Legend
Application Area

<table>
<thead>
<tr>
<th>Extraction phases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remaining ironstone</td>
</tr>
</tbody>
</table>

P1 - Photographs (see Appendix A2)

Ponds (P7) 'LGS Ponds'
Groundwater ponding (P1 & P2)
Drainage to ground (P3)
Seepages (P4)
Seepages (P5)
Grotto Spinney Spring S2

Spring S3 (P6)

Worked and restored

Image dated May 2009
Groundwater levels at observation boreholes

- EP1
- EP2
- EP3
- EP4
- EP5
- EP6
- PA
- PB
- PC

Groundwater levels in m(AOD) over time from Jan-96 to Dec-13 with specific points labeled for each borehole.
Legend

- Application Area
- Base of Northampton Sand Formation
- Remaining ironstone reserves

Flow direction

Image dated May 2009

Scale

0 100 200 m

Title
Conceptual groundwater flow pattern

Project
Pitsford Quarry

Date
June-14

Drawing
1681/HIA-02/09

Scale
as shown
APPENDIX 1681/HIA-02/A2

Photographs
(site visit on 14 November 2013)
Photo 1: Water ponded in quarry floor

Photo 2: Water ponded in quarry floor
Photo 3: Bottom of drainage channel
Photo 4: Seepage

Photo 5: Flow from seepages
Photo 6: Seepage in field east of Grotto Spinney

Photo 7: Pond in base of restored workings (‘LGS Ponds’)

June 2014
APPENDIX 1681/HIA-02/A3

Ecological sites within a 2 km radius of Pitsford Quarry
APPENDIX 1681/HIA-02/A4

Areas of future mineral extraction
(drawings supplied by GP Planning)
APPENDIX 1681/HIA-02/A5

Proposed Restoration of Phase 1
(drawings supplied by GP Planning)
DRAWINGS
Image dated May 2009

P1 - Photographs (see Appendix A2)

Legend
Application Area

Extraction phases

Remaining ironstone

Spring S3 (P6)

Grotto Spinney Spring S2

Monitoring borehole EP2

Ponds (P7) 'LGS Ponds'

Groundwater ponding (P1 & P2)

Drainage to ground (P3)

Seepages (P4)

Seepages (P5)

Worked and restored
Legend

- Application Area
- Base of Northampton Sand Formation
- Remaining ironstone reserves
- Groundwater flow
- Groundwater flow intercepted in base of quarry
- Ponded groundwater drained to southeast
- Surface water discharge to ground
- Increased groundwater flow
- Reduced groundwater flow
- Seepage, boggy ground
- Spring (S3)
- Spring (S2)
- Conceptual groundwater flow pattern

Image dated May 2009

Flow direction

[Diagram showing conceptual groundwater flow pattern with various flow paths and catchment areas marked]
Hydrogeological Impact Assessment in support of a Review of Old Mineral Permission at Pitsford Quarry, Northamptonshire

Report ref: 1681/HIA-02
Final Rev1
June 2014

Report prepared for:

GP Planning Ltd
The Stables
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Hydrogeological Impact Assessment in support of a Review of Old Mineral Permission at Pitsford Quarry, Northamptonshire

Report ref: 1681/HIA-02
Final Rev1
January 2014

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Checked by: C C Leake BSc MSc FGS
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1 INTRODUCTION

1.1 Background

Pitsford Quarry is located approximately 7 km north of the centre of Northampton and 1 km south of Pitsford Village, Northamptonshire. Pitsford Quarry has been owned and operated by Peter Bennie Ltd since 2001. The quarry is currently closed due to uneconomic market conditions.

Hafren Water has been requested to prepare an assessment of potential impacts on the water environment arising from the continued extraction of ironstone within ‘Phase 1’ of the quarry.

1.2 Objectives

The principal objectives of this study are to:

- Determine baseline conditions in relation to the water environment at Pitsford Quarry and its surroundings
- Identify any potential impacts from short-term operational phases and restoration
- Assess the magnitude and significance of potential impacts
- Derivation of appropriate mitigation measures for any identified potential impacts

1.3 Data sources

The following sources of data were used in this study:

British Geological Survey (BGS)
- 1:50,000 scale geological map, Sheet 185 Northampton
- Geological logs of nearby boreholes

Ordnance Survey (OS)
- Explorer 1:25,000 scale map, Sheet 223, Northampton & Market Harborough

The Environment Agency (EA)
- Licensed abstractions
- Licensed discharges
- Active and historical landfills
- Rainfall data
- Surface water quality

Natural England
- Sites of Special Scientific Interest

Local Authorities (Daventry District Council)
- Private water abstractions

1.4 Methodology of investigation

Baseline conditions of the water environment have been defined by the collation and analysis of existing data and field observations. The potential effects of the proposed development upon the extant water environment have been assessed by reference to the baseline data and a series of matrices (Appendix 1681/HIA-02/A1), developed to ensure a rigorous and consistent approach to the assessment of potential impacts. Mitigation measures have been proposed where appropriate.
2 SITE SETTING

2.1 Location

The Application Area is located approximately 1 km south of Pitsford Village, Northamptonshire (Drawing 1681/HIA-02/01) and is centred on National Grid Reference (NGR) SP 757 670. The Application Area, which covers approximately 9 hectares (Ha), includes Pitsford Quarry Phase 1, the access route from Harborough Road (A508), the existing weighbridge, wheelwash and offices location.

The Application Area (‘the site’) is bounded to the west and north by former quarry workings, now restored, and agricultural land to the south and east. The nearest residential property, Fox Covert Farm, is located 140 m west of the site.

Access to the site is currently from the A508, Harborough Road, located to the west of the quarry.

2.2 Landform

The site lies on the southern side of an interfluve between two tributaries of the Brampton Branch at an elevation of approximately 100 metres Above Ordnance Datum (mAOD). South of the site, the ground slopes down at a gradient of 1:17 towards an unnamed stream, which flows to the west. To the east the ground rises up towards Pitsford Pond, a disused fishing lake. North of the site, the ground rises gradually to reach 125 mAOD to the east of Pitsford Village.

2.3 Site visit

The present situation in the Phase 1 area and immediate surroundings is shown on Drawing 1681/HIA-02/02. A site visit was undertaken on 14\textsuperscript{th} November 2013 and photographs taken during the visit are presented in Appendix 1681/HIA-02/A2.

Within the deepest parts of Phase 1, between the unworked ironstone to the north and partially backfilled area to the south, groundwater discharging from the ironstone has ponded on the underlying mudstone (Photographs 1 and 2). A channel has been cut into the spoil material to allow this water to drain away to the south where it seeps into the restored spoil material (Photograph 3). The ground to the south of this point is noticeably boggy and wet.

In the field to the southeast, an area along the western boundary has been left fallow, presumably due to the boggy nature of the ground. Seepages can be seen in places in this area (Photographs 4 and 5).

In the field directly to the south of the site, there is a spring discharge approximately 100 m from the northern boundary with the site (Photograph 6). A review of Google Earth images suggests that this spring emerged sometime between 2005 and 2009. From the 1:25,000-scale Ordnance Survey map, the elevation of this new spring is at a similar elevation as the spring in Grotto Spinney (approximately 90 mAOD).

North of the site, where previous mineral workings have been restored to a community woodland, there are two pools (referred to as the ‘LGS Ponds’, Photograph 7) in the deepest part of the area, just to the north of the Phase 1 quarry area.
3 BASELINE CONDITIONS

3.1 Background

Baseline (ie existing) conditions at the site are set out below and include information relating to the environmental setting as well as current activities at the site. Knowledge of baseline conditions has been developed based on published literature, site-derived data and a site visit.

A conceptual model which sets out the current understanding of the geology and hydrogeology has been developed on the basis of the baseline data and has been used to identify potential sources of impact.

3.2 Hydrology

The hydrology of the site and its environs has been derived from Ordnance Survey maps, a water features survey and data provided by the Environment Agency.

The locations of the water features discussed in this section are shown on **Drawing 1681/HIA-02/03**.

3.2.1 Rainfall

The nearest Environment Agency rain gauge (Station No 159426) is located at Pitsford Reservoir at NGR SP 7589 6864, approximately 1.7 km north of the site. The long-term average (LTA) rainfall is 633 mm/annum. Monthly LTA rainfall is shown on Table 1681/HIA-02/T1.

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>41</td>
<td>50</td>
<td>48</td>
<td>53</td>
<td>58</td>
<td>54</td>
<td>63</td>
<td>48</td>
<td>50</td>
<td>55</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 1681/HIA-02/T1: Long-term average monthly rainfall at Pitsford Reservoir rain gauge

3.2.2 Watercourses

The largest watercourse in the vicinity of the site is the Brampton Branch, located 2.5 km west of the site. The river flows from north to south, to its confluence with the River Nene at Northampton, 7 km to the south.

The site lies between two tributaries of the Brampton Branch, the Pitsford Arm to the north and Moulton Arm (or Moulton Brook) to the south, both flowing from east to west:

- The nearest tributary, Moulton Arm, is located 450 m south of the site’s southern boundary. It rises 5.5 km east of the site, to the northeast of the village of Moulton, and joins the Brampton Branch 2.2 km to its west.

- The second tributary lies 1.6 km north of the site and joins the Brampton Branch 2.3 km to the northwest. The tributary was dammed in 1956, just north of Pitsford Village, to form a large reservoir, Pitsford Water, now managed by Anglian Water.

A small watercourse flows north to south along the eastern boundary of the site, joining the Moulton Arm approximately 500 m to the south of the site.
3.2.3 Springs and wells

According to the 1:25,000-scale Ordnance Survey map, historical maps and information from Daventry District Council, there are a number of springs located within 2 km of the site. Their locations are presented on Drawing 1681/HIA-02/03.

- There are 11 springs to the south of the site, marked S1 to S11, all discharging into watercourses draining into the southern tributary (Moulton Arm) of the Brampton Branch. The nearest of these springs are S2 (Grotto Spinney), located 190 m south of the southwest corner of the site and S3, a relatively newly emerged spring, 110 m to the south. The spring at Grotto Spinney is surrounded by a Grade II listed structure built in around 1770. Three springs, S9, S10 and S11, are located south of the unnamed Brampton Branch tributary.

- There are 6 springs to the north of the site, S12 to S17. All discharge into watercourses draining into the northern tributary of the Brampton Branch. The closest of these springs to the site is S13, located 1.1 km away and just to the east of Pitsford Village.

- Two springs, S18 and S19, are located to the west of the Brampton Branch.

A number of wells are shown on the 1:50 000-scale Ordnance Survey map and the geological map (BGS Sheet 185), as indicated on Drawing 1681/HIA-02/03. The closest, W5, is located approximately 1 km to the southwest of the site boundary.

3.2.4 Ponds and waterbodies

Five waterbodies are located within 2 km of the site:

- Immediately to the north of the site are two ponds, referred to as the ‘LGS Ponds’ in the base of a previously worked area and now restored as a community woodland.

- There is a pond in a residential property 290 m to the west of the quarry, possibly associated with Spring S1.

- Pitsford Pond lies 280 m to the east of the site boundary, within an area of restored ironstone workings. The pond has an area of approximately 0.7 Ha and has been used in the past as a fishery.

- An artificial lake is located within the valley of the Moulton Arm tributary of the Brampton Branch at Boughton Park, 500 m southwest of the site. The lake covers an area of approximately 1.2 Ha.

- Pitsford Reservoir is located 1.4 km north of the site and covers 740 Ha. The reservoir is a designated Site of Special Scientific Interest (SSSI).

There are several small ponds located to the north of Pitsford, 1.3 km north of the site.

3.2.5 Landfill sites

Locations of historic and operational landfills are shown on Drawing 1681/HIA-01R/04 and summarised in Table 1681/HIA-02/T2.
Table 1681/HIA-02/T2: Details of landfill sites within 2 km

<table>
<thead>
<tr>
<th>Name</th>
<th>NGR</th>
<th>Distance &amp; direction</th>
<th>Waste</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitsford/Moulton Lane Stone Quarry</td>
<td>SP 760 669</td>
<td>0.2 km E</td>
<td>Inert</td>
<td>Historic (Dec 1940 – Dec 1987)</td>
</tr>
<tr>
<td>Pitsford</td>
<td>SP 753 674</td>
<td>0.55 km NW</td>
<td>Inert</td>
<td>Historic (Dec 1985 - ?)</td>
</tr>
<tr>
<td>Boughton Grange Quarry</td>
<td>SP 746 658</td>
<td>1.35 km SW</td>
<td>Inert</td>
<td>Historic (Jan 1982 – Dec 1986)</td>
</tr>
<tr>
<td>Boughton</td>
<td>SP 746 658</td>
<td>1.35 km SW</td>
<td>Inert</td>
<td>Historic (Dec 1986 – Dec 1991)</td>
</tr>
<tr>
<td>Boughton Quarry</td>
<td>SP 747 655</td>
<td>1.75 km SW</td>
<td>Inert</td>
<td>Closed in 2012</td>
</tr>
</tbody>
</table>

3.2.6 Protected sites and areas of ecological interest
Sites of ecological interest within a 2 km radius of the site were obtained using the Multi Agency Geographic Information for the Countryside website (MAGIC) and via a data request to Northamptonshire Biodiversity Records Centre undertaken as part of the ecological assessment (Conservation Constructions, January 2014). A plan showing all relevant sites within a 2 km radius of Pitsford Quarry is shown in Appendix 1681/HIA-02/A3.

There is only one statutory designated site within 2 km of Pitsford Quarry and that is Pitsford Reservoir, located 1.7 km to the north, a designated Site of Special Scientific Interest (SSSI) covering approximately 409 Ha. It is a major site for passage and wintering waterfowl and supports a significant number and variety of breeding birds, including great crested grebe and reed warbler. Grassland bordering the reservoir provides additional habitats valuable to a wide range of flora and fauna. There is a small colony of the locally uncommon Essex Skipper butterfly. The location of Pitsford Reservoir SSSI is shown on Drawing 1681/HIA-02/03.

There are a number of non-stautory sites within a 2 km radius of the quarry, as indicated in Appendix 1681/HIA-02/A3. A full list and description of these sites is given in the Ecological Impact Assessment (Conservation Constructions, January 2014) and only those identified as potentially groundwater-dependant are considered here.

- Pitsford Quarry Local Geological Site (LGS), located within T’s Wood Local Wildlife Site (LWS). The LGS was designated due to an exposure of calcareous sand over ironstone in an area of former quarry workings. The geological exposure is now flooded and the ponds are reported to have supported a population of great crested newts in the past.

- Notes from Regionally Important Geological Site (RIGS) Group indicate that there is residual ironstone present in this area and the lake is partially cut down into the underlying clay (Evaluation From, dated 8th May 2000).

- Grotto Spinney LWS. A spring (S2 on Drawing 1681/HIA-02/03) emerges in this small area of woodland. Freshwater shrimp are reported to be present.

- Boughton Hall Park Lake LWS. Wetland and woodland habitat, eutrophic water lowland mixed deciduous woodland and rivers.

3.2.7 Surface water abstraction
Only one licensed surface water abstraction occurs within 2 km of the site. Licence No.
5/32/03/*S/002 permits Anglian Water Services Ltd to abstract 19,900 Ml/a from Pitsford Reservoir.

3.2.8 Discharge consents

There are 11 discharge consents within 2 km of the site. Their locations are shown on Drawing 1681/HIA-02/04 and summarised on Table 1681/HIA-02/T3.

<table>
<thead>
<tr>
<th>Map ID</th>
<th>Consent N°</th>
<th>Receiving water</th>
<th>Type</th>
<th>NGR</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>AWNNF13358</td>
<td>Moulton Brook</td>
<td>SC</td>
<td>SP 77131 66400</td>
<td>Moulton A Pumping Station</td>
</tr>
<tr>
<td>B</td>
<td>PRNNF01651</td>
<td>Trib of Moulton Stream</td>
<td>UA</td>
<td>SP 75350 66880</td>
<td>Fox Covert Farm</td>
</tr>
<tr>
<td>C</td>
<td>GWNLF40086</td>
<td>Groundwater</td>
<td>AA</td>
<td>SP 74535 67356</td>
<td>Covey Farm Nurseries</td>
</tr>
<tr>
<td>D</td>
<td>PRNNF18698</td>
<td>Trib of Faxton Brook</td>
<td>UA</td>
<td>SP 75010 68038</td>
<td>Spring Hill Farm</td>
</tr>
<tr>
<td>E</td>
<td>PRNNF04380</td>
<td>Trib Brampton Branch River</td>
<td>UA</td>
<td>SP 74950 68570</td>
<td>Old Brickworks Site</td>
</tr>
<tr>
<td>F</td>
<td>AWNNF13329</td>
<td>Faxton Brook</td>
<td>TA</td>
<td>SP 75280 68690</td>
<td>Pitsford WTW Sludge Lagoon A</td>
</tr>
<tr>
<td>G</td>
<td>AWNNF2016</td>
<td>Trib of Brampton Branch River</td>
<td>TA</td>
<td>SP 75330 68780</td>
<td>Pitsford A</td>
</tr>
<tr>
<td>H</td>
<td>AWNNF13328</td>
<td>Pitsford Reservoir</td>
<td>TA</td>
<td>SP 75760 68770</td>
<td>Pitsford WTW (ASG Filter Backwash WR)</td>
</tr>
<tr>
<td>I</td>
<td>AWNNF13159</td>
<td>Trib of Faxton Brook</td>
<td>TA</td>
<td>SP 75550 68450</td>
<td>Pitsford WTW</td>
</tr>
<tr>
<td>J</td>
<td>AWNNF13563</td>
<td>Trib of Faxton Brook</td>
<td>SB</td>
<td>SP 75518 68415</td>
<td>Pitsford SPS</td>
</tr>
<tr>
<td>K</td>
<td>PR5NF5280</td>
<td>Trib of Pitsford Water</td>
<td>UA</td>
<td>SP 76520 68770</td>
<td>Moulton Grange</td>
</tr>
<tr>
<td>L</td>
<td>EPRLP3720XG</td>
<td>Stream to Pitsford Creek</td>
<td>YZ</td>
<td>SP 77069 68358</td>
<td>Moulton College</td>
</tr>
</tbody>
</table>

Table 1681/HIA-02/T3: Discharge consents

3.2.9 Surface water quality

There are no surface water quality data for the watercourse to the south of the site that receives spring discharges from the Northampton Sand Formation.

The Environment Agency monitors water quality in the Brampton Branch at Northampton (NGR SP 75300 59700), which is taken to represent quality over a 6 km reach. In 2009, the biological grading was reported to be Grade B, while the grading for Ammonia was ‘A’ and for dissolved oxygen ‘B’. In terms of biological classification, the river water quality is close to that expected for an unpolluted river, although high concentrations of nitrate are reported.
3.3 Geology

3.3.1 Regional

Regional bedrock geology comprises mainly mudstones, ironstones, sandstones and limestones of Jurassic age. Strata broadly dip southeastwards with younger rock outcropping in the southeast (Drawing 1681/HIA-02/05).

Regional superficial geology comprises Alluvium and River Gravels, Boulder Clay (Till) and Glacial sand & gravels. The Alluvium and River Gravels are confined to the main river valleys, while the deposits of Boulder Clay are found on the higher ground on the interfluves, as shown on Drawing 1681/HIA-02/05.

The regional solid geology is summarised in Table 1681/HIA-02R/T4.

<table>
<thead>
<tr>
<th>Group</th>
<th>Formation</th>
<th>Obsolete Name</th>
<th>Description</th>
<th>Thickness (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Oolite</td>
<td>Blisworth Limestone</td>
<td>Great Oolite limestone</td>
<td>Limestone</td>
<td>2 – 7</td>
</tr>
<tr>
<td>Rutland Formation</td>
<td>Upper Estuarine Series</td>
<td>Variegated clays and silty mudstones, limestone and marls Mudstone</td>
<td>5 - 9</td>
<td></td>
</tr>
<tr>
<td>Inferior Oolite</td>
<td>Lower Lincolnshire Limestone</td>
<td></td>
<td>Limestone</td>
<td>0 - 3</td>
</tr>
<tr>
<td>Grantham Formation</td>
<td>Lower Estuarine Series</td>
<td>Pale sand and sandstone with darker silts in places</td>
<td>2- 5</td>
<td></td>
</tr>
<tr>
<td>Northampton Sand Formation</td>
<td>Northampton Sand</td>
<td>Ironstone ferruginous and sandy limestones</td>
<td>4 - 23</td>
<td></td>
</tr>
<tr>
<td>Upper Lias</td>
<td>Whitby Mudstone Formation</td>
<td>Upper Lias</td>
<td>Mainly mudstone with thin limestones and shales at base</td>
<td>47 - 60</td>
</tr>
<tr>
<td>Middle Lias</td>
<td>Marlstone Rock Formation</td>
<td>Marlstone Rock Bed</td>
<td>Ironstone and ferruginous limestone</td>
<td>1 -3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Silts, mudstones and thin silty limestones</td>
<td>16 - 30</td>
</tr>
</tbody>
</table>

Table 1681/HIA-02/T4: Summary of solid geology

3.3.2 Local geology

Local bedrock geology at the site consists of Northampton Sand Formation (NSF) underlain by Whitby Mudstone Formation. The younger Grantham Formation outcrops to the north of the site and the Whitby Mudstone crops out in the valley to the south.

Superficial deposits are sparse; with Alluvium confined to the tributary valley to the south and an area of Till deposits to the northeast of the site.

A number of borehole records are held by the British Geological Survey (BGS) for the vicinity of the site. However, most of these only penetrate a short distance into the Northampton Sand Formation (NSF) and do not record the base of the Formation. Six piezometers were installed.
by Peter Bennie Ltd, the owner of Pitsford Quarry, between the A508 and Pitsford Pond for the purpose of monitoring groundwater levels. No geological logs are available, but the depth to the base of the NSF is available. Locations of the boreholes are shown on Drawing 1681/HIA-02/05 together with the elevation of the base of the NSF.

A borehole, drilled in August 2008 (SP76NE/137) just to the north of the site, proved the base of the ironstone at a depth of 17 m below ground level (mbgl) with a stiff grey clay beneath (BGS Borehole Records). The coordinates of this borehole provided in the BGS records are considered to be suspect as it does not correlate with records available from the piezometers installed by Peter Bennie Ltd.

3.3.3 Quarry workings
The Northampton Sand Formation has been widely quarried within the region for iron, building stone and aggregate. The underlying ‘Lias clay’ (Whitby Mudstone) has also been worked in places. The areas of quarrying are shown on Drawing 1681/HIA-02/06 and described below.

- Pitsford Quarry. Worked since the early 1970s and now largely restored to agricultural land and community woodland. In some areas the whole of the Northampton Sand Formation was removed, whilst in others only the basal ironstone was removed and the limestone returned as restoration fill. The current working area (Phase 1) has been mothballed since 2006 due to the lack of demand for the product.

- Moulton Lane Stone Quarry. This area was restored partly to rough grassland and partly to a pond (Pitsford Pond) which until recently was used as a fishery. The western part of the quarry was used as a landfill (see Section 3.2.5). Evidence suggests that the quarry also worked the underlying mudstone, possibly for brickmaking.

- Boughton Quarry and Boughton Grange Quarry. These former ironstone quarries lie approximately 1.2 km to the south west of the site boundary and south of Moulton Brook. Boughton Grange Quarry has been restored using landfilling and Boughton Quarry is now restored, with filling completed in 2012, but with waste recycling operations retained on the quarry floor in the centre of the site.

3.4 Hydrogeology

3.4.1 Aquifer status and regional context
The Northampton Sand Formation and overlying Grantham Formation are classified as ‘Secondary A’ and ‘Secondary B’ aquifers respectively by the Environment Agency. The underlying Whitby Mudstone Formation has no designated aquifer status.

Designated productive strata in the area are confined to the outcrops of Lower Lincolnshire Limestone and Blisworth Limestone Formation, which are classified as Principal Aquifers.

3.4.2 Aquifer characteristics
According to Jones et al (The physical properties of minor aquifers in England and Wales, BGS 2000), groundwater flow in the Northampton Sand Formation is a combination of matrix and fracture flow. In the upper weathered zone, where the intergranular cement has been removed, flow is both intergranular and via fractures. The lower, unweathered, section often remains cemented and flow is via the fracture system. It is unclear if this division occurs in the formation in the vicinity of the site.

As noted in Section 3.3, the Northampton Sand Formation has been worked over a significant area to the west of the site, as well as at the site itself. Some of these former quarries have
been restored to agricultural use. The groundwater system in these areas will have been changed from that prevalent in the undisturbed aquifers.

It is understood that in the area to the west of Pitsford Quarry Phase 1, only the Ironstone was removed and the limestone overburden was used to backfill the quarry void. Therefore, there is likely to permeable material resting on the mudstones of the Whitby Mudstone Formation.

3.4.3 Hydraulic conductivity

Jones et al (2000) do not record any data for the Northampton Sand Formation. A review of nearby borehole records has enabled some data to be collated:

- A borehole (SP 76NE/137) drilled in the vicinity of the site, but the exact location of which is uncertain, recorded no drawdown after pumping for 2 hrs at 2 m³/hr. This suggests a very high permeability. However, there are no detailed records of the test, so the measurements of drawdown may not be reliable.

- A borehole at White Lodge Farm (SP 87SW/38, NGR SP 81800 74200) recorded a discharge of 39 m³/day from 4 m of Northampton Sand. Drawdown was not recorded, but the difference between the rest water level and the pump setting depth was 4 m. Using this as the maximum drawdown and substituting the values into the Logan Approximation equation a transmissivity of 11.9 m²/d can be estimated:

\[
T = \frac{1.22 \times Q}{s}
\]

Where:  
\( T \) = transmissivity (m²/d)  
\( Q \) = discharge (m³/d)  
\( s \) = steady state drawdown (m)

This gives an estimated hydraulic conductivity of 2.9 m/d for a 4 m thick aquifer. It is noted that in this borehole the Northampton Sand aquifer is under confined conditions and may not be representative of the unconfined, weathered aquifer.

3.4.4 Source protection zones

The nearest groundwater source protection zone (SPZ) is located approximately 7 km southeast of the site.

3.4.5 Groundwater abstractions

Licensed abstractions:

There are no licensed groundwater abstractions within a 2 km radius of the site.

Private water supplies:

According to Daventry District Council four private water supplies exist within 2 km of the site. Their details are shown on Table 1681/HIA-01/T5 and locations on Drawing 1681/HIA-02/07.

<table>
<thead>
<tr>
<th>Location</th>
<th>NGR</th>
<th>Map ID</th>
<th>Type</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring Meadow Farm</td>
<td>SP 768 664</td>
<td>S6</td>
<td>Spring</td>
<td>Coordinates of farm given, may not be location of spring</td>
</tr>
<tr>
<td>Spectacle Lodge</td>
<td>SP 768 661</td>
<td>S10</td>
<td>Spring</td>
<td>Spring not shown at this location on maps</td>
</tr>
<tr>
<td>Holly Lodge</td>
<td>SP 768 657</td>
<td>W6</td>
<td>Well</td>
<td></td>
</tr>
<tr>
<td>Fox Covert Farm</td>
<td>SP 754 669</td>
<td>S1</td>
<td>Spring</td>
<td></td>
</tr>
</tbody>
</table>
Table 1681/HIA-02/T5: Private water supplies within a 2 km radius of the site

The springs at S1 and S6 (see Section 3.2.3) are closest to the site at distances of 300 m and 1.1 km respectively.

3.4.6 Groundwater levels and distribution

There is limited information available on current groundwater levels. One measurement taken in borehole SP76NE/137 in August 2008 recorded a groundwater level at 11.8 mbgl and in monitoring borehole EP2 a groundwater elevation of 94.77 m AOD was recorded on 14 November 2013.

Records of groundwater levels recorded in a series of monitoring boreholes are available for the period 1996 to 2004. The locations of the monitoring boreholes are shown on Drawing 1681/HIA-02/07. Time-series data from groundwater monitoring are shown on Drawing 1681/HIA-02/08. No general monitoring has been undertaken since October 2004, but borehole EP2 was dipped during a recent site visit and found to be similar to previous measurements.

Groundwater contours for April 2004 are shown on Drawing 1681/HIA-02/08, based on monitoring boreholes up-gradient of the ironstone workings and spring elevations. The two boreholes located immediately down-gradient of the workings show little variation and do not appear to respond to the groundwater level rises observed in the up-gradient boreholes. These contours indicate groundwater flow in a southwesterly direction, towards the spring discharge points south of the site.

3.4.7 Groundwater quality

There are no data available on groundwater quality.

3.4.8 Conceptual hydrogeology

Pitsford Quarry Phase 1 is located on the southeastern side of an area of restored quarry workings. To the north the ground has been restored as Community Woodland and to the west as agricultural land. To the south and east of the site is unworked Northampton Sand Formation.

The Northampton Sand Formation (NSF) forms the main aquifer unit at this location, with the underlying Whitby Mudstone Formation acting as an impermeable base. Where the Northampton Sand has been worked for ironstone, it is considered that the materials used for restoration are such that they do not prevent the flow of groundwater. Groundwater level data indicate that groundwater flow is from northeast to southwest.

The edge of the Northampton Sand aquifer is approximately 270 m south of the southwestern corner of the site but may approach to within 50 m of the southeastern corner. There are two discrete spring discharges (S2 and S3 on Drawing 1681/HIA-02/07) located down-gradient of the site. There are also discharges apparent along the shallow valley feature to the south of the site (Drawing 1681/HIA-02/02) where the ground is very boggy. The spring at Grotto Spinney (S2) has existed for over 200 years, while the spring at S3 appears to have emerged sometime between 2005 and 2009. A third spring, at Fox Covert Farm (S1), lies to the south west of the site and is not down-gradient of the proposed working area.

The conceptualisation of the groundwater flow pattern in the immediate vicinity of Phase 1 is illustrated on Drawing 1681/HIA-02/09. Groundwater flows from the northeast through a mixture of undisturbed NSF and restored quarry workings. This groundwater flow will support water levels in the LGS Ponds, in addition to any surface water inflow and incident rainfall. Within Phase 1 itself, groundwater discharges into the base of the workings from the unworked ironstone to the north. This discharge accumulates on the impermeable mudstone floor and to
reduce the resulting ponding, a drainage channel was cut into restored material to the south. The drain channels water to the south east where it seeps into the permeable backfill material in the restored area.

It is suggested that the drainage channel, cut sometime between 2005 and 2009, has the effect of diverting the normal northeast-southwest groundwater flow towards the southeastern corner of the site and away from the spring discharge at Grotto Spinney. The diverted flow discharges into the shallow valley to the south east where, during the site visit, the field margin was observed to be boggy with several seepages points visible. A second component of this flow appears to have emerged in the field to the south of the quarry to form the spring at S3. The appearance of this spring also appears to have coincided with the time period during which the drain was cut in the quarry floor.
4 PROPOSED DEVELOPMENT

4.1 Mineral extraction

A plan showing the proposed future areas of mineral extraction are shown in Appendix 1681/HIA-02/A4 as Drawing GPP/PB/PR/13/06.

Ironstone will be removed by hydraulic excavator. Refuelling of mobile plant will be restricted to areas of hardstanding near the quarry offices. Fuel will be held in double-skinned tanks within an appropriately sized bunded area.

4.2 Water management

Management of water on the site comprises a simple drainage system which currently channels groundwater and surface water flowing into the floor of the quarry to the south east where it is allowed to seep into backfill material in the base of the quarry (Drawing GPP/PB/PR/13/06, Photo 3, Appendix 1681/HIA-02/A2). Subsequently, this water is discharged to the local surface water system to the south of the site.

4.3 Restoration proposals

The proposed restoration plan for the site is shown in Appendix 1681/HIA-02/A5 as Drawing GPP/PB/PR/14/08. Restoration will be undertaken using soils and mineral waste already available on-site. These are considered to be relatively permeable and unlikely to inhibit groundwater flow. Details of how the restored site will impact on surface water and groundwater flows are illustrated on Drawing 1681/HIA-02/10.

Approximately 75% of the restored area will drain into a surface water pond located against the unworked western side of the site. Water held in the pond will infiltrate into the undisturbed ironstone aquifer and promote increased groundwater flow south towards Grotto Spinney. Over the remainder of the site, surface water runoff will be directed into the watercourse passing north to south along the eastern side of the site.

Within the restored area a number of features are proposed to enhance biodiversity. These are illustrated on Drawing GPP/PB/PR/14/08, in Appendix 1681/HIA-02/A5.

4.4 Water management post-restoration

No active management will be required after restoration.
5 ASSESSMENT OF IMPACTS

5.1 Methodology

An assessment of the potential effects of the restoration of Pitsford Pond on its environs has been undertaken.

Potential impacts were assessed with consideration of the following factors:

- Magnitude of the impact
- Spatial extent of the impact
- Cumulative impacts
- Sensitivity of the receiving environment

Mitigation measures and residual impacts have been considered as part of the assessment. The method of assessment is detailed in Appendix 1681/HIA-02/A1 together with the matrices used to provide a robust and repeatable method of assessment.

5.2 Catchment sensitivity

The characteristics of the baseline water environment are used to form a basis from which the impact assessment can be undertaken. Details of how the baseline catchment sensitivity is assessed are provided in Table A.1 of Appendix 1681/HIA-02/A1.

Pitsford Quarry is located within an area previously worked to extract ironstone, part of the Northampton Sand Formation, which is classified by the Environment Agency as a Secondary A Aquifer.

The site is not located within an SPZ and there are no licensed groundwater abstractions down-gradient of the site. There is one private water supply to the west, but this is not thought to be directly impacted by activities on site. In addition, the extent of the aquifer down-gradient of the site is limited and the underlying impermeable base of the unit crops out south of the site.

There are no surface water abstractions within 2 km of the site.

Groundwater discharges to surface to the south and southeast of the site into the Moulton Arm, which flows into the Brampton Branch. There are no designated ecological sites located within 2 km downstream of the discharge.

Based on the above hydrological and hydrogeological factors, the overall catchment sensitivity is considered to be ‘low’. However, the springs down gradient (south) of the site are sensitive to changes in their groundwater catchments and, therefore, they have been given a sensitivity of ‘medium’.

5.3 Potential impacts during mineral extraction

5.3.1 Groundwater levels

No dewatering will be required on the site and it is considered that there will be no impact from the site on surrounding groundwater levels.

The potential for additional impact on groundwater level up- and down-gradient of the site is considered to be ‘negligible’ with a significance of impact of ‘none’.
5.3.2 Groundwater abstractions
There are no licensed groundwater abstractions within 2 km of the site. The potential for impact on abstractions is considered to be ‘negligible’ with a significance of impact of ‘none’.

5.3.3 Groundwater quality
Refuelling and servicing of mobile plant will not take place within the quarry and therefore, this is not to be considered a risk to water quality. However, there is a risk from accidental spillage of hydrocarbons which might impact the spring discharges.

The potential for impact on groundwater is considered to be ‘low’ with a significance of impact of ‘none’.

5.3.4 Surface water flows
It is considered that the development of the site will not alter the overall volume of discharge to surface water and ultimately into the Moulton Arm watercourse. There will, therefore be no impacts on the Boughton Hall Park Lake LWS. However, the actual points of discharge, the springs to the south of the site may change (location and volume), as has happened in the past.

The potential for impact on surface water flows in the ultimate receiving watercourse (Moulton Arm) for discharge from the Northampton Sand is considered to be ‘negligible’ with a significance of impact of ‘none’.

The magnitude of impact on springs is considered to be ‘medium’ with a significance of ‘moderate’. In this respect it should be noted that preventing discharge at the spring that currently emerges in the field south of the quarry (S3) would be beneficial to the farmer. Changes to the flow of Spring S2 would impact on the features that have resulted in the designation of Grotto Spinney as a LWS.

5.3.5 Surface water quality
As discharge of water from the site will soak away into backfill comprised of natural soils derived from the site before discharging to the surface water system, the potential for impact on surface water quality is considered to be ‘low’ with a significance of impact of ‘minor’.

5.4 Potential impacts after restoration
The site will be restored using mineral waste and soils derived from the site. No imported materials will be used. Due to the nature of these materials, it is considered that impacts on groundwater quality due to the site restoration will be ‘negligible’ with a significance of ‘none’.

The present restoration plan indicates that the contouring will result in most of the site runoff collecting in an artificial pond on the west side of the site. The pond will allow overflow to enter the unworked ironstone to the west of the quarry, thus increasing groundwater flow in this area. The groundwater will ultimately discharge via springs and flow into the surface watercourse (Mouton Arm) to the south. The increased groundwater flow on the western side should result in increased discharge in the spring at Grotto Spinney.

The potential for impact on surface water flows in the ultimate receiving watercourse (Moulton Arm) for discharge from the Northampton Sand is considered to be ‘negligible’ with a significance of impact of ‘none’.

The magnitude of impact on springs is considered to be ‘medium’ with a significance of ‘moderate’.
6 MITIGATION MEASURES AND RESIDUAL IMPACTS

6.1 During mineral working

Currently the passive drainage from the site is directed to the south east and is thought to be causing poor ground conditions in the south east as well as directing flow to a ‘new’ spring (S3) in the field to the south. There is also thought to be some diversion of flow from the Grotto Spinney spring as a result.

To mitigate this impact it is proposed that a new channel is cut in the quarry backfill from the areas of ponded groundwater towards the southwest. This may encourage a return to the general northeast-southwest groundwater flow direction. If this is implemented, it is suggested that there is periodic monitoring of the springs at S2 and S3 to assess if there have been any changes in flow.

With this measure successfully in place, the magnitude of impact on springs is considered to be ‘low’ with a significance of ‘minor’.

6.2 Post restoration

The proposed restoration contours show that most of the surface water drainage would be to the west and infiltrate to groundwater, while a smaller proportion would drain to the southeast into an existing watercourse.

The restoration material placed in the base of the quarry should be sufficiently permeable to allow groundwater to flow from the north east to the spring discharges to the south. Most of the surface water runoff in the restored sitet will be directed to a pond on the western side of the site from where it will infiltrate into the unworked Northampton Sand Formation. Together with the new channel in the quarry floor (above), this should increase groundwater flow to the west of the quarry. The result should be increased discharge from the spring at Grotto Spinney and reduced flow at spring S3.

It is suggested that spring flows at Grotto Spinney are monitored for a period during and after restoration to establish if there is an improvement in discharge. However, it should be noted that the springs rely on fissure flow in the Northampton Sand Formation and as such their flows can be unpredictable, as can the position from which they emerge.

With this measure in place, the magnitude of impact on springs is considered to be ‘low’ with a significance of ‘minor’.

6.3 Cumulative impacts

Cumulative impacts have been assessed with respect to groundwater levels, groundwater quality, surface water quality and the restoration proposals.

Cumulative impacts are those which result from changes caused by past, present or future foreseeable actions and can be defined under two categories:

Incremental impact - when one impact occurs at the same time as another from a separate development

Combined impact - relates to kinds of impact caused by the development on a particular location

There are no other developments in the vicinity that would result in an adverse cumulative impact on the receptors identified.
7 SUMMARY AND CONCLUSIONS

- Pitsford Quarry Phase 1 is located on the south eastern edge of an area of former, and now restored, ironstone workings.

- It is intended to restore the area to agricultural use using mineral waste and retained soils.

- The site lies in the catchment of the Brampton Branch, a tributary of the River Nene. A small watercourse, the Moulton Arm, flows from west to east to the south of the site, joining the Brampton Branch 2.4 km to the west of the site.

- The site is located on the Northampton Sand Formation, classified by the Environment Agency as a Secondary A aquifer. Groundwater levels recorded between 1996 and 2004 show groundwater flow to the southwest.

- There are no licensed groundwater abstractions within 2 km of the site. One private water supply is recorded from a spring to the west of the site at Fox Covert Farm. The spring is not directly down-gradient of the site.

- Groundwater passing through the site discharges to the surface water system to its south and southeast where the base of the Northampton Sand Formation crops out against the underlying Whitby Mudstone Formation.

- There are no surface water abstractions within 2 km of the site.

- It is proposed to extract the remaining ironstone reserves in Phase 1. These lie between restored workings to the north and partially restored workings to the south. It is not considered that extracting this material will result in any significant changes to the current groundwater and surface water regime around the site.

- It is considered likely that works to improve the drainage in the quarry undertaken between 2005 and 2009 have resulted in the diversion of some groundwater flow away from the spring at Grotto Spinney and towards the shallow valley south east of Phase 1. One consequence appears to have been the emergence of a new spring in the middle of the field to the south.

- It is considered that removing the remaining ironstone reserves in Phase 1 will have minimal impact on the surrounding current water environment. However, some modification of the current passive drainage in the quarry has been suggested in order to mitigate against impacts caused by past activities which may have resulted in reduced spring flows at Grotto Spinney and the emergence of a new spring.

- Restoration will be undertaken using materials already on site and no additional materials will be imported. Therefore the risks of changes to ground and surface water quality are considered to be minimal.

- The proposed restoration contours will promote the flow of surface water runoff to a pond on the west of the site and subsequent infiltration into the aquifer comprising unworked Northampton Sand.

- Some mitigation measures have been suggested to ensure that the groundwater flow through the restored site is, as far as possible, in a general northeast to southwest direction in order to ensure an adequate groundwater discharge at Grotto Spinney.
APPENDIX 1681/HIA-02/A1

Assessment methodology
Method of assessment

The method of assessment of hydrological and aquatic effects has involved:

- Characterisation of the baseline environment
- Determination of the sensitivity of key catchments and watercourses
- Evaluation of the significance of predicted effects taking account of the magnitude of effects (before and after mitigation)
- Evaluation of the sensitivity of the baseline environment affected

A rigorous and consistent approach to the assessment has been adopted using matrices to help classify sensitivity of the resource, and determine the scale and significance of effects.

Baseline sensitivity

The characterisation of the baseline water environment has involved the review of data and identification of sensitivities. The characterisation of catchment sensitivities has been guided by the matrix presented in Table 1681/HIA-02/A1.1 which lists indicative criteria.

The criteria for sensitivity are based approximately on hierarchy of factors relating to the quality of the aquatic environment. The criteria have been used to guide the analysis of the sensitivity of the baseline hydrological, hydrogeological and water quality environment.

<table>
<thead>
<tr>
<th>Sensitivity category</th>
<th>Sensitivity criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjacent to Application Area</td>
</tr>
<tr>
<td>High sensitivity</td>
<td>SSSI or Aquatic Natura 2000 site Wetland/watercourse habitat of particular ecological importance Highly vulnerable groundwater Significant peat deposits on sloping ground</td>
</tr>
<tr>
<td>Medium sensitivity</td>
<td>Wetland watercourse habitat of particular ecological importance Moderately vulnerable groundwater Significant peat deposits</td>
</tr>
<tr>
<td>Low sensitivity</td>
<td>Low vulnerability groundwater Superficial peat deposits</td>
</tr>
<tr>
<td>Not sensitive</td>
<td>No aquatic habitats or watercourses present No significant groundwater present</td>
</tr>
</tbody>
</table>

Table 1681/HIA-02/A1.1: Catchment sensitivity classification
Impact prediction and evaluation

The prediction and assessment of effects on hydrology, hydrogeology and other aquatic resources has been undertaken using a series of tables to document the various potential impacts from aspects of the proposed project. Impacts have been predicted for the proposed development based on the guideline criteria for impact magnitudes set out in Table 1681/HIA-02/A1.2.

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Guideline criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Total loss of, or alteration to, key features of the baseline resource such that post-development characteristics or quality would be fundamentally and irreversibly changed, eg watercourse realignment</td>
</tr>
<tr>
<td>Medium</td>
<td>Total loss of, or alteration to, key features of the baseline resource such that post-development characteristics or quality would be partially changed, eg in-stream permanent bridge works</td>
</tr>
<tr>
<td>Low</td>
<td>Small changes to the baseline resource which are detectable but the underlying characteristics or quality of the baseline situation would be similar to pre-development conditions, eg culverting of very small watercourses</td>
</tr>
<tr>
<td>Negligible</td>
<td>A very slight change from baseline conditions, which is barely distinguishable and approximates to the 'no change' situation, eg short-term compaction from plant movements</td>
</tr>
</tbody>
</table>

Table 1681/HIA-02/A1.2: Impact magnitude

Using these criteria a series of generic impacts have been predicted for the proposed development. Residual effects have been predicted taking into account site-specific mitigation.

The significance of the predicted effects has been assessed in relation to the sensitivities of the baseline resource. A matrix of significance was developed to provide a consistent framework for evaluation and is presented in Table 1681/HIA-02/A1.3. Guideline criteria for the various categories of effect are included in Table 1681/HIA-02/A1.4.

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Sensitivity</th>
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<tr>
<td>High</td>
<td>Major</td>
</tr>
<tr>
<td>Medium</td>
<td>Moderate</td>
</tr>
<tr>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td>Negligible</td>
<td>None</td>
</tr>
</tbody>
</table>

Table 1681/HIA-02/A1.3: Significance matrix

<table>
<thead>
<tr>
<th>Significance</th>
<th>Definition</th>
<th>Guideline criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>No detectable change to the environment</td>
<td>No effects on drainage patterns, surface and groundwater quality or aquatic habitat</td>
</tr>
<tr>
<td>Minor</td>
<td>A small but detectable change to the environment</td>
<td>Localised changes in drainage patterns or groundwater flows, or changes resulting in minor and reversible effects on surface and groundwater quality or aquatic habitats</td>
</tr>
</tbody>
</table>
Significance | Definition | Guideline criteria
---|---|---
Moderate | A larger, but non-fundamental change to the environment | Changes in water quality or quantity affecting part of a catchment or groundwaters of moderate vulnerability, or changes resulting in loss of conservation value to aquatic habitats or designated areas

Major | A fundamental change to the environment | Changes in water quality or quantity affecting widespread catchments or groundwater reserves of strategic significance, or changes resulting in substantial loss of conservation value to aquatic habitats and designations

Table 1681/HIA-02/A1.4: Significance of effects categories

In the above classification, fundamental changes are those which are permanent, detrimental and would result in widespread change to the baseline environment.

The matrices used to guide the assessment have been applied with a degree of flexibility since the evaluation of effects would always be subject to particular location-specific characteristics which need to be taken into account. For this reason, the evaluation of impact significance, in particular, would not always correlate exactly with the cells in the relevant matrix where professional judgement and knowledge of local conditions may result in a slightly different interpretation of the impact concerned. Cumulative effects have been taken into account through prediction and evaluation of effects at a catchment-wide level.