A2Dominion South

NW Bicester Eco Development

Groundwater Supply: Feasibility Study

Technical Briefing Note

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Technical Briefing Note

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1 INTRODUCTION

1.1 Brief

Hyder Consulting (UK) Ltd (Hyder) were instructed by A2Dominion (Gerry Walker e-mail of 24 July 2013) to conduct a desk study based feasibility study for a groundwater supply for Bicester Eco Town (referred to as the" Site" in this report).

1.2 Scope

The agreed scope of work is:

a) Review existing desk study information;

b) Review Catchment Abstraction Management Strategy;

c) Discussions with Environment Agency to identify early any issues with abstraction licensing;

d) Identification and assessment of water interests;

e) Review of (known) water quality and any issues;

f) Develop a hydrogeological conceptual model;

g) Analytical appraisal of anticipated well volumes, radius of influence and potential effects on neighbouring water interests; and

h) Produce a Technical Briefing Note (this report) – identifying initial feasibility of a groundwater supply scheme.

1.3 Bicester Eco Town Water Needs

Details of the water strategy for Bicester Eco Town is presented in the Hyder (April 2011) NW Bicester Eco Development, Water Cycle Study Outline Stage. This discusses the average consumption for an average household, which was estimated as 159 litres per person per day (L/person/day). The Bicester Eco Town water strategy includes the need for use of water efficient devices and for water re-use for some non-potable water uses. The proposed residential property water use will be at least 110 L/person/day; meeting level 4 of the Code for Sustainable Homes as a minimum. Preliminary calculations in this report are based on a worst case 150 litres/person/day (as advised, P. Harker e-mail 28 August 2013).

The total Bicester Eco Town population is expected to be in the region of 13,000 residents on completion of the development. In addition there are proposed new primary schools, a secondary school and various businesses and community buildings. The preliminary annual water demand has been calculated by Hyder (P Harker e-mail 28 August 2013) as below:

Table 1.1 – Preliminary Water Demand Estimate

Type	Annual Water Demand (Litres)	Demand (Equivalent cubic metres per day)	Demand (Equivalent Litres Per Second
Residential Units (5000)	**716,881,443**	1964	22.7
Primary School	**71,200,000**	195	2.3
Secondary School	**20,160,000**	55	0.6
Business/ Employment	**86,237,288**	236	2.7
Retail/ leisure	**21,152,542**	58	0.7
Community	**5,536,000**	15	0.2
Total	**921,167,274**	2524	29.2

1.4 Information Sources

Table 1.2 – Summary of Information sources

Subject	Main Source Of Information
Geology	BGS sheet 219, Buckingham, S&D (2002), 1:50,000). BGS (2002) Sheet 219, sheet explanation of the geology. BGS borehole/well records (BGS website)
Hydrogeology	BGS UK Hydrogeology Viewer (1:625 000 scale) covers Bicester. BGS well borehole/well records (BGS website)
Groundwater resources	CAMS (EA website) Existing abstraction licences and discharge permits (EA data request and Envirocheck, 2010) Existing private water supplies (LA)
Water Quality	Pollution incidents (Envirocheck, 2010) Regional (EA website and data request) Local from private water supplies (LA)

BGS is British Geological Survey;
EA is Environment Agency
LA is local authority (Cherwell District Council)

2 SITE DESCRIPTION AND SURROUNDINGS

Figure 2.1 shows the extent (green hatch) of the Site, which is located immediately north east of Bicester town. The Ordnance Survey (OS) grid reference of the Site centre is SP 566 243.

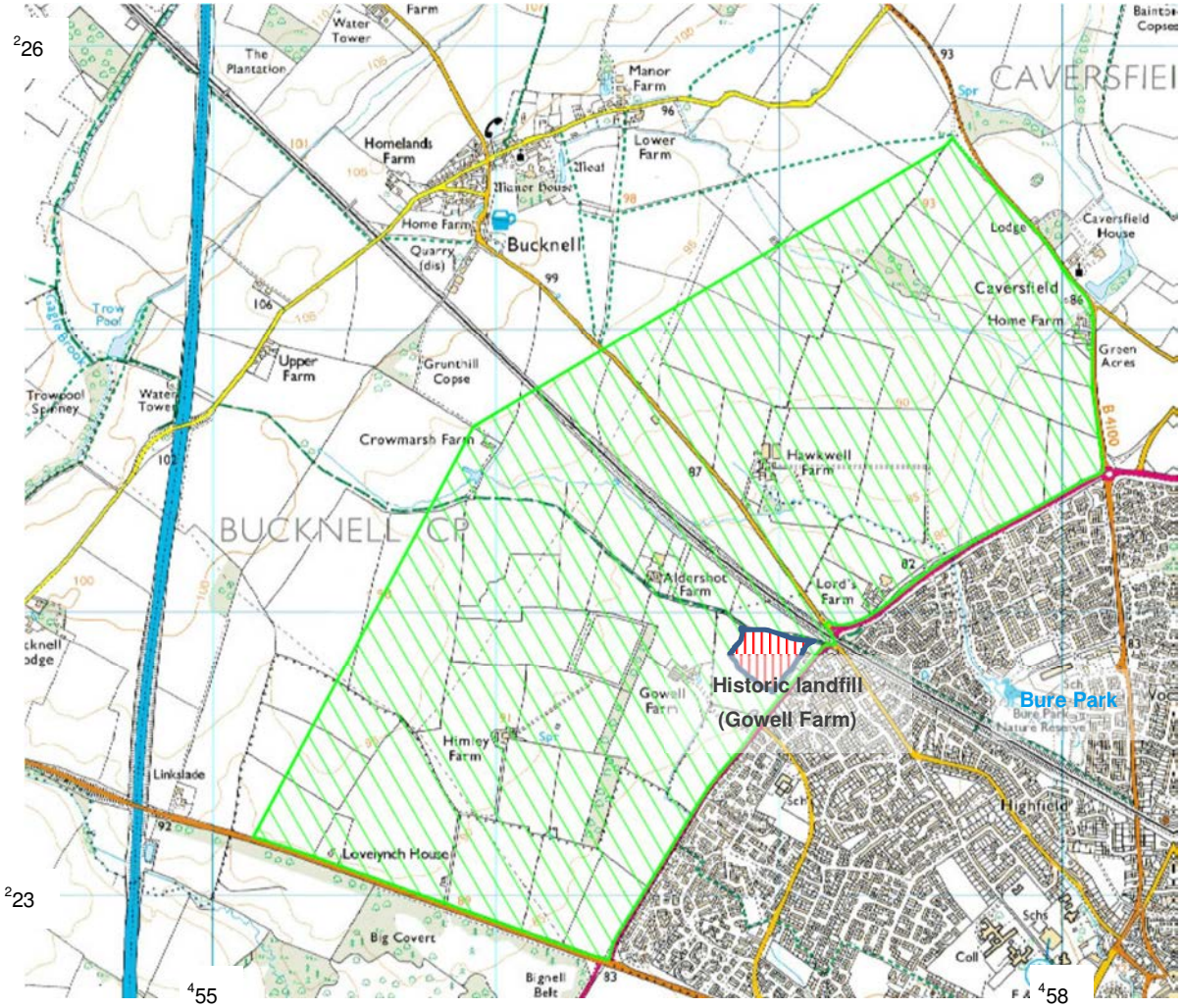


Figure 2.1 – Site location of Bicester Eco Town

The Site currently comprises mostly farm land including several farm houses. Bucknell Road and the railway line run through the centre of the Site. “B” roads border the Site to the east and south-south-west. The A4095 road and Bicester town border the Site to the south-east. Streams run through the Site as marked by the thin blue lines in Figure 2.1. These generally flow towards the SE to SSE and join the River Ray 7 km away, south of Bicester.

Bure Park Nature Reserve is located approximately 500 metres from the southern site boundary (Figure 2.1). See Appendix 1.

Ardley Cutting & Quarry Site of Special Scientific Interest (SSSI) is located west of the Site (Envirocheck 2010, see Appendix 1).

An historic landfill is recoded as present on the Site at Gowell Farm. Records suggest that this location may have been previously quarried for limestone. Also a local authority recorded landfill site is recorded at approximately the same location (Envirocheck 2010, see Appendix 1).

Several other historic landfills are recorded off Site on the EA website (approximate O.S. grid references of landfill site centres are shown):

- Ardley Fields Farm 2 (4542 2255);
- Ardley Inert Area (ditto);
- Disused Tip at Elm Farm Quarry, Stratton Audley (waste 1948 to 1975) (4599 2253).

Authorised landfills within 2 km of the Site boundary are also shown on the EA website:

- Ardely Quarry (southern extension) (4542 2263) (edge of 2 km radius)
- Glebe Farm, Fringford. (4591 2274)

3 GEOLOGY AND HYDROGEOLOGY

3.1 Regional Geology

The regional geology comprises a patchy outcrop of generally thin superficial deposits such as alluvium and head deposits over bedrock comprising mostly limestone and mudstone of the Jurassic. The regional stratigraphy, in order of increasing depth, is summarised in Table 3.1. Figure 3.1 and Figure 3.2 shows an extract of BGS Sheet 219 and legend.

BGS Sheet 219 (1:50,000) shows “Bicester 1 Borehole”, located at grid reference 5878 2081, as being a deep borehole of c. 400 m depth. This has been used in the sheet cross section 2.

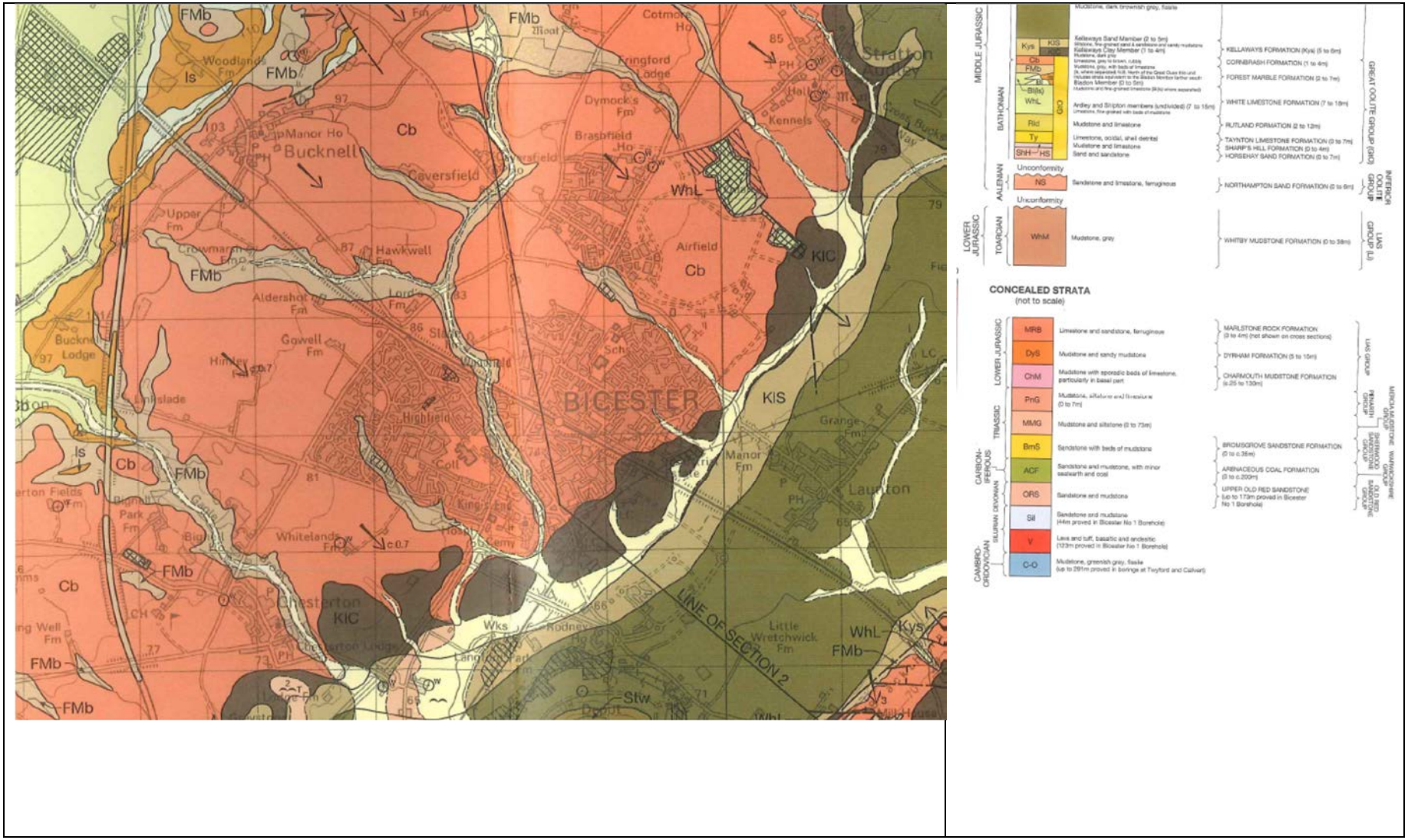


Figure 3.1 – Regional Geology Map (BGS copyright: [C09/013-CCSL] British Geological Survey @ NERC. All rights reserved)

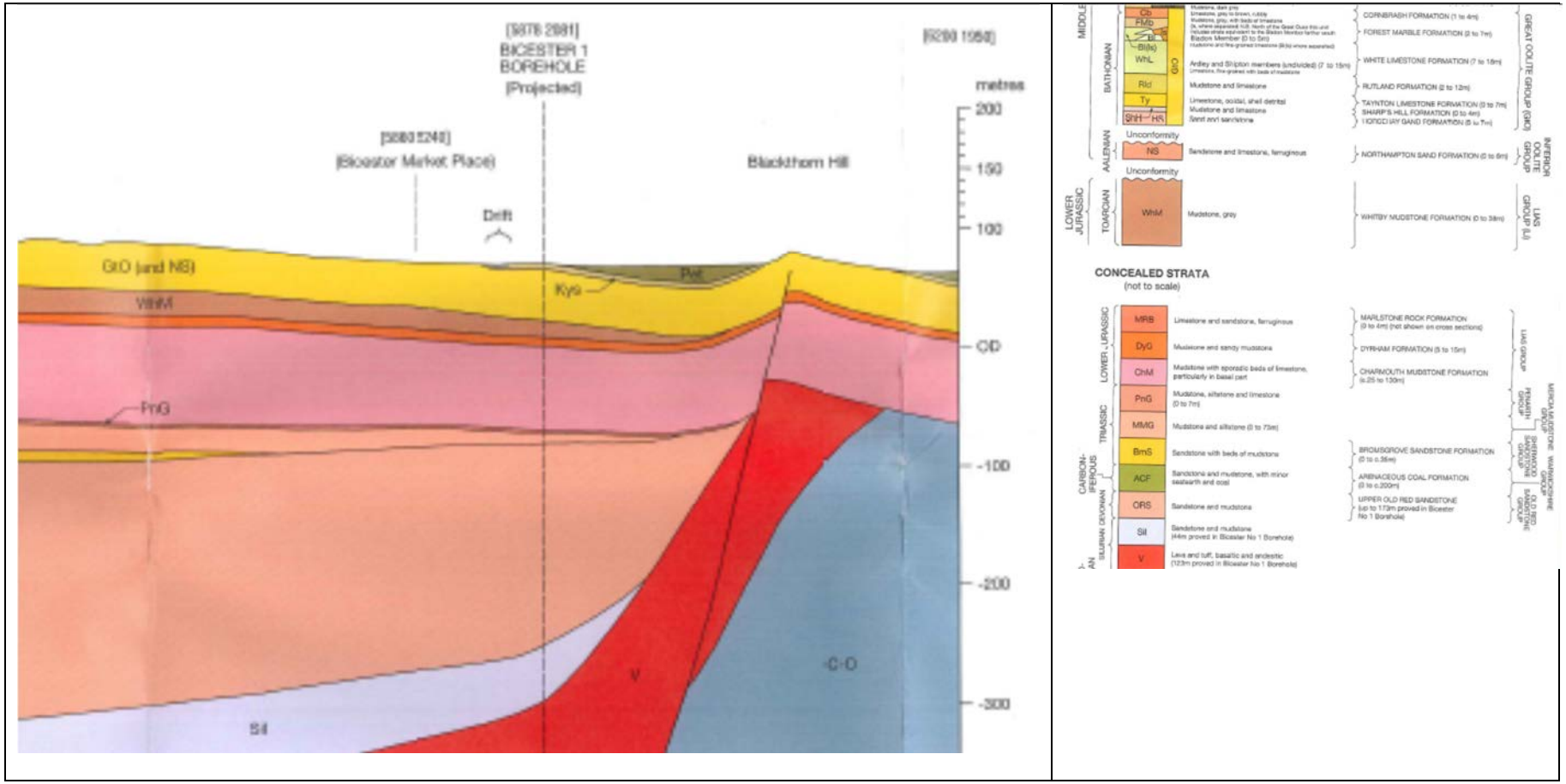


Figure 3.2 – Regional Geological Section (Line of Section 2)

Table 3.1 - Summary of Bedrock Stratigraphy

Geological Group (Age)	Formation	Description	Thickness range (metres)
Great Oolite Group (Middle Jurassic)	Cornbrash Formation	Rubbly Limestone	1 – 4
	Forest Marble Formation	Pale grey mudstone with beds of flaggy limestone	2 - 7
	White Limestone Formation	Mainly fine grained limestone (mudstone may be present)	7 - 15
	Rutland Formation	Mudstone, calcareous mudstone and limestone	2 – 12
	Taynton Limestone Formation	Shell fragment and ooidal limestone	0 – 7
	Sharps Hill Formation	Mudstone. calcareous mudstone and limestone	0 – 4
	Horsehay Sand formation	Sand and sandstone (previous name, "White Sands")	0 – 7
Inferior Oolite Group (Middle Jurassic)	Undifferentiated but includes Northampton Sand Formation (NS)	Sandstone and limestone, ferruginous.	0 - 6
Lias Group (Lower Jurassic)	Whitby Mudstone Formation	Medium and dark grey fossiliferous mudstone and siltstone	0 - 38
	Marlstone Rock Fm. (MRB), Dyrham Fm.(DyS)	MRB: limestone, sandstone ; DyS: mudstone and sandy mudstone	MRB 0– 4; DyS 5- 15
	Charmouth Mudstone Formation	Mudstone with sporadic beds of limestone	25 - 130
Penarth Group and **Mercia Mudstone Group** (PnG) (MMG) (Triassic)	(undifferentiated)	PnG: mudstone, siltstone, limestone.	PnG: 0-7; MMG:10-20
Sherwood Sandstone Group (Triassic)	Bromsgrove Sandstone Formation	Sandstone with beds of mudstone	0 – 15 [2]
Old Red Sandstone Grp. (Devonian)	Upper Old Red Sandstone	Sandstone and mudstone.	Up to 173 m proved[3]
(Silurian)	(undifferentiated)	Sandstone and mudstone	44 m proved[3]
(Silurian)	(undifferentiated)	Lava and tuff, basaltic and andesitic	123 m proved[3]

Notes: 1.Stratigraphy and thicknesses based on BGS sheet 219 and explanation booklet interpretations unless otherwise stated; 2 Thickness based on BGS sheet 219 cross-section 2;

3. Thickness proved in Bicester No. 1 Borehole (according to BGS sheet 219).

3.2 Geology of the Site

Ground investigations have been conducted at the Site and comprise window sample drilled holes, rotary boreholes, trial pits and soak away tests in pits (various reports including Hyder September 2010 to Hyder September 2012 listed in section 8). The ground investigations have been for geotechnical purposes and the maximum depth of investigation is 8 metres below ground level (bgl).

Superficial deposits were either thin or absent with bedrock strata encountered close to ground level.

The whole of the Site area is underlain by the Cornbrash Formation, with the exception of the Forest Marble Formation cropping out in the floors and sides of the stream valley features.

3.3 Regional Hydrogeology

Overview

The main hydrogeological units identified from the geological sequence are summarised in Table 3.2 in order of increasing depth.

Table 3.2 – Regional Aquifers and Aquicludes

Unit	Type	Permeability, m/d	Transmissivity of aquifers, m^2/d	Storage of aquifers	Depth to top, mbgl (thickness, m)
Great Oolite [1]	Aquifer (Secondary) (fracture flow; semi-unconfined) (fracture flow, confined)	Inter quartile range of 2.5 E^{-4} to 3.0 E^{-3} m/day and a geometric mean of 9.8E^{-5} m/d (core data)	Inter quartile Range: 37 to 825. Geometric Mean: 212	Specific yield : 3%. Storage coefficient interquartile Range: 1.0 E^{-4} to 6.8 $E^{-4.}$	c. Ground surface (c. 40)
Lias mudstones	Aquiclude (locally aquitards)		-	-	c. 40 mbgl; (c. 130 m)
Old Red Sandstone [2]	Aquifer (Secondary)		Inter quartile Range:49 Geometric mean:11	Minimum, maximum storage coefficient 1.9 E^{-4} to 5.0 E^{-2}	c.160 m (c. 200 m)

1. Values of transmissivity and storage from the Major Aquifers Manual (BGS, EA 1997);
2. Values of transmissivity and storage from the Minor Aquifers Manual (BGS, EA 2000)

Great Oolite Aquifer

Bicester lies towards the eastern edge of the Great Oolite aquifer, classed as a moderately productive aquifer capable of supporting local supplies. Further towards the Cotswolds the Great Oolite and the Inferior Oolite form a principal aquifer which overlies the Lias Group. Beneath Bicester the Inferior Oolite appears to be absent.

The Great Oolite limestone aquifer comprises an alternating sequence of limestones and clays; the limestone beds are thinly bedded and typically not laterally persistent. The aquifer is characterised by low storativity and high transmissivity; this is demonstrated by a highly responsive aquifer with large seasonal variations. Spring lines are well-developed at the boundary of geological contacts and provide significant base flow to rivers (BGS website).

The yield of individual wells varies and is particularly dependent on the number of fissures encountered and their degree of interconnection. Large scale structure (e.g. zones of geological faults) may also account for regional variations in permeability (BGS, EA 1997).

The Table 3.2 Great Oolite permeability and transmissivity values are based on Cotswold examples, where the aquifer is thicker and is of a higher transmissivity (only available reliable data). Therefore the values of permeability may be higher than for Bicester.

Old Red Sandstone Aquifer

The Old Red Sandstone (ORS) is deep below the whole region and little data are currently available. Published data relate to other UK regions. Data from the Minor Aquifers Manual (BGS, EA 2000) have been summarised in Table 3.2; it is likely that the Bicester example is from deeper strata which may have consequently lower transmissivity and storage values.

The Minor Aquifers manual (BGS, EA 2000) comments that “in spite of the great thickness attained by the Old Red Sandstone, the permeability (and hence the transmissivity) is limited.” This is in part due to the presence of mudstone, siltstones and marls. In the actual sandstone the primary porosity can also be low. In general the predominant flow mechanism is via fractures, with much of the storage likely to occur in joint- and fault-related fracture systems (BGS, EA 2000).

The ORS may be overlain by 0 to 15 m thick Bromsgrove Sandstone Formation (Sherwood Sandstone Group). This formation would be expected to be in hydraulic continuity with the ORS aquifer and would increase the thickness and transmissivity of the ORS aquifer.

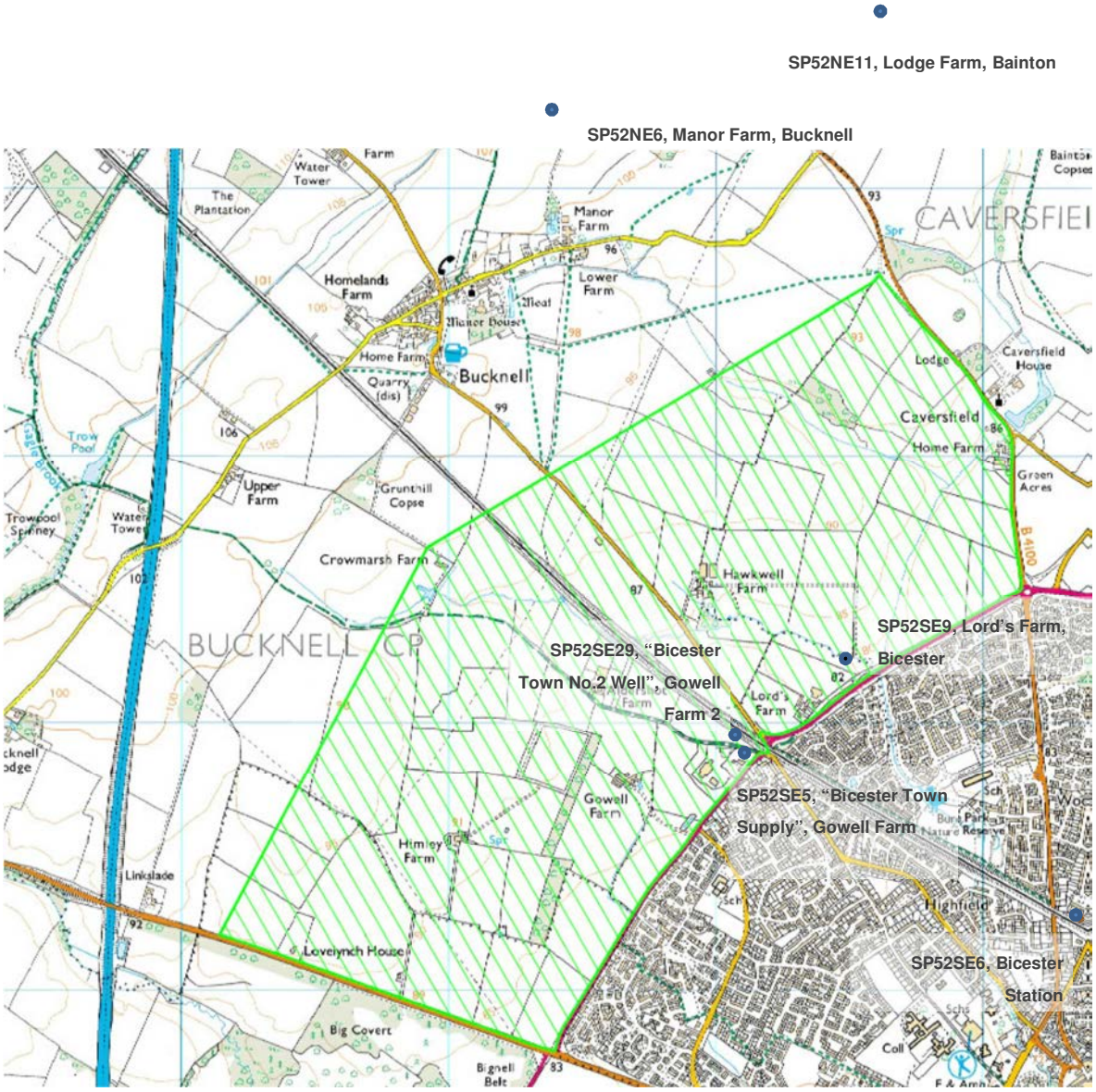
The ORS is expected to be underlain by Silurian sandstones and mudstones. There is limited information available for these strata and it is likely that deeper drilling could make anything more that marginal gains with respect to water supply.

Historic Wells

Historic well and borehole records have been obtained. These are generally of old wells drilled in the Great Oolite Group and underlying Northampton Sandstone Formation (latter where present). The records show that the Great Oolite was used for water supply including for Bicester town in the 1930’s. Associated pumping test data for these locations are generally limited to a stated yield and absent or brief drawdown information. Yields stated in these records for the Great Oolite in this area are typically between 0.5 to 11 litres per second. Further discussion is presented in section 6.2. Historic well and borehole records are summarised in Table 3.3 below and locations are approximated on Figure 3.3.

Table 3.3 – Summary of Historic Wells

Name	Location; O.S. grid reference	Recorded Yield, (calculated) cubic metres per day	Recorded Yield, (calculated) litres/second	Ground level (mAOD); Depth (mbgl)	Interpreted Strata within well screen or open bore	Notes
BGS SP52NE6	Manor Farm, Bucknell; 456350,226250	39	0.5	97.5 mAOD 77 mbgl	Uncertain (Great Oolite, Inferior Oolite and top of Lias mudstone?)	Year of 1924; Drawdown of 60 m.
BGS SP52NE11	LODGE FARM BAINTON; 457670,226770	196	2.4 (yield during 8 hours of pumping)	? mAOD 41 mbgl	Uncertain (Great Oolite, Inferior Oolite and top of Lias mudstone?)	Year 1949; Drawdown of c. 1 m. Recovered to rest level within 3 minutes
BGS SP52SE5	"Bicester Town Supply", Gowell Farm, nr. Bicester; 457090,223840	715	8.8 to 0.6 (9 hours pumping per day in 1934)	84.4 mAOD 34 mbgl (BGS scan title says 43)	Great Oolite Group	Test in 1934. Artesian flow of 7.6 L/s. Artesian head c. 1 m (1934). "Bulk of water" from 32 mbgl in 3 m thick (Taynton?) rock. Handwritten note on BGS record says, "bore caved in; pump removed".
BGS SP52SE6	Bicester Station; 458510,223190	872	10.8 (artesian flow of 4 L/s)	77.7 mAOD 37 mbgl	Great Oolite Group	Year? Artesian flow. Main water strike at 30.5 mbgl in <5 m thick sands (Serford Beds facies, sands of the Chipping Norton Limestone Fm.?)
BGS SP52SE9	Lord's Farm, Bicester 457450,224230	147	1.8	79.2 mAOD 80 mbgl	Great Oolite Group (base at c. 37 mbgl)` with Lias clays logged below)	Year 1941. Water struck at 4, 27 and 75 mbgl (inferred as coincident with White Limestone Fm., Horsehay Fm. and possible Lias limestone band
BGS SP52SE29	"Bicester Town No.2 Well"	770	9.5	85.5 mAOD 43 mbgl	Great Oolite Group	Year drilled 1936. 14 days pumping test. Rest water level 69 mAOD (16 mbgl). Pumped drawdown at 57 mAOD. Well base in top of Lias Clay with only 0.9 m of Northampton Sand (Inferior Oolite) above the Lias Clay.



Key: ● Historical well location (approximate)

Figure 3.3 – Historic Well Locations

Aquifer Vulnerability

The EA Groundwater Vulnerability Map shows that the Great Oolite aquifer has high vulnerability to surface pollution. This is due to the thin or absent cover of superficial deposits.

3.4 Site Hydrogeology

The Hyder (February 2011) Geotechnical Interpretative Report - Masterplan Site, states that within the trial pits, groundwater was encountered between 0.6 to 2.6 m in trial pits TP7, TP8, TP9 TP10, TP13 and TP18 respectively (location plan in Hyder, February 2011) . The remaining trial pits were dry. Trial pits TP7 to TP10 and TP13 were carried out after a period of heavy rain. Groundwater monitoring, following completion of the ground investigation at the Masterplan site, was carried out. The results suggest that excavations for shallow foundations may encounter some groundwater flow in some areas, particularly after heavy rain. The groundwater strikes within the trial pits generally coincide with the top of the limestone (Cornbrash Limestone). It is

not known whether these recorded water levels are indicative of the Great Oolite aquifer as a whole. The above report indicates they may have been caused (at least in part) by perched water after a rainfall event.

There is insufficient data to determine a groundwater flow direction, but locally it will probably be towards the nearest stream and regionally, down-dip towards the south-east.

Water courses sometimes follow lines of geological faults in the Great Oolite (BGS, EA 1997) which are also locations of higher permeability and greater flow. Therefore the location of the un-named streams on Site (Figure 2.1) may be influenced by the structural geology (i.e. main fissure orientations); indeed there is an apparent orthogonal shape to the stream pattern on Site. The Forest Marble Formation (mudstones with flaggy limestones) crops out at the sides and bottom of the small streams (Figure 3.1). Therefore the hydraulic connection of the streams with formations beneath the Forest Marble Formation may be limited depending on the thickness and permeability of the formation.

3.5 Lord's Farm Well

The Lord's Farm well is located within the Eco Town Site. The EA have sent a pumping test summary report (2 pages) for the well (Appendix 1) (EA, 2013b). The report summarises a test conducted on 3 June 2003. The test pumping rate was 3 m^3/hour (equivalent to 0.83 L/s) giving a drawdown of 0.91 m. A semi-artesian aquifer was noted based on the reported overflowing of the well during winter periods. The EA reported no visible impact on the local stream during the pumping test. The report also states a licence application for 60 m^3/day (0.7 L/s) although this may have been unsuccessful as the reported licence amount is currently 48 m^3/day (Table 4.1).

4 WATER RESOURCES, QUALITY AND INTERESTS

4.1 Water Resources

Abstraction Licences

There are no groundwater source protection zones that cross the Site (EA, August 2013) and hence no major potable water supplies (such as public water supply wells) appear to within 5 km of the Site centre.

The Environment Agency has confirmed, in response to a data record request (EA, 2012) that there is one licensed groundwater abstraction within the Site. Two other licensed abstractions are situated within 3.5 km of the Site centre; details are shown in Table 4.1. No details of depth, aquifer or pumped water levels are available. Locations are shown on Figure 4.1.

Table 4.1 – Licensed Groundwater Abstractions (within 3.5 km of Site)

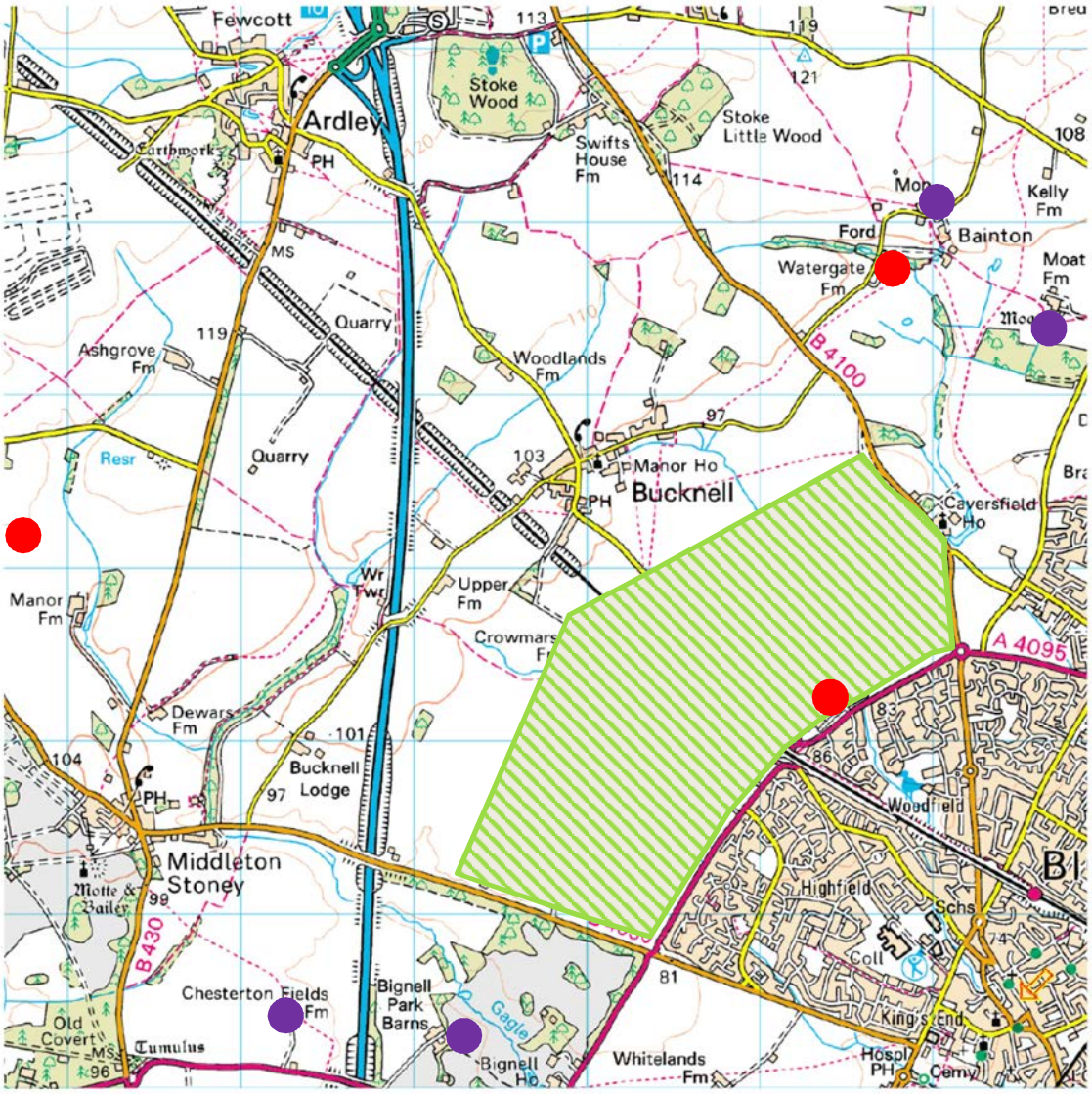
Licence Holder	Licence No. and type	Location	Distance from Site, km approx.	Quantity (cubic metres per day)	Equi-valent L/s	Quantity (cubic metres, annual)	Use and Status
W V MALINS & SON	28/39/14/0348 (Full licence) LORDS FARM - BOREHOLE	457400, 224200	On site	48	0.6	17,520	General Farming & Domestic (Current)
CF Hilsdon, Manor Fm.	28/39/14/ 102	452700 225200	1 km from site boundary (to NE)	20	0.2	7,319	General Farming & Domestic
J Hunter, Watergate Fm.	28/39/14/ 0048	457700 226700	3 km from site boundary (to WNW)	24	0.3	8,901	General Farming & Domestic

Private Water Supplies

Cherwell District Council has provided private water supply data. Such abstractions are small, i.e. less than 20 m^3/day. Details are shown below although none are located actually on Site. Locations are shown on Figure 4.1. It is possible that other private water supplies exist but the data are not held by the LA. Water quality data is discussed in section 4.2.

Table 4.2 – Private Water Supplies (within 3 km of Site centre)

Name	Location	Notes
Moats Farm	458725, 226489	Borehole. Water sample last taken in 2006
Chesterton Fields Farm	454322, 222393	Borehole. Water sample last taken in 2005
Bainton Manor	4580, 2270	Source not recorded. Water sample last taken in 2003
Bignell Park Farm	455167, 222335	Borehole. Water sample last taken in 2005



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KEY: Licensed abstraction; Private Water Supply

Bicester Eco Town area

Figure 4.1 – Groundwater Abstraction Locations (approximate)

Catchment Abstraction Management Strategy

A Catchment Abstraction Management Strategy (CAMS) details how water resources will be managed within a catchment and cover a 6-year timeframe. The Site lies within the Cherwell CAMS (EA, December 2012). The CAMS is sub-divided into areas following surface water catchments and the Bicester area is discussed as part of the Ray catchment. The CAMS document discusses water resources mostly in terms of surface water. In this region the most important factor is ensuring that sufficient flow flows towards the River Thames. The summary of the status of The Ray resources as assessed at assessment point number 4 ("AP4") is presented in Table 4.3.

Table 4.3 – CAMS Summary of Bicester Area (part of The Ray)

Item	Surface Water	Groundwater
CAMS Local Resource Status	Water available for licensing' at low flows. This status is overridden by the flow requirements of the Thames. Status changed to 'Water not available for licensing' at low flows	Not directly stated
Implication for New Licences	No new consumptive licences will be granted at low flows	All new consumptive groundwater licences in direct hydraulic continuity with surface water will be subject to a determined flow at Kingston gauging station. Consumptive groundwater licences, which do not have a direct impact and immediate impact on river flow, may be permitted all year. Restrictions will be determined case-by-case based on the nature and scale of the abstraction. All licences will be time limited to the CAMS common end date
	Licences for non-consumptive purposes or with a net benefit to the environment may be granted irrespective of the resource availability status	
Renewals and Management of Existing Licences	There will be a presumption of renewal, subject to the other renewal criteria and local considerations. Time-limited licences may be renewed with more restrictive terms and conditions. For example, the licensed quantity may be reduced to reflect actual abstraction	
Trading of Licences	EA likely to allow trades of recent actual abstraction and licensed abstraction, but little demand for trading is expected within the water body since water is available for new abstractions.	

Notes:
Information based on the Ray area as detailed in the CAMS (EA December 2012)

4.2 Water Quality

4.2.1 Regional Water Quality

River Basin Management Plans – Groundwater

The EA website (EA, 2013) shows that area around Bicester is of:

- poor "chemical quality" both currently and projected for 2015;
- good "quantitative quality" both currently and projected for 2015.

The waterbody name, that underlies the Site, is Bicester-Otmoor Cornbrash. This is assumed to indicate that the mapping refers to the thin, shallow Cornbrash Formation, stratigraphically near the top of the Great Oolite Group (see Table 3.1).

The Tackley Jurassic waterbody, located north of Bucknell, tentatively assessed as up hydraulic gradient of the Site, is shown as good chemical and quantitative quality. The BGS sheet 219 (BGS, 2002) (Figure 3.1) shows this area as comprising White Limestone Formation. It is not clear why the Tackley Jurassic waterbody is of better groundwater quality than the Bicester-Otmoor Cornbrash waterbody since both have no superficial deposits and both are agricultural areas. Possibly the Cornbrash, being thin as well as cropping out at ground surface, means that it is more susceptible to pollution.

Published Groundwater Vulnerability to Pollution

The EA website (EA, 2013) shows that area around Bicester is designated as a:

- Minor Aquifer of High Vulnerability to pollution from surface.

Nitrate Vulnerable Zones (NVZ)

The EA website (EA, 2013) shows that:

- The area around Bicester is designated within a surface water NVZ;
- A more limited area, but including most of the Site, is within a groundwater NVZ.

The EA (September 2013) state that most principal and secondary aquifers across the South East are classed as NVZs (EA, 2013b).

EA Water Quality Data

A brief assessment of received EA water quality data (EA, 2013b) has been conducted; the data comprises results from two monitoring boreholes (Figure 4.2). The geology at the Kirklington monitoring location is the Cornbrash Formation (BGS, 2013a) which is the same as at the Eco Town Site. The geology at the Wendlebury location is shown as the Kellaways Clay Member of the Great Oolite Group (BGS, 2013a); younger than found at the Site. Both monitoring locations appear to be down hydraulic gradient compared to the Eco Town site and both within the Great Oolite aquifer. The Wendlebury location may be influenced by an unnamed River Ray tributary although the outcrop of Kellaway Clay may limit its influence.

Table 4.4 summarises the recorded major ion chemistry. The major ion chemistry shows strong influence from the natural carbonate dominated strata of the Great Oolite; bicarbonate and alkalinity concentrations are high relative to other non-carbonate aquifers.

Table 4.4 – EA Water Quality, Major Ions

Parameter	UKDWS	Minimum	Maximum	Number of Tests
Calcium	-	80	113	40
Magnesium	-	12	18	45
Sodium	200	71	93	45
Potassium	-	5	8	45
Chloride	250	18	22	40
Sulphate	250	115	155	40
Alkalinity ($HCO_{3)}$	-	336	399	40
Nitrate (NO_3/l)	50	Less than 0.9	7.2	40

All results are mg/l

The presented results indicate similarity with confined groundwaters of the Great Oolite aquifer when compared against the same strata from the Cotswolds (BGS, EA 2003). However sodium and sulphate concentrations recorded in Table 4.4 are greater that the Cotswolds example and may indicate more ionic exchange related to longer residence times or other external unknown influences.

The nitrate concentrations shown in Table 4.4 are all less than the drinking water standard. The results are relatively low for an agricultural area and are typical of a confined aquifer where diffuse anthropogenic influences (e.g. application of fertilisers) have less influence. The EA said that there are unable to comment on nitrate concentrations below the Eco Town Site (EA, 2013b).

Virtually all hydrocarbon compounds are recorded as below detection level and therfore contamination from hydrocarbons appears to be low. Detection was recorded for three results (bentazone, m-p xylene and ethyl benzene at Wendlebury Chicken Farm); these are shown in the below table. The results are less than the UK drinking water standard. In addition three gas chromatography-mass spectrometry (GCMS) scans detected target compounds; the recorded concentrations were low (generally less than 1 µ/l).

Table 4.5 – EA Water Quality, Selected Data

Parameter	UKDWS	Minimum	Maximum	Number of Tests
Nitrate (mg NO_3/l)	11.3	Less than 0.9	7.2	40
Bentazone (µ/l)	500	Less than detected	0.00754	9
m-p xylene (µ/l)	500	Less than 0.2	0.59	10
ethyl benzene (µ/l)	300	Less than 0.1	0.12	10

Note: Bentozone water quality standard available is for surface water quality only and relates to the WFD; xylene and ethylbenzene drinking water quality standards shown are for WHO as no specific UK drinking water standard are available. Results are from Wendlebury Chicken Farm and Kirklington Park Farm, located 2 km S of the Site boundary and 4.5 km W of the Site respectively. These are EA monitoring boreholes installed within the Great Oolite aquifer.

KEY: EA Groundwater Quality Monitoring Location

Figure 4.2 – EA Water Quality Monitoring Locations (approximate)

Private Water Supply Water Quality Data

Cherwell District Council has provided private water supply data (section 4.1) within 3 km of the Site centre. Data are from single sampling events, between 2003 and 2006. Water analyses of the borehole supplies are expected to be from the Great Oolite aquifer and are summarised below.

Table 4.5 – Water Quality Data (Private Water supplies)

Parameter	UKDWS	Minimum	Maximum	Number of Tests
pH (pH units)	6.5 to 10	7.4	7.6	2
Electrical Conductivity (µ S/cm at 20 °C)	2500	706	728	2
Total Coliforms (cfu/100 ml)	0	1	9	2
Nitrate ($mgNO_3/l$)	50	57.1	58.4	2

Note: Results are from Chesterton Fields Farm and Bignell Park Farm.

The results indicate that, based on the limited data, nitrate concentrations of the Great Oolite aquifer, at these locations, exceed the UK drinking water standards (UK DWS)..

Local bacteriological contamination is also evidenced. A larger testing suite would be needed to assess the groundwater quality suitability with respect to other contaminants.

Old Red Sandstone Aquifer Water Quality

There are no water quality data currently available. The aquifer is deep and unlikely to receive direct rainfall recharge. Therefore high residence times of groundwater may mean a high mineral content (e.g. high iron, manganese and other trace metals). Water quality could tend towards brackish rather than fresh.

Pollution Records

The Envirocheck records (2010) shows one pollution incident to controlled waters:

- stream 200m south of southern site boundary just upstream of Bure Nature Reserve (Envirocheck, 2010, item B2) located at approx. 4576 2239) (Appendix 1)

The Bure Nature Reserve could be a receptor from upstream contamination, if it occurred, including from the Site. The above pollution incident is unlikely to represent a Site groundwater quality problem; the source is more likely to be related to the urban location of the reserve.

Landfills

Landfills can be a potential source of groundwater pollution. Locations of historic and authorised landfills are summarised in section 2. The Gowell Farm historic landfill, on Site, may be a potential source of contamination (Great Oolite aquifer) although may be generally down hydraulic gradient of most of the Site.

Historic and authorised landfills at Ardley are approximately 2 km north-west of the Site and therefore are likely to be up-hydraulic gradient of the Site and a potential source of contamination of the Great Oolite aquifer

Discharges

Discharges to ground, and to a lesser extent, discharges to surface water can be a potential source of contamination to groundwater. Envirocheck (2010) (Appendix 1) shows that there are:

- 3 existing discharge consents on the Site

Two of the consents are located at Himley Farm and Lord's Farm (Figure 2.1); they are not adjacent to a water course and therefore may be discharges to ground. No further information is available but they could relate to domestic septic tanks and hence could be a local source of contamination to the Great Oolite aquifer. Further checks would be needed to confirm if necessary. The third discharge is located on a stream beside filter beds at Caversfield and therefore appears to be a discharge to surface water.

4.2.2 Site Water Quality

Water analyses were carried out as part of Hyder ground investigations using the shallow standpipes. Therefore these are not directly related to the water quality of the whole Great Oolite aquifer or deeper strata. Emphasis was checking for heavy metal contamination and to a lesser extent, hydrocarbon contamination. The results indicated uncontaminated water based on the testing of the selected samples which were below UK drinking water standards (Hyder 2010 to 2012). A larger testing suite would be needed to assess the groundwater quality suitability for drinking water.

The offsite water quality testing does not give a clear indication of whether the Eco Town site groundwater has high nitrate as there is apparently conflicting evidence when comparing the

results of the EA monitoring locations and the private water supplies. The EA website shows poor “chemical quality” which may indicate high nitrates, but is possibly related to the Cornbrash Formation only (section 4.2.1). Deeper formations within the Great Oolite Group may be of better quality as at the Eco Town site the White Limestone Formation is overlain by thin Forest Marble Formation mudstones (Table 3.1).

4.3 Water Interests and Features Summary

A preliminary summary of water interests and water features is presented in Table 4.5. The search radius is between 3 km to 6 km depending on feature.

Private water supplies, other than those locations provided by the LA, may exist. Private water supplies are likely to be from the Great Oolite aquifer, if a borehole source.

Springs are characteristic of Great Oolite caused by water colleting on layered geology and also rising through fissured rock. The occurrence of the springs should be checked if necessary (walkover, historical maps). Springs may be an important contributor to stream flow and any private water supplies.

All the listed water features or interests relate the Great Oolite aquifer. The deep Old Red Sandstone aquifer is not in hydraulic connection with these given the c. 130 m thick aquiclude or aquitard strata above the Old Red Sandstone aquifer.

Table 4.5– Preliminary Summary of Water Features and Interests

Water Feature/Interest	Location	Distance from Site	Notes
Groundwater Abstractions			
Public Water Supply Sources	None	None < 5 km	None
Lord's Farm Borehole (licence))	475400, 224200	On Site	Licensed groundwater abstraction (Great Oolite aquifer). See Table 4.1.
Manor Farm Well (licence)	452700, 225200	1 km (NE)	Licensed groundwater abstraction (Great Oolite aquifer). See Table 4.1.
Water Farm Well (licence)	457700, 226700	3 km (WNW)	Licensed groundwater abstraction (Great Oolite aquifer). See Table 4.1.
Private Water Well Abstractions (unlicensed)	4 or more locations	Off site	Rural, isolated properties may utilise small groundwater supplies of which EA would protect. Wells likely to be in Great Oolite aquifer. See Table 4.2.
Springs			
Spring at Himley Green	TBC	On Site	Noted on Envirocheck (2010)
Other springs	Not known	Not known	Springs are characteristic of Great Oolite
Water Courses			
Un-named streams on Site	See Figure 2.1	On Site and within 3 km	Great Oolite may be an important contributor to base flow of local streams.
River Ray	e.g. SP 600 182	6 km (S)	R. Ray fed by numerous streams including those from Site. R. Ray flows to Thames.
SSSI's and Nature Reserves			
Ardley Cutting & Quarry Site SSSI		TBC (W)	Envirocheck 2010 information source
Bure Park Nature Reserve	SP 577 238	0.5 km (S)	Wildfowl reserve; wetland. Downstream from Site.
Upper Ray Meadows Nature Reserve	TBC (beside A41)		Grassland and wetland beside River Ray.

5 HYDROGEOLOGICAL CONCEPTUAL MODEL

The hydrogeological conceptual model, inferred from the preceding geological and hydrogeological information, is summarised in Figure 5.1. In summary:

- The Great Oolite aquifer (a fracture flow aquifer) underlies the whole site and is in probable hydraulic connection/partial connection to surface water streams. Springs typically occur due to local shallow low permeability beds or intersection of highly fissured ground;
- The Great Oolite aquifer is 30 – 40 metres thick extending from ground surface. It comprises a sequence of limestones, mudstones and sandstones including the Cornbrash Formation (rubbly limestone) at ground surface at White Limestone Formation beneath the interlaying mudstones of the Forest Marble Formation;
- The thin or absent cover of superficial deposits means that the Great Oolite it is vulnerable to pollution from the surface (e.g. spillages, landfill or diffuse pollution). The shallow, thin Cornbrash Limestone which crops out at ground surface at the Site is vulnerable. The presence of the Forest Marble Formation mudstones may give protection locally to deeper formations, depending on the thickness and permeability of the mudstones;
- A high nitrate concentration may be present in the Great Oolite aquifer but there is conflicting information from offsite EA monitoring locations (low nitrate) and offsite private water supply wells (high nitrates). Published information tentatively indicates that high nitrates may be present in the shallow Cornbrash Formation but may be better in the deeper formations within the Great Oolite Group. ;
- Licensed groundwater abstractions at and in the vicinity of the site appear to be from boreholes constructed in the Great Oolite aquifer, with well screen intakes across most of the formations ;
- The Great Oolite typically has highest permeability where fissuring is greatest and streams sometimes occur at these locations due to geological structural influence of their location. Storage is typically low and therefore shows large seasonal variation of levels;
- Historical wells completed in the Great Oolite aquifer had relatively low yields (c. 2 to 11 L/s). There appears to have been a decline of the use of these wells to redundancy or lower licenced or unlicensed abstraction rates. This may indicate that the sustainability of higher yields is problematic;
- The Old Red Sandstone aquifer is approximately 160 m deep and extends to around 400 m deep;
- The Old Red Sandstone aquifer is overlain by thick mudstones and is therefore not in hydraulic continuity with the shallower aquifer;
- The Old Red Sandstone aquifer is predominantly a fracture flow aquifer and may behave as a complex multi-layered aquifer but with the potential for fracture closure with increasing depth. Published transmissivity values are low;
- The Bromsgrove Sandstone Formation (0 – 15 m thick) may be present and if so would slightly increase the thickness and transmissivity of the Old Red Sandstone aquifer, being in hydraulic continuity with it;
- The Old Red Sandstone does not receive direct rainfall recharge in the region and therefore long residence times of groundwater mean the potential for leaching out of minerals. The water could tend to be more brackish than at shallow depths and there could be elevated mineral content of say iron, manganese and trace metals;

- Geological faults (e.g. BGS sheet 219 mapped fault located 1 km to the north or other smaller unmapped faults) are likely to give locally more fissured and therefore higher permeability zones in the bedrock.

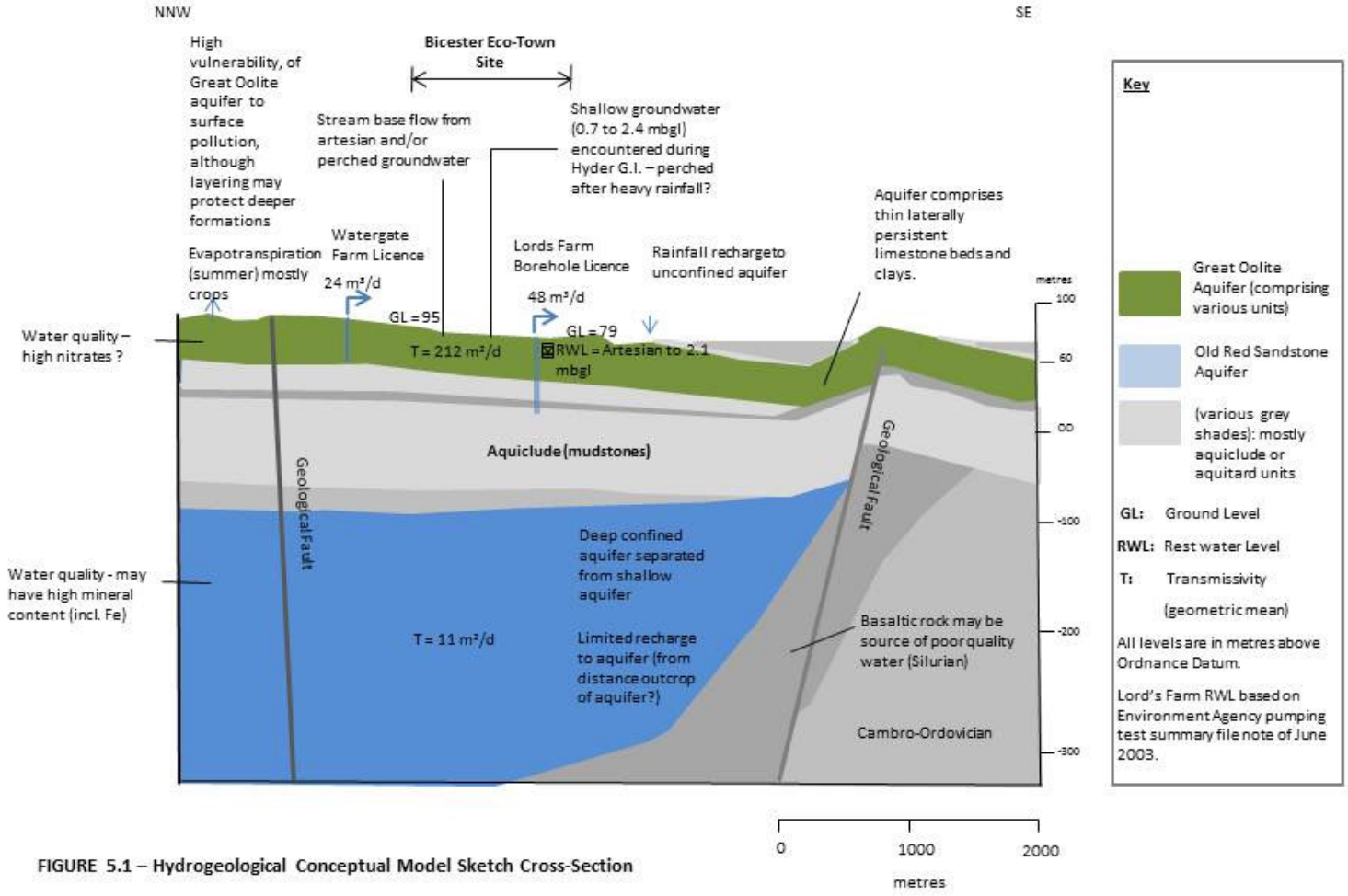

FIGURE 5.1 – Hydrogeological Conceptual Model Sketch Cross-Section

6 APPRAISAL OF A NEW SUPPLY

6.1 Feasibility

The feasibility of a new groundwater supply is largely determined by several key factors and is summarised in Table 6.1:

- Yield – can it be demonstrated that the required yield can be given from the proposed well?
- Sustainability of yield – evidence needed to demonstrate likely longevity of yield;
- Water quality needs to be suitable for potable water (or economic treatment is available);
- Environmental impacts should be low.

Table 6. 1 – Feasibility Summary of Aquifers for New Supply

Factor	Great Oolite Aquifer	ORS Aquifer
Yield	Marginal. More than one well would be needed. Spacing and location may be problematic.	Marginal. More than one well likely would be needed.
Sustainability	Probably low due to low storage. Susceptible to dry periods as water levels tend to fall quickly.	Marginal due to slow recharge and aquifer typically has low transmissivity.
Water Quality	High vulnerability to any surface pollution in shallow formations. Possibly greater protection for deeper formations. Current water quality shown as “poor”, probably relating to the shallowest formation. Further water quality information required to assess whether treatment would be required.	More information required. High mineral content possible due to likely long residence times.
Environmental Impact	Lord’s Farm Borehole (licensed) may be impacted. Stream flows on Site may be impacted.	Negligible as separated by thick aquiclude.

6.2 Analytical Appraisal

An analytical appraisal of anticipated well volumes, radius of influence and potential distance-drawdown effects (relevance to on neighbouring water interests) has been conducted. The analysis is tentative as it is based on the very limited pumping test data from the historical wells and published aquifer parameters for the same aquifers found outside the region.

The rest groundwater level in the Great Oolite is assumed to be shallow (e.g. approximately 0 to 2 mbgl); a saturated thickness of 37 m has been assumed and has been estimated from the local borehole logs. The rest piezometric pressure in the Old Red Sandstone is assumed to be at ground level. Reliable data for the whole of the aquifers are not available. These need to be confirmed and caution is required because the below calculations may not be sufficiently conservative if the rest water level is lower.

Great Oolite Aquifer

Historical wells data analysis (Cooper and Jacob 1946 in Krusemann and De Ridder) indicates a median permeability of $1.7E^{-5}$ m/s (transmissivity of c. 52 m^2/day). The maximum calculated permeability is 8.0 E^{-5} m/s (data thought unreliable as only 8 hour test). The results are less than the Major Aquifers (EA, BGS 1997) interquartile range (Table 3.2) but the latter is probably representative of the aquifer in the Cotswolds rather than in the Bicester area.

The On-Site Lord's Farm licensed abstraction is relatively small (48 m^3/day or 0.5 L/s) and calculated drawdown (Dupuit-Forcheimer in CIRIA C515) at the well, using the above permeability, is less than 2 metres. This concurs with the 2003 pumping test summary report (section 3.5). Therefore the radius of influence form Lord's Farm is calculated as being minimal (less than 50 m).

A new well in the Great Oolite aquifer would not be able to achieve the 29 L/s in a single well when calculated using the Dupuit-Forcheimer method (in CIRIA C515). This is based on the median permeability. The yield is theoretically possible for the above maximum permeability but with a theoretical drawdown in the well of over half the aquifer thickness. This is not considered sustainable when considering seasonal water level variation.

New multiple wells in the Great Oolite would only be feasible if more than approximately seven wells were used (each of 4 L/s) based on the Dupuit-Forcheimer calculation method. The assumed permeability, being relatively low, would mean that the radius of influence of these would be relatively small (c. 100 m). This distance would be a first approximation for well spacing and the required distance from sensitive water features or interests.

Old Red Sandstone Aquifer

Calculation of achievable yield (using Thiem equation in CIRIA C515) indicates only moderate yields (c. 15 L/s) are available if the published transmissivity geometric mean (11 m^2/day) is used and a large theoretical drawdown (150 m) to near the top of the aquifer. Full penetration of the aquifer is assumed.

At least two wells in the Old Red Sandstone aquifer (each of 15 L/s) would be required to achieve the required yield of 29 L/s (based on calculations using the Thiem equation in CIRIA C515). The calculated radius of influence is c.400 m. calculation method. This distance would be a first approximation for well spacing. Additional well(s) should be considered for contingency purposes.

6.3 Effect on Water Features and Interests

Potential effects on neighbouring water interests are presented in the below table. Anticipated well volumes and drawdowns are estimated in this section and are based on published aquifer properties.

Table 6.2 – Qualitative Assessment of Effects on Neighbouring Water Interests

Feature Type	Detail	New Great Oolite Well	New ORS Well	Possible Mitigation
Public Water Supply Wells	No wells within 5 km	No effect	No effect	Not needed
Licensed Wells (domestic and farming)	Lord's Farm, Watergate Farm	Potential to deepen pumped water level and reduce yields.	No effect	Locate any new Great Oolite well at c. 100 m distance from existing well
Local Springs	One at Himley Farm on Site. Others?	Potential to reduce or stop spring flow	No effect	Locate any new Great Oolite well at 100 m distance from spring features
Local Streams	On Site streams	Potential to reduce flow. Potential to reduce flow downstream incl. R. Ray (see CAMS section 4)	No effect	Locate any new Great Oolite well at 100 m distance from streams
Stream Water Quality	-	Turbidity if temporarily released to stream	pH, Eh and mineral content	Locate any new well away from streams or identify mitigation
Groundwater Quality		No effect	Potentially high mineral content in ORS.	Normal best practice techniques for well casing
SSSI's and Nature Reserves	e.g. Bure Park	Could reduce stream inflow to wetland	No effect	Locate any new Great Oolite well at 100 m distance from streams

6.4 Preliminary Well Design and Investigation

The preliminary design of new wells and investigation and licensing considerations is briefly summarised below. This is based on the desk study information presented earlier in this report and should be considered as a first approximation in relation to yield and well spacing estimates (due to scarcity of data).

Well Locations Options:

Great Oolite	Supply not recommended (unless reduced supply). If so then restrictions required for potential spillage of pollutants (e.g. fuel tanks)
Old Red Sandstone	No restrictions other than suitable spacing if multiple wells (400 m). Best yields may be achieved near geological faults.

Investigation Strategy:

Great Oolite	Supply not recommended (unless reduced supply). Water quality assessment.
Old Red Sandstone	Exploratory hole drilling to 400 metres deep. Pumping test. Water quality assessment.

Licensing Requirements:

Great Oolite	Supply not recommended (unless reduced supply). If so, then: Investigation consent for drilling and pumping test then Full Licence application. Likely need to prove negligible derogation of Lord's Farm borehole (or private negotiation) plus negligible reduction of stream flow.
Old Red Sandstone	Exploratory hole drilling to 400 metres deep. Ditto above. Need to prove sustainability of yield and appropriate water quality. Pumping test.

Borehole Construction:

	Depth, m	No. of Wells	Casing, Liner
Great Oolite	40	Supply not recommended (unless reduced supply). If so, then multiple wells may be required.	Casing: to c. 10 m depth; Liner: 30 m length screen
Old Red Sandstone	400	Two plus contingency	Casing: to c. 160 m depth; Open hole to c. 400 m (or well screen of 240 m length).

Notes:
Well spacing for Great Oolite aquifer assumes low yielding (c. 4 L/s) multiple wells (see section 6.2). For a large yield well (probably not possible) the distance drawdown effects would need to be reassessed.

7 CONCLUSIONS

The Great Oolite aquifer underlies the whole site and is approximately 30 to 40 m thick extending from ground surface; it comprises beds of limestone, mudstones and sandstones. The aquifer is assessed as being marginal as a potential source of groundwater for the Eco-Town. This is due to the relatively low yields of historical wells (c. 2 to 10 l/s) and the assessed relatively low transmissivity. There may or may not be a partial hydraulic connection to surface water streams. Any new abstraction would need to demonstrate negligible impact on stream flows due to CAMS restrictions. The absence of superficial deposits means that the aquifer may be vulnerable to surface spillages although layering may protect deeper formations. Published information tentatively indicates that high nitrates may be present in the shallow Cornbrash Formation but may be better in the deeper formations within the Great Oolite Group.

There is a potential second aquifer unit comprising the Brosmsgrove Sandstone (0 - 15 m thick) and the Old Red Sandstone Group (ORS) (c. 170 m thick). This has been termed the ORS aquifer in this report and it underlies the whole site. Utilisation of this aquifer would mean deep drilling to around 400 m depth.

The ORS, whilst thick, can have relatively low permeability for sandstone and the presence of an open fracture network would be important. The ORS does not receive direct rainfall recharge in the region and therefore likely long residence times of groundwater mean the potential for leaching out of minerals. The water could tend to be more brackish than at shallow depths and there could be elevated iron, manganese and trace metals. No water quality data for this aquifer in this region are currently available.

Water demand for the Eco-Town has been estimated (by others) and is equivalent to 29 litres per second (L/s). Further work will be needed to assess whether peak demand management and water treatment requirements will require a different peak abstraction rate.

There is one existing groundwater abstraction licence (Lord's Farm) within the Eco Town site area. The licensed abstraction rate is 48 m3/day (0.6 L/s) and the well utilises the Great Oolite aquifer. The Environment Agency would seek quantification that any new abstraction would not derogate this supply. Alternatively negotiations could be instigated on a private basis to discuss the provision of an alternative supply. At this stage, given the above listed problems of a new Great Oolite water supply, then this is not proposed.

The Great Oolite aquifer as a potential source for a new water supply for the Eco-Town seems unlikely based on the desk study presented in this report. Alternatively the Great Oolite could be considered as a potential water supply for only part of the Eco-Town water requirement, subject to further assessment of water quality (e.g. for nitrate) and assessment of the likely long term water quality with respect to vulnerability to surface spillages.

Whilst the ORS might represent a better potential source for a new water supply for the Eco-Town; the available information suggests that it has relatively limited permeability meaning that two or more wells (15 L/s each would be needed (based on initial calculations). Spacing of c. 400 m would be required between wells. However, there is very limited data available for this aquifer and, whilst the calculations are moderately conservative, it is possible that yields are lower due to the depth of the aquifer (causing closure of fractures) or lower than assumed rest piezometric level. Water quality, as stated above is unknown but it is likely that some treatment will be required before potable use.

8 REFERENCES

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Appendix 1 – Envirocheck Information (extracts from the 2010 report)

Map ID	Details	Quadrant Reference (Compass Direction)	Estimated Distance From Site	Contact	NGR
1	**Local Nature Reserves** Name: Bure Park Multiple Area: N Area (m2): 83957.83 Source: Natural England Designation Date: 5th December 2005	(SE)	53	3	457592 224148
2	**Nitrate Vulnerable Zones** Name: Not Supplied Description: Surface Water - Designated 2006 Source: Department for Environment, Food and Rural Affairs (DEFRA - formerly FRCA)	(N)	0	4	455900 227700
3	**Sites of Special Scientific Interest** Name: Ardley Cutting & Quarry Multiple Areas: N Total Area (m2): 401251.72 Source: Natural England Reference: 1000903 Designation Details: Geological Conservation Review Designation Date: 12th May 1988 Date Type: Notified Designation Details: Local Wildlife Trust Reserve Designation Date: 12th May 1988 Date Type: Notified	C3NE (W)	407	3	455933 224998

Map ID	Details	Quadrant Reference (Compass Direction)	Estimated Distance From Site	Contact	NGR
1	**Discharge Consents** Operator: A G Phipps, Esq. Property Type: Domestic Property (Multiple) Location: Home Farm Complex Home Farm Banbury Road Caversfield, Bicester Oxfordshire Ox27 0tg Authority: Environment Agency, Thames Region Catchment Area: Not Supplied Reference: Cawm.0566 Permit Version: 1 Effective Date: 19th November 2002 Issued Date: 16th January 2003 Revocation Date: Not Supplied Discharge Type: Sewage Discharges - Final/Treated Effluent - Not Water Company Discharge Environment: Freshwater Stream/River Receiving Water: The Town Brook **Status: New Consent (Water Resources Act 1991, Section 88 & Schedule 10 as amended by Environment Act 1995)** Positional Accuracy: Located by supplier to within 10m	D2NE (SE)	0	1	458020 225040
2	**Discharge Consents** Operator: Mr. M.S. Purewal Property Type: Domestic Property (Single) Location: The Old Vicarage, Caversfield, Near Bicester, Oxon Authority: Environment Agency, Thames Region Catchment Area: Not Supplied Reference: Ctwc.1546 Permit Version: 2 Effective Date: 30th January 2007 Issued Date: 30th January 2007 Revocation Date: 31st March 2019 Discharge Type: Sewage Discharges - Final/Treated Effluent - Not Water Company Discharge Environment: Irrigation Area Receiving Water: Cornbrash **Status: Modified (Water Resources Act 1991, Schedule 10 as amended by Environment Act 1995)** Positional Accuracy: Located by supplier to within 10m	D3SW (SE)	389	1	458500 224750
2	**Discharge Consents** Operator: Mr. M.S. Purewal Property Type: Domestic Property (Single) Location: The Old Vicarage, Caversfield, Near Bicester, Oxon Authority: Environment Agency, Thames Region Catchment Area: Not Given Reference: CTWC.1546 Permit Version: 1 Effective Date: 27th March 1987 Issued Date: 27th March 1987 Revocation Date: 30th January 2007 Discharge Type: Sewage Discharges - Final/Treated Effluent - Not Water Company Discharge Environment: Irrigation Area Receiving Water: Cornbrash **Status: Transferred from COPA 1974** Positional Accuracy: Located by supplier to within 100m	D3SW (SE)	389	1	458500 224750
3	**Local Authority Pollution Prevention and Controls** Name: Teslayne Engineering Location: Unit 4 The Courtyard, Caversfield, Bicester, Ox27 8tg Authority: Cherwell District Council, Environmental Health Department Permit Reference: CDC P/WOB/011 Dated: Not Supplied Process Type: Local Authority Air Pollution Control Description: PG1/1Waste oil burners, less than 0.4MW net rated thermal input **Status: Application Not Yet Authorised** Positional Accuracy: Manually positioned to the address or location	D2NE (SE)	0	2	458065 225047
	Nearest Surface Water Feature	D1NE (W)	0	-	457282 225207

Map ID	Details	Quadrant Reference (Compass Direction)	Estimated Distance From Site	Contact	NGR
3	**Historical Landfill Sites** Licence Holder: Not Supplied Location: Bicester, Oxfordshire Name: Gowell Farm Operator Location: Not Supplied Boundary Accuracy: As Supplied Provider Reference: EAHLD13573 First Input Date: Not Supplied Last Input Date: Not Supplied Specified Waste Type: Deposited Waste included Inert, Industrial, Commercial and Household Waste EA Waste Ref: -9999 Regis Ref: Not Supplied WRC Ref: 3100/0027 BGS Ref: Not Supplied Other Ref: 13.6.5723, TP0230	A12NE (E)	0	1	456880 223813
	Local Authority Landfill Coverage Name: Cherwell District Council - Has supplied landfill data		0	2	462471 222097
	Local Authority Landfill Coverage Name: Oxfordshire County Council - Has supplied landfill data		0	6	462471 222097
4	**Local Authority Recorded Landfill Sites** Location: Gowell Farm, Bicester Reference: 14 Authority: Cherwell District Council, Environmental Health Department **Last Reported Status: Unknown** Types of Waste: Ash, Glass, Brick, Pottery Date of Closure: Not Supplied Positional Accuracy: Positioned by the supplier Boundary Quality: Good	A12NE (E)	0	2	456879 223829

Map ID	Details	Quadrant Reference (Compass Direction)	Estimated Distance From Site	Contact	NGR
1	**Discharge Consents** Operator: Catharine Murfitt Property Type: Domestic Property (Single) Location: Himley Barns Middleton Stoney Road Chesterton Bicester Oxfordshire Ox26 1rt Authority: Environment Agency, Thames Region Catchment Area: Cherwell and Ray (Oxon) Reference: Npswqd005893 Permit Version: 1 Effective Date: 16th December 2008 Issued Date: 15th December 2008 Revocation Date: Not Supplied Discharge Type: Sewage Discharges - Final/Treated Effluent - Not Water Company Discharge Environment: Freshwater Stream/River Receiving Water: Tributary Of Pingle Stream **Status: New Consent (Water Resources Act 1991, Section 88 & Schedule 10 as amended by Environment Act 1995)** Positional Accuracy: Located by supplier to within 10m	A11SE (E)	0	1	456035 223498
	Nearest Surface Water Feature	A12NE (E)	0	-	456908 223635
2	**Water Abstractions** Operator: W & W Malins Licence Number: 28/39/14/0214 Permit Version: 100 Location: Lords Farm, Bicester (A) Authority: Environment Agency, Thames Region Abstraction: General Farming And Domestic Abstraction Type: Water may be abstracted from a single point Source: Groundwater Daily Rate (m3): 10 Yearly Rate (m3): 1763 Details: Great Oolite Authorised Start: 01 January Authorised End: 31 December Permit Start Date: 8th May 1967 Permit End Date: Not Supplied Positional Accuracy: Located by supplier to within 100m	A16NE (NE)	0	1	456900 224500
	Water Abstractions Operator: A D Woodley Ltd Licence Number: 28/39/14/0123 Permit Version: 100 Location: Whitelands, Bicester (A) Authority: Environment Agency, Thames Region Abstraction: General Farming And Domestic Abstraction Type: Water may be abstracted from a single point Source: Groundwater Daily Rate (m3): 20 Yearly Rate (m3): 1818 Details: Great & Inferior Oolite Authorised Start: 01 January Authorised End: 31 December Permit Start Date: 9th January 1967 Permit End Date: Not Supplied Positional Accuracy: Located by supplier to within 100m	A4SE (SE)	754	1	456700 222100
	Groundwater Vulnerability Geological Classification: Minor Aquifer (Variably permeable) - These can be fractured or potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability including unconsolidated deposits. Although not producing large quantities of water for abstraction, they are important for local supplies and in supplying base flow to rivers Soil Classification: Soils of High Leaching Potential (H3)- Coarse textured or moderately shallow soils which readily transmit non-absorbed pollutants and liquid discharges but which have some ability to attenuate absorbed pollutants because of their large clay or organic matter contents Map Sheet: Sheet 30 Northern Cotswolds Scale: 1:100,000	A12SE (E)	0	1	456817 223520
	Groundwater Vulnerability Geological Classification: Minor Aquifer (Variably permeable) - These can be fractured or potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability including unconsolidated deposits. Although not producing large quantities of water for abstraction, they are important for local supplies and in supplying base flow to rivers Soil Classification: Soils of High Leaching Potential (U) - Soil information for restored mineral workings and urban areas is based on fewer observations than elsewhere. A worst case vulnerability classification (H) assumed, until proved otherwise Map Sheet: Sheet 30 Northern Cotswolds Scale: 1:100,000	A12SE (E)	0	1	456817 223520

Map ID	Details	Quadrant Reference (Compass Direction)	Estimated Distance From Site	Contact	NGR
6	**BGS Recorded Mineral Sites** Site Name: Gowell Farm Location: Bicester, Oxford, Oxfordshire Source: British Geological Survey, National Geoscience Information Service Reference: 57413 Type: Opencast **Status: Ceased** Operator: Unknown Operator Operator Location: Not Supplied Periodic Type: Jurassic Geology: Cornbrash Formation Commodity: Limestone Positional Accuracy: Located by supplier to within 10m	B9NW (W)	0	3	456996 223880
	BGS 1:625,000 Solid Geology Description: Cornbrash	(NW)	0	3	456217 225693
	Coal Mining Affected Areas In an area which may not be affected by coal mining				
	Potential for Collapsible Ground Stability Hazards No Hazard				
	Potential for Compressible Ground Stability Hazards Hazard Potential: No Hazard Source: British Geological Survey, National Geoscience Information Service	B14SW (E)	0	3	457625 224012
	Potential for Compressible Ground Stability Hazards Hazard Potential: Moderate Source: British Geological Survey, National Geoscience Information Service	B14NW (N)	0	3	457650 224425
	Potential for Compressible Ground Stability Hazards Hazard Potential: Moderate Source: British Geological Survey, National Geoscience Information Service	B13NW (NW)	0	3	457275 224350
	Potential for Compressible Ground Stability Hazards Hazard Potential: Moderate Source: British Geological Survey, National Geoscience Information Service	B13NE (NW)	0	3	457325 224325
	Potential for Compressible Ground Stability Hazards Hazard Potential: Moderate Source: British Geological Survey, National Geoscience Information Service	B14SW (E)	0	3	457625 224012
	Potential for Compressible Ground Stability Hazards Hazard Potential: Moderate Source: British Geological Survey, National Geoscience Information Service	B14NW (N)	0	3	457675 224550
	Potential for Ground Dissolution Stability Hazards Hazard Potential: Very Low Source: British Geological Survey, National Geoscience Information Service	B13SE (N)	0	3	457575 224025
	Potential for Ground Dissolution Stability Hazards Hazard Potential: No Hazard Source: British Geological Survey, National Geoscience Information Service	B13SE (N)	0	3	457575 224025
	Potential for Ground Dissolution Stability Hazards Hazard Potential: Very Low Source: British Geological Survey, National Geoscience Information Service	B14SW (E)	0	3	457700 224012
	Potential for Ground Dissolution Stability Hazards Hazard Potential: No Hazard Source: British Geological Survey, National Geoscience Information Service	(SW)	193	3	456900 223175
	Potential for Landslide Ground Stability Hazards Hazard Potential: Very Low Source: British Geological Survey, National Geoscience Information Service	(W)	0	3	456700 224300
	Potential for Running Sand Ground Stability Hazards Hazard Potential: No Hazard Source: British Geological Survey, National Geoscience Information Service	B14SW (E)	0	3	457625 224012
	Potential for Running Sand Ground Stability Hazards Hazard Potential: Low Source: British Geological Survey, National Geoscience Information Service	B14NW (N)	0	3	457675 224550
	Potential for Running Sand Ground Stability Hazards Hazard Potential: Low Source: British Geological Survey, National Geoscience Information Service	B14NW (N)	0	3	457650 224425
	Potential for Running Sand Ground Stability Hazards Hazard Potential: Low Source: British Geological Survey, National Geoscience Information Service	B13NW (NW)	0	3	457275 224350

Map ID	Details	Quadrant Reference (Compass Direction)	Estimated Distance From Site	Contact	NGR
4	**Historical Landfill Sites** Licence Holder: Not Supplied Location: Bicester, Oxfordshire Name: Gowell Farm Operator Location: Not Supplied Boundary Accuracy: As Supplied Provider Reference: EAHLD13573 First Input Date: Not Supplied Last Input Date: Not Supplied Specified Waste Type: Deposited Waste included Inert, Industrial, Commercial and Household Waste EA Waste Ref: -9999 Regis Ref: Not Supplied WRC Ref: 3100/0027 BGS Ref: Not Supplied Other Ref: 13.6.5723, TP0230	B9NW (W)	0	1	457155 223885
	Local Authority Landfill Coverage Name: Cherwell District Council - Has supplied landfill data		0	2	462510 222289
	Local Authority Landfill Coverage Name: Oxfordshire County Council - Has supplied landfill data		0	6	462510 222289
5	**Local Authority Recorded Landfill Sites** Location: Gowell Farm, Bicester Reference: 14 Authority: Cherwell District Council, Environmental Health Department **Last Reported Status: Unknown** Types of Waste: Ash, Glass, Brick, Pottery Date of Closure: Not Supplied Positional Accuracy: Positioned by the supplier Boundary Quality: Good	B9NW (W)	0	2	457154 223881

Map ID	Details	Quadrant Reference (Compass Direction)	Estimated Distance From Site	Contact	NGR
1	**Discharge Consents** Operator: Messrs Wej & Tmf Malins Property Type: Domestic Property (Single) Location: Lords Farm Lords Lane Bicester Oxfordshire Ox27 7hl Authority: Environment Agency, Thames Region Catchment Area: Not Supplied Reference: Cawm.0876 Permit Version: 1 Effective Date: 16th September 2004 Issued Date: 16th November 2004 Revocation Date: Not Supplied Discharge Type: Trade Effluent Discharge-Site Drainage Discharge Environment: Freshwater Stream/River Receiving Water: Trib Of The Town Brook **Status: New Consent (Water Resources Act 1991, Section 88 & Schedule 10 as amended by Environment Act 1995)** Positional Accuracy: Located by supplier to within 10m	B13SE (N)	0	1	457510 224170
1	**Discharge Consents** Operator: Messrs Wej & Tmf Malins Property Type: Domestic Property (Single) Location: Lords Farm Lords Lane Bicester Oxfordshire Ox27 7hl Authority: Environment Agency, Thames Region Catchment Area: Not Supplied Reference: Cawm.0877 Permit Version: 1 Effective Date: 16th September 2004 Issued Date: 16th November 2004 Revocation Date: Not Supplied Discharge Type: Sewage Discharges - Final/Treated Effluent - Not Water Company Discharge Environment: Freshwater Stream/River Receiving Water: Trib Of The Town Brook **Status: New Consent (Water Resources Act 1991, Section 88 & Schedule 10 as amended by Environment Act 1995)** Positional Accuracy: Located by supplier to within 10m	B13SE (N)	0	1	457520 224180
	Nearest Surface Water Feature	B13SE (N)	0	-	457583 224208
2	**Pollution Incidents to Controlled Waters** Property Type: Not Given Location: BICESTER Authority: Environment Agency, Thames Region Pollutant: General Note: Not Supplied Incident Date: 16th December 1997 Incident Reference: 37374 Catchment Area: Not Given Receiving Water: Not Given Cause of Incident: Not Given Incident Severity: Category 3 - Minor Incident Positional Accuracy: Located by supplier to within 100m	B10NW (SE)	405	1	457700 223800
3	**Water Abstractions** Operator: W V Malins & Son Licence Number: 28/39/14/0348 Permit Version: 1 Location: Lords Farm - Borehole Authority: Environment Agency, Thames Region Abstraction: General Farming And Domestic Abstraction Type: Water may be abstracted from a single point Source: Groundwater Daily Rate (m3): Not Supplied Yearly Rate (m3): Not Supplied Details: Underground Strata At Lords Farm, Bicester. Authorised Start: 01 January Authorised End: 31 December Permit Start Date: 1st April 2008 Permit End Date: Not Supplied Positional Accuracy: Located by supplier to within 100m	B13SE (NW)	0	1	457400 224200

Appendix 2- Lord's Farm Well 2003 Pumping Test

PUMPING TEST SUMMARY (Thames Region EA)

APPLICATION		**Consent No:**	TP 02/W/16
Applicant:	Tim Mallins of Lords Farm	**File Ref:**	WRW/A/1105
Site:	Lords Farm, Bicester	**Well Index No:**	
NGR:	SP 5742 2424		
Quantities:	60 m^3/d and 21900 m^3 per year		
Purpose:	For supplying dairy cattle (300 in the summer and 500 in the winter)		

GEOLOGY

Strata:	Cornbrash and Forest Marble on Great Oolite.
Aquifer:	Great Oolite

BOREHOLE CONSTRUCTIONS

Borehole Depth:	79.3 m
Diameter:	457 mm
Linings:	No info – presumably slotted through the Great Oolite.
New/Existing:	New
Drilling Company:	Not known

TEST CONDITIONS

Quantities:	3 m^3/h for around an hour or so.
Radius of Search:	Decided a radial survey would not be necessary as the borehole is semi-artesian.

TEST RESULTS

Test Date : 3rd June 2003

Pumping Rate: 3 m^3/h – abstracts 500 litres in 5 minutes around 6 times an hour.
ABH RWL: 1.22 m **PWL:** 2.13 m **Drawdown:** 0.91 m

OTHER OBSERVATIONS:

None

REPORT:

The borehole is an old borehole originally drilled by the Ministry of Defence in 1941 (borehole card SP 52/18). According to Mr Mallins the borehole is artesian in the winter and during the summer water levels are only 5 to 7 feet below ground level. This was confirmed during the site visit when the rest water level was only around 4 feet below ground level (or 1.22m).

The borehole uses an automated pumping system which fills a bowser based on water demand. The bowser has a capacity of 500 litres and is filled using a 100 litre pump operating for around 5 minutes. According to Mr Mallins this operates around 6 times an hour and operates all day. This means that the total daily abstraction is around 70,000 litres or 70 cubic metres which is

slightly above our previous estimate.

On operation of the pump the water level declines from a rest water level of around 4 feet (1.22 m)to a pumping water level around 7 feet (2.13 m) below ground level. Recovery is relatively rapid to the rest water level of 4 feet. Thus the abstraction is causing a minimal decline in water levels.

After some time spent viewing the pumping system the stream 50m to the north of the borehole was examined. This was found to contain some flowing water. In addition the stream to the east near the road was examined and also contained some water. Neither of these streams will be affected by this abstraction as the borehole abstracts from the Great Oolite aquifer and the stream flows on the Forest Marble.

RECOMMENDATION:

As the borehole is semi-artesian and drawdowns are relatively low there are no issues licensing this borehole. However Mr Mallins needs to be contacted to confirm the required daily licence limit for the borehole. The borehole can thus be licensed for a limit of **60 m^3/d and 21900 m^3 per year.**

M. Leeson
11th July 2003