UK Flood Risk
Flood Risk Consultants

Flood Risk/Surface Water (SuDS) Assessment

Land at Barrow Brook, Clitheroe BB7 9BJ

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Executive Summary

UK Flood Risk Consultants has been commissioned to prepare this Flood Risk Assessment (FRA) in support of a proposal consisting of a residential development located at the land at Barrow Brook, Clitheroe BB7 9BJ.

The main sources of information to undertake flood risk assessment are the flood maps and data of the Environment Agency and the previous flood studies by the Local Authority.

The proposed development is categorised as 'more vulnerable'.

The nearest main river from the site is Barrow Brook with the risk of fluvial flooding. The site had no history of flooding.

The Environment Agency's Flood Maps show that the site lies within the Flood Zone 1 (low probability flooding). The Environment Agency's flood risk map indicates that the site is located outside the flood risk zone.

The flood risk from other sources including surface water, underground water, sewer and reservoir is low.

In order to minimise the damage and to enable quick recovery and clean up after the flooding event, it is proposed that flood resilient measures will be implemented.

As the site is located within a flood zone area, it will be necessary to make sure that the residents are fully aware of the flood risk and flood warning and evacuation during an extreme event. If necessary, during a flood event the first floor will provide a safe haven for the residents. The residents are advised to utilise the Environment Agency's Flood Warning Service available in the area.

The proposed development will lead to an increase in the surface runoff. It is estimated that approximately 290m^3 of attenuation storage will be required for storing the runoff from the 1 in 100 year 6 hour rainfall event. The surface runoff will be mitigated by implementing appropriate SuDS measures. Geo-cellular storage tanks will be implemented to attenuate the surface runoff.

This report demonstrates that the proposal will be safe, in terms of flood risk, for its design life and will not increase the flood risk elsewhere.

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Abbreviations

Abbreviation	Description
mAOD	Metres Above Ordnance Datum
DEFRA	Department for Environment, Food, and Rural Affairs
EA	Environment Agency
FRA	Flood Risk Assessment
LLFA	Lead Local Flood Authority
NPPF	National Planning Policy Framework
SFRA	Strategic Flood Risk Assessment
PFRA	Preliminary Flood Risk Assessment
SuDS	Sustainable Drainage Systems

1.0 Background

UK Flood Risk Consultants has been commissioned to prepare this Flood Risk Assessment (FRA) in support of a proposal consisting of a residential development located at the land at Barrow Brook, Clitheroe BB7 9BJ.

This FRA has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF) and the Environment Agency's Flood Risk Assessment (FRA) Guidance Note 3. and the best practices in flood risk management.

The National Planning Policy Framework sets out planning policy in order to avoid inappropriate development in areas at risk of flooding by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere.

2.0 FRA Requirements

A flood risk assessment should be undertaken for most developments located within one of the flood zones. This included developments:

- in flood zone 2 or 3 including minor development and change of use,
- 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, where they could be affected by sources of flooding other than rivers and the sea (eg, surface water drains, reservoirs),
- in an area within flood zone 1 which has critical drainage problems as notified by the Environment Agency.

The Environment Agency's standing advice should be followed if carrying out a flood risk assessment of a development classed as:

- a minor extension (household extensions or non-domestic extensions less than 250 square metres) in flood zone 2 or 3
- 'more vulnerable' in flood zone 2 (except for landfill or waste facility sites, caravan or camping sites)
- 'less vulnerable' in flood zone 2 (except for agriculture and forestry, waste treatment, mineral processing, and water and sewage treatment)
- 'water compatible' in flood zone 2.

3.0 General Description of the Site and the Proposals

3.1. Description of the site

The proposal site is located at the land at Barrow Brook, Clitheroe BB7 9BJ centred on the OS NGR 374151,438029 (**Appendix A Figure 1**). Ribble Valley Borough Council is the Local Planning Authority.

The access to the site is via A59. The site is currently being utilised as a open pastoral land. The surrounding area is mix of residential and agricultural (**Appendix A Figure 2)**.

The nearest watercourse from the site is Barrow Brook. The site topography is slightly slopping towards north with the general elevation varying from 88.26mAOD to 98.22mAOD. Further details about the existing site are provided in **Appendix B**.

3.2. Proposed Development

The proposal consists of a residential development. Further details about the proposals have not been provided during the writing of this report.

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4.0 Development and Flood Risk Policy

4.1. National Planning Policy Framework (NPPF)

The National Planning Policy Framework (NPPF) is the main driving policy which was issued by the Department for Communities and Local Government in March 2012. The NPPF sets out planning and policies related to development planning and flood risk using a sequential characterisation of risk based on planning zones and the Environment Agency's Flood Maps. The aim of the flood risk assessment is to identify which Flood Zones the site is located in and vulnerability classification relevant to the proposed development, based on an assessment of current and future conditions.

4.2. Flood Zones

The Flood Zones refer to the probability of river and sea flooding which ignores the presence of defences. The national flood maps have been developed by the Environment Agency that shows the risk of tidal and/or fluvial flooding across England and Wales for different return period events. The Environment Agency's Flood Maps are the maps which have been developed using broad scale hydraulic modelling. It is therefore important to understand that the flood maps may not be very accurate at a site-specific level which may need further field observation and measurements. The Flood Zones do not take into account of the climate change impacts which must be considered in any flood risk assessment as required by the NPPF.

4.3. Sequential and Exception Tests

As set out in the NPPF, the overall aim of the Sequential Test should be to steer new development to Flood Zone 1 (Low Probability Flooding). Where there are no reasonably available sites in Flood Zone 1, the Local Authority should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required. Where there are no reasonably available sites in Flood Zones 1 or 2, the suitability of sites in Flood Zone 3 should be considered, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required.

As the proposal site is located in Flood Zone 1, the Sequential Test will not be required for this site.

The Exception Test, as set out in paragraph 102 of the Framework, is a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where

suitable sites at lower risk of flooding are not available. There are two requirements to meet for the Exception Tests. The proposed development will provide wider sustainability benefits to the community that outweigh flood risk, and that it will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.

4.4. Vulnerability of Use and Flood Risk Assessment

The proposed development is categorised as 'more vulnerable' development (**Table 2**). The site is located in Flood Zone 1. The proposed development is therefore considered appropriate at this location (**Table 3**). It should be ensured that all types of flood risk are considered as part of the Flood Risk Assessment: *'A site-specific Flood Risk Assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall'.*

This FRA aims to demonstrate that the proposal will remain safe for its lifetime and will not increase flood risk elsewhere.

4.5. NPPF Flood Zones

Table 1 below shows the NPPF Flood Zones and the requirements and policy aims in terms of undertaking site-specific flood risk assessment.

Table 1 - NPPF Flood Zones and Requirements (NPPF Technical Guidance Table 1)

Zone 1: Low Probability Flood Zone	**This is defined as the land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).**
Appropriate uses	All uses of land are appropriate in this zone.
FRA requirements	For development proposals on sites comprising 1 ha or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a FRA.
Policy aims	Developers and local authorities should seek opportunities to reduce the overall level of flood risk through the layout and form of the development, and the appropriate application of sustainable drainage

	techniques.
Zone 2: Medium Probability Flood Zone	**This is defined as the land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1%) in any year.**
Appropriate uses	The water-compatible, less vulnerable and more vulnerable uses of land and essential infrastructure in Table 2 are appropriate in this zone. Highly vulnerable uses in Table 2 are only appropriate in this zone if the Exception Test is passed.
FRA requirements	All proposals in this zone should be accompanied by a FRA.
Policy aims	Developers and local authorities should seek opportunities to reduce the overall level of flood risk through the layout and form of the development, and the appropriate application of sustainable drainage techniques.
Zone 3a: High Probability Floo Zone	**This is defined as the land assessed as having a 1 in 100 or greater annual probability of river flooding (<1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.**
Appropriate uses	The water-compatible and less vulnerable uses of land in Table 2 are appropriate in this zone. The highly vulnerable uses (Table 2) should not be permitted in this zone. The more vulnerable and essential infrastructure uses in Table 2 should only be permitted in this zone if the Exception Test is passed.
FRA requirements	All proposals in this zone should be accompanied by a FRA.
Policy aims	Developers and local authorities should seek opportunities to:

	❖ reduce the overall level of flood risk through the layout and form of the development and the appropriate application of sustainable drainage techniques; ❖ relocate existing development to land with a lower probability of flooding; ❖ create space for flooding to occur by allocating and safeguarding open space for flood storage.
Zone 3b: Functional Floodplain	**This is the land where water has to flow or be stored in times of flood. This zone is generally defined as the land which would flood with an annual probability of 1 in 20 (5%AEP) or greater in any year. The Local Council may define the Functional Floodplain area with a different annual probability of event.**
Appropriate uses	Only the water-compatible uses and the essential infrastructure listed in Table 2 that has to be there should be permitted. It should be designed and constructed to: ❖ remain operational and safe for users in times of flood; ❖ result in no net loss of floodplain storage; ❖ not impede water flows; ❖ not increase flood risk elsewhere.
FRA requirements	All proposals in this zone should be accompanied by a FRA.
Policy aims	In this zone, developers and local authorities should seek opportunities to: ❖ reduce the overall level of flood risk through the layout and form of the development and the appropriate application of sustainable drainage techniques; ❖ relocate existing development to land with a lower probability of flooding.

Table 2 - Flood Risk Vulnerability Classification (NPPF Technical Guidance Table 2)

Essential Infrastructure	Essential transport infrastructure and strategic utility infrastructure, including electricity generating power stations and grid and primary substations.
Highly Vulnerable	❖ Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations and 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, ❖ Social services homes, prisons and hostels. ❖ Buildings used for: dwelling houses, student halls of residence, drinking establishments, nightclubs, hotels and sites used for holiday or short-let caravans and camping. ❖ Non–residential uses for health services, nurseries and education. ❖ Landfill and waste management facilities for hazardous waste.
Less Vulnerable	❖ Buildings used for shops, financial, professional and other services, restaurants and cafes, offices, industry, storage and distribution, and assembly and leisure. ❖ Land and buildings used for agriculture and forestry. ❖ Waste treatment (except landfill and hazardous waste facilities), minerals working and processing (except for sand and gravel). ❖ Water treatment plants and sewage treatment plants (if adequate pollution control measures are in place).

Water-compatible Development	❖ Flood control infrastructure, water transmission infrastructure and pumping stations. ❖ Sewage transmission infrastructure and pumping stations. ❖ Sand and gravel workings. ❖ Docks, marinas and wharves, navigation facilities. ❖ MOD defence installations. ❖ Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location ❖ Water-based recreation (excluding sleeping accommodation). ❖ Lifeguard and coastguard stations. ❖ Amenity open space, nature conservation and biodiversity, outdoor sports and recreation. ❖ Essential sleeping or residential accommodation for staff required by uses in this category, subject to a warning and evacuation plan.

Table 3 - Flood Risk Vulnerability and Flood Zone 'compatibility'

Vulnerability Classification (Refer Table 2)		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zones	Flood Zone 1	✓	✓	✓	✓	✓
	Flood Zone 2	✓	✓	Exception Test	✓	✓
	Flood Zone 3a	Exception Test	✓	✖	Exception Test	✓
	Flood Zone 3b	Exception Test	✓	✖	✖	✖

✓ Development is appropriate

✖ Development should not be permitted

5.0 Assessment of Flood Risk

5.1. History of Flooding

The Ribble Valley Borough Council's Strategic Flood Risk Assessment (Level 1 SFRA, May 2010), hereafter referred to as SFRA, has provided a brief overview of the flooding history in the area. A record of the major floods that have affected the Ribble catchment since 1600 has been put together from the British Hydrological Society's "Chronology of British Hydrological Events" and from the Environment Agency Section 105 – River Ribble Survey in 1998. The Environment Agency study found major flood events that had been reported in local newspapers. The major flood events occurred in 1771 (Ribble), 1775 (Ribble), 1866 (Ribble Calder), 1881 (Ribble, Calder, Hodder), 1923 (Ribble, Calder), and in 1936, 1995, 2000 and 2002. Despite these events, there were no records of flooding at the site.

5.2. Risk of Fluvial Flooding

The site is located in close proximity to the Barrow Brook with the risk of fluvial flooding. The Environment Agency's Flood Map around the site is shown in **Appendix A Figure 3** which shows that the site lies within the Flood Zone 1 (low probability flooding).

Flood Zone 1 is an area where flooding from rivers and the sea is very unlikely. There is less than a 1 in 1000 chance of flooding occurring in any one given year (i.e. a less than 0.1% annual probability of flooding). **Figure 4** shows the Environment Agency's flood risk map which indicates that the site is located outside of the flood risk zone.

5.3. Risk of Tidal Flooding

The watercourse is not influenced by tidal waves at this location. The risk of tidal flooding is therefore low.

5.4. Risk of Flooding From Artificial Water Bodies

There were no known flood risks from any artificial water bodies near the site.

5.5. Risk of Groundwater Flooding

In recent years groundwater has been recognised as a significant source of flooding in the UK. According to the British Geological Survey, groundwater flooding occurs when the water table in permeable rocks rises to enter basements/cellars or comes up above the ground surface. Groundwater flooding is not necessarily linked directly

to a specific rainfall event and is generally of longer duration than other causes of flooding (possibly lasting for weeks or even months).

In accordance with the SFRA, the groundwater flooding was not considered by the Environment Agency to be a significant flood risk factor in the RVBC area.

Evidence of historical groundwater flooding within the SFRA is very limited, however it is important to recognise that the risk of groundwater flooding is highly variable and heavily dependent upon local conditions at any particular time.

According to the information available from the landowner, there were no records of any groundwater flooding incidents around the site. Based on these evidences and information, it is reasonable to consider that the risk of groundwater flooding to the site is low.

5.6. Risk of Surface Water Flooding

The surface water flooding arises when the infiltration capacity of land or the drainage capacity of a local sewer network is exceeded and the excess rainwater flows overland. The severity of surface water flooding depends on several factors such as the degree of saturation of the soil before the event, the permeability of soils and geology, hill slope steepness and the intensity of land use.

Information on the risk of surface water flooding is held by the Environment Agency. The Environment Agency's Surface Water Flood Risk Maps are provided in **Appendix A Figure 5 and Figure 6** which indicate that the risk of surface water flooding to the site is 'low'.

5.7. Risk of flooding from Reservoirs

The Environment Agency's reservoir flood map in **Appendix A Figure 7** indicated that a small part of the proposed development site is located within the maximum extent of flooding from reservoir. However, according to the Environment Agency, the reservoir flooding is extremely unlikely to happen and reservoirs in the UK have an extremely good safety record; indeed there has been no loss of life in the UK from reservoir flooding since 1925. The Environment Agency is the enforcement authority for the Reservoirs Act 1975 in England and Wales. All large reservoirs must be inspected and supervised by reservoir panel engineers on a regular basis. It is therefore assumed that these reservoirs are regularly inspected and essential safety work is carried out. These reservoirs therefore present a managed residual risk.

5.8. Flood Risk from Sewers

Sewer flooding is often caused by excess surface water entering the drainage network causing sewers to surcharge.

The SFRA has provided a very limited information on sewer flooding within the area, however, there were no records of sewer flooding incidents at the site. It is important to note that previous sewer flood incidents or the lack thereof do not indicate the current or future risk to the site as upgrade work could have been carried out to alleviate any issues or conversely in areas that have not experienced sewer flooding incidents the local drainage infrastructure could deteriorate leading to future flooding.

According to the information obtained from the landowner, there were no records of sewer flooding incidents at the site in the past.

5.9. Impact of Climate Change

The Environment Agency released new climate change guidance for flood risk assessments on 19th February 2016 outlining the allowances for the impact of climate change on peak river flows, peak rainfall intensities, sea level rise, offshore wind speeds and extreme wave height. They are based on climate change projections and different scenarios of carbon dioxide (CO2) emissions to the atmosphere. There are different allowances for different epochs or periods of time over the next century.

The range of allowances in **Table 4** below is based on percentiles. A percentile is a measure used in statistics to describe the proportion of possible scenarios that fall below an allowance level. The 50th percentile is the point at which half of the possible scenarios for peak flows fall below it and half fall above it. The central allowance is based on the 50th percentile, higher central is based on the 70th percentile and the upper end is based on the 90th percentile.

Table 4 - Peak river flow allowances by river basin district (use 1961 to 1990 baseline)

River basin district	Allowance category	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)
Northumbria	Upper end	20%	30%	50%
	Higher central	15%	20%	25%
	Central	10%	15%	20%

Humber	Upper end	20%	30%	50%
	Higher central	15%	20%	30%
	Central	10%	15%	20%
Anglian	Upper end	25%	35%	65%
	Higher central	15%	20%	35%
	Central	10%	15%	25%
South East	Upper end	25%	50%	105%
	Higher central	15%	30%	45%
	Central	10%	20%	35%
Thames	Upper end	25%	35%	70%
	Higher central	15%	25%	35%
	Central	10%	15%	25%
South West	Upper end	25%	40%	85%
	Higher central	20%	30%	40%
	Central	10%	20%	30%
Severn	Upper end	25%	40%	70%
	Higher central	15%	25%	35%
	Central	10%	20%	25%
Dee	Upper end	20%	30%	45%
	Higher central	15%	20%	25%
	Central	10%	15%	20%
North West	Upper end	20%	35%	70%
	Higher central	20%	30%	35%
	Central	15%	25%	30%

Solway	Upper end	20%	30%	60%
	Higher central	15%	25%	30%
	Central	10%	20%	25%
Tweed	Upper end	20%	25%	45%
	Higher central	15%	20%	25%
	Central	10%	15%	20%

Using peak river flow allowances for flood risk assessments

The guideline suggests to consider the flood zone and the appropriate flood risk vulnerability classification to decide which allowances applies to the development or plan.

In flood zone 2

Essential infrastructure – use the higher central and upper end to assess a range of allowances

Highly vulnerable – use the higher central and upper end to assess a range of allowances

More vulnerable – use the central and higher central to assess a range of allowances

Less vulnerable – use the central allowance

Water compatible – use none of the allowances

In flood zone 3a

Essential infrastructure – use the upper end allowance

Highly vulnerable – development should not be permitted

More vulnerable – use the higher central and upper end to assess a range of allowances

Less vulnerable – use the central and higher central to assess a range of allowances

Water compatible – use the central allowance

In flood zone 3b

Essential infrastructure – use the upper end allowance

Highly vulnerable – development should not be permitted

More vulnerable – development should not be permitted

Less vulnerable – development should not be permitted

Water compatible – use the central allowance

Assessment of Climate Change Impact for the Site

The site is located within the North West River Basin District. As the site is located in Flood Zone 1, the climate change allowances are not directly relevant for the fluvial flood risk assessment for this site.

6.0 Mitigation Measures

6.1. Recommended Finished Floor Level

In order to afford a level of protection against flooding it is normally recommended that finished floor levels are set a nominal 300mm above the 1 in 100 year annual probability fluvial flood (1% AEP) including an allowance for climate change. However, as the site is located in Flood Zone 1, raising the finished floor level on the ground of flood risk will not be necessary.

6.2. Flood Warning and Evacuation

As the site is located in Flood Zone 1, flood warning and evacuation will not be relevant.

6.3. Surface Water Runoff Management

The proposed development will lead to an increase in the impermeable surface area. It is therefore likely that the surface runoff will be increased post-development.

The surface runoff from the site will be mitigated by implementing appropriate SuDS.

The Environment Agency suggests that the developers should demonstrate that the disposal of surface water from the site will not exacerbate existing flooding from new development within Flood Zones 3 and 2, development greater than 1 ha in Flood Zone 1 and within areas that are known to suffer from surface water drainage or sewer flooding.

A surface water drainage assessment should be undertaken to demonstrate that surface water runoff from the proposed development can be effectively managed without increasing flood risk elsewhere.

6.3.1. Estimation of Greenfield Runoff Rates

The estimation of the Greenfield Runoff rate has been undertaken using the HR Wallingford's Greenfield Runoff Estimation tool available on the website: http://www.uksuds-.com/greenfieldrunoff_js.htm. The aim of the tool is to provide flow rate information based on a minimum amount of data so that anybody can use the tool. The methodology is built around the concept that a flow rate discharge constraint is needed for storm water runoff from a site, resulting in attenuation volume being needed. In addition, current drainage criteria include the requirement for the 100 year 6 hour volume to be controlled.

The tool is based on the results of simple model analysis and correlating the results against key known site parameters. As such the results need to be treated as providing indicative information only and should not be used to produce final designs of drainage systems without additional modelling being carried out.

The peak flow estimation can now be estimated using two different formulae.

1) The formula developed in IH124 (IH 1994) and use of the FSSR growth curve information for regions of the UK (FSSR 14),

2) The use of FEH statistical correlation equation revised in 2008.

However, only the IH124 method can be used without providing specific parameter values. Therefore this method has been used for estimating greenfield runoff rate from the proposed development site.

Details about the parameters used in the estimation are provided in **Appendix C** and the results are summarised in **Table 5** below. Any proposed development within the site should consider the greenfield runoff rates especially for addressing surface water discharge requirements from the developed site. These greenfield runoff rates have been utilised while developing the detailed drainage strategy for the site.

Table 5 – Greenfield Runoff Rates

Events	Calculated Greenfield runoff rates (l/s)
Qbar	9.41
1 in 1 year	8.19
1 in 30 year	15.99
1 in 100 year	19.57

6.3.2. Estimation of Surface Runoff Attenuation

HR Wallingford's technique has been used for estimating surface water attenuation requirements for sites. The estimation is based on a 1 in 100 year rainfall event of 6-hour duration. The Greenfield Runoff rates have been used as shown in **Table 6**. The estimation is based on the long-term storage volume. Climate change has been considered in the design where a climate change allowance factor of 30% has been utilised. The total site area considered for the estimation is 1.06ha with 50% area to be impermeable (i.e.0.53ha). The design parameters and the estimated attenuation of storage have been given in **Appendix D**. The estimated surface water storage volumes are summarised in **Table 6** below. The table shows that approximately 290m^3 of attenuation storage will be required for storing the excess runoff from the site.

Table 6 Estimated Surface Water Attenuation (all units in m^3)

Storage Type	Storage (m^3)
Interception storage	21.20
Attenuation storage	**288.78**
Long term storage	22.26
Treatment storage	63.60
Total storage	332.24

6.3.3. SuDS

The requirements for SuDS will ensure that any redevelopment or new development does not negatively contribute to the surface water flood risk of other properties and instead provides a positive benefit to the level of risk in the area. It will also ensure

that appropriate measures are taken to increase the flood resilience of new properties and developments in surface water flood risk areas, such as those identified as being locally important flood risk areas.

The SudS hierarchy and management train has been discussed in Paragraph 1.3.2 of the SuDS Manual (C697) which aims to mimic the natural catchment processes as closely as possible. The general hierarchy of the SuDS measures is provided in **Table 7** below.

Table 7 General Hierarchy of SuDS Measures

Measures	Definition/Description
Prevention	The use of good site design and housekeeping measures to prevent runoff and pollution (e.g. rainwater harvesting/reuse).
Source control	Control of runoff at or very near its source (e.g. soakaways, porous and pervious surfaces, green roofs).
Site control	Management of water in a local area on site (e.g. routing water to large soakaways, infiltration or detention basins)
Regional control	Management of runoff from a site or several sites (e.g. balancing ponds, wetlands).

Table 8 below presents the feasibility assessment of the SuDS measures for the site.

Table 8 General Assessment of SuDS measures for the site

SuDS Measures	Issues/Description	Feasibility for the site
Prevention Good site design and housekeeping/rainwater harvesting/infiltration devices/education.	Surface runoff can be improved by implementing rainwater harvesting using water butts.	Yes
Source Control Porous and pervious materials/soakaways/green roof/infiltration trenches/disconnect downpipes to drain to lawns or infiltrate to soakaway.	Feasibility of soakaways or porous pavement will require field infiltration tests.	Yes
Site and Regional Control	Geo-cellular underground	

Infiltration/detention basins/ balancing ponds/ wetlands/underground storage/swales/retention ponds.	storage tanks can be implemented to store surface runoff from extreme rainfall event (1 in 100 year plus climate change)	Yes

6.3.4. Proposed Sustainable Urban Drainage Systems (SuDS)

Geo-cellular underground attenuation tanks will be proposed in order to improve the surface runoff from the site. The layout of the tanks and its dimensions (area and depth) will be determined to suit the site conditions. This will be to the client's discretion ensuring 290m^3 of attenuation storage is provided.

The stored water will be discharged into the Barrow Brook near the northern site boundary subject to the approval of the Environment Agency at a rate not more than the greenfield runoff rate using hydrobrakes or similar flow control devices as shown in **Appendix E**.

Oil Interceptors

Oil interceptors will be provided prior to discharging the water into the attenuation tank. The system will include several treatment elements such as gullyceptors, Biomats & treatment geotextiles. The suitability of these types will be assessed based on the ground conditions and advice will be sought from the supplier of these products.

Repair/Maintenance and use

The landowners will be fully responsible for regular repair and maintenance of the storage tanks. The repair and maintenance will include regular inspection of silt traps, manholes, pipework and pre-treatment devices, with removal of sediment and debris as required.

7.0 Conclusion

The proposal consists of a residential development located at the land at Barrow Brook, Clitheroe BB7 9BJ.

The proposed development is categorised as 'more vulnerable'.

The nearest main river from the site is Barrow Brook with the risk of fluvial flooding. The site had no history of flooding.

The Environment Agency's Flood Maps show that the site lies within the Flood Zone 1 (low probability flooding). The Environment Agency's flood risk map indicates that the site is located outside the flood risk zone.

The flood risk from other sources including surface water, underground water, sewer and reservoir is low.

In order to minimise the damage and to enable quick recovery and clean up after the flooding event, it is proposed that flood resilient measures will be implemented.

As the site is located within a flood zone area, it will be necessary to make sure that the residents are fully aware of the flood risk and flood warning and evacuation during an extreme event. If necessary, during a flood event the first floor will provide a safe haven for the residents. The residents are advised to utilise the Environment Agency's Flood Warning Service available in the area.

The proposed development will lead to an increase in the surface runoff. It is estimated that approximately 290m^3 of attenuation storage will be required for storing the runoff from the 1 in 100 year 6 hour rainfall event. The surface runoff will be mitigated by implementing appropriate SuDS measures. Geo-cellular storage tanks will be implemented to attenuate the surface runoff.

This report demonstrates that the proposal will be safe, in terms of flood risk, for its design life and will not increase the flood risk elsewhere.

Appendix A Collection of Figures

Appendix B Existing Site Plans

Appendix C Greenfield Runoff Rates

Appendix D Surface Water Storage Requirements