Kaya
Consulting Limited

Arun Estates

Proposed Development Mounthooly Jedburgh

Stage 1 - Flood Risk Assessment

February 2019

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1 Introduction

Kaya Consulting Ltd. was commissioned by Arun Estates through Ferguson Planning to carry out a Stage 1 assessment of the risk of flooding for the proposed development on land at Mounthooly near Jedburgh.

The site is currently a grassed field, situated 5km north of Jedburgh. It is bounded by the A698 and a local access road to the south and east respectively, with existing development to the north and west. A general site location can be seen in Figure 1.

The Jed Water flows from south to north approximately 250m to the west of the site and the River Teviot flows approximately 450m to the north. Consultation of the SEPA Flood Map indicates that the site may be at risk of flooding from these watercourses. Given the risk, an initial modelling study and Stage 1 flood risk assessment has been undertaken.

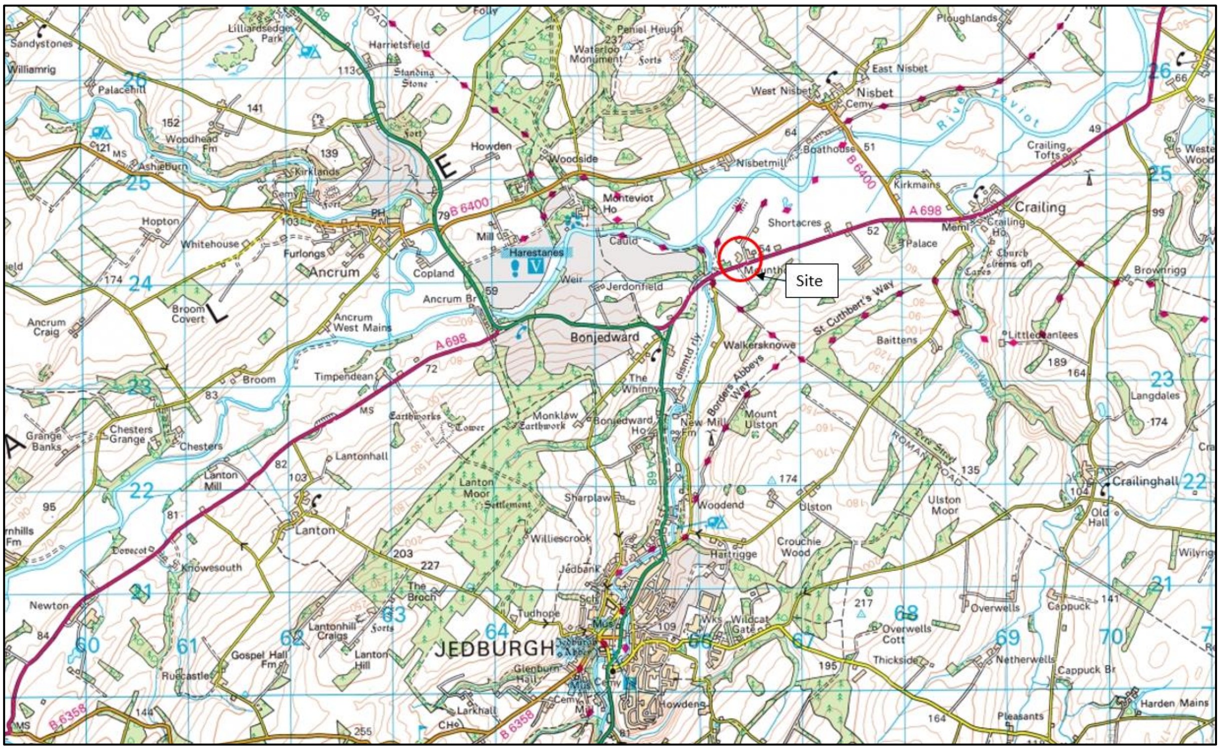
The scope of work includes the following:

- Liaise with Borders flooding team with a view of obtaining relevant information held by the council, including predicted peak water levels at site and flood inundation maps;
- Site walkover;
- Hydrological calculations to ascertain the 200 year flows in the Jed Water and Teviot;
- Mathematical modelling of both watercourses using 1D/2D modelling techniques. As the site is covered by 1m LiDAR data we will extract channel details from LiDAR, we do not propose to require topographic survey of the channel at this time. Structure dimensions will be estimated during site visit;
- Prepare 200 year flood map for site; and
- Compose a short report based on the above.

Information made available to Kaya Consulting Ltd. for the study includes the following:

- Site location map; and
- LiDAR.

Figure 1: General location of the proposed development



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2 Legislative and Policy Aspects

2.1 National Planning Policy

The current version of the Scottish Planning Policy (SPP) was published in June 2014 and replaces the previous version which was published in February 2010. The SPP sets out national planning policies which reflect Scottish Government's priorities for operation of the planning system and for the development and use of land. It relates to:

- the preparation of development plans;
- the design of development, from initial concept through to delivery; and
- the determination of planning applications and appeals.

The National Planning Framework (NPF) provides a statutory framework for Scotland's long term spatial development and sets out the Scottish Government's spatial development priorities for the next 20 to 30 years. The SPP sets out the policy that will help to deliver the objectives of the NPF.

Some extracts from the SPP are listed below:

Policy Principles

255. The planning system should promote:

- *a precautionary approach to flood risk from all sources, including coastal, water course (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts), taking account of the predicted effects of climate change;*
- *flood avoidance: by safeguarding flood storage and conveying capacity, and locating development away from functional flood plains and medium to high risk areas;*
- *flood reduction: assessing flood risk and, where appropriate, undertaking natural and structural flood management measures, including flood protection, restoring natural features and characteristics, enhancing flood storage capacity, avoiding the construction of new culverts and opening existing culverts where possible; and*
- *avoidance of increased surface water flooding through requirements for Sustainable Drainage Systems (SuDS) and minimising the area of impermeable surface.*

256. To achieve this, the planning system should prevent development which would have a significant probability of being affected by flooding or would increase the probability of flooding elsewhere. Piecemeal reduction of the functional floodplain should be avoided given the cumulative effects of reducing storage capacity.

257. Alterations and small-scale extensions to existing buildings are outwith the scope of this policy, provided that they would not have a significant effect on the storage capacity of the functional floodplain or local flooding problems.

Key Documents

- *Flood Risk Management (Scotland) Act 2009*
- *Updated Planning Advice Note on Flooding*

- *Delivering Sustainable Flood Risk Management (Scottish Government, 2011).*
- *Surface Water Management Planning Guidance (Scottish Government, 2013).*

Delivery

258. Planning authorities should have regard to the probability of flooding from all sources and take flood risk into account when preparing development plans and determining planning applications. The calculated probability of flooding should be regarded as a best estimate and not a precise forecast. Authorities should avoid giving any indication that a grant of planning permission implies the absence of flood risk.

259. Developers should take into account flood risk and the ability of future occupiers to insure development before committing themselves to a site or project, as applicants and occupiers have ultimate responsibility for safeguarding their property.

Development Planning

260. Plans should use strategic flood risk assessment (SFRA) to inform choices about the location of development and policies for flood risk management. They should have regard to the flood maps prepared by Scottish Environment Protection Agency (SEPA), and take account of finalised and approved Flood Risk Management Strategies and Plans and River Basin Management Plans.

261. Strategic and local development plans should address any significant cross boundary flooding issues. This may include identifying major areas of the flood plain and storage capacity which should be protected from inappropriate development, major flood protection scheme requirements or proposals, and relevant drainage capacity issues.

262. Local development plans should protect land with the potential to contribute to managing flood risk, for instance through natural flood management, managed coastal realignment, washland or green infrastructure creation, or as part of a scheme to manage flood risk.

263. Local development plans should use the following flood risk framework to guide development. This sets out three categories of coastal and watercourse flood risk, together with guidance on surface water flooding, and the appropriate planning approach for each (the annual probabilities referred to in the framework relate to the land at the time a plan is being prepared or a planning application is made):

- ***Little or No Risk*** *– annual probability of coastal or watercourse flooding is less than 0.1% (1:1000 years)*
    - *No constraints due to coastal or watercourse flooding.*
- ***Low to Medium Risk*** *– annual probability of coastal or watercourse flooding is between 0.1% and 0.5% (1:1000 to 1:200 years)*
    - *Suitable for most development. A flood risk assessment may be required at the upper end of the probability range (i.e. close to 0.5%), and for essential infrastructure and the most vulnerable uses. Water resistant materials and construction may be required.*
    - *Generally not suitable for civil infrastructure. Where civil infrastructure must be located in these areas or is being substantially extended, it should be designed to be capable of remaining operational and accessible during extreme flood events.*
- ***Medium to High Risk*** *– annual probability of coastal or watercourse flooding is greater than 0.5% (1:200 years)*
    - *May be suitable for:*

- *residential, institutional, commercial and industrial development within built-up areas provided flood protection measures to the appropriate standard already exist and are maintained, are under construction, or are a planned measure in a current flood risk management plan;*
- *essential infrastructure within built-up areas, designed and constructed to remain operational during floods and not impede water flow;*
- *some recreational, sport, amenity and nature conservation uses, provided appropriate evacuation procedures are in place; and*
- *job-related accommodation, e.g. for caretakers or operational staff.*

- *Generally not suitable for:*
  - *civil infrastructure and the most vulnerable uses;*
  - *additional development in undeveloped and sparsely developed areas, unless a location is essential for operational reasons, e.g. for navigation and water-based recreation, agriculture, transport or utilities infrastructure (which should be designed and constructed to be operational during floods and not impede water flow), and an alternative, lower risk location is not available; and*
  - *new caravan and camping sites.*
- *Where built development is permitted, measures to protect against or manage flood risk will be required and any loss of flood storage capacity mitigated to achieve a neutral or better outcome.*
- *Water-resistant materials and construction should be used where appropriate. Elevated buildings on structures such as stilts are unlikely to be acceptable.*

Surface Water Flooding

- *Infrastructure and buildings should generally be designed to be free from surface water flooding in rainfall events where the annual probability of occurrence is greater than 0.5% (1:200 years).*
- *Surface water drainage measures should have a neutral or better effect on the risk of flooding both on and off the site, taking account of rain falling on the site and run-off from adjacent areas.*

Development Management

264. It is not possible to plan for development solely according to the calculated probability of flooding. In applying the risk framework to proposed development, the following should therefore be taken into account:

- *the characteristics of the site;*
- *the design and use of the proposed development;*
- *the size of the area likely to flood;*
- *depth of flood water, likely flow rate and path, and rate of rise and duration;*
- *the vulnerability and risk of wave action for coastal sites;*
- *committed and existing flood protection methods: extent, standard and maintenance regime;*
- *the effects of climate change, including an allowance for freeboard;*
- *surface water run-off from adjoining land;*
- *culverted watercourses, drains and field drainage;*
- *cumulative effects, especially the loss of storage capacity;*
- *cross-boundary effects and the need for consultation with adjacent authorities;*
- *effects of flood on access including by emergency services; and*
- *effects of flood on proposed open spaces including gardens.*

265. Land raising should only be considered in exceptional circumstances, where it is shown to have a neutral or better impact on flood risk outside the raised area. Compensatory storage may be required.

266. The flood risk framework set out above should be applied to development management decisions. Flood Risk Assessments (FRA) should be required for development in the medium to high category of flood risk, and may be required in the low to medium category in the circumstances described in *the framework above, or where other factors indicate heightened risk. FRA will generally be required for applications within areas identified at high or medium likelihood of flooding/flood risk in SEPA's flood maps.*

267. Drainage Assessments, proportionate to the development proposal and covering both surface and foul water, will be required for areas where drainage is already constrained or otherwise problematic, or if there would be off-site effects.

268. Proposed arrangements for SuDS should be adequate for the development and appropriate long-term maintenance arrangements should be put in place.

2.2 SEPA Flood Map

The SEPA third generation flood maps show the likely extent of flooding for high, medium and low likelihood for fluvial, pluvial (surface water) and tidal flows. Consultation of the map indicates that the site could potentially be at risk from fluvial flooding.

2.3 SEPA Technical Flood Risk Guidance

The latest version of SEPA 'Technical Flood Risk Guidance for Stakeholders' would need to be consulted when undertaking flood risk assessments (current version is 10, July 2018). This technical guidance document is intended to outline methodologies that may be appropriate for hydrological and hydraulic modelling and sets out what information SEPA requires to be submitted as part of a Flood Risk Assessment.

SEPA Policy 41 sets out roles and responsibilities of SEPA and Planning Authorities.

2.4 SEPA Flood Risk and Land Use Vulnerability Guidance

The Version 4 of the guidance (2018) states that:

"*The purpose of this guidance is to:*

- *aid understanding of the relative vulnerability to flooding of different land uses;*
- *assist in the interpretation of SEPA's Flood Risk Planning Guidance, which is based upon the risk framework.*

SEPA has created this guidance to assist in our assessment of the vulnerability to flooding of different types of land use. Table 1 classifies the relative vulnerability of land uses, grouping them into five categories from Most Vulnerable through to Water Compatible Uses.

The classification comprises five categories: 1. Most Vulnerable Uses; 2. Highly Vulnerable Uses; 3. Least Vulnerable Uses ; 4. Essential Infrastructure; 5. Water Compatible Uses.

The classification (Table 1) is linked to the risk framework in SPP by a matrix of flood risk (Table 2). Table 2 gives a very brief outline of SEPA's likely planning response for each of the three flood risk categories of the risk framework relative to each of the five vulnerability categories.

In producing this guidance, SEPA has sought to refine and enhance the vulnerability classification and definitions identified in the SPP risk framework.

Table 1: SEPA Land Use Vulnerability Classification[1]

1. Most Vulnerable Uses	2. Highly Vulnerable Uses	3. Least Vulnerable Uses	4. Essential Infrastructure	5. Water Compatible Uses[3]
For the purpose of this guidance, **Most Vulnerable Uses** include land uses that are defined as both ***civil infrastructure*** and ***most vulnerable*** in the SPP 2014 glossary. Civil infrastructure is denoted with an asterisk (*) in the list below. Most Vulnerable Uses therefore comprise: • police stations* • ambulance stations* • fire stations* • command centers and telecommunications installations required to be operational during flooding* • emergency dispersal points* • hospitals* • schools* • care homes* • nurseries • residential institutions, e.g. prisons, children's homes • basement dwellings • isolated dwelling(s) in sparsely populated areas • dwelling houses situated behind informal embankments[2] • caravans, mobile homes, chalets and park homes intended for permanent residential use • holiday caravan, chalet, and camping sites • installations requiring hazardous substance consent (but where there is demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or with energy infrastructure, that require a coastal or water-side location, or other high flood risk areas, then the facilities should be classified as **Essential Infrastructure – see column 4**).	Comprise: • buildings used for dwelling houses • social services homes (ambulant /adult) • hostels and hotels • student halls of residence • non-residential uses for health service • landfill and sites used for waste management facilities for hazardous waste	Comprise: • shops • financial, professional, and other services • restaurants and cafés • hot-food takeaways • drinking establishments • nightclubs • offices • general industry • storage and distribution • non-residential institutions not included in Most Vulnerable or Highly Vulnerable Uses • assembly and leisure • land and buildings used for agriculture and forestry that are subject to planning control • waste treatment (except landfill and hazardous waste facilities) • minerals working and processing (except for sand and gravel)	Comprises: • essential transport infrastructure (including mass evacuation routes) that has to cross the area at risk • essential utility infrastructure that has to be located in a flood risk area for operational reasons (this includes electricity generating power stations and grid and primary sub-stations, sewage treatment plants and water treatment works, wind turbines and other energy generating technologies) • installations requiring hazardous substance consent **only** where there is demonstrable need to locate such installations for the bulk storage of materials with port or other similar facilities, or with energy infrastructure that requires a coastal, water-side, or other high flood risk area location.	Comprise: • flood control infrastructure • environmental monitoring stations • 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 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 operational warning[4] and evacuation plan.

[1] Developments that combine a mixture of uses should be placed in the higher of the relevant classes of flood risk vulnerability. The impact of a flood on the particular land use could vary within each vulnerability class. In particular, a change of use to a dwelling house within the 'Highly Vulnerable' category could significantly increase the overall flood risk, especially in relation to human health and financial impacts. Any proposal for a change of use to a dwelling house should therefore be supported by a flood risk assessment. The redevelopment (including change of use) of an existing building or site provides a valuable opportunity to reduce the vulnerability of that site to flooding and therefore to reduce overall flood risk. This can be achieved through changes to less vulnerable land uses and improvements to the management of flood risk on the site.

[2] Embankments not formally constituted under flood prevention legislation including agricultural flood embankments constructed under permitted development rights.

[3] Advice in the SPP risk framework on these activities is limited. The nature of the above activities necessitates locations that are prone to flooding. Generally, it is difficult to recommend a specific annual return period to guide development decisions for such uses. SEPA would recommend that the risk of flooding should be assessed giving particular consideration to:

1. Specific locational requirements of the development and availability of alternative locations;
2. Consideration of any loss of floodplain storage (in riverside developments) that may increase flood risk to nearby existing development and options to mitigate against this;
3. Appropriate mitigation measures, including water resistance and resilience measures;
4. Health and safety implications and the need for access, egress, and evacuation, with specific consideration of, and provision of, measures to provide for these where:
   - The development will attract the public especially vulnerable people such as children and old people.
   - Large numbers of the public may gather and where evacuation routes are limited.
   - Hazardous materials are stored or processed.

[4] In this context, specific warning does not mean a formal flood warning from SEPA. SEPA does not support the provision of flood warning as a viable reason to develop in flood risk areas. Warning is a non-structural measure that does not physically prevent flooding and has associated uncertainties.

Table 2: SEPA Matrix of Flood Risk (to be read in conjunction with our Flood Risk Planning Guidance)

Classification / Flood Risk	Most Vulnerable Uses	Highly Vulnerable Uses	Least Vulnerable Uses	Essential Infrastructure	Water Compatible Uses
Little or no risk (<0.1% AP)	No constraints	No constraints	No constraints	No constraints	No constraints
Low to medium risk (0.1% - 0.5% AP)	Generally not suitable for Civil Infrastructure: where Civil Infrastructure must be located in these areas, or is being substantially extended, it should be designed to be capable of remaining operational and accessible during extreme flood events (i.e. 0.1% AP). May be suitable for other Most Vulnerable Uses if the risk from a 0.1%AP event can be alleviated through appropriate mitigation, or where one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	Generally suitable for development though an FRA may be required at upper end of the probability range (i.e. close to 0.5% AP).	Generally suitable for development though an FRA may be required at upper end of the probability range (i.e. close to 0.5% AP).	Generally suitable for development.	Generally suitable for development.
Medium to high risk within built up area (>0.5% AP)	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use.	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use.	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use.	Suitable for essential infrastructure, designed and constructed to remain operational during floods (i.e. 0.5% AP), and not impede water flow.	Generally suitable for development - job related accommodation and some recreational, sport, amenity and nature conservation uses are only suitable provided that appropriate evacuation procedures are in place

	• Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	• Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim. • The site is protected by a flood protection scheme of the appropriate standard that is already in existence and maintained, is under construction, or is planned for in a current flood risk management plan.	• Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim. • The site is protected by a flood protection scheme of the appropriate standard that is already in existence and maintained, is under construction, or is planned for in a current flood risk management plan.		
Medium to high risk within undeveloped and sparsely developed area (>0.5% AP)	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	Generally suitable where a flood risk location is required for operational reasons and an alternative lower-risk location, is not available – development should be designed and constructed to be operational during floods (i.e. 0.5% AP), and not impede water flow.	Generally suitable for development - job related accommodation and some recreational, sport, amenity and nature conservation uses are only suitable provided that appropriate evacuation procedures are in place, and an alternative, lower risk location is not available.

2.5 Flood Risk Management (Scotland) Act 2009

The Flood Risk Management (Scotland) Act 2009 came into force on 26 November 2009. The Act repealed the Flood Prevention (Scotland) Act 1961 and introduces a more sustainable and streamlined approach to flood risk management, suited to present and future needs and to the impact of climate change. It encourages a more joined up and coordinated process to manage flood risk at a national and local level.

The Act brings a new approach to flood risk management including a framework for coordination and cooperation between all organisations involved in flood risk management, new responsibilities for SEPA, Scottish Water and local authorities in relation to flood risk management, a revised and streamlined process for flood protection schemes, new methods to enable stakeholders and the public to contribute to managing flood risk; and SEPA to act as a single enforcement authority for the safe operation of Scotland's reservoirs.

2.6 Controlled Activities Regulations

The Water Environment (Controlled Activities) (Scotland) Amended Regulations 2013 (CAR) brings new controls for discharges, abstractions, impoundments and engineering works in or near inland waters. Any such work requires authorisation (licence) from the Scottish Environment Protection Agency (SEPA) who are responsible for the implementation of the Act. The Regulations include a requirement that surface water discharge must not result in pollution of the water environment. It also makes Sustainable Drainage Systems (SuDS) a requirement for new development, with the exception of runoff from a single dwelling and discharges to coastal waters.

2.7 Climate Change

The SPP states that "*planning system should promote a precautionary approach to flood risk from all sources, including coastal, water course (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts), taking account of the predicted effects of climate change."*

One of the sustainable policy principles within the National Planning Framework is supporting climate change mitigation and adaptation including taking account of flood risk.

SEPA recommend a 20% increase in peak flow for the 0.5% AEP (1:200) event, in accordance with DEFRA (Department of Environment, Food and Rural Affairs) and recent Scottish Government research. Although the 2009 climate change predictions (UKCP09) provides information on spatial variations, for current studies a 20% increase in peak flows is assumed.

It is recommended that any site drainage design considers future estimates of increased precipitation and follows an adaptive approach.

The Climate Change (Scotland) Act 2009 also makes

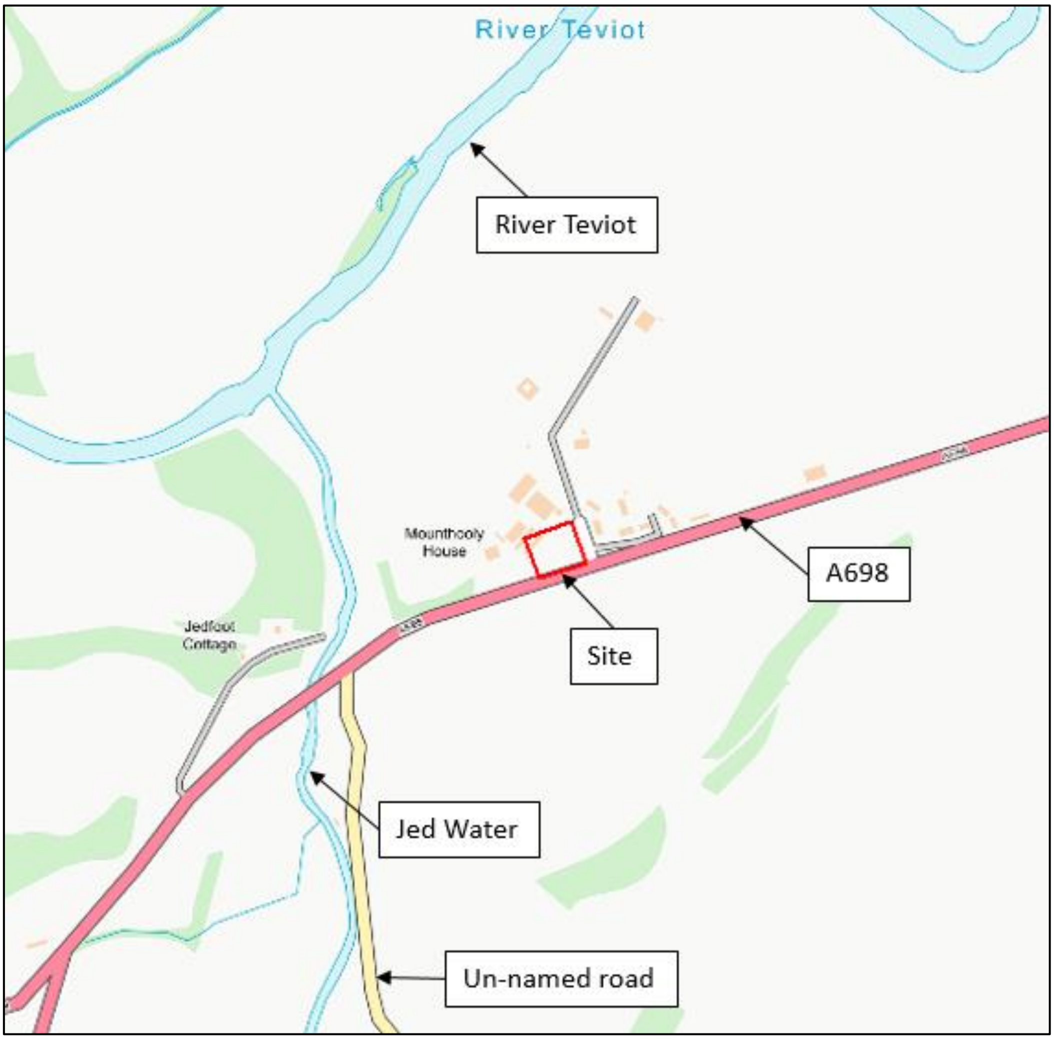
3 Site Location and Description

The site is comprised of a grassed field measuring approximately 0.4ha in area and situated 5km north of Jedburgh in the Scottish Borders. The site is bounded to the south by the A698, a local access road to the east and existing development to the north and west. Figure 2 shows the site and surrounding area.

Two watercourses flow in close proximity to the site. The River Teviot flows from east to west, approximately 450m to the north of the site; and the Jed Water which flows from south to north approximately 250m to the west. The Jed Water discharges into the River Teviot close to the north-west of the site. The confluence and both channels are also shown in Figure 2.

No other open watercourses are indicated close to the site based on Ordnance Survey maps.

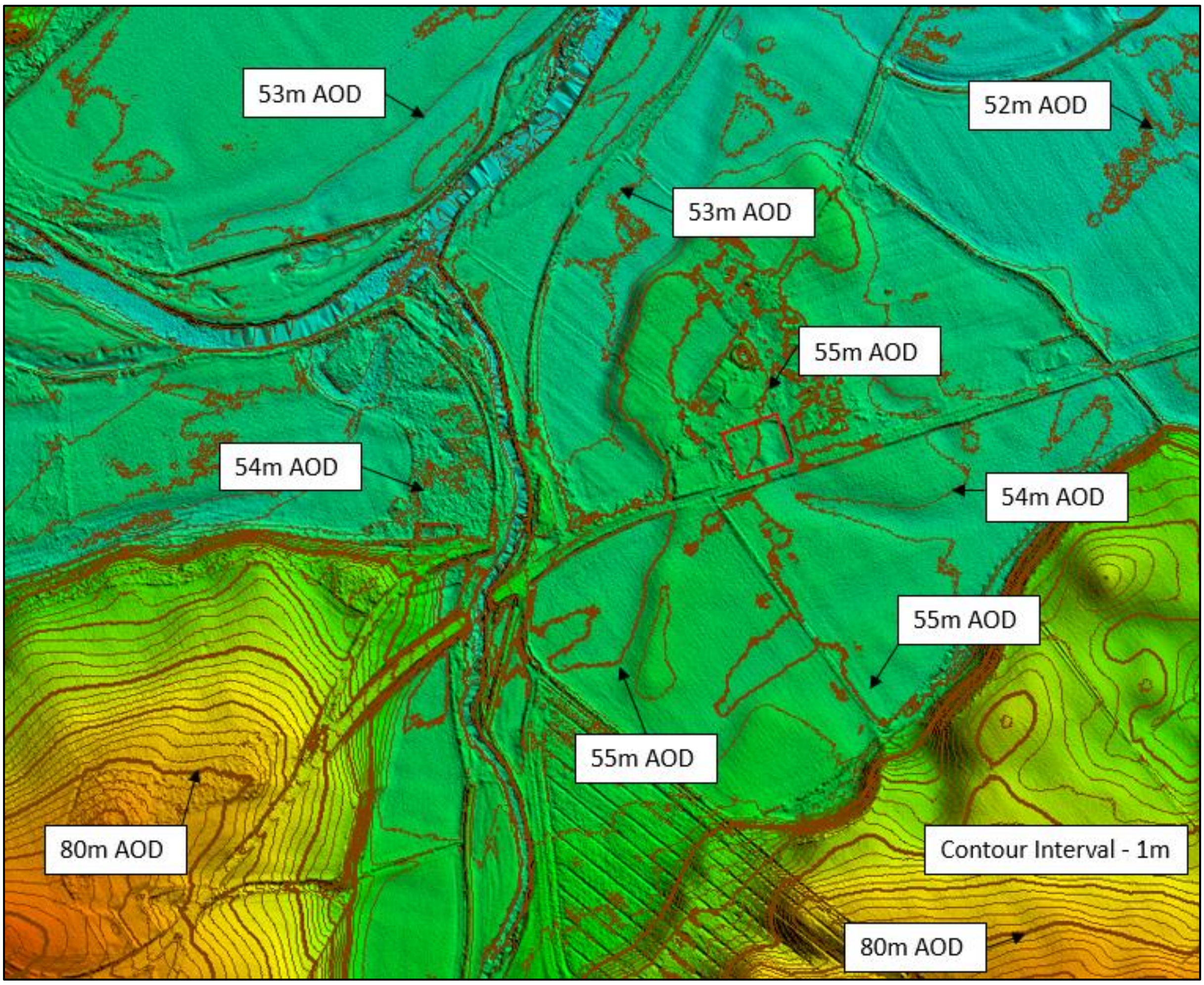
Figure 2: Detailed site location



Ground levels at the site and surround have been derived using 2m LiDAR data. Ground levels at the site are approximately 55m AOD (Above Ordnance Datum), see Figure 3 which shows the topography of the site and surrounding area (1m contours). The site is situated on relatively flat land with minor undulations within the adjacent area. Levels in the River Teviot valley vary by only a couple of metres over the approximately 1.25km width of the valley floor.

Ground levels rise to the south of the site and land also falls towards the west and north down to both river channels.

Figure 3. Topography of the site and surrounding area



Historical mapping of the area is available on the National Library of Scotland web service, when viewed on the 09/01/2019, does not show any difference from the water features on current maps.

An internet search for historical flooding of the watercourses resulting in;

- A news bulletin by the Scottish Borders Council identifying that the A698 at Mounthooly was closed due to flooding on the 27th January 2016;
- A news article on STV on the 5th December 2015 also indicated that the A698 near the site was closed due to flooding; and

- Ian Chalmers from Scottish Boarders Council Flood and Coastal Management Team reported Flooding at Mounthooly during storms in winter 2015/16 reporting

"Many of the fields and the A698 road from Bonjedward to Crailing flooding (picture shown in Photo 1) There were properties in the area affected by significant flooding at this time also. The nearby Caddy Mann Restaurant has been suffered from surface water ponding in their car park on a few occasions."

Picture 1 shows flooding to the A698 approximately 200 m to the east of the site.

The site is situated on the A698 between Bonjedward and Crailing, and Caddy Mann Restaurant is located opposite of the site to the east. Therefore, these reports of flooding, although not explicitly at the site area, are in close proximity, suggesting the site requires further investigation.

Photo 1. Flooding A698 (courtesy of Ian Chalmers: Scottish Boarders Council)

4 Hydrological Analysis

A hydrological assessment was undertaken to estimate design flows in the Jed Water and River Teviot close to the site.

Catchment characteristics for three locations have been extracted from the FEH (Flood Estimation Handbook) web-service, see Table 1.

Table 1. Catchment Characteristics

Parameter	River Teviot Downstream of Jed Water	River Teviot Upstream of Jed Water	Jed Water at the River Teviot Confluence
EASTING (m)	336250	365850	366050
NORTHING (m)	624700	624350	624300
AREA (km^2)	859.09	710.86	147.30
ALTBAR (m)	249	249	247
ASPBAR (°)	48	63	5
ASPVAR	0.14	0.14	0.25
BFIHOST	0.44.10	0.4390	0.4470
DPLBAR (km)	30.32	31.59	21.19
DPSBAR (m/km)	116.80	118.20	110.20
FARL	0.9840	0.9820	0.9970
LDP	54.22	53.67	37.27
PROPWET	0.580	0.580	0.570
SAAR (mm)	985	1002	901
SAAR4170 (mm)	1046	1064	961
SPRHOST	42.31	42.08	43.47
URBCONC1990	-	-	-
URBEXT1990	0.0032	0.0029	0.0047
URBLOC1990	-	-	-
URBCONC2000	-	-	0.7480
URBEXT2000	0.0044	0.0040	0.0064
URBLOC2000	-	-	0.3590

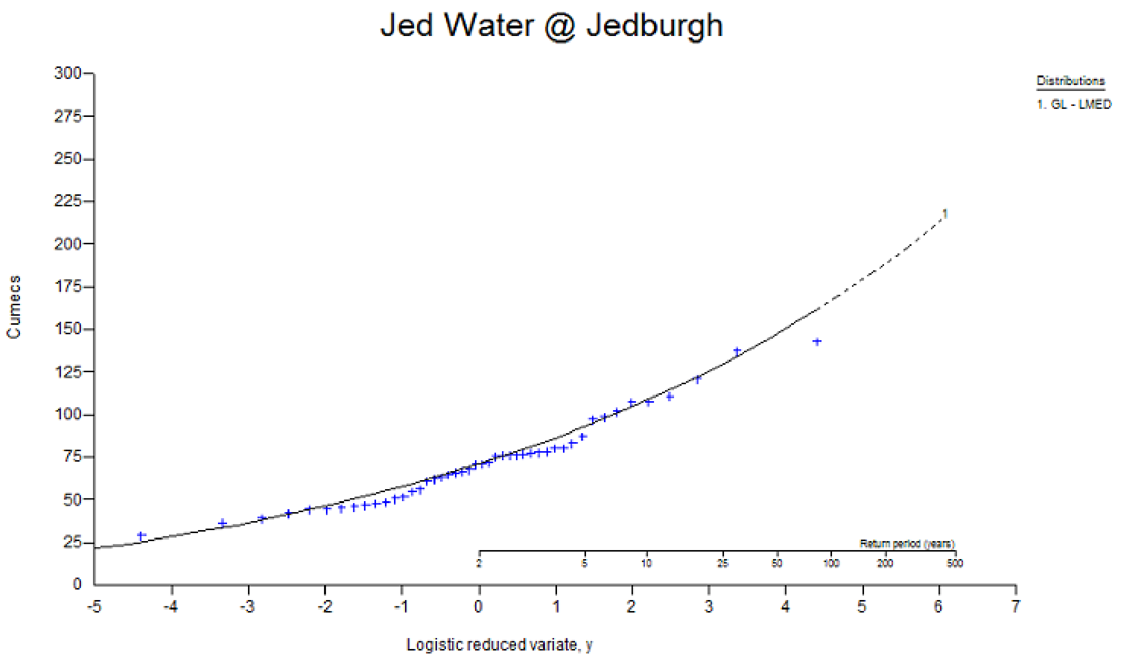
4.1 Statistical Assessment

4.1.1 Jed Water

SEPA operate a flow gauging station on the Jed Water which is located in the town of Jedburgh, upstream of the site (21024 - Jed Water @ Jedburgh). This gauging station has been identified as suitable for Qmed and Pooling Group analysis. Based on the online FEH web-service, the catchment of the watercourse at the gauge is $140km^2$, compared to the catchment at the confluence of the River Teviot which is estimated to be $147km^2$.

A Single Site Analysis was conducted for this gauging site using available AMAX data from 1971 – 2017. Figure 4 shows the Single Site Frequency graph for the Jed Water at the Jedburgh gauge. Based on the results of the assessment, the estimated 200 year flow is 188.7m³/s using the General Logistic distribution.

Figure 4. Single Site Analysis at the Jed Water Gauge



Flows of the Single Site Analysis have been factored up by 1.05 (increase in catchment area) which results in a predicted flow of approximately 198m³/s.

A FEH Pooling Group Assessment was also undertaken for the Jed Water catchment at the confluence with the Teviot Water. The resulting Pooling Group is provided in Table 2 below.

Table 2. Pooling Group for Jed Water

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
21024 (Jed Water @ Jedburgh)	0.081	46	70.96	0.199	0.156	0.617
19011 (North Esk @ Dalkeith Palace)	0.247	44	36.856	0.324	0.282	0.912
55013 (Arrow @ Titley Mill)	0.266	49	27.253	0.19	0.176	1.671
12006 (Gairn @ Invergairn)	0.29	28	59.871	0.202	0.085	0.643
9003 (Isla @ Grange)	0.299	58	52.514	0.241	0.157	0.784
9004 (Bogie @ Redcraig)	0.319	26	31.622	0.312	0.274	0.599
23002 (Derwent @ Eddys Bridge)	0.342	11	48.41	0.171	0.032	1.002
13001 (Bervie @ Inverbervie)	0.398	27	35.577	0.212	0.141	1.118
21032 (Glen @ Kirknewton)	0.42	44	44.45	0.267	0.236	0.507
11004 (Urie @ Pitcaple)	0.435	18	21.42	0.306	0.268	0.522
43004 (Bourne @ Laverstock)	0.446	45	2.157	0.328	0.31	0.863
21013 (Gala Water @ Galashiels)	0.471	52	51.252	0.24	0.25	1.811

43012 (Wylye @ Norton Bavant)	0.501	48	4.643	0.18	0.043	2.339
21025 (Ale Water @ Ancrum)	0.512	33	51.665	0.214	0.097	0.612
Total		529				
Weighted means				0.241	0.182	

Heterogeneity Measure: Pooling Group is acceptably homogeneous; H2 = 1.99

Results from the Pooling Group assessment predicts in a flow of approximately 207 m^3/s for the Jed Water at the confluence with the River Teviot using station 21024 (Jed Water @ Jedburgh) as a donor for Qmed.

4.1.2 River Teviot

The River Teviot drains a catchment of approximately 859 km^2 downstream of the Jed Water confluence. SEPA also operate a gauging station on the River Teviot – (21008 Teviot@Ormiston Mill). A Pooling Group assessment has been undertaken downstream of the confluence to estimate the total flows including the Jed Water.

The results of the final Pooling Group are provided below.

Table 3: Pooling Group for River Teviot downstream of Jed Water

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
11002 (Don @ Haughton)	0.21	35	113.041	0.221	0.235	1.215
7002 (Findhorn @ Forres)	0.216	59	356.203	0.228	0.233	1.044
27080 (Aire @ Oulton Lemonroyd)	0.266	32	150.232	0.151	0.181	0.559
23015 (North Tyne @ Barrasford)	0.292	22	422.68	0.152	0.183	0.667
50001 (Taw @ Umberleigh)	0.324	59	240.88	0.203	0.275	1.069
23004 (South Tyne @ Haydon Bridge)	0.349	58	452.368	0.148	0.219	1.115
24009 (Wear @ Chester le Street)	0.349	40	244.945	0.152	0.088	1.342
28018 (Dove @ Marston on Dove)	0.363	56	112.663	0.127	0.07	1.161
25001 (Tees @ Darlington Broken Scar)	0.364	61	388.89	0.178	0.102	1.077
28010 (Derwent @ Longbridge Weir)	0.366	51	142.703	0.207	0.286	1.79
27007 (Ure @ Westwick Lock)	0.368	62	281.504	0.191	0.236	0.281
21008 (Teviot @ Ormiston Mill)	0.386	58	352.154	0.185	0.15	0.679
Total		593				
Weighted means				0.18	0.19	

Heterogeneity Measure: Pooling Group is acceptably homogeneous; H2 = 1.29

Results from the Pooling Group assessment predict in a flow of approximately 657 m^3/s for the River Teviot downstream of the Jed Water confluence. Station 21008 was used as a donor for Qmed.

4.1.3 Design Flows for Catchments

Pooling Group results summarised in Table 3 show that the total flow predicted to arrive downstream of the confluence is approximately 657 m^3/s. Flows in the Jed Water are also calculated which predict a flow of approximately 207 m^3/s; therefore, for modelling purposes, the flow in the River Teviot (upstream of the confluence) is predicted to be approximately 450 m^3/s (657 m^3/s – 207 m^3/s).

The estimated flows from the three methods are tabulated in Table 3.

Table 4: Summary of 200 year design flows

Flow Estimation Point	Catchment Area (km^2)	Proportion of total	200 year flow (m^3/s)	200 year plus climate change (m^3/s)
Jed Water	**147**	**17%**	**207**	**248**
Teviot Upstream	**712**	**83%**	**450**	**540**
Teviot Downstream	**859**	**100**	**657**	**788**

5 Mathematical Modelling

5.1 Background

A linked 1D-2D model of the River Teviot and Jed Water was developed from cross-sections extracted from LiDAR data using Flood Modeller Pro mathematical modelling software. This approach was taken to provide an initial assessment of the floodplain extent. If a more detailed assessment is required then the mathematical model would require survey of the river channels and relevant hydraulic structures.

5.2 1D Model Development

A 1D model of the River Teviot and Jed Water was developed using cross sections extracted from LiDAR data of the area. In total, 13 cross-sections were incorporated into the model, and 12 model interpolates were added to improve model stability. Cross-sections were extracted perpendicular to the direction of the flow and extending from high points on either side of the channel. Figure 5 shows the cross-section locations.

The model incorporated a flow hydrograph boundary at the upstream model extent based on the design flows identified in Chapter 4. To be conservative the 200 year events were run concurrently to peak at 15.5 hrs which is the design storm for the River Teviot.

The downstream boundary was set as “normal depth” at the measured bed slope at the downstream end of the model.

The Roughness (Manning’s n) parameters used in the model include:

- Values of 0.035 to represent the channel.
- Values of 0.065 to represent roughness values on overbank areas

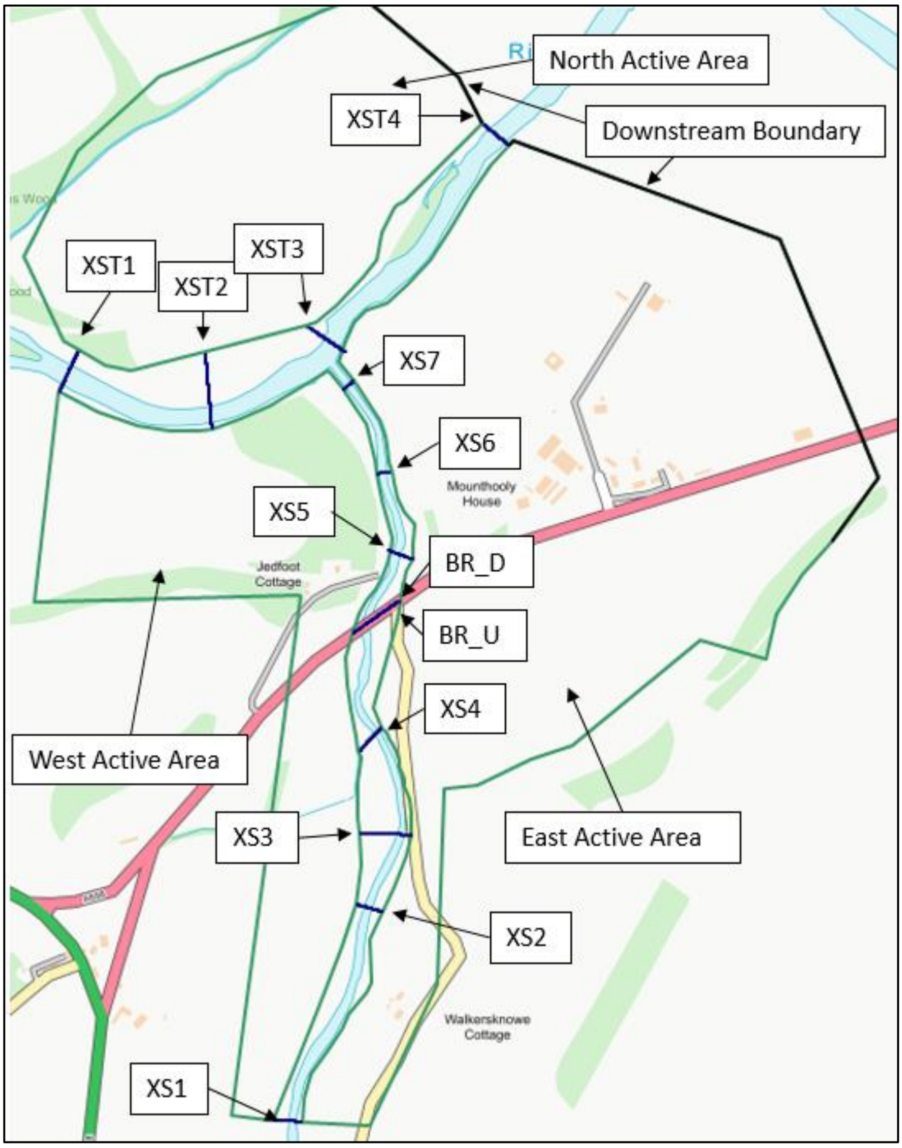
The A698 road bridge was assessed using LiDAR data and online mapping and was included in the model as a (USBPR1978) flat bottom bridge.

5.3 1D-2D Linked Model Development

A 2D modelling approach was used to represent overbank flows and adjacent floodplains. The 2D domain was connected to the 1D at the top of the banks, either side of the channel. Cross sections were deactivated at bank tops to avoid double counting of floodplain areas. The model 1D and 2D domains can be seen in Figure 5.

The 2D model domain was run using a 2m grid size, and a 0.055 roughness (Manning's n) value used throughout the model.

Figure 5. Model Schematic



5.4 Modelling Results

Figure 6 show the results from the 1D / 2D linked flood model and Figure 7 for the 1 in 200 year event plus an allowance of 20% for climate change. Predicted water levels for modelled cross-sections are shown in Table 5.

Model results show that the site would be inundated during the 200 year event, with flood waters overtopping on the right-hand bank of the Jed Water, upstream of the A698 road bridge, before flowing west and north at the location where the level of the road drops. Flood waters would cross the road and are predicted to inundate the site, before flowing north to join the floodplain of the River Teviot. Depths within the site are predicted to reach up to 0.92m and 0.94m during the 200 year and 200 year + 20% climate change events respectively.

Figure 6. Predicted 1 in 200 year floodplain

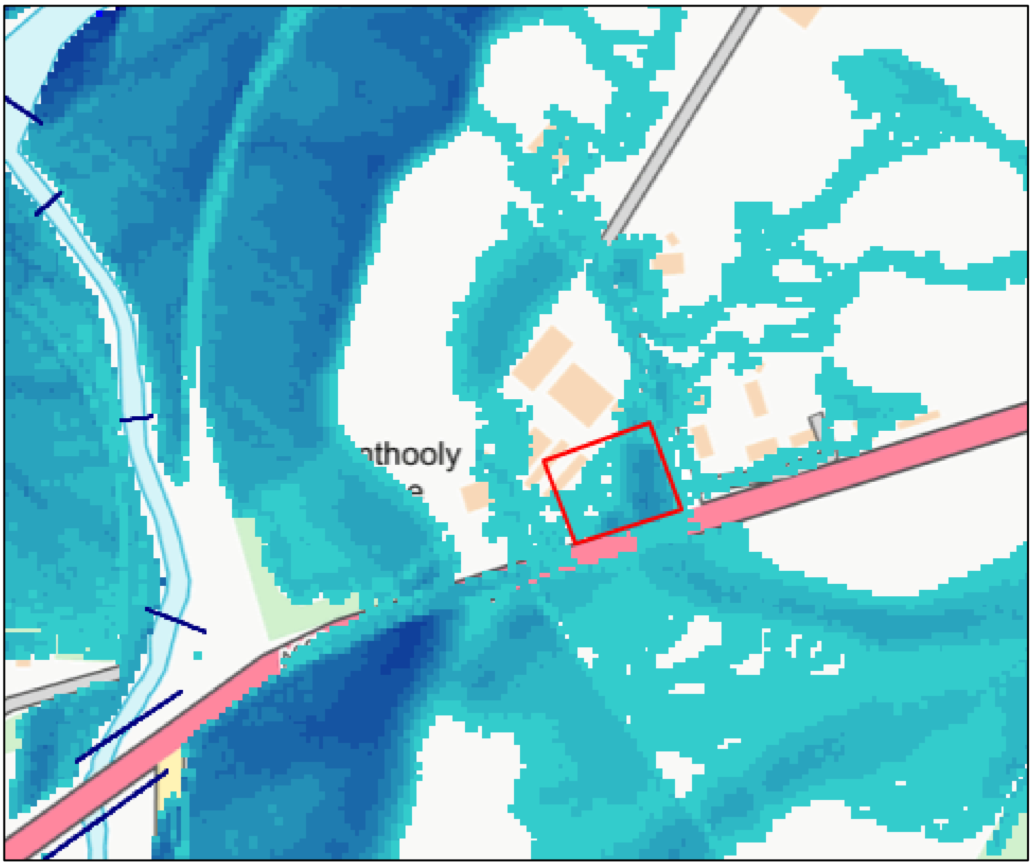


Figure 7. Predicted 1 in 200 year + 20% climate change floodplain

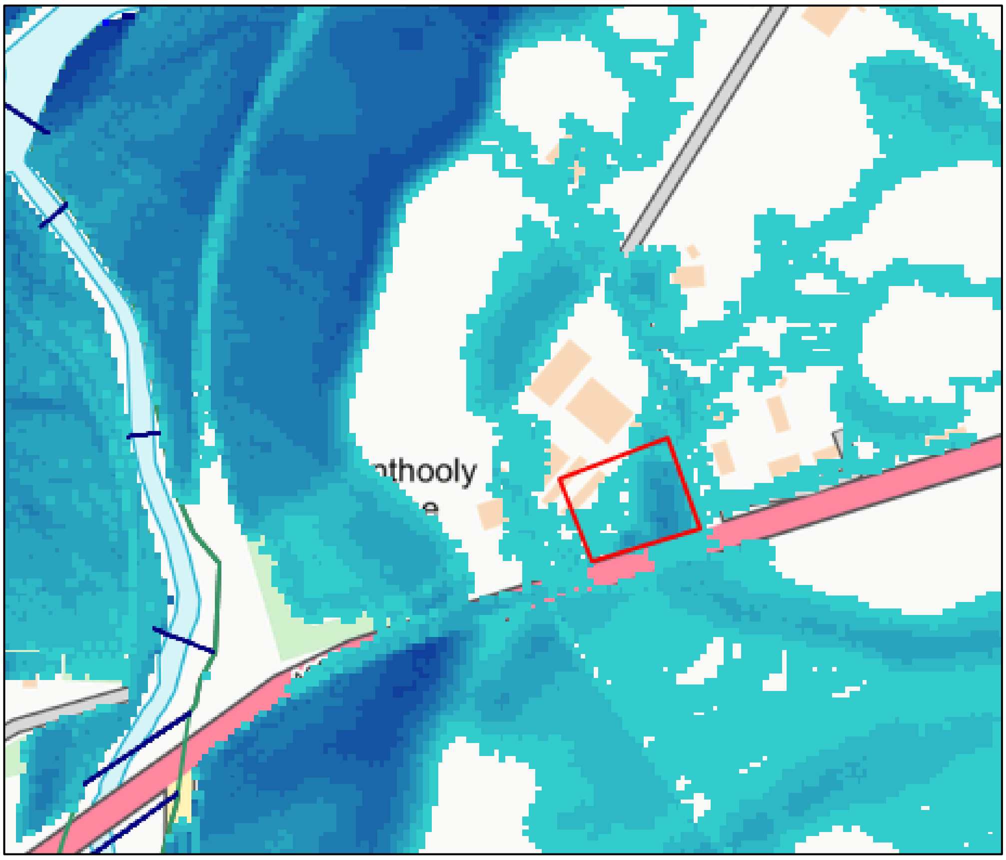


Table 5. 1D Cross Section Results

XS	1 in 200 year Peak Flood Levels (m AOD)	1 in 200 year Peak Flood Levels (m AOD)
1	59.64	59.77
2	57.72	57.83
3	56.99	57.07
4	56.39	56.57
BR_U	55.92	55.96
BR_D	55.92	55.97
5	55.29	55.33
6	54.77	54.93
7	54.57	54.72
T1	54.95	55.07
T2	54.79	54.93
T3	54.52	54.63
T4	53.78	53.92

5.5 Sensitivity Analysis

A model sensitivity analysis provides an illustration of the effect of changing key model parameters on the important model outputs (in this case flood levels, extents and depths). If model parameters are varied within the range of possible input values, then a sensitivity analysis can also provide an indication of uncertainty associated with the model predictions.

A sensitivity analysis was undertaken considering the following parameters;

- An increase in flow of 20% to represent future climate change;
- Manning's "n" values for the channel, floodplain, and culverts within the 1D environment were increased by 20% from design values
- Downstream boundary was reduced by 50%
- Blockage of 25% to River Teviot downstream of the site to simulate blockage of a crossing

The results of this sensitivity analysis can be seen in Table 6 showing the maximum water levels in the 1D model.

Table 6. Model Results and Sensitivity Results

XS	1 in 200 year Peak Flood Levels (m AOD)	Change from 1 in 200 year event (m)			
		1 in 200 year + cc	**Manning's + 20%**	**Change boundary**	**Blockage**
1	59.64	0.13	0.12	0.00	0.00
2	57.72	0.11	0.07	0.00	0.00
3	56.99	0.08	0.08	0.00	0.00
4	56.39	0.18	0.08	0.00	0.00
BR_U	55.92	0.04	0.03	0.00	0.00
BR_D	55.92	0.05	0.01	0.00	0.00
5	55.29	0.04	0.05	0.00	-0.01
6	54.77	0.15	0.06	0.01	0.00
7	54.57	0.15	0.05	0.05	0.00
T1	54.95	0.12	0.13	0.02	0.00
T2	54.79	0.14	0.08	0.01	0.00
T3	54.52	0.11	0.04	0.06	0.00
T4	53.78	0.14	0.04	0.08	0.00

The results show that the model behaves as it is expected to in term of the climate change and roughness increase results.

Water levels increase by up to 0.08m by increasing the downstream boundary slope, this suggests that the boundary could be moved further downstream in order to have no impact on the River Teviot at the confluence with the Jed Water. However, the flooding mechanism at the site is driven from the overtopping of the Jed Water which is well away from the downstream boundary and it was deemed appropriate for this Stage 1 assessment. If there is further, more detailed modelling, survey of channel sections downstream of the current model boundary is recommended.

Blockage of the Teviot channel by 25% does not affect water levels in the 1D channel due to the significant amount of bypassing and flooding of adjacent floodplains. Therefore, the model is not sensitive to blockage downstream of the site.

6 Flood Risk Assessment

The flood risk assessment considers the risk from:

- Watercourses;
- Surface water flooding;
- Groundwater flooding; and
- Infrastructure.

The assessment also considers risks associated with access to the site.

6.1 Fluvial Flooding

A Flood Modeller Pro 1D/2D linked model of the Jed Water and River Teviot was developed to predict the 200 year and 200 year + climate change floodplain close to the site. Flood extents are provided in Figures 6 and 7 and show that the site is almost entirely inundated during both modelling scenarios.

The model is based on topographical data which has been extracted from LiDAR data (including channel cross-sections), so with more detailed modelling (surveyed channel cross-sections) flood extents could potentially be reduced. However, the predicted depth of flooding is quite deep (0.9m) and the predicted flood extent in this report is similar to that of the SEPA flood maps; therefore, the likelihood of the site being situated out with the 200 year flood extent is thought to be low.

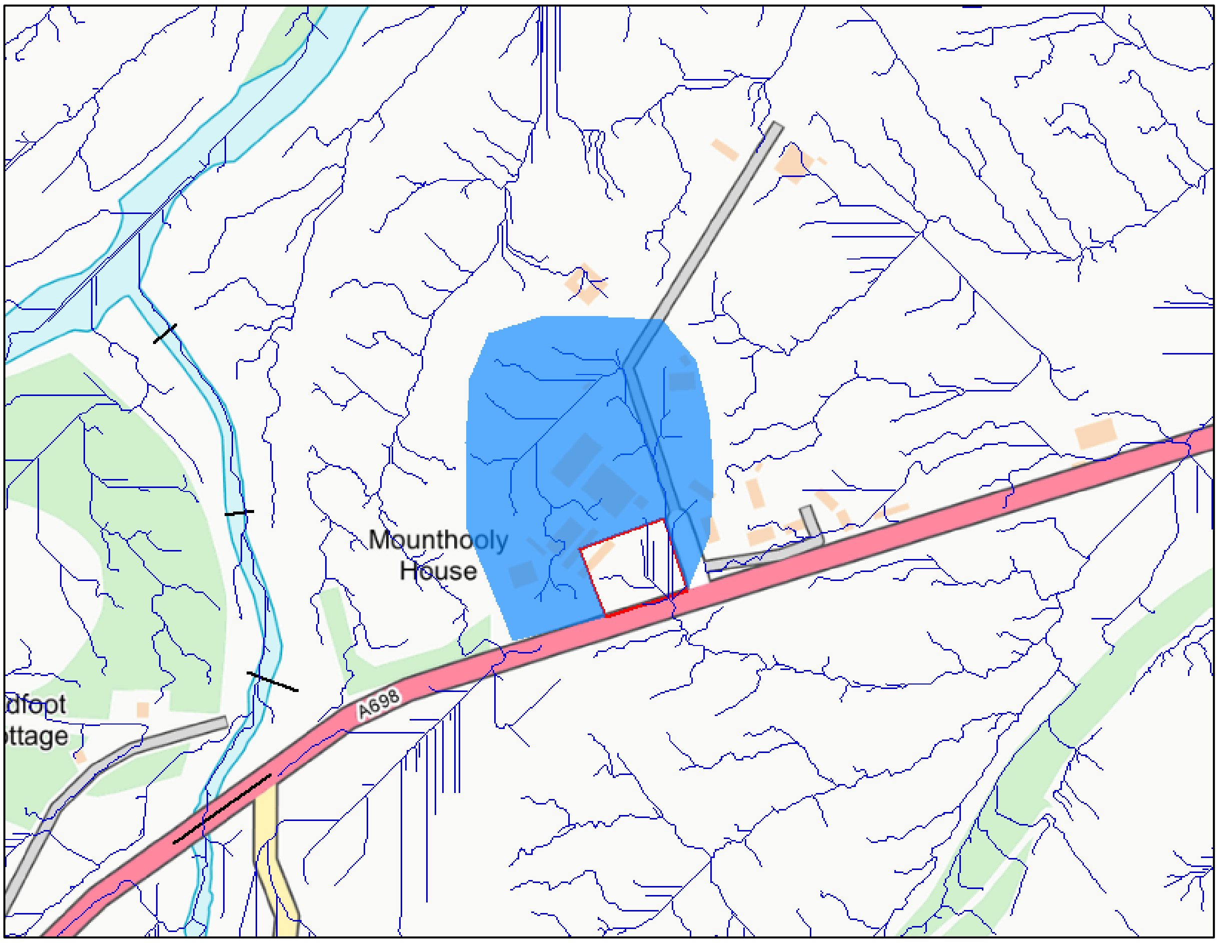
Based on SPP, land within the 200 year floodplain extent is not normally suitable for most types of development including residential and commercial.

6.2 Surface Water Flooding

The SEPA surface water flood maps do not indicate that the site is at risk from surface water flooding. A flow pathway analysis was undertaken using GIS software and LiDAR data to assess potential overland flow routes for water to reach the site, results shown in Figure 8.

A small area approximately 3.7ha is able to flow to the access road to the east of the site, with the potential for surface water to enter the site on its eastern edge. This area contains a significant portion of developed land; therefore it is expected that there would be drainage systems to manage the surface water within this area. As a result, the flood risk from surface water (not generated from the river) would appear relatively low. However, if development proceeds, it is recommended that ground levels area landscaped to route any surface water able to enter the site to the southern edge of the site and to ensure that ground levels do not direct surface water towards buildings.

Figure 8. Overland Flow pathways



6.3 Groundwater Flooding

The SEPA groundwater maps do not indicate that the site is at risk from flooding from groundwater as a primary source. Given the proximity of the site to the Jed Water and River Teviot, it is likely that groundwater levels are controlled by water levels in these watercourses. During flooding, groundwater levels in some areas of the site will sit close to the surface. When river levels are lower, the groundwater levels are also likely to be lower, therefore the site is not considered at risk from groundwater as a primary source, i.e., not associated with elevated river levels.

If locally raised groundwater levels are identified during site investigations, suitable mitigation measures would need to be employed in terms of foundation design and choice of SuDS.

6.4 Drainage System and Existing Sewers

The design of the site drainage system is not part of this commission. As the site and land surrounding it is currently developed, the area is served by an existing drainage system. Discussions should be held with the council, SEPA and Scottish Water to discuss appropriate requirements for SuDS.

It is recommended that runoff from the site is attenuated to greenfield rates, Within the site ground levels and overland flow pathways should be designed to convey any excess flows (in the event of rainfall in excess of design conditions or blockage to the drainage system) through the site to the River Teviot without ponding or flooding properties. As with all drainage systems, a maintenance regime should be put in place to ensure all components of the drainage system function as designed.

6.5 Site Access

SEPA guidance states that safe and flood free pedestrian and vehicle access and egress should be provided to the site during extreme flood events for emergency access. Due to the predicted overtopping the Jed Water and flooding of the A698, safe and flood free access to the site for both pedestrian and vehicles cannot be achieved.

7 Flood Risk Summary and Conclusions

This report describes a Stage 1 flood risk assessment for a proposed development at Mounthooly, near Jedburgh in the Scottish Borders.

The Jed Water and River Teviot flow north and west close to the site. A 1D-2D linked model of both channels and adjacent floodplains was constructed using FloodModeller software. Model results indicated that the site is predicted to lie within the 200 year floodplain of the Jed Water, which flows to the west of the side. Flood waters are predicted to overtop the A698, to the west of the site, before flooding the site. Flood extents are provided in Figures 6 and 7 and show that the site is almost entirely inundated during the 200 year and 200 year plus climate change events.

The model is based on topographical data extracted from LiDAR, if more detailed modelling is undertaken (including survey of channel cross-sections) flood extents could potentially be reduced. However, the predicted flooding is quite deep (0.9m) and the predicted flood extent in this report is similar to that on the SEPA flood maps. Given the size of the rivers, additional survey would be costly and based on this report, it would appear that there is high risk that the site would still be considered at risk from flooding.

Based on Scottish Planning Policy, land within the 200 year floodplain extent would not normally be suitable for most types of development including residential and commercial. We understand that Planning in Principle has been obtained for this site in the past and as a result we would recommend discussions are held with SEPA and the council.

Modelling predicts that access to the site would not be flood free due to the A698 being flooded. SEPA are also likely to object to the development due to a lack of flood-free access to the site during a 200 year event.

The site is not considered to be at significant risk from groundwater or surface water flooding as a primary source.

It should be noted that risk of flooding can be reduced but not totally eliminated, given the potential for events exceeding design conditions and the inherent uncertainty associated with estimating hydrological parameters for any given site.