Hydrogeological Risk Assessment
for White Mills Marina, Grendon, Earls Barton, Northants

Report ref: 1738/HRA
FINAL
December 2013

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3.1 ASSESSMENT METHODOLOGY

3.1.1 Background

3.1 A Planning Application is being prepared for construction of a 141-berth marina, adjacent to the River Nene at Grendon, Earls Barton, Northamptonshire. The scheme will include a marina basin, ancillary buildings, upgraded highway access, new access roads, parking, landscaping and the ancillary extraction of minerals prior to the construction of the marina.

3.2 The size and scope of the proposed development is such that an Environmental Statement is required and Hafren Water Ltd has been appointed to investigate water-related matters associated with the scheme. The proposal is being promoted by GJP Marina Developments Ltd.

3.1.2 Approach

3.3 An investigation of the water environment in the vicinity of the proposed development has been undertaken and included:

- The collation of baseline data from published and unpublished sources, the developer and investigations previously undertaken to identify mineral within the site
- The development of a conceptual model of the local water regime
- The identification of potential impacts and the development of mitigation measures, if appropriate
- Discussions with the developer to determine detail of the means of managing water during the construction phase

3.4 Discussions with the Environment Agency (EA) highlighted that their principal interest was to determine if potential for impact upon existing abstractors existed, however all aspects were investigated in detail.

3.1.3 Scope of work

3.5 The content of this Hydrogeological Risk Assessment (HRA) has been determined on the basis of the Scoping Opinion prepared by GJP Marina Developments Ltd (July 2013) and the subsequent response from the Environment Agency (EA) given in their letter of 31st July 2013 (EA ref AN/2013/117518/01-LO1). The section within the letter of relevance to this assessment is Item 2.0, Groundwater and Contaminated Land. The above referenced letter states:

3.6 “We recommend that a Hydrogeological Risk Assessment (HRA) is carried out for the construction period to ascertain if any groundwater users/features would be affected by any dewatering operations. This should be included with the Environmental Statement”.

3.7 This scope of work was confirmed in a brief telephone conversation with Jim Branson of the EA (Groundwater and Contaminated Land) on 6th November 2013.

3.1.4 Assessment methodology

3.8 The potential effects of the proposed development upon the extant water environment have been assessed by reference to baseline data and the application of a series of matrices, discussed below, to ensure a rigorous and consistent approach.
3.9 The criteria for sensitivity are based on a hierarchy of factors relating to the quality of the aquatic environment. These criteria have been used to guide the analysis of the sensitivity of the local baseline hydrological, hydrogeological and water quality environment.

3.10 The characterisation of catchment sensitivity has been guided by the matrix presented in Table Vol 3/HRA/T1, which lists indicative criteria.

<table>
<thead>
<tr>
<th>Sensitivity category</th>
<th>Sensitivity criteria</th>
<th>Adjacent to Application Area</th>
<th>Downstream or within catchment</th>
</tr>
</thead>
<tbody>
<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>
<td>Aquatic Natura 2000 site or SSSI immediately downstream or adjacent to site</td>
<td></td>
</tr>
<tr>
<td>Medium sensitivity</td>
<td>Wetland watercourse habitat of particular ecological importance Moderately vulnerable groundwater Significant peat deposits</td>
<td>Aquatic Natura 2000 site or SSSI further downstream of the catchment. Sensitive locally designated site of ecological interest</td>
<td></td>
</tr>
<tr>
<td>Low sensitivity</td>
<td>Low vulnerability groundwater Superficial peat deposits</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Not sensitive</td>
<td>No aquatic habitats or watercourses present No significant groundwater present</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

Table Vol 3/HRA/T1: Catchment sensitivity classification (self-defined criteria)

3.11 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 associated with the proposed mineral extraction. The magnitude of impact has been predicted for future working based on the guideline criteria set out in Table Vol 3/HRA/T2.

<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 re-alignment</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 Vol 3/HRA/T2: Impact magnitude (self-defined criteria)

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

3.13 The significance of the predicted effects has been assessed in relation to the sensitivities of the baseline environment. The matrix of significance provides a consistent framework for evaluation and is presented in Table Vol 3/HRA/T3. Guideline criteria for the various categories of significance of effect are included in Table Vol 3/HRA/T4.

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Major</td>
<td>Major</td>
<td>Moderate</td>
<td>Minor</td>
</tr>
<tr>
<td>Medium</td>
<td>Major</td>
<td>Moderate</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td>Low</td>
<td>Moderate</td>
<td>Minor</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Negligible</td>
<td>Minor</td>
<td>Minor</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Table Vol 3/HRA/T3: Matrix of Impact significance

<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>
<tr>
<td>Moderate</td>
<td>A larger, but non-fundamental change to the environment</td>
<td>Changes in water quality or quantity affecting part of a catchment or groundwater reserves of moderate vulnerability, or changes resulting in loss of conservation value to aquatic habitats or designated areas</td>
</tr>
<tr>
<td>Major</td>
<td>A fundamental change to the environment</td>
<td>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</td>
</tr>
</tbody>
</table>

Table Vol 3/HRA/T4: Definition and comments on ‘Significance’

3.14 The matrices used to guide the impact assessment have been applied with some flexibility since the evaluation of effects is always subject to particular location-specific characteristics, which need to be taken into account. For this reason, the evaluation of impact significance, in particular, does 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.
### 3.1.5 Data sources

British Geological Survey
- Sheet 186, Wellingborough, Bedrock and Superficial Deposits, 1:50,000 Scale, 2007
- Geodata website: borehole records
- BGS website: Geology of Britain viewer

Ordnance Survey
- Topographic map, Sheet 224, Corby, Kettering and Wellingborough, 1:25,000 scale

Envirocheck
- Data search of all pertinent water-related features

Data supplied by GJP Marina Developments Ltd
- Results of mineral evaluation drilling (Boreholes BH1-4), September 2009
- Summary geological information, Hanson Aggregates, November 2004

MAGIC website
- Details of designated sites of ecological interest

Google Earth website
- Satellite imagery
3.2 BASELINE CONDITIONS

3.2.1 Comment

3.15 Detailed information relating to the site setting and the development is given elsewhere within the Planning Application. However, a brief overview of the development, as it relates to the water environment, is given herein to provide background against which consideration of the hydrology, geology and hydrogeology is subsequently made.

3.2.2 Site setting

3.16 The proposed marina is situated on land off Station Road, near Earls Barton, Northamptonshire, NN6 0RB, National Grid Reference (NGR) SP 8570 6211. The land is generally level, however elevations increase slightly on its east, north and south perimeters. Ground elevations vary between 46 and 48 metres Above Ordnance Datum (mAOD).

3.17 Mineral extraction has been undertaken extensively in the floodplain of the River Nene. The closest such workings are historic and located immediately to the east of the site, on the opposite side of Station Road to the Application Area. Earls Barton Quarry, which is operated by Hanson Aggregates, is located to the southeast of the Application Area. The historic workings of this site approach to within 600 m of the Application Area and the mineral processing plant, stockpile area etc are located some 400 m to the east-southeast.

3.2.3 Hydrology

3.18 The proposed marina is situated within the surface water catchment of the River Nene Navigation, which parallels the southern boundary of the proposed marina. The overall river flow direction is northeastwards. A 9-10 m standoff will remain between the river bank and the boundary of the proposed marina.

3.19 Water features described within the report are shown on Drawing Vol 3 Ch 2 (3.19).

3.20 Navigation within the River Nene is facilitated by a system of man-made channels and locks, examples of which occur immediately to the south of the Application Area. In this reach of the watercourse three separate channels exist: a northern canalised section and lock, a straightened section and the pre-existing natural, meandering course to the south.

3.21 A ditch is situated in the northern section of the footprint of the proposed marina. It originates approximately 600 m to the west of the Application Area and flows eastwards, passing in a culvert beneath Station Road. It then turns southwards and discharges into the River Nene. Within the Application Area, it is proposed to divert the ditchcourse slightly to the north.

3.22 A west-northwest to east-southeast orientated culverted ditch transects the Application Area. It was constructed to convey water from a gravel bed situated to the west and used since Victorian times to filter water derived from a sewage works. The effluent discharge has long ceased, however the covered ditch conveys water collected from field drains to the west of the Application Area to the River Nene. The ditch discharges to the river immediately to the southeast of the Application Area at NGR SP 8576 6206.

3.23 Mineral extraction, both historic and current, has resulted in the presence of numerous waterbodies within the floodplain of the River Nene. Waterbodies have formed in worked-out areas of mineral extraction. The closest such feature is located approximately 700 m to the east of the boundary of the Application Area.
3.24 An abandoned river meander has formed a waterbody approximately 150 m to the southwest of the Application Area.

3.25 A raingauge (Station No 159426) is located at Pitsford Reservoir (NGR SP 7589 6864), approximately 11.5 km to the northwest of the site. The long-term average (LTA) rainfall is 633 mm/annum. Monthly LTA rainfall is shown on Table Vol 3/HRA/T5.

<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 Vol 3/HRA/T5: Long-term average monthly rainfall at Pitsford Reservoir raingauge (mm)

3.2.4 Designated sites of ecological interest

3.26 Sites of ecological and conservation interest within 2 km of the site have been identified using the Multi-Agency Geographic Information for the Countryside (MAGIC) website and cross-reference with the ecological assessment report produced by Consultants SKR. Locations of designated sites are shown on Drawing Vol 3 Ch 2 (3.26).

3.27 The western boundary of the Upper Nene Valley Gravel Pits Site of Special Scientific Interest (SSSI) is located approximately 60 m east of the Application Area. The SSSI covers 1382.9 hectares (Ha), of which 144.9 Ha is located within 2.5 km of the Application Area boundary. The majority of the SSSI within 2 km of the site is located on the southern bank of the River Nene. However, 20.4 Ha is located on the north bank to the east of the Application Area. The SSSI is designated due to its breeding bird assemblage of lowland open waters, water bird species and rare example of wet floodplain woodland.

3.28 All of the area of ecological interest in the section of the SSSI immediately to the east of the Application Area is located in an area of former mineral extraction. The historic removal of the mineral, which led to lowering of the ground surface to an elevation close to that of the watertable is responsible for creating the ecological interest of this section of the SSSI.

3.29 The Upper Nene Valley Gravel Pits is also designated as a Special Protection Area (SPA) and Ramsar site. The SPA and Ramsar Areas within 2 km of the Application Area are located on the southern bank of the River Nene and cover 124.5 Ha.

3.30 No other designated ecological sites occur within 2 km of the proposed marina.

3.2.5 Geology

3.31 The details of the geology of the site have been determined from trial pits undertaken by Hanson (2004), results of mineral evaluation drilling in 2009 and BGS records.

3.32 The geology comprises a variety of superficial deposits situated above the laterally extensive Whitby Mudstone Formation. The regional geology is shown on Drawing Vol 3 Ch 2 (3.32).

3.33 The superficial deposits comprise Alluvium which consists of clays, silts, sands and gravels. A borehole drilled within the centre of the site in 2009, BH02/09 (NGR SP 85653 62113) proved approximately 1.1 m of topsoil, silt and clay overlying 0.9 m of coarse brown sand and 'small' gravel. Firm brown and silty clay, grading to hard grey clay, was
encountered from 2.0 m to the base of the borehole at 3.0 m. The proportion of sand and gravel decreases northwards within the site, such that within borehole BH03/09 (NGR SP 85669 62198) the coarsest material recorded was a ‘very silty, sand clay with some stones’, in the interval 1.0-1.15 m below ground level (mbgl). The locations of the boreholes are shown on Drawing Vol 3 Ch 2 (3.33) and their logs are included as Appendix Vol 3 Ch 2 (3.33).

3.34 A mineral evaluation programme was undertaken by Hanson Aggregates in September 2004, during which eleven trial pits were excavated, of which five (TP1-5) were located within the area of the proposed marina. This also proved thickening sand and gravel deposits southwards. Based on the investigation above, within the Application Area the superficial deposits, situated above the Whitby Mudstone Formation, are typically 2-4 m thick, with an average of some 2.5 m.

3.35 The Whitby Formation, which is laterally extensive and situated beneath the superficial deposits throughout the Application Area is described as:

3.36 “Medium and dark grey fossiliferous mudstones and siltstone, laminated and bituminous in parts, with thin siltstone or silty mudstone beds and rare, fine-grained calcareous sandstone beds; dense, smooth argillaceous limestone nodules are very common at some horizons; phosphatic at some beds. Nodular and fossiliferous limestones occur at the base in some areas”.

3.2.6 Hydrogeology

Aquifer status

3.37 The superficial deposits are designated by the Environment Agency as Secondary Aquifer – A. The underlying Whitby Formation is designated as Unproductive Strata.

Groundwater levels

3.38 An indication of groundwater levels can be gained from data within the borehole logs discussed above. Water strikes were recorded whilst drilling the two mineral evaluation boreholes at depths of 1.1 mbgl, in each. Whilst it is recognised that water strike data should be treated with caution, the coincidence of its occurrence with the first presence of silt/sand suggests that it represents the local watertable.

3.39 The limited vertical extent of the ‘aquifer’ is evidenced by the maximum thickness of arenaceous deposits recorded in the boreholes which were 2.5 m and 1 m in boreholes BH01/09 and BH02/09 respectively.

3.40 Comparison of the groundwater levels and geology shown on the borehole logs indicates that the sand and gravel is fully saturated and this was assumed for the purposes of calculations (see below).

Aquifer properties

3.41 Determination of aquifer properties is necessary to calculate groundwater ingress, the key parameter for such calculations being hydraulic conductivity.

3.42 An approximation method to determine hydraulic conductivity was derived by Hazen (1982) which relates hydraulic conductivity and particle diameter. The method assumes a uniform material and the results are therefore considered to be indicative only. The relationship is of the form:
\[ k = C \left( D_{10} \right)^2 \]  
Equation 1

Where 
- \( k \) = hydraulic conductivity (cm/s)
- \( D_{10} \) = particle size such that 10% are finer (cm)
- \( C \) = constant taken to be 40-180. 100 is appropriate for use in the deposit at the site

3.43 Particle size is taken from grading analysis undertaken by Hanson.

3.44 Therefore, \( k = 100 \times (0.025)^2 = 0.0625 \text{ cm/s or } 54 \text{ m/d}. \)

3.45 The assumptions inherent within the method are such that the calculated volumes are significantly greater than those which would pertain in the field. As such they are regarded as highly conservative, ‘worst case’, values.

Abstractions

a) Licensed abstractions

3.46 Details of licensed abstractions within a 2 km radius of the centre of the Application Area were determined from Envirocheck data. Details are summarised in the table below and their locations are shown on Drawing Vol 3 Ch 2 (3.46).

<table>
<thead>
<tr>
<th>Licence No</th>
<th>Location</th>
<th>Source</th>
<th>Licence holder</th>
<th>NGR (SP)</th>
<th>Distance (m)</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/32/05/G/010</td>
<td>Earls Barton gravel pit</td>
<td>GW Gravel pit</td>
<td>Hanson Quarry Products</td>
<td>8630 6220 8634 6215</td>
<td>550 580</td>
<td>MW, MW,DS</td>
</tr>
<tr>
<td>5/32/05/G30</td>
<td>Well 1, Lower End Farm</td>
<td>GW Jurassic</td>
<td>E Ward &amp; Son</td>
<td>8472 6308 8480 6247</td>
<td>1245 820</td>
<td>GF, D, D</td>
</tr>
<tr>
<td></td>
<td>Well 2, Lower End Farm</td>
<td>GW Jurassic</td>
<td>T C Elderton</td>
<td>8710 6319 8710 6320</td>
<td>1700 1710</td>
<td>GF, D, D, SI</td>
</tr>
<tr>
<td>5/32/09/S/163</td>
<td>Two wells at Earls Barton</td>
<td>GW Wells</td>
<td>Grendon Lakes Ltd</td>
<td>8760 6250 8760 6250</td>
<td>1885</td>
<td>SI</td>
</tr>
</tbody>
</table>

Key: GW = groundwater, MW = mineral washing, SW = surface water, DS = domestic supply, GF = general farming, SI = spray irrigation

Table Vol 3/HRA/T6: Summary of licensed abstractions within 2 km radius of the centre of the site (NGR SP 8565 6210)

b) Unlicensed abstractions

3.47 The details of private water supplies within a 2 km radius of the site was determined by liaison with the Environmental Health Department of the Borough of Wellingborough. There are no such sources within the search area.
3.3 WORKING METHODS AND WATER MANAGEMENT

3.3.1 Working methods

Extraction and sealing

3.48 Prior to creation of the marina, the land (and mineral beneath) will be excavated. The works will therefore include two phases: the extraction of minerals and construction of the marina.

3.49 The marina basin will be constructed by the excavation of overburden and sand and gravel and its export from the site. The 'as dug' material will be transported to a mineral processing plant prior to sale. Within the footprint of the marina all of the superficial deposits will be removed to expose the clay that is situated beneath.

3.50 The site lies within a floodplain and so it will have to be dewatered to allow progress of both excavation and construction of the marina. This constraint means that excavation will proceed between March and October so that it is outside of the peak flooding period. As there is only approximately 20-30,000 m³ of mineral to extract this would be dealt with in a 4-5 month period. Therefore, if possible, the mineral will be extracted between March/April and August/September. If the site can be kept dewatered then the marina would be constructed during the following 6-9 month period. This means that works could be completed by June/July the following year. If there are problems dewatering the site during the winter, then it would be allowed to flood after the mineral extraction phase and be dewatered the following spring. This would mean that marina construction would be completed by the following autumn.

3.51 The topsoil and subsoil will be stripped from the marina footprint and stockpiled on-site. The mineral will then be extracted to a depth of 4-5 m. The sides of the basin will be engineered (to create an above ground structure) and so will be constructed out of some form of retaining wall, which will also minimise groundwater ingress. This may be steel piles, concrete panels or stone/concrete gabions (final design to be confirmed). Once the side structure is in place the topsoil will be replaced in the basin and surrounding it. A vehicular access and car park will be constructed at the northern end of the site (furthest from the river) at the same time as the basin. A 9-10 m buffer strip of land will remain between the extraction area and the River Nene. This will only be breached in one small place, to allow access to boats, once the main works to the marina have been completed.

Dewatering and water management

3.52 To allow safe and efficient excavation, the superficial deposits will be dewatered. The water ingressing to the site will be derived from both groundwater inflow and rainfall, both from the footprint of the site itself and its surface water catchment.

3.53 Water will be discharged to the adjacent River Nene, following settlement to ensure that its quality complies with the conditions stipulated on the Environmental Permit, which will be obtained from the Environment Agency.

Water volumes

a) Groundwater ingress

3.54 Lowering of the watertable to the base of the superficial deposits will induce groundwater to flow into the developing marina basin. The volume of inflow has been estimated using two methods.

3.55 The Thiem formula can be applied which equates the dewatered marina basin to a large diameter well. A range of hydraulic conductivity values and the actual configuration of the workings, at their greatest extent, have been used in the calculations to represent a
The worst-case scenario. The calculations and variables utilised are shown in Appendix Vol 3 Ch 3 (3.55).

<table>
<thead>
<tr>
<th>Hydraulic conductivity (m/d)</th>
<th>10</th>
<th>25</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>l/s m³/d</td>
<td>l/s m³/d</td>
<td>l/s m³/d</td>
<td></td>
</tr>
<tr>
<td>5.4 469</td>
<td>5.4 469</td>
<td>5.4 469</td>
<td></td>
</tr>
<tr>
<td>9.5 817</td>
<td>9.5 817</td>
<td>9.5 817</td>
<td></td>
</tr>
<tr>
<td>14.7 1271</td>
<td>14.7 1271</td>
<td>14.7 1271</td>
<td></td>
</tr>
</tbody>
</table>

Table Vol 3/HRA/T7: Theoretical groundwater inflow for a range of hydraulic conductivity values based upon Thiem calculations

3.56 The presence of the river to the south of the site and the assumed good hydraulic connection between groundwater within the sand and gravel and river water is such that inflow volumes greater than those defined above could, theoretically, occur from this direction.

3.57 An estimate of inflow from the river has been made using the Darcy relationship, which is of the form:

\[ Q = k i A \]  

Where: \( Q \) = inflow (m³/d)  
\( k \) = hydraulic conductivity (m/d) – 10, 25 and 50  
\( i \) = hydraulic head gradient (dimensionless) – 2.4/9 = 0.27  
A = cross-sectional area of aquifer per linear metre (m²) – 2.5

\[
\begin{array}{ccc}
  k & 10 \text{ m/d} & 25 \text{ m/d} & 50 \text{ m/d} \\
  \text{m}^3/\text{d} & \text{l/s} & \text{m}^3/\text{d} & \text{l/s} & \text{m}^3/\text{d} & \text{l/s} \\
  6.7 & 0.1 & 16.9 & 0.2 & 33.7 & 0.4 \\
\end{array}
\]

Table Vol 3/HRA/T8: Estimated inflow from river boundary per metre

3.58 An estimate of the total volume of groundwater ingress has been made assuming ingress occurs from half the area of the void at the maximum extent of development and that half of the southern boundary of the marina (i.e. that adjacent to the River Nene) has been excavated but not clay-lined. This is a worst case as material would be emplaced against the sides of the marina basin progressively. Utilising the above assumptions, the total volume of groundwater ingress for a mineral permeability of 50 m/d would be:

\[(14.7/2) + (0.6 \times 33.7) = \sim 27.5 \text{ l/s}\]

3.59 The indicated values should be regarded as a ‘worst case’ maximum as inflow to the developing marina basin would be reduced significantly by the placement of material against the faces of the marina basin, as described above. Furthermore, the value of hydraulic conductivity utilised, 50 m/d, is considered to be the highest likely value.

b) Rainfall-derived water

3.60 Rainwater will enter the working void, which will require removal, in addition to that derived from groundwater. The average volume of rain-derived water can be determined by considering the depth of rain that occurs within the wettest month (68 mm in August, see Table Vol 3/HRA/T5) and multiplying it by the catchment area. At the greatest extent of dewatering, the rainfall catchment area is estimated to be some 5 Ha. The total average monthly, ‘worst case’ volume of rain is thus 3,400 m³, which equates to a continuous pumping requirement of c1.3 l/s. This volume is extremely small and can
readily be managed by the proposed water management regime (Section ‘Discharge off-site’).

Radius of influence of dewatering
3.61 When pumping is maintained to lower water levels a cone of depression develops around the dewatered area within which the watertable is depressed. An estimate of the radius of influence of dewatering can be made using the relationship:

\[ R_o = 3000 \sqrt{\frac{h}{k}} \]

Where \( R_o \) = radius of influence (m)
\( h \) = drawdown at dewatered face (m)
\( k \) = hydraulic conductivity (m/d)

3.62 Assuming a ‘high average’ aquifer thickness of 2.4 m and a range of hydraulic conductivity values (5, 25 and 50 m/d) to account for uncertainty, the theoretical radius of influence of drawdown can be calculated.

<table>
<thead>
<tr>
<th>Hydraulic conductivity (m/d)</th>
<th>5</th>
<th>25</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius of influence (m)</td>
<td>77</td>
<td>122</td>
<td>173</td>
</tr>
</tbody>
</table>

Table Vol 3/HRA/T9: Theoretical radius of influence of drawdown

3.63 The progressive placement of low permeability material against the faces of the marina, once they are at their final positions, will reduce significantly the radius of influence of dewatering.

Discharge off-site
3.64 All of the water which ingresses to the void during construction of the marina will require discharge off-site. It is proposed to create settlement and balancing capacity within the Application Area at an initial stage of site development. Water would be pumped from a sump within the floor of the developing marina to the proposed settlement lagoons from where it would weir over to enter the River Nene by gravity drainage.

3.65 The principal anticipated water quality issue associated with the discharge off-site is suspended solids that may be derived from mobilised fines. These will be settled-out in the basal drainage ditches, the pump sump and settlement lagoons. An Environmental Permit will be required to allow the discharge of water off-site.

Post-development water management
3.66 After the completion of the marina, the water within it will be connected to the river and further active water management will not be necessary.
3.4 EVALUATION AND ASSESSMENT OF EFFECTS

3.4.1 Comment

3.67 The dewatering associated with the construction of the proposed marina has potential to impact upon the local water environment. The potential for impact arises principally due to watertable lowering, however the discharge of water off-site during the construction phase also requires consideration. All of the potential impacts discussed in this chapter relate to the construction phase. Residual effects which may occur when the marina is operational are discussed in Chapter 3.5, Residual effects.

3.68 The means of determining the impacts which are used below are defined in Section 3.1.4 above.

3.4.2 Catchment sensitivity

3.69 Based upon the criteria given within Table Vol 3/HRA/T1, the catchment sensitivity is designated ‘medium’ due to the presence of a SSSI/SAC downstream of the catchment.

3.4.3 River Nene

Water volume

3.70 During dewatering a small volume of water may be induced to flow from the river bed into the surrounding sand and gravel, thence the excavations. However, all of the water ingressing to the workings will be discharged into the river upstream of the area where any adverse impact may occur. There will thus be no net effect on river flows.

3.71 The impact magnitude is therefore ‘negligible’ with an impact significance of ‘minor’.

Water quality

3.72 During the construction phase the principal contractor will be required to employ adequate dewatering systems, silt traps, oil and fuel interceptors to prevent pollution of watercourses. All oils and fuels for construction purposes will be stored in double-bunded tanks located sufficiently far enough away from watercourses for any spillages to be safely dealt with.

3.73 Settlement of suspended solids will occur within the ditches which are to be created within the floor of the workings and in settlement facilities. Water discharged off-site will thus be of good quality and comply with conditions imposed within the Environmental Permit.

3.74 All materials used in the construction process will be stored in a fenced-off compound. The bin areas will also be located within this compound in order that they can be adequately monitored for correct usage by site personnel. Weekly collection of construction waste will prevent debris being blown around the site causing pollution and nuisance.

3.75 A 9-10 m buffer strip will be retained between any excavations and the River Nene during construction of the marina. This will ensure that no sediment from the excavations enters the river. This buffer will also mean that machinery will not be working on the banks of the River Nene for the majority of construction. Therefore, the probability of adverse impact from any spills/leaks from machinery is significantly reduced. The only time machinery will work close to the river is when the entrance to the marina is finally created, and no machinery will be refuelled adjacent to the river. These works, and all works close to the River Nene, will be undertaken through consultation with the EA and following best
practice guidelines. Therefore, no impacts on water quality during construction of the marina are predicted.

3.76 The impact of magnitude is deemed to be ‘negligible’ with a significance of ‘minor’.

3.4.4 Abstractions

3.77 The absence of abstractions in close proximity and on the same side of the River Nene to the site, either licensed or unlicensed, combined with the small impact of the construction of the marina on the water environment is such that the impact is defined as ‘negligible’ and the significance as ‘none’.

3.4.5 Sites of ecological interest

3.78 Dewatering will locally decrease the elevation of the watertable, and could thereby lead to a reduction of shallow groundwater availability for groundwater dependent eco-systems. The proximity of Upper Nene Valley Gravel Pits SSSI to the Application Area is such that the potential for adverse impact has to be considered carefully. The ‘worst case’ indicated radius of influence of dewatering, 173 m, would impinge upon the western boundary of the SSSI.

3.79 However, several mitigating circumstances pertain:

- The radius of influence indicated is likely to be greatly overstated. A value of 122 m is more likely and even this value uses conservative parameters
- The magnitude of drawdown decreases exponentially away from the dewatered face. At a distance of 60 m from the marina, the drawdown experienced would be some 30% of the total drawdown (Ref Figure 13, CIRIA Report 113, 2005). Assuming a ‘worst case’ watertable drawdown of 2.4 m, a maximum drawdown of 0.75 m could theoretically be observed at the western margin of the wet woodland. In reality the adjacency of the River Nene would be likely to act as a source of recharge water and the effects of drawdown would be naturally mitigated
- Material will be emplaced against all the excavated faces of the marina, thereby minimising groundwater ingress and associated watertable lowering

3.80 The marina will be 700 m from the nearest wetland area and over 1 km from confirmed wetlands of ornithological importance. In addition, references to the SPA state that the waterbodies are reliant on sporadic flooding rather than constant water levels in the river or groundwater supplies. Therefore, excavation of the marina is highly unlikely to directly affect the main sources of water to the SPA. However, the marina will be linked to the River Nene which does form part of the SPA. The EA concluded that the marina will not increase the capacity of the river around the site, and will therefore not affect the local hydrology, eg neighbouring fields may still seasonally flood. However, the increased area of standing water may benefit the local bird population. Therefore, no significant affects on hydrology, and therefore, ecology, are predicted (a separate Flood Risk Assessment exists, which has been agreed in principle with the EA and should be read in conjunction with this report).

3.81 Taking all of these comments into account the impact magnitude is considered to be ‘minor’ and the impact significance ‘minor’ to ‘none’.
3.5 RESIDUAL EFFECTS

3.5.1 River Nene

Water volume
3.82 During operation the marina is not anticipated to have any potential for impact upon water volumes in the River Nene. The impact magnitude is ‘negligible’ and the significance ‘none’.

Water quality
3.83 The River Nene is already used by boats. Therefore, as the marina will not be directly introducing boats to the river (e.g. it is not a construction yard), merely giving existing boats a place to moor overnight, there is no reason for its creation to deteriorate water quality below existing levels. Although more boats may be encouraged to visit the area due to the presence of the marina, there is no evidence to suggest that increased boat numbers would deteriorate water quality around the SPA (especially when the EA licensing and regulation of boats is considered). In addition, the only area of hardstanding will be the car park in the northern section of the site (furthest from the river) which will be at the base of a newly-created bund. Therefore, as water from the car park cannot enter the marina or the river, no impacts on water quality from run-off are predicted. There will also be no abstraction from, or discharge into, the river, further reducing the probability of adverse impacts on water quality due to operation of the marina.

3.84 Boats using the marina will be refuelled by members of staff who will be fully trained in pollution prevention directly associated with the Inland Waterways environment. The operators will have all necessary equipment such as absorbent booms which can be quickly deployed to deal with any fuel spillages, either on land or into the marina basin.

3.85 The proposal will not adversely affect the quality of the water as all foul disposal from boats are either by cassette unit, which can be disposed of safely in the facilities building “Elsan” room, or pumped directly from the boat by a land-based “Pump-Out” unit to an underground holding tank. This tank will have an above ground alarm system to advise the operators that the tank is full and requires emptying.

3.86 The impact magnitude is defined as ‘negligible’ and the significance ‘minor’.

3.5.2 Abstractions

3.87 There is not considered to be any potential to impact adversely upon water abstractions. The impact magnitude is ‘negligible’ and the impact significance ‘none’.

3.5.3 Sites of ecological interest

3.88 There is not considered to be any potential for residual effects upon ecology. The impact magnitude is ‘negligible’ and the significance ‘none’.
3.6 SUMMARY and CONCLUSIONS

3.89 It is proposed to create a marina by the extraction of superficial deposits. Sand and gravel comprises a proportion of the material to be excavated and this will be exported from site, as dug, to a mineral processing plant.

3.90 The water environment within the Application Area and its environs has been investigated by reference to published and unpublished data. Detailed information relating to the near-surface geology exists in the form of trial pits and mineral evaluation boreholes.

3.91 The marina is located immediately to the north of the River Nene, and a connection to the river will be provided. A 9-10 m standoff will remain between the southern boundary of the marina and the river bank.

3.92 The landform and hydrology of the valley of the River Nene in the vicinity of the Application Area has been modified significantly due to historic and current mineral extraction. The closest such feature to the Application Area is Earls Barton Quarry, which is located to the southeast.

3.93 The Upper Nene Valley Gravel Pits Site of Special Scientific Interest (SSSI) is located approximately 60 m east of the Application Area. The majority of the SSSI within 2 km of the site is located on the opposing southern bank of the River Nene. However, 20.4 Ha of the SSSI is located on the north bank east of the Application Area. The Upper Nene Valley Gravel Pits is also designated as a Special Protection Area (SPA) and Ramsar site. The SPAs and Ramsar Areas within 2 km of the site comprise the areas on the southern bank of the River Nene and cover 124.5 Ha.

3.94 The geology comprises a variety of superficial deposits situated above the laterally extensive Whitby Mudstone Formation. The superficial deposits comprise Alluvium which consists of clays, silts, sands and gravels.

3.95 The superficial deposits are designated by the Environment Agency as a Secondary A Aquifer. The underlying Whitby Formation is designated as Unproductive Strata.

3.96 An indication of groundwater levels can be gained from data within some of the borehole logs discussed above. Water strikes were recorded whilst drilling boreholes 01/09 and 02/09 at depths of 1.1 m below ground level (mbgl), at each site. Comparison of the groundwater levels and geology shown on the borehole logs indicates that the sand and gravel is fully saturated and this was assumed for the purposes of calculations.

3.97 Details of licensed abstractions within a 2 km radius of the centre of the Application Area were determined from Envirocheck data. Four such licences were identified and their details obtained. There are no unlicensed water abstractions within a 2 km radius of the Application Area.

3.98 To allow safe and efficient excavation, the superficial deposits will be dewatered. The water ingressing to the site will be derived from groundwater inflow as well as rainfall, both from the footprint of the site itself and its surface water catchment.
3.99 Water will be discharged to the adjacent River Nene, following settlement to ensure that its quality complies with the likely conditions stipulated on an Environmental Permit, which need to be requested from the Environment Agency.

3.100 The potential impacts of the proposed development, both during construction and operational phases have been considered. A series of tables have been used so that the impact magnitude and its significance is assumed in a systematic manner. None of the identified potential impacts require specific mitigation measures other than the adoption of standard good-practice methods relating to storage of contaminants and fuelling and maintenance of mobile plant.
DRAWINGS
APPENDIX VOL 3 CH 2 (3.33)

Logs of boreholes BH01 and 02/09
# Daily Borehole Log

<table>
<thead>
<tr>
<th>Site</th>
<th>Pastures Farm</th>
<th>Drill Method</th>
<th>S/A</th>
<th>Rig No.</th>
<th>1500/1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>John Skinner</td>
<td>Hole Dia.</td>
<td>6&quot;</td>
<td>Log No.</td>
<td>1 Of 4</td>
</tr>
<tr>
<td>Crew Names</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day</td>
<td>Tuesday</td>
<td>Date</td>
<td>01/09/09</td>
<td>Start</td>
<td>08:00 AM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stop</td>
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<tr>
<td>Borehole</td>
<td></td>
<td></td>
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<td>01/09</td>
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## Strata Description

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<thead>
<tr>
<th>Strata Description</th>
<th>From</th>
<th>To</th>
<th>Thickness</th>
<th>Type</th>
<th>Depth</th>
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<tbody>
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<td></td>
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<tr>
<td>Firm brown topsoil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm grey silty clay with brown patches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft damp brown silty sandy clay with occasional small gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water strike</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft damp brown very silty sandy clay with some stones</td>
<td>1.10</td>
<td>2.00</td>
<td>0.90</td>
<td>bulk</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Small to medium gravel with some mainly coarse brown sand and</td>
<td>2.00</td>
<td>2.30</td>
<td>0.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occasional thin clay lenses</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine to coarse brown silty sand and gravel with some flints</td>
<td>2.30</td>
<td>2.63</td>
<td>0.33</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Fine to coarse brown sand and gravel with some flints</td>
<td>2.63</td>
<td>2.85</td>
<td>0.22</td>
<td>Bulk</td>
<td>2.63</td>
<td>3</td>
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<tr>
<td>Firm brown sandy clay with some stones</td>
<td>2.85</td>
<td>3.00</td>
<td>0.15</td>
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<td>2.85</td>
<td></td>
</tr>
<tr>
<td>Firm grey clay with occasional stones</td>
<td>3.00</td>
<td>3.45</td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand and gravel lens</td>
<td>3.45</td>
<td>3.50</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm grey clay with some small chalk pieces</td>
<td>3.50</td>
<td>4.00</td>
<td>0.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm to hard grey clay with some small chalk pieces</td>
<td>4.00</td>
<td>4.50</td>
<td>0.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borehole completed</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Drilled this shift 4.50

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>08:00 AM</th>
<th>06:00 PM</th>
<th>Daywork, Chisel, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth Cased</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth of Hole</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks:

Signature on behalf of client: [Signature]

Drilling and Servicing Co Ltd  [Website]

11 Bennetts Hill, Dunton Bassett, Lutterworth, LE17 5JL.
Tel: 01455 209314 Fax: 01455 201251 Mobile: 07836 665418/7
## Daily Borehole Log

<table>
<thead>
<tr>
<th>Site</th>
<th>Pastures Farm</th>
<th>Drill Method</th>
<th>S/A</th>
<th>Rig No.</th>
<th>1500/1</th>
<th>Crew Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>John Skinner</td>
<td>Hole Dia.</td>
<td>6&quot;</td>
<td>Log No.</td>
<td>2 Of 4</td>
<td>J Hall</td>
</tr>
</tbody>
</table>

**Day** Wednesday  **Date** 02/09/09  **Start** 08:00 AM  **Stop** 06:00 PM  **Borehole** 02/09/03/09

### Strata Description

<table>
<thead>
<tr>
<th>Strata</th>
<th>From</th>
<th>To</th>
<th>Thickness</th>
<th>Type</th>
<th>Depth</th>
<th>no</th>
</tr>
</thead>
<tbody>
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<td>Bh 02/09 - SP85653,62113</td>
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<tr>
<td>Firm brown topsoil</td>
<td>G/L</td>
<td>0.25</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft to firm grey silty clay with orange brown and</td>
<td>0.25</td>
<td>0.90</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>brown patches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft to firm brown and grey silty clay with sandy</td>
<td>0.90</td>
<td>1.10</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>patches and</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>some stones</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fine to coarse brown very silty sand and gravel</td>
<td>1.10</td>
<td>1.20</td>
<td>0.10</td>
<td>bulk</td>
<td>1.10</td>
<td>1</td>
</tr>
<tr>
<td>Mainly coarse brown sand and small gravel with some</td>
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<td>1.70</td>
<td>0.50</td>
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<td>1.20</td>
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</tr>
<tr>
<td>large gravel</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fine to coarse brown sand and small gravel with some</td>
<td>1.70</td>
<td>2.00</td>
<td>0.30</td>
<td></td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>large gravel</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Firm brown and grey silty clay</td>
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<td>2.05</td>
<td>0.05</td>
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<tr>
<td>Firm grey silty clay</td>
<td>2.05</td>
<td>2.80</td>
<td>0.75</td>
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<tr>
<td>Hard grey clay</td>
<td>2.80</td>
<td>3.00</td>
<td>0.20</td>
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<td></td>
</tr>
<tr>
<td>Borehole completed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Bh 03/09 - SP85669,62198                              |      |     |           |          |       |     |
| Firm brown topsoil                                    | G/L  | 0.25| 0.25      |          |       |     |
| Firm light brown silty clay with grey patches         | 0.25 | 0.70| 0.45      |          |       |     |
| Soft light brown silty clay with grey patches and     | 0.70 | 1.00| 0.30      |          |       |     |
| some sandy patches                                    |      |     |           |          |       |     |
| Soft light brown very silty sandy clay with some       | 1.00 | 1.15| 0.15      |          |       |     |
| stones                                                |      |     |           |          |       |     |
| Firm brown silty clay with grey patches and some      | 1.15 | 2.20| 1.05      |          |       |     |
| stones                                                |      |     |           |          |       |     |
| Firm to hard grey clay                                | 2.20 | 2.80| 0.60      |          |       |     |
| Very hard brown mudstone                              | 2.80 | 2.85| 0.05      |          |       |     |
| Borehole completed                                    |      |     |           |          |       |     |

| Bh 04/09 - SP85589,62167                              |      |     |           |          |       |     |
| Firm brown topsoil                                    | G/L  | 0.30| 0.30      |          |       |     |
| Firm brown silty clay with grey patches               | 0.30 | 0.95| 0.65      |          |       |     |
| Wet brown very silty sandy stoney clay                | 0.95 | 1.75| 0.80      |          |       |     |
| Fine to coarse brown silty sand and some small to     | 1.15 | 1.70| 0.15      | bulk     | 1.75  | 1   |
| large gravel                                          |      |     |           |          |       |     |
| Firm grey and brown silty clay                        | 1.70 | 2.00| 0.10      |          | 1.90  |     |
| Firm to hard grey clay                                | 2.00 | 3.10| 1.10      |          |       |     |
| Borehole completed                                    |      |     |           |          |       |     |

### Time of Day

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>08:00 AM</th>
<th>06:00 PM</th>
<th>Daywork, Chisel, etc.</th>
</tr>
</thead>
</table>

### Remarks

Drilled this shift 8.95

Drilling and Servicing Co Ltd

[Signature on behalf of client:]

11 Bennets Hill, Dunton Bassett, Lutterworth, LE17 5JJ.
Tel: 01455 209914 Fax: 01455 202651 Mobile: 07836 665419/7

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APPENDIX VOL 3 CH 3 (3.55)

Calculations of greenfield run-off and storm flow volumes for 1 in 10-year event
**Effective Radius of working phase 125m (calculated for rectangular pit after Somerville, 1988)**

Effective Radius (estimated from Figure calculated from funder’s report)

Where \( r \) = radius of influence (m)

- \( h_s \) = seepage face (m)
- \( r_w \) = radius of working area (m)
- \( k \) = hydraulic conductivity (m/s)

\[
Q = \pi k \left[ h_o^2 - h_w^2 \right] / \ln \left( r_w / r_o \right)
\]

**Groundwater Inflow Calculations: Thiem formula**

Where \( Q \) = groundwater ingress rate (m³/d)

- \( k \) = hydraulic conductivity (m/d)
- \( h_o \) = saturated thickness before drawdown (m)
- \( h_w \) = saturated aquifer thickness after drawdown + \( b \) (m)
- \( r_w \) = radius of working area (m)
- \( r_o \) = \( r_w \) + radius of influence (m)
- \( h_s \) = nominal value for height of seepage face in workings (m)

**Assumptions**

| Initial saturated thickness (h) | 2.5 m |
| Radius of working area (rw) | 150 m |
| Drawdown (h) | 2.4 m |
| Seepage face (hs) | 0.1 m |
| Radius of influence constant | 3000 m |

**Hydraulic conductivity values**

<table>
<thead>
<tr>
<th>Min</th>
<th>Median</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>25</td>
<td>50</td>
</tr>
</tbody>
</table>

**Seepage face and sat. thickness after dewatering have been given nominal values**

150-2000 for trenches, 3000 radial

**RESULTS - Groundwater Inflow, Q**

<table>
<thead>
<tr>
<th>Hydraulic conductivity (m/d)</th>
<th>10.0</th>
<th>25.0</th>
<th>50.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater Inflow, Q</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m³/d</td>
<td>l/s</td>
<td>m³/d</td>
<td>l/s</td>
</tr>
<tr>
<td>468.7</td>
<td>5.4</td>
<td>817.2</td>
<td>9.5</td>
</tr>
</tbody>
</table>

radius of influence 77 , 122 , 173 m