/basins in peaty soils.
Edmondbyers, Hunstanworth, Rookhope, Lintzgarth	Peat on higher ground – permeable but often supersaturated	Limestone (variable permeability)	Elevated	Infiltration techniques are unlikely to function effectively. High groundwater levels and buoyancy of structures key issues for ponds/basins in peaty soils.
Consett, Lanchester and Annfield Plain	Glacial till in river valley – low permeability	Coal Measures of variable permeability	Falls relatively steeply west to east	Infiltration devices unlikely to function efficiently. Basin/ponds need to take into account topography.
Langley Park, Witton Gilbert, Sacriston, Esh Winning, Bournemoor	Glacial till - Low permeability on high ground, relatively high permeability in low lying areas	Limestone (variable permeability)	Falls relatively steeply west to east. Flat along Wear corridor.	Infiltration potential around low lying areas (Chester-le-Street and Durham). They will be less effective in elevated areas further west.
Easington Colliery, Pittington, Murton, Haswell, South Hetton, Ludworth	Low-intermediate permeability	Limestone (variable permeability)	Falls relatively undulating east to west from higher ground	Infiltration and detention systems may function subject to local conditions and SuDS requirements

Area	Superficial Geology	Solid Geology	Topography	Possible SuDS
Ireshope Moor	Peat on high ground with Glacial Till in valleys	Limestone (variable permeability)	Elevated. Land falls rapidly into the valley of the Wear and tees respectively	Infiltration unlikely to function effectively. High water table and buoyancy of structures possible issues for ponds/basins
Westhope Moor / Stanhope	Peat on high ground with Glacial Till in valley of the Wear	Limestone (variable permeability)	Elevated. Land falls rapidly into the valley of the Wear and tees respectively	Infiltration unlikely to function effectively. High water table and buoyancy of structures possible issues for ponds/basins
Wolsingham and Tow Law / Hamsterley and Witton-le-Wear	Drift on higher ground with Glacial Till in valley bottom. Both low permeability	Limestone (variable permeability)	Falls relatively steeply west to east toward River Wear	Infiltration SuDS unlikely to function effectively
Crook and Howden-le-Wear / Willington / Witton Park / Spennymoor / Brandon	Glacial drift on higher ground (low permeability) with thicker till deposits in lower areas with relatively high permeability	Limestone (variable permeability)	Falls relatively steeply to Wear; flat along Wear corridor	Infiltration SuDS likely to function effectively in low lying areas. Less likely to function in elevated areas including around Stanley Crook and Counden.
Peterlee / Coxhoe, Trimdon, Trindon Colliery, Bowburn, and Wingate	Low to intermediate permeability	Limestone (variable permeability)	Relatively undulating falling west from higher ground	Infiltration and detention systems may function subject to local conditions and SuDS requirements
East Coast	Intermediate to high permeability	Limestone (variable permeability)	Relatively undulating falling towards coastal fringe	Infiltration and detention systems likely to operate effectively subject to local conditions and requirements
Grains o' th' Beck	Peat	Limestone (variable permeability)	Elevated	Infiltration unlikely to function effectively. High water table and buoyancy of structures possible issues for ponds/basins