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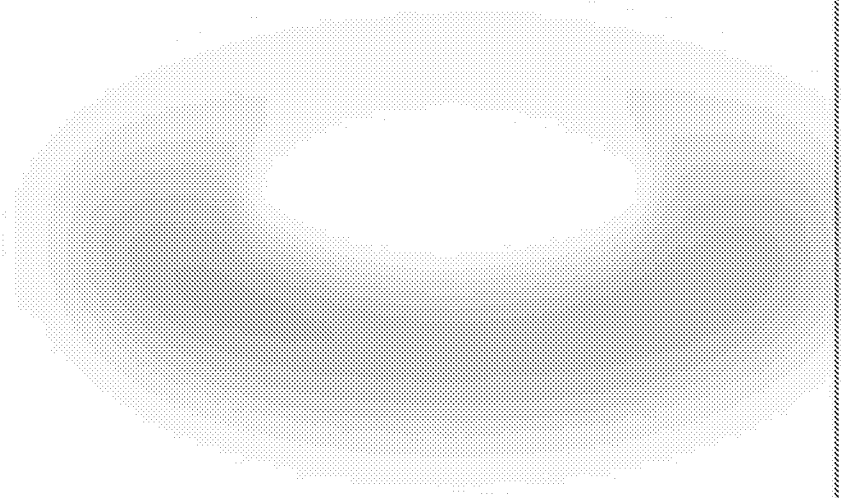
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PROJECT: PHASE 1 FLOOD RISK ASSESSMENT**LOCATION:** GLADSTONE COTTAGES, ANGMERING**PREPARED FOR:** INSPIRED DESIGN STUDIO LTD

Proposed New Dwelling as Extension of Existing Terrace

4 GLADSTONE COTTAGES
WATER LANE
ANGMERING
WEST SUSSEX
BN16 4EJ

PROJECT #: 2123

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Summary

The proposed development site is located at 4 Gladstone Cottages, Water Lane, Angmering, BN16 4EJ. The proposed development is for the construction of a new dwelling as part of an end of terrace. The assessment has been carried out using current best practices, and against the criteria set out in the NPPF.

As such, and following an analysis of EA flood risk maps, recorded / modelled river levels, topographic and anecdotal information, it can be concluded that the risk and impact of flooding from fluvial sources is currently moderate and would remain so following redevelopment.

The risk of flooding from surface water and groundwater has been deemed to be moderately significant, and the risk of flooding from sewers has been deemed to be relatively low.

As such, and given that:

- a. the site lies within an existing developed area;
- b. the site lies within an area where the Black Ditch Extension is culverted;
- c. flood defence barriers shall be produced for the site, to a level of 6.49m AOD (1:100yr +CC flood level + 300mm);
- d. the development will provide flood compensatory storage on the site which will provide a 33.67m³ betterment over the existing flood storage potential;
- e. a safe access and egress route will be provided by a formal flood warning and evacuation plan, which will be agreed with emergency planners, and tied in to the existing emergency plans for the area, and;
- f. in terms of flood vulnerability, significant betterment can be achieved through the implementation of flood warning procedures and flood resilient construction;

following the guidelines contained within the NPPF, the proposed development is considered to be suitable assuming appropriate mitigation (including adequate warning and evacuation procedures) can be maintained for the lifetime of the development.

Development Description	Existing	Proposed
Development Type:	Garden of Gladstone Cottages	Construction of a new dwelling as part of an end of terrace
(Number of Bedrooms):	N/A ¹	2
EA Vulnerability Classification:	N/A ¹	More vulnerable
Ground Level:	Approx. 5.952mAOD to 7.174mAOD	
Level of Sleeping Accommodation:	N/A ¹	Sleeping accommodation located on first floor
Impermeable Surface Area:	N/A ¹	45m ²
Surface Water Drainage:	N/A ¹	
Development Size:	N/A ²	45m ²
Risk to Development	Summary	Comment
EA Flood Zone:	Flood Zone 3a	Proposed development Flood Zone 3a
Flood Source:	Fluvial	Black Ditch Extension Culvert
Undefended 1% AEP level	6.11mAOD	Node 1
Undefended 1% +CC AEP level	6.19mAOD	
Undefended 0.1% AEP level	6.36mAOD	
Recorded Flood Events in Area:	Yes	Unknown source, 1980, EA data Undated historic sewer flooding, SFRA Flooding of Water Lane, 2012, unknown source
Recorded Flood Events at Site:	Yes	Unknown source, 1980, EA data
SFRA Available:	Yes	Arun District Council, Feb 2008
Management Measures	Summary	Comment
Ground floor level above extreme flood levels:	No floor rising not possible due to other planning constraints – flood barriers provided	
Safe Access/Egress Route:	Yes	Used in conjunction with the EA Flood Warning Service
Flood Resilient Design:	Yes	Bedrooms above Ground floor, solid concrete floors throughout the Ground floor, Ground floor electrics brought down from ceiling
Site Drainage Plan:	N/A ¹	Drainage to be part of later planning stage
Flood Warning & Evacuation Plan:	Yes	EA Flood Warning Service
Offsite Impacts	Summary	Comment
Displacement of floodwater:	None	Flood compensation provided
Increase in surface run-off generation:	N/A ¹	Drainage to be part of later planning stage
Impact on hydraulic performance of channels:	None	No direct impact on channel

Table S1: Summary of flood risks, impacts and proposed flood mitigation measures.

N/A¹ not required for this assessmentN/A² data not available

Development Description and Location

Proposed Development and Location

The proposed development site is located at 4 Gladstone Cottages, Water Lane, Angmering, West Sussex, BN16 4EJ (*Figure 1*).

The proposed development is for the construction of a new dwelling as part of an end of terrace. Ground levels across the proposed development footprint vary between approximately 5.952mAOD and 7.174mAOD (*Source: 2m LiDAR*).

Vulnerability Classification

Under the NPPF, the proposed development is classified as “more vulnerable”.

Sequential Test/ Exception Test

Under the NPPF, all new planning applications must undergo a *Sequential Test*. This test must be implemented by local planning authorities with a view to locating particularly vulnerable new developments (e.g. residential, hospitals, mobile homes etc.) outside of the floodplain. The test refers to the EA Flood Zones described in Table 2. For reference, the NPPF *Sequential Test: Flood Risk Vulnerability and Flood Zone ‘Compatibility’* Table is reproduced below.

Flood Risk Vulnerability Classification		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test Required	✓	✓
	Zone 3a	Exception Test Required	✓	✗	Exception Test Required	✓
	Zone 3b (functional floodplain)	Exception Test Required	✓	✗	✗	✗

Table 1: The Sequential Test: Flood Risk Vulnerability and Flood Zone ‘Compatibility’ Table as specified by the National Planning Policy Framework (NPPF). Shaded cells denote the proposed re-development. Please note: ✓ means development is appropriate; ✗ means the development should not be permitted. (Source: NPPF)

Using the principles of the Sequential Test outlined above, the proposed development is ‘more vulnerable’ and is located within Flood Zone 3a (as defined by the EA). As such, under the NPPF, this development would require implementation of the Exception Test further to passing the Sequential Test.

For the Exception Test to be passed, the proposed development must meet the following criteria:

- it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh the flood risk, as informed by a Strategic Flood Risk Assessment;

- a Flood Risk Assessment demonstrates that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

(Source: NPPF)

As such, and in order to address these requirements, the planning application submitted by Inspired Design Studio Ltd is required to be accompanied by a FRA which shows that the development can be achieved in a sustainable manner, with an overall reduction of flood risk to the site and surrounding area.

Definition of Flood Hazard

Sources of Flooding to the Site

Communication with the EA has identified the following potential sources of flooding to the site:

Fluvial:	Black Ditch Extension (culvert)
Tidal:	N/A
Surface:	N/A
Groundwater:	In Area
Sewer:	N/A
Artificial sources:	N/A

Mechanisms and History of Flooding

Fluvial

Communication with the EA suggests that the site lies within Flood Zone 3a (High Risk), with a >1% annual chance of fluvial flooding from the Black Ditch Extension in the absence of all defences. However the Black Ditch at this location is culverted, with the closest upstream open channel being located approximately 125m from the proposed development site. The Black Ditch remains culverted for another approximately 410m downstream of the proposed development before coming to the surface again, near Angmering Village Hall.

The Black Ditch Extension's channel as it enters the culvert is approximately 5.45mAOD with a sharp topographic increase to approximately 7.24mAOD just downstream of the culvert entrance, this is an approximate topographic increase of 1.79m (*Figure 4*). This means that water levels within the Black Ditch Extension channel must reach over approximately 1.79m depth before water will overtop the culvert feature and enter Water Lane (*See Figures 4 – 6 for Black Ditch Extension channel profiles.*)

Over land flow of water, caused by the failure of the culvert, would travel down slope along Water Lane until it reached the open channel of the Black Ditch at the junction between Water Lane, Station Road and Arundel Road.

As part of the West Sussex County Council's Operation Watershed, to reduce the impact of flooding to communities within West Sussex, Angmering Parish Council has invested in a publicly viewable web camera to monitor the Black Ditch Extension culvert grill for

obstructions. This was proven to work in February 2014 (as described on the West Sussex County Council Operation Watershed page) when during a heavy rainfall event it was noted that debris was blocking the culvert grill and causing the culvert to become overwhelmed. The EA was informed of the blockage, and remediation was undertaken. This remediation work meant water levels upstream of the grill were reduced and flooding along Water Lane did not occur.

Modelled flood levels for Gladstone Cottages was provided to Ambiental by the EA, for the 1:100yr, 1:100yr (with allowance for climate change) and 1:1000yr fluvial flood event with the assumption of no defences. Taking the maximum flood levels provided and comparing them to the minimum topographic site level has provided flood depths at the development location of 0.16m for the 1:100yr event, 0.24m for the 1:100yr event (with allowance for climate change) and 0.41m for the 1:1000yr event.

Modelled flood extents provided by the EA from this 2010 modelling show the site to be within the fluvial 1:100yr and 1:100yr (with allowance for climate change) flood event extents. These modelled flood extents also show that the 1:20yr flood event extent is confined to the area surrounding the Black Ditch Extension outside of the culvert.

The Arun District Council SFRA Actual and Residual Risk of Flooding from Rivers map shows the development site to be outside the range of both the actual (1% AEP, 2006) and residual (0.1% AEP, 2006) risk of flooding as shown on the map (*Figure 7*). The SFRA also shows the site to be outside the projected 2106 1% AEP defended and 2056 1% AEP defended river flood extents (*Figure 8*). Both of these maps are low resolution and cover a wide geographical area.

The flood alleviation works which have taken place since the last recorded flood event, caused by the culvert blocking, have been proven to reduce the occurrence of flooding in 2014, and as such the risk of flooding from this source is considered to be **moderately significant**.

Surface

No record of surface water flooding at the site has been provided to Ambiental by the EA.

The EA risk of flooding from surface water map shows the site to be located in a region potentially effected by surface water flooding. Surface water flood risk on site is shown to be 'Low' (annual chance of flooding between 0.1% - 1%).

The Arun District Council SFRA, Historic Flood Map shows Water Lane, which is the road on which the proposed development is located, to have been affected by both surface water flooding and flooding from an unknown cause. No detailed records for these flood events are available from the SFRA.

Due to this the risk of flooding from this source is considered to be **moderately significant**.

Groundwater

No record of groundwater flooding at the site has been provided to Ambiental by the EA.

The Arun District Council SFRA has highlighted the site to be within a Groundwater Emergence Zone, and as such flood risk from this source has the potential to be high. The Arun District Council SFRA, Historic Flood Map shows Water Lane, which is the road on which the proposed development is located, to have been affected by flooding from an unknown cause. No detailed records for this flood event are available from the SFRA. Due to the

unknown nature of this flooding event the risk of flooding from this source is considered to be **moderately significant**.

Sewer

The Arun District Council SFRA, Feb 2008 Historic Flood Map shows the area surrounding the development to have been affected by 1 instance of sewer flooding (*Figure 9*). However no details are provided surrounding this historic flood event and at the time of writing it is not known whether the site was affected by this flood event.

No anecdotal records of sewer flooding at the site have been provided.

Due to this the risk of flooding from this source is considered to be **relatively low**.

Surface Water Drainage Strategy

Post development there will be an increase in building footprint of approximately 45m². The development plans show a car parking area for 2 cars east of the proposed new construction. This report recommends that this parking area is paved using a permeable paving system, which will keep the impermeable surface area to a minimum for the development. Sustainable drainage should also be considered for the property with a rainwater harvesting system to collect rainwater landing on the developments roof.

Prior to the development it is recommended that a drainage strategy should be undertaken.

Probability of Flooding

Flood Zone

Initial communication with the EA suggested that the proposed development site lies within the EA Flood Zone 3a (1:100yr or greater chance of fluvial flooding).

This information is supported by the EA flood risk map (*Figure 2*) which has been produced in part using JFLOW – a relatively coarse, national scale flood modelling strategy. These maps indicate the potential spatial extent of a fluvial/tidal flood event which has a magnitude that is, on average, likely to occur once in every one/two hundred years (i.e. the 1:100/1:200 year fluvial/tidal floodplain respectively).

It is important to note that only the *potential* floodplain is shown; ***the mitigating effects of any flood defences currently in place are not considered***. For reference, the definition of the NPPF flood risk zones is included overleaf in Table 2.

	Description
Zone 1	Low Probability. This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
Zone 2	Medium Probability. This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year.
Zone 3a	High Probability. This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
Zone 3b	The Functional Floodplain. This zone comprises land where water has to flow or be stored in times of flood. SFRA's should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the EA, including water conveyance routes).

Table 2: Definition of the NPPF Flood Zones. (Source: EA)

Probability of the Site Flooding

According to the EA Floodmap the site is located within Flood Zone 3a, with at least a 1% annual probability of fluvial flooding.

Existing Rates and Volumes of Run-Off Generated by the Site

The existing site forms part of the garden of the adjacent dwelling, and as such is covered largely by permeable surfaces. Post development there will be an increase in impermeable building footprint of approximately 45m². The developer has committed to keeping the impermeable footprint of the development as small as possible by using permeable paving for the proposed car parking area. The developer has committed that run-off from the development will be limited to the existing site run-off rates for all events up to the 1 in 100 year storm (plus an allowance for climate change). As such, the development will have negligible impact in terms of surface water run-off generation.

Pre-development it is recommended that a drainage strategy should be undertaken.

Climate Change

How will the Site be affected by Climate Change?

According to the NPPF, climate change is likely to increase the flow in rivers by 20%. As such, the site may be more likely to be affected by flooding. The 2010 modelled flood extents provided by the EA shows the site will be affected by 0.24m of flood depth for the 1:100yr flood event (with allowance for climate change).

Furthermore, increases in rainfall would lead to an increased risk of surface water flooding.

Detailed Development Proposals

Development Layout

The proposed development is for the construction of a new dwelling as part of an end of terrace.

Please see Appendix A for development plans.

Residual Risks

Identification of Residual Risks

Residual risks are those remaining after applying the sequential approach to the location of development and taking mitigating actions. Examples of residual flood risk include:

- the failure of flood management infrastructure such as a breach of a raised flood defence, blockage of a surface water conveyance system, overtopping of an upstream storage area, or failure of a pumped drainage system;
- failure of a reservoir, or;
- a severe flood event that exceeds a flood management design standard, such as a flood that overtops a raised flood defence, or an intense rainfall event which the drainage system cannot cope with.

The site does not benefit from flood defences and as such there is no residual risk of defence failure to the site.

The EA's risk of flooding from reservoirs map shows the site to be located outside of all maximum extents of flooding from reservoir failure.

The proposed development is for the construction of a new residential dwelling and as such it is understood that communication shall be undertaken between the developers and the local water authorities in relation to the required sewer connections. As such the risk of flooding from sewer failure is likely to be addressed as part of the development.

Flood Risk Management Measures

Protection Measures

Given that the site resides in an area at risk of flooding, the proposed development may require flood mitigation measures. As such, the developer has agreed to implement the following measures:

- Using solid concrete floors throughout the ground floor;
- Bringing down electrical services from ceilings on the ground floor;
- Maintaining internal access from the ground floor to the first floor of the property;

- Keep all bedrooms to the 1st floor;
- Provide demountable flood barriers which will provide protection to a level of 300mm above the 1:100yr +CC flood event level (top of barrier to be a minimum of 6.49mAOD);
- Provide flood compensatory storage on site which will provide a betterment in relation to the site's storage potential and as such will provide a betterment in relation to flood risk off site; and,
- Using permeable paving for all new car parking areas and patio areas associated with the development.

Post development, a **formal flood warning and evacuation plan will be implemented**. The site owner will be responsible for receiving and acting on any given warning. Upon receipt of an extreme flood warning, the site will be evacuated, and will not be reoccupied until the warning has been lifted.

The EA operates a 24-hour telephone service on 0845 988 1188 that provides frequently updated flood warnings and associated floodplain information. Further information can be found on www.environment-agency.gov.uk/floodline. Floodline Warnings Direct is a free service operated by the EA that provides flood warnings direct to occupants by telephone, mobile phone, fax or pager.

- On receipt of a **FLOOD ALERT**, the individual property owners and occupiers should:
 - Monitor the situation via local media;
 - Make themselves aware of forecast local weather conditions;
 - Alert both current visitors, and those scheduled to arrive, of the situation;
 - Prepare to evacuate if necessary.
- On receipt of a **FLOOD WARNING**, the individual property owners and occupiers should:
 - Follow advice to “go in, stay in, and tune in”;
 - Move all vehicles to an area outside of the potential flood extent, if safe to do so;
 - Alert scheduled visitors that they should seek alternative accommodation;
 - Be prepared to follow instruction from the Emergency Services.
- On receipt of a **SEVERE FLOOD WARNING**, the individual property owners and occupiers should:
 - Follow advice to “go in, stay in, and tune in”;
 - Remain attentive to local media forecasts and news bulletins;
 - Do not evacuate unless instructed to do so by the Emergency Services;
 - Only when instructed to evacuate by the Emergency Services, leave the property and follow the agreed evacuation plan.

It is recommended that the site be evacuated upon receipt of a severe flood warning. This will help to ensure that the site is unoccupied during a potential flood event.

It has been agreed that as an additional precautionary measure an evacuation route shall be communicated to all site users so as to enable evacuation from the site in the event of a flood warning being issued.

Access/Egress

In order for an access/ egress route to be acceptable under the NPPF, the combination of flood depths, velocities and debris must be analysed. The methodology for calculating "Flood Hazard" is reproduced below and overleaf according to the methodology stated within the "Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purposes – Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1":

This table is recommended for development planning and control use.

Table 4 – Hazard to People Classification using Hazard Rating ($HR = d \times (v + 0.5) + DF$) for (Source Table 13.1 of FD2320/TR2 - Extended version)

HR	Depth of flooding - d (m)												
	DF = 0.5						DF = 1						
Velocity v (m/s)	0.05	0.10	0.20	0.25	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.0	0.03 + 0.3 = 0.33	0.03 + 0.3 = 0.33	0.06 + 0.3 = 0.36	0.07 + 0.3 = 0.37	0.09 + 0.3 = 0.39	0.12 + 0.3 = 0.42	0.15 + 0.3 = 0.45	0.18 + 0.3 = 0.48	0.24 + 0.3 = 0.54	0.30 + 0.3 = 0.60	0.45 + 0.3 = 0.75	0.60 + 0.3 = 0.90	0.75 + 0.3 = 1.05
0.1	0.03 + 0.5 = 0.53	0.06 + 0.5 = 0.56	0.12 + 0.5 = 0.62	0.15 + 0.5 = 0.65	0.18 + 0.5 = 0.68	0.24 + 0.5 = 0.74	0.30 + 0.5 = 0.80	0.36 + 0.5 = 0.86	0.48 + 0.5 = 0.98	0.60 + 0.5 = 1.10	0.90 + 0.5 = 1.40	1.20 + 0.5 = 1.70	1.50 + 0.5 = 2.00
0.2	0.06 + 0.5 = 0.56	0.12 + 0.5 = 0.62	0.24 + 0.5 = 0.74	0.30 + 0.5 = 0.80	0.36 + 0.5 = 0.86	0.48 + 0.5 = 0.98	0.60 + 0.5 = 1.10	0.72 + 0.5 = 1.22	0.96 + 0.5 = 1.46	1.20 + 0.5 = 1.70	1.80 + 0.5 = 2.30	2.40 + 0.5 = 2.90	3.00 + 0.5 = 3.50
0.3	0.09 + 0.5 = 0.59	0.15 + 0.5 = 0.65	0.30 + 0.5 = 0.80	0.36 + 0.5 = 0.86	0.42 + 0.5 = 0.92	0.54 + 0.5 = 1.04	0.66 + 0.5 = 1.16	0.78 + 0.5 = 1.28	1.08 + 0.5 = 1.58	1.32 + 0.5 = 1.82	1.92 + 0.5 = 2.42	2.52 + 0.5 = 3.02	3.12 + 0.5 = 3.62
0.4	0.12 + 0.5 = 0.62	0.18 + 0.5 = 0.68	0.36 + 0.5 = 0.86	0.42 + 0.5 = 0.92	0.48 + 0.5 = 0.98	0.60 + 0.5 = 1.10	0.72 + 0.5 = 1.22	0.84 + 0.5 = 1.34	1.14 + 0.5 = 1.64	1.38 + 0.5 = 1.88	2.08 + 0.5 = 2.58	2.68 + 0.5 = 3.18	3.28 + 0.5 = 3.78
0.5	0.15 + 0.5 = 0.65	0.24 + 0.5 = 0.74	0.48 + 0.5 = 0.98	0.54 + 0.5 = 1.04	0.60 + 0.5 = 1.10	0.72 + 0.5 = 1.22	0.84 + 0.5 = 1.34	0.96 + 0.5 = 1.46	1.26 + 0.5 = 1.76	1.50 + 0.5 = 2.00	2.10 + 0.5 = 2.60	2.70 + 0.5 = 3.20	3.30 + 0.5 = 3.80
0.6	0.18 + 0.5 = 0.68	0.30 + 0.5 = 0.80	0.60 + 0.5 = 1.10	0.66 + 0.5 = 1.16	0.72 + 0.5 = 1.22	0.84 + 0.5 = 1.34	0.96 + 0.5 = 1.46	1.08 + 0.5 = 1.58	1.44 + 0.5 = 1.94	1.68 + 0.5 = 2.18	2.38 + 0.5 = 2.88	2.98 + 0.5 = 3.48	3.58 + 0.5 = 4.08
0.8	0.24 + 0.5 = 0.74	0.36 + 0.5 = 0.86	0.72 + 0.5 = 1.22	0.78 + 0.5 = 1.28	0.84 + 0.5 = 1.34	1.00 + 0.5 = 1.50	1.12 + 0.5 = 1.62	1.24 + 0.5 = 1.74	1.68 + 0.5 = 2.18	1.92 + 0.5 = 2.42	2.52 + 0.5 = 3.02	3.12 + 0.5 = 3.62	3.72 + 0.5 = 4.22
1.0	0.30 + 0.5 = 0.80	0.45 + 0.5 = 0.95	0.90 + 0.5 = 1.40	0.96 + 0.5 = 1.46	1.02 + 0.5 = 1.52	1.20 + 0.5 = 1.70	1.32 + 0.5 = 1.82	1.44 + 0.5 = 1.94	1.92 + 0.5 = 2.42	2.16 + 0.5 = 2.66	2.76 + 0.5 = 3.26	3.36 + 0.5 = 3.86	3.96 + 0.5 = 4.46
1.5	0.45 + 0.5 = 0.95	0.60 + 0.5 = 1.10	1.20 + 0.5 = 1.70	1.26 + 0.5 = 1.76	1.32 + 0.5 = 1.82	1.50 + 0.5 = 2.00	1.62 + 0.5 = 2.12	1.74 + 0.5 = 2.24	2.28 + 0.5 = 2.78	2.52 + 0.5 = 3.02	3.12 + 0.5 = 3.62	3.72 + 0.5 = 4.22	4.32 + 0.5 = 4.82
2.0	0.60 + 0.5 = 1.10	0.90 + 0.5 = 1.40	1.80 + 0.5 = 2.30	1.86 + 0.5 = 2.36	1.92 + 0.5 = 2.42	2.10 + 0.5 = 2.60	2.22 + 0.5 = 2.72	2.34 + 0.5 = 2.84	2.88 + 0.5 = 3.38	3.12 + 0.5 = 3.62	3.72 + 0.5 = 4.22	4.32 + 0.5 = 4.82	4.92 + 0.5 = 5.42
2.5	0.75 + 0.5 = 1.25	1.10 + 0.5 = 1.60	2.20 + 0.5 = 2.70	2.26 + 0.5 = 2.76	2.32 + 0.5 = 2.82	2.50 + 0.5 = 3.00	2.62 + 0.5 = 3.12	2.74 + 0.5 = 3.24	3.36 + 0.5 = 3.86	3.60 + 0.5 = 4.10	4.20 + 0.5 = 4.70	4.80 + 0.5 = 5.30	5.40 + 0.5 = 5.90
3.0	0.90 + 0.5 = 1.40	1.35 + 0.5 = 1.85	2.70 + 0.5 = 3.20	2.76 + 0.5 = 3.26	2.82 + 0.5 = 3.32	3.00 + 0.5 = 3.50	3.12 + 0.5 = 3.62	3.24 + 0.5 = 3.74	3.96 + 0.5 = 4.46	4.20 + 0.5 = 4.70	4.80 + 0.5 = 5.30	5.40 + 0.5 = 5.90	6.00 + 0.5 = 6.50
3.5	1.05 + 0.5 = 1.55	1.50 + 0.5 = 1.95	3.00 + 0.5 = 3.50	3.06 + 0.5 = 3.56	3.12 + 0.5 = 3.62	3.30 + 0.5 = 3.80	3.42 + 0.5 = 3.92	3.54 + 0.5 = 4.04	4.32 + 0.5 = 4.82	4.56 + 0.5 = 5.06	5.16 + 0.5 = 5.66	5.76 + 0.5 = 6.26	6.36 + 0.5 = 6.86
4.0	1.20 + 0.5 = 1.70	1.65 + 0.5 = 2.15	3.30 + 0.5 = 3.80	3.36 + 0.5 = 3.86	3.42 + 0.5 = 3.92	3.60 + 0.5 = 4.10	3.72 + 0.5 = 4.22	3.84 + 0.5 = 4.34	4.68 + 0.5 = 5.18	4.92 + 0.5 = 5.42	5.52 + 0.5 = 6.02	6.12 + 0.5 = 6.62	6.72 + 0.5 = 7.22
4.5	1.35 + 0.5 = 1.85	1.80 + 0.5 = 2.30	3.60 + 0.5 = 4.10	3.66 + 0.5 = 4.16	3.72 + 0.5 = 4.22	3.90 + 0.5 = 4.40	4.02 + 0.5 = 4.52	4.14 + 0.5 = 4.64	5.04 + 0.5 = 5.54	5.28 + 0.5 = 5.78	5.88 + 0.5 = 6.38	6.48 + 0.5 = 6.98	7.08 + 0.5 = 7.58
5.0	1.50 + 0.5 = 2.00	1.95 + 0.5 = 2.45	3.90 + 0.5 = 4.40	3.96 + 0.5 = 4.46	4.02 + 0.5 = 4.52	4.20 + 0.5 = 4.70	4.32 + 0.5 = 4.82	4.44 + 0.5 = 4.94	5.40 + 0.5 = 5.90	5.64 + 0.5 = 6.14	6.24 + 0.5 = 6.74	6.84 + 0.5 = 7.34	7.44 + 0.5 = 7.94
5.5	1.65 + 0.5 = 2.15	2.10 + 0.5 = 2.60	4.20 + 0.5 = 4.70	4.26 + 0.5 = 4.76	4.32 + 0.5 = 4.82	4.50 + 0.5 = 5.00	4.62 + 0.5 = 5.12	4.74 + 0.5 = 5.24	5.76 + 0.5 = 6.26	6.00 + 0.5 = 6.50	6.60 + 0.5 = 7.10	7.20 + 0.5 = 7.70	7.80 + 0.5 = 8.30
6.0	1.80 + 0.5 = 2.30	2.25 + 0.5 = 2.75	4.50 + 0.5 = 5.00	4.56 + 0.5 = 5.06	4.62 + 0.5 = 5.12	4.80 + 0.5 = 5.30	4.92 + 0.5 = 5.42	5.04 + 0.5 = 5.54	6.12 + 0.5 = 6.62	6.36 + 0.5 = 6.86	6.96 + 0.5 = 7.46	7.56 + 0.5 = 8.06	8.16 + 0.5 = 8.66
6.5	1.95 + 0.5 = 2.45	2.40 + 0.5 = 2.90	4.80 + 0.5 = 5.30	4.86 + 0.5 = 5.36	4.92 + 0.5 = 5.42	5.10 + 0.5 = 5.60	5.22 + 0.5 = 5.72	5.34 + 0.5 = 5.84	6.48 + 0.5 = 6.98	6.72 + 0.5 = 7.22	7.32 + 0.5 = 7.82	7.92 + 0.5 = 8.42	8.52 + 0.5 = 9.02
7.0	2.10 + 0.5 = 2.60	2.55 + 0.5 = 3.05	5.10 + 0.5 = 5.60	5.16 + 0.5 = 5.66	5.22 + 0.5 = 5.72	5.40 + 0.5 = 5.90	5.52 + 0.5 = 6.02	5.64 + 0.5 = 6.14	6.84 + 0.5 = 7.34	7.08 + 0.5 = 7.58	7.68 + 0.5 = 8.18	8.28 + 0.5 = 8.78	8.88 + 0.5 = 9.38
7.5	2.25 + 0.5 = 2.75	2.70 + 0.5 = 3.20	5.40 + 0.5 = 5.90	5.46 + 0.5 = 5.96	5.52 + 0.5 = 6.02	5.70 + 0.5 = 6.20	5.82 + 0.5 = 6.32	5.94 + 0.5 = 6.44	7.20 + 0.5 = 7.70	7.44 + 0.5 = 7.94	8.04 + 0.5 = 8.54	8.64 + 0.5 = 9.14	9.24 + 0.5 = 9.74
8.0	2.40 + 0.5 = 2.90	2.85 + 0.5 = 3.35	5.70 + 0.5 = 6.20	5.76 + 0.5 = 6.26	5.82 + 0.5 = 6.32	6.00 + 0.5 = 6.50	6.12 + 0.5 = 6.62	6.24 + 0.5 = 6.74	7.68 + 0.5 = 8.18	7.92 + 0.5 = 8.42	8.52 + 0.5 = 9.02	9.12 + 0.5 = 9.62	9.72 + 0.5 = 10.22
8.5	2.55 + 0.5 = 3.05	3.00 + 0.5 = 3.50	6.00 + 0.5 = 6.50	6.06 + 0.5 = 6.56	6.12 + 0.5 = 6.62	6.30 + 0.5 = 6.80	6.42 + 0.5 = 6.92	6.54 + 0.5 = 7.04	8.16 + 0.5 = 8.66	8.40 + 0.5 = 8.90	9.00 + 0.5 = 9.50	9.60 + 0.5 = 10.10	10.20 + 0.5 = 10.70
9.0	2.70 + 0.5 = 3.20	3.15 + 0.5 = 3.65	6.30 + 0.5 = 6.80	6.36 + 0.5 = 6.86	6.42 + 0.5 = 6.92	6.60 + 0.5 = 7.10	6.72 + 0.5 = 7.22	6.84 + 0.5 = 7.34	8.64 + 0.5 = 9.14	8.88 + 0.5 = 9.38	9.48 + 0.5 = 9.98	10.08 + 0.5 = 10.58	10.68 + 0.5 = 11.18
9.5	2.85 + 0.5 = 3.35	3.30 + 0.5 = 3.80	6.60 + 0.5 = 7.10	6.66 + 0.5 = 7.16	6.72 + 0.5 = 7.22	6.90 + 0.5 = 7.40	7.02 + 0.5 = 7.52	7.14 + 0.5 = 7.64	9.12 + 0.5 = 9.62	9.36 + 0.5 = 9.86	9.96 + 0.5 = 10.46	10.56 + 0.5 = 11.06	11.16 + 0.5 = 11.66
10.0	3.00 + 0.5 = 3.50	3.45 + 0.5 = 3.95	6.90 + 0.5 = 7.40	6.96 + 0.5 = 7.46	7.02 + 0.5 = 7.52	7.20 + 0.5 = 7.70	7.32 + 0.5 = 7.82	7.44 + 0.5 = 7.94	9.60 + 0.5 = 10.10	9.84 + 0.5 = 10.34	10.44 + 0.5 = 10.94	11.04 + 0.5 = 11.54	11.64 + 0.5 = 12.14

Flood Hazard Rating (HR)	Colour Code	Hazard to People Classification
Less than 0.75		Very low hazard - Caution
0.75 to 1.25		Danger for some – includes children, the elderly and the infirm
1.25 to 2.0		Danger for most – includes the general public
More than 2.0		Danger for all – includes the emergency services

Flood Hazard Rating (HR) and thresholds

The revised 'hazard rating' expression based primarily, on consideration to the direct risks of people exposed to floodwaters.

$$HR = d \times (v + a) + DF$$

where, HR = (Flood) hazard rating;

d = depth of flooding (m);

v = velocity of floodwaters (m/sec); and

DF = debris factor (0, 0.5, 1 depending on probability that debris will lead to a hazard)

a = a constant of 0.5

This final revised Flood Hazard Rating formula from the Flood Risks to People project is presented on page 10 (section 3.5) of FD2321/TR1. The formula is identical in both FD2320 and FD2321 reports.

Extracts from the Supplementary Note to FD2320/TR2 and FD2321/TR1 describing the methodology for calculating 'Flood Hazard' under the NPPF (Source: EA)

Further to the Flood Hazard Mapping tables from FD2320/21, it is clear that for an access/egress route to be considered 'safe' under the NPPF; the route must fall within the 'Low Degree of Flood Hazard' classification.

The proposed route is to leave the property onto Water Lane and travel east until the junction with Weavers Hill where users will then travel south down Weavers Hill. This route is approximately 157m long and brings users into Flood Zone 1, with access to main travel routes out of the area if required. An alternative escape route, travelling away from the Black Ditch Extension culvert entrance can be used by site users travelling west down Water Lane to the junction with Cumberland Road, where users would travel south down Cumberland Crescent into Flood Zone 1, from here pedestrian access to the south of Angmering is possible.

Detailed flood depths along the evacuation routes are not available at this time, however an undefended 1:100 year plus an allowance for climate flood event is shown to have a flood depth of 0.33m on Water Lane. This flood depth means that the escape routes does not fall into the 'Low Degree of Flood Hazard' classification regardless of water velocity.

As such the proposed escape routes are to be used in the event of a flood warning being issued for the area, and site users should not follow the evacuation route if flood water is evident, making the evacuation route acceptable under the NPPF.

The Black Ditch Extension being culverted at the location of the development, and with the publicly viewable culvert webcam providing further early warning of potential culvert exceedance, the evacuation route would be used when a flood warning was issued, prior to a flooding event.

Additionally, the development itself is located across Ground and 1st floors, and as such safe refuge is available for users on the 1st floor. Occupants should only follow the escape route in the event of a flood warning. If extreme flooding is already evident then occupants should remain within the property unless advised otherwise by emergency services. Historical records of flooding suggest that flooding is often caused by debris blocking the grill. This culvert is monitored by CCTV so that clearance of this debris can occur, as is evident from previous events occurring in February 2012 (Described in detail in the section Mechanisms and History of Flooding; Fluvial).

Off Site Impacts

Impact to Flood Risk Elsewhere

The proposal is for the construction of a new dwelling as part of an end of terrace. The development will increase impermeable covering on the site by approximately 45m². However the developer has committed to keeping this increase to a minimum by using permeable paving throughout the development and committing that run-off from the development will be limited to the existing site run-off rates for all events up to the 1 in 100 year storm (plus an allowance for climate change).

The developer has agreed to provide compensatory flood storage on site to mitigate against the increase in built footprint on site. As such, there will be no loss of flood storage on site post development. The flood compensatory storage scheme proposed will provide a 33.67m³ betterment over the existing situation and as such may help to reduce the flood risk off site.

Compensatory Flood Storage

Given that the proposed development is located within the EA's Flood Zone 3, and that there will be 45m² of built footprint introduced into the flood plain, it is necessary to assess the loss of potential flood storage capacity following development, and how this can be compensated for on the site.

Comparison of the modelled flood levels with site topography confirms that the site will be inundated by the modelled 1:100 year with climate change flood event.

It is understood that compensation should aim to be provided for on a "level for level" and "volume for volume" basis to mimic floodplain characteristics prior to the proposed development.

To analyse compensation on a "level for level" basis as well as "volume for volume" basis, land above the 1:100yr floodplain (with allowance for climate change) will need to be lowered into the floodplain.

"Level for level" compensation involves the reduction in level of nearby ground, so that the same volume is available at every flood level before and after the development, which can freely fill and drain. As such, for a design flood level, each stage (or level) should be provided with the same storage volume, i.e. at each level (the EA have recommended 0.2m vertical intervals) the excavated and filled volumes should be equal.

Analysis of topographic levels and interpolated modelled flood level show that there is an area suitable for providing compensatory flood storage at the proposed development site. In order to assess flood storage in 0.2m bands, 0.2m contours were generated to intersect with the 1:100yr + CC flood level.

The proposed built footprint is located within the 1:100yr + CC flood extent. Ambiantal have overlain the flood extent, based on the EA flood levels provided onto the digital elevation model formed through remotely sensed LiDAR. The volume of flood storage lost was calculated within each 0.2m band.

Figure 1 overleaf shows the modelled 1:100yr +CC flood level overlain the site, with each colour band defining the 20cm flood bands used within flood compensation.

To allow car parking at the development to remain level, and to allow for better landscaping flood compensation has over compensated within some bands to allow for these architectural requirements. Table 3 shows the cumulative volume lost within each 20cm band

and the volume of flood compensatory storage provided by the proposed re-profiling of the site.

The proposed flood compensatory storage scheme as set out within Table 3 and Figure 2 will provide a betterment (+33.67m³) in relation to flood storage volumes over the existing situation and as such may reduce the risk of flooding downstream of the site.

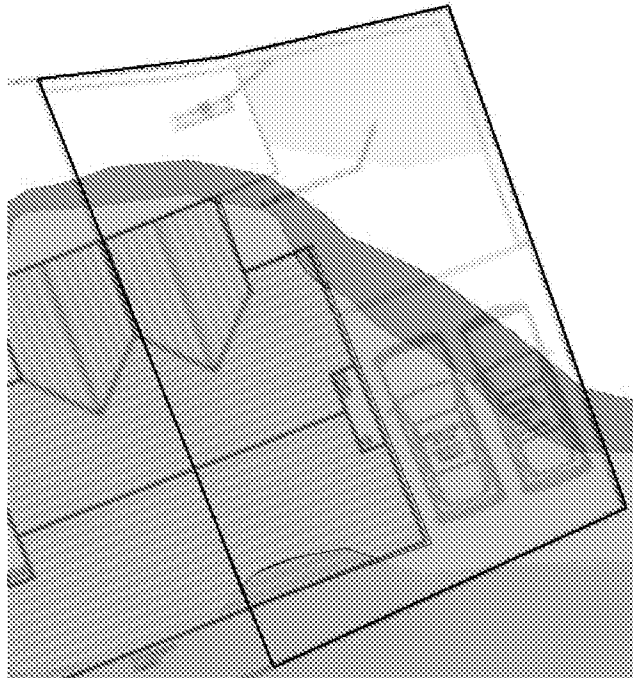


Figure 1: 1:100yr +CC flood level overlain site plan and remotely sensed LiDAR. (Source: LiDAR, Inspired Design Studio)

	5.55 – 5.79 mAOD	5.79 – 5.99 mAOD	5.99 – 6.19 mAOD	6.19 – 6.39 mAOD	Above 6.39 mAOD
Area Lost (m ²)	N/A	2.33	42.34	0.41	N/A
Total Cumulative Volume Lost (m ³)	N/A	0.47	8.93	9.02	N/A
Total Storage Area Provided (m ²)	N/A	36.68	56.29	1.11	N/A
Total Cumulative Storage Volume Provided (m ³)	N/A	7.34	18.59	26.15	N/A

Table 3: Compensatory flood storage calculations

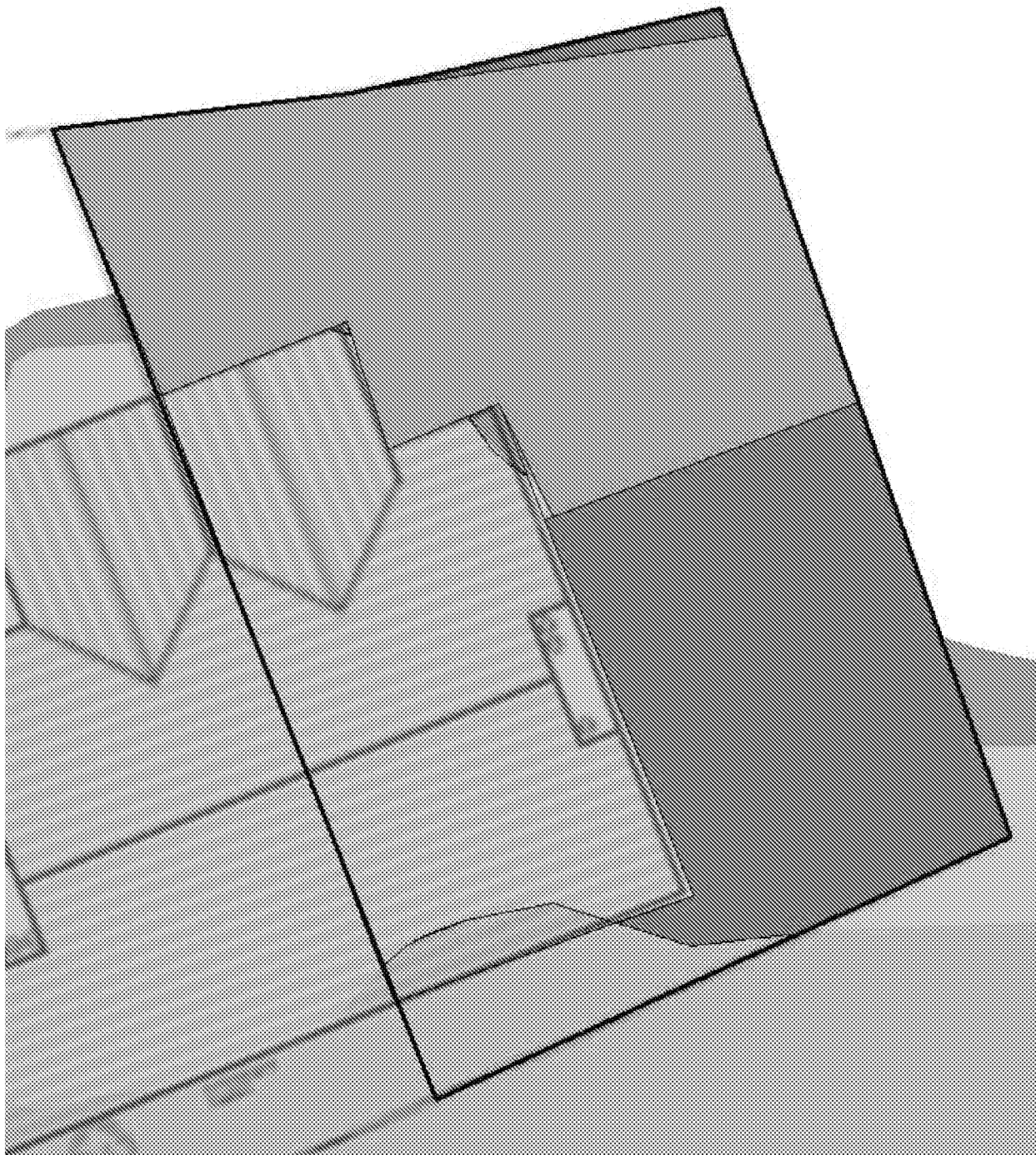


Figure 2: Proposed compensatory flood storage areas, taking into account car parking areas

Generation of Run-Off

Based on the development plans provided, and given that all external hard landscaping shall be of permeable design, the development will increase the impermeable surface coverage on site by approximately 45m².

As such, any change in surface water runoff from the development will likely be negligible.

Conclusions

The proposed development site is located at 4 Gladstone Cottages, Water Lane, Angmering, BN16 4EJ. The proposed development is for the construction of a new dwelling as part of an end of terrace. The assessment has been carried out using current best practices, and against the criteria set out in the NPPF.

As such, and following an analysis of EA flood risk maps, recorded / modelled river levels, topographic and anecdotal information, it can be concluded that the risk and impact of flooding from fluvial sources is currently moderate and would remain so following redevelopment.

The risk of flooding from surface water and groundwater has been deemed to be moderately significant, and the risk of flooding from sewers has been deemed to be relatively low.

As such, and given that:

- g. the site lies within an existing developed area;
- h. the site lies within an area where the Black Ditch Extension is culverted;
- i. flood defence barriers shall be produced for the site, to a level of 6.49mAOD (1:100yr +CC flood level + 300mm);
- j. the development will provide flood compensatory storage on the site which will provide a 33.67m³ betterment over the existing flood storage potential;
- k. a safe access and egress route will be provided by a formal flood warning and evacuation plan, which will be agreed with emergency planners, and tied in to the existing emergency plans for the area, and;
- l. in terms of flood vulnerability, significant betterment can be achieved through the implementation of flood warning procedures and flood resilient construction;

following the guidelines contained within the NPPF, the proposed development is considered to be suitable assuming appropriate mitigation (including adequate warning and evacuation procedures) can be maintained for the lifetime of the development.

The findings and recommendations of this report are for the use of the client who commissioned the assessment, and no responsibility or liability can be accepted for the use of the report or its findings by any other person or for any other purpose.

Dr. J. B. Butler

B.Sc., M.Phil., PhD.

Ambiental Technical Solutions Ltd.

January 2015

Appendix A – Supporting Information

Figure 1: Wider Location Plan;

Figure 2: EA Flood Risk Map;

Figure 3: EA Surface Water Flood Risk Map;

Figures 4 - 6: Topographic relations between the culvert and the proposed development;

Figure 7: Actual and Residual Flood Risk Map;

Figure 8: Actual Flood Risk Map taking into account Climate Change;

Figure 9: Historic Flood Events Map;

Pages 26 - 31: EA Product 4;

Pages 32 – 34: Development Plans.

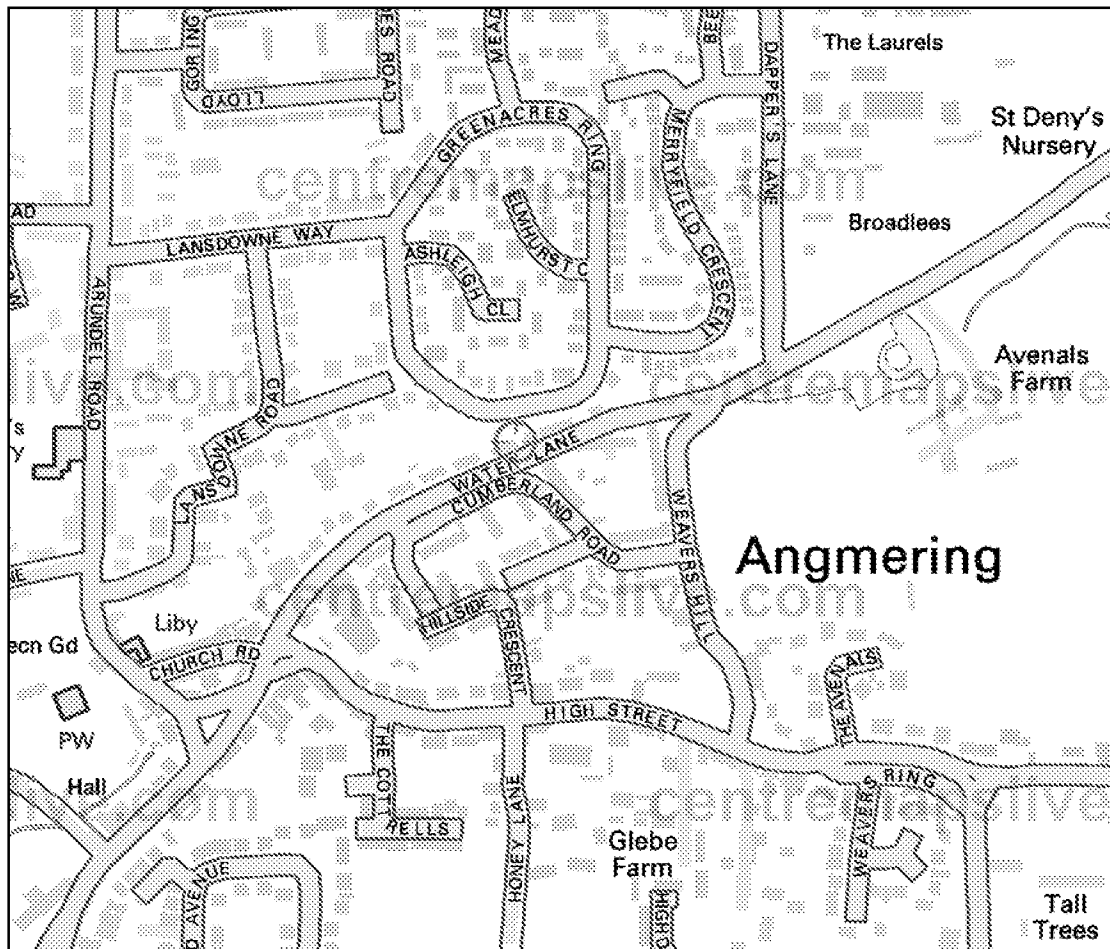


Figure 1: Wider Location Plan (Source: Centre Maps)

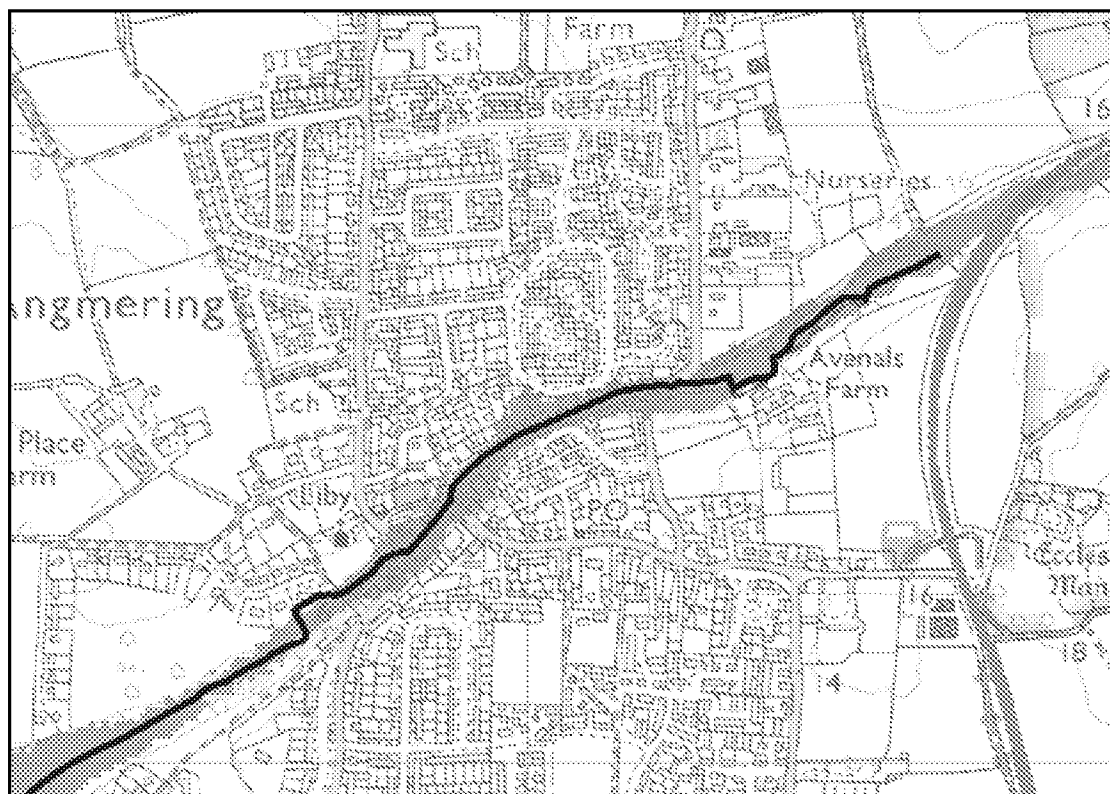


Figure 2: EA Floodmap (Source: EA)

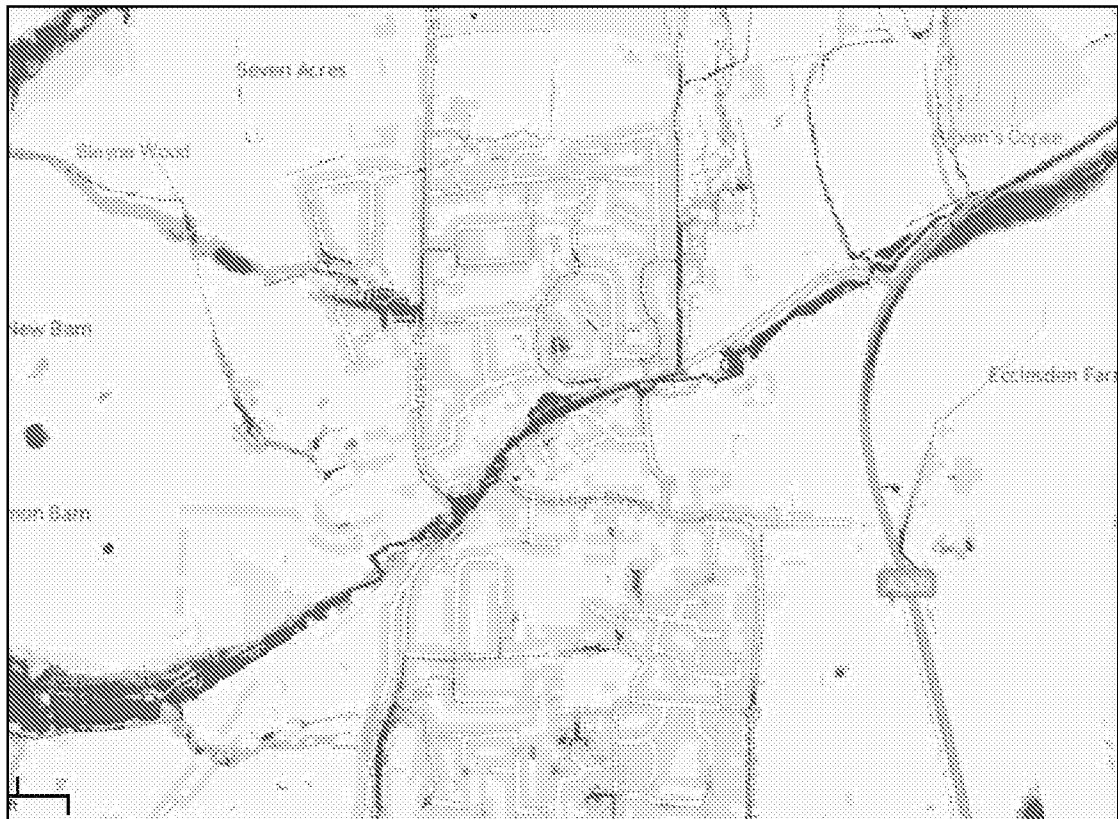


Figure 3: EA Surface water Floodmap (Source: EA)

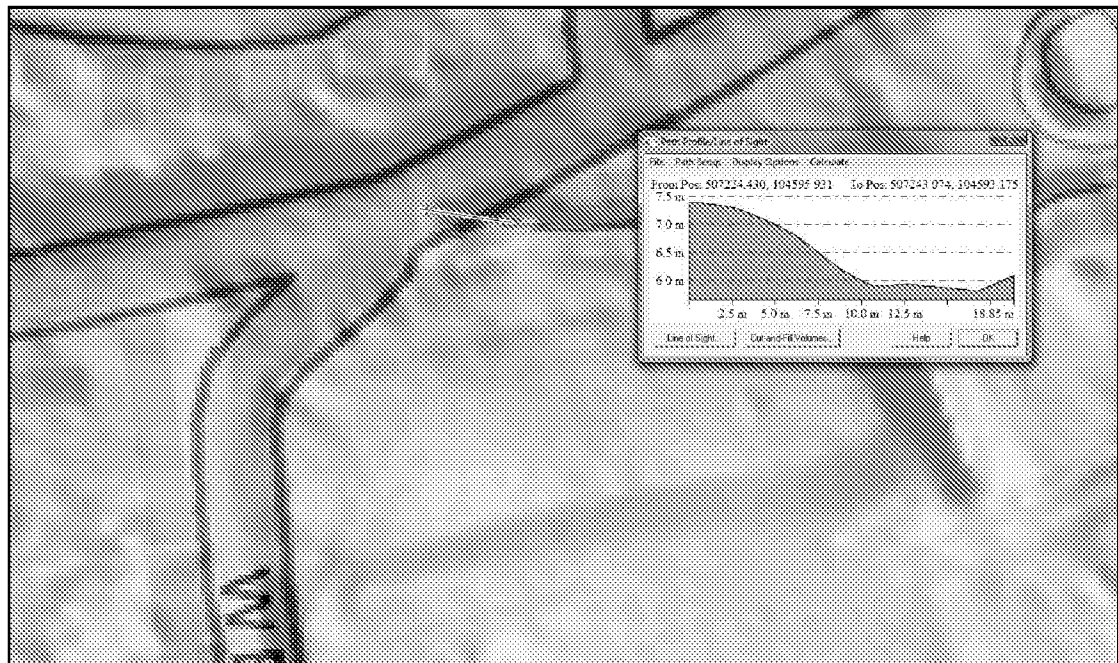


Figure 4: Topographic cross section from culvert to Water Lane (Source: OS Street View and 2m LiDAR)

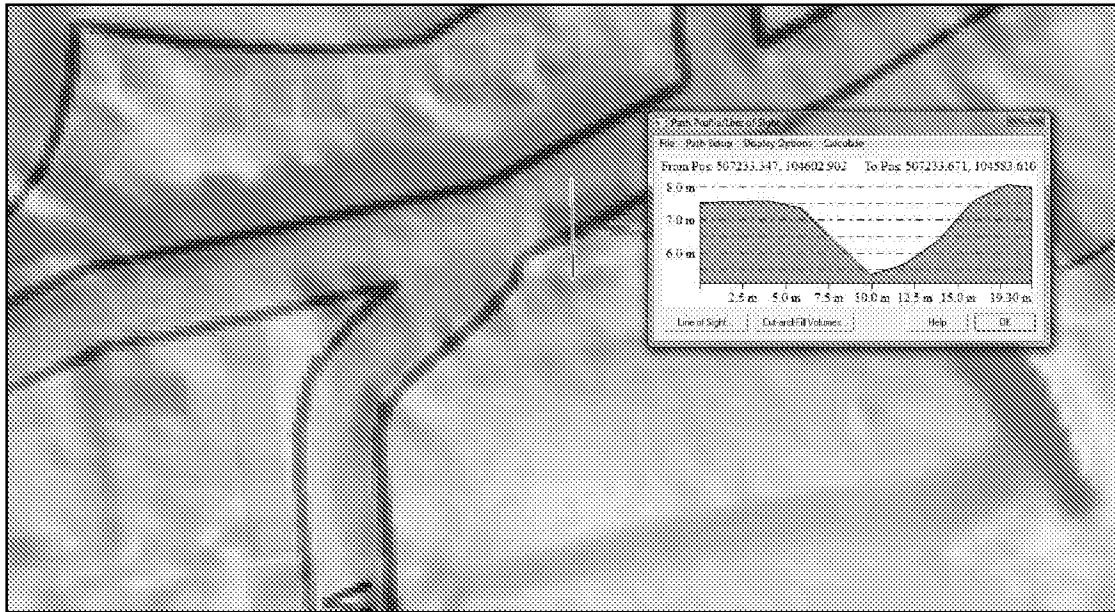


Figure 5: Topographic cross section of culvert (Source: OS Street View and 2m LiDAR)



Figure 6: Topographic cross section from culvert to the proposed development (Source: OS Street View and 2m LiDAR)



Notes:

The Arun SFRA is a strategic assessment of flooding. Users of the SFRA should be aware of this when interpreting the information presented. The user is directed to the SFRA reports which outline the uncertainties associated with the studies.

Particular attention is drawn to the following:

- Flood extent boundaries are not considered definitive. Land adjacent to these areas may also be at risk.
- Some flooding mechanisms have not been included in the assessment. The "coastal risk area" is based on advice from LA Engineers and requires further assessment.

Arun District Council SFRA

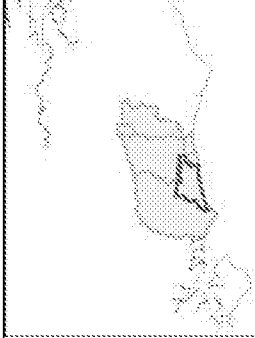
Map A1-F - Actual and Residual Risk of Flooding from Rivers



CAPITA SYMONDS

Legend

- Arun District Boundary
- Actual Defenders Fluvial Flood Risk (7% AEP, 2006)
- Residual Extended Fluvial Flood Risk (1% AEP, 2006)

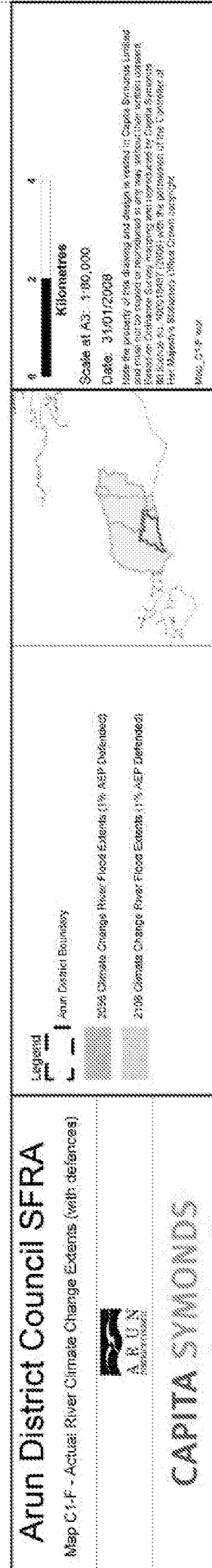


Scale at A0: 1:50,000

Date: 31/03/2008

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Scale: 1:50,000





Notes:

The Arun SFRA is a strategic assessment of flooding. Users of the SFRA should be aware of this when interpreting the information presented. The user is directed to the SFRA reports which outline the considerations associated with the studies.

Particular attention is drawn to the following:

- Flood extent boundaries are not considered definitive. Land adjacent to these areas may also be at risk.
- Some flooding mechanisms have not been included in the assessment. The coastal risk area is based on advice from LA Engineers and requires further assessment.

Arun District Council SFRA

Map H - Historic Flood Events



CAPITA SYMONDS

Legend

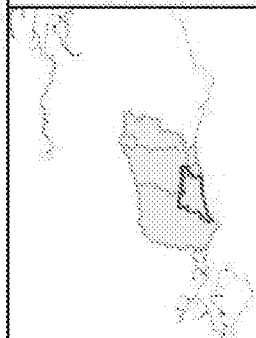
Arun District Boundary

Historic Flood Events - Points

- Coastal
- Fluvial
- Surface Water
- Sewer
- Failure
- Unknown

Historic Flood Events - Areas

- Coastal
- Fluvial
- Surface Water
- Unknown



Kilometres

Scale at A3: 1:50,000

Date: 31/01/2008

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Map H-001

Natalie James
Ambiental
Sussex Innovation Centre
Science Park Square
Brighton
BN1 9SB

Our ref: SSD/5375/PC
Your ref:

Date: 03/12/2014

Dear Natalie

Provision of Product 4 for 4 Gladstone Cottages, Water Lane, Angmering BN16 4EJ

Thank you for your request to use Environment Agency data. The information is attached.

If you have requested this information to help inform a development proposal, then you should note the detail in the attached advisory text on the use of Environment Agency Information for Flood Risk Assessments / Flood Consequence Assessments.

Supporting Information

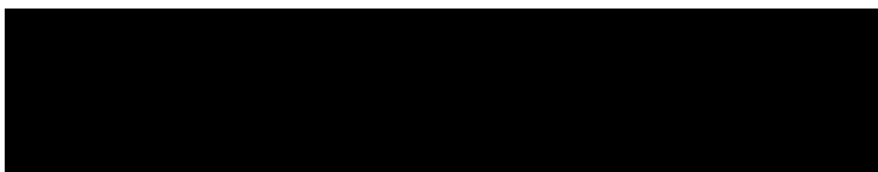
This information is provided subject to the enclosed notice, which you should read.

Modelled Flood Levels

The flood levels and extents attached have been taken from the 2010 Lower Tidal River Arun Flood Modelling study. These levels represent undefended fluvial flood risk.

Flood Defences

There are no raised flood defences in this area.



Flood History

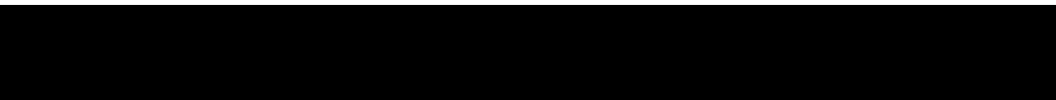
Our records show that a flood event affected this location in 1980. Please see the recorded event outline attached.

I would recommend contacting Arun District Council for a more comprehensive flood history check.

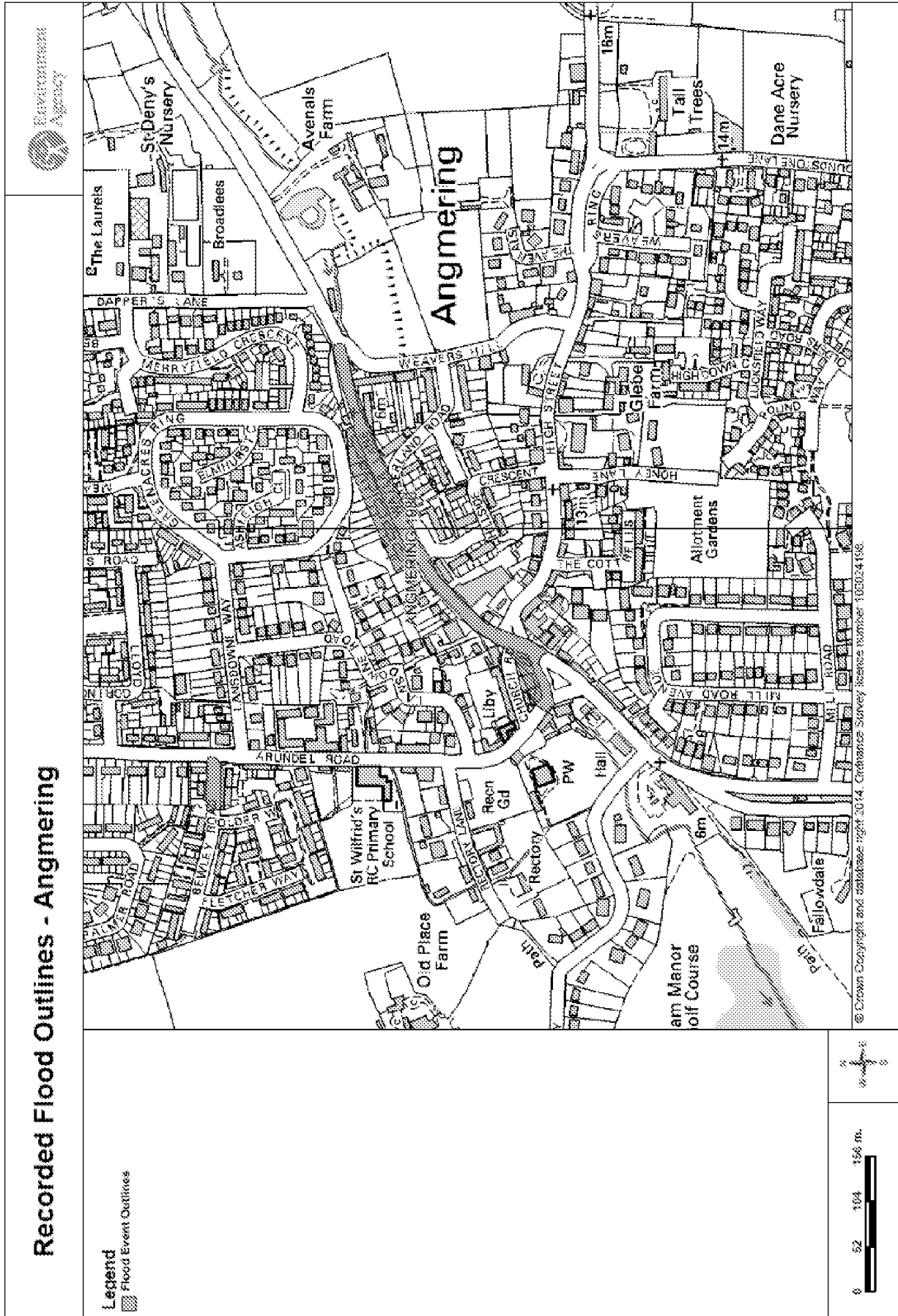
If you have any queries or would like to discuss the content of this letter further please don't hesitate to contact me.

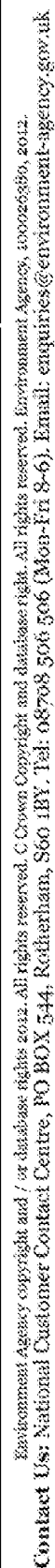
Yours faithfully

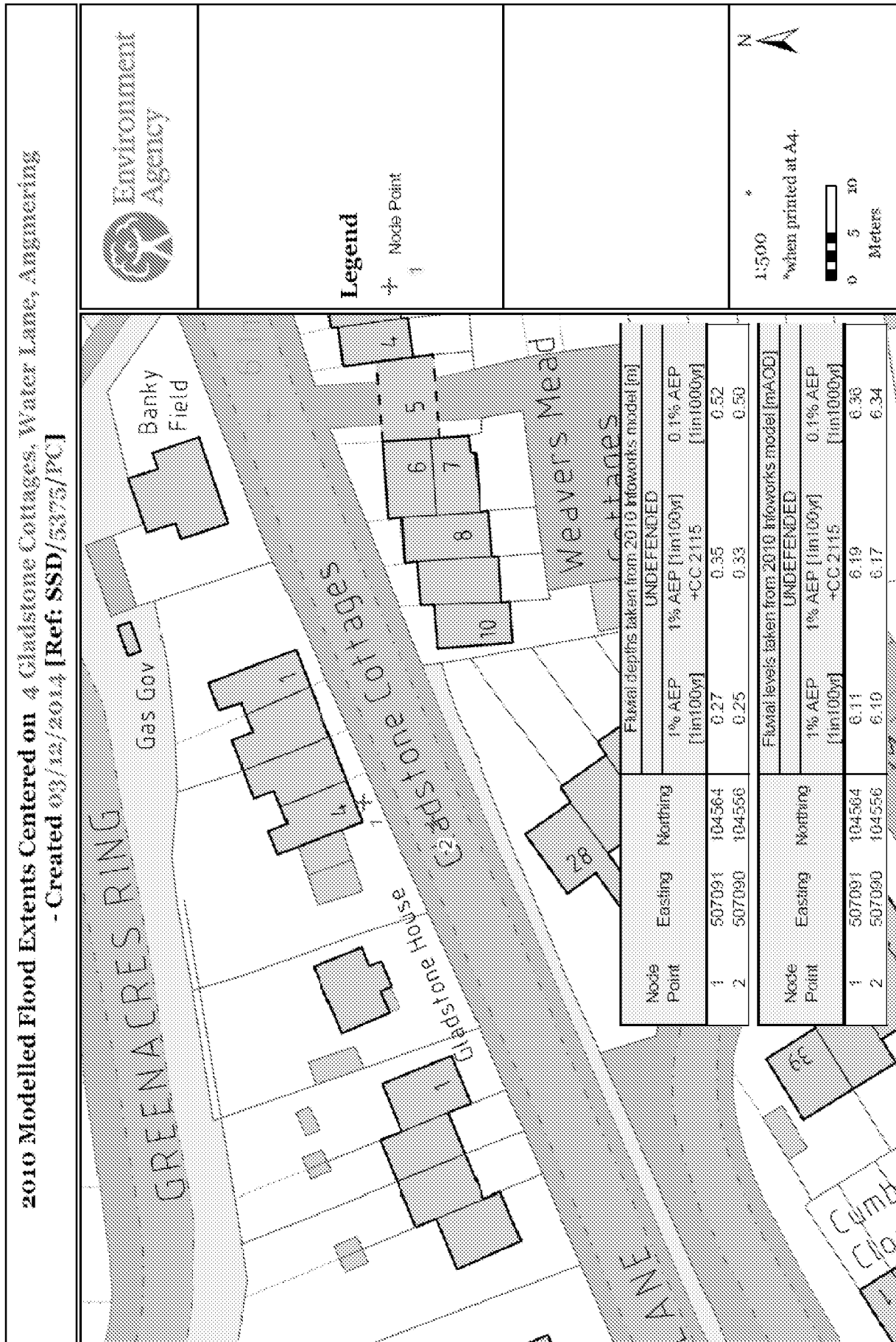
Jon Denman
FCRM Officer
Partnership and Strategic Overview Team – West Sussex



Enc. Detailed FRA/FCA Map, Flood Levels and extents
[Standard Notice]

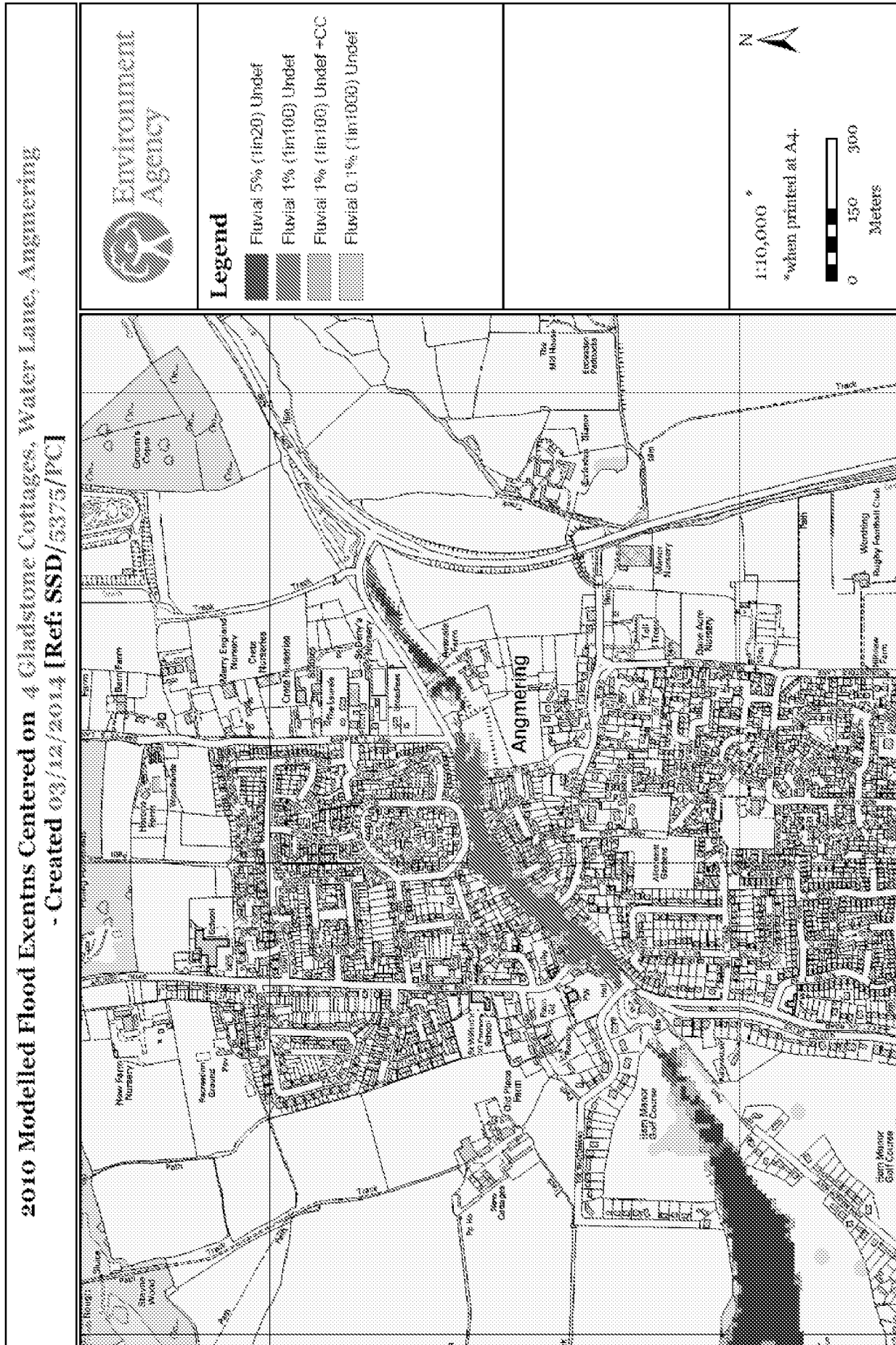


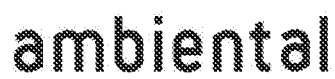


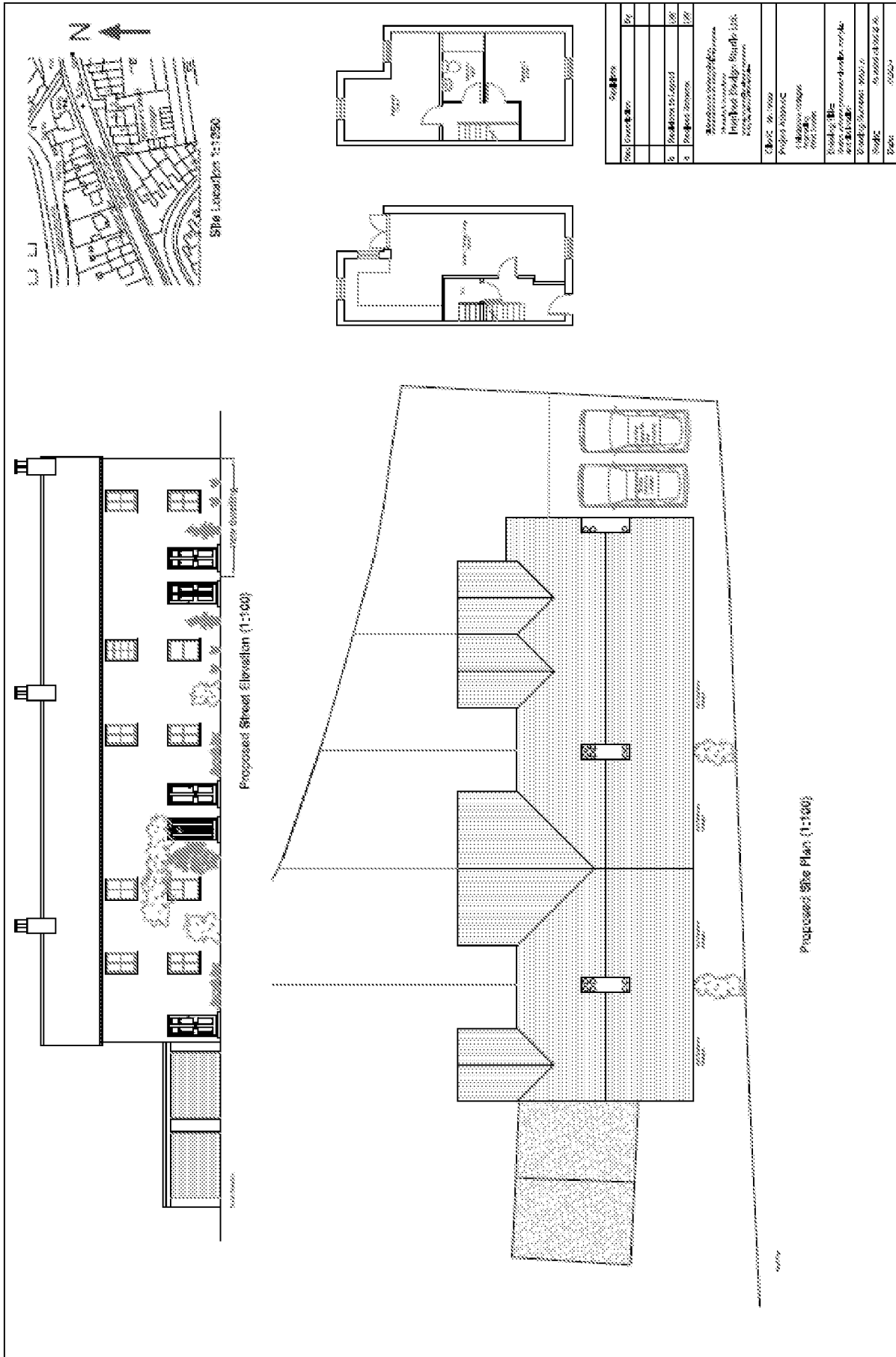


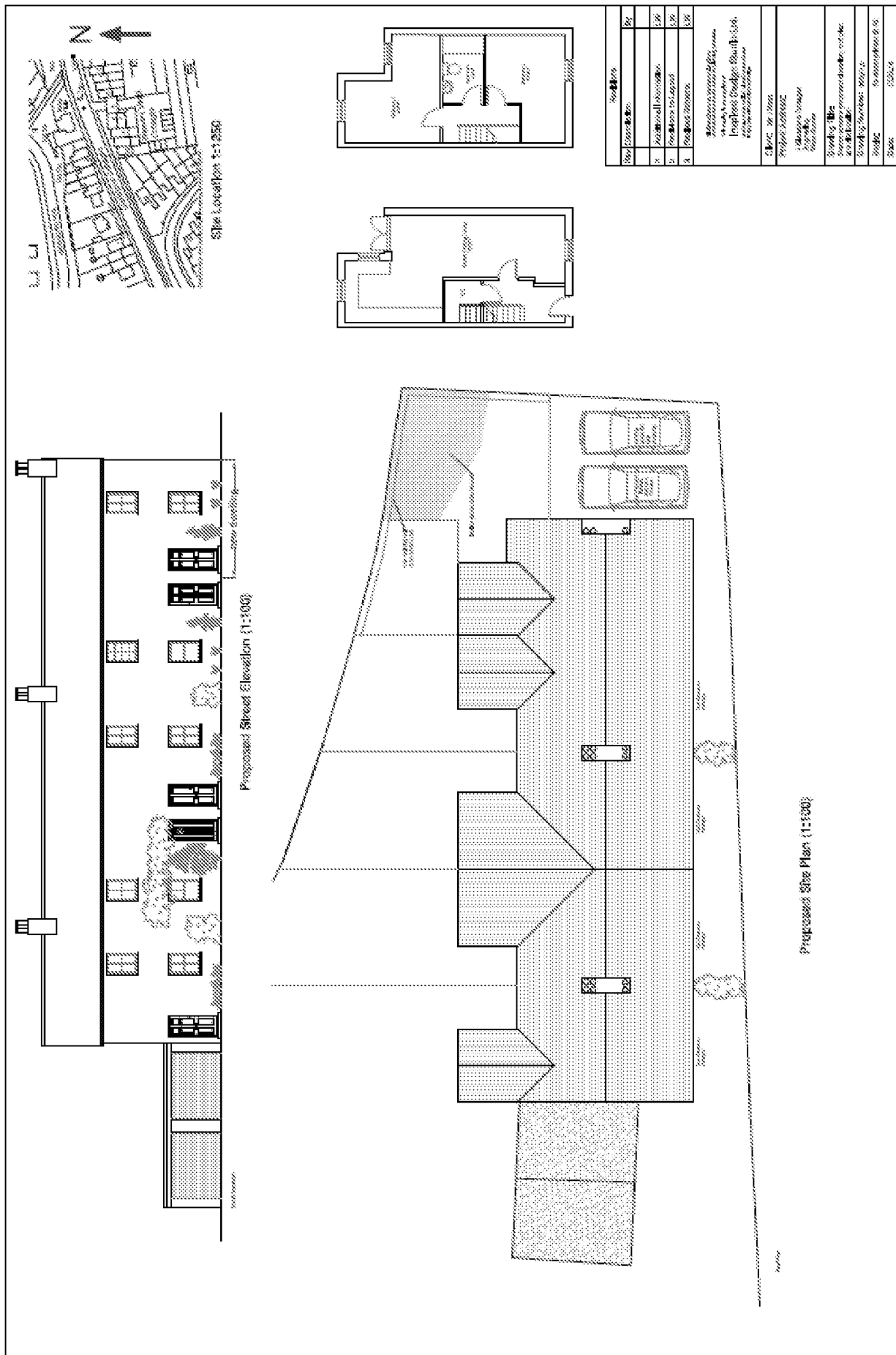
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Contact Us: National Customer Contact Centre, PO BOX 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk









Appendix B – Information Relating To JFlow

JFLOW and flood outlines (Source: EA)

Flood Zones have been produced using JFLOW, a nationally consistent model. JFLOW has been used to produce the 1% (1 in 100 year) and 0.1% (1 in 1000 year) flood outlines.

The flood outlines have been developed by applying flow and tide models to a 3D ground level map of England and Wales, known as a Digital Terrain Model (DTM). This is created by flying an aircraft over the whole of the country using radar to record and create a contoured model of the land. This DTM is used as the basis of a grid of cells which is used to estimate the extent of flooding in a flood of a given return period or probability.

The size of the flood event (1 in 100 or 1 in 1000 year) is determined by the inflows to the JFLOW model, which are calculated using statistical techniques from the Flood Estimation Handbook. The technique used is based upon catchment descriptors and data transfer, the details of these can be found in the Flood Estimation Handbook volume 3. The Flood Estimation Handbook provides a consistent technique for estimating inflows to the national model and its methods are widely accepted.

The methodology is a raster-based approach, driven by an underlying Digital Elevation Model (DEM).

- Each cell has a ground level and water depth
- Water can move to any of surrounding 8 cells where the water level is lower
- Water will pond in low spots until the water level is high enough to spill
- The velocity of movement depends on water surface slope and surface roughness

The above points describe the basic principles of the model. The two underlying principles are:

- Mass conservation within each cell
- Calculation of the fluxes between the cells

Each grid cell is treated as a small storage area. Mass conservation is applied to each grid cell. The flux between cells is calculated using a form of the generalised weir equation.

Efficient coding is achieved by keeping a list of all currently wet cells and a list of newly wet cells. This avoids having to search through each cell in the ground grid.

For whole catchment modelling, the hydrographs used as inflow boundary conditions represent the whole hydrograph at that inflow location and a simple conceptual method has been derived to account for the amount of flow within the channel banks. A simple solution was therefore sought which would approximately account for the proportion of flow contained within the channel without requiring further information about the channel.

The simple conceptual method used involves two assumptions:

1. That bankfull flow (Q_b) is equal to Q_{MED} as calculated by the Flood Estimation Handbook (FEH) methods. Q_{MED} has a return period of 2 years. This assumption derives from the concept of dominant discharge in fluvial geomorphology (Wolman and Leopold, 1957; Wolman and Miller, 1960) where the cross-section shape is assumed to be formed by a discharge with a recurrence interval of 1-2 years.

2. That the additional channel flow (Q_c) scales with both Q_b and depth above bankfull (d).

The basis of the current model is that each grid cell acts as a small flood cell and the links to each of the surrounding cells are automatically calculated. It is therefore capable of simulating the inundation extent at a level of detail equal to the underlying DEM. It is fundamentally volume conservative and so, in a given time period, will simulate the peak water levels across the floodplain depending on the volume of water that has entered the floodplain. This approach is a half-way house between the common 1D hydrodynamic models and a 2D hydrodynamic model.

Limitations

JFLOW was used to produce flood maps for the whole of England and Wales for all catchments greater than 3 sq km in a consistent manner. The method is therefore very generalised and therefore cannot take account of information that may be very significant locally. This might include:

1. Effects of bridges and other structures including flood defences are not taken into account.
2. Errors in the DTM, caused by trees and buildings for example.
3. The effect of reservoirs and urban drainage and other man made influences on the flow regime can only be taken into account in a very general sense in JFLOW.
4. The channel is assumed to be able to take the 2 year flow. This may not be true especially in those modified by man.
5. Hydraulic roughness is assumed to be the same everywhere in JFLOW, but of course it is not.

For these and many other reasons, the flood outlines produced by JFLOW can only be taken as a rough guide, showing where more detailed flood risk assessments are essential. Flood risk assessments should also be undertaken near small watercourses whose catchments are too small to have been included in the JFLOW modelling