Land at Kingsmeadow, Peebles

Flood Risk Assessment

November 2019

Waterman Infrastructure & Environment Limited

Broxden House, Broxden Business Park, Lamberkine Drive, Perth PR1 1RA www.watermangroup.com

Client Name: Granton Homes Ltd.
Document Reference: WIE15880-100-R-1-4-3-FRA
Project Number: WIE15880

Quality Assurance – Approval Status

This document has been prepared and checked in accordance with
Waterman Group's IMS (BS EN ISO 9001: 2015, BS EN ISO 14001: 2015 and BS OHSAS 18001:2007)

Issue	Date	Prepared by	Checked by	Approved by
1-1-3	11/06/19	Nicola Day	Kim McKissock	Kim McKissock
1-2-3	18/06/19	Nicola Day	Kim McKissock	Kim McKissock
1-3-3	19/07/19	Nicola Day	Kim McKissock	Kim McKissock
1-4-3	05/11/19	Ruairi Doyle	Kim McKissock	Kim McKissock

Comments

1-1-3	First issue for comment
1-2-3	Updated following comments
1-3-3	Updated following further comments
1-4-3	Updated following comments

Comments

Disclaimer

This report has been prepared by Waterman Infrastructure & Environment Limited, with all reasonable skill, care and diligence within the terms of the Contract with the client, incorporation of our General Terms and Condition of Business and taking account of the resources devoted to us by agreement with the client.

We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above.

This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies on the report at its own risk.

Contents

Figures

Tables

Appendices

Contents

Land at Kingsmeadow, Peebles

Project Number: WIE15880

Document Reference: WIE15880-100-R-1-4-3-FRA

1. Executive Summary

Waterman Infrastructure & Environment Ltd ('Waterman') was instructed by Granton Homes Ltd., to carry out a Flood Risk and Drainage Assessment in support of a proposed residential development for land east of Kingsmeadow House in Peebles.

The report describes the existing conditions of the site, and any features that may influence flood risk or the drainage of the site. It assesses the potential sources of flooding to the site, taking a risk-based approach in accordance with Scottish Planning Policy (SPP, 2014). The report considers flooding from coastal, fluvial, groundwater, pluvial, and infrastructural sources.

The proposed residential development is to include local community facilities and associated infrastructure and landscaping.

1.1 Flood Risk Assessment

The assessment confirmed that there was "Little to no" risk of flooding from coastal sources and "Low" risk of flooding from pluvial, groundwater, infrastructure and artificial sources.

The SEPA flood map indicates that the northern portion of the site is located within the High (10% AEP), Medium (0.5% AEP) and Low (0.1% AEP) likelihood fluvial food extents. Floodwater originates from the River Tweed and Soonhope Burn, which flow in easterly direction approximately 20m north of the development site.

A flood model of the River Tweed was constructed to estimate the extent of fluvial flood risk to the proposed development. The estimated flood levels from the model were used to generate flood maps for a range of return periods, including the 1 in 200-year and 1 in 200-year plus climate change flood events. The original model and associated assessment were completed in 2015 and gained planning permission in principle (15/00822/PPP), however due to changes in flow estimation and hydraulic modelling standards, as well as updated gauge records, the assessment required updating.

Modelling results indicate a relatively small area of flooding occurs towards the north-eastern corner of the development area during the 1 in 200-year event, with floodwaters breaching areas along the northern boundary of the site during the 1 in 200-year + 33%CC event. Based on the indicative layout plans, it is anticipated that floodwaters can be retained within the landscaped areas and will not impact on the built development. In compliance with current planning policy, all proposed infrastructure should be located away from this area to ensure the development is protected during a climate change flood.

FFLs should be constructed at least 600mm above the adjacent 200-year + climate change flood levels. Based on the model results, the FFLs along the northern boundary of the site should therefore be set to a minimum of 159.02m AOD, with all proposed buildings located out with the functional floodplain (1 in 200-year flood extents), wherever possible. The current layout plan shows that the proposed building has been located out with the 1 in 200-year flood extents.

The results also show that the remainder of the site is not at risk of flooding during a 1 in 200-year plus climate change event.

The SEPA flood map does not indicate the site as being at risk of flooding from pluvial sources. However, as the site is currently greenfield, the proposed development will significantly increase impermeable surfacing within the site boundary. Therefore, suitable drainage measures should be incorporated to ensure that there is no increase in flood risk to the development and surrounding area from pluvial sources up to the 1 in 200-year + climate change event. SuDS will be provided as part of the drainage network to treat and attenuate surface water flows, prior to discharge into the suitable discharge points on the River Tweed.

1.2 Recommendations

A summary of recommendations is as follows:

- FFLs should be constructed at least 600mm above the adjacent 200-year + climate change flood levels.
- Suitable drainage measures should be incorporated to ensure that there is no increase in flood risk to the development and surrounding area from pluvial sources up to the 1 in 200-year + climate change event.

2. Introduction

2.1 Background

Waterman Infrastructure & Environment Ltd ('Waterman') was instructed by Granton Homes Ltd. to prepare a Flood Risk and Drainage Assessment for a proposed residential development for land to the east of Kingsmeadow House in Peebles (hereafter referred to as 'the site').

This Flood Risk and Drainage Assessment will comprise the following;

- Consultation with SEPA and Scottish Borders Council to determine the flood risk and drainage requirements for the development, and obtain any records of historic flooding or flood information relevant to the site;
- Determine the risk to the site and proposed development from all sources of flooding, namely fluvial, pluvial, groundwater, drainage, and infrastructure failure;
- Review of existing flood studies, if available, obtain SEPA gauging station data and carry out a comparison of recorded and predicted flows to verify data to be used in the hydraulic modelling, where applicable;
- Update the existing 1D hydraulic model of the River Tweed to determine overland flow routes and extents of out-of-bank flood waters;
- Production of flood extents drawings for a range of return periods; and
- Make recommendations for further works and mitigation.

2.2 Limits of Report

The findings of this report have been informed by review of information provided by 3rd parties, consultation with relevant statutory bodies and a site walkover survey.

The report does not consider flooding from the water supply network such as water mains, and associated infrastructure, however a high-level review indicates that the site is not located within close proximity to the of existing water supply network. However, further on-site investigation should be undertaken to determine the location of any private water supplies which may intersect the site. Where existing water supply infrastructure is identified, it is assumed that the required stand-off distances to any developed area will be observed during the detailed design stage and/or water supply infrastructure will be relocated within proposed access roads, in-line with the latest design standards and best practice guidance.

This report does not include detailed modelling of drainage.

This assessment has been carried out based on the information made available at the time of writing and should be reviewed during detailed design, as further information becomes available.

2.3 Approach

The report describes the existing conditions of the site, and any features which may influence the site. It assesses the potential sources of flooding to the site, taking a risk-based approach in accordance with Scottish Planning Policy (SPP, 2014). The report considers flooding from fluvial, coastal, pluvial, groundwater and artificial sources.

SPP uses a risk framework approach to flooding whereby sites are assessed based on annual exceedance probability (AEP) which defines the likelihood of a given magnitude of event occurring in any given year. A 1 in 200-year event, for example, has a probability of 0.5% of occurring in any given year. Sites are classed

as having “Little or no risk” (<0.1% AEP), “Low to Medium risk” (0.1-0.5% AEP), or “Medium to High risk” (>0.5% AEP). Sites considered to be at “Medium” to High” risk of flooding are generally not considered suitable for development.

3. Development Site

3.1 Location & Description of Site

The site is located within the grounds of Kingsmeadow House in Peebles and covers an area of approximately 0.43ha. The site currently comprises a large children's playground, a hardstanding gravel access track that borders the site and provides access from Kingsmeadow Road, and other hardstanding areas alongside some green areas and tree cover. Hardstanding covers in excess of 700m^2 of the site. The grid reference for the site centre is NGR: 326018, 639922.

A location plan is provided in **Figure 1** below.

Figure 1. Site Location Plan

Contains Ordnance Survey data © Crown copyright and database right 2019.

3.2 Topography

A topographical survey, including river cross-sections survey, was undertaken at the site and was carried out to Ordnance Survey National Grid, with elevations relative to Ordnance Datum. The topographical survey scope included the site boundary and immediate surrounding area.

The survey shows that the access road leading up to the development increases in elevation from 158.56m AOD adjacent to Kingsmeadow Road to 159m AOD adjacent to the location of the proposed development. The majority of the site has an elevation exceeding 158.5m AOD. The area proposed to be developed generally slopes to the northeast from an elevation of 159.7m AOD to 157.5m AOD down towards the River Tweed. The adjacent access track slopes from approximately 158.6m AOD to 157.5m AOD down towards the River Tweed.

The topographical survey can be seen in **Appendix A**.

An aerial site photograph is presented in **Figure 2**, below.

Figure 2. Aerial Photography of the site and surrounding estate.

3.3 Historic Land Use

Historical maps indicate that the site has remained much the same for over 100 years and is a part of the grounds of Kingsmeadow House. Historical maps show a mostly wooded area, much like the site is today.

3.4 Existing Drainage

There are nearby existing public combined sewers of up to 375mm in diameter, that convey flows from the Kingsmeadows area towards the Peebles Wastewater Treatment Works (WWTW), approximately 1km north-west of the site. A 300mm diameter combined overflow is noted to intersect the site toward the western boundary and discharges to the River Tweed at NGR: 326046, 639946.

A 1180mm diameter surface water sewer is shown to convey flows from the west toward a outfall on the River Tweed which intersects the grounds of 'The Lodge', approximately 90m west of the site.

3.5 Watercourses & Water Features

The River Tweed lies approximately 15m north of the site boundary. The Soonhope Burn discharges into the River Tweed approximately 40m northwest of the site. The Eddleston Water lies approximately 1km west of the site where it discharges into the River Tweed.

A land drain is located along the eastern boundary of the Kingsmeadow House grounds ownership boundary, which discharges into the River Tweed, approximately 180m northwest of the proposed development site. The drain was noted to be dry during the site visit.

There are no further watercourses or water features within the vicinity of the site.

3.6 Geology and Hydrogeology

The character of the underlying geology is an important consideration and can indicate the behaviour of hydrological processes. Large grained Sedimentary rocks, or those with significant faults and fractures such as karst landscapes, can indicate good catchment porosity. Other rock types such as metamorphic or small grained sedimentary rocks, like mudstone, are less permeable. Equally, the types of superficial deposits can also indicate differing hydrological behaviours. The presence of deposits such as sands and gravels often indicate good drainage whereas clays and other fine grained Glacial Till deposits might suggest poor permeability and therefore fast runoff and increased flood risk.

The following assessment of ground conditions is based on a desktop analysis and may therefore differ from conditions identified during any future ground investigation.

The British Geological Survey (BGS) Geoindex was employed to assess the mapped superficial deposits within the development boundary. The online viewer indicates that the north of the site is mostly overlain by alluvial deposits of SILT, SAND and GRAVEL while the south of the site is overlain by glaciofluvial deposits of SILT, SAND and GRAVEL. This would suggest that the geology has good permeability but would also highlight that some of this site was once a floodplain.

The BGS Geoindex was also employed to assess the mapped bedrock within the development boundary. The online viewer indicates that underlying bedrock is of the Galla Unit 2 Wacke formation, likely made up of SANDSTONE and poorly-sorted angular grains of quartz and/or feldspar and small rock fragment set in a compact, clay-fine matrix.

The BGS Geoindex indicates a low productivity aquifer of the Gala Group, which comprises highly indurated greywackes with limited groundwater in the near-surface weathered zone and secondary fractures.

Local boreholes records made available online on the BGS Geoindex includes boreholes within the general vicinity of the site. These indicate that the geology of the surrounding area is mainly composed of SAND, GRAVEL and COBBLES with seams of CLAY. Record NT23NE3652/6, located approximately 190m east of the site, details that groundwater was encountered approximately 3.7m below ground level.

As the superficial soils within the development site are likely to contain concentrations of silty/sandy clay, and groundwater levels are likely to fluctuate with the levels within the adjacent watercourse and associated floodplains, infiltration is unlikely to be feasible within the site boundary. However, further ground investigation should be undertaken during the detailed design stage to determine the suitability of infiltration as a means of surface water disposal.

3.7 Proposed Development

The proposed development involves the redevelopment of the site through the construction of a three-storey apartment block to the east of the existing Kingsmeadow House. The indicative plans suggest the development will comprise of approximately 10 residential apartments with associated communal parking, garages, courtyard and landscaping.

An indicative layout plan is provided in **Appendix B**.

4. Data Acquisition

Flood and Drainage information was collected from several sources. These were as follows:

- Scottish Environment Protection Agency (SEPA);
- Scottish Borders Council (SBC);
- Historical flood information;
- Chronology of British Hydrological Events; and
- Internet Search.

4.1 Scottish Environment Protection Agency (SEPA)

SEPA is the flood warning authority in Scotland and is responsible for monitoring river levels, rainfall, tidal predictions and weather forecasts across Scotland to predict the likelihood and timing of flooding. SEPA also has a strategic role in managing flood risk and has a duty to provide flood risk advice to Planning Authorities when consulted in relation to applications for development where the Planning Authority considers there may be a risk of flooding.

A review of information available via SEPA online at http://map.sepa.org.uk/floodmap/map.htm was carried out. Mapping of groundwater, fluvial, coastal and pluvial flood risk as well as potentially vulnerable areas was examined.

The SEPA flood risk management map indicates that the northern boundary of the site is at risk of flooding from the River Tweed. Based on SEPA mapping, the site is within an area specifically defined as a Potentially Vulnerable Area (PVA), like the majority of Peebles.

As part of their planning response in March 2019 (PCS/163952), SEPA objected to the development as the existing flood risk assessment was considered out-of-date and advised that an updated model should be undertaken, using the 2015 River Tweed post-flood survey information to calibrate the model. SEPA advised that SBC should be contacted to obtain this information.

SEPA were contacted by Waterman in May 2019 to confirm the suitability of the existing model configuration, appropriate flow estimation methods and whether SEPA would consider options to allow development of the site.

In their response, SEPA advised that the existing model configuration is likely to be acceptable and calibration with recent flood event information should indicate the appropriateness of the model's use to predict accurate flood levels and extents at the site. With regards to flow estimation, SEPA advised that whilst they did not disagree with the indicative flows produced using the Single Site and Enhanced Single Site methods, a conservative approach to flow estimation was strongly recommended, particularly in the setting of Finished Floor Levels (FFLs). SEPA also advised that a climate change allowance of 33% should be adopted for the site (Tweed catchment), in-line with their most recent guidance[1].

SEPA also noted that they could not support new development within the functional floodplain, in-line with Scottish Planning Policy, nor could they provide detailed comments until the updated flood model and associated outputs were reviewed internally.

As part of the consultation. SEPA also provided annual maximum flow and stage data for the Peebles gauging station, for the period covering the significant 2015 flood event.

The correspondence with SEPA is supplied in **Appendix C.**

[1] SEPA (2019): Climate Change Allowances for Flood Risk Assessment in Land Use Planning.

4.2 Scottish Borders Council (SBC)

Under the terms of the Flood Prevention (Scotland) Act 1961, the Flood Prevention and Land Drainage (Scotland) Act 1997, and the Flood Risk Management (Scotland) Act 2009, Scottish Borders Council (SBC), as designated Flood Prevention Authority, has specific responsibilities, powers and duties in relation to flood prevention matters. This includes the role of implementing controls to ensure development proposals have adequate surface water runoff and flood prevention controls.

As part of their planning response in February 2019 (B48/2678), SBC advised that the site is located within an area considered to be at risk flooding during the 1 in 200-year flood event (0.5% AEP), as indicated by SEPA flood mapping. SBC noted that although the site may be at "Medium" to "High" risk of flooding from the River Tweed, the proposed finished floor level of 158.7m AOD provided 600mm freeboard above the previously modelled 1 in 200-year + climate change flood level (158.08m AOD) and was therefore considered acceptable.

However, due to SEPA's planning response in March 2019 (refer to **Section 4.1**), further consultation was undertaken with SBC in May 2019 to obtain 2015 River Tweed post-flood survey information. In their response, SBC advised that since 2016, the council have undertaken a flood study in Peebles that assessed flood risk associated with the River Tweed, which included areas within and around the proposed development site. SBC advised that the outputs of the study indicates that only the eastern corner of the development site is at risk during the 1 in 200-year modelled flood event.

SBC also provided a link to the council's online flood studies database, in addition to specific flow and stage information for the most significant event on the council's record for the Peebles gauge, which occurred in December 2015. SBC confirmed that use of the provided flow and stage information for model calibration was acceptable.

The correspondence with SBC is supplied in **Appendix D**.

4.3 Historic Flood Information

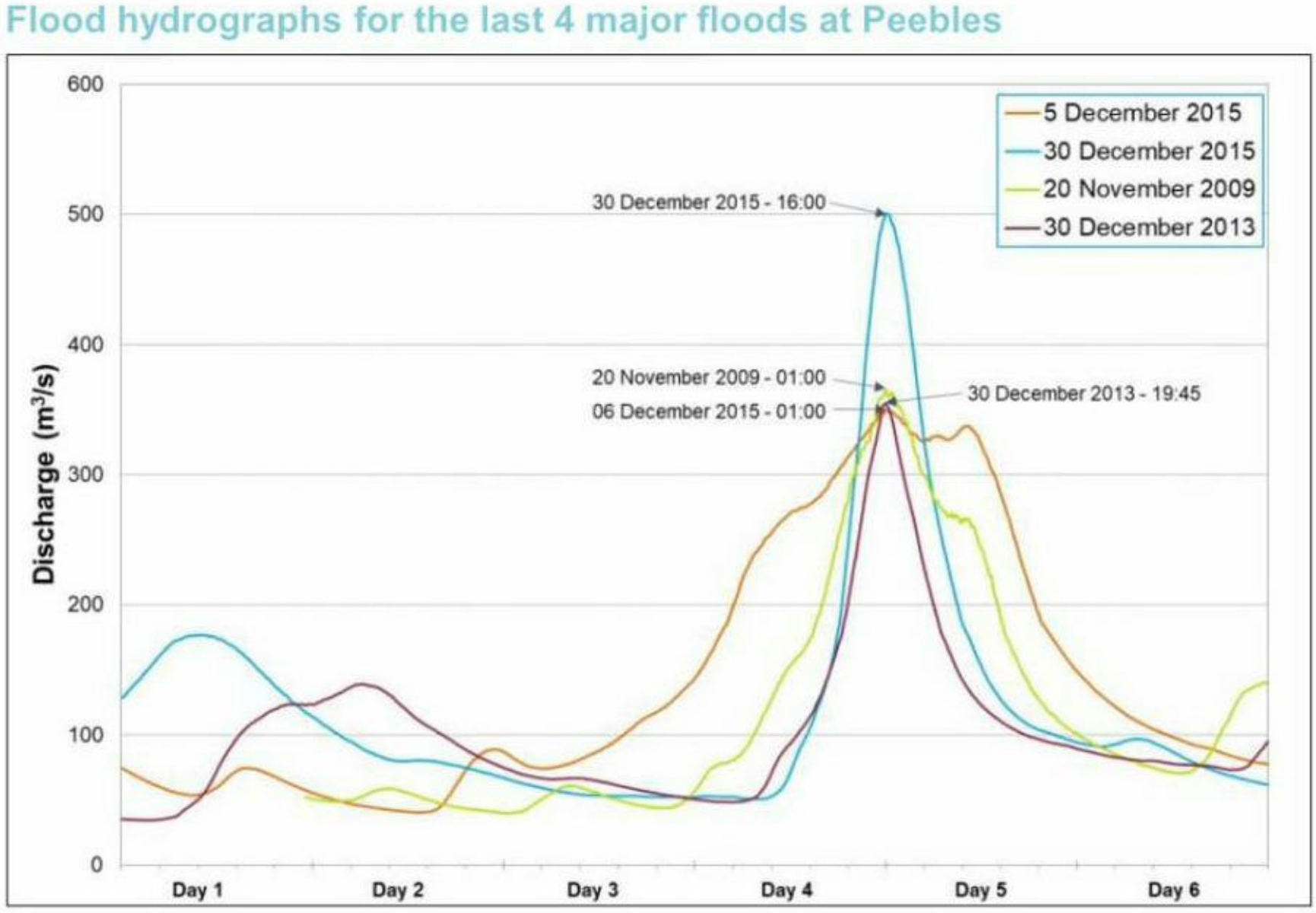
4.3.1 SBC Flood Record

During consultation, SBC provided a link to the council's online flood studies database which includes a formal flood records for Peebles, extending back to 1937. A total of 12 significant floods are described in this record, in addition to a flood hydrograph for the last four major floods at Peebles.

Of the 12 flood events described, 6 include references of inundation at Tweed Green, located approximately 860m upstream of the site. A record from 1977 notes that widespread flooding was documented across the region where several bridges swept away, with many areas of residential, commercial and agricultural land also affected by the floods.

An extract showing the flood hydrograph from SBC's flood record is presented in **Figure 3**, below.

Figure 3: Extract from the SBC Flood Studies Database - Flood Hydrograph for Peebles



4.3.2 Previous Flood Studies

A number of flood studies have been undertaken on the River Tweed at Peebles, which were mostly for individual developments or to identify individual flow pathways. Of particular note are several flood models which were undertaken to determine flood risk at Tweedbridge Court (approximately 1.1 km north-west of the site) and the Gytes Leisure Centre (Approximately 500m north-west of the site). In addition to modelled flood studies, several post-flood surveys have been undertaken, including that which documented floodwaters associated with Storm Frank in December 2015.

The most recent publications comprise the Peebles Flood Study (2017) and a follow-up Appraisal Report (2019) both undertaken by JBA, which include modelled flood extents for a range of return periods up to and including the extreme 1 in 1000-year event. A plan detailing the estimated 1 in 200-year fluvial flood extents from the 2017 Peebles Flood Study is included in **Appendix D**. The plan shows the majority of the development site is located out with the modelled flood extents, with a relatively small area of flooding toward the north-eastern site corner where flood depths were estimated between 0.25m – 0.75m. The plan also shows an area of flooding approximately 100m west of Kingsmeadow House at 'The Lodge', associated with a topographical low in the area.

With regards to the significant flood event in December 2015, a review of the post-flood survey information by JBA indicated that the storm equated to an event rarity of 55-70 years.

4.3.3 SEPA Peebles Gauging Station Data

SEPA operate a gauging station on the River Tweed approximately 184m upstream of Kingsmeadow House, on the southern bank of the river (NTR258400). The gauge is a velocity area station with a cableway, set at a datum level of 154.5765m.

SEPA and SBC provided a copy of the maximum flow and stage data recorded at the Peebles gauging station during the most significant flood event on record, as summarised in **Table 1**, below.

Table 1: Maximum Flow and Stage data for the RiverTweed at Peebles

Water Year	Date of flood	Flow (m^3/s)	Stage (m)	Flood Level (m)
2015	30/12/2015	499.99	3.654	158.23

4.4 Chronology of British Hydrological Events

A review of British Hydrological Society (BHS) Chronology of British Hydrological Events (http://www.cbhe.hydrology.org.uk/index.php) website was carried out. Place names of the surrounding area were searched to uncover any recorded historic flooding events.

A summary of the records available is provided in **Table 2**, below.

Table 2. Historic Instances of Flooding in Peebles.

Year	Month	Quotation
1891	9	Rainfall observer for Melrose noted "rain 1.6in followed by heavy floods, crops, sheep and bridges being swept away. The Tweed has been known 4ft higher, but its tributaries the Gala and Leader have not been so high in living memory." Rainfall observed for Peebles (Kailzie) noted severe gale of wind and rain from N.N.E 3.4in of rain falling in 36 hours. The Tweed itself did not come down in excessive flood until it was swollen by its tributaries, the Lyne, Eddlestone, Leithen, and Gala waters; these were all perfect torrents, washing away roads and bridges, and raising the Tweed to a height that no one remembers before....."
1926	11	A flood affected the borders, causing great damage. Late on the Thursday night a violent gale with heavy rain swept across the Borders seriously affecting the Selkirk area. By the following morning, the River Ettrick was five feet above its usual level, over-running the Selkirk Cauld and flooding Victoria Park. [Water washed over the footbridge between Bridge St and the town.] Railway traffic was completely suspended... Galashiels was also badly affected, the Abbotsford House being flooded... At Peebles many roads and bridges were impassable and the football ground was under four feet of water. The snow on the hills surrounding Hawick melted in the downpour and in quick time the Teviot was in flood. Very soon the lower parts of the town were flooded.... the water at Kelsco Bridge was over 12 feet high.... a stretch of railway embankment at Langholm was washed away....."
1897	08	Excessive flooding of the burns at the head of Moffat Water and of St. Mary's Loch. Apparently the fall was heaviest near Whitecombe Edge (2695ft), at the south of Peebles and north of Dumfriesshire. The main road from Selkirk to Moffat was blocked in several places for lengths of more than 100 yards; at Warmy Sike it is reported to have been covered for 130 yards, in places 6 ft Deep.

4.5 Internet Search

A thorough internet search of online articles was carried out to uncover any historic evidence of flooding within the vicinity of the site. Although there are many articles detailing floods in Peebles and the wider

Tweed catchment, two articles of particular relevance to the most recent significant flood event are noted below;

- A BBC news report published on 30th December 2015 (Available at https://www.bbc.co.uk/news/av/uk-35197781/uk-floods-storm-frank-batters-scottish-border-town-peebles) details the impacts of Storm Frank in Peebles, where power cuts, landslips and widespread flooding were documented. A video taken at the scene shows significant floodwaters passing beneath the Priorsford footbridge located approximately 700m upstream of the site.
- A news report by The Herald, also published on the 30th December 2015 (Available at https://www.heraldscotland.com/news/14173118.storm-frank-police-declare-major-incident-in-peebles-as-storm-continues-to-batter-scotland/), provides details on the severe flood warning issued by SEPA, associated with Storm Frank. Police Scotland reportedly declared a 'major incident' in Peebles due to unprecedented flooding and the risk to life and property in the local area.

5. Flood Risk Assessment

Sources of Flooding and Risk

5.1 Fluvial Flooding

The SEPA flood map indicates that areas of the site to the east (adjacent to the Dollar Burn) and south are located within the Medium (0.5% AEP) and Low (0.1% AEP) likelihood flood extents. The map also indicates that the western side of the development is located within a Potentially Vulnerable Area (PVA 09/04 – Eddleston, Peebles, Innerleithen, Selkirk, Stow and Galashiels), due to a combination of fluvial and surface water flood risk.

Consultation with SEPA (refer to **Appendix C**) details requirements for the exiting flood model to be updated using the latest flood risk parameters and historic flood information.

Correspondence with SBC (refer to **Appendix D**) indicates that fluvial flooding is a known risk in the vicinity of the site and several incidences of flooding have been recorded within close proximity to the site, which have been attributed to the River Tweed.

Although a land drain is present along the eastern ownership boundary, approximately 130m east of the developable area, the channel was noted to be dry during the site visit and is understood to take overland flows during extreme events only. As such, the overriding fluvial flood risk within the site vicinity is associated with the River Tweed.

Based on the information above, a more detailed assessment of fluvial flood risk associated with the River Tweed is required. Further details and the results of this assessment are provided in **Section 6**.

5.2 Coastal Flooding

The SEPA flood map indicates that the site is not likely affected by coastal flooding caused by high tides, storm surges and local bathymetric effects.

The site is noted to lie in excess of 70km from reaches of the River Tweed that are likely to be affected by coastal surges caused by tides or winds.

The proposed development site is considered to be at an overall “little to no” risk of flooding from coastal sources.

5.3 Pluvial Flooding

Overland or sheet flow may occur when intense rainfall exceeds the infiltration capacity of the ground, when it is already saturated, or when it is impermeable. The site may be at risk of pluvial flooding if it lies between an upstream catchment and the natural drainage channel. Risk of flooding from overland flows is considerably higher in areas where the surrounding topography results in an accumulation of flows.

The SEPA flood map indicates that the site is not considered to be at of surface water flooding. However, areas to the north and south of the development site, including the land drain to the east of the site, are at a High (1% AEP), Medium (0.5% AEP) and Low (0.1% AEP) risk of flooding from pluvial sources, associated with topographic lows and flows originating within the River Tweed. The map also indicates that the site is located within a Potentially Vulnerable Area (PVA 09/04 – Eddleston, Peebles, Innerleithen, Selkirk, Stow and Galashiels), due to a combination of fluvial and surface water flood risk.

As the site is predominantly greenfield, the proposed development will significantly increase impermeable surfacing within the site boundary. Suitable drainage measures should therefore be incorporated to ensure that the development remains protected from flooding from pluvial sources up to the 1 in 200-year flood event plus climate change.

Such mitigation measures would reduce the risk of pluvial flooding to the site to “Low” risk.

5.4 Groundwater Flooding

Groundwater flooding is not common in Scotland as a flood mechanism in its own right, however it can exacerbate flooding from other sources.

The bedrock beneath the site is indicated on the Geoindex to consist of a low productivity aquifer of the Gala Group, which comprises highly indurated greywackes with limited groundwater in the near-surface weathered zone and secondary fractures.

Local boreholes records made available online on the BGS Geoindex includes boreholes within the general vicinity of the site. These indicate that the geology of the surrounding area is mainly composed of SAND, GRAVEL and COBBLES with seams of CLAY. Record NT23NE3652/6, located approximately 190m east of the site, details an encounter with groundwater at approximately 3.7m below ground level.

The SEPA groundwater map indicates the site is located out-with an area considered to be at risk of groundwater contributing to flooding from other sources.

No incidences of flooding recorded within the local area detail groundwater flooding as a contributing factor to flood events originating from other sources.

It can be concluded from the available information that the proposed development site is at an overall “Low” risk of groundwater exacerbating flood risk from other sources.

5.5 Flooding from Infrastructure & Artificial Sources

5.5.1 Drainage

Blockages or overloading of pipes, sewers, drainage channels and failure of pumping stations can result in flooding from the drainage system.

Scottish Water has the public drainage duty and is responsible for the drainage of surface water from roofs and any paved ground surface within the boundary of a property (excluding private pipework or guttering). Additionally, Scottish Water helps to protect homes from flooding caused by sewers either overflowing or becoming blocked.

Private pipework or guttering within the property boundary remains the responsibility of the property owner. Therefore, a drainage maintenance strategy should be developed and followed to ensure regular maintenance of the onsite drainage infrastructure is undertaken. This could be developed as part of a private inspection and maintenance agreement with a third-party company and will help reduce the likelihood of blockages or failures. Additionally, site-wide mitigation measures should be implemented, where deemed necessary, to minimise the risk of sewer flooding from on-site and off-site sources.

It is noted that a 300mm diameter combined sewer overflow intersects the development site toward the western site boundary. As such, the proposals should ensure that the required stand-off distances to any developed area will be observed during the detailed design and/or existing Scottish Water infrastructure will be relocated within proposed access roads, in-line with the latest design standards and best practice guidance.

The site is considered to be at “Low” risk of flooding from drainage infrastructure, if appropriate mitigation and maintenance measures are put in place.

5.5.2 Reservoirs

The failure of reservoirs or dams can lead to serious flooding in areas located downstream of such infrastructure.

Current SEPA flood maps indicate that there are two reservoirs located upstream of the River Tweed that could pose a flood risk to the development in the event of flooding or failure, namely: Talla Reservoir and Fruid Reservoir, located approximately 23km and 26km south-west of the site, respectively.

Although the site is located within close proximity to the SEPA reservoir flood extents, the associated reservoirs are owned and maintained by Scottish Water and are considered to be in a good condition. Due to an ongoing inspection and maintenance regime, as required by law, it is considered highly unlikely that either of these two reservoirs are at risk of catastrophic failure.

Therefore, the site is considered to be at an overall "Low" risk of flooding from reservoir or dam failure.

5.5.3 Flood Defences

The site is not currently protected by a formal flood defence scheme. Therefore, the site is considered to be at an overall "Little to no" risk of flooding from flood defence failure.

5.5.4 Canals

The failure of canals can lead to serious flooding in areas located downstream of such infrastructure.

The site is not located within close proximity to the Scottish Canal network therefore the site is considered to be at "Little to no" risk of flooding from canals.

6. Flood Modelling

Due to the proximity of the site to the River Tweed and the potential flood risk indicated on the SEPA flood maps, a detailed hydraulic flood model was constructed to predict flood extents and flood levels within the vicinity of the proposed development site. The model includes assessment of the River Tweed and the Soonhope Burn, including any associated in-channel structures such as bridges, weirs and culverts (where applicable). Modelling of the River Tweed and Soonhope Burn was originally carried out in 2015 and gained planning permission in principle (15/00822/PPP), however due to changes in flow estimation and hydraulic modelling standards, as well as updated gauge records the assessment required updating.

6.1 Hydrological Assessment

A Hydrological Assessment was undertaken to estimate peak flows within the River Tweed and Soonhope Burn, using a combination of mapping, aerial photography, gauging station data (where applicable), Flood Estimation Handbook (FEH) data and specialist software.

A detailed breakdown of the hydrological assessment is provided in **Appendix E**, with estimated peak flows for each method summarised in **Table 3**, below.

Table 3: Summary of Flow Estimates for the River Tweed

Method	1 in 200-year (m^3/s)	1 in 200-year + 33% CC (m^3/s)
Single Site Method	653.43	869.06
Enhanced Single Site Method	579.38	770.58
ReFH2	469.31	624.18

6.1.1 Conclusion

Based on the information presented in **Appendix G**, and in-line with SEPA advice (refer to **Appendix C**), the most conservative peak flow estimate (single site analysis), with the addition of 33% climate change allowance, was adopted for use in the updated flood model. The IH124 method was used to estimate flows for the Soonhope Burn. The 1 in 200-year flood flow was estimated to be 9.2 m^3/s. With an additional allowance of 33% for climate change, the flows were estimated as 12.2 m^3/s.

A summary of the adopted peak flow estimates is provided in **Table 4**, below.

Table 4: Summary of Adopted Peak Flow Estimates

Watercourse	1 in 200-year flow (m^3/s)	1 in 200-year flow + 33% CC (m^3/s)
River Tweed	653.4	869.1
Soonhope Burn	9.2	12.2
Total	**662.6**	**881.3**

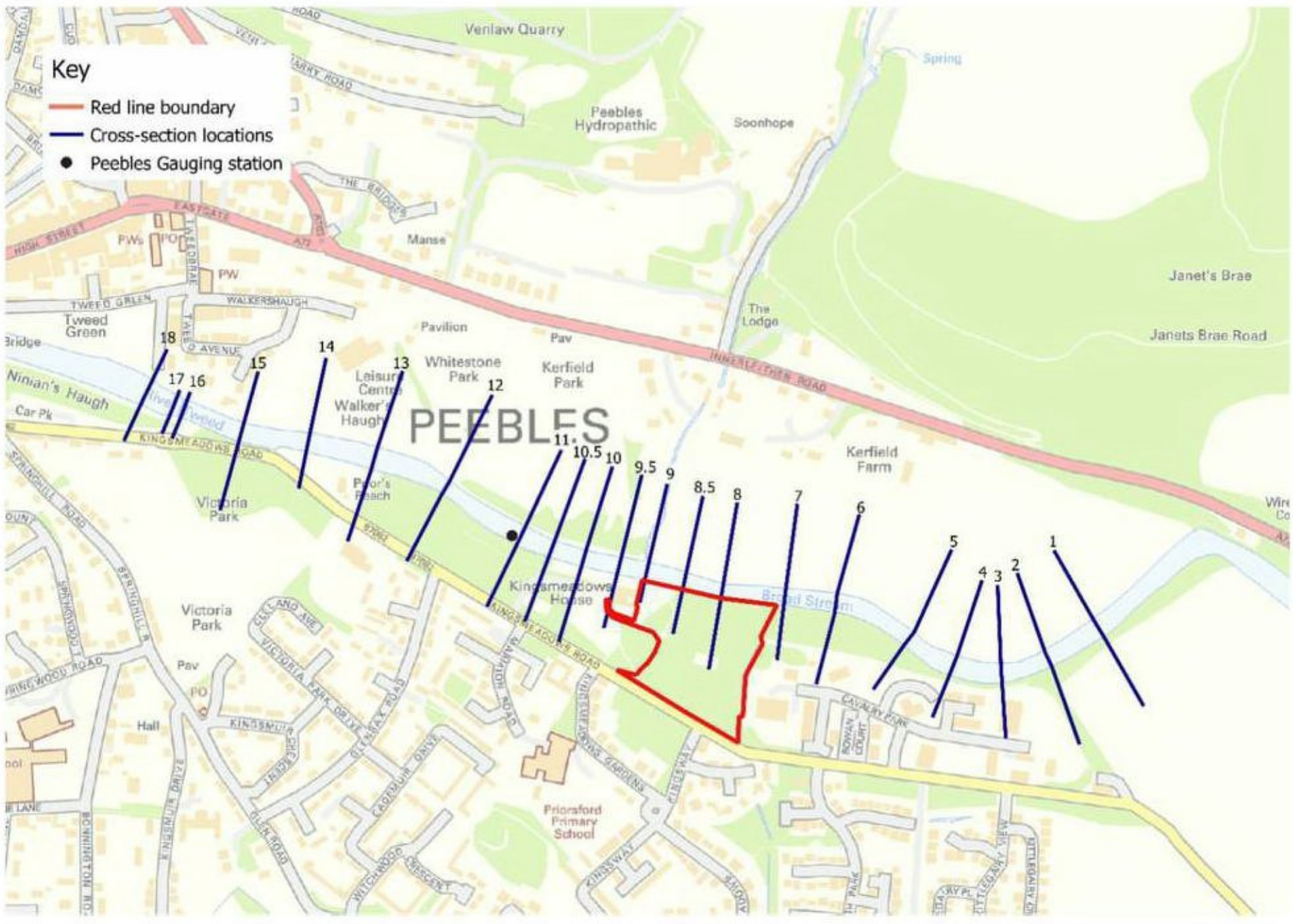
6.2 Modelling Methodology

The previously developed Flood Risk Assessment and hydraulic model has been utilised in this assessment to assess the risk of flooding to the proposed development site to the east of Kingsmeadow House. Due to the time elapsed since the previous study, undertaken in 2015, SEPA advised that the previous flood model was now of out-of-date and required updating to include for the latest flood information.

Hes-Ras software was used to update the previous 1D model, to represent a range of flows up to and including the 1 in 200-year flood event (0.5% AEP), with an additional 33% allowance for climate change, in order to determine the likely flood extents and associated flood risk to the proposed development site.

Cross-sections extracted from the topographical survey were used to create the 1D model, using 12D software. A bridge structure was inserted into the model between cross-sections 16 and 17, to represent the Priorsford footbridge located approximately 700m upstream of the site. The model was run using a steady flow analysis, with an initial flow rate on the River Tweed of 869.1 m^3/s, which is the calculated 1 in 200-year flood flow rate plus 33% allowance for climate change. A flow change location was added at the confluence with the Soonhope Burn to replicate the increase in flows, therefore the flow was increased to 881.3 m^3/s, at river station 9. **Figure 4** details the cross-sections locations used within the model.

Figure 4: Cross-section Locations



Contains Ordnance Survey data © Crown copyright and database right 2019.

A 3D model of the river was developed by manipulating the topographical survey using Civil 3D software. The estimated flood levels from the HEC-RAS model were used to generate flood maps for the relevant flood design flows.

6.3 Modelling Assumptions

Based on a review of aerial photography in conjunction with observations recorded during the site walkover, a Manning's value of n = 0.03 was assigned to the channel bed, representing a based on a clean, straight, full channel with no rifts or deep pools. Manning's values ranging between 0.03 to 0.05 were assigned to the banks to reflect the varying conditions recorded on-site such as short grass, high grass and scattered brush with weeds.

An example of the channel conditions is provided in **Figure 5**, illustrating the variance in roughness across the left and right banks of the River Tweed.

Figure 5: Looking downstream toward Kingsmeadow House

The model was run using a Normal Depth downstream boundary condition of 0.0026 m/m, based on the slope of the downstream river section.

During the model update, three interpolated sections were intersected into the model adjacent to the proposed development site (cross-sections 10.5, 9.5 and 8.5), to obtain a more accurate representation of flood extents in these areas. Interpolations were based on the information extracted from the topographic survey.

No further assumptions were included within the updated model.

6.4 Modelling Results

The 1D model was simulated using HEC-RAS with the estimated 1 in 200-year flood flow rate and the 1 in 200-year flood flow rate including 33% allowance for climate change, in-line with SEPA advice and current guidance.

Review of the modelling results indicates that a relatively small area of flooding occurs towards the north-eastern corner of the site during the 1 in 200-year event, reaching a level of 158.03m AOD immediately adjacent to the site (cross-section 9). During the 1 in 200-year + 33% climate change event, floodwaters are shown to breach areas along the northern boundary of the site, reaching a level of 158.42m AOD (cross-section 9).

Modelled water levels at each cross-section are summarised in **Table 5**, with the predicted flood extents presented in **Appendix F**.

The model results show that no other areas of the site are at risk of flooding from the River Tweed, up to and including the 1 in 200-year plus 33% climate change event.

Due to the nature of the development proposals and the relative size of the development site, it is considered reasonable that any vulnerable infrastructure can be located out-with areas considered to be at risk of fluvial flooding and at a sufficient distance and minimum Finished Floor Level (FFLs) to ensure that the development will remain safe and dry in a climate change event.

FFLs in the northern portion of the site should be constructed at least 600mm above the adjacent 200-year plus climate change flood levels. Based on the model results, the FFLs along the northern boundary of the site should therefore be set to a minimum of 159.02m AOD, with buildings located out with the functional floodplain (1 in 200-year flood extents), wherever possible. The proposed layout plan shows the building has been located out with the 1 in 200-year flood extents.

6.5 Model Verification

The maximum flow and stage data obtained by SEPA (refer to **Section 4.3.3**) was used to carry out verification of the model. The gauging station is located at cross-section 11 in the model, therefore the model result at this location should correspond with the level recorded during the flood event, which was 158.23m. The base model (assuming the above conditions noted in **Sections 6.2** and **6.3**) was run with a flow of 499.99 m^3/s, which resulted in a flood level at cross-section 11 of 158.26m. This is noted to be 0.03m higher than that recorded during the flood event and is therefore considered to be a negligible difference. With this in mind, the model is considered to accurately represent the flood levels with the River Tweed. The results of the verification run can be seen in **Appendix G**.

Table 5 : Modelling Results

Cross-section		Description/location	Modelled Flood Levels (m AOD)	
			Single-site Analysis 1 in 200	Single-site Analysis 1 in 200 + 33% CC
River Tweed	18	50m Upstream of Priorsford Footbridge	162.16	162.97
	17	Upstream face of Priorsford Footbridge	161.38	161.91
	16	Downstream face of Priorsford Footbridge	160.05	160.87
	15	Dismantled Railway LOB (left overbank)	158.80	159.20
	14	Gyte Leisure Centre LOB	158.81	159.28
	13	Adjacent to Day Centre LOB	158.86	159.31
	12	Whitestone Park LOB	158.80	159.26
	11	Kerfield Park LOB	158.60	159.02
	10.5	Interpolated section	158.52	158.93
	10	Between Kingsmeadow Lodge and House ROB	158.45	158.89
	9.5	Interpolated section	158.31	158.76
	9	Kingsmeadow House ROB (right overbank)	158.03	158.42
	8.5	Interpolated section	157.93	158.34
	8	Wooded area adjacent to Kingsmeadow House ROB	157.79	158.25
	7	Eastern boundary of the site ROB	157.89	158.33
	6	West of Industrial Estate ROB	157.80	158.25
	5	Centre of Industrial Estate ROB	157.73	158.17
	4	Centre on Industrial Estate ROB	157.45	157.85
	3	On Bend in River Tweed	157.19	157.57
	2	Eastern boundary of Industrial Estate	156.82	157.09
	1	Downstream end section	156.26	156.47

6.6 Sensitivity Analysis

An appropriate sensitivity analysis was carried out to determine the sensitivity of design water levels to key model parameters, such as channel roughness and blockage scenarios. This is a standard verification procedure required by SEPA to ensure the model is stable and running as intended, as detailed in SEPA's Technical Flood Risk Guidance for Stakeholders[2].

The results of the sensitivity analysis are presented in **Appendix H**.

[2] SEPA (2015) Technical Flood Risk Guidance for Stakeholders, Version 9.1. Available at: https://www.sepa.org.uk/media/162602/ss-nfr-p-002-technical-flood-risk-guidance-for-stakeholders.pdf

6.6.1 Design Flows

The model was run with a range of flows of different return periods to ensure there were no anomalies in the model. As the proposed 1 in 200-year and 1 in 200-year plus 33% climate change design flows were the most conservative, and therefore highest, of those estimated it was not deemed necessary to increase these flows as part of the sensitivity analysis.

Water levels increased in line with the design flows, as would be expected.

6.6.2 Roughness Values

Appropriate Manning's roughness values for the model were determined using information provided in the report by Chow from 1959. As part of the sensitivity analysis, the "normal" Manning's values were increased and decreased by 20% to represent differences in channel roughness.

The model proves to be susceptible to variations in the roughness of the channel. The 'Plus N' scenario results in increases in flood depths and extents in the vicinity of the site. The impact is caused by a reduction in fluvial-carrying capacity of the channel as a result of the increase in hydraulic roughness. This results in a higher water level in channel, resulting in a greater volume of water spilling onto the floodplain, as would be expected.

The reverse is true for the 'Minus N' model. The lower hydraulic roughness allows a greater volume of water to flow within the channel before spilling onto the floodplain leading to a smaller flood extent, as would be expected.

6.6.3 Blockage Scenarios

Blockage scenarios were simulated on the only bridge structure within the modelled reach (cross-section 16), which represents the Priorsford footbridge bridge located approximately 700m upstream of the site. Although it is considered unlikely that a blockage at this particular structure would cause a significant impact to flood extents at the site, 50% and 100% blockage scenarios were simulated nonetheless to test the sensitivity of the model to this parameter.

Review of the blockage scenarios indicates a slight alteration to flood extents upstream of the site, however no considerable impacts were noted at the immediate site boundary, as would be expected.

6.6.4 Boundary Condition

The base model was run with a Normal Depth downstream boundary condition. The model was run with the Normal Depth altered by +20% and -20%, as a Critical Depth downstream boundary condition. Slight changes were noted in the water levels at the cross-sections directly upstream of the end of the reach for the altered Normal Depth boundary conditions, however no changes were noted for the Critical Depth run.

6.6.5 Summary

The results of the sensitivity analysis show that the model responds as expected to alterations in key model parameters and is therefore considered stable. A summary of the sensitivity analysis is presented in **Table 6**, below.

Table 6 : Summary of Sensitivity Analysis Results

River Section		Modelled Sensitivity Analysis 1 in 200-year Levels (m AOD)					
		Manning's n -20%	Manning's n +20%	Blockage Scenario A (50%)	Blockage Scenario B (100%)	Normal Depth Boundary -20%	Normal Depth Boundary +20%
River Tweed	18	162.15	162.17	163.03	164.36	162.16	162.16
	17	161.38	161.38	162.37	163.8	161.38	161.38
	16	160.05	160.05	161	162.16	160.05	160.05
	15	158.74	159.14	158.8	158.8	158.8	158.8
	14	158.64	159.1	158.81	158.81	158.81	158.81
	13	158.67	159.06	158.86	158.86	158.86	158.86
	12	158.66	158.98	158.8	158.8	158.8	158.8
	11	158.49	158.76	158.6	158.6	158.6	158.6
	10.5	158.43	158.68	158.52	158.52	158.52	158.52
	10	158.37	158.6	158.45	158.45	158.45	158.45
	9.5	158.25	158.48	158.31	158.31	158.31	158.31
	9	157.87	158.27	158.03	158.03	158.03	158.03
	8.5	157.75	158.16	157.93	157.93	157.93	157.93
	8	157.64	158.04	157.79	157.79	157.79	157.79
	7	157.73	158.05	157.89	157.89	157.89	157.89
	6	157.65	157.95	157.8	157.8	157.8	157.8
	5	157.63	157.84	157.73	157.73	157.73	157.73
	4	157.33	157.57	157.45	157.45	157.45	157.45
	3	156.97	157.32	157.19	157.19	157.19	157.19
	2	156.82	156.82	156.82	156.82	156.82	156.82
	1	156.26	156.26	156.26	156.26	156.49	156.3

7. Flood Risk Mitigation Measures

Fluvial Flooding

The proposed development is considered by SEPA to be a "Highly Vulnerable Use" with respect to Land Use Vulnerability. The development is, therefore, required to be protected from fluvial flooding up to the 1 in 200-year flood event with an allowance for climate change. To comply with SEPA and planning requirements, a freeboard of 600mm is required above the maximum adjacent flood level, to finished floor level, with all proposed buildings located out with the functional floodplain wherever possible.

Based on the modelling results detailed in **Section 6**, a relatively small area of flooding occurs towards the north-eastern corner of the site during the 1 in 200-year event, with floodwaters breaching areas along the northern boundary of the site during the 1 in 200-year + 33%CC event. Based on the indicative layout plan, it is anticipated that floodwaters can be retained within the landscaped areas and will not impact on the built development. In compliance with current planning policy, all proposed infrastructure should be located away from this area to ensure the development is protected during a climate change flood.

FFLs should be constructed at least 600mm above the adjacent 200-year + climate change flood levels. Based on the model results, the FFLs along the northern boundary of the site should therefore be set to a minimum of 159.02m AOD, with all proposed buildings located out with the functional floodplain (1 in 200-year flood extents), wherever possible. The current layout plan shows that the proposed building has been located out with the 1 in 200-year flood extents.

Assuming these recommendations are incorporated into the design proposals, the site is considered to be at "Low" risk of fluvial flooding.

To provide further protection to the development, it is proposed to ensure that all ground generally slopes away from the proposed buildings at a sufficient gradient to ensure that floodwaters cannot enter. Where disabled access is proposed to a building, ramps should also slope away from the building to ensure overland flows cannot pose a flood risk.

Pluvial Flooding

As the site is currently greenfield, the proposed development will significantly increase impermeable surfacing within the site boundary. Therefore, suitable drainage measures should be incorporated to ensure that there is no increase in flood risk to the development and surrounding area from pluvial sources up to the 1 in 200-year + climate change event. SuDS should be provided as part of the drainage network to treat and attenuate surface water flows, prior to discharge to a suitable discharge point on the River Tweed.

8. Conclusions and Recommendations

8.1 Conclusions

Suitable mitigation measures will ensure that the development proposals can proceed without significantly increasing the risk of flooding to the site or the surrounding areas.

8.2 Flood Risk Assessment

The assessment confirmed that there was “Little to no” risk of flooding from coastal sources and “Low” risk of flooding from fluvial, pluvial, groundwater, infrastructure and artificial sources.

The SEPA flood map indicates that the northern portion of the site is located within the High (10% AEP), Medium (0.5% AEP) and Low (0.1% AEP) likelihood fluvial food extents. Floodwater originates from the River Tweed and Soonhope Burn, which flow in easterly direction approximately 20m north of the development site.

A flood model of the River Tweed was constructed to estimate the extent of fluvial flood risk to the proposed development. The estimated flood levels from the model were used to generate flood maps for a range of return periods, including the 1 in 200-year and 1 in 200-year plus climate change flood events.

Modelling results indicate a relatively small area of flooding occurs towards the north-eastern corner of the site during the 1 in 200-year event, with floodwaters breaching areas along the northern boundary of the site during the 1 in 200-year + 33%CC event. Based on the indicative layout plan, it is anticipated that floodwaters can be retained within the landscaped areas and will not impact on the built development. In compliance with current planning policy, all proposed infrastructure should be located away from this area to ensure the development is protected during a climate change flood.

FFLs should be constructed at least 600mm above the adjacent 200-year + climate change flood levels. Based on the model results, the FFLs along the northern boundary of the site should therefore be set to a minimum of 159.02m AOD, with all proposed buildings located out with the functional floodplain (1 in 200-year flood extents), wherever possible. Current development plans show that the proposed building has been located out with the 1 in 200-year food extents.

The results also show that the remainder of the site is not at risk of flooding during a 1 in 200-year plus climate change event.

The SEPA flood map does not indicate the site as being at risk of flooding from pluvial sources. However, as the site is currently greenfield, the proposed development will significantly increase impermeable surfacing within the site boundary. Therefore, suitable drainage measures should be incorporated to ensure that there is no increase in flood risk to the development and surrounding area from pluvial sources up to the 1 in 200-year + climate change event. SuDS will be provided as part of the drainage network to treat and attenuate surface water flows, prior to discharge into the suitable discharge points on the River Tweed.

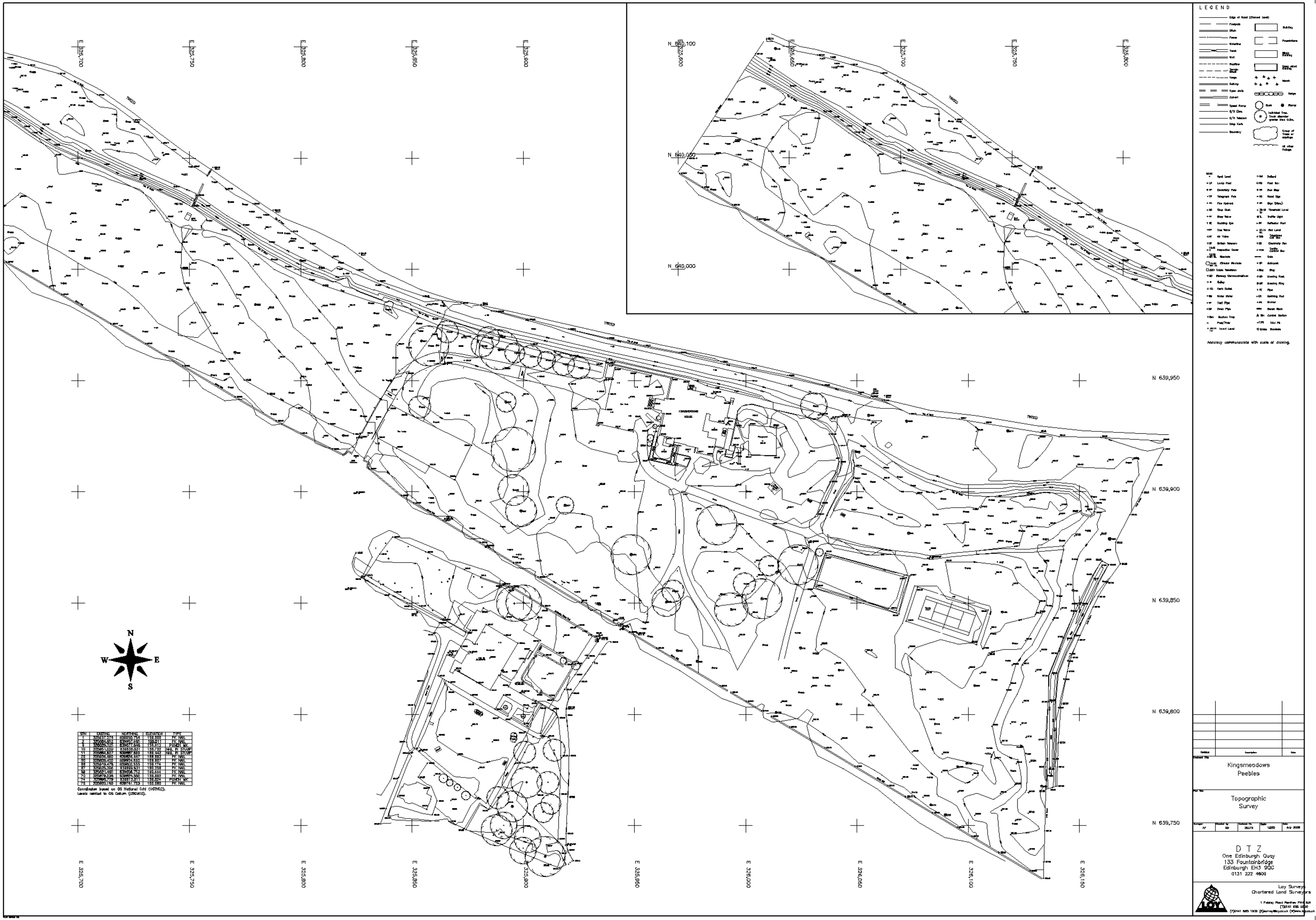
8.3 Recommendations

A summary of recommendations is as follows;

- FFLs should be constructed at least 600mm above the adjacent 200-year + climate change flood levels.
- Suitable drainage measures should be incorporated to ensure that there is no increase in flood risk to the development and surrounding area from pluvial sources up to the 1 in 200-year + climate change event.

APPENDICES

A. Topographical Survey


LEGEND
N 640,100
N 640,050
N 640,000
N 639,950
N 639,900
N 639,850
N 639,800
N 639,750
E 325,700
E 325,750
E 325,800
E 325,850
E 325,900
E 325,950
E 326,000
E 326,050
E 326,100
E 326,150
N
S
E
W
Kingsmeadows
Peebles
Topographic
Survey
D T Z
One Edinburgh Quay
133 Fountainbridge
Edinburgh EH3 9QG
0131 222 4609
Loy Surveys
Chartered Land Surveyors

B. Proposed Layout Plan

0 1 2 3 4 5 6

1:100 scale at A1 size

Grass

SN

SN

Deck

Deck

Flat 2 80m²

Private Garage

1 in 200 year flood event line

1 in 200 year flood event +33% line

+157.46 ex

+157.87 ex

+157.48 ex

+164.99 ex

+157.74 ex

Grass

Turning area

+158.50 road level

+157.90 ex

Paved Courtyard

Plant

Private Garages

Bike store

+158.05 pro

Deck

Flat 3 102m²

+158.4

+158.85

ramp up

Entry

+159.25

Existing stone tower and walls.

Refuse store with timber screen

Communal parking

+159.01 existing

+158.84 ex

Grass

+159.24 ex

+158.33 ex

Communal parking

Turning area for service vehicles

Drop Off

+159.10 existing

+158.42 ex

Revision	Date
B- Building moved to avoid flood event line	10.05.19
A. Plan updated	10/07/15

ZONE ARCHITECTS

211 Granton Road
Edinburgh EH5 1HD
Tel 0131 551 1973
Fax 0131 551 3469

project
Kingsmeadows House
Peebles

client
Granton Homes

drawing
Site Plan

scale
1:100 at A1

date
June 2015

drawn by

revision no
B

drawing no
329-004

C. SEPA Correspondence

Nicola Day

From: Milne, Alasdair <alasdair.milne@SEPA.org.uk>
Sent: 08 May 2019 14:44
To: Kim McKissock
Subject: RE: FAO Alasdair Milne - PCS/163952ld Proposed Development Kingsmeadow 19/00182/PPP

Kim,

Further to your email of 1 May below, I have discussed this with our hydrologists and would advise as follows:

As per our previous response, we are unable to comment on whether the proposed development is acceptable until we have reviewed the full FRA and we retain the right to object following provision of this if we are not satisfied that the development accords with the principles of Scottish Planning Policy. However, we can offer the following response to your enquiries.

1. As per our previous response, SEPA are unable to support new development within the functional floodplain due to the potential impact on flood risk elsewhere. However, we note from the information provided that the functional floodplain is shown to only just encroach on the footprint of the building and that the topography of the site is such that the site slopes up to the building. The information provided indicates that a volume of $0.39m^3$ is likely to be displaced, which we accept is unlikely to have any impact on the floodplain. Whilst we acknowledge the above, we would still strongly recommend that the building footprint is moved back to prevent any flood water from encroaching on the building exterior.

2. You have carried out a review of the hydrology given an extra 10 years of data exists which includes significant flows in 2015/16. You have provided updated flows based on Single Site analysis and also Enhanced Single Site analysis. Whilst we do not disagree with the flow estimates provided, we would strongly recommend a conservative approach is used in adopting design flows, particularly in the setting of finished floor levels. We also strongly recommend an allowance for climate change is made and would note that our guidance on climate change uplifts is being updated imminently and will reflect current best data with a regional flow uplift for the Tweed catchment being 33% (based on the study from The Centre for Ecology and Hydrology (2011) entitled 'An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change' based upon UKCP09 projections).

3. Please note that we are reliant on the accuracy and completeness of any information supplied by the applicant in undertaking our review, and can take no responsibility for incorrect data or interpretation made by the authors.

I trust these comments are of assistance – please do not hesitate to contact me if you require any further information.

Regards
Alasdair

Alasdair Milne
Senior Planning Officer
Scottish Environment Protection Agency
Strathallan House
Castle Business Park
Stirling
FK9 4TZ

Telephone 01786 452537
Mobile 07827 978405

www.sepa.org.uk

From: Kim McKissock <kim.mckissock@watermangroup.com>
Sent: 01 May 2019 12:07
To: Planning South East <Planning.SE@SEPA.org.uk>
Subject: RE: FAO Alasdair Milne - PCS/163952ld Proposed Development Kingsmeadow 19/00182/PPP

Apologies, I never attached the flood extents plan with my previous email. Please now find attached.

Regards
Kim

Kim McKissock
Associate Director
Waterman Infrastructure & Environment Ltd
t +44 1738 449801 | **m** +44 7825668401 | dd +44 3300602645

From: Kim McKissock
Sent: 01 May 2019 12:06
To: 'Planning South East' <Planning.SE@SEPA.org.uk>
Subject: FAO Alasdair Milne - PCS/163952ld Proposed Development Kingsmeadow 19/00182/PPP

Hi Alasdair,

Further to your comments below, we have carried out a preliminary assessment to determine the likely extents of the 1 in 200 year floodplain to enable our client to determine whether the development is still feasible.

We have carried out an updated assessment of flows within the River Tweed and run these through the updated Hec Ras model (including 2 additional cross-sections at the at risk location). We have run two 1 in 200 year flow rates in the model runs – Method A (single site) which is the same method used in the original model using the updated figures so is most directly comparable to the flows used previously in the model, and Method B (enhanced single site). A ReFH2 check was also carried out. The flows are as follows;

Original Method A Flow (Single Site 2008/2015 FRA) = 563.4 m^3/s
Updated Method A (Single Site 2019) = 653 m^3/s
Method B (Enhanced Single Site) = 579 m^3/s
ReFH2 = 469 m^3/s

As there are only 58 years worth of data available for the River Tweed gauge best practice guidance would indicate that the single site method is no longer be considered suitable for defining the 200-year flood events. We carried out an additional check which included the enhanced single site method of flow estimation which would also be considered acceptable according to current best practise, which produces lower peak flows. The ReFH2 flows are significantly lower.

As you can see from the results of the Method B model runs (which we have assumed would be considered most appropriate), the flood water extends within the footprint of the proposed development. This has been estimated to be approximately 1.2m at the widest section, at a very shallow depth and cover an area of 6.8m^2. Given that the maximum possible depth of the flooding at the corner of the building is 0.26m and the site slopes up towards the building, the maximum volume of flooding that can be displaced is much less than the flood footprint. The segment of development shown within the flood extents was assessed in Civil 3D software to determine the volume that would be displaced. This was determined to be 0.39m^3 which is unlikely to impact on the flood storage capacity a river the size of the River Tweed.

Although this initial assessment does not include the sensitivity analysis or verification of levels with the flood event data, the assessment was based on the existing hydraulic model which was previously approved.

With this in mind, would SEPA be willing to consider options to allow the development to progress?

Regards
Kim

Kim McKissock
Associate Director
Waterman Infrastructure & Environment Ltd
t +44 1738 449801 | m +44 7825668401 | dd +44 3300602645

From: Planning South East <Planning.SE@SEPA.org.uk>
Sent: 11 April 2019 14:16
To: Kim McKissock <kim.mckissock@watermangroup.com>
Subject: RE: FAO Alasdair Milne - PCS/163952ld Proposed Development Kingsmeadow 19/00182/PPP

Kim

Further to your email of 7 April below, having consulted with our flood risk hydrologists I can advise as follows:

We previously objected to this application and requested that the previous Flood Risk Assessment (FRA) be updated to include recent, significant flood events on the River Tweed. You have consulted us in order for us to advise you further on our requirements and to determine what would be considered acceptable in terms of flood risk to develop in this area. Without seeing the results of the updated FRA we are unable to comment on whether a development in this area would be acceptable but we can offer the following response to your enquiries.

SEPA are unable to support development within the functional floodplain as this will result in an overall increase in flood risk which is contrary to Scottish Planning Policy and the Flood Risk Management (Scotland) Act 2009. Although landraising and associated compensatory storage can be modelled to indicate no increase in flood risk elsewhere, it is unlikely that storage and conveyance can be replicated to mimic the natural floodplain processes and as such avoidance of the floodplain, except in exceptional circumstances, should be observed. We believe it is unlikely in this area that a tangible flood benefit could be provided through provision of compensatory storage given the extent and depth of flooding observed.

Review of the previous FRA indicates that the modelling is likely to be acceptable, however, we have not carried out a review of the previous model and it is for you to decide whether it is appropriate to determine flood risk at this site. Calibration of the model using information from recent flood events should indicate whether the extents of the modelling are appropriate to predict accurate flood levels and extents at the site.

Please note that we are reliant on the accuracy and completeness of any information supplied by the applicant in undertaking our review, and can take no responsibility for incorrect data or interpretation made by the authors.

I trust these comments are of assistance – please do not hesitate to contact me if you require any further information.

Regards
Alasdair

Alasdair Milne
Senior Planning Officer
Scottish Environment Protection Agency
Strathallan House
Castle Business Park
Stirling
FK9 4TZ

Telephone 01786 452537

Mobile 07827 978405
www.sepa.org.uk

From: Kim McKissock <kim.mckissock@watermangroup.com>
Sent: 07 April 2019 16:00
To: Planning South East <Planning.SE@SEPA.org.uk>
Subject: FAO Alasdair Milne - PCS/163952ld Proposed Development Kingsmeadow 19/00182/PPP

Hi Alasdair,

With reference to your planning objection letter of 5th March 2019, we have been approached by Granton Homes to provide an updated flood risk assessment. As you will be aware, planning permission was previously granted in 2015, however the development was delayed and the permission lapsed. Prior to confirming our scope, we have been asked to confirm the parameters for providing an updated flood risk assessment and determine whether there would be any scope to develop in the proposed location if the development boundary is only slightly within the floodplain (less than 1m or similar). In addition, determine whether flood storage compensation that would provide betterment could be considered.

We acknowledge that FEH data has been updated since the previous flood study and that flood evidence data is available to calibrate flows and predicted flood extents. We intend to carry out an updated hydrological assessment and re-run the existing 1D flood model with updated flow data. Can you confirm that the existing flood model is considered sufficient and does not require extending?

The original flood modelling of 2008 (which was reviewed in the FRA update of 2015) identified that a small section of the proposed building was located within the functional floodplain (see attached flood extents). As can be seen from the attached extents drawings, the area predicted to be at risk of flooding is between two modelled cross-sections. It is our intention to include additional cross-sections at this location to further define the flood extents at the risk location. We acknowledge that estimated flows and the climate change allowance may be higher than in the previous flood study, however it is unclear whether this would increase the flood extents within the site as the opposite bank of the River Tweed is significantly lower than the site and contains embankments, so flood extents within the site may be lower on the site. With this in mind, we need to rerun the model with the updated flows to determine the extents.

We note that the objection is based on the current extents of flooding, however if this was determined to slightly less but still skirt the boundary of the new development, would this be considered if additional compensation was proposed? We acknowledge that development of greenfield sites within the functional floodplain is no longer accepted, however Granton homes have access to areas of land within the vicinity of the site and could provide compensatory storage that could provide a betterment to existing flooding. Would this be considered?

Happy to discuss. If you have any queries or require further information, please do not hesitate to contact me.

Regards
Kim

Kim McKissock
Associate Director
Waterman Infrastructure & Environment Ltd

Broxden House | Broxden Business Park | Lamberkine Drive | Perth PH1 1RA
t +44 1738 449801 | **m** +44 7825668401 | dd +44 3300602645
www.watermangroup.com | LinkedIn | Twitter

D. Scottish Borders Council Correspondence

Consultation Reply

ENVIRONMENT AND INFRASTRUCTURE

To: HEAD OF PLANNING AND REGULATORY SERVICE

FAO: Ranald Dods **Your Ref:** 19/00182/PPP

From: HEAD OF ENGINEERING & INFRASTRUCTURE **Date:** 28th February 2019

Contact: Lauren Addis **Ext:** 6517 **Our Ref:** B48/2678

Nature of Proposal: Erection of residential apartments (renewal of previous consent 15/00822/PPP)

Site: Site in Grounds of Kingsmeadows House Kingsmeadows, Kingsmeadows Road, Peebles, Scottish Borders

---

In terms of information that this Council has concerning flood risk to this site, I would state that The Indicative River, Surface Water & Coastal Hazard Map (Scotland) known as the "third generation flood mapping" prepared by SEPA indicates that the site is at risk from a flood event with a return period of 1 in 200 years. That is the 0.5% annual risk of a flood occurring in any one year.

The Indicative River & Coastal Flood Map (Scotland) has primarily been developed to provide a strategic national overview of flood risk in Scotland. Whilst all reasonable effort has been made to ensure that the flood map is accurate for its intended purpose, no warranty is given.

Due to copyright restrictions I cannot copy the map to you however, if the applicant wishes to inspect the maps they can contact me to arrange a suitable time to come in and view them.

Review of the application shows that the proposed site is located within the 1 in 200 year (0.5% annual probability) flood extent of the River Tweed and may be at medium to high risk of flooding.
A Flood Risk Assessment was undertaken in 2015 by Waterman Infrastructure and Environment to support previous application 15/00822/PPP at this site.

Hydraulic modelling has been undertaken using a 1 in 200 year flow of 687.14m^3/s. The maximum flood level at cross section 10 (Kingsmeadow House ROB) is 157.86mAOD and 158.08mAOD with a consideration for climate change. It is proposed that the development will have a finished floor level of 158.7mOD. These floor levels are acceptable and provide 600mm of freeboard above the 1 in 200 year plus climate change flood level.

The FRA recommends a number of mitigation measures to reduce the risk of flooding including extending an existing embankment. Should a full application be submitted for this site we would require that details of the proposals to alter the embankment are submitted for approval as well as details of associated compensatory storage.

Details of proposed SuDS for the development should also be submitted for approval.

Please note that this information must be taken in the context of material that this Council holds in fulfilling its duties under the Flood Risk Management (Scotland) Act 2009.

Lauren Addis
Technician
Flood Risk and Coastal Management

Nicola Day

From: Chalmers, Ian <Ian.Chalmers@scotborders.gov.uk>
Sent: 29 May 2019 15:56
To: Kim McKissock
Subject: RE: River Tweed Post-flood Events survey 2015
Attachments: AEM-JBAU-PB-00-AG-A-0017-Flood_Mapping_Tweed DM 0.5 AP Event.pdf

Hi Kim,

Great, please see attached the 1 in 200 year flood mapping developed for the Tweed incl. Peebles.

Please also see the link to our flood study mapping etc. which includes mapping at different return periods.
http://bordersfloodstudies.com/downloads/

Regards, Ian

From: Kim McKissock [mailto:kim.mckissock@watermangroup.com]
Sent: 29 May 2019 11:50
To: Chalmers, Ian <Ian.Chalmers@scotborders.gov.uk>
Subject: RE: River Tweed Post-flood Events survey 2015

Hi Ian,

Thank you for the information, this is extremely helpful.

Would you be able to provide the 1 in 200 year mapping as indicated below.

I assumed that calibrating the model with the flow and stage you note below will be sufficient, rather than assessing levels against the post-flood event report as requested by SEPA.

Thanks in advance.

Regards
Kim

Kim McKissock
Associate Director
Waterman Infrastructure & Environment Ltd
t +44 1738 449801 | **m** +44 7825668401 | dd +44 3300602645

From: Chalmers, Ian <Ian.Chalmers@scotborders.gov.uk>
Sent: 21 May 2019 09:37
To: Kim McKissock <kim.mckissock@watermangroup.com>
Subject: RE: River Tweed Post-flood Events survey 2015

Hi Kim,

I see that SEPA made this request in their response.

Since 2016, we have undertaken a flood study in Peebles that has measured flood risk from the River Tweed (incl. at Kingsmeadows). This flood mapping is for all of the Tweed in Peebles so wasn't developed as a site-specific case for Kingsmeadows but has been developed by the Council so I could pass over the 1 in 200 year mapping if required?

This mapping shows the only risk to be at the East side of the site and is similar to the SEPA mapping but less extensive on the site (only a small section in the east corner at risk in our mapping).

In our Hydrology report for the Peebles study, the design flow information in the attachment was presented – SEPA agreed with these estimated design flows.

During the 2015/16 event, the highest flow we had was 30/12/16 at 16:15 = 499.99m³/s. Stage was 3.65m. Please see the Peebles gauge flows & water levels over Dec 21st 2015- 3rd Jan 16.

If you had other specific information that you need, please let me know.

Regards, Ian

From: Kim McKissock [mailto:kim.mckissock@watermangroup.com]
Sent: 15 May 2019 11:11
To: Chalmers, Ian <Ian.Chalmers@scotborders.gov.uk>
Subject: River Tweed Post-flood Events survey 2015

Hi Ian, hope you are well.

We spoke some time ago (3 years-ish) about the proposed development at Kingsmeadow, Peebles. We have been appointed by Granton Homes to update the flood risk assessment to support the proposed development (Planning application number 19/00182/PPP).

In their planning response (PCS/163952), SEPA objected to the development as the existing flood risk assessment was considered out of date. As part of the updated flood risk assessment, updated modelling is required. SEPA have requested that the 2015 River Tweed Post-flood survey information is used to calibrate the updated model, and that this information should be obtained from Scottish Borders Council. Is this something you can provide? If not, would you be able to provide a contact that can help?

Please let me know if there is any information you require from us.

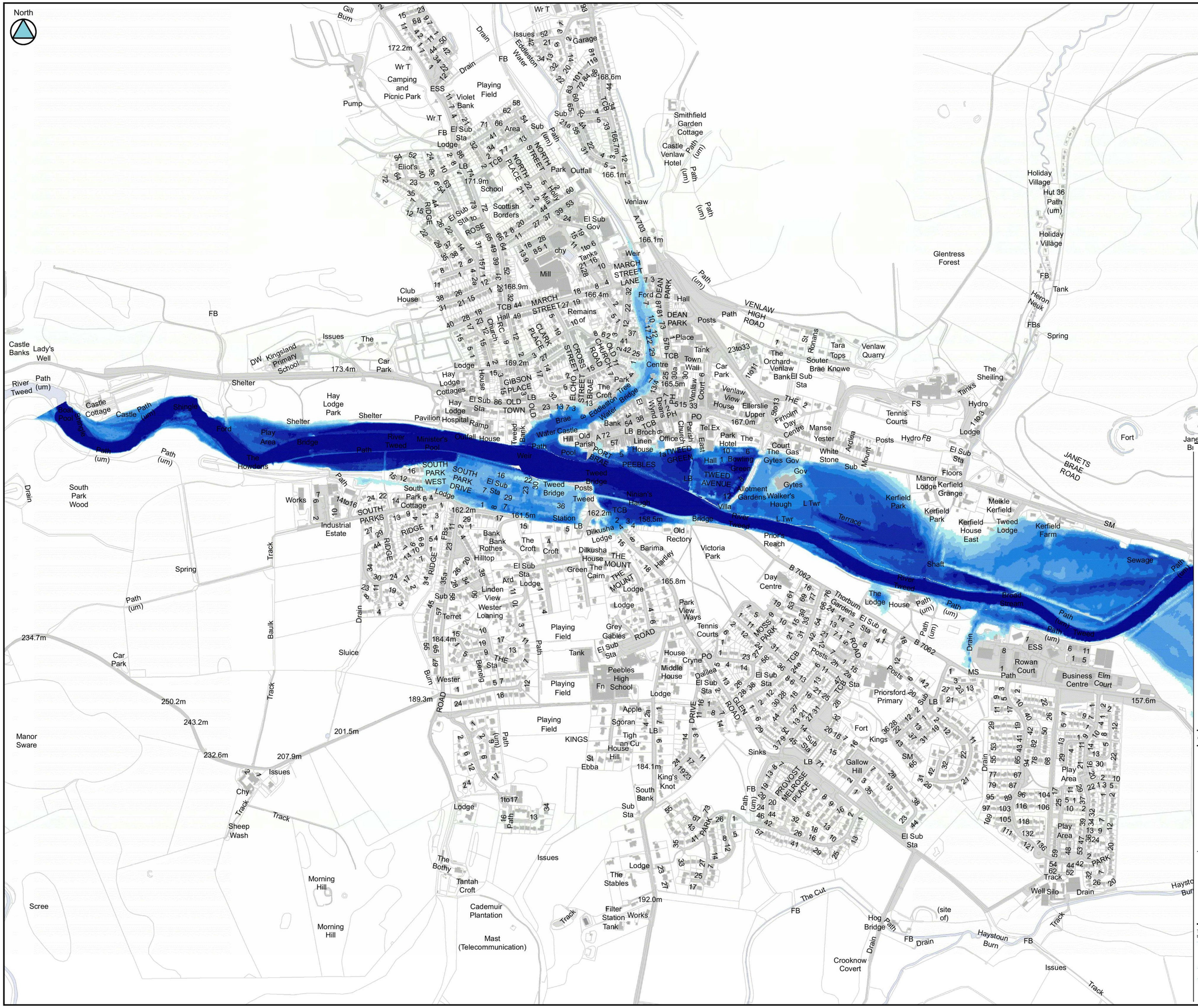
Thank you in advance.

Regards
Kim

Kim McKissock
Associate Director
Waterman Infrastructure & Environment Ltd

Broxden House | Broxden Business Park | Lamberkine Drive | Perth PH1 1RA
t +44 1738 449801 | **m** +44 7825668401 | dd +44 3300602645
www.watermangroup.com | LinkedIn | Twitter

This email and any files transmitted with it are privileged, confidential and subject to copyright. Any unauthorised use or disclosure of any part of this email is prohibited. If you are not the intended recipient please inform the sender immediately; you should then delete the email and remove any copies from your system. The views or opinions expressed in this communication may not necessarily be those of Scottish Borders Council. Please be advised that Scottish Borders Council's incoming and outgoing email is subject to regular monitoring and any email may require to be disclosed by the Council under the provisions of the Freedom of Information (Scotland) Act 2002 .



JBA consulting
Unit 2.1 Quantum Court
Research Avenue South
Heriot Watt Research Park
Edinburgh
EH14 4AP
United Kingdom
www.jbaconsulting.co.uk
t: +44 (0)131 319 2940
f: +44 (0)131 319 2944
e: info@jbaconsulting.co.uk

Other offices at Coleshill, Doncaster, Dublin, Exeter, Glasgow, Haywards Heath, Isle of Man, Limerick, Newcastle upon Tyne, Newport, Peterborough, Saltaire, Skipton, Tadcaster, Thirsk, Wallingford & Warrington

for

SCOTTISH BORDERS COUNCIL

River Tweed
Fluvial Flood Map
Do Minimum 0.5% AP (Q200) Event

Scale: 1:5000	Drawn	T Fletcher	Nov '17
	Checked	A Pettit	Nov '17
	Approved	A Pettit	Nov '17

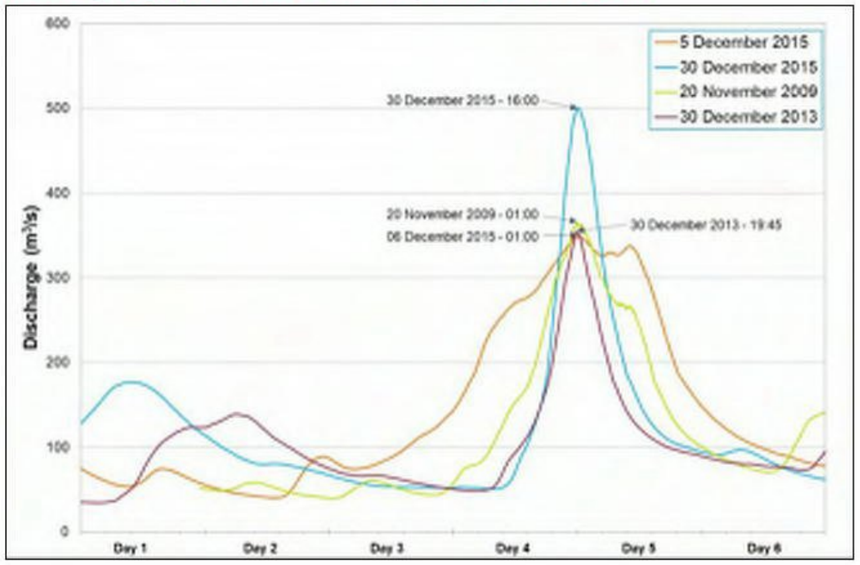
Digital File Name: AEM-JBAU-PB-00-AG-A-0017-Flood_Mapping_Tweed-S0-P01.01.MXD

Drawing Number:	Sheet No.:	Status:	Rev.:
DM 0.5% AP Event	1 of 5	S4	P01

Original @ A1

Flood Record

Flood hydrographs for the last 4 major floods at Peebles



Oct 1949
River Tweed & Eddleston Water flooded. Uncertainty of peak flow. Half dozen houses and Morelands Hospital flooded to 6-8 feet.

Aug 1948
Large scale flooding in the Borders

Jan 1962
A hospital, roads, homes and factories flooded. Many roads impassable. The flood event is known to have affected a large part of the Borders region.

Oct 2005
Some flooding from the Eddleston Water.

Nov 2009
River Tweed flooded at Tweed Green. Property was also flooded at Cardrona.

Dec 2015
The Tweed Green inundated by the River Tweed on two occasions. Internal property flooding to a number of residential properties including the Nursing home on Tweed Green.

Jan 2018
Tweed Green partially inundated by the River Tweed. Also flooding of the Gytes Leisure Centre pitches.

1930 1940 1950 1960 1970 1980 1990 2000 2010 2020

1937
River Tweed flooding to Tweed Green and Tweed Avenue.

1951
Multiple locations of flooding witnessed.

1977
A flood is known to have affected a large part of the region, including Peebles. Several bridges were swept away. Residential and commercial properties and agricultural land were also affected.

Jan 2005
Property around Tweed Green flooded from the River Tweed.

Dec 2013
Tweed Green inundated from the River Tweed. No properties reported to have flooded internally. Flooding on Gytes Leisure Centre pitches recorded almost 200m from river banks.

E. Hydrological Assessment

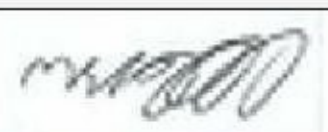
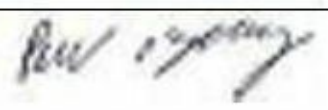
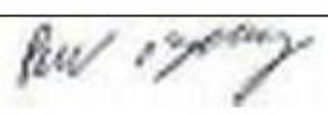
Flood estimation calculation record

Introduction

This document is a supporting document to the Environment Agency's Flood Estimation Guidelines. It provides a record of the calculations and decisions made during flood estimation. It will often be complemented by more general hydrological information given in a project report. The information given here should enable the work to be reproduced in the future. This version of the record is for studies where flood estimates are needed at multiple locations.

Contents

Approval

	Signature	Name and qualifications	For Environment Agency staff: Competence level (see below)
Calculations prepared by:		Matthew Savill	Level 1
Calculations checked by:		Peter O'Flaherty	Level 3
Calculations approved by:		Peter O'Flaherty	Level 3

Environment Agency competence levels are covered in Section 2.1 of the flood estimation guidelines:

- Level 1 – Hydrologist with minimum approved experience in flood estimation
- Level 2 – Senior Hydrologist
- Level 3 – Senior Hydrologist with extensive experience of flood estimation

ABBREVIATIONS

AM	Annual Maximum
AREA	Catchment area (km^2)
BFI	Base Flow Index
BFIHOST	Base Flow Index derived using the HOST soil classification
CFMP	Catchment Flood Management Plan
CPRE	Council for the Protection of Rural England
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
FSR	Flood Studies Report
HOST	Hydrology of Soil Types
NRFA	National River Flow Archive
POT	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
SPR	Standard percentage runoff
SPRHOST	Standard percentage runoff derived using the HOST soil classification
Tp(0)	Time to peak of the instantaneous unit hydrograph
URBAN	Flood Studies Report index of fractional urban extent
URBEXT1990	FEH index of fractional urban extent
URBEXT2000	Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH	Windows Frequency Analysis Package – used for FEH statistical method

1 Method statement

1.1 Overview of requirements for flood estimates

Item	Comments
Give an overview which includes: • Purpose of study • Approx. no. of flood estimates required • Peak flows or hydrographs? • Range of return periods and locations • Approx. time available	Peak flow estimates are required for the River Tweed as it runs through Peebles as inputs for a steady state model of the watercourse. Only flood estimates for the River Tweed are required. As the hydraulic model is run in steady state only peak flow estimates are required. Peak flow estimates will be derived for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.5%+CC and 0.1% AEP events. This hydrological assessment is only an update to the original assessment carried out in 2015. As such the scope of the assessment is limited to updating the previous assessment.

1.2 Overview of catchment

Item	Comments
Brief description of catchment, or reference to section in accompanying report	The River Tweed upstream of Peebles is rural (URBEXT2000 of 0.0025) and dominated by hill grazing with some forest and arable areas. Soils are generally impermeable (BFIHOST of 0.517), Palaeozoic and igneous formations with substantial superficial deposits in the valleys. There are notable floodplains in the catchment and flows are heavily attenuated by the Fruid Reservoir (FARL of 0.974).

1.3 Source of flood peak data

Was the HiFlows UK dataset used? If so, which version? If not, why not? Record any changes made	Yes – Version 7

1.4 Gauging stations (flow or level)

(at the sites of flood estimates or nearby at potential donor sites)

Water-course	Station name	Gauging authority number	NRFA number (used in FEH)	Grid reference	Catch-ment area (km²)	Type (rated / ultrasonic / level…)	Start and end of flow record
Tweed	Peebles	14979 (SEPA)		NT258400	694	Velocity Area	1939-present

*Taken from nearest available point on watercourse in FEH web service

1.5 Data available at each flow gauging station

Station name	Start and end of data in HiFlows-UK	Update for this study?	Suitable for QMED?	Suitable for pooling?	Data quality check needed?	Other comments on station and flow data quality – e.g. information from HiFlows-UK, trends in flood peaks, outliers.

Station name	Start and end of data in HiFlows-UK	Update for this study?	Suitable for QMED?	Suitable for pooling?	Data quality check needed?	Other comments on station and flow data quality – e.g. information from HiFlows-UK, trends in flood peaks, outliers.
Peebles	1939-Present	No	Yes	Yes	No	
Give link/reference to any further data quality checks carried out						

1.6 Rating equations

Station name	Type of rating e.g. theoretical, empirical; degree of extrapolation	Rating review needed?	Reasons – e.g. availability of recent flow gaugings, amount of scatter in the rating.
Peebles	Rating derived from current meter gaugings. Gauged to QMED, bypassing occurs above 2.6m	No	This has been recently derived and outside the scope of this assessment.
Give link/reference to any rating reviews carried out			

1.7 Initial choice of approach

Is FEH appropriate? (it may not be for very small, heavily urbanised or complex catchments). If not, describe other methods to be used.	Site is suitable for an FEH assessment since the catchment is significantly larger than 0.5km^2 and almost entirely rural.
Outline the conceptual model, addressing questions such as: • Where are the main sites of interest? • What is likely to cause flooding at those locations? (peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides…) • Might those locations flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir? • Is there a need to consider temporary debris dams that could collapse?	Given the size of the catchment upstream the flooding is likely to be predominantly volume driven. The valley is v-shaped in the vicinity of the site with a raised bank (site-side), so the flood mechanism would simply be water rising to breach the raised bank, with subsequent inundation of the land beyond.
Any unusual catchment features to take into account? e.g. • highly permeable – avoid ReFH if BFIHOST>0.65, use permeable catchment adjustment for statistical method if SPRHOST<20% • highly urbanised – avoid ReFH if URBEXT1990>0.125; consider FEH Statistical or other alternatives • pumped watercourse – consider lowland catchment version of rainfall-runoff method • major reservoir influence (FARL<0.90) – consider flood routing • extensive floodplain storage – consider choice of method carefully	The catchment is partially attenuated (FARL of 0.955) and there is moderate infiltration and catchment porosity (BFIHOST of 0.532 and SPRHOST of 33.28%). The catchment is also relatively wet in terms of rainfall (SAAR of 1140).

Initial choice of method(s) and reasons Will the catchment be split into subcatchments? If so, how?	The proposed methodology is: • Undertake a ReFH2 analysis • Undertake a WINFAP analysis for the site. Contrast results and ascertain which methodology is most suitable to take forward analysis. It is considered likely that a statistical method will be taken forward due to the high quality of gauged data available nearby to the site from the Tweed@Peebles.
Software to be used (with version numbers)	FEH web service WINFAP-FEH v7 / ReFH2

2 Locations where flood estimates required

The table below lists the locations of subject sites. The site codes listed below are used in all subsequent tables to save space.

2.1 Summary of subject sites

Site code	Watercourse	Site	Easting	Northing	AREA on FEH Web Service (km^2)	Revised AREA if altered
KGM	Tweed	Kingsmeadow	325350	640200	697.15	n/a
Reasons for choosing above locations		Due to its proximity to the site it has been chosen to carry out the assessment on the location of the Tweed@Peebles gauge				

2.2 Important catchment descriptors at each subject site (incorporating any changes made)

Site code	FARL	PROPWET	BFIHOST	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	SPRHOST	URBEXT	FPEXT
KGM	0.974	0.56	0.517	25.22	181.0	1140	37.16	0.0025	0.0506

2.3 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes (refer to maps if needed)	No question marks were highlighted over the catchment area on WINFAP and therefore it is considered likely that this value is accurate. Further checks on catchment area are outside the scope of this assessment.
Record how other catchment descriptors (especially soils) were checked and describe any changes. Include before/after table if necessary.	A brief look at the Soils data from the BGS show that it is in agreement with WINFAP and the soils data found on the FEH Web Service.
Source of URBEXT	URBEXT2000 taken from WINFAP
Method for updating of URBEXT	n/a

3 Statistical method

3.1 Overview of estimation of QMED at each subject site

Site code	Method	Initial estimate of QMED (m^3/s)	Data transfer				Final estimate of QMED (m^3/s)
			NRFA numbers for donor sites used (see 3.3)	Distance between centroids d_{ij} (km)	Power term, a	Moderated QMED adjustment factor, (A/B)[a]	
KGM	AM	177.465	n/a	n/a	n/a	n/a	177.465
Are the values of QMED consistent, for example at successive points along the watercourse and at confluences?			This value is consistent with QMED estimates from other gauges along the River Tweed.				

Notes

Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer; CD – Catchment descriptors alone.

When QMED is estimated from POT data, it should also be adjusted for climatic variation. Details should be added below.

When QMED is estimated from catchment descriptors, the revised 2008 equation from Science Report SC050050[Error! Bookmark not defined.] should be used. If the original FEH equation has been used, say so and give the reason why.

The data transfer procedure is the revised one from Science Report SC050050. The QMED adjustment factor A/B for each donor site is given in Table 3.3. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial estimate from catchment descriptors.

If more than one donor has been used, give the weights used in the averaging.

3.2 Search for donor sites for QMED

Comment on potential donor sites	As the gauge is rated up to QMED it was not considered necessary to attempt donor transfer for the site.
Mention: • Number of potential donor sites available • Distances from subject site • Similarity in terms of AREA, BFIHOST, FARL and other catchment descriptors • Quality of flood peak data Include a map if necessary. Note that donor catchments should usually be rural.	

3.3 Donor sites chosen and QMED adjustment factors

NRFA no.	Reasons for choosing or rejecting	Method (AM or POT)	Adjust-ment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjust-ment ratio (A/B)
n/a	n/a	n/a	n/a	n/a	n/a	n/a

3.4 Derivation of pooling groups

The composition of the pooling groups is given in the Annex. Several subject sites may use the same pooling group.

Target return period (years) for all pooling groups			200	
Name of group	**Site code for which group derived**	**Changes made to default pooling group, with reasons** Note also any sites that were investigated but retained in the group.	**Distribution and reason for choice**	**Parameters (before urban adjustment)** Note any permeable catchment adjustments
Pool	KGM	Dee@Polhillick removed due to discordancy as one peak flow has been applied to the whole record. 567 years of record Pooling group is acceptably homogenous with a z-value that gives an acceptable fit.	GL as recommended by SEPA guidance	No parameter adjustments
Note: Pooling groups were derived using the original FEH procedures / the revised procedures from Science Report SC050050 (2008).				

3.5 Derivation of flood growth curves at subject sites

Site code	**Method:** SS – Single site P – Pooled J – Joint analysis ESS – Enhanced Single Site	**If P or J, name of pooling group (3.4)**	**If SS, distribution used and reason for choice If J, details of averaging**	**If SS, parameters of distribution** (location, scale and shape)	**Growth factor for 100-year return period**
KGM	ESS	Pool	n/a	n/a	2.764
KGM	SS	n/a	GL as recommended by SEPA guidance	Location – 1.00 Scale – 0.198 Shape - -0.312	3.032
Note: Growth curves were derived using the original FEH procedures / the revised procedures from Science Report SC050050 (2008).					

3.6 Flood estimates from the statistical method

Site code	**Flood peak (m^3/s) for the following return periods (in years)**								
	2	**5**	**10**	**20**	**50**	**100**	**200**	**500**	**1000**
KGM-ESS	177.47	236.69	282.52	334.14	415.65	490.43	579.38	723.81	857.96
KGM-SS	177.47	238.51	288.56	347.48	444.73	538.07	653.43	849.17	1038.88

4 Revitalised flood hydrograph (ReFH2) method

4.1 Parameters for ReFH2 model

Note: If parameters are estimated from catchment descriptors, they are easily reproducible so it is not essential to enter them in the table.

Site code	Method: OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer (give details)	Tp (hours) Time to peak	C_{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
KGM	CD	4.462	384.285	54.587	1.555
Brief description of any flood event analysis carried out (further details should be given below or in a project report)		n/a Flood event analysis was considered outside the scope of the assessment. Given the high quality of gauge data and discrepancies between the REFH2 and statistical estimates it is not likely that they will be taken forward			

4.2 Design events for ReFH2 method

Site code	Urban or rural	Season of design event (summer or winter)	Storm duration (hours)	Storm area for ARF (if not catchment area)
KGM	Rural	Winter	09:30	0.861
Are the storm durations likely to be changed in the next stage of the study, e.g. by optimisation within a hydraulic model?			A single storm duration will be taken forward for use in the hydraulic model.	

4.3 Flood estimates from the ReFH2 method

Site code	Flood peak (m^3/s) for the following return periods (in years)								
	2	5	10	20	50	100	200	500	1000
BRP	177.343	225.164	259.417	295.765	351.667	404.642	469.310	578.064	678.095

5 FEH rainfall-runoff method – *not used*

Given the size of the Tweed catchment it is thought that REFH2 and statistical estimates will be more applicable to the site.

5.1 Parameters for FEH rainfall-runoff model

Methods:
FEA : Flood event analysis
LAG : Catchment lag
DT : Catchment descriptors with data transfer from donor catchment
CD : Catchment descriptors alone
BFI : SPR derived from baseflow index calculated from flow data

5.2 Donor sites for FEH rainfall-runoff parameters

5.3 Inputs to and outputs from FEH rainfall-runoff model

6 Small catchment methods – *not used*

This section records any estimates of design flows for small catchments using methods other than the FEH. In this case, the Institute of Hydrology Report 124 method has been used as an alternative. Other methods can be added or substituted if needed.

6.1 Parameters for IH Report 124 method

6.2 Flood estimates from the IH Report 124 method at each subject site

7 Discussion and summary of results

7.1 Comparison of results from different methods

This table compares peak flows from various methods with those from the FEH Statistical method at example sites for two key return periods. Blank cells indicate that results for a particular site were not calculated using that method.

Site code	Ratio of peak flow to FEH Single Site Statistical peak			
	Return period 2 years		Return period 100 years	
	ReFH2	ESS	ReFH2	ESS
BRP	0.99	1	0.75	0.91

7.2 Final choice of method

Choice of method and reasons – include reference to type of study, nature of catchment and type of data available.	It was decided to take forward the single site estimates forward for use in the hydraulic model. ReFH2 flows were discounted as they are significantly lower than the other methods. There is less than 60 years of record at the gauge and therefore it is a significant extrapolation of the period of record to derive up to the 0.5% AEP event using these fittings. Current hydrological practise suggests that the enhanced single site analysis would be preferable as it includes more years of data. However, it was decided to go with the single site estimates as there is high confidence in the gauged record and rating. It also provides higher peak flow estimates and so it was decided to take forward the more conservative flow estimates.

7.3 Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	**The main assumption with the single site estimates are that the rating at the Tweed@Peebles gauge accurately represents the relationship between stage and flow at the gauge. Another significant assumption is that the period of record is representative of the conditions in the catchment over the much longer period of the target return period**
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed	The use of both statistical estimates to producing a 0.5% AEP are outside the range of return periods recommended. The singles site estimate is only reliable up to a 2% AEP event and the enhanced single site is only reliable up to a 1% AEP event.
Give what information you can on uncertainty in the results – e.g. confidence limits for the QMED estimates using FEH **3** 12.5 or the factorial standard error from Science Report SC050050 (2008).	Confidence in the QMED estimate is very high. Assuming that the gauge rating is correct the upper bound and lower bound of the QMED estimate give the same estimate as QMED itself.
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	The results would be suitable for use in a future study until future years of water data are available.
Give any other comments on the study, for example suggestions for additional work.	Further work could take the form of investigating the possibility of calibrating the ReFH2 model using the gauge data for the Tweed@Peebles

7.4 Checks

Are the results consistent, for example at confluences?	n/a - only one location considered
What do the results imply regarding the return periods of floods during the period of record?	The December 2015 event (499m^3/s) is considered between a 2% and 1% AEP event.
What is the 100-year growth factor? Is this realistic? (The guidance suggests a typical range of 2.1 to 4.0)	The 100-year growth factor of 3.03 is within the typical range
If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow?	The 1000-year flow is 1.93 times the 100-year flow. This is within a sensible range.
What range of specific runoffs (l/s/ha) do the results equate to? Are there any inconsistencies?	The 50% AEP event gives a specific runoff of 2.56l/s/ha and the 1% AEP event gives a specific runoff of 7.75l/s/ha
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	The flows are comparable but slightly smaller than those used in the SBC consultation for planning application 19/00182/PPP. These flows did not take into account for the December 2015 event. SEPA have been consulted regarding the flow estimates produced as part of this study and had no objection to the scale of the estimates. SEPA did not have sight of the entire methodology, only the flows produced.
Are the results compatible with the longer-term flood history?	No long-term flood history is available
Describe any other checks on the results	Further checks on the results were outside the scope of this study.

7.5 Final results

Site code	Flood peak (m^3/s) for the following return periods (in years)								
	2	5	10	20	50	100	200	500	1000
KGM	177.47	238.51	288.56	347.48	444.73	538.07	653.43	849.17	1038.88

If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, name of ISIS model, or reference to table below)	These are not required

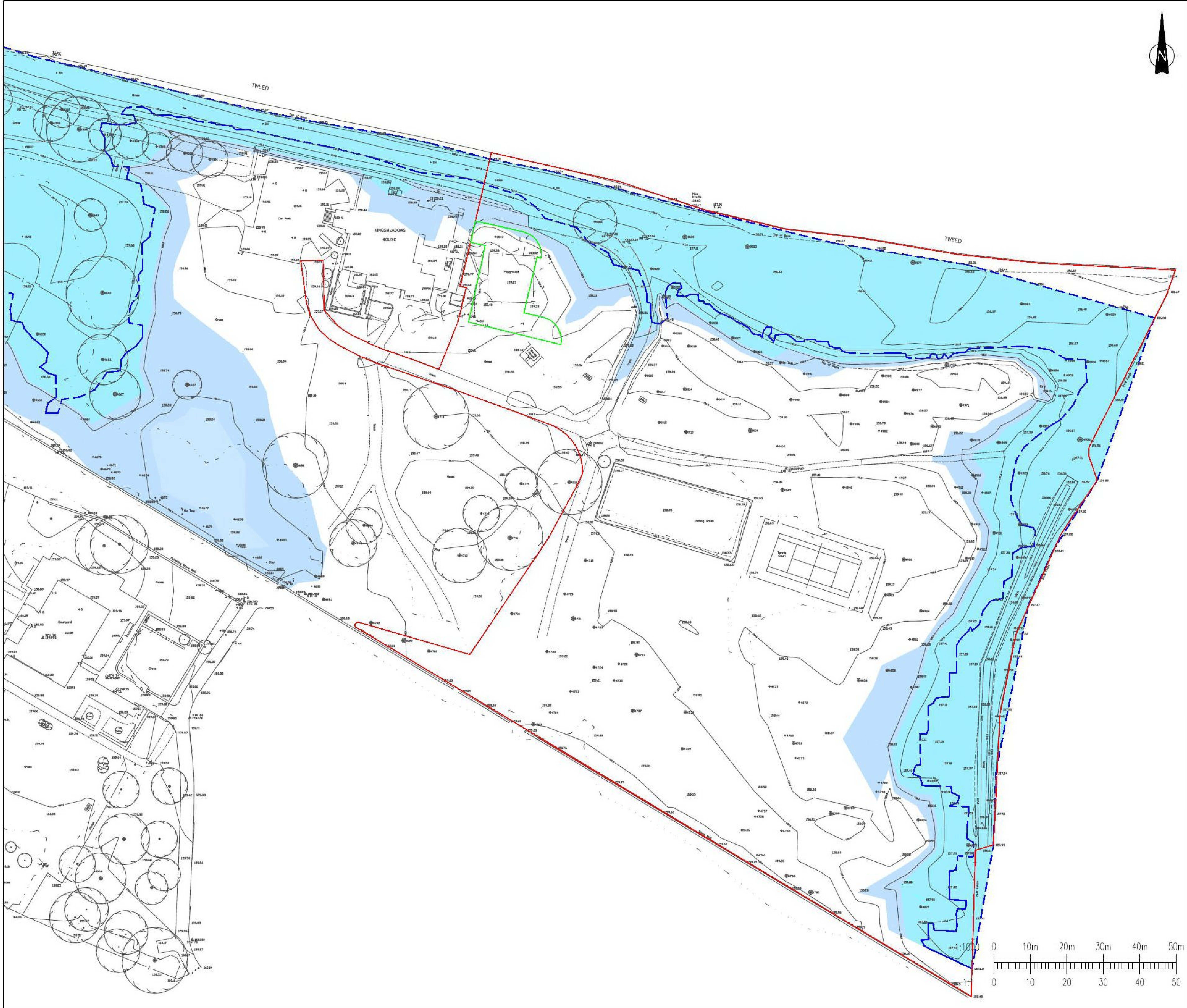
8 Annex - supporting information

8.1 Pooling group composition

Table 1: Pooling group Pool for Tweed@Peebles

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
21003 (Tweed@Peebles)	0.000	58	177.465	0.210	0.312	0.492
23004 (South Tyne @ Haydon Bridge)	0.157	58	452.368	0.148	0.219	1.307
50002 (Torridge @ Torrington)	0.172	56	238.486	0.192	0.205	0.365
7002 (Findhorn @ Forres)	0.206	59	356.203	0.228	0.233	1.060
84004 (Clyde @ Sills of Clyde)	0.217	51	196.355	0.174	0.214	0.888
76005 (Eden @ Temple Sowerby)	0.251	53	257.263	0.248	0.417	1.906
83006 (Ayr @ Mainholm)	0.320	31	248.945	0.157	0.217	1.503
50001 (Taw @ Umberleigh)	0.323	59	240.880	0.203	0.275	0.093
27002 (Wharfe @ Wetherby Flint Mill)	0.323	81	235.996	0.161	0.230	0.730
25001 (Tees @ Darlington Broken Scar)	0.330	61	388.890	0.178	0.102	1.657
Total		567				

F. Modelled Flood Extents



KEY:

SINGLE SITE METHOD FLOOD EXTENTS

- 1 IN 200 YEAR
- 1 IN 200 YEAR PLUS 33% CLIMATE CHANGE
- SCOTTISH BORDERS COUNCIL 1 IN 200 YEAR MODELLED FLOOD EXTENTS
- OWNERSHIP BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY

Rev	Date	Description	By
A02	18.06.19	UPDATED OWNERSHIP BOUNDARY AND PROPOSED DEVELOPMENT ADDED	RD
A01	05.06.19	ISSUED FOR INFORMATION	RD

Amendments

Project
Kingsmeadows Residential Apartments FRA

Title
FLOOD EXTENTS
FOR 1 IN 200 YEAR AND 1 IN 200 YEAR PLUS 33% CC FLOOD EVENTS

Client
GRANTON HOMES LTD

Waterman

Broxden House Broxden Business Park Lamberkine Drive Perth PH1 1RA
t 01738 449 801
mail@watermangroup.com www.watermangroup.com

Drawing Status
PRELIMINARY

Designed by	ND	Checked by	KM	Project No WIE15880
Drawn by	RD	Date	06.06.19	
Scales @ A3 work to figured dimensions only	1:1000			Computer File No WIE-10440-SA-92-0200.dwg

Publisher	Zone	Category	Number	Revision
WIE	SA	92	0200	A02

File Path N:\Projects\WIE15880_Kingsmeadow FRA Update\1007_CAD\92\

A3-Wat-S, WIE-10440-SA-NS-CIVIL-3D-1 in 200yr+CC, WIE-10440-SA-NS-SU_2D-XX

WIE15880 Kingsmeadow FRA - Modelled 1 in 200-year event

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Flow Area (m2)	Top Width (m)	Froude # Chl
Kingsmead	18	200	653.43	155.59	162.16	600.93	135.92	0.19
Kingsmead	17	200	653.43	155.24	161.38	222.41	60.81	0.53
Kingsmead	16	200	653.43	155.05	160.05	145.01	50.76	0.87
Kingsmead	15	200	653.43	154.56	158.8	181.27	86.57	0.77
Kingsmead	14	200	653.43	154.36	158.81	248.33	142.9	0.61
Kingsmead	13	200	653.43	154.7	158.86	324.01	156.67	0.46
Kingsmead	12	200	653.43	154.05	158.8	388.18	183.76	0.4
Kingsmead	11	200	653.43	153.99	158.6	348.03	157.26	0.44
Kingsmead	10.500*	200	653.43	153.85	158.52	338.19	156.59	0.47
Kingsmead	10	200	653.43	153.72	158.45	342.09	210.54	0.49
Kingsmead	9.5000*	200	653.43	153.76	158.31	313.96	185.24	0.54
Kingsmead	9	200	662.63	153.81	158.03	260.82	146.02	0.66
Kingsmead	8.5000*	200	662.63	153.34	157.93	277.47	154.73	0.63
Kingsmead	8	200	662.63	152.87	157.79	283.92	163.47	0.63
Kingsmead	7	200	662.63	153.29	157.89	413.93	204.04	0.41
Kingsmead	6	200	662.63	153.59	157.8	411.08	226.29	0.44
Kingsmead	5	200	662.63	152.99	157.73	418.06	176.62	0.38
Kingsmead	4	200	662.63	153.08	157.45	308.14	145.2	0.51
Kingsmead	3	200	662.63	152.17	157.19	273.17	138.84	0.6
Kingsmead	2	200	662.63	152.2	156.82	236.52	145.29	0.72
Kingsmead	1	200	662.63	152.72	156.26	282.6	241.76	0.74

WIE15880 Kingsmeadow FRA - Modelled 1 in 200-year +33%CC event

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Flow Area (m2)	Top Width (m)	Froude # Chl
Kingsmead	18	200 +33%	869.06	155.59	162.97	711.51	135.92	0.2
Kingsmead	17	200 +33%	869.06	155.24	161.91	254.34	60.81	0.59
Kingsmead	16	200 +33%	869.06	155.05	160.87	191.05	62.86	0.86
Kingsmead	15	200 +33%	869.06	154.56	159.2	215.75	89.38	0.82
Kingsmead	14	200 +33%	869.06	154.36	159.28	314.64	143.39	0.6
Kingsmead	13	200 +33%	869.06	154.7	159.31	394.5	157.44	0.47
Kingsmead	12	200 +33%	869.06	154.05	159.26	472.74	185.32	0.4
Kingsmead	11	200 +33%	869.06	153.99	159.02	416.32	174.4	0.47
Kingsmead	10.500*	200 +33%	869.06	153.85	158.93	411.36	196.84	0.5
Kingsmead	10	200 +33%	869.06	153.72	158.89	443.27	249.62	0.5
Kingsmead	9.5000*	200 +33%	869.06	153.76	158.76	404.31	206.63	0.54
Kingsmead	9	200 +33%	881.29	153.81	158.42	319.51	162.93	0.68
Kingsmead	8.5000*	200 +33%	881.29	153.34	158.34	342.16	157.8	0.64
Kingsmead	8	200 +33%	881.29	152.87	158.25	359.07	164.78	0.62
Kingsmead	7	200 +33%	881.29	153.29	158.33	504.13	206.85	0.42
Kingsmead	6	200 +33%	881.29	153.59	158.25	515.32	234.04	0.44
Kingsmead	5	200 +33%	881.29	152.99	158.17	495.86	178.4	0.4
Kingsmead	4	200 +33%	881.29	153.08	157.85	366.45	146.17	0.53
Kingsmead	3	200 +33%	881.29	152.17	157.57	325.93	139.53	0.63
Kingsmead	2	200 +33%	881.29	152.2	157.09	277.1	149.61	0.79
Kingsmead	1	200 +33%	881.29	152.72	156.47	333.36	243.16	0.79

G. Verification Run

WIE15880 Kingsmeadow FRA - Model Verification

Normal depth boundary condition

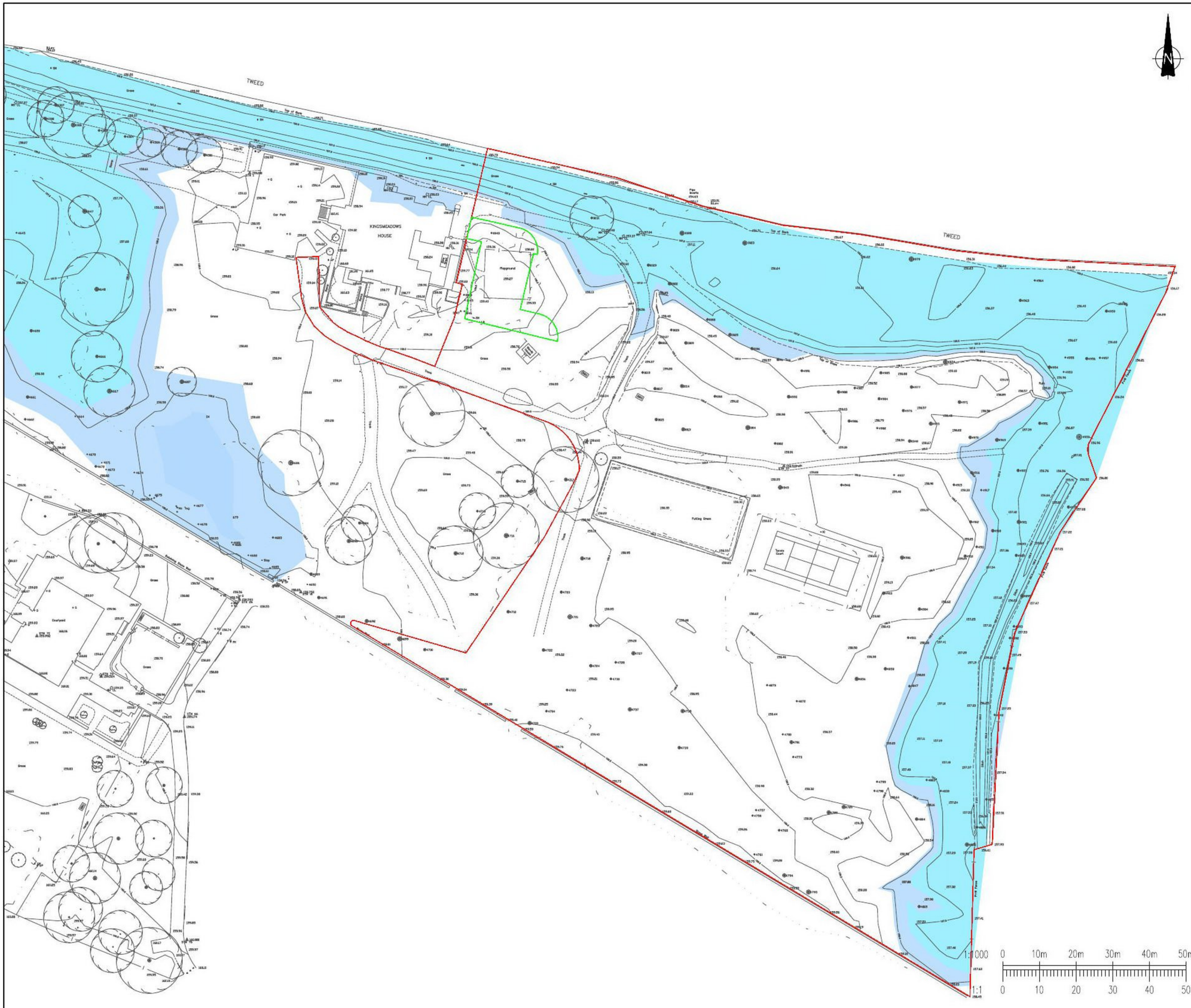
Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Flow Area (m2)	Froude # Chl
Kingsmeadow	18	499.99	155.59	161.53	515.52	0.18
	17	499.99	155.24	160.85	183.01	0.5
	16	499.99	155.05	159.42	112.47	0.88
	15	499.99	154.56	158.57	160.9	0.68
	14	499.99	154.36	158.43	193.72	0.62
	13	499.99	154.7	158.49	266.76	0.45
	12	499.99	154.05	158.43	319.53	0.4
	11	499.99	153.99	158.26	294.94	0.42
	10.500*	499.99	153.85	158.19	286.02	0.44
	10	499.99	153.72	158.1	274.3	0.47
	9.5000*	499.99	153.76	157.97	256.65	0.52
	9	499.99	153.81	157.7	213.01	0.64
	8.5000*	499.99	153.34	157.59	225.6	0.62
	8	499.99	152.87	157.39	218.4	0.65
	7	499.99	153.29	157.52	337.83	0.41
	6	499.99	153.59	157.41	324.79	0.44
	5	499.99	152.99	157.36	352.22	0.37
	4	499.99	153.08	157.11	259.19	0.48
	3	499.99	152.17	156.89	230.5	0.56
	2	499.99	152.2	156.53	194.75	0.68
	1	499.99	152.72	156.13	250.72	0.64

WIE15880 Kingsmeadow FRA - Model Verification

Critical depth boundary condition

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Flow Area (m2)	Froude # Chl
Kingsmeadow	18	499.99	155.59	161.53	515.52	0.18
	17	499.99	155.24	160.85	183.01	0.5
	16	499.99	155.05	159.42	112.47	0.88
	15	499.99	154.56	158.57	160.9	0.68
	14	499.99	154.36	158.43	193.73	0.62
	13	499.99	154.7	158.49	266.77	0.45
	12	499.99	154.05	158.43	319.54	0.4
	11	499.99	153.99	158.26	294.95	0.42
	10.500*	499.99	153.85	158.19	286.02	0.44
	10	499.99	153.72	158.1	274.3	0.47
	9.5000*	499.99	153.76	157.97	256.66	0.52
	9	499.99	153.81	157.7	213	0.64
	8.5000*	499.99	153.34	157.59	225.57	0.62
	8	499.99	152.87	157.39	218.47	0.65
	7	499.99	153.29	157.52	337.89	0.4
	6	499.99	153.59	157.41	324.89	0.44
	5	499.99	152.99	157.36	352.3	0.37
	4	499.99	153.08	157.12	259.31	0.48
	3	499.99	152.17	156.89	230.76	0.56
	2	499.99	152.2	156.53	194.75	0.68
	1	499.99	152.72	156.08	238.71	0.68

H. Model Sensitivity Analysis



KEY:

SINGLE SITE METHOD FLOOD EXTENTS

- 1 IN 200 YEAR WITH MANNING'S 'n' –20%
- 1 IN 200 YEAR PLUS 33% CLIMATE CHANGE WITH MANNING'S 'n' –20%
- OWNERSHIP BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY

Rev	Date	Description	By
A02	18.06.19	UPDATED OWNERSHIP BOUNDARY AND PROPOSED DEVELOPMENT BOUNDARY ADDED	RD
A01	05.06.19	ISSUED FOR INFORMATION	RD

Amendments

Project
Kingsmeadows Residential Apartments FRA

Title
FLOOD EXTENTS
FOR 1 IN 200 YEAR AND 1 IN 200 YEAR PLUS 33% CC FLOOD EVENTS WITH MANNING'S 'n' -20%

Client
GRANTON HOMES LTD

Broxden House Broxden Business Park Lamberkine Drive Perth PH1 1RA
t 01738 449 801
mail@watermangroup.com www.watermangroup.com

Drawing Status
PRELIMINARY

Designed by	ND	Checked by	KM	Project No	WIE15880
Drawn by	RD	Date	06.06.19		
Scales @ A3 work to figured dimensions only	1:1000			Computer File No	WIE-10440-SA-92-0201.dwg

Publisher	Zone	Category	Number	Revision
WIE	SA	92	0201	A02

File Path N:\Projects\WIE15880_Kingsmeadow FRA Update\10\7_CAD\92\

A3-Wat-S, WIE-10440-SA-NS-CIVIL-3D-n-20%, WIE-10440-SA-NS-SU_2D-XX

WIE15880 Kingsmeadow FRA - Sensitivity Analysis: Mannings n -20%

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Flow Area	Top Width	Froude # Chl
Kingsmead	18	100	538.07	155.59	161.65	531.78	135.92	0.19
Kingsmead	18	100 +33%	715.64	155.59	162.21	608.4	135.92	0.21
Kingsmead	18	200	653.43	155.59	162.15	600.1	135.92	0.19
Kingsmead	18	200 +33%	869.06	155.59	162.96	710.6	135.92	0.2
Kingsmead	17	100	538.07	155.24	161.02	199.99	60.76	0.49
Kingsmead	17	100 +33%	715.64	155.24	161.14	207.65	60.78	0.62
Kingsmead	17	200	653.43	155.24	161.38	222.41	60.81	0.53
Kingsmead	17	200 +33%	869.06	155.24	161.91	254.34	60.81	0.59
Kingsmead	16	100	538.07	155.05	159.58	119.51	48.07	0.88
Kingsmead	16	100 +33%	715.64	155.05	160.22	153.51	51.39	0.89
Kingsmead	16	200	653.43	155.05	160.05	145.01	50.76	0.87
Kingsmead	16	200 +33%	869.06	155.05	160.87	191.05	62.86	0.86
Kingsmead	15	100	538.07	154.56	158.48	153.39	84.23	0.77
Kingsmead	15	100 +33%	715.64	154.56	158.88	187.58	87.09	0.81
Kingsmead	15	200	653.43	154.56	158.74	175.85	86.12	0.8
Kingsmead	15	200 +33%	869.06	154.56	159.2	215.75	89.38	0.82
Kingsmead	14	100	538.07	154.36	158.18	163.13	113.16	0.77
Kingsmead	14	100 +33%	715.64	154.36	158.74	238.32	142.75	0.7
Kingsmead	14	200	653.43	154.36	158.64	223.82	142.54	0.69
Kingsmead	14	200 +33%	869.06	154.36	158.97	270.38	143.18	0.73
Kingsmead	13	100	538.07	154.7	158.41	254.52	155.9	0.52
Kingsmead	13	100 +33%	715.64	154.7	158.8	314.67	156.56	0.52
Kingsmead	13	200	653.43	154.7	158.67	294.8	156.34	0.52
Kingsmead	13	200 +33%	869.06	154.7	159.1	361.34	157.08	0.53
Kingsmead	12	100	538.07	154.05	158.39	313.16	182.49	0.44
Kingsmead	12	100 +33%	715.64	154.05	158.79	385.39	183.72	0.44
Kingsmead	12	200	653.43	154.05	158.66	361.54	183.31	0.44
Kingsmead	12	200 +33%	869.06	154.05	159.09	441.48	184.66	0.45
Kingsmead	11	100	538.07	153.99	158.25	294.01	154.48	0.45
Kingsmead	11	100 +33%	715.64	153.99	158.6	347.92	157.25	0.49
Kingsmead	11	200	653.43	153.99	158.49	330.31	155.56	0.47
Kingsmead	11	200 +33%	869.06	153.99	158.87	390.89	165.92	0.51
Kingsmead	10.500*	100	538.07	153.85	158.2	287.27	153.86	0.47
Kingsmead	10.500*	100 +33%	715.64	153.85	158.54	339.93	157.15	0.51
Kingsmead	10.500*	200	653.43	153.85	158.43	322.78	155.07	0.49
Kingsmead	10.500*	200 +33%	869.06	153.85	158.8	385.68	189.15	0.53
Kingsmead	10	100	538.07	153.72	158.13	279.07	174.64	0.5
Kingsmead	10	100 +33%	715.64	153.72	158.49	349.61	212.7	0.52
Kingsmead	10	200	653.43	153.72	158.37	324.29	204.13	0.51
Kingsmead	10	200 +33%	869.06	153.72	158.77	413.56	241.15	0.53
Kingsmead	9.5000*	100	538.07	153.76	158.03	266.31	163.87	0.54
Kingsmead	9.5000*	100 +33%	715.64	153.76	158.36	323.62	189.8	0.57
Kingsmead	9.5000*	200	653.43	153.76	158.25	302.92	178.69	0.56
Kingsmead	9.5000*	200 +33%	869.06	153.76	158.65	380.98	206.62	0.58
Kingsmead	9	100	546.17	153.81	157.7	212.64	144.94	0.7
Kingsmead	9	100 +33%	726.41	153.81	157.98	253.94	145.87	0.75
Kingsmead	9	200	662.63	153.81	157.87	238.64	145.52	0.74
Kingsmead	9	200 +33%	881.29	153.81	158.18	282.47	146.5	0.79
Kingsmead	8.5000*	100	546.17	153.34	157.57	221.85	153.67	0.69
Kingsmead	8.5000*	100 +33%	726.41	153.34	157.84	263.94	154.47	0.74
Kingsmead	8.5000*	200	662.63	153.34	157.75	249.99	154.21	0.72
Kingsmead	8.5000*	200 +33%	881.29	153.34	158.05	296.27	155.28	0.78
Kingsmead	8	100	546.17	152.87	157.41	221.8	161.25	0.69
Kingsmead	8	100 +33%	726.41	152.87	157.74	274.61	163.31	0.72
Kingsmead	8	200	662.63	152.87	157.64	259.38	163.04	0.71
Kingsmead	8	200 +33%	881.29	152.87	157.94	308.52	163.9	0.76
Kingsmead	7	100	546.17	153.29	157.48	329.5	202.31	0.46
Kingsmead	7	100 +33%	726.41	153.29	157.86	407.38	203.91	0.46
Kingsmead	7	200	662.63	153.29	157.73	381.19	203.37	0.46
Kingsmead	7	200 +33%	881.29	153.29	158.15	467.07	205.46	0.47
Kingsmead	6	100	546.17	153.59	157.38	317.93	219.89	0.49
Kingsmead	6	100 +33%	726.41	153.59	157.78	407.44	226.05	0.49
Kingsmead	6	200	662.63	153.59	157.65	377.29	223.99	0.49
Kingsmead	6	200 +33%	881.29	153.59	158.09	477.24	231.19	0.49
Kingsmead	5	100	546.17	152.99	157.37	354.78	175.97	0.4
Kingsmead	5	100 +33%	726.41	152.99	157.76	422.72	176.67	0.41
Kingsmead	5	200	662.63	152.99	157.63	399.97	176.43	0.41
Kingsmead	5	200 +33%	881.29	152.99	158.05	474.86	177.21	0.42
Kingsmead	4	100	546.17	153.08	157.1	257.46	144.55	0.52
Kingsmead	4	100 +33%	726.41	153.08	157.45	307.37	145.18	0.56
Kingsmead	4	200	662.63	153.08	157.33	290.85	144.95	0.54
Kingsmead	4	200 +33%	881.29	153.08	157.71	345.72	145.82	0.58
Kingsmead	3	100	546.17	152.17	156.78	215.31	137.81	0.66
Kingsmead	3	100 +33%	726.41	152.17	157.1	259.66	138.67	0.7
Kingsmead	3	200	662.63	152.17	156.97	241.45	138.42	0.7
Kingsmead	3	200 +33%	881.29	152.17	157.38	298.42	139.17	0.71
Kingsmead	2	100	546.17	152.2	156.61	206.69	142.53	0.7
Kingsmead	2	100 +33%	726.41	152.2	156.9	248.18	147.01	0.75
Kingsmead	2	200	662.63	152.2	156.82	236.52	145.29	0.72
Kingsmead	2	200 +33%	881.29	152.2	157.09	277.09	149.61	0.79
Kingsmead	1	100	546.17	152.72	156.14	253.05	240.94	0.69
Kingsmead	1	100 +33%	726.41	152.72	156.34	302.77	242.32	0.74
Kingsmead	1	200	662.63	152.72	156.26	282.6	241.76	0.74
Kingsmead	1	200 +33%	881.29	152.72	156.47	333.36	243.16	0.79

KEY:

SINGLE SITE METHOD FLOOD EXTENTS

- 1 IN 200 YEAR WITH MANNING'S 'n' +20%
- 1 IN 200 YEAR PLUS 33% CLIMATE CHANGE WITH MANNING'S 'n' +20%
- OWNERSHIP BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY

Rev	Date	Description	By
A02	18.06.19	UPDATED OWNERSHIP BOUNDARY AND PROPOSED DEVELOPMENT BOUNDARY ADDED	RD
A01	05.06.19	ISSUED FOR INFORMATION	RD

Amendments

Project
Kingsmeadows Residential Apartments FRA

Title
FLOOD EXTENTS
FOR 1 IN 200 YEAR AND 1 IN 200 YEAR PLUS 33% CC FLOOD EVENTS WITH MANNING'S 'n' +20%

Client
GRANTON HOMES LTD

Waterman
Broxden House Broxden Business Park Lamberkine Drive Perth PH1 1RA
t 01738 449 801
mail@watermangroup.com www.watermangroup.com

Drawing Status
PRELIMINARY

Designed by	ND	Checked by	KM	Project No	WIE15880
Drawn by	RD	Date	06.06.19		
Scales @ A3 work to figured dimensions only	1:1000			Computer File No	WIE-10440-SA-92-0202.dwg

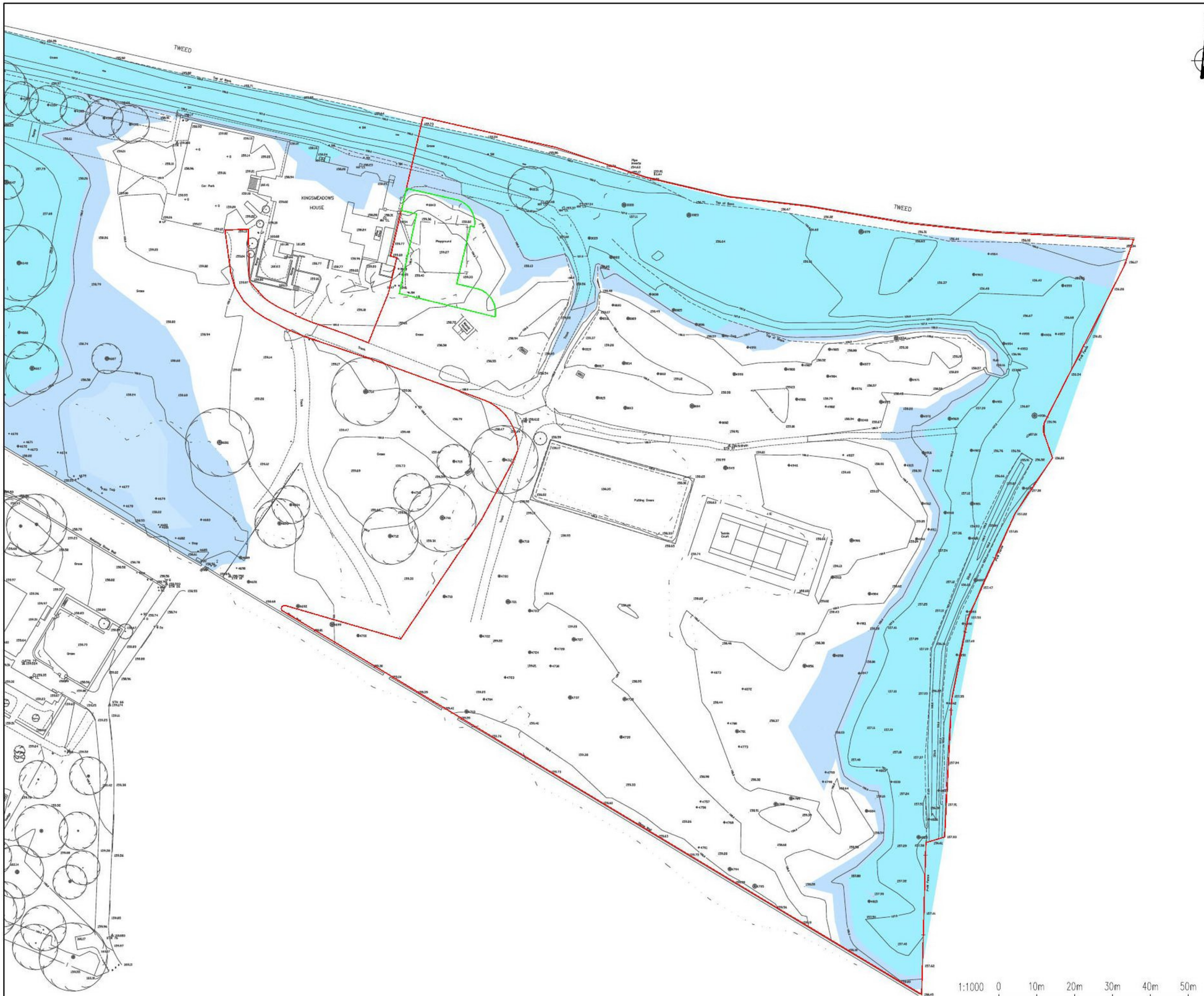
Publisher	Zone	Category	Number	Revision
WIE	SA	92	0202	A02

File Path N:\Projects\WIE15880_Kingsmeadow FRA Update\10\7_CAD\SU

A3-Wat-S, WIE-10440-SA-NS-CIVIL-3D-n+20%, WIE-10440-SA-NS-SU_2D-XX

WIE15880 Kingsmeadow FRA - Sensitivity Analysis: Mannings n+20%

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Flow Area	Top Width	Froude # Chl
Kingsmead	18	100	538.07	155.59	161.66	533.51	135.92	0.19
Kingsmead	18	100 +33%	715.64	155.59	162.23	610.63	135.92	0.21
Kingsmead	18	200	653.43	155.59	162.17	601.93	135.92	0.19
Kingsmead	18	200 +33%	869.06	155.59	162.98	712.52	135.92	0.2
Kingsmead	17	100	538.07	155.24	161.02	199.99	60.76	0.49
Kingsmead	17	100 +33%	715.64	155.24	161.14	207.65	60.78	0.62
Kingsmead	17	200	653.43	155.24	161.38	222.41	60.81	0.53
Kingsmead	17	200 +33%	869.06	155.24	161.91	254.24	60.81	0.59
Kingsmead	16	100	538.07	155.05	159.58	119.51	48.07	0.88
Kingsmead	16	100 +33%	715.64	155.05	160.22	153.51	51.39	0.89
Kingsmead	16	200	653.43	155.05	160.05	145.01	50.76	0.87
Kingsmead	16	200 +33%	869.06	155.05	160.86	190.35	62.83	0.86
Kingsmead	15	100	538.07	154.56	158.9	190.02	87.29	0.6
Kingsmead	15	100 +33%	715.64	154.56	159.26	221.3	89.82	0.66
Kingsmead	15	200	653.43	154.56	159.14	210.74	88.97	0.64
Kingsmead	15	200 +33%	869.06	154.56	159.52	245.18	91.83	0.7
Kingsmead	14	100	538.07	154.36	158.81	247.92	142.89	0.5
Kingsmead	14	100 +33%	715.64	154.36	159.25	310.42	143.37	0.5
Kingsmead	14	200	653.43	154.36	159.1	289.37	143.27	0.5
Kingsmead	14	200 +33%	869.06	154.36	159.57	357.65	144.2	0.51
Kingsmead	13	100	538.07	154.7	158.78	311.01	156.52	0.4
Kingsmead	13	100 +33%	715.64	154.7	159.21	378.78	157.27	0.41
Kingsmead	13	200	653.43	154.7	159.06	355.88	157.02	0.4
Kingsmead	13	200 +33%	869.06	154.7	159.53	430.31	157.84	0.41
Kingsmead	12	100	538.07	154.05	158.69	367.24	183.41	0.36
Kingsmead	12	100 +33%	715.64	154.05	159.13	448.2	184.78	0.36
Kingsmead	12	200	653.43	154.05	158.98	420.82	184.31	0.36
Kingsmead	12	200 +33%	869.06	154.05	159.46	509.75	185.95	0.36
Kingsmead	11	100	538.07	153.99	158.49	331.58	155.6	0.39
Kingsmead	11	100 +33%	715.64	153.99	158.9	397.04	167.47	0.41
Kingsmead	11	200	653.43	153.99	158.76	374.25	161.63	0.41
Kingsmead	11	200 +33%	869.06	153.99	159.22	452.47	183.31	0.43
Kingsmead	10.500*	100	538.07	153.85	158.42	321.47	154.98	0.41
Kingsmead	10.500*	100 +33%	715.64	153.85	158.82	389.63	191.4	0.43
Kingsmead	10.500*	200	653.43	153.85	158.68	363.65	175.64	0.43
Kingsmead	10.500*	200 +33%	869.06	153.85	159.14	451.95	206.9	0.44
Kingsmead	10	100	538.07	153.72	158.33	317.2	200.59	0.43
Kingsmead	10	100 +33%	715.64	153.72	158.76	411.02	240.26	0.44
Kingsmead	10	200	653.43	153.72	158.6	375.19	229.2	0.44
Kingsmead	10	200 +33%	869.06	153.72	159.08	492.36	249.96	0.44
Kingsmead	9.5000*	100	538.07	153.76	158.22	296.58	173.13	0.47
Kingsmead	9.5000*	100 +33%	715.64	153.76	158.63	377.08	206.62	0.48
Kingsmead	9.5000*	200	653.43	153.76	158.48	345.63	196.14	0.48
Kingsmead	9.5000*	200 +33%	869.06	153.76	158.96	445.33	206.66	0.48
Kingsmead	9	100	546.17	153.81	158.01	258.36	145.96	0.55
Kingsmead	9	100 +33%	726.41	153.81	158.41	316.87	159.06	0.57
Kingsmead	9	200	662.63	153.81	158.27	296.86	146.88	0.56
Kingsmead	9	200 +33%	881.29	153.81	158.72	368.53	164.23	0.57
Kingsmead	8.5000*	100	546.17	153.34	157.89	272.18	154.63	0.54
Kingsmead	8.5000*	100 +33%	726.41	153.34	158.3	334.96	157.39	0.55
Kingsmead	8.5000*	200	662.63	153.34	158.16	313.16	156.18	0.54
Kingsmead	8.5000*	200 +33%	881.29	153.34	158.61	385.92	175.85	0.55
Kingsmead	8	100	546.17	152.87	157.77	279.56	163.4	0.53
Kingsmead	8	100 +33%	726.41	152.87	158.19	348.23	164.59	0.54
Kingsmead	8	200	662.63	152.87	158.04	324.71	164.18	0.53
Kingsmead	8	200 +33%	881.29	152.87	158.5	400.84	167.91	0.54
Kingsmead	7	100	546.17	153.29	157.78	390.96	203.57	0.37
Kingsmead	7	100 +33%	726.41	153.29	158.19	474.96	205.76	0.38
Kingsmead	7	200	662.63	153.29	158.05	446.02	204.7	0.38
Kingsmead	7	200 +33%	881.29	153.29	158.51	540.83	210.73	0.39
Kingsmead	6	100	546.17	153.59	157.67	382.71	224.36	0.4
Kingsmead	6	100 +33%	726.41	153.59	158.09	478.19	231.26	0.4
Kingsmead	6	200	662.63	153.59	157.95	445.18	228.77	0.4
Kingsmead	6	200 +33%	881.29	153.59	158.41	553.85	236.89	0.4
Kingsmead	5	100	546.17	152.99	157.57	390.6	176.34	0.35
Kingsmead	5	100 +33%	726.41	152.99	157.98	462.54	177.08	0.36
Kingsmead	5	200	662.63	152.99	157.84	437.81	176.82	0.36
Kingsmead	5	200 +33%	881.29	152.99	158.3	518.58	182.66	0.37
Kingsmead	4	100	546.17	153.08	157.33	290.66	144.94	0.45
Kingsmead	4	100 +33%	726.41	153.08	157.7	344.74	145.8	0.48
Kingsmead	4	200	662.63	153.08	157.57	325.93	145.49	0.47
Kingsmead	4	200 +33%	881.29	153.08	157.99	386.77	146.84	0.5
Kingsmead	3	100	546.17	152.17	157.1	259.7	138.67	0.53
Kingsmead	3	100 +33%	726.41	152.17	157.44	307.44	139.29	0.56
Kingsmead	3	200	662.63	152.17	157.32	290.32	139.06	0.55
Kingsmead	3	200 +33%	881.29	152.17	157.71	344.78	140.53	0.58
Kingsmead	2	100	546.17	152.2	156.61	206.69	142.53	0.7
Kingsmead	2	100 +33%	726.41	152.2	156.9	248.18	147.01	0.75
Kingsmead	2	200	662.63	152.2	156.82	236.52	145.29	0.72
Kingsmead	2	200 +33%	881.29	152.2	157.09	277.1	149.61	0.79
Kingsmead	1	100	546.17	152.72	156.14	253.05	240.94	0.69
Kingsmead	1	100 +33%	726.41	152.72	156.34	302.77	242.32	0.74
Kingsmead	1	200	662.63	152.72	156.26	282.61	241.76	0.74
Kingsmead	1	200 +33%	881.29	152.72	156.47	333.34	243.16	0.79



KEY:

SINGLE SITE METHOD FLOOD EXTENTS

- 1 IN 200 YEAR WITH 50% BLOCKAGE
- 1 IN 200 YEAR PLUS 33% CLIMATE CHANGE WITH 50% BLOCKAGE
- OWNERSHIP BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY

Rev	Date	Description	By
A02	18.06.19	UPDATED OWNERSHIP BOUNDARY AND PROPOSED DEVELOPMENT BOUNDARY ADDED	RD
A01	05.06.19	ISSUED FOR INFORMATION	RD

Amendments

Project
Kingsmeadows Residential Apartments FRA

Title
FLOOD EXTENTS
FOR 1 IN 200 YEAR AND 1 IN 200 YEAR PLUS 33% CC FLOOD EVENTS WITH 50% BLOCKAGE

Client
GRANTON HOMES LTD

Broxden House Broxden Business Park Lamberkine Drive Perth PH1 1RA
t 01738 449 801
mail@watermangroup.com www.watermangroup.com

Drawing Status
PRELIMINARY

Designed by	ND	Checked by	KM	Project No	WIE15880
Drawn by	RD	Date	06.06.19		
Scales @ A3 work to figured dimensions only	1:1000			Computer File No	WIE-10440-SA-92-0203.dwg

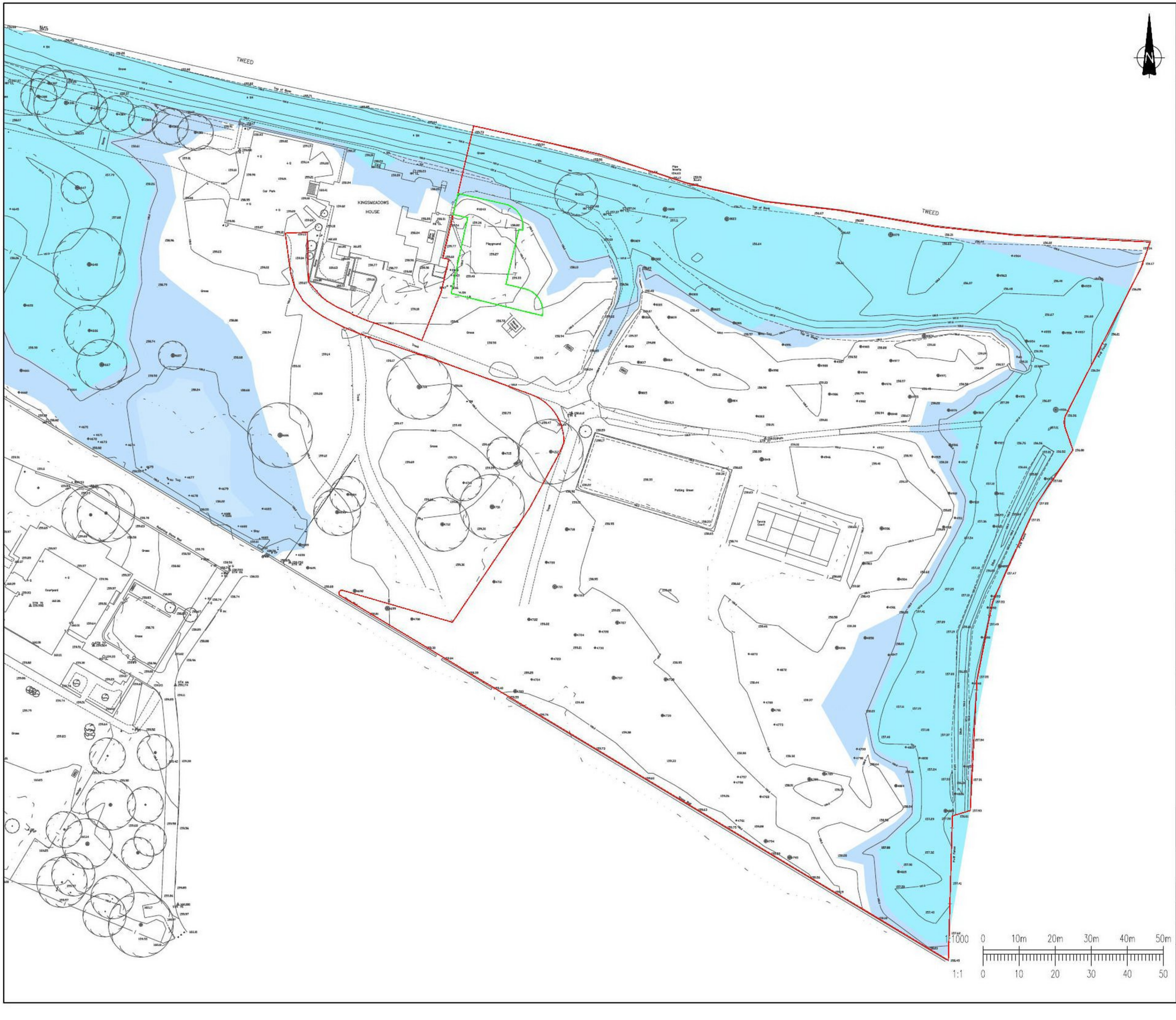
Publisher	Zone	Category	Number	Revision
WIE	SA	92	0203	A02

File Path N:\Projects\WIE15880_Kingsmeadow FRA Update\0017_CAD\92\

A3-Wat-S, WIE-10440-SA-NS-CIVIL-3D-50% Blockage, WIE-10440-SA-NS-SU_2D-XX

WIE15880 Kingsmeadow FRA - Sensitivity Analysis: 50% Blockage

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
Kingsmead	18	100	538.07	155.59	162.4		162.45	0.000103	1.19	634.36	135.92	0.15
Kingsmead	18	100 +33%	715.64	155.59	163.29		163.36	0.000107	1.32	755.32	135.92	0.15
Kingsmead	18	200	653.43	155.59	163.03		163.08	0.000104	1.27	719.15	135.92	0.15
Kingsmead	18	200 +33%	869.06	155.59	163.93		164.01	0.000113	1.43	842.17	135.92	0.16
Kingsmead	17	100	538.07	157.63	161.76	160.84	162.3	0.001907	3.75	195.47	60.81	0.59
Kingsmead	17	100 +33%	715.64	157.63	162.59	161.26	163.19	0.00172	4.02	245.73	60.81	0.58
Kingsmead	17	200	653.43	157.63	162.37	161.1	162.92	0.001694	3.87	232.3	60.81	0.57
Kingsmead	17	200 +33%	869.06	157.63	163.13	161.63	163.81	0.001745	4.34	278.6	60.81	0.59
Kingsmead	16	100	538.07	157.63	160.37	160.37	161.83	0.008665	6.07	113.6	56.22	1.17
Kingsmead	16	100 +33%	715.64	157.63	161.15	161.15	162.46	0.005796	5.87	166.16	63.75	1
Kingsmead	16	200	653.43	157.63	161	161	162.22	0.005704	5.66	156.61	63.27	0.98
Kingsmead	16	200 +33%	869.06	157.63	161.57	161.57	163.03	0.005701	6.28	193.17	64.7	1.01
Kingsmead	15	100	538.07	154.56	158.63	158.48	159.38	0.002795	4.28	166.64	85.35	0.7
Kingsmead	15	100 +33%	715.64	154.56	158.89	158.88	159.91	0.003592	5.06	188.45	87.16	0.8
Kingsmead	15	200	653.43	154.56	158.8	158.74	159.73	0.003316	4.79	181.27	86.57	0.77
Kingsmead	15	200 +33%	869.06	154.56	159.2	159.2	160.32	0.003691	5.38	215.75	89.38	0.82
Kingsmead	14	100	538.07	154.36	158.54	158.18	159.1	0.002148	3.75	209.14	142.32	0.61
Kingsmead	14	100 +33%	715.64	154.36	158.95		159.51	0.002042	3.91	268.26	143.17	0.61
Kingsmead	14	200	653.43	154.36	158.81		159.37	0.002079	3.86	248.33	142.9	0.61
Kingsmead	14	200 +33%	869.06	154.36	159.28		159.84	0.001955	4.02	314.63	143.39	0.6
Kingsmead	13	100	538.07	154.7	158.59		158.86	0.001186	2.7	282.77	156.21	0.45
Kingsmead	13	100 +33%	715.64	154.7	158.99		159.28	0.001187	2.89	345.06	156.9	0.46
Kingsmead	13	200	653.43	154.7	158.86		159.14	0.001188	2.83	324.01	156.67	0.46
Kingsmead	13	200 +33%	869.06	154.7	159.31		159.62	0.001179	3.03	394.5	157.44	0.47
Kingsmead	12	100	538.07	154.05	158.53		158.73	0.000883	2.54	338.89	182.93	0.4
Kingsmead	12	100 +33%	715.64	154.05	158.94		159.15	0.000876	2.69	413.39	184.19	0.4
Kingsmead	12	200	653.43	154.05	158.8		159.01	0.000879	2.64	388.18	183.76	0.4
Kingsmead	12	200 +33%	869.06	154.05	159.26		159.49	0.000866	2.8	472.73	185.32	0.4
Kingsmead	11	100	538.07	153.99	158.36		158.61	0.000997	2.69	310.38	154.97	0.42
Kingsmead	11	100 +33%	715.64	153.99	158.72		159.02	0.001116	3.02	367.56	160.37	0.45
Kingsmead	11	200	653.43	153.99	158.6		158.88	0.001077	2.91	348.03	157.26	0.44
Kingsmead	11	200 +33%	869.06	153.99	159.02		159.35	0.001187	3.24	416.31	174.4	0.47
Kingsmead	10.500*	100	538.07	153.85	158.29		158.56	0.00109	2.84	301.53	154.19	0.44
Kingsmead	10.500*	100 +33%	715.64	153.85	158.64		158.97	0.001221	3.18	357.26	166.34	0.48
Kingsmead	10.500*	200	653.43	153.85	158.52		158.83	0.001177	3.07	338.19	156.59	0.47
Kingsmead	10.500*	200 +33%	869.06	153.85	158.93		159.3	0.001291	3.41	411.36	196.84	0.5
Kingsmead	10	100	538.07	153.72	158.21		158.5	0.001239	3.03	293.01	185.48	0.47
Kingsmead	10	100 +33%	715.64	153.72	158.58		158.91	0.001314	3.3	369.04	222.57	0.49
Kingsmead	10	200	653.43	153.72	158.45		158.77	0.001289	3.21	342.09	210.54	0.49
Kingsmead	10	200 +33%	869.06	153.72	158.89		159.23	0.001302	3.44	443.26	249.62	0.5
Kingsmead	9.5000*	100	538.07	153.76	158.09		158.43	0.001481	3.27	275.28	165.02	0.51
Kingsmead	9.5000*	100 +33%	715.64	153.76	158.44		158.83	0.001604	3.59	337.7	194.11	0.54
Kingsmead	9.5000*	200	653.43	153.76	158.31		158.7	0.001589	3.51	313.96	185.24	0.54
Kingsmead	9.5000*	200 +33%	869.06	153.76	158.76		159.16	0.001531	3.68	404.3	206.63	0.54
Kingsmead	9	100	546.17	153.81	157.81		158.34	0.002329	3.92	229.9	145.33	0.64
Kingsmead	9	100 +33%	726.41	153.81	158.14		158.73	0.002489	4.28	278.01	146.4	0.67
Kingsmead	9	200	662.63	153.81	158.03		158.59	0.002461	4.18	260.82	146.02	0.66
Kingsmead	9	200 +33%	881.29	153.81	158.42		159.05	0.00255	4.53	319.51	162.91	0.68
Kingsmead	8.5000*	100	546.17	153.34	157.73		158.21	0.002057	3.85	246.47	154.14	0.6
Kingsmead	8.5000*	100 +33%	726.41	153.34	158.05		158.59	0.002249	4.23	295.86	155.25	0.64
Kingsmead	8.5000*	200	662.63	153.34	157.93		158.46	0.002222	4.13	277.47	154.73	0.63
Kingsmead	8.5000*	200 +33%	881.29	153.34	158.34		158.91	0.002228	4.39	342.15	157.8	0.64
Kingsmead	8	100	546.17	152.87	157.5	157.41	158.08	0.002424	4.21	235.37	162.62	0.65
Kingsmead	8	100 +33%	726.41	152.87	157.93		158.47	0.002176	4.26	306.88	163.87	0.63
Kingsmead	8	200	662.63	152.87	157.79		158.33	0.002224	4.22	283.92	163.47	0.63
Kingsmead	8	200 +33%	881.29	152.87	158.25		158.79	0.002085	4.36	359.07	164.78	0.62
Kingsmead	7	100	546.17	153.29	157.63		157.84	0.000979	2.56	360.63	202.95	0.41
Kingsmead	7	100 +33%	726.41	153.29	158.03		158.25	0.000997	2.75	441.15	204.6	0.42
Kingsmead	7	200	662.63	153.29	157.89		158.11	0.00099	2.68	413.93	204.04	0.41
Kingsmead	7	200 +33%	881.29	153.29	158.33		158.58	0.001007	2.89	504.13	206.85	0.42
Kingsmead	6	100	546.17	153.59	157.53		157.76	0.001106	2.7	350.59	222.16	0.44
Kingsmead	6	100 +33%	726.41	153.59	157.94		158.18	0.00107	2.84	442.83	228.59	0.44
Kingsmead	6	200	662.63	153.59	157.8		158.03	0.001082	2.79	411.08	226.29	0.44
Kingsmead	6	200 +33%	881.29	153.59	158.25		158.5	0.001049	2.95	515.31	234.04	0.44
Kingsmead	5	100	546.17	152.99	157.47		157.63	0.00078	2.35	372.06	176.14	0.37
Kingsmead	5	100 +33%	726.41	152.99	157.87		158.05	0.000823	2.57	442.01	176.87	0.39
Kingsmead	5	200	662.63	152.99	157.73		157.9	0.00081	2.5	418.06	176.62	0.38
Kingsmead	5	200 +33%	881.29	152.99	158.17		158.38	0.000854	2.74	495.85	178.39	0.4
Kingsmead	4	100	546.17	153.08	157.22		157.54	0.001356	3.02	274.03	144.75	0.48
Kingsmead	4	100 +33%	726.41	153.08	157.58		157.95	0.001484	3.34	326.16	145.5	0.51
Kingsmead	4	200	662.63	153.08	157.45		157.81	0.001447	3.24	308.14	145.2	0.51
Kingsmead	4	200 +33%	881.29	153.08	157.85		158.27	0.001567	3.58	366.44	146.16	0.53
Kingsmead	3	100	546.17	152.17	156.98		157.42	0.001834	3.61	243.64	138.45	0.57
Kingsmead	3	100 +33%	726.41	152.17	157.31		157.82	0.00203	4	289.7	139.06	0.61
Kingsmead	3	200	662.63	152.17	157.19		157.68	0.001986	3.89	273.17	138.84	0.6
Kingsmead	3	200 +33%	881.29	152.17	157.57		158.14	0.002144	4.27	325.92	139.53	0.63
Kingsmead	2	100	546.17	152.2	156.61	156.61	157.25	0.002873	4.25	206.69	142.53	0.7
Kingsmead	2	100 +33%	726.41	152.2	156.9	156.9	157.64	0.003213	4.72	248.18	147.01	0.75
Kingsmead	2	200	662.63	152.2	156.82	156.82	157.51	0.00302	4.51	236.52	145.29	0.72
Kingsmead	2	200 +33%	881.29	152.2	157.09	157.09	157.94	0.003559	5.12	277.1	149.61	0.79
Kingsmead	1	100	546.17	152.72	156.14	156.14	156.59	0.003037	3.7	253.04	240.94	0.69
Kingsmead	1	100 +33%	726.41	152.72	156.34	156.34	156.86	0.003384	4.09	302.77	242.32	0.74
Kingsmead	1	200	662.63	152.72	156.26	156.26	156.77	0.003375	4.01	282.6	241.76	0.74
Kingsmead	1	200 +33%	881.29	152.72	156.47	156.47	157.07	0.00383	4.47	333.74	243.17	0.79



KEY:

SINGLE SITE METHOD FLOOD EXTENTS

- 1 IN 200 YEAR WITH 100% BLOCKAGE
- 1 IN 200 YEAR PLUS 33% CLIMATE CHANGE WITH 100% BLOCKAGE
- OWNERSHIP BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY

Rev	Date	Description	By
A02	18.06.19	UPDATED OWNERSHIP BOUNDARY AND PROPOSED DEVELOPMENT BOUNDARY ADDED	RD
A01	05.06.19	ISSUED FOR INFORMATION	RD

Amendments

Project
Kingsmeadows Residential Apartments FRA

Title
FLOOD EXTENTS
FOR 1 IN 200 YEAR AND 1 IN 200 YEAR PLUS 33% CC FLOOD EVENTS WITH 100% BLOCKAGE

Client
GRANTON HOMES LTD

Broxden House Broxden Business Park Lamberkine Drive Perth PH1 1RA
t 01738 449 801
mail@watermangroup.com www.watermangroup.com

Drawing Status
PRELIMINARY

Designed by	ND	Checked by	KM	Project No	WIE15880
Drawn by	RD	Date	06.06.19		
Scales @ A3 work to figured dimensions only	1:1000			Computer File No	WIE-10440-SA-92-0204.dwg

Publisher	Zone	Category	Number	Revision
WIE	SA	92	0204	A02

File Path N:\Projects\WIE15880_Kingsmeadow FRA Update\100-7_CAD\92\

A3-Wat-S, WIE-10440-SA-NS-CIVIL-3D-50% Blockage, WIE-10440-SA-NS-SU_2D-XX

WIE15880 Kingsmeadow FRA - Sensitivity Analysis: 100% Blockage

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Flow Area	Top Width	Froude # Chl
Kingsmead	18	100	538.07	155.59	163.89	835.8	135.92	0.1
Kingsmead	18	100 +33%	715.64	155.59	164.66	940.31	135.92	0.11
Kingsmead	18	200	653.43	155.59	164.36	900.24	135.92	0.11
Kingsmead	18	200 +33%	869.06	155.59	165.3	1027.52	135.92	0.12
Kingsmead	17	100	538.07	160	163.42	217.47	60.81	0.58
Kingsmead	17	100 +33%	715.64	160	164.06	256.35	60.81	0.61
Kingsmead	17	200	653.43	160	163.8	240.34	60.81	0.61
Kingsmead	17	200 +33%	869.06	160	164.61	289.5	60.81	0.62
Kingsmead	16	100	538.07	160	161.88	131.45	64.7	1.25
Kingsmead	16	100 +33%	715.64	160	162.3	158.47	64.7	1.27
Kingsmead	16	200	653.43	160	162.16	149.55	64.7	1.26
Kingsmead	16	200 +33%	869.06	160	162.64	180.7	64.7	1.28
Kingsmead	15	100	538.07	154.56	158.63	166.64	85.35	0.7
Kingsmead	15	100 +33%	715.64	154.56	158.89	188.45	87.16	0.8
Kingsmead	15	200	653.43	154.56	158.8	181.27	86.57	0.77
Kingsmead	15	200 +33%	869.06	154.56	159.2	215.75	89.38	0.82
Kingsmead	14	100	538.07	154.36	158.54	209.14	142.32	0.61
Kingsmead	14	100 +33%	715.64	154.36	158.95	268.26	143.17	0.61
Kingsmead	14	200	653.43	154.36	158.81	248.33	142.9	0.61
Kingsmead	14	200 +33%	869.06	154.36	159.28	314.63	143.39	0.6
Kingsmead	13	100	538.07	154.7	158.59	282.77	156.21	0.45
Kingsmead	13	100 +33%	715.64	154.7	158.99	345.06	156.9	0.46
Kingsmead	13	200	653.43	154.7	158.86	324.01	156.67	0.46
Kingsmead	13	200 +33%	869.06	154.7	159.31	394.5	157.44	0.47
Kingsmead	12	100	538.07	154.05	158.53	338.89	182.93	0.4
Kingsmead	12	100 +33%	715.64	154.05	158.94	413.39	184.19	0.4
Kingsmead	12	200	653.43	154.05	158.8	388.18	183.76	0.4
Kingsmead	12	200 +33%	869.06	154.05	159.26	472.73	185.32	0.4
Kingsmead	11	100	538.07	153.99	158.36	310.38	154.97	0.42
Kingsmead	11	100 +33%	715.64	153.99	158.72	367.56	160.37	0.45
Kingsmead	11	200	653.43	153.99	158.6	348.03	157.26	0.44
Kingsmead	11	200 +33%	869.06	153.99	159.02	416.31	174.4	0.47
Kingsmead	10.500*	100	538.07	153.85	158.29	301.53	154.19	0.44
Kingsmead	10.500*	100 +33%	715.64	153.85	158.64	357.26	166.34	0.48
Kingsmead	10.500*	200	653.43	153.85	158.52	338.19	156.59	0.47
Kingsmead	10.500*	200 +33%	869.06	153.85	158.93	411.36	196.84	0.5
Kingsmead	10	100	538.07	153.72	158.21	293.01	185.48	0.47
Kingsmead	10	100 +33%	715.64	153.72	158.58	369.04	222.57	0.49
Kingsmead	10	200	653.43	153.72	158.45	342.09	210.54	0.49
Kingsmead	10	200 +33%	869.06	153.72	158.89	443.26	249.62	0.5
Kingsmead	9.5000*	100	538.07	153.76	158.09	275.28	165.02	0.51
Kingsmead	9.5000*	100 +33%	715.64	153.76	158.44	337.7	194.11	0.54
Kingsmead	9.5000*	200	653.43	153.76	158.31	313.96	185.24	0.54
Kingsmead	9.5000*	200 +33%	869.06	153.76	158.76	404.3	206.63	0.54
Kingsmead	9	100	546.17	153.81	157.81	229.9	145.33	0.64
Kingsmead	9	100 +33%	726.41	153.81	158.14	278.01	146.4	0.67
Kingsmead	9	200	662.63	153.81	158.03	260.82	146.02	0.66
Kingsmead	9	200 +33%	881.29	153.81	158.42	319.51	162.91	0.68
Kingsmead	8.5000*	100	546.17	153.34	157.73	246.47	154.14	0.6
Kingsmead	8.5000*	100 +33%	726.41	153.34	158.05	295.86	155.25	0.64
Kingsmead	8.5000*	200	662.63	153.34	157.93	277.47	154.73	0.63
Kingsmead	8.5000*	200 +33%	881.29	153.34	158.34	342.15	157.8	0.64
Kingsmead	8	100	546.17	152.87	157.5	235.37	162.62	0.65
Kingsmead	8	100 +33%	726.41	152.87	157.93	306.89	163.87	0.63
Kingsmead	8	200	662.63	152.87	157.79	283.92	163.47	0.63
Kingsmead	8	200 +33%	881.29	152.87	158.25	359.06	164.78	0.62
Kingsmead	7	100	546.17	153.29	157.63	360.63	202.95	0.41
Kingsmead	7	100 +33%	726.41	153.29	158.03	441.15	204.6	0.42
Kingsmead	7	200	662.63	153.29	157.89	413.93	204.04	0.41
Kingsmead	7	200 +33%	881.29	153.29	158.33	504.12	206.85	0.42
Kingsmead	6	100	546.17	153.59	157.53	350.59	222.16	0.44
Kingsmead	6	100 +33%	726.41	153.59	157.94	442.84	228.59	0.44
Kingsmead	6	200	662.63	153.59	157.8	411.08	226.29	0.44
Kingsmead	6	200 +33%	881.29	153.59	158.25	515.3	234.04	0.44
Kingsmead	5	100	546.17	152.99	157.47	372.06	176.14	0.37
Kingsmead	5	100 +33%	726.41	152.99	157.87	442.01	176.87	0.39
Kingsmead	5	200	662.63	152.99	157.73	418.06	176.62	0.38
Kingsmead	5	200 +33%	881.29	152.99	158.17	495.84	178.39	0.4
Kingsmead	4	100	546.17	153.08	157.22	274.03	144.75	0.48
Kingsmead	4	100 +33%	726.41	153.08	157.58	326.17	145.5	0.51
Kingsmead	4	200	662.63	153.08	157.45	308.14	145.2	0.51
Kingsmead	4	200 +33%	881.29	153.08	157.85	366.43	146.16	0.53
Kingsmead	3	100	546.17	152.17	156.98	243.64	138.45	0.57
Kingsmead	3	100 +33%	726.41	152.17	157.31	289.72	139.06	0.61
Kingsmead	3	200	662.63	152.17	157.19	273.17	138.84	0.6
Kingsmead	3	200 +33%	881.29	152.17	157.57	325.88	139.52	0.63
Kingsmead	2	100	546.17	152.2	156.61	206.69	142.53	0.7
Kingsmead	2	100 +33%	726.41	152.2	156.9	248.18	147.01	0.75
Kingsmead	2	200	662.63	152.2	156.82	236.52	145.29	0.72
Kingsmead	2	200 +33%	881.29	152.2	157.09	277.1	149.61	0.79
Kingsmead	1	100	546.17	152.72	156.14	253.04	240.94	0.69
Kingsmead	1	100 +33%	726.41	152.72	156.34	301.69	242.29	0.74
Kingsmead	1	200	662.63	152.72	156.26	282.87	241.77	0.73
Kingsmead	1	200 +33%	881.29	152.72	156.48	335.2	243.21	0.79

WIE15880 Kingsmeadow FRA - Sensitivity Analysis: Boundary Condition-20%

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
Kingsmeadow	18	100	538.07	155.59	161.66		161.73	0.000173	1.42	532.56	135.92	0.19
Kingsmeadow	18	100 +33%	715.64	155.59	162.22		162.32	0.000205	1.64	609.41	135.92	0.21
Kingsmeadow	18	200	653.43	155.59	162.16		162.24	0.000178	1.52	600.93	135.92	0.19
Kingsmeadow	18	200 +33%	869.06	155.59	162.97		163.08	0.000189	1.7	711.51	135.92	0.2
Kingsmeadow	17	100	538.07	155.24	161.02	159.52	161.57	0.001213	3.63	199.99	60.76	0.49
Kingsmeadow	17	100 +33%	715.64	155.24	161.14	160.13	162.05	0.001954	4.68	207.65	60.78	0.62
Kingsmeadow	17	200	653.43	155.24	161.38	160.05	162.05	0.001369	4.03	222.41	60.81	0.53
Kingsmeadow	17	200 +33%	869.06	155.24	161.91	160.91	162.82	0.001708	4.75	254.34	60.81	0.59
Kingsmeadow	16	100	538.07	155.05	159.58	159.58	161.03	0.004249	5.77	119.51	48.07	0.88
Kingsmeadow	16	100 +33%	715.64	155.05	160.22	160.22	161.83	0.00409	6.21	153.51	51.39	0.89
Kingsmeadow	16	200	653.43	155.05	160.05	160.05	161.54	0.003945	5.96	145.01	50.76	0.87
Kingsmeadow	16	200 +33%	869.06	155.05	160.87	160.87	162.51	0.003661	6.38	191.05	62.86	0.86
Kingsmeadow	15	100	538.07	154.56	158.63	158.48	159.38	0.002795	4.28	166.64	85.35	0.7
Kingsmeadow	15	100 +33%	715.64	154.56	158.89	158.88	159.91	0.003592	5.06	188.45	87.16	0.8
Kingsmeadow	15	200	653.43	154.56	158.8	158.74	159.73	0.003316	4.79	181.27	86.57	0.77
Kingsmeadow	15	200 +33%	869.06	154.56	159.2	159.2	160.32	0.003691	5.38	215.75	89.38	0.82
Kingsmeadow	14	100	538.07	154.36	158.54	158.18	159.1	0.002148	3.75	209.15	142.32	0.61
Kingsmeadow	14	100 +33%	715.64	154.36	158.95		159.51	0.002042	3.91	268.28	143.17	0.61
Kingsmeadow	14	200	653.43	154.36	158.81		159.37	0.00208	3.86	248.33	142.9	0.61
Kingsmeadow	14	200 +33%	869.06	154.36	159.28		159.84	0.001954	4.02	314.65	143.39	0.6
Kingsmeadow	13	100	538.07	154.7	158.59		158.86	0.001186	2.7	282.78	156.21	0.45
Kingsmeadow	13	100 +33%	715.64	154.7	158.99		159.28	0.001187	2.89	345.08	156.9	0.46
Kingsmeadow	13	200	653.43	154.7	158.86		159.14	0.001189	2.83	324	156.67	0.46
Kingsmeadow	13	200 +33%	869.06	154.7	159.31		159.62	0.001179	3.03	394.52	157.44	0.47
Kingsmeadow	12	100	538.07	154.05	158.53		158.73	0.000883	2.54	338.91	182.93	0.4
Kingsmeadow	12	100 +33%	715.64	154.05	158.94		159.15	0.000876	2.69	413.41	184.19	0.4
Kingsmeadow	12	200	653.43	154.05	158.8		159.01	0.000879	2.64	388.17	183.76	0.4
Kingsmeadow	12	200 +33%	869.06	154.05	159.26		159.49	0.000866	2.8	472.76	185.32	0.4
Kingsmeadow	11	100	538.07	153.99	158.36		158.61	0.000997	2.69	310.4	154.97	0.42
Kingsmeadow	11	100 +33%	715.64	153.99	158.72		159.02	0.001116	3.02	367.58	160.37	0.45
Kingsmeadow	11	200	653.43	153.99	158.6		158.88	0.001077	2.91	348.02	157.26	0.44
Kingsmeadow	11	200 +33%	869.06	153.99	159.02		159.35	0.001187	3.24	416.35	174.41	0.47
Kingsmeadow	10.500*	100	538.07	153.85	158.29		158.56	0.00109	2.84	301.54	154.19	0.44
Kingsmeadow	10.500*	100 +33%	715.64	153.85	158.64		158.97	0.001221	3.18	357.29	166.38	0.48
Kingsmeadow	10.500*	200	653.43	153.85	158.52		158.83	0.001177	3.07	338.18	156.59	0.47
Kingsmeadow	10.500*	200 +33%	869.06	153.85	158.93		159.3	0.001291	3.41	411.41	196.85	0.49
Kingsmeadow	10	100	538.07	153.72	158.21		158.5	0.001239	3.03	293.01	185.48	0.47
Kingsmeadow	10	100 +33%	715.64	153.72	158.58		158.91	0.001314	3.3	369.08	222.58	0.49
Kingsmeadow	10	200	653.43	153.72	158.45		158.77	0.001289	3.21	342.08	210.54	0.49
Kingsmeadow	10	200 +33%	869.06	153.72	158.89		159.23	0.001302	3.43	443.33	249.63	0.5
Kingsmeadow	9.5000*	100	538.07	153.76	158.09		158.43	0.00148	3.27	275.28	165.02	0.51
Kingsmeadow	9.5000*	100 +33%	715.64	153.76	158.44		158.83	0.001603	3.59	337.76	194.13	0.54
Kingsmeadow	9.5000*	200	653.43	153.76	158.31		158.7	0.00159	3.51	313.95	185.23	0.54
Kingsmeadow	9.5000*	200 +33%	869.06	153.76	158.76		159.16	0.00153	3.68	404.36	206.63	0.54
Kingsmeadow	9	100	546.17	153.81	157.82		158.34	0.002328	3.92	229.96	145.33	0.64
Kingsmeadow	9	100 +33%	726.41	153.81	158.15		158.73	0.002484	4.28	278.19	146.41	0.67
Kingsmeadow	9	200	662.63	153.81	158.03		158.59	0.002462	4.18	260.77	146.02	0.66
Kingsmeadow	9	200 +33%	881.29	153.81	158.42		159.05	0.002549	4.52	319.58	163.07	0.68
Kingsmeadow	8.5000*	100	546.17	153.34	157.73		158.21	0.002055	3.84	246.59	154.14	0.6
Kingsmeadow	8.5000*	100 +33%	726.41	153.34	158.05		158.59	0.002247	4.22	295.93	155.26	0.64
Kingsmeadow	8.5000*	200	662.63	153.34	157.93		158.46	0.002224	4.13	277.4	154.73	0.63
Kingsmeadow	8.5000*	200 +33%	881.29	153.34	158.34		158.91	0.002227	4.39	342.25	157.81	0.64
Kingsmeadow	8	100	546.17	152.87	157.49	157.41	158.08	0.002431	4.22	235.09	162.62	0.66
Kingsmeadow	8	100 +33%	726.41	152.87	157.93		158.47	0.002173	4.26	307.02	163.88	0.63
Kingsmeadow	8	200	662.63	152.87	157.79		158.33	0.00223	4.23	283.62	163.47	0.63
Kingsmeadow	8	200 +33%	881.29	152.87	158.25		158.79	0.002083	4.36	359.19	164.78	0.62
Kingsmeadow	7	100	546.17	153.29	157.63		157.84	0.00098	2.56	360.42	202.94	0.41
Kingsmeadow	7	100 +33%	726.41	153.29	158.03		158.25	0.000996	2.75	441.29	204.6	0.42
Kingsmeadow	7	200	662.63	153.29	157.89		158.11	0.000992	2.68	413.65	204.04	0.41
Kingsmeadow	7	200 +33%	881.29	153.29	158.33		158.58	0.001006	2.89	504.26	206.86	0.42
Kingsmeadow	6	100	546.17	153.59	157.53		157.76	0.001108	2.7	350.29	222.14	0.44
Kingsmeadow	6	100 +33%	726.41	153.59	157.94		158.18	0.001068	2.84	443.02	228.6	0.44
Kingsmeadow	6	200	662.63	153.59	157.8		158.03	0.001085	2.79	410.68	226.27	0.44
Kingsmeadow	6	200 +33%	881.29	153.59	158.25		158.5	0.001048	2.95	515.49	234.05	0.44
Kingsmeadow	5	100	546.17	152.99	157.47		157.62	0.000782	2.36	371.8	176.14	0.37
Kingsmeadow	5	100 +33%	726.41	152.99	157.87		158.05	0.000822	2.57	442.17	176.87	0.39
Kingsmeadow	5	200	662.63	152.99	157.73		157.9	0.000812	2.5	417.73	176.62	0.38
Kingsmeadow	5	200 +33%	881.29	152.99	158.17		158.38	0.000853	2.73	496	178.42	0.4
Kingsmeadow	4	100	546.17	153.08	157.21		157.54	0.00136	3.02	273.68	144.74	0.49
Kingsmeadow	4	100 +33%	726.41	153.08	157.58		157.95	0.001481	3.34	326.38	145.5	0.51
Kingsmeadow	4	200	662.63	153.08	157.45		157.81	0.001453	3.24	307.69	145.19	0.51
Kingsmeadow	4	200 +33%	881.29	153.08	157.85		158.27	0.001564	3.58	366.64	146.17	0.53
Kingsmeadow	3	100	546.17	152.17	156.98		157.42	0.00185	3.62	242.82	138.44	0.57
Kingsmeadow	3	100 +33%	726.41	152.17	157.32		157.83	0.00202	3.99	290.21	139.06	0.61
Kingsmeadow	3	200	662.63	152.17	157.19		157.68	0.002007	3.9	272.09	138.83	0.6
Kingsmeadow	3	200 +33%	881.29	152.17	157.58		158.14	0.002136	4.26	326.33	139.53	0.63
Kingsmeadow	2	100	546.17	152.2	156.61	156.61	157.25	0.002873	4.25	206.69	142.53	0.7
Kingsmeadow	2	100 +33%	726.41	152.2	156.9	156.9	157.64	0.003213	4.72	248.18	147.01	0.75
Kingsmeadow	2	200	662.63	152.2	156.82	156.82	157.51	0.00302	4.51	236.52	145.29	0.72
Kingsmeadow	2	200 +33%	881.29	152.2	157.09	157.09	157.94	0.003559	5.12	277.1	149.61	0.79
Kingsmeadow	1	100	546.17	152.72	156.3	156.14	156.62	0.002083	3.18	293.15	242.06	0.58
Kingsmeadow	1	100 +33%	726.41	152.72	156.59	156.34	156.92	0.002081	3.37	363	244.84	0.59
Kingsmeadow	1	200	662.63	152.72	156.49	156.26	156.82	0.002081	3.31	338.57	243.31	0.58
Kingsmeadow	1	200 +33%	881.29	152.72	156.8	156.47	157.15	0.002081	3.52	415.37	244.84	0.59

WIE15880 Kingsmeadow FRA - Sensitivity Analysis: Boundary Condition+20%

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Flow Area	Top Width	Froude # Chl
Kingsmeadow	18	100	538.07	155.59	161.66	532.56	135.92	0.19
Kingsmeadow	18	100 +33%	715.64	155.59	162.22	609.41	135.92	0.21
Kingsmeadow	18	200	653.43	155.59	162.16	600.93	135.92	0.19
Kingsmeadow	18	200 +33%	869.06	155.59	162.97	711.51	135.92	0.2
Kingsmeadow	17	100	538.07	155.24	161.02	199.99	60.76	0.49
Kingsmeadow	17	100 +33%	715.64	155.24	161.14	207.65	60.78	0.62
Kingsmeadow	17	200	653.43	155.24	161.38	222.41	60.81	0.53
Kingsmeadow	17	200 +33%	869.06	155.24	161.91	254.34	60.81	0.59
Kingsmeadow	16	100	538.07	155.05	159.58	119.51	48.07	0.88
Kingsmeadow	16	100 +33%	715.64	155.05	160.22	153.51	51.39	0.89
Kingsmeadow	16	200	653.43	155.05	160.05	145.01	50.76	0.87
Kingsmeadow	16	200 +33%	869.06	155.05	160.87	191.05	62.86	0.86
Kingsmeadow	15	100	538.07	154.56	158.63	166.64	85.35	0.7
Kingsmeadow	15	100 +33%	715.64	154.56	158.89	188.45	87.16	0.8
Kingsmeadow	15	200	653.43	154.56	158.8	181.27	86.57	0.77
Kingsmeadow	15	200 +33%	869.06	154.56	159.2	215.75	89.38	0.82
Kingsmeadow	14	100	538.07	154.36	158.54	209.14	142.32	0.61
Kingsmeadow	14	100 +33%	715.64	154.36	158.95	268.26	143.17	0.61
Kingsmeadow	14	200	653.43	154.36	158.81	248.33	142.9	0.61
Kingsmeadow	14	200 +33%	869.06	154.36	159.28	314.68	143.39	0.6
Kingsmeadow	13	100	538.07	154.7	158.59	282.77	156.21	0.45
Kingsmeadow	13	100 +33%	715.64	154.7	158.99	345.06	156.9	0.46
Kingsmeadow	13	200	653.43	154.7	158.86	324	156.67	0.46
Kingsmeadow	13	200 +33%	869.06	154.7	159.31	394.54	157.44	0.47
Kingsmeadow	12	100	538.07	154.05	158.53	338.89	182.93	0.4
Kingsmeadow	12	100 +33%	715.64	154.05	158.94	413.38	184.19	0.4
Kingsmeadow	12	200	653.43	154.05	158.8	388.17	183.76	0.4
Kingsmeadow	12	200 +33%	869.06	154.05	159.26	472.79	185.32	0.4
Kingsmeadow	11	100	538.07	153.99	158.36	310.38	154.97	0.42
Kingsmeadow	11	100 +33%	715.64	153.99	158.72	367.56	160.37	0.45
Kingsmeadow	11	200	653.43	153.99	158.6	348.02	157.26	0.44
Kingsmeadow	11	200 +33%	869.06	153.99	159.02	416.38	174.43	0.47
Kingsmeadow	10.500*	100	538.07	153.85	158.29	301.53	154.19	0.44
Kingsmeadow	10.500*	100 +33%	715.64	153.85	158.64	357.25	166.33	0.48
Kingsmeadow	10.500*	200	653.43	153.85	158.52	338.18	156.59	0.47
Kingsmeadow	10.500*	200 +33%	869.06	153.85	158.93	411.45	196.86	0.49
Kingsmeadow	10	100	538.07	153.72	158.21	293.01	185.48	0.47
Kingsmeadow	10	100 +33%	715.64	153.72	158.58	369.03	222.56	0.49
Kingsmeadow	10	200	653.43	153.72	158.45	342.08	210.54	0.49
Kingsmeadow	10	200 +33%	869.06	153.72	158.89	443.39	249.65	0.5
Kingsmeadow	9.5000*	100	538.07	153.76	158.09	275.28	165.02	0.51
Kingsmeadow	9.5000*	100 +33%	715.64	153.76	158.44	337.68	194.11	0.54
Kingsmeadow	9.5000*	200	653.43	153.76	158.31	313.96	185.23	0.54
Kingsmeadow	9.5000*	200 +33%	869.06	153.76	158.77	404.44	206.63	0.54
Kingsmeadow	9	100	546.17	153.81	157.81	229.9	145.33	0.64
Kingsmeadow	9	100 +33%	726.41	153.81	158.14	277.98	146.4	0.67
Kingsmeadow	9	200	662.63	153.81	158.03	260.81	146.02	0.66
Kingsmeadow	9	200 +33%	881.29	153.81	158.42	319.68	163.26	0.68
Kingsmeadow	8.5000*	100	546.17	153.34	157.73	246.47	154.14	0.6
Kingsmeadow	8.5000*	100 +33%	726.41	153.34	158.05	295.81	155.25	0.64
Kingsmeadow	8.5000*	200	662.63	153.34	157.93	277.46	154.73	0.63
Kingsmeadow	8.5000*	200 +33%	881.29	153.34	158.35	342.37	157.82	0.64
Kingsmeadow	8	100	546.17	152.87	157.5	235.37	162.62	0.65
Kingsmeadow	8	100 +33%	726.41	152.87	157.93	306.81	163.87	0.63
Kingsmeadow	8	200	662.63	152.87	157.79	283.89	163.47	0.63
Kingsmeadow	8	200 +33%	881.29	152.87	158.25	359.34	164.79	0.62
Kingsmeadow	7	100	546.17	153.29	157.63	360.63	202.95	0.41
Kingsmeadow	7	100 +33%	726.41	153.29	158.03	441.08	204.6	0.42
Kingsmeadow	7	200	662.63	153.29	157.89	413.91	204.04	0.41
Kingsmeadow	7	200 +33%	881.29	153.29	158.33	504.43	206.86	0.42
Kingsmeadow	6	100	546.17	153.59	157.53	350.59	222.16	0.44
Kingsmeadow	6	100 +33%	726.41	153.59	157.94	442.75	228.58	0.44
Kingsmeadow	6	200	662.63	153.59	157.8	411.03	226.29	0.44
Kingsmeadow	6	200 +33%	881.29	153.59	158.25	515.71	234.07	0.44
Kingsmeadow	5	100	546.17	152.99	157.47	372.06	176.14	0.37
Kingsmeadow	5	100 +33%	726.41	152.99	157.87	441.94	176.87	0.39
Kingsmeadow	5	200	662.63	152.99	157.73	418.03	176.62	0.38
Kingsmeadow	5	200 +33%	881.29	152.99	158.17	496.18	178.46	0.4
Kingsmeadow	4	100	546.17	153.08	157.22	274.03	144.75	0.48
Kingsmeadow	4	100 +33%	726.41	153.08	157.58	326.08	145.49	0.51
Kingsmeadow	4	200	662.63	153.08	157.45	308.09	145.19	0.51
Kingsmeadow	4	200 +33%	881.29	153.08	157.86	366.88	146.17	0.53
Kingsmeadow	3	100	546.17	152.17	156.98	243.64	138.45	0.57
Kingsmeadow	3	100 +33%	726.41	152.17	157.31	289.52	139.05	0.61
Kingsmeadow	3	200	662.63	152.17	157.19	273.06	138.84	0.6
Kingsmeadow	3	200 +33%	881.29	152.17	157.58	326.83	139.54	0.63
Kingsmeadow	2	100	546.17	152.2	156.61	206.69	142.53	0.7
Kingsmeadow	2	100 +33%	726.41	152.2	156.9	248.18	147.01	0.75
Kingsmeadow	2	200	662.63	152.2	156.82	236.52	145.29	0.72
Kingsmeadow	2	200 +33%	881.29	152.2	157.09	277.1	149.61	0.79
Kingsmeadow	1	100	546.17	152.72	156.14	253.04	240.94	0.69
Kingsmeadow	1	100 +33%	726.41	152.72	156.38	312.03	242.58	0.71
Kingsmeadow	1	200	662.63	152.72	156.3	291.15	242	0.71
Kingsmeadow	1	200 +33%	881.29	152.72	156.58	359.55	244.68	0.72

waterman

UK and Ireland Office Locations