Haigh Huddleston & Associates
Civil Structural Engineering Consultants

Firth Buildings, 99-101 Leeds Road, Dewsbury, WF12 7BU t 01924 464342 f 01924 450662
e trevor.haigh@haighhuddleston.co.uk

FLOOD RISK ASSESSMENT

ON

Land at West Street
Worsbrough,
Barnsley
South Yorkshire

FOR

The Ebor Sipp
re RGM Oddie
c/o Walker Cipps

E12/5820/FRA001

June 2013

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

Haigh Huddleston Associates is the trading name of Haigh Huddleston Associates Limited
Registered Office: Firth Buildings, 99-101 Leeds Road, Dewsbury, WF12 7BU
Registered in England Number 6458196

1.0 INTRODUCTION

1.1 This report is commissioned to investigate and report on the Flood Risk for this site in accordance NPPF 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 at West Street, Worsbrough, Barnsley South Yorkshire and is situated around Ordnance Survey grid reference SE 35846 03689. A site location plan is shown on Figure 1 in Appendix A

2.2 The site is triangular in nature and situated on the outskirts of a residential area. There are residential properties to the north, east and west. To the south is Worsbrough Country Park. Beyond the residential properties to the north east there is a small area of open fields. The site area is approximately 2.17ha.

2.3 The site is a former industrial development and is predominantly covered with paved areas and existing industrial buildings. There are some areas of rough grass around these buildings. West Street forms the northern Boundary of the site and the former Dearne and Dove Canal abuts the southern boundary. The River Dove runs approx 50m to the south of the site. Midway along the northern boundary of the site there is an electrical sub-station. The services that serve the properties are still in the ground. There is sporadic/substantial tree and shrub growth adjacent the southern site boundaries.

2.4 The majority of the site has a tarmac or concrete hardstanding, with an area of approx. 1.48ha covered with hard standing or roofed areas. These do not all appear to be connected to the drainage systems. There are existing inspection chambers on site and some gullies but the lower areas do not

appear to be fully drained. A public footpath is shown running adjacent to the canal on the southern boundary.

2.5 The site generally falls from a high point of 59.7m AOD in the north east towards a low point of 53 AOD in the south east corner. The site slopes from north to south at an average gradient of approximately 1 in 20. The southern boundary is generally flat with only a slight gradient from west to east.

3.0 EXISTING DRAINAGE

3.1 The nearest Public sewers are an existing 305 mm dia. foul sewer and a 225mm surface water sewer that run in West Street. These both fall from the east to west and are recorded as 2.3 to 3m deep. There are also combined sewers running to the south of the site on the opposite side of the canal. These are shown as 750mm and 450mm diameter with depths of 1.45m to 1.65m deep. To the east of the site is a 450mm diameter combined sewer that runs north to south approximately 50m to the east of the site boundary. There is also a 600mm diam surface water sewer that runs north to south through open fields approx 85m to the east of the site and discharges tpo the River Dove 80m to the south west of the site close to Powder Mill Lane Bridge over the river.

3.2 The depth of the combined sewers in West Street do not appear to be sufficient to service the whole site by gravity. This may be possible however if there is a significant amount of ground raising in the south of the site. Alternatively the provision of a Foul Water Pumping Station may be needed to ensure the whole site can be drained and allow a full development of the site.

3.3 Yorkshire Water report that there is no capacity for increased surface water discharges from the site in the existing public sewerage system. They have requested that the use of sustainable drainage systems are fully investigated prior to approval of any discharges from site. They recommend the River Dove as a suitable point of discharge subject to land drainage and Environment agency approvals. Any discharge of surface water from the site will have to be attenuated down to existing discharges from the site which may even reduce to an agricultural discharge rate of 5Lit/sec/ha despite the

site being previously developed. In the first instance the use of infiltration methods should be investigated.

3.4 The use of a water-course for a surface water discharge or the limited use of infiltration methods may however require further negotiations with controlling authorities on this item. The current requirement from Land Drainage Authority in this area would be to limit the site discharges to agricultural levels if infiltration systems are not used.

3.5 There are foul and surface water systems to the east that could be utilised for foul and surface water discharges subject to further talks with Yorkshire Water to determine if there is any remaining capacity in these systems for a discharge from the site. The size of the pipes suggest this may be the case. This could negate the need for an onsite pumping station for both foul and surface water run off from the site subject to verification of the depth of these sewers.

3.6 They have not reported any capacity problems for foul water flows into the systems.

3.7 The existing discharges from the site should be verified to establish where the existing flows currently discharge. This will be need to be carried out prior to submission of an application to allow verification by Yorkshire water and the land drainage authority that the status quo is being maintained for this site. Yorkshire Water are unlikely to reduce any requirement for storm water storage if the drainage for the site is not proven. An onsite drainage investigation using CCTV techniques will be required to establish current drainage systems and routes. They would wish the developer to follow the hierarchy of the requirements of H3 of the Building Regulations 2000. The preferred hierarchy being soak-aways, infiltration systems and watercourses or main sewers, in that priority order.

4.0 PROPOSED DEVELOPMENT

4.1 The proposed development is for residential development. It is envisaged the whole development could amount to approx. 30 detached, semi-detached and terrace townhouses with associated roads and car parking areas.

4.2 The site has been previously developed and examination of the historic plans shows the site occupied by saw mills and a small chemical works in 1892. This plan also shows a small reservoir on the north-eastern corner and the route of the Dearne and Dove Canal appears to have run through the southern area of the site. This may explain why the southern area of the site has remained undeveloped. There was also a railway to the south of the site which has now been removed. The presence of the reservoir would suggest that there may be surface water culverts or land drainage systems on the site. Obviously further investigation of the onsite drainage is a requirement to enable detail design of future drainage systems.

5.0 PROPOSED SURFACE WATER DRAINAGE

5.1 In the first instance the use of soakaways and infiltration systems should be investigated and if these appear to be unsuitable based on the infiltration tests then alternative systems can be investigated. Whilst the site has previously been developed the un-attenuated surface water run off from this site could overload the downstream sewers and/or land drainage catchment. Therefore discharges should be managed by the use of surface water storage systems. The site currently does have some existing impermeable areas relating to the roofs and hard paved areas. The current point of discharge of these is not verified at this time. If they do not connect to the land drainage system at some point then the site would have to be designed too achieve agricultural discharge rates. These would be around the 5 lit/sec/ha. Further discussions with Yorkshire Water, and Barnsley MBC - Land Drainage Department, and the Environment Agency will be necessary to formerly agree discharge rates. The estimated discharges from the site would probably result in a maximum allowable discharge of approx 10 lit/s for the whole site. This would be pro-rata to 5lit/sec/ha.

5.2 The flows will be controlled by a hydraulic flow device such as a Hydrobrake or similar. This would mean that storm-water storage would have to be provided on site. Prior to this however a point of discharge to a surface water sewer or watercourse would have to be agreed with a right to discharge in perpetuity granted. This may entail making agreements with third parties and riparian owners of the watercourses. The EA would /may also need to approve any such discharge rate and water quality.

5.3 Due to the small nature of the site and the land uptake required it is proposed to provide storage in oversize pipes or a tank at the lower eastern end of the site. This will be designed to cater for storms up to and including the 100year storm with due allowances for climate change. In accordance with NPPF this would mean an extra 20-30% based on the site usage and possible duration of development. The levels of the outfall discharge points to the surface water sewers may mean that ground levels in the south west corner of the site may need to be raised on site to allow gravitational discharges for these areas. Alternatively they may have to be pumped from a surface water pumping station. The ground raising could be as much as 2m to provide cover to drainage systems if the site could not discharge to the sewers to the east of the site.

5.4 The sizes of the storm water storage facilities would need to determined accurately in the final designs but preliminary calculations have been made and are attached to this report in appendix D. The existing paved areas amount to an area of 14835 sq.m. This would give an annual storm peak discharge of 206 lit / sec. Normally a 30% reduction in peak flows would be required but as the whole site may not connect to the systems we would suggest a figure of 80lit/sec should be taken for estimating purposes. If the system is shown not to connect, then discharges would have to be down to agricultural rates of around 10 lit/sec. These show that the volumes of storage required for the reduced run off would be 89cum for the 30 year storm, 136cum for the 100 year storm and, 193 cu.m for the 100 year storm with 30% allowance for climatic change. For the agricultural discharges the volumes of storage required for the reduced run off would be 303cum for the 30 year storm, 435cum for the 100 year storm and, 580 cu.m for the 100 year storm with 30% allowance for climatic change. This is all in accordance with the National Planning policy Framework Technical guidance issued in March

2012 and previously in NPPF. The volumes of storage for the 100 year and 100 year plus climate change can include flooding to roads and designated areas but must ensure that no buildings are flooded. The most economic way of providing this would be in detention basins but these do take up significant areas of land and on a small site such as this become uneconomic leaving the land undevelopable. It is therefore proposed to provide all of the storage in oversize pipes or a underground tank at the eastern end of the site.

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

5.6 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. The systems can also be adopted as part of the Public Sewer systems.

6.0 FLOOD RISK

6.1 The site currently falls with flood zone 1 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 appropriate.

6.2 Due to the size of the development over 1Ha it will be necessary to prepare a site Specific Flood risk Assessment for the site.

6.3 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.

6.4 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.

6.5 Based on the published Environment Agency Flood Risk Maps the site does not fall within the 0.1% Flood Risk nor does it fall within the 1% Flood Risk area. The site therefore falls within the low probability zone 1. The proposed residential development falls within the More Vulnerable Classification in Table 02 Technical Guidance to NPPF. The sequential test is therefore considered passed and development is considered appropriate in accordance with Table 3 Technical Guidance to NPPF.

6.6 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.

6.6.1 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.

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

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

6.6.4 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.

6.7 Discussion of Flood risks

6.7.1 Flood Risk from Watercourses, River & Tidal

6.7.2 Although the River Dove runs close to the site the site appears not to fall within the 1% probability Flood Risk Maps as published by the Environment Agency nor does it fall within the 0.1% Flood Risk Area. The site is therefore considered not at risk from fluvial flooding.

6.7.3 The site falls from west to east and from north to south. The nearest watercourse is some 4m below the lowest level of the site and there are no recorded flood events on site.

6.7.4 The site falls outside all recorded flood zones from fluvial sources. The risk of flooding from river or tidal water is therefore considered acceptable for the type of development.

6.8 Risk of Flooding from overland flows from adjacent land.

6.8.1 The site lies on a sloping site with residential development to three sides. To the south of the site the land is substantially lower than the site. To the north the adjacent development is higher than the site and falls towards the site. The extent of land falling to wards the site is however very limited and would not generate significant overland flows towards the site.

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

6.8.3 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.

6.9 Risk of Flooding from Rainwater Falling on Site

6.9.1 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 attenuated to ensure no surcharging of systems down stream.

6.9.2 Storms up to the once in 100 year risk, and allowances to be made for climatic change, can be managed by the use of storm water storage systems. The design of these systems would be dependant on the agreed discharge for the site as noted earlier in this report. Suffice that the design can be detailed to cater for storm up to the 100 year return period with an allowance made for climatic change. This would currently suggest a 20 to 30% increase in flood water storage volume requirements. 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.

6.9.3 If the underlying ground is not suitable for percolation then the system should be made to connect to the existing surface water system. The discharge from this system would be limited to agreed l discharge rates. This may be 70% or existing annual storm discharges proved by investigation of the existing system or agricultural rates. If the discharge is limited to this level then it will be necessary to provide under ground storm water attenuation tanks on site. The storage system should be designed to cater for a 30 or 100 year storm and additional storage to cater for climatic change could be catered for above ground in designated flood areas such as car parks or shallow swales or public open spaces. The space for these would however be extremely limited and not considered as a suitable alternative for this site

6.9.4 The storage volumes can be provided by the use of oversized pipes or underground tanks as discussed earlier in this report. The flows would have to be controlled by a “Hydrobrake” or similar low maintenance flow control device. If these are provided the risk of onsite flooding from rainfall would be effectively controlled to acceptable levels.

6.9.5 The effects of the development on adjacent land should also be considered as part of this risk assessment.

6.9.6 The development of the site may increase the currently positively drained impermeable area of the site and hence increase the surface water run off from its current status. This in itself will increase the flood risk to adjacent properties and those in the downstream catchment if flows are not attenuated. The limitation on the current discharge, and/or the use of infiltration systems for the site, would reduce the off-site flood risk further to an acceptable level.

6.9.7 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.

7.0 CONCLUSIONS

7.1 In our opinion the site is not at risk of flooding from river or tidal water up to a 1% return period nor is it at risk for storms in excess of the 0.1% risk level.

7.2 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.

7.3 It would be necessary to provide storm water attenuation tanks on site to limit flows from the development. These may necessitate some the need for some ground raising to the southern half of the site to allow gravitational discharge from the site. Discharges would have to be limited to agricultural rates of discharge to ensure flood risks downstream are not increased if positive drainage from the site cannot be proved.

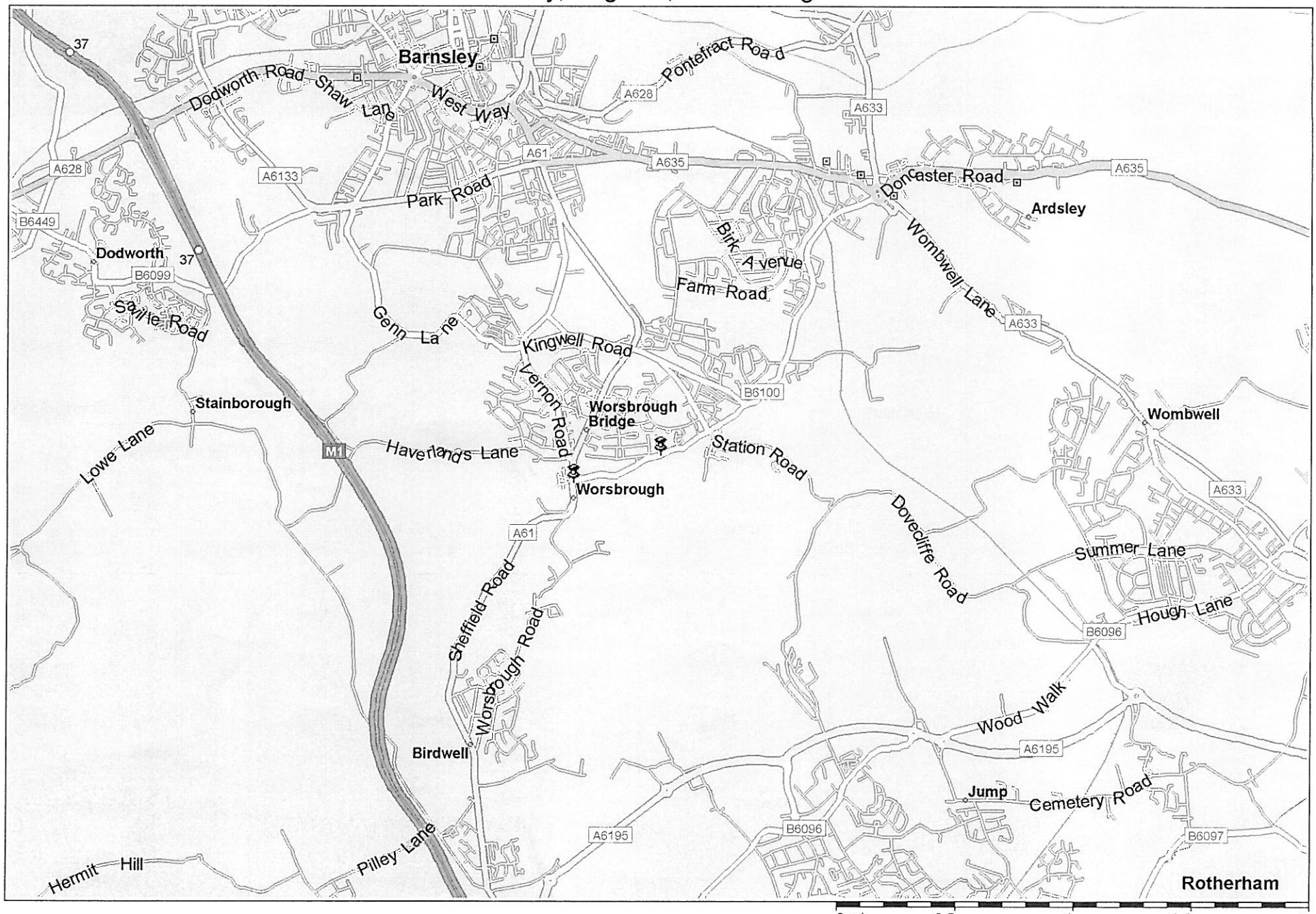
7.4 If the measures outlined above are implemented we would consider that the requirements of NPPF can be satisfied.

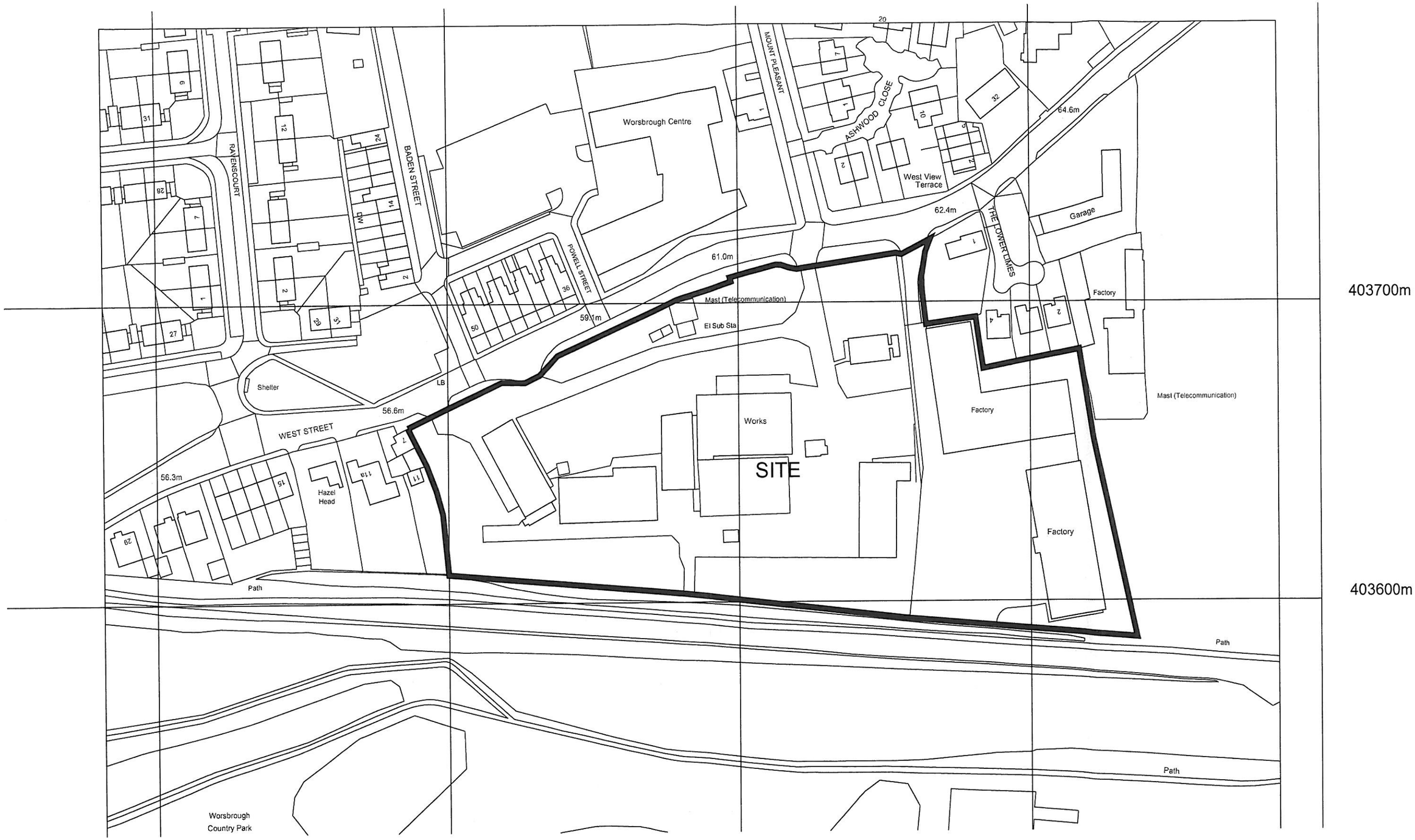
T.Haigh B.Sc., C.Eng., M.I.C.E.

APPENDIX A

LOCATION PLANS

Barnsley, England, United Kingdom





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e trevor.haigh@haighhuddleston.co.uk

Client	J R Paley Associates
Project	West Street, Worsborough
Detail	Site Location Plan

Scale	Dwn	Chkd	Date	Dwg No.
1:1250	MD		May '13	E13/5820/01

OS GRID REFERENCE 435900, 403650

APPENDIX B

AERIAL VIEWS

Google earth

feet 1000

meters 300

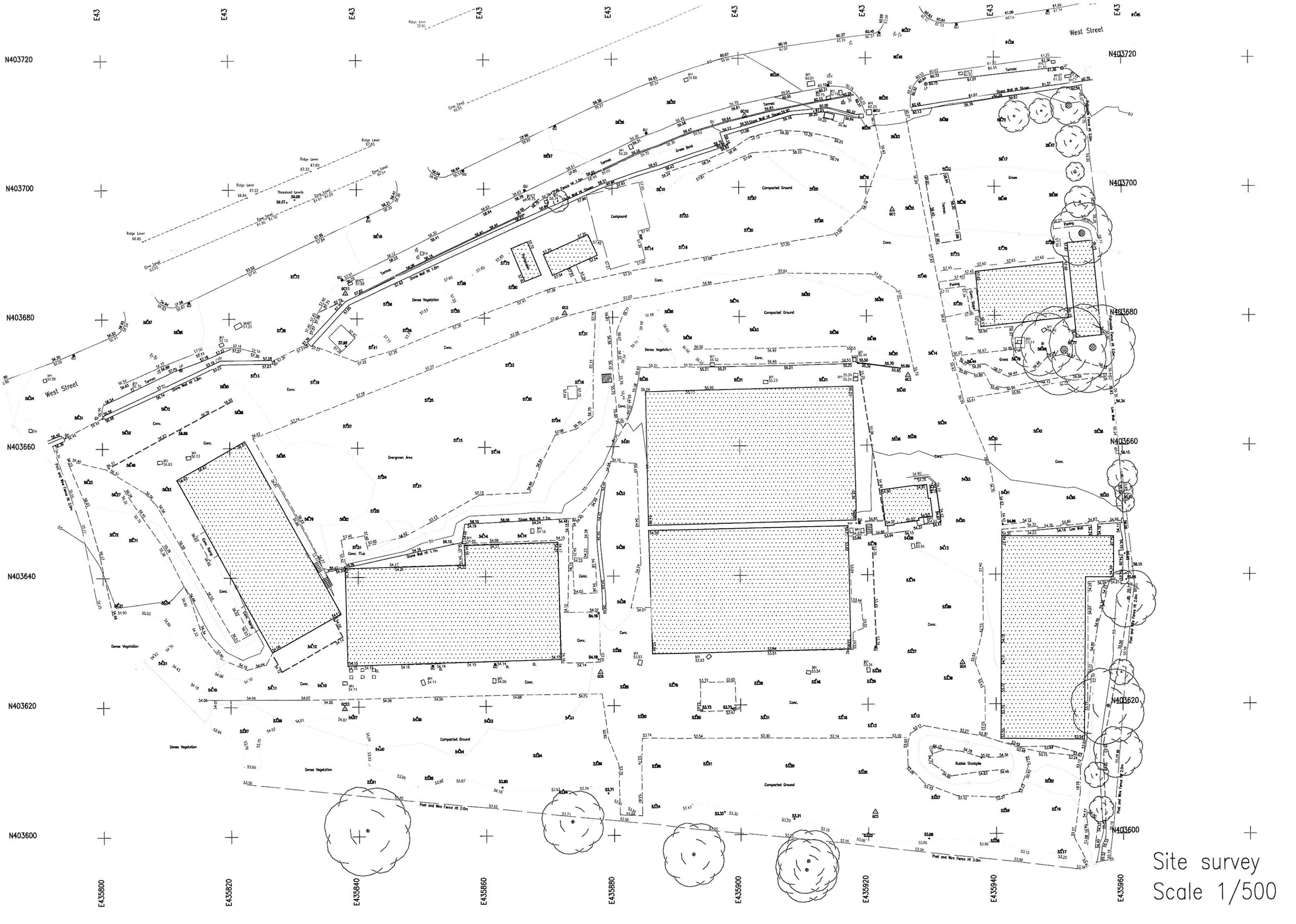
Google earth

feet 900

meters 200

APPENDIX C

EXISTING SITE SURVEY



Site survey
Scale 1/500

APPENDIX D

FLOOD RISK MAP

Environment Agency

Enter a postcode or place name: Barnsley, Barnsley Go

Other topics for this area... Risk of Flooding from Rivers and Sea

Risk of Flc

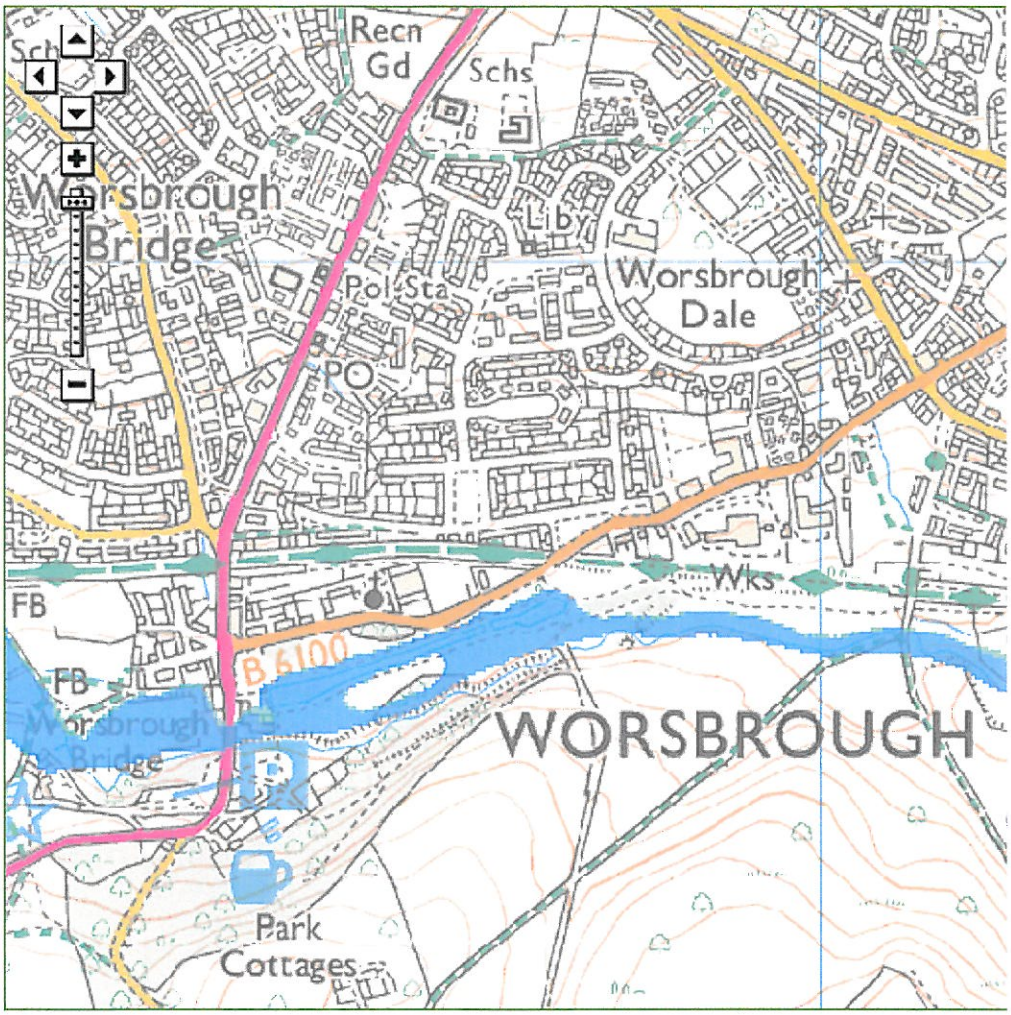
Map legend

Click on the map to see what is the Risk of Flooding at a particular location.

Flood Maps

- Flooding from rivers or sea without defences
- Extent of extreme flood
- Flood defences (Not all may be shown*)
- Areas benefiting from flood defences (Not all may be shown*)
- Main rivers

X: 435,904;Y: 403,673 at scale 1:10,000



More about flooding:

Understanding the flood map

A more detailed explanation to help you understand the flood map shown above.

Current flood warnings

We provide flood warnings online 24 hours a day. Find out the current flood warnir

APPENDIX E

YORKSHIRE WATER DRAINAGE RECORDS

YorkshireWater

RECEIVED
03 JUN 2013
MWA

Yorkshire Water Services
Developer Services
Sewerage Technical Team
PO BOX 52
Bradford
BD3 7AY

Tel: 0845 120 8482
Fax: (01274) 372 834

Email:
Technical.Sewerage@yorkshirewater.co.uk

For telephone enquiries ring:

Kashif Khan on (0845)120 8482

29th May 2013

Haigh Huddleston & Associates
Firth Buildings
99-101 Leeds Road
Dewsbury
WF12 7BU

For the attention of Michael Dean

Your Ref: E13/5820
Our Ref: P006277

Dear Sir,

Land Off West Street, Worsborough - Pre-Planning Sewerage Enquiry P058440

Thank you for your enquiry received 3rd May 2013. Our charge of £77.00 (plus VAT) will be added to your account with us, reference MWA057. You will receive an invoice for your account in due course. Please find enclosed a complimentary extract from the Statutory Sewer Map. This indicates the recorded position of the public sewers. The following comments reflect our view, with regard to the public sewer network only, based on a 'desk top' study of the site:

Development of the site should take place with separate systems for foul and surface water drainage. The separate system should extend to the public sewer.

Foul water domestic waste should discharge to the 300 mm diameter public foul sewer in West Street, at a point adjacent to the site and/or the 450mm diameter public combined sewer in railway land to the south, at a point approximately 11 metres from the site.

From the information supplied, it is not possible to determine if the whole site will drain by gravity to the public sewer network. If the site, or part of it, will not drain by gravity, then it is likely that a sewage pumping station will be required to facilitate connection to the public sewer network. If sewage pumping is required, foul water discharge must not exceed 6 (six) litres per second.

The developer's attention is drawn to Requirement H3 of the Building Regulations 2000. This establishes a preferred hierarchy for surface water disposal. Consideration should firstly be given to discharge to soakaway, infiltration system and watercourse in that priority order.

Sustainable Drainage Systems (SUDS), for example the use of soakaways and/or permeable hardstanding etc, may be a suitable solution for surface water disposal appropriate in this situation. You are advised to seek comments on the suitability of SUDS in this instance from the appropriate authorities.

Where appropriate, soakaways, swales and infiltration trenches (SUDS) may be adopted as part of the public sewer network. Further information may be seen in the DEFRA publication 'Interim Code of Practice for Sustainable Drainage Systems' (ISBN 0-86017-904-4). If the developer is considering adoption of SUDS they should contact our Developer Services Team on 0845 120 84 82.

The local public sewer network does not have capacity to accept any additional discharge of surface water from the proposal site. The developer is advised to contact the Environment Agency/local Land Drainage Authority with a view to establishing a suitable watercourse for discharge.

It is understood that a watercourse River Dove, is located through land approximately 75 metres to the south of the site. This appears to be the obvious place for surface water disposal.

As a last resort and subject to providing satisfactory evidence as to why the other methods of surface water disposal have been discounted, curtilage surface water discharges to the public sewer will be restricted to the level of run-off - i.e. same rate of discharge - to that from the existing use of the site minus a 30% reduction in the existing discharge. To maintain the "status quo" in the public sewer network, any discharge of surface water from the site should take place with similar rates of flow and/or measured areas discharging to similar points of connection to that of the existing use of the site. You will need to demonstrate positive drainage, based on a 1 in 1 year storm, to the public sewer to Yorkshire Water by means of investigation and calculation carried out at your expense.

To do this, Yorkshire Water requires to see existing and proposed drainage layouts with pipe sizes, gradients and connection points, measured impermeable areas of the present and proposed use of the site, along with the calculations that show the existing and proposed discharge rate from the site to the public sewer.

Please note further restrictions on surface water disposal from the site may be imposed by other parties. You are strongly advised to seek advice/comments from the Environment Agency/Land Drainage Authority, with regard to surface water disposal from the site.

Prospectively adoptable sewers and pumping stations must be designed and constructed in accordance with the WRc publication "Sewers for Adoption - a design and construction guide for developers" 6th Edition as supplemented by Yorkshire Water's requirements, pursuant to an agreement under Section 104 of the Water Industry Act 1991. An application to enter into a Section 104 agreement must be made in writing prior to any works commencing on site. Please contact our Developer Services Team (telephone 0845 120 84 82) for further information.

The public sewer network is for domestic sewage purposes. This generally means foul water for domestic purposes and, where a suitable surface water or combined sewer is available, surface water from the roofs of buildings together with surface water from paved areas of land appurtenant to those buildings. Land and highway drainage have no right of connection to the public sewer network. No land drainage to be connected/discharged to public sewer.

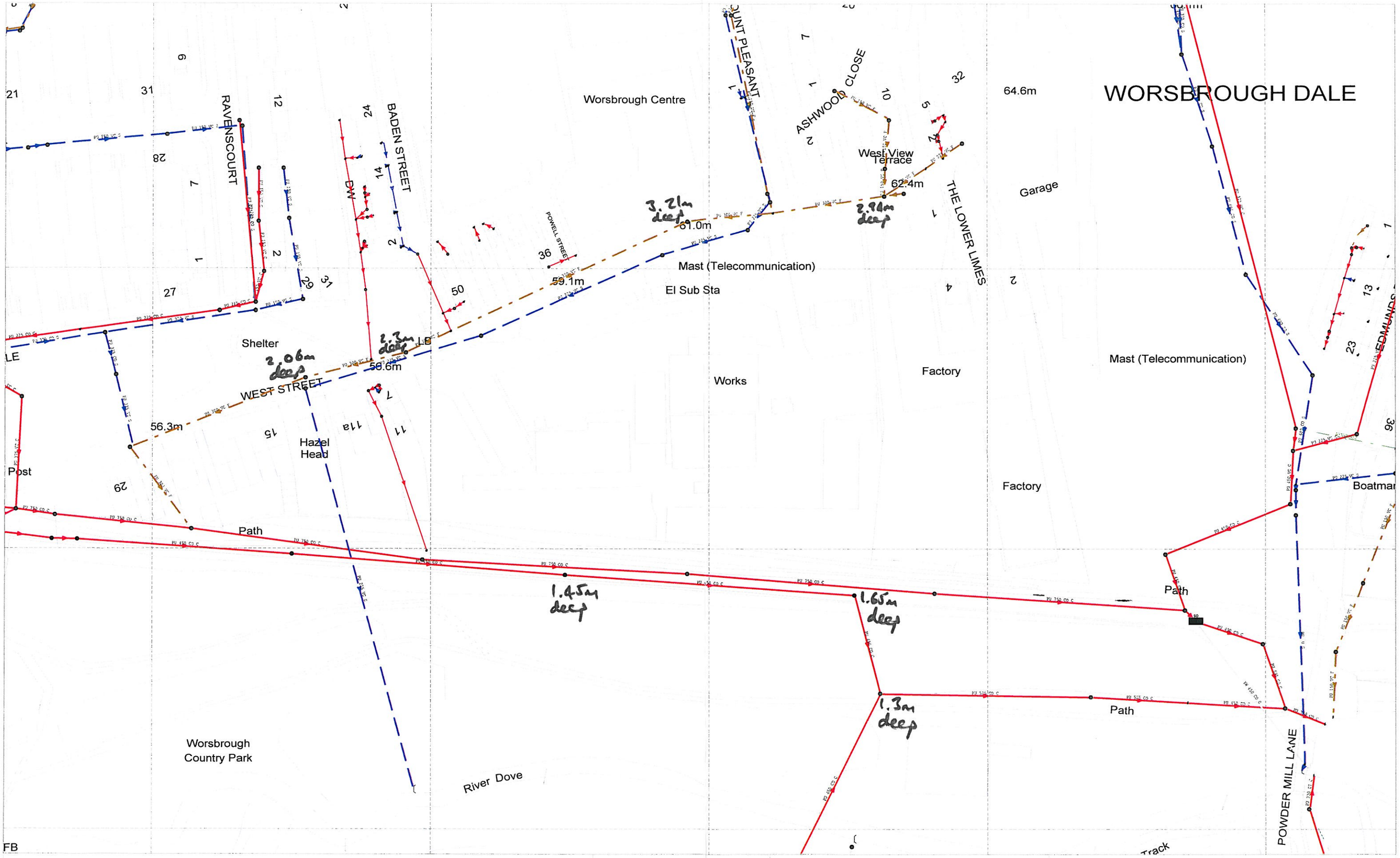
As a last resort, highway drainage may be accepted under certain circumstances. If it can be demonstrated, through satisfactory evidence, that SUDS are not a viable option, there are no watercourses or highway drains available and if capacity is available within the public sewer network, highway drainage discharges to the public sewer network may be permitted. In this event, the developer may be required to enter into a formal agreement with Yorkshire Water Services under Section 115 Water Industry Act 1991 to discharge non-domestic flows into the public sewer network.

Any new connection to an existing public sewer will require the prior approval of Yorkshire Water. You may obtain an application form from our website (www.yorkshirewater.com) or by telephoning 0845 120 84 82.

All the above comments are based upon the information and records available at the present time. The information contained in this letter together with that shown on any extract from the Statutory Sewer Map that may be enclosed is believed to be correct and is supplied in good faith. Please note that capacity in the public sewer network is not reserved for specific future development. It is used up on a 'first come, first served' basis. You should visit the site and establish the line and level of any public sewers affecting your proposals before the commencement of any design work.

Yours faithfully

Developer Services Team



FB

435723 : 403538

Map Name : SE3503SE

Yorkshire Water,
PO Box 500,
Halifax Road,
Bradford BD6 2LZ
Contact Name :
K KHAN
Contact Tel :

Title

Notes

Partial Key

Foul Sewer = F
Combined Sewer = C
Surface Water Sewer = SW
Trade Sewer = TD
Partially Separate = PS

Date Req : 29/05/2013, 12:28:59

Source : Sewer Network Enquiry

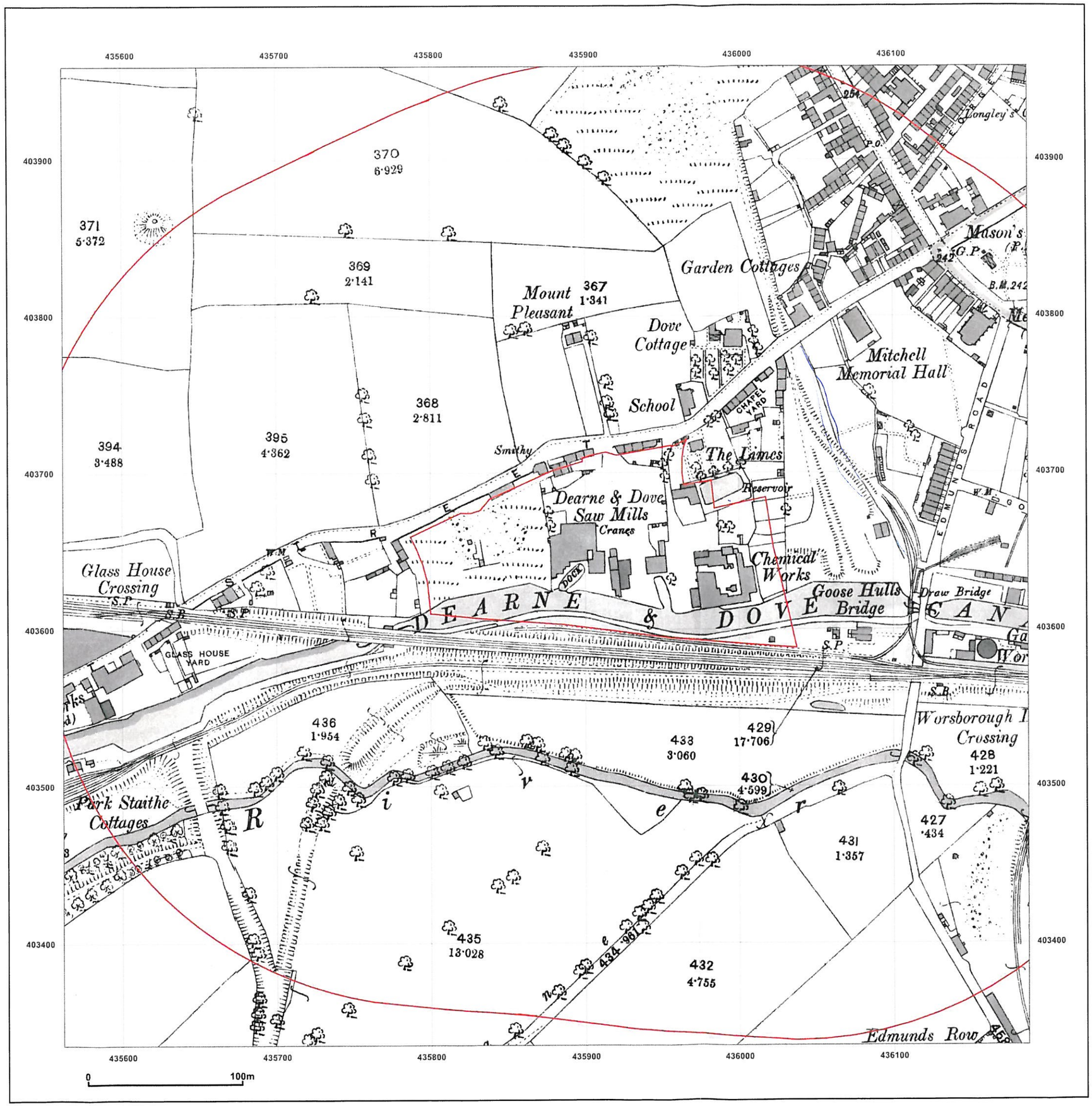
Date Gen : 29/05/2013, 12:29:11

UPN: Undefined

Originator: K KHAN, New Development - Waste Water,

APPENDIX F

HISTORIC PLAN



GroundSure
ENVIRONMENTAL INSIGHT

Site Details:

LAND ADJACENT TO 7-9 WEST STREET,WORSBROUGH,BARNSLEY, S70 5PF

Client Ref: 5820
Report Ref: GS-772218
Grid Ref: 435874, 403647

Map Name: County Series
Map date: **1892**
Scale: 1:2,500
Printed at: 1:2,500

N
W E
S

Surveyed 1892
Revised 1892
Edition N/A
Copyright N/A
Levelled N/A

Ordnance Survey
Licensed Partner

Produced by
GroundSure Environmental Insight
T: 08444 159000
E: info@groundsure.com
W: www.groundsure.com

Production date: 01 May 2013

To view map legend click here *Legend*

APPENDIX G

STORMWATER STORAGE CALCULATIONS

HAIGH HUDDLESTON ASSOCIATES **Stormwater Storage Calculations**

Client **J R Paley**

Site **Worsborough** **Agricultural run off**

Design storm 100 M5-60 19 mm
r 0.35
Site area sq m. 21470
Imp Area sq m. 9750
T of Conc min 4 Time to Flow
Allow Discharge 10 Lit / sec Imp Ratio 0.45

Storm Duration Mins	Intensity mm/hr	Depth mm	Vol In cu.m	Vol Out cu.m	Storage cu.m.	Q	t
10	81.8	13.63	132.93	8.29	124.63	221.72	0.2
20	59.8	19.93	194.35	14.25	180.10	162.09	0.2
30	47.6	23.80	232.05	20.21	211.84	129.02	0.3
50	34.4	28.67	279.50	32.14	247.36	93.24	0.4
60	30.3	30.30	295.43	38.11	257.32	82.13	0.5
120	18.7	37.40	364.65	73.93	290.72	50.69	0.8
180	14.1	42.30	412.43	109.77	302.65	38.22	1.0
240	11.5	46.00	448.50	145.63	302.87	31.17	1.3
300	9.8	49.00	477.75	181.50	296.25	26.56	1.5
360	8.7	52.20	508.95	217.38	291.57	23.58	1.7
420	7.9	55.30	539.18	253.28	285.90	21.41	1.9
480	7.5	60.00	585.00	289.22	295.78	20.33	2.0
540	6.9	62.10	605.48	325.12	280.36	18.70	2.1
600	6.38	63.80	622.05	361.01	261.04	17.29	2.3

Storage **302.87**

Length of 1800	119.02			
Length of 1500	171.40	Culvert	2.4*1.5m	84.13
Length of 1200	267.79	culvert	3.6*1.8m	46.74
Length of 1050	349.73	culvert	1.5*1.8m	134.61
Length of 900	476.21			
Length of 750	685.23			
Length of 600	1070.21			

100 year storm

Intensity mm/hr	Depth mm	Vol In cu.m	Vol Out cu.m	Storage cu.m.
101.27	16.88	164.56	8.29	156.27
74.03	24.68	240.61	14.25	226.35
58.93	29.46	287.28	20.21	267.06
42.59	35.49	346.02	32.14	313.88
37.51	37.51	365.74	38.11	327.63
23.15	46.30	451.44	73.93	377.51
17.46	52.37	510.58	109.77	400.81
14.24	56.95	555.24	145.63	409.61
12.13	60.66	591.45	181.50	409.96
10.77	64.62	630.08	217.38	412.70
9.78	68.46	667.50	253.28	414.22
9.29	74.28	724.23	289.22	435.01
8.54	76.88	749.58	325.12	424.46
7.90	78.98	770.10	361.01	409.09

Storage **435.01**

Length of 1800	170.948
Length of 1500	246.186
Length of 1200	384.625
Length of 1050	502.32
Length of 900	683.98
Length of 750	984.19
Length of 600	1537.14

100year plus 20% climate

Intensity mm/hr	Depth mm	Vol In cu.m	Vol Out cu.m	Storage cu.m.
121.52	20.25	197.47	8.29	189.18
88.84	29.61	288.73	14.25	274.47
70.71	35.36	344.73	20.21	324.52
51.10	42.59	415.23	32.14	383.08
45.01	45.01	438.88	38.11	400.78
27.78	55.56	541.72	73.93	467.80
20.95	62.84	612.70	109.77	502.93
17.08	68.34	666.29	145.63	520.66
14.56	72.79	709.75	181.50	528.25
12.92	77.55	756.10	217.38	538.71
11.74	82.15	801.00	253.28	547.72
11.14	89.14	869.08	289.22	579.86
10.25	92.26	899.49	325.12	574.38
9.48	94.78	924.12	361.01	563.11

Storage **579.86**

Length of 1800	227.868
Length of 1500	328.159
Length of 1200	512.694
Length of 1050	669.58
Length of 900	911.724
Length of 750	1311.89
Length of 600	2048.96

	Footprint Area (m)					
Aquacell Storage Crates	797.026	30 year	Pond 900mm deep	336.522	30 year	11m swale	50.5	30 year
(400mm deep)	1144.765	100 year		483.345	100 year		72.5	100 year
	1525.938	100 year plus climactic		644.285	100 year plus climatic		96.6	100 year plus climatic

HAIGH HUDDLESTON ASSOCIATES **Stormwater Storage Calculations**

Client **J R Paley**

Site **Worsborough** **50% of existing runoff**

Design storm 100 M5-60 19 mm
r 0.35
Site area sq m. 21470
Imp Area sq m. 9750
T of Conc min 4 Time to Flow
Allow Discharge 80 Lit / sec Imp Ratio 0.45

Storm Duration Mins	Intensity mm/hr	Depth mm	Vol In cu.m	Vol Out cu.m	Storage cu.m.	Q	t
10	81.8	13.63	132.93	60.27	72.65	221.72	1.4
20	59.8	19.93	194.35	105.72	88.63	162.09	2.0
30	47.6	23.80	232.05	151.29	80.76	129.02	2.5
50	34.4	28.67	279.50	242.73	36.77	93.24	3.4
60	30.3	30.30	295.43	288.50	6.93	82.13	3.9
120	18.7	37.40	364.65	564.90	-200.25	50.69	6.3
180	14.1	42.30	412.43	843.01	-430.58	38.22	8.4
240	11.5	46.00	448.50	1121.92	-673.42	31.17	10.3
300	9.8	49.00	477.75	1401.37	-923.62	26.56	12.0
360	8.7	52.20	508.95	1682.06	-1173.11	23.58	13.6
420	7.9	55.30	539.18	1963.47	-1424.29	21.41	14.9
480	7.5	60.00	585.00	2247.64	-1662.64	20.33	15.7
540	6.9	62.10	605.48	2529.07	-1923.60	18.70	17.1
600	6.38	63.80	622.05	2810.38	-2188.33	17.29	18.5

100 year storm

Intensity mm/hr	Depth mm	Vol In cu.m	Vol Out cu.m	Storage cu.m.
101.27	16.88	164.56	60.27	104.29
74.03	24.68	240.61	105.72	134.88
58.93	29.46	287.28	151.29	135.98
42.59	35.49	346.02	242.73	103.29
37.51	37.51	365.74	288.50	77.24
23.15	46.30	451.44	564.90	-113.46
17.46	52.37	510.58	843.01	-332.43
14.24	56.95	555.24	1121.92	-566.68
12.13	60.66	591.45	1401.37	-809.92
10.77	64.62	630.08	1682.06	-1051.98
9.78	68.46	667.50	1963.47	-1295.97
9.29	74.28	724.23	2247.64	-1523.41
8.54	76.88	749.58	2529.07	-1779.49
7.90	78.98	770.10	2810.38	-2040.28

100year plus 20% climate

Intensity mm/hr	Depth mm	Vol In cu.m	Vol Out cu.m	Storage cu.m.
121.52	20.25	197.47	60.27	137.20
88.84	29.61	288.73	105.72	183.00
70.71	35.36	344.73	151.29	193.44
51.10	42.59	415.23	242.73	172.50
45.01	45.01	438.88	288.50	150.39
27.78	55.56	541.72	564.90	-23.17
20.95	62.84	612.70	843.01	-230.31
17.08	68.34	666.29	1121.92	-455.63
14.56	72.79	709.75	1401.37	-691.63
12.92	77.55	756.10	1682.06	-925.97
11.74	82.15	801.00	1963.47	-1162.47
11.14	89.14	869.08	2247.64	-1378.57
10.25	92.26	899.49	2529.07	-1629.58
9.48	94.78	924.12	2810.38	-1886.26

			Storage	88.63		
Length of 1800	34.83					
Length of 1500	50.16	Culvert	2.4*1.5m	24.62	53.73	
Length of 1200	78.36	culvert	3.6*1.8m	13.68	29.85	
Length of 1050	102.34	culvert	1.5*1.8m	39.39	85.97	
Length of 900	139.35					
Length of 750	200.51					
Length of 600	313.17					

		Storage	135.98
Length of 1800	53.4378		
Length of 1500	76.957		
Length of 1200	120.233		
Length of 1050	157.02		
Length of 900	213.81		
Length of 750	307.65		
Length of 600	480.51		

			Storage	193.44
Length of 1800	76.0163			
Length of 1500	109.473			
Length of 1200	171.033			
Length of 1050	223.37			
Length of 900	304.149			
Length of 750	437.644			
Length of 600	683.529			

	Footprint Area (m)					
Aquacell Storage Crates	233.227	30 year	Pond 900mm deep	98.4737	30 year	11m swale	14.8	30 year
(400mm deep)	357.850	100 year		151.092	100 year		22.7	100 year
	509.049	100 year plus climactic		214.932	100 year plus climatic		32.2	100 year plus climatic