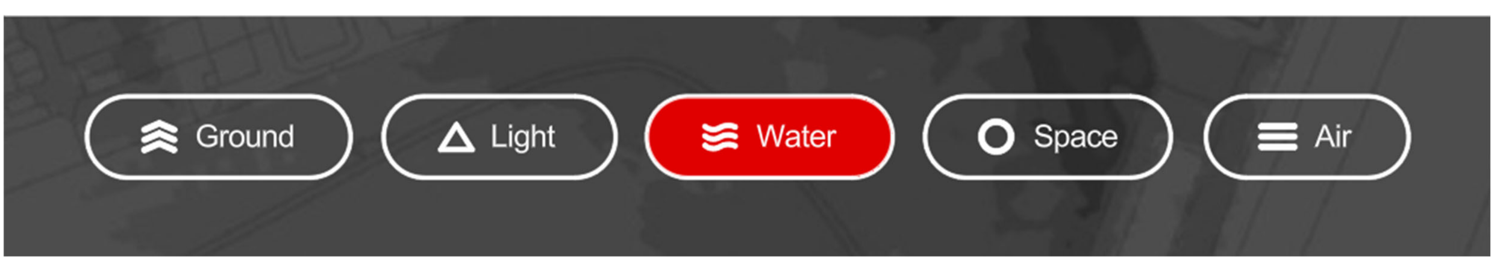
Client: AY Developers

Flood Risk Assessment for
the Proposed Development
at 74 Old Shoreham Road,
New Monks Farm, Lancing

November 2025



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1 Background and Scope of Appraisal

Flooding is a major issue in the United Kingdom. The impacts can be devastating in terms of the cost of repairs, replacement of damaged property and loss of business. The objectives of the Flood Risk Assessment (FRA) are therefore to establish the following:

- whether a proposed development is likely to be affected by current or future flooding from any source.
- whether the development will increase flood risk elsewhere within the floodplain.
- whether the measures proposed to address these effects and risks are appropriate.
- whether the site will pass Part B of the Exception Test (where applicable).

EPS has been commissioned by AY Developers to prepare a Flood Risk Assessment (FRA) for the proposed development at **74 Old Shoreham Road, New Monks Gate, Lancing, BN15 0QZ**.

This appraisal has been undertaken in accordance with the requirements of the National Planning Policy Framework (2024) and the National Planning Practice Guidance Suite (August 2022) that has been published by the Department for Communities and Local Government. The *Flood Risk and Coastal Change* planning practice guidance included within the Suite represents the most contemporary technical guidance on preparing FRAs. In addition, reference has also been made to Local Planning Policy.

To ensure that due account is taken of industry best practice, this FRA has been carried out in line with the CIRIA Report C624 'Development and flood risk - guidance for the construction industry'.

2 Development Description and Planning Context

2.1 Site Location and Existing Use

The site is located at OS coordinates 519005, 105640, off Old Shoreham Road in Lancing. The site covers an area of approximately 0.6 hectares and currently comprises the existing property (no.74), as well as the associated open and currently unused land to the rear. This section of land is surrounded by watercourses to the south and east, with overgrown land on the western boundary. The location of the site in relation to the surrounding area is shown in Figure 2.1 below.

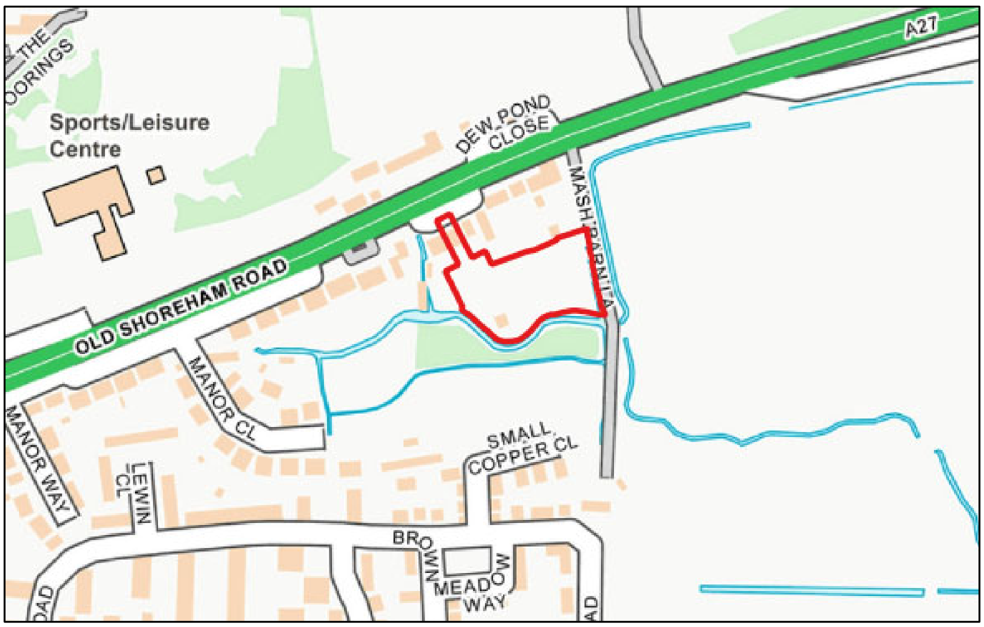


Figure 2.1 – Location map (contains Ordnance Survey data © Crown copyright and database right 2025).

The site plan included in Appendix A.1 of this report provides more detail in relation to the site location and layout.

2.2 Proposed Development

The proposals for development comprise the demolition of the original bungalow to create access to the rear and the erection of 9 no. houses (Figure 2.2). The proposed development also incorporates specialist drainage strategies to help sustainably manage runoff generated on site as a result of the 9 no dwellings and access road.

Figure 2.2 – Proposed site layout.

Drawings of the proposed scheme are included in Appendix A.1 of this report.

2.3 Flood Zone Classification

When appraising the overall risk of flooding to a site, generally the starting point is the Environment Agency's (EA) 'Flood Map for Planning' (Figure 2.3). These maps and the associated information are intended for guidance and cannot provide details for individual properties. They do not take into account other considerations such as existing flood defences, alternative flooding mechanisms and detailed site-based surveys. They do, however, provide high level information on the type and likelihood of flood risk in any particular area of the country. The Flood Zones are classified as follows:

Zone 1 – *Low probability of flooding* – This zone is assessed as having less than a 1 in 1000 annual probability of river or sea flooding in any one year.

Zone 2 – *Medium probability of flooding* – This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding or between 1 in 200 and 1 in 1000 annual probability of sea flooding in any one year.

Zone 3a – *High probability of flooding* - This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding or 1 in 200 or greater annual probability of sea flooding in any one year.

Zone 3b – *The Functional Floodplain* – This zone comprises land where water has to flow or be stored in times of flood and can be defined as land which would flood during an event having an annual probability of 1 in 30 or greater. This zone can also represent areas that are designed to flood in an extreme event as part of a flood alleviation or flood storage scheme.

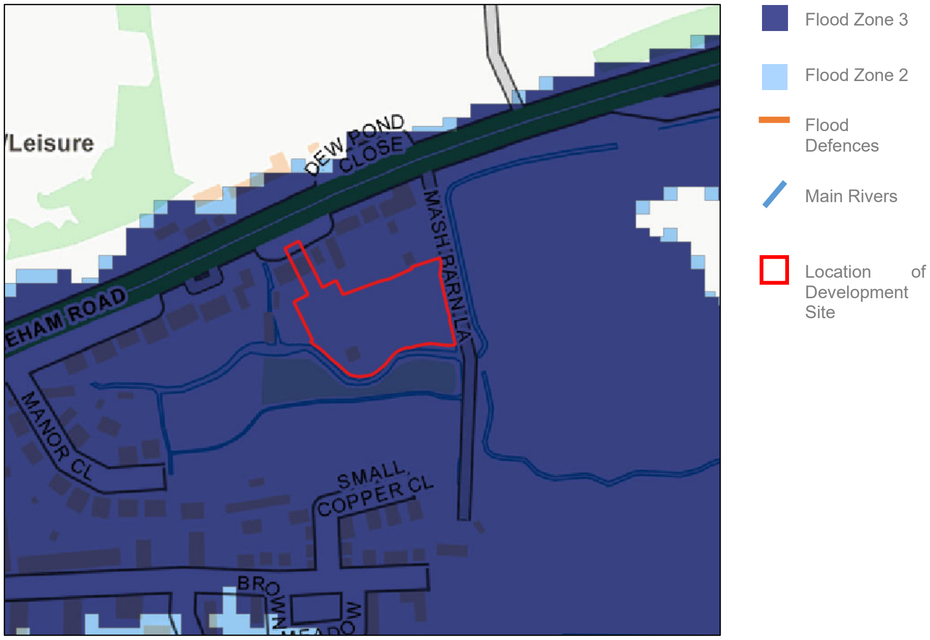


Figure 2.3 – EA's 'Flood Map for Planning' (© Environment Agency, mapping contains Ordnance Survey Data © Crown copyright and database right 2025).

Figure 2.3 shows the development site is located within Flood Zone 3. This mapping does not distinguish between high-risk areas and the functional floodplain, i.e., Zones 3a and 3b. This is an important differentiation that needs to be made by the FRA because the NPPF states that no development, other than essential transport and utilities infrastructure, should be located within the functional floodplain.

The NPPG states that the Functional Floodplain is land where water has to flow or be stored in times of flood. The NPPG provides the following definition:

> *The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters.*

Based on information provided by the EA and that derived as part of this appraisal, the following Functional Floodplain test is applied:

Do predicted flood levels show that the site will be affected by an event having a return period of 1 in 30 years or less?	**x**
Is the site defended by flood defence infrastructure that prevents flooding for events having a return period of 1 in 30 years or greater?	✓
Does the site provide a flood storage or floodwater conveyance function?	**x**
Does the site contain areas that are 'intended' to provide transmission and storage of water from other sources?	**x**
Is site within the functional floodplain (Zone 3b)?	**No**

Table 2.1 – Functional floodplain test.

The flood zone mapping and associated information has been summarised in Table 2.2 below.

Flood Zone (percentage of site within zone)		**Source of Flooding**	**Benefiting from existing flood defences**
Zone 1	**0%**		
Zone 2	**0%**		
Zone 3a	**100%**	Tidal	Yes
Zone 3b	**0%**		

Table 2.2 – Flood zone classification.

2.4 The Sequential Test

Local Planning Authorities (LPA) are encouraged to take a risk-based approach to proposals for development in or affecting flood risk areas through the application of the Sequential Test. The objectives of this test are to steer new development away from high-risk areas towards those areas at lower risk of flooding. However, in some locations where developable land is in short supply there can be an overriding need to build in areas that are at risk of flooding. In such circumstances, the application of the Sequential Test is used to ensure that the lower risk sites are developed before the higher risk ones.

The National Planning Policy Framework (NPPF) requires the Sequential Test to be applied at all stages of the planning process. A Sequential Test has been prepared (by UNDA Consulting) to support the proposed development, nonetheless this FRA will help to provide supporting information on the risk of flooding towards the site and surrounding areas.

2.5 The Exception Test

The application of the Exception Test will depend on the type and nature of the development, in line with the Flood Risk vulnerability classification set out in the NPPG. This has been summarised in Table 2.3 below.

Flood Risk Vulnerability Classification	Zone 1	Zone 2	Zone 3a	Zone 3b
Essential Infrastructure – Essential transport infrastructure, strategic utility infrastructure, including electricity generating power stations.	✓	✓	e	e
High Vulnerability – Emergency services, basement dwellings, caravans and mobile homes intended for permanent residential use.	✓	e	×	×
More Vulnerable – Hospitals, residential care homes, buildings used for dwelling houses, halls of residence, pubs, hotels, non-residential uses for health services, nurseries and education.	✓	✓	e (shaded)	×
Less Vulnerable – Shops, offices, restaurants, general industry, agriculture, sewerage treatment plants.	✓	✓	✓	×
Water Compatible Development – Flood control infrastructure, sewerage infrastructure, docks, marinas, ship building, water-based recreation etc.	✓	✓	✓	✓
Key : ✓ Development is appropriate × Development should not be permitted e Exception Test required			Shaded cell represents the classification of this development	

Table 2.3 - Flood risk vulnerability and flood zone incompatibility.

From the above it can be seen that the development falls into a classification that requires the Exception Test to be applied. For the Exception Test to be passed it should be demonstrated that:

A. *the development would provide wider sustainability benefits to the community that outweigh the flood risk; and*

B. *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.*

Both parts of the test will have to be passed for development to be allocated or permitted.

Demonstrating that the development provides wider sustainability benefits to the community that outweigh flood risk is outside the scope of this report. Nevertheless, reference is made to the SFRA to establish the key risks associated with flooding and to help demonstrate that this objective can be achieved. The key focus of this FRA is therefore to establish whether the site is likely to pass Part B of the Exception Test.

3 Climate Change

The global climate is constantly changing, but it is widely recognised that we are now entering a period of accelerating change. Over the last few decades there have been numerous studies into the impact of potential changes in the future and there is now an increasing body of scientific evidence which supports the fact that the global climate is changing as a result of human activity. Past, present, and future emissions of greenhouse gases are expected to cause significant global climate change during this century.

The nature of climate change at a regional level will vary: for the UK, projections of future climate change indicate that more frequent short-duration, high-intensity rainfall and more frequent periods of long-duration rainfall could be expected.

These effects will tend to increase the size of Flood Zones associated with rivers, and the amount of flooding experienced from other inland sources. The rise in sea level will change the frequency of occurrence of high water levels relative to today's sea levels. It will also increase the extent of the area at risk should sea defences fail. Changes in wave heights due to increased water depths, as well as possible changes in the frequency, duration and severity of storm events are also predicted.

3.1 Planning Horizon

To ensure that any recommended mitigation measures are sustainable and effective throughout the lifetime of the development, it is necessary to base the appraisal on the extreme flood level that is commensurate with the planning horizon for the proposed development. The NPPF and supporting Planning Practice Guidance Suite state that residential development should be considered for a minimum of 100 years.

3.2 Potential Changes in Climate

Extreme Sea Level

Global sea levels will continue to rise, depending on greenhouse gas emissions and the sensitivity of the climate system. The relative sea level rise in England also depends on the local vertical movement of the land, which is generally falling in the south-east and rising in the north and west.

Reference to guidance published by the EA specifies allowances for different epochs and regions across England. The predicted rates of relative sea level rise for the 'South East' region, relevant to the subject site, are shown in Table 3.2 below. These values which correspond with the Higher Central and Upper End percentiles (the 70th and 90th percentile respectively).

Administrative Region	Allowance Category	Net Sea Level Rise (mm/yr) (Relative to 2000)			
		2000 to 2035	2036 to 2065	2066 to 2095	2096 to 2125
South East	Higher Central	5.7	8.7	11.6	13.1
	Upper End	6.9	11.3	15.8	18.2

Table 3.1 – Recommended contingency allowances for net sea level rise.

From these values, the extreme sea level at the site can be seen to change with time and this change is not linear. The 1 in 200 year extreme sea level at the site has therefore been calculated for a number of steps between the current day and the year 2115 and these values are shown in the table below.

Year	'Higher Central' Scenario	'Upper End' Scenario
Current Day (year 2017)	4.24	4.24
2035	4.34	4.36
2065	4.60	4.70
2075	4.72	4.86
2095	4.95	5.18
2115	**5.21**	**5.54**

Table 3.2 – Climate change impacts on extreme sea levels for a 1 in 200 year return period event based on values taken from the EA's Coastal Flood Boundary Condition database.

The development that is the subject of this FRA is classified as residential and therefore the extreme sea level is taken as 5.21m AODN in the 'Higher Central' scenario, and 5.54m AODN in the 'Upper End' scenario.

Offshore Wind Speed and Extreme Wave Height

As a result of increased water depths resulting from changes in the climate, wave heights may change. The climate change allowances for offshore wind speed and wave height are shown in the table below and where appropriate have been applied as part of this appraisal. These figures are applicable around the entire English coast and are relative to a 1990 baseline. They also include a sensitivity allowance which should be used to show that the range of impact of climate change is understood.

Parameter	2000 to 2055	2056 to 2125
Offshore wind speed allowance	+5%	+10%
Offshore wind speed sensitivity test	+10%	+10%
Extreme wave height allowance	+5%	+10%
Extreme wave height sensitive test	+10%	+10%

Table 3.3 – Recommended climate change allowance and sensitivity ranges for offshore wind speed and extreme wave height (relative to 1990).

Peak Rainfall Intensity

Recognising that the impact of climate change will vary across the UK, the allowances were updated in May 2022 to show the anticipated changes to peak rainfall across a series of management catchments. The proposed development site is located in the **Adur and Ouse Management Catchment**, as defined by the 'Peak Rainfall Allowance' maps, hosted by the Department for Environment, Food and Rural Affairs. Guidance provided by the EA states that this mapping should be used for site-scale applications (e.g. drainage design), in small catchments (less than $5km^2$), or urbanised drainage catchments. For large rural catchments, the peak river flow allowances should be used.

The development site lies within an urbanised drainage catchment and therefore, the Peak Rainfall Allowances for the Adur and Ouse Management Catchment should be applied.

For each Management Catchment, a range of climate change allowances are provided for two time epochs and for each epoch, there are two climate change allowances defined. These represent different levels of statistical confidence in the possible scenarios on which they are calculated. The two levels are as follows:

- Central: based on the 50th percentile
- Upper End: based on the 90th percentile

The EA has provided guidance regarding the application of the climate change allowances and how they should be applied in the planning process. The range of allowances for the Management Catchment in which the development site is located are shown in the Table below.

Management Catchment Name	Annual exceedance probability	Allowance Category	2050s	2070s
Adur and Ouse	3.3 %	Central	20%	20%
		Upper End	35%	40%
	1 %	Central	20%	25%
		Upper End	45%	45%

Table 3.4 – Recommended peak rainfall intensity allowances for each epoch for the Adur and Ouse Management Catchment.

For a development with a design life of 100 years the Upper End climate change allowance is recommended to assess whether:

- there is no increase in flood risk elsewhere, and;
- the development will be safe from surface water flooding.

As identified above, the recommended allowance for peak rainfall intensity is 45%. The detailed pluvial flood model created by Herrington Consulting (as discussed in the following sections) has included the Upper End +45% climate change allowance to appraise the risk of flooding from surface water.

4 Definition of Flood Hazard

4.1 Site Specific Information

Information from a wide range of sources has been referenced to appraise the true risk of flooding at this location. This section summarises the additional information collected as part of this FRA.

Site specific flood level data provided by the EA – The EA has provided the model results of the Adur Coastal Modelling (including the 2019 Adur Tidal Walls Scheme modelling), which have been referenced as part of this appraisal.

The publicly available 'Risk of Flooding from Surface Water' (RoFSW) GIS dataset has also been studied to provide additional information regarding this source of flooding.

Site specific flood level data provided by Herrington Consulting Limited (HCL) – In order to accurately assess the risk from surface water flooding on site, and how this interacts with the adjacent watercourse and ditches, HCL have been commissioned to undertake site-specific numerical flood modelling to assess the risk of flooding from pluvial sources to the proposed development. The results of which are discussed in later stages of this report.

Information contained within the SFRA – The Adur and Worthing SFRA (2024) contains detailed mapping showing historic flood records for a wide range of sources. This document has been referenced as part of this site-specific FRA.

Information on localised flooding contained within the SWMP – A Surface Water Management Plan (SWMP) is a study to understand the risk of flooding that arises from local surface water flooding, which is defined by the Flood and Water Management Act 2010 as flooding from surface runoff, groundwater, and ordinary watercourses. Such a document has been prepared for Lancing (2015) and has therefore been referenced as part of this site-specific FRA.

Information provided by Southern Water – Southern Water has provided the results of an asset location search for the site. The response is included in Appendix A.2.

Site specific topographic surveys – A topographic survey has been undertaken for the site and a copy of this is included in Appendix A.1. From the survey, it can be seen that the level of the site varies between 1.00m and 3.00m AODN Above Ordnance Datum Newlyn (AODN). Within the land to rear of the existing property, ground levels gradually reduce to the southeast, however the land levels are fairly uniform throughout the area.

The below Figure displays the surrounding area land levels and elevations using the EA's 1m resolution LiDAR data. The area to the north of the site is topographically higher than the site itself, with the Lancing land drains also identified to the south and east of the site.

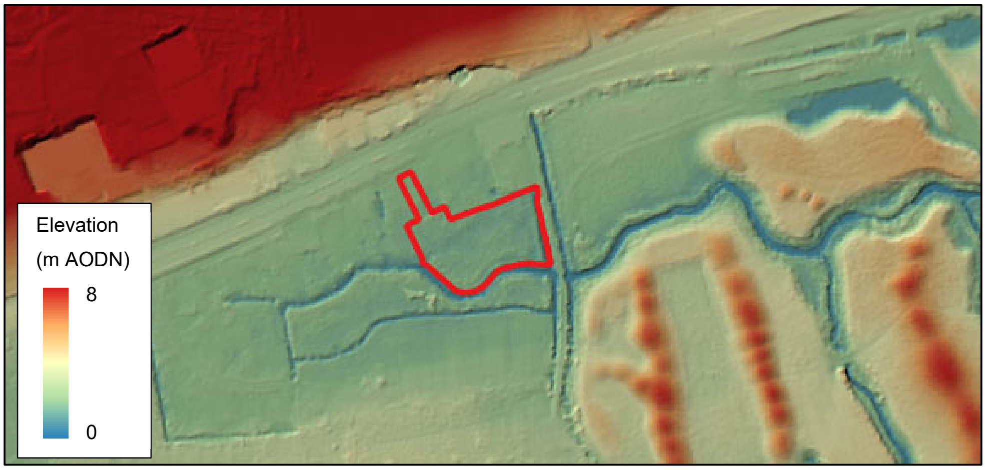


Figure 4.1 - EA's 1m resolution LiDAR data presented over OS Mapping, site boundary in red (© Environment Agency - contains Ordnance Survey data © Crown copyright and database right 2025).

Geology – Reference to the British Geological Survey (BGS) map shows that the underlying solid geology in the location of the subject site is Newhaven Chalk. Overlying this are superficial deposits of Alluvium (Clay, Silt, Sand and Peat) and Head (Clay, Silt, Sand and Gravel).

Infiltration testing was undertaken on site using double ring infiltrometers. The results from this investigation have been considered within the modelling produced alongside this FRA.

Historic flooding – Old Shoreham Road, as well as the wider Lancing area has historically experienced flooding from groundwater and pluvial sources, as a result of present shallow aquifers and surface water flow paths respectively. Nonetheless, the historic flooding has recently highlighted the need for improvements and maintenance of the nearby defences, improving the historic figures, discussed in further detail below and throughout this report.

Existing Flood Risk Management Measures and defences - Inspection of the SFRA identifies that the '*The majority of defences in Adur District and Worthing Borough provide a standard of protection of at least 4% AEP, with many of the defences in Adur District providing a standard of protection of 1% AEP or greater.*'

However, the introduction of the Shoreham Adur Tidal Walls Flood Defence Scheme, as well as the newly implemented tidal defences and groundwater pumping infrastructure as part of the recently constructed adjacent New Monks Farm development, result in the development site now benefiting from a 1 in 300-year (0.33% AED) standard or protection.

4.2 Potential Sources of Flooding

The main sources of flooding have been assessed as part of this appraisal. The specific issues relating to each one and its impact on this development are discussed below. Table 4.1 at the end of this section summarises the risks associated with each of the sources of flooding.

Flooding from Tidal sources (Sea and Tidal Adur) – The site lies within Flood Zone 3a as shown on the EA's 'Flood Map for Planning' (Figure 2.3). The flood zone maps are used as a consultation tool by planners to highlight areas where more detailed investigation into the risk of flooding is required.

As discussed earlier, the development site benefits from both primary and EA maintained defences. As a result, the area benefits from defences with a 1 in 300-year standard of protection. In addition, there are secondary privately owned flood defence and groundwater pumping infrastructure providing yet further flood risk management.

Modelling provided by the EA shows that when the existing flood defences are considered the site remains unaffected by floodwater from tidal sources during the design event. This modelling does not include the above mentioned additional New Monks Farm flood defences, which further strengthen this point.

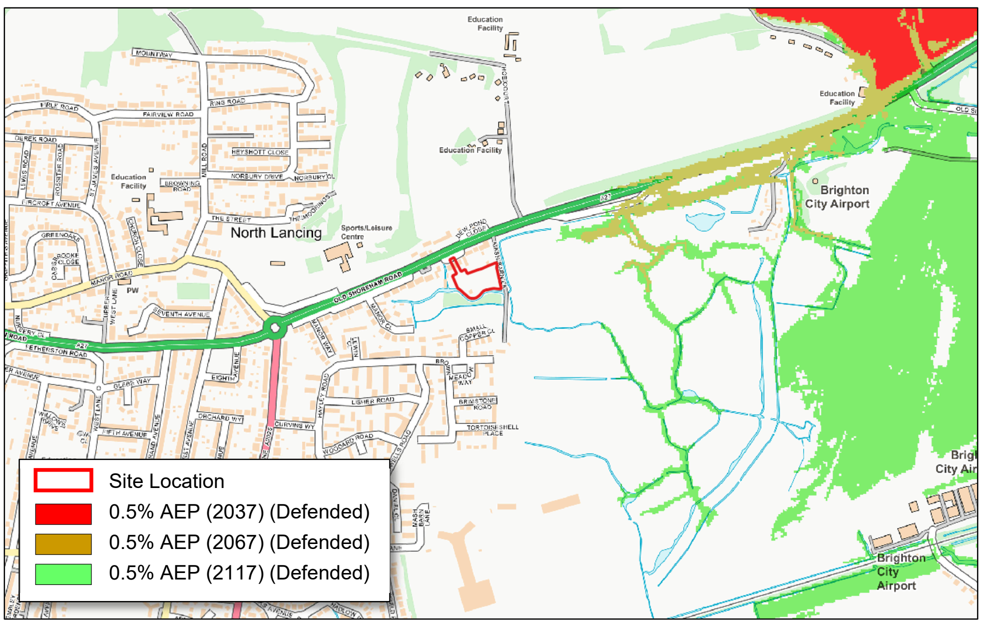


Figure 4.2 – EA's modelled flood extent for a defended scenario during a range of AEPs (© Environment Agency, mapping contains Ordnance Survey Data © Crown copyright and database right 2025).

It is acknowledged that there is a requirement to consider the impact of the 'residual risk' scenario, whereby defences may have failed, or a breach event occurred. In this case, no such event is available and, even if an event was, nor would it consider the impact of the Monks Farm defences as they are not modelled by the EA.

The EA's Adur Coastal (2019) Mapping and Modelling Study does not include data for a breach scenario. Nevertheless, the EA's Adur Coastal modelling (2012) includes the 'undefended' data for the design event (0.5% AEP for the year 2115). Under this scenario, the results reveal that the flood level on site would be 5.39m AODN.

Nevertheless, it is not considered appropriate to apply this scenario to the scheme design, as this event assumes that both the primary and secondary defences are removed, which is wholly unrealistic. Similarly, a breach scenario would require the catastrophic failure of both lines of defences simultaneously during an extreme storm event. Nevertheless, in the absence of any other data, this flood event has been considered.

Notwithstanding this, even if this event were to occur, whilst the dwellings are not elevated above the undefended flood level, safe refuge would be available within the upper floors of each dwelling, therefore providing a safe place of refuge for this extremely unlikely event.

Considering the standard of protection of the tidal flood defences and through the additional mitigation proposed in this report, the risk of flooding from this source is considered to be *low*.

Flooding from Rivers (Fluvial) – Inspection of OS mapping identifies that there are no fluvially dominated Main Rivers or watercourses within close proximity of the development and the site. The modelled risk of flooding towards the site is tidally dominated and as such the risk of flooding from this source is considered to be *low.*

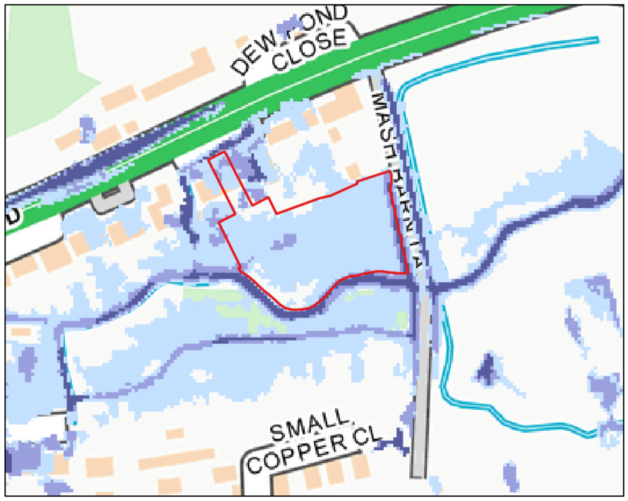
Flooding from Ordinary or Man-Made Watercourses - Inspection of the site and surrounding area reveals land drainage ditches surround the southern section of the site. The Lancing land drains are extensive, due to the aforementioned historical groundwater flood events.

In line with other Lancing land drains and culverts, it is anticipated that the culvert directly to the south of the development site (Marsh Barn Lane Culvert) has been designed to manage in-channel flows up to the 100-year plus climate change event. Nonetheless, in the event of an extreme event, the topography of the culvert in comparison to the designed finished flood levels mean that the flood water would have to cover the wider area before reaching any residential dwellings, and likely not impact the residents of the development.

Furthermore, the land drains within this area of Lancing have recently undergone clearing and re-arrangement works, increasing the efficiency and storage capacities within the wider area. Moreover, the New Monks Farm development and associated groundwater pumping infrastructure also help manage the levels within the nearby watercourses. The actual risk of flooding from this source has therefore been considered to be *low.*

Flooding from Surface Water – Surface water, or overland flooding, typically occurs in natural valley bottoms as normally dry areas become covered in flowing water and in low spots where water may pond. This mechanism of flooding can occur almost anywhere but is likely to be of particular concern in any topographical low spot, or where the pathway for runoff is restricted by terrain or man-made obstructions.

The EA's 'Flood Risk from Surface Water' map (Figure 4.3) shows the development site is located in an area classified as having a 'very low' 'to 'high' risk of surface water flooding following an extreme rainfall event. Nevertheless, the risk is considered to increase when taking into account the impacts of climate change. Therefore, the risk of flooding from this source has been investigated further in Section 5.



Probability of Flooding

Figure 4.3 – Data derived from EA's 'Flood Risk from Surface Water' map (© Environment Agency) overlying mapping from Ordnance Survey Data © Crown copyright and database right 2025).

Flooding from Groundwater – Water levels below the ground rise during wet winter months and fall again in the summer as water flows out into rivers. In very wet winters, rising water levels may lead to the flooding of normally dry land, as well as reactivating flow in 'bournes' (streams that only flow for part of the year).

Groundwater flooding is most likely to occur in low-lying areas that are underlain by permeable rock (aquifers). The underlying geology in this area is Newhaven Chalk. Given the low-lying nature of this area and the proximity to the coast, there is potential for the groundwater table to become elevated. However, the location of the proposed development in relation to the adjacent New Monks Farm recent development, and associated flood defences and groundwater pumps, means that the risk from groundwater flooding is improved significantly, in relation to the wider Lancing area.

Mitigation is provided by the neighbouring site through the newly developed pumping system and level control, which although has the main objective of managing groundwater for the nearby Airport, impacts the wider groundwater table too. The Lancing land drains have also been recently altered to help transport and manage groundwater within the area, providing further benefits. The flood risk scoping assessment prepared by others (Berrys), identified that information was received explaining that the system is working well, and groundwater levels have been recorded to be lower than previous years, despite record rainfall in corresponding recent years.

Furthermore, as explained within Section 7 of this report, the floor levels of the dwellings will be raised to help provide further mitigation and flood protection to the residents. Taking all of the above into consideration, the risk of flooding from groundwater has been concluded to be *low.*

Flooding from Sewers – In urban areas, rainwater is typically drained into surface water sewers or sewers containing both surface and wastewater known as “combined sewers”. Flooding can result when the sewer is overwhelmed by heavy rainfall, becomes blocked, or has inadequate capacity; this will continue until the water drains away.

Inspection of the asset location mapping provided by Southern Water (Figure 4.4) identifies that the sewers in this area are foul only.

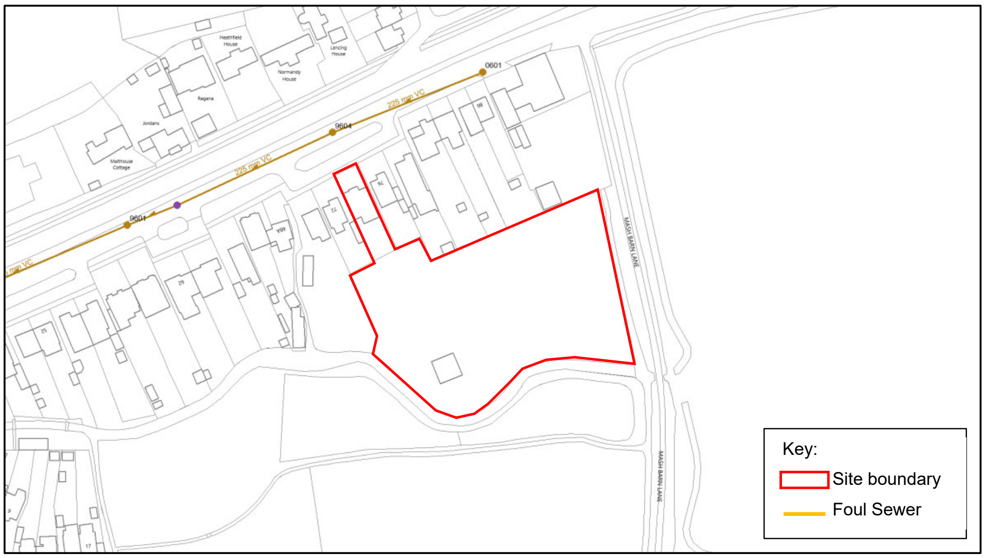


Figure 4.4 - Asset location mapping provided by Southern Water (a full scale copy can be found in Appendix A.2).

The historic records set out in the SFRA identify that the site falls within a large region which has experienced 45 incidents of flooding from sewers between 2013 and 2023. However, the sewer flooding data used in the SFRA (provided by Southern Water) is relatively coarse and is limited to postcode data. Consequently, the area shown by the SFRA to have been affected by sewer flooding in the past is comparatively large, when in reality these recorded flood events are likely to be smaller isolated incidents. This is supported by the fact that there are no known records of the site being affected by sewer flooding in the past. The risk of flooding is therefore considered to be *low*.

Nonetheless avoid the risk of floodwater accumulating on site as a result of the new development, it is recommended that all sewers are fitted with non-return valves. This will reduce the possibility of floodwater flowing back through the new sewer systems and into the properties, should there be a failure in the system off-site.

Flooding from Reservoirs, Canals and Other Artificial Sources – Non-natural or artificial sources of flooding can include reservoirs, canals, and lakes, where water is retained above natural ground level. In addition, operational and redundant industrial processes including mining, quarrying, and sand or gravel extraction, may also increase the depth of floodwater in areas adjacent to these features.

The potential effects of flood risk management infrastructure and other structures also needs to be considered. For example, reservoir or canal flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure.

Inspection of the OS mapping for the area shows that there are no artificial sources of flooding within close proximity to the site. In addition, the EA's 'Flood Risk from Reservoirs' map shows that the site is not within an area considered to be at risk of flooding from reservoirs. Therefore, the risk of flooding from this source is considered to be *low.*

A summary of the overall risk of flooding from each source is provided in Table 4.1 below.

Source of Flooding	Initial Level of Risk	Appraisal method applied at the initial flood risk assessment stage
Tidal Sources (Sea and River Adur)	Low	OS mapping, existing defences within the SFRA and the EA's 'Flood Map for Planning'
Rivers (Fluvial)	Low	OS mapping, existing defences within the SFRA and the EA's 'Flood Map for Planning'
Ordinary and Man-Made Watercourses	Low	OS mapping, existing defences within the SFRA and aerial height data
Surface Water	Assessed in further detail in Section 5	EA's 'Flood Risk from Surface Water' map, and historic records contained within the SFRA, aerial height data, OS mapping and site-specific topographic survey
Groundwater	Low	BGS groundwater flood hazard maps, Defra Groundwater Flood Scoping Study, aerial height data, OS mapping, site-specific topographic survey, historic records in the SFRA, and nearby BGS Borehole survey records
Sewers	Low	Aerial height data, OS mapping, site-specific topographic survey, asset location data provided by Southern Water and historic sewer records contained within the SFRA
Artificial Sources	Low	OS mapping and EA's 'Flood Risk from Reservoirs' map

Table 4.1 – Summary of flood sources and risks.

5 Probability and Consequence of Flooding

It has been identified in Section 4 that the EA's mapping shows the site could be subject to flooding from surface water following an extreme rainfall event. Therefore, this section appraised the risk of flooding from this source in more detail.

Whilst the EA's 'Flood Risk from Surface Water' map (Figure 4.3) is helpful for preliminary analysis to identify areas potentially at risk of flooding, the mapping often is not representative of the actual on-site risk.

For example, the EA's surface water mapping is produced from 1m resolution LiDAR data, which can present certain inaccuracies within the dataset. These inaccuracies may be especially prevalent within this area of Lancing, when closer inspection indicates that during the 'high' likelihood of occurrence event, surface water stems from the nearby culverts and land drains, which may not have been accurately modelled during the LiDAR process. Furthermore, the EA's mapping does not consider accurate infiltration data and therefore may not accurately represent reality of the underlying strata as a whole.

To address these potential pitfalls and allow the risk of flooding to the site to be appraised in greater detail, HCL have been commissioned to undertake a site-specific pluvial modelling study. The HCL modelling represents-site geology and also incorporates the site-specific topographic survey.

5.1 Baseline Scenario (i.e. Existing site conditions)

When appraising the risk of flooding to new development it is necessary to assess the impact of the 'design flood event'. Flood conditions can be predicted for a range of return periods, and these are expressed in either years or as a probability, i.e., the probability that the event will occur in any given year, or Annual Exceedance Probability (AEP). The design flood event is taken as the 1 in 100 year (1% AEP) event for pluvial flooding, including an appropriate allowance for climate change (refer to Section 3.2).

Within the modelling, the pluvial flooding during the 'baseline scenario' (site only, no proposed development) has been created to help gain a more representative and spatially accurate understanding of the true risk of flooding to the current site.

Figure 5.1 below displays the design pluvial event (1 in 100 year return period, including a 45% allowance for climate change). From the mapping, it is evident that the site is predicted to be subject to flooding.

Figure 5.1 – Extent of flooding during the design pluvial event for the baseline conditions, as modelled by HCL (© Herrington Consulting Ltd and contains Ordnance Survey data © Crown copyright and database right 2025).

5.2 Proposed Scenario

As well as refining the risk of flooding to the existing site, it is also necessary to quantify the risk of flooding to the site post-development, and to confirm the proposed developemnt does not impact offsite.

As part of the development, it is proposed to raise land levels onsite to raise the proposed dwellings as a form of mitgation – further information is provided on this in Section 7.1. Furthermore, the drainage strategy (which has been prepared by others) proposes to include filder drains along the northern boundary of the site. These filter drains are deisgned to capture surface water flows onto the site from offsite and divert it to the watercourse network.

When these measures are included, the proposed dwellings are shown to remain unaffected by flooding during the design pluvial event, as shown on Figure 5.2 below.

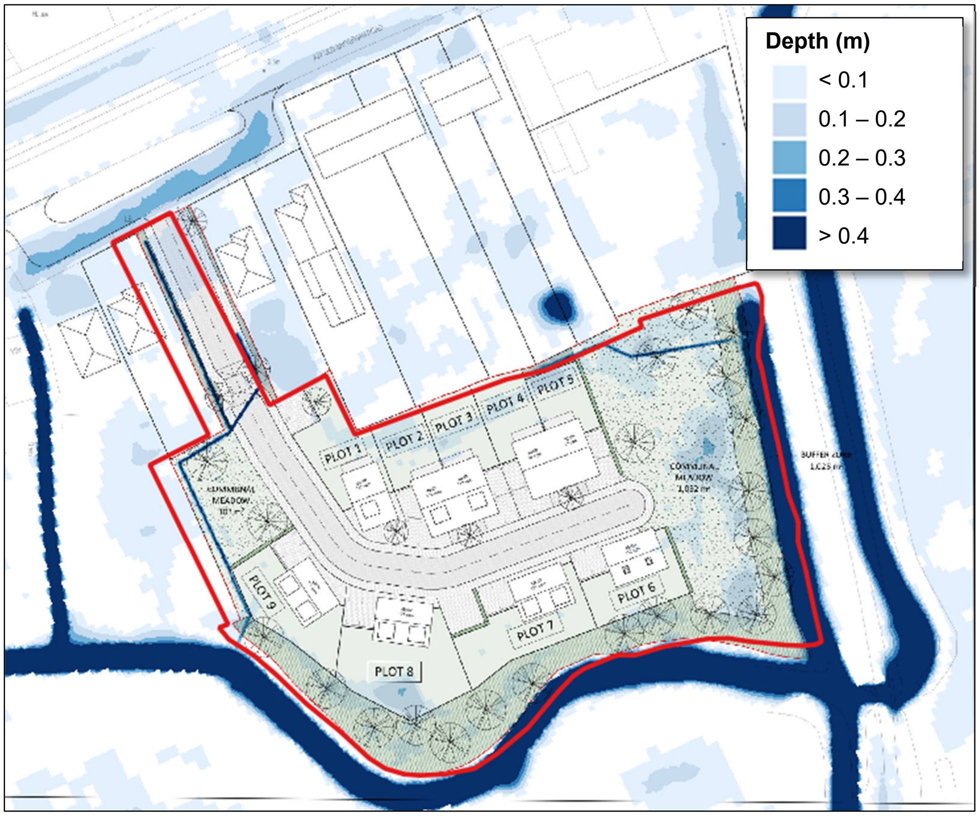


Figure 5.2 – Extent and depth of flooding during the design pluvial event for the proposed development scenario, as modelled by HCL (© Herrington Consulting Ltd).

6 Offsite Impacts and Other Considerations

6.1 Displacement of Floodwater

The construction of new buildings within the floodplain has the potential to displace water and to increase the risk elsewhere by raising flood levels. A compensatory flood storage scheme can be used to mitigate this impact, ensuring the volume of water displaced is minimised.

The numerical pluvial flood modelling undertaken by Herrington Consulting Limited (HCL) has identified that although some areas within the site red line boundary will experience marginal increases in flood depth, many areas which were modelled to flood during the existing baseline conditions (no development or drainage system) have now been modelled to experience less or even no flooding during the design pluvial event.

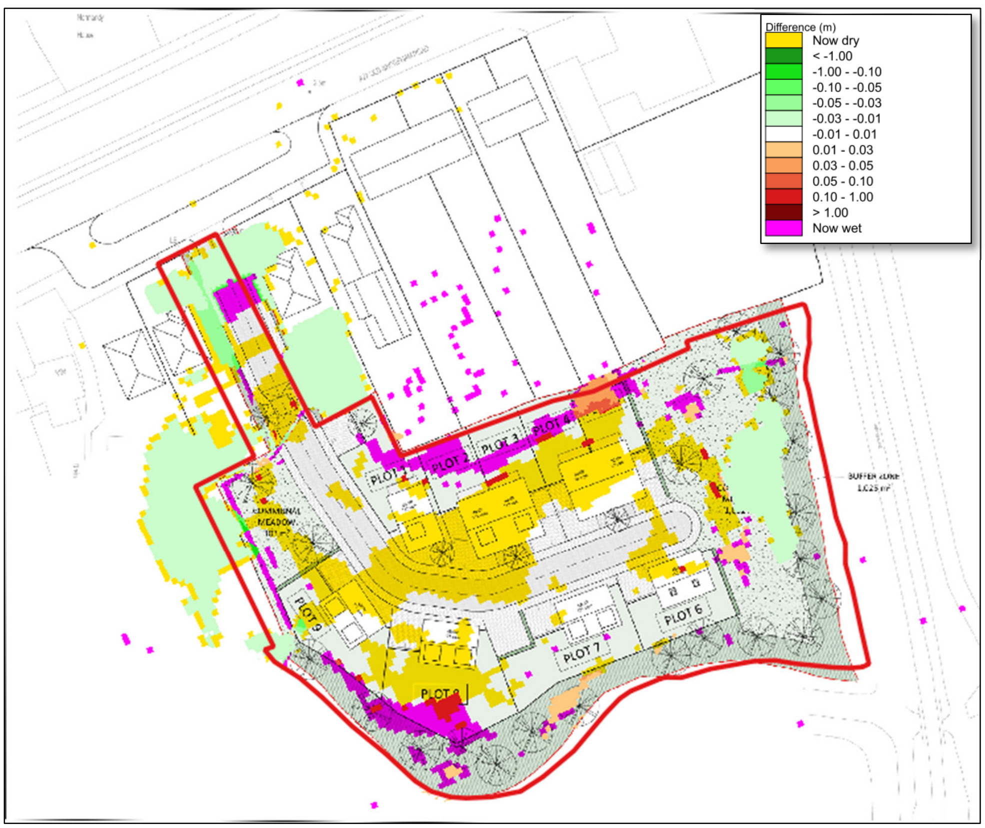


Figure 6.1 – HCL Model results displaying the 'Flood Level Difference (impact) post development, minus the existing (© Herrington Consulting Ltd).

As displayed in the above Figure, it is evident that the mitigation included would provide benefits both onsite, and offsite. This is shown by the areas in green and yellow which indicate a reduction in flooding. In particular, the area offsite towards the west of the development is shown to benefit from a reduction in flood risk adjacent to the existing properties during the design pluvial event. Additionally, much of the area within the centre of the development is predicted to remain dry during the proposed scenario event, particularly areas where the dwellings, and the resident's associated access, are located. In addition, the northern most section of the entrance to the site from Old Shoreham Road is modelled to have noticeably less flooding. As a result, access and egress from the site will be achievable for the residents during the design pluvial event.

The areas within the red line boundary which are modelled to now flood, are in areas whereby the risk to the residents would be lowest, for example in gardens or the eastern green space. Although these areas now impacted by surface water, the risk to the residents has been reduced as a result.

The scattering of pink 'now wet' grid cells in the offsite neighbouring rear gardens is a model effect. These are a product of very minor and inevitable alterations in model timestep resulting from different peak flow speeds in the existing scenario and proposed scenario model runs. Occasionally, scattered impacts like these can also be a result of instability in the model. However, there are no such warnings from the model logs to suggest that this could be the case and the model is stable. Scattered impacts like this should be ignored in favour of focussing on the gross changes between the scenarios as these represent the actual impact of the post development scenario.

In conclusion, the proposed raising of the floor levels will provide further benefits to the residents, and other mitigation measures have been recommended within Section 7 of this report. The pluvial model report created by HCL (Appendix A.3) has been submitted alongside this FRA, which further details the achieved results produced within the modelling.

When the risk of tidal flooding is also considered, the proposed development has been shown to remain unaffected under design flood conditions. Consequently, the development will not displace floodwater during this scenario.

6.2 Public Safety and Access

The NPPF states that safe access and escape should be available to/from new developments located within areas at risk of flooding. The Practice Guide goes on to state that access routes should enable occupants to safely access and exit their dwellings during design flood conditions and that vehicular access should be available to allow the emergency services to safely reach the development.

When the proposed development is considered, it can be seen that the site is currently protected from tidal flooding under the design flood event, and consequently safe access and escape from the proposed dwellings can be achieved during the design tidal flood event. The modelling provided by HCL also identifies that the depth of surface water flooding along the access route to the site has been reduced. From Figure 6.1 above it can be seen that residents would be able to exit the development site during the extreme pluvial event, although the dwellings will also provide safe refuge in the event that the access to the wider area is not possible.

6.3 Proximity to Culverts, Land Drains and Watercourses

Under the Land Drainage Act 1991, as amended by the Flood and Water Management Act 2010, an Internal Drainage Board (IDB) is responsible for the regulation of watercourses located within defined ‘internal drainage districts. The site subject to this FRA is located within the jurisdiction of the West Sussex LLFA.

The West Sussex LLFA Culvert Policy states that *“Buildings and structure must not be sited within 5 metres from the outer edge of new or existing culverts/ watercourses.”* Inspection of the scheme drawings identifies that the proposed dwellings are located outside of the 5m easement from the nearest watercourse (Marsh Barn Lane Culvert) and as such will not compromise any of the LLFAs requirements.

7 Flood Mitigation Measures

The key objectives of flood risk mitigation are:

- to reduce the risk of the development being flooded.
- to ensure continued operation and safety during flood events.
- to ensure that the flood risk downstream of the site is not increased by increased runoff.
- to ensure that the development does not have an adverse impact on flood risk elsewhere.

The following section of this report examines ways in which the risk of flooding at the development site can be mitigated.

Mitigation Measure	Appropriate	Comment
Raising floor levels Land raising	✓	Refer to Section 7.1
Flood resistance & resilience	✓	Refer to Section 7.2
Flood Warning	✓	Refer to Section 7.3
Compensatory floodplain storage	x	Not required – Refer to Section 6.1
Alterations/ improvements to channels and hydraulic structures	x	Not required
Flood defences	x	Not required
Surface Water Management Strategy	x	In this instance, a drainage strategy has been prepared by others
Careful location of development within site boundaries (i.e., Sequential Approach)	x	The entire site is located within Flood Zone 3, therefore it is not possible to target lower risk areas within the site boundary.

Table 7.1 – Appropriateness of mitigation measures.

7.1 Land Raising and Raising Floor Levels

It has been identified that the site could be subject to flooding following an extreme pluvial event in its current state (the baseline scenario). Consequently, raised FFLs have been considered within the design scheme, with the minimum floor levels as follows:

Living Accommodation = 3.15m AODN

Sleeping Accommodation = 6.00m AODN

Consideration of the residual risk flood event has been given to the sleeping accommodation level. During the undefended tidal extreme scenario, the flood level on site is 5.39m AODN. The FFLs of all sleeping accommodation have therefore been designed to 6.00m AODN, to provide the recommended 600mm freeboard to this extreme event.

The scheme drawings identify that land levels have been raised where appropriate to facilitate this elevated floor level, and the proposed scenario flood modelling shows that with all dwellings raised at this level, the dwellings are not predicted to be subject to flooding.

7.2 Flood Resistance and Resilience

Whilst it is proposed that all dwellings be elevated to manage the risk of flooding, it is recommended that flood resistance and resilience measures be included as a precautionary approach.

Typical examples of flood resistance and resilience measures which may be appropriate for the development site include (but are not limited to) the following:

- Raising floor slab level further.
- Bringing the electrical supply in at first floor.
- Placing boilers and meter cupboards on the first floor.
- Water-resistant plaster/tiles on the walls of the ground floor.
- Solid stone or concrete floors with no voids underneath.
- Covers for doors and airbricks.
- Non-return valves on new plumbing works.
- Avoidance of studwork partitions on the ground floor.

Details of flood resilience and flood resistance construction techniques can be found in the document '*Improving the Flood Performance of New Buildings; Flood Resilient Construction*', which can be downloaded from www.gov.uk.

A Code of Practice (CoP) for Property Flood Resilience (PFR) has been put in place to provide a standardised approach for the delivery and management of PFR. Further information on the CoP and guidance on how to make a property more flood resilient can be accessed, and downloaded, from the Construction Industry Research and Information Association (CIRIA) Website:

https://www.ciria.org/Resources/Free_publications/CoP_for_PFR_resource.aspx

7.3 Flood Warning

Although significantly reduced, the risk of pluvial flooding on site and particularly within the wider area, is still present. Monitoring of the Met Office "Weather Warnings" may also provide an early indication of when surface water flooding within the wider Lancing area might be expected: (www.metoffice.gov.uk/weather/uk/uk_forecast_warnings.html).

As discussed within Section 4, the actual risk of flooding from tidal sources is low. Nonetheless, areas within the wider Lancing area will not benefit from the same level of on-site flood defence. With the sophisticated techniques now employed by the EA to predict the onset of flood events, the opportunity now exists for all residents to stay informed as to whether the nearby areas and roads within a higher flood risk classification are at risk from an oncoming event.

This forewarning could be sufficient to either allow residents to evacuate the area or prepare themselves and their property for a flood event. It is therefore recommended that the occupants of the site sign up to the EA's Flood Warning Service either by calling 0345 988 1188, or by visiting; www.gov.uk/sign-up-for-flood-warnings

8 Conclusions and Recommendations

The overarching objective of this report is to appraise the risk of flooding at 74 Old Shoreham Road, to ensure that the proposals for development are acceptable and that any risk of flooding to the occupants of the proposed residential units is appropriately mitigated. In addition, the NPPF also requires the risk of flooding offsite to be managed, to prevent any increase in flood risk as a result of the development proposals. This report has therefore been prepared to appraise the risk of flooding from all sources and to provide a sustainable solution for managing the surface water runoff discharged from the development site, in accordance with the NPPF and local planning policy.

In this case a bespoke Sequential Test assessment has been undertaken by others, with the support of this FRA. From Section 2 it can be seen that the proposed development is situated within Flood Zone 3a and is a development type that is classified as being ‘more vulnerable’. Consequently, it has been necessary to apply the Exception Test to determine whether suitable and appropriate mitigation can be incorporated into the design of the scheme to ensure that it is sustainable in terms of flood risk.

The risk of flooding has therefore been considered across a wide range of sources and it is only the risk of surface water flooding that has been shown to have any bearing on the development during the baseline conditions. However, when this risk is examined in detail, it has been demonstrated that with appropriate mitigation, the development will significantly improve the impact of surface water flooding onsite and offsite, not increasing flood risk elsewhere whilst also providing benefits to the predicted flooding in neighbouring developments.

The introduction of the proposed drainage strategy, raised FFLs to 3.15m AODN and other recommended mitigation measures result in the risk of flooding from surface water being greatly improved within the development and offsite.

Consequently, it has been shown that the development will meet the requirements of the NPPF and is therefore appropriate for its location within a flood risk area.

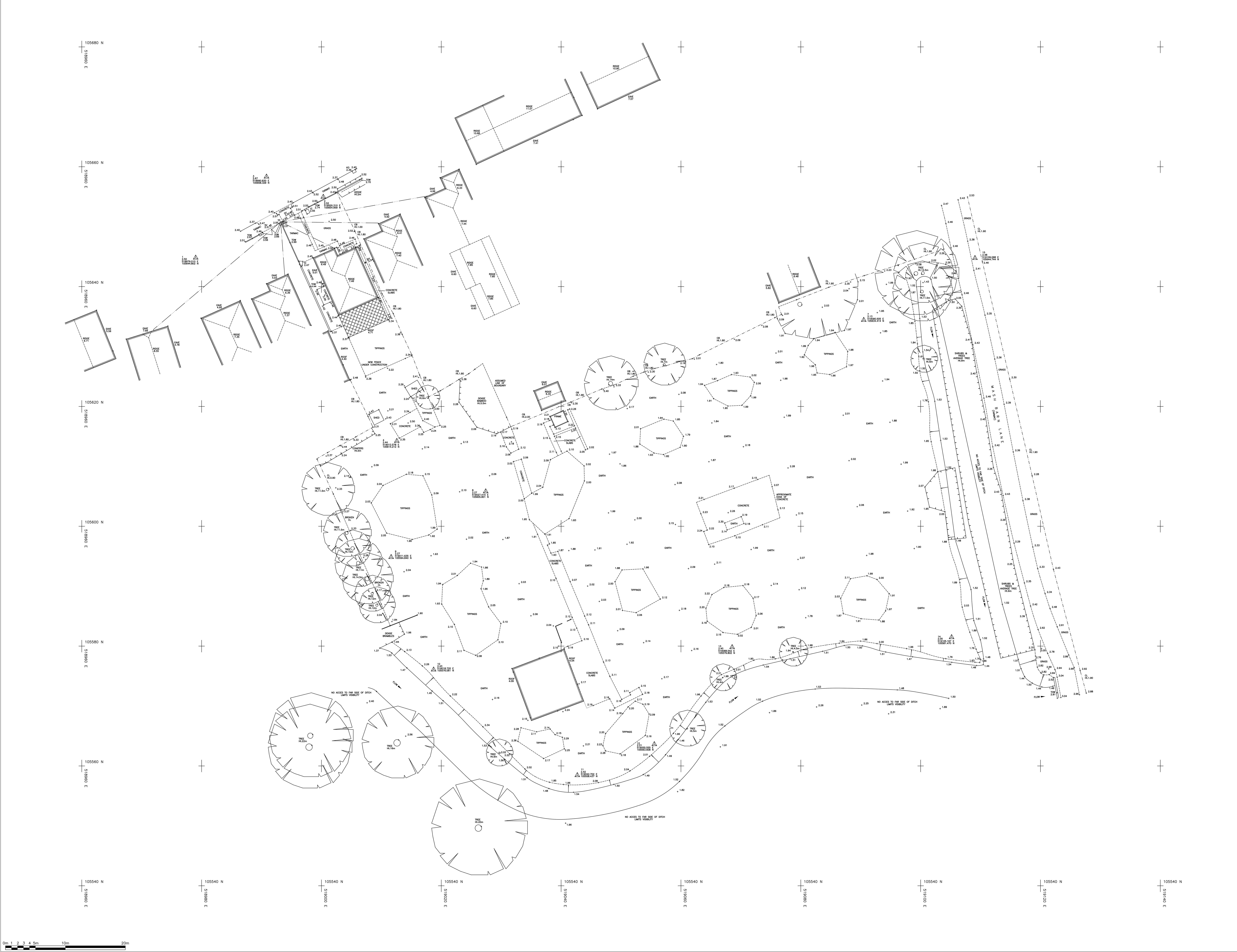
9 Appendices

Appendix A.1 – Drawings

Appendix A.2– Southern Water Asset Location Data

Appendix A.3 – 4071_Old_Shoreham_Road_Surface_Water_Modelling_Nov24

Appendix A.1 – Drawings



LAYER INFORMATION

0	EMPTY
BORDER	TITLEBLOCK & BORDER
BTELECOM	BRITISH TELECOM MH'S ETC.
BTLINES	BRITISH TELECOM ROUTES
BUILDING	BUILDING OUTLINE.
CABLETV	CABLE TV COVERS.
CONTOURS	CONTOURS
CROSSES	POINT MARKERS
DRAINAGE	MH'S GULLYS ETC.
ELECTRIC	ELECTRICAL MH'S ETC.
FENCES	FENCE LINES
FOUL	FOUL WATER MH'S
FURNITURE	STREET FURNITURE
GAS	GAS MH'S,VALVES ETC.
GASLINES	GAS ROUTING
GRID	GRID
LEVELS	LEVELS
ROADS	ROAD OUTLINE
STATIONS	SURVEY STATIONS
STORM	STORM WATER MH'S, GULLY'S ETC.
SURFACES	SURFACE EDGES
TEXT	TEXT
TREES	TREE OUTLINE & FOLIAGE
UNKNOWN	UNKNOWN SERVICES
WALLS	WALLS
WATER	WATER OUTLINE.
WSERVICES	WATER METERS, STOP VALVES ETC.

LINETYPES & SYMBOLS

BUILDING OUTLINE
KERB LINE
FENCE
SURFACE EDGE
FOUL DRAINAGE
STORM DRAINAGE
OVERHEAD CABLES
FOLIAGE OUTLINE
1 80.72 426.975 E 254.263 N SURVEY STATION
GATES
TREE CANOPY
SLOPE SYMBOL

LEGEND

AB	AIR BRICK	NP	NAME PLATE
AV	AIR VALVE	OB	OPEN BOARDED FENCE
B	BOLLARD	OP	OPEN PAILING FENCE
BB	BELISHA BEACON	P	POST
BM	OS BENCH MARK	PC	POST & CHAIN FENCE
BS	BUS STOP	PCB	POLICE CALL BOX
BTB	BRITISH TELECOM BOX	PH	PUBLIC HOUSE
BW	BARB WIRE FENCE	PL	PAVEMENT LIGHT
CB	CLOSE BOARD FENCE	PM	PARKING METER
CH	COAL HOLE	PR	POST & RAIL FENCE
CHY	CHIMNEY	PW	POST & WIRE FENCE
CI	CORRUGATED IRON FENCE	PWM	POST & WIRE MESH
CL	CHAIN LINK FENCE	RE	RODDING EYE
CM	CELLAR MANHOLE	RS	ROAD SIGN
CP	CHESTNUT PAILING FENCE	RTW	RETAINING WALL
CTV	CABLE TELEVISION POINT	SIP	SERVICE INDICATOR POST
DC	DRAINAGE CHANNEL	SV	STOP VALVE
DK	DROP KERB	TCB	TELEPHONE CALL BOX
ELEC SUB	ELECTRICITY SUB	TOW	TOP OF WALL
STN.	STATION	TP	TELEGRAPH POLE
EP	ELECTRICITY POLE	TS	TRAFFIC SIGNAL
FB	FOOT BRIDGE	UTL	UNABLE TO LIFT.
FE	FIRE ESCAPE	VP	VENT PIPE
FH	FIRE HYDRANT	WB	WASTE BIN
FP	FOOTPATH	WM	WATER METER
FS	FLAGSTAFF	WO	WASH OUT
G	GULLY		
GR	GRATING		
GV	GAS VALVE		
H	HYDRANT		
IC	INSPECTION COVER		
IL	INVERT LEVEL		
IR	IRON RAILINGS		
KO	KERB OUTLET (GULLY)		
LP	LAMP POST		
LB	LETTER BOX		
MISC	MIXED CONSTRUCTION FENCE		
MH	MANHOLE		
MHBT	BRITISH TELECOM		
MHE	ELECTRICAL		
MHG	GAS		
MHMC	MERCURY		
MP	MILE POST		
NB	NOTICE BOARD		

NORTH (INDICATIVE)

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CLIENT
SKIFTER AJETI
AY DEVELOPERS
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NOTES
LEVELS AND COORDINATES BASED ON ORDNANCE SURVEY BY G.P.S.

PLEASE DO NOT SCALE OFF A PRINTED PLAN.

JOB REF. 9543

SCALE	SHEET SIZE
1:200	A0 LANDSCAPE
DATE	SURVEYED BY
DECEMBER 2022	CS

Legend

key plan

rev date by notes

PRELIMINARY

Residential Development of
Land Rear of 74 Old Shoreham Rd and
74 Old Shoreham Rd
project name

AY Developers Ltd
client name

Proposed Site Plan
drawing title

866-200-L-000
drawing number

revision

JL architect	AG drawn by	JL checked by
866 job reference	1 : 500 scale @ A3	08.04.2025 first issued

agenda 21
architects studio

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Appendix A.2 – Southern Water Asset Location Data

Date: 25/10/24 | Scale: 1:1250 | Map Centre: 519090,105625 | Data updated: 24/09/24 | Our Ref: 1605079 - 1

Wastewater Plan A3
Powered by digdat

The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determined on site. This plan is produced by Southern Water Services Ltd (c) Crown copyright and database rights 2024 Ordnance Survey AC0000808122 .This map is to be used for the purposes of viewing the location of Southern Water plant only. Any other uses of the map data or further copies is not permitted.

WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.

Foul Gravity Sewer
Combined Gravity Sewer
Culverted Water Course or Treated Effluent
Surface Water Gravity Sewer
Rising Main, Vacuum or Syphon
Combined Outfall
Surface Water Outfall
Foul Outfall
Surface Water Inlet
Combined Pumping Station
Surface Water Pumping Station
Foul Pumping Station
WTW Water Treatment Works
Section 104 Area
Building Over Agreement Area
Foul Manhole
Combined Manhole
Surface Water Manhole
Side Entry Manhole, Demarcation Chamber, Dummy Manhole or Surface Water Soakaway

flood@herringtonconsulting.co.uk

4071/JA

WATER for LIFE
from Southern Water.

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
0601	F	2.67	1.56	
9601	F	2.99	0.97	
9604	F	1.33	1.33	

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Appendix A.3 – 4071 Old Shoreham Road Surface Water Modelling Nov24

Technical Note: Modelling Surface Water at 74 Old Shoreham Road, Lancing

herrington
Part of eps

Author(s): N. West BSc MCIWEM

Checked by: S. Maiden-Brooks BSc. (Hons) MSc. C.Eng C.WEM MCIWEM

Project: 4071 – Old Shoreham Road

Date:	25 November 2024
Revision:	1st ISSUE

1. Background Information

1.1. Herrington Consulting has been commissioned to undertake numerical flood modelling for 74 Old Shoreham Road in Lancing. The purpose of the modelling is to support a Flood Risk Assessment (FRA) and planning application for the development of 9 residential units on the land to the rear of no.74 which will include the removal of the existing bungalow to provide access. The location of the site is shown in Figure 1.

1.2. The National mapping for Risk of Flooding from Surface Water indicates surface water flood risks at the site. Therefore, this model represents surface water (pluvial) flood risks exclusively. This technical note details the setup of the model representing the existing and proposed development conditions. Number 74, its neighbours, and other nearby streets are recognised to be at risk of groundwater flooding. However, these risks have been dealt with, by others, separately from this modelling study.

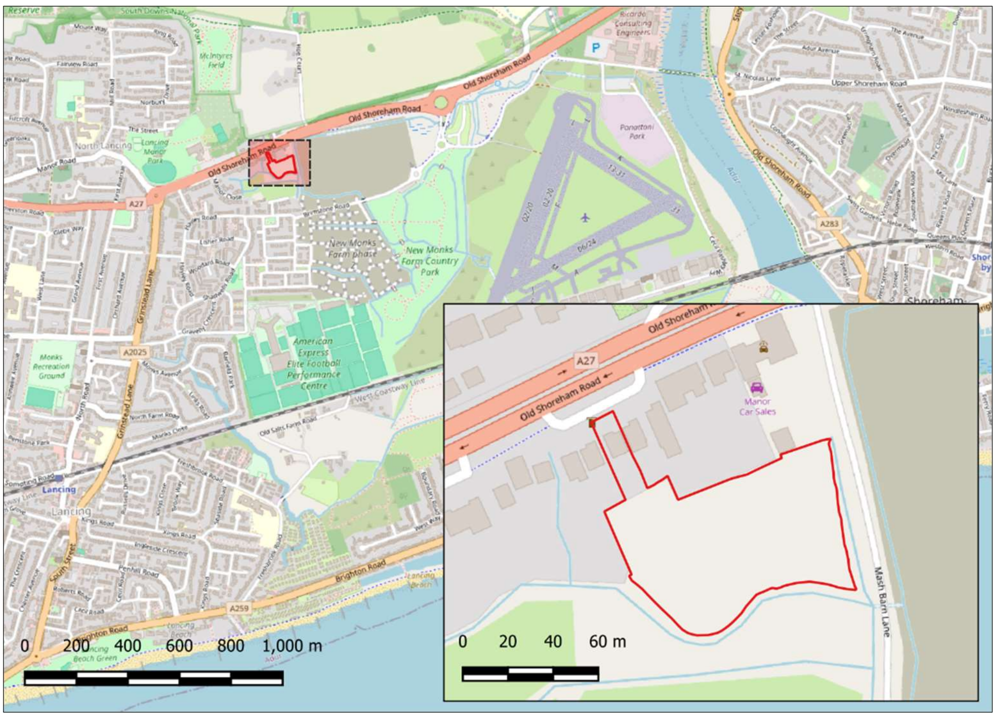

Figure 1 – Site location

1.3. A topographic survey of the site has previously been undertaken in 2023 and has been made available to inform this modelling study.

1.4. The larger part of the site sites to the rear (the south) of the properties on Old Shoreham Road The elevations on Old Shoreham Road at the entrance to number 74 are around 2.5 mODN, dropping to between 2.0 mODN and 2.2 mODN on the developable area.

1.5. The southern and eastern perimeters are bound by the ditches which drain the nearby groundwater springs. Downstream of the site Marsh Barn Lane runs north to south and parallel with the eastern perimeter Elevations on Marsh Barn Lane are around 2.2 mODN to 2.4 mODN.

1.6. The ditches that drain the area route through a recently upgraded culvert beneath Marsh Barn Lane. This culvert was upgraded as part of the extensive improvements to groundwater drainage in the area linked to the neighbouring New Monks Farm development. Downstream of Marsh Barn Lane extensive improvements to ditches have been made as part of New Monks Farm so as to connect the drainage in the area efficiently with the pumping stations that connect into the Adur River.

1.7. The as-build construction drawings of the ditches, pipes, culverts, and land raising for New Monks Farm have kindly been provided by the Civil Engineering Practice. The model geometry downstream of Marsh Barn Lane has been based on these detailed drawings, including the 1D representation of channels and pipes/culverts. These were crucial to the model setup while much of the recent works in the downstream region were not represented in the available LiDAR.

2. Numerical Flood Model - Technical Methodology

2.1. The model has been constructed using the TUFLOW 2-dimensional (2D) numerical flood modelling system, version TUFLOW 2023-03-AF_w64. The model has several 1-dimensional (1D) structures placed into the 2D domain, to represent the important culverts near the site and the network of ditches that are prolific in the areas downstream of the site; these have been constructed in ESTRY (TUFLOW's 1D channel and pipe flow model). The most recent version of TUFLOW has been used to take advantage of TUFLOW's Highly Parallelised Computation (HPC) using Graphical Processing Unit (GPU). This approach uses the latest advances in the TUFLOW software to ensure the detail is captured and capitalises on improved model run times to allow the entire catchment to be modelled.

2.2. The 2D Digital Elevation Model (DEM) of the catchment and floodplain uses a grid resolution of 8 m to represent the remote parts of the wider catchment, reducing to 1 m on-site and on roads off-site (to improve flow routing representation), with a further reduction to 0.25m to represent small-scale on-site features. The ground elevations of the DEM are based upon the EA's 1 m LiDAR Composite Digital Terrain Model (DTM) originating 2022.

2.3. The LiDAR levels, Figure 2, have been compared with the site-specific topographic survey levels. Differences between the LiDAR and topographic survey measurements range ±0.15m. No modification of the model DEM has been undertaken using the topographic survey levels while the key features of the site have already been represented sufficiently by the LiDAR. The preference has been to remain consistent with the neighbouring ground elevations and not impact any flow paths with 'steps' in grid levels.

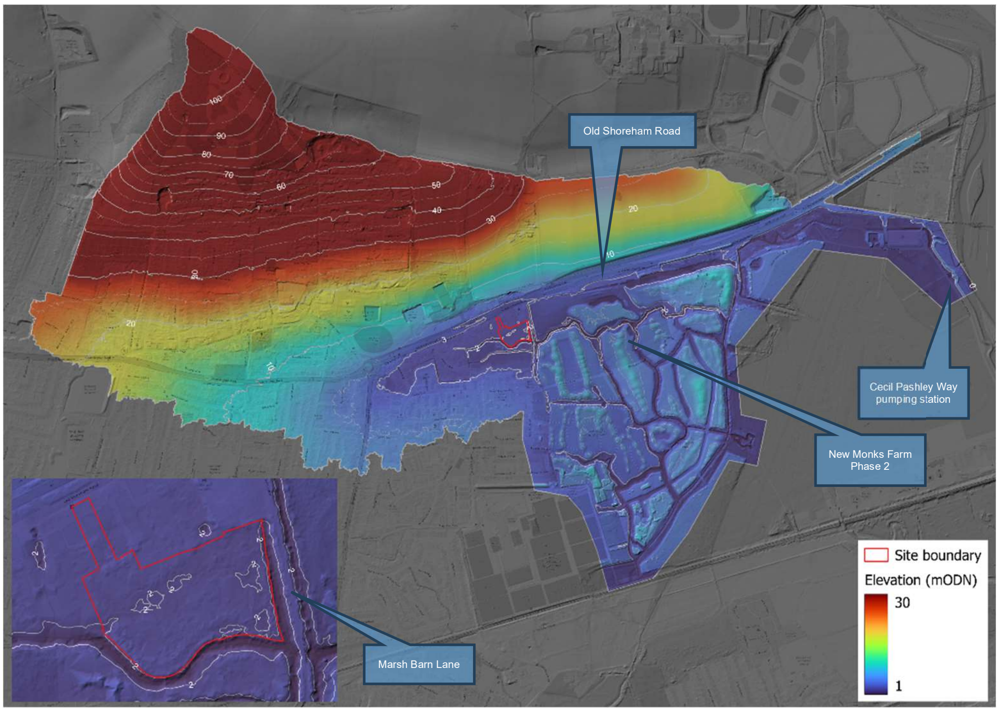

Figure 2 – Ground elevations within the catchment and model domain

2.4. The catchment in which the site is located drains into the wide and low-lying areas to the east which are bound on their eastern perimeter by the tidal defences (two of; primary and set-back secondary) of the Adur. This large low-lying area is typified by numerous drainage ditches and is actively drained to the tidal Adur by two pumping stations. The pumping stations include the Cecil Pashley Way screw-type pumping station some 1.5 km away, installed as part of the recent New Monks Farm development. With no gravity outfall to the Adur the large low-lying areas provide necessary significant storage volume for water in the catchment and represent the downstream 'boundary' to the model. Except for an arbitrary small pumping rate (unqualified) applied to the Cecil Pashley Way pumping station to prevent stagnation in the model there is no materially impactful outflow from the model.

2.5. No meaningful pumping rate has been identified that can be applied to the Cecil Pashley Way pumping station. Online research reveals that the pumping station has a primary purpose of reducing ground water levels in the wider area (including the site at Old Shoreham Road) in order to reduce the general risks of ground water flooding locally and therefore alleviate some of the issues that have been recognised with slow/poor drainage. An arbitrary estimate of the rate has been made of 0.5 m^2/s. Testing during model setup identified that this rate was sufficient to prevent stagnation in the model but did not impact flood levels on site during extreme conditions. The water levels on-site are dominated by the flow in its immediate vicinity. Friction dominates the flows in the low-lying areas downstream and thus prevents any impact on-site by the rates applied at the pumping station. Therefore, no further sensitivity testing of the pumping station rates was investigated.

2.6. The model applies a spatially varying Manning's n roughness based on the land use types of the Ordinance Survey VectorMap and the values proposed by Chow (1959). These applied values are presented in Table 1.

Feature Code	Manning's n value	Representation
10021	0.30	Buildings
10053	0.05	Land
10183, 10172	0.025	Roads Tracks and Paths
10056	0.04	Land
10089	0.03	Water
10185, 10123	0.03	Roads Tracks and paths
10096	0.03	Man made embankment
10111	0.08	Thick vegetation and trees

Table 1 – Manning's n values and land use types

2.7. While buildings are attributed a value of 0.3 (legacy standard value for feature code 10021) this is now curtailed automatically in TUFLOW HPC to 0.1 as part of the Wu viscosity formulation. Sensitivity testing to raise this limit back to 0.3 has not been undertaken with respect to the implementation of buildings. However, the impact of the 0.1 limitation has been tested with respect to the representation of the filter drains included as part of the proposed development and is detailed in Section 4.

2.8. Several extreme flow events have been simulated within the model, including:

- 1 in 30 year return period event (3.3%AEP, Annual Exceedance Probability), with and without climate change (40%);
- 1 in 100 year return period event (1%AEP) with and without climate change (45%); and
- 1 in 1,000 year return period event (0.1%AEP), with and without climate change.

2.9. The importance of the geology in the catchment has been recognised. The geology is complex and provides two (vertically layered) groundwater aquifers. While the groundwater risks are not the subject of this modelling study, the rate of transfer of surface water into the ground water is of particular relevance as this will impact surface water volumes. Therefore, soil infiltration rates have been measured using a double ring infiltrometer. This testing has been carried out by

Peter Baxter Associates (PBA) and the report is enclosed. The testing included three locations around the site; first in the front garden of 74 Old Shoreham Road, second in the rear garden, and the third in the proposed development land to the rear. Three infiltration rates were measured and are summarised in Table 2.

Location	Rate (mm/hr)
Front garden	200
Rear garden	10
Land to the rear	6

Table 2 – Measured soil infiltration rates

2.10. A review of the Cranfield SoilScapes data reveals two main soil types. One of these represents the upper catchment and is chalky and freely draining. The upper catchment is typified by an absence of surface water drainage ditches or infrastructure. The second of these is a clay soil with poor drainage characteristics, typically found in the lower parts of the catchment. Numerous springs are located along Old Shoreham Road and nearby, being apparent in both the digital mapping and the LiDAR. These springs are anticipated to link directly with the boundary between the two soil types. The SoilScapes mapping data arbitrarily aligns the edge of the clay soil with Old Shoreham Road and not the mapped springs, as shown in Figure 3. A network of ditches route the water from the springs downstream.

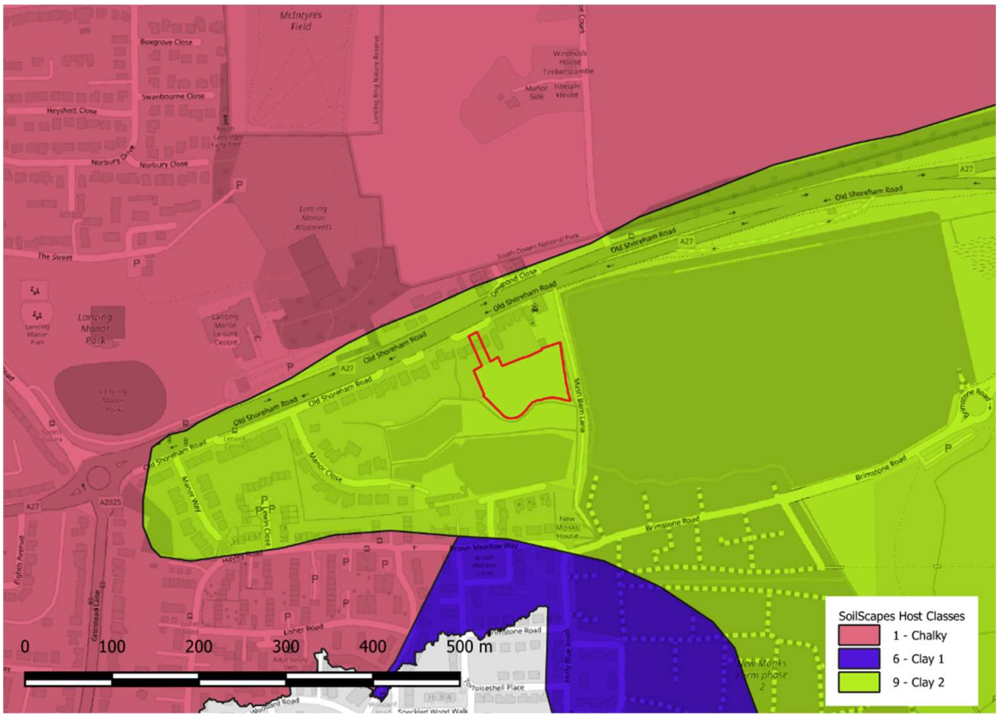

Figure 3 – SoilScapes host classes

2.11. The accuracy of the SoilScapes mapping is considered low and the exact position of the chalky/clayey boundary may vary. The infiltrometer test in the front garden also aligns approximately with spring-line boundary. The high infiltration rate in the front garden can be considered to be representative of a freely draining chalky soil. Similarly, the much lower infiltration rates of the rear garden and land to the rear can be considered to be representative of the clayey soils type. Therefore, the SoilScapes digital mapping has been applied the model with a minor adjustment such that the boundary between the two soils has been located to run beneath the property, and therefore position the chalky soil in the front garden and the clayey soil to the rear. The lower rate of 6 mm/hr has been applied to the clayey soil throughout the model while the 10 mm/hr rate has not been used in the model.

2.11.1. No infiltration has been applied in the ditches or drains in the model. A rate of 12 mm/hr has been applied to the roads in the catchment to represent the highways drainage in line with the approach applied in the national surface water mapping modelling.

2.12. Rainfall data from the FEH online service was applied in the ReFH2.3 software to generate the appropriate hyetographs for application to the model. The rainfall hyetographs have been applied to the whole of the model domain which represents the complete upper catchment and includes an adjustment to widen the downstream areas to represent the wider historic floodplain.

2.12.1. During initial model setup, different rainfall event durations were tested to find the worst-case condition. The 1-hour event provided very slightly deeper water on site than the 3-, 4-, and 6-hour events. All subsequent tests used the 1-hour duration rainfall event.

2.13. The culvert beneath Marsh Barn Lane is a rectangular concrete 2 m wide and 1 m high, with an invert or 0.79 mODN (details from the Civil Engineering Practice). This culvert was initially implemented in the model with SX-type boundaries connecting to the 2D domain either side of Marsh Barn Lane.

2.13.1. During initial model setup the culvert proved very difficult to fully stabilise with regular negative depths recorded in the logs. The model never became unstable as a result of these negative depths. However, it was evident that this behaviour was affecting the water levels some 200 m upstream and downstream of the culvert (which included the site) and were clearly evident when the difference plots were reviewed to compare the pre- and post-development conditions; the impacts of the proposed development were difficult to discern from the 'noise' generated by the instability at the culvert.

2.13.2. Every effort was made to control and prevent the stability issues at the Marsh Barn Lane culvert. However, the minimal water level gradients through the entire area drive very little flow through the culvert. Subsequent oscillations in the flow direction and general stagnation of the water levels in the model (due to the exceptionally low flows throughout) provide difficult conditions in the culvert to stabilise.

2.13.3. Therefore, the culvert has instead been represented in the 2D domain with a 2d_zsh file adjustment to the geometry where a 2 m wide cut-through has been applied to the embankment of Marsh Barn Lane. This represents a potentially under-restrictive conduit at Marsh Barn Lane. However, considering the very low flows in the ditches and minimal water surface gradient the 'open' conduit is increasingly unlikely to mis-represent the actual situation. Considering the difficulties in implementing a stable culvert here there are very limited options for sensitivity testing available.

2.13.4. The 1D channel representation of the culvert beneath Marsh Barn Lane has been left active in the model for posterity, although its dimensions have been reduced to 0.01 m height and 0.01 m width. This is sufficient to exclude the culvert from any practical use.

2.13.5. The representation of the culvert with the 2D cut-through completely alleviates the negative depths and any impact on the water level and removes any impact on the results that prevent the direct comparison of the pre- and post-development mode results.

3. Post development Scenario

3.1. The proposed post development scenario includes land raising to approximately 3.0 mODN. This is proposed in combination with a series of filter drains along some perimeter sections of the site to prevent negative off-site impacts.

3.2. The extent of the land raising is shown in Figure 4. The location and routing of the filter drains is shown in Figure 5. The filter drains have been positioned to intercept overland flows and prevent backing up of surface water and any impacts off-site.

Figure 4 – Proposed site plans

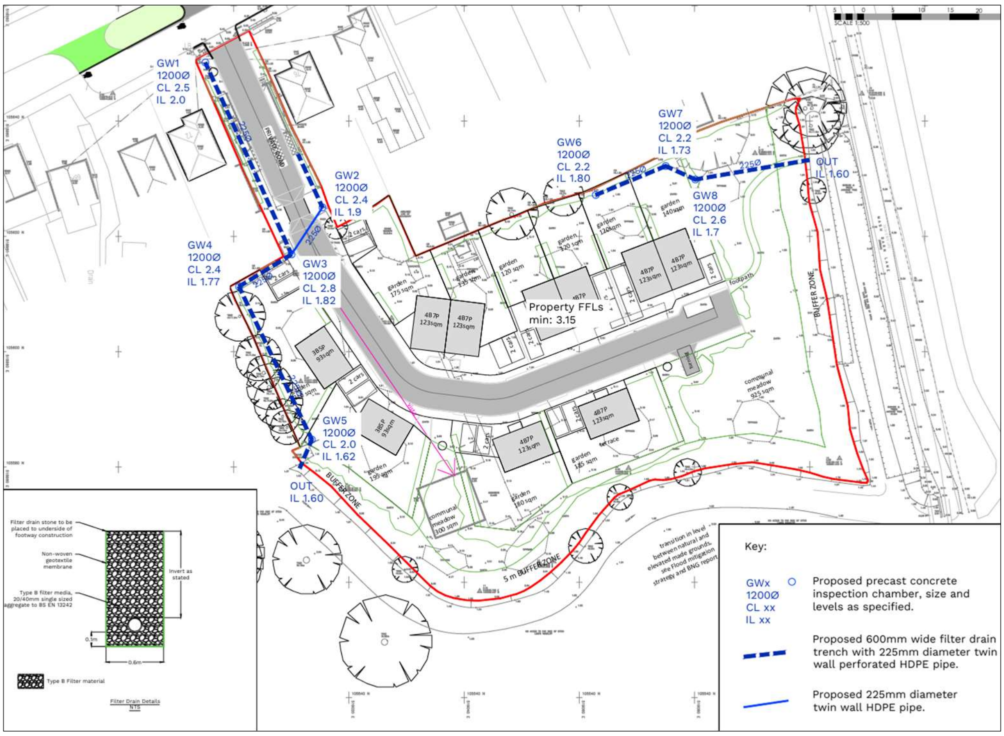

Figure 5 – Proposed routing of filter drains and drain design

3.3. The TUFLOW software does not yet include specific features for the inclusion of filter drains. Advice received from TUFLOW software support suggested two potential methods by which the filter drains could be represented. However, these require either iterative runs of the model to reach the singular results required, or the use of the TUFLOW interlayer functionality. Neither suggestion suits the specific situation for the proposed design particularly well. Therefore, a physical representation in the model grid was chosen that includes a conservative approach whereby the conveyance by the filter drains is under-represented (i.e. they flow less in the model than they would in reality).

3.3.1. The chosen approach requires a high resolution in the model grid combined with high roughness to represent the 'pit' of the drain only and the gravel contained within it. The presence of the perforated pipe in the base of the filter drain pit has been excluded from the model, and thus makes the representation in the model conservative (flows less in the model than in reality).

3.3.2. The filter drains are proposed to be 0.6 m wide and filled with well graded gravel. The gravel can reasonably be assumed to have a void ratio of 0.35, or near one-third of its true cross-sectional area. Therefore, the pit in the model can be represented by a reduction in width. The nearest subdivision of the grid resolution is 0.25 m, and therefore the model grid has been resolved at 0.25 m for the routes of the filter drains. Initial testing of the increased resolution included a grid of 0.125 m but memory limitations on the workstation hardware prevented such a high resolution from being applied in the model.

3.3.3. The modelled filter drain 'pit' has been combined with a high Manning's n value of 0.1 (the natural limit of the TUFLOW HPC Wu formulation). This increased Manning's n value represents the resistance to flows by the gravel in the pit. While there are no recommendations for representing flows through the void space of a gravel the choice of high Manning's n becomes arbitrary. Therefore, a sensitivity test was conducted to understand the impact that other values of Manning's n could have for the conveyance in the pit. This test requires that the default upper limit of Manning's n be raised in the model setup. For this sensitivity test only, the limit was raised to 0.7 so that a value of 0.5 could be tested representing the gravels in the filter drains. Only very minor alterations to the operation of the filter drains were observed as a result of this test. These minor changes were not of significance to the operation of the drains and therefore the representation of the filter drain gravels with high Manning's can be considered insensitive to further increases include those outside of the normal range of those values.

3.3.4. The model includes a necessary deviation from the design shown in Figure 5. This relates to the pipe crossing beneath the access road, where the pipe has been included as a filter drain instead of a pipe only. This is necessary to increase the overall flow capacity of the crossing under the road.

3.4. Table 3 lists the models run for the TUFLOW baseline conditions and initial testing. All simulations use the TUFLOW control file 4071_*OldShrm_~s1~_~e1~_~s2~.tcf*. All baseline simulations are designated *A3* while the post development scenario is designated *C3*.

Scenario	s1	e1	s2	Comment
Existing conditions	A3	P30	000	3.3%AEP
		P30cc40		3.3%AEP+40% climate change
		P100		1%AEP
		P100cc45		1%AEP+45% climate change (higher central)
		P1000		0.1%AEP
Post development	C3	P100cc45		Proposed development scenario
Sensitivity tests	A3	P100cc45	nUP	Manning's n roughness +20%
			nDN	Manning's n roughness -20%
	C3		MHi	Manning's upper limit of 0.1 raised to test filter drains with a Manning's n of 0.5

Table 3 – List of model simulations with corresponding events

3.5. Table 4 lists and describes the files used in the TUFLOW model setup, including geometry files, boundary files for both 2D and 1D.

File name	Description
2d_code_4071_Active_Area_A_R.SHP 2d_loc_4071_Grid_A_L.SHP 2d_qnl_4071_Grid_Res_C1_R.SHP	2D files controlling the active area of the model, the grid orientation and resolution
TQmerge_AdurRight_DTM_1m.TIF	LiDAR data interpolated into the model grid
2d_zsh_4071_NMF_landscaping_A2_R 2d_zsh_4071_Setback_defence_A2_L 2d_zsh_4071_ditches_A2_L 2d_zsh_4071_ditches_A2_P 2d_zsh_4071_Roads_routing_A2_L 2d_zsh_4071_Channel_Slopes_A2_R 2d_zsh_4071_Channel_Slopes_A2_L 2d_zsh_4071_Channel_Slopes_A2_P	Adjustments to the model grid geometry for features not represented well in the LiDAR.
2d_zsh_4071_MBL_culvert_artificial_A_R	Marsh Barn Lane embankment artificial culvert cut through (see methodology section for reasoning)
2d_zsh_4071_buildings_offsite_A_R	Offsite neighbouring buildings
2d_zsh_4071_74OldShorehamRd_A_R_R	Existing on-site building
2d_zsh_4071_Proposed_Landscaping_C1_R 2d_zsh_4071_Proposed_Landscaping_C1_L 2d_zsh_4071_Proposed_Landscaping_C1_P	Adjustments to the model grid geometry for the proposed land raising and filter drains.

2d_zsh_4071_Berrys_drains_A2_L 2d_zsh_4071_Berrys_drains_A1_P	
2d_soil_4071_measured_rates_A_R 2d_soil_4071_Impermeable_watercourses_A_R 2d_soil_4071_Roads_drainage_A1_R 2d_soil_4071_Berrys_dains_A1_R	Soils infiltration rates applied to the model.
2d_mat_4071_Roads_A2_R 2d_mat_4071_Berrys_drains_A_R 2d_mat_4071_Berrys_drains_high_C_R	Materials files specifying land use types; includes the roughness applied to the filter drains (standard representation, and the higher value for sensitivity testing)
2d_bc_4071_SX_A2_R 2d_bc_4071_SX_A2_L	1D – 2D boundary interface connection between the pipe and the 2D representation of the watercourse
2d_sa_4071_GW_pump_A_R	Abstraction point representing the pumping station at Cecil Pashley Way
1d_nwk_4071_Culverts_A2_L 1d_nwk_4071_Culverts_A2_UP_L 1d_nwk_4071_Culverts_A2_DN_L	Representation of several culverts in the model (mainly on New Monks Farm lands); includes alternative versions which match to sensitivity testing of Manning's n roughness

Table 4 – TUFLOW model files

4. Sensitivity Testing

4.1. Several key sensitivity tests have been undertaken to ensure a full understanding of model behaviour. These have included:

- Manning's n roughness value +20%; and
- Manning's n roughness value -20%.

4.2. Other sensitivity tests have been undertaken that relate specifically to the setup of the model and therefore have been detailed in the relevant sections of this report.

4.3. **Manning's n values ±20% –** the surface roughness in the model represents typical conditions with respect to seasonal vegetative growth. However, vegetation can change significantly between summer and winter, and therefore greatly affect the speed at which flood water may transit through an area.

4.3.1. The results show that the variance of Manning's n by +20% and -20% results in flood levels varying in the river adjacent to the-site by 0.008 m and -0.014 m respectively. On this basis, the seasonal growth and variation in vegetation is not considered to be significant and therefore, no further adjustment has been made or investigated.

5. Simulation Messages

5.1. The model simulation reports no significant messages before or during the simulation that require further investigation.

6. Results

6.1. The graphical model results are appended to this technical report and are listed in Table 5.

Model result no.	Scenario	Event	Scenario	Output	Figure No.
1	Existing	1:30 year, present day	Design event	Max depth	A.1
2		1:30 year, +40% climate change		Max depth	A.2
3		1:100 year, present day		Max depth	A.3
4		1:100 +45% climate change [2125]		Max depth	A.4
5	Post development	1:100 +45% climate change [2125]		Max depth	A.5
6	Difference plot (impacts)	1:100 +45% climate change [2125]		Flood level difference	A.6
7	Existing	1:1,000 year, present day		Max depth	A.7

Table 5 - List of appended figures

6.2. In summary, the results show that the filter drains more than compensate for the displacement by the proposed land raising, and overall have a positive impact off-site with a reduction in the flood level in the vicinity of neighbouring property numbers 72 and 76.

6.2.1. All negative impacts are contained on-site.

6.2.2. There are no impacts downstream of the site.

6.3. These results require that the filter drain is continuous beneath the access road.

7. Enclosed Documents

7.1. The following documents have been enclosed with this technical note:

- Modelling results;
- Topographic survey;
- Soil infiltration testing report; and
- Proposed development plan.