THOMAS CONSULTING
STRUCTURAL & CIVIL DESIGN ENGINEERS

TC/L9861/2021/02

FLOOD RISK ASSESSMENT & DRAINAGE STRATEGY

AT

Castle Lane
Barnacre-with-Bonds
Garstang
Lancashire
PR3 1RB

FOR

JWPC Chartered Town Planners

C/O

MS. C COONEY

REPORT VERIFICATION

Site Address	Castle Lane, Barnacre-with-Bonds, Garstang, Lancashire, PR3 1RB

Document Reference	TC/L9861/2021/02 Flood Risk Assessment & Drainage Strategy Report
Version	02
Date released	09 February 2021
Originator	Alex Woodger BEng (Hons) GMICE
Checked	Julian Pearson BSc (Hons) EngTech MICE
Verified	Kieron Hounslow BEng (Hons) CEng MIStructE

Issue no	Date	Status	Report version	Issued by
01	09/02/2021	Final	01	JP
02	22/06/2021	Updated	02	JP

CONTENTS

APPENDICES

1 INTRODUCTION

1.1 Project Scope / Client Brief

Thomas Consulting (TC) has been commissioned by JWPC Chartered Town Planners on behalf of Ms Cooney to carry out a site-specific flood risk assessment and a drainage strategy report in accordance with the National Planning Policy Framework (NPPF) to support a formal planning application which would subsequently fulfil the requirements of the Local Planning Authority, Lead Local Flood Authority, and the Sewerage Undertaker.

1.2 Site Location & Topography

The site is located at Castle Lane, Barnacre-with-Bonds, Garstang, Lancashire, PR3 1RB and the report is for a proposed housing development. The approximate Ordnance Survey (OS) grid reference for the site is 349635 444934 and the location of the site is shown on Figure 1.

A copy of the development proposals can be found in Appendix A of this report.

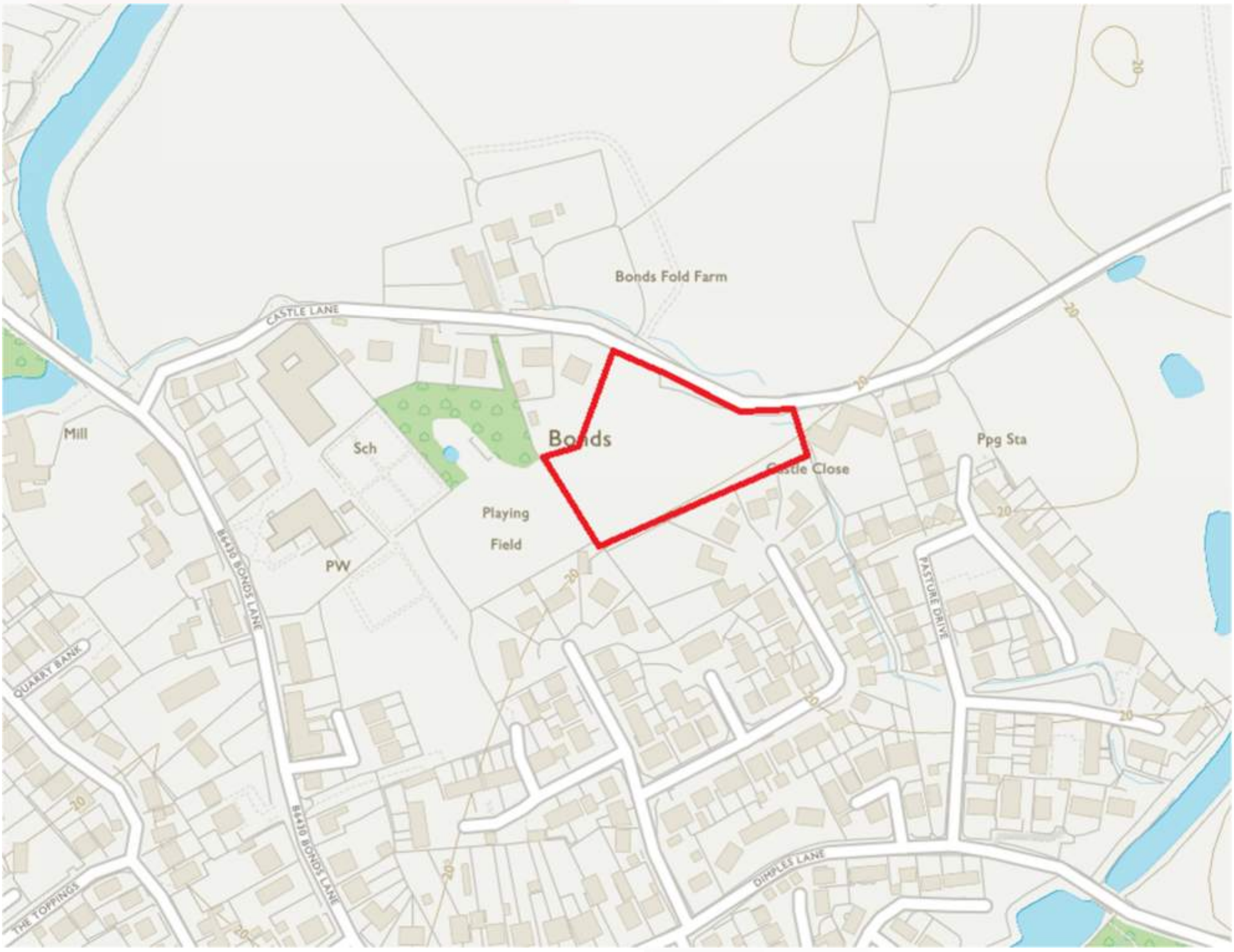

Figure 1: Site Location Plan (Source: OS Maps, 2021)

The site covers a total area of approximately 0.755 ha (7,553 m^2) and comprises farmland. The site is located approximately 640m south of the village of Garstang and gently slopes down from west to east which an average elevation of 18mAOD. The site is bound to the north by Castle Lane, two residences and beyond this more farmland. To the east and south is residential dwellings. To the west is another field and beyond that a cemetery. A topographical survey to Ordnance Datum has been provided by SurveyEng Ltd and can be seen on Drawing Number JWPC.TS.01. It is worth noting the topographical survey shows that there is a large, flooded area to the east of the site which could not be surveyed at the time and will need to be considered as part of this FRA.

A copy of the topographical survey can be found in Appendix B of this report.

1.3 Development Class in terms of Planning

The NPPF and its Planning Practice Guidance (PPG) states any development other than the following outlined below is classed as a major development.

- Minor non-residential extensions: industrial/commercial/leisure etc extensions with a footprint less than 250 square meters.
- Residential development consisting of less than 10 dwellings or less than 0.5ha in size.
- Alterations: development that does not increase the size of buildings e.g. alterations to external appearance.
- Householder development: For example, sheds, garages, games rooms etc within the curtilage of the existing dwelling, in addition to physical extensions to the existing dwelling itself. This definition excludes any proposed development that would create a separate dwelling within the curtilage of the existing dwelling e.g. subdivision of houses into flats.

1.4 Planning Policy

The NPPF and its PPG follows on to state a site-specific flood risk assessment is required for the following site proposals.

- A site proposed in Flood Zone 2 or 3 including minor development and change of use in development type to a more vulnerable class.
- More than 1 hectare (ha) in Flood Zone 1
- Less than 1 ha in Flood Zone 1, including a change of use in development type to a more vulnerable class (for example from commercial to residential), where they could be affected by sources of flooding other than rivers and the sea (for example surface water drains, reservoirs)
- In an area within Flood Zone 1 which has critical drainage problems as notified by the Environment Agency

1.5 Environment Agency Flood Map for Planning

National Planning Policy Framework (NPPF) Flood Zones comprise Flood Zone 1, Flood Zone 2, and Flood Zone 3. The Environment Agency's Indicative Flood Map for Planning (Figure 2) shows that part of the site is located within the NPPF defined Flood Zone 2.

Flood Zones are based on an areas Annual Exceedance Probability (AEP) of River or Sea Flooding. For example, Flood Zone 1 has a 'Low Probability' of flooding as it has an AEP of <0.1% (Less than 1 in 1000 year) of occurring in any one year. Flood Zone 2 has a 'Medium Probability' having an AEP of 0.1-1.0% (1 in 1000 – 1 in 100 year) chance of river flooding, or 0.1-0.5% (1 in 1000 – 1 in 200 year) chance of tidal/sea flooding.

Flood Zones 3 is split between 'a' and 'b' classifications. Flood Zone 3a has a 'High Probability' of flooding as it has an AEP of >1.0% (More than 1 in 100 year) chance of river flooding, or >0.5% (More than 1 in 200 year) chance of sea/tidal flooding. Flood Zone 3b (The Functional Floodplain) comprises land where water has to flow or be stored in times of flooding. Local planning authorities should identify in the Strategic Flood Risk Assessments areas of function floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map for Planning).

The extent of the flood zones does not take into account the presence of any formal flood defences, or other features which also act as informal flood defences.

The NPPF is accompanied by the Planning Practice Guidance (PPG) documents which classifies each development into a vulnerability class, depending on the type of development, which are outlined in Figure 3. According to the PPG a residential development would fall under the "More Vulnerable" class. "More Vulnerable" developments are acceptable in Flood Zone 2 as shown in Figure 4.

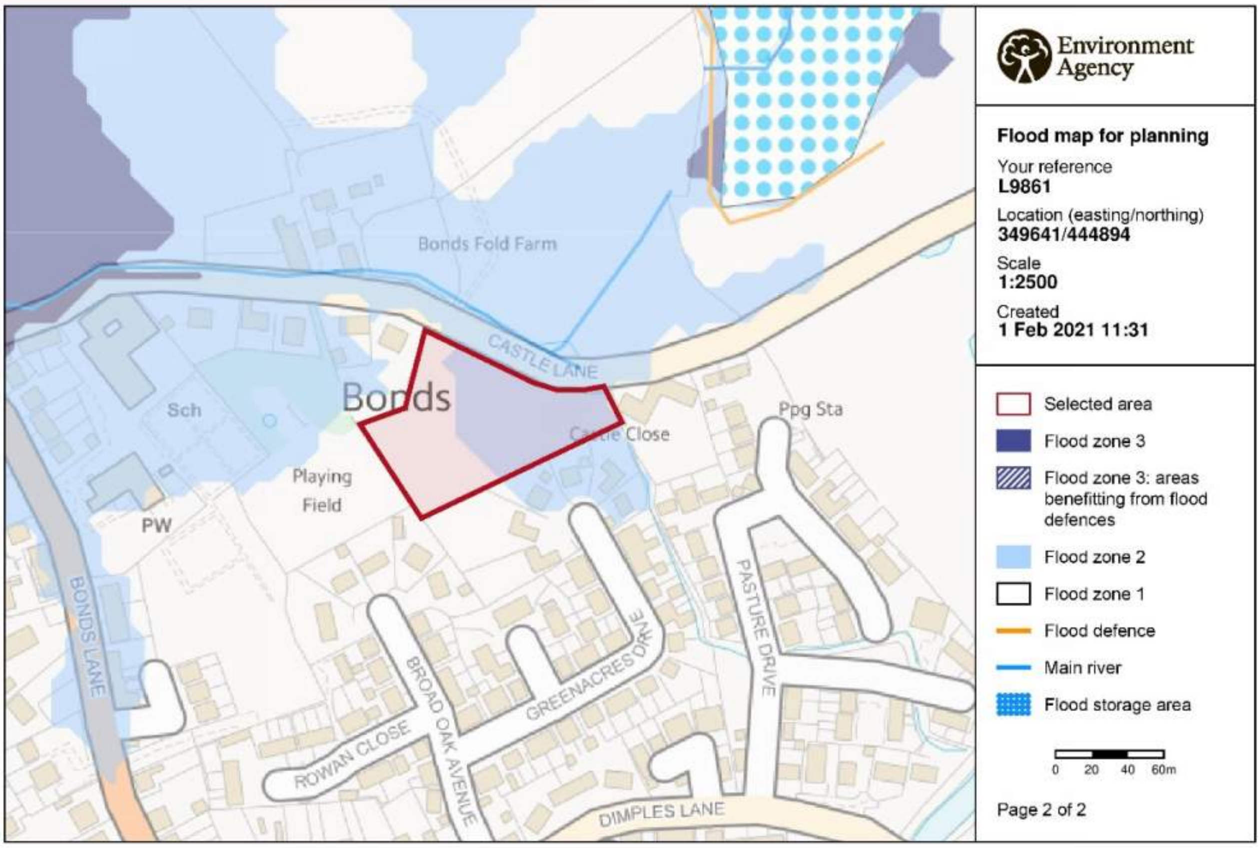

Figure 2: Environment Agency Flood Zone Map (Source: Environment Agency, 2021, GOV.UK)

Vulnerability Classification	Development
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 operation during flooding. • Emergency dispersal points • Basement dwellings • Caravans, mobile homes and park homes intended for permanent residential use • Installations requiring hazardous substances consent
More Vulnerable	• Hospitals • Residential institutions such as residential care homes, children's homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non-residential uses for health services, nurseries and education 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
Less Vulnerable	• 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 distributions; non-residential institutions not included in the 'more vulnerable' class; and assemble and leisure. • Land and buildings used for agriculture and forestry • Waste treatment (except landfill & hazardous waste facilities) • Minerals working & processing (except for sand & gravel working) • Water treatment works which do not need to remain operational during times of flood • Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place.
Water-Compatible Development	• Flood control infrastructure • Water transmission infrastructure & pumping stations • Sewage transmission infrastructure & pumping stations • Sand & gravel working • Docks, marinas and wharves • Navigation facilities • Ministry of Defence installations • Ship building, repairing & dismantling, dockside fish processing & refrigeration & compatible activities requiring a waterside location • Water based recreation (excluding sleeping accommodation) • Lifeguard and coastguard stations • Amenity open space, nature conservation & biodiversity, outdoor sports and recreation and essential facilities such as changing rooms • Essential ancillary sleeping or residential accommodation for staff required by uses in this category subject to a specific warning & evacuation plan.

Figure 3: NPPF Flood Risk Vulnerability Classification (Source: National Planning Practice Guidance, 2014)

Flood Zones	Flood Risk Vulnerability Classification				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	✗	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	✗	✗	✗	✓*

Key:

✓ Development is appropriate

✗ Development should not be permitted.

Figure 4: NPPF Flood Risk Vulnerability Classification (Source: National Planning Practice Guidance, 2014)

1.6 Proposed Development in context of Planning

Although the site footprint is approximately 7,553m² (0.7553 hectares) and therefore less than 1 hectare, part of the site is located in Flood Zone 2. Therefore, in accordance with National Policy a Site-Specific Flood Risk Assessment is required to assess the potential sources of flood risk to the site and explore any potential mitigation measures required.

2 SITE CHARACTERISTICS

2.1 Site Geology & Hydrogeology

British Geological Survey (BGS) and Land Information Systems (LandIS) mapping indicates the site is underlain by the geology sequences outlined in Table 1. The EA Groundwater Vulnerability Map indicates the site is situated in area of medium groundwater vulnerability and within Groundwater Source Protection Zone 3 and Drinking Water Protected Area for Surface Water. The development site is situated within a "Unproductive" groundwater vulnerability zone.

Principal Aquifers - These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

Secondary A Aquifers - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

Secondary B Aquifers - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons, and weathering. These are generally the water-bearing parts of the former non-aquifers.

Secondary (Undifferentiated) Aquifers - has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

Geological Layer	Classification	Description	Aquifer Class
Soil	Soilscape 18	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils	N/A
Superficial (Drift)	Till	Devensian – Diamicton	Secondary (Undifferentiated)
Bedrock (Solid)	Sherwood Sandstone Group	Sandstone	Principal

Table 1: Site Geological Summary

2.2 Existing Watercourses

According to the EA Main River Maps the closest known watercourse is directly north of the site adjacent to Castle Lane. This watercourse is called Greenhalgh Castle Brook and travels approx. 0.3km west before it reaches the River Wyre. According to the Flood Map for Planning it looks as though this watercourse is associated with numerous flood issues within the area. The waiter course is classed as a Statutory Main River.

2.3 Existing Sewers

Detailed UU Sewer records have been purchased as part of this study and a copy of the A1 plans can be found in Appendix C of this report.

There are numerous sewers within the vicinity of the site. However the sewers serving the housing developments to the South of the site mainly consist of rising mains for both surface and foul water. The site in question could not utilise these systems due to the closed boundary of the development and would have to pass through private land. It is also unlikely the existing systems would have capacity for a new development. Therefore the only accessible sewers are those located to the North of the site;

- 100mmø Foul Water Rising Main in Castle Lane to the North of the site. Discharges into a 150mmø Combined Gravity Sewer directly Northwest of the site in Castle Lane. The rising main serves numerous housing developments from roads such as Spalding Avenue and Pasture Drive etc.

2.4 Ground Conditions

Intrusive ground investigations have not been undertaken at the time of writing this report. A site-specific ground investigation should be completed before detailed design to confirm existing ground conditions. BGS records show only one borehole in the surrounding area of the site, located 260m to the west, with reference SD44SE141. The record, however, is devoid of information and provides no insight into the ground conditions of the area.

3 ASSESSMENT OF FLOOD RISK

3.1 Flood Risk Terminology

Flood risk considers both the probability and consequence of flooding. Flood events are often described in terms of their probability of recurrence or probability of occurring in any one year. The threshold between a medium flood and a large flood is often regarded as the 1 in 100-year event. This is an event which statistical analysis suggests will occur on average once every hundred years. However, this does not mean that such an event will not occur more than once every hundred years. Table 2 shows the event return periods expressed in years and annual expectance probabilities as a fraction and a percentage. For example, a 1 in 100-year event has a 1% probability of occurring in any one year, i.e. a 1 in 100 probability. A 1000-year event has a 0.1% probability of occurring in any one year, i.e. a 1 in 1000 probability.

Return Period (Years)	Annual Exceedance Probability (AEP)	
	Decimal	Percentage
2	0.5	50%
10	0.1	10%
25	0.04	4%
50	0.02	2%
100	0.01	1%
200	0.005	0.5%
500	0.002	0.2%
1000	0.001	0.1%

Table 2: Flood return periods and exceedance probabilities

3.2 Fluvial Flood Risk

The site is located adjacent to the main river known as Greenhalgh Castle Brook and is in close enough proximity to be at risk of flooding. Greenhalgh Castle Brook is explained in Section 2.2 of this report. The Flood Zone 2 outline in Figure 2 and the Fluvial Flood Map in Figure 5 indicates part of the site is at low risk of fluvial flooding. The area determined to be at risk matches the flooded area shown on the topographical survey (Appendix B). Reference to the Flood Map for Planning in Figure 2, the watercourse is associated with numerous flood zones and flows through an area allocated by the EA as a Flood Storage Area. This is located to the north and is upstream of the site in question. The Flood Storage Area is also surrounded by a Flood Defence which is covered in Section 3.3 of this report.

The fluvial flood map in Figure 5 shows areas that may be at risk of fluvial flooding from rivers or the sea. High risk is a >3.3% Annual Exceedance Probability (AEP) event, meaning this area has a chance of flooding of greater than 1 in 30 years (dark blue). This takes into account the effect of any flood defences in the areas. However, these defences reduce but do not completely stop the chance of flooding as they can be overtopped or fail. Medium risk is an AEP event of between 3.3-1% (1 in 30 - 1 in 100 - year, blue) chance of flooding. Low risk is an AEP event of between 1-0.1% (1 in 100 – 1 in 1000-year, light blue) chance of flooding. Very Low risk is an AEP event of <0.1% (Less than 1 in 1000 year, white) chance of flooding.

The Flood Map shows the current best information on the extent of the extreme flood from rivers or the sea that would occur without the presence of flood defences. The potential impact of climate change is not considered by the mapping.

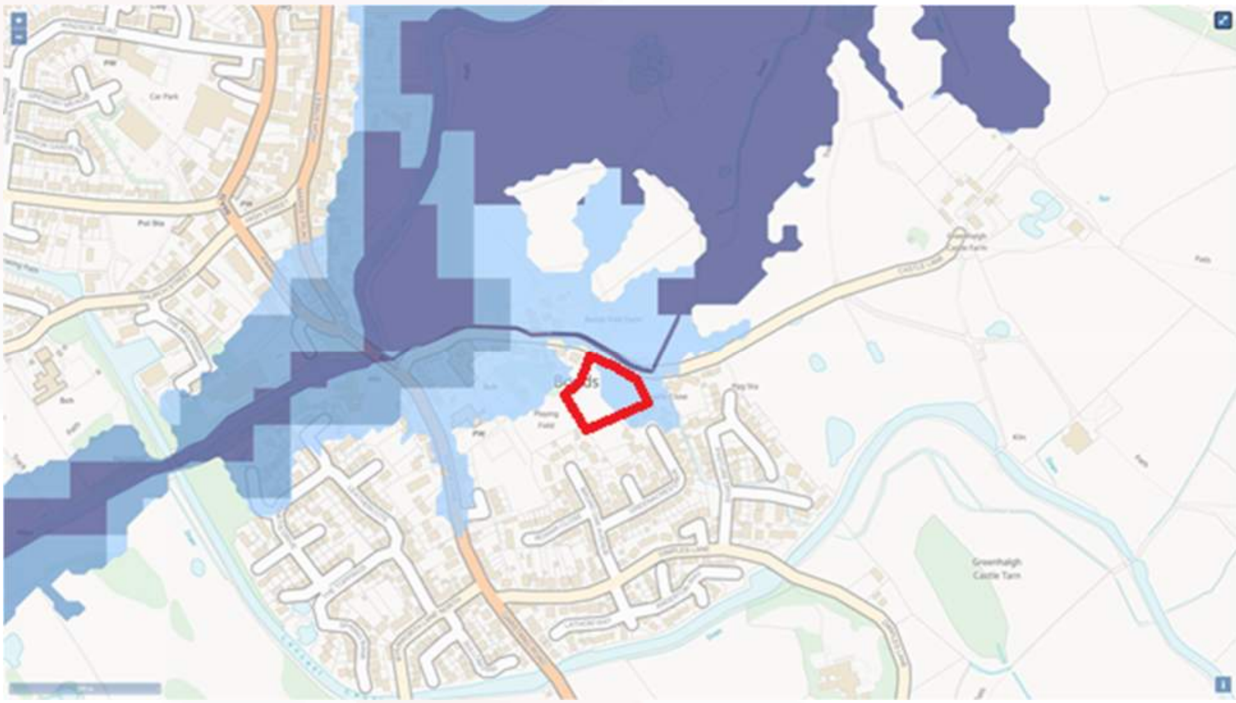

Figure 5: Environment Agency Fluvial Flood Map (Source: Environment Agency, 2021, GOV.UK)

3.3 Product 4 – Environment Agency Data

TC contacted the EA on the 11th of February 2021 to enquire about any Product 4 datasets held for the site. The EA responded on the 9th of March 2021 to confirm they held information for the site. All correspondence and Product 4 data can be found in Appendix D of this report.

The Flood Zones Map referenced CL204781 corresponds with the Flood Map for Planning in Figure 2 and shows Greenhalgh Watercourse, Greenhalgh Culvert and Greenhalgh Castle Brook, the latter which can be seen in Figure 6 below. As part of the Product 4 data in Appendix D the EA have provided a plan with referenced defences which is dated February 15, 2021. The following defence references are of interest to the site;

- 36204
- 36203
- 77831

As can be seen in Figure 7 and Figure 8 the above refences are formalised embankments providing defence from Fluvial Sources. The embankment is maintained by the EA and has been designed to protect downstream areas at risk of flooding up to a 50-year return period (2% AEP). The embankment is approximately 570m in length ad is 1-2m in height. Levels are between 18.93mAOD and 20.12mAOD.

Figure 6: Picture of Greenhalgh Castle Brook opposite Castle Lane and the site in question (Source: Google Maps, 2021)

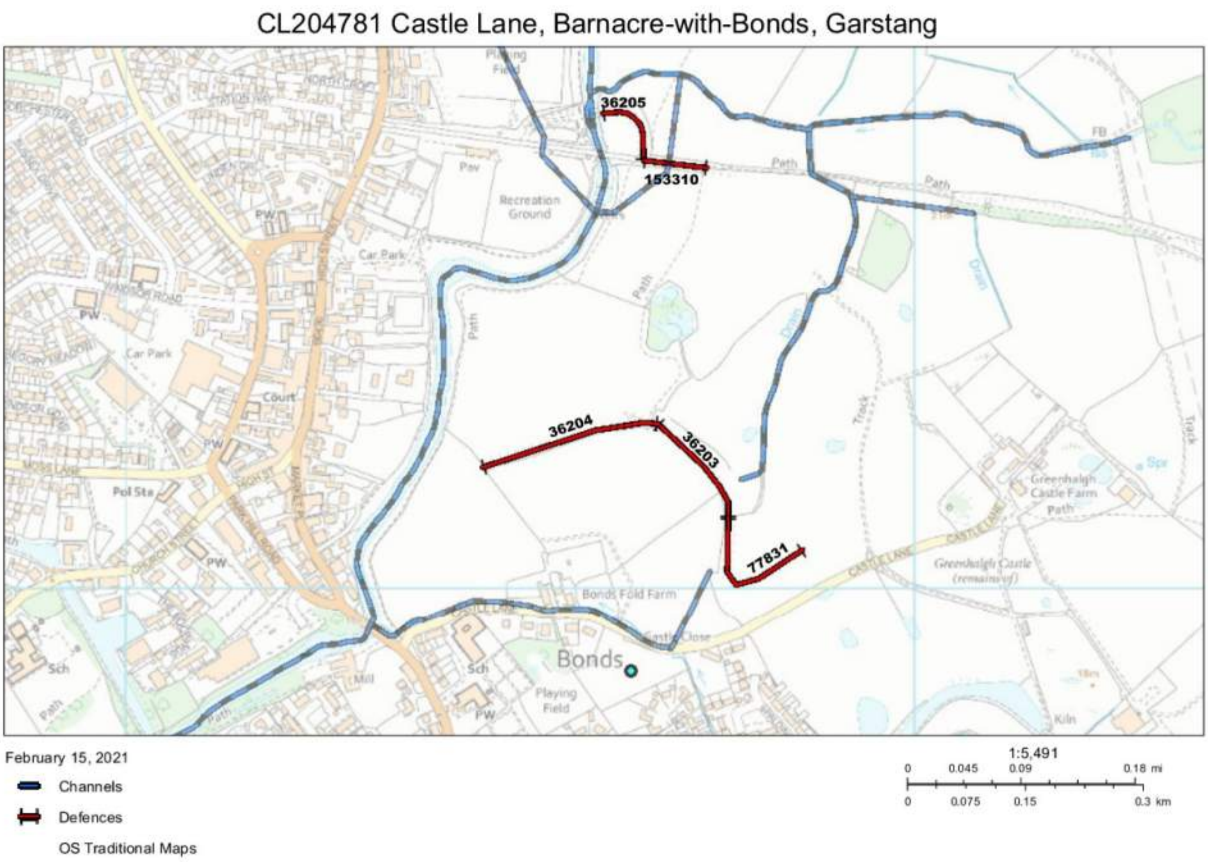

Figure 7: EA Defence Reference Plan (Source: Environment Agency, 2021)

Site Location	Castle Lane, Barnacre-with-Bonds, Garstang	CL204781

Fluvial Defences

Asset ID	National Grid Reference	Asset Type	Protection Type	Location	Maintained By	Design Standard (Return Period)	Overall Condition Grade (Excellent 1-5 Very Poor)	Effective Crest Level (m) UCL (mAOD)	Effective Crest Level (m) DCL (mAOD)	E.C.L Data Quality (Reliable 1-4 Unreliable)	Length (m)	Height (m)
36204	SD 49453 45154	Embankment	Fluvial	Concrete Ramp to End of Embankment	Environment Agency	50	2	20.08	18.93	2	230.56	1
36203	SD 49675 45209	Embankment	Fluvial	Change in bank profile to concrete ramp over embankment	Environment Agency	50	2	20.08	20.12	2	154.1	1.5
77831	SD 49764 45090	Embankment	Fluvial	Bonds Culvert to Change in bank profile	Environment Agency	50	2	19.99	20.06	1	184.48	2
36205	SD 49605 45602	Embankment	Fluvial	Doors to Old Railway Line	Environment Agency	50	2	20.16	20.05	2	99.31	3
153310	SD 49656 45542	Embankment	Fluvial	Old Railway Line	Environment Agency	50	2	20.11	20.11	1	80.9	2

The Environmental Permitting (England and Wales) Regulations 2016 require a permit to be obtained for any activities which will take place:

- **on or within 8 metres of a flood defence structure or culvert (16 metres if tidal)**
- **on or within 16 metres of a sea defence**

Figure 8: EA Defence Details Table (Source: Environment Agency, 2021)

The maps show that the site would be Fluvial Defended for the 1% AEP which has been modelled at a level of 18.90mAOD. The effects of 35% climate change would also be contained with a level of 19.04mAOD.

Once 70% climate change is allowed for over the 1% AEP a flood level of 18.06mAOD is associated with the site.

The 0.1% AEP level associated with the site is 18.31mAOD.

3.4 Surface Water Flood Risk

The EA have mapped areas prone to surface water flooding based on historic flooding information received from the lead local flood authorities and modelling based on a LiDAR/IfSAR digital terrain model, Ordnance Survey information on urban areas and a direct rainfall approach using Flood Estimation Handbook (FEH) methodology. The critical (worst case) of the 1,3 and 6-hour storm durations have been mapped with no areal reduction factor applied. No allowance is made for climate change, the mapping therefore indicates the current predicted flood risk.

The maps work in the same colour coding as described above for the fluvial maps where High-Risk AEP events are displayed in Dark Blue, Medium Risk in Blue, Low Risk in Light Blue, and Very Low Risk in White. The maps do not account for culverts/underground drainage and due to digital terrain model resolutions may also underestimate or omit small drainage channels/ditches. Figure 9 shows the resulting predicted flood risk from surface water.

Figure 9: Environment Agency Surface Water Flood Map (Source: Environment Agency, 2021, GOV.UK)

The EA surface water flood map indicates the site is at low to medium risk of surface water flooding with a predicted chance of flooding of between 1 in 1000 year (0.1% AEP) and 1 in 30 year (3.3% AEP). This is likely due to low topography that captures water in flood events and ponds until it can slowly drain into the adjacent Greenhalgh Castle Brook. This is confirmed by the topographic survey which indicates a large area that could not be surveyed due to it being flooded at the time of the survey. Careful consideration to this area of the site must be made as part of the drainage design. This area would ideally be kept separated from the habitable areas which would form part of the housing development.

According to the EA surface water flood mapping this area is likely to flood between 300 to 900mm in depth due to causes from surface water flood risk.

3.5 Wyre Strategic Flood Risk Assessments

The following documents have been received and studied as part of this report;

- Wyre Borough Council – Level 1 Strategic Flood Risk Assessment – July 2016
- Jacobs – Wyre Level 2 Strategic Flood Risk Assessment – October 2016
- Critical Drainage Areas Map

The Level 1 Strategic Flood Risk Assessment (SFRA) has been studied to understand the potential flood risk associated with the site that have not already been assessed through the EA and the DEFRA information portals. Of interest were historical flood events, outlined in Figure 7-1, Page 34 of the report, in which no events occurred to the beck adjacent to the site in question. However, numerous events covered Garstang in general. The other area of interest was the groundwater flood mapping the report provides in Figure 9-3, Page 45 of the report and this is expanded on in Section 3.6 of this report.

The Level 2 SFRA completed by Jacobs for Wyre Borough Council concentrates on areas more at risk of flooding. Garstang is covered in Section 3.5, Page 33 of their report. However, the site and Greenhalgh Castle Brook are not included within the critical areas of risk nor, is it shown be critical on the Critical Drainage Areas Map produced by Wyre Borough Council.

3.6 Groundwater Flood Risk

An intrusive ground investigation has not been undertaken at the time of writing this report. A site-specific Phase 2 ground investigation should be conducted before detailed design to check for any groundwater strikes. BGS records only show one borehole in the vicinity located 260m to the west of the site. However, the record is devoid of any information and provides no insight into groundwater levels in the area. Wyre Borough Council – Level 1 SFRA holds information on groundwater flood risk and indicates the site is at 0-<25% at risk of flooding from groundwater sources as can be seen in Figure 10 below.

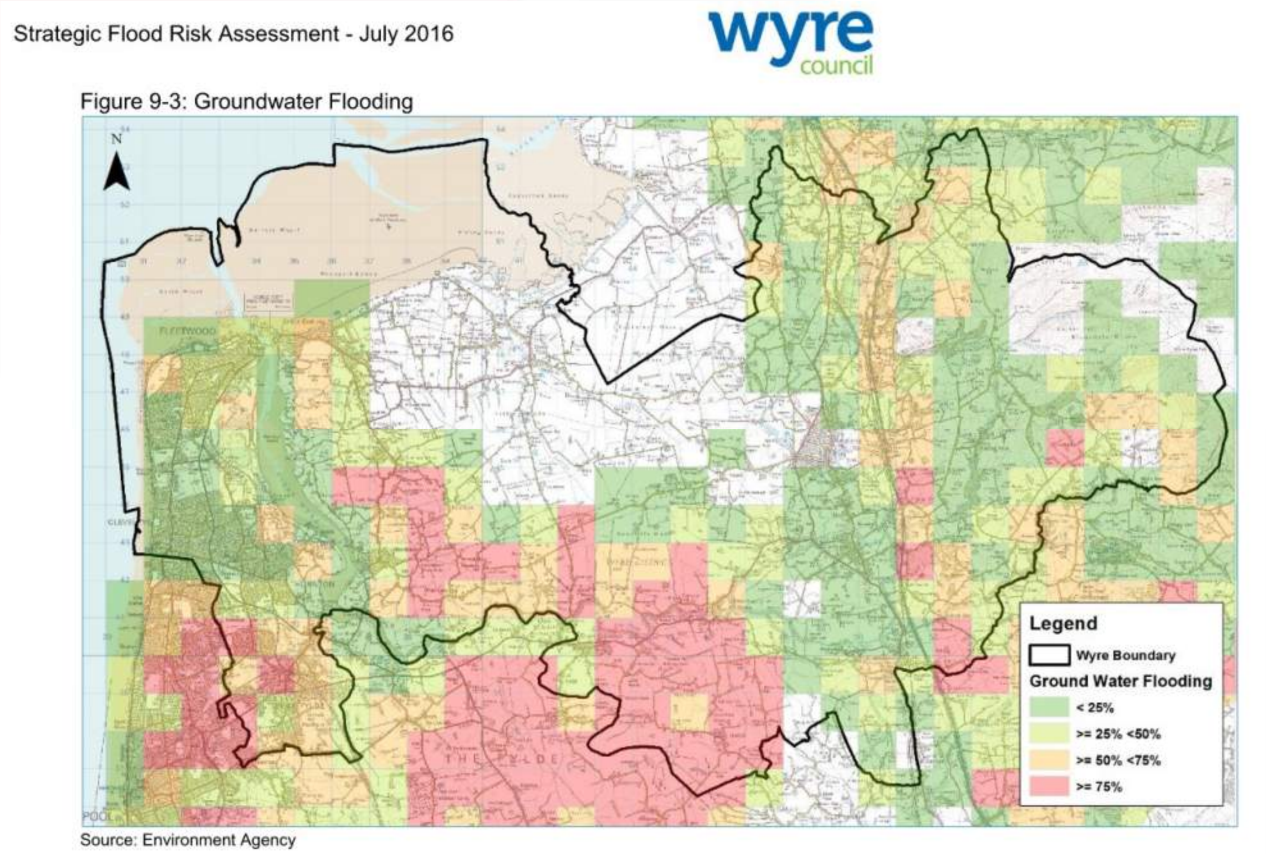

Figure 10: Groundwater Flood Map Wyre Borough Council – Level 1 SFRA (Source: Wyre Borough Council – Level 1 SFRA – 2016)

3.7 Flooding from Artificial Sources

The Reservoir Flood Map which can be seen in Figure 11, indicates the maximum extend of flooding from reservoirs highlighted in light blue. As can be seen the site is not at risk of flooding from reservoirs and has no other canals or artificial sources nearby that pose any risk of flooding.

Figure 11: Environment Agency Reservoir Flood Map (Source: Environment Agency, 2021, GOV.UK)

3.8 Flooding from Sewers

UU do not provide information on flood risk from their assets. As discussed in Section 2.3, detailed UU Sewers records have been purchased as part of this assessment and no surface water sewers are located within the site boundary or close enough to be of concern. The only sewer nearby is a 100mmø Foul Water Rising Main in Castle Lane which if was to flood would most likely spill in a westerly direction down Castle Lane.

4 FLOOD MITIGATION

4.1 Summary of Flood Risk

Source of Flood Risk	Predicted Flood Risk (AEP, %)	Interpreted Risk Classification	Justification
Fluvial	1 - 0.1%	Low	As predicted by EA
Tidal	N/A	N/A	As predicted by EA
Surface Water	0.1 – 3.3%	Low - Medium	As predicted by EA
Groundwater	0 - <25% (Not AEP Relevant)	Low	As predicted by EA in Wyre Level 1 SFRA. Phase 2 required to confirm.
Artificial Sources	N/A	Very Low	As predicted by EA and observation of sources on OS Maps
Sewer	N/A	Very Low	UU do not provide information on flooding from their assets. Therefore, based on observation of detailed UU sewer records.

Table 3: Summary of Flood Risk

4.2 Mitigation Methods

The Flood Map for Planning in Figure 2 shows part of the site situated in Flood Zone 2. The topographical survey which can be found in Appendix B shows an area of the site to the east (area can be also seen in Figure 12) which is flooded, and this corresponds with the Low risk fluvial outline in Figure 5 and the Medium to Low risk Surface Water outline in Figure 9. As there was clear evidence of flooding on the site TC enquired about Product 4 data with the EA, who provided information on their flood defences to the north of the site as discussed in Section 3.3 of this report. Due to the upstream defences it is understood the site is only to flood in the 1% AEP + 70% CC scenario and the 0.1% AEP scenario. It would be unrealistic to protect the site for the 0.1% AEP, however, the 1% AEP + 70% CC could be allowed for within the design.

Based on the flood mapping mentioned above and the flood outline from the topographical survey, which was taken during wet weather season, it has been presumed that approximately 2/3 of the site will be available for habitable areas and/or infrastructure. To protect any inhabitants on the development, the entirety of the flooded area has been left as green/landscaped. Where the existing flooding occurs a retention pond has been proposed to promote biodiversity and improve the aesthetic look of the site. Surrounding this retention pond reed beds are proposed to promote ecological growth and provide further spillage storage for storms above the flood area presented on the mapping and topographical survey.

The site entrance will be designed as to not allow flood flows down the access road and instead ensure any overland flows are directed towards Greenhalgh Castle Brook or the retention pond. The inclusion of the retention pond has also provided an excellent opportunity to provide a public amenity area.

Figure 12: Picture of the eastern extent of the site prone to flooding (Source: Google Maps, 2021)

The developments drainage strategy will likely need to review and consider the effects of a surcharged outfall. Reviewing this scenario will allow for exceedance routing to be adequately designed into the development as not to displace flood waters elsewhere that could cause concern to areas of risk (i.e. habited areas). Lastly, the access road will likely need to be raised slightly as it enters the site allowing the plots to then also be of a slightly raised nature (approximately 300mm above existing ground levels) to allow any exceedance flows within the developed areas to be conveyed down the proposed infrastructure during extreme rainfall events and above the aforementioned flood levels.

As can be seen in Figure 13 the existing land conveys overland flows to this flooded area and out of the existing access road. Therefore, this pattern will be maintained for the exceedance flows which may occur during extreme periods of rainfall or when the outfall is surcharged.

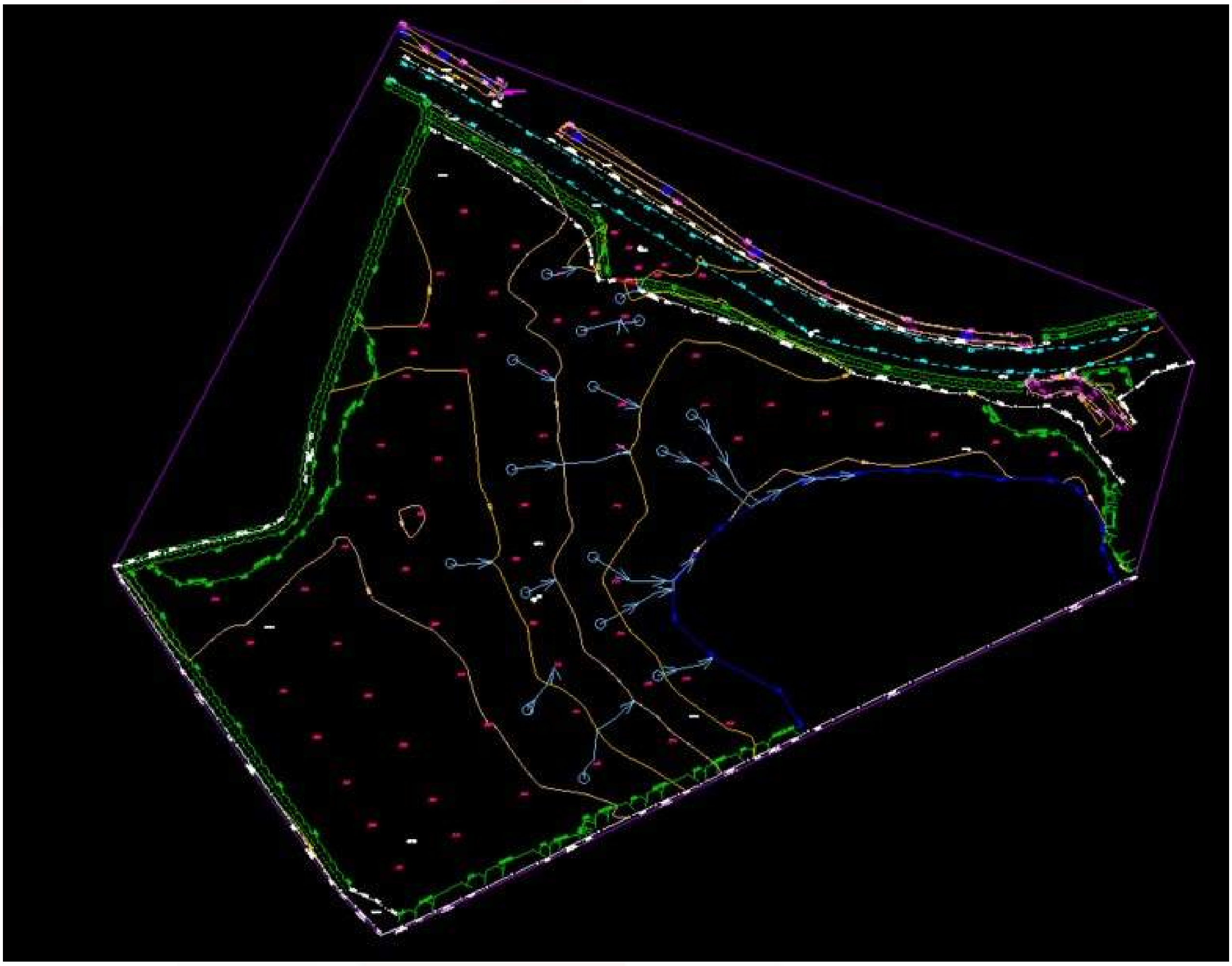

Figure 13: Overland Flow Tracing on Existing Site

5 FUTURE DRAINAGE STRATEGY CONSIDERATIONS

5.1 Site Areas

The total site area is approximately 0.755ha (7,553m²). To support the exploration of options for the potential site drainage, the spatial extent of different types of proposed land cover on the site have been assessed. Table 4 shows the estimated existing land cover areas. Table 5 shows the estimated proposed land cover areas, indicating housing roof areas cover 17% of the total site area, parking and paved areas cover 11% and road areas cover 6%. The remainder of the site is covered by gardens and soft landscaped areas (65%).

Table 4: Existing Land Cover Areas

Land Cover	Area		Percentage of total site area
	m^2	Ha	
Total impermeable area	0.0	0.0	0%
Remaining permeable area	7553	0.755	100%

Table 5: Proposed Land Cover Areas

Land Cover	Area		Percentage of total site area
	m^2	Ha	
Total housing roof area +10% Urban Creep	1310	0.131	17%
Total parking and paved area	849	0.085	11%
Total road area	472	0.047	6%
Garden & landscaped areas	4922	0.492	65%

The site can be subdivided into land cover that could be permeable and that which could be impermeable. Potential impermeable areas are regarded as housing, parking, roads, driveways, and walkways. All other areas (principally gardens) are regarded as having a permeable surface. Table 6 gives the areas of potentially permeable and impermeable land cover and shows that impermeable areas could cover 35% of the site with permeable areas covering 65%.

Table 6: Area of Potentially Impermeable & Permeable Land Cover

Land Cover	Area		Percentage of total site area
	m^2	Ha	
Total impermeable area	2631	0.263	35%
Remaining permeable area	4922	0.492	65%

For the purpose of an outline design for planning the total impermeable area has been split between the first 8 manholes which all service the site within the main access road.

5.2 Urban Creep

BS 8582:2013 outlines best practice with regard to Urban Creep. Although not a statutory requirement, future increase in impermeable area due to extensions and introduction of impervious positively drained areas will need to be considered as part of a drainage strategy for the site. An uplift of 10% on impermeable areas associated with plots only (excluding roads & paved areas) must be included within the contributing areas at detailed design.

5.3 Rate of Runoff Assessment

Full details of the calculations and the methodology for deriving the Peak Rate of Runoff are in included in Appendix E. A summary of the results is included in Table 7 below.

Table 7: Surface Water Rate of Runoff Results – Entire Development

Peak Rate of Runoff (l/s)		
Event	**Pre-Development Greenfield**	**Proposed Post-Development Restriction**
Q1	4.9	5.7
QBAR	5.7	5.7
Q10	7.8	5.7
Q30	9.7	5.7
Q100	11.8	5.7
Q100 + 30% CC	15.4	5.7

5.4 Surface Water Disposal

A drainage design should consider the hierarchy outlined in the SuDS manual. The approach considers infiltration drainage in preference to disposal to a watercourse, in preference to discharge to a public sewer.

5.5 Climate Change

Projections of future climate change indicate that more frequent short-duration, high intensity rainfall and more frequent periods of long-duration rainfall are likely to occur over the next few decades in the UK. These future changes will have implications for river flooding and for local flash flooding. These factors will lead to increased and new risks of flooding within the lifetime of planned developments.

In February 2016, new climate change guidance issued by the Environment Agency came into effect outlining the anticipated changes in extreme rainfall intensity.

Table 8 shows anticipated changes in extreme rainfall intensity in small and urban catchments. Guidance states that for site-specific flood risk assessments and strategic flood risk assessments, both the central and upper end allowances should be assessed to understand the range of impacts. A climate change allowance of 40% should be used for the purpose of drainage design based on the 100-year anticipated design life of the proposed development.

Table 8: Peak Rainfall Intensity Allowance in Small and Urban Catchments

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

5.6 Consideration of SuDS Components

A full range of SuDS components and techniques have been considered for the development of the site and their applicability to the site is discussed below.

- **Green roofs** – Have not been considered due to limitations in water volume retention. They are also not very suitable for conventional houses due to roof pitch.

- **Soakaways** – Soakaways are typically suitable for residential developments; however, due to the evidential flood issues and the fact the site is in numerous protection zones it is advised that soakaways are not utilised throughout the site.

- **Permeable paving** – Infiltration methods are not suitable as noted above. However, Type C impermeable/conveyed permeable paving systems could be utilised. However, they may not be the most suitable or effective method of conveying water due to the flooding issues located around the site.

- **Swales** – Swales provide a good option for conveyance and treatment. Swales could be considered as a way of capturing and conveying runoff towards a storage structure. However, as the basin is to flood to avoid the risk of surcharging at surface level through the implementation of swales a below ground system would be a more reliant and safer construction for the habitable areas of the site.

- **Detention Basin / Pond and Wetland** – As discussed within the Flood Risk Assessment, the existing area of the site which is subjected to flooding will be kept as a landscaped area. A detention basin provides maximum storage but in dry weather periods can become a hazard to people falling in and can sometimes be unsightly. Ponds have less storage due to having an all-year round water balance, however, they do promote biodiversity and can be a nice feature to a housing development and public amenity space. The open area to the east of the site will be utilised using one of these methods. The area will have to also be assessed under surcharged scenarios and designed as though to not overspill and increase flood risk elsewhere.

- **Geocellular Storage Tanks** – This is considered the simplest form of SuDS storage due to it being installed underground and providing high storage volumes. However, it provides little to no treatment to runoff effluent and therefore requires either another form of SuDS upstream of the tank or a manufactured separator/silt trap. It could be that geocellular storage tanks or oversized pipework will be required in addition to a detention basin to account for the storage losses of the detention basin due to existing flooding. However, the basin/pond will be the main focus to contain all surface water.

5.7 Surface Water Drainage Design Parameters

The surface water drainage system has been designed on the following basis using the modified rational method and a generated rainfall profile:

5.7.1 Rainfall Model

The calculations use the FSR data from the Flood Studies Report 1975.

5.7.2 Percentage Impermeability (PIMP)

The percentage impermeability (PIMP) for all impermeable areas is modelled as 100%. The entirety of the impermeable areas is therefore assumed to be positively drained.

5.7.3 Volumetric Runoff Coefficient (Cv)

The volumetric runoff coefficient describes the volume of surface water which runs off an impermeable surface following losses due to infiltration, depression storage, initial wetting, and evaporation. The coefficient is dimensionless. Default industry standard volumetric runoff coefficients are 0.75 for summer and 0.84 for winter.

5.7.4 Design Storm

The design storm has been set to 2 years in accordance with BS EN 752-2008.

5.7.5 Simulations

The simulations will be set to run storm durations up to 4320 minutes (3 days), usually 1400 minutes (24 hours / 1 day) would be sufficient but due to the existing flooding from Greenhalgh Castle Brook a surcharged outfall will need to be assessed. The surcharged outfall will allow surface water to continue to grow until the simulation is stopped. Therefore, as a realistic target 3 days duration is the maximum likely scenario for the storage to be assessed. The return period being focused on will be the 100 years + 40% CC (modelled as 41% to differentiate the effects of 40% with no surcharge).

5.8 Surface Water Drainage Proposals

As can be seen in Appendix A (development plans) and Appendix G (drainage layout plan) the pond has a base area of 480m² with 1 in 4 side slopes and is 1 meter deep. This equates to a total volume of 655m³. The SuDS should be sized to contain a future 100-year return period (1% AEP) event of critical duration with the future effects of climate change (CC) (40%) and urban creep (UC) (10% to housing area only) accounted for.

As discussed in Section 5.3 the existing greenfield QBar is 5.7l/s. Guidelines within the NPPF and the EA document entitled DEFRA - Sustainable Drainage Non-Statutory Technical Standards dated March 2015 state that runoff should not be increase above that of the pre-development greenfield runoff rate. Therefore, considering any proposed development layout this discharge rate is required to be achieved.

Based on the above assessment the following SuDS techniques are proposed:

- Pond
- Hydro-Brake Flow Control

It is proposed the entirety of the sites impermeable area runoff is to be drained via a combination of rainwater pipes, highway gullies and channel drains and passed through a shallow below ground drainage system (has to be shallow due to the level of the beck base) and stored within the pond whilst surface water runoff is restricted and discharged off site at greenfield QBar rates.

Causeway flow allows flow through ponds to be modelled. However, outfalls and inlets must be balanced with the base horizontally. As can be seen in Figure 14 there is more than enough storage within the pond for the 100-year return period of critical duration + 40% CC + 10% UC. However, the pond has also been designed to withstand surcharging of the adjacent Greenhalgh Castle Brook.

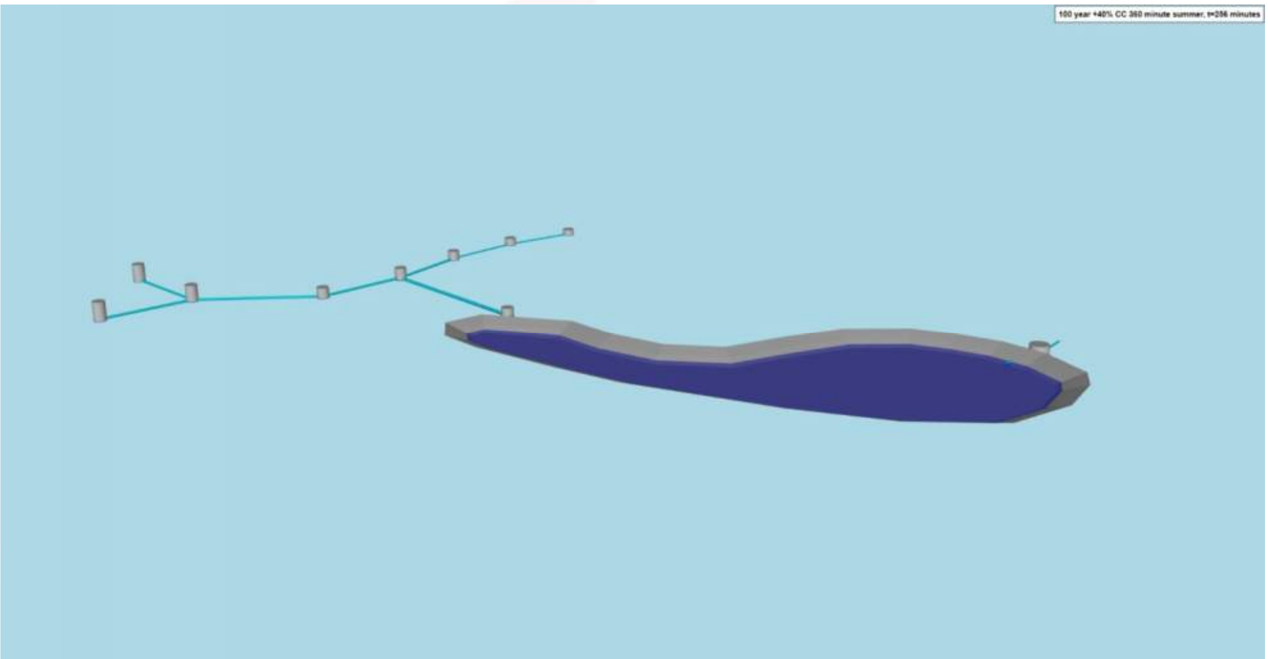

Figure 14: Causeway Flow Simulation of 100-year Return Period + 40% CC of critical duration non-surcharged

The top of the watercourse bank is approximately 17.25mAOD which has also been set as the crest of the pond. The water level within the watercourse is recorded on the topo survey at approximately 16.55mAOD (reading taken in winter months), therefore, the pipe outfall must be above this water level. The water depth within the pond when set horizontally, the outfall fully surcharged (submerged), simulated with a 100-year return period +40% allowance for CC and 10% allowance for UC, with the maximum simulation set at 3 days for the critical duration is 560mm (0.56m).

As can be seen in Figure 15, a water depth of 560mm from the ponds base equates to a storage volume of 321.8m³. The pond has a total storage volume of 654.2m³, this means that if 321.8m³ of freeboard was allowed for the balancing pond would require a balancing volume of 332.4m³. This would set the outlet invert at 575mm above the base of the bond to achieve the required balancing volume. This water level equates to 16.825mAOD. There is approximately 75mm of fall to the watercourse through the below ground network which would give an Outfall invert of 16.755mAOD, 205mm above the water level obtained during the winter months.

Subsequently this means the pond will have a balanced water level approximately 575mm deep all year round (dependant on evaporation etc during extended dry weather periods) and have enough capacity to easily store a 100-year storm + 40% CC + 10% UC in a non-surcharged scenario. The pond will also have the storage capacity to contain 3 days (4320-minute storm) of rainfall in which beyond this scenario the pond would overflow and spill in a north easterly direction as it would in its existing state.

Storms of a lower probability could risk the eventuality of the storage exceeding. Especially given the flood defences upland can only contain around a similar AEP to that of the storage provided on site. The dwellings however, would be protected above the majority of storm scenarios with FFL's all set above the 1% AEP + 70% CC flood level of 18.06mAOD.

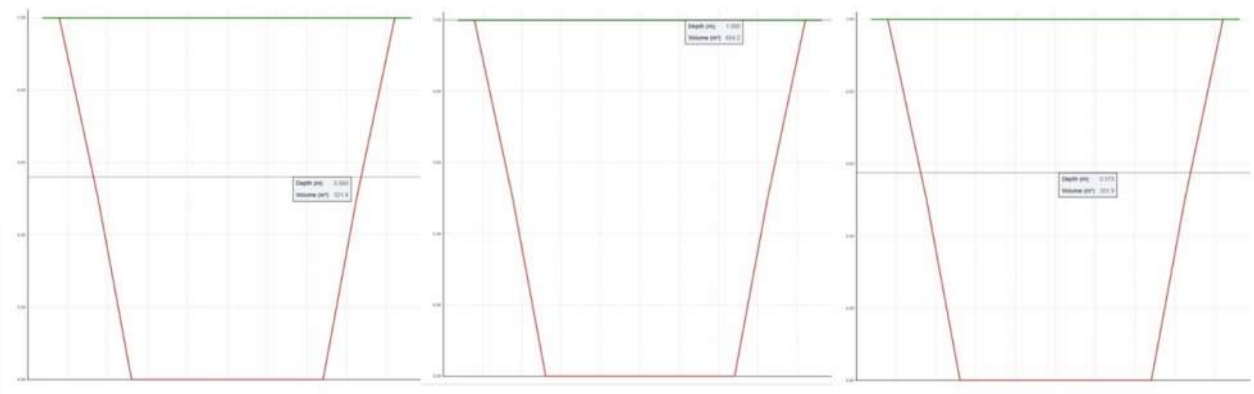

Figure 15: Causeway Flow pond depths and volumes

5.9 Designing for Local Drainage System Failure, Blockage and Exceedance

Exceedance routing in association to localised drainage failures, blockages and exceedance should be made in accordance with the general principles discussed in CIRIA Report C635 – Designing for Exceedance in Urban Drainage. The proposed surface water drainage, where practical, should be designed to ensure there is no increased risk of flooding to the buildings on the site or elsewhere as a result of extreme rainfall, lack of maintenance, blockages, or other causes.

The site drainage has been designed to store a 100-year design storm including a 40% allowance for climate change. The drainage systems will also provide capacity for lower probability (greater design storm events) which are not critical duration. Exceedance flows shall be retained on site within the drainage system as far as practical however for storms of a greater return period it may be necessary to pass forward more flow or spill flows. In this unlikely event, exceedance flows from the flow control chamber and pond will spill to Greenhalgh Castle Brook whilst the manholes within the access road could surcharge and exceedance flows be conveyed down through the site within the highway into Castle Lane away from the proposed development and again towards Greenhalgh Castle Brook downstream from the outfall.

5.10 Treatment Processes

It is recommended that treatment of the surface water run-off should be considered in accordance with CIRIA Report C753 – The SuDS Manual.

Treatment of the surface water run-off from the dwellings will first be completed via advanced silt traps, which will be placed upstream of any storage placed within the individual plots or access road. Secondly treatment will be provided within the retention pond/basin prior to surface water being discharged to Greenhalgh Castle Brook.

The simple index method as outlined in the SuDS manual has been used and full calculations can be found in Appendix H. A summary of the calculations can be found in Table 9 below.

Table 9: Drainage Treatment – Simple Index Method Approach Results

Results Summary			
Roof Area Treatment Component: Pond or Wetland			
Indices	**Suspended Soils**	**Metals**	**Hydrocarbons**
Pollution Hazard	**0.2**	**0.2**	**0.05**
Pollution Mitigation	**0.7**	**0.7**	**0.5**
Treatment Suitability	Adequate	Adequate	Adequate
Roof Area Treatment Component: Pond or Wetland			
Indices	**Suspended Soils**	**Metals**	**Hydrocarbons**
Pollution Hazard	**0.5**	**0.4**	**0.4**
Pollution Mitigation	**0.7**	**0.7**	**0.5**
Treatment Suitability	Adequate	Adequate	Adequate

6 FOUL WATER DRAINAGE STRATEGY

Foul water discharge produced from the site shall be conveyed via a gravity fed below ground drainage system located within the main access road. As can be seen in the outline drainage plan in Appendix G, proposed manhole referenced FW09 is the final chamber on the system with a cover level of 17.662 and an incoming invert level of 16.283. This manhole has been proposed in order to connect the system serving the development to the existing combined sewer located within Castle Lane. The UU manhole reference for the proposed connection in Castle Lane is 5904 and has a Cover Level of 17.67 and an Invert Level of 15.82. The outgoing pipe from this sewer is clay and is 150mm in diameter.

The distance between proposed manhole FW09 and the UU manhole 5904 is approximately 57.2m. To achieve a connection between the two manholes a 150mm diameter pipe laid at 1 in 138.5 will be required. In addition to this the foul water system like the surface water network shall have to be installed with a concrete surround applied to it or a protective slab in order to achieve the levels required due to insufficient cover beneath a highway.

Under Section 106 of The Water Industry Act 1991, 'the owner / occupier of any premises shall be entitled to have his or hers drain/sewer communicate with the public sewer of any sewerage undertaker and thereby to discharge foul water and surface water from those premises or that private sewer.' Unless 'the making of the communication would be prejudicial to the undertaker's sewerage system'.

Preliminary foul water discharge calculations have been undertaken in accordance with Sewer Sector Guidance, Design and Construction Guide, Clause B3.1. The estimated predicted peak design flow rate from the development is 0.42l/s.

Table 10: Foul Runoff Results

Sewer Sector Guidance, Design and Construction Guide, Clause B3.1	
Peak Load Based on Number of Dwellings, 9 no. units @ 4000 l/day	36000
Total Foul Flow (l/s)	0.42

7 CONCLUSIONS

- The site is approximately 0.755ha in total, with part of the site located within Flood Zone 2.
- The proposed development is classed as a minor development and according to the NPPF's PPG as a residential development the site is classed as more vulnerable to flood risk. More vulnerable developments are deemed acceptable in Flood Zone 2 provided a sufficient FRA and Drainage Strategy is provided. Additionally all habitable areas are located in Flood Zone 1.
- The site is located next to the ordinary watercourse known as Greenhalgh Castle Brook. There is also a nearby Combined Sewer in Castle Lane approximate 45m west from the site boundary. This sewer is an asset of United Utilities and is 1.85m deep and has an outgoing pipe diameter of 150mm.
- The site is at a low risk to fluvial sources. Low to medium risk of surface water flooding and low risk to groundwater sources. The site is at very low risk to all other sources.
- Product 4 data was available and has been included within this report. The EA flood defences have been designed to withstand a 1 in 50-year storm with top of defence levels ranging between 18.93mAOD and 20.12mAOD. The site is at risk of flooding from the 1% AEP + 70% CC event and 0.1% AEP event. The flooded area which was observed during winter 2021 has been self-contained and plots raised at least 300mm above the 1% AEP + 70% CC flood level.
- The site runoff is to be maintained at pre-development greenfield runoff rate. This has been calculated at 5.7l/s. Therefore, by developing the proposed housing estate and associated landscaping a betterment would be provided ensuring greenfield runoff rates across almost all storm scenarios.
- The SuDS provided have been designed to contain a 100-year storm return period plus the effects of climate change and urban creep. Additionally, the SuDS have the capacity to store a 3-day storm with an AEP of 1% before exceedance flows would be required. This has been analysed under a surcharged outfall state.
- The balance within the pond would be 575mm deep all year round excluding the effects of long-term infiltration and evaporation.
- Treatment will be provided by sumps and silt traps within upstream units and then via the primary method provided by the retention pond. Treatment has been analysed using the simple index method outlined within the SuDS Manual.
- Exceedance routes have been highlighted on the drainage layout plan provided at the back of this report. Exceedance would occur beyond a 3-day storm with a return period of 1% AEP. Exceedance flows continue the natural route of flow to the east and onto Castle Lane towards Greenhalgh Castle Brook to the north of the site.
- Foul shall discharge via gravity off site to the nearby UU combined sewer located within Castle Lane. The discharge rate from the site has been calculated at 0.42l/s.
- During the detailed design an operation and maintenance plan will be required for the drainage network and SuDS devices. The inlet pipe of the pond will also require further analyses under a surcharged state due to being permanently submerged. Additionally the catchment area of the pond will also need to be finalised and added to the contributed area.

8 REFERENCES

[1] Ministry of Housing, Communities and Local Government, *National Planning Policy Framework*, July 2018.

[2] Ministry of Housing, Communities and Local Government, *Planning Practice Guidance to the National Planning Policy Framework*, October 2019. (Some parts of the guidance backdate)

[3] GOV.UK, DEFRA/Environment Agency Online Portal.

[4] British Geological Survey (BGS), Superficial Deposits and Bedrock Geology Viewer.

[5] Land Information System (LANDIS), Soilscapes Viewer

[6] Magic Maps, Natural England Online Portal.

[7] Environment Agency, Main River Map Viewer.

[8] Wyre Council, Jacobs, *Level 2 Strategic Flood Risk Assessment Report and community Assessment*, August 2017.

[9] Marshall & Bayliss, *Flood Estimation for Small Catchments*, *Report No. 124 (IoH 124)*, Institute of Hydrology, June 1994.

[10] D.B Boorman, J.M. Hollis & A. Lilly, 1995. *Hydrology of soil types, Report No. 126. (IoH126) Institute of Hydrology*, November 1995.

[11] UK SuDS Online Tool in accordance with Environment Agency report SC030419*, Rainfall Runoff Management for Developments*, October 2013

[12] CIRIA, *The SUDS Manual Version 6, Report C753*, 2015.

[13] CIRIA, *Designing for Exceedance in Urban Drainage – Good Practice*, *Report C635*, 2006.

[14] DEFRA, *Sustainable Drainage Systems – Non-statutory technical standards for sustainable drainage systems,* March 2015.

[15] LASOO, *Non-statutory SUDS technical standards guidance,* 2016.

[16] NERC, Flood Studies Report (FSR), Institute of Hydrology, 1975.