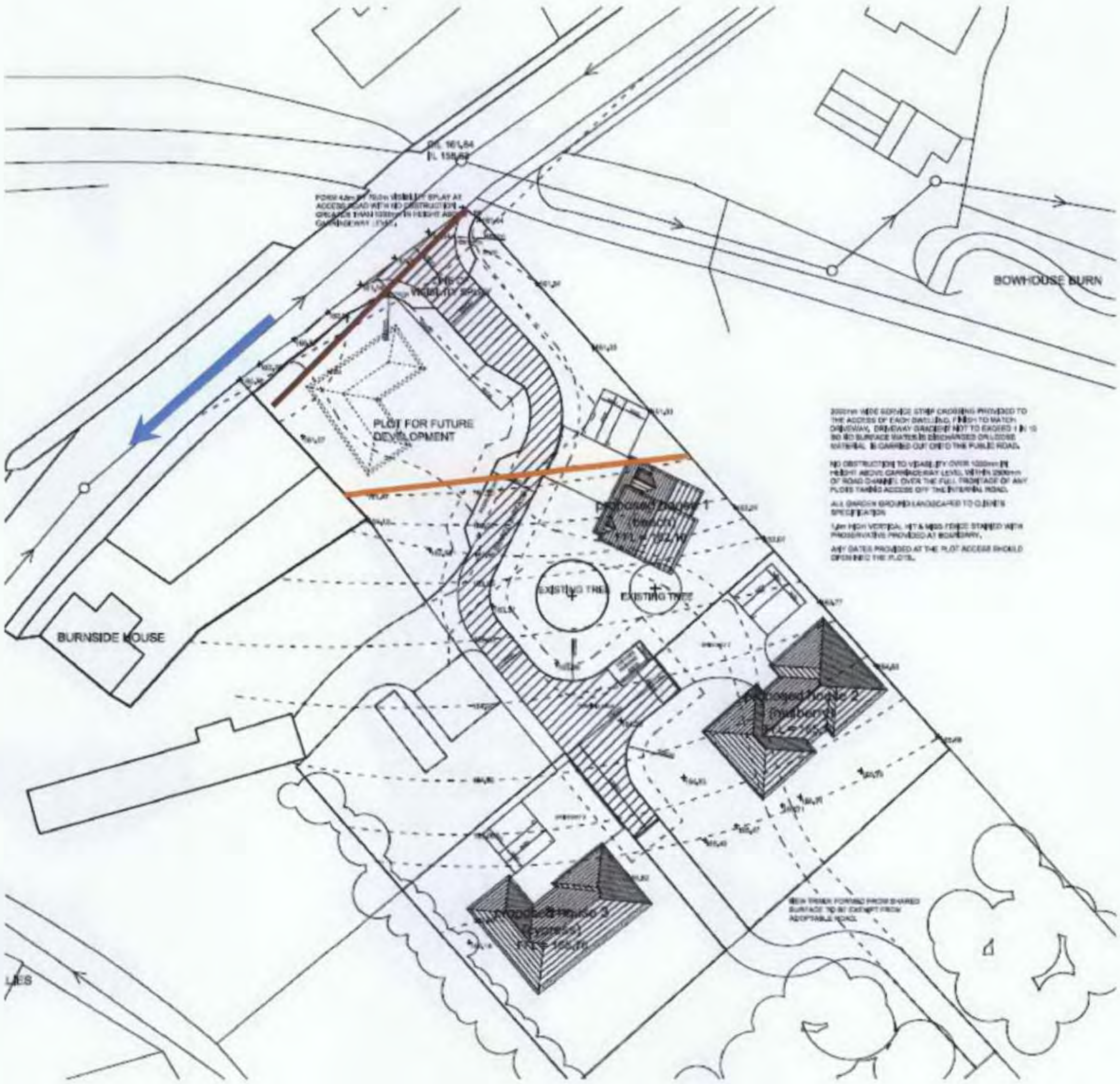
Figure 2. Site topographical levels



Key

Level 1.5m above burn

Level 2.5m above burn

Predicted direction of any floodwater due to topography

Site Investigation Report: Flood Risk Appraisal

For Proposed

Development Site

at

Standburn

Falkirk

December 2009

Prepared for

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by

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Contents

1. Introduction

An initial baseline flood risk appraisal was carried out during December 2008 at Standburn, Polmont, Falkirk as part a series of site investigations for a proposed development of three dwellinghouses adjacent to existing housing. The three houses are proposed for the southern part of the site on the highest ground, with the lower ground being garden/amenity space and for access. The proposed development area (NS 927 746) is a brownfield site and was previously occupied by approximately 70 houses but is currently includes mix of hard standing, gravel track, and some developing scrub, with patches of tall ruderals and brambles and is situated south of and adjacent to the B825 on ground rising southwards away from the road. At the northern side of the road a small burn, the Bowhouse burn [which originates approximately 0.5km northwest (NS 921 747) of the site] runs eastwards adjacent to the road, culverted northeast of the site to pass under the road and re-emerges in a field east of the proposed development area. It is the presence of this burn that resulted in Falkirk Council requesting a Flood Risk Assessment report as part of the submissions to the Planning Authority for the planning application for the proposed development. Falkirk Council requested additional data in late autumn 2009, and most of this data is now included in this updated report.

2. Catchment Description

The Bowhouse burn is a small tributary burn of the river Avon. The upper catchment of the Bowhouse burn is very small at <1km^2, with the burn arising at NS 921 747 approximately 500m northwest of the proposed development area from marshy ground at approximately 165m above sea level (ASL) in a wide valley between four gently rising hills between 180-190m ASL in a post glacial "rolling hills" landscape. The burn runs southeast enters a long culvert (Culvert 1) before emerging in the village of Standburn (Culvert 2) just across the B825 from the proposed development area, it is canalised adjacent to the road over a 30m length, then passes through another culvert (Culvert 3) under the road (NS 927 747), and re-emerges 50m away to the southeast in the adjacent field (Culvert 4), where it emerges in a steep-sided V-shaped valley running down to Bowhouse, and on to the confluence with the river Avon another 2km to the east. A topographical map of the area with contours can be viewed at:

http://www.ordnancesurvey.co.uk/oswebsite/getamap/

Note: The burn bed sits at least 1.5m below the bank top. Flood water levels have not been known to exceed the bank top during the last 20 years, including during the regional flood incidents during summer 2004-2005 and November 2009. The only known flooding in this area was during 2008 when the stormwater drain gully in the road surface adjacent to the development site became choked with fallen leaves, and water pooled on the road until the drain was cleared.

During November 2009, the water levels in the burn adjacent to the main road were variable between 30-75mm deep. Flow rate was measured as <0.20m/sec. where the burn passes under the main road the culvert (Culvert 3) dimensions were 600mm x 860mm. Previous stormwater levels from early in November 2009 were at 250mm above normal flow levels, and if extreme flood levels were experienced in this section water would spill out of the confines of the burn into the ground north of the road before there was any potential to crest the roadside wall and enter the roadway or development site (wall top is 2.44m above normal burn levels). At the western end of the wall the burn is 1m below the wall top, so this is the "weak" point where any flood water could pass around the end of the wall and enter the roadway - therefore levels at the eastern end of the open section are not relevant as water will not reach the wall top at the eastern end due to the lower egress point at the western end of the wall. NB: Flow rate to the east of the road, downstream of Culvert 4 was measured as 0.6m/sec (increased due to gradient).

Upstream of the open section by the road the burn is culverted (Culvert 2) for some distance from NS92698 74724, with the culvert dimensions 1000mm x 600mm above normal flow levels, which at this point were 180mm deep in the mouth of the culvert but only 50mm deep in the normal burn bed immediately adjacent to the culvert. The upstream culvert (Culvert 1) to this section lies at NS92620 74713, where the culverted section begins by entering the base of a substantial earthen bank or bund approximately 4m high. Immediately adjacent to the bund on the upstream side is an extensive area of low-lying marshy grassland at least 350m^2 in area, which is only 300mm above the normal water flow levels in the burn. The burn in this section is also choked with vegetation, which also slows the burn flow rate from upstream. Water flow in this section of burn was almost non-existent due to heavy choking with vegetation (<0.15m/sec). This section of burn passes through a young woodland plantation, which as time passes will mature and intercept and slow more rainfall than it can at present. The burn origins are just upstream of the woodland area. Flow rates were measured using a stopwatch over a 2m stretch, water levels being so low or vegetation so dense that it was impractical to measure over a longer stretch.

3. Proposed Development Site Levels

The northern edge of the site boundary of the proposed development area is situated a minimum of 1.5 metres above the bank top of the burn but the majority of the site is at least 5m above the bank top level of the corridor, and the nearest proposed location for a house on the site is 2.5m above the level of the burn, although it is the intention of the developer to uplift the northeastern corner for that property to a level 3-3.5m above burn level due to slope and changes in ground levels.

4. Flood Risk Appraisal

The Scottish Executive directed SEPA to indicate areas in Scotland where there is a 0.5% (1:200) or greater probability of being flooded in any given year. SEPA produced an interactive 1:25,000 scale Indicative River and Coastal Flood Map for Scotland, which can be viewed at (*http://www.sepa.org.uk/flooding/mapping/*). This map includes the potential flood risk envelopes for rivers and burns with catchments >3km^2 and from the sea. From this interactive map it was determined that the nearest location to the proposed development site to potentially be affected by flooding from rivers is almost 2km downstream to the east at NS 946 751, just east of the A801 road at Bowhouse. There is therefore ***no estimated 1:200 or greater flood risk*** identified by SEPA for the Standburn village area from any catchment >3km^2. **However**, this assessment by SEPA is based on the current risk from flooding only AND is only for catchments >3km^2. It cannot take any exceptional localised flooding due to unpredictable factors such as backing up of water volumes due to the burn channel becoming impeded or blocked by debris at "pinch points" during flood events into account due to their unpredictable causes and nature of the event.

SEPA has also noted the following considerations for users of the flood data on their website:

"It does not provide enough detail to accurately estimate the flood risk associated with individual properties or specific point locations. ***Local factors such as flood defence schemes, structures in or around river channels such as bridges, buildings and other local influences, which might affect a flood, have not been included.*** *Furthermore, the flood map only shows flooding from rivers or the sea and does not account for flooding from other sources such as surface water runoff, surcharged culverts (where rivers which have been channelled underground flood) or drainage systems."*

"The flood map provides an overview of flood risk only and, given the inherent uncertainty in flood estimation methods and the main input dataset, further detailed local studies may still be required to accurately assess the risk of flooding for a local area or to provide an indication of flood risk for a specific location or property. It is not suitable for determining flood risk for insurance purposes or property enquiries.

All users of the map should take into account:

- *It is based on a digital terrain model with a vertical accuracy in the range 0.7m – 1.0m, on a grid spacing of 5m;*
- *It is not relevant to catchments below 3km²- which the local catchment is,* ***with the local burn having a catchment of <1km², so this must be assessed separately.***
- *It does not attempt to take account of surface run-off, surcharged culverts, blockages and structures such as bridges or buildings which can significantly affect the flow of water;*
- *It does not take account of flood prevention schemes and coastal defences."*

5. Conclusions

Given the site elevations, location relatively near the "headwaters" of the small burn, gradient of the road between the proposed development site and burn, and historical information provided by local residents it is estimated that there is no significant flood risk (1:200 year or greater) to any of the three properties that may be built on the proposed development site, particularly if the proposed development does not include any additional development <3m above the level of the burn bank top: it is now likely that the northernmost proposed property on the site will have its levels uplifted to be a minimum of 3.5m above the bank top level of the burn due to changes in land levels across the site, and that the section of driveway near the property will also be uplifted to counter any potential for flooding. At <1km², the upper catchment of the burn is very small and passes through young woodland and rank grassland, all of which attenuate rates of run-off into the burn (with future predicted interception increasing greatly as the woodland matures), low lying marshy grassland and then a culvert built through a 5m high and wide earth bund that will serve as a pinch point upstream of the site, so that any potentially significant floodwaters that could arise would be held back in the extensive marshy area due to the bottleneck that the culvert creates. In addition, the potential for future predicted flooding will be reduced as the woodland area upstream matures and so serves to attenuate rates of run-off much further.

A major blockage of the watercourse above Culvert 1or 2 would simply result in water entering the marshy grassland area. Above Culvert 1.

A blockage adjacent to the road (Culvert 3 or Culvert 4) would result in pooling of water on the road and into the entrance driveway of the site but levels indicate that water would drain away southeastwards beyond the site due to topography if flood conditions persisted rather than flooding the proposed dwellings. Blockage at Culvert 4 may result in some backing up of water up the drainage network from outfall to the proposed development area, although the changes in ground levels (rise to site) should mean that this is very limited in potential. Location of gully pots etc. should still bear this possibility in mind in the final design.

Historically, there are no records of catastrophic flood events in Standburn during the last 20 years, and given the burn location, topography, and normal flow levels it is predicted that the potential for flooding in the future will not increase substantially.

Note: This assessment is based on the information available at the time of reporting in the form of SEPA data, topographical information, historical data, perceived normal maximum levels of run-off, and site levels, and the author accepts no liability for any developmental issues regarding present or future use of the study area (including ecological and environmental). No hydraulic modelling was performed as part of this assessment due to budgetary constraints prior to planning approval.

Note: The proposed development area was previously used for housing (approximately 70 dwellings), and the drainage system still exists. At present it is intended to tie in the stormwater drainage for the three houses into the existing stormwater system given that the original drainage network served approximately 70 properties, and is still considered to be in working order by the architect and engineers on this project. In addition, it is also proposed to create a Sustainable Urban Drainage System for the development, for which an initial design has been provided by WMA Civil Engineers utilising filter trenches and flow control manholes within the developmental area (see Figures 3 & 4 for locations and full details of the specifications of manholes, filter trenches, road gullies etc.), and tying in with the existing surface water drainage system in the site remaining from the previous development. This has been assessed by the engineers and TBB Architects as being suitable for use based on pipe diameter and condition of the system although the finalised design for this scheme will require approval from the Local Authority. Full details of the drainage schematics will be issued separately by WMA to the client for submission to the Local Authority as large scale hard copies.

Figure 1. Site and watercourse location

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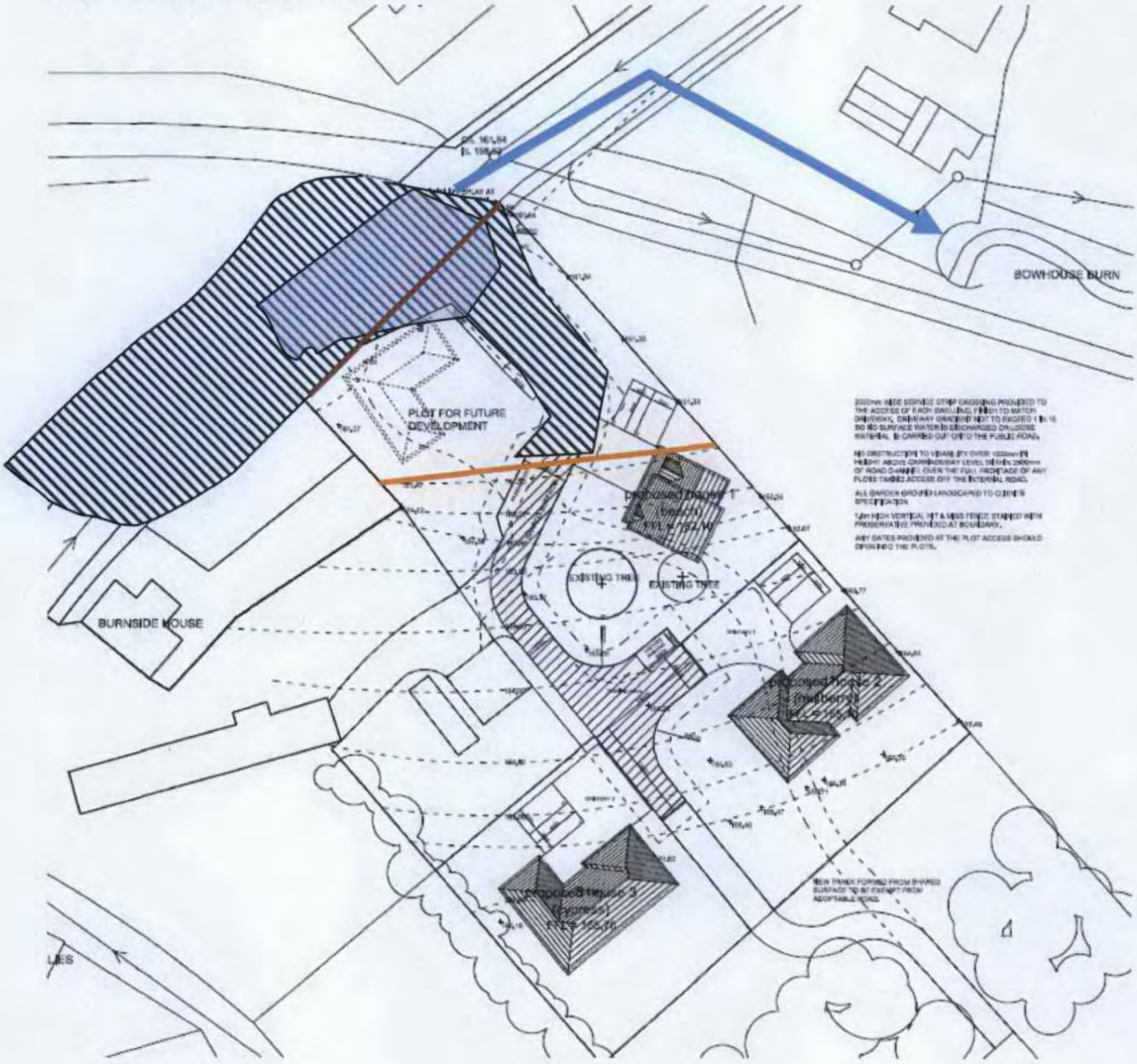
Key

Indicative site boundary

Indicative route of burn pre- and post- development (culverted section indicated by dotted line), and arrowhead indicating direction of flow at both low and storm levels.

1-4 Culvert locations – see text for details.

Figure 2. Site topographical levels



Key

Level 1.5m above burn

Level 2.5m above burn

Approximate area subject to temporary storm flooding due to blocked road drain during 2008.

Area assessed as being at risk of flood due to levels

Direction of flow of floodwater

Figures 3. & 4. Are provided as electronic copies on CD-ROM accompanying hard copies of this report. They are also available from WMA, Consulting Civil & Structural Engineers, Station Masters Office, Dalmeny Station, Station Road, South Queensferry, Edinburgh, EH30 9JP, E-mail: office@wma-sq.co.uk

Figure 3. WMA: Road and Drainage Layout and Notes

Figure 4. WMA: Road and Drainage details

STANDBURN VILLAGE
FLOOD RISK ASSESSMENT – LEVEL 3

ISSUE DATE: AUGUST 2010

AUTHORS: MANUELA TOTH CENG MCIWEM & PAUL BAKER PHD, MIEEM

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Appendices

1. INTRODUCTION

Acorna Associates Ltd. was commissioned to carry out a flood risk assessment for the proposed development at Standburn Village, Falkirk.

This project constitutes a continuation of the flood risk appraisal submitted by Acorna Associates Ltd. in December 2009 and takes regard to feedback received from Falkirk Council.

The scope of this report includes:

- A review of topographic information including a field survey to obtain exact section measurements of the channel and culverts;
- An estimation of flood flows (100 and 200 year return period event flows including climate change);
- Burn modelling using mathematical river modelling software;
- An estimation of the capacities of culverts and the channel in the vicinity of the site;
- Assessment of flood levels; and
- Assessment of flood flow pathways, during complete blockage of the culvert at the site.

The following relevant information was made available for the study:

- Acorna Associates Ltd.: Flood Risk Appraisal, December 2009;
- Letter from SEPA dated 8 January 2010;
- Email correspondence by Falkirk Council commenting on the updated Flood Risk Appraisal by Acorna Associated Ltd., undated; and
- Proposed site plan by TBB Architecture including topographic data, Drawing No.4859/01.A, July 2009.

2. SITE DESCRIPTION

2.1 LOCATION

The site is located at Standburn, near Falkirk, at NGR NS 927 746. It is fringed by the B825 to the northwest, existing housing to the southwest, fields and scrub to the east and south.

2.2 SITE CHARACTERISTICS

The proposed site is brownfield and was previously occupied by housing but currently consists of a mix of hard standing, gravel track and developing scrub. It is understood that the drainage system for this historic housing development still exists.

The total area of the site is in the order of 1 hectare.

The site has a standard annual average rainfall (SAAR) of about 980 mm (source: FEH CD-ROM). This is below average rainfall for Scotland (average 1400mm) but about average for the UK (average 1000mm).

The topography of the site falls in a general south to north direction, towards the B825 road. The highest point of the site is at approximately 166m AOD and the lowest point at 161m AOD.

A ground investigation report was not available to this study.

2.3 PROPOSED DEVELOPMENT

It is proposed to build three dwelling houses adjacent to existing housing with associated access track and garden areas. The site also includes an area marked on schematics as a "*Plot for future development*".

The lowest lying house proposed as part of the submitted development has a First Floor Level (FFL) of 161.0 mAOD, and is located at an elevation of approximately 161.4mAOD.

3. SUMMARY OF PREVIOUS REPORTING

Reporting thus far has highlighted the proximity of the Bowhouse Burn to the site which flows through two culverted sections (C2 and C3) within Standburn.

The Bowhouse Burn is located to the north and east of the site, outwith the site boundary. At its closest point to the site it flows through a culvert (C3) underneath the B825.

The burn has a catchment area of less than 1km^2 in the vicinity of the proposed development site. It is a tributary to the River Avon, and has a catchment of about 4km^2 at its confluence. The catchment is rural in character with fairly low permeability soils (SPRHOST 50%) and no lochs. Flood response would hence be expected to be flashy.

Flows in the burn are not monitored. The closed SEPA gauging site is on the River Avon at Polmonthill (Station Id 17005), which is too far away and covers a too large catchment (195km^2) to be of relevance to the site.

It is understood that flood water levels have not been known to exceed the bank top during the past 20 years. The website 'Chronology of British Hydrological Events' (http://www.dundee.ac.uk/geography/cbhe/) does not list any flooding incidents at Standburn. It is understood that flooding of the road adjacent to the site occurred in 2008, caused by a blocked stormwater drain gully.

Reporting by Acorna Associates Ltd concluded that there is no significant flood risk (1:200 year or greater) to any of the three proposed properties with thresholds at least 3m above bank level of the burn.

SEPA did not highlight any objections to building on this site based on flood risk grounds, but requested that one level of runoff treatment shall be provided using SuDS (Sustainable urban Drainage Systems).

Falkirk Council requested the flood risk study to provide some more detail in relation to the culverts. Thus this report is providing an assessment of culvert capacities and flow pathways should culverts become blocked. Although some sketches were already provided in the previous reporting the Council requested further mapping for visual presentation.

4. DESIGN FLOW ESTIMATION

Design flood peaks for a range of return periods have been estimated using the FSR/FEH rainfall-runoff, ReFH and IH124 methods. Catchment parameters were used from the nearest catchment in the FEH CD-ROM, the catchment area was obtained from Ordnance Survey (OS) mapped information. An allowance for climate change up to the 2080s time horizon of 20% was added to the 200-year design peak flow.

SEPA does not advocate the revitalised FSR/FEH method for use in Scotland. However, the method has been used here for comparison purposes. Appendix A provides audit trails of the calculations.

Table 1: Estimated catchment flows

Catchment Parameters	
Nat Grid Ref	NS 92650 74700
Area (km^2)	0.5
SAAR (mm)	977
BFIHOST (-)	0.305
SPRHOST (%)	49.98
Rain Duration (hour)	4.25 FEH / 2.25 ReFH

Method:	**FSR/FEH**	**ReFH**	**IH124**
Return Period (years)	Peak Flow (m^3/sec)		
2	**0.4**	0.4	0.4
10	**0.7**	0.6	0.6
25	**0.8**	0.7	0.7
50	**0.9**	0.8	0.9
100	**1.1**	1.0	1.1
200	**1.3**	1.1	1.2
200 + climate change	**1.5**	1.3	1.5

Encouragingly the three methods result in similar design flood peak estimates. The FSR/FEH method will be taken forward in calculations.

5. RIVER MODELLING

5.1 MODEL SETUP

The model was set up in Hec-Ras mathematical river software.

Six channel cross-sections were surveyed. Further sections added to the model were interpolated from the surveyed ones. Two culverts (C2 and C3) were included into the model. A model schematic is provided in Appendix B.

Prior to entering culvert C2 the Bowhouse Burn flows through a heavily vegetated wetland area. The storage and attenuation effects such a wetland affords were not explicitly modelled – however the wetland has significance when interpreting modelling results. Through this wetland a 0.5m wide, small tributary/drain joins the burn from the south. An upstream flow split was not included into the model as the area of interest lies downstream of this confluence.

There are three culverts of significance to the flood risk modelling. Culvert C1 is located some 200m upstream of the village, crossing underneath a farm track. The model starts at the downstream end of this culvert. Culvert C1 was not explicitly included in the model. However, measurements were taken during a site survey in order to ascertain its capacity in comparison with culvert C2 and C3.

River sections were taken at the upstream and downstream ends of culverts C2 and C3. A final section was taken some 70m downstream of culvert C3. The model was extended by a further 100m by interpolation, in order to reduce any potential downstream model boundary effects on the area of interest.

The burn is generally of average steepness, with a total gradient between the surveyed upstream and downstream sections of 0.02 (approximately 1 in 50). However, the gradient is not homogeneous along the reach, being rather stepped in character, essentially flattening through each culvert.

Roughness coefficients in the model (Manning's n) were set at 0.035 in-stream, and were increased to 0.45 for out of bank flows on the flood plain and decreased to 0.02 through culverts and at walls.

Appendix C provides photographs and survey information of the three culverts.

The upstream boundary condition is a constant flow and the downstream boundary normal depth. The model was run in a steady state mode.

Because both modelled culverts have different dimensions at inlet and outlet some sensitivity tests were carried out to ascertain the most reasonable set up of the culverts within the model (see Appendix E).

It is noted, that throughout the modelled flow range Froude numbers stayed below 1 indicating subcritical flow.

5.2 *CULVERT CAPACITY*

Table 2 summarises the dimensions of the culverts (see also Appendix C):

Table 2: Estimated catchment flows

	Shape	Width (m)	Rise (m)	Gradient	Invert (mAOD)	Approx. Length (m)
Culvert 1 – outlet	arch	0.92	1.05	0.0625	163.52	25
Culvert 2 – inlet	arch	1.08	1.00	0.0375	160.1	74
Culvert 2 – outlet	arch	1.07	0.80	0	160.2	
Culvert 3 – inlet	box	1.75	0.87	0	159.2	76
Culvert 3 - outlet	arch	1.05	1.20	0.0375	158.55	

The culvert capacity was calculated using the mathematical river model. Both culverts C2 and C3 operate under outlet control.

The culvert capacity for C2, without causing back up of flows, was found to be approximately 0.9 m^3/s, corresponding to a return period of about 1 in 50 years.

The culvert capacity for C3, without causing back up of flows, was found to be approximately 1.3 m^3/s, corresponding to a return period of about 1 in 200 years.

It follows that culvert **C2 poses a constriction to flows reaching culvert C3**.

The culvert capacity for C1 was not separately calculated. It is reasoned that culvert C1 does not pose a constriction to flood flows up to 200 year return period upstream due to the facts that:

a) it is of similar dimension as the other two culverts and hence of similar capacity; and

b) it is located upstream of the wetland tributary, which is estimated to cater for approximately 25% of catchment flows of the Bowhouse Burn at Standburn, and thus this culvert will receive notably lower flood flow peaks.

5.3 *CHANNEL CAPACITY*

Using design peak flows up to the 200 year plus climate change event (Table 1), the channel capacity was only reached at modelled section 90. Bankfull is reached at between 2 – 5 year return period flows. (Note, as a rule of thumb, bankfull of a natural channel is considered to be close to QMED – the median flood, which equates to a 2 year return period flow.)

Section 90 is located upstream of culvert C2 within the wetland. The result indicates that **the wetland will take on flood storage and attenuation function** from return period flows as low as 5 – 10 years.

5.4 *ESTIMATED FLOOD EXTENT*

From culvert capacity considerations it becomes clear that during the design events (200 year and 200 year plus climate change) a significant proportion of the design peak flow will not flow through culvert C2, instead backing up of flows will occur, leading to spillage into the wetland, where processes such as storage, attenuation, ground infiltration and evaporation will take place. As such culvert C2 affords an informal flood protection to Standburn, akin to purpose built upstream flood storage schemes.

It shall be noted that the extent of the wetland sections was clipped at either end, in order to keep modelled cross-section width homogeneous. Adding a section with a very wide flood bank would not be realistic within a steady state model. In fact, in order to capture the flood storage and attenuation caused by the wetland, i.e. caused by the wide low lying out-of-bank corridor to the south of the channel, would require an dynamic modelling approach using flood storage cells within the model as a 2D (two dimensional approach) or a specific 3D approach. As such results given by the steady state model are to be considered as rather conservative.

Although it is hence concluded that during a 200-year design flood event flows downstream of culvert C2 will be closer to the capacity of $0.9m^3/s$ (1 in 50 year return period) than to reach the estimated peak of $1.3m^3/s$ (1 in 200 year return period), results will be presented for the latter. This is a rather conservative approach. Table 3 lists the corresponding modelled water levels. As in this instance we are looking at future/as-built levels a typical freeboard[1] of 0.5m is applied.

Table 3: Modelled water levels

				Design peak flow: $0.9m^3/s$	
Section	**Location**	**Bank level (mAOD)**	**Type of bank**	**Water level (mAOD)**	**Water level plus freeboard (mAOD)**
90	Upstream of C3	160.88	wetland	161.24	161.7
70	**Downstream of C3**	**162.43**	**wall**	**160.50**	**161.0**
40	**Upstream of C2**	**160.92**	**wall**	**159.98**	**160.5**
20	Downstream of C2	158.92		158.77	159.3

[1] *In order to determine the flood threshold levels a freeboard allowance should be made. Freeboard is defined in the Environment Agency's Fluvial Freeboard Guidance Note as follows:*

> *'Freeboard is an allowance to take account of:*
>
> *Physical processes that affect the defence level, that have not been allowed for in the design water level; (this includes scour, waves, settlement)*
>
> *Adverse uncertainty in the prediction of physical processes that affect the defence level.' (this includes accuracy of the hydrological analysis, hydraulic modelling, hydraulic and topographic data, etc)*

				Design peak flow: 1.3m³/s		Design peak flow: 1.5m³/s	
Section	**Location**	**Bank level (mAOD)**	**Type of bank**	**Water level (mAOD)**	**Water level plus freeboard (mAOD)**	**Water level (mAOD**	**Water level plus freeboard (mAOD)**
90	Upstream of C3	160.88	wetland	161.87	162.4	162.29	162.8
70	**Downstream of C3**	**162.43**	**wall**	**160.58**	**161.1**	**160.62**	**161.1**
40	**Upstream of C2**	**160.92**	**wall**	**160.27**	**160.8**	**160.49**	**161.0**
20	Downstream of C2	158.92		158.82	159.3	158.85	159.4

It is noted that water could escape from the Bowhouse Burn at the downstream end of culvert C2 (section 70), were the wall commences (see Plate 2b). This gap around the wall is at an elevation of 161.0mAOD. Water would then flow towards a low point (depression) in the road at 160.6mAOD a short distance to the west of the site boundary – approximately on a line on the B825 halfway between culverts C2 and C3. However this scenario would potentially only be the case during a 1 in 200 year event and has been modelled to be in the order of 10cm.

The lowest point at the entrance to the development is at 160.99mAOD (at NGR NS92734 74739 –confirmed during site visit). As such the development site is at the edge of the rather conservatively modelled flood extent including freeboard. The lowest lying proposed house is located at an elevation of approximately 161.4mAOD, *House 1* with a FFL of 162.1mAOD, and is well above the conservatively modelled flood levels.

In reality flood levels will be much lower due to the restriction of flows through culvert C2 and upstream storage and attenuation within a wetland. As such it is considered that water levels during the 200 year event will be rather in the order of the 1 in 50 year event. Hence the development site lies completely outside the high risk flood corridor, and it is more likely that the water will not leave the watercourse. This means that the *Plot for future development* with a min FFL of 161.0mAOD also lies outwith the high risk flood zone.

5.5 ESTIMATED FLOOD PATHWAYS DURING CULVERT BLOCKAGE

The council also requested consideration be given to the scenario that either culvert should completely become blocked. For this purpose flow low-points and flow pathways were examined during a site visit.

It is noted that culvert blockage events cannot be given a return period and are typically thought to be rather extreme / unlikely scenarios, in particularly the case when considering complete blockage. However, it is prudent to consider flow pathways for emergencies.

Should culvert C2 become fully blocked flows will back up into the upstream wetland and spread out. It is thought unlikely that flows would reach Standburn or the B825 road, as an approximately 5m high embankment is located above culvert C2 (see schematic of Appendix B),which would prevent flows in an easterly direction.

Should culvert C3 become fully blocked flows could top out from Bowhouse Burn at the downstream end of culvert C2 should storage within the reach between C2 and C3 be exceeded (at an elevation of 161.0mAOD as described above). The left hand (northern) bank of the Bowhouse Burn rises steadily and flood waters would preferentially spill to the lower right bank. The right hand bank is protected by a wall adjacent to the B825 road (see Plate

5), between heights of 162.4mAOD at culvert C2 to 160.9mAOD at culvert C3, apart from a low point where the wall commences (see Plate 2b).

Water would then flow towards a low point (depression) in the road at 160.6mAOD a short distance to the west of the site boundary. Continued spillage of water towards this low point could potentially reach into the development site and spread over the western corner, eventually reaching a level at around 161.3mAOD, that would allow flows to pass in an easterly direction across the site, but not reaching any of the presently proposed new houses.

This could have access implication to the site, and flooding around the "*Plot for future development*", and should be given consideration for emergency procedures. For instance it may be prudent to design elevations and/or the drainage pattern of the access road and "*Plot for future development*" in such a way to allow these potential extreme flood waters to swiftly drain in a westerly direction rather than providing a block and exacerbating the depth of water within the flooded depression. The plot is not part of the current planning submission and these comments are merely made to make the developer aware that a future planning proposal for that area may actually be a costly and ill advised exercise.

6. CONCLUSION AND RECOMMENDATIONS

1. The proposed development site lies outwith the high risk (1 in 200 year) flood corridor.
2. Culvert C2 poses a constriction to flood flows. The upstream located wetland will provide flood storage and attenuation from flood flows as low as 1 in 5 year return period. As a consequence downstream flows will be reduced.
3. No additional flood risk would emanate from a blockage of culvert C2, as flows would spill into the upstream wetland.
4. Should culvert C3 become blocked, there is a risk that water could exit the Bowhouse Burn and collect in a depression in the B825 road a short distance to the west of the development site. Continued spillage could potentially reach into the development site and eventually flow in a westward direction across the proposed access track at an elevation of approximately 161.3mAOD. It is recommended to give this potential extreme flow pathway consideration when designing the access track and landscaping of the area indicated as the "*Plot for future development*". Proposed new housing is located at an elevation above 161.4mAOD and hence is located outwith the potential extreme flood flow pathway.

Appendix A:
Flow estimation audit trails

FILE=4BE2.dat ISIS VER= 6.1.0.36
****
ISIS
****

HYDROLOGICAL DATA

Catchment: Standb_FEH
****
Catchment Characteristics
****
Easting : 292650 Northing : 674700
Area : 0.500 km2
DPLBAR : 1.310 km
DPSBAR : 43.400 m/km
PROPWET : 0.580
SAAR : 977.000 mm
Urban Extent : 0.000
c : -0.017
d1 : 0.438
d2 : 0.459
d3 : 0.312
e : 0.244
f : 2.275
SPR : 49.980 %
****
Summary of estimate using Flood Estimation Handbook rainfall-runoff method
****
Estimation of T-year flood
==========================
Unit hydrograph time to peak : 2.166 hours
Instantaneous UH time to peak : 2.041 hours
Data interval : 0.250 hours
Design storm duration : 4.250 hours
Critical storm duration : 4.283 hours
Return period for design flood : 200.000 years
requires rain return period : 246.667 years
ARF : 0.982
Design storm depth : 60.236 mm
CWI : 123.770
Standard Percentage Runoff : 49.980 %
Percentage runoff : 53.367 %
Snowmelt rate : 0.000 mm/day
Unit hydrograph peak : 0.051 (m3/s/mm)
Quick response hydrograph peak : 1.237 m3/s
Baseflow : 0.014 m3/s
Baseflow adjustment : 0.000 m3/s
Hydrograph peak : 1.252 m3/s
Hydrograph adjustment factor : 1.000

Flags
=====
Unit hydrograph flag : FSRUH
Tp flag : FEHTP
Event rainfall flag : FEHER
Rainfall profile flag : WINRP
Percentage Runoff flag : FEHPR
Baseflow flag : F16BF
CWI flag : FSRCW
****

FILE=9BCC.dat ISIS VER= 6.1.0.36
****
ISIS
****

HYDROLOGICAL DATA

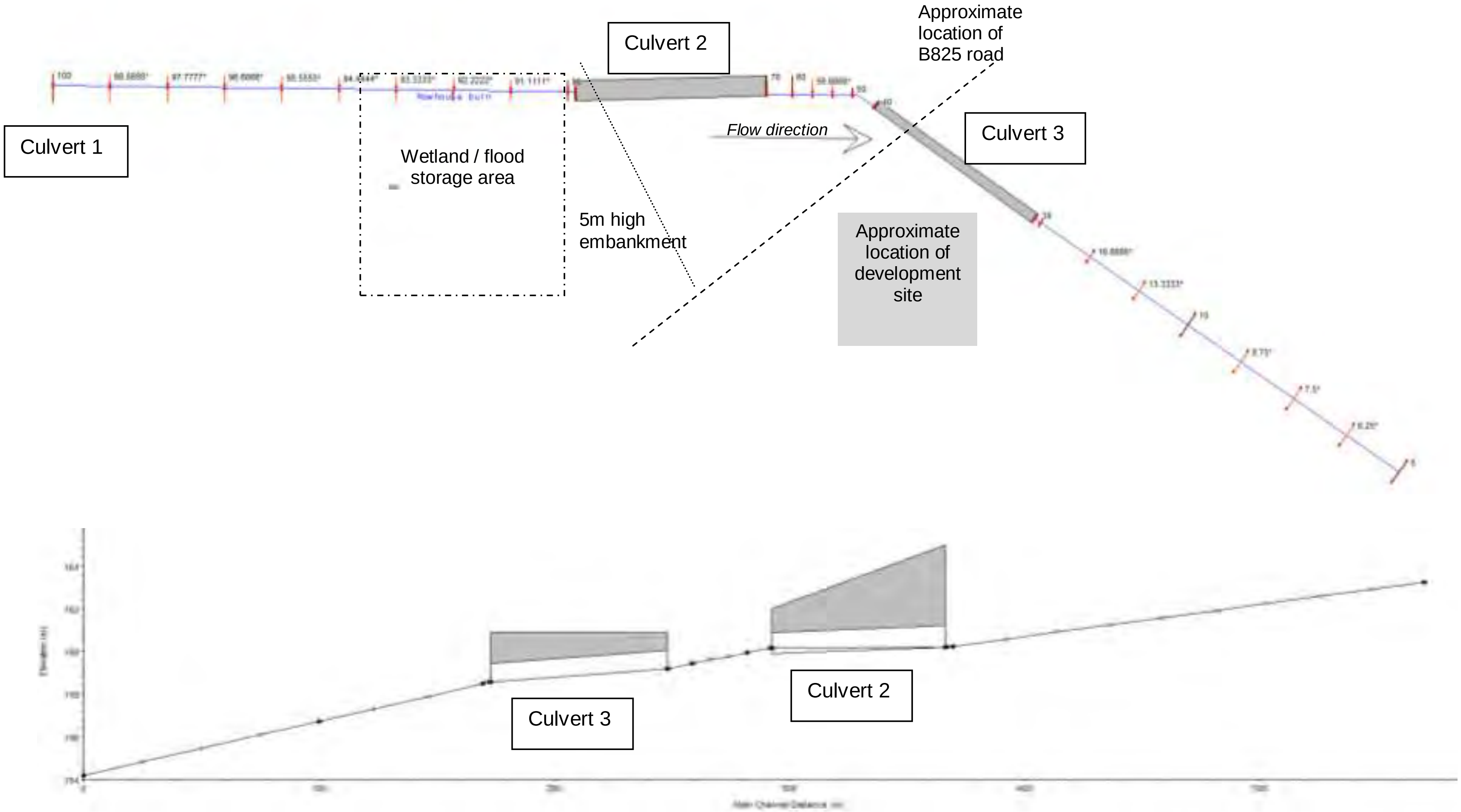
Catchment: Stadnb_FSR
****
Catchment Characteristics
****
Easting : 292650 Northing : 674700
Area : 0.500 km2
DPLBAR : 1.310 km
DPSBAR : 43.400 m/km
PROPWET : 0.580
BFIHOST : 0.305
SAAR : 977.000 mm
Urban Extent : 0.000
c : -0.017
d1 : 0.438
d2 : 0.459
d3 : 0.312
e : 0.244
f : 2.275
****
Summary of estimate using Revitalised Flood Hydrograph rainfall-runoff model
Calculations from ReFH software computational engine, v1.4.0003
ReFH © Wallingford HydroSolutions or CEH (NERC) 2007
****
Estimation of T-year flood
==========================
Season : WINTER
(Seasonality determined by URBEXT = 0.000)
==
Rainfall
==
Event rainfall flag : DESIGN
Rainfall profile flag : DESIGN
Flood return period : 200.000 years
Data interval : 0.250 hours
Design storm duration : 2.250 hours
Critical storm duration : 2.289 hours
ARF flag : ReFH Design Standard
Areal reduction factor (ARF) : 0.977
SCF flag : ReFH Design Standard
Seasonal correction factor : 0.702
DDF storm depth : 46.943 mm
Design storm depth : 32.221 mm
Peak rainfall [design] : 8.763 mm
==
Loss model
==
Cmax flag : Catchment descriptors
Cmax donor correction factor : 1.000
Cmax value : 220.210
Cini flag : ReFH Design Standard
Cini value : 127.402
alpha_T flag : ReFH Design Standard
alpha_T value : 0.791
Maximum runoff : 60.2%
Minimum runoff : 46.0%
==
Routing model
==
Time-to-peak (Tp) flag : Catchment descriptors
Tp donor correction factor : 1.000
Instantaneous UH time to peak : 1.158 hours
Up flag : ReFH Design Standard
Dimensionless UH peak : 0.650
Uk flag : ReFH Design Standard
Uk value used : 0.800
Dimensionless UH kink ordinate : 0.270
UH ordinate multiplier : 0.120
Unit hydrograph kink abscissa : 2.316 hours
Unit hydrograph time base : 4.164 hours
==
Baseflow model
==
Baseflow lag (BL) flag : Catchment descriptors
BL donor correction factor : 1.000
BL value : 20.590
Baseflow recharge (BR) flag : Catchment descriptors
BR donor correction factor : 1.000
BR value : 0.855
Initial Baseflow (BF0) flag : ReFH Design Standard
BF0 value : 0.029
Maximum Baseflow : 0.110 m3/s
==
Output summary
==

Direct runoff hydrograph peak : 1.031 m3/s
Minimum allowable flow : 0.000 m3/s
Total flow hydrograph peak : 1.096 m3/s
Hydrograph scaling factor : 1.000

****

Appendix B:
Model schematic

Model schematic



Appendix C:
Plates