



Warblington Road
Emsworth
(7 Unit Scheme at appeal)

PINS Ref: APP/X1735/W/20/3252953

FLOOD RISK ASSESSMENT

On behalf of
Mr. Charles Glanville

ITR/MT/5042/FRA.6a
August 2020

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1.0 INTRODUCTION

- 1.1 Bellamy Roberts LLP has been retained by Mr. Charles Glanville to prepare an updated Flood Risk Assessment (FRA) in support of planning application (APP/19/00623), submitted in June 2019, for a residential development of 7 dwellings on land south of Warblington Road, Emsworth which is now the subject of a planning appeal (APP/X1735/W/20/3252953). The site is currently occupied by a single residential dwelling (46 Warblington Road) and this is to remain. This assessment has been undertaken to ascertain whether there are any constraints to the development of this site, and to assess the impact of the proposal, with regard to flood risk.
- 1.2 The site has an approximate area of 0.83ha and is located in Flood Zone 1. Government guidance states that Flood Risk Assessments are generally only necessary in Flood Zone 1 when the development area is greater than 1ha. However, an FRA is required for developments of less than 1ha when the proposed development will provide a more vulnerable use class. This Assessment has been prepared to accompany an indicative sustainable drainage design, and will also consider the expected greenfield run-off rates, soil types, and Environment Agency (EA) Flood Mapping.
- 1.3 Consultation comments were received from the Environment Agency (30th July 2019) and further information was requested. A copy of the EA comments are provided at **Appendix 1**, and this FRA has been prepared to address the issues raised by the EA. In summary, the EA has requested the following:
- Confirmation of the proposed Finished Floor Levels;
 - Provision of safe access and egress routes; and
 - Provision of resistance and resilience measures.
- 1.4 In addition to the above, the EA also advised after the determination of the application and during the course of the current appeal (by way of its consultation response of 23rd June 2020 on a current planning application for 9 dwellings (LPA Ref. APP/20/00376)) on the same site that that application should add an appropriate freeboard to the design flood levels for 2115 to achieve Finished Floor Levels (FFLs) that will make the development flood resilient for its lifetime. In anticipation that the EA will make the same comments on the updated FRA Version 6 (May 2020) which formed part of the

appeal submission documents this version (version 6a) has been updated to address the potential freeboard concerns raised by the EA for the 9 dwelling scheme.

Site Location and Features

- 1.5 The National Grid reference for the site is 474407, 105452. For clarity, a site location plan is provided at Figure 1.

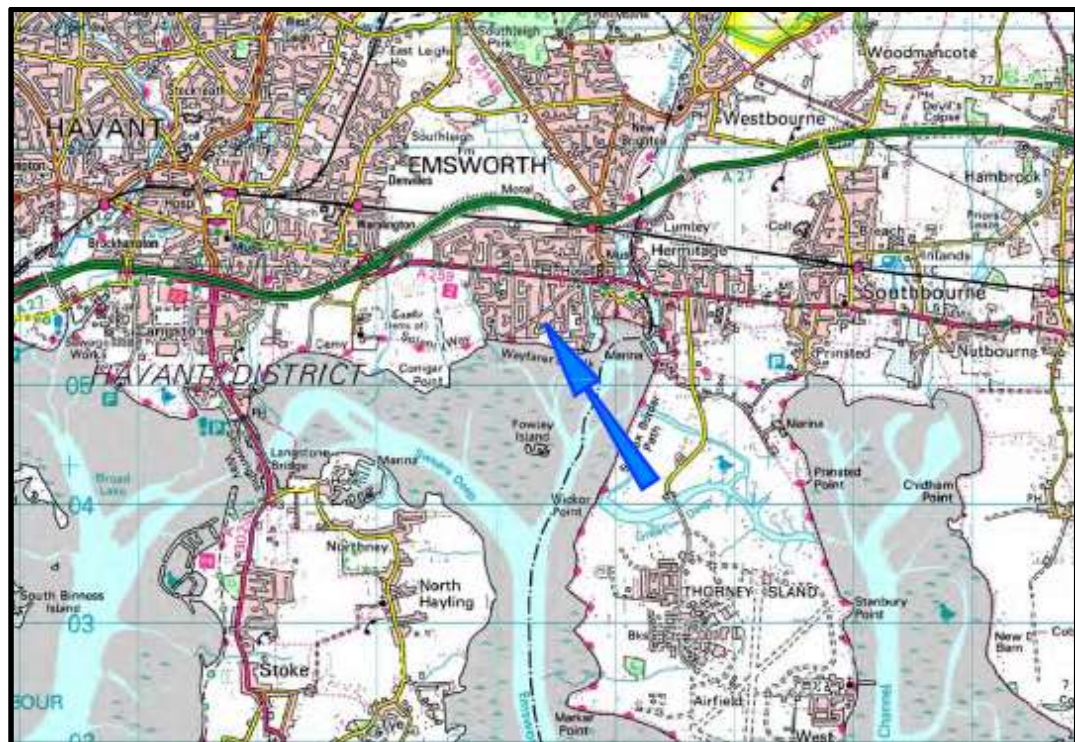


Figure 1: Site Location Plan

Site Topography

- 1.6 The topography falls from 6.75m in the northern corner to 1.98m in the southern corner. See Figure 2 on the following page.



Figure 2: (Source LIDAR) – Topography of site

- 1.7 The site is accessed off Warblington Road which borders the northern boundary of the site. Residential development is located on all sides other than the southern boundary which is bounded by Chichester Harbour.

Appropriateness of Development Proposal

- 1.8 National guidance states that Flood Zone 1 is suitable for all types of development. Reproduced at Figure 3 is an extract from the EA Flood Zone map which demonstrates that the proposed dwellings will lie within Flood Zone 1. The southern extent of the application site is shown to be located within Flood Zone 3, and it will be ensured that

no dwellings will be located within this area. The site access will also be located solely within Flood Zone 1.

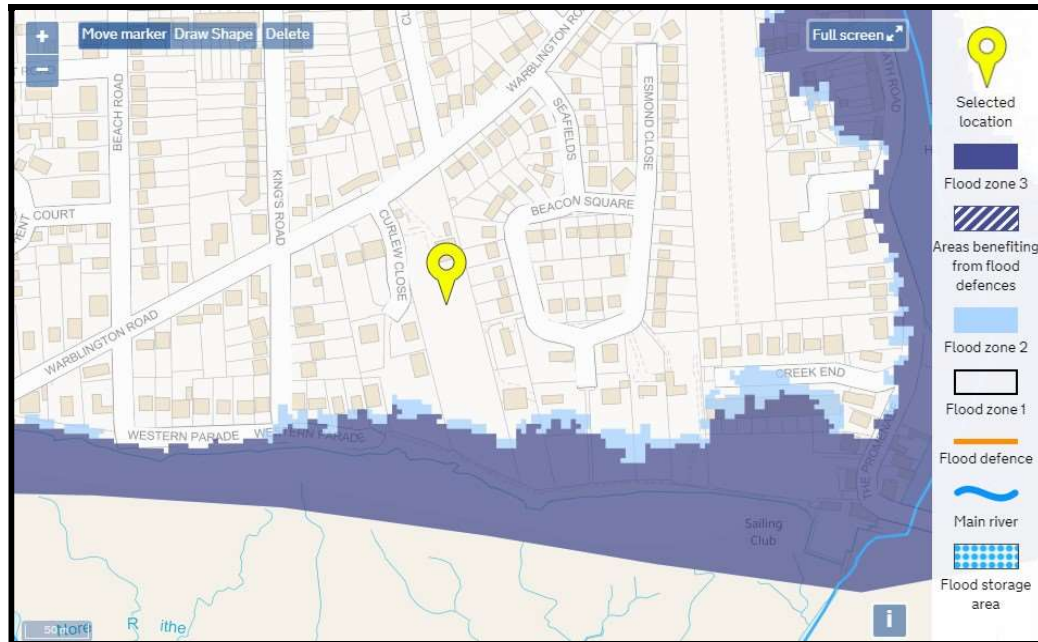


Figure 3: Flood Zone Map (Source: EA)

- 1.9 An extract from the EA surface water flood risk map is provided in Figure 4. This demonstrates that the site is not at risk of flooding from this source.

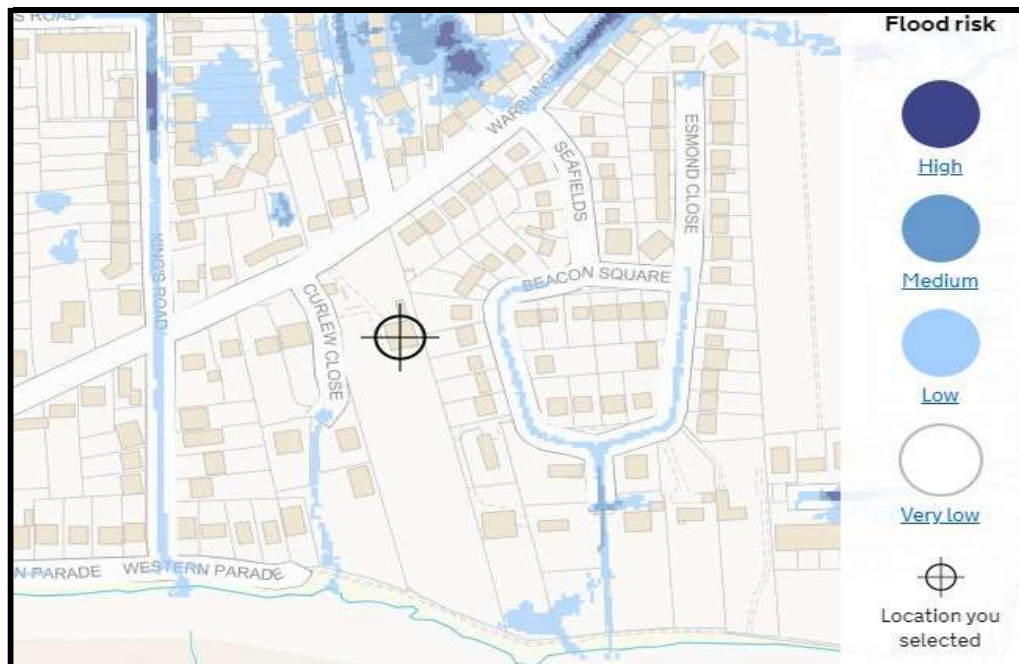


Figure 4: Surface Water Flood Risk Map (Source: EA)

- 1.10 In addition to surface water flood risk, it is also important to consider the risk of flooding from rivers and the sea. In this regard, EA mapping has further been interrogated to determine the risk posed from this type of flooding (see Figure 5).

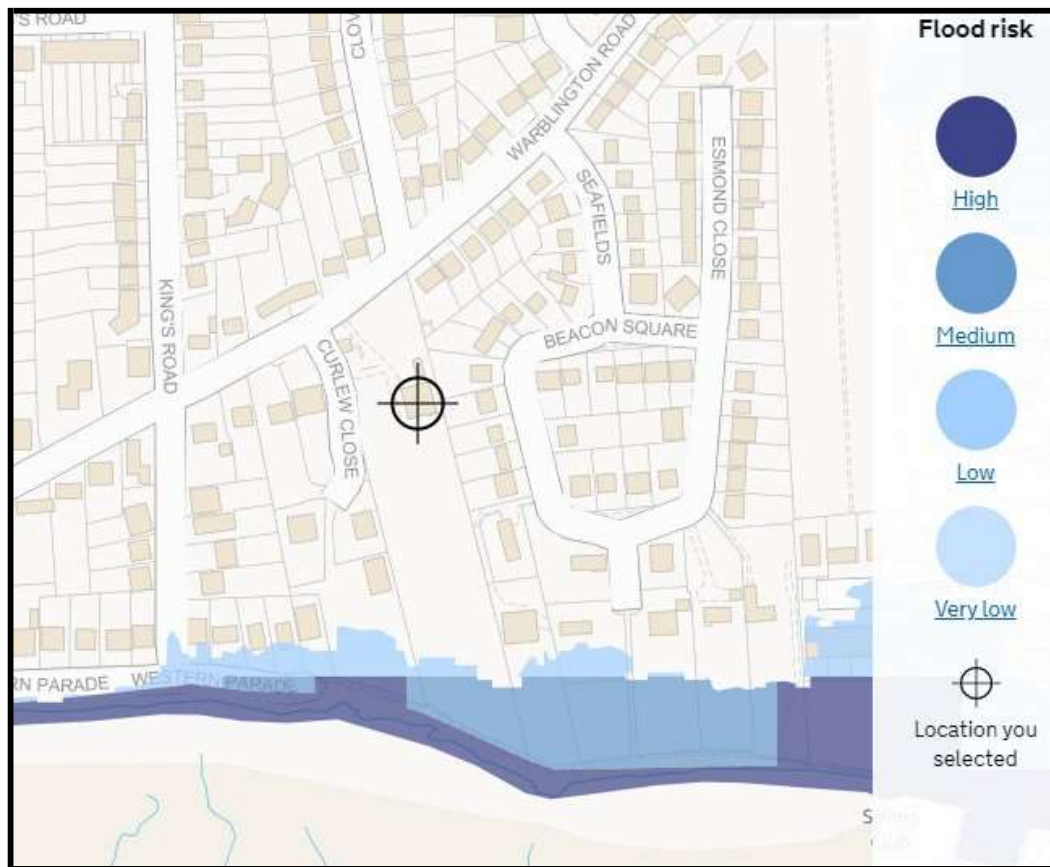


Figure 5: Rivers/Sea Flood Risk Map (Source: EA)

- 1.11 Figure 5 demonstrates that the southern extremity of the site has a low to medium risk of river or sea flooding.
- 1.12 The proposed development has been designed with due regard to this potential risk. As such, the proposed units have not been located within the area at risk of flooding.
- 1.13 Given the site's location, it is important to consider rising sea levels as a result of climate change. In this regard, the Product 4 Package and Emsworth to Littlehampton West Bank Coastal Modelling Report (2016) has been obtained from the EA. This reveals a maximum flooding level of 4.59m AOD which occurs during the 0.5% AEP storm event for the year 2115. A copy of both documents are provided at **Appendix 2**.
- 1.14 When designing the appropriate FFLs for the proposed units, it is appropriate to include an additional 'freeboard' allowance on top of the forecasted flood level to account for residual uncertainty. The freeboard level has been calculated using the Environment

Agency (EA) document '*Accounting for residual uncertainty: updating the freeboard guide*' (February 2017), and the data received from the EA, including the Product 4 package and the Emsworth to Littlehampton West Bank Coastal Modelling (2016).

1.15 The method of determining the level of residual uncertainty involves assigning confidence scores to different aspects of the evidence and combining these estimates into an overall confidence rating. The three stages of this assessment are as follows:

- Stage 1 - Identify and record all primary sources of uncertainty
- Stage 2 - Estimate the magnitude of the residual uncertainties
- Stage 3 - Determine the appropriate response

1.16 The results of Stages 1 and 2 are set out in Table 1, which accords with Tables 3.1 and 3.2 of the EA freeboard guidance.

Table 1: Scale of Residual Uncertainty

Consideration	Applicability	Score	Reasons
How appropriate is the flood risk analysis?	Yes	1	There have been no changes in the intervening period that would affect the accuracy of the model.
How well is the flood plain modelled?	Yes	1	LIDAR coverage of the floodplain was used, with the majority of the area covered with 1m data.
How well has the potential for defence failure been modelled?	N/A	-	No flood defences at the site.
What is the confidence in the hydrology?	N/A	-	Tidally dominated site.
How good is the coastal/estuarine/tidal boundary?	Yes	1	The Chichester Harbour Model is within the desired calibration accuracy of +/- 150mm. The water level rise for climate change was based on the latest UKCP09 sea-level change guidance.
How have the fluvial threats been represented?	N/A	-	Tidally dominated site.
How have coastal threats been represented?	Yes	1	2D model. Wave overtopping based on EurOtop methods. Up to date Bathymetry data used in assessment. Eight annual likelihoods modelled (20, 5, 3.33, 1.33, 1, 0.5, 0.2, and 0.1% AEP events)
How has surface water run-off been represented?	N/A	-	The site is not at risk of surface water flooding.
How have groundwater hazards been represented?	N/A	-	No history of groundwater flooding.
What is the strength of evidence?	Yes	1	The wave model was calibrated against ten storm events. Further calibration took place using four more recent storm events. Calibration accuracy +/-150mm.

- 1.17 To calculate the confidence rating, the two lowest scores in Table 1 are applied to Table 3.3 within the EA freeboard guidance to determine the confidence rating. In this instance, the two lowest scores are '1' and in this regard the confidence rating has been calculated as '5 star', which indicates that the flood modelling is highly likely to be locally reliable. A '5 star' confidence rating corresponds to a minimum freeboard depth of 300mm.
- 1.18 In this regard, it will be ensured that the proposed dwellings will have a minimum FFL of 4.89m AOD (i.e. 2115 flood level of 4.59m AOD + 300mm freeboard allowance). It will also be ensured that the level of the road will be set at a minimum level of 4.89m AOD. To ensure safe access for all vehicles, including emergency vehicles. It is suggested that this is controlled by a suitably worded planning condition.

Ground Investigation Data

- 1.19 Soakaway testing, in accordance with BRE365, has previously been undertaken at the site. The testing observed that no infiltration was possible and concluded that the soils are not likely to perform to a satisfactory standard. The full testing results are attached at **Appendix 3**.
- 1.20 In addition, British Geological Survey mapping indicates that there are superficial deposits of sand, silt and clay (fluvial in origin), and the bedrock at the site is chalk. The BGS mapping extract is provided at **Appendix 4**.

2.0 FLOOD RISK ASSESSMENT

Flood Risk Assessment Methodology and Objectives

- 2.1 It is recognised that developments that are designed without regard to flood risk may endanger lives, damage property, cause disruption to the wider community, damage the environment, be difficult to insure and require additional expense on remedial works. Current guidance on development and flood risk identifies several key aims for a development to ensure that it is sustainable in flood risk terms. These aims are as follows:
- the development should not be exposed to flood risk such that the health, safety and welfare of the users of the development, or the population elsewhere, are threatened;

- the development should not be at a significant risk of flooding and should not be susceptible to damage due to flooding;
- safe access to and from the development should be possible during flood events;
- the development should not increase flood risk elsewhere;
- the development should not prevent safe maintenance of watercourses or maintenance and operation of flood defences;
- the development should not be associated with an onerous or difficult operation and maintenance regime to manage flood risk. The responsibility for any operation and maintenance required should be clearly defined;
- future users of the development should be made aware of any flood risk issues relating to the development;
- the development design should be such that future users will not have difficulty obtaining insurance or mortgage finance, or in selling all or part of the development, as a result of flood risk issues;
- the development should not lead to degradation of the environment, and;
- the development should meet all of the above criteria for its entire lifetime, including consideration of the potential effects of climate change.

2.2 This Assessment has been prepared with due consideration of these sustainability aims, to inform the proposed scheme. A development lifetime of 100 years has been assumed in line with PPG guidance on residential development life cycles.

Existing Greenfield Run-off Rates

2.3 The existing greenfield run-off rates have been obtained from within the MicroDrainage computer software (see **Appendix 5**), which has identified the following Qbar figures:

- Qbar - 3.4l/s
- Q1 - 2.9l/s
- Q30 - 7.7l/s
- Q100 - 10.9l/s

3.0 DRAINAGE STRATEGY

Disposal of Surface and Foul Water

- 3.1 The existing dwelling (46 Warblington Road) utilises the Southern Water surface/foul water sewers located in the vicinity of the application site. The location of the existing foul and surface water sewers is provided on the plan attached at **Appendix 6**.
- 3.2 The surface water sewer borders the western boundary of the application site and outfalls into Chichester Harbour. There are two foul water sewers in the vicinity of the site, one bisects the application site on a broadly west/east alignment and the other is located within Warblington Road.

Surface Water

- 3.3 In accordance with SuDS principles, the proposal will initially seek to provide soakaway drainage to serve each plot. However, based on the results of the infiltration testing previously undertaken at the site, the sub-strata is not suitable for soakaway drainage (see Appendix 3).
- 3.4 In this regard, an alternative option has been considered which will provide three storage tanks within the site to store the surface water from the proposed units and carriageway (all driveways are to be permeable paving). Each tank will discharge into the nearby surface water sewer. The discharge rate will be controlled via a hydro-brake, and will be limited to 10.9 l/s, as per the calculated Qbar figure (see paragraph 2.3). The total storage capacity has been calculated using the MicroDrainage software for the 1 in 100 year, + 40% allowance for climate change, storm event. The indicative surface water drainage strategy is provided at **Appendix 7** and the accompanying MicroDrainage analysis is at **Appendix 8**, which shows no risk of flooding during the modelled storm events.
- 3.5 As stated previously, it will be ensured that the Finished Floor Level (FFL) of the proposed dwellings, and level of the access road, will be a minimum of 4.89m AOD, i.e. above the 2115 estimated flood level of 4.59m AOD and to also include a freeboard allowance of 300mm. Flood resistant construction can prevent entry of water or minimise the amount that may enter a building where there is short duration flooding outside with water depths of 0.6 metres or less. This form of construction should be used with caution and accompanied by resilience measures, as effective flood

exclusion may depend on occupiers ensuring some elements, such as barriers to doorways, are put in place and maintained in a good state. Examples of flood resistance measures include flood doors and windows; and non-return valves fitted on drain/pipes.

- 3.6 In accordance with Planning Practice Guidance, the proposed buildings should be designed and constructed with flood resilience measures in mind, thus reducing the impact in the unlikely event that flood water enters the proposed buildings, to ensure no permanent damage is caused, structural integrity is maintained and drying and cleaning is easier. In this regard, the proposed dwellings will be designed in accordance with the Communities and Local Government document entitled, 'Improving the Flood Performance of New Buildings - Flood Resilient Construction'. Examples of flood resilience measure include raised electrical sockets; sump and pump systems; and using water resistant materials in kitchens and bathrooms.

Foul Water

- 3.7 With regards to the foul water strategy, it is proposed that plots 5 and 6 will connect to the existing foul water sewer within Warblington Road, and the remainder (plots 1-4 and plot 7) will connect to the foul water sewer that bisects the site. The foul strategy is shown on the plan at Appendix 7.

Maintenance and Management

- 3.8 The continued management and maintenance of the drainage system will be essential in ensuring the continued protection of the development from the surface water flooding.
- 3.9 Visual inspection of the drainage network and outfalls should be undertaken on a regular basis to identify any siltation/blockage/disrepair of the drainage network and attenuation facilities.
- 3.10 A surface water management system therefore needs to be drawn up as part of any planning consent that is issued for the site.

4.0 SUMMARY AND CONCLUSIONS

- 4.1 Bellamy Roberts LLP has been retained by Mr. Charles Glanville to undertake an updated Flood Risk Assessment (FRA) in support of a planning appeal (APP/X1735/W/20/3252953), for a residential development comprising 7 units on land south of Warblington Road, Emsworth.
- 4.2 Environment Agency mapping has been reviewed and it has been determined that the site lies wholly within Flood Zone 1, and no risk of flooding from sources such as surface water and rivers.
- 4.3 Due to the topography of the application site, part of the proposed built development falls within the estimated future tidal flood risk area for 2115. In this regard, floor levels of the southernmost properties (Plots 1 and 2) , and the access road, will be designed to be above the 2115 estimated flood level of 4.59m AOD and will also include a freeboard allowance of 300mm, i.e. a minimum FFL of 4.89m AOD.
- 4.4 Surface water storage tanks will be provided to serve the proposed dwellings and access road. Each tank will discharge into the nearby surface water sewer and the discharge rate will be controlled via a hydro-brake, limited to the calculated Qbar figure of 10.9l/s.
- 4.5 With regards to the foul water strategy, it is proposed that the northernmost plots will connect to the existing foul water sewer within Warblington Road, and the remaining plots will connect to the foul water sewer that bisects the site.

APPENDICES

APPENDIX 1

Havant Borough Council
Development Control
Civic Offices Civic Centre Road
Havant
Hampshire
PO9 2AX

Our ref: HA/2019/121470/01-L01
Your ref: APP/19/00623
Date: 30 July 2019

Dear Sir/Madam

RETAIN THE EXISTING 'FOWLEY COTTAGE' DWELLING AND CONSTRUCTION OF 6NO. 5 BED DETACHED DWELLINGS, TWO ON THE WARBLINGTON ROAD FRONTAGE AND FOUR TO THE REAR GARDEN AREA. ACCESS TO PLOT 5 TO BE TAKEN OFF WARBLINGTON ROAD, ACCESS TO PLOTS 1-4 AND 6 TO BE TAKEN OFF CURLEW CLOSE FOWLEY COTTAGE, 46 WARBLINGTON ROAD, EMSWORTH, PO10 7HH

Thank you for the consultation on the above application, please quote our reference on all correspondence.

We have reviewed the information as submitted and have the following comments.

Environment Agency position

In the absence of an acceptable flood risk assessment (FRA) we object to this application and recommend that planning permission is refused.

Reason

The submitted FRA does not comply with the requirements for site-specific flood risk assessments, as set out in paragraphs 30 to 32 of the Flood Risk and Coastal Change section of the planning practice guidance.

The FRA does not therefore adequately assess the flood risks posed by the development. In particular, the FRA fails to:

- take the impacts of climate change into account adequately. Flood risk mitigation measures to address flood risk for the lifetime of the development included in the design are inadequate because they will not make the development resilient to the flood levels for 2115 of 4.5m AOD as stated in paragraph 1.14 of FLOOD_RISK_ASSESSMENT-1180237 (FRA) submitted with the application. Consequently the development proposes inadequate:

Environment Agency
Guildbourne House Chatsworth Road, Worthing, West Sussex, BN11 1LD.
Customer services line: 03708 506 506
www.gov.uk/environment-agency

Cont/d..

- Raised finished floor levels. Paragraph 1.16 of the FRA states “*In this regard, floor levels of the southernmost properties could be designed to be above the 2115 estimated flood level of 4.5m AOD*”, but it does not specify what they will actually be. The drawing in Appendix 6 titled “*Foul and Surface Water Drainage Strategy*” shows the 2 southern most properties as having finished floor levels (FFL) of 4.2mAOD and 4.1mAOD which are both below the expected 2115 flood level of 4.5mAOD.
- consider the requirement for flood emergency planning including flood warning and evacuation of people for a range of flooding events up to and including the extreme event
 - Safe access and egress routes
- consider how a range of flooding events (including extreme events) will affect people and property
 - Resistance and resilience measures

Overcoming our objection

To overcome our objection, the applicant should submit a revised FRA which addresses the points highlighted above.

Advice to Applicant

Finished floor levels (FFL)

The FRA needs to ensure that built development proposals incorporate adequate flood risk mitigation up to the design flood level for 2115 of 4.5mAOD (as stated in the FRA). The following government website will assist the applicant in determining the adequate freeboard for the development (this includes coastal, estuarine and tidal) :

<https://www.gov.uk/government/publications/accounting-for-residual-uncertainty-an-update-to-the-fluvial-freeboard-guide>

Safe access and egress

The application needs to demonstrate that occupants can remain safe for the lifetime of the development when allowances for climate change are taken into consideration. There needs to be sufficient flood risk mitigation up to the design flood level and/or specified arrangements for safe access and egress.

Flood resistance and resilience

We strongly recommend the use of flood resistance and resilience measures if appropriate. Physical barriers, raised electrical fittings and special construction materials are just some of the ways you can help reduce flood damage.

Revised FRA

If this cannot be achieved, we are likely to maintain our objection. Please re-consult us on any revised FRA submitted and we'll respond within 21 days of receiving it.

Environmental permit

Planning permission does not remove the requirement for an Environmental Permit. The Environmental Permitting (England and Wales) Regulations 2016 require a permit to be obtained for any activities which will take place:

- on or within 8 metres of a main river (16 metres if tidal)
- on or within 8 metres of a flood defence structure or culvert (16 metres if tidal)
- on or within 16 metres of a sea defence
- involving quarrying or excavation within 16 metres of any main river, flood defence (including a remote defence) or culvert

- in a floodplain more than 8 metres from the river bank, culvert or flood defence structure (16 metres if it's a tidal main river) and you don't already have planning permission.

For further guidance please visit <https://www.gov.uk/guidance/flood-risk-activities-environmental-permits> or contact our National Customer Contact Centre on 03702 422 549. The applicant should not assume that a permit will automatically be forthcoming once planning permission has been granted, and we advise them to consult with us at the earliest opportunity.

Please do not hesitate to contact me on the number below should you have any queries on the above information.

Yours faithfully

Mrs Sophie Brown
Sustainable Places Planning Advisor

Direct dial 02030 257250

Direct e-mail planningSSD@environment-agency.gov.uk

APPENDIX 2

Matt Twinberrow
Bellamy Roberts
Clover House
Western Lane
Odiham
Hampshire
RG29 1TU

Our ref: SSD177914
Date: 07/08/2020

Dear Matt Twinberrow,

Enquiry Regarding Product 4 for Flood Risk Assessment for Fowley Cottage, Warblington Road, Emsworth, PO10 7HH.

Thank you for your enquiry which was received on 14 July 2020.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004. The information is attached.

The information on Flood Zones in the area relating to this address is as follows:

The site is in an area located within Flood Zone 1, 2 & 3 as shown on our Flood Map for Planning (Rivers and Sea).

Note - This information relates to the area that the above named property is in and is not specific to the property itself as it is influenced by factors such as the height of door steps, air bricks or the height of surrounding walls. We do not have access to this information and is not currently used in our flood modelling.

Flood Zone definitions can be found at www.gov.uk/guidance/flood-risk-and-coastal-change#Table-1-Flood-Zones

Flood Defences

There are no formal raised flood defences in the vicinity of the site.

Model Information

The model used was the Chichester Coastal Modelling (2D) which was completed by JBA Consulting in 2016.

Flood History

We hold no record of previous flooding events affecting this site.

Please note our records are not comprehensive and may not include all events. I recommend contacting the Lead Local Flood Authority, **Hampshire County Council** or the Local Authority, **Havant District Council** for a more comprehensive flood history check.

[FRA advisory text](#)

Name	Product 4
Description	Detailed Flood Risk Assessment Map for Fowley Cottage, Warblington Road, Emsworth, PO10 7HH.
Licence	Open Government Licence
Information Warnings	The flood risk data provided is based on existing EA hydraulic models for existing 0.5% annual probability events with an allowance for climate change. Please note the climate change allowances provided are not up to date. These were updated on 17 December 2019. You should refer to ' Flood risk assessments: climate change allowances ' for the most up to date allowances. You will need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
Information Warning - OS background mapping	<i>The mapping of features provided as a background in this product is © Ordnance Survey. It is provided to give context to this product. The Open Government Licence does not apply to this background mapping. You are granted a non-exclusive, royalty free, revocable licence solely to view the Licensed Data for non-commercial purposes for the period during which the Environment Agency makes it available. You are not permitted to copy, sub-license, distribute, sell or otherwise make available the Licensed Data to third parties in any form. Third party rights to enforce the terms of this licence shall be reserved to OS.</i>
Attribution	Contains Environment Agency information © Environment Agency and/or database rights. Contains Ordnance Survey data © Crown copyright 2020 Ordnance Survey 100024198.

Data Available Online

Many of our flood datasets are available online:

- Flood Map For Planning ([Flood Zone 2](#), [Flood Zone 3](#), [Flood Storage Areas](#), [Flood Defences](#), [Areas Benefiting from Defences](#))
- [Risk of Flooding from Rivers and Sea](#)
- [Historic Flood Map](#)
- [Current Flood Warnings](#)

Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Yours sincerely,

Tom Lamboo

FCRM Officer, Partnership & Strategic Overview West Sussex, Solent and South Downs

Environment Agency, Guildbourne House, Chatsworth Road, Worthing, West Sussex, BN11 1LD

Flood Map for Planning (Rivers and Sea). Centred PO10 7HH. Created 03/08/2020.



1: 10,000

0 Metres 250



Flood Map for Planning (Rivers & Sea)

- Defences
- Flood Storage Areas
- Areas benefiting from flood defences
- Flood Zone 3
- Flood Zone 2

Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Use of Environment Agency Information for Flood Risk Assessments

Important

The Environment Agency are keen to work with partners to enable development which is resilient to flooding for its lifetime and provides wider benefits to communities. If you have requested this information to help inform a development proposal, then we recommend engaging with us as early as possible by using the pre-application form available from our website:

<https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion>

We recognise the value of early engagement in development planning decisions. This allows complex issues to be discussed, innovative solutions to be developed that both enables new development and protects existing communities. Such engagement can often avoid delays in the planning process following planning application submission, by reaching agreements up-front. We offer a charged pre-application advice service for applicants who wish to discuss a development proposal.

We can also provide a preliminary opinion for free which will identify environmental constraints related to our responsibilities including flooding, waste, land contamination, water quality, biodiversity, navigation, pollution, water resources, foul drainage or Environmental Impact Assessment.

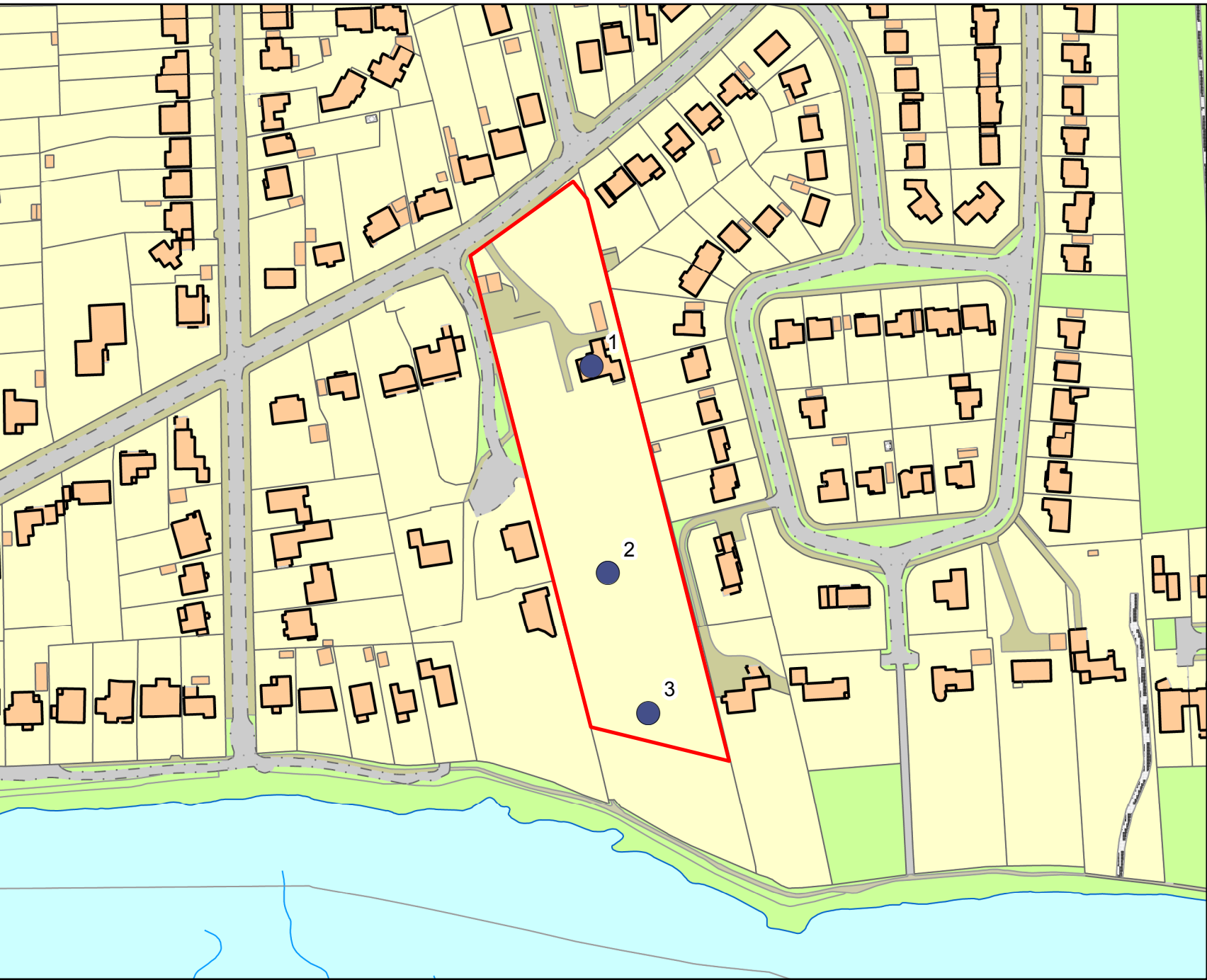
In preparing your planning application submission, you should refer to the Environment Agency's Flood Risk Standing Advice and the Planning Practice Guidance for information about what flood risk assessment is needed for new development in the different Flood Zones. This information can be accessed via:

<https://www.gov.uk/flood-risk-assessment-standing-advice>
<http://planningguidance.planningportal.gov.uk/>

You should also consult the Strategic Flood Risk Assessment or other relevant materials produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk Assessment (FRA) where one is required, but does not constitute such an assessment on its own.
2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or surface water runoff. Information produced by the local planning authority referred to above may assist here.
3. Where a planning application requires an FRA and this is not submitted or is deficient, the Environment Agency may raise an objection.





Environment
Agency

N


Legend

-  Site_Nodes
-  Site_Boundary

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:2,000



00.0450.09
Kilometers

Product 4 Flood Risk Data Requested by: Bellamy Roberts

Site: Fowley Cottage, Warblington Road, Emsworth, PO10 7HH

Table 1: Water Levels: Tidal Undefended

Node Ref	NGR		Modelled Flood Levels in Metres AOD			
	Eastings	Northings	Undefended Annual Exceedance Probability			
			0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	474404	105497	-	-	-	-
2	474410	105420	-	-	4.57	-
3	474425	105368	-	3.96	4.57	-

Table 2: Water Levels: Tidal Defended

Node Ref	NGR		Modelled Flood Levels in Metres AOD			
	Eastings	Northings	Defended Annual Exceedance Probability			
			0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	474404	105497	-	-	-	-
2	474410	105420	-	-	4.59	-
3	474425	105368	-	3.95	4.59	-

Table 3: Water Depths: Tidal Undefended

Node Ref	NGR		Modelled Flood Depths in Metres			
	Eastings	Northings	Undefended Annual Exceedance Probability			
			0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	474404	105497	-	-	-	-
2	474410	105420	-	-	0.01	-
3	474425	105368	-	0.13	0.74	-

Table 4: Water Depths: Tidal Defended

Node Ref	NGR		Modelled Flood Depths in Metres			
	Eastings	Northings	Defended Annual Exceedance Probability			
			0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	474404	105497	-	-	-	-
2	474410	105420	-	-	0.01	-
3	474425	105368	-	0.17	0.81	-

All levels taken from: Chichester (2D)

Produced on: 07/08/2020

There is no additional information or health warnings for these levels/depths or the model from which they have been produced.



Environment Agency



Legend

-  Site_Boundary
-  0.5% AEP (Defended Tidal)
-  0.5% AEP (2070) NPPF (Defended Tidal)
-  0.5% AEP (2115) NPPF (Defended Tidal)
-  0.1% AEP (Defended Tidal)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:10,000



0 0.225 0.45
Kilometers



Environment Agency



Legend

-  Site_Boundary
-  0.5% AEP (Un defended Tidal)
-  0.5% AEP (2070) NPPF (Un defended Tidal)
-  0.5% AEP (2115) NPPF (Un defended Tidal)
-  0.1% AEP (Un defended Tidal)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:10,000



0 0.225 0.45
Kilometers

Risk of flooding from Surface Water. Centred PO10 7HH. Created 03/08/2020.



1: 10,000

0 Metres 250



Likelihood of flooding from Surface Water

- High ($\geq 3.3\%$)
- Medium (3.3% - 1%)
- Low (1% - 0.1%)
- Very Low

Likelihood of flooding from Surface Water

- High:** Greater than or equal to 3.3% (1 in 30) chance in any given year
- Medium:** Less than 3.3% (1 in 30) but greater than or equal to 1% (1 in 100) chance in any given year
- Low:** Less than 1% (1 in 100) but greater than or equal to 0.1% (1 in 1,000) chance in any given year
- Very Low:** Less than 0.1% (1 in 1,000) chance in any given year

This information is shown on the Risk of Flooding from Surface Water map on GOV.UK.

Solent & South Downs Area

Pre-application Advice Note

September 2019

This document sets out the environmental issues we will consider when providing our planning application consultation advice to Local Councils. It can be used by applicants, developers and consultants at the pre-planning stage.

Fluvial Flood Risk

Development must be safe and should not increase the risk of flooding.

You can view a site's flood zone on the Flood Map for Planning on our website: <https://flood-map-for-planning.service.gov.uk>

If your proposed development is located within flood zone 2 or 3 you should consult the Flood Risk and Coastal Change pages of the National Planning Policy Guidance (NPPG)
<http://planningguidance.communities.gov.uk/blog/guidance/flood-risk-and-coastal-change/>

Here you can determine whether the flood risk vulnerability of your proposed development and the flood zone are compatible. You can also establish if there are flood risk sequential test and exception test requirements for your proposed development. In the first instance we recommend the developer/applicant liaises with the Local Planning Authority (LPA) to undertake the Sequential Test in accordance with the National Planning Policy Framework (NPPF).

If your proposed development is located within flood zone 2 or 3 and its vulnerability and flood zone are considered acceptable under the NPPG then a site specific Flood Risk Assessment (FRA) is required to support any subsequent planning application. This is required by paragraph 163 of the NPPF: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf

Guidance on the content of a site specific FRA can be found in the NPPG and online: <https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications>

More detailed flood risk modelling data is available to help you produce a FRA please contact our Customers and Engagement team at SSDenquiries@environment-agency.gov.uk.

Climate Change Allowances

On 19 February 2016, we published new guidance for planners and developers on how to use climate change allowances in a site-specific FRA: <https://www.gov.uk/guidance/flood-risk-assessments-climatechange-allowances>

Groundwater Quality

Development must not cause pollution to the water environment.

Source Protection Zones

We have defined Source Protection Zones (SPZs) for 2000 groundwater sources such as wells, boreholes and springs used across the country for public drinking water supply. These zones are more sensitive to contamination from activities that might cause pollution in the area. The closer the activity, the greater the risk.



SPZ1s are the areas designated as most at risk from contamination and development activities and in these areas we may consider it inappropriate for development to discharge foul or surface water into the ground.

To see if your proposed development is located within a Source Protection Zone, please use our online map: <https://magic.defra.gov.uk/>

Contaminated Land

The NPPF takes a precautionary approach to land contamination. Before the principle of development can be determined, land contamination should be investigated to see whether it could preclude certain development due to environmental risk or cost of remediation. Where contamination is known or suspected, a desk study, site investigation, remediation and other works may be required to enable safe development.

Pollution

If the proposed development use has the potential to pollute ground or surface water receptors then an assessment to establish whether the risk of pollution is acceptable or can be mitigated will be required within any planning application.

Foul Drainage

When drawing up wastewater treatment proposals for any development, the first presumption is to provide a system of foul drainage discharging into a public sewer to be treated at a public sewage treatment works (those provided and operated by the water and sewerage companies). This should be done in consultation with the sewerage company of the area prior to the submission of a formal planning application.

If connection to a public sewage treatment plant is not feasible, a package sewage treatment plant may be considered. If you would like further advice please call 03708 506 506.

Cemeteries

The development of new cemeteries in areas where groundwater vulnerability is high should be avoided, except where the thickness and nature of the unsaturated zone, or the impermeable formations beneath the site, protect groundwater; or where the long-term risk is mitigated by appropriate engineering methods.

Main Rivers

Ecology

In accordance with the National Planning Policy Framework (NPPF), any development proposal should avoid significant harm to biodiversity and seek to protect and enhance it. Opportunities to incorporate biodiversity in and around the development will be encouraged.

Your scheme should be designed with a naturalised buffer zone of at least 8 metres from the main river to protect and enhance the conservation value of the watercourse and ensure access for flood defence maintenance.

This buffer zone should be managed for the benefit of biodiversity for example by the planting of locally appropriate, UK native species. The buffer zone should be undisturbed by development with no fencing, footpaths or other structures. This buffer zone will help provide more space for flood waters, provide improved habitat for local biodiversity and allows access for any maintenance requirements.

To identify any Main Rivers in proximity to your proposed development please see our Main Rivers Consultation Map: <http://apps.environment-agency.gov.uk/wiyby/151293.aspx>

customer service line
03708 506 506

www.gov.uk/environment-agency

incident hotline
0800 80 70 60

floodline
0345 988 1188

Culverting

The Environment Agency is likely to oppose culverting as it is damaging to the ecological integrity of the river channel and its corridor and acts as a barrier to the movement of wildlife, including fish and may also increase flood risk. If the proposal will impact an existing culvert the Environment Agency may oppose planning consent for development either over, or within 8 metres of an existing culvert. Wherever possible, existing culverts should be removed and the river channel and bankside habitat reinstated to restore the ecological continuity of the river channel and its corridor.

Water Framework Directive (WFD)

Any marine works below MHWS require an assessment of possible impacts on Water Framework Directive (WFD) . The assessment should include all elements of the works that fall within, or have the potential to affect, a WFD water body and any of the protected areas therein (including Bathing Waters and Shellfish Waters).

The WFD assessment should follow the 'Clearing the Waters for All' guidance available at <https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters>

Where appropriate, a WFD Assessment should assess any potential impacts and demonstrate that the required enhancements will be delivered. In some cases the requirements of a WFD assessment can be incorporated into an Environmental Impact Assessment (EIA). Any development that has the potential to cause deterioration in classification under WFD or that precludes the recommended actions from being delivered in the future is likely to be considered unacceptable to us.

Permits & Consents

Environmental Permitting Regulations

To see if your proposed development requires an Environmental Permit under the Environment Permitting Regulations please refer to our website: <https://www.gov.uk/guidance/check-if-you-need-an-environmental-permit>

From 6 April 2016 an Environmental Permit is required for any proposed works or structures, in, under, over or within 8 metres of the top of the bank of designated Main River, and within 16 metres of a tidal defence.

Ordinary Watercourse Consent

The prior written consent of the relevant Lead Local Flood Authority is required for the erection of any flow control structures, culverting or diversion of ordinary watercourses, including streams, land drains and ditches.

Marine Licence

A marine licence may be required for any activities at the mean high water spring tide up to the territorial limit. This also includes the waters of every estuary, river or channel where the tide flows at mean high water spring tide.

Any development must demonstrate how adverse impacts on migratory fish, bathing waters, shellfish waters, designated sites, protected and priority species and habitats will be avoided, minimised, mitigated and if necessary compensated for. Works within or affecting a Water Framework Directive (WFD) waterbody will need to demonstrate that compliance with WFD objectives will be achieved. 'Clearing the Waters for All' provides guidance on how the impacts on WFD should be addressed, and should be used when preparing an assessment, including the screening and scoping of activities. <https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters>

Further pre-application options

The information provided above details generic information which may or may not be applicable to your development. We are able to provide more detailed and bespoke advice and answer technical questions for a charged fee of £100 per person per hour +VAT.

If you are interested in finding out more about this service, please email:

planningssd@environment-agency.gov.uk

We can explain this service and provide you with a bespoke quote for further pre-application advice that you may require please see .gov - <https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion>

Please note

Please note that the view expressed in this letter by the Environment Agency is in response to the enquiry only and does not represent our final view in relation to any future planning application made in relation to this site.

We reserve the right to change our position in relation to any such application.

As part of this preliminary response we have not technically reviewed any documents. This opinion is based on the information submitted and current planning policy and guidance.

If you have any questions please contact the Solent & South Downs Sustainable Places team:

planningssd@environment-agency.gov.uk

To make a request for data

Please submit your request for data to ssdenquiries@environment-agency.gov.uk. You should get the information within 20 working days. We will tell you when to expect the information if we need more time.

There are many datasets available online at www.data.gov.uk including flood maps, historic landfill, waste exemptions, consented discharges to controlled waters, and much more.

customer service line
03708 506 506

www.gov.uk/environment-agency

incident hotline
0800 80 70 60

floodline
0345 988 1188

Emsworth to Littlehampton West Bank Coastal Modelling

Final report

April 2016

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Revision History

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Final Report / April 2016	Comments addressed from EA	Emma Dauben

Contract

This report describes work commissioned by the Environment Agency. The Environment Agency's representative for the contract was Emma Dauben. The JBA Consulting Project Manager for the contract was Matthew Hird and Robert Quirke, Emma Rendle, Ian Gaskell, Kathryn Williams and Thomas van Lanschot carried out the work.

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Senior Analyst

Purpose

This document has been prepared as a final report for the Environment Agency. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to the Environment Agency.

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JBA is aiming to reduce its per capita carbon emissions.

Executive Summary

The study was commissioned by the Environment Agency, to investigate the risk of coastal flooding along several key sections of the West Sussex coastline. The study area includes the communities of Littlehampton, Bognor Regis, Pagham, Selsey, Wittering and Bosham and will aim to detail the vulnerability of each of these communities to flooding from the sea based on a range of possible scenarios.

Much of the coastline within the study area is defended to a high standard of protection and previous studies have shown that still water flooding is unlikely, even during extreme surge events. As such, most flooding results through wave action or defence failure. To quantify the flood risk detailed hydraulic models were constructed to enable the production of coastal flood risk extents.

The study used comprehensive extreme sea-level and wave information, improved quality topographic data and advanced inundation modelling techniques to produce revised tidal flood risk information, including Flood Zones 2 and 3. The revised Flood Zones were used to examine the potential impacts of climate change on flood risk, investigating flooding on a community based scale. Climate change simulations were completed using both NPPF and UKCP09 guidance, both to 2070 and 2115.

In summary, the study objectives included:

- Simulation of a range of defended scenarios including the effects of wave overtopping for the 20%, 5%, 3.33%, 1.33%, 1%, 0.5%, 0.5% (2070 UKCP09), 0.5% (2115 UKCP09), 0.5% (2070 NPPF), 0.5% (2115 NPPF), 0.2% and 0.1% AEP events;
- Assess the sensitivity of wave overtopping estimation due to different profile schematisations, beach states and percentile overtopping rates;
- Analyse the projected impact of rising sea levels associated with climate change on flood extents and depths using both NPPF and UKCP09 guidance;
- Provide an indicative standard of protection estimate for the coastal defences based on still water levels and the calculated overtopping volumes;
- Update the current Environment Agency Flood Zones; and
- Improvement the current Environment Agency Flood Warning Procedures for the above communities.

The study objectives were met through the construction of new coastal models, including:

- a wave transformation model to transform the offshore waves into the nearshore,
- wave overtopping modelling to calculate wave overtopping discharges using data from the wave transformation model, and
- the adaption and development of two flood inundation models to map the flood risk.

New flood map components

The new tidal Flood Zones derived for this study are similar to the previous Flood Zones, albeit slightly more extensive. The proposed Flood Warning thresholds are generally lower than the current Flood Alert and Warning thresholds, due to the method of calculation using first property to flood rather than defence crest levels. In the Arun model, the proposed Flood Warning Area A includes significant inundation at Littlehampton West Bank from the River Arun as a result of still water flooding as well as coastal flooding at Bognor Regis and Pagham Harbour. Flood Warning Area B (the area between the 0.5% AEP defended flood extent and Flood Zone 2 extent) includes additional flooding at Climping, Elmer, Bognor Regis, Selsey and Bracklesham. Likewise in the Chichester Harbour model, the new Flood Zones are similar to the existing Flood Zones, with slight increases in extent for most regions. The most noticeable increases are at Birdham and on Thorney Island.

Impact of Climate Change

In addition to the present day flood simulations used to produce the revised Flood Zones for the study area, climate change simulations for the 0.5% AEP event were also modelled. These simulations indicate the expected increase in flood risk up to the year 2115 based on the latest UKCP09 and NPPF guidance on sea-level rise estimates. These simulations, which were run for the 0.5% AEP event, show that with the increases to still water level, the region and its current defence structures are vulnerable to flooding due to climate change. The defence network along

the coast becomes heavily inundated as a result of increased wave overtopping of the current defences. In the Arun model, during the 0.5% AEP defended simulation, 968 properties were flooded, compared with 5,115 and 7,090 to 2115 based on UKCP09 and NPPF guidance respectively. In the Chichester Harbour model 1,581 properties were flooded during the 0.5% AEP event, compared with 9,190 and 16,663 to 2115 based on UKCP09 and NPPF guidance respectively.

The climate change wave overtopping scenario suggests that the effects of climate change could make still water flooding and wave overtopping an increasing hazard. The coastal frontage at risk of increased flooding includes Bognor Regis, Selsey, Bracklesham, East Wittering, West Wittering, West Itchenor, Bosham, Emsworth, Thorney Island and Hayling Island. The impacts of climate change on the West Sussex coastline are going to be an ever increasing hazard to both residential and commercial property and infrastructure.

Impact on critical infrastructure

As part of the study, the first critical infrastructure to flood for both Arun and Chichester models were identified. The first to flood in the Arun to East Head model domain was a sewage pumping station in Littlehampton, with a water level threshold of 3.84m relating to the water level at Littlehampton gauge. In the Chichester Harbour model, the first to flood was also an electricity sub-station, on Hayling Island with postcode PO11 0NQ. The water level threshold for this sub-station was 3.14m which related to the Wittering tidal curve.

Limitations and recommendations

The approaches taken in this study include the most appropriate methods currently available for flood inundation modelled on the scale of the study area. However, the results of a floodplain model are only as accurate as the input data that are used. Whilst all due care and diligence was applied such that the data management and methods used in the study are appropriate, the results should be viewed with a margin of caution given the inherent uncertainty in floodplain modelling and in particular in the estimation of wave overtopping.

A number of assumptions were made and there are elements of subjectivity throughout all stages of the modelling process. These assumptions include decisions taken with regard to the application of the joint probability approach and the profiles used for the wave overtopping schematisations, for example. A full list of the assumptions and limitations is included in the final chapter.

Overall, the work undertaken to update the Flood Map should provide users with a map that can be applied with greater confidence than previous versions. In light of the limitations highlighted there are a number of recommendations for future work and updates which could be undertaken to improve confidence in the modelling.

It is recommended that the joint probability approach is reviewed once new practices from the State of the Nation project come into use.

Following the winter storms of 2013/14 it is recommended that the CFB data are updated to account for the additional gauged data and the notable extremes that occurred.

The model should be updated to use the latest version of the TUFLOW software to allow incorporation of the operational control rules.

As many of the beaches are shingle beach defences it is recommended that an alternative method is used to calculate the wave overtopping, such as X-Beach-G, to take account of the dynamic response of the beach throughout the course of the event and compare these to the rates used within this study.

The results of this study should not be used for design purposes and should a flood risk assessment be required for a specific location within the modelled domain a separate investigation should be undertaken to investigate the specific risks and considerations for each site.

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Abbreviations

1D	One dimensional
2D	Two dimensional
ABD.....	Areas Benefiting from Defences
AIMS	Asset Information Management System
BKB.....	Bracklesham wave buoy
CCO	Channel Coastal Observatory
CD	Chart Datum
CEFAS	Centre for Environment Fisheries and Aquaculture Science
CFB.....	Coastal Flood Boundary
CS3X.....	Met Office surge model
Defra	Department for the Environment, Food and Rural Affairs
DSM	Digital Surface Model
DTM	Digital Terrain Model
ESL	Extreme sea level
EurOtop.....	European Overtopping Manual
GIS.....	Geographic Information System
GMT	Greenwich Mean Time
GPD	Generalised Pareto Distribution
HAT	Highest Astronomical Tide
HGI.....	Hayling Island wave buoy
HR.....	Hazard Rating
JONSWAP	Joint North Sea Wave Project
LIDAR	Light Detecting and Ranging
mAOD	metres Above Ordnance Datum
NPPF	National Planning and Policy Framework
NRD	National Receptor Data

PoT	Peaks over Threshold
OS.....	Ordnance Survey
RFRA	Residual Flood Risk Area
RMSE.....	Root Mean Square Error
RST	Rustington wave buoy
S.....	South
SE	South East
SoP	Standard of Protection
SW	South West
SWAN	Simulating WAVes Nearshore
SWL	Still Water Level
TUFLOW.....	Two-dimensional Unsteady FLOW
UK	United Kingdom
UKCP09	UK Climate Projections 09
WWIII	Wave Watch 3

1 Introduction

1.1 Study objectives

The study was commissioned by the Environment Agency, to investigate the risk of coastal flooding along parts of the West Sussex coastline. The study area extended from Emsworth in the west to Littlehampton in the east, encompassing the communities of Emsworth, Bosham, Chichester, Wittering, Bracklesham, Selsey, Pagham, Bognor Regis and Climping. The study aimed to detail the vulnerability of each of these communities to flooding from the coastal processes through a range of possible defended, undefended and breach model scenarios.

The study had a number of key objectives. The first was to consider the flooding expected from a series of defended scenarios to simulate the present day defences for a range of extreme tidal events. Much of the coastline within the study area is defended with a mixture of shingle beaches and hard defences. The standard of protection (SoP) provided by these defences makes still water level (SWL) flooding unlikely. Therefore, the main flood risk stems from wave overtopping. It is essential that flooding from both the SWL and wave overtopping is better understood within the study area. The results from this modelling will be used by the Environment Agency, for a variety of applications including assessment of flood risk for new developments, flood warnings and supporting decision making on maintenance and defence schemes.

A further objective of the study was to update the current Environment Agency Flood Zones. To do so required the modelling of a number of undefended scenarios. Areas Benefiting from Defences (ABDs) were created using the outputs from both defended and undefended scenarios to ascertain the value of the defences.

In addition to present day scenarios, the study investigated the impact of predicted sea-level rise for both defended and undefended scenarios. The sea-level rise was based on projected sea levels for the years 2070 and 2115 using estimates from the National Planning Policy Framework (NPPF) and from the UK Climate Projections 2009 (UKCP09) data. This information is used for decision making on the sustainability of development within flood risk areas and early warning on weaknesses in the current defence line.

Finally, improvements to the existing flood warning systems were required to help ensure that suitable warnings are issued for areas at flood risk and to limit the incidence of unnecessary warnings for unaffected areas. The sensitivity analysis described as part of the first objective was also be used to inform the range of possible impacts on communities within the flood risk zone.

The principal driver for the study is to gain an understanding of the coastal flood risk in the study area making use of the most up to date data. In February 2011, the Environment Agency's Evidence Directorate published the study *Improved Coastal Flood Boundary (CFB)¹ Conditions for the UK mainland and islands*. This project, which resulted in the derivation of new extreme sea-level estimates, was undertaken as part of the joint Environment Agency/Defra Flood and Coastal Erosion Risk Management Research and Development Programme (SC060064). As a result of the new estimates, the tidal Flood Zones produced previously are now out-of-date. Finally, in July 2011 new guidance with respect to future sea-level rise was released based on the UKCP09 report.

The main objectives of the study were to:

- produce tidal graphs based on the CFB sea-level data;
- produce a wave transformation model to transform the offshore waves into the nearshore;
- schematise the flood defences to calculate wave overtopping along the coastal frontage;
- use ForeCoast to assess the frequency of overtopping and flooding over a period of 20-years using hindcast data;
- produce two dimensional (2D) TUFLOW hydrodynamic models to represent flood depths, velocities, extents, and hazards for the open coast, estuaries and harbours along the coastline;
- estimate flood levels for the 20, 5, 3.33, 1.33, 1, 0.5, 0.2 and 0.1% Annual Exceedance Probability (AEP) flood events;

¹ Defra, SEPA, The Scottish Government, Environment Agency (2011). Coastal flood boundary conditions for UK mainland and islands. Project: SC060064/TR2: Design sea-levels.

- estimate flood levels for the 0.5% AEP plus climate change flood event based sea-level rise estimates from the National Planning Policy Framework and the medium emission 95th percentile UKCP09 scenario for the years 2070 and 2115;
- produce breach model flood extents for five locations and three AEP events;
- map extents of the above events for both defended and undefended scenarios and produce updated Flood Zones 2 and 3;
- derive the ABDs;
- produce flood onset and duration grids for a selection of scenarios;
- produce Flood Hazard Rating outputs;
- provide estimates of the SoP provided by the defences;
- update the coastal Flood Warning Areas and use ForeCoast to optimise the Flood Alert and Warning thresholds against the hindcast data; and
- produce a study report summarising all of the work undertaken.

The dominant source of flood risk in the tidal floodplain is related to the coincident occurrence of a high astronomical tide, the passage of a storm surge and the effects of both sea and wind related waves. This risk was the main focus of this study. The study did not investigate the flood risk associated with fluvial flooding, surface water or groundwater flooding.

1.2 Study extent

The study area extended from Emsworth in the west to Littlehampton in the east, encompassing the communities of Emsworth, Bosham, Chichester, Wittering, Bracklesham, Selsey, Pagham, Bognor Regis and Climping. Figure 1-1 shows the study area.



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Figure 1-1: Study extent

The following sections describe the main urban areas within the study extent moving from Emsworth in the west to Littlehampton in the east.

1.3 Emsworth

Emsworth is located at the north western corner of Chichester Harbour. This area is sheltered from the effects of waves but is at risk from still water flooding. The defended and undefended model extents from the previous studies indicate that there are few defences.

1.4 Chichester

Although not directly exposed to oceanic forces and largely sheltered by land, the Chichester area is considered a flood risk through still water flooding. The area of Chichester incorporates many urbanised areas as well as important infrastructure. Flooding through overtopping is not considered to be a risk at this site due to the sheltered nature of the location. Four sites were included in the wave overtopping calculations in the Chichester Harbour model, including three at West Wittering and one at Emsworth to confirm whether wave overtopping poses additional risk.

1.5 Wittering

West Wittering has in recent years been inundated through tidal still water flooding and has consequently had coastal defences built and improved to prevent flooding. It was recommended in the North Solent Shoreline Management Plan², and the Pagham to East Head Coastal Defence Strategy, that improvements are made to West Wittering's flood defences. The defences at this location comprise of large sand and shingle beaches leading to a long earth and rock embankment which protects the low lying planes which are designated as a flood risk zone. The three defences in the Chichester Harbour model mentioned above incorporate this stretch of defence.

East Wittering is located on the open coast. The frontage along this stretch of the coast faces south-west leaving it vulnerable to both storm waves generated by the local prevailing wind, and swell waves which have an uninterrupted pathway from the Atlantic. The wave exposure here means that the risk of wave overtopping is high and it is this that forms the main coastal flood mechanism for the area. The defences along this stretch are primarily comprised of shingle beaches with regular groynes and an intermittent low earth embankment reinforced with timbers for small lengths of the shoreline.

1.6 Bracklesham Bay

The Environment Agency's Flood Zone maps show regions of low lying land likely to be at flood risk in the Bracklesham Bay area which extends inland. The reclaimed marsh land to the south-west towards the Medmerry outfall area is at a particular risk of flooding. The Medmerry coastline itself has in recent years been breached, the sediment washed out and flood water inundating into the adjacent low lying areas. The Environment Agency has since built major new flood defences between Bracklesham and Selsey to the south, which fall under the Medmerry managed realignment scheme. The original coastline has since fallen back to create a vast new flood designated area as well as designated salt water marsh and wetlands along the river bank. On edge of the newly created wetlands is an earth and rock embankment, which is illustrated in Figure 1-2.

² Beachy Head to Selsey Bill Shoreline Management Plan First Review, Final Report, May 2006, Halcrow
2014s0753_Emsworth to Littlehampton_Coastal final report_v2.docx



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Figure 1-2: Medmerry managed realignment scheme

1.7 Selsey

The town of Selsey is a major Sussex south coast resort attracting a large number of visitors each year in local holiday parks. The town is situated to the south-east of Medmerry and the new defence system. The town lies on a peninsular and is therefore exposed to open sea from the east and the west.

The land north of the town is low lying and has historically been flooded as mentioned in Section 2.2. Much of this coastline is regularly exposed to storm and high water waves and is, therefore, protected by a series of significant defences. The west side being exposed to Atlantic storms has a shingle beach backed by high concrete wave return walls, promenades, rock dumped armouring and rock revetments. Given the height of the defences this section of coast is highly unlikely to flood during still water events. However, wave overtopping should be considered a mechanism for flooding and in recent years the threat from waves has been severe. To the west of Selsey, a new privately funded defence scheme has been constructed to protect the 3,000 holiday chalets and static caravans at the Bunn Leisure complex. The scheme incorporates rock groynes and a wide recharged beach, Figure 1.3.



Figure 1-3: Wide shingle beach and rock groynes at Bunn Leisure complex

The eastern side of Selsey has defence crest levels which are capable of defending the town against the most extreme still water levels. Although there may be lower potential wave energy when compared to the west side, refracting waves and storms from easterly directions means that wave overtopping is still the main coastal flood risk mechanism for this stretch of coastline. Large stretches have long continuous defences tying in to high ground; including a long promenade and wave return wall with high crest levels around dense urban areas, significant infrastructure and property. There is a shingle beach which extends along this area and varies in width and height. Historically Selsey has been periodically cut off from the mainland when low ground between Pagham and Bracklesham has become inundated. The new managed realignment at Medmerry should prevent this from being an immediate threat in the near future.

1.8 Pagham

Pagham lies to the north-east of Selsey and is separated by a large lagoon and river system. The coastline stretching from Pagham lagoon to the western extent of the defences at Bognor Regis is south-east facing and therefore somewhat sheltered from Atlantic storms; however it is exposed to refracting swell wave, localised fetch limited storm waves and extreme sea levels. Wave overtopping is not the primary flood mechanism at Pagham although it is exposed and has flooded in the past due to beach erosion of the natural sediments, and high water during periods of increased set-up and storm surge events. The primary defence running the length of this site is shingle beach defences being natural and manmade. Since the 1960s the shingle beach has been managed through both groynes and beach recharge. A natural build-up of material on the harbour spits has meant that recharging has not been required since 2004. This build-up of material has impacted on Pagham Beach as the spit has grown and migrated towards the beach; if this migration continues the spit could eventually close the entrance to the harbour (Figure 1.4). The proximity of the spit has forced the incoming and outgoing tidal currents into a narrower channel which has resulted in the erosion of Pagham Beach, potentially putting the properties on the beach at risk. Emergency repairs in the form of rock armour have been put in place to provide some protection for the beach. A process of adaptive management was adopted and urgent works to manage the erosion were undertaken. The coastal management at Pagham is detailed in the Pagham to East Head Coastal Defence Strategy.



Figure 1-4: Pagham Beach and spit now almost converge

There are a number of management plans associated in this area that have been completed or are in the process of being improved in the near future:

- Adaptive management commenced at Pagham and East Head (2009)
- Medmerry managed realignment (2014)
- Selsey West Beach improvements (2013)
- East Wittering and Bracklesham improvements (2014)
- West Wittering flood banks (2013).

1.9 Bognor Regis

The town of Bognor Regis is a major holiday destination for the south coast of the UK and is the largest urbanised area within the study extent. Its coastline faces predominantly to the south-east and is exposed to wave action. Historically the area has been inundated by extreme sea levels during surge and storm events. The Aldingbourne rife discharges through a pumped outfall and is at risk from tide locked fluvial flooding and inundation from wave overtopping of the defences.

Overtopping is also a coastal flooding mechanism in this area but only in extreme events due to the level of coastal protection. The coastal defences are predominantly shingle ridges with some sections also having additional protection from wave return walls, wide promenades, and rear splash walls (Figure 1.5).

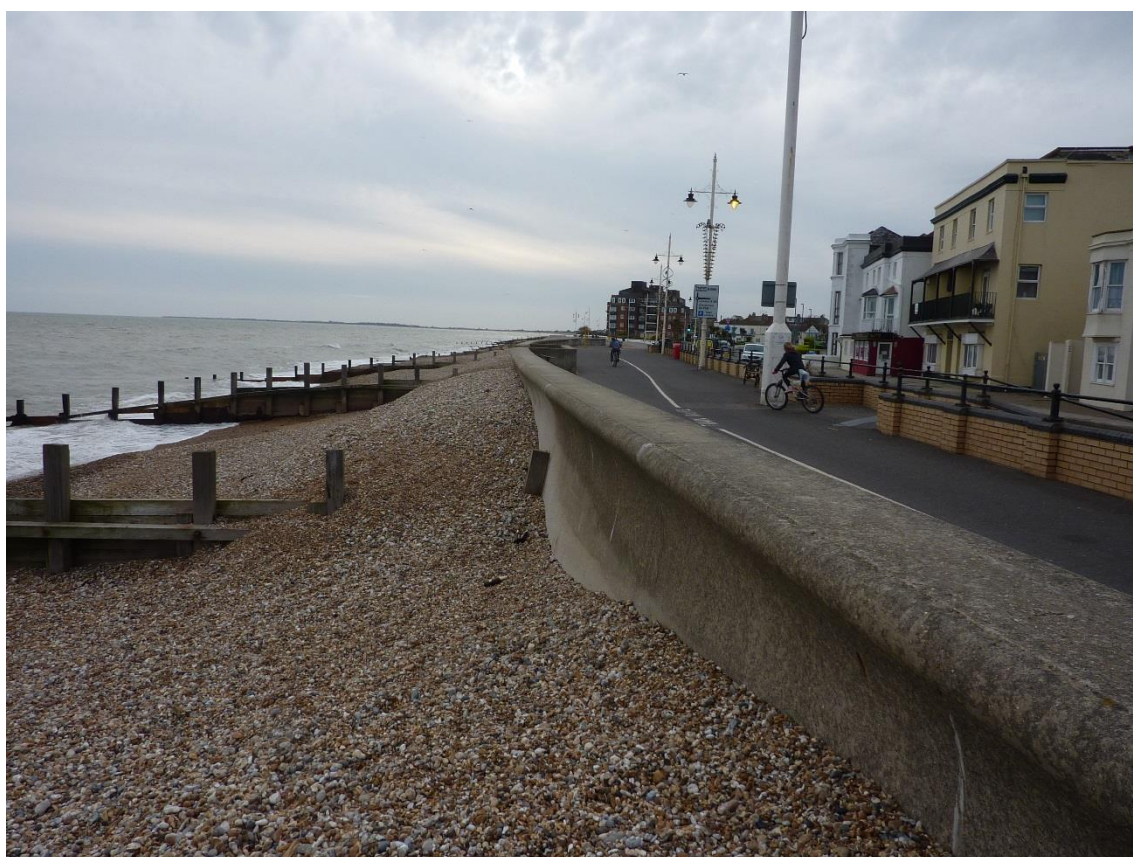


Figure 1-5: Flood defences in Bognor Regis

The area between the town centres moving towards Elmer includes a promenade with lower crest levels and a shingle beach. A series of offshore breakwaters have been constructed to help stabilise the beach and provide additional coastal protection (Figure 1.6).



Figure 1-6: Elmer coastal defence and beach management system (image courtesy of South Downs Coastal Group)

http://www.sdcg.org.uk/sdcg_right2.html)

1.10 Climping

The town of Climping lies close to the River Arun and is at risk from both coastal and fluvial flooding. The few properties that do lie within close proximity to the coastline are protected by a high wall and irregular rock armouring. The first line of defence in the area is the shingle beach which historically has been monitored and managed by the Environment Agency. However, the Environment Agency will cease maintenance of this defence in the near future. The A259 road crossing to the north of Climping is elevated above the floodplain and has been assessed as providing a 1.5% AEP standard of protection against fluvial flooding.

Outside of the urban stretches of coastline the defences become simpler, comprising of shingle beaches, high earth banks and sand dunes.

1.11 Report structure

In addition to this introductory chapter, the report includes the following chapters and appendices:

- **Chapter 2 (Qualitative description of flood response)** reviews the mechanisms of coastal flood risk in the study area.
- **Chapter 3 (Modelling approach)** outlines the three principal components of numerical modelling applied, including wave transformation, wave overtopping and flood inundation modelling.
- **Chapter 4 (Input data)** discusses the data that were gathered and used within the study and how these were applied within the modelling.
- **Chapter 5 (Technical method and implementation)** summarises the approaches taken to model the wave transformation, wave overtopping and flood inundation.
- **Chapter 6 (Model proving)** summarises the model sensitivity tests and the performance against the calibration and validation events.
- **Chapter 7 (Results)** discusses the model results and summarises the flood risk in the main urban areas.
- **Chapter 8 (Flood warning updates)** outlines the proposed updates to the Flood Alert and Flood Warning areas.
- **Chapter 9 (Conclusions)** summarises the main findings from the study and includes some recommendations.

2 Qualitative description of flood response

2.1 Introduction

The first stage in the development of any flood inundation model involves consideration of three factors:

- (1) The local mechanisms of flooding (source);
- (2) Floodwater pathways and conveyance (pathway); and
- (3) The impacts of the flooding (receptor).

It is essential that the model developed accounts for these processes in as realistic a manner as possible; otherwise the results of the model are less reliable. In this chapter, the principal mechanisms of flooding, its flow paths, and its impacts will be discussed.

2.2 Mechanisms of flooding

The study area for this project is diverse, containing sandy beaches, sand dunes, shingle beaches, hard and soft defences, breakwaters, groynes and a major managed realignment scheme at Medmerry. The tidal flood defence network is well developed in the study area. This defence system, assuming that it remains intact during an extreme event, effectively separates the sea from the coastal and estuary floodplains for all but the most extreme still water level storm events. When the flooding from wave overtopping is taken into account the actual standard of the defences is much lower.

Flooding from fresh water sources (i.e. from fluvial flooding and the arterial drainage network) is usually insignificant when compared to floodwaters from the largely tidally influenced estuaries of the West Sussex coastline. The primary goal of this study was to simulate, as realistically as possible, the mechanisms and consequences of major coastal flood events. Clearly, the key driving mechanism during a coastal event is the sea. However, the manner in which the sea floods the land is also highly dependent on the topography of the land and its defences, as well as the presence of tidal rivers, which can act as important conduits of saltwater flooding.

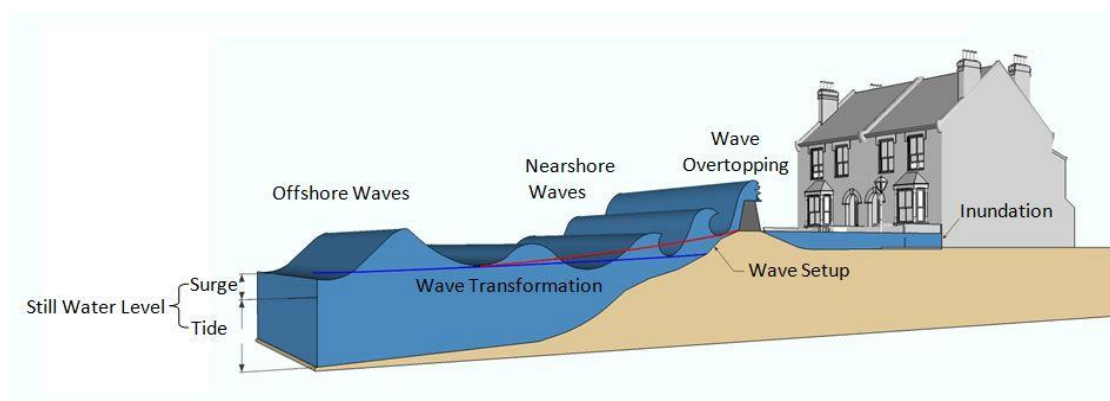


Figure 2-1: Components of sea-level variation that lead to coastal flooding

Figure 2-1 illustrates the components of sea-level variation that contribute to coastal flooding during a storm event. The base sea-level, often referred to as the 'Still Water Level', comprises of the underlying astronomical 'tide' and the passage of a large scale storm 'surge'. These two components determine the average sea-level for a particular location and time. Whilst this variable is very important in terms of coastal flooding, still water-induced flooding is limited to sheltered locations such as tidal rivers and harbours. Not surprisingly, the sea is not "still" and for the more exposed locations, the presence of waves needs to be accounted for. For the exposed locations, such as the coastal frontage at Selsey and Bognor Regis, most flooding can occur through 'wave overtopping', rather than still water flooding.

Wave action is a complex process controlled by a number of factors. The manner in which these factors combine determines the magnitude of any wave induced flood impact. Waves generate in deep water and then propagate towards land. As they do so, they enter shallower bathymetry where wave transformation processes occur, including shoaling, diffraction, refraction, depth limitation and breaking. The consequence of these processes is that the properties of the waves, when they reach the base of flood defences, are quite different to the waves in deep water. It is these nearshore waves that are of most importance because they interact with beaches and defences and lead to wave overtopping.

Wave overtopping is a complex process controlled by the state of the sea (depth, wave properties) and the geometry of local flood defences. There is a long history of flood defence development in the study area and a wide range of flood defence types. These defences include a variety of embankments, revetment, vertical seawalls, return-walls and shingle beaches.

Unfortunately, no one numerical model is capable of simulating both still water flooding and wave overtopping. Therefore, it is necessary to evaluate wave overtopping discharges separately and then to include these as inputs to a coastal flood inundation model. Similarly, it is necessary to derive the still water and fluvial hydraulic boundaries for the model separately and then to include these as inputs.

2.3 Source-pathway-receptor analysis

The sources of flooding detailed in section 2.2 are caused by a combination of still water levels, wave overtopping and wave set-up. The floodwater induced from these different flood mechanisms can potentially be conveyed through the study areas in the following ways:

- The open coastal frontages, which are liable to flooding resulting from the combination of extreme still water sea-levels, wave set-up and wave overtopping; and
- The principal tidal estuaries in the study area (including Chichester and Pagham harbours), where the mechanism of flooding is still water flooding resulting from the inland propagation of the tide and surge along these estuary channels; these estuaries are largely sheltered from significant wave set-up or overtopping.

3 Modelling approach

3.1 Overview

The Sussex coastline is dominated by low lying land that is protected by flood defence networks. Overtopping or breaching of these defences will result in floodwaters spreading out across the land. To help understand this flood risk, several modelling tools were used to transform offshore waves into the nearshore, to calculate volumes of wave overtopping based on the nearshore wave heights, and to simulate flood inundation from both extreme still water level flooding and wave overtopping volumes.

The model system architecture that was used can be seen in Figure 3-1. The individual components of this system are discussed in detail below.

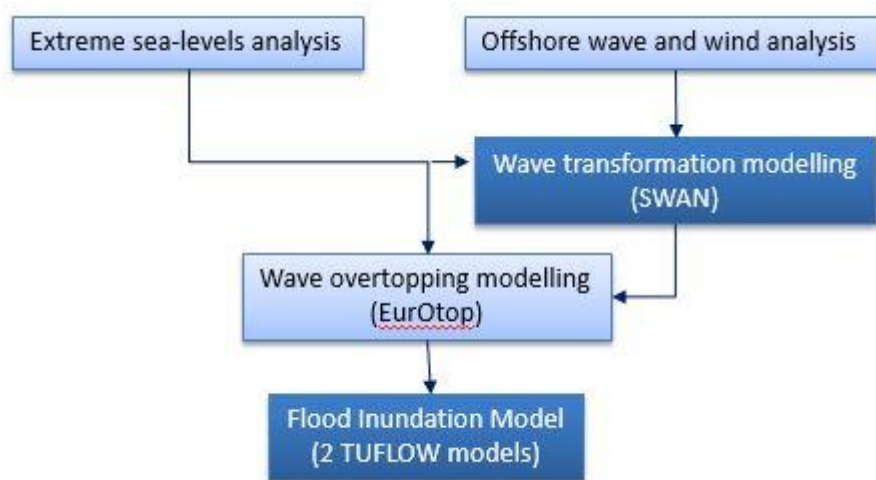


Figure 3-1: Coastal flood modelling system architecture

3.2 Wave transformation modelling

To transform offshore wave heights into the nearshore, wave transformation modelling was undertaken using the SWAN (Simulating Waves Nearshore) wave model. SWAN is a third generation wave model incorporating complex physics for the description of nearshore processes. It is an open source package (no licence required) used widely for research and commercial applications, developed by internationally recognised experts at the Delft University of Technology³. A new SWAN model was developed for use within this study. The wave transformation model development, calibration and simulations are discussed further in Chapter 9.

3.3 Wave overtopping

As mentioned in section 2.2 wave overtopping has to be calculated separately, as no one model is capable of simulating both still water flooding and wave overtopping. The techniques used to calculate wave overtopping values are discussed in Chapter 5 and are based on EurOtop methods. There are some uncertainties inherent in this process such as the manual schematisation of flood defences, the initial wave heights, the storm duration and the output results being estimates of the mean overtopping discharge rather than exact values.

3.4 Inundation modelling

Flood inundation modelling was undertaken using TUFLOW⁴; a fully hydrodynamic flood model well suited to modelling the progression of flood waves across a 2D floodplain. Whilst TUFLOW is a well proven model, its key limitation in terms of this study is with respect to the conveyance of flow along river channels such as the Arun, where the flow is largely 1 dimensional (1D). For these types of channel, 2D models such as TUFLOW, on their own, tend to underestimate conveyance

³ SWAN User Manual, SWAN Cycle III version 40.81, Delft University of Technology, 2010

⁴ TUFLOW (Two-dimensional Unsteady Flow) simulates depth-averaged, two and one-dimensional free-surface flows. TUFLOW's fully two-dimensional solution algorithm solves the full two-dimensional, depth averaged, shallow water equation.

resulting in uncertainty in the model outputs. However, the use of TUFLOW alone avoids unnecessary complexity and represents the real world processes to a suitable level of accuracy to achieve the objectives of this study. TUFLOW is particularly good at representing the progression of floodwaters in the out of bank situations brought about by extreme events.

3.5 Model schematisation

The study extent covers a wide area and two separate TUFLOW models were required to map the main flood risk in the area. The models were created with an 8m grid resolution. An 8m grid size allows accurate representation of the general topography and bathymetry and provides detail on possible flow routes. An 8m grid size will not accurately represent some of the finer topographic details (i.e. anything smaller than 8m), however, the important features such as defences will manually be read into the model to ensure they are represented. Following the completion of the modelling within this study, the Estuary modelling standards (CH2MHill, 2015) were released and these recommend a grid resolution of less than 6m to be able to accurately model flow velocities and hazards. The models are described in more detail in the Model Development Report that accompanies this summary report.

4 Input data

4.1 Data used

The flood models developed for this study required data from a wide range of sources. These can be categorised as ground data, flood defence data and inflow boundary data. The nature of these data and their sources is described below.

4.2 Data availability

4.2.1 Ground data

The largest overall dataset required for the study was the ground level data. These datasets were required to represent the surface upon which the progression of the flood wave moves across and interacts within the study area. The ground level data used in the study consisted of a variety of types, including terrain data, bathymetry data, and surveyed defence crest data. It was necessary to attribute the terrain data with estimates of the expected roughness of these surfaces to allow the progression of the flood wave in the model was appropriate. This involved the use of detailed Ordnance Survey (OS) mapping data.

Terrain data

Light Detection and Radar (LIDAR) data for the project were provided by the Environment Agency and form the main source of terrain data used. The LIDAR data available to the project can be seen in Figure 4-1. These datasets were supplied in 0.25m, 0.5m, 1m and 2m resolution grids with each dataset covering some portion of the floodplain.

LIDAR coverage in the study area is complete (Figure 4-1) with the majority of the area covered with 1m data. The higher resolution data was used in preference to the lower resolution data so the 0.25m LIDAR is layered on top of the 0.5m, the 0.5m on top of the 1m and the 1m on top of the 2m such that the model used the most accurate elevation data to create the model grid. The LIDAR data are of higher resolution than necessary to represent the surface of the floodplain for modelling purposes, as the model grid size is 8m, but it was still used and read into the model to benefit from the more accurate levels. At Pagham harbour the spit is evolving rapidly; the LIDAR used in this area was from a 1m resolution survey in October 2010.

Once the holes in the DTM were filled using interpolation techniques, the grid was inspected for the presence of bridges and culverts. The openings that are associated with these structures on the ground were not represented in the terrain data used to construct the Digital Terrain Model (DTM). Instead, these structures are represented as solid features which would impede flow routes. It was therefore necessary to 'cut through' the DTM at the location of bridges and culverts to allow the flow of floodwater on the floodplain was not unrealistically constrained. These modifications were not made directly to the DTM itself, instead, lines called gully lines, were drawn across the structures in a Geographical Information System (GIS). These gully lines were then used by TUFLOW, during a model simulation, to cut through the DTM and allow flow through the structures.

As discussed in section 2.2, the study area has large flat areas of marshland, which includes a dense arterial drainage network. Many of the drainage channels on the floodplain are of the order of a metre or two wide. Consequently, many of the culverts associated with these small drains are of a similar width. The resolution of the modelling for this study was 8m; if gully lines were used for these structures the flow allowed through would be unrealistically large. For these smaller structures such as culverts on drainage ditches and river channels less than 8m wide, 1D culvert units were used within the flood inundation model to take account of the dimensions of the structures, invert levels, estimates of internal roughness and loss coefficients.