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FLOOD RISK ASSESSMENT

ON

Dean Bottom Mills
Storthes Hall Bridge
High Burton
Huddersfield
West Yorkshire

FOR

Mr Boothroyd
David Storrie Planning

E13/5884/FRA002

July 2016

T. Haigh B.Sc., C.Eng., M.I.C.E.

1.0 INTRODUCTION

1.1 This report is commissioned to investigate and report on the Flood Risk for this site in accordance NPPG 2012 and the proposals for drainage of this site when redeveloped as residential land. The report is based on information supplied by the client and from relevant authorities in both written and verbal format. Some of this information is in verbal form only. No liability can be accepted for information supplied by third parties which is subsequently found to be inaccurate or incorrect.

2.0 THE SITE

2.1 The site is located of Storthes Hall Lane, Highburton, Huddersfield, West Yorkshire and is situated around Ordnance Survey grid reference 413300,418900. A site location plan is shown on Figure 1 in Appendix A

2.2 The site is roughly rectangular in nature and situated on the outskirts of a residential area. There are a few residential properties to the south of the site and industrial properties to the north, east and west. To the south, west and north beyond the immediate development is open pasture land. Beyond the properties to the east there is Highburton which is a small village. The site area is approximately 0.3ha.

2.3 The site is former industrial works and is predominantly covered buildings and hard paved areas. There are some areas covered with unbound stone and scalpings to form car parks. There are no readily permeable areas visible on site. The properties fronts onto Storthes Hall Lane with a single storey lock up garage and other mill buildings to the rear of the site. The access to the residential properties at the rear of the site forms the western boundary and Thunder Bridge Dike forms the eastern boundary. There is sporadic/substantial tree and shrub growth adjacent to site boundaries in the northern section and a large number of trees on the eastern bank of the watercourse.

2.4 There appears to be existing discharges to the watercourse from the site with rainwater pipes and drains discharging direct to the watercourse evident.

2.5 The site is generally flat with a slight dip in the central area of the site. The site generally falls from a high point of 95.8m AOD in the north east to 95.08 in the middle of the site. The site slopes from both north and south to a central low point at an average gradient of approximately 1 in 80. The land to the north falls to wards the site to form a shallow valley between the land and the site. The land to the east of the site rises steeply away from the watercourse to over 10m above the site level. The access road into the site and to adjacent properties is around the 95.3m AOD level.

3.0 PROPOSED DEVELOPMENT

3.1 The proposed development is for conversion of existing industrial buildings to residential development utilising the same buildings or footprint as previous. It is envisaged the whole development could amount to approx. 8 terraced units and one detached house with associated roads and car parking areas.

3.2 The site has been previously developed and examination of the historic plans shows the site has been developed for industrial uses for over 80 years.

4.0 PROPOSED SURFACE WATER DRAINAGE

4.1 In the first instance the use of soakaways and infiltration systems should be investigated and if these appear to be suitable based on the infiltration tests then alternative systems then they should be utilised. The site has previously been developed with un-attenuated surface water run off from the impermeable areas on site which covers approx. 95% of the site. Run off from the redeveloped site should be reduced by 30% in accordance with current planning directives and guidance. The site currently does have existing impermeable areas relating roofs or hard paved areas. The current discharge of storm water from the site would appear to be the watercourse to the eastern boundary of the site. The current impermeable area draining to the beck is around 1200sq.m. This would relate to peak annual storm discharge of around 15 lit/s. A 30% reduction in impermeable areas, and hence discharges from the site, can be achieved by using permeable

pavements and providing open garden areas. Further discussions with Yorkshire Water, and Kirklees MBC - Land Drainage Department, and the Environment Agency will be necessary to formerly agree this proposal.

4.2 The proposed drainage system should mimic the existing points of discharge to the watercourse and this would have to be agreed and approved by the Environment Agency, with a right to discharge in perpetuity granted. The EA would /may also need to approve any such discharge rate and water quality.

4.3 If infiltration systems or on-site balancing is utilised then the risk to downstream properties would be negligible in relation to flood water flows in the downstream catchment.

4.5 If the measures outlined above are implemented we would consider that the site can be developed in accordance with current Water Authority and Land Drainage Authority requirements without an increase in the food risk to properties in the downstream catchment.

5.0 FLOOD RISK

5.1 The site currently falls with flood zone 3 as shown on the Environment Agency Websites. The development is classified as More Vulnerable in Table 2 of the Technical Guidance to the National Planning Policy Framework March 2012 and table 3 of that document also states that the proposed residential development is not appropriate.

5.2 Due to the size of the development under 1Ha it will not be necessary to prepare a site Specific Flood risk Assessment for the site.

5.3 There are a number of potential flooding mechanisms that NPPF now requires are evaluated for each proposed development site. Each method of flooding requires an assessment to be made on its probability relative to the site development. The normal requirement of the document is for no flooding of properties for storms up to a 1% probability or a once in a 100 years storm. The risk assessment also includes for flooding both on site and off site, and the effects of the development on the downstream catchment or the flow

regime of the watercourse. NPPF also requires that the effects of severe storms above the normal 1% probability are reviewed together with the effects of climatic change relating to the design life of the development.

5.4 It also requires that the effects of climate change are taken into account together with the impacts of extreme events and flood defence failures. Prior to this the Sequential Test outlined in NPPF, must also be applied to each development site.

5.5 Based on the published Environment Agency Flood Risk Maps the site does fall within the 1% Flood Risk nor the site therefore falls within the high probability zone 3. The proposed residential development falls within the More Vulnerable Classification in Table 02 Technical Guidance to NPPF. The sequential test is not therefore considered passed and development is considered in appropriate in accordance with Table 3 Technical Guidance to NPPF.

5.6 NPPF requires that each flooding mechanism is addressed and levels of risk evaluated. We consider there are three main risks of flooding to the site the alternative mechanisms are not applicable to this site.

5.6.1 Inundation from floodwaters leaving watercourses or rivers entering the site. This can include the effects on culverted watercourses and where the risk of blockage can occur and from breach scenarios.

5.6.2 Rainwater falling on the site and not being able to leave the site at sufficient rate to prevent flooding on the site.

5.6.3 Overland flows from adjacent land sites due to surcharging of sewerage systems or other watercourses.

5.6.4 The impact of the developed site on the existing drainage systems and off-site surface water systems must also be assessed as part of this flood risk assessment.

5.7 Discussion of Flood risks

5.7.1 Flood Risk from Watercourses, River & Tidal

5.7.2 The nearest watercourse shown on the O.S Survey is Thunder Bridge Dike that runs adjacent to the eastern boundary of the site. Thunder Bridge Dike is classed as main river and runs south top north out falling to the River Colne 7km to the north of the site. The site appears to fall within the 1% probability Flood Risk Maps as published by the Environment Agency. The site is therefore considered at risk from fluvial flooding.

5.7.3 The site is generally flat with very slight falls towards the central area. The bank height of the beck adjacent to the site is between 94.8 and 95m. There appears to be a low wall on parts of the bank that may have been installed to prevent flooding in the past. The wall is designated as a privately maintained flood protection measure on the EA plans and is reported to provide a 1 in 20 year protection to the site.

5.7.4 Thunder Bridge Dike has been modelled as part of the Fenay Beck Flood Mapping Study. The results of this show that immediately upstream of the site Ch 7200 the flood water levels for the 100 year storm are 95.577 rising to 95.826 when climatic effects are added. Immediately below the site (ch 7042) at the bridge the levels are 95.288 and 95.613 m respectively. This suggests that the site could be flooded to a depth of 200 to 400mm for the hundred year flood level. This increases to around 800mm when the 1000 year flood event is considered. The current floor levels for Building A (units 1-4) are 95.23m; for building B (units 4-8) are 95.23m and for building C the floor level is 95.60m. the corresponding modelled 100 year floodwater levels for the beck immediately adjacent to these blocks are for Building A (units 1-4) are 95.36m; for Building B (units 4-8) are 95.43m and for Building C the 100 year flood level is 95.50m. When 30% climate change is considered the flood water levels rise for Building A (units 1-4) are 95.67m ; for building B (units 4-8) are 95.72m and for Building C the 100 year flood level is 96.16 m. By raising the existing floor levels in Building A and Building B by 450mm the floor would be above the 100 year plus climate change flood water levels. By raising the existing floor levels in Building C by 200mm it would also be above the 100 year plus climate change flood water levels.

5.7.5 The only way development could proceed on this site would be for the floor levels on the site to be raised above the 100 year flood level. We would suggest that a minimum floor levels are set above the 100 year plus climate change levels for each building as outlined above. This would entail raising the floor levels in parts by around 450mm. since the buildings are existing and are to remain this would not raise issues regarding the displacement of flood water caused by the new development

5.7.6 In order to develop the site the site would need to pass and exceptions test which is predominantly a planning matter and not included in this report.

5.7.7 It should be noted that the footprint of the existing buildings are not considered to be flooded with in zone 3; the surrounding land is considered to be within flood zone 3 and any displacement of the land in these areas to allow development require the need to provide for the volumes of displaced flood water. There is no reason to raise existing levels for the development provided access to the properties can be shown to comply with Building regulations and this could be compensated for by a slight lowering of site levels. The rear garden levels can be lowered to provide this storage. If this is implemented development of the site may be acceptable. The existing bank level would remain to the along the watercourse which will ensure that the rear gardens are not at risk of flooding up to the 1 in 50 year event. A simple 150mm diameter discharge pipe from each garden with a simple flap valve will allow the garden areas to drain down slowly after any flood event but not flood unless the 1 in 20 year storm is experienced.

5.7.8 The site falls inside all recorded flood zones from fluvial sources. The risk of flooding from river or tidal water is therefore considered high for this type of development.

5.7.9 The area of the existing road into the site is shown as falling outside of zone 3 but within zone 2. The road level is close to the 100 year plus climate change flood water levels and will therefore be passable during the 100 year flood event. We would however suggest that the access road in the western area of the site is raised to a minimum level of 95.65m (a rise of approx. 300mm) which means that the site can be accessed even during the 1 in 1000 year

flood event. To ensure there is no displacement of floodwater we would suggest that the access road be built on a storage crate system that will allow a volume equivalent to the built up levels of the road to be provided beneath the road construction whilst still allowing any flood water to the west of the site to pass beneath the new access road. Even when the 1000 year event is considered the site would still be accessible by vehicular traffic. In addition the raised access way will afford a safer access for existing property to the south of the site which also remains within Flood Zone 3.

5.7.10 The possibility of extreme storms up to the 1 in 1000 year and beyond need to be considered. The units would still be at risk for the extreme flood conditions and whilst this is a low risk the possible effects need to be considered. It would therefore be prudent to utilise flood resilient construction within the ground floor areas as an additional measure. Some measure of flood protection could also be utilised. This would entail raised service connections to the ground floor area; Flood resilient finishes to the ground floor area; the use of solid floors or flood sealing vents to suspended floors. This may mean the use of tiled walls, high level electrical sockets and a separate electrical system. The external entrances to the lower ground floor and emergency exits could also incorporate demountable flood barriers to prevent water ingress at that level. This would obviously only be required in extreme events greater than the 1 in 100 year flood event.

5.7.11 The residents will need to subscribe to the flood warning system already operated by the EA to ensure they are aware of any risks to personnel and property due to flooding from the watercourse. Whilst it would not be necessary to evacuate the site up to the 100 year flood event, even with climatic effects included, it would allow garden areas to be cleared of any possible debris.

5.8 Risk of Flooding from overland flows from adjacent land.

5.8.1 The site lies on a very shallow slope open fields to three sides. To the south and east of the site the land is substantially higher than the site. To the north the adjacent development is lower than the site and falls away from the site. The risk of any overland flow is principally from the south and west. The land to the east is higher but any flows will be intercepted by the watercourse and the existing public highway. The threat of overland flows from the west

cannot be discounted due to the topography but the catchment to this side is however limited and would not generate significant overland flows towards the site. There will be an open crate system beneath the new raised access which will allow any overland flows to pass beneath the road and thence across the site without flooding to the dwellings and allow flood waters that may have left the watercourse up stream to pass through the site.

5.8.2 The surrounding area to the east is served by adopted drainage systems and as such the level of risk of flooding from surcharged sewers is considered to be less than 1%.

5.8.3 It would be prudent to ensure there is an overland flood route through the site to cater for extreme storms. We would suggest that ensuring external levels are designed to provide such a route, will effectively reduce this risk to an acceptable level.

5.9 Risk of Flooding from Rainwater Falling on Site

5.9.1 The risk of flooding from water falling on site and not being able to leave is considered to be low due to the topography of the site. These flows would however need to be consider to ensure no surcharging of systems down stream.

5.9.2 Since there will be a 30% reduction in the impermeable area on the site the run offs from the site will be reduced once developed. With this system in place the flows from the site into the surface water systems are considered acceptable particularly in relation to flood water flows in the downstream watercourse.

5.9.3 We therefore consider the effects on flood risk to adjacent properties are not significantly affected by the proposed development provided attenuation of flows takes place.

6.0 CONCLUSIONS

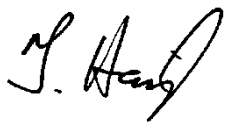
6.1 In our opinion the site is at risk of flooding from river or tidal water up to a 1% return period and it is at risk for storms in excess of the 0.1% risk level. The only way of developing the site would be the raising of floor levels of the existing buildings above the critical flood levels and the provision of compensatory flood water storage for the site where levels are raised on site.

6.2 The development of the site with the use of soakaways or other infiltration methods is to be investigated but is thought to be unlikely due to the infiltration capacity of the underlying strata.

6.3 Discharges would have to be limited to agreed rates of discharge, but currently 95% of the site discharge directly to the beck. Once developed only 70% of the site would be impermeable and as such the proposed discharge rates from the site are reduced to 70% of the current discharge rates.

6.4 By raising the site access road levels the site can be made accessible even during the 1 in 100 year event and also provide a safe access for dwelling beyond the site.

6.5 Raising levels on part of the site would have displaced floodwaters elsewhere. By lowering the garden areas and providing a crate system beneath the raised access road, flood water can still be accommodated on site without the dwelling being flooded and the flood water to the west of the site in the 100 year storm can still cross the site. The scheme will allow the garden areas to remain dry up to the 1 in 50 year event.



T.Haigh B.Sc., C.Eng., M.I.C.E.

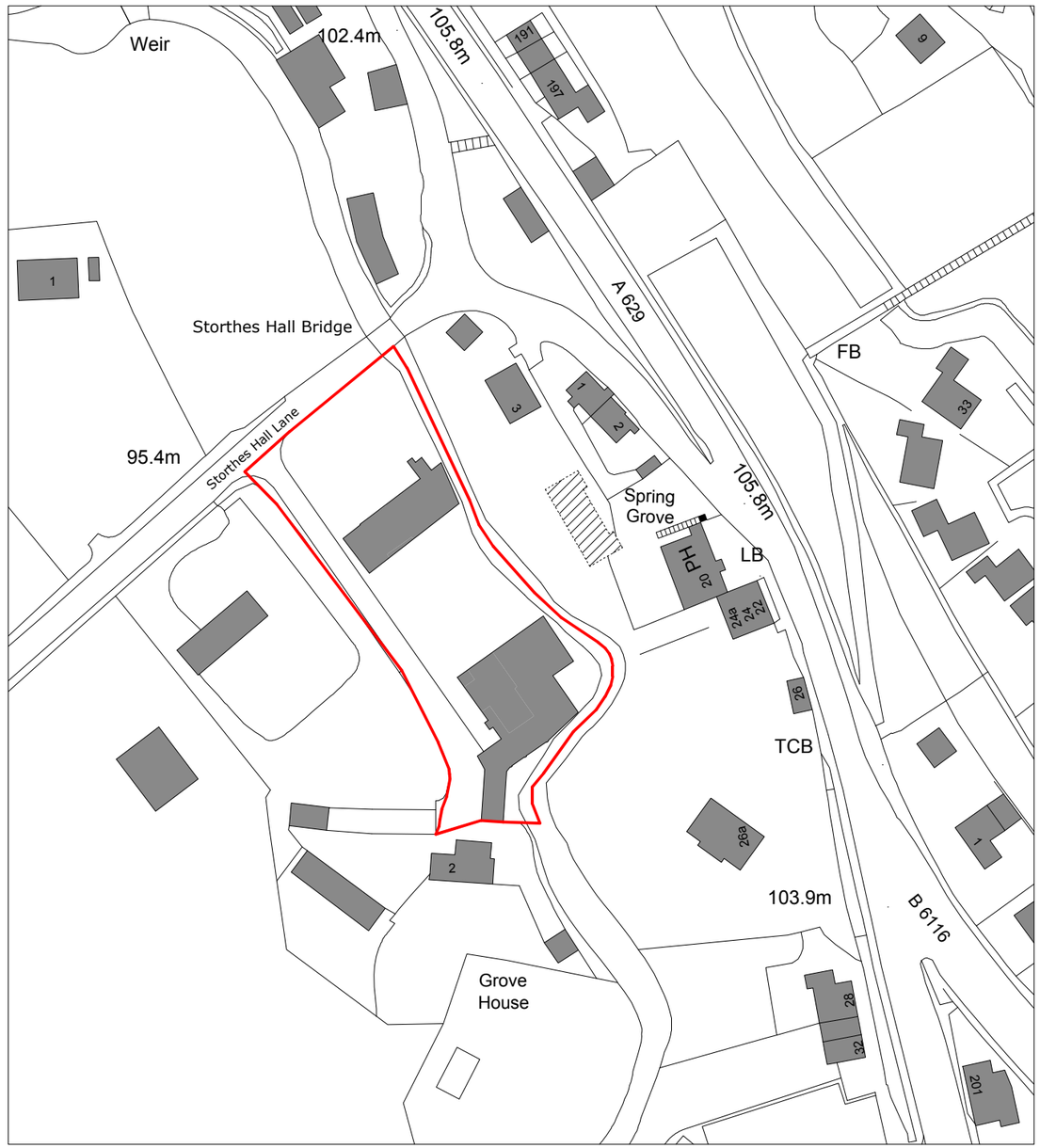
APPENDIX A

LOCATION PLAN

Dene Bottom Works, Storthes Hall Lane, Kirkburton, HD8 0PP

Location nts

Location 1:1250



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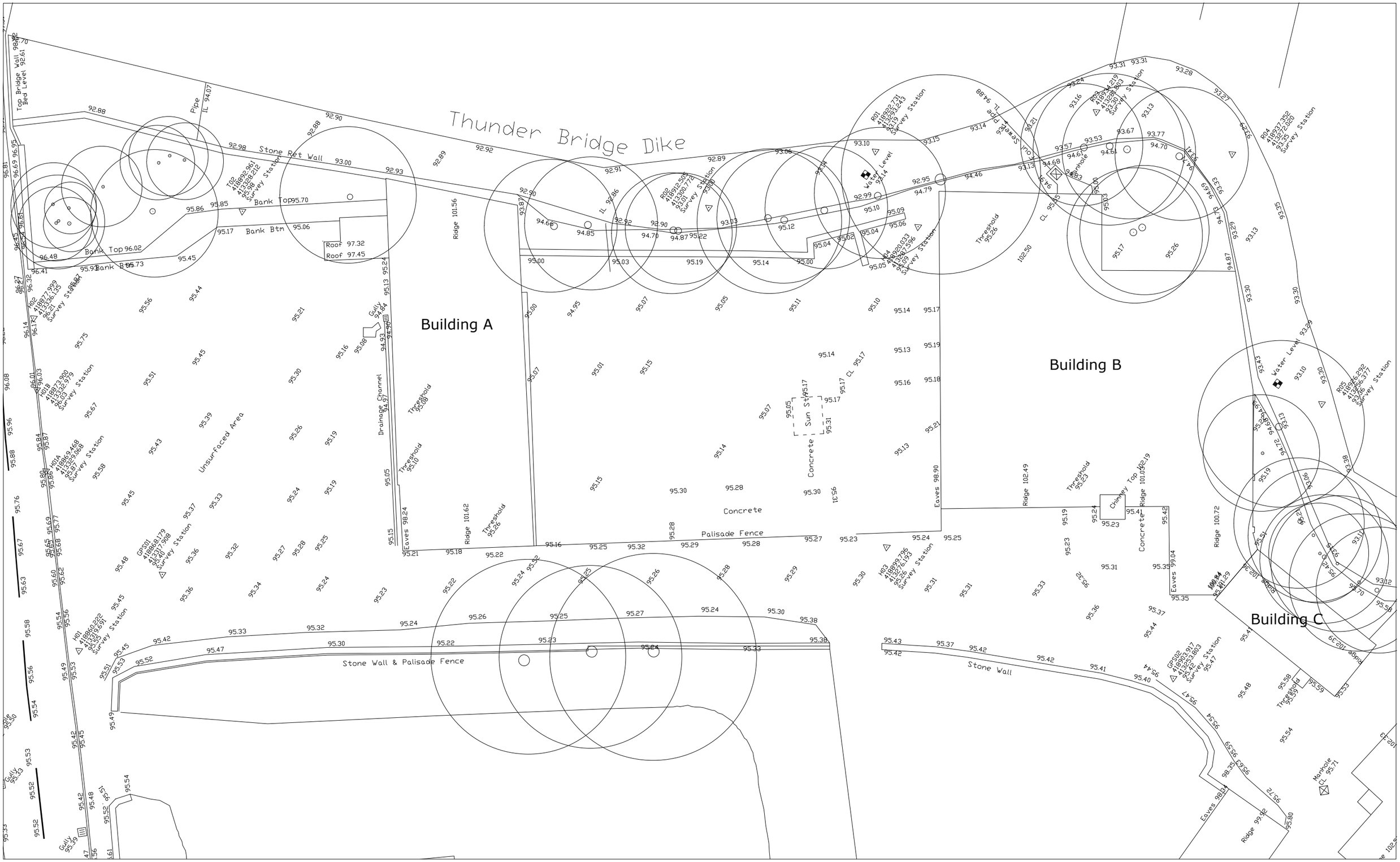
0 10 20 30 40 50 100m

APPENDIX B

SITE SURVEY



0 2 4 6 8 10 20m

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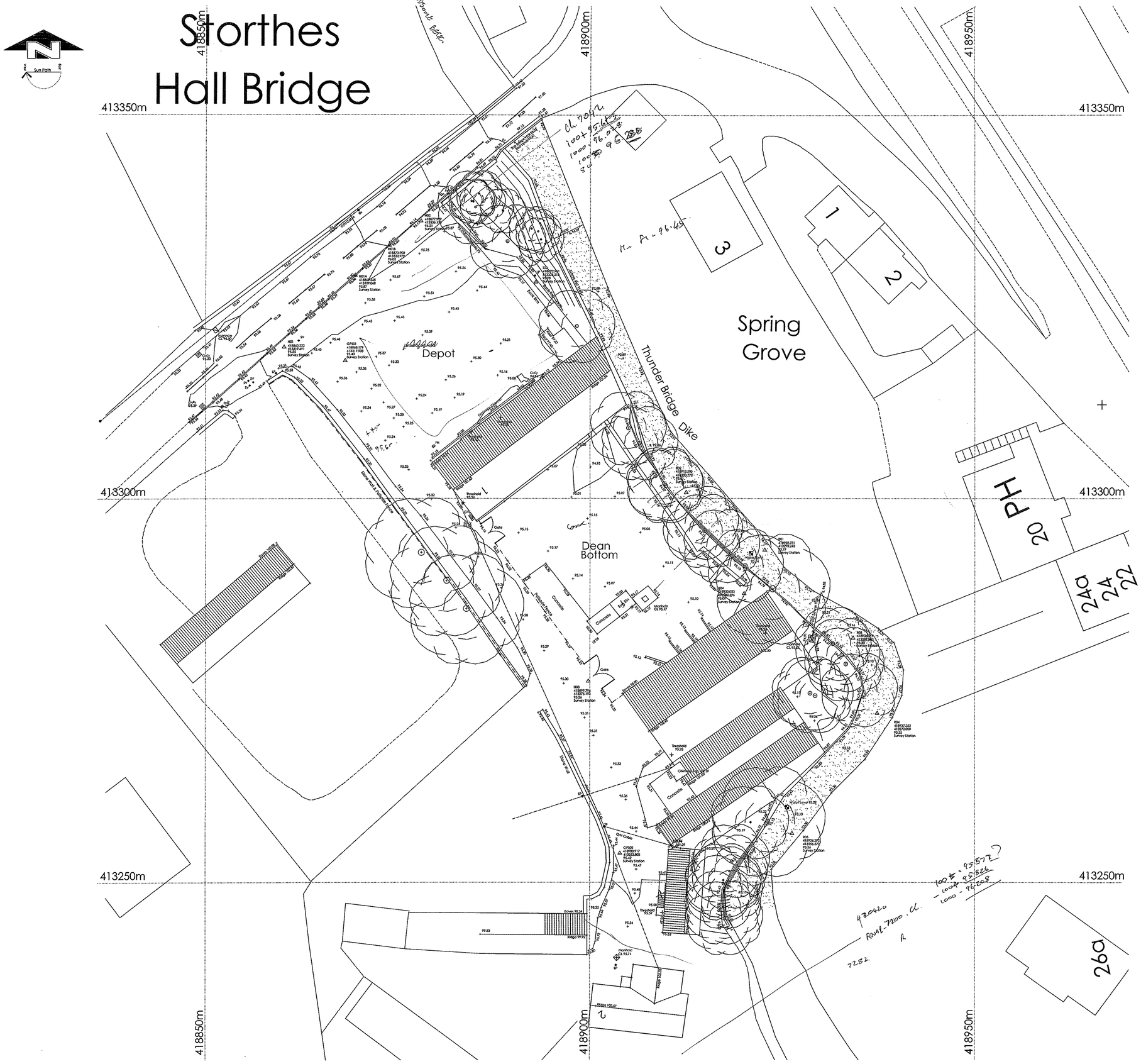
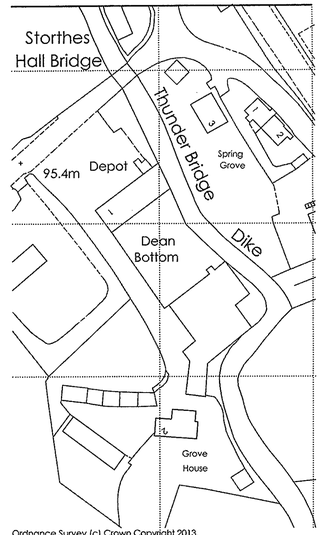
37 Victoria Gardens, Horsforth, Leeds, LS18 4PJ
07881 611195 info@nuton.co.uk

Rev A	Scale 1:250 @ A3		Job no 150018
Title Topographic survey			
Project Dene Bottom Works conversion			
Drawn DN	Date 14/3/16		Drg no p03

Storthes Hall Bridge



Location Plan — Scale 1:1000



Survey Control Co-ordinates

Reference	East	North	Elevation	Description
GPS01	418908.179	413317.906	95.40	Survey Station
GPS02	418903.917	413253.803	95.42	Survey Station
H01	418860.222	413319.691	95.55	Survey Station
H01A	418869.468	413329.068	95.87	Survey Station
H01B	418873.900	413332.979	96.03	Survey Station
H02	418877.997	413336.135	96.21	Survey Station
H03	418899.796	413276.193	95.26	Survey Station
H04	418920.033	413287.595	95.09	Survey Station
R01	418922.731	413293.243	93.19	Survey Station
R02	418912.505	413300.772	93.01	Survey Station
R03	418934.219	413281.803	93.30	Survey Station
R04	418937.352	413272.000	93.30	Survey Station
R05	418928.092	413256.377	93.36	Survey Station

Control & Datum Information

Grid Orientation:
Survey related to Ordnance Survey "OSGB36" at control point GPS01 realtime correction received via Leica Geosystems "Smart Net" service.

Level Datum:
OS Orthometric hts

Rev	Description	By	Date

Surv.	Drawn	Date	Chkd	Date
NH	NH	15.08.13		

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Title. Site Plan

Site. Storthes Hall Road
Kirk Burton
Huddersfield

COMPUTER GENERATED DRAWING - DO NOT ALTER

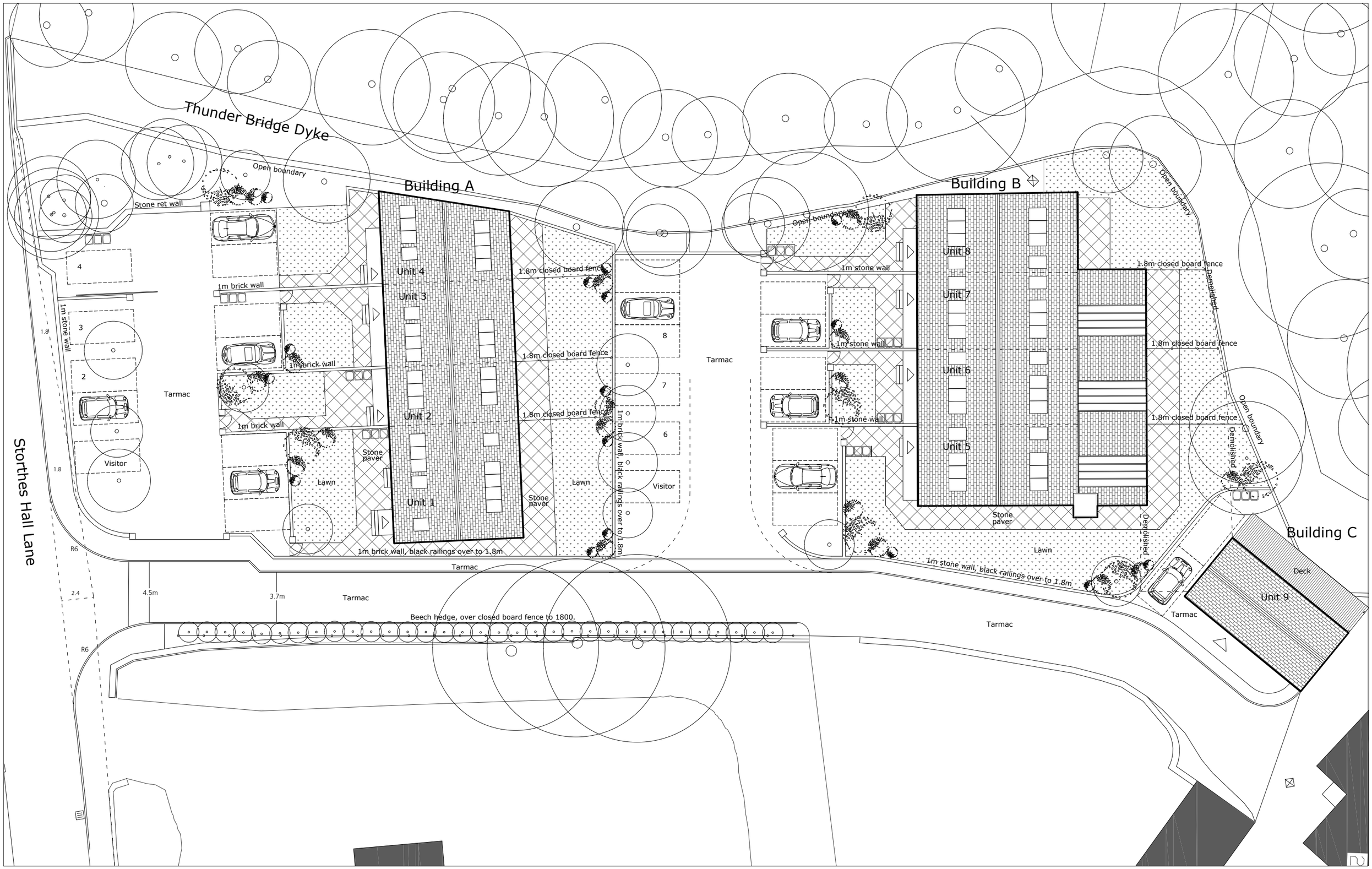
Dwg No. HHA_013_Storthes Hall

Sheet No. 1

SCALE	1/250	REV.	

APPENDIX C

PROPOSED SITE DEVELOPMENT PLANS



Footprint
Existing - 799m²
Proposed - 648m²
-19%

Volume
Existing - 4535m³
Proposed - 4868m³
+7%

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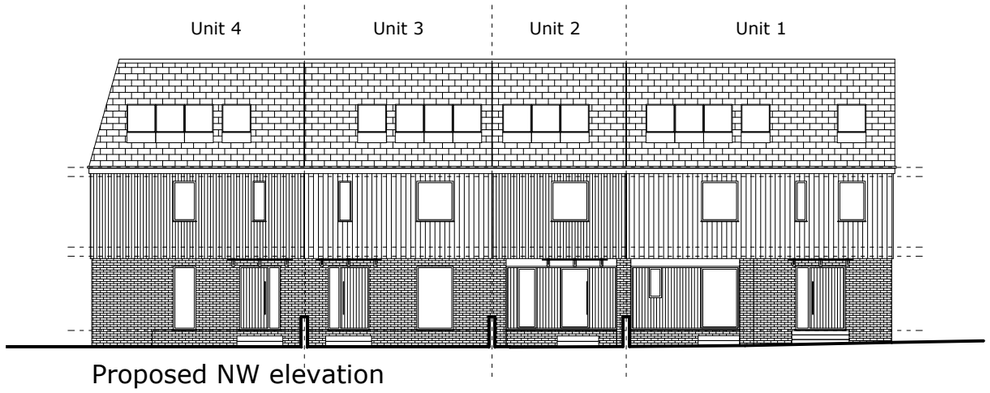
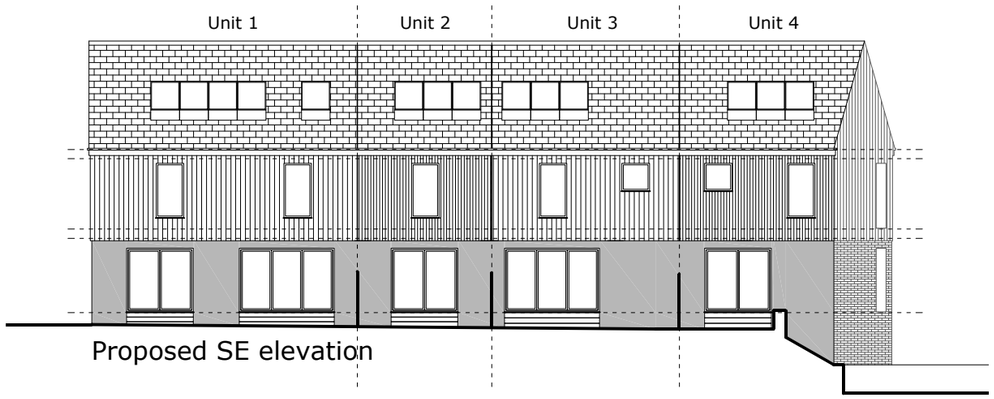
37 Victoria Gardens, Horsforth, Leeds, LS18 4PJ
07881 611195 info@nuton.co.uk

Rev A	Scale 1:250 @ A3		Job no 150018
Title Proposed Site plan			
Project Dene Bottom Works conversion			
Drawn DN	Date 14/3/16		Drg no p09

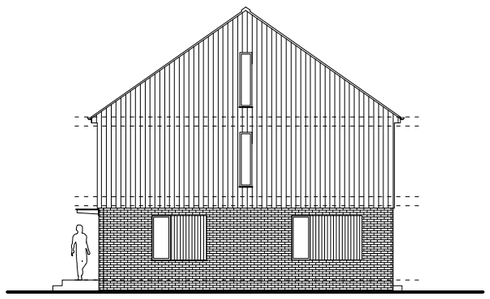
Proposed building A



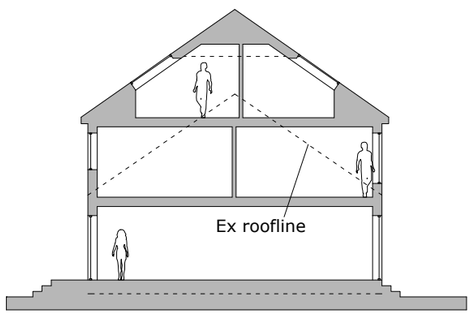
Proposed NW elevation



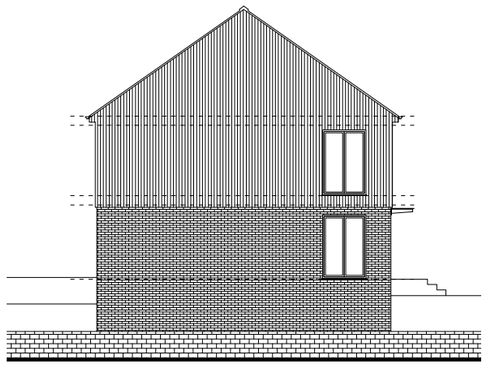
Proposed SE elevation



Proposed SW elevation

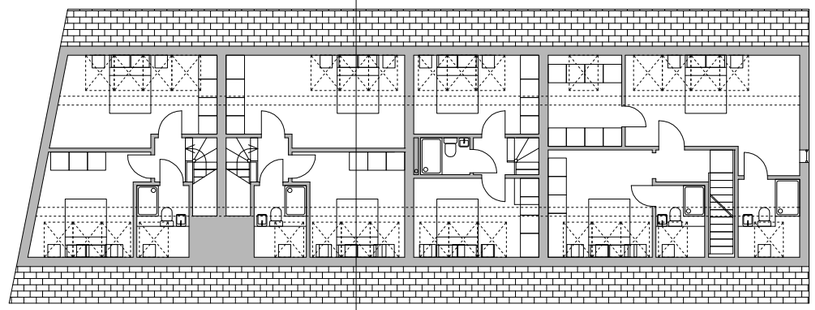


Proposed section A-A

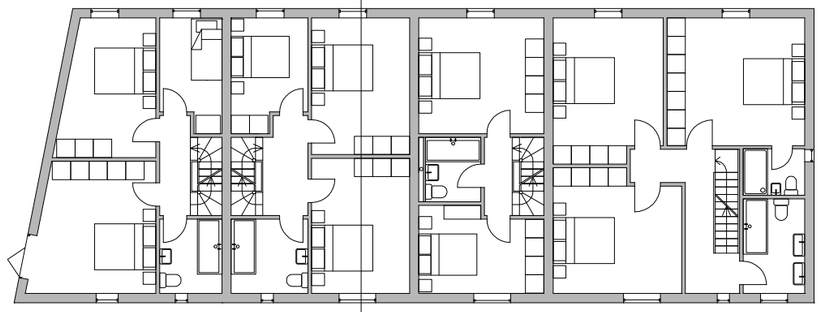


Proposed NE elevation

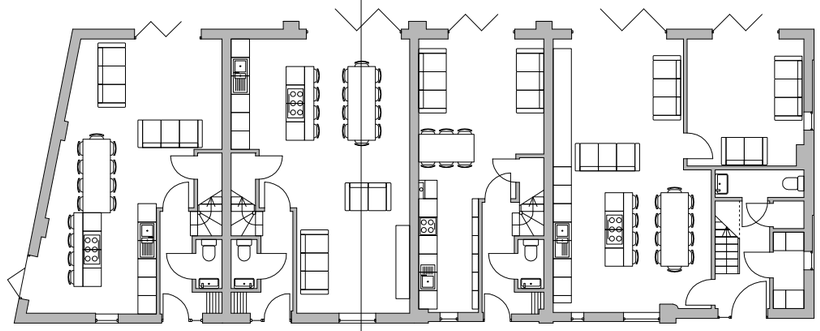
A



Proposed second floor



Proposed first floor



Proposed ground floor

A

Materials

Roof - Slate
First floor walls - Natural cedar cladding
Ground floor walls - Existing brick made good, Smooth scratch render to SW elevation, in basalt grey
Windows and doors - Black, with timber infil panels
Roof windows - The Rooflight Company "Neo Frameless"
RWG's - Black

Floor areas (m²)

	Unit 1	Unit 2	Unit 3	Unit 4
GEA inc <1.5m	249	126	177	171
GEA ex <1.5m	207	105	147	142

0 2 4 6 8 10 20m

37 Victoria Gardens, Horsforth, Leeds, LS18 4PJ
07881 611195 info@nuton.co.uk

Rev A	Scale 1:200 @ A3		Job no 150018
Title Proposed building A			
Project Dene Bottom Works conversion			
Drawn DN	Date 14/3/16		Drg no p06

Proposed building B

Materials

Roof
Slate

First floor walls
Grey stained larch

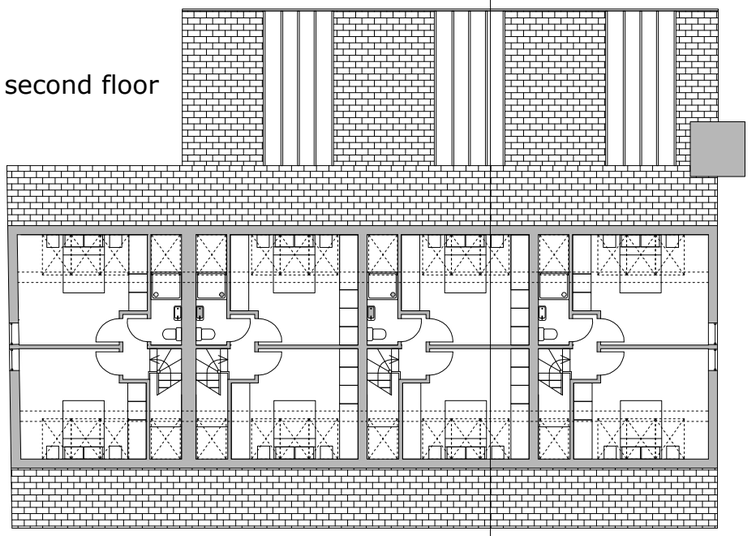
Ground floor walls
Existing stone made good

Windows and doors
Black, with timber infil panels

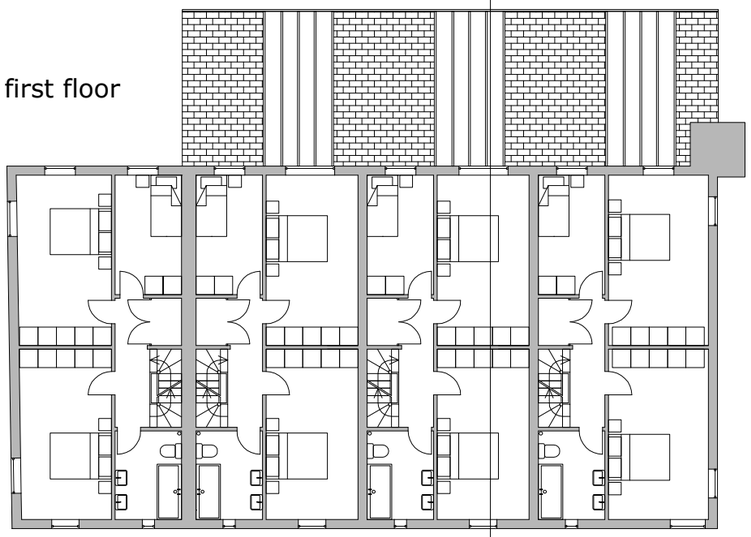
Roof windows
The Rooflight Company "Neo Frameless"

RWG's
Black

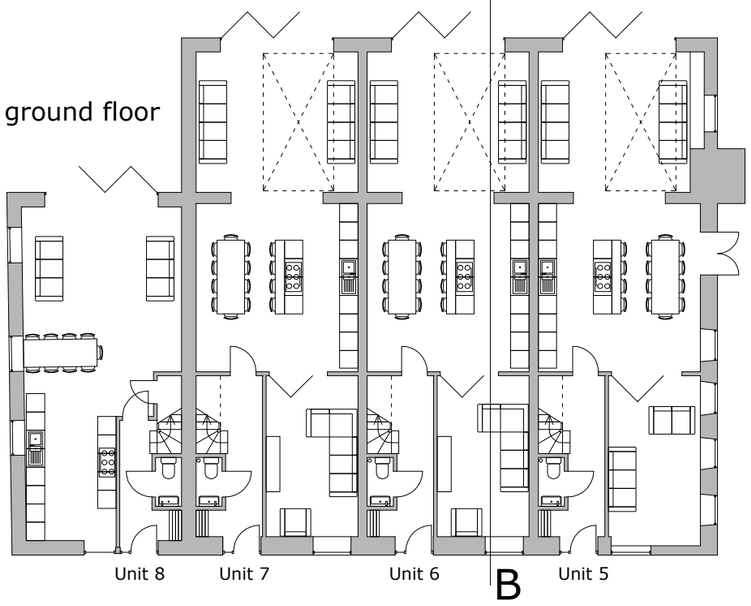
Proposed second floor

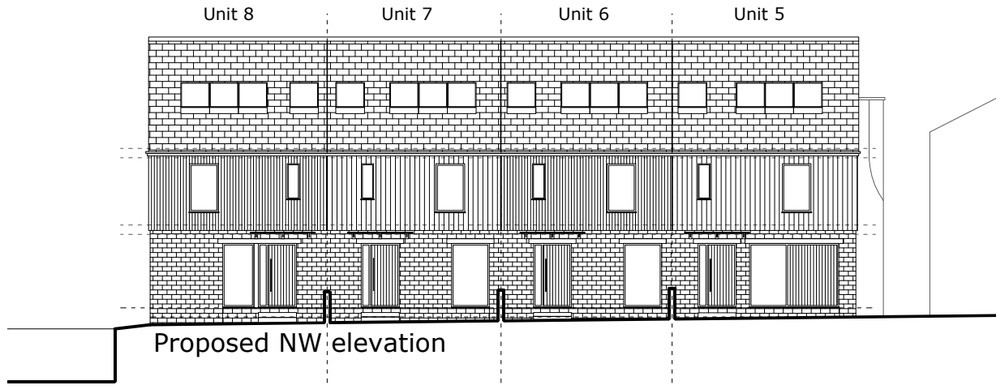


Proposed first floor

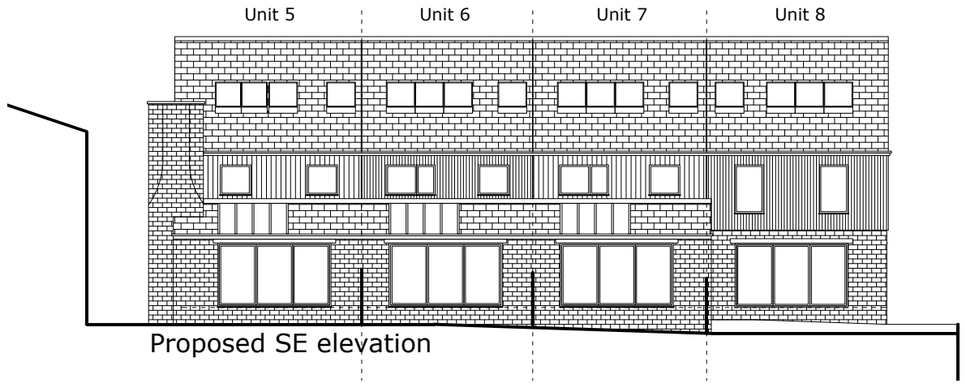


Proposed ground floor





Proposed NW elevation

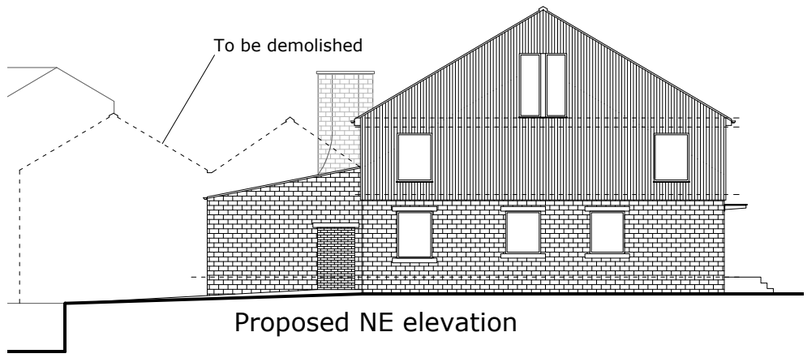


Proposed SE elevation

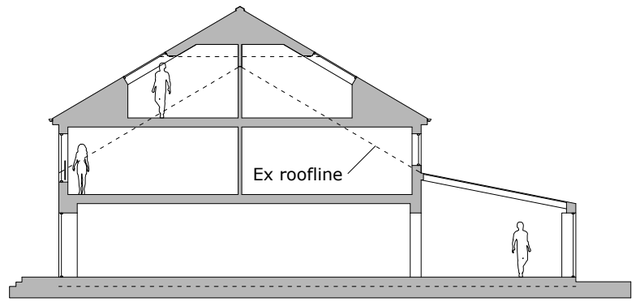
Proposed SW elevation

Floor areas (m²)

	Unit 5	Unit 6	Unit 7	Unit 8
GEA inc <1.5m	243	226	230	207
GEA ex <1.5m	207	193	197	173



Proposed NE elevation



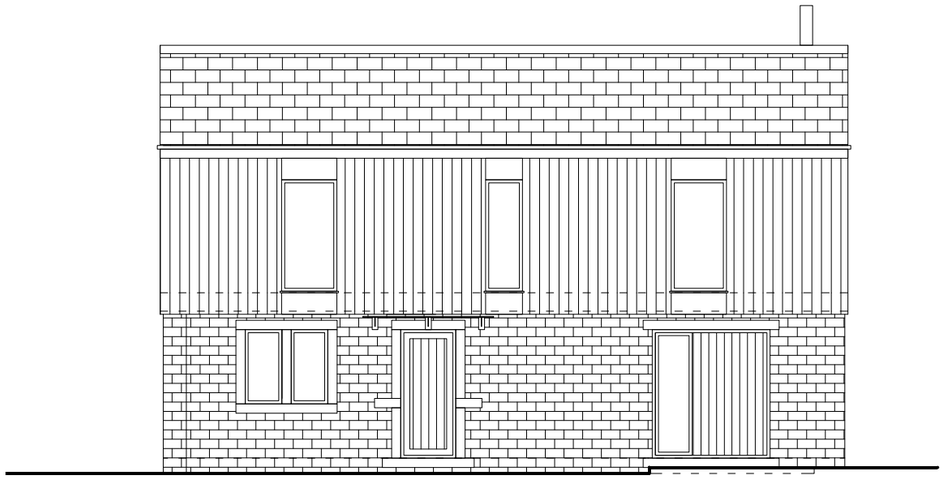
Proposed section B-B

0 2 4 6 8 10 20m

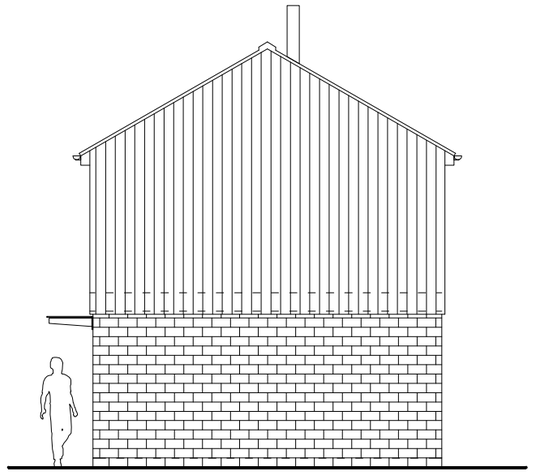
37 Victoria Gardens, Horsforth, Leeds, LS18 4PJ
07881 611195 info@nuton.co.uk

Rev A	Scale 1:200 @ A3	Job no 150018
Title Proposed building B		
Project Dene Bottom Works conversion		
Drawn DN	Date 14/3/16	Drg no p07

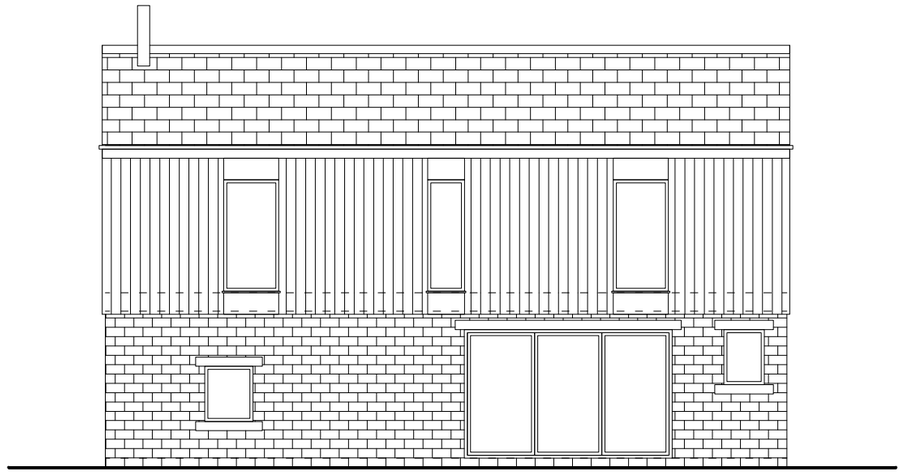
Proposed building C



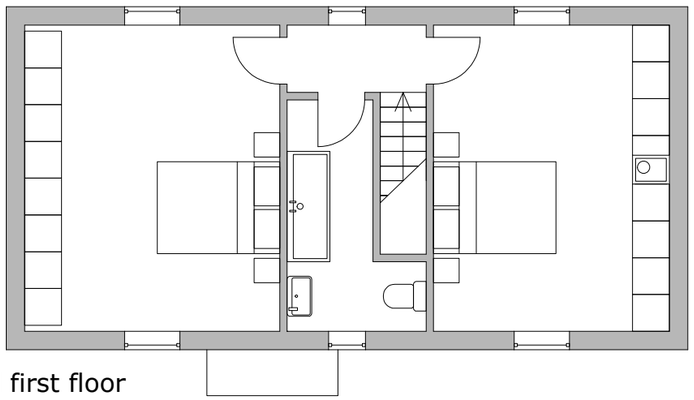
Proposed west elevation



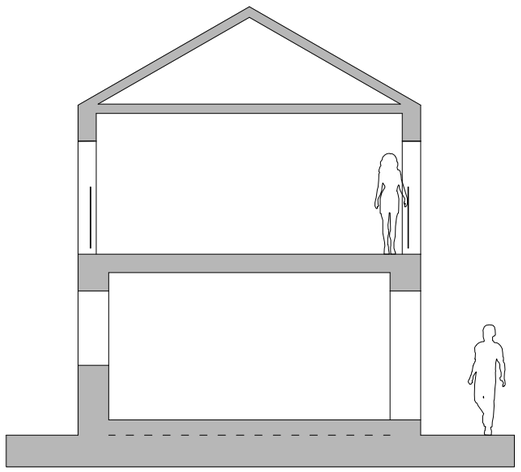
Proposed south elevation



Proposed east elevation



Proposed first floor



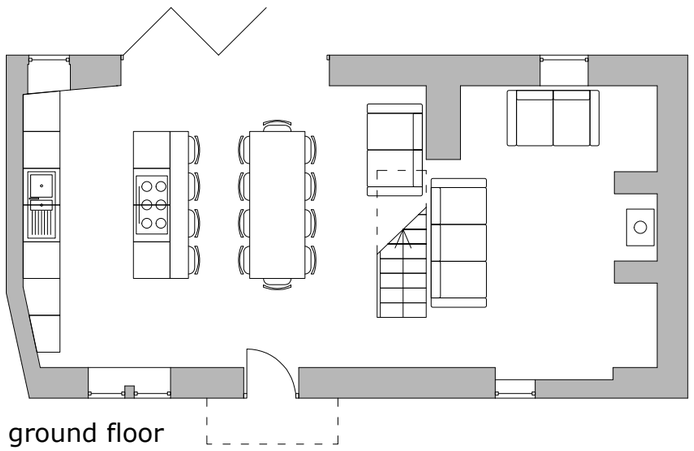
Proposed section

Materials

Roof - Slate
First floor walls - Grey stained larch
Ground floor walls - Existing stone made good
Windows and doors - Black, with timber infil panels
Roof windows - The Rooflight Company "Neo Frameless"
RWG's - Black

Area

Total GEA 124m²



Proposed ground floor

0 1 2 3 4 5 10m

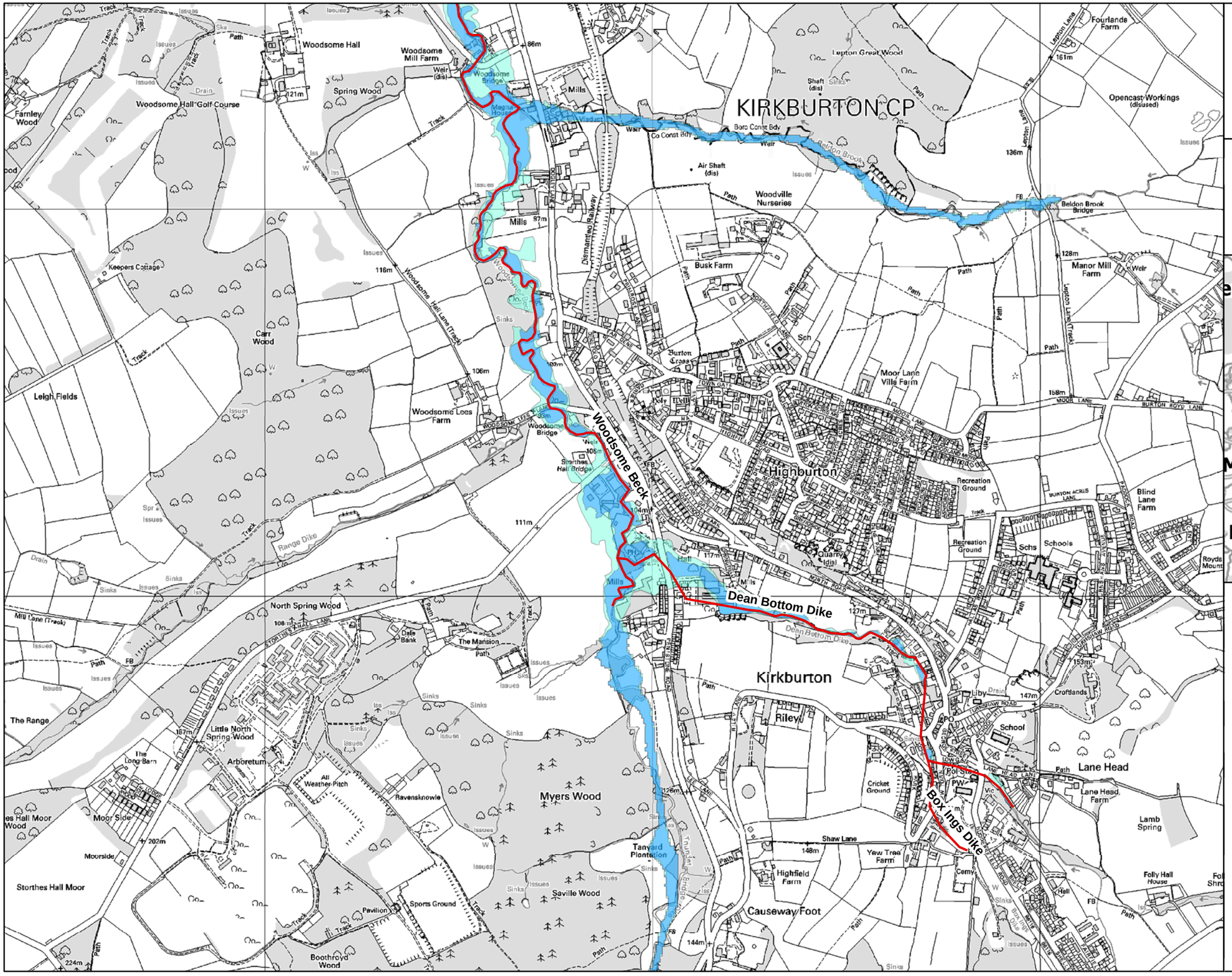
nuton
37 Victoria Gardens, Horsforth, Leeds, LS18 4PJ
07881 611195 info@nuton.co.uk

Rev A	Scale 1:100 @ A3	Job no 150018
Title Proposed building C		
Project Dene Bottom Works conversion		
Drawn DN	Date 14/3/16	Drg no p08

APPENDIX D

ENVIRONMENT AGENCY FLOOD MAPS & MODEL SHEETS

Flood Map for Dean Bottom Works, Huddersfield - Date Created: 09/08/2013 Ref: 26652



Environment Agency

www.environment-agency.gov.uk

Scale: 1:10,000

N W E S

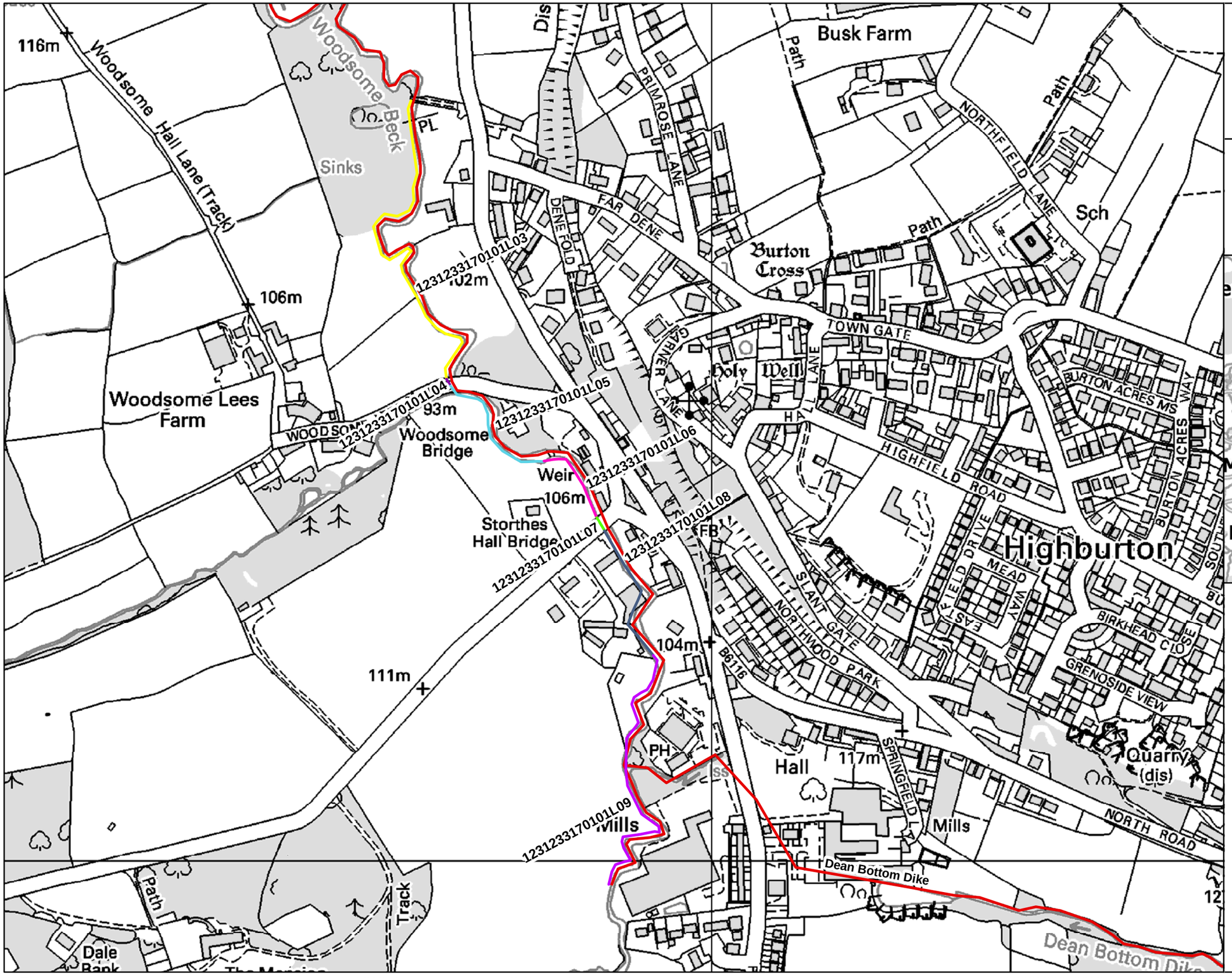
when reproduced @ A3

LEGEND

- Main River
- Flood Zone 3 (FZ3)
- Flood Zone 2 (FZ2)

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Asset Location Map for Dean Bottom Works, Huddersfield - Date Created: 09/08/2013 Ref: 26652



Environment Agency

www.environment-agency.gov.uk

Scale: 1:4,000

when reproduced @ A3

N
W E
S

LEGEND

Main River

Defence

ASSETREFER

- 1231233170101L03
- 1231233170101L04
- 1231233170101L05
- 1231233170101L06
- 1231233170101L07
- 1231233170101L08
- 1231233170101L09

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

RFI no: 26652 Asset Information

Asset Reference	Asset Type	Maintainer	Asset Protection Type	Asset Description	Asset Location	Estimated Design Standard	Bank	Actual Downstream Crest Level	Actual Upstream Crest Level	Overall Condition Rating
1231233170101L03	maintained channel	private	fluvial	Natural Channel	Woodsome Lees Lane to Dogley Nature Reserve Bridge	20	left	No Data	No Data	3
1231233170101L04	maintained channel	private	fluvial	Stone Road bridge abutment	Woodsome Lees Lane road bridge	20	left	No Data	No Data	3
1231233170101L05	maintained channel	private	fluvial	Natural Channel	Up stream of Woodsome Lees Lane bridge	20	left	No Data	No Data	3
1231233170101L06	maintained channel	private	fluvial	Walled Channel	Down Stream of Storthes Hall lane Bridge	20	left	No Data	No Data	3
1231233170101L07	maintained channel	private	fluvial	Road Bridge Abutment	Storthes Hall Lane	20	left	No Data	No Data	3
1231233170101L08	maintained channel	private	fluvial	Walled Channel	Up stream of Storthes Hall Lane	20	left	No Data	No Data	3
1231233170101L09	maintained channel	private	fluvial	Natural Channel	Bottled Water Mills, Dean bottome confluence to rear of Hublic House	20	left	No Data	No Data	2

Taking climate change into account

11. Global sea level will continue to rise, depending on greenhouse gas emissions and the sensitivity of the climate system. The relative sea level rise in England also depends on the local vertical movement of the land, which is generally falling in the south-east and rising in the north and west. In preparing a Strategic Flood Risk Assessment or a site-specific flood risk assessment, the allowances for the rates of relative sea level rise shown in table 4 should be used as a starting point for considering flooding from the sea, along with the sensitivity ranges for wave height and wind speed in table 5.

Table 4: Recommended contingency allowances for net sea level rises

	Net sea level rise (mm per year) relative to 1990			
	1990 to 2025	**2025 to 2055**	**2055 to 2085**	**2085 to 2115**
East of England, east midlands, London, south-east England (south of Flamborough Head)	4.0	8.5	12.0	15.0
South-west England	3.5	8.0	11.5	14.5
North-west England, north-east England (north of Flamborough Head)	2.5	7.0	10.0	13.0

Notes to table 4:

a. For deriving sea levels up to 2025, the 4mm per year, 3mm per year and 2.5mm per year rates (covering the three geographical groups respectively), should be applied back to the 1990 base sea level year. From 2026 to 2055, the increase in sea level in this period is derived by adding the number of years on from 2025 (to 2055), multiplied by the respective rate shown in the table. Subsequent time periods 2056 to 2085 and 2086 to 2115 are treated similarly.

b. Refer to Department for Environment, Food and Rural Affairs *FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts,* October 2006, for details of the derivation of this table. In particular, Annex A1 of this Note shows examples of how to calculate sea level rise.

c. Vertical movement of the land is incorporated in the table and does not need to be calculated separately.

12. The rise in sea level will change the frequency of occurrence of high water levels relative to today's sea levels, assuming no change in storminess. There may also be secondary impacts such as changes in wave heights due to increased water depths, as well as possible changes in the frequency, duration and severity of storm events. A 10 per cent sensitivity allowance should be added to offshore wind speeds and wave heights by the 2080s.

13. In making an assessment of the impacts of climate change on flooding from the land, rivers and sea as part of a flood risk assessment, the sensitivity ranges in table 5 may provide an appropriate precautionary response to the uncertainty about climate change impacts on rainfall intensities, river flow, wave height and wind speed.

Table 5: Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights

Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	*+5%*	*+10%*	*+20%*	*+30%*
Peak river flow	*+10%*	*+20%*		
Offshore wind speed	*+5%*		*+10%*	
Extreme wave height	*+5%*		*+10%*	

Notes to table 5:

a. Refer to Department for Environment, Food and Rural Affairs *FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts,* October 2006, for details of the derivation of this table.

b. For deriving peak rainfall, for example, between 2025 and 2055 multiply the rainfall measurement (in mm per hour) by 10 per cent and between 2055 and 2085 multiply the rainfall measurement by 20 per cent. So, if there is a 10mm per hour event, for the 2025 to 2055 period this would equate to 11mm per hour; and for the 2055 to 2085 period, this would equate to 12mm per hour. Other parameters in table 5 are treated similarly.

14. Sensitivity testing of the flood map produced by the Environment Agency, using the 20 per cent from 2025 to 2115 allowance for peak flows, suggests that changes in the extent of inundation are negligible in well-defined floodplains, but can be dramatic in very flat areas. However, changes in the depth of flooding under the same allowance will reduce the return period of a given flood. This

means that a site currently located within a lower risk zone (e.g. Zone 2 in table 1) could in future be re-classified as lying within a higher risk zone (e.g. Zone 3a in table 1). This in turn could have implications for the type of development that is appropriate according to its vulnerability to flooding (see table 2). It will therefore be important that developers, their advisors and local authorities refer to the current flood map and the Strategic Flood Risk Assessment when preparing and considering proposals.

15. Flooding in estuaries may result from the combined effects of high river flows and high sea surges. When taking account of impacts of climate change in flood risk assessments covering tidal estuaries, it will be necessary for the allowances for sea level rise in table 4 and the allowances for peak flow, wave height and wind speed in table 5 to be combined.[11]

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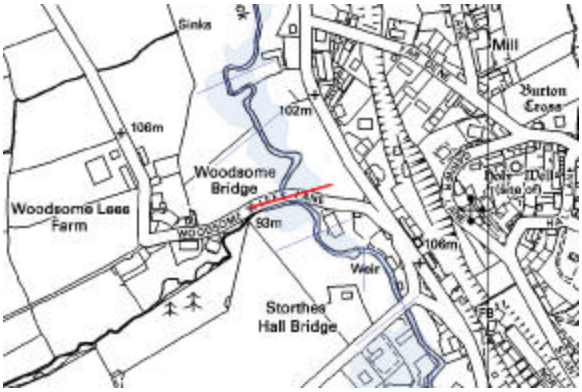
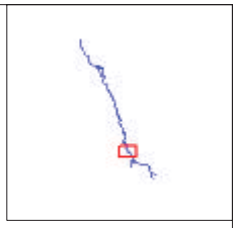
[11] Refer to Defra *FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts*, October 2006. Annex A2 gives details of joint probability analysis. www.defra.gov.uk/environ/fcd/pubs/pagn/climatechangeupdate.pdf

Location Plan



Cross Section References



River: FENAY BECK

Reach: 1

Chainage: 6799

Section Type: BRIDGE, SECTION, SPILL

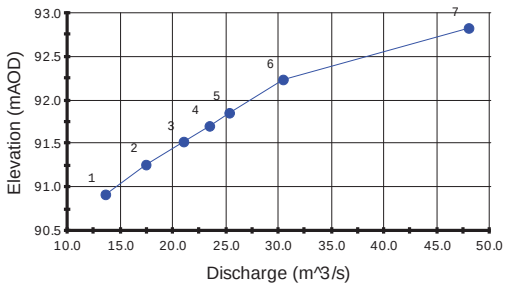
OS NGR: Unknown

Survey Dwg Ref: N/A

Photograph Ref: FENA1_6799c.jpg

Next
Section d/s: 6799d
Section u/s: 6873

Rating Curve



Number represents model profile number

Summary of Results

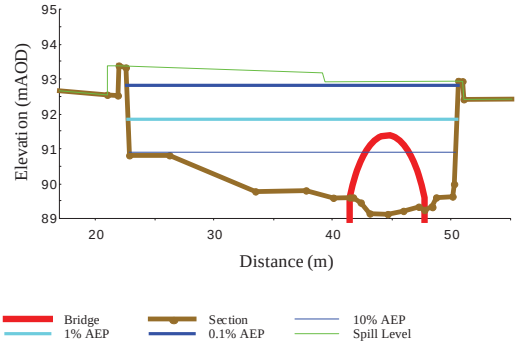
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	13.6	90.924	0.49
2	4.0	17.5	91.263	0.47
3	2.0	21.0	91.527	0.48
4	1.3	23.5	91.706	0.48
5	1.0	25.4	91.856	0.48
6	1.0	30.4	92.237	0.48
7	0.1	48.0	92.826	0.54

Level of Left Bank 93.335 mAOD

Level of Right Bank 92.948 mAOD

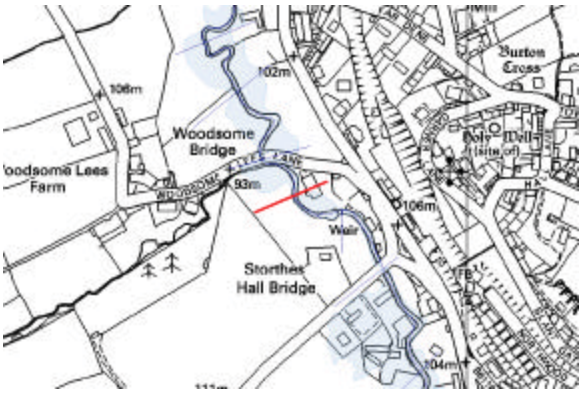
AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile

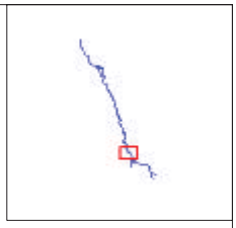


FENAY BECK: 1: CROSS SECTION NUMBER 6799u

Location Plan



Cross Section References



River: FENAY BECK

Reach: 1

Chainage: 6873

Section Type: SECTION

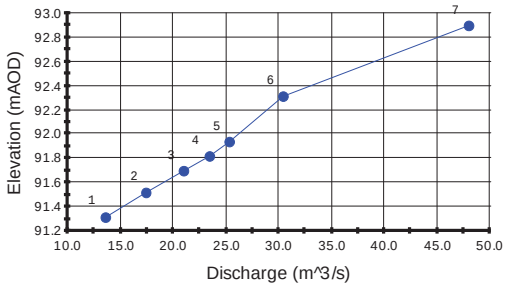
OS NGR: Unknown

Survey Dwg Ref: N/A

Photograph Ref: FENA1_6873a.jpg

Next
Section d/s: 6799u
Section u/s: 6946d

Rating Curve



Number represents model profile number

Summary of Results

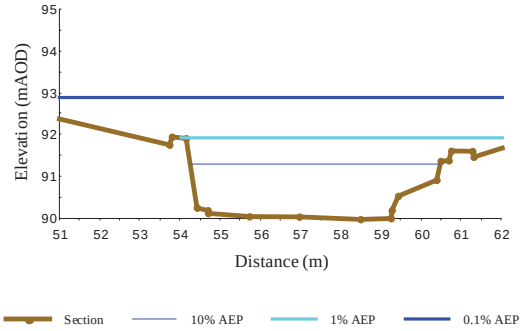
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	13.6	91.317	2.00
2	4.0	17.5	91.522	2.15
3	2.0	21.0	91.700	2.23
4	1.3	23.5	91.822	2.25
5	1.0	25.4	91.939	2.22
6	1.0	30.4	92.313	1.52
7	0.1	48.0	92.895	1.00

Level of Left Bank 91.966 mAOD

Level of Right Bank 91.634 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

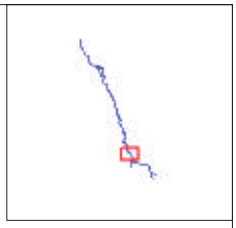
Cross Section Profile



FENAY BECK: 1: CROSS SECTION NUMBER 6873

Location Plan

Cross Section References



River: FENAY BECK

Reach: 1

Chainage: 6946

Section Type: SECTION, SPILL

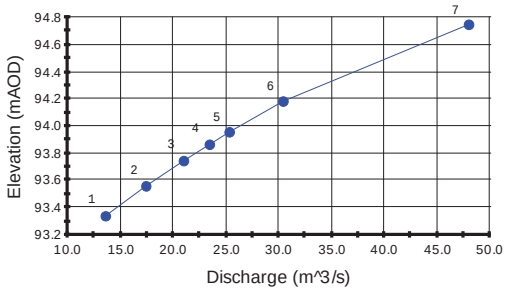
OS NGR: Unknown

Survey Dwg Ref: N/A

Photograph Ref: FENA1_6946b.jpg

Next
Section d/s: 6946d
Section u/s: 7042d

Rating Curve



Number represents model profile number

Summary of Results

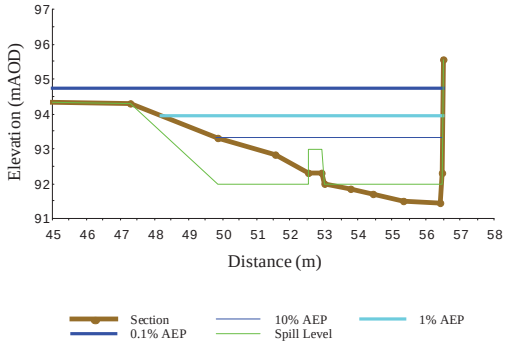
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	13.6	93.343	1.85
2	4.0	17.5	93.563	1.96
3	2.0	21.0	93.748	2.04
4	1.3	23.5	93.867	2.09
5	1.0	25.4	93.957	2.12
6	1.0	30.4	94.183	2.19
7	0.1	48.0	94.743	2.00

Level of Left Bank 94.304 mAOD

Level of Right Bank 95.558 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

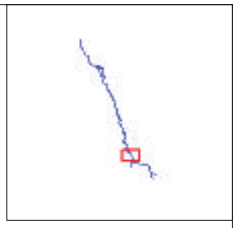
Cross Section Profile



FENAY BECK: 1: CROSS SECTION NUMBER 6946u

Location Plan

Cross Section References



River: FENAY BECK

Reach: 1

Chainage: 7042

Section Type: BRIDGE, SECTION, SPILL

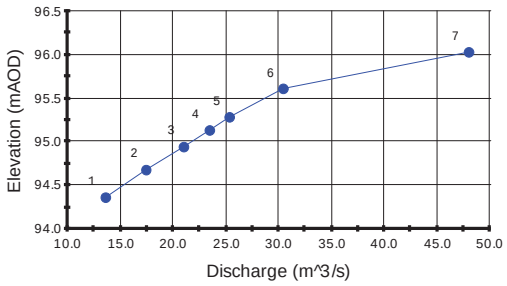
OS NGR: Unknown

Survey Dwg Ref: N/A

Photograph Ref: FENA1_7042b.jpg

Next
Section d/s: 7042d
Section u/s: 7200

Rating Curve



Number represents model profile number

Summary of Results

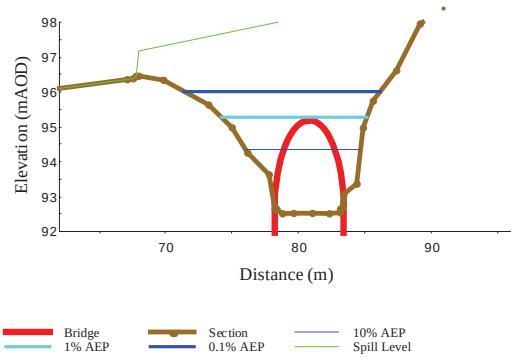
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	13.6	94.368	1.16
2	4.0	17.5	94.682	1.20
3	2.0	21.0	94.946	1.23
4	1.3	23.5	95.135	1.23
5	1.0	25.4	95.288	1.23
6	1.0	30.4	95.613	1.08
7	0.1	48.0	96.028	0.88

Level of Left Bank 96.474 mAOD

Level of Right Bank 99.037 mAOD

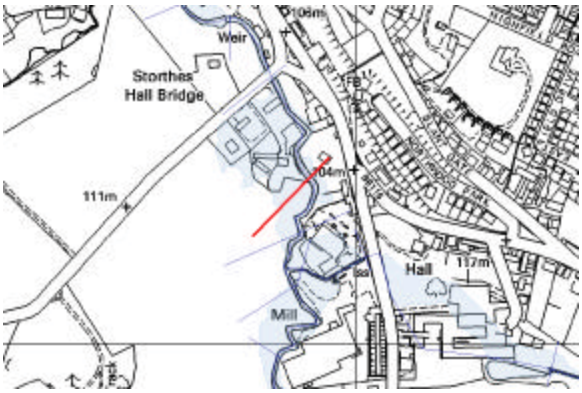
AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile

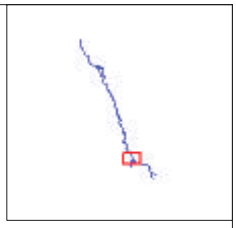


FENAY BECK: 1: CROSS SECTION NUMBER 7042u

Location Plan



Cross Section References



River: FENAY BECK

Reach: 1

Chainage: 7200

Section Type: SECTION

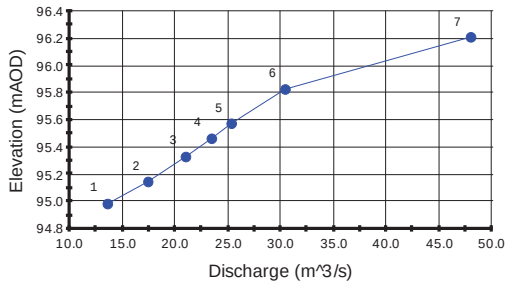
OS NGR: Unknown

Survey Dwg Ref: N/A

Photograph Ref: FENA1_7200.jpg

Next
Section d/s: 7042u
Section u/s: 7282

Rating Curve



Number represents model profile number

Summary of Results

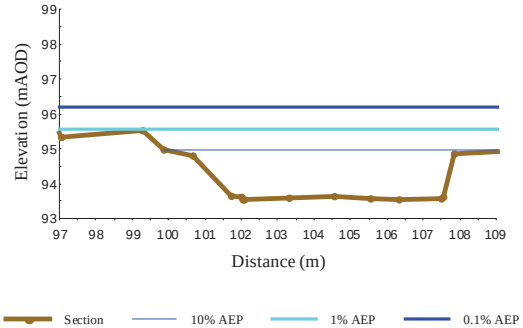
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	13.6	94.989	0.72
2	4.0	17.5	95.151	0.65
3	2.0	21.0	95.333	0.59
4	1.3	23.5	95.467	0.54
5	1.0	25.4	95.577	0.51
6	1.0	30.4	95.826	0.43
7	0.1	48.0	96.208	0.41

Level of Left Bank 95.539 mAOD

Level of Right Bank 94.880 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

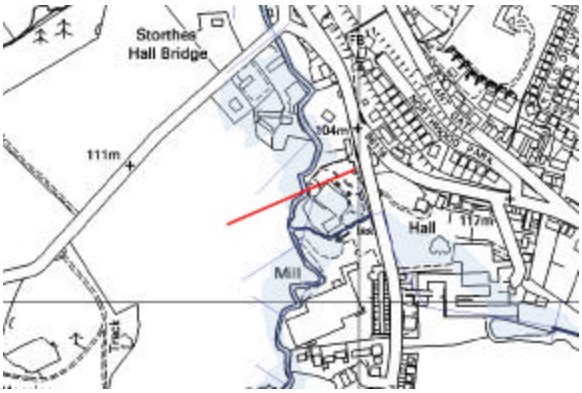
Cross Section Profile



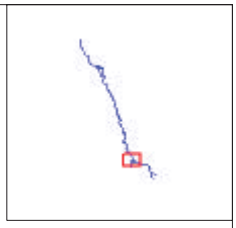
FENAY BECK: 1: CROSS SECTION NUMBER 7200

Environment Agency - North East Region
Fenay Beck Flood Mapping Study
ISIS Hydraulic Model Summary Sheet

Location Plan



Cross Section References



River: FENAY BECK

Reach: 1

Chainage: 7282

Section Type: SECTION

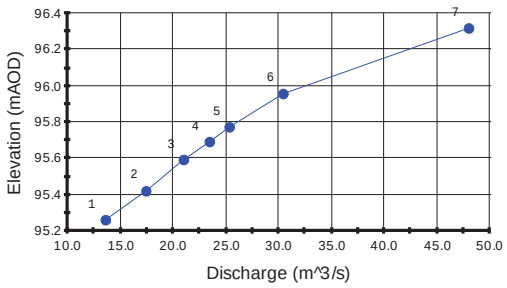
OS NGR: Unknown

Survey Dwg Ref: N/A

Photograph Ref: FENA1_7282.jpg

Next
Section d/s: 7200
Section u/s: 7362d

Rating Curve



Number represents model profile number

Summary of Results

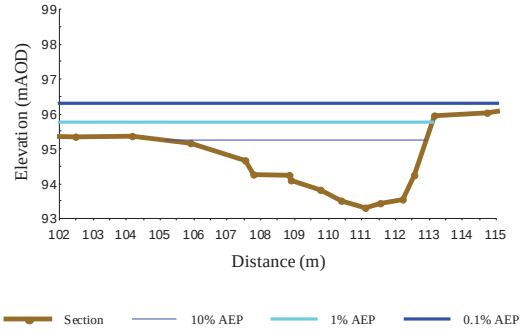
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	13.6	95.264	1.72
2	4.0	17.5	95.423	1.80
3	2.0	21.0	95.594	1.54
4	1.3	23.5	95.693	1.44
5	1.0	25.4	95.774	1.36
6	1.0	30.4	95.957	1.25
7	0.1	48.0	96.316	1.22

Level of Left Bank 95.376 mAOD

Level of Right Bank 95.955 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

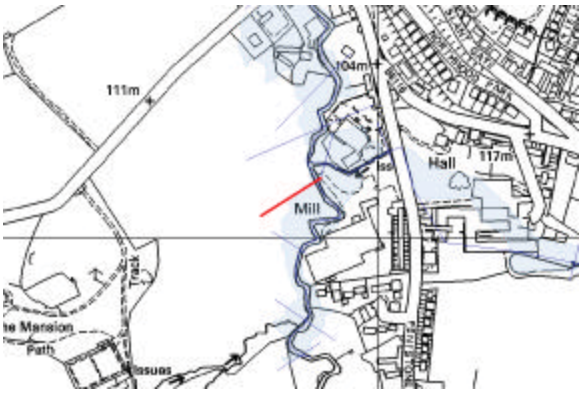
Cross Section Profile



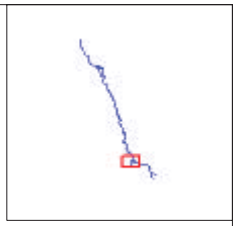
FENAY BECK: 1: CROSS SECTION NUMBER 7282

Print Date: 08/06/2007

Location Plan



Cross Section References



River: FENAY BECK

Reach: 1

Chainage: 7362

Section Type: SECTION

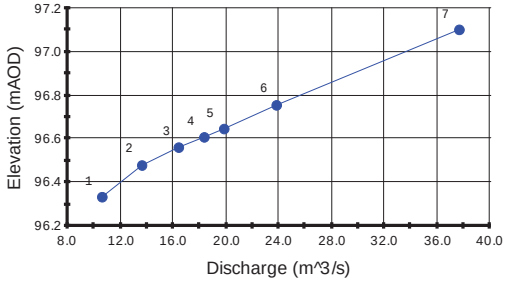
OS NGR: Unknown

Survey Dwg Ref: N/A

Photograph Ref: FENA1_7362.jpg

Next
Section d/s: 7362d
Section u/s: 7509

Rating Curve



Number represents model profile number

Summary of Results

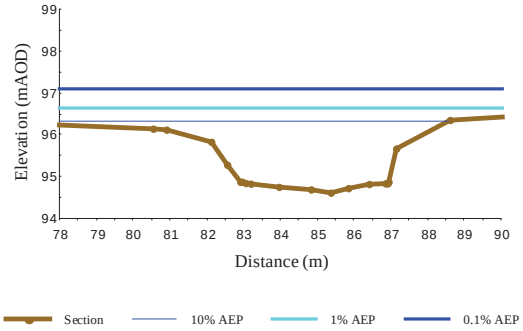
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	10.6	96.336	1.22
2	4.0	13.6	96.480	1.20
3	2.0	16.4	96.562	1.22
4	1.3	18.4	96.609	1.22
5	1.0	19.9	96.647	1.21
6	1.0	23.8	96.756	1.19
7	0.1	37.6	97.101	1.15

Level of Left Bank 96.132 mAOD

Level of Right Bank 96.356 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile



FENAY BECK: 1: CROSS SECTION NUMBER 7362u

Location Plan

Cross Section References

River: FENAY BECK

Reach: 1

Chainage: 7509

Section Type: SECTION

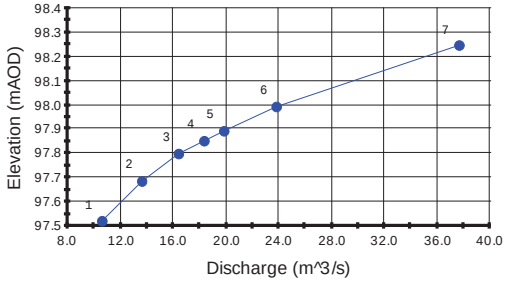
OS NGR: Unknown

Survey Dwg Ref: N/A

Photograph Ref: FENA1_7509a.jpg

Next
Section d/s: 7362u
Section u/s: 7610

Rating Curve



Number represents model profile number

Summary of Results

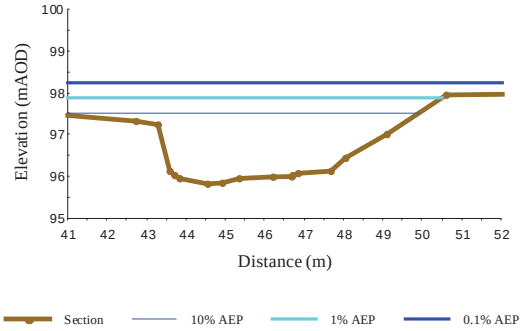
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	10.6	97.523	1.28
2	4.0	13.6	97.687	1.26
3	2.0	16.4	97.800	1.19
4	1.3	18.4	97.853	1.19
5	1.0	19.9	97.893	1.20
6	1.0	23.8	97.994	1.21
7	0.1	37.6	98.246	1.32

Level of Left Bank 97.257 mAOD

Level of Right Bank 97.959 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

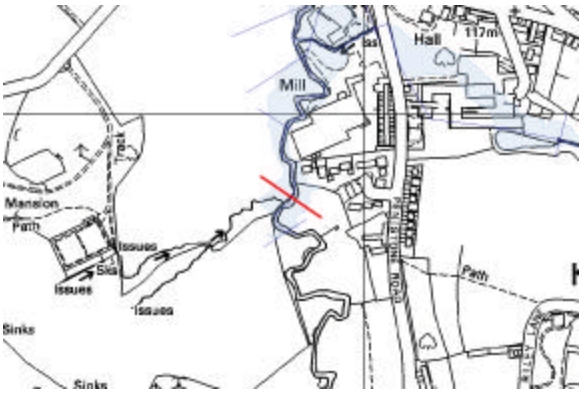
Cross Section Profile



FENAY BECK: 1: CROSS SECTION NUMBER 7509

Environment Agency - North East Region
Fenay Beck Flood Mapping Study
ISIS Hydraulic Model Summary Sheet

Location Plan



Cross Section References

River: FENAY BECK

Reach: 1

Chainage: 7610

Section Type: SECTION

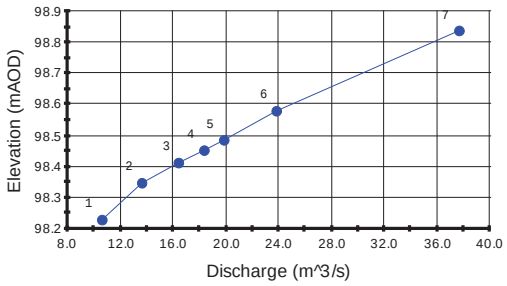
OS NGR: Unknown

Survey Dwg Ref: N/A

Photograph Ref: FENA1_7610.jpg

Next
Section d/s: 7509
Section u/s: 7670

Rating Curve



Number represents model profile number

Summary of Results

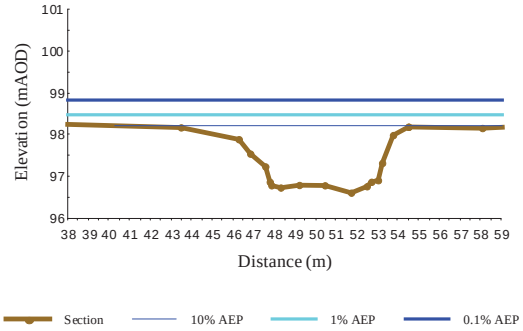
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	10.6	98.231	1.01
2	4.0	13.6	98.349	0.92
3	2.0	16.4	98.414	0.91
4	1.3	18.4	98.454	0.90
5	1.0	19.9	98.487	0.89
6	1.0	23.8	98.580	0.86
7	0.1	37.6	98.837	0.87

Level of Left Bank 98.186 mAOD

Level of Right Bank 98.198 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile

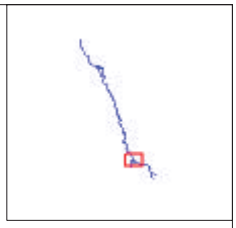


FENAY BECK: 1: CROSS SECTION NUMBER 7610

Print Date: 08/06/2007

Location Plan

Cross Section References



River: DEAN BOTTOM DIKE

Reach: 1

Chainage: 118

Section Type: SECTION

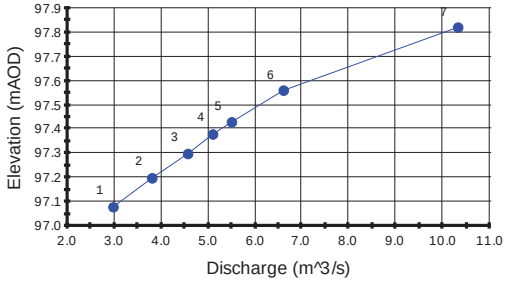
OS NGR: SE 19013 13110

Survey Dwg Ref: N/A

Photograph Ref: DEAN1_0118a.jpg

Next
Section d/s: 108.4
Section u/s: 396

Rating Curve



Number represents model profile number

Summary of Results

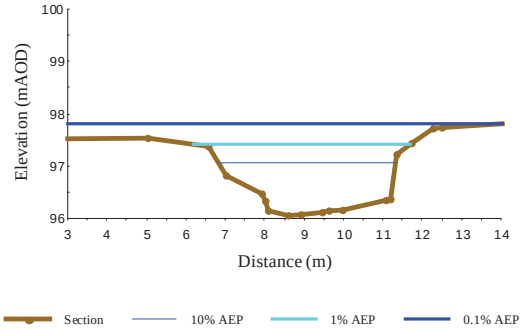
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	3.0	97.080	0.90
2	4.0	3.8	97.200	0.99
3	2.0	4.6	97.300	1.05
4	1.3	5.1	97.380	1.09
5	1.0	5.5	97.430	1.10
6	1.0	6.6	97.560	1.13
7	0.1	10.3	97.820	1.27

Level of Left Bank 97.550 mAOD

Level of Right Bank 97.730 mAOD

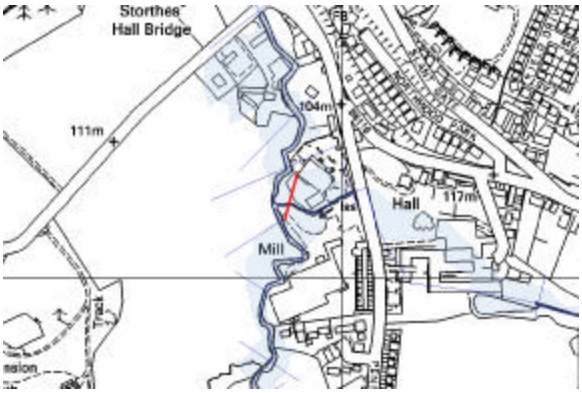
AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile



DEAN BOTTOM DIKE: 1: CROSS SECTION NUMBER 118

Location Plan



Cross Section References

River: DEAN BOTTOM DIKE

Reach: 1

Chainage: 22

Section Type: SECTION

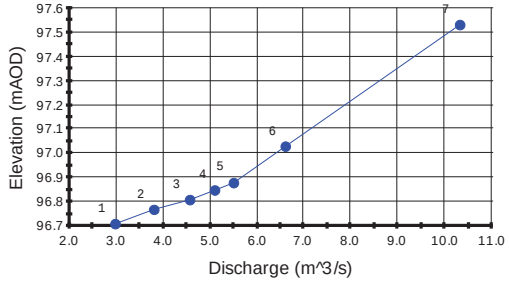
OS NGR: SE 18930 13095

Survey Dwg Ref: N/A

Photograph Ref: DEAN1_0022.jpg

Next
Section d/s: 14.6666
Section u/s: 31.6

Rating Curve



Number represents model profile number

Summary of Results

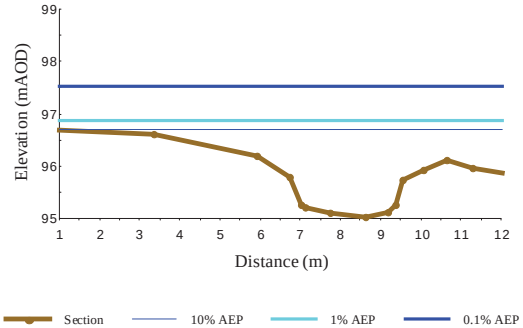
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	3.0	96.710	0.23
2	4.0	3.8	96.770	0.27
3	2.0	4.6	96.810	0.31
4	1.3	5.1	96.850	0.33
5	1.0	5.5	96.880	0.35
6	1.0	6.6	97.030	0.36
7	0.1	10.3	97.530	0.39

Level of Left Bank 96.620 mAOD

Level of Right Bank 96.130 mAOD

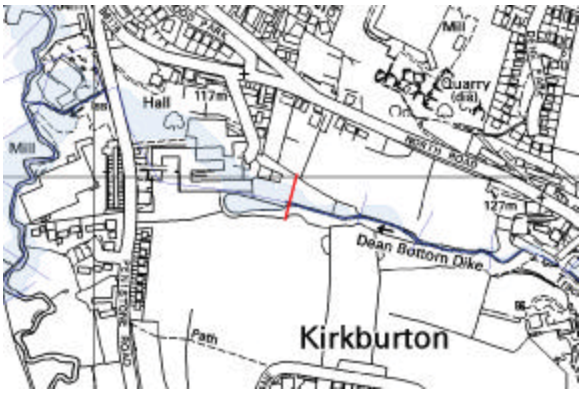
AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile

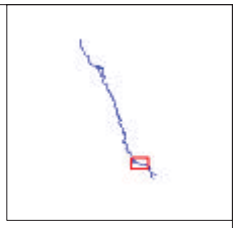


DEAN BOTTOM DIKE: 1: CROSS SECTION NUMBER 22

Location Plan



Cross Section References



River: DEAN BOTTOM DIKE

Reach: 1

Chainage: 396

Section Type: BRIDGE, CULVERT, SECTION

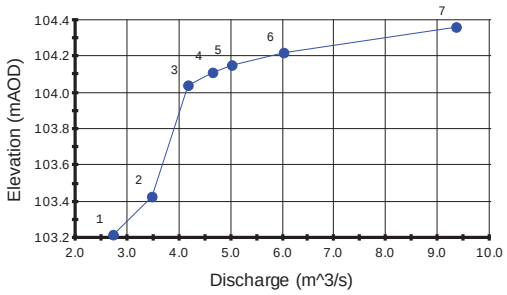
OS NGR: SE 19255 12965

Survey Dwg Ref: N/A

Photograph Ref: DEAN1_0396a.jpg

Next
Section d/s: 118
Section u/s: 405.4

Rating Curve



Number represents model profile number

Summary of Results

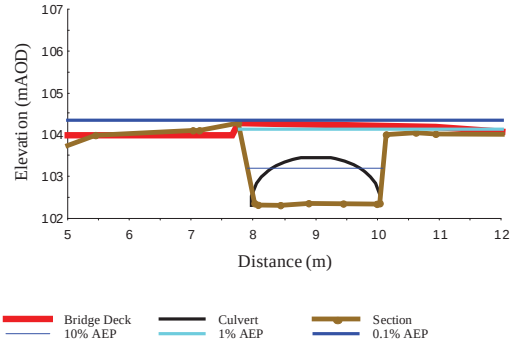
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	2.7	103.220	1.53
2	4.0	3.5	103.430	1.51
3	2.0	4.2	104.040	0.93
4	1.3	4.7	104.110	0.96
5	1.0	5.0	104.150	0.98
6	1.0	6.0	104.220	1.04
7	0.1	9.3	104.360	1.23

Level of Left Bank 104.290 mAOD

Level of Right Bank 104.020 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile

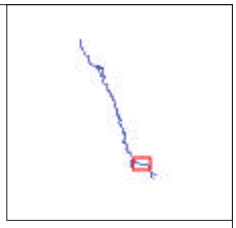


Note aspect ratio is not unity.

DEAN BOTTOM DIKE: 1: CROSS SECTION NUMBER 396

Location Plan

Cross Section References



River: DEAN BOTTOM DIKE

Reach: 1

Chainage: 490

Section Type: SECTION

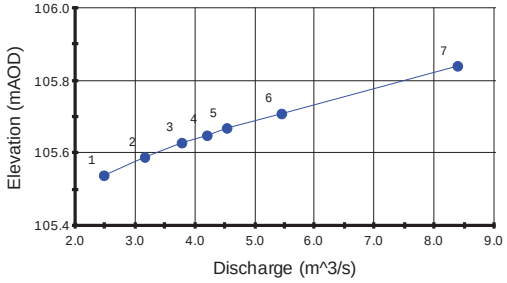
OS NGR: SE 19346 12947

Survey Dwg Ref: N/A

Photograph Ref: DEAN1_0490.jpg

Next
Section d/s: 480.6
Section u/s: 499.222

Rating Curve



Number represents model profile number

Summary of Results

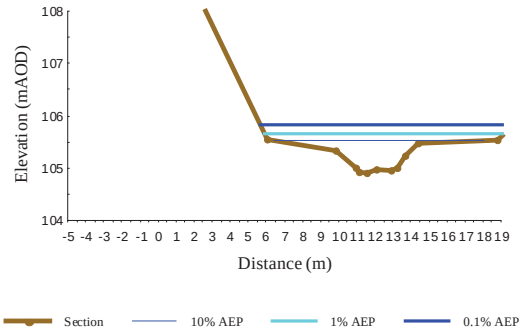
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	10.0	2.5	105.540	1.07
2	4.0	3.2	105.590	1.13
3	2.0	3.8	105.630	1.18
4	1.3	4.2	105.650	1.22
5	1.0	4.5	105.670	1.24
6	1.0	5.4	105.710	1.31
7	0.1	8.4	105.840	1.49

Level of Left Bank 109.880 mAOD

Level of Right Bank 105.490 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile



DEAN BOTTOM DIKE: 1: CROSS SECTION NUMBER 490