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Table of contents

Chapter                  Pages

Executive summary       iv
1. Introduction         6
   1.1. Background       6
   1.2. Policy and legislative context 6
2. Assessment method    8
   2.1. WFD WebTAG methodology 8
3. Baseline conditions  11
   3.1. Site option      11
   3.2. Surface water and drainage 11
   3.3. Flood risk       12
   3.4. Geology          13
   3.5. Hydrogeology     13
   3.6. Land designations 14
4. Hydrogeological and hydrological risk assessment 17
   4.1. Review of activities proposed and potential impacts 17
   4.2. Receptors       17
   4.3. Identification of pathways 17
   4.4. Appraisal of magnitude of impact on receptors 18
   4.5. Mitigation measures 19
   4.6. Residual effects 20
5. Site investigation and monitoring 21
6. Conclusions          22
   6.1. Overall         22
   6.2. Operation       22
   6.3. Restoration     22

Tables

Table 2-1 Importance of water feature or resource 8
Table 2-2 Magnitude of potential impacts 9
Table 2-3 Significance of impacts 10
Table 3-1 Surface water bodies within 1 km of the site option 12
Table 3-2 Geological units present beneath the site option 13
Table 3-3 Summary of surface and groundwater monitoring stations 14
Table 3-4 Groundwater Body WFD Status 14
Table 3-5 Ecological sites within 1 km of the site option 15
Table 3-6 Type and number of surface water and groundwater abstractions within 2 km of the site option 15
Table 4-1 Sensitive Receptors at Huntsmans 17
Table 4-2 Appraisal of Magnitude of Impact on Receptors 18

List of figures

Figure 1 General site option location and layout
Figure 2 Detailed site option and parcels, OS mapping.
Figure 3 Surface water bodies and flood zones
Figure 4 Areas susceptible to groundwater flooding
Figure 5a  Superficial geology underlying the site
Figure 5b  Bedrock geology underlying the site
Figure 6  Designated Sites
## Executive summary

### Project Outline
Gloucestershire County Council is preparing a new county-wide Minerals Local Plan to replace its 2003 plan. Consideration is being given to expanding several crushed rock (limestone) quarries throughout the county. Before any decisions are taken, hydrogeological impact assessments are being conducted. Presently Atkins Ltd has been commissioned to assess the effect of potential quarry expansions of limestone (crushed rock) workings in the Cotswolds and Forest of Dean and the development of a new sand and gravel quarry in the Severn Vale area.

### Site Overview
The site at Huntsmans is located within the Cotswolds AONB approximately 6.5 km west of Stow-on-the-Wold. The site option is 39 ha of agricultural land adjacent to the existing Huntsman’s Quarry. Land use in the surrounding area is dominated by agriculture.

### Geology
No superficial deposits are mapped onsite.

The bedrock is the interbedded limestones of the Fuller’s Earth and Sharp’s Hill Formation (Jurassic) and peloidal limestones of the White Limestone Formation (Jurassic).

### Hydrology / Hydrogeology
The site is located within the River Windrush (ordinary watercourse) catchment. No river flood zones are present within a 1 km radius of the site.

The White Limestone Formation bedrock is classified as a Principal aquifer by the Environment Agency, capable of supplying potable supply and/or river base flow on a strategic scale.

### Land Designations
A Source Protection Zone 3 is present approximately 750 m south east of the site option boundary associated with two potable water abstractions.

Barton Bushes SSSI is located 730 m to the north west of the site. Two Key Wildlife Sites are located within 1 km of the site boundary.

### Impact Appraisal
The main risk of quarrying onsite is related to impact to Principal aquifer (Significant) and flooding (Significant) assuming that during/after quarrying, open areas will be backfilled with low permeability inert material. As a result of the restoration surface water runoff will be increased and groundwater flow paths altered.

Low significance impacts are expected to be felt in the Barton Bushes SSSI.

### Mitigation Measures
It is considered that the potential impacts could be mitigated by good design including the use of Sustainable Drainage Systems and including measures to maintain groundwater connectivity.

### Site Investigation and monitoring recommendations
It is recommended that a programme of site monitoring be carried out; monthly monitoring of groundwater levels for a period of at least 12 months prior to quarrying works, which should continue through the operation phase. Monitoring during the aftercare period should also be continued to demonstrate that any mitigation measures included are effective. Locations should be targeted, agreed with the Mineral Planning Authority in advance if possible and should ensure that there is adequate spatial coverage to understand groundwater flow around the sites. Collaboration with other proposed minerals sites in the area may be required. Precipitation data can be collected from the Environment Agency/Meteorological Office to supplement...
Water quality should also be monitored to determine any potential contamination, focusing on the River Windrush. The monitoring routine can follow the same as that for groundwater levels.

| Conclusions          | Backfilling of the site using low permeability material may inhibit groundwater flow in the area and result in lower groundwater levels. If mitigation measures are properly implemented, risk of flooding, impact to local abstractions and impact to the SSSI will be reduced during quarrying and following the restoration of the site. |
1. **Introduction**

1.1. **Background**

Gloucestershire County Council (herein referred to as “the County Council”) is the Mineral Local Planning Authority (MPA) for the entirety of Gloucestershire. The County Council is preparing a new county-wide Minerals Local Plan to replace its previously adopted minerals local plan, which has been in place since 2003.

As part of this work, Atkins has been commissioned by the County Council to undertake a review of previous hydrological studies and undertake a hydrogeological assessment concerning a number of potential mineral extraction sites across the Cotswolds, Forest of Dean and Severn Vale mineral resource areas. These sites are described by the Council as ‘site options’ and are currently under consideration for inclusion within the new county wide minerals local plan.

Atkins has completed hydrogeological impact assessments to cover each of the 6 extraction site options under consideration for inclusion within a new county-wide minerals local plan. This equates to 5 quarries to extract crushed rock (limestone) and one for sand and gravels (see Figure 1 for the site option locations).

This report provides an appraisal and utilisation of existing local evidence, much of which has been provided by the County Council. This includes water resources information that has been submitted to accompany mineral planning applications, which are either likely to have an influence or encompass the areas identified as site options, and technical work in support of other environmental strategies, plans and proposals.

1.2. **Policy and legislative context**

This initial hydrogeological assessment will be carried out in-line with the statutory and non-statutory guidance set out in the national, regional and local plans below:

**EU Legislation:**
- Water Framework Directive (WFD)\(^1\)

**UK legislation:**
- Town and Country Planning Act 1990 (as amended)
- The Environmental Permitting (England and Wales) Regulations 2010 (as amended)

**National policy:**
- Groundwater Protection: Policy and Practice (GP3)\(^3\)
- Catchment Flood Management Plans
- The National Planning Policy Framework (NPPF)\(^4\) published in March 2012
- The Planning Practice Guidance to the NPPF\(^5\).

**Local policy:**
- Gloucestershire Waste Core Strategy\(^6\)

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• Gloucestershire Revised Minerals and Waste Development Scheme (MWDS)\textsuperscript{7}

2. Assessment method

2.1. WFD WebTAG methodology

Assessment criteria have been used based on the methodology for appraising the impact of projects (plan level appraisal) set out in the Department for Transport’s (DfT) Transport Analysis Guidance (TAG) Unit A3 Environmental Impact Appraisal\(^8\) and the specific guidance for the water environment sub-objective set out in TAG Unit 10.2 (10.2.12 Impact Appraisal)\(^9\). Although this methodology has been developed for the assessment of road and bridge projects it can be used to assess the impacts of other developments such as the proposed mineral extraction sites.

The methodology takes into account the importance of the feature (Table 2-1), the magnitude of any predicted impact (Table 2-2) and thus assesses the significance of predicted effects on the water environment.

The severity of a specific potential effect is then derived by considering both the importance (or sensitivity) of the feature and the magnitude of the impact (impacts must be quantified where possible, also estimating the change from the baseline conditions and the range of uncertainty). The significance of the impacts must be identified. This has been addressed in the derivation of significance of potential effects matrix shown in Table 2-3 which gives the significance of effect as a function of the sensitivity of the receptor and magnitude of impact.

Table 2-1 Importance of water feature or resource

<table>
<thead>
<tr>
<th>Importance</th>
<th>Criteria</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>Feature with a high quality and rarity, regional or national scale and limited potential for substitution.</td>
<td>Aquifer providing potable water to a large population (Groundwater). Important fish population (Surface water). Floodplain or defence protecting more than 100 residential properties (Flood Risk).</td>
</tr>
<tr>
<td>High</td>
<td>Feature with a high quality and rarity, local scale and limited potential for substitution. Feature with a medium quality and rarity, regional or national scale and limited potential for substitution.</td>
<td>WFD “High” status water body (Surface water). Aquifer providing potable water to a small population (Groundwater). Notable fish population (Surface water). Floodplain or defence protecting up to 10 industrial premises (Flood risk).</td>
</tr>
<tr>
<td>Medium</td>
<td>Feature with a medium quality and rarity, local scale and limited potential for substitution. Feature with a low quality and rarity, regional or national scale and limited potential for substitution.</td>
<td>WFD “Good” status water body (Surface water). Aquifer providing abstraction water for agricultural or industrial use (Groundwater). Floodplain or defence protecting up to 10 industrial premises (Flood risk).</td>
</tr>
<tr>
<td>Low</td>
<td>Feature with a low quality and rarity, local scale and limited potential for</td>
<td>WFD “Less than good” status (Surface water).</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Importance</th>
<th>Criteria</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>substitution.</td>
<td>Unproductive strata (Groundwater).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Floodplain with limited existing development (Flood risk).</td>
</tr>
</tbody>
</table>

Table 2-2   Magnitude of potential impacts

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Criteria</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Adverse</td>
<td>Results in loss of feature</td>
<td>• Loss of important fishery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Change in WFD classification of river reach.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Compromise employment source.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Loss of flood. storage/increased flood risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution of potable source of abstraction.</td>
</tr>
<tr>
<td>Moderate Adverse</td>
<td>Results in adverse impact on integrity of feature or loss of part of feature.</td>
<td>• Loss in productivity of a fishery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contribution of a significant proportion of the effluent in the receiving river, but deemed insufficient to change its WFD classification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduction in the economic value of the feature.</td>
</tr>
<tr>
<td>Slight Adverse</td>
<td>Results in minor adverse impact on feature.</td>
<td>• Measurable changes in feature, but of limited size and/or proportion.</td>
</tr>
<tr>
<td>Negligible</td>
<td>Results in an impact on feature but of insufficient magnitude to affect use/integrity.</td>
<td>• Discharges to watercourse but no significant loss in quality, fishery productivity or biodiversity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No significant impact on the economic value of the feature.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No increase in flood risk.</td>
</tr>
<tr>
<td>Slight beneficial</td>
<td>Results in minor beneficial impact on feature or a reduced risk of adverse effect occurring.</td>
<td>• Measurable changes in feature, but of limited size and/or proportion.</td>
</tr>
</tbody>
</table>
Moderate beneficial | Results in moderate improvement of feature | • Enhanced productivity of a fishery.
• Reduction in a significant proportion of the effluent in a receiving river, but not sufficient to change its WFD classification.
• Moderate reduction in flood risk.

Large beneficial | Results in major improvement of feature | • Removal of major existing polluting discharge to a watercourse.
• Major reduction in flood risk.

<table>
<thead>
<tr>
<th>Table 2-3</th>
<th>Significance of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnitude of potential impact</td>
<td>Importance / Sensitivity of attribute</td>
</tr>
<tr>
<td></td>
<td>Very high</td>
</tr>
<tr>
<td>Large Adverse</td>
<td>Very Significant</td>
</tr>
<tr>
<td>Moderate Adverse</td>
<td>Highly Significant</td>
</tr>
<tr>
<td>Slight Adverse</td>
<td>Significant</td>
</tr>
<tr>
<td>Negligible</td>
<td>Low Significance</td>
</tr>
</tbody>
</table>

In applying this methodology to both construction and operational stages, significant effects would be those of low significance or above. If an adverse significant effect is identified, whether it is of low, medium or high sensitivity, then potential mitigation measures have been developed to reduce or mitigate this effect. When beneficial impacts are identified, then opportunities for further environmental enhancement can be considered.
3. Baseline conditions

3.1. Site option
The site option is located in the north of the Cotswolds Area of Outstanding National Beauty (AONB), approximately 6.5 km west of Stow-on-the-Wold and 1.3 km north of Naunton. The site option consists of a single parcel of land, located at National Grid Reference location 411971, 225048. The site is approximately 39 ha in size, however part of the extension would be used for the storage of soils, limiting the extraction area to 14.6 ha\(^{10}\). The site slopes eastward to 205 mAOD from 240 mAOD at the western boundary; a topographic depression is present intersecting the site from the south west to the north east. An overview plan of the site option is provided in Figure 2.

The site is bounded by the active Huntsman’s Quarry to the north, Buckle Street to the east and agricultural land to the south and west. The surrounding land use is dominated by agriculture and the site option is comprised entirely of open fields. The nearest properties are located as follows; a residential building 110 m to the north east and a farm/outbuilding approximately 70 m to the east, Summerhill Farm is approximately 180 m to the south.

3.2. Surface water and drainage
The surface water bodies within 1km of the site, and their associated flood zones are presented on Figure 2 and details of the main rivers, watercourses and drains are presented within Table 3-1.

3.2.1. Main rivers
No main rivers are located within the immediate vicinity of the site option. The closest, River Windrush, is located approximately 5 km south east of the site at Bourton-on-the-Water, following the confluence of the Rivers Eye and Dickler.

3.2.2. Ordinary watercourses (Lead local flood authority (GCC))
The site option is located within the upper catchment of the Rivers Windrush and Eye (ordinary watercourses). The River Windrush flows from the north west to south east, and is located approximately 1.3 km south of the site, the River Eye is approximately 2.2 km east of the site, and flows from north to south.

No drains are shown within the site boundary on the available mapping although it is possible some agricultural drainage ditches are not shown. A series of mapped springs feeds an unnamed tributary of the Windrush approximately 175 m south of the site.

3.2.3. Lakes and ponds
No lakes or ponds are indicated within the site option on OS and satellite mapping, however several ponds and a small lake are associated with the workings of Huntsman’s Quarry to the north east, including a small pond adjacent to the northern boundary. The locations of these ponds are presented within Table 3-1.

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3.2.4. Water Framework Directive status

Table 3-1 Surface water bodies within 1 km of the site option

<table>
<thead>
<tr>
<th>Water body name / ID</th>
<th>Location (NGR)</th>
<th>Hydromorphological status</th>
<th>Current ecological quality (Certainty)</th>
<th>Current chemical quality (Certainty)</th>
<th>Value/Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unnamed tributary of River Windrush</td>
<td>175 m south of the Site (412201, 224606)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Low</td>
</tr>
<tr>
<td>Quarry lagoon</td>
<td>20 m north of Site (412274, 225238)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Low</td>
</tr>
<tr>
<td>Pond</td>
<td>245 m north east of Site (412616, 225271)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Low</td>
</tr>
<tr>
<td>Pond</td>
<td>270 m north east (412658, 225275)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Low</td>
</tr>
<tr>
<td>Lake</td>
<td>550 m north east (412519, 225767)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Low</td>
</tr>
</tbody>
</table>

3.3. Flood risk

This section summarises the relevant data on flooding that is available for the site option.

3.3.1. Surface water flooding

The majority of the site is recorded as not at risk of surface water flooding\(^{11}\). A small area coincident with the topographic depression crossing the site is shown to be at risk from events with annual probabilities of occurrence up to 1%.

3.3.2. River flooding

Figure 3 shows that no river flood zones are present\(^{12}\) within a 1 km radius of the site.

3.3.3. Groundwater flooding

No information on the probability of groundwater flooding occurring is available, however information on the areas susceptible to groundwater flooding has been provided by the Environment Agency\(^{13}\). As indicated on Figure 4, three quarters of the site is situated within an area where less than 25% of each 1 km grid square is susceptible to groundwater flooding.

The data should not be interpreted as identifying areas where groundwater is actually likely to flow or pond, thus causing flooding, and does not give any indication of the probability of frequency that flooding may occur.

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\(^{13}\) Environment Agency, 2015. Areas susceptible to Groundwater Flooding [GIS shapefile].
3.3.4. Sewer flooding
As the site option is in a rural area and it is unlikely that significant discharges to sewers will be required, sewer flooding has not been considered.

3.4. Geology
This section provides a summary of the geology that underlies the site option. The geological units that are present beneath the site are listed within Table 3-2. The geology in the surrounding area is extensively faulted and a fault divides the site option from the northwest to the southeast. No superficial deposits are mapped onsite. Plans showing bedrock geology underlying the site option are provided in Figure 5.

Table 3-2 Geological units present beneath the site option

<table>
<thead>
<tr>
<th>Geological formation (geological period)</th>
<th>Member</th>
<th>Geological description</th>
<th>Approximate thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial deposits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None mapped</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedrock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuller’s Earth and Sharp’s Hill Formation (Jurassic)</td>
<td>Undifferentiated</td>
<td>Silicate-mudstone, grey, bedded, variably calcareous, grading to lime-mudstone, fossiliferous, with units of thinly interbedded, more or less silicate-muddy limestone</td>
<td>0 – 19 m</td>
</tr>
<tr>
<td>Great Oolite Group (Jurassic)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Limestone Formation</td>
<td></td>
<td>Limestone, peloidal</td>
<td>60-90 m</td>
</tr>
<tr>
<td>Subcrop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salperton Limestone Formation (Jurassic)</td>
<td></td>
<td>Pale grey to brown rubbly, ooidal, peloidal and finely shell-detrital packstone to grainstone.</td>
<td>10-15 m</td>
</tr>
</tbody>
</table>

Source: BGS Lexicon of Named Rock Units. Available at [http://www.bgs.ac.uk/lexicon/lexicon](http://www.bgs.ac.uk/lexicon/lexicon) accessed on 25 February 2016

3.5. Hydrogeology
This section provides a summary of the hydrogeology for the site option.

3.5.1. Aquifers
The White Limestone Formation bedrock aquifer is classified as a Principal aquifer by the Environment Agency. The limestone is thinly bedded and highly fractured with subordinate layers of mudstone. Intergranular permeabilities and storage are low; the main flow mechanism is fracture flow which may be enhanced by solution.

The Environment Agency considers the bedrock aquifer to be Highly Vulnerable to pollution. This means the area is able to easily transmit pollution through to groundwater. Such areas are typically characterised by high leaching soils, and the absence of low permeability drift deposits.

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3.5.2. Aquifer properties

There is no available hydrogeological assessment of the properties of the aquifer beneath the site or within close proximity of the site. The BGS geo index has identified this aquifer as a “Significant limestone aquifer yielding up to 40 l/s. Locally perched with many springs. Becoming brackish at depth in confined aquifer”. As such the transmissivity, porosity, yield and hydraulic conductivity of the aquifer is not known. Therefore it is recommended that a full hydrogeological assessment of the aquifer beneath the site is conducted prior to the start of the mineral extraction operations in order to fully evaluate the potential risks of the operations at the site.

3.5.3. Monitoring locations and groundwater flow

The Centre of Ecology and Hydrology (CEH) have a number of surface water monitoring points throughout the UK. One of which is located approximately 5 km SE from the site boundary on the River Windrush. The BGS monitors groundwater throughout the UK and stores it on a publically available database, the UK Hydrometric Register. A groundwater monitoring station is located approximately 24 km south west of the site, monitoring the Forest Marble Formation of the Great Oolite Group to a depth of 61 mbgl. The available monitoring stations are summarised in Table 3-4.

Table 3-3 Summary of surface and groundwater monitoring stations

<table>
<thead>
<tr>
<th>Surface/groundwater monitoring station</th>
<th>Grid reference</th>
<th>Area covered (km²)</th>
<th>Mean flow (m³/s)</th>
<th>Groundwater level L₉₅ (mAOD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface: 39142 – Windrush at Bourton on the Water</td>
<td>SP16002090</td>
<td>65.5</td>
<td>0.71</td>
<td>-</td>
</tr>
<tr>
<td>Ground: SP00/62 Ampney Crucis</td>
<td>SP05950190</td>
<td>-</td>
<td>-</td>
<td>102.85</td>
</tr>
</tbody>
</table>

3.5.4. Water Framework Directive status

The WFD status of groundwater bodies is determined using quantitative and quality components and is measured as being either Good or Poor (Table 3-4). The limestone bedrock beneath the site option is contained within the Burford Jurassic Groundwater Body.

Table 3-4 Groundwater Body WFD Status

<table>
<thead>
<tr>
<th>Waterbody name (ID)</th>
<th>Current quantitative quality (Certainty)</th>
<th>Current chemical quality (Certainty)</th>
<th>Overall risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burford Jurassic (GB40601G600400)</td>
<td>Good (No information available)</td>
<td>Poor (Uncertain)</td>
<td>At Risk (Poor)</td>
</tr>
</tbody>
</table>

3.6. Land designations

This section summarises the relevant protected areas and historic land uses within 1 km of the site option.

3.6.1. Source protection zones

A Source Protection Zone 3 is located approximately 750 m south east of the site option boundary, associated with two private abstractions for potable supply (Section 3.6.4).

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https://ea.sharefile.com/share?cmd=d&id=s0c6fa39b82a46e9a#/view/s0c6fa39b82a46e9a7_k=zbz7l8 Accessed on 17 February 2016
3.6.2. **Historical land use and pollution incidents**

No pollution incidents are reported within 1 km of the site option according to Environment Agency mapping 18 and the Environment Agency reports no historical landfills within 1 km19.

3.6.3. **Protected areas**

The site option is located within the Cotswolds AONB and a SSSI Impact Risk Zone. Magic Mapping indicates there are two SSSI sites located within 1 km of the site boundary20. Huntsman’s Quarry SSSI (1.6 ha) is located 400 m to the north east and is designated for its geological interest, the most significant exposure of the Cotswolds Slate of the Middle Jurassic in Gloucestershire21. Barton Bushes SSSI (5.7 ha) is of biological interest and is located approximately 730 m to the north west of the site option22. Additionally two Scheduled Ancient Monuments, Bowl Barrow and Summerhill Prehistoric Site are located within 1 km of the site.

Gloucestershire County Council Key Wildlife Sites are designated areas with a rich diversity of habitats that provide refuges and corridors for wildlife across Gloucestershire. Some of which may contain plant species sensitive to groundwater levels, or aquatic life sensitive to changes in water quality. 2 Key wildlife sites are located within 1 km of the site and are presented on Figure 6.

Table 3-5 **Ecological sites within 1 km of the site option**

<table>
<thead>
<tr>
<th>Type/ designation</th>
<th>Name</th>
<th>Location relative to the site option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSSI</td>
<td>Huntsman’s Quarry SSSI (Geological designation)</td>
<td>400 m to the north east</td>
<td>n/a</td>
</tr>
<tr>
<td>SSSI</td>
<td>Barton Bushes SSSI (Biological designation)</td>
<td>730 m to the north west</td>
<td>Medium</td>
</tr>
</tbody>
</table>

In addition there are 2 Key Wildlife Sites located within 1 km of the site boundary, as shown on Figure 6.

3.6.4. **Abstractions**

There are no abstractions on-site. No licensed abstractions are present within 1 km of the site option. No un-licensed (private) abstractions are located within 1 km of the site option, abstractions are located immediately outside the 1 km radius are summarised in Table 3-6 below.

Table 3-6 **Type and number of surface water and groundwater abstractions within 2 km of the site option**

<table>
<thead>
<tr>
<th>WFD water body Name</th>
<th>Location</th>
<th>Purpose</th>
<th>Max annual abstraction (m³/year)</th>
<th>Maximum daily abstraction / volume (m³/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>1.1 km north east of Site (413655, 225386)</td>
<td>Commercial and domestic drinking water</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>1.2 km north east of Site (413208,</td>
<td>Domestic drinking water</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>WFD water body Name</th>
<th>Location</th>
<th>Purpose</th>
<th>Max annual abstraction (m³/year)</th>
<th>Maximum daily abstraction / volume (m³/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>226058</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Hydrogeological and hydrological risk assessment

4.1. Review of activities proposed and potential impacts

It is proposed that the GCC allocates several sites throughout the county for further mineral extraction and expansion. One of the sites which is being considered for limestone (crushed rock) extraction is located at Huntsman’s Quarry. This study aims to carry out a hydrogeological assessment of the site area and examine the risks posed by any future development to specific receptors and the pathways that may cause this risk to affect receptors within the boundary of the proposed development area. For the purposes of this assessment it has been assumed that work has taken place and the quarried areas have been backfilled with clay, therefore this is an assessment of the worst case scenario.

The proposed activities at the site and across all site options involve mineral extraction within the parcel. The mineral resource of interest at Huntsmans is (crushed rock) limestone which underlies the entire site option.

The most significant potential impacts are focussed on flooding and impacts to the Principal aquifer (Table 4-2). The restoration of the site using low permeability inert infill may introduce contamination to the aquifer and will present a barrier to groundwater flow, resulting in an elevated risk of groundwater flooding. Surface run-off will be increased due to the reduction in permeability of subsurface deposits.

4.2. Receptors

A summary of the receptors for the site option at Huntsman’s Quarry is presented in Table 4-1.

Table 4-1 Sensitive Receptors at Huntsmans

<table>
<thead>
<tr>
<th>Controlled waters</th>
<th>Sensitive land use</th>
<th>Flood risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unnamed tributary of River Windrush</td>
<td>Key wildlife sites</td>
<td>Summerhill Farm</td>
</tr>
<tr>
<td>Principal aquifer</td>
<td>Barton Bushes SSSI</td>
<td>Huntsman’s Quarry offices</td>
</tr>
<tr>
<td>Lakes/Ponds</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The limestone bedrock beneath the site option is classified as a Primary aquifer, two private groundwater abstraction licenses are located 1.1 km and 1.2 km south east of the site boundary.

An unnamed tributary of the River Windrush (ordinary watercourse) is the closest waterbody to the site option. A number of ponds/lakes within 1km of the site all represent potential receptors; however the significance of these are relatively low owing to their distances from the site with the closest 245 m north east of the site boundary. There are three sensitive land uses located within 1 km of the site boundary; two GCC Key Wildlife Sites (areas with a rich diversity of habitats that provide refuges and corridors for wildlife across Gloucestershire) and a SSSI.

4.3. Identification of pathways

There are three main pathways which will be affected by any change in flow paths:

- Groundwater;
- Surface (overland flow) water; and
- Fluvial (river) water pathways

The main pathway for any potential flooding issues lies within the groundwater (dominated by fissure flow) and surface water runoff as potential transport mechanisms. Surface water induced flooding may be exacerbated by the local topography, the reduction in aquifer storage may increase the susceptibility of
localised groundwater flooding in the area surrounding the site option should shallow groundwater be present.

4.4. **Appraisal of magnitude of impact on receptors**

The significance of any effect on the identified receptors is likely to vary depending on a number of factors, such as the sensitivity of the relevant waters, the current conditions within the site and the magnitude of any impact. Such impacts have been displayed in Table 4-2.

**Table 4-2 Appraisal of Magnitude of Impact on Receptors**

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Importance</th>
<th>Impact</th>
<th>During operation</th>
<th>After restoration</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakes/Ponds</td>
<td>Low</td>
<td>Increase or decrease in water levels due to groundwater diversion</td>
<td><strong>Moderate Adverse</strong> Possible dewatering to facilitate mineral extraction may reduce the flow of water feeding these features</td>
<td><strong>Moderate Adverse</strong> The use of inert fill may introduce barriers to groundwater flow and therefore may affect the level of water in the lakes.</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Principal aquifer</td>
<td>High</td>
<td>Dewatering and diversion of groundwater from this area of the aquifer. Decrease in water quality.</td>
<td><strong>Large Adverse</strong> Groundwater in the area is known to supply two potable private water abstractions. Therefore any alteration to the quality or lowering of the groundwater table due to de-watering could significantly impact upon potable supplies that rely on the aquifer as a water source. It should be noted that current adjacent quarrying has not penetrated the water table.</td>
<td><strong>Large Adverse</strong> Restoration of the site with low permeability inert fill may produce a barrier to groundwater flow which can impact on local private potable abstractions and introduce contamination to the aquifer.</td>
<td>Highly Significant</td>
</tr>
<tr>
<td>Tributary of River Windrush</td>
<td>Low</td>
<td>Changes to base flow as a result of dewatering and/or inert infill.</td>
<td><strong>Slight Adverse</strong> De-watering activities during operations may result in diversion of water from the unnamed tributary of the River Windrush as groundwater flow paths are interrupted.</td>
<td><strong>Slight Adverse</strong> Impacts on groundwater flow as a result of the small area proposed for working are unlikely to be significant in terms of the overall flow. This will need to be confirmed during the details work to support any application.</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Barton Vale KWS and Warren Beds KWS</td>
<td>Medium</td>
<td>Changes in groundwater levels and/or quality can impact sensitive vegetation and have knock-on</td>
<td><strong>Slight Adverse</strong> Due to the distance involved, the presence of a stream between the site and the KWSs it is considered unlikely that any impact will be observed.</td>
<td><strong>Slight Adverse</strong> Due to the distance involved and the presence of a stream between the site and the KWS, it is considered unlikely that any impact will be observed.</td>
<td>Insignificant</td>
</tr>
</tbody>
</table>
### Mitigation measures

It is recognised that the proposed mineral extraction activities could, absent any mitigation, have various adverse impacts upon the water environment. However, it is anticipated that potential operators would, as part of their applications, undertake detailed site investigations and monitoring, and provide a more detailed assessment of the impacts. Where a development is an EIA development, this would be presented in the relevant chapter of the Environmental Statement, as well as within a flood risk assessment compatible with the requirements of the NPPF. For non-EIA developments it is still expected that the effects of the development on the water environment, with particular attention to flood risk, will be properly considered and documented. Where necessary it is expected that mitigation measures will be detailed within the application to reduce the impacts to acceptable levels.

Mitigation measures to reduce the impact of dewatering are likely to include some, or all of:

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Importance</th>
<th>Impact</th>
<th>Magnitude During operation</th>
<th>Magnitude After restoration</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barton Bushes (SSSI)</td>
<td>Medium</td>
<td>Changes to water availability Discharge of polluted water</td>
<td>Slight Adverse</td>
<td>Slight Adverse</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>As a designated SSSI, any potential change in hydrological conditions could potentially impact on integrity of the site. However, the SSSI is a long way from the site and is not known to be water-dependent so the impacts are likely to be limited.</td>
<td>As a designated SSSI, any potential change in hydrological conditions could potentially impact on integrity of the site. However, the SSSI is a long way from the site and is not known to be water-dependent so the impacts are likely to be limited.</td>
<td></td>
</tr>
<tr>
<td>Flood Risk</td>
<td>High</td>
<td>Increased risk of flooding from rivers, surface water and groundwater</td>
<td>Moderate Adverse</td>
<td>Moderate Adverse</td>
<td>Significant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dewatering may to be required and discharge of this water may give rise to an increased risk of flooding if the capacity of the receiving stream is exceeded. Any stockpiling of materials within areas susceptible to surface water flooding may increase the risk of flooding off site due to a reduction in flood plain storage.</td>
<td>The backfilling of the mineral working with lower permeability material, may increase the amount of runoff from the site following a rainfall event and may therefore increase the risk of flooding. The lower permeability materials are likely to block the migration of groundwater through the site and therefore, water levels may rise up-gradient of the site. This may give rise to an increased risk of groundwater flooding locally.</td>
<td></td>
</tr>
</tbody>
</table>
• Subdivision of the working area into smaller cells to reduce the active perimeter; and
• Control of dewatering volumes, and if necessary, suspension of pumping during storm event, to ensure receiving waters have appropriate capacity for the flow.

Mitigation measures to reduce impact on water quality are likely to include some, or all of:

• Use of bunded tanks and drip trays to prevent spillages;
• Use of settlement (silt) ponds or proprietary equipment to reduce the silt content of discharged water;
• Compliance with quality limits set by the Environment Agency; and,
• Use of clean inert materials only for restoration.

Measures to minimise the impact of flood risk are likely to include some, or all of:

• Placing buildings, stockpiles and other infrastructure outside the flood plain and outside areas at risk of surface water flooding where ever possible;
• Where storage within a flood risk areas is required, place it at as low a risk as possible, which will commonly be as close to the edge of the zone as possible;
• Restore the sites to existing ground level and no higher, in order to not impact upon flood plain storage;
• Provide flow balancing using sustainable drainage systems, such that the greenfield (pre-development) rate of runoff is not exceeded in line with current SuDS guidance23; and,
• Provide safe pathways for groundwater to move around or through the infilled site, such that groundwater levels do not rise above the pre-development levels.

4.6. Residual effects

If mitigation measures are implemented with the addition of a stringent monitoring programme, the residual effects of the mineral extraction activities at Huntsmans should be negligible.

5. Site investigation and monitoring

It is recommended that the following parameters be monitored before, during and after quarry operations:

- **Groundwater levels** – Monthly monitoring for a period of 12 months prior to quarrying, during operation (at a higher frequency if required) and during the aftercare and management period. Locations should be identified to provide good coverage of the proposed site, taking into account the need to understand groundwater/surface water interaction and should as far as possible, be located so that they can function for the whole of the period required.

- **Precipitation** – Data can be collected from Environment Agency or Meteorological Office at the same times and for the same period as groundwater levels are recorded.

- **Water Quality** – pH, dissolved oxygen, Biochemical Oxygen Demand (BOD), conductivity, ammonia, nitrates, suspended solids and other relevant chemical parameters should be measured to ensure the unnamed tributary, and subsequently the River Windrush, are not contaminated.
6. **Conclusions**

6.1. **Overall**
The site at Huntsmans is under consideration by the GCC for mineral extraction. The area is gently sloping eastwards and there is a topographic depression running west to east which is at a low risk of flooding from surface water. The site is not at risk from flooding from rivers or the sea and less than 25% of the site area is susceptible to groundwater flooding.

6.2. **Operation**
The area to the north and east of the proposed site option has been largely quarried as part of the existing Huntsman's Quarry. This current operation has not penetrated the water table, and as a result the quarry workings remain unsaturated.

6.3. **Restoration**
It is proposed that all parcels will be restored to agriculture using inert fill. This restoration has the potential to increase flood risk, by increasing surface water runoff and damming groundwater flow paths.

Mitigation measures to manage these risks are available and the council should ensure that well designed mitigation is included in any applications that are submitted.