Tappers Farm, Oxford Road, Bodicote

GreenSquare

Drainage Strategy and Flood Risk Assessment

May 2021

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Document Control Sheet

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1. INTRODUCTION

1.1 Background

1.1.1 PHG Consulting has been commissioned by GreenSquare Homes to review available information and prepare this Drainage Strategy and FRA to support a reserved matters planning application for land at Tappers Farm, Oxford Road, Bodicote, Banbury, OX15 4BN.

1.1.2 The report sets out a drainage strategy, including surface and foul water management, and Flood Risk Assessment.

1.2 Existing site

1.2.1 The Development Site covers an area of approximately 2.19 ha located at National Grid Reference SP461383. The Development Site is mainly greenfield with the existing farm and out-buildings to the south of the site. The approximate site location is shown in Figure 1.

Figure 1. Site location. National Grid reference: SP461383. Nearest Postcode: OX15 4BN.

1.3 Surface Water Features

1.3.1 The site is mainly open greenfield and farm buildings. There is no evidence of surface water features within the site.

1.3.2 The nearest main river or water body to the development are the Sor Brook, which is located approximately 1 km to the south of the site and Oxford Canal positioned 1 km to the north.

Figure 2: Nearest Surface Water Features

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1.4 Geology and Hydrogeology

1.4.1 Figure 3 below is an extract from WRAP map showing that the site is located in WRAP Class 1 that is potentially permeable.

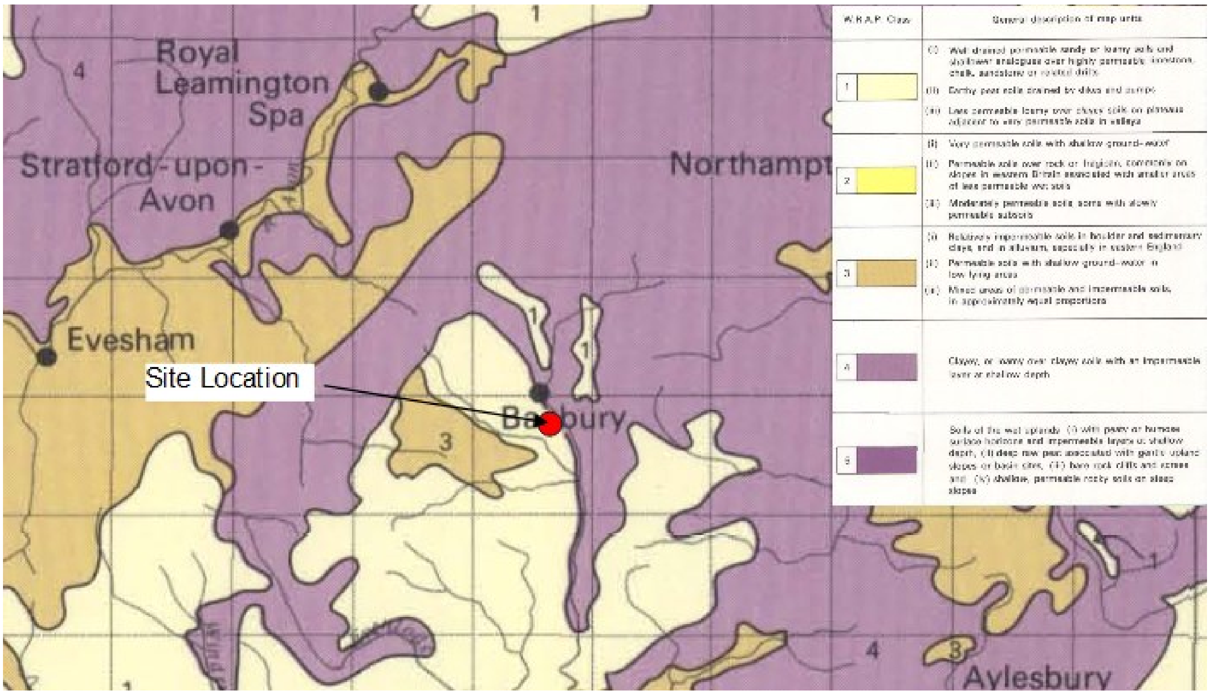

Figure 3. The Wallingford Procedure WRAP Map soil classification extract

1.4.2 The site investigation report indicates that the use of infiltration is suitable.

1.4.3 Groundwater was encountered during the intrusive works undertaken in December 2020 following a period of wet weather. Groundwater was located in excess of 2.5 to 3m b.g.l.

1.5 Development Proposals

1.5.1 The proposal comprises the provision of 46 residential units with associated infrastructure. The scheme already benefits from Outline Planning Permission 18/00792/OUT. Site Plan is included in Appendix A.

2. DRAINAGE STRATEGY

2.1 Existing Drainage

2.1.1 As shown in Appendix C there is an existing 150mm foul sewer within Oxford Road to the east of the site, along with other smaller drainage within the adjacent residential area.

2.1.2 There is no evidence of any usable surface water drains or watercourses across the site. Existing surface water drainage from the farm is likely to drain to ground or to the local adopted foul system.

2.2 Surface Water Management Approach

2.2.1 Following site investigation, the use of infiltration on site appears suitable. Extracts of the site investigation is included with Appendix B.

2.2.2 Infiltration rates have been confirmed suitable to discharge via infiltration. The worst-case rate of 0.05 m/hr has been used in calculations.

2.2.3 The site runoff will discharge to ground via infiltration. The main highway serving the site will be drained via porous paving and offered for adoption to Oxfordshire County Council via a Section 38 Agreement. Design and calculations have been provided via Tobermore and included within Appendix D.

2.2.4 All private surface water drainage will be managed on plot, either via private porous paving to or private cells. Appendix E shows a typical private cell system calculated using the FEH-13 data.

2.2.5 The preliminary hydraulic surface water design is to 1 in 100-year return period with an additional 40% increase in rainfall intensity due to climate change

2.3 Proposed Foul Drainage

2.3.1 The proposed system is gravity-based.

2.3.2 The proposed foul water network will connect to the existing adopted system within Oxford Road. The connection will be made under Section 106 Notice with Thames Water. Main foul system within the development shall be offered for adoption to Thames Water via a Section 104 Agreement.3

2.3.3 The proposed foul water network is presented in Figure 4.

Figure 4: Proposed Foul Water Network

3. FLOOD RISK ASSESSMENT

3.1 Legislation

3.1.1 This assessment has been conducted in accordance with Oxfordshire County Council Planning Policy Guidance and guidelines for Sustainable Drainage in Oxford.

3.2 Definition of Flood Risk

3.2.1 Flood risk is the product of the likelihood or chance of a flood occurring (flood frequency) and the consequence or impact of the flooding (flood consequence).

3.3 Flood Frequency

3.3.1 Flood frequency is identified in terms of the return period and annual probability. For example, a 1 in 100-year flood event has a 1% annual probability of occurring. Table 1 below provides a conversion between return periods and annual flood probabilities.

Table 1: Flood Probability Conversion Table

Return Period (years)	2	5	10	20	50	100	200	1000
Annual Flood Probability (%)	50	20	10	5	2	1	0.5	0.1

3.4 Flood Zone

3.4.1 The proposed development is located entirely within Zone 1 of Environment Agency Flood Map for Planning so is at low risk of fluvial or tidal flooding, i.e. less than 1 in 1000-year event.

3.5 Flood Risk Vulnerability Classification

3.5.1 The proposed development is residential so classed as highly vulnerable.

3.6 Flood Risk Vulnerability Classification and Flood Zone Compatibility

3.6.1 As indicated by Environment Agency Flood Map for Planning, the development is located entirely within Zone 1, therefore the proposed land use is appropriate.

3.7 Other Sources of Flooding

3.7.1 The site is well protected from overland flow by existing topography.

3.7.2 The Environment Agency Risk of Flooding from Surface Water surface water flood map shows an area of approx. 540 m^2 in the centre of the site at low risk (1 in 1000 year probability) of Surface Water Flooding (Figure 5 below).

Figure 5. Local Low Risk of Flooding from Surface Water

3.7.3 The development will not result in increased surface water flood risk within the site or downstream.

3.8 Summary of Existing Flood Risk

3.8.1 The proposed development site is at very low risk of flooding from rivers, groundwater and overland flows. EA Flood Maps are presented in Appendix F.

4. CONCLUSIONS

4.1.1 The surface water runoff from the development will be managed solely by infiltration as the infiltration potential has been confirmed by appropriate testing and no exception criteria have been encountered (i.e. shallow groundwater, ground contamination, ground instability, etc.) .

4.1.2 Proposed foul water system will be offered for adoption under Section 104 Agreement.

4.1.3 There will be no surface water flooding/runoff from impermeable area leaving the site for 1 in 100-year with a 40% allowance for increase in rainfall intensity due to climate change.

4.1.4 The development is located in an area at very low risk of flooding. Minor localised Low Risk of Surface Water flooding has been identified in the centre of the site due to the existing site topography, which will be mitigated post-development. The development will not result in increase of the risk of flooding on the site or downstream.

APPENDIX A – ENGINEERING LAYOUT

GENERAL NOTES

1. Do Not Scale.
2. The contractor is to check and verify all buildings and site dimensions all levels, including sewer invert levels, before works start on site. The contractor is to comply in all aspects with the current building legislation, British Standards, building regulations etc.
3. Positions of existing services/statutory undertakers apparatus adjacent to or crossing proposed excavations are to be checked by the contractor prior to starting work.
4. This drawing is to be read in conjunction with and checked against all other drawings, Engineering Details, Specification and any structural, geotechnical or other specialist document provided.
5. Any anomaly or contradiction between any of the above is to be reported to Greensquare.
6. This drawing is schematic for clarity only, positions of pipes and manholes may vary due to site conditions.

ROAD AND SEWER ADOPTION NOTES

1. All works for adoption under a Section 38 agreement shall be carried out to the approval of Oxfordshire County Council.
2. All works for adoption under a Section 104 agreement shall be carried out to the National Water Council guide 'Sewers for Adoption' 8th edition and Thames Water requirements.
3. Streetlighting positions to be pegged on site and agreed by the Local Authority PRIOR to erection commencing.

DRAINAGE NOTES

1. All private drainage shall be in accordance with BS8301 and relevant sections of Approved Document H of the Building Regulations.
2. The contractor is to check the level of existing sewers being used as outfalls or crossing proposed drainage runs PRIOR to laying any pipes. Any discrepancies are to be reported to the Engineer
3. Private house drainage will be flexibly jointed plastic or clay pipework. Diameter 100mm unless shown otherwise.
4. All connections for House Drainage shall be 100mm unless noted otherwise and must extend 500mm behind the back of footway/homezone road. All connections when laid shall be plugged, protected as necessary and marked with a stake for future use.
5. For private drains where cover to pipes is less than 900mm in vehicular areas or 600mm in other areas protection in the form of a 100mm thick concrete pad shall be provided over the pipe granular surround.
6. Where pipes pass through screen walls, footings or retaining walls lintels are to be provided over. Under buildings pipes shall be surrounded with 150mm thickness of granular material. Where drains pass within 1m of buildings the wall foundation shall be taken down below the invert of the pipe.
7. Where drains do not exceed 600mm deep, plastic or clay access fittings minimum diameter 225mm shall be used. Elsewhere proprietary plastic or precast concrete inspection chambers shall be used. Unless shown otherwise FW inspection chambers are to be 750mm below dpc level and SW chambers and rodding eyes to be 600mm below dpc.
8. All gullies and rainwater downpipes connected directly to drains are to be roddable.
9. House levels shown are dpc and adjacent garage floors are to be 150mm lower unless shown otherwise. Levels at drainage access points are inverts.
10. Drainage runs should be laid at a minimum of 5.0m form the rear of properties where practical to allow for future extensions.
11. All drainage shall be laid upstream and each run between manholes shall be laid complete prior to backfilling. Where this is not practical trial holes or other means of identifying the line and level of services shall be carried out prior to works commencing.
12. All branch drains, or connections, are to discharge to the collectors obliquely, and in the direction of the main flow.
13. All low spots on hardstanding areas to have yard gullies/ACO.

LEGEND

- Foul Water Sewer/Lateral Drain (adoptable)
- Foul Water Manhole (adoptable)
- Adopted Foul Water Sewer (existing)
- Surface Water Sewer (adoptable)
- Surface Water Manhole (adoptable)
- 134.50 Building D.P.C. Level
- 135.50 Proposed Finished Ground Level
- Additional Underbuild (below d.p.c. as shown)
- Retaining Wall - (Height shows difference in levels - finished level at bottom and top).
- Steps (to be Part M Compliant)
- Porous Paving (adoptable)

Rev:	Date	Details	By.	Chk.

Amendments

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Project:
GreenSquare Group
Oxford Road
Bodicote

Drawing Title:
Engineering Layout

Drawn:	Chk:	Status:	Scale:
TL	SJD	Planning	1:500 @ A1

Date:	Job No.	Drg. No.	Rev:
May-21	2192	100	

APPENDIX B – SITE INVESTIGATION EXTRACTS

EXECUTIVE SUMMARY	
Location and Brief Site Description	The site is located off Oxford Road, Bodicote, OX15 4BN. The site comprises predominantly an open field with a farm shop, barns and caravan storage present in the southern corner of the site. No potential sources of contamination were noted on-site.
Ground Conditions	Generalised ground conditions from the ground investigation comprise (top down): • Made ground encountered from ground level to between 0.15m and 0.25m bgl. • Natural strata encountered from 0.15mbgl to between 0.45m and 4.00m bgl. • Solid geology encountered from 0.2m bgl to between 0.65m and 4.00m bgl. • No groundwater was encountered during the investigation, but groundwater was recorded in two boreholes between 2.53m and 3.41m bgl.
Human Health - Soils Contamination	• Arsenic (total) was encountered in all tested samples of made ground and natural soils, above residential screening values with home grown produce, however background soil chemistry showed that elevated arsenic is naturally occurring and an area wide issue. The arsenic concentrations identified on site are not uncommon and can be much higher within the District. • The EHO at the local council advised that concentrations such as the ones recorded are not atypical for the area. They stated that often no remedial measures are required in this situation, as background levels are so elevated, and it would not be cost-beneficial [or sustainable] to enforce a requirement for clean cover / removal of soils across the entirety of the Bodicote area. • The EHO made an outline recommendation that supplementary bioaccessibility testing for the arsenic be carried out. • PBET testing revealed the bioaccessible fraction of arsenic was max. 5.3%and therefore adopting this maximum fraction to convert all total concentrations to bioavailable concentrations, the bioavailable arsenic concentrations are all below the residential screening value of 37mg/kg and no further action is considered to be required. • Localised lead and nickel contamination was encountered in one sample of made ground and one sample of natural clay respectively, above residential screening values with home grown produce. • No other determinands were encountered above their respective screening values. • No asbestos was encountered in any samples. • Statistical analysis found the lead exceedance to be an outlier or hotspot.
Ground Gas	Based on the monitoring to date, the site is classified as Green under the NHBC traffic light classification system. Full radon protection measures are required on-site, which will mitigate against any ground gas. Ground gas monitoring is ongoing, and a full assessment will be undertaken on completion of the scheduled monitoring.
Outline Remedial Strategy	The lead in WS01 is a hotspot which should be mitigated by removal of the source or pathway. The nickel exceedance, when compared with the generic screening criteria for public open space was not found to be in exceedance and therefore based on the current development layout, is not considered a significant risk. Preliminary discussions with the Contaminated Land officer indicate that this is a known issue in the general area and they take a pragmatic view. Physiologically-Based Extraction Testing (PBET) has been undertaken for arsenic, showing that the bioavailable fraction of arsenic is generally very low (5.3% max) and therefore risks are considered to be low, and no further remediation is considered to be required. Full radon protective measures are necessary according to current guidance. Verification of the above will be required, with validation reports produced.
Waste	All samples were screened against the HazWasteOnline screening tool and were all found to be Non-Hazardous. Waste acceptance criteria (WAC) testing was outside of the scope of this investigation. If it is anticipated that the gravel strata in the vicinity of WS01 is to be removed from site or re-used on-site, that this material is segregated for additional testing. It should not be utilised in any areas where contact with site end-users is possible due to elevated lead concentrations.

EXECUTIVE SUMMARY	
Foundations and Floor Slabs	Strip foundations are considered suitable. In the northern and eastern areas of the site, these can found on natural limestone gravel at a minimum of 0.45m bgl, providing allowable bearing capacities of upwards of 250kN/m^2. In the southern area, bearing on the weathered marlstone will be required at a minimum of 0.90m bgl, providing an allowable bearing capacity of 110kN/m^2. Localised deepening to 2.00m bgl in the area of WS01 and WS02 will be required, providing at bearing capacity of 140kN/m^2 at this depth. In WS07, where interbedded clay and gravel was encountered, foundations can found on the first gravel layer at 1.0m bgl, providing a bearing capacity of at least 150kN/m^2. The foundation solutions detailed above would keep total settlement within acceptable limits, although in transitional areas foundations would need adequate reinforcement to mitigate against differential settlement. Suspended floor slabs are recommended, however ground bearing floor slabs may be adopted.
Concrete Classification	DS-1 AC-1 conditions prevail.
Highways Design	Superficial Strata CBR – cohesive/fine soils– 3-5% Superficial Strata CBR – granular/coarse soils– up to 60% The above should be confirmed by in-situ testing at formation level by a specialist geotechnical engineer during construction.
Sustainable Drainage Systems (SUDS)	Drainage to soakaways is considered potentially suitable for this site. Indicative soil infiltration rates range from 1.43x10^{-5}m/s to 1.46x10^{-4}m/s.
Further Work	The following further works will be required to progress to the construction phase: • Completion of ground gas monitoring programme. • Issue gas assessment / update gas assessment within this report. • Design of Remedial Strategy and confirmation with the Local Authority, if required. • Demolition Asbestos survey. • Tree survey by qualified arboriculturist. • Detailed foundation design by a structural engineer, including foundation zonation plan and depth schedule. • Production of Ground Gas Protection Measures Verification Plan, if required. • Production of Materials Management Plan (MMP) under the CL:AIRE DoWCoP, if required. • Implementation of the Remedial Strategy and verification of the remedial works.

This executive summary should be read in conjunction with the full report, reference JW/C3797/9600 and not as a standalone document.

PROJECT QUALITY CONTROL DATA SHEET

Site Name:	Oxford Road, Bodicote		
Document Name:	Geo-Environmental Assessment Report		
Reference:	JW/C3797/9600		
Status:	-	06/11/2020	Interim.
	-	01/12/2020	Final.

Issued By:	Client:	Engineer:
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	CEnv Chartered Environmentalist	THE GEOLOGICAL SOCIETY CGeol CHARTERED GEOLOGIST Fellow No. 1003068

4.0 METHOD OF INVESTIGATION

4.1 Objectives

To confirm the risks to the identified receptors and confirm the ground conditions in respect to the identified geotechnical and geo-environmental risks, an appropriate intrusive investigation was undertaken as per the recommendations of the Phase I Desk Study Assessment.

The aim of the fieldwork was to:

- Investigate ground conditions on the site.
- Install standpipes to allow future monitoring.
- Assess the potential contamination on the site and obtain samples for contamination screening.
- Assess the potential impact of any contamination on controlled waters.
- Obtain geotechnical information on the ground conditions at the site for preliminary foundation design and preliminary pavement design purposes.
- Give an assessment of the geo-environmental risks associated with redevelopment of the site.

4.2 Site Works

The following site works have been undertaken as part of the intrusive investigation between the dates of 16th and 18th September 2020. Supplementary hand dug trial pits were undertaken on 5th November 2020.

Method	No.	Range Depths (m bgl)	Purpose
Trial pits – JCB 3CX	7	2.05 – 2.75	Establish general ground conditions and gain good coverage. Allow hand shear vane tests (HSVs) to be carried out on suitable cohesive arisings and obtain samples for contamination and geotechnical testing.
Window sample boreholes – Tracked WS rig	8	0.90 – 4.00	Establish general ground conditions on site. Allow Standard Penetration Tests (SPTs) to be carried out and obtain samples for contamination and geotechnical testing. Installation of ground gas and water monitoring wells.
Infiltration tests (2 tests per location)	3	1.286 – 1.575	Obtain infiltration rates for drainage design.
Trial pits – hand dug	3	0.20 – 0.70	TP03A, TP06A and WS07A were undertaken as supplementary works on 5/11/20 to obtain additional targeted samples for total and bioaccessible arsenic analysis.

The surveyed locations of the exploratory holes are indicated on the Exploratory Hole Location Plan, Drawing No C3797/02. The exploratory hole logs are presented in Appendix B.

The exploratory holes were logged by an experienced geo-environmental engineer in general accordance with the following guidance:

- BS 5930:2015+A1:2020 Code of Practice for Site Investigations.
- BS EN 14688-1:2018 Geotechnical Investigation and Testing – Identification and classification of soil.
- BS EN ISO 14689:2018 Geotechnical investigation and testing – Identification and classification of rock.

In the south of the site (WS01, WS02, WS06, WS07, TP01, TP02) the topsoil or made ground was underlain by sand to depths of up to 0.8m bgl (TP01) and was underlain by thicker clay soils which were generally described as stiff, however locally soft and lower strength clays were encountered (low SPT values of 3 and 4 were recorded at 1.2m bgl in WS01 and WS02 respectively, and were in part described as damp and soft or firm). In WS01 and WS02 the SPT values improved below 2.0m bgl.

The shallow clay was present to depths of up to 3.0m bgl (WS02) in this area, and in WS02 and WS07, the thick clay was interbedded with thinner layers of gravel (sub 0.5m thick), ultimately refusing (SPT N-Value >50) in the weathered bedrock at circa 4.0m bgl.

In TP01, TP02 and WS01, located to the south of WS02 and WS07, the weathered bedrock (gravel/cobbles) was encountered between depths of 2.2m and 2.5m bgl.

The inferred boundary between the shallow bedrock and thicker clay deposits is shown on the attached Ground Conditions Plan, C3797/03.

5.5 Groundwater

No groundwater was encountered during the main investigation, although the strata was locally described as damp. Water was encountered during the monitoring programme from visit 2, however it's likely that this water was perched and has seeped into the boreholes. The depths and locations present are shown in the table below:

Location	Depth During Monitoring Period, where encountered (range) (m)
WS01	2.53
WS02	2.70 – 3.15
WS04	NGW
WS05	NGW
WS06	NGW
WS07	2.97 – 3.41

5.6 Observations

Contamination

During the works undertaken by BSL, no visual or olfactory evidence of contamination was observed.

Stability of Excavations/Boreholes

The sides of the trial pits were generally stable. Minor collapses occurred in the clay deposits when undertaking infiltration testing in SA01.

The majority of the exploratory holes refused on the limestone encountered across the site. The only two locations that penetrated the limestone gravel, cobbles and boulders were WS02 and WS07. As these locations were in close proximity of each other, it's likely that this area has undergone a higher degree of weathering than the rest of the site.

6.0 TEST RESULTS

6.1 Geotechnical Laboratory Testing

Plasticity Index Analysis
Plasticity index results ranged between 16% and 35%, indicating the cohesive soils to be generally of high to very high plasticity, with one sample of medium plasticity. Associated water contents ranged between 20% and 48%.

After modification of particle size in accordance with NHBC Chapter 4.2, the modified plasticity indices are in the range 8.96% to 30.10% indicating the cohesive soils to be of very low to medium volume change potential.

6.2 Aggressive Ground Conditions – Geotechnical Chemical Testing

The test results for the assessment of aggressive ground conditions are presented in Appendix D. The results are summarised and assessed within Section 8.0 of this report.

6.3 In Situ Geotechnical Testing

In Situ Hand Shear Vane Tests
In general, the cohesive soils were unsuitable for shear vanes due to the gravel content. However, four hand shear vane tests were carried out on suitable cohesive soils recovered from the trial pits. Each shear vane result recorded represents the mean value of three tests undertaken at the specified depth.

The results and distribution of the hand shear vane tests are recorded in kPa on the Exploratory Hole Logs which are presented in Appendix B.

In Situ Standard Penetration Tests
Standard Penetration Tests (SPTs) were carried out within the window sample and cable percussive boreholes at regular 1.0m to 1.5m intervals. The results of the individual blows and the N-values are recorded on the Exploratory Hole Logs in Appendix B.

All SPT N values are uncorrected. Density and strength descriptors are reported in accordance with the guidelines stated in BS 5930:2015+A1:2020, incorporating requirements of BS EN ISO 14688-1:2002, BS EN ISO 14688-2:2004 and BS EN ISO 14689-1:2003.

Soil Infiltration Test Results
Soil infiltration test tests were undertaken within trial pits at 3 No. locations across site, a summary of the results is presented in the table below. These were carried out in general accordance with BRE Digest 365 (BRE 2016) where infiltration rates allow three test runs during a working day (or where there is no infiltration), but where low infiltration rates were encountered the available time may not have been sufficient to fully comply with the BRE test method.

Where less than three tests were possible in a particular location the results provided should be considered as indicative only. Further discussion concerning the suitability of infiltration testing at the site is provided in Section 7.9.

Location	Stratum Type	Depth (m)	Infiltration Rate (m/sec)	
			Test 1	Test 2
SA01	Sandy clayey GRAVEL with high cobble content	Test 1: 1.575 Test 2: 1.510	2.23×10^{-5}	1.43×10^{-5}

Location	Stratum Type	Depth (m)	Infiltration Rate (m/sec)	
			Test 1	Test 2
SA02	Sandy GRAVEL with high cobble content	Test 1: 1.507 Test 2: 1.405	4.66×10^{-5}	8.93×10^{-5}
SA01	Sandy GRAVEL with high cobble content	Test 1: 1.370 Test 2: 1.286	1.46×10^{-4}	1.44×10^{-4}

The full test results are presented in Appendix D.

6.4 Geo-Environmental Testing

Chemical Laboratory Testing

The chemical test results for soils are presented in Appendix C. The results are summarised and assessed within Section 8.0 of this report.

Ground Gas Monitoring

Monitoring installations have been monitored on 5 occasions to date out of 6 visits scheduled. The results are presented in Appendix E and are summarised and assessed within Section 8.0 of this report.

For the purposes of this assessment, it is likely that groundwater is present within the permeable bedrock and therefore the groundwater has been classed as mobile.

Stratum	No. Samples	Characteristic SO_4 (g/l)	Characteristic pH	DS Class	ACEC Class
Made Ground	2	0.034	7.1	DS-1	AC-1
Weathered Bedrock	8	0.0325	7.6	DS-1	AC-1
Solid Geology	2	0.018	7.9	DS-1	AC-1

Based on the above, the results of laboratory pH and sulphate content, alongside the BRE full suite tests, indicate that sulphate class DS-1 and ACEC Class AC-1 conditions prevail in accordance with BRE Special Digest 1 "Concrete in aggressive ground" 2005.

The specific concrete mixes (the Design Concrete Class) to be used on site will be determined by the site-specific concrete requirements in terms of the durability and structural performance. These are assessed in terms of the Structural Performance Level (SPL) and any need for Additional Protective Measures (APM) detailed in Part D of BRE Special Digest 1 with further guidance in Pt E and F.

7.8 Highways

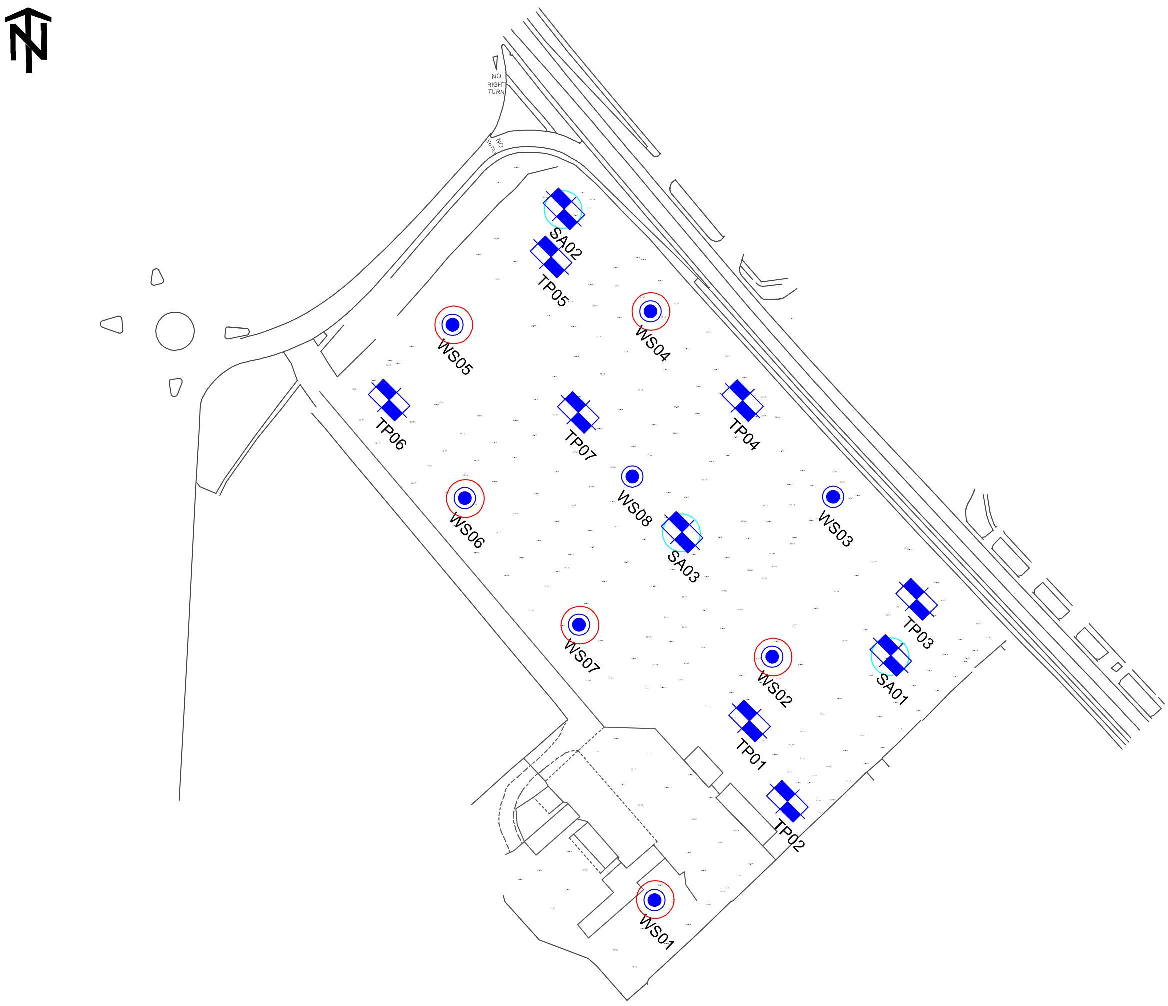
Based on Table 5.1 from DMRB IAN 73/06 Rev 1 equilibrium CBR values of up to 60% are likely to be achieved in undisturbed natural granular soils and 3-5% for natural clays soils for pavement design purposes, unless proven otherwise by in-situ testing at formation level by a specialist geotechnical engineer.

Based on the fines content of the soils, they are considered to be frost susceptible, therefore highway construction should be a minimum thickness of 450mm to mitigate against the risk.

Care should be taken to ensure the stratum at formation level is protected against inclement weather, as this is likely to lead to surface deterioration and a decrease in soils strengths.

7.9 Sustainable Drainage Systems (SUDS)

The tests undertaken across the site indicate good drainage conditions. Based on the infiltration rates obtained, in the order of 10^{-5} and 10^{-4} m/s, it is likely that drainage to soakaways will be feasible at the site. We recommend the design of soakaway drainage is carried out in accordance with BRE 365 and CIRIA C753. Consideration should also be given to future maintenance, as the infiltration capacity can be reduced over time as a result of blinding through ingress of fines.



KEY

- TPXX — TRIAL PIT
- WSXX — WINDOW SAMPLE BOREHOLE
- SOAKAWAY INFILTRATION TEST
- BOREHOLE INSTALLATION

NOTES

1. ALL DIMENSIONS TO BE CHECKED ON SITE BEFORE COMMENCING WORKS. ANY DISCREPANCIES ARE TO BE REPORTED TO THE ARCHITECT & ENGINEER FOR VERIFICATION. FIGURED DIMENSIONS ONLY ARE TO BE TAKEN FROM THIS DRAWING.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ENGINEERS REPORTS. THIS DRAWING IS COPYRIGHT OF BSL.
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REV	DATE	DESCRIPTION	BY	CKD

BROWNFIELD SOLUTIONS LTD

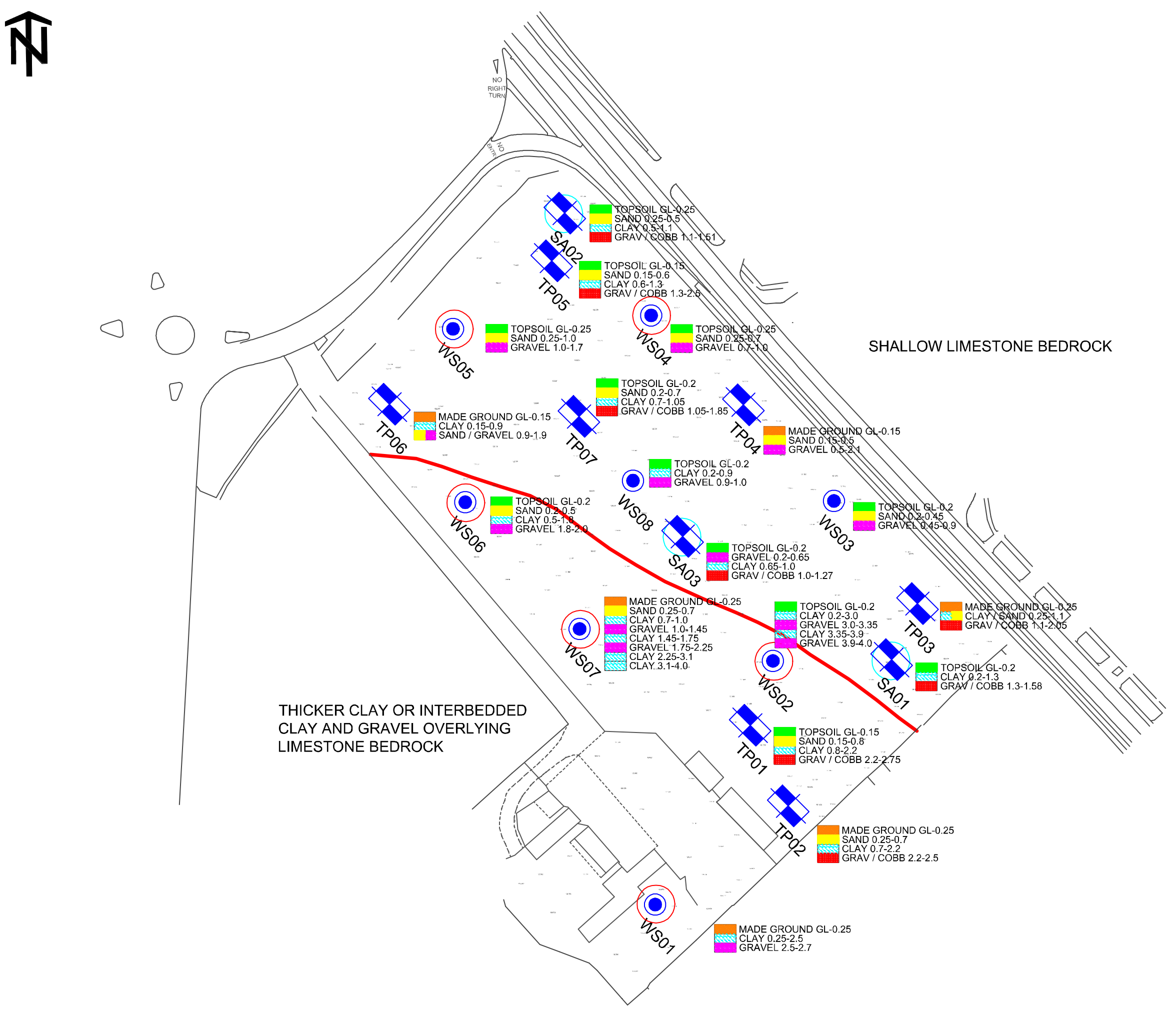
CLIENT
HOLLINS STRATEGIC LAND

PROJECT TITLE
BODICOTE, OXFORDSHIRE

DRAWING TITLE
EXPLORATORY HOLE LOCATION PLAN

DRAWING No.	REVISION	SCALE	DATE
C3797/02	-	NTS	15/09/20

DRAWN BY	CHECKED BY
JW	WG



KEY

- TPXX — TRIAL PIT
- WSXX — WINDOW SAMPLE BOREHOLE
- SOAKAWAY INFILTRATION TEST
- BOREHOLE INSTALLATION
- INFERRED BOUNDARY BETWEEN SHALLOW BEDROCK AND THICKER CLAY DEPOSITS

NOTES

1. ALL DIMENSIONS TO BE CHECKED ON SITE BEFORE COMMENCING WORKS. ANY DISCREPANCIES ARE TO BE REPORTED TO THE ARCHITECT & ENGINEER FOR VERIFICATION. FIGURED DIMENSIONS ONLY ARE TO BE TAKEN FROM THIS DRAWING.
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3. DRAWING NOT FOR CONSTRUCTION PURPOSES.

REV	DATE	DESCRIPTION	BY

BROWNFIEL
SOLUTIONS LT

CLIENT
HOLLINS STRATEGIC LAND

PROJECT TITLE
OXFORD ROAD, BODICOTE

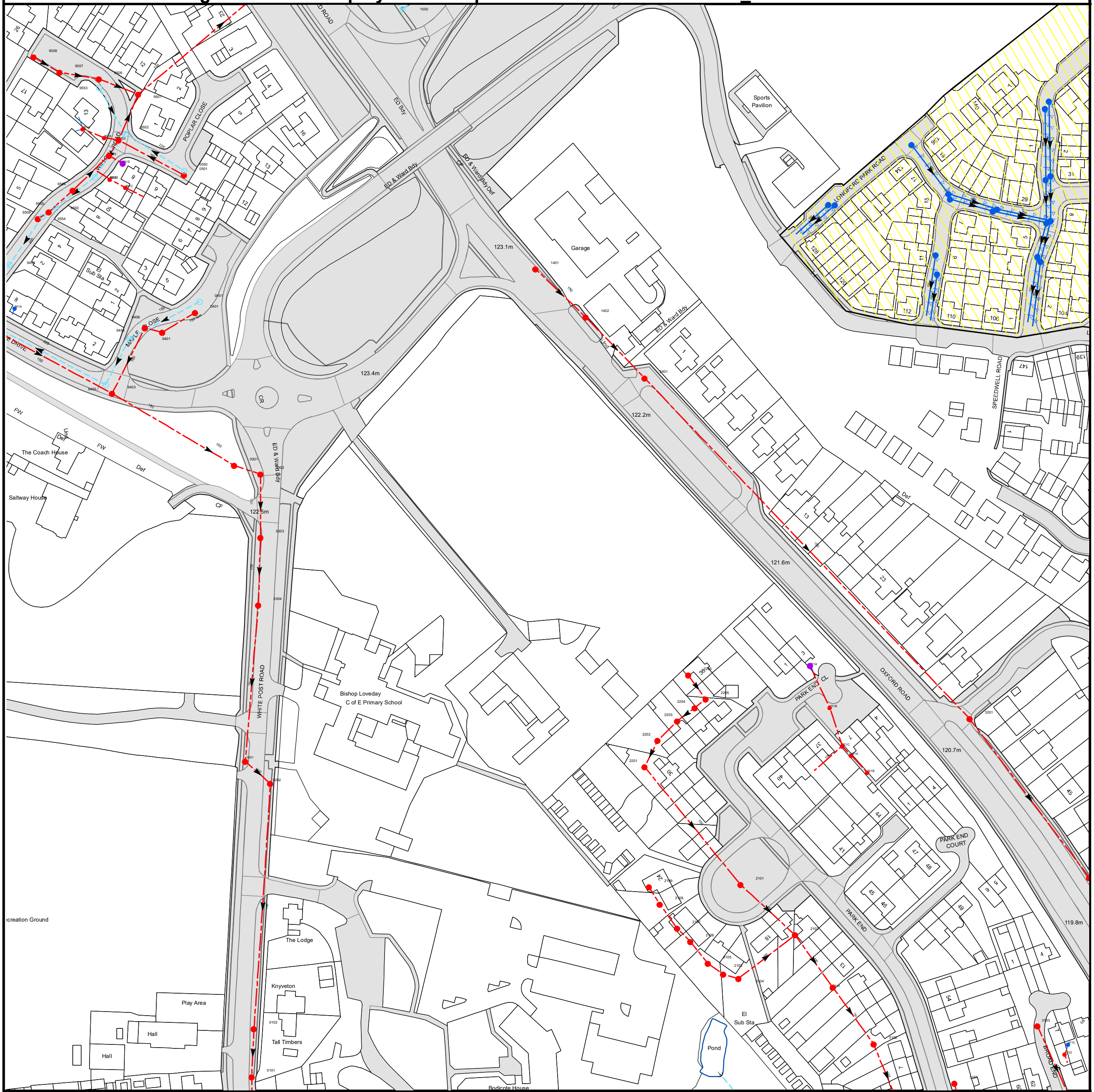
DRAWING TITLE
GROUND CONDITIONS PLAN

DRAWING No.	REVISION	SCALE	DATE
C3797/03	-	NTS	20/10/2

DRAWN BY	CHECKED BY
JW	WG

APPENDIX C – THAMES WATER SEWER MAPS

CommercialDW Drainage and Water Enquiry Sewer Map- CDWS/CDWS Standard/2020_4328909



The width of the displayed area is 500m

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

APPENDIX D – SURFACE WATER CALCULATIONS, ADOPTABLE POROUS PAVING, 100 YEAR + 40% CLIMATE CHANGE

GEOMAN

44 Elmwood Avenue, Belfast BT9 6AZ | 02890 664 941 | www.geoman.co.uk

Preliminary Permeable Paving Design

Oxford Rd, Bodicote

Location Address:	Oxford Rd, Bodicote
Designed:	Geoman Ltd.
Date:	12/05/2021
Design Reference Number/Version:	21-5566
Type of Design:	Infiltration Permeable Paving Design
Tobermore **Sales Executive Contact:**	Adam Preece

Technical Support and Back Up

If you have any questions relating to this design, please contact the people listed below:

Contact:	Contact Number:	Email Address:
Cleona Cunningham (Geoman Ltd.)	+44(0)2890664941	geoman@geoman.co.uk
Adam Preece (Tobermore Ltd.)	+44(0)7974243397	A.Preece@tobermore.co.uk

Contents

1.0 Proposed Section

It is proposed to install Tobermore Hydropave as the surfacing to approximately **1990m^2** of the development to create a permeable paving system on site. This includes the permeable paving areas at the proposed Oxford Rd, Bodicote as shown on PHG Consulting Engineers dwg no.100 – Engineering Layout.

We have assumed it is proposed to store water in the coarse graded aggregate (CGA) subbase and allow infiltration into the subgrade below. For the permeable paving areas it is assumed they will need to accommodate loading as per Loading Category 6 (<70 standard axles per day). Please advise if a more onerous loading is to be considered.

A permeable membrane should be provided at sub-base formation level. A plan showing the assumed hydropave areas are indicated on Geoman's drawing no SK21-5566-01. Indicative proposed sections of the Hydropave infiltration system are shown on Geoman Ltd. drawing SK21-5566-02 for Category 6.

For preliminary design purposes we have made the following assumptions:

1. The proposed formation level CBR will be at least 3%. This should be confirmed via in-situ testing prior to construction. If lower values are recorded this design will need to be reviewed.
2. A minimum infiltration rate of 0.05m/hr has been assumed. Please advise if a lower infiltration rate is required, as the design will have to be revised. If the infiltration rate is lower than we have assumed, then the depth of course graded aggregate will have to increase.

1.1 Infiltration – Hydropave Summary

Category Type:	Category 6 (<70 standard axles per day)
Paving Block:	**Tobermore Hydropave** (200x100x80mm deep)
Laying Course:	50mm thickness of 6.3-2mm grit to BS EN13242:2002
Dense Bitumen Macadam:	N/A
Coarse Graded Aggregate:	Category 6- Minimum 420mm depth for storage.
Geotextiles:	Please contact us for further info
Impermeable Liner:	1800 gauge permeable geotextile
Drawing Number:	SK21-5566-02

1.2 Tobermore Hydropave Product to be used on Scheme

Product Name:	Tobermore Hydropave
Size:	200x100x80mm deep
Color:	TBC
Finish:	Standard
Strength:	> 3.6MPa or 250 N/m
Manufactured to:	BS EN 1338:2003
Installed to:	BS EN 7533-3:2005
Laying pattern:	Herringbone

3.1 Site Levels

If there is a fall in the subbase formation level, there will be a considerable loss in effective storage within the CGA when compared to a flat site. We would therefore recommend that the subbase formation level is kept virtually flat, with only a slight fall (1:250). If the formation level cannot be provided infiltration trenches must be used. The sizes and dimensions of infiltration trenches are to be confirmed at detailed design stage.

The paved Hydropave surface should have no slopes steeper than 1:20 to ensure that water can infiltrate through the joints.

It is assumed that any fall greater than 1:20 will run off into an area with a max 1:20 fall and infiltrate into the permeable subbase.

Site levels should be confirmed prior to construction.

3.0 Hydraulic Design

The thickness of a permeable pavement's crushed rock base has to be calculated on the basis of the need to store water and also on structural requirements. In this section, the thickness calculation based on the storage of water is set out.

The thickness of the sub-base necessary for water storage depends upon the factor r, which is the ratio of the 60-minute storm rainfall depth to the 2-day maximum rainfall depth. This factor varies across the UK and implies a 5-year storm return period. For greater return periods a correction factor, Z2, given in Table 4 should be applied to the five-year return period rainfall value and the sub-base calculated in accordance with Table 2.

3.1 Table 01: Hydraulic Design Parameters

Town/ City	M560 (mm)	r Value	SAAR (mm)	WRA P	Soil Index	Return Period		Climate Change	
Bodicote	20.10	0.42	650.00	4.00	0.45	100	years	Factor	1.30

The method undertaken to vary the storm return period for any duration is as follows:

It is assumed that the depth of rainfall occurring during a 60-minute storm recurring every 5 years is 20.10mm in the area. The depth of rainfall occurring every five years over storm durations other than 60-minutes is obtained as follows:

The design rainfall depth for any given return period and storm duration can be found by multiplying 20.10mm by a factor Z1, which requires knowledge of 'r', the ratio of 60-minute to 2-day rainfalls for a 5-years return period.

The $M_5$60 storm for Bodicote may be taken as 20.10mm, with an 'r' value of 0.42. The relevant Z1 factors may be taken and multiplied by the rainfall to give a quantity for each storm duration, shown in Table 2.

3.2 Table 02: Z1 Factored Storm Durations

	Storm Duration									
	Minutes					Hours				
	5	**10**	**15**	**30**	**60**	**2**	**4**	**6**	**10**	**24**
Z1	0.38	0.53	0.64	0.81	1.00	1.20	1.42	1.57	1.74	2.16
M5 – D rainfall	7.64	10.65	12.86	16.28	20.10	24.12	28.54	31.56	34.97	43.42

Z2 factors are then applied to vary storm return period. This preliminary design considers a 1 in 100-year storm, plus 40% to account for climate change. The rainfall multiplied by the Z2 factor is return dependent.

3.3 Table 03: Rainfalls for 1 in 100 Year Storm

Return Period:	Storm Duration									
100	Minutes					Hours				
	5	**10**	**15**	**30**	**60**	**2**	**4**	**6**	**10**	**24**
Rainfall (mm)	13.67	20.46	25.16	32.57	40.79	48.57	56.56	61.77	67.51	80.87
x CC Factor	17.77	26.60	32.71	42.34	53.03	63.14	73.53	80.31	87.76	105.13

3.4 Site Analysis Parameters

Category 6 (<70 standard axles per day)

- Total area of Tobermore Hydropave approximately **1990m^2** (to include permeable paving areas)
- Total Catchment Area approximately **2390m^2** (this includes the Hydropave areas + 20% of the additional Hardstanding area).
- It was assumed that a minimum depth of 420mm of coarse graded aggregate for storage will be included below the Category 6.

For preliminary design purposes we have made the following assumptions:

1. The proposed formation level CBR will be at least 3%. This should be confirmed via in-situ testing prior to construction. If lower values are recorded this design will need to be reviewed.
2. A minimum infiltration rate of 0.05m/hr has been assumed. Please advise if a lower infiltration rate is required, as the design will have to be revised. If the infiltration rate is lower than we have assumed, then the depth of course graded aggregate will have to increase.

Please check these areas and which, if any, of the other surrounding areas are to be included. Please also check that the assumed minimum infiltration rate is appropriate and CBR can be achieved.

3.5 Critical Storm Duration Calculation

The following table indicates the Factors of Safety for the proposed Hydropave system for storm durations up to 24 hours. The void ratio of the coarse graded aggregate was assumed to be is 0.32, with the minimum depth of the CGA for water storage to be 420mm under the Hydropave blocks. See the proposed sections on drawing SK21-5566-02 for Category 6.

Category 6 (<70 standard axles per day)

Storm Duration	Depth of rainfall (mm) 100 year storm	Volume entering Hydropave (m^3)	Outflow to Storm Sewer (m^3)	Infiltration to Subgrade (m^3)	Storage Required (m^3)	Storage Capacity (m^3)	Factor of Safety
5 minutes	17.77	42.46	0.00	0.83	41.63	267.59	6.43
10 minutes	26.60	63.54	0.00	1.66	61.88	267.59	4.32
15 minutes	32.71	78.14	0.00	2.49	75.65	267.59	3.54
30 minutes	42.34	101.14	0.00	4.98	96.16	267.59	2.78
1 hour	53.03	126.70	0.00	9.96	116.74	267.59	2.29
2 hours	63.14	150.83	0.00	19.91	130.92	267.59	2.04
4 hours	73.53	175.66	0.00	39.82	135.84	267.59	1.97
6 hours	80.31	191.85	0.00	59.73	132.12	267.59	2.03
10 hours	87.76	209.66	0.00	99.55	110.11	267.59	2.43
24 hours	105.13	251.16	0.00	238.92	12.24	267.59	21.87

The critical storm duration therefore 4 hours.

4.0 Structural Design & Summary

It is proposed to install Tobermore Hydropave as the surfacing to approximately **1990m²** of the development to create a permeable paving system on site. This includes the permeable paving areas at the proposed Oxford Rd, Bodicote as shown on PHG Consulting Engineers dwg no.100 – Engineering Layout.

We have assumed it is proposed to store water in the coarse graded aggregate (CGA) subbase and allow infiltration into the subgrade below. For the permeable paving areas it is assumed they will need to accommodate loading as per Loading Category 6 (<70 standard axles per day). Please advise if a more onerous loading is to be considered.

A permeable membrane should be provided at sub-base formation level. A plan showing the assumed hydropave areas are indicated on Geoman's drawing no SK21-5566-01. Indicative proposed sections of the Hydropave infiltration system are shown on Geoman Ltd. drawing SK21-5566-02 for Category 6.

For preliminary design purposes we have made the following assumptions:

1. The proposed formation level CBR will be at least 3%. This should be confirmed via in-situ testing prior to construction. If lower values are recorded this design will need to be reviewed.
2. A minimum infiltration rate of 0.05m/hr has been assumed. Please advise if a lower infiltration rate is required, as the design will have to be revised. If the infiltration rate is lower than we have assumed, then the depth of course graded aggregate will have to increase.

Please inform Geoman if this is incorrect as we will need to revise the preliminary design.

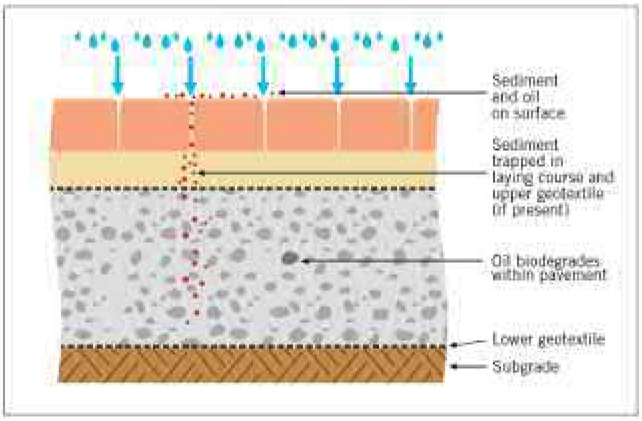
We normally highlight that all our proposals for permeable paving are marked 'Feasibility only – not for construction'. Clients should review the proposals and issue comments where appropriate. Proposals are based on information received from a salesperson or site team and may not have been checked by the parties to the construction contract. Geoman Ltd has not checked these proposals.

Instructions to proceed and issue drawings 'for construction' can only come from the Client, Scheme Architect or Scheme Engineer. This can only happen once they have checked the proposal and the assumptions and only if all their requirements have been taken into account will they instruct the contractor to proceed.

4.1 Petrol Interceptor requirements

Permeable pavements are effective at removing pollution from runoff and as a consequence oil separators are not required. The following is an extract from the Interpave Guidelines which demonstrates this:

"Concrete block pavements are very effective at removing pollution from runoff, unlike attenuation tanks. The pollutants may either remain on the surface (particularly with zero gradients) or may be flushed into the underlying pavement layers where many of the pollutants are filtered and trapped or degrade over time.



Hydrocarbons may degrade but other contaminants, such as heavy metals, do not break down and remain within the pavement structure for a long period of time, making permeable pavements ideal for areas where vehicles are stored or maintained. Further information on pollution removal is provided in CIRIA Reports C 697, C 609 and C 582 (CIRIA 2007, 2004 and 2001). The research that has been undertaken demonstrates the effectiveness of permeable pavements in reducing pollution. They can for example remove between 60% and 95% of total suspended solids (i.e. silt) and 70% to 90% of hydrocarbons. When subjected to low level oil drips, such as in car parks, the pavements can continue to biodegrade the hydrocarbons indefinitely.

'Pollution Prevention Guideline' PPG 3 (Environment Agency, 2006) identifies the beneficial performance of permeable pavements in removing pollution from runoff. It states that: *"Techniques thatcontrol pollution close to the source, such as permeable surfacesor infiltration trenches, can offer a suitable means of treatmentfor runoff from low risk areas such as roofs, car parks, and nonoperationalareas."*

Oil separators are not required when permeable pavements are used. Indeed permeable pavements are more effective at removing a wider range of pollutants from runoff than oil separators (CIRIA,
2004). If additional treatment is required for higher risk areas it is normally more effective to use green SUDS methods such as swales or wetlands, as these also treat a wider range of pollutants."

4.2 Construction Considerations

Sub-base material (coarse graded aggregate) should be placed in layers not exceeding 150mm in thickness or twice the nominal maximum aggregate size. Unlike traditional pavement construction, the open-graded materials should not be fully compacted to eliminate any voids, as this will compromise the performance of the system.

It is likely that excessive compaction will result in the displacement of the open graded aggregate by the compaction equipment. The open-graded material should be compacted such that its maximum density is achieved for the particular aggregate type and grading without compromising the final void percentage offered by the material.

Each layer should be suitably compacted before the next layer is placed to prevent any potential settlement of the pavement after completion.

Due to the nature of both the sub-layers and the block paving, care should be taken during the construction process to prevent dirt or detritus contaminating the sub-base and compromising the permeability of the system. For example, the trafficking of the sub-base as a site access route should not be undertaken. Should other construction or maintenance work take place close to the pavement which may affect the infiltration of the pavement, suitable protective measures should be implemented.

Edge restraints should be sufficiently robust to resist the lateral displacement from imposed loadings placed upon the pavement. The edge restraint may take the form of associated fittings, walls or buildings or be formed from precast concrete, clay or natural stone kerb systems, either existing or newly constructed features. The restraint must provide a consistent vertical face to a level below the laying course material.

Appendix A – Aggregates

Please Refer to BS7533-13 2009 Guide for the design of permeable pavements constructed with concrete paving blocks and flags, natural stone slabs and setts and clay pavers.

Laying Course and jointing material

- Laying course requires 6.3-2mm sized grit to BSEN 13242:2002. In particular, the material should be categorised as LA20 according to Table 9, SZ18 according to Table 10 and MDE15 according to Table 11 within this standard. The grit should be insoluble in dilute hydrochloric acid and should be naturally occurring material. In our experience, incorrect use of aggregates is one of the most common reasons for failure of a permeable paving design.

Course Graded Aggregate (CGA)

- Requires 32% of voids spacing for the storage of water. CGA should comply with the requirements of BSEN 13242:2002. The material should be designated Type 4/20 (4mm minimum and 20mm maximum particle size). In our experience, incorrect use of aggregates is one of the most common reasons for failure of a permeable paving design.

Capping

- Capping material is included in order to achieve a firm-working platform so that the overlying layers can be correctly installed. The permeable paving designs are normally designed for 5% CBR, If not then the appropriate increase in capping material should be used. All capping materials should meet the requirements of either 6F1 or 6F2 of Table 6.1 of Highways Agency's '*Specification for Highway Works-Series 600-Earthworks*'

Please note: If you obtain the appropriate technical information for the aggregates which you plan to use on a permeable paving scheme please send them to us so we can give feedback on if they meet BS 7533-13:2009 and BSEN 13242:2002 requirements. Depending on the project size we would strongly advise customers that aggregates used in the construction of a permeable paving system should be tested to ensure conformity during the construction of the project.

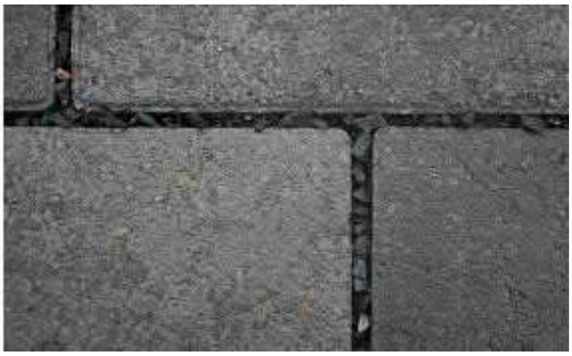
Appendix B – Installation

Paving should be installed to BS7533-3:2005.

i. A permeable paving design relies heavily on using the correct aggregates. Prior to installation, we would ask you to test both the 4/20mm coarse graded aggregate and also the 6.3-2mm bedding and jointing grit as per the relevant British Standard specification (BS EN 13242:2002). In particular, the material should be categorized as LA20 according to Table 9, SZ18 according to Table 10 and MDE15 according to Table 11 within this standard. The grit should be insoluble in dilute hydrochloric acid and should be naturally occurring material. In our experience, incorrect use of aggregates is one of the most common reasons for failure of a permeable paving design.

ii. All joints must be filled to the top with 6.3-2mm grit. Joints which are not fully filled can lead to possible movement of the blocks after use. We recommend that after a few weeks use that any joints, which have settled and are not full, are topped up with grit. Joints should be kept filled at all times. You need approximately 1 ton of grit for every 100m2 of 80mm paving.

iii. Care should be taken that the permeable joints do not become contaminated as work on the scheme is completed. Special care needs to be taken when soft landscaping is carried out so that soil does not enter the joints.

All joints must be filled to the top with 6.3-2mm grit.

Appendix C – Geoman Services

Geoman Ltd offers design services in relation to permeable paving products in general accordance with the Interpave design guide:

Where certain information is not provided assumptions will be made in order to produce an answer. The project team should check any assumptions in a site investigation or using tests at the construction stage.

Often the project team will update and make changes to our proposal based on their detailed knowledge of the scheme and its requirements.

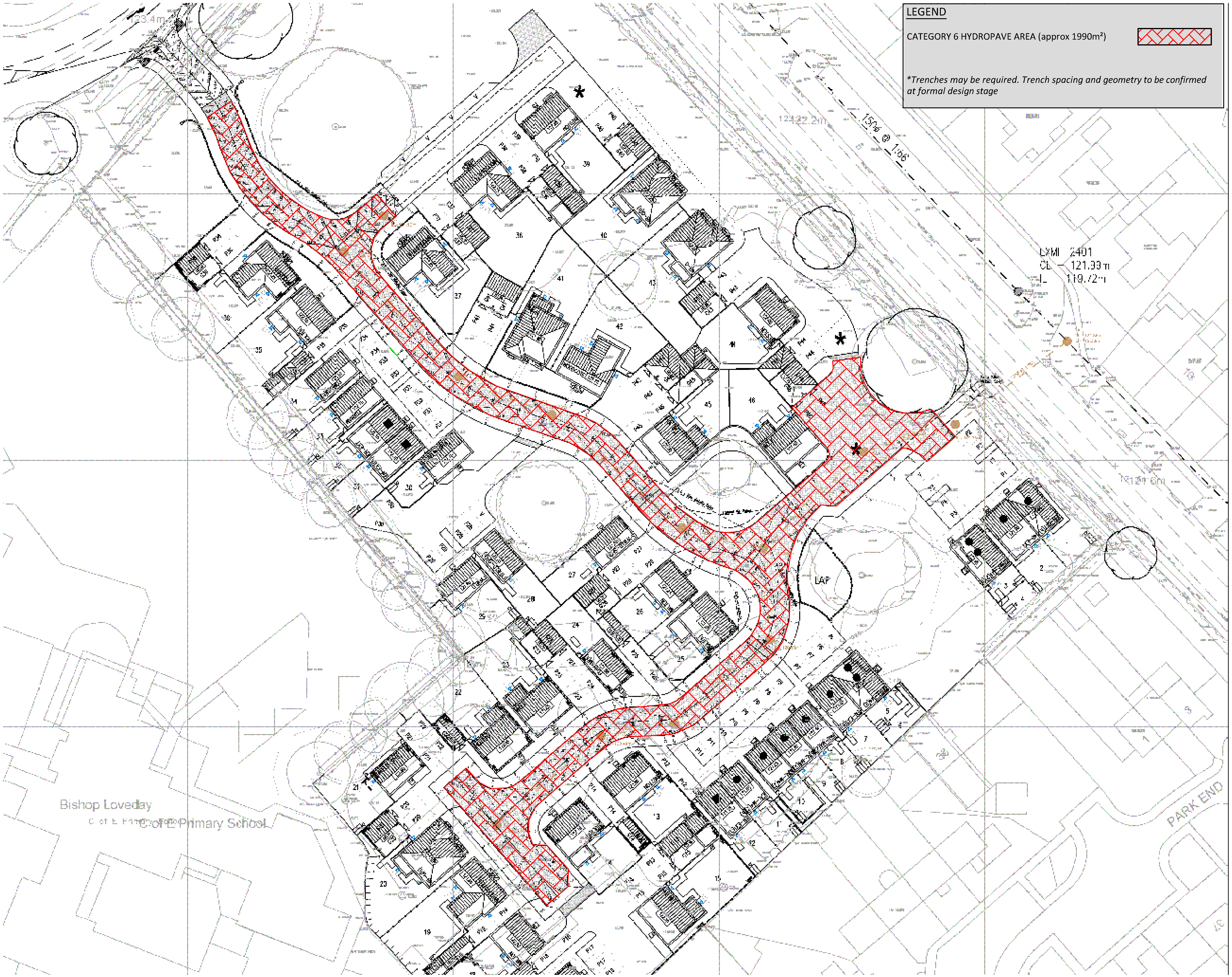
Our deliverable documents include a design signed off by a chartered engineer recording all the information provided. The project team should check that all the information used is current. The Project Consulting Engineer still has a duty to check the design provided.

This service excludes supervision of the works. Responsibility for supervision of the works remains with the Resident Engineer, usually a representative of the Project Consulting Engineer. If this supervisory service is required, Geoman should be given a brief and asked to formally quote for it by the project team. Invoices will be made direct to the project team or client for this supervisory service.

Occasionally some projects have the specialized aspects of the works billed as contractor design or a form of warranty may be required. Geoman Ltd can offer an indemnified design as above and in addition will make visits as we see fit in order to check that the works are being undertaken correctly. Often this service will consist of one or two visits, occasionally we are requested to supervise full time. Good liaison is required with the Principal Contractor and if defects are not correct we reserve the right to report any concerns direct to the project team.

The Principal Contractor still has a duty to install the system correctly and make any changes advised.

Any site supervisory staff still has a duty to record and notify Geoman of any activities that give rise to concern in our absence. If this supervisory service is required, Geoman should be given a brief and asked to formally quote for it by the project team. Invoices will be made direct to the project team, Principal Contractor or client for this supervisory service.



NOTES

1. A permeable paving design relies heavily on using the correct aggregates. Prior to installation, we would ask you to test both the 4/20 mm coarse graded aggregate and also the 6.3-2 mm bedding and jointing grit as per the relevant British Standard specification (BS 7533-13:2009). in particular, the material should be categorised as LA30, FI20 and MDE20 according to Table A.3, within this standard. The grit should be insoluble in dilute hydrochloric acid and should be naturally occurring material. In our experience, incorrect use of aggregates is one of the most common reasons for failure of a permeable paving design.

2. All joints must be filled to the top with 6.3-2 mm grit. Joints which are not fully filled can lead to possible movement of the blocks after use. We recommend that after a few weeks use that any joints, which have settled and are not full, are topped up with grit. Joints should be kept filled at all times. You need approximately 1 ton of grit for every 100 m^2 of 80mm paving.

3. Care should be taken that the permeable joints do not become contaminated as work on the scheme is completed. Special care needs to be taken when soft landscaping is carried out so that soil does not enter the joints.

4. All dimensions in mm's unless otherwise specified.

5. All paving should be installed in accordance with BS 7533-3:2005 by a competent experienced paving contractor.

6. All aggregates should be installed in accordance with the material specifications table.

7. Base of sub-base/soakaways to be constructed on competent horizon with a CBR value in excess of 3%.

8. A minimum infiltration rate of 0.05m/hr was assumed for the purposes of this design. Please advise is a lower infiltration rate is required, as the design will have to be revised .

9. The maximum storm return period assumed in the preliminary analysis was 1 in 100 years, plus an additional 40% rainfall for climate change.

This drawing must be used in conjunction with Geoman Ltd. design document 21-5566.

10. This design is to be used with Tobermore products only and is not valid for any other manufacture.

INSTALLATION METHODOLOGY

GENERAL
Works to be carried out in accordance with BS 7533-13:2009 guide for the design of permeable pavements .

SUB-GRADE
Sub-grade preparation is to be carried out in accordance with Specification for Highway Works Clause 616 - preparation and surface treatment of format ion. remove all soft spo ts and fill with suitable replacement mater ial before compaction. Sub-grade design CBR taken as greater than or equal to 3% and is the responsibility of the Project Designer for the overall project.

KERBS/EDGINGS
Kerb haunching must extend a minimum of 150mm below the base of the kerb to provide a firmly restrained pavement.

CAPPING
Capping is to be provided in accordance with the BS requirements. Structural capping requirements and site traffic loading are the respons ibility of the Principal Designer.

PERMEABLE GEOTEXTILE
The permeable separation geotextile should be laid on the subgrade/capping with a minimum 3% CBR. Refer to manufacturer's specification on installation , but min. 300mm overlapping joints to be provided. The geotextile should be brought up to the top of kerbing/edgeing and cut flush with paving surface.

SUB-BASE
The 4/20 coarse graded aggregate sub-base should be placed in maximum 150mm layers and compacted to clause 802 requirements. The final compaction pass should be undertaken without vibration. Compaction should not crush the individual particles or reduce the void ratio below 32% minimum design value.

LAYING COURSE
Lay and screed to level approx. 50mm deep of 2-6.3mm grit in accordance with BS 7533-13:2009. A small trial area should be laid prior to construction to determine accuracy of final levels.

BLOCK LAYING
Herringbone pattern with 2 no. rows of stretcher course around perimeter. Paving to be plate vibrated prior to infilling of jointing material. Brush in jointing material between joints and carry out final plate vibration.

FOR COMMENT

Rev. 0		CC	12.05.21
Issue / Revision:		Drawn:	Date:

Designer:

GEOMAN
44 Elmwood Avenue, Belfast, BT9 6AZ 02890 664941 geoman@geoman.co.uk

Project Title:

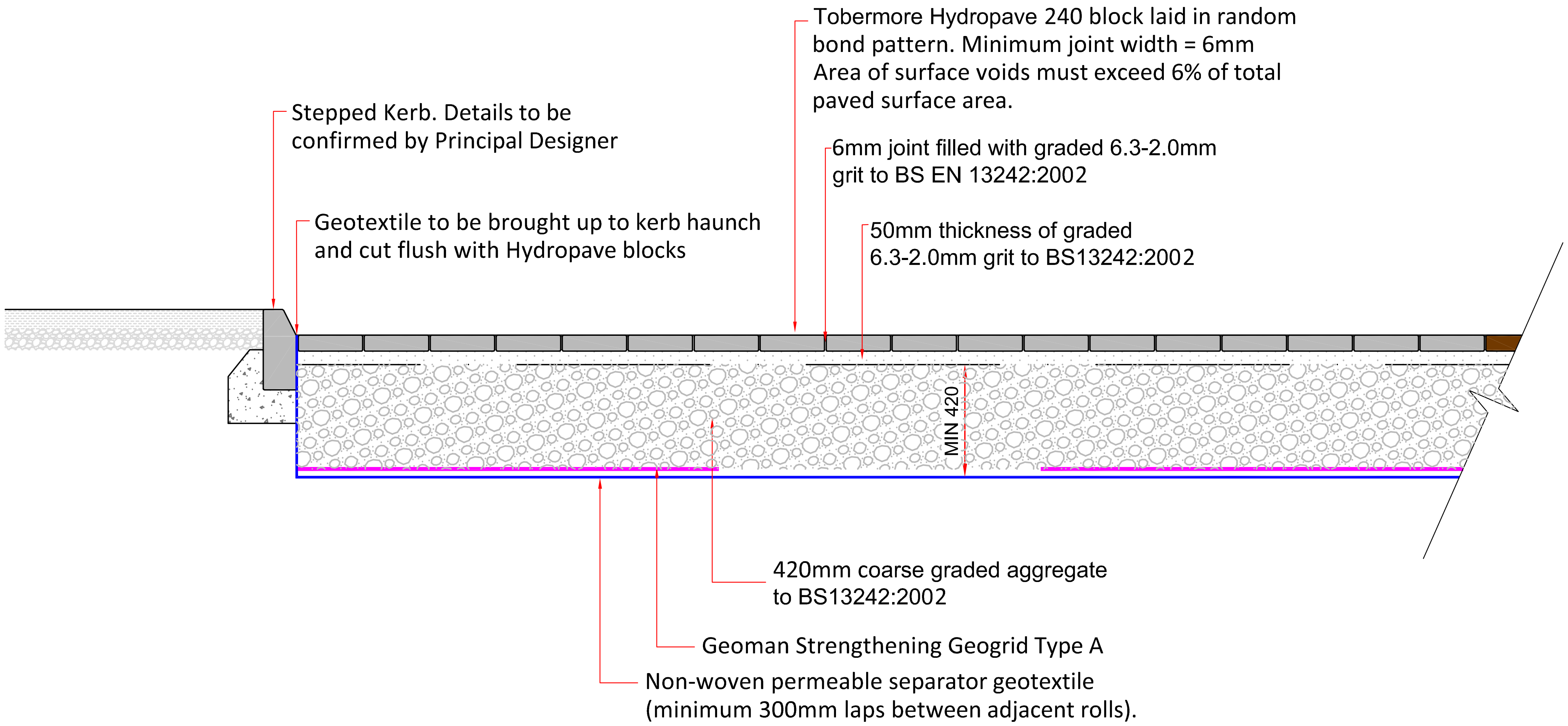
Oxford Rd, Bodicote

Tobermore

Drawing Title:

Infiltration System
Part 1/2

Designed:		Date:	Project No: 21-5566
Drawn:	CC	Date: 12.05.21	Scale: 1:700
Approved:		Date:	
Drawing No:	SK21-5566-01		Revision: 0



TYPICAL SECTION THROUGH TOBERMORE HYDROPAVE INFILTRATION SYSTEM
Category 6 **only** (1:20)

Please note for a Formal Hydropave design the Design Warranty must be completed and returned to Geoman prior to construction

NOTES

1. A permeable paving design relies heavily on using the correct aggregates. Prior to installation, we would ask you to test both the 4/20 mm coarse graded aggregate and also the 6.3-2 mm bedding and jointing grit as per the relevant British Standard specification (BS 7533-13:2009). in particular, the material should be categorised as LA30, FI20 and MDE20 according to Table A.3, within this standard. The grit should be insoluble in dilute hydrochloric acid and should be naturally occurring material. In our experience, incorrect use of aggregates is one of the most common reasons for failure of a permeable paving design.

2. All joints must be filled to the top with 6.3-2 mm grit. Joints which are not fully filled can lead to possible movement of the blocks after use. We recommend that after a few weeks use that any joints, which have settled and are not full, are topped up with grit. Joints should be kept filled at all times. You need approximately 1 ton of grit for every 100 m^2 of 80mm paving.

3. Care should be taken that the permeable joints do not become contaminated as work on the scheme is completed. Special care needs to be taken when soft landscaping is carried out so that soil does not enter the joints.

4. All dimensions in mm's unless otherwise specified.

5. All paving should be installed in accordance with BS 7533-3:2005 by a competent experienced paving contractor.

6. All aggregates should be installed in accordance with the material specifications table.

7. Base of sub-base/soakaways to be constructed on competent horizon with a CBR value in excess of 3%.

8. A minimum infiltration rate of 0.05m/hr was assumed for the purposes of this design. Please advise is a lower infiltration rate is required, as the design will have to be revised .

9. The maximum storm return period assumed in the preliminary analysis was 1 in 100 years, plus an additional 40% rainfall for climate change.

This drawing must be used in conjunction with Geoman Ltd. design document 21-5566.

10. This design is to be used with Tobermore products only and is not valid for any other manufacture.

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Works to be carried out in accordance with BS 7533-13:2009 guide for the design of permeable pavements .

SUB-GRADE
Sub-grade preparation is to be carried out in accordance with Specification for Highway Works Clause 616 - preparation and surface treatment of format ion. remove all soft spo ts and fill with suitable replacement mater ial before compaction. Sub-grade design CBR taken as greater than or equal to 3% and is the responsibility of the Project Designer for the overall project.

KERBS/EDGINGS
Kerb haunching must extend a minimum of 150mm below the base of the kerb to provide a firmly restrained pavement.

CAPPING
Capping is to be provided in accordance with the BS requirements. Structural capping requirements and site traffic loading are the respons ibility of the Principal Designer.

PERMEABLE GEOTEXTILE
The permeable separation geotextile should be laid on the subgrade/capping with a minimum 3% CBR. Refer to manufacturer's specification on installation , but min. 300mm overlapping joints to be provided. The geotextile should be brought up to the top of kerbing/edgeing and cut flush with paving surface.

SUB-BASE
The 4/20 coarse graded aggregate sub-base should be placed in maximum 150mm layers and compacted to clause 802 requirements. The final compaction pass should be undertaken without vibration. Compaction should not crush the individual particles or reduce the void ratio below 32% minimum design value.

LAYING COURSE
Lay and screed to level approx. 50mm deep of 2-6.3mm grit in accordance with BS 7533-13:2009. A small trial area should be laid prior to construction to determine accuracy of final levels.

BLOCK LAYING
Herringbone pattern with 2 no. rows of stretcher course around perimeter. Paving to be plate vibrated prior to infilling of jointing material. Brush in jointing material between joints and carry out final plate vibration.

FOR COMMENT

Issue / Revision:	Drawn:	Date:
Rev. 0	CC	12.05.21

Designer:

GEOMAN
44 Elmwood Avenue, Belfast, BT9 6AZ 02890 664941 geoman@geoman.co.uk

Project Title:

Oxford Rd, Bodicote

Tobermore

Drawing Title:

Infiltration System
Part 2/2

Designed:		Date:	Project No: 21-5566
Drawn:	CC	Date: 12.05.21	Scale: As Shown at A3
Approved:		Date:	
Drawing No:	SK21-5566-02		Revision: 0

GEOMAN

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DESIGN WARRANTY

This agreement is made the (DATE) between (Element Designer) Geoman Ltd whose address is 44 Elmwood Avenue, Belfast BT9 6AZ and (Client)… whose address is on behalf of (Principal Designer)….. whose address is …..

Copyright in Our Design

This design has been produced for the site stated in the design document only. All advise is specific to this development. The completed design, including all calculations, drawings, specifications and any advice produced on behalf of Geoman is subject to the law of copyright. Geoman will retain exclusive retain copyright and other intellectual property rights. This design and advise is not to be used for any other project with prior written consent from Geoman. For these purposes "Design" means the design attached to these conditions. This includes any design included in the specification and/ or any other design or technical advice provided by Geoman in connection with the Project, including any revisions, amendments and updates made by Geoman to these design and/or design advice. "Development" means the client's specified project location (where "client" include any contractor, architect, specifier or agent who is identified as the client) in connection with which the design is supplied.

Now it is hereby agreed in consideration of the payment of …… excluding VAT by ….. to Geoman Ltd, receipt of which Geoman Ltd hereby acknowledges:

1. Geoman Ltd (The Element Designer) warrants that it has exercised reasonable care and diligence in the performance of its services to ……. (The Client) under the appointment.
2. In the event of any breach of this agreement:
   a. Subject to sub-clauses (b) and (c), The element designer shall be liable for the reasonable costs of repair, renewal and/or reinstatement of any part or parts of the development to the extent that the purchaser reasonably incurs such costs and the purchaser becomes liable or by way of financial contribution for such costs. The element designer shall not be liable for other losses incurred by the purchaser.
   b. Without prejudice to any other exclusion or limitation of liability, damages, loss, expense or costs the element designer's liability for such costs of the repair, renewal or reinstatement in question shall be further limited to that proportion thereof as it would be just and equitable to require the element designer to pay having regard to the extent of the element designer's responsibility for the same and on the assumptions that:
      i. all other element designers, consultants and advisors, contractors and subcontractors involved in the development have provided contractual undertakings on terms no less onerous than those set out in clause 1 to the purchaser in respect of the carrying out of their obligations in connection with the development and;
      ii. that there are no exclusions of or limitations of liability nor joint insurance or co-insurance provisions between the purchaser and any other party referred to in this clause 2 and any such party who is responsible to any extent for such costs is contractually liable to the purchaser for the same and
      iii. all the parties referred to in this clause 2 have paid to the purchaser such proportion of such costs that it would be just and equitable for them to pay having regard to their responsibilities for the same.
   c. The element designer shall be entitled in any actions or proceedings by the purchaser to rely in any limitation or exclusion in the appointment and to raise the equivalent rights in defence of liability as it would have against the client under appointment.
   d. The obligations of the element designer under or pursuant to this agreement shall not be released or diminished by the appointment of any person by the purchaser to carry out any independent enquiry into any relevant matter.
3. The element designer has exercised reasonable skill and care to see that, unless authorised by the client in writing, or where such authorisation is given orally, confirmed by the element Designer to the client in writing, materials specified by it for use in the development are in accordance with the guidelines contained in the edition of the publication 'Good Practice in Selection of Construction Materials' (Ove Arup & Partners) current at the date of its specification.
4. The purchaser shall have no authority to issue any direct or instruction to the element designer in relation to the appointment.
5. The element designer shall not be liable for any use by the purchaser, the client, the principal designer or its appointee of any of the documents for any purpose other than that for which the same were prepared by or on behalf of the element designer.
6. This design and advise provided to the principal engineer by the element designer is specific to the development stated in this design document. The client acknowledge that to complete this design, the element designer have relied upon the information, supplied by the client and any professional advisors working on this development. Geoman (the element designer) can take no responsibility for any failure or defect arising for incomplete, inaccurate or misleading information we have received for you or arising from any other third party engaged in this development. This design and advise have been provided on the basis that the element designer approved products will be used in construction. If any other products other than the element designers approved products are used for construction, the element designer can no accept responsibility for the preformance of those products. This design and/or advise will not be valid for the use of any other products other than the element designer's approved products.
7. The element designer shall maintain professional indemnity insurance in an amount each year of not less than (…) pounds in the aggregate for the period of insurance in respect of each and every occurrence or series of occurrences arising out of one event for a period of five years from the date of practical completion of the design under this agreement and provided that such insurance is available at commercially reasonable rates. The element designer shall inform the purchaser if such insurance ceases to be available at reasonable commercial rates in order that the element designer and purchaser can discuss the best means of protecting their respective positions. The element designer shall on reasonable request provide evidence that such insurance is being maintained.
8. The purchaser may assign by way of absolute legal assignment only the benefit of this agreement to a third party who also takes an assignment of the purchaser's interest in the premises (The 'first assignee'). The First Assignee may assign by way of absolute legal assignment only the benefit of this agreement to a third party who also takes an assignment of the First Assignee's interest in the premises. Any such assignment shall only be effective if written notice thereof is given to the element designer. No further or other assignment of this agreement shall be permitted.
9. Any notice to be given by the element designer shall be deemed to be duly given if it is delivered by hand or sent by recorded (signed for) or special delivery to the purchaser at the above mentioned address; and any notice given by the purchaser shall be deemed to be duly given if it is delivered by hand or sent by recorded (signed for) or special delivery to the element designer at the above address. Any such notices shall be deemed to have been received 48 hours after being posted (subject to proof to the contrary).
10. No action or proceedings for any breach of this agreement shall be commenced against the element designer after the expiry of five years from the date of practical completion of the relevant part of the premises or, in the event that practical completion is not achieved, the date that the element Designer finished its services under the appointment.
11. Nothing in this agreement confers or purports to confer on any third party any benefit or any right to enforce any term of this agreement pursuant to the Contracts (rights of third parties) Act 1999.
12. This agreement is subject to the law of England and Wales and the parties hereto subject to the jurisdiction of the courts of England and Wales.

As witness the hands of the parties hereto:

Signed by or on behalf of the Element Designer

For and on behalf of Geoman Ltd

Signed by or on behalf of the Client

For and on behalf of … Ltd

APPENDIX E – SURFACE WATER CALCULATIONS, TYPICAL PRIVATE DOMESTIC CELL, 100 YEAR + 40% CLIMATE CHANGE

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 589 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	122.637	0.387	0.2	5.5	O K
30 min Summer	122.751	0.501	0.2	7.1	O K
60 min Summer	122.865	0.615	0.2	8.8	O K
120 min Summer	122.948	0.698	0.2	9.9	O K
180 min Summer	122.990	0.740	0.2	10.5	O K
240 min Summer	123.012	0.762	0.2	10.9	O K
360 min Summer	123.023	0.773	0.2	11.0	O K
480 min Summer	123.013	0.763	0.2	10.9	O K
600 min Summer	122.999	0.749	0.2	10.7	O K
720 min Summer	122.983	0.733	0.2	10.4	O K
960 min Summer	122.947	0.697	0.2	9.9	O K
1440 min Summer	122.876	0.626	0.2	8.9	O K
2160 min Summer	122.787	0.537	0.2	7.7	O K
2880 min Summer	122.716	0.466	0.2	6.6	O K
4320 min Summer	122.608	0.358	0.1	5.1	O K
5760 min Summer	122.530	0.280	0.1	4.0	O K
7200 min Summer	122.476	0.226	0.1	3.2	O K
8640 min Summer	122.435	0.185	0.1	2.6	O K
10080 min Summer	122.403	0.153	0.1	2.2	O K
15 min Winter	122.684	0.434	0.2	6.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	150.129	0.0	19
30 min Summer	98.442	0.0	34
60 min Summer	61.699	0.0	64
120 min Summer	36.503	0.0	122
180 min Summer	26.840	0.0	182
240 min Summer	21.541	0.0	242
360 min Summer	15.719	0.0	360
480 min Summer	12.501	0.0	430
600 min Summer	10.429	0.0	488
720 min Summer	8.972	0.0	552
960 min Summer	7.044	0.0	682
1440 min Summer	4.968	0.0	954
2160 min Summer	3.485	0.0	1364
2880 min Summer	2.716	0.0	1760
4320 min Summer	1.932	0.0	2548
5760 min Summer	1.534	0.0	3288
7200 min Summer	1.304	0.0	4032
8640 min Summer	1.152	0.0	4752
10080 min Summer	1.042	0.0	5448
15 min Winter	150.129	0.0	19

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	122.813	0.563	0.2	8.0	O K
60 min Winter	122.942	0.692	0.2	9.9	O K
120 min Winter	123.039	0.789	0.2	11.2	O K
180 min Winter	123.090	0.840	0.2	12.0	O K
240 min Winter	123.118	0.868	0.2	12.4	O K
360 min Winter	123.139	0.889	0.2	12.7	O K
480 min Winter	123.133	0.883	0.2	12.6	O K
600 min Winter	123.114	0.864	0.2	12.3	O K
720 min Winter	123.094	0.844	0.2	12.0	O K
960 min Winter	123.051	0.801	0.2	11.4	O K
1440 min Winter	122.958	0.708	0.2	10.1	O K
2160 min Winter	122.835	0.585	0.2	8.3	O K
2880 min Winter	122.735	0.485	0.2	6.9	O K
4320 min Winter	122.586	0.336	0.1	4.8	O K
5760 min Winter	122.480	0.230	0.1	3.3	O K
7200 min Winter	122.408	0.158	0.1	2.2	O K
8640 min Winter	122.355	0.105	0.1	1.5	O K
10080 min Winter	122.319	0.069	0.1	1.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	98.442	0.0	33
60 min Winter	61.699	0.0	62
120 min Winter	36.503	0.0	120
180 min Winter	26.840	0.0	178
240 min Winter	21.541	0.0	236
360 min Winter	15.719	0.0	348
480 min Winter	12.501	0.0	456
600 min Winter	10.429	0.0	554
720 min Winter	8.972	0.0	576
960 min Winter	7.044	0.0	724
1440 min Winter	4.968	0.0	1036
2160 min Winter	3.485	0.0	1472
2880 min Winter	2.716	0.0	1900
4320 min Winter	1.932	0.0	2680
5760 min Winter	1.534	0.0	3456
7200 min Winter	1.304	0.0	4176
8640 min Winter	1.152	0.0	4840
10080 min Winter	1.042	0.0	5448

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 446181 238355 SP 46181 38355
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.020

Time (mins) From:	To:	Area (ha)
0	4	0.020

Model Details

Storage is Online Cover Level (m) 123.350

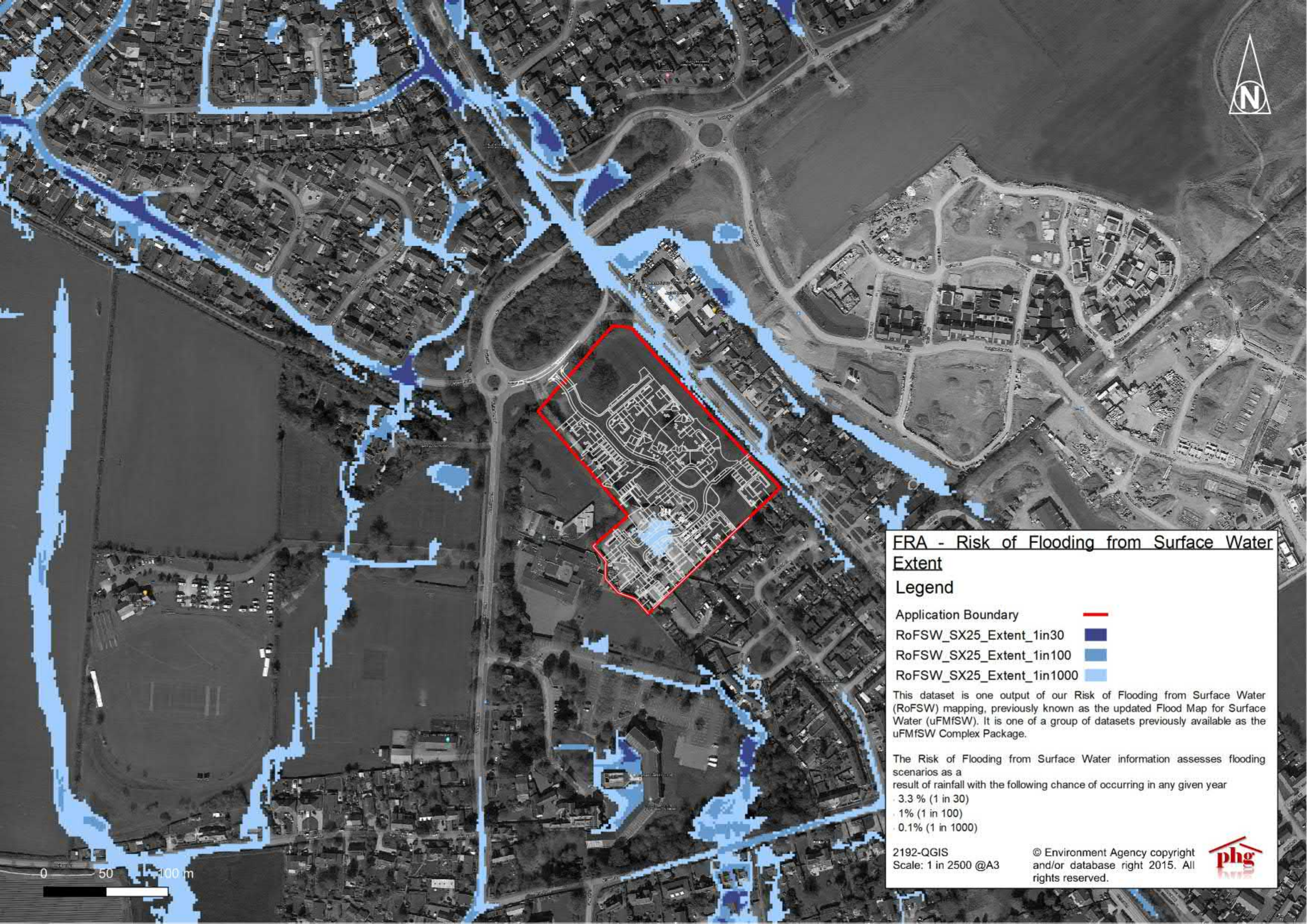
Cellular Storage Structure

Invert Level (m) 122.250 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.05148 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.05148

Depth (m)	**Area (m^2)**	**Inf. Area (m^2)**	**Depth (m)**	**Area (m^2)**	**Inf. Area (m^2)**
0.000	15.0	15.0	1.100	0.0	31.0
1.000	15.0	31.0			

APPENDIX F – EA FLOOD MAP


N
FRA - Flood Map for Planning (Rivers and Sea)
Legend
Application Boundary
Flood_Map_for_Planning_Rivers_and_Sea_Flood_Zone_2
Flood_Map_for_Planning_Rivers_and_Sea_Flood_Zone_3
Flood Zone 3 - the best estimate of the areas of land at risk of flooding, when the presence of flood defences are ignored and covers land with a 1 in 100 (1%) or greater chance of flooding each year from Rivers; or with a 1 in 200 (0.5%) or greater chance of flooding each year from the Sea.
Flood Zone 2 - the best estimate of the areas of land at risk of flooding, when the presence of flood defences are ignored and covers land between Zone 3 and the extent of the flooding from rivers or the sea with a 1 in 1000 (0.1%) chance of flooding each year. This dataset also includes those areas defined in Flood Zone 3.
This dataset is designed to support flood risk assessments in line with Planning Practice Guidance; and raise awareness of the likelihood of flooding to encourage people living and working in areas prone to flooding to find out more and take appropriate action.
2192-QGIS
Scale: 1 in 10000 @A3
Environment Agency Dataset
phg
0
250
500 m



N
FRA - Risk of Flooding from Surface Water Extent
Legend
Application Boundary
RoFSW_SX25_Extent_1in30
RoFSW_SX25_Extent_1in100
RoFSW_SX25_Extent_1in1000
This dataset is one output of our Risk of Flooding from Surface Water (RoFSW) mapping, previously known as the updated Flood Map for Surface Water (uFMfSW). It is one of a group of datasets previously available as the uFMfSW Complex Package.
The Risk of Flooding from Surface Water information assesses flooding scenarios as a result of rainfall with the following chance of occurring in any given year
3.3 % (1 in 30)
1% (1 in 100)
0.1% (1 in 1000)
2192-QGIS
Scale: 1 in 2500 @A3
© Environment Agency copyright and/or database right 2015. All rights reserved.
phg
0
50
100 m

Environment Agency

Flood map for planning

Your reference	Location (easting/northing)	Created
BODI01	**446183/238339**	**18 May 2021 13:24**

Your selected location is in flood zone 1, an area with a low probability of flooding.

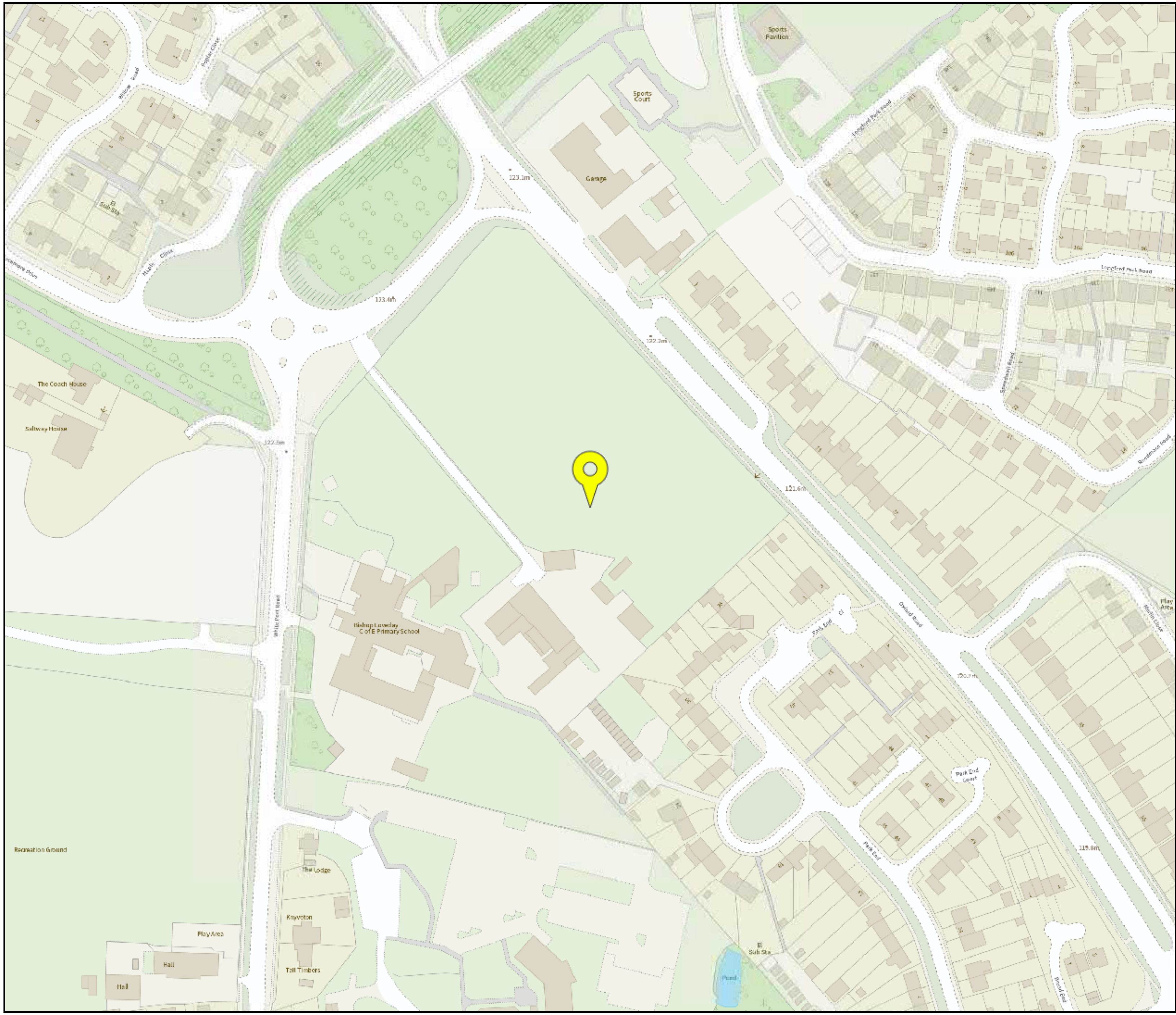
This means:

- you don't need to do a flood risk assessment if your development is smaller than 1 hectare and not affected by other sources of flooding
- you may need to do a flood risk assessment if your development is larger than 1 hectare or affected by other sources of flooding or in an area with critical drainage problems

Notes

The flood map for planning shows river and sea flooding data only. It doesn’t include other sources of flooding. It is for use in development planning and flood risk assessments.

This information relates to the selected location and is not specific to any property within it. The map is updated regularly and is correct at the time of printing.



Environment Agency

Flood map for planning

Your reference
BODI01

Location (easting/northing)
446183/238339

Scale
1:2500

Created
18 May 2021 13:24

Selected point

Flood zone 3

Flood zone 3: areas benefitting from flood defences

Flood zone 2

Flood zone 1

Flood defence

Main river

Flood storage area

0 20 40 60m