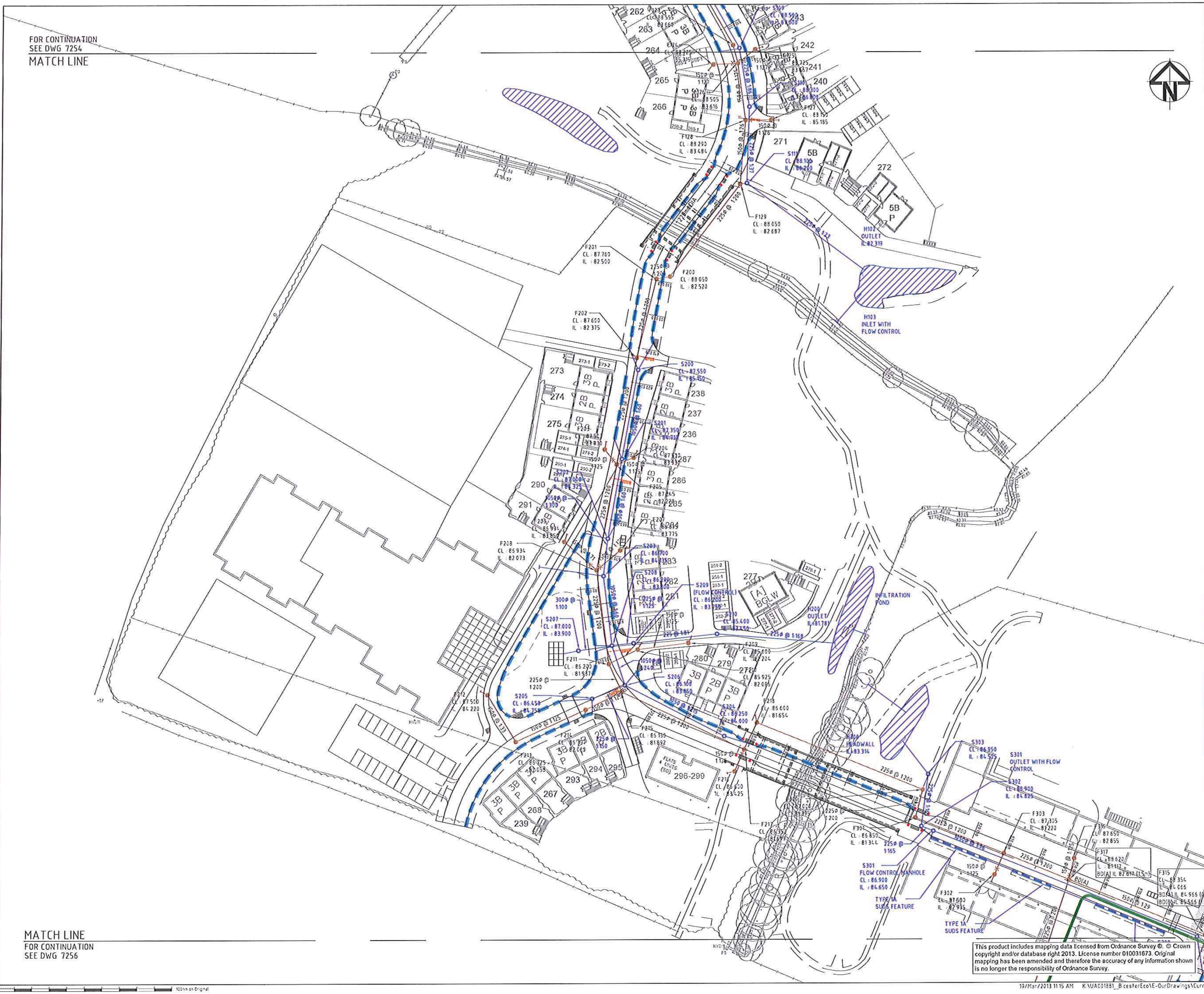


KEY

- SURFACE WATER DRAINAGE
- 150mm DIA PIPE FOUL WATER DRAINAGE
- ROADSIDE SUDS FEATURE
- KERB DRAINAGE (HYDROKERB)
- FOUL PUMPING MAIN
- MANHOLE WITH BACKDROP
- HEADWALL
- POND
- BASIN
- SWALE
- CELLULAR STORAGE

NOTES:
SCHEME TO BE LIT IN ACCORDANCE WITH OCC SPECIFICATIONS AND IN LINE WITH OCC CARBON FOOTPRINT LIGHTING PRACTICES OCC TO PROVIDE SCHEME LIGHTING LAYOUT AND DETAILS

1. DO NOT SCALE FROM THIS DRAWING USE FIGURED DIMENSIONS ONLY
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR PRIOR TO CONSTRUCTION OR MANUFACTURE ANY DISCREPANCIES TO BE REPORTED TO THE ENGINEER
3. ALL WORKS TO BE UNDERTAKEN IN ACCORDANCE WITH MCDHW - SPECIFICATION FOR HIGHWAY WORKS, SEWERS FOR ADOPTION AND O C C DETAILS AND SPECIFICATION

Issue	Description	Date
11	DRAINAGE NOTE REMOVED	21/01/13
10	HIGHWAY BOUNDARY AND DRAINAGE REVISED	05/11/12
09	GENERAL REVISIONS	19/10/12
08	MASTERPLAN REVISED	05/10/12
07	DESIGN REVISED	27/07/12
06	DESIGN REVISED	22/06/12
05	DESIGN REVISED	MAR 12
04	POND CONNECTIONS REVISED	21 10 11
03	DRAINAGE CHECK ISSUE	05 10 11
02	DESIGN REVISED	JULY 11

Status: DRAFT

Scales	1:500	Author M LLEWELLIN
Original Size	A1	Checker S ADAVIES
Height Datum	O.S.	Approver S ADAVIES
Grid	O.S.	© Copyright reserved

Filename: 7253-7256-UA001881-UP21D-S38-12-SPINE ROAD DRAINAGE DWG

Client: a2dominion

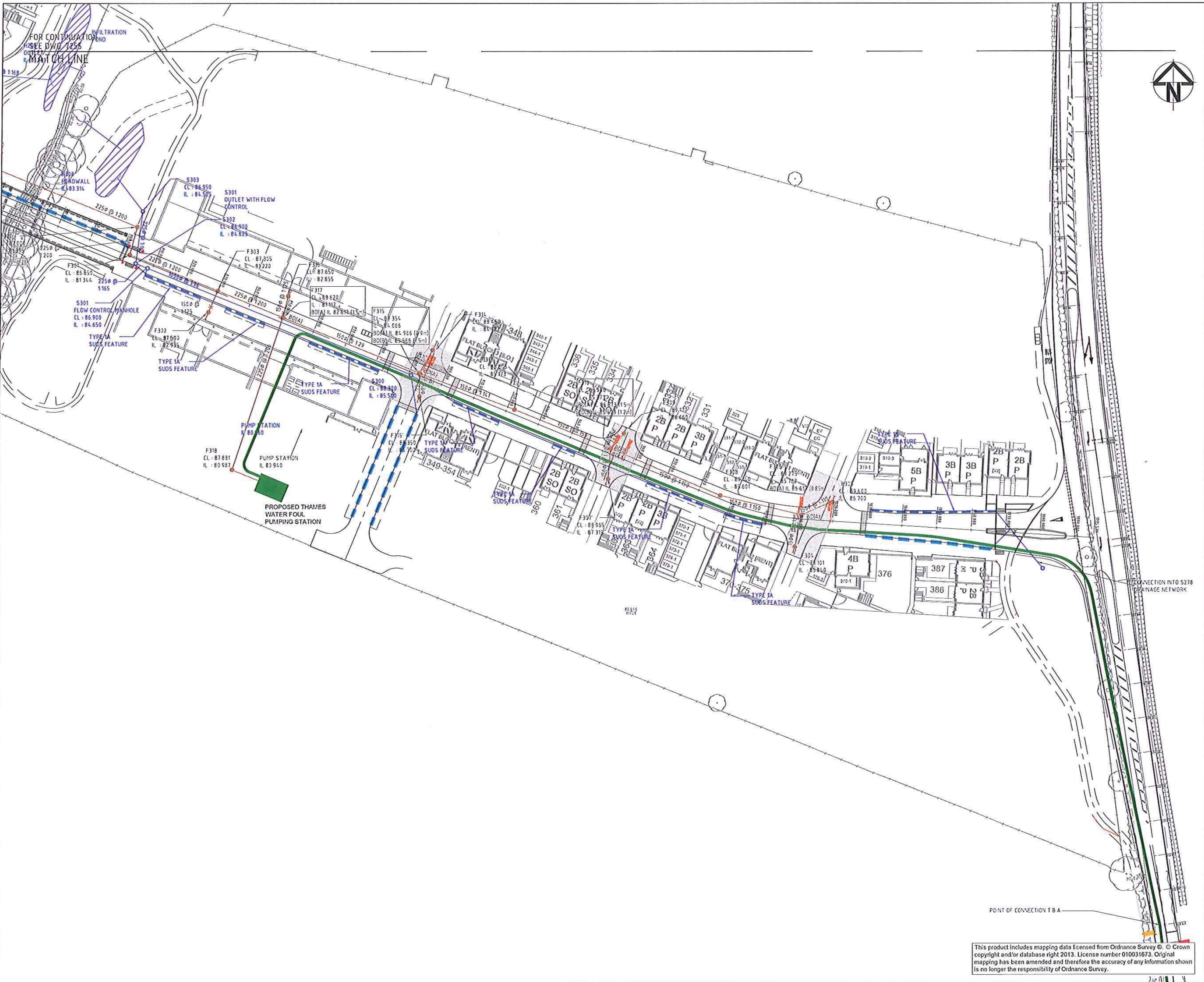
Hyder Consulting (UK) Limited
29, Bressenden Place
London
SW1E 5DZ
Tel: +44 (0)870 000 3006
Fax: +44 (0)870 000 3906

Project: BICESTER ECO DEVELOPMENT EXEMPLAR SITE

Title: EXEMPLAR SITE (S38) FOUL AND SURAFCE WATER DRAINAGE SHEET 3 OF 4

Drawing No 7255 — Project No UA001881 — Issue 11

CAD FILE: K:\UA001881_BicesterEco\E-OurDrawings\Current\Civil Engineering\7253-7256-UA001881-UP21D-S38-12-SPINE ROAD DRAINAGE.dwg
PRINTED BY: PW68098 - MARCH/19/2013 - 11:15AM UPDATED BY: PW68098 - MARCH/13/2013 - 2:28PM



This product includes mapping data licensed from Ordnance Survey ©. © Crown copyright and/or database right 2013. License number 010031673. Original mapping has been amended and therefore the accuracy of any information shown is no longer the responsibility of Ordnance Survey.

KEY

- SURFACE WATER DRAINAGE
- 150mm DIA PIPE FOUL WATER DRAINAGE
- ROADSIDE SUDS FEATURE
- KERB DRAINAGE (HYDROKERB)
- FOUL PUMPING MAIN
- MANHOLE WITH BACKDROP
- HEADWALL
- POND
- BASIN
- SWALE

NOTES
SCHEME TO BE LIT IN ACCORDANCE WITH OCC SPECIFICATIONS AND IN LINE WITH OCC CARBON FOOTPRINT LIGHTING PRACTICES OCC TO PROVIDE SCHEME LIGHTING LAYOUT AND DETAILS

1. DO NOT SCALE FROM THIS DRAWING USE FIGURED DIMENSIONS ONLY.
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR PRIOR TO CONSTRUCTION OR MANUFACTURE ANY DISCREPANCIES TO BE REPORTED TO THE ENGINEER
3. ALL WORKS TO BE UNDERTAKEN IN ACCORDANCE WITH MCDHW – SPECIFICATION FOR HIGHWAY WORKS, SEWERS FOR ADOPTION AND O C C DETAILS AND SPECIFICATION

Issue	Description	Date
11	HIGHWAY BOUNDARY REVISED	05/11/12
10	GENERAL REVISIONS	19/10/12
09	LAYOUT UPDATED & BACKDROPS ADDED	25/09/12
08	DESIGN REVISED	12/09/12
07	DESIGN REVISED	27/07/12
06	DESIGN REVISED	22/05/12
05	DESIGN REVISED	MAR 12
04	POND CONNECTIONS REVISED	21.10.11
03	DRAINAGE CHECK ISSUE	05.10.11
02	DESIGN REVISED	JULY 11

Status: DRAFT

Scales	1:500	Author M LLEWELLIN
Original Size	A1	Checker S A DAVIES
Height Datum	O.S.	Approver S A DAVIES
Grid	O.S.	© Copyright reserved

Filename 7253-7256-UA001881-UP21D-S38-12-SPINE ROAD DRAINAGE.DWG

Client: a2dominion

Hyder Consulting (UK) Limited
29, Bressenden Place
London
SW1E 5DZ
Tel: +44 (0)870 000 3006
Fax: +44 (0)870 000 3906

Project: BICESTER ECO DEVELOPMENT EXEMPLAR SITE

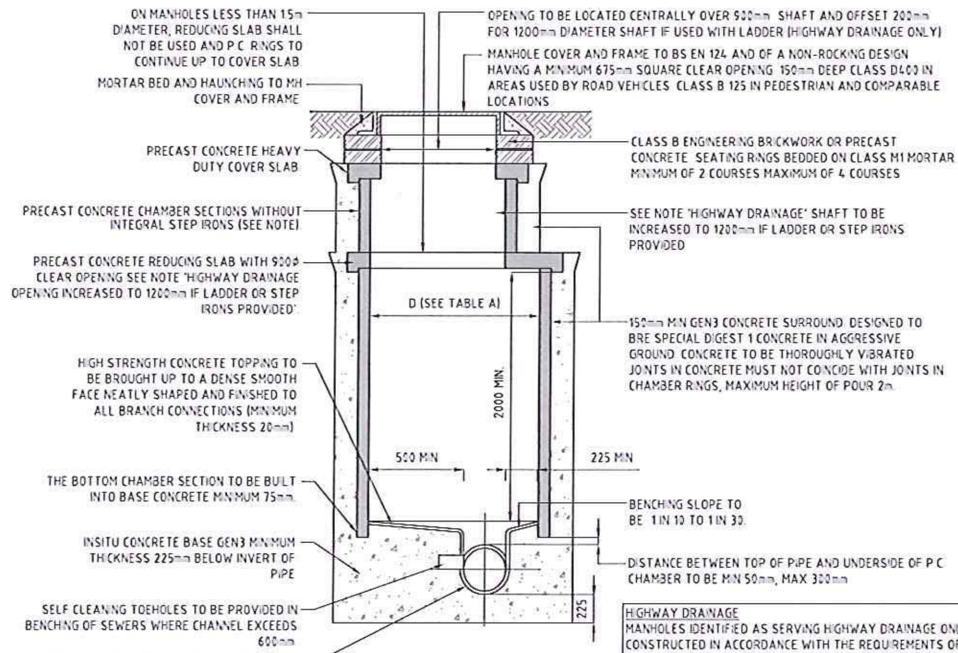
Title: EXEMPLAR SITE (S38) FOUL AND SURFACE WATER DRAINAGE SHEET 4 OF 4

Drawing No	Project No	Issue
7256	UA001881	11

CAD FILE : K:\UA001881_BicesterEco\E-OurDrawings\Current\Civil Engineering\7253-7256-UA001881-UP21D-S38-12-SPINE ROAD DRAINAGE.dwg
PRINTED BY PW68098 - MARCH/15/2013 - 11:16AM UPDATED BY PW68098 - MARCH/13/2013 - 2:28PM

100mm on Original

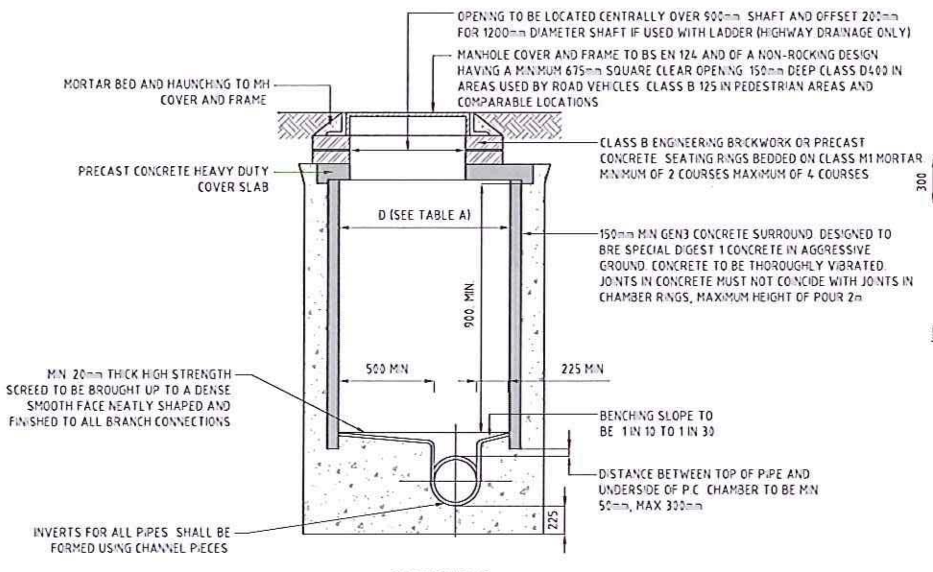
19/Mar/2013 11:16 AM K:\UA001881_BicesterEco\E-OurDrawings\Current\Civil Engineering\7253-7256-UA001881-UP21D-S38-12-SPINE ROAD DR.



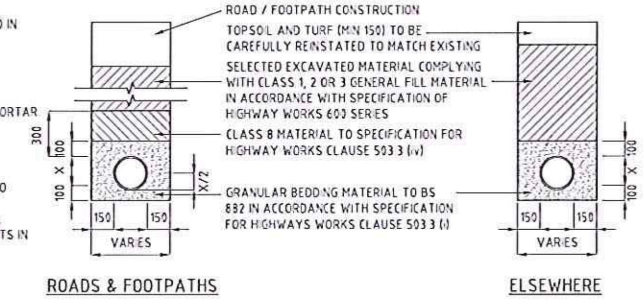
SECTION A-A

HIGHWAY DRAINAGE

MANHOLES IDENTIFIED AS SERVING HIGHWAY DRAINAGE ONLY SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS OF THE HIGHWAY AUTHORITY. THE CONTRACTOR SHALL CONSULT WITH THE HIGHWAY AUTHORITY AS TO WEATHER STEP IRONS ARE REQUIRED. THE MINIMUM SHAFT DIAMETER FOR USE WITH STEP IRONS IS 1200mm



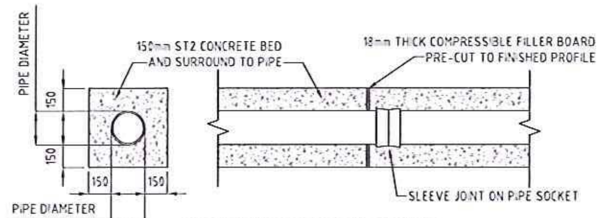
SECTION B-B



DETAILS OF SEWER CONNECTION

NOTES

1. ALL BACKFILL, PIPE BEDDING AND SURROUND MATERIAL SHALL BE IN ACCORDANCE WITH CESWI (5th EDITION) AND WIS 4-08-02
2. DIMENSION X IS THE EXTERNAL DIAMETER OF THE PIPE
3. THE MINIMUM OR MAXIMUM WIDTH OF THE TRENCH APPLIES ON AND BELOW A LINE 300mm ABOVE THE OUTSIDE TOP OF THE PIPE. ABOVE 300mm LINE THE TRENCH BACKFILL MATERIAL SHALL BE AS DESCRIBED INS CESWI AND WIS.



CONCRETE PROTECTION TO PIPES

ABSOLUTE MINIMUM COVER TO BE 600mm IN CARRIAGEWAY

NOTES

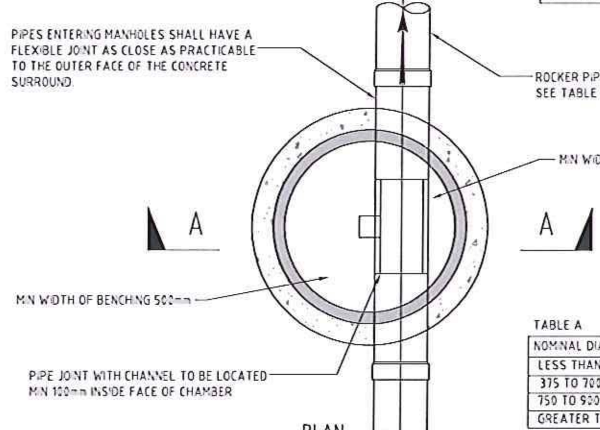
1. ANY GAP BETWEEN SPIGOT AND SOCKET SHALL BE FILLED WITH RESILIENT MATERIAL TO PREVENT ENTRY OF CONCRETE
2. ALL PIPES WITHIN THE PROPOSED ROADS ARE TO BE FILLED WITH WATER AND WHERE NECESSARY PROVIDED WITH SIDE RESTRAINTS PRIOR TO CONCRETE SURROUND BEING POURED TO ENSURE PIPES DO NOT FLOAT.

TABLE C

PIPE DIAMETER (mm)	GRANULAR MATERIAL SIZE (mm)
100	10mm NOMINAL SINGLE SIZE 1
150	0mm OR 14 mm NOMINAL SINGLE SIZE
150 to 500	10mm, 14 mm OR 20mm NOMINAL SINGLE SIZE
OVER 500	10mm, 14mm, 20mm OR 40mm NOMINAL SINGLE SIZE

NOTES

1. BACKFILL MATERIAL TO BE LAID IN MAXIMUM 250mm LAYERS LOOSE DEPTH AND COMPACTED
2. DIMENSION X IS THE EXTERNAL DIAMETER OF THE PIPE



PLAN

TABLE B

NOMINAL DIAMETER (mm)	EFFECTIVE LENGTH (mm)
150-600	600
601-750	1000
OVER 750	1250

ALL PIPES ENTERING THE BOTTOM OF THE MANHOLE TO HAVE SOFFITS LEVEL

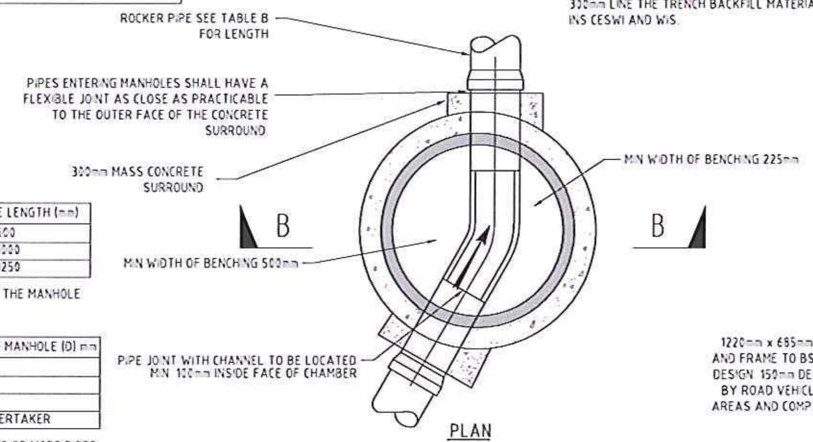
TABLE A

NOMINAL DIA OF SEWER(mm)	INTERNAL DIAMETER OF MANHOLE (D) mm
LESS THAN 375mm	1200
375 TO 700	1500
750 TO 900	1800
GREATER THAN 900	CONSULT UNDERTAKER

THE SIZES QUOTED IN TABLE A ARE A MINIMUM. IF TWO OR MORE PIPES ENTER THE MANHOLE THE SIZE SHOULD BE INCREASED TO ENSURE ADEQUATE BENCHING

MANHOLE TYPE A

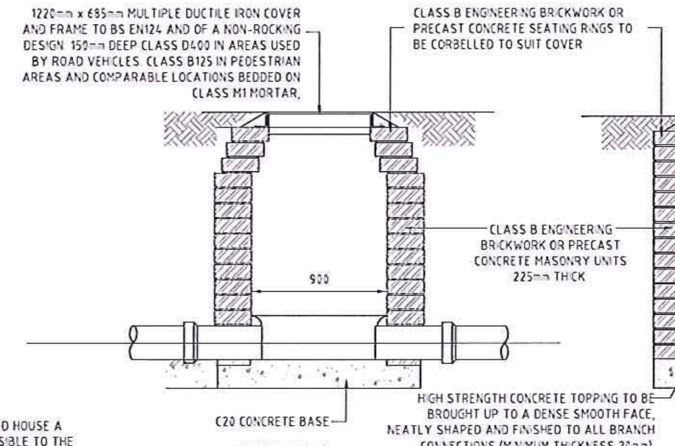
DEPTH FROM COVER LEVEL TO SOFFIT OF PIPE 3.0m TO 6.0m



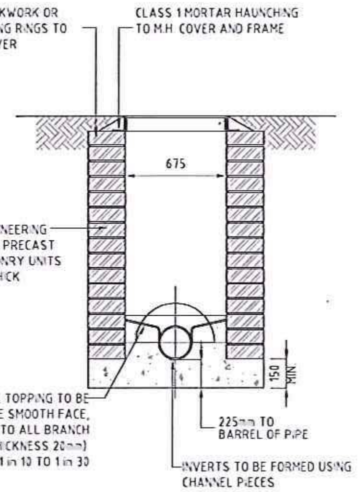
PLAN

MANHOLE TYPE B

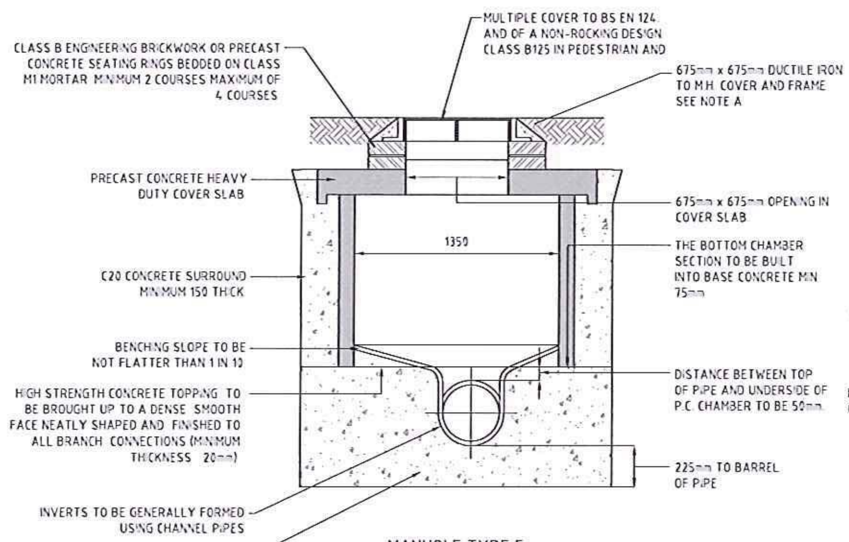
MAXIMUM DEPTH FROM COVER LEVEL TO SOFFIT OF PIPE 3.0m



SECTION C-C



SECTION D-D



MANHOLE TYPE E

DEPTH FROM COVER LEVEL TO SOFFIT OF PIPE 1.0m TO 1.5m
MAXIMUM SEWER DIAMETER 375mm

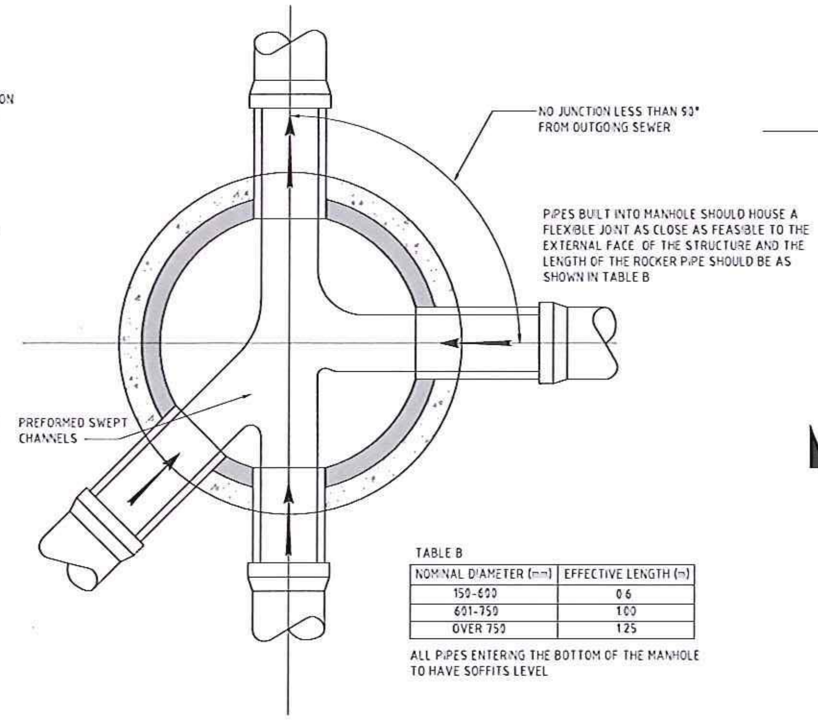
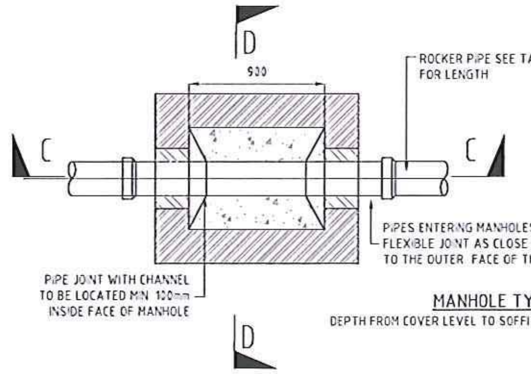


TABLE B

NOMINAL DIAMETER (mm)	EFFECTIVE LENGTH (m)
150-600	0.6
601-750	1.00
OVER 750	1.25

ALL PIPES ENTERING THE BOTTOM OF THE MANHOLE TO HAVE SOFFITS LEVEL

TYPICAL ARRANGEMENT OF PIPE JUNCTIONS WITHIN MANHOLES



NOTES

INTERNAL DIMENSIONS OF MANHOLE NORMALLY 1240mm x 675mm BUT MANHOLE WIDTH SHOULD BE INCREASED FOR PIPES LARGER THAN 225mmØ TO GIVE A MINIMUM 225mm BENCHING EACH SIDE WITH THE BRICKWORK/MASONRY CORBELLED DOWN TO SUIT COVER

PLAN

MANHOLE TYPE D

DEPTH FROM COVER LEVEL TO SOFFIT OF PIPE LESS THAN 1.0m

NOTES:

1. DO NOT SCALE FROM THIS DRAWING USE FIGURED DIMENSIONS ONLY.
2. ALL DRAWINGS TO BE CHECKED PRIOR TO CONSTRUCTION OR MANUFACTURE. ANY DISCREPANCIES TO BE REPORTED TO THE ENGINEER IMMEDIATELY.
3. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS STATED OTHERWISE.
4. THE DESIGN, CONSTRUCTION AND MATERIALS FOR ALL ADOPTABLE DRAINAGE APPARATUS MUST COMPLY WITH "SEWERS FOR ADOPTION 6TH EDITION" AND THE PARTICULAR REQUIREMENTS OF THE STATUTORY UNDERTAKER FOR FOUL SEWERS AND HIGHWAY AUTHORITY FOR HIGHWAY SURFACE WATER DRAINAGE
5. ANY WORKS TO AN EXISTING ADOPTED SEWER MUST BE CARRIED OUT BY AN APPROVED CONTRACTOR AND MUST BE CARRIED OUT UNDER THE APPROPRIATE AGREEMENT.
6. INSTALLATION OF STRUCTURED WALL PLASTIC PIPES MUST BE CARRIED OUT BY A CONTRACTOR WHO IS ACCREDITED TO THE BRITISH PLASTICS FEDERATION - PLASTIC PIPE GROUP. A CERTIFICATE CONFIRMING THE CONTRACTORS ACCREDITATION MUST BE SUPPLIED TO THE ADOPTING AUTHORITY.
7. THE CONTRACTOR SHALL CONFIRM WITH ADOPTING AUTHORITY PRODUCT GROUP THE ACCEPTABILITY OF ALL PLASTIC PIPES PRIOR TO ORDER
8. PRECAST CONCRETE HEAVY DUTY COVER, SLAB AND CHAMBER SECTION B.S.5911, APPROPRIATELY RIMED AND BEDDED ON CLASS M1 MORTAR PROPRIETARY BITUMEN OR RESIN MASTIC SEALANT
9. SEWERS LAID WITHIN THE HIGHWAY SHOULD HAVE A MINIMUM COVER OF 1.2m MEASURED FROM THE TOP OF THE PIPE BARREL TO THE FINISHED ROAD SURFACE, IN ORDER TO AVOID INTERFERENCE WITH UNDERGROUND UTILITY PIPES AND CABLES. WHERE THIS IS NOT POSSIBLE, THE SEWERS SHALL INCORPORATE A 150mm THICK ST4 CONCRETE BED AND SURROUND WITH FLEXIBLE JOINTS NOT EXCEEDING 6.0m IN LENGTH
10. SEWERS NOT LAID WITHIN THE HIGHWAY SHOULD BE LAID AT A SUFFICIENT DEPTH TO AVOID INTERFERENCE WITH LAND DRAINS OR CULTIVATION. A COVER OVER THE SHALLOWEST PART OF THE PIPELINE OF 900mm WILL NORMALLY SATISFY THIS REQUIREMENT. WHERE THIS IS NOT PRACTICABLE, THE SEWERS SHALL INCORPORATE A 150mm THICK ST4 CONCRETE BED AND SURROUND WITH FLEXIBLE JOINTS NOT EXCEEDING 6.0m IN LENGTH
11. OUTGOING PIPES 600mm DIAMETER OR GREATER ARE TO BE FITTED WITH SAFETY CHAINS AND HAND POSTS
12. PIPES TO BE LAID WITH THEIR SOFFITS LEVEL OR AS SPECIFIED ON THE CONTRACT DRAWINGS
13. REFER TO MANHOLE SCHEDULE FOR DETAILS OF COVERS, PIPE SIZES, INVERT LEVELS, MANHOLE DIAMETER, ETC.

Issue	Description	Date
02	NOTES REVISED	MAR 12
01	FIRST ISSUE	JULY 11

Status

Scales	AS SHOWN	Author PR WILLIAMS
Original Size	A1	Checker M PEARSON
Height Datum	-	Approver S A DAVIES
Grid	O.S.	© Copyright reserved

Filename 7265-UA001881-UP21D-S38-02-DRAINAGE DETAILS.DWG

Client

a2dominion

Hyder Consulting (UK) Limited
29, Bressenden Place
London
SW1E 5DZ
Tel: +44 (0)870 000 3006
Fax: +44 (0)870 000 3906

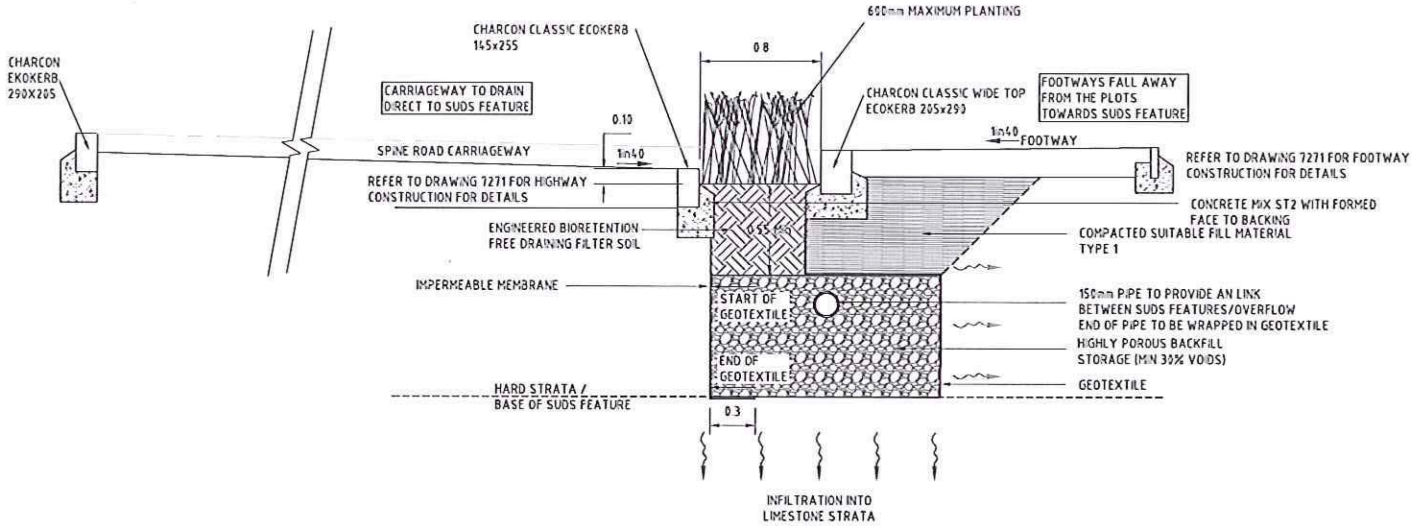
Project

BICESTER ECO DEVELOPMENT EXEMPLAR SITE

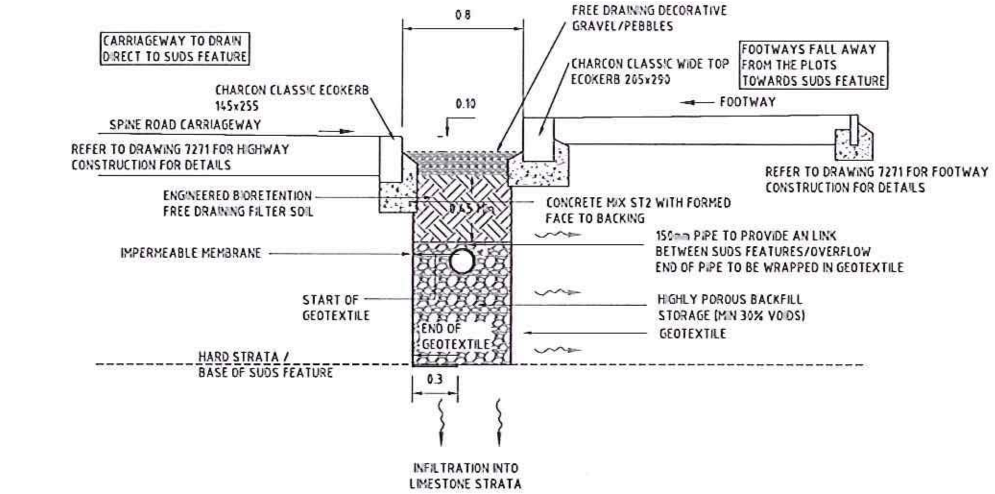
Title

EXEMPLAR SITE (S38) TYPICAL DRAINAGE DETAILS

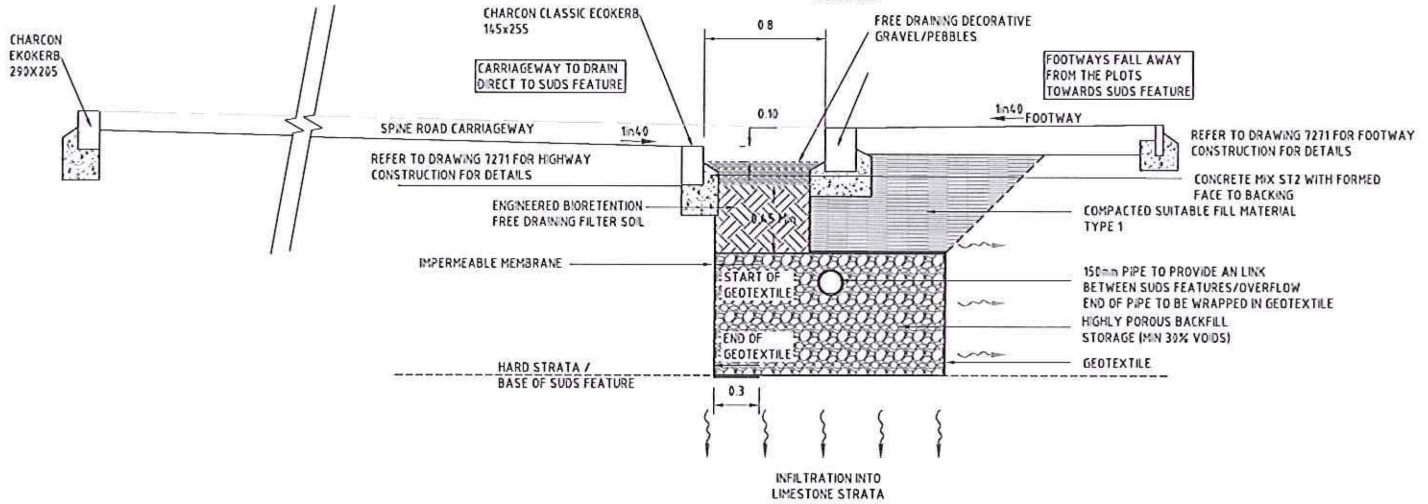
Drawing No	Project No	Issue
7265	UA001881	02



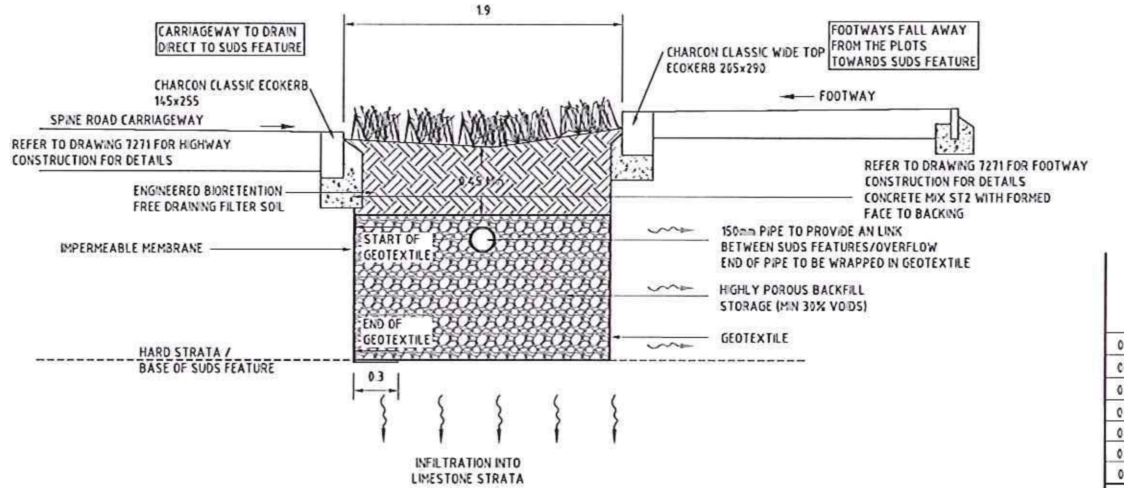
REVISED SUDS FEATURE-TYPE 1A -PLANTED
SCALE 1:25



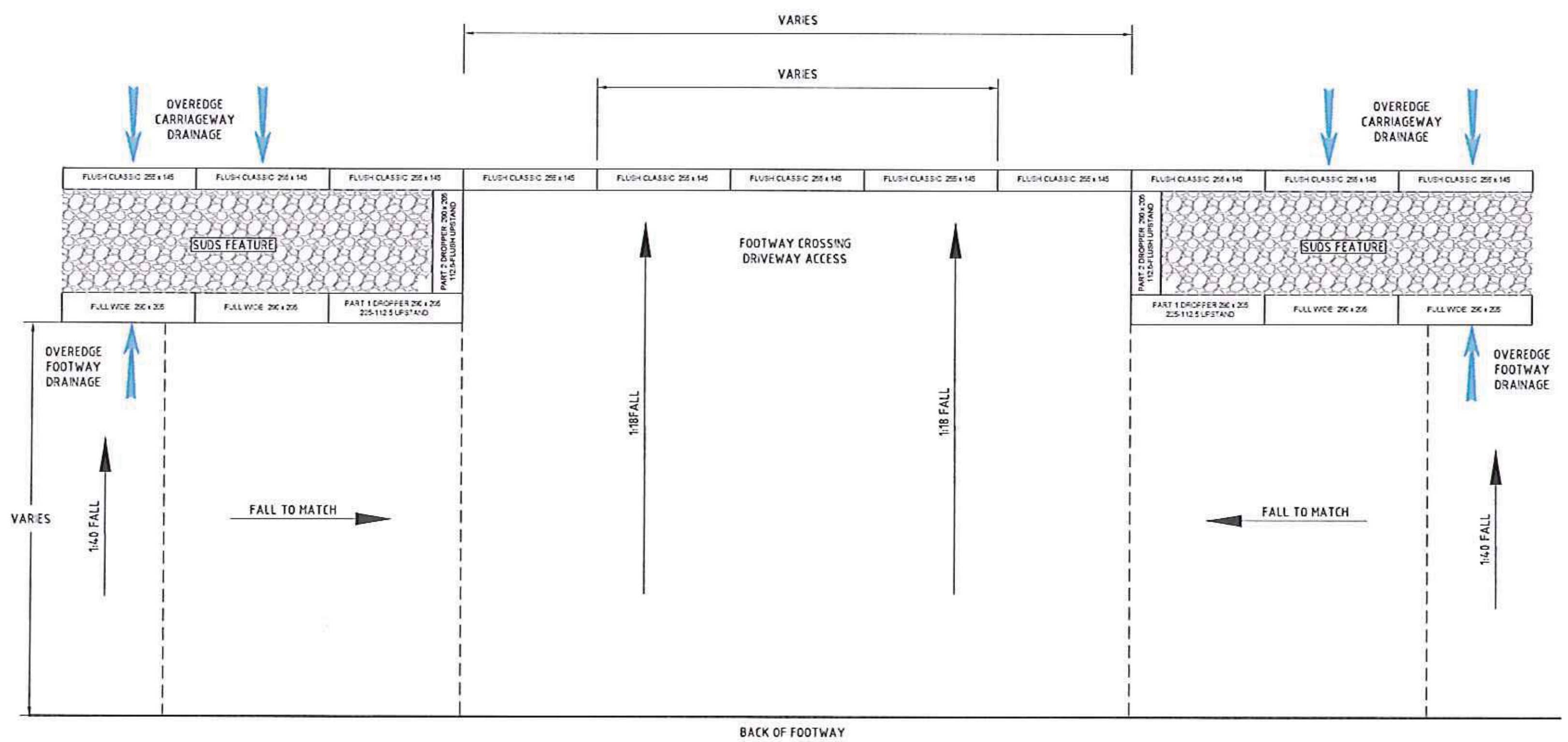
REVISED SUDS FEATURE-TYPE 1B
SCALE 1:25



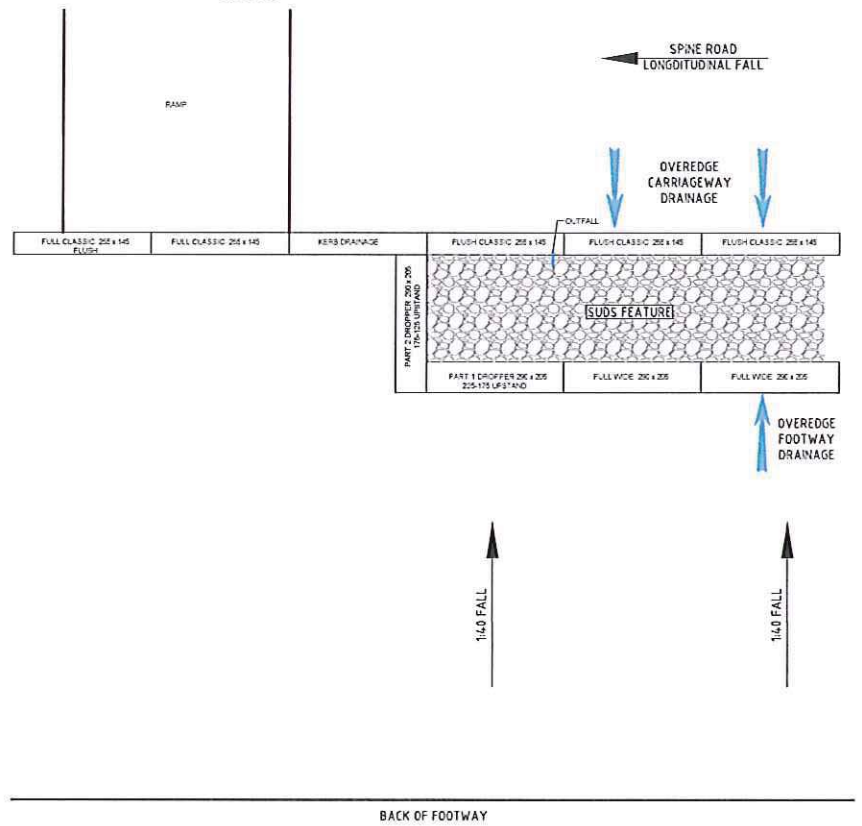
REVISED SUDS FEATURE-TYPE 1A-NON PLANTED
SCALE 1:25



REVISED SUDS FEATURE-TYPE 2 (Northern Site)
SCALE 1:25



FOOTWAY CROSSING DETAIL
SCALE 1:25



SUDS / SPEED TABLE DETAIL
SCALE 1:25

NOTES:
1. DO NOT SCALE FROM THIS DRAWING USE FIGURED DIMENSIONS ONLY
2. ALL DRAWINGS TO BE CHECKED PRIOR TO CONSTRUCTION OR MANUFACTURE. ANY DISCREPANCIES TO BE REPORTED TO THE ENGINEER IMMEDIATELY.
3. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.
4. THE DESIGN, CONSTRUCTION AND MATERIALS FOR ALL ADOPTABLE DRAINAGE APPARATUS MUST COMPLY WITH "SEWERS FOR ADOPTION 6TH EDITION" AND THE PARTICULAR REQUIREMENTS OF THE STATUTORY UNDERTAKER
5. SEE DWG 2271 FOR FOOTWAY/CARRIAGEWAY DETAILS
6. ENGINEERED BIORETENTION SPECIFICATION TBC
7. POROUS BACKFILL SPECIFICATION TBC

Issue	Description	Date
07	KERB HAUNCH REVISED	22/01/13
05	DETAILS REVISED	05/11/12
05	MINOR REVISIONS	27/07/12
04	REVISED TO OCC SOMMENTS	20 APR 12
03	REVISED TO OCC SOMMENTS	MAR 12
02	SECOND ISSUE	FEB 12
01	FIRST ISSUE	AUG 11

Status: DRAFT

Scales	AS SHOWN	Author ML
Original Size	A1	Checker SD
Height Datum	–	Approver SD
Grid	O.S.	© Copyright reserved

Filename: 7277-UA001881-UP21D-S38-07-SWALE DETAILS.DWG

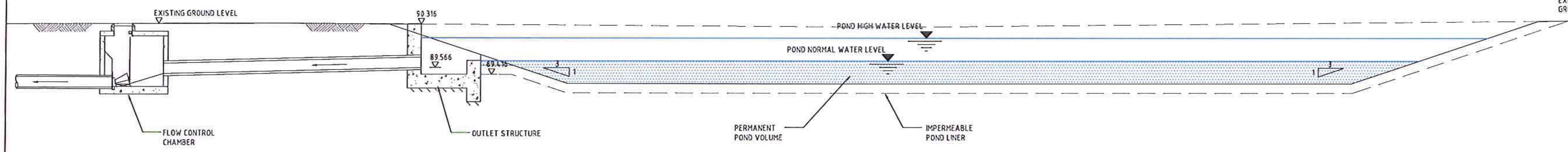
Client: a2dominion

Hyder Consulting (UK) Limited
29, Bressenden Place
London
SW1E 5DZ
Tel: +44 (0)870 000 3006
Fax: +44 (0)870 000 3906

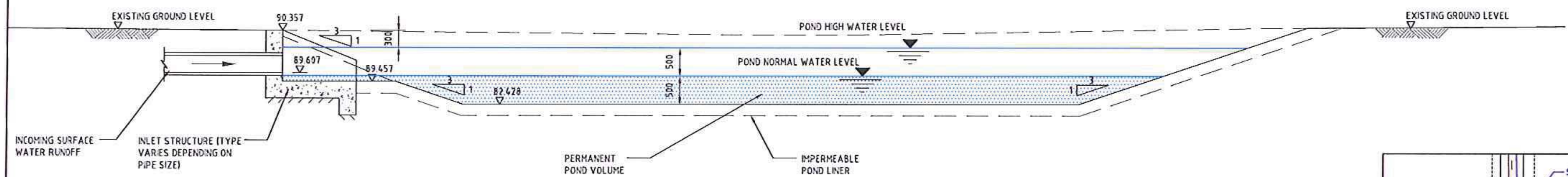
Project: BICESTER ECO DEVELOPMENT EXEMPLAR SITE

Title: EXEMPLAR SITE (S38) SUDS TYPE DETAILS

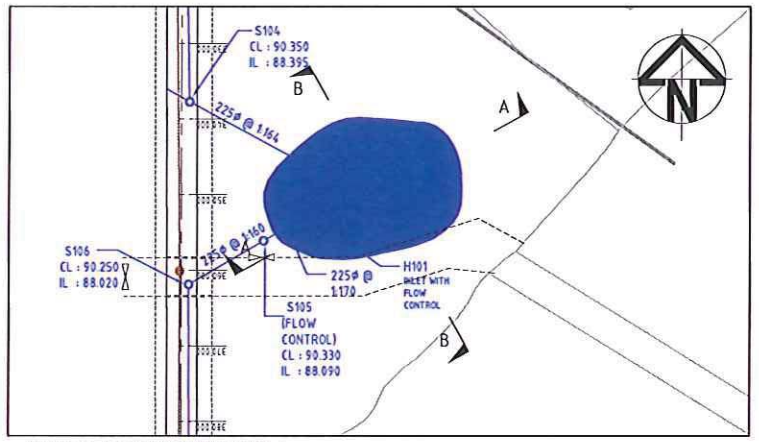
Drawing No	Project No	Issue
7277	UA001881	07



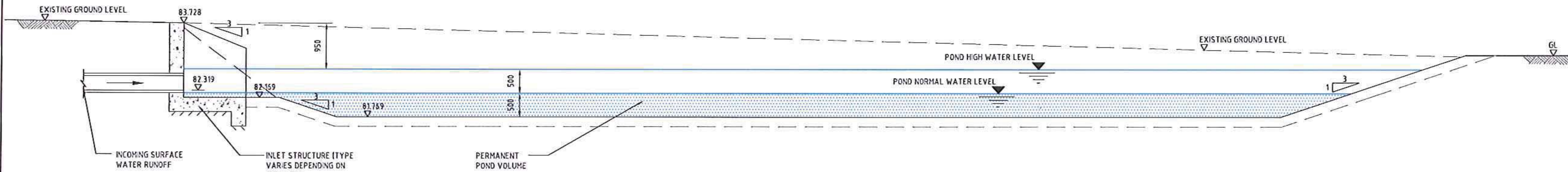
SECTION A - A
SCALE 150



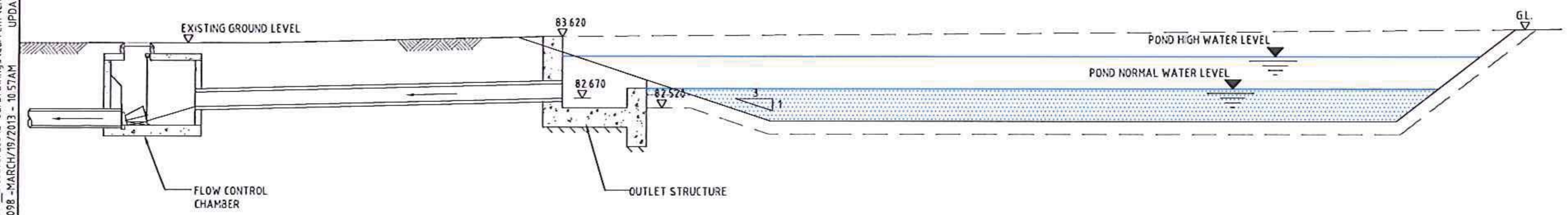
SECTION B - B
SCALE 150



PLAN OF STORAGE STRUCTURE 1
SCALE 1500

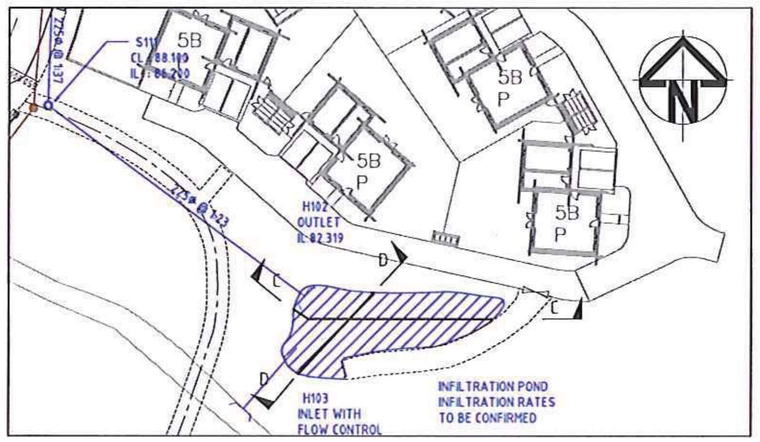


SECTION C - C
SCALE 150



SECTION D - D
SCALE 150

SECTION D - D
SCALE 150



PLAN OF STORAGE STRUCTURE 2
SCALE 1500

NOTES:

1. DO NOT SCALE FROM THIS DRAWING USE FIGURED DIMENSIONS ONLY
2. ALL DRAWINGS TO BE CHECKED PRIOR TO CONSTRUCTION OR MANUFACTURE. ANY DISCREPANCIES TO BE REPORTED TO THE ENGINEER IMMEDIATELY.
3. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS STATED OTHERWISE.
4. THE DESIGN, CONSTRUCTION AND MATERIALS FOR ALL ADOPTABLE DRAINAGE APPARATUS MUST COMPLY WITH "SEWERS FOR ADOPTION 6TH EDITION" AND THE PARTICULAR REQUIREMENTS OF THE STATUTORY UNDERTAKER

Issue	Description	Date
03	DRAINAGE REVISED	05/11/12
02	SECOND ISSUE	MAR 12
01	FIRST ISSUE	AUG 11

Status: DRAFT

Scales	AS SHOWN	Author PR WILLIAMS
Original Size	A1	Checker M PEARSON
Height Datum	-	Approver S A DAVIES
Grid	O.S.	© Copyright reserved

Filename: 7278-UA001881-UP21D-S38-03-SWALE DETAILS.DWG

Client: a2dominion

Hyder Consulting (UK) Limited
29, Bressenden Place
London
SW1E 5DZ
Tel: +44 (0)870 000 3006
Fax: +44 (0)870 000 3906

Project: BICESTER ECO DEVELOPMENT EXEMPLAR SITE

Title: EXEMPLAR SITE (S38) SUDS DETAILS SHEET 2 OF 2

Drawing No	Project No	Issue
7278	UA001881	3

CAD FILE : K:\UA001881_BicesterEco\E-OurDrawings\Current\Civil Engineering\7278-UA001881-UP21D-S38-03-SWALE DETAILS.dwg
PRINTED BY : PW68098 - MARCH/19/2013 - 10:57AM UPDATED BY: PW68098 - MARCH/19/2013 - 10:55AM

100mm on Original

19/Mar/2013 10:57 AM K:\UA001881_BicesterEco\E-OurDrawings\Current\Civil Engineering\7278-UA001881-UP21D-S38-03-SWALE DETAILS.dwg

V1

Appendix C

Flood Risk Assessment

Full NW Bicester development site Modelling

Technical Note: ISIS River Modelling Hydrology and Hydraulics
TUFLOW Surface Water Modelling Summary

TECHNICAL NOTE

Date 17th February 2014

Reference 5011-UA005241-BMR-01

Subject Bicester Eco Town ISIS Model Extension

1.1 Introduction

An ISIS model of the River Bure and tributaties was constructed in 2010 / 2011 to inform the Flood Risk Assessment (FRA) for the Bicester Eco Town Exemplar Site. This ISIS model has subsequently been updated to include an additional tributary stream, the Hawkswell Tributary. This technical note summarises the methodology adopted in order to incorporate this stream into the existing ISIS model.

1.2 Hydrological Assessment

The Hawkswell Tributary sits within the catchment of the Langford Brook; the homogenous nature of this catchment meant that a simple area ratio approach was used to split the flows into those generated by the Langford Brook and those generated by the Hawkswell Tributary. Figure 1 shows the relative catchment sizes, which are summarised in Table 1.

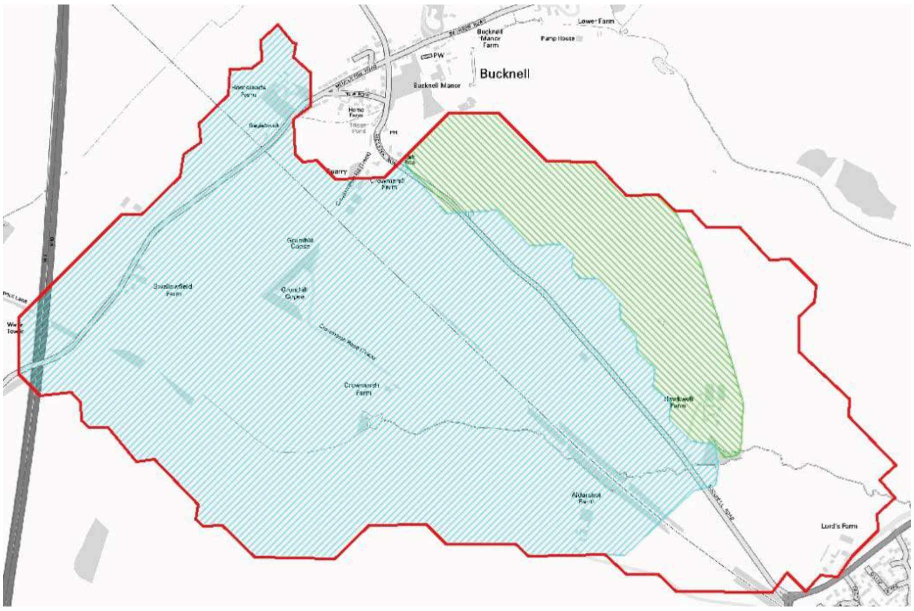


Figure 1 Langford Brook / Hawkswell Tributaries

Catchment	Area (km²)	Ratio
Langford Brook (u/s Hawkswell Confluence	1.92	0.69
Langford Brook (d/s Hawkswell Confluence	0.50	0.18
Hawkswell Tributary	0.37	0.13
TOTAL	2.79	1

Table 1 Langford Brook / Hawkswell Tributary Ratios

The area ratio was used to factor the peak flows for the Langford Brook catchment as shown in Table 2.

Catchment	1% AEP	1% AEP plus Climate Change	0.1% AEP
Langford Brook (u/s Hawkswell Confluence	0.65	0.78	1.17
Langford Brook (d/s Hawkswell Confluence	0.17	0.20	0.31
Hawkswell Tributary	0.12	0.15	0.23
TOTAL	0.94	1.13	1.70

Table 2 Langford Brook / Hawkswell Tributary Flows

The Langford Brook upstream of the Hawkswell confluence and the Hawkswell Tributary were added as point inflows to the respective upstream nodes in the ISIS model. The Langford Brook downstream of the Hawkswell confluence was added as a lateral inflow.

1.3 Hydraulic Model

No survey data was availale for the Hawkswell Tributary.Consequently, LiDAR data was combined with observations made during the site visit, in order to define the channel dimensions and elevations.The main channel was defined as a trapezoidal channel with the elevation extracted from LiDAR data and the base and top widths taken from site visit measurements. A roughness value of n = 0.05 was applied to the tributary sections as the site visit indicated that the channel was overgrown with weeds and pools.

The Hawkswell Tributary was linked to the Langford Brook using an ISIS open junction.

Appendix C – TUFLOW Surface Water Modelling Summary

Introduction

As part of the Bicester Flood Risk Assessment (FRA), Hyder were commissioned to create a surface water model to identify key flow paths and flood risk areas within the Bicester Eco Town development site boundary. The study area is outlined below in Figure 1.

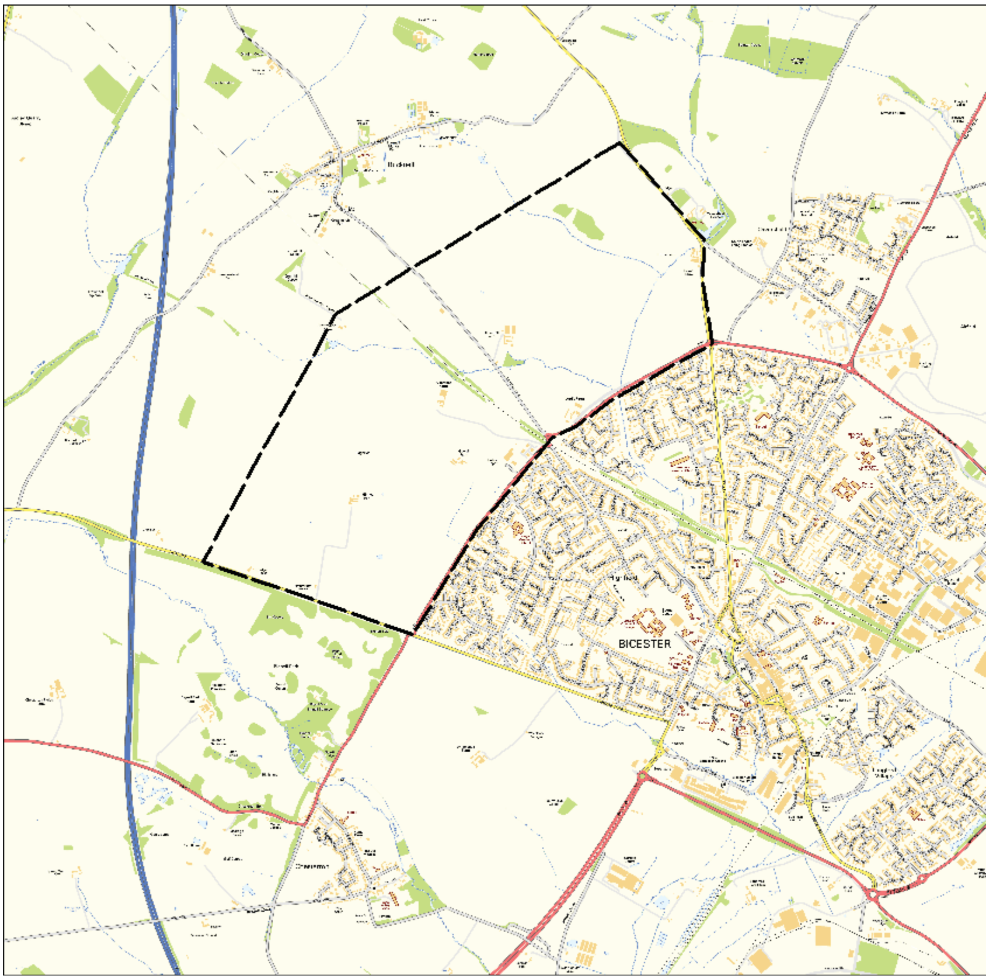


Figure 1 Bicester Eco Town Study Area (black dashed polygon)

1.1 Model Development

To improve understanding of the surface water flow paths and flood risk across the Eco Town site a 2-Dimensional (2D) direct rainfall model was created using TUFLOW. TUFLOW is a hydrodynamic modelling package which can be used for 2D modelling of overland flow or as a 1D-2D linked model where there is an interaction with linear flow features.

This approach enables the effect of the topography on overland flood routes to be simulated by direct application of a rainfall profile to a 2D hydraulic model domain.

1.1.1 Data Sources

The following data was provided to assist with the direct rainfall model development:

Data	Source
LiDAR	Environment Agency Geomatics 2m DTM
Channel Survey Data	Supplied by Maltby Land Surveys (August 2010) and Hyder Consulting (January 2010)
Mapping	Ordance Survey Opensource Raster Mapping

A site visit was also undertaken by Hyder Consulting in September 2013 to verify and supplement the above information (see Section 1.1.11)

1.1.2 Hydrological Modelling

The Bicester Eco Town model was constructed to analyse the impact of a range of rainfall events across the development site by assessing flow paths and flood depths.

The model was designed to simulate the current surface water flood risk across the Eco Town site prior to development. This will allow the assessment of surface water flood risk and the incorporation of SuDS in strategic locations to ensure that there is adequate drainage in place once the site is developed.

The site is predominantly agricultural with two main watercourses, the Langford Brook and the River Bure intersecting the site. There are also several smaller drainage ditches to the south of the railway line and running along the periphery of the development site. A full description of the hydrological features on the site is given in the Flood Risk Assessment.

The model does not incorporate infiltration losses and assumes that as the predominant land use is agriculture there is no current drainage system in place, this gives a very conservative estimate of the runoff from the land. The following key assumptions were made to generate the model input:

- Initial Loss – None
- Infiltration Loss – None
- Drainage System - None

1.1.3 Design Rainfall

Rainfall inputs were generated from the FEH CD-ROM (v4) based on the site catchment boundary. The following rainfall events were generated:

- 3.33% AEP (1 in 30 chance of occurring in any given year)
- 1% AEP (1 in 100 chance of occurring in any given year)
- 1% AEP (1 in 30 chance of occurring in any given year) plus 30% climate change

1.1.4 Critical Storm Duration

The critical storm duration can change rapidly even within a small area, due to the topography, land use, size of the upstream catchment and nature of the drainage systems. The ideal approach would be to model a wide range of durations. However, this is not always practical when using 2D models which have long simulation times.

A high level investigation was undertaken to assess the effect of rainfall event duration on the Bicester Eco Town study area. The intention of the investigation was to show variation in critical duration across the study area and thus identify a single critical duration for the model. The 7.25 hour duration was selected as the critical duration for the study area.

1.1.5 Runoff Coefficients

No runoff coefficients have been applied to the rainfall; therefore the entire rainfall hyetograph is applied to the model.

1.1.6 Software Version

The Bicester Eco Town model has been run using the 2012 32 bit double precision version of TUFLOW.

1.1.7 Hydraulic Model Parameters

The Eco Town model hydraulic parameters were set up as follows:

Model Parameters	
Grid Size	4m
Time Step	2 seconds
Storm Duration	7.25 hours
Event AEP	3.33%, 1% and 1% +CC
Total Simulation Length	15 hours

Table 1 Model Parameters

1.1.8 Digital Terrain Model

A key component of the TUFLOW modelling process was the acquisition of a Digital Terrain Model (DTM). TUFLOW utilises standard GIS packages to manage, manipulate and present input and output data. In order to model surface water TUFLOW requires terrain data. This can be from a variety of sources (GPS, LiDAR, photogrammetry etc) but the more detailed and accurate the source of data, the more accurate and reliable the solution is likely to be. The study utilises a 2m LiDAR DTM dataset supplied by the Environment Agency.

Filtered DTM data was used in the Eco Town surface water model. This provided partial coverage of the study area (Figure 2). The gap to the north of the site was filled in using contour data as this was the best available data for this location although it should be noted that it does not identify the level of topographic detail that the LiDAR data does. The contour data was combined with the LiDAR to create one seamless ground model for the study area.

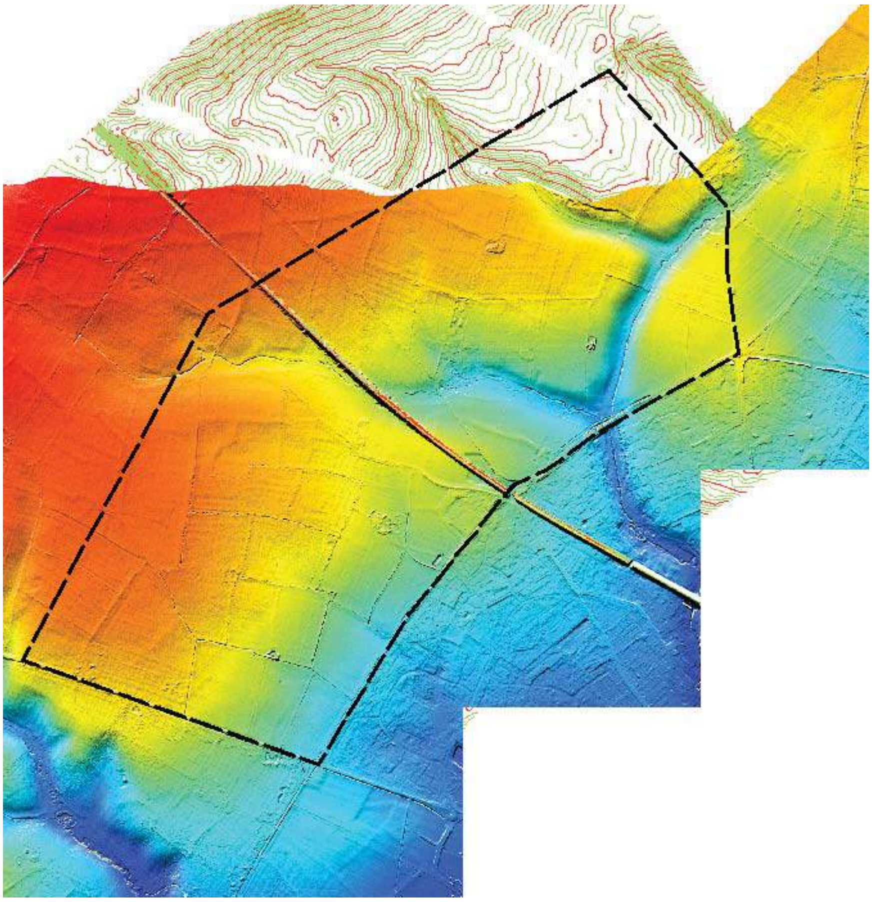


Figure 2 Bicester Eco Town LiDAR Coverage (study area = black dashed line)

Standard practice for TUFLOW modelling is to use filtered LiDAR as it removes interference and distortion caused by buildings and trees to represent the 'bare earth'.

While the majority of the data provided was of a suitable standard, there was one issue identified following initial model runs that required corrective measures. Where the contour derived ground model and the LIDAR had been combined a step had been created which was causing instabilities to occur in the model. To reduce the impact of this step a z-shape polygon was created to smooth the transition between the two datasets (Figure 3).

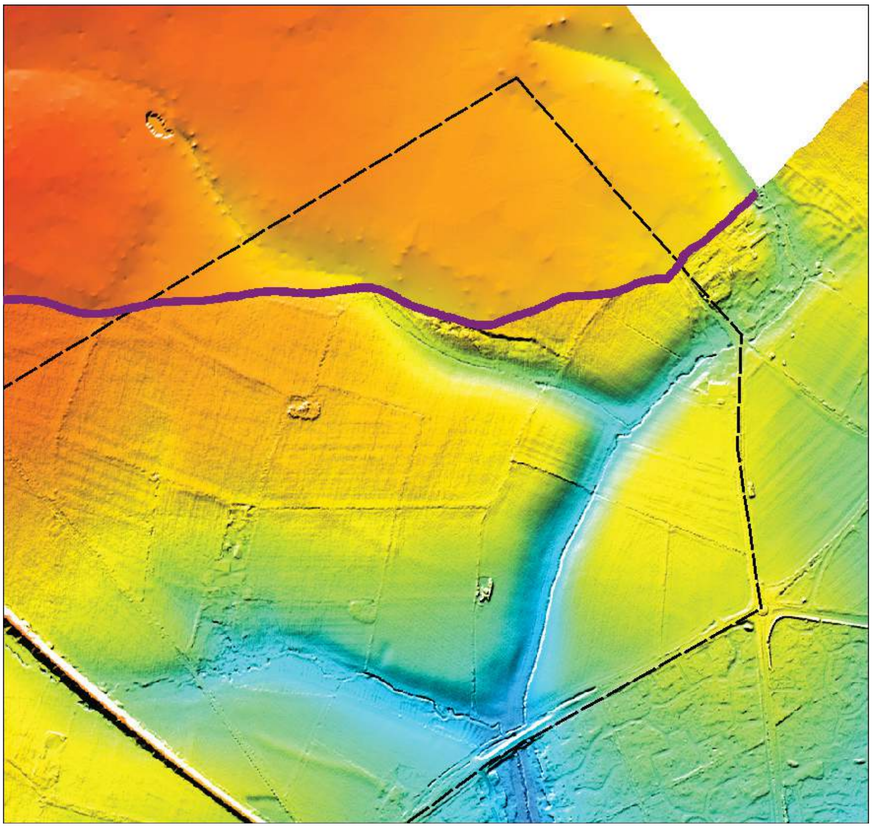


Figure 3 DTM Step Smoothing (purple polygon)

1.1.9 Grid Size

The Bicester Eco Town model has been created at a 4m grid resolution. This grid size was chosen to ensure that key features were represented while ensuring a reasonable model run time.

1.1.10 Floodplain Structures

During the development of the initial model, several raised structures (e.g. bridges, underpasses and subways) were highlighted as they had not been filtered out of the DTM. These features create unnatural barriers to flow where in reality flow would pass beneath or through the structure. To model these structures 1D nwk lines and 2D bc lines were drawn over the features. The 1D structures were populated with elevations from the DTM or survey (where available) on either side of the structure to effectively model the structure through the feature. The 1D nwk nodes and 2D bc lines are then read into TUFLOW where the structure is modelled.

1.1.11 Watercourses

The river channels of the Langford Brook and the River Bure were sufficiently defined in the underlying LiDAR so no additional detail was added to represent these watercourses, it was also assumed that the LiDAR level in the brook would be representative of the water level in the brook prior to the rainfall event, therefore it was not necessary to alter this level. Structural crossings such as under the railway line on the Langford Brook were added into the model using the method outlined in Section 1.1.10 above. The invert and culvert dimensions were taken from the FRA 1D ISIS model.

Following a site visit on the 23rd September 2013 all open ditches within the model domain were identified and where possible measurements of channel dimensions were taken. This included drainage ditches to the south of the railway line and adjacent to Hawes Lane on the periphery of the site boundary.

To represent these watercourses a 2D Flow Constriction (fc) shape was used. This allowed for the definition of the channel width, bed level and bank tops. The fc shape unit was used to ensure that the watercourse width was taken into account and the feature was not applied across an entire 4m TUFLOW cell. One layered fc shape was used to represent a double culvert under Hawes Road between two highway drainage ditches as the 1D nwk and 2D bc lines which were initially used were not conveying flow through the culverts.

1.1.12 Downstream Boundaries

In order to represent flow out of the model domain HQ (Stage versus Flow) boundary lines were added at the edge of the 2d model domain. These boundaries were defined based on the slope of the local DTM, with the modelling software automatically calculating the HQ relationship.

1.1.13 Manning's Values

A constant roughness has been assumed based on the predominant land use in the study area. The roughness value assumed is 0.05.

1.1.14 Model Run Time

The Eco Town model was initially run for fifteen hours. The model files were checked to ensure that the modelled depths were not increasing and that no further flow paths were being formed across the site.

1.2 Model Stability

An assessment of the model stability was made by analysing the mass balance (cumulative error %) for each model run. The warnings in the model output files were also checked to ensure that these were not highlighting any fundamental issues with the model. This assessment was an important stage in establishing the accuracy of the model outputs.

The range of cumulative error should be +/- 5% for a majority of each simulation. Figure 4 outlines the cumulative error range in the Eco Town model. As can be seen in the figure all of the modelled return periods report very high cumulative errors at the beginning of the model simulation. This is caused by the initial wetting process at the beginning of the rainfall event whereby a large number of model cells become wet instantaneously. The mass error for all models reduces and becomes more consistent beyond the three hour mark with the rest of the simulation falling within the recommended range. As the errors occur at the beginning of the simulation at varying times and are not prolonged it is deemed unlikely that they would have an impact on the model results.

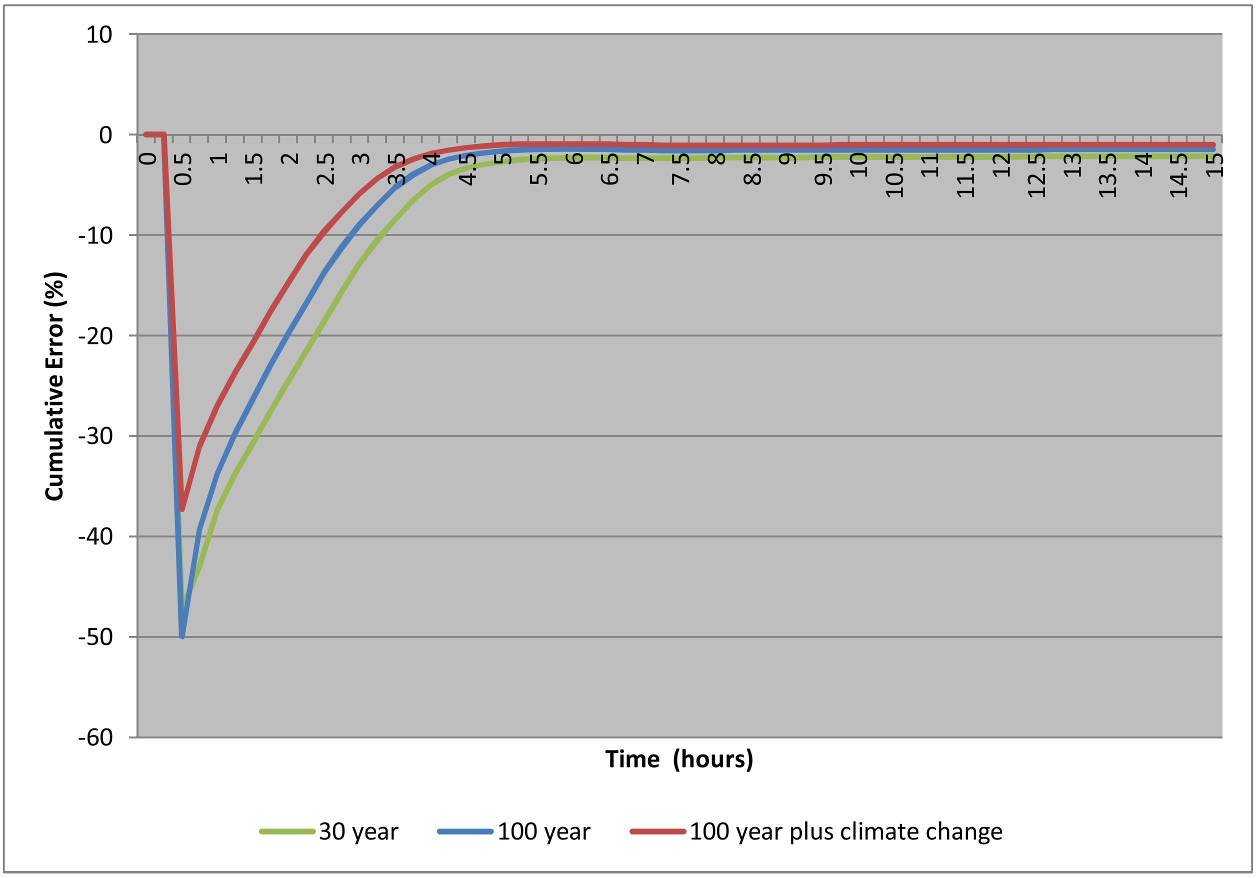


Figure 4 – Bicester Eco Town Model Mass Balance

The TUFLOW warning messages were checked and no significant warnings were identified. The majority of warnings related to locations where culverts through raised structures had been added highlighting that changes were being made to the ground level in these locations.

1.3 Model Output Files

In order to assess areas at risk of surface water flooding, flood depths greater than 0.05m were analysed. The depth grids were broken down into depth bands to allow for the identification of areas at risk of overland flow and deep ponding (>1.5m).

Figure 5 1% AEP Modelled Depths

Figure 5 illustrates the predominant flow paths across the site which correspond with the routes of the Langford Brook and the River Bure. The flow paths to the south of the railway line are not as well defined as they tend to follow smaller open drainage ditch channels or natural depressions in the open fields.

The full mapped outputs are available in Appendix D.

1.4 Model Validation

The surface water modelling was validated during a Hyder site visit to establish if the mapped areas of risk are realistic. The mapping was verified on site and areas of ponding in the model corresponded well with natural features seen on site.

1.5 Model Limitations

There are a number of limitations associated with the modelling methodology:

- The below ground sewerage infrastructure including the combined sewers adjacent to the Eco Town site have not been modelled and therefore their ability to convey surface water from the site has not been taken into account
- The modelled topography of the northern section of the site is based on topographic contours which provide less detail than LiDAR. Therefore there is a degree of uncertainty relating to the model results in this area.
- The ground representation is based on a grid of points at a 4m spacing and therefore any variations falling within this distance have not been modelled.
- Obstructions such as railway embankments have been modelled however culvert crossings beneath them (unless clearly seen on OS maps or available in survey data) have not always been included.
- The model assumes that the ground is impermeable and therefore all rainfall reaching the site is converted to runoff.
- The capacity of the watercourses has not been explicitly modelled and therefore there is a tendency for surface water build up along the river floodplain.

1.6 Conclusions and Recommendations

As part of Bicester Eco Town Flood Risk Assessment a surface water model was developed for the development site. The model was designed to allow for the identification of key flow paths and an assessment of surface water flood risk across the site.

As a result of the surface water modelling the following mechanisms of flooding were identified:

- Ponding of flow in topographical depressions.
- Ponding upstream of structures with small underpasses/subways.
- Overland flow along topographical lows and valley channels.

Several recommendations for future improvements to the models are outlined below.

- Develop an integrated 1D/2D model to improve the representation and interaction with the fluvial network.
- The underground drainage network along the periphery of the site could be taken into account to assess the effectiveness of the existing network to convey surface water.
- Re-run the model as and when improved LiDAR becomes available for the northern area of the site.
- Obtain survey data for key structures within to improve the accuracy of the modelled output.

- Obtain more information relating to key structural crossings to improve the accuracy of the modelled output.
- Increase the model resolution in key locations to improve the accuracy of the modelled flow paths.
- Re-run the model with the proposed development and SuDS drainage network in place to ensure the proposed network is sufficient to prevent ponding of surface water and the development is not at risk of key overland flood routes.

Appendix D

Flood Risk Assessment

Mapped Flood Extents

0004-UA005241-BMD-01-Pluvial Model Depths 3.33% AEP
0005-UA005241-BMD-01-Pluvial Model Depths 1% AEP
0006-UA005241-BMD-01-Pluvial Model Depths 1% AEP+CC
0007-UA005241-BMD-06-Q1000_Modelled_Flood_Outline
0008-UA005241-BMD-03-Q100CC_Modelled_Flood_Outline
0009-UA005241-BMD-03-Q100_Modelled_Flood_Outline