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FLOOD RISK ASSESSMENT

ON

Land at Former Fire Station
Manchester Road
Marsden,
Huddersfield,
West Yorkshire

FOR

S & B Homes Ltd

E17/7092/FRA001

December 2017

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

Haigh Huddleston Associates is the trading name of Haigh Huddleston Associates Limited
Registered Office: St Oswald House, St Oswald Street, Castleford, WF10 1DH
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 with Planning Practise Guidance- Flood Risk and Coastal Change April 2015 (PPG-FRCC) . 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 the former fire station, Manchester Road, Marsden. It is situated around Ordnance Survey grid reference 404939, 411461. A site location plan is included in Appendix A.

2.2 The site is irregular in shape and divided into four separate areas by steel palisade fences and concrete post and chain link fences. The overall site area is approximately 0.30ha.

2.3 The eastern half of the site is primarily overgrown hard standing with the single storey stone build fire station adjacent the northern boundary. There is vehicular access to this area from Manchester Road in the north eastern corner. In the north west corner is an area of overgrown gravels surrounded by a steel palisade fence. Vehicular access to this is from the property to the west.

2.4 In the south west of the site is a wooded area with pedestrian access through the dividing fences. A gas governor is located here in an area of hardstanding that is separated from the remainder of the site by a concrete post and chain link fence.

2.5 The eastern, southern and western boundaries are formed by a stone wall. The north western boundary with the property to the north west is formed in a mix of chain link fence, concrete panel fence and steel palisade fence.

2.6 The site slopes from east to west at an average grade of 1 in 53. A high point of approximately 188.500m AOD is located in the eastern corner of the site and a low point of approximately 186.86m towards the western corner.

3.0 EXISTING DRAINAGE

3.1 The nearest Public sewers are shown in Manchester Road although the Environmental report suggests that there is a surface water culvert crossing the site from east to west close to the frontage of the site. The levels and sizes of these sewers were likely to be reported by Yorkshire water as inadequate to drain the surface water from the redeveloped site without attenuation. They will most likely be suitable for foul flows from the site.

3.2 The surface water from the site would normally be required to connect into existing watercourses. A culverted watercourse is recorded crossing the site from north west to south east. This supposedly connects two lengths of un-named tertiary river. Recent on-site investigations utilising dye-testing on the upstream section of this water course have proved that the culvert passes to the north of Manchester Road, over 40m north of the position indicated in the Groundsure report. If this cannot be proved to cross the site, or other connecting drainage systems, within the vicinity of the site, then it will be necessary to prove the existing discharge from the site. If so proven, this would possibly allow a restricted discharge to the combined sewers subject to confirmation that this would be would be acceptable to Yorkshire water. If this cannot be achieved then there is a distinct possibility that this site may require an off-site requisitioned sewer.

4.0 PROPOSED DEVELOPMENT

4.1 The proposed development is for semi-detached and terraced houses with associated roads drives and car parking areas.

5.0 PROPOSED SURFACE WATER DRAINAGE

5.1 In the first instance the use of soakaways and infiltration systems appears to be not to be possible based on local knowledge of the area. The site is likely to be underlain by clays, overlying mudstones and grit stones at shallow depth. No infiltration testing has been carried out to date but trial pitting on a nearby site shows a depth of clay overburden in excess of 2m. Care would have to be taken to ensure that the drainage field will not introduce springs in the area due to the topography of the surrounding land. For these reasons the use of infiltration systems are considered unsuitable for this site.

5.2 Any un-attenuated surface water run off from this site would significantly affect the downstream catchment in either the combined sewers or the land drainage catchment system. Therefore discharges should be managed by the use of surface water storage systems and flow control systems. The site is a former fire station surrounded by a hard standing area to the side and rear. The roof area of the existing building discharges into a gully to the front of the building and the hard paved area falls towards several back inlet gullies to the rear of the fire station prior to discharging into the combined public sewer. Based on a 30% reduction of the existing impermeable area the estimated restricted discharge rate is 19lit/sec. We are currently in negotiations with Yorkshire Water to agree discharges rates to the combined public sewer.

5.3 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.

5.4 Due to the small nature of the site, and the land uptake required for storage basins of either type, it is proposed to provide storm-water storage in oversize pipes or an underground tank at the lower area of the site. The land up take for the slopes around a storage basin or pond would be prohibitive and severely reduce the developable area of the site such that it would not meet Planning Density requirements. The tank should be designed to cater for storms up to and including the 100year storm with due allowances for climate change. In accordance with PPG-FRCC this would mean an extra 30% based on the site usage and possible duration of development.

5.5 The sizes of the storm water storage facilities would need to determined accurately in the final designs but preliminary calculations have been made. This figure has been used in a simple spreadsheet to estimate the volume of storage required based on the existing site area of 3000sq.m and an estimated restricted discharge rate of 19 lit/sec. These show that the volumes of storage required would be 21cu.m for the 30 year storm, 32cu.m for the 100 year storm and 39cu.m for the 100 year storm with 30% allowance for climatic change. This is all in accordance with the Planning Practise Guidance- Flood Risk and Coastal Change April 2015 (PPG-FRCC). It is proposed to provide all of the storage in oversize pipes or an underground tank at the south eastern end of the site.

5.5 If on-site balancing and restricted discharges is utilised the change in flood 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 with zone 2 and 3 immediately adjacent to the western boundary as shown on the Environment Agency Websites. The development is classified as More Vulnerable in Table 2 of the Planning Practise Guidance- Flood Risk and Coastal Change April 2015 (PPG-FRCC) and table 3 of that document also states that the proposed residential development is appropriate.

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

6.3 There are a number of potential flooding mechanisms that PPG-FRCC 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. PPG-FRCC 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 PPG-FRCC, 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 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 east to west and from south to north. 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.

6.7.5 The EA flood risk maps show a risk of flooding from surface water flooding that the site is free from risk other than at low risk and then only just enters the site. If the culverts exist the risk is considered to be medium due to the steepness and limited nature of the catchment. A flood route through the site should be incorporated into the proposed site levels. To achieve this the road pattern should mimic the overland flood water route where possible. Houses fronting this road should be set approx. 350mm above the road level.

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 two sides. To the north and west of the site the ground levels are lower than the site. To the south and east the adjacent development is higher than the site and falls in parts towards the site. It is possible that these areas drainage systems pass through the site. Whilst there is a fall towards the site from the south and east the topographical catchment is small. The extent of land falling directly towards the site is therefore limited and would not generate significant overland flows towards the site.

6.8.2 The surrounding area to the south and east 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. Finished floor levels for the units should be a minimum of 300mm above back of kerb level.

6.8.4 There is a risk of overland flows if the sewerage system as to be surcharged, become blocked or suffered structural collapse. Storm water could leave the system and flow along the highways. The road kerbs would tend to direct the flows either to the east of the development. Floor levels should be set a minimum of 300mm above existing ground levels on the plot as a precautionary measure.

6.8.5 The volumes of water required to create sufficient flood levels to flow over Carrs Road to the south of the site would need to be very significant before any flows traversed the road into the adjacent residential housing. This is considered to be in excess of the 1% flood risk and the probability of over land flows from this source is considered a sufficiently low risk for the site.

6.8.6 The risk of flooding from reservoirs also needs to be considered. There are major reservoirs upstream of the site, namely Butterley, Blakeridge and Wessenden Head reservoir is situated some 1200m to the south west of the site and at a much higher elevation. The flood risk plans for reservoir breach shows the flood extents extending into the site from its western edge if a breach occurred. Buildings along this south western edge should be raised a minimum of 450mm above existing ground levels as a precaution. The probability of a breach of the dam is considered low due the requirements for regular inspection and maintenance of the reservoir under the Reservoirs Act.

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 medium to high due to the topography of the site. These flows would however need to be attenuated to ensure no surcharging of the offsite systems down-stream.

6.9.2 Storms up to the once in 100 year risk can be managed by the use of storm water storage systems which would have to incorporate allowances to cater for climatic change, currently 30 % for housing developments in this area. The design of these systems would be dependent 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. With this system in place the flows from the site into the surface water systems are considered acceptable.

6.9.3 If the underlying ground is not suitable for percolation then the system should be made to connect to the existing combined sewers crossing the site at a restricted rate of 19.0lit/sec, to be agreed with Yorkshire Water. If the discharge is to be limited to this level, then it will be necessary to provide underground storm water attenuation tanks on site. The storage system should be designed to cater for a 30 or 100 year storm. Additional storage of 30% 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 suitable 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. The development of the site would slightly increase the impermeable area of the site and hence 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 the use of infiltration systems for the site, would reduce the off-site flood risk further to an acceptable level. During the construction works the adjacent properties need to be protected from direct run off from the site due to loss of vegetation. The schemes should provide a construction phase scheme to limit run off from the site and capture any siltation before it enters the drainage system. This can be done by the installation of swales and bunds on the site boundary together with filtration pipes in swales to provide required storage and removal of silts from the overland flows. These could be left in situ to provide further protection in exceedance events.

6.9.6 We therefore consider the effects on flood risk to adjacent properties are not significantly affected by the proposed development.

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 not possible due to the infiltration capacity of the underlying ground and the strong possibility of ground water flows re-emerging due to the steep nature of the topography of the area. The infiltration capacity of the drainage field is not considered suitable for the development and therefore attenuation systems will be required.

7.3 It will be necessary to provide storm water attenuation tanks on site which may need ground raising to the north east corner of the site to allow gravitational discharge from

the site. Discharges would have to be limited to rates agreed with Yorkshire Water to ensure flood risks downstream are not increased.

7.4 The site is partially at risk of flooding from reservoirs but since this is evaluated around at the once in 100 year risk and possibly lower due the regular maintenance and inspection of the upstream reservoir.

7.5 If the measures outlined above are implemented we would consider that the requirements of PPG-FRCC can be satisfied.

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

APPENDIX A

LOCATION PLAN

Enviro Insight

Address:	**MANCHESTER ROAD, SLAITHWAITE, HUDDERSFIELD, HD7 5JX**
Date:	**13 Nov 2017**
Reference:	**GS-4463510**
Client:	**Haigh Huddleston & Associates**

NW N NE

W E

SW S SE

Aerial Photograph Capture date:	26-Mar-2012
Grid Reference:	404939,411461
Site Size:	0.30ha

Report Reference: GS-4463510
Client Reference: SB_HOMES_7092

APPENDIX B

TOPOGRAPHICAL SURVEY

0m	Scale 1:50	4m
0m	Scale 1:100	8m
0m	Scale 1:200	16m
0m	Scale 1:500	40m
0m	Scale 1:1250	100m

(When to scale of original plan bar = 8cm)

Former Fire Station

Emergency House

Gas Plant

Bus Shelter

1.3m high stone wall

2.4m high steel pallisade fence

1.5m high stone wall

2.4m high steel pallisade fence

2.4m high steel pallisade fence

2.4m high steel pallisade fence

concrete panel fence

chain link fence

2.4m high concrete post and chain link fence

2.4m high concrete post and chain link fence

2.4m high concrete post and chain link fence

stone wall

stone wall

steel pallisade fence over stone wall

max 2.0m high stone wall

STN1 E 971.240 N 2000.000 El 187.090

STN2 E 971.240 N 2000.000 El 187.090

STN3 E 1002.850 N 1986.630 El 187.400

STN4 E 1011.420 N 1959.940 El 188.140

STN5 E 979.170 N 1971.470 El 187.270

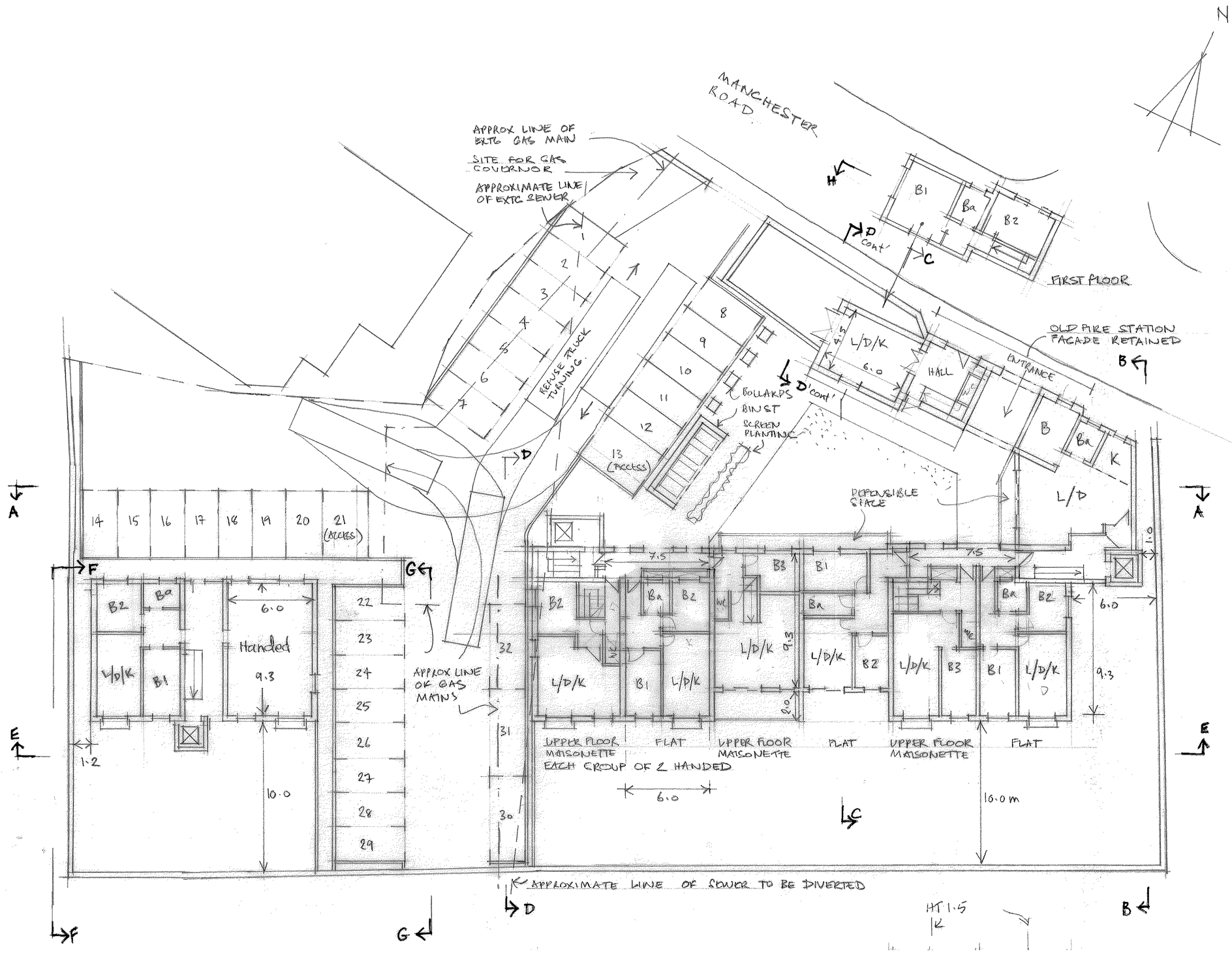
STN7 E 945.450 N 1952.550 El 186.800

NOTE:
1. Tree locations indicative only.
2. Perimeter of site is banked up with earth so not a true reflection of ground levels.

Sk 06 - Topographical Survey.
Former Fire Station, Manchester Road, Marsden.
Scale 1:200 @ A2.
November 2017.

APPENDIX C

PLANNING LAYOUT


N
MANCHESTER ROAD
APPROX LINE OF EXTG GAS MAIN
SITE FOR GAS GOVERNOR
APPROXIMATE LINE OF EXTG SEWER
H
B1
Ba
B2
D cont'
C
FIRST FLOOR
OLD FIRE STATION FACADE RETAINED
B
L/D/K
6.0
HALL
W.C
ENTRANCE
D cont'
BOLLARDS
BIN ST
SCREEN PLANTING
REFUSE TRUCK TURNING
D
1
2
3
4
5
6
7
8
9
10
11
12
13 (ACCESS)
14
15
16
17
18
19
20
21 (ACCESS)
A
F
G
E
B
K
L/D
DEFENSIBLE SPACE
7.5
1.0
6.0
9.3
B3
22
23
24
25
26
27
28
29
32
31
30
APPROX LINE OF GAS MAINS
Handed
1.2
10.0
UPPER FLOOR MAISONETTE
FLAT
UPPER FLOOR MAISONETTE
FLAT
UPPER FLOOR MAISONETTE
FLAT
EACH GROUP OF 2 HANDED
6.0
10.0 m
APPROXIMATE LINE OF SEWER TO BE DIVERTED
HT 1.5
D
F
G
B
E
A

APPENDIX D

YORKSHIRE WATER RECORDS

404786 : 411250	Map Name : SE0411SE	Title

Yorkshire Water,
PO Box 500,
Halifax Road,
Bradford BD6 2LZ
Contact Name :
Search Advisor H BROOK
Contact Tel : 75 4487

Notes

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

This plan is furnished as a general guide only and no warranty as to its correctness is given or implied. This plan must not be relied upon in the event of excavations or other works made in the vicinity of public sewers. No house or property connections are shown.

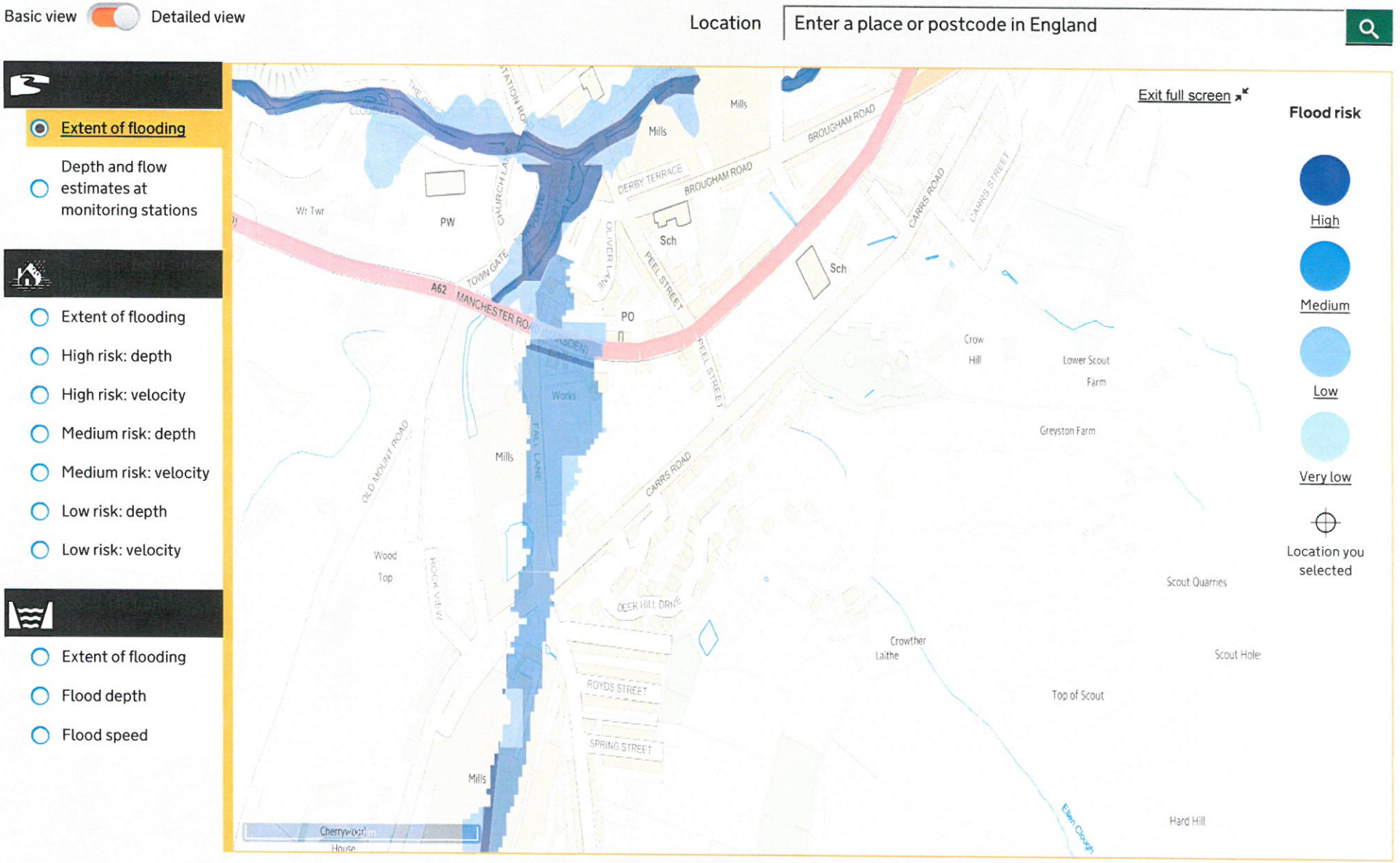
Date Req : 14/11/2017, 08:50:40
Source : Sewer Network Enquiry

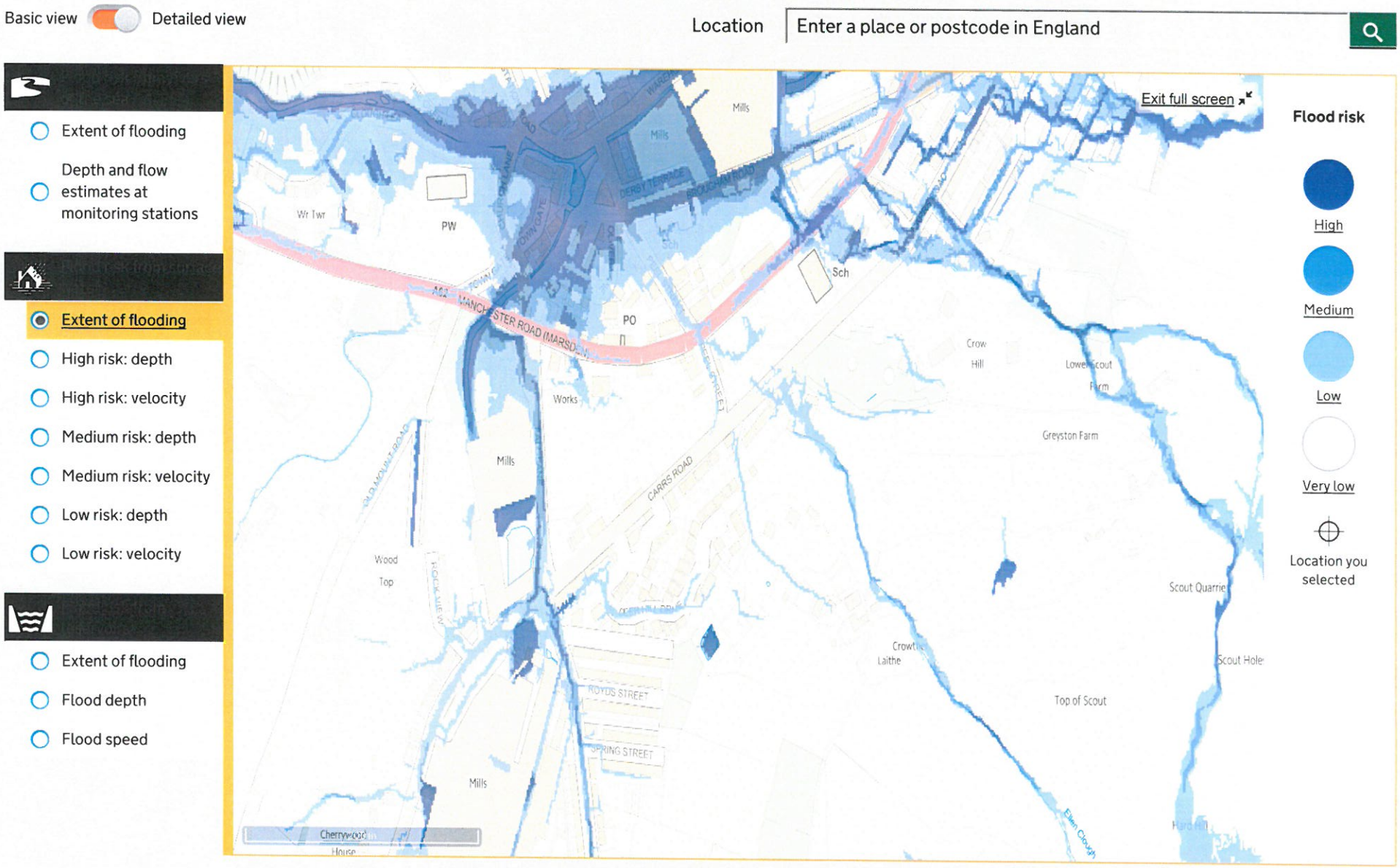
UPN: Undefined Originator: H BROOK, Safe-Move, 75 4487

APPENDIX E

FLOOD RISK MAPS

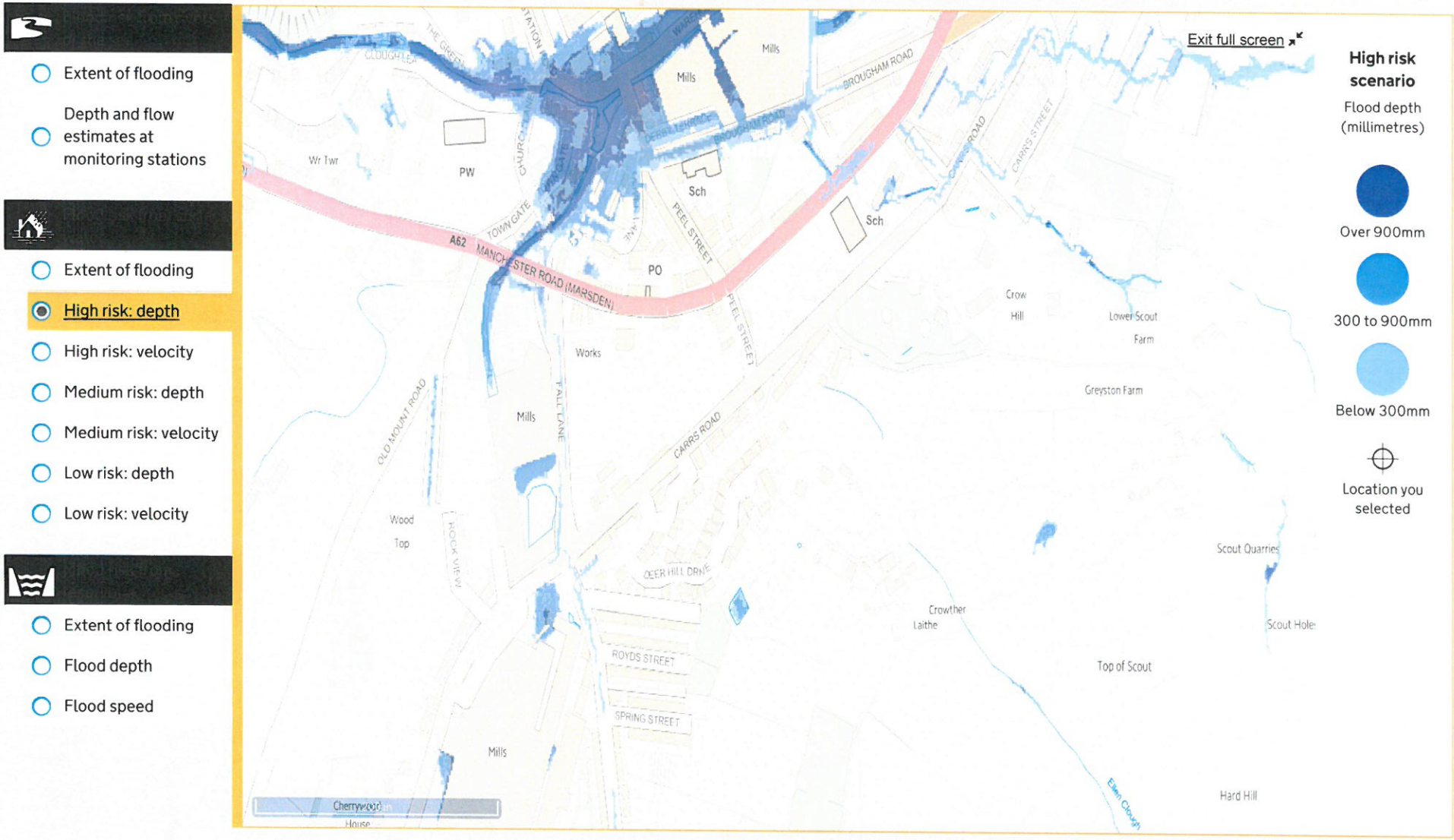

Exit full screen
Development location
Flood zone 3
Areas benefiting from flood defences
Flood zone 2
Flood zone 1
Flood defence
Main river
Flood storage area
Reddisher Farm
Rough Lee Farm
REDDISHER ROAD
Sta
Warehouse Hill
DIRKER DRIVE
HIGH LEA
PW
STATION ROAD
Mills
BROUGHAM ROAD
DERBY TERRACE
Sch
CHURCH LANE
Wr Twr
TOWN GATE
A62 MANCHESTER ROAD
PO
OLIVER LANE
FEEL STREET
CARRS ROAD
CARRS STREET
B6107
Piper Stones
arsden
Crow Hill
Lower Scout Farm
Greyston Farm
Manor House Farm
OLD MOUNT ROAD
FALL LANE
Wood Top
ROCK VIEW
DEER HILL DRIVE
Crowther Laithe
Scout Quarries
Scout Holes
50 m


Basic view
Detailed view
Location
Enter a place or postcode in England
Extent of flooding
Depth and flow estimates at monitoring stations
Extent of flooding
High risk: depth
High risk: velocity
Medium risk: depth
Medium risk: velocity
Low risk: depth
Low risk: velocity
Extent of flooding
Flood depth
Flood speed
Exit full screen
Flood risk
High
Medium
Low
Very low
Location you selected
A62
MANCHESTER ROAD
BROUGHAM ROAD
DERBY TERRACE
CARRS ROAD
CARRS STREET
PEEL STREET
TOWN GATE
OLIVER LANE
CHURCH LANE
OLD MOUNT ROAD
ROCK VIEW
DEER HILL DRIVE
ROYDS STREET
SPRING STREET
FALL LANE
Mills
Works
PO
Sch
PW
Wr Twr
Crow Hill
Lower Scout Farm
Greyston Farm
Wood Top
Crowther Laithe
Scout Quarries
Scout Hole
Top of Scout
Hard Hill
Ellen Clough
Cherrywood House


Basic view
Detailed view
Location
Enter a place or postcode in England
Extent of flooding
Depth and flow estimates at monitoring stations
Extent of flooding
High risk: depth
High risk: velocity
Medium risk: depth
Medium risk: velocity
Low risk: depth
Low risk: velocity
Extent of flooding
Flood depth
Flood speed
Exit full screen
Flood risk
High
Medium
Low
Very low
Location you selected
MANCHESTER ROAD (MARSD...
CARRS ROAD
ROYDS STREET
SPRING STREET
Mills
Works
Crow Hill
Greyston Farm
Scout Quarrie
Top of Scout
Scout Hole
Wood Top
Crowther Laithe
Ellen Clough
Cherrywood House

Basic view Detailed view

Location Enter a place or postcode in England



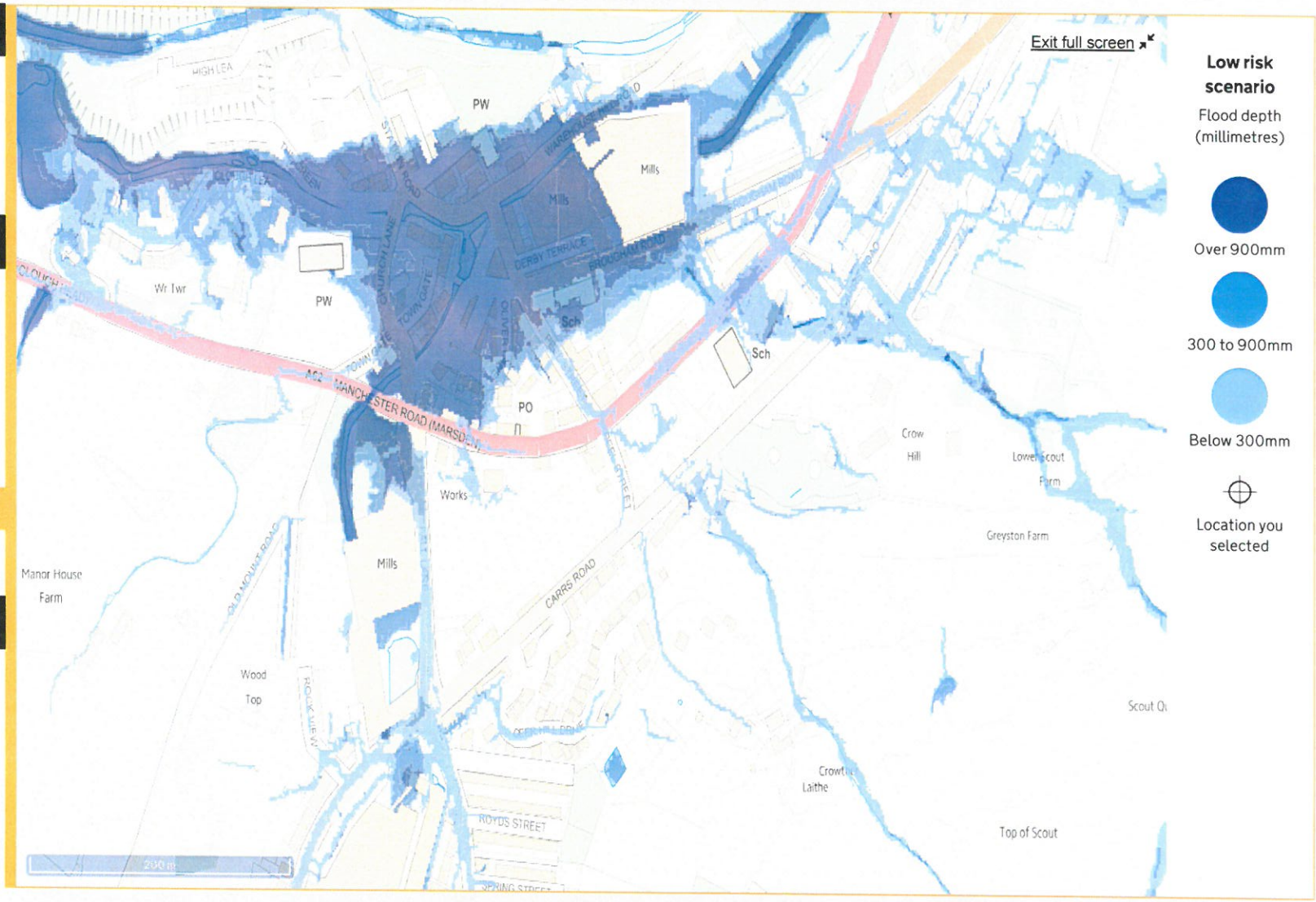
Basic view Detailed view

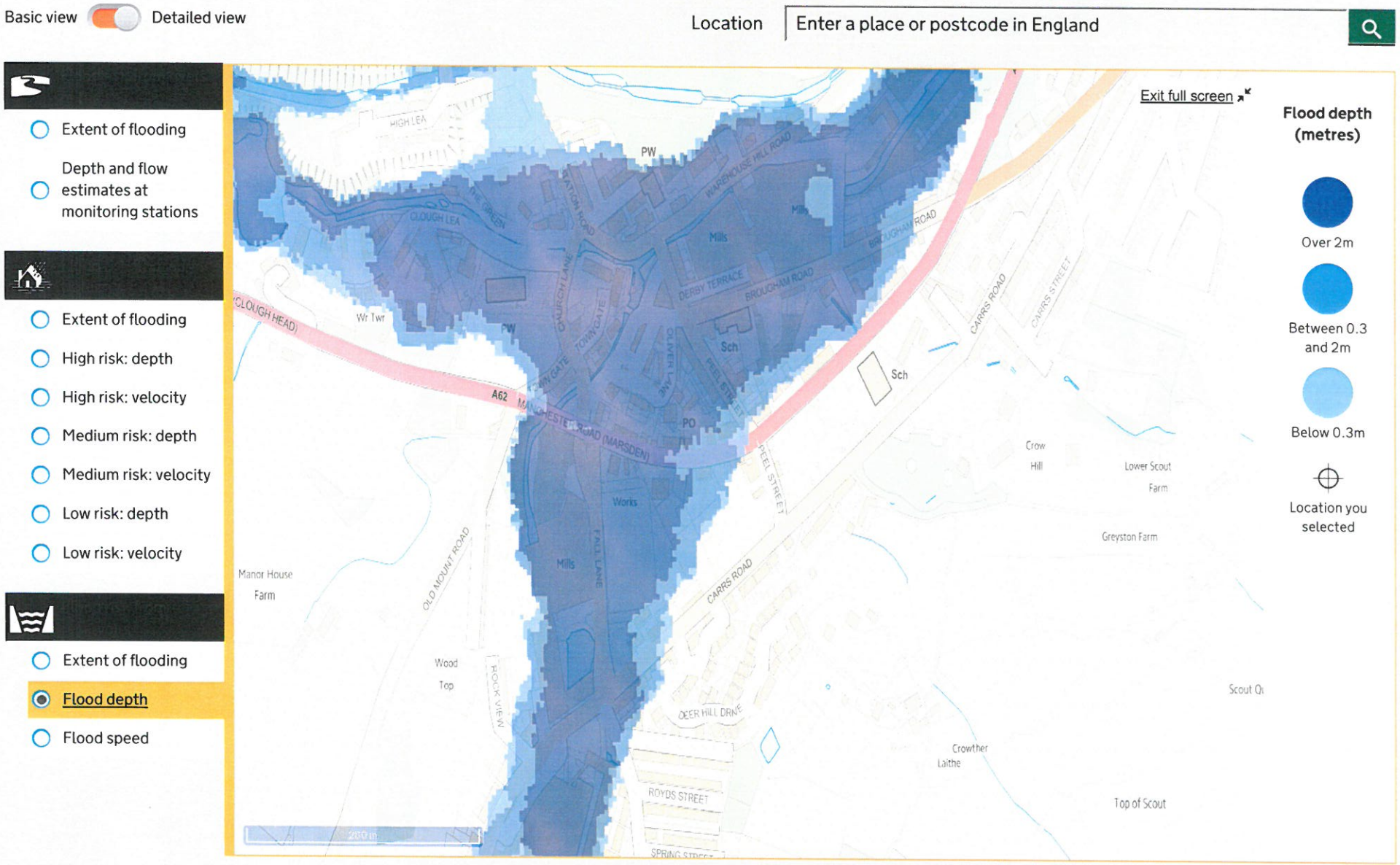
Location Enter a place or postcode in England

- Extent of flooding
- Depth and flow estimates at monitoring stations

- Extent of flooding
- High risk: depth
- High risk: velocity
- Medium risk: depth
- Medium risk: velocity
- Low risk: depth
- Low risk: velocity

- Extent of flooding
- Flood depth
- Flood speed




Basic view
Detailed view
Location
Enter a place or postcode in England
Extent of flooding
Depth and flow estimates at monitoring stations
Extent of flooding
High risk: depth
High risk: velocity
Medium risk: depth
Medium risk: velocity
Low risk: depth
Low risk: velocity
Extent of flooding
Flood depth
Flood speed
Exit full screen
Flood depth (metres)
Over 2m
Between 0.3 and 2m
Below 0.3m
Location you selected
A62
CLOUGH HEAD
MANCHESTER ROAD (MARSDEN)
CLOUGH LEA
HIGH LEA
WARREHOUSE HILL ROAD
BROUGHAM ROAD
DERBY TERRACE
CARRS ROAD
CARRS STREET
STATION ROAD
GAUKROOK LANE
TOWNGATE
OLD MOUNT ROAD
FALL LANE
PEEL STREET
ROCK VIEW
DEER HILL DRIVE
ROYDS STREET
SPRING STREET
Mills
Works
Sch
PO
PW
Wr Twr
Crow Hill
Lower Scout Farm
Greyston Farm
Manor House Farm
Wood Top
Crowther Laithe
Top of Scout
Scout Qr
250 m

APPENDIX F

STORMWATER STORAGE CALCULATIONS

Haigh, Huddleston Associates **Stormwater Storage Calculations** December 2017

Client **S B Homes** E17/ 7092

Site **Fire Station, Manchester Road, Marsden**

Design storm 100 M5-60 20 mm
r 0.37
Site area sq m. 3000 existing impermeable 1960 Annual peak flow l/s
Imp Area sq m. 2325 existing Discharge 27.244 lit/sec l/s
T of Conc min 5 Time to Flow
Allow Discharge 19.00 Lit / sec Imp Ratio 0.78

Storm Duration	Intensity	Depth	Vol In	Vol Out	Storage	Q	t	100 year storm Intensity	Depth	Vol In	Vol Out	Storage	100year plus climate Intensity	Depth	Vol In	Vol Out	Storage
Mins	mm/hr	mm	cu.m	cu.m	cu.m.			mm/hr	mm	cu.m	cu.m	cu.m.	mm/hr	mm	cu.m	cu.m	cu.m.
10	81.8	13.63	31.70	15.05	16.65	52.87	1.8	101.27	16.88	39.24	15.05	24.19	111.25	18.54	43.11	15.05	28.06
20	59.8	19.93	46.35	25.70	20.65	38.65	2.5	74.03	24.68	57.38	25.70	31.68	81.33	27.11	63.03	25.70	37.33
30	47.6	23.80	55.34	36.38	18.96	30.77	3.1	58.93	29.46	68.50	36.38	32.12	64.74	32.37	75.26	36.38	38.88
50	34.4	28.67	66.65	57.83	8.82	22.23	4.3	42.59	35.49	82.51	57.83	24.68	46.78	38.99	90.64	57.83	32.81
60	30.3	30.30	70.45	68.57	1.88	19.58	4.9	37.51	37.51	87.21	68.57	18.64	41.21	41.21	95.81	68.57	27.24
120	18.7	37.40	86.96	133.54	-46.58	12.09	7.9	23.15	46.30	107.65	133.54	-25.89	25.43	50.86	118.26	133.54	-15.28
180	14.1	42.30	98.35	199.02	-100.67	9.11	10.4	17.46	52.37	121.75	199.02	-77.26	19.18	57.53	133.75	199.02	-65.26
240	11.5	46.00	106.95	264.73	-157.78	7.43	12.8	14.24	56.95	132.40	264.73	-132.33	15.64	62.56	145.45	264.73	-119.28
300	9.8	49.00	113.93	330.60	-216.68	6.33	15.0	12.13	60.66	141.04	330.60	-189.56	13.33	66.64	154.94	330.60	-175.66
360	8.7	52.20	121.37	396.84	-275.48	5.62	16.9	10.77	64.62	150.25	396.84	-246.59	11.83	70.99	165.06	396.84	-231.78
420	7.9	55.30	128.57	463.29	-334.72	5.11	18.6	9.78	68.46	159.17	463.29	-304.12	10.74	75.21	174.86	463.29	-288.43
480	7.5	60.00	139.50	530.56	-391.06	4.85	19.6	9.29	74.28	172.70	530.56	-357.86	10.20	81.60	189.72	530.56	-340.84
540	6.9	62.10	144.38	597.02	-452.63	4.46	21.3	8.54	76.88	178.75	597.02	-418.27	9.38	84.46	196.36	597.02	-400.66
600	5.5	55.00	127.88	659.24	-531.36	3.55	26.7	6.81	68.09	158.31	659.24	-500.93	7.48	74.80	173.91	659.24	-485.33
900	4	60.00	139.50	989.81	-850.31	2.59	36.7	4.95	74.28	172.70	989.81	-817.11	5.44	81.60	189.72	989.81	-800.09
1200	3.2	64.00	148.80	1321.34	-1172.54	2.07	45.9	3.96	79.23	184.21	1321.34	-1137.12	4.35	87.04	202.37	1321.34	-1118.97
1440	2.8	67.20	156.24	1587.46	-1431.22	1.81	52.5	3.47	83.19	193.43	1587.46	-1394.03	3.81	91.39	212.49	1587.46	-1374.97

			Storage	20.65		Storage	32.12		Storage	38.88
Length of 1800	8.11				Length of 1800	12.6242		Length of 1800	15.2771	
Length of 1500	11.68	Culvert	2.4*1.5m	5.74	Length of 1500	18.1804		Length of 1500	22.001	
Length of 1200	18.26	culvert	3.6*1.8m	3.19	Length of 1200	28.4039		Length of 1200	34.3728	
Length of 1050	23.84				Length of 1050	37.10		Length of 1050	44.8911	
Length of 900	32.46				Length of 900	50.51		Length of 900	61.1253	
Length of 750	46.71				Length of 750	72.68		Length of 750	87.954	
Length of 600	72.96				Length of 600	113.52		Length of 600	137.37	
					lengthof 2400mm	7.10		lengthof 2400mm	8.59511	

tank 1500mm deep sq.m area of 500mm deep aquacrates
Area req'd 1 in 30 yr 13.76462963 Pond 900mm deep 22.941 30 year 30 year 41.29389
1 in 100 yr 21.41654658 35.6942 100 year 100 year 64.24964
1 in 100 yr + c/c 25.91712658 43.1952 100 year plus climatic 100 year plus 30% 77.75138 7.5 m square