Flood Risk Assessment in support of a Review of Old Mineral Permission at Pitsford Quarry, Northamptonshire

Report ref: 1681/FRA-01 Version 2
FINAL

June 2014

Report prepared for:

GP Planning Ltd
The Stables
Long Lane
EAST HADDON
Northamptonshire
NN6 8DU
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Prepared by: C Ishemo BSc MSc PhD

Checked by: 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. It is currently closed due to uneconomic market conditions, but extraction of ironstone for building stone and crushed aggregate will at some stage recommence under existing Planning Permission DA/97/1140/C.

Hafren Water has been commissioned to undertake a Flood Risk Assessment (FRA) to accompany the Review of Old Mineral Permission (ROMP).

1.2 Scope of the assessment

Environment Agency standing advice on development and flood risk requires an FRA to be undertaken as the site is over 1 hectare (Ha). The FRA complies with guidance outlined in the National Planning Policy Framework (NPPF), which states that development should not increase flood risk elsewhere and therefore looks for the use of Sustainable Drainage Systems (SuDS) to reduce run-off rates.

Flood risk to and from the Application Area (defined in Section 1.7 of this report) has been assessed and quantified. Flood risk mitigation measures are recommended.

1.3 Location and surrounding area

The Application Area can be found approximately 1 km south of Pitsford Village, Northamptonshire (Drawing 1681/FRA-01/01) and is located at National Grid Reference (NGR) SP 757 671. The Application Area, which covers 9.0 Ha, includes the access track from Harborough Road (A508), existing weighbridge, wheelwash and offices. Details of the Application Area are shown on Drawing 1681/FRA-01/02.

Pitsford Quarry (‘the site’) is bounded to the north and west by former quarry workings, now restored, and agricultural land to the east and south. The nearest residential property, Fox Covert Farm, is located 140 m west of the western site boundary. A grade II listed structure stands at ‘Grotto Spinney,’ 190 m south of the south-western corner of the site (see Photograph 6).

A minor road between Pitsford village and the larger village of Moulton touches the northeast corner of the site.

Access to the site is currently via a track from the A508, Harborough Road, located to the west of the quarry. The length of the track is approximately 485 m.

1.4 Hydrology

1.4.1 Background

The hydrology of the site and its environs has been derived from Ordnance Survey maps. Locations of water features are shown on Drawing 1681/FRA-01/01. Drawing 1681/FRA-01/03 shows the site within the Environment Agency’s indicative flood risk map.

1.4.2 Watercourses

The Brampton Branch of the River Nene is located 2.5 km west of the site. This river flows southward towards the centre of Northampton, where it joins the River Nene.
The topography of the area may be described as “rolling hills.” The site lies half-way up the southern slope of one such hill, which forms a ridge between the valleys of two eastern tributaries of the Brampton Branch.

The site belongs to the southern of the two catchments, known as the Moulton Arm of the Brampton Branch. The northern valley is the Pitsford Arm.

The catchment boundary directly north of the site is situated approximately 120 m Above Ordnance Datum (mAOD), while the Moulton Arm stream lies 1 km south of the boundary at an elevation of 75 mAOD. The Pitsford Arm valley directly north of the site has similar elevations. The valley-side average gradients are thus in the order of 4%. However, gradients in the Moulton Arm valley steepen on approach to the watercourse, whereas they are more constant on the north-facing slope down to the Pitsford Arm.

- The eastern boundary of the site itself is the natural drainage line of a valley feature giving rise to a first-order stream. This drainage line runs southward for approximately 700 m from the northeast corner of the site, before joining the Moulton Arm. At the confluence, the FEH CD-ROM (Version 3) gives an estimated catchment area of 0.7 km$^2$ for the small stream.

- The Moulton Arm rises 5.5 km east of the site, to the northeast of the village of Moulton, approaches to within 450 m south of the site’s southern boundary, and continues westward to join the Brampton Branch 2.2 km southwest of the site. The FEH CD-ROM (Version 3) provides a catchment area of 13.9 km$^2$ for this watercourse at the confluence of the site’s eastern boundary channel, and 17.1 km$^2$ in total. The Baseflow Index derived from the Hydrology of Soil Types data is approximately 0.7 for this total catchment, indicating high rates of infiltration and relatively low rates of run-off.

- As mentioned above, the Pitsford Arm of the Brampton Branch is located in a separate, well-defined valley to the north of the site. This stream is the outflow of the third largest reservoir in the UK, Pitsford Water, which is managed by Anglian Water. This stream is not considered any further in this FRA, since it does not exchange surface water with the site.

1.4.3 Waterbodies
Three waterbodies are located within 2 km of the site:

- A waterbody (Pitsford Pond) is located 200 m to the east, within an area of restored ironstone workings, used as a fishery. The waterbody has an area of approximately 0.7 Ha.

- A waterbody is located within the valley of the Brampton Branch tributary at Boughton Park, 500 m southwest of the site at closest approach. The waterbody covers an area of approximately 1.2 Ha.

- Pitsford Water, a potable water supply reservoir administered by Anglian Water, is located some 1.4 km north of the site (at closest approach) and covers an area of 740 Ha. The reservoir is a designated Site of Special Scientific Interest (SSSI).

1.4.4 Springs
According to the 1:25,000-scale Ordnance Survey map, historical maps and information from Daventry District Council, a number of springs are located within 2 km of the site. Their locations are presented on Drawing 1681/FRA-01/01.
Eleven springs occur to the south of the site, all discharging into watercourses draining into the Moulton Arm of the Brampton Branch. The nearest of these springs is located 110 m south of the site. One of the springs emerges within a grade II listed structure within ‘Grotto Spinney,’ approximately 190 m south of the site’s south-western corner. Three springs are located south of the Moulton Arm.

Six springs are located to the north of the site. All drain northwards into the Pitsford Arm of the Brampton Branch. The closest of these springs to the site is located 1.1 km away and just to the east of Pitsford Village.

1.5 Climate change

Within the UK, projections of future climate change indicate that there will be more frequent, short duration, high intensity rainfall events and periods of long duration rainfall. The NPPF recommends that the effects of climate change are incorporated into Flood Risk Assessments. Recommended precautionary sensitivity ranges for peak rainfall intensities and peak river flows are outlined in the technical guidance to the NPPF, Table 5.

1.6 Ground conditions

Local bedrock geology at the site consists of the Northampton Sand Formation underlain by Whitby Mudstone Formation. The younger Stamford Member (part of the Great Oolite Group) outcrops to the north and immediately east of the site and the Whitby Mudstone outcrops 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 to the northeast of the site.

The soils are freely draining, highly fertile, sandy loams. The Baseflow Index derived from the local Hydrology of Soil Types data is approximately 0.7, indicating high rates of infiltration and relatively low rates of run-off.

1.7 Site description and proposed development

The Application Area is shown on Drawing 1681/FRA-01/02. It comprises the access track from the A508, the plant and facilities yard, the existing quarry void and an area of restored grassland currently occupying the southwest corner and southern boundary.

It is proposed to continue extraction of the ironstone reserves within the Application Area, as shown in Drawing 1681/FRA-01/04. The extracted mineral is to be processed before being despatched from the site. Existing ground elevations in the proposed working areas are 4-5 m below the surrounding ground level. The workings are anticipated to lower the quarry floor in these areas by a further 2-3 m, bringing these areas to approximately the same elevation as the rest of the quarry floor.

After extraction operations have been completed, it is proposed to restore the current Application Area to agriculture, as shown on Drawing 1681/FRA-01/05, using mineral waste and soils. Topsoil and subsoil for the restoration are stored on site ready for re-use.

1.8 Flood vulnerability classification

As a mineral extraction and processing site, the proposed development will be classed as ‘less vulnerable’ to flooding, in accordance with the NPPF.
2 FLOOD RISK TO THE SITE DURING OPERATIONS

2.1 Background

The risk of flooding at the site has been assessed by examining the likelihood of flooding, the hazard caused if the site were to flood and its vulnerability. This has been undertaken for a variety of mechanisms using both quantitative and qualitative methods. The level of flood risk involved is then classified, using the criteria set out in Appendix 1681/FRA-01/A2.

As mentioned in Section 1.8 of this report, the development is categorised as ‘less vulnerable’ in the NPPF.

2.2 Fluvial flooding

2.2.1 Flood risk from the Moulton Arm

The Environment Agency’s indicative flood map (Drawing 1681/FRA-01/03) clearly shows the floodplain of the Moulton Arm, 450 m south of the site boundary. It can be seen that this floodplain does not come near the site boundary, and in fact the entirety of the site is situated within Flood Zone 1, where the probability of fluvial flooding in any one year is less than 0.1% (on average, less than 1 fluvial flood in 1000 years). Furthermore, the lowest part of the site’s boundary lies at approximately 90 m AOD, whereas the stream bank of the Moulton Arm lies 15 m lower at 75 m AOD, at its closest approach. Therefore, the degree of flood risk posed to the site by the Moulton Arm can be considered negligible.

2.2.2 Flood risk from the minor stream adjacent to the site

The possibility of flooding from minor watercourses not included in the indicative flood map has to be assessed. As noted in Section 1.4.2, a minor stream runs southwards along the site’s eastern boundary, and the total catchment area of this drainage path is 0.7 km$^2$ at its confluence with the Moulton Arm. The catchment area on leaving the site boundary has not been estimated, but will be somewhat smaller than this.

This drainage path has been investigated during a site visit and using aerial photography. As can be seen from Photograph 1681/FRA-01/P1, no watercourse is apparent immediately adjacent to the site boundary. It is thought likely that a ditch runs along the eastern side of the hedge shown in the photograph. At the southeastern corner of the site, this ditch emerges from beneath the hedge before entering a short concrete culvert of approximately 450 mm internal diameter to convey water beneath an access track. The only water seen entering this culvert is considered to be groundwater emerging from the site itself. The flow discharges into a short stretch of open channel and then enters an iron pipe that runs down the side of the valley towards the Moulton Arm. Having investigated this drainage line and having found it to be a small ditch, the degree of flood risk that it poses to the site can be considered ‘negligible’.

2.2.3 Fluvial flood risk conclusion

Referring to Appendix 1681/FRA-01/A2, the fluvial flood hazard to the development is evaluated as ‘negligible’, resulting in a ‘negligible’ consequence of flooding. As the site lies in Flood Zone 1, its likelihood of flooding is considered ‘low’, leading to a ‘very low’ flood risk. Mitigation measures to protect the site from fluvial flooding are therefore not required.

2.3 Groundwater flooding

The proposed working area is shown on Drawing 1681/FRA-01/04. This drawing also shows an existing area of groundwater emergence. Photograph 1681/FRA-01/P4 shows this groundwater ponding from within the site.
This groundwater ponding is presumed to arise due to the lowering of the quarry floor close to the top surface of the underlying mudstones, creating a spring zone. The proposed development will involve the cutting back of the ironstone layer that may be playing a part in conveying the groundwater to the current spring zone. Therefore, it may move or extend the spring zone northwards within the site.

Currently, this emerging groundwater is discharged by run-off into an excavated channel from which it re-infiltrates (see Photograph 1681/FRA-01/P5). As shown in the photograph, the existing infiltration channel is capable of conveying more flow than it currently receives. Therefore, it is considered capable of accommodating an increased rate of groundwater emergence – conceivably developing due to climatic variability – thereby preventing the development of significant depths of ponded groundwater in such circumstances.

Consequently, the overall risk to the site from groundwater flooding is considered to be 'low.' A measure to mitigate against the residual risk of groundwater flooding is proposed in Section 8 of this report.

2.4 Surface water run-off

As seen from the contours on Drawing 1681/FRA-01/01, the site may receive surface water run-off from approximately 25.6 Ha of greenfield land adjacent to its northern boundary. As noted in Section 1.3, this area comprises former quarry workings that have now been restored (to community woodland). The suitability of the restoration soils for tree growth suggests some permeability and therefore that high rates of run-off are unlikely. During the summer, interception by tree foliage would also reduce runoff.

2.4.1 Incoming surface water run-off – methodology

The peak run-off rate expected from the external source area in the 1-in-100-years rainfall event is calculated in Appendix 1681/FRA-01/A1 using the IH124 method (Equation 7.1, Institute for Hydrology Report No 124, 1994). This formula gives the mean annual peak flow ($Q_{\text{BAR}}$) as follows:

$$
Q_{\text{BAR(rural)}} = 0.00108 \times \text{AREA}^{0.89} \times \text{SAAR}^{1.17} \times \text{SOIL}^{2.17}
$$

Where:
- $Q_{\text{BAR(rural)}}$: mean annual flood, with a return period of 2.3 years (m$^3$/s)
- AREA: catchment area (km$^2$)
- SAAR(1941-1970): Standard Average Annual Rainfall (1941 to 1970) (mm)
- SOIL: soil index

The SAAR4170 value used was 608 (taken from the Flood Estimation Handbook) and the SOIL index used was 0.15 (reflecting the wooded nature of the catchment).

$Q_{\text{BAR(rural)}}$ can be multiplied using the UK Flood Studies Report regional growth curves to produce peak flood flows for any return period.

The effects of predicted climate change over the working lifetime of the quarry also need to be considered, increasing runoff in accordance with recommendations in the Technical Guidance to the NPPF, Table 5 (2012). In order to cover the intended 15-year period of validity for this ROMP, a 20% increase in peak runoff rate is applicable.

2.4.2 Incoming surface water run-off – evaluation

Drawing 1681/FRA-01/06 shows the 25.6 Ha greenfield area assumed to be shedding surface water run-off into the site. This area stretches along the northern boundary,
including the northern edge of the access road. The resulting 1-in-100-year peak surface water run-off rate into the working site, accounting for climate change, would be approximately 38 l/s. As the northern site boundary is 1 km long, this implies a flux of 0.038 l/s/m. Due to the fact that the access road is aligned across the prevailing slope, it is considered likely that this sheet flow would traverse the road and continue southwards towards the Moulton Arm.

The run-off entering the plant yard and quarrying area would join direct rainfall. The combined run-off can be directed to storage areas in the working area, as considered necessary by the owners to maintain operations. The standing water shown in Photograph 1681/FRA-01/P4 is an example of this. All plant within the site will be mobile, allowing it to be located out of such areas of accumulation. This water will discharge to the southeast corner of the site, where the run-off will join the existing drainage pathway running south towards the Moulton Arm. The run-off may also re-infiltrate into the ground at the southeastern corner of the site. As noted in Section 2.3, this is also the existing situation in the inactive quarry.

In light of the above, the risk within the operational site from surface water flooding is considered to be ‘low.’ A measure to mitigate against the residual risk of surface water flooding is proposed in Section 8 of this report.

2.5 Flooding from sewers and water mains

No sewers are known to pass by or through the site. However, it is understood that a 21-inch water main runs in a north-south direction, a few metres east of the eastern site boundary. Referring to Photograph 1681/FRA-01/P1, it can be seen that the eastern site boundary is bunded and therefore any leakage or flooding from this main would not enter the site. Such leakage would flow southwards and spread out on the floodplain of the Moulton Arm, eventually entering that watercourse.

Consequently, the risk within the working site from flooding by sewers and water mains is adjudged ‘very low’, and measures to mitigate this flood risk pathway are not considered to be necessary.
3 FLOOD RISK FROM THE SITE TO THE SURROUNDING AREA, DURING OPERATIONS

3.1 Fluvial flooding

As observed in Section 2.2 of this report, the entire Application Area lies in Flood Zone 1. Therefore, the proposed development will not influence the flow of any water already within a channel or floodplain. Therefore, it will pose ‘very low’ fluvial flood risk to external receptors, and this mode of external flooding is considered no further.

3.2 Groundwater flooding

As noted in Section 2.3, groundwater is currently emerging in the previously worked area, running off along a drainage channel and re-infiltrating before reaching the site boundary. As the site lies on a hillside, it might be expected that this water could emerge further downslope. In fact, a recent site visit has revealed spring zones in some nearby areas of the valley side. The groundwater catchment of these springs is not restricted to the site itself, but may include a large part of the interfluve between the Moulton Arm and the Pitsford Arms.

Such spring zones are also considered as minor groundwater flooding – in this case, with very low depths and slow velocities. The flooding pathway continues downslope to join the Moulton Arm. Any local groundwater flow that has not emerged on the hillside will also be captured by that watercourse, which acts as a sink for both surface and subsurface flows.

The only receptors between source and sink are agricultural land, which is classed as ‘less vulnerable’ to flooding, in the NPPF, and the grade II listed structure at ‘Grotto Spinney’. This structure was built in the 1770s to house the spring and may be considered a ‘water-compatible development’ under the NPPF (see Photograph 6). Referring to the criteria in Appendix 1681/FRA-01/A2, the flood hazard is therefore ‘negligible.’

The findings of the site visit indicate that the operational site has little effect on the delivery of groundwater flooding to the receptor. Consequently, the groundwater flood risk to external receptors from the proposed development is considered to be ‘very low,’ and measures to mitigate against such flooding are not considered to be necessary.

3.3 Flooding by surface water run-off

The proposals involve the removal of Northampton Sand Ironstone from the top of the Whitby Mudstone, thereby exposing a generally less permeable surface. This might alter surface water run-off from the site to the surrounding area, thereby increasing flood risk. However, both of the surfaces in question are consolidated sedimentary rock, and so are significantly less permeable than soils. They are also expected to exhibit similar degrees of weathering.

While there might be some difference between the average infiltration rates of the two surfaces, it can be expected that both of these average rates are some orders of magnitude lower than the rainfall rate experienced during a design storm. Consequently, it is considered that the change in surface from weathered ironstone to weathered mudstone will not discernibly change the run-off characteristics of the site.

With reference to the flood risk assessment criteria in Appendix 1681/FRA-01/A2, the flood risk posed to external receptors by surface water run-off from the operational development is considered to be ‘very low,’ and measures to mitigate this risk are not considered to be necessary.
3.4 Flooding by sewers or water mains

No sewers are known to pass by or through the site, and so the workings will not affect the pathway between such a source and any receptors. However, as noted in Section 2.5, a 21-inch water main runs adjacent to the eastern site boundary. Again as noted in Section 2.5, bunding along this site boundary prevents any exchange of water between the main and the site, thus removing the site from the source-receptor pathway in this case. Consequently, the risk of flooding by sewers and water mains, posed by the working quarry to external receptors, is considered to be ‘very low’, and measures to mitigate this flood risk pathway are not considered to be necessary.
4 SUMMARY OF IMPACTS OCCURRING DURING OPERATIONS

A summary of the flood risk impacts occurring during operations is given in Table 1681/FRA-01/T1.

<table>
<thead>
<tr>
<th>Hydrological Component at Site</th>
<th>Sensitivity (Flood Consequence)</th>
<th>Magnitude (Increase in Flood Likelihood)</th>
<th>Significance (Increase in Flood Risk)</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>RISK TO PLANT YARD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluvial flow</td>
<td>Negligible</td>
<td>Low</td>
<td>Very Low</td>
<td>In Flood Zone 1</td>
</tr>
<tr>
<td>Groundwater flow</td>
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<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>Surface water run-off</td>
<td>Low</td>
<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>Sewers/water mains</td>
<td>Negligible</td>
<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>RISK TO QUARRYING AREAS</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluvial flow</td>
<td>Negligible</td>
<td>Low</td>
<td>Very Low</td>
<td>In Flood Zone 1</td>
</tr>
<tr>
<td>Groundwater flow</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>To be mitigated by drainage</td>
</tr>
<tr>
<td>Surface water run-off</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>To be mitigated by drainage</td>
</tr>
<tr>
<td>Sewers/water mains</td>
<td>Low</td>
<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>RISK TO EXTERNAL RECEPTORS</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fluvial flow</td>
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<td>Low</td>
<td>Very Low</td>
<td>Site will not be in contact with fluvial waters</td>
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<tr>
<td>Groundwater flow</td>
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<td>Very Low</td>
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</tr>
<tr>
<td>Sewers/water mains</td>
<td>Not Known</td>
<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
</tbody>
</table>

Table 1681/FRA-01/T1: Assessment of impacts during operations
5 FLOOD RISK TO THE SITE AFTER RESTORATION

5.1 Background

The restoration plan for the Application Area is shown on Drawing 1681/FRA-01/05. The overall site will be returned to agriculture, as described in Section 1.7. The NPPF categorises this land use as ‘less vulnerable’ to flooding.

5.2 Fluvial flooding

As discussed in Section 2.2.1, the Moulton Arm will pose negligible risk of flooding to the operational site, and this will not change on restoration.

The restoration plans involve removal of the bund forming the eastern site boundary. A small ditch within the eastern site boundary is currently proposed that will receive runoff from areas within the site’s eastern half. The existing ditch, just outside the eastern site boundary, will remain. As noted in Section 2.2.2, flood risk posed by the small catchment of these ditches is not considered to be significant.

5.3 Groundwater flooding

As noted in Section 3.2, the Application Area and the groundwater flood receptor lie within the pathway between groundwater source and sink. The source is aquifer recharge occurring on the interfluve between the Moulton and Pitsford Arms, while the sink is the Moulton Arm.

The landform of the restored site will be similar to that of the operational site in that it will be lower than the pre-excavation landform, and may therefore attract more emergence of groundwater than previously. As shown on the restoration plan (Drawing 1681/FRA-01/05), there will be a new pond in the western margin of the restored working area. The local groundwater table is expected to intersect this pond. The effect of this will be that the pond water level will fluctuate somewhat, around the average water table level. These groundwater-influenced water levels are expected to remain similar to those observed in the existing site. They will be evident only in the aforementioned, new pond. Consequently, the degree of groundwater flood risk to the restored site is considered to be ‘very low,’ and measures to mitigate against such flooding are not considered to be necessary.

5.4 Surface water and water mains flooding

As noted in Section 2.4, the site may receive surface water runoff from approximately 25.6 Ha of greenfield land adjacent to its northern boundary. Most of the drainage from this land is expected to run across the former access road and plant site, continuing southwards without entering the restored working area. Surface runoff entering the restored working area would come from the most easterly part of the source area, this being of the order of 10 ha in extent.

The proposed restoration landform would route such runoff into the pond in its western margin. The runoff would infiltrate from this pond into the local groundwater, as in the existing site. Therefore, the degree of surface water flood risk to the restored site is considered to be ‘very low’, and measures to mitigate this risk are not considered to be necessary. A similar conclusion applies to any water leakage from the adjacent water main.
6  FLOOD RISK POSED BY THE SITE TO THE SURROUNDING AREA, AFTER RESTORATION

6.1 Background

The restoration plan for the Application Area is shown on Drawing 1681/FRA-01/05. The overall site will constitute an agricultural area, as described in Section 1.7.

6.2 Fluvial flooding

As observed in Section 2.2 of this report, the entire Application Area lies in Flood Zone 1. Therefore, the restored site will not influence the flow of any water already within a channel or floodplain. Therefore, it will pose 'very low' fluvial flood risk to external receptors, and this mode of external flooding is not considered further.

6.3 Groundwater flooding

As noted in Section 3.2, the Application Area and the groundwater flood receptors lie within the pathway between groundwater source and sink. The source is aquifer recharge occurring on the interfluve between the Moulton and Pitsford Arms, while the sink is the Moulton Arm. The receptors are the grade II listed structure at ‘Grotto Spinney’ and agricultural land downslope of the existing spring zones below the site.

Again as noted in Section 3.2, site inspection has indicated that the operational site has little effect on the delivery of groundwater flooding to the receptors. In the case of the restored site, the minimal effect of the operational site on these groundwater flows would be reduced further, since the minor losses to surface drainage that would occur during operations would no longer occur after restoration.

Therefore, the groundwater flood risk to external receptors from the proposed development is considered to be 'very low,' and measures to mitigate against such flooding are not considered to be necessary.

6.4 Flooding by surface water run-off

Restoration of the site will slightly increase the ground surface gradients within it. The maximum and minimum ground levels within the existing plant yard and working area are approximately 95 m and 90 mAOD, respectively. By comparison, the site restoration will increase the maximum ground level to 105 mAOD, similar to neighbouring land off the northern site boundary. This can be expected to increase the run-off rate from the site.

The restoration will also increase the permeability and run-off storage capacity of the site surface through topsoil application and re-vegetation. This can be expected to reduce the rate of run-off from the site.

The peak run-off rates for the existing site and for the restored site have been estimated using the Rational Method, in Appendix 1681/FRA-01/A1. The Rational Method to give peak flows \( Q_p \) is of the form:

\[
Q_p = 2.78 \times C i A
\]

Where: \( C \) = run-off co-efficient (dimensionless)

\( i \) = rainfall intensity (mm/hr)

\( A \) = catchment area (Ha)

A rainfall event duration of 6 hours was assumed, since the Rational Method does not
estimate critical duration.

The run-off coefficient, C, was assigned a value of 0.6 for the existing site and 0.35 for the restored site, taking into account slope, the effects of vegetation (or lack thereof) and soil type.

The effects of predicted climate change over the lifetime of the development were also considered. The increases in rainfall intensities are based upon recommendations in the NPPF Flood Risk Technical Guidance Table 5 (2012). It is assumed that climate change does not affect the existing site. However, the restored site is anticipated to continue in perpetuity, for which a 30% increase in rainfall intensity is applicable.

The results in Appendix 1681/FRA-01/A1 suggest that the run-off from the site during the 1-in-100-year storm would be lower after restoration than it would be from the existing site. It is therefore concluded that the proposed restoration will reduce the flood risk posed to external receptors by surface water run-off from the site.

With reference to the flood risk assessment criteria in Appendix 1681/FRA-01/A2, the flood risk posed to external receptors by surface water run-off from the restored site is considered to be ‘very low,’ and measures to mitigate this risk are not considered to be necessary.

6.5 Flooding by sewers or water mains

As noted in Section 3.4, no sewers are known to pass by or through the site. However, a 21-inch water main runs adjacent to the eastern site boundary. The proposed restoration may remove bunding that currently prevents the exchange of water between the site and this water main.

As discussed in Section 2.5, the current flowpath, for leakage from this main, leads directly southward towards the Moulton Arm. On inspection of the restoration plan on Drawing 1681/FRA-01/05, it is considered that, after restoration, such leakage would first be captured by a new valley feature within the restored site, slightly west of the existing minor stream. This valley would deliver the flow to the same point as in the existing case, but with a small delay due to the slightly longer flowpath. Therefore, any flooding of downstream receptors due to a water main leak would not be affected by the restored site.

Consequently, the risk of flooding by sewers and water mains, posed by the restored site to external receptors, is considered to be ‘very low’, and measures to mitigate this flood risk pathway are not considered to be necessary.
7 SUMMARY OF IMPACTS OCCURRING AFTER RESTORATION

A summary of the flood risk impacts occurring after restoration is given in Table 1681/FRA-01/T2.

<table>
<thead>
<tr>
<th>Hydrological Component at Site</th>
<th>Sensitivity (Flood Consequence)</th>
<th>Magnitude (Increase in Flood Likelihood)</th>
<th>Significance (Increase in Flood Risk)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>RISK TO RESTORED SITE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluvial flow</td>
<td>Negligible</td>
<td>Low</td>
<td>Very Low</td>
<td>In Flood Zone 1</td>
</tr>
<tr>
<td>Groundwater flow</td>
<td>Negligible</td>
<td>Medium</td>
<td>Very Low</td>
<td>Restored site will be ‘less vulnerable’</td>
</tr>
<tr>
<td>Surface water run-off</td>
<td>Negligible</td>
<td>Medium</td>
<td>Very Low</td>
<td>Restored site will be ‘less vulnerable’</td>
</tr>
<tr>
<td>Sewers/water mains</td>
<td>Negligible</td>
<td>Low</td>
<td>Very Low</td>
<td>Restored site will be ‘less vulnerable’</td>
</tr>
<tr>
<td>RISK TO EXTERNAL RECEPTORS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluvial flow</td>
<td>Not Known</td>
<td>Low</td>
<td>Very Low</td>
<td>Site will not be in contact with fluvial waters</td>
</tr>
<tr>
<td>Groundwater flow</td>
<td>Not Known</td>
<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>Surface water run-off</td>
<td>Not Known</td>
<td>Low</td>
<td>Very Low</td>
<td>Restoration may reduce pluvial flood risk</td>
</tr>
<tr>
<td>Sewers/water mains</td>
<td>Not Known</td>
<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
</tbody>
</table>

Table 1681/FRA-01/T2: Assessment of impacts after restoration
8 MITIGATION MEASURES

8.1 Background

Table 1681/FRA-01/T3 shows which combinations of flooding sources and receptors require mitigation.

<table>
<thead>
<tr>
<th></th>
<th>OPERATIONAL SITE</th>
<th>RESTORED SITE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To development</td>
<td>To external receptor</td>
</tr>
<tr>
<td>Fluvial</td>
<td>Not required</td>
<td>Not required</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Required</td>
<td>Not required</td>
</tr>
<tr>
<td>Surface water</td>
<td>Required</td>
<td>Not required</td>
</tr>
<tr>
<td>Sewer and/or mains-derived</td>
<td>Not required</td>
<td>Not required</td>
</tr>
</tbody>
</table>

Table 1681/FRA-01/T3: Flooding pathways requiring mitigation

8.2 Drainage of proposed working areas

As noted in Sections 2.3 and 2.4, some surface water and groundwater may enter the proposed working areas from sources upslope of the site, as well as from within the site itself. This water can be dealt with by arrangement of the quarry floor to guide runoff into areas convenient for the maintenance of operations. Outflow from these storage areas will run to the southeast corner of the site where it will join the existing drainage pathway running south towards the Moulton Arm. The run-off may also re-infiltrate into the ground at the southeastern corner of the site.

As noted in Section 2.2.2, site inspection has found that southward drainage along the valley feature east of the site passes under an access track, via a 450 mm concrete culvert. This culvert was found to be almost completely full of silt, although its remaining capacity was sufficient to convey the small flows observed during the site visit.

In the interest of preventing the bypassing of this culvert during high-intensity events, it is recommended to remove the silt and perform periodical clearance to maintain its transmission capacity. This mitigation measure will be sufficient to reduce any ponding of water in the site’s southeast corner, and will also reduce the incidence of any overland flow in the fields downslope of the culvert.
9 SUMMARY AND CONCLUSIONS

9.1 A Review of Old Mineral Permission is being carried out for Phase 1 of Pitsford Quarry, an ironstone working near Northampton. The Application Area is a total of 9.0 Ha and includes the access track from the A508, the plant yard and the existing Phase 1 quarry void. Under the National Planning Policy Framework, a Flood Risk Assessment is required for this development as it is greater than 1 Ha in extent.

9.2 The proposal involves resumption of mineral extraction in the quarry void, processing the aggregate mineral in the quarry void and building stone in the adjoining plant yard. On completion of extraction operations, it is proposed to restore the site to agriculture using reserved mineral waste and soils, but retaining ground levels lower than the pre-existing surface.

9.3 Due to its topographical position, the site is entirely within Flood Zone 1, where the probability of fluvial flooding in any one year is less than or equal to 0.1%. Consequently, the risk of fluvial flooding to the proposed operational site is not considered to be significant.

9.4 The existing site receives surface water runoff and groundwater emergence from source areas north of the site. These flows have previously been dealt with by storage on the quarry floor, with a drainage channel taking outflows away downslope to join a nearby ditch. Re-infiltration of the flow also occurs within the channel. It is anticipated that flooding of the proposed operations can be prevented using the same or similar arrangement, subject to the clearance of a silted-up culvert in the receiving ditch. Consequently, the risk of pluvial and groundwater flooding to the operational site is not considered to be significant.

9.5 No sewers are known to pass near to the site. However, a 21-inch water main runs adjacent to the site’s eastern boundary. There is a bund between the site and the route of this water main, which will prevent any flooding of the operational site in the event of leakage. Consequently, the flood risk posed to the operational site by the water main is not considered to be significant.

9.6 As noted above, the operational quarry will not be affected by flooding from fluvial, pluvial, groundwater or man-made sources. In connection with this, the flood risk assessment has also found that neither the working quarry nor the restored site will affect or modify the flows between such flood sources and any external receptors. Consequently, flood risk from the site to any external receptors has not been found to be significant.

9.7 As an agricultural area, the restored site will be categorised as ‘less vulnerable’ to flooding by the National Planning Policy Framework (NPPF). It will be an agricultural hill-slope and pond constructed of mineral waste outside the indicative floodplain, and will not include any buildings. These facts lead to the conclusion that there will be no significant flood risk to the restored site.

9.8 Significant flood risks to the proposed development have not been identified. Nor has the development been found to increase any flood risk to external receptors. Therefore, it has not been necessary to consider any flood risk mitigation measures in connection with the development, with the exception that the culvert in the ditch to the east of the site should be cleared of silt.

9.9 In light of the above, the proposed development is considered to satisfy the flood risk requirements of the NPPF and associated technical guidance.
DRAWINGS 1 – 3
Legend
- Application Area
- Springs
- Catchment divide

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Pitsford Quarry
1:25,000
Nov-2013

Site location and water features

Client: GP Planning
The Stable, Long Lane
East Haddon
Northamptonshire
NN6 8DU

Project: Pitsford Quarry

Drawing: 1681/FRA-01/01
Date: Nov-2013
Scale: 1:25,000
Legend

Application Area

Approximate ground elevation contours (mAOD)

Existing restored area

Client

GP Planning
The Stable, Long Lane
East Haddon
Northamptonshire
NN6 8DU

Project

Pitsford Quarry

Title

Existing land-use

Drawing

1681/FRA-01/02

Date

Nov-2013

Scale

1:5,000
Legend

- Application Area
- Flooding from rivers or sea without defences
- Extent of extreme flood
- Flood defences
- Areas benefiting from flood defences
- Main river

Indicative flood risk map

Environment Agency (2013)

Hafren Water

Barkers Chambers, Barker Street, Shrewsbury, SY1 1SB
Tel. 01743 355 770
Fax. 01743 357 771

GP Planning
The Stable, Long Lane
East Haddon
Northamptonshire
NN6 8DU

Client

Title

Project
Pitsford Quarry

Drawing
1681/FRA-01/03
Date
Nov-2013
Scale
1:15,000

Environment Agency (2013)
Proposed restoration of Phase 1

Locally sourced soils and planting for biodiversity
Legend

Application Area

- External source area

- Runoff from external source area

GP Planning
The Stable, Long Lane
East Haddon
Northamptonshire
NN6 8DU

Title: Runoff from external source area

Project: Pitsford Quarry

Drawing: 1681/FRA-01/06

Date: Nov-2013

Scale: 1:10,000
PHOTOGRAPHS
Photograph 1: Looking south along valley feature next to eastern boundary of site

Photograph 2: Looking south along eastern boundary of site
Photograph 3: Looking northwest across site

Photograph 4: Groundwater ponding in central part of site
Photograph 5: Looking upstream along drainage gully leading from groundwater pond

Photograph 6: The grotto within Grotto Spinney
APPENDIX 1681/FRA-01/A1

Run-off calculations
Surface Water Runoff from External Source Areas, Entering Site

Institute of hydrology report no. 124 (IH124)

\[ Q_{\text{BAR(rural)}} = 0.00108 \text{AREA}^{0.89} \text{SAAR}^{1.17} \text{SOIL}^{2.17} \]

Where:

- \( Q_{\text{BAR(rural)}} \): mean annual flood (return period 2.3 years) (m\(^3\)/s)
- \( \text{AREA} \): catchment area (km\(^2\))
- \( \text{SAAR(4170)} \): standard average rainfall for the period 1941 to 1970 (mm)
- \( \text{SOIL} \): soil index

\( Q_{\text{BAR(rural)}} \) can be factored by the UK Flood Studies Report regional growth curves to produce peak flood flows for any return period.

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>0.2560 km(^2)</td>
</tr>
<tr>
<td>( \text{SAAR(4170)} )</td>
<td>608</td>
</tr>
<tr>
<td>SOIL</td>
<td>0.15</td>
</tr>
<tr>
<td>FSR region</td>
<td>5</td>
</tr>
<tr>
<td>Return period</td>
<td>2</td>
</tr>
<tr>
<td>Growth curve factor</td>
<td>0.89</td>
</tr>
</tbody>
</table>

### Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q_{\text{BAR(rural)}} )</td>
<td>8.8 l/s</td>
</tr>
<tr>
<td>( Q ) (1in2yr)</td>
<td>7.8 l/s</td>
</tr>
<tr>
<td>( Q ) (1in2yr)</td>
<td>0.3 l/s/ha</td>
</tr>
<tr>
<td>( Q ) (1in100yr)</td>
<td>1.2 l/s/ha</td>
</tr>
</tbody>
</table>

NB: calculation based on 0.5 km\(^2\) and then scaled down to actual catchment size. The IH124 methodology is designed for sites > 0.5 km\(^2\) but can be linearly interpolated to represent smaller catchments.

<table>
<thead>
<tr>
<th>Return period (yr)</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>25</th>
<th>50</th>
<th>100</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q ) (l/s)</td>
<td>0.3</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>( Q ) (l/s) - baseline climate</td>
<td>7.8</td>
<td>11.3</td>
<td>14.5</td>
<td>19.8</td>
<td>24.9</td>
<td>31.3</td>
<td>39.2</td>
</tr>
<tr>
<td>Climate Change % Increase in Peak Flow</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Q ) (l/s) - future climate</td>
<td>9.4</td>
<td>13.6</td>
<td>17.4</td>
<td>23.7</td>
<td>29.9</td>
<td>37.6</td>
<td>47.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Length of Receiving Site Boundary (m)</th>
<th>990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflow per metre (l/s/m)</td>
<td>0.009, 0.014, 0.018, 0.024, 0.030, 0.038, 0.048</td>
</tr>
</tbody>
</table>

P:\Projects\Pitsford ROMP (1681)\Working\FRA\Runoff Attenuation Pitsford Phase1.xls/GreenfieldIntoSite
**Runoff Rates from Existing Site and from Restored Site**

<table>
<thead>
<tr>
<th>Topography</th>
<th>Operational Site</th>
<th>Restored Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max height</td>
<td>mAOD</td>
<td>95</td>
</tr>
<tr>
<td>Min height</td>
<td>mAOD</td>
<td>90</td>
</tr>
<tr>
<td>Typical flow path</td>
<td>m</td>
<td>680</td>
</tr>
<tr>
<td>Typical slope</td>
<td>m</td>
<td>0.007</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td>Area</td>
<td>Ha</td>
<td>9.00</td>
</tr>
</tbody>
</table>

| Climate Change   |                  | 0             | 30            |
| (% Rainfall Increase) |              |               |               |

<table>
<thead>
<tr>
<th>Return Period</th>
<th>years</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>100</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>hours</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Rainfall *1</td>
<td>mm</td>
<td>37.7</td>
<td>45.0</td>
<td>56.7</td>
<td>67.3</td>
<td>79.8</td>
</tr>
<tr>
<td>Rainfall intensity</td>
<td>mm/hr</td>
<td>6.3</td>
<td>7.5</td>
<td>9.4</td>
<td>11.2</td>
<td>13.3</td>
</tr>
<tr>
<td>Discharge from Existing Site *2</td>
<td>l/s</td>
<td>94.4</td>
<td>112.7</td>
<td>141.7</td>
<td>168.3</td>
<td>199.7</td>
</tr>
<tr>
<td>Discharge from Restored Site *2</td>
<td>l/s</td>
<td>71.6</td>
<td>85.5</td>
<td>107.5</td>
<td>127.6</td>
<td>151.4</td>
</tr>
</tbody>
</table>

The Rational Method to give peak flow \( Q_p \) is in the form:

\[
Q_p = 2.78 \cdot CiA
\]

Where:
- \( C \) = co-efficient of run-off (dimensionless)
- \( i \) = rainfall intensity (mm/hr)
- \( A \) = catchment area (Ha)

*1 Obtained from FEH CD-ROM v3  
*2 Climate change factored into rainfall intensity at this stage
APPENDIX 1681/FRA-01/A2

Flood Risk Assessment criteria
Assessment of Flood Risk

Assessment of flood risk is undertaken following the requirements outlined in the National Planning Policy Framework (NPPF). Although each assessment is specific to the site and mechanism of flooding in question a general method is followed when making all assessments. This method is outlined below.

The assessment of flood risk is undertaken by considering the likelihood of flooding and the consequence of flooding as outlined in Table 1.

<table>
<thead>
<tr>
<th>Likelihood of Flooding</th>
<th>Consequence of Flooding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>Very Low</td>
</tr>
<tr>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Table 1: Assessment of Flood Risk

Likelihood of Flooding

Likelihood of flooding is outlined in Table 1 of the NPPF Technical Guide. For some fluvial sources ie main watercourses the Environment Agency’s flood maps are used to determine the likelihood of flooding. For other mechanisms of flooding assessment is made using other sources of data such as historical information, flow data etc. In some situations it may be necessary to undertake monitoring or modelling to determine likelihood of flooding. In others a more qualitative approach can be taken.

Consequence of Flooding

The assessment of flood consequence is undertaken by considering the Vulnerability of the site and the hazard of flooding at the site as outlined in Table 2.

<table>
<thead>
<tr>
<th>Flood Hazard</th>
<th>Vulnerability of Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>Water Compatible</td>
</tr>
<tr>
<td>Low</td>
<td>Less Vulnerable</td>
</tr>
<tr>
<td>Medium</td>
<td>More Vulnerable</td>
</tr>
<tr>
<td>High</td>
<td>Highly Vulnerable</td>
</tr>
</tbody>
</table>

Table 2: Assessment of Flood Consequence

Flood Hazard

Assessment of flood hazard is undertaken for each possible flooding mechanism and specific to the site in question. An outline of the considerations taken into account when determining the hazard categories used within this report are outlined below:

- **Very high**: High depths of inundation (>600 mm). High velocities of floodwater entering the site (>0.15 m/sec for residential, >0.3 m/sec for commercial). Restricted access/egress to the site.
- **High**: Depths of inundation up to 600 mm. Floodwater flowing across site at speeds of >0.15 m/s. Access/egress possible but may be through floodwaters.
Medium  Inundation of the site below 600 mm. Slack floodwaters with either very low velocities or on the edge of the floodplain. Easy access and egress.


Negligible  No flooding on-site.

**Vulnerability of Site**
Vulnerability of the site is determined using classifications outlined in Table 2 of the NPPF Technical Guide.