10th January 2022

Draft Assessment Report – Flood Risk Surface Water to Marlingford

21-105 Easton Phase 3 and 4

1.0 Introduction

An offer of service was made by 4D Geo Ltd (4D) to the client (Easton Parish Council) for a limited scope fee proposal for ground consultancy services including a report on flood risk at a site for proposed development at Easton Phase 3 and 4.

The proposal was accepted, and the works instructed by email.

Only a short period of time was available for this draft report and comments are brief as a result.

The site covers approximately 16 Hectares (ha) on the west side of the village. Development comprises residential use by Persimmon Homes and is part of a wider masterplan for the village.

The site area is approximately maximum dimension 550m west to east and 550m south to north with approximate elevation between 43 and 38m above Ordnance Datum (maOD). The site location is shown in Figure 1 extract from https://www.openstreetmap.org.

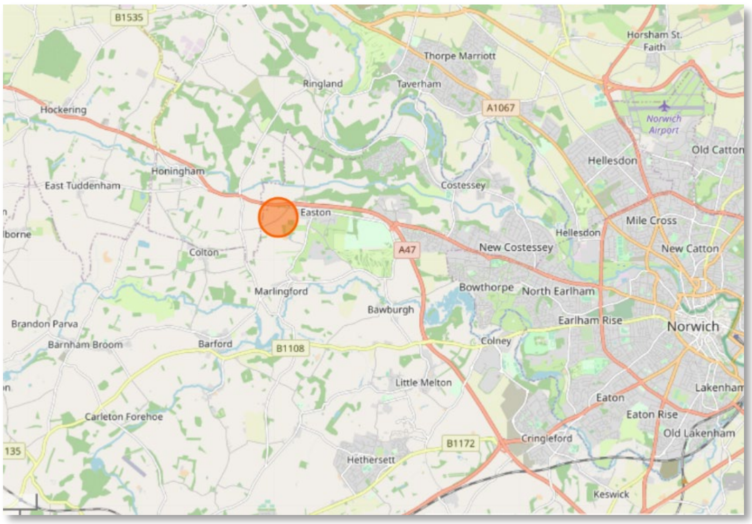


Figure 1

The site occupies land just on the south side of a topographic peak which slopes south to the River Yare at about 1.5 kilometres away at the village of Marlingford. Easton College Campus lies approximately between Easton and Marlingford.

	The River Tud is north of Easton beyond the A47 dual carriageway at about 1 kilometre distance. The proposed development is as shown in Figure 2.  Figure 2 The proposed development is subject to the South Norfolk Council planning authority and the existing masterplan. It has not been possible to fully research the planning portal at this stage of the investigation but there may be relevant further information for the project in the public domain. The three planning application references are as follows; Approved Development 2014/2611 The erection of 890 dwellings; the creation of a village heart to feature an extended primary school, a new village hall, a retail store and areas of public open space; the relocation and increased capacity of the allotments; and associated infrastructure including public open space and highway works. Reserved matters 2021/2417 350 Dwellings, & 2021/2652 Drainage basins.	
2.0 **Bespoke Objectives**	This is a bespoke report for which no standard template exists, and comments on the work of other practitioners. Comment is intended to be factual but variations in opinion/interpretation of information is provided and is intended to be fair and reasonable. Easton Parish Council has requested support from an independent consultant to help understand the flood risk aspects of the development via surface water.	

	The primary objective of this report is to provide opinion on potential increased flood risk to the area from surface water. Particularly Marlingford village south of Easton which is understood to have suffered from flood events in the past. A secondary objective is to set out some of the regional geology and hydrogeology evidence.	
3.0 **Methodology**	This report comprises a limited period desk-based study of existing relevant information available at the time on the SNC planning portal and from other sources. Desk study practice for engineering is covered in British Standard BS 5930:2015 Code of practice for site investigations and in British Standard BSEN1997-2:2007 Eurocode 7: Geotechnical Design – Part 2: Ground investigation and testing. For contamination the relevant standard is BS 10175:2011+A2:2017 Investigation of potentially contaminated sites. Code of practice. This report does not comprise a comprehensive desk study according to British Standards. Reference has also been made to relevant parts of The SuDS Manual CIRIA C753 © CIRIA 2015 RP992 Version 6 including 2016, 2018, 2019.	
4.0 **Evidence**	The following evidence was used in this assessment. Evidence is used to compile a ground model of geology and potential water pathways and flow directions.	
4.1 **BGS Records**	Geologists map outcrops using a convention either bedrock or superficial deposits. Bedrock being older (more than about 2.6 million years) compared to more recently deposited superficial materials. In Norfolk the relevant common bedrock is the chalk and the common superficial deposits are sand and clay or mixtures. Some geological labels are obvious, but Diamicton locally usually means a mix of particles predominantly clay. The British Geological Survey (BGS) mapping http://mapapps.bgs.ac.uk/geologyofbritain/home.html? shows the site is underlain by bedrock of Chalk Formation (undifferentiated) - Chalk. Sedimentary Bedrock formed approximately 72 to 94 million years ago in the Cretaceous Period. Local environment previously dominated by warm chalk seas. Chalk can be expected to be many metres deep with no different bedrock strata beneath affecting the project. Superficial deposits are Sheringham Cliffs Formation - Sand And Gravel. Superficial Deposits formed up to 3 million years ago in the Quaternary Period. Local environment previously dominated by ice age conditions (U). These sedimentary deposits are glacigenic in origin. They are detrital, created by the action of ice and meltwater, they can form a wide range of deposits and geomorphologies associated with glacial and inter-glacial periods during the Quaternary.	

Superficial deposits to the west and south are Lowestoft Formation - Diamicton. Superficial Deposits formed up to 2 million years ago in the Quaternary Period. Local environment previously dominated by ice age conditions (U). These sedimentary deposits are glacigenic in origin. They are detrital, created by the action of ice and meltwater, they can form a wide range of deposits and geomorphologies associated with glacial and inter-glacial periods during the Quaternary.

The map extract is shown below in Figure 3 including the approximate site location.

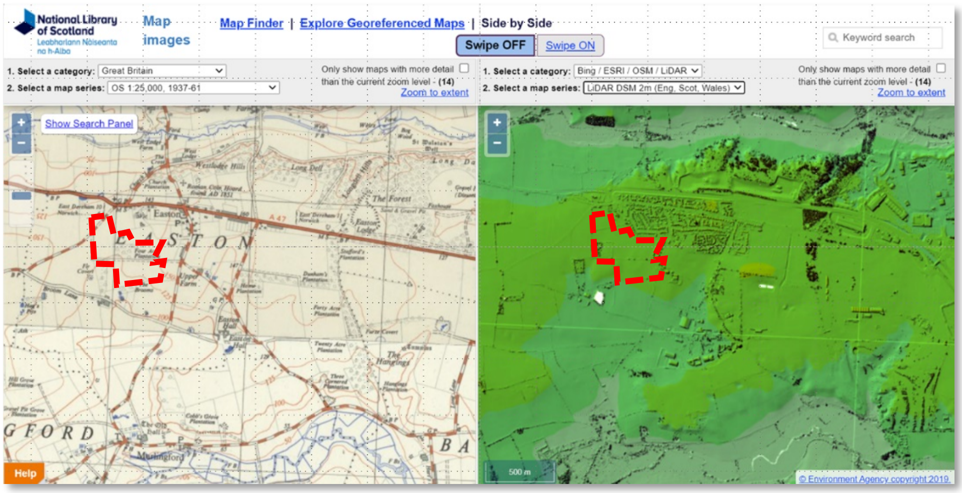
Pink is the sand and blue/green is the clay geology. Geology is mapped at surface with no regard for thickness of deposits. Knowledge of deposit thicknesses and characterisation in engineering is provided by ground investigations and archive borehole records.

Figure 3

There are relevant archive BGS records near the site which have been used in interpretation for the ground model. Particularly BGS ID: 514720 : BGS Reference: TG11SW47 British National Grid (27700) : 613500,310640 shows chalk at about 20m above Ordnance Datum capped by sand and gravel with a thin layer of clay (0.6m) at 23m depth.

This report recognises that for glacial soil although the BGS lithology descriptions might be for instance sand and gravel, local variations such as layers, lenses and pockets of clay or more clayey soil characterisations may occur.

Furthermore, old borehole records were not necessarily described or verified to modern standards and a degree of interpretation is required. As an example, highly weathered chalk could be described in a hand sample as clay, and the reverse is also possible. There is often a layer of disturbed and transported chalk near the surface of the strata, and complex weathering may extend many metres into it.

	In regional assessments over kilometre distances good generalisations can be made to fit observed facts such as the direction of river flows. There is risk in transferring generalisations to site scenarios without adequate characterisation of the ground conditions by investigation.	
4.2 **Ordnance Survey Mapping and LiDAR**	Ordnance Survey mapping and LiDAR (Light Detection and Ranging) is available freely on the internet at The National Library of Scotland https://maps.nls.uk/. Figure 4 below shows the site in a side-by-side format.  Figure 4 The Ordnance Survey mapping shows valley feature by contours. The LiDAR image shading also reveals the valley features with extra detail.	
4.3 **Groundwater**	Government provides information on the environment in the UK including via https://magic.defra.gov.uk/MagicMap.aspx. Information on groundwater is provided under the Landscape heading. Aquifers are generally permeable and may be used for water resource and are ranked in order of how favourable/valuable they are from Principal to Unproductive. The approximate site location is shown in Figure 5 by a black arrow and the aquifer designation map shows the superficial deposits to be Secondary A for the sand.	

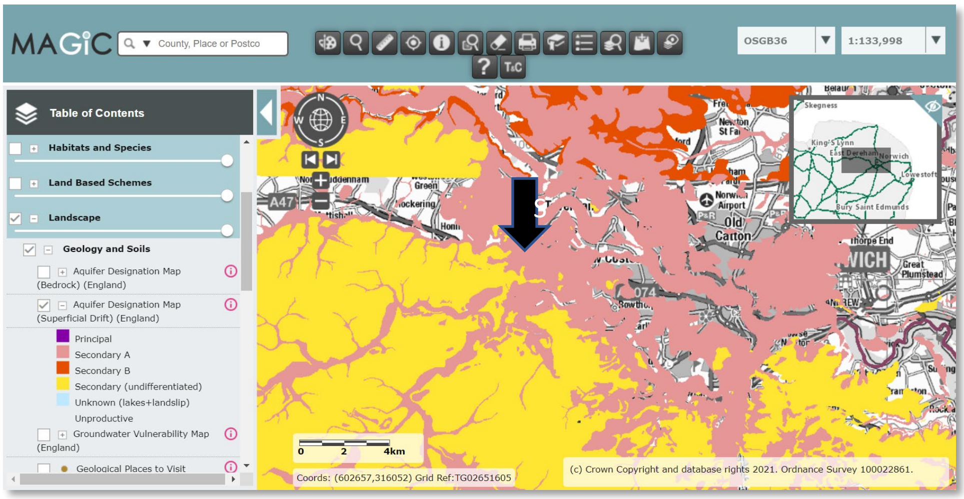


Figure 5

The bedrock is a principal aquifer (chalk).

Source Protection Zones (SPZs) are defined around potable groundwater abstraction sites (not private supplies to domestic property) in Figure 6 below. The purpose is to provide additional protection to drinking water quality (a receptor).

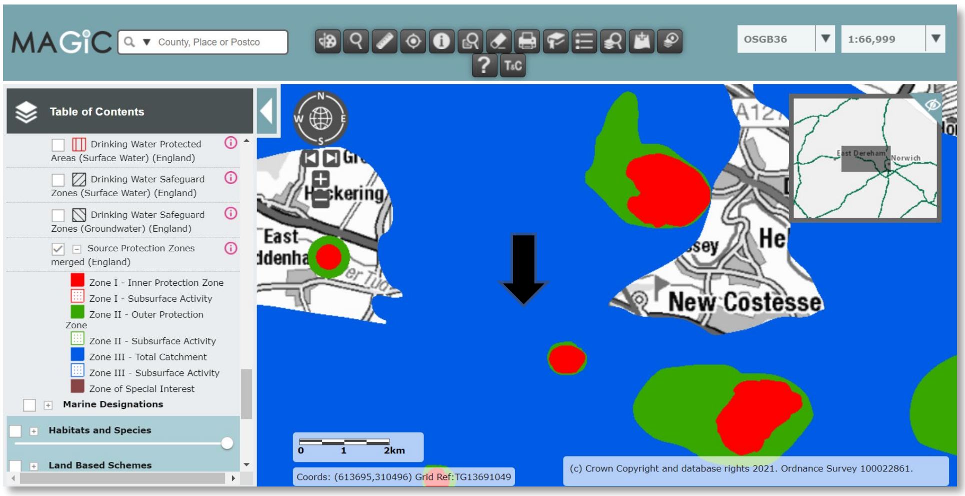


Figure 6

The site is in a source protection zone, inferred to be upstream of a potable water abstraction to the south east (assumed at Easton College) which could affect groundwater flow locally.

The Hydrogeological Map of East Anglia https://webapps.bgs.ac.uk/data/maps/maps.cfc?method=viewRecord&mapId=11532 shows regional flow characteristics north and east as shown in Figure 7.

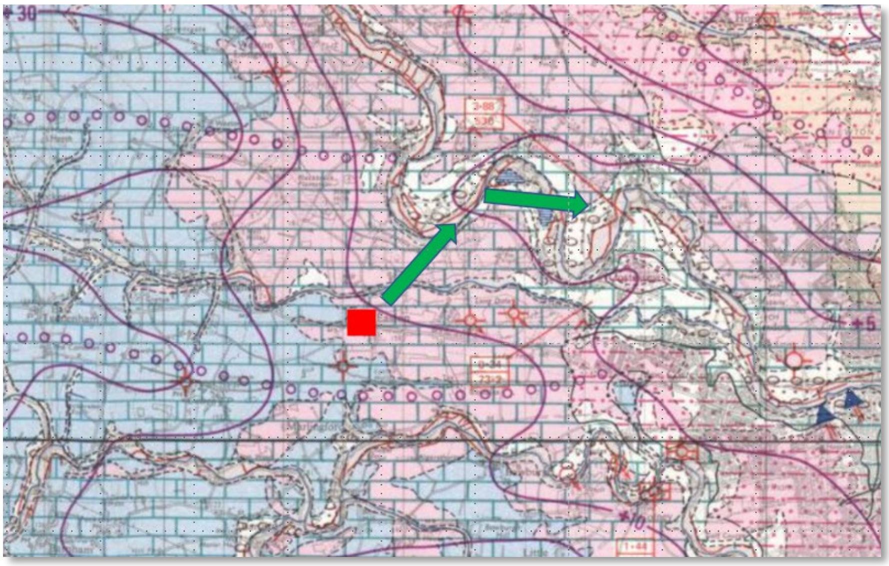


Figure 7

4.3

Government Surface Water Flood Risk

The government publishes information on flooding by an interactive mapping service https://flood-warning-information.service.gov.uk/long-term-flood-risk/.

Figure 8 below shows the site mapped for flood risk, low risk: velocity. Different map outputs can be obtained for different scenarios.

Surface water flow is shown on to the site from the north and east. Flow paths are also shown to the west through the plantation and south to Marlingford/Yare via Broom Farm where there is an agricultural reservoir.

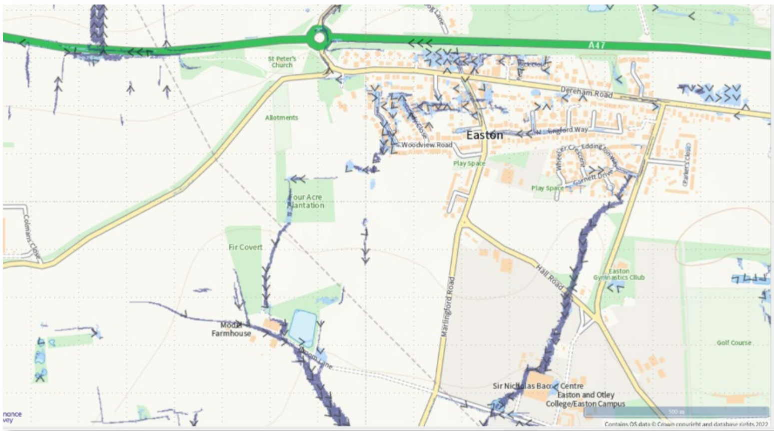


Figure 8

4.4

Developer Report

The relevant developer's report is

Schema Engineering Limited Hydraulic Modelling & Drainage Strategy Report Easton Phases 3 & 4, Norfolk Report Reference: 0156/HMRDS Revision A Date originated: 24th November 2021 Prepared for: Persimmon Homes (Anglia).

	The report describes the modelling and the drainage strategy to comprise infiltration by individual plot soakaways, swales, permeable paving and where necessary diversion to two infiltration basins, and one attenuation basin having an overflow to drains near Easton College. One infiltration basin is inside the development planning application but an extra planning application has been made for the other basins as they lie outside the original application site. Ground investigation has been undertaken.	
4.5 **Ground investigation Reports**	The relevant ground investigation report from application 2014/2611 has three boreholes on the site to depths between 5 and 10m below existing ground level. All three boreholes encountered coarse soils of sand and gravel with no groundwater. The Schema report includes ground investigation by Microgeotechnical Limited comprising 24 trial pits to 0.8m or 2.0m depth including infiltration tests. Only one of the positions recorded clay to fail to drain in a test (SA07 & TP1). A summary table of the results is included in Appendix 1 of this report. In general test results are good or fair using a subjective assessment of infiltration rates at varying depths. The ground investigation reports are consistent with the mapping in general and the variations in clay layers and content are typical for variable glacial deposits. Deep boreholes for characterisation of geology below trial pit depth is very sparse and groundwater levels (including perched water) are not investigated by standpipes for instance.	
4.6 **The SUDS Manual C753**	From the SUDs Manual; Relevant Section 25 Infiltration design methods and specifically 25.3 Infiltration Testing Methods and 8.4 Infiltration Assessment. Initial design may be undertaken from soil descriptions to British Standards and permeabilities (Table 25.1), but field tests are required using the approved test, such as the BRE365 method used in this case. Land stability (geohazards) and contamination are also prominent factors. The BRE365 methodology was intended for design of soakaways and has been routinely adopted by engineers for other devices; basins and permeable paving. The test for design is intended to be undertaken at the location of the device to remove uncertainties regarding ground variations in the immediate locality. This approach may not work for highly variable soil or large devices/sites having few tests. Equally, design guidance which requires the lowest infiltration rate to be used in design could be unrepresentative and promoting less sustainable practice without due consideration of the geology conditions. Section 8.4 of C753 includes a checklist (Table B6) intended for use by the approving bodies (and the designers). Examples of a completed checklist or a report to comply with the requirements of B6 have not been discovered.	

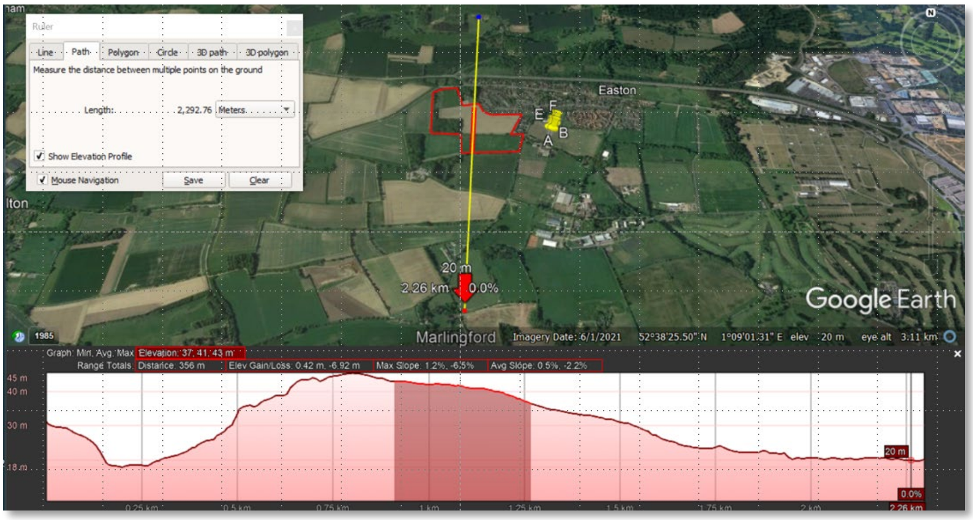
4.7 **Site Walkover & Reconnaissance**	Although a site walkover has not been achieved, reconnaissance of the wider area was undertaken on the 4th & 5th January 2022. Ordnance Survey maps were also consulted. The reconnaissance confirmed the topography from mapping from the site peak to a steep valley north to Ringland and the River Tud, compared to shallow slopes south to Marlingford. Rain at the time of the visit demonstrated many surface water puddles on minor roads south of the site, but far less on the north side of the A47. No springs or rising water features were observed on either side of the peak but the reconnaissance was limited to accessible areas and mapping.	
4.8 **Adjacent Development**	No relevant adjacent development was researched at this stage.	
5.0 **Ground Model**	The evidence above is used to construct 2 & 3 dimensional models of the topography over the geology. Outputs from the model are qualitive and generally subjective to be validated by consultation and additional testing. Due to the need for models to be visualised, vertical exaggeration is used to draw the geology. A section between the River Tud and Marlingford through the site at Easton has been used taken from Google Earth as Figure 9.  Figure 9	

Figure 10 shows the section at approximately 1:1 or little vertical exaggeration.

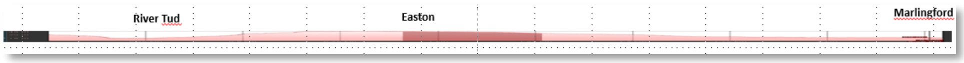


Figure 10

5.1

Preliminary Geological Ground Model

The geological model is developed in Figure 11 using a vertical exaggeration and interpretation of various sources.

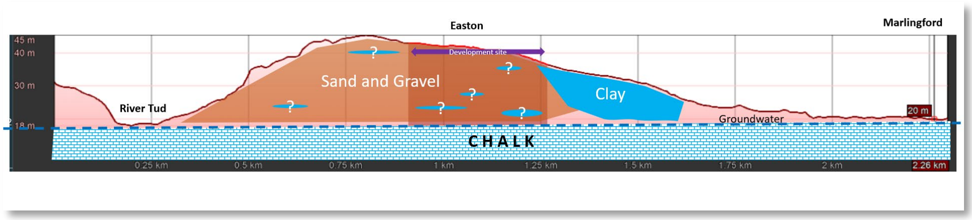


Figure 11

5.2

Pre-development Drainage Model

The pre-development drainage model is simplified to show some assumptions regarding flow directions in Figure 12.

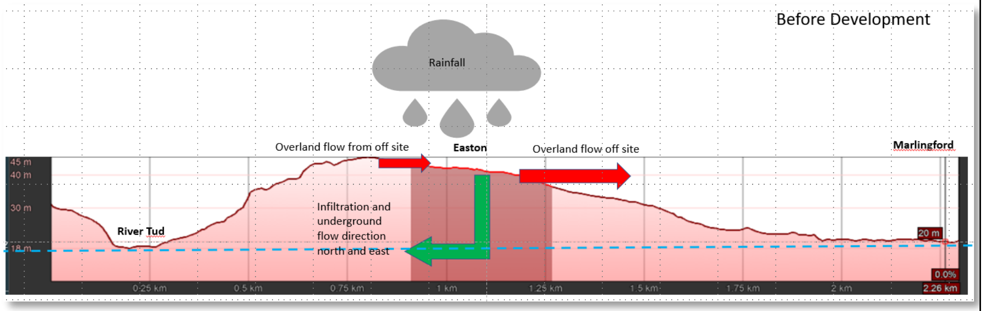


Figure 12

5.3

Post-development Model

After development the model is adapted to reduce overland flow to zero or near zero, but pipe flow to ditch is included outfall at Easton College nearer to Marlingford. We note implications of flows and quantities are not fully understood.

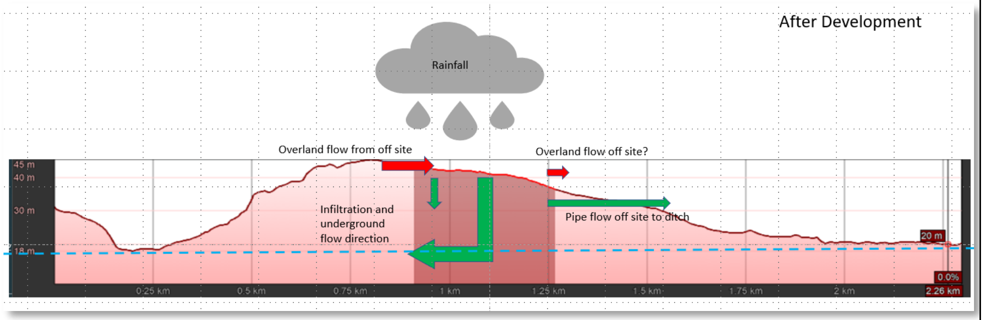
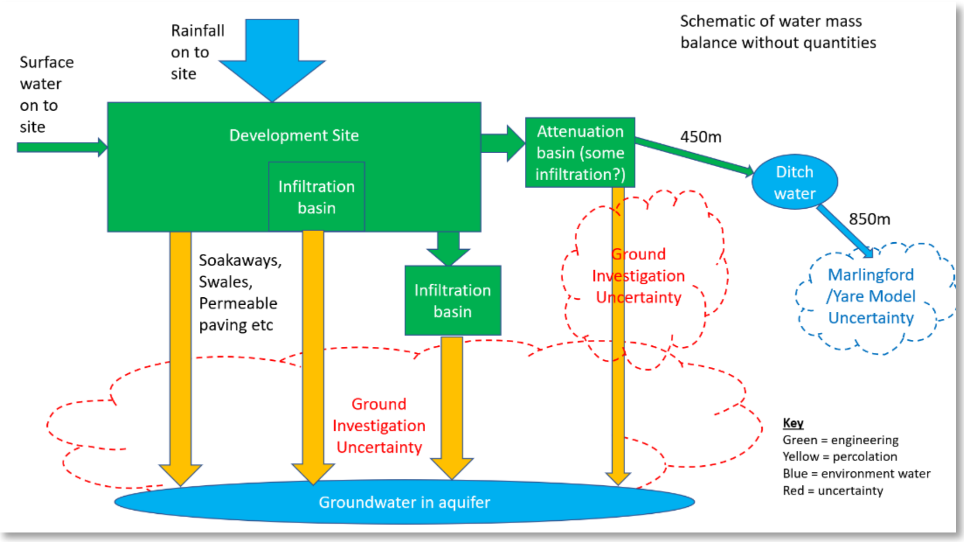
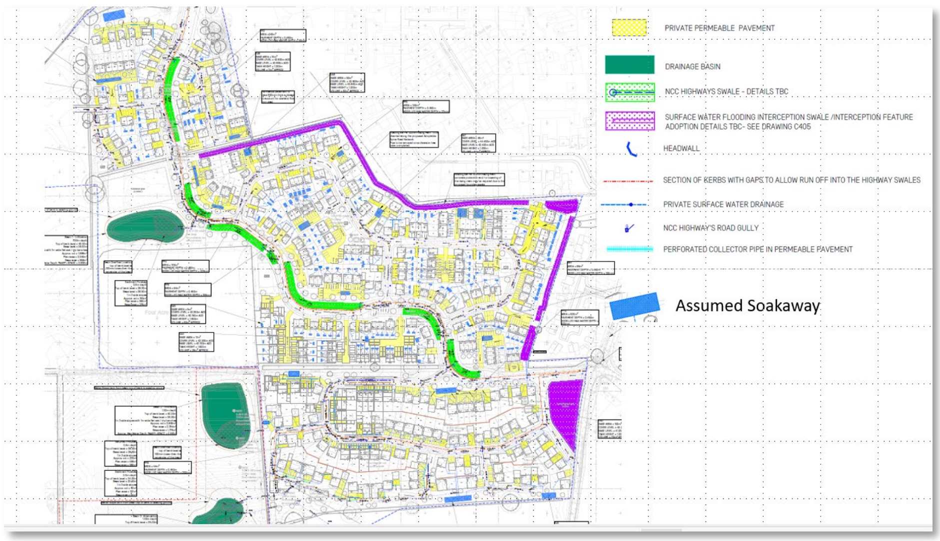
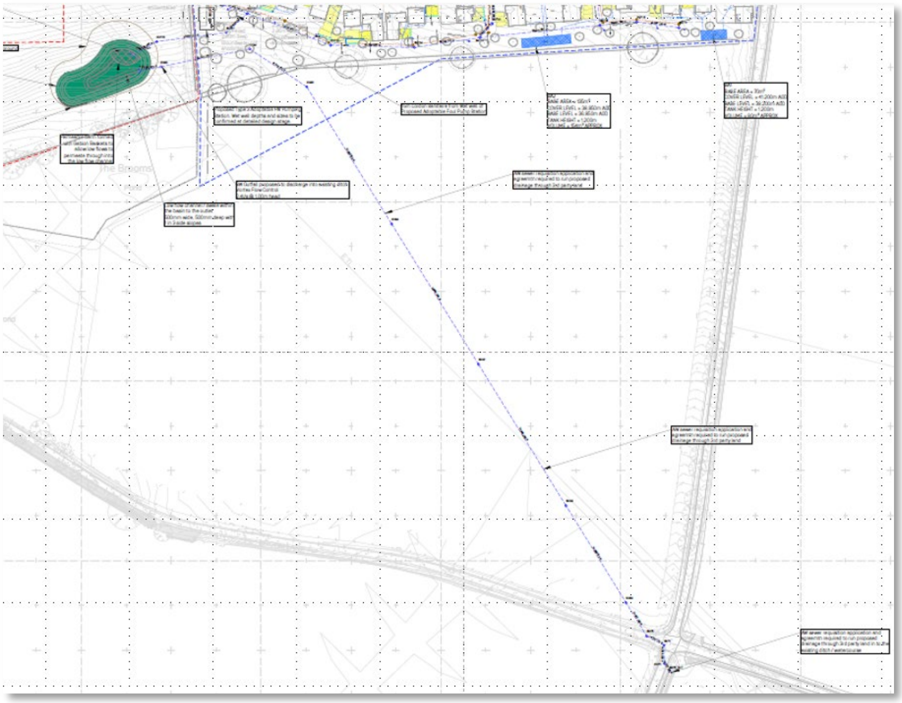


Figure 13

5.4 **Engineering Schematic**	 Figure 14	
5.5 **Engineering Proposal Plan (Site)**	The engineering proposal drawing in Figure 15 shows how overland flows from off site would be intercepted on the north east boundary and a swale runs from north to south east. Many roofs are drained to soakaways (assumed in legend) but some are drained to basins. Permeable paving is widely used either soaking or diverted to basins. Highway drains to basins. Two basins are infiltration; north and middle. One basin (south) is attenuation.  Figure 15	
5.6	From the south attenuation basin, a pipe is shown crossing fields to the crossroads west of Easton College into ditches as Figure 16.	

Engineering Proposal Off-site South Pipe	 Figure 16	
6.0 **Comments**	Initial comments are as follows; On site flows have been identified as set out in the researches from overland to the north, and rainfall. Current site drainage appears to be by infiltration through topsoil and overland flow south; at least partially contributing to the drain water courses above Marlingford. Roads between Marlingford and Easton have surface water in evidence during rainfall. Although an apparently compliant set of testing has been undertaken, the fieldwork concentrates on the ground level to 0.8-3.5m depth range. One borehole from the original planning application has been discovered to 10m depth. Long term groundwater levels or the presence of any unfavourable clay layers has not been provided. The checklist from The SUDs Manual has not been presented. Engineering proposals for the development intercept and divert surface water to infiltration devices; soakaways, swales, permeable paving and basins. Where flow exceeds overall capacity, a pipe distributes to a ditch west of Easton College above Marlingford. Quantities of flows are not understood at this stage so risk estimation to flooding Marlingford via ditches during exceedance are not known. Infiltration devices are observed likely to work well, although there is potential opportunity for further testing and design detailing. It is noted topsoil has been included as part of some tests which is assumed not to	

	be representative of permeable paving in service so results may not be accurate in service. The ground characterisation investigation of infiltration zones may be under estimating potential in the south west corner due to an unfavourable result in clay at SA07 (which was not inside the proposed basin as drawn). As an alternative to the off-site pipework, a larger basin or deeper infiltration devices may be preferred to intercept draining strata of sand and gravel. It is acknowledged that the Environment Agency are not minded to accept infiltration soakaways deeper than 2m, but the reasons for this preference is not explicit in responses. Other projects are known to have successfully deployed deep soakaways via boreholes in the Norwich area. Having regard for the wider groundwater flow regime, extra flooding south of the site at Marlingford via groundwater from concentrated infiltration in engineered devices is not known. Percolation from infiltration would have to spread south via a preferential pathway such as a clay layer, but the existing ground investigation data does not extend to the groundwater level. Regional groundwater flow is shown north and east by reliable sources. There is a groundwater abstraction at Easton College which could affect groundwater levels locally but unlikely to affect the regional model. Clay geology may provide some sort of cut-off from groundwater to the north of Marlingford, although evidence for this is weak. Springs or other rising water features on the slopes south of the development site were not observed in mapping or reconnaissance. Anticipation of the geological model nearer to Marlingford becomes more complex and borehole information is less frequent but with more strata layers to consider. Compliance with the SUDs manual may not be a requirement in planning.	
7.0 Limitations to Reports	The content of this report represents the outcome of standard process undertaken by an experienced practitioner using skill & care to the methodology described. Absence of hazardous materials or conditions cannot be assured between sample locations or due to changing circumstances before and since the report's limited data set was sourced. 4D GEO LTD cannot be responsible for errors in third party data supplied in making the report and subsequent judgements. This report was made for the client alone and third parties use the information and judgements contained at their own risk.	
	End of report	

APPENDIX I – Infiltration Rates

Test	Depth (m)	Rate (m/s)	Drainage Assessment	Assumed device	Comment
1	0.8	6x10-5	Good	Soakaway	Topsoil, clayey
2	0.8	1x10-5	Good	Soakaway	Topsoil, clayey
3	2.0	8x10-6	Fair	Soakaway	No clay
4	0.8	7x10-6	Fair	Soakaway	Topsoil, clayey
5	0.8	5x10-6	Fair	Soakaway	Topsoil, clayey
6	2.0	2x10-6	Poor	Perm pave	clayey
7	2.0	1x10-?	Fail	Basin South	Not in basin, sand over clay layer to 3.5m (TP1)
8	2.0	7x10-6	Fair	Perm pave	clayey
9	2.0	1x10-5	Good	Soakaway	No clay
10	0.8	7x10-5	Good	Perm pave	Topsoil, no clay
11	0.8	3x10-6	Poor	Perm pave	Topsoil no clay
12	0.8	1x10-5	Good	Perm pave	Topsoil, no clay
13	2.0	2x10-5	Good	Soakaway	No clay
14	0.8	3x10-5	Good	Soakaway	Topsoil, no clay
15	0.8	7x10-6	Fair	Soakaway	Topsoil, no clay
16	2.0	1x10-5	Good	Soakaway	No clay
17	0.8	1x10-6	Poor	Soakaway	No topsoil, no clay
18	2.0	7x10-6	Fair	Basin North	No clay
19	0.8	2x10-5	Good	Perm pave	Topsoil, no clay
20	2.0	6x10-6	Fair	Perm pave	No topsoil, no clay
21	0.8	2x10-5	Good	Perm pave	No topsoil, no clay
22	2.0	6x10-5	Good	Basin Middle	No clay
23	2.0	2x10-5	Good	Basin Middle	No clay
24	2.0	5x10-6	Fair	Basin South	No clay, closer to basin than 7?

Table notes;

Subjective assessment of rate.

Below 1x10-6 very poor/fail

Below 5x10-6 poor

More than 5x10-6 fair

More than 1x10-5 good

More than 1x10-4 excellent

Topsoil in test may be affecting rate and not necessarily representative of construction conditions for permeable paving.

Presence of clay in soil descriptions.

Location of TP1 and TP4 not carried over to Infiltration Zones Drawing