Some pages between 16 – 85 have been redacted

Wensum NBS Site ID Screening and Selection

Final

August 2023

Prepared for
Water Resources East

WATER RESOURCES EAST

www.jbaconsulting.com

Document Status

Issue date	08/2023
Issued to	Luke Waterman
BIM reference	KVT-JBAU-XX-XX-RP-EN-0001-A1.P0.01
Revision	2
Prepared by	Rowan Barker BSc, FGS Hydrogeologist
Reviewed by	Alex Jones [BSc, MSc, CGeol, FGS Principal Hydrogeologist
Authorised by	Alex Jones [BSc, MSc, CGeol, FGS Principal Hydrogeologist

Carbon Footprint

JBA is committed to championing sustainability and has made The Ten Principles of the UN Global Compact part of its culture and operations. We have a Group-wide objective to be a Net Zero carbon emissions business.

Contract

JBA Project Manager	Alex Jones BSc MSc CGeol FGS
Address	Salts Mill. Victoria Road, Saltaire, Shipley, BD18 3LF
JBA Project Code	2023s0820

This report describes work commissioned by Water Resources East, by an instruction dated 19/06/2023. The Client's representative for the contract was Luke Waterman of Water Resources East. Alex Jones and Rowan Barker of JBA Consulting carried out this work.

Purpose and Disclaimer

Jeremy Benn Associates Limited ("JBA") has prepared this Report for the sole use of Water Resources East and its appointed agents in accordance with the Agreement under which our services were performed.

JBA has no liability for any use that is made of this Report except to Water Resources East for the purposes for which it was originally commissioned and prepared.

No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by JBA. This Report cannot be relied upon by any other party without the prior and express written agreement of JBA.

The conclusions and recommendations contained in this Report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by JBA has not been independently verified by JBA, unless otherwise stated in the Report.

The methodology adopted and the sources of information used by JBA in providing its services are outlined in this Report. The work described in this Report was undertaken between June 2023 and July 2023 and is based on the conditions encountered and the information available during the said period. The scope of this Report and the services are accordingly factually limited by these circumstances.

Where assessments of works or costs identified in this Report are made, such assessments are based upon the information available at the time and where appropriate are subject to further investigations or information which may become available.

JBA disclaims any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to JBA's attention after the date of the Report.

Certain statements made in the Report that are not historical facts may constitute estimates, projections, or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the Report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. JBA specifically does not guarantee or warrant any estimates or projections contained in this Report.

Unless otherwise stated in this Report, the assessments made assume that the sites and facilities will continue to be used for their current purpose without significant changes.

Where field investigations are carried out, these have been restricted to a level of detail required to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in issuing this Report.

Contents

List of Figures

List of Tables

[redacted]

[redacted]

1 Introduction

1.1 Background

JBA Consulting have been commissioned by the Water Resources East (WRE) to Identify a range of sites for potential RAF creation for water resources benefits in the Wensum Catchment, west of Norwich. The focus of this project is on improving the water resources status of the Chalk aquifer in the area and low flows in rivers by increasing recharge to the principal chalk aquifer. WRE and the Environment Agency wish to build an evidence base to demonstrate what is possible, and ground-truthing the recently completed JBA NBS for water resources modelling via implementation, in the Wensum is the first step. The Wensum catchment is mainly underlain by chalk covered by complex superficial deposits, with the north overlain by the moderately permeable Sheringham Cliff Formation and the south by the low permeability Lowestoft Till Formation deposits.

This report details the identification of a series of sites for infiltration features across the Wensum catchment. This is a high level screening process based on a number of parameters outlined in the kick off meeting dated 20/06/2023. These parameters include hydrogeological parameters and constraints such as Public Rights of Ways, Sites of Special Scientific Interest, and flood zones.

1.2 Wensum and RAFS

1.2.1 Topography, Hydrology, Geology

The Wensum catchment begins with the Tat in the west at around 80mAOD and slopes eastwards to its lowest point in the Wensum floodplain at around 10mAOD, with the river flowing generally eastwardly. The Wensum catchment includes several tributaries, the main being: River Blackwater, Wendling Beck, and the Tud. Downstream of the Wensum's confluence with the Tud, the Wensum enters the River Yare, southeast of Norwich city centre.

The superficial geology units of the area are based on the latest BGS mapping of the area. The catchment can be split into the following areas:

South of the Catchment:

- The south area of the catchment is dominated by low permeability Lowestoft Till which can be found at higher elevations in the lower catchment.
- Throughout the valley floors, alluvium deposits can be found along river courses with river terraces and head deposits on the valley sides.

- Briton’s Lane Member sands and gravels can be found scattered throughout the catchment overlaying Till in many areas, especially in the north of the catchment over the Sheringham Formation.

In the north and centre of Wensum Catchment:

- The high ground is overlain by the Sheringham Formation, predominantly the clay, silt, sand, and gravel member. Outcropping along the edge of the valley floor, glacial fluvial deposits are found along the main channel of the Wensum and partially along its confluence with Wendling Beck.
- Next to the glacial fluvial deposits lie an area of sandy Sheringham Formation south of the River Wensum.
- Towards the east of the catchment, around the Wensum’s confluence with the River Yare, the Sheringham Sands and Gravels outcrop along the valley sides surrounding the alluvium along the valley floor

The Chalk underlies the whole area dipping gently eastward (less than 1 degree). There are only small areas of Chalk outcropping due to the erosion of drift deposits in river valleys for example in the west and east of the Wensum River valley. The Crag overlies the Chalk in two locations on the eastern fringes of the catchment. The Crag infills depressions in the eroded Chalk surface and varies in composition from sand and gravels.

The two types of till (the Lowestoft Till and the Sheringham Cliff Formation) have varying permeabilities; north of the Wensum, the hills are covered by the moderately permeable Sheringham Cliffs Formation. Whereas the south of the Wensum, the hills are covered by low permeability Lowestoft Till Formation deposits. Figure 1-1 shows the superficial geology of the Wensum Catchment.

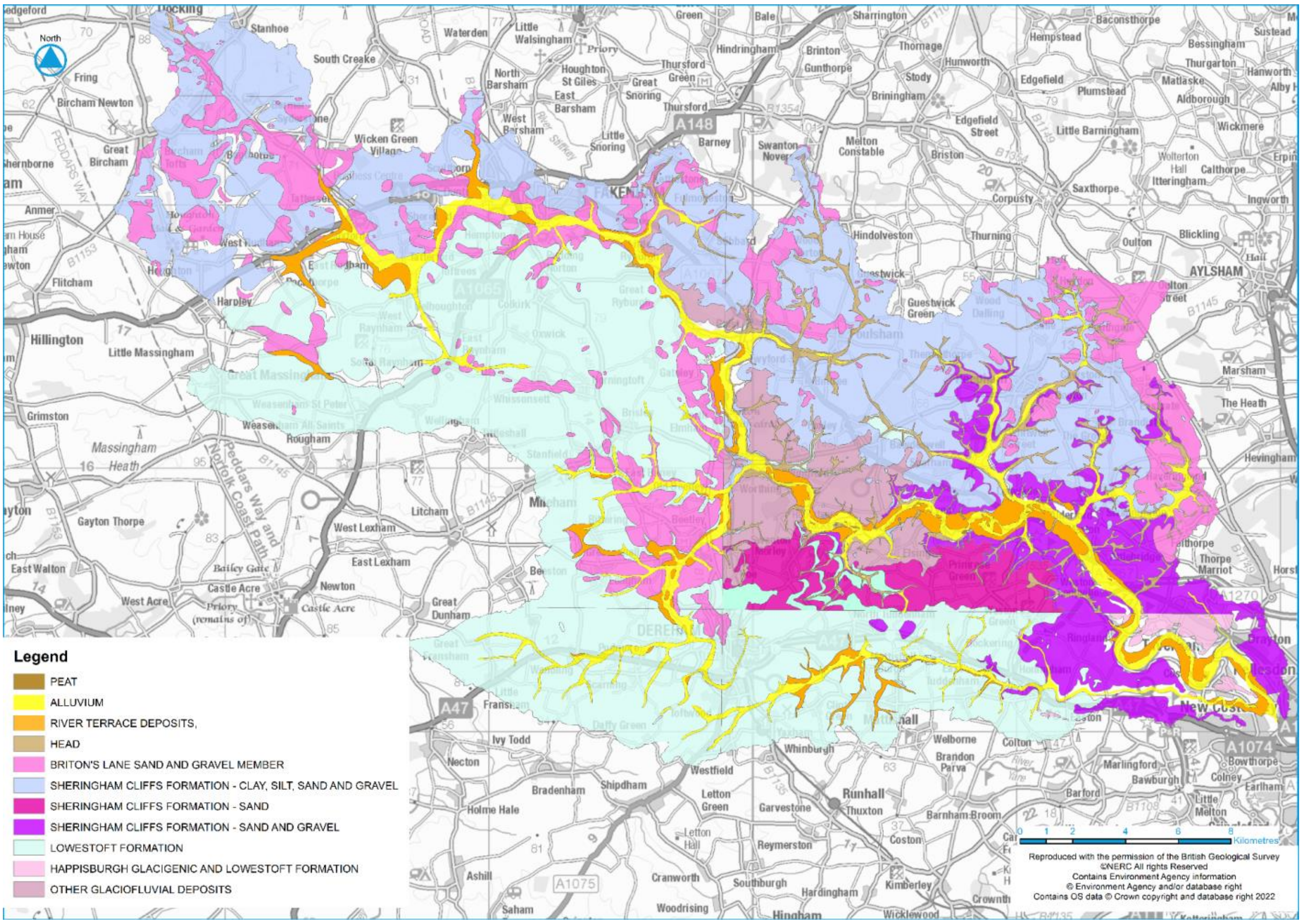


Figure 1-1: Superficial Geology

1.3 Ruoff Attenuation Features

Runoff Attenuation Features (RAFs) take runoff and hold it on the ground surface for longer, leading to more infiltration. The simple spreadsheet report identifies and discusses two sorts of RAFs. In simple terms there are:

- sRAFs - Surface RAFs - which collect runoff from the surface of a field;
- cRAFs - which impound water in ditches and ponds to store and spread it on the adjacent land and thereby enhance infiltration.

For the cRAFs, three distinct settings were identified in the analysis:

- Headwater cRAFs - these are at the top of the local ditch drainage system They have a catchment size of 160,000 to 240,000m^2 (mid-size 200,000m^2).
- Valley cRAFs - these are slightly further down the system, where drains in general occupy the bottom of small valleys and often contain ditches or streams. The ditches here may be small streams or ephemerally dry ditches. These have a catchment size of 1,200,000 to 1,640,000m^2 (mid-size 2,000,000m^2).
- Boundary cRAFs - this is where runoff flow pathways, generated on the low and moderate permeability Till areas, cross onto high permeability outcrop chalk. These have three general catchments sizes which capture the variation in the size of the flow paths off the Tills onto the chalk (ranging from approx. 350m x 350m to 900 x 900m):
  - Small - 120,000 - 285,000m2 (mid-size - 202,500m^2).
  - Medium - 285,000- 450,000m2 (mid-size - 367,500m^2).
  - Large - 450,000 - 800,000m2 (mid-size - 625,000m^2).

For this investigation, areas where Valley cRAFs and Boundary cRAFS can be implemented have been selected to maximise the effect and increase the ability to monitor them. Table 1-1 shows the parameters for different types of cRAFs. The percentage cover relates to the percentage of area the RAF covers in relation to its catchment so the RAFs cover approximately 1% of the catchment that drains to them

Table 1-1:Individual cRAF parameters

	1% of Catchment		Maximum Size	
cRAF Type	Width	Length	Width	Length
Headwater cRAF	20	100	150 (Lowestoft), 100 (Sheringham)	200
Valley cRAF	71	200	200	200
Small Boundary cRAF	20	100	200	200
Medium Boundary cRAF	25	148	200	200
Large Boundary cRAF	50	126	200	200

1.4 Meeting Outcomes

A meeting between JBA, the EA, and WRE was held on Tuesday 20/06/2023. Present at the meeting were; Luke Waterman (WRE), Jack Beard (Future Water), Rob Cunningham (TNC), Sam Philips (EA), Sean Arnott (EA), Mark Whiteman (EA), Alex Jones (JBA), and Rowan Barker (JBA).

During this kick-off meeting a number of criteria were selected as key parameters when selecting the 20 sites. These were:

- Interested Landowners; WRE were to lead this if possible.
- Land use; Pasture or Fallow land was targeted. Areas with Trees, Hedgerows and Arable Farmland was avoided.
- Size; Target areas with capacity for Valley cRAFs or equivalent. This is in order to be more certain a flow can be measurable through them.
- Geology; Boundary cRAFs on the chalk or Valley cRAFs on the Sheringham Cliff Formation. Initially Lowestoft Till has been excluded due to low permeability.
- Monitoring; Sites with ditches are more favourable due to the ability to measure flows entering and leaving the RAF.
- No flood impact on certain infrastructure; Public Right of Ways (PRoW), Buildings, Other infrastructure, or aesthetic impacts to the surrounding land.
- Representative of the catchment; non irregular sites compared to the catchment considering; Catchment Size, Slope, Geology, Topography, and Land Use.
- Other potential parameters; possibility of a RAF system (smaller flow pathways entering larger ones) and/or the addition of sediment traps within the catchment. The cover of utilities across the site and designated sites were also considered in order to avoid additional restriction.

All the following parameters were considered when selecting 20 potential sites.

1.5 Screening process

Previous modelling reports within the Wensum catchment carried out by JBA identified numbers of potential RAFs in the catchment. Although not based a site selection process, it does give an indication of the number of features that could be incorporated in a catchment. .Table 1-2 shows the number of RAFs identified across the Wensum catchment.

Table 1-2: Wensum Initial RAF count

Type	Count
SRAFs	9670
Lowestoft Headwater cRAF	691
Lowestoft Valley cRAF	121
Sherringham Cliff Headwater cRAFs	373
Sherringham Cliff Valley cRAFs	64
Large Boundary cRAFs	46
Medium Boundary cRAFs	64
Small Boundary cRAFs	139

In prior mode exercises, over 10,000 sRAFs and cRAFS where identified, including 64 potential Sheringham Cliff Valley cRAFs and 46 potential large Boundary cRAFs were identified across the Wensum catchment. Which is a high proportion of the number of cRAFs modelled. Following on from this process, using the parameters and constraints discussed in Section 1.4, 20 sites were identified across the catchment. Figure 1-3 shows all the cRAFs and sRAFS identified.

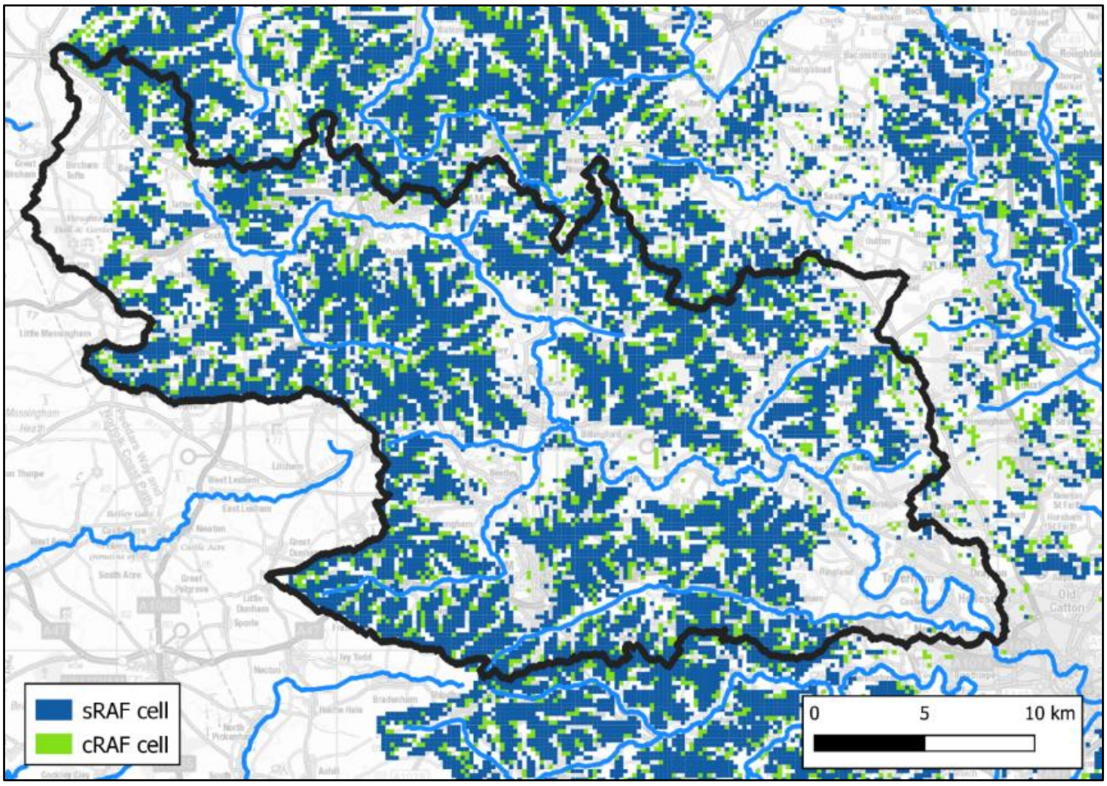


Figure 1-2: Original Screen Report RAF sites across the Wensum

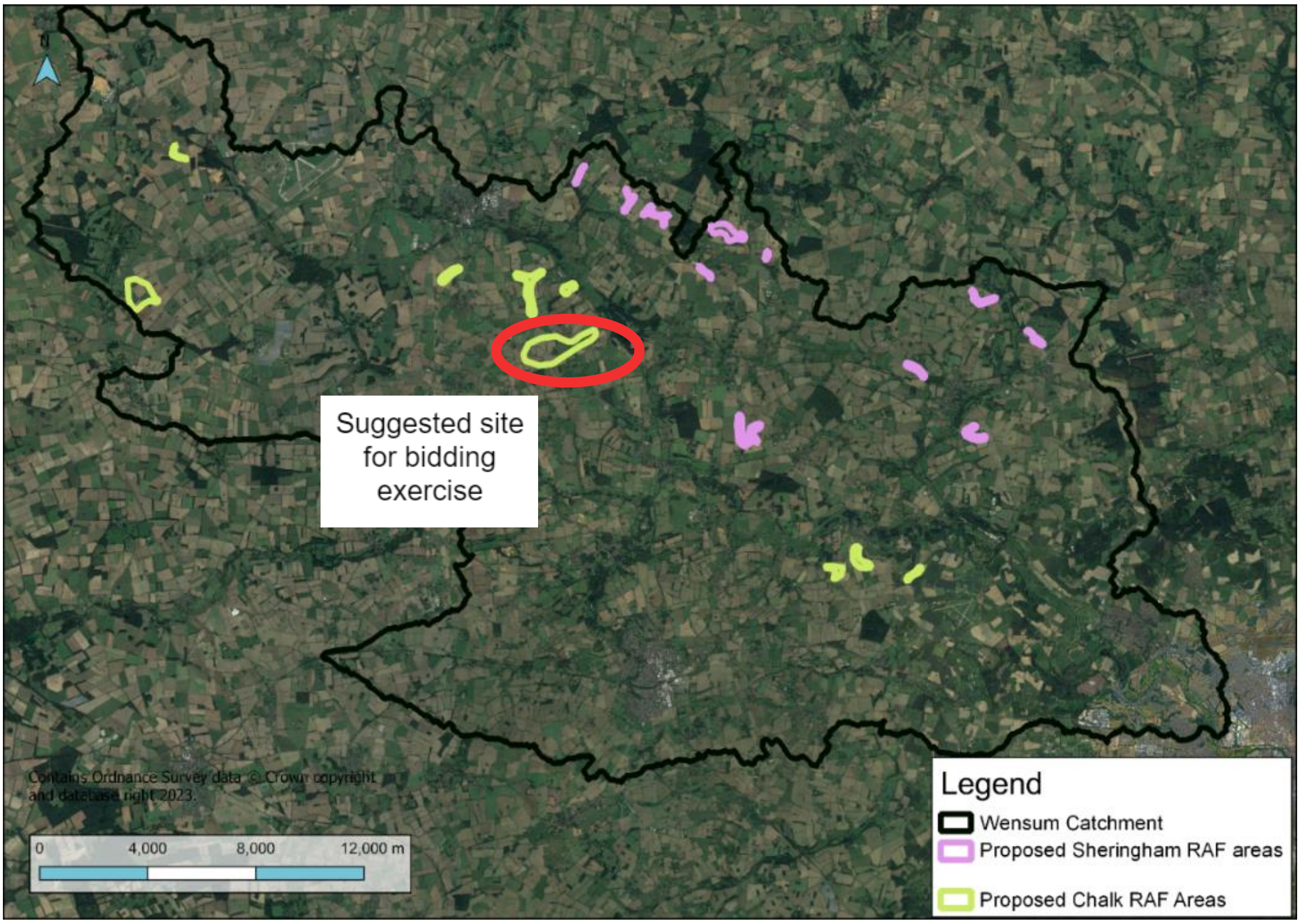


Figure 1-3: Potential RAF Locations

The 20 sites consisted of 11 potential Valley cRAFs (Sheringham RAF Areas) areas across the Sheringham Cliff Formation, which equates to 18% of the total identified in the modelling report outlined in Figure 1-2. The other 9 identified were Large Boundary cRAFs (Chalk RAF Areas) on the outcropped chalk. This equates to approximately 20% of the total identified in the modelling report. In general, these areas are larger than would be required for a RAF, which would allow some micro siting within in them.

1.6 Review Criteria

The 20 identified sites were then reviewed individually against the parameters and constraints identified in section 1.4 and tabulated in the format below. Table 1-3 outlines the various parameters and constraints used to screen the 20 sites. Explanations of why these parameters were used is also included.

Table 1-3: Review Criteria for Screening Selection

	Parameter	Description of parameter
	Easting	Easting
	Northing	Northing
Geology	RAF Type	RAF type is determined by the size and location of the RAF: Two types of RAF have been selected for this screening. -Valley cRAFS are relatively large and have a catchment size of 1,200,000 to 1,640,000m^2 (mid-size 2,000,000m^2). Here drains in general occupy the bottom of small valleys and often contain ditches or streams. The ditches here may be small streams or ephemerally dry ditches. - Large Boundary cRAFs; These are where runoff flow pathways, generated on the low and moderate permeability Till areas, cross onto high permeability outcrop chalk and sands and gravels.
	Superficial	Superficial geology affects the rate of infiltration into the underlying aquifer. Targeting areas with relatively permeable superficial deposits (Sheringham Cliff Formation or Britons Lane Sands and Gravels) will mean RAFs on these deposits have higher infiltration rates and reduced runoff. Furthermore, targeting areas with no overlying superficial will also means overlying RAFs have a greater effect on recharging the chalk aquifer below.
	Bedrock	The whole catchment is underlain by mostly chalk and in some places the Crag. Both these are classified as a Principal Aquifers. Principal and secondary aquifers supply significant quantities of drinking water, and water for business needs. RAF location is important in regard to recharging the underlying aquifer via infiltration.
	WWNP GIS Information	GIS outputs used in previous investigations to identify potential recharge areas. See Appendix A.
Catchment, Topography and Size	Catchment Size	Catchment size is also based on flow accumulation. Boundary cRAFS have three general catchments sizes which capture the variation in the size of the flow paths off the Tills onto the chalk (ranging from approx. 350m x 350m to 900 x 900m): ▪ Small - 120,000 - 285,000m2 (mid-size - 202,500m^2) ▪ Medium - 285,000- 450,000m2 (mid-size - 367,500m^2) ▪ Large - 450,000 - 800,000m2 (mid-size - 625,000m^2). Valley cRAFs have larger catchments as these often occupy small valleys with numerous ditches or streams. These have a catchment size of 1,200,000 to 1,640,000m^2 (mid-size 2,000,000m^2). Only Large or >large Boundary and Valley cRAFs have been selected to see the greatest effects of infiltration. All Boundary cRAFs and Valley cRAFS have been identified using Flow Accumulation.
	Valley Floor Length (m)	The length of the delineated valley floor. Marked by the site boundary.
	Valley Width (m)	Width of the delineated valley floor shown by the catchment storage layer.
	Valley Fall (mAOD)	The change in elevation between the upstream and downstream end of the valley bottom. Steep valleys are harder to create RAFs on with a sufficiently large inundation area.
	RAF occupies whole valley width?	Does the catchment storage layer occupy the whole valley floor. Further down the system where there are fluvial flood zones, RAFs could only occupy the valley edges making them harder to implement.
	Proportion of site that would be developed	This gives an indication of the proportion of the site that would be developed into a RAF. Some sites are so large that only 1/8 or 1/4 of the site would need to create the dimensions of the RAFs identified in Section 1.3.
	Drain Present	Drains being present on site means that flows into and out of the RAF can be measurable. Installing two V-notch weirs (one at either end) would allow flows to be monitored in the RAF.
	Current Land Use	Pasture was targeted as it would be most easily transformed into RAF features compared to arable land or woodland.
	Catchment Characteristics	Identification of land type uses If there are pollution sources up gradient, the installation of RAFs could lead to increased pollution in the aquifer. Proximity to towns/villages.
Ownership	Multiple Owners	This was identified via the countryside stewardship schemes. Where the land is not in stewardship, the ownership was not identified. The more owners on of the site, the more permissions/stakeholder engagement needed.

Modelled Effect			Each site has had the modelled effect of the RAF calculated. This was based on the simple spreadsheet tool developed to produce a simplified version of the 4R recharge model. The main variables changed were the catchment size, and the permeability of catchment and the location of the RAF. The size of the RAFs was not varied. In each site with numerous possible RAFs locations, the downstream end of each has been numbered and changes in annual average run off and recharge have been calculated, showing the change between the baseline and the new scenario.
Constraints	Designations SSSI, SAC, SPA, RAMSAR		RAF creation within any of these ecological designations could have adverse effects and therefore RAFs were selected outside of these areas.
	SPZ (Source Protection Zone)		RAFs could increase the infiltration of pollutants from the surrounding catchment into the groundwater. Therefore, sites within SPZ 1 and 2 were excluded, but SPZ 3 was included due to their distance from the abstraction point in SPZ 1.
	Stewardship Agreements		Countryside Stewardship Agreements provide incentives for farmers and landowners who look after and improve the environment. This is an indication of landowners who may be favourable to RAF creation on their land as well as any schemes in place that could be affected by RAF creation.
	SSSI Impact Zones		SSSI Impact Risk Zones are used to assess planning applications for likely impacts on SSSIs/SACs/SPAs & Ramsar sites (England). This has a particular focus on discharge and water supplies, the two most likely to be impacted.
	Cat 1 and 2 Pollution Incidents		Category 1 incidents have a serious, extensive, or persistent impact on the environment, people, or property. Category 2 incidents have a lesser, yet significant, impact. RAFs created in the vicinity of pollution incidents might create a more direct pathway of pollutants to groundwater.
	Access		RAF areas where access requires crossing numerous landowners' property or lack of access means construction, monitoring and maintenance may be difficult.
	Fluvial Flood Zones		Fluvial Flood Zones are generally found at the base of a valley surrounding the main watercourse. RAF creation in this area is not possible due the reduction in flood storage, the RAF would cause.
	Buildings		Buildings within the area should be considered either as a risk of pollution entering the RAF (Livestock buildings might be a sources of pollution) or risk to the buildings itself if the surrounding ground becomes saturated.
	Roads		Roads that run parallel or across the potential RAF area could be flooded.
	PRoW		Public Right of Ways are areas which are accessible to the public. RAF creation must avoid flooding them.
	Hedgerow/trees		Trees and hedgerows could be damaged by RAFs. Flooded out trees could die and lead to health and safety concerns.
	Utilities	Visible	Overhead telephone masts or other utilities could pose an issue during RAF construction. Sourced from Google Earth.
		Gas	Underground services pose a serious risk when breaking ground. Sourced from Home - LinesearchbeforeUdig (lsbud.co.uk). *Only free data used during this check*
		Other	Underground services pose a serious risk when breaking ground. Sourced from Home - LinesearchbeforeUdig (lsbud.co.uk). *Only free data used during this check*
	Potential Nutrient sources		Nutrient sources from farms can enter RAFs resulting in increased concentrations of nitrates and phosphorus in groundwater. Sources upgradient of RAFs should be considered when selecting potential RAF areas due to pooling of pollutants and nutrients in RAF areas.
Discussion	Reasons to rule out		Summary of any particular constraints that may rule out the proposed RAF.
	Potential Short list?		The top sites identified with the fewest constraints will be identified here
	Other		Other factors which may determine the proposed area being short listed or ruled out.

1.7 Utilities

A Utilities search was undertaken to ensure potential sites where not at risk of damaging underground services or creating health and safety concerns during the construction phase. All utility searches were high level using either google earth and ordinance survey to identify overhead service such as telephone masts and wiring, or a free request through Linesearch for any underground services present in Early July 2023. Cadent Gas via Line search provided us with Gas line plans for each of the sites however no other service plans (e.g., electricity or telecommunications) were freely available and therefore further investigation is required.

A full services check would be required in later development stages.

1.7.1 Under Drainage

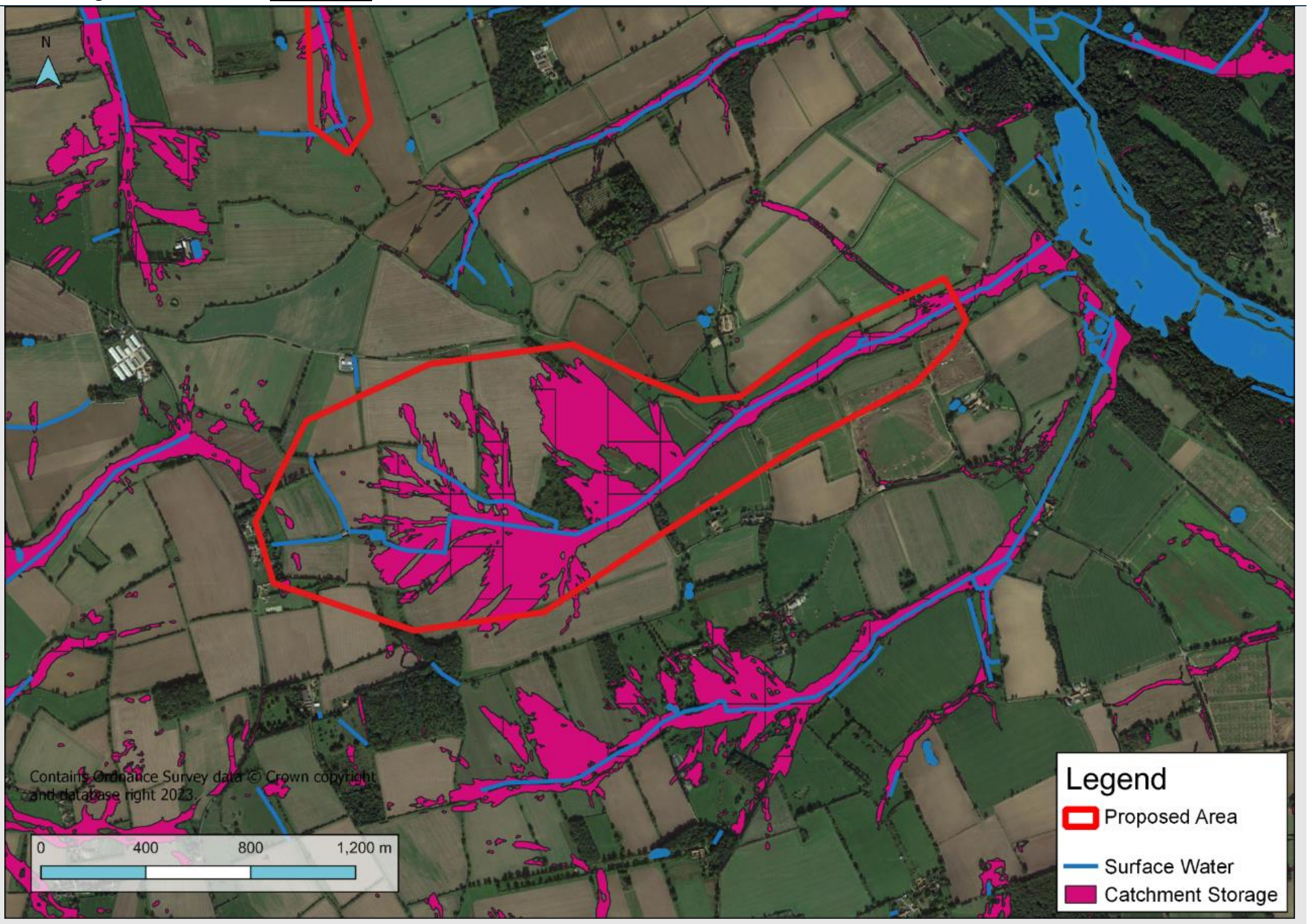
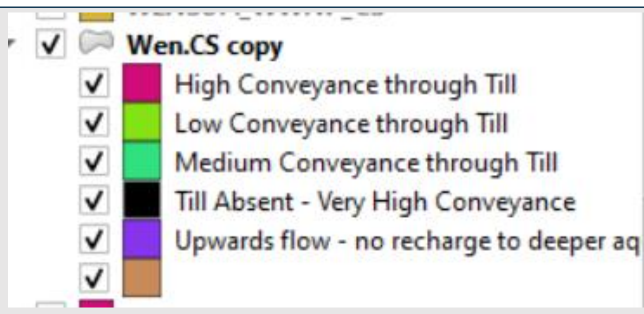
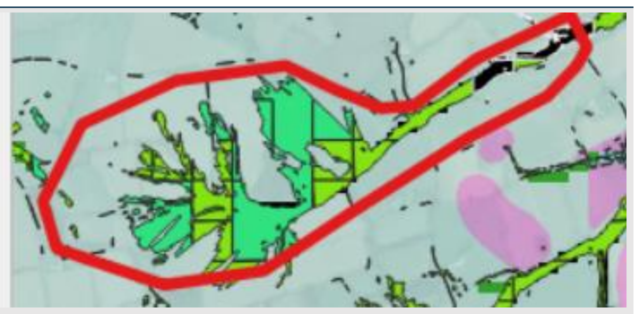
Under drainage is likely to be present in RAF areas where arable farmland is found. Furthermore some sections of land which are now currently pasture have the potential for under drainage if historically they have been arable land. Each site if selected will require investigation into whether under drainage could be present and would need to be blocked if they were..

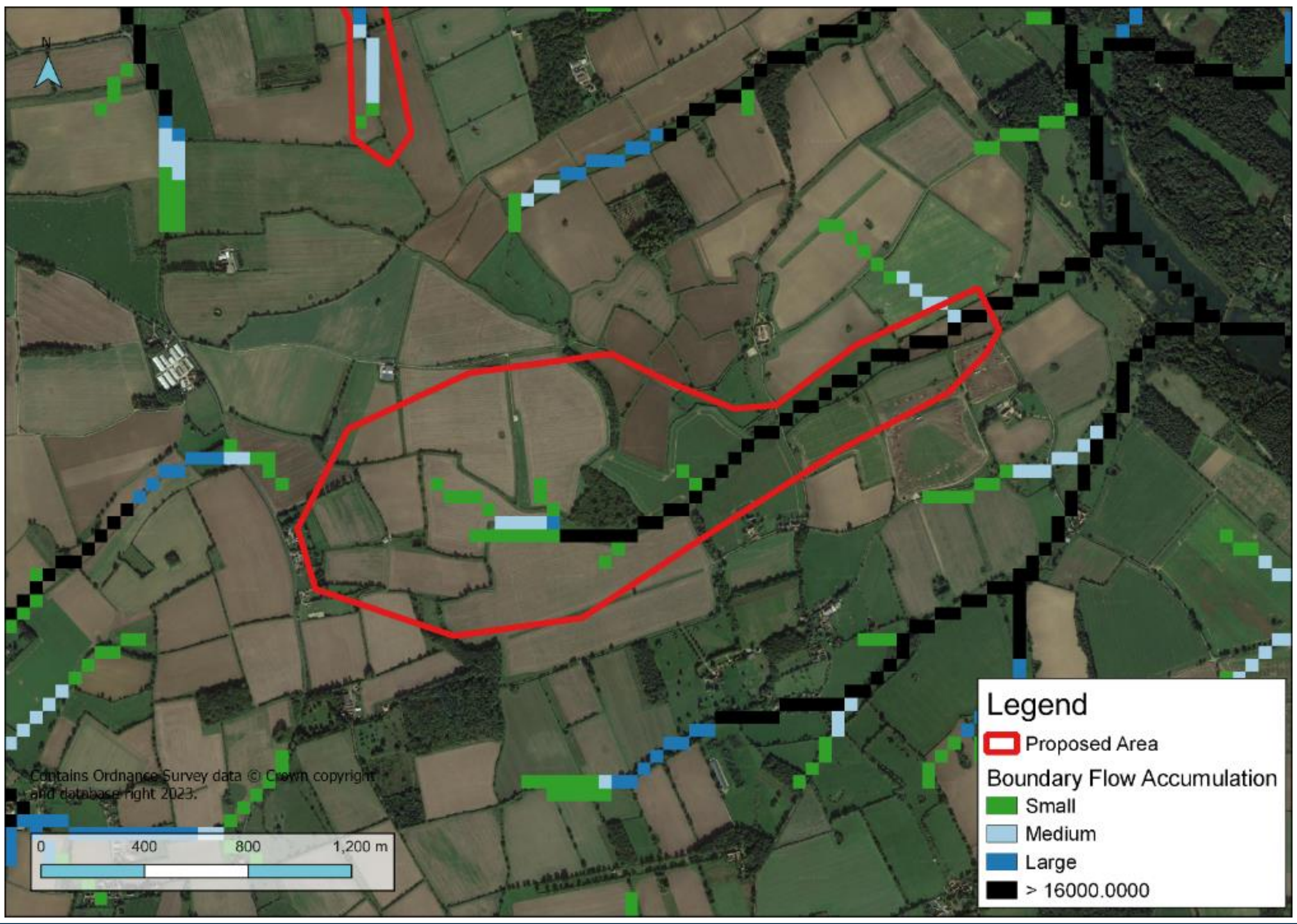
The following site is an example to help facilitate costings for the bid exercise.

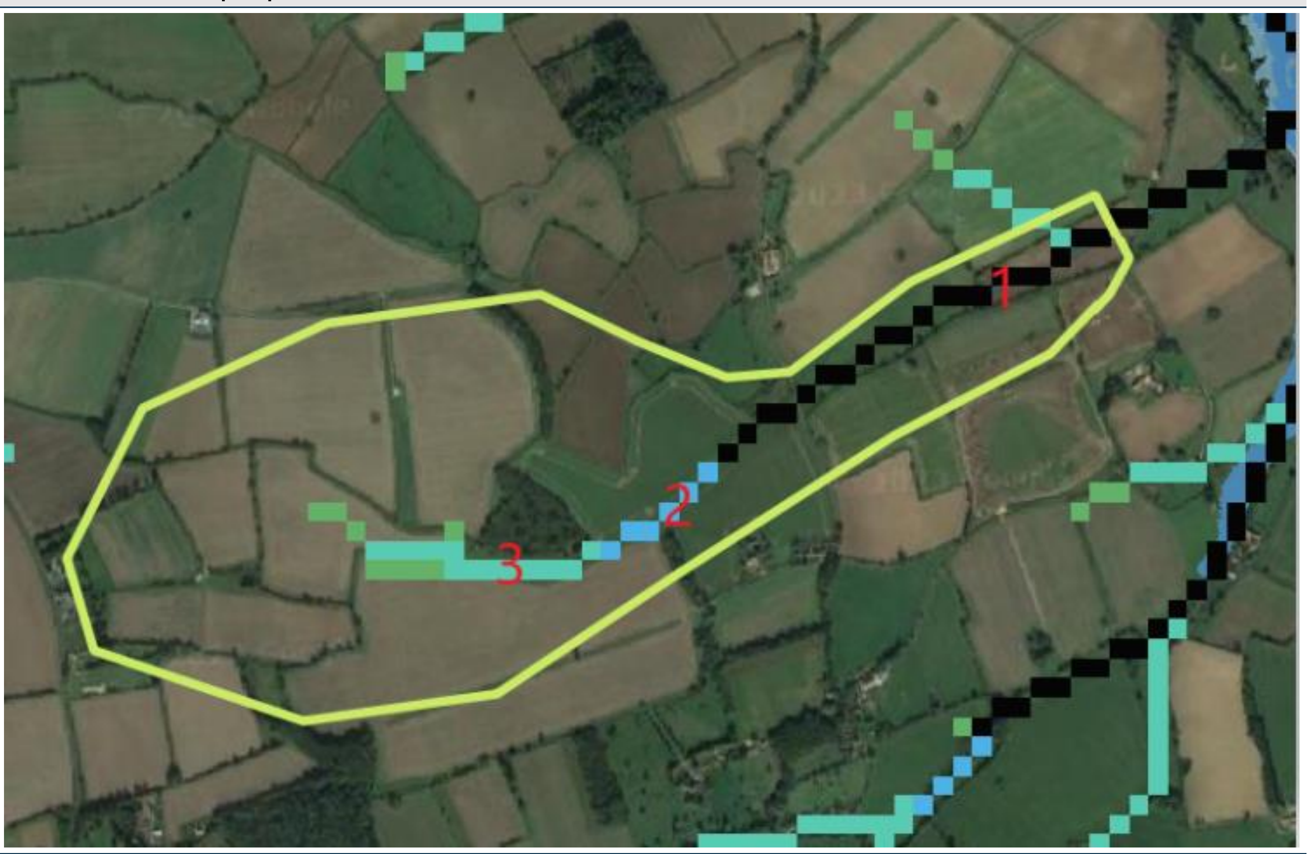
Actual site for works will be chose once the project and landowner engagement has commenced.

Please **refrain from any landowner engagement** prior to the project commencing.

Table 3-8: [redacted]

	Parameter	[redacted]
	Easting	[redacted]
	Northing	
		
Geology	RAF Type	Boundary/Valley cRAF
	Superficial	Lowestoft Till
	Bedrock	Chalk
	WWNP GIS Information	 
Topo and Size	Catchment Size	2387500m3 >Large



	Valley Length (m)	2900
	Valley Width (m)	150
	Valley Fall (mAOD)	33.5076.5
	Does RAF occupy the whole valley width?	Yes
	Proportion of site that would be developed	Circa 1/8
	Drain Present	Yes, several large agricultural drains present throughout the proposed area.
	Current Land Use	Mixture of arable and pasture with arable across the western sections and pasture (pig farms) occupying the lower elevations towards the east.
	Catchment Characteristics	Mixture of arable and pasture with various villages, the closest being [redacted] 500m south of the site.
	Multiple Landowners	Unknown, however likely as several farms surround the area and are likely to own sections of the proposed area.
Modelled Effect	Locations of Model Results	
	1- 2387500m3	see table below

Parameter	Unit	Baseline	Scenario	Change	Change (%)
Runoff	m3/a	321,728	280,569	- 41,159.0	-12.8%
	mm/a	135	118	- 17.2	-12.8%
Recharge	m3/a	64,237	97,970	33,733.5	52.5%
	mm/a	27	41	14.1	52.5%

2- 1582500m3

Parameter	Unit	Baseline	Scenario	Change	Change (%)
Runoff	m3/a	214,485	180,114	- 34,371.6	-16.0%
	mm/a	136	114	- 21.7	-16.0%
Recharge	m3/a	64,237	94,511	30,274.9	47.1%
	mm/a	41	60	19.1	47.1%

3- 947500m3

Parameter	Unit	Baseline	Scenario	Change	Change (%)
Runoff	m3/a	128,691	101,080	- 27,610.6	-21.5%
	mm/a	136	107	- 29.1	-21.5%
Recharge	m3/a	64,237	90,414	26,176.9	40.8%
	mm/a	68	95	27.6	40.8%

Constraints	Designations SSSI, SAC, SPA, RAMSAR	None	
	SPZ	None	
	Stewardship Agreements	None	
	SSSI Impact Zones	Discharges: Any discharge of water or liquid waste of more than 5m³/day to ground (i.e., to seep away) or to surface water, such as a beck or stream. Water Supply: Large infrastructure such as warehousing / industry where total net additional gross internal floorspace following development is 1,000m² or more.	Both are not applicable as the proposal does not fall into these categories.
	Cat 1 and 2 Pollution Incidents	None	

Access

Numerous access points to the site due to its large size:

Access via [redacted]

Access via [redacted]

Access off Intersecting Road:

			
	Fluvial Flood Zones	None	
	Buildings	One barn located in the west section of the site. Unlikely to be affected	
	Roads	No roads however numerous access tracks run across the sites and fields. Will not be affected.	
	PRoW	several small public footpaths cross the site through [redacted] and beyond from the church. Must be considered when choosing RAF location.	
	Hedgerow/trees	Mostly found along field boundaries with a cluster in the centre of the area referred to as [redacted]	
	Utilities	Visible	Telephone masts present across the site north to south in orientation.
		Gas	Low Risk (No gas lines found).
		Other	Requires Payment.
	Potential Nutrient sources	Surrounding arable farmland- limited, pig farms present in the east of the area.	
Discussion	Reasons to rule out	Limited access in the south due to pig farms, more potential in western and central sections. Limited infiltration through low conveyance Till in the west.	
	Potential Short list?	Yes	
	Other	Numerous small pathways connecting to larger ones.	

A Identifying Potential WWNP and Groundwater Recharge Areas

A.1 Estimating Recharge Potential

The quantities of recharge water that a NBS intervention can generate is in part controlled by the infiltration through the soil layer and the structure and permeability of the units beneath. This is shown in Figure A1. A GIS process has been created to classify the potential initial infiltration, and which aquifers might be recharged. The initial infiltration classification is based on the infiltration recharge limit of the recharge domains. To assess which aquifers could be recharged, two questions are needed:

- •Is the aquifer present beneath the area?
- •How easily does water pass through the overlying aquitard layers?

The first can be answered through the model layer grids (see Figure A2- A6 showing presences or absence of strata. Table A1 summarises the GIS model summary of layers.

The second is dependent on assessing the rate of vertical movement through a layer. In the case of the London Clay (which is not present in the Wensum but is in the neighbouring Bure Catchment which has also been assessed), where it is present, there is no recharge to the Chalk modelled (Figure A6).

For Layer 2, which includes the variable till (both in presences, thickness, and permeability), a classification of vertical water movement through layer 2 is presented Table A1.Table A3 shows an example attribute table summarising the findings.

These parameters are based on assumptions taken from modelling efforts in the Wensum Catchment therefore further validation is needed through pilots and monitoring.

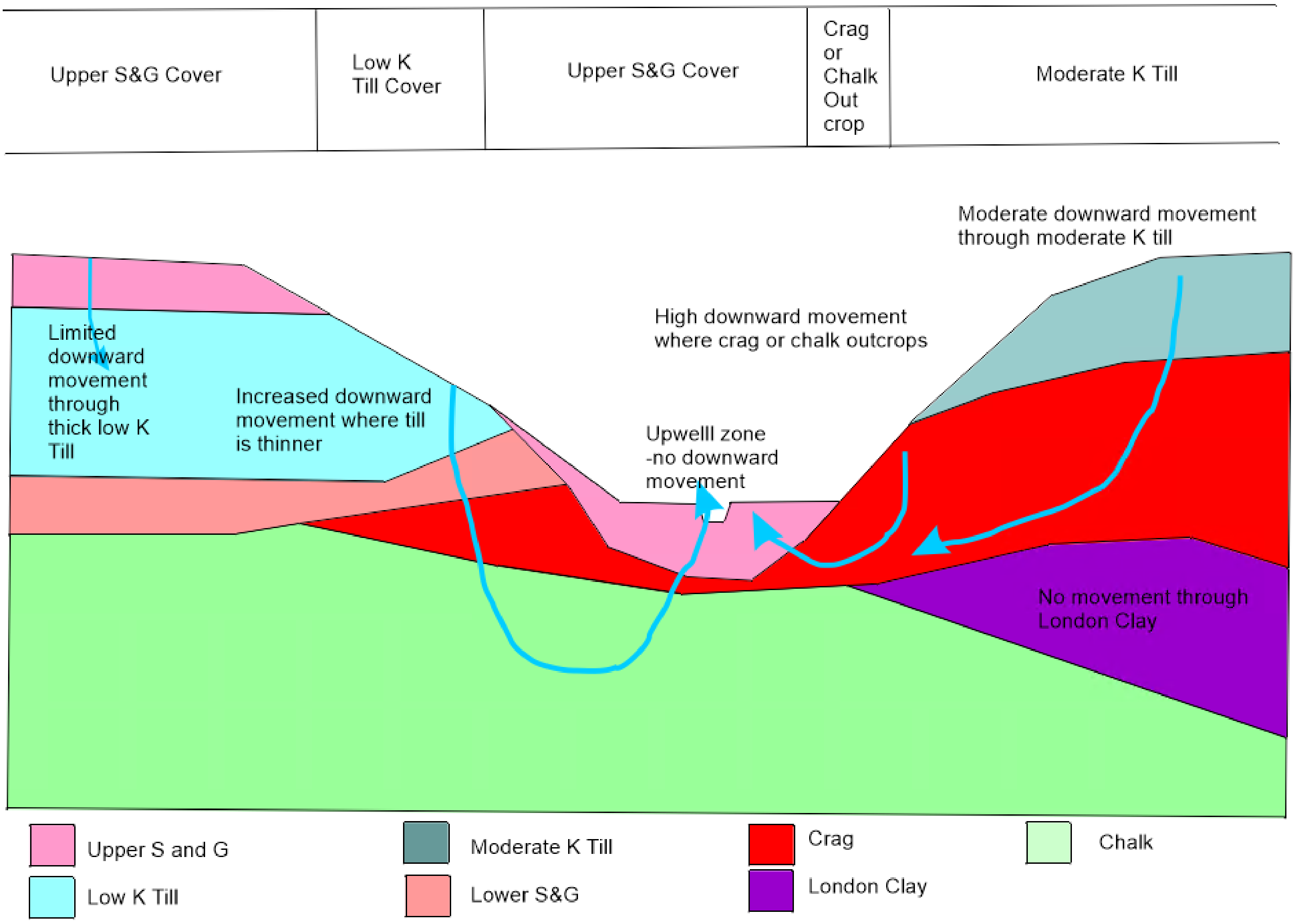


Figure A1 : Conceptual Site Model

Table A1 :Layer 2 Conductance Categories to Layer 3

Flow Categories	Recharge Discussion
Till Not Present (High Conductance)	If till layer is not there it will not affect recharge
Upwards flow (No Conductance)	This is present along the main valley floors. Where there is upward vertical flow, recharge will just be to the Shallow System (Layer 1) at times when groundwater levels are below the surface. These are areas of discharge for the chalk aquifer.
High Conductance	Categories can be defined on the conductance through Layer 2 (till). This will split the downwards vertical range into three categories e.g. 30+mm/d - high 10-30 mm/d - medium 0 - 10 mm/d - low This is banding to show the variability within the catchments.
Medium Conductance	
Low Conductance	

The table below summarises how the model layers have been used to assess recharge mechanism for the which aquifers.

Table A2 : GIS Summary for Wensum and Bure

Model Layer	Name	Discussion	GIS Requirements
As Appropriate	Alluvium	This layer is not in the model, and it is assumed despite its potential low permeability will have a limited role in retarding flows to lower layers. Where it does have an aquifer role, it works jointly with the Upper Sands and Gravels.	Do not represent
1	Upper Sand and Gravel (glacial river terrace)	The first aquifer present.	Identify as present or absent
2	Glacial Till	This is a relatively widespread aquitard that separates layer 1 from the layers below. It varies in the amount of water it allows through.	Produce Conductance Layer
3	Lower Glacial Sands and Gravels and Craig	This is a relatively widespread aquifer.	Identify as present or absent
4	London Clay	This is present in the east of the Bure - where present it separates layer 3 from Chalk	Identify as present or absent
5	Top Chalk	Chalk underlies the whole area, and it is in direct contact with layer 3 where that layer is present, except where London Clay is present.	Presence or absence of London Clay
6	Bottom Chalk	Not of relevant for recharge work.	Not of relevant for recharge work

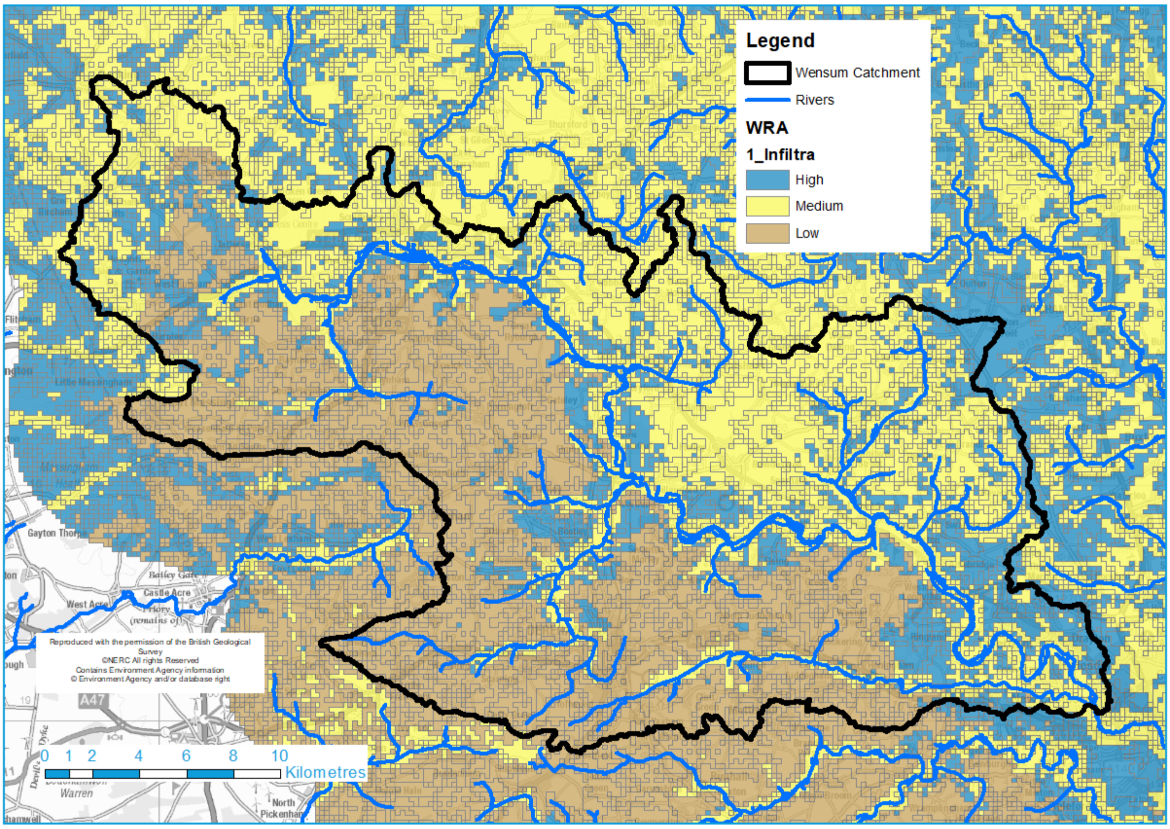


Figure A2: Infiltration Classes

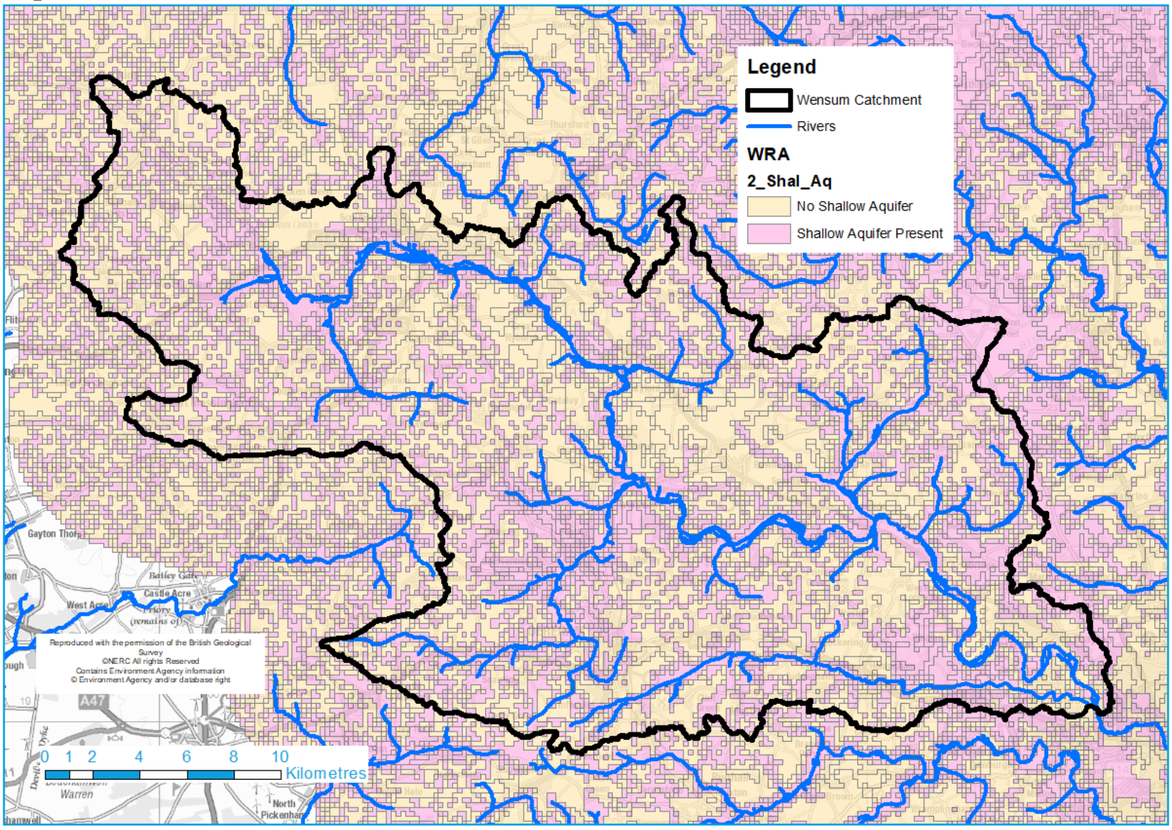


Figure A3: Shallow Aquifer Presence

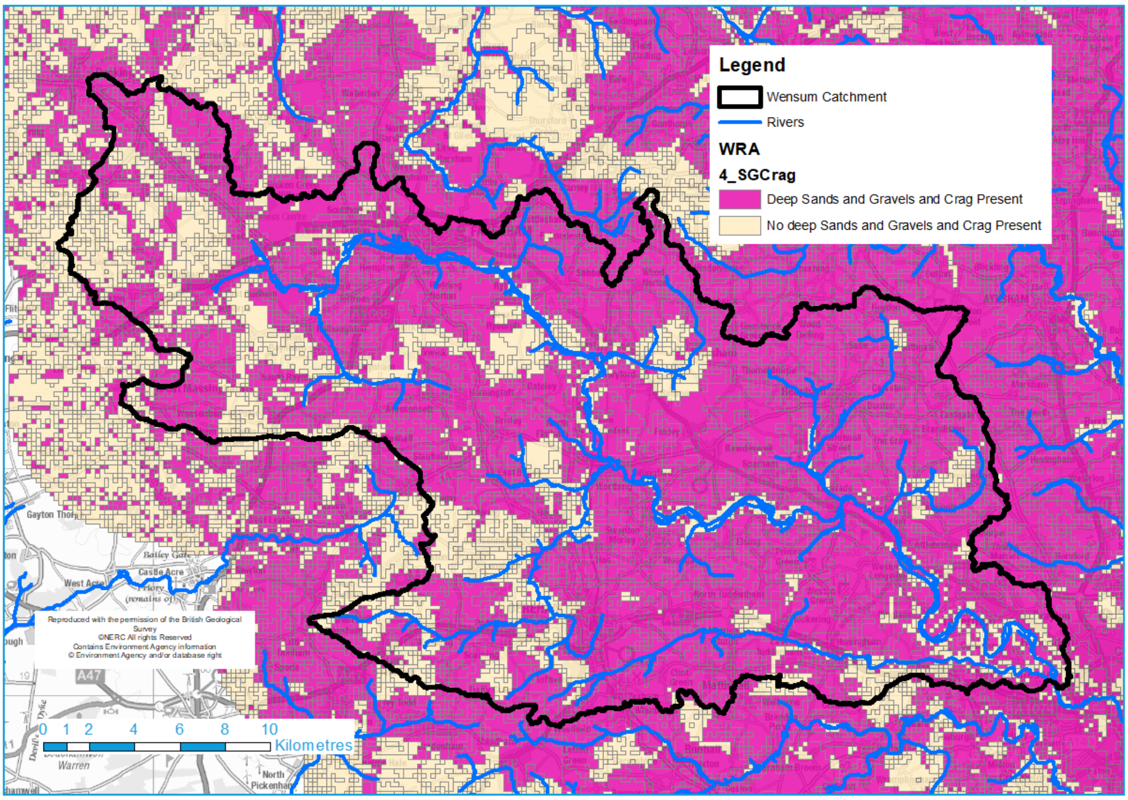


Figure A4: Depper Sand and Gravel and Crag Presence

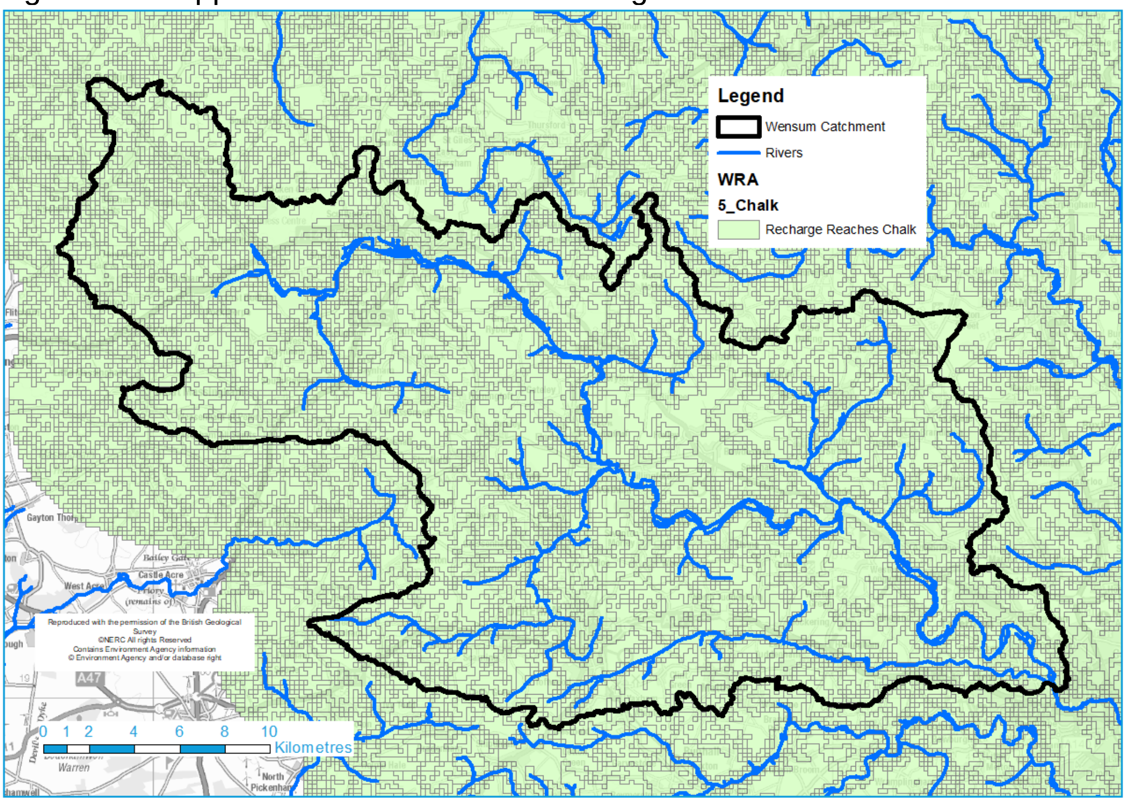


Figure A5: London Clay Presence

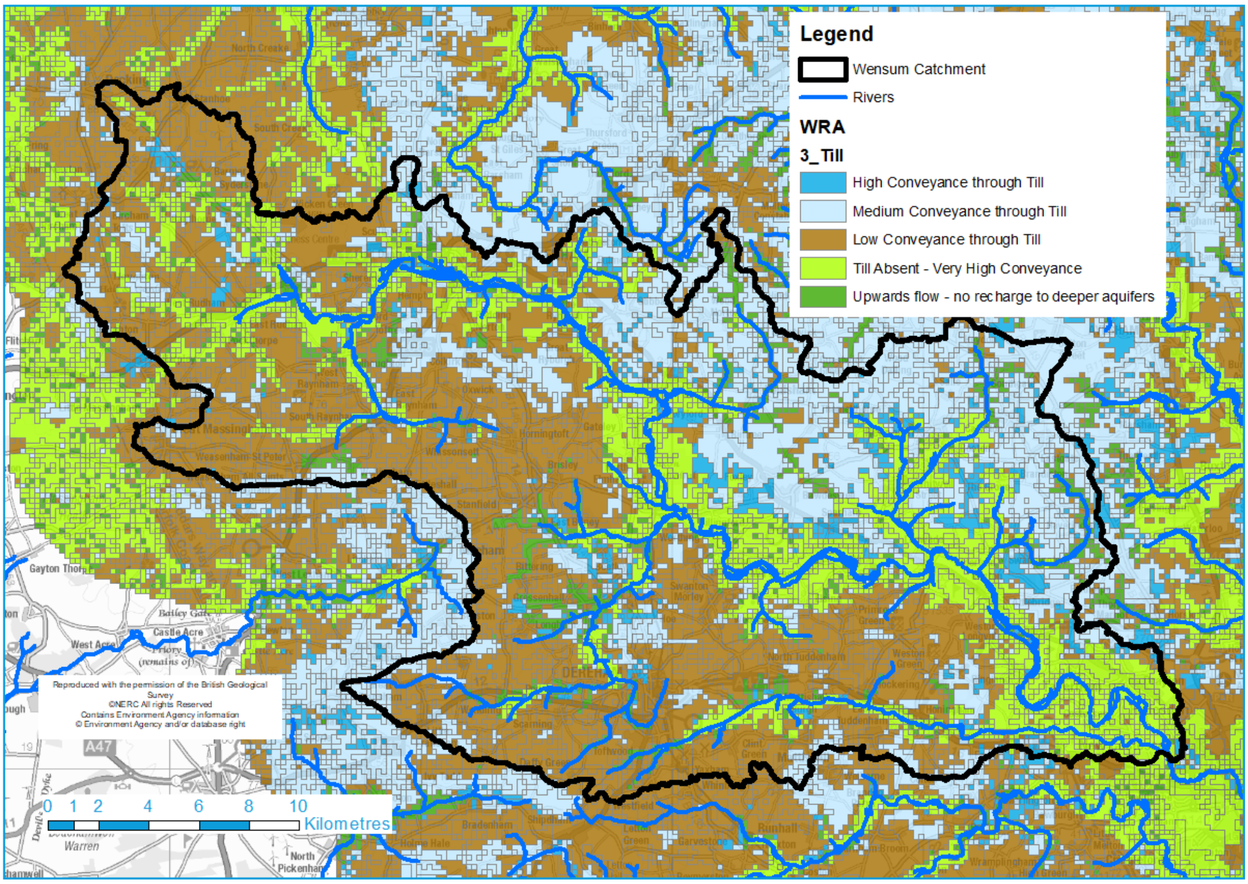


Figure A6: Conveyance Through Layer 2 Till

Table A3: Example Attribute Table with Summary

1_Infiltration	2_Shal_Aq	3_Till	4_SGCrag	5_Chalk	Summary
High	Shallow Aquifer Present	High Conveyance through the till	Deep Sands and Gravels Present	Recharge Reaches Chalk	High amounts of recharge to shallow aquifer. A significant proportion of this can find its way through the till to the deeper aquifers
Low	No Shallow Aquifer Present	Low Conveyance through the till	No deep Sands and Gravels Present	Recharge Reaches Chalk	Low permeability till present so there is little infiltration. A proportion of this small amount will find its way to the deeper aquifers
Low	No Shallow Aquifer Present	Low Conveyance through the till	Deep Sands and Gravels Present	London Clay blocks recharge to Chalk	As cell above, but the presence of the London Clay means the recharge doesn’t reach the Chalk
High	Shallow Aquifer Present	Upwards flow – no recharge to deeper aquifer	Deep Sands and Gravels Present	Recharge Reaches Chalk	Area of upwelling so recharge only reaches the shallow aquifer despite there being no aquitard layers beneath. Note it says “Recharge Reaches Chalk, but there is no recharge that makes it this far.

JBA consulting

Offices at

Bristol
Coleshill
Doncaster
Dublin
Edinburgh
Exeter
Glasgow
Haywards Heath
Leeds
Limerick
Newcastle upon Tyne
Newport
Peterborough
Portsmouth
Saltaire
Skipton
Tadcaster
Thirsk
Wallingford
Warrington

Registered Office
1 Broughton Park
Old Lane North
Broughton
SKIPTON
North Yorkshire
BD23 3FD
United Kingdom

+44(0)1756 799919
info@jbaconsulting.com
www.jbaconsulting.com
Follow us:

Jeremy Benn
Associates Limited

Registered in England
3246693

JBA Group Ltd is
certified to:
ISO 9001:2015
ISO 14001:2015
ISO 27001:2013
ISO 45001:2018

CHAS Accredited Contractor CHAS.co.uk
IEMA
CYBER ESSENTIALS CERTIFIED
CIEEM REGISTERED
ARMED FORCES COVENANT