R. G. PARKINS & PARTNERS LTD

CONSULTING CIVIL & STRUCTURAL ENGINEERS

FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY

TEEWOOD FARM
WADDINGTON
LANCASHIRE

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Disclaimer

This report was produced by R. G. Parkins & Partners Ltd for The Trustees of the Colthurst Estate for the specific purpose of providing a Flood Risk Assessment and Drainage Strategy for the proposed redevelopment of Teewood Farm, Waddington, Lancashire.

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GLOSSARY OF TERMS

Term	Description
AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BGL	Below Ground Level
BGS	British Geological Survey
CC	Climate Change
DSM	Digital Surface Model
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
FFL	Finished Floor Level
FRA	Flood Risk Assessment
GIS	Geographical Information System
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
NPPF	National Planning Policy Framework
OS	Ordnance Survey
RGP	R G Parkins and Partners Ltd
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage System
UU	United Utilities

1.0 INTRODUCTION

1.1 Background

This following report has been prepared by R. G. Parkins & Partners Ltd (RGP) for The Trustees of the Colthurst Estate in support of proposals for the demolition of several existing farm buildings, the conversion of two stone barns into dwellings and new access arrangements, at Teewood Farm, Waddington, Lancashire.

RGP has been appointed to undertake a Flood Risk Assessment and Outline Surface and Foul Water Drainage Strategy in accordance with the National Planning Policy Framework (NPPF) to support a planning application that fulfils the requirements of the Local Planning Authority and the Sewerage Undertaker.

The following study assesses flood risk to the site and proposed development and demonstrates the proposed development will not adversely affect flood risk elsewhere.

1.2 Planning Policy

The NPPF [1] and its Planning Practice Guidance [2] states “a site-specific flood risk assessment should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving: sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a strategic flood risk assessment as being at increased flood risk in the future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.”

Due to the development being residential and smaller than 0.5 ha, the development is classed as minor development in accordance with The Town and Country Planning Order 2015 [3].

1.3 The Development in the Context of Planning Policy

The area covered by the application is 0.17 ha (hectares) and by reference to the Environment Agency Flood Map, the site lies in Flood Zone 1. The latest site layout plan by John Coward Architects (drawing number 18103-02G) is included in Appendix A for reference. An FRA is not an requirement for this development, however one has been included to inform the drainage strategy.

Table 2 of the NPPF’s Planning Practice Guidance [2] classifies each development into a vulnerability class, depending on the type of development, which are outlined in Table 1.1. As a residential dwellings, the site is classified as ‘more vulnerable’. ‘More Vulnerable’ development classes are deemed acceptable in terms of flood risk within Flood Zone 1.

Table 1.1 Flood Risk Vulnerability Classification

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.

2.0 SITE CHARACTERISATION

2.1 Site Location

The proposed site is located approximately 1.60 km north west of Waddington village centre off Slaidburn Road (B6478) at National Grid Co Ordinates 372221E 445468N. The sites location is shown in Figure 2.1.

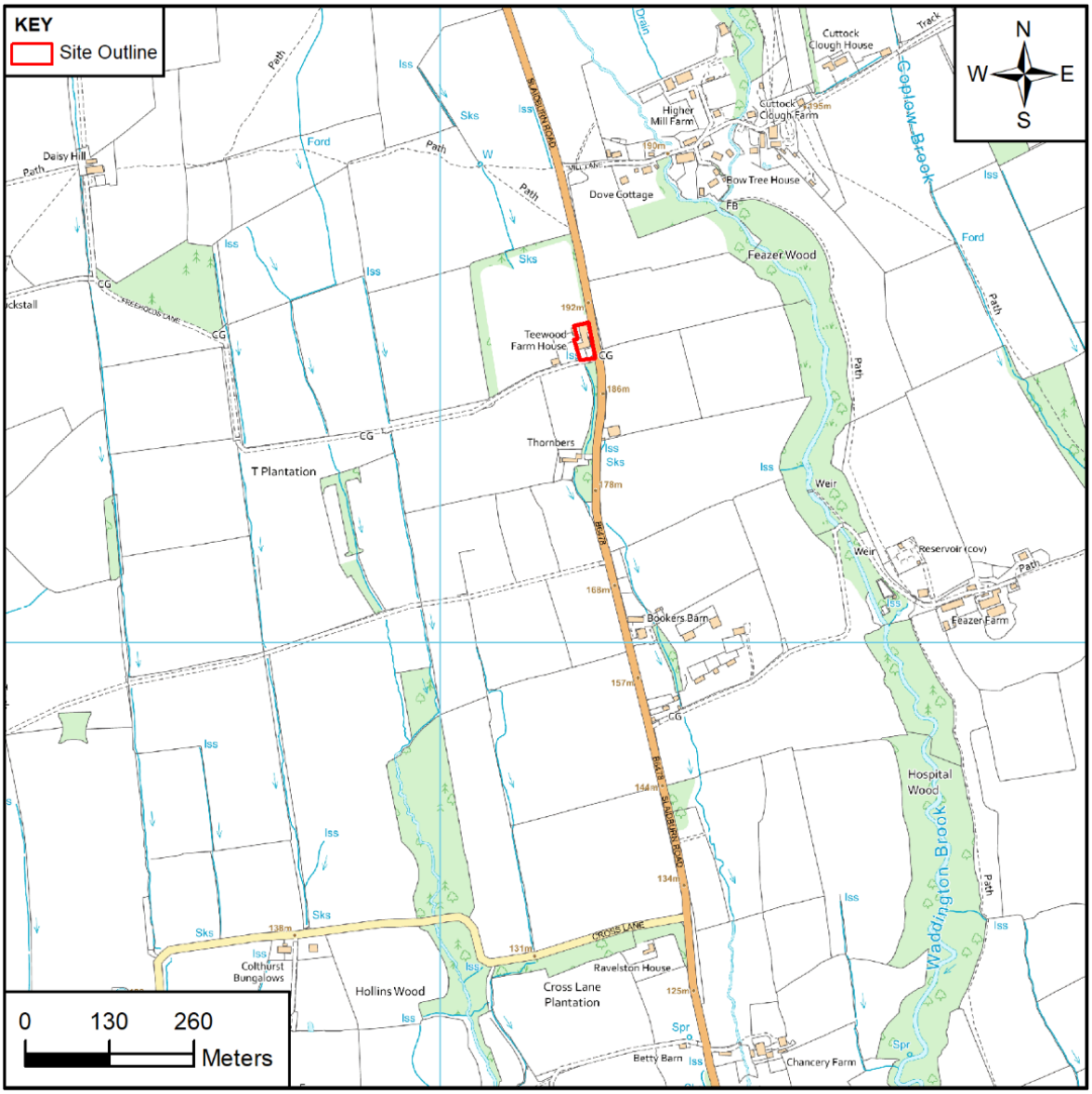


Figure 2.1 Site Location

2.2 Site Description

The site is Brownfield and covers approximately 0.17 ha (1700 m²). Teewood Farm is divided into numerous buildings comprising a farm house and several barns. The majority of the farm buildings are abandoned; however the west side of the farm house is occupied.

The site is bounded to the north by an access track, with entry onto Slaidburn Road, agricultural land lies further north and to the west. Freeholds Lane lies immediately south of the site providing access to the existing farmhouse. Slaidburn Road lies to the east.

Topographically, the site is relatively flat with levels across the site at approximately 189.00 to 190.80 mAOD, with the highest elevations in the east north towards the access road.

2.3 Development Proposals

The latest development proposals involve the demolition of the newer farm buildings, the conversion of two stone barns into dwellings and the creation of new access arrangements and landscaped areas. The existing farm house will not be affected.

2.4 Geology & Hydrogeology

British Geological Survey (BGS) [4] and Land Information Systems (LandIS) [5] mapping indicates the site is underlain by the geological sequences outlined in Table 2.1. The EA Groundwater Vulnerability Map [6] indicates the nearest Groundwater Source Protection Zone is a Zone 1 which is situated approximately 3.0km north of the site. The development site overlies a minor aquifer with 'Low' vulnerability.

Table 2.1 Site Geological Summary

Geological Unit	Classification	Description	Aquifer Classification
Soil	Soilscape 17	Slowly permeable seasonally wet acid loamy and clayey soils	N/A
Drift	Till, Devensian-Diamicton	Clay, silt, sand and gravel	**Summary:** Secondary Undifferentiated
Solid	Clitheroe Limestone Formation & Hodder Mudstone Formation	Mudstone	**Summary:** Secondary A

2.5 Existing Watercourses

The largest watercourse, Waddington Brook lies approximately 340 m east of the proposed development site. This is a minor watercourse and as such is maintained by Lancashire County Council as the LLFA.

There nearest watercourse/drainage channel lies north west of the proposed site. This drainage channel is culverted under the field immediately west of the existing farmhouse and under Freeholds Lane, reappearing immediately south of the development site. Its exact line and condition are unknown.

2.6 Existing Sewers

Reference to the United Utilities sewer records indicates that there are no public sewers in the vicinity of the site. It is assumed the existing farmhouse is served by a packaged treatment plant or septic tank.

2.7 Ground Conditions

Ground investigations have not been undertaken at the site. A site walkover confirmed the site was comprised entirely of hardstanding.

BGS records state ground conditions comprise superficial deposits of glacial till and it is therefore highly unlikely ground conditions would be favourable for infiltration.

Testing undertaken by RGP at a nearby site (c. 1.0 km south) on 27th February 2019 found ground make up to consist of light brown sandy gravelly clay overlaying dark brown firm boulder clay. Infiltration testing was undertaken at depths of 1.4 m and 0.8 m within two trial holes.

TP01 failed to drain with no discernible decrease in water level over a one hour period. There was a decrease in water level in TP02, however after 2 hours, this also failed to drain and both tests were subsequently abandoned and the soil can be described as very impermeable. There was also seepage of groundwater within TP01 suggesting a high groundwater table, reeds in a nearby field also support this.

It is therefore concluded that infiltration drainage would also not be viable of Teewood Farm.

3.0 ASSESSMENT OF FLOOD RISK

3.1 Background

The following risk assessment has been carried out in accordance with the National Planning Policy Framework [1] and its Planning Practice Guidance [2] on Flood Risk. The broad aim of the guidance is to reduce the number of people and properties within the natural and built environment at risk of flooding. To achieve this aim, planning authorities are required to ensure that flood risk is properly assessed during the initial planning stages.

Responsibility for this assessment lies with the developers and they must demonstrate:

- Whether the proposed development is likely to be affected by flooding.
- Whether the proposed development will increase flood risk in other parts of the hydrological catchment.
- That the measures proposed to deal with any flood risk are sustainable.

The developer must prove to the Local Planning Authority and the Lead Local Flood Authority that the existing flood risk or the flood risk associated with the proposed development can be satisfactorily managed.

3.2 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 3.1 shows the event return periods expressed in years and annual exceedance 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.

Table 3.1 Flood Return Periods and Exceedance Probabilities

Return Period (years)	Annual Exceedance Probability (AEP)	
	Fraction	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%

3.3 Data Collection

The following information was referred to for the Flood Risk Assessment:

- Environment Agency Flood Map for Planning covering the site and adjacent area
- Environment Agency Surface Water Flood Risk Map
- Environment Agency Reservoir Flood Risk Map
- Environment Agency Historic Flood Map
- United Utilities sewer records
- British Geological Survey Groundwater Flooding Susceptibility Map
- Development layout plan provided by John Coward Architects (Appendix A)
- Topographic survey provided by D2R Survey

3.4 Environment Agency Flood Map for Planning

The Environment Agency Flood Map for Planning [6] (Figure 3.1) has been reviewed to assess the level of flood risk to the area. The flood map shows areas that may be at risk of fluvial flooding in a 1% (1 in 100 year, dark blue) or 0.1% (1 in 1000 year, light blue) Annual Exceedance Probability (AEP) event. Alternatively, if the flood risk is tidal the flood map will show areas predicted to be at risk of flooding from the sea in a 0.5% AEP event (1 in 200 year, dark blue) or a 0.1% AEP event (1 in 1000 year, light blue).

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.

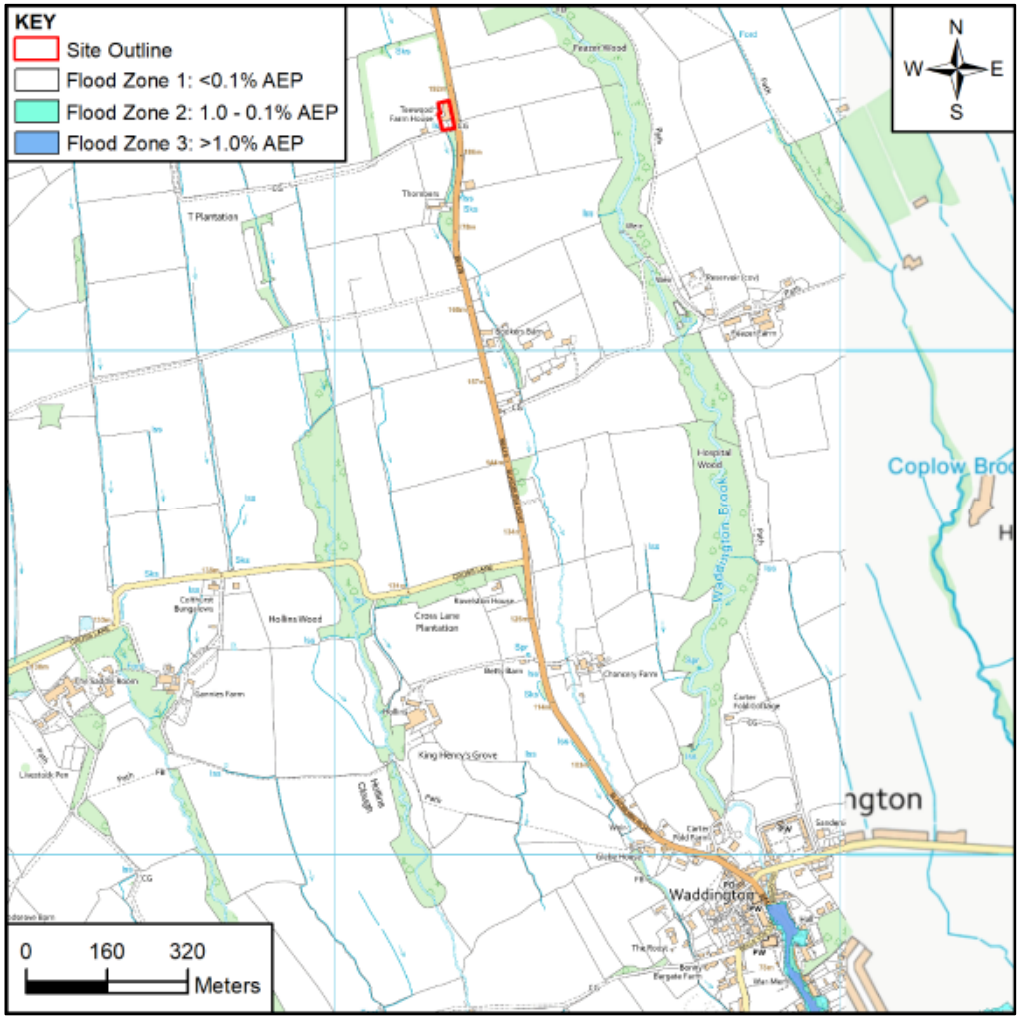


Figure 3.1 Environment Agency Flood Map for Planning

Reference to Figure 3.1 indicates the site lies within Flood Zone 1 and is considered to be at 'Very Low' risk of flooding from fluvial sources with an AEP of less than 0.1% (1 in 1000 year).

The watercourses in the vicinity of the site are classed as 'minor' watercourses and as such are regulated by the LLFA (Lancashire County Council) and are therefore not represented by the EA mapping (Figure 3.1), which only identifies flood risk from main rivers.

3.5 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 Authority 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 do not account for culverts / underground drainage and due to digital terrain model resolution may also underestimate or omit small drainage channels / ditches. Figure 3.2 shows the resulting predicted flood risk from surface water.

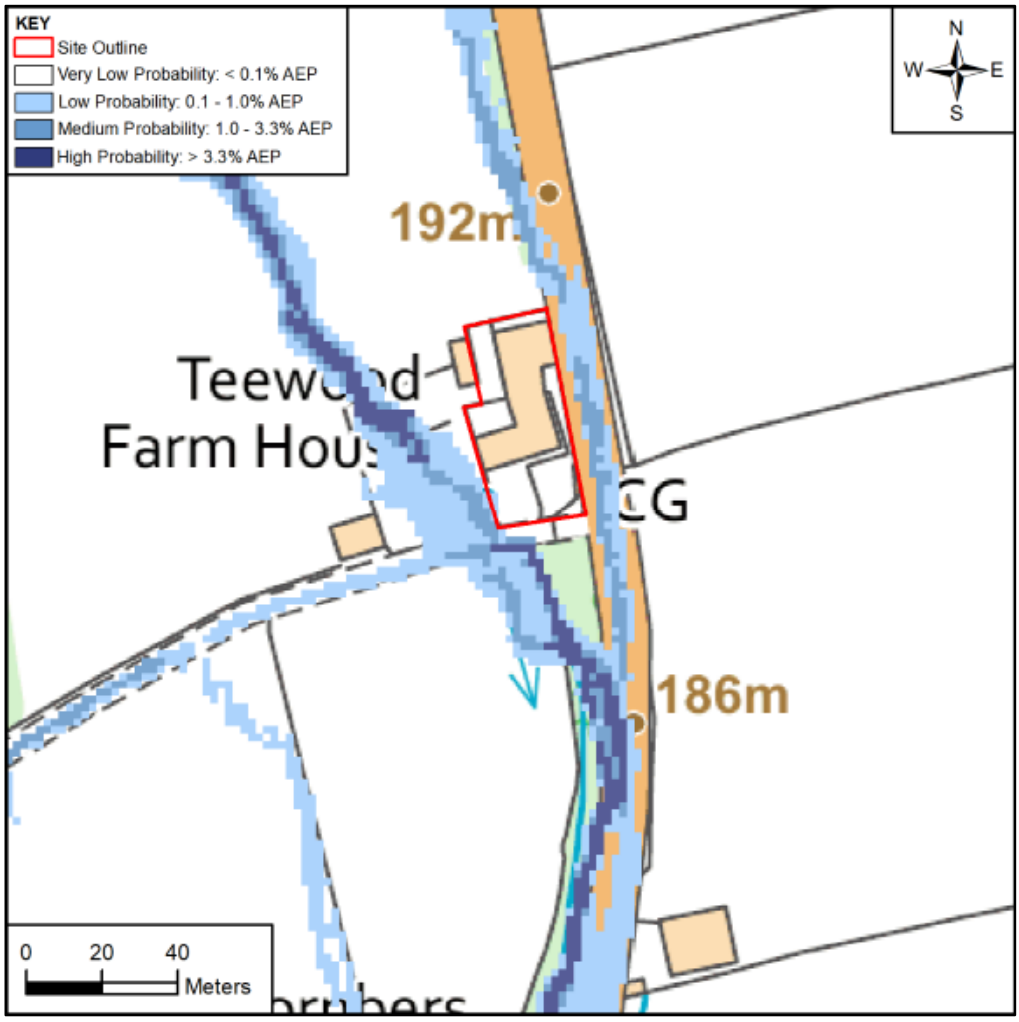


Figure 3.2 Environment Agency Surface Water Flood Map

The EA surface water flood map predicts a flow route west of the site associated with all probability events. For the 'High' and 'Medium' probability events, the flood extents are confined to a relatively narrow channel, however, during a 'Low' probability event, the flood extent is much larger. The flooding is associated with a drainage channel which is culverted under the field and under Freeholds Lane. Further analysis of the EA mapping indicates the associated flood depth for the 0.1% AEP event is predicted to be no greater than 300 mm, due to the velocity of runoff and gradient of the site. No surface water flooding is however shown within the site.

3.6 Groundwater Flood Risk

The British Geological Survey (BGS) has calculated groundwater flooding susceptibility across Britain. There are several mechanisms that increase the risk of groundwater flooding, including prolonged rainfall, high in-bank river levels and artificial structures. Figure 3.3 indicates the site has the potential for groundwater flooding to occur at the surface.

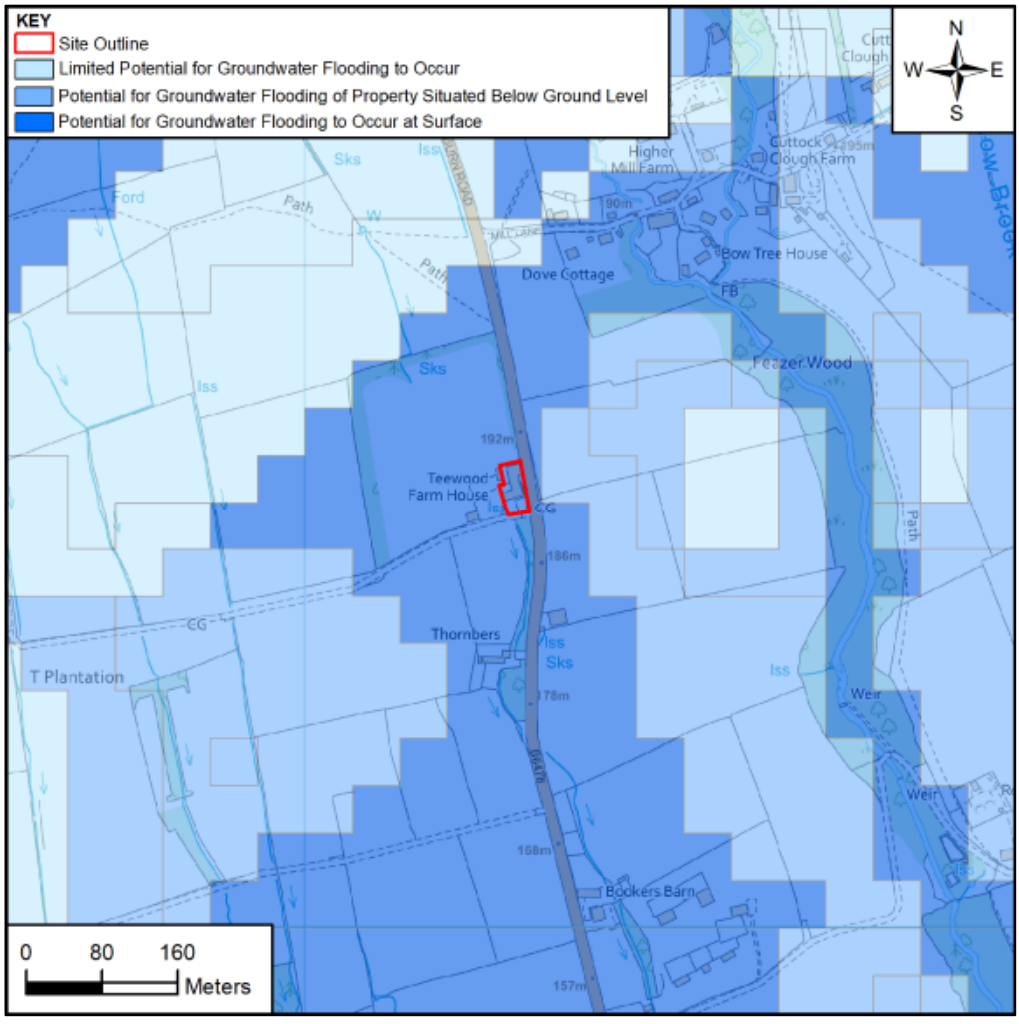


Figure 3.3 BGS Groundwater Susceptibility Flood Map

The bedrock geology is comprised of mudstone, a Secondary A aquifer, a permeable layer capable of supporting water supply. The mudstone is overlaid by Till Devensian, which has been proven by the preliminary ground investigations to be impermeable. The risk is likely to be influenced by the hydraulic continuity between groundwater and the watercourses/ditches in the vicinity of the site.

3.7 Flooding from Reservoirs, Canals or Other Artificial Sources

The Ordnance Survey map indicates that there are no reservoirs [6], canals or artificial structures in the proximity of the site.

3.8 Flooding from Sewers

United Utilities (UU) do not provide information on flood risk from their assets. There are no known sewers within the vicinity of the site, the associated risk is therefore low.

4.0 FLOOD MITIGATION

4.1 Summary of Flood Risk

The risk of flooding within the site from rivers, surface water, sewers, artificial sources and reservoirs is considered to be low. However, flooding from groundwater could cause issues on site and therefore it is recommended that mitigation measures are put in place to manage these issues. A summary of the predicted flood risk is outlined in Table 4.1.

Table 4.1 Flood Risk Summary

Source of Flood Risk	Interpreted Risk Classification	Justification
Fluvial	Low	As predicted by EA model
Surface Water	Low	As predicted by EA model
Groundwater	Medium	Indicated by BGS susceptibility maps
Artificial Sources	Extremely Unlikely	As identified by the EA
Sewer	Very Low	Engineering judgement based on sewer records

There is no requirement to raise FFL's and providing external levels are set to ensure they fall around the proposed dwellings, additional drainage is not required. The latest development proposals indicate threshold levels will be set 150 mm below the FFLs.

4.2 Permitted Development

In terms of development within Flood Zone 1, 'more vulnerable' development is appropriate in this zone, as set out in Table 3 of NPPF Planning Practice Guidance [2], included in Table 4.2.

Table 4.2 Flood Risk Vulnerability & Flood Zones Compatibility

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

5.0 SURFACE WATER DRAINAGE STRATEGY

5.1 Introduction

The principal aim of the following drainage strategy is to design the development to avoid, reduce and delay the discharge of rainfall to public sewers and watercourses in order to protect watercourses and reduce the risk of localised flooding, pollution and other environmental damage.

In order to satisfy these criteria this surface water runoff assessment and drainage design has been undertaken in accordance with the following reports and guidance documents:

- SuDS Manual, CIRIA Report C753, 2015 [9].
- Code of Practice for Surface Water Management, BS8582:2013, November 2013. [10]
- Preliminary Rainfall Runoff Management for Developments, Defra/EA, W5-074/A/TR/1, Revision D [11].
- Designing for Exceedance in Urban Drainage – Good Practice, CIRIA Report C635, 2006 [12].
- Flood Estimation Handbook (FEH) [13].
- Flood Studies Report (FSR), Volume 1, Hydrological Studies, 1993 [14].
- Flood Studies Supplementary Report No 14 (FSSR14), Review of Regional Growth Curves, 1983 [15].
- Flood Estimation for Small Catchments, Marshall & Bayliss, Institute of Hydrology, Report No. 124 (IoH 124), 1994 [16].
- Non-Statutory Technical Standards for SuDS [17]

The following assessment and drainage strategy is based on the latest site layout plan by John Coward Architects Ltd (18103-02G) included in Appendix A.

Any alterations to the site plan resulting in changes to impermeable areas will require the drainage strategy to be revisited.

5.2 Site Areas

To support the exploration of options for site drainage, the spatial extent of different types of proposed land cover on the site have been measured.

Table 5.1 shows the measured proposed land cover areas. The highest percentage is garden and landscaped areas at 40% of the total site area. Housing covers 14%, parking and paved areas 14% and the access road 26%.

Table 5.1 Land Cover Areas

Land Cover	Area		Percentage of total site area
	m^2	Ha	
Total housing roof area + 10% urban creep	245	0.025	14%
Total parking and paved area	340	0.034	20%
Total road area	435	0.044	26%
Garden areas	680	0.068	40%

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 5.2 gives the areas of potentially permeable and impermeable land cover and this shows that impermeable areas could cover 60% of the site and permeable areas 40%.

Table 5.2 Area of Potentially Impermeable & Permeable Land Cover

Land Cover	Area		Percentage of total site area
	m^2	Ha	
Total impermeable area	1020	0.102	60%
Remaining permeable area	680	0.068	40%

Currently the impermeable area of the site totals 1260 m^2, approximately 74% of the total site area.

5.3 Surface Water Disposal

Surface water disposal has been considered in line with the hierarchy outlined in the SuDS Manual. The approach considers infiltration drainage in preference to disposal to watercourse, in preference to discharge to sewer.

5.3.1 Infiltration

Infiltration testing has no been undertaken at the site, BGS records show superficial deposits to be Till, Devensian; infiltration drainage is therefore unlikely to be successful at the site.

5.3.2 Positive Drainage

The entire impermeable area of the site will require a positive drainage solution. A drainage ditch is located immediately west of the site, flowing in a south easterly direction. In line with the SuDS hierarchy for surface water disposal, discharge of surface water shall be to this drainage ditch.

5.4 Rate of Runoff Assessment

The pre-development brownfield calculations have been undertaken in accordance with methodology described in The Wallingford Procedure – V4 Modified Rational Method, Table A1 (Hydraulic Research 1983).

The site is less than 200 ha therefore the Greenfield calculations have been undertaken in accordance with methodology described in IoH 124 [16]. For catchments of less than 50ha the Greenfield runoff rate is scaled according to the size of the catchment in relation to a 50-ha site. Currently the site is brownfield and occupied by farm buildings.

Full details of the calculations and the methodology for deriving the Peak Rate of Runoff are in included in Appendix C. A summary of the results is included in Table 5.4.

Table 5.3 Surface Water Rate of Runoff Results

Rate of Runoff (l/s)			
Event	**Greenfield**	**Existing Brownfield**	**Post Development (Proposed))**
Q1	1.1	12.4	9.8
QBAR	1.2	18.2	14.4
Q10	1.7	24.8	19.5
Q30	2.1	31.4	23.9
Q100	2.6	39.2	30.9
Q100 + 30 CC	3.4	50.9	40.1

Without attenuation or infiltration, the proposed development would decrease the Rate of Runoff from the developed areas of the site, due to the reduction in impermeable areas and the introduction of landscaped areas within the site.

5.5 Surface Water Drainage Design

It is not practical to attenuate runoff due to site levels and the invert level of the proposed point of connection to the drainage channel south of the site. It is therefore proposed that runoff from the roofs and driveways will discharge unattenuated into the drainage channel as is the current situation. The access road will comprise a stone chipping surface and will therefore be permeable.

In line with the Non-Statutory Technical Standards [17] for developments that were previously developed, discharge rates should not exceed the rate of discharge from the development prior to

redevelopment for all events. Without any attenuation, the proposed development provides betterment and therefore meets these criteria.

It is however recommended a drainage survey is undertaken to confirm the line and condition of the culverted drainage ditch west of the site and also of the existing drainage connections from the farm buildings.

For further detail refer to the Drainage Layout Plan (K35392/A1/02) included in Appendix A.

6.0 FOUL WATER DRAINAGE STRATEGY

Preliminary foul water discharge calculations have been undertaken in accordance with British Water Code of Practice Flows and Loads [18], the results of which are presented in Table 6.1. There are no public sewers in the vicinity of the site and as such connection into the public system is unfeasible. A single packaged treatment plant is proposed serving both dwellings. We recommend a Kingspan Klargester BioDisc BB.

Table 6.1 Foul Runoff Results

Property size	P/ dwelling	Number of dwellings	P total
5-bedroom house	7	1	7
3-bedroom house	5	1	5

Design P for treatment plant sizing	Flow l/day	BOD g	Ammonia as N g
12	1800	720	96

Foul water shall be connected to the plant by 100 mm diameter pipes. Detailed design shall account for a gradient steeper than 1:80 to reduce the likelihood of blockages upstream of the treatment plant. Should the gradient be deemed too shallow, an electric pump may need to be installed.

The proposed packaged treatment plant will discharge 1.80 m³/day of treatment effluent to the existing drainage ditch (to be further investigated) to the south of the site. The treatment plant will therefore be in accordance with the 'General binding rules' for small sewage discharges to surface water and will not require an environmental permit.

7.0 CONCLUSIONS AND RECOMMENDATIONS

In consideration of the Flood Risk Assessment and proposed Drainage Strategy for the site the following conclusions and recommendations are made:

- The site is located within Flood Zone 1 and is at Low risk of flooding from fluvial sources. The site is also identified as being at Low risk of flooding from surface water, sewers and other artificial sources.

- By reference to the National Planning Policy Framework [1] on Flood Risk, More Vulnerable development is acceptable within these flood zones.

- It is not practical to attenuate runoff due to site levels and the invert level of the proposed point of connection to the drainage channel south of the site. It is therefore proposed that runoff from the roofs and driveways will discharge unattenuated into the drainage channel. The access roads surface will comprise stone chippings and will therefore be permeable. This is in line with current guidance provided in the Non-Statutory Technical Standards.

- Foul flows from the site shall be connected to a packaged treatment plant and treated effluent will be discharged to the drainage to the drainage ditch south of the site. The rates are in accordance with the 'General Binding Rules' for small sewage treatment plant discharge and will not require an environmental permit.

8.0 REFERENCES

[1] Ministry of Housing, Communities and Local Government, *National Planning Policy Framework*, February 2019.

[2] Ministry of Housing, Communities and Local Government, *Planning Practice Guidance to the National Planning Policy Framework*, Accessed March 2019.

[3] Defra/Environment Agency, The Town and Country Planning Order 2015, 2015 No.595, April 2015.

[4] British Geological Survey (BGS), GeoIndex Onshore, Superficial Deposits and Bedrock Geology, 1: 50,000.

[5] Land Information System (LANDIS)- Soilscapes viewer, Accessed March 2019. http://www.landis.org.uk/soilscapes

[6] Environment Agency Spatial Data Catalogue, WMS Links, March 2019. http://environment.data.gov.uk/ds/catalogue/#/catalogue

[7] Defra/Environment Agency, Flood and Coastal Defence R & D Programme- Flood Risks to People Phase 2, FD2321/TR2, March 2006.

[8] Defra/Environment Agency, Flood and Coastal Defence R & D Programme- Flood Risk Assessment Guidance for New Development Phase 2, FD2320/TR2, October 2005.

[9] CIRIA, *The SUDS Manual*, Report C753, 2015.

[10] BS8582:2013, Code of Practice for Surface Water Management, November 2013.

[11] DEFRA/EA, *Preliminary Rainfall Runoff Management for Developments*, W5-074/A/TR/1, Revision D, September 2005.

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

[13] Centre for Ecology and Hydrology, *Flood Estimation Handbook, Vols. 1 – 5 & FEH CD-ROM 3,* 2009.

[14] Institute of Hydrology, *Flood Studies Report, Volume 1, Hydrological Studies*, 1993.

[15] Institute of Hydrology, Flood Studies Supplementary Report No 14 – Review of Regional Growth Curves, August 1983.

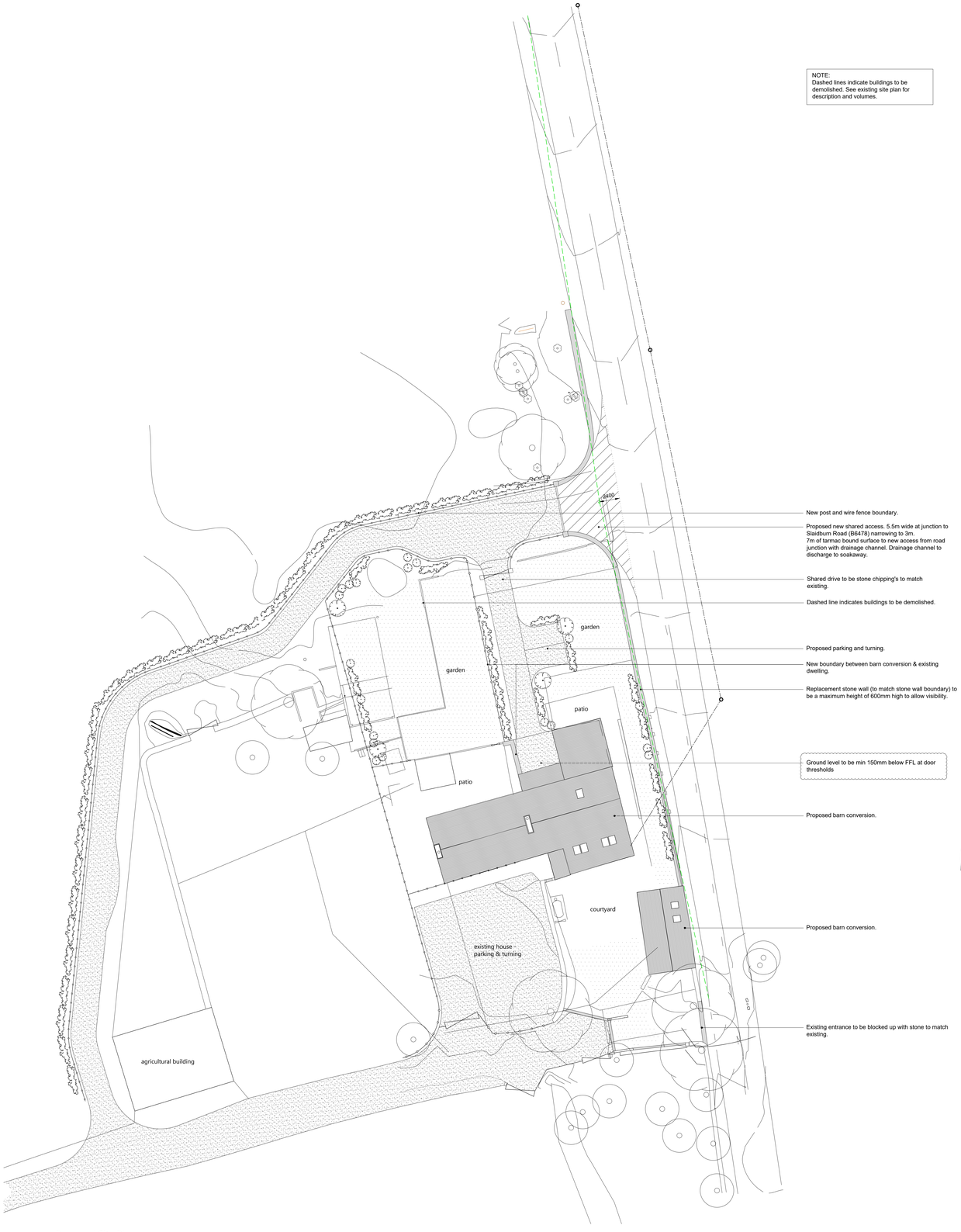
[16] Marshall & Bayliss, 1994. *Flood Estimation for Small Catchments*, *Report No. 124 (IoH 124)*, Institute of Hydrology.

[17] Department for Environment, Food and Rural Affairs, Non-*statutory Technical Standards for Sustainable Drainage Systems*, March 2015

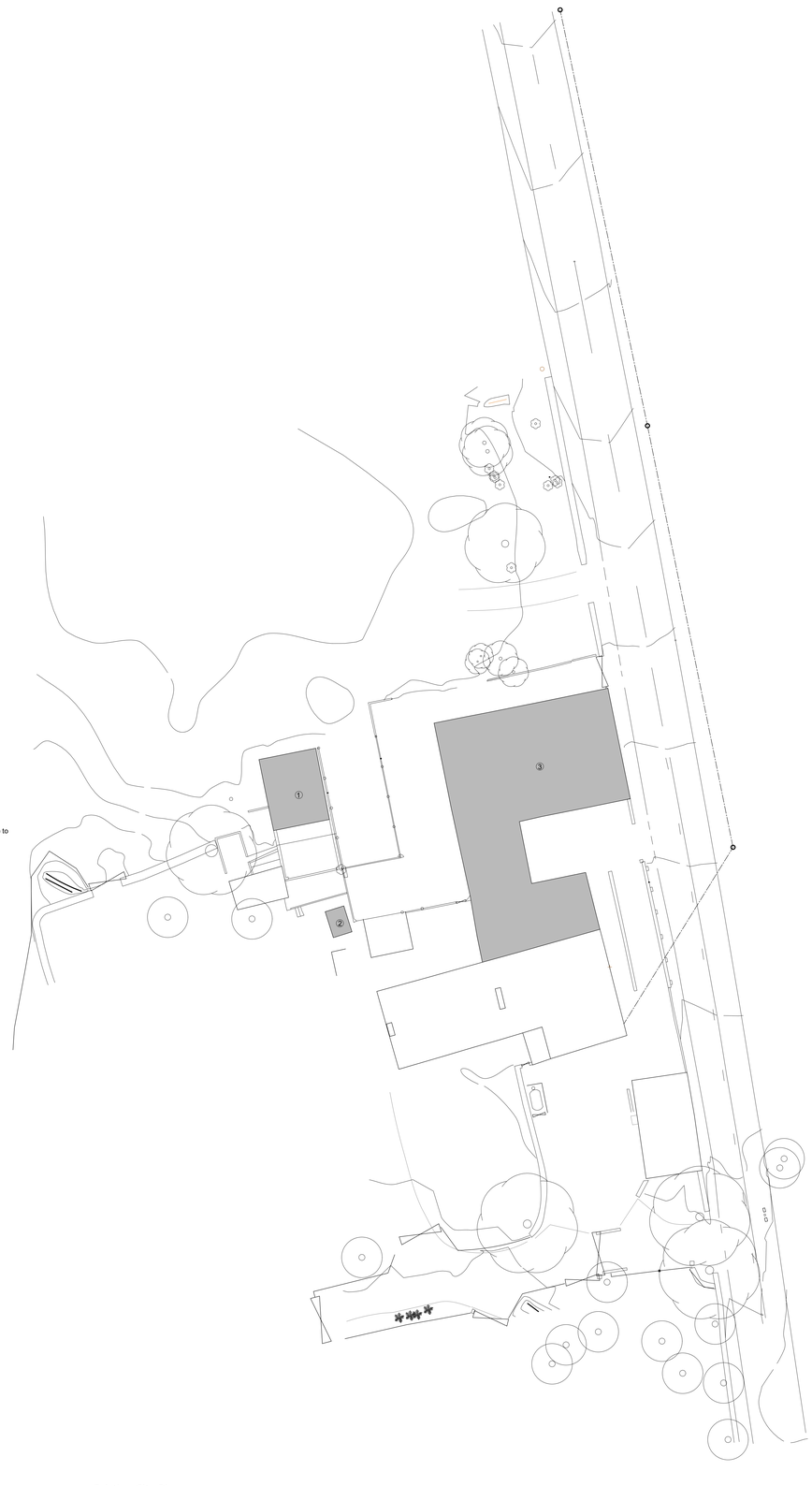
[18] British Water, Flows and Loads-4, Sizing Criteria, Treatment Capacity for Sewage Treatment Systems (2013)

APPENDIX A: DEVELOPMENT PROPOSALS

NOTE:
Dashed lines indicate buildings to be demolished. See existing site plan for description and volumes.



Proposed Site Plan
Scale 1:200



Existing Site Plan
Scale 1:200

Schedule of building to be demolished		
Building ref. no.	Description	Area (m2)
1	Barn	40.5
2	Shed	5.2
3	Collection of barns and outbuildings	309

N

REV	COMMENT	BY	DATE
G	Note added	sg	16-04-19
F	Alteration to driveway following client comment	cb	18-03-19
E	Alteration to driveway following client comment	cb	06-03-19
D	Client name amended	sg	07-02-19
C	Access onto carriageway amended	sg	09-01-19
B	Visibility splays amended	sg	07-01-19
A	General amendments	sg	12-12-18

PROJECT
Conversion of Teewood Farm Barns into Dwellings
Teewood Farm Barns
Slaidburn Road
Waddington

CLIENT
Mr Michael and Dr George Fisher

TITLE
Site Plan

SCALE/ A0	DRAWN	CHECKED	DATE
1:200	sg	rg	Dec '18
JOB NO	DRAWING NO		REVISION
18103	02		G

JOHN COWARD ARCHITECTS LIMITED
No. 3 Unsworth's Yard,
Ford Road,
Lancaster,
Cumbria, LA11 6PG
Tel : (015395) 36596

DO NOT SCALE – IF IN DOUBT ASK
USE FIGURED DIMENSIONS ONLY

OPEN WATERCOURSE/DRAINAGE DITCH

189.11

LINE OF EXISTING CULVERTED WATERCOURSE/DRAINAGE DITCH (to be confirmed)

IC

EXISTING INSPECTION CHAMBERS

EXISTING SURFACE WATER SEWER FOR EXISTING FARMHOUSE (to be confirmed)

RWP

CL 189.85

CONNECTION LOCATION OF EXISTING SURFACE WATER SEWER (to be confirmed)

RWP

RWP

RWP

REPLACED CONNECTION TO WATERCOURSE/DRAINAGE DITCH (to be confirmed)

RWP

CONNECTION LOCATION OF EXISTING SURFACE WATER SEWER (to be confirmed)

188.067

OPEN WATERCOURSE/DRAINAGE DITCH

N
NW NE
W E
SW SE
S

Revisions	Date	Initial	Suffix

Client:
THE COLTHURST ESTATE

Project:
BETTY BARN AND
TEEWOOD FARM

Drawing Title:
TEEWOOD FARM
DRAINAGE LAYOUT

R. G. PARKINS & PARTNERS LTD
CONSULTING CIVIL & STRUCTURAL ENGINEERS
Meadowside, Kendal, LA9 6NY
Tel: 01539 729393
Fax: 01539 740609
Email: mail@rgparkins.com
97 King Street, Lancaster, LA1 1RH
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Email: office@rgparkinslancaster

Drawn by: JB | Checked by: OS | Issue Purpose:
Scale: 1:100 | Issue Date: 22/03/19 | INFORMATION
Drawing Number: K35392/A1/01

APPENDIX B: CALCULATIONS

R G PARKINS & PARTNERS LTD	CALCULATION		Job No.	K35392	Page	1 of 8
Meadowside	Job	Teewood Farm	Drg no.	N/A	Date	25/03/2019
Shap Road		Waddington	Revision	Orig	Initial	RH
KENDAL LA9 6NY	Title	Rate of Run-Off			Checked	OS

DESIGN BASIS MEMORANDUM - PEAK RATE OF RUN-OFF CALCULATION

Design Brief

The following peak rate of run-off calculations have been undertaken to determine changes in peak flow resulting from the development of a greenfield or brownfield site. These calculations are for the **Peak Rate of Run-Off** requirements only.

Background Information & References

The site area **is less than** 200ha and the Greenfield (pre-development) calculation has been undertaken in accordance with methodology described by Marshall & Bayliss, Institute of Hydrology, Report No. 124, Flood Estimation for Small Catchments, 1994 (IoH 124).

In addition, the following references have been used in the preparation of these calculations:

- Interim Code of Practice for Sustainable Drainage Systems (SUDS), CIRIA, 2004
- CIRIA, The SUDS Manual, Report C753, 2015
- Flood Estimation Handbook (FEH)
- Flood Studies Report (FSR), Volume 1, Hydrological Studies, 1993
- Flood Studies Supplementary Report No 2 (FSSR2), The Estimation of Low Return Period Floods
- Flood Studies Supplementary Report No 14 (FSSR14), Review of Regional Growth Curves, 1983
- Planning Practice guidance of the National Planning Policy Framework, Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights.

Proposed Land Use Changes

Changes to the existing site are as follows:

Brownfield Site to Brownfield Site (Reduced Impermeable Area)

Results Summary

Rate of Run-Off (l/s)			
Event	**Greenfield**	**Brownfield**	**Post-Development**
Q1	1.1	12.4	9.8
QBAR	1.2	18.2	14.4
Q10	1.7	24.8	19.5
Q30	2.1	30.4	23.9
Q100	2.6	39.2	30.9
Q100 + 30% CC	3.4	50.9	40.1

SITE AREAS (LAND COVER AREAS)

Existing Impermeable & Permeable Land Cover

Total Site Area: **0.17** ha **1700** m²

Existing Impermeable & Permeable Land Cover

Land Cover	Area		Percentage of total site area
	m²	ha	
Total impermeable area	1260	0.126	74%
Remaining permeable area	440	0.044	26%

Proposed Land Cover Areas

Land Cover	Area		Percentage of total site area
	m²	ha	
Total housing roof area + 10%	245	0.025	14%
Total parking and paved area	340	0.034	20%
Total road area	435	0.044	26%
Garden & landscaped areas	680	0.068	40%

Proposed Impermeable & Permeable Land Cover

Land Cover	Area		Percentage of total site area
	m²	ha	
Total impermeable area	1020	0.102	60%
Remaining permeable area	680	0.068	40%

ESTIMATION OF QBAR (RURAL) (GREENFIELD RUNOFF RATE)

IoH 124 based on research on small catchments < 25 km2

Method is based on regression analysis of response times
using catchments from 0.9 to 22.9 km^2

$QBAR_{rural}$ is mean annual flood on rural catchment
$QBAR_{rural}$ depends on SOIL, SAAR and AREA most significantly

$QBAR_{rural} = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$

For SOIL refer to FSR Vol 1, Section 4.2.3 and 4.2.6 and IoH 124

Contributing watershed area

Area, A	=	500000	m^2	insert 50 ha for EA
	=	0.500	km^2	small catchment method
	=	50.000	ha	

SAAR = **1297** mm — From UKSuds website (point data)

Soil index based on soil type, SOIL

$$= \frac{(0.1S1+0.3S2+0.37S3+0.47S4+0.53S5)}{(S1+S2+S3+S4+S5)}$$

Where:			
S1	=		%
S2	=		%
S3	=		%
S4	=	**100**	%
S5	=		%
		100	%

UK Suds website provides a value of 4 based on the equivalent Host value. This seems reasonable based on ground investigation.

So, SOIL = **0.47**

Note: for very small catchments it is far better to rely on local site investigation information.

$QBAR_{rural}$	=	0.497	m^3/s
	=	496.7	l/s

Small rural catchments less than 50 ha
The Environment Agency recommends that this method should be used for development sizes from 0 to 50 ha and should linearly interpolate the formula to 50 ha.

So, catchment size	=	**1250**	m^2	Excluding significant open space which would remain disconnected from the positive drainage system during flood events.
	=	0.001	km^2	
	=	0.125	ha	
$QBAR_{rural\ site}$	=	0.00124	m^3/s	
	=	**1.24**	l/s	

R G PARKINS & PARTNERS LTD	CALCULATION		Job No.	K35392	Page	4 of 8
Meadowside	Job	Teewood Farm	Drg no.	N/A	Date	25/03/2019
Shap Road		Waddington	Revision	Orig	Initial	RH
KENDAL LA9 6NY	Title	Rate of Run-Off			Checked	OS

GREENFIELD RETURN PERIOD ORDINATES

QBAR can be factored by the UK FSR regional growth curves for return periods <2 years and for all other return periods to obtain peak flow estimates for required return periods.

These regional growth curves are constant throughout a region, whatever the catchment type and size.

See Table 2.39 for region curve ordinates
Use FSSR2 Growth Curves to estimate Qbar

Reference- Pg 173-FSR V.1, ch 2.6.2

Region = **10**

Use Figure A1.1 to determine region

GREENFIELD RETURN PERIOD FLOW RATES

Return Period	Ordinate	Q (l/s)
1	0.87	1.08
2	0.93	1.15
5	1.19	1.48
10	1.38	1.71
25	1.64	2.04
30	1.7	2.11
50	1.85	2.30
100	2.08	2.58
200	2.32	2.88
500	2.73	3.39
1000	3.04	3.77

Ordinate from FSSR2

Interpolation taken from Figure 24.2 (pg 515) SuDS Manual

R G PARKINS & PARTNERS LTD	CALCULATION		Job No.	K35392	Page	5 of 8
Meadowside	Job	Teewood Farm	Drg no.	N/A	Date	25/03/2019
Shap Road		Waddington	Revision	Orig	Initial	RH
KENDAL LA9 6NY	Title	Rate of Run-Off			Checked	OS

ESTIMATE OF BROWNFIELD RUNOFF

Total site impermeable area, A = **1250** m²

M5-60 rainfall depth = **21** mm *[Flood Studies Report (NERC, 1975)]*

Ratio M5-60/M5-2Day, r = **0.24** *[The Wallingford Proceedure - V4 Modified Rational Method, Fig A.2 (Hydraulics Research, 1983)]*

Storm Duration = 15 mins Anticipated critical duration for the site - usually 15 minutes

Duration factor, Z1 = 0.56 *[The Wallingford Proceedure - V4 Modified Rational Method, Fig A.3b (Hydraulics Research, 1983)]*

M5-15 rainfall depth = 11.8 mm

Return period ratio, Z2

M1-15	0.61
M10-15	1.23
M30-15	1.50
M100-15	1.94

[The Wallingford Proceedure - V4 Modified Rational Method, Table A1 (Hydraulics Research, 1983)]

Rainfall

	Depth (mm)	Intensity, i (mm/hr)
M1-15	7.2	29
M10-15	14.4	58
M30-15	17.7	71
M100-15	22.8	91

Peak discharge, Qp = Cv Cr i A

Where:

Cv = Volumetric Runoff Coefficient
Cr = Routing Coefficient
i = Rainfall intensity (mm/hour)

Cv = 0.95
Cr = 1.3

Peak Runoff

	l/s
Q1	12.4
Q10	24.8
Q30	30.4
Q100	39.2

R G PARKINS & PARTNERS LTD	CALCULATION		Job No.	K35392	Page	6 of 8
Meadowside	Job	Teewood Farm	Drg no.	N/A	Date	25/03/2019
Shap Road		Waddington	Revision	Orig	Initial	RH
KENDAL LA9 6NY	Title	Rate of Run-Off			Checked	OS

ESTIMATION OF QBAR (BROWNFIELD RUNOFF RATE)

See Table 2.39 for region curve ordinates

Use FSSR2 Growth Curves to estimate Qbar

Reference- Pg 173-FSR V.1, ch 2.6.2

Region = **10**

Use Figure A1.1 to determine region

Return Period	Ordinate
1	0.87
2	0.93
5	1.19
10	1.38
25	1.64
30	1.70
50	1.85
100	2.08
200	2.32
500	2.73
1000	3.04

Ordinate from FSSR2

Interpolation taken from Figure 24.2 (pg 515) SuDS Manual

Qbar

Ordinate used	l/s
10 year	17.9
30 year	17.9
100 year	18.8

Proposed Brownfield Runoff, Qbar = 18.21 l/s

Using the average Qbar derived from three ordinates.

R G PARKINS & PARTNERS LTD	CALCULATION		Job No.	K35392	Page	7 of 8
Meadowside	Job	Teewood Farm	Drg no.	N/A	Date	25/03/2019
Shap Road		Waddington	Revision	Orig	Initial	RH
KENDAL LA9 6NY	Title	Rate of Run-Off			Checked	OS

ESTIMATE OF BROWNFIELD RUNOFF

Total site impermeable area, A = **985** m²

M5-60 rainfall depth **21** mm *[Flood Studies Report (NERC, 1975)]*

Ratio M5-60/M5-2Day, r **0.24** *[The Wallingford Proceedure - V4 Modified Rational Method, Fig A.2 (Hydraulics Research, 1983)]*

Storm Duration 15 mins Anticipated critical duration for the site - usually 15 minutes

Duration factor, Z1 0.56 *[The Wallingford Proceedure - V4 Modified Rational Method, Fig A.3b (Hydraulics Research, 1983)]*

M5-15 rainfall depth = 11.8 mm

Return period ratio, Z2

M1-15	0.61
M10-15	1.23
M30-15	1.50
M100-15	1.94

[The Wallingford Proceedure - V4 Modified Rational Method, Table A1 (Hydraulics Research, 1983)]

Rainfall

	Depth (mm)	Intensity, i (mm/hr)
M1-15	7.2	29
M10-15	14.4	58
M30-15	17.7	71
M100-15	22.8	91

Peak discharge, Qp = Cv Cr i A

Where:

Cv = Volumetric Runoff Coefficient
Cr = Routing Coefficient
i = Rainfall intensity (mm/hour)

Cv = 0.95
Cr = 1.3

Peak Runoff

	l/s
Q1	9.8
Q10	19.5
Q30	23.9
Q100	30.9

R G PARKINS & PARTNERS LTD	CALCULATION		Job No.	K35392	Page	8 of 8
Meadowside	Job	Teewood Farm	Drg no.	N/A	Date	25/03/2019
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ESTIMATION OF QBAR (BROWNFIELD RUNOFF RATE)

See Table 2.39 for region curve ordinates

Use FSSR2 Growth Curves to estimate Qbar

Reference- Pg 173-FSR V.1, ch 2.6.2

Region = **10**

Use Figure A1.1 to determine region

Return Period	Ordinate
1	0.87
2	0.93
5	1.19
10	1.38
25	1.64
30	1.70
50	1.85
100	2.08
200	2.32
500	2.73
1000	3.04

Ordinate from FSSR2

Interpolation taken from Figure 24.2 (pg 515) SuDS Manual

Qbar

Ordinate used	l/s
10 year	14.1
30 year	14.1
100 year	14.8

Proposed Brownfield Runoff, Qbar = 14.35 l/s

Using the average Qbar derived from three ordinates.