

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

Draft Scope for Flood Risk Assessment for Angmering Flood Alleviation Scheme

Version 1.0

Originator

Ray Drabble, Engineer, West Sussex Lead Local Flood Authority

16 OCT '20

Independent Reviewer

Date: 16/10/20

orthing Councils

Date: 16/10/20

Kevin Macknay, Manager, West Sussex Lead Local Flood Authority

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

Contents

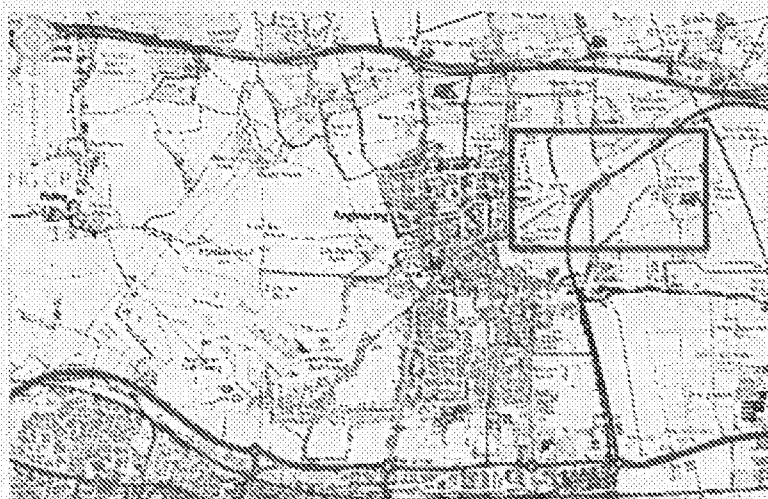
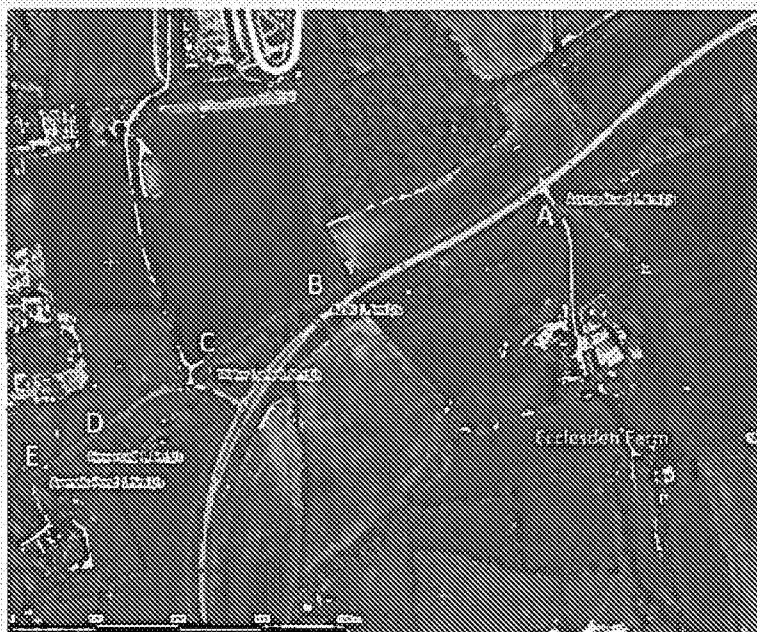
Executive Summary	3
1.0 Introduction	5
2.0 Background	6
3.0 Site Description	9
4.0 Description of the Proposed FAS;	11
5.0 Scope for the FRA.....	12
6.0 Existing Reports and References.....	13
7.0 Baseline Assessment of Flood Risk.....	14
7.2 Tidal and Fluvial Flood Risk to the Site.....	14
7.4 Modelled Flood Levels	15
7.5 Updated modelled simulations of fluvial flood risk	15
7.6 Baseline fluvial simulation for the Land South of Water Lane.....	16
7.8 Flood Risk from Surface Water	17
7.9 Risk of Flooding from Groundwater.....	18
7.10 Flood Risk from Reservoirs.....	19
7.11 Flood Risk from Sewers and Drains.....	19
8.0 Flood Risk as a Consequence of the Proposed Angmering FAS	20
8.1 Modelling of Scenario 3	20
8.7 Culverted Road Access without implementation of the FAS.	25
8.6 Flood risk to Agricultural Land	28
9.0 Conclusions	31
10.0 Recommendation.....	32

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

Executive Summary

This Flood Risk Assessment (FRA) has been prepared by West Sussex Lead Local Flood Authority (LLFA) for the Angmering Flood Alleviation Scheme (FAS) to assess all potential sources of flood risk to the scheme and also the effects of the scheme on flood risk to people and property in the vicinity of the scheme. West Sussex LLFA is the lead authority for the scheme.

The Angmering FAS extends across the area shown below from just downstream of the Southern Water Treatment Works near the Patching roundabout on the A27 to the Weavers Lane Trash Screen at the top of Water Lane, Angmering.



The rationale for the FAS has been to exploit the natural topography of the flood plain for the principal watercourse, the Black Ditch, and modify existing structures (and one proposed structure) to restrict flows during significant storm events. Incapacity of the culverted section of the Black Ditch and consequential surcharging of storm flows has historically been a principle source of flooding. The frequency with which fluvial flooding currently occurs is between 10% and 20% annual exceedance probability (AEP).

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

The effects of the scheme have been modelled using the Environment Agency's InfoWorks RS model.

The results of the modelling demonstrate that implementation of the scheme will result in no net increase in flood risk and the potential exists to reduce the frequency of fluvial flood risk in Water Lane to between a 2% and 1% AEP.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

1.0 Introduction

1.1 This Flood Risk Assessment (FRA) has been prepared by West Sussex Lead Local Flood Authority (LLFA) for the Angmering Flood Alleviation Scheme (FAS), the individual elements of which extend across the area shown in Figure 1. 1. While the purpose of the FAS is to significantly reduce pluvial and fluvial flood risk in Angmering, this assessment will present the results of the FRA required by the NPPF that includes the assessments of flood risk from all sources both to the site and as a result of the scheme.

1.2 The format for the FRA is set out below:

Section 2	Background to the FAS;
Section 3	Site Description;
Section 4	Description of the Proposed FAS;
Section 5	Scope for the FRA;
Section 6	Existing Reports and References;
Section 7	Baseline Assessment of Flood Risk
Section 8	Flood Risk as a Consequence of the Proposed Angmering FAS
Section 9	Conclusions; and
Section 10	Recommendation

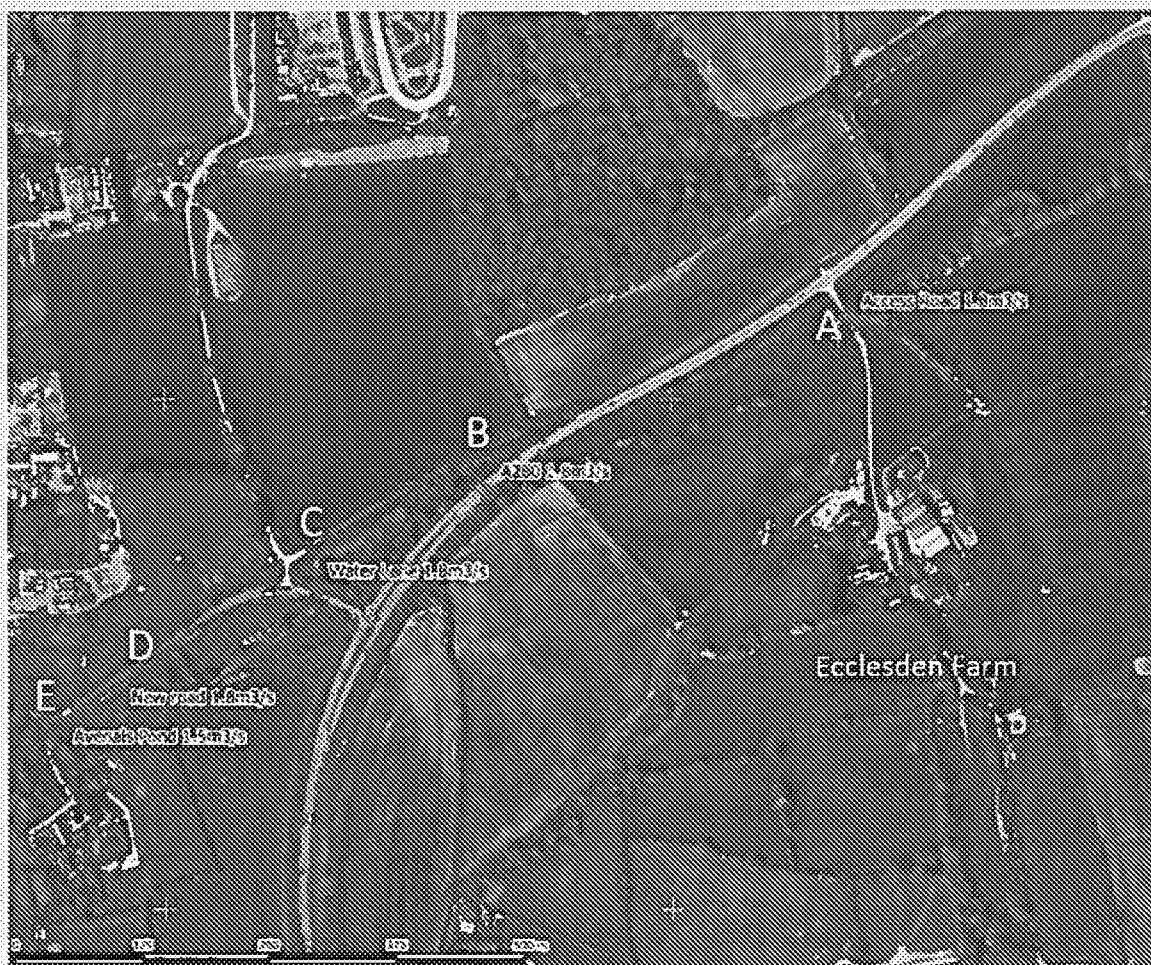


Figure 1.1: The extent of interventions comprising the proposed Angmering FAS.

2.0 Background

- 2.1 Angmering village lies about 2 miles north of the English Channel and the upper part of the village sits on the dip slope of the South Downs. It is prone to surface water flooding and fluvial flooding in Water Lane and the centre of the village (Figures 2.1, 2.2 & 2.3). In 1980, 26 properties flooded and a similar number again in 2012 (Reference A). The majority of these flooding incidents occurred along Water Lane, where the Black Ditch, designated as a main river, is culverted under the road. The Black Ditch has a catchment approaching 25km² extending into the Downs to the North and East. Environment Agency (EA) modelling undertaken to assess flood risk indicates that flooding occurs for anything above a one in five year event (Reference B). This flood risk has long been the focus of potential interventions to reduce the frequency / severity of flooding. The most recent of these has been investigations undertaken by the EA dating from September 2017 to identify whether a flood alleviation scheme could be taken forward.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

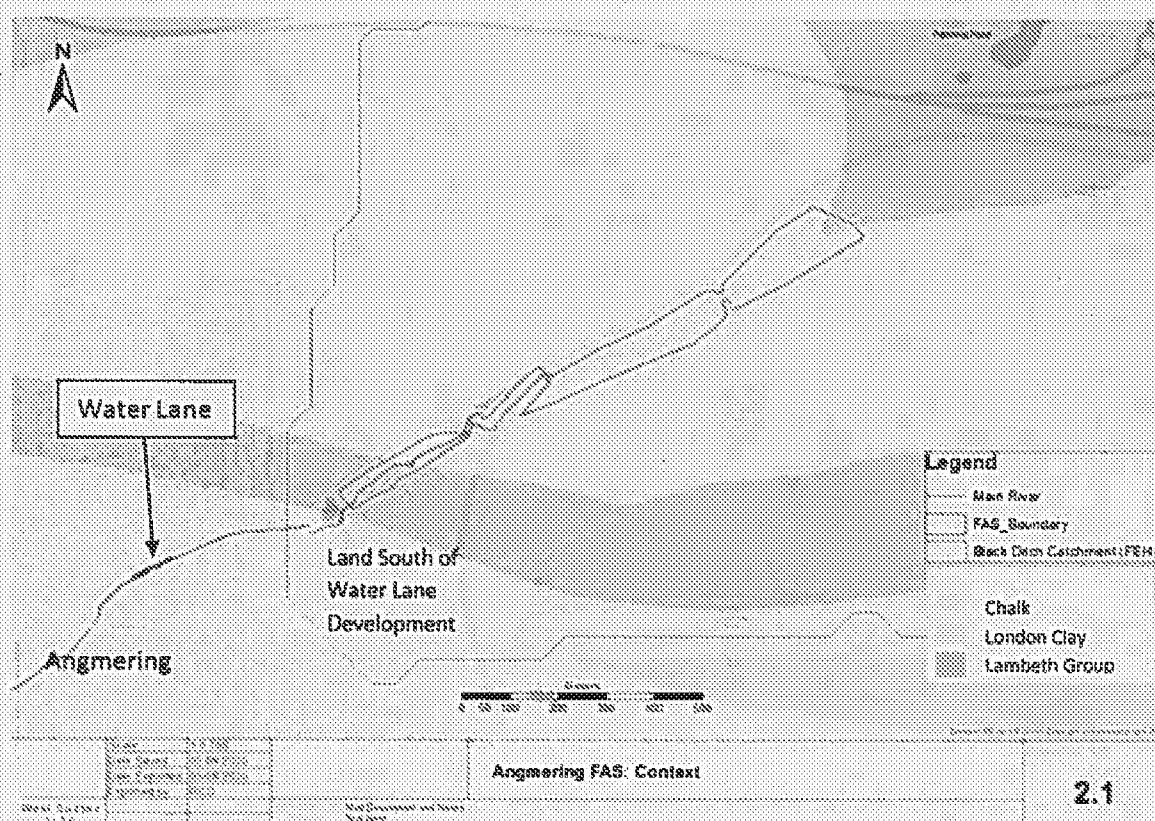


Figure 2. 1 Angmering FAS: context

- 2.2 In January 2020, by mutual agreement, the EA handed responsibility for the management of this project over to the LLFA together with the Black Ditch model that formed a key source of analyses informing earlier investigations.
- 2.3 Work undertaken by the LLFA in August 2017 had identified potential opportunities for attenuation largely using the natural topography and existing features in the Black Ditch upstream of Water Lane at 3 locations, namely: upstream of the Black Ditch culvert under the A280 based upon a maximum surface (elevation of flood water) of 14.6m above ordnance datum (AoD) ($8,377\text{m}^3$); upstream of the Avenals Farm Culvert based upon a max surface of 10.5m AoD ($1,650\text{m}^3$); and potentially a proportion of the $8,566\text{m}^3$ capacity of the A280 attenuation area (Figure 2.4).
- 2.4 In summer 2020, at the recommendation of the Angmering Advisory Group, the LLFA made inquiries about a bridge structure that was forming part of the planning application for Land South of Water Lane (Figure 2.1) as it was considered critical that the FAS took this into consideration. The LLFA learnt that Barratt David Wilson (BDW) homes were intending to construct a free standing bridge for the Land South of Water Lane development. In noting that the access road to the development would have a minimum elevation of 12.7m AoD and maximum elevation of 13.5m AoD, an opportunity was identified to change the design for the road access to a culverted embankment that would allow significantly more flood attenuation storage on the upstream side of this new road access. At a meeting on 23 July 2020 of BDW, the EA and the LLFA there was broad agreement on the principal of exploring this option as a cost effective means of delivering a key element of the Angmering FAS.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

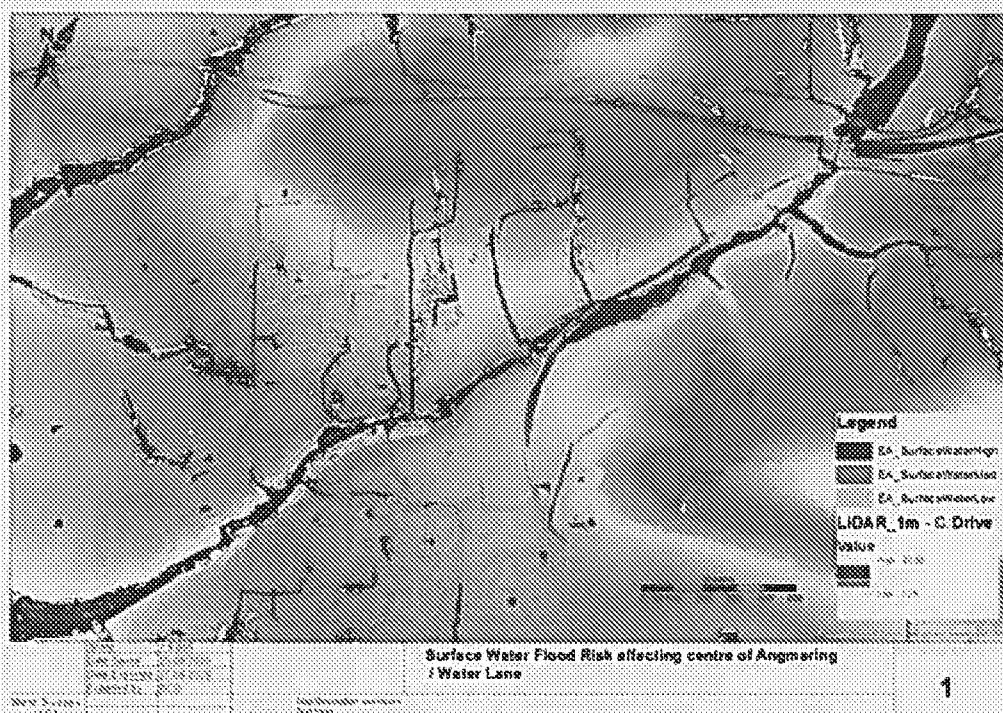


Figure 2. 2 : Extract from risk of flooding from surface water map: Angmering
High surface water flood risk represents an Annual Exceedance Probability (AEP) of more than 3.3%;
Medium between 1% and 3.3% and Low between 1% and 0.1 %.

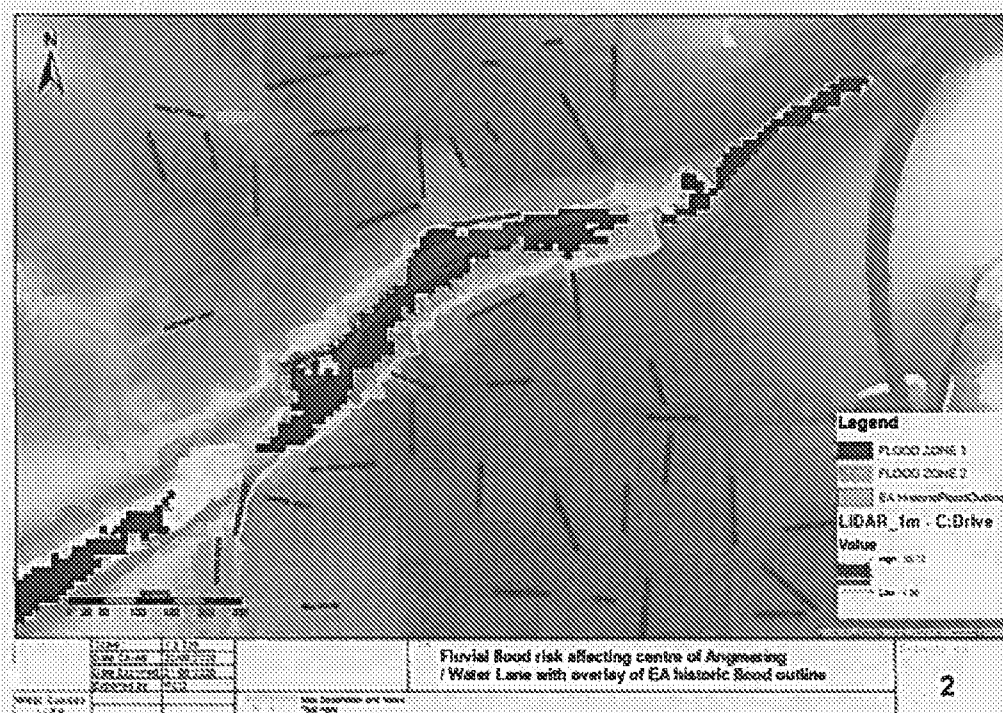


Figure 2. 3 Extract from EA mapping: extent of flooding from rivers and the sea: Angmering
FZ3 represents a high risk of flooding, i.e. an AEP of greater than 3.3%; FZ2 represents a Medium risk (AEP of between 3.3% and 1 %).

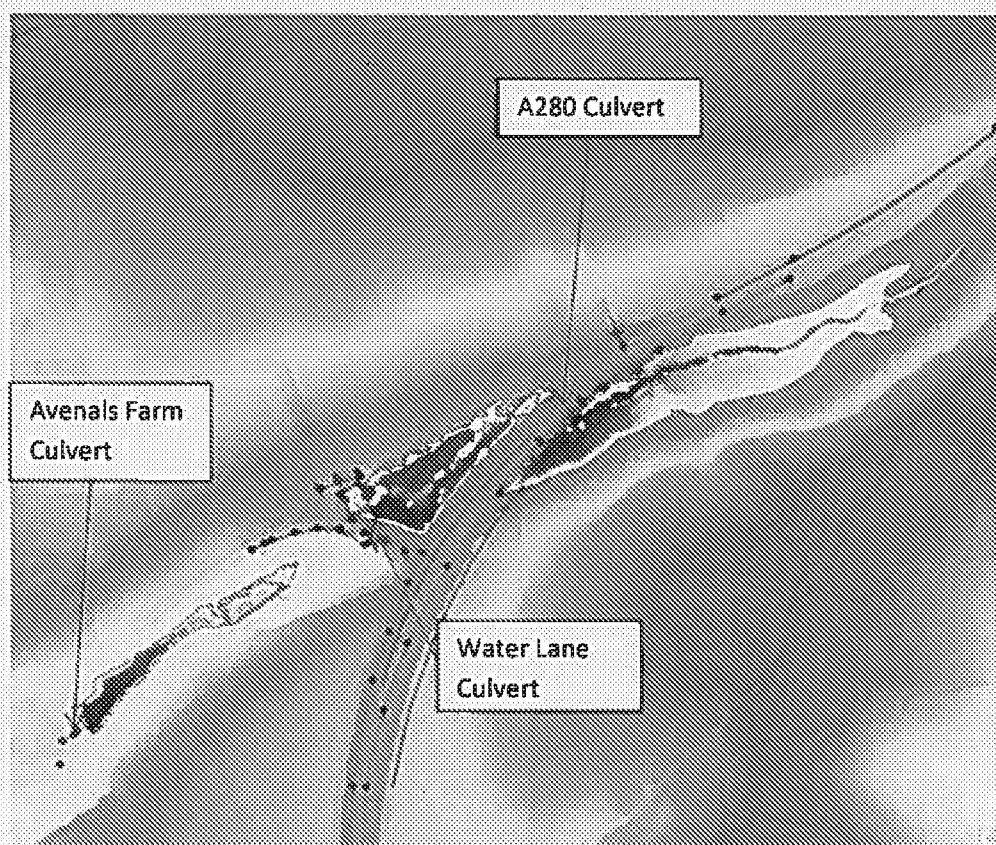


Figure 2. 4: Initial analyses of potential storage capacity in the Black Ditch using existing features.

3.0 Site Description

3.1 At the point that The Black Ditch enters in culvert at the Weavers Lane Trash Screen at the top of Water Lane, the catchment for the ditch extends over approximately 25km² (Figure 3.1). The bulk of the catchment (80%) is underlain by a bedrock of chalk (light green in Figure 3.1) but the section of the Black Ditch encompassed by the FAS comprises a bedrock of almost exclusively London Clay (buff shading). The superficial geology for the extent of the FAS is shown in Figure 3.2. This comprises alluvial deposits in the channel of the Black Ditch and head deposits of clay, silt, sand and gravel. The A27 effectively bisects the catchment with direct run-off north of the A27 channelling via Patching Pond. As the outfall from Patching Pond is restricted, from a pluvial perspective, run-off is predominantly restricted to south of the A27. Earlier modelling (Reference A) identified four main flow paths as the main contributors towards flooding of the town, specifically:

- Water Lane - Surface water run-off running south west down Water Lane towards the village centre;
- Black Ditch - Fluvial flood risk overloading the Water Lane culvert;
- Dappers Lane - Surface water run-off running south down Dappers Lane and then south west towards the village centre;¹ and

¹ Much of this surface water contributes to the culverted Black Ditch in Water Lane or to surface water flooding where this system is at capacity.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

- Ancient Woodland (TQ 05370) to East of Weavers Hill - surface water run-off flows north west down fields towards Black Ditch and Water Lane².

3.2 Further analyses by WSP including modification of the catchment within the urban extent of Angmering to take into consideration key surface water drainage infrastructure catchments has resulted in refinements being made to the model, which summarised comprises:

- The incorporation of flows from the High Street, part of Arundel Road and Station Road;
- The removal of flows that do not enter the Black Ditch owing to conveyance by surface water infrastructure out of the catchment; this applies particularly to a proportion of Angmering to the South of the Black Ditch which does not enter the ditch.

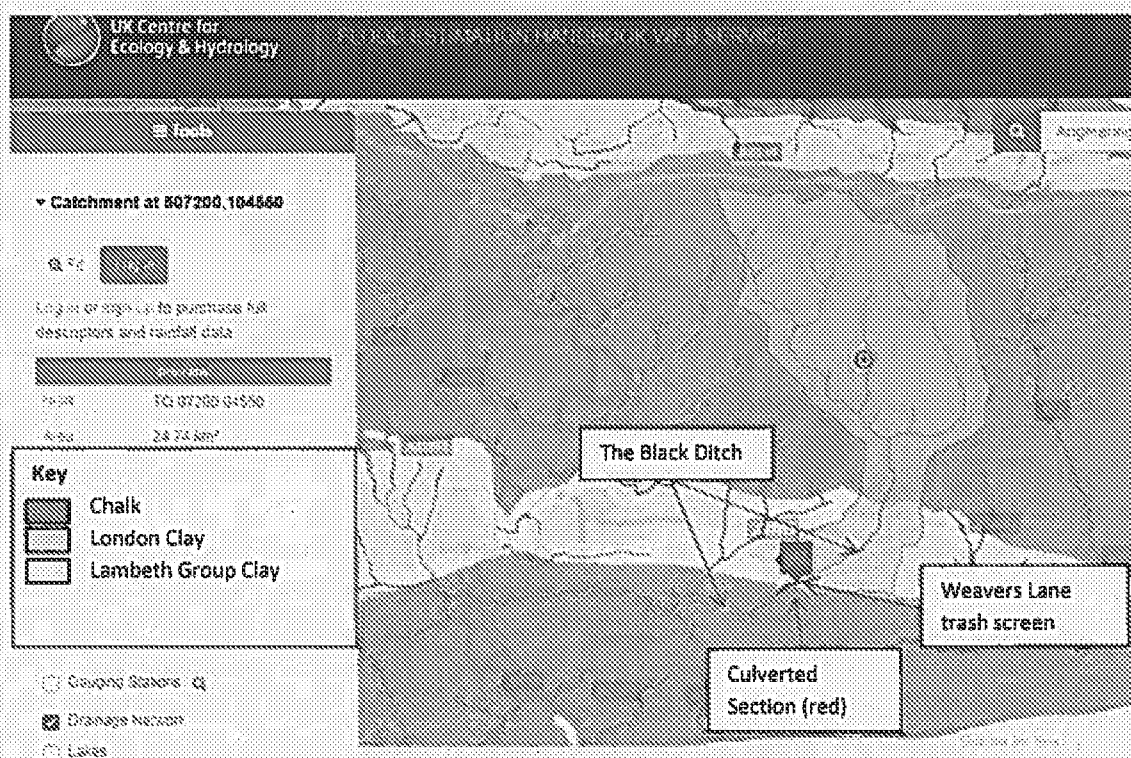


Figure 3. 1: Catchment for the Black Ditch as it enters in culvert at the top of Water Lane.

Source: UK Centre for Ecology and Hydrology.

² Again, if the flows are as described then they would form part of the existing surface water flooding that the scheme is intended to alleviate.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

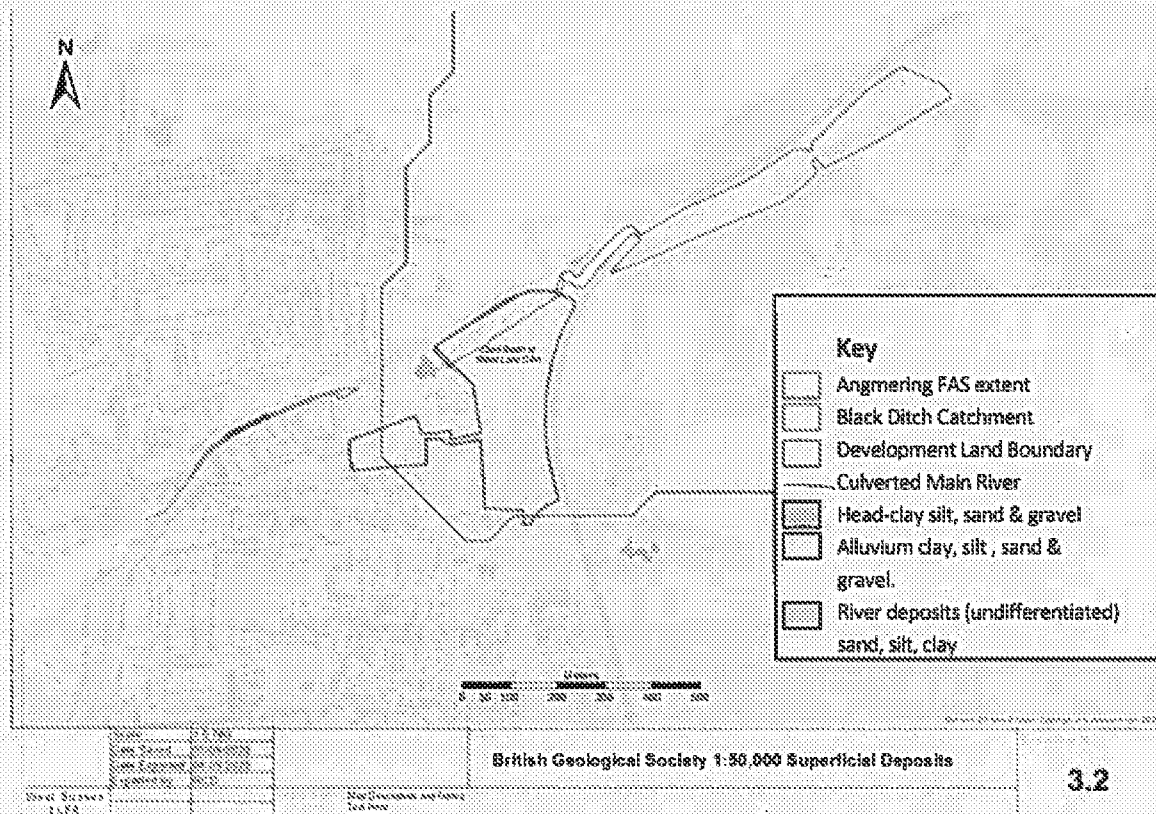


Figure 3. 2: British Geological Society 1:50,000 superficial deposits

4.0 Description of the Proposed FAS;

4.1 As described in paragraph 2.3, the FAS had its origins in early work that sought to use the natural topography and existing features to store water in the catchment upstream of the culverted section of the Black Ditch. The basic premise informed by the outline design modelling, is that if for all but extreme storm events peak flows could be restricted to a critical flow of $1.5\text{m}^3/\text{s}$ (i.e. the constrained flow on the culverted section between the base of Water Lane and the outfall at the southern eastern corner of St. Mary's Church yard) then it would be possible to prevent in many cases the system surcharging and pluvial/fluvial flooding occurring.

4.2 The outline FAS now comprises restrictions on peak flows as set out below (see locations A to E in Figure 1.1):

- Location A. Upstream of the access track to Ecclesden Farm to fully exploit the capacity of the existing pond;
- Location B. At the upstream side of the culvert under the A280; restriction of peak flows to $1.8\text{m}^3/\text{s}$.
- Location C. At the discharge from the balancing pond area serving the A280; restriction of peak flows to $1.8\text{m}^3/\text{s}$.
- Location D. Upstream of the proposed access road to the 'Land South of Water Lane' development; restriction of peak flows on the main culvert to $1.8\text{m}^3/\text{s}$;
- Location E. Upstream of the current access road serving Avenals Farm; restriction of peak flows to $1.5\text{m}^3/\text{s}$.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

The above flow constrictions and the type of hydraulic controls need to be tested via detailed modelling and may change during the detailed design of the scheme.

In addition, the scheme will remove accumulated sediment of the culverted section of the Black Ditch that runs underneath Water Lane and consider mechanisms to minimise entry of silt into the culverted sections from upstream.

5.0 Scope for the FRA

5.1 While the overall scope of the FRA is set by the NPPF (as summarised in paragraph 1.1 of this document and amplified by national planning practice guidance) at the commencement of this assessment the LLFA sought guidance from the EA on aspects that it would wish to see included. In response the EA recommended that the FRA needs to take into account the following, specifically in relation to the Land South of Water Lane development:

- Floodplain modelling needs to assess the existing storage available now, and how much this can be increased by;
- Floodplain modelling should include the box culvert and identify the additional land/storage for the 1 in 100 flood plus climate change projections;
- This will include establishing impacts on the SUDS from the development, to upstream and downstream landowners and 3rd parties, and overweiring of the box culvert;
- Due to the present stream bed it may be problematic in establishing an invert level for the box culvert installation; the watercourse channel at this location is not very defined. As such, the EA recommends that the design of the culvert takes this into consideration and that the invert of the proposed culvert be set an appropriate level, to allow for any future works to create a more defined channel;
- Avenals Farm road culvert is clearly undersized. The modelling required for the FRA needs to take this into account upstream, and also possibly downstream.

5.2 In relation to the final bullet, Avenals Farm road currently is shown at Medium Flood risk between the 3.3% AEP and the 1% AEP. While the culvert may be undersized to accommodate current storm flows, the strategy within the FRA is to attenuate storm flows further upstream and apply further throttling on the Avenals Farm culvert to restrict it to 1.5m³/s.

5.3 An original FRA was undertaken for the Land South of Water Lane Development in 2017 (Reference C). This original FRA will be updated by BDW for the road access to support the current planning application for the same. It will be based upon a detailed design of a culverted embankment to support the FAS.

5.4 A key consideration for the FRA for the Angmering FAS, is to assess the risk of flooding to people / property as a consequence of constructing a culverted embankment for the road access to the Land South of Water Lane development without the remaining elements of the FAS being in place i.e. the throttles on flows upstream and downstream. To a large degree this risk has been designed out because the culvert has been oversized to a 3.5m wide and

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

3.0m high culvert to work better hydraulically with a proposed FAS weir structure, located just upstream of this culvert. Thus the 3.5m wide and 3.0m high oversized culvert has more than a 0.6m high freeboard for the 100 year plus climate change event, with or without the FAS in place. The scenario of a stand-alone culverted access to the Land South of Water Lane development has been modelled and is assessed in Section 8 for flood risk. This FRA necessarily forms an addendum to the FRA being prepared by BDW.

- 5.5 Given the scope to use the new BDW access road (for the Land South of Water Lane development) other existing embankments and culverts and a sizeable pond for attenuation, the FAS as currently envisaged is considered to be a low-cost, low negative environmental impact option. Delivery of the scheme proposed i.e. predominantly comprising relatively small flow control structures on existing culverts should allow a solution to be delivered at a significantly lower cost than originally envisaged by the Outline Business Case in 2016 that allotted a net present value to the project of £1.37M.

6.0 Existing Reports and References

- 6.1 A number of key reports have informed this FRA, many of which have already been referred to in the text, and where appropriate these are included as appendices within this FRA.

6.2 *Angmering Flood Alleviation Scheme: Options Modelling Report*

The above report is of central importance to this assessment because it provides an overview of the EA model for the Black Ditch against which baseline the FAS flood risk has been assessed. Key relevant text from this report has been included for completeness to inform the reader of the evolution of the model upon which the assessment has been made.

- 6.3 The original model for Angmering was included as a small sub-model in the Lower Tidal River Arun Strategy (LTRAS) InfoWorks RS model, which was built in 2010 by Atkins. This was later picked by Mott MacDonald in 2015, to carry out modelling work as part of an initial assessment, to improve the model and give sufficient detail to allow high level options to be tested to understand the available benefits.

- 6.4 The initial assessment had the key limitation that asset data within the model was of poor quality; the model representation of the Water Lane culvert was based on existing readily available information including a partially complete CCTV survey, and river cross sections were generated from Lidar data with manual amendments made to match observed water levels. For these reasons it was identified that an update of the model was required to improve the detail in the Angmering catchment.

- 6.5 The model was updated by the Environment Agency to inform the Options Modelling report and the Outline Business Case (OBC) stage of the project to test options based on updated topographic survey and an updated manhole survey. An integrated 1D- 2D model was built in InfoWorks ICM. The model utilised the latest InfoWorks ICM modelling software to predict flood extents based upon inputs from hydrological inflows and direct rainfall. The model has been calibrated against two storm events in 2012 and 2015.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

7.0 Baseline Assessment of Flood Risk

7.1 The assessment firsts considers all sources of flooding to the proposed FAS and how these in turn may impact flooding from the scheme. Section 8 will then assess flood risk as a consequence of the FAS.

7.2 Tidal and Fluvial Flood Risk to the Site

The EA Black Ditch Model extends approximately 1km downstream of Angmering. The hydraulic component of the model does not incorporate any allowance for tidal effects. This has been discussed with the EA that has agreed that any tidal influence on flooding to Angmering in relation to The Black Ditch is *de minimis*.

7.3 The Black Ditch enters in culvert at the top of Water Lane at the current eastern urban extent of Angmering and Water Lane follows the original route of the watercourse through the village. As a consequence, Water Lane and many of the properties that are adjacent to it are within fluvial flood extents (Figure 7.1).

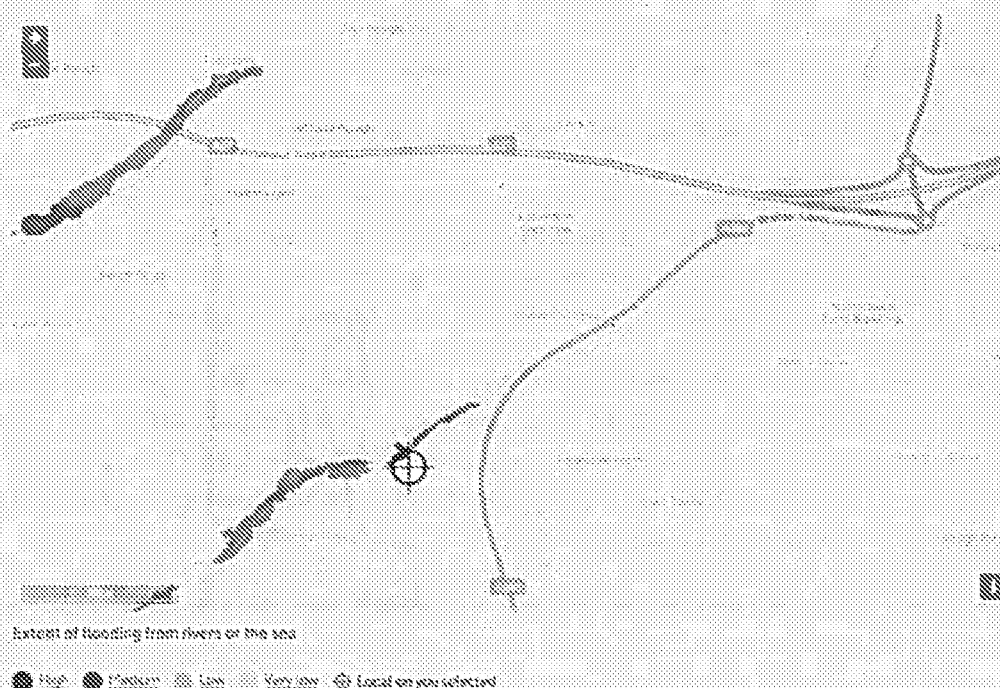


Figure 7.1 Extent of flooding from the rivers or the sea: source: <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

These properties are identified as being at Medium risk i.e. each year this area has a chance of flooding of between 1% and 3.3%. This takes into account the effect of any flood defences in the area. These defences reduce but do not completely stop the chance of flooding as they can be overtopped, or fail. The mapping also does not take into consideration property level protection, which a number of the owners on Water Lane have implemented to reduce risk to their own properties. It is noted that the Land South of Water Lane development south of The Black Ditch is not shown as currently being at risk of fluvial flooding.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

7.4 Modelled Flood Levels

As the EA model is being used as the basis for simulation of flood levels in response to storm events, the EA has confirmed that a formal Product 4 request is not required to ascertain the modelled flood levels. Predicted baseline flood levels extracted from the model are shown in Table 8.1 below. The information has been presented there for ease of comparison with the modelled depths for full implementation of the FAS.

7.5 Updated modelled simulations of fluvial flood risk

Outline modelling has been undertaken to a sufficient detail to assess the effect of the FAS. Further modelling as part of the detailed design will fully assess the constrictions required to quantify the amount of attenuation storage that can be safely stored.

The baseline flood risk to Angmering from a 1% AEP plus 45% climate change event (1% AEP + 45% CC) is shown in Figure 7.2.

The depth of flooding shown in Figure 7.2 for the centre of Angmering for this extreme event is broadly similar to the information provided on the gov.uk risk of flooding from surface water map with flooding in the centre of the village predicted to reach 1m depth in places as has occurred at times in the past.

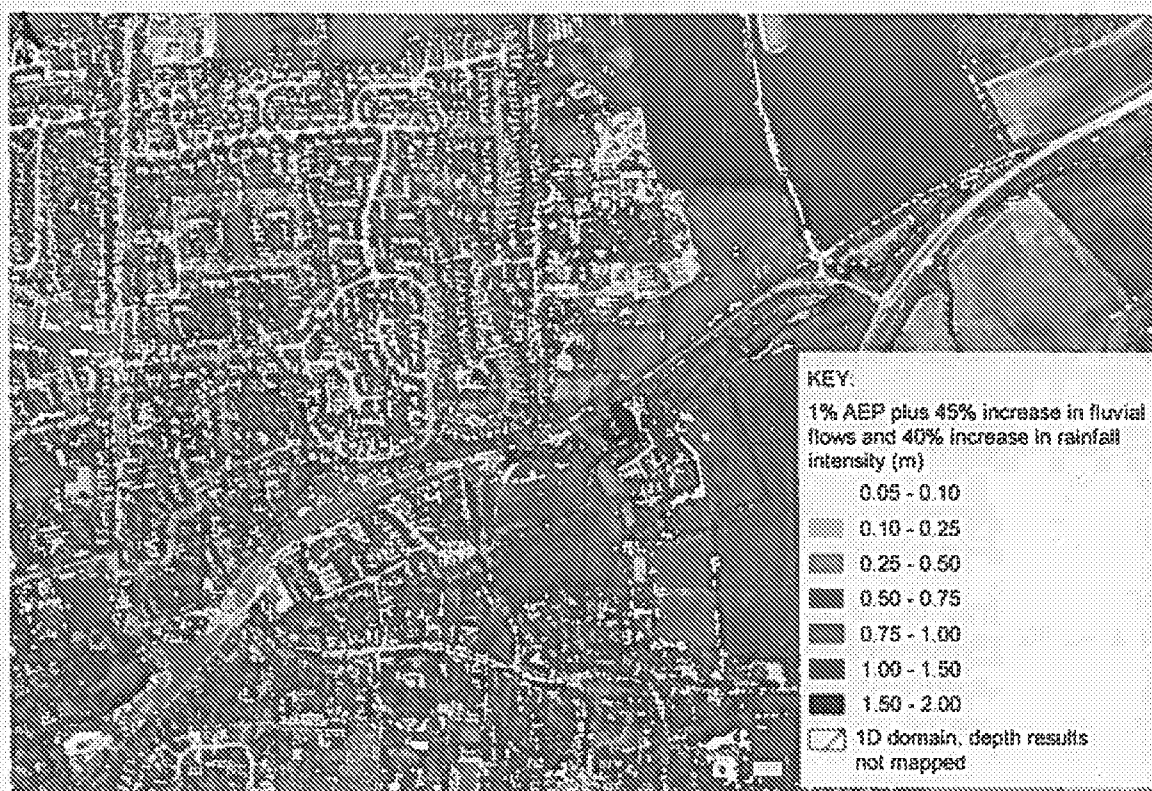


Figure 7.2: Baseline flood risk to Angmering from a 1% AEP + 45%cc event

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

7.6 Baseline fluvial simulation for the Land South of Water Lane

As discussed in paragraph 5.3 a key requirement of this FRA is to assess the effect of the scheme on flood risk on the new development at Land South of Water Lane including the access road. In order to this the following scenarios have been modelled:

- Scenario 1: Baseline (existing with no new road or FAS)
- Scenario 2: Road access with new culvert plus weir structure just upstream (only partial implementation of the FAS)
- Scenario 3: Road access with new culvert plus full FAS (with attenuation at many locations along the Black Ditch)

Summary results for the modelling for Scenario 1 (Baseline) are included below; Scenarios 2 and 3 that incorporate the modelled effects of the Angmering FAS are included in Section 8.

7.7 The baseline flood risk for the Land South of Water Lane Site is shown in Figure 7.3.

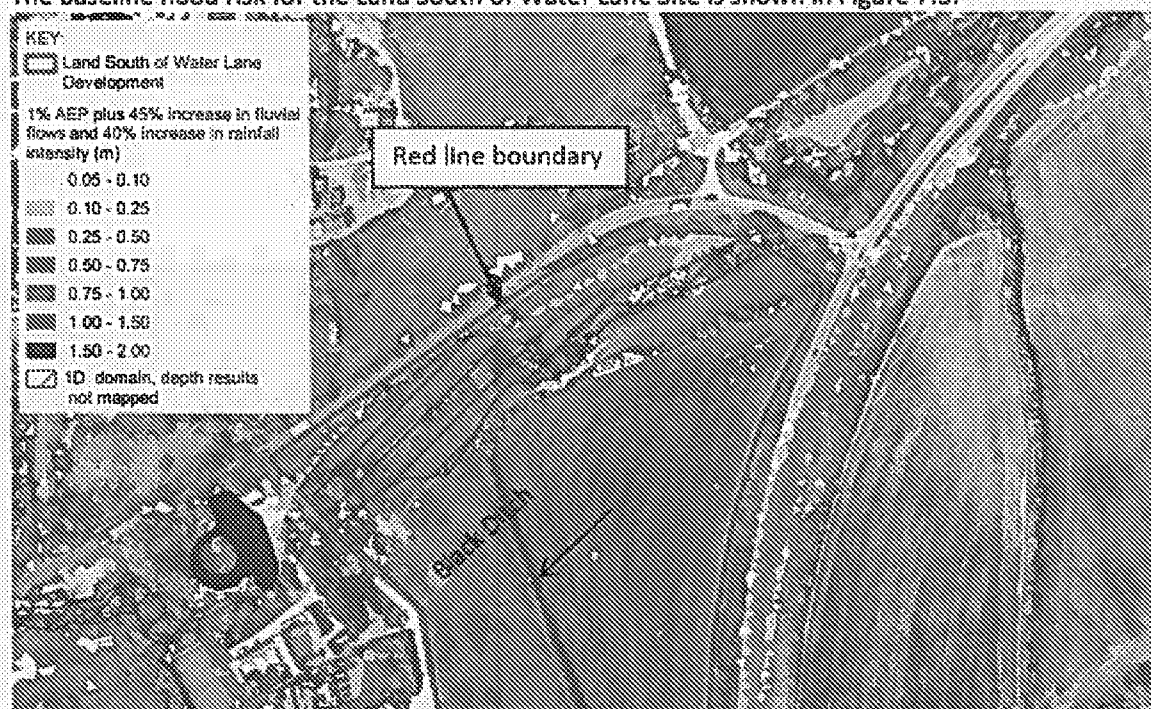


Figure 7.3: Scenario 1: baseline flood risk for the Land South of Water Lane development from a 1% AEP + cc event

It can be seen from the information above, that flood water is almost entirely confined to the main floodplain with little effect to the higher elevation land to the south that is earmarked for development. This corroborates the information provided in Figure 7.4 and with past experience (Plate 7.1)



Plate 7.1: Black Ditch in flood taken 17 January 2014; source: Angmering Parish Council

7.8 Flood Risk from Surface Water

Surface Water flood risk to Angmering is shown in Figure 7.4 below.

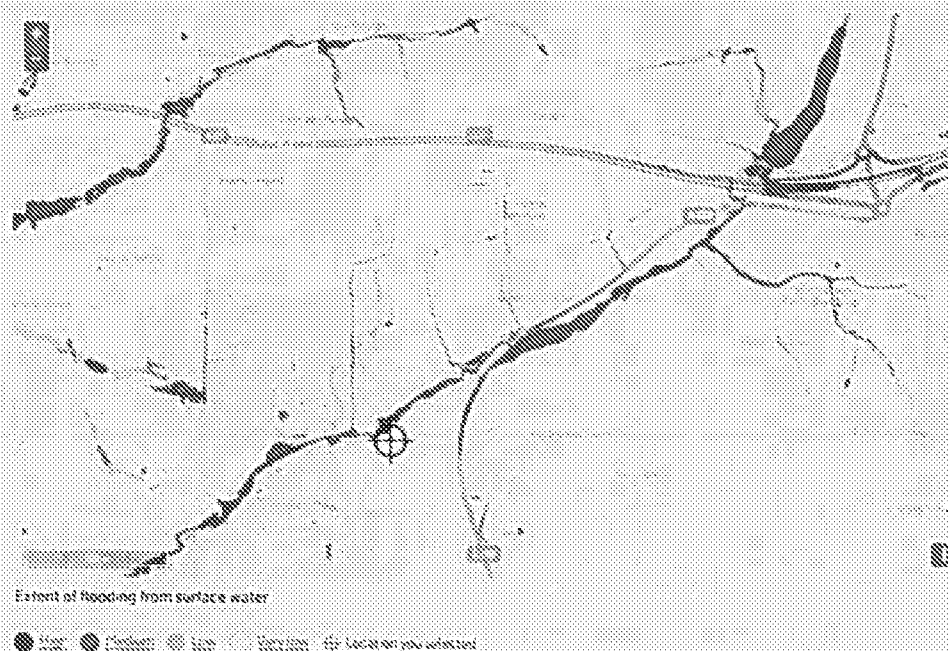


Figure 7.4: Extent of flood risk from surface water: source: <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

Surface Water flood risk to Angmering is predominantly within the fluvial Flood Zone 3 extent in relation to the Black Ditch and it is a reflection of the lack of capacity of the existing culverts to accommodate storm flows. Figure 7.4 shows High flood risk affecting the whole of Water Lane i.e. a probability in any one year in excess of 3.3%. However, further

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

modelling demonstrates that the risk of surface water flooding is as high as 20% when the drainage system is prone to surcharge. The Land South of Water Lane development plot experiences very little surface water flooding. Also evident from Figure 7.4 is the existing attenuation that occurs upstream of the Avenals Fam track, the Water Lane Black Ditch culvert and the A280 culvert, all locations at which the FAS will further exploit the capacity of the topography to accommodate storm water in conjunction with restriction of flows.

7.9 Risk of Flooding from Groundwater

The underlying clay geology and aspect of Angmering on the dip slope of the Downs, renders groundwater flood risk generally for the village. Figure 7.5 shows the groundwater flood risk superimposed upon superficial geology.

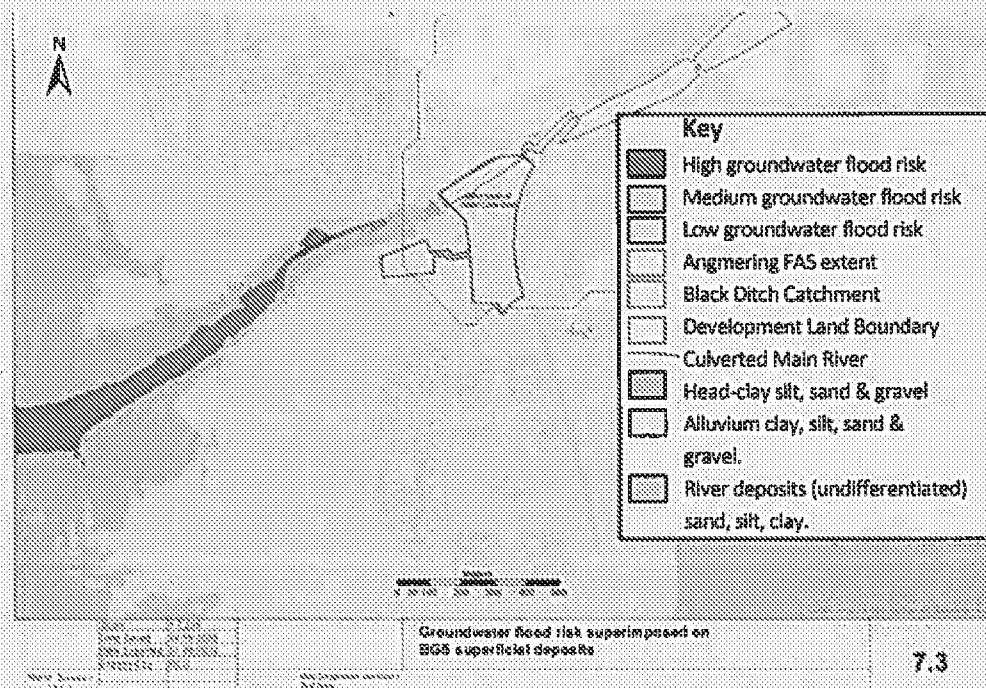


Figure 7.5 Groundwater flood risk (GeoSmart data) superimposed upon superficial geology.

Where flood risk is shown as higher this is associated with base flows to the Black Ditch and in overall significance, this is outweighed by the surface water flooding and fluvial flooding that occurs along the watercourse.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

7.10 Flood Risk from Reservoirs

There is no flood risk from reservoirs to Angmering nor to the extent of the FAS (Figure 7.6).



Figure 7.6: Extent of flood risk from reservoirs: source: <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

7.11 Flood Risk from Sewers and Drains

There is a high flood risk associated with the surface water sewers in Water Lane and the Centre of Angmering for which the AEP is estimated to be approximately 20%. Fundamentally this is due to lack of capacity in the system to accommodate stormflows in an already surcharged system from the significant upstream catchment (see also plate 7. 2). However, accumulation of silt in the system is a further contributory problem.

- 7.12 Historic records of flooding associated with drainage are reported in the Arun District SFRA (Reference D) which states: *1980/81: Angmering village flooded on three separate occasions: 20 September 1980, 10 October 1980 and 2 June 1981 due to combination of heavy rainfall and blockages of drainage ditches and culverts. The June 1981 flood was the most severe of the three, with sewage being reported to be within the flood water [after Rodway Planning Consultancy: Planning Appraisal (Ref A/122/12) for West End Nursey, Roundstone Lane, Angmering].*



Plate 7.2: Evidence of the surface water sewer surcharging in Water Lane (date photo was taken is not known).

8.0 Flood Risk as a Consequence of the Proposed Angmering FAS

8.1 Modelling of Scenario 3

The proposed FAS will reduce water levels along the long culvert in Water Lane in Angmering. This reduction in water level originates from attenuating flows upstream along the Black Ditch. It will assist in reducing surface water flood risk in the village (as there will be less backwater effect, into the surface water drains that discharge into this long culvert). The FAS will have a lesser beneficial effect on reducing surface water flood risk for short high intensity storms as flows in the Black Ditch will be smaller, when compared to longer duration storms. No detailed modelling of the town network system has been undertaken at this stage and therefore it is not possible to quantify the betterment associated with high intensity short duration storms.

- 8.2 The FAS flood risk to Angmering from a 1% AEP storm plus 45% climate change allowance is shown in Figure 8.1.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0



Figure 8.1: FAS flood risk to Angmering from a 1% AEP + 45% cc event



Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

- 8.3 The flood extents and the number of properties at risk for the full FAS are not dissimilar when compared to the baseline however peak flood depths within the Town are reduced by approximately half. Figure 8.2 shows that reductions in flood depths equal to or in excess of 0.1m occur for much of Water Lane. This demonstrates that even for the 100year plus climate change event, the FAS is able to reduce flood risk.
- 8.4 In view of the extension of the 1D domain in the model and the plots, and the absence of detail on depths, differences in flood depth have been extracted from the model for key locations (see Figure 8.3 below) specifically:
1. Junction of Water Lane and Church Road
 2. A localised low point in Water Lane;
 3. Upstream of Avenals Farm access;
 4. Upstream of proposed road access to BDW development;
 5. Upstream of Water Lane culvert;
 6. Upstream of A280 culvert; and
 7. Upstream of Ecclesden Farm access track.



Figure 8.3: Locations for extraction of depth change data from modelling.

- 8.5 Baseline modelled flood depths at the 7 locations shown in Figure 8.3 are included in Table 8.1 below. For ease of direct comparison, the modelled depths at these same locations is shown in Table 8.2.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

Table 8.1: Baseline (Scenario 1) - peak flood depths (m) at key locations

Location Number	Location Name	Return Period			
		20	50	100	100+CC
1	Junction Water Lane and Church Road	0.368	0.444	0.484	0.603
2	Localised low spot in Water Lane	0.181	0.255	0.30	0.464
3	Upstream of Avenals Farm access	1.514	1.661	1.872	2.244
4	Upstream of proposed BDW access	1.0	1.14	1.351	1.713
5	Upstream of Water Lane culvert;	0.956	1.078	1.255	1.784
6	Upstream of A280 culvert	1.412	1.522	1.727	2.233
7	Upstream of Ecclesden Farm access	1.806	2.326	2.544	2.637

Table 8.2: Full FAS (Scenario 3) – Peak Flood Depths (m) at Key locations

Location Number	Location Name	Return Period			
		20	50	100	100+CC
1	Junction Water Lane and Church Road	0.342	0.4	0.431	0.528
2	Localised low spot in Water Lane	0.151	0.190	0.218	0.356
3	Upstream of Avenals Farm access	1.868	1.873	2.085	2.224
4	Upstream of proposed BDW access	1.722	1.956	2.224	2.235
5	Upstream of Water Lane culvert;	1.747	2.688	3.033	3.474
6	Upstream of A280 culvert	1.479	2.834	3.089	3.535
7	Upstream of Ecclesden Farm access	1.763	2.272	2.470	2.608

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

- 8.6 The FAS once fully implemented will incorporate a 3.5m wide by 3.0m high culverted road access (Scenario 3) and a weir control structure with orifice control just upstream of the crossing. As it is anticipated that the constriction will be lifted (for example by opening penstocks) for the 100 year plus CC event, the flood extents upstream of the crossing remain similar to the baseline, as shown in Figure 8.4. Flood levels for the extreme design storm event behind the weir will not exceed 11.7m AoD; the invert level for the balancing pond for the Land South of Water Lane development is currently shown as 11.8m AoD; the outfall for the balancing pond has a confirmed invert level of 11.685m AoD. Given the relatively low level of discharge from the new development, it is suggested that there should be sufficient head in the detention basin to provide continuity of flows with the outfall partially submerged.

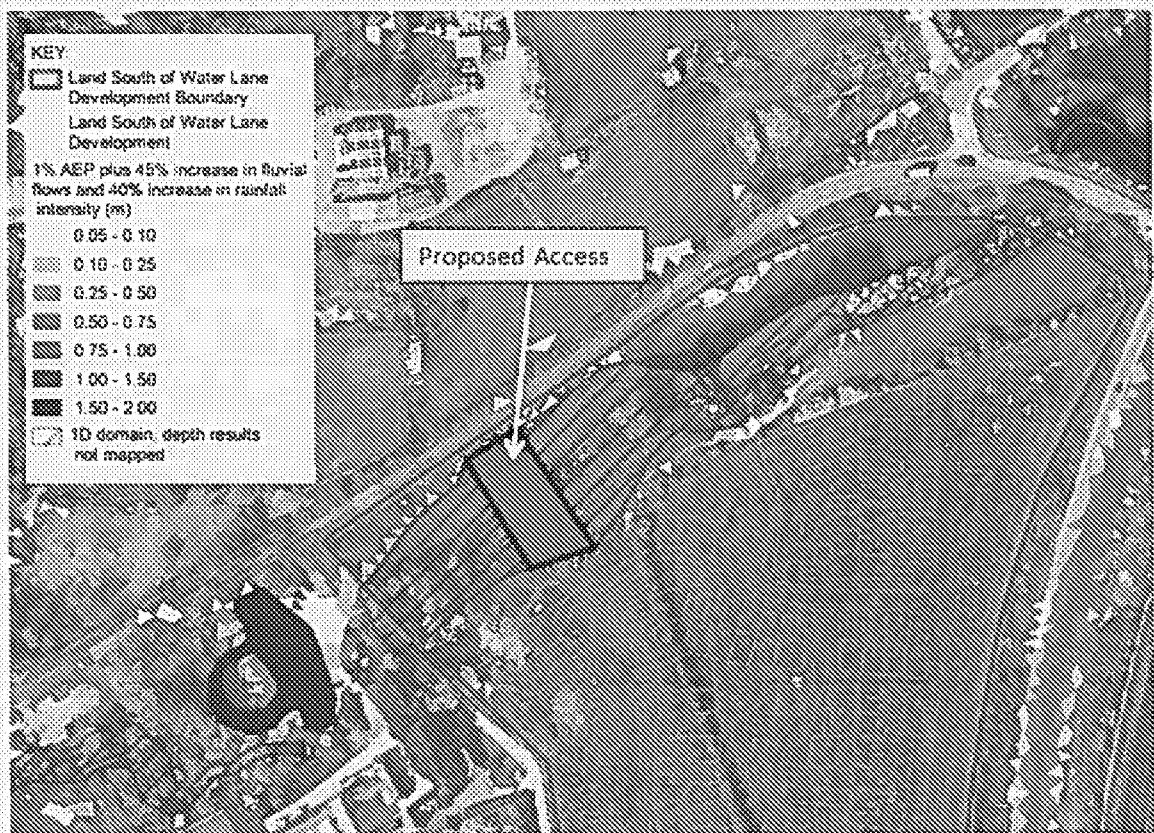


Figure 8.4: Scenario 3: Flood risk to the Land South of Water Lane development for a fully implemented FAS, from a 1% AEP + 45% CC event.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

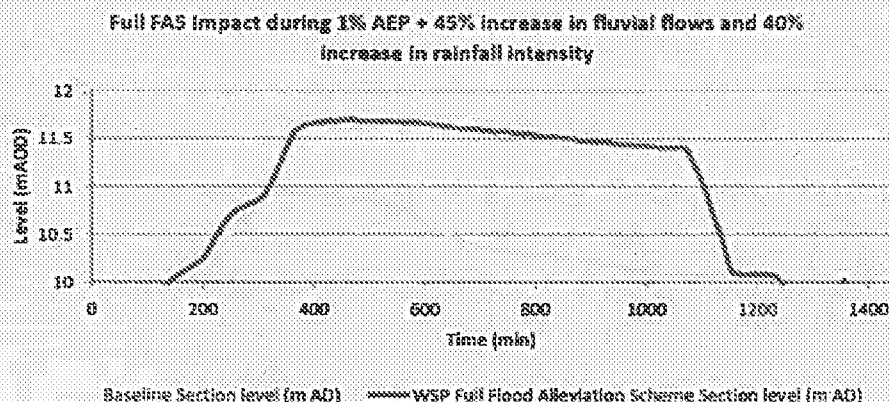


Figure 8.5: Flood levels immediately upstream of the Road Access to Land South of Water Lane for a Full FAS 1% AEP event plus 45% cc (Scenario 3).

8.7 Culverted Road Access without implementation of the FAS.

The scenario in which the culverted road access is constructed without implementation of the remainder of the FAS (Scenario 2) has also been assessed; both to simulate a short-term risk that there is a delay between completion of the road access and the remainder of the scheme being built; and a longer-term situation in which the FAS were not constructed for other reasons, such as lack of funding or approval. The fluvial flood risk for the 1% AEP + 45% CC storm event for the stand-alone culverted road access is shown in Figure 8.6.

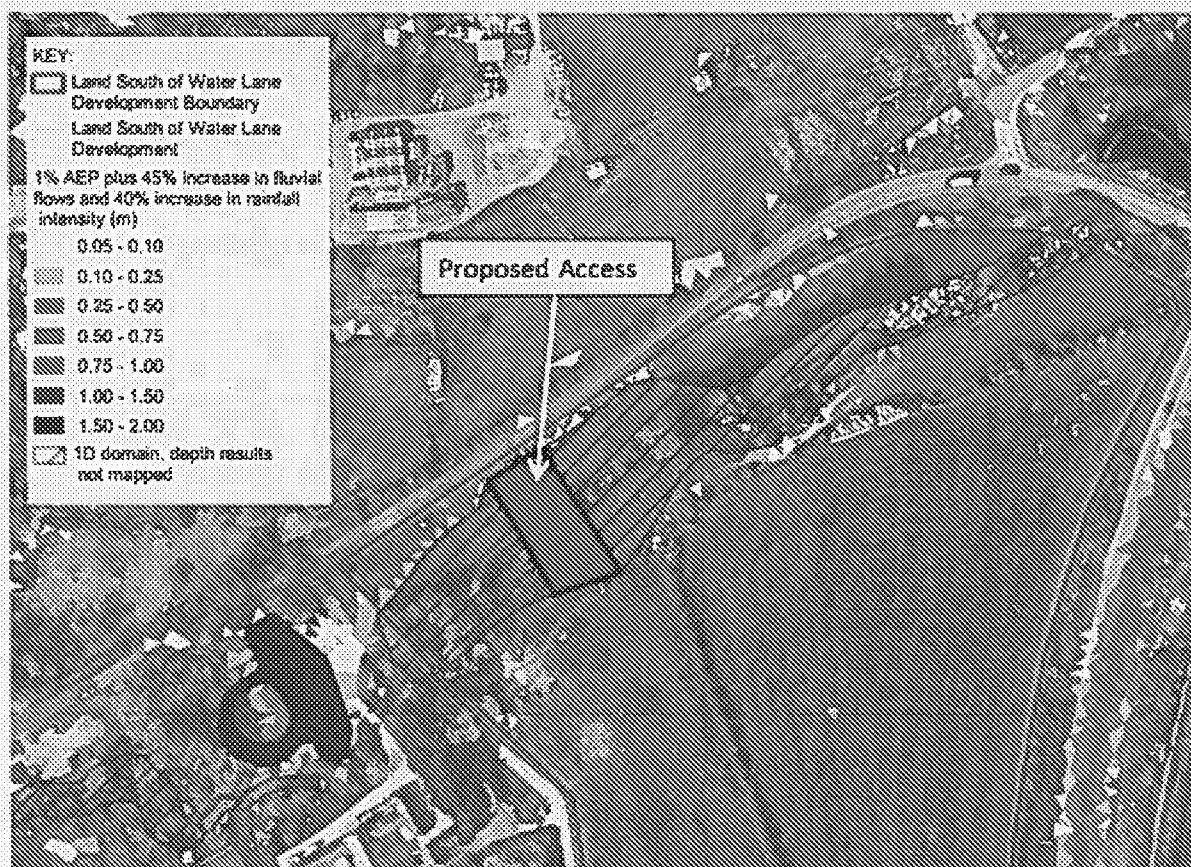


Figure 8.6: Scenario 2: flood risk to the Land South of Water Lane development for a stand-alone culverted embankment access from a 1% AEP + 45% CC event.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

For Scenario 2, the weir and orifices are included upstream of the new access road which creates some backwater effect; however not full backwater as the constrictions have been assumed to be fully open for the 1% AEP plus 45% cc storm event. A depth difference plot for Scenario 2 has been included below (Figure 8.7) and a Table (8.3) of depths at the key locations that can be compared with Table 8.1.



Figure 8.7: Depth difference plot: baseline – un-throttled culverted embankment 1% AEP + 45%cc event.

Table 8.3: Partial scheme (Scenario 2) – peak flood depths (m) at key locations

Location Number	Location Name	Return Period	
		100	100+CC
1	Junction Water Lane and Church Road	0.465	0.568
2	Localised low spot in Water Lane	0.286	0.424
3	Upstream of Avenals Farm access	1.854	2.224
4	Upstream of proposed BDW access	1.765	1.935
5	Upstream of Water Lane culvert;	2.013	2.534
6	Upstream of A280 culvert	1.727	2.233
7	Upstream of Ecclesden Farm access	2.544	2.637

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

8.6 Flood risk to Agricultural Land

Most potential receptors for consideration of flood risk lie within the new Land South of Water Lane development and the properties in / around Water Lane. However, some analyses has been undertaken to assess the impacts of attenuation upstream of the culvert under the A280. From consultation with the Landowner it has been established that the only field regularly in use for arable (as opposed to grazing) is that shown in plate 7.2.

8.7 Baseline and FAS flood risk for the area upstream of the A280 culvert are shown in Figures 8.8 and 8.9 respectively.



Plate 8.2: Location of arable field in Ecclesden Agricultural Holding Act tenancy

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

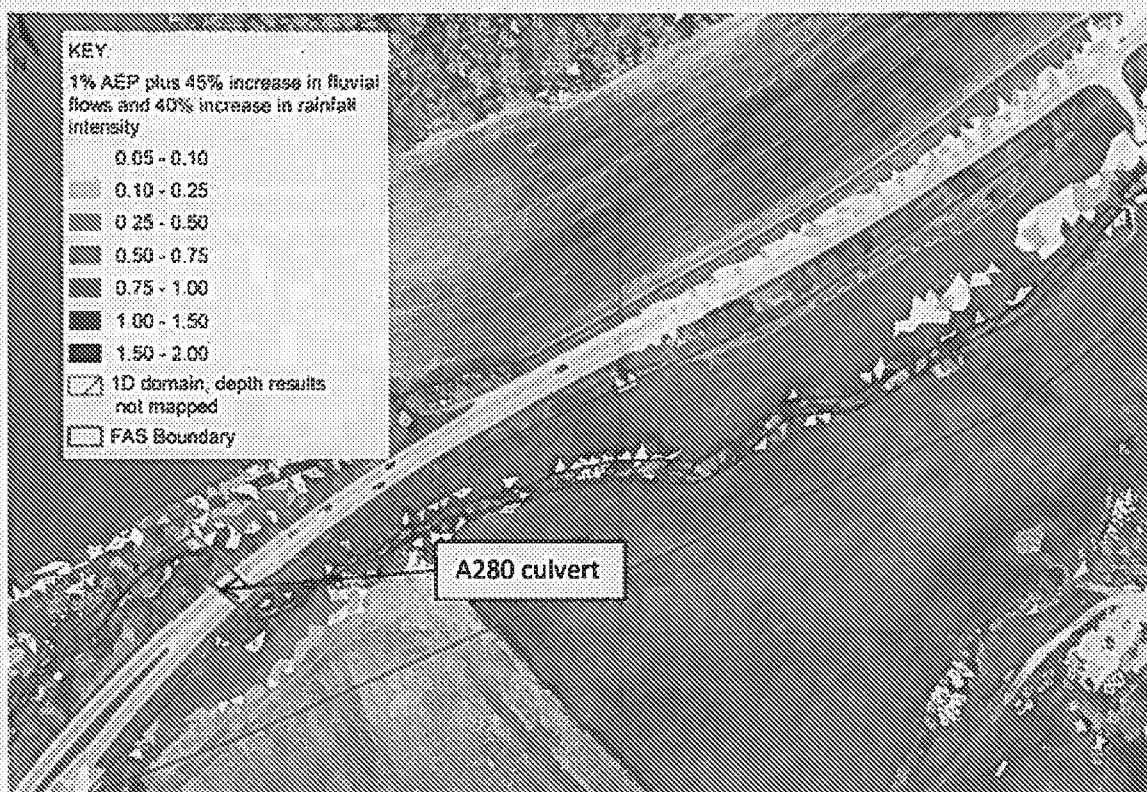


Figure 8.8: Baseline flood risk for a 1% AEP + 45%cc event; area surrounding the A280 culvert.

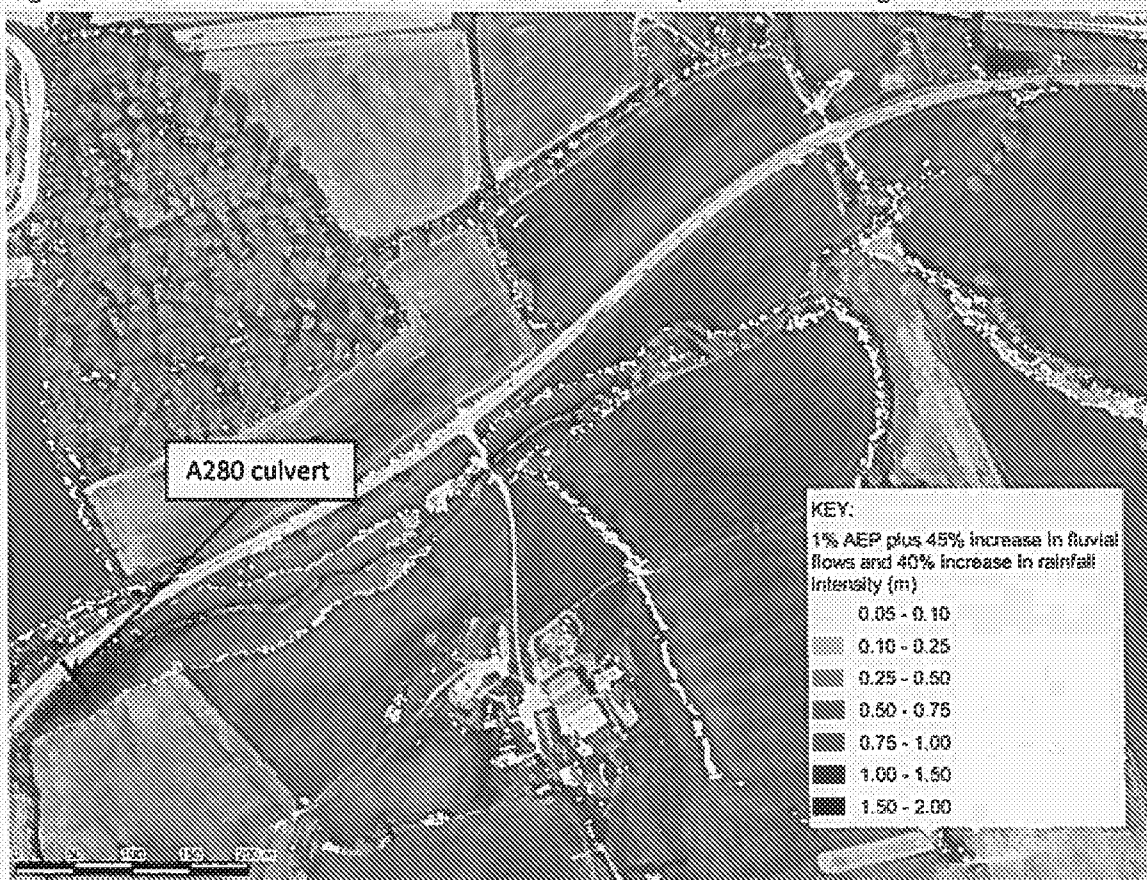


Figure 8.9: FAS fluvial flood risk for a 1% AEP + 45% cc event; area surrounding the A280 culvert.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

- 8.8 It will be noted that the extent of inundation onto the arable land and depth of flood water is quite limited, for the most part less than 1m. Furthermore, the modelling suggests that the duration for which out of bank flows would be exceeded is 10-12 hours.
- 8.9 The total extent of agricultural land affected by the FAS is shown in Figure 8.10 below that also includes maximum flood depths. It will be noted that 0.26ha of arable land (4% area within the FAS boundary) is affected by the scheme with most of the attenuation area subsuming pasture in the floodplain; (see breakdown set out in Table 8.1 below).
- 8.10 The relatively small impact in terms of interference with agricultural land is further demonstrated by the willingness of the landowner and tenant farmer to support the scheme.



Figure 8.10: Overlay of peak flood attenuation extent on agricultural land with breakdown by arable / grazing land areas.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

Table 8.1: Breakdown of agricultural land affected by the FAS.

Land Use	FAS Boundary Area (m2)	Baseline Area (m2)	Area affected Baseline %	Option 4 Area (m2)	Area affected %
Mature vegetation	13,461	4,827	7.6%	6,986	11.0%
Channel	4,727	4,727	7.5%	4,727	7.5%
Pasture	40,206	14,300	22.6%	19,151	30.2%
Arable	4,949	294	0.5%	2,605	4.1%
Unaffected Land (FAS)		39,195	61.9%	29,874	47.2%
Total Area	63,343		100%		100%

9.0 Conclusions

1. The village of Angmering experiences a combination of fluvial / surface water flooding, the principal cause of which is lack of capacity in the culverted section of the Black ditch in Water Lane and Angmering village centre to cope with storm run-off from the upstream catchment extending ~25km² into the downs.
2. Modelling using the EA's Black Ditch model suggests the frequency of flooding to be between a 10% and 20% annual exceedance probability (AEP).
3. The topography of the land upstream of the Weavers Lane trash screen at the head of the Water Lane culvert is such that it offers significant storage capacity and the opportunity to restrict the flows on the Black Ditch and attenuate storm water at a number of locations.
4. Additionally, the opportunity to restrict flows using the road embankment for the new access road to the Land South of Water Lane development significantly reduces the complexity and cost of the FAS and therefore increases its viability.
5. The FAS, as currently proposed in outline, comprises restrictions on peak flows as set out below:
 - a. Upstream of the access track to Ecclesden Farm to fully exploit the capacity of the existing pond;
 - b. At the upstream side of the culvert under the A280; restriction of peak flows to 1.8m³/s.
 - c. At the discharge from the balancing pond area serving the A280; restriction of peak flows to 1.8m³/s.
 - d. Upstream of the proposed access road to the 'Land South of Water Lane' development; restriction of peak flows on the main culvert to 1.8m³/s;
 - e. Upstream of the current access road serving Avenals Farm; restriction of peak flows to 1.5m³/s.

In addition, the scheme will remove accumulated sediment of the culverted section of the Black Ditch that runs underneath Water Lane and consider mechanisms to minimise entry of silt into the culverted sections from upstream.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

6. Initial modelling suggests that implementation of the scheme would reduce the frequency of fluvial flood risk in Water Lane to between a 2% and 1% AEP. This estimate may change as part of the detailed modelling however it is the right order of magnitude.
7. Groundwater flows are principally those associated with base flows to the Black Ditch that in terms of flood risk significance are outweighed by the fluvial flows / surface water flows. The FAS is not anticipated to impact upon groundwater flooding.
8. Given the scope to use the new BDW access road (for the Land South of Water Lane development) other existing embankments and culverts and a sizeable pond for attenuation, the FAS as currently envisaged is considered to be a low-cost, low negative environmental impact option.
9. As a precautionary measure, the culvert beneath the access road to the Land South of Water Lane development has been designed such that there would be negligible change to the baseline design of a 'free-standing bridge' as originally planned for this location. The 'throttling' mechanism (a weir structure with orifice control gates beneath) can be fitted upstream of the proposed 3.5m wide and 3m high culvert, which has been oversized to accommodate the flow paths from the weir structure.

10.0 Recommendation

As a relatively low cost low environmental impact option that will offer significant benefits in terms of flood risk reduction to the community of Angmering this scheme is recommended for approval by the EA.

Flood Risk Assessment for Angmering Flood Alleviation Scheme: V 1.0

References:

- A. Environment Agency (2015). SSD & KSL – Initial Assessments Angmering Fluvial & Surface Water FAS -IMSE100357 August 2015.
- B. Environment Agency (2018). Angmering Flood Alleviation Scheme: Options Modelling Report dated 4 December 2018.
- C. Idom Merebrook (2017). Land to the South of Water Lane, Angmering, Flood Risk Assessment.
- D. Arun District Council (2016) Level 1 and Level 2 Strategic Flood Risk Assessment Final Report November 2016 .