vectos.

FLOOD MODELLING REPORT

Firethorn Developments Limited

Land at North West Bicester

February 2021

Contents

Appendices

1 Introduction

Authorisation

1.1 This flood modelling study has been undertaken by Vectos on behalf of Firethorn Developments Limited. This has been undertaken to support the outline planning application (21/01630/OUT) at North West Bicester.

Background

1.2 Town Brook, an ordinary watercourse, flows alongside the east boundary of the site. A tributary of Town Brook, another ordinary watercourse, flows alongside the south boundary of the site (these are further described in Section 3).

1.3 The Environment Agency Flood Map for Planning (available from https://flood-map-for-planning.service.gov.uk/) identifies the fluvial flood extents across the site associated with Town Brook. These are presented in Figure 1, which shows that Town Brook results in some relatively limited flooding alongside the east site boundary.

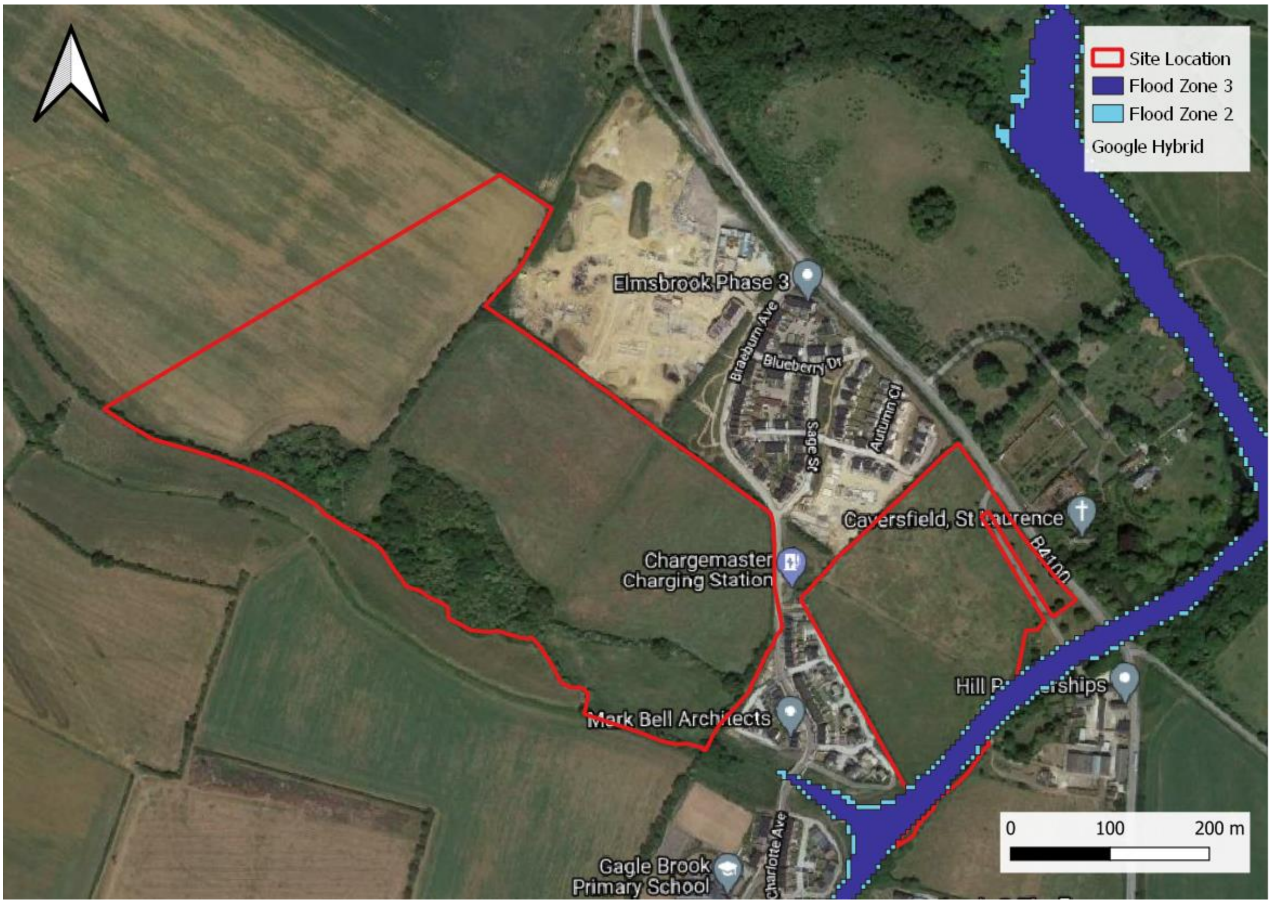


Figure 1: Flood Zone 3 and Flood Zone 2

1.4 Typically, the Flood Map for Planning excludes watercourses with catchment areas less than 3 km^2. This includes the tributary on the south site boundary. However, flooding associated with this tributary is presented on the Risk of Flooding from Surface Water map. These surface water flood zones are presented in Figure 2. Similar to Town Brook, some relatively limited flooding is identified alongside the site boundary.

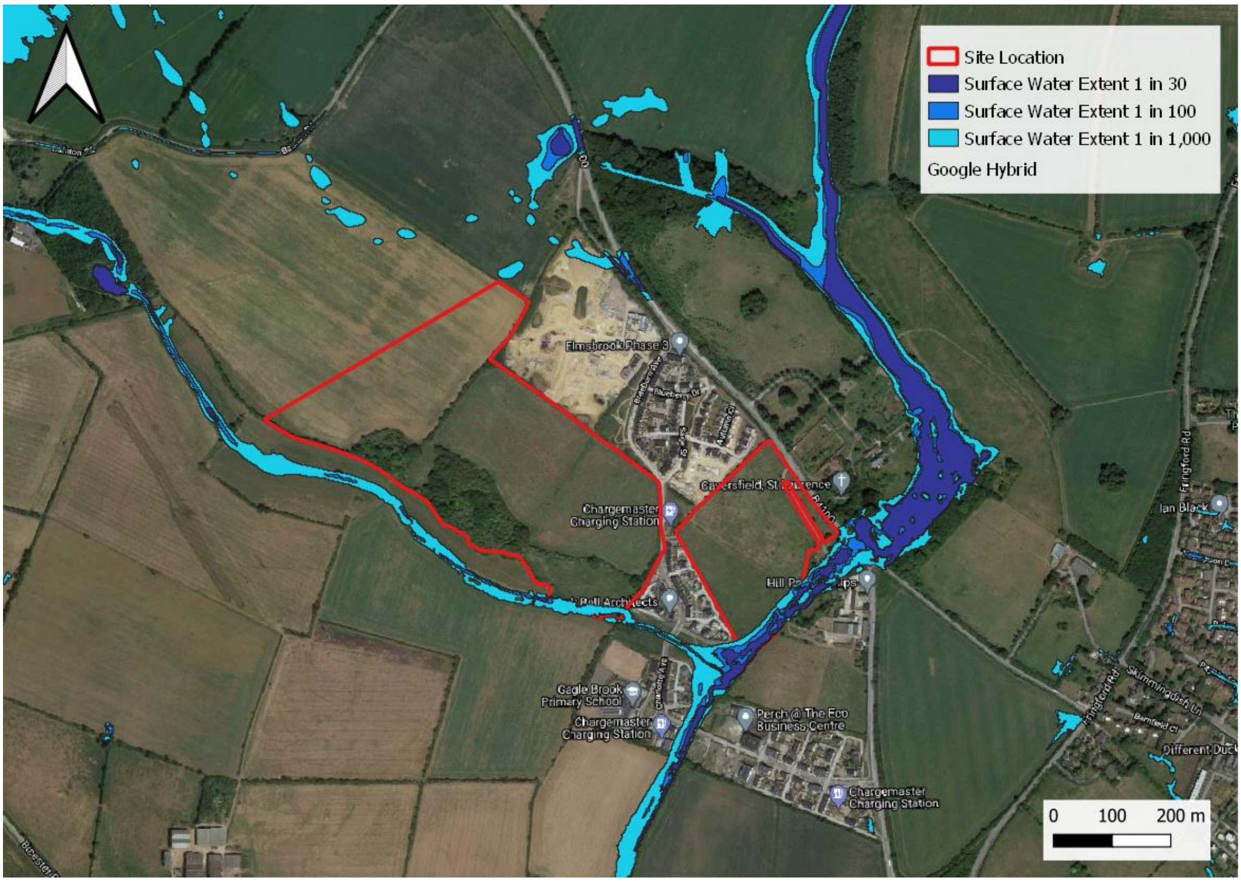


Figure 2: Surface Water Flood Zones

1.5 In the proximity of the site, the Flood Map for Planning has been derived using JFLOW. This is a broad-brush flood modelling technique, which was developed as part of the national flood mapping programme. The methodology takes little or no account of watercourse capacity, nor does it allow for hydraulic structures, and is often found to result in an overestimation of flooding. A similar approach was adopted for the Risk of Flooding from Surface Water map and the accuracy of the associated flood mapping can be poor.

1.6 The Flood Risk Assessment (FRA) prepared to support the planning application at the site considered these sources of flood risk and made allowances for climate change. However, following their review of the FRA, the Environment Agency (EA) stipulated the need for hydraulic modelling to obtain a more reliable estimation of flood risk, which should be used for comparison to development proposals.

Purpose of this Report

1.7 The purpose of this report is to summarise details of the flood modelling undertaken. The flood modelling objectives were defined at the outset of this study, these were:

i) Derive hydrological boundaries (i.e. design inflows) for the study area;

ii) Develop a baseline 1D-2D hydraulic model of the site, extending both up and downstream;

iii) Simulate the hydraulic model for a series of design inflow events;

iv) Derive baseline flood maps for the site for comparison to the existing flood zones, Land Use Parameters Plans, Framework Plan and Illustrative Masterplan.

1.8 The work has been undertaken in accordance with the guidelines set out in the National Planning Policy Framework (NPPF).

2 Consultation

2.1 A modelling methodology was prepared and issued to the EA for comment. The EA response was used to inform the preparation of the flood model. Details are enclosed in Appendix A.

3 Flood Model Development

3.1 The flood model has been developed to improve the understanding of fluvial flood risk at the site. The flood model comprises of two parts: the hydrological model and the hydraulic model. Both of which are discussed in this section.

Hydrological Modelling

3.2 The hydrological assessment allows for the calculation of watercourse flows, or design hydrographs, which are subsequently used as inflow boundary conditions in the hydraulic model.

3.3 The hydrographs were estimated using the latest methodologies described in the Flood Estimation Handbook (FEH). Ultimately, the statistical method has been selected to derive design hydrographs at the site due to the permeable nature of the catchment. This method was found to result in slightly lower peak flows than the ReFH (2.2) method.

3.4 Design hydrographs have been derived to represent three separate runoff contributions. These relate to two upstream catchment areas and from within the model reach itself (i.e. applied as lateral inflows). Figure 3 shows the extents of the contributing areas for which design hydrographs have been derived.

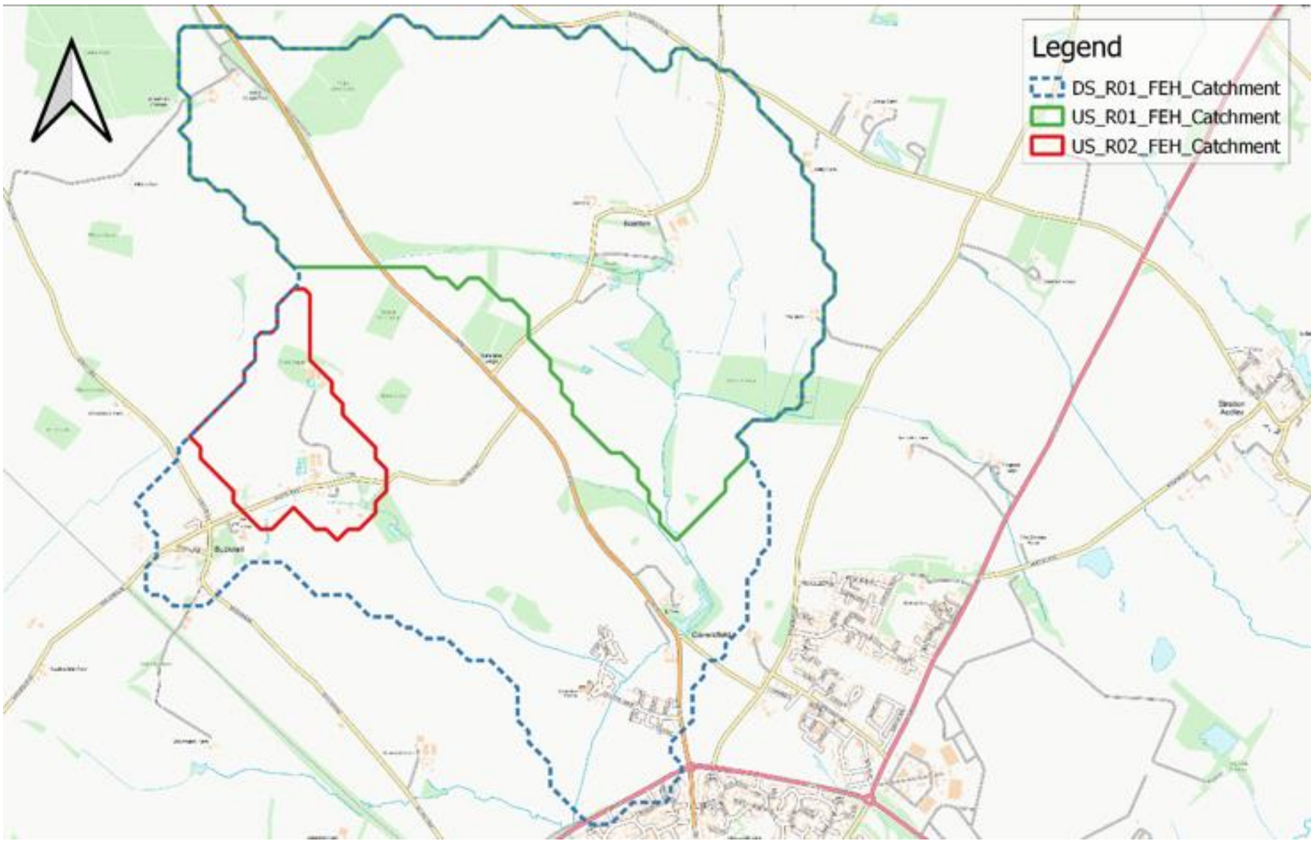


Figure 3: Hydrological Areas

3.5 Table 1 presents a summary of the peak flows associated with each design event, for the total catchment area. It also includes the size of each catchment, which has been used to scale the peak flows. These scaled peak flows are also identified. The lateral peak flows were estimated by deducting the peak flows associated with the two upstream catchment areas (i.e. R01 and R02) from the total catchment peak flow.

Table 1: Estimated Peak Flows (m^3/s)

Design Event	Catchment			
	Total	Reach 1	Reach 2	Lateral
	7.60 km^2	3.88 km^2	0.53 km^2	3.19 km^2
1 in 20	0.64	0.33	0.04	0.27
1 in 100	0.98	0.50	0.07	0.41
1 in 100 + 15%CC	1.13	0.58	0.08	0.47
1 in 100 + 25%CC	1.23	0.63	0.09	0.51
1 in 1000	1.74	0.89	0.12	0.73

3.6 A hydrograph shape was obtained from the ReFH2 method and applied to all inflows.

3.7 Full details of the hydrological analysis are outlined in Appendix B.

Baseline Hydraulic Modelling

3.8 The baseline hydraulic model has been developed using TUFLOW software. TUFLOW is an industry standard computational engine that provides one-dimensional (1D) and two-dimensional (2D) solutions of the free-surface flow equations to simulate hydrodynamic behaviour in river, floodplains and urban drainage environments. The 1D component uses a tool built into TUFLOW, called ESTRY. The TUFLOW software version used was 2020-10-AA-iDP-w64.

3.9 General details concerning the hydraulic model development, parameters and assumptions are outlined in the following sections.

Hydraulic Model Approach and Extent

3.10 A linked 1D-2D model has been developed including the entire extent of the existing flood zones on site. It has also extended 600 m upstream and 800 m downstream of the site. A 1D model of the stream network and hydraulic structures has been incorporated to accurately represent in channel hydraulics, with this linked to a 2D floodplain domain.

3.11 The 1D model extends across the full length of the 2D model. The downstream extent was chosen because it was located sufficiently far from the site in order to minimise boundary effects.

3.12 Figure 4 illustrates the extent of the 1D and 2D model.

Model Grid Size

3.13 The model was constructed with a 2 m grid cell size. This was chosen as it represented a good balance between the degree of precision (i.e. ability to model overland flow paths along roads or through ditches) and model run (“simulation”) times.

Topographic Data

3.14 1 m resolution LiDAR (Light Detection And Ranging) data, which was captured in 2020, was downloaded to provide a Digital Terrain Map (DTM) of the study area including the site and surrounding catchment. This covered the entire 2D model extent and was used to represent floodplain ground levels.

Figure 4: 1D and 2D Model Extent

3.15 The site topographic survey was used to validate the LiDAR data. The two data sets were found to compare well across the site. Consequently, the LiDAR was considered to be acceptable for use as part of the hydraulic model.

3.16 A cross section topographic survey of the watercourse and hydraulic structures was captured across the full length of the 1D model. Details are enclosed in Appendix C.

Upstream Boundary Conditions

3.17 The hydrographs derived as part of the hydrological modelling were incorporated into the hydraulic model as upstream boundary conditions (i.e. inflows). The two upstream catchments were incorporated into the most upstream 1D cross section / node, for Reach 1 and Reach 2. The lateral inflows were proportioned across the model reach (see Figure 5).

Downstream Boundaries

3.18 A stage-discharge boundary was added to allow water to exit the 2D model at the downstream extent. The stage-discharge relationship is calculated automatically by TUFLOW based on gradients determined from LiDAR data.

3.19 A fixed water level of 78.14 m AOD was applied as a downstream boundary for the 1D model. This was the surveyed water level and is thought to represent a typical likely dry weather flow condition. Alternative, more conservative, methods for a downstream boundary condition were tested but introduced instability into the model during model testing.

Figure 5: Inflow Locations

3.20 The results in the proximity of the site were not considered to be sensitive to this boundary condition given the distance and level differences. However, the sensitivity of the model to this downstream boundary conditions was tested and is discussed in Section 5 of this report.

Structures

3.21 The watercourse survey captured a total of 21 structures, which are summarised in Table 2. All surveyed structures were included in the hydraulic model. Figure 6 presents the location of these various structures.

3.22 On Reach 1 a lake is present upstream of the B4100 (see Figure 7). Water flows both in and out of the lake at the same location (at node 01450). However, an overflow is present at the downstream extent of the lake, which flows in a culvert beneath the B4100. The water level in the lake was set to be full (i.e. 85.04 m AOD, which is equivalent to the invert level of the culvert that provides flow into it).

3.23 The only surveyed feature that was ignored is a small pond located at the upstream extent of Reach 2. The modelled watercourse supplies flow to this pond, but its inclusion was thought to offer no benefit to the accuracy of the model results. In theory it could offer some storage potential, so its exclusion was conservative.

Figure 6: Structure Locations

Floodplain Topography

3.24 The only change to the floodplain topography was the inclusion of a stone wall that surrounds the lake. A gap in this wall was included, at the location of a small gate.

Hydraulic Roughness

3.25 Hydraulic roughness is the measure of the amount of frictional resistance water experiences when passing over land and channel features. Manning's 'n' coefficient values provide a measure of these roughness values. The river channel and floodplain were assigned a roughness value with reference to standard values (Chow, 1959).

3.26 Roughness values are variable and include a default value of 0.06 for arable land and 0.02 for roads, for example. Limited variation in Manning's values was noted across the small rural model extent.

3.27 Roughness land uses were defied using aerial photography, which was considered adequate given the rural floodplain and small variation in land use.

Figure 7: Lake and Wall Locations

Figure 8: Wall Surrounding the Lake

3.28 A relatively high Manning's value of 0.06 was adopted for the 1D river channel. This was because a reasonable amount of vegetation was noted to creep into the channel during summer months. Therefore, a conservative approach was adopted to represent these summer conditions.

Linking

3.29 The 2D model was dynamically linked to the 1D model using a 'HX' boundary, which transfers flows based on a water level between the two models.

Model Run Parameters

3.30 The default TUFLOW Classic model run parameters were used and adopted for all simulations.

Design Runs

3.31 The baseline and proposed hydraulic models were simulated for the following design events:

i) 1 in 20 year event.

ii) 1 in 100 year event.

iii) 1 in 100 year event plus a 15% allowance for climate change event (central estimate).

iv) 1 in 100 year event plus a 25% allowance for climate change event (higher central estimate).

v) 1 in 1000 year event.

3.32 These climate change allowances are in accordance with latest Planning Practice Guidance, which indicates that the central estimate (i.e. 15%) is applicable for the site. It is this 1 in 100 year event plus a 15% allowance for climate change event that represents the key design event which development must be protected from.

3.33 Based on the recommended ranges for the cell size, a 0.5 second timestep was adopted for the 2D TUFLOW model. A 0.25 second timestep was adopted for the 1D component.

4 Model Results

Model Stability

4.1 The stability of a model is critical to the understanding of the robustness and its ability to simulate a flood event accurately.

4.2 Stability in the model is assessed by examining the cumulative error (or mass balance) of the model, as well as the warnings output by the model during the simulation.

4.3 The 1 in 100 year plus 15% climate change event was run using TUFLOW Classic. Iterations of the model were undertaken to improve stability etc, where necessary. The cumulative error of the model is within the range of ±1.3% throughout the simulation. No negative depths were encountered. Various warnings and checks occurred prior to the simulation, which were found to be of little consequence and were therefore considered acceptable.

4.4 Similar observations were made for the wider design simulations.

Baseline Model Results

4.5 The results have been summarised through the presentation of a flood map showing the various design events. This is shown in Figure 9. Further flood mapping is enclosed in Appendix D.

4.6 It can be seen that in a 1 in 20 year event, flooding is limited to the confluence of the two streams. However, in a 1 in 100 year event, flooding on the east site boundary occurs. This is a result of the capacity restriction associated with a series of hydraulic structures downstream of the B4100. Under the model extreme events, the flood extents become broader but limited other areas experience flooding. It is noted that floodwater is contained within the banks of Reach 2. The downstream reach of the model first floods in a 1 in 1000 year event.

4.7 The 1 in 1000 year flood event generates the most extensive floodplain out of the various design events investigated. Figure 10 compares this with the flood extent on the Flood Map for Planning (i.e. Flood Zone 2). It shows that the flood extents derived from this study are smaller than that presented on the Flood Map for Planning. They are also smaller than the flood extents presented on the Risk of Flooding from Surface Water Map (Figure 12).

4.8 As part of the FRA prepared to support the planning application, a climate change flood extent was derived based on the extrapolation of JFLOW flood levels. The resultant flood extent is shown in Figure 13. This extrapolated flood extent, along with the flood extents presented on the Flood Map for Planning and Risk of Flooding from Surface Water Map, were all originally used to inform the Land Use Parameters Plans, Framework Plan and Illustrative Masterplan associated with the planning submission. This ensured that the proposed development (including SuDS) was entirely steered out of the floodplain.

4.9 The flood extents prepared as part of this flood modelling study are no greater than those extents previously available and it can be concluded therefore, that the development remains safe from flooding without impacting on third parties. This is therefore in accordance with the requirements of planning policy.

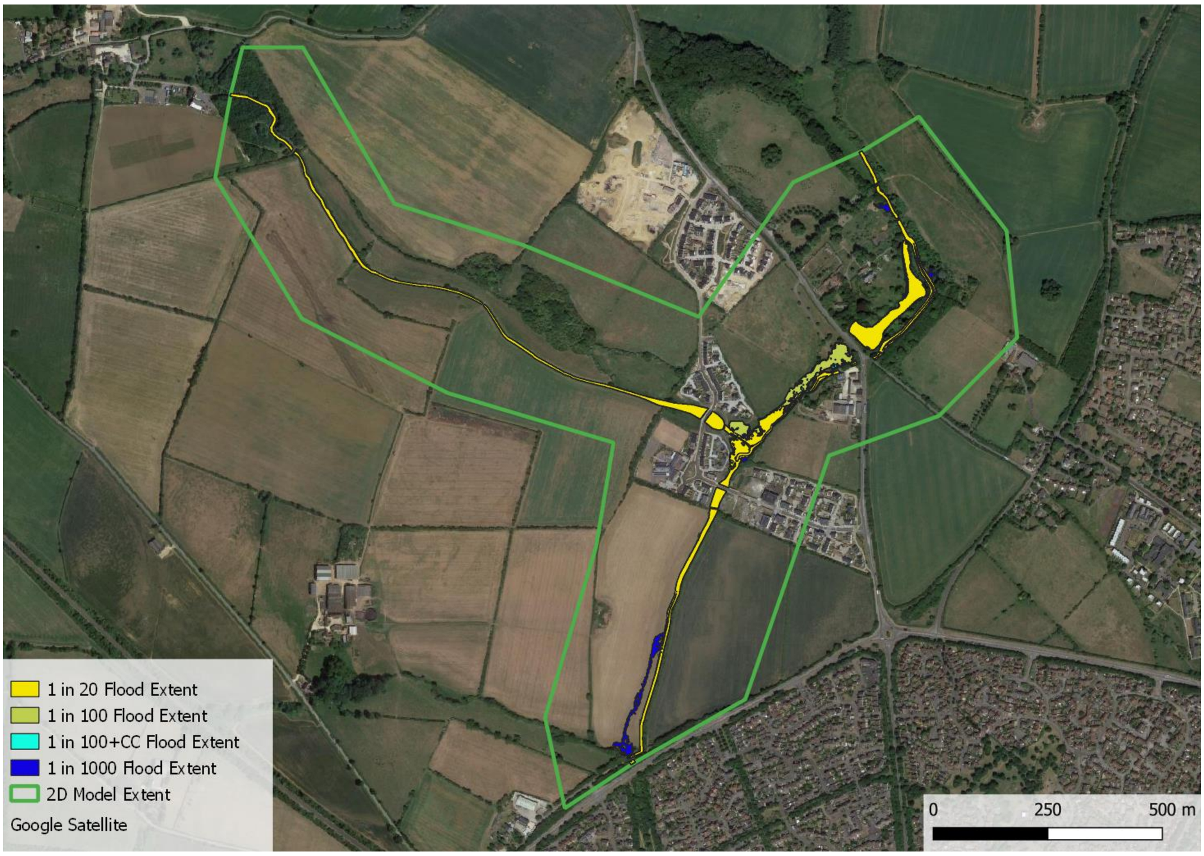


Figure 9: All Flood Extents

Figure 10: Comparison of Modelled 1 in 1000 Year Event and Flood Zone 2

Figure 11: Comparison of Modelled 1 in 100 Year Event and Flood Zone 3

Figure 12: Comparison of Modelled 1 in 1000 Year Event and Surface Water Flood Extent

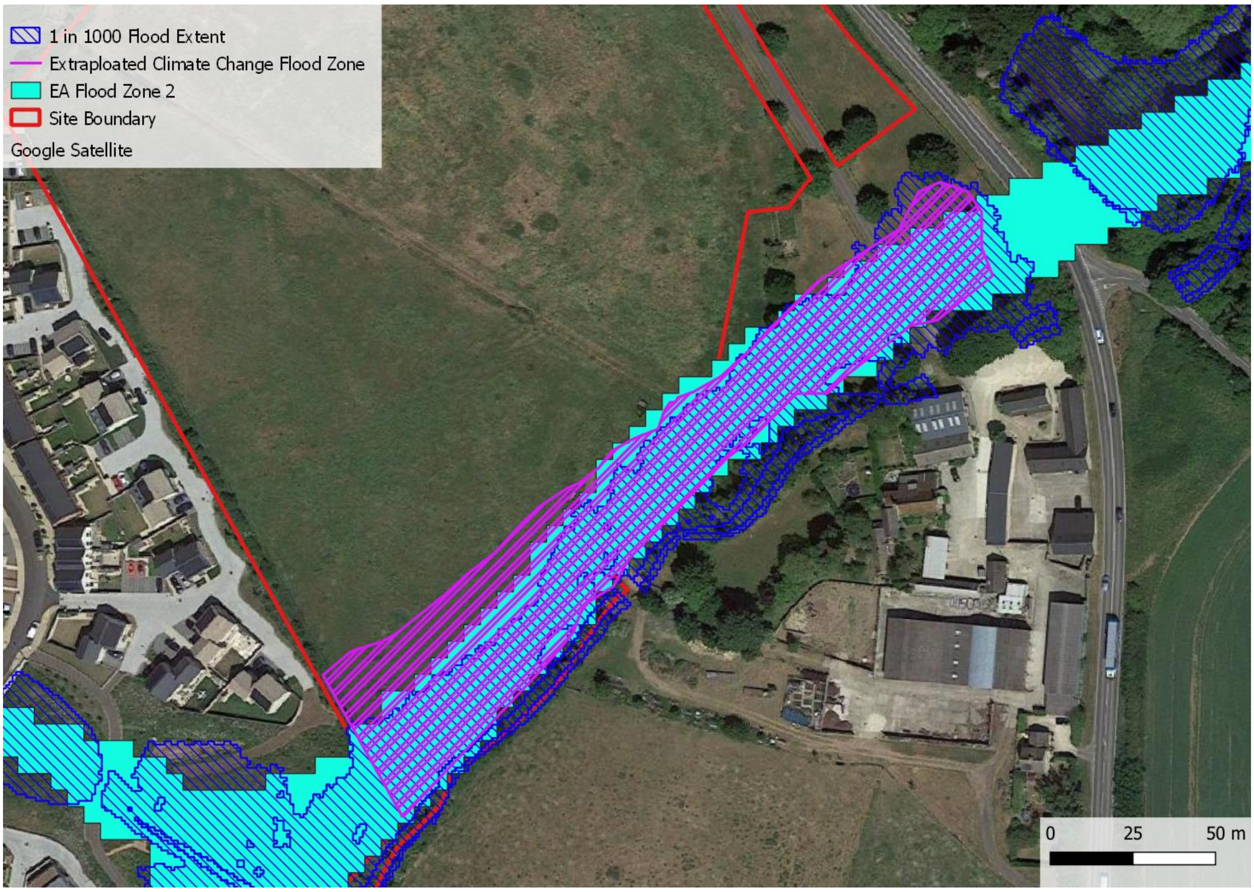


Figure 13: Comparison of Modelled 1 in 1000 Year Event and FRA Extrapolated Flood Zone

Model Uncertainty

4.10 The catchment upstream of the site is ungauged and permeable. Therefore, some uncertainty exists with respect to the accuracy of the hydrological and hydraulic model. The results presented are the best available, within the confines of available information.

5 Sensitivity Testing

5.1 Sensitivity testing is the process of adjusting key parameters within the hydraulic model to examine the impact. This allows an understanding of how any uncertainty associated with those parameters may affect the outcome of the model. Sensitivity testing is often undertaken in the absence of data used for the calibration purposes. Sensitivity testing has been undertaken on the following parameters:

i) Manning's 'n' roughness;

ii) Flow;

iii) Downstream boundary condition; and

iv) Blockages.

5.2 The sensitivity testing has been undertaken on the basis of the 1 in 100 year event.

Manning's 'n' Roughness

5.3 Manning's 'n' roughness was adjusted by ±20% in the channel and floodplain. The results of this sensitivity test are identified in Figure 14 and 15, which are difference maps compared to the baseline model.

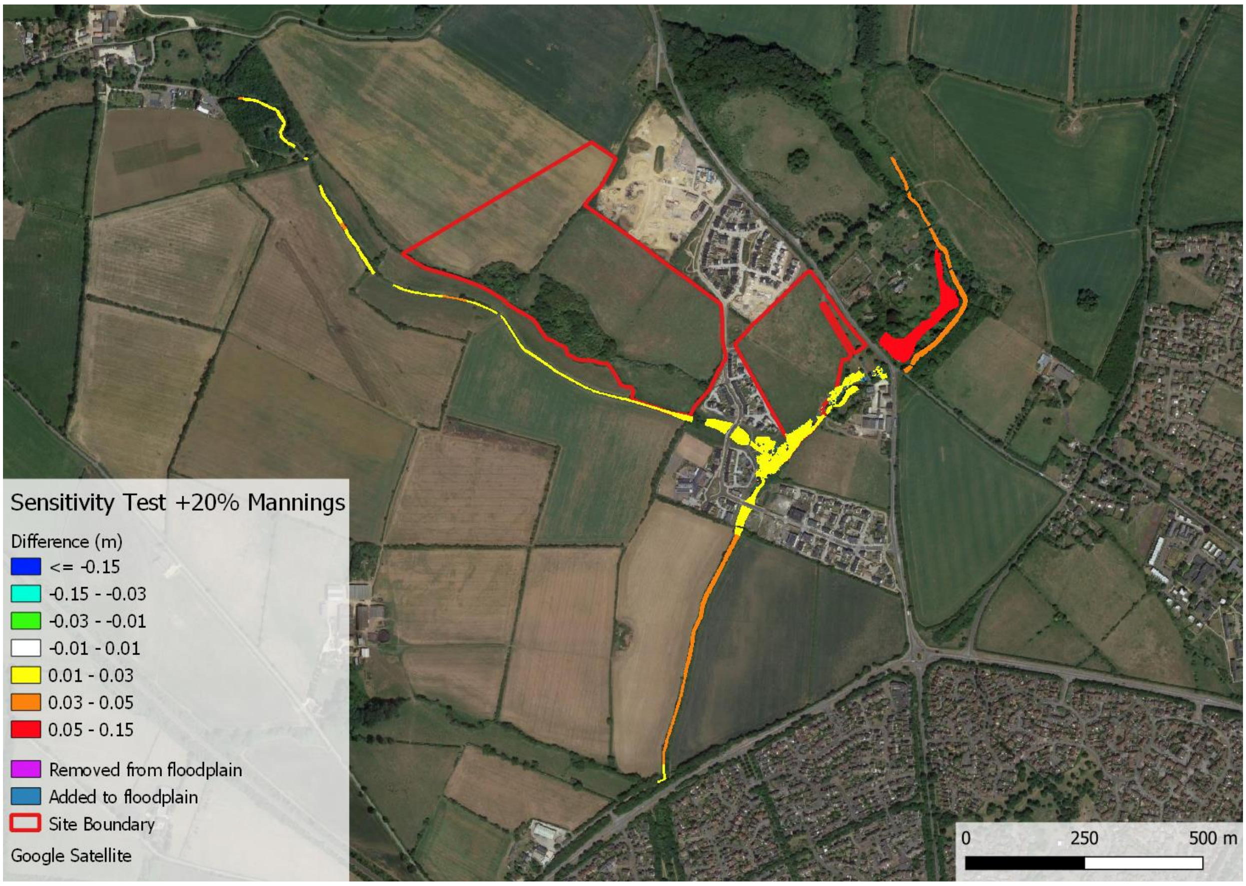


Figure 14: Manning's Plus 20% Difference Map

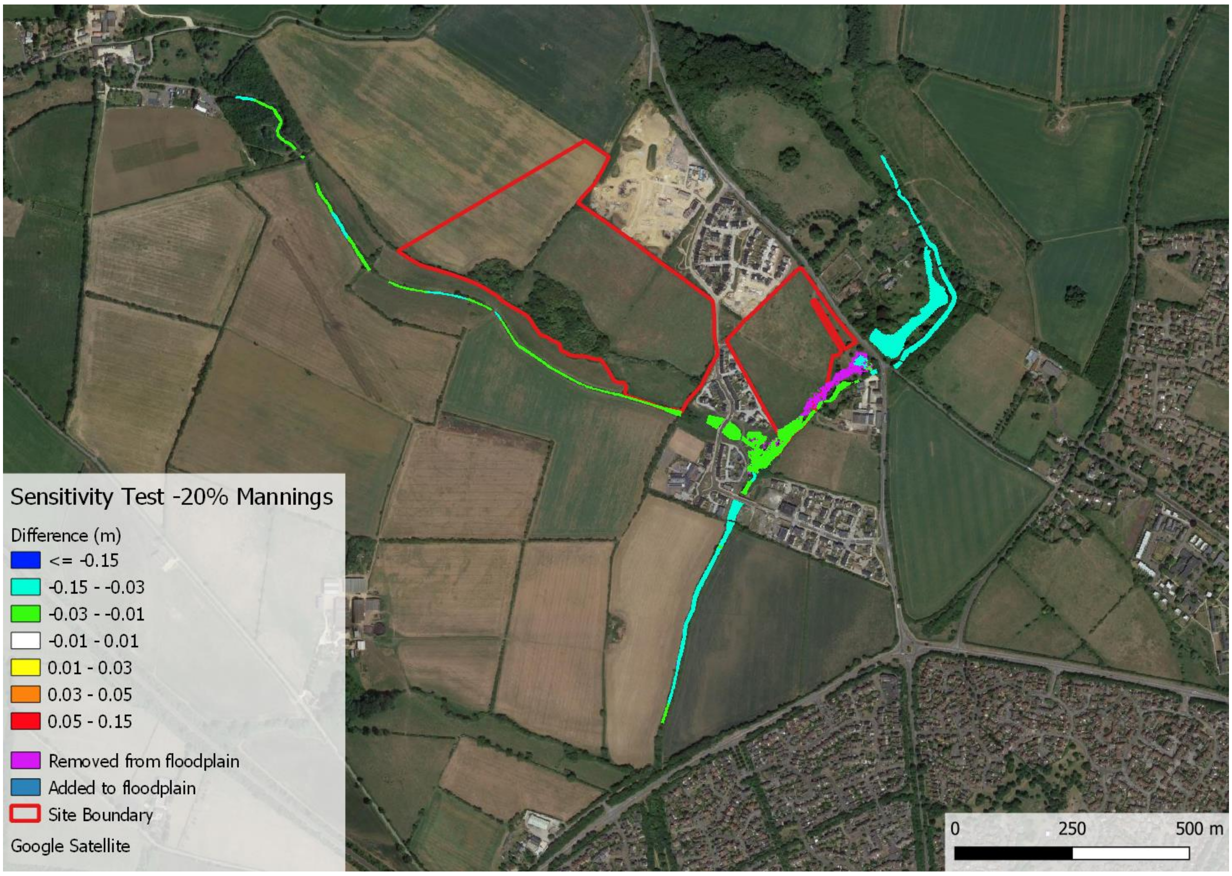


Figure 15: Manning's Minus 20% Difference Map

5.4 The results of the sensitivity testing show a similar impact in both the decreased and increased scenarios. The variation in peak water level is minor for what is a relatively significant adjustment to roughness values. The model is therefore not considered to be particularly sensitive to Manning's roughness.

Flow

5.5 The upstream boundary condition (i.e. inflow) was adjusted by ±20%. The results of this sensitivity test are identified in Figure 16 and 17, which are difference maps compared to the baseline model.

5.6 The results of the sensitivity testing show a similar impact in both the decreased and increased scenarios. The variation in peak water level is minor for what is a relatively significant adjustment to inflow values. The model is therefore not considered to be particularly sensitive to inflows.

Downstream Boundary Conditions

5.7 The downstream boundary condition was modified by applying an elevated water level throughout the simulation in both 1D and 2D. This was increased from 78.14 m AOD to 79.5 m AOD. A level of 79.5 m AOD was determined based on the estimated flood level for the 1 in 1000 year event from the Flood Map for Planning. It meant that the culvert on the downstream boundary was submerged throughout the simulation in the sensitivity test. The results of this sensitivity test are identified in Figure 18, which is a difference map compared to the baseline model.

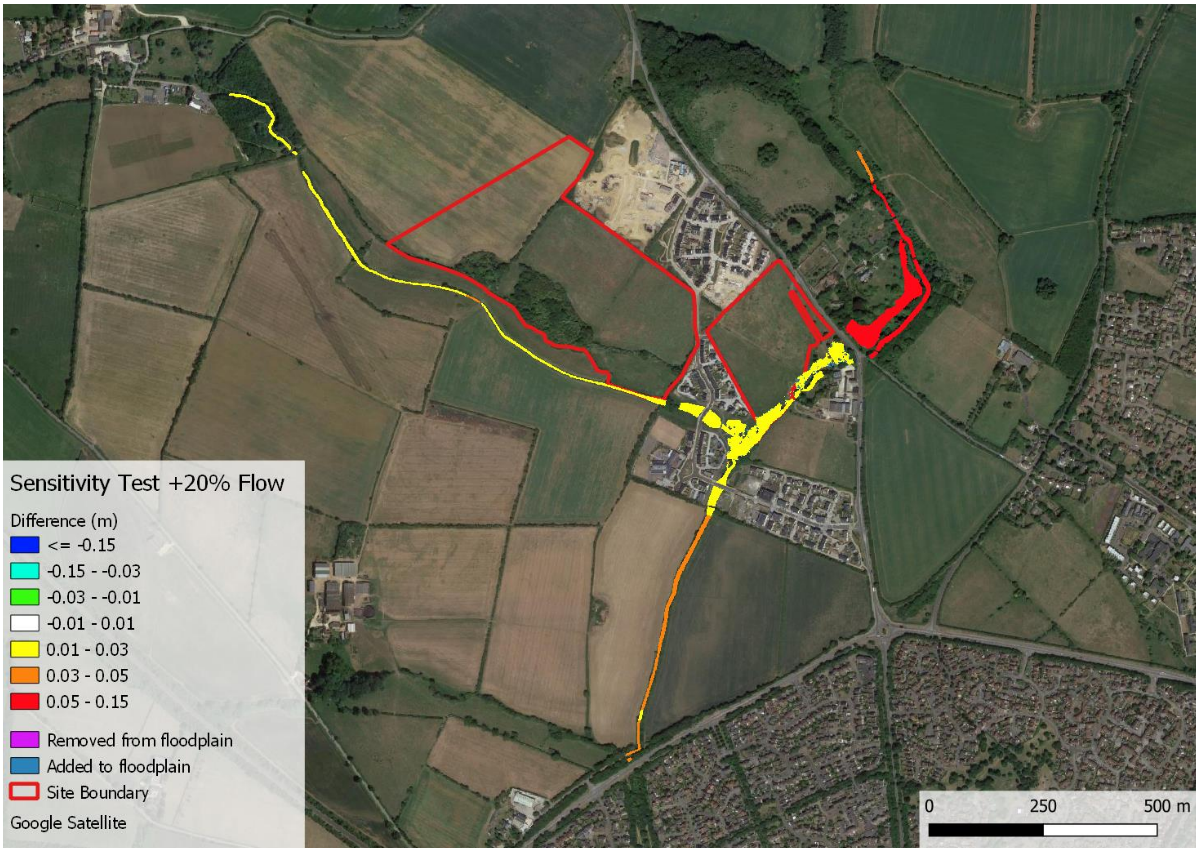


Figure 16: Flow Plus 20% Difference Map

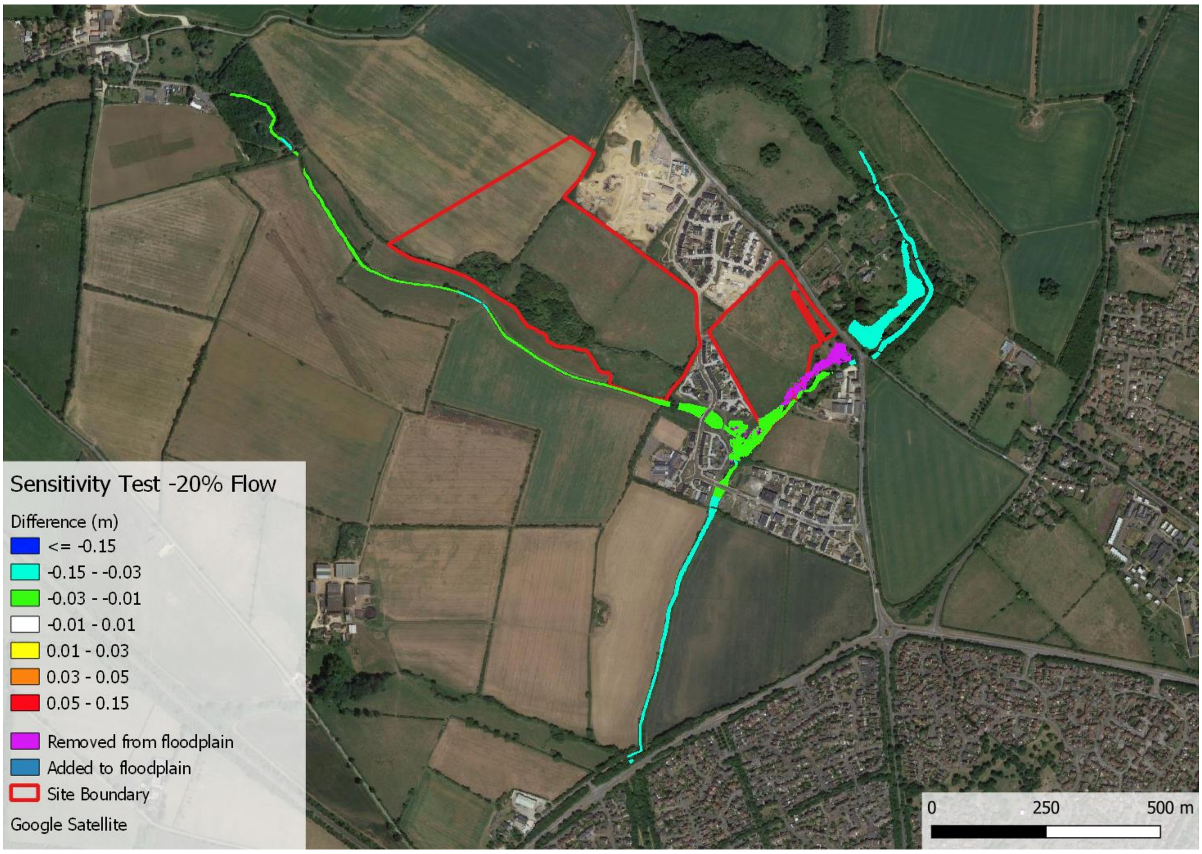


Figure 17: Flow Minus 20% Difference Map

Figure 18: Increased Downstream Boundary Difference Map

5.8 The impacts are significant at the downstream end of the hydraulic model, but with distance upstream from the downstream boundary, the effects become less significant. The effects of the downstream boundary were not felt at the site. This is important because it confirms that any uncertainty associated with the downstream boundary is likely to have no effect upon peak water levels at the site.

Summary

5.9 Generally, the watercourse was found to be relatively insensitive to adjustments of key parameters within the hydraulic model. Consequently, the model is considered to offer a robust representation of the watercourse for this assessment and peak water levels/flood extents are considered reliable.

Blockages

5.10 Whilst not required by the EA, as part of their model methodology review, the impact of blockages was also assessed. Following a site visit it was considered that the hydraulic structures most likely to increase flooding on site were beneath the B4100.

5.11 If these were to block, water would accumulate upstream in the proximity of the lake and spill towards the site once flood levels get high enough to flow through the gap/gate in the wall. As part of this blockage assessment, the lake was set to be full (i.e. above culvert inlet / outlet level and up to bank top). This conservative approach was not possible under a non-blocked scenario, because water drains out of the lake into the stream at the start of the simulation. To achieve this, the culvert inlet / outlet was modelled as 100% blocked.

5.12 As series of very conservative blockage scenarios have been assessed, which are as described below:

1. Main culvert beneath B4100 100% blocked, lake full – see Figure 19
2. All culverts beneath B4100 100% blocked, lake full – see Figure 20
3. All culverts on site 100% blocked, lake not full – see Figure 21

Figure 19: Blockage Scenario 1

5.13 The flood depth results are presented in Figure 22 to 24. Ultimately, whilst different flood mechanisms are identified as a result of the three blockage scenarios the flood extents on site are no greater than that identified in the 1 in 1000 year event. Therefore, the conclusions drawn in Section 4 are still valid.

Figure 20: Blockage Scenario 2

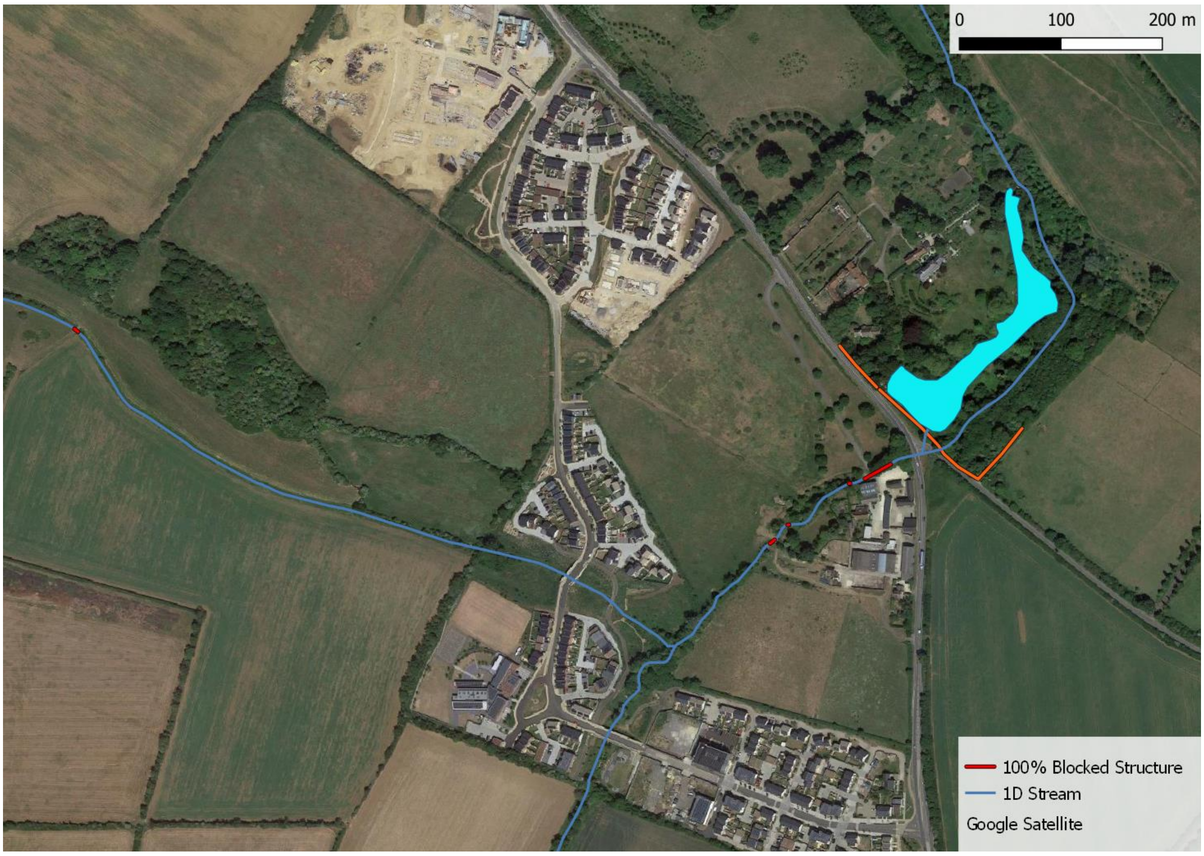


Figure 21: Blockage Scenario 3

Figure 22: Flood Depth Map – Blockage Scenario 1

Figure 23: Flood Depth Map – Blockage Scenario 2

Figure 24: Flood Depth Map – Blockage Scenario 3

6 Conclusion

6.1 This flood modelling study has been undertaken by Vectos on behalf of Firethorn Developments Limited. This has been undertaken to support the outline planning application (21/01630/OUT) at North West Bicester.

6.2 Following the EA review of the planning submission, they stipulated the need for hydraulic modelling to obtain a reliable estimation of flood risk, which should be used for comparison to development proposals.

6.3 The flood modelling study has been completed using 1D-2D ESTRY-TUFLOW software to investigate the fluvial flood risk associated with two ordinary watercourses on the site boundary. This has shown that the existing Flood Map for Planning and Risk of Flooding from Surface Water map overestimate the floodplain in the proximity of the site.

6.4 Given that the Land Use Parameters Plans, Framework Plan and Illustrative Masterplan for the proposed development were all based on these desktop sources of flood risk, it can be concluded that the development remains safe from flooding without impacting on third parties.

Appendix 1

Environment Agency Correspondence

creating a better place

Environment Agency

Mr Nick Bosanko
Vectos
4 Colston Avenue
Bristol
Avon
BS1 4ST

Our ref: WA/2021/129288/01-L01
Agreement No: ENVPAC/1/THM/00590

Your ref: 21/01630/OUT

Date: 04 October 2021

Dear Mr Bosanko

Planning advice for North West Bicester

Thank you for accepting our offer to provide detailed planning advice. The advice detailed below is intended to inform your development proposal. It is not our statutory response to a planning application consultation.

We are providing this advice under Agreement No. ENVPAC/1/THM/00590 and Firethorn Developments will be invoiced accordingly.

We have reviewed the proposed modelling methodology you submitted by email dated 22/07/2021.

Please note that we are only providing you with our advice on the matters as outlined in our offer as requested.

Hydrology
The proposed hydrological analysis will be performed using ReFH2 and statistical techniques for all key design storms. This is an appropriate approach. The return periods of 5%, 1%, 1% CC and 0.1% AEP are appropriate, although further return periods such as 10%, 2% and 0.5%AEP should be considered. The climate change uplift is noted as 35% for the Thames higher central estimate. A further climate change simulation with an upper end estimate is suggested. Any climate change uplifts should follow appropriate climate change guidance.

A sensitivity test should be completed with flow + /- 20% for the 1% AEP return period.

The location for the hydrological analysis is appropriate.

Hydraulics

A 1D-2D model is appropriate for this study, with the 1D-2D links using HX boundaries. The 2D model extent matches the proposed 1D so the whole model will be 1D in-channel and 2D floodplain. A 2m cell size using 1m LiDAR is appropriate and should give good resolution of the model without heavily compromising run times.

The survey coverage is appropriate and appears to contain all future intended structures across the river channels. Any further alterations to the site plans around the channel should be incorporated into the model.

The 2D Manning's roughness is suggested as 0.05 for agricultural fields and aerial photography will be used to define other roughness values. Whilst this is appropriate it is suggested that mastermap data is used to define the roughness values on the floodplain, with updates to the roughness used for the design/with scheme simulation.

The downstream boundary location appears to be appropriate. Vectos describes the initial backwater calculation showing an appropriate distance downstream of the site. Results at this location should be investigated following to ensure that there is no flow or stage increase in the design/with scheme simulations. Any increase will require further investigation and possibly the requirement to map the knock-on effects downstream of the proposed model.

Sensitivity tests have not been included within the methodology proposal. These should be undertaken with + /-20% sensitivities to the inflows, manning's n and downstream boundary.

The modelling will be required to follow Environment Agency guidance which you can access through the following link:
https://www.gov.uk/government/publications/river-modelling-technical-standards-and-assessment

Conclusions
The modelling methodology is reasonable for the study. As mentioned above further considerations should be taken for inflows and sensitivity tests and particular attention should be given to the downstream boundary, although the methodology supplied suggests initial tests suggest it is appropriate.

Next steps
Any modelling compiled in support of the development at North West Bicester will need to undergo a technical review by the Environment Agency. Please note that a review can take anywhere between 3 – 8 weeks depending on the nature of the model and programme of reviews already underway.

Final comments
Once again, thank you for contacting us with your enquiry. Our comments are based on our available records and the information as submitted to us.

I hope the above advice is helpful. If there is any further work you anticipate needing our detailed advice on in relation to this project, please let me know so it can be incorporated into this charging agreement.

Disclaimer
Please note that the views expressed in this report by the Environment Agency, is a response to a pre-application enquiry only and **does not represent our final view in**

relation to any future statutory consultations made in relation to this site. We reserve the right to change our position in relation to any such application.

We have only provided advice in relation to the environmental constraints as outlined in our offer as requested. However, we will comment on all environmental constraints within our remit in our statutory response.

Please quote our reference number in any future correspondence. If you have any queries please feel free to contact me.

Yours sincerely

Miss Sarah Green
Sustainable Places - Planning Advisor

Direct dial 0208 474 9253
Direct e-mail planning_THM@environment-agency.gov.uk

Appendix 2

Hydrological Analysis

(See digital version for all details)

Flood estimation report:

Land at Northwest Bicester

Introduction

This report template is a supporting document to the Environment Agency's Flood Estimation Guidelines. It provides a record of the hydrological context, the method statement, the calculations and decisions made during flood estimation and the results.

Contents

Approvals

Revision stage	Analyst / Reviewer name & qualifications	Amendments	Date
Method statement preparation	GEORGE FRISBY	N/A	02/11/2021
Initial calculations preparation	GEORGE FRISBY	N/A	02/11/2021
Calculations - Revision 1 preparation	GEORGE FRISBY	N/A	02/11/2021
Report Update in Response to EA Comments	GEORGE FRISBY		04/02/2022

Review by Matthew Scott

Abbreviations

AEP................................ annual exceedance probability
AM.................................. Annual Maximum
AREA .... Catchment area (km^2)
BFI .... Base Flow Index
BFIHOST .... Base Flow Index derived using the HOST soil classification
CPRE.............................. Council for the Protection of Rural England
FARL............................... FEH index of flood attenuation due to reservoirs and lakes
FEH................................. Flood Estimation Handbook
FSR................................. Flood Studies Report
HOST.............................. Hydrology of Soil Types
NRFA.............................. National River Flow Archive
OS.................................. Ordnance Survey
POT................................. Peaks Over a Threshold
QMED............................. Median Annual Flood (with return period 2 years)
ReFH .... Revitalised Flood Hydrograph method
ReFH2 .... Revitalised Flood Hydrograph 2 method
SAAR.............................. Standard Average Annual Rainfall (mm)
SPR................................. Standard percentage runoff
SPRHOST .... Standard percentage runoff derived using the HOST soil classification
Tp(0) .... Time to peak of the instantaneous unit hydrograph
URBAN .... Flood Studies Report index of fractional urban extent
URBEXT1990 .... FEH index of fractional urban extent
URBEXT2000 .... Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH .... Windows Frequency Analysis Package – used for FEH statistical method

1 SUMMARY OF ASSESSMENT

1.1 Summary

This table provides a summary of the key information contained within the detailed assessment in the following sections. The aim of the table is to enable quick and easy identification of the type of assessment undertaken. This should assist in identifying an appropriate reviewer and the ability to compare different studies more easily.

Catchment location	North Bicester - 457650,224300
Purpose of study and scope	Inflows for hydraulic model – A lumped catchment (DS_R01) and two sub catchments (US_R01 and US_R02).
Key catchment features	Permeable Catchment – Rural
Flooding mechanisms	Fluvial and potential Groundwater
Gauged / ungauged	Ungauged
Final choice of method	FEH
Key limitations / uncertainties in results	Interaction with Groundwater during long duration storm events.

1.2 Note on flood frequencies

The frequency of a flood can be quoted in terms of a return period, which is defined as the average time between years with at least one larger flood, or as an annual exceedance probability (AEP), which is the inverse of the return period.

Return periods are output by the Flood Estimation Handbook (FEH) software and can be expressed more succinctly than AEP. However, AEP can be helpful when presenting results to members of the public who may associate the concept of return period with a regular occurrence rather than an average recurrence interval. Results tables in this document contain both return period and AEP titles; both rows can be retained or the relevant row can be retained and the other removed, depending on the requirement of the study.

The table below is provided to enable quick conversion between return periods and annual exceedance probabilities.

Annual exceedance probability (AEP) and related return period reference table

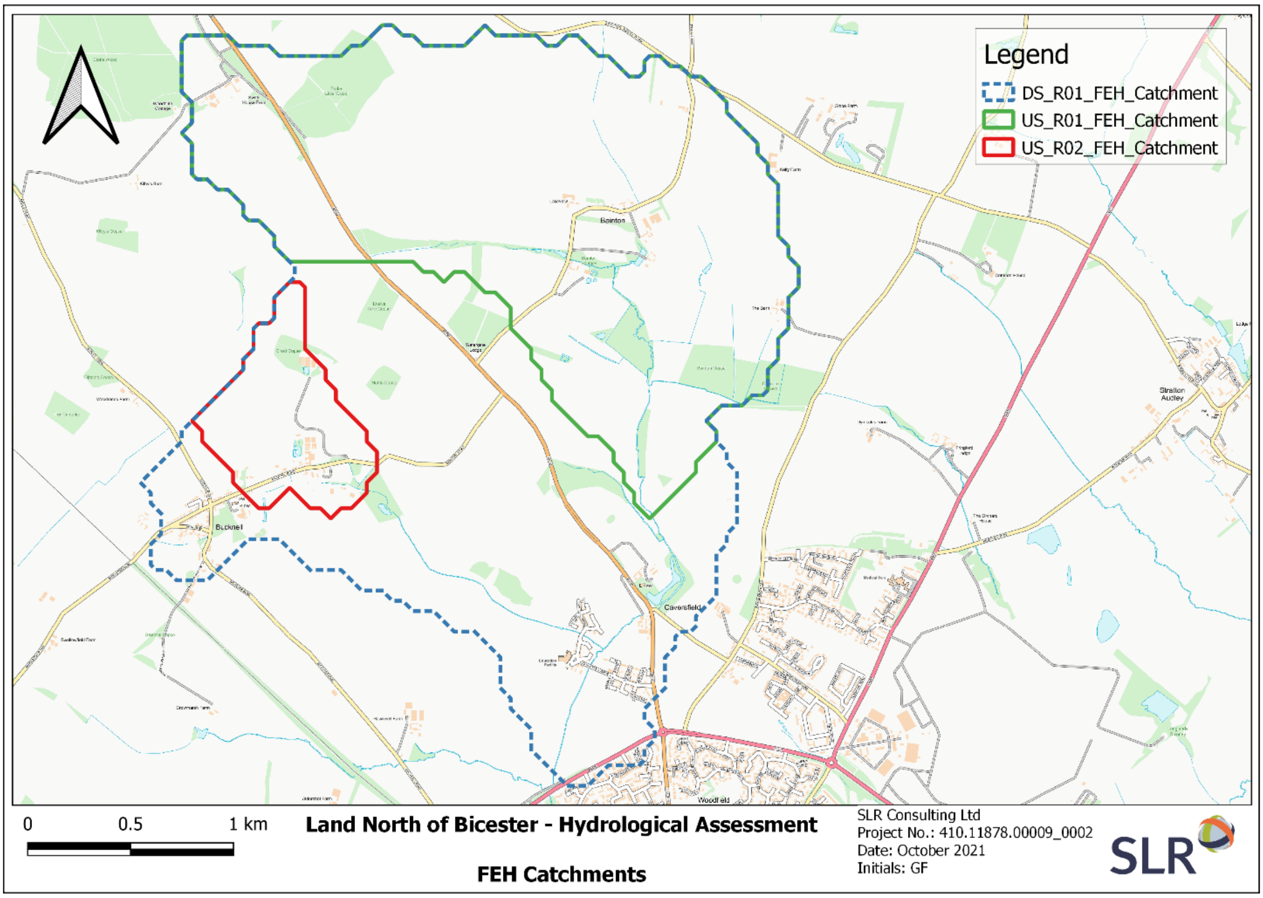
AEP (%)	50	20	10	5	3.33	2	1.33	1	0.5	0.1
AEP	0.5	0.2	0.1	0.05	0.033	0.02	0.0133	0.01	0.005	0.001
Return period (yrs)	2	5	10	20	30	50	75	100	200	1,000

2 METHOD STATEMENT

2.1 Requirements for flood estimates

Overview	Estimate peak flows and generate associated hydrographs for use as upstream boundary conditions/inflows to a hydraulic model covering Bainton, Swallowfield Farm and Caversfield. 1 lumped catchment and 2 sub catchments. 0.05, 0.01 and 0.001 AEP flood events Allowance for climate change (CC) of 15 and 25% (allowance for relevant EA catchment) applied to the 0.01 AEP hydrographs in the hydraulic model.
Project scope	No existing hydrological studies incorporated into this assessment.

2.2 The catchment



Description	The total area is divided into one lumped catchment and 2 sub catchments as shown in the figure above. The two main catchment watercourses converge at 457882, 224889 before flowing south west – under the A4095 Bicester bypass, which forms the lumped catchment (DS_R01) outlet. The Geology of the catchment is predominantly Cornbrash Formation Limestone, with in channel bedrock of Forest Marble Limestone and Mudstone and superficial deposits of alluvium (clay, silt, sand and gravel). The porous limestone in the catchment leads to high levels of permeability. Rural, predominantly agricultural catchment area with low relief, falling from approx. 120m Above Ordnance Datum in the northern upper end of the catchment, to 80m AOD at the Bicester bypass and catchment outlet.

2.3 Source of flood peak data

Source	NRFA peak flows dataset, Version 10, released August 202021. This contains data up to water year 2019/20.

2.4 Gauging stations (flow or level)

All Gauging stations below are deemed suitable for QMED estimates

Water-course	Station name	NRFA number	Distance (km)	BFIHOST	Catchment area (km²)	QMED observed	Pooling Suitability
Bedford	Thornborough Mill	33005	11.34	0.822	387.67	21.8	Yes
Cherwell	Enslow Mill	39021	17.72	0.48	555.45	19.3	Yes
Tove	Cappenham Bridge	33018	22.39	0.59	132.55	17.04	No
Cherwell	Banbury	39026	24.7	0.368	204.59	16.731	No
Evenlode	**Cassington Mill**	**39034**	**24.86**	**0.41**	**427.14**	**20.6**	**Yes**
Thames	Days Weir	39002	29.63	0.699	3480.00	148.014	Yes

2.5 Hydrological understanding of catchment

Conceptual model	Main site of interest is at Caversfield House, and therefore flood risk is dominated by flows in US_R01. Therefore, the critical duration for this reach will dictate the durations for the other catchments.
Unusual catchment features	FEH catchment descriptors indicate the catchment is highly permeable – with very high BFIHOST of 0.822 and a low SPRHOST of 15.59%.

2.6 Initial choice of approach

Is FEH appropriate?	Yes
Initial choice of method(s) and reasons How will hydrograph shapes be derived if needed? Will the catchment be split into sub-catchments? If so, how?	FEH statistical method – Including permeable adjustment method as the SPRHOST of the catchment is below the threshold of 20%. Hydrographs will be derived using ReFH2. FEH statistical method will be completed on the total lumped catchment (DS_R01). ReFH2 completed on the lumped catchment and the sub catchments. US_R01 and US_R02 sub catchment hydrographs to be scaled proportionately using the FEH statical method and the relative peak flows derived from the ReFH2 hydrographs.
Software to be used (with version numbers)	FEH Web Service[1] / WINFAP 42.7282[2] / ReFH spreadsheet / ReFH2.3 / Flood Modeller Pro

[1] CEH 2015. The Flood Estimation Handbook (FEH) Online Service, Centre for Ecology & Hydrology, Wallingford, UK.

[2] WINFAP 4 © Wallingford HydroSolutions Limited 2016.

3 LOCATIONS WHERE FLOOD ESTIMATES REQUIRED

The table below lists the locations of subject sites. The site codes listed below are used in all subsequent tables to save space.

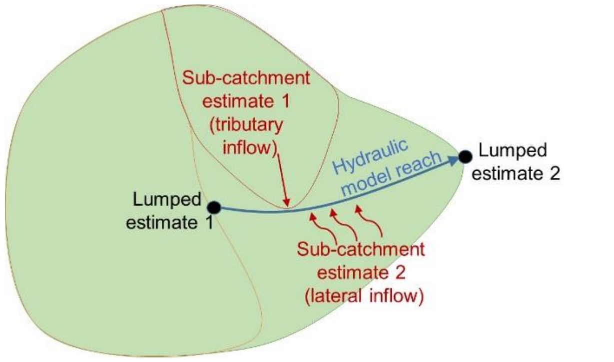
3.1 Summary of subject sites and key catchment descriptors

Site code	Type of estimate L: lumped catchment S: Sub-catchment	Watercourse (all officially unnamed)	Easting	Northing	AREA on FEH Webservice	BFI HOST	SPR HOST (%)	URBEXT 2000	FARL
DS_R01	L	Reach 1	457650	224300	7.60	0.822	15.59	0.0105	0.965
US_R01	S	Reach 1	458100	225550	3.88	0.788	18.08	0.0071	1
US_R02	S	Reach 2	456700	225700	0.53	0.754	20.58	0.0165	1

Note: Lumped catchments (L) are complete catchments draining to points at which design flows are required.

Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system. There is no need to report any design flows for sub-catchments, as they are not relevant: the relevant result is the hydrograph that the sub-catchment is expected to contribute to a design flood event at a point further downstream in the river system. This will be recorded within the hydraulic model output files. However, catchment descriptors and ReFH model parameters should be recorded for sub-catchments so that the results can be reproduced.

The schematic diagram illustrates the distinction between lumped and sub-catchment estimates.



3.2 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes	The FEH webservice catchment delineation was checked against OS mapping contours and contoured 2m LiDAR data and was found to be an appropriate estimate for the catchment.
Record how other catchment descriptors were checked and describe any changes.	Checked against OS mapping and BGS superficial/bedrock geology and hydrogeology maps. High permeability values were validated due to the predominant limestone geology of the area.

4 STATISTICAL METHOD

4.1 Application of Statistical method

What is the purpose of applying this method?	Statistical method applied only for the overall lumped catchment (DS_R01). This is the only catchment deemed appropriate for this type of analysis – with the subcatchments being too small (less than 5km²)

4.2 Overview of estimation of QMED at each subject site

Site code	QMED (rural) from CDs (m³/s)	Final method	Data transfer					Urban adjust-ment factor UAF	Final estimate of QMED (m³/s)
			NRFA numbers for donor sites used (see 4.3)	Distance between centroids d_{ij} (km)	Moderated QMED adjustment factor, $(A/B)^a$	If more than one donor			
						Weight	Weighted ave. adjustment		
DS_01	0.290	0.298	1	24.86		1	-	-	**0.298**

Are the values of QMED spatially consistent?	-
Method used for urban adjustment for subject and donor sites	WINFAP v4[3]

Parameters used for WINFAP v4 urban adjustment if applicable

Impervious fraction for built-up areas, IF	Percentage runoff for impervious surfaces, PR_{imp}	Method for calculating fractional urban cover, URBAN
0.3	70%	From updated URBEXT2000

Notes

Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer (with urban adjustment); CD – Catchment descriptors alone (with urban adjustment); BCW – Catchment descriptors and bankfull channel width (add details); LF – Low flow statistics (add details).

The QMED adjustment factor A/B for each donor site is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial (rural) estimate from catchment descriptors.

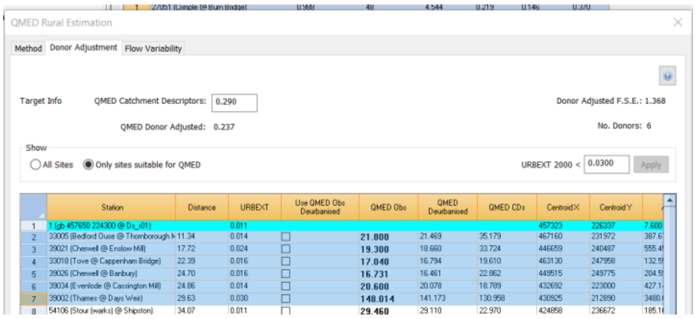
Important note on urban adjustment

The method used to adjust QMED for urbanisation published in Kjeldsen (2010)**Error! Bookmark not defined.** in which PRUAF is c alculated from BFIHOST is not correctly applied in WINFAP-FEH v3.0.003. Significant differences occur only on urban catchments that are highly permeable. This is discussed in Wallingford HydroSolutions (2016)[3].

[3] Wallingford HydroSolutions (2016). WINFAP 4 Urban adjustment procedures.

4.3 Search for donor sites for QMED (if applicable)

Comment on potential donor sites	The 5 closest donor sites are listed in Section 2.4. Gauging station 39034 (Evenlode @ Cassington Mill) has been selected as this is the only catchment with similar geology and to DS_R01 – with majority limestone and permeable bedrock. This is reflected in the high value of BFI HOST. Therefore the relationship between the observed and Catchment Descriptor values of QMED (ratio of 1.07) is incorporated in to the QMED estimation. If all 6 geographically nearest gauging stations are used, the donor adjusted estimate for QMED is 0.237. We are therefore using a more conservative (higher) estimate of donor adjusted QMED based upon study of the underlying geology of the local catchments.



4.4 Derivation of pooling groups and growth curves

The pooling group has been generated using WINFAP v.4. Station 206006 (Annalog @ Recorder) has been removed due to old dataset and 72014 (Conder @ Galgate) has been added to being a suitable small catchment. The pooling group can be found in **Appendix 01** along with the details of the application of the permeable adjustment method. Only the GL distribution can be applied to the permeable adjustment method.

4.5 Derivation of flood growth curves at subject sites – Perm adjusted GL distribution

Site code	Flood peak (m^3/s) for the following return periods (in years)									
	2	5	10	20	25	50	100	200	500	1000
	Flood peak (m^3/s) for the following AEP (%) events									
	50	20	10	5	3.33	2	1.33	1	0.5	0.1
DS_R01	1.000	1.445	1.784	2.161	2.294	2.751	3.285	3.915	4.926	5.854

4.6 Flood estimates from the statistical method

Site code	Flood peak (m^3/s) for the following return periods (in years)									
	2	5	10	20	25	50	100	200	500	1000
	Flood peak (m^3/s) for the following AEP (%) events									
	50	20	10	5	3.33	2	1.33	1	0.5	0.1
DS_R01	**0.30**	**0.43**	**0.53**	**0.64**	**0.68**	**0.82**	**0.98**	**1.17**	**1.47**	**1.74**

6 REVITALISED FLOOD HYDROGRAPH 2 (REFH2) METHOD

6.1 Application of ReFH2 method

The ReFH2 (version 2.3) method has been applied at all lumped and sub-catchments. The ReFH2 identified critical storm duration for the US-R01 (key reach for the site) catchment has been applied to all other catchments in the study so that uniform storm durations can be applied throughout the hydraulic model.

The ReFH2 full details and parameterisation can be found in **Appendix 02**.

7 DISCUSSION AND SUMMARY OF RESULTS

7.1 Comparison of results from different methods

The table below shows the comparison in ReFH2 and statistical peak flows for the lumped downstream catchment.

Site code	DS_R01 Flood peak (m^3/s) for the following return periods (in years)									
	2	5	10	20	25	50	100	200	500	1000
	DS_R01 Flood peak (m^3/s) for the following AEP (%) events									
	50	20	10	5	3.33	2	1.33	1	0.5	0.1
Statistical Method	**0.30**	**0.43**	**0.53**	**0.64**	**0.68**	**0.82**	**0.98**	**1.17**	**1.47**	**1.74**
ReFH2				**0.84**			**1.24**			**2.19**

Final Peak flows for all sub catchments shown below.

Design Event	Catchment			
	Total	Reach 1	Reach 2	Lateral
	7.60 km^2	3.88 km^2	0.53 km^2	3.19 km^2
1 in 20	0.64	0.33	0.04	0.27
1 in 100	0.98	0.50	0.07	0.41
1 in 100 + 15%CC	1.13	0.58	0.08	0.47
1 in 100 + 25%CC	1.23	0.63	0.09	0.51
1 in 1000	1.74	0.89	0.12	0.73

Due to the catchment being permeable, it is deemed more appropriate to use the peak flows from the statistical method analysis. These include allocation for the permeable adjustment method and adjusted QMED from a suitable donor catchment with similar catchment characteristics and geology. These significant elements of the catchment are not considered fully by the ReFH2 calculations.

The US_R01 ReFH2 (key catchment) hydrograph shape has been used for all catchments to allow for the correct estimation of the lateral inflows. The same hydrograph shape must be applied for all sub catchments and the lumped catchment as the lateral inflow is calculated by subtracting the two upstream sub catchments from the downstream lumped catchment flow. This lateral inflow divided and applied at 10 discrete locations along the model reach as shown in the accompanying hydraulic modelling report.

The ReFH2 hydrograph is scaled using the relationship of the ReFH2 and statistical method peak flows for DS_R01, as this is the only location where the statistical method has been applied. The scaling factor for each sub catchment is based upon the relative catchment areas.

The final scaled hydrographs are contained in **Appendix 03**.

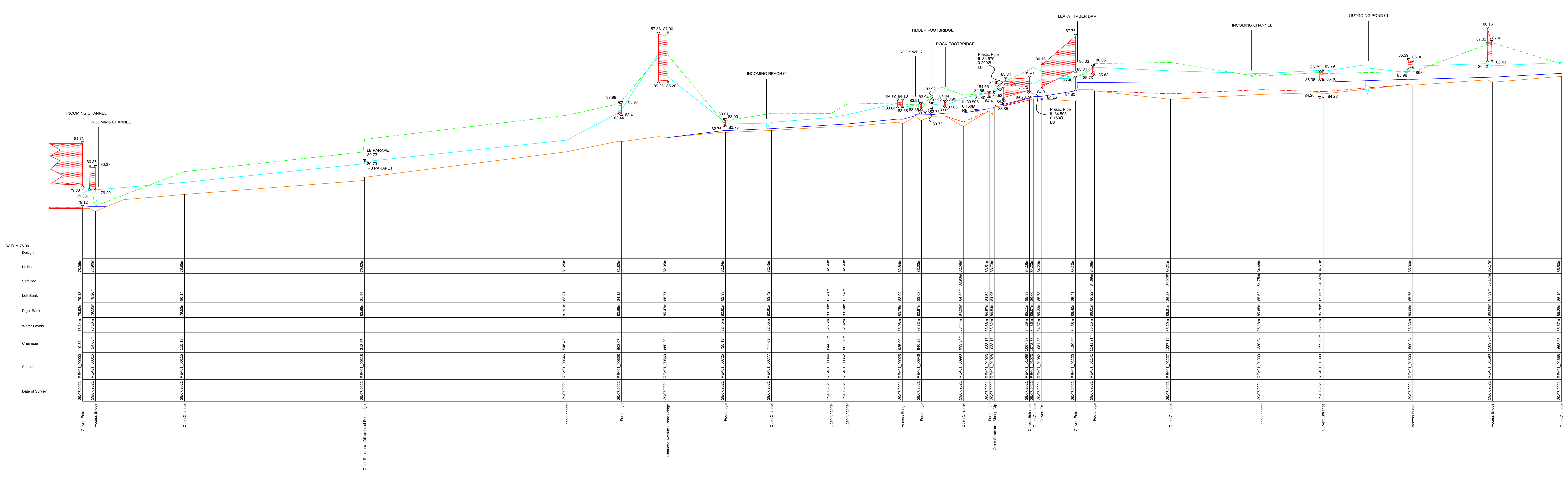
Appendix 3

Watercourse Survey

LONG SECTION KEY:

- WATER LEVEL
- BED LEVEL
- SILT LEVEL
- STRUCTURES
- RIGHT BANK
- LEFT BANK

VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'X' ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS



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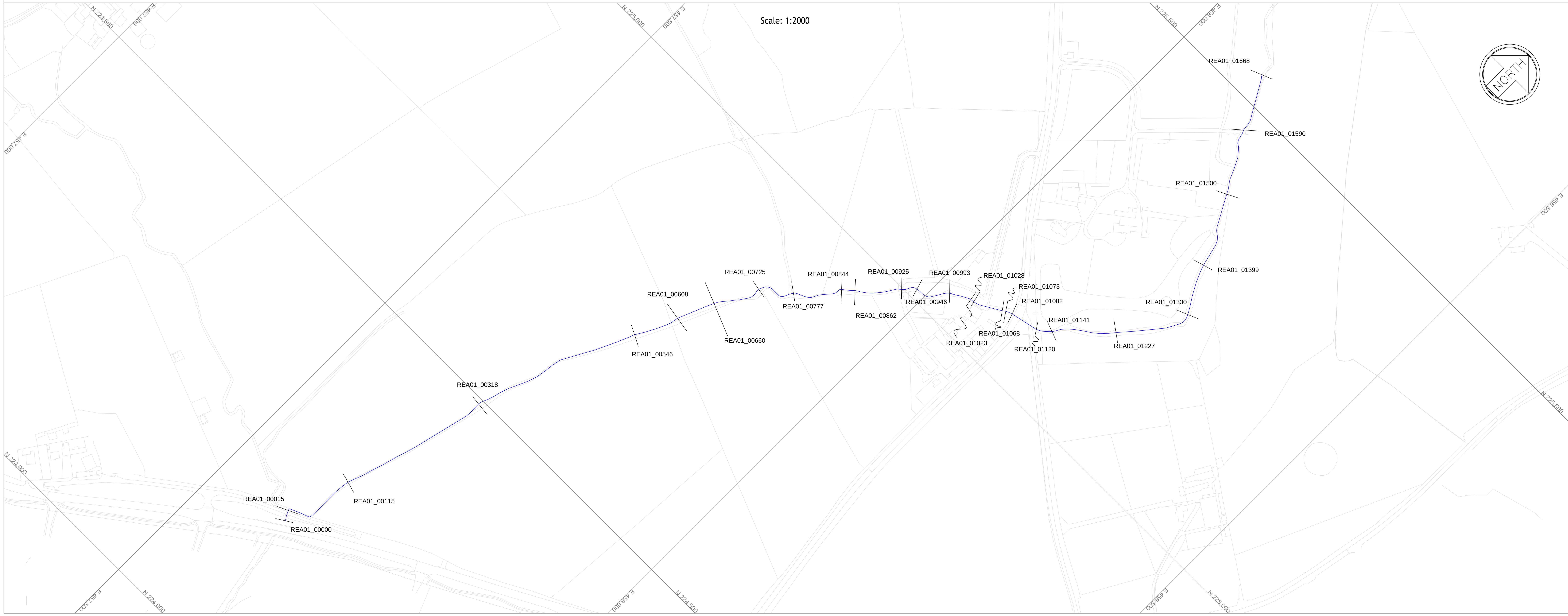

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NOTES:

SURVEY LEGEND

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

ID	Description	Easting	Northing	Height
E6-1	PK Nail	457834.606	224786.156	86.984

STORM GEOMATICS

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PROJECT
NW Bicester Survey

SITE
Reach 01
Charlotte Ave, Bicester OX27 8BL
Long Section & Location Plan
Sheet 1 of 1

SURVEYED BY: Storm Geomatics Ltd | *Project Ref: 21FD1391*

SURVEY DATE: July 2021

SCALE: As Shown (A0 Sheet)	DRN: MBM	CHKD: SRD
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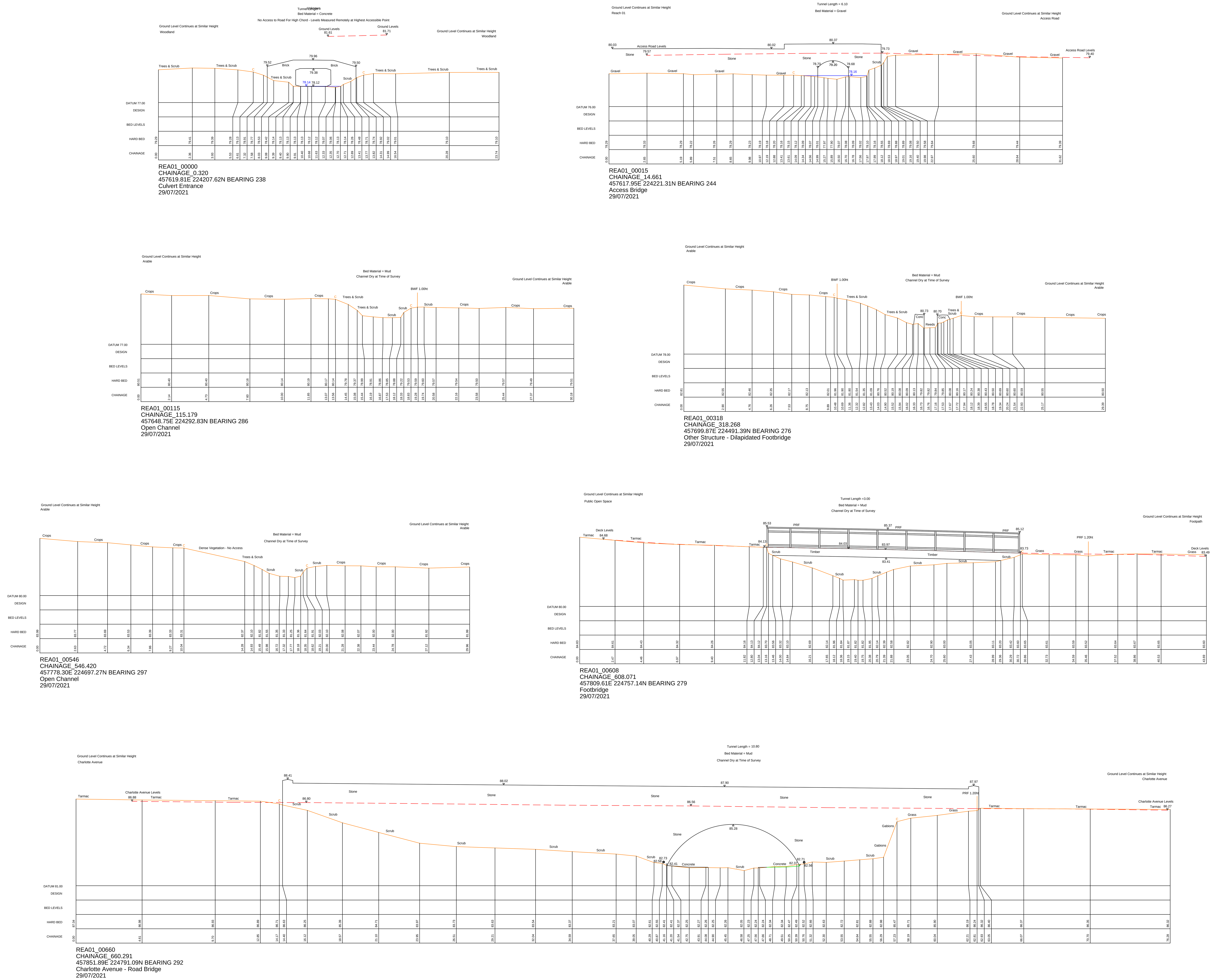

CROSS SECTION KEY:
WATER LEVEL
BED LEVEL
SILT LEVEL

NOTES:

SURVEY LEGEND

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

ID	DESCRIPTION	Easting	Northing	Height
E6-1	PK Nail	457834.606	224786.156	86.984

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SITE
Reach 01
Charlotte Ave, Bicester OX27 8BL
REA01_00000 to REA01_00660
Sheet 1 of 3

SURVEYED BY: Storm Geomatics Ltd — *Project Ref: 21FD1391*

SURVEY DATE: July 2021

SCALE: 1:100 (A0 Sheet)	DRN: MBM	CHKD: SRD
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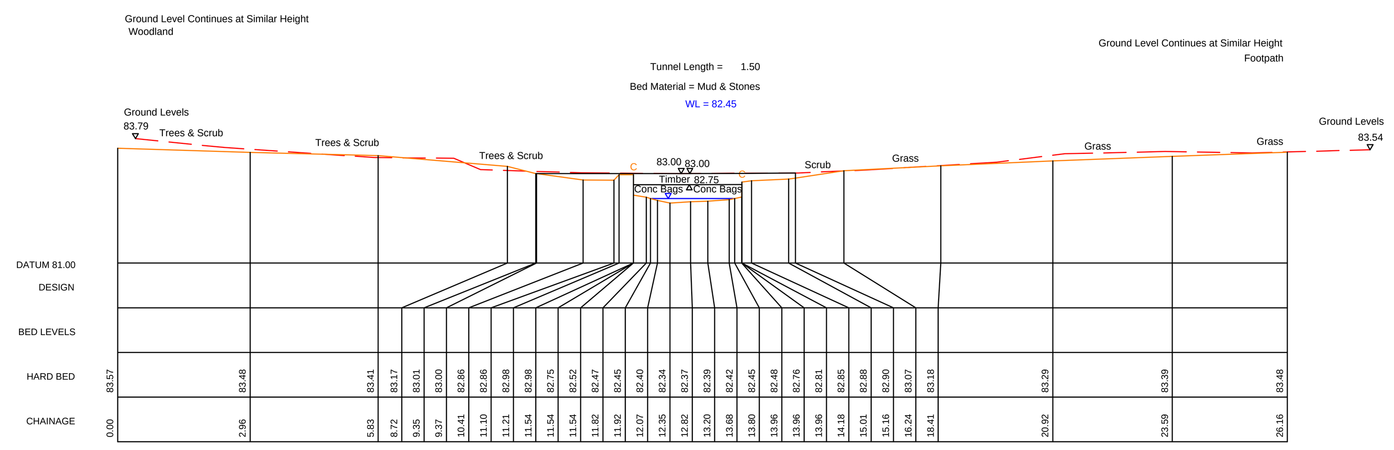
CROSS SECTION KEY:

WATER LEVEL

BED LEVEL

SILT LEVEL



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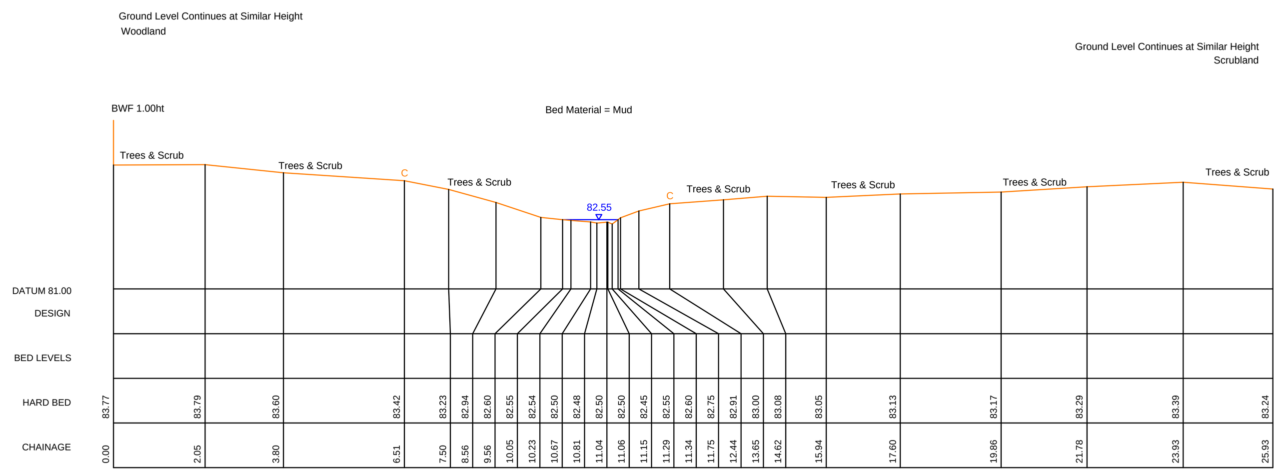
Footbridge
29/07/2021



REA01_00777
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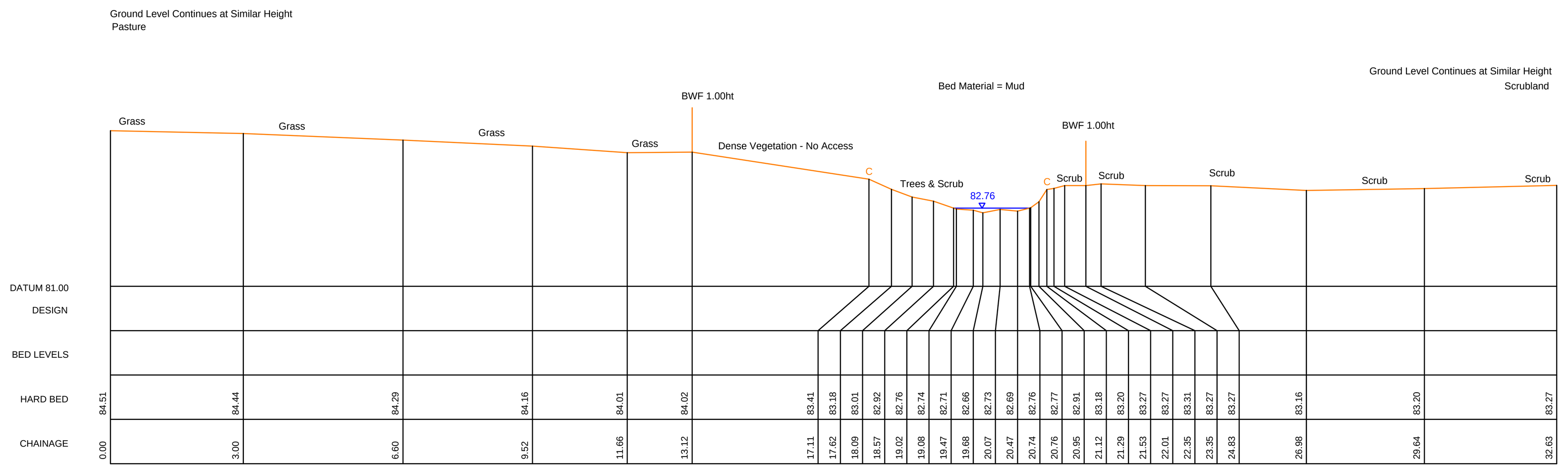
Open Channel
29/07/2021



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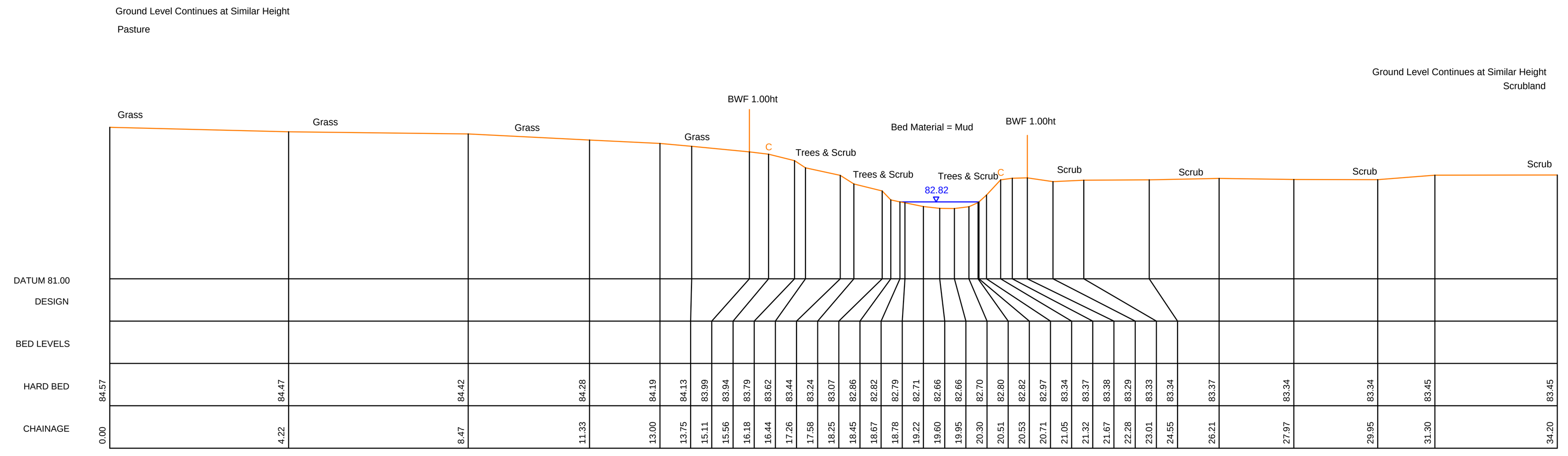
Open Channel
29/07/2021



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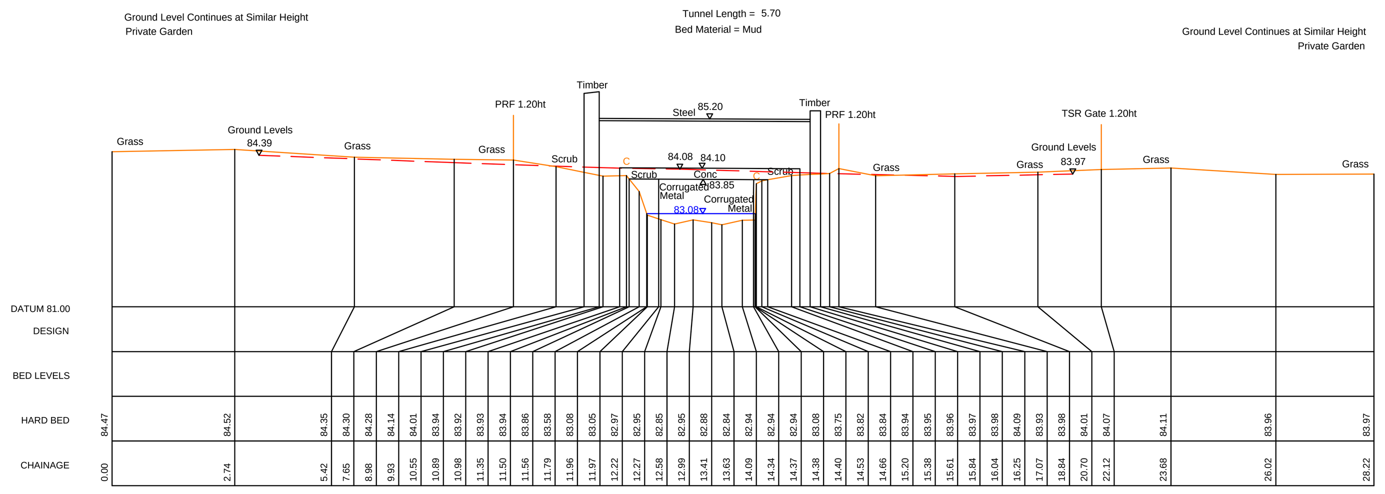
Open Channel
29/07/2021



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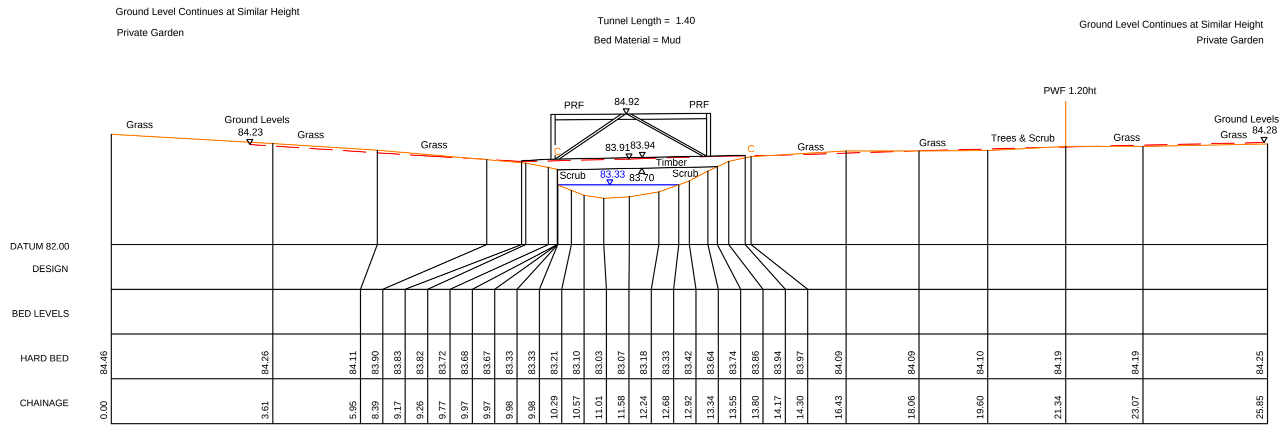
Access Bridge
29/07/2021



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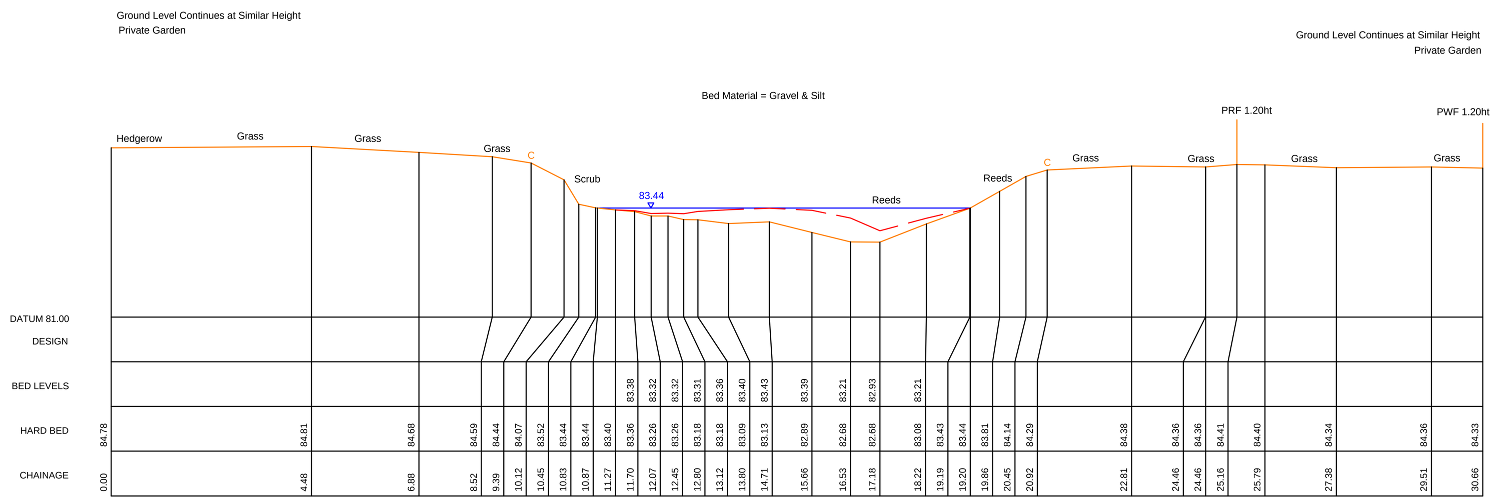
Footbridge
29/07/2021



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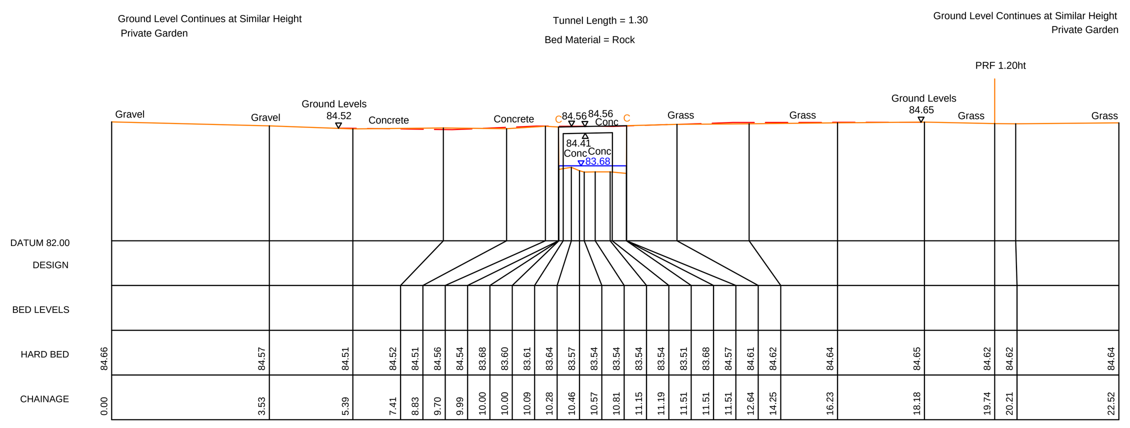
29/07/2021



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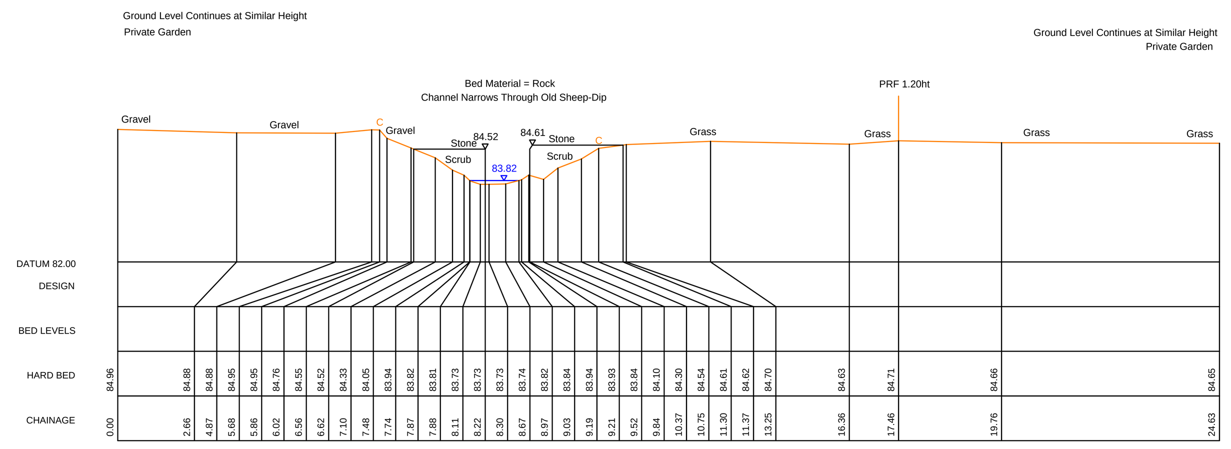
Footbridge
29/07/2021



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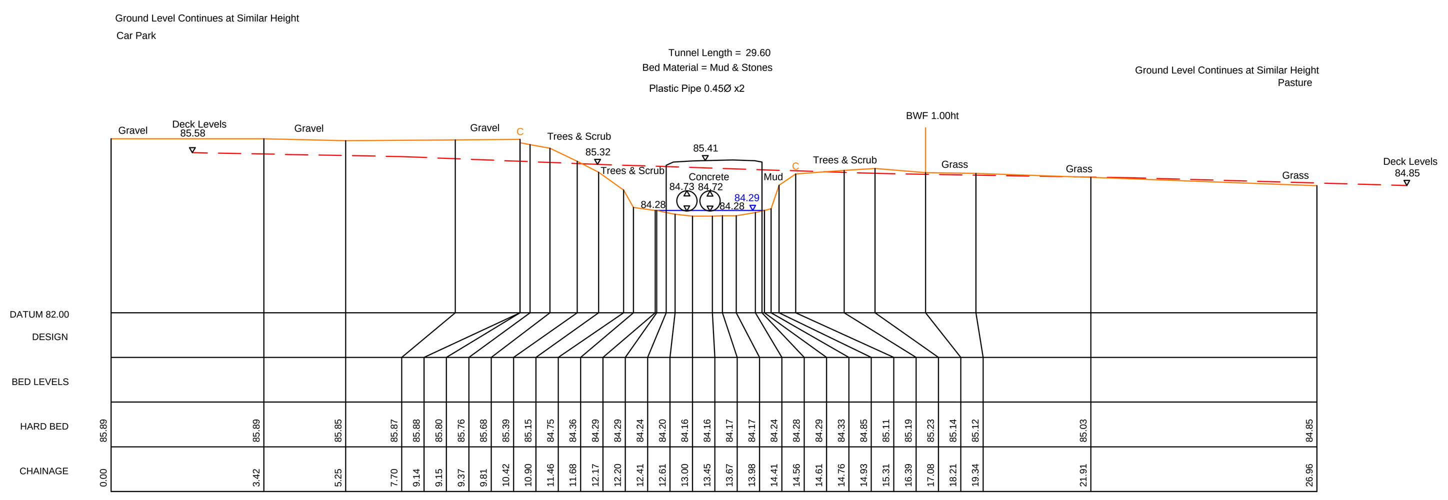
Other Structure - Sheep-Dip
29/07/2021



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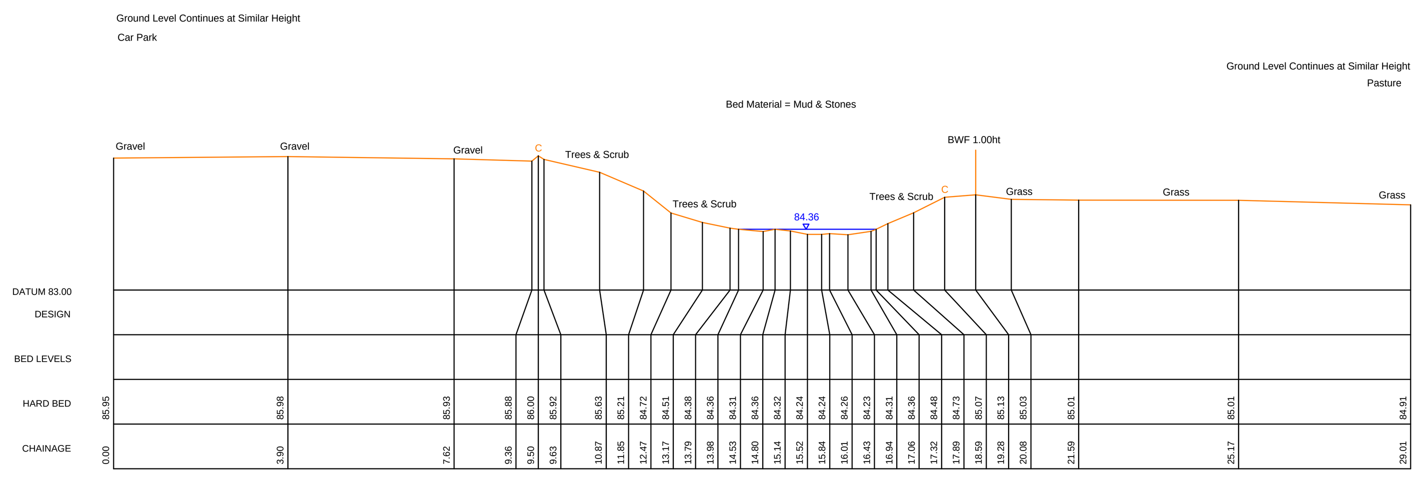
Culvert Entrance
29/07/2021



REA01_01073
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Open Channel
29/07/2021

NOTES:
ALL CROSS SECTIONS VIEWED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RB	RIGHT BANK
B	BOLLARD	FL	FLOOR LEVEL	RE	RODDING EYE
BB	BELISHA BEACON	FP	FENCE POST	RS	ROAD SIGN
BDY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTW	RETAINING WALL
BH	BOREHOLE	G	GULLY	RWP	RAINWATER PIPE
BL	BED LEVEL	GL	GROUND LEVEL	SC	STOP COCK
BRK	BRICKWORK	GP	GATE POST	SDP	STAND PIPE
BS	BUS STOP	GM	GAS MARKER	SK	SOAKAWAY
BM	BENCH MARK	GV	GAS VALVE	SL	SOFFIT LEVEL
BW	BRICK WALL	HW	HEAD WALL	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
CBF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	SP	SIGN POST
CIF	CORRUGATED IRON FENCE	IRF	IRON RAILING FENCE	SPF	STEEL PALLISADE FENCE
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	STN	STATION
CLF	CHAIN LINK FENCE	JB	JUNCTION BOX	SV	SLUICE VALVE
CONC	CONCRETE	KIG	KERB INLET GULLY	SVP	SOIL VENT PIPE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CHESTNUT PALING FENCE	LFB	LIFEBUOY	TCB/TCP	TELEPHONE CALL BOX/POST
CR	CYCLE RACK	LP	LAMP POST	TC	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
CUL	CULVERT	MF	MISCELLANEOUS FENCING	THL	THRESHOLD LEVEL
DK	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DOWNPIPE	MP	MOORING PILE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DR	DRAIN	MS	MILE STONE	TS	TREE STUMP
DWB	DOG WASTE BIN	NB	NOTICE BOARD	TSR	TUBULAR STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	VP	VENT PIPE
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	WB	WASTE BIN
ECF	ELECTRIC CABLE FENCE	OS	OS Grid (15)	WL	WATER LEVEL/WATER LINE
ECP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	PILE	WMF	WIRE MESH FENCE
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PRF	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

ID	DESCRIPTION	Easting	Northing	Height
E6-1	PK Nail	457834.606	224786.156	86.984

STORM GEOMATICS
Tel: 01608 664910
mail@storm-geomatics.com
www.storm-geomatics.com

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PROJECT
NW Bicester Survey

SITE
Reach 02
Charlotte Ave, Bicester OX27 8BL
REA01_00725 to REA01_01073
Sheet 2 of 3

SURVEYED BY: Storm Geomatics Ltd	Project Ref: 21FD1391	
SURVEY DATE: July 2021		
SCALE: 1:100 (A0 Sheet)	DRN: MBM	CHKD: SRD
DATUM: OS Newlyn (15)	DATE: 06/08/2021	DATE: 12/08/2021
GRID: OS Grid (15)	DRAWING NO. 21FD1391/02	REV. –
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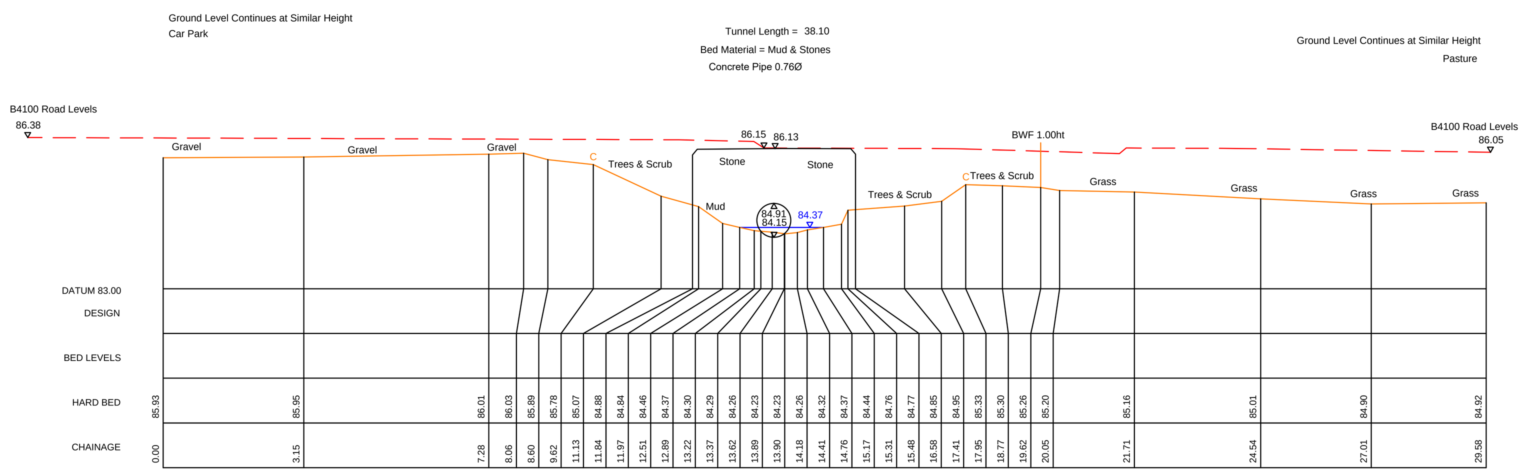
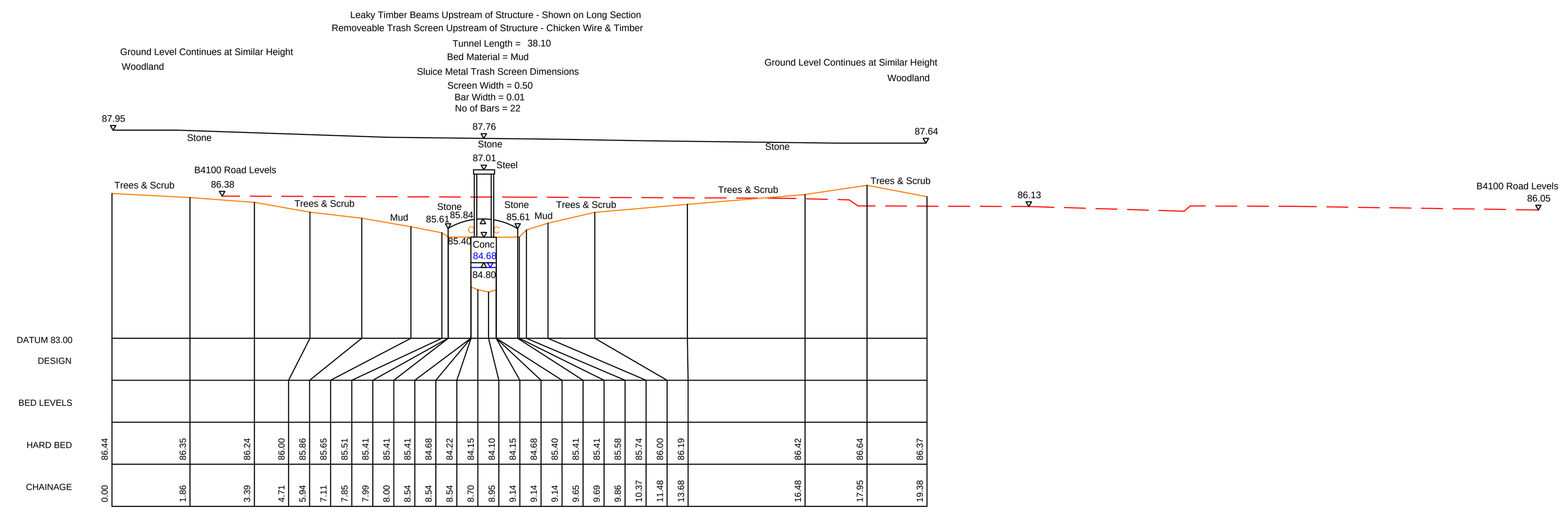
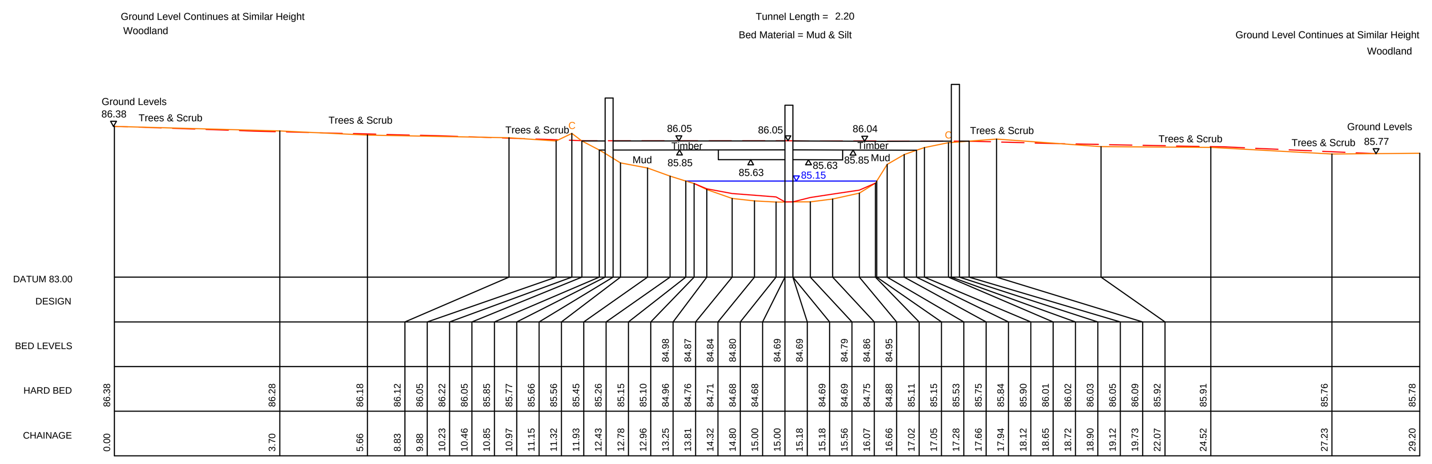
CROSS SECTION KEY:
WATER LEVEL
BED LEVEL
SILT LEVEL



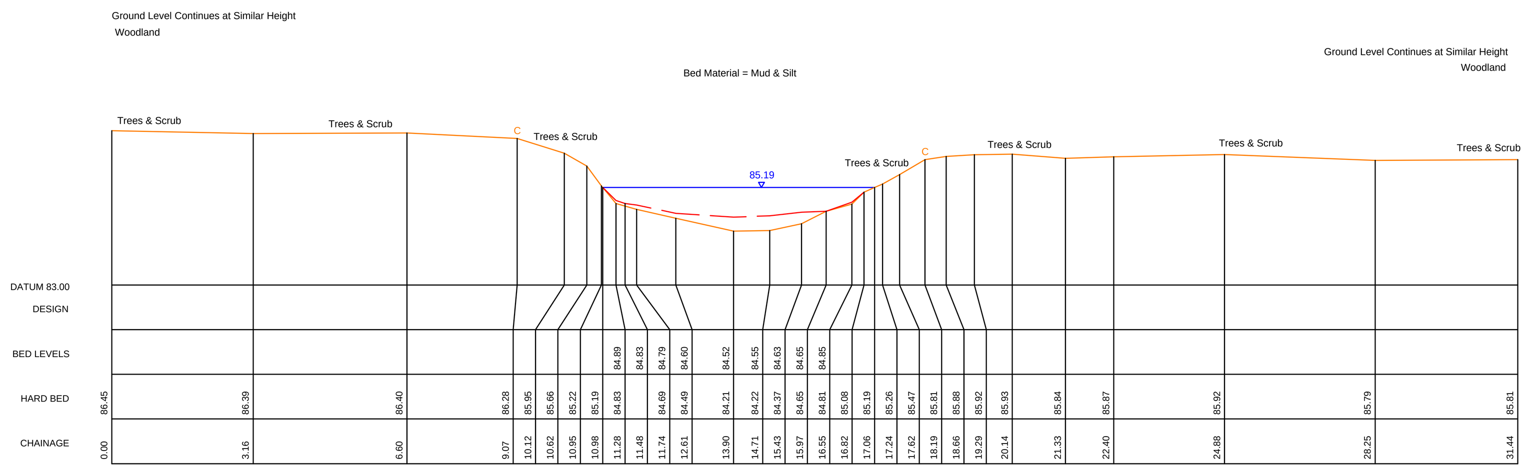
REA01_01082
CHAINAGE_1081.881
458103.48E 225065.76N BEARING 340
Culvert Exit
29/07/2021



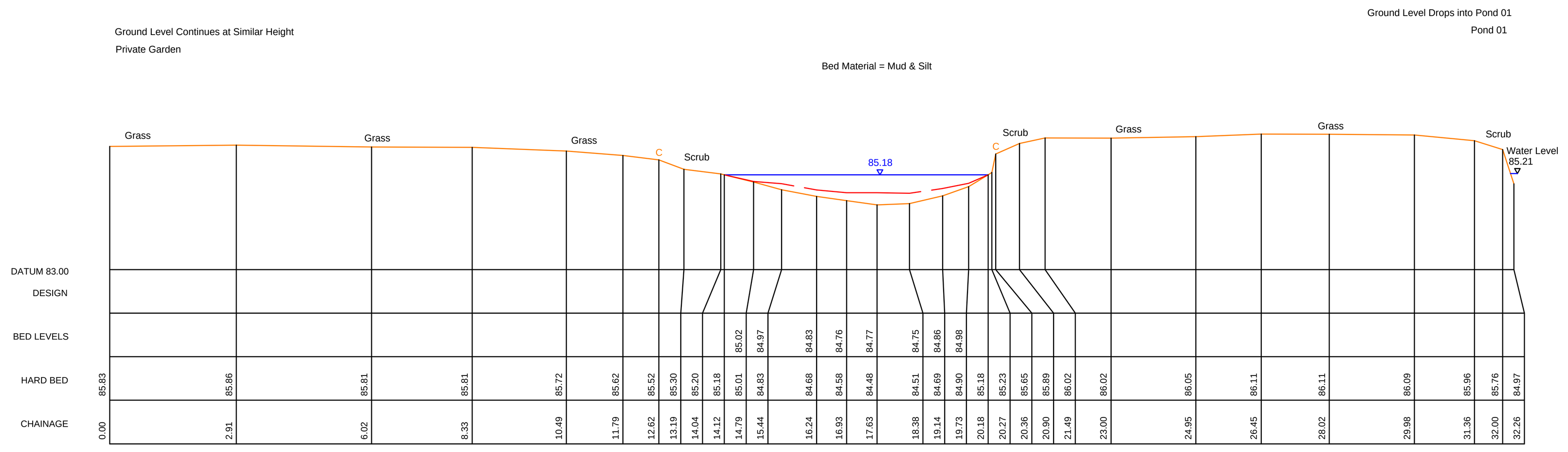
REA01_01120
CHAINAGE_1119.997
458140.85E 225079.54N BEARING 327
Culvert Entrance
29/07/2021



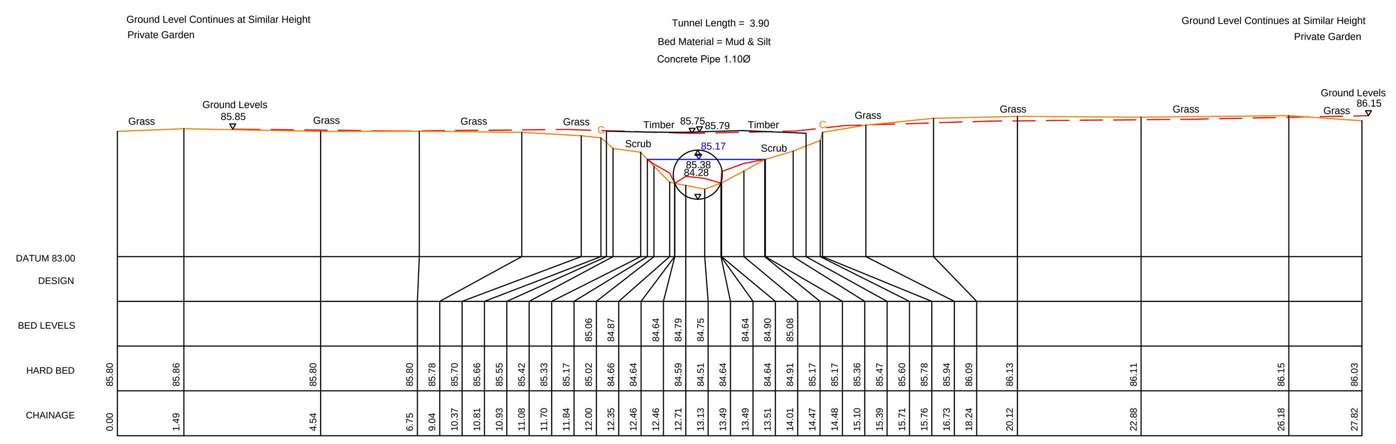
REA01_01141
CHAINAGE_1141.211
458165.83E 225094.68N BEARING 290
Footbridge
29/07/2021



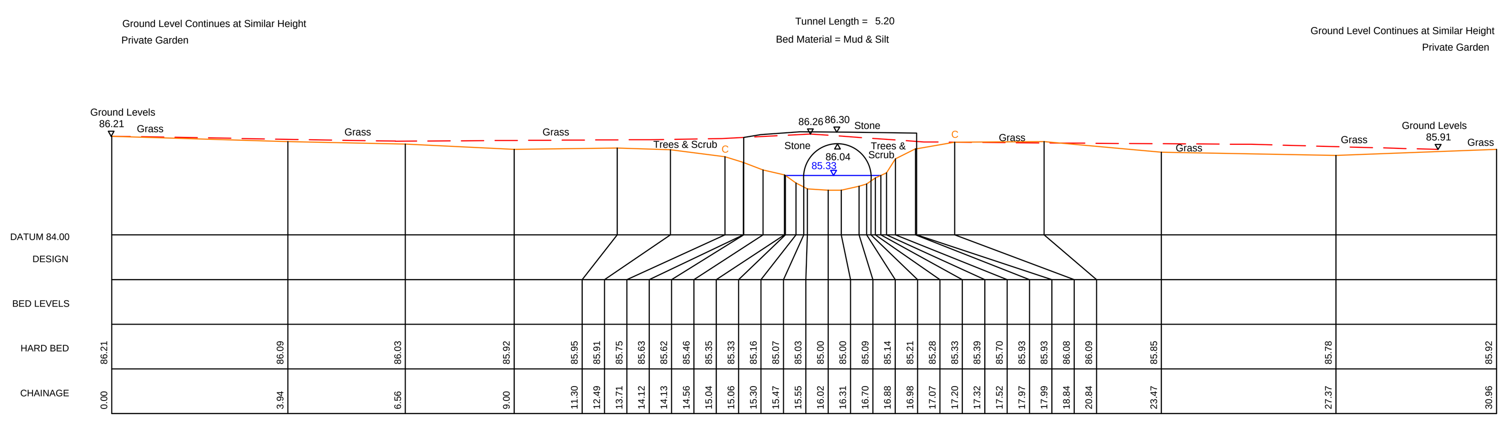
REA01_01227
CHAINAGE_1227.121
458224.78E 225150.67N BEARING 306
Open Channel
29/07/2021



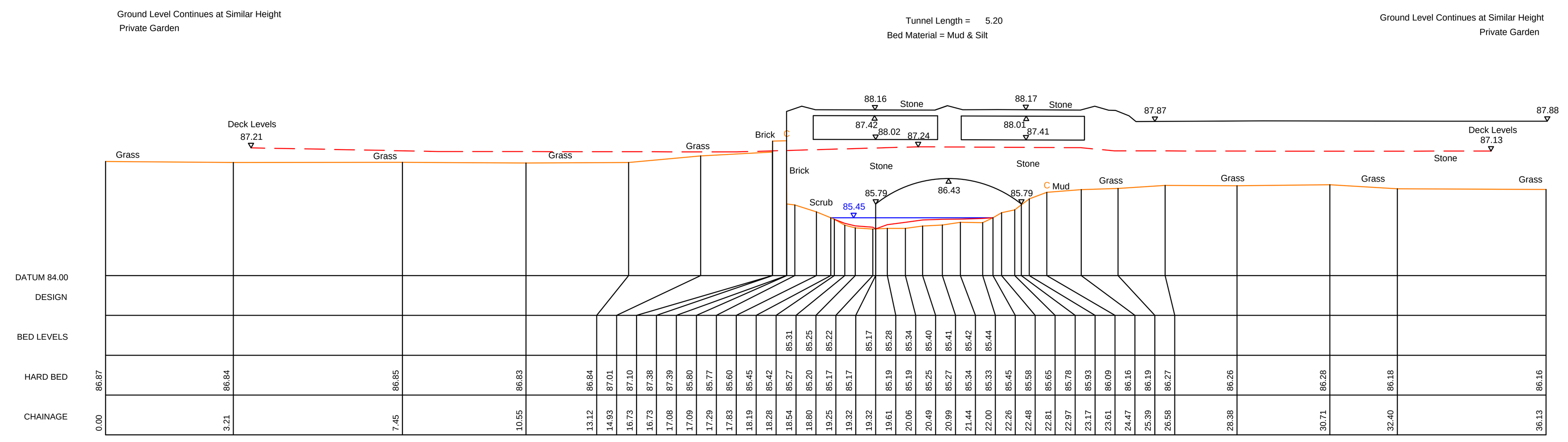
REA01_01330
CHAINAGE_1330.036
458278.86E 225249.12N BEARING 247
Open Channel
29/07/2021



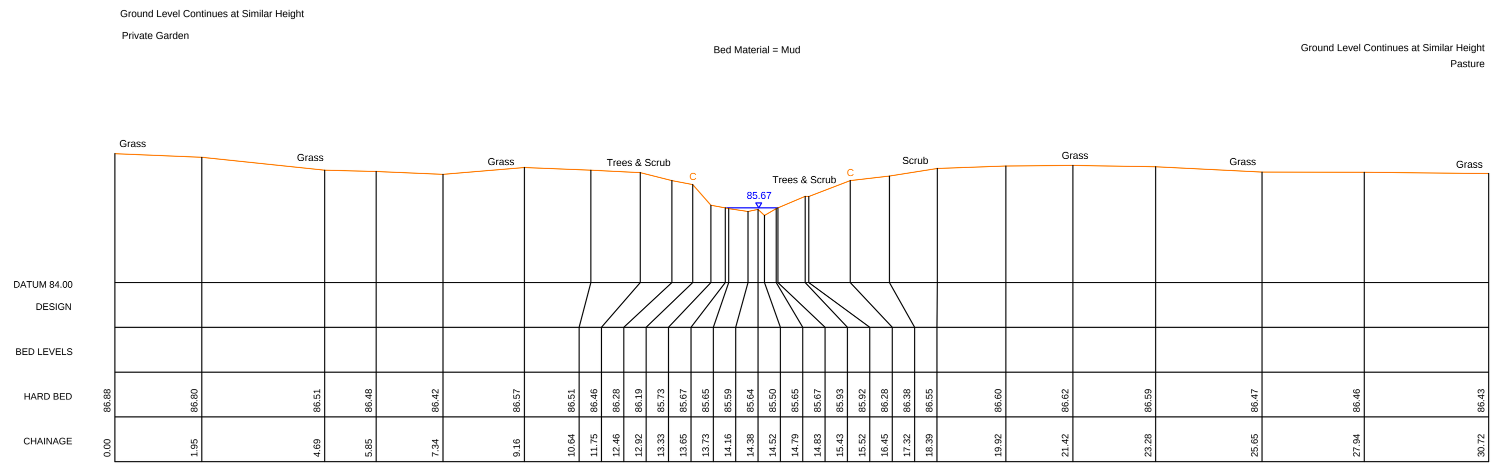
REA01_01399
CHAINAGE_1399.031
458245.06E 225307.74N BEARING 254
Culvert Entrance
29/07/2021



REA01_01500
CHAINAGE_1500.238
458202.32E 225399.93N BEARING 243
Access Bridge
29/07/2021



REA01_01590
CHAINAGE_1589.872
458158.56E 225481.99N BEARING 229
Access Bridge
29/07/2021



REA01_01668
CHAINAGE_1668.084
458122.03E 225543.27N BEARING 248
Open Channel
29/07/2021

NOTES:

SURVEY LEGEND

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

ID	DESCRIPTION	Easting	Northing	Height
E6-1	PK Nail	457834.606	224786.156	86.984

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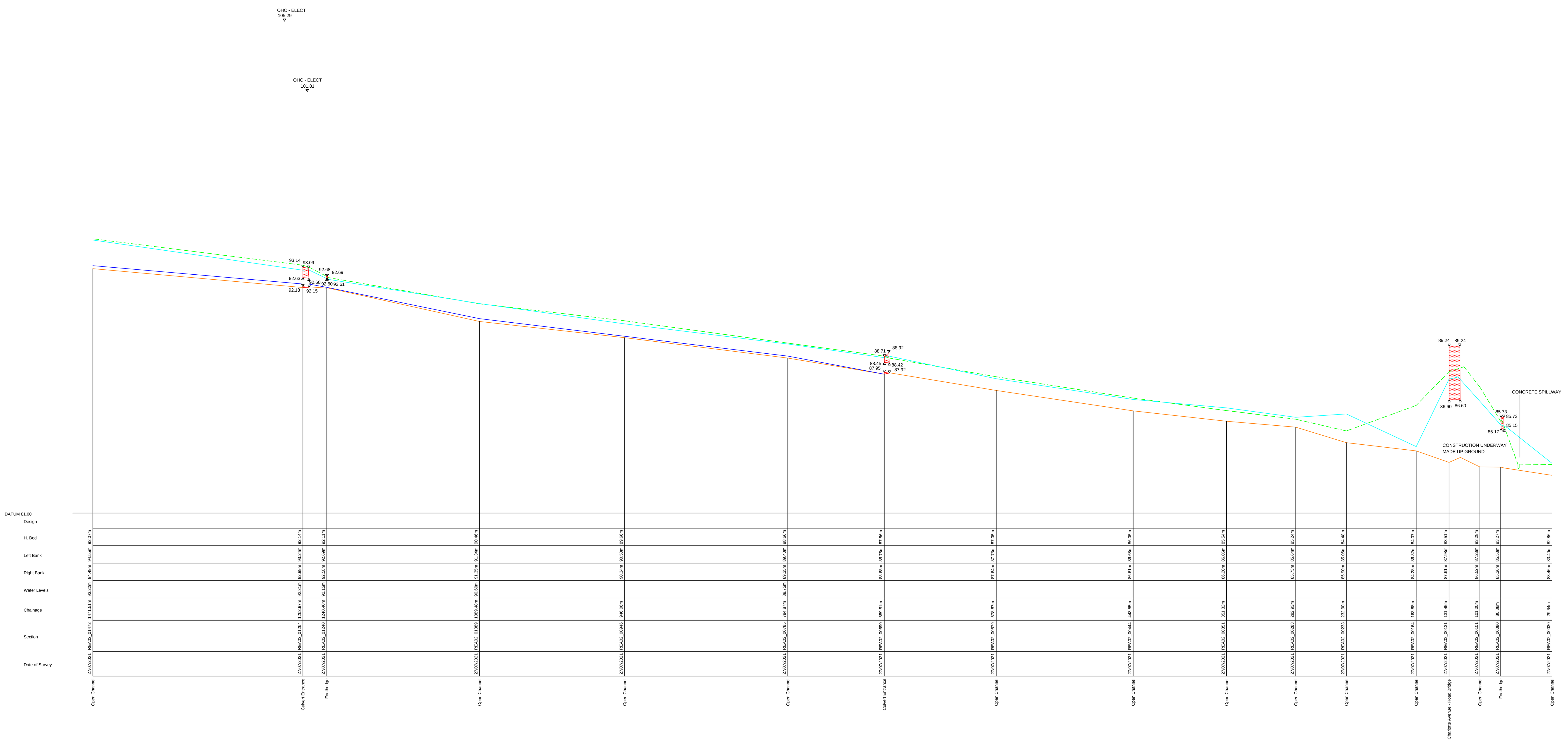
PROJECT
NW Bicester Survey

SITE
Reach 01
Charlotte Ave, Bicester OX27 8BL
REA01_01082 to REA01_01668
Sheet 3 of 3

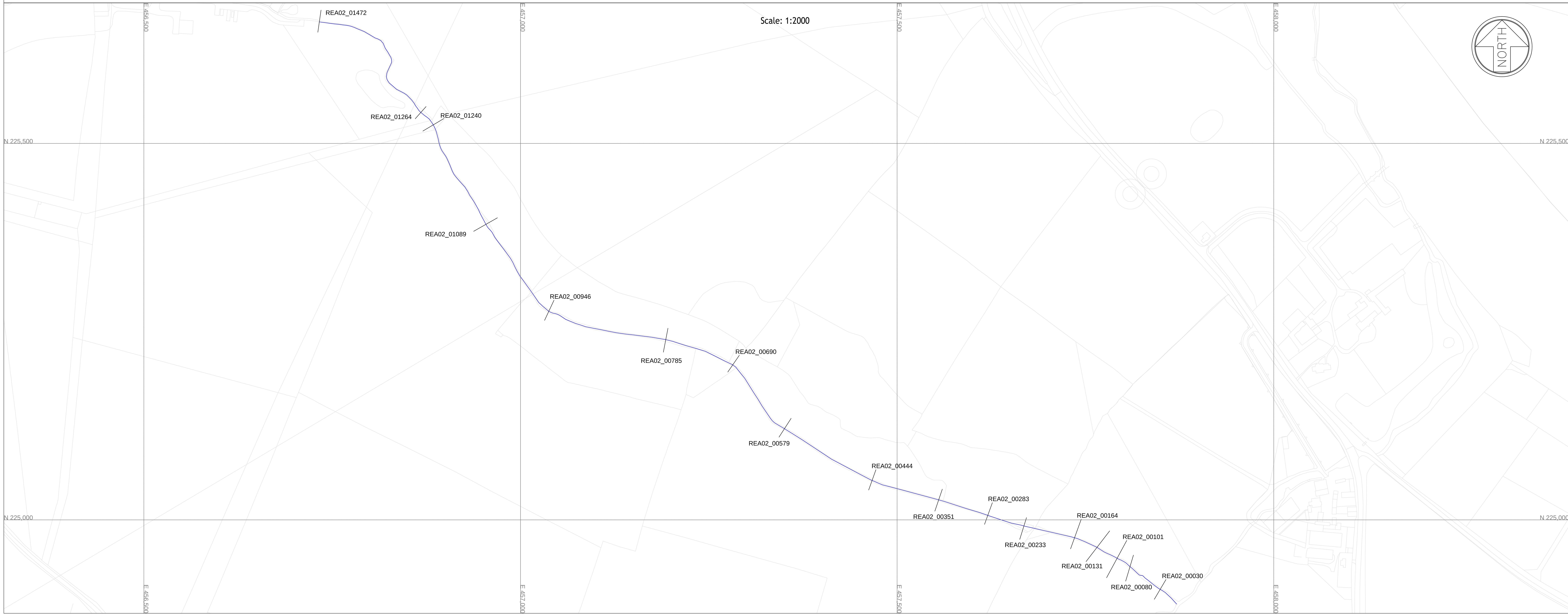
SURVEYED BY: Storm Geomatics Ltd — Project Ref: 21FD1391
SURVEY DATE: July 2021
SCALE: 1:100 (A0 Sheet) — DRN: MBM — CHKD: SRD
DATUM: OS Newlyn (15) — DATE: 06/08/2021 — DATE: 12/08/2021
GRID: OS Grid (15) — DRAWING NO. 21FD1391/03 — REV. –
CAD FILENAME: REA01_XS.dwg

LONG SECTION KEY:

WATER LEVEL	
BED LEVEL	
SILT LEVEL	
STRUCTURES	
RIGHT BANK	VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'C' ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS
LEFT BANK	



Scale: 1:2000H 1:100V



Scale: 1:2000

NOTES: ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RB	RIGHT BANK
B	BOLLARD	FL	FLOOR LEVEL	RE	RODDING EYE
BB	BELISHA BEACON	FP	FENCE POST	RS	ROAD SIGN
BDY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTW	RETAINING WALL
BH	BOREHOLE	G	GULLY	RWP	RAINWATER PIPE
BL	BED LEVEL	GL	GROUND LEVEL	SC	STOP COCK
BRK	BRICKWORK	GP	GATE POST	SDP	STAND PIPE
BS	BUS STOP	GM	GAS MARKER	SK	SOAKAWAY
BM	BENCH MARK	GV	GAS VALVE	SL	SOFFIT LEVEL
BW	BRICK WALL	HW	HEAD WALL	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
CBF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	SP	SIGN POST
CIF	CORRUGATED IRON FENCE	IRF	IRON RAILING FENCE	SPF	STEEL PALLISADE FENCE
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	STN	STATION
CLF	CHAIN LINK FENCE	JB	JUNCTION BOX	SV	SLUICE VALVE
CONC	CONCRETE	KIG	KERB INLET GULLY	SVP	SOIL VENT PIPE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CHESTNUT PALING FENCE	LFB	LIFEBUOY	TCB/TCP	TELEPHONE CALL BOX/POST
CR	CYCLE RACK	LP	LAMP POST	TC	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
CUL	CULVERT	MF	MISCELLANEOUS FENCING	THL	THRESHOLD LEVEL
DK	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DOWNPIPE	MP	MOORING PILE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DR	DRAIN	MS	MILE STONE	TS	TREE STUMP
DWB	DOG WASTE BIN	NB	NOTICE BOARD	TSR	TUBULAR STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	VP	VENT PIPE
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	WB	WASTE BIN
ECF	ELECTRIC CABLE FENCE	OS	OS Grid (15)	WL	WATER LEVEL/WATER LINE
ECP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	PILE	WMF	WIRE MESH FENCE
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PRF	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

ID	Description	Easting	Northing	Height
E6-1	PK Nail	457834.606	224786.156	86.984

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PROJECT
NW Bicester Survey

SITE
Reach 02
Charlotte Ave, Bicester OX27 8BL
Long Section & Location Plan
Sheet 1 of 1

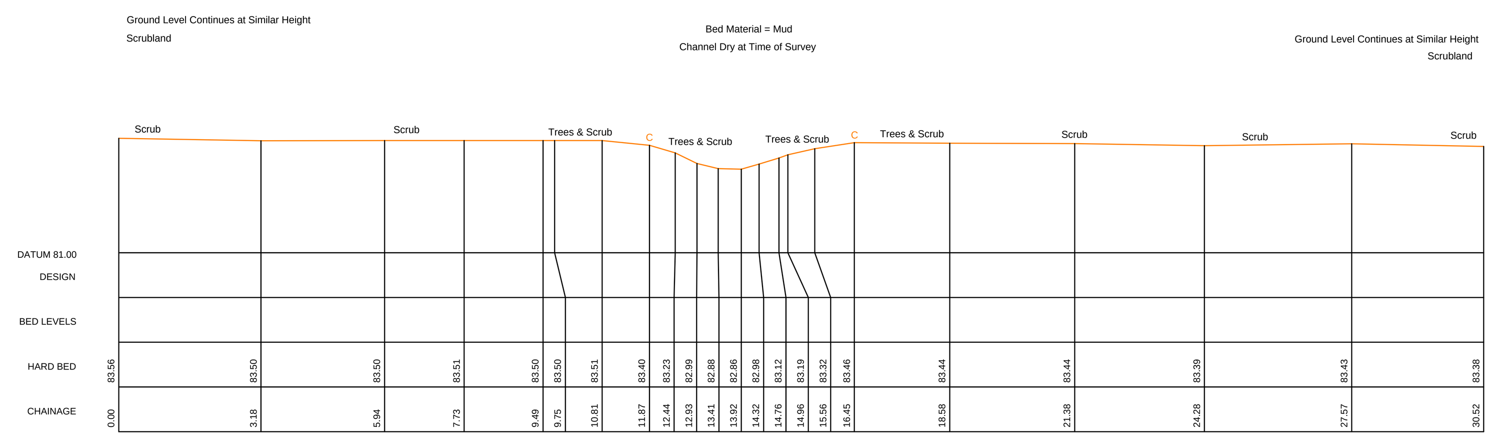
SURVEYED BY: Storm Geomatics Ltd — Project Ref: 21FD1391

SURVEY DATE: July 2021

SCALE: As Shown (A0 Sheet)	DRN: MBM	CHKD: SRD
DATUM: OS Newlyn (15)	DATE: 06/08/2021	DATE: 12/08/2021
GRID: OS Grid (15)	DRAWING NO. 21FD1391-07	REV. –

CAD FILENAME: REA02_LS+LP.dwg

CROSS SECTION KEY:
WATER LEVEL
BED LEVEL
SILT LEVEL



REA02_00030
CHAINAGE_29.644
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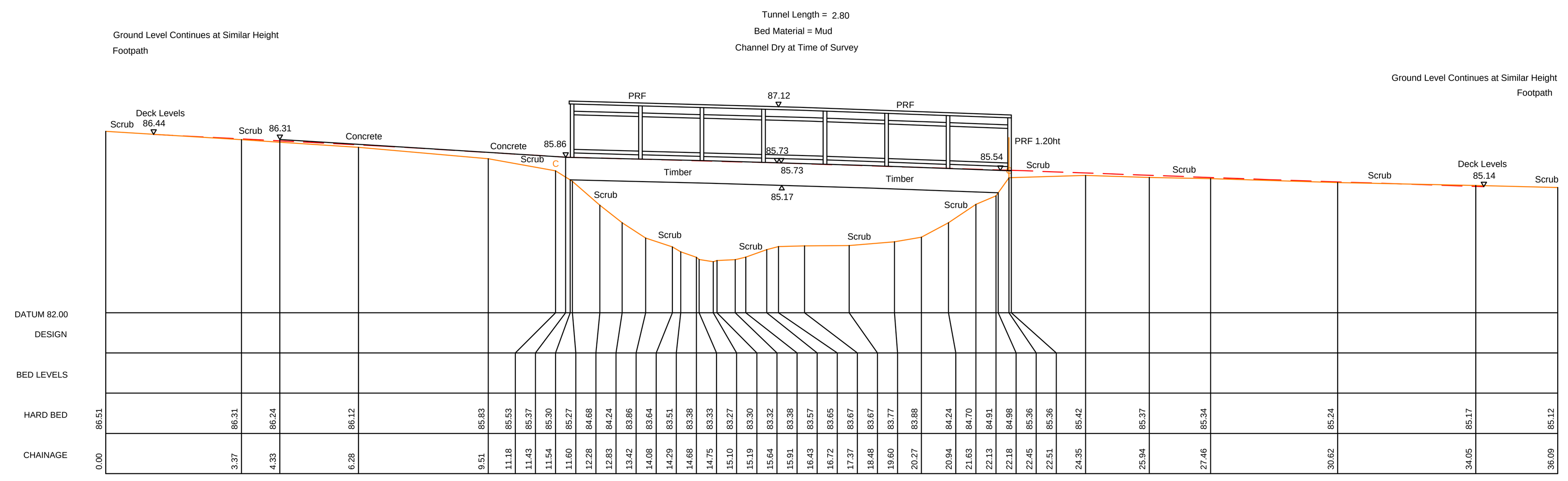
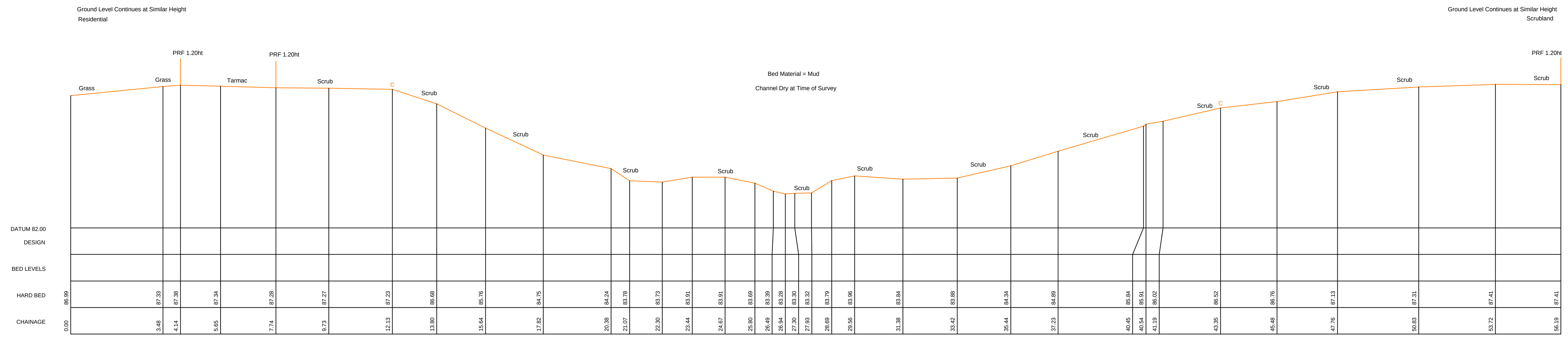
Open Channel
27/07/2021



REA02_00080
CHAINAGE_80.383
457813.79E 224953.18N BEARING 197
Footbridge
27/07/2021



REA02_00101
CHAINAGE_101.001
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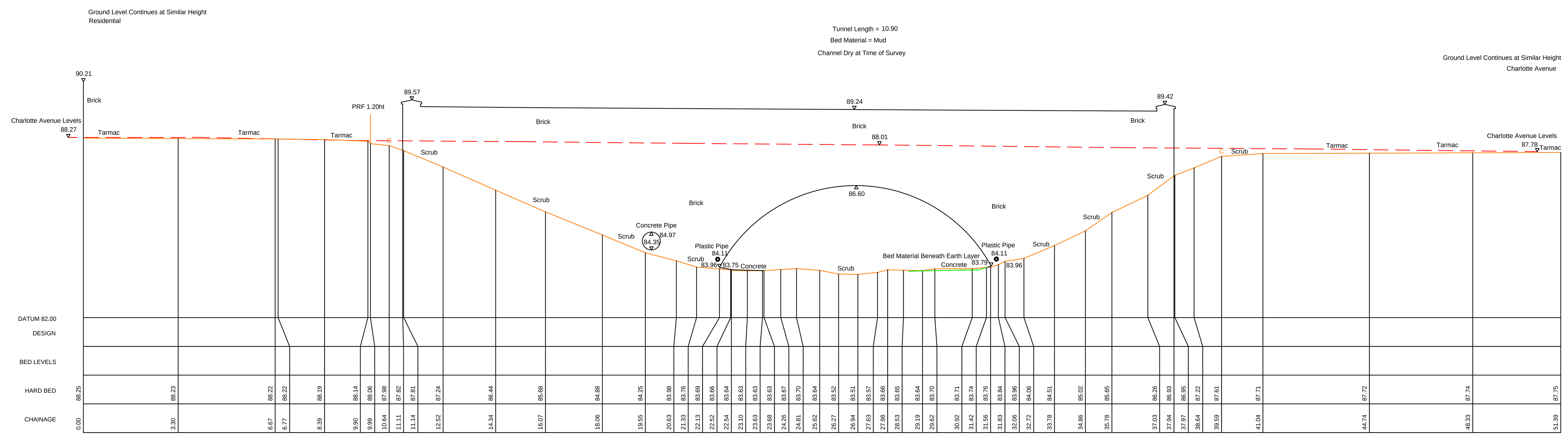
Open Channel
27/07/2021



REA02_00131
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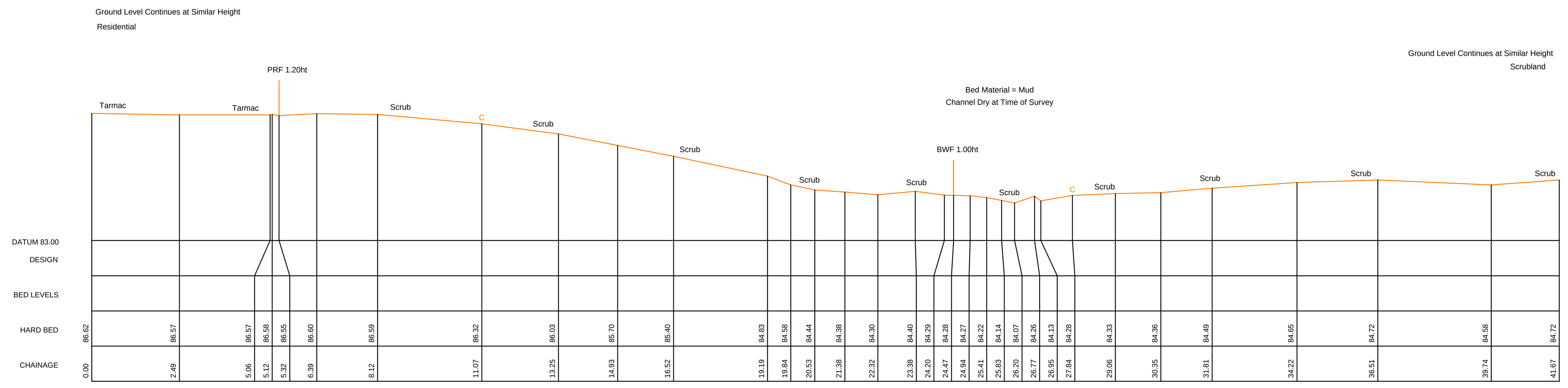
Charlotte Avenue - Road Bridge
27/07/2021



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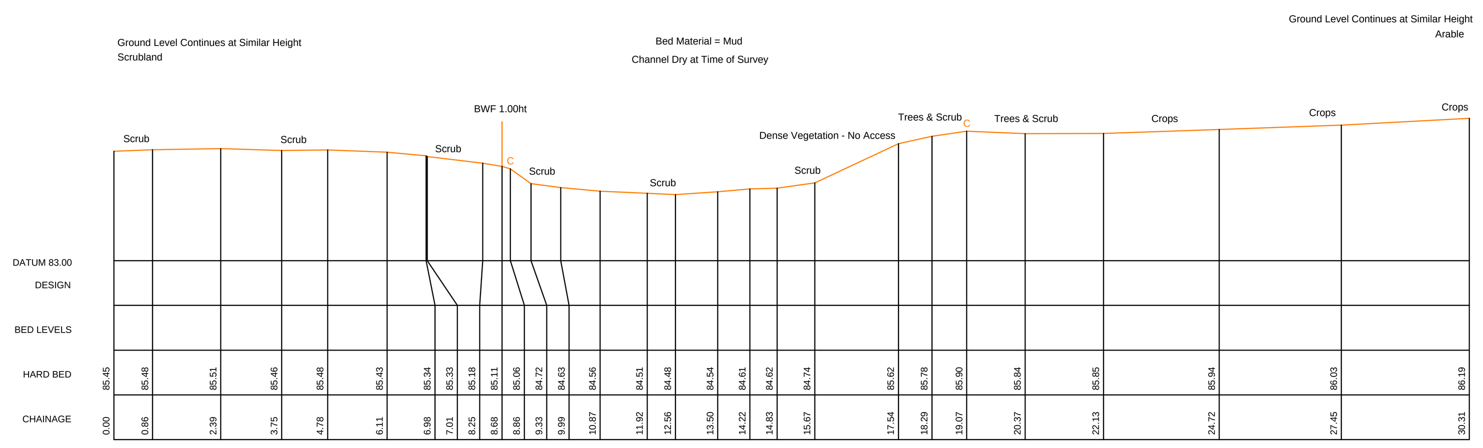
Open Channel
27/07/2021



REA02_00233
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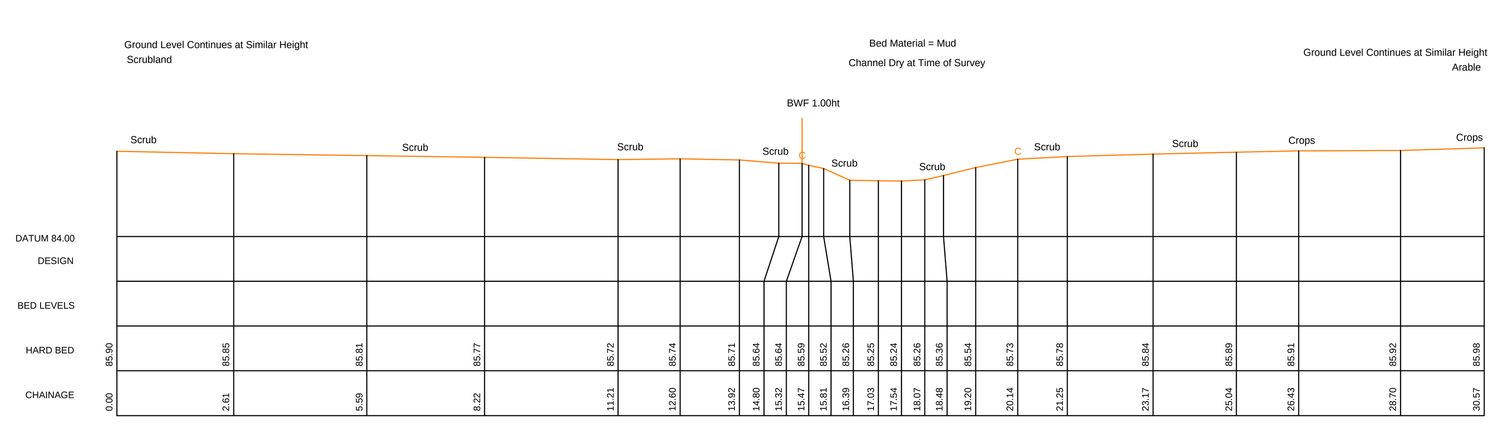
Open Channel
27/07/2021



REA02_00283
CHAINAGE_282.932
457626.51E 225022.79N BEARING 200
Open Channel
27/07/2021

NOTES:

SURVEY LEGEND

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

ID	DESCRIPTION	Easting	Northing	Height
EA-1	PK Nail	457834.606	224786.156	86.984

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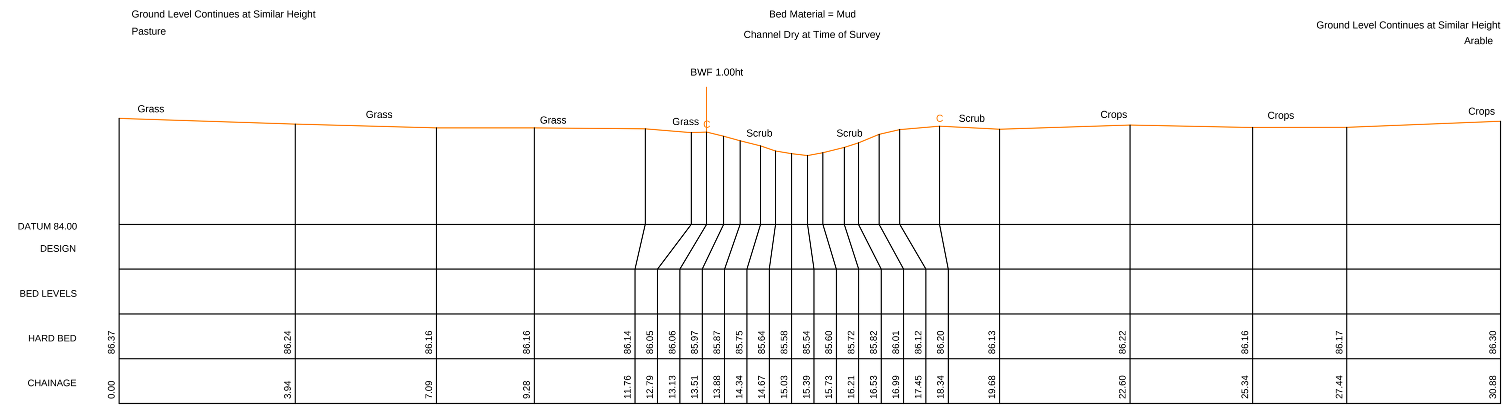
NW Bicester Survey

SITE
Reach 02
Charlotte Ave, Bicester OX27 8BL
REA02_00030 to REA02_00283
Sheet 1 of 2

SURVEYED BY: Storm Geomatics Ltd	Project Ref: 21FD1391
SURVEY DATE: July 2021	
SCALE: 1:100 (A0 Sheet)	DRN: MBM — CHKD: SRD
DATUM: OS Newlyn (15)	DATE: 06/08/2021 — DATE: 12/08/2021
GRID: OS Grid (15)	DRAWING NO. 21FD1391/05 — REV. —
CAD FILENAME: REA02_XS.dwg	



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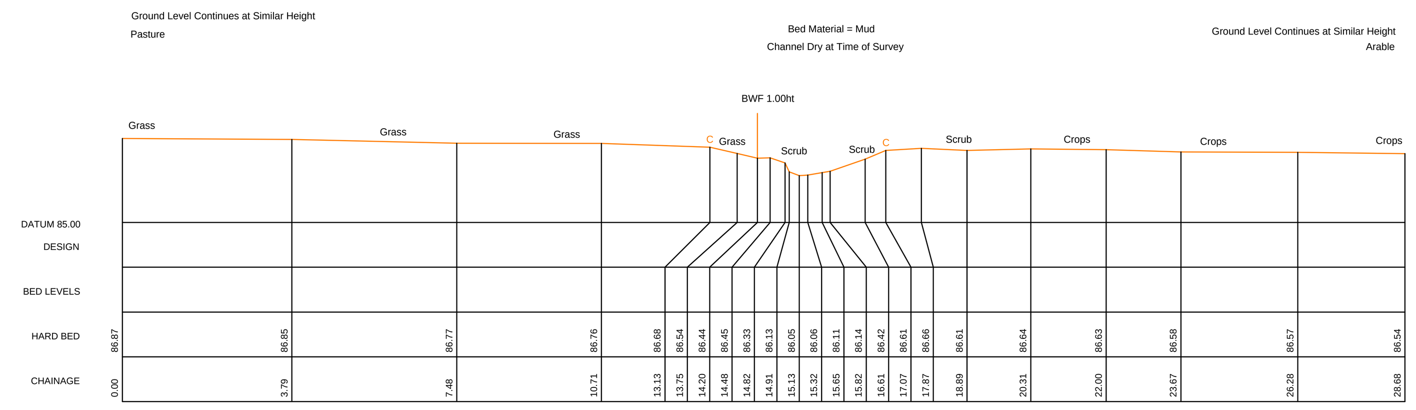
Open Channel
27/07/2021



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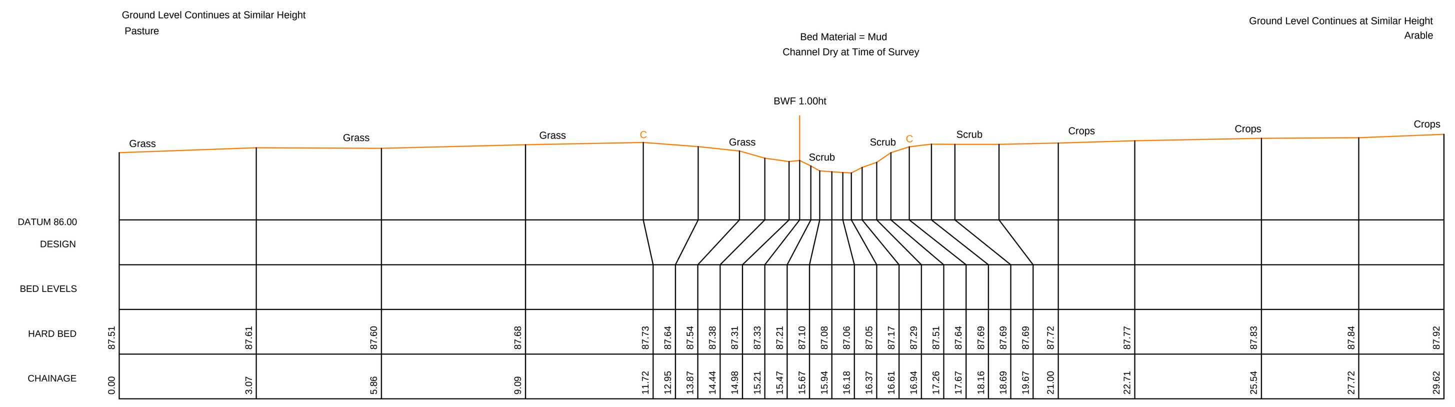
Open Channel
27/07/2021



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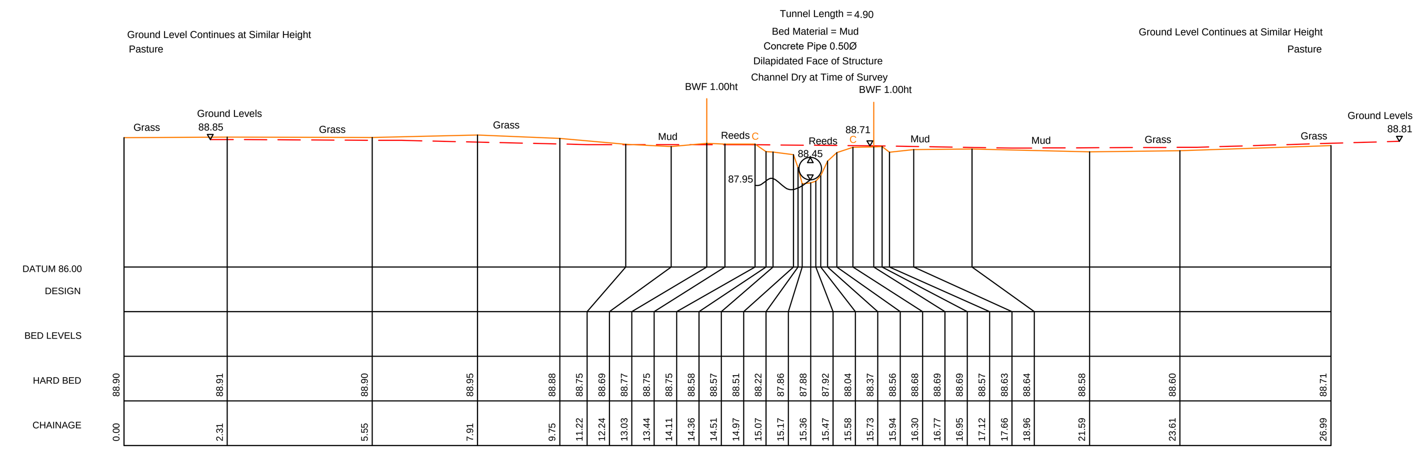
Open Channel
27/07/2021



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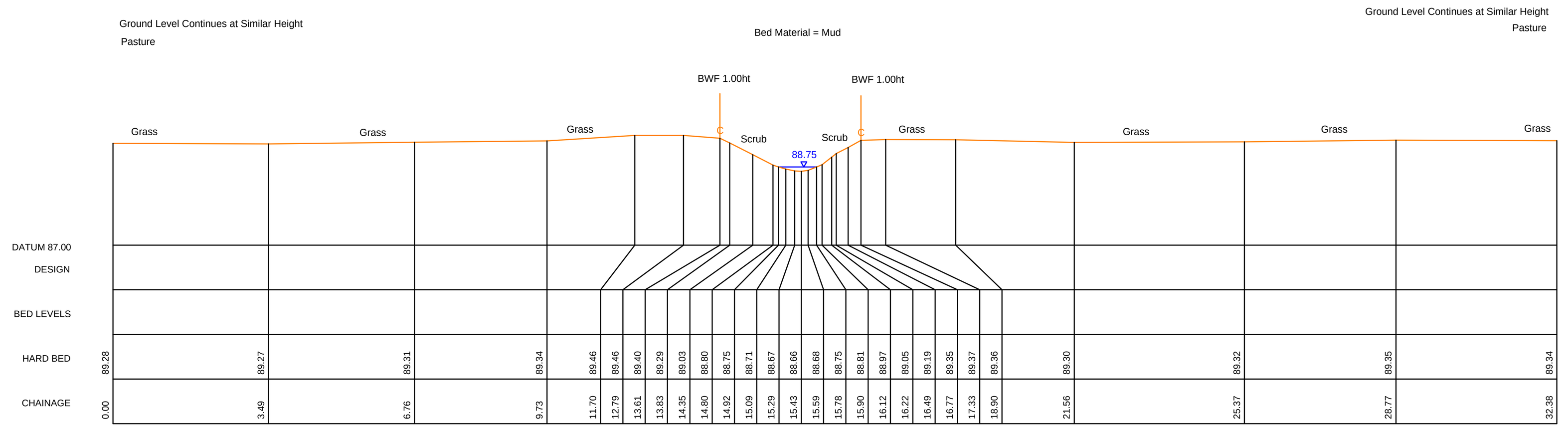
Culvert Entrance
27/07/2021



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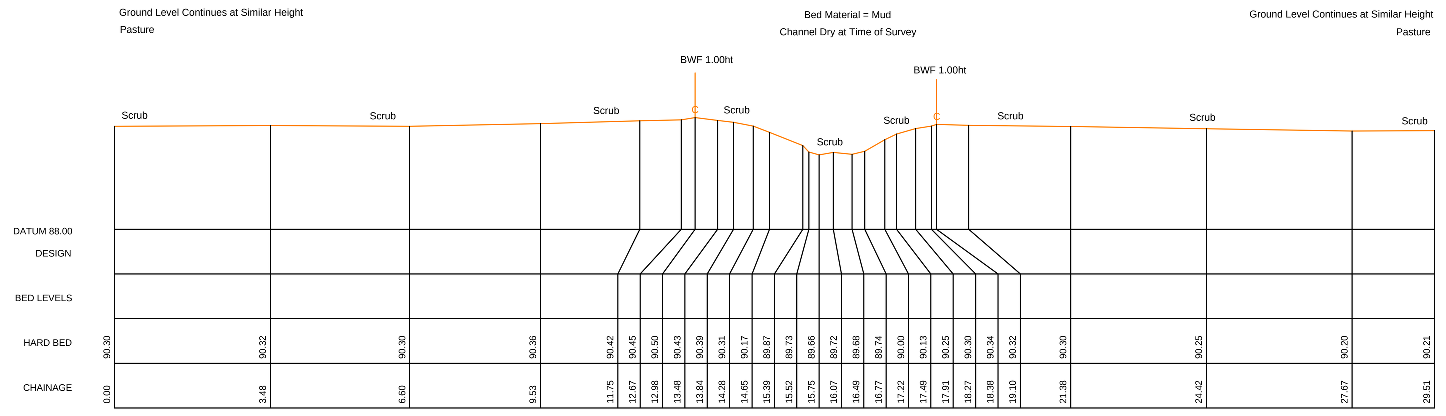
Open Channel
27/07/2021



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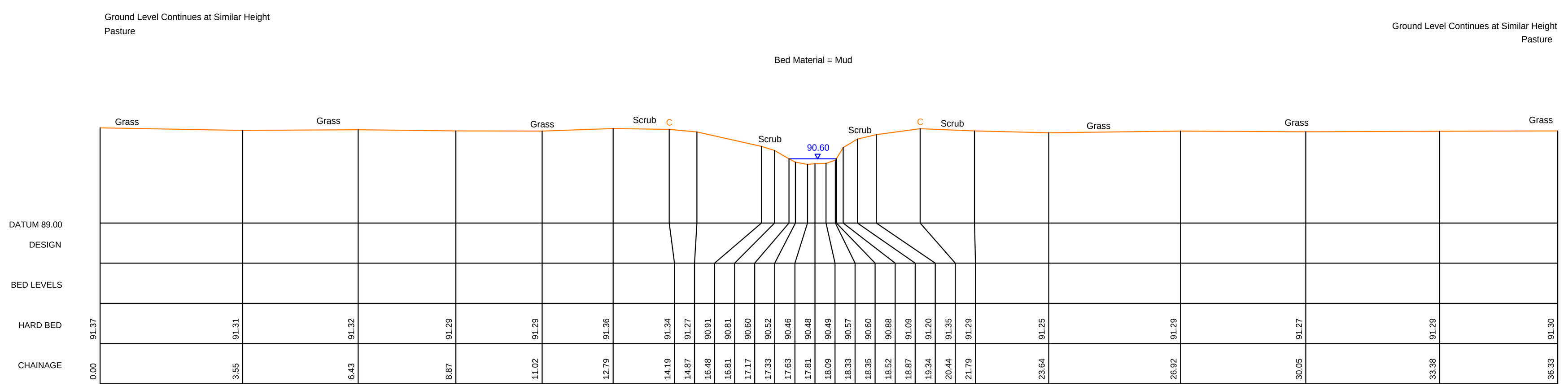
Open Channel
27/07/2021



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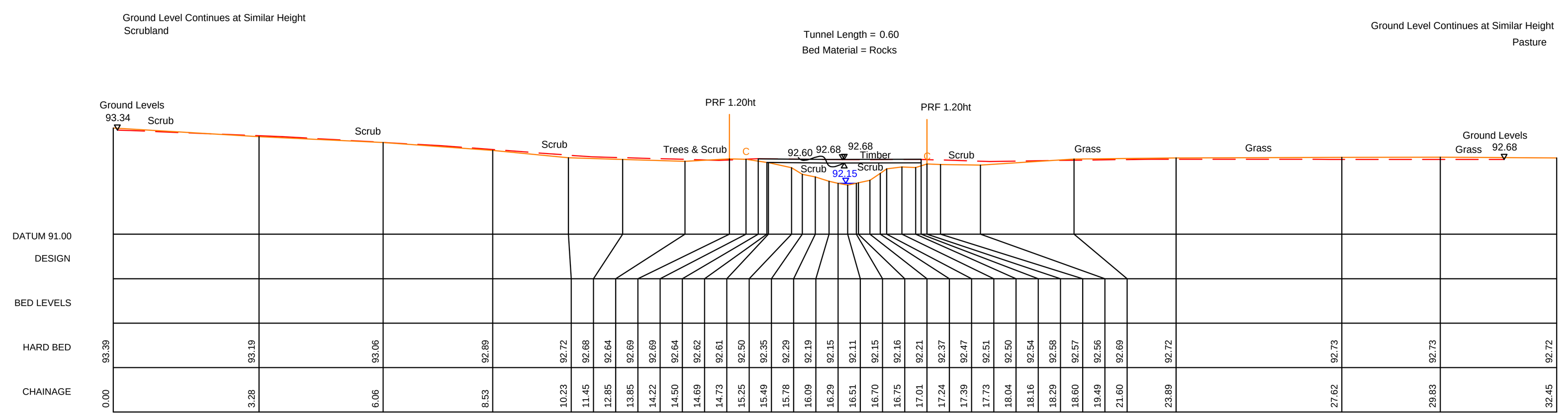
Open Channel
27/07/2021



REA02_01240
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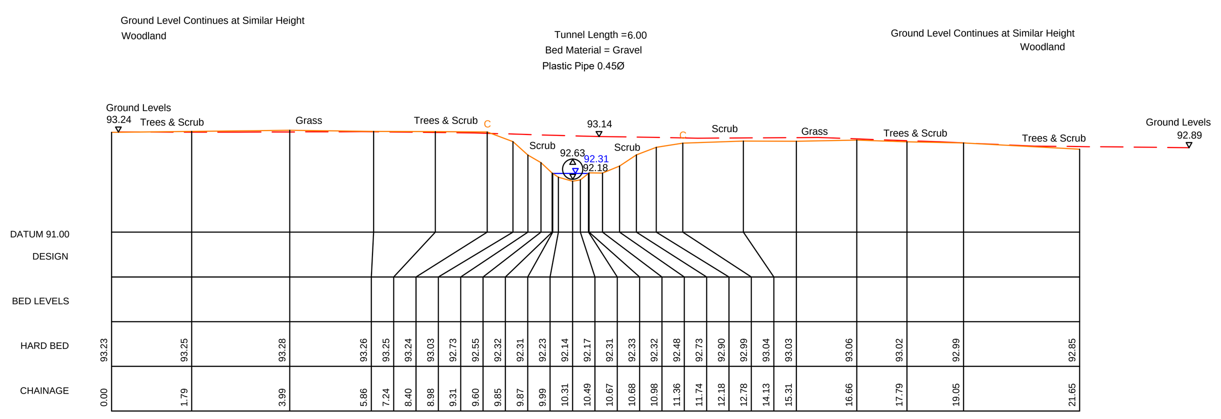
Footbridge
27/07/2021



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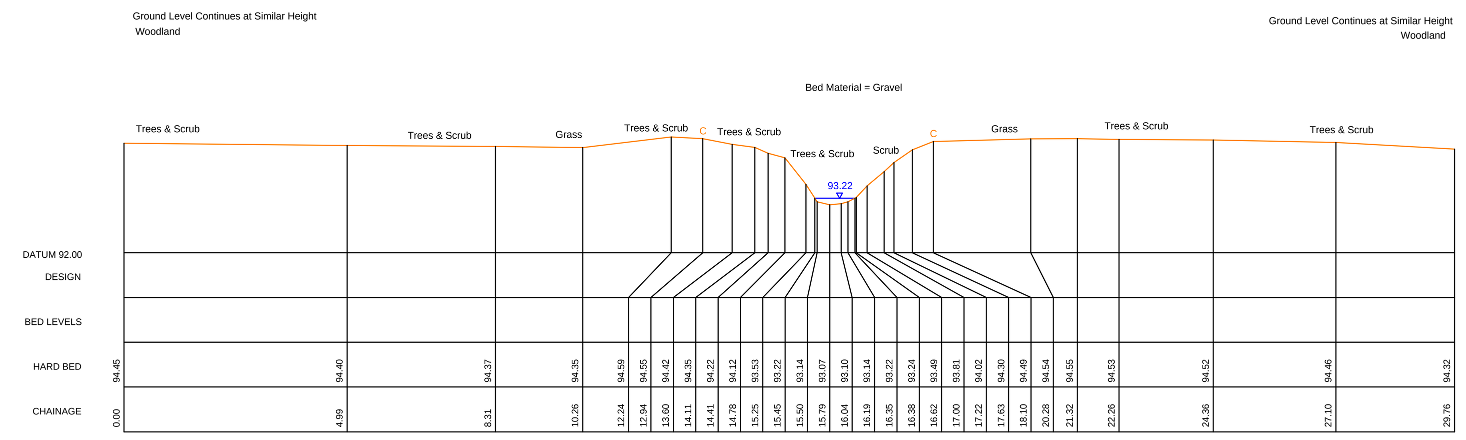
Culvert Entrance
27/07/2021



REA02_01472
CHAINAGE_1471.508
456735.22E 225677.07N BEARING 188
Open Channel
27/07/2021

CROSS SECTION KEY:
WATER LEVEL
BED LEVEL
SILT LEVEL

NOTES:
ALL CROSS SECTIONS VIEWED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RB	RIGHT BANK
B	BOLLARD	FL	FLOOR LEVEL	RE	RODDING EYE
BB	BELISHA BEACON	FP	FENCE POST	RS	ROAD SIGN
BDY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTW	RETAINING WALL
BH	BOREHOLE	G	GULLY	RWP	RAINWATER PIPE
BL	BED LEVEL	GL	GROUND LEVEL	SC	STOP COCK
BRK	BRICKWORK	GP	GATE POST	SDP	STAND PIPE
BS	BUS STOP	GM	GAS MARKER	SK	SOAKAWAY
BM	BENCH MARK	GV	GAS VALVE	SL	SOFFIT LEVEL
BW	BRICK WALL	HW	HEAD WALL	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
CBF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	SP	SIGN POST
CIF	CORRUGATED IRON FENCE	IRF	IRON RAILING FENCE	SPF	STEEL PALLISADE FENCE
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	STN	STATION
CLF	CHAIN LINK FENCE	JB	JUNCTION BOX	SV	SLUICE VALVE
CONC	CONCRETE	KIG	KERB INLET GULLY	SVP	SOIL VENT PIPE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CHESTNUT PALING FENCE	LFB	LIFEBUOY	TCB/TCP	TELEPHONE CALL BOX/POST
CR	CYCLE RACK	LP	LAMP POST	TC	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
CUL	CULVERT	MF	MISCELLANEOUS FENCING	THL	THRESHOLD LEVEL
DK	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DOWNPIPE	MP	MOORING PILE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DR	DRAIN	MS	MILE STONE	TS	TREE STUMP
DWB	DOG WASTE BIN	NB	NOTICE BOARD	TSR	TUBULAR STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	VP	VENT PIPE
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	WB	WASTE BIN
ECF	ELECTRIC CABLE FENCE	OS	OS Grid (15)	WL	WATER LEVEL/WATER LINE
ECP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	PILE	WMF	WIRE MESH FENCE
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PRF	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

ID	DESCRIPTION	Easting	Northing	Height
E6-1	PK Nail	457834.606	224786.156	86.984

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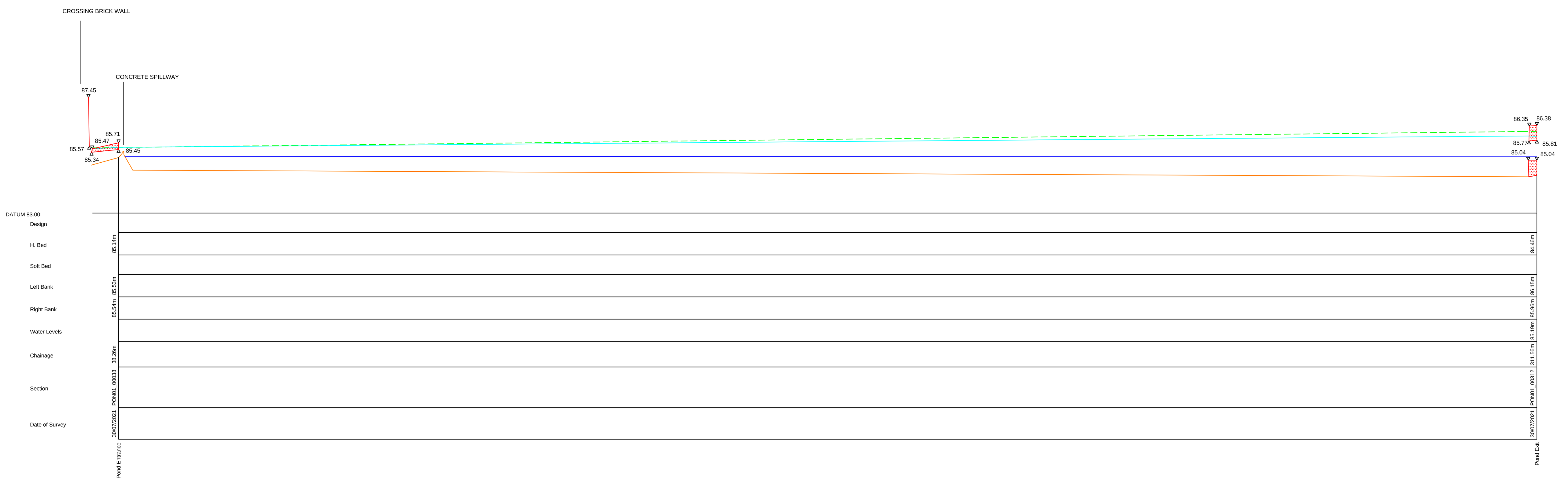
PROJECT
NW Bicester Survey

SITE
Reach 02
Charlotte Ave, Bicester OX27 8BL
REA02_00351 to REA02_01472
Sheet 2 of 2

SURVEYED BY: Storm Geomatics Ltd		Project Ref: 21FD1391
SURVEY DATE: July 2021		
SCALE: 1:100 (A0 Sheet)	DRN: MBM	CHKD: SRD
DATUM: OS Newlyn (15)	DATE: 06/08/2021	DATE: 12/08/2021
GRID: OS Grid (15)	DRAWING NO. 21FD1391/06	REV. –
CAD FILENAME: REA02_XS.dwg		

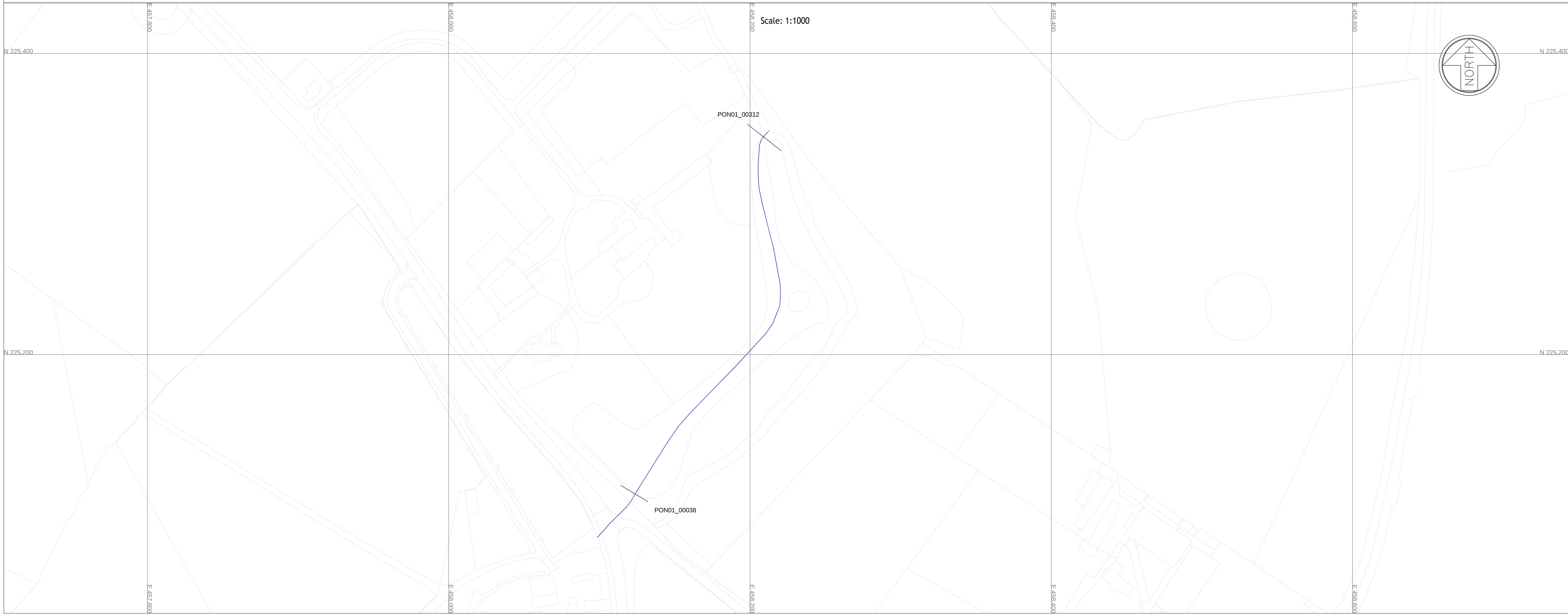
LONG SECTION KEY:

WATER LEVEL	
BED LEVEL	
SILT LEVEL	
STRUCTURES	
RIGHT BANK	VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'C' ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS
LEFT BANK	



Scale: 1:500H 1:100V

Scale: 1:1000



NOTES: ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RB	RIGHT BANK
B	BOLLARD	FL	FLOOR LEVEL	RE	RODDING EYE
BB	BELISHA BEACON	FP	FENCE POST	RS	ROAD SIGN
BDY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTW	RETAINING WALL
BH	BOREHOLE	G	GULLY	RWP	RAINWATER PIPE
BL	BED LEVEL	GL	GROUND LEVEL	SC	STOP COCK
BRK	BRICKWORK	GP	GATE POST	SDP	STAND PIPE
BS	BUS STOP	GM	GAS MARKER	SK	SOAKAWAY
BM	BENCH MARK	GV	GAS VALVE	SL	SOFFIT LEVEL
BW	BRICK WALL	HW	HEAD WALL	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
CBF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	SP	SIGN POST
CIF	CORRUGATED IRON FENCE	IRF	IRON RAILING FENCE	SPF	STEEL PALLISADE FENCE
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	STN	STATION
CLF	CHAIN LINK FENCE	JB	JUNCTION BOX	SV	SLUICE VALVE
CONC	CONCRETE	KIG	KERB INLET GULLY	SVP	SOIL VENT PIPE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CHESTNUT PALING FENCE	LFB	LIFEBUOY	TCB/TCP	TELEPHONE CALL BOX/POST
CR	CYCLE RACK	LP	LAMP POST	TC	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
CUL	CULVERT	MF	MISCELLANEOUS FENCING	THL	THRESHOLD LEVEL
DK	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DOWNPIPE	MP	MOORING PILE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DR	DRAIN	MS	MILE STONE	TS	TREE STUMP
DWB	DOG WASTE BIN	NB	NOTICE BOARD	TSR	TUBULAR STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	VP	VENT PIPE
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	WB	WASTE BIN
ECF	ELECTRIC CABLE FENCE	OS	OS Grid (15)	WL	WATER LEVEL/WATER LINE
ECP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	PILE	WMF	WIRE MESH FENCE
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PRF	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

ID	Description	Easting	Northing	Height
E6-1	PK Nail	457834.606	224786.156	86.984

STORM GEOMATICS
Tel: 01608 664910
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CLIENT
Vectos

PROJECT
NW Bicester Survey

SITE
Pond 01
Charlotte Ave, Bicester OX27 8BL
Long Section & Location Plan
Sheet 1 of 1

SURVEYED BY: Storm Geomatics Ltd

Project Ref: 21FD1391

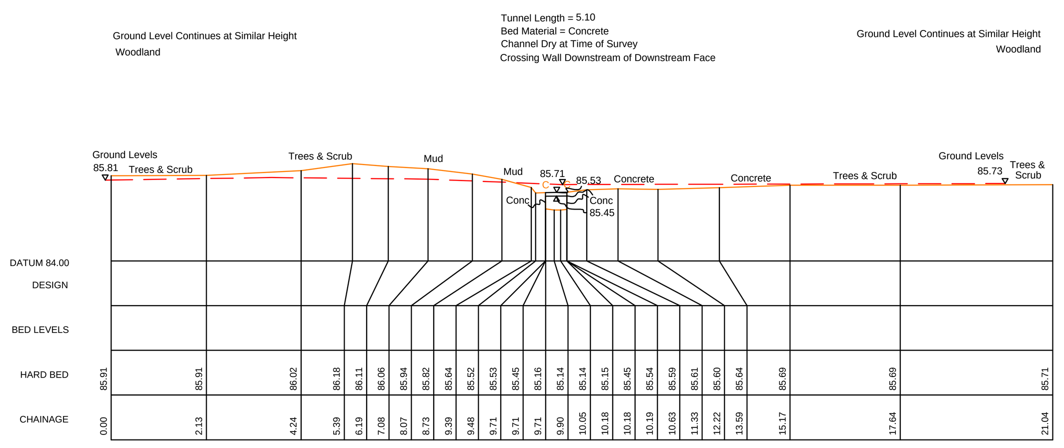
SURVEY DATE: July 2021

SCALE: As Shown (A0 Sheet)	DRN: MBM	CHKD: SRD
DATUM: OS Newlyn (15)	DATE: 06/08/2021	DATE: 12/08/2021
GRID: OS Grid (15)	DRAWING NO. 21FD1391-09	REV. –

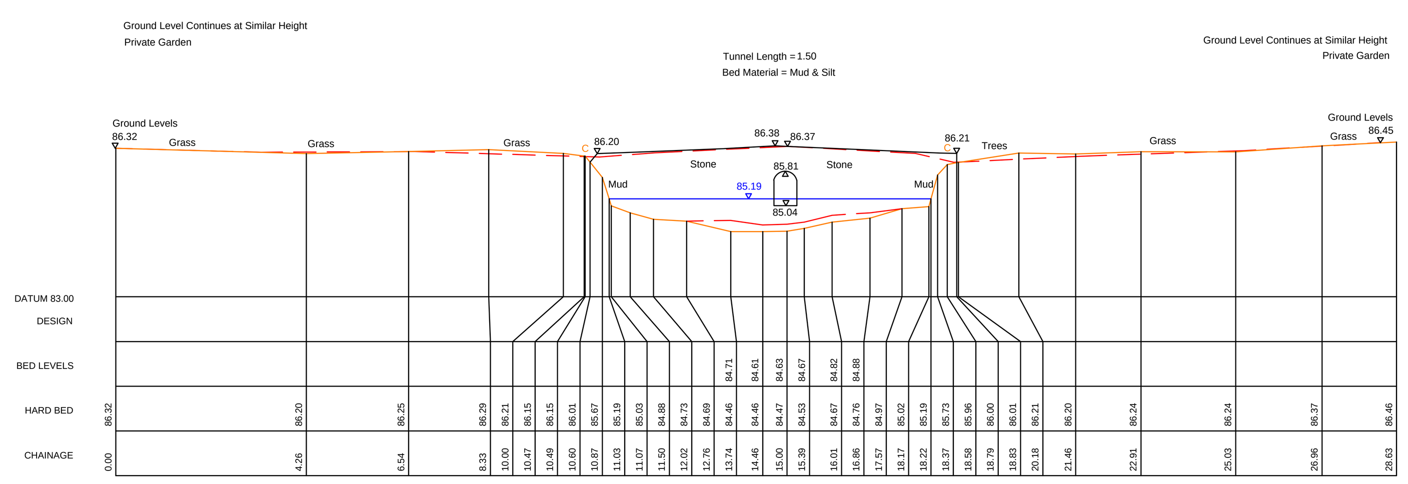
CAD FILENAME: PON01_LS+LP.dwg

CROSS SECTION KEY:

- WATER LEVEL
- BED LEVEL
- SILT LEVEL



PON01_00038
CHAINAGE_38.260
458132.30E 225102.27N BEARING 301
Pond Entrance
30/07/2021



PON01_00312
CHAINAGE_311.556
458220.74E 225335.43N BEARING 308
Pond Exit
30/07/2021

NOTES:
ALL CROSS SECTIONS VIEWED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RB	RIGHT BANK
B	BOLLARD	FL	FLOOR LEVEL	RE	RODDING EYE
BB	BELISHA BEACON	FP	FENCE POST	RS	ROAD SIGN
BDY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTW	RETAINING WALL
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(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

ID	DESCRIPTION	Easting	Northing	Height
E6-1	PK Nail	457834.606	224786.156	86.984

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CLIENT
Vectos

PROJECT
NW Bicester Survey

SITE
Pond 01
Charlotte Ave, Bicester OX27 8BL
PON01_00038 to PON01_00312
Sheet 1 of 1

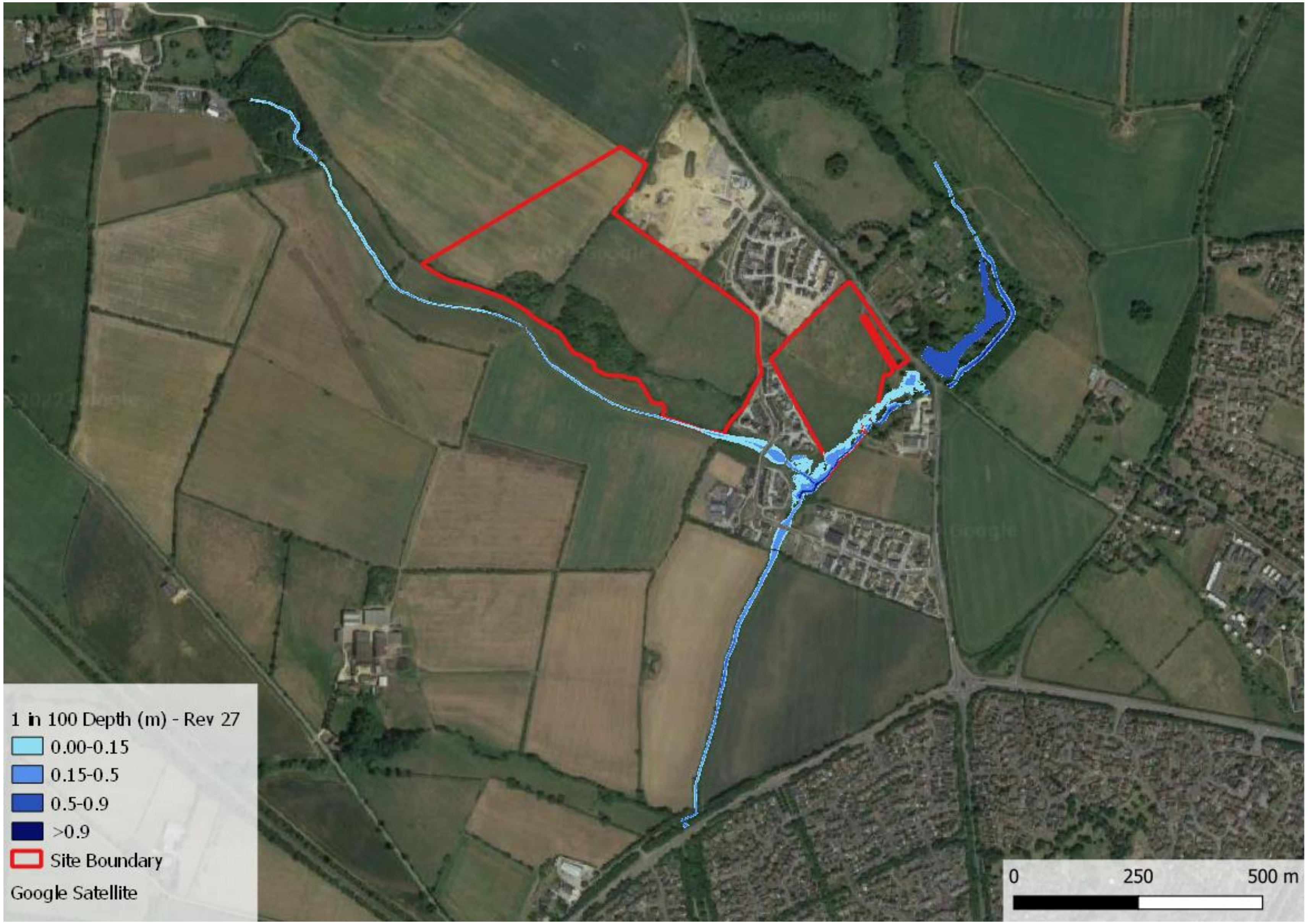
SURVEYED BY: Storm Geomatics Ltd — *Project Ref: 21FD1391*
SURVEY DATE: July 2021

SCALE: 1:100 (A0 Sheet)	DRN: MBM	CHKD: SRD
DATUM: OS Newlyn (15)	DATE: 06/08/2021	DATE: 12/08/2021
GRID: OS Grid (15)	DRAWING NO. 21FD1391/08	REV. –
CAD FILENAME: PON01_XS.dwg		

Appendix 4

Flood Mapping


1 in 20 Depth (m) - Rev 27
0.00-0.15
0.15-0.5
0.5-0.9
>0.9
Site Boundary
Google Satellite
0
250
500 m


1 in 100 Depth (m) - Rev 27
0.00-0.15
0.15-0.5
0.5-0.9
>0.9
Site Boundary
Google Satellite
0
250
500 m


1 in 100_CC Depth (m) - Rev 27
0.00-0.15
0.15-0.5
0.5-0.9
>0.9
Site Boundary
Google Satellite
0
250
500 m

1 in 100+HC-CC Depth (m) - Rev 27
0.00-0.15
0.15-0.5
0.5-0.9
>0.9
Site Boundary
Google Satellite
0
250
500 m

1 in 1000 Depth (m) - Rev 27
0.00-0.15
0.15-0.5
0.5-0.9
>0.9
Site Boundary
Google Satellite
0
250
500 m

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