

Residential Development, University of Chichester Bognor Campus

Flood Risk Assessment Addendum Report
University of Chichester

March 2019

Quality information

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Executive Summary

This Flood Risk Assessment (FRA) Addendum is a review of the findings of a previous FRA submitted in March 2016 for the proposed University of Chichester EDTP - Bognor Campus development by WSP | Parsons Brinckerhoff, as well as a review of policy changes and studies undertaken since the previous submission to determine the effects these have on floods mitigation requirements for the development.

The 2016 FRA was undertaken for the entire development which comprised of the new STEM university building south of the ordinary watercourse that runs through the centre of the site, as well as the residential buildings north of the watercourse. As the university's engineering and technology building has now been constructed, this Addendum will focus solely on how any design changes to the proposed residential buildings will need to be mitigated against, as well any proposed changes to policy, studies and datasets.

Section 6 considers the evaluation of flood risk to the site and as a result of the development, both from the 2016 FRA and this Addendum, with changes to flood risk assessment will discussed and justified.

Table 1-1: Comparison of flood risk evaluation between 2016 FRA and this Addendum

Source of flood risk	2016 FRA Report		FRA Addendum Report	
	To the site	From the development	To the site	From the development
Coastal and tidal	Moderate	Moderate	Moderate	Moderate
Fluvial and surface water	High	Moderate	High	High
Groundwater	Low	Low	Low	Low
Sewer and Drainage Infrastructure	Low	Low	Low	Low
Artificial sources	Negligible	Negligible	Negligible	Negligible

The impact of the development on fluvial and surface water flows is likely to be high without mitigation, as the proposed residential buildings may intercept flows from the ordinary watercourse and overland flows across the site in a 1 in 5 year event and above. However, suitable mitigation has been proposed to compensate for this flood risk, both within the 2016 FRA Report and this Addendum, as detailed in Section 7.

The 2016 FRA proposed surface water drainage measures and the proposed mitigation measure of constructing the residential buildings upon piers to provide a void beneath the buildings and raising floor levels above the design flood event level. Further mitigation required as a result of this Addendum consists of:

- Due to changes in the proposed footprint of the residential buildings, an updated drainage strategy is required; and
- This Addendum has determined a Flood Evacuation Plan (FEP) should be prepared prior to construction of the residential buildings. This will ensure safe access and egress is possible from the residential buildings during and up to a design flood event without impeding flow routes, as well as determining evacuation procedures in the event of a tidal breach scenario.

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1. Introduction

1.1 Commission

AECOM was commissioned by University of Chichester in May 2018 to prepare an addendum to the March 2016 Flood Risk Assessment (FRA) by WSP | Parsons Brinckerhoff for the development of the Bognor Campus site on Felpham Way, Bognor Regis. The nearest postcode is PO21 1HP.

This FRA Addendum Report considers the impacts to and resulting from the proposed changes to the development, in accordance with the National Planning Policy Framework (NPPF)¹ and associated Flood Risk and Coastal Change Planning Practice Guidance (PPG)².

1.2 Background

In March 2016, WSP | Parsons Brinckerhoff provided a Flood Risk Assessment as part of the documentation for a planning application, for the proposed development at the University of Chichester Engineering and Digital Technology Park (EDTP) – Bognor Campus. The application site was found to be located in Flood Zone 3, associated with tidal flooding. However, this designation does not account for coastal flood defences to the south of the site placing the development within an area of residual flood risk.

The proposed residential student accommodation of the development was not taken forward to construction following the FRA; however it is now planned that the remaining development should proceed. A number of the planning policy and datasets upon which the original FRA relied upon have since been updated and an addendum is now required to support the site planning application process. Therefore an addendum to the original FRA is required.

1.3 Report Layout

This section details the layout of the report and what is encompassed by each chapter of this Addendum:

- Introduction: Explanation of the scope of the report, planning application background for the development, assessment methodology of flood risk, and the overall aims and objectives of the report.
- Site Context and Proposed Development: This chapter provides an overview of the proposed development and the planning history, the location and topography of the development site, and the requirements for flood risk assessment based upon the Sequential and Exception Tests.
- Summary of Findings, Conclusions and Recommendations of the Previous Flood Risk Assessment: This chapter considers the findings of the previous FRA, what flood risk sources were established, what existing drainage was in the vicinity of the site, and the proposed surface water drainage measures to mitigate the flood risk to and as a result of the development.
- Review of Policy Published since 2016: This chapter considers relevant national, regional and local flood policy published since the 2016 FRA Report and the impact it has on flood risk assessment of the development.
- Review of Studies and Data Published since 2016: This chapter is an assessment of additional studies and data that have been submitted since the previous FRA that may affect the assessment of flood risk to or from the development, or the requirements to mitigate this flood risk.

¹ Communities and Local Government (2012) 'National Policy Planning Framework', Department for Communities and Local Government: London.

² Communities and Local Government (2014) 'Guidance: Flood Risk and Coastal Change', available at <https://www.gov.uk/guidance/flood-risk-and-coastal-change>

- **Summary of Flood Risk:** This chapter is a summary of flood risk to the site based upon the findings of the 2016 FRA and the findings of this Addendum report. Table 6-1 compares the level of flood risk determined by the previous FRA and this report.
- **Mitigation of Flood Risk:** This chapter details what mitigation is required to satisfy the policy requirements set out in the report, in light of the flood risk assessment. This states what mitigation from the 2016 FRA is still valid and what additional measures need to be undertaken in light of changes to the development, policy, and dataset findings.
- **Conclusion:** This chapter summarizes the findings of the report and the consequent mitigation requirements.

1.4 Flood Risk Assessment Methodology

The aim of this FRA addendum is to assess the potential flood risk to and from the development, taking into account the minor design changes including secondary staircase access routes and an additional floor to each of the three main residential blocks. It is not anticipated that the level of flood risk itself will change, as the site is still located within Flood Zone 3, residual risk in terms of planning.

However, the level of detail with regard to the risk may be improved, as there is now new breach modelling available for the site and higher resolution surface water modelling data from the Environment Agency.

This FRA addendum report has been prepared in accordance with the NPPF and it is proposed that it is submitted in conjunction with the original 2016 report. The addendum is a desk based assessment using existing information and includes the following:

- Review of strategic flood risk information publically available from the Local Planning Authority and Lead Local Flood Authority (Arun District Council/West Sussex County Council) and the Environment Agency since 2016;
- Site-specific Product 4 information from the Environment Agency providing flood risk information relevant to the site;
- Qualitative assessment of any updates to datasets (post 2016) used to report the risk of flooding both arising from development and posed to the development from all sources of flooding including tidal (breach modelling), fluvial, surface water runoff, groundwater, artificial sources (such as canals and reservoirs) and flooding from local drainage features;
- Discussion and recommendations for flood mitigation measures and residual risk mitigation measures, where applicable;
- Provide recommendations on how surface water from the site can be managed in a sustainable way. This will include allowances for future Climate Change and how the Proposed Development can satisfy national and local planning policy.

1.5 Determining the Level of Risk

The approach to this FRA involves a desk-based review of available information to establish the likely flooding sources and mechanisms for the Site. Once the flood risk has been established, mitigation measures are recommended where necessary and further work identified.

1.6 Aims and Objectives

The aim of this report is to assess the flood risk associated with the proposed development. As stated in paragraph 102 of the NPPF¹, a site-specific FRA should:

“... demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.”

The NPPF PPG Note² states that the objectives of a site-specific flood risk assessment are to establish:

- whether a proposed development is likely to be affected by current or future flooding from any source;
- whether it will increase flood risk elsewhere;
- whether the measures proposed to deal with these effects and risks are appropriate;
- the evidence for the local planning authority to apply (if necessary) the Sequential Test; and,
- whether the development will be safe and pass the Exception Test, if applicable.

Given that this FRA is an addendum to a previous report in 2016, it will review any data received since 2016, and provide a description of any changes to flood risk at the site raised by new data or by the proposed changes to the development. As such, this report should be considered in conjunction with the previous report from 2016.

2. Site Context and Proposed Development

2.1 General

The University of Chichester previously received permission (planning application no. BR/54/16/PL) to construct a new Engineering and Digital Technology building, residential student accommodation and associated car parking. The proposed student accommodation was not taken forward at the time, however it is proposed that this Phase of the development now goes ahead and thus an update is required to the original FRA.

The new planning application outlines a revised brief for the residential development:

- Additional staircases for alternative emergency access/egress;
- Additional floor above existing proposed building for increased residential space.

2.2 Location

The site is located at National Grid Reference SZ 94395 99695, in Bognor Regis, West Sussex.

The site lies at the eastern end of the University of Chichester Bognor Campus, approximately 500 metres to the north of the sea (south coast English Channel). Bordering the site to the south is Butlin's Bognor Regis Resort, to the east is the residential area of Felpham and to the north are college football fields and Aldwick Cricket Club.

The main river of Aldingbourne Rife runs approximately 50 metres to the east of the site, as well as a tributary ordinary watercourse that runs west to east through the middle of the site. The proposed residential buildings are situated to the north of the stream, with the academic building that commenced construction after the 2016 FRA to the south of the stream.

2.3 Topography

The 2016 FRA provided a topographic survey of the site, which shows ground levels for the existing site vary from -0.82mAOD in the watercourse at the centre of the site, to 3.12mAOD in the southwest corner.

2.4 The Sequential Test

Section 10 of the NPPF¹ and the associated Flood Risk and Coastal Change PPG² provide the current national policy and guidance for planning with respect to flood risk.

The NPPF¹ considers the vulnerability of different forms of development to flooding and classifies proposed uses accordingly as detailed in Table 2 of the PPG², which is reproduced in Table 2-1 below. The vulnerability classification of the proposed development is boxed in red within this table.

Table 2-1: PPG² (Table 2) Flood Risk Vulnerability Classification

Vulnerability Classification	Development Uses
Essential infrastructure	Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. Wind turbines.
Highly Vulnerable	Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding. Emergency dispersal points. Basement dwellings. Caravans, mobile homes and park homes intended for permanent residential use. Installations requiring hazardous substances consent. Hospitals Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels.
More Vulnerable	Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels.
Less Vulnerable	Non-residential uses for health services, nurseries and educational establishments. Landfill* and sites used for waste management facilities for hazardous waste. Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan. Police, ambulance and fire stations which are not required to be operational during flooding. Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'More Vulnerable' class; and assembly and leisure. Land and buildings used for agriculture and forestry. Waste treatment (except landfill* and hazardous waste facilities). Minerals working and processing (except for sand and gravel working). Water treatment works which do not need to remain operational during times of flood. Sewage treatment works Flood control infrastructure. Water and sewage transmission infrastructure and pumping stations. Sand and gravel working.
Water-Compatible Development	Docks, marinas and wharves, lifeguard and coastguard stations, and water-based recreation (excluding sleeping accommodation). Navigation facilities. Ministry of Defence defence installations. Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.

Table 3 of the NPPF¹ illustrates a matrix detailing which vulnerability classifications are appropriate for development within each Flood Zone. This is reproduced in Table 2-2.

Table 2-2: NPPF¹ (Table 3) Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability Classification (Table 2 NPPF)	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Flood Zone					
1	✓	✓	✓	✓	✓
2	✓	Exception Test required	✓	✓	✓
3a [†]	Exception Test required [†]	x	Exception Test required	✓	✓
3b*	Exception Test required*	x	x	x	✓*

✓ – Development is appropriate x – Development should not be permitted

[†] In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

* In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

The proposed development comprises 'used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels' which fall into the "More Vulnerable" category.

As clarified in the previous FRA report and in Section 5.1 of this addendum, the site is within Flood Zone 3a and is at residual risk due to the presence of flood defences. In accordance with the flood risk vulnerability table (Table 2-2); the development is therefore classified as requiring an Exception Test.

2.5 The Exception Test

The previous FRA stated that the Application Site is the only land owned by University of Chichester in the vicinity of the existing Bognor Campus, and therefore this is the only feasible site available for development. The Exception Test requires the proposed development to show that:

1. It will provide wider sustainability benefits to the community that outweigh the flood risk:
 - Issues of wider sustainability benefits to the community were addressed in the supporting planning application documents of the previous application.
2. It will be safe for its lifetime without increasing flood risk elsewhere and where possible reduce flood risk overall:
 - This FRA Addendum and the 2016 FRA demonstrate how the proposed development can be implemented with appropriate mitigation measures despite the flood risks to the Application Site, enabling occupants and users to be safe from flooding for the lifetime of the development (50 years), accounting for the effects of climate change without increasing flood risks elsewhere.

3. Summary of Findings, Conclusions and Recommendations of the Previous Flood Risk Assessment

3.1 Flood History

The 2016 FRA considered the Environment Agency data and found no records of previous flood events affecting this site. The report also stated that West Sussex County Council have no records of flooding within the site, however it was noted that the area around the site was affected by storms in June 2012, when the storm return period for the event was in excess of the normal design capacity for the surface water system. Southern Water also had no records of flooding for this area.

3.2 Flood Risk

The 2016 FRA Report provided an assessment of flood risk to and from the development due to all flood sources. The following is the summary of flood risk assessment from the previous report:

- Under normal conditions, the site is not at risk of flooding from coastal and tidal sources, and the sea defences provide adequate protection up to the 0.1% AEP flood event until at least 2068;
- The Tidal Breach Map of the Arun District Council (Arun District Council SFRA, Map B³) showed that the site is at risk of flooding if the tidal defences were to be breached. However it was recognised that a breach would only be likely if the tidal defences were not maintained, and in accordance with Local Policy the local defences would continue to be maintained;
- Environment Agency detailed flood mapping shows the northern half of the site is within Flood Zone 3⁴, i.e. an AEP of between 1% and 0.1%. Undefended fluvial levels for the 0.1% AEP event ranged from 2.14 to 2.76mAOD, and the northern half of the site is at risk of flooding⁵;
- The Arun District Council SFRA modelled the risk of flooding from fluvial sources with the presence of defences for the 1% AEP event (with and without account for climate change), and the site was not at risk of fluvial flooding in this scenario. This model however only accounted for the Aldingbourne Rife and not the ordinary watercourse running through the site;
- Hydraulic modelling showed that waters entering the ordinary watercourse on the Application Site from the surface water sewer network caused it to overtop and flood the site in conjunction with overland flows from south and north of the watercourse. A 1% AEP rainfall event with 20% climate change resulted in a peak water level of 1.54mAOD on the Application Site to the north of the watercourse;
- The hydraulic model of the site assessed pluvial and overland flow sources, and the upstream catchment including the Southern Water surface water sewer network. The results of the baseline model confirmed that the site is at risk of surface water flooding. Flooding occurs on the eastern boundary to the north of the watercourse in the 20% annual probability (1 in 5 year) event;
- The Application Site was indicated as being at high risk of groundwater flooding by the SFRA and ESI maps. The Ground Investigation undertaken by WSP | Parsons Brinckerhoff in December 2015 showed groundwater levels to be very high during the winter, however there were no reported incidents of groundwater flooding from the investigation or in correspondence with stakeholders;
- The modelling and site layout showed that the Proposed Development includes buildings within the floodplain of the ordinary watercourse and therefore has the potential to displace

³ Strategic Flood Risk Assessment – Arun District; Arun District Council, May 2008 – accessed by WSP | Parsons Brinckerhoff in July 2015, now superseded by 2016 SFRA Update

⁴ Environment Agency's detailed flood mapping – Appendix C; Flood Risk Assessment, University of Chichester EDTP – Bognor Campus; WSP | Parsons Brinckerhoff, March 2016

⁵ Environment Agency's detailed flood mapping – Appendix C; Flood Risk Assessment, University of Chichester EDTP – Bognor Campus; WSP | Parsons Brinckerhoff, March 2016

flood water from the floodplain, resulting in increased flooding to neighbouring properties;
and,

- It was also established within the previous FRA that an increase in impermeable land cover and alteration of existing overland flow paths would increase flood risk.

3.3 Site Drainage

The 2016 FRA identified two foul rising mains (600mm and 750mm diameters) running along the eastern boundary of the site, as well as a further decommissioned foul rising main in the southeast of the site. The two sewers are joined by a third towards the south of the site where they discharge to a combined sewer along Upper Bognor Road.

The existing site is Greenfield and hence there is no existing site drainage, with runoff passing into the ordinary watercourse in the centre of the site via infiltration and overland flow.

Surface water runoff from the site was calculated for both the existing and post development conditions and an estimate of surface water storage volume (considering an allowance of 20% climate change) was determined.

Surface water runoff calculations indicated that the estimated mean annual maximum Greenfield runoff rate (Q_{BAR}) for the existing site is 2.9l/s per 1ha of developable site, or 9.1l/s for the entire 3.14ha site. The previous drainage strategy intended to limit the discharge to the existing rate through flood risk management measures.

3.4 Flood Management Plan

The 2016 FRA recommended provision of flood risk mitigation measures to ensure the Proposed Development remains safe over its lifetime and does not increase flood risk to neighbouring properties.

A drainage scheme utilizing swales, a wetland area, a small pond and attenuation tanks is intended to allow the Proposed Development to be drained for events up to and including the 1% annual probability (including 20% climate change allowance). However, the selected attenuation methods will need to be designed such that groundwater infiltration cannot occur. Hydraulic modelling was undertaken of the post development scenario to ensure no increase in risk from surface water flooding occurs to the site or surrounding areas.

The 2016 FRA stated that the proposed residential buildings north of the watercourse will be built on piers with the soffit of the void space underneath set to 300mm above the design flood level. This will limit the impact of the proposed buildings on the overland flood flows or floodplain displacement, in accordance with the National Planning Policy Framework (NPPF)⁶. The finished floor levels will be elevated further to accommodate the floor construction, to 2.75m AOD.

The Proposed Development was designed to limit the runoff rate to a mean annual maximum Greenfield rate (Q_{BAR}) of 9.1l/s for all events up to the design event, in accordance with the Non-Statutory Sustainable Drainage Technical Standards⁷.

As groundwater levels were found to be at shallow levels on the site, it was determined that infiltration methods would not be feasible and attenuation features would be lined to prevent groundwater ingress. It was also noted that geocellular units will require weighting down to ensure flotation does not occur in high groundwater areas.

For events greater than the design event, the storage volumes provided would be exceeded and the area north of the watercourse would flow beneath the buildings into the watercourse. In the south of the site water would flow along paths lower than the structures so as to minimise the risk of flooding to buildings. Safe access and egress would be from the main entrance to the University and via the central bridge over the watercourse.

⁶ National Planning Policy Framework; Department for Communities and Local Government, 2012;

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/262122/nppf-2012.pdf

⁷ Sustainable drainage systems: non-statutory technical standards; Department for Environment, Food & Rural Affairs, 2015;

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468122/sustainable-drainage-systems-non-statutory-technical-standards.pdf

A drainage strategy was outlined in the 2016 FRA, which states that flows generated from the proposed 1.47ha impermeable area will need to be attenuated in order that a Greenfield discharge rate can be maintained without causing additional flooding to the site.

The drainage strategy suggests discharging via a range of drainage systems including swales, a wetland, a pond, permeable paving and underground storage tanks. In the northern area of the site consisting of the three residential student accommodation buildings, car parking areas and pedestrian walkways, rainfall collected from roofs was proposed to be conveyed directly to underground storage tanks beneath landscaped areas surrounding the buildings, with water released at a controlled rate to the watercourse. The tanks are designed to contain the 3.3% annual probability event without any outflow.

Runoff from hardstanding areas was designed to be collected and attenuated via permeable paving, a pipe drainage system and geocellular storage.

The total volume of storage provided in the north of the site would accommodate a 1% AEP event with a 20% allowance on rainfall intensity for climate change. Total storage provided in the northern area of the site by the accompanying drainage strategy was 624m³, with a maximum discharge rate for this catchment of 3.1l/s to the northern outfall.

As required by the Environment Agency's Flood Risk Assessments: Climate Change Allowances⁸, the 2016 FRA also considered the impact of a 40% increase in peak rainfall intensity. The additional generated volume compared to a 20% allowance was 180m³ distributed across the whole site. In the northern area water would flow towards the watercourse along the roads and pathways however would not cause flooding to the proposed accommodation buildings due to the raised levels.

The 2016 FRA clearly stated the ownership and maintenance regime of the onsite drainage system, including maintenance requirements for each sustainable drainage element of the system for the lifetime of the development.

⁸ Environment Agency Flood Risk Assessments: climate change allowances; Environment Agency, 2016;
www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

4. Review of Policy Published since 2016

4.1 Environment Agency Climate Change Allowances (2017)

In February 2017 the Environment Agency updated the latest climate change allowances⁹, which supports the NPPF in making an allowance for climate change within flood risk assessment to help 'minimise vulnerability and provide resilience to flooding and coastal change in the future'.

The allowances provide predictions of anticipated change for:

- Peak river flow by river basin district
- Peak rainfall intensity
- Sea level rise
- Offshore wind speed and extreme wave height

The allowance categories are provided in upper end, higher central and central bands. The allowance used is based on the flood risk vulnerability classification of the development – derived from the type of development and flood zone. For a more vulnerable development within Flood Zone 3a, the higher central and upper end allowances should be used to assess a range of allowances. Table 4-1 provides the forecast increase in peak river flows for the South East. This will have increased significance if breach modelling or new studies show any differences in how the development is affected by risks of flooding.

Table 4-1: Peak river flow allowances by river basin district

River basin district	Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2059)	Total potential change anticipated for the '2080s' (2070 to 2115)
South East	Upper end	25%	50%	105%
	Higher central	15%	30%	45%
	Central	10%	20%	35%

Environment Agency guidance suggests that for flood risk assessments, both the central and upper end allowances for anticipated changes in river flow allowances should be considered.

Table 4-2 provides the forecast increase in peak rainfall intensity over small/urban catchments. This will have significance when assessing surface water management of the site.

Table 4-2: Peak rainfall intensity allowance in small and urban catchments

River basin district	Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2059)	Total potential change anticipated for the '2080s' (2070 to 2115)
Applies across all of England	Upper end	10%	20%	40%
	Central	5%	10%	20%

⁹ Flood risk assessments: climate change allowances; Environment Agency; February 2017. Available at <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances> accessed 21st June 2018

Environment Agency guidance suggests that for flood risk assessments, both the central and upper end allowances for anticipated changes in extreme rainfall intensity should be considered during design of the surface water drainage strategy, in order to understand the potential range of impact. AECOM's Drainage Strategy¹⁰ states that a climate change allowance of 40% will be adopted for peak rainfall intensity, in line with the Environment Agency's Climate Change Allowances (2017) i.e. total potential change anticipated in 2080, allowance category Upper End.

The drainage strategy has developed appropriate surface water flooding mitigation for the buildings revised footprint based on the above climate change allowances.

The Environment Agency also provided updated guidance on sea level allowances and offshore wind speed and extreme wave heights, and the following tables demonstrate the possible impact of climate change on the residual coastal/tidal flood risk to the development.

Table 4-3 provides the forecast increase for each time frame for sea level rise for the region. The Environment Agency expect sea level rise to increase the rate of coastal erosion, and it is recommended that the shoreline management policy for the area is considered to assess the policy for maintaining defences.

Table 4-3: sea level allowance for each epoch in millimetres (mm) per year with cumulative sea level rise for each epoch in brackets (use 1990 baseline)

Area of England	1990 to 2025	2026 to 2055	2056 to 2085	2086 to 2115	Cumulative rise 1990 to 2115 / metres (m)
East, east midlands, London, south east	4 (140mm)	8.5 (255mm)	12 (360 mm)	15 (450 mm)	1.21 m

Wave heights may increase due to increased water depths, and the increase in frequency, duration and severity of storms. The Environment Agency use a single allowance for each epoch for wind speed and wave height, with a 10% sensitivity allowance to understand the range of impact, as detailed in Table 4-4.

Table 4-4: offshore wind speed and extreme wave height allowance (use 1990 baseline)

Applies around all the English coast	1990 to 2055	2056 to 2115
Offshore wind speed allowance	+5%	+10%
Offshore wind speed sensitivity test	+10%	+10%
Extreme wave height allowance	+5%	+10%
Extreme wave height sensitivity test	+10%	+10%

The revised Environment Agency allowances mean that the previous Flood Risk Assessment may no longer provide sufficient mitigation for fluvial and surface water flooding. The revision in sea level and extreme wave height allowances may mean a change in residual risk of coastal/tidal flooding,

¹⁰ Chichester University Drainage Strategy, AECOM, November 2018

although the site is considered to be defended by the coastal flood defences for at least the lifetime of the development.

5. Review of Studies and Data Published since 2016

5.1 Arun District Council Strategic Flood Risk Assessment (2016)

The Strategic Flood Risk Assessment (SFRA) published in August 2016 states the FRA requirements and guidance for developers based on over-arching principles based on flood risk within Arun District.

As a minimum, an FRA should demonstrate that the development is protected to the 1 in 100 year fluvial and surface water and 1 in 200 year tidal flood scenario, and it is safe for the intended lifespan during the design flood event, including an allowance for climate change.

A technical assessment is required to assess the practical feasibility of flood risk mitigation, as well as the financial viability and long term maintenance implications. Detail is needed of safe access and egress during flood events, including climate change, and how this links to flood warning and emergency evacuation where necessary. Consideration is also required as to the safety implications during events where the design capacity is exceeded.

The SFRA states that the minimum acceptable standard of protection against flooding for any new residential property within flood risk areas in the Arun district is:

- 1 in 100-year event for fluvial flooding;
- 1 in 200-year event for tidal flooding;
- 1 in 100-year storm for surface water flooding;
- Developments vulnerable to flood risk as a result of blockage or exceedance of structures should be protected beyond the 1 in 100 years plus climate change scenario; and
- An allowance for climate change for the lifetime of the development needs to be included for all scenarios, in line with the latest guidance for climate change.

Any proposed raised floor levels should be agreed with Arun District Council, and should be a minimum of 600mm above the maximum water level caused by the above stated events. The SFRA also states that free and voluntary movement of people is needed during a design flood as well as potential for evacuation for a more extreme flood. The developer should review the proposed access in consultation with Arun District Council and the Environment Agency. Ideally these routes should be above the design flood level although in some cases limited depths may be acceptable.

Within the SFRA a number of development control policy recommendations have been set out, with some relevant to specific flood zones. These include but are not limited to the following stipulations for Flood Zone 3a:

- Normally no buildings should be constructed within eight metres of the banks of watercourses, for maintenance and ecological corridors.
- Residual risks should be assessed, and the Environment Agency consulted regarding whether there is a need for a breach analysis to map a rapid inundation zone.
- Developments should not impede flow routes, reduce floodplain storage or consume flood storage.

5.2 Environment Agency Site Specific Flood Risk Data (2018)

The Environment Agency provided a Product 4 (Detailed Flood Risk) for the University of Chichester, Bognor Regis Campus site which included the Emsworth to Littlehampton tidal model and a fluvial model for the Aldingbourne Catchment. The Flood Risk figures provided are in Appendix A of this report.

The site is shown to be predominantly within Flood Zone 3, and modelled flood outlines show the northern half of the site (where the proposed accommodation is situated) inundated in a 0.1% AEP undefended fluvial event.

Almost the entire site is shown to be inundated by a 0.5% AEP undefended tidal event, with water levels and depths at nodes within the site provided. The likelihood of surface water flooding is deemed to be low (1% - 0.1% AEP) across the northern half of the site, apart from an area north of where the watercourse discharges offsite where it is medium risk (3.3% to 1% AEP).

Appropriate surface water management has been considered in the AECOM drainage strategy to ensure that measures are taken to reduce the existing and additional risk of surface water flooding as a combined result of the development and climate change.

The modelled flood depths in metres for fluvial and tidal, defended and undefended events have been provided for 2 nodes within the site. Node 1 refers to an area north of the site and node 2 refers to the location where the proposed accommodation blocks will be situated.

The flood water depth and level information provided by the Environment Agency and displayed in Appendix A indicates that the 1% AEP defended fluvial flood event would result in no flooding of the site. However, when climate change is considered (for the 105% allowance) a level of 1.93m AOD of flood water is expected at the site.

Appropriate consideration is required of the residual risk of tidal flooding as a result of a breach, given the potential flood depths. However it should be recognised that a breach is only likely if the tidal defences were not maintained, however it is assumed these will be maintained for the lifetime of the development in accordance with local and national policy.

5.3 Environment Agency Mapping

The Environment Agency's Long Term Flood Risk Information is updated periodically and therefore has also been considered in this FRA Report¹¹, providing detailed flood risk information for the site area. The Flood Risk from Rivers or the Sea Map takes into account the effect of any flood defences in the area but states that the residual risk of fluvial or tidal flooding remains high within the site, in the northern half above the watercourse.

The Environment Agency Information indicates that there is no risk to the development as a result of reservoir flooding.

¹¹ Long term flood risk information; Environment Agency; © Crown copyright and database rights 2017 OS 100024198. Available at <https://flood-warning-information.service.gov.uk/long-term-flood-risk> accessed on 25th June 2018

6. Summary of Flood Risk

6.1 Tidal Flood Risk

The 2016 FRA report found that the site is situated within Flood Zone 3a. The updated site specific flood risk data obtained from the Environment Agency shows that undefended tidal flood events would result in inundation of the site in up to 3.19m deep (ground level of 1.1m AOD and a depth of flood water of 4.29m) for a 0.5% AEP event with an allowance for climate change within the lifetime of the development.

The presence of coastal flood defences mean that the site is protected up to a 0.1% AEP flood event until 2068. It is expected that the coastal defences would be maintained for the lifetime of the development in accordance with local and national policy. As a result the risk of tidal flooding to the development can be considered moderate, however with a high residual risk in the event of a breach. Due to the significant levels of tidal flooding in the event of a breach, the proposed buildings would result in the displacement of flood water; therefore the risk of the proposed development exacerbating tidal flood risk is moderate.

6.2 Fluvial and Surface Water Flood Risk

The 2016 FRA stated that no evidence was found of flood records on the site, and modelling showed that the site was not found to flood from the Aldingbourne Rife up to a 1% AEP fluvial defended event.

Hydraulic modelling undertaken in 2016 however showed that the ordinary watercourse that passes through the site flooded is a result of flows from the surface water sewer network, resulting in a peak level of 1.54mOD for the 1% AEP event, including a 20% allowance for climate change. Considering the topographical survey from the previous FRA, this would result in flooding of up to 0.5m deep to the majority of the site north of the watercourse.

The hydraulic modelling also showed that overland flows across the site run into the watercourse and during a 20% AEP (1 in 5 year) event flooding occurs at the eastern boundary of the site, north of the watercourse.

The updated Environment Agency Climate Change Allowance guidance indicates that for a development with a lifetime of 50 years in the South East region, peak river flow allowances should be considered for 30% and 50% increases and peak rainfall allowances of 20% and 40% increases. This could result in an increased design flood level impacting the northern half of the site.

The proposed buildings are within the watercourse floodplain and overland flow path to the watercourse, and will result in an increase in impermeable ground. Flood risk to the development as a result of combined fluvial and surface water sources is high. Without mitigation such as the proposed pier foundations the proposed development would result in the displacement of surface waters and the ordinary watercourse floodplain flows and therefore the risk of the proposed development exacerbating fluvial and surface water flooding is high.

A calculation has been undertaken to determine the total volume of compensatory storage required due to the structures piers located in the floodplain based on a flood depth of 0.83m (1.93 mAOD) i.e. the 1% AEP event for the year 2115. A compensatory storage volume of **20m³** is required and will be provided within the onsite storage pond. Further details of the pond are provided in the Drainage Strategy.

6.3 Groundwater Flood Risk

Groundwater levels were reported to be high in close proximity to the watercourse, likely dictated by the fluvial levels; however there were no recorded occurrences of groundwater flooding on the site. The underlying bedrock of the site is a combination of Lambeth Group (clay, silt and sand) and multiple Chalk Formations. Previous borehole records reference in the 2016 FRA Report showed that water had been encountered 2.5m below ground level in the Chalk half of the site and 3.2m below ground level in the Lambeth Group half of the site. There are no basements or underground car parks proposed for the site and the foundations of the residential buildings will be piled foundations. These

foundations are unlikely to make a significant impact to groundwater levels across the site. Flood risk to and from the development from groundwater sources remains low.

6.4 Sewer Flood Risk

The previous FRA did not find a history of sewer flooding or any significant risks within the site of sewer flood risk to or from the development. Surface water from the development will not drain into the sewer network so will have no impact on this source. Flood risk to and from the development from sewer and drainage infrastructure remains low.

6.5 Artificial Flood Risk

There are no canals in the vicinity of the site and the Environment Agency's online mapping¹¹ indicates the site is not at risk of reservoir flooding. Flood risk to and from the development from artificial sources remains negligible.

6.6 Comparison of Flood Risk with 2016 FRA report

This section considers the evaluation of flood risk to the site and as a result of the development, both from the 2016 FRA and this Addendum. Any changes to flood risk assessment will be discussed and justified.

Table 6-1: Comparison of flood risk evaluation between 2016 FRA and this Addendum

Source of flood risk	2016 FRA Report		FRA Addendum Report	
	To the site	From the development	To the site	From the development
Coastal and tidal	Moderate	Moderate	Moderate	Moderate
Fluvial and surface water	High	Moderate	High	High
Groundwater	Low	Low	Low	Low
Sewer and Drainage Infrastructure	Low	Low	Low	Low
Artificial sources	Negligible	Negligible	Negligible	Negligible

The impact of the development on fluvial and surface water flows is likely to be high without mitigation, as the proposed residential buildings may intercept flows from the ordinary watercourse and overland flows across the site in a 1 in 5 year event and above. However, suitable mitigation has been proposed to compensate for this flood risk, both within the 2016 FRA Report and this Addendum, as detailed in Section 7.

7. Mitigation of Flood Risk

7.1 Overview

The following mitigation is set out in order to meet the requirements of the policy set out in this report and the previous FRA report. This is built upon the recommendations of the 2016 report.

7.2 Summary of Flood Risk Mitigation

The following recommendations of the 2016 FRA report are still valid:

- Residential buildings to the north of the watercourse in areas of flood risk will need to be built on piers, with the soffit of the void area below the buildings set to 600mm above the defended fluvial 1% AEP plus climate change event, at 2.53m AOD. The highest allowance of climate change has been considered for the '2080s' (2070 to 2115). As stated within the Arun District SFRA, the proposed raised floor levels within the residential buildings should be agreed with Arun District Council, and should be a minimum of 600mm above the maximum water level caused by the above stated events. The proposed finished floor level of 2.75m AOD is therefore sufficient. The design water level of 1.93m AOD for the 1% AEP plus climate change event has been agreed by the Environment Agency and correspondence has been included within in Appendix B.

Further consideration is needed however of the following:

- The site run-off is to be limited to the greenfield runoff rate, 5l/s for rainfall events up to a 1% AEP plus 40% climate change allowance, via attenuation in permeable paving, swales, a wetland area, a small pond and underground storage tanks; and
- A Flood Evacuation Plan (FEP) should be prepared, prior to the commencement of construction of the student residence to assess the viability of access and egress to the site during flooding. The Arun District SFRA states that free and voluntary movement of people is needed during a design flood as well as potential for evacuation for a more extreme flood. Access should be reviewed in consultation with the council and the Environment Agency, taking into account that ideally access routes should be above the design flood level (although in some cases limited depths may be acceptable). As stated within the SFRA, the development (including access routes) should not impede flow routes, reduce floodplain storage or consume flood storage.
- The FEP should also consider that the Environment Agency modelled flood levels for a tidal breach scenario during a 0.5% AEP event for the year 2115 at the node nearest the proposed residential buildings is 4.29m AOD, which is likely to be approximately 1.5 metre above the finished floor level of the ground floor; and
- The FEP should consider the development of a flood warning and evacuation plan to manage the residual fluvial and tidal risk to site in the event of a breach scenario.

8. Conclusion

Following a review of policy documents and studies and data published since the 2016 FRA Report, it can be concluded that:

- The modelled fluvial flood levels caused by a 1% AEP plus climate change for the Upper End allowance '2080s' (2070 to 2115), are appropriate for use as the design flood event;
- AECOM's drainage strategy has outlined surface water mitigation measures for the 40% climate change allowance in the form of attenuation and the use of building foundation piers are still appropriate;
- Consideration is required with regards to safe access and egress from the site during a design flood event without impeding overland flow routes or reducing floodplain storage as part of a Flood Evacuation Plan prior to construction; and
- A flood warning and evacuation plan is advised to manage the residual fluvial and tidal flood risk and should be prepared prior to the commencement of construction of the student residence and publicised to all residents.

Appendix A – Product 4 Site Specific Flood Risk Data

Appendix B – Correspondence

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